Puget Sound Nearshore Ecosystem Restoration Project

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Strategic Restoration Conceptual Engineering — Design Report

May 2012 — Final

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Cover photo: Lilliwaup Estuary (ESA)

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Acronyms and Abbreviations

ACR	Action Characterization Report
AASHTO	American Association of State Highway and Transportation Officials
BNSF	Burlington Northern Santa Fe
BPA	Bonneville Power Administration
CCC	Civilian Conservation Corps
CDT	Concept Design Team
cfs	Cubic feet per second
CMP	Corrugated metal pipe
CY	Cubic yards
DEM	Digital Elevation Model
EHW	Extreme high water
ELJ	Engineered log jam
FEMA	Federal Emergency Management Agency
GI	General Investigation
GIS	Geographic information system
GLO	General Land Office
H-Sheet	Hydrographic sheet
HDPE	High-density polyethylene
I-5	Interstate 5
LF	Linear feet
LiDAR	Light Detection and Ranging
LLTK	Long Live the Kings
LOTT	Lacey-Olympia-Tumwater-Thurston
LWD	Large woody debris
MHHW	Mean higher high water
MHW	Mean high water
MLW	Mean low water
MLLW	Mean lower low water
mph	Miles per hour
MSL	Mean sea level
MTL	Mean tide line
NAVD	North American Vertical Datum
NAS	Naval Air Station
NER	National Ecosystem Restoration
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Service
NPDES	National Pollutant Discharge Elimination System
ppt	Parts per trillion
PSE	Puget Sound Energy
PSNERP	Puget Sound Nearshore Ecosystem Restoration Project
PUD	Public Utility District
SF	Square feet
SLR	Sea level rise

T-Sheet	Topographic sheet
U&A	Usual and Accustomed
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UW	University of Washington
VLM	Vertical land movement
WDFW	Washington Department of Fish and Wildlife
WDNR	Washington Department of Natural Resources
WPCF	Water pollution control facility
WRDA	Water Resources Development Act
WRIA	Water Resource Inventory Area
WSDOT	Washington State Department of Transportation
WSEL	Water surface elevation
WWTP	Wastewater treatment plant

INTRODUCTION

Background

The Washington Department of Fish and Wildlife (WDFW) and the U.S. Army Corps of Engineers (USACE) co-lead PSNERP, a General Investigation (GI) of Puget Sound. PSNERP was initiated to: (1) evaluate significant ecosystem degradation in the Puget Sound Basin; (2) formulate, evaluate, and screen potential strategies to address these problems; and (3) identify actions and projects to restore and preserve critical nearshore habitat. One aim of this multifaceted GI is to secure substantial federal funding (under the Water Resources Development Act or WRDA) for projects that restore the Puget Sound nearshore.

This report presents engineering design concepts for a suite of potential nearshore restoration *actions* that may be eligible for authorization through WRDA[1]. PSNERP will use the conceptual design information to assess the costs and benefits of each restoration action and formulate a comprehensive plan for restoring the Puget Sound nearshore. The plan will analyze future conditions with and without a strategic nearshore restoration project. This will allow the USACE and WDFW to compare the benefits of implementing nearshore restoration with the future conditions if no action is taken. The ecological and socioeconomic effects of restoration will be expressed in terms of change in ecosystem outputs. The USACE will use this information to select a portfolio of restoration actions that meet federal cost-effectiveness criteria. The selected actions will be evaluated further to verify their suitability for the National Ecosystem Restoration (NER) Plan proposed to be authorized for implementation.

All of the restoration actions described in this conceptual engineering design report will have the potential to provide important ecological benefits regardless of whether they are deemed appropriate for federal authorization. Some of the actions may be more suitable for implementation at the local level through non-federal programs or partnerships. Report authors and PSNERP team members anticipate that the design information provided by the report will support not only potential implementation of projects through WRDA, but also implementation through other federal and non-federal programs, authorities, and funding sources.

This report was prepared by a team of engineering firms led by Environmental Science Associates (ESA). WDFW hired this team to provide concept-level (10%) design services for an initial suite of candidate restoration actions. ESA's team (referred to here as the Concept Design Team or CDT) includes ESA PWA (formerly Phillip Williams Associates, now a fully owned subsidiary of ESA); Anchor QEA; Coastal Geologic Services (CGS); KPFF; and Pacific Survey and Engineering (PSE). Completion of conceptual designs and review of the report was supported by PSNERP team members, project proponents who initially identified the potential restoration actions, and USACE technical experts.

[1] This report uses the term *action* instead of *project* to denote individual restoration efforts that occur within a larger site. For some sites, such as the Skagit River delta, several actions may be proposed. The area where an action is proposed is referred to as the *action area.*

Selection and Screening of Candidate Restoration Actions

The candidate restoration actions PSNERP selected for conceptual design were drawn from PSNERP's analysis of process-based nearshore restoration needs, and from a list of existing restoration opportunities identified by restoration proponents from various governmental and non-governmental organizations throughout the Puget Sound Basin (Figure 1 and Table 1). Each action represents a location where one or more restoration measures can be applied to improve the integrity and resilience of the nearshore ecosystem. According to PSNERP analysis of Puget Sound conditions and program guidance documents, implementing these actions will help achieve nearshore conservation strategies upon which the comprehensive restoration plan for Puget Sound is based (Cereghino et al. 2012) (Table 2).

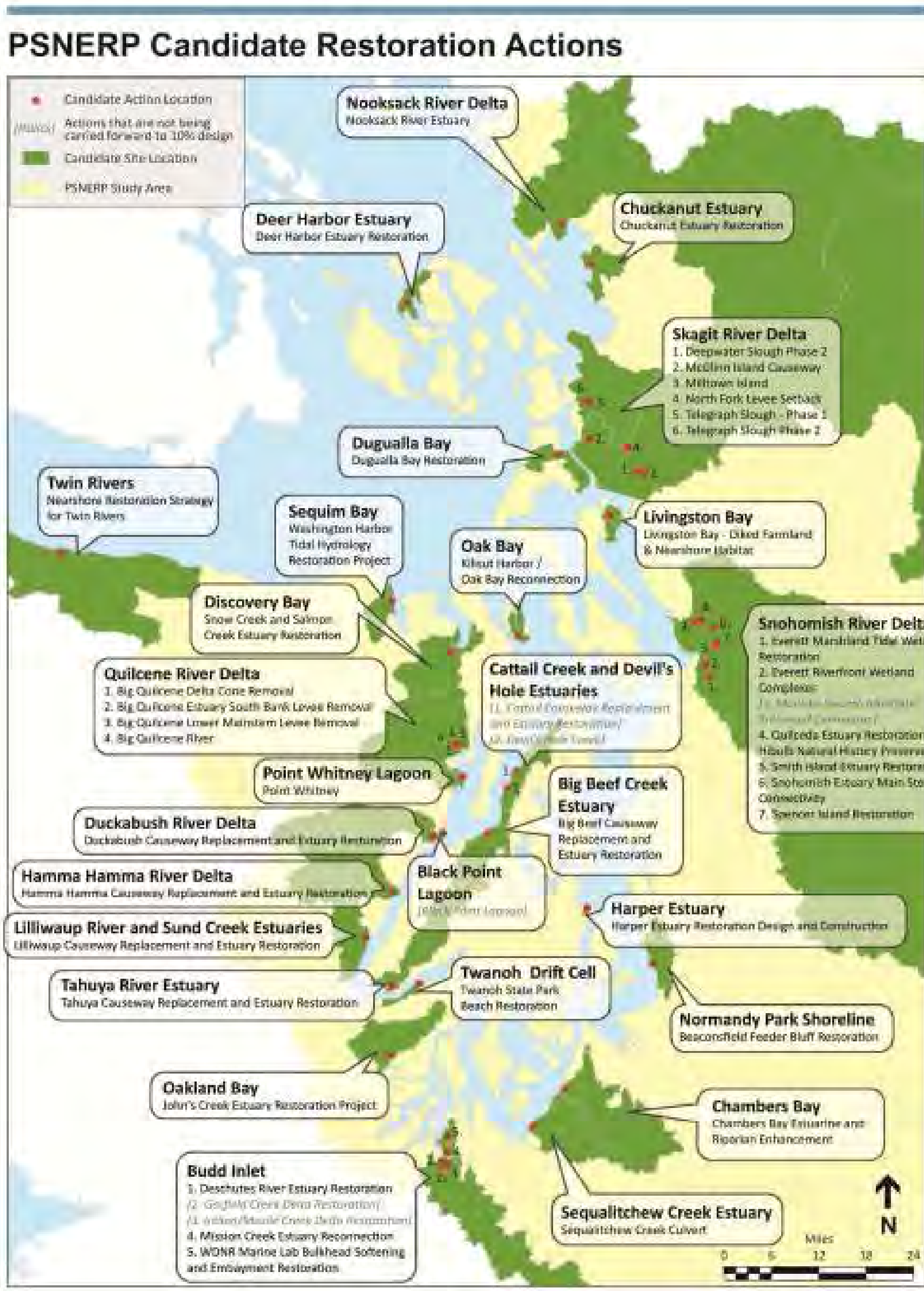

Figure 1. Location of PSNERP Candidate Restoration Actions

Table 1. PSNERP's Candidate Restoration Actions, Local Proponents, and CDT Lead Designer

Action ID	Action Name	Project Proponent	CDT Lead Designer
1499	Beaconsfield Feeder Bluff Restoration	City of Normandy Park	CGS
1256	Big Beef Causeway Replacement and Estuary Restoration	Hood Canal Coordinating Council	CGS with KPFF
1076	Big Quilcene Delta Cone Removal	Hood Canal Coordinating Council	Anchor with KPFF
1074	Big Quilcene Estuary South Bank Levee Removal	Hood Canal Coordinating Council	
1077	Big Quilcene Lower Mainstem Levee Removal	Hood Canal Coordinating Council	
1078	Big Quilcene River	Hood Canal Coordinating Council	
1801	Chambers Bay Estuarine and Riparian Enhancement	South Puget Sound Salmon Enhancement Group	Anchor with KPFF
1642	Chuckanut Estuary Restoration	City of Bellingham	Anchor with KPFF
1101	Deepwater Slough Phase 2	Washington Dept. of Fish & Wildlife	ESA PWA
1648	Deer Harbor Estuary Restoration	People for Puget Sound	CGS
1003	Deschutes River Estuary Restoration	Squaxin Island Tribe	ESA PWA
1012	Duckabush Causeway Replacement and Estuary Restoration	Hood Canal Coordinating Council	ESA PWA with KPFF
1609	Dugualla Bay Restoration	Skagit River Systems Cooperative	Anchor with KPFF
1126	Everett Marshland Tidal Wetland Restoration	City of Everett	Anchor
1127	Everett Riverfront Wetland Complexes	City of Everett	ESA
1047	Hamma Hamma Causeway Replacement and Estuary Restoration	Hood Canal Salmon Enhancement Group	Anchor with KPFF
1505	Harper Estuary Restoration Design and Construction	Kitsap County	KPFF/ESA
1447	John's Creek Estuary Restoration Project	Cascade Land Conservancy	Anchor
1552	Kilisut Harbor / Oak Bay Reconnection	Jamestown S'Klallam Tribe	CGS
1346	Lilliwaup Causeway Replacement and Estuary Restoration	Hood Canal Coordinating Council	PWA with KPFF
1618	Livingston Bay - Diked Farmland & Nearshore Habitat	Whidbey Camano Land Trust	ESA PWA
1092	McGlinn Island Causeway	Skagit River Systems Cooperative	ESA PWA
1091	Milltown Island	Skagit River Systems Cooperative	Anchor with KPFF
1457	Mission Creek Estuary Reconnection	City of Olympia	ESA

Action ID	Action Name	Project Proponent	CDT Lead Designer
1190	Nearshore Restoration Strategy for Twin Rivers	Lower Elwha Tribe	CGS
1055	Nooksack River Estuary	Whatcom Action Area Local Integrating Organization	ESA/PWA
1102	North Fork Levee Setback	Skagit Watershed Council	ESA PWA w KPFF
1379	Point Whitney	Washington Dept. of Fish & Wildlife	ESA PWA
1136	Quilceda Estuary Restoration	Tulalip Tribes	ESA
1467	Sequalitchew Creek Culvert	South Puget Sound Salmon Enhancement Group	Anchor with KPFF
1142	Smith Island Estuary Restoration	Snohomish County	Anchor
1805	Snohomish Estuary Mainstem Connectivity	Tulalip Tribes	ESA
1230	Snow Creek and Salmon Creek Estuary Restoration	North Olympic Salmon Coalition, Hood Canal Coordinating Council, Jefferson County Conservation District	ESA PWA with KPFF
1149	Spencer Island Restoration	Snohomish County, Ducks Unlimited	ESA PWA
1404	Tahuya Causeway Replacement and Estuary Restoration	Mason County	Anchor with KPFF
1633	Telegraph Slough - Phase 1	Skagit River System Cooperative	Anchor with KPFF
1635	Telegraph Slough Phase 2	Skagit Watershed Council, Washington Dept. of Fish and Wildlife	
1421	Twanoh State Park Beach Restoration	Washington State Parks	CGS
1237	Washington Harbor Tidal Hydrology Restoration Project	Jamestown S'Klallam Tribe	Anchor with KPFF
1684	WDNR Marine Lab Bulkhead Softening	Washington Dept. of Natural Resources	CGS
1261	Black Point Lagoon	Hood Canal Coordinating Council	NA
1271	Cattail Causeway Replacement and Estuary Restoration	Naval Base Bangor	NA
1286	Devil's Hole Creek	Naval Base Bangor	NA
1004	Garfield Creek Delta Restoration	City of Olympia	NA
1005	Indian/Moxlie Creek Delta Restoration	City of Olympia	NA
1131	Maulsby Swamp Mudflats/Enhanced Connection	City of Everett	NA
NA indicates action failed screening criteria and was not carried forward to 10% design			

Table 2. Description of PSNERP's Restoration Strategies for Puget Sound

#	Strategy Name	Description
1	River Delta	Protect and restore freshwater input and tidal processes where major river floodplains meet marine waters.
2	Beach	Protect and restore sediment input and transport processes to littoral drift cells where bluff erosion sustains beach structure.
3	Barrier Embayment	Protect and restore sediment input and transport processes to littoral drift cells where bluff erosion sustains barrier beaches that form barrier embayments and restore the tidal flow processes within these partially closed systems.
4	Coastal Inlet	Protect and restore tidal flow processes in coastal inlets, and protect and restore freshwater input and detritus transport processes within these open embayment systems.

The CDT visited each action location and met with the local restoration proponents to review and document restoration goals and opportunities at each locale. Following the field visits, the CDT identified initial restoration alternatives for each potential action and summarized the findings in a series of Action Characterization Reports (ACRs), which were delivered to PSNERP in October 2010 (Appendix A). Each ACR describes the potential restoration opportunities in terms of ecological effectiveness and engineering feasibility. Based on the initial action characterization results, the CDT evaluated each action using primary and secondary screening criteria to determine if the action was appropriate for 10% engineering design (Table 3).

Table 3. Screening Criteria Used to Identify Actions that are Suitable for 10% Design

1	Criterion	Yes	No
Fatal Flaws: A *No response* on any question results in a *No Go* determination. Otherwise, the action is recommended for 10% design.			
1a	The local proponent has not precluded PSNERP's involvement in the concept design.		
1b	The candidate action is sufficiently described and spatially defined to enable us to design restoration alternatives and determine quantity estimates.		
1c	The candidate action is consistent with one or more PSNERP restoration strategies, and an alternative can be described which addresses one or more of the associated restoration objectives.		
Additional Criteria: A *No response* on one or more questions means the action may not be suitable for 10% design. If the action has all *Yes* responses, the action is recommended for 10% design.			
2	**Criterion**	**Yes**	**No**
2a	There is an alternative for this action that could restore ecosystem processes to a substantial portion of their historic (less degraded) state.		
2b	The restored action area will support a broad representation of nearshore ecosystem components appropriate for that geomorphic setting.		
2c	There are no obvious and significant problems external to the action area that would jeopardize the restoration outcome.		
2d	The contributing basin provides for flood discharge, wood recruitment, organism dispersal and sediment supply to support the restored system.		
2e	The restored action area will form a contiguous large patch that is well connected to a surrounding terrestrial and marine landscape.		
2f	The restored ecosystem components within the action area will be internally connected in a way that allows for the unconstrained movement of organisms, water, and sediments.		

Six actions did not meet the screening criteria and were not recommended for further design work (Appendix A). After reviewing the ACRs and preliminary screening results with the local proponents, PSNERP elected to carry 40 of the original 46 candidate actions forward to 10% design. In addition, multiple actions at the Big Quilcene River site were combined into one action, and two phases of the Telegraph Slough action were combined into one; this brought the total number of actions being carried forward to 10% design from 40 to 36. Each of these 36 actions is described in a subsequent chapter of this report.

Restoration Design within PSNERP's Framework

PSNERP's restoration strategies are aimed at restoring damaged or degraded ecosystem processes. Process-based restoration involves making intentional changes to an ecosystem to allow erosion, accretion, tidal exchange, accumulation of wood debris, and other natural process to occur. Process-based restoration is often distinguished from species-based restoration which aims to improve the services an ecosystem provides to a single species or group of species as opposed to improving the entire ecosystem. It is anticipated that process-based restoration will deliver benefits to the diverse array of species that rely upon nearshore ecosystems in a manner that is sustainable and reduces the need for future interventions at the restored site. PSNERP has documented representative relationships between "valued ecosystem components", including juvenile salmonids, forage fish, and shorebirds, as part of a series of technical reports, available on the program website (http://www.pugetsoundnearshore.org/technical_reports.htm).

In PSNERP's framework, each candidate restoration action involves removing one or more ecosystem *stressors* using specific *management measures*. Stressors are physical alterations that interrupt, preclude, or displace nearshore processes. PSNERP documented the presence of the following stressors throughout Puget Sound as part of the Strategic Needs Assessment (Schlenger et al. 2011): nearshore fill, tidal barriers, shoreline armoring, railroads, nearshore roads, marinas, breakwaters and jetties, overwater structures, dams, stream crossings, impervious surfaces, and land cover development.

PSNERP used stressor information to calculate a *degradation score* for a series of nearshore analysis units. The CDT supplemented this relatively coarse scale information on stressors with additional site-specific information gathered during the field investigations to create restoration concepts for each action. The design concepts presented here document the amount of each stressor to be removed at each action location. PSNERP will use the information concerning stressor removal to recalculate the degradation scores and quantify the benefits of each restoration alternative.

Management measures are the restoration, rehabilitation, and enhancement activities (as well as protection, management, and regulatory endeavors) that remove stressors to recover or improve nearshore ecosystems. PSNERP defined 21 management measures for protecting and restoring Puget Sound (Clancy et al. 2009; http://www.pugetsoundnearshore.org/technical_papers/management_measures.pdf). Each candidate restoration action involves applying one or more of these management measures to achieve the site-specific restoration objectives. The measures that are the primary focus of this conceptual design report are the ones that have the most direct effect on nearshore processes and require in-depth engineering analysis, including:

- Topography Restoration: dredging, fill removal, or addition of surface material so that the physical structure of beaches, shorelines, and tidal wetlands can be restored.
- Armor Removal or Modification: removal of coastal erosion protection structures, including rock revetments, bulkheads, and retaining walls, to reinitiate sediment delivery and transport within beach systems.
- Hydraulic Modification: modification of culverts, tide gates, or levees to improve tidal or fluvial connectivity and the associated conditions in marsh and lagoon habitats.

- Berm or Dike Removal or Modification: removal of structures to restore tidal inundation and restoration of tidal wetland ecosystems.
- Channel Rehabilitation or Creation: restoration or creation of tidal, alluvial, and distributary channels to restore the natural movement and exchange of water, sediment, and/or detritus.

Other management measures such as Beach Nourishment, Contaminant Removal/ Remediation, Debris Removal, Groin Removal, Invasive Species Control, Large Wood Placement, Physical Exclusion, Overwater Structure Removal or Modification, Species/ Habitat Enhancement, Substrate Modification, Reintroduction of Native Animals, and Revegetation are used for some actions depending on the specific restoration opportunities available. Management measures such as Public Outreach/ Education, Habitat Protection Policies and Regulations, and Property Acquisition and Conservation are common to all actions.

Definition of Conceptual (10%) Design

Conceptual (10%) design is the first step in the restoration design sequence. Typically projects move from the concept stage (10%) to preliminary design (35%) to final design (which often involves 60, 90, and 100% design plans). While there are no precise definitions for 10% design, conceptual design generally involves identifying site-scale restoration alternatives for an action area and comparing them in terms of their relative costs, benefits, and feasibility. Action area boundaries were estimated to represent the area affected by the proposed restoration actions. A more precise, but still approximate, estimate of the lands required for construction (referred to as required project lands) was also calculated for each action. The action area and required project lands boundaries are shown in the figures and drawings that accompany each action. For purposes of this contract, 10% design involves the following:

- Describing site conditions and restoration opportunities;
- Describing how specific management measures will be applied to remove stressors and restore processes;
- Identifying the potential need for land acquisition;
- Describing the primary design considerations that might affect feasibility, cost and/or success of the project;
- Describing the ecological evolution of the restored site;
- Quantifying the type and amount of stressor removal at each action area;
- Describing uncertainties and/or risks associated with property acquisition, flooding, weak soils, contamination, etc.;
- Assessing risks caused by projected sea level change;
- Describing additional information needs; and
- Estimating quantities for all the major design elements.

A major goal of the 10% design process is defining data gaps and uncertainties that will need to be addressed in subsequent design phases, since detailed site investigations are typically not performed at the conceptual design stage. Subsequent design studies could include, for example, property boundary surveys, topographic surveys, geotechnical analyses, contaminant tests, cultural resources assessments, and hydrodynamic models.

Ideally, the conceptual design process enables a project proponent to select a preferred alternative for each action that can be developed in more detail during the later design stages.

To ensure that a feasible and effective restoration alternative can be found for each of PSNERP's candidate actions, the CDT attempted to identify a broad spectrum of what might be possible within each action area. Thus, each action is represented in terms of a *full restoration* alternative and a *partial restoration* alternative. Bracketing a wide range of restoration possibilities for each action in this way bolsters PSNERP's ability to:

- Identify the combination of restoration measures that maximizes ecosystem benefits compared to costs, consistent with federal ecosystem restoration objectives;
- Select a subset of actions to move forward to preliminary design (35%); and
- Secure authorization for federal funding sufficient to implement a comprehensive restoration plan for Puget Sound (even though the plan may be scaled back as the design progresses).

Definition of Full Restoration

For each candidate action, the full restoration alternative is designed to maximize ecological benefits by fully removing stressors—regardless of cost. As a result, the full restoration alternative for each action is not necessarily the most cost effective way to restore the site. Optimizing ecological benefits means that in some cases, the full restoration includes activities such as excavation of starter channels or tidal channels to trigger natural processes and accelerate site evolution. For planning purposes, the full restoration alternative assumes that private properties can be acquired and that most infrastructure such as secondary roads and local utilities can be modified, relocated, or removed to fully restore processes. Major infrastructure such as regional transmission lines, state highways, and railroads are treated as constraints to full restoration and addressed accordingly. Although these assumptions are important for fully delineating the scope of federal authority that would be needed to implement these actions using WRDA appropriations, PSNERP recognizes that the full restoration alternative may not be appropriate for some actions. In particular, PSNERP recognizes that acquisition of private lands and infrastructure relocation hinge on landowner willingness, stakeholder support, and myriad other factors that have not been fully investigated at the concept design stage.

Full restoration as presented here involves applying specific process-based management measures to remove the causes of process degradation, which vary depending on the strategy/shoreform (Table 4). The description of a full restoration alternative is intended to assist the planning process by describing a site's near-maximum potential. In most cases, PSNERP recognizes that site-specific feasible, cost-effective, and socially acceptable alternatives may be scaled back through subsequent steps in the design process.

Table 4. Full Restoration Objectives, Target Processes, and Associated Management Measures

Full Restoration Objective	Target Processes (primary in bold)	Management Measures
River Deltas - Ecosystem processes can be fully restored by removing the dominant stressors to a degree that allows undegraded tidal flows and freshwater inputs necessary to support a full range of delta ecosystem processes, focusing on the reestablishment of complex wetlands that include oligohaline transition and tidal freshwater components	**Tidal flow** **Freshwater input** (including alluvial sediment delivery) Erosion and accretion of sediments Distributary channel migration Tidal channel formation and maintenance Detritus recruitment and retention Exchange of aquatic organisms	Berm or dike removal, frequently complemented by channel rehabilitation, and topographic restoration
Beaches - Ecosystem processes can be fully restored by removing or modifying barriers to the movement of sediment from source (bluffs) to sinks (beaches) to a degree that allows the full range of beach processes	**Sediment supply** Sediment transport Erosion and accretion of sediments Detritus recruitment and retention	Armor removal Groin removal (where cross-shore structures impound sediment, and starve down-drift beaches)
Embayments - Ecosystem processes can be fully restored by removing the dominant stressors to a degree that allows undegraded tidal flows necessary to support a full range of embayment ecosystem processes	**Sediment supply** **Sediment transport** **Tidal flow** Erosion and accretion of sediments Detritus recruitment and retention Tidal channel formation and maintenance	Armor removal Groin removal Berm or dike removal (in some settings) Topographic restoration (where embayments have been filled) Channel rehabilitation Hydraulic modification (where restoration of natural tidal channel formation and maintenance processes is constrained)
Coastal Inlets - Ecosystem processes can be fully restored by removing the dominant stressors to a degree that allows undegraded tidal flows and freshwater inputs necessary to support a full range of coastal inlet ecosystem processes	**Tidal flow** **Freshwater input** (including alluvial sediment delivery) Tidal channel formation and maintenance Detritus recruitment and retention	Berm or dike removal Topographic restoration (where inlets have been filled) Hydraulic modification (for restoring tidal flow in some settings but may not provide a full range of ecosystem processes)

Definition of Partial Restoration

Each candidate action is also represented by a partial restoration alternative. The partial restoration alternative differs from full restoration in that it: (1) generally does not fully remove stressors, and (2) is typically more constrained in terms of the scope, scale, and/or complexity of restoration features involved. Partial restoration alternatives typically involve fewer management measures, have smaller or more constrained tidal openings, have a smaller footprint, and/or require less property acquisition than full restoration. In some cases, the partial restoration alternative is configured to take advantage of properties that are believed to have willing owners (which needs to be confirmed). Partial restoration generally reflects the local proponent's needs and desires and may include public access features such as trails, boat launches, and other amenities that are necessary to satisfy local interests.

As an example, the full restoration alternative for the Chuckanut Estuary Restoration action (Chapter 5, #1642) involves removing the existing railroad berm crossing the estuary and replacing it with a bridge. The partial restoration alternative, by comparison, removes only 290 feet of the berm. The smaller opening in the partial restoration alternative was sized to provide the desired tidal velocities and complexity of tidal circulation and wave action within the estuary, while minimizing the engineering complexities associated with replacing over 2,000 linear feet of an active railroad line. Despite not achieving full removal of stressors, the CDT attempted to define partial restoration alternatives for this and other actions which would:

- Support a wide range of ecosystem processes;
- Provide wide representation of ecosystem components appropriate for the shoreform;
- Include contiguous large patches that are well connected to each other and to a surrounding alluvial, terrestrial, and marine landscape;
- Be internally connected to allow for the unconstrained movement of organisms, water, and sediments; and
- Ensure adequate flood discharge, wood recruitment, organism dispersal, and sediment supply to support functions.

Report Organization and Design Assumptions

Each of the following 36 chapters of this report describes the 10% design concept for a candidate restoration action. Each chapter includes background information on the action area, historical maps, an overview of the design concept, and details for the major restoration features. The text is organized to emphasize issues that are important to PSNERP's restoration framework: stressors and management measures. Plan view and cross section drawings depicting the key design elements are provided for the full and partial restoration alternatives for each action. A digital geodatabase also accompanies this report. The geodatabase has additional geospatial information on the restoration features and elements for ach action, which in some cases is not depicted easily on the (two-dimensional) plan view or cross section drawings. An engineer's estimate of quantities is also provided for each action and each alternative. Additional maps depicting current and historic shoreform type for each action area are included in Appendix D.

This report presents design concepts to support development of a comprehensive restoration plan for Puget Sound; these designs are not ready for construction. The designs are intended to help PSNERP determine the least-costly way of attaining its Sound-wide restoration objectives.

This report does not identify or address all of the social, political, or economic implications of the proposed restoration actions. That work will occur as part of subsequent design and analysis.

Design Elements Common to All Actions

The restoration actions described in this report share a number of common elements and have some similar underlying design assumptions. This section describes those commonalities to minimize repetition of information in each of the design chapters that follow.

Rail, Roadway, and Bridge Standards

Many of the actions involve replacement or modifications of transportation facilities such as railroads, roadways, and bridges. For the 10% design, the CDT assumes that all road and bridge work will conform to Washington State Department of Transportation (WSDOT) standards and comply with local agency requirements. Rail modifications would need to be coordinated with rail operators including Burlington Northern Santa Fe (BNSF) and will conform to their standards. Deviations, if needed, would be identified in subsequent stages of design.

The 10% design work focused primarily on identifying feasible horizontal alignments for proposed rail, road, and bridge improvements. The CDT developed general standards for establishing bridge elevations based on available topographic data (mainly LiDAR) and assumptions about clearance needs. In most cases the lead designer assumed a bridge height of extreme high water (EHW) +3 feet, or mean higher high water (MHHW) +3 feet (Table 5). Bridge elevations may need to be adjusted during subsequent design stages to account for sea level change and other factors.

Table 5. Methods for Establishing Bridge Elevations (ft) for 10% Design (NAV88)

Action	MHHW	EHW	STRUCTURE DEPTH	DECK ELEV.	METHOD FOR ESTABLISHING BRIDGE ELEV.
Big Quilcene					
Full		29.8	5'-2"	38.0	EHW + 3 FT
Partial		22.7	5'-2"	39.0	EHW + 3 FT
Big Beef Causeway Replacement and Estuary Restoration					
	13.47		5'-2"	23.0	MHHW + 3 FT
Chambers Bay Estuarine and Riparian Enhancement					
Road		15		25.9	EHW + 3 FT
Rail		16.5	8'-7"	28.1	
Chuckanut Estuary Restoration					
West End		12.7	4'-2"	16.6	0' clear (bottom of

Action	MHHW	EHW	STRUCTURE DEPTH	DECK ELEV.	METHOD FOR ESTABLISHING BRIDGE ELEV.
					girder at EHW)
East End		12.7	4'-2"	18.0	EHW +1.1 clear
Deer Harbor					
	7.23		5'-2"	15.55	MHHW + 3 FT
Deschutes River Estuary Restoration					
	10.43		5'-2"	18.6	MHHW + 3 FT
Duckabush Causeway Replacement and Estuary Restoration					
Full	8.87		5'-2"	18.5 (min.)	MHHW + 3 FT
Partial	8.87		6'-6"	18.5 (min.)	MHHW + 3 FT
Dugualla Bay Restoration					
Full		12.8	6'-6"	22.3	EHW + 3 FT
Partial		12.8	5'-2"	21.0	EHW + 3 FT
Everett Marshland Tidal Wetland Restoration					
Full - Road A		23.0	5'-2"	23.0	These bridges will be inundated at the 5-yr event of the Snohomish River
Full - Road B		24.0	5'-2"	23.0	
Full - Rail 2		23.0	4'-2"	23.0	
Partial - Road C		25.0	5'-2"	18.0	
Partial - Road D		23.0	5'-2"	21.0	
Partial - Rail 2		23	4'-2"	24.0	
Partial - Rail 3		23.0	4'-2"	23.0	
Partial - Rail 5		24.5	4'-2"	24.0	
Hamma Hamma Causeway Replacement and Estuary Restoration					
Full		12.0	3'-6"	21	Exceeds EHW + 3 FT
Partial		12.0	3'-6"	20	Exceeds EHW + 3 FT
Kilisut Harbor / Oak Bay Reconnection					
	7.40		5'-2"	15.57	MHHW + 3 FT
Lilliwaup Causeway Replacement and Estuary Restoration					
	8.87		5'-2"	17.04	MHHW + 3 FT
McGlinn Island Causeway					
Full	8.84		6'-6"	18.34	MHHW + 3 FT
Nooksack River Estuary					*County Standard for River System is 10-yr flood +2' clear*
Several Structures - Shallow Girder Section	8.2		6'-6"	17.7	MHHW + 3 FT
Several Structures - Thick Girder Section	8.2		5'-2"	16.4	MHHW + 3 FT
Sequalitchew Creek					
Full		unknown	8'-7"	match existing	Exceeds EHW + 3 FT
Snohomish Estuary Mainstem Connectivity					*County Standard for*

Action	MHHW	EHW	STRUCTURE DEPTH	DECK ELEV.	METHOD FOR ESTABLISHING BRIDGE ELEV.
					River System is 10-yr flood +2' clear
Full (three bridges)	9.2		5'-2"	22.2	Exceeds MHHW + 3 FT
Partial (three bridges)	9.2		6'-6"	25	Exceeds MHHW + 3 FT
Snow and Salmon Creek					*Unknown if EHW includes SLR*
Full	7.41	10.8	5'-2"	19.0	EHW + 3 FT
Partial	7.41	10.8	6'-6"	20.3	EHW + 3 FT
Tahuya Causeway Replacement and Estuary Restoration					
		14.1	3'-6"	20.6	EHW + 3 FT
Telegraph Slough - Phase 1 & 2					
Road		14.0	6'-6"	23.5	EHW + 3 FT
Rail		14.0	4'-2"	21.2	EHW + 3 FT
Washington Harbor					
		11.5	5'-2"	19.7	EHW + 3 FT

Public Outreach and Property Acquisition

None of the actions could be successfully implemented without extensive coordination with the local proponents, affected property owners, and other stakeholders. As a result, public education/outreach is a common component of all the restoration actions described here. Federal ecosystem restoration principles (USACE ER 1105-2-100) require collaboration and coordination with federal and non-federal partners, with those who have an interest in the restoration, and with the public. Public engagement must include disseminating information about proposed activities, understanding the public's needs and concerns, and consulting members of the public before decisions are reached. PSNERP is committed to ongoing coordination with affected stakeholders throughout the subsequent stages of the design process.

Public outreach and stakeholder engagement are especially critical for those actions that could adversely affect established recreational and/or commercial uses. Some of the actions (e.g., Deepwater Slough, #1101) occur on public lands that are popular recreational waterfowl hunting areas. Other actions (e.g., Hamma Hamma Causeway, #1047; Point Whitney Lagoon, #1379) could jeopardize commercial or recreational shellfish production and harvest. Dam removals at Chambers Bay (#1801) and Deschutes Estuary (#1003) would affect public resources, water rights, and other amenities that have large constituencies. If these or other actions with significant social, political, or economic implications move forward, PSNERP intends to work closely with affected stakeholders to evaluate potential tradeoffs, mitigate adverse impacts, and secure support for implementation.

All but a few of the actions would require acquisition or conservation of private property through purchase, easement, or other means (some of the actions are located wholly on state or publicly owned land). In the case of several actions, the potential property acquisition/conservation needs could be substantial if the full restoration alternative or some version of it were carried forward. The CDT attempted to identify the required project lands including lands to be acquired for each action based on readily available parcel data so that property needs could be considered when selecting a preferred alternative and weighing overall costs and benefits. The CDT determined the area of required projects lands by estimating the area directly affected by proposed construction activities including access and staging. Property requirements also depend on the area of potential hydraulic effect (i.e., area influenced by inundation or flooding following restoration) associated with each action, as hydraulic considerations may trigger the need for additional acquisition or easements (e.g., flowage easements). For most actions, the area of potential hydraulic effect is the same as the construction footprint, but for some actions the potential hydraulic effect extends beyond the area needed for construction. The required project lands area (i.e., the construction footprint) and the area of potential hydraulic effect are depicted on the plan view drawings for each action and/or in the geodatabase that corresponds to the project.

The willingness of property owners to make their lands available for restoration is often unknown at this point, and will need to be assessed during subsequent design stages. Federal ecosystem restoration principles specify that land acquisition should be minimized (generally not more than 25% of total project costs).

Regulatory Compliance and Permitting

All of the actions involve work in wetlands, waters of the state/waters of the U.S., and other sensitive or protected habitats. The actions will therefore need to comply with multiple and sometimes overlapping local, state, and federal laws, including but not limited to:

- National Environmental Policy Act
- State Environmental Policy Act
- Clean Water Act Sections 404 and 401
- National Pollutant Discharge Elimination System
- Endangered Species Act
- National Historic Preservation Act
- State Hydraulic Code
- State Shoreline Management Act
- Local Development Codes and Critical Areas Ordinances

The specific permits required and agencies involved will vary depending on the location and nature of the work associated with each action. A complete description of the permit/regulatory needs will be determined during subsequent design stages. Even though the proposed restoration actions will have beneficial effects on nearshore resources, impacts of construction (e.g., pile driving, excavation, dewatering, etc.) will need to be fully evaluated pursuant to applicable statutes and policies.

All of the actions that involve work below the ordinary high water mark of any waterbody will need to adhere to timing restrictions mandated by state and federal agencies. The restrictions are designed to prevent in-water construction activity during periods of salmonid migration and/or forage fish spawning. Regulatory agencies determine specific "windows" when in-water work is allowed on a case-by-case basis depending on the location of the work and the species present. Table 6 provides the approximate work "windows" for estuarine/saltwater habitats in Puget Sound.

Table 6. In-Water Work Windows for Estuarine/ Saltwater Habitats in Puget Sound

Species	Allowed in-water work window (approximate)
Salmon and bull trout	July to March
Herring	April to January
Sand lance	March to October
Surf smelt	April to September

Sea Level Change Risk Analysis

PSNERP is required to consider the effects of projected changes in sea level on proposed restoration actions[2]. To fulfill this requirement, the CDT qualitatively evaluated each action and each restoration alternative in terms of three scenarios that USACE uses for coastal investigations: "low," "intermediate," and "high" (Table 7). Local sea level rise change is produced by the combined effects of global sea level rise and local factors such as vertical land movement (VLM) (e.g., tectonic movement, isostatic rebound) and seasonal ocean elevation changes due to atmospheric circulation effects (Mote et al. 2008). Due to the position of tectonic plates, rates of VLM vary around Puget Sound with some areas experiencing uplift and others undergoing subsidence. Areas of uplift, such as the northwest portion of the Olympic Peninsula along the Strait of Juan de Fuca, may exceed projected sea level rise rates and result in a decrease in sea level (as shown in Table 7). SLR projections for each action will be refined using localized tide gauge data during later design stages.

The data represented in these scenarios are coarse approximations of sea level trends for a period of 50 years into the future with changes that may be nearly imperceptible from year to year. For these and other reasons, readers are advised not to place too much significance on absolute numbers, or significant digits, in this rapidly evolving area of scientific study.

[2] See Corps of Engineers Circular EC 1165-2-211 regarding "Incorporating Sea-Level Change Considerations in Civil Works Programs"(140.194.76.129/publications/eng-circulars/ec1165-2-211/entire.pdf).

Table 7. Puget Sound Nearshore Sea Level Change Analysis (centimeters increase (+) during the period of analysis, 2015 – 2065)

	Low Scenario (Extrapolate Historical)	Intermediate Scenario (Global SLR – VLM= Net SLR)			High Scenario (Global SLR – VLM= Net SLR))		
Puget Sound Sub-basin	Net SLR	Global SLR	VLM	Net SLR	Global SLR	VLM	Net SLR
Strait of Juan de Fuca	-8	21	17	4	63	17	46
San Juan Islands and Strait of Georgia	-8	21	17	4	63	17	46
Hood Canal	-8	21	17	4	63	17	46
Whidbey	-8	21	17	4	63	17	46
North Central Puget Sound	-8	21	17	4	63	17	46
South Central Puget Sound	13	21	-2	23	63	-2	65
South Puget Sound	13	21	-2	23	63	-2	65

Cultural/Historical Resources, Contaminant Surveys, and Endangered Species Act Consultation

The U.S. Fish and Wildlife Service (USFWS) is supporting the conceptual design process by performing the following services for each candidate action:

- Conducting Level I Environmental Contaminant Surveys, including record searches, onsite interviews, and assessments for each action area;
- Researching, identifying, and documenting cultural and historic resources to provide baseline information to expedite future compliance with Section 106 of the National Historic Preservation Act; and
- Developing information about the presence of Endangered Species Act-listed species and species of concern in each action area and providing guidelines for future project implementation.

The results of this work will be reported in a separate document to be completed in 2011. As a result, this design report contains minimal information about these specific topics pending completion of the USFWS study. The presence of Endangered Species Act-listed species and species of concern, contaminated soils, and cultural resources is reported for each action area where known, but this information should be considered preliminary and subject to future investigation and verification.

Best Management Practices

All of the actions will involve earthwork and exposure of bare ground. The conceptual designs assume that standard best management practices will be implemented to control erosion and sedimentation and ensure construction areas are stabilized as needed to prevent adverse impacts. PSNERP will prepare standard temporary erosion and sediment control plans for all actions later in the design process. Specific measures will vary depending on the location and nature of the work associated with each action. In addition, specific measures may be required under action-specific permit requirements.

A complete description of best management practices will be determined during subsequent design stages.

Monitoring

Each restoration action has associated monitoring needs and opportunities that are necessary for achieving success. Monitoring is essential for informing our understanding of restoration as a science, and for providing accountability to project proponents and stakeholders.

Although it is difficult at the conceptual design stage to identify all of the monitoring opportunities and needs that a given action presents, the CDT attempted to identify preliminary performance indicators for each candidate action that could provide valuable information for assessing and documenting restoration outcomes.

The CDT developed a standard list of monitoring parameters based on information in PSNERP's management measures technical report concerning restoration evaluation (Table 8). Using professional judgment, the CDT noted which of these parameters might constitute a key performance metric based on the nature of the restoration being proposed, the action area conditions, and other specific factors. This information should be considered preliminary, pending development of a more comprehensive and programmatic nearshore restoration monitoring program for Puget Sound as well as a more detailed understanding of the needs and opportunities at each action area.

Table 8. Standard Monitoring Parameters Used to Denote Key Performance Indicators

Monitoring Parameter	Description
Topographic stability	Important for actions involving removal of armoring, often useful in conjunction with sediment accretion and erosion monitoring; helps assess effects of restoration on sediment processes.
Sediment accretion / erosion	Important for assessing sediment accumulation and effects on estuary morphology and habitat.
Wood accumulation	Important for documenting distribution of woody debris in restored channels and elsewhere.
Soil / substrate conditions	Important for projects involving beach or bluff restoration.
Vegetation establishment	Important for actions where revegetation is planned or where habitats are intended to transition (e.g., mudflat to marsh); also important in areas that are graded to marsh plain elevations to encourage recolonization.
Marsh surface evolution / accretion	Important for berm and levee removal actions or other restoration involving reintroduction of tidal action to blocked coastal inlets.
Tidal channel cross-section / density	Important for actions involving channel excavation or rehabilitation; also important for actions targeting increase in tidal channel density; can help to verify stability of tidal channel modifications.
Water quality (contaminants)	Important for actions that may change drainage patterns or

Monitoring Parameter	Description
	have sensitive receptor sites; important where water quality issues have been documented.
Salinity	Important where restoration alters freshwater flow; also helpful for actions where existing shellfish operations may be at risk.
Shellfish production	Important for actions where existing shellfish operations may be at risk.
Extent of invasive species	Important for action areas with existing infestations of invasive species.
Animal species richness	General parameter that provides an indication of overall ecological benefits.
Fish (salmonid) access/use	Important for many berm and levee removal actions and hydraulic modification actions where fish passage barriers are removed.
Forage fish production	Important for beach restoration projects or for action areas where restoration may alter beach characteristics.
Wildlife species use	General parameter that provides an indication of overall ecological benefits.

For estimating monitoring quantities, the CDT somewhat arbitrarily assumed that monitoring for a key performance parameter (e.g., erosion/ sedimentation, vegetation establishment, etc.) would require 5 crew-days (a crew-day is two people working 8 hours each) per year for a 5-year monitoring period. Some actions may require more or less monitoring, so this estimate should be considered preliminary (see *Approach to Quantity Estimation* below for more information).

Adaptive Management

Adaptive management is the suite of activities that must occur following a restoration action to ensure the benefits are achieved over time. Adaptive management incorporates long-term monitoring to improve scientific understanding of the effects of various restoration actions on the nearshore ecosystem.

It is challenging at the concept design stage to know what types of adaptive management these restoration actions will require, but the following general needs seem likely given the suite of actions and management measures in PSNERP's portfolio:

- Topography modifications to adjust site elevations to achieve target habitat, "jump-start" channel development, or make up for slower-than-expected erosion;
- Adjustments to channel openings to achieve target tidal prism;
- Installation of woody debris or other features to create desired structural attributes;
- Plant installation to replace dead/dying material, stabilize eroding slopes, or create habitats as topography evolves; and
- Nourishment of substrates due to erosion.

PSNERP will prepare a comprehensive adaptive management program for the suite of actions it brings forward to implementation. Additional information concerning the adaptive management needs at each action area will be prepared during the subsequent design stages.

Operations and Maintenance

Many of the restoration actions involve modifying infrastructure such as bridges, culverts, and levees. These structures will require ongoing operations and maintenance in order to maintain the benefits of the restoration action over time. The types of ongoing operations and maintenance that will be required to maintain benefits associated with the proposed restoration actions include, but are not limited to:

- Routine inspections;
- Levee repair to correct for settlement, erosion, or other signs of compromised integrity;
- Removal of debris/wrack blocking bridge and/or culvert openings;
- Scour protection around bridge pilings; and
- Mechanical adjustments to ensure properly functioning tide gates.

Restoration areas that are accessible to the public may have specific management or operational needs such as maintenance of trails, signage, docks/boat launches, or exclusionary devices (fences). A more complete understanding of the specific operations and maintenance needs associated with each action will be compiled during the subsequent design stages.

Approach to Quantity Estimation

A key component of the 10% design phase is the estimate of construction quantities. PSNERP will rely on the quantity estimates as a basis for determining likely construction costs. Because it is difficult to develop precise estimates for some quantities without the type of detailed information that typically comes later in the design process, estimates reported here assume a contingency of about +50% (30% design contingency and 20% construction contingency).

The CDT developed a standard template for estimating quantities associated with each action. Quantities are listed separately for both the full and partial restoration alternatives. Each line item has a description that provides additional information to the audience, which is assumed to be either the cost estimator or a technical reviewer. Lump sums or units of “each” are also used with detailed descriptions.

The quantity estimates can be derived from the plan and section drawings included with each action. Backup is provided via digital files used to create the plan and cross section drawings. (Digital files are available from PSNERP.)

Ideally, the quantity estimate will be in units that are compliant with cost-benefit analysis. For example, linear feet (LF) of bulkhead removal with a description of bulkhead height and material allows for more direct adjustment, if needed, to change the cost-benefit (e.g., adjust to 500 LF of bulkhead removal instead of 800 LF). More detail on the quantity estimates is provided in Appendix B.

Applied Geomorphology Guidelines and Hierarchy of Openings

The CDT developed project-specific guidelines to help standardize the design approach and aid in quality control (Appendix C). The geomorphology guidelines use empirical models calibrated with data collected from field sites and are most useful when the site parameters lie within the range of the calibration data. Parameters include tide range, sediment and vegetation, fluvial effects, salinity (which affects plant types and geomorphology), and in some cases wave and littoral climate. The guidelines are organized as follows:

1. Tides: Tide design parameters are identified for National Ocean Service tide stations selected to represent the varying tides in Puget Sound. Tide ranges are tabulated. Tidal datum conversions from Mean Lower Low Water (MLLW) to North American Vertical Datum (NAVD88) are provided at each tide station.

2. Tidal Marsh Channels: Regression lines and graphs are provided to relate channel geometry (channel cross sectional area, width and depth) to marsh area and tidal prism. A set of regressions and graphs are provided for each tide station identified in (1), based on the tide range. A procedure is provided to estimate channel geometry with combined tidal and stream discharge.

3. Tidally Influenced Fluvial Channels: Guidance for tidally influenced fluvial channels is to use historic data, remnant channel geometry, and available published data on a site-specific basis.

4. Tidal Inlets: A set of graphs are provided for tidal inlets where wave action and littoral drift affect the channel geometry and, in particular, limit the tide range. The graphs allow prediction of the tidal prism necessary for an open inlet and the size of the inlet cross section for a given tidal prism.

5. Beach Geometry: Guidance is provided to estimate the berm elevation of coarse sediment beaches.

Because so many of the restoration actions included in this report involve removing or reducing tidal barriers, the CDT also attempted to define the relative degree of benefit provided by tidal openings of different sizes and locations in terms of a benefit hierarchy (Appendix C). The benefits are described in terms of improvements in natural processes, structure, and function. By understanding how various openings impact the nearshore ecosystems, crossings of tidal and tidally influenced fluvial channels can be designed to provide maximum benefits.

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1. BEACONSFIELD FEEDER BLUFF RESTORATION (#1499)

Local Proponent	City of Normandy Park
Delta Process Unit	NA
Shoreline Process Unit(s)	4015
Strategy(ies)	2 - Beach
Restoration Objectives	Remove shoreline armoring and restore sediment supply, detritus import and exchange, physical disturbance

1.1 Description of the Action

This action entails acquisition and restoration of an armored yet largely undeveloped feeder bluff that is located within a long drift cell. The drift cell has incurred substantial degradation of sediment supply and other nearshore processes due to the presence of concrete bulkheads and rock revetments. The proposed restoration would remove the shore armor and restore sediment supply in the drift cell. Please see the Introduction chapter for important information regarding PSNERP and for context related to this restoration project.

1.2 Action Area Description and Context

The Beaconsfield bluff is located just north of Marine View Park in Normandy Park, in the South Central Puget Sound Subbasin. The action area is composed of several narrow parcels along 1,000 feet of shoreline, 80% of which is armored with intermittent concrete vertical bulkheads and rock revetments. A single-family residence (the Hadley house) is located at the top of the 290-foot-high bluff. Most of the parcels extend from the beach up the lower elevation portion of the steep bluff face, in a configuration described as a cluster of narrow “piano key” parcels.

A feasibility assessment by Coastal Geologic Services, Inc. (Johannessen et al. 2006) included detailed topographic mapping of the bluff, backshore and intertidal areas, shore change analysis, bluff sediment budget, and restoration recommendations. One conclusion of that assessment was that as long as the Hadley house remains present, shore armoring would need to be retained waterward of the house to curb marine-induced erosion that could further endanger this precariously placed house. The action area is shown in Figure 1-1.

Figure 1-1. Action Area and Vicinity

1.2.1 Historic Condition

The Beaconsfield site was mapped as a bluff-backed beach in the PSNERP change analysis in both current and historic conditions. Figures 1-2A and 1-2B provide historic maps of the area.

Historic geomorphic analyses of the region identified this bluff as one of the highest restoration priorities in terms of sediment supply along the east shore of King County. This is due to the large volume and high quality (beach quality) of sediment supply that could be derived from the bluff, and the degree to which sediment supply has been degraded in the drift cell (Johannessen et al. 2005). The Hadley house was built in 1946. According to the former resident Elinore Hadley, her family initiated construction of the concrete bulkheads in the early 1950s and the rockeries during the 1960s.

Beaconsfield is located within net shore-drift cell KI-7-3, which exhibits northward net shore-drift from Des Moines Beach, located just north of the Des Moines Marina, to Three Tree Point (Johannessen et al. 2005). This cell has been considerably altered due to the development of the Des Moines Marina breakwater and extensive residential bulkheads. A small cell with southward transport from Des Moines Beach to the north side of the breakwater has developed in the wave shadow of the marina breakwater. Historically, cell KI-7-3 originated south of Saltwater State Park, which is approximately 3.8 miles south of the current origin. The cumulative impacts of many residential bulkheads throughout the drift cell, and the truncated condition of the cell, have further reduced littoral drift volumes, which would have sustained down-drift beaches and associated nearshore habitats. If restored, the 290-foot-high Beaconsfield bluff could reintroduce an important source of sediment and improve down-drift nearshore processes.

1.2.2 Natural Environment

The Beaconsfield nearshore represents a common beach type found in the Puget Sound region, consisting of a narrow sand and pebble high-tide beach that extends waterward to a sandy low-tide terrace. The beach is backed by a steep bluff composed of glacially-derived deposits. The beach is moderately exposed to both the south and northwest, with a maximum measured fetch of 11 miles to the southwest and 10.5 miles to the northwest. The southerly orientation of the Beaconsfield site, combined with predominant and prevailing southerly wind and waves, result in northward net shore-drift.

The bluff is composed of Vashon till overlying Vashon advance outwash deposits, as well as older glacial and interglacial sediment. Considerable outwash sand and gravel is exposed in the upper portions of the bluff, which is described as consisting of "well bedded sandy gravel to more common medium and fine-grained sand" (Booth 1991), with finer grained sediment more prevalent near the base of the bluff. Marine bluff slopes averaged 42 degrees across measured profiles (Johannessen et al. 2006). Grain size analysis of bluff sediment samples revealed that the bluff contained a high percentage of suitable forage fish spawning sediment substrate, as well as upper beach–building sediment (Johannessen et al. 2006).

Shallow landslides occur along the bluff face where armoring does not preclude marine-induced erosion. However, fewer landslides have occurred landward of shore armor; these may have been initiated by a combination of subsurface processes and land uses, such as vegetation clearing and surface water management (e.g., excessive lawn watering near bluff crest). When compared to other commonly occurring deposits in central Puget Sound, the Beaconsfield bluff stands out as an excellent source of sediment for the beaches of this long drift cell. Forage fish spawning has been documented approximately 1,200 to 1,500 feet north of the site (Salmonscape 2010).

The Beaconsfield feasibility assessment estimated the current sediment input of the surrounding Beaconsfield site to be approximately 25% of the historic volumes as averaged since bulkhead installation 50 years ago (Johannessen et al. 2006). Landslides at the site diminished in abundance following bulkhead installation at the site, further emphasizing the value of restoring this nearshore sediment source.

Two major vegetation assemblages occur on the bluff. Vegetation occurring along the northern portion of the bluff consists of Pacific madrone, Douglas fir, western red cedar and western hemlock. Big-leaf maples are interspersed within the assemblage along the upper reaches near the bluff crest. The understory consists of salal, bracken fern, oceanspray and false Soloman's seal. The southern portion of the bluff is dominated by Pacific madrone and big-leaf maple with an understory consisting of salal, oceanspray and honeysuckle. Younger, early-successional vegetation, often associated with natural disturbance, dominates the lower bluff face, particularly where shallow landslides have occurred. Driftwood occurs in places at the toe of the bluff and in some areas has been washed atop the shore armoring. Marine water appears to routinely overwash the soil landward of the armor, creating conditions for halophytic vegetation to colonize. Halophytic vegetation assemblages growing in the backshore and atop soil landward of armor include Pacific gumweed, native dune grass, common arrow-grass and salt grass.

Invasive species occur landward of armor at the bluff toe. These include Scot's broom, Himalayan blackberry, and English ivy.

1.2.3 Human Environment

This action area is located in a moderately heavily developed portion of Puget Sound. Dense development further landward has altered stream flows, impaired water quality in area streams, and greatly reduced forest cover. However, Marine View Park located a short distance south provides relatively high-quality habitats with forested bluffs and uplands. The Marine View Park nearshore is of similar character to the Beaconsfield site, however in a far more pristine condition. These unarmored bluff-backed beaches have considerable driftwood accumulations, shallow landslides with active large woody debris recruitment, and well sorted sediment across the beach profile (e.g., pebble/sand beachface, with sandy backshore).

The Hadley house is a 4,772-square-foot, single-family residence located at the top of the bluff. The house was set back only 14 feet from the bluff crest when measured in 2006. As long as the Hadley house is present, some shore armor will likely need to be retained to slow marine-induced erosion.

1.3 Restoration Design Concept

1.3.1 Restoration Overview and Key Design Assumptions

The restoration alternatives are illustrated in Figures 1-3 through 1-5. Shore armor (bulkheads and rock revetments) spans approximately 830 lineal feet of the Beaconsfield action area. Full restoration involves complete removal of the shore armor and cannot move forward without acquisition of the Hadley property. Partial restoration involves partial removal of the shore armor and allows the house to remain. The partial alternative could be implemented as the first phase of a phased approach, which would be completed if/when the Hadley property is acquired. A prior assessment (Johannessen et al. 2006) determined that as long as the Hadley house is present, some shore armor will likely need to be retained to slow marine-induced erosion. Approximately 288 lineal feet of armor would need to be retained to protect the Hadley house near the south end of the site. The option of moving the Hadley house landward away from the eroding bluff was deemed infeasible because of the brick construction of the house and the topographic and slope stability constraints on the property.

Partial restoration objectives include restoration of sediment input processes via armor removal to the greatest extent possible without exacerbating the existing threat of erosion waterward of the Hadley home. Even with the shore armor in place (which slows marine-induced erosion), the Hadley house is vulnerable to mass wasting, which could compromise the foundation or structural integrity of the house, or result in a more catastrophic slope failure that could be triggered by heavy precipitation or earthquakes.

Because it leaves some of the existing armor in place to protect the Hadley house, the partial restoration alternative would have less ecological benefit than the full restoration alternative.

The full restoration alternative would remove roughly 830 lineal feet of shoreline armoring (Figure 1-3). Partial restoration would remove only 660 lineal feet (Figure 1-4). Following armor removal, minor topographic restoration or regrading of soil landward of armor would occur where necessary (this may be backfill, which would need to be further evaluated). However, it is assumed that the upper beach will naturally grade to its former configuration upon exposure to wave energy, and that "deferred erosion" of the bluff toe will occur until a new dynamic equilibrium is established.

Key design elements associated with the full and partial restoration alternatives are shown in Table 1-1.

Table 1-1. Key Design Elements

Element	Full Restoration	Partial Restoration
Structure Removal	Acquire Hadley property and remove house	Not included
Armor Removal	Remove 830 LF of shore armor (bulkheads and rock revetments) from 20 properties	Remove armor (bulkheads and rock revetments) from 660 LF of bluff-backed beach shoreline. Maintain one section of concrete bulkhead waterward of the Hadley residence located at the top of the bluff
Beach	Minor regrading of sediment landward of bulkheads to recreate a gently sloping upper beach	Same as full restoration

1.3.2 Restoration Features – Primary Process-Based Management Measures

Armor Removal/Modification

The full restoration alternative entails removal of 830 LF of shore armor including concrete bulkheads and rock revetments (although some of the rock is stacked) (Figure 1-3). The total bulkhead length including the return walls associated with each concrete structure is 491 feet. The concrete bulkheads measure approximately 4 to 5 feet in height and are in reasonable condition, with some visible cracks in the face of the bulkheads. Rock armor removal for the full restoration alternative is approximately 700 CY. These rock revetments are composed of rocks measuring 2.4 to 4 feet wide, which are loosely stacked one to two rocks high. The toe of the armoring infringes below MHHW (+8.1 to 9.5 feet NAVD88; MHHW = +9.2 feet NAVD88) except at the north end of the site. Feeder bluff sediment input will benefit approximately 4 miles of down-drift shores.

Armor removal for the partial restoration alternative cumulatively measures 660 LF of shore. This entails removal of 329 LF of concrete bulkhead (348 LF including return walls) and approximately 535 CY of rock revetment, while maintaining armor waterward of the Hadley house (Figure 1-4). One short return wall will need to be constructed at each end of the retained armor, using salvaged rock from the revetment sections that will be removed. Feeder bluff sediment input will benefit approximately 4 miles of down-drift shores within the net shore-drift cell.

Berm or Dike Removal/Modification - NA

Channel Rehabilitation/Creation - NA

Groin Removal/Modification - NA

Hydraulic Modification - NA

Overwater Structure Removal - NA

Topography Restoration

For both full and partial restoration alternatives, minor regrading of the impounded sediment, likely of local origin, would be conducted following armor removal to recreate a gently sloping upper beach. Full restoration would entail rough grading of approximately 250 CY of pebbly sand, and partial restoration would entail the same for approximately 150 CY. It is assumed that the upper beach topography and sediment grade and composition will naturally adapt to the historic configuration through exposure to wave energy within weeks, and that “deferred erosion” of the bluff toe will occur until a new dynamic equilibrium is established over a longer period.

1.3.3 Restoration Features – Additional Management Measures

Beach Nourishment - NA

Contaminant Removal/Remediation - NA

Debris Removal - NA

Invasive Species Control

Invasive species eradication is recommended for both the full and partial restoration alternatives. Scot’s broom and Himalayan blackberry are found along the lower bluff face and several other locations on the bluff. Using mechanical removal methods, these species would be removed from approximately 2 acres under both alternatives. Under the full restoration alternative, these species would also be eradicated from approximately 0.5 acres of upland in the action area (where the Hadley home currently exists).

Large Wood Placement

No new large wood will be imported with restoration. Existing drift logs atop the bulkheads that are to be removed will be temporarily stockpiled during removal, then placed back onto the uppermost beach in the latter stages of restoration.

Physical Exclusion - NA

Pollution Control - NA

Revegetation - NA

Reintroduction of Native Animals - NA

Substrate Modification - NA

Species Habitat Enhancement - NA

1.3.4 Restoration Features – Other

With full restoration, the Hadley house at the bluff crest would need to be demolished and the debris removed from the site. This is a 1950s brick house of 4,772 square feet. In addition, the paved walkways and a portion of the driveway, miscellaneous small planters, and similar residential features would need to be removed by truck via upland access.

1.3.5 Land Requirements

The Beaconsfield action area is located in a residential area with high parcel density. Twelve parcels (7.8 acres), including the Hadley house parcel, would need to be acquired or easements secured to complete the full restoration design. The partial restoration alternative entails acquisition of a total of 6 parcels (2.1 acres) and does not require acquisition of the Hadley house parcel.

Acquisition and demolition of the Hadley house is recommended as part of the full restoration alternative. The Cascade Land Conservancy is actively negotiating the purchase of another parcel. The Hadley house has not yet been acquired, nor is it in negotiation at this time, although attempts have been made in the past.

While acquisition is the preferred option, and has been completed for several beach parcels, securing easements for other parcels (excluding the Hadley parcel) may be a more feasible option. This is especially the case for the northern parcels that contain structures set back from the bluff crest far enough to be safe from expected bluff recession following bulkhead removal. Approximately 100 feet of the northernmost concrete bulkhead extends into public tidelands. Permission may also be required from WDNR to remove the northernmost bulkhead in the action area as it appears it may partially extend onto public tidelands.

1.3.6 Design Considerations

The primary design consideration is bluff stability following armor removal. A moderate amount of "deferred" bluff erosion is expected to occur shortly after removal (within 0 to 3 years) as the bluff toe is exposed to wave attack and the position of the shoreline migrates to a more natural contemporary position. It is likely that if all armor was removed, the Hadley house would be further at risk due to this deferred erosion. This leads to the difference between the partial and full restoration alternatives: The partial restoration alternative maintains a portion of the bulkhead below the Hadley house to prevent additional risk to the structure (Figures 1-3 and 1-4).

1.3.7 Construction Considerations

All construction activities taking place on the beach (armor removal, regrading) will take place via barge access due to the inherent challenge of accessing the site from the high-relief uplands. The reinforced concrete bulkheads will require breaking up to facilitate removal. An excavator-mounted jack hammer should prove sufficient for this purpose, although this may require saw cuts. Once demolished, the bulkhead and rock would be loaded onto the barge for offsite disposal. The rock would likely be of some value for salvage by a contractor. Following removal of the armor, sediment landward of the bulkheads would undergo minor rough grading to resemble adjacent unarmored beach elevations. Large woody debris found waterward or landward of armoring would be stockpiled during construction and placed in the backshore (MHHW +1 or 2 feet) following grading.

Invasive species removal would be conducted from land, as well as demolition and removal of the Hadley home in the full restoration alternative.

1.4 Extent of Stressor Removal

Table 1-2 describes the amount of stressor removal with the full and partial restoration alternatives.

Table 1-2. Stressor Removal

Stressor	Full Restoration	Partial Restoration
Armor (LF)	830	660

1.5 Expected Evolution of the Action Area

Without restoration, the bulkheads are expected to continue to slow marine-induced erosion of the bluff toe. Ongoing background erosion and wave reflection caused by armor will likely narrow, coarsen, and reduce the areal extent of upper beach habitats (such as potential forage fish spawning areas) until the shore armor structures are removed. Down-drift beaches that historically relied on sediment derived from the armored bluff may also slightly erode and coarsen in (sediment) composition without the natural sediment input. This could also lead to structural changes in intertidal habitats as well as reduced area. Shore armor largely precludes marine-induced erosion; however, bluff erosion initiated from other drivers such as heavy precipitation will continue to cause bluff recession. The adjacent unarmored bluffs will continue to recede at the background rate of erosion (or possibly a greater rate), which will result in a greater offset between the armored and unarmored shorelines. The unarmored bluffs adjacent to armor will likely have additional erosion due to end effects. Overtopping of armor will likely occur with increasing frequency, which will contribute to structure failure. Over time (on the order of 20 to 40 years), the armor will become less effective and begin to fail, although at different times, leaving debris on the beach partially impeding natural processes. The Hadley house may be increasingly endangered.

The full restoration alternative will lead to accelerated short-term bluff erosion as “deferred” erosion/mass wasting occurs, and long-term bluff erosion as the system adjusts. Armor removal will allow the natural beach profile to be restored within approximately one year at the site by uncovering the beach from just below MHHW up through the backshore. Bluff recession and sediment input will augment adjacent and down-drift habitats over the 4-mile-long drift cell, which did not receive sediment as a result of the armoring. Local large woody debris recruitment as well as driftwood deposition will likely contribute to the action area and nearby Marine View Park. Sediment along the adjacent and down-drift shores will likely become slightly finer in composition, and potential forage fish spawning habitat may slightly expand. Due to the lack of site-specific data and understanding of the relative rate of sediment transport after armor removal, it is difficult to predict when down-drift habitats may experience benefits. Once the bluff reaches equilibrium, erosion is expected to slow to a rate comparable to bluffs of similar exposure in the region. The time to reach bluff equilibrium is also unknown, but it is anticipated to be on the order of 15 to 30 years. With acquisition and demolition of the Hadley house, the bluff could recede free of threats to infrastructure.

The partial restoration alternative would involve a similar scenario, with the remaining section of bulkhead in the south-central portion of the action area providing shore protection until inevitable failure. The structures would likely be reconstructed prior to failure. The partial restoration alternative would augment sediment supply, which could ameliorate the adjacent beach habitats as well as benefiting down-drift shores.

Both full and partial restoration alternatives will increase upper beach habitat area that is currently buried beneath the armor. Full restoration will obviously recover more upper intertidal beach and backshore area, sediment input, large woody debris deposition and recruitment, and area receiving the benefits of overhanging marine riparian vegetation.

1.6 Uncertainties and Risks

No substantial risks are associated with the full restoration alternative. The Hadley house is currently at risk due to slope stability issues and the proximity of the house to the bluff crest (14 feet), with or without any change, and the full restoration alternative would remove this risk. The partial restoration alternative would bring the chance of increased slope stability issues through end effects or flanking erosion at the ends of the retained armor. It is unlikely that partial restoration will exacerbate slope stability problems waterward of the Hadley property due to adjacent bluff recession, but this should be evaluated further. Sea level rise and climate change also contribute to the uncertainty in the rate at which the bluff will recede following armor removal.

1.6.1 Risks Associated with Projected Sea Level Change

Table 1-3 compares potential risks associated with projected sea level changes based on professional judgment.

Table 1-3. Risks of Sea Level Change

	Projected Sea Level Change		
	High (65cm)	**Intermediate (21cm)**	**Low (13cm)**
Full Restoration	Increased bluff recession mitigated through removal of structures from bluff crest	Increased bluff recession mitigated through removal of structures from bluff crest	Little change; very minor increased bluff recession mitigated through removal of structures from bluff crest
Partial Restoration	Increased risk to Hadley house due to frequent wave overtopping of the remaining low-elevation bulkheads	Infrequent overtopping of remaining low-elevation bulkheads leads to additional risk to Hadley house	Very minor increase in overtopping of remaining low-elevation bulkheads may lead to additional risk to Hadley house

1.7 Potential Monitoring Opportunities

The restoration of the Beaconsfield site provides a great research opportunity: to document the restoration of the site and monitor changes in sediment supply for a drift cell that has incurred considerable reduction of bluff sediment input. Baseline monitoring of action area beaches as well as those down-drift could help to answer questions regarding the benefits of armor removal projects, as well as the impacts of armor, which can be a difficult variable to isolate in the complex nearshore systems of the Puget Sound region. The key monitoring needs and opportunities associated with this action are summarized in Table 1-4.

Table 1-4. Monitoring Needs and Opportunities

Monitoring Parameter	Key Performance Indicator	Note
Topographic stability	X	Monitor beach and bluff
Sediment accretion / erosion	X	Assess conditions onsite and down-drift
Wave height period and direction		Results to complement sediment accretion / erosion monitoring
Wood accumulation	X	Monitor backshore LWD accumulation and variability
Soil / substrate conditions	X	Assess upper beach sediment for change
Vegetation establishment		
Marsh surface evolution / accretion		
Tidal channel cross-section / density		
Water quality (contaminants)		
Salinity		
Shellfish production		
Extent of invasive species	X	
Animal species richness	X	

Monitoring Parameter	Key Performance Indicator	Note
Fish (salmonid) access/use		
Forage fish production	X	
Wildlife Species Use		
Effectiveness of Exclusion Devices		

1.8 Information Needed for Subsequent Design

This conceptual design report represents an initial step in the restoration design sequence. The design concepts described above were developed based on readily available information without the level of site-specific survey and investigation that is necessary to support subsequent design and implementation. Substantial additional information will be required at the preliminary and later design stages to confirm the design assumptions, refine quantity estimates, address property and regulatory issues, obtain stakeholder support, and fill in data gaps. The extent to which this information is collected for preliminary design (or a later design stage) will depend upon the available budget, schedule and other factors. This section attempts to define the most essential information needs for this action.

- Property Investigation/Survey – More detailed information on property boundary locations will be needed to finalize the design, confirm acquisition requirements and support negotiations with property owners. Major discrepancies currently exist between on-the-ground parcel monuments and the King County digital parcel data.
- Topographic/Bathymetric Survey – The survey data would be used to refine design of key project elements and develop detailed construction and demolition plans. Survey data could also be used as a baseline for pre- and post-construction monitoring and hydrodynamic modeling.
- Geotechnical Investigation – Additional investigation into the extent and composition of the shore armor needs to be undertaken to refine the quantities estimate presented here, and confirm/ensure the accuracy of the design concept. This is particularly true for portions of structures that are below beach grade. The partial restoration alternative needs to include a geotechnical investigation to determine the extent of bluff instability resulting from partial removal, with specific emphasis on the stability of the Hadley house; this needs to occur prior to and potentially during construction.
- Cultural Resources Investigation – Surveys for archaeological and historic resources may be required for this action area. This is particularly important in areas proposed for excavation.
- Sea Level Change Projection – Estimates of sea level change for the conceptual design were based on calculations provided by the Washington Department of Fish and Wildlife and the Corps of Engineers using guidance in Corps' Engineering Circular No. 1165-2-211. Projections for each project area will be refined using localized tide gauge data during later design stages.
- Other – The location and rate of bluff erosion may require further investigation and a survey of grain size distribution on beaches in the action area and down-drift should also be considered.

1.9 Quantity Estimates

The quantity spreadsheets for the full and partial restoration alternatives are provided in Exhibits 1-1 and 1-2.

1.10 References

Booth, D.B. 1991. Geologic map of Vashon and Maury Islands, King County, Washington. USGS Miscellaneous Field Studies; Map MF-2161.

Johannessen, J.W., A. MacLennan, and A. McBride. 2005. *Inventory and assessment of current and historic beach feeding sources/erosion and accretion areas for the marine shorelines of Water Resource Inventory Areas 8 & 9.* Prepared by Coastal Geologic Services, Inc., Bellingham, WA. Prepared for King County Department of Natural Resources and Parks, Seattle, WA.

Johannessen, J.W. A. MacLennan and J. Waggoner. 2006. *Beaconsfield on the Sound Bulkhead Removal Feasibility Study*. Prepared for the Cascade Land Conservancy.

Salmonscape. 2010. http://wdfw.wa.gov/webmaps/salmonscape.

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0 300
Feet
0 80
Meters

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Historic Map (T-Sheet)
Action Name: Beaconsfield Feeder Bluff Restoration
PSNERP ID #: 1499
Figure 1- 2A

0 300
Feet

0 80
Meters

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Historic Map (T-Sheet) and River History Project Data
Action Name: Beaconsfield Feeder Bluff Restoration
PSNERP ID #: 1499
Figure 1- 2B

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Legend

- Existing Tide MLLW
- Existing Tide MHHW
- Bulkheads
- Rock Revetment
- Required Project Lands
- Section Line

BEACONSFIELD CONVERSION

FIXED DATUM — TIDAL DATUM

MHHW 9.16 NAVD88 2.52 MLLW

0.00 FT MHHW = 9.16 FT NAVD88
-9.16 FT MHHW = 0.00 FT NAVD88
0.00 FT MLLW = -2.52 FT NAVD88
2.52 FT MLLW = 0.00 FT NAVD88

Source: VDATUM (47.402222, 122.335556)

PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

North 0 100 Feet

SOURCE:
Washington Public Lands Database (2006); King County Parcels (2007); Action Area (PSNERP, 2010), USGS Aerial (2002)

Lead Contractor: ESA
Design Lead: CGS, J. Johannessen, LEG
Date: 05/2012

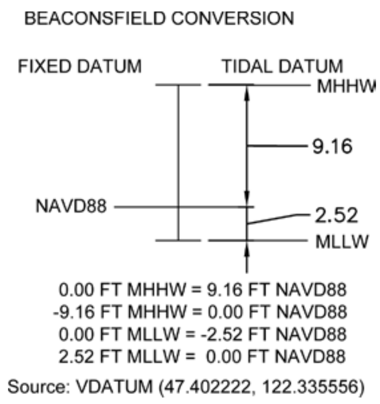
Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Plan
Site Name: Normandy Park Shore
Action Name: Beaconsfield Feeder Bluff Restoration
PSNERP ID #:1499
Full Restoration

Figure 1-3

Legend

- Rock Revetments
- Existing Tide MLLW
- Existing Tide MHHW
- Remove Bulkheads
- Rock Revetment
- Required Project Lands
- Section Line



North 0 100 Feet

SOURCE:
Washington Public Lands Database (2006); King County Parcels (2007); Action Area (PSNERP, 2010), Kind County Aerial (2002)

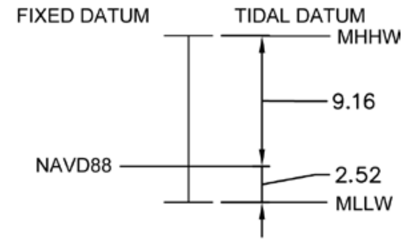
Lead Contractor: ESA
Design Lead: CGS, J. Johannessen, LEG
Date: 05/2012

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Plan
Site Name: Normandy Park Shore
Action Name: Beaconsfield Feeder Bluff Restoration
PSNERP ID #:1499
Partial Restoration

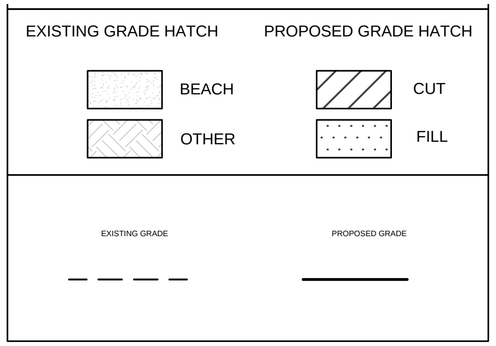
Figure 1-4

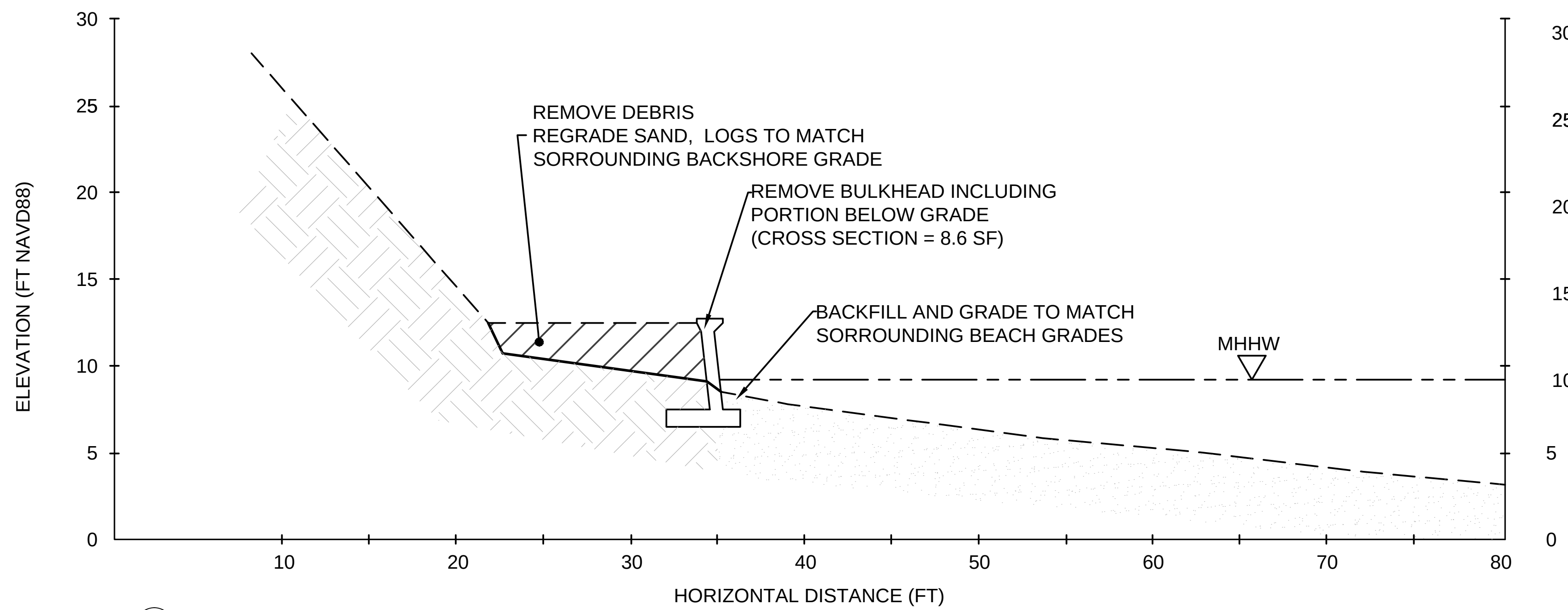
BEACONSFIELD CONVERSION



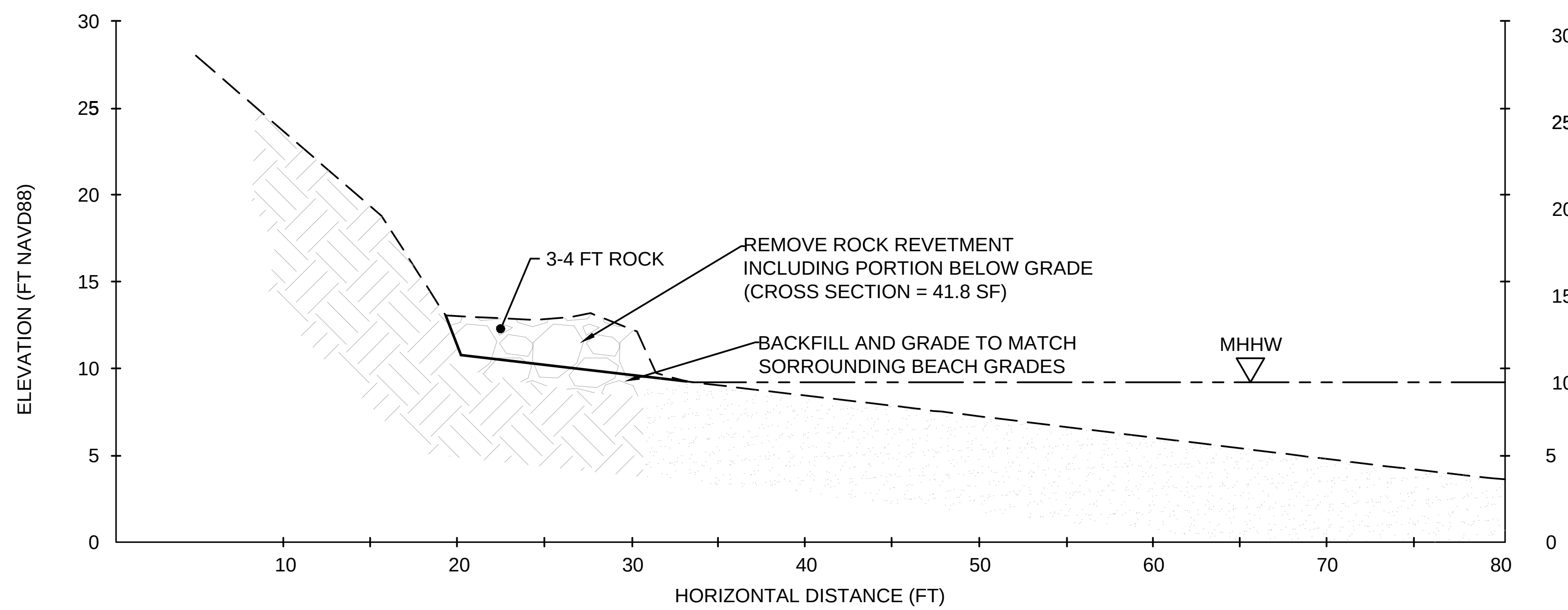
0.00 FT MHHW = 9.16 FT NAVD88
-9.16 FT MHHW = 0.00 FT NAVD88
0.00 FT MLLW = -2.52 FT NAVD88
2.52 FT MLLW = 0.00 FT NAVD88

Source: VDATUM (47.402222, 122.335556)





A CONCRETE BULKHEAD REMOVAL TYPICAL SECTION



B ROCK REVETMENT REMOVAL TYPICAL SECTION

PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: CGS, J. Johannessen, LEG
Date: 05/2012

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Section
SITE NAME: **Normandy Park Shoreline**
ACTION NAME: **Beaconsfield Feeder Bluff Restoration**
PSNERP ID#: **1499**
Full and Partial Restoration

Figure 1-5

Full Restoration Quantity Estimate

Action Name: Beaconsfield Feeder Bluff Restoration
Action #: 1499
Date: February 2011 Revised May 2012
By: Jonathan Waggoner, Coastal Geologic Services

REMEDY: ***Removal of concrete bulkheads and rock revetments at the base of a feeder bluff***
Construction Period: 5 weeks

Item	Unit of Measure	Material Name	Qty	Description of Item	Indicate section of design report where item is described
ACQUISITION AND CONSERVATION				Based on available mapping information	
Required Project Lands	Acre		11.6	Total land required For action	1.3
Proponent / Partner-owned lands	Acre		4	Estimate of lands currently owned by Proponent (i.e., Public lands). This measure includes 1.4 acres of WDNR owned tidelands.	1.3
Lands To Be Acquired	Acre		7.6	Includes 4.5 acre Hadley property, which is likely unbuildable due to unstable slopes on north, south, and marine sides. Approximately 3.1 acres of northern two parcels will require easement / permission for bulkhead removal due to potential slope destabilization.	1.3
Material Sites				Not Used: See Earthwork - Imported Fill.	
MOBILIZATION AND ACCESS for construction activities				Description required for each item to facilitate cost estimating	
Mobilization - Typical (Equipment, Personnel, Planning, Financial)	LS		1	Mobilization of upland structure demolition team and barge-based demolition team. Typically, assume 10% of other items.	1.3
Mobilization - Remote (Equipment, Personnel, Planning, Financial)	LS		NA	Up front cost for nontypical or remote locations. Assume 12% of other items	
Site Access	LS		NA	Use for special situations (e.g.. new bridge, new access roads) for the purposes of construction access. Include description.	
Barge Access	Days		8	Demolition materials to be exported by barge due to lack of good land access	1.3
Temporary Traffic Control (one of the following)					
none	LS		NA		
signs	LS		NA		
flags / spotters	LS		NA		
unique	LS		NA		
Temporary Roadway	SF		NA		
Control of Water	LS		NA		
Relocation Activities				Not Used: See Utilities, Structures	
Site Demolition Activities					
Clearing and Grubbing (one or more of following)					
Clear Vegetation - Local Disposal	AC		NA		
Clear /Grub Vegetation - Local Disposal	AC		NA		
Clear /Grub Vegetation - Offsite Disposal	AC		NA		
Clear, stockpile - large woody debris	CY	beach logs	60	Clear large woody debris from removal areas and redistribute afterwards - rough estimate from experience - Quantity varies daily	1.3
Hydraulic Structures - Small	LS		NA		
Hydraulic Structures - Large	LS		NA		
Utilities	LS or LF		50	Remove utilities from house (types unknown) - Utilities serving other buildings on site to remain - assumed linear distance from house down driveway within likely area impacted by demolition	1.3
Buildings	SF	house	4772	SF of the Hadley home which will require demolition and removal	1.3
Pavement	LS or SF		1200	Concrete walkways and patio around Hadley Home - driveway to remain for landward building	1.3
Bulkheads	LF		491	Reinforced concrete bulkhead - approximately 9 SF in cross section	1.3
Rock revetments	CY		700	Large rock, 3-4 ft, in four sections - assumed to average 4 FT thick over and area of 4,770 SF - no subsurface investigations were performed	1.3
Large Coastal Structures	LF		NA		
Demolition / Removal - Bridge	SF or CY		NA		
Removal - Misc. (e.g. angular rock from beach)	Ton		NA		
Demolition / Removal - Boat Ramp	SF		NA		
Haul - Offsite Disposal of Demolition Debris	Miles		40	Likely deep-water disposal by barge or barge to offload for upland disposal	1.3
Hazardous/Contaminated Waste Removal					
Contaminated Earthwork	CY		NA		
Hazardous Earthwork	CY		NA		
Construct Temporary Features					
EARTHWORK					
Excavation					
Excavation - Upland	CY		NA		
Excavation - Lowland	CY		250	Rough grading of sediment impounded behind concrete bulkhead after removal - based on typical cross sectional area of 30 SF over an alongshore length of 225 LF	1.3
Dredging - Bucket - Land	CY		NA		
Dredging - Bucket - Marine	CY		NA		
Dredging - Hydraulic	CY		NA		
Fine Grading	AC		NA		
Fill Placement - local borrow					
Side cast	CY		NA		
Haul - uncontrolled placement	CY		NA		
Haul, place, compact	CY		NA		
Stockpile - uncontrolled placement	CY		NA		
Stockpile - controlled placement	CY		NA		
Conveyor placement from stockpile land/water	CY		NA		
Imported Fill					
Select Fill	CY		NA		
Gravel Borrow, including haul	CY		NA		
Sand / Gravel for Beach Nourishment	CY		NA		
Cobble for Shore Nourishment	CY		NA		
Embankment Compaction	CY		NA		
Topsoil	CY		NA		
RESTORATION Features					
Channel Rehab / Creation	SF		NA		
Large Wood Placement	EA		NA		
Invasive Species Control	Acre		2.5		1.3
Physical Exclusion Devices	LF or EA		NA		
Other Restoration Features/ Activities	LS		NA		
Structures	EA				
Water Control Structures - Culverts with Gates	EA		NA		
Water Control Structures - Weirs	EA		NA		
Rock Slope Protection	LF		NA		
Other	EA		NA		
Elevated Boat Ramp	SF		NA		
Fencing	SF		NA		
Utilities					
Water	LF		NA		
Gas	LF		NA		
Electric	LF		NA		
Sewer	LF		NA		
Telecommunications	LF		NA		
Other	LF		NA		
Roadway / Railway					
Roadway (Type)	SF		NA		
Roadway - Traffic Signal	LS		NA		
Culvert (type)	LF		NA		
Culvert - Jacking	LF		NA		
Culvert - Horizontal Pile Driving	LF		NA		
Bridge - Foundations, Deck and appurtenances	SF		NA		
Railway - Box Girder	SF		NA		
Railway - Foundation	LF		NA		
Railway - Shoe fly	LF		NA		
Permanent Access Features					
Roads	Level		NA		
Utility Access Routes	varies		NA		
Erosion Control Features	L.F.		NA		
Public Access or Recreation Features					
Trails	SF		NA		
Bridges	SF		NA		
Kiosk	EA		NA		
Restrooms	EA		NA		
Interpretive Signs	EA		NA		
Parking Area	SF		NA		
Other	EA		NA		
Vegetation & Erosion Control					
Hydroseeding	AC		NA		
Planting	AC		NA		
Vegetation Maintenance	AC-YR		2.5	Per acre as part of Invasive Species Control described in drawings and narrative for 5 years	
Erosion / sediment BMPs - Temp.	AC		NA		
Erosion / sediment BMPs - Permanent	AC		NA		
Waterside controls - Temporary	LF		900	Silt fence or turbidity curtain or other water based temporary actions	1.3
Construction Management					
Construction oversight	weeks		5	Quantity based on construction duration/ # of construction seasons	1.3
Materials testing			NA		
Design and Detailed Site Investigations					
Survey & Property, Utility Research	LS		1	% of construction cost	1.8
35% Design	LS		1	35% x 25% x Engineer's Estimate	1.8

Full Restoration Quantity Estimate

Action Name: Beaconsfield Feeder Bluff Restoration
Action #: 1499
Date: February 2011 Revised May 2012
By: Jonathan Waggoner, Coastal Geologic Services

REMEDY: ***Removal of concrete bulkheads and rock revetments at the base of a feeder bluff***
Construction Period: 5 weeks

	Item	Unit of Measure	Material Name	Qty	Description of Item		Indicate section of design report where item is described
	65% design	LS		1	65% x 25% x Engineer's Estimate less the cost for 35% PS&E		1.8
	90% design	LS		1	35% x 25% x Engineer's Estimate less the cost for 35% + 65%PS&E		1.8
	100% design	LS		1	25% x Engineer's Estimate less previous costs		1.8
	Geotechnical Studies			NA	Refer to design report for description of need		
	Cultural Studies			NA	Refer to design report for description of need		
	HTWR Studies			NA	Refer to design report for description of need		
Project Agreement Activities					Unable to provide credible estimate at 10% design		
Site-Specific Adaptive Management Features & Activities					List if known		
Monitoring Activities					Assume 5 crew-days/year for each monitoring parameter in design report for 5 yrs		
	Monitoring (Type)	crew-days		175			
Operations & Maintenance					Unable to provide credible estimate at 10% design		

Partial Restoration Quantity Estimate

Action Name: Beaconsfield Feeder Bluff Restoration
Action #: 1499
Date: February 2011 Revised April 2012
By: Jonathan Waggoner, Coastal Geologic Services

REMEDY: ***Removal of concrete bulkheads and rock revetments at the base of a feeder bluff***
Construction Period: 2 weeks

	Item	Unit of Measure	Material Name	Qty	Description of Item	Indicate section of design report where item is described
ACQUISITION AND CONSERVATION					Based on available mapping information	
	Required Project Lands	Acre		6.1	Total land required For action	1.3
	Proponent / Partner-owned lands	Acre		4	Estimate of lands currently owned by Proponent (i.e., Public lands). This measure includes 1.4 acres of WDNR owned tidelands.	1.3
	Lands To Be Acquired	Acre		2.1	Includes parcels to be acquired or permission/easements obtained to perform bulkhead removal on property.	1.3
Material Sites					Not Used: See Earthwork - Imported Fill.	
MOBILIZATION AND ACCESS for construction activities					Description required for each item to facilitate cost estimating	
	Mobilization - Typical (Equipment, Personnel, Planning, Financial)	LS		1	Up front costs such as bonding, planning and other staff time and financing. Typically, assume 8% of other items.	1.3
	Mobilization - Remote (Equipment, Personnel, Planning, Financial)	LS		NA	Up front cost for nontypical or remote locations. Assume 12% of other items	
	Site Access	LS		NA	Use for special situations (e.g.. new bridge, new access roads) for the purposes of construction access. Include description.	
	Barge Access	Days		10	Demolition materials to be exported by barge due to lack of good land access	1.3
	Temporary Traffic Control (one of the following)					
	none	LS		NA		
	signs	LS		NA		
	flags / spotters	LS		NA		
	unique	LS		NA		
	Temporary Roadway	SF		NA		
	Control of Water	LS		NA		
Relocation Activities					Not Used: See Utilities, Structures	
Site Demolition Activities						
	Clearing and Grubbing (one or more of following)				Use one or more of the following categories of clearing and grubbing	
	Clear Vegetation - Local Disposal	AC		NA		
	Clear /Grub Vegetation - Local Disposal	AC		NA		
	Clear /Grub Vegetation - Offsite Disposal	AC		NA		
	Clear, stockpile - large woody debris	CY		30	Clear large woody debris from removal areas and redistribute afterwards - rough estimate from experience - Actual quantity varies daily	1.3
	Hydraulic Structures - Small	LS		NA		
	Hydraulic Structures - Large	LS		NA		
	Utilities	LS or LF		NA		
	Buildings	LS or SF		NA		
	Pavement	LS or SF		NA		
	Bulkheads	LF		348	Reinforced concrete bulkhead - approximately 9 SF in cross section	1.3
	Rock revetments	CY		535	Large rock, 3-4 ft - 50 CY to be reused on site for return walls - assumed to average 4 FT thick over and area of 3,650 SF - no subsurface investigations were performed	1.3
	Large Coastal Structures	LF		NA		
	Demolition / Removal - Bridge	SF or CY		NA		
	Removal - Misc. (e.g. angular rock from beach)	Ton		NA		
	Demolition / Removal - Boat Ramp	SF		NA		
	Haul - Offsite Disposal of Demolition Debris	Miles		40	Likely deep-water disposal by barge or barge to offload for upload disposal	1.3
Hazardous/Contaminated Waste Removal						
	Contaminated Earthwork	CY		NA	Excavation, off haul and disposal within a licensed landfill, complete	
	Hazardous Earthwork	CY		NA	Excavation, off haul and disposal within a licensed hazardous waste landfill, complete	
Construct Temporary Features						
EARTHWORK					Expand to include equipment, etc. to facilitate cost estimating.	
	Excavation	CY		150	Rough grading of sediment impounded behind concrete bulkhead after removal - based on typical cross sectional area of 30 SF over an alongshore length of 135 LF	1.3
	Excavation - Upland	CY		NA		
	Excavation - Lowland	CY		NA		
	Dredging - Bucket - Land	CY		NA		
	Dredging - Bucket - Marine	CY		NA		
	Dredging - Hydraulic	CY		NA		
	Fine Grading	AC		NA		
	Fill Placement - local borrow					
	Side cast	CY		NA		
	Haul - uncontrolled placement	CY		NA		
	Haul, place, compact	CY		NA		
	Stockpile - uncontrolled placement	CY		NA		
	Stockpile - controlled placement	CY		NA		
	Conveyor placement from stockpile land/water	CY		NA		
	Imported Fill					
	Select Fill	CY		NA		
	Gravel Borrow, including haul	CY		NA		
	Sand / Gravel for Beach Nourishment	CY		NA		
	Cobble for Shore Nourishment	CY		NA		
	Embankment Compaction	CY		NA		
	Topsoil	CY		NA		
RESTORATION Features						
	Channel Rehab / Creation	SF		NA		
	Large Wood Placement	EA		NA		
	Invasive Species Control	Acre		2	Per acre control described in drawings and narrative	1.3
	Physical Exclusion Devices	LF or EA		NA		
	Other Restoration Features/ Activities	LS		NA		
Structures		EA				
	Water Control Structures - Culverts with Gates	EA		NA		
	Water Control Structures - Weirs	EA		NA		
	Rock Slope Protection	LF		30	Two return walls (15 FT ea) at north and south end of remaining bulkhead sections, constructed of revetment rock removed from elsewhere on site. Volume based on professional judgment and existing return walls on site	1.3
	Other	EA		NA		
	Elevated Boat Ramp	SF		NA		
	Fencing	SF		NA		
Utilities						
	Water	LF		NA		
	Gas	LF		NA		
	Electric	LF		NA		
	Sewer	LF		NA		
	Telecommunications	LF		NA		
	Other	LF		NA		
Roadway / Railway						
	Roadway (Type)	SF		NA		
	Roadway - Traffic Signal	LS		NA		
	Culvert (type)	LF		NA		
	Culvert - Jacking	LF		NA		
	Culvert - Horizontal Pile Driving	LF		NA		
	Bridge - Foundations, Deck and appurtenances	SF		NA		
	Railway - Box Girder	SF		NA		
	Railway - Foundation	LF		NA		
	Railway - Shoe fly	LF		NA		
Permanent Access Features						
	Roads	Level		NA		
	Utility Access Routes	varies		NA		
	Erosion Control Features	L.F.		NA		
Public Access or Recreation Features						
	Trails	SF		NA		
	Bridges	SF		NA		
	Kiosk	EA		NA		
	Restrooms	EA		NA		
	Interpretive Signs	EA		NA		
	Parking Area	SF		NA		
	Other	EA		NA		
Vegetation & Erosion Control						
	Hydroseeding	AC		NA		
	Planting	AC		NA		
	Vegetation Maintenance	AC-YR		2	Per acre as part of Invasive Species Control described in drawings and narrative for 5 years	
	Erosion / sediment BMPs - Temp.	AC		NA		
	Erosion / sediment BMPs - Permanent	AC		NA		
	Waterside controls - Temporary	LF		800	Silt fence or turbidity curtain or other water based temporary actions	1.3
Construction Management						
	Construction oversight	weeks		1	Quantity based on construction duration/ # of construction seasons	1.3
	Materials testing					
Design and Detailed Site Investigations						
	Survey & Property, Utility Research	LS		1	estimate-property boundaries at beach/bulkheads; excludes acquisition boundary issues	1.8
	35% Design	LS		1	35% x 25% x Engineer's Estimate	1.8
	65% design	LS		1	65% x 25% x Engineer's Estimate less the cost for 35% PS&E	1.8

Partial Restoration Quantity Estimate

Action Name: Beaconsfield Feeder Bluff Restoration
Action #: 1499
Date: February 2011 Revised April 2012
By: Jonathan Waggoner, Coastal Geologic Services

REMEDY: *Removal of concrete bulkheads and rock revetments at the base of a feeder bluff*
Construction Period: 2 weeks

	Item	Unit of Measure	Material Name	Qty	Description of Item		Indicate section of design report where item is described
	90% design	LS		1	35% x 25% x Engineer's Estimate less the cost for 35% + 65%PS&E		1.8
	100% design	LS		1	25% x Engineer's Estimate less previous costs		1.8
	Geotechnical Studies			1	Determine extent of bluff instability with partial removal, with emphasis on Hadley house		1.8
	Cultural Studies			NA	Refer to design report for description of need		
	HTWR Studies			NA	Refer to design report for description of need		
Project Agreement Activities					Unable to provide credible estimate at 10% design		
Site-Specific Adaptive Management Features & Activities					List if known		
Monitoring Activities					Assume 5 crew-days/year for each monitoring parameter in design report		
	Monitoring (Type_)	crew-days		175	Assume 5 crew-days/year for each monitoring parameter in design report for 5 yrs		
Operations & Maintenance					Unable to provide credible estimate at 10% design		

2. BIG BEEF CAUSEWAY REPLACEMENT AND ESTUARY RESTORATION (#1256)

Local Proponent	Hood Canal Coordinating Council
Delta Process Unit	NA
Shoreline Process Unit(s)	2088
Strategy(ies)	3 - Barrier Embayment
Restoration Objectives	Restore natural tidal influence and sediment transport in the Big Beef Creek barrier estuary by replacing the existing causeway with an elevated structure that spans the embayment mouth

2.1 Description of the Action

Restoration of the estuary would entail removing fill and armor associated with the current Seabeck Highway causeway and bridge, and replacing it with an elevated structure that spans the embayment mouth. This action would recreate the historic opening to Hood Canal and allow restoration of most of the historic spit at the mouth of Big Beef Harbor. Tidal exchange and associated nearshore processes would be restored. Please see the Introduction chapter for important information regarding PSNERP and for context related to this restoration project.

2.2 Action Area Description and Context

Big Beef Harbor is located on the north end of Hood Canal on the Kitsap Peninsula across from Toandos Peninsula in the Hood Canal Subbasin. This historic barrier estuary has been considerably altered by the construction of the Seabeck Highway, which runs along the shore over the barrier (a naturally dynamic spit), and constrains the mouth of the estuary with armoring and fill. An undersized bridge span causes degraded tidal flow, with subsequent effects on sediment transport, erosion and accretion of sediments, tide channel formation and maintenance, detritus import and export, and physical disturbance. The change in hydraulics and tidal flushing, and the armoring on the waterward side of the causeway and remnant barrier, have reduced the quality of the nearshore habitat. The action area is shown in Figure 2-1.

Figure 2-1. Action Area and Vicinity

2.2.1 Historic Condition

Historically, the narrow barrier that embays Big Beef Harbor extended westward across just under half of the mouth of the embayment. The current condition of the embayment mouth is a filled causeway for Seabeck Highway that runs over the northeast corner of the estuary, the western portion of the spit, and then extends across to the southwest shore. The current bridge opening is approximately 100 feet wide but is narrower at high water, while the narrowest point of the historic opening measured approximately 440 feet wide at high water (based on T-sheet 1558b, 1884). Wooden bridges originally spanned the entrance to the harbor as far back as the T-sheet mapping in 1884.

In 1916, new pilings were driven and the bridge was replanked. The bridge was rebuilt again in 1942 and "...the entrance was filled to form a causeway in its present form. This has cut down the flushing of the bay, accelerated filling of the estuary, and the encroachment of grassland has been rapid" (Salo, undated). Accelerated sedimentation within the harbor may have also occurred due to upland land uses including clear cutting. The uplands were first logged in 1895 and again in the 1940s-1950s. Historic maps are provided in Figures 2-2A and 2-2B.

Tidal wetland area in the Big Beef Estuary has also declined by approximately 16% since historic times (Simenstad et al. 2009). This may be due to a combination of upland encroachment (causeway and other fill) and increased sedimentation (Gillman 2010). The main tide channel was historically located further east or more centered in the harbor, adjacent to the terminus of the historic spit, while currently it is located along the southwest shore. Lower Big Beef Creek was channelized as early as the 1950s, and the University of Washington (UW) research station installed a weir structure at the upper edge of the tidal marsh in the 1960s-1970s. Some of the former tidal marsh at the stream mouth has been filled by access roads, artificial channels, and diking associated with the UW facility. The UW research station will be maintained with this project.

2.2.2 Natural Environment

Big Beef Harbor is a barrier estuary located in the northern part of Hood Canal directly south of the Toandos Peninsula. The waterward shoreline faces north-northwest and has a maximum fetch of 12.5 miles to the north-northeast. Net shore-drift originates at a divergence zone located northeast of the mouth of Anderson Creek, which is approximately 2 miles northeast of Big Beef Harbor. The cell exhibits southwestward drift, past the mouth of Big Beef Harbor, and terminates at the head of Seabeck Bay.

Big Beef Creek flows into the head of the estuary. Three species of anadromous salmonids spawn here including coho, chum, and steelhead. The creek and the associated watershed contain high-quality habitats. Approximately 400 acres of the watershed, including the lower 1.5 miles of the creek, are owned by the UW. The entire drainage basin measures 9,390 acres. Big Beef Harbor encompasses 27 acres of estuarine habitat including tidal wetlands, grasslands, tide channels, and mudflats. Waterward of the barrier and causeway, extensive sand and gravel flats provide habitat for invertebrates, shellfish, and other nearshore species.

2.2.3 Human Environment

The estuary and uplands are predominantly in private ownership. Approximately 11% of the shoreline is armored, and roads occur along approximately 2 acres of nearshore area. Eighteen percent of the shoreline was mapped as artificial, located along the road prism/fill area that encompasses the current causeway (Simenstad et al. 2009).

The current bridge was built in 1974 of poured concrete with concrete piles. The southwest abutment was repaired in 2009, which caused an approximately 1-month-long closure. The detour route for residents on the southwest side of the harbor reportedly required an additional 15 minutes when traveling to the main urban centers. Overhead utility lines run along the causeway and bridge; no other utilities appear to be located in the alignment.

The Big Beef Creek watershed is a system with extensive long-term fish monitoring data. This creek is a Salmon Recovery Funding Board funded Intensively Monitored Watershed and the reference creek for the entire Hood Canal area for coho salmon. The weir currently restricts upstream passage of non-native adult salmon returns and has been an important element in research on the wild coho stock (Schmitt 2000).

2.3 Restoration Design Concept

2.3.1 Restoration Overview and Key Design Assumptions

Figures 2-3 through 2-5 illustrate the restoration alternatives. Full restoration of the Big Beef Creek Estuary (Figure 2-3) entails the removal of the causeway fill to fully restore tidal flow, sediment supply, sediment transport, and tidal channel formation and maintenance within the embayment. The full restoration alternative would also restore the littoral transport process in the net shore-drift cell that continues southwestward past the site by removing the higher velocity tidal jets concentrated at the narrow embayment opening. The fill associated with the roadway would need to be removed over an approximately 750-foot-long area (including the current bridge section) and the roadway removed or elevated. This would restore the opening back to pre-development condition (pre T-sheet era) by spanning the entire area from the right-of-way on the spit to the low bank at the west shore, with the new elevated roadway (bridges) immediately south of the current road alignment (Figures 2-3 and 2-5).

Complete road removal will not be an acceptable option for the local project proponent. This action has the new bridge and approaches placed immediately south of the current causeway and bridge, as the road would need to be kept open during construction of the new bridge to maintain traffic flow, although short-term closures would be required. Proposed roadway construction will transition the bridge alignment to the existing roadway alignment both vertically and horizontally.

The partial restoration alternative consists of a shorter bridge, 350 feet long (Figure 2-4). The partial restoration alternative would expand the causeway fill footprint into the Big Beef Estuary east of the proposed bridge with roadway fill required for the bridge approach (Figure 2-5). This fill would have a much smaller surface area than the causeway area removed. The action would restore most processes, although likely with slightly muted tidal flow, sediment supply, sediment transport, and tidal channel formation and maintenance. The partial restoration alternative would likely mitigate the altered littoral drift along the Hood Canal shore. Similar to the full restoration alternative, the partial restoration alternative will position the proposed bridge alignment directly south of the existing alignment to maintain Seabeck Highway traffic during construction. Additionally, approximately 400 LF of new filled causeway is needed to transition from the proposed bridge alignment to the existing roadway alignment (vertically and horizontally).

Key design elements associated with full and partial restoration alternatives are shown in Table 2-1.

Table 2-1. Key Design Elements

Element	Full Restoration	Partial Restoration
Existing Bridge	Remove existing bridge and concrete appurtenances	Remove existing bridge and concrete appurtenances
Causeway Fill	Remove causeway fill (except in far northeast portion of estuary)	Remove half of causeway fill length (except in far northeast portion of estuary)
Causeway Armor	Remove rock revetment	Remove half of rock revetment length; move a portion of revetment closer to new alignment

Element	Full Restoration	Partial Restoration
Causeway Pavement	Remove causeway pavement	Remove half of causeway pavement
Bridge	Construct new 750-foot bridge	Construct new 350-foot bridge
New Fill	Place sediment fill for roadway and shoulders to align with proposed bridge	Place sediment fill for roadway and shoulders to align with proposed bridge
Roadway and Shoulders	Construct new roadway and shoulders to align with proposed bridge	Construct new roadway and shoulders to align with proposed bridge
Estuary Channel	Restore estuary channel	Create estuary channel

2.3.2 Restoration Features – Primary Process-Based Management Measures

Armor Removal/Modification

The full restoration alternative would entail removal of the approximately 635 LF (885 CY) rock revetment (near-vertical rockery) associated with the road causeway that constrains the opening to Big Beef Harbor and the western abutment of the existing bridge (Figures 2-3 and 2-5). The partial restoration alternative would entail removal of approximately 215 LF (290 CY) of rock revetment. Additionally, the rock revetment extending 140 LF east of the new bridge will be moved southward to protect the new roadway fill and provide shore protection for the realigned partial causeway (Figures 2-4 and 2-5).

The full and partial restoration alternatives would entail removal of a 60 LF steel sheet pile wall of 20-foot height, and 140 CY of rock slope protection that stabilized the western abutment of the existing bridge. Additionally, the remains of an old pier (25 feet long) located immediately north of the western bridge abutment would be removed. No decking remains, only part of the pile structure and partial rock fill. Armor removal also includes picking up scattered angular rock from the intertidal zone that has tumbled waterward of rock revetments and is outside of the berm or dike removal area (estimated at 250 CY in full restoration alternative and 200 CY in partial restoration alternative).

Berm or Dike Removal/Modification

The full restoration alternative would remove approximately 27,335 CY of fill (505 CY of quarry spall, 23,065 CY of upland fill, and 3,765 CY of lowland beach) associated with removal of the causeway as a means to widen the embayment mouth back to pre-development condition (Figures 2-3 and 2-5). The partial restoration alternative would entail removal of approximately 11,515 CY of fill (160 CY of quarry spall, 9,680 CY of upland fill, and 1,675 CY of lowland beach) associated with limited removal of the causeway fill (Figures 2-4 and 2-5).

Channel Rehabilitation/Creation

The full restoration alternative would restore 4,125 SF of existing tidal estuary channel south of the new road, around the spit, to enhance low tidal exchange. The partial restoration alternative would create 5,400 SF of estuary channel south of the new road fill that will establish flow around the spit and ensure low tidal exchange.

Groin Removal/Modification - NA

Hydraulic Modification

The existing Seabeck Highway bridge at Big Beef Harbor will be replaced with a longer spanning bridge. The full and partial restoration alternatives would remove the existing 100 LF (4,000 SF) three-span concrete slab Seabeck Highway vehicle bridge, along with 20 LF (800 SF) of concrete bridge abutments and concrete pilings. The full restoration alternative would construct 750 LF of Type 2, five-span concrete girder bridge with 150-foot spans (Figure 2-5). The partial restoration alternative would construct 350 LF of Type 2, three-span concrete girder bridge with 116.7-foot spans (Figure 2-5).

Overwater Structure Removal and Replacement – NA

Topography Restoration

The full and partial restoration alternatives include topography restoration at the west and east ends of the proposed bridge through removal of fill and accreted sediment. This would lower elevations to match the existing sand flats of the outer portion of the harbor.

2.3.3 Restoration Features – Additional Management Measures

Beach Nourishment

Beach nourishment is not anticipated to be required for this site. It is assumed that at least a small portion of the fill material in the causeway (which was reportedly derived from a large cut into glacial sediment during road grading many decades ago) will be suitable for a newly exposed beach surface in the several small areas where it will be exposed. These areas include the mid-upper intertidal zone on the north side of the new road alignment transition areas with both full and partial restoration alternatives. Existing conditions will need to be further investigated in the next design stage to determine if this assumption is correct.

Contaminant Removal/Remediation - NA

Debris Removal - NA

Invasive Species Control - NA

Large Wood Placement - NA

Physical Exclusion - NA

Pollution Control - NA

Revegetation

The full restoration alternative would revegetate approximately 2,735 SF of the newly uncovered backshore near the east and west ends of the proposed bridge with dunegrass and other salt-tolerant herbaceous backshore plants. The partial restoration alternative would revegetate 1,965 SF of the newly uncovered backshore near the east and west ends of the proposed bridge. Additional narrow bands adjacent to the roadway would have small quantities of topsoil imported (200 CY for full and 160 CY for partial) and these areas would be vegetated.

Reintroduction of Native Animals - NA

Substrate Modification - NA

Species Habitat Enhancement - NA

2.3.4 Restoration Features – Other

NA

2.3.5 Land Requirements

The local proponent has no explicit requirements other than the need for a roadway with equivalent capacity. The full and partial restoration alternatives require permanent acquisition of 2,400 SF of lands to the west of the proposed bridge for roadway alignment, and for tie-in to accommodate the proposed bridge alignment located south of the current alignment. Full restoration would require 12,305 SF of temporary easement for fill removal (Figures 2-3 and 2-5). Partial restoration would require 4,605 SF of temporary easement for fill removal to the north of the alignment, and permanent acquisition of 9,750 SF to the south of the alignment for proposed roadway fill (Figures 2-4 and 2-5).

The full and partial restoration alternatives would need to maintain the overhead utility lines along the bridge and roadway. This includes three power poles along the proposed bridge and roadway alignment for both alternatives.

2.3.6 Design Considerations

WDFW and UW staff have both stated that due to the extensive long-term monitoring, associated research projects, and contract work carried out at the Big Beef Creek Research Station, neither organization is willing to see the weir at the head of the harbor removed.

It is likely that the roadway will not be allowed to be closed for a long period of time as it would increase the travel times for residents on the southwest side of the estuary. The proposed bridge alignment will be parallel to the existing causeway in order to maintain traffic and minimize road closures during construction.

Concrete bridge elements are preferred over steel given the highly corrosive coastal environment. One means of supporting the bridge would consist of concrete columns supported on drilled shafts. The assumed embedment depths of the drilled shafts are 100 feet. Other foundation types including pre-cast piles and concrete shell piles should be considered during design.

For this study, the proposed bridge elevation is based on the MHHW elevation, plus 3 feet, plus the depth of the deck and girders. The new bridge deck will be higher than the existing grade; therefore, a ballast/fill section will be needed to transition from bridge structure to the existing roadway. The proposed roadway will meet current design standards and will meet or exceed equivalent capacity. The road will include two 12-foot lanes and two 8-foot shoulders (Figure 2-5). The proposed roadway geometry includes vertical and horizontal alignment considerations. The total length of improvements (bridge and road structures) for the full restoration alternative is 1,400 LF. The total length of improvements (bridge and road construction) for the partial restoration alternative is 1,015 LF.

Subsequent design would need to evaluate the magnitude of potential sediment export from the embayment, as well as the need for management of potentially accreted sediments. Substantial export of accreted sediment from the estuary does not appear to be a likely risk based on limited field reconnaissance. However, some amount of sediment is likely to be exported following intertidal channel adjustments and increased wave energy inside of the harbor. This is a potentially important issue because Tribal shellfish beds are located on the north side of the causeway. The degree of risk cannot be assessed at this time without better bathymetry and topography data. These data should be collected and addressed at the 35% design level.

2.3.7 Construction Considerations

Select fill removed from the causeway with the full or partial restoration alternative can be reused for roadway fill. Excess fill can be transported to a site 20 miles away as is typically done by Kitsap County Public Works. Full restoration will reuse 6,615 CY of fill to be placed south of the current alignment for roadway fill. Partial restoration requires 8,475 CY of fill for proposed elevated roadway construction, of which most will be reuse. For partial restoration, there is a possibility that a small amount of imported fill will be needed, but the exact quantity is uncertain at this stage of design. If imported fill is needed, the haul distance is estimated to be 20 miles.

Upland and lowland excavation equipment will be required for both alternatives. Full restoration will require 13 to 15 months for construction, while partial restoration will require 11 to 13 months. The full and partial restoration alternatives will offset the new bridge alignment by 35 feet to the south from the current road alignment to maintain Seabeck Highway traffic during construction. Traffic would be limited to one reversible lane on the roadway.

A temporary construction trestle consisting of pile-supported finger piers at each bent location would need to be constructed to facilitate the installation of the drilled shafts and placement of bridge girders. Heavy machinery such as a drilled-shaft oscillator and crane could be moved between finger piers via the existing causeway at night. If the alignment is moved to the waterward side (north side) of the causeway, a full-length construction trestle would be necessary. This option should be considered during additional design work.

A construction staging area at least 15 feet wide will be needed for both full and partial restoration. Staging could be done from the existing causeway. To maintain Seabeck Highway traffic, only the current shoulder and one lane can be used for staging. The causeway at the north side of the existing roadway alignment could also be used for staging on the east side of the bridge. The staging area would extend the full length of the proposed bridge, as well as 100 feet beyond the ends of the bridge on each side. Further consideration for staging areas will be analyzed during detailed design.

It is assumed that the contractor will be able to install one shaft per week. Large-diameter casing shoring would be required to keep out water and allow access to the top of the shaft for column form placement and removal. Once the shafts are installed, the columns are cast inside the shoring casing. After the casing is removed, the cast-in-place pilecaps and bridge superstructure are constructed. Concrete bridges require very little maintenance and the operation and maintenance costs are anticipated to be low. The current standard is to inspect bridges every 2 years.

The full restoration alternative will require approximately 1,440 feet of turbidity curtain for in-water temporary erosion control. The partial restoration alternative will require 795 feet of turbidity curtain. Stabilized construction entrances, sediment ponds, and hydroseeding would likely be required to stabilize roadway embankments.

2.4 Extent of Stressor Removal

Table 2-2 describes the amount of stressor removal with full and partial restoration alternatives.

Table 2-2. Stressor Removal

Stressor	Full Restoration	Partial Restoration
Tidal Barrier (LF)	690	270
Fill (area)	1.65 acres	0.71 acre
Armor (LF)	635	215

2.5 Expected Evolution of the Action Area

Without restoration, tidal exchange will remain muted, along with associated impacts discussed above. Tidal currents through the existing bridge will remain well above natural velocities, limiting the ability of fish and wildlife to access Big Beef Harbor. Sedimentation may occur at unnaturally high levels landward of the causeway, potentially causing the salt marsh vegetation at the head of the harbor to advance northward.

With implementation of the full restoration alternative, the harbor would be generally changed back to pre-causeway conditions. The harbor would be well-suited for sustainable maintenance of intertidal habitats in the full restoration scenario, as the main stressors would be removed and the system could adjust to gradual changes in freshwater or sediment input. Over time, the full restoration alternative is expected to bring the sedimentation rate south of the highway back to natural rates. The opening of the harbor mouth may result in an unknown quantity of accreted sediment being exported from the estuary, if not mechanically removed. However, bathymetry and sediment data are lacking.

The partial restoration alternative would reestablish a harbor mouth of approximately half of the natural width. However, the northeast portion of the harbor may continue to experience reduced flushing and inputs of nutrients. This alternative would likely reduce the potentially unnatural sedimentation rates south of the causeway, but not down to pre-development levels. Sediment export may also occur with partial restoration if this is not adequately mitigated.

2.6 Uncertainties and Risks

The lower portions of the embayment have reportedly experienced increased sedimentation since the causeway was installed (as discussed above). Removal of the causeway could cause a substantial export of sediment from the embayment toward an area of Tribal and recreational shellfish harvesting.

Complete removal of the southwestern bridge abutment and fill under both alternatives may cause an increase in the erosion rate on both the Hood Canal and embayment sides of the new roadway alignment. The fill in this area has acted as a groin to some extent, causing some amount of sediment to accumulate northwest of the current bridge. The west shore of the embayment has also been mostly sheltered from waves by the causeway, and restoration of the site would likely result in some amount of renewed erosion. It appears that several houses are located near the low bank in this area.

2.6.1 Risks Associated with Projected Sea Level Change

Sea level change over the next 50 years is not anticipated to be a major concern with restoring processes in the embayment due to the intertidal nature of the action area. The three sea level change scenarios would result in a sustainable ecologic benefit with both full and partial restoration alternatives. Tidal exchange and associated benefits would generally increase with higher sea levels.

Under the higher sea level change scenario, the salt marsh at the head of the bay may shrink with both the full and partial restoration alternatives. The relict spit at the mouth of the bay, which has not received littoral sediment since the causeway was constructed, would also not receive sediment in the partial restoration alternative, and would likely erode or become further inundated progressively with the higher sea level change scenarios. This is particularly true for the partial restoration alternative. However, under the full restoration alternative, even with littoral connectively to the drift cell, the degree of bulkheading in the cell would reduce the sediment supply to the spit.

Bluff erosion landward of the current causeway is a risk mentioned above, which would be exacerbated with greater sea level change.

The roadway and bridge elevations will be raised with both full and partial restoration alternatives. This should allow for continued use of the roadway with the sea level change scenarios. The high scenario would result in an increase in erosion rates of the estuary shores, and a handful of residences may be threatened to a greater degree with restoration as compared to existing conditions. Table 2-3 compares potential risks associated with projected sea level changes based on professional judgment.

Table 2-3. Risks of Sea Level Change

	Projected Sea Level Change		
	High (46cm)	**Intermediate (4cm)**	**Low (-8cm)**
Full Restoration	Salt marsh at bay head reduced. Relict spit at bay mouth may not have adequate sediment to remain in place due to offsite reduction in sediment supply. Increased bluff recession likely inside estuary.	Salt marsh at bay head may be reduced slightly. Relict spit at bay mouth may not have adequate sediment to remain in place due to offsite reduction in sediment supply (and sea level change). Increased bluff recession likely inside estuary.	No risk to ecologic processes in general.
Partial Restoration	Salt marsh at bay head reduced. Relict spit at bay mouth will likely not have adequate sediment to remain in place due to partial removal (and sea level change). Increased bluff recession likely inside estuary.	Salt marsh at bay head reduced. Relict spit at bay mouth will likely not have adequate sediment to remain in place due to partial removal (and sea level change). Increased bluff recession likely inside estuary.	No risk to ecologic processes in general.

2.7 Potential Monitoring Opportunities

Monitoring is important for evaluating the success of the partial or full restoration alternative. A combination of field surveys and aerial photographs would be used to document biological and physical changes to the landscape. Monitoring data can be used to refine adaptive management and corrective actions, as needed. Some of the key monitoring needs and opportunities associated with this action are summarized in Table 2-4.

Table 2-4. Monitoring Needs and Opportunities

Monitoring Parameter	Key Performance Indicator	Note
Topographic Stability	X	Monitor bed elevations below weir
Sediment Accretion / Erosion	X	Assess sedimentation rates south of the highway Monitor bed elevations below weir Monitor estuarine changes
Wood Accumulation		
Soil / Substrate Conditions		
Vegetation Establishment	X	Backshore and other areas
Marsh Surface Evolution / Accretion		
Tidal Channel Cross-Section / Density		
Water Quality (Contaminants)		
Salinity		
Shellfish Production	X	Monitor north side of the highway
Extent Of Invasive Species		
Animal Species Richness	X	Changes due to increased opening size
Fish (Salmonid) Access/Use	X	Changes due to increased opening size
Forage Fish Production		
Hydraulics	X	Tide range and current velocity
Wildlife Species Use		
Effectiveness Of Exclusion Devices		

2.8 Information Needed for Subsequent Design

This conceptual design report represents an initial step in the restoration design sequence. The design concepts described above were developed based on readily available information without the level of site-specific survey and investigation that is necessary to support subsequent design and implementation. Substantial additional information will be required at the preliminary and later design stages to confirm the design assumptions, refine quantity estimates, address property and regulatory issues, obtain stakeholder support, and fill in data gaps. The extent to which this information is collected for preliminary design (or a later design stage) will depend upon the available budget, schedule and other factors. This section attempts to define the most essential information needs for this action.

- Property Investigation/Survey – More detailed information on property boundary location will be needed to finalize the design, confirm acquisition requirements, and support negotiations with property owners. A Franchise Utility Agreement process is needed for utility relocation.
- Topographic/Bathymetric Survey – Advancing the full and partial restoration design work requires a full 1-foot contour interval topography survey of the entire causeway and areas immediately adjacent to the action areas. This would include bathymetry of the estuary bottom in a 150-foot-wide swath both north and south of the causeway. A temporary tide gage may be required in the early design stages to obtain site-specific tidal statistics.
- Geotechnical Investigation – Additional geotechnical study is needed to support bridge foundation design for full and partial restoration alternatives within the area for the proposed bridges. Hydraulic engineering analysis is recommended for scour protection requirements and minimum bridge clearance over water.
- Cultural Resources Investigation – Surveys for archaeological and historic resources may be required for this action area.
- Erosion Investigation – Erosion of the bluff and potential impacts to the homes on the bluff should be assessed as part of this project.
- Hydrodynamic Model – Estimates of channel velocities and waves before and after restoration are recommended to assess scour potential and to design countermeasures for the project area.
- Inlet Morphology and Estuarine Response Investigation – We recommend additional study to ascertain whether excavation of sediment from the estuary is desired and the likely effect(s) on flood and erosion hazards.

2.9 Quantity Estimates

The quantity spreadsheets for the full and partial restoration alternatives are provided in Exhibits 2-1 and 2-2.

2.10 References

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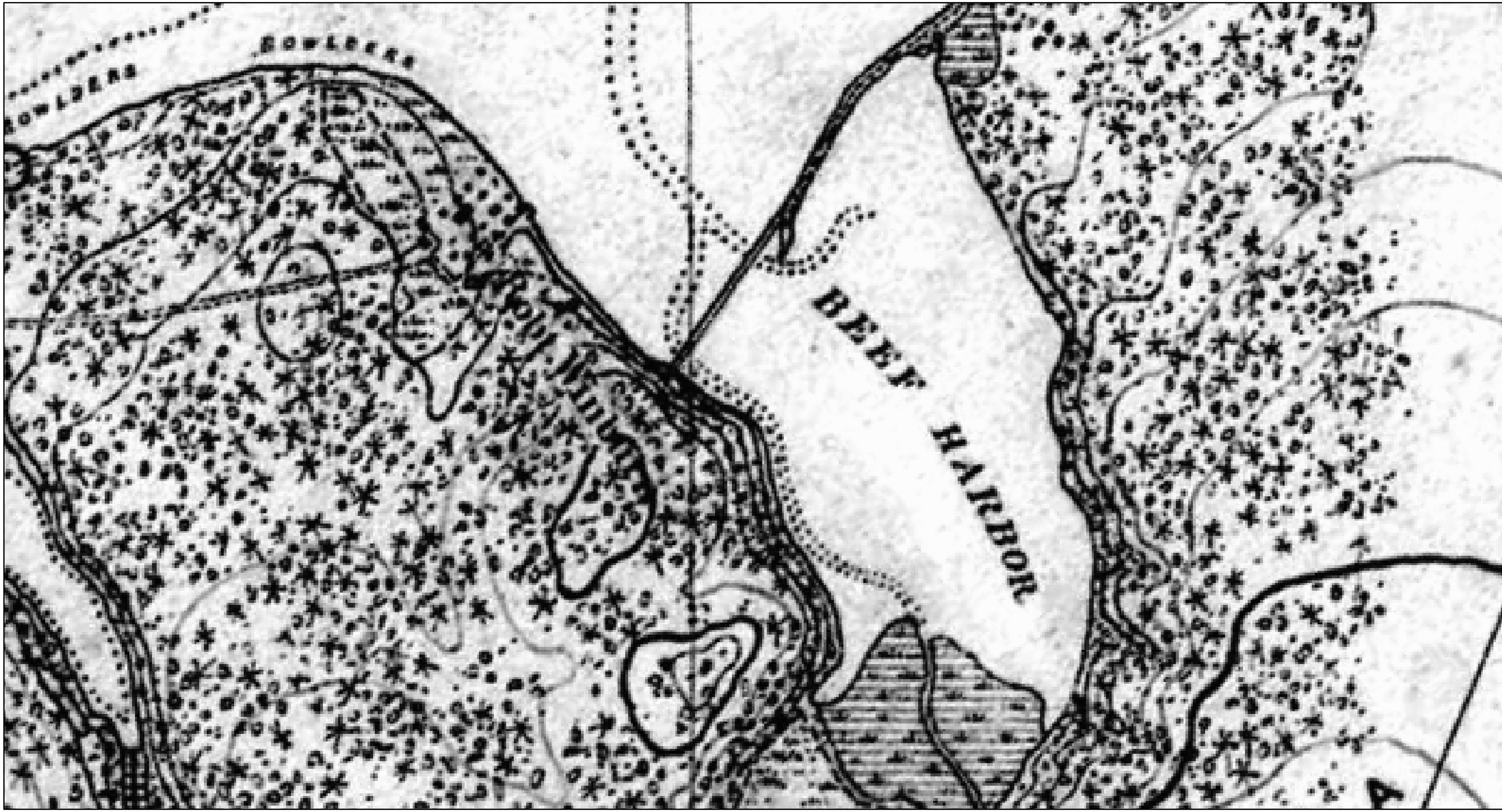
U.S. Coast and Geodetic Survey. 1884. T-sheet No. 1558b; Hood's Canal, Sheet No. 2, Washington Territory.



0 260
Feet
0 80
Meters

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Historic Map (T-Sheet)
Action Name: Big Beef Causeway Replacement and Estuary Restoration
PSNERP ID #: 1256
Figure 2- 2A

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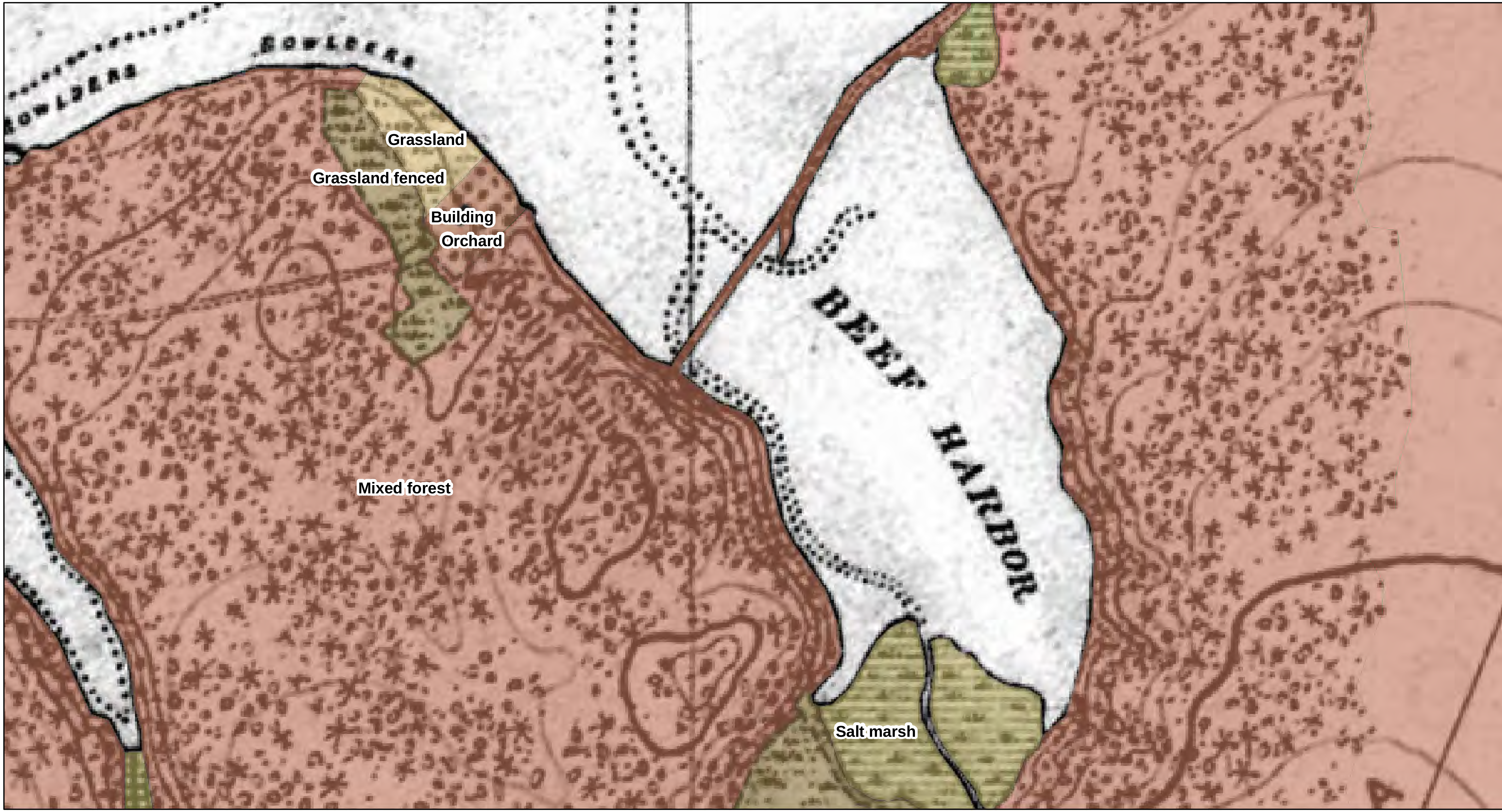

0 260 Feet
0 80 Meters

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Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64

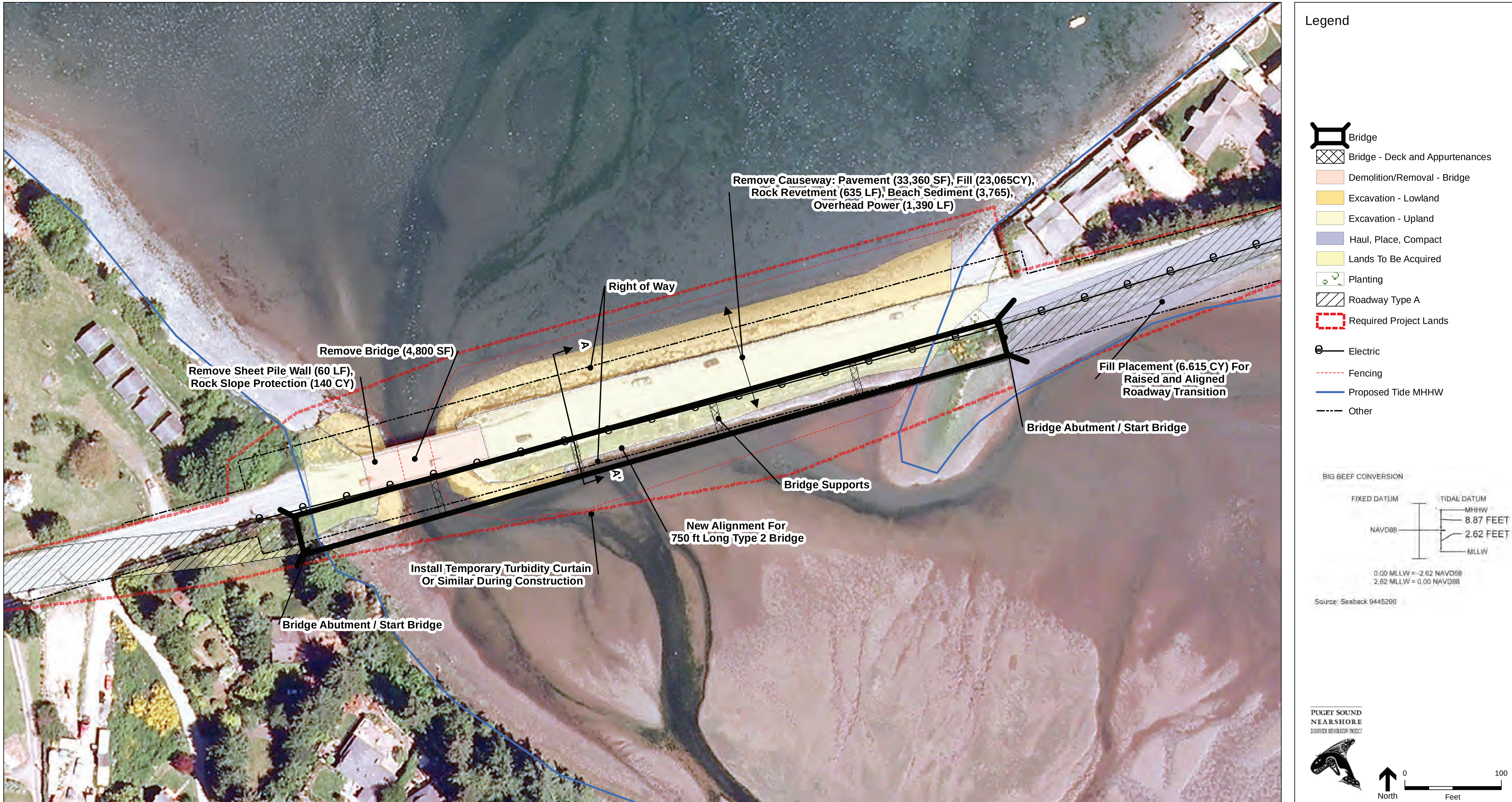
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Historic Map (T-Sheet) and River History Project Data

Action Name: Big Beef Causeway Replacement and Estuary Restoration

PSNERP ID #: 1256

Figure 2- 2B



SOURCE: Washington Public Lands Database (2006); Washington Counties Parcels (2009); Action Area (PSNERP, 2010)

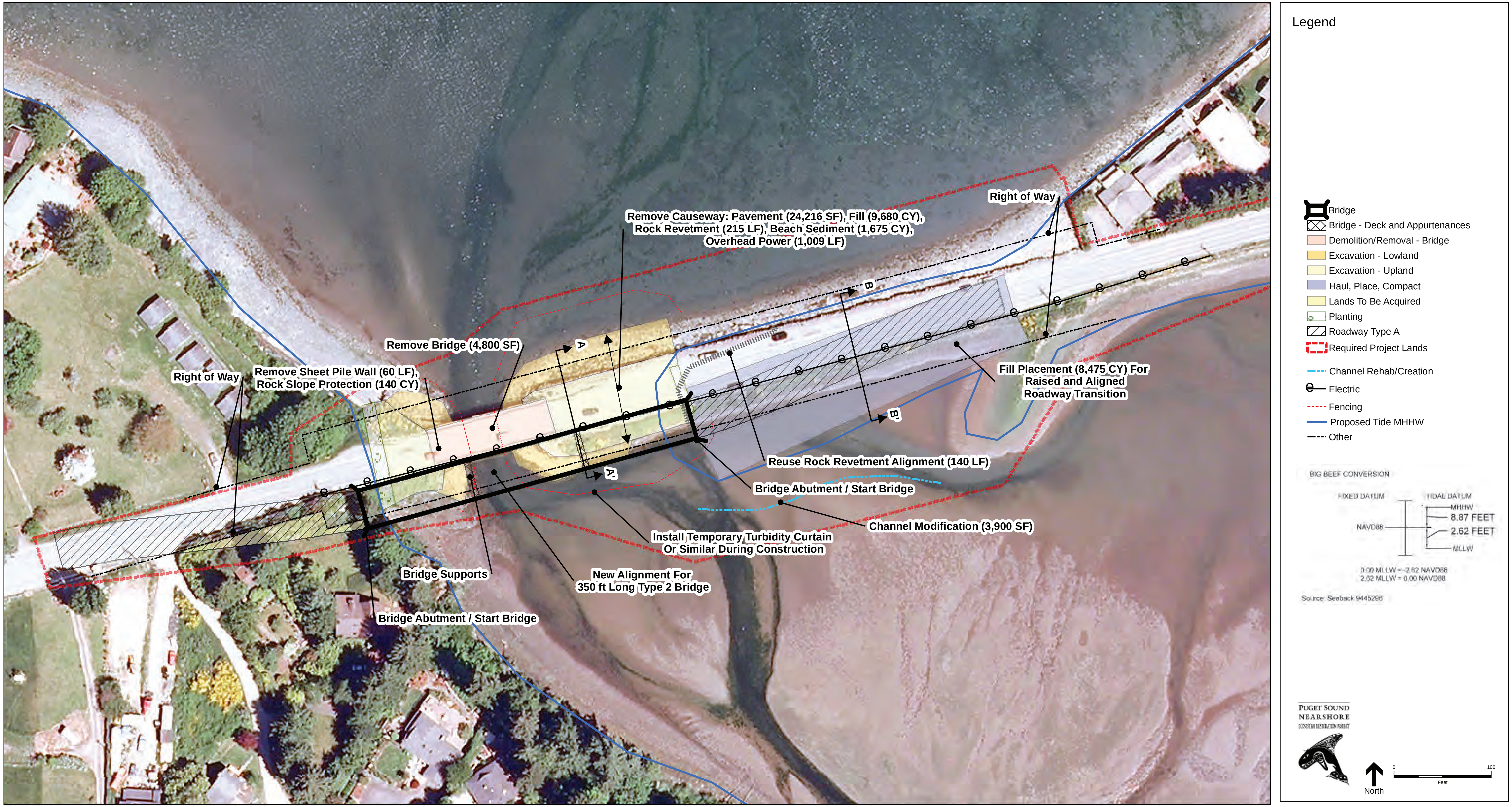
Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64

WDFW Contract # 100-000204 (CAPS No. 10-1461)

Lead Contractor: ESA
Design Lead: CGS, Jim Johannessen
Date: 2/15/2011

Conceptual Design Plan
Site Name: Big Beef Creek Estuary
Action Name: Big Beef Causeway Replacement and Estuary Restoration
PSNERP ID #:1256
Full Restoration

Figure 2-3



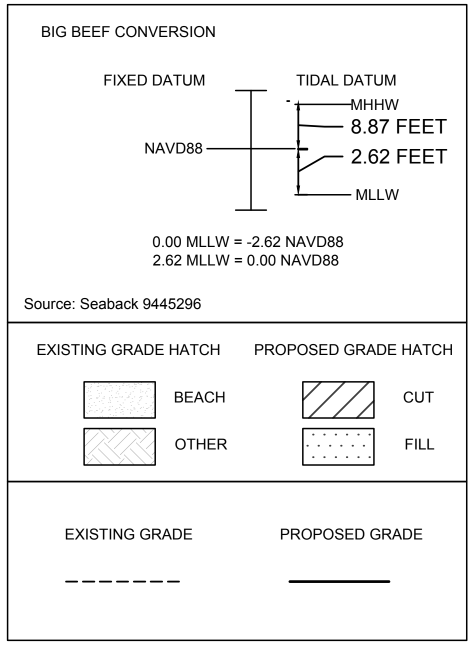
SOURCE: Washington Public Lands Database (2006); Washington Counties Parcels (2009); Action Area (PSNERP, 2010)

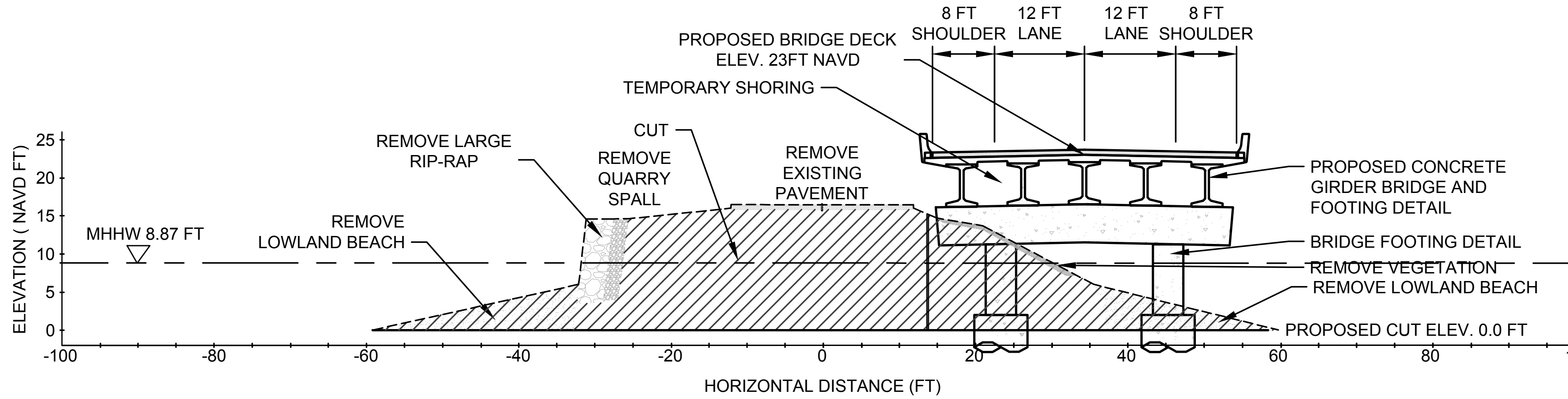
Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Lead Contractor: ESA
Design Lead: CGS, Jim Johannessen
Date: 2/15/2011

Conceptual Design Plan
Site Name: Big Beef Creek Estuary
Action Name: Big Beef Causeway Replacement and Estuary Restoration
PSNERP ID #:1256
Partial Restoration

Figure 2-4





Ⓐ FULL AND PARTIAL RESTORATION, TYPICAL SECTION

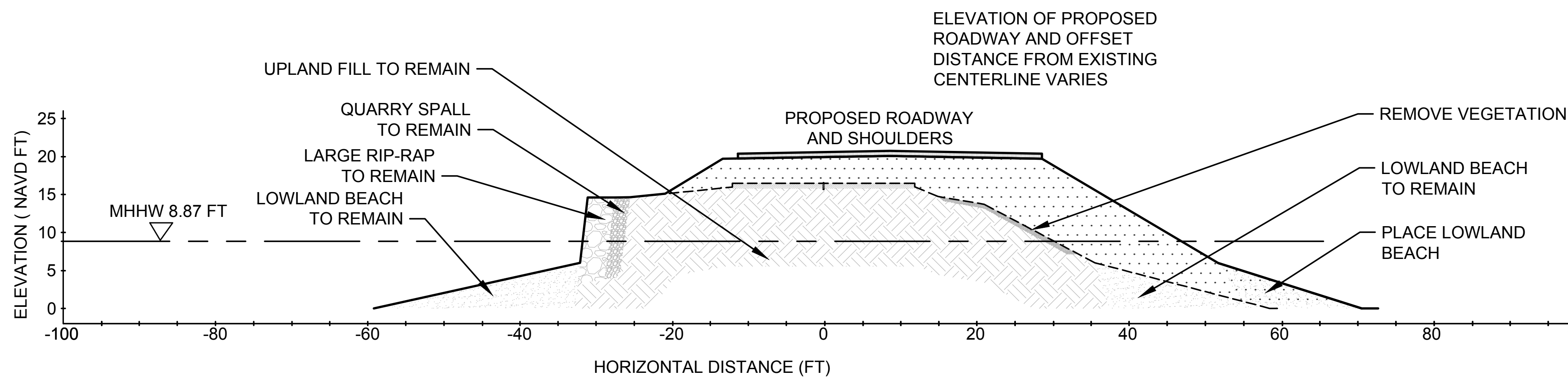
Location shown on plan view map, Typical cross section has been averaged

TYPICAL SECTION DEPICTING TIDAL BARRIER REMOVAL (BIG BEEF CAUSEWAY FILL, ARMOR AND BEACH) AND PROPOSED BRIDGE CONSTRUCTION.

FULL RESTORATION CONSTRUCTS A 750 LF BRIDGE ALONG THE ENTIRE CAUSEWAY ALIGNMENT.

PARTIAL RESTORATION CONSTRUCTIONS A SHORTER 330 LF BRIDGE.

TYPICAL SECTION DEPICTING PARTIAL RESTORATION SECTIONS WHERE CAUSEWAY ROADWAY REMAIN, FILL IS NEEDED FOR PROPOSED BRIDGE ALIGNMENT TO TIE INTO EXISTING ROAD ALIGNMENT.



Ⓑ PARTIAL RESTORATION, TYPICAL SECTION

CROSS SECTION DIMENSIONS HAVE BEEN ALTERED TO SHOW TYPICAL CONDITIONS

Full Restoration Quantity Estimate

Action Name: Big Beef Causeway Replacement and estu
Action #: 1256
Date: February 2011
By: Coastal Geologic Services

REMEDY: ***Restore natural tidal influence and sediment transport in the Big Beef Creek barrier estuary by replacing the existing causeway with an elevated structure that spans the historic embayment mouth.***

Construction Period: 13-15 months total for construction of new bridge and tie-in to existing road alignment. and project activities >>

	Item	Unit of Measure	Material Name	Qty	Description of Item	Indicate section of design report where item is described
ACQUISITION AND CONSERVATION						
	Required Project Lands	Acre		3.11	Total land required For action, permanent and temporar	2.3.5
	Proponent / Partner-owned lands	Acre		2.7	Etimate of lands currently owned by Proponent (i.e., Public lands	2.3.5
	Lands To Be Acquired Temporarily	Acre		0.28	12,305 SF of Temporary easement for fill removal	2.3.5
	Lands to be Acquired Permanently	Acre		0.13	2,400 SF west of proposed bridge for roadway alignment tie-in and transition + 3,250 SF south of alignment for elevated roadway fill	2.3.5
Material Sites					Not Used: See Earthwork - Imported Fill.	
MOBILIZATION AND ACCESS for construction activities						
	Mobilization - Typica (Equipment, Personnel, Planning, Financial)	LS		1	Up front costs such as bonding, planning and other staff time and financing. Typically, assume 8% to 10% of other items.	
	Mobilization - Remote (Equipment, Personnel, Planning, Financial	LS		0	Not appicable to this action	
	Site Access	LS		0	Use for special situations (e.g.. new bridge, new access roads) for the purposes of construction access Include description.	
	Barge Access	Days		0	Not appicable to this action	
	Temporary Traffic Control (one of the following)					
	none	LS		0	Not appicable to this action	
	signs	LS		1	Typical Construction Signage	
	flags / spotters	LS		1	Flags and spotters only during roadway transition connection	
	unique	LS		0	Not appicable to this action	
	Temporary Roadway	SF		0	Includes construction of temporary adjacent roadway or bypass roadways and for vehicle and pedestrian travel through or around site	
	Control of Water	LS		0	Not appicable to this action	
Relocation Activities					Not Used: See Utilities, Structures	
Site Demolition Activities						
	Clearing and Grubbing (one or more of following)				Use one or more of the following categories of clearing and grubbing	
	Clear Vegetation - Local Disposal	AC		0	Vegetation removed above grade and disposed locally	
	Clear /Grub Vegetation - Local Disposal	AC		0.06	2,735 SF of newly uncovered backshore near east end of bridge. Vegetation roots also removed and disposed locally	2.3.3
	Clear /Grub Vegetation - Offsite Disposal	AC		0	Vegetation is taken offsite and disposed - use for noxious invasives, etc	
	Clear, stockpile - large woody debris	CY		0	Vegetation is segregated and stockpiled / prepared for reuse on site	
	Hydraulic Structures - Small	LS		0	Not appicable to this action	
	Hydraulic Structures - Large	LS		0	Not appicable to this action	
	Utilities	LF		1390	Relocate overhead power onto new bridge and realigned road	2.3.5
	Buildings	LS or SF		0	Not appicable to this action	
	Pavement	SF		33360	Removal of 24' Roadway	2.3.2
	Bulkheads	LF		60	approximate 20 FT height (total), steel sheet pile wall	2.3.2
	Rock revetments	LF		635	near vertical large rip-rap, causeway armor, 885 CY, along shoreline and under bridge	2.3.2
	Rock Slope Protection	CY		140	Medium Rip Rap, rock slope protection on west end of bridge	2.3.2
	Large Coastal Structures	LF, SF or CY		0	Not appicable to this action	
	Demolition / Removal - Bridge	SF		4000	100 LF, 40 ft wide, 3-span concrete slab	2.3.2
	Demolition / Removal Concrete Bridge Appurtenances	SF		800	20 LF, bridge approach slabs	2.3.2
	Removal - Misc. (e.g. angular rock from beach)	CY		250	For loose rock scattered across intertidal	2.3.2
	Demolition / Removal - Pier Remnant	SF		120	Remians of old pier, 25 ft long, piles, cross ties and rock only; at north side of west end of current bridge	2.3.2
	Haul - Offsite Disposal of Demolition Debris	Miles		20	Placeholder	2.3.7
Hazardous/Contaminated Waste Removal						
	Contaminated Earthwork	CY		0	Not appicable to this action	
	Hazardous Earthwork	CY		0	Not appicable to this action	
Construct Temporary Features						
	Temporary construction trestle	LS		1	for pile installation	
	Temporary shoring	LS		1	for bridge construction	
EARTHWORK					Expand to include equipment, etc. to facilitate cost estimating.	
	Excavation					
	Excavation - Upland Fill	CY		23065	Remove road causeway, 0.99 acres, Conducive for transitional earthwork equipment, including scrapers, with high production and low cost. Resue select material for roadway fill, haul rest 20 miles off site	2.3.2
	Excavation - Upland Quarry Spall	CY		505	635 LF, near vertical, between upland fill and large riprap armor, along shoreline and under bridge, resue select for revetment realignment, haul other 20 miles off site	2.3.2
	Excavation - Lowland Beach	CY		3765	0.66 acre, Low ground pressure equipment required for intertidal portion of causeway removal, resue select material south of new roadway alignment. Haul other off site 20 miles. Will be likely completed by land based earthwork equipment removing causeway and surrounding beach veneer, working back to land, after new bridge and road is in place. Will be further evaluated at later design stages	2.3.2
	Dredging - Bucket - Land	CY		0	Not appicable to this action	
	Dredging - Bucket - Marine	CY		0	Not appicable to this action	
	Dredging - Hydraulic	CY		0	Not appicable to this action	
	Fine Grading	AC		0	Not appicable to this action	
	Fill Placement - local borrow				This is additive to Earthwork -Excavation	
	Side cast	CY		0	Not appicable to this action	
	Haul - uncontrolled placement	CY		0	Not appicable to this action	
	Haul, place, compact	CY		6615	South of current road alignment, for elevated roadway fill, Resue of select excavated causeway fi	2.3.7
	Stockpile - uncontrolled placement	CY		0	Intermediate step, for subsequent off haul or use elsewhere on site	
	Stockpile - controlled placement	CY		0	intermediate step, for subsequent off haul or use elsewhere on site. Can use this for drying material for subsequent controlled compacted fil	
	Conveyor placement from stockpile land/water	CY		0	Some projects may require conveyor placement	
	Imported Fill					
	Select Fill	CY		0	Imported select material - describe use, e.g. levee, root base mix, etc;	
	Gravel Borrow, including haul	CY		0	Not appicable to this action	
	Sand / Gravel for Beach Nourishment	CY		0	Minor beach nourishment using slavaged sediment from causeway fill only	2.3.3
	Cobble for Shore Nourishment	CY		0	Not appicable to this action	
	Embankment Compaction	CY		0	Not appicable to this action	
	Topsoil	CY		200	For revegetation of road shoulder areas	2.3.3
RESTORATION Features						
	Channel Rehab / Creation	SF		4125	15 feet wide, 275LF channel.	2.3.2
	Large Wood Placement	EA		0	Not appicable to this action	
	Invasive Species Control	Acre		0	Not appicable to this action	
	Physical Exclusion Devices	LF or EA		0	Not appicable to this action	
	Other Restoration Features/ Activities	LS		0	Not appicable to this action	
Structures		EA				
	Water Control Structures - Culverts with Gates	EA		0	Not appicable to this action	
	Water Control Structures - Weirs	EA		0	Not appicable to this action	
	Rock Slope Protection	LF		0	Not appicable to this action	
	Other	EA		0	Not appicable to this action	
	Elevated Boat Ramp	SF		0	Not appicable to this action	
	Fencing	SF		0	Not appicable to this action	
Utilities						
	Water	LF		0	Not appicable to this action	
	Gas	LF		0	Not appicable to this action	
	Electric	LF		1390	Overhead power	2.3.5
	Sewer	LF		0	Not appicable to this action	
	Telecommunications	LF		0	Not appicable to this action	
	Other	LF		0	Not appicable to this action	
Roadway / Railway						
	Roadway (Type)	SF		26838	Typical roadway 42' wide	
	Roadway - Traffic Signal	LS		0	Not appicable to this action	
	Culvert (type)	LF		0	Not appicable to this action	
	Culvert - Jacking	LF		0	Not appicable to this action	
	Culvert - Horizontal Pile Driving	LF		0	Not appicable to this action	
	Bridge Deck	SF		30000	Precast Concrete Girder Bridge with 150' Spans, 750 LF (40' wide x 750'	2.3.6
	Bridge - Foundations	LF		160	(4) 40' CIP Concrete pile caps w/ (2) 7' Dia Drilled Shafts 100' Embed At Each Pile Cap	2.3.6
	Railway - Box Girder	SF		0	Not appicable to this action	
	Railway - Foundation	LF		0	Not appicable to this action	
	Railway - Shoe fly	LF		0	Not appicable to this action	
Permanent Access Features						
	Roads	Level		2	Level 1 direct access, Level 2 moderately difficult, Level 3 difficult access	
	Utility Access Routes	varies		0	Not appicable to this action	
	Erosion Control Features	AC		5.6	Stabilized Construction Entrances, Sediment Ponds, Hydro Seed to Stabilize Roadway Embankment	2.3.7
Public Access or Recreation Features						
	Trails	SF		0	Not appicable to this action	
	Bridges	SF		0	Not appicable to this action	
	Kiosk	EA		0	Not appicable to this action	

Full Restoration Quantity Estimate

Action Name: Big Beef Causeway Replacement and estu
Action #: 1256
Date: February 2011
By: Coastal Geologic Services

REMEDY: ***Restore natural tidal influence and sediment transport in the Big Beef Creek barrier estuary by replacing the existing causeway with an elevated structure that spans the historic embayment mouth.***

Construction Period: 13-15 months total for construction of new bridge and tie-in to existing road alignment. and project activities >>

	Item	Unit of Measure	Material Name	Qty	Description of Item		Indicate section of design report where item is described
	Restrooms	EA		0	Not appicable to this action		
	Interpretive Signs	EA		0	Not appicable to this action		
	Parking Area	SF		0	Not appicable to this action		
	Other	EA		0	Not appicable to this action		
Vegetation & Erosion Control							
	Hydroseeding	AC		0.5	Native grass mix on roadway embankment		2.3.7
	Planting	AC		0.06	revegetate newly uncovered backshore, dunegrass and other salt-tolerant herbaceous backshore plant		2.3.3
	Vegetation Maintenance	AC-YR		0.06	Includes weeding, plant replacement for one yea		2.3.3
	Erosion / sediment BMPs - Temp.	AC		5.6	BMPs for control of drainage - describe. Assume compliance with Construction General NPDES included		2.3.7
	Erosion / sediment BMPs - Permanent	AC			May want to separate slopes over 25% into separate category		
	Waterside controls - Temporary	LF					
	In-water controls - Temporary	LF		1440	turbidity curtain for water based temporary actions		2.3.7
Construction Management							
	Construction oversight	months		15	Quanity based on constructon duration/ # of construction seasons		
	Materials testing				Included in cost of material - no separate quantity		
Design and Detailed Site Investigations							
	Survey & Property, Utility Research	LS		1	rquired		
	35% Design	LS		1	rquired		
	65% design	LS		1	rquired		
	90% design	LS		1	rquired		
	100% design	LS		1	rquired		
	Geotechnical Studies			1	Geotechnical investigation and recommendations for bridge foundation type		2.8
	Cultural Studies			1	Likely required; details not known at this point		2.8
	Erosion investigation			1	Refer to design report for description of need		2.8
	Hydrodynamic model development			1	Refer to design report for description of need		2.8
	Inlet Morphology and Estuarine Reponse study			1	Refer to design report for description of need		2.8
	HTWR Studies				Refer to design report for description of need		
Project Agreement Activities					Unable to provide credibale estimate at 10% design		
Monitoring Activities					Assume 5 crew-days/year for each monitoring parameter in design report for 5 yrs		
	Monitoring (Type)	crew-days		175			
Operations & Maintenance							

Partial Restoration Quantity Estimate

Action Name: Big Beef Causeway Replacement and estu
Action #: 1256
Date: February 2011
By: Coastal Geologic Services

REMEDY: ***Restore majority of natural tidal influence and sediment transport in the Big Beef Creek barrier estuary by replacing the existing causeway with an elevated structure that spans roughly half of the historic embayment mouth.***
Construction Period: 11-13 months total for construction of new bridge and tie-in to existing road alignment.

	Item	Unit of Measure	Material Name	Qty	Description of Item	Indicate section of design report where item is described
ACQUISITION AND CONSERVATION					Based on available mapping information	
	Required Project Lands	Acre		2.4	Total land required For action, permanent and temporar	2.3.5
	Proponent / Partner-owned lands	Acre		2.0	Etimate of lands currently owned by Proponent (i.e., Public lands	2.3.5
	Lands To Be Acquired Temporarily	Acre		0.11	4,605 SF of Temporary easement for fill removal	2.3.5
	Lands to be Acquired Permanently	Acre		0.29	2,400 SF west of proposed bridge for roadway alignment tie-in and transition + 9,750 SF south of alignment for elevated roadway fil	2.3.5
Material Sites					Not Used: See Earthwork - Imported Fill.	
MOBILIZATION AND ACCESS for construction activities					Description required for each item to facilitate cost estimating	
	Mobilization - Typica (Equipment, Personnel, Planning, Financial)	LS		1	Up front costs such as bonding, planning and other staff time and financing. Typically, assume 8% t 10% of other items.	
	Mobilization - Remote (Equipment, Personnel, Planning, Financial	LS		0	Not appicable to this actior	
	Site Access	LS		0	Not appicable to this actior	
	Barge Access	Days		0	Not appicable to this actior	
	Temporary Traffic Control (one of the following)				Includes installation of traffic signals, signage, signmen, etc. There are 4 types as follows	
	none	LS		0	Not appicable to this actior	
	signs	LS		1	Typical Construction Signage	
	flags / spotters	LS		1	Flags and spotters only during roadway transition connectior	
	unique	LS		0	Not appicable to this actior	
	Temporary Roadway	SF		0	Not appicable to this actior	
	Control of Water	LS		0	Not appicable to this actior	
Relocation Activities					Not Used: See Utilities, Structures	
Site Demolition Activities					Demolition and removal of structures (description required), temporary features and relocations, itemized separately); Clearing and grubbing of vegetation, and removal of minor debris (rocks, slabs) - description required.	
	Clearing and Grubbing (one or more of following)				Use one or more of the following categories of clearing and grubbing	
	Clear Vegetation - Local Disposal	AC		0	Vegetation removed above grade and disposed locally	
	Clear /Grub Vegetation - Local Disposal	AC		0.05	1,965 SF of newly uncovered backshore near east end of bridge. Vegetation roots also removed and disposed locally	2.3.3
	Clear /Grub Vegetation - Offsite Disposal	AC		0	Vegetation is taken offsite and disposed - use for noxious invasives, etc	
	Clear, stockpile - large woody debris	CY		0	Vegetation is segregated and stockpiled / prepared for reuse on site	
	Hydraulic Structures - Small	LS		0	Not appicable to this actior	
	Hydraulic Structures - Large	LS		0	Not appicable to this actior	
	Utilities	LF		1009	Relocate overhead power onto new bridge	2.3.5
	Buildings	LS or SF		0	Not appicable to this actior	
	Pavement	SF		24216	Removal of 24FT width 1009 LF Roadway	2.3.2
	Bulkheads	LF		60	approximate 20 FT height (total), steel sheet pile wal	2.3.2
	Rock revetments	LF		215	near vertical large rip-rap, causeway armor, 290 CY, along shoreline and under bridg	2.3.2
	Rock Slope Protection	CY		140	Medium Rip Rap, rock slope protection on west end of bridge	2.3.2
	Large Coastal Structures	LF, SF or CY		0	Not appicable to this actior	
	Demolition / Removal - Bridge	SF		4000	100 LF, 40 ft wide, 3-span concrete slab	2.3.2
	Demolition / Removal Concrete Bridge Appurtenances	SF		800	20 LF, 40 ft bridge approach slabs	2.3.2
	Removal - Misc. (e.g. angular rock from beach)	CY		200	Removal of loose rock scattered across intertidal.	2.3.2
	Demolition / Removal - Pier Remnant	SF		120	Remians of old pier, 25 ft long, piles, cross ties and rock only; at north side of west end of current bridge	2.3.2
	Haul - Offsite Disposal of Demolition Debris	Miles		20	Placeholder	2.3.7
Hazardous/Contaminated Waste Removal						
	Contaminated Earthwork	CY		0	Not appicable to this actior	
	Hazardous Earthwork	CY		0	Not appicable to this actior	
Construct Temporary Features						
	Temporary construction trestle	LS		1	For pile installation	
	Temporary shoring	LS		1	For bridge construction	
EARTHWORK					Expand to include equipment, etc. to facilitate cost estimating.	
	Excavation				Per yard excavation w/out expected haul	
	Excavation - Upland Fill	CY		9680	Remove road causeway, 0.40 acres, Conducive for transitional earthwork equipment, including scrapers with high production and low cost. Resue select material for roadway fill, haul rest 20 miles off site	2.3.2
	Excavation - Upland Quarry Spall	CY		160	215 LF, near vertical, between upland fill and large liprap armor, along shoreline and under bridge, resue select for revetment realignment, haul other 20 miles off site	2.3.2
	Excavation - Lowland Beach	CY		1675	0.31 acre, Low ground pressure equipment required for intertidal portion of causeway removal. Will be likely completed by land based earthwork equipment removing causeway and surrounding beach veneer, working back to land, after new bridge and road is in place. Will be further evaluated at later design stages.	2.3.2
	Dredging - Bucket - Land	CY		0	Not appicable to this actior	
	Dredging - Bucket - Marine	CY		0	Not appicable to this actior	
	Dredging - Hydraulic	CY		0	Not appicable to this actior	
	Fine Grading	AC		0	Not appicable to this actior	
	Fill Placement - local borrow				This is additive to Earthwork -Excavation	
	Side cast	CY		0	Not appicable to this actior	
	Haul - uncontrolled placement	CY		0	Not appicable to this actior	
	Haul, place, compact	CY		8475	South of current road alignment, for elevated roadway fill	2.3.7
	Stockpile - uncontrolled placement	CY		0	Not appicable to this actior	
	Stockpile - controlled placement	CY		0	Not appicable to this actior	
	Conveyor placement from stockpile land/water	CY		0	Not appicable to this actior	
	Imported Fill					
	Select Fill	CY		0	Not appicable to this actior	
	Gravel Borrow, including haul	CY		0	Not appicable to this actior	
	Sand / Gravel for Beach Nourishment	CY		0	Minor beach nourishment using slavaged sediment from causeway fill onl	2.3.3
	Cobble for Shore Nourishment	CY		0	Not appicable to this actior	
	Embankment Compaction	CY		0	Not appicable to this actior	
	Topsoil	CY		160	For revegetation of road shoulder areas	2.3.3
RESTORATION Features						
	Channel Modification	SF		3900	361 CY, 260 LF of 15FT width and 2.5FT depth channel	2.3.2
	Large Wood Placement	EA		0	Not appicable to this actior	
	Invasive Species Control	Acre		0	Not appicable to this actior	
	Physical Exclusion Devices	LF or EA		0	Not appicable to this actior	
	Other Restoration Features/ Activities	LS		0	Not appicable to this actior	
Structures		EA				
	Water Control Structures - Culverts with Gates	EA		0	Not appicable to this actior	
	Water Control Structures - Weirs	EA		0	Not appicable to this actior	
	Rock Slope Protection	LF		0	Not appicable to this actior	
	Other	EA		0	Not appicable to this actior	
	Elevated Boat Ramp	SF		0	Not appicable to this actior	
	Fencing	SF		0	Not appicable to this actior	
Utilities						
	Water	LF		0	Not appicable to this actior	
	Gas	LF		0	Not appicable to this actior	
	Electric	LF		1009	Overhead power	2.3.5
	Sewer	LF		0	Not appicable to this actior	
	Telecommunications	LF		0	Not appicable to this actior	
	Other	LF		0	Not appicable to this actior	
Roadway / Railway						
	Roadway (Type)	SF		22678	Typical roadway 42' wide	
	Roadway - Traffic Signal	LS		0	Not appicable to this actior	
	Culvert (type)	LF		0	Not appicable to this actior	
	Culvert - Jacking	LF		0	Not appicable to this actior	
	Culvert - Horizontal Pile Driving	LF		0	Not appicable to this actior	
	Bridge Deck	SF		14000	Precast Concrete Girder Bridge with 117' Spans, 350 LF (40' wide x 350	2.3.6
	Bridge - Foundations	LF		80	(2) 40' CIP Concrete pile caps w/ (2) 7' Dia Drilled Shafts 100' Embed At Each Pile Ca	2.3.6
	Railway - Box Girder	SF		0	Not appicable to this actior	
	Railway - Foundation	LF		0	Not appicable to this actior	
	Railway - Shoe fly	LF		0	Not appicable to this actior	
Permanent Access Features						
	Roads	Level		2	Level 1 direct access, Level 2 moderately difficult, Level 3 difficult access	
	Utility Access Routes	varies		0	Not appicable to this actior	
	Erosion Control Features	AC		5.4	Stabilized Construction Entrances, Sediment Ponds, Hydro Seed to Stabilize Roadway Embankments	2.3.7
Public Access or Recreation Features						
	Trails	SF		0	Not appicable to this actior	
	Bridges	SF		0	Not appicable to this actior	
	Kiosk	EA		0	Not appicable to this actior	
	Restrooms	EA		0	Not appicable to this actior	

Partial Restoration Quantity Estimate

Action Name: Big Beef Causeway Replacement and estu
Action #: 1256
Date: February 2011
By: Coastal Geologic Services

REMEDY: ***Restore majority of natural tidal influence and sediment transport in the Big Beef Creek barrier estuary by replacing the existing causeway with an elevated structure that spans roughly half of the historic embayment mouth.***
Construction Period: 11-13 months total for construction of new bridge and tie-in to existing road alignment.

	Item	Unit of Measure	Material Name	Qty	Description of Item		Indicate section of design report where item is described
	Interpretive Signs	EA		0	Not appicable to this actior		
	Parking Area	SF		0	Not appicable to this actior		
	Other	EA		0	Not appicable to this actior		
Vegetation & Erosion Control							
	Hydroseeding	AC		0.3	Native grass mix on roadway embankment		2.3.7
	Planting	AC		0.05	revegetate newly uncovered backshore, dunegrass and other salt-tolerant herbaceous backshore plant		2.3.3
	Vegetation Maintenance	AC-YR		0.05	Includes irrigation, weeding, plant replacement for one yea		2.3.3
	Erosion / sediment BMPs - Temp.	AC		5.4	BMPs for control of drainage - describe. Assume compliance with Construction General NPDES included		2.3.7
	Erosion / sediment BMPs - Permanent	AC			May want to separate slopes over 25% into separate category		
	Waterside controls - Temporary	LF					
	In-water controls - Temporary	LF		795	turbidity curtain for water based temporary actions		2.3.7
Construction Management							
	Construction oversight	months		13	Quanity based on constructon duration/ # of construction seasons		
	Materials testing				Included in cost of material - no separate quantity		
Design and Detailed Site Investigations							
	Survey & Property, Utility Research	LS		1	rquired		
	35% Design	LS		1	rquired		
	65% design	LS		1	rquired		
	90% design	LS		1	rquired		
	100% design	LS		1	rquired		
	Geotechnical Studies			1	Geotechnical investigation and recommendations for bridge foundation type		2.8
	Cultural Studies			1	Likely required; details not known at this point		2.8
	Erosion investigation			1	Refer to design report for description of need		2.8
	Hydrodynamic model development			1	Refer to design report for description of need		2.8
	Inlet Morphology and Estuarine Reponse study			1	Refer to design report for description of need		2.8
	HTWR Studies						
Project Agreement Activities					Unable to provide credibale estimate at 10% design		
Site-Specific Adaptive Management Features & Activities					List if known		
Monitoring Activities					Assume 5 crew-days/year for each monitoring parameter in design report for 5 yrs		
	Monitoring (Type)	crew-days		175			
Operations & Maintenance					Unable to provide credible estimate at 10% design		

3. BIG QUILCENE RIVER RESTORATION (#1074, 1076, 1077, 1078)

Local Proponent	Hood Canal Salmon Enhancement Group (HCSEG) and Hood Canal Coordinating Council
Delta Process Unit	QUL
Shoreline Process Unit(s)	NA
Strategy(ies)	1 – River Delta
Restoration Objectives	Remove fill and dikes to restore tidal hydrology and freshwater input, sediment input, sediment transport, erosion and accretion of sediments, distributary channel migration, tidal channel formation, detritus import and export, and exchange of aquatic organisms

3.1 Description of the Action

The proposed action would build upon previous restoration efforts on the Big and Little Quilcene Rivers by removing stressors, primarily dikes and roadway fill, and restoring floodplain hydrology and connections to distributary channels through the delta. Please see the Introduction chapter for important information regarding PSNERP and for context related to this restoration project.

3.2 Action Area Description and Context

This action is within the Hood Canal Subbasin. The Big Quilcene and Little Quilcene Rivers form adjoining deltas with an extensive mudflat and estuarine marsh complex at the north end of Quilcene Bay, an arm of Dabob Bay on the west side of Hood Canal. The mudflat/marsh system is approximately 1.5 miles long (north/south) and 0.75 mile wide (east/west). A complex network of tidal distributary and blind channels provides tidal and freshwater circulation. A full range of habitat types is found within this upper bay including mudflat, estuarine marsh, freshwater marsh (forested and emergent), and upland forested habitats. The latter two habitats are better represented at the Big Quilcene River Estuary than at the Little Quilcene River.

These habitats support several species of salmon and shellfish. Salmonid species using this estuary include: fall Chinook, summer and fall chum, coho, winter steelhead, and sea-run and resident cutthroat trout. Hood Canal summer chum, which are federally listed as threatened, use the action area (Perkins Geosciences et al. 2005). Shellfish resources include clams, oysters, and mussels. The area supports the native Olympia oyster as well (WDFW 2010a).

The action area is in and adjacent to the town of Quilcene, Washington. The action area includes residential properties, roadways, a bridge, and other developed properties. The action area also includes wooded areas, pasture, mudflat, tidal marsh, dikes, and other features adjacent to the delta and estuary of the Big and Little Quilcene Rivers.

Linger Longer Road, which is owned and maintained by Jefferson County, crosses the Big Quilcene River at a bridge approximately 0.75 mile upstream of Quilcene Bay. Rodgers Street, another north-south roadway owned and maintained by Jefferson County, once crossed the Big Quilcene River at a bridge approximately 1,000 feet upstream of Linger Longer Road. The bridge has been removed, but the bridge approaches remain. Dikes were constructed along both the Big and Little Quilcene Rivers to protect the town of Quilcene and adjacent properties from flooding. Flooding continues to be a challenge for the town of Quilcene and neighboring areas.

Construction of dikes along the rivers interrupted natural hydraulic processes, including periodic avulsion of the rivers and flow from the main river channels to distributary channels in the delta. Sediment deposition on the Big Quilcene River has been confined by the dikes to a short section of the river, where the river channel has aggraded and is higher than the adjacent floodplain. The changes in sediment transport and other geomorphic processes have also resulted in accelerated progradation of the delta into Quilcene Bay.

The restoration of the Big Quilcene and Little Quilcene Rivers has been ongoing since 1996. The project is proceeding and components have been implemented as funding is available. The work completed to date on the Big Quilcene River includes dike removal, duck pond removal, Schinke Dike removal, engineered log jam construction, and the Linger Longer Feasibility Study. On the Little Quilcene River, the lower 2,000 feet of river and floodplain were restored, dikes were removed, and sediment was removed from the delta cone (Brocksmith 2010). The action area and vicinity are shown in Figure 3-1.

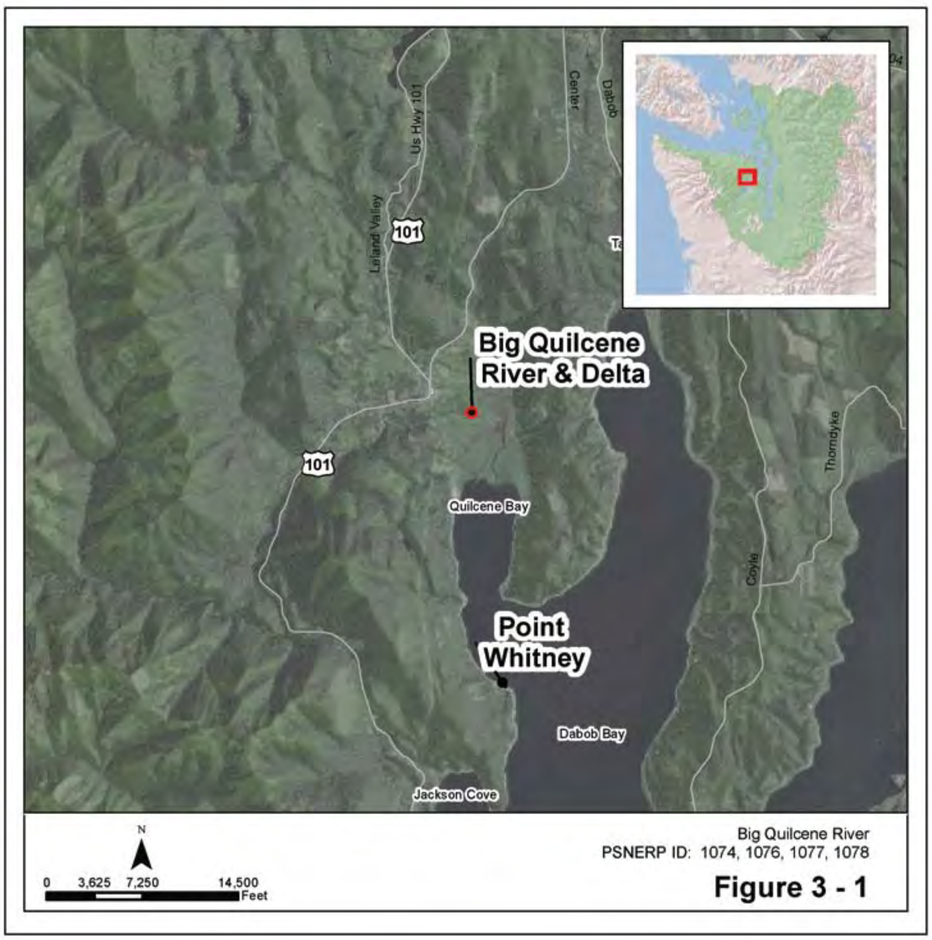


Figure 3-1. Action Area and Vicinity

3.2.1 Historic Condition

The lower part of the Big Quilcene River flows across a 0.75-mile-wide estuarine delta. Mudflat and estuarine marsh at the deltas of the Big Quilcene River and Little Quilcene River merge at the north end of Quilcene Bay. Prior to being diked, the Big Quilcene River would periodically switch course (avulse) across different portions of the delta. Relict distributary channels on the north floodplain and delta still convey floodwaters. Access to distributary channels on both sides of the river is blocked by dikes. The present river channel is higher (aggraded) than surrounding land in many locations. The entire alluvial fan-delta area is mapped as an Avulsion Hazard Zone in the U.S. Bureau of Reclamation 2004 channel migration zone study, meaning that the river could potentially switch course into one of the old channels (Klawon 2004).

An avulsion took place within the action area in 1992, when the river eroded through an unarmored dike below the power line corridor and took a southeast course before heavy equipment was used to restore the river to its former course and stabilize the dike with riprap revetment.

Several relict distributary channels cross the floodplain north of the present position of the Big Quilcene River. An 1883 topographic sheet (T-sheet) map shows the river occupying a channel north of its present location, which now exists as a relict distributary channel (Figures 3-2A and 3-2B). The original plat map for the town of Quilcene shows the river winding through town along another alignment. According to analysis completed by the project proponents (Perkins Geosciences et al. 2005), flows exceeding the 1.5-year flood overtop the left bank of the existing river channel upstream of Rodgers Street and flow through relict distributary channels in the left floodplain north of the existing river channel. Flood flows in the left floodplain cross Rodgers Street at a low point approximately 500 feet north of the existing river channel and continue to the northeast, crossing the bend in Linger Longer Road before connecting downstream with the Little Quilcene River and discharging to Quilcene Bay.

The Big Quilcene River delta was formed through natural depositional processes, yet intensive logging in the watershed during the last century has contributed to a massive increase in sediment load and transport in the Big Quilcene River as well as deposition in the river and delta where the river gradient flattens. The size of the delta appears to suggest that the background rate of delta building is significant. The recent aggradation rate and pattern may be related to upstream increases in sediment supply and diking; however, natural alluvial fan building processes are also at work.

The Big Quilcene River dikes have historically confined all the sediment deposition to a narrow strip. As a result, the river bed has aggraded and the delta has prograded more than 1,500 feet into Quilcene Bay since 1947 (Perkins Geosciences et al. 2005). The dikes and accelerated delta progradation have decreased access from the river into small estuarine channels that are important for juvenile salmonids. About two-thirds of the deposited gravel was removed from the channel between 1971 and 2000 to reduce flooding. No gravel has been removed since 2000 (Perkins Geosciences et al. 2005).

Logging in the watershed has been mostly curtailed for a number of reasons, and ongoing operations employ better conservation practices. The U.S. Forest Service is also decommissioning and repairing logging roads in the national forest, which will further reduce the sediment loading in the watershed.

An existing dike along the north side of the Big Quilcene River extends downstream from Rodgers Street to the area downstream of Linger Longer Road and upstream of the BPA power line corridor. A segment of the north dike downstream of the BPA corridor was removed in 1995, and some frequently flooded houses behind the remaining dike further upstream have been voluntarily sold to Jefferson County and removed. The remaining houses and properties on the north side of the dike are still subject to flooding, mostly of roads and yards. In addition, flooding closes the bend on Linger Longer Road north of the bridge nearly every year.

An existing dike along the south side of the Big Quilcene River is higher and longer than the north dike. It protects 40 to 45 single-family residences and other structures on the south side of the river, which are accessed via the Linger Longer Road bridge. Flooding of the Linger Longer Road bend isolates these residences on the south side of the river. The existing south dike system upstream of Rodgers Street is not maintained and overtops at approximately a 25-year event. The dike does not overtop downstream, but due to the height of the river above the lowland, even during small floods the south floodplain has been inundated by seepage through the dike. Flooding of properties south of the dike results in septic system failure and pollution.

Historic T-sheet maps from 1883 (Figures 3-2A and 3-2B) show the Little Quilcene River delta and estuary merging with the mudflat and marsh estuary habitats of the Big Quilcene River on the south and with Donovan Creek on the northeast. Similar changes have occurred along the Little Quilcene River as along the Big Quilcene River in terms of diking for agriculture, and aggrading and prograding of the river delta due to upstream logging practices. The proponents have completed a significant restoration project in the delta of the Little Quilcene River involving dike removal, delta cone removal, and channel and marsh restoration, similar to those actions proposed for the Big Quilcene River (Brocksmith 2010). However, a large diked area remains on the south bank of the Little Quilcene River within its delta. This remaining dike limits connectivity and channel morphology between the Big and Little Quilcene River Estuaries.

3.2.2 Human Environment

The major structures present in the action area include dikes and bank armoring on the north and south sides of the Big Quilcene River downstream from Rodgers Street. The dikes are armored with rock in most locations. The south dike is much longer than the north dike. The north dike extends from just upstream of Rodgers Street to a point approximately 350 feet downstream of Linger Longer Road. The south dike upstream of Rodgers Street includes two cross dikes that connect the south dike along the river channel to the hillside south of the river. The south dike extends from upstream of Rodgers Street to a point approximately 0.5 mile downstream of Linger Longer Road. The dikes upstream of Rodgers Street on the south side of the river consist of marginal berms that are not maintained.

The existing infrastructure in the action area includes a network of rural residential and collector roadways. A bridge that crossed the Big Quilcene River on Rodgers Street has been removed, with portions of the abandoned abutment and revetment remaining in place. The sole remaining crossing in the area is a bridge on Linger Longer Road, approximately 1,000 feet downstream of Rodgers Street. Linger Longer Road bridge is an 81-foot, single-span, concrete girder bridge.

On the Little Quilcene River, the remaining dike is located on the south side of the river. The existing dike is approximately 2,800 feet long. It extends along the south side of the river to within 1,000 feet of the mudflat and then curls back to the south and west to protect farmland west of the downstream end of the dike. East Quilcene Road partially separates the Little Quilcene River and Donovan Creek Estuaries.

Agriculture on diked lands and aquaculture in intertidal areas are major land uses within the action area, in addition to residential development. Public and private tidelands are managed for clam, oyster, and mussel aquaculture. These aquaculture activities include commercial and Tribal (commercial, ceremonial, and subsistence) shellfish growing and harvest. WDFW manages lands in the action area that provide Tribal and recreational shellfish harvest, among other public uses (WDFW 2010a).

According to readily available information, property owners in the Big Quilcene River project area include Jefferson County, WDFW, and multiple private owners of small parcels. The County-owned land is located in a relatively continuous 300- to 700-foot-wide corridor along the north side of the Big Quilcene River from Rodgers Street to WDFW lands at the mouth of the river and at the BPA power line corridor. WDFW's lands include a larger group of parcels on both sides of the river mouth and a smaller parcel at the BPA power line corridor. The south side of the Big Quilcene River consists mostly of private parcels of varying sizes, except at the river mouth mentioned above. These private lands are affected by river processes including flooding, and would need to be acquired with the full restoration alternative. Conservation groups and the County have ongoing efforts to acquire strategically important lands, only where necessary.

Coast Seafoods owns a large shellfish bed and processing facility on the south side of the Big Quilcene River delta (WDFW 2010b). This facility is the largest private employer in Jefferson County (Brocksmith 2010). Changes from either alternative are not intended to displace this facility.

The remaining dike on the south bank of the Little Quilcene River is privately owned. Utilities in the action area include overhead electrical distribution lines located along Linger Longer Road. There appear to be no utilities attached to the Linger Longer Road bridge.

A BPA transmission corridor is located approximately 800 feet west of Linger Longer Road. The BPA corridor traverses the delta from north to south with a series of steel towers, H-frame timber supports, and high-voltage power lines. It is assumed that residential areas north and south of the Big Quilcene River within the action area are served by overhead electrical and communication lines along local roads. More detailed information on existing utilities and the need for utility relocations will be required to support subsequent design phases.

3.3 Restoration Design Concept

3.3.1 Restoration Overview and Key Design Assumptions

The proposed restoration would restore estuarine hydrology, sediment transport, and other hydraulic and geomorphic processes by removing and replacing dikes, armoring, and roadways within the action area. Restoration will benefit juvenile chum salmon and non-natal juvenile Chinook salmon. Restoration will improve the survival of juvenile salmon by improving access to nursery habitat in the estuary and wetland, and allowing for improved acclimatization to the salinity of Hood Canal. Chum smolts are currently flushed out of the mainstem into deep water where they are subjected to a higher rate of predation, as opposed to migrating through multiple tidal sloughs where they can rest and feed during acclimatization. Removing the singular and channelized access to the estuary will also reduce predation rates on returning adult salmon by predators such as seals.

The goal of the full restoration alternative is full stressor removal. The partial restoration alternative resembles the proponent's proposed action and was developed to more fully address land ownership patterns and landowner constraints. The alternatives are described in more detail below and shown in Figures 3-3 through 3-7.

Full Restoration Alternative

The full restoration alternative (Figure 3-3) consists of the following elements:

- Removal of the remaining dikes on the Big Quilcene River delta and estuary.
- Rerouting of the portion of Linger Longer Road north of the Big Quilcene River to the alignment of Rodgers Street.
- Removal of the existing 81-foot concrete girder bridge over the Big Quilcene River at Linger Longer Road.
- Construction of an elevated bridge section across the floodplain and across the Big Quilcene River at Rodgers Street.
- Construction of a setback dike (levee) on the north floodplain of the Big Quilcene River to protect homes in that area.
- Removal of homes and infrastructure in the floodplain that would be exposed to flooding following removal of dikes.
- Reconnection of the road to Linger Longer Road south of the Big Quilcene River.
- Reconnection of distributary channels on the north and south sides of the Big Quilcene River downstream of the BPA transmission line corridor.
- Excavation of the delta cone that has developed as a result of past diking and armoring practices to restore natural topography, as well as hydraulic and morphological processes in the river delta.

A setback dike would be constructed on the left floodplain north of the river to prevent flooding of homes in that area, unless additional properties that would be at risk can be acquired and infrastructure removed. In addition, as a potential future phase of the full restoration, the dike along the south side of the Little Quilcene River could be removed to restore connectivity between the Big and Little Quilcene River deltas and estuary as a whole. The full restoration alternative would require extensive property acquisition, road relocation, and removal of existing infrastructure within the Big Quilcene River floodplain.

Partial Restoration Alternative

The partial restoration alternative (Figure 3-4) is more consistent with the project proponent's original description of the project, and requires less purchase and relocation of private residences and other properties. The partial restoration alternative includes:

- Construction of 2,250 feet of new setback dike on the north bank of the Big Quilcene River.
- Removal of 1,350 feet of existing riverine dike on the north bank of the Big Quilcene River, from Rodgers Street to downstream of Linger Longer Road.
- Removal of the easternmost 2,200 feet of riverine dike on the south bank of the Big Quilcene River downstream of Linger Longer Road.
- Removal of 500 LF of Rodgers Street roadway and road embankment.

- Removal of the existing 81-foot-long concrete girder bridge over the Big Quilcene River at Linger Longer Road.
- Construction of a 1,335 LF elevated bridge across the north floodplain and Big Quilcene River channel at Linger Longer Road.
- Excavation of a pilot channel at the preferred avulsion site to reduce splaying.
- Reinforcement and raising of the remaining south bank dike and cross dikes at key locations.

Summary of Key Design Elements

Table 3-1 highlights key design elements associated with the full and partial restoration alternatives.

Table 3-1. Key Design Elements

Element	Full Restoration	Partial Restoration
Dike – South Side of Little Quilcene River Channel	As an optional future phase of the project, remove dike completely	Not included
Dike – North Side of Big Quilcene River Channel	Remove dike completely, install 2,250 feet of setback dike unless property at risk from additional flooding is acquired	Same as full restoration
Dike – South Side Of Channel	Remove dike completely	Remove 2,200 feet of dike downstream of Linger Longer Road. Reinforce remaining dike at key locations
Delta Cone	Excavate delta cone	Not included
Distributary Channels	Reconnect channels downstream of the BPA transmission line corridor	Excavate pilot channel at preferred avulsion site
Linger Longer Road Bridge	Remove existing bridge completely	Remove existing bridge completely, install a 1,355-foot elevated bridge and approaches across north floodplain and Big Quilcene River channel
Linger Longer Road Roadway	Remove existing roadway north and south of bridge	Remove existing roadway north of bridge
Rodgers Street Bridge	Install new 975-foot bridge spanning river at Rodgers Street	Not included
Rodgers Street Roadway	Replace 350 LF of roadway to transition to proposed bridge, install roadway connection south to Linger Longer Road	Remove approximately 500 LF of roadway north of Big Quilcene River
Other Roads	Remove existing residential roadways in floodplain on both sides of river where structures are removed	Remove existing residential roadways in floodplain on north side of river where structures are removed
Utilities	Remove existing utilities in roadways to be removed	Remove utilities in roadways to be removed

Element	Full Restoration	Partial Restoration
Property Acquisition	Acquire and vacate impacted private properties, including properties in Big Quilcene River floodplain north and south of river	Acquire and vacate impacted private properties in floodplain north of Big Quilcene River

3.3.2 Restoration Features – Primary Process-Based Management Measures

Armor Removal/Modification

The existing dikes on the north and south sides of the Big Quilcene River and on the south side of the Little Quilcene River are armored with riprap along most of their lengths to protect the dikes against erosion. Armor removal described in this section would occur where berms or dikes are removed. The full restoration alternative would include removal of all armoring associated with the dikes on both sides of the Big Quilcene River (approximately 6,450 LF of armoring). As a potential future phase, approximately 2,800 LF of armoring could also be removed from the dike along the south side of the Little Quilcene River. The partial restoration alternative would include removal of approximately 1,350 LF of armoring along the dike on the north side of the Big Quilcene River, and approximately 2,200 LF of armoring along the dike on the south side of the Big Quilcene River.

Berm or Dike Removal/Modification

The primary stressors within the action area include existing dikes on the north and south sides of the Big Quilcene River and on the south side of the Little Quilcene River. The dikes were constructed to protect private property from flooding. However, the existing dikes have channelized the rivers, blocking connections to other channels and causing the Big Quilcene River to aggrade downstream of Linger Longer Road. The dikes generally isolate the Big Quilcene River channel from the floodplain. However, floodwaters overtop the north bank upstream of Rodgers Street and inundate the floodplain north of the existing dike on the Big Quilcene River during floods exceeding the 1.5-year storm event. Floodwaters also overtop the dike on the south side of the Big Quilcene River upstream of Rodgers Street during a 25-year storm event.

The full restoration alternative would include removal of all remaining dikes on both sides of the Big Quilcene River. Approximately 1,350 LF of dike would be removed along the north side of the Big Quilcene River, and approximately 5,100 LF of dike would be removed along the south side of the Big Quilcene River. As a potential future phase of full restoration, approximately 2,800 LF of dike could be removed along the south side of the Little Quilcene River. The partial restoration alternative would include removal of approximately 1,350 LF of dike along the north side of the Big Quilcene River, and approximately 2,200 LF of dike along the south side of the Big Quilcene River.

Channel Rehabilitation/Creation

The existing Big Quilcene River channel has been isolated from distributary channels and blind channels in its floodplain and delta by the existing dikes along the north and south sides of the river. The channel downstream of Rodgers Street is also more narrow and constrained compared to the portion of the river channel that flows freely through the floodplain upstream of Rodgers Street.

The full restoration alternative proposes to remove stressors constraining the main river channel, reconnect distributary channels by excavating 1,600 LF of pilot channels downstream of the BPA transmission line corridor on both the north and south sides of the Big Quilcene River with the main river channel, and excavate the delta cone formed by aggradation of the channel downstream of Linger Longer Road. As was noted previously, channelization of the river downstream of Rodgers Street has increased aggradation of the river channel. As a result, the existing river downstream of Linger Longer Road is higher than the adjacent floodplain. Removal of the dikes constraining the north and south sides is likely to result in eventual avulsion of the river. Overall, the full restoration actions would allow the river to migrate through the floodplain and flow freely through distributary channels to Quilcene Bay. Additional engineering analysis is needed in subsequent design phases to determine pilot channel geometry.

The partial restoration alternative proposes a partial removal of stressors that constrain the main river channel and excavation of a pilot channel at a preferred avulsion site downstream of Rodgers Street. Due to aggradation and the resulting elevation of the river channel relative to the adjacent floodplain, removal of the dike along the north side of the river will likely result in eventual avulsion of the river downstream of Rodgers Street. Excavation of a 1,100 LF pilot channel downstream of Rodgers Street will encourage the avulsion to occur at a preferred location and prevent splaying. Overall, the partial restoration actions would allow for the river to flow freely across the north floodplain of the Big Quilcene River through old channels in the floodplain that are currently isolated from the main channel except during floods. Additional engineering analysis is needed in subsequent design phases to determine pilot channel geometry.

Groin Removal/Modification - NA

Hydraulic Modification - NA

Overwater Structure Removal - NA

Topography Restoration - NA

3.3.3 Restoration Features – Additional Management Measures

Beach Nourishment - NA

Contaminant Removal/Remediation - NA

Debris Removal - NA

Invasive Species Control - NA

Large Wood Placement - NA

Physical Exclusion - NA

Pollution Control - NA

Revegetation

Revegetation would be limited to areas of bare ground above tidal influence, but within the floodplain where primarily riparian woody species would colonize. The revegetation proposed is intended to minimize colonization by invasive species in these riparian floodplain areas. Because the restoration areas are relatively large and natural native seed sources are abundant for recolonization, subsequent design phases should assess areas where risks of erosion or invasive species necessitate revegetation. For the 10% design, it is assumed that revegetation of tidal marsh areas is not necessary and will occur by recolonization.

The full restoration alternative would necessitate grading and some revegetation in certain areas to prevent floodplain erosion and restore floodplain habitat. Areas of bare ground that require revegetation in this alternative include setback dike and road embankments, and areas where roads and buildings are removed. These areas would need to be vegetated with native species to protect them from erosion and inhibit establishment of invasive species. A combination of hydroseeding and limited live staking and bare root plantings would be used. Live stakes and bare root plantings of riparian species toward the lower end of these embankments (where hydrology supports riparian species such as Sitka spruce, willows, red alder, black hawthorne, and other species) is anticipated. These plantings will also diversify habitat for fish and wildlife and speed up the restoration trajectory. A total of 8.7 acres of hydroseeding and an equal area of planting are proposed for full restoration.

The partial restoration alternative would also require grading and limited revegetation as described for full restoration, but covering a smaller area of 2.5 acres.

Reintroduction of Native Animals - NA

Substrate Modification - NA

Species Habitat Enhancement - NA

3.3.4 Restoration Features – Other

Additional restoration features of the full restoration alternative are construction of a setback dike to protect private property in the town of Quilcene, installation of an elevated bridge and approaches at Rodgers Street to span the river channel and floodplain, and construction of a roadway connecting the new bridge at Rodgers Street with Linger Longer Road south of the floodplain (Figures 3-3 and 3-5). Approximately 2,250 LF of setback dike would be constructed, extending both north and west from the southerly curve in Freemont Avenue. The proposed bridge would extend from the setback levee south approximately 975 feet to the south side of the floodplain. The bridge deck would be 28 feet wide, with a top elevation of approximately 38.0 feet NAVD 88 (40.6 feet MLLW). Bridge approaches would replace existing roadways at both ends of the bridge to provide a transition in elevation between the existing roadway and the bridge deck. A 1,420-foot-long roadway would be constructed from the south end of the bridge along the foot of the hill south of the river, to an intersection with Linger Longer Road approximately 1,500 feet south of the existing Big Quilcene River bridge.

The partial restoration alternative would include replacement of the existing Linger Longer Road bridge and roadway north of the bridge with an elevated bridge and new bridge approaches (Figures 3-4 and 3-6). The new bridge would be 28 feet wide and 1,355 feet long. A new 220-foot roadway approach would be constructed at the north end of the bridge. A new 230-foot roadway approach would be constructed at the south end of the bridge.

Jefferson County residents on the south side of the Big Quilcene River and employees of Coast Seafoods need access to the south side of the river through Linger Longer Road. Both the full and partial restoration alternatives will provide continued access to the south side of the Big Quilcene River. The full restoration alternative would provide permanent access via the new bridge at Rodgers Street and roadway connection to the south end of Linger Longer Road. The partial restoration alternative would provide permanent access via a new bridge at Linger Longer Road.

3.3.5 Land Requirements

Both the full and partial restoration alternatives would require acquisition of private properties. For the full restoration alternative, dikes protecting private properties on both the north and south sides of the Big Quilcene River would be removed. Approximately 16 small privately held parcels on the north side of the river would be impacted. The rest of the property that would be impacted on the north side of the river has already been acquired by Jefferson County or is owned by WDFW. Approximately 54 parcels on the south side of the river within the floodplain would be exposed to flooding by removal of the dike along the south side of the Big Quilcene River. These privately held parcels would also need to be acquired and vacated.

As an option to acquiring all of the properties within the floodplain, the proponent may wish to explore the possibility of entering into voluntary agreements with property owners upstream of Linger Longer Road to accept the risks of occasional flooding on their properties. However, this analysis assumes that a total of 70 parcels, comprising 59 acres of privately held property, would need to be acquired if the full restoration alternative were to be implemented (Figure 3-3). Additional right-of-way would also be needed for the roadway connecting Rodgers Street to the south end of Linger Longer Road. The right-of-way would generally be within the area of privately held parcels that would be acquired for the full restoration alternative.

For the partial restoration alternative, approximately 10 parcels on the north side of the river would be impacted and would need to be acquired. Other properties that would be impacted on the north side of the river are owned by Jefferson County and WDFW. Most of the private properties on the south side of the river would continue to be protected by the remaining portion of the south dike. However, approximately 16 parcels would be impacted by removal of the downstream end of the dike on the south side of the river. The proponent and Jefferson County are engaged in ongoing efforts to acquire the properties that would be impacted. Several properties on the south side of the river are already under public ownership.

A total of 26 parcels, comprising 23.5 acres of privately held property, would need to be acquired if the partial restoration alternative is implemented (Figure 3-4). Property acquisition requirements will need to be verified during subsequent design phases so that consultations with affected landowners can occur.

3.3.6 Design Considerations

Right-of-Way and Property Impacts

A primary design consideration for the full restoration alternative includes the impact to private lands on the south side of the Big Quilcene River. Dike removal and restoration of the floodplain under the full restoration alternative would require the acquisition of currently floodprone properties that would be subject to increased flooding as a result of the action. Right-of-way would also need to be secured for the roadway connection from Rodgers Street to the south end of Linger Longer Road. The design would also need to consider impacts to private property and access issues created by constructing an elevated bridge approach on Rodgers Street south of Quilcene Avenue.

The partial restoration alternative was developed with primary consideration for impacts to private property. Dike removal and restoration of the floodplain on the north and south sides of the Big Quilcene River will impact a relatively small number of private properties. Additional right-of-way would need to be secured for construction of the proposed bridge at Linger Longer Road along an alignment that is adjacent to the existing roadway and bridge. The right-of-way would mostly be through properties that would otherwise need to be acquired due to impacts that will result from removal of the north dike along the Big Quilcene River. The design of the bridge approaches would also need to consider impacts to private property, and access issues created by constructing elevated bridge approaches adjacent to private property.

Traffic and Access to the South Side of the Big Quilcene River

The main route for traffic from the town of Quilcene to residences on the south side of the Big Quilcene River is via Linger Longer Road. This road also serves businesses and a Port-operated marina. This road has a functional classification of rural local access and is owned and maintained by Jefferson County. The standard roadway section includes two 11-foot travel lanes and 3-foot shoulders for a total width of 28 feet. The design speed for this roadway classification is 40 mph. The road also provides access to shellfish beds and WDFW lands south of the river channel. Jefferson County has indicated that restoration needs to include continued access to the south side of the Big Quilcene River.

Under the full restoration alternative, access would be established via a new elevated bridge on Rodgers Street. Rodgers Street formerly had a bridge crossing along this alignment. As part of the full restoration alternative, the Rodgers Street roadway would be improved and the crossing reestablished, with the roadway profile raised to a bridge deck elevation of 38.0 feet NAVD 88 (40.6 feet MLLW). This would provide 3 feet of clearance from the low chord of the structure to the design water surface elevation. Rodgers Street would be closed during bridge construction. The proposed bridge would be approximately 975 feet long, with nine 108-foot spans of 5-foot-2-inch-deep pre-cast concrete girders. The bridge substructure would consist of columns supported on drilled shafts (Figure 3-7). The assumed embedment depth of the drilled shafts is 100 feet.

Analysis of traffic flows and patterns has not been completed. Additional analysis is needed to ensure that permanently shifting the main flow of southbound traffic from Linger Longer Road to Rodgers Street would meet Jefferson County's traffic engineering requirements. The full restoration alternative would require construction of a connecting roadway from the bridge at Rodgers Street to the south end of Linger Longer Road. The alignment would follow along the edge of the hillside at the south and west edges of the historic floodplain/meander zone limits. Intersection improvements would be needed at two intermediate intersections, as well as at the point of connection to Linger Longer Road.

Under the partial restoration alternative, the existing bridge at Linger Longer Road and the roadway north of Linger Longer Road would be replaced with a bridge to span the north floodplain and the river channel. The bridge would have a deck elevation of 30.9 feet NAVD 88 (33.5 feet MLLW) to provide 3 feet of clearance from the low chord of the structure to the design water surface elevation. The proposed bridge would be approximately 1,355 feet long, with twelve 114-foot spans of 5-foot-2-inch-deep pre-cast concrete girders. The bridge substructure would consist of columns supported on drilled shafts (Figure 3-7). The proposed bridge and roadway improvements would be constructed adjacent to the existing Linger Longer Road in order to maintain access to the south side of the river along the existing Linger Longer Road during construction.

Tides and Flooding

The design of improvements in the Big Quilcene River delta and floodplain needs to accommodate fluctuating tide levels and flooding. The Big Quilcene Linger Longer Reach Study (Perkins Geosciences et al. 2005) concluded that the tidal influence on water surface elevations in the Big Quilcene River only impacts the main river channel from Quilcene Bay to a point that is more than 1,000 feet downstream of Linger Longer Road. That analysis concluded that tides would have no influence on the water surface elevations at Linger Longer Road or Rodgers Street. Consequently, the primary consideration for the design of new bridges at Linger Longer Road and Rodgers Street is the 100-year floodwater surface elevation.

The Big Quilcene Linger Longer Reach Study evaluated water surface elevations for existing flood conditions and for conditions proposed under a range of potential improvement alternatives, none of which exactly reflect the full and partial restoration alternatives described for this study. For instance, the delta cone removal in full restoration was not included in this study. Therefore, additional hydraulic analysis is needed to determine the water surface elevations that would occur under the conditions that are proposed for the full and partial restoration alternatives, if either of these alternatives are taken to a more refined level of design. This analysis would occur during subsequent design phases.

For the full restoration alternative, the new bridge would be constructed at Rodgers Street. The hydraulic analysis completed for the Big Quilcene Linger Longer Reach Study (Perkins Geosciences et al. 2005) indicates that the 100-year floodwater surface elevation at a section just upstream of Rodgers Street under existing conditions is approximately 29.8 feet NAVD 88 (32.4 feet MLLW). The water surface profile drops quickly through this reach of the river channel. Less than 200 feet downstream of Rodgers Street, the 100-year floodwater surface elevation would be 2 feet lower.

It is assumed that the water surface elevations would drop under the conditions proposed for full restoration because dikes, the delta cone, and other constrictions in the river channel downstream of Rodgers Street would be removed. As a conservative starting point for 10% design of the bridge at Rodgers Street, a water surface of 29.8 feet NAVD 88 (32.4 feet MLLW) was assumed, and a 3-foot allowance was provided for debris clearance. Design of the setback dike as part of the full restoration alternative would also need to consider 100-year flood elevations and provide the same level of flood protection for remaining private properties as the existing dike. The size and extent of the setback dike required would be refined through further hydraulic analysis as part of subsequent phases of design.

For the partial restoration alternative, a new elevated bridge would be constructed adjacent to the existing Linger Longer Road and bridge to span the floodplain north of the existing river and the existing river channel. The analysis presented in the Big Quilcene Linger Longer Reach Study (Perkins Geosciences et al. 2005) indicates that the existing 100-year flood elevation at Linger Longer Road is approximately 22.7 feet NAVD88 (25.3 feet MLLW).

It is also likely that the water surface elevations would drop under the conditions proposed for partial restoration because the roadway embankment, dikes, delta cone, and other constrictions in the river channel would be removed. As a conservative starting point for 10% design of the bridge at Linger Longer Road, a water surface of 22.7 feet NAVD88 (25.3 feet MLLW) was assumed and a 3-foot allowance was provided for debris clearance. Design of the setback dike and reinforcement of the existing dike on the south side of the Big Quilcene River as part of the partial restoration alternative would also need to consider 100-year flood elevations and provide the same level of flood protection for remaining private properties as the existing dike. The size and extent of the setback dike required would be refined through further hydraulic analysis as part of subsequent phases of design.

Environmental Resources

Construction of a new bridge and roadway, as outlined for the full restoration alternative, would likely require extensive clearing and earthwork that could have a negative impact on local environmental resources. The design of the project would need to consider and include measures to minimize or prevent negative impacts. In addition, the full restoration alternative would include removal of existing infrastructure, structures, and other items that could potentially contain hazardous materials. Consideration would need to be given during detailed design to the type of items to be removed and their disposal or potential for reuse.

WDFW shellfish managers have raised concerns about restoration of the Quilcene River Estuary and its potential impact on shellfish resources in the action area, including potential impacts to Tribal and recreational shellfish use and resources (WDFW 2010b). These shellfish managers have also identified a primary design consideration on their lands. The design consideration pertains to any action that allows a southward migration of the Big Quilcene River at the mouth where WDFW lands are located. Their concerns include reductions in shellfish productivity from a number of processes associated with the restoration measures. WDFW shellfish managers have also raised concerns about any potential negative effects on the Olympia oyster restoration efforts in the lower intertidal zone in Quilcene Bay (WDFW 2010a).

As noted previously, an avulsion of the Big Quilcene River took place in 1992 when the river eroded through an unarmored dike on the south side of the river below the power line corridor. The river took a southeast course before heavy equipment was used to restore the river to its former course and stabilize the dike with riprap revetment. It is anticipated that avulsions will occur in the future, especially if dikes are removed as part of full or partial restoration. Additional analysis would need to be completed during subsequent design phases to assess the long-term impacts of dike removal, river migration, changing sediment conditions, and the potential reversal of delta progradation on shellfish productivity.

3.3.7 Construction Considerations

Equipment

Construction of either alternative would likely require heavy equipment, such as tracked excavators and front end loaders, for dike excavation and placement of fill for setback dikes; dump trucks for hauling excess material; and road graders and compactors for construction of roadway improvements.

For both the full and partial restoration alternatives, a drilled-shaft oscillator would be used to install the drilled shafts for bridge construction. It is assumed that the contractor would be able to install one shaft per week. Large-diameter casing shoring would be required to keep out water and allow access to the top of the shaft for column form placement and removal. Once the shafts are installed, the columns would be cast inside the shoring casing. After the casing is removed, the cast-in-place pilecaps and bridge superstructure would be constructed.

Use of equipment on soft soils in marsh areas and mudflats would be minimized by working from the existing roadway embankment or other local road surfaces or dike tops. Where this is not possible, low-ground-pressure tracked vehicles and/or wood lagging mats or other measures would be used as required by permits.

Haul and Disposal

Both alternatives would require excavation, haul, and disposal of material from the existing dikes and armoring. Both alternatives would also include the stockpile and placement of fill for dikes and roadways. The full restoration alternative would include extensive demolition and removal of an existing bridge, roadways, utilities, structures, and other items within the existing floodplain. Consideration should be give to reuse of materials and handling of hazardous materials. The partial restoration alternative would include more limited demolition and removal. It is anticipated that some of the earth materials generated from dike removal would be reused or wasted within the action area. Construction of either alternative would require identification of stockpile and disposal locations and haul routes. For 10% design, it is assumed that all demolition materials and excess excavated materials will be disposed of offsite within 20 miles.

Timing and Duration

The construction of restoration improvements would require coordination with permitting agencies, including Jefferson County. The County will need to provide input on timing of road closures and overwater construction. For the full restoration alternative, construction of the bridge is estimated to last 12 to 14 months. For the partial restoration alternative, the estimated construction duration for the bridge is 18 months.

Access and Traffic Control

Construction access to most of the site would be available via local roads from Highway 101. Both alternatives would affect the flow of traffic along Rodgers Street and Linger Longer Road. Consideration should be given to traffic control and scheduling of roadway closures to minimize the impact on local residents and businesses.

In addition, several private properties are accessed via Linger Longer Road and Rodgers Street. The full restoration alternative would require acquisition of most of these properties because they will be impacted by dike removal and modifications to the floodplain. Under the full restoration alternative, access for the proposed Rodgers Street bridge construction would be provided via Rodgers Street and land just adjacent to the roadway. For the partial restoration alternative, access for construction of the proposed bridge at Linger Longer Road would be provided via Linger Longer Road and land just adjacent to the road. Under either alternative, maintenance and restoration of access to private properties that are to remain would need to be addressed.

Staging

There should be adequate room for staging equipment and materials on property within the action area currently held by Jefferson County. The proponent would need to identify staging and stockpile areas and work out an agreement for use of the site with Jefferson County prior to construction.

Diversion and Care of Water

Restoration work would require implementation of best management practices, such as silt fences, floating sediment curtains in tidal areas, cofferdams, pumping, and temporary conveyance, to prevent pollution of Quilcene Bay and the Big Quilcene and Little Quilcene Rivers. It is anticipated that most of the upland work would be completed using typical dewatering techniques.

Utilities

Known utilities include overhead power and telecommunications lines along Linger Longer Road. It is assumed that overhead power and telecommunications also extend to residences along Freemont Avenue, Quilcene Avenue, Rodgers Street, and south of the Big Quilcene River. No information has been available regarding water and sewer utilities in the area. A map produced by Jefferson County indicates that a public water system exists in the town of Quilcene, but that the service area does not extend across the

Big Quilcene River. For 10% design, it was assumed that the properties south of the Big Quilcene River are served by private wells and septic systems.

Full restoration would require removal or abandonment of existing underground utilities, wells, and septic systems on properties affected within the floodplain. There are no known utilities attached to the existing bridge crossing at Linger Longer Road, and therefore no utilities are proposed for the new crossing at Rodgers Street as part of the full restoration alternative. Coordination with the local utility providers during design will identify any improvements they may be interested in making in conjunction with this project.

For the partial restoration alternative, utilities would be located and replaced, as needed, for modifications to Linger Longer Road and construction of the proposed bridge.

3.4 Extent of Stressor Removal

Table 3-2 identifies the amount of stressor removal with the full and partial restoration alternatives. The potential benefit area on the Big Quilcene River is the entire 0.75-mile-wide delta from Rodgers Street downstream. The benefit area on the Little Quilcene River would be the lower 2,000 feet of river south of where previous restoration was accomplished.

Table 3-2. Stressor Removal

Stressor	Full Restoration	Partial Restoration
Fill - Dikes (LF)	6,450	3,550
Armor - Dikes (LF)	6,450	3,550
Nearshore Roads (LF)	6,930	500
Impervious Surfaces (SF)	168,375	70,000

3.5 Expected Evolution of the Action Area

Full stressor removal within the floodplain downstream of Rodgers Street would improve the floodplain and estuary at the mouth of the Big Quilcene River. Removal of dikes and roadways, and excavation of the delta cone, would allow the Big Quilcene River to move through the floodplain. Avulsion of the existing channel would likely occur in the near term near Linger Longer Road, with gravel and sediment plugging the existing channel at the avulsion site.

With the removal of the remaining dikes, and migration of the Big and Little Quilcene Rivers across their deltas, progradation is anticipated to significantly diminish or completely cease. This change is anticipated as a result of dike removal and channel avulsion allowing coarse sediments to drop out of the system at the upper edge of the deltas, with only finer sediments depositing across the lower delta. A similar though more muted process has begun on the Little Quilcene River delta following removal of the north dike. Historic distributary channels in the Big Quilcene River delta that are currently disconnected from the main channel would be reconnected as floodwaters erode and overtop the banks of the existing channel.

As flow returns to different channels in the estuary, tidal channels and sloughs would develop where smolts can acclimate. Removal of the channelized entrance would also create improved conditions for migrating adult salmonids by restoring multiple entrances to the system, providing improved refuge from predators. Removal of the south levee would allow for the river to move freely across the south part of its floodplain and reconnect with distributary channels from the Big Quilcene River delta.

Partial restoration would not include full stressor removal, so the changes in the estuary would not be as dramatic. The expected changes would include avulsion of river channel upstream of Linger Longer Road, and migration of at least a portion of the flow in the existing river channel to an avulsion channel in the floodplain on the north side of the river. The avulsion channel would convey water under the proposed bridge at Linger Longer Road and through a broad, relatively low-lying basin toward Quilcene Bay. The avulsion channel would be shorter than the existing channel. A more complex channel is anticipated to form along this avulsion route. Over the years of flooding and other geomorphic changes, the flow could potentially change back and forth between the avulsion channel and the existing river channel. Partial restoration would also eventually create more favorable habitat by restoring flow to distributary channels on the north and south sides of the existing river channel, and shifting flow away from the single channelized river delta.

3.6 Uncertainties and Risks

The following uncertainties and risks have been identified during 10% design:

- Geomorphic Conditions – Limited analysis has been done to evaluate the potential changes to sediment transport and shoreform dynamics that would result from the restoration actions. Because the natural sediment transport and geomorphic processes in the action area have been modified for such a long time, it is difficult to predict what changes would follow stressor removal. Additional geomorphic analysis would be needed as part of more detailed design to more confidently predict potential changes to sediment transport and shoreform dynamics. Additional analysis would also be needed to more precisely determine quantities for delta cone material removal and channel excavation in subsequent design phases.

- Geotechnical Conditions – No field investigations have been completed to characterize the subsurface soil conditions in the action area. Subsurface soil conditions could potentially have a significant impact on the feasibility and costs related to bridge construction for both the full and partial restoration alternatives.

- Impact to Shellfish Beds – The proponent has indicated that WDFW requires continued access to shellfish beds south of the existing river channel and wants to ensure that changes do not negatively impact aquaculture operations. Potential impacts to shellfish aquaculture operations are not well understood. The impacts may be more significant for the full restoration alternative because the floodplain and delta south of the river could be impacted to a much greater extent. Alternatively, full restoration could eventually decrease the larger effects of complete loss of shellfish growing areas by reversing progradation of uplands into the bay.

- Property Issues – Both the full and partial restoration alternatives would impact private properties. The extent of the full restoration alternative on private properties within the floodplain on both sides of the river would be significant. The feasibility of the full restoration alternative would depend on the proponent's ability to negotiate several challenging property acquisitions. Property issues would likely be much easier to resolve for the partial restoration alternative.

- Environmental Hazards – The full restoration alternative would involve extensive demolition and restoration activities. The type, construction, and hazard risk of the materials to be removed, abandoned, or disposed of as part of the full restoration alternative is not well understood.

3.6.1 Risks Associated with Projected Sea Level Change

The risk of sea level change for either restoration alternative is small. The estuary system has demonstrated high sediment load and rapidly aggrading marsh plain conditions as compared to historic conditions. In addition, the recent study completed for the proponent (Perkins Geosciences et al. 2005) indicated that under existing conditions, the tidal influence on river hydraulics only extends up the river to a section that is more than 1,000 feet downstream of Linger Longer Road. A 46-centimeter (1.5-foot) rise in sea level, which is the "high" condition projected by the U.S. Army Corps of Engineers (USACE 2010), could extend tidal conditions further upstream, but the impact would not likely extend as far up as Linger Longer Road.

Also, removal of dikes and other obstructions will likely reduce floodwater surface elevations and further reduce the impact of tides on flood hydraulics in the main river channel. Bridge, dike, and roadway improvements proposed as part of the full and partial restoration alternatives from Linger Longer Road upstream would accommodate flooding but not account for changes in sea level. Table 3-3 qualitatively compares the risks of projected sea level change.

Table 3-3. Risks of Sea Level Change

	Projected Sea Level Change		
	High (46 cm)	**Intermediate (4 cm)**	**Low (-8 cm)**
Full Restoration	Low infrastructure risk to roads and utilities. Low risk of sediment supply not keeping pace with sea level change. Low risk of increased tidal prism causing channel scour particularly at bridges.	None to low	None
Partial Restoration	Low infrastructure risk to roads and utilities. Low risk of sediment supply not keeping pace with sea level change. Low risk of increased tidal prism causing channel scour particularly at bridges.	None to low	None

3.7 Potential Monitoring Opportunities

Monitoring is important for evaluating restoration results. A combination of field surveys and aerial photographs would be used to document biological and physical changes to the river and mudflat/marsh systems. Monitoring data can be used to refine adaptive management and corrective actions, as needed. Some of the major monitoring needs and opportunities associated with this action are summarized in Table 3-4.

Table 3-4. Monitoring Needs and Opportunities

Monitoring Parameter	Key Performance Indicator	Note
Topographic Stability	X	Assess effects of restoration on channel dynamics / movement
Sediment Accretion / Erosion	X	Check for changes in progradation rates
Wood Accumulation		
Soil / Substrate Conditions		
Vegetation Establishment	X	
Marsh Surface Evolution / Accretion	X	
Tidal Channel Cross-Section / Density	X	Document distributary channel reconnection and tidal channel development
Water Quality (contaminants)		
Salinity	X	Monitor salinity and temperature in the estuary
Shellfish Production	X	Monitor effects of restoration on adjacent shellfish operations
Extent of Invasive Species	X	Use information to gauge need for additional planting
Animal Species Richness		
Fish (salmonid) Access/Use	X	Document increased access and rearing habitat
Forage Fish Production		
Wildlife Species Use		
Effectiveness of Exclusion Devices		

3.8 Information Needed for Subsequent Design

This 10% design report represents an initial step in the restoration design sequence. The design concepts described above were developed based on readily available information without the level of site-specific survey and investigation that is necessary to support subsequent design and implementation. Substantial additional information will be required at the preliminary and later design stages to confirm the design assumptions, refine quantity estimates, address property and regulatory issues, obtain stakeholder support, and fill in data gaps. The extent to which this information is collected for preliminary design (or a later design stage) will depend upon the available budget, schedule and other factors. This section attempts to define the most essential information needs for this action. Refer to the Introduction chapter for additional information.

- Subsurface Soil Information – A preliminary field investigation, including soil borings, sampling, and testing, would be needed to complete preliminary design of bridge supports and roadway improvements. A geotechnical report would be needed with recommendations regarding foundation types for bridges.

- Property and Topographic/Bathymetric Survey – Property boundary and topographic/bathymetric surveys by a licensed surveyor would be necessary for locating facilities and property lines. Survey data would be used in negotiating property acquisition for the restoration design. A more detailed survey of topographic/bathymetric features, including the existing river channel, would be useful in providing accurate preliminary designs and quantities for roadway improvements, bridges, and removal of existing features.
- Additional As-built Information – Additional as-built information for the existing bridges, roadways, and existing utilities would be needed to understand demolition and removal requirements and develop preliminary design details for new facilities.
- Hydrodynamic and Hydraulic Analysis – Additional hydraulic modeling may be needed to more precisely define design water surface elevations under the full restoration alternative and provide recommendations for scour and minimum bridge clearance over water. Hydrodynamic modeling of the movement of water through the delta could help to more clearly understand the impact that the proposed restoration actions would have on the topography of the delta. This information would be particularly important for understanding potential impacts on aquaculture activities. The specific modeling approach/method needs to be determined.
- Hazardous Materials Assessment – If preliminary investigations suggest that hazardous material could be present in the action area, additional soil and sediment analysis related to demolition of utilities, roads, or buildings may be needed. The introductory chapter describes the Phase I site investigations that are occurring as part of this overall effort via a separate contract.
- Cultural Resources Investigation – Surveys for archaeological and historic resources may be required for this action area. This is particularly important for areas proposed for excavation or other ground disturbance.

3.9 Quantity Estimates

The design quantities are largely developed from LiDAR data sets lacking the resolution to accurately quantify all elements of construction. These are supplemented by unmeasured estimates made during one site visit at high tide and areal take-offs from available imagery. The quantity spreadsheets for the full and partial restoration alternatives are provided in Exhibits 3-1 and 3-2.

3.10 References

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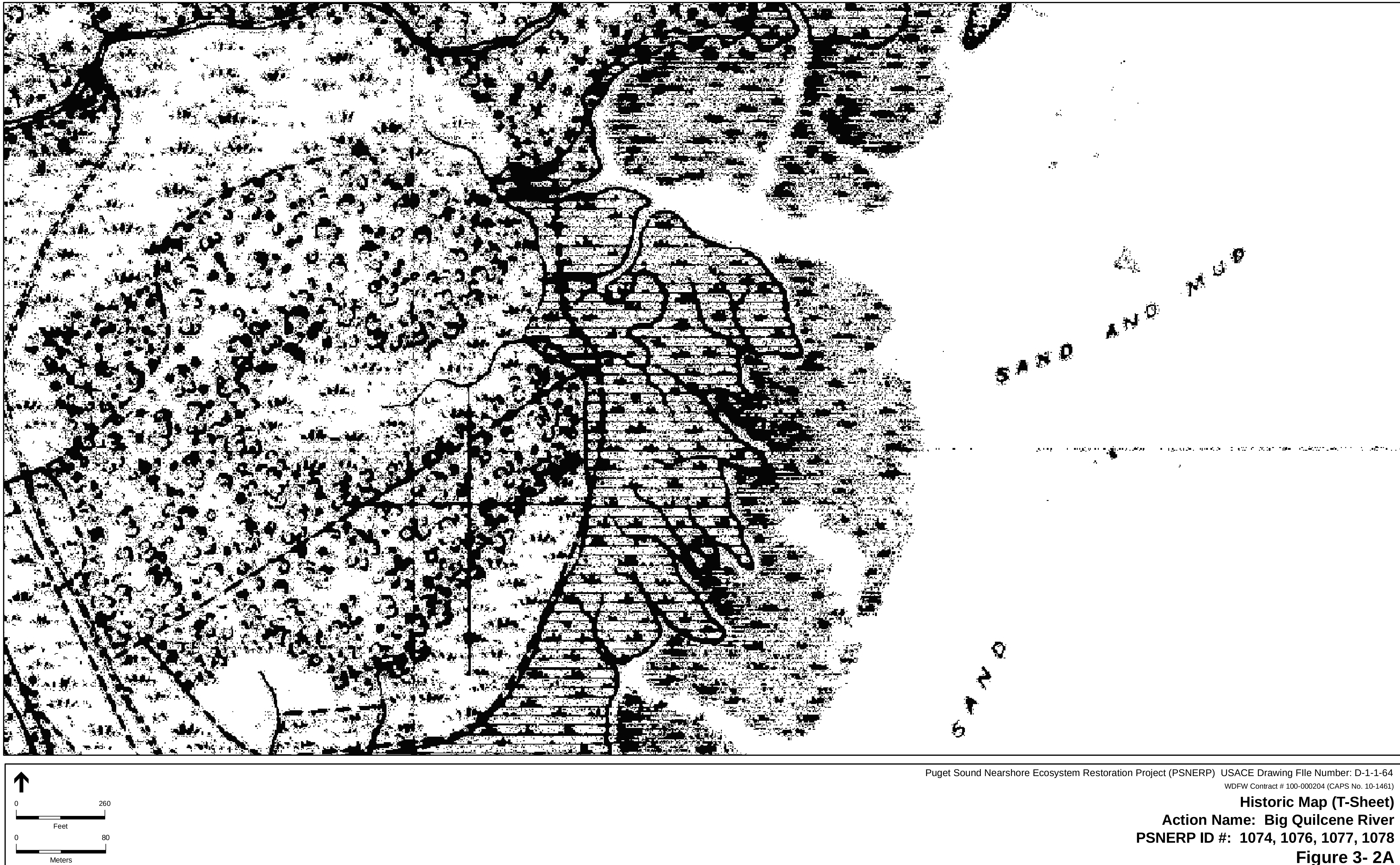

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Historic Map (T-Sheet)
Action Name: Big Quilcene River
PSNERP ID #: 1074, 1076, 1077, 1078
Figure 3- 2A

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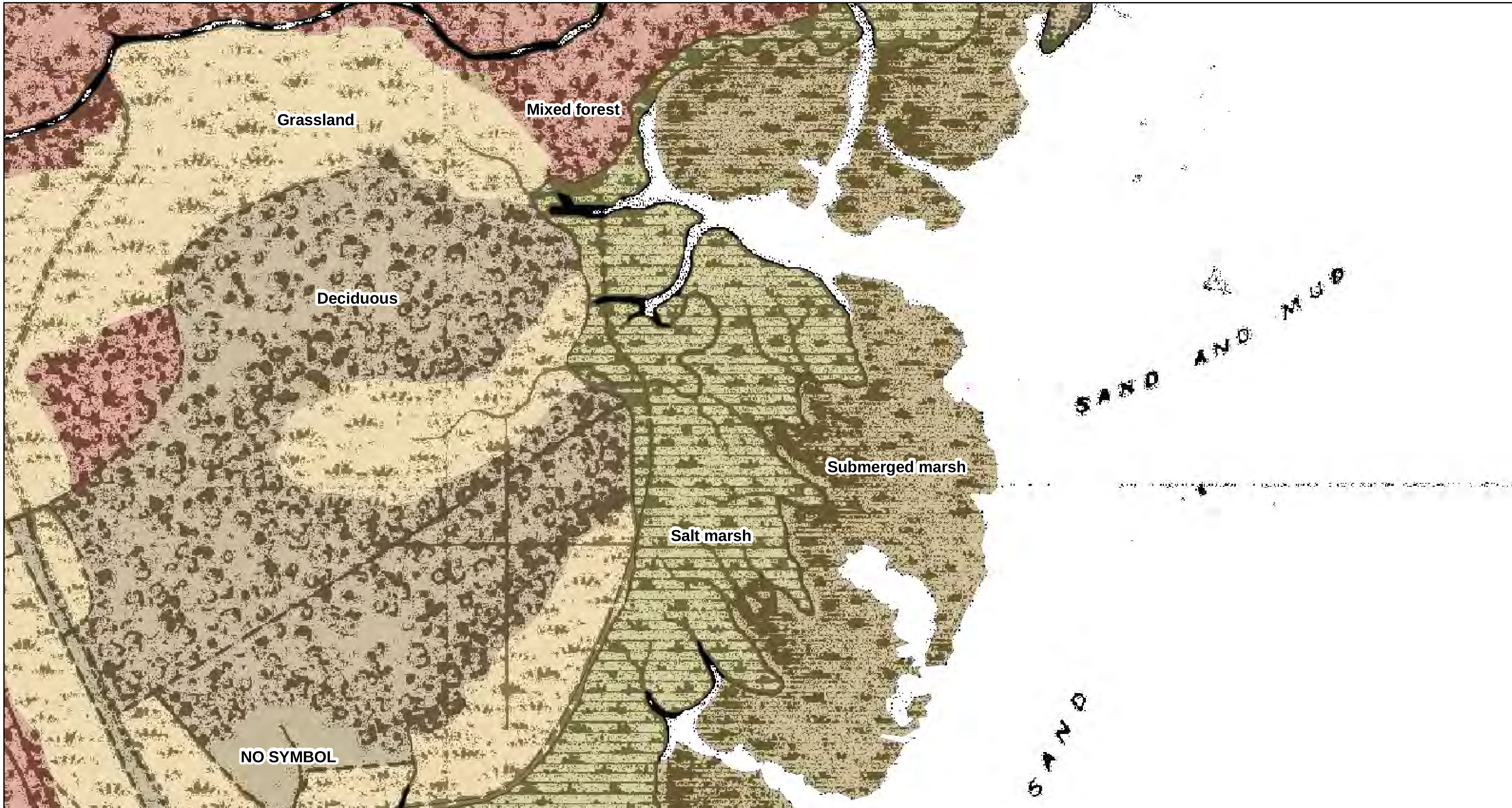

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64

WDFW Contract # 100-000204 (CAPS No. 10-1461)

Historic Map (T-Sheet) and River History Project Data

Action Name: Big Quilcene River

PSNERP ID #: 1074, 1076, 1077, 1078

Figure 3- 2B

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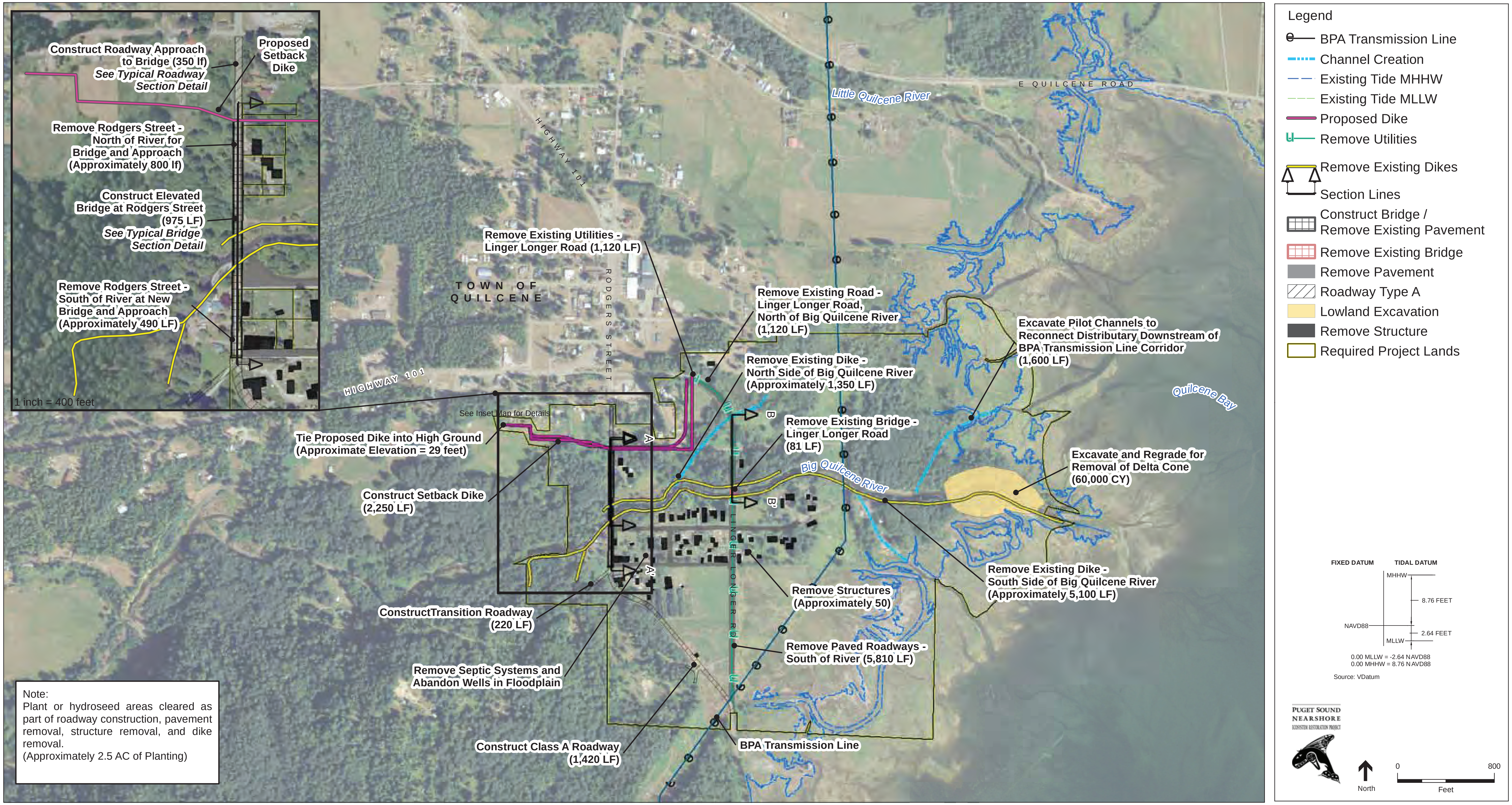


Note:
Plant or hydroseed areas cleared as part of roadway construction, pavement removal, structure removal, and dike removal.
(Approximately 2.5 AC of Planting)

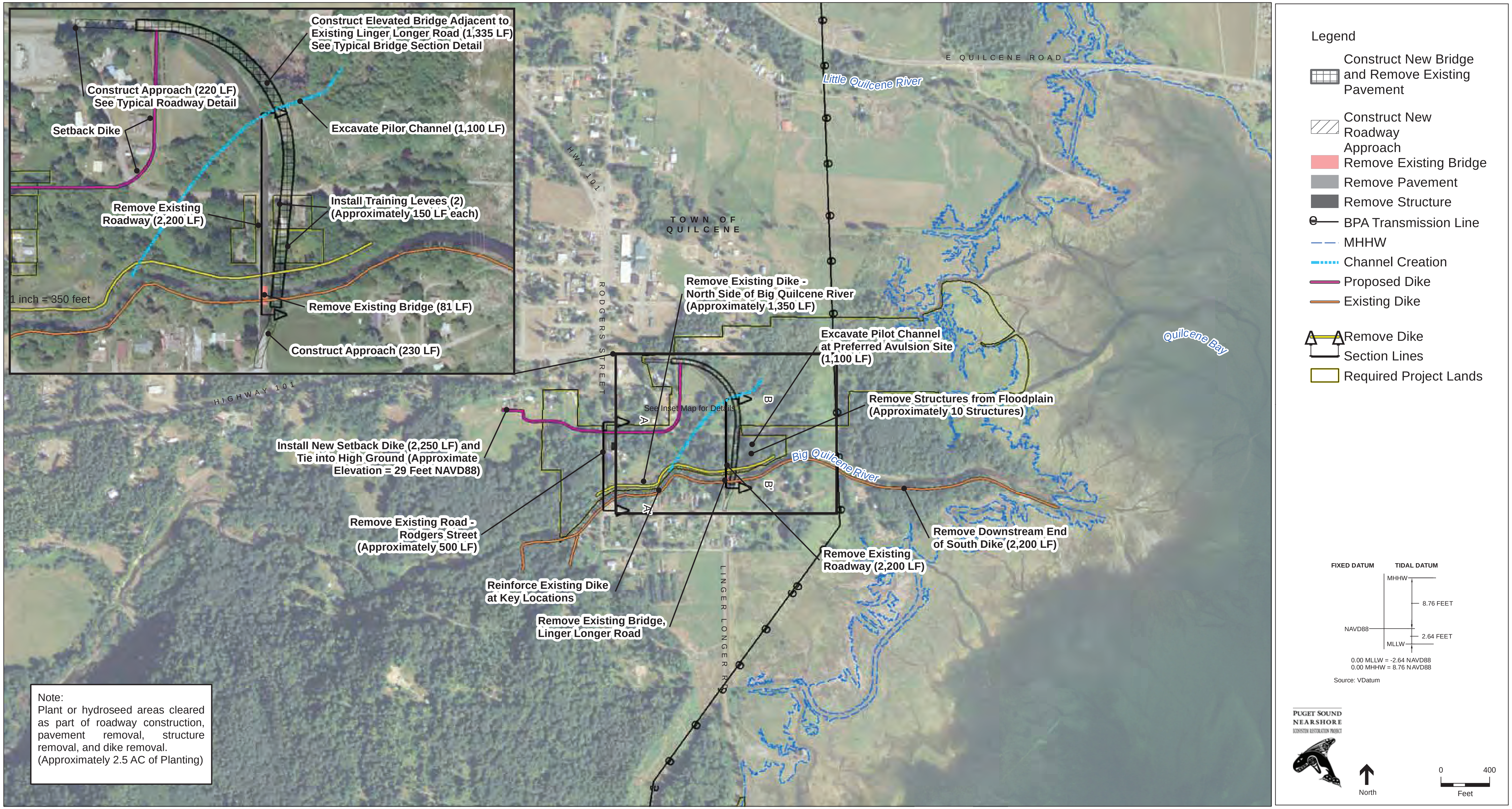
SOURCE: Washington Counties Parcels (2009); Action Area (PSNERP, 2010); NAIP Orthoimagery (USDA, 2009)

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Lead Contractor: ESA
Design Lead: Anchor QEA, David Rice
Date: 02/23/2011

Conceptual Design Plan
Site Name: Big Quilcene Delta
Action Name: Big Quilcene River Restoration
PSNERP ID #: 1074, 1076, 1077, 1078
Full Restoration

Figure 3-3



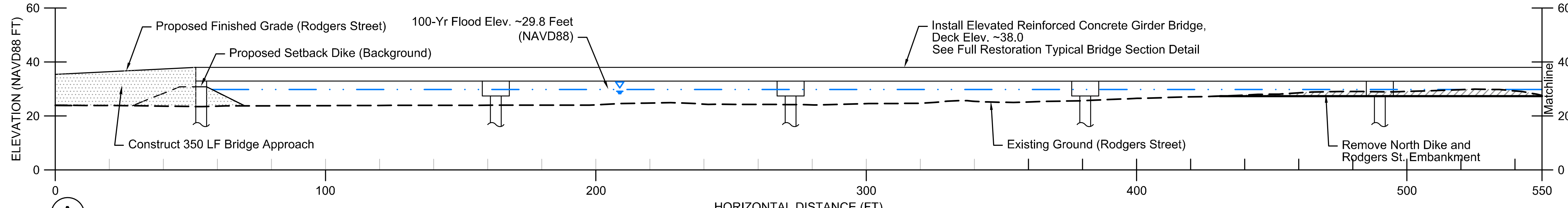
SOURCE: Washington Public Lands Database (2006); Washington Counties Parcels (2009); Action Area (PSNERP, 2010)

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

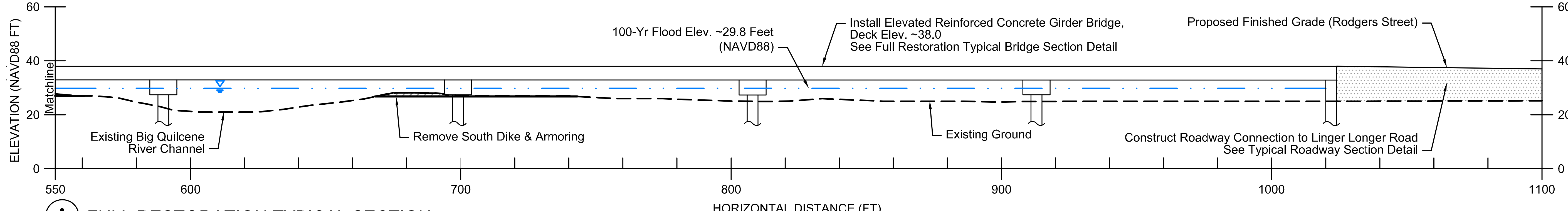
Lead Contractor: ESA
Design Lead: Anchor QEA, David Rice
Date: 02/23/2011

Conceptual Design Plan
Site Name: Big Quilcene Delta
Action Name: Big Quilcene River Restoration
PSNERP ID #: 1074, 1076, 1077, 1078
Partial Restoration

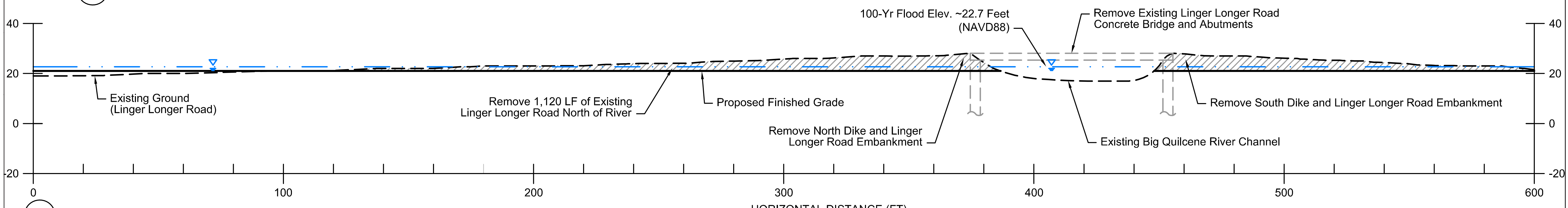
Figure 3-4



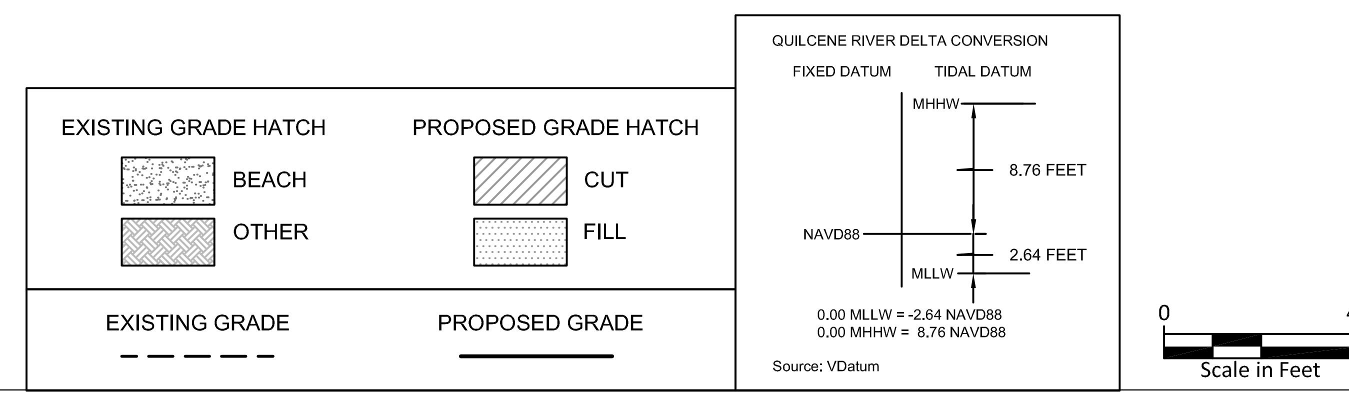
A FULL RESTORATION TYPICAL SECTION



A FULL RESTORATION TYPICAL SECTION



B FULL RESTORATION TYPICAL SECTION



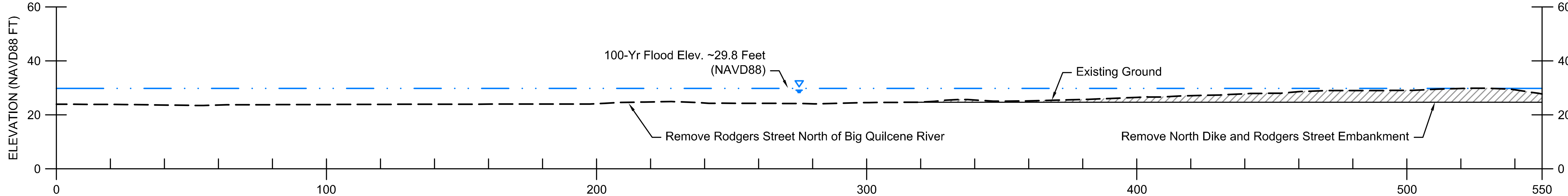
PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: Anchor with KPFF
Date: 03/2011

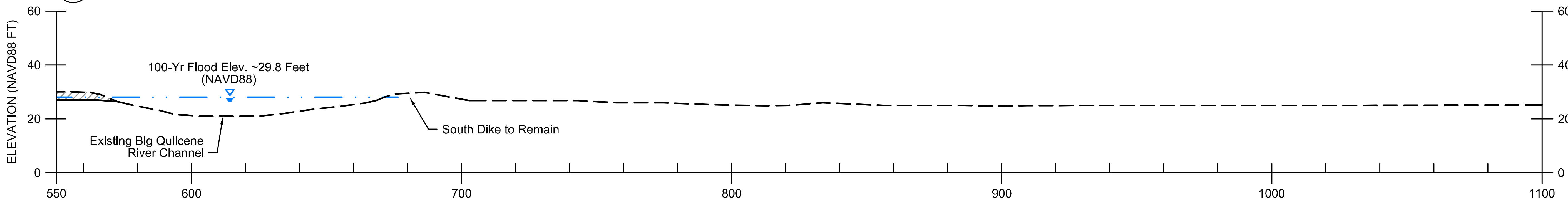
Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Section
SITE NAME: **Quilcene River Delta**
ACTION NAME: **Big Quilcene Combined**
PSNERP ID#: **1074 , 1076, 1077, 1078**
Full Restoration

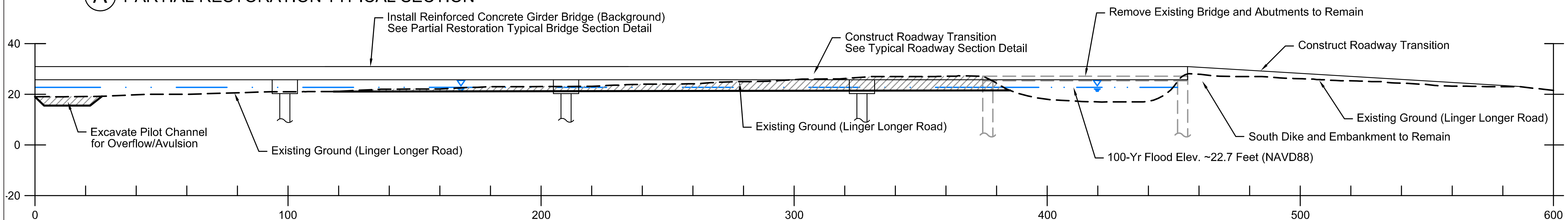
Figure 3-5



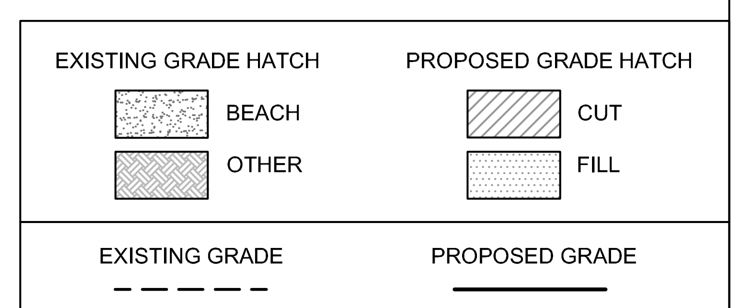
A PARTIAL RESTORATION TYPICAL SECTION

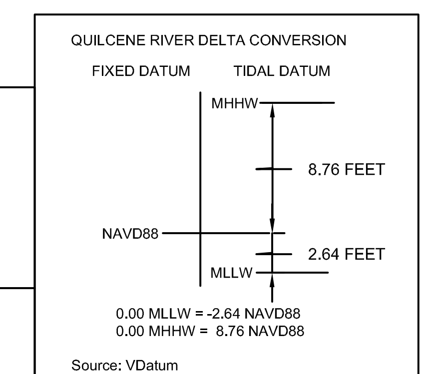


A PARTIAL RESTORATION TYPICAL SECTION



B PARTIAL RESTORATION TYPICAL SECTION





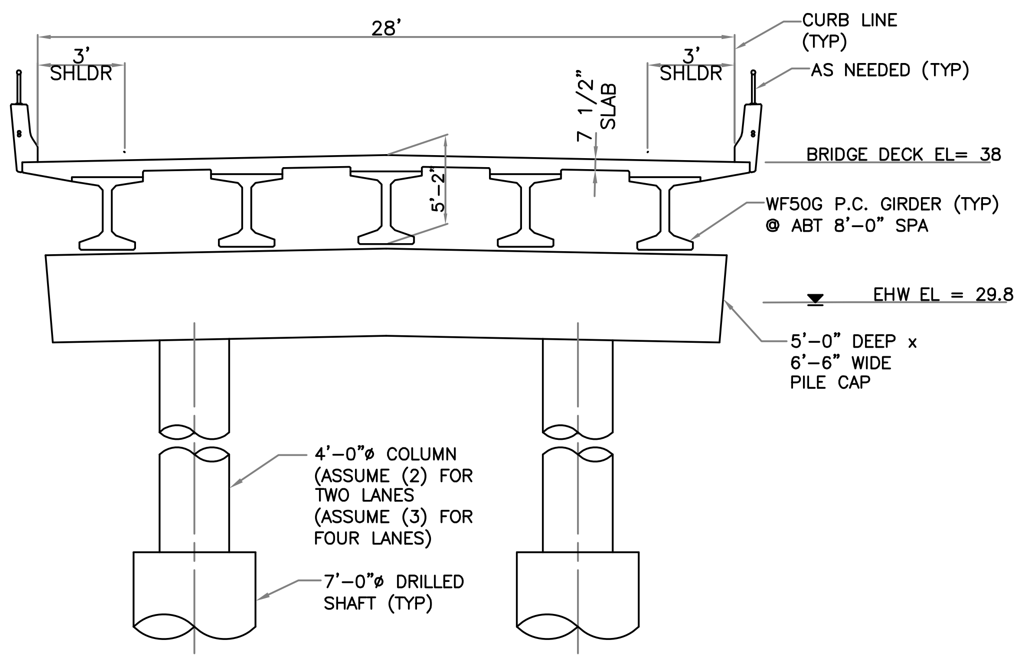
PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: Anchor with KPFF
Date: 3-2011

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

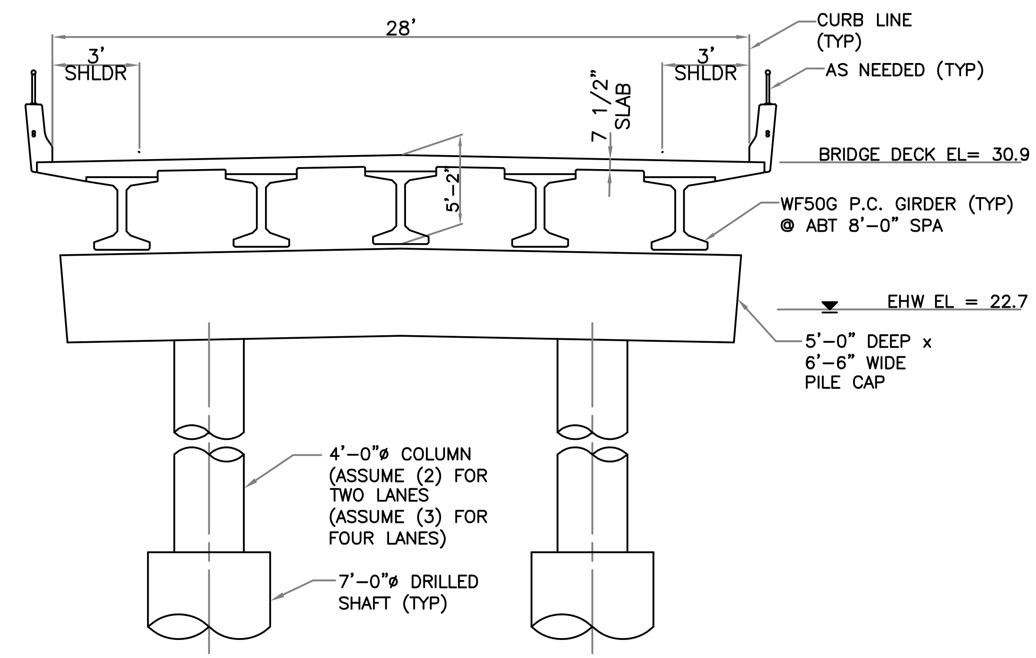
Conceptual Design Section
SITE NAME: **Quilcene River Delta**
ACTION NAME: **Big Quilcene Combined**
PSNERP ID#: **1074 , 1076, 1077, 1078**
Partial Restoration

Figure 3-6



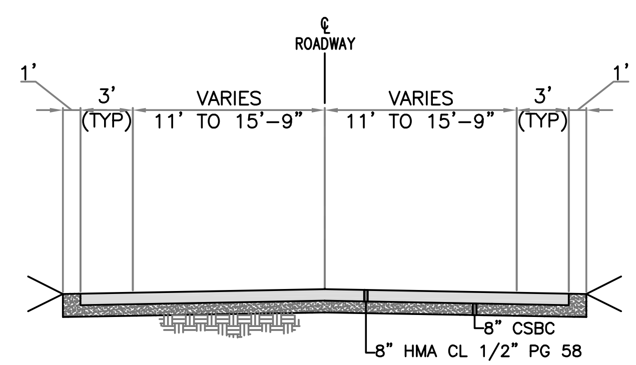
FULL RESTORATION
NOTE: 108' SPAN
EXTREME HIGH WATER (EHW) = EL 29.8

FULL RESTORATION
TYPICAL ROADWAY BRIDGE
SECTION DETAIL
Not to Scale
Section Provided by KPFF



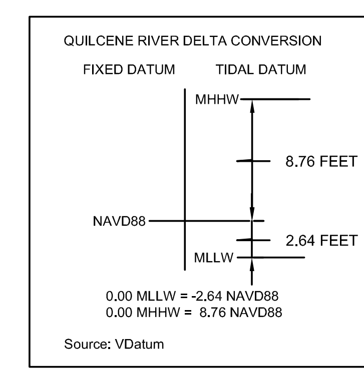
PARTIAL RESTORATION
NOTE: 114' SPAN
EXTREME HIGH WATER (EHW) = EL 22.7

PARTIAL RESTORATION
TYPICAL ROADWAY BRIDGE
SECTION DETAIL
Not to Scale
Section Provided by KPFF



DESIGN SPEED = 25 MPH

TYPICAL ROADWAY
SECTION DETAIL
Not to Scale
Section Provided by KPFF



PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: Anchor with KPFF
Date: 3/2011

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Section
SITE NAME: **Quilcene River Delta**
ACTION NAME: **Big Quilcene Combined**
PSNERP ID#: **1074 , 1076, 1077, 1078**
Full & Partial Restoration

Figure 3-7

Full Restoration Quantity Estimate

Action Name: Big Quilcene River Delta
Action #: PSNERP ID #1074,1076, 1077, 1078
Date: February 2011
By: Rice, P.E., Anchor QEA

REMEDY: *Dike Removal, Bridge Relocation, Roadway Removal, Removal of Infrastructure in Floodplain, Setback Dike Construction, Roadway Construction*
Construction Period: Approximately 86 Weeks

	Item	Unit of Measure	Material Name	Qty	Description of Item	Indicate section of design report where item is described
ACQUISITION AND CONSERVATION					Based on available mapping information	
	Required Project Lands	Acre		212	Total land required For action…Public Properties + Public ROW + Private Properties	3.3.5
	Proponent / Partner-owned lands	Acre		152.9	Public Lands that will be Impacted by Action, Including Road Right-of-Way	3.3.5
	Lands To Be Acquired	Acre		59.1	Private Properties to be Acquired Within Floodplain…No Acquisitions Assumed for L Q Dike Removal	3.3.5
Material Sites					Not Used: See Earthwork - Imported Fill.	
MOBILIZATION AND ACCESS for construction activities					Description required for each item to facilitate cost estimating	
	Mobilization - Typical (Equipment, Personnel, Planning, Financial)	LS		1	Assume 8% of other Construction Cost Items	
	Mobilization - Remote (Equipment, Personnel, Planning, Financial)	LS		0	Not Applicable	
	Site Access	LS		0	Not Applicable	
	Barge Access	Days		0	Not Applicable	
	Temporary Traffic Control (one of the following)				Includes installation of traffic signals, signage, signmen, etc. There are 4 types as follows:	
	none	LS		0	Not Applicable	
	signs	LS		1	Construction Signage at both sites to alert of Construction & Lane shifting	
	flags/spotters crews at both sides for transitions	LS		1	Flags and spotters only during roadway transition connection	
	unique	LS		0	Not Applicable	
	Temporary Roadway	SF		0	Not Applicable	
	Control of Water	LS		1	Diversion of water for bridge construction, dewatering of excavations for roadway construction.	
Relocation Activities					Not Used: See Utilities, Structures	
Site Demolition Activities					Demolition and removal of structures (description required), temporary features and relocations, itemized separately); Clearing and grubbing of vegetation, and removal of minor debris (rocks, slabs) - description required.	
	Clearing and Grubbing (one or more of following)				Use one or more of the following categories of clearing and grubbing	
	Clear Vegetation - Local Disposal	AC		0	Not Applicable	
	Clear /Grub Vegetation - Local Disposal	AC		8.7	Clear, Grub 6o feet wide at roadway, 20 feet at dikes, 50 feet at setback dike, 10 feet on sides of bridge	3.3.3
	Clear /Grub Vegetation - Offsite Disposal	AC		0	Not Applicable	
	Clear, stockpile - large woody debris	CY		0	Not Applicable	
	Hydraulic Structures - Small	LS		0	Not Applicable	
	Hydraulic Structures - Large	LS		0	Not Applicable	
	Utilities	LF		6,930	Remove Any Utilities in removed roads, Type and Exact Quantity unknown	3.3.7
	Buildings	LS		1	Remove 49 structures, Mostly Residential, in Floodplain on N and S Sides of Big Quilcene River	3.3.5, 3.3.6
	Abandon Wells	LS		1	Abandon existing wells in floodplain…~24 wells per DOE well log viewer	3.3.7
	Remove Septic Systems	LS		1	Remove septic systems at properties to be acquired within floodplain…~40 to 45 residences	3.3.7
	Pavement	SF		166,320	Remove Pavement	3.3.1, 3.3.2
	Bulkheads	LF or SF		0	Not Applicable	
	Rock revetments	Ton		1,672	Assumes Rip Rap Along Full Length of Dike to Be Removed, 5 Feet Wide, 1 Foot Deep	3.3.1, 3.3.2
	Large Coastal Structures	LF, SF or CY		0	Not Applicable	
	Demolition / Removal - Bridge	SF		2,916	Remove Concrete Bridge	3.3.1, 3.3.2
	Removal - Misc. (e.g. angular rock from beach)	Ton		0	Not Applicable	
	Demolition / Removal - Boat Ramp	SF		0	Not Applicable	
	Removal - in-water Piling	Number of Piles		0	Not Applicable	
	Haul - Offsite Disposal of Demolition Debris	Miles		20	Estimate distance (to nearest 10 miles) to disposal site for materials, veg clear and grub, etc.	3.3.7
Hazardous/Contaminated Waste Removal					These items for earthwork of quality not compatible with wetlands, requiring special handling and disposal. Describe basis for classification as contaminated or hazardous. State known or suspected contamination, describe known similar work.	
	Contaminated Earthwork	CY		0	Not Applicable	
	Hazardous Earthwork	CY		0	Not Applicable	
Construct Temporary Features					Use as needed for unusual temporary features not included elsewhere (see TESC below)	
EARTHWORK					Expand to include equipment, etc. to facilitate cost estimating.	
	Excavation	CY			Per yard excavation w/out expected haul	3.3.1, 3.3.2
	Excavation - Upland - Roadway Embankments	CY	Fill	3,800	Removal of existing Existing Rodgers St and Linger Longer Road Embankments.	
	Excavation - Lowland - Dikes	CY	Fill	29,000	Removal of existing South Channel Dikes, 3 dikes, total length~9,250	
	Excavation - Lowland - Pilot Channels	CY	Native	4,000	Excavate native material for pilot channels, 1,600 LF total length	
	Excavation - Lowland - Delta Cone Removal	CY	Native	60,000	Remove material from channel and overbanks at delta	
	Dredging - Bucket - Land	CY		0	Not Applicable	
	Dredging - Bucket - Marine	CY		0	Not Applicable	
	Dredging - Hydraulic	CY		0	Not Applicable	
	Fine Grading	AC		0	Not Applicable	
	Fill Placement - local borrow				This is additive to Earthwork -Excavation	3.3.1, 3.3.2
	Side cast	CY		0	Not Applicable	
	Haul - uncontrolled placement	CY		0	Not Applicable	
	Haul, place, compact - Fill for Roadway	CY	Fill	6,500	Fill for construction of roadway and bridge approaches.	
	Haul, place, compact - Setback Dike	CY	Fill	8,400	Fill for construction of setback dike	
	Stockpile - uncontrolled placement	CY		0	Not Applicable	
	Stockpile - controlled placement	CY	Fill	29,000	Assume dike fill removal goes into stockpile for roadway construction, disposal	
	Conveyor placement from stockpile land/water	CY		0	Not Applicable	
	Imported Fill				Includes purchase, delivery and placement or as noted / described	3.3.1, 3.3.2
	Select Fill	CY		0	Not Applicable	
	Gravel Borrow, including haul	CY		0	Not Applicable	
	Sand / Gravel for Beach Nourishment	CY		0	Not Applicable	
	Cobble for Shore Nourishment	CY		0	Not Applicable	
	Embankment Compaction	CY		0	Not Applicable	
	Topsoil	CY		0	Not Applicable	
	Rock Armoring for Setback Dike	Ton		590	Rip-rap or quarry spall armoring for setback dike	
RESTORATION Features						
	Channel Rehab / Creation	SF		96,000	Distributary channel construction (SF) and main channel restoration, excluding excavation	3.3.1, 3.3.2
	Large Wood Placement	EA		0	Not Applicable	
	Invasive Species Control	Acre		0	Not Applicable	
	Physical Exclusion Devices	LF or EA		0	Not Applicable	
	Other Restoration Features/ Activities	LS		0	Not Applicable	
Structures		EA			KPFF to provide additional inputs	
	Water Control Structures - Culverts with Gates	EA		0	Not Applicable	
	Water Control Structures - Weirs	EA		0	Not Applicable	
	Rock Slope Protection	LF		0	Not Applicable	
	Other	EA		0	Not Applicable	
	Elevated Boat Ramp	SF		0	Not Applicable	
	Fencing	SF		0	Not Applicable	
Utilities					Replacement or relocation. Designer to provide size and material and have separate line item for each run. Incidentals include earthwork, testing, hook up fees, etc. These quantities do not include demolition of existing utilities, real estate / easements, design fees. Describe the owner if known, and whether utility franchise will install (e.g.. electric is typically installed by electrical franchise).	
	Water	LF		0	Not Applicable	
	Gas	LF		0	Not Applicable	
	Electric	LF		0	Not Applicable	
	Sewer	LF		0	Not Applicable	
	Telecommunications	LF		0	Not Applicable	
	Other	LF		0	Not Applicable	
Roadway / Railway					KPFF expected to participate in these estimates	
	Roadway	SF	Pavement	43,945	Roadway 8" ASPH w/ 8" Base Width varies 28 and up	3.3.4, 3.3.6
	Roadway intersection	SF	Pavement	4,000	Minor Intersection	3.3.4, 3.3.6
	Roadway - Switch (potential)	LS			Street lights, etc. (Temporary traffic control handled under Temporary Facilities)	
	Culvert (type)	LF		0	Not Applicable	
	Culvert - Jacking	LF		0	Not Applicable	
	Culvert - Horizontal Pile Driving	LF		0	Not Applicable	
	Bridge - Deck	SF	Bridge	29,250	Prestressed Precast Girder Bridge with 108' Spans	3.3.4, 3.3.6
	Railway - Box Girder	SF		0	Not Applicable	
	Bridge - Foundation	LF		280	(10) 28' CIP Concrete pile caps w/ (2) 7' Dia Drilled Shafts 100' Embed At Each Pile Cap	3.3.4, 3.3.6
	Railway - Shoe fly	LF		0	Not Applicable	
Permanent Access Features					KPFF expected to participate in these estimates	
	Roads	Level	1	1	Private Drive Access	
	Utility Access Routes	varies		0	Not Applicable	
	Erosion Control Features	AC		50	Stabilized Construction Entrances, Sediment Ponds, Hydro Seed to Stabilize Roadway Embankments	

Full Restoration Quantity Estimate

Action Name: Big Quilcene River Delta
Action #: PSNERP ID #1074,1076, 1077, 1078
Date: February 2011
By: Rice, P.E., Anchor QEA

REMEDY: ***Dike Removal, Bridge Relocation, Roadway Removal, Removal of Infrastructure in Floodplain, Setback Dike Construction, Roadway Construction***
Construction Period: Approximately 86 Weeks

Item	Unit of Measure	Material Name	Qty	Description of Item	Indicate section of design report where item is described
Public Access or Recreation Features				KPFF expected to participate in these estimates	
Trails	SF		0	Not Applicable	
Bridges	SF		0	Not Applicable	
Kiosk	EA		0	Not Applicable	
Restrooms	EA		0	Not Applicable	
Interpretive Signs	EA		2	tdb	
Parking Area	SF		0	Not Applicable	
Other	EA		0	Not Applicable	
Vegetation & Erosion Control					
Hydroseeding	AC	Hydroseed	8.7	Hydroseed upland clearing and removal areas.	
Planting	AC	Plant	8.7	Plant riparian clearing and removal areas, wooded areas, etc.	
Vegetation Maintenance	AC-YR		0	Includes irrigation, weeding, plant replacement for one year	
Erosion / sediment BMPs - Temp.	LS		1	Erosion/sediment control BMPs - Silt fences, cofferdams, temporary pumping and conveyance	
Erosion / sediment BMPs - Permanent	AC		0	May want to separate slopes over 25% into separate category	
Waterside controls - Temporary	EA, LF, LS		0	Silt curtain or other water based temporary actions	
Construction Management					
Construction oversight	weeks		86	8-10 Months for Removals and Roadway Construction, 12-14 Months for Bridge Construction, Overlap	
Materials testing				Included in cost of material - no separate quantity	
Design and Detailed Site Investigations					
Survey & Property, Utility Research	LS		1	% of construction cost	
35% Design	LS		1	35% x 25% x Engineer's Estimate	
65% design	LS		1	65% x 25% x Engineer's Estimate less the cost for 35% PS&E	
90% design	LS		1	35% x 25% x Engineer's Estimate less the cost for 35% + 65%PS&E	
100% design	LS		1	25% x Engineer's Estimate less previous costs	
Geotechnical Studies	LS		1	Borings, Test Pits, Testing, Geotech Report With Foundation Recommendations, Cut/Fill Slopes, Etc.	
Cultural Studies	LS		1	Refer to design report for description of need	
HTWR Studies				Refer to design report for description of need	
Project Agreement Activities				Unable to provide credibale estimate at 10% design	
Site-Specific Adaptive Management Features & Activities				List if known	
Monitoring Activities				Assume 5 crew-days/year for each monitoring parameter in design report for 5 yrs	
Monitoring (Type)	crew-days		225		
Operations & Maintenance				Unable to provide credible estimate at 10% design	

Partial Restoration Quantity Estimate

Action Name: Big Quilcene River Delta
Action #: PSNERP ID #1074,1076, 1077, 1078
Date: February 2011
By: David Rice, P.E., Anchor QEA

REMEDY: North *Dike Removal, Overflow Bridge Construction, Roadway Removal, Removal of Infrastructure in Floodplain, Setback Dike Construction*
Construction Period: Approximately 80 Weeks

Item	Unit of Measure	Material Name	Qty	Description of Item	Indicate section of design report where item is described
ACQUISITION AND CONSERVATION				Based on available mapping information	
Required Project Lands	Acre		85	Total land required For action	3.3.5
Proponent / Partner-owned lands	Acre		61.5	Public Lands that will be Impacted by Action, Including Road Right-of-Way	3.3.5
Lands To Be Acquired	Acre		23.5	Private Properties to be Acquired Within Floodplain that will be Impacted by Action	3.3.5
Material Sites				Not Used: See Earthwork - Imported Fill.	
MOBILIZATION AND ACCESS for construction activities				Description required for each item to facilitate cost estimating	
Mobilization - Typical (Equipment, Personnel, Planning, Financial)	LS		1	Assume 8% of other Construction Cost Items	
Mobilization - Remote (Equipment, Personnel, Planning, Financial)	LS		0	Not Applicable	
Site Access	LS		0	Not Applicable	
Barge Access	Days		0	Not Applicable	
Temporary Traffic Control (one of the following)				Includes installation of traffic signals, signage, signmen, etc. There are 4 types as follows:	
none	LS		0	Not Applicable	
signs	LS		1	Construction Signage at both sites to alert of Construction & Lane shifting	
flags/spotters crews at both sides for transitions	LS		1	Flags and spotters only during roadway transition connection	
unique	LS		0	Not Applicable	
Temporary Roadway	SF		0	Not Applicable	
Control of Water	LS		1	Diversion of water for bridge construction, dewatering of excavations for roadway construction.	
Relocation Activities				Not Used: See Utilities, Structures	
Site Demolition Activities				Demolition and removal of structures (description required), temporary features and relocations, itemized separately); Clearing and grubbing of vegetation, and removal of minor debris (rocks, slabs) - description required.	
Clearing and Grubbing (one or more of following)				Use one or more of the following categories of clearing and grubbing	
Clear Vegetation - Local Disposal	AC		0	Not Applicable	
Clear /Grub Vegetation - Local Disposal	AC		5.3	Clear, 20 feet width at dike removal, 10 feet on sides of road/bridge, 50 feet width at setback dike	3.3.3
Clear /Grub Vegetation - Offsite Disposal	AC		0	Not Applicable	
Clear, stockpile - large woody debris	CY		0	Not Applicable	
Hydraulic Structures - Small	LS		0	Not Applicable	
Hydraulic Structures - Large	LS		0	Not Applicable	
Utilities	LF		500	Remove Any Utilities in removed roads	3.3.7
Buildings	LS		1	Remove 5 Buildings, Mostly Residential, in Floodplain on N of Big Quilcene River	3.3.5, 3.3.6
Abandon Wells	LS		1	Abandon existing wells in floodplain…~4 wells per DOE well log viewer	3.3.7
Remove Septic Systems	LS		1	Remove septic systems at properties to be acquired within floodplain…~3 residences	3.3.7
Pavement	SF		72,600	Remove Pavement	3.3.1, 3.3.2
Bulkheads	LF or SF		0	Not Applicable	
Rock revetments	Ton		920	Assumes Rip Rap Along Full Length of Dike to Be Removed, 5 Feet Wide, 1 Foot Deep	3.3.1, 3.3.2
Large Coastal Structures	LF, SF or CY		0	Not Applicable	
Demolition / Removal - Bridge	SF		2,268	(81' x 28')	3.3.1, 3.3.2
Removal - Misc. (e.g. angular rock from beach)	Ton		0	Not Applicable	
Demolition / Removal - Boat Ramp	SF		0	Not Applicable	
Demolition / Removal - in-water Piling	Number of Piles		0	Not Applicable	
Haul - Offsite Disposal of Demolition Debris	Miles		20	Estimate distance (to nearest 10 miles) to disposal site for materials, veg clear and grub,	3.3.7
Hazardous/Contaminated Waste Removal				These items for earthwork of quality not compatible with wetlands, requiring special handling and disposal. Describe basis for classification as contaminated or hazardous. State known or suspected contamination, describe known similar work.	
Contaminated Earthwork	CY		0	Not Applicable	
Hazardous Earthwork	CY		0	Not Applicable	
Construct Temporary Features				Use as needed for unusual temporary features not included elsewhere (see TESC below)	
EARTHWORK				Expand to include equipment, etc. to facilitate cost estimating.	
Excavation	CY			Per yard excavation w/out expected haul	3.3.1, 3.3.2
Excavation - Upland - Roadway Embankments	CY	Fill	3,600	Removal of existing Existing Rodgers St Embankment	
Excavation - Lowland - Dikes	CY	Fill	13,600	Removal of existing dikes, 1 dike, total length~1,350 South Dike + 2,200 North Dike	
Excavation - Lowland - Pilot Channels	CY	Native	3,300	Excavate native material for pilot channel, 800 LF total length	
Dredging - Bucket - Land	CY		0	Not Applicable	
Dredging - Bucket - Marine	CY		0	Not Applicable	
Dredging - Hydraulic	CY		0	Not Applicable	
Fine Grading	AC		0	Not Applicable	
Fill Placement - local borrow				This is additive to Earthwork -Excavation	3.3.1, 3.3.2
Side cast	CY		0	Not Applicable	
Haul - uncontrolled placement	CY		0	Not Applicable	
Haul, place, compact - Fill for Roadway	CY	Fill	1,800	Fill for construction of roadway and bridge approaches.	
Haul, place, compact - Fill for Setback Dike	CY	FIll	8,400	Fill for construction of setback dike.	
Stockpile - uncontrolled placement	CY		0	Not Applicable	
Stockpile - controlled placement	CY	Fill	13,600	Assume dike fill removal goes into stockpile for roadway construction, disposal	
Conveyor placement from stockpile land/water	CY		0	Not Applicable	
Imported Fill				Includes purchase, delivery and placement or as noted / described	3.3.1, 3.3.2
Select Fill	CY		0	Not Applicable	
Gravel Borrow, including haul	CY		0	Not Applicable	
Sand / Gravel for Beach Nourishment	CY		0	Not Applicable	
Cobble for Shore Nourishment	CY		0	Not Applicable	
Embankment Compaction	CY		0	Not Applicable	
Topsoil	CY		0	Not Applicable	
Rock Armoring for Setback Dike	Ton		590	Rip-rap or quarry spall armoring for setback dike	
RESTORATION Features					
Channel Rehab / Creation	SF		22,000	Distributary channel construction (SF) and main channel restoration, excluding excavation	3.3.1, 3.3.2
Large Wood Placement	EA		0	Not Applicable	
Invasive Species Control	Acre		0	Not Applicable	
Physical Exclusion Devices	LF or EA		0	Not Applicable	
Other Restoration Features/ Activities	LS		0	Not Applicable	
Structures	EA			KPFF to provide additional inputs	
Water Control Structures - Culverts with Gates	EA		0	Not Applicable	
Water Control Structures - Weirs	EA		0	Not Applicable	
Rock Slope Protection	LF		0	Not Applicable	
Other	EA		0	Not Applicable	
Elevated Boat Ramp	SF		0	Not Applicable	
Fencing	SF		0	Not Applicable	
Utilities				Replacement or relocation. Designer to provide size and material and have separate line item for each run. Incidentals include earthwork, testing, hook up fees, etc. These quantities do not include demolition of existing utilities, real estate / easements, design fees. Describe the owner if known, and whether utility franchise will install (e.g.. electric is typically installed by electrical franchise)	
Water	LF		0	Not Applicable	
Gas	LF		0	Not Applicable	
Electric	LF		0	Not Applicable	
Sewer	LF		0	Not Applicable	
Telecommunications	LF		0	Not Applicable	
Other	LF		0	Not Applicable	
Roadway / Railway				KPFF expected to participate in these estimates	
Roadway	SF		12,600	Roadway 8" ASPH w/ 8" Base (450'x28')	3.3.4, 3.3.6
Roadway - Switch (potential)	LS			Street lights, etc. (Temporary traffic control handled under Temporary Facilities)	
Culvert (type)	LF		0	Not Applicable	
Culvert - Jacking	LF		0	Not Applicable	
Culvert - Horizontal Pile Driving	LF		0	Not Applicable	
Bridge - Deck	SF		37,940	Prestressed Precast Girder Bridge with 114' Spans (1355'x28')	3.3.4, 3.3.6
Railway - Box Girder	SF		0	Not Applicable	
Bridge - Foundation	LF		308	(11) 28' CIP Pilecaps w/ (2) 7' Dia Drilled Shaft foundations ea,100' embed at each end	3.3.4, 3.3.6
Railway - Shoe fly	LF		0	Not Applicable	

Partial Restoration Quantity Estimate

Action Name: Big Quilcene River Delta
Action #: PSNERP ID #1074,1076, 1077, 1078
Date: February 2011
By: David Rice, P.E., Anchor QEA

REMEDY: North *Dike Removal, Overflow Bridge Construction, Roadway Removal, Removal of Infrastructure in Floodplain, Setback Dike Construction*
Construction Period: Approximately 80 Weeks

	Item	Unit of Measure	Material Name	Qty	Description of Item	Indicate section of design report where item is described
Permanent Access Features					KPFF expected to participate in these estimates	
	Roads	Level			Level 1 direct access, Level 2 moderately difficult, Level 3 difficult access	
	Utility Access Routes	varies		0	Not Applicable	
	Erosion Control Features	AC		5.3	Stabilized Construction Entrances, Sediment Ponds, Hydro Seed to Stabilize Roadway Embankments	
Public Access or Recreation Features					KPFF expected to participate in these estimates	
	Trails	SF		0	Not Applicable	
	Bridges	SF		0	Not Applicable	
	Kiosk	EA		0	Not Applicable	
	Restrooms	EA		0	Not Applicable	
	Interpretive Signs	EA		2	tbd	
	Parking Area	SF		0	Not Applicable	
	Other	EA		0	Not Applicable	
Vegetation & Erosion Control						
	Hydroseeding	AC	Hydroseed	2.5	Hydroseed upland clearing and removal areas.	
	Planting	AC	Planting	2.5	Plant riparian clearing and removal areas, wooded areas, etc.	
	Vegetation Maintenance	AC-YR		0	Includes irrigation, weeding, plant replacement for one year	
	Erosion / sediment BMPs - Temp.	LS		1	Erosion/sediment control BMPs - Silt fences, cofferdams, temporary pumping and conveyance	
	Erosion / sediment BMPs - Permanent	AC		0	May want to separate slopes over 25% into separate category	
	Waterside controls - Temporary	EA, LF, LS		0	Silt curtain or other water based temporary actions	
Construction Management						
	Construction oversight	weeks		80	6-7 Months for Removals and Roadway Construction, 12-14 Months for Bridge Construction	
	Materials testing				Included in cost of material - no separate quantity	
Design and Detailed Site Investigations						
	Survey & Property, Utility Research	LS		1	% of construction cost	
	35% Design	LS		1	35% x 25% x Engineer's Estimate	
	65% design	LS		1	65% x 25% x Engineer's Estimate less the cost for 35% PS&E	
	90% design	LS		1	35% x 25% x Engineer's Estimate less the cost for 35% + 65%PS&E	
	100% design	LS		1	25% x Engineer's Estimate less previous costs	
	Geotechnical Studies	LS		1	Borings, Test Pits, Testing, Geotech Report With Foundation Recommendations, Cut/Fill Slopes, Etc.	
	Cultural Studies	LS		1	Refer to design report for description of need	
	HTWR Studies				Refer to design report for description of need	
Project Agreement Activities					Unable to provide credibale estimate at 10% design	
Site-Specific Adaptive Management Features & Activities					List if known	
Monitoring Activities					Assume 5 crew-days/year for each monitoring parameter in design report for 5 yrs	
	Monitoring (Type)	crew-days		225		
Operations & Maintenance					Unable to provide credible estimate at 10% design	

4. CHAMBERS BAY ESTUARINE AND RIPARIAN ENHANCEMENT (#1801)

Local Proponent	South Puget Sound Salmon Enhancement Group (SPSSEG)
Delta Process Unit	NA
Shoreline Process Unit(s)	3004, 3003
Strategy(ies)	4 - Coastal Inlet
Restoration Objectives	Remove barriers to tidal and freshwater inflow, sediment erosion/accretion, channel formation and maintenance, and detritus input to restore historic coastal inlet and back barrier landforms

4.1 Description of the Action

Alterations to the size, shape, and shoreline of the Chambers Bay Estuary have significantly limited the nearshore processes of the estuary, including tidal hydrology and sediment erosion and accretion. Restoration of the estuary would include the removal of a small dam near the middle to upper portion of the historic estuary, daylighting some or all of the currently culverted spring-fed creek (Garrison Springs), expanding the connection of the estuary to Puget Sound by widening a relatively short railroad trestle, and restoring tidal marsh and riparian vegetation communities. Please see the Introduction chapter for important information regarding PSNERP and for context related to this restoration project.

4.2 Action Area Description and Context

Chambers Bay is located at the confluence of Chambers Creek and Puget Sound, in the South Puget Sound Subbasin. The area is bordered by the towns of University Place, Lakewood, and Steilacoom. The Chambers Bay action area is bounded on the west side by the BNSF railroad causeway and trestle and the mouth of Chambers Bay. On the south and east sides, the action area is bounded by the Chambers Creek Road right-of-way, which includes a BNSF rail spur in the southern portion of the right-of-way, a former mill site, and the banks of the waters impounded behind the Chambers Creek dam. The north side of the action area is bounded by the steep banks of the Chambers Creek ravine, and at the north end of the site, the Chambers Creek Road right-of-way. Land ownership includes both public and private properties. The action area is shown in Figure 4-1.

Figure 4-1. Action Area and Vicinity

4.2.1 Historic Condition

Based on the historic topographic sheet (T-sheet) mapping from the late 1800s, the Chambers Bay mouth was historically defined by a barrier beach extending from the south (Figures 4-2A and 4-2B). The embayment extended approximately 7,500 feet upstream from the barrier beach. T-sheet mapping delineated the steeply sloping areas above the shoreline as mixed forest with kelp (likely eelgrass) mapped off the mouth of the bay. It appears that an intertidal area, assumed to be tidal mudflats, marsh, or some combination of the two, existed throughout the entire extent of the embayment based on mapping. Nearly 61 acres of estuarine mixing intertidal area were mapped; however, the mapping and interpretation of the mapping do not indicate clearly the historical extent of specific marsh, mudflat, and tidal channels.

The site has changed due to the dam in the upper estuary, the railroad line and trestle seaward of the historic mouth of the bay, conversion of the historic barrier beach spit into upland area, and nearshore fill and armoring along the shoreline (installed to stabilize lower Chambers Creek Road, the marina [former lumber mill], a bridge, the BNSF rail line, and two mills). The paper mill is no longer active and is currently being demolished.

The north side of the bay was the site of the Steilacoom gravel pit, one of the largest producing gravel mines on the Puget Sound shoreline. Chambers Bay has been repeatedly dredged as a navigable waterway. The bay previously served as a log storage facility for the mills, and as receiving waters for industrial discharges from the paper mill. The mill outfall was relocated to just outside the bay entrance in the 1970s (Pierce County 2010).

4.2.2 Natural Environment

Chambers Bay is the lower end of an extensive steep-angled ravine, with steep forested slopes incised between two plateaus. The lower portion of Chambers Creek within the ravine is formed by three tributaries: Leach and Flett Creeks, and the outlet of Steilacoom Lake. These three tributaries drain the primarily residential areas of University Place, South Tacoma, Lakewood, and Fircrest.

To the north and south of the mouth of Chambers Bay, bluff-backed beaches were historically present. Currently, these areas are heavily modified. The bluff north of the mouth of Chambers Bay was removed during sand and gravel mining operations, and this area currently accommodates the BNSF railroad corridor that runs north/south along Puget Sound in this area. In the area south of the mouth of Chambers Bay, the historic bluff-backed beach has been replaced by both the BNSF railroad corridor and Chambers Creek Road, disconnecting the bluff from the beach as a sediment source.

Three smaller ravines drain to Chambers Bay on the southeast side. The southernmost drainage (south of the marina) is approximately 0.5 mile long. The center drainage, known as Garrison Springs, is approximately 0.5 mile long; its lower half is within a culvert under the abandoned paper mill. The northern drainage is near the paper mill/sewer utility property line and is approximately 0.25 mile long. The northern drainage is mapped as No Name Creek and drains into the bay via a culvert.

The Fort Steilacoom Golf Course is located between the two northern ravines on the plateau southeast of the bay. Along the entire length of the bay's south shoreline, riparian forest vegetation covers the hillside. The riparian forest is fairly continuous, but it is separated from aquatic areas by the presence of Chambers Creek Road, the closed paper mill, and an inactive railroad track. Along the north shoreline, there is a riparian corridor consisting of a steeply sloping narrow band of scrub vegetation mixed with patches of forest. The scrub vegetation is dominated by invasive species (including Himalayan blackberry and Scot's broom).

The intertidal areas of Chambers Bay consist of mudflats and tidal channels. Little to no salt marsh or brackish marsh vegetation exists below the dam, except for small pockets of marsh grasses protected by the small historic spit of land (which is known to include cultural resources) on the north side of the bay and on the east side of the marina. Upstream of the dam, freshwater emergent wetland vegetation is abundant, a sign of succession associated with basin sedimentation.

As stated previously, it is unclear to what extent salt marsh and brackish marsh existed in the bay historically. Historic photographs of the bay indicate steeply sloped adjacent shorelines. Recent bathymetric studies by Pierce County confirm that eelgrass beds occur off the mouth of Chambers Bay, but not within the bay (Pierce County 2010).

4.2.3 Human Environment

The Chambers Bay Estuary shoreline is extensively modified. On the north side of the bay, past gravel mining stopped within 50 feet of the natural shoreline where the original hillside remains. Above this remaining steep sloping area is the primary development area of Pierce County's 930-acre Chambers Creek Properties, including the County's

Chambers Creek Regional Wastewater Treatment Plant. The area south of the treatment plant and including most of the Chambers Bay Estuary is primarily designated for public access facilities (e.g., meadows, boat launch, parking, trails) in the approved Chambers Creek Properties Master Site Plan (Pierce County 2010).

The Pierce County Sewer Utility owns the riparian areas alongside the north and south sides of the bay and along the impoundment above the dam, plus nearly all lands under the bay and impoundment itself. These areas are governed by the adopted Master Site Plan. The areas above and below the dam provide significant public recreation opportunities including hiking, skim boarding, fishing (fresh and saltwater), kayaking, and bird and wildlife watching (Pierce County 2010).

Lower Chambers Creek Road runs from University Place along the north side of the ravine and shifts to the south side of the bay via a bridge on the upstream side of the dam. The dam is a sloping structure that is approximately 12 feet high, and may potentially be overtopped by saltwater during very extreme high tide conditions. However, no historic evidence of overtopping has been found (Pierce County 2010). After crossing the bridge, lower Chambers Creek Road/Lafayette Street runs along the south side of the bay through the town of Steilacoom, connecting to the cities of Lakewood and DuPont, Joint Base Lewis-McChord, and I-5.

In addition to local utilities, major natural gas transmission lines, water transmission lines, and sanitary sewer collection lines are located under Chambers Creek Road adjacent to the estuary and dam. Major electrical transmission lines span Chambers Creek Canyon in the action area (Pierce County 2010). More detailed information on existing utilities and the need for utility relocations will be required to support subsequent design phases.

The former paper mill site is a large, flat impervious area created in the 1920s by the use of water cannons blasting the adjoining hillsides into Chambers Bay. It was at that time when Garrison Springs was extended via culvert to the new shoreline. Near the mouth of the bay, a small private marina exists on filled land of a former lumber mill lying behind the railroad causeway (Pierce County 2010).

The BNSF railroad runs across the shoreline at the mouth of Chambers Bay on an elevated berm. The natural and historic entrance to the bay was relocated in 1916 by the construction of the causeway and bridge (Pierce County 2010). The dual-track Chambers Bay BNSF bridge is a unique lift bridge. Its dual counterweights act in an opposing pivot to lift the short drawspan, thus allowing boats to pass in and out and maintaining the navigable waterway. The BNSF mainline (dual and triple track with 60 to 80 trains per day) is shared with the Union Pacific Railroad and Amtrak. This is the major route that connects the ports of Vancouver, British Columbia, and Los Angeles, California, through Seattle and Tacoma, Washington, and Portland, Oregon (Pierce County 2010).

As noted above, most of the land on the north and south sides of the bay, under the bay and the impoundment, and in the adjacent riparian areas is in public ownership (Pierce County Sewer Utility). The former paper mill site is privately owned, is being demolished and is currently for sale. Downstream of the former mill site on the south shoreline, the land is in both public and private ownership.

Ownership will need to be verified, but it appears there are only a few larger parcels, with a relatively small number of public and private landowners (e.g., five or fewer) who own the shoreline and submerged areas. WDFW owns and operates a fish capture and acclimation facility adjacent to the Chambers Creek dam in conjunction with its Garrison Springs hatchery. The dam was constructed in 1938 to impound water for use by the gravel mine (now County-owned), paper mill, and state fisheries operators (Pierce County 2010). Fish ladders were installed at the same time. The County continues to use its senior water rights from the impoundment (adjacent pump structures). WDFW uses water on a pass-through basis, and the former mill owner is currently not utilizing their water pumping facilities adjacent to the dam (Pierce County 2010).

Ownership of the dam itself is not fully clear due to the complex nature of the originating agreements. Ownership will likely be determined by Pierce County and the mill owner through a separate process. It is clear that the dam is located on Pierce County Sewer Utility property.

The existing storm drainage infrastructure for the abandoned mill will likely be modified during the demolition and eventual redevelopment processes. As noted above, culverts drain Garrison Springs and other natural drainages to the bay. Nearly all of the runoff from lower Chambers Creek Road from 64th Street West, past the wastewater treatment plant, former mill, and from the residential developments on the south side of the bay, drains into the estuary and adjacent natural drainages with little or no treatment (Pierce County 2010).

4.3 Restoration Design Concept

4.3.1 Restoration Overview and Key Design Assumptions

The railroad causeway and Chambers Creek dam inhibit the free flow of tidal and fluvial waters. These features, along with shoreline armoring and private development in the estuary, are impacting the natural geomorphic processes that are responsible for creating and maintaining nearshore habitat. Removal of these features will allow for tidal hydrology, the natural transport of sediment, and freshwater inputs across the current and historic Chambers Bay Estuary.

The restoration alternatives are illustrated in Figures 4-3 through 4-8. A key assumption regarding removal of the dam is that the water rights associated with the impoundment and fish hatchery can be accommodated through alternative approaches or at other locations. Restoration will also rely on cooperation of private and public landowners who are affected by the project. Acquisition of private and public properties in whole or in part may be required to accommodate restoration activities.

The full restoration alternative (Figure 4-3) would entail:

- Removing the dam, contaminated sediment, and nearshore armoring and fill.
- Removing and relocating the road bridge upstream of the dam.
- Removing fill at the dam, road bridge, former mill site, along the road and railroad alignment, and at an isolated location just upstream of the former mill.
- Relocating lower Chambers Creek Road, major infrastructure (transmission and collection systems), and local utility services, and removing the inactive railroad tracks to the former mill.
- Daylighting and restoring Garrison Springs Creek and No Name Creek in the adjacent ravine, which runs through the former mill property.
- Replacing the railroad berm and shorter causeway with a full spanning trestle.
- Removing the covered boat moorage and marina currently located between the BNSF railroad and the historic barrier beach.

- Removing the marina armoring, fill, and buildings on the historic barrier beach.
- Restoring/protecting the historic tidal wetland bench along the north shoreline near the mouth while protecting known archaeological/cultural resources in that location.
- Removing invasive vegetation and replanting with native vegetation.
- Replacing, relocating, and/or acquiring existing surface water resources (e.g., via new groundwater or surface water rights) and related infrastructure.

The partial restoration alternative would include (Figure 4-4):

- Removing the dam, potentially contaminated sediment, and nearshore armoring and fill.
- Restoring the former paper mill site through a more limited daylighting of Garrison Springs Creek, removing shoreline armoring and some fill, a more limited setback of Chambers Creek Road/utility alignment away from the shoreline, and regrading and revegetating the new aquatic and riparian areas.
- Removing the inactive railroad track downstream of the former mill site, relocating the road and utilities away from the shoreline, removing shoreline armoring, regrading the shoreline, and planting riparian vegetation.
- Removing invasive vegetation and replanting native vegetation along the north shoreline.
- Restoring/protecting the historic tidal wetland bench along the north shoreline near the mouth while protecting known archaeological/cultural resources in that location.
- Replacing, relocating, and/or acquiring existing surface water resources (e.g., via new groundwater or surface water rights) and related infrastructure.

The partial restoration alternative would allow more muted tidal hydrology and sediment erosion and accretion processes at the mouth of Chambers Bay compared to the full restoration alternative. The partial restoration alternative does not widen the existing opening at the mouth created by the railroad trestle. Although the limited opening may provide some tidal impoundment during outgoing tides, it is roughly the same opening width as was shown in the historic T-sheets. The partial restoration alternative would not reactivate the historic barrier beach east of the trestle. The partial restoration alternative as it pertains to roads and utilities is similar to the full restoration alternative, though reduced in scale (Figure 4-4). The extent of the realignment and the amount of nearshore fill removal (Chambers Bay Road) is more limited in the partial restoration alternative. No changes are proposed to the railroad berm in the partial restoration alternative.

Based on Hughes (2002), analysis for the partial alternative found that the existing cross-sectional area of the inlet is adequate for both the exiting tidal prism and the tidal prism post-restoration. Table 4-1 summarizes the assumptions and parameters used in the evaluation.

Table 4-1. Assumptions and Parameters

Mean Tide Level (MTL)	7.67 feet (2.34 m) relative to MLLW
Existing area	2,110,393.80 SF(196,062 m2)
Existing inlet width	147.6 feet (45 m)
Proposed Partial Restoration area	2,525,773.10 SF (234,652 m2)
Proposed Partial Restoration inlet width	147.6 feet (45 m)
Average depth	9.08 feet (2.77 m) (assumed)
Median grain size of sediment	8 mm = .008 m (assumed)
Specific gravity of sediment	2.6 (assumed)
Gravity	9.81 m/s2
Effective tidal prism (existing)	19,179,077.39 cubic feet (543,091 m3)
Effective tidal prism (partial restoration)	22,954,038.63 cubic feet (649,986 m3)

Using the equations from Hughes (2002) and the above parameters, the minimum cross sectional area of the existing inlet was found to be 193.75 SF (18 square meters). Given an armored inlet width of 147.6 feet (45 meters), a depth of 1.31 feet (0.4 meters) relative to MTL is needed for the existing inlet to be stable. The current depth of the inlet at MHHW is approximately 13.12 feet (4 meters) at the deepest point; which corresponds to an elevation of 544.62 feet (1.66 meters) relative to MTL. Therefore, for existing conditions there is more than the required cross-sectional area necessary for the inlet to be considered as stable.

For the proposed inlet under the partial alternative, the equations from Hughes (2002) and the above parameters found the minimum cross sectional area to be 226.04 SF (21 square meters). Given the existing conditions, the partial restoration inlet is also considered stable. In contrast to the full alternative, the partial restoration alternative was developed to: (1) avoid impacts to the BNSF railroad, and (2) preserve the existing marina. Changes to the railroad were considered likely to be infeasible given BNSF's requirements of no interruption in service and ongoing operations and maintenance. The marina represents an active business that is likely to remain.

An overview of the key components of the full and partial restoration alternatives is provided in Table 4-2.

Table 4-2. Key Design Elements

Element	Full Restoration	Partial Restoration
Chambers Creek Dam	Remove dam structure, support buildings, and abutment fill	Same as full restoration
Impounded Sediments	Remove impounded sediments behind dam	Same as full restoration
Water Pumping Facilities	Replace, relocate, and/or acquire existing surface water resources (new groundwater or surface water rights) and related infrastructure	Same as full restoration
Chambers Creek Road Bridge	Replace bridge with full span, remove abutment fill, and replace utilities at bridge crossings	Similar to full restoration but with less realignment and fill removal
Mill Site Fill	Remove fill to re-establish historic MHHW line at the Mill Site; plant estuarine marsh and backshore beach	Remove fill to daylight Garrison Springs Creek; plant estuarine marsh and backshore beach
Garrison Springs Creek	Daylight creek	Same as full restoration
Unnamed creek	Daylight creek	Daylight mouth of creek; replace culvert under Chambers Creek Road
Inactive Railroad	Removal inactive rail spur within Mill Site and to east	Same as full restoration
Lower Chambers Creek Road	Realign roadway into railroad spur footprint; new bridge across Garrison Springs Creek; flatten slopes of road armoring; replace large riprap with smaller shoreline erosion protection aggregate; realign utilities as necessary for new road alignment; remove bulkhead	Similar to full restoration, but no bulkhead removal
Marina	Remove marina structures in upland and in-water areas; remove marina fill and paving on historic sand spit/barrier beach; restore barrier beach	No change from existing condition
BNSF Railroad	Remove existing active rail, railroad berm fill, and railroad bridge, replace with full-span rail bridge	No change from existing condition

4.3.2 Restoration Features – Primary Process-Based Management Measures

Armor Removal/Modification

The south bank of Chambers Creek along Chambers Creek Road is heavily armored with quarry spall and larger rock riprap to protect the road. Both the full and partial restoration alternatives entail shifting Chambers Creek Road further from the shoreline, into the alignment of the abandoned BNSF spur and portions of the mill site property.

Shifting the road will allow the slope to be flattened as described under *Topography Restoration* below. This flattening would eliminate the need for rock armoring in many areas, and reduce the size of armor needed in constrained areas where the road cannot be significantly moved. Where armor is still required on the newly graded steeper slopes, the armor would be further modified by placement of an overlay of finer-grained substrate to fill the interstices of the armor (see *Substrate Modification* section below).

South of the mill site it is assumed that the roadway would shift approximately 20 to 30 feet under the full and partial restoration alternatives. At the mill site, the road is assumed to shift even farther.

Unique to the full restoration alternative, additional armor will be removed from the Chambers Creek Estuary. As part of the railroad berm removal, armoring associated with the berm fill would be removed. In addition, armoring currently protecting the shoreline of the marina would be removed under the full restoration alternative. Neither area of armoring would be changed under the partial restoration alternative.

The full restoration alternative results in approximately 8,100 LF of armor removal along the rail causeway, at the marina, at the mill site, and along Chambers Creek Road south of the mill. The size of the armor to be removed will be determined during subsequent design phases. The full restoration alternative also results in 1,000 LF of armor modification along the Chambers Creek Road corridor where access is constricted; buried armor would be used with an overlay of finer grained substrate. The partial restoration alternative results in approximately 2,900 LF of armor removal at the mill site, and 1,000 LF of armor modification.

Berm or Dike Removal/Modification

The full restoration alternative includes removal of the BNSF berm fill at the mouth of Chambers Bay, and replacement of this fill with an elevated railway trestle (Figure 4-3). As part of this work, the existing BNSF drawspan bridge would be removed. Based on LiDAR topography, the crest elevation of the berm is interpreted to be elevation 24.7 feet MLLW (21 feet NAVD88), with a crest width of approximately 25 feet and side slopes estimated to be 2H:1V. Removal of approximately 1,300 LF of the berm would entail excavation of an estimated 68,000 CY of material (not including the armor removal discussed elsewhere) under the full restoration alternative. BNSF would be in favor of an action that would remove the drawspan, as maintaining and operating this span impacts BNSF operations on this portion of the rail corridor.

Under the partial restoration alternative, the berm would remain and there would be no change in this area (Figure 4-4).

Channel Rehabilitation/Creation

Under the full and partial restoration alternatives, the dam across Chambers Creek would be removed (see *Hydraulic Modification* section below). This dam was constructed in 1938 (Pierce County 2010) and is listed as 22 feet high (no elevation or reference datum provided) in the Washington dam database. It is presumed that during its operation, sediment has been impounded on the upstream side of the dam, although the thickness of impounded sediments is unknown.

Following dam removal, it is anticipated that impounded sediments will be scoured and transported downstream. In order to control the rate of scour and to minimize unintended consequences associated with this downstream transport of sediment, the full and partial restoration alternatives include some excavation of the impounded sediments to create a preferential channel for the initial flow of the restored Chambers Creek.

For estimate purposes, it is assumed that up to a 3-foot-deep channel would be created (Figures 4-5 and 4-6). Considering typical dredging tolerances, the volume estimate also includes an additional 2-foot allowable overdredge, resulting in a total volume based on an assumed 5-foot thickness of sediments excavated from a channel behind the dam prior to dam demolition. The actual thickness of impounded sediments, as well as sediment quality (chemistry), and design of the channels, would need to be confirmed during detailed design. Removal of up to 5 feet of sediments would result in a volume of 7,300 CY.

Groin Removal/Modification - NA

Hydraulic Modification

Both the full and partial restoration alternatives entail the removal of the Chambers Creek dam and the associated abutment fill and supporting structures (Figures 4-3 and 4-4). State dam records (Ecology 2010) list the dam as an earthen structure and indicate a crest length of 170 feet; aerial photography indicates that the visible spillway portion of the dam is 100 feet wide. The dam is listed as 22 feet high, and the spillway crest is interpreted to be at approximate elevation 16.7 feet MLLW (13 feet NAVD88) based on LiDAR records.

Removal of the dam would entail excavation of an estimated 6,200 CY of fill in the spillway area, as well as appurtenant structures such as sheet piles and fish ladder. Removal of the additional fill associated with the dam abutments is discussed under *Topography Restoration* below.

Overwater Structure Removal

Under the full restoration alternative, 77,100 SF of overwater structures associated with the floating docks and covered boat slips at the marina would be removed. The partial restoration alternative does not include overwater structure removal.

Topography Restoration

Topography restoration would occur in multiple locations under both the full and partial restoration alternatives. At the dam, fill from both abutments would be removed. Under the full and partial restoration alternatives, this amounts to an estimated 90,100 CY of removal.

Under the full restoration alternative, 236,000 CY of fill from the former mill site would be removed (Figures 4-3 and 4-5). Under the partial restoration alternative, an estimated 144,000 CY of fill would be removed to daylight Garrison Springs Creek and to provide a setback for Chambers Creek Road through the mill site (Figures 4-4 and 4-6).

Under the full restoration alternative, south of the mill site, an estimated 11,000 CY of fill would be removed (including bulkhead backfill) to realign Chambers Creek Road. Under the partial restoration alternative, an estimated 3,700 CY of fill would be removed in this area.

At the marina, an estimated 46,600 CY of fill would be removed under the full restoration alternative to restore the historic topography of the sand spit/barrier beach that existed before the railroad berm was constructed. No fill would be removed from this area under the partial restoration alternative.

Across the creek from the marina, the tidal wetland would be restored through excavation of fill. Based on a review of LiDAR topography, an estimated 2 feet of material would be excavated over 1 acre under both the full and partial restoration alternatives, resulting in 6,500 CY of removal.

4.3.3 Restoration Features – Additional Management Measures

Beach Nourishment

Beach nourishment applies to the full restoration alternative in the areas that will be directly affected by the removal of the railroad causeway and marina. Historically, this area was a sand spit/barrier beach, and excavation of fill (as discussed under *Topography Restoration*) will restore grades here. At the barrier beach, the quality of the material that will be exposed at the base of the excavation during topographic restoration is unknown. In addition, a limited sediment supply from the armored drift cell to the south is impacted by the presence of the railroad. Therefore, it has been assumed that once the restored grade has been established, some beach nourishment will be necessary to provide a more natural barrier beach substrate on the excavated surface.

The full restoration alternative includes 4.1 acres of beach nourishment in the area of the topography restoration in the marina, with an assumed depth of 2 feet of beach nourishment fill consisting of sand and gravel. Because this area is unchanged in the partial restoration alternative, there is no beach nourishment associated with that action.

Contaminant Removal/Remediation

The potential for contamination of fill material at the mill site has been identified, and targeted removals of contaminated soils have been completed at the site. This work was accomplished by the landowners under a Remedial Investigation/Feasibility Study process in cooperation with Ecology (CH2MHill 2007). While it is believed that most contaminated soil has been removed from the site, there is the potential for additional contaminated soils to be present.

The full and partial restoration alternatives remove significant amounts of fill associated with the mill. Because the potential for soil contamination is unknown, an allowance of 2,000 CY has been assumed to be contaminated for the full restoration alternative, and 1,000 CY for the partial restoration alternative.

In addition to soils associated with the former mill site, impounded sediments are proposed for removal behind the dam. It is unknown whether contamination is present in impounded sediments. However, it is possible that contamination may be present based on historic and court evidence of extensive use of copper sulfate for algae treatments in Lake Steilacoom, and urban runoff/spills from the Tacoma Landfill and residential/commercial areas of West Tacoma, Fircrest, University Place, and Lakewood (Pierce County 2010). The estimates assume 50% of the material excavated as impounded sediments is at or above thresholds requiring remediation. This equates to approximately 3,500 CY of sediment for the full and partial restoration alternatives. This assumption is unverified and has been made for planning purposes only. The nature and extent of potential contamination will need to be determined during subsequent design.

It would be important to remove all contamination from impounded sediments (even beyond the footprint of removal depicted in Figures 4-3 and 4-4) prior to dam removal in order to prevent the potential redistribution of contamination downstream after the dam is removed.

Full restoration includes removal of fill at the marina. There are no known or documented sources of potential contamination in this fill, and thus it has been assumed that additional contaminated soil removal would not be required in this area under the full restoration alternative. The soil quality at the marina will need to be more fully evaluated to confirm this assumption during subsequent design.

There is a data gap regarding the potential presence and/or distribution of contamination at the mill site, in impounded sediments, and at the marina. Additional chemistry data would need to be collected during subsequent design phases to more fully understand the potential volumes and costs associated with contaminant removal, and the net benefit of implementing this management measure for each restoration alternative in the Chambers Bay Estuary.

Debris Removal

Under the full and partial restoration alternatives, derelict creosote piles would be removed from the estuary. Most of the piles identified appear to be associated with a historic dock that may have been present in the marina area. Based on review of shoreline aerial oblique photos, an allowance for removal and disposal of up to 150 piles has been included, although an actual inventory would need to be made during detailed design.

In addition to derelict piles, there is occasional debris, including concrete rubble, along the shoreline. The amount and distribution of debris has not been quantified. For estimating purposes, an allowance for up to an additional 100 tons of debris removal and disposal has been assumed for the full and partial restoration alternatives. This allowance would need to be reevaluated during detailed design.

Invasive Species Control

Invasive species will be removed and replaced from multiple areas under both the full and partial restoration alternatives, as described under the *Revegetation* discussion. Due to the heavy Himalayan blackberry and Scot's broom presence on the north slope of Chambers Bay, it has been assumed that an herbicide suitable for use near aquatic environments would be applied after clearing and grubbing this 8.4-acre area.

Large Wood Placement - NA

Physical Exclusion - NA

Pollution Control - NA

Revegetation

Portions of the hillside on the north bank of Chambers Bay are currently covered by non-native invasive vegetation. In addition, removal of fill at the former mill site and along Chambers Creek Road will present opportunities for revegetation of riparian corridors and replacement of impervious pavement with native plant species. In both the full and partial restoration alternatives, approximately 8.4 acres of the slope north of Chambers Bay would be cleared of invasive plants and revegetated with native species.

Revegetation with emergent estuarine marsh and backshore beach species would be performed as part of the restoration of the tidal wetland near the marina on the north side of Chambers Bay under the full and partial restoration alternatives. An estimated 1 acre would be revegetated with estuarine and backshore beach species. Additional estuarine species growth and development is expected to occur naturally (without planting) on the restored barrier beach and at the former marina under the full restoration alternative. Additional colonization by estuarine marsh species is anticipated upstream of the dam removal and at the former mill site. The precise area is difficult to quantify due to anticipated changes in sediment distribution affecting tidal elevations in these areas. The extent of predicted estuarine marsh colonization in these areas will be determined in subsequent design phases.

Finally, under the full restoration alternative, an estimated 6.7 acres of land at the mill site and along the Garrison Springs Creek corridor would be revegetated with native riparian vegetation after fill is removed, pavement demolished, and the stream daylighted. An estimated 1.9 acres of native riparian revegetation would be included at these locations under the partial alternative.

Reintroduction of Native Animals - NA

Substrate Modification

Substrate will be modified in areas where shoreline excavation (i.e., topography restoration) is performed under both the full and partial restoration alternatives. Because of the unknown quality of material that will be exposed on the excavated surface, it has been assumed that a 2-foot-thick overlay of sand and gravel (below the MHHW line) would be applied to restore the excavated surface to more natural conditions. Above MHHW, a transition to topsoil will occur to support riparian vegetation. For both the full and partial restoration alternatives, an estimated 2.4 acres of substrate would be modified in the area topographically restored at the dam abutments.

For the full restoration alternative, it has been estimated that 8.1 acres of substrate would be modified at the mill site with similar material as at the dam abutments.

Under the partial restoration alternative, it is assumed that 6.2 acres of substrate would be modified at the mill site.

Species Habitat Enhancement - NA

4.3.4 Restoration Features – Other

NA

4.3.5 Land Requirements

Construction of this action will affect of 43.5 acres of private and public lands with a variety of land uses. Land ownership is a combination of public and private. Private parcels and some public parcels/rights (approximately 31 acres) would need to be acquired via purchase, easement or other similar means in full or in part for both restoration alternatives. Major transmission/collection systems and local utilities would need to be relocated under Chambers Creek Road, and at the Chambers Creek Road bridge crossing upstream of the dam.

For the full restoration alternative, an estimated 12.4 acres of public land and 31.1 acres of private land would be directly affected by the action. For the partial restoration alternative, an estimated 11.9 acres of public land and 9.5 acres of private land are directly affected.

4.3.6 Design Considerations

The dam provides impounded water for use by Pierce County, the former paper mill and WDFW. Significant quantities of perfected and senior water rights are directly associated with the dam and its impoundment. Source replacement and compensation for these water rights and water quantities will need to be addressed prior to removal of the dam and upstream sediment (Pierce County 2010). For conceptual design, it was assumed that replacement or relocation of the existing infrastructure may be needed after dam demolition. An analysis of water rights and these facilities will be conducted in a future design phase.

The dam is also used as a fish capture and acclimation facility and to collect hatchery broodstock, so the design must consider an alternative facility option to serve that function. Preliminary discussions between the local proponent and WDFW have identified the potential to relocate the hatchery operations to Garrison Creek at the former paper mill site after the culverted portion of the creek drainage has been daylighted. A feasibility analysis of hatchery relocation will be conducted in a future design phase.

The dam and the WDFW capture and acclimation facility currently restrict upstream passage of all fish species (non-hatchery species are currently released to continue upstream). Through preliminary discussions, the local proponent has learned that NMFS has a concern about non-native Chinook entering the Chambers Creek system because this would negatively impact a naturally spawning wild population.

Potential contamination of sediment upstream of the dam and at the former paper mill is also an important consideration. Both of these issues will require further investigation during subsequent phases of design.

Chambers Creek Road is a major route connecting University Place and other communities to the north (Tacoma, Fircrest, Gig Harbor, etc.) with the town of Steilacoom, cities of Lakewood and DuPont, Joint Base Lewis-McChord, and I-5. Lower Chambers Creek Road/Lafayette Street is an important and highly traveled commuter and local traffic route with an average of more than 9,300 vehicles per day (Pierce County 2010). Vehicular access must be maintained on this route. Maintaining emergency access is a requirement along this route as there are limited arterial routes into and out of Steilacoom.

Right-of-way acquisition and issues with relocating a portion of the road, utilities, and the creek bridge could be significant. Because of the constrained width of the roadway corridor in the area of the bulkhead, a new, shorter bulkhead may be required to support Chambers Creek Road so that flatter, more natural slopes could be created in the estuary in front of the bulkhead under the full restoration alternative. The constrained Chambers Creek roadway corridor also presents a limitation on potential roadway setbacks, and thus limits the degree to which creek slopes can be flattened in some areas. Depending on hydraulic modeling that would need to be completed during detailed design, some areas might require larger armor rock to be placed to ensure the stability of the roadway corridor. If those conditions are identified during detailed design, it is assumed the armor materials would be buried beneath a surface treatment of a more natural, habitat-compatible substrate.

For the full restoration alternative, the proposed railroad trestle will be constructed on the east side of the existing rail to maintain rail service along this corridor. The proposed double-track railway bridge would consist of 80-foot spans with modified American Association of State Highway and Transportation Officials (AASHTO) Type IV girders. Each bent would consist of 4-foot-diameter columns with 7-foot-diameter drilled shafts (Figure 4-7B and 4-8). The drilled shaft embedment depth is assumed to be 100 feet. Other bridge types such as pile-supported trestle would be investigated during later stages of design. No railway bridge is proposed for the partial restoration alternative.

The full restoration alternative has two proposed vehicle bridges (Figure 4-7). The first bridge will be approximately 370 feet long, with two spans of about 185 feet consisting of 7-foot-11-inch-deep spliced pre-cast concrete girders. The second bridge will be approximately 200 feet long, with two spans of about 100 feet consisting of 5-foot-2-inch-deep pre-cast concrete girders. Concrete bridges require very little maintenance. The current standard is to inspect bridges every 2 years.

The partial restoration alternative also has two proposed vehicle bridges (Figure 4-7). Both proposed bridges will be approximately 200 feet long, with two spans of about 100 feet consisting of 5-foot-2-inch-deep pre-cast concrete girders.

Chambers Creek Road today is a two-lane roadway with paved shoulders. A left-turn lane located at the entrance to the marina allows northbound vehicles a refuge for turning into the marina. It was likely constructed to address a sight distance deficiency and prevent rear-end collisions. The restoration concepts will bring the roadway up to the current design standards which would provide 12-foot travel lanes and sidewalks. Under the full restoration alternative, the left-turn provision is not proposed since the marina would no longer exist. Under the partial restoration alternative, the limits of roadway improvements do not extend to this area.

There is a gap in improvements along Chambers Creek Road under both alternatives between the existing mill site and the bridge over Chambers Creek (within unincorporated Pierce County). Improvements to add sidewalks and accommodate parking have not been included as part of the restoration at this time; however, during design, inclusion of sidewalks along this portion should be evaluated through consultation with Steilacoom, University Place, and Pierce County Public Works. Between the former mill and the bridge, the shoulders are heavily used for on-street parking, and to provide access to off-street areas also used for parking.

The changes to the Chambers Creek Road alignment and replacement of the bridge over Chambers Creek pose significant impacts to utilities and cultural resources known to be located in that area (currently protected by roadway). Along Chambers Creek Road, 5,100 LF of overhead distribution power lines would require relocation with the full restoration alternative, and 2,500 LF will be relocated under the partial restoration alternative (Figures 4-3 and 4-4). This includes a portion along the limits of the proposed realignment near the mill site and at the creek crossing, where it has been assumed that poles will need to be relocated and wires raised. This is because the new bridge will be at a higher elevation, and due to changes to the topography as a result of the dam removal and changes to the roadway.

A water main and sanitary sewer force main also run the length of Chambers Creek Road within the action area limits. These too would be relocated within the same limits as described for the electrical lines above, and would be supported from the bridges at the water crossings. The water main today crosses Chambers Creek on a series of piles. Assuming that the pile-supported water main may be compromised once the dam is removed and the topography changes, the water main and sewer force main would be relocated to the bridge.

Intersection improvements would be needed at the north end of the bridge to transition the roadway to the existing grades. Improvements would include grading and paving. The intersection is not signalized today and the improvements are not expected to warrant a new signal. There are a significant number of utilities in this intersection including a sewer lift station, electrical duct banks and manholes, high-pressure gas, water, and sewer. Some adjustments to final grade are anticipated for the lift station manhole, and it has been assumed that some relocation of the other utilities will be necessary due to unavoidable conflicts during construction. For conceptual design it was assumed that adjustments may be required for approximately five sanitary sewer manholes (including the lift station), four water valves, four gas valves, one telecommunication vault, and one electrical vault.

All of the proposed improvements to Chambers Creek Road would require stormwater flow control and water quality treatment to current standards. The design of these facilities will be part of a future design stage.

The proponent has stated a need for stakeholder and public coordination during subsequent phases of design given the scope of this action and multiple stakeholders involved (SPSSEG 2010).

4.3.7 Construction Considerations

The restoration work would be performed using commonly available demolition and earthwork equipment, from both the water and land. Excavation of impounded sediments under the full and partial restoration alternatives would need to be performed before or in conjunction with dam removal in order to minimize the downstream transport of sediments after the dam is completely removed.

The utility and bridge crossings upstream of the dam create difficult constraints for conventional mechanical excavation equipment and methods. It may be necessary to use hydraulic excavation methods due to limited clearance beneath overwater utilities and between utility and bridge foundation supports. If mechanical excavation methods are feasible, access for staging mechanical equipment is limited. A portable, flexi-float type barge would need to be lifted into the Chambers Creek dam impoundment in pieces, and assembled once in the water to support a mechanical dredging operation.

Prior to topography restoration at the dam, upland structures and supporting utilities would need to be demolished. The dam includes sheet pile bulkheads and a sheet pile fish ladder that would be demolished as well.

For the proposed vehicle bridges, a drilled-shaft oscillator would be used to install the drilled shafts. To eliminate access challenges for installation of the center pier foundation at the Chambers Bay Creek crossing, a single-span bridge should be considered during later stages of design. It is assumed that the contractor will be able to install one shaft per week. Large-diameter casing shoring would be required to keep out water and allow access to the top of the shaft for column form placement and removal. Once the shafts are installed, the columns are cast inside the shoring casing. After the casing is removed, the cast-in-place pilecaps and bridge superstructure are constructed.

Limited-duration closures of the roadway during construction of the Chambers Creek bridge have been assumed to be feasible (based on post-earthquake related closure impacts). A detour would be established to direct traffic to and from the town of Steilacoom to follow Steilacoom Boulevard SW to Custer Road SW and then to Bridgeport Way West as an access route to Lakewood and University Place. Coordination with Public Works and emergency services would be needed during design to verify this plan would be acceptable. Maintaining local access from the south (via Steilacoom) and from the north (via University Place) would be required as there are existing developments and critical facilities lacking other access options. The alternative to closing Chambers Creek Road during bridge construction would be to construct the new bridge on an alignment offset from the existing alignment.

Realignment of Chambers Creek Road south of the bridge would be done after demolition of the mill site and the abandoned BNSF rail spur. During road realignment, traffic flow on the existing road would need to be maintained due to the critical nature of this roadway. Thus Chambers Creek Road will remain open to traffic during most of construction. Within certain limits, however, the roadway will be restricted to a single lane with flaggers and spotters for a period of time.

Under both the full and partial restoration alternatives, topography restoration at the mill site would need to be staged so that the existing road could be maintained while the Garrison Springs Creek excavation occurred, and while the new bridge over Garrison Springs is constructed. Once a new alignment of Chambers Creek Road is in operation, removal of the existing road and topography restoration along the shoreline in this area could be completed.

Under the full restoration alternative, the bulkhead supporting Chambers Creek Road would not be demolished until the roadway was realigned and in operation.

The BNSF causeway provides significant wave protection to Chambers Bay. Under the full restoration alternative, removal of the causeway would be one of the last restoration actions taken so that the remainder of the restoration upstream of the causeway could be completed under relatively protected conditions. In order to remove the causeway, a parallel alignment for the BNSF railroad would need to be constructed so that train service could be maintained during construction.

Building along the same rail alignment was not assumed possible given the challenges with removing the drawspan bridge while maintaining regular bridge traffic. With the inboard alignment, piles or drilled shafts would likely need to be installed from a barge. Once the drilled shafts are installed, the basic construction sequence would be casting the columns and pilecaps, setting the bridge girders with a crane, and finally placing the ballast, ties and rail. New track connections to the existing rail will be required to be constructed by BNSF union workers.

Under the full restoration alternative, structures would need to be demolished and utilities and pavement removed before grading work would be completed at the marina.

The full restoration alternative is expected to require approximately 3 years for construction. The partial restoration alternative is expected to require 2 years for construction. Property acquisition, design development, and permitting timelines are not included in these durations. However, in both alternatives, the time required to complete these upfront activities is expected to be substantial.

It is assumed for full and partial restoration that all excavated and demolished materials will be disposed of offsite in an upland location. Specific disposal sites will need to be identified in later design phases, but are assumed to be within 20 miles of the project site. Certain materials are expected to contain contaminants and will require disposal at licensed facilities.

Staging and stockpiling is assumed to occur on one or more of the upland areas at the former mill site or adjacent to the dam. If this space is not adequate or permittable, arrangements for additional space will need to be made with Pierce County Sewer Utility for use of County lands to the west and north of the action area.

4.4 Extent of Stressor Removal

Table 4-3 presents the amount of stressor removal under both the full and partial restoration alternatives.

Table 4-3. Stressor Removal

Stressor	Full Restoration	Partial Restoration
Tidal Barrier (LF)	1,300	0
Fill (acres)	19.5	10.0
Armor (LF)	9,000	2,900
Nearshore Roads (LF)	2,985	1,979
Railroad (LF)	0 (see tidal barrier and breakwater/jetty	0
Marinas (acres)	4.1	0
Breakwaters & Jetties (LF)	1,300	0
Dams (LF)	100	100

4.5 Expected Evolution of the Action Area

Following full restoration, the opening at the mouth of the newly restored estuary and across the intertidal mudflats within Chambers Bay will migrate, erode, and accrete as part of natural tidal hydrodynamic and sediment transport processes. The new tidal channel network excavated from the impounded sediments will likely become more complex than the single tidal starter channel that will exist immediately following construction.

Sediment deposition within Chambers Bay will be affected due to increased tidal currents into and out of the restored estuary. Substantial sediment from erosion of impounded materials is anticipated to deposit within the restored estuary, as well as along the shoreline, and may also be carried farther out into Puget Sound due to larger ebb tide currents. The degree to which this is expected to occur will be evaluated during a subsequent design phase.

The sediment deposition, freshwater inputs, and tidal hydrology within the restored estuary will support development of a more complex tidal channel network in the area of the current dam impoundment. Littoral transport along the shoreline will be affected by tidal currents into and out of the estuary, which may change the location and extent of shoreline features adjacent to the estuary mouth including the restored barrier beach.

The floodplain within the restored upper estuary (dam impoundment) will change dramatically from existing conditions following construction. The type and extent of vegetation will change within the restored upper estuary, as the environment shifts from primarily freshwater marsh in the reservoir to salt marsh and tidal channels. In addition, the impounded sediments from the dam will only be partially removed. The removal of the dam will result in a sustained lowering of the grades upstream of the current dam to a future equilibrium condition that will be lower than current grades where sediment has deposited.

Increased tidal flow and wave energy into the estuary will increase topographic and habitat complexity. Sediment transport processes (due to increased tidal and wave energy in the estuary) will induce patterns of sediment erosion (in tidal channels) and deposition (in backwater areas) within the estuary.

A feasibility analysis of fish hatchery relocation will be conducted in a future design phase. If the fish hatchery were relocated after the removal of Chambers Creek dam, and subsequently replaced within the estuary, Garrison Springs would likely serve as the new location for salmon broodstock rearing. At the mouth of Chambers Bay, the BNSF railroad would continue to operate, but on an elevated trestle. However, the former sand spit/barrier beach at the present-day marina would be sustained through wave and tidal action, sediment transport from the drift cell to the south of the action area, and sediment discharges from Chambers Bay. Because sediment supply updrift and downdrift of the mouth of Chambers Bay will not be improved under either restoration alternative, the sand spit/barrier beach may require periodic monitoring and maintenance, including beach nourishment, if sediment sources are not adequate to ensure its continued function.

Under the partial restoration alternative, the evolution of the action area with respect to the Chambers Creek dam removal is similar to what would be expected under the full restoration alternative. Because the railroad berm is maintained under this alternative, wave energy would continue to be significantly more muted in the estuary. As a result, the development of channel complexity may be more limited and occur over a longer time than under the full restoration alternative. In addition, sediment transport within the bay will also occur over a longer timeframe than with full restoration.

4.6 Uncertainties and Risks

Full and partial restoration of the Chambers Bay Estuary present several uncertainties, risks and significant costs. The inability to acquire privately and publicly owned lands , such as the former mill site, dam and impoundment, the inactive railroad tracks, and the covered boat storage and marina (due to cost considerations, legal constraints and/or landowner willingness), could put some of the restoration objectives at risk.

Removal of the dam will potentially alter flood risks within Chambers Bay. The southern shoreline is presently within the A1 Zone on FEMA flood insurance maps. Increased fetch from removing the railroad berm in the full restoration alternative may increase the potential for wave setup and runup along the southern shoreline. The potential change in flood risks will need to be evaluated in more detail in subsequent design.

Pierce County has significant perfected and senior water rights and water quantities associated with the dam and its impoundment (Pierce County 2010). Under both the full and partial restoration alternatives, removal of the dam would require securing replacement water rights from another source. The dam also supports a WDFW fish hatchery. The former paper mill and WDFW also have water rights and appropriations. Removal of the structures around the dam would necessitate eliminating the hatchery, which may require replacement elsewhere, as well as potential resolution of water rights issues.

The former paper mill and sediments impounded above the dam very likely contain contaminants (based on historic information and current land uses in the watershed). The potential presence of contamination in marina fill soils is currently unknown. The nature and extent of contaminants in all these areas will need to be determined as part of subsequent design. Restoration actions would need to be coordinated with site cleanup.

Known and documented locations of pre-settlement cultural resources are currently protected by the bay's configuration, lower Chambers Creek Road, and existing infrastructure. While restoration aims to restore these pre-settlement conditions, there is some risk of encountering cultural resources with significant excavation activities. As the former paper mill site was created by hydroblasting adjacent hillsides to fill that portion of the bay, it is highly unlikely that the daylighting of the culverted extension of Garrison Springs would encounter any cultural resources (Pierce County 2010). The risks, costs and uncertainties will require further investigation.

Chambers Creek Road is a major arterial with average daily traffic of 9,300 vehicles. Restoration would need to preserve this capacity. Temporary traffic routing would be required through tight corridors to accommodate realignment of the road and bridge replacement. The roadway and action area contain significant corridors for major transmission/collection facilities and local utilities services. The financial and engineering feasibility of relocation of these facilities needs to be determined. These apply to both the full and partial restoration alternatives.

4.6.1 Risks Associated with Projected Sea Level Change

Sea level change is not believed to be a major issue with restoring the habitats in the bay due to the topography and public ownership. One risk and uncertainty at the barrier beach if the trestle is replaced is the lack of sediment supply from the historic drift cell to the south. This shoreline is now substantially armored by the BNSF railroad and may not have the available sediment supply to support this barrier beach spit. However, this risk and uncertainty is balanced by the sediment supply from within the Chambers Creek watershed and that is impounded by the dam. Once the dam is removed, only limited sediment is proposed to be removed to implement the restoration. The remaining accumulated sediment will be transported downstream over an extended period.

Estuarine habitat is expected to retreat further upstream into the Chambers Creek valley in response to sea level change. Given the steep walls of the creek upstream of the dam, sea level change has the potential to constrain the footprint of estuarine habitat compared to conditions that would exist during the period immediately following dam removal.

In terms of infrastructure, if a trestle replaces the BNSF berm and inadequate sediment supply results in significant barrier beach erosion, wave energy within the bay will increase and could threaten Chambers Creek Road if it is not raised and is no longer armored.

Table 4-4 compares potential risks associated with projected sea level changes based on professional judgment.

Table 4-4. Risks of Sea Level Change

	Projected Sea Level Change		
	High (65 cm)	**Intermediate (21 cm)**	**Low (13 cm)**
Full Restoration	Estuarine habitat would be expected to retreat upstream in response to sea level change; in steep walled areas upstream of the dam, the area available for estuarine habitat is expected to become constrained by projected sea level rise Rail causeway will be replaced by a trestle that can be designed to accommodate sea level change; the current elevation of the existing causeway, 24.7 feet MLLW (21 feet NAVD) 88, is approximately 5 feet higher than the projected extreme high water elevation Chambers Creek Road - inundation would be expected if the road is maintained at its current elevation of 17.7 feet MLLW (14 feet NAVD 88); the road would need to be raised to accommodate sea level change	Risks to estuarine habitat are similar, but lower than the high scenario Risks to the rail trestle are similar, but lower than the high scenario Chambers Creek Road at its current elevation would be approximately 0.4 feet higher than the projected extreme high water under this scenario wave action or creek flooding could overtop the roadway and cause erosion of the road base	Risks to estuarine habitat are similar, but substantially lower than the high scenario Risks to the rail trestle are similar to but substantially lower than the high scenario Chambers Creek Road at its current elevation would be approximately 0.7 feet higher than the projected extreme high water under this scenario; wave action or creek flooding could overtop the roadway and cause erosion of the road base

	Projected Sea Level Change		
	High (65 cm)	Intermediate (21 cm)	Low (13 cm)
Partial Restoration	Estuarine habitat would be expected to retreat upstream in response to sea level change; in steep walled areas upstream of the dam, the area available for estuarine habitat is expected to become constrained by projected sea level rise The rail causeway would be subject to greater erosion and would be expected to require additional armoring to accommodate sea level change Chambers Creek Road inundation would be expected if the road is maintained at its current elevation of 17.7 feet MLLW (14 feet NAVD88); the road would need to be raised to accommodate sea level change under this scenario	Risks to estuarine habitat are similar, but lower than the high scenario Risks to the rail causeway are similar to but lower than the high scenario, plus the erosive forces would be marginally lower Chambers Creek Road at its current elevation would be approximately 0.4 feet higher than the projected extreme high water under this scenario; wave action or creek flooding could overtop the roadway and cause erosion of the road base	Risks to estuarine habitat are similar, but substantially lower than the high scenario Risks to the rail causeway are similar to the high scenario but substantially lower, plus the erosive forces would be lower Chambers Creek Road at its current elevation would be approximately 0.7 feet higher than the projected extreme high water under this scenario; wave action or creek flooding could overtop the roadway and cause erosion of the road base

4.7 Potential Monitoring Opportunities

Monitoring is important for evaluating restoration success. A combination of field surveys and aerial photographs would be used to document biological and physical changes to the landscape. Monitoring data can be used to refine adaptive management and corrective actions, as needed. Some of the main monitoring needs and opportunities associated with this action are summarized in Table 4-5.

Table 4-5. Monitoring Needs and Opportunities

Monitoring Parameter	Key Performance Indicator	Note
Topographic Stability	X	Monitor sand spit/barrier beach
Sediment Accretion / Erosion	X	Monitor opening at the mouth of newly restored estuary and across the intertidal mud flats; monitor erosion of impounded materials and deposition within Chambers Bay; monitor littoral transport along the shoreline adjacent to the estuary mouth and restored barrier beach
Wood Accumulation		

Monitoring Parameter	Key Performance Indicator	Note
Soil / Substrate Conditions		
Vegetation Establishment	X	
Marsh Surface Evolution / Accretion		
Tidal Channel Cross-Section / Density	X	Monitor new tidal channel network excavated from the impounded sediments
Water Quality (contaminants)		
Salinity	X	Monitor temperature/salinity in the estuary
Shellfish Production	X	
Extent Of Invasive Species		
Animal Species Richness	X	
Fish (salmonid) Access/Use	X	Monitor changes in fish access/ use upstream of dam
Forage Fish Production		
Wildlife Species Use		
Effectiveness Of Exclusion Devices		

4.8 Information Needed for Subsequent Design

This conceptual design report represents an initial step in the restoration design sequence. The design concepts described above were developed based on readily available information without the level of site-specific survey and investigation that is necessary to support subsequent design and implementation. Substantial additional information will be required at the preliminary and later design stages to confirm the design assumptions, refine quantity estimates, address property and regulatory issues, obtain stakeholder support, and fill in data gaps. The extent to which this information is collected for preliminary design (or a later design stage) will depend upon the available budget, schedule, and other factors. This section attempts to define the most essential information needs for this action. Refer to the Introduction chapter for additional information.

- Property Investigation/Survey – More detailed information on parcel ownership, utilities, and property boundary location will be needed to finalize the design, confirm quantities and acquisition requirements, and support negotiations with property owners.
- Topographic/Bathymetric Survey – The survey data would be used to refine design of key project elements, improve quantity estimates, and develop detailed construction and demolition plans. Survey data could also be used as a baseline for pre- and post-construction modeling, including hydrodynamic modeling.
- Geotechnical Investigation –Geotechnical study and recommendations on soils and sediments will be required to finalize design of the bridge and trestle foundations, to design excavation side slopes, and to determine the location, number, and condition of derelict piles and any other significant debris fields.

- Cultural Resources Investigation – Surveys for archaeological and historic resources may be required to determine the extent of known resources (e.g., under the roadway or on the historic spit) and the potential for additional cultural resources to be present in the action area. This is particularly important in areas proposed for excavation.
- As-built Documentation – Future design efforts will need as-built plans for the Chambers Creek dam and possibly other site features. Identification and quantification of water resources, water rights, and related infrastructure within the action area will also be required.
- Hydraulic Analysis/ Modeling – Hydrological modeling may be required to determine potential flood flows and required shoreline treatments under current and future tidal conditions, including the potential effect of sea level change. This information would also be used to confirm the size of bridge and culvert openings. A temporary tide gage may be needed in the early design stages to obtain site-specific tidal statistics. For the full restoration alternative, wind/wave data collection and modeling would be necessary for the design of a trestle to replace the BNSF causeway.
- Sediment Transport Study – Modeling and assessment of sediment transport dynamics will be necessary to evaluate upstream and downstream impacts and the potential magnitude of impounded sediment erosion and migration once the dam is removed.
- Contaminant Surveys – If preliminary investigations confirm that hazardous material is present in the action area, additional soil and sediment analysis may be needed. There is potential for contamination of sediment upstream of the dam and at the former mill. The potential for contamination in marina soils is unknown. Studies to identify beneficial reuse and/or disposal options for the excavated materials may be appropriate for this action. The introductory chapter describes the Phase I site investigations that are occurring as part of this overall effort via a separate contract.
- Fisheries – Hatchery run impacts on native fish need to be evaluated in coordination with NMFS in relation to the removal of the dam and relocation of the existing hatchery.
- Water Rights – A feasibility analysis for obtaining a replacement water right to allow dam removal is needed.
- Sea Level Change Projection – Estimates of sea level change for the conceptual design were based on calculations provided by the Washington Department of Fish and Wildlife and the Corps of Engineers using guidance in Corps' Engineering Circular No. 1165-2-211. Projections for each project area will be refined using localized tide gauge data during later design stages.
- Other – Additional studies may include evaluation of alternative forms of erosion control and the use of local material for beach nourishment.

4.9 Quantity Estimates

The design quantities are largely developed from LiDAR data sets lacking the resolution to accurately quantify all elements of construction. These are supplemented by unmeasured estimates made during one site visit at high tide and areal take-offs from available imagery. The quantity spreadsheets for the full and partial restoration alternatives are provided in Exhibits 4-1 and 4-2.

4.10 References

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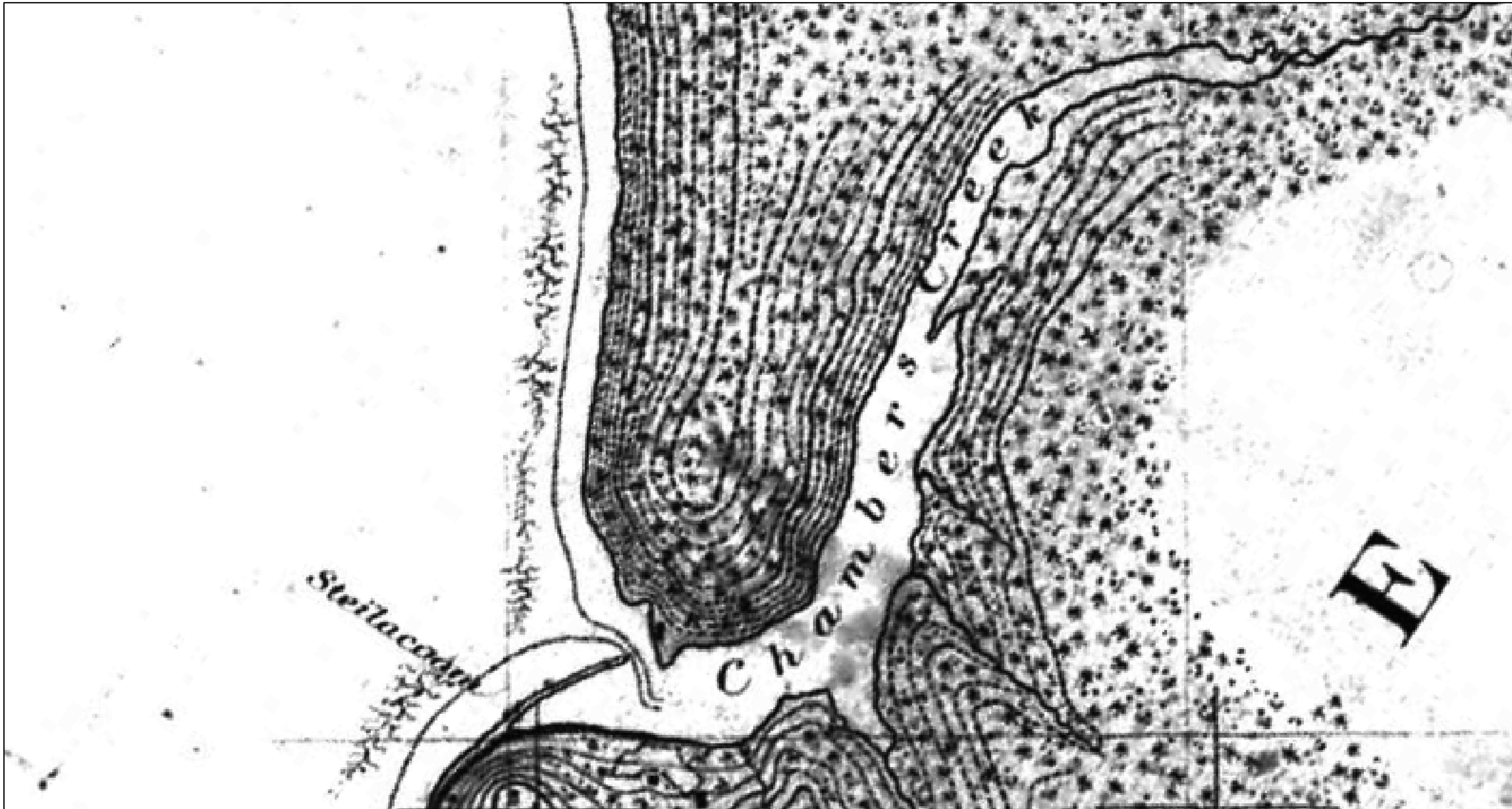
South Puget Sound Salmon Enhancement Group (SPSSEG). 2010. Comments from South Puget Sound Salmon Enhancement Group provided to WDFW on PSNERP Action Characterization Reports. November, 2010.



Feet 0 600
Meters 0 180

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

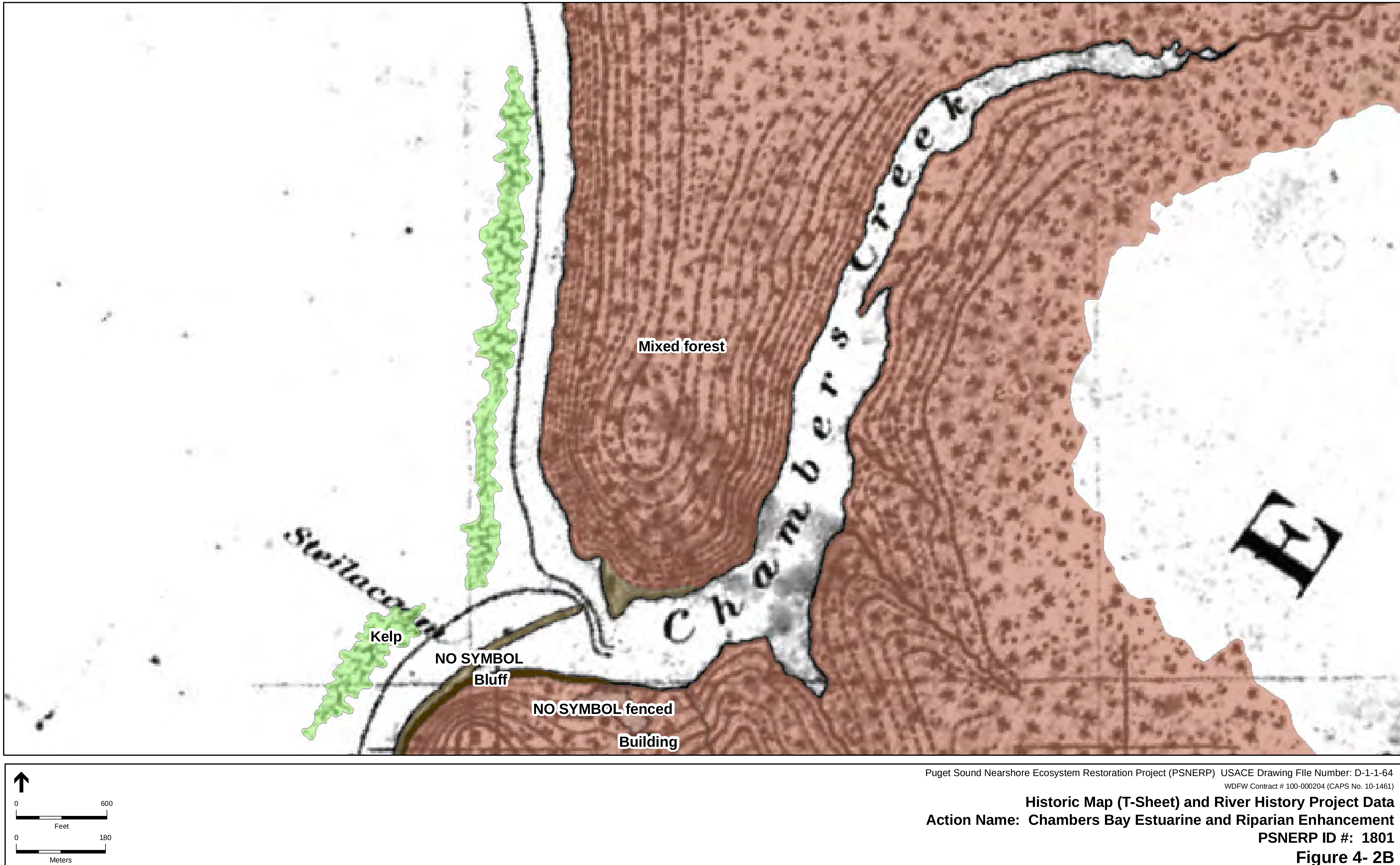
Historic Map (T-Sheet)

Action Name: Chambers Bay Estuarine and Riparian Enhancement

PSNERP ID #: 1801

Figure 4- 2A

S:\GIS\Projects\210xxx\210337_PSNERP_NEARSHORE\Projects\2-TSheets_rev.mxd (DLP; 2/24/2011)



Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64

WDFW Contract # 100-000204 (CAPS No. 10-1461)

Historic Map (T-Sheet) and River History Project Data

Action Name: Chambers Bay Estuarine and Riparian Enhancement

PSNERP ID #: 1801

Figure 4- 2B

S:\GIS\Projects\210xxx\210337_PSNERP_NEARSHORE\Projects\2-TSheets_rev.mxd (DLP; 2/24/2011)

Legend

Bulkhead	Dredging - Bucket - Marine	Bridge
Channel Rehab/Creation	Excavation - Lowland	Planting
Existing Stream	Excavation - Upland	Proposed Railway
Existing Tide MLLW	Removal - Marina	Roadway Type A
Existing Tide MHHW	Remove Buildings	Section Line
Proposed Tide MHHW	Remove Pavement	
Other - Replace Armor	Required Project Lands	
Utility Relocation		
Hydraulic Structures - Large		

CHAMBERS BAY CONVERSION

FIXED DATUM — TIDAL DATUM

MHHW

9.77

NAVD88

3.74

MLLW

0.00 FT MHHW = 9.77 FT NAVD88
-9.77 FT MHHW = 0.00 FT NAVD88
0.00 FT MLLW = -3.74 FT NAVD88
3.74 FT MLLW = 0.00 FT NAVD88

Source:
VDATUM (LAT. 47.184767, LONG. -122.580363)

PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

North 0 280 Feet

SOURCE: SOURCE: Washington Public Lands Database (2006); Washington Counties Parcels (2009)
Service Layer Credits: Image courtesy of USGS © 2012 Microsoft Corporation

Lead Contractor: ESA
Design Lead: Anchor QEA, J. LaPlante, PE
Date: 07/2012

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Plan
Site Name: Chambers Bay
Action Name: Chambers Bay Estuarine and Riparian Enhancment
PSNERP ID #: 1801
Full Restoration

Figure 4-3

Legend

- Utility Relocation
- Hydraulic Structures - Large
- Existing Stream
- Existing Tide MLLW
- Existing Tide MHHW
- Proposed Tide MHHW
- Channel Rehab/Creation
- Other - Replace Armor
- Section Line
- Bridge
- Dredging - Bucket - Marine
- Excavation - Lowland
- Excavation - Upland
- Planting
- Proposed Roadway Type A
- Remove Pavement
- Required Project Lands

CHAMBERS BAY CONVERSION

FIXED DATUM — TIDAL DATUM

MHHW

9.77

NAVD88

3.74

MLLW

0.00 FT MHHW = 9.77 FT NAVD88
-9.77 FT MHHW = 0.00 FT NAVD88
0.00 FT MLLW = -3.74 FT NAVD88
3.74 FT MLLW = 0.00 FT NAVD88

Source:
VDATUM (LAT. 47.184767, LONG. -122.580363)

PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

North

0 200
Feet

SOURCE: Washington Public Lands Database (2006); Washington Counties Parcels (2009); Bing Maps (2011)

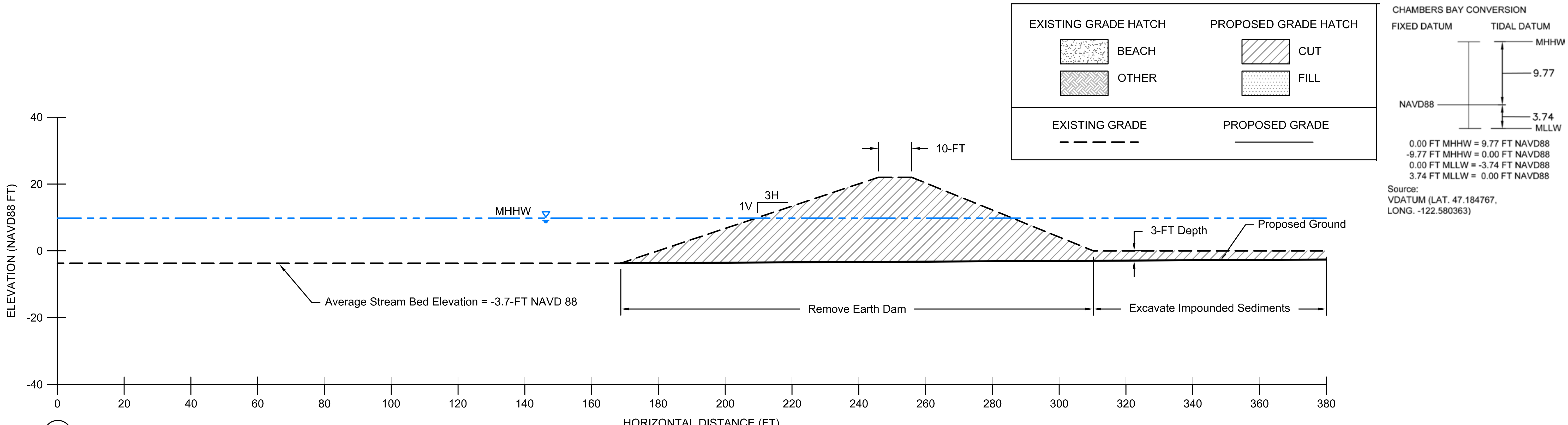
Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64

WDFW Contract # 100-000204 (CAPS No. 10-1461)

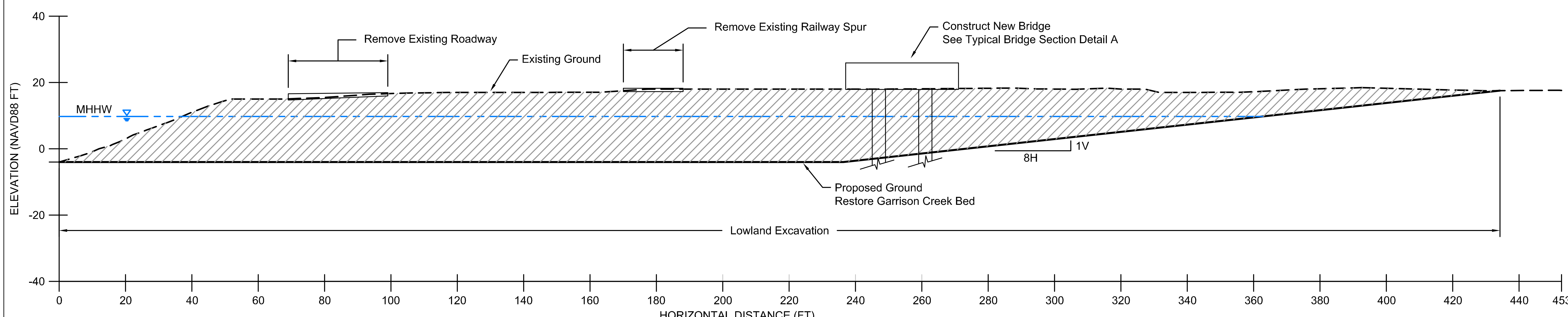
Lead Contractor: ESA
Design Lead: Anchor QEA, J. Laplante, PE
Date: 05/2012

Conceptual Design Plan
Site Name: Chambers Bay
Action Name: Chambers Bay Estuarine and Riparian Enhancment
PSNERP ID #: 1801
Partial Restoration

Figure 4-4



(A) FULL RESTORATION TYPICAL SECTION



(B) FULL RESTORATION TYPICAL SECTION

0 30
Scale in Feet

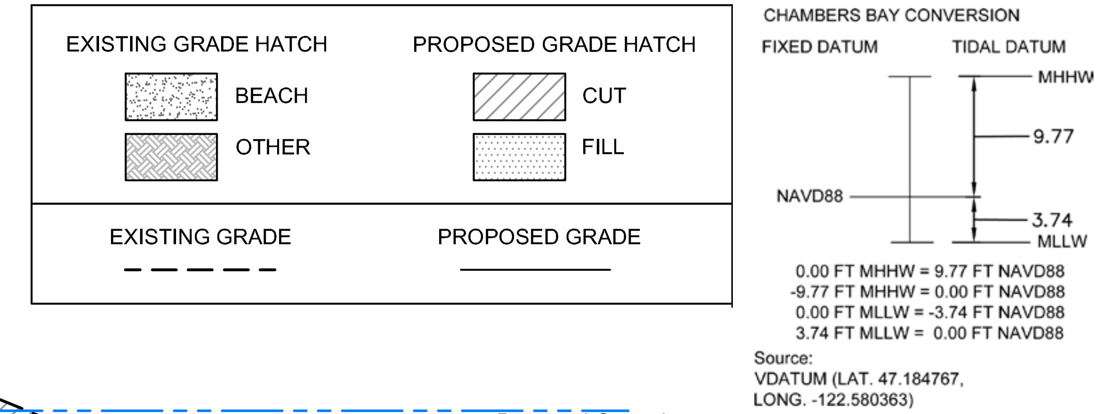
PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

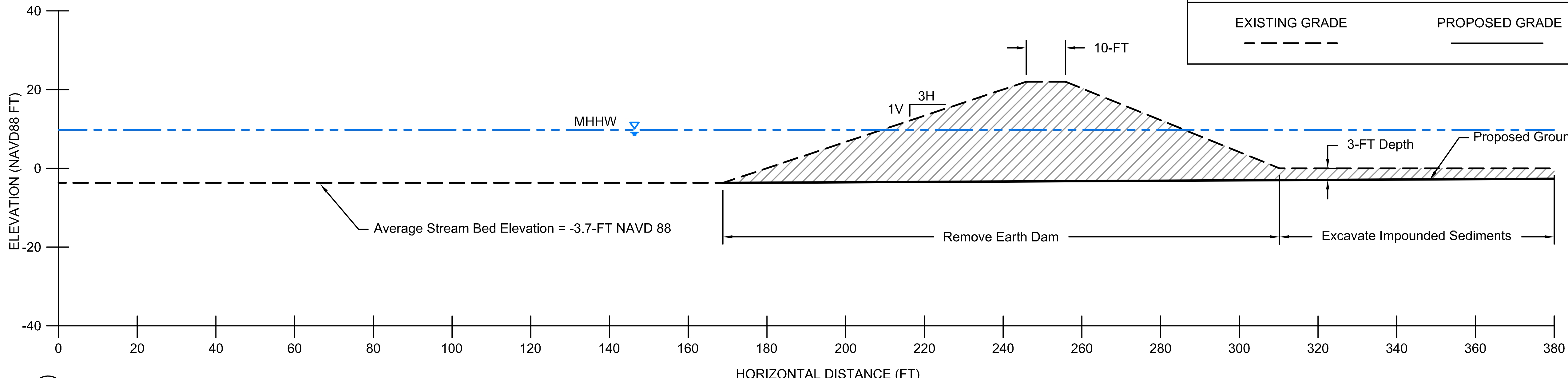
Lead Contractor: ESA
Design Lead: Anchor, J. LaPlante, PE
Date: 05/2012

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

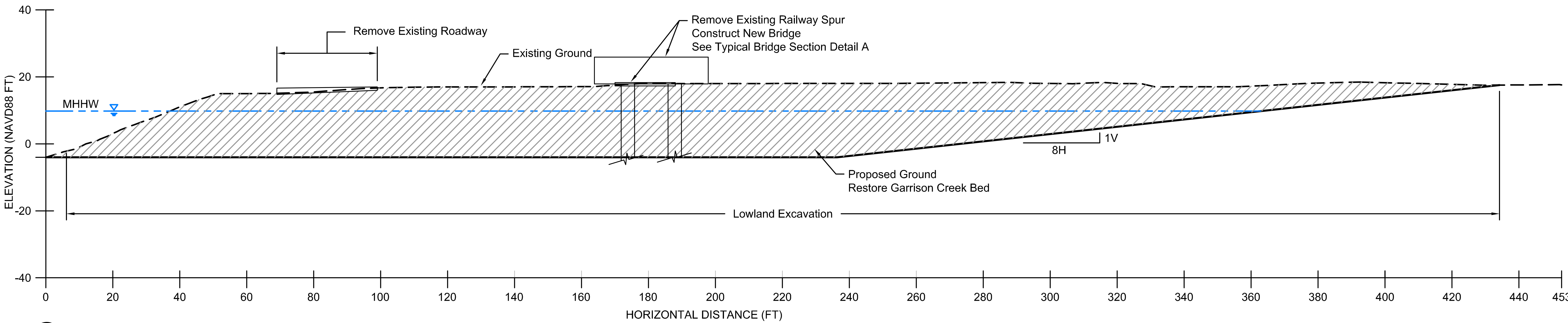
Conceptual Design Section
SITE NAME: **Chambers Bay**
ACTION NAME: **Chambers Bay Estuarine and Riparian Enhancement**
PSNERP ID#: **1801**
Full Restoration

Figure 4-5





Ⓐ PARTIAL RESTORATION TYPICAL SECTION



Ⓑ PARTIAL RESTORATION TYPICAL SECTION

0 30
Scale in Feet

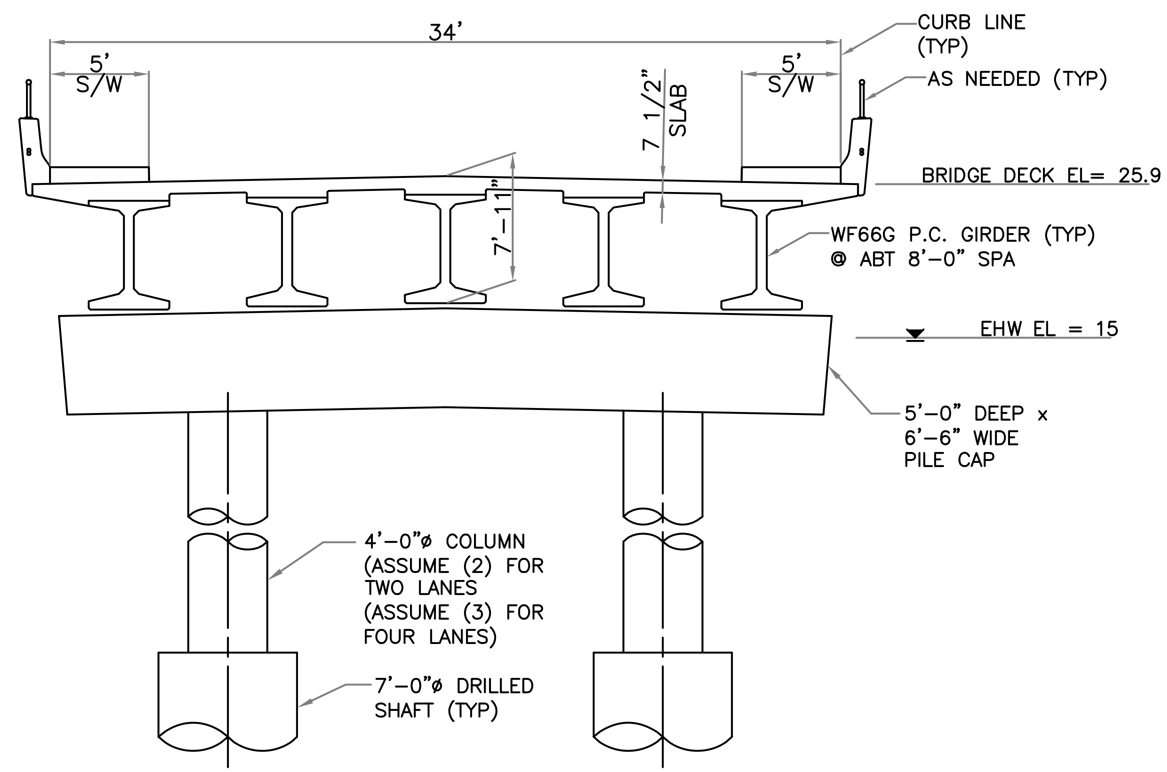
PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: Anchor, J. LaPlante, PE
Date: 05/2012

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Section
SITE NAME: **Chambers Bay**
ACTION NAME: **Chambers Bay Estuarine and Riparian Enhancement**
PSNERP ID#: **1801**
Partial Restoration

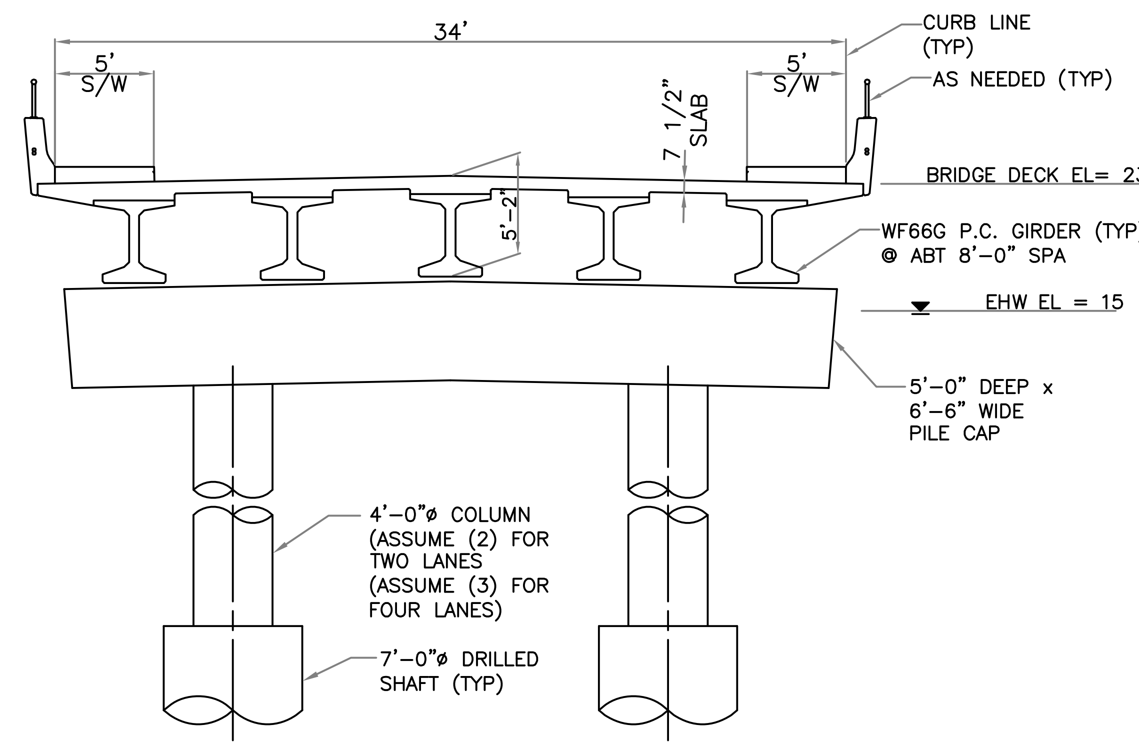
Figure 4-6



CONCRETE GIRDER BRIDGE

NTS

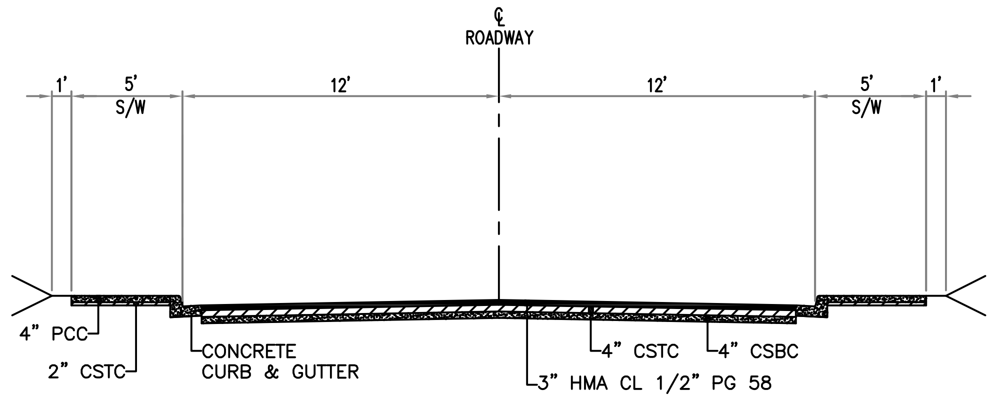
NOTE: FULL AND PARTIAL RESTORATION
185' SPLAN (FULL) AND 113' SPAN (PARTIAL) RESTORATION
EXTREME HIGH WATER (EHW) = EL 15



CONCRETE GIRDER BRIDGE

NTS

NOTE: FULL AND PARTIAL RESTORATION
100' SPAN
EXTREME HIGH WATER (EHW) = EL 15

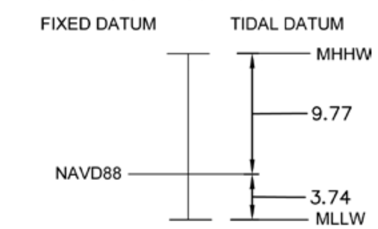


TYPICAL ROADWAY

NTS

FULL AND PARTIAL RESTORATION
DESIGN SPEED = 35 MPH

CHAMBERS BAY CONVERSION



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-9.77 FT MHHW = 0.00 FT NAVD88
0.00 FT MLLW = -3.74 FT NAVD88
3.74 FT MLLW = 0.00 FT NAVD88

Source:
VDATUM (LAT. 47.184767,
LONG. -122.580363)

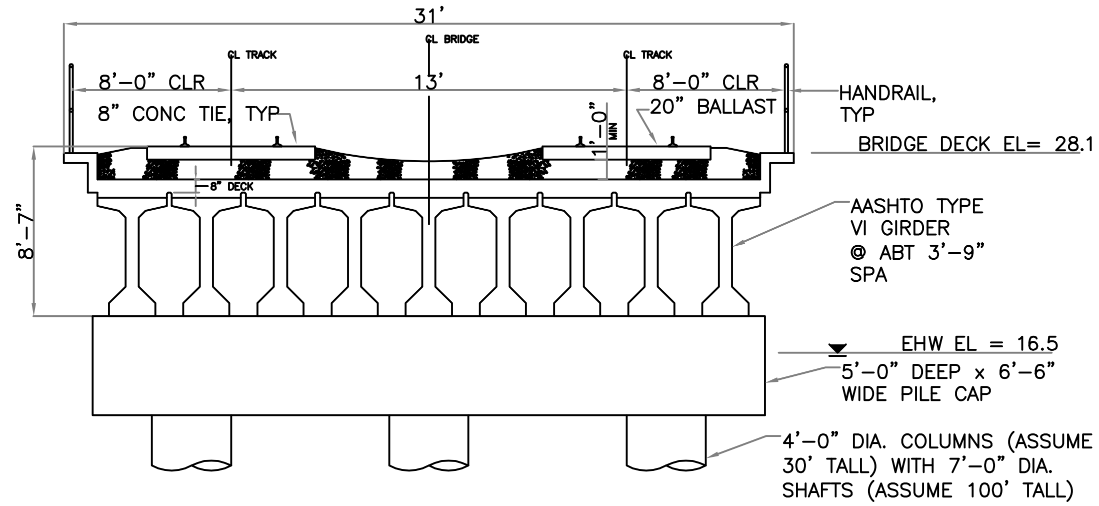
PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: Anchor, J. LaPlante, PE
Date: 05/2012

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

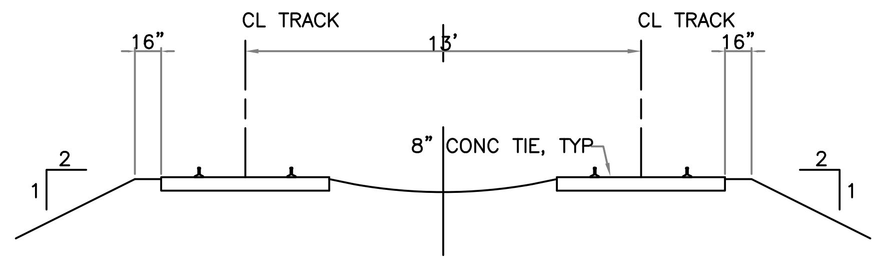
Conceptual Design Section
SITE NAME: **Chambers Bay**
ACTION NAME: **Chambers Bay Estuarine and Riparian Enhancement**
PSNERP ID#: **1801**
Full & Partial Restoration

Figure 4-7



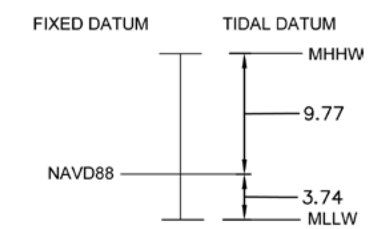
TRESTLE
NTS

NOTE: FULL RESTORATION
80' SPAN
EXTREME HIGH WATER (EHW) = EL 16.5



BALLASTED/FILL TRACK
NTS

CHAMBERS BAY CONVERSION



0.00 FT MHHW = 9.77 FT NAVD88
-9.77 FT MHHW = 0.00 FT NAVD88
0.00 FT MLLW = -3.74 FT NAVD88
3.74 FT MLLW = 0.00 FT NAVD88

Source:
VDATUM (LAT. 47.184767,
LONG. -122.580363)

PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: Anchor, J. LaPlante, PE
Date: 05/2012

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Section
SITE NAME: **Chambers Bay**
ACTION NAME: **Chambers Bay Estuarine and Riparian Enhancement**
PSNERP ID#: **1801**
Full & Partial Restoration

Figure 4-8

Full Restoration Quantity Estimate

Action Name: Chambers Bay
Action #: 1801
Date: February 2011 — Revised May 2012, July 2012
By: J. Laplante — Revised with backcheck updates: 24 August 2011

REMEDY: ***Remove Dam, abutments, appurtenant structures and impounded sediments. Replace Chambers Creek Road Bridge. Remove fill at mill site and daylight Garrison Springs Creek, with a new bridge crossing. Remove marina. Relocate lower Chambers Creek Road and remove shoreline armoring and bulkhead. Remove railroad causeway and replace with elevated trestle. Remove fill in tidal marsh and restore vegetation. Remove invasive vegetation on hillside north of Chambers Creek.***

Construction Period: 3 years

Item	Unit of Measure	Material Name	Qty	Description of Item	Indicate section of design report where item is described
ACQUISITION AND CONSERVATION				Based on available mapping information	
Required Project Lands	Acre		43.5	Total land required For actior	4.3.5
Proponent / Partner-owned lands	Acre		12.4	Estimate of lands currently owned by Proponent (i.e., Public lands	4.3.5
Lands To Be Acquired	Acre		31.1	Estimate land required to be acquired for action prior to implementatio	4.3.5
Material Sites				Not Used: See Earthwork - Imported Fill.	
MOBILIZATION AND ACCESS for construction activities				Description required for each item to facilitate cost estimating	
Mobilization - Typical (Equipment, Personnel, Planning, Financial)	LS		1	Mobilize earthwork equipment for excavation and demolition. Mobilize hydraulic dredge (or mechanical dredge on fl float barge system) for reservoir channel dredging. Mobilize pile driving equipment for new road bridges and new tra trestle crossing	4.3.7
Mobilization - Remote (Equipment, Personnel, Planning, Financial`	LS		NA		n/a
Site Access	LS		1	New bridge for Garrison Springs crossing. Mobilize equipment into Chambers Creek Reservoir - difficult access int reservoir.	4.3.7
Barge Access	Days		450	Barge access for bridge construction in Chambers Creek reservoir (180 days). Barge access for dam demolition (6 days). Barge access for BNSF trestle bridge construction (180 days). Barge access for marina overwater structure demolition (15 days); Barge access for marsh restoration excavation (15 days)	4.3.7
Temporary Traffic Control (one of the following)				Includes installation of traffic signals, signage, signmen, etc. There are 4 types as follows:	
none	LS		NA		n/a
signs	LS		1	This action would require two types of traffic control. This particular item for construction signs exclusively is intende for the detour signage necessary during construction of the replacement bridge over Chambers Creek. Estimated duration of bridge construction is 6 months. Signs = signs only, costs typically around 1% of total roadway costs	not specifically discussed
flags / spotters	LS		1	Maintenance of traffic would require reducing traffic on Chambers Creek Road to a single lane in each direction times. It is assumed that the work requiring this single lane closure would have a duration of four months.	not specifically discussed
unique	LS		NA		n/a
Temporary Roadway	SF		NA		n/a
Control of Water	LS		2	(1) Bypass of dam during dam removal. Assume 3 month duration for water control installation and excavation (estimated 6,200 cy). If the dam does not have a low-flow bypass already, bypass to be accomplished after demolition of fish hatchery building and constructing a lined channel or pipeline through the north abutment. Dam to be isolated by sheet piles or similar water control structure during removal. (2) Bypass of Garrison Springs creek during excavation for daylighting. Assume 4 month duration for excavation work (500 cy/day, 22 days/month); Flow rate TBD during detailed design	not specifically discussed
Relocation Activities				Not Used: See Utilities, Structures	
Site Demolition Activities				Demolition and removal of structures (description required), temporary features and relocations, itemized separately Clearing and grubbing of vegetation, and removal of minor debris (rocks, slabs) - description required.	
Clearing and Grubbing (one or more of following)				Use one or more of the following categories of clearing and grubbing	
Clear Vegetation - Local Disposal	AC		3.4	3.4 acres for roadwork (KPFF)	4.3.3
Clear /Grub Vegetation - Local Disposal	AC		NA		n/a
Clear /Grub Vegetation - Offsite Disposal	AC		8.4	8.4 acres of clearing and grubbing invasives for riparian planting north of Chambers Creek. Steep hillside worl	4.3.3
Clear, stockpile - large woody debris	CY		NA	Correct quantity sheets will be submitted.	n/a
Hydraulic Structures - Small	LS		1	Remove water intake structure upstream of Chambers Creek Reservoir dam. Assume 250 linear feet of 12-inch diam pipeline, inclined fish screen, 10-inch diam fish bypass pipe, 40 CY of reinforced concret	not specifically discussed
Hydraulic Structures - Large	LS		1	Remove Chambers Creek Reservoir Dam. Dam is 22 feet high with 100 foot wide spillway. Earthen construction. Dam appurtenances include 400 LF of steel sheet pile for demolition (fish ladders). 6,200 cy estimated fill volume. Details to be confirmed during subsequent design. Water control and sediment removal estimated separately.	4.3.2
Utilities	LF		14,340	Gas – impacts were assumed in the area of the intersection north of the bridge (300 LF) north to south. Electrical, Sewer, and Water – all relocation limits for approximately the length of the removed roadway (approx 4380 LF) and near the bridge over Chambers Creek (300 LF) for a total of 4,680 LF for each	4.3.6
Buildings	SF		54,000	7,300 square feet of buildings at dam abutments (fish hatchery, support building, and water intake building), 46,700 square feet of buildings at the marina	4.3.2
Pavement	SF		518,736	Includes 164,736 SF removal of pavement along Chambers Creek Rd, and 354,000 SF of pavement removal at former mill site	not specifically discussed
Bulkheads	LF		525	Remove wooden bulkhead along Chambers Creek Road. Assumed 10 feet high above mudline. Wood lagging between wood pile vertical supports	4.3.6
Rock revetments	LF, Ton or CY		NA		n/a
Large Coastal Structures	CY		68,000	Removal of BNSF rail causeway, not including armor. Assumed 25-foot wide crest, 21 feet high, 2:1 side slopes and 1300 foot length	4.3.2
Demolition / Removal - Bridge	SF		12,600	3,000 SF for Chambers Creek Road Bridge (30' x 100'); 9,600 SF for Rail Trestle drawbridge (40' x 240') - to be confirmed during subsequent desigr	4.3.7
Demolition / Removal - Floating Docks	SF		77,100	Removal of floating docks and floating covered structures at Marina. Assumes water-based demolition operation	4.3.2
Removal - Misc. (e.g. angular rock from beach)	Ton		12,300	1 acre at causeway; 0.2 acres at marina, 0.2 acres at Chambers Creek Road bulkhead 0.7 acres at mill site; Assume average thickness of 2 feet, and conversion of 1.85 tons/cy. For loose rock scattered across intertid	4.3.2
Demolition / Removal - Boat Ramp	SF		NA		n/a
Demolition / Removal - Rail	LF		8,220	Removal of 3,000 LF of abandoned BNSF rail spur from main line into former mill site; Removal of 3,400 LF of rail along existing causeway. Removal 1,820 LF rail in Mill Site	4.3.7
Demolition / Removal - Pile pulling	EA		150	Allowance based on review of aerial obliques. Area upstream of marina. Includes disposal. Assume creosote piles, all located within 100 feet of shoreline	4.3.3
Demolition / Removal - Miscellaneous Debris	Ton		100	Allowance. Actual volume to be assessed during detailed desigr	4.3.3
Haul - Offsite Disposal of Demolition Debris	Miles		20	Estimate distance (to nearest 10 miles) to disposal site for materials, veg clear and grub, etc	4.3.3
Hazardous/Contaminated Waste Removal				These items for earthwork of quality not compatible with wetlands, requiring special handling and disposal. Describe basis for classification as contaminated or hazardous. State known or suspected contamination, describe known similar work.	
Contaminated Earthwork	CY		2,700	Assume 2,000 cy at mill site (approximately 1% of excavated volume) and 700 cy of sediment from the impounded dam (10% of excavated sediment). Excavation, off haul and disposal within a licensed landfill, complete	4.3.3
Hazardous Earthwork	CY		NA		n/a
Construct Temporary Features				Use as needed for unusual temporary features not included elsewhere (see TESC below)	
EARTHWORK				Expand to include equipment, etc. to facilitate cost estimating.	
Excavation				Per yard excavation w/out expected haul	
Excavation - Upland	CY		247,000	Excavation of fill at former mill site, and along Chambers Creek roadway corridor south of mill site. Mill site area = 354,000 square feet & avg. elevation 18' NAVD88; assume 1/2 of the area would be a full depth excavation, and 1/2 of the area would be a sloped excavation. Full depth excavation to elevation -4' NAVD88, with a 2-foot overexcavation allowance (24-foot thick cut). For Chambers Creek Road corridor, 27,000 sq.ft. excavation from existing avg. elevation 14' NAVD88 to current mudline at bulkhead/toe of slope of 5' NAVD88, with 2-foot overexcavation allowance. 236,000 cy at mill site, and 11,000 cy in Chambers Creek Road corridor	4.3.2
Excavation - Lowland	CY		46,600	Excavation of fill on sand spit at marina. Does not include excavation of causeway fill. Excavation of causeway fill covered under Large Coastal Structures demolition. Average marina elevation 16 feet NAVD88. Assume final average grade +11 (5 foot cut) and include allowance for 2 feet of overexcavation (total 7 foot cut); 179,700 square feet	4.3.2
Dredging - Bucket - Land	CY		90,100	Excavation of fill at dam abutments, and Chambers Creek Bridge abutments. Excavation would start as upland, an relatively unconstrained but would be largely performed and completed below the water surface, in the tidally influenced environment in front of the dam, and in the reservoir behind the dam. North dam abutment = 65,750 square feet & avg. elevation 18' NAVD88. South Dam abutment = 29,000 square feet & avg. elevation 16' NAVD88 Chambers Creek Bridge abutment = 9,000 square feet & avg. elevation 18' NAVD88. Assume base of excavation -4' NAVD888, with 2 foot overex/overdredge allowance (to elevation -6' NAVD88	4.3.2
Dredging - Bucket - Marine	CY		6,500	Excavate 2 feet of material to restore marsh north of marina. Assume marine-based operation. Include allowance f 2 feet of overdredge (total 4 foot thick cut); 43,900 square fee	4.3.2
Dredging - Hydraulic	CY		7,300	Excavate channels into impounded sediments. Assume hydraulic dredge due to site access. 39,200 square feet (excavation. Assume 3 foot deep channel, and 2 foot allowable overdredge (5 foot thick total cut); Includes costs for dewatering dredged sedimen	4.3.2
Fine Grading	AC		12.2	8.1 acres in the mill site; 4.1 acres in the marina area	4.3.2
Fill Placement - local borrow				This is additive to Earthwork -Excavation	
Side cast	CY		NA	Excavated material placed within reach of excavator / dredge - assume includes some shaping by buck	n/a
Haul - uncontrolled placement	CY		465,500	Sum of all stockpiled material (293,600CY + 171,900CY). Assume 20-mile haul. Transportation and seconc handling - estimate distance.	4.3.2
Haul, place, compact	CY		0	Transportation and second handling - estimate distance, placement in lifts, moisture conditioning, compaction testing.	n/a
Stockpile - uncontrolled placement	CY		293,600	Sum of all excavation volumes (247,000CY + 46,600CY). Assume material would not need to be dried, but migh need to be stockpiled prior to load out and shipping	4.3.2
Stockpile - controlled placement	CY		171,900	Sum of all dredge volumes plus BNSF causeway fill (90,100CY + 6,500CY + 7,300CY + 68,000CY). Assume stockpile needed for drying and/or sorting prior to offsite shipment. intermediate step, for subsequent off haul or use elsewhere on site. Can use this for drying material for subsequent controlled compacted f	4.3.2
Conveyor placement from stockpile land/water	CY		NA		n/a
Imported Fill				Includes purchase, delivery and placement or as noted / described	
Select Fill	CY		NA		n/a
Gravel Borrow, including haul	CY		35,900	Substrate modification in the excavated dam abutments, mill site area, and chambers creek road area. Includ purchase, delivery and placement. Assume 2-foot thick layer of material placed. Dam abutments = 103,750 sq.ft. (2.4 acres). Mill Site = 354,000 sq.ft. (8.1 acres). Chambers Creek Road = 27,000 sq.ft. (0.6 acres	4.3.3
Sand / Gravel for Beach Nourishment	CY		13,300	Beach restoration in the sand spit area following marina removal. Assumed 2 feet thick over 179,700 square feet Material source to be identified during detailed design. Include purchase, transport and placement. special borrow and sorting required; identify material source	4.3.3
Cobble for Shore Nourishment	CY		1000	Assume this would be a buried armor layer of 1-foot thick over the 0.6 acre Chambers Creek Road offset area Include purchase, delivery and placement. Source to be identified during detailed design. special borrow and sortir required; identify material source	4.3.2
Embankment Compaction	CY		NA		n/a

Full Restoration Quantity Estimate

Action Name: Chambers Bay
Action #: 1801
Date: February 2011 Revised May 2012, July 2012
By: J. Laplante Revised with backcheck updates: 24 August 2011

REMEDY: ***Remove Dam, abutments, appurtenant structures and impounded sediments. Replace Chambers Creek Road Bridge. Remove fill at mill site and daylight Garrison Springs Creek, with a new bridge crossing. Remove marina. Relocate lower Chambers Creek Road and remove shoreline armoring and bulkhead. Remove railroad causeway and replace with elevated trestle. Remove fill in tidal marsh and restore vegetation. Remove invasive vegetation on hillside north of Chambers Creek.***

Construction Period: 3 years

Item	Unit of Measure	Material Name	Qty	Description of Item	Indicate section of design report where item is described
Topsoil	CY		3,200	Allowance for 2 acres of topsoil to be used in restoration areas at Mill Site. Assume depth of 1 foot of topsc	4.3.3
RESTORATION Features					
Channel Rehab / Creation	SF		NA	Channel construction (SF) including imported sediment and habitat materials, excluding excavatic	n/a
Large Wood Placement	EA		NA	Per each log, Including drift logs, lower river log jams, etc	n/a
Invasive Species Control	Acre		8.4	Same area as counted under clear and grub - offsite disposal, for the riparian restoration north of Chambers Creek. Due to heavy blackberry, this item would include spot spray of Rodeo or similar to control invasives following the clear and grub	4.3.3
Physical Exclusion Devices	LF or EA		NA		n/a
Other Restoration Features/ Activities	LS		NA		n/a
Structures	EA				
Water Control Structures - Culverts with Gates	EA		NA		n/a
Water Control Structures - Weirs	EA		NA		n/a
Rock Slope Protection	LF		NA		n/a
Other	EA		NA		n/a
Elevated Boat Ramp	SF		NA		n/a
Fencing	SF		NA		n/a
Roadway Bulkhead	LS		1	Allowance for potential sheet pile wall needed for setback Chambers Creek Road. Assume 525 LF of wall would nee to be replaced with the road setback. Replacement would occur in the area of the existing wall, however because of the ability to set back the road, the new wall would be approximately 5 feet high from the road surface to the mudline in the creek.	
Utilities				Replacement or relocation. Designer to provide size and material and have separate line item for each run. Incidentals include earthwork, testing, hook up fees, etc. These quantities do not include demolition of existing utilities, real estate / easements, design fees. Describe the owner if known, and whether utility franchise will install (e.g., electric is typically installed by electrical franchise)	
Water	LF		4,680	Size unknown	4.3.6
Gas	LF		300	High pressure, size unknowr	4.3.6
Electric	LF		4,680	Overhead Transmissior	4.3.6
Sewer	LF		4,680	Force main, unknown size.	4.3.6
Telecommunications	LF		NA		n/a
Other	LF		NA		n/a
Roadway / Railway					
Roadway (2 at 12-ft wide lanes; 5-ft wide sidewalks)	SF		164,412	Two-way two-lane roadway with 5-ft sidewalks. Refer to Plans for pavement sectio	4.3.6
Roadway - Traffic Signal	LS		NA		n/a
Culvert (type)	LF		84	84 lf 4'x6' Precast Reinf. Conc. Box Culvert	not specifically discussec
Culvert - Jacking	LF		NA		n/a
Culvert - Horizontal Pile Driving	LF		NA		n/a
Bridge 1 - Superstructure	SF		11,470	370-lf roadway 7'-11" girder. Bridge crossing daylighted Garrison Springs creek Includes elements such as approach slab, abutment, barriers, and railings. Approach slabs can be assumed to have standard length of 25 feet. For the purpose of estimating guardrail it can be assumed that a length of 100 lf at each corner of the bridge will be needed (400 LF total)	4.3.6
Bridge 2 - Superstructure	SF		6,200	200-lf roadway 5'-2" girder. New bridge crossing at the former Chambers Creek Reservoir Includes elements such as approach slab, abutment, barriers, and railings	4.3.6
Bridge 1 - Foundation	LF		32	Drilled shaft foundation; depth 100-f	4.3.6
Bridge 2 - Foundation	LF		32	Drilled shaft foundation; depth 100-f	4.3.6
Rail	LF		5,850	Double track, mainline: rail transition (north end)=533 LF, new trestle railroad bridge=1,486 LF, rail transition (south end)= 905 LF; total= 2,924 LF x 2 (for dual rail)=approximately 5,850LF. Rail tie spacing will depend on type of tie used (timber or concrete), the traffic density, and standards. For cost purposes, assume Timber = 19.5 to 21.25", Prestressed concrete = 24 to 26".	4.3.6
Railway - Box Girder	SF		46,066	Prestressed box girder bridge, 1486 lf in lengtl	4.3.6
Railway - Foundation	LF		589	Prestressed box girder bridge, 1486 lf in lengtl	4.3.6
Railway - Shoe fly	LF		NA		n/a
Permanent Access Features					
Roads	Level		NA		n/a
Utility Access Routes	varies		NA		n/a
Erosion Control Features	L.F.		NA		n/a
Public Access or Recreation Features					
Trails	SF		NA		n/a
Bridges	SF		NA		n/a
Kiosk	EA		NA		n/a
Restrooms	EA		NA		n/a
Interpretive Signs	EA		2	Include # interpretive signs based on number of local public access points	not specifically discussec
Parking Area	SF		NA		n/a
Other	EA		NA		n/a
Vegetation & Erosion Control					
Hydroseeding	AC		NA		n/a
Planting	AC		16.1	8.4 acres for banks on the north side of Chambers Creek. 6.7 acres for the corridor along the restored Garris(Springs creek and the area within the mill site footprint); 1 acre for the tidal wetland on the north side of Chambers Creek by the marina.	4.3.3
Vegetation Maintenance	AC-YR		15.1	All areas described under planting (above), with the exception that active maintenance would not be performed in th 1-acre tidal wetland due to limited access	4.3.3
Erosion / sediment BMPs - Temp.	AC		10	Typical BMPs used for this project may include stabilized construction entrances, sediment ponds or settlement tanks, hydroseed or mulch to stabilize roadway embankments, and silt fence	not specifically discussed
Erosion / sediment BMPs - Permanent	AC		8.4	Erosion control for north bank of Chambers Creek prior to establishment of native vegetation plantings. Erosic control measures sufficient for 60 to 100 percent slopes in this area. Measures to be determined during detailed design.	not specifically discussed
Waterside controls - Temporary	LF		1,000	Allowance for 1000 LF of silt curtain during excavation of dam abutment soils, to control release of turbidit downstream	not specifically discussed
Construction Management					
Construction oversight	weeks		200	Assume 2 years for overwater work; 1 year for earthwork; 1 year for finish work. Needs to be evaluated in more det during design developmen	4.3.7
Materials testing				Included in cost of material - no separate quantity	n/a
Design and Detailed Site Investigations					
Survey & Property, Utility Research	LS		1	% of construction cost	4.8
35% Design	LS		1	% of construction cost	n/a
65% design	LS		1	% of construction cost	n/a
90% design	LS		1	% of construction cost	n/a
100% design	LS		1	% of construction cost	n/a
Geotechnical Studies				Refer to design report for description of need	4.8
Cultural Studies				Refer to design report for description of need	4.8
HTWR Studies				Refer to design report for description of need	4.8
Project Agreement Activities				Unable to provide credible estimate at 10% design	
Site-Specific Adaptive Management Features & Activities				List if known	
Monitoring Activities				Assume 5 crew-days/year for each monitoring parameter in design report for 5 yrs	
Monitoring (Type _)	crew-days		200		4.7
Operations & Maintenance				Unable to provide credible estimate at 10% design	

Partial Restoration Quantity Estimate

Action Name:	Chambers Bay	
Action #:	1801	
Date:	February 2011	Revised May 2012, July 2012
By:	J. Laplante	Revised with backcheck updates: 24 August 201

REMEDY: *Remove Dam, abutments, appurtenant structures and impounded sediments. Replace Chambers Creek Road Bridge. Partially remove fill at mill site and daylight Garrison Springs Creek, with a new bridge crossing. Relocate lower Chambers Creek Road and remove shoreline armoring. Remove fill in tidal marsh and restore vegetation. Remove invasive vegetation on hillside north of Chambers Creek.*

Construction Period: 3 years

Item	Unit of Measure	Material Name	Qty	Description of Item	Indicate section of design report where item is described
ACQUISITION AND CONSERVATION				Based on available mapping informatic	
Required Project Lands	Acre		21.4	Total land required For actioi	4.3.5
Proponent / Partner-owned lands	Acre		11.9	Estimate of lands currently owned by Proponent (i.e., Public land	4.3.5
Lands To Be Acquirec	Acre		9.5	Estimate land required to be acquired for action prior to implementati	4.3.5
Material Sites				Not Used: See Earthwork - Imported Fill	
MOBILIZATION AND ACCESS for construction activities				Description required for each item to facilitate cost estimatir	
Mobilization - Typical (Equipment, Personnel, Planning, Financial)	LS		1	Mobilize earthwork equipment for excavation and demolition. Mobilize hydraulic dredge (or mechanical dredge flexi-float barge system) for reservoir channel dredging. Mobilize pile driving equipment for new road bridges and new train trestle crossing	4.3.7
Mobilization - Remote (Equipment, Personnel, Planning, Financia	LS		NA		n/a
Site Access	LS		1	New bridge for Garrison Springs crossing. Mobilize equipment into Chambers Creek Reservoir - difficult acces into reservoir.	4.3.7
Barge Access	Days		255	Barge access for bridge construction in Chambers Creek reservoir (180 days). Barge access for dam demoliti (60 days). Barge access for marsh restoration excavation (15 days)	4.3.7
Temporary Traffic Control (one of the following)				Includes installation of traffic signals, signage, signmen, etc. There are 4 types as follow	
none	LS		NA		n/a
signs	LS		1	This action would require two types of traffic control. This particular item for construction signs exclusively intended for the detour signage necessary during construction of the replacement bridge over Chambers Creek. Estimated duration of bridge construction is 6 months. Signs = signs only, costs typically around 1% of total roadway costs	not specifically discussed
flags / spotters	LS		1	Maintenance of traffic would require reducing traffic on Chambers Creek Road to a single lane in each direction at times. It is assumed that the work requiring this single lane closure would have a duration of four months.	not specifically discussed
unique	LS		NA		n/a
Temporary Roadway	SF		NA		n/a
Control of Water	LS		2	(1) Bypass of dam during dam removal. Assume 3 month duration for water control installation and excavation (estimated 6,200 cy). If the dam does not have a low-flow bypass already, bypass to be accomplished after demolition of fish hatchery building and constructing a lined channel or pipeline through the north abutment. Dam to be isolated by sheet piles or similar water control structure during removal. (2) Bypass of Garrison Springs creek during excavation for daylighting. Assume 4 month duration for excavation work (500 cy/day, 22 days/month); Flow rate TBD during detailed desigr	not specifically discussed
Relocation Activities				Not Used: See Utilities, Structures	
Site Demolition Activities				Demolition and removal of structures (description required), temporary features and relocations, itemized separately); Clearing and grubbing of vegetation, and removal of minor debris (rocks, slabs) - description required	
Clearing and Grubbing (one or more of following)				Use one or more of the following categories of clearing and grubbii	
Clear Vegetation - Local Disposa	AC		1.6	1.6 acres for roadwork (KPFF)	4.3.3
Clear /Grub Vegetation - Local Disposa	AC		NA		n/a
Clear /Grub Vegetation - Offsite Disposal	AC		8.4	8.4 acres of clearing and grubbing invasives for riparian planting north of Chambers Creek. Steep hillside work.	4.3.3
Clear, stockpile - large woody debri	CY		NA		n/a
Hydraulic Structures - Small	LS		1	Remove water intake structure upstream of Chambers Creek Reservoir dam. Assume 250 linear feet of 12-inch diam pipeline, inclined fish screen, 10-inch diam fish bypass pipe, 40 CY of reinforced concre	not specifically discussed
Hydraulic Structures - Large	LS		1	Remove Chambers Creek Reservoir Dam. Dam is 22 feet high with 100 foot wide spillway. Earthen constructic Dam appurtenances include 400 LF of steel sheet pile for demolition (fish ladders). 6,200 cy estimated fill volun Details to be confirmed during subsequent design. Water control and sediment removal estimated separately.	4.3.2
Utilities	LF		7,020	Gas – impacts were assumed in the area of the intersection north of the bridge (300 LF) north to south. Electrical, Sewer, and Water – all relocation limits for approximately the length of the removed roadway (approx 2240 LF) for each	4.3.6
Buildings	SF		54,000	7,300 square feet of buildings at dam abutments (fish hatchery, support building, and water intake building), 46,700 square feet of buildings at the marin	4.3.2
Pavement	SF		330,580	Includes 62,080 SF removal of pavement along Chambers Creek Rd, and 268,500 SF of pavement removal at former mill site	not specifically discussed
Bulkheads	LF		NA		4.3.6
Rock revetments	LF, Ton or CY		NA		n/a
Large Coastal Structures	CY		0		n/a
Demolition / Removal - Bridge	SF		3,000	3,000 SF for Chambers Creek Road Bridge (estimated 30' x 100', to be confirmed during subsequent design)	4.3.7
Demolition / Removal - Floating Dock	SF		NA		n/a
Removal - Misc. (e.g. angular rock from beach)	Ton		4,000	0.7 acres at mill site; Assume average thickness of 2 feet, and conversion of 1.85 tons/cy. For loose rock scattered across intertidal	4.3.2
Demolition / Removal - Boat Ram	SF		NA		n/a
Demolition / Removal - Rail	LF		4,820	Removal of 3,000 LF of abandoned BNSF rail spur from main line into former mill site; Removal 1,820 LF rail in Mill Site.	4.3.7
Demolition / Removal - Pile pulling	EA		150	Allowance based on review of aerial obliques. Area upstream of marina. Includes disposal. Assume creosote piles, all located within 100 feet of shorelin	4.3.3
Demolition / Removal - Miscellaneous Debri	Ton		100	Allowance. Actual volume to be assessed during detailed desig	4.3.3
Haul - Offsite Disposal of Demolition Debri	Miles		20	Estimate distance (to nearest 10 miles) to disposal site for materials, veg clear and grub, et	4.3.3
Hazardous/Contaminated Waste Removal				These items for earthwork of quality not compatible with wetlands, requiring special handling and disposal. Describe basis for classification as contaminated or hazardous. State known or suspected contamination, describe known similar work	
Contaminated Earthwork	CY		2,100	Assume 1,400 cy at mill site (approximately 1% of excavated volume) and 700 cy of sediment from the impounded dam (10% of excavated sediment). Excavation, off haul and disposal within a licensed landfill, complete	4.3.3
Hazardous Earthworl	CY		NA		n/a
Construct Temporary Features				Use as needed for unusual temporary features not included elsewhere (see TESC belo	
EARTHWORK				Expand to include equipment, etc. to facilitate cost estimatin	
Excavation	CY			Per yard excavation w/out expected hau	
Excavation - Upland	CY		147,900	Excavation of fill at former mill site, and along Chambers Creek roadway corridor south of mill site. Mill site area = 268,500 square feet & avg. elevation 18' NAVD88; assume 56,000 sq.ft. would be a full depth excavation, and balance of the area would be a sloped excavation. Full depth excavation to elevation -4' NAVD88, with a 2-foot overexcavation allowance (24-foot thick cut). For Chambers Creek Road corridor, 18,000 sq.ft. sloped excavation from existing avg. elevation 14' NAVD88 to current mudline toe of slope of 5' NAVD88, with 2-foot overexcavation allowance. 144,200 cy at mill site, and 3,700 cy in Chambers Creek Road corridor.	4.3.2
Excavation - Lowlanc	CY		0		n/a
Dredging - Bucket - Land	CY		90,100	Excavation of fill at dam abutments, and Chambers Creek Bridge abutments. Excavation would start as upland and relatively unconstrained but would be largely performed and completed below the water surface, in the tidally influenced environment in front of the dam, and in the reservoir behind the dam. North dam abutment = 65,750 square feet & avg. elevation 18' NAVD88. South Dam abutment = 29,000 square feet & avg. elevation 16' NAVD88. Chambers Creek Bridge abutment = 9,000 square feet & avg. elevation 18' NAVD88. Assume base of excavation -4' NAVD888, with 2 foot overex/overdredge allowance (to elevation -6' NAVD	4.3.2
Dredging - Bucket - Marine	CY		6,500	Excavate 2 feet of material to restore marsh north of marina. Assume marine-based operation. Include allowar for 2 feet of overdredge (total 4 foot thick cut); 43,900 square fe	4.3.2
Dredging - Hydraulic	CY		7,300	Excavate channels into impounded sediments. Assume hydraulic dredge due to site access. 39,200 square fe of excavation. Assume 3 foot deep channel, and 2 foot allowable overdredge (5 foot thick total cut); Includes co for dewatering dredged sedimer	4.3.2
Fine Grading	AC		6.2	6.2 acres in the mill site	4.3.2
Fill Placement - local borrow				This is additive to Earthwork -Excavatio	
Side cast	CY		NA		n/a
Haul - uncontrolled placement	CY		251,800	Sum of all stockpiled material (Line 79 and Line 80). Assume 20-mile haul. Transportation and second handlir estimate distance	4.3.2
Haul, place, compact	CY		NA	Transportation and second handling - estimate distance, placement in lifts, moisture conditioning, compaction testing.	n/a
Stockpile - uncontrolled placement	CY		147,900	Sum of all excavation volumes (Line 68 and 69). Assume material would not need to be dried, but might neec be stockpiled prior to load out and shippinc	4.3.2
Stockpile - controlled placement	CY		103,900	Sum of all dredge volumes plus BNSF causeway fill (Line 70 + Line 71 + Line 72). Assume stockpile needed for drying and/or sorting prior to offsite shipment. intermediate step, for subsequent off haul or use elsewhere on site. Can use this for drying material for subsequent controlled compacted t	4.3.2
Conveyor placement from stockpile land/wate	CY		NA		n/a
Imported Fill				Includes purchase, delivery and placement or as noted / describe	
Select Fill	CY		NA		n/a
Gravel Borrow, including haul	CY		28,900	Substrate modification in the excavated dam abutments, mill site area, and chambers creek road area. Include purchase, delivery and placement. Assume 2-foot thick layer of material placed. Dam abutments = 103,750 sq.ft. (2.4 acres). Mill Site = 268,500 sq.ft. (6.2 acres). Chambers Creek Road = 18,000 sq.ft. (0.4 acres	4.3.3
Sand / Gravel for Beach Nourishmen	CY		NA		4.3.3

Partial Restoration Quantity Estimate

Action Name: Chambers Bay
Action #: 1801
Date: February 2011 | Revised May 2012, July 2012
By: J. Laplante | Revised with backcheck updates: 24 August 201

REMEDY: ***Remove Dam, abutments, appurtenant structures and impounded sediments. Replace Chambers Creek Road Bridge. Partially remove fill at mill site and daylight Garrison Springs Creek, with a new bridge crossing. Relocate lower Chambers Creek Road and remove shoreline armoring. Remove fill in tidal marsh and restore vegetation. Remove invasive vegetation on hillside north of Chambers Creek.***

Construction Period: 3 years

Item	Unit of Measure	Material Name	Qty	Description of Item	Indicate section of design report where item is described
Cobble for Shore Nourishment	CY		700	Assume this would be a buried armor layer of 1-foot thick over the 0.4 acre Chambers Creek Road offset are Include purchase, delivery and placement. Source to be identified during detailed design. special borrow and sorting required; identify material source	4.3.2
Embankment Compactior	CY		NA		n/a
Topsoil	CY		800	Allowance for 0.5 acres of topsoil to be used in restoration areas at Mill Site. Assume depth of 1 foot of tops	4.3.3
RESTORATION Features					
Channel Rehab / Creatior	SF		NA		
Large Wood Placemen	EA		NA		n/a
Invasive Species Control	Acre		8.4	Same area as counted under clear and grub - offsite disposal, for the riparian restoration north of Chambers Creek. Due to heavy blackberry, this item would include spot spray of Rodeo or similar to control invasives following the clear and grul	4.3.3
Physical Exclusion Devices	LF or EA		NA		n/a
Other Restoration Features/ Activitie	LS		NA		n/a
Structures	EA				n/a
Water Control Structures - Culverts with Gates	EA		NA		
Water Control Structures - Weirs	EA		NA		n/a
Rock Slope Protectior	LF		NA		n/a
Other	EA		NA		n/a
Elevated Boat Ramp	SF		NA		n/a
Fencing	SF		NA		n/a
Roadway Bulkhead	LS		NA		n/a
Utilities				Replacement or relocation. Designer to provide size and material and have separate line item for each run. Incidentals include earthwork, testing, hook up fees, etc. These quantities do not include demolition of existing utilities, real estate / easements, design fees. Describe the owner if known, and whether utility franchise will install (e.g. electric is typically installed by electrical franchise	
Water	LF		2,240	Size unknowr	4.3.6
Gas	LF		300	High pressure, size unknowr	4.3.6
Electric	LF		2,240	Overhead Transmissior	4.3.6
Sewer	LF		2,240	Force main, unknown size	4.3.6
Telecommunications	LF		NA		n/a
Other	LF		NA		n/a
Roadway / Railway					
Roadway (2 at 12-ft wide lanes; 5-ft wide sidewalks	SF		105,192	Two-way two-lane roadway with 5-ft sidewalks. Refer to Plans for pavement secti	4.3.6
Roadway - Traffic Signa	LS		NA		n/a
Culvert (type)	LF		30	24" RCP culvert for crossing Unnamed Creek. Size and type of pipe to be confirmed during detailed design	not specifically discussed
Culvert - Jacking	LF		NA		n/a
Culvert - Horizontal Pile Driving	LF		NA		n/a
Bridge 1 - Superstructure	SF		6,200	200-lf roadway 7'-11" girder. Includes elements such as approach slab, abutment, barriers, and railing	4.3.6
Bridge 2 - Superstructure	SF		6,200	200-lf roadway 5'-2" girder. Includes elements such as approach slab, abutment, barriers, and railing	4.3.6
Bridge 1 - Foundatior	LF		32	Drilled shaft foundation; depth 100-f	4.3.6
Bridge 2 - Foundatior	LF		32	Drilled shaft foundation; depth 100-f	4.3.6
Rail	LF		NA		n/a
Railway - Box Girde	SF		NA		n/a
Railway - Foundatior	LF		NA		n/a
Railway - Shoe fly	LF		NA		n/a
Permanent Access Features					
Roads	Level		NA		n/a
Utility Access Routes	varies		NA		n/a
Erosion Control Features	L.F.		0		n/a
Public Access or Recreation Features					
Trails	SF		NA		n/a
Bridges	SF		NA		n/a
Kiosk	EA		NA		n/a
Restrooms	EA		NA		n/a
Interpretive Signs	EA		2	Include # interpretive signs based on number of local public access point	not specifically discussec
Parking Area	SF		NA		n/a
Other	EA		NA		n/a
Vegetation & Erosion Control					
Hydroseeding	AC		NA		n/a
Planting	AC		11.3	8.4 acres for banks on the north side of Chambers Creek. 1.9 acres for the corridor along the restored Garris Springs creek and the area within the former mill site footprint); 1 acre for the tidal wetland on the north side of Chambers Creek by the marina	4.3.3
Vegetation Maintenance	AC-YR		10.3	All areas described under planting (above), with the exception that active maintenance would not be performed the 1-acre tidal wetland due to limited access	4.3.3
Erosion / sediment BMPs - Temp.	AC		6	Typical BMPs used for this project may include stabilized construction entrances, sediment ponds or settlement tanks, hydroseed or mulch to stabilize roadway embankments, and silt fenc	not specifically discussed
Erosion / sediment BMPs - Permanent	AC		8.4	Erosion control for north bank of Chambers Creek prior to establishment of native vegetation plantings. Erosi control measures sufficient for 60 to 100 percent slopes in this area. Measures to be determined during detailed design.	not specifically discussed
Waterside controls - Temporary	LF		1,000	Allowance for 1000 LF of silt curtain during excavation of dam abutment soils, to control release of turbic downstream	not specifically discussed
Construction Management					
Construction oversight	weeks		150	Assume 1 year for overwater work; 1 year for earthwork; 1 year for finish work. Needs to be evaluated in m detail during design developmer	4.3.7
Materials testing					n/a
Design and Detailed Site Investigations					
Survey & Property, Utility Researcl	LS		1	% of construction cost	4.8
35% Design	LS		1	% of construction cost	n/a
65% design	LS		1	% of construction cost	n/a
90% design	LS		1	% of construction cost	n/a
100% design	LS		1	% of construction cost	n/a
Geotechnical Studies					4.8
Cultural Studies					4.8
HTWR Studies					4.8
Project Agreement Activities				Unable to provide credible estimate at 10% desic	
Site-Specific Adaptive Management Features & Activities				List if known	
Monitoring Activities				Assume 5 crew-days/year for each monitoring parameter in design report for 5 y	
Monitoring (Type)	crew-days		200		4.7
Operations & Maintenance				Unable to provide credible estimate at 10% desigı	

5. CHUCKANUT ESTUARY RESTORATION (#1642)

Local Proponent	City of Bellingham
Delta Process Unit	NA
Shoreline Process Unit(s)	7161
Strategy(ies)	4 - Coastal Inlet
Restoration Objectives	Restore the natural hydrodynamic regime (waves and tidal circulation) and sediment erosion and accretion processes in the bay; restore tidal flow and tidal channel formation and maintenance at the salt marsh and creek mouth

5.1 Description of the Action

This action would restore the natural hydrodynamic regime (waves and tidal circulation) and sediment erosion and accretion processes in Chuckanut Bay. Tidal flow, tidal channel formation, and channel maintenance within the estuary would be restored. Actions include the complete or partial removal of the existing railroad berm and construction of a railroad bridge. Full restoration would also include removing stressors at Chuckanut Village Marsh and the Chuckanut Creek mouth associated with nearshore roads, overwater structures, and nearshore fill. Please see the Introduction chapter for important information regarding PSNERP and the context of this restoration project.

5.2 Action Area Description and Context

Chuckanut Estuary is a pocket estuary located at the north end of Chuckanut Bay in the San Juan/Georgia Strait Subbasin. Construction of a railroad berm[1] (currently operated by BNSF) at the mouth of Chuckanut Estuary has altered hydrodynamics and sediment transport within the estuary, reducing the complexity in tidal circulation patterns and decreasing wave action and sediment erosion and accretion. The construction of an unpaved road and culvert along portions of the northeastern shoreline has impacted tidal exchange with the existing landward brackish marsh (Chuckanut Village Marsh). Tidal elevations within Chuckanut Estuary are similar to those within Chuckanut Bay due to tidal exchange through a 210-foot opening (bridge section) in the railroad berm. However, the tidal exchange dynamic between the estuary and the bay is constrained compared to historical flow dynamics. The action area is shown in Figure 5-1.

[1] The railroad berm is considered a large coastal structure (as opposed to upland or lowland fill) because it is built across a coastal body of water.

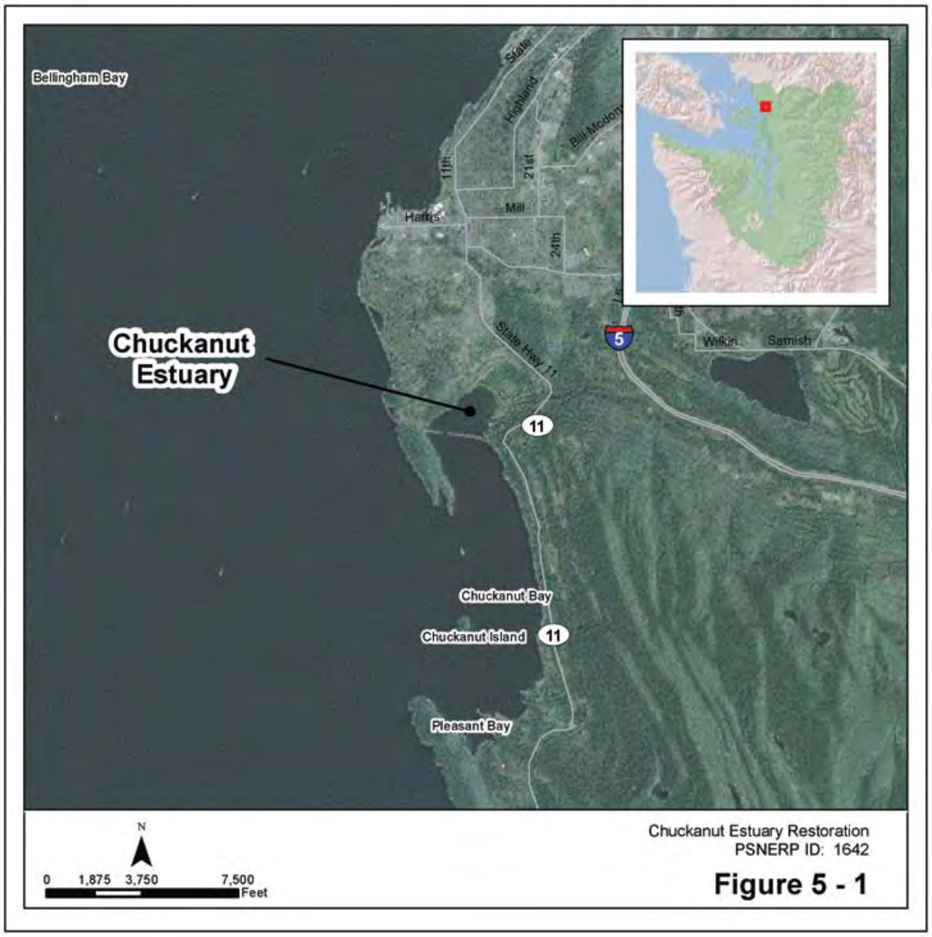


Figure 5-1. Action Area and Vicinity

5.2.1 Historic Condition

Based on the historic topographic sheet (T-sheet) and hydrographic sheet (H-sheet) mapping from the late 1800s, Chuckanut Estuary was a shallow embayment without a well defined tidal channel. The mouth of the estuary was approximately 2,400 feet wide and faced due south into Chuckanut Bay (Figures 5-2A and 5-2B). The northwestern shoreline within the estuary would have been subject to impacts by storm waves from the south, although the estuary is partially sheltered to the southwest from the longer fetch across Bellingham Bay. The extent of the tidal flats along the northeastern and southeastern shorelines of the estuary appears to be similar in spatial extent to historical conditions. However, there is evidence that the sediments were once coarser (sands and gravels) than those observed at present (mudflat) (Rubash 2009).

The elevation of the intertidal area within the estuary has changed significantly since construction of the railroad bridge/berm. Comparisons to the 1887 survey (H-sheet) and 2006 LiDAR have shown a decrease in elevation (from 1 to 2.5 feet) in the northeastern portion of the estuary and an increase in elevation in the estuary approximately 1,000 feet landward of the railroad berm (from 0.5 to 1.5 feet). The railroad was initially constructed as a bridge in 1904 and converted along most of its length to a rock berm in the 1920s.

Chuckanut Creek empties into Chuckanut Estuary along the southeastern shoreline. Historically, the creek channel within the estuary ran adjacent to the shoreline. At present, the channel runs northwest out through the middle of the estuary. It is thought that the lack of wave action in the estuary following construction of the berm has allowed the channel to migrate from its historical alignment. Historic plant and animal communities have changed over time; however, the correlation between observed habitat changes and construction of the railroad bridge/berm is unclear.

A roadway built along the northeastern shoreline of the estuary limited tidal inundation to the Chuckanut Village Marsh located upland. Roadway construction likely began in the 1930s, and the roadway extended across the entire length of the eastern shoreline by the 1960s (Northwest Ecological Services 2009). The western portion of the roadway has since been revegetated, and the eastern portion remains as public access to the estuary and a small parking area.

Early human activity in the estuary has been documented by the existence of shell middens (several thousand years old) and the remains of a prehistoric house on the Woodstock Farm site. Photographs from the 1930s show evidence of a log boom and pier in the southeastern corner of the estuary.

The railroad bridge and later the berm were built on public land on a city street right-of-way. There is no record of leases or permits being obtained for the construction.

5.2.2 Natural Environment

The northwestern shore of the estuary is rock outcrop or steep rocky slopes fronted by sand/gravel beach that is predominantly unvegetated. A forested slope exists above the shore around most of the estuary. The shore condition changes in an easterly direction, with the beach sediments becoming finer and increased woody and riparian vegetation. The northeastern shore of the estuary is a low-lying berm that separates the estuary from a salt marsh. The berm is a remnant of the roadway prism that spanned the entire eastern shoreline of the estuary in the 1960s (Northwest Ecological Services 2009). The western portion of the berm/roadway prism has been revegetated with riparian vegetation along its crest, with discontinuous areas of wetland vegetation. The salt marsh is connected to the estuary by an undersized culvert.

Chuckanut Creek is located in the northeast corner of the estuary. The shore in this area is mudflat, with fringing marsh and riparian/marsh vegetation. The southeast shoreline consists of steep upland slopes and a sand/gravel bench at the waterline which transitions to mudflat farther out into the estuary. The upland slopes are a combination of sand/gravel sediment and rocky outcrop, and there is evidence of slumping of the slope in several locations along the southern shoreline.

Sediments within the active tidal channel in the vicinity of the bridge opening are a mix of sands and gravels. A flood shoal composed of finer sediments has developed inside the estuary in line with the opening in the railroad berm.

5.2.3 Human Environment

The railroad berm is approximately 2,200 feet long and currently has a 210-foot-long bridge section towards its western end that acts as the tidal opening for the estuary. The berm is armored with rock riprap approximately 2 to 4 feet in diameter (from observation). The railroad was initially constructed as a full bridge and later converted along most of its length to a rock berm. The remaining portion of bridge (circa 1950) is approximately 212 feet long and consists of wooden piles and a wooden deck. The rail is a single-track mainline that is part of the BNSF Bellingham Subdivision network. There is an existing tunnel just west of the rail alignment crossing Chuckanut Bay. Based on conversations with BNSF, the current bridge is scheduled for replacement within the next 10 years.

The tidelands within Chuckanut Estuary and the land under the railroad bridge and berm are currently owned by the City of Bellingham. The City of Bellingham also owns the salt marsh on the northeast side of the estuary, the Woodstock Farm site located at the southeastern corner of the estuary (which includes a good portion of the southeastern shoreline), and several other upland parcels south of the estuary. The estuary is mostly undeveloped along the northwestern shoreline due to steep rocky slopes. However, a residential community is present at the top of the slope, and it appears that some portions of the beach in that area are privately owned, but the terrain severely limits access to the water from those residences.

The low-lying berm along the northeastern shoreline is owned by the City of Bellingham. Public access to the estuary is provided along this shoreline by a public road and a gravel parking area just upland of the shore. It appears that this road was built over the natural outlet of the salt marsh. The area is a popular launching point for kayaks and canoes. The shallow water depths and the restriction imposed by the railroad bridge limit the use of the estuary by larger vessels.

Several private residences are located in the northeastern corner of the estuary. The residences are fronted by three small docks and an in-water L-shaped berm. Portions of the residential development, roads, docks, in-water fill, and utilities are located at the historic mouth of Chuckanut Creek. The southeastern shoreline is moderately undeveloped due to the steep upland terrain and the presence of the mouth of Chuckanut Creek. The shoreline is in private ownership to the north (along that shoreline), but a significant portion of the shoreline to the south toward the landside connection with the railroad berm is owned by the City of Bellingham and is part of the Woodstock Farm site.

There are local roads and utilities accessing residential and City-owned property on all sides of the estuary except the northwest side that is undeveloped. There are no known utilities associated with the railroad, except those needed for railroad operation. Existing utilities and the need for utility relocations should be investigated during subsequent design phases.

5.3 Restoration Design Concept

5.3.1 Restoration Overview and Key Design Assumptions

The Chuckanut Bay Estuary would be fully reconnected to Bellingham Bay by replacing the existing railway berm with a railway bridge. This single action would restore tidal flow, erosion and accretion of sediments, and tidal channel formation and maintenance in the mudflat; would provide physical disturbance; and would improve exchange of aquatic organisms. Removal of the railroad berm tidal barrier would increase wave energy and restore historical circulation patterns, in addition to increasing the intertidal area within the estuary that is currently covered by the railway berm.

Partial restoration would involve widening the current bridge opening from 210 feet to 500 feet. A single wider opening is preferred over multiple smaller openings for several reasons: (1) to increase the amount of wave energy that can propagate into the estuary, (2) to restore historic sediment transport processes to the estuary as much as possible without full berm removal, and (3) to minimize tidal velocities and associated scour within proposed tidal channels and adjacent shorelines.

The partial restoration more than doubles the size of the existing opening. The width of the opening was selected based on best professional judgment according to guidelines described in the *Heirarchy of Openings Memorandum* (Appendix C). The memorandum describes a set of five channel opening conditions, largely around channel morphology. The existing conditions at Chuckanut fall into the second category, where the full tidal range is operating, but the opening is constricted to the point where channel scour occurs. The partial restoration alternative is intended the provide both increased wave energy and associated sediment transport, but also improved conditions that decrease substantially or eliminate channel scour and allow the natural channel morphology to be restored (but not allowing for channel migration). This falls into the third level of opening. Full restoration is providing either the fourth or fifth level of opening (full removal of tidal barriers).

While the proposed size of the opening will increase wave energy and sediment transport potential within the estuary, the size of the opening will need to be optimized using better bathymetry data and wave and tidal circulation modeling during future design phases.

The restoration alternatives are illustrated in Figures 5-3 through 5-7. The full restoration alternative includes (Figures 5-3, 5-5, and 5-7):

- Construction of a railroad bridge on the waterward side of Chuckanut Bay or south of the existing railway berm. The bridge must be built and opened prior to demolition of the railway berm to meet the service requirements of BNSF. Terminating ballast/fill sections for the proposed rail crossing will be constructed at the shoreline where the proposed rail alignment meets the existing rail track (Figure 5-5B).
- Removal of the existing wood railroad bridge and railway berm fill across the mouth of Chuckanut Bay.
- Demolition and removal of the railway berm armor rock and any rock that may have migrated off the slope of the berm.
- Removal of the gravel parking area to restore connection of the salt marsh to the estuary adjacent to the Chuckanut Creek mouth. Parking may be relocated offsite depending on public access requirements and available public land in the vicinity.
- Removal of other stressors including nearshore fill, docks and associated in-water piling, and land cover development at the Chuckanut Creek mouth that are inhibiting tidal channel formation and maintenance.

The partial restoration alternative includes (Figures 5-4 and 5-6):

- Widening the tidal opening of the estuary by removing the existing 210-foot-long wood bridge and approximately 290 LF of railway berm (to the east of the existing bridge) and replacing it with a 500-foot-long railroad bridge on the existing rail alignment.

Most of these changes are consistent with the local proponent’s description of potential restoration activities. However, the restoration associated with the mouth of Chuckanut Creek was not identified by the proponent. Key design elements associated with full and partial restoration alternatives are shown in Table 5-1.

Table 5-1. Key Design Elements

Element	Full Restoration	Partial Restoration
Railroad Crossing	Remove existing 210 LF railroad bridge,4,800 LF of berm and armor Replace with new bridge	Remove 290 LF of berm and armor, and 210 of railroad bridge Replace with new bridge
Roadway Fill	Remove fill between estuary and marsh along north shoreline	Not included
Gravel Parking Area and Culvert	Relocate parking area and replace culvert with channel to reconnect marsh with estuary	Not included
In-Water Fill and Piling, Docks	Remove in-water fill and piling and three docks adjacent to private homes	Not included

Mean tidal elevations within the estuary should not change significantly from existing conditions for either full or partial restoration. The current bridge opening allows full tidal inundation into the estuary. However, storm tide elevations may increase slightly within the estuary due to removal of the tidal barrier in full or partial restoration. The tidal datum for this action area is taken from the tidal benchmark for Bellingham, Washington (NOAA 9449211), and the elevation and water levels below relative to MLLW:

	MLLW	NAVD 88
MHHW	8.50 ft	8.02 ft
MLLW	7.79 ft	7.31 ft
MTL	5.07 ft	4.59 ft
MSL	4.95 ft	4.47 ft
MLW	2.35 ft	1.87 ft
MLLW	0 ft	-0.48 ft

Extreme high tide (the approximate highest of the high tides throughout the year excluding storm surge) was taken from tidal predictions at Chuckanut Bay (NOAA TWC1169) and is approximately 9.7 feet MLLW (9.2 feet NAVD88). Storm winds and waves from the south exposed fetch are not uncommon. These storms can increase local sea level above the tidal elevation depending on the direction, duration, and severity of the storm event. For the purposes of this study, storm surge (the combination of wind and wave setup) is estimated to be on the order of 1 foot (ESA 2010). The effects of wind and waves on water surface elevation within the estuary will become more pronounced following full restoration and may be slightly increased following partial restoration. Wave and hydrodynamic modeling and evaluation will need to be completed at later design phases to determine design water level and wave conditions for existing and proposed conditions.

For the purposes of this evaluation, wind and wave setup have been assumed equal to 1.5 feet (see Appendix C). The base design still water level used for evaluation of project elements was extreme high tide plus wind and wave setup (10.7 feet NAVD88). The future design still water level, which takes into account estimated sea level rise for the area, is 1.5 feet higher than the base level (12.2 feet NAVD88). This water level was used for design of restoration actions inside the estuary (e.g., marsh creation). For evaluation of the proposed railroad bridge, an additional 1.0 foot of elevation was added to take into account the influence of waves during a high frequency storm event (13.2 feet NAVD88).

5.3.2 Restoration Features – Primary Process-Based Management Measures

Armor Removal/Modification

The existing railroad berm slopes are protected with large armor rock. Armor rock will be removed from the entire length of the railroad berm on both the bay and estuary sides for full restoration (approximately 3,248 LF net removal) (Figure 5-3). Partial restoration includes removal of armor rock on both sides of the approximately 290 LF section of the railroad berm removed (total of 580 LF of armored shoreline removed) (Figure 5-4).

Berm or Dike Removal/Modification

With the full restoration alternative, Chuckanut Estuary will be fully reconnected to Bellingham Bay by replacing the existing railway berm with a railway bridge. Mean tidal elevations would remain unchanged in the estuary, as the current opening in the berm allows the full tidal range to be realized.

The existing railroad berm will be removed along its entire length (2,200 LF) to meet existing adjacent grades, and be replaced with a 2,556 LF railroad bridge (Figures 5-3, 5-5 and 5-7). The railroad bridge will be built south of the existing railroad berm. Full restoration will also include the removal of the roadway berm along the northeastern shoreline, and the removal of a small L-shaped earthen berm located in the intertidal area in front of private residences. Both of these berms will be excavated down to match adjacent existing grades (Figure 5-5A).

The volume of material removed from the estuary will be approximately 59,000 CY from the railroad berm and 245 CY from the L-shaped berm and roadway berm (Figure 5-5A). Removal of these berms will return 4 acres of tidelands within the estuary to intertidal elevations.

With the partial restoration alternative, increasing the size of the bridged section of the railroad berm would allow for lower tidal velocities within the opening (compared to current conditions) and would allow additional wave energy to propagate into the estuary. The partial restoration alternative would increase the complexity of the tidal circulation and wave action within the estuary to some degree, but would not return the estuary to historical conditions. The northwestern shoreline would still remain somewhat sheltered from wave impact, and tidal circulation would remain channelized. Historical sediment transport patterns (sediment settling along the southeastern and southern shorelines) would not be fully restored, and continued creation/maintenance of a flood shoal is anticipated.

The partial restoration alternative includes removal of 290 LF of berm east of the existing bridge section down to existing grade on either side of the berm. This alternative includes construction of a 500 LF bridge section to replace the old 210 LF bridge section and 290 LF of removed railroad berm (Figures 5-4, 5-6 and 5-7). This action will remove approximately 7,300 CY of material from the estuary and restore 0.5 acre of estuary tidelands.

Groin Removal/Modification - NA

Hydraulic Modification - NA

Overwater Structure Removal

The full restoration alternative includes removal of three small docks located along the northeastern shoreline fronting private residences (Figure 5-3). The overwater area of the docks is approximately 0.1 acre. The docks will be left in place under the partial restoration alternative.

Topography Restoration - NA

5.3.3 Restoration Features – Additional Management Measures

Beach Nourishment - NA

Contaminant Removal/Remediation - NA

Debris Removal

As part of the complete removal of the railroad berm in the full restoration alternative, armor rock that has been displaced from the slopes of the berm onto the seabed of Chuckanut Estuary will be removed. The partial restoration alternative includes removal of displaced armor rock only for 290 LF where the berm is removed. This management measure also includes piling removal.

Invasive Species Control - NA

Large Wood Placement -NA

Physical Exclusion - NA

Pollution Control - NA

Revegetation - NA

Reintroduction of Native Animals - NA

Substrate Modification - NA

Species Habitat Enhancement - NA

5.3.4 Restoration Features – Other

The local proponent anticipates continuing to provide shoreline public access in the vicinity of the salt marsh outlet. This would require relocation of the gravel parking area and access road to address the stressors on the salt marsh in the full restoration alternative.

5.3.5 Land Requirements

The full restoration alternative would require an easement from the City of Bellingham to construct the railroad bridge, which will be located along a different alignment than the current railroad berm. Docks and the L-shaped berm are located on private property, and would require permission and an easement from the current property owners or purchase of their tideland properties to complete those actions. The local proponent would need to relocate the existing gravel parking area and access road to allow the marsh located landward of the road to be reconnected to the estuary.

The partial restoration alternative has no land requirements because the proposed railway bridge is in-line with the existing tracks, and work would be performed from a barge or on the railroad grade (such as track construction).

5.3.6 Design Considerations

BNSF Railway will need to continue operations along the railway during construction of the project. This section of track is part of the mainline and it is heavily used by both cargo and passenger trains. The need to keep the rail line operational during construction of the project will dictate the alignment of the bridge (for both complete and partial removal options) and will likely be a factor in locating the opening if the partial removal option is implemented. In addition, there is an existing tunnel just west of the rail alignment crossing Chuckanut Bay that constrains both horizontal and vertical alignment changes.

In the full restoration alternative, the curvature of the track at the southern location and the tunnel located at the northern land connection will impact the alignment of the proposed bridge. In the partial restoration alternative, the curvature of the track at the southern land connection complicates adding a proposed bridge in that location. Widening the existing straight bridge location appears to be more feasible.

BNSF typically uses steel H-pile sections for bridge piles in new structures. Because this location is part of the coastal saltwater environment, a coating system for steel piles and/or sacrificial thickness would be required to ensure satisfactory long-term performance. Other pile types such as pre-cast concrete piles or shell piles should also be considered during later stages of design. The assumed embedment depth of the piles is 100 feet.

The alignment of the proposed bridge with the full restoration alternative will provide better construction access via barge/crane than if constructed landward or north of the existing rail line. The design of the proposed bridge assumes no interruption of service of the mainline BNSF railroad crossing Chuckanut Bay during construction of the proposed rail alignment. The proposed bridge girder length and pile/pilecap spacing will be 36 feet. The proposed track alignment curvature will meet or exceed that of the existing track curvature. A ballast/fill section will be needed to transition from bridge structure to the existing track section with the full restoration alternative. The length of this transitional fill is minimized to limit intertidal fill impacts and restore the full width of the Chuckanut Bay and Estuary interface. The design of the proposed bridge structure (both restoration alternatives) assumes little or no interruption of service to the mainline BNSF railroad.

For the partial restoration alternative, a 500-foot-long bridge consisting of steel piles, pre-cast concrete pilecaps, and pre-cast concrete girders will replace the existing 210-foot wooden bridge. The proposed bridge girder length and pile/pilecap spacing will be 26 feet. The assumed depth of piles is 100 feet embedded.

Bridges will require annual inspection, along with occasional cleaning of dirt and stray ballast from the bridge seats and clearing of brush and collected debris underneath the bridge. Minimizing maintenance requirements for the bridge will be considered during design of the proposed railroad bridge for both restoration alternatives.

The City of Bellingham will be completing construction of the Chuckanut Village Marsh Restoration Project in February 2011 (CGS October 2009). This project includes replacing the undersized culvert under the roadway with a larger culvert, and reestablishing a native salt marsh buffer along the publicly owned sections of the shoreline. Continued public shoreline access on City of Bellingham-owned land will need to be accommodated. This will require relocating the gravel parking area removed in the full restoration alternative to facilitate the marsh reconnection to the larger estuary.

5.3.7 Construction Considerations

It is anticipated that the contractor will be able to drive 5 to 7 piles per day for the proposed railroad bridge under the full restoration alternative. Pile driving could be accomplished from a pile driving barge for the majority of the alignment. Ballast would be removed and then piles would be driven. Once piles are driven, the pre-cast concrete pilecaps are set into place and the piles welded to embedded plates in the caps. The proposed pre-cast bridge girders are then set on the pilecaps and the ballast, ties and rails are installed. A barge-based crane would be required for this construction.

Proposed track connections to the existing rail will be required to be constructed by BNSF union workers based on union contract requirements. The contractor would provide construction for the balance of the project. Access and staging will be provided via a barge with a crane. A pile driving rig on rail would be used during allowable work windows. An allowable work window of up to 8 hours is estimated with prior coordination and scheduling through BNSF.

The proposed bridge in the partial restoration alternative would need to be built using the “building under traffic” method of construction. This means that the proposed bridge portions must be built without any track closure. The “track and time” authority is used to occupy the railroad during construction windows. During these construction windows, the contractor will drive 1 to 3 piles between existing bents accessed from the rail. Prior to pile driving, potholing should be done to verify the location of the existing abandoned pile bents at the rock berm.

Once all of the piles are driven with the partial restoration alternative, the pre-cast concrete pilecaps are lowered and slid into place below the existing track and welded to the steel piles. At the rock berm portion, local excavation will need to be done to facilitate pilecap installation and the welded pilecap connections. Once the pilecaps are in place, a portion of the existing track is removed and the proposed pre-cast bridge girders, ballast, ties, and rail are placed and connected to the existing railroad. An excavator will be required along the railway berm portion, and will require close coordination with railway operations to ensure adequate construction windows. This process of removing track sections and placing proposed girders and track is repeated until the entire stretch of proposed construction is complete, all while maintaining train traffic.

Other construction methods will be evaluated during subsequent design phases.

5.4 Extent of Stressor Removal

Table 5-2 describes the stressor removal areas for the full and partial restoration alternatives.

Table 5-2. Stressor Removal

Stressor	Full Restoration	Partial Restoration
Tidal Barrier (LF)	2,200	290
Fill[2] (acres)	3.4	0.5
Armor (LF)	3,248	580
Nearshore Roads (LF)	400	NA

[2] The fill removal is represented in the quantity spreadsheets as “Large Coastal Structure” and represents demolition of the railroad berm.

5.5 Expected Evolution of the Action Area

Changes to the hydrodynamics of the system would impact sediment transport and sedimentation in the estuary. Finer sediments that have been accumulating just inside the estuary opening would be transported out of the estuary, or would settle along the southern and southeastern shorelines as has occurred historically. Changes to hydrodynamics, water depths, and bottom substrate following removal of the berm may allow a return to pre-disturbance conditions.

At the salt marsh and berm, changes to the road would result in an improved connection that would restore tidal flow, and support tidal channel formation and maintenance, detritus import and export, and exchange of aquatic organisms. At the Chuckanut Creek mouth, removal of nearshore fill and overwater structures would result in improved tidal channel formation and maintenance, and solar incidence.

Following full restoration, the tidal channels at the mouth of Chuckanut Estuary and across the intertidal areas of the estuary, as well as the mouth of Chuckanut Creek, will migrate, erode, and accrete as part of natural tidal hydrodynamic and sediment transport processes. The current tidal channel under the existing bridge section is anticipated to fill in as sediment from littoral drift and other sediment transport processes returns to historic conditions with the return of the estuary to its natural planform. Increased tidal flow and wave energy into the estuary will increase topographic and habitat complexity within the estuary tidelands. Changes to the site following restoration activities should provide habitat conducive to shellfish and eelgrass beds, which were historically present in the estuary (Rubash 2009).

Partial restoration will allow for additional tidal flow and wave energy within the estuary, but will not fully return the estuary to its historic hydrodynamic regime. The remaining railroad berm will continue to act as a tidal barrier. The tidal channel under the bridge is anticipated to migrate within the new 500-foot opening and completely or partially fill in; however, the flow into and out of the estuary will still be constrained by the remaining railway berm. Littoral drift within the site will not be restored, but sediment transport potential within the estuary will be increased to some degree over existing conditions. Planform changes within the estuary will be minimal, but they are anticipated to provide habitat benefits compared to present conditions.

5.6 Uncertainties and Risks

Chuckanut Estuary restoration appears to be a promising opportunity in that a single action would provide for complete restoration of the historic hydrodynamic regime at the site. The largest challenges faced by the project include quantifying post-restoration topographic and bathymetric changes within the estuary, and addressing the logistics of demolishing the railroad berm and constructing the proposed bridge (in whole or in part).

Restoration of complex hydrodynamics (tidal circulation and wave energy) within the estuary will have an effect on the sediment transport, planform change, and tidal channel formation within the estuary. Changes to hydrodynamics and wave climate within the estuary following restoration can be quantified through the use of properly calibrated two-dimensional and three-dimensional tidal circulation and wave models.

The extent and magnitude of sediment transport and planform changes within the estuary after restoration are more difficult to predict using numerical or physical models. Even with robust evaluation, there will be uncertainties and risks associated with how the estuary topography and bathymetry will evolve post-restoration. These uncertainties and risks include potential impacts to the private waterfront properties on the shoreline of the estuary, as well as potential storm-related damage from increased wave energy, and redistribution (erosion and accretion) of sediments and large woody debris/driftwood affecting the configuration of the shoreline.

These risks and uncertainties are anticipated to be greater with the full restoration alternative than the partial restoration alternative, due to the significant difference in the length of the exposure to wave energy between the two alternatives, and the long fetch distance to the south of the railroad. Shoreline monitoring and an associated adaptive management strategy should be employed to ensure negative impacts to shoreline properties within the estuary are minimized to the extent possible.

Along the rock berm, the original bridge is assumed to have been abandoned and not removed. Existing pile locations should be verified by examining as-builts and/or by potholing. If steel piles are chosen, driving noises due to hammer impact can be substantial. Noise mitigation measures, such as the use of bubble curtains, should be considered and may be required in order to obtain environmental permits. Removal of timber piles is typically accomplished by full removal. Cutting these piles at the mud line is typically only allowed by permit agencies if full removal is unsuccessful and results in pile breakage. There is a risk that pile breakage will occur, and more careful excavation around each pile and cutting a certain distance (for example, 1 foot or more below mud line) would likely be required in these instances.

5.6.1 Risks Associated with Projected Sea Level Change

Sea level rise does not appear to be a major issue in terms of the railroad at this action area. The track elevation has sufficient overwater clearance even considering the high estimate of sea level rise for the project area (1.5 feet). However, sea level rise could impact private and public property in the vicinity of the salt marsh and Chuckanut Creek mouth, particularly with increased exposure to waves from the south due to bridge lengthening and improved tidal circulation to the salt marsh and creek mouth. Salt marsh habitat created as part of full restoration may be converted to other more abundant habitat types (such as mudflat) over time due to sea level rise.

In addition, existing residential development in the immediate vicinity of the creek mouth is in low-lying land and currently falls within the extent of the FEMA 100-year floodplain (FEMA 2004). These properties are vulnerable to flooding and sea level rise regardless of changes at the railroad bridge. Table 5-3 provides a qualitative comparison of sea level change risks.

Table 5-3. Risks of Sea Level Change

	Projected Sea Level Change		
	High (46cm)	**Intermediate (4cm)**	**Low (-8cm)**
Full Restoration	Increased risk of flooding to homes built along the shoreline. Changes to marsh vegetation along the northwestern shoreline and mouth of Chuckanut Creek. Increased wave energy and sediment transport potential within the estuary.	Slightly increased risk of flooding to homes built along the shoreline of the estuary.	None

	Projected Sea Level Change		
	High (46cm)	Intermediate (4cm)	Low (-8cm)
Partial Restoration	Increased risk of flooding to homes built along the shoreline. Changes to marsh vegetation along the northwestern shoreline and mouth of Chuckanut Creek. Potential for increase in wave energy and sediment transport potential within the estuary.	Slightly increased risk of flooding to homes built along the shoreline of the estuary.	None

5.7 Potential Monitoring Opportunities

Monitoring of the site is important for evaluating the success of the partial or full restoration alternatives. A combination of field surveys and aerial photographs would be used to document biological and physical changes to the landscape. Monitoring data can be used to refine adaptive management and corrective actions, as needed. Some of the key performance indicators are shown in Table 5-4.

Table 5-4. Monitoring Needs and Opportunities

Monitoring Parameter	Key Performance Indicator	Note
Topographic Stability	X	Monitor shorelines adjacent to private property to ensure there are no negative impacts due to restoration activities
Sediment Accretion / Erosion	X	Same as topographic stability
Wood Accumulation	X	Monitor changes to accumulation of large woody debris and driftwood associated with opening of estuary mouth to wave energy
Soil / Substrate Conditions		
Vegetation Establishment	X	Evaluate increase to eelgrass within estuary post-restoration
Marsh Surface Evolution / Accretion	x	Evaluate changes at marsh where road berm lowered and at mouth of Chuckanut Creek
Tidal Channel Cross-Section / Density	X	Evaluate changes in tidal channel at current bridge and other changes to tidal channels
Water Quality (contaminants)		
Salinity	X	Monitor tidal inundation
Shellfish Production	X	Evaluate increase of shellfish within estuary post-restoration
Extent of Invasive Species		

Monitoring Parameter	Key Performance Indicator	Note
Animal Species Richness		
Fish (salmonid) Access/Use	X	Monitor salmonid use at the mouth of Chuckanut Creek
Forage Fish Production	X	Monitor forage fish production within the estuary
Wildlife Species Use		
Effectiveness of Exclusion Devices		

5.8 Information Needed for Subsequent Design

This conceptual design report represents an initial step in the restoration design sequence. The design concepts described above were developed based on readily available information without the level of site-specific survey and investigation that is necessary to support subsequent design and implementation. Substantial additional information will be required at the preliminary and later design stages to confirm the design assumptions, refine quantity estimates, address property and regulatory issues, obtain stakeholder support, and fill in data gaps. In general, issues requiring additional analysis and investigation include but are not limited to:

- Property Investigation/Survey – More detailed information on parcel ownership, utility locations, and property boundary locations will be needed to finalize the design, confirm acquisition requirements, and support negotiations with property owners, especially for the full restoration alternative.
- As-built Information – More information regarding the existing railroad bridge and berm (i.e., depth of armor stone, etc.) will be needed (if available) to finalize design and construction costs for both full and partial restoration.
- Topographic/Bathymetric Survey – Bathymetry survey data within Chuckanut Estuary and Chuckanut Bay offshore of the current railroad berm would be required for design of both restoration alternatives. Full restoration would require a topographic survey of the railway tracks to the east and west of the proposed railway bridge, railway berm, roadway berm, and L-shaped berms. Partial restoration would require topographic survey of the existing railroad berm. These survey data would be used to inform required hydrodynamic modeling, the design of project elements, and development of a construction and demolition plan for the site. Elevations of the existing rails to the east and west of proposed railway sections will be used to evaluate the feasibility of meeting maximum grade allowance with proposed bridge lengths. Survey data would also be used as a baseline for pre- and post-construction modeling. This survey would also need to identify any debris (such as armor rock) that is beyond the limits of the railroad berm toe for demolition and removal purposes.
- Geotechnical Investigation – The design of the railroad bridge will require an extensive geotechnical investigation and recommendations to confirm foundation type (steel pile) and determine the size and pile length for the proposed bridge. Geotechnical borings along the proposed alignment of the railroad bridge will be needed to develop these recommendations. In addition, potholing to determine the locations of the wood bridges buried in the rock berm would be needed prior to final design. Additional geotechnical investigation will be required to

determine the subsurface sediment characteristics of the existing railroad berm, roadway berm, gravel parking area, and proposed alignment for the new creek channel between the estuary and the marsh.

- Cultural Resources Investigation – Surveys for archaeological and historic resources may be required for this action area. This is particularly important in areas proposed for excavation and trenching.
- Hydraulic Analysis/Modeling – Tidal circulation and wave modeling will be required to evaluate impacts to the estuary and adjacent properties following restoration. The models will also be used to optimize the size of the opening in the partial restoration alternative, and to provide design criteria for the railroad bridge proposed for the mouth of Chuckanut Creek. Results from the modeling will be utilized by a hydraulic engineer to provide recommendations for scour and minimum bridge clearance over water. A temporary tide gage may be required in the early design stages to obtain site-specific tidal statistics.
- Contaminant Survey – If preliminary investigations suggest that hazardous material could be present in the action area, additional soil and sediment analysis may be needed. The introductory chapter describes the Phase I site investigations that are occurring as part of this overall effort via a separate contract.
- Fill – Fill materials for the railway bridge and fill track sections will be evaluated during subsequent design phases, based on results of geotechnical investigation and hydraulic analysis.
- Parking - Potential location(s) for relocating the parking area for full restoration need to be evaluated. A feasibility study should be completed to develop an alternative location for the parking area currently located along the shoreline. The study is needed because appropriate space available appears to be very limited.

5.9 Quantity Estimates

The cost estimate spreadsheets for the alternatives are provided in Exhibits 5-1 and 5-2. The design quantities are largely developed from LiDAR data sets lacking the resolution to accurately quantify all elements of construction. In particular, the small L-shaped berm and roadway berm separating the marsh from the estuary are poorly resolved in available LiDAR topography. LiDAR data were supplemented by observations made during one site visit at lower tide and areal take-offs from available imagery.

5.10 References

Coastal Geologic Services. 2007. *Whatcom County Nearshore Habitat Restoration Prioritization.* Prepared for Whatcom County Resources Committee.

Coastal Geologic Services. 2009. Chuckanut Village Marsh Final Plans. Prepared for the City of Bellingham. October 2009. (Available at http://www.cob.org/documents/pw/environment/restoration/chuckanut-village-marsh-final-plans.pdf)

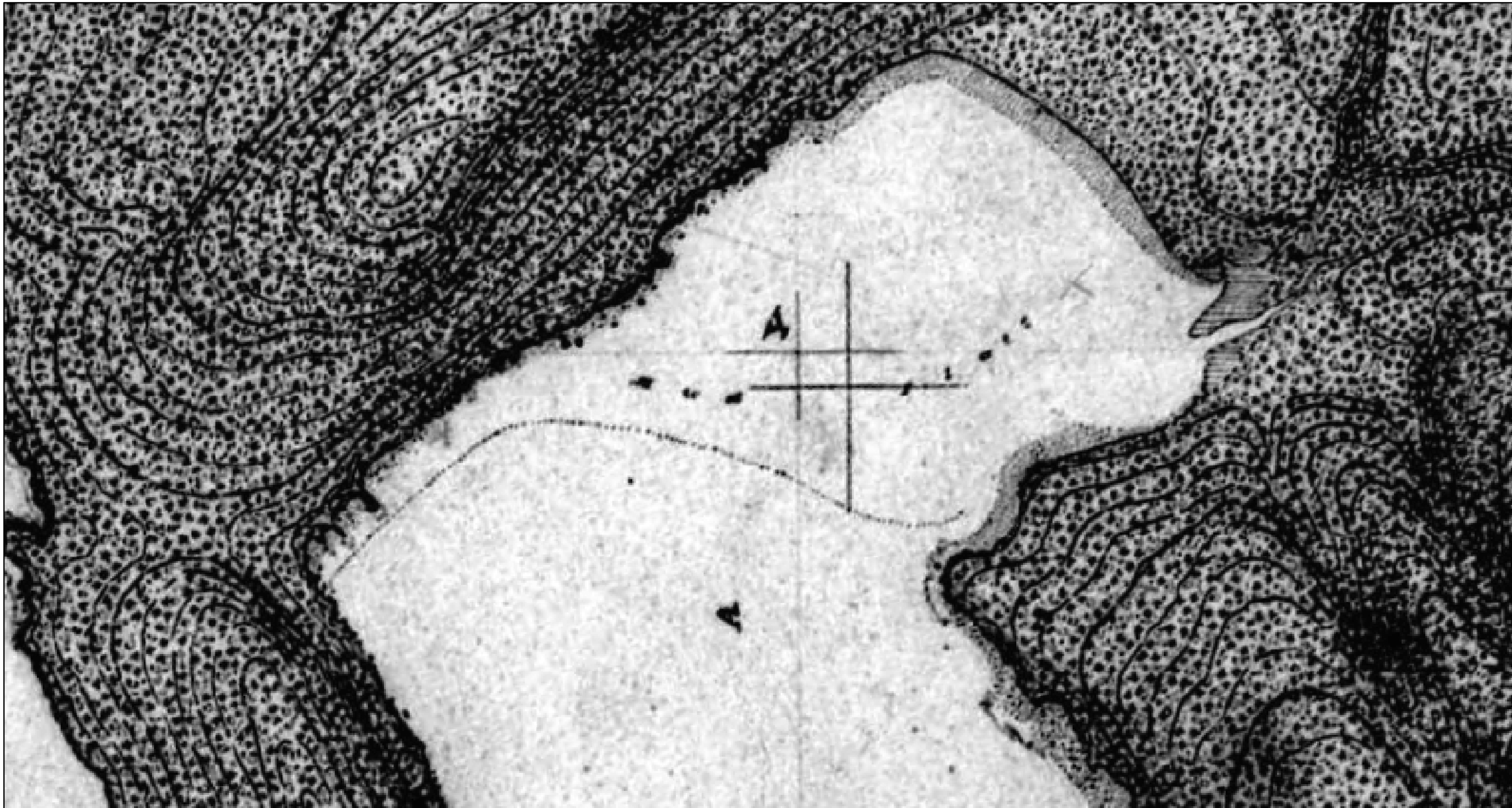
ESA. 2010. PSNERP Applied Geomorphology Guidelines, December 2010.

FEMA (Federal Emergency Management Agency). 2004. Flood Insurance Rate Map, Whatcom County All Jurisdictions, Map ID# 53073C1675D. Effective Date January 16, 2004.

NOAA (National Oceanic and Atmospheric Administration). 1888. HO1887, NOAA Hydrographic Survey in the vicinity of Bellingham Bay, Washington.

Northwest Ecological Services, LLC. 2009. *Wetland Characterization: Chuckanut Village Marsh.* Prepared for Whatcom County Public Works.

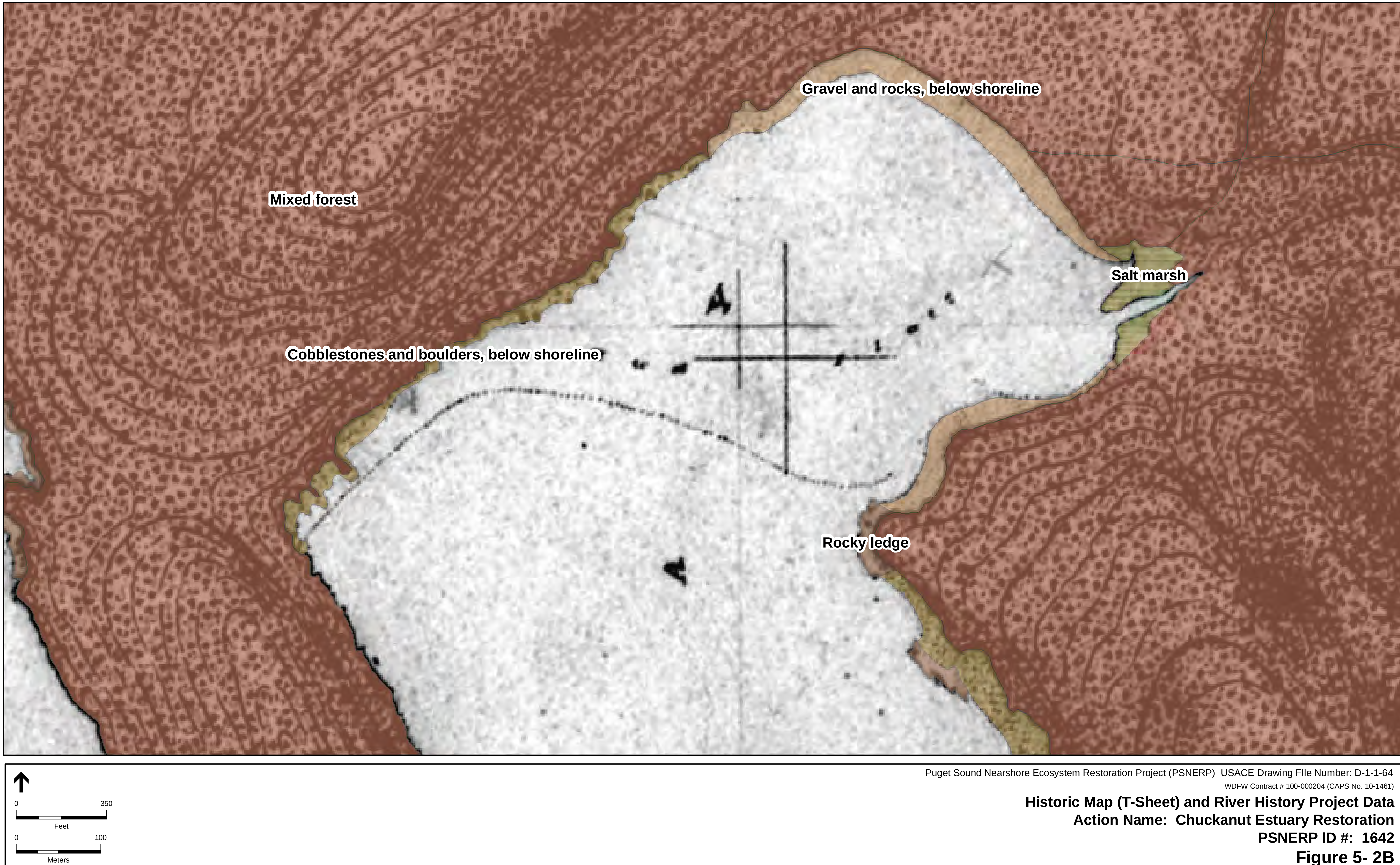
Rubash, B. 2009. *Changes in Intertidal Surface Elevation from 1988 to 2006 in Northern Chuckanut Bay*.



0 350
Feet
0 100
Meters

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Historic Map (T-Sheet)
Action Name: Chuckanut Estuary Restoration
PSNERP ID #: 1642
Figure 5- 2A

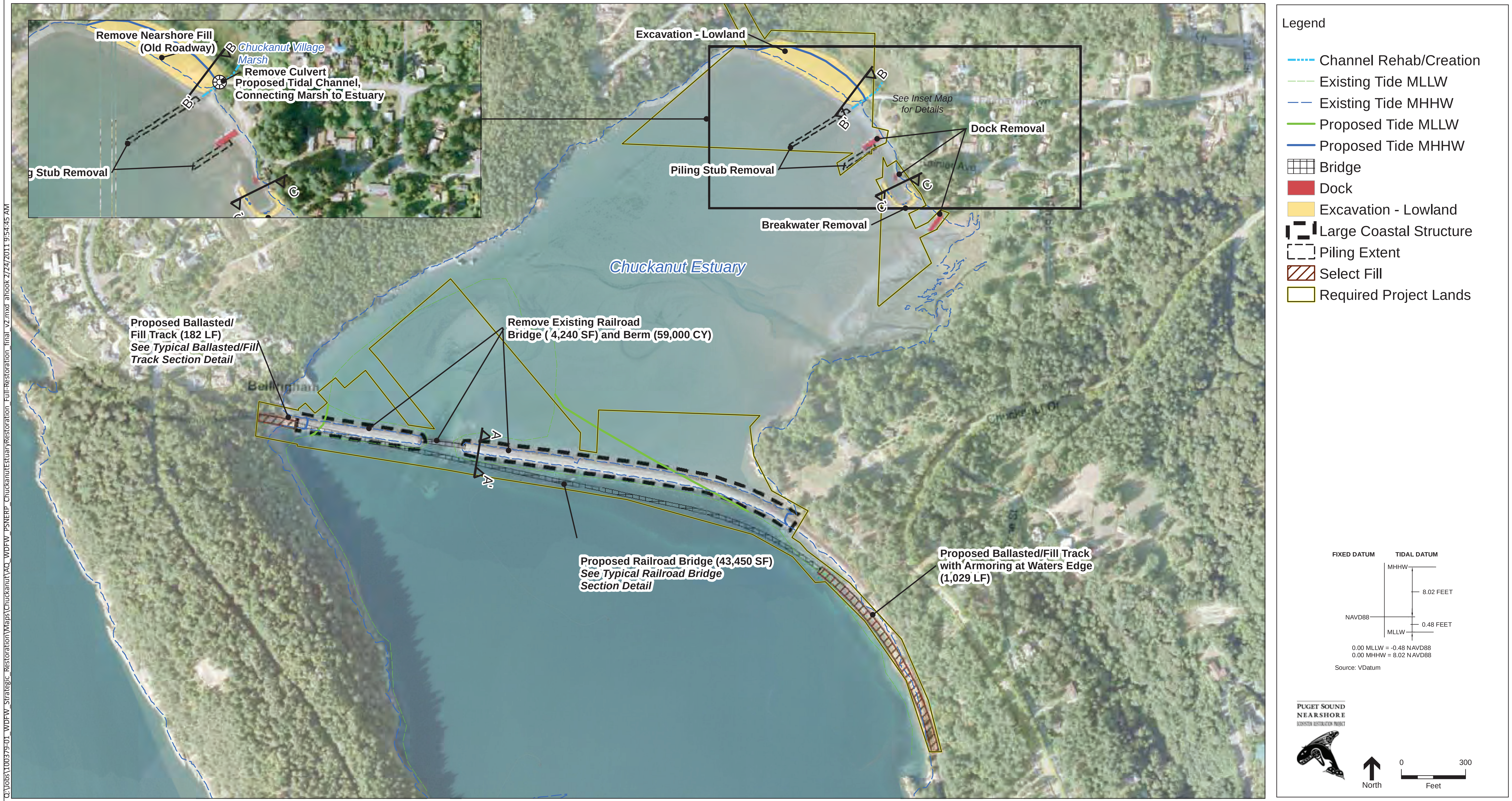


Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64

WDFW Contract # 100-000204 (CAPS No. 10-1461)

Historic Map (T-Sheet) and River History Project Data
Action Name: Chuckanut Estuary Restoration
PSNERP ID #: 1642
Figure 5- 2B

S:\GIS\Projects\210xxx\210337_PSNERP_NEARSHORE\Projects\2-TSheets_rev.mxd (DLP; 2/24/2011)



SOURCE: Bing Imagery (2011)

Lead Contractor: ESA
Design Lead: Anchor QEA, Kathy Ketteridge
Date: 02/18/2011

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Plan
Site Name: Chuckanut Estuary
Action Name: Chuckanut Estuary Restoration
PSNERP ID #: 1642
Full Restoration

Figure 5-3

Q:\Jobs\100379-01_WDFW_Strategic_Restoration\Maps\Chuckanut\AQ_WDFW_PSNERP_ChuckanutEstuaryRestoration_Partial-Restoration_final_v2.mxd ahook 2/24/2011 10:02:16 AM

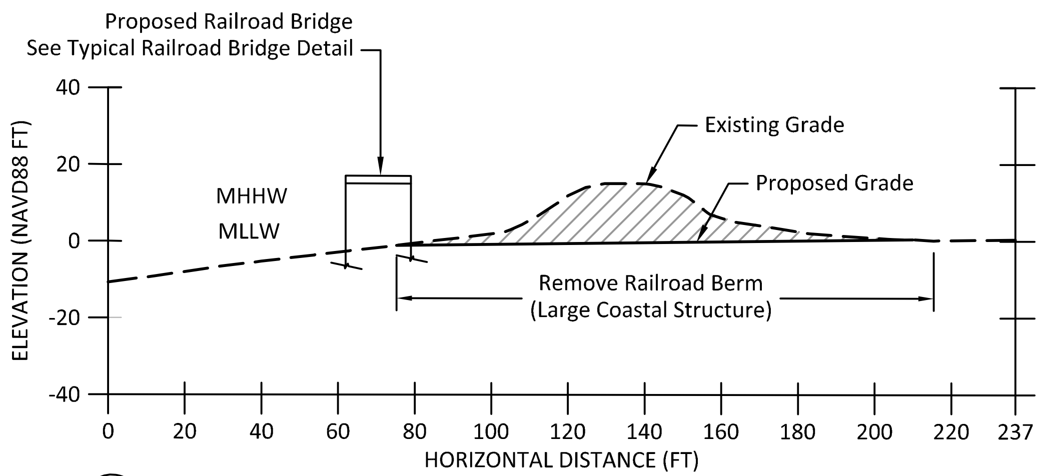
SOURCE: High Resolution Orthoimagery (USGS, 2009); Action Area (PSNERP, 2010)

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

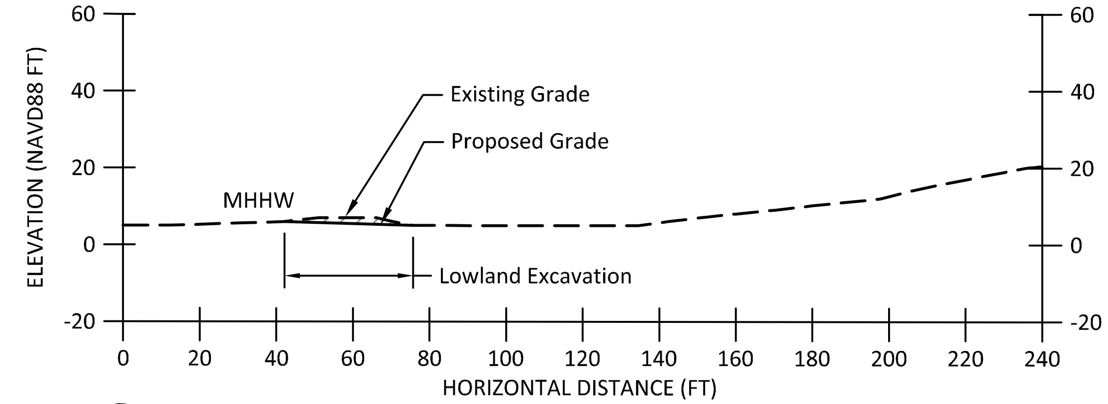
Lead Contractor: ESA
Design Lead: Anchor QEA, Kathy Ketteridge
Date: 2/2011

Conceptual Design Plan
Site Name: Chuckanut Estuary
Action Name: Chuckanut Estuary Restoration
PSNERP ID #: 1642
Partial Restoration

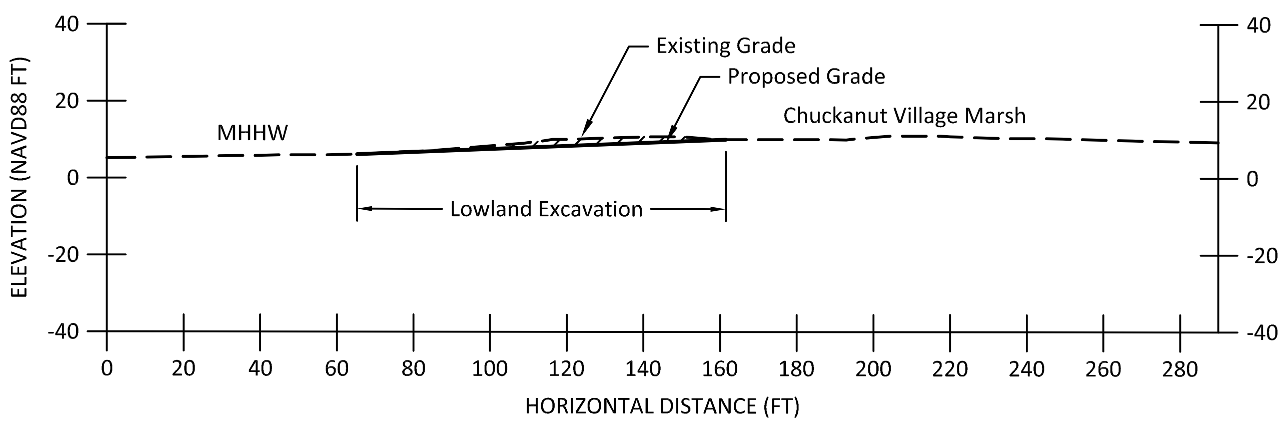
Figure 5-4



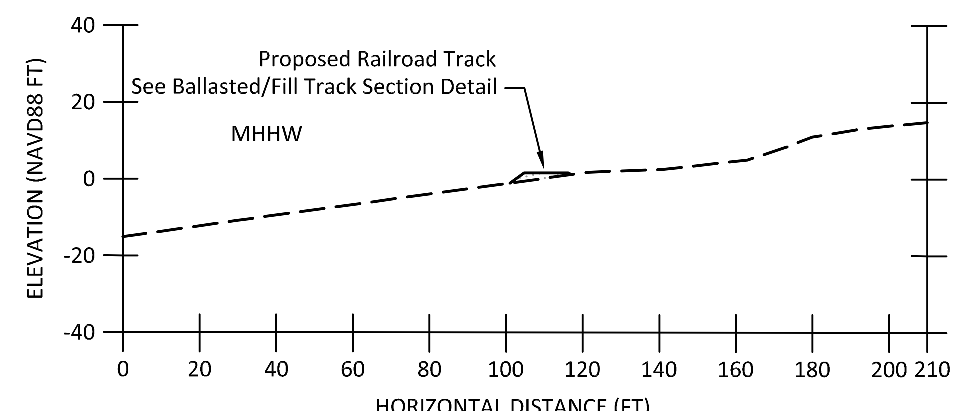
A FULL RESTORATION TYPICAL SECTION



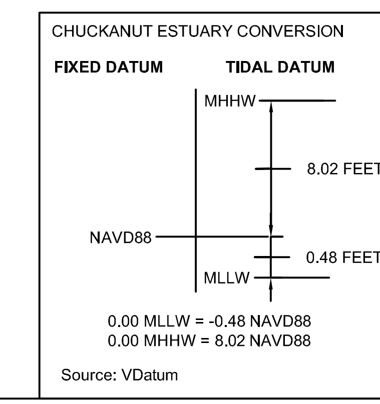
C FULL RESTORATION TYPICAL SECTION

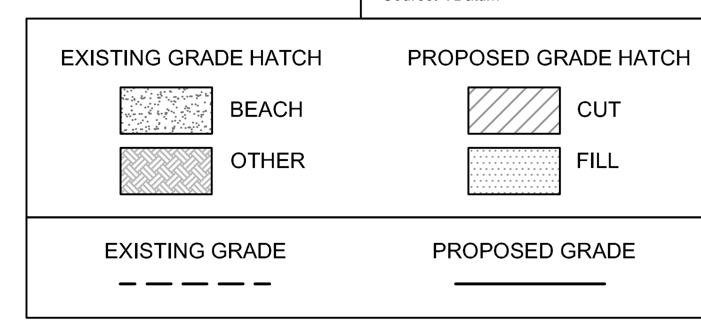


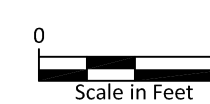
B FULL RESTORATION TYPICAL SECTION



D FULL RESTORATION TYPICAL SECTION







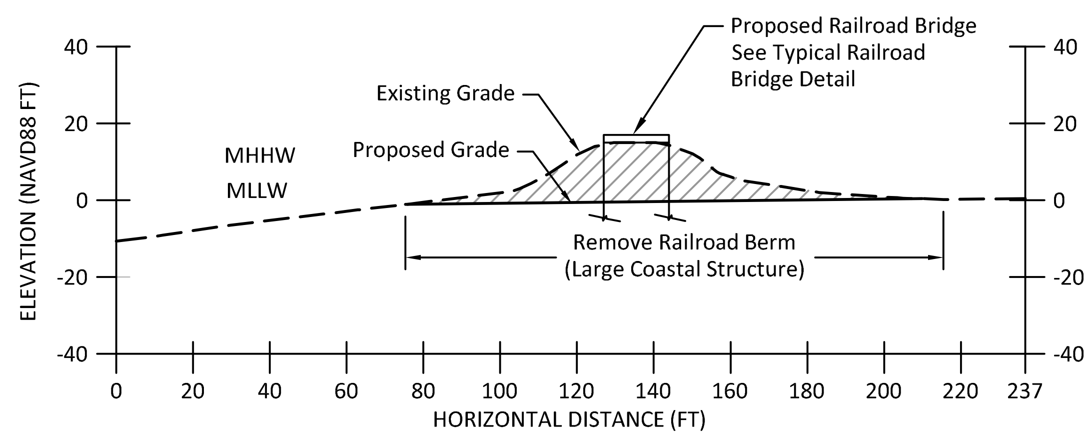
PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: Anchor with KPFF
Date: 3/2011

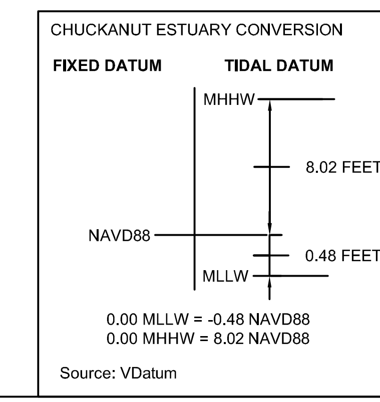
Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

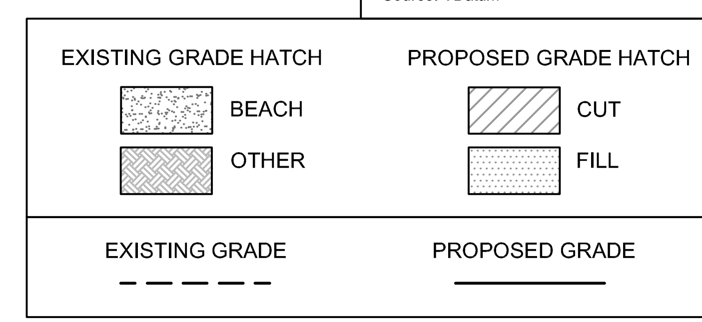
Conceptual Design Section
SITE NAME: **Chuckanut Estuary**
ACTION NAME: **Chuckanut Estuary Restoration**
PSNERP ID#: **1642**
Full Restoration

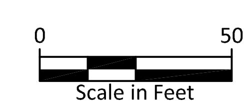
Figure 5-5



Ⓐ PARTIAL RESTORATION TYPICAL SECTION







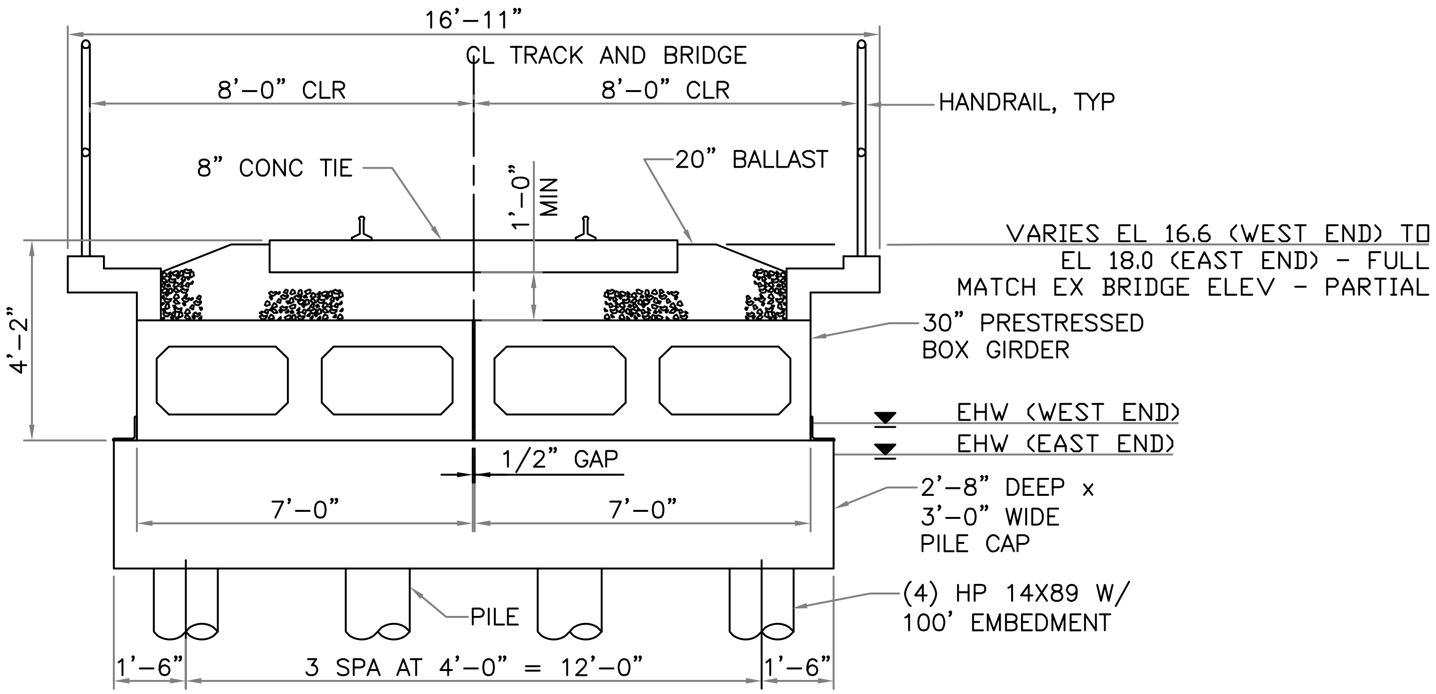
PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: Anchor with KPFF
Date: 3/2011

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Section
SITE NAME: **Chuckanut Estuary**
ACTION NAME: **Chuckanut Estuary Restoration**
PSNERP ID#: **1642**
Partial Restoration

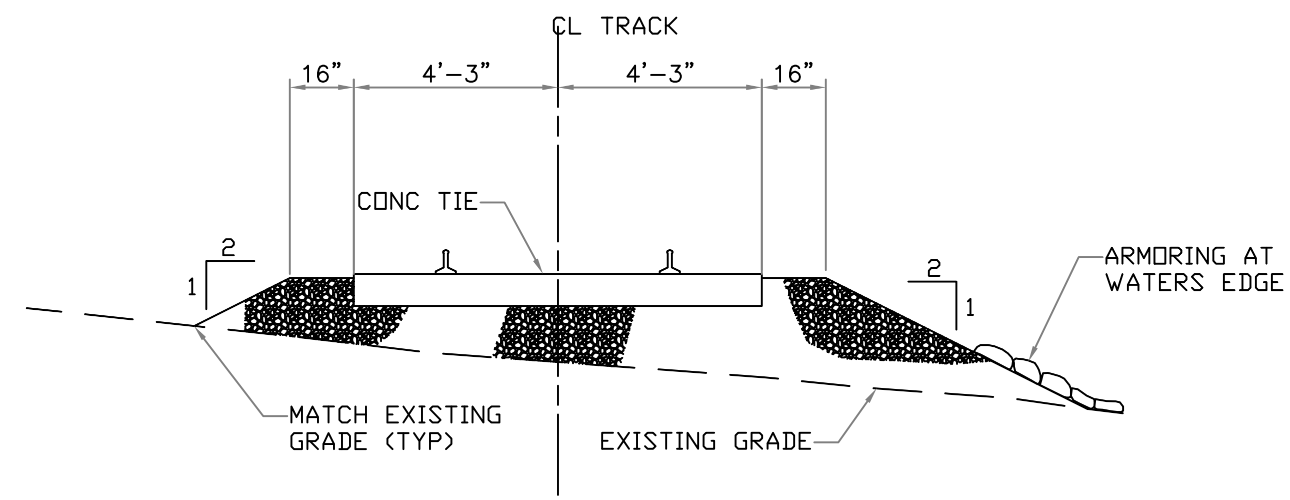
Figure 5-6



NOTE: 36' SPAN (FULL) 26' SPAN (PARTIAL)

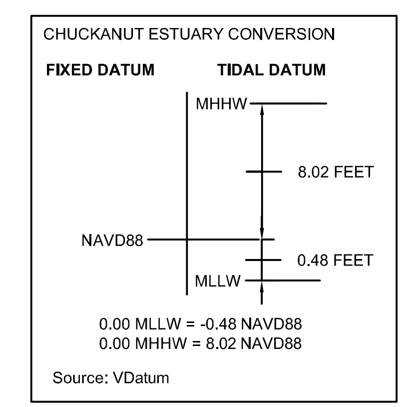
▼ EXTREME HIGH WATER (EHW) = EL 12.7

TYPICAL RAILROAD BRIDGE
SECTION DETAIL
Not to Scale
Section Provided by KPFF



NOTE: RAIL ELEVATION IS 16.5 TO 16.6 WEST OF THE NEW BRIDGE AND 18 TO 18.5 EAST OF THE NEW BRIDGE (FULL)

TYPICAL BALLAST / FILL TRACK
SECTION DETAIL
Not to Scale
Section Provided by KPFF



PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: Anchor with KPFF
Date: 3/2011

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Section
SITE NAME: **Chuckanut Estuary**
ACTION NAME: **Chuckanut Estuary Restoration**
PSNERP ID#: **1642**
Full and Partial Restoration

Figure 5-7

Full Restoration Quantity Estimate

Action Name: Chuckanut Estuary Restorati
Action #: 1642
Date: February 2011
By: Kathy Ketteridge, Anchor QEA

REMEDY: ***Remove Railroad berm and replace with bridge***
Construction Period: 14 weeks (in-water work 12 weeks)

Item	Unit of Measure	Material Name	Qty	Description of Item	Indicate section of design report where item is described
ACQUISITION AND CONSERVATION				Based on available mapping information	
Required Project Lands	Acre			Total land required For action	
Proponent / Partner-owned lands	Acre			Etimate of lands currently owned by Proponent (i.e., Public lands)	
Lands To Be Acquired	Acre			Estimate land required to be acquired for action prior to implementation	
Material Sites				Not Used: See Earthwork - Imported Fill.	
MOBILIZATION AND ACCESS for construction activities				Description required for each item to facilitate cost estimating	
Mobilization - Typical (Equipment, Personnel, Planning, Financial)	LS		1	Up front costs such as bonding, planning and other staff time and financing. Typically, assume 8% to 10% of other items.	5.3
Mobilization - Remote (Equipment, Personnel, Planning, Financial)	LS		1	Up front cost for nontypical or remote locations. Assume 12% of other items	5.3
Site Access	LS			Use for special situations (e.g.. new bridge, new access roads) for the purposes of construction access. Include description.	
Barge Access	Days		58	Describe need for barge access	5.3
Temporary Traffic Control (one of the following)				Includes installation of traffic signals, signage, signmen, etc. There are 4 types as follows:	
none	LS			None = no traffic control	
signs	LS		1	Signs = signs only, costs typically around 1% of total roadway costs	5.3
flags / spotters	LS			Flags and spotters = signs plus entails a greater level of effort. Describe the duration of this activity. This can be about 3% of total roadway costs.	
unique	LS			Unique = Greater effort than flags / spotters. Describe as basis for cost estimate.	
Temporary Roadway	SF			Includes construction of temporary adjacent roadway or bypass roadways and for vehicle and pedestrian travel through or around site.	
Control of Water	LS			Use for special situations that require draining the site using pumps or water control structures, and bypassing water during construction. Can also be used for multi-year projects. Description required, including estimate duration.	
Relocation Activities				Not Used: See Utilities, Structures	
Site Demolition Activities				Demolition and removal of structures (description required), temporary features and relocations, itemized separately); Clearing and grubbing of vegetation, and removal of minor debris (rocks, slabs) - description required.	
Clearing and Grubbing (one or more of following)				Use one or more of the following categories of clearing and grubbing	
Clear Vegetation - Local Disposal	AC			Vegetation removed above grade and disposed locally	
Clear /Grub Vegetation - Local Disposal	AC			Vegetation roots also removed and disposed locally	
Clear /Grub Vegetation - Offsite Disposal	AC		0.3	Vegetation is taken offsite and disposed - use for noxious invasives, etc.	5.3
Clear, stockpile - large woody debris	CY			Vegetation is segregated and stockpiled / prepared for reuse on site.	
Hydraulic Structures - Small	LS			Removal of tide control and significant drainage structures that require excavation, cofferdam and or water control. Describe type of structure, elevation etc. For major structures (dam, diversion), use different line.	
Hydraulic Structures - Large	LS			Dam removal (describe and state whether this item includes water control and sediment removal or these are in separate items)	
Docks	SF		4,300		5.3
Utilities	LS or LF				
Buildings	LS or SF				
Pavement	LS or SF				
Bulkheads	LF or SF			Use this for bulkheads…if large and difficult, consider using Large Coastal Structures.	
Rock revetments	LF, Ton or CY				
Large Coastal Structures (Railroad Berm Fill)	CY		59000	Use this item for breakwaters, jetties, groins, reinforced concrete seawalls and any structure that requires larger equipment and power to break up and or remove	5.3
Demolition / Removal - Railroad Bridge	SF		4240	Use this item for structures that require cranes or other special removal staging	5.3
Demolition/Removal - In-water Piling	EA		1050		5.3
Removal - Misc. (e.g. angular rock from beach)	Ton			For loose rock scattered across intertidal.	
Demolition / Removal - Boat Ramp	SF			This is a special item but happens at least once…others can also be added as needed.	
Haul - Offsite Disposal of Demolition Debris	Miles			Estimate distance (to nearest 10 miles) to disposal site for materials, veg clear and grub, etc.	
Hazardous/Contaminated Waste Removal				These items for earthwork of quality not compatible with wetlands, requiring special handling and disposal. Describe basis for classification as contaminated or hazardous. State known or suspected contamination, describe known similar work.	
Contaminated Earthwork	CY			Excavation, off haul and disposal within a licensed landfill, complete	
Hazardous Earthwork	CY			Excavation, off haul and disposal within a licensed hazardous waste landfill, complete	
Construct Temporary Features				Use as needed for unusual temporary features not included elsewhere (see TESC below)	
EARTHWORK				Expand to include equipment, etc. to facilitate cost estimating.	
Excavation	CY			Per yard excavation w/out expected haul	
Excavation - Upland	CY			Conducive for transitional earthwork equipment, including scrapers, with high production and low cost.	
Excavation - Lowland	CY		250	Requires low ground pressure equipment and or mats; low production bucket methods, typically hydraulic excavator and front end loaders.	5.3
Dredging - Bucket - Land	CY			Excavation below ground water or underwater; reach limited low production.	
Dredging - Bucket - Marine	CY			Floating or amphibious equipment with excavator, clamshell or dragline bucket	
Dredging - Hydraulic	CY			Hydraulic cutter / suction dredge to slurry and pump sediments	
Fine Grading	AC			Small tolerance grading after rough grading.	
Fill Placement - local borrow				This is additive to Earthwork -Excavation	
Side cast	CY			Excavated material placed within reach of excavator / dredge - assume includes some shaping by bucket	
Haul - uncontrolled placement	CY			Transportation and second handling - estimate distance.	
Haul, place, compact	CY			Transportation and second handling - estimate distance, placement in lifts, moisture conditioning, compaction testing.	
Stockpile - uncontrolled placement	CY			Intermediate step, for subsequent off haul or use elsewhere on site.	
Stockpile - controlled placement	CY			intermediate step, for subsequent off haul or use elsewhere on site. Can use this for drying material for subsequent controlled compacted fill	
Conveyor placement from stockpile land/water	CY			Some projects may require conveyor placement	
Imported Fill				Includes purchase, delivery and placement or as noted / described	
Select Fill	CY			Imported select material - describe use, e.g. levee, root base mix, etc;	
Gravel Borrow, including haul	CY			WSDOT standard item	
Sand / Gravel for Beach Nourishment	CY			special borrow and sorting required; identify material source	
Cobble for Shore Nourishment	CY			special borrow and sorting required; identify material source	
Embankment Compaction	CY			WSDOT standard item	
Topsoil	CY				
RESTORATION Features					
Channel Rehab / Creation	SF			Channel construction (SF) including imported sediment and habitat materials, excluding excavation	
Large Wood Placement	EA		4	Per each log, Including drift logs, lower river log jams, etc.	5.3
Invasive Species Control	Acre			Per acre control described in drawings and narrative	
Physical Exclusion Devices	LF or EA			Human or wildlife exclusions including fences, barriers, mooring buoys, etc	
Other Restoration Features/ Activities	LS			Describe other items not included elsewhere	
Structures	EA			KPFF to provide additional inputs	
Water Control Structures - Culverts with Gates	EA			Describe type, number of openings (e.g. pipes), expected materials, dimensions	
Water Control Structures - Weirs	EA			Describe, length, type, anticipated materials	
Rock Slope Protection	LF			Describe slope, rock size, layering, use of fabric, back up quantities per foot.	
Other	EA			Describe	
Elevated Boat Ramp	SF			Pile or pier supported to allow sediment drift	
Fencing	SF			Describe, type, height etc.	
Utilities				Replacement or relocation. Designer to provide size and material and have separate line item for each run. Incidentals include earthwork, testing, hook up fees, etc. These quantities do not include demolition of existing utilities, real estate / easements, design fees. Describe the owner if known, and whether utility franchise will install (e.g.. electric is typically installed by electrical franchise)	
Water	LF				
Gas	LF				
Electric	LF				
Sewer	LF				
Telecommunications	LF				
Other	LF			Others = whatever is required (e.g.. power towers, petroleum, jet fuel, etc.)	
Roadway / Railway				KPFF expected to participate in these estimates	
Roadway (Type)	SF			Typical roadway, not including earthwork and temporary or permanent traffic controls. Provide a description. Assume a standard pavement section or describe if special section anticipated.• Pavement• Base Course• Storm Drainage Collection and Conveyance (incl. trenching, backfill, etc.)• Stormwater Treatment	
Roadway - Traffic Signal	LS			Street lights, etc. (Temporary traffic control handled under Temporary Facilities)	
Culvert (type)	LF			Provide specific culver size and type	
Culvert - Jacking	LF			Through railway	
Culvert - Horizontal Pile Driving	LF			Through railway	

Full Restoration Quantity Estimate

Action Name: Chuckanut Estuary Restorati
Action #: 1642
Date: February 2011
By: Kathy Ketteridge, Anchor QEA

REMEDY: *Remove Railroad berm and replace with bridge*
Construction Period: 14 weeks (in-water work 12 weeks)

	Item	Unit of Measure	Material Name	Qty	Description of Item	Indicate section of design report where item is described
	Bridge - Foundations, Deck and Appurtenances	SF			Include elements such as approach slab, abutment, barriers, railings, etc. to conform to one of three or four types to be developed	
	Railway - Box Girder Bridge	SF		43452	Standard	5.3
	Railway - Foundation	LF		1152	Standard	5.3
	Railway - Shoe fly	LF			Temporary alignment	
Permanent Access Features					KPFF expected to participate in these estimates	
	Roads	Level			Level 1 direct access, Level 2 moderately difficult, Level 3 difficult access	
	Utility Access Routes	varies			Describe utility access feature, such as boardwalk or all-weather gravel road	
	Erosion Control Features	L.F.			Describe quantity of expected erosion control measures	
Public Access or Recreation Features					KPFF expected to participate in these estimates	
	Trails	SF			Describe trail feature, such as gravel, mulch, asphalt concrete.	
	Bridges	SF			Describe bridge feature, such as wooden pedestrian, or H20 vehicle.	
	Kiosk	EA			Describe kiosk feature, such as size, material.	
	Restrooms	EA			Describe restroom feature, such as size, material.	
	Interpretive Signs	EA	1		Include # interpretive signs based on number of local public access points	
	Parking Area	SF			Describe parking area, such as size, material.	
	Other	EA			Describe other recreational features (see Corps criteria, ER 1105-2-100 for compatibility with ecosystem objectives)	
Vegetation & Erosion Control						
	Hydroseeding	AC			Describe desired seed mix (e.g.. native plants cost more)	
	Planting	AC			Describe, provide breakdown on unit area basis.	
	Vegetation Maintenance	AC-YR			Includes irrigation, weeding, plant replacement for one year	
	Erosion / sediment BMPs - Temp.	AC			BMPs for control of drainage - describe. Assume compliance with Construction General NPDES included	
	Erosion / sediment BMPs - Permanent	AC			May want to separate slopes over 25% into separate category	
	Waterside controls - Temporary	LF	Silt Curtain	7534	Silt curtain or other water based temporary actions	5.3
Construction Management						
	Construction oversight	weeks			Quanity based on constructon duration/ # of construction seasons	
	Materials testing				Included in cost of material - no separate quantity	
Design and Detailed Site Investigations						
	Survey & Property, Utility Research	LS		1	% of construction cost	5.8
	35% Design	LS		1	35% x 25% x Engineer's Estimate	5.8
	65% design	LS		1	65% x 25% x Engineer's Estimate less the cost for 35% PS&E	5.8
	90% design	LS		1	35% x 25% x Engineer's Estimate less the cost for 35% + 65%PS&E	5.8
	100% design	LS		1	25% x Engineer's Estimate less previous costs	5.8
	Geotechnical Studies	LS			Refer to design report for description of need	
	Cultural Studies	LS			Refer to design report for description of need	
	Tidal Circulation and wave modeling/studies	LS			Refer to design report for description of need	
Project Agreement Activities					Unable to provide credibale estimate at 10% design	
Site-Specific Adaptive Management Features & Activities					List if known	
Monitoring Activities					Assume 5 crew-days/year for each monitoring parameter in design report for 5 yrs	
	Monitoring (Type)	crew-days		250		
Operations & Maintenance					Unable to provide credible estimate at 10% design	

Partial Restoration Quantity Estimate

Action Name: Chuckanut Estuary Restorati
Action #: 1642
Date: February 2011
By: Kathy Ketteridge, Anchor QEA

REMEDY: ***Remove 210' portion of Railraod Berm and replace with Bridge***
Construction Period: 10 weeks (in-water work 8 weeks)

Item	Unit of Measure	Material Name	Qty	Description of Item	Indicate section of design report where item is described
ACQUISITION AND CONSERVATION				Based on available mapping information	
Required Project Lands	Acre			Total land required For action	
Proponent / Partner-owned lands	Acre			Etimate of lands currently owned by Proponent (i.e., Public lands)	
Lands To Be Acquired	Acre			Estimate land required to be acquired for action prior to implementation	
Material Sites				Not Used: See Earthwork - Imported Fill.	
MOBILIZATION AND ACCESS for construction activities				Description required for each item to facilitate cost estimating	
Mobilization - Typical (Equipment, Personnel, Planning, Financial)	LS		1	Up front costs such as bonding, planning and other staff time and financing. Typically, assume 8% to 10% of other items.	5.3
Mobilization - Remote (Equipment, Personnel, Planning, Financial)	LS		1	Up front cost for nontypical or remote locations. Assume 12% of other items	5.3
Site Access	LS		1	Use for special situations (e.g.. new bridge, new access roads) for the purposes of construction access. Include description.	5.3
Barge Access	Days		40	Describe need for barge access	5.3
Temporary Traffic Control (one of the following)				Includes installation of traffic signals, signage, signmen, etc. There are 4 types as follows:	
none	LS			None = no traffic control	
signs	LS		1	Signs = signs only, costs typically around 1% of total roadway costs	5.3
flags / spotters	LS			Flags and spotters = signs plus entails a greater level of effort. Describe the duration of this activity. This can be about 3% of total roadway costs.	
unique	LS			Unique = Greater effort than flags / spotters. Describe as basis for cost estimate.	
Temporary Roadway	SF			Includes construction of temporary adjacent roadway or bypass roadways and for vehicle and pedestrian travel through or around site.	
Control of Water	LS			Use for special situations that require draining the site using pumps or water control structures, and bypassing water during construction. Can also be used for multi-year projects. Description required, including estimate duration.	
Relocation Activities				Not Used: See Utilities, Structures	
Site Demolition Activities				Demolition and removal of structures (description required), temporary features and relocations, itemized separately); Clearing and grubbing of vegetation, and removal of minor debris (rocks, slabs) - description required.	
Clearing and Grubbing (one or more of following)				Use one or more of the following categories of clearing and grubbing	
Clear Vegetation - Local Disposal	AC			Vegetation removed above grade and disposed locally	
Clear /Grub Vegetation - Local Disposal	AC			Vegetation roots also removed and disposed locally	
Clear /Grub Vegetation - Offsite Disposal	AC			Vegetation is taken offsite and disposed - use for noxious invasives, etc.	
Clear, stockpile - large woody debris	CY			Vegetation is segregated and stockpiled / prepared for reuse on site.	
Hydraulic Structures - Small	LS			Removal of tide control and significant drainage structures that require excavation, cofferdam and or water control. Describe type of structure, elevation etc. For major structures (dam, diversion), use different line.	
Hydraulic Structures - Large	LS			Dam removal (describe and state whether this item includes water control and sediment removal or these are in separate items)	
Utilities	LS or LF				
Buildings	LS or SF				
Pavement	LS or SF				
Bulkheads	LF or SF			Use this for bulkheads…if large and difficult, consider using Large Coastal Structures.	
Rock revetments	LF, Ton or CY				
Large Coastal Structures (Railroad Berm Fill)	CY		7300	Use this item for breakwaters, jetties, groins, reinforced concrete seawalls and any structure that requires larger equipment and power to break up and or remove	5.3
Demolition / Removal - Bridge	SF		4240	Use this item for structures that require cranes or other special removal staging	5.3
Demolition/Removal - In-water piling	EA		234		5.3
Removal - Misc. (e.g. angular rock from beach)	Ton			For loose rock scattered across intertidal.	
Demolition / Removal - Boat Ramp	SF			This is a special item but happens at least once…others can also be added as needed.	
Haul - Offsite Disposal of Demolition Debris	Miles			Estimate distance (to nearest 10 miles) to disposal site for materials, veg clear and grub, etc.	
Hazardous/Contaminated Waste Removal				These items for earthwork of quality not compatible with wetlands, requiring special handling and disposal. Describe basis for classification as contaminated or hazardous. State known or suspected contamination, describe known similar work.	
Contaminated Earthwork	CY			Excavation, off haul and disposal within a licensed landfill, complete	
Hazardous Earthwork	CY			Excavation, off haul and disposal within a licensed hazardous waste landfill, complete	
Construct Temporary Features				Use as needed for unusual temporary features not included elsewhere (see TESC below)	
EARTHWORK				Expand to include equipment, etc. to facilitate cost estimating.	
Excavation	CY			Per yard excavation w/out expected haul	
Excavation - Upland	CY			Conducive for transitional earthwork equipment, including scrapers, with high production and low cost.	
Excavation - Lowland	CY			Requires low ground pressure equipment and or mats; low production bucket methods, typically hydraulic excavator and front end loaders.	
Dredging - Bucket - Land	CY			Excavation below ground water or underwater; reach limited low production.	
Dredging - Bucket - Marine	CY			Floating or amphibious equipment with excavator, clamshell or dragline bucket	
Dredging - Hydraulic	CY			Hydraulic cutter / suction dredge to slurry and pump sediments	
Fine Grading	AC			Small tolerance grading after rough grading.	
Fill Placement - local borrow				This is additive to Earthwork -Excavation	
Side cast	CY			Excavated material placed within reach of excavator / dredge - assume includes some shaping by bucket	
Haul - uncontrolled placement	CY			Transportation and second handling - estimate distance.	
Haul, place, compact	CY			Transportation and second handling - estimate distance, placement in lifts, moisture conditioning, compaction testing.	
Stockpile - uncontrolled placement	CY			Intermediate step, for subsequent off haul or use elsewhere on site.	
Stockpile - controlled placement	CY			intermediate step, for subsequent off haul or use elsewhere on site. Can use this for drying material for subsequent controlled compacted fill	
Conveyor placement from stockpile land/water	CY			Some projects may require conveyor placement	
Imported Fill				Includes purchase, delivery and placement or as noted / described	
Select Fill	CY			Imported select material - describe use, e.g. levee, root base mix, etc;	
Gravel Borrow, including haul	CY			WSDOT standard item	
Sand / Gravel for Beach Nourishment	CY			special borrow and sorting required; identify material source	
Cobble for Shore Nourishment	CY			special borrow and sorting required; identify material source	
Embankment Compaction	CY			WSDOT standard item	
Topsoil	CY				
RESTORATION Features					
Channel Rehab / Creation	SF			Channel construction (SF) including imported sediment and habitat materials, excluding excavation	
Large Wood Placement	EA		4	Per each log, Including drift logs, lower river log jams, etc.	5.3
Invasive Species Control	Acre			Per acre control described in drawings and narrative	
Physical Exclusion Devices	LF or EA			Human or wildlife exclusions including fences, barriers, mooring buoys, etc	
Other Restoration Features/ Activities	LS			Describe other items not included elsewhere	
Structures	EA			KPFF to provide additional inputs	
Water Control Structures - Culverts with Gates	EA			Describe type, number of openings (e.g. pipes), expected materials, dimensions	
Water Control Structures - Weirs	EA			Describe, length, type, anticipated materials	
Rock Slope Protection	LF			Describe slope, rock size, layering, use of fabric, back up quantities per foot.	
Other	EA			Describe	
Elevated Boat Ramp	SF			Pile or pier supported to allow sediment drift	
Fencing	SF			Describe, type, height etc.	
Utilities				Replacement or relocation. Designer to provide size and material and have separate line item for each run. Incidentals include earthwork, testing, hook up fees, etc. These quantities do not include demolition of existing utilities, real estate / easements, design fees. Describe the owner if known, and whether utility franchise will install (e.g., electric is typically installed by electrical franchise).	
Water	LF				
Gas	LF				
Electric	LF				
Sewer	LF				
Telecommunications	LF				
Other	LF			Others = whatever is required (e.g.. power towers, petroleum, jet fuel, etc.)	
Roadway / Railway				KPFF expected to participate in these estimates	
Roadway (Type_)	SF			Typical roadway, not including earthwork and temporary or permanent traffic controls. Provide a description. Assume a standard pavement section or describe if special section anticipated.• Pavement• Base Course• Storm Drainage Collection and Conveyance (incl. trenching, backfill, etc.)• Stormwater	
Roadway - Traffic Signal	LS			Street lights, etc. (Temporary traffic control handled under Temporary Facilities)	
Culvert (type)	LF			Provide specific culver size and type	
Culvert - Jacking	LF			Through railway	
Culvert - Horizontal Pile Driving	LF			Through railway	
Bridge - Foundations, Deck and Appurtenances	SF			Include elements such as approach slab, abutment, barriers, railings, etc. to conform to one of three or four types to be developed	
Railway - Box Girder Bridge	SF		8500	Standard	5.3
Railway - Foundation	LF		320	Standard	5.3
Railway - Shoe fly	LF			Temporary alignment	
Permanent Access Features				KPFF expected to participate in these estimates	
Roads	Level			Level 1 direct access, Level 2 moderately difficult, Level 3 difficult access	
Utility Access Routes	varies			Describe utility access feature, such as boardwalk or all-weather gravel road	
Erosion Control Features	L.F.			Describe quantity of expected erosion control measures	
Public Access or Recreation Features				KPFF expected to participate in these estimates	
Trails	SF			Describe trail feature, such as gravel, mulch, asphalt concrete.	
Bridges	SF			Describe bridge feature, such as wooden pedestrian, or H20 vehicle.	
Kiosk	EA			Describe kiosk feature, such as size, material.	
Restrooms	EA			Describe restroom feature, such as size, material.	
Interpretive Signs	EA		1	Include # interpretive signs based on number of local public access points	5.3
Parking Area	SF			Describe parking area, such as size, material.	

Partial Restoration Quantity Estimate

Action Name: Chuckanut Estuary Restorati
Action #: 1642
Date: February 2011
By: Kathy Ketteridge, Anchor QEA

REMEDY: ***Remove 210' portion of Railraod Berm and replace with Bridge***
Construction Period: 10 weeks (in-water work 8 weeks)

	Item	Unit of Measure	Material Name	Qty	Description of Item		Indicate section of design report where item is described
	Other	EA			Describe other recreational features (see Corps criteria, ER 1105-2-100 for compatibility with ecosystem objectives)		
Vegetation & Erosion Control							
	Hydroseeding	AC			Describe desired seed mix (e.g.. native plants cost more)		
	Planting	AC			Describe, provide breakdown on unit area basis.		
	Vegetation Maintenance	AC-YR			Includes irrigation, weeding, plant replacement for one year		
	Erosion / sediment BMPs - Temp.	AC			BMPs for control of drainage - describe. Assume compliance with Construction General NPDES included		
	Erosion / sediment BMPs - Permanent	AC			May want to separate slopes over 25% into separate category		
	Waterside controls - Temporary	LF	Silt Curtain	1000	Silt curtain or other water based temporary actions		5.3
Construction Management							
	Construction oversight	weeks			Quanity based on constructon duration/ # of construction seasons		
	Materials testing				Included in cost of material - no separate quantity		
Design and Detailed Site Investigations							
	Survey & Property, Utility Research	LS		1	% of construction cost		5.8
	35% Design	LS		1	35% x 25% x Engineer's Estimate		5.8
	65% design	LS		1	65% x 25% x Engineer's Estimate less the cost for 35% PS&E		5.8
	90% design	LS		1	35% x 25% x Engineer's Estimate less the cost for 35% + 65%PS&E		5.8
	100% design	LS		1	25% x Engineer's Estimate less previous costs		5.8
	Geotechnical Studies	LS			Refer to design report for description of need		5.8
	Cultural Studies	LS			Refer to design report for description of need		
	Tidal circulation and wave modeling/studies	LS			Refer to design report for description of need		
Project Agreement Activities					Unable to provide credibale estimate at 10% design		
Site-Specific Adaptive Management Features & Activities					List if known		
Monitoring Activities					Assume 5 crew-days/year for each monitoring parameter in design report for 5 yrs		
	Monitoring (Type)	crew-days		250			
Operations & Maintenance					Unable to provide credible estimate at 10% design		

6. DEEPWATER SLOUGH PHASE 2 (#1101)

Local Proponent	Washington Department of Fish and Wildlife
Delta Process Unit	SKG
Shoreline Process Unit(s)	NA
Strategy(ies)	1 – River Delta
Restoration Objectives	Removal of perimeter and internal dikes to restore a complex channel and network connected to adjacent tidal sloughs

6.1 Description of the Action

This action seeks to restore tidal action to diked areas and reconnect the historic distributary channel system on both sides of Deepwater Slough. The project entails the lowering and breaching of dikes, the creation of new tidal channel networks, and the creation of new distributary and blind channels. Please see the Introduction chapter for important information regarding PSNERP and for context related to this restoration project.

6.2 Action Area Description and Context

The action area is located in the Whidbey Subbasin of Puget Sound on the South Fork of the Skagit River. Deepwater Slough is just downstream and south of the town of Conway, where the South Fork bifurcates into Freshwater Slough and Steamboat Slough as it drains to Skagit Bay. The area consists of approximately 450 diked acres in two islands on either side of Deepwater Slough. For this report the two islands are referred to as Deepwater West and Deepwater East.

Deepwater Slough Phase 2 involves the complete removal of dikes around each of the two islands of diked, farmed and managed wetland left after Phase 1. Together with complete removal of the dikes, the existing drainage network would be filled, a new blind channel network would be excavated, and new distributary channels created. The action area is shown in Figure 6-1.

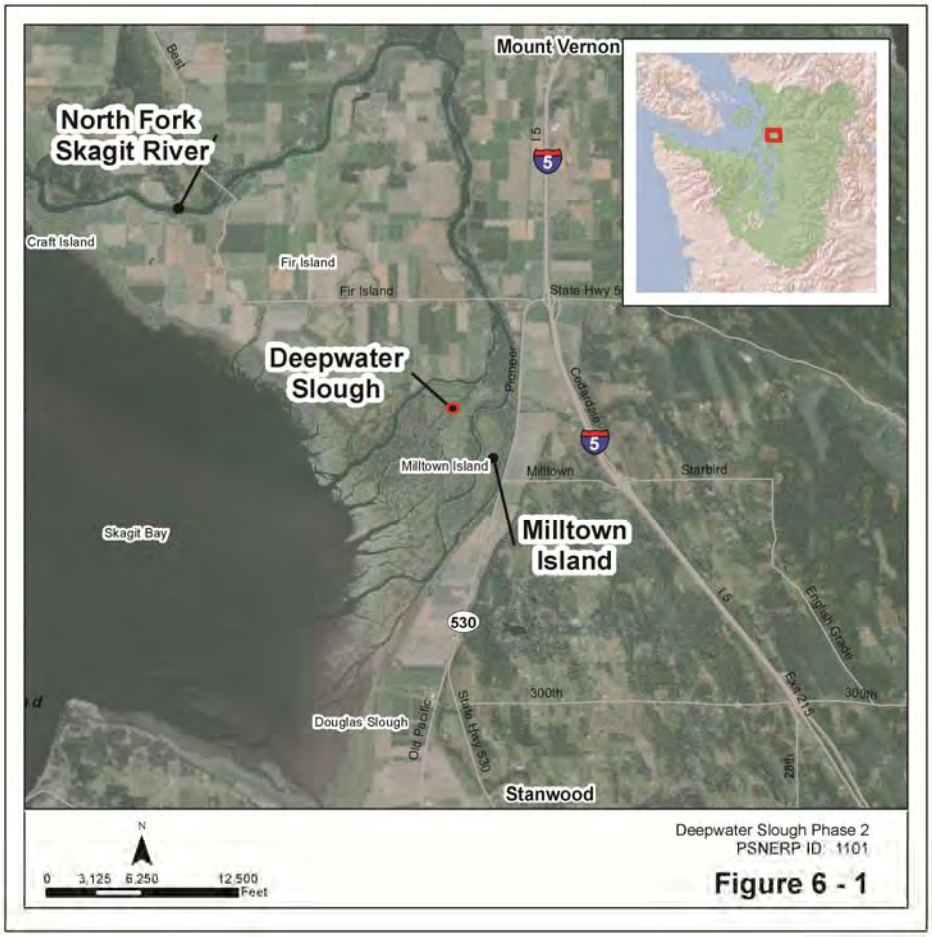


Figure 6-1. Action Area and Vicinity

6.2.1 Historic Condition

The action area lies on two significant gradients in terms of salinity and elevation. The Deepwater Slough site lies on a salinity gradient from estuarine emergent marsh, estuarine scrub-shrub, and forested-riverine zones (Collins 2002). Estuarine wetlands were extensive in the floodplains of the Skagit River, accounting for at least 27% of land area (Collins 1998, p.7). The Skagit River delta also had extensive freshwater wetlands covering a further 22% of the land area (freshwater wetlands include riverine tidal areas in which tidal backwater augmented the effects of flooding). The delta had numerous distributary and blind tidal channels which, because of its diverging-spreading form, were dominated by estuarine channels.

Deposition patterns associated with these channels created topographic gradients. The highest areas were northwards upstream, where there was initial deposition of coarser material from fluvial sources. Elevations lowered and the sediment became finer southward where estuarine processes dominated. There was also an elevation gradient laterally with distance from the distributary channels. Coarser, better drained soils were found in the natural levees along the banks of the distributary channels, which formed distinctive riparian corridors.

Diking, ditching, and filling greatly diminished the extent of freshwater and estuarine wetlands and blind tidal channels, impacting both the elevation and salinity gradients. In the Skagit River, nearly all wetlands had been diked, drained, and ditched by the early 20th century. The Deepwater Slough site was hydrologically disconnected from the Skagit River by a series of diking projects beginning in the late 1800s. Much of the northern, higher parts of both islands were diked by the time of the 1886 topographic sheet mapping (Figures 6-2A and 6-2B). Later diking projects, such as the U.S. Army Corps of Engineers' Skagit River Project in 1911, extended agricultural conversion southwards. Deepwater Slough, a major distributary channel, was disconnected from the Skagit River during this period.

WDFW obtained these lands in the late 1940s and early 1950s and has managed them primarily for waterfowl hunting. Restoration of Deepwater Slough Phase 1, completed in 2000, reconnected Deepwater Slough to the Skagit River by removing 2.8 miles of dike and restoring tidal and river hydrology to 221 acres in three areas of historic estuary (Hood, 2004). Existing dikes were breached, but a new cross dike was built to enclose a smaller portion of the island for waterfowl management. This managed area is now proposed for restoration of estuarine processes. The previously restored areas are shown on Figures 6-3 and 6-4.

6.2.2 Natural Environment

Currently, the site is isolated from the river and tides by dikes. Distributary and subsidiary tidal channel networks which formerly were connected to the main slough channels, as well as other non-mainstem open water, estuarine, palustrine, and riverine habitats, are reduced in extent, altered, or obliterated. Drainage channels and associated culverts and gates control water levels on the site, which is divided into sub-areas by cross dikes. This has led to subsidence of the site and obliteration of the natural drainage network. The elevation gradients have also been lost as the site is flatter than it would have been historically. The dikes mimic the natural levees to some degree but are higher and more compacted.

Vegetation and wetland habitats have been significantly altered from historical conditions. The site is located in a transition zone between forested riverine tidal and estuarine emergent habitats. Much of the natural forest, shrub, and herbaceous vegetation has been eliminated. Large, formerly forested areas and other habitats have been replaced with seasonally planted cereal grain cropland that includes weedy and invasive wetland and upland species. These farmed portions are seasonally flooded via a series of water control structures in order to attract waterfowl. Some areas retain emergent and scrub-shrub wetland conditions, although they are cut off from tidal influence and use by native aquatic biota. Forests exist on dikes and other high areas.

6.2.3 Human Environment

The islands are a very popular waterfowl hunting area and have been actively managed to support this use for decades. This is one of only two remaining sites on the Skagit Wildlife Area that provide agricultural enhancements for wintering waterfowl habitat. As a result, this managed habitat is considered to be a very valuable recreational resource and there could be considerable opposition to any restoration that precludes ongoing hunting.

The only infrastructure on the islands is associated with drainage and waterfowl production activities. There are no utilities crossing the action area. As part of the Phase 1 project, a bridge was constructed across Deepwater Slough to connect the two islands.

6.3 Restoration Design Concept

6.3.1 Restoration Overview and Key Design Assumptions

The primary stressors are the combination of remaining tidal barriers and their associated drainage ditches. Breaching and lowering of dikes to suitable elevations is intended to restore combined tidal/freshwater (low salinity) hydrology to support channel formation and scrub-shrub wetland community development (Figures 6-3 through 6-6). Specific process-based restoration objectives to be achieved with this action include:

- Tidal channel formation and maintenance.
- Tidal flow.
- Distributary channel migration.
- Erosion and accretion of sediments.
- Exchange of aquatic organisms.

Phase 1 of the project restored flow to the Deepwater Slough distributary channel. Phase 2 (this action) would restore the same ecosystem processes associated with the channel, as well as restoring distributary channels, habitat connectivity, estuarine habitat, and blind tidal channels within the site. Monitoring shows heavy fish usage of the Phase 1 area, which is likely to increase with the Phase 2 action. Given the lack of constraints, this is an opportunity to restore the natural gradients of the delta that have been severely impacted by diking.

Phase 2 would restore ecosystem processes by allowing tidal freshwater flows to support a full range of delta ecosystem processes. The full restoration alternative (Figure 6-3) is expected to provide a range of delta ecosystem components based on elevation and tidal regime, including tidal fresh and oligohaline transition swamp, salt marsh, tide flat, subtidal flat, distributary channel, tidal channel, and riparian forest. Given the subsided nature of the site, the habitats restored will be toward the lower elevation tidal estuarine marsh and associated channels, with riparian forest being difficult to reestablish except on existing higher topographic areas. The action therefore emphasizes the use of material generated by dike lowering and channel creation to create low berms in the forested wetland elevation range.

Together with Phase 1, the system would be internally connected through a network of shifting distributaries that allow for the unconstrained movement of organisms, water, and sediments. Phase 1 of the Deepwater Slough restoration project improved fish usage. The interior tidal channel network included in the full restoration alternative of Phase 2 would provide additional foraging habitat for juvenile salmon (SRSC and WDFW 2005).

The full restoration alternative would include creating breaches through the lowered dikes to support distributary and blind channels within the site. Existing dikes along

Freshwater Slough and Deepwater Slough would be lowered to support natural colonization by woody species.

The primary difference between the full and partial restoration alternatives is the extent of initial channel excavation within the site. The extent of excavation is greater in the full restoration alternative in order to accelerate channel development. The full restoration alternative would also include excavation of blind tidal channel networks within each island. The partial restoration alternative (Figure 6-4) would include the dike lowering and dike breaches, but would not include excavation of interior channels. Instead, the partial restoration alternative would rely upon natural channel forming processes to create a channel network within the breached site gradually over time.

The full restoration alternative would lower the dikes all around Deepwater West and remove the internal cross dike. The dike on the western side of Deepwater East, adjacent to Deepwater Slough, would also be lowered. The dike adjacent to Steamboat Slough would be left in place to avoid disturbing mature forested wetland habitat along the banks. Lowering the dike would increase the frequency of inundation during flood events and allow the establishment of forested wetland. The dikes would be lowered to between 10.5 and 13.5 feet MLLW (9 to 12 feet NAVD88, based on the La Conner tide gage) based upon the elevation range of forested wetland observed in the Skagit delta (PWA 2002). The dikes would not be lowered to grade as the inside of the islands has subsided following dike construction. Approximately 13,500 feet of dike would be lowered on Deepwater West and 4,700 feet on Deepwater East. The cross dike in Deepwater West would be lowered to between 10.5 and 13.5 feet MLLW (9 to 12 feet NAVD88), over a length of 2,100 feet. Material generated from dike lowering would be sidecast into an adjacent borrow ditch and used to widen the forested wetland. It is assumed the dikes were originally constructed from onsite materials.

The full restoration alternative would create two new distributary channels in Deepwater West, both connecting Freshwater Slough to Deepwater Slough. Two new distributary channels in Deepwater East would connect Freshwater Slough and Steamboat Slough with Deepwater Slough. The distributary channels are open ended, wide, shallow and relatively straight channels intended to convey both tidal and fluvial flood flows. The dimensions and planform have been based on the existing Deepwater Slough distributary channels and their location on historic alignments. The channels would be 45 to 75 feet wide and 5 to 8 feet below existing grade. In Deepwater West, there would be 6,700 feet of new distributary channel and 14,900 feet in Deepwater East. The new distributary channels would be connected to the existing tidal sloughs by breaches through the lowered dikes. The breaches would be 140 feet wide and 12 feet deep, with an additional 100 feet of dike on either side being lowered further to existing grade. The channels and breaches would be fully excavated since they would be slow to develop without active manipulation. The main channel-forming process here is avulsion during flood events. These events are relatively rare so evolution of these channels would be much slower than a system governed by tidal flows alone. Typically the main flow may switch between distributary channels due to the dynamic nature of the delta. On occasion a channel may become blocked and act as a blind tidal slough. Blind starter channels, draining into the distributary channels, would be excavated to encourage their development as described in the *Applied Geomorphology Guidelines and Hierarchy of Openings* (Appendix C). A total of approximately 4,000 LF of blind starter channel would be created about 3 feet below existing grade and about 10 feet wide.

Excavated material from all interior channels would be sidecast adjacent to the channels to create low discontinuous berms at elevations suitable to support a riparian woodland corridor (Figure 6-5). The berms would have occasional breaks to facilitate drainage and circulation to lower areas away from the channels. The berms would have an elevation of between 10.5 and 13.5 feet MLLW (9 to 12 feet NAVD88) based upon the elevation range of forested wetland observed in the Skagit delta (PWA 2002).

The partial restoration alternative would lower the dike all around Deepwater West and remove the internal cross dike. The dike on the western side of Deepwater East, adjacent to Deepwater Slough, would also be lowered. The dikes would be lowered to between 10.5 and 13.5 feet MLLW (9 to 12 feet NAVD88). Approximately 13,500 feet of dike would be lowered on Deepwater West and 4,700 feet on Deepwater East. The cross dike in Deepwater West would be lowered to between 10.5 and 13.5 feet MLLW (9 to 12 feet NAVD88), for a length of 2,100 feet. Material generated from dike lowering would be sidecast into an adjacent borrow ditch and used to widen the forested wetland. Ten breaches would be excavated through the lowered dikes; four in Deepwater West and six in Deepwater East. The breaches would be 140 feet wide and 12 feet deep, with an additional 100 feet of dike on either side being lowered further to existing grade. The breaches would be excavated to accelerate the evolution of the channel network. This alternative does not include the creation of distributary channels or tidal channel networks.

Table 6-1 shows key design elements associated with the full and partial restoration alternatives.

Table 6-1. Key Design Elements

Element	Full Restoration	Partial Restoration
Dike Lowering	13,500 LF of dike lowered on Deepwater West and 4,700 LF on Deepwater East to support riparian woodland corridor	Same as full restoration
Internal Dikes	Lower internal dikes (2,100 LF) and use material to fill internal drainage ditches	Same as full restoration
Breaches	Breach lowered dikes in 10 locations to connect distributary and blind channels to Freshwater, Deepwater and Steamboat Sloughs	Same as full restoration
Distributary Channels	Excavate tidal channel network within each island following relict channel alignments where possible. About 6,700 LF of channels created on Deepwater West and 14,900 LF of channels created on Deepwater East	Not included
Tidal Channels	Excavate 4,000 LF of blind starter channels	Not included

6.3.2 Restoration Features – Primary Process-Based Management Measures

Armor Removal/Modification – NA

Berm or Dike Removal/Modification

Both the full and partial restoration alternatives include lowering the existing dikes along Deepwater West (13,500 LF) and Deepwater East (4,700 LF). The dikes would be lowered to create a wide, low berm similar to the natural levees adjacent to the banks of sloughs in the region that support riparian woodland corridors. Internal cross dikes would also be lowered (2,100 LF) with excavated material used to fill drainage ditches. Dike surfaces would be ripped to break up overcompacted soils and prepare for revegetation.

Channel Rehabilitation/Creation

The partial and full restoration alternatives include 10 dike breaches to support a distributary and blind channel network (Figures 6-3 and 6-4). At the northern end of each island, breaches along Freshwater Slough and Steamboat Slough would allow sediment-rich flows from the South Fork Skagit River to enter the site. At the southwest end of each island, breaches into existing blind slough channels would allow flows to discharge to Deepwater Slough or Steamboat Slough.

The full restoration alternative (Figure 6-3) also includes excavation of a sinuous distributary channel network to facilitate estuarine and riverine flows and circulation within the site. Within Deepwater West, about 6,700 LF of distributary channels (about 50 feet wide) would be excavated. Channel excavation on Deepwater East would include about 14,900 LF of distributary channels (about 80 feet wide). Approximately 4,000 feet of blind starter channel would be created, about 3 feet below existing grade and about 10 feet wide.

The partial restoration alternative would not include an interior tidal channel network.

Groin Removal/Modification – NA

Hydraulic Modification

Both the full and partial restoration alternatives include lowering the existing dikes along Freshwater Slough and Deepwater Slough to create low, natural levees adjacent to the banks (Figure 6-5 and 6-6). Internal cross dikes would also be lowered to match surrounding elevations. Additionally the lowered dikes would be breached in 10 locations. These lowered and breached dikes would allow high flows to discharge overbank and through the breaches into the islands. The additional storage and flow capacity provided by the islands would lower flood elevations to some degree within the site vicinity and potentially upstream from the project site.

Overwater Structure Removal – NA

Topography Restoration - NA

6.3.3 Restoration Features – Additional Management Measures

Beach Nourishment – NA

Contaminant Removal/Remediation – NA

Debris Removal – NA

Invasive Species Control – NA

Large Wood Placement – NA

Physical Exclusion – NA

Pollution Control – NA

Revegetation – NA

Reintroduction of Native Animals – NA

Substrate Modification – NA

Species Habitat Enhancement – NA

6.3.4 Restoration Features – Other

The bridge between the two islands crossing Deepwater Slough, constructed as part of Phase 1, would be removed following the completion of the dike lowering. Access between the islands would no longer be required following restoration of tidal inundation. The bridge is designed to be disassembled, and the intent of the Phase 1 project was that it would be removed and reused elsewhere as part of Phase 2.

6.3.5 Land Requirements

Construction of this action will affect 367 acres of recreational lands that were previously used for agriculture. The land is owned by WDFW, so there are no additional properties to be acquired. There is a long-term agreement with the U.S. Army Corps of Engineers who implemented Deepwater Slough Phase 1. There is a formal maintenance or project life agreement regarding dike, bridge, and drainage infrastructure.

6.3.6 Design Considerations

There are no significant constraints due to ownership, infrastructure, or structures. Some channel excavation may be necessary within the existing marsh just outside the boundary of the site to expand existing blind channels and allow for riverine flows to pass through the site. The channels have been designed according to the *Applied Geomorphology Guidelines and Hierarchy of Openings* (Appendix C). As part of final design, channel sizing would be refined for estuarine tidal prism and riverine flows and to provide adequate fill to create low berms to support an adjacent riparian corridor. Breaches may be oversized to provide adequate capacity for short-term tidal prism and allow for adequate sediment to enter the site.

The proposed restoration may be incompatible with the ongoing use of this area for waterfowl hunting. WDFW and the Fish and Wildlife Commission have made commitments to the waterfowl hunting community to continue to manage and maintain the islands and Deepwater Slough according to the current management regime. Additional consultation with the Fish and Wildlife Commission and other stakeholders will be required before this design can move forward. Replacement recreation lands may need to be secured.

6.3.7 Construction Considerations

Construction would have to be sequenced with interior marsh work first, breaches and dike lowering last.

Barge equipment access is possible, but primarily from the west along Freshwater Slough. Barge access may be needed for perimeter dike lowering and dike breaches, depending on whether all material can be sidecast in an adjacent area. The existing bridge connecting the islands would need to be inspected prior to use by heavy construction equipment. Truck access may require temporary access roads to stockpile or to fill sections of existing channels.

The present diked nature of the site would allow for construction of the distributary channel network within the islands year-round. The upper portions of the tidal channel network could be constructed primarily with upland equipment including scrapers and end dumps. Portions of the tidal channel network may require excavators due to high groundwater levels. At channel bottom elevations, wet materials that are difficult to handle and haul or place should be expected.

Internal dikes may be lowered with upland equipment; however, placement of fill within the existing drainage ditches would require work with dozers or front end loaders. The existing dikes adjacent to Freshwater Slough and Deepwater Slough may be lowered primarily with upland equipment, provided this work occurs during the dry season. Breaches would require work with excavators. Final dike lowering and breaching should be coordinated and include a plan for access as tidal waters enter the site.

6.4 Extent of Stressor Removal

Table 6-2 shows the amount of stressor removal with full and partial restoration alternatives.

Table 6-2. Stressor Removal

Stressor	Full Restoration	Partial Restoration
Tidal Barrier (LF)	20,300 LF of dike along Freshwater Slough and Deepwater Slough lowered to natural levee elevations	20,300 LF of dike along Freshwater Slough and Deepwater Slough lowered to natural levee elevations
Fill (acres)	About 4.5 acres of dike would be removed for breaches	About 4.5 acres of dike would be removed for breaches

6.5 Expected Evolution of the Action Area

Without the restoration project, the islands surrounding Deepwater Slough would remain diked and likely continue to be actively managed for waterfowl. The assumption is that the farmed portions would continue to be seasonally flooded. Dikes, cross dikes, drainage channels, and associated culverts and gates, which control water levels on the site, would have to be maintained and adapted to rising sea levels if necessary. The continued drainage of the site may lead to further subsidence. Some areas would continue to have emergent and scrub-shrub wetland conditions, although they would remain cut off from tidal influence and isolated from use by native aquatic biota.

The full restoration alternative would reestablish a number of distributary channel connections across the islands. These channels would evolve over time as the flow paths through the site are reestablished. The increased flow through the new channels would result in erosion of portions of the existing distributary channels they connect to areas outside the project site. In addition to these morphological changes, the salinity and sedimentation patterns would change as a result of the new distributary channel network, distributing water differently around the delta.

Diking resulted in considerable subsidence, and land elevations have lowered relative to the tidal frame. These lower elevations typically support more intertidal emergent marsh and less scrub-shrub and forested wetland than likely existed prior to diking and subsidence.

In a restored marsh, floodwater transports suspended sediments that deposit in the slack waters of the flooded site. As the emergent marsh/mudflat rises in elevation, the period of inundation decreases and the rate of sedimentation declines. The elevation of the subsided site is anticipated to evolve, in response to estuarine sedimentation processes, to intertidal emergent marsh between 7.1 and 11.3 feet MLLW—the extent and nature or specific marsh communities would vary across this range of elevations.

The rate at which the mudflat and marsh build up depends on the amount of sediment carried into the site by flood waters, the rate of relative sea level change, the resuspension of deposited sediments, and the rate of organic accretion. The balance between sea level change and net accretion would determine the ultimate equilibrium emergent marsh elevation.

Concurrent with the physical evolution of the marsh, the tidal drainage system within the islands would evolve. The higher order channels would be excavated before breaching. Lower order channels would be allowed to develop naturally. As the marsh evolves from primary colonized mudflat to low emergent marsh and then to high emergent marsh, the density of tidal drainage channels changes. In the young marsh, elevations are low, tidal prism is large and drainage density high. As sediments accrete beyond a certain point, tidal prism is reduced and drainage density decreases. Channel density therefore varies with elevation and age of restoration. A low marsh would tend to have more small channels in complex drainage patterns, while a higher or older marsh would tend to have a less complex drainage pattern with fewer small channels. Borrow ditches or drains would be blocked to prevent them from capturing and dominating the evolution of the tidal drainage system.

6.6 Uncertainties and Risks

Uncertainty exists in the long-term evolution of the site. There have been major shifts in flow and sediment load between the South and North Fork channels in the past. Such a shift in the future could reduce the supply of sediment to the restored wetlands, reducing accretion rates and the ability to respond to accelerated sea level change.

The creation of new distributary channels may lead to the abandonment or avulsion of a distributary channel. This may lead to changes in the salinity and sedimentation patterns around the river delta, with impacts beyond the project boundaries.

Opposition from hunting groups that have traditionally used these lands and consider this to be a place that provides unique hunting opportunities could pose a risk to implementation of this restoration action. Recent restoration projects (Wiley Slough and Leque Island) have impacted waterfowl hunting opportunities. User groups have been demanding replacement lands for their loss of access and changes in land use. Concerned users and the agricultural community were able to slow project implementation of Wiley Slough and Leque Island, and are preparing legal funds for other restoration projects that may impact hunting access or agricultural production. WDFW has not been effective in finding replacement lands that user groups believe have long-term viability and that do not take agricultural land out of private production.

6.6.1 Risks Associated with Projected Sea Level Change

Table 6-3 compares potential risks associated with projected sea level changes based on professional judgment.

Table 6-3. Risks of Sea Level Change

	Projected Sea Level Change		
	High (46 cm)	**Intermediate (4 cm)**	**Low (-8 cm)**
Full Restoration	Changes to the salinity gradient of the Skagit River in response to climate change and other factors influencing freshwater discharges could affect habitat distribution Sediment supply may be insufficient for wetlands to keep up with relative sea level change	Negligible	Negligible
Partial Restoration	Same as full restoration	Negligible	Negligible

6.7 Potential Monitoring Opportunities

Monitoring is important for evaluating restoration success. A combination of field surveys and aerial photographs would be used to document biological and physical changes to the landscape. Monitoring data can be used to refine adaptive management and corrective actions, as needed. Some of the main monitoring needs and opportunities associated with this action are summarized in Table 6-4.

Table 6-4. Monitoring Needs and Opportunities

Monitoring Parameter	Key Performance Indicator	Note
Topographic Stability		
Sediment Accretion/Erosion		
Wood Accumulation		
Soil/Substrate Conditions		
Vegetation Establishment	X	Assess shifts from scrub-shrub and forested wetland to emergent marsh
Marsh Surface Evolution/Accretion		
Tidal Channel Cross Section/Density	X	Monitor density and development of tidal channel network
Water Quality (contaminants)		
Salinity	X	Monitor temperature/salinity spatially and temporally
Shellfish Production		
Extent of Invasive Species	X	
Animal Species Richness	X	
Fish (salmonid) Access/Use	X	
Forage Fish Production		
Wildlife Species Use		
Effectiveness of Exclusion Devices		

6.8 Information Needed for Subsequent Design

This conceptual design report represents an initial step in the restoration design sequence. The design concepts described above were developed based on readily available information without the level of site-specific survey and investigation that is necessary to support subsequent design and implementation. Substantial additional information will be required at the preliminary and later design stages to confirm the design assumptions, refine quantity estimates, address property and regulatory issues, obtain stakeholder support, and fill in data gaps. The extent to which this information is collected for preliminary design (or a later design stage) will depend upon the available budget, schedule and other factors. This section attempts to define the most essential information needs for this action. Refer to the Introduction chapter for additional information. The extent to which this information is collected for preliminary design (or a later design stage) will depend upon the available budget, schedule and other factors. This section attempts to define the most essential information needs for this action.

- Topographic/Bathymetric Survey – The survey data would be used to refine design of key project elements, confirm that target elevations are appropriate for the desired ecosystem components (low marsh, etc.), and develop detailed construction and demolition plans. Survey data could also be used as a baseline for pre- and post-construction modeling, including hydrodynamic modeling. A temporary tide gauge may be required in the early design stages to obtain site-specific tidal statistics.

- Cultural Resources Investigation – Surveys for archaeological and historic resources may be required for this action area. This is particularly important in areas proposed for excavation.
- Hydraulic Analysis/Modeling – Hydrodynamic modeling may be necessary to inform the design of natural levee elevations. Ideally, elevations can be based on local natural analogs. If flood capacity improvements are a significant driver for project implementation, then hydrodynamic modeling may help demonstrate benefits and optimize design grades and channel sizes to balance restoration goals with flood capacity goals. Hydraulic modeling may also be necessary to inform hydraulic connections between proposed and existing channels in southern portion of action area and refine the channel and breach sizing.
- Sediment Transport Study – Assessment of sediment transport dynamics may be needed to optimize the breach dimensions and locations and to address concerns about restored tidal marsh evolution and sustainability with rising sea levels.
- Contaminant Survey – If preliminary investigations suggest that hazardous material could be present in the action area, additional soil and sediment analysis may be needed. The introductory chapter describes the Phase 1 site investigations that are occurring as part of this overall effort via a separate contract.
- Sea Level Change Projection – Estimates of sea level change for the conceptual design were based on calculations provided by the Washington Department of Fish and Wildlife and the Corps of Engineers using guidance in Corps' Engineering Circular No. 1165-2-211. Projections for each project area will be refined using localized tide gauge data during later design stages.
- Other - Excavated materials will need to be evaluated for suitability for reuse.

6.9 Quantity Estimates

The quantity spreadsheets for the full and restoration alternatives are provided in Exhibits 6-1 and 6-2.

6.10 References

Collins, B. 1998. *Preliminary assessment of historic conditions of the Skagit River in the Fir Island area: Implications for salmonid habitat restoration*. Prepared for the Skagit River System Cooperative.

Collins, B. 2002. *Mid-19th century stream channels and wetlands interpreted from archival sources for three north Puget Sound estuaries*. Skagit River System Cooperative.

Hood, G. 2004. *Deepwater Slough Restoration Monitoring Report: 2000-2003.* Skagit River System Cooperative.

PWA. 2002. *Fir Island Delta Restoration Feasibility Study*. Prepared for Skagit Watershed Council.

SRSC and WDFW (Skagit River System Cooperative and Washington Department of Fish and Wildlife). 2005 *Skagit Chinook Recovery Plan*.

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64

WDFW Contract # 100-000204 (CAPS No. 10-1461)

Historic Map (T-Sheet)

Action Name: Deepwater Slough Phase 2

PSNERP ID #: 1101

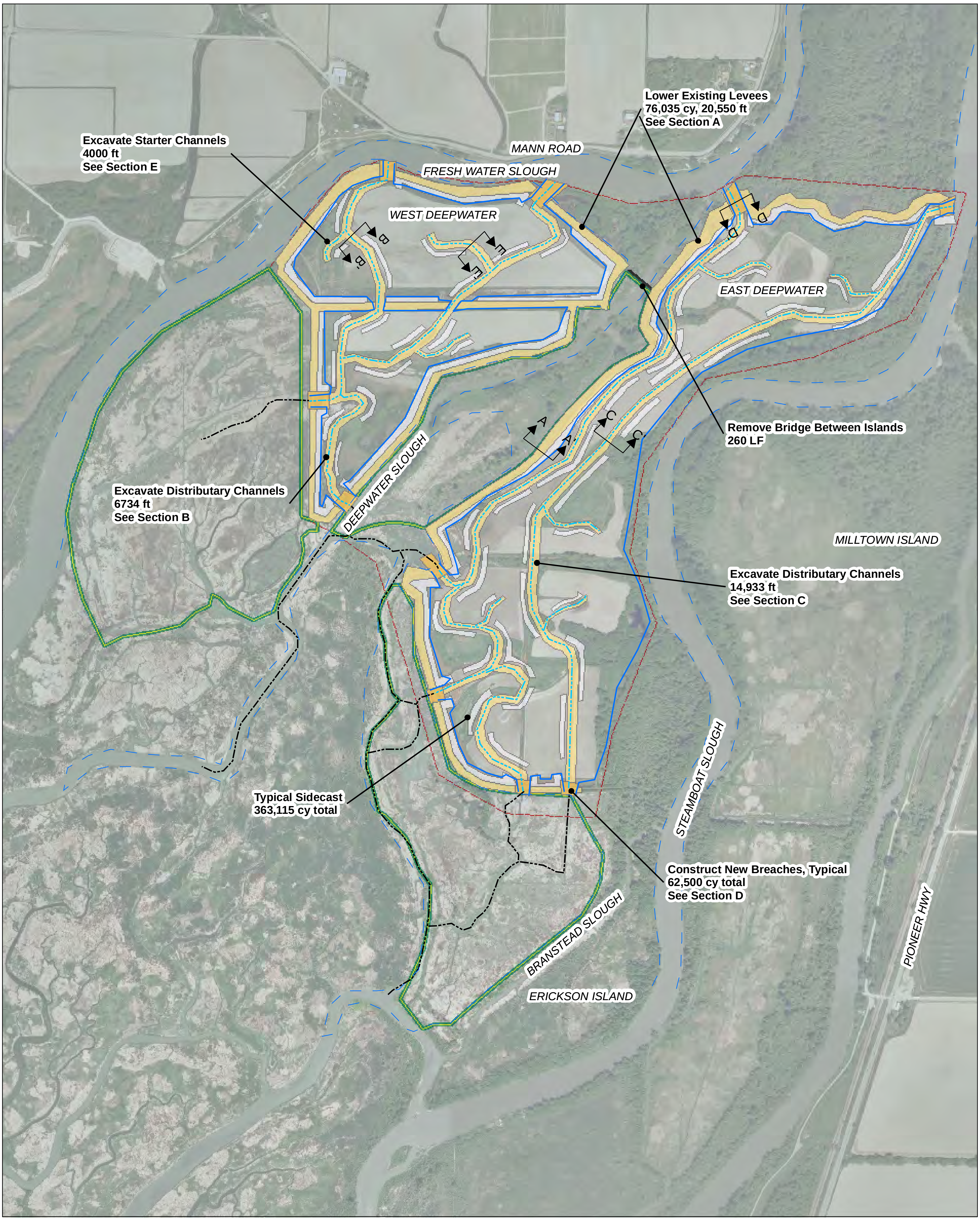
Figure 6- 2A

S:\GIS\Projects\210xxx\210337_PSNERP_NEARSHORE\Projects\2-TSheets_rev.mxd (DLP; 2/24/2011)

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Historic Map (T-Sheet) and River History Project Data
Action Name: Deepwater Slough Phase 2
PSNERP ID #: 1101
Figure 6- 2B

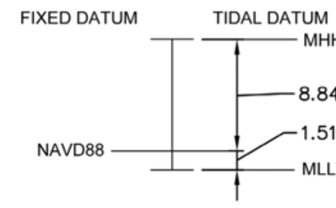
S:\GIS\Projects\210xxx\210337_PSNERP_NEARSHORE\Projects\2-TSheets_rev.mxd (DLP; 2/24/2011)



Legend

- Demolition/Removal - Bridge
- Dredging - Bucket - Land
- Excavation - Lowland
- Side Cast
- Required Project Lands
- Previously Restored Areas
- A A' Typical Cross Section
- Proposed Tide MHHW
- Existing Tide MHHW
- Channel Rehab/Creation
- Existing Channels

DEEPWATER SLOUGH CONVERSION



0.00 FT MHHW = 8.84 FT NAVD88
-8.84 FT MHHW = 0.00 FT NAVD88
0.00 FT MLLW = -1.51 FT NAVD88
1.51 FT MLLW = 0.00 FT NAVD88

Source: LaConner, Swinomish Tide Gauge (NOS #9448558). See Table 1, Appendix C.

North

0 500
Feet

PUGET SOUND NEARSHORE

SOURCE: Washington Public Lands Database (2006);
Washington Counties Parcels (2009); Action Area (PSNERP, 2010)

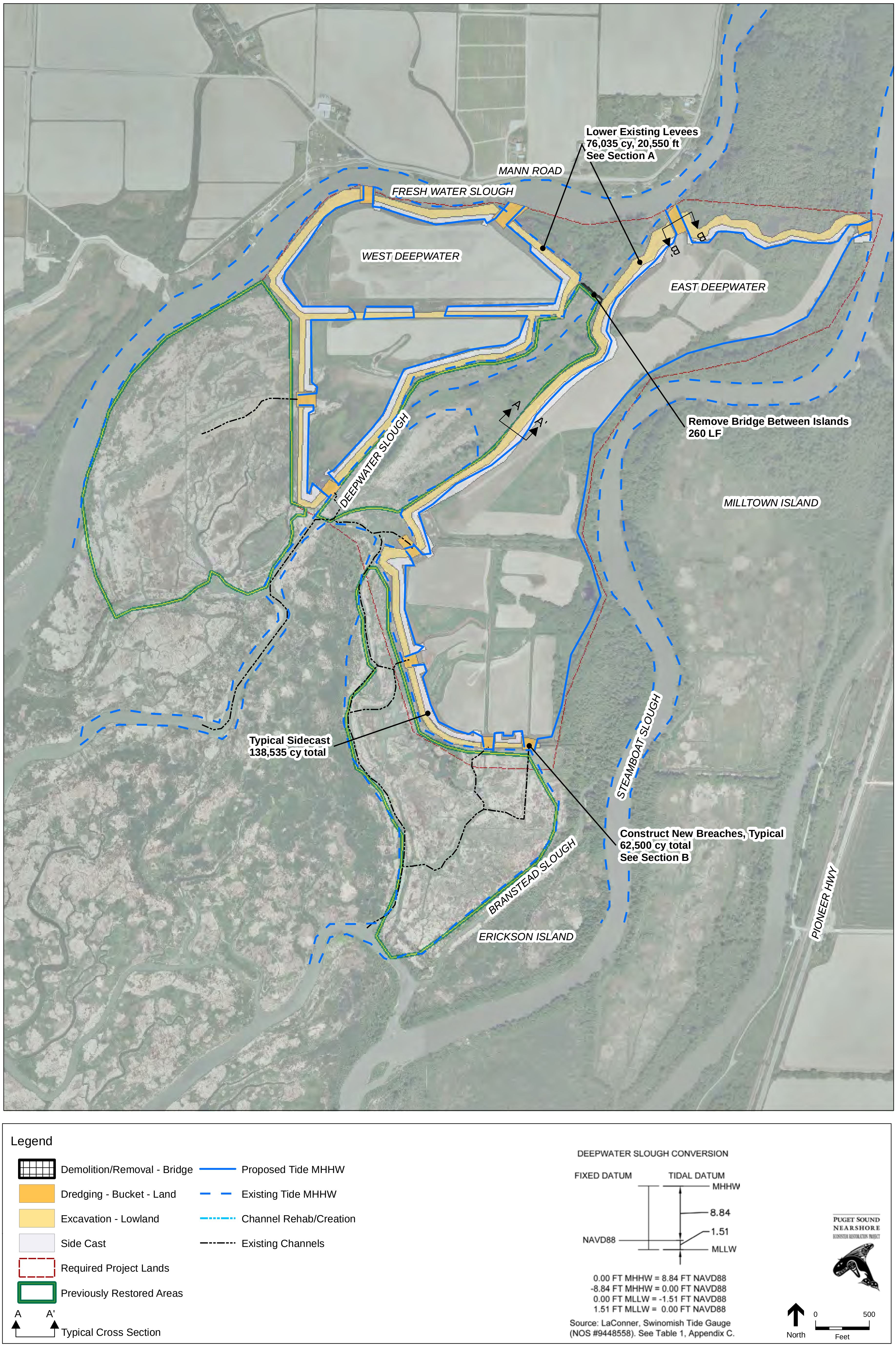
Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64

WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Plan
Site Name: Skagit River Delta
Action Name: Deepwater Slough Phase 2
PSNERP ID #: 1101
Full Restoration

Lead Contractor: ESA
Design Lead: ESA PWA, L. White, PE
Date: 07/2012

Figure 6-3



SOURCE: Washington Public Lands Database (2006);
Washington Counties Parcels (2009); Action Area (PSNERP, 2010)

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Lead Contractor: ESA
Design Lead: ESA PWA, L. White, PE
Date: 05/2012

Conceptual Design Plan
Site Name: Skagit River Delta
Action Name: Deepwater Slough Phase 2
PSNERP ID #: 1101
Partial Restoration

Figure 6-4

Full Restoration Quantity Estimate

Action Name:	Deepwater Slough Phase 2	
Action #:	1101	Revised May 2012
Date:	February 2011	**Revised with backcheck updates: 06 July 2011**
By:	L. White	

REMEDY: ***Remove levees, construct breaches and distributary channels through subsided site***

Construction Period: 32 week construction duration

Item	Unit of Measure	Qty	Description of Item	Indicate section of design report where item is described
ACQUISITION AND CONSERVATION			Based on available mapping information	
Required Project Lands	Acre	367	Total land required For actioı	6.3
Proponent / Partner-owned lands	Acre	367	Estimate of lands currently owned by Proponent (i.e., Public lands	6.3
Lands To Be Acquired	Acre	NA	Estimate land required to be acquired for action prior to implementatic	
MOBILIZATION AND ACCESS for construction activities			Description required for each item to facilitate cost estimating	
Mobilization - Typica (Equipment, Personnel, Planning, Financial)	LS	1	Up front costs such as bonding, planning and other staff time and financing. Typically, assume 8% to 10% of othe items.	6.3
Site Access	LS	NA		
Barge Access	Days	10	Barge access for mobilization at start and end of construction for transport to islanc	6.3
Temporary Traffic Control (one of the following)			Includes installation of traffic signals, signage, signmen, etc. There are 4 types as follow	
none	LS	NA		
signs	LS	NA		
flags / spotters	LS	NA		
unique	LS	NA		
Temporary Roadway	SF	NA		
Control of Water	LS	NA		
Relocation Activities			Not Used: See Utilities, Structures	
Clearing and Grubbing (one or more of following)			Use one or more of the following categories of clearing and grubbing	
Clear Vegetation - Local Disposal	AC	NA		
Clear /Grub Vegetation - Local Disposal	AC	71	Vegetation roots also removed and disposed locall	6.3
Clear /Grub Vegetation - Offsite Disposal	AC	NA		
Clear, stockpile - large woody debris	CY	NA		
Hydraulic Structures - Small	LS	10	Removal of water control structures - pipes with flapgates (?). Not identified but must be present on site to maintain existing dry condition on subsided site	6.3
Hydraulic Structures - Large	LS	NA		
Utilities	LS or LF	NA		
Buildings	LS or SF	NA		
Pavement	LS or SF	NA		
Bulkheads	LF or SF	NA		
Rock revetments	LF, Ton or CY	NA		
Large Coastal Structures	LF, SF or CY	NA		
Demolition / Removal - Bridge	SF or CY	3400	From Google Earth, bridge is 225 feet long by 15 ft wide. Bridge to be removed, salvaged, and used elsewhere	
Removal - Misc. (e.g. angular rock from beach)	Ton	NA		
Demolition / Removal - Boat Ramp	SF	NA		
Haul - Offsite Disposal of Demolition Debris	Miles	NA		
Hazardous/Contaminated Waste Removal			These items for earthwork of quality not compatible with wetlands, requiring special handling and disposal. Describe basis for classification as contaminated or hazardous. State known or suspected contamination, describe known similar work.	
Contaminated Earthwork	CY	NA		
Hazardous Earthwork	CY	NA		
Construct Temporary Features			Use as needed for unusual temporary features not included elsewhere (see TESC below)	
EARTHWORK			Expand to include equipment, etc. to facilitate cost estimating.	
Excavation			Per yard excavation w/out expected haul	
Excavation - Upland	CY	NA		
Excavation - Lowland	CY	76035	Requires low ground pressure equipment and or mats; low production bucket methods, typically hydraulic excavator and front end loaders	6.3
Levee Lowering	CY	*76035*	*Excavate levee using excavators, LGP; 3.7cy/lf x 20550lf-sidecast berms or ditch blocks*	6.3
Channels	CY	*224580*	Excavate channels using excavators, LGI	6.3
Dredging - Bucket - Land	CY	62500	Excavate levee using excavators, LGI	6.3
Dredging - Bucket - Marine	CY	NA		
Dredging - Hydraulic	CY	NA		
Fine Grading	AC	NA		
Fill Placement - local borrow			This is additive to Earthwork - Excavatioı	
Side cast	CY	363115	Excavated material placed within reach of excavator / dredge - assume includes some shaping by bucl	6.3
Levee Lowering	CY	*76035*	Sidecast levee lowering material; see Excavation - Lowland abo	6.3
Channels	CY	*224580*	Includes: starter = 2,667 CY; 3rd order = 39,731CY; 4th order = 182,183C'	6.3
Breach Excavation	CY	*62500*	Sidecast excavated breach material to create training berm; see Dredging - Bucket - Land abo	6.3
Haul - uncontrolled placement	CY	NA		
Haul, place, compact	CY	NA		
Stockpile - uncontrolled placement	CY	NA		
Stockpile - controlled placement	CY	NA		
Conveyor placement from stockpile land/water	CY	NA		
		NA		
Imported Fill		NA		
Select Fill	CY	NA		
Gravel Borrow, including haul	CY	NA		
Sand / Gravel for Beach Nourishment	CY	NA		
Cobble for Shore Nourishment	CY	NA		
Embankment Compaction	CY	NA		
Topsoil	CY	NA		
RESTORATION Features				
Channel Rehab / Creation	SF	NA		6.3
Large Wood Placement	EA	NA		
Invasive Species Control	Acre	NA		
Physical Exclusion Devices	LF or EA	NA		
Other Restoration Features/ Activities	LS	NA		
Structures	EA			
Water Control Structures - Culverts with Gates	EA	NA		
Water Control Structures - Weirs	EA	NA		
Rock Slope Protection	LF	NA		
Other	EA	NA		
Elevated Boat Ramp	SF	NA		
Fencing	SF	NA		
Utilities			Replacement or relocation. Designer to provide size and material and have separate line item for each run. Incidentals include earthwork, testing, hook up fees, etc. These quantities do not include demolition of existing utilities, real estate / easements, design fees. Describe the owner if known, and whether utility franchise will insta (e.g., electric is typically installed by electrical franchise	
Water	LF	NA		
Gas	LF	NA		
Electric	LF	NA		
Sewer	LF	NA		
Telecommunications	LF	NA		
Other	LF	NA		
Roadway / Railway				
Roadway (Type_)	SF	NA	Typical roadway, not including earthwork and temporary or permanent traffic controls. Provide a description. Assume a standard pavement section or describe if special section anticipated.• Pavement• Base Course• Storm Drainage Collection and Conveyance (incl. trenching, backfill, etc.)• Stormwater Treatment	
Roadway - Traffic Signal	LS	NA		
Culvert (type)	LF	NA		
Culvert - Jacking	LF	NA		
Culvert - Horizontal Pile Driving	LF	NA		
Bridge - Foundations, Deck and Appurtenances	SF	NA		
Railway - Box Girder	SF	NA		
Railway - Foundation	LF	NA		
Railway - Shoe fly	LF	NA		
Permanent Access Features				
Roads	Level	NA		
Utility Access Routes	varies	NA		
Erosion Control Features	L.F.	NA		
Public Access or Recreation Features				
Trails	SF	NA		

Full Restoration Quantity Estimate

	Action Name:	Deepwater Slough Phase 2				
	Action #:	1101	Revised May 2012			
	Date:	February 2011	**Revised with backcheck updates: 06 July 2011**			
	By:	L. White				
	REMEDY: ***Remove levees, construct breaches and distributary channels through subsided site***					
	Construction Period: 32 week construction duration					
	Item	**Unit of Measure**	**Qty**	**Description of Item**		**Indicate section of design report where item is described**
	Bridges	SF	NA			
	Kiosk	EA	NA			
	Restrooms	EA	NA			
	Interpretive Signs	EA	NA			
	Parking Area	SF	NA			
	Other	EA	NA			
Vegetation & Erosion Control						
	Hydroseeding	AC	NA			
	Planting	AC	NA			
	Vegetation Maintenance	AC-YR	NA			
	Erosion / sediment BMPs - Temp.	AC	NA			
	Erosion / sediment BMPs - Permanent	AC	NA			
	Waterside controls - Temporary	EA, LF, LS	NA			
Construction Management						
	Construction oversight	weeks	32	Quantity based on construction duration/ # of construction seasons		6.3
	Materials testing		NA			
	Proponent in-kind Services	Man-Days	NA			
	Government Oversight	Man-Days	NA			
	Quality Control & Testing	L.S.	NA			
	Quality Assurance With Testing	L.S.	NA			
Design and Detailed Site Investigations						
	Survey & Property, Utility Research	LS	NA			
	35% Design	LS	NA			
	65% design	LS	NA			
	90% design	LS	NA			
	100% design	LS	NA			
	Geotechnical Studies		NA			
	Cultural Studies		NA			
	HTWR Studies		NA			
Project Agreement Activities				Unable to provide credible estimate at 10% design		
Site-Specific Adaptive Management Features & Activities				List if known		
Monitoring Activities				Assume 5 crew-days/year for each monitoring parameter in design report for 5 yrs		
	Monitoring (Type_)	crew-days	150			
Operations & Maintenance				Unable to provide credible estimate at 10% design		

Partial Restoration Quantity Estimate

Action Name:	Deepwater Slough Phase 2	
Action #:	1101	Revised May 2012
Date:	February 2011	**Revised with backcheck updates: 06 July 2011**
By:	L. White	

REMEDY: ***Remove levees, construct breaches and distributary channels through subsided site***
Construction Period: 15 week construction duration

Item	Unit of Measure	Qty	Description of Item	Indicate section of design report where item is described
ACQUISITION AND CONSERVATION			Based on available mapping information	
Required Project Lands	Acre	367	Total land required For action	6.3
Proponent / Partner-owned lands	Acre	367	Estimate of lands currently owned by Proponent (i.e., Public lands	6.3
Lands To Be Acquired	Acre	NA	Estimate land required to be acquired for action prior to implementation	
MOBILIZATION AND ACCESS for construction activities			Description required for each item to facilitate cost estimating	
Mobilization - Typical (Equipment, Personnel, Planning, Financial)	LS	1	Up front costs such as bonding, planning and other staff time and financing. Typically, assume 8% to 10% of other items.	6.3
Site Access	LS	NA		
Barge Access	Days	10	Barge access for mobilization at start and end of construction for transport to island	6.3
Temporary Traffic Control (one of the following)			Includes installation of traffic signals, signage, signmen, etc. There are 4 types as follow	
none	LS	NA		
signs	LS	NA		
flags / spotters	LS	NA		
unique	LS	NA		
Temporary Roadway	SF	NA		
Control of Water	LS	NA		
Relocation Activities			Not Used: See Utilities, Structures	
Clearing and Grubbing (one or more of following)			Use one or more of the following categories of clearing and grubbing	
Clear Vegetation - Local Disposal	AC	NA		
Clear /Grub Vegetation - Local Disposal	AC	35	Vegetation roots also removed and disposed locall	6.3
Clear /Grub Vegetation - Offsite Disposal	AC	NA		
Clear, stockpile - large woody debris	CY	NA		
Hydraulic Structures - Small	LS	10	Removal of water control structures - pipes with flapgates (?). Not identified but must be present on site to maintain existing dry condition on subsided site	6.3
Hydraulic Structures - Large	LS	NA		
Utilities	LS or LF	NA		
Buildings	LS or SF	NA		
Pavement	LS or SF	NA		
Bulkheads	LF or SF	NA		
Rock revetments	LF, Ton or CY	NA		
Large Coastal Structures	LF, SF or CY	NA		
Demolition / Removal - Bridge	SF or CY	3400	From Google Earth, bridge is 225 feet long by 15 ft wide. Bridge to be removed, salvaged, and used elsewhere	
Removal - Misc. (e.g. angular rock from beach)	Ton	NA		
Demolition / Removal - Boat Ramp	SF	NA		
Haul - Offsite Disposal of Demolition Debris	Miles	NA		
Hazardous/Contaminated Waste Removal			These items for earthwork of quality not compatible with wetlands, requiring special handling and disposal. Describe basis for classification as contaminated or hazardous. State known or suspected contamination, describe known similar work.	
Contaminated Earthwork	CY	NA		
Hazardous Earthwork	CY	NA		
Construct Temporary Features			Use as needed for unusual temporary features not included elsewhere (see TESC below)	
EARTHWORK			Expand to include equipment, etc. to facilitate cost estimating.	
Excavation			Per yard excavation w/out expected haul	
Excavation - Upland	CY	NA		
Excavation - Lowland	CY	76035	Requires low ground pressure equipment and or mats; low production bucket methods, typically hydraulic excavator and front end loaders	6.3
Levee Lowering	*CY*	*75310*	*Excavate levee using excavators, LGP*	6.3
Dredging - Bucket - Land	CY	62500	Excavate 10 breaches through the levees into marsh / slough channe	6.3
Dredging - Bucket - Marine	CY	NA		
Dredging - Hydraulic	CY	NA		
Fine Grading	AC	NA		
Fill Placement - local borrow			This is additive to Earthwork -Excavation	
Side cast	CY	138535	Excavated material placed within reach of excavator / dredge - assume includes some shaping by buck	6.3
Levee Lowering	*CY*	*76035*	*Sidecast levee lowering material*	6.3
Breach excavations	*CY*	*62500*	*Sidecast excavated breach material to create training berm*	6.3
Haul - uncontrolled placement	CY	NA		
Haul, place, compact	CY	NA		
Stockpile - uncontrolled placement	CY	NA		
Stockpile - controlled placement	CY	NA		
Conveyor placement from stockpile land/water	CY	NA		
Imported Fill			Includes purchase, delivery and placement or as noted / describe	
Select Fill	CY	NA		
Gravel Borrow, including haul	CY	NA		
Sand / Gravel for Beach Nourishment	CY	NA		
Cobble for Shore Nourishment	CY	NA		
Embankment Compaction	CY	NA		
Topsoil	CY	NA		
RESTORATION Features				
Channel Rehab / Creation	SF	NA		
Large Wood Placement	EA	NA		
Invasive Species Control	Acre	NA		
Physical Exclusion Devices	LF or EA	NA		
Other Restoration Features/ Activities	LS	NA		
Structures	EA			
Water Control Structures - Culverts with Gates	EA	NA		
Water Control Structures - Weirs	EA	NA		
Rock Slope Protection	LF	NA		
Other	EA	NA		
Elevated Boat Ramp	SF	NA		
Fencing	SF	NA		
Utilities			Replacement or relocation. Designer to provide size and material and have separate line item for each run. Incidentals include earthwork, testing, hook up fees, etc. These quantities do not include demolition of existing utilities, real estate / easements, design fees. Describe the owner if known, and whether utility franchise will insta (e.g., electric is typically installed by electrical franchise	
Water	LF	NA		
Gas	LF	NA		
Electric	LF	NA		
Sewer	LF	NA		
Telecommunications	LF	NA		
Other	LF	NA		
Roadway / Railway				
Roadway (Type)	SF	NA		
Roadway - Traffic Signal	LS	NA		
Culvert (type)	LF	NA		
Culvert - Jacking	LF	NA		
Culvert - Horizontal Pile Driving	LF	NA		
Bridge - Foundations, Deck and Appurtenances	SF	NA		
Railway - Box Girder	SF	NA		
Railway - Foundation	LF	NA		
Railway - Shoe fly	LF	NA		
Permanent Access Features				
Roads	Level	NA		
Utility Access Routes	varies	NA		
Erosion Control Features	L.F.	NA		
Public Access or Recreation Features				
Trails	SF	NA		
Bridges	SF	NA		
Kiosk	EA	NA		
Restrooms	EA	NA		
Interpretive Signs	EA	NA		
Parking Area	SF	NA		

Partial Restoration Quantity Estimate

	Action Name:	Deepwater Slough Phase 2				
	Action #:	1101	Revised May 2012			
	Date:	February 2011	**Revised with backcheck updates: 06 July 2011**			
	By:	L. White				
	REMEDY: ***Remove levees, construct breaches and distributary channels through subsided site***					
	Construction Period: 15 week construction duration					
	Item	**Unit of Measure**	**Qty**	**Description of Item**		**Indicate section of design report where item is described**
	Other	EA	NA			
Vegetation & Erosion Control						
	Hydroseeding	AC	NA			
	Planting	AC	NA			
	Vegetation Maintenance	AC-YR	NA			
	Erosion / sediment BMPs - Temp.	AC	NA			
	Erosion / sediment BMPs - Permanent	AC	NA			
	Waterside controls - Temporary	EA, LF, LS	NA			
Construction Management						
	Construction oversight	weeks	15	Quantity based on construction duration/ # of construction seasons		6.3
	Materials testing		NA			
	Proponent in-kind Services	Man-Days	NA			
	Government Oversight	Man-Days	NA			
	Quality Control & Testing	L.S.	NA			
	Quality Assurance With Testing	L.S.	NA			
Design and Detailed Site Investigations						
	Survey & Property, Utility Research	LS	NA			
	35% Design	LS	NA			
	65% design	LS	NA			
	90% design	LS	NA			
	100% design	LS	NA			
	Geotechnical Studies		NA			
	Cultural Studies		NA			
	HTWR Studies		NA			
Project Agreement Activities				Unable to provide credible estimate at 10% design		
Site-Specific Adaptive Management Features & Activities				List if known		
Monitoring Activities				Assume 5 crew-days/year for each monitoring parameter in design report for 5 yrs		
	Monitoring (Type)	crew-days	150			
Operations & Maintenance				Unable to provide credible estimate at 10% design		

7. DEER HARBOR ESTUARY RESTORATION (#1648)

Local Proponent	People For Puget Sound
Delta Process Unit	NA
Shoreline Process Unit(s)	7055
Strategy(ies)	4 - Coastal Inlet
Restoration Objectives	Remove barriers to tidal and freshwater flow on constrained coastal inlet to restore hydrology, sediment erosion/accretion, channel formation and maintenance, and detritus input

7.1 Description of the Action

Restoration at Deer Harbor Estuary entails widening the mouth of the inlet to allow full tidal flushing, which will require replacing the bridge, footings, and fill with a wider bridge span over the mouth of the inlet. This action also involves removing fish passage barriers, restoring freshwater flow in the inlet tributaries, and planting riparian vegetation. Please see the Introduction chapter for important information regarding PSNERP and for context related to this restoration project.

7.2 Action Area Description and Context

Deer Harbor encompasses the largest estuary on Orcas Island, which is within the San Juan/Georgia Strait Subbasin. Deer Harbor is an open coastal inlet in southwest Orcas Island. The Cayou Valley Lagoon, also know as the Deer Harbor Lagoon or Slough, is located north of the Channel Road bridge. Tidal flushing from the larger bay into the northern inlet is limited by fill and shore armor associated with Channel Road bridge. Subsequent changes to nearshore processes associated with reduced flushing have altered conditions within the estuary including tidal prism, freshwater hydrology, plant communities, and tidal flow. The action area is shown in Figure 7-1.

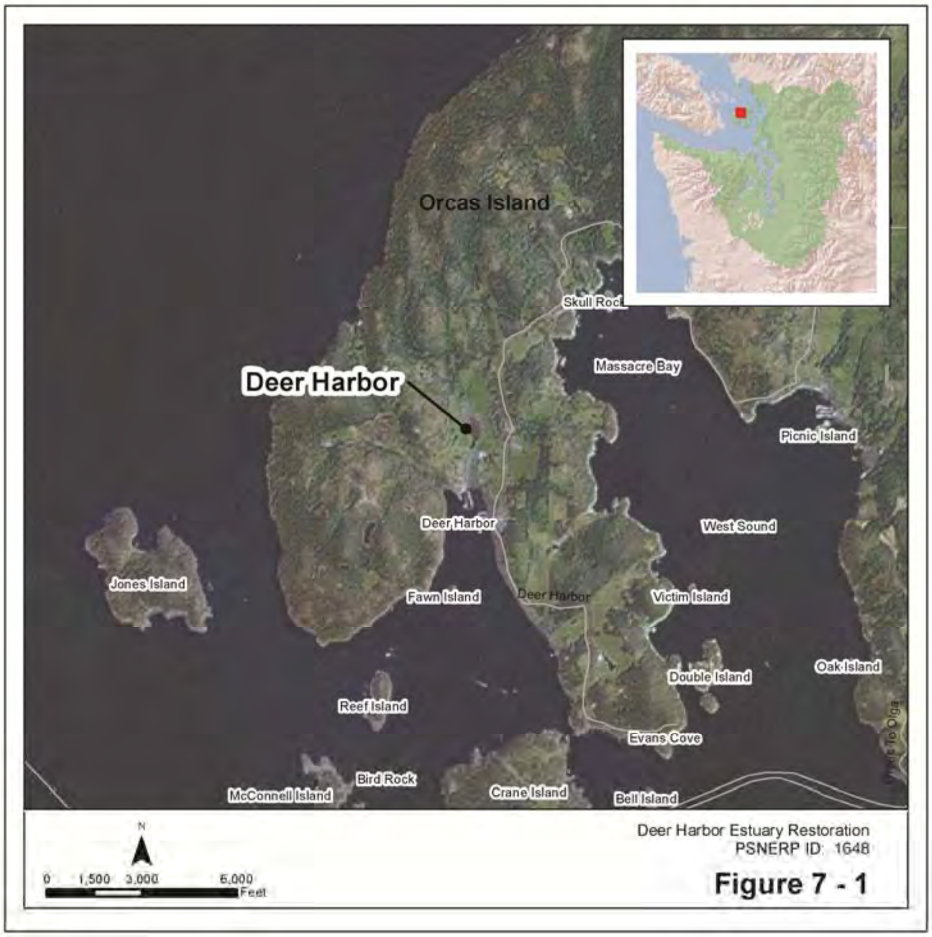


Figure 7-1. Action Area and Vicinity

7.2.1 Historic Condition

The Deer Harbor inlet is defined as the area north of the Channel Road bridge. The inlet was mapped as an open coastal inlet in both current and historic mapping in the PSNERP change analysis. Fill and armor have constrained the mouth of the inlet (or lagoon) both horizontally and vertically, which has reduced the tidal prism and degraded channel formation and maintenance and tidal flow processes within the inlet. The inlet mouth historically measured 90 to 110 feet wide at mean high water, compared to its current width of approximately 50 feet, with substantially lesser widths at intertidal elevations.

The inlet sedimentation patterns, habitats, and vegetation patterns have incurred notable changes that correlate with the installation of the fill and armor (DHRPT 2005). Historically, much of the sediment from the watershed was likely transported out of the inlet into deeper waters, but much of it is now trapped landward of the inlet mouth due to the rock sill. First- and second-order channels, which are visible in historic aerial photographs, were also present in the inlet up to the 1970s. These channels are no longer present and have been filled due to limited flushing. Historic topographic sheet (T-sheet) 2229 shows the low waterline in the outer part of Deer Harbor (USCGS 1895), indicating that the inlet likely completely drained at low tide (Figures 7-2A and 7-2B). This was verified in the feasibility study through multiple accounts by local residents (DHRPT 2005).

Long-time Deer Harbor residents claim that the estuary historically supported rich shellfish and finfish resources. Residents recall harvesting native oysters, Dungeness crab, and shiner perch in the inlet. Salmon (chum and coho) were observed in the inlet and swimming up the creek as late as the 1940s (DHRPT 2005). Since that time estuary species richness has decreased significantly, and only a small number of salmon and other native fish species now use the estuary (DHRPT 2005).

7.2.2 Natural Environment

The Deer Harbor Estuary is composed of the larger Deer Harbor and Cayou Valley Lagoon (the “inlet”) as well as the tidally affected reaches of Fish Trap Creek and a smaller unnamed creek, both of which flow into the north end of the inlet. The total watershed area is approximately 740 acres. Net shore-drift is northward along the east shore of Deer Harbor and terminates near the northern extent of the bay, considerably south of the inlet mouth and the action area (Johannessen 1992). Much of the Deer Harbor action area is encompassed within an area of no appreciable drift. The elevation of MHHW in the Deer Harbor Estuary is estimated to be +7.2 feet MLLW (DHRPT 2005), equivalent to +6.7 feet NAVD 88.

Rock fill under the Channel Road bridge forms a significant artificial grade control, effectively dividing the estuary into three distinct regions: from Fish Trap Creek to the crest of the rock fill under the bridge (mean gradient 0.007 feet/foot); below the bridge (mean gradient 0.056 feet/foot); and where the channel extends into the larger bay (0.0046 feet/foot) (DHRPT 2005).

Sediment characteristics and bottom elevations are distinct within each reach. Substrate consists of soft gray, clay mud in both the inlet and the mouth of Fish Trap Creek. Bottom elevations range from between +5.5 feet MLLW at the mouth of Fish Trap Creek to -3.0 feet MLLW at the mouth of the inner harbor, a distance of about 3,100 feet.

At the inlet outlet, bottom sediment consists of both angular riprap (12 to 24 inches diameter) to natural cobbles and gravel. The inner harbor channel substrate consists of a mix of gravel and cobble, surrounded by mud and sand flats. Adjacent to the shoreline there is greater variability in sediment composition from mudflat, sand, and gravel to bedrock outcrops. Sediment dynamics were monitored as part of the feasibility study from September to May 2004. During the wet season, a pattern of sediment deposition was found in the upper inlet and bank erosion in a portion of the lower half.

Emergent marsh vegetation is found along approximately 3.4 acres of the gently sloping east shore of the estuary. Four small patches of eelgrass at the mouth of the inner harbor (-3 to -6 feet MLLW) cover a combined area of 0.53 acre. Another small patch of eelgrass is found approximately 75 feet north of the Channel Road bridge (DHRPT 2005).

7.2.3 Human Environment

Fish Trap Creek, the primary source of freshwater flow into Deer Harbor, has incurred severe reduction in natural flow rate due to construction of numerous artificial ponds and a water diversion (DHRPT 2005). Land development activities in the Deer Harbor watershed, manipulation of the tributary streams and, especially, the construction of the Channel Road bridge have altered the freshwater hydrology, sediment transport patterns, and tidal flow patterns in the estuary. It is believed that these impacts have in turn eliminated shellfish populations in the inlet, impacted salmonid rearing and spawning habitat in the tributaries, and degraded salmonid feeding habitat in the estuary.

The current inlet mouth is approximately 50 feet wide and tapers down in width to a rock sill at a minimum elevation of +4.2 feet MLLW. The sill traps water in the inlet during low tide. Currently the water surface in the inlet does not drop below +4.5 feet MLLW (DHRPT 2005).

In addition to the horizontal constraint created by the placement of fill and rock armoring at the inlet outlet, the bed of the channel was partially filled with approximately 400 CY of rock armor, although the feasibility report estimated this volume at 200 to 250 CY (DHRPT 2005). The fill and armor were placed to halt scouring soon after bridge construction in approximately 1970, resulting in a more than 2.5-foot change of grade between the inlet outlet and the inner harbor.

This sill effectively controls tidal stage within the inlet, allowing flow into the inlet when the stage in the inner harbor is above +4 feet MLLW, and preventing ebb when the stage in the inlet drops below +4.0 to 4.2 feet MLLW. This has resulted in a significantly shortened duration of the tidal cycle (DHRPT 2005) and elevated water temperatures and sedimentation in the inlet.

Fish passage restrictions in Fish Trap Creek have been addressed by People For Puget Sound within the boundaries of the Connor property, including removing the head cut that acted as a barrier in the lowermost creek. Extensive revegetation efforts have also been undertaken near the lagoon. People For Puget Sound is also seeking additional funding to address watershed diversions and artificial pond issues through a comprehensive watershed education and demonstration project. This includes riparian stewardship, plantings, and pond retrofits conducted on the Connor property.

7.3 Restoration Design Concept

7.3.1 Restoration Overview and Key Design Assumptions

Restoration of the Deer Harbor inlet would entail removal of the existing Channel Road bridge; excavation of fill to restore tidal flow, sediment supply, sediment transport, and tidal channel formation; and construction of a new longer single-span bridge. The existing timber bridge is approximately 50 feet long and provides a crossing for three utility conduits. Complete road and bridge removal will not be an acceptable option for the local project proponent because there is no alternative route or feasible replacement route to the houses west of the bridge.

Figures 7-3 through 7-6 illustrate the restoration alternatives. Full and partial restoration includes complete removal of the bridge, riprap that has reduced the inlet depth under the bridge, and associated fill to widen the entrance. The restored inlet bottom would be at approximately +1.5 feet MLLW (+1.0 feet NAVD 88). Full restoration would construct a new 110-foot Type 2 concrete girder bridge structure (the cross hatched polygon with boundary starting in middle of current bridge shown in Figure 7-3). Partial restoration entails construction of a 90-foot Type 1 voided slab, single-span bridge (the cross hatched polygon with boundary starting in middle of current bridge shown in Figure 7-4).

This full alternative meets the full design standard for the horizontal curvature of the roadway. The roadway alignment is shifted to the north, or landward, from existing to take advantage of available existing right-of-way. In this alternative additional curves are incorporated where the proposed alignment matches existing to push the roadway to the north (where there is available right-of-way) and to the west of the existing bridge (resulting in less impact to the beach) as compared to an alignment that shifted waterward.

The existing roadway at the water's edge is showing signs of subsidence due to scour. The trees at the edge of roadway are falling into the water compromising the subgrade of the road as they do so.

The proposed bridge length for the full restoration alternative is 110 feet; no intermediate piers are proposed. The bridge abutments will require foundations. For the purpose of estimating quantities it can be assumed that these will be a single row of 4-foot-diameter drilled shafts at 12-foot spacing, 100-foot minimum depth. Travel lanes are 10 feet in width minimum, however due to the curvature of the roadway lane widths are wider on the curve to account for tracking of trucks (assumed design vehicle WB-50). The bridge deck will have a total width of 47 feet not including the width of the barriers, which is wider than the roadway itself. Additional bridge deck width is needed to provide a sufficient number of girders to accommodate the overhang. Alternatives to this approach to the decking include:

1. Casting the deck with a curve to mimic the channelization of the roadway. This will only minimize the variable overhang, not eliminate it.
2. Install a cast-in-place box girder bridge. The work would require placing formwork within the water and would have a maximum length of 120 feet.

The structure depth is 5 ft, 2 inches; providing 3 feet clear from MHHW will place the bridge deck at an elevation of 15.55. The bridge will be equipped with an Oregon Type 3 railing to provide sight distance beyond the bridge limits from Lichen Lane.

Lichen Lane will be realigned to intersect Channel Road west of the new bridge. This will result in additional right-of-way impacts and costs to reconstruct Lichen Lane on a new alignment. The vertical alignment of Lichen Lane will also be raised to match into the raised alignment of Channel Road.

The size of the opening and the decision to remove the riprap sill under the bridge in the full restoration alternative are aimed at recreating the pre-development estuary opening. This pre-development width was controlled by a resistant bedrock outcrop on the east shore; a number of natural structural controls such as this exist in the adjacent reach to the south. The 110-foot-long span will restore natural processes, while a longer bridge would not provide additional benefit, except perhaps in a very high sea level rise scenario. Therefore, a longer span was not selected. Although subsurface exploration still needs to be completed, with the existing understanding of the site, a longer (or shorter) opening does not appear appropriate for the full restoration alternative.

The 90-foot-long bridge for partial restoration, along with removal of the riprap sill under the bridge, was selected for both process restoration and practical reasons. The 90-foot-long opening has 18% less opening width and approximately 20% less cross sectional area relative to the full restoration alternative, but would still restore processes to a moderate extent. Using the *Geomorphology Guidelines* and *Hierarchy of Openings* (Appendix C), the general approach was for a slightly less than natural opening in width while removing the vertical control on flow. Using Appendix C, it was estimated that the range of relevant processes would be restored at slightly lower levels than with the full restoration alternative, however modeling should provide more rigorous analysis of the level of process restoration. Removing the riprap sill under the bridge will be a key part of the approach to restore process.

The 90-foot-long span is also practical. The 10% level bridge designs have a substantial vertical height and cost difference for spans longer than 90 feet. The 90-foot-long bridge is 3.5 feet high, while longer spans available for consideration are at least 5.1 feet high, which is an important issue for this low-elevation road area.

One-way traffic would need to be maintained during construction of the new bridge, although short-term closures would be required for both full and partial restoration alternatives. Construction phasing of both alternatives proposes to cut the existing bridge in half, removing the north half while the south half remains open to traffic under the full restoration alternative (vice versa for the partial alternative). This will provide an adequate work zone for construction of the new bridge in this portion of the right-of-way. The remaining portion of the existing bridge may need to be temporarily braced. Under the full alternative, the new alignment will meet the full design standard for roadway curvature. For the partial alternative, the slightly more southern alignment was selected to provide roadway curvature closer to standard, but curvature is still not up to standards (see Design Considerations). Under both alternatives, the proposed roadway construction will transition the bridge alignment to the existing roadway alignment both vertically and horizontally. Channel Road and Lichen Lane will be realigned to accommodate the proposed bridge location for both full and partial restoration alternatives.

Table 7-1 shows the key design elements associated with full and partial restoration alternatives.

Table 7-1. Key Design Elements

Element	Full Restoration	Partial Restoration
Existing Channel Road Bridge	Remove existing 50-foot timber bridge Plant native vegetation in backshore (1,000 SF) and adjacent to roadway	Same as full restoration
Riprap	Remove riprap reducing channel depth	Same as full restoration
Fill	Remove upland and lowland fill to create 110-foot-wide opening	Remove upland and lowland fill to create 90-foot-wide opening
Pavement	Remove roadway pavement	Same as full restoration
New Bridge Construction	Construct 110-foot Type 2 concrete girder bridge	Construct 90-foot Type 1 voided concrete slab bridge
Roadway Construction	Construct new roadway to align with proposed bridge	Same as full restoration

7.3.2 Restoration Features – Primary Process-Based Management Measures

Armor Removal/Modification

The full restoration alternative would remove the approximately 400 CY of riprap armoring the channel and stabilizing the side slopes of the current bridge (depicted by the orange polygon in Figure 7-3). Partial restoration would remove a slightly smaller amount (390 CY) of riprap armoring the channel and stabilizing the side slopes of the current bridge (orange polygon in Figure 7-4). The riprap varies in size from 3-foot rock boulders to quarry spall. The new channel bottom would be at a minimum depth of +1.5 feet MLLW (+1.0 feet NAVD 88)

Berm or Dike Removal/Modification

The full restoration alternative would remove approximately 1,250 CY of upland fill, 8,890 SF of pavement, and 750 SF of vegetation associated with widening the inlet to 110 feet. Partial restoration would entail removal of approximately 950 CY of upland fill, 8,890 SF of pavement, and 365 SF of vegetation associated with widening the inlet to 90 feet.

Channel Rehabilitation/Creation

Full restoration would remove approximately 800 CY of lowland fill and reworked beach sediment (17,050 SF) associated with channel contouring. Partial restoration entails removing 500 CY of lowland fill and beach sediment (13,950 SF) associated with channel contouring.

Groin Removal/Modification - NA

Hydraulic Modification

The full and partial restoration alternatives will remove the existing 50-foot-long timber Channel Road bridge and associated timber piles.

Overwater Structure Removal - NA

Topography Restoration

The full and partial restoration alternatives create opportunities for topography restoration at the west and east ends of the proposed bridge. Removal of fill and accreted sediment would lower elevations to meet the rehabilitated inlet channel depths, which attempt to recreate historic conditions (Figures 7-5 and 7-6). The full restoration alternative would provide a slightly larger area of topography restoration than the partial restoration alternative.

7.3.3 Restoration Features – Additional Management Measures

Beach Nourishment

Beach nourishment is not anticipated to be required for this site. It is assumed that at least a small portion of the removed lowland beach and/or fill material will be suitable for the limited areas of newly exposed upper intertidal surface. Existing conditions will need to be further investigated in the next design stage to determine if this assumption is correct.

Contaminant Removal/Remediation - NA

Debris Removal

Creosote-treated piles (approximately 16), creosote-treated timbers, and planking would be removed as part of the bridge removal. They would be disposed of properly in an offsite upland facility under both restoration alternatives. The specific number of piles and disposal location will be determined in a later design stage.

Invasive Species Control - NA

Large Wood Placement - NA

Physical Exclusion - NA

Pollution Control - NA

Revegetation

The full and partial restoration alternatives would revegetate approximately 1,000 SF of the newly uncovered backshore near the east and west ends of the proposed bridge. Additional narrow bands adjacent to the roadway would have small quantities of topsoil imported (200 CY for full restoration and 160 CY for partial restoration) and would be hydroseeded with native grass mix (up to 0.1 acre).

Reintroduction of Native Animals - NA

Substrate Modification - NA

Species Habitat Enhancement - NA

7.3.4 Restoration Features – Other

NA

7.3.5 Land Requirements

Construction of this action will affect of 1.05 acres of tidelands and upland. For both alternatives, the proposed alignments attempted to minimize the amount of additional right-of-way as much as possible. The full restoration alternative entails acquiring 0.18 acre of land for new bridge and road alignment (Figure 7-3). The partial restoration alternative would require acquisition of 1,450 SF of land south of the existing alignment (cross hatched bridge and roadway polygons outside of the right-of-way line, Figure 7-4).

A temporary easement will need to be acquired for fill removal and channel contouring. Full restoration entails acquiring 0.07 acre of land for a temporary easement (depicted on Figure 7-3). Partial restoration entails acquiring 9,440 SF of temporary easement (excavation polygons outside the right-of-way on Figure 7-4).

This action will result in potential changes in flood risk to properties that border the area of required project lands previously described. The restoration of tidal flow will change the frequency and duration of inundation during high water events. Easements on private property, such as flowage or temporary construction access, may be required.

7.3.6 Design Considerations

The full restoration alternative includes a new single-span bridge, 110 feet long, constructed of pre-cast concrete girders with an approximate depth of 5.2 feet. Standard WSDOT pre-cast concrete girders are an efficient and economical bridge type for single-span bridges.

The partial restoration alternative includes a new single-span bridge, 90 feet long, constructed of pre-cast, pre-stressed, voided slabs with an approximate depth of 3.5 feet. Voided concrete slab bridges are an efficient and economical bridge type for single-span bridges. The deck elevation of both of the proposed structures was based on the MHHW level plus 3 feet, plus the depth of the bridge structure (girders and deck for the full restoration and voided slab for the partial restoration).

The existing road geometry is substandard. The proposed alignment will be parallel to the existing bridge structure in both full and partial restoration alternatives (Figures 7-3 and 7-4).

Under the full alternative, the new alignment will meet the County's full design standard for the horizontal curvature of the roadway. The partial alternative alignment will deviate from the County's standard road curvature criteria, but it will meet or exceed equivalent capacity. The local access road will be designed to County standards and will include two 10-foot-wide lanes, each lane having a 1-foot shy distance. The proposed roadway geometry includes vertical and horizontal alignment considerations with respect to the new bridge deck elevation.

There have been some problems to date gaining property owner cooperation for the proposed action. This is true for at least one of the owners of the inlet bottom, and cooperation of the adjacent boatyard landowner has not been secured to date.

7.3.7 Construction Considerations

Removal of timber piles is typically accomplished by cutting or breaking them at the ground line. In a sensitive marine environment, more careful excavation around each pile and cutting a certain distance, a foot or more below ground line, may be required. The existing timber bridge piles are treated with creosote, which may limit potential disposal sites. A crane positioned on one end of the bridge is required to set the concrete spans in place.

To maintain at least one lane of traffic at all times throughout construction, the proposed bridge is offset from existing to allow the potential for half of the new bridge to be constructed first and then half the existing trestle structure to be demolished. A second option would be to build a temporary bridge to be used during bridge demolition and construction. The optimal construction sequencing will be determined based on the results of constructability analyses to be conducted in a future design stage. Lichen Lane will be realigned to intersect Channel Road west of the new bridge. This will result in additional right-of-way impacts and costs to reconstruct Lichen Lane on a new alignment. The vertical alignment of Lichen Lane will also be raised to match into the raised alignment of Channel Road.

Girders will be too long to deliver to the site from the ferry terminal. Two options exist:

1. Deliver girders to site on a barge. A crane will be set up to place the girders on the abutments. This same crane can be used to lift girders from the barge and place them on site. This may take a number of attempts to deliver all girders to the site, assuming two to three girders can be delivered during a single high tide cycle. However, the draft clearance for a barge in the estuary is uncertain and may preclude barge access at the site.
2. The other option is to bring the barge to the boat ramp located ¼ mile directly to south. A crane will be needed to place the girders on a truck and deliver them to the site. As with the first option, draft clearance may be an issue.

If barges are unable to access the estuary, an alternative barge landing location will be determined and the girders will be delivered to the site via truck.

The three existing utility conduits (approximately 450 LF) that cross under the existing bridge will be relocated onto the proposed bridge structure.

A construction staging area of at least 15 feet wide will be needed for both full and partial restoration. To maintain traffic, only the current shoulder and one lane can be used for staging. Due to possible right-of-way constraints, further consideration for staging areas will be analyzed during later, more detailed design. The new bridge girders can be lifted using cranes stationed at each end of the bridge.

The construction duration, including removal, is estimated to be 7 months for either alternative. Concrete bridges require very little maintenance. The current standard is to inspect bridges every 2 years.

7.4 Extent of Stressor Removal

Table 7-2 describes the amount of stressors to be removed with this action.

Table 7-2. Stressor Removal

Stressor	Full Restoration	Partial Restoration
Tidal Barrier (LF)	60 LF gain; 110 LF total improvement width	40 LF gain; 90 LF total improvement width
Fill (area)	NA – Fill removal associated with tidal barrier	NA – Fill removal associated with tidal barrier
Armor (LF)	NA – Riprap armor removal associated with tidal barrier	NA – Riprap armor removal associated with tidal barrier

7.5 Expected Evolution of the Action Area

Excavation would lower the inlet bottom in the shallow areas just north of the bridge and under the bridge. However, some volume of fine-grained sediment within the inlet is anticipated to be transported south of the bridge after restoration. This will be further evaluated at later design stages.

Initial adjustment and establishment of vegetation and other short-term transitions are likely in the greater bridge area a few hundred feet north of the roadway. Intertidal area will increase slightly. Substrate in the inlet is anticipated to become coarser over time, likely increasing shellfish habitat. Water quality will likely improve due to increased flushing (such as lower temperatures).

7.6 Uncertainties and Risks

Erosion and export of accreted sediment from the inlet north of the bridge is possible (DHRPT 2005) with both restoration alternatives. However, large volumes of sediment export do not appear likely in a short timeframe, nor does the risk to resources such as eelgrass appear substantial. Some amount of sediment is likely to be exported following intertidal channel adjustments and increased wave energy inside of the harbor. This is a potentially important issue because a small private boatyard is located immediately south of the bridge. The ability to acquire property or easements is unknown, but may be problematic.

7.6.1 Risks Associated with Projected Sea Level Change

Table 7-3 compares potential risks associated with projected sea level changes based on professional judgment.

Table 7-3. Risks of Sea Level Change

	Projected Sea Level Change		
	High (65cm)	**Intermediate (21cm)**	**Low (13cm)**
Full Restoration	Will shift salt marsh in the inlet landward but there is generally adequate room May have drift log impacts with bridge during storms but this is generally a low woody debris area Increased wave energy in lagoon	Will shift salt marsh in the inlet landward but there is room for this Minor increased wave energy in lagoon	Negligible
Partial Restoration	Will shift salt marsh in the inlet landward but there is generally adequate room May have drift log impacts with bridge during storms but this is generally a low woody debris area Increased wave energy in lagoon	Will shift salt marsh in the inlet landward but there is generally room for this Minor increased wave energy in lagoon	Negligible

7.7 Potential Monitoring Opportunities

Monitoring is important for evaluating restoration success. Monitoring data can be used to refine adaptive management and corrective actions, as needed. A combination of field surveys and aerial photographs would be used to document biological and physical changes to the landscape. The primary monitoring needs and opportunities associated with this action are summarized in Table 7-4.

Table 7-4. Monitoring Needs and Opportunities

Monitoring Parameter	Key Performance Indicator	Note
Topographic Stability		
Sediment Accretion / Erosion	x	Monitor amount of sediment exported following intertidal channel adjustments and increased wave energy inside of the harbor
Wood Accumulation		
Soil / Substrate Conditions		
Vegetation Establishment		
Marsh Surface Evolution / Accretion	x	Monitor changes in marsh elevation and plant assemblages
Tidal Channel Cross-Section / Density	x	Monitor formation and development of tide channels following restoration
Water Quality (contaminants)		
Salinity		
Shellfish Production	x	Monitor effects on native oysters and other resources
Extent of Invasive Species		
Animal Species Richness		
Fish (salmonid) Access/Use	x	Monitor for improved fish passage
Forage Fish Production		
Wildlife Species Use		
Effectiveness of Exclusion Devices		

7.8 Information Needed for Subsequent Design

This conceptual design report represents an initial step in the restoration design sequence. The design concepts described above were developed based on readily available information without the level of site-specific survey and investigation that is necessary to support subsequent design and implementation. Substantial additional information will be required at the preliminary and later design stages to confirm the design assumptions, refine quantity estimates, address property and regulatory issues, obtain stakeholder support, and fill in data gaps. The extent to which this information is collected for preliminary design (or a later design stage) will depend upon the available budget, schedule and other factors. This section attempts to define the most essential information needs for this action.

- Property Investigation/Survey – More detailed information on parcel ownership and property boundary location will be needed to finalize the design, confirm acquisition requirements, and support negotiations with property owners.

- Topographic/Bathymetric Survey – The survey data would be used to refine design of key project elements and develop detailed construction and demolition plans. Survey data could also be used as a baseline for pre- and post-construction modeling. A temporary tide gauge may be required in the early design stages to obtain site-specific tidal statistics.
- Geotechnical Investigation – Additional geotechnical study will be required to support bridge foundations for full and partial restoration alternatives.
- Cultural Resources Investigation – Surveys for archaeological and historic resources may be required for this action area. This is particularly important in areas proposed for excavation.
- Hydraulic Analysis/Modeling – Hydraulic engineering analysis is recommended for selecting the optimal bridge length and configuration, which is underway for People For Puget Sound. Additional analysis will also have to occur for scour protection requirements and minimum bridge clearance over water.
- Sediment Studies – Further design development would need to evaluate the magnitude of potential sediment export from the inlet, as well as the need for management of potentially accreted sediments within the inlet. The degree of risk should be addressed after new hydrodynamic and sediment transport modeling is completed for People For Puget Sound in the first half of 2011. In addition, excavated materials may be evaluated for suitability for reuse.
- Contaminant Survey – A disposal location will need to be identified for the creosote-treated materials removed as part of the bridge removal. If preliminary investigations suggest that additional hazardous material could be present in the action area, additional soil and sediment analysis may be needed. The introductory chapter describes the Phase I site investigations that are occurring as part of this overall effort via a separate contract.
- Sea Level Change Projection – Estimates of sea level change for the conceptual design were based on calculations provided by the Washington Department of Fish and Wildlife and the Corps of Engineers using guidance in Corps' Engineering Circular No. 1165-2-211. Projections for each project area will be refined using localized tide gauge data during later design stages.
- Other – Evaluation of potential impacts to downstream marina as a result of increased currents may be needed. The need for slope protection for the abutments should also be investigated.

7.9 Quantity Estimates

The quantity spreadsheets for the full and partial restoration alternatives are provided in Exhibits 7-1 and 7-2.

7.10 References

DHRPT (Deer Harbor Restoration Project Team). 2005. *Deer Harbor Estuary Habitat Restoration Project, Orcas Island, Washington. Draft Environmental Assessment and Feasibility Study Report.* Prepared for the Salmon Recovery Funding Board, IAC/SRFB Grant No. 02-1577N for People For Puget Sound.

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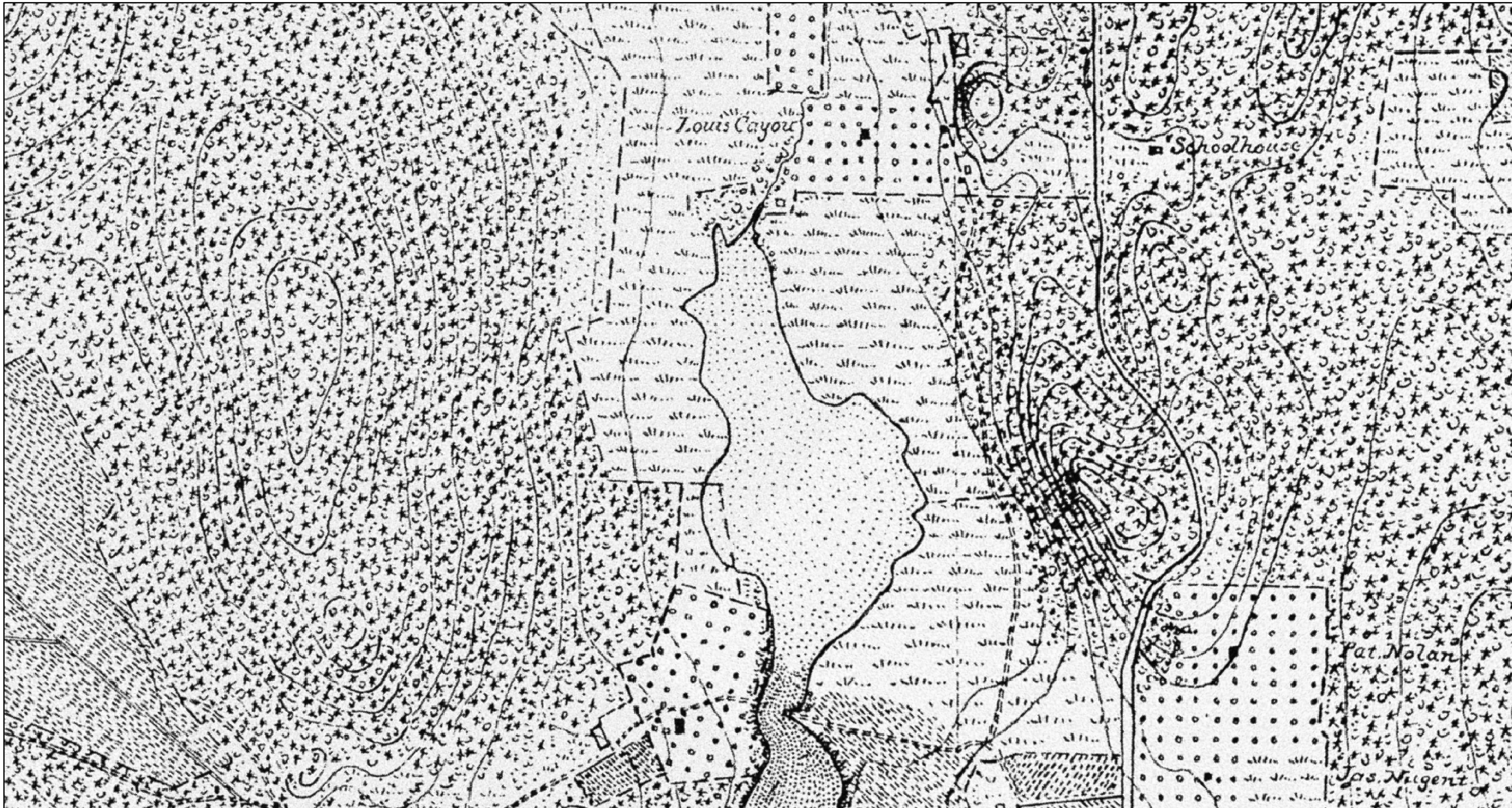

0 340
Feet
0 100
Meters

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Historic Map (T-Sheet)
Action Name: Deer Harbor Estuary Restoration
PSNERP ID #: 1648
Figure 7- 2A

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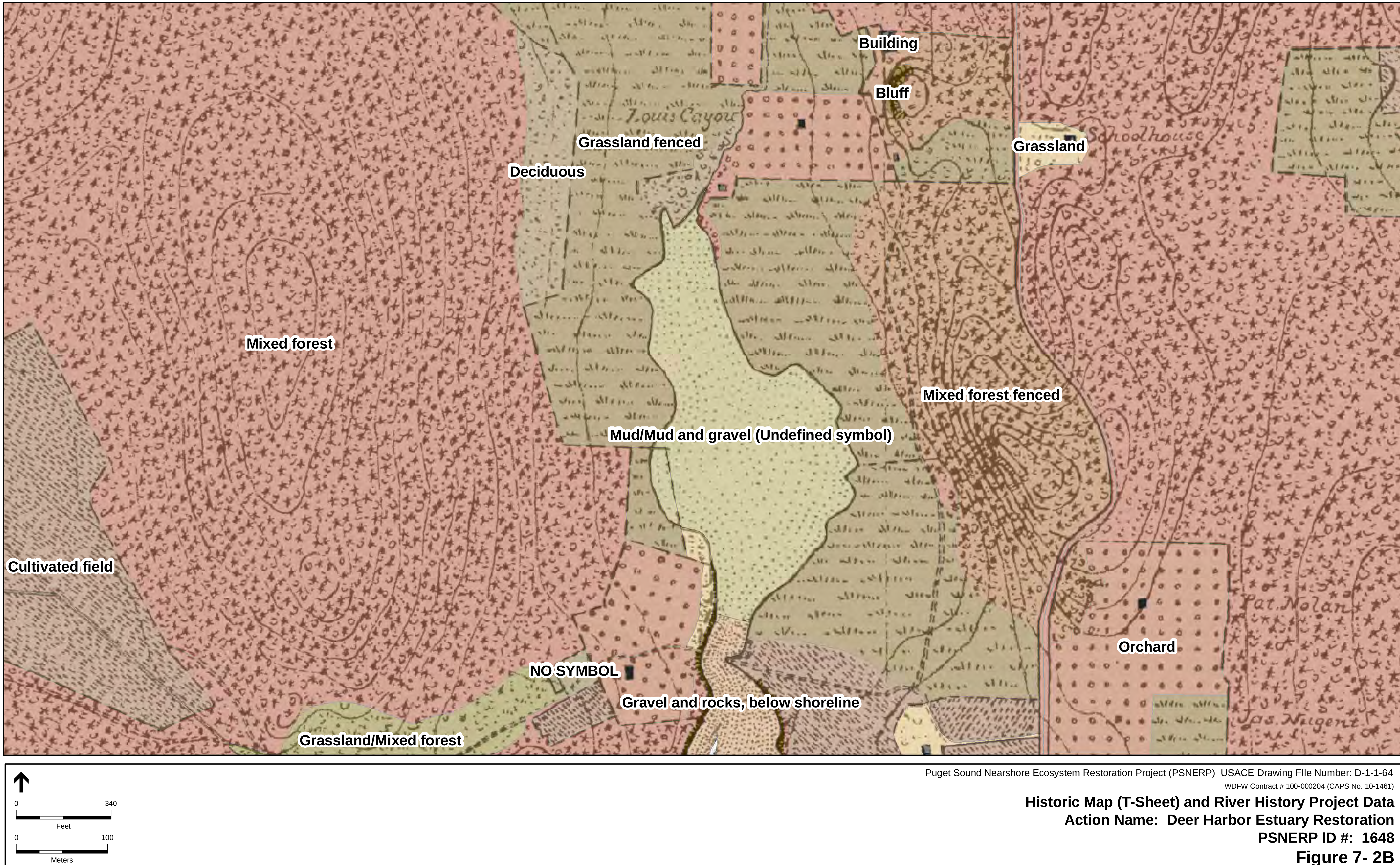


Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64

WDFW Contract # 100-000204 (CAPS No. 10-1461)

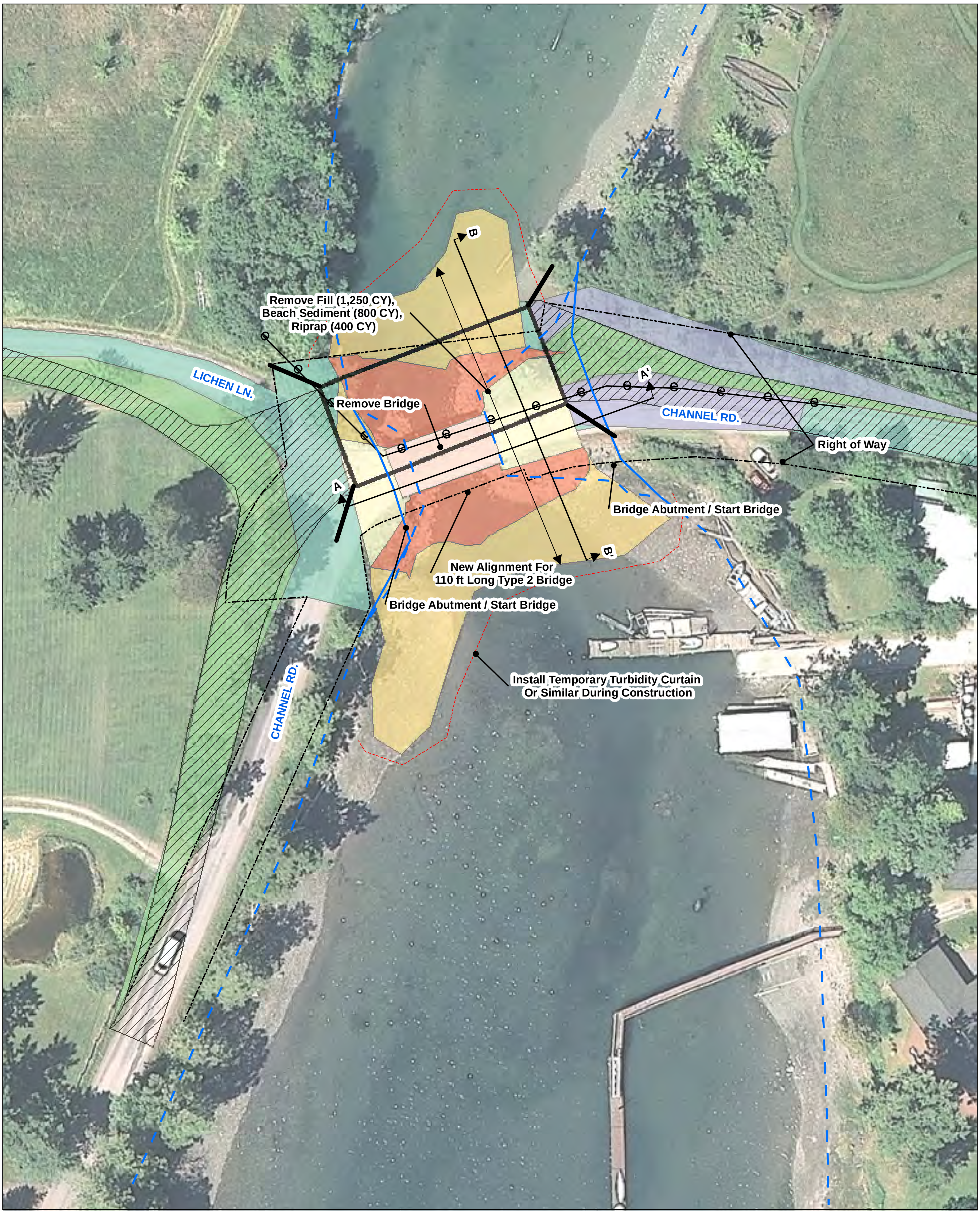
Historic Map (T-Sheet) and River History Project Data

Action Name: Deer Harbor Estuary Restoration

PSNERP ID #: 1648

Figure 7- 2B

S:\GIS\Projects\210xxx\210337_PSNERP_NEARSHORE\Projects\2-TSheets_rev.mxd (DLP; 2/24/2011)



Legend

- Bridge
- Demolition/Removal - Bridge
- Excavation - Lowland
- Excavation - Upland
- Removal - Misc. (e.g. angular rock from beach)
- Roadway Type A
- Required Project Lands
- Existing Tide MHHW
- Proposed Tide MHHW
- Electric
- Fencing
- Other
- Section Line

DEER HARBOR CONVERSION

FIXED DATUM TIDAL DATUM

MHHW 7.23 NAVD88 0.53 MLLW

0.00 FT MHHW = 7.23 FT NAVD88
-7.23 FT MHHW = 0.00 FT NAVD88
0.00 FT MLLW = -0.53 FT NAVD88
0.53 FT MLLW = 0.00 FT NAVD88

Source: Friday Harbor Tide Gauge (NOS #9449880). See Table 1, Appendix C.

PUGET SOUND NEARSHORE

North 0 40 Feet

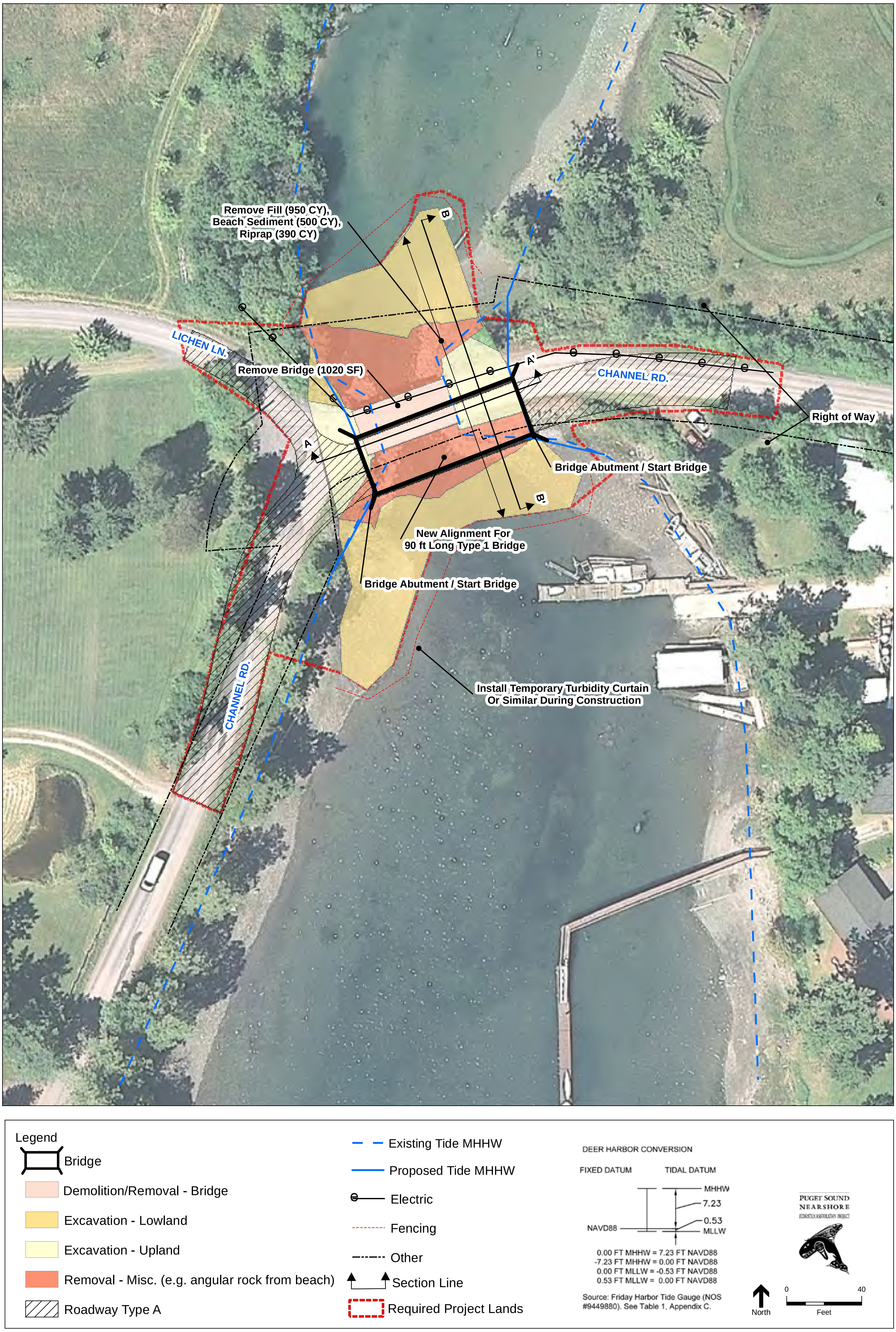
SOURCE:
Washington Public Lands Database (2006); Washington Counties Parcels (2009); Action Area (PSNERP, 2010)

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Plan
Site Name: Deer Harbor, Orcas Island
Action Name: Deer Harbor Estuary Restoration
PSNERP ID #:1648
Full Restoration

Lead Contractor: ESA
Design Lead: CGS, J. Johannessen
Date: 5/2012

Figure 7-3



SOURCE:
Washington Public Lands Database (2006); Washington Counties Parcels (2009); Action Area (PSNERP, 2010)

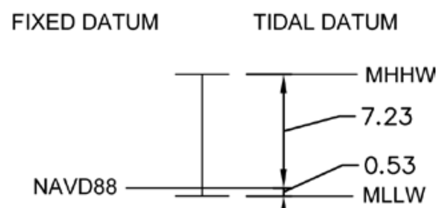
Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Lead Contractor: ESA
Design Lead: CGS, J. Johannessen
Date: 5/2012

Conceptual Design Plan
Site Name: Deer Harbor, Orcas Island
Action Name: Deer Harbor Estuary Restoration
PSNERP ID #:1648
Partial Restoration

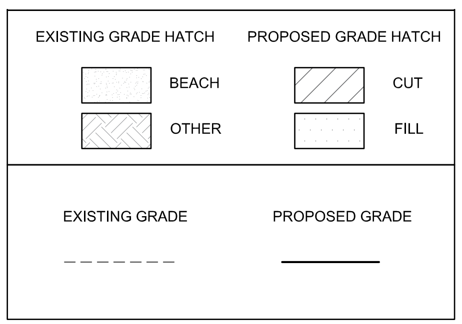
Figure 7-4

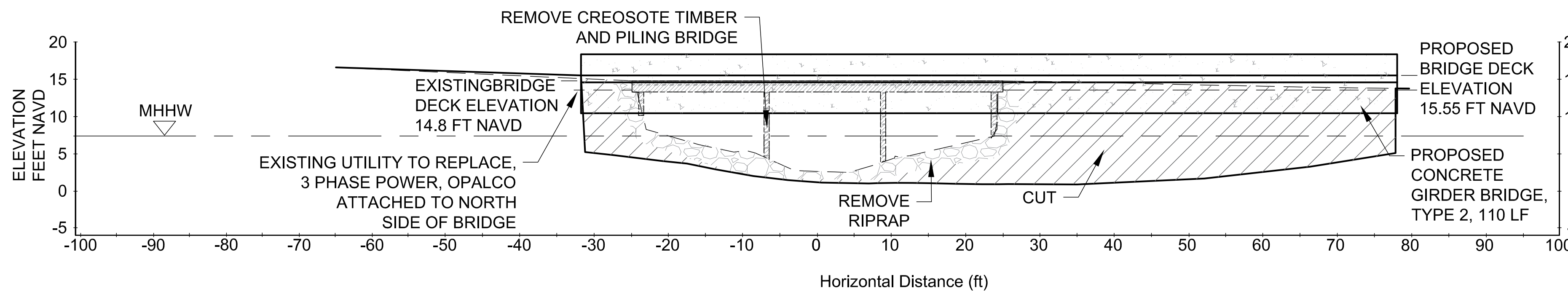
DEER HARBOR CONVERSION



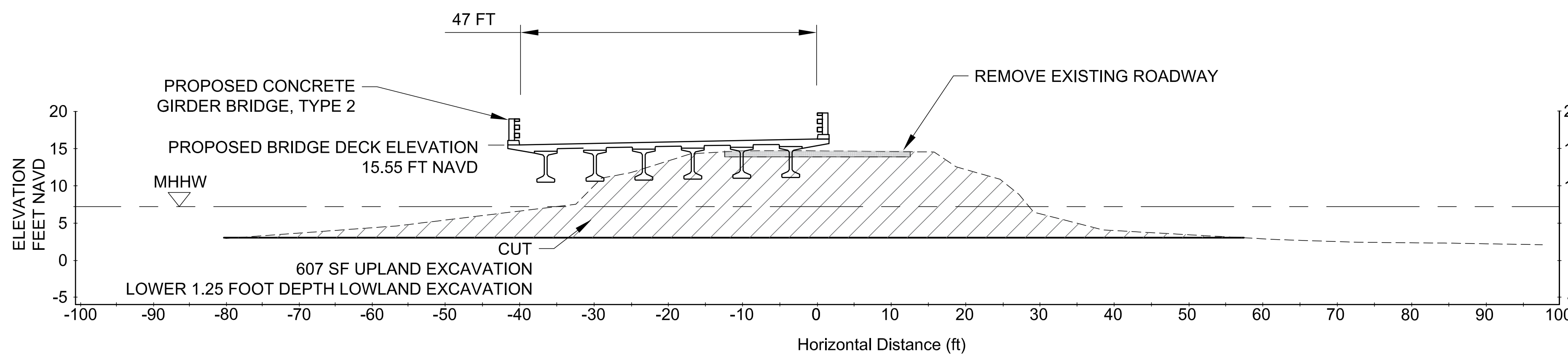
0.00 FT MHHW = 7.23 FT NAVD88
-7.23 FT MHHW = 0.00 FT NAVD88
0.00 FT MLLW = -0.53 FT NAVD88
0.53 FT MLLW = 0.00 FT NAVD88

Source: Friday Harbor Tide Gauge (NOS #9449880). See Table 1, Appendix C.





(A) FULL RESTORATION, CENTERLINE, LOOKING NORTH TYPICAL SECTION



(B) FULL RESTORATION, LOOKING EAST TYPICAL SECTION

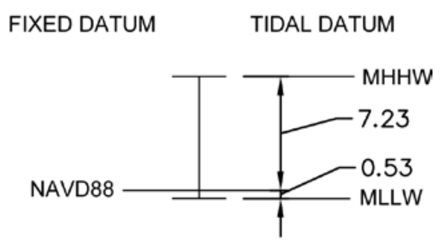
PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: CGS, J. Johannessen, LEG
Date: 05/2012

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)
Conceptual Design Section
SITE NAME: **Deer Harbor Estuary**
ACTION NAME: **Deer Harbor Estuary Restoration**
PSNERP ID#: **1648**
Full Restoration

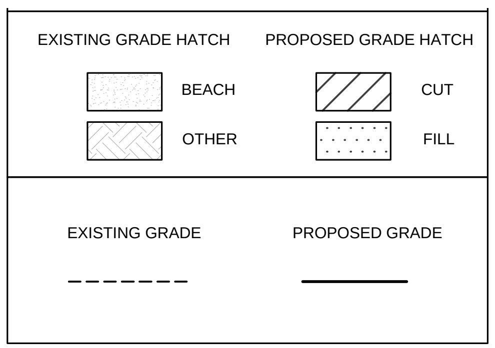
Figure 7-5

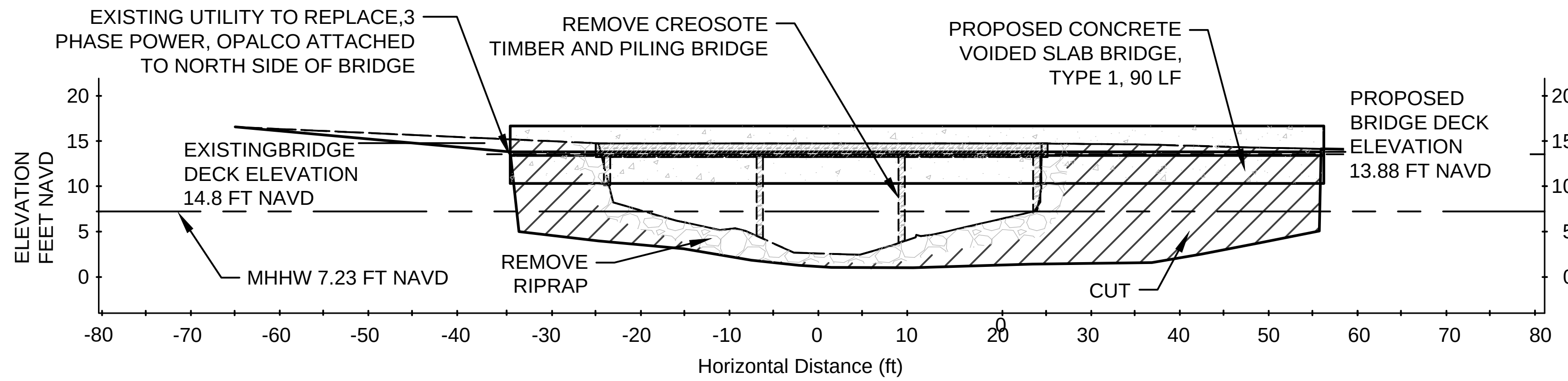
DEER HARBOR CONVERSION



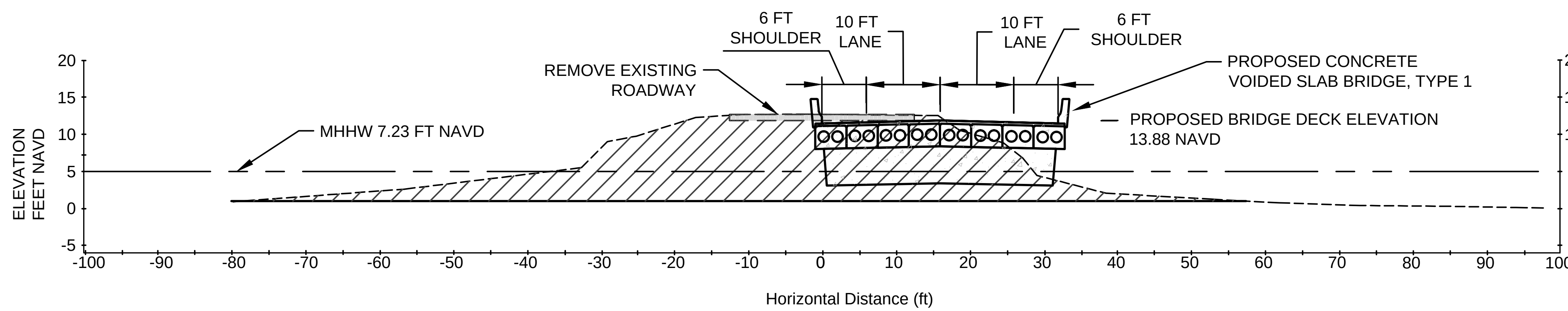
0.00 FT MHHW = 7.23 FT NAVD88
-7.23 FT MHHW = 0.00 FT NAVD88
0.00 FT MLLW = -0.53 FT NAVD88
0.53 FT MLLW = 0.00 FT NAVD88

Source: Friday Harbor Tide Gauge (NOS #9449880). See Table 1, Appendix C.





Ⓐ PARTIAL RESTORATION, CENTERLINE, LOOKING NORTH TYPICAL SECTION



Ⓑ PARTIAL RESTORATION, LOOKING EAST TYPICAL SECTION

PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: CGS, J. Johannessen, LEG
Date: 05/2012

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Section
SITE NAME: **Deer Harbor Estuary**
ACTION NAME: **Deer Harbor Estuary Restoration**
PSNERP ID#: **1648**
Partial Restoration

Figure 7-6

Full Restoration Quantity Estimate

Action Name: Deer Harbor
Action #: 1648
Date: July 20, 2011 Revised May 2012
By: Coastal Geologic Services

REMEDY: W*idening the mouth of the (filled) inlet to allow full tidal flushing, which will require replacing the bridge, footings and fill with a wider bridge span over the mouth of the inlet. Three utility conduits will be relocated on new bridge structure.*

Construction Period: Roadway and bridge demolition and replacement anticipated to take 7 months

Item	Unit of Measure	Material Name	Qty	Description of Item	Indicate section of design report where item is described
ACQUISITION AND CONSERVATION					
Required Project Lands	Acre		1.05	Total land required For action	7.3.5
Proponent / Partner-owned lands	Acre		0.8	Estimate of lands currently owned by Proponent (i.e., Public lands) 34,854 SF (3238 SM)	
Lands To Be Acquired - Permanent	Acre		0.18	7,470 SF (694 + 57 = 694 SM) of lands needs to be acquired permanently for new bridge and road	7.3.5
Lands To Be Acquired - Temporarily	Acre		0.07	3,229 SF (300 SM) for temporary access for fill removal for widening and channel contours	7.3.5
Material Sites					
MOBILIZATION AND ACCESS for construction activities					
Mobilization - Typical (Equipment, Personnel, Planning, Financial)	LS		1	Up front costs such as bonding, planning and other staff time and financing. Typically, assume 8% to 10% of other items.	
Mobilization - Remote (Equipment, Personnel, Planning, Financial)	LS		NA		
Site Access	LS		NA		
Barge Access	Days		NA		
Temporary Traffic Control (one of the following)					
none	LS		NA		
signs	LS		1	Construction Signage at both sites to alert of Construction & Lane shifting	
flags / spotters	LS		1	Flags and spotters only during roadway transition connection	
unique	LS		NA		
Temporary Roadway	SF		NA		
Control of Water	LS		NA		
Relocation Activities					
Site Demolition Activities					
Clearing and Grubbing (one or more of following)					
Clear Vegetation - Local Disposal	AC		NA		
Clear /Grub Vegetation - Local Disposal	SF		11540	Vegetation roots also removed and disposed locally, polygonal area, 70+201+801 SQ M is approximately 11,540SF	7.3.2
Clear /Grub Vegetation - Offsite Disposal	AC		NA		
Clear, stockpile - large woody debris	CY		NA		
Hydraulic Structures - Culverts	LS		NA		
Hydraulic Structures - Large	LS		NA		
Utilities	LF		885	3 utility conduits on bridge containing electrical and telephone- demo along entire length of improvements. Existing electrical vault will need to be adjusted to grade.	7.3.2
Buildings	LS or SF		NA		
Pavement	SF		15375	Removal of 570 LF of 20' roadway on Channel Road and 265 lf of 15' roadway on Lichen	7.3.2
Bulkheads	LF or SF		NA		
Demolition/Removal - Armor on Railroad Berm	LF, Ton or CY		NA		
Demolition / Removal - Railroad Berm	LF, SF or CY		NA		
Demolition / Removal - Bridge	SF		1020	Removal of 50' Timber Bridge, 51LF x 20'	7.3.2
Removal - Misc. (e.g. angular rock from beach)	CY		400	Rip rap lining channel and rock slope protection for existing bridge, 6500 SF polygon x 1.66FT Height; thickness estimated, no sub surface data exists	7.3.2
Demolition / Removal - in-water Piling	Number of Piles		16	Removal of Timber Creosoted Piles in bridge and abutments	7.3.2
Haul - Offsite Disposal of Demolition Debris	Miles		20	Placeholder	
Hazardous/Contaminated Waste Removal					
Contaminated Earthwork	CY		NA		
Hazardous Earthwork	CY		NA		
Construct Temporary Features					
temporary shoring	LS		1	For bridge construction	
EARTHWORK					
Excavation				Per yard excavation w/out expected haul	
Excavation - Upland	CY		1250	Conducive for transitional earthwork equipment, including scrapers, with high production and low cost, 55 LF (35 LF on east side, 20 LF on west side of bridge) x 605 SF average/typical XS area estimated from Typical CADD Section for all fill above 4 ft NAVD	7.3.2
Excavation - Lowland	CY		800	Requires low ground pressure equipment and or mats; low production bucket methods, typically hydraulic excavator and front end loaders. Lower elevation area, 17050 SF 1.25 average height	7.3.2
Dredging - Bucket - Land	CY		NA		
Dredging - Bucket - Marine	CY		NA		
Dredging - Hydraulic	CY		NA		
Fine Grading	AC		NA		
Fill Placement - local borrow					
Side cast	CY		585	Fill for roadway transition to newly raised and realigned bridge. 7860 SF with average 2' height.	7.3.2
Haul - uncontrolled placement	CY		NA		
Haul, place, compact	CY		NA		
Stockpile - uncontrolled placement	CY		NA		
Stockpile - controlled placement	CY		NA		
Conveyor placement from stockpile land/water	CY		NA		
Imported Fill					
Select Fill	CY		NA		
Gravel Borrow, including haul	CY		NA		
Sand / Gravel for Beach Nourishment	CY		NA		
Cobble for Shore Nourishment	CY		NA		
Embankment Compaction	CY		NA		
Topsoil	CY		NA		
RESTORATION Features					
Channel Rehab / Creation	SF		17050	Channel rehab calculations are based on the SF of lowland excavation for the channel area- surface treatment only, polygonal area	7.3.2
Large Wood Placement	EA		NA		
Invasive Species Control	Acre		NA		
Physical Exclusion Devices	LF or EA		NA		
Other Restoration Features/ Activities	LS		NA		
Structures	EA				
Water Control Structures - Culverts with Gates	EA		NA		
Water Control Structures - Weirs	EA		NA		
Rock Slope Protection	LF		NA	Not planned at this stage, after Geotechnical analysis might require bridge footing stabilization	
Other	EA		NA		
Elevated Boat Ramp	SF		NA		

Full Restoration Quantity Estimate

Action Name: Deer Harbor
Action #: 1648
Date: July 20, 2011 Revised May 2012
By: Coastal Geologic Services

REMEDY: W*idening the mouth of the (filled) inlet to allow full tidal flushing, which will require replacing the bridge, footings and fill with a wider bridge span over the mouth of the inlet. Three utility conduits will be relocated on new bridge structure.*

Construction Period: Roadway and bridge demolition and replacement anticipated to take 7 months

	Item	Unit of Measure	Material Name	Qty	Description of Item		Indicate section of design report where item is described
	Fencing	SF		NA			
Utilities							
	Water	LF		NA			
	Gas	LF		NA			
	Electric	LF		885	3 utility conduits on bridge		7.3.5
	Sewer	LF		NA			
	Telecommunications	LF		885	Telephone		
	Other	LF		NA			
Roadway / Railway							
	Roadway	SF		16970	Roadway 20' Min. Width with 8" ASPH & 12" Base		
	Roadway Minor Intersection	SF		995	Intersection Pavement		
	Roadway - Switch (potential)	LS		NA			
	Culvert (type)	LF		NA			
	Culvert - Jacking	LF		NA			
	Culvert - Horizontal Pile Driving	LF		NA			
	Bridge Deck	SF		5170	cast-in-place box girder bridge with (1) 110' Span (47' wide x 110')		7.3.6
	Bridge -Foundation	LF		NA	assumed to be a single row of 4-foot diameter drilled shafts at 12-foot spacing, 100-foot minimum depth		7.3.6
	Railway - Shoe fly	LF		NA			
Permanent Access Features							
	Roads	Level		2	Level 2 moderately difficult		7.3.6
	Utility Access Routes	varies		NA			
	Erosion Control Features	AC		1	Stabilized Construction Entrances, Sediment Ponds, Hydro Seed to Stabilize Roadway Embankments		7.3.7
Public Access or Recreation Features							
	Trails	SF		NA			
	Bridges	SF		NA			
	Kiosk	EA		NA			
	Restrooms	EA		NA			
	Interpretive Signs	EA		1	tdb		
	Parking Area	SF		NA			
	Other	EA		NA			
Vegetation & Erosion Control							
	Hydroseeding	AC		0.1	Native grass mix along roadway embankment, polygonal area		7.3.3
	Planting	AC		0.02	1000 SF Backshore vegetation at restored upper intertidal and lower supratidal areas, polygonal area		7.3.3
	Vegetation Maintenance	AC-YR		NA			
	Erosion / sediment BMPs - Temp.	AC		1.0	BMPs for control of drainage - describe. Assume compliance with Construction General NPDES included		7.3.7
	Erosion / sediment BMPs - Permanent	AC		NA			
	Waterside controls - Temporary	EA, LF, LS		NA			
	In-water controls - Temporary	LF		440	turbidity curtain for water based temporary actions		7.3.7
Construction Management							
	Construction oversight	Months		7	Quantity based on construction duration/ # of construction seasons		7.3.7
	Materials testing			NA			
Design and Detailed Site Investigations							
	Survey & Property, Utility Research	LS		1	% of construction cost		7.8
	35% Design	LS		1	35% x 25% x Engineer's Estimate		7.8
	65% design	LS		1	65% x 25% x Engineer's Estimate less the cost for 35% PS&E		7.8
	90% design	LS		1	35% x 25% x Engineer's Estimate less the cost for 35% + 65%PS&E		7.8
	100% design	LS		1	25% x Engineer's Estimate less previous costs		7.8
	Geotechnical Studies			1	Refer to design report for description of need		7.8
	Cultural Studies			1	Refer to design report for description of need		7.8
	HTWR Studies			NA			7.8
Project Agreement Activities					Unable to provide credible estimate at 10% design		
Site-Specific Adaptive Management Features & Activities					List if known		
Monitoring Activities					Assume 5 crew-days/year for each monitoring parameter in design report for 5 yrs		
	Monitoring (Type)	crew-days		125			
Operations & Maintenance					Unable to provide credible estimate at 10% design		

Partial Restoration Quantity Estimate

Action Name: Deer Harbor
Action #: 1648
Date: February 2011 Notes updated June 9, 2011 To show additional dimensions
By: Coastal Geologic Services Revised May 2012

REMEDY: Widening the (filled) mouth of the inlet to allow enhanced tidal flushing, which will require replacing the bridge, footings and fill with a wider bridge span. Three utility conduits will be relocated on new bridge structure.
Construction Period: Roadway and bridge demolition and replacement anticipated to take 7 months

Item	Unit of Measure	Material Name	Qty	Description of Item		Indicate section of design report where item is described
ACQUISITION AND CONSERVATION						
Required Project Lands	Acre		0.43	Total land required For action, polygonal area		7.3.5
Proponent / Partner-owned lands	Acre		0.18	Estimate of lands currently owned by Proponent (i.e., Public lands), polygonal area		
Lands To Be Acquired - Permanent	Acre		0.03	1450 SF of lands needs to be acquired permanently for new bridge and road alignment, polygonal area		7.3.5
Lands to Be Acquired - Temporary	Acre		0.22	9440 SF for temporary access for fill removal for widening and channel contours, polygonal area		7.3.5
Material Sites						
MOBILIZATION AND ACCESS for construction activities						
Mobilization - Typical (Equipment, Personnel, Planning, Financial)	LS		1	Up front costs such as bonding, planning and other staff time and financing. Typically, assume 8% to 10% of other items.		
Mobilization - Remote (Equipment, Personnel, Planning, Financial)	LS		NA			
Site Access	LS		NA			
Barge Access	Days		NA			
Temporary Traffic Control (one of the following)				Includes installation of traffic signals, signage, signmen, etc. There are 4 types as follows:		
none	LS		NA			
signs	LS		1	Construction Signage at both ends to alert of Construction & Lane shifting		
flags / spotters	LS		2	Flags and spotters during roadway transition connection and construction		
unique	LS		NA			
Temporary Roadway	SF		NA			
Control of Water	LS		NA			
Relocation Activities						
Site Demolition Activities						
Clearing and Grubbing (one or more of following)						
Clear Vegetation - Local Disposal	AC		NA			
Clear /Grub Vegetation - Local Disposal	SF		365	Vegetation roots also removed and disposed locally, polygonal area		7.3.2
Clear /Grub Vegetation - Offsite Disposal	AC		NA			
Clear, stockpile - large woody debris	CY		NA			
Hydraulic Structures - Culverts	LS		NA			
Hydraulic Structures - Large	LS		NA			
Utilities	LF		414	3 utility conduits on bridge - demo along entire length of improve for proper bending radius. Unit cost for 3 conduits 138LF x 3 conduits		7.3.2
Buildings	LS or SF		NA			
Pavement	SF		8890	Removal of 20' Roadway, 444.5 LF		7.3.2
Bulkheads	LF or SF		NA			
Demolition/Removal - Armor on Railroad Berm	LF, Ton or CY		NA			
Demolition / Removal - Railroad Berm	LF, SF or CY		NA			
Demolition / Removal - Bridge	SF		1020	Removal of 50' Timber Bridge, 50LF x 20.4'		7.3.2
Removal - Misc. (e.g. angular rock from beach)	CY		390	Rip rap lining channel and rock slope protection for existing bridge, 6500 SF polygon x 1.66FT Height; thickness estimated, no sub surface data exists		7.3.2
Demolition / Removal - in-water Piling	Number of Piles		16	Removal of Timber Creosoted Piling		7.3.2
Haul - Offsite Disposal of Demolition Debris	Miles		NA	Placeholder		
Hazardous/Contaminated Waste Removal						
Contaminated Earthwork	CY		NA			
Hazardous Earthwork	CY		NA			
Construct Temporary Features						
temporary shoring	LS		1	For bridge construction		
EARTHWORK						
Excavation				Per yard excavation w/out expected haul		
Excavation - Upland	CY		950	Includes excavation of the road causeway fill area above the tidal areas, 62 LF x 410 average/typical XS area estimated in CADD		7.3.2
Excavation - Lowland	CY		500	Requires low ground pressure equipment and or mats; low production bucket methods, typically hydraulic excavator and front end loaders. 110LF x 122 average/typical XS area estimated in CADD		7.3.2
Dredging - Bucket - Land	CY		NA			
Dredging - Bucket - Marine	CY		NA			
Dredging - Hydraulic	CY		NA			
Fine Grading	AC		NA			
Fill Placement - local borrow				This is additive to Earthwork -Excavation		
Side cast	CY		NA			2.3.2
Haul - uncontrolled placement	CY		NA			
Haul, place, compact	CY		NA			
Stockpile - uncontrolled placement	CY		NA			
Stockpile - controlled placement	CY		NA			
Conveyor placement from stockpile land/water	CY		NA			
Imported Fill						
Select Fill	CY		NA			
Gravel Borrow, including haul	CY		NA			
Sand / Gravel for Beach Nourishment	CY		NA			
Cobble for Shore Nourishment	CY		NA			
Embankment Compaction	CY		NA			
Topsoil	CY		NA			
RESTORATION Features						
Channel Rehab / Creation	SF		13950	Channel rehab calculations are based on the SF of lowland excavation for the channel area-surface treatment only, polygonal area		7.3.2
Large Wood Placement	EA		NA			
Invasive Species Control	Acre		NA			
Physical Exclusion Devices	LF or EA		NA			
Other Restoration Features/ Activities	LS		NA			
Structures	EA					
Water Control Structures - Culverts with Gates	EA		NA			
Water Control Structures - Weirs	EA		NA			
Rock Slope Protection	LF		NA	Not planned at this stage, after Geotechnical analysis might require bridge footing stabilization		
Other	EA		NA			
Elevated Boat Ramp	SF		NA			
Fencing	SF		NA			
Utilities						
Water	LF		NA			
Gas	LF		NA			
Electric	LF		414	3 utility conduits on bridge - demo along entire length of improve for proper bending radius. Unit cost for 3 conduits, 138LF x 3 conduits		7.3.5
Sewer	LF		NA			
Telecommunications	LF		NA			
Other	LF		NA			
Roadway / Railway						
Roadway	SF		6600	Roadway 20' Wide with 8" ASPH & 12" Base, 330 LF		
Roadway Minor Intersection	SF		610	Intersection Pavement, polygonal area		
Roadway - Switch (potential)	LS		NA			
Culvert (type)	LF		NA			
Culvert - Jacking	LF		NA			
Culvert - Horizontal Pile Driving	LF		NA			

Partial Restoration Quantity Estimate

Action Name:	Deer Harbor		
Action #:	1648		
Date:	February 2011	Notes updated June 9, 2011	To show additional dimensions
By:	Coastal Geologic Services	Revised May 2012	

REMEDY: Widening the (filled) mouth of the inlet to allow enhanced tidal flushing, which will require replacing the bridge, footings and fill with a wider bridge span. Three utility conduits will be relocated on new bridge structure.
Construction Period: Roadway and bridge demolition and replacement anticipated to take 7 months

	Item	Unit of Measure	Material Name	Qty	Description of Item		Indicate section of design report where item is described
	Bridge Deck	SF		2880	Voided Slab Precast Concrete Bridge, Type 1, with 90' Span (32'wide x 90')		7.3.6
	Bridge -Foundation	LF		0	Assumed to be a single row of 4-foot diameter drilled shafts at 12-foot spacing, 100-foot minimum depth		7.3.6
	Railway - Foundation	LF		NA			
	Railway - Shoe fly	LF		NA			
Permanent Access Features							
	Roads	Level		2	Level 2 moderately difficult		7.3.6
	Utility Access Routes	varies		NA			
	Erosion Control Features	AC		0.55	Stabilized Construction Entrances, Sediment Ponds, Hydro Seed to Stabilize Roadway Embankments, polygonal area		7.3.7
Public Access or Recreation Features							
	Trails	SF		NA			
	Bridges	SF		NA			
	Kiosk	EA		NA			
	Restrooms	EA		NA			
	Interpretive Signs	EA		1	tbd		
	Parking Area	SF		NA			
	Other	EA		NA			
Vegetation & Erosion Control							
	Hydroseeding	AC		0.1	Native grass mix along roadway embankment, polygonal area		7.3.3
	Planting	AC		0.02	1000 SF Backshore vegetation at restored upper intertidal and lower supratidal areas, polygonal area		7.3.3
	Vegetation Maintenance	AC-YR		NA			
	Erosion / sediment BMPs - Temp.	AC		0.43	BMPs for control of drainage - describe. Assume compliance with Construction General NPDES included, polygonal area (geodatabase)		7.3.7
	Erosion / sediment BMPs - Permanent	AC		NA	NA		
	Waterside controls - Temporary	EA, LF, LS		NA	NA		
	In-water controls - Temporary	LF		385	turbidity curtain for water based temporary actions		7.3.7
Construction Management							
	Construction oversight	Months		7	Quantity based on construction duration/ # of construction seasons		7.3.7
	Materials testing				Included in cost of material - no separate quantity		
Design and Detailed Site Investigations							
	Survey & Property, Utility Research	LS		1	% of construction cost		7.8
	35% Design	LS		1	35% x 25% x Engineer's Estimate		7.8
	65% design	LS		1	65% x 25% x Engineer's Estimate less the cost for 35% PS&E		7.8
	90% design	LS		1	35% x 25% x Engineer's Estimate less the cost for 35% + 65%PS&E		7.8
	100% design	LS		1	25% x Engineer's Estimate less previous costs		7.8
	Geotechnical Studies			1	Refer to design report for description of need		7.8
	Cultural Studies			1	Refer to design report for description of need		7.8
	HTWR Studies			NA			7.8
Project Agreement Activities					Unable to provide credible estimate at 10% design		
Site-Specific Adaptive Management Features & Activities					List if known		
Monitoring Activities					Assume 5 crew-days/year for each monitoring parameter in design report for 5 yrs		
	Monitoring (Type)	crew-days		125			
Operations & Maintenance					Unable to provide credible estimate at 10% design		

8. DESCHUTES RIVER ESTUARY RESTORATION (#1003)

Local Proponent	Squaxin Island Tribe
Delta Process Unit	DES
Shoreline Process Unit(s)	NA
Strategy(ies)	1 – River Delta
Restoration Objectives	Restore tidal processes, tidal channel formation, sediment transport, and natural hydrodynamic processes by removing a tide gate and associated stressors

8.1 Description of the Action

The action is to restore tidal dynamics to the Deschutes Estuary by removal of the 5th Avenue dam. Capitol Lake would be replaced by a functioning Deschutes Estuary that would reconnect the Deschutes River and Budd Inlet. In addition, dredging of the lakebed and primary river channel prior to restoration of the estuary would provide sediment for creation of intertidal habitat inside the restored estuary and elsewhere in Budd Inlet. Please see the Introduction chapter for important information regarding PSNERP and the context of this restoration project.

8.2 Action Area Description and Context

The Deschutes River Estuary in the South Puget Sound Subbasin is known as Capitol Lake. The lake was created by impoundment of the estuary by a tide gate in 1951. The action area is at the head of Budd Inlet and covers the historical area of the Deschutes Estuary, from Tumwater Falls in the south and extending into Budd Inlet in the north near the municipal marina of Olympia. The 346-acre action area is shown in Figure 8-1.

Figure 8-1. Action Area and Vicinity

8.2.1 Historic Condition

Historical maps of the area are provided in Figures 8-2A and 8-2B. Prior to 1869, the Deschutes River and its tributaries flowed unrestricted into Budd Inlet, where Capitol Lake now exists. The Deschutes River delta consisted of alluvial deposits, with limited areas of tidal marshes and braided channels (Hayes et al. 2008). Though the precise historical extent of tidal marsh and mudflat environments is poorly understood, a repeated theme of early observers is the extensive nature of mudflats across much of south Budd Inlet (Hayes et al. 2008). The 1873 U.S. Coast Survey of then-called Budd's Inlet shows the Deschutes Estuary as a waterway, with the first constriction of the estuary mouth near the 4th Avenue bridge. Subsequent surveys performed during the next few decades, but prior to installation of the dam, indicate the presence of mudflats as well as increasing encroachment by railroad trestles.

The Deschutes Estuary was dammed in 1951 to create a freshwater reflecting pool below the Washington State Capitol campus. Subsequently, the basin became known as Capitol Lake. The bathymetry and shape of the historic Deschutes Estuary in 1949 and modern Capitol Lake in 2004 are different. The wide tidal channel in the estuary has been replaced by less defined channels and submerged banks. The bathymetric difference between the historic estuary and the modern lake shows the most radical changes have occurred in South and Middle Basins, with bed level elevation decreases of more than

6 feet due to sedimentation. The depth of the tidal channel in North Basin also shows a large decrease of 6 to 10 feet due to sedimentation. Immediately south of the dam, depths have increased by more than 9 feet from scour generated by dam operations, creating a hole on the lake side of the dam structure. The average decrease in depth since 1949 suggests that 1.7 million CY of sediment has accumulated, or a 60% volume reduction due to filling and sedimentation within the modern lake boundary (George et al. 2006).

8.2.2 Natural Environment

Capitol Lake is at the head of Budd Inlet and is separated into four distinct but connected basins: North Basin, Middle Basin, South Basin, and Percival Cove. The 276-acre lake lies on a north-south axis, with the Deschutes River entering from the south via Tumwater Falls. South Basin has three vegetated islands; the other basins are open water. The hydrodynamics in Budd Inlet outside of Capitol Lake are marine-dominated, with a complex semi-diurnal tide that has a maximum range of 16 feet during spring tides at Gull Harbor, located 4.75 miles north of Capitol Lake on the east side of Budd Inlet. Inside the lake, there are two sources of fresh water – the Deschutes River and Percival Creek from the west.

The 57-mile Deschutes River is monitored with several USGS river gauging stations along the length of the river. The station closest to the lake is Station #12080010 at the E Street bridge in Tumwater. The annual average flow of the Deschutes River is approximately 420 cfs; however, the flow fluctuates widely within a year. A distinct wet season is observed from November to April, with episodic large flood events greater than 1,400 cfs; the largest flows on record exceed 8,000 cfs during a 50-year flood event. Other more frequent return interval flows include 3,300 cfs (2 year), 5,700 cfs (10 year), and 7,000 cfs (25 year). The river flow is approximately 105 cfs during the dry season, which spans from May to October. Percival Creek has no known gauging stations. The 1984 Capitol Lake Restoration Analysis reported the freshwater and sediment contribution of the creek to be significantly smaller than that from the Deschutes River (George et al. 2006).

The area immediately surrounding the lake varies in topography. In general, the banks are steep on the eastern side and less so along the western side of the lake. Most of the shorelines of the lake are developed, with a narrow strip of riparian vegetation remaining. The steep banks and bluffs are heavily vegetated with mixed evergreen forest typical of southern Puget Sound watersheds. Small freshwater marshes in South Basin are associated with mitigation sites. Geologic maps of the region show mostly unconsolidated alluvial deposits and glacial deposits. Volcanic and sedimentary rock beds are also found throughout the watershed.

Wildlife that use Capitol Lake include birds (52 species, including aerial-foraging, diving birds, gulls/terns, shorebirds, raptors, wading birds and waterfowl), freshwater fish (16 species), bats (4 species), aquatic or semi-aquatic mammals (5 species), and more than a dozen invertebrate species (Hayes et al. 2008). Sixteen species of wildlife are federally or state listed as endangered, threatened, or candidate species.

8.2.3 Human Environment

The modern 5th Avenue dam consists of a 16-foot-high earthen and concrete dam, an 82-foot-wide concrete structure with two radial tide gates, spillway, and a fishway supporting a causeway. The causeway extends 5th Avenue, connecting downtown Olympia to the transportation corridors on the western side of Capitol Lake. The tide gate is composed of two radial gates to regulate lake level and a fish ladder. The dam has a fish ladder, but it is a barrier to the natural migration of anadromous fish. A municipal marina is directly northeast of the dam, and the Port of Olympia is north of the marina.The BNSF railroad trestle, which existed before the dam, divides North Basin and Middle Basin. Construction of the Deschutes Parkway separated Percival Cove from Middle Basin, and completion of the I-5 overpass bridge in 1957 split South Basin from Middle Basin.

Several public spaces are contained within the original estuary boundaries – Marathon Park and Heritage Park in North Basin, the Capitol Lake Interpretative Center and Heritage Park wetland mitigation site in Middle Basin, and Tumwater Historical Park in South Basin.

8.3 Restoration Design Concept

8.3.1 Restoration Overview and Key Design Assumptions

The current configuration of the Deschutes Estuary as Capitol Lake has eliminated estuarine functions and intertidal habitat. The design concept is to restore tidal processes, tidal channel formation, sediment transport, and natural hydrodynamic processes by removing the dam and associated stressors. In addition, intertidal habitat would be created in North and Middle Basins while stabilizing vital transportation infrastructure.

Figures 8-3 through 8-8 illustrate the restoration alternatives. Removal of the 5th Avenue dam, coupled with dredging of the lakebed prior to removal, constitutes the full restoration alternative (Figure 8-3). The dredge spoils would be used to create intertidal habitat along the western side of the Deschutes Estuary and to protect the Deschutes Parkway. Excess sediment potentially can be used for other nearby projects or disposed of offsite (location to be determined). The 5th Avenue dam, currently across the mouth of the Deschutes Estuary and creating Capitol Lake, would be replaced by a 500-foot span bridge that would allow unrestricted tidal exchange with Budd Inlet. In addition, realignment of stormwater outfalls and reinforcement of concrete structures would be necessary to maintain the integrity of existing infrastructure around the current lake. Flood protection measures would be necessary around parks and other public spaces to ensure resilience from restored tidal processes, such as increased water levels and flow velocities.

Because a partial removal of the 5th Avenue dam is not possible, an alternative design for the restored estuary was developed by the Capitol Lake Adaptive Management Program and has been adapted here as the partial restoration alternative (Figure 8-4). Called the "dual basin" alternative, this option would restore tidal processes to most of the estuary. A portion of the eastern side of North Basin would become a pool impounded by a new wall or similar barrier. This barrier would be approximately 2,000 feet in length, with two water control gates or structures to manage the water level within the created pool. The pool could be freshwater or marine water, although the cost analysis and engineering design study recommended a marine water pool that allows tidally dependent circulation and flushing (Moffatt and Nichol 2007). The impact of this partial restoration option would be a reduction of the overall Deschutes Estuary area and a somewhat reduced intertidal habitat area. The impoundment would not substantially affect the hydrodynamics of the estuary.

Key design elements associated with full and partial restoration alternatives are summarized in Table 8-1.

Table 8-1. Key Design Elements

Element	Full Restoration	Partial Restoration
5th Avenue Dam	Remove dam and abutment fill	Remove dam and abutment fill
Accumulated Sediment In Middle Basin	Dredge sediment	Dredge sediment
New 5th Avenue Bridge	Construct bridge	Construct bridge
Deschutes Parkway	Stabilize roadway with dredge sediment and fill	Stabilize roadway with dredge sediment and fill
North Basin Barrier	No action	Construct barrier
Bridges	Provide scour protection to I-5 and railroad trestle bridges	Provide scour protection to I-5 and railroad trestle bridges
Trails	Elevate trails on boardwalks where necessary	Elevate trails on boardwalks where necessary
Vegetation	Plantings and emergent vegetation	Plantings and emergent vegetation

8.3.2 Restoration Features – Primary Process-Based Management Measures

Armor Removal/Modification

The return of tidal processes would require protection of existing infrastructure such as the I-5 bridge, 4th Avenue bridge, and BNSF railroad trestle. George et al. (2006) calculated current speeds during extreme hydrological events of approximately 16.7 feet per second (ft/s) at the I-5 bridge, 17.4 ft/s at the 4th Avenue bridge, and 7.9 ft/s at the railroad trestle. Moffat and Nichol (2007) used those velocity estimates to analyze the existing scour protection and assess the need for new or additional scour protection at these bridges. In addition, the new 5th Avenue bridge would require armoring. Existing riprap would be replaced with similar volumes of larger stone, although no rock sizing calculations were performed as part of the conceptual design analysis or the Moffatt and Nichol (2007) study. Quantities of armor modification are 200 feet (4th Avenue bridge), 650 feet (I-5 bridge), and 700 feet (railroad trestle). Moffatt and Nichol (2007) estimated 140 CY of material to extend the architectural cladding on the 4th Avenue bridge to the mudline. The same study estimated approximately 2,000 CY of armoring material would be needed to protect the banks of the 4th and 5th Avenues bridges.

Berm or Dike Removal/Modification - NA

Channel Rehabilitation/Creation

The accumulated sediment in the basin would be exposed to a large tide range and episodic fluvial events, which constitute large flood risks and sudden morphological changes. To alleviate these risks, the primary channel through the Deschutes Estuary would be deepened by dredging to increase the capacity of the waterway. The previous sediment management study by George et al. (2006) was referenced to determine the extent of dredging necessary to prevent filling of the downstream marina and the Port of Olympia following removal of the dam.

Most of the dredge spoils will consist of sandy silt and silty sand. The newly dredged channel would be a two-stage channel, with a wide main channel and smaller terraces grading back to the existing invert elevation of Middle Basin. The bottom width of the main channel would be approximately 275 feet, while the left bank terrace would have a width of 100 feet, and the right bank terrace a width of 50 feet. The average excavation depths for the channel dredging are 2 feet at the terraces and 6 feet at the main channel. This represents a new dredged invert elevation of approximately -12 feet MLLW (-8 feet NAVD88) for the main channel and -8 feet MLLW (-4 feet NAVD88) for the terraces.

The estuary would be reconnected with Budd Inlet under the 5th Avenue bridge by preparing the opening from the channel to the inlet. As much as possible, the historic path of the channel would be maintained, although the current configuration of North Basin would somewhat limit the sinuosity. For the partial restoration alternative, some allowance for the barrier would be required, but this would not change the dredge quantities. Approximately 410,000 CY would be removed from the channel at Middle Basin.

Groin Removal/Modification – NA

Hydraulic Modification

The 5th Avenue dam would be removed in its entirety as the primary component of both the full and partial restoration alternatives (Figures 8-3 and 8-4). The 16-foot-high earth embankment dam, two radial tide gates, a concrete fish ladder, and the concrete spillway would all be demolished.

The removal of the earth dam would entail excavation of the upland fill material, as well as dredging of the embankment below the water line. As part of the dam removal, the existing invert in this area would be lowered to better match conditions near the existing outlet and downstream area of the dam. It is anticipated that the minimum invert elevation would be approximately -20 feet MLLW (-16 feet NAVD88). The total excavation volume for upland excavation (above elevation 10 feet) is approximately 44,000 CY. It is assumed that all of the material from excavation will be hauled offsite for disposal. The total excavation volume for dredging (below elevation 10 feet) is approximately 77,000 CY. The dredged material would be reused within the action area. The dredging volume also includes an area between the 4th and 5th Avenue bridges that would be lowered to the design elevation of -20 feet MLLW (-16 feet NAVD88). The total volume of excavation required to remove the existing dam and lower the channel invert would be approximately 121,000 CY.

The removal of the 5th Avenue dam and bridge constitutes the primary restoration action. The current structure, described above, would be demolished and a new 500-foot bridge span would allow reconnection of the estuary and Puget Sound. The reestablishment of tidal flows would create a markedly different environment from the freshwater Capitol Lake. While the dam removal would be identical for both restoration alternatives, the barrier in the partial restoration alternative (Figure 8-4) would substantially alter the hydrodynamics in North Basin by affecting the free flow of water. Beyond North Basin, there would not be impacts to the hydrodynamics.

Overwater Structure Removal – NA

Topography Restoration

A significant portion of the material dredged from the Middle Basin channel would be used to reconstruct the western shore of North Basin and Middle Basin (Figures 8-5, 8-7 and 8-6). The western bank is oversteepened, eroding, and partially protected by rock and riprap. The dredged sediments would be placed on top of the rock buttress to stabilize the Deschutes Parkway road embankment. The intent of the new slope would be to utilize a portion of the dredged sediments and to create a more natural slope for the estuary. The slope restoration would allow for localized sediment erosion and accretion resulting from tidal action and vegetation of the slope in the intertidal zone.

Four typical cross sections were developed for the western shore. The typical sections vary in their dimension but are generally described as having:

- Upland topsoil placement at embankment, 3 foot depth, 3:1 side slope, terrace width of 10 to 25 feet.
- Dredge sediment placement from elevation 16 feet to varying depth (0 to -5 feet MLLW or +4 to -1 feet NAVD88).
- 25:1 slope above elevation 14 feet MLLW (10 feet NAVD88), 15:1 or 20:1 slope below elevation 14 feet MLLW (10 feet NAVD88).

Cross sectional areas for topsoil and dredge sediment were applied to the length of shore represented by each typical section. A single section was developed for the North Basin (length = 2,800 feet). Three typical sections were developed for the Middle Basin. The northern section extends from the railroad bridge to the middle of Percival Cove (length = 1,000 feet); the central section extends from the middle of Percival Cove to Lakeridge Drive SW (length = 840 feet); the southern section extends from Lakeridge Drive SW to the trail at the southern end of Middle Basin (length = 2,350 feet). The total estimated volume of topsoil to be placed at the western shore is approximately 16,000 CY. The total estimated volume of dredged sediment to be placed at the western shore is approximately 383,000 CY.

Additional dredged sediment would be placed within Percival Cove around the perimeter of the cove to rebuild the sediment-depleted system. A total volume of 50,000 CY would be placed, with an average depth of 3 feet over a 150-foot band along the intertidal shoreline.

8.3.3 Restoration Features – Additional Management Measures

Beach Nourishment – NA

Contaminant Removal/Remediation

Moffatt and Nichol (2007) estimated that up to 25% of the dredged sediment from the entrance at 5th Avenue and the Middle Basin channel could be contaminated with purple loosestrife seeds (a non-native, invasive plant species). This estimate is considered to be an upper maximum based on other studies and dredge disposal activities from the marinas.

No specific contaminant investigations were conducted as part of the conceptual design, but the estimated amount of contaminated sediment requiring offsite treatment and disposal is 54,000 CY. This amount was based in part on using the upper bound of 25% and the balance of cut and fill within the site. It was assumed that some amount of dredged sediment is contaminated and will require special handling and disposal. This amount would be removed from the estuary basin for offsite disposal during the pre-restoration dredging. Moffatt and Nichol (2008a) identified the open water disposal site for contaminated material at Commencement Bay (round trip distance 86 miles) as a likely recipient of the contaminated sediment. Other options include nearshore restoration or reuse within Budd Inlet.

Debris Removal – NA

Invasive Species Control – NA

Large Wood Placement – NA

Physical Exclusion – NA

Pollution Control – NA

Revegetation

The upper elevations along the western shore of the restored estuary sediment would be revegetated. Upland vegetation (riparian trees, shrubs, and grasses) would be planted on the upland topsoil slope and terrace. Marsh and wetland vegetation would be planted on the gently sloped portion of the placed sediment above and within the intertidal zone. The total surface area requiring revegetation is approximately 17.5 acres, with 7.9 acres in North Basin and 9.6acres in Middle Basin.

Reintroduction of Native Animals – NA

Substrate Modification – NA

Species Habitat Enhancement – NA

8.3.4 Restoration Features – Other

Slope Stabilization (Rock Buttress)

The fill upon which the Deschutes Parkway is constructed would be subject to slope failures if not protected from the tidal action of the restored estuary. The design of the rock buttress is similar to that presented in Moffatt and Nichol (2008a) with depths varying along the western shore of North and Middle Basins. The intent of the rock buttress is to stabilize the softer underlying material by weighing it down in place and provide erosion protection. The rock would be placed directly on the existing slope (Figures 8-5, 8-7 and 8-6). Excavation would be used only to key in the toe of the buttress. The rock buttress would extend from an elevation of approximately 13 feet to a depth that varies by location. The face of the buttress would have a slope of 3:1, with the interface slope of the rock and existing grade at approximately 2:1. The total volume of rock required for the buttress is approximately 65,500 CY. A typical WSDOT rock gradation would be used for the rock buttress. Though the rock has not been specifically sized, a gradation with a majority of the rock diameter at 1.0 to 2.0 feet is anticipated.

Trails and Pedestrian Bridges

A large and heavily used trail system encompasses North Basin, extending along the western side of Middle Basin, and continuing into South Basin. For the purposes of the conceptual design, trails were assumed to be either existing without any planned changes, requiring some form of improvement, or needing to be reconstructed (e.g., boardwalks, as in the case of the South Basin area trails). The total length of trails to be improved is approximately 1.3 miles, and approximately 0.2 mile of new trails would be constructed. Two pedestrian bridges would be constructed as part of the trail network.

Bulkhead – Surface Treatment

Following removal of the 5th Avenue dam, the Arc of Statehood bulkhead on the eastern side of North Basin would require additional treatment to provide protection from the effects of salt water against the concrete wall. Moffat and Nichol (2007) recommend applying an epoxy mix sealant to the concrete for protection. This is only required for the full restoration alternative (Figure 8-3). The total surface area of treatment was estimated to be 25,000 SF based on a length of 2,500 feet and an assumed total wall height of 10 feet.

Boat Launches

The canoe launch at the Capitol Lake Interpretative Park and the boat launch at Marathon Park would need to be rebuilt or relocated to account for tidal variations. This was not specifically included in the quantity estimate.

Control of Water during Construction

Moffatt and Nichol (2008a) provide a discussion of construction methods for the new 5th Avenue bridge, including the construction of a coffer dam and a 96-inch bypass pipe to move the flow of the Deschutes River around the construction site.

Stormwater Outfalls

Stormwater outfalls at Capitol Lake would require replacement or modification to protect against salt water. Additionally, stormwater outfalls along the length of Deschutes Parkway would require modification or replacement. These facilities were not identified or quantified as part of this conceptual design.

8.3.5 Land Requirements

Most of the action area is part of the Washington State Capitol Campus. The state-owned aquatic lands of the Capitol Lake basin are managed by the Washington Department of General Administration under a lease agreement from WDNR. Additional right-of-way may need to be acquired to accommodate the new roadway section (per City of Olympia standards).

8.3.6 Design Considerations

The 4th Avenue bridge, Deschutes Parkway, and I-5 bridge pose restrictions on the width of the estuary mouth, as well as the extent to which the river and tidal channels can meander. The placement of additional protection for the bridges will increase the amount of hardened shoreline. There are no access considerations.

Nine invasive species have been introduced to the action area. Seven of these exotic species (American bullfrog, common carp, brown bullhead, smallmouth bass, largemouth bass, yellow perch, and nutria) threaten native fauna and habitats. The salinity introduced by removing the dam would make habitats less suitable for these species. While reintroduction of estuarine conditions would favor the remaining two exotic species (soft-shelled clam and Manila littleneck clam), both of these serve as food for native species and are not known to negatively affect native fauna. An additional invasive species, the New Zealand mud snail, has been identified in Capitol Lake. There is significant concern about its spread to other freshwater bodies. The mud snail cannot tolerate high salinity and would be disfavored under estuarine conditions; however, the presence of the snail impacts where the dredge spoils can be deposited.

In contrast to other estuaries in Puget Sound, Budd Inlet is relatively contaminated with aromatic and chlorinated hydrocarbons in sediments and bottom-dwelling fishes (Stehr et al. 1998). The sediment in Capitol Lake would need to be analyzed for contaminant concentrations.

Lack of support for the action among some constituents creates additional considerations in terms of the timing and feasibility of this action.

8.3.7 Construction Considerations

The primary construction components are demolition of the current 5th Avenue bridge, dam, and roadway; construction of the new 5th Avenue bridge and roadway; dredging of

Middle Basin sediments and abutment fill; and placement of sediment. Placement of riprap, additional trail construction, and secondary restoration elements are also considerations, but not described for this conceptual report. Construction of the 2,000-foot tidal barrier is the only significant addition for the partial restoration alternative. All of this work could be completed within 12 months, depending on the dredge and placement methods selected. Moffatt and Nichol (2007) described a construction sequence for both the bridges and dredging. The abbreviated sequence is:

1. Construct a temporary, two-lane access road from Deschutes Parkway up the hill to the roundabout.
2. Widen the temporary access road and complete construction of the new roadway west of the bridge (including the west and south legs of the T-junction). The temporary retaining wall would remain in place as a new, permanent retaining wall is constructed to retain fill for the entire new roadway.
3. Using land-based equipment, overexcavate around the 4th Avenue bridge pier. Place pre-cast concrete cladding to match the existing piers, and place riprap scour protection around the base of the pier.
4. Construct a cofferdam around the 5th Avenue dam and extending east to the location of the planned new 5th Avenue bridge abutment on the east bank. This construction will include a 96-inch-diameter pipe for bypassing Deschutes River flow past the cofferdam.
5. Working in the dry and using conventional equipment, demolish the dam, excavate the new channel within the area encompassed by the cofferdam, and construct the east abutment of the new bridge and associated riprap scour protection.
6. Remove the cofferdam and allow tidal flow to enter the restored Deschutes Estuary. This should be performed at slack tide, during a neap tidal cycle, to decrease the immediate tidal flows through the new opening.
7. Using land-based equipment, complete demolition of the roadway and excavate the remainder of the 500-foot channel.
8. Construct the new 5th Avenue bridge across the newly opened inlet.

For the dredging, work would occur prior to dam removal. The lake has been drawn down many times over the dam's lifespan without any apparent risk to the dam integrity. Dredging would progress from one end of Deschutes Parkway to the other, with the different activities described below occurring in parallel at different parts of the roadway. One possible construction method would be to draw down the water in the lake, allowing the edge work to be carried out using land-based equipment.

1. Using land-based equipment, excavate the toe of the slope to allow the rock buttress to be keyed in. Any existing slope protection rock would be stockpiled for reuse. Place the rock buttress, working from the toe of the slope to the upper slope within each shoreline section.
2. Construct rock dikes along the toe of the slope using wide-tread or low-pressure-tired equipment working on the mudflat. The rock dike will act as an offshore containment berm for the sediments placed in step 3.
3. Use hydraulic equipment to dredge the channel, with pipeline delivery of the dredge material slurry to the slope behind the low dike. Let the slurry water (supernatant) drain back into the lake and recycle with the dredging process.

4. After the dredged materials on the slope behind the dikes drain and dry, use the wide-tread or low-pressure-tired equipment to smooth and shape it.
5. Remove the rock toe dikes. Apply any topsoil treatment to the upper slopes, together with other treatment (e.g., jute matting for short-term stabilization) that is required.
6. Hydroseed the slopes with appropriate intertidal and riparian vegetation. Plant herbaceous plugs and/or woody trees and shrubs.

For the construction of the tidal reflecting pool barrier for the partial restoration alternative, the major effort would be driving the sheet-pile wall. The steel sheet piles would be coated before installation to reduce rusting exacerbated by the saltwater environment. The sheet piles could be driven from a barge using a vibratory hammer. This works by reducing the friction between the sheet pile and the soil to enable the sheet to penetrate the soil. Once the sheet piles are driven, the pedestrian walkway can be installed.

8.4 Extent of Stressor Removal

Table 8-2 describes the amount of stressors to be removed with this action.

Table 8-2. Stressor Removal

Stressor	Full Restoration	Partial Restoration
Tidal Barrier (LF)	500	500
Fill (SF)	112,000	112,000

8.5 Expected Evolution of the Action Area

The restored Deschutes Estuary and current Capitol Lake are entirely different environments on divergent ecological paths. Without restoration, the freshwater lake will continue to accumulate sediment, leading to emergent islands in each basin (three already exist in South Basin) that may eventually merge into a freshwater marsh. The Deschutes River would be confined within the wetlands, and the habitat would be dominated by freshwater species, including the invasive flora and fauna described above. Further shifts in the topography and amount of exposed water area could negatively affect the listed species of concern, although new species may colonize the marshes. Ecologically, this system is dependent on the presence of the 5th Avenue bridge and dam.

In contrast, the restored Deschutes Estuary would function as a southern Puget Sound estuary, with tidal processes maintaining sediment transport, salinity ranges, and estuarine biodiversity. Restoring the tidal processes by removal of the tide gate would allow development of intertidal habitat, tidal channel formation, sediment and nutrient conveyance, and circulation and mixing processes for freshwater and marine water. Biological assessments anticipate a number of species would respond to the restoration action. Hayes et al. (2008) estimated that the restored estuary would positively impact 18 species of marine benthic invertebrates, 10 species of marine fishes, 8 species of anadromous fishes, and 18 species of birds. Conversion of freshwater vegetation to brackish water tolerant species would also occur at the fringes of the estuary's emergent mudflats.

Sediment naturally exported from the estuary will be an ongoing issue that will require future adaptive management decisions, including maintenance dredging options (George et al. 2006, Moffatt and Nichol 2007). Implementation of restoration actions will require the development and implementation of a sediment management plan, and a funding strategy to equitably distribute maintenance costs commensurate with benefits. For example, George et al. (2006) found increased sedimentation but only slight increases in current velocities in the port and marina downstream of the restored estuary. In addition, public education and involvement would be critical to the long-term success of the restoration action.

8.6 Uncertainties and Risks

The options to address the sediment accumulation inside Capitol Lake are the source of most uncertainties. Geomorphic changes will be rapid and widespread with the reintroduction of tidal forces to the basin (George et al. 2006). Without pre-restoration dredging, dynamic equilibrium is estimated to occur within 5 to 10 years, but with significant deposition of sediment in the downstream marina and port. The estimates of dredging and soil excavation do not balance with the placement of dredged material adjacent to Deschutes Parkway as described by Moffatt and Nichol (2007). In order to maintain the desired estuarine processes, it does not seem feasible to balance the cut and fill solely by placement of fill within the Middle and North Basins. It would be undesirable to extend the placement of the dredged material in the North and Middle Basins eastward to use more material because it would channelize the flow through the estuary, rather than maintaining the pocket-like features that otherwise would exist in the North Basin in either the full or partial restoration designs.

The suitability of the dredged material for reuse onsite will need to be verified as the design work progresses. If sediment needs to be hauled and disposed of offsite, construction costs would increase dramatically, although the access to the BNSF railroad lines would be beneficial. Some options proposed for the surplus dredged and excavated material include:

- Offsite disposal at Commencement Bay.
- Placement of a portion of the material within Percival Cove (which is a relatively sediment-starved system).
- Delivery of the material to other nearby restoration sites such as the proposed Garfield Creek or Indian/Moxlie Creek sites immediately north of the estuary.

The methods used to dredge this site are uncertain and will need to be confirmed based on subsequent analysis. Stakeholder concerns regarding potential increase of sediment flow into Budd Inlet could delay construction of the project.

In addition, differing positions exist among stakeholders regarding the use of existing railroad fill as pedestrian trails. Public access should be considered as an enhancement of the estuary restoration designs where it does impinge on the ecological functions, a perspective embraced by the project proponent.

8.6.1 Risks Associated with Projected Sea Level Change

The full tidal reconnection of the North and South Basins would open the surrounding land and facilities to the effects of sea level rise. Moffatt and Nichol (2008a) identified several specific features that would be impacted. They developed cost estimates for these items in the low-lying infrastructure study. Table 8-3 compares potential risks associated with projected sea level changes based on professional judgment.

Table 8-3. Risks of Sea Level Change

	Projected SLC		
	High (65 cm)	**Intermediate (21cm)**	**Low (13cm)**
Full Restoration	Given the urban location of the project there are a number of actions that will be required as sea level rises: Raise berm along Arc of Statehood and install stormwater pump station. Raise Deschutes Parkway near BNSF crossing, replace BNSF railroad trestle, and raise rail track west of Capitol Lake. Construct perimeter dikes for parking and restroom at Marathon Park, for parking at GA Powerhouse, and to protect the Old Brewhouse.	Negligible	Negligible
Partial Restoration	Same as full but need to raise height of tidal barrier and pedestrian footpath.	Negligible	Negligible

8.7 Potential Monitoring Opportunities

Monitoring is important for evaluating restoration success, especially for a high-visibility action affecting an iconic feature. A combination of field surveys and aerial photographs would be used to document biological and physical changes to the landscape. Monitoring data can be used to refine adaptive management and corrective actions as needed. The monitoring needs and opportunities associated with this action are summarized in Table 8-4.

Table 8-4. Monitoring Needs and Opportunities

Monitoring Parameter	Key Performance Indicator	Note
Topographic Stability	X	Monitor slope stability near dam area
Sediment Accretion / Erosion	X	Monitor to assess need for dredging
Wood Accumulation		
Soil / Substrate Conditions		
Vegetation Establishment	X	Monitor development of intertidal habitats

Monitoring Parameter	Key Performance Indicator	Note
Marsh Surface Evolution / Accretion		
Tidal Channel Cross-Section / Density	X	Monitor tidal channel formation, reestablishment of circulation and mixing processes for fresh water and marine water
Water Quality (contaminants)	X	Monitor sediment and nutrient conveyance
Salinity	X	Monitor salinity and temperature
Shellfish Production		
Extent of Invasive Species	X	Assess species response to restoration action
Animal Species Richness	X	Assess species response to restoration action
Fish (salmonids) Access/Use	X	Assess species response to restoration action
Forage Fish Production		
Wildlife Species Use	X	Assess species response to restoration action
Effectiveness of Exclusion Devices		

8.8 Information Needed for Subsequent Design

This conceptual design report represents an initial step in the restoration design sequence. The design concepts described above were developed based on readily available information without the level of site-specific survey and investigation that is necessary to support subsequent design and implementation. Substantial additional information will be required at the preliminary and later design stages to confirm the design assumptions, refine quantity estimates, address property and regulatory issues, obtain stakeholder support, and fill in data gaps. The extent to which this information is collected for preliminary design (or a later design stage) will depend upon the available budget, schedule and other factors. This section attempts to define the most essential information needs for this action.

- Utility Investigation/Survey – More detailed information on utility locations will be needed to finalize the designs. The low-lying infrastructure investigation by Moffatt and Nichol (2008b) provides some preliminary direction on utilities and sewers.
- Geotechnical Investigation – Additional geotechnical study will be required including foundation type and hydraulic engineer recommendations for scour and minimum bridge clearance over water, walls, and slopes.
- Groundwater Investigation – Additional studies regarding the existing and anticipated groundwater movement under the different restoration scenarios can expand the preliminary information provided by Moffatt and Nichol (2008b).

- Cultural Resources Investigation – Surveys for archaeological and historic resources may be required for this action area.
- Contaminant Survey – Additional investigation may be required to document the presence and extent of hazardous materials in the action area. The introductory chapter describes the Phase I site investigations that are occurring as part of this overall effort via a separate contract.

8.9 Quantity Estimates

The quantity spreadsheets for the full and partial restoration alternatives are provided in Exhibits 8-1 and 8-2.

8.10 References

Cascade Economics LLC, Northern Economics, Inc., and Spatial Informatics Group LLC.2007. *Deschutes Estuary Feasibility Study: Net Social and Economic Benefit Analysis Final Report.* Prepared for Capitol Lake Adaptive Management Plan Steering Committee and Washington Department of Fish and Wildlife

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Hayes, M.P., T. Quinn, T.L. Hicks. 2008. *Implications of Capitol Lake Management for Fish and Wildlife.* Washington Department of Fish and Wildlife. Prepared for the CLAMP Steering Committee.

Moffatt & Nichol Engineers, EDAW, Inc., GeoEngineers. 2007. *Engineering Design and Cost Estimates, Final Report, Deschutes Estuary Feasibility Study, Phase 3.* Prepared for Washington Department of Fish and Wildlife, February 9, 2007.

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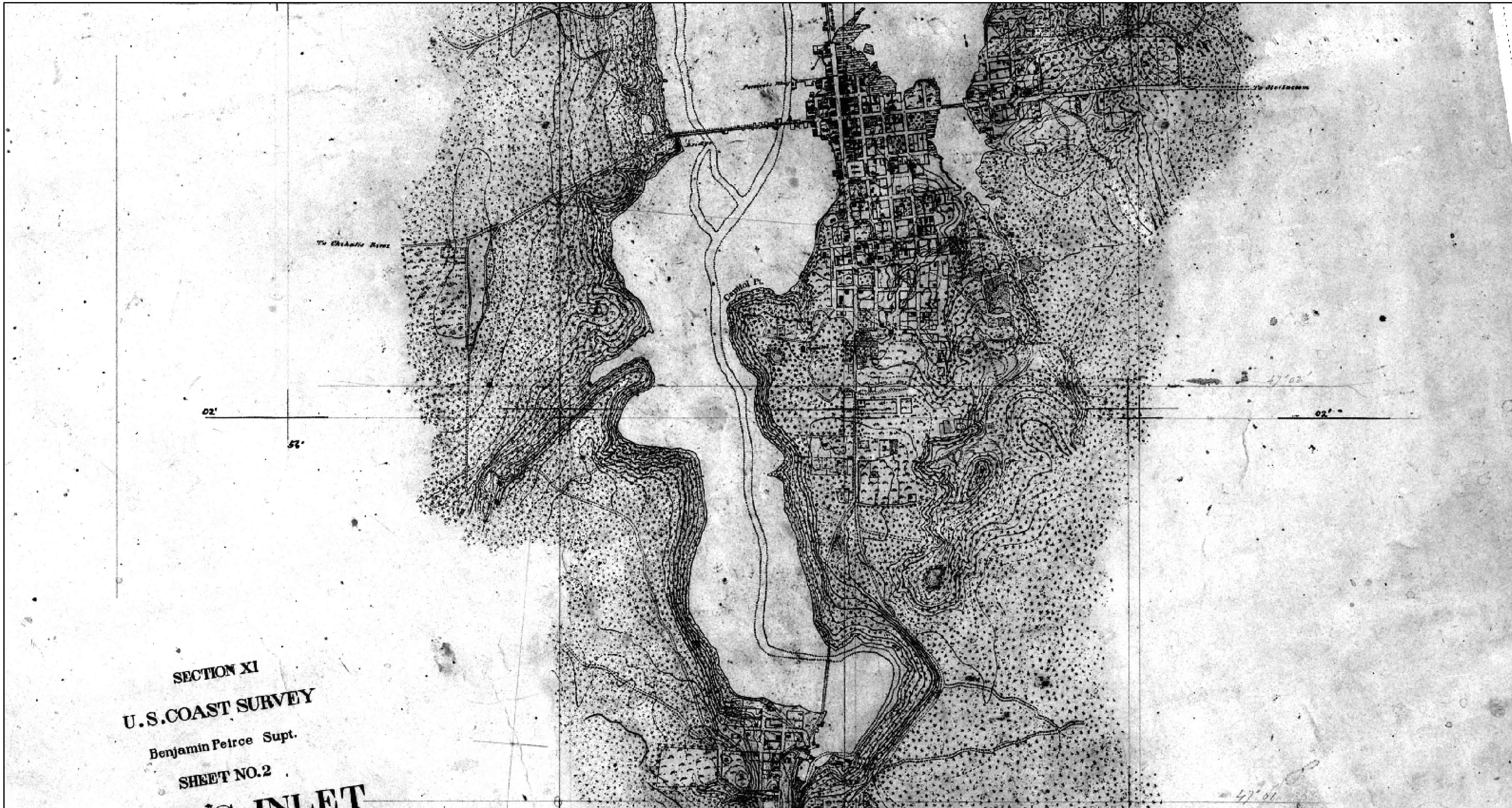
Stehr, C.M., L.L. Johnson, and M.S. Myers. 1998. Hydropic vacuolation in the liver of three species of fish from the U.S. West Coast: Lesion description and risk assessment associated with contaminant exposure. *Diseases of Aquatic Organisms* 32:119-135.



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0 1,400
Feet
0 440
Meters

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64

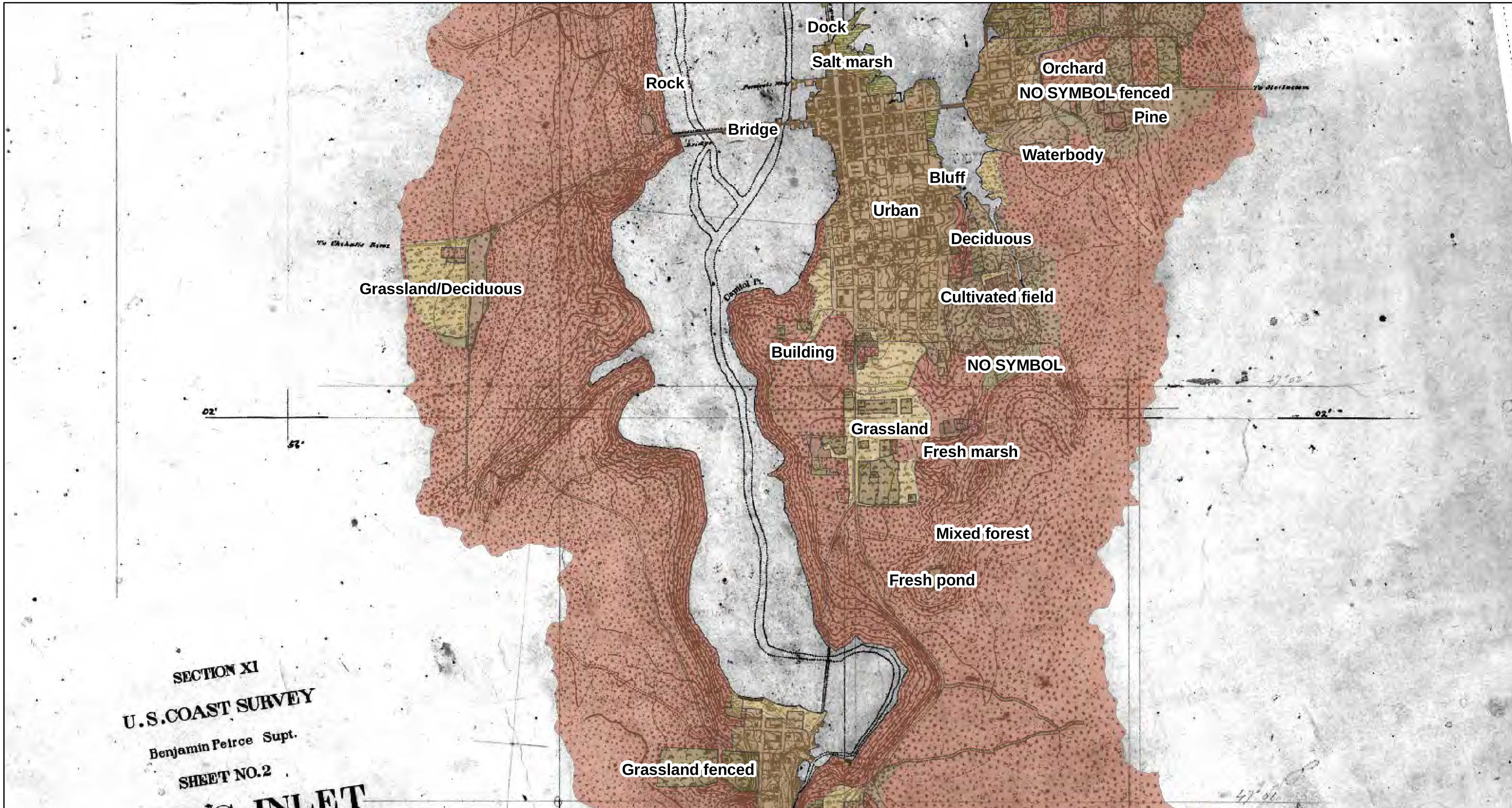
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Historic Map (T-Sheet)

Action Name: Deschutes River Estuary Restoration

PSNERP ID #: 1003

Figure 8- 2A



Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64

WDFW Contract # 100-000204 (CAPS No. 10-1461)

Historic Map (T-Sheet) and River History Project Data

Action Name: Deschutes River Estuary Restoration

PSNERP ID #: 1003

Figure 8- 2B

S:\GIS\Projects\210xxx\210337_PSNERP_NEARSHORE\Projects\2-TSheets_rev.mxd (DLP; 2/24/2011)

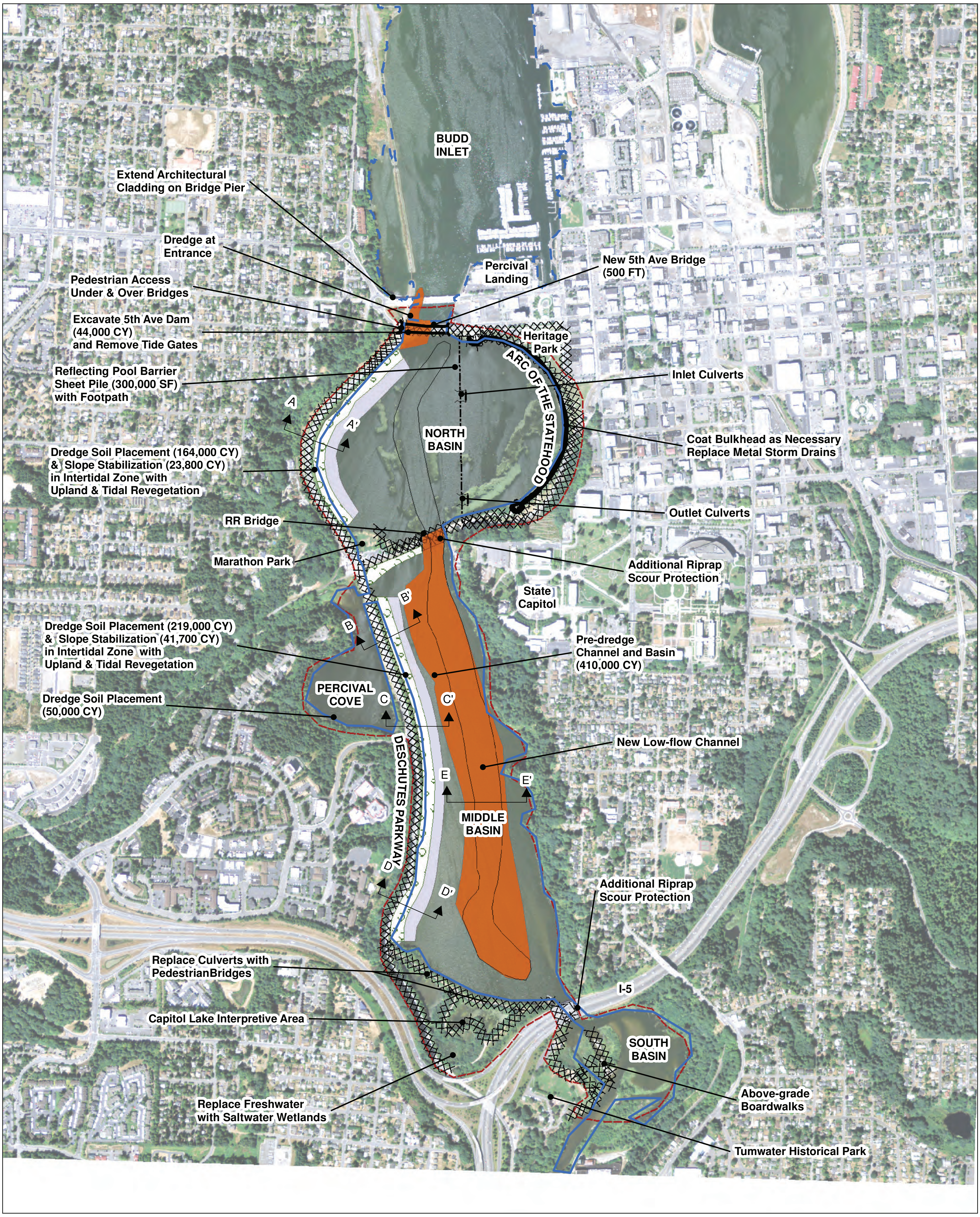
SOURCE: Washington Public Lands Database (2006); Washington Counties Parcels (2009); NAIP (2006)

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Plan
Site Name: Budd Inlet
Action Name: Deschutes River Estuary Restoration
PSNERP ID #:1003
Full Restoration

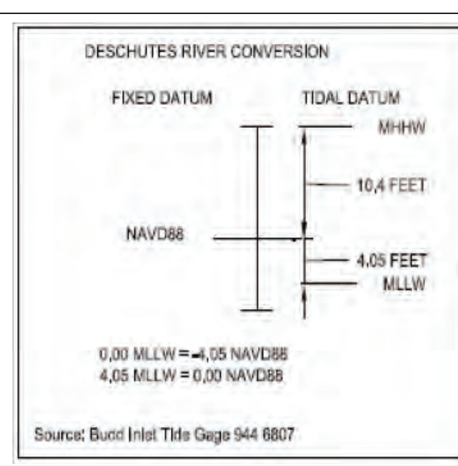
Lead Contractor: ESA
Design Lead: ESA PWA
Date: 2/2011

Figure 8-3



Legend

- Bridge
- Dredging - Hydraulic
- Haul - Uncontrolled Placement
- Low-flow Channel
- Planting
- Required Project Lands
- Rock Slope Protection
- Water Control Structures - Culverts with Gates
- Barrier
- Bulkheads
- Existing Tide MHHW
- Proposed Tide MHHW
- Trails



PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

North

0 340 Feet

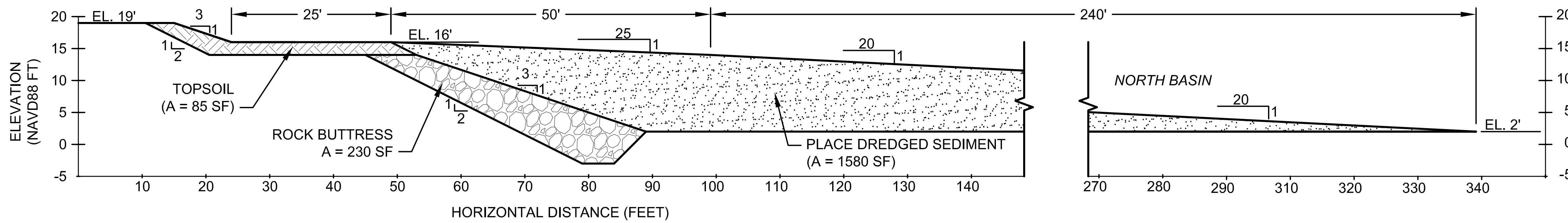
SOURCE: Washington Public Lands Database (2006); Washington Counties Parcels (2009); NAIP (2006)

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

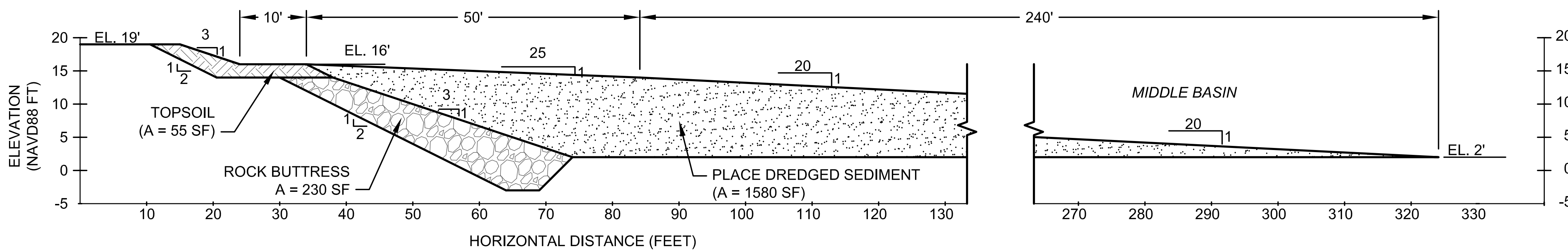
Lead Contractor: ESA
Design Lead: ESA PWA
Date: 2/2011

Conceptual Design Plan
Site Name: Budd Inlet
Action Name: Deschutes River Estuary Restoration
PSNERP ID #:1003
Partial Restoration

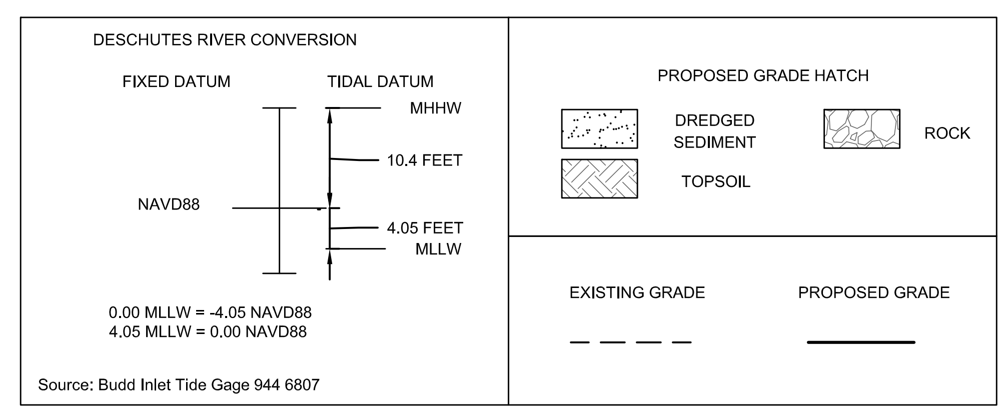
Figure 8-4

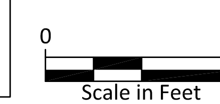


Ⓐ NORTH BASIN - TYPICAL SECTION



Ⓑ MIDDLE BASIN - NORTHERN TYPICAL SECTION



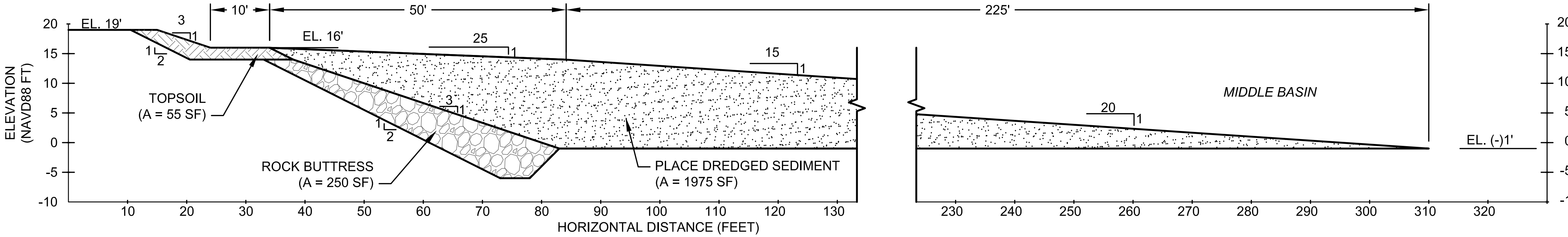


PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: ESA PWA
Date: 3/2011

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Section
SITE NAME: **Budd Inlet**
ACTION NAME: **Deschutes River Estuary Restoration**
PSNERP ID#: **1003**
Full Restoration



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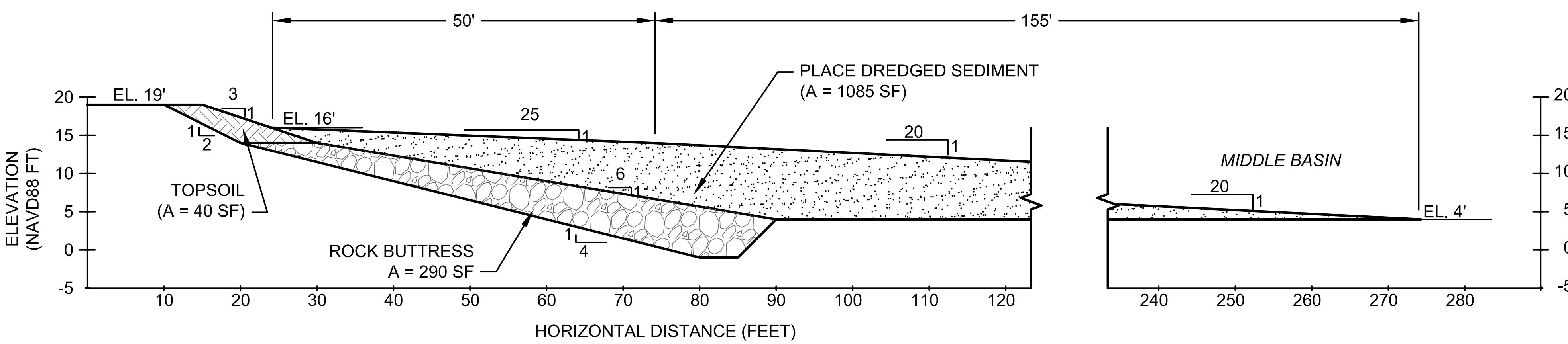
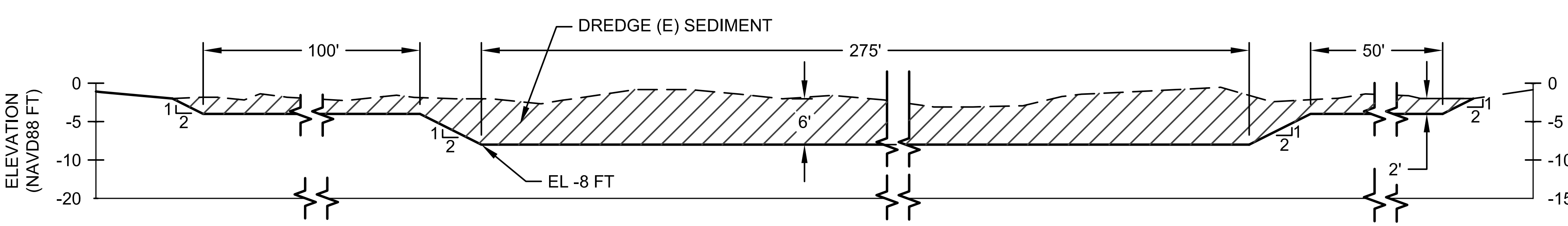
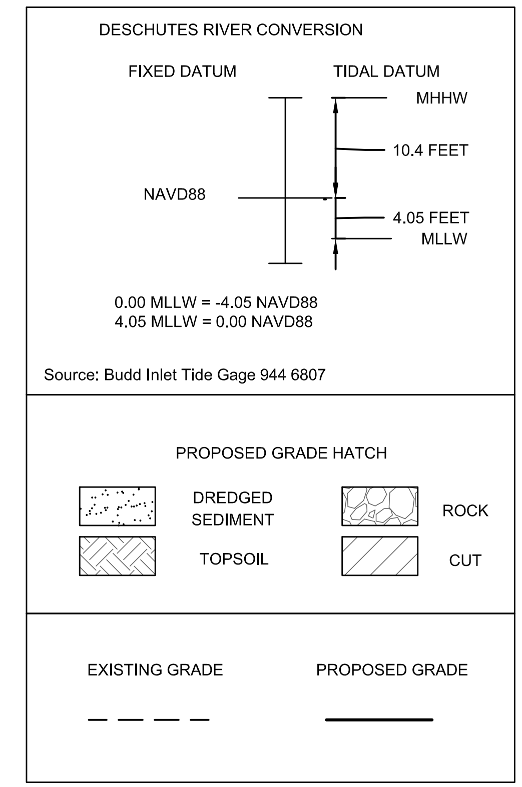


D MIDDLE BASIN - SOUTHERN TYPICAL SECTION



E MIDDLE BASIN CHANNEL - DREDGING - TYPICAL SECTION

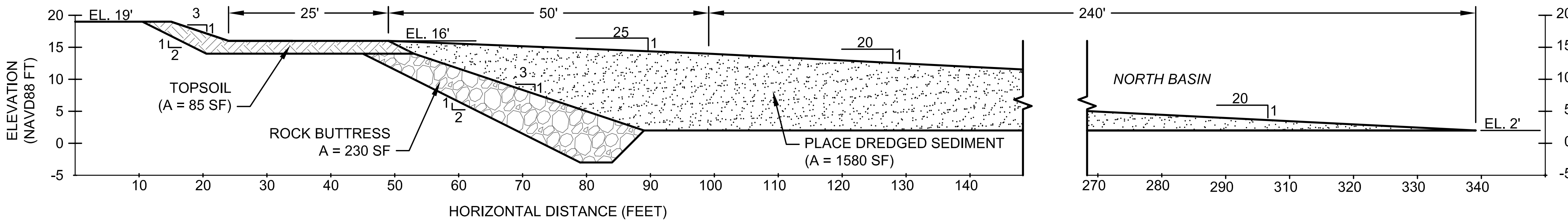


PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: ESA PWA
Date: 3/2011

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Section
SITE NAME: **Budd Inlet**
ACTION NAME: **Deschutes River Estuary Restoration**
PSNERP ID#: **1003**
Full Restoration



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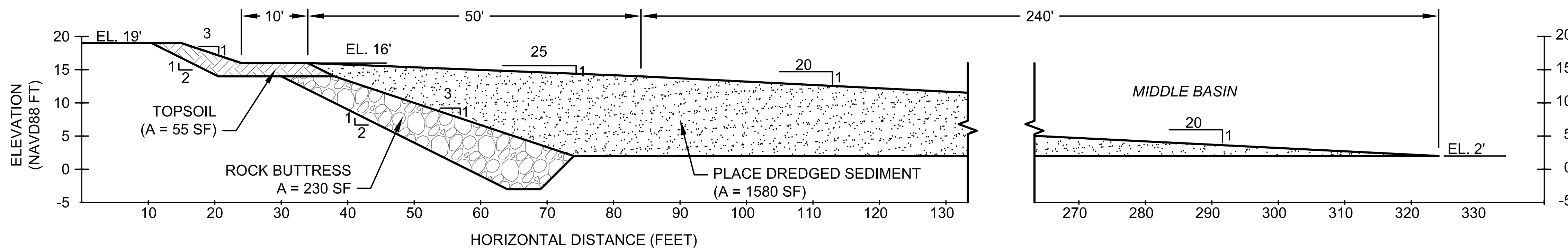

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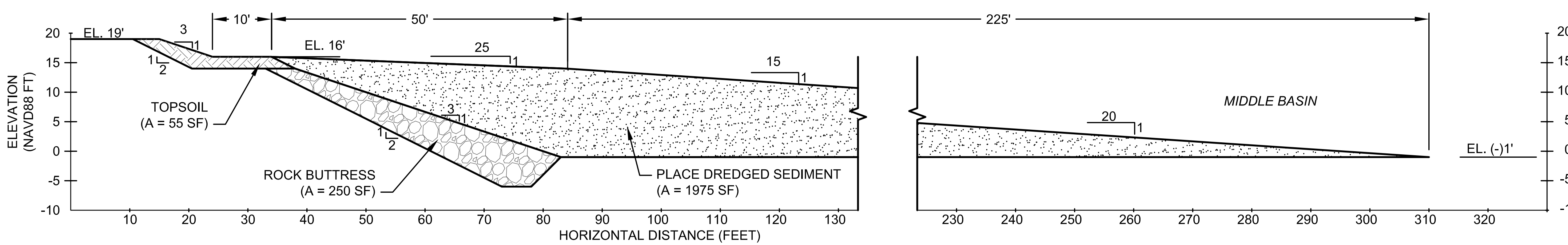
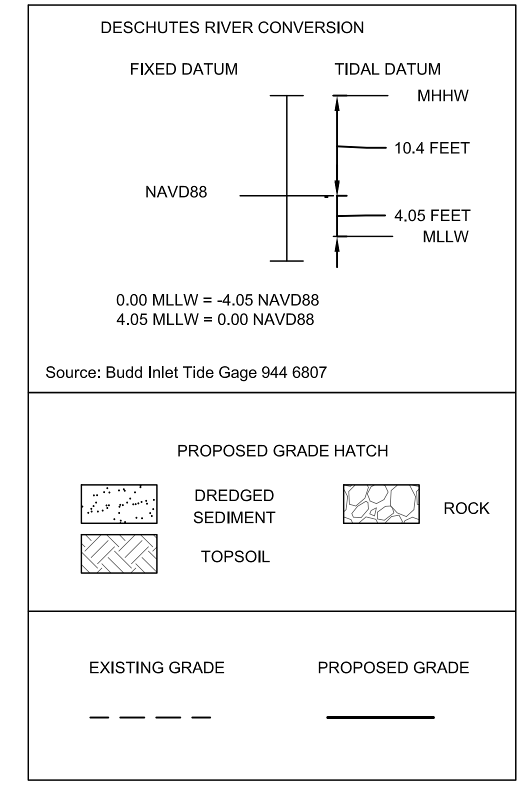
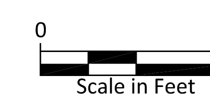


(C) MIDDLE BASIN - CENTRAL TYPICAL SECTION





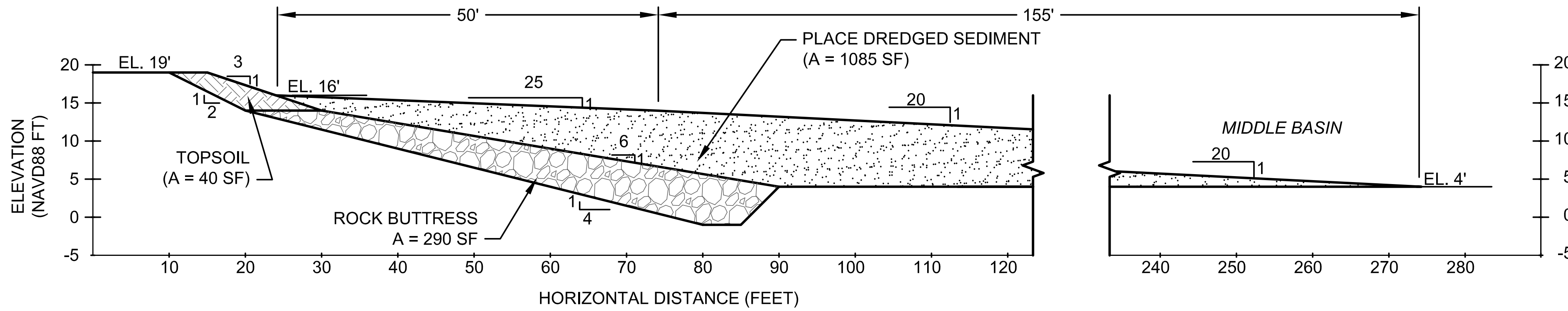
PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: ESA PWA
Date: 03/2011

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Section
SITE NAME: **Budd Inlet**
ACTION NAME: **Deschutes River Estuary Restoration**
PSNERP ID#: **1003**
Partial Restoration

Figure 8-7



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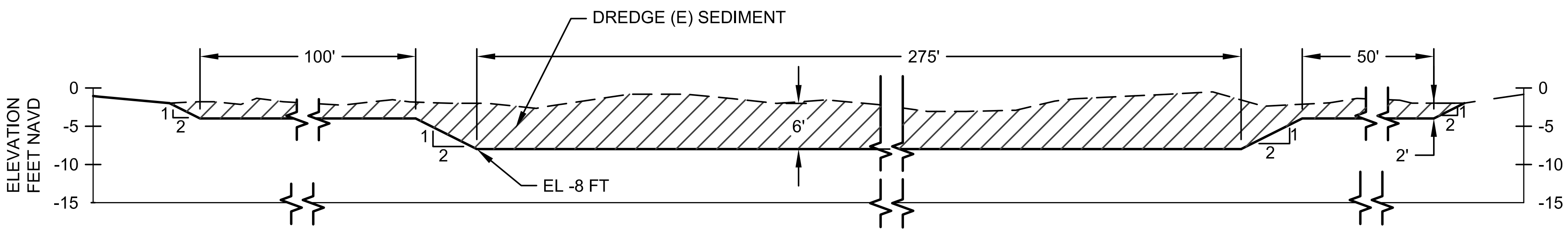
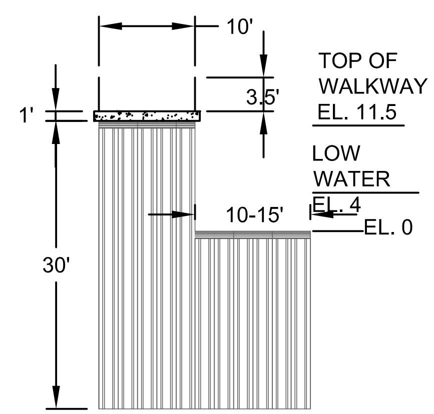
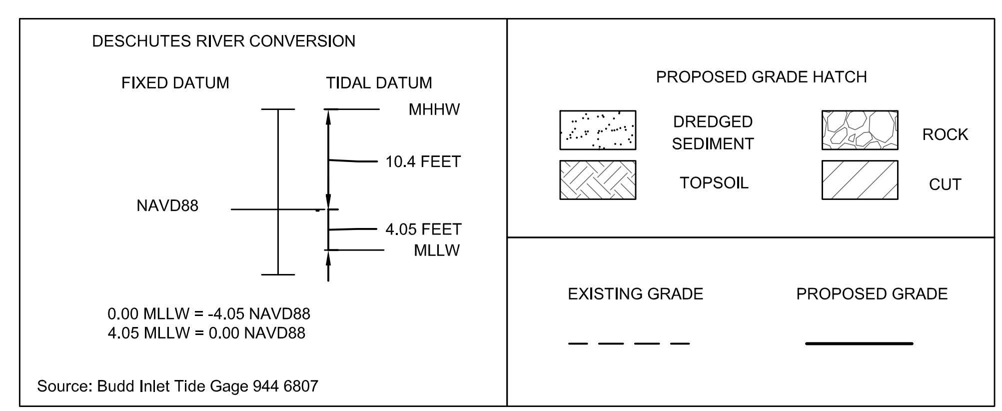
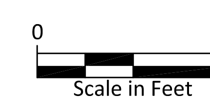


E MIDDLE BASIN CHANNEL - TYPICAL SECTION



F REFLECTING POOL BARRIER SECTION





PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: ESA PWA
Date: 03/2011

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Section
SITE NAME: **Budd Inlet**
ACTION NAME: **Deschutes River Estuary Restoration**
PSNERP ID#: **1003**
Partial Restoration

Figure 8-8

Full Restoration Quantity Estimate

Action Name: Deschutes River Estuary Restoration
Action #: 1033
Date: February 2011
By: ESA PWA with KPFF

REMEDY: ***restore tidal dynamics to Deschutes Estuary by removal of the 5th Avenue dam***
Construction Period: 12 months

	Item	Unit of Measure	Material Name	Qty	Description of Item << provide detailed exlanation specific to this action; indicate section of design report where item is described>>		Indicate section of design report where item is described
ACQUISITION AND CONSERVATION					Based on available mapping information		
	Required Project Lands	Acre		346	Total land required For action		
	Proponent / Partner-owned lands	Acre		346	Etimate of lands currently owned by Proponent (i.e., Public lands)		
	Lands To Be Acquired	Acre		0	Estimate land required to be acquired for action prior to implementation		
Material Sites					Not Used: See Earthwork - Imported Fill.		
MOBILIZATION AND ACCESS for construction activities					Description required for each item to facilitate cost estimating		
	Mobilization - Typical (Equipment, Personnel, Planning, Financial)	LS		0	Up front costs such as bonding, planning and other staff time and financing. Typically, assume 8% to 10% of other items.		
	Mobilization - Remote (Equipment, Personnel, Planning, Financial)	LS		0	Up front cost for nontypical or remote locations. Assume 12% of other items		
	Site Access	LS		0	Use for special situations (e.g.. new bridge, new access roads) for the purposes of construction access. Include description.		
	Barge Access	Days		0	Access may be required for offsite transport of dredged sediment to Commencement Bay 200,000 + CY		
	Temporary Traffic Control (one of the following)						
	none	LS		0	Not Applicable to Action		
	signs	LS		1	Typical Construction Signage		
	flags / spotters	LS		1	Flags and spotters only during roadway transition connection		
	unique	LS		0	Not Applicable to Action		
	Temporary Roadway	SF		0	Not Applicable to Action		
	Control of Water	LS		1	Required for construction of new 5th Ave Dam. Components likely include coffer dam and bypass (96-inch)		8.3.4
Relocation Activities					Not Used: See Utilities, Structures		
Site Demolition Activities					Demolition and removal of structures (description required), temporary features and relocations, itemized separately); Clearing and grubbing of vegetation, and removal of minor debris (rocks, slabs) - description required.		
	Clearing and Grubbing (one or more of following)						
	Clear Vegetation - Local Disposal	AC		0	Not Applicable to Action		
	Clear /Grub Vegetation - Local Disposal	AC		0	Not Applicable to Action		
	Clear /Grub Vegetation - Offsite Disposal	AC		0	Not Applicable to Action		
	Clear, stockpile - large woody debris	CY		0	Not Applicable to Action		
	Hydraulic Structures - Culverts	LS		0	Not Applicable to Action		
	Hydraulic Structures - Large	LS		1	Dam removal - Remove earthen & concrete dam 5m deep x 25m wide		8.3.2
	Utilities	LF		1700	Reroute 1700' of sewer, water lines and 2 gas lines at 4th/5th Ave corridor		
	Buildings	LS or SF		0	Not Applicable to Action		
	Pavement	SF		95682	Removal of 74' Roadway (including sidewalks and shoulder) and Deschutes Pkwy		8.3.2
	Bulkheads	LF or SF		0	Not Applicable to Action		
	Demolition/Removal - Armor on Railroad Berm	LF, Ton or CY		0	Not Applicable to Action		
	Demolition / Removal - Railroad Berm	LF, SF or CY		0	Not Applicable to Action		
	Demolition / Removal - Bridge	SF		0	Not Applicable to Action		
	Removal - Misc. (e.g. angular rock from beach)	Ton		0	Not Applicable to Action		
	Demolition / Removal - in-water Piling	Number of Piles		0	Not Applicable to Action		
	Haul - Offsite Disposal of Demolition Debris	Miles		86	Commencement Bay (86 miles round trip)		8.3.3
Hazardous/Contaminated Waste Removal					These items for earthwork of quality not compatible with wetlands, requiring special handling and disposal. Describe basis for classification as contaminated or hazardous. State known or suspected contamination, describe known similar work.		
	Contaminated Earthwork	CY		54,000	Removal of contaminated dredged material. (~11% of total dredged material)		8.3.3
	Hazardous Earthwork	CY		0	Not Applicable to Action		
Construct Temporary Features					Use as needed for unusual temporary features not included elsewhere (see TESC below)		
EARTHWORK					Expand to include equipment, etc. to facilitate cost estimating.		
	Excavation	CY		0	Not Applicable to Action		
	Excavation - Upland	CY		44,000	Upland portion of 5th Ave dam		8.3.2
	Excavation - Lowland	CY		0	Not Applicable to Action		
	Dredging - Bucket - Land	CY		0	Not Applicable to Action		
	Dredging - Bucket - Marine	CY		0	Not Applicable to Action		
	Dredging - Hydraulic	CY		410,000	Middle Basin channel dredging and dredging at North Basin entrance		8.3.2
	Dredging - Hydraulic	CY		77,000	North Basing entrance dredging at dam		8.3.2
	Fine Grading	AC		0	Not Applicable to Action		
	Fill Placement - local borrow				This is additive to Earthwork -Excavation		
	Side cast	CY		0	Not Applicable to Action		
	Haul - uncontrolled placement	CY		383,000	Dredged sediment placement at western shore of North & Middle Basins		8.3.2
	Haul - uncontrolled placement	CY		50,000	Dredged sediment placement at Percival Cove		8.3.2
	Haul - uncontrolled placement	CY		98,000	Off-site disposal of surplus sediment (44,000 CY of upland excavation + 54,000 CY contaminated sediment)		8.3.2, 8.3.3
	Haul, place, compact	CY		0	Not Applicable to Action		
	Stockpile - uncontrolled placement	CY		0	Not Applicable to Action		
	Stockpile - controlled placement	CY		0	Not Applicable to Action		
	Conveyor placement from stockpile land/water	CY		0	Not Applicable to Action		
	Imported Fill						
	Select Fill	CY		0	Not Applicable to Action		
	Gravel Borrow, including haul	CY		0	WSDOT standard item		
	Sand / Gravel for Beach Nourishment	CY		0	special borrow and sorting required; identify material source		
	Cobble for Shore Nourishment	CY		0	special borrow and sorting required; identify material source		
	Embankment Compaction	CY		0	WSDOT standard item		
	Topsoil	CY		16,000	Topsoil placement at western shore of North & Middle Basins		8.3.2
RESTORATION Features							
	Channel Rehab / Creation	SF		0	Not Applicable to Action		
	Large Wood Placement	EA		0	Not Applicable to Action		
	Invasive Species Control	Acre		0	Not Applicable to Action		
	Physical Exclusion Devices	LF or EA		0	Not Applicable to Action		
	Other Restoration Features/ Activities	LS		1	Sediment curtains at Middle and North Basins during dredging and placement		
Structures		EA					
	Water Control Structures - Culverts with Gates	EA		0	Not Applicable to Action		
	Water Control Structures - Weirs	EA		0	Not Applicable to Action		
	Rock Slope Protection	CY		65,500	Rock Buttress (1-2 ft dia rock)		8.3.4
	Rock Slope Protection	LF		1,550	5th Ave, 4th Ave and Railroad bridge - scour protection		8.3.2
	Other - Bulkhead treatment	EA		25,000	Arc of Statehood surface treatment to protect against salt water (25,000 SF)		8.3.4
	Other - Stormwater outfalls	EA		1	Unknown number to be replaced or upgraded at Capitol Lake and Deschutes Parkway.		8.3.4
	Elevated Boat Ramp	SF		0	Not Applicable to Action		
	Fencing	SF		0	Not Applicable to Action		
Utilities							
	Water	LF		800	800' on new 5th ave bridge		n/a
	Gas	LF		1600	2 lines on new 5th ave bridge of 800'		n/a
	Electric	LF		0	Not Applicable to Action		
	Sewer	LF		800	800' on new 5th ave bridge		n/a
	Telecommunications	LF		0	Not Applicable to Action		
	Other	LF		0	Others = whatever is required (e.g.. power towers, petroleum, jet fuel, etc.)		
Roadway / Railway							
	Roadway	SF		53650	Typical Roadway 74' wide, new section per City of Olympia		8.3.1
	Roadway - Switch (potential)	LS		0	Street lights, etc. (Temporary traffic control handled under Temporary Facilities)		
	Culvert (type)	LF		0	Provide specific culver size and type		
	Culvert - Jacking	LF		0	Through railway		
	Culvert - Horizontal Pile Driving	LF		0	Through railway		
	Bridge Deck	SF		33750	Precast Concrete Girder Bridge with 100' spans (450'x75')		8.3.1
	Bridge - Foundation Drilled Shafts	LF		375	(5) 75' CIP Concrete pile caps with (2) 7' drilled shafts 100' embed at each pile cap		8.3.1
	Railway - Shoe fly	LF		0	Temporary alignment		
Permanent Access Features					KPFF expected to participate in these estimates		
	Roads	Level		1%	Level 1 direct access, Level 2 moderately difficult, Level 3 difficult access		
	Utility Access Routes	varies		0	Describe utility access feature, such as boardwalk or all-weather gravel road		
	Erosion Control Features	AC		2.2	Stabilized Construction Entrances, Sediment Ponds, Hydro Seed to Stabilize Roadway Embankments		

Full Restoration Quantity Estimate

Action Name: Deschutes River Estuary Restoration
Action #: 1033
Date: February 2011
By: ESA PWA with KPFF

REMEDY: ***restore tidal dynamics to Deschutes Estuary by removal of the 5th Avenue dam***
Construction Period: 12 months

	Item	Unit of Measure	Material Name	Qty	Description of Item << provide detailed exlanation specific to this action; indicate section of design report where item is described>>		Indicate section of design report where item is described
Public Access or Recreation Features							
	Trails	SF		66,000	New Trails (10 ft width)		8.3.4
	Trails	SF		10,900	Improved trails (10 ft width)		8.3.4
	Bridges	SF		600	2 pedestrian bridges (12 ft by 25 ft)		8.3.5
	Kiosk	EA		0	Not Applicable to Action		
	Restrooms	EA		0	Not Applicable to Action		
	Interpretive Signs	EA		0	Not Applicable to Action		
	Parking Area	SF		0	Not Applicable to Action		
	Other	EA		0	Not Applicable to Action		
Vegetation & Erosion Control							
	Hydroseeding	AC		0	Not Applicable to Action		
	Planting	AC		17.5	Upland and wetland/marsh planting at western shore of North & Middle basins.		8.3.3
	Vegetation Maintenance	AC-YR		0	Not Applicable to Action		
	Erosion / sediment BMPs - Temp.	AC		2.2	BMPs for control of drainage - describe. Assume compliance with Construction General NPDES included		n/a
	Erosion / sediment BMPs - Permanent	AC		0	Not Applicable to Action		
	Waterside controls - Temporary	EA, LF, LS		0	Not Applicable to Action		
Construction Management							
	Construction oversight	weeks		60	Assume 15 months for bridge and road. Quanity based on constructon duration/ # of construction seasons		n/a
	Materials testing				Included in cost of material - no separate quantity		
Design and Detailed Site Investigations							
	Survey & Property, Utility Research	LS		0	% of construction cost		
	35% Design	LS		0	35% x 25% x Engineer's Estimate		
	65% design	LS		0	65% x 25% x Engineer's Estimate less the cost for 35% PS&E		
	90% design	LS		0	35% x 25% x Engineer's Estimate less the cost for 35% + 65%PS&E		
	100% design	LS		0	25% x Engineer's Estimate less previous costs		
	Geotechnical Studies			0	Refer to design report for description of need		
	Cultural Studies			0	Refer to design report for description of need		
	HTWR Studies			0	Refer to design report for description of need		
Project Agreement Activities					Unable to provide credible estimate at 10% design		
Site-Specific Adaptive Management Features & Activities					List if known		
Monitoring Activities					Assume 5 crew-days/year for each monitoring parameter in design report for 5 yrs		
	Monitoring (Type)	crew-days		250			
Operations & Maintenance					Unable to provide credible estimate at 10% design		

Partial Restoration Quantity Estimate

Action Name: Deschutes River Estuary Restoration
Action #: 1033
Date: February 2011
By: ESA PWA with KPFF

REMEDY: restore tidal dynamics to Deschutes Estuary by removal of the 5th Avenue dam
Construction Period: 12 months

	Item	Unit of Measure	Material Name	Qty	Description of Item		Indicate section of design report where item is described
ACQUISITION AND CONSERVATION					Based on available mapping information		
	Required Project Lands	Acre		346	Total land required For action		
	Proponent / Partner-owned lands	Acre		346	Etimate of lands currently owned by Proponent (i.e., Public lands)		
	Lands To Be Acquired	Acre		0	Estimate land required to be acquired for action prior to implementation		
Material Sites					Not Used: See Earthwork - Imported Fill.		
MOBILIZATION AND ACCESS for construction activities					Description required for each item to facilitate cost estimating		
	Mobilization - Typical (Equipment, Personnel, Planning, Financial)	LS		1	Up front costs such as bonding, planning and other staff time and financing. Typically, assume 8% to 10% of other items.		
	Mobilization - Remote (Equipment, Personnel, Planning, Financial)	LS		0			
	Site Access	LS		0			
	Barge Access	Days		0			
	Temporary Traffic Control (one of the following)						
	none	LS		0	Not Applicable to Action		
	signs	LS		1	Typical Construction Signage		
	flags / spotters	LS		1	Flags and spotters only during roadway transition connection		
	unique	LS		0	Not Applicable to Action		
	Temporary Roadway	SF		0	Not Applicable to Action		
	Control of Water	LS		1	Required for construction of new 5th Ave Dam. Components likely include coffer dam and bypass (96-inch)		8.3.4
Relocation Activities					Not Used: See Utilities, Structures		
Site Demolition Activities					Demolition and removal of structures (description required), temporary features and relocations, itemized separately); Clearing and grubbing of vegetation, and removal of minor debris (rocks, slabs) - description required.		
	Clearing and Grubbing (one or more of following)						
	Clear Vegetation - Local Disposal	AC		0	Not Applicable to Action		
	Clear /Grub Vegetation - Local Disposal	AC		0	Not Applicable to Action		
	Clear /Grub Vegetation - Offsite Disposal	AC		0	Not Applicable to Action		
	Clear, stockpile - large woody debris	CY		0	Not Applicable to Action		
	Hydraulic Structures - Culverts	LS		0	Not Applicable to Action		
	Hydraulic Structures - Large	LS		1	Dam removal - Remove earthen & concrete dam 5m deep x 25m wide		8.3.2
	Utilities	LF		1700	Reroute 1700' of sewer, water lines and 2 gas lines at 4th/5th Ave corridor		
	Buildings	LS or SF		0	Not Applicable to Action		
	Pavement	SF		95682	Removal of 74' Roadway (including sidewalks and shoulder) and Deschutes Pkwy		8.3.2
	Bulkheads	LF or SF		0	Not Applicable to Action		
	Demolition/Removal - Armor on Railroad Berm	LF, Ton or CY		0	Not Applicable to Action		
	Demolition / Removal - Railroad Berm	LF, SF or CY		0	Not Applicable to Action		
	Demolition / Removal - Bridge	SF		0	Not Applicable to Action		
	Removal - Misc. (e.g. angular rock from beach)	Ton		0	Not Applicable to Action		
	Demolition / Removal - in-water Piling	Number of Piles		0	Not Applicable to Action		
	Haul - Offsite Disposal of Demolition Debris	Miles		86	Commencement Bay (86 miles round trip)		8.3.3
Hazardous/Contaminated Waste Removal					These items for earthwork of quality not compatible with wetlands, requiring special handling and disposal. Describe basis for classification as contaminated or hazardous. State known or suspected contamination, describe known similar work.		
	Contaminated Earthwork	CY		54,000	Removal of contaminated dredged material. (~11% of total dredged material)		8.3.3
	Hazardous Earthwork	CY		0	Not Applicable to Action		
Construct Temporary Features					Use as needed for unusual temporary features not included elsewhere (see TESC below)		
EARTHWORK					Expand to include equipment, etc. to facilitate cost estimating.		
	Excavation	CY		0	Not Applicable to Action		
	Excavation - Upland	CY		44,000	Upland portion of 5th Ave dam		8.3.2
	Excavation - Lowland	CY		0	Not Applicable to Action		
	Dredging - Bucket - Land	CY		0	Not Applicable to Action		
	Dredging - Bucket - Marine	CY		0	Not Applicable to Action		
	Dredging - Hydraulic	CY		410,000	Middle Basin channel dredging and dredging at North Basin entrance		8.3.2
	Dredging - Hydraulic	CY		77,000	North Basing entrance dredging at dam		8.3.2
	Fine Grading	AC		0	Not Applicable to Action		
	Fill Placement - local borrow				This is additive to Earthwork -Excavation		
	Side cast	CY		0	Not Applicable to Action		
	Haul - uncontrolled placement	CY		383,000	Dredged sediment placement at western shore of North & Middle Basins		8.3.2
	Haul - uncontrolled placement	CY		50,000	Dredged sediment placement at Percival Cove		8.3.2
	Haul - uncontrolled placement	CY		98,000	Off-site disposal of surplus sediment (44,000 CY of upland excavation + 54,000 CY contaminated sediment)		8.3.2, 8.3.3
	Haul, place, compact	CY		0	Not Applicable to Action		
	Stockpile - uncontrolled placement	CY		0	Not Applicable to Action		
	Stockpile - controlled placement	CY		0	Not Applicable to Action		
	Conveyor placement from stockpile land/water	CY		0	Not Applicable to Action		
	Imported Fill						
	Select Fill	CY		0	Not Applicable to Action		
	Gravel Borrow, including haul	CY		0	WSDOT standard item		
	Sand / Gravel for Beach Nourishment	CY		0	special borrow and sorting required; identify material source		
	Cobble for Shore Nourishment	CY		0	special borrow and sorting required; identify material source		
	Embankment Compaction	CY		0	WSDOT standard item		
	Topsoil	CY		16,000	Topsoil placement at western shore of North & Middle Basins		8.3.2
RESTORATION Features							
	Channel Rehab / Creation	SF		0	Not Applicable to Action		
	Large Wood Placement	EA		0	Not Applicable to Action		
	Invasive Species Control	Acre		0	Not Applicable to Action		
	Physical Exclusion Devices	LF or EA		0	Not Applicable to Action		
	Other Restoration Features/ Activities	LS		1	Sediment curtains at Middle and North Basins during dredging and placement		
Structures		EA					
	Water Control Structures - Culverts with Gates	EA		0	Not Applicable to Action		
	Water Control Structures - Weirs	EA		0	Not Applicable to Action		
	Rock Slope Protection	CY		65,500	Rock Buttress (1-2 ft dia rock)		8.3.4
	Rock Slope Protection	LF		1,550	5th Ave, 4th Ave and Railroad bridge - scour protection		8.3.2
	Other - Bulkhead treatment	EA		25,000	Arc of Statehood surface treatment to protect against salt water		8.3.4
	Other - Stormwater outfalls	EA		1	Unknown number to be replaced or upgraded at Capitol Lake and Deschutes Parkway.		8.3.4
	Other - Tidal barrier in North Basin	SF		300,000	Sheet pile barrier to create pool adjacent to Arc of the Statehood		8.3.1
	Other - Tide gates	LS		8	Culverts for maintaining constant water level in reflecting pool		8.3.2
	Elevated Boat Ramp	SF		0	Not Applicable to Action		
	Fencing	SF		0	Not Applicable to Action		
Utilities							
	Water	LF		800	800' on new 5th ave bridge		n/a
	Gas	LF		1600	2 lines on new 5th ave bridge of 800'		n/a
	Electric	LF		0	Not Applicable to Action		
	Sewer	LF		800	800' on new 5th ave bridge		n/a
	Telecommunications	LF		0	Not Applicable to Action		
	Other	LF		0	Others = whatever is required (e.g.. power towers, petroleum, jet fuel, etc.)		
Roadway / Railway							
	Roadway	SF		53650	Typical Roadway 74' wide, new section per City of Olympia		8.3.1
	Roadway - Switch (potential)	LS		0	Street lights, etc. (Temporary traffic control handled under Temporary Facilities)		
	Culvert (type)	LF		0	Provide specific culver size and type		
	Culvert - Jacking	LF		0	Through railway		
	Culvert - Horizontal Pile Driving	LF		0	Through railway		
	Bridge Deck	SF		33750	Precast Concrete Girder Bridge with 100' spans (450'x75')		8.3.1
	Bridge - Foundation Drilled Shafts	LF		375	(5) 75' CIP Concrete pile caps with (2) 7' drilled shafts 100' embed at each pile cap		8.3.1
	Railway - Shoe fly	LF		0	Temporary alignment		
Permanent Access Features					KPFF expected to participate in these estimates		
	Roads	Level		1%	Level 1 direct access, Level 2 moderately difficult, Level 3 difficult access		
	Utility Access Routes	varies		0	Describe utility access feature, such as boardwalk or all-weather gravel road		
	Erosion Control Features	AC		2.2	Stabilized Construction Entrances, Sediment Ponds, Hydro Seed to Stabilize Roadway Embankments		

Partial Restoration Quantity Estimate

Action Name:	Deschutes River Estuary Restoration
Action #:	1033
Date:	February 2011
By:	ESA PWA with KPFF

REMEDY: restore tidal dynamics to Deschutes Estuary by removal of the 5th Avenue dam
Construction Period: 12 months

	Item	Unit of Measure	Material Name	Qty	Description of Item		Indicate section of design report where item is described
Public Access or Recreation Features							
	Trails	SF		66,000	New Trails (10 ft width)		8.3.4
	Trails	SF		10,900	Improved trails (10 ft width)		8.3.4
	Bridges	SF		600	2 pedestrian bridges (12 ft by 25 ft)		8.3.5
	Kiosk	EA		0	Not Applicable to Action		
	Restrooms	EA		0	Not Applicable to Action		
	Interpretive Signs	EA		0	Not Applicable to Action		
	Parking Area	SF		0	Not Applicable to Action		
	Other	EA		0	Not Applicable to Action		
Vegetation & Erosion Control							
	Hydroseeding	AC		0	Not Applicable to Action		
	Planting	AC		17.5	Upland and wetland/marsh planting at western shore of North & Middle basins.		8.3.3
	Vegetation Maintenance	AC-YR		0	Not Applicable to Action		
	Erosion / sediment BMPs - Temp.	AC		2.2	BMPs for control of drainage - describe. Assume compliance with Construction General NPDES included		n/a
	Erosion / sediment BMPs - Permanent	AC		0	Not Applicable to Action		
	Waterside controls - Temporary	EA, LF, LS		0	Not Applicable to Action		
Construction Management							
	Construction oversight	weeks		60	Assume 15 months for bridge and road. Quanity based on constructon duration/ # of construction seasons		n/a
	Materials testing				Included in cost of material - no separate quantity		
Design and Detailed Site Investigations							
	Survey & Property, Utility Research	LS		0	% of construction cost		
	35% Design	LS		0	35% x 25% x Engineer's Estimate		
	65% design	LS		0	65% x 25% x Engineer's Estimate less the cost for 35% PS&E		
	90% design	LS		0	35% x 25% x Engineer's Estimate less the cost for 35% + 65%PS&E		
	100% design	LS		0	25% x Engineer's Estimate less previous costs		
	Geotechnical Studies			0	Refer to design report for description of need		
	Cultural Studies			0	Refer to design report for description of need		
	HTWR Studies			0	Refer to design report for description of need		
Project Agreement Activities					Unable to provide credible estimate at 10% design		
Site-Specific Adaptive Management Features & Activities					List if known		
Monitoring Activities					Assume 5 crew-days/year for each monitoring parameter in design report for 5 yrs		
	Monitoring (Type)	crew-days		250			
Operations & Maintenance					Unable to provide credible estimate at 10% design		

9. DUCKABUSH CAUSEWAY REPLACEMENT AND ESTUARY RESTORATION (#1012)

Local Proponent	Hood Canal Coordinating Council
Delta Process Unit	DUC
Shoreline Process Unit(s)	2047
Strategy(ies)	1 – River Delta
Restoration Objectives	Restore processes by removing obstructions formed by roadways, reactivating distributary channels, and reconnecting distributary channels to the delta wetland

9.1 Description of the Action

The action would restore the natural geomorphology to the Duckabush River delta wetlands by removing major roadway obstructions, excavating channels, and removing fill. The action would realign Highway 101 across the estuarine delta to restore tidal connection to the estuary. A surface street crossing (Shorewood Road) and adjacent fill at a distributary channel (Pierce Slough) would also be removed. Multiple tidally influenced distributary river channels would be reestablished, and blind tidal channels would be excavated within the marsh areas. Please see the Introduction chapter for important information regarding PSNERP and for context related to this restoration project.

9.2 Action Area Description and Context

The Duckabush River is one of several major river systems in the Hood Canal Subbasin draining the east slope of the Olympic Mountains to Hood Canal. The broad river delta fans out into the canal on the south side of Black Point Peninsula. The Highway 101 causeway crosses the delta, spanning the main channel and a northern distributary channel via bridges. The area south of the river delta is primarily a basaltic shoreline with a few pocket beaches. The river and the feeder bluff on the side of Black Point Peninsula provide abundant sediment for the drift cell that begins at the central portion of the delta and continues north to the cuspate spit at Quatsop Point. Residential development is concentrated just south of the delta and on the north and east sides of Black Point. The action area is shown in Figure 9-1.

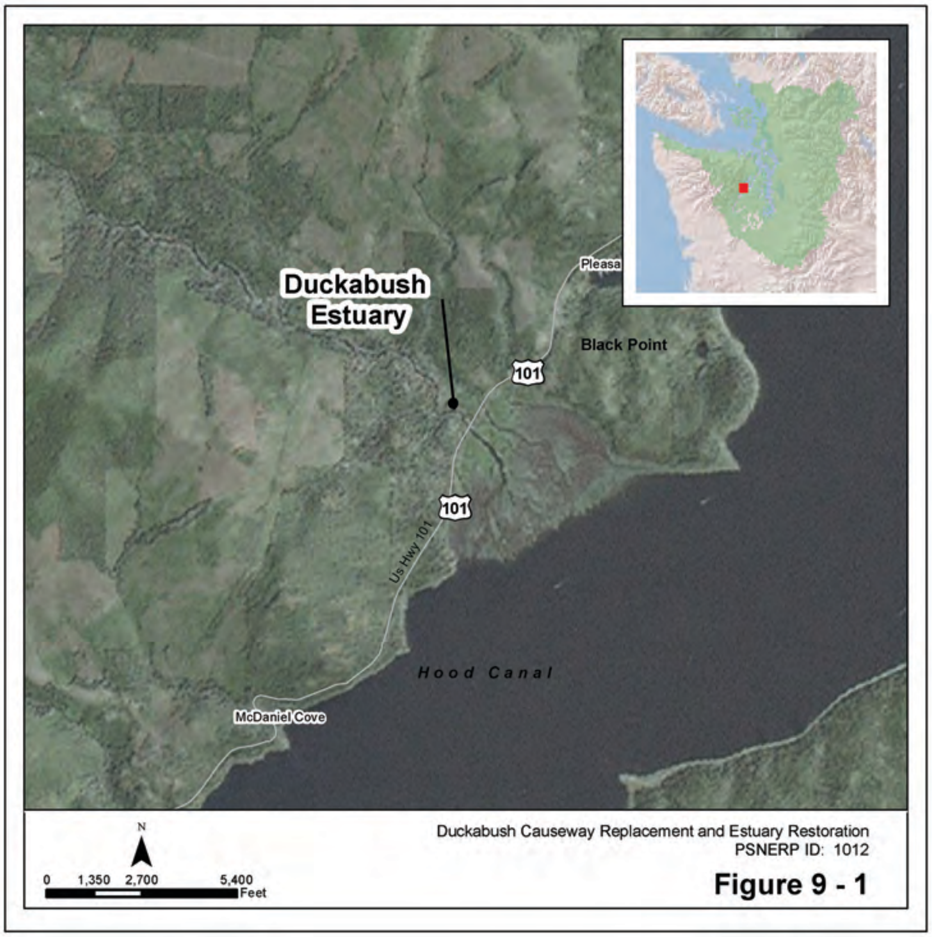


Figure 9-1. Action Area and Vicinity

9.2.1 Historic Condition

The 1883 topographic sheet (T-sheet) shows two distributary channels at the outlet of the Duckabush River (Figures 9-2A and 9-2B). The banks of the river transition from mixed forest and grassland upstream, to salt marsh and submerged marsh at the mouth of the estuary. Some settlement had occurred at the time of the survey, with an orchard visible on the north side of the northern channel and a crossing on the mainstem of the river upstream of the distributary channels. A developed tidal channel network was present in the outboard marsh between the two main channels and north of the northern channel. A single road is shown to access the settlement from the north at the northern edge of the marsh, cross a tidal slough (Pierce Slough), and then cross the mainstem of the river upriver from the more recent alignments (existing and previous crossings are farther east).

9.2.2 Natural Environment

The Duckabush Estuary is home to trumpeter swans, bald eagles, and regionally significant winter waterfowl. Harbor seals haul out here throughout the year and pupping occurs in the winter. The extensive mud and gravel flats are productive shellfish beds. Salt marshes and eelgrass beds characterize the upper and lower intertidal and subtidal areas, respectively. Herring use this eelgrass for spawning. Just to the east of the delta there is abundant riparian vegetation. At the drift cell terminus at Quatsop Point, an exemplary cuspate spit forms, enclosing a high salt marsh.

The Duckabush River opens to a wide valley within the action area. The river is contained within a single channel through the site before emptying into the marsh and submerged marsh outboard of the site. The historic northern arm of the river has been blocked, is aggraded, and is a dead-end channel in the middle portion of the site. Both channels are tidally influenced and pass under bridge crossings. Training berms are in place at the southern arm, just upstream of the Highway 101 crossing, to control lateral movement of the channel. The northern channel branches to form smaller dead-end channels upstream of Highway 101, and receives freshwater flow from a connection to the small tributary that crosses Shorewood Road.

Pierce Slough, located at the northwest corner of the site, is partially disconnected from tidal flows by the culverted Highway 101 crossing. A remnant tidal channel network exists outboard of the highway between the north and south channels. The northern tidal channel network appears to have aggraded over time, though it is partially present today.

9.2.3 Human Environment

The Duckabush River Estuary was bisected by a historic roadway and bridge that spanned the two distributary channels. A portion of the roadway, dikes, and abutments remain in place today. The majority of this infrastructure was removed and replaced in 1934 with two separate bridges as part of the construction of Highway 101.

The Olympic Canal Tract private residential area is accessed from Highway 101 at the north of the area, near Pierce Slough, along Duckabush Road and Shorewood Road. A small culvert under Shorewood Road allows flow from a small tributary to reach the estuary. The Olympic Canal Tract is the only dense residential development in the basin, with several hundred small lots on approximately 300 acres located immediately upstream from Highway 101 on both sides of the river (HDR 2009).

The Duckabush Fire Station is located at Shorewood Road on fill placed within the estuary. An overhead power line travels parallel to Highway 101 and provides power to the Olympic Canal Tract via a westerly overhead line across the estuary. More detailed information on existing utilities and the need for utility relocations will be required to support subsequent design phases. The entire valley floor at the action area is prone to flooding during large runoff events and high tides.

9.3 Restoration Design Concept

9.3.1 Restoration Overview and Key Design Assumptions

Highway 101 cuts across the intertidal river delta and estuary wetland complex, severely affecting water flow, sediment transport, and morphology. Removal or reduction of this stressor would restore and improve physical and ecologic processes. The restoration alternatives are illustrated in Figures 9-3 through 9-6.

Reconnection of the north distributary channel (reported previously as the mainstem) would improve estuary processes by restoring delivery of fresh water and fluvial sediment. Removal/bridging of existing surface streets (Duckabush River Road, Shorewood Road) would reconnect freshwater and tidal flows to remnant distributary, tidally influenced channels and tributary wetlands. Removal of training berms along the active river channel would reconnect the river to its intertidal floodplain and wetlands, restoring floodplain and estuary wetland processes, and increasing channel density. Removing these multiple stressors would restore dynamics and promote greater diversity of delta wetland habitats. The new bridge crossings and channel dimensions were determined using the methods of the *Applied Geomorphology Guidelines and Hierarchy of Openings* (Appendix C).

Roadways, Bridges and Utilities

The full restoration alternative includes the removal of approximately 3,300 LF of Highway 101 embankment including two existing bridges (Figure 9-3). The highway would be replaced with an elevated structure, with new roadway approaches at either end of the bridge. Duckabush Road would be realigned both horizontally and vertically to connect to the new highway bridge. Duckabush Road would be placed on piles to allow restoration of Pierce Slough and connection with the marsh to the northwest. The overhead power lines that currently run parallel to the existing roadway would be relocated to the new structure.

The partial restoration alternative (Figure 9-4) includes removal of approximately 3,300 LF of Highway 101 including two existing bridges. The highway would be replaced with an elevated structure, with new roadway approaches at either end of the bridge (Figure 9-6). Duckabush Road would be realigned both horizontally and vertically to connect to the new highway bridge. A 100-foot-long bridge would be constructed at Duckabush Road to allow tidal exchange with the marsh to the northwest. The overhead power lines that currently run parallel to the existing roadway would be relocated to the new structure.

New roadway embankments would be required at the north and south approaches to the new Highway 101 bridges. The precise dimensions of the roadway would require more detailed design. We assumed approaches of 600 feet, ramping up to a height of 6 feet above existing roadway at the bridge abutments. A 30-foot top width and 2:1 side slopes were used.

The partial restoration alternative has a greater length of road on fill, and includes a 14-foot-high (above the marsh plain) embankment on the north approach, near Duckabush Road. The total fill volumes are 6,100 CY for the full restoration alternative and 16,000 CY for the partial restoration alternative.

The 150-foot section of Shorewood Road and existing culvert would be removed to make room for a restored (widened) distributary channel (Pierce Slough). The design assumes that vehicular access to private property can be gained from either end of Shorewood Road. For the partial restoration alternative, a new 70-foot-long bridge would be constructed.

Distributary Channels

Distributary channels would be excavated at or near their historic configurations. Large and small distributary channels would be excavated to thalweg elevations of 2.6 feet to 6.6 feet MLLW(0 feet and 4 feet NAVD88), respectively, and top widths of 50 feet (Figure 9-5). These channels were sized based on historic data, primarily the drawings for the existing Highway 101 (Washington State 1933), and interpretation that the datum was close to MSL, which is about 6.8 feet MLLW (4.1 feet NAVD88). Historic maps, LiDAR, and aerial photographs were used to locate the excavations.

Two large distributary channels would be created, connecting to the existing Duckabush River mainstem on the north side, and ending at the remnant channel in the middle of the delta (Figures 9-3 and 9-4). Four small distributary channels would be excavated, and two existing channel connections expanded farther toward Hood Canal. One of the new small distributary channels would reestablish Pierce Slough at or near its historic alignment.

Intertidal Marsh – Fill Removal and Channels

The road embankment would be excavated and removed to match the adjacent grade on the downstream side, which is at elevation 11.6 to 12.6 feet MLLW (9 to 10 feet NAVD88). Six areas of about 2 to 6 acres each would have channels excavated to establish natural intertidal marsh morphology (Figures 9-3 and 9-4). The channel cross sections have been sized using the *Applied Geomorphology Guidelines* (Appendix C). The channels include first-, second-, and third-order (largest) cross sections, connected to the distributary channels (Figure 9-5). The fire station, pavement, and fill near Shorewood Road would be removed and revegetated with native riparian species.

Table 9-1 summarizes key design elements associated with the full and partial restoration alternatives.

Table 9-1. Key Design Elements

Element	Full Restoration	Partial Restoration
Roadway Removal	Remove 3,300 LF of Hwy 101 embankment, approximately 300 feet of Duckabush Road, and 150 feet of Shorewood Road and culvert	Same as full restoration
New Roadway	Build 1,500 LF of new highway and 150 feet of Duckabush Road	Build 2,100 feet of new highway, 150 feet of Duckabush Road, and 80 feet of new Shorewood Road
Bridge Removal	Remove two existing Hwy 101 bridges	Same as full restoration
New Bridges	Build one 1,700-foot bridge (14 spans at 121 feet) Build 150-foot bridge approach at Duckabush Road	Build one 1,100-foot bridge (8 spans at 138 feet) Build 100-foot bridge approach at Duckabush Road
Shorewood Road	Remove 150-foot section of Shorewood Road	70-foot bridge at Shorewood Road

Element	Full Restoration	Partial Restoration
Overhead Power	Relocate to new alignment	Relocate to new alignment
Distributary Channels (large)	670 feet of north channel connection to the mainstem of Duckabush River and 460 feet of south channel connection to mainstem	Same as full restoration
Distributary Channels (large)	2,200 feet of Pierce Slough reconstruction on historic alignment; 2,000 feet of other tidal channels	1,900 feet of Pierce Slough reconstruction; 2,000 feet of other tidal channels
Tidal (blind) Channels	Construct 2,400 LF of marsh channels up to second order	Construct 2,400 LF of marsh channels up to second order
Fill Removal	Remove training berms along river (0.7 acre), road embankment and roads (3.5 acres), and developed areas (2.5 acres)	Remove training berms along river (0.7 acre), road embankment and roads (3.3 acres), and developed areas (2.5 acres)

9.3.2 Restoration Features – Primary Process-Based Management Measures

Armor Removal/Modification – NA

Berm or Dike Removal/Modification

Realignment of Highway 101 and use of bridges would substantially reduce the amount of roadway embankment fill (1,950 feet net embankment removal for full restoration and 1,270 feet for partial restoration) (Figures 9-3 and 9-4). The roadway removals would allow natural hydraulic conveyance, sediment transport, transport of nutrients, and dynamic geomorphology.

The existing Highway 101 causeway would be completely removed as part of the full restoration alternative, and mostly removed (all but the northern portion north of intersection with Duckabush Road) with partial restoration. The roadway and embankment would be excavated to the elevation of the existing adjacent marsh plain at the outboard side of the roadway (approximately 11.6 feet MLLW or 9 feet NAVD88) (Figure 9-5). A typical cross section was developed to estimate the volume of fill removal required. Three embankment sections require removal: eastern (400 feet), central (600 feet) (between the bridges), and western (750 feet) for a total removal of 1,750 LF (not including the adjacent roadway sections). The estimated volume of material to be excavated from the Highway 101 causeway is approximately 42,100 CY.

Earth embankment training berms on both sides of the current main channel of the Duckabush River (south channel) direct flow through the southern bridge. This berm would be removed as part of both alternatives in order to allow the channel to migrate freely. Currently there are approximately 620 LF of training berms. A typical cross section of 20-foot top width, crest elevation of 16 feet, and 2:1 side slopes was used to estimate the volume of berm removal. The berms would be lowered to an elevation of approximately 8 feet to match existing grade elevations on the outside of the berms.

Approximately 6,600 CY of fill material would be excavated as part of the training berm removal.

Approximately 150 LF of Shorewood Road would be removed as part of the full restoration alternative. A typical cross section of 25-foot top width, crest elevation of 12 feet, and 2:1 side slopes was used to estimate the volume of berm removal. The berms would be lowered to an elevation of approximately 8 feet to match existing grade elevations on the outside of the berms. Approximately 750 CY of fill material would be excavated as part of the Shorewood Road removal.

Channel Rehabilitation/Creation

The conceptual design includes channel excavation pending further assessment of costs and benefits. Excavating channels provides an opportunity to affect channel planform in terms of density, sinuosity, and bifurcation. Channels also allow rapid establishment of inundation frequency associated with target elevations such as marsh plains. Excavation can also confirm that obstructions to channel formation are removed. The extent of channel excavation affects costs, so the decision to excavate should be weighed against the benefits of allowing "natural" channels to form without excavation. Starter channels are a compromise, where the excavated channel is smaller than the expected channel, allowing scour and complexity to occur.

The full restoration alternative would excavate 1,130 feet of large distributary channels (50-foot top width and 9 to 10 feet deep) and 4,200 feet of small distributary channels (50-foot top width and 5 to 6 feet deep). The partial restoration alternative includes a slightly smaller total length of small distributary channel excavation (3,930 feet).

The large distributary channels to be excavated are located north of the mainstem. They connect with remnant channels cut off by the Highway 101 embankment. One is called North Channel and one is called South Channel. The North Channel was identified by local proponents as a key restoration item. The South Channel was added based on a review of the Highway 101 drawings (Washington State 1933). These channels would restore distribution of sediment and fresh water to the delta, and provide additional intertidal habitat.

The small distributary channels reconnect remnant channels, which were cut off by Highway 101 or filled in by sediment. Pierce Slough would be reconnected from Shorewood Road to the remnant North Channel west of Highway 101. The full restoration alternative would restore the historic alignment north of Duckabush Road. For the partial restoration alternative, the connection would be located farther south due to the bridge location, and a blind channel would be extended north of Duckabush Road into the pocket wetland. These channels would distribute water, sediment, and nutrients and provide typically lower velocity side channel habitat for fish. These channels would facilitate restoration of natural channel mouth morphology and may be captured through mainstem avulsion or meander processes.

Approximately 2,400 feet of new tidal channels would be excavated in wetland basins ranging from 2 to 6 acres and totaling 16 acres. These channels would increase tidal inundation to the delta and enhance marsh vegetation. The channels are expected to enhance the wetland habitat directly by providing low-velocity intertidal areas for fish and foraging areas for birds.

Groin Removal/Modification – NA

Hydraulic Modification – NA

Two existing concrete bridges would be removed: Duckabush Slough bridge (101/265) which is 121 LF, and Duckabush River bridge (101/266) which is 168 LF.

Overwater Structure Removal – NA

Topography Restoration

Approximately 5.1 acres of filled and developed area would be cleared and restored; these areas are expected to revert to forested wetland. Under the full restoration alternative, the upland fill areas at the existing fire station at Shorewood Road, and the parking lot at the west end of the action area, would be lowered by approximately 2 feet. Under the partial restoration alternative, only the parking lot area would be excavated.

9.3.3 Restoration Features – Additional Management Measures

Beach Nourishment – NA

Contaminant Removal/Remediation – NA

Debris Removal – NA

Invasive Species Control – NA

Large Wood Placement

Both alternatives include placement of large wood within the newly constructed and reconnected channels to provide structural integrity and complexity to the channels. It is estimated that six large woody debris structures consisting of three to four logs each would be placed within the action area (Figures 9-3 and 9-4). The large woody debris would be included in both the full and partial restoration alternatives.

Physical Exclusion – NA

Pollution Control – NA

Revegetation

Total planting would cover approximately 3.5 acres. About 2.5 acres of developed areas would be restored, including 2 acres from the parking lot near the south approach to Highway 101, and 0.5 acre at the fire station near Shorewood Road. Also, cut and fill slopes associated with the roadway work would be planted with native grasses (approximately 1 acre). The intertidal marsh would not be planted and is expected to revegetate naturally from seeds and rhizomes.

Reintroduction of Native Animals – NA

Substrate Modification – NA

Species Habitat Enhancement – NA

9.3.4 Restoration Features – Other

NA

9.3.5 Land Requirements

Most of the action area is owned by WDFW, except the land adjacent to the mainstem of the Duckabush River which is owned by the Olympic Canal Maintenance Company, and the fire station property which is owned by Jefferson County (HCCC 2010). Negotiations with private property owners would be required prior to restoration. An additional 0.8 acre of public land would be needed for the project (Jefferson County property that includes the fire station), plus 4.3 acres of private land owned by Olympic Canal Maintenance Company, for a total of 5.1 acres.

Additional right-of-way may need to be acquired along the alignment of the new highway to allow for roadway and bridge construction. The proposed alignment is located north of the current alignment to avoid complete road closures during construction. The proposed alignment is coincident with much of the historic road alignment (pre-1930s).

Overhead power lines and possibly other utilities would be relocated along the new highway alignment.

9.3.6 Design Considerations

Private Property / Residences in Floodplain

Private residences located in the low supratidal areas between the mainstem and Pierce Slough are subject to flooding under existing conditions. Expansion of the Shorewood Road crossing of the remnant Pierce Slough channel should reduce backwater and flood risk under high runoff conditions. However, a study of existing and with-project flood risk should be conducted to document expectations and identify actions to reduce potential damage.

Public Use of Parking Lot

The parking lot would be removed to accommodate the footprint of the new Highway 101 alignment. A small parking lot and access to the delta will be developed and maintained adjacent to the roadway for safe public access to the delta under both alternatives.

Shellfish Beds, Sensitive to River Discharges

There is concern that allowing natural channel avulsion by removing levees and other barriers may allow advection of fresh water toward shellfish beds, which could be detrimental. The design should consider ways to mitigate this risk while not compromising the goal of restoration. As an option, shellfish bed restoration could be employed, although the likelihood of success has not been evaluated.

Historic Bridge

The Duckabush River Bridge 101/266 is on the National Register of Historic Places. The project will be required to comply with Section 106 of the National Historic Preservation Act. Prior to demolition, significant documentation of the existing bridge would be required. Projects that involve historic bridge structures must follow the guidelines set forth in the WSDOT Environmental Procedures Manual M 31-11.09 and other regulatory guidelines.

Channel Excavation

Geotechnical stability of cut slopes should be considered, so that the extent of the effect of excavating large distributary channels is better delineated.

Property Access

A private property is accessed via a driveway that connects to Duckabush Road just west of the Highway 101 intersection. This driveway would be reconfigured to conform to the new intersection layout and higher road grades.

Building Demolition

The full restoration alternative includes the removal of the fire station building and hardened surfaces at Shorewood Road.

Utilities

The overhead power, telephone, and telecommunications lines (approximately 3,200 feet) that currently pass along the existing causeway would be relocated to the new bridge and roadway alignment. Additionally, an overhead electric/phone line approximately 550 feet long runs from Highway 101 near the northern channel to the fire station. This utility line would be removed as part of the full restoration alternative but would remain with the partial restoration alternative.

Roadway Fill

The fill volume for the new roadway embankments is not prismatic; more accurate estimates can be achieved by way of additional cross sections. The northern approach for the partial restoration alternative extends into lowland that may have weak soils, requiring special considerations for slope stability, bearing, and settlement. This would be considered in a future geotechnical analysis.

The design assumes that all roadway material is imported. However, a substantial volume of material would be excavated for the project, and some of this material may be suitable for the new roadway.

9.3.7 Construction Considerations

Distributary Channel Excavation

The distributary channel excavation cross sections have 2:1 slopes (Figure 9-5). This is a steep slope, especially for the two large distributary channels that require excavation to approximately 10 feet below existing grade. We have assumed that a track-mounted crane with a clamshell (or dragline) bucket could accomplish the excavation in the wet, and that slopes would be stable during construction. Further consideration of constructability is recommended, including subsurface exploration of soil properties and a geotechnical report. Also, sloughing of the banks should be expected, and the limits of excavation should be evaluated to prevent impacts on adjacent areas.

From an ecological standpoint, sloughing would provide a diversity of grades, site evolution and habitat, but with some increase in sediment transport and turbidity. Alternatively, wider and flatter cross sections can be excavated, with the assumption that the channels would evolve during high flow events.

Channel Excavation in Delta

Excavation would be required at a few locations that are well within the delta and away from established access roads. Construction of these areas would need to occur before distributary channels are excavated through the delta cone deposits. While marine equipment could be used, the complexity of offloading the excavated sediment and taking it upland would add costs; therefore, the use of marine equipment is not considered practical.

9.4 Extent of Stressor Removal

Table 9-2 describes the amount of stressor removal with full and partial restoration.

Table 9-2. Stressor Removal

Stressor	Full Restoration	Partial Restoration
Tidal Barrier (LF)	1,950	1,270
Fill (area) Channels	5.7 acres	5.2 acres
Fill (area) Training Berms	0.7 acre	0.7 acre
Fill (area) Development	2.5 acres	2.5 acres
Nearshore Roads (LF)	Same as tidal barrier	Same as tidal barrier

9.5 Expected Evolution of the Action Area

The restored area would be unusually dynamic following construction, with distributary channels scouring and filling as flows distribute, constructed banks adjust, and vegetation establishes. A dynamic equilibrium is expected, with landscape changes associated primarily with high fluvial discharge events, but also high coastal storm conditions as well as dry periods. The salinity levels are expected to increase upstream in some areas, but overall salinity would be more dynamic temporally and spatially. A diverse and dynamic array of habitats is expected. There is little difference between the expected evolution of the full and partial restoration alternatives.

Without restoration, the site is expected to experience continued delta cone growth and extension into Hood Canal, and increased sediment deposition upstream of the Highway 101 corridor. Additionally, the historic northern channel will remain disconnected and continue to aggrade. These changes could increase flood risk to private property by causing increased backwater elevations.

9.6 Uncertainties and Risks

Fire Station Relocation Feasibility

The local proponents are negotiating with Jefferson County to allow removal of the fire station on Shorewood Road.

Road Closure Feasibility

The feasibility of removing Shorewood Road has not been investigated other than to confirm that access to properties could be maintained.

Flood Risks

Replacing the culvert at the fire station with a short bridge, and removing the Highway 101 causeway fill, should reduce flooding due to fluvial events while also not increasing tidal flooding. The flood risk with and without the project should be further evaluated and communicated with property owners and local jurisdictions prior to completing design.

Roadway Earthwork

The extent of roadway earthwork is presently uncertain due to the complexity of the fill prism, unknown settlement, and other geotechnical considerations. This risk is primarily for the partial restoration alternative, and it applies to the northern approach embankment near Duckabush Road, where a fill height of 14 feet is estimated.

Utilities

Existing utilities are expected to be encountered due to roadway removal, but the locations are unknown.

9.6.1 Risks Associated with Projected Sea Level Change

Table 9-3 provides a qualitative comparison of sea level change risks associated with this action.

Table 9-3. Risks of Sea Level Change

	Projected Sea Level Change		
	High (46 cm)	**Intermediate (4 cm)**	**Low (-8 cm)**
Full Restoration	The Hwy 101 bridge clearances may be reduced to below standards Habitat mix may change but overall the natural environment should be fairly resilient Nearshore properties would be subject to increased flood and erosion risk	Negligible Impact	Negligible Impact

	Projected Sea Level Change		
	High (46 cm)	Intermediate (4 cm)	Low (-8 cm)
Partial Restoration	The Hwy 101 bridge clearances may be reduced to below standards Habitat mix may change but overall the natural environment should be fairly resilient Nearshore properties would be subject to increased flood and erosion risk	Negligible Impact	Negligible Impact

9.7 Potential Monitoring Opportunities

Monitoring is important for evaluating the success of the restoration. A combination of field surveys and aerial photographs would be used to document biological and physical changes to the landscape. Monitoring data can be used to refine adaptive management and corrective actions, as needed. Some of the key monitoring needs and opportunities associated with this action are summarized in Table 9-4.

Table 9-4. Monitoring Needs and Opportunities

Monitoring Parameter	Key Performance Indicator	Note
Topographic Stability	X	Evaluate excavated channels
Sediment Accretion / Erosion	X	
Wood Accumulation		
Soil / Substrate Conditions		
Vegetation Establishment	X	Monitor restored areas for forested wetland development
Marsh Surface Evolution / Accretion	X	
Tidal Channel Cross-Section / Density	X	Monitor distibutary channel development
Water Quality (Contaminants)		
Salinity		
Shellfish Production	X	Monitor effects on shellfish operations
Extent of Invasive Species		
Animal Species Richness		
Fish (Salmonid) Access/Use		
Forage Fish Production		
Wildlife Species Use		
Effectiveness of Exclusion Devices		

9.8 Information Needed for Subsequent Design

This conceptual design report represents an initial step in the restoration design sequence. The design concepts described above were developed based on readily available information without the level of site-specific survey and investigation that is necessary to support subsequent design and implementation. Substantial additional information will be required at the preliminary and later design stages to confirm the design assumptions, refine quantity estimates, address property and regulatory issues, obtain stakeholder support, and fill in data gaps. The extent to which this information is collected for preliminary design (or a later design stage) will depend upon the available budget, schedule, and other factors. The *Design Considerations* and *Construction Considerations* sections describe some of the information needs for this action. Additional information needs include:

- Property Investigation/Survey – More detailed information on parcel ownership, utilities, and property boundary locations will be needed to finalize the design, confirm acquisition requirements, and support negotiations with property owners.
- Topographic/Bathymetric Survey – The survey data would be used to refine design of key project elements and develop detailed construction and demolition plans. Survey data could also be used as a baseline for pre- and post-construction modeling, including hydrodynamic modeling. A temporary tide gage may be required in the early design stages to obtain site-specific tidal statistics.
- Geotechnical Investigation – Additional geotechnical study will be required to finalize design of bridge, road, and other infrastructure and to determine slope stability issues.
- Cultural Resources Investigation – Surveys for archaeological and historic resources may be required for this action area. Effects of the action on the historic bridge structure will also need to be addressed.
- Hydraulic Analysis/Modeling – Tidal circulation, flood, and hydrodynamic modeling will be required to evaluate impacts to infrastructure and adjacent properties following restoration, to optimize the size of the bridge openings.
- Contaminant Survey – If preliminary investigations suggest that hazardous material could be present in the action area, additional soil and sediment analysis may be needed. The introductory chapter describes the Phase I site investigations that are occurring as part of this overall effort via a separate contract.
- River Morphology Study - A study of river morphology in terms of risk of avulsion through developed areas is recommended. This is a due diligence action in recognition of private property. However, the restoration plans are consistent with historic conditions which did not indicate a channel through the developed areas.

9.9 Quantity Estimates

The quantity spreadsheets for the full and partial restoration alternatives are provided in Exhibits 9-1 and 9-2.

9.10 References

HCCC (Hood Canal Coordinating Council). 2010. Duckabush Estuary Property Ownership. Cartographer: Luke Cherney, June 2010.

WSDOT (Washington State Department of Transportation). 1933. Drawings for SR 101, Duckabush River – North, Jefferson County, Sheet 1, Contract 1763.

0 300
Feet
0 80
Meters

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Historic Map (T-Sheet)
Action Name: Duckabush Causeway Replacement and Estuary Restoration
PSNERP ID #: 1012
Figure 9- 2A

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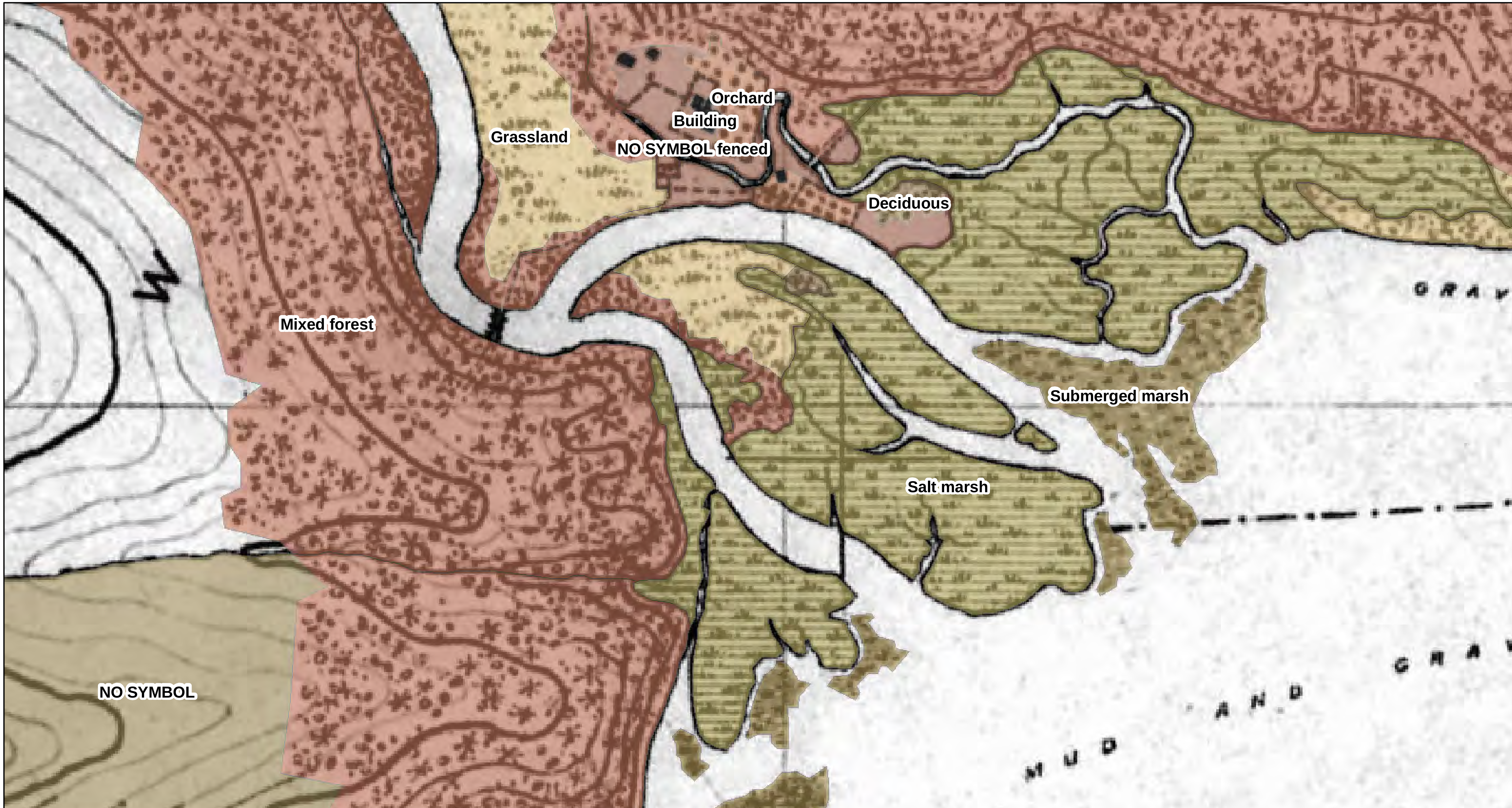
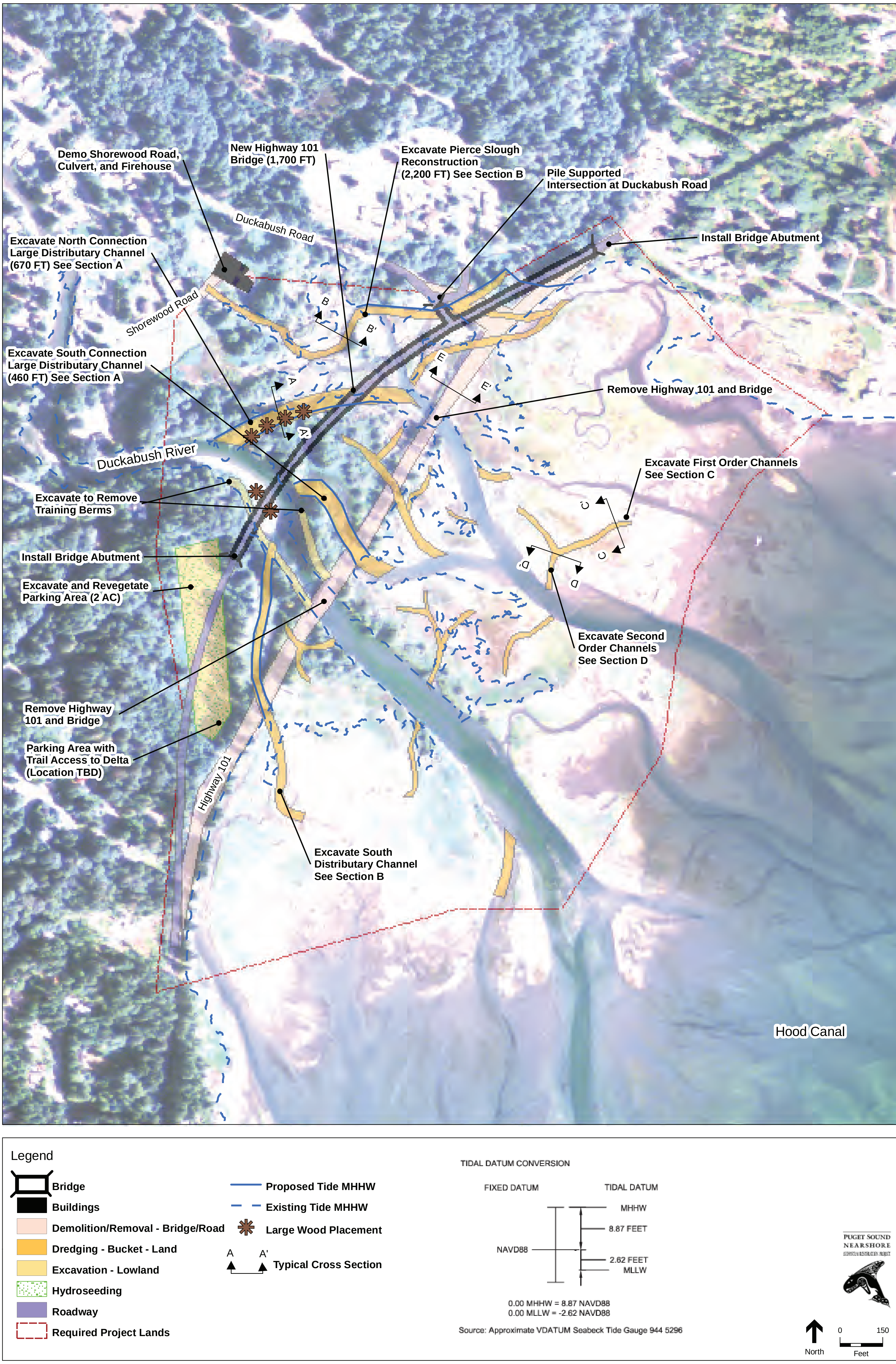


0 300
Feet
0 80
Meters

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Historic Map (T-Sheet) and River History Project Data
Action Name: Duckabush Causeway Replacement and Estuary Restoration
PSNERP ID #: 1012
Figure 9- 2B

S:\GIS\Projects\210xxx\210337_PSNERP_NEARSHORE\Projects\2-TSheets_rev.mxd (DLP; 2/24/2011)



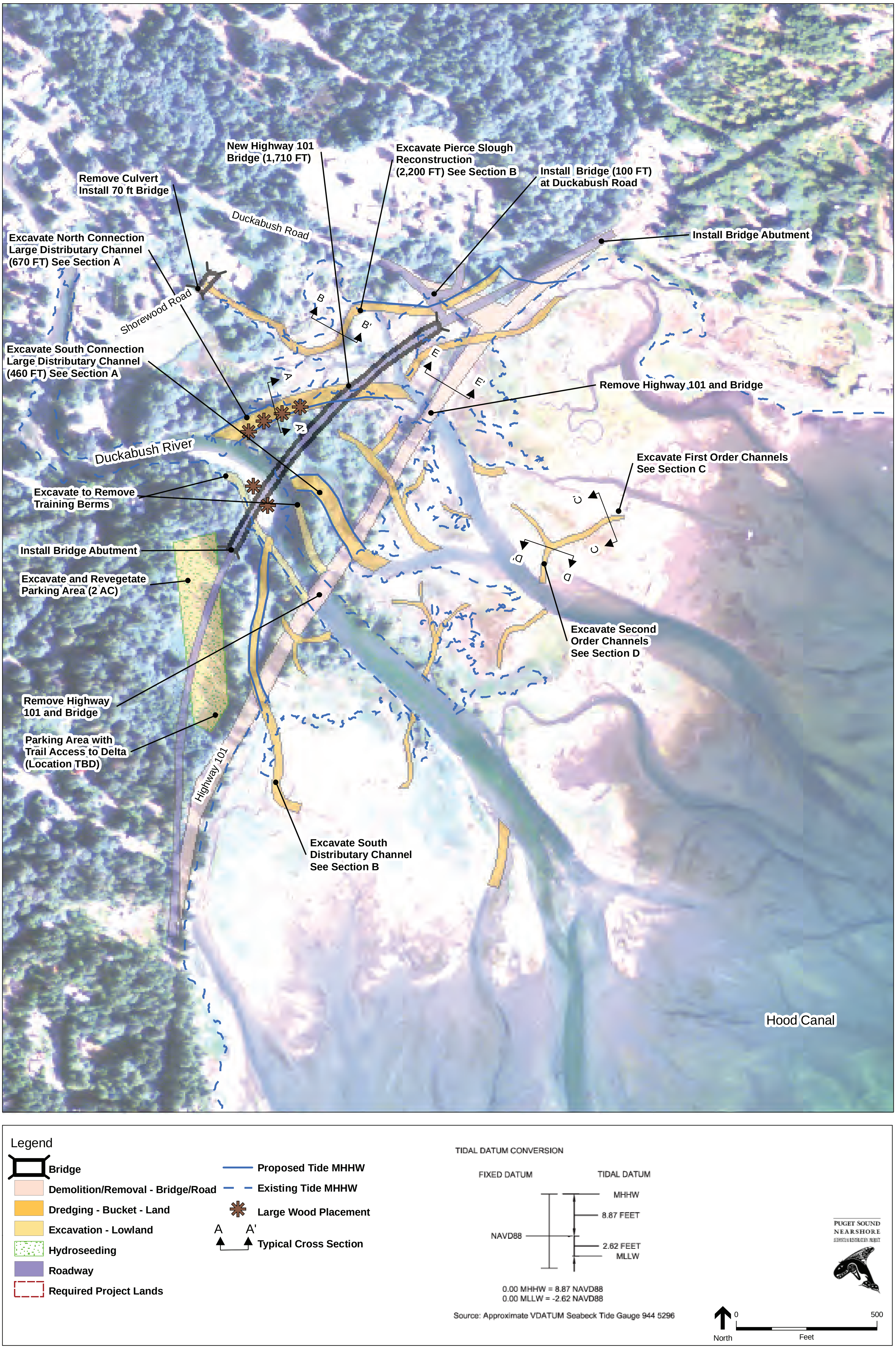
SOURCE: Washington Public Lands Database (2006);
Washington Counties Parcels (2009); Action Area (PSNERP, 2010)

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Lead Contractor: ESA
Design Lead: ESA PWA with KPFF
Date: 2/2011

Conceptual Design Plan
Site Name: Duckabush
Action Name: Duckabush Causeway Replacement & Estuary Restoration
PSNERP ID #:1012
Full Restoration

Figure 9-3



SOURCE: Washington Public Lands Database (2006); Washington Counties Parcels (2009); NAIP (2006)

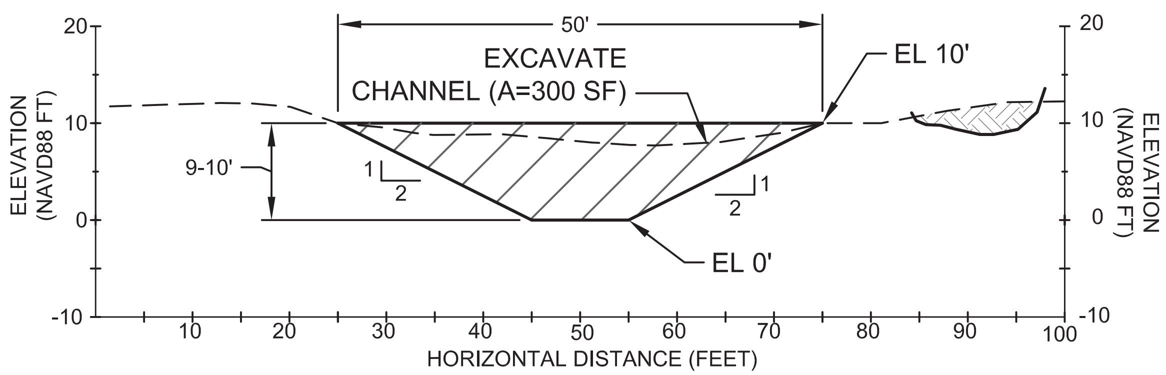
Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64

WDFW Contract # 100-000204 (CAPS No. 10-1461)

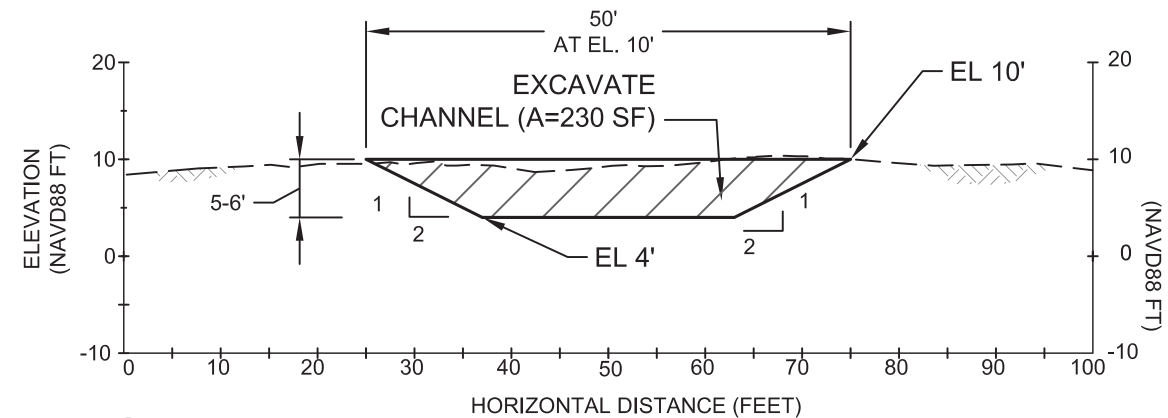
Lead Contractor: ESA
Design Lead: ESA PWA with KPFF
Date: 2/2011

Conceptual Design Plan
Site Name: Duckabush
Action Name: Duckabush Causeway Replacement & Estuary Restoration
PSNERP ID #:1012
Partial Restoration

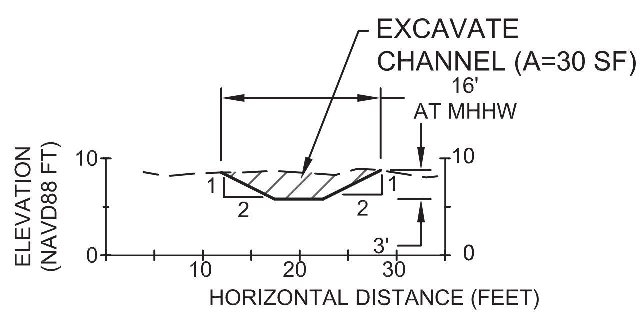
Figure 9-4



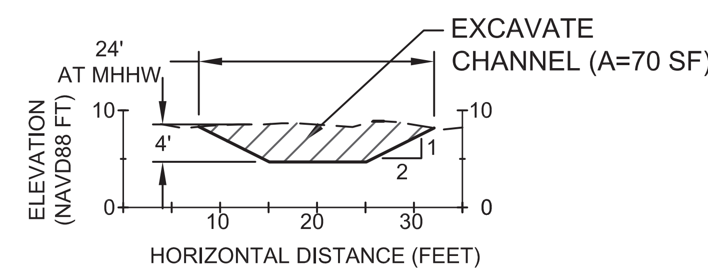
(A) FULL AND PARTIAL RESTORATION
LARGE DISTRIBUTARY CHANNEL - TYPICAL SECTION



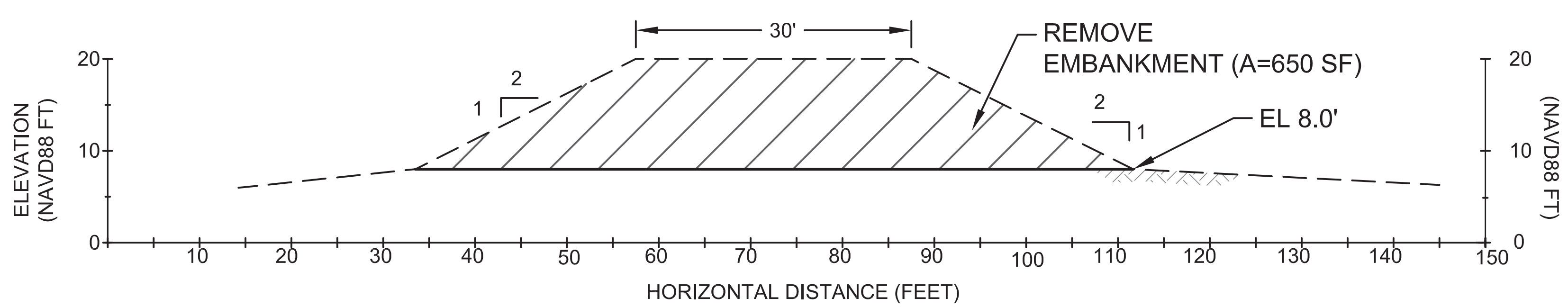
(B) FULL AND PARTIAL RESTORATION
SMALL DISTRIBUTARY CHANNEL - TYPICAL SECTION



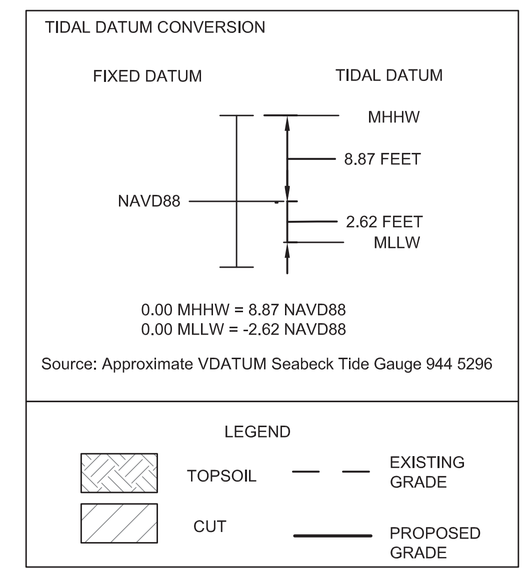
(C) FULL AND PARTIAL RESTORATION
FIRST ORDER CHANNEL - TYPICAL SECTION



(D) FULL AND PARTIAL RESTORATION
SECOND ORDER CHANNEL - TYPICAL SECTION



(E) FULL AND PARTIAL RESTORATION
CAUSEWAY EMBANKMENT - TYPICAL SECTION

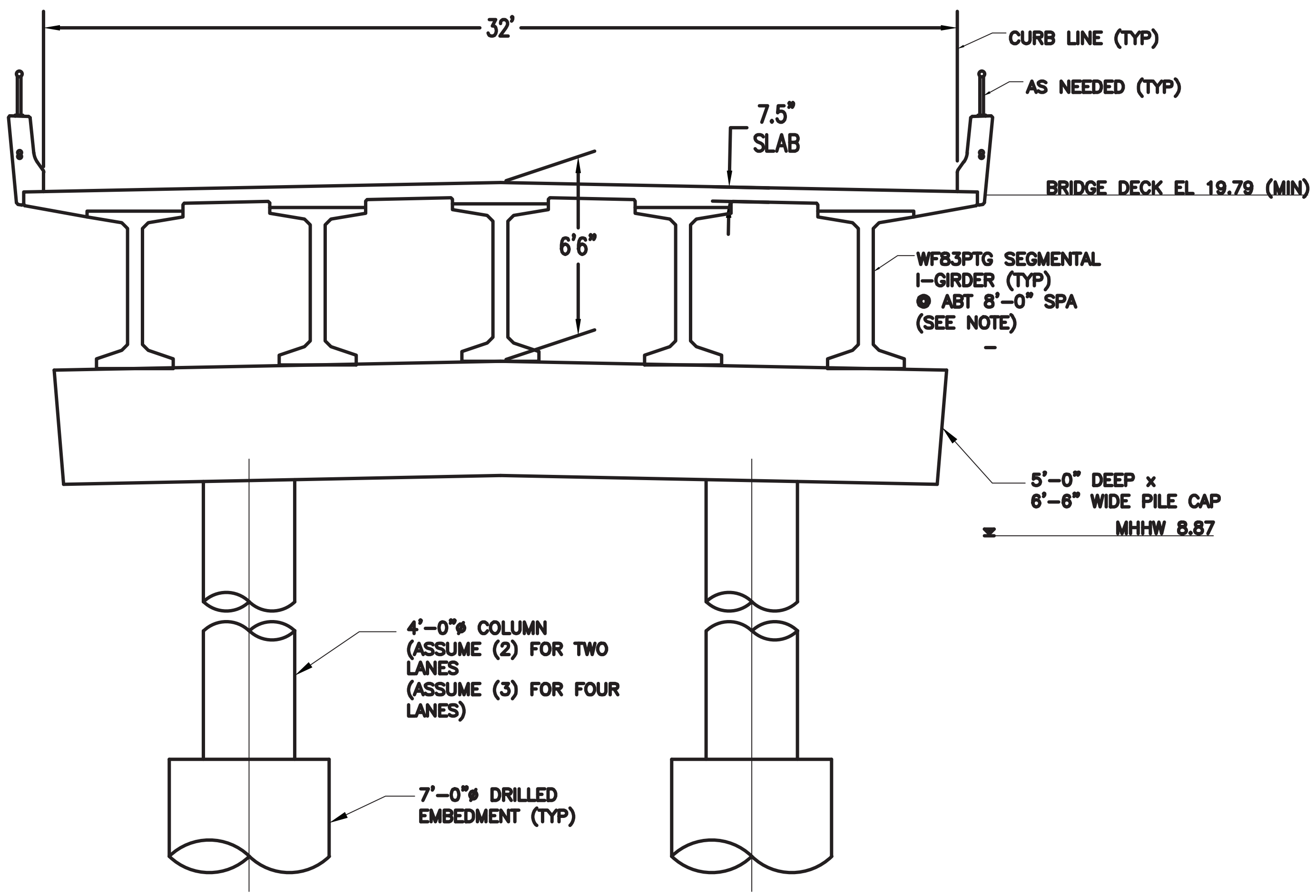


PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

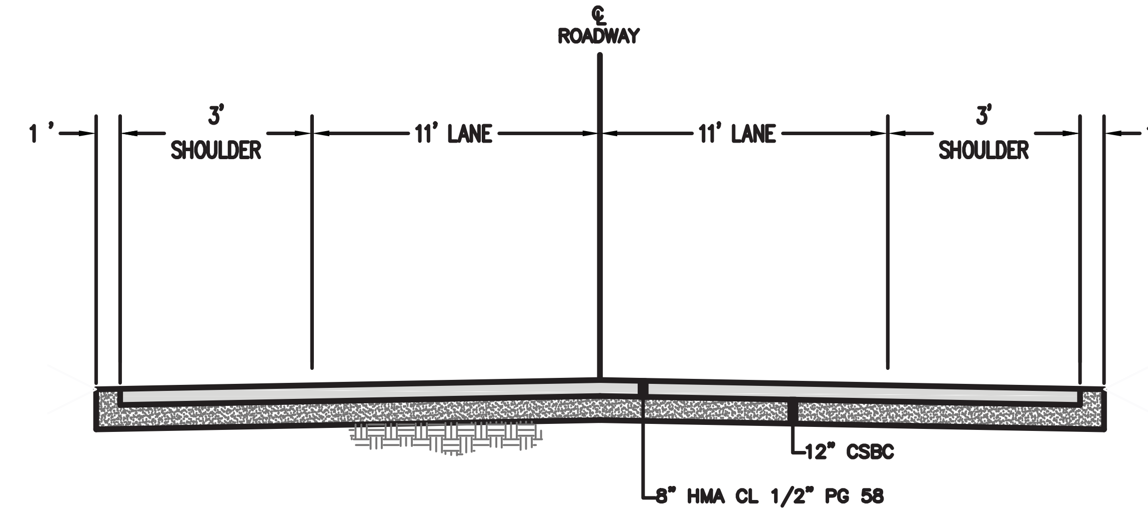
Lead Contractor: ESA
Design Lead: ESA PWA with KPFF
Date: 3/2011

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)
Conceptual Design Section
SITE NAME: **Duckabush River Delta**
ACTION NAME: **Duckabush Causeway Replacement and Estuary Restoration**
PSNERP ID#: **1012**
Full Restoration & Partial Restoration

Figure 9-5



BRIDGE SECTION
NTS



ROADWAY SECTION
NTS

Figure 9-6

Full Restoration Quantity Estimate

Action Name:	Duckabush
Action #:	
Date:	February 2011
By:	ESA PWA with KPFF

REMEDY: ***restore tidal dynamics to Deschutes Estuary by removal of the 5th Avenue dam***
Construction Period: 12 months

Item	Unit of Measure	Material Name	Qty	Description of Item	Indicate section of design report where item is described
ACQUISITION AND CONSERVATION				Based on available mapping information	
Required Project Lands	Acre		321	Total land required For action. This includes the open water area within the action boundary on the plan figure.Most of this land is open water owned by WDFW.	9.3.5
Proponent / Partner-owned lands	Acre		315.9	Etimate of lands currently owned by Proponent (i.e., Public lands)	9.3.5
Lands To Be Acquired	Acre		5.1	0.8 acres owned by Jefferson County at Firehouse and up to 4.3 acres owned by Olympic Canal Maintenance Company on either bank of the Duckabush River, mostly upstream of highway 101.	9.3.5
Material Sites				Not Used: See Earthwork - Imported Fill.	
MOBILIZATION AND ACCESS for construction activities				Description required for each item to facilitate cost estimating	
Mobilization - Typical (Equipment, Personnel, Planning, Financial)	LS		1	Up front costs such as bonding, planning and other staff time and financing. Typically, assume 8% to 10% of other items.	
Mobilization - Remote (Equipment, Personnel, Planning, Financial)	LS		0		
Site Access	LS		0		
Barge Access	Days		0		
Temporary Traffic Control (one of the following)				Includes installation of traffic signals, signage, signmen, etc. There are 4 types as follows:	
none	LS		0		
signs	LS		1	Typical Construction Signage	
flags / spotters	LS		1	Flags and spotters only during roadway transition connection	
unique	LS		0		
Temporary Roadway	SF		0		
Control of Water	LS		0		
Relocation Activities				Not Used: See Utilities, Structures	
Site Demolition Activities				Demolition and removal of structures (description required), temporary features and relocations, itemized separately); Clearing and grubbing of vegetation, and removal of minor debris (rocks, slabs) - description required.	
Clearing and Grubbing (one or more of following)				Use one or more of the following categories of clearing and grubbing	
Clear Vegetation - Local Disposal	AC			Vegetation removed above grade and disposed locally	
Clear /Grub Vegetation - Local Disposal	AC		1.6	Vegetation roots also removed and disposed locally	n/a
Clear /Grub Vegetation - Offsite Disposal	AC			Vegetation is taken offsite and disposed - use for noxious invasives, etc.	
Clear, stockpile - large woody debris	CY			Vegetation is segregated and stockpiled / prepared for reuse on site.	
Hydraulic Structures - Culverts	LS		1	Removal of CMP culvert at Shorewood Road, 2-3 ft dia CMP, L=30 ft	9.3.1
Hydraulic Structures - Large	LS				
Utilities	LF		3200	Overhead power	9.3.6
Utilities - overhead power	LF		550	Overhead power from Highway 101 to Fire station	9.3.6
Buildings	SF		2050	Fire station Building	9.3.6
Pavement	SF		92960	Removal of 30' Roadway	n/a
Pavement	SF		76,500	Removal of parking surface at western end of site	
Bulkheads	LF or SF		0		
Demolition/Removal - Armor on Railroad Berm	LF, Ton or CY		0		
Demolition / Removal - Railroad Berm	LF, SF or CY		0		
Demolition / Removal - Bridge	SF		8850	removal of 175 LF bridge and 120 LF bridge	9.3.1
Removal - Misc. (e.g. angular rock from beach)	Ton		0		
Demolition / Removal - in-water Piling	Number of Piles		0		
Haul - Offsite Disposal of Demolition Debris	Miles		40	Assumed suitable disposal site is located within 40 miles of Duckabush Action Area	n/a
Hazardous/Contaminated Waste Removal				These items for earthwork of quality not compatible with wetlands, requiring special handling and disposal. Describe basis for classification as contaminated or hazardous. State known or suspected contamination, describe known similar work.	
Contaminated Earthwork	CY		0		
Hazardous Earthwork	CY		0		
Construct Temporary Features				Use as needed for unusual temporary features not included elsewhere (see TESC below)	
EARTHWORK				Expand to include equipment, etc. to facilitate cost estimating.	
Excavation	CY			Per yard excavation w/out expected haul	
Excavation - Upland	CY		750	Shorewood Rd removal - (150 LF x 130 SF)	9.3.2
Excavation - Upland	CY		37,000	Highway 101 causeway (1750 FT x 650 SF)	9.3.2
Excavation - Upland	CY		6,600	Duckabush River training berms (620 FT x 290 SF)	9.3.2
Excavation - Upland	CY		4,300	Duckabush Road approach to Highway 101 (200 FT x 650 SF)	9.3.2
Excavation - Upland	CY		6,453	Parking lot at south approach to highway 101. Assume about 2 acres outside of new road embankment, 2' deep	9.3.2
Excavation - Upland	CY		1,613	Firehouse area near Shorewood Road. Assume about 0.5 acres and 2' deep.	9.3.2
Excavation - Lowland	CY		0		
Dredging - Bucket - Land	CY		12,600	Channel excavation - Large Distributary channel (1130 FT x 300 SF)	9.3.2
Dredging - Bucket - Land	CY		35,800	Channel excavation - Small Distributary channel (4200 FT x 230 SF)	9.3.2
Dredging - Bucket - Land	CY		700	Channel excavation - First order Channel (650 x 30 SF SF)	9.3.2
Dredging - Bucket - Land	CY		4,600	Channel excavation - Second order channel (1760 FT x 70 SF)	9.3.2
Dredging - Bucket - Marine	CY		0		
Dredging - Hydraulic	CY		0		
Fine Grading	AC		0		
Fill Placement - local borrow					
Side cast	CY		0		
Haul - uncontrolled placement	CY				
Haul, place, compact	CY		0		
Stockpile - uncontrolled placement	CY		0		
Stockpile - controlled placement	CY		0		
Conveyor placement from stockpile land/water	CY		0		
Imported Fill					
Select Fill	CY		6,100	Includes imported fill to construct new roadway from existing grade. Assume embankment height ramps up to 6' above grade at bridge abutment from zero zero at terminous. Assume 600' long transition from zero height to 6' height. 30' wide and 2:1 slopes	9.3.1
Gravel Borrow, including haul	CY		0		
Sand / Gravel for Beach Nourishment	CY		0		
Cobble for Shore Nourishment	CY		0		
Embankment Compaction	CY		6100	WSDOT standard item compaction of roadway embankment	9.3.1
Topsoil	CY		0		
RESTORATION Features					
Channel Rehab / Creation	SF		0		
Large Wood Placement	EA		6	3-4 log structures	9.3.3
Invasive Species Control	Acre		0		
Physical Exclusion Devices	LF or EA		0		
Other Restoration Features/ Activities	LS		0		
Structures	EA				
Water Control Structures - Culverts with Gates	EA		0		
Water Control Structures - Weirs	EA		0		
Rock Slope Protection	LF		0		
Other	EA		0		
Elevated Boat Ramp	SF		0		
Fencing	SF		0		
Utilities				Replacement or relocation. Designer to provide size and material and have separate line item for each run. Incidentals include earthwork, testing, hook up fees, etc. These quantities do not include demolition of existing utilities, real estate / easemen	
Water	LF		?	Unknown	
Gas	LF		?	Unknown	
Electric	LF		3200	Overhead power onto highway	
Sewer	LF		?	Unknown	9.3.6
Telecommunications	LF		?	Unknown	
Other	LF		?	Unknown	
Roadway / Railway				KPFF expected to participate in these estimates	
Roadway	SF		43600	Typical Roadway 28' wide	9.3.1
Roadway - Switch (potential)	LS		0		
Culvert (type)	LF		0		
Culvert - Jacking	LF		0		
Culvert - Horizontal Pile Driving	LF		0		
Bridge Deck	SF		54400	Precast Concrete Girder Bridge with 14 spans @ 121'	9.3.1
Bridge -Foundation	LF		256	(8) 32' CIP Concrete pile caps w/ (2) 7' Dia Drilled Shafts 100' Embed At Each Pile Cap	9.3.1
Railway - Shoe fly	LF		0	Temporary alignment	

Full Restoration Quantity Estimate

Action Name: Duckabush
Action #:
Date: February 2011
By: ESA PWA with KPFF

REMEDY: ***restore tidal dynamics to Deschutes Estuary by removal of the 5th Avenue dam***
Construction Period: 12 months

	Item	Unit of Measure	Material Name	Qty	Description of Item		Indicate section of design report where item is described
Permanent Access Features					KPFF expected to participate in these estimates		
	Roads	Level		1%	Level 1 direct access, Level 2 moderately difficult, Level 3 difficult access		n/a
	Utility Access Routes	varies		0			
	Erosion Control Features	AC		4.4	Stabilized Construction Entrances, Sediment Ponds, Hydro Seed to Stabilize Roadway Embankments		n/a
Public Access or Recreation Features					KPFF expected to participate in these estimates		
	Trails	SF		0			
	Bridges	SF		0			
	Kiosk	EA		0			
	Restrooms	EA		0			
	Interpretive Signs	EA		1	TBD		
	Parking Area	SF		0			
	Other	EA		0			
Vegetation & Erosion Control							
	Hydroseeding	AC		3.5	Hydroseeding of Parking lot, Firehouse, new earth embankments		9.3.3
	Planting	AC		3.5	Parking lot and Firehouse to have trees and bushes planted., include other hydrossed area as well.		9.3.3
	Vegetation Maintenance	AC-YR		0			
	Erosion / sediment BMPs - Temp.	AC		0			
	Erosion / sediment BMPs - Permanent	AC		4.4	May want to separate slopes over 25% into separate category		n/a
	Waterside controls - Temporary	EA, LF, LS		0			
Construction Management							
	Construction oversight	weeks		96	(Assume 24 mo for bridge, road & demo) Quanity based on constructon duration/ # of construction seasons		n/a
	Materials testing			0			
Design and Detailed Site Investigations							
	Survey & Property, Utility Research	LS	1		% of construction cost		
	35% Design	LS	1		35% x 25% x Engineer's Estimate		
	65% design	LS	1		65% x 25% x Engineer's Estimate less the cost for 35% PS&E		
	90% design	LS	1		35% x 25% x Engineer's Estimate less the cost for 35% + 65%PS&E		
	100% design	LS	1		25% x Engineer's Estimate less previous costs		
	Geotechnical Studies	LS	1		Refer to design report for description of need		
	Cultural Studies	LS	1		Refer to design report for description of need		
	Hydraulic modeling of flood hazards	LS	1		Refer to design report for description of need		
	HTWR Studies	LS	1		Refer to design report for description of need		
Project Agreement Activities					Unable to provide credibale estimate at 10% design		
Site-Specific Adaptive Management Features & Activities					List if known		
Monitoring Activities					Assume 5 crew-days/year for each monitoring parameter in design report for 5 yrs		
	Monitoring (Type_)	crew-days		150			
Operations & Maintenance					Unable to provide credible estimate at 10% design		

Partial Restoration Quantity Estimate

Action Name: Duckabush
Action #:
Date: February 2011
By: ESA PWA with KPFF

REMEDY: restore tidal dynamics to Deschutes Estuary by removal of the 5th Avenue dam
Construction Period: 12 months

	Item	Unit of Measure	Material Name	Qty	Description of Item	Indicate section of design report where item is described
ACQUISITION AND CONSERVATION					Based on available mapping information	
	Required Project Lands	Acre		321	Total land required For action. This includes the open water area within the action boundary on the plan figure.Most of this land is open water owned by WDFW.	9.3.5
	Proponent / Partner-owned lands	Acre		315.9	Etimate of lands currently owned by Proponent (i.e., Public lands)	9.3.5
	Lands To Be Acquired	Acre		5.1	0.8 acres owned by Jefferson County at Firehouse and up to 4.3 acres owned by Olympic Canal Maintenance Company on either bank of the Duckabush River, mostly upstream of highway 101.	9.3.5
Material Sites					Not Used: See Earthwork - Imported Fill.	
MOBILIZATION AND ACCESS for construction activities					Description required for each item to facilitate cost estimating	
	Mobilization - Typical (Equipment, Personnel, Planning, Financial)	LS		1	Up front costs such as bonding, planning and other staff time and financing. Typically, assume 8% to 10% of other items.	
	Mobilization - Remote (Equipment, Personnel, Planning, Financial)	LS			Up front cost for nontypical or remote locations. Assume 12% of other items	
	Site Access	LS		0		
	Barge Access	Days		0		
	Temporary Traffic Control (one of the following)					
	none	LS		0	None = no traffic control	
	signs	LS		1	Typical Construction Signage	
	flags / spotters	LS		1	Flags and spotters only during roadway transition connection	
	unique	LS		0		
	Temporary Roadway	SF		0		
	Control of Water	LS		0		
Relocation Activities					Not Used: See Utilities, Structures	
Site Demolition Activities					Demolition and removal of structures (description required), temporary features and relocations, itemized separately); Clearing and grubbing of vegetation, and removal of minor debris (rocks, slabs) - description required.	
	Clearing and Grubbing (one or more of following)					
	Clear Vegetation - Local Disposal	AC				
	Clear /Grub Vegetation - Local Disposal	AC		1.6	Vegetation roots also removed and disposed locally	n/a
	Clear /Grub Vegetation - Offsite Disposal	AC				
	Clear, stockpile - large woody debris	CY				
	Hydraulic Structures - Culverts	LS				9.3.1
	Hydraulic Structures - Large	LS		0		
	Utilities - overhead power	LF		3200	overhead power along Highway 101	9.3.6
	Buildings	SF				
	Pavement	SF		92960	Removal of 3,320 LF of 28' Roadway	9.3.1
	Bulkheads	LF or SF		0		
	Demolition/Removal - Armor on Railroad Berm	LF, Ton or CY		0		
	Demolition / Removal - Railroad Berm	LF, SF or CY		0		
	Demolition / Removal - Bridge	SF		8850	Removal of 175 LF bridge and 120 LF bridge	9.3.1
	Removal - Misc. (e.g. angular rock from beach)	Ton		0		
	Demolition / Removal - in-water Piling	Number of Piles		0		
	Haul - Offsite Disposal of Demolition Debris	Miles		40	Assumed suitable disposal site is located within 40 miles of Duckabush Action Area	n/a
Hazardous/Contaminated Waste Removal					These items for earthwork of quality not compatible with wetlands, requiring special handling and disposal. Describe basis for classification as contaminated or hazardous. State known or suspected contamination, describe known similar work.	
	Contaminated Earthwork	CY		0		
	Hazardous Earthwork	CY		0		
Construct Temporary Features					Use as needed for unusual temporary features not included elsewhere (see TESC below)	
EARTHWORK					Expand to include equipment, etc. to facilitate cost estimating.	
	Excavation	CY			Per yard excavation w/out expected haul	
	Excavation - Upland	CY		37,000	Highway 101 causeway (1750 FT x 650 SF)	9.3.2
	Excavation - Upland	CY		6,600	Duckabush River training berms (620 FT x 290 SF)	9.3.2
	Excavation - Upland	CY		4,300	Duckabush Road approach to Highway 101 (200 FT x 650 SF)	9.3.2
	Excavation - Lowland	CY		0		
	Excavation - Upland	CY		6,453	Praking lot at south approach to highway 101. Assume about 2 acres outsie new road embankment, 2' deep	9.3.2
	Dredging - Bucket - Land	CY		12,600	Channel excavation - Large Distributary channel (1130 FT x 300 SF)	9.3.2
	Dredging - Bucket - Land	CY		33,500	Channel excavation - Small Distributary channel (3930 FT x 230 SF)	9.3.2
	Dredging - Bucket - Land	CY		700	Channel excavation - First Order Channel (650 x 30 SF SF)	9.3.2
	Dredging - Bucket - Land	CY		4,600	Channel excavation - Second order channel (1760 FT x 70 SF)	9.3.2
	Dredging - Bucket - Marine	CY		0		
	Dredging - Hydraulic	CY		0		
	Fine Grading	AC		0		
	Fill Placement - local borrow					
	Side cast	CY		0		
	Haul - uncontrolled placement	CY				
	Haul, place, compact	CY		0		
	Stockpile - uncontrolled placement	CY		0		
	Stockpile - controlled placement	CY		0		
	Conveyor placement from stockpile land/water	CY		0		
	Imported Fill					
	Select Fill	CY		15,000	Includes imported fill to construct new roadway from existing grade. Assume 30' top width and 2:1 side slopes. Assume 14' height on north approach due to location over low area to northwest of intersection of duckabush and existing 101. Assume this embankment height tapers to zero at northern terminous. At south embankment, assume 600' long transition from zero height to 6' height.	9.3.1
	Gravel Borrow, including haul	CY		0		
	Sand / Gravel for Beach Nourishment	CY		0		
	Cobble for Shore Nourishment	CY		0		
	Embankment Compaction	CY		15,000	WSDOT standard item compaction of roadway embankment	9.3.1
	Topsoil	CY		0		
RESTORATION Features						
	Channel Rehab / Creation	SF		0		
	Large Wood Placement	EA		6	3-4 log structures	9.3.3
	Invasive Species Control	Acre		0		
	Physical Exclusion Devices	LF or EA		0		
	Other Restoration Features/ Activities	LS		0		
Structures		EA				
	Water Control Structures - Culverts with Gates	EA		0		
	Water Control Structures - Weirs	EA		0		
	Rock Slope Protection	LF		0		
	Other	EA		0		
	Elevated Boat Ramp	SF		0		
	Fencing	SF		0		
Utilities					Replacement or relocation. Designer to provide size and material and have separate line item for each run. Incidentals include earthwork, testing, hook up fees, etc. These quantities do not include demolition of existing utilities, real estate / easements, design fees. Describe the owner if known, and whether utility franchise will install (e.g., electric is typically installed by electrical franchise).	
	Water	LF		?	Unknown	
	Gas	LF		?	Unknown	
	Electric	LF		3200	Overhead power onto highway	9.3.6
	Sewer	LF		?	Unknown	
	Telecommunications	LF		?	Unknown	
	Other	LF		?	Unknown	
Roadway / Railway						
	Roadway	SF		63,600	Typical Roadway 28' wide	9.3.1
	Roadway - Switch (potential)	LS		0		
	Culvert (type)	LF		0		
	Culvert - Jacking	LF		0		
	Culvert - Horizontal Pile Driving	LF		0		
	Bridge Deck	SF		35200	Precast Concrete Girder Bridge with 8 spans @ 138'	9.3.1
	Bridge - Foundation Drilled Shafts	LF		160	(5) 32' CIP Concrete pile caps w/ (2) 7' Dia Drilled Shafts 100' Embed At Each Pile Cap	9.3.1
	Railway - Shoe fly	LF		0		
Permanent Access Features					KPFF expected to participate in these estimates	
	Roads	Level		1%	Level 1 direct access, Level 2 moderately difficult, Level 3 difficult access	n/a
	Utility Access Routes	varies		0		
	Erosion Control Features	AC		4.4	Stabilized Construction Entrances, Sediment Ponds, Hydro Seed to Stabilize Roadway Embankments	n/a
Public Access or Recreation Features					KPFF expected to participate in these estimates	
	trails	SF		0		
	bridges	SF		0		

Partial Restoration Quantity Estimate

Action Name: Duckabush
Action #:
Date: February 2011
By: ESA PWA with KPFF

REMEDY: restore tidal dynamics to Deschutes Estuary by removal of the 5th Avenue dam
Construction Period: 12 months

	Item	Unit of Measure	Material Name	Qty	Description of Item		Indicate section of design report where item is described
	kiosk	EA		0			
	restrooms	EA		0			
	Interpretive Signs	EA		1	TBD		
	parking area	SF		0			
	Other	EA		0			
Vegetation & Erosion Control							
	Hydroseeding	AC		3.5	Hydroseeding of Parking lot, Firehouse, new earth embankments		9.3.3
	Planting	AC		3.5	Parking lot and Firehouse to have trees and bushes planted., include other hydrossed area as well.		9.3.3
	Vegetation Maintenance	AC-YR		0			
	Erosion / sediment BMPs - Temp.	AC		4.4	BMPs for control of drainage - describe. Assume compliance with Construction General NPDES included		n/a
	Erosion / sediment BMPs - Permanent	AC		0			
	Waterside controls - Temporary	EA, LF, LS		0			
Construction Management							
	Construction oversight	weeks		72	(18 mo for bridge, road & demo) Quanity based on construction duration/ # of construction seasons		n/a
	Materials testing			0			
Design and Detailed Site Investigations							
	Survey & Property, Utility Research	LS	1		% of construction cost		
	35% Design	LS	1		35% x 25% x Engineer's Estimate		
	65% design	LS	1		65% x 25% x Engineer's Estimate less the cost for 35% PS&E		
	90% design	LS	1		35% x 25% x Engineer's Estimate less the cost for 35% + 65%PS&E		
	100% design	LS	1		25% x Engineer's Estimate less previous costs		
	Geotechnical Studies	LS	1		Refer to design report for description of need		
	Cultural Studies	LS	1		Refer to design report for description of need		
	Hydraulic modeling of flood hazards	LS	1		Refer to design report for description of need		
	HTWR Studies	LS	1		Refer to design report for description of need		
Project Agreement Activities					Unable to provide credible estimate at 10% design		
Site-Specific Adaptive Management Features & Activities					List if known		
Monitoring Activities					Assume 5 crew-days/year for each monitoring parameter in design report for 5 yrs		
	Monitoring (Type)	crew-days	150				
Operations & Maintenance					Unable to provide credible estimate at 10% design		

10. DUGUALLA BAY RESTORATION (#1609)

Local Proponent	Skagit River Systems Cooperative
Delta Process Unit	NA
Shoreline Process Unit(s)	6025
Strategy(ies)	3 - Barrier Embayment
Restoration Objectives	Remove barriers to tidal hydrology and restore the historic salt marsh estuary

10.1 Description of the Action

This action would modify or remove an existing shoreline dike, roadway, and tide gate/pump station system to allow tidal exchange between Dugualla Bay and Dugualla Lake, creating a restored salt marsh system. A portion of State Route 20 will also be replaced with a bridge to allow for restoration of the floodplain. Please see the Introduction chapter for important information regarding PSNERP and for context related to this restoration project.

10.2 Action Area Description and Context

Dugualla Bay is located in the Whidbey Subbasin on the northeast side of Whidbey Island within the western portion of Skagit Bay. The action area includes Dugualla Lake and the lower Dugualla Creek drainage, a former estuary and salt marsh, now separated from the marine waters of Dugualla Bay by a dike, and adjacent tidelands, for a total of approximately 600 acres. To create agricultural land, Dike Road and an associated dike and tide gate/pump station system were constructed at the inlet to Dugualla Lake around 1918. This eliminated tidal inundation and changed the lake into a freshwater lake and marsh. The proposed restoration would return tidal inundation to Dugualla Lake and restore the historic marsh and tidal channels by removing the dike, tide gate, and pump station.

The action area includes properties under private and public ownerships, and some of the properties are actively farmed. There are several support buildings and residential structures on the north and south sides of Dugualla Lake. Ault Field, part of the Whidbey Naval Air Station (NAS), is located farther to the west of State Route 20, but encompasses a substantial portion of the action area. The action area is shown in Figure 10-1.

Figure 10-1. Action Area and Vicinity

10.2.1 Historical Condition

Based on the historic topographic sheet (T-sheet) mapping from the late 1800s, the area currently occupied by Dugualla Lake and the lower Dugualla Creek drainage was a large estuary and salt marsh system connected to Dugualla Bay through one primary low tide channel (Figures 10-2A and 10-2B). The east side of the historic tidal marsh was defined by two barrier beaches, a shorter one extending from the north, and a longer one extending from the south. The T-sheet shows a small island between the two barrier beaches that appears to indicate a secondary high tide outlet channel. No mudflat limit is shown on the T-sheet at the outlet of the historic estuary; only a beach 100 to 250 feet wide. At present, this location is characterized by extensive mudflat.

The estuary and marsh were in existence until at least 1908, as evidenced in topographic maps from that time (Washington State Conservation Commission 2000). Drainage District 1 was created in 1918 for the purpose of creating agricultural land at the site, and this is the likely timeframe for construction of the dike and tide gate system (Kearsley and Hossley 1995). Two 4-foot-diameter culverts were constructed to connect Dugualla Lake to Dugualla Bay through the Dike Road embankment. The outlet is located on the beach along the western shoreline of the bay directly across Dike Road from the pumping station. Diking District 3 was established in 1915 and retains ownership and management of Dugualla Lake at present. NAS Whidbey, whose property is within the

Dugualla Creek drainage, currently operates the pumping system between Dugualla Lake and the bay (Washington State Conservation Commission 2000). NAS Whidbey has an interest in maintaining the water level in the lake in order to limit waterfowl use, which poses a risk to low-flying jets approaching Ault Field to the west (Hinton 2010).

Construction of the dike and pumping system has eliminated tidal inundation from the historical footprint of the estuary. Estuarine and salt marsh habitat in the area has been changed to a freshwater lake and freshwater marsh.

10.2.2 Natural Environment

The Dugualla drainage is located on the northeast side of Whidbey Island. At approximately 4,200 acres in size, this drainage is the fifth largest in WRIA 6 (Washington State Conservation Commission 2000). Dugualla Creek, which has its headwaters near Ault Field on the NAS Whidbey, drains adjacent uplands, Ault Field, and runoff from State Route 20 through a box culvert under State Route 20 into Dugualla Lake. Dugualla Lake receives additional freshwater input from extensive hillside seepage from uplands east of State Route 20 and runoff from local roads (Lowe 2010).

Dugualla Lake and Dugualla Creek have no tidal inundation other than a very limited seepage zone on the west surface of the dike. The area west of the dikes and east of State Route 20 consists of terrestrial grasslands (used for grazing), planted agricultural fields, Dugualla Lake, and associated freshwater wetlands. Forested lands are extensive on adjacent hillsides. West of State Route 20, there are extensive cultivated agricultural lands, and extensive cattail marsh following the Dugualla Creek corridor with forested lands on the adjacent hillsides. The area further west in the NAS Whidbey boundary appears to be fallow agricultural lands.

The shoreline of Dugualla Bay is primarily mudflat with a gravel and sand backshore. Net littoral drift along the shoreline at the action area and south of the action area is toward the north. North of the action area, the littoral drift is toward the south (Washington State Department of Ecology 2002). In addition to littoral drift from the south, the primary sediment source for intertidal areas is fine sediment from the North Fork Skagit River, which is located directly east of the site. The elimination of tidal inundation into the historic estuary at Dugualla Bay has likely increased sedimentation and mudflat creation in this area (Hinton 2010). As a result of this blockage of sediment supply to the historic inner bay, the elevation of the mudflat is higher than the elevation of Dugualla Lake and adjacent agricultural lands. The sediment regimen may also have changed from historical conditions due to the Skagit Delta prograding into Skagit Bay, thereby increasing the extent of mudflats.

10.2.3 Human Environment

Dugualla Lake is officially managed by Diking District 3 (Hinton 2010). The water surface elevation in the lake is controlled by a pumping system, maintained by NAS Whidbey. The water is pumped through two 4-foot-diameter culverts through the Dike Road embankment to an outlet on the beach in Dugualla Bay (Washington State Conservation Commission 2000). The outlets of both culverts are buried by sediment, with only the top of the headwall visible on the beach, due to continued sediment deposition on the mudflats along Dugualla Bay. Water pumped through culverts is released forcefully, and often vertically, through the buried outlet where it pools close to the outlet and then flows through the mudflat in a single sinuous channel at low tide out into the bay. Dugualla Lake and Dugualla Creek are separated from Dugualla Bay by

Dike Road and a secondary dike system that runs to the east of Dike Road along the southern shoreline of the bay. Dike Road is a two-lane collector owned and maintained by Island County. It serves as an alternative route to State Route 20 during emergency evacuations.

State Route 20 is a two-lane highway (WSDOT designation R1) and the primary north-south route along Whidbey Island. State Route 20 has speed limits posted at 55 mph within the action area limits. It is constructed on roadway fill more than 2,800 feet in length traversing the historic estuary. Dugualla Creek passes beneath State Route 20 via a cast-in-place culvert, 13 feet wide by 6 feet high, with a mid-span support wall.

The land surrounding Dugualla Lake is used for agricultural purposes, with livestock grazing in the area and various planted crops both east and west of State Route 20. There are several support buildings and residential structures on the north and south sides of Dugualla Lake, as well as to the west of State Route 20 and near Dike Road. Several of these structures will be at risk of flooding if tidal hydrology is restored to the action area.

The lands in the action area consist of a mix of ownerships. Lands on the southeast side of the lake and extending to Dugualla Bay are owned by the Whidbey Camano Land Trust. Various private parties own the lands on the north, south, and southwest sides of the lake. State Route 20 is owned by WSDOT, and Dike Road is an Island County facility. Property directly west of State Route 20 is privately owned and actively farmed with a retail produce stand located adjacent to State Route 20. Ault Field, owned by NAS Whidbey, is located farther to the west of State Route 20 but encompasses a substantial portion of the action area.

The main Island County electrical transmission lines are owned by PSE and run on overhead lines along the length of Dike Road. A buried fiber optic cable also runs the length of Dike Road. More detailed information on existing utilities and the need for utility relocations will be required to support subsequent design phases. NAS Whidbey utilizes airspace above the restoration site as a flight corridor.

10.3 Restoration Design Concept

10.3.1 Restoration Overview and Key Design Assumptions

The restoration at Dugulla Bay proposes to return tidal inundation and sediment transport to the estuary by removing dikes, road embankment, and a tide gate, and restoring tidal channels. Both alternatives will require the purchase of private property within the footprint of the historical tidal estuary, including private homes and agricultural land around Dugualla Lake and agricultural land and produce stand west of State Route 20. The number of structures to be acquired and removed will be determined during later stages of design.

The restoration alternatives are illustrated in Figures 10-3 through 10-9. The full restoration alternative would return historic tidal inundation to the area and restore the footprint of the historic estuary through the following measures (Figure 10-3):

- Complete removal of the Dike Road embankment between Frostad Road and Frost Lane and reconnection of Dugualla Lake to Dugualla Bay (Figure 10-3).
- Rerouting of PSE transmission lines that currently run the length of Dike Road (to State Route 20 alignment).
- Rerouting of the fiber optic cable that currently runs through the Dike Road embankment (Figure 10-3).

- Removal of all infrastructure associated with the tide gate and pumping system between Dugualla Lake and Dugualla Bay, including pipes, culverts, pumps, headwalls, etc.
- Complete removal of the dike that runs east of Dike Road along the bay shoreline in the southeastern corner of the site.
- Restoration of the barrier beaches from the north and south that defined the tidal channel entrance historically.
- Filling of existing drainage channels.
- Shoreline restoration in the vicinity of the newly created barrier beach spits and limited revegetation.
- Removal of approximately 2,800 LF of the State Route 20 road embankment and replacement with a 2,850 LF bridge span, where bridge height is designed to accommodate predicted local sea level rise; deck elevation is 22.3 feet NAVD 88 (Figure 10-5A).
- Excavation of a starter tidal channel with approximately 20 feet of bottom width at an elevation of approximately 0 feet NAVD 88 (Figure 10-6C).
- Control of invasive vegetation within areas not affected by tidal inundation.

The partial restoration alternative proposed for Dugualla Bay targets full tidal hydrology for the unfilled portion of the historical estuary area west of Dike Road (Figures 10-4, 10-7, 10-8 and 10-9). The partial restoration action includes the following major elements:

- Removal of approximately 750 LF of Dike Road in the vicinity of the existing tide gate/pumping station, and construction of a 750-foot-long bridge to span the opening and maintain vehicle passage and utilities support along Dike Road. The roadway embankment/dike would be raised 3 feet to the north and south of the breached section to address sea level rise. The southern portion of Dike Road that runs south toward Frostad Road would be raised approximately 11 feet to keep the roadway out of the floodplain following removal of the shoreline dike (including the effects of sea level change). The geometry of Dike Road will follow the existing alignment (Figures 10-7A and 10-7B).
- Excavation of a starter tidal channel with approximately 20 feet of bottom width at an elevation of approximately 0 feet NAVD 88 (Figure 10-8D).
- Modification of power lines to span the new bridged section of Dike Road.
- Modification of the fiber optic line that currently runs through the road embankment to span the new bridged section of Dike Road.
- Removal of the shore parallel dike that runs east of and separate from Dike Road along the bay shoreline in the southeastern corner of the site.
- Modifications to State Route 20 that will realign the roadway prism to the east on the current alignment. This is similar to full restoration, but with a smaller bridge to replace the existing culvert. The proposed bridge is 200 feet in length with an intermediate pier. A new roadway fill embankment will be constructed parallel to the existing, which will be removed upon completion (Figure 10-9).
- Connect the southeastern corner of the site (currently located between Dike Road and the shoreline dike), which is slated for salt marsh restoration, with the larger

estuary via a large box culvert under Dike Road.

- Shoreline restoration including revegetation.
- Control of invasive vegetation within areas not affected by tidal inundation.
- Filling in of existing drainage channels.

Under the full alternative, two new spans are proposed to allow tidal flux into the historical estuary. Historical maps and empirical relationships between tidal prism and channel size were used to develop estimates of a channel system that will form after tides can reoccupy the basin. This analysis suggested that the channel width would be approximately 200 feet, with a channel bottom between -2 to -5 feet NAVD 88. The span widths were selected to achieve the goals of full tidal inundation and allow for natural sedimentation and channel migration patterns.

The 750 LF span on Dike Road represents approximately 3.75 times the historical channel width and about 27 percent of the historical estuary width. The span width will provide for some channel migration and development of marshplain and ebb/flood shoals, but will not restore the historical condition in this location. Substantial mudflat development has occurred since the closure of Dike Road, suggesting that greater span width would help to reduce the risk of sedimentation blocking the inlet and reducing the effective tidal prism, especially as the tidal basin will be smaller than the historical condition due to fill for SR 20 and Whidbey NAS.

The 200 LF span on SR 20 was selected based on similar scaling down from historical conditions. The 200 LF span will allow the highway to bridge the relict channel in this location which is anticipated to allow full tidal hydrology to the remaining low area west of SR 20.

Tidal channel excavation is required to create a channel through the substantial mudflat that has accumulated on the bay side of Dike Road. The dimensions of the eventual form of the outlet channel were developed using the analytical approach described above. The proposed channel excavation is much smaller than the historical condition to reduce the amount of initial excavation that would be required. The proposed channel section was developed to allow for full tidal flux into the restoration site, and it is assumed that the channel would evolve over time (likely expanding) to match the new site condition. The length of the channel was developed to be long enough to daylight the target elevation (0 ft NAVD 88) on the mudflat on the Dugualla Bay side of Dike Road.

The partial restoration alternative will not provide full removal of stressors but is anticipated to result in a muted tidal regime. The full width of the estuary will not be restored at State Route 20 or at the mouth at Dugualla Bay. Tidal inundation and sediment transport into and out of the restored estuary will be limited by the width of the breach through Dike Road and the width of the opening at State Route 20. Restoration of nearshore processes will also be limited due to the setback dike and box culvert at Dike Road.

	MLLW	NAVD 88
MHHW	10.80 feet	9.02 feet
MLLW	9.91 feet	8.13 feet
MTL	6.28 feet	4.5 feet
MSL	4.95 feet	3.17 feet
MLW	2.64 feet	0.86 feet
MLLW	0 feet	-1.78 feet

Tidal datum information was taken from NOAA tide gage Crescent Harbor, Whidbey Island NOAA Gage #9447952.

The partial restoration alternative is consistent with the proponent's description of potential restoration activities that could be conducted within the action area. However, the full restoration alternative, which includes closure of Dike Road, is a significantly expanded scope of restoration. The full restoration alternative, while not consistent with the proponent's current plans, are supported in principle by the Whidbey Camano Land Trust for their lands within the action area (Lowe 2010). Island County has plans to use portions of the southeastern corner of the action area (owned by the Land Trust) as freshwater wetland mitigation for planned road improvements on nearby Frostad Road.

The key design elements associated with full and partial restoration alternatives are shown in Table 10-1.

Table 10-1. Key Design Elements

Element	Full Restoration	Partial Restoration
Dike Road	Remove entire roadway berm	Remove 750 LF of roadway berm/dike and replace with bridge section. Raise the northern portion of the roadway (adjacent to the breach) an additional 3 feet. Raise the southern portion of the roadway toward Frostad Road approximately 11 feet (move road onto setback dike). Construct a box culvert through roadway embankment/setback dike
Tide Gate/Pump Station	Remove all infrastructure associated with existing tide gate/pump station	Same as full restoration
Utilities	Reroute all utilities around the estuary along the new State Route 20 alignment	Reroute all utilities across the new bridge section for Dike Road
Shoreline Dike	Remove all of dike within action area	Build setback dike in Dike Road alignment with box culvert to connect restored estuary on east side of Dike Road
State Route 20	Remove roadway embankment and replace with 2,850-foot-long bridge	Build new roadway berm east of the new roadway location. Raise roadway to 14.8 feet (NAVD 88) to keep roadway out of floodplain. Install 200-foot-long bridge and remove existing roadway embankment
Dugualla Creek culvert at State Route 20	Culvert will be removed and replaced with bridge	Same as full restoration
Linear Ditches	Fill ditches	Same as full restoration

Element	Full Restoration	Partial Restoration
Shoreline Restoration	Grading, placement of sand and gravel, and revegetation of historic spit	Revegetation of the new tidal channel opening through Dike Road
Invasive Species	Control of invasive species within new floodplain extent	Same as full restoration
Properties in Floodplain	Acquire all at-risk properties, remove multiple private structures/homes; number of structures to be determined during later stages of design	Same as full restoration

10.3.2 Restoration Features – Primary Process-Based Management Measures

Armor Removal/Modification

In full restoration, approximately 3,160 LF of rock riprap armoring will be removed from the seaward side of the perimeter dike (Figure 10-3). The extent of armoring removed would be significantly less in partial restoration (2,180 LF) because only a portion of the roadway is being removed (Figure 10-4). Additional armor removal may be associated with existing outfalls to be removed. Existing rock riprap to be removed should be evaluated for reuse in both alternatives in subsequent phases of design.

Berm or Dike Removal/Modification

Differing amounts of dike removal on the eastern perimeter of the estuary are proposed for full and partial restoration. For full restoration, the entire eastern perimeter dike, as well as Dike Road, is removed (50,300 CY) and replaced with a restored barrier beach within the action area (Figure 10-3). For partial restoration, dike removal is limited to a targeted location where historic connectivity existed along the northeast corner of the estuary (20,550 CY), and Dike Road remains (Figure 10-4).

Other sections of dikes and road embankments will be removed within the estuary to increase inundated areas. For full restoration, the State Route 20 road embankment will be removed within the extent of the floodplain (152,320 CY) and replaced with a bridge (Figure 10-5A). In partial restoration, the State Route 20 roadway embankment will be moved eastward, sloping up to meet the deck elevation at the north and south sides of the bridge (103,300 CY). The existing State Route 20 roadway embankment will then be removed (130,640 CY). The existing culverts under State Route 20 will be replaced with a 200-foot-long bridge (Figure 10-4). The full and partial restoration alternatives include removal of the shoreline dike east of Dike Road (20,000 CY), and removal of small berms located around Dugualla Lake (1,700 CY).

Channel Rehabilitation/Creation

Both full and partial restoration alternatives include the creation of a tidal channel that will restore full tidal inundation (both elevation and phase) to the restored estuary. The full and partial restoration alternatives will have approximately the same tidal prism post-restoration; therefore, the proposed channel geometry and alignment are the same for both alternatives. However, the full restoration alternative removes the entire Dike Road embankment, allowing a larger migration zone for the tidal channel than partial restoration (Figures 10-3 and 10-4).

Historical and analytical evaluations were completed for the action area to evaluate the equilibrium channel size for the restored estuary. The equilibrium channel size represents the size of the channel that will form over time (through natural coastal processes) under site-specific tidal hydrodynamics, once the site has been restored.

Two H-sheets exist for Dugualla Bay and its vicinity: one from 1890 (H02050), which is before the estuary was separated from the bay; and one from 1939 (H06476), which shows evidence of dikes constructed across the mouth of the estuary. Study of the recorded conditions at the site shows a single channel into the estuary ranging in depth from approximately -3.7 feet NAVD 88 (2 feet MLLW) to -9.7 feet NAVD 88 (-8 feet MLLW). The channel width is approximately 200 feet as delineated in the H-sheet. This appears to be from top of bank to top of bank. As a comparison, the H-sheet from 1939 shows that the defined tidal channel across the mudflats in Dugualla Bay is all but gone, with a remnant low-lying area along the northern shoreline of the bay with elevations on the order of -1.7 feet NAVD 88 (0 feet MLLW).

Two different analytical methods were used to estimate channel dimensions for the restored Dugualla Lake, with similar results from both calculations. In Figure 2 of the *Applied Geomorphology Guidelines and Hierarchy of Openings* (Appendix C), empirical models calibrated with field data were used to develop a relationship between the surface area of a marsh and its associated channel hydraulic geometry. For the proposed 720-acre surface area of Dugualla Lake, the predicted cross sectional area of the channel would be 2,150 SF. Assuming the historical channel width of 200 feet, this equates to a channel depth of approximately 11 feet MHHW. This is equivalent to channel thalweg elevation of approximately -2.0 feet NAVD 88.

The second method was taken from *GITI Report 3: Tidal Prism / Inlet Area Relationships* by James T. Jarrett of the U.S. Army Corps of Engineers (USACE 1976). This paper used data from inlets on the Atlantic, Pacific, and Gulf Coasts of the United States and developed relationships between the tidal prism flowing through the inlet and its associated area. Multiple equations were developed based on the location of the inlet and the jetty configurations. The tidal prism of Dugualla Lake was estimated by calculating the volume of the basin filled to local MHHW (+9.02 feet NAVD 88) using the available Digital Elevation Model (DEM) and subtracting the volume at MLLW (-1.78 feet NAVD 88). The resulting tidal prism was approximately 3,300 acre-feet (144 million cubic feet). This calculation excluded the depth of Dugualla Lake (which is a data gap for this study) and future topography changes within the restored estuary and is thus approximate. Again assuming the historical channel width (top of bank to top of bank) of 200 feet, the predicted channel depth at mean sea level (MSL) was 9 feet. This corresponds to a thalweg elevation of approximately -5 feet NAVD 88.

Both the historical and analytical evaluation suggest that over time, the tidal regime in the estuary following full and partial restoration would result in a channel averaging about 200 feet wide (top of bank to top of bank) with a thalweg between -2 feet and -5 feet NAVD 88. Because the action area was separated from the bay, significant deposition has occurred along the shoreline adjacent to the historical mouth of the estuary. Mudflats along this stretch of shoreline have elevations of approximately 5.0 feet NAVD 88 (from LiDAR). Returning the channel to its historical width and depth would involve a tremendous amount of lowland excavation and dredging of the mudflats, and would limit complexity and migration of the channel based on natural processes. Therefore, both full and partial restoration include excavation of a starter channel, which will allow full tidal inundation into the estuary and restore tidal hydrodynamics and sediment transport processes to the action area. The channel alignment will follow the historical alignment shown on the H-sheet (approximately). The channel will have a 20-foot bottom width at 0 feet NAVD 88 with an average 40-foot top width. Over time, these processes will provide the mechanism to develop the larger and deeper equilibrium channel geometry estimated above.

Groin Removal/Modification - NA

Hydraulic Modification

In both the full and partial restoration alternatives, the following will be removed: tide gate/pump station, two 4-footdiameter culverts through the Dike Road embankment, and one cast-in-place culvert that is 13 feet wide by 6 feet high with a mid-span support wall under State Route 20. In addition, a new box culvert (approximately 6 feet) is proposed through the setback dike at Dike Road in the partial restoration alternative.

Overwater Structure Removal - NA

Topography Restoration

Historical topography of the site will not be restored in whole for either full or partial restoration alternatives. However, actions proposed will restore targeted areas of the topography to approximate historical conditions.

The topography of the interior of the action area will be modified in full restoration by removing smaller upland berms. Partial restoration of the uplands is similar. Existing ditches within the action area will be filled in to promote sheet flow and limit channelized flow within the newly restored estuary. Approximately 7,200 LF of ditch will be filled in for both partial and full restoration alternatives (Figures 10-3 and 10-4). Onsite materials will be considered for filling the existing ditches (if they are determined to be suitable in subsequent phases of design).

Additional changes to the topography within the restored estuary will occur over time for both full and partial restoration alternatives. The topography of the restored area will return to a condition that resembles historical conditions; however, the shape of the final planform is difficult to predict. The full restoration alternative offers the best opportunity to return the action area to historical topography.

10.3.3 Restoration Features – Additional Management Measures

Beach Nourishment

The full restoration alternative will remove the entire Dike Road embankment and restore the location and elevation of the historic tidal spit (Figure 10-3). Following removal of the roadway embankment, the excavated area will be augmented with imported sand and gravel to restore a functioning intertidal beach along the shoreline adjacent to the proposed tidal channel/opening. For both full and partial restoration alternatives, the excavation of the shoreside dike will require some augmentation of the sediments left behind. Imported sand and gravel will be placed (14,450 CY, assuming am average depth of approximately 18 inches over half of the shoreline restoration area shown on Figures 10-3 and 10-4) to restore the upper intertidal area following removal of the dike. The nature of materials that will be exposed when removing road and dike fill is not known. While drift will provide sediment over time, it is reasonable from a technical standpoint (and prudent for cost estimating) to assume that some amount of nourishment import and placement will be required to more rapidly restore areas affected by excavation to functional conditions.

Contaminant Removal/Remediation

There is a possibility of contamination in the sediments within Dugualla Lake due to a previous upland fuel spill. A sediment characterization will be required for Dugualla Lake sediments to evaluate the existence and/or extent of contamination. Depending on the results, further investigation of upland sediments may also be required.

Debris Removal - NA

Invasive Species Control

There is a possibility that control of the invasive cordgrass *Spartina* sp. may be necessary after restoration. Control of invasive vegetation within the restoration site will occur in areas not affected by tidal inundation. For quantity estimating purposes this is assumed to be approximately 245 acres, with a total upland invasive removal/management area of about 12 acres.

Large Wood Placement- NA

Physical Exclusion - NA

Pollution Control - NA

Revegetation

Shoreline restoration will include revegetation with supratidal grasses and herbaceous perennials.

Reintroduction of Native Animals - NA

Substrate Modification - NA

Species Habitat Enhancement - NA

10.3.4 Restoration Features – Other

NA

10.3.5 Land Requirements

Construction of this action will affect of 487 acres of agricultural and residential lands. A total of 452 acres of private land would need to be acquired via purchase, easements or other similar means due to flooding risk. The property acquisition requirements for full and partial restoration appear to be similar. State Route 20 would require a new right-of-way for both full restoration (land located under the new bridge) and partial restoration (roadway embankment will be moved eastward and raised).

The main Island County electrical transmission lines, owned by PSE, run over land along the length of Dike Road. Fiber optic cable is also located within the Dike Road embankment. Relocated fiber optic and electrical lines will be located within the existing and future roadway rights-of-way. Additional easements may be necessary for the overhead power if the aerial requirements extend beyond what WSDOT would acquire for the roadway. If the alignment for the overhead electrical power were to continue directly north to Jones Road where State Route 20 turns to the west, PSE would need to acquire an easement along that corridor.

10.3.6 Design Considerations

Demolition of Dike Road, reconstruction of State Route 20, and rerouting of power lines and fiber optic cable are the primary considerations for full restoration. The main partial restoration consideration would be reconstruction of State Route 20. For both full and partial restoration alternatives, evaluation of the performance of the starter channel would be a critical design consideration for design of the channel, upland bridge sections and culverts, and final design elevations for roadways.

There is a strong possibility of encountering cultural resources in this location based on historic conditions (estuary). This possibility will need to be evaluated and considered during design of both the full and partial restoration alternatives.

This bay historically supported Olympia oysters in a large shell-structured oyster reef habitat that was lost due to diking and filling. Future restoration design should consider the reestablishment of this now rare historic intertidal habitat (WDFW 2010).

Specific design considerations for roadways are provided below for full and partial restoration alternatives.

For the full restoration alternative:

- The new alignment of State Route 20 will be constructed parallel to the existing roadway in order to maintain traffic for the duration of construction. The highway is posted at 50 mph and has a design speed of 60 mph. The alignment will be designed to the current standards for its functional classification.
- The bridge width is 30 feet including shoulders. The elevation on the deck of the structure will be 22.3 feet to provide 3 feet of clearance between the design water surface elevation and the low chord of the bridge. The proposed bridge will be approximately 2,850 feet long with 19 spans of about 150 feet consisting of 6-foot-6-inch-deep pre-cast concrete girders (Figure 10-6).
- The removal of Dike Road will take out an emergency evacuation route for residents who live to the southeast. A suitable alternative may be Hoffman Road, which is located approximately 1 mile west of State Route 20. Additional consultation with Island County Public Works will be needed to verify the suitability of this route.
- The removal of Dike Road will also require the relocation of overhead electrical transmission and distribution lines, and fiber optic located beneath the roadway prism. The new routing for these utilities is presumed to follow E Frostad Road west and parallel the new State Route 20 alignment. The electrical lines may continue north directly to Jones Road and turn east to close the loop. An easement will be required to span the hillside between State Route 20 and Jones Road. The fiber optic duct bank, however, will continue to follow the State Route 20 alignment west to the intersection with Jones Road and then loop back to the east. The ultimate configurations will be refined through consultation with the franchise utility owners. In addition, multiple residential structures with utilities will need to be removed prior to inundation.

For the partial restoration alternative:

- The geometry of the realigned State Route 20 will have similar design considerations as the full restoration alternative. The proposed bridge will be 200 feet long with two spans of about 100 feet consisting of 5-foot-2-inch-deep pre-cast concrete girders (Figure 10-4).
- Dike Road will be raised to a minimum elevation of 14.8 feet along the entire existing alignment. The horizontal geometry meets the standards for the 35 mph design speed for this roadway classification with use of superelevation, so no changes are proposed. The roadway embankment will transition up to a bridge

section (elevation 21 feet NAVD 88) spanning the tidal channel.

- The proposed bridge on Dike Road will be approximately 750 feet long with seven spans spaced at about 107 feet consisting of 5-foot-2-inch-deep pre-cast concrete girders.
- The bridge has been designed along a curved horizontal alignment. During the design of this action, a straight alignment along the bridge should be evaluated. While this would result in a longer bridge with construction further into the estuary, it would provide a benefit in terms of constructability and sight distance.
- The finished grade of State Route 20 will be a minimum of 14.8 feet along its entire length, approximately 9 feet higher than the existing roadway elevation. The intent is that the highway will remain open to traffic during construction and, therefore, the new alignment has been shown to be constructed parallel to the existing. The roadway embankment will transition up to a bridge section (elevation 21 feet NAVD 88) spanning the tidal channel.
- For both bridges considered for partial restoration, the bridge substructure consists of columns supported on drilled shafts. The assumed embedment depths of the drilled shafts are 100 feet.

10.3.7 Construction Considerations

Construction activities within the estuary would be completed first for both alternatives, since equipment access would be limited under tidal action after the dike is breached. Staging areas for construction are assumed to be available in the upland areas surrounding Dugualla Lake for both full and partial restoration, as construction will be completed before Dike Road is breached.

The majority of the earthwork could be accomplished with low-ground-pressure equipment such as a tracked excavator. This equipment could also be used to place other materials such as sand/gravel on the restored tidal spit and the adjacent upper intertidal shoreline. All excavated materials will be disposed of offsite with the exception of armoring debris that has been identified as suitable for reuse on site. A disposal location for the fill will be determined during a later design stage.

Earthwork seaward of the dike would be limited to low tide hours, most likely in the summer and possibly only during certain tidal cycles. Excavation of the proposed tidal channel would be accomplished in the dry to the extent possible.

Temporary shoring would be required during the demolition of the tide gate/pumping system and the construction of the Dike Road bridge as part of the partial restoration alternative. Other utilities that would be affected include transmission lines, fiber optic cable, and utilities associated with residential structures that would need to be removed prior to tidal inundation.

A drilled-shaft oscillator would be used to install the drilled shafts. It is assumed that the contractor will be able to install one shaft per week. Large-diameter casing shoring would be required to keep water out and allow access to the top of the shaft for column form placement and removal. Once the shafts are installed, the columns are cast inside the shoring casing. After the casing is removed, the cast-in-place pilecaps and bridge superstructure are constructed.

Access and staging for the proposed State Route 20 bridge construction will be provided via the land adjacent to the causeway. Access and staging for the proposed Dike Road bridge construction will be provided via the existing roadway berm.

For the full restoration alternative, construction of the 19-span bridge structure would require up to 16 months. For the partial restoration alternative, construction of the two-span and seven-span bridge structures would require up to 6 months and 10 months, respectively. Concrete bridges require very little maintenance. The current standard is to inspect bridges every 2 years.

Settlement of the native soils from the addition of roadway fill under the partial restoration alternative is not anticipated to be significant. However, geotechnical evaluation will be needed to confirm that any soil consolidation would occur during construction, without the need for extended settlement monitoring.

10.4 Extent of Stressor Removal

Table 10-2 describes the amount of stressors to be removed with this action.

Table 10-2. Stressor Removal

Stressor	Full Restoration	Partial Restoration
Tidal Barrier (LF)	7,100	4,280
Fill (SF)	556,000	108,000
Armor (LF)	3,160	2,180
Nearshore Roads (LF)	3,310	0

10.5 Expected Evolution of the Action Area

Following full restoration, the tidal channel constructed at the mouth of newly restored estuary and across the intertidal mudflats within Dugualla Bay will migrate, erode, and accrete as part of natural tidal hydrodynamic and sediment transport processes. The tidal channel network will likely become more complex than the single tidal starter channel that will exist immediately following construction. Sediment deposition along the western shoreline of Dugualla Bay will be affected due to increased tidal currents into and out of the restored estuary. Substantial sediment is anticipated to deposit within the restored estuary, as well as along the shoreline, and may also be carried farther out into Dugualla Bay due to larger ebb tide currents. The sediment deposition, freshwater inputs, and tidal hydrology within the restored estuary will support development of a more complex tidal channel network than the single Dugualla Creek channel and lake that exist. Littoral transport along the shoreline will be affected by tidal currents into and out of the estuary, which may change the location and extent of shoreline features adjacent to the estuary mouth, including the restored barrier beach.

The floodplain within the restored estuary will change dramatically. The type and extent of vegetation will be altered as the environment shifts from primarily freshwater marsh and agricultural fields to saltwater marsh and tidal channels. Increased tidal flow and wave energy will increase topographic and habitat complexity within the estuary tidelands. Sediment transport processes (due to increased tidal and wave energy in the estuary) will induce patterns of sediment erosion (in tidal channels) and deposition (in backwater areas) within the estuary.

Partial restoration will allow for full tidal inundation of the estuary. Partial removal of Dike Road (limited to a 750 LF section) will limit the ability of the tidal channel to migrate within its historic footprint. The remainder of the State Route 20 road embankment will impede tidal flow to areas west of the roadway, and continue to confine the flow to a 200-foot-wide channel under the roadway. Changes to the floodplain and vegetative cover of the restored estuary will be similar to full restoration. Some anticipated differences include limited channel migration at Dike Road and State Route 20, and less complex sediment transport patterns with the estuary and along the shoreline at the mouth.

Invasive species are known to be present within the diked sections of Dugualla Bay that support agricultural lands and residences. No specific areas have been delineated. Changes in site hydrology associated with the tidal exchange will create conditions not likely to be tolerated by many of these species. However, other invasive species may adapt or increase under changed conditions, and careful invasive species control will be necessary to support the establishment of native vegetation within the action area.

10.6 Uncertainties and Risks

The potential for contamination of sediments within Dugualla Lake due to a past fuel spill at NAS Whidbey remains a risk for any restoration alternative. A sediment characterization would be needed to evaluate the nature and extent of any contamination and inform restoration design efforts (Lowe 2010).

Private landowners do not all appear to be in favor of the restoration project, in particular the farm located to the south of the lake (Hinton 2010). The willingness of all the landowners to cooperate and sell property or provide easements is uncertain. In addition, there may be operational issues at the Naval Air Station that could interfere with construction; coordination with NAS Whidbey will minimize these risks.

Logistics involved in permanent and temporary road closures (Dike Road removal and construction on State Route 20) and in rerouting the power and fiber optic lines are significant uncertainties for the full restoration alternative in particular.

Dike Road and State Route 20 are built on earthen berms over potentially liquefiable underlying soils (former tidal marsh). These roads may be at risk for significant damage during a major earthquake event if no restoration is undertaken. The restoration project provides more certainty than no action regarding the ability of the pile-supported road structures to withstand earthquakes.

There is anecdotal information questioning the stability of Dike Road and its ability to withstand an earthquake or other natural disaster (PSNERP 2010). The slope stability of Dike Road under partial restoration will need to be evaluated further in subsequent design stage.

10.6.1 Risks Associated with Projected Sea Level Change

Sea level change as estimated for the project area will increase the extent of tidal inundation into the restored estuary. This will need to be taken into account when evaluating properties at risk of flooding post-project, and designing the proposed improvements to State Route 20, Dike Road, and utility corridors. Sea level change under the high scenario is expected to result in changes to the distribution of estuary habitats, such as marsh, and distribution of adjacent upland riparian habitats. Table 10-3 compares potential risks associated with projected sea level changes based on professional judgment.

Table 10-3. Risks of Sea Level Change

	Projected Sea Level Change		
	High (46 cm)	**Intermediate (4 cm)**	**Low (-8 cm)**
Full Restoration	Moderate to high: Will significantly increase the footprint and elevation of the flooded area and will require additional land acquisition of flooded properties. Will increase the deck/roadway elevation for proposed roadway improvements. May increase flooding outside of the project area along drainage pathways into the estuary during high tide. Shifts in estuary and riparian habitats anticipated to higher elevation ranges. Increased tidal prism will affect channel development and morphology.	Low: Will slightly increase the footprint of the flooded area and may require additional land acquisition of flooded properties. Will slightly increase the deck/roadway elevation for proposed roadway improvements.	None
Partial Restoration	Moderate to high: Will significantly increase the footprint of the flooded area and require additional acquisition of flooded properties. Will increase the deck/roadway elevation for proposed roadway improvements. May increase flooding outside of the project area along drainage pathways into the estuary during high tide. May require larger culvert under Dike Road and larger bridge section at State Route 20. Shifts in estuary and riparian habitats anticipated to higher elevation ranges. Increased tidal prism will affect channel development and morphology. Some scour at State Route 20 and Dike Road bridge abutments may require armor.	Low: Will slightly increase the footprint of the flooded area and may require additional land acquisition of flooded properties. Will slightly increase the deck/roadway elevation for proposed roadway improvements. May require slightly larger culvert under Dike Road.	None

10.7 Potential Monitoring Opportunities

Monitoring is important for evaluating restoration success. A combination of field surveys and aerial photographs would be used to document biological and physical changes to the landscape. Monitoring data can be used to refine adaptive management and corrective actions, as needed. Some of the key monitoring needs and opportunities associated with this action are summarized in Table 10-4.

Table 10-4. Monitoring Needs and Opportunities

Monitoring Parameter	Key Performance Indicator	Note
Topographic Stability		
Sediment Accretion / Erosion	X	Monitor patterns of sediment erosion (in tidal channels) and deposition (in backwater areas) within the estuary. Monitor littoral transport along the shoreline, near the estuary mouth and the restored barrier beach. Monitor suspended sediment load data from the North Fork Skagit.
Wood Accumulation		
Soil / Substrate Conditions		
Vegetation Establishment	X	Document changes in type and extent of vegetation from freshwater to saltwater marsh.
Marsh Surface Evolution / Accretion		
Tidal Channel Cross-Section / Density	X	Document development of complex tidal channel network.
Water Quality (contaminants)		
Salinity	X	Monitor temperature/salinity spatially and temporally.
Shellfish Production		
Extent of Invasive Species	X	Monitor for changes in type/extent of invasive species once tidal hydrology is restored.
Animal Species Richness	X	
Fish (salmonid) Access/Use	X	
Forage Fish Production		
Wildlife Species Use		
Effectiveness of Exclusion Devices		

10.8 Information Needed for Subsequent Design

This conceptual design report represents an initial step in the restoration design sequence. The design concepts described above were developed based on readily available information without the level of site-specific survey and investigation that is necessary to support subsequent design and implementation. Substantial additional information will be required at the preliminary and later design stages to confirm the design assumptions, refine quantity estimates, address property and regulatory issues, obtain stakeholder support, and fill in data gaps. This section attempts to define the most essential information needs for this action.

- Property Investigation/Survey – More detailed information on parcel ownership and property boundary locations will be needed to finalize the design, confirm acquisition requirements, and support negotiations with property owners.
- Topographic/Bathymetric Survey – Bathymetry survey data within Dugualla Lake and Dugualla Bay adjacent to the project site would be required for design of both restoration alternatives. Full and partial restoration would require a topographic survey of the entire upland area that would be affected by tidal inundation, as well as State Route 20, Dike Road, and other dikes/fill within the project area. In addition, survey information for all hydraulic structures (culvert at State Route 20, tide gate infrastructure) and utilities would be required. The survey data would be used to refine design of key project elements and develop detailed construction and demolition plans. Survey data could also be used as a baseline for pre- and post-construction modeling, including hydrodynamic modeling.
- Geotechnical Investigation – Geotechnical investigations and recommendations for bridge foundation and slope stability of Dike Road and State Route 20 are needed. Hydraulic engineering recommendations for scour and minimum bridge clearance over water are needed based on modeling.
- Cultural Resources Investigation – Surveys for archaeological and historic resources may be required for this action area as it has a high likelihood of having past use by Native Americans. This is particularly important in areas proposed for excavation.
- Hydraulic Analysis/Modeling – Tidal circulation, flood, and wave modeling will be required to evaluate impacts to the estuary and adjacent properties post-restoration and validate the assumptions outlined in the *Applied Geomorphology Guidelines and Hierarchy of Openings* (Appendix C). The models will also be used to optimize the size of the opening in the partial restoration alternative, and to provide design criteria for proposed roadway and utility improvements for both restoration alternatives. Results from the modeling will be utilized by a hydraulic engineer to provide recommendations for culvert sizing (for partial restoration) and scour and minimum deck/bridge elevations for both State Route 20 and Dike Road (both full and partial restoration). A temporary tide gauge may be needed in the early design stages to obtain site-specific tidal statistics. Modeling and analysis could be used to update floodplain maps.
- Contaminant Survey – If preliminary investigations suggest that hazardous material could be present in the action area, additional soil and sediment analysis may be needed. A sediment characterization study of Dugualla Lake and Creek is recommended, given the proximity and anecdotal information about potential fuel spills at NAS Whidbey affecting this waterbody. The introductory chapter describes the Phase I site investigations that are occurring as part of this overall effort via a separate contract.

- Sediment Transport Study – Assessment of sediment transport dynamics may be needed to optimize the channel opening and to address concerns about restored tidal marsh evolution and sustainability. Sediment transport evaluations should be conducted (based on modeling results) to optimize the channel opening and other planned excavation activities to reduce the risk of infilling of the constructed channel and restored estuary over time.
- Sea Level Change Projection – Estimates of sea level change for the conceptual design were based on calculations provided by the Washington Department of Fish and Wildlife and the Corps of Engineers using guidance in Corps' Engineering Circular No. 1165-2-211. Projections for each project area will be refined using localized tide gauge data during later design stages.
- Other – The location and extent of invasive species require further documentation. The suitability of excavated materials for use as onsite fill and armoring should also be evaluated.

10.9 Quantity Estimates

The design quantities are largely developed from LiDAR data sets lacking the resolution to accurately quantify all elements of construction. These are supplemented by unmeasured estimates made during one site visit at high tide and areal take-offs from available imagery. The quantity spreadsheets for the full and partial restoration alternatives are provided in Exhibits 10-1 and 10-2.

10.10 References

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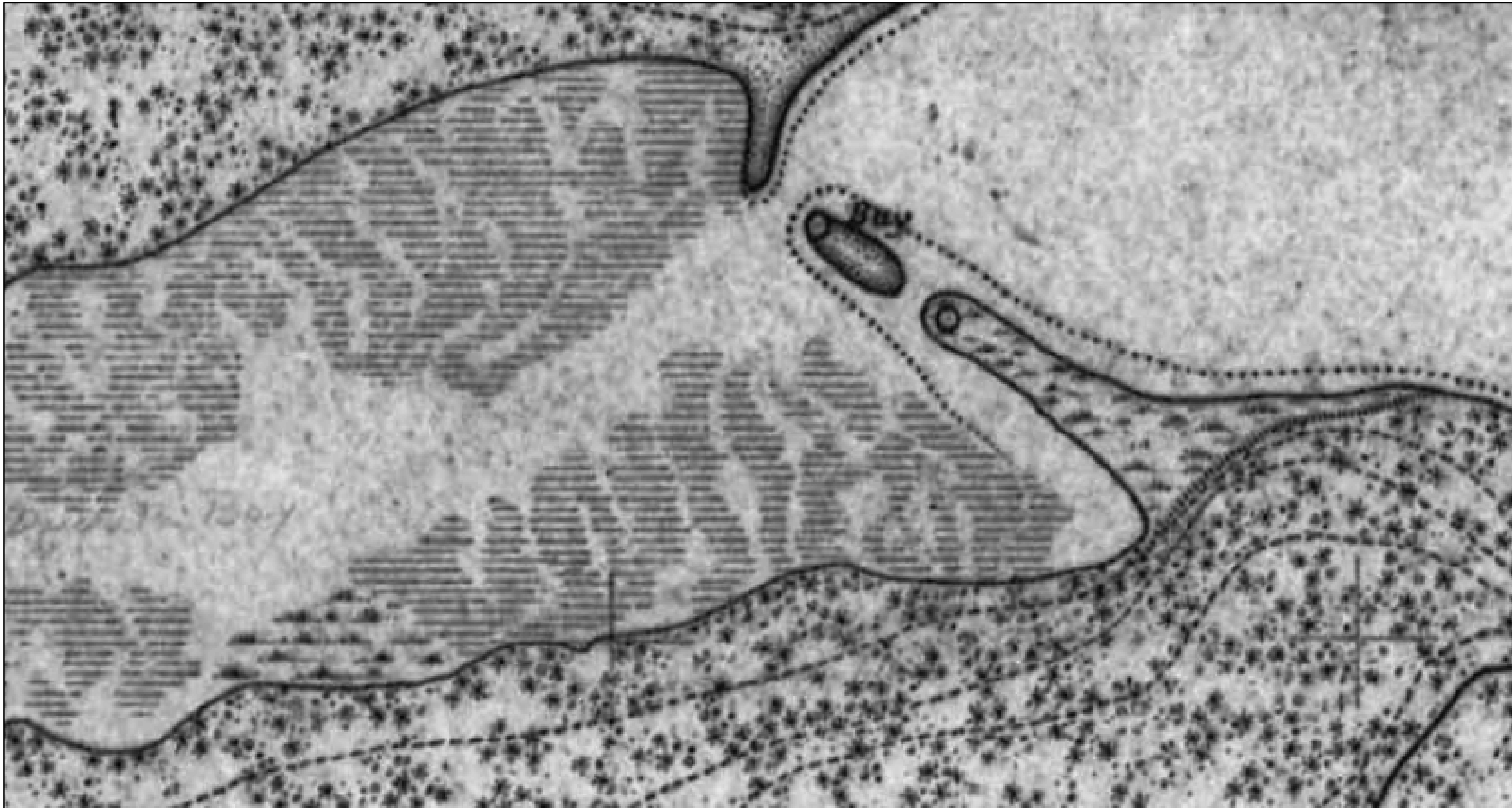

0 540
Feet
0 160
Meters

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Historic Map (T-Sheet)
Action Name: Dugualla Bay Restoration
PSNERP ID #: 1609
Figure 10- 2A

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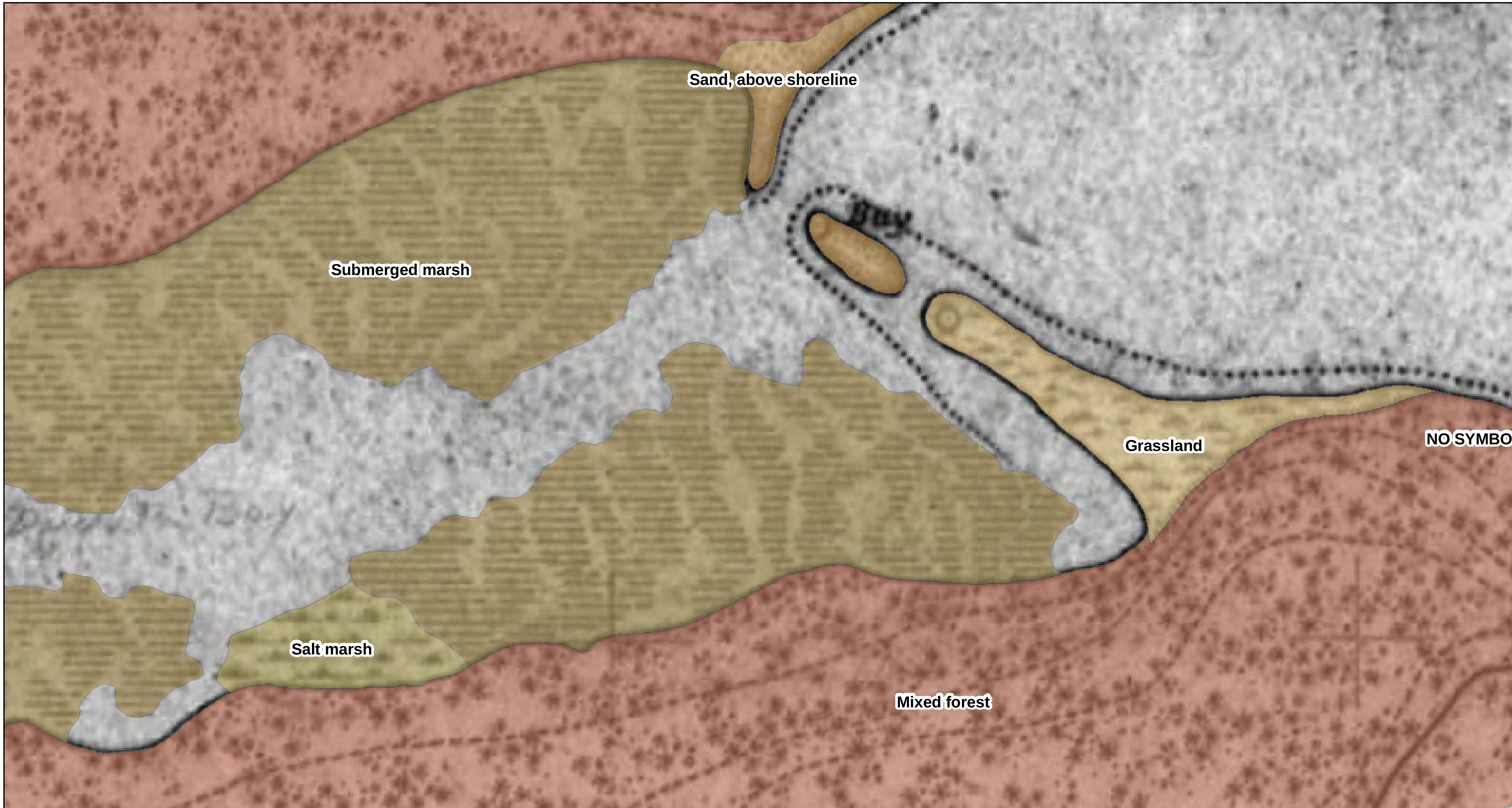

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Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64

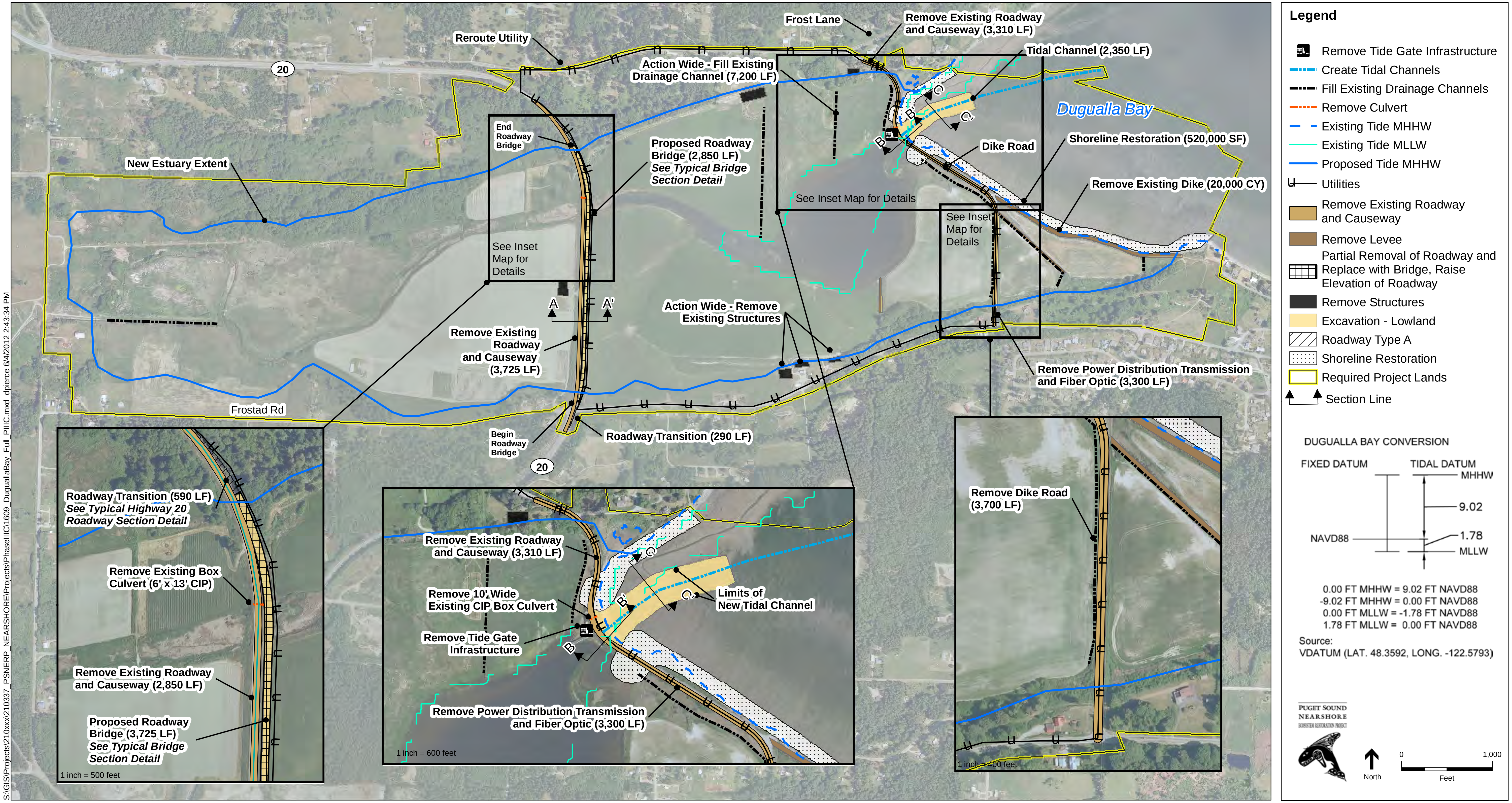
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Historic Map (T-Sheet) and River History Project Data

Action Name: Dugualla Bay Restoration

PSNERP ID #: 1609

Figure 10- 2B



S:\GIS\Projects\210xxx\210337_PSNERP_NEARSHORE\Projects\PhaseIIC\1609_DuguallaBay_Full_PIIIC.mxd dpierce 6/4/2012 2:43:34 PM

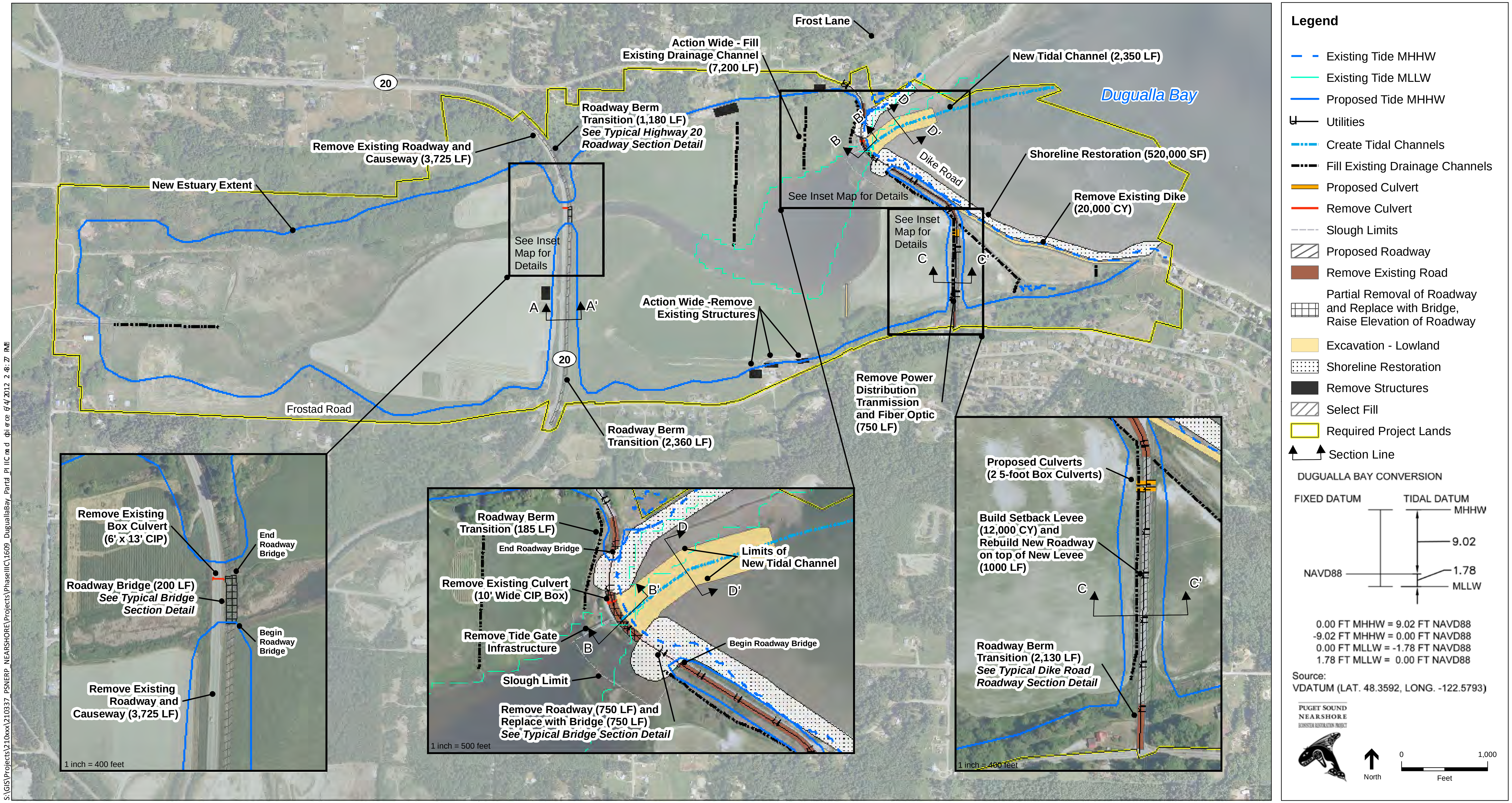
SOURCE: Washington Counties Parcels (2009); Action Area (PSNERP, 2010); High Resolution Orthoimagery (USGS, 2009)

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Lead Contractor: ESA
Design Lead: Anchor QEA, G. Sassen, ASLA
Date: 05/2012

Conceptual Design Plan
Site Name: Dugualla Bay
Action Name: Dugualla Bay
PSNERP ID #: 1609
Full Restoration

Figure 10-3



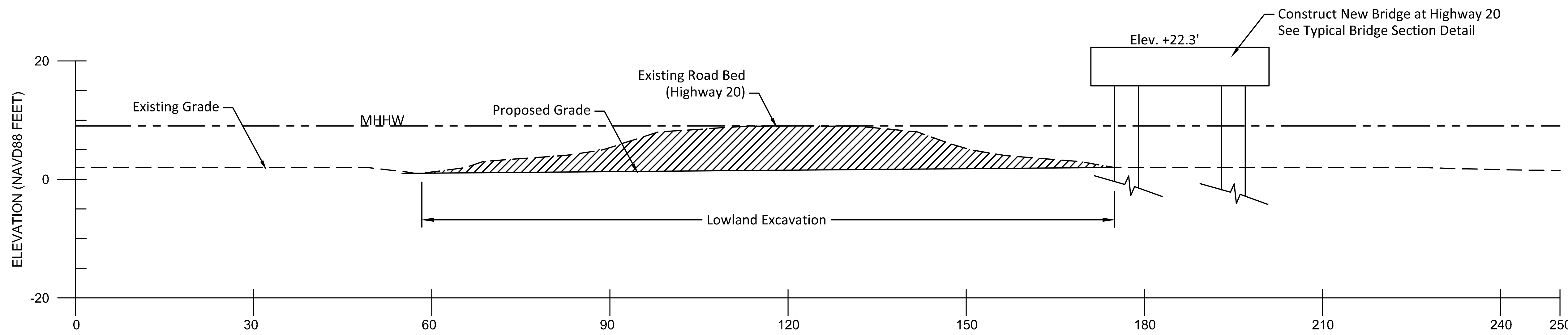
SOURCE: Washington Counties Parcels (2009); Action Area (PSNERP, 2010); High Resolution Orthoimagery (USGS, 2009)

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

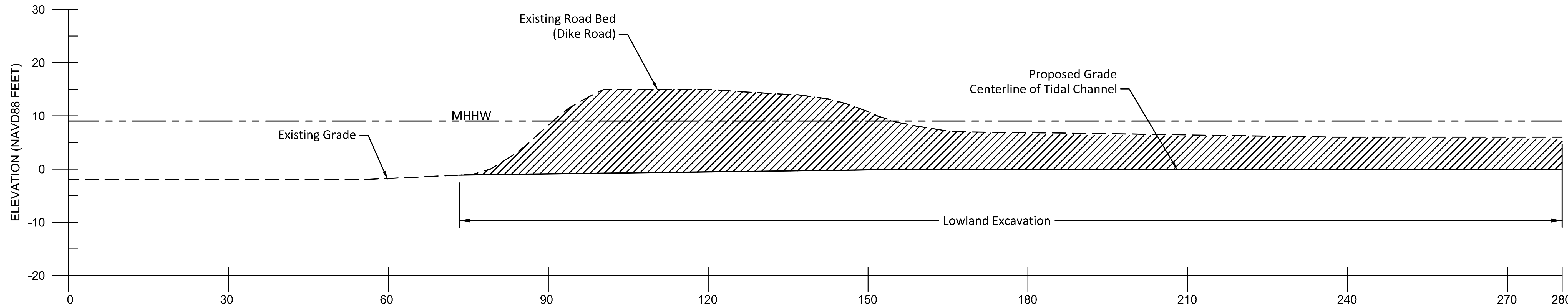
Lead Contractor: ESA
Design Lead: Anchor QEA, G. Sassen, ASLA
Date: 05/2012

Conceptual Design Plan
Site Name: Dugualla Bay
Action Name: Dugualla Bay
PSNERP ID #: 1609
Partial Restoration

Figure 10-4

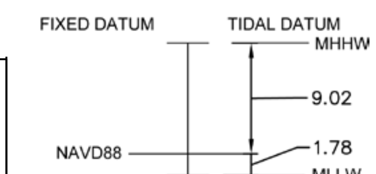


A FULL RESTORATION TYPICAL SECTION



B FULL RESTORATION TYPICAL SECTION

DUGUALLA BAY CONVERSION



0.00 FT MHHW = 9.02 FT NAVD88
-9.02 FT MHHW = 0.00 FT NAVD88
0.00 FT MLLW = -1.78 FT NAVD88
1.78 FT MLLW = 0.00 FT NAVD88

Source:
VDATUM (LAT. 48.3592, LONG. -122.5793)

EXISTING GRADE HATCH	PROPOSED GRADE HATCH
BEACH	CUT
OTHER	FILL
EXISTING GRADE	PROPOSED GRADE

NOTES: Elevation of MHHW within the restored estuary is assumed to be the same as the MHHW elevation seaward of the existing dike for the purposes of the conceptual design.

0 20
Scale in Feet

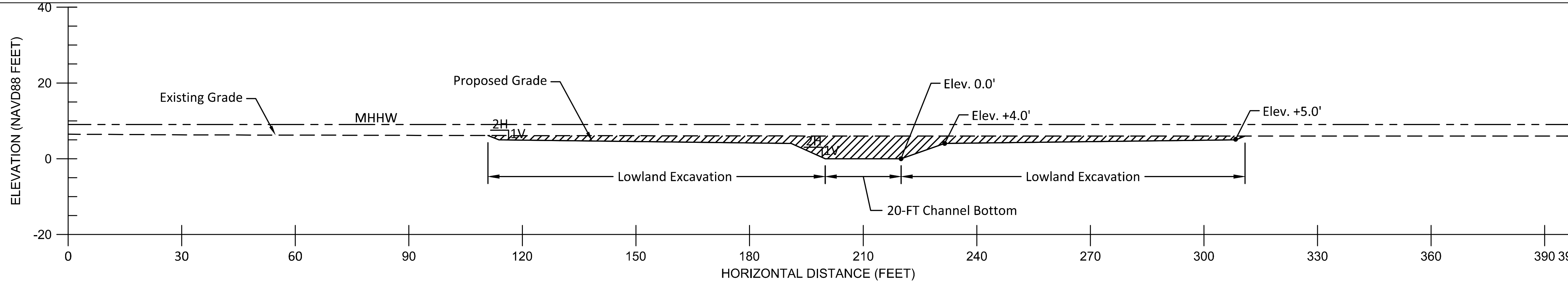
PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: Anchor with KPFF, G. Sassen, ASLA
Date: 05/2012

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Section
SITE NAME: **Dugualla Bay**
ACTION NAME: **Dugualla Bay Restoration**
PSNERP ID#: **1609**
Full Restoration

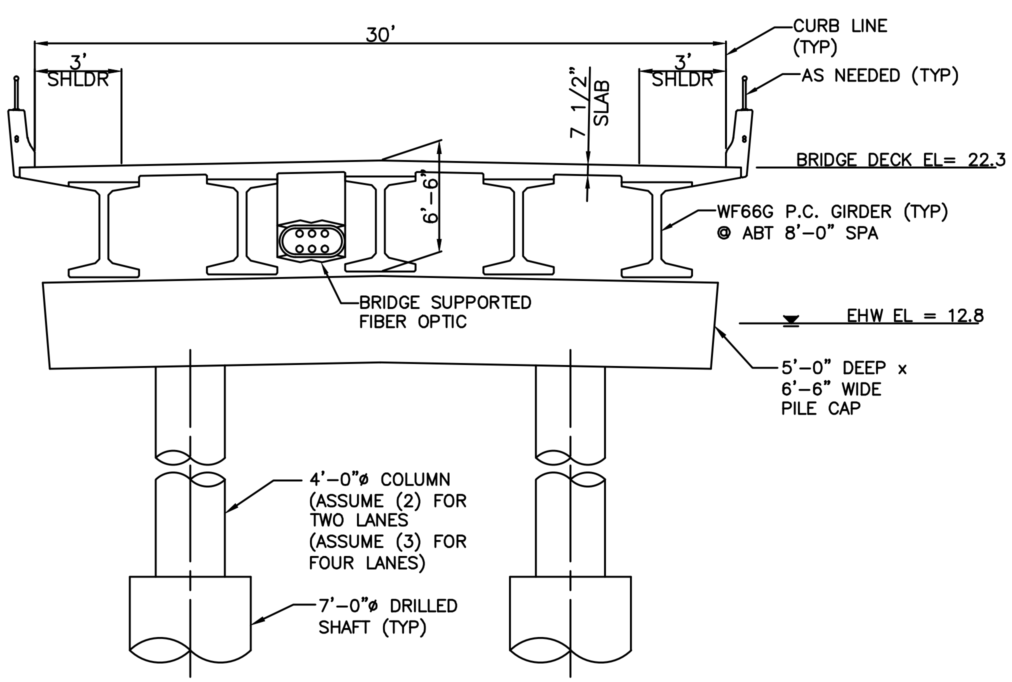
Figure 10-5



C FULL RESTORATION TYPICAL SECTION

NOTES: Elevation of MHHW within the restored estuary is assumed to be the same as the MHHW elevation seaward of the existing dike for the purposes of the conceptual design.

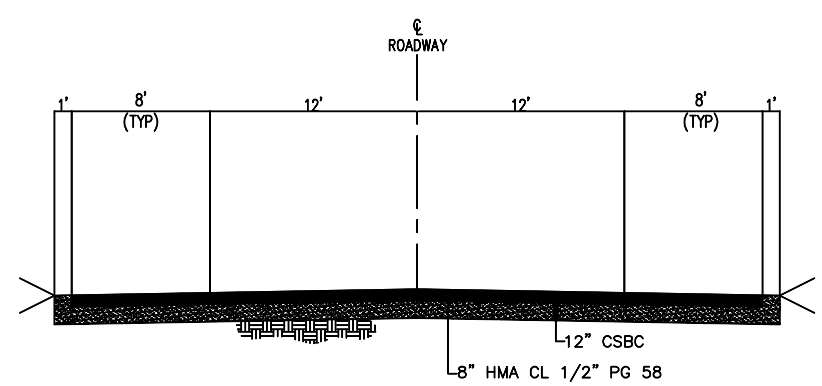
EXISTING GRADE HATCH	PROPOSED GRADE HATCH
BEACH	CUT
OTHER	FILL
EXISTING GRADE	PROPOSED GRADE



SECTION/DETAIL
Typical Bridge
Not to Scale
Section Provided by KPFF

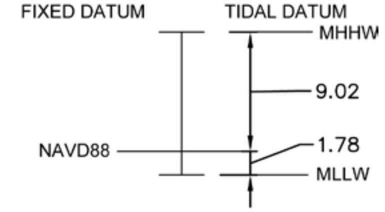
NOTE: 150' SPAN (FULL SR20)
EXTREME HIGH WATER (EHW) = EL 12.8

NOTE: 150' SPAN (FULL SR20)
EXTREME HIGH WATER (EHW) = EL 12.8



SECTION/DETAIL
Typical Highway 20 Roadway
Not to Scale
Section Provided by KPFF

DUGUALLA BAY CONVERSION



0.00 FT MHHW = 9.02 FT NAVD88
-9.02 FT MHHW = 0.00 FT NAVD88
0.00 FT MLLW = -1.78 FT NAVD88
1.78 FT MLLW = 0.00 FT NAVD88
Source:
VDATUM (LAT. 48.3592, LONG. -122.5793)

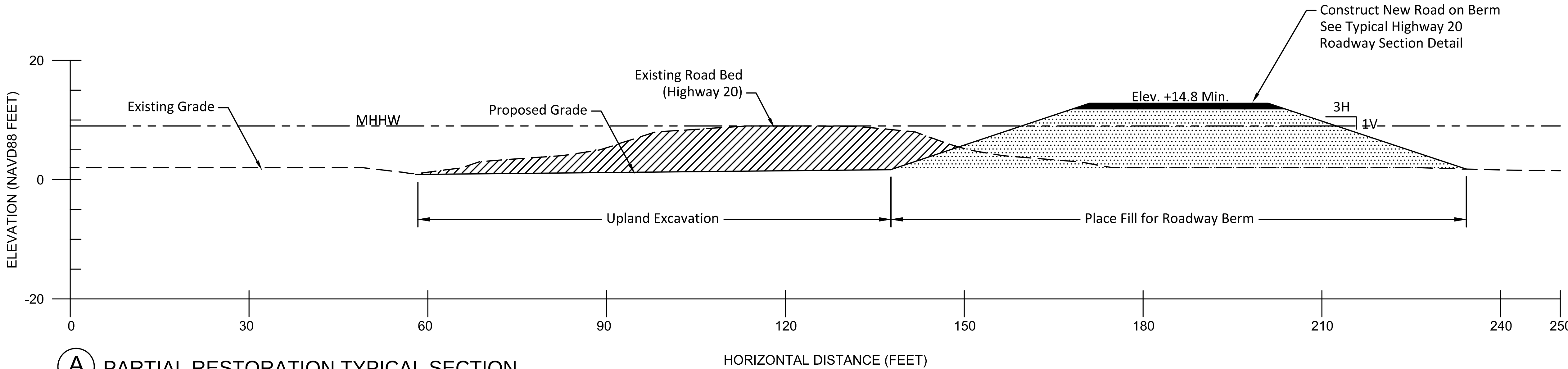
PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: Anchor with KPFF, G. Sassen, ASLA
Date: 05/2012

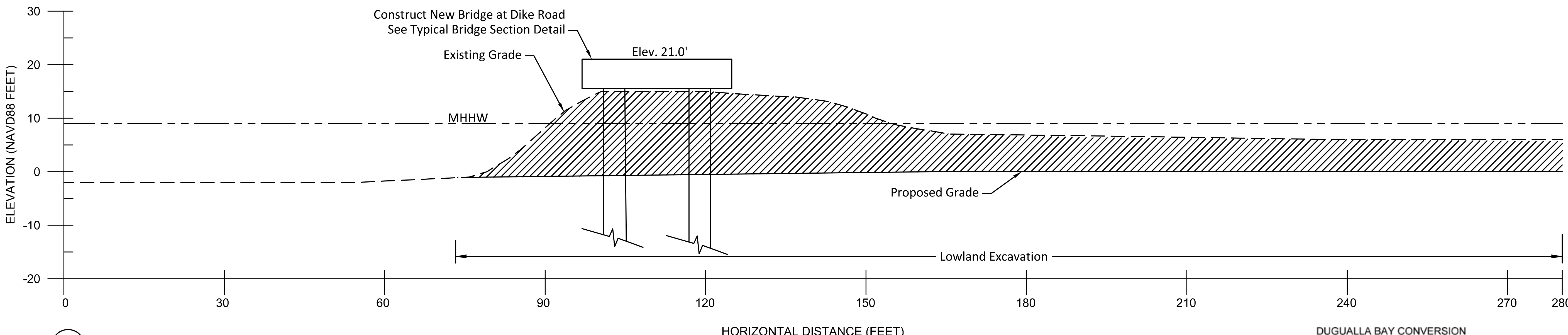
Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Section
SITE NAME: **Dugualla Bay**
ACTION NAME: **Dugualla Bay Restoration**
PSNERP ID#: **1609**
Full Restoration

Figure 10-6



(A) PARTIAL RESTORATION TYPICAL SECTION

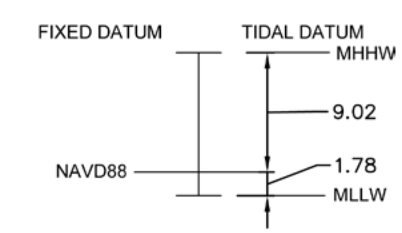


(B) PARTIAL RESTORATION TYPICAL SECTION

EXISTING GRADE HATCH		PROPOSED GRADE HATCH	
	BEACH		CUT
	OTHER		FILL
EXISTING GRADE	— — — — —	PROPOSED GRADE	————

NOTES: Elevation of MHHW within the restored estuary is assumed to be the same as the MHHW elevation seaward of the existing dike for the purposes of the conceptual design.

DUGUALLA BAY CONVERSION



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-9.02 FT MHHW = 0.00 FT NAVD88
0.00 FT MLLW = -1.78 FT NAVD88
1.78 FT MLLW = 0.00 FT NAVD88

Source:
VDATUM (LAT. 48.3592, LONG. -122.5793)

0 20
Scale in Feet

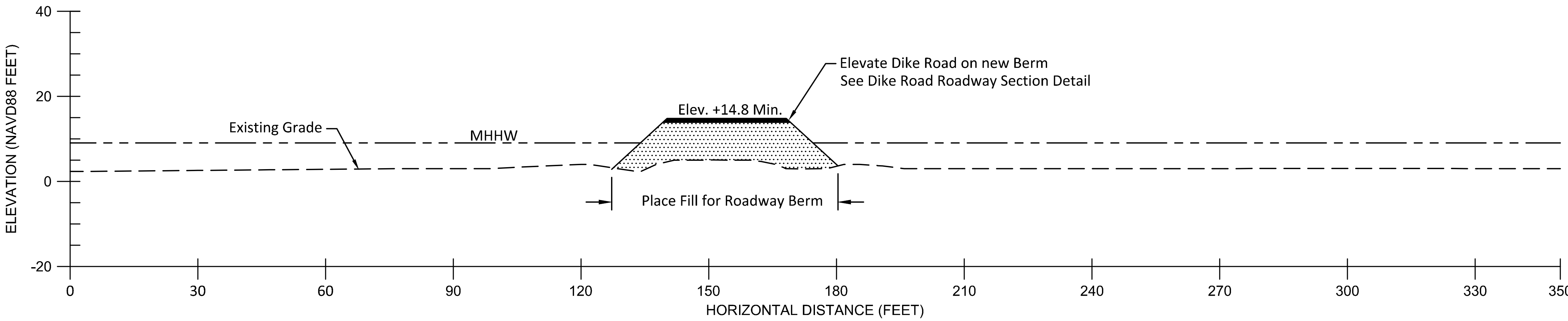
PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: Anchor with KPFF, G. Sassen, ASLA
Date: 05/2012

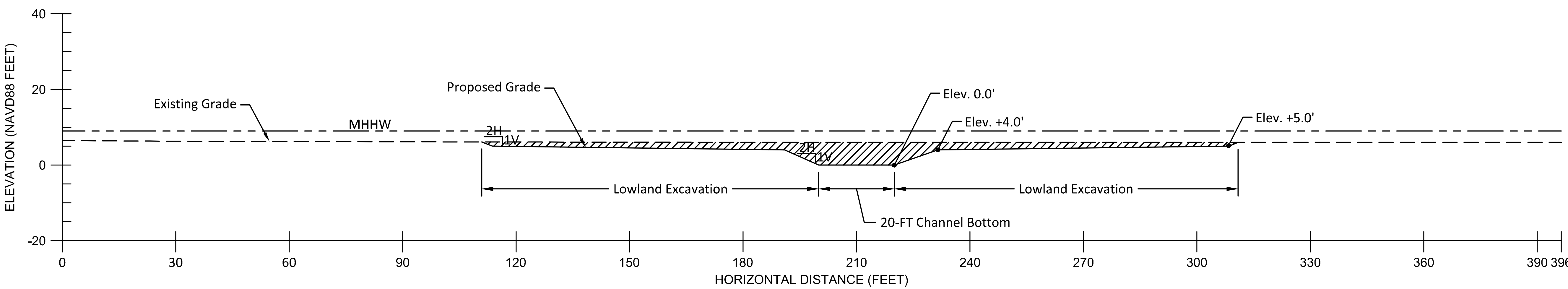
Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Section
SITE NAME: **Dugualla Bay**
ACTION NAME: **Dugualla Bay Restoration**
PSNERP ID#: **1609**
Partial Restoration

Figure 10-7

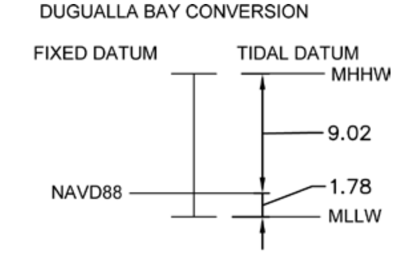


(C) PARTIAL RESTORATION TYPICAL SECTION



(D) PARTIAL RESTORATION TYPICAL SECTION

DUGUALLA BAY CONVERSION



0.00 FT MHHW = 9.02 FT NAVD88
-9.02 FT MHHW = 0.00 FT NAVD88
0.00 FT MLLW = -1.78 FT NAVD88
1.78 FT MLLW = 0.00 FT NAVD88

Source:
VDATUM (LAT. 48.3592, LONG. -122.5793)

0 30
Scale in Feet

EXISTING GRADE HATCH	PROPOSED GRADE HATCH
BEACH	CUT
OTHER	FILL
EXISTING GRADE	PROPOSED GRADE

NOTES: Elevation of MHHW within the restored estuary is assumed to be the same as the MHHW elevation seaward of the existing dike for the purposes of the conceptual design.

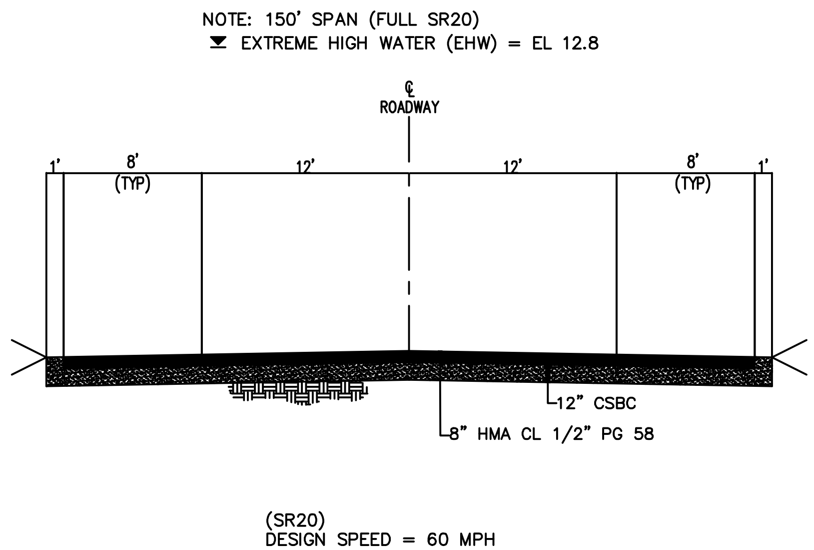
PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: Anchor with KPFF, G. Sassen, ASLA
Date: 05/2012

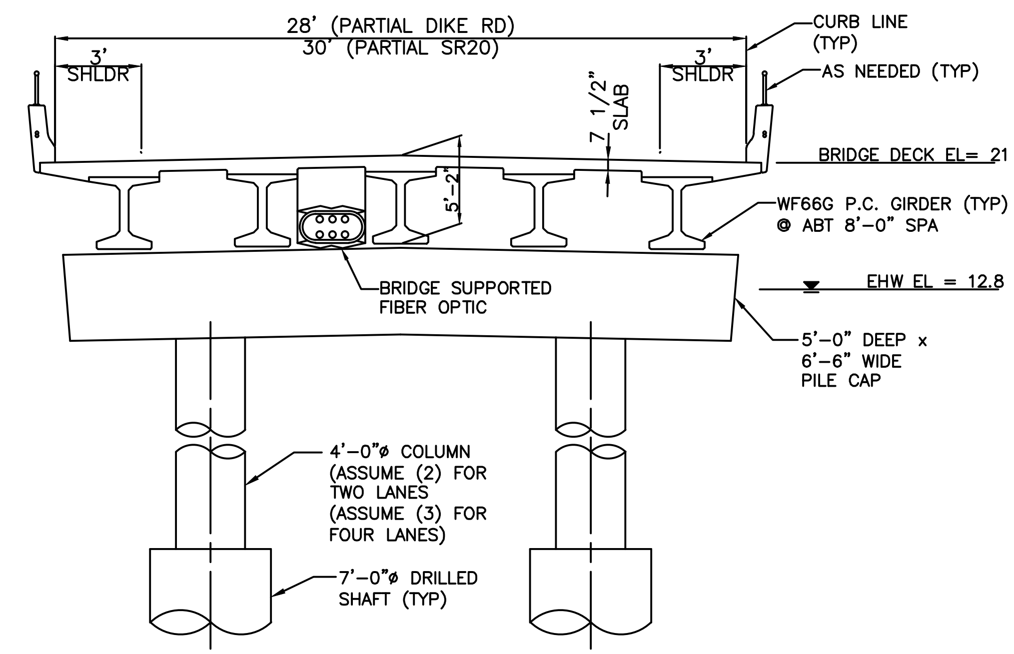
Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Section
SITE NAME: **Dugualla Bay**
ACTION NAME: **Dugualla Bay Restoration**
PSNERP ID#: **1609**
Partial Restoration

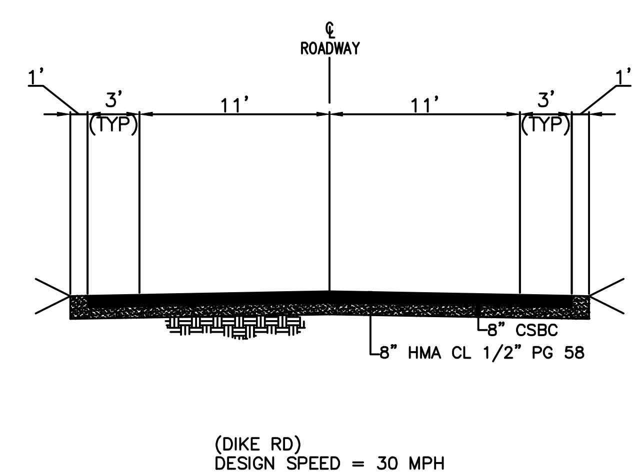
Figure 10-8



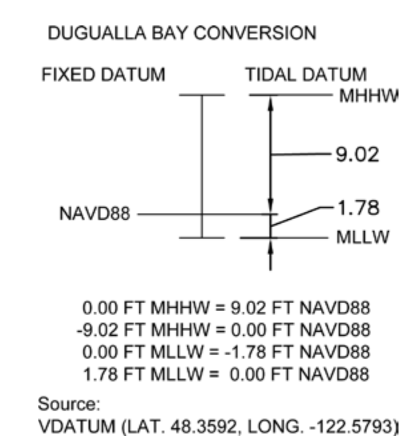
SECTION/DETAIL
Typical Highway 20 Roadway
Not to Scale
Section Provided by KPFF



SECTION/DETAIL
Typical Bridge
Not to Scale
Section Provided by KPFF



SECTION/DETAIL
Typical Dike Road Roadway
Not to Scale
Section Provided by KPFF



PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: Anchor with KPFF, G. Sassen, ASLA
Date: 05/2012

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)
Conceptual Design Section
SITE NAME: **Dugualla Bay**
ACTION NAME: **Dugualla Bay Restoration**
PSNERP ID#: **1609**
Partial Restoration

Figure 10-9

Full Restoration Quantity Estimate

Action Name: Dugualla Bay
Action #: 5/27/1904 0:00
Date: February 2011 Revised May 2012
By: Gisele Sassen, Anchor QEA, LLC

REMEDY: ***Remove dikes and road embankments to restore tidal exchange within estuary and construct bridge***
Construction Period: 78 weeks of construction

Item	Unit of Measure	Material Name	Qty	Description of Item		Indicate Section of design report where item is described
ACQUISITION AND CONSERVATION				Based on available mapping information		
The design quantities are largely developed from LiDAR data sets lacking the resolution to accurately quantify all elements of construction. These are supplemented by unmeasured estimates made during one site visit at high tide and areal take-offs from available imagery.						
Required Project Lands	Acre		487	Total land required For action; other areas include the SR 20 ROW and land owned by the Diking District ; not including Navy property		10.3
Proponent / Partner-owned lands	Acre		35	Whidbey Camano Land Trust property		10.3
Lands To Be Acquired	Acre		452	Estimated prinate property required to be acquired for action prior to implementation		10.3
Material Sites				Not Used: See Earthwork - Imported Fill.		
MOBILIZATION AND ACCESS for construction activities				Description required for each item to facilitate cost estimating		
The design quantities are largely developed from LiDAR data sets lacking the resolution to accurately quantify all elements of construction. These are supplemented by unmeasured estimates made during one site visit at high tide and areal take-offs from available imagery.						
Mobilization - Typical (Equipment, Personnel, Planning, Financial)	LS		1	Up front costs such as bonding, planning and other staff time and financing. Typically, assume 8% to 10% of other items.		10.3
Mobilization - Remote (Equipment, Personnel, Planning, Financial	LS		NA			
Site Access	LS		1	New SR 20 Bridge		10.3
Barge Access	Days		NA			
Temporary Traffic Control (one of the following)				Includes installation of traffic signals, signage, signmen, etc. There are 4 types as follows		
none	LS		NA			
signs	LS		2	Construction signage at both sides to alert of construction & lane shifting		10.3
flags / spotters; crews at both sides for transitions	LS		1	Flags and spotters only durng roadway transition connection at SR20, approx. duration 2 month		10.3
unique	LS		NA			
Temporary Roadway	SF		NA			
Control of Water	LS		1	Temporary control of water associated with dike breach at former Dike Road		10.3
Relocation Activities				Not Used: See Utilities, Structures		
Site Demolition Activities				Demolition and removal of structures (description required), temporary features and relocations, itemized separately); Clearing and grubbing of vegetation, and removal of minor debris (rocks, slabs) - description required.		
The design quantities are largely developed from LiDAR data sets lacking the resolution to accurately quantify all elements of construction. These are supplemented by unmeasured estimates made during one site visit at high tide and areal take-offs from available imagery.						
Clearing and Grubbing (one or more of following)				Use one or more of the following categories of clearing and grubbing		
Clear Vegetation - Local Disposal	AC		NA			
Clear /Grub Vegetation - Local Disposal	AC		NA			
Clear /Grub Vegetation - Offsite Disposal	AC		NA			
Clear, stockpile - large woody debris	CY		NA			
Hydraulic Structures - Small	LS		1	Removal of tide gate and pumping system at Dike Road; 10-foot wide box culvert at Dike Road; 6'by13' box culvert at SR 20		10.3
Hydraulic Structures - Large	LS		NA			
	SF		NA			
Utilities	LS or LF					
Overhead Electrical Transmission	LF		3300	PSE Overhead Power Lines and poles at Dike Road		10.3
Overhead Distrubution	LF		3300	PSE Overhead Power Lines and poles at Dike Road		10.3
Telecommunications	LF		3300	Fiber Optic at Dike Road		10.3
Buildings	LS		1	Remove misc. buildings		10.3
Pavement	SF		241680	Remove Pavement on SR 20 (3725'x40') & Dike Rd (3310'x28')		10.3
Culvert	LF		80	6'x13' CIP Box Culvert at SR 20		10.3
Culvert	LF		80	Culvert at Dike Rd 10' wide		10.3
Bulkheads	LF or SF		NA			
Rock revetments	LF		3,159	Remove rock riprap armoring from the seaward side of the perimeter dike		10.3
Large Coastal Structures (perimeter dike fill)	CY		NA			
Demolition / Removal - Railroad Bridge	SF		NA			
Demolition/Removal - In-water Piling	EA		NA			
Removal - Misc. (e.g. angular rock from beach)	Ton		NA			
Demolition / Removal - Boat Ramp	SF		NA			
Haul - Offsite Disposal of Demolition Debris	Miles		20	Estimate distance (to nearest 10 miles) to disposal site for materials, veg clear and grub, etc.		10.3
Hazardous/Contaminated Waste Removal				These items for earthwork of quality not compatible with wetlands, requiring special handling and disposal. Describe basis for classification as contaminated or hazardous. State known or suspected contamination, describe known similar work.		
Contaminated Earthwork	CY		NA			
Hazardous Earthwork	CY		NA			
Construct Temporary Features				Use as needed for unusual temporary features not included elsewhere (see TESC below)		
EARTHWORK				Expand to include equipment, etc. to facilitate cost estimating.		
The design quantities are largely developed from LiDAR data sets lacking the resolution to accurately quantify all elements of construction. These are supplemented by unmeasured estimates made during one site visit at high tide and areal take-offs from available imagery.						
Excavation	CY		NA	Per yard excavation w/out expected haul		
Excavation - Upland	CY		NA			
Excavation - Lowland	CY		239,000	Perimeter and secondary dikes, SR 20 road berm, Dike Road, misc. berms, mudflat excavation		10.3
Dredging - Bucket - Land	CY		NA			
Dredging - Bucket - Marine	CY		NA			
Dredging - Hydraulic	CY		NA			
Fine Grading	AC		NA			
Fill Placement - local borrow				This is additive to Earthwork -Excavation		
Side cast	CY		NA			
Haul - uncontrolled placement	CY		NA			
Haul, place, compact	CY		NA	Transportation and second handling - estimate distance, placement in lifts, moisture conditioning, compaction testing.		
Stockpile - uncontrolled placement	CY		NA			
Stockpile - controlled placement	CY		NA			
Conveyor placement from stockpile land/water	CY		NA			
Imported Fill						
Select Fill	CY		30,200	Fill existing 6-foot wide and 4-foot deep (assumed dimensions) drainage channels, SR 20 roadway berm transition		10.3
Gravel Borrow, including haul	CY		NA			
Sand / Gravel for Beach Nourishment	CY		14,450	Import and place sand and gravel (18 inch average depth) for shoreline restoration. Will be placed in 50% of the 520,000 SF area identified on the figures as "Shoreline Restoration". 260,000 SF x 18 IN= 14,450 CY		10.3
Cobble for Shore Nourishment	CY		NA			
Embankment Compaction	CY		23,800	SR 20 roadway berm transition		10.3
Topsoil	CY		3,211	Marsh plantings at barrier beach, 6 inch depth		10.3
RESTORATION Features						
The design quantities are largely developed from LiDAR data sets lacking the resolution to accurately quantify all elements of construction. These are supplemented by unmeasured estimates made during one site visit at high tide and areal take-offs from available imagery.						
Channel Rehab / Creation	SF		NA	Channel construction (SF) including imported sediment and habitat materials, excluding excavation		
Invasive Species Control	Acre		NA	Per acre control described in drawings and narrative		
Other Restoration Features/ Activities	LS		NA	Describe other items not included elsewhere		
Structures	EA					
The design quantities are largely developed from LiDAR data sets lacking the resolution to accurately quantify all elements of construction. These are supplemented by unmeasured estimates made during one site visit at high tide and areal take-offs from available imagery.						
Water Control Structures - Culverts with Gates	EA		NA			
Water Control Structures - Weirs	EA		NA			
Rock Slope Protection	LF		NA			
Other	EA		NA			
Elevated Boat Ramp	SF		NA			
Fencing	SF		NA			

Full Restoration Quantity Estimate

Action Name: Dugualla Bay
Action #: 5/27/1904 0:00
Date: February 2011 Revised May 2012
By: Gisele Sassen, Anchor QEA, LLC

REMEDY: ***Remove dikes and road embankments to restore tidal exchange within estuary and construct bridge***
Construction Period: 78 weeks of construction

	Item	Unit of Measure	Material Name	Qty	Description of Item		Indicate Section of design report where item is described
Utilities					Replacement or relocation. Designer to provide size and material and have separate line item for each run. Incidentals include earthwork, testing, hook up fees, etc. These quantities do not include demolition of existin utilities, real estate / easements, design fees. Describe the owner if known, and whether utility franchise will install (e.g.. electric is typically installed by electrical franchise		
	The design quantities are largely developed from LiDAR data sets lacking the resolution to accurately quantify all elements of construction. These are supplemented by unmeasured estimates made during one site visit at high tide and areal take-offs from available imagery.						
	Water	LF		NA			
	Gas	LF		NA			
	Electric	LF		NA			
	Electric Transmission	LF		11125	PSE Overhead lines and poles at Dike Rd routed via SR2(		10.3
	Eletctric Distribution	LF		11125	PSE Overhead lines and poles at Dike Rd routed via SR2(		10.3
	Sewer	LF		NA			
	Telecommunications	LF		14375	Fiber Optic at Dike Rd routed via SR20		10.3
	Other	LF		NA	Others = whatever is required (e.g.. power towers, petroleum, jet fuel, etc.		
Roadway / Railway							
	The design quantities are largely developed from LiDAR data sets lacking the resolution to accurately quantify all elements of construction. These are supplemented by unmeasured estimates made during one site visit at high tide and areal take-offs from available imagery.						
	Roadway (Type_)	SF		35200	Roadway 8" ASPH w/ 12" Base 40' wide x 880LF on SR2(		10.3
	Roadway - Traffic Signal	LS		NA			
	Culvert (type)	LF		NA			
	Culvert - Jacking	LF		NA			
	Culvert - Horizontal Pile Driving	LF		NA			
	Bridge - Deck	SF		85500	Prestressed Precast Girder Bridge with 150' Spans 2850'x30'		10.3
	Bridge - Foundation	LF		600	(20) 30' CIP Concrete pile caps w/ (2) 7' Dia Drilled Shafts 100' Embed At Each Pile Ca		10.3
	Railway - Box Girder Bridge	SF		NA			
	Railway - Foundation	LF		NA			
	Railway - Shoe fly	LF		NA			
Permanent Access Features							
	The design quantities are largely developed from LiDAR data sets lacking the resolution to accurately quantify all elements of construction. These are supplemented by unmeasured estimates made during one site visit at high tide and areal take-offs from available imagery.						
	Roads	Level		NA			
	Utility Access Routes	varies		NA			
	Erosion Control Features	AC		19	Stabilized Construction Entrances, Sediment Ponds, Hydro Seed to Stabilize Roadway Embankment		10.3
Public Access or Recreation Features							
	The design quantities are largely developed from LiDAR data sets lacking the resolution to accurately quantify all elements of construction. These are supplemented by unmeasured estimates made during one site visit at high tide and areal take-offs from available imagery.						
	Trails	SF		NA			
	Bridges	SF		NA			
	Kiosk	EA		NA			
	Restrooms	EA		NA			
	Interpretive Signs	EA		1	tbd		10.3
	Parking Areas	SF		NA			
	Other	EA		NA			
Vegetation & Erosion Control							
	The design quantities are largely developed from LiDAR data sets lacking the resolution to accurately quantify all elements of construction. These are supplemented by unmeasured estimates made during one site visit at high tide and areal take-offs from						10.3
	Hydroseeding	AC		0.26	Ecology lawn seed mix; sideslopes of SR 20 transitional road section		10.3
	Planting	AC		4	Salt marsh at barrier beach		10.3
	Vegetation Maintenance	AC		4	Includes irrigation, weeding, plant replacement for one yea		10.3
	Erosion / sediment BMPs - Temp.	AC		NA	BMPs for control of drainage - describe. Assume compliance with Construction General NPDES include		
	Erosion / sediment BMPs - Permanent	AC		NA	May want to separate slopes over 25% into separate categor		
	Waterside controls - Temporary	LF		3,000	Silt curtain tidal channel creatio		10.3
Construction Management							
	The design quantities are largely developed from LiDAR data sets lacking the resolution to accurately quantify all elements of construction. These are supplemented by unmeasured estimates made during one site visit at high tide and areal take-offs from available imagery.						
	Construction oversight	weeks		78	Quanity based on constructon duration/ # of construction seasons		10.3
	Materials testing			NA	Included in cost of material - no separate quantity		
Design and Detailed Site Investigations							
	The design quantities are largely developed from LiDAR data sets lacking the resolution to accurately quantify all elements of construction. These are supplemented by unmeasured estimates made during one site visit at high tide and areal take-offs from available imagery.						
	Survey & Property, Utility Research	LS		1	% of construction cost		10.8
	35% Design	LS		1	35% x 25% x Engineer's Estimate		10.8
	65% design	LS		1	65% x 25% x Engineer's Estimate less the cost for 35% PS&E		10.8
	90% design	LS		1	35% x 25% x Engineer's Estimate less the cost for 35% + 65%PS&E		10.8
	100% design	LS		1	25% x Engineer's Estimate less previous costs		10.8
	Geotechnical Studies	LS		1	Refer to design report for description of need		10.8
	Cultural Studies	LS		1	Refer to design report for description of need		10.8
	Tidal Circulation and wave modeling/studies	LS		1	Refer to design report for description of need		10.8
Project Agreement Activities					Unable to provide credible estimate at 10% desigr		
Site-Specific Adaptive Management Features & Activities					List if known		
Monitoring Activities					Assume 5 crew-days/year for each monitoring parameter in design report for 5 yrs		
	Monitoring (Type)	crew-days		175			
Operations & Maintenance					Unable to provide credible estimate at 10% design		

Partial Restoration Quantity Estimate

Action Name:	Dugualla Bay		
Action #:	1609		
Date:	February 2011	**Revised with backcheck updates: 30 June 2011**	
By:	Gisele Sassen, Anchor QEA	Revised May 2012	

REMEDY: ***Partially remove dikes and road embankments to restore tidal exchange within estuary and construct road berms and bridges***

Construction Period: 78 - 104 weeks of construction

Item	Unit of Measure	Material Name	Qty	Description of Item	Indicate Section of design report where item is described
ACQUISITION AND CONSERVATION				Based on available mapping information	
The design quantities are largely developed from LiDAR data sets lacking the resolution to accurately quantify all elements of construction. These are supplemented by unmeasured estimates made during one site visit at high tide and areal take-offs from available imagery.					
Required Project Lands	Acre		487	Total land required For action; other areas include the SR 20 ROW and land owned by the Diking District; Navy owned land not included	10.3
Proponent / Partner-owned lands	Acre		35	Whidbey Camano Land Trust property	10.3
Lands To Be Acquired	Acre		452	Estimated private property required to be acquired for action prior to implementation	10.3
Material Sites				Not Used: See Earthwork - Imported Fill.	
MOBILIZATION AND ACCESS for construction activities				Description required for each item to facilitate cost estimating	
The design quantities are largely developed from LiDAR data sets lacking the resolution to accurately quantify all elements of construction. These are supplemented by unmeasured estimates made during one site visit at high tide and areal take-offs from available imagery.					
Mobilization - Typical (Equipment, Personnel, Planning, Financial)	LS		1	Up front costs such as bonding, planning and other staff time and financing. Typically, assume 8% to 10% of other items.	10.3
Mobilization - Remote (Equipment, Personnel, Planning, Financial	LS		1	Up front cost for nontypical or remote locations. Assume 12% of other items	10.3
Site Access	LS		1	Use for special situations (e.g.. new bridge, new access roads) for the purposes of construction access. Include description.	10.3
Barge Access	Days		NA		
Temporary Traffic Control (one of the following)				Includes installation of traffic signals, signage, signmen, etc. There are 4 types as follows	
none	LS		NA		
signs	LS		2	Construction Signage at both sites to alert of Construction & Lane shifting	10.3
flags/spotters crews at both sides for transitions	LS		1	Flags and spotters only during roadway transition connection at SR20, approx duration 2 month	10.3
unique	LS		NA		
Temporary Roadway	SF		NA		
Control of Water	LS		1	Temporary control of water related to Dike Road bridge and dike breach	10.3
Relocation Activities				Not Used: See Utilities, Structures	
The design quantities are largely developed from LiDAR data sets lacking the resolution to accurately quantify all elements of construction. These are supplemented by unmeasured estimates made during one site visit at high tide and areal take-offs from available imagery.					
Site Demolition Activities				Demolition and removal of structures (description required), temporary features and relocations, itemized separately); Clearing and grubbing of vegetation, and removal of minor debris (rocks, slabs) - description required.	
The design quantities are largely developed from LiDAR data sets lacking the resolution to accurately quantify all elements of construction. These are supplemented by unmeasured estimates made during one site visit at high tide and areal take-offs from available imagery.					
Clearing and Grubbing (one or more of following)				Use one or more of the following categories of clearing and grubbing	
Clear Vegetation - Local Disposal	AC		NA		
Clear /Grub Vegetation - Local Disposal	AC		NA		
Clear /Grub Vegetation - Offsite Disposal	AC		NA		
Clear, stockpile - large woody debris	CY		NA		
Hydraulic Structures - Small	LS		1	Removal of tide gate and pumping system at Dike Road; 10-foot wide box culvert at Dike Road; 6'by13' box culvert at SR 20	10.3
Hydraulic Structures - Large	LS		NA		
Utilities	LS or LF		NA		
Overhead Electrical Transmission	LF		750	PSE Overhead Power Lines and poles at Dike Rd	10.3
Overhead Distribution	LF		750	PSE Overhead Power Lines and poles at Dike Rd	10.3
Telecommunications	LF		750	Fiber Optic at Dike Rd	10.3
Buildings	LS		1	Remove misc. buildings	10.3
Pavement	SF		213820	Remove Pavement on SR20 (3725'x40') & Dike Rd (2315'x28')	10.3
Culvert	LF		80	6'x13' CIP Box Culvert at SR20	10.3
Culvert	LF		80	Culvert at Dike Rd 10' wide CIP Box Culvert	10.3
Bulkheads	LF or SF		NA		
Rock revetments	LF		2182	Remove rock riprap armoring from seaward side of perimeter dike slated for removal	10.3
Large Coastal Structures (Road Berm Fill)	CY		NA		
Demolition / Removal - Bridge	SF		NA		
Demolition/Removal - In-water piling	EA		NA		
Removal - Misc. (e.g. angular rock from beach)	Ton		NA		
Demolition / Removal - Boat Ramp	SF		NA		
Haul - Offsite Disposal of Demolition Debris	Miles		20	Estimate distance (to nearest 10 miles) to disposal site for materials, veg clear and grub, etc.	10.3
Hazardous/Contaminated Waste Removal				These items for earthwork of quality not compatible with wetlands, requiring special handling and disposal. Describe basis for classification as contaminated or hazardous. State known or suspected contamination, describe known similar work.	
Contaminated Earthwork	CY		NA		
Hazardous Earthwork	CY		NA		
Construct Temporary Features				Use as needed for unusual temporary features not included elsewhere (see TESC below)	
EARTHWORK				Expand to include equipment, etc. to facilitate cost estimating.	
The design quantities are largely developed from LiDAR data sets lacking the resolution to accurately quantify all elements of construction. These are supplemented by unmeasured estimates made during one site visit at high tide and areal take-offs from available imagery.					
Excavation	CY			Per yard excavation w/out expected haul	
Excavation - Upland	CY		NA		
Excavation - Lowland	CY		210,000	Perimeter and secondary dikes, SR 20 road berm, Dike Rd, misc. berms, mudflat excavation	10.3
Dredging - Bucket - Land	CY		NA		
Dredging - Bucket - Marine	CY		NA		
Dredging - Hydraulic	CY		NA		
Fine Grading	AC		NA		
Fill Placement - local borrow				This is additive to Earthwork -Excavation	
Side cast	CY		NA		
Haul - uncontrolled placement	CY		NA		
Haul, place, compact	CY		NA		
Stockpile - uncontrolled placement	CY		NA		
Stockpile - controlled placement	CY		NA		
Conveyor placement from stockpile land/water	CY		NA		
Imported Fill				Includes purchase, delivery and placement or as noted / described	
Select Fill	CY		116,900	Fill existing drainage channels, SR 20 & Dike Rd roadway transition berms	10.3
Gravel Borrow, including haul	CY		NA		
Sand / Gravel for Beach Nourishment	CY		14,450	Import and place sand and gravel (18 inch average depth) for shoreline restoration. Will be placed in 50% of the 520,000 SF area identified on the figures as "Shoreline Restoration". 260,000 SF x 18 IN= 14,450 CY	10.3
Cobble for Shore Nourishment	CY		NA		
Embankment Compaction	CY		113,700	Volume of road berms (SR 20 & Dike Rd). CY amount assumes entire fill volume for road embankments: SR-20: 86,000 CY plus Dike Road: 27,700 CY = 113,700 CY; see volume back-up provided	10.3
Topsoil	CY		1,600	Marsh plantings shoreline restoration, topsoil 6 inch depth	10.3
RESTORATION Features					
The design quantities are largely developed from LiDAR data sets lacking the resolution to accurately quantify all elements of construction. These are supplemented by unmeasured estimates made during one site visit at high tide and areal take-offs from available imagery.					
Channel Rehab / Creation	SF		NA		
Invasive Species Control	Acre		12	Per acre control described in drawings and narrative	
Other Restoration Features/ Activities	LS		NA		
Structures	EA				
The design quantities are largely developed from LiDAR data sets lacking the resolution to accurately quantify all elements of construction. These are supplemented by unmeasured estimates made during one site visit at high tide and areal take-offs from available imagery.					
Water Control Structures - Culverts with Gates	EA		NA		
Water Control Structures - Weirs	EA		NA		
Rock Slope Protection	LF		120	Armoring of slopes adjacent to tidal channel at new Dike Rd bridge	10.3
Other	EA		NA		
Elevated Boat Ramp	SF		NA		
Fencing	SF		NA		

Partial Restoration Quantity Estimate

Action Name: Dugualla Bay
Action #: 1609
Date: February 2011 **Revised with backcheck updates: 30 June 2011**
By: Gisele Sassen, Anchor QEA Revised May 2012

REMEDY: ***Partially remove dikes and road embankments to restore tidal exchange within estuary and construct road berms and bridges***
Construction Period: 78 - 104 weeks of construction

	Item	Unit of Measure	Material Name	Qty	Description of Item	Indicate Section of design report where item is described
Utilities					Replacement or relocation. Designer to provide size and material and have separate line item for each run. Incidentals include earthwork, testing, hook up fees, etc. These quantities do not include demolition of existir utilities, real estate / easements, design fees. Describe the owner if known, and whether utility franchise wil install (e.g.. electric is typically installed by electrical franchise	
	The design quantities are largely developed from LiDAR data sets lacking the resolution to accurately quantify all elements of construction. These are supplemented by unmeasured estimates made during one site visit at high tide and areal take-offs from available imagery.					
	Water	LF		0	The only known utilities are the overhead power and fiber optic cable. If additional utilities are assumed, the 2315 LF may be used	
	Gas	LF		0	The only known utilities are the overhead power and fiber optic cable. If additional utilities are assumed, the 2315 LF may be used	
	Electric Transmission	LF		2315	PSE Overhead lines and poles at Dike Rd	10.3
	Electric Distribution	LF		2315	PSE Overhead lines and poles at Dike Rc	10.3
	Sewer	LF		0	The only known utilities are the overhead power and fiber optic cable. If additional utilities are assumed, the 2315 LF may be used	
	Telecommunications	LF		2315	Fiber Optic Ductbank routed over bridge	10.3
	Other	LF		NA		
Roadway / Railway						
	The design quantities are largely developed from LiDAR data sets lacking the resolution to accurately quantify all elements of construction. These are supplemented by unmeasured estimates made during one site visit at high tide and areal take-offs from available imagery.					
	Roadway	SF		141600	Roadway 8" ASPH w/ 12" Base 40' wide x 3540' on SR2C	10.3
	Roadway	SF		64820	Roadway 8" ASPH w/ 8" Base 28' wide x 2315' on Dike Rc	10.3
	Roadway - Traffic Signal	LS		NA		
	Culvert (type)	LF		160	(2) 5-foot box culverts at Dike Road (5'x80' each	10.3
	Culvert - Jacking	LF		NA		
	Culvert - Horizontal Pile Driving	LF		NA		
	Bridge - Deck	SF		27000	Prestressed Precast Girder Bridge with 100' Spans at SR20 (200'x30') & 107' Spans at Dike Rd (750'x28'	10.3
	Railway - Box Girder Bridge	SF		NA		
	Bridge - Foundation	LF		314	(3) 30' CIP Concrete pile caps total on SR20 & (8) 28' Dike Rd w/ (2) 7' Dia Drilled Shafts 100' Embed At Each Pile Cap	10.3
	Railway - Shoe fly	LF		NA		
Permanent Access Features						
	Roads	Level		NA		
	Utility Access Routes	varies		NA		
	Erosion Control Features	AC		19	Stabilized Construction Entrances, Sediment Ponds, Hydro Seed to Stabilize Roadway Embankment	10.3
Public Access or Recreation Features						
	The design quantities are largely developed from LiDAR data sets lacking the resolution to accurately quantify all elements of construction. These are supplemented by unmeasured estimates made during one site visit at high tide and areal take-offs from available imagery.					
	Trails	SF		NA		
	Bridges	SF		NA		
	Kiosk	EA		NA		
	Restrooms	EA		NA		
	Interpretive Signs	EA		1	Include # interpretive signs based on number of local public access points	10.3
	Parking Area	SF		NA		
	Other	EA		NA		
Vegetation & Erosion Control						
	The design quantities are largely developed from LiDAR data sets lacking the resolution to accurately quantify all elements of construction. These are supplemented by unmeasured estimates made during one site visit at high tide and areal take-offs from available imagery.					
	Hydroseeding	AC		8	Erosion control seed mix	10.3
	Planting	AC		2	Marsh within shoreline restoration area	10.3
	Vegetation Maintenance	AC-YR		2	Includes irrigation, weeding, plant replacement for one yea	10.3
	Erosion / sediment BMPs - Temp.	AC		NA		
	Erosion / sediment BMPs - Permanent	AC		NA		
	Waterside controls - Temporary	LF		3,000	Silt curtain or other water based temporary actions	10.3
Construction Management						
	The design quantities are largely developed from LiDAR data sets lacking the resolution to accurately quantify all elements of construction. These are supplemented by unmeasured estimates made during one site visit at high tide and areal take-offs from available imagery.					
	Construction oversight	weeks		78-104	Quantity based on construction duration/ # of construction seasons	10.3
	Materials testing			NA		
Design and Detailed Site Investigations						
	The design quantities are largely developed from LiDAR data sets lacking the resolution to accurately quantify all elements of construction. These are supplemented by unmeasured estimates made during one site visit at high tide and areal take-offs from available imagery.					
	Survey & Property, Utility Research	LS		1	% of construction cost	10.8
	35% Design	LS		1	35% x 25% x Engineer's Estimate	10.8
	65% design	LS		1	65% x 25% x Engineer's Estimate less the cost for 35% PS&E	10.8
	90% design	LS		1	35% x 25% x Engineer's Estimate less the cost for 35% + 65%PS&E	10.8
	100% design	LS		1	25% x Engineer's Estimate less previous costs	10.8
	Geotechnical Studies	LS		1	Refer to design report for description of need	10.8
	Cultural Studies	LS		1	Refer to design report for description of need	10.8
	Tidal circulation and wave modeling/studies	LS		1	Refer to design report for description of need	10.8
Project Agreement Activities					Unable to provide credible estimate at 10% desigr	
Site-Specific Adaptive Management Features & Activities					List if known	
Monitoring Activities					Assume 5 crew-days/year for each monitoring parameter in design report for 5 yrs	
	Monitoring (Type)	crew-days		175		
Operations & Maintenance					Unable to provide credible estimate at 10% design	

11. EVERETT MARSHLAND TIDAL WETLAND RESTORATION (#1126)

Local Proponent	City of Everett
Delta Process Unit	Delta SNH
Shoreline Process Unit(s)	NA
Strategy(ies)	1 – River Delta
Restoration Objectives	Remove dikes and drainage structures to restore tidal hydrology to wetland complex

11.1 Description of the Action

This action would restore tidal hydrology and channel-forming processes to diked farmland that was historically tidally influenced wetlands connected to the Snohomish River. The proposed restoration entails relocating dikes and roadways, altering and filling drainage canals, restoring tidal channels, and reconnecting streams to the tidal area. Please see the Introduction chapter for important information regarding PSNERP and the context of this restoration project.

11.2 Action Area Description and Context

The Everett Marshland action area is located along the west bank of the Snohomish River southwest of the point where Ebey Slough branches off the mainstem. The action area, within the Whidbey Subbasin, is located east of and in the floodplain below I-5, mostly within the Everett city limits.

The 1,065-acre action area lies within the upstream portion of the Snohomish River Estuary. The action area is located along the south and west sides of the Snohomish River and Lowell-Snohomish River Road (the road sits on top of the current south/west river dike) and east of Lowell-Larimer Road. Although it is within the 100-year floodplain of the Snohomish River, the action area is completely cut off from tidal hydrology by dikes and drainage structures installed to support agricultural land uses.

This action area is within the 6,000-acre Marshland Flood Control District (created in 1938) that abuts the Snohomish River between river miles 7 and 15.5. In addition to roads and dikes, the action area is bisected by the BNSF railroad running generally northwest/southeast, and two regional transmission lines operated by PSE and BPA oriented generally east/west. Parallel subsurface petroleum pipelines operated by BP are also located in the southeast corner of the action area. The action area is shown in Figure 11-1.

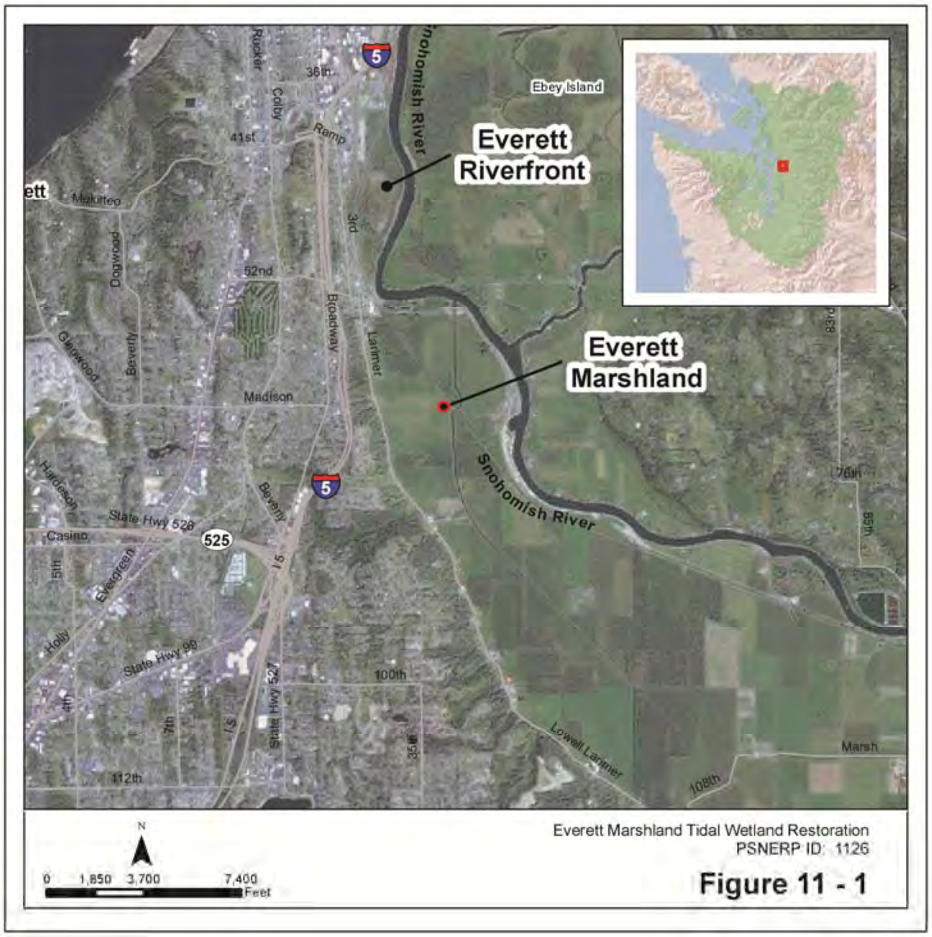


Figure 11-1. Action Area and Vicinity

11.2.1 Historic Condition

Prior to the mid-19th century, the Snohomish Estuary contained about 10,000 acres of tidal marsh. The estuary area was likely historically used by Native Americans for hunting, fishing, and gathering. The Marshland area has been described as containing thousands of acres of oxbow channels, beaver ponds, and emergent and forested (tidal) wetlands (Tulalip Tribes 2001; SBSRF 2005).

Beginning in approximately 1860, extensive timber harvesting, levee/dike construction, ditching and draining of marsh areas, and farming/livestock grazing by early settlers initiated a significant decline in the area and quality of estuarine marsh habitat, driven by reduction in natural estuarine processes. By 1885, diking and draining within the greater Marshland area had "altered more than half of the original wetlands" (Toth and Houck 2001). Extensive removal of riparian forests, wooded marsh, and large woody debris from the Marshland area significantly reduced salmonid acclimation, flood refuge, and juvenile rearing areas. Associated effects have included reduced edge habitat complexity and fragmentation in habitats, affecting productivity of the main river and eliminating active salmonid use of the remnant marsh channels. In the Snohomish Estuary as a whole, the tidal marsh accessible to salmonids is now only one-sixth (approximately 17%) of its historic abundance, and only 25% of the historic blind tidal sloughs remain (Haas and Collins 2001).

The topographic sheets (T-sheets) do not show the smaller blind dendritic and stream channels that are presumed to have historically existed along the Snohomish River within the Marshland action area (Figures 11-2A and 11-2B). The T-sheets show primarily wooded marsh in the action area, with a fringe of deciduous forest bordering the Snohomish River mainstem. Aerial photography from the 1930s era and examination of LiDAR topography show the presence of one major slough channel (Hardscrabble Slough) extending from the mainstem river near the current Marshland Pump Station, in a southwesterly direction to the alluvial fan at the mouth of the Wood Creek ravine. In addition, a second large slough channel is visible on LiDAR imagery at the south and southeast portion of the action area. It appears that these channels were eliminated when the Marshland Canal was constructed (Anchor Environmental and ICF Jones and Stokes 2008). Stakeholder documentation suggests that Marshland area tidal channels (e.g., Hardscrabble Slough and Wood Creek) supported significant populations of cutthroat trout and salmonids in the early to mid-1900s (Alexander 2008) prior to the Marshland Pump Station construction in 1961 (Reasoner 2010).

A former landfill and former creosote plant are located at the northwest portion of the action area. Both are potentially sources of contamination, but they are the result of actions by different landowners at different time periods (Anchor Environmental and ICF Jones and Stokes 2008). These former land uses are adjacent but appear to be separated by the Lowell-Snohomish River Road and river dike. Currently, the action area is protected from flooding up to approximately 5-year event magnitude by dikes totaling about 8.5 miles in length.

The Marshland Pump Station, located at the northerly limit of the Marshland Canal and operated by the Marshland Flood Control District, discharges drainage from the surrounding agricultural area (historic marsh) to the Snohomish River under a Lowell-Snohomish River Road bridge. Wood Creek, the only perennial fish-bearing stream within the action area, drains into Marshland Canal in the southern portion of the action area. No fish passage exists at the Marshland Pump Station. Fish that gain access to the Marshland action area during levee overtopping in flood events are either stranded or potentially injured or killed by the pumps when draining the Marshland Canal. Slide gates at the pump station are sometimes opened after floods to more quickly evacuate floodwaters from the interior of the diked area, enabling fish migration back to the river.

11.2.2 Natural Environment

Historic tidal marsh areas and remnant tidal channels have been converted to agricultural use within the action area. Sediment characteristics are not fully known, but will be reviewed based on available information during subsequent more detailed phases of design. Based on available soils mapping and site observations, surficial soils are expected to consist primarily of sands, silts, and clays, with underlying peat as noted below. Soils within the action area include a wide range of loamy soil types (from gravelly sandy loam to silt clay loam) to "muck" or organic soils. The majority of the area consists of Puget silty clay loam and Mukilteo muck. Most of these soil types are considered "prime farmland if drained" (Anchor Environmental and ICF Jones and Stokes 2008; NRCS 2009). Stakeholders suggest that thick lenses of peat underlay the marsh area, and that subsidence and settlement of the marsh area continues to occur. The areas bordering the Marshland Canal are the lowest within the action area. The highest areas are located along the Snohomish River mainstem and along Lowell-Larimer Road.

Within the Marshland reach of the upper section of the estuary, the National Wetland Inventory identifies 239 acres of wetlands (of which the action area is a part). Of this, 96 acres are palustrine forested/scrub-shrub (freshwater) wetlands. Of particular significance is the remnant forested wetland at the northwest corner of the action area. This Sitka spruce-dominated wetland pre-dates the current diking and drainage infrastructure. Other wetland areas are palustrine emergent (freshwater) wetlands (Anchor Environmental and ICF Jones and Stokes 2008).

Western hemlock, Douglas fir, Sitka spruce, red alder, and big-leaf maple make up most of the limited remaining mixed forest cover. The riparian buffer along the mainstem river has very limited width due to presence of the river dike and Lowell-Snohomish River Road. Within the action area, the widest riparian forest and scrub-shrub habitat along the mainstem river is located north of Lowell-Snohomish River Road and west of the Marshland Canal. This riparian area is more than 300 feet wide. Within the action area, fish and wildlife conservation areas make up 29% of the land area (Anchor Environmental and ICF Jones and Stokes 2008).

Normal tidal fluctuation ranges from approximately -2.3 feet (MLLW elevation) to +8.8 feet (MHHW elevation) NAVD 88 vertical datum at Possession Sound, Everett. Based on available LiDAR mapping (NOAA NWFSC and PSLC 2009), Marshland area elevations typically range between approximately -2 and 4 feet NAVD 88 in the Marshland Canal channel, and between approximately 2 and 10 feet NAVD 88 in the adjacent agriculture or wetland areas. Developed areas (farm structures) along the west side of the action area (abutting Larimer Road) range from approximately 14 to 25 feet NAVD 88 and above. In comparison, top-of-dike elevations appear to range between approximately 18 and 20 feet NAVD 88.

The entire Marshland action area, except for some fringe areas along the east side of Larimer Road, is within the Snohomish River 100-year floodplain. Protection of existing dikes is reported to be in the 5-year event range (proposed setback dikes will be constructed to a similar standard).

11.2.3 Human Environment

The primary anthropogenic features within the Marshland action area include:

- The levees along the south and west bank of the Snohomish River supporting Lowell-Snohomish River Road and associated bridge at the Marshland Pump Station outlet.
- The BNSF mainline railway tracks with existing earthen fill and trestle bridge channel crossings extending across the action area.
- The Marshland Canal, associated drainage channels, pump station, and outlet channel to the Snohomish River.
- Larimer Road and associated farmhouses and agricultural structures along the west periphery of the action area.
- BPA and PSE regional power transmission lines (seven total, in two primary corridors) that extend across the action area.

- Two buried liquid petroleum pipelines in the southeast corner of the action area.
- The Simpson property landfill in the northwest corner of the action area.
- A sedimentation pond at the Wood Creek outlet to Marshland Canal.
- Elevated residential structures behind the river levee in the east portion of the action area.

The action area is bisected by the north/south alignment of the Marshland Canal, which runs through the center of the action area and drains all 6,000 acres of the Marshland Flood Control District agricultural lands. The Marshland Pump Station pumps the drainage from this canal to the Snohomish River through the dike at the north end of the action area. A substantial network of other local drainage including six channelized streams drains to the Marshland Canal within the action area (Anchor Environmental and ICF Jones and Stokes 2008).

Utilities affecting the action area include the BPA and PSE regional power transmission lines and the BP-Olympic liquid petroleum pipelines as noted above. Maintenance access is required along those lines. Existing water and sewer lines are reported as aligned in Larimer Road but should not be affected. Local electrical power is provided to the area via Snohomish Public Utility District (PUD) power lines located along Lowell-Larimer and Lowell-Snohomish River Roads. Water supply mainlines to the City of Everett are located south of Lowell-Snohomish River Road, west of the Marshland Pump Station, and connect to Ebey Island on the north (Anchor Environmental and ICF Jones and Stokes 2008). A proposal exists to run a trunk sewer line down the Lowell-Snohomish River Road (Cunningham 2010). More detailed information on existing utilities and the need for utility relocations will be required to support subsequent design phases.

11.3 Restoration Design Concept

11.3.1 Restoration Overview and Key Design Assumptions

The restoration alternatives are illustrated in Figures 11-3 through 11-7. Both alternatives propose removal of barriers to tidal hydrology and restoration of sediment transport processes, distributary channel morphology, and the distribution of woody debris.

Full Restoration Alternative

To meet PSNERP objectives for process-based restoration, full restoration is defined as the comprehensive removal of key stressors posed by tidal barriers, nearshore roads, and stream crossings (Marshland Pump Station). The following actions are included in the full restoration alternative (Figure 11-3):

- Remove and realign most of the Snohomish River dike and associated realignment of Lowell-Snohomish River Road (approximately 1.5-mile section).
- Relocate the road and its embankment (to prevent flooding) along the northeast side of the BNSF railroad.
- Create bridge openings in the road embankment at all blind and stream/distributary channel crossings with matching crossings in the railway.

- Remove and relocate the Marshland Pump Station to the south end of the action area, truncating the Marshland Canal at the site of the new pump station. Construct a new pump station discharge channel to the Snohomish River at the south end of the action area.
- Reconnect tidally influenced mainstem river habitat along 1.5 miles of river frontage where the existing road and dike are removed; the width of this area varies from zero to 2,000 feet.
- Reconnect tidal hydrology to diked farmland southwest of the existing BNSF railroad through two existing or modified BNSF railway crossings at the existing Marshland Canal, and the former Hardscrabble Slough. The existing trestle at the Marshland Canal is more than 1,500 feet long.
- Include the area between the BPA and PSE transmission lines in the restored tidal area, with tidal connections under BPA and PSE access corridors to the restored areas to the north and south. Inclusion of this area will increase the total area of restored hydrology significantly while still allowing for access to transmission lines (via raised access corridors with multiple box culverts) on the west side of the BNSF railroad.
- Include all public and private land on the east side of the BNSF railroad in the tidal hydrology restoration action.
- Include the private lands within the 100-year floodplain (and not considered "Buildable Land" by City of Everett) in the northwest corner of the action area west of the BNSF railroad; this area includes a large patch of remnant Sitka spruce-dominated forested wetland.
- Fill all existing drainage ditches.
- Remove and remediate waste materials at the northwest portion of the action area east of BNSF railroad (former private landfill and creosote plant).
- Restore dendritic blind channels throughout the tidal marsh restoration area using natural processes initiated by "starter channels" branching off two primary slough channels.
- Reconnect Wood Creek to the southeast tidally restored area and Snohomish River via a restored (Hardscrabble Slough) channel to provide fish passage, restore natural freshwater and sediment inputs, and reactivate sediment deposition processes in the tidal marsh.
- Connect five smaller western hillside ephemeral and perennial streams to the restored tidal marsh.
- Construct new setback dikes to protect the regional transmission lines and gas pipelines where located west of the BNSF railroad.

Full restoration would result in a significant reduction in the total length of dikes compared to the partial restoration alternative, due to inclusion of additional private lands and relocation of Lowell-Snohomish River Road and dike. The number of cross dikes is also significantly reduced and limited to the three regional utility corridors. These utility corridor access dikes are set lower than other dikes to allow for evacuation of floodwaters.

Full restoration would provide more direct connectivity of the historic tidal marsh with the mainstem river channel, and a larger area of tidal marsh restored compared to partial restoration (876 acres under full restoration compared to 418 acres under partial). It would also improve connectivity between restored areas and existing high-quality Sitka spruce wetlands. The full restoration alternative would restore tidal hydrology and channel-forming processes to nearly all of the diked farmland that was historically tidally influenced wetlands. Channel-forming processes include a substantial widening of the area on the west bank of the Snohomish River for more complex and varied channel morphology. This alternative also includes a complex network of slough channels to develop and connect with adjacent perennial streams (including Wood Creek) and the mainstem Snohomish River.

Non-tidal marsh actions include creating passive recreational areas as part of the dike relocation and restoration on public lands. Recreational features would consist primarily of dike-top trails along Lowell-Snohomish River Road (regional trail link), wildlife viewing areas, and parking areas above the 100-year floodplain.

Partial Restoration Alternative

The partial restoration alternative proposes to restore a much smaller area to tidal hydrology (418 acres) but includes extensive slough channels as well. The partial restoration alternative consists of (Figure 11-4):

- Relocation of the Marshland Pump Station to the south end of the action area and truncating of the Marshland Canal for discharge to the Snohomish River near the southeast action area limit.
- Reconnection of tidal hydrology to the adjacent diked farmland (historic tidal marsh area) through three bridged flow paths under Lowell-Snohomish River Road. These locations include the existing pump station outlet (after this facility is removed) and at two other locations further south and east. Tidal hydrology under the BNSF railroad would be restored using three existing railway crossings at the current Marshland Canal and the former Hardscrabble Slough locations, and one further south at the Spane Farm.
- Restoration of dendritic blind channels throughout the marsh restoration area using natural processes initiated by “starter channels.”
- Reconnection of Wood Creek to the southeast tidally restored area and Snohomish River to provide fish passage, restore natural freshwater and sediment inputs, and reactivate sediment deposition processes in the tidal marsh.
- Connection of smaller western hillside ephemeral and perennial streams to the restored tidal marsh.
- Connection of privately owned, mature forested wetland habitat to the tidal marsh area through a fish-passable tide gate.
- Filling in of existing drainage ditches in all tidally restored areas.
- Construction of new setback dikes on portions of the south, west, and north sides of the tidally restored areas, along with other interior areas, to protect regionally significant power transmission lines and adjacent non-participating properties from flooding (at existing protection levels).
- Maintenance of the Lowell-Snohomish River Road on its existing alignment.

- Along the rail alignment, the partial restoration alternative is similar to the full restoration alternative, except that the upgraded railroad bridge #3 opening is 270 LF. This decrease in width occurs due to the proposed dikes protecting properties in the center of the action area. The upgrades to this bridge focus on the 270 feet where regular tidal flows will occur. The full length of the existing 1,750 LF railroad trestle will remain and serve to pass flood flows that overtop dikes in 5-year or greater events.

In addition to these actions, other non-tidal marsh actions include:

- Passive recreational areas would be created along the west side of the action area periphery (Lowell-Larimer Road).
- Sections of the historic tidal marsh would be preserved or conserved as freshwater wetlands, or in continued agricultural use where property owners are unwilling to allow tidal marsh restoration.
- Maintenance access would be preserved to two regional power transmission line corridors that extend across the action area along the perimeter of the restored tidal marsh areas, and to two liquid petroleum pipelines in the southeast portion of the action area.

The partial restoration alternative was developed to be consistent with the City of Everett's (the proponent's) approved Marshland Subarea Plan (Anchor QEA et al. 2009). The Subarea Plan, which was approved in 2009, is a land use planning document that includes implementation measures for the preferred alternative. The City evaluated conceptual restoration plans covering the entire action area as part of the EIS for the Subarea Plan (Anchor Environmental and ICF Jones and Stokes 2008; Anchor QEA et al. 2009). Ultimately, the City limited the proposed restoration actions to "willing" property owners.

The partial restoration alternative reflects the approved Subarea Plan and includes only willing property owners, and avoids remediation activities associated with the private landfill and creosote plant. The full restoration alternative includes and affects all property owners regardless of their expressed willingness identified through the subarea planning process. Therefore, the local proponent does not support the full restoration alternative.

Design Water Surface Elevations

Design water surface elevations are based on the following assumptions. Mean tidal elevations within the estuary should not change significantly for either full or partial restoration alternative. Predicted (astronomical) tides for this action area based on the Vdatum program (NOAA 2010) relative to the MLLW datum near the estuary mouth (at I-5/Smith Island) and relative to the fixed NAVD 88 datum are as follows:

	MLLW	NAVD 88
MHHW	10.89 feet	9.07 feet
MHW	10.04 feet	8.21 feet
MTL	6.31 feet	4.48 feet
MLW	2.57 feet	0.74 feet
MLLW	0.00feet	-2.03 feet

The tidal datums presented above consider astronomical tides at Possession Sound. The pump station on the Marshlands action is at approximate River Mile 7 of the Snohomish River meaning that tide levels at the action area will be modified by freshwater flows in the Snohomish River. Daily tidal datums at the action area will likely be somewhat higher than in Possession Sound, but the precise relationships for MLLW and MHHW are not known at this time.

The Snohomish County Flood Insurance Study Draft Digital Flood Insurance Rate Map Update (FEMA 2010) reports the 100-year tidally influenced stillwater elevation (100-year flood frequency tide elevation plus surge) for the Snohomish River at Ebey and Steamboat Sloughs (mouth at Possession Sound assumed) to be elevation 12.2 feet NAVD 88. Wind wave setup could be higher at that location, but is not expected to translate upstream to the action area.

The future tidally influenced design water level, which takes into account estimated sea level change for the action area of 1.5 feet (high scenario), would then translate to a future conditions tidally influenced design water elevation of 13.7 feet NAVD 88. This future predicted water level (with high sea level change scenario) was used for 10% design of restoration actions inside the action area (e.g., marsh restoration).

These elevations were also used for evaluation of the proposed railroad bridges, and for Lowell-Snohomish River Road bridges (for tidal fluctuation effect), although higher river-induced flood levels control the design water levels under river flooding conditions. The Snohomish County Flood Insurance Study Update (FEMA 2010) reports the 100-year Snohomish River-induced flooding elevations throughout the action area to be as follows:

Location	10-year flood elevation (NAVD 88)	100-year flood elevation (NAVD 88)
at RM 7.0 (1)	18.0	22.7
at RM 8.0 (2)	19.6	24.0
at RM 9.0 (3)	21.2	25.2

(1) At downstream limit of action area
(2) At Ebey Slough confluence within action area
(3) At upstream limit of action area

Key Design Elements

The key design elements associated with full and partial restoration alternatives are shown in Table 11-1.

Table 11-1. Key Design Elements

Element	Full Restoration	Partial Restoration
Dike Removal and Relocation	Remove one segment of Snohomish River dike totaling 12,800 LF Build 13,800 LF of setback dikes in four locations	Remove two segments of Snohomish River dike totaling approximately 400 LF Setback dikes in two locations total 22,100 LF
Hydraulic Structures	Relocate Marshland Pump Station from the north end to the south end of the action area, restoring tidal hydrology to 876 acres	Relocate Marshland Pump Station from the north end to the south end of the action area, restoring tidal hydrology to 418 acres
Drainage and Tidal Channels	Fill existing drainage ditches including the Marshland Canal. Construct two primary north/south channels to convey flows through the restored areas and the Snohomish River Construct diked channel to convey relocated Marshland Canal Pump Station discharge to the Snohomish River	Fill existing drainage ditches including the Marshland Canal Construct a primary branching north/south channel to convey flows through restored areas and the Snohomish River Construct separate channel to convey relocated Marshland Canal Pump Station discharge to the Snohomish River
Freshwater Streams	Reconnect Wood Creek and four other perennial streams to the restored Hardscrabble Slough channel	Reconnect Wood Creek to Snohomish River. Connect four other streams to primary channel in north tidally restored area
Lowell-Snohomish River Road	Relocate 9,600 LF of road onto setback Snohomish River dike parallel to BNSF railroad Construct roadway bridges in two locations (295 and 850 LF) Plant riparian vegetation on road embankment	Lowell-Snohomish River Road remains in existing location Construct roadway bridges in two locations (200 LF each) Plant riparian vegetation on road embankment
BNSF Railroad	Railroad in current alignment Upgrade bridges in two locations	Railroad in current alignment Upgrade bridges in three locations.
Utilities	Construct setback dikes (7,500 LF) under PSE and BPA transmission lines for maintenance access Some PSE towers only accessible by boat at high tides and floods Petroleum pipeline protected with new setback (full height) dike for maintenance access	Construct setback dikes (9,600 LF) to protect PSE and BPA transmission lines from tidal flows and floods less than 5 years Maintenance access remains same as existing Petroleum pipeline protected with new setback (full height) dike for maintenance access

Element	Full Restoration	Partial Restoration
Private Lands and Structures	Acquire or obtain easements for restoration on all private (non-infrastructure) lands Remove all residential and agricultural structures within 100-year floodplain Obtain easements for restoration actions affecting infrastructure	Acquire private lands or obtain easements for setback dikes and road relocation No residential or commercial structure removal required
Environmental Remediation	Remediate Simpson landfill and former creosote plant	No environmental remediation proposed

11.3.2 Restoration Features – Primary Process-Based Management Measures

Armor Removal/Modification

Armor may exist on some of the dikes to be removed along the Snohomish River; the exact amount, size and location will need to be determined as part of the subsequent design efforts. Some armor may be required on transmission line towers east of the BNSF railroad berm. Armor at the outlet channel of the Marshland Pump Station will be removed in the full and partial restoration alternatives.

Berm or Dike Removal/Modification

Dike and berm removal and modification is one of the primary components of the full and partial restoration alternatives (Figures 11-3 through 11-7). The BNSF railroad and Lowell-Snohomish River Road will be designed to maintain existing railway and road surface grades. These grades are adequate to protect these facilities from normal tidal and stream flows. However, they are not raised because dike-top elevations are set across the estuary and Marshland Flood Control District to allow for controlled overtopping during 5-year and greater flood events.

Substantial modifications to areas with utility infrastructure (PSE and BPA electrical transmission lines and petroleum pipelines) are addressed by providing dikes for access and flood protection. In full restoration, the PSE transmission towers are protected with raised islands, but the areas beneath the transmission lines would only be accessible by boat during daily high tides or flood conditions. Dikes under the PSE and BPA transmission lines in the full restoration alternative are also set at elevation 14 feet NAVD 88 to provide maintenance access in all normal tidal conditions, but not during floods. These dikes are set lower than setback dikes in this alternative to facilitate evacuation of floodwaters. All other setback dikes in both restoration alternatives would be designed to match existing dike elevations and 5-year flood levels.

Dike removal is proposed down to adjacent marsh plain elevations in most cases. However, due to the low topography in the area east of the BNSF railroad, the dike removal soils from this portion of the action area would be used to raise grades outside of distributary channels. These raised areas would target marsh plain elevations found in nearby reference sites in undiked areas bordering the Snohomish River.

Channel Rehabilitation/Creation

Channel rehabilitation would include filling existing drainage ditches, constructing two north/south channels to convey tidal and freshwater flow, and improving connectivity to creeks from hillsides west of the action area. In addition, a new diked channel is proposed at the outlet of the relocated Marshland Pump Station to convey pumped drainage from the Marshland Canal south of the action area to the Snohomish River (Figures 11-3 through 11-6).

The *Applied Geomorphology Guidelines and Hierarchy of Openings* (Appendix C, Figure 8) were used at the existing Marshland Canal outlet to size the required breach opening cross section area, top width, and depth below MHHW. This relationship used the projected marsh area (below MHHW) within Marshlands that would be tidally inundated after the levee is breached (876 acres for full restoration and 418 acres for partial restoration). Since the topography transitions down in the marsh area to the lower marsh elevations, the required cross section area was then applied as the minimum area of the combined marsh channel and marsh plain below MHHW elevation to determine the minimum cross section upstream of the breach opening.

In full restoration, channel rehabilitation will reconnect Hardscrabble Slough to the Snohomish River, Wood Creek, and the other four perennial streams draining the hillside west of the action area. In addition, full restoration includes excavating a primary sinuous flow path for tidal flows and groundwater in low portions oriented north/south through the eastern portion of the action area. This primary channel would include starter channels to support formation of a dendritic/blind channel network.

Groin Removal/Modification - NA

Hydraulic Modification

Under full restoration (Figure 11-3), the existing pump station outlet channel would be used as the slough channel terminus. Large culverts would be installed in five locations, including two channels passing under two setback dikes for transmission line maintenance and one for conveying pumped drainage from the relocated Marshland Pump Station through the Snohomish River dike to the river. Two new road bridges (Road Bridges A and B) on the relocated Lowell-Snohomish River Road and two modified bridges (Rail Bridges #2 and #3) on the existing BNSF railroad would convey tidal flows and fresh water in two primary channels beneath the railroad berm and relocated Snohomish River dike.

Under partial restoration (Figure 11-4), the existing pump station outlet channel would be used as the slough channel terminus. Large culverts with tide gates would be installed in six locations to convey drainage and floodwaters from dike-protected to tidal areas. Two new road bridges (Road Bridges C and D) on the existing Lowell-Snohomish River Road/Snohomish River dike would convey tidal flows to the restored area. The southern bridge would also convey the rerouted Marshland Canal flows to the river. Three modified bridges (Rail Bridges #2, #3, and #5) on the existing BNSF railroad would provide conveyance of tidal and freshwater flows via three channels. Wood Creek would be reconnected to the Snohomish River via a new tide gate and culvert and channel. Four other streams would connect to the primary channel in the north tidally restored area; the north stream would have a hydraulically controlled tide gate and culvert.

Overwater Structure Removal - NA

Topography Restoration - NA

11.3.3 Restoration Features – Additional Management Measures

Beach Nourishment - NA

Contaminant Removal/Remediation

The full restoration alternative would affect two areas where potential contamination exists, or where dike removal and setback may expose contaminated soils to tidal hydrology: a former landfill and former creosote plant (Figure 11-3). While the former creosote plant site is currently exposed to tidal hydrology, the former landfill is not. The remedy is expected be overseen by the Washington State Department of Ecology and based on a remedial investigation and feasibility study conforming to the Model Toxics Control Act.

Debris Removal - NA

Invasive Species Control

Reed canarygrass and Himalayan blackberry inhabit areas with either freshwater hydrology or upland conditions. Upland invasive species are anticipated to be eradicated by the restoration of tidal hydrology. However, very low salinity levels in tidally restored areas that do not have persistent standing water may allow reed canarygrass to persist. Strategic removal of reed canarygrass and potentially other species such as Himalayan blackberry is recommended.

Large Wood Placement - NA

Physical Exclusion - NA

Pollution Control - NA

Revegetation

Revegetation will be limited primarily to dike and road embankments which will need to be vegetated with native species to protect them from erosion, and inhibit establishment of invasive species. A combination of hydroseeding and limited live staking and bare root plantings will be used. Live stakes and bare root plantings of riparian species are anticipated toward the lower end of these embankments (where hydrology supports riparian species such as Sitka spruce, willows, red alder, black hawthorne, and other species).

Reintroduction of Native Animals - NA

Substrate Modification - NA

Species Habitat Enhancement - NA

11.3.4 Restoration Features – Other

The local proponent's requirements include: (1) commitment to compliance with the Snohomish Basin Salmon Conservation Plan goals and objectives, (2) conditions imposed by the stakeholder-preferred restoration plan reflecting property ownership/use limitations, (3) limitations imposed by the agreements to be achieved with BPA, PSE, and BP-Olympic regarding the major utilities extending through the action area, (4) agreements potentially required with BNSF Railway, (5) conditions imposed by the various property acquisition agreements, and the need to secure additional required properties, and (6) provisions for passive recreational use of City of Everett property including access and trails, and trail use along Lowell-Snohomish River Road. To address the last requirement of the local proponent, new recreational features (trails) are proposed in the partial restoration alternative as shown on Figure 11-4. For the full restoration alternative, the relocation of Lowell-Snohomish River Road will need to include space for a trail and the locations will be determined in a future design stage. In both alternatives, the recreational trails and access features would be completed separately from the proposed action and would be the responsibility of the City of Everett.

11.3.5 Land Requirements

Construction of this action will affect of 1,115 acres of private agricultural and public recreational lands. Land requirements include: (1) property acquisitions or conservation easement agreements with affected private property owners, and (2) agreements with Snohomish County (road and utility relocations), Marshland Flood Control District, BNSF Railway, and affected utility owners. Approximately 537 acres of private land that will need to be acquired via purchase, easement or other similar means.

The action area includes numerous public and private landowners. The largest landowners are the City of Everett (proponent) and the Spane family, who each own more than 300 acres in the northern and southern portions of the action area, respectively. The proponent's lands are undeveloped and are currently leased for agricultural use. These public lands were purchased originally for recreational use. The proponent is currently supportive of only passive recreational use (including trails) on their lands (Cunningham 2010). Other public ownerships include Snohomish County land between Lowell-Snohomish River Road and the river in the Norwegian Bay area. The Marshland Flood Control District also owns flood control and drainage facilities in the action area, including the large pump station and other facilities.

Large private landowners or easement holders include the BNSF Railway, BPA, PSE, BP (petroleum pipelines), and Simpson. There are numerous agricultural landowners with varying sized parcels, one radio tower operator, and one religious organization that own the remainder of the lands. Most of the area for tidal marsh restoration under the proponent's Subarea Plan (partial restoration alternative) is in areas owned by the City of Everett or the Spane family. A significant private land acquisition program would be required to implement full restoration. This alternative would require acquisition or conservation easements for all private property, as well as easements for infrastructure modifications.

Much of the land in the action area is publicly owned by the proponent or other public agencies. However, a significant number of private land acquisition or conservation easements are needed to implement the partial restoration alternative, as well as easements for infrastructure modifications. These lands include only those where property owners expressed a willingness to participate in or support restoration during the Marshland Subarea planning process (Anchor et al. 2009). Fair compensation will be provided to these owners in the form of outright purchase of the land, easements, or tax incentives. Most private landowners within the action area have expressed a willingness to participate in restoration in some form. Several have also expressly stated they are not interested in participating in restoration actions on their parcels and have been excluded from any restoration-related changes in the partial restoration alternative. For private landowners willing to participate in restoration, many have expressed limitations on what types of restoration are acceptable and other operational requirements for utility and transportation infrastructure (see *Restoration Features- Other*).

Approvals from Snohomish County, BNSF Railway, PSE, petroleum pipeline and water main owners will need to be obtained for modification to these facilities or facility access.

11.3.6 Design Considerations

Major Infrastructure Modifications

Transportation – Roads

Lowell-Snohomish River Road is located within the City of Everett and has a functional classification of Local Access "B" per the Marshland Subarea Plan. The standard roadway section for this classification is 32 feet wide between face of curbs and includes sidewalk. Total width measured to back of sidewalk is 42 feet. The design and posted speed is 30 mph. The new roadway alignment proposed under the full restoration alternative will be designed to the meet the full standard for this classification; no deviations are proposed other than accommodating a trail route. For the partial restoration alternative, only those portions of the roadway that are replaced to transition to the bridge will be brought to the current standard. Modifications to Lowell-Snohomish River Road will need to meet the road classification and design standards for City of Everett in some portions and Snohomish County in others, based on local jurisdiction boundaries within the action area.

The minimum roadway elevation along the new alignment will match existing road and dike grades, except at roadway bridges where the elevation will be increased to 23.0 feet. The new road embankment will be considered a setback dike, and will keep the road above tidal levels, but will overtop at 5-year flood levels. The bridges will be built higher to match railroad bridge elevations. The proposed road bridge lengths for the full restoration alternative will be approximately 295 feet and 850 feet with three spans and seven spans (Road Bridge A and B, respectively). These bridge lengths are based either on matching railroad bridge openings (Road Bridge A) or on passing flows in the preliminary hydraulic analysis for 10% design (Road Bridge B). Further hydraulic evaluations will occur in subsequent design phases.

Both proposed bridge lengths (Road Bridge C and D) for the partial restoration alternative will be approximately 200 feet with two spans. All proposed bridges will consist of 5-foot-2-inch-deep pre-cast concrete girders (Figure 11-7). An existing road bridge over the Marshland Canal adjacent to the existing Marshland Pump Station will remain in place.

Intermediate bridge piers consist of columns supported on drilled shafts. The assumed embedment depth of the drilled shafts is 100 feet. The single-span bridge will have pile-supported abutments.

Transportation – Rail

Five railroad bridges exist along the railroad alignment today. The piers for all will be armored with rock protection. For modifications to channels proposed under existing railroad bridges, and where replacement bridges are not proposed, a key design assumption is that existing structural features (e.g., abutments and pilings) will need to be protected using riprap or acceptable rock slope stabilization that is also compatible with fish passage requirements to address scour protection.

Under the full restoration alternative, the 1,750 LF railroad trestle will be bisected by a proposed transmission line access dike. This dike is proposed to be lower than the railroad bridge, and will pass beneath the trestle and terminate at the proposed setback dike with the relocated Lowell-Snohomish River Road. The full length of the 1,750 LF railroad trestle will remain open and will continue to pass flood flows that overtop the transmission line and Lowell-Snohomish River Road setback dike. The portion of the railroad bridge (Rail Bridge #3) that will be upgraded will be 850 LF to match the opening of the proposed Lowell-Snohomish River Road setback dike and road bridge. This 850 LF opening is the width open to normal tidal flows passing beneath the railroad and the Lowell-Snohomish River Road bridge. Tidal hydrology is likely to reach the 900 LF portion of the existing railroad trestle that is outside the proposed transmission line access dike.

Under full and partial restoration alternatives, the ground elevation over a center 50-foot portion of the existing 290-foot timber rail trestle (Rail Bridge #2) will be lowered 4 feet to excavate a channel. This 50-foot section of the bridge will need to be replaced with new trestle structure. If pile capacities are not adversely affected by soil excavation, maintaining the existing structure may be possible. This would need to be coordinated with BNSF Railway during later stages of design.

Replacement of the railway bridge section assumes little or no interruption of service to the mainline BNSF railroad. The proposed replacement structure consists of 30-inch-deep pre-cast concrete box girders supported on H-pile bents (Figure 11-7). It is assumed that three spans and four replacement bents will be required over the 50-foot stretch.

BNSF Railway typically uses steel H-pile sections for bridge piles in new structures. Because this location is part of the coastal saltwater environment, a coating system for steel piles and/or sacrificial thickness would be required to ensure satisfactory long-term performance. Other pile types such as pre-cast concrete piles should also be considered during design. The assumed depth of piles is 100 feet embedded.

An existing concrete pier trestle currently spans across the Everett Slough and the adjacent floodplains. Most of the concrete piers are rarely subjected to water inundations except for the occasional flood. With restoration, all of these piers will be subjected to regular inundations due to tidal fluctuations. Although trestle replacement would likely not be required, measures may be needed to protect the piers from tidal effects.

Utilities

The Marshland area serves as a major utility corridor for the BPA and PSE. Both have several transmission lines that traverse the action area which are a major component of the regional power grid. No utility relocations are proposed as part of either action; utilities will be protected in place through construction of a series of dikes. As the design proceeds, coordination with these providers will be needed to address access to their facilities.

A petroleum pipeline consisting of 16-inch and 20-inch-diameter mains owned by BP-Olympic is located within the southeastern corner of the Marshland action area. The restoration alternatives would not result in direct impacts to these lines.

Local electrical power overhead lines (Snohomish County PUD) are located within the Lowell-Snohomish River Road prism. Water supply mainlines to the City of Everett are located south of Lowell-Snohomish River Road, west of the Marshland Pump Station. There is also a proposal to extend a trunk sewer line along Lowell-Snohomish River Road (Cunningham 2010). All of the utilities in Lowell-Snohomish River Road will have to be relocated (10,000 LF) with the full restoration alternative, but not with the partial restoration alternative, except at proposed road bridges. Lowell-Larimer Road, which bounds the western limits of the action area, serves as the utility corridor for local electrical utility (Snohomish PUD), water distribution, and sanitary sewer. There will be no impacts to this infrastructure in Lowell-Larimer Road.

Hydrology and Hydraulic Considerations

Hydrology and hydraulic considerations include: (1) protection of infrastructure and adjacent properties (or in the partial restoration alternative, non–participating properties) from normal tidal high water and flooding; (2) designing suitable conditions for the full restoration alternative of tidal exchange in the restored slough channels; and (3) offsite drainage for the Marshland Pump Station and Canal. For the partial restoration alternative, the added major design consideration would be no modification of the existing south and east Snohomish River dike as part of Lowell-Snohomish River Road, except bridged crossings. These crossings would be created for improved connectivity of the mainstem river and historic tidal marsh. Under partial restoration, the existing bridge at the Marshland Canal outlet is assumed to remain (approximately 140-foot span with vertical concrete abutments to low water level). The second crossing would include an approximate 200-foot span bridge matching the existing road elevation at approximately elevation 18 feet NAVD 88, and with the channel under it excavated to at least elevation -2.0 feet NAVD 88.

In order to convey pumped drainage from the Marshland Canal south of the action area to the Snohomish River, several improvements are needed in both restoration alternatives. First is relocation of the Marshland Pump Station at the south end of the action area. This pump station will be updated to not only provide all drainage requirements for the large area to the south, but also to meet current fish passage requirements. At the outlet of the relocated pump station, a proposed channel would convey pumped drainage to the Snohomish River (Figures 11-3 and 11-4). The Marshland Pump Station drains a very large area of diked farmland that did not historically drain through the action area. There are also concerns with water quality in the Marshland Canal; therefore, directing this relocated pump station discharge directly to the Snohomish River in full restoration was deemed preferable for 10% design.

Flood gates are also needed at the outlet of the pump station. At the BNSF railroad berm and Lowell-Snohomish River Road dike, a large culvert will be installed by horizontal driving through the railroad and roadway in the full restoration alternative. This culvert will convey pumped drainage from the channel described above. Additional fill may be needed between the two embankments to accept the driven culvert. Alternatively, the portion beneath the roadway can be installed by cut-and-cover but would require a roadway closure for a period of time. In the partial restoration alternative, the existing rail trestle and a new road bridge will convey this pumped drainage and tidal flows to the Snohomish River.

In the full restoration alternative, four large box culvets are needed to convey tidal and freshwater flows through the proposed dikes for PSE and BPA electrical transmission line access. These culverts also provide floodwater evacuation. For partial restoration, a series of seven culverts with tide gates are needed for local drainage or conveying streams in dike-protected areas to tidally restored areas. At streams, additional design considerations for fish-passable tide gates are required. These culverts are sized based on preliminary hydraulic analysis for 10% design. Additional hydraulic analysis will be needed in subsequent design phases to confirm or refine the size of these culverts.

Geotechnical Considerations

No subsurface geotechnical investigation data was available as part of the 10% design assessment of the full and partial restoration alternatives. The design of the action had to rely on limited prior anecdotal evidence of subsurface soils conditions in the general project area without formal geotechnical design assessment. That evidence suggests that large depths of compressible peat deposits exist within the marsh plain, which may result in geotechnical challenges, such as long-term differential settlement, associated with constructing the added setback dikes, hydraulic structures, and the proposed Lowell-Snohomish Road realignment (in full restoration). Other issues include the potential for differential settlement to affect BP pipeline that runs across the site and for the proposed access levees to induce downdrag on the BPA and PSE transmission lines.

A key assumption during conceptual design was that the new setback dikes and roadway prism would be constructed on a suitable foundation including over-excavation of the fill prism base, and pile-support of hydraulic structures (soils pre-loading in improvement areas may also be required). It was also assumed that the embankment fill would partially come from suitable on-site excavation (e.g., excavated material from the existing roadway/dike fill prism assumed) combined with imported structural fill. For those embankment conditions, a side slope of 2:1 is typically adequate to meet embankment loading slope stability criteria. Additional geotechnical analysis will be needed in subsequent design phases to confirm or refine the side slopes, consider the use of pilings for hydraulic structures, and determine optimal construction phasing of levees.

Ecological Considerations

The full restoration alternative restores the maximum connectivity and diversity of habitat through dike removal and setback and infrastructure modifications. Process restoration is achieved by restoring all historic distributary channels and all of the historic marsh plain within the action area, with the exception of the transportation infrastructure footprint. Effectiveness is also achieved by restoring full tidal hydrology, channel development, and sediment transport processes.

Areas of subsidence east of the BNSF railroad are a consideration, given that sediment supply to these areas may not raise them sufficiently to historic marsh plain elevations. Partial restoration results in significantly less connectivity of the two tidal marsh restored areas with the mainstem Snohomish River than full restoration. The main process effectiveness considerations with partial restoration are providing adequate sediment supply to subsided areas for development of diverse tidal marsh habitats.

11.3.7 Construction Considerations

Marsh, Earthwork, and Pump Station Construction

For the full and partial restoration alternatives, it is assumed that multiple trackhoe excavators (low-ground-pressure type) will be used to complete marsh channel excavations, construct dikes, locally place/remove excavated materials for temporary stockpiles, and fill existing marsh channels from stockpiles. In addition, other conventional excavation equipment would be used for existing road removal and dike lowering (for full restoration). Loaders, dump trucks, soil compaction equipment, dewatering wells, pumps, piping, and construction water quality treatment devices will also be needed to prepare the site for excavation and move significant amounts of earth.

Controlled placement and compaction of suitable embankment fill materials will be needed for dike construction and fill of agricultural channels. Overexcavation is assumed to be needed at the base of constructed dikes and roadway embankments to clear and grub vegetation and unsuitable subgrade materials prior to embankment fill placement. Dependent on geotechnical investigation findings during preliminary (35%) design, pre-load of the dike and roadway embankment areas may be required for up to a 1-year period to allow for larger, short-term embankment settlement.

Temporary construction access roads would be used to maximize the efficiency of earthwork operations, import materials, and haul unsuitable materials offsite. It is assumed that construction access will generally follow proposed dike and marsh channel creation alignments, but further evaluation will be needed in succeeding stages of design. Haul and disposal areas for excavated and demolished materials would generally be located offsite. However, due to the low topography of the area east of the BNSF railroad, the dike removal soils from this portion of the action area would be used to raise grades outside of distributary channels. This approach will reduce offsite haul and disposal, and improve habitat restoration performance in subsided areas.

A staging and stockpile area for full and partial restoration could be located at the higher elevation land along Lowell-Larimer Road on the Spane property. A second potential staging and stockpile area could be located at Rotary Park at the northwest portion of the action area along Lowell-Snohomish River Road. A suitable location would need to be finalized during final design and prior to bidding.

Construction of the new Marshland Pump Station at the south end of the action area will need to occur before the existing pump station can be removed. During construction of the new pump station, Marshland Canal flows will continue to be bypassed through the action area to the existing pump station for discharge to the river. Once the new pump station is operational, flows can be diverted through the created channel (constructed by building dikes on both sides), to the new Snohomish River outfall culvert under the BNSF railroad and Lowell-Snohomish River Road. Once that flow diversion is completed, the marsh construction can proceed, continuing to use the existing pump station for construction dewatering of the marsh construction areas. After that work is complete, the existing pump station can be removed, and the new Lowell-Snohomish River Road bridge crossings can be opened for reestablishment of the tidal marsh prism exchange (Figures 11-3 and 11-4).

Construction for a site of this scale is envisioned to occur over at least two summer construction seasons, and likely three seasons when considering the pump station and embankment pre-load requirements.

Bridge Construction

For the bridges that carry the roadway, a drilled-shaft oscillator would be used to install the drilled shafts. It is assumed that the contractor will be able to install one shaft per week. A large-diameter casing shoring would be required to keep out water and allow access to the top of the shaft for column form placement and removal. Once the shafts are installed, the columns are cast inside the shoring casing. After the casing is removed, the cast-in-place pilecaps and bridge superstructure are constructed.

Concrete bridges require very little maintenance. The current standard is to inspect bridges every 2 years.

The new portion of the railroad trestle must be built without any track closure. During construction windows coordinated with BNSF Railway, the contractor will drive anywhere from one to three piles between existing bents accessed from the rail. Once all of the piles are driven, the pre-cast pilecaps will be lowered and slid into place below the existing track and welded to the piles. Existing track sections will then be removed and replaced with new sections until the entire length is replaced.

11.4 Extent of Stressor Removal

Table 11-2 describes the amount of stressors to be removed with this action.

Table 11-2. Stressor Removal

Stressor	Full Restoration	Partial Restoration
Tidal Barrier (LF)	12,800	400
Fill (acres)	14.6	1.4
Armor (LF)	250	250
Nearshore Roads (LF)	12,800	400
Railroad Upgrades (LF)	900	520
Stream Crossings	1-Marshland Pump Station Relocation	1-Marshland Pump Station Relocation

11.5 Expected Evolution of the Action Area

Initially following full restoration, much of the action area will be below tidal marsh elevations due to subsidence related to diking and drainage. However, the overall marsh surface is anticipated to gradually aggrade due to sediment deposition from Snohomish River floods and, to a much smaller extent, sediment from small tributaries on the west side of the project area. Three bands of higher elevation land associated with the edge of the floodplain (west), restored Hardscrabble Slough (center), and Snohomish River (east) will extend north/south through the action area. These areas of higher ground will initially colonize with marsh and riparian vegetation.

The course of the restored Wood Creek may shift between the restored Hardscrabble Slough channel and the proposed primary channel in the low area to the east. Because Wood Creek carries a relatively high sediment load, its long-term location, along with sediments from the Snohomish River, will influence where sediment is distributed. Tidal hydrology will result in distribution of sediment and channel formation throughout the restored area. Blind channel development is anticipated to occur rapidly from the starter channels due to the large tidal prism in full restoration. During Snohomish River flood events, more episodic channel morphology and sediment transport changes are anticipated, as well as some distribution of woody debris in the restored channels and elsewhere.

Under the partial restoration alternative, the speed of sedimentation and distribution will be different due to the more limited openings to the Snohomish River mainstem (one existing opening at Marshland Canal and two new openings south and east of this one). These three smaller openings may concentrate sediment delivery more locally, with gradual and episodic redistribution from tides and flood events. The shorter length of the Wood Creek restored channel will result in a more localized distribution of sediment. Vegetation changes in the restored areas will be similar to full restoration initially, with long-term patterns highly dependent on sediment distribution and accumulation.

Operation and maintenance issues associated with the restoration include removal of debris from beneath the railroad and road bridges and the culverts and tide gates after major floods. Woody debris from these maintenance operations can be placed within the action area to support habitat structure and complexity.

11.6 Uncertainties and Risks

Uncertainties and risks for this action area include:

- The willingness of private landowners to sell or grant easements for restoration of their property.
- The design and construction requirements needed to satisfy the BNSF Railway, PSE, BPA, and the petroleum and water pipeline owners. Civil and geotechnical investigations will address some of the uncertainties and risks, as well as hydrologic and hydrodynamic modeling.
- Seismic liquefaction risks associated with moving the Snohomish River dike and Lowell-Snohomish River Road with full restoration. Geotechnical investigations and analysis will be needed to address this risk and uncertainty.
- A potential lack of sediment supply to the action area. This risk is very low with the full restoration alternative because it proposes full connectivity to the mainstem river. This risk is higher with the partial restoration alternative due to the limited length of dike removal and restricted flow velocities. Risk is lowered by the upstream location of the action area above all of the distributary channels and other large estuary restoration projects.
- Potential increased risks to critical utility infrastructure associated with tidal prism and river flooding modifications caused by existing dike removal and setback levee/dike additions. These risks can be mitigated in most cases with adequate design and analysis including hydrologic modeling of flood flows.

- Cultural resource risks associated with excavations below pre-settlement grades. No known cultural resource sites exist within the action area however.
- Contamination risks associated with the former landfill and creosote plant.
- Risk in the full restoration alternative of mainstem river migration occurring in unforeseen ways (e.g., under road and railroad) due to significant low-lying lands west of the river. This risk can be mitigated with adequate design and analysis including hydrodynamic modeling.
- Long-term differential settlement risks resulting from poor soils encountered in relocating dikes, Lowell-Snohomish River Road, and the Marshland Pump Station. There are also potential risks to critical utility infrastructure associated with settlement. This risk can be mitigated with adequate design and analysis including geotechnical investigation.

11.6.1 Risks Associated with Projected Sea Level Change

The action area is strategically located at the upstream portion of the Snohomish River Estuary. This upgradient location provides an important long-term opportunity to respond to habitat migration associated with sea level change. All of the other large Snohomish River Estuary project locations (existing and proposed) are located downgradient in the estuary. The action area is also the only large-scale Snohomish River Estuary action located on the mainstem Snohomish River and not on a distributary channel. This relationship to the mainstem river, in combination with the upgradient location, is significant for restoration as the river is the main sediment source for the estuary. This action is therefore well positioned to address sea level change and long-term sediment supply concerns. Table 11-3 compares potential risks associated with projected sea level changes based on professional judgment.

Table 11-3. Risks of Sea Level Change

	Projected Sea Level Change		
	High (46 cm)	**Intermediate (4 cm)**	**Low (-8 cm)**
Full Restoration	Low infrastructure risks mitigated by design and higher water levels for flood protection superseding projected sea level change Low risk of sediment supply not keeping pace with sea level change and conversion of restored marsh habitats to lower elevation (mudflat). Mitigated by upgradient estuary location and mainstem river location plus degree of mainstem dike removal Low risk of increased tidal prism from sea level change increasing channel erosion particularly at bridges and culverts. Sea level change risk is superseded by high water levels and volumes associated with flooding	Low infrastructure risks mitigated by design for projected sea level change Low risk of sediment supply not keeping pace with sea level change and conversion of restored marsh habitats to lower elevation (mudflat) Low risk of increased tidal prism from sea level change increasing channel erosion particularly at bridges and culverts	None
Partial Restoration	Low infrastructure risks mitigated by design and higher water levels for flood protection superseding projected sea level change Moderate risk of sediment supply not keeping pace with sea level change and conversion of restored marsh habitats to lower elevation (mudflat). Mitigated by upgradient estuary location and mainstem river location. Risk is higher for partial restoration due to limited dike removal constricting sediment delivery Low risk of increased tidal prism from sea level change increasing channel erosion particularly at bridges and culverts. Sea level change risk is superseded by high water levels and volumes associated with flooding	Low infrastructure risks mitigated by design for projected sea level change Low risk of sediment supply not keeping pace with sea level change and conversion of restored marsh habitats to lower elevation (mudflat) Low risk of increased tidal prism from sea level change increasing channel erosion particularly at bridges	None

11.7 Potential Monitoring Opportunities

Monitoring is important for evaluating restoration success. A combination of field surveys and aerial photographs would be used to document biological and physical changes to the landscape. Monitoring data can be used to refine adaptive management and corrective actions, as needed. Some of the main monitoring needs and opportunities associated with this action are summarized in Table 11-4.

Table 11-4. Monitoring Needs and Opportunities

Monitoring Parameter	Key Performance Indicator	Note
Topographic Stability		
Sediment Accretion / Erosion	X	Monitor sediment transport changes
Wood Accumulation	X	Monitor distribution of woody debris in restored channels and elsewhere
Soil / Substrate Conditions		
Vegetation Establishment	X	Monitor marsh and riparian colonization of areas of higher ground
Marsh Surface Evolution / Accretion	X	Monitor changes in marsh due to sediment deposition
Tidal Channel Cross-Section / Density	X	Monitor blind channel development and overall channel morphology
Water Quality (contaminants)		
Salinity		
Shellfish Production		
Extent of Invasive Species		
Animal Species Richness		
Fish (salmonid) Access/Use	X	Monitor to determine if salmonid production goals are being met for estuary
Forage Fish Production		
Wildlife Species Use		
Effectiveness of Exclusion Devices		

11.8 Information Needed for Subsequent Design

This conceptual design report represents an initial step in the restoration design sequence. The design concepts described above were developed based on readily available information without the level of site-specific survey and investigation that is necessary to support subsequent design and implementation. Substantial additional information will be required at the preliminary and later design stages to confirm the design assumptions, refine quantity estimates, address property and regulatory issues, obtain stakeholder support, and fill in data gaps. This section attempts to define the most essential information needs for this action.

- Property Investigation/Survey – More detailed information on parcel ownership, utilities, and property boundary locations will be needed to finalize the design, confirm acquisition requirements, and support negotiations with property owners.

- Topographic/Bathymetric Survey – The survey data would be used to refine design of key project elements and develop detailed construction and demolition plans. Survey data could also be used as a baseline for pre- and post-construction modeling, including hydrodynamic modeling. A temporary tide gauge may be required in the early design stages to obtain site-specific tidal statistics.
- Geotechnical Investigation – Geotechnical investigations and recommendations will be required to finalize design of bridge, road removal, and rail infrastructure and to address questions of slope stability of setback dikes. Geotechnical analysis will be needed to determine the depth and extent of compressible peat deposits in the marsh plain. This information will be needed to confirm or refine the side slopes of the setback levees, hydraulic structures, and the proposed Lowell-Snohomish Road realignment, and the type of construction equipment that may be used to construct the interior drainage channel network.
- Cultural Resources Investigation – Surveys for archaeological and historic resources may be required for this action area as it has a high likelihood of having past use by Native Americans. This is particularly important for areas proposed for excavation and trenching.
- Hydraulic Analysis/Modeling – Tidal circulation, flood, and hydrodynamic modeling will be required to evaluate impacts to infrastructure and adjacent properties following restoration. The models will also be used to optimize the size of the bridge and culvert openings in the partial restoration alternative, and to provide design criteria for proposed roadway and utility improvements for both restoration alternatives. Results from the modeling will be utilized by a hydraulic engineer to provide recommendations for culvert sizing and scour and minimum deck/bridge elevations for Lowell-Snohomish River Road and BNSF bridges (both full and partial restoration alternatives). Hydraulic engineering recommendations for scour and minimum bridge clearance over water are needed based on modeling. In early design stages, a temporary tide gauge should be installed to get site specific tidal statistics at the site and validate hydraulic models after development.
- Sediment Transport Studies – Sediment transport evaluations should be conducted to optimize the channel opening and to address concerns about restored tidal marsh evolution and sustainability.
- Contaminant Survey – If preliminary investigations suggest that hazardous material could be present in the action area, additional soil and sediment analysis may be needed. A soil and sediment environmental characterization study of the landfill and former creosote plant are likely to be needed for full restoration. These two locations should be investigated as two separate sites. The introductory chapter describes the Phase I site investigations that are occurring as part of this overall effort via a separate contract.
- Tidal datum transformation – Collect site specific water level data to allow for better understanding of how freshwater flows influence tide levels in this section of the Snohomish River.
- Sea Level Change Projection – Estimates of sea level change for the conceptual design were based on calculations provided by the Washington Department of

Fish and Wildlife and the Corps of Engineers using guidance in Corps' Engineering Circular No. 1165-2-211. Projections for each project area will be refined using localized tide gauge data during later design stages.

- Other – Maintenance and access for the water mains at the north end of the action area will also need to be determined for the full restoration alternative. Modeling will be used to determine potential effects of this alternative on these water mains. An analysis of utility protection will also need to be conducted for existing transmission lines and powerpoles. Fish passage requirements at the pump station will also need to be investigated.

11.9 Quantity Estimates

The design quantities are largely developed from LiDAR data sets lacking the resolution to accurately quantify all elements of construction. These are supplemented by unmeasured estimates made during one site visit at high tide and areal take-offs from available imagery. The quantity spreadsheets for the full and partial restoration alternatives are provided in Exhibits 11-1 and 11-2.

11.10 References

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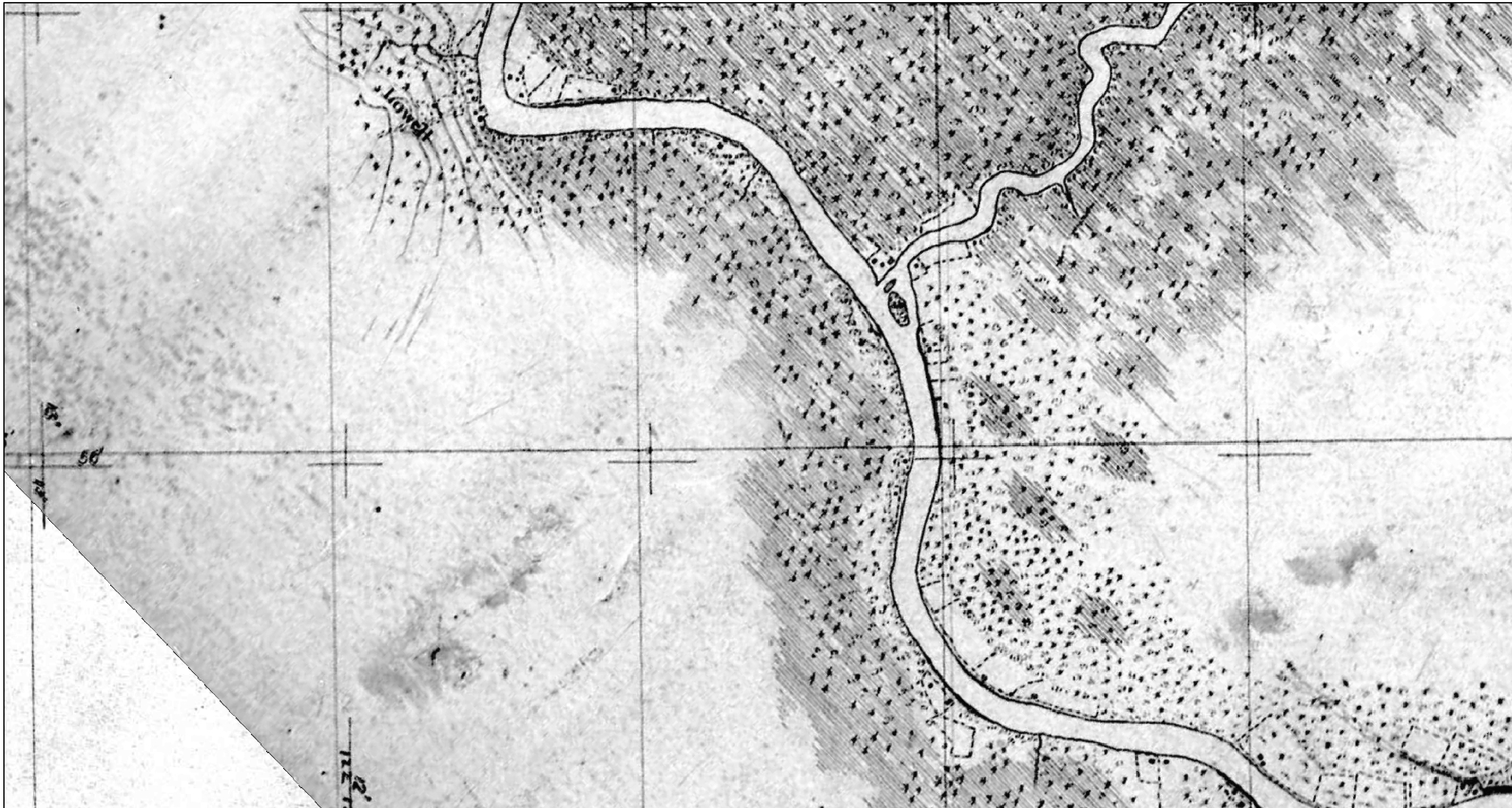

0 1,280
Feet
0 400
Meters

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Historic Map (T-Sheet)

Action Name: Everett Marshland Tidal Wetland Restoration

PSNERP ID #: 1126

Figure 11- 2A

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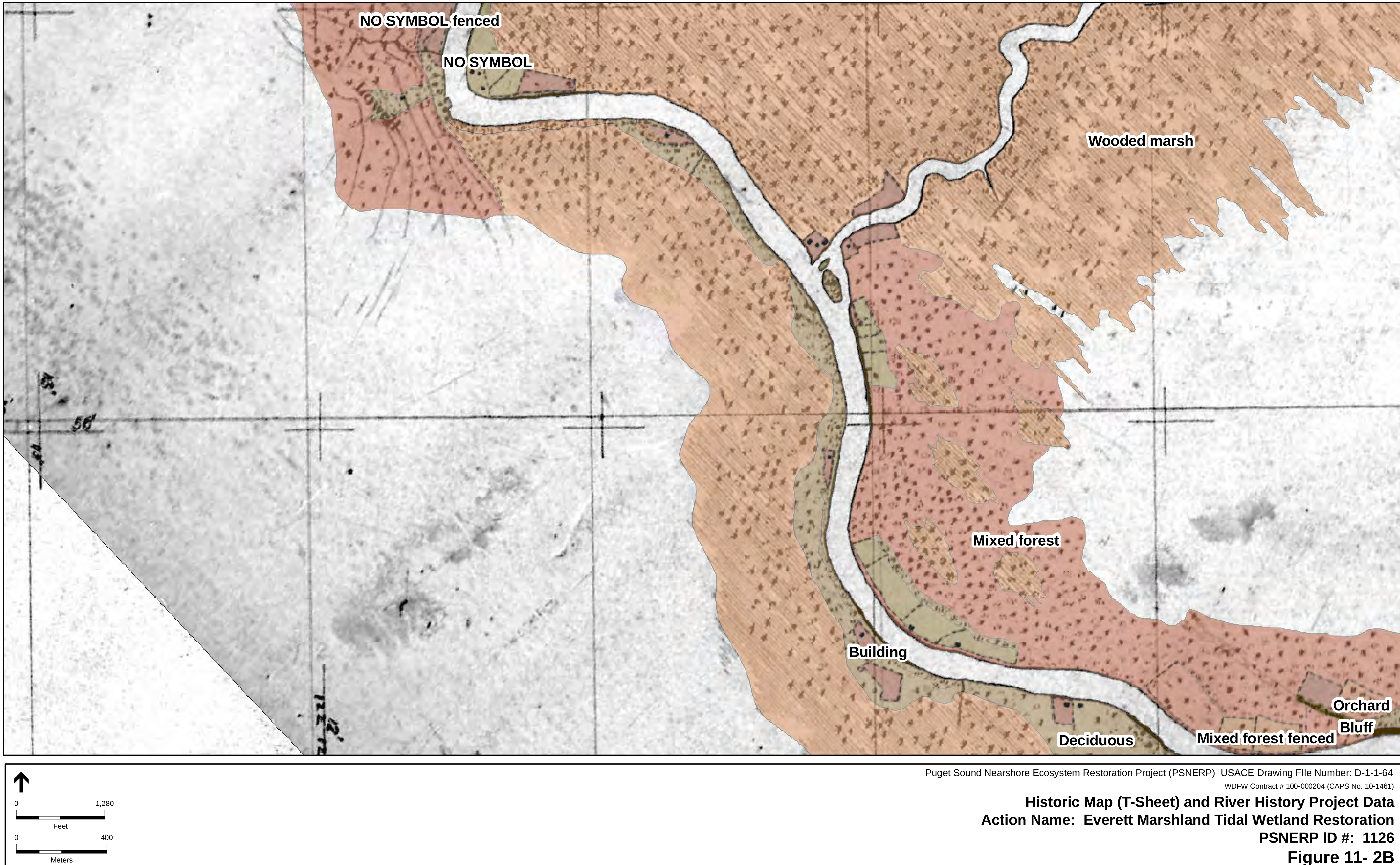

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Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64

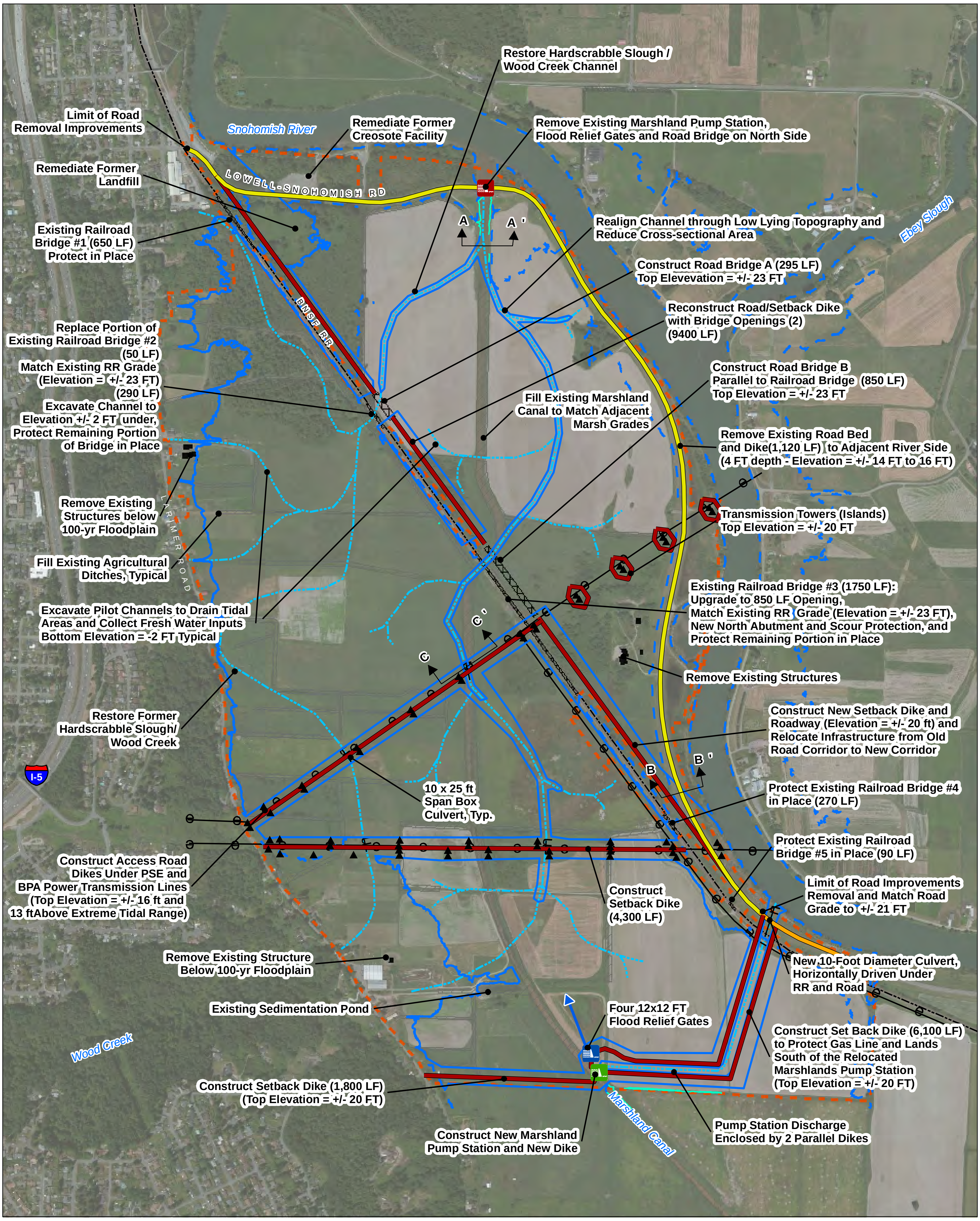
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Historic Map (T-Sheet) and River History Project Data

Action Name: Everett Marshland Tidal Wetland Restoration

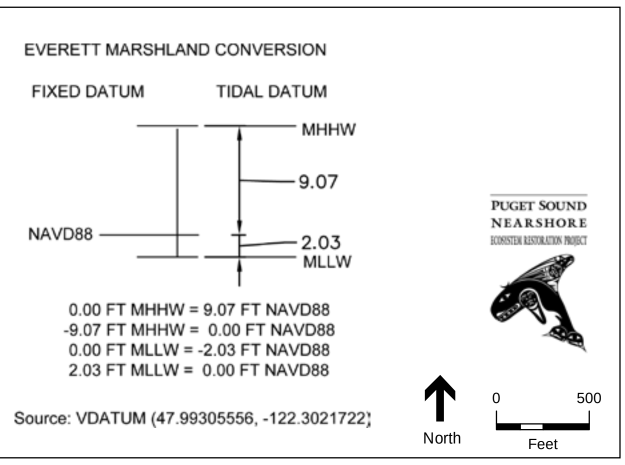
PSNERP ID #: 1126

Figure 11- 2B



Legend

Existing Utility Tower	Dike Construction	Existing Tide MHHW
Flood Relief Gates	Dike Removal	Existing Tide MLLW
New Pump Station	Existing Dike	Other
Remove Pump Station	Channel Rehab/Creation	Proposed Tide MHHW
Bridge	Electric	Utilities
Buildings		Existing Perennial Stream
Required Project Lands		Section Line
Select Fill		



SOURCE: Snohomish County, 2009; Bing Maps, 2011

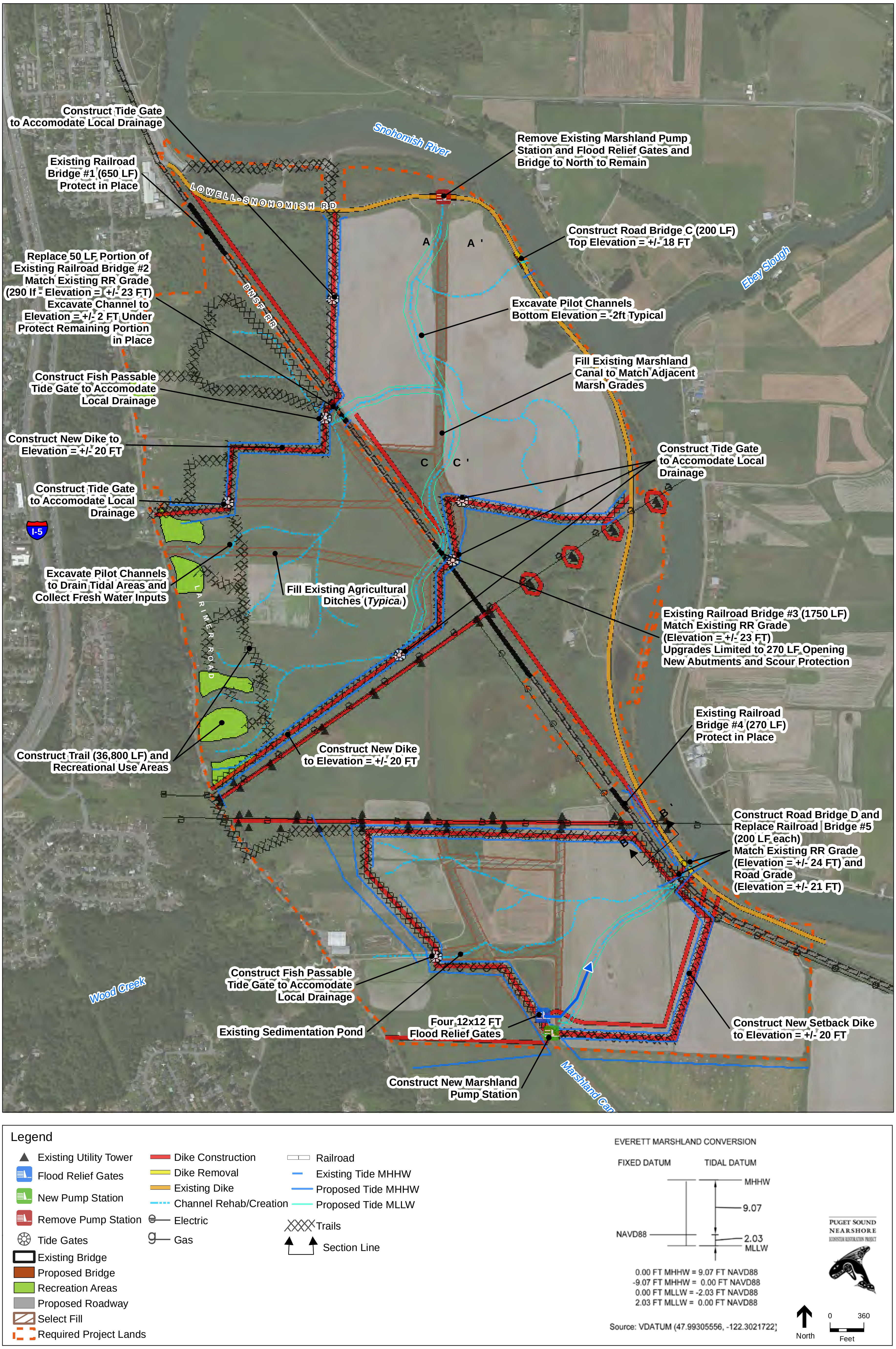
Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64

WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Plan
Site Name: Everett Marshlands
Action Name: Everett Marshland Tidal Wetland Restoration
PSNERP ID#: 1126
Full Restoration

Lead Contractor: ESA
Design Lead: Anchor QEA, J. Bibee P.E.
Date: 05/2012

Figure 11-3



SOURCE: Snohomish County, 2009; Bing Maps, 2011

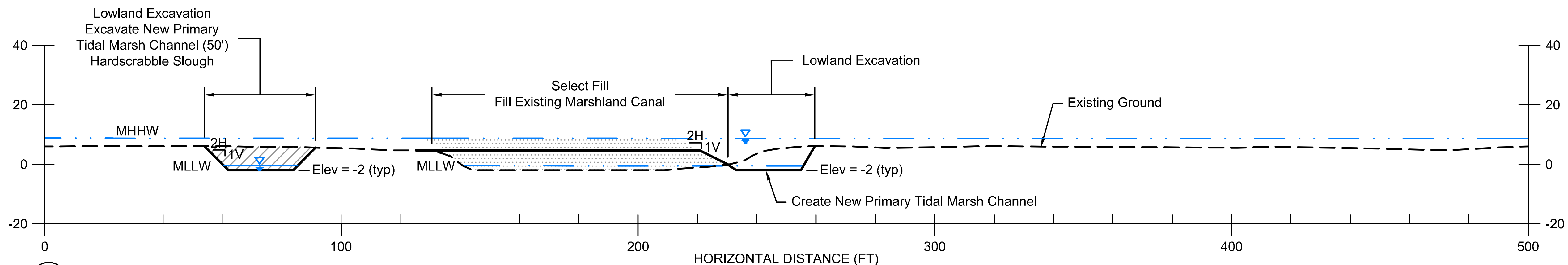
Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64

WDFW Contract # 100-000204 (CAPS No. 10-1461)

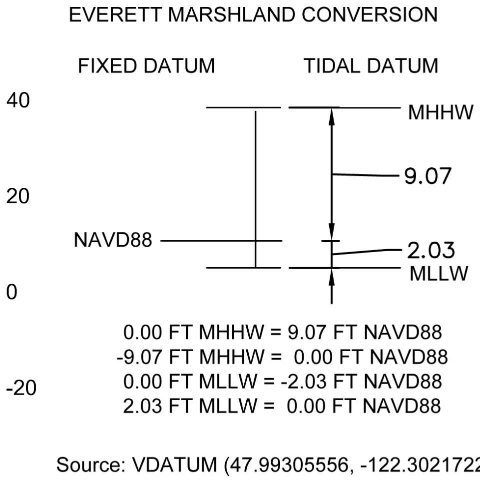
Conceptual Design Plan
Site Name: Everett Marshlands
Action Name: Everett Marshland Tidal Wetland Restoration
PSNERP ID#: 1126
Partial Restoration

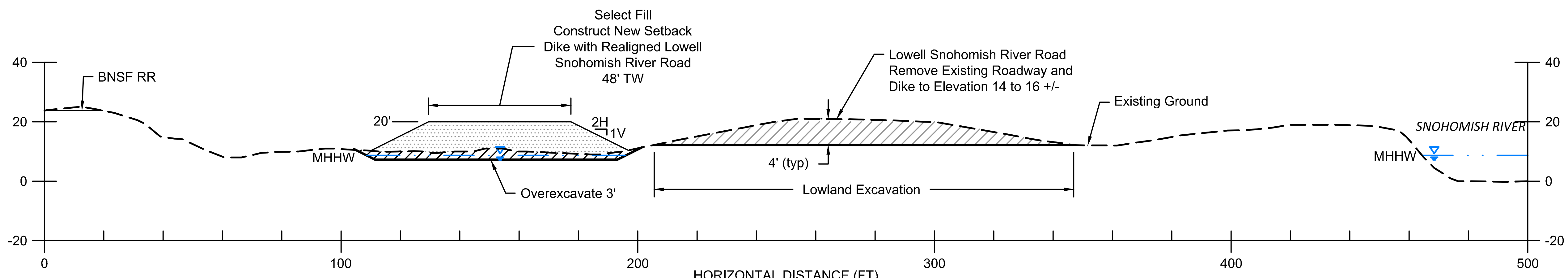
Lead Contractor: ESA
Design Lead: Anchor QEA, J. Bibee P.E.
Date: 05/2012

Figure 11-4



A FULL RESTORATION TYPICAL SECTION





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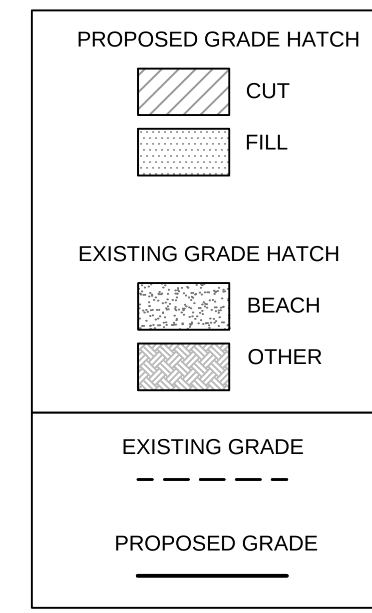
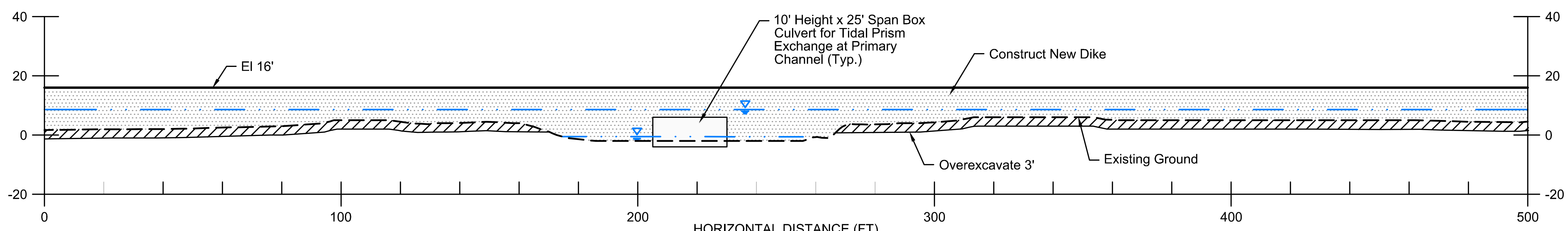
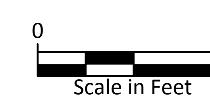




C FULL RESTORATION TYPICAL SECTION



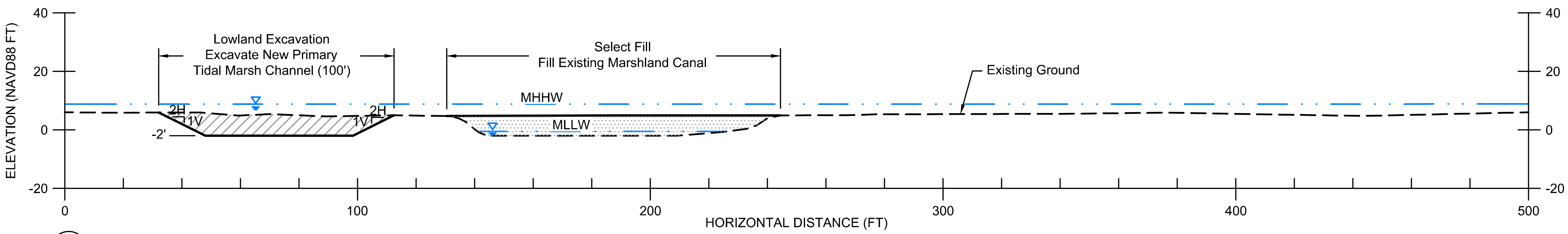
PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: Anchor, J. Bibee, PE
Date: 05/2012

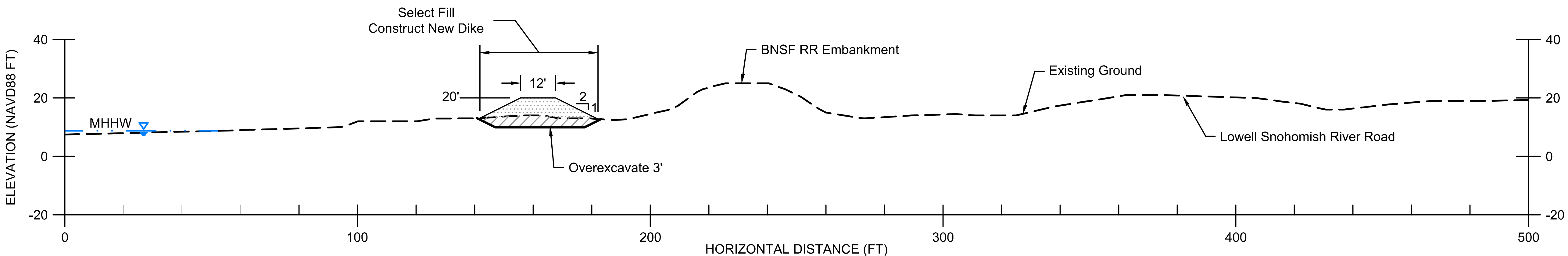
Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Section
SITE NAME: **Snohomish River Delta**
ACTION NAME: **Everett Marshland Tidal Wetland Restoration**
PSNERP ID#: **1126**
Full Restoration

Figure 11-5



A PARTIAL RESTORATION TYPICAL SECTION



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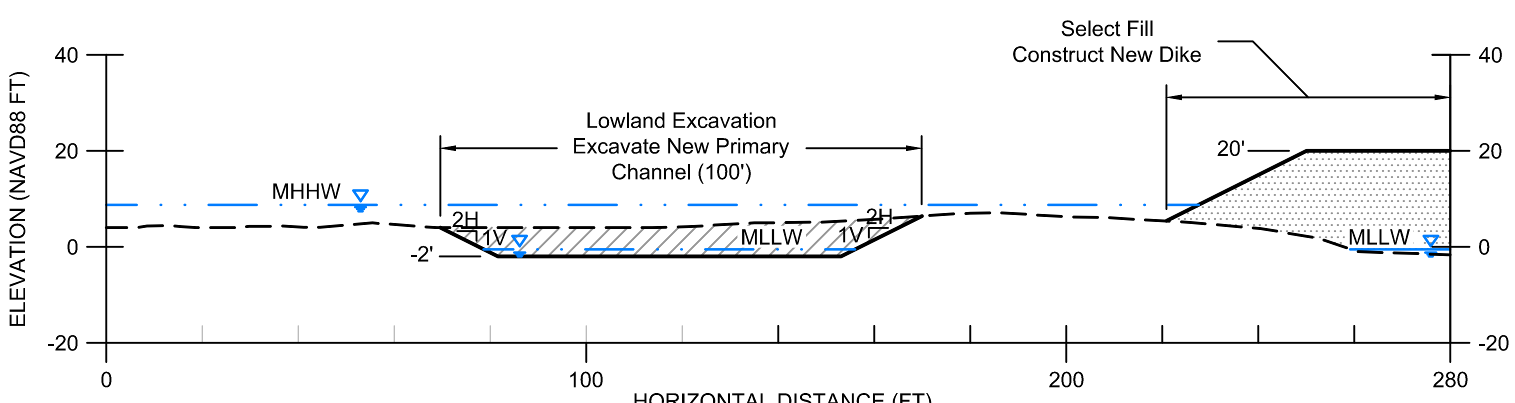

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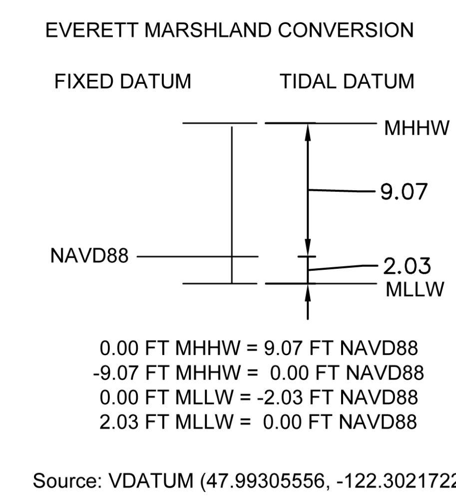
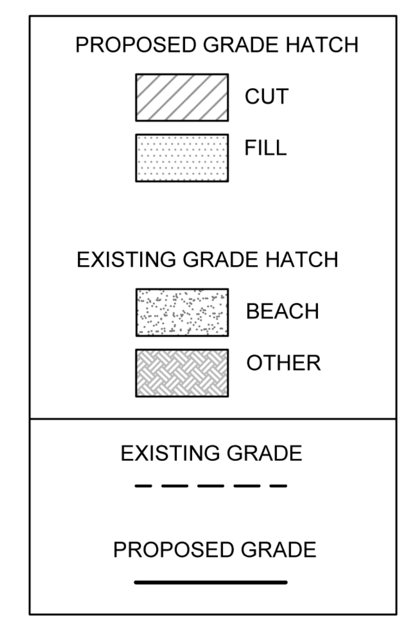




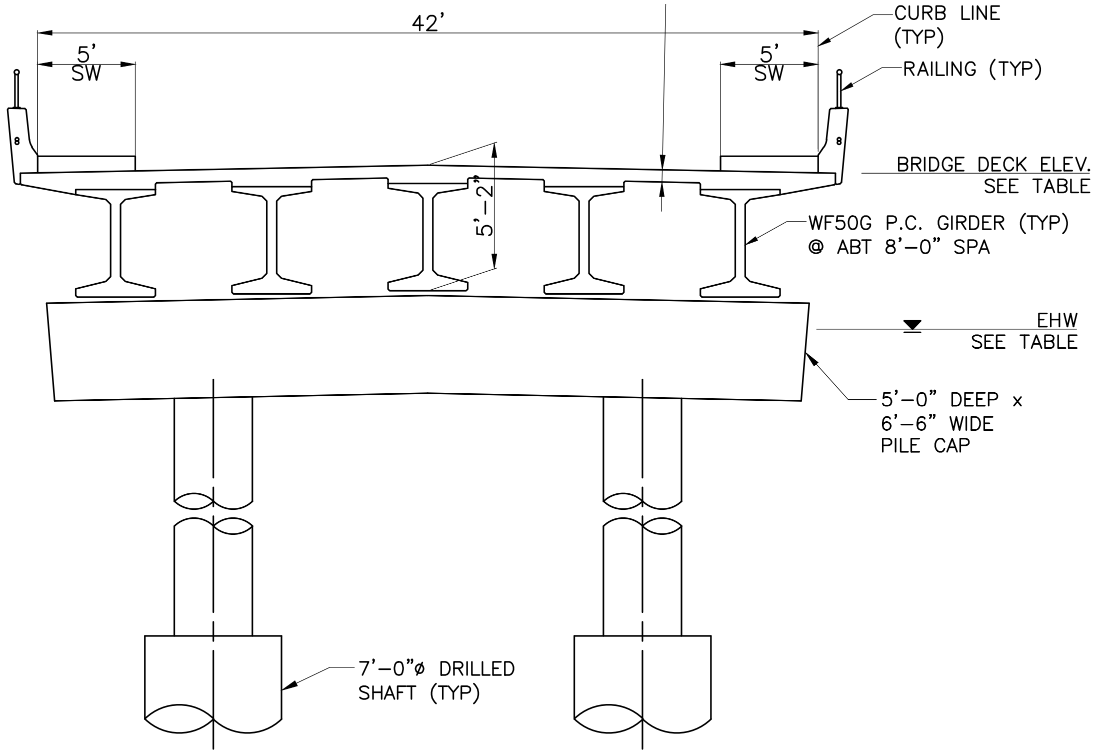
PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: Anchor, J. Bibee, PE
Date: 05/2012

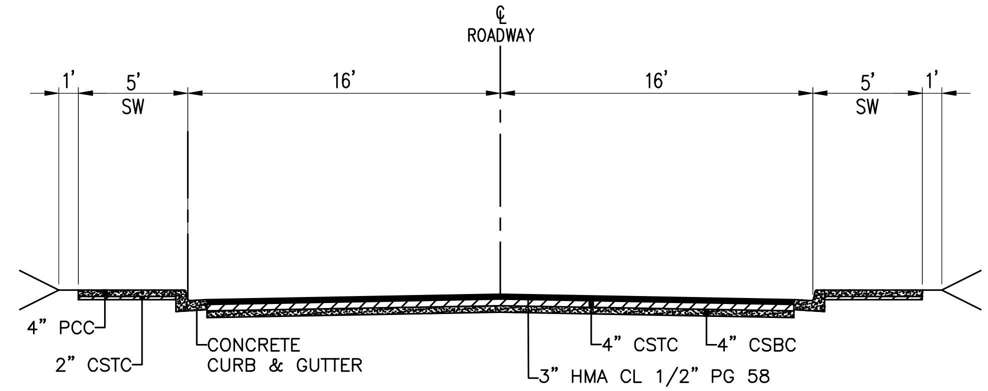
Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Section
SITE NAME: **Snohomish River Delta**
ACTION NAME: **Everett Marshland Tidal Wetland Restoration**
PSNERP ID#: **1126**
Partial Restoration

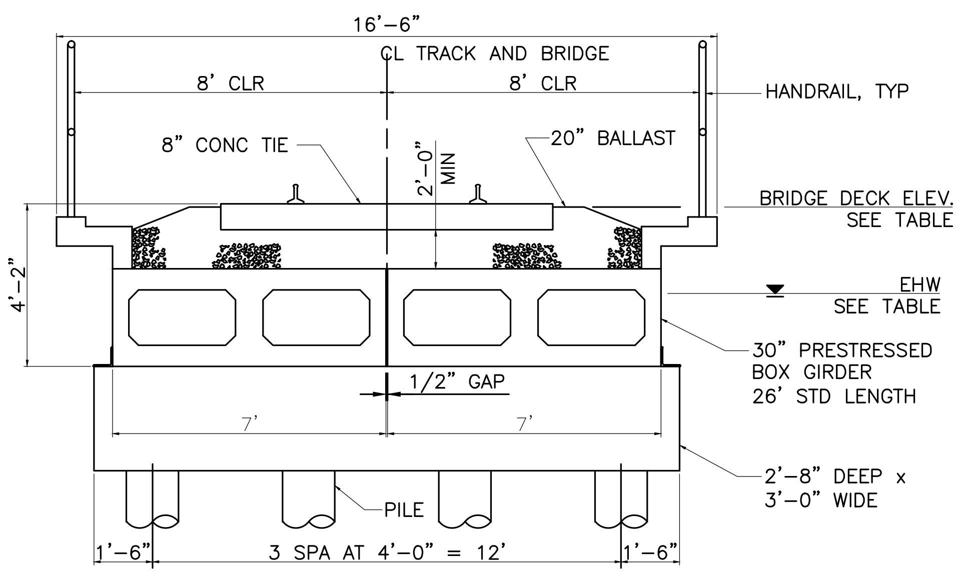
Figure 11-6



TYPICAL ROADWAY BRIDGE
SECTION DETAIL
Not to Scale
Section Provided by KPFF



TYPICAL ROADWAY
SECTION DETAIL
Not to Scale
Section Provided by KPFF



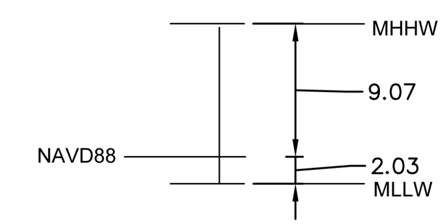
TYPICAL RAILROAD BRIDGE
SECTION DETAIL
Not to Scale
Section Provided by KPFF

BRIDGE DESIGN				
BRIDGE	LENGTH (LF)	EHW (NAVD88)	BRIDGE DECK ELEV. (NAVD88)	SPAN LENGTH (LF)
FULL RESTORATION				
ROAD BRIDGE A	295	23.0	23.0	98
ROAD BRIDGE B	850	24.0	23.0	120
RAIL BRIDGE 2	50	23.0	23.0	26
RAIL BRIDGE 3	850	23.0	23.0	26
PARTIAL RESTORATION				
ROAD BRIDGE C	200	25.0	18.0	100
ROAD BRIDGE D	200	23.0	21.0	100
RAIL BRIDGE 2	50	23.0	23.0	26
RAIL BRIDGE 3	270	23.0	23.0	36
RAIL BRIDGE 5	200	24.5	24.0	36

BRIDGES WILL BE CONSTRUCTED TO MATCH EXISTING GRADES. NO CHANGES ARE PROPOSED TO THE VERTICAL ALIGNMENT AND NO ADJUSTMENTS MADE TO BE CLEAR OF THE EXTREME HIGH WATER.

EVERETT MARSHLAND CONVERSION

FIXED DATUM TIDAL DATUM



0.00 FT MHHW = 9.07 FT NAVD88
-9.07 FT MHHW = 0.00 FT NAVD88
0.00 FT MLLW = -2.03 FT NAVD88
2.03 FT MLLW = 0.00 FT NAVD88

Source: VDATUM (47.99305556, -122.3021722)

PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: Anchor, J. Bibee, PE
Date: 05/2012

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Section
SITE NAME: **Snohomish River Delta**
ACTION NAME: **Everett Marshland Tidal Wetland Restoration**
PSNERP ID#: **1126**
Full & Partial Restoration

Figure 11-7

Full Restoration Quantity Estimate

Action Name: Everett Marshland
Action #: 1126 — Revised May 2012
Date: February 2011 — **Revised with backcheck updates: 30 June 2011**
By: D. Cisakowski and J. Bibee, Anchor QEA

***REMEDY:** Restore 876 acres of priority tidal estuarine/freshwater riverine marsh habitats through reconnection of historic marsh to Snohomish River.*
Primary management measures required include removal of approx. 2.4 mi. of existing Lowell-Snohomish Rd /dike; reconstruction of approx. 1.8 mi. of new replacement roadway on setback dike parallel to BNSF RR; construction of approximately 2.8 mi. of new setback and cross-dikes (beyond new road); removal of the Marshland pump station and its reconstuction at the south end of the action area; construction of two new bridges along existing road aligment (295 ft and 850 ft spans); upgrades to existing BNSF RR bridges totaling approximately 900 ft length; installation of 3-sided box culverts at 4 locations along new utility access dikes for tidal exchange; removal of existing outlet channel aroming; filling of the existing Marshland Canal and agricultural drainage channels within action area; creation of approx. 3.6 mi. of new primary marsh channels and 3.4 mi. of new secondary marsh channels; protection of existing utility lines (power and natural gas) including rebuild and protection of 4 existing towers; and creation of vegetated scrub shrub hummock area with excess excavation in the marsh plain.
Construction Period: Estimate two to three construction summer seasons plus limited upland work over winter - estimated 12 to 18 months total

Item	Unit of Measure	Material Name	Qty	Description of Item	Indicate section of design report where item is described
ACQUISITION AND CONSERVATION				Based on available mapping information	
Required Project Lands	Acre		1,115	Total land required for action - Total area within action area. Approx. 876 ac. of that area would be restored to beneficial fish use through tidal/freshwater connection	11.3
Proponent / Partner-owned lands	Acre		464	Estimate of lands currently owned by Proponent (i.e., Public lands) - Government or quasi-government ownerships within the action area	11.3
Lands To Be Acquired	Acre		537	Estimate land required to be acquired for action prior to implementation - Total of 55 affected private parcels with 22 individual owners (8 are willing sellers per Marshland subarea plan	11.3
Material Sites				Not Used: See Earthwork - Imported Fill.	
MOBILIZATION AND ACCESS for construction activities				Description required for each item to facilitate cost estimating	
Mobilization - Typical (Equipment, Personnel, Planning, Financial)	LS		1	Up front costs such as bonding, planning and other staff time and financing. Typically, assume 8% to 10% of other items.	11.3
Mobilization - Remote (Equipment, Personnel, Planning, Financial)	LS		NA		
Site Access	LS		NA		
Barge Access	Days		20	Assume barge needed for Marshland Canal outlet channel excavation north of Lowell-Snohomish Rd bridge removal	11.3
Temporary Traffic Control (one of the following)				Includes installation of traffic signals, signage, signmen, etc. There are 4 types as follows	
none	LS		NA		
signs	LS		NA		
flags / spotters	LS		1	Traffic control needed only during the final connection back into the existing alignment of Lowell-Snohomish River Rd. Two locations will be involved. It is assumed that construction at each location will a crew of flaggers and spotters for a duration of one week.	11.3
unique	LS		NA		
Temporary Roadway	SF		NA		
Control of Water	LS		1	May need to de-water base of new set back dikes and road embankments. Not possible to estimate with confidence at the 10% design as geotechnical investigation is not available	11.3
Relocation Activities				Not Used: See Utilities, Structures	
Site Demolition Activities				Demolition and removal of structures (description required), temporary features and relocations, itemized separately); Clearing and grubbing of vegetation, and removal of minor debris (rocks, slabs) - description required	
Clearing and Grubbing (one or more of following)				Use one or more of the following categories of clearing and grubbing	
Clear Vegetation - Local Disposal	AC		NA	Vegetation removed above grade and disposed local	
Clear /Grub Vegetation - Local Disposal	AC		NA	Vegetation roots also removed and disposed locally	
Clear /Grub Vegetation - Offsite Disposal	AC		0.7	Strip and dispose 1 foot surface soil for dike transmission tower islands (4	11.3
Clear /Grub Vegetation - Offsite Disposal	AC		7.1	Strip and dispose 1 foot surface soil off Lowell-Snohomish Rd side slopes to lower existing dike/roa	11.3
Clear /Grub Vegetation - Offsite Disposal	AC		25.4	Strip and dispose 1 foot surface soil for low wide dikes to protect OHP transmission lines (2	11.3
Clear /Grub Vegetation - Offsite Disposal	AC		13.3	Strip and dispose 1 foot surface soil for setback dikes to gas line and lands soutl	11.3
Clear /Grub Vegetation - Offsite Disposal	AC		18.8	Strip and dispose 1 foot surface soil for reconstructed road/setback dike	11.3
Clear /Grub Vegetation - Offsite Disposal	AC		0.2	Strip and dispose 1 foot surface soil for pump station outlet channe	11.3
Clear /Grub Vegetation - Offsite Disposal	AC		19.7	Strip and dispose 1 foot surface soil for new primary marsh channels	11.3
Clear /Grub Vegetation - Offsite Disposal	AC		6.7	Strip and dispose 1 foot surface soil for new secondary marsh channels	11.3
Clear, stockpile - large woody debris	CY		NA	Vegetation is segregated and stockpiled / prepared for reuse on site	
Hydraulic Structures - Small	LS		NA		
Hydraulic Structures - Large	LS		1	Removal of existing 500 cfs Marshland pump station and flood relief gates (4). Existing pump station to be used for action area dewatering during construction after new pump station to south is constructed and operational. Work includes control of water and sediment during removal of existing pump station after marsh area work is complete	11.3
Utilities	LF		NA		
Buildings	SF		150,640	Removal of buildings located within the action area tidal restoration limits	11.3
Pavement	LF or SF		336,000	Removal of pavement on Lowell-Snohomish Rd	11.3
Bulkheads	LF or SF		NA		
Rock revetments	LF		250	Removal of assumed rock revetment on Snohomish river banks at existing pump station outle	11.3
Large Coastal Structures	LF, SF or CY		NA		
Demolition / Removal - Bridge	SF or CY		NA		
Removal - Misc. (e.g. angular rock from beach)	Ton		NA		
Demolition / Removal - Boat Ramp	SF		NA		
Haul - Offsite Disposal of Demolition Debris	Miles		20	North County Recycling and Transfer Station 19600 63rd Avenue NE	11.3
Hazardous/Contaminated Waste Removal				These items for earthwork of quality not compatible with wetlands, requiring special handling and disposal. Describe basis for classification as contaminated or hazardous. State known or suspected contamination, describe known simila work.	
Contaminated Earthwork	CY		NA		
Hazardous Earthwork	LS		1	Simpson landfill (29 acre parcel) remediation for new road across and possible tidal/riverine effects. Unable to provide credible estimate at 10% design. Estimated parcel area for remediation provided. Environmental Assessment and RIFS likely required to define limits and level of contamination (hazardous earthwork assumed).	11.3
Hazardous Earthwork	LS		1	Historic creosote facility (Rotary Park 11.3 acres) remediation for lowering of adjacent Lowell-Snohomish Rd and possible tidal/riverine effects. Unable to provide credible estimate at 10% design. Estimated parcel area for remediation provided. Environmental Assessment and RIFS likely required to define limits and level of contamination (hazardous earthwork assumed)	11.3
Construct Temporary Features				Use as needed for unusual temporary features not included elsewhere (see TESC below)	
EARTHWORK				Expand to include equipment, etc. to facilitate cost estimating.	
Excavation	CY		NA		
Excavation - Upland	CY		NA		
Excavation - Lowland	CY		3,620	Excavation at base of OHP transmission towers pads	11.3
Excavation - Lowland	CY		126,060	Excavation at base of low dikes for OHP transmission lines	11.3
Excavation - Lowland	CY		67,750	Excavation at base of setback dikes (other than new road	11.3
Excavation - Lowland	CY		94,500	Excavation at base of new reconstructed road/dike	11.3
Excavation - Lowland	CY		170,570	Excavation for primary/secondary marsh channels and pump station outlet channe	11.3
Excavation - Lowland	CY		91,020	Excavation to lower existing Lowell-Snohomish Rd/dike	11.3
Dredging - Bucket - Land	CY		NA		
Dredging - Bucket - Marine	CY		NA		
Dredging - Hydraulic	CY		NA		
Fine Grading	AC		NA		
Fill Placement - local borrow				This is additive to Earthwork -Excavation	
Side cast	CY		NA		
Haul - uncontrolled placement	CY		325,620	Haul of material excavated excluding strippage (within one foot of surface) to stockpile for use as Marshland channel fi and hummocks creation; distance less than one mile	11.3
Haul - controlled placement	CY		91,020	Haul of material excavated to lower Lowell-Snohomish Rd/dike; for use as reconstructed new road/setback dike embankment; distance less than one mile	11.3
Haul, place, compact	CY		NA		
Stockpile - uncontrolled placement	CY		325,620	Stockpile and placement of material excavated excluding strippage (within one foot of surface); for use as channel fill and for created hummocks.	11.3
Stockpile - controlled placement	CY		91,020	Stockpile and placement of material excavated to lower road; for use as new reconstructed road/dike embankmer	11.3
Conveyor placement from stockpile land/water	CY		NA		
Imported Fill				Includes purchase, delivery and placement or as noted / described	
Select Fill	CY		11,185	Imported select material for use as transmission tower embankmen	11.3
Select Fill	CY		503,750	Imported select material for use as low dike embankment for OHP transmission lines	11.3
Select Fill	CY		258,000	Imported select material for use as setback dike embankments (other than new road)	11.3
Select Fill	CY		337,900	Imported select material for use as new reconstructed road/dike embankment.	11.3
Gravel Borrow, including haul	CY		NA		
Sand / Gravel for Beach Nourishment	CY		NA		
Cobble for Shore Nourishment	CY		NA		
Embankment Compaction	CY		1,110,835	WSDOT standard item	11.3
Topsoil	CY		NA		
Channel Rehab / Creation	SF		NA		
Large Wood Placement	EA		190	Allowance for LWD placement in restored primary channels - approx. 1 piece per 100 ft	11.3
Invasive Species Control	Acre		26.3	ISC area assumed equivalent to clear/grub areas of new primary and secondary marsh channel	11.3
Physical Exclusion Devices	LF or EA		NA		
Other Restoration Features/ Activities	LS		NA		
Structures	EA				
Water Control Structures - Culverts with Gates	EA		NA		
Water Control Structures - Weirs	EA		NA		
Rock Slope Protection	LF		NA		
New Marshland Pump Station and Appurtenant Facilities	EA		1	Construct new Marshland Pump Station - 500 cfs estimated design flow, approx. 30 ft static lift - 1200 HP (existing station pumps combined HP rating, 4- 250 HP, 2- 100 HP)	11.3
New Flood Relief Structure with Motorized Sluice Gates and Appurtenant Facilities	EA		1	Construct new flood relief gates - assume 4- 12' X 12' motorized sluice gates in concrete structure adjacent to new pump station (estimated size based on rough size of existing flood relief gates at existing pump station	11.3
Elevated Boat Ramp	SF		NA		
Fencing	SF		NA		

Full Restoration Quantity Estimate

Action Name: Everett Marshland
Action #: 1126 — Revised May 2012
Date: February 2011 — **Revised with backcheck updates: 30 June 2011**
By: D. Cisakowski and J. Bibee, Anchor QEA

REMEDY: Restore 876 acres of priority tidal estuarine/freshwater riverine marsh habitats through reconnection of historic marsh to Snohomish River.
Primary management measures required include removal of approx. 2.4 mi. of existing Lowell-Snohomish Rd /dike; reconstruction of approx. 1.8 mi. of new replacement roadway on setback dike parallel to BNSF RR; construction of approximately 2.8 mi. of new setback and cross-dikes (beyond new road); removal of the Marshland pump station and its reconstuction at the south end of the action area; construction of two new bridges along existing road aligment (295 ft and 850 ft spans); upgrades to existing BNSF RR bridges totaling approximately 900 ft length; installation of 3-sided box culverts at 4 locations along new utility access dikes for tidal exchange; removal of existing outlet channel aroming; filling of the existing Marshland Canal and agricultural drainage channels within action area; creation of approx. 3.6 mi. of new primary marsh channels and 3.4 mi. of new secondary marsh channels; protection of existing utility lines (power and natural gas) including rebuild and protection of 4 existing towers; and creation of vegetated scrub shrub hummock area with excess excavation in the marsh plain.
Construction Period: Estimate two to three construction summer seasons plus limited upland work over winter - estimated 12 to 18 months total

Item	Unit of Measure	Material Name	Qty	Description of Item	Indicate section of design report where item is described
Utilities				Replacement or relocation. Designer to provide size and material and have separate line item for each run. Incidental include earthwork, testing, hook up fees, etc. These quantities do not include demolition of existing utilities, real estate / easements, design fees. Describe the owner if known, and whether utility franchise will install (e.g.. electric is typically installed by electrical franchise)	
Water	LF		750	Relocate hydrants hydrants on Lowell Snohomish River Road to new roadway alignment. Change to water is mainl removal/abandonment. Allowance of 750 lf provided to connect to existing mains and run new main along hew roadway alignment to desired location of hydrants. Impacts, if any, to service line crossing the River at the north end of the site are expected to be minima	
Gas	LF		NA		
Electric	LF		10,000	Relocate PUD Conductor to follow entire length of new roadway alignment. Existing conductor consists of approximately 5,000 lf of overhead and 3,500 lf of underground. Appurtenances to be relocated include six meters and two electrical vaults.	11.3
Sewer	LF		NA		
Telecommunications	LF		NA		
Other - Electric	EA		4	Protect existing PSE and BPA OHP transmission lines; Rebuild four transmission towers at created islands affecting 2,000 ft of PSE transmission line	
Roadway / Railway					
Roadway (2-16 ft lanes with 5 ft sidewalks)	SF		391,700	Two-lane roadway with 5-ft sidewalks. Refer to Plans for pavement sectior	11.3
Roadway - Traffic Signal	LS		NA		
Culvert (10' Diam Steel)	LF		290	Pipe material suitable for horizontal pipe drivinc	11.3
3-Sided Box Culvert 1	LF		60	25'W x 10'H Precast Conc. 3-sided Box Culver	11.3
3-Sided Box Culvert 2	LF		60	25'W x 10'H Precast Conc. 3-sided Box Culver	11.3
3-Sided Box Culvert 3	LF		70	25'W x 10'H Precast Conc. 3-sided Box Culver	11.3
3-Sided Box Culvert 4	LF		60	25'W x 10'H Precast Conc. 3-sided Box Culver	11.3
Culvert - Jacking	LF		NA		
Culvert - Horizontal Pipe Driving	LF		290	Drive 10' diam. culvert beneath railroad and roadway	11.3
Road Bridge B - Superstructure	SF		35,700	850-lf precast concrete girder bridge. Depth of girder is 5'-2". Includes elements such as approach slab, abutment, barriers, and railings. Significant O&M costs associated with this bridge. Design elev of bridge deck is below the 100-yr flood elevatior	11.3
Road Bridge A - Superstructure	SF		12,390	295-lf precast concrete girder bridge. Depth of girder is 5'-2". Includes elements such as approach slab, abutment, barriers, and railings. Significant O&M costs associated with this bridge. Design elev of bridge deck is at the 100-yr flood elevatior	11.3
Road Bridge B - Foundation	LF		252	Drilled shaft foundation; depth 100-ft	11.3
Road Bridge A - Foundation	LF		84	Drilled shaft foundation; depth 100-ft	11.3
Rail	LF		100	Single track, mainline	11.3
Rail Bridge 2 - Superstructure	SF		825	Prestressed box girder bridge, 50 lf in length; Constructed under traffic	11.3
Rail Bridge 3 - Superstructure	SF		14,025	Prestressed box girder bridge, 850 lf in length; Constructed under traffic	
Rail Bridge 2 - Foundation	LF		60	HP 14x89 pile foundation, 100' depth	11.3
Rail Bridge 3 - Foundation	LF		525	HP 14x89 pile foundation, 100' depth	
Railway - Shoe fly	LF		NA		
Permanent Access Features					
Roads	Level		NA		
Utility Access Routes	L.F.		15,000	Dike top (12' width) all-weather gravel roac	11.3
Erosion Control Features	L.F.		15,000	Overtopping erosion protection of new collective new dikes (other than new roac	11.3
Public Access or Recreation Features					
Trails	SF		NA		
Bridges	SF		NA		
Kiosk	EA		NA		
Restrooms	EA		NA		
Interpretive Signs	EA		NA		
Parking Area	SF		NA		
Other	EA		NA		
Vegetation & Erosion Control					
Hydroseeding	AC		42	Native seed grass seed mix for removed dike and new dike side slopes	11.3
Planting	AC		35	Plant created hummocks with native shrub/scrub species	11.3
Vegetation Maintenance	AC-YR		35	Includes temporary irrigation, weeding, plant replacement for one yea	11.3
Erosion / sediment BMPs - Temp.	LS		1	Temporary erosion/sedimentation control and treatment BMPs for control of work area drainage located upstream of Marshland Canal pump station (use pump station for discharge of treated flows to Snohomish River). Assume compliance with Construction General NPDES includec	11.3
Erosion / sediment BMPs - Permanent	AC		NA		
Waterside controls - Temporary	LF		200	Turbidity curtain at Marshland Canal outlet	11.3
Construction Management					
Construction oversight	weeks		75	Assume 6 month construction season for three construction seasons.	11.3
Materials testing				Included in cost of material - no separate quantity	
Design and Detailed Site Investigations					
Survey & Property, Utility Research	LS		1	% of construction cost	11.8
35% Design	LS		1	35% x 25% x Engineer's Estimate	11.8
65% design	LS		1	65% x 25% x Engineer's Estimate less the cost for 35% PS&E	11.8
90% design	LS		1	35% x 25% x Engineer's Estimate less the cost for 35% + 65%PS&E	11.8
100% design	LS		1	25% x Engineer's Estimate less previous costs	11.8
Geotechnical Studies	LS		1	Geotech study needed to design new dikes and road. Significant peat deposits in marsh area are expected. Pre-load (1-yr assumed) should be added for all dikes and roads in estimating pending more definitive geotechnical findings.	11.8
Cultural Studies	LS		1	Cultural resources investigation need assumed for action area	11.8
HTWR Studies	LS		1	Simpson and prior creosote parcels in NW corner of action area assumed to require environmental site assessment; Likely need for RIFS for cleanup action as part of full restoration	11.8
Project Agreement Activities				Unable to provide credible estimate at 10% design	
Site-Specific Adaptive Management Features & Activities				List if known	
Monitoring Activities				Assume 5 crew-days/year for each monitoring parameter in design report for 5 yrs	
Monitoring (Type_)	crew-days		150		
Operations & Maintenance				Unable to provide credible estimate at 10% design	

Partial Restoration Quantity Estimate

Action Name: Everett Marshland
Action #: 1126 — Revised May 2012
Date: February 2011 — **Revised with backcheck updates: 30 June 2011**
By: D. Cisakowski and J. Bibee, Anchor QEA

Remedy: ***Restore 535 acres of priority tidal estuarine/freshwater riverine marsh habitats through reconnection of historic marsh to Snohomish River.***
Primary management measures required include construction of approximately 4.0 mi. of new setback and cross-dikes; removal of the Marshland pump station and its reconstruction at the south end of the action area; construction of two new bridges along existing Lowell-Snohomish road alignment (200 ft. spans each); upgrade/replacement of existing BNSF RR bridges totaling 250 ft in length; removal of existing outlet channel armoring; filling of the existing Marshland Canal and agricultural drainage channels within action area; creation of approx. 2.2 mi. of new primary marsh channels and 3.4 mi. of new secondary marsh channels; installation of culverts with fish passable gates are 7 locations (including Wood Creek connection); protection of existing utility lines (power and natural gas) with setback dikes; and creation of vegetated scrub shrub hummock area with excess excavation in the marsh plain.
Construction Period: Estimate two to three construction summer seasons plus limited upland work over winter - estimated 12 to 18 months total

Item	Unit of Measure	Material Name	Qty	Description of Item	Indicate section of design report where item is described
ACQUISITION AND CONSERVATION				Based on available mapping information	
Required Project Lands	Acre		1,115	Total land required for action - Total area within action area. Approx. 535 ac. of that area would be restored to beneficial fish use through tidal/freshwater connectio	11.3
Proponent / Partner-owned lands	Acre		464	Estimate of lands currently owned by Proponent (i.e., Public lands) - Government or quasi-government ownerships within the action area	11.3
Lands To Be Acquired	Acre		355	Estimate land required to be acquired for action prior to implementation- Total of 28 affected private parcels with 8 individual owners (willing sellers per Marshland subarea pla	11.3
Material Sites				Not Used: See Earthwork - Imported Fill.	
MOBILIZATION AND ACCESS for construction activities				Description required for each item to facilitate cost estimating	
Mobilization - Typical (Equipment, Personnel, Planning, Financial	LS		1	Up front costs such as bonding, planning and other staff time and financing. Typically, assume 8% to 10% of other items.	11.3
Mobilization - Remote (Equipment, Personnel, Planning, Financial	LS		NA		
Site Access	LS		NA		
Barge Access	Days		30	Assume barge needed for new bridge channel outlet excavations at Snohomish River confluence	11.3
Temporary Traffic Control (one of the following)				Includes installation of traffic signals, signage, signmen, etc. There are 4 types as follow	
none	LS		NA		
signs	LS		NA		
flags / spotters	LS		1	Construction signage necessary to establish detour route for closure of Lowell-Snohomish River Road for the duration bridge and road construction. Duration of construction expected to be 8 months if both bridges are constructed simultaneously.	11.3
unique	LS		NA		
Temporary Roadway	SF		NA		
Control of Water	LS		1	May need to de-water base of new set back dikes and road embankments. Not possible to estimate with confidence at the 10% design as geotechnical investigation is not availabl	11.3
Relocation Activities				Not Used: See Utilities, Structures	
Site Demolition Activities				Demolition and removal of structures (description required), temporary features and relocations, itemized separately) Clearing and grubbing of vegetation, and removal of minor debris (rocks, slabs) - description requir	
Clearing and Grubbing (one or more of following)				Use one or more of the following categories of clearing and grubbing	
Clear Vegetation - Local Disposal	AC		NA	Vegetation removed above grade and disposed loca	
Clear /Grub Vegetation - Local Disposal	AC		NA	Vegetation roots also removed and disposed locall	
Clear /Grub Vegetation - Offsite Disposal	AC		10.1	Strip and dispose 1 foot surface soil for north cross-dike (4,870 l	11.3
Clear /Grub Vegetation - Offsite Disposal	AC		12.9	Strip and dispose 1 foot surface soil for central cross-dike (6,300 l	11.3
Clear /Grub Vegetation - Offsite Disposal	AC		19.4	Strip and dispose 1 foot surface soil for south cross-dike (10,080 l	11.3
Clear /Grub Vegetation - Offsite Disposal	AC		13.3	Strip and dispose 1 foot surface soil for new primary marsh channe	11.3
Clear /Grub Vegetation - Offsite Disposal	AC		7.5	Strip and dispose 1 foot surface soil for new secondary marsh channe	11.3
Clear, stockpile - large woody debris	CY		NA	Vegetation is segregated and stockpiled / prepared for reuse on si	
Hydraulic Structures - Smal	LS		NA		
Hydraulic Structures - Large	LS		1	Removal of existing 500 cfs Marshland pump station and flood relief gates (4). Existing pump station to be used for action area dewatering during construction after new pump station to south is constructed and operational. Work includes control of water and sediment during removal of existing pump station after marsh area work is compl	11.3
Utilities	LF		NA		
Buildings	SF		NA		
Pavement	LF or SF		45,000	Removal of pavement on Lowell-Snohomish R	11.3
Bulkheads	LF or SF		NA		
Rock revetments	LF		250	Removal of assumed rock revetment on Snohomish river banks at existing pump station ou	11.3
Large Coastal Structures	LF, SF or CY		NA		
Demolition / Removal - Bridge	SF or CY		NA		
Removal - Misc. (e.g. angular rock from beach)	Ton		NA		
Demolition / Removal - Boat Ramp	SF		NA		
Hazardous/Contaminated Waste Removal				These items for earthwork of quality not compatible with wetlands, requiring special handling and disposal. Describe basis for classification as contaminated or hazardous. State known or suspected contamination, describe known similar work.	
Contaminated Earthwork	CY		NA		
Hazardous Earthwork	LS		NA		
Construct Temporary Features				Use as needed for unusual temporary features not included elsewhere (see TESC below)	
EARTHWORK				Expand to include equipment, etc. to facilitate cost estimating.	
Excavation	CY		NA		
Excavation - Uplanc	CY		NA		
Excavation - Lowland	CY		39,410	Excavation at base of north cross-dike (4,870 l	11.3
Excavation - Lowland	CY		58,350	Excavation at base of central cross-dike (6,300 l	11.3
Excavation - Lowland	CY		118,420	Excavation at base of south cross-dike (10,080 l	11.3
Excavation - Lowland	CY		97,160	Excavation for new primary marsh channel	11.3
Excavation - Lowland	CY		18,800	Excavation for new secondary marsh channel	11.3
Dredging - Bucket - Land	CY		NA		
Dredging - Bucket - Marine	CY		NA		
Dredging - Hydraulic	CY		NA		
Fine Grading	AC		NA		
Fill Placement - local borrow				This is additive to Earthwork -Excavatio	
Side cast	CY		NA		
Haul - uncontrolled placement	CY		210,670	Haul of material excavated excluding strippage (within one foot of surface) to stockpile for use as Marshland channel fill and hummocks creation; distance less than one mil	11.3
Haul, place, compac	CY		NA		
Stockpile - uncontrolled placement	CY		210,670	Stockpile and placement of material excavated excluding strippage (within one foot of surface); for use as channel fill and for created hummocks	11.3
Stockpile - controlled placemer	CY		NA		
Conveyor placement from stockpile land/water	CY		NA		
Imported Fill				Includes purchase, delivery and placement or as noted / describ	
Select Fill	CY		143,980	Imported select fill for north cross-dike embankment (4,870	11.3
Select Fill	CY		228,650	Imported select fill for central cross-dike embankment (6,300	11.3
Select Fill	CY		320,280	Imported select fill for south cross-dike embankment (10,080	11.3
Gravel Borrow, including haul	CY		NA		
Sand / Gravel for Beach Nourishment	CY		NA		
Cobble for Shore Nourishment	CY		NA		
Embankment Compaction	CY		692,910	WSDOT standard iten	11.3
Topsoil	CY		NA		
RESTORATION Features					
Channel Rehab / Creatior	SF		NA		
Large Wood Placement	EA		120	Allowance for LWD placement in restored primary channels - approx. 1 piece per 100	11.3
Invasive Species Control	Acre		20.8	ISC area assumed equivalent for clear/grub areas of new primary and secondary marsh chann	11.3
Physical Exclusion Devices	LF or EA		NA		
Other Restoration Features/ Activities	LS		NA		
Structures	EA				
Water Control Structures - Culverts with Gates	EA		1	Wood Creek Culvert with fish passable tide gates - Assume double 6'X6' RCB with hydraulically-actuated, side-hinged tide gates	11.3
Water Control Structures - Culverts with Gates	EA		6	Local drainage culverts with fish passable tide gates - Assume single 3'X3' RCB with hydraulically-actuated, side-hinged tide gates	11.3
Water Control Structures - Weirs	EA		NA		
Rock Slope Protection	LF		NA		
New Marshland Pump Station and Appurtenant Facilities	EA		1	Construct new Marshland Pump Station - 500 cfs estimated design flow, approx. 30 ft static lift - 1200 HP (existing station pumps combined HP rating, 4- 250 HP, 2- 100 HF	11.3
New Flood Relief Structure with Motorized Sluice Gates and Appurtenant Facilities	EA		1	Construct new flood relief gates - assume 4- 12' X 12' motorized sluice gates in concrete structure adjacent to new pump station (estimated size based on rough size of existing flood relief gates at existing pump stati	11.3
Elevated Boat Ramp	SF		NA		
Fencing	SF		NA		

Partial Restoration Quantity Estimate

Action Name:	Everett Marshland		
Action #:	1126		Revised May 2012
Date:	February 2011		**Revised with backcheck updates: 30 June 2011**
By:	D. Cisakowski and J. Bibee, Anchor QEA		

Remedy: Restore 535 acres of priority tidal estuarine/freshwater riverine marsh habitats through reconnection of historic marsh to Snohomish River.
Primary management measures required include construction of approximately 4.0 mi. of new setback and cross-dikes; removal of the Marshland pump station and its reconstruction at the south end of the action area; construction of two new bridges along existing Lowell-Snohomish road alignment (200 ft. spans each); upgrade/replacement of existing BNSF RR bridges totaling 250 ft in length; removal of existing outlet channel armoring; filling of the existing Marshland Canal and agricultural drainage channels within action area; creation of approx. 2.2 mi. of new primary marsh channels and 3.4 mi. of new secondary marsh channels; installation of culverts with fish passable gates are 7 locations (including Wood Creek connection); protection of existing utility lines (power and natural gas) with setback dikes; and creation of vegetated scrub shrub hummock area with excess excavation in the marsh plain.
Construction Period: Estimate two to three construction summer seasons plus limited upland work over winter - estimated 12 to 18 months total

Item	Unit of Measure	Material Name	Qty	Description of Item	Indicate section of design report where item is described
Utilities				Replacement or relocation. Designer to provide size and material and have separate line item for each run. Incidentals include earthwork, testing, hook up fees, etc. These quantities do not include demolition of existing utilities, real estate / easements, design fees. Describe the owner if known, and whether utility franchise will install (e.g.. electric is typically installed by electrical franchise)	
Water	LF		NA		
Gas	LF		NA	Assumed that construction of So. Bridge can avoid impact with liquid petroleum pipeline crossing riv	
Electric	LF		NA	PSE and BPA OH Transmission lines unaffected. PUD Overhead Conductor - No impac	
Sewer	LF		NA		
Telecommunications	LF		NA	No impact. Comcast has OH communication lines that traverse the site from east to wes	
Other	LF				
Roadway / Railway					
Roadway (2-12-ft lanes with 5 ft sidewalks)	SF		46,200	Two-lane roadway with 5-ft sidewalks. Refer to Plans for pavement secti	11.3
Roadway - Switch (potential)	LS		NA		
Culvert (type)	LF		NA		
Culvert - Jacking	LF		NA		
Culvert - Horizontal Pipe Driving	LF		NA		
Bridge 1 - Superstructure	SF		8,400	200-lf precast concrete girder bridge. Depth of girder is 5'-2". Includes elements such as approach slab, abutment, barriers, and railinc	11.3
Bridge 2 - Superstructure	SF		8,400	200-lf precast concrete girder bridge. Depth of girder is 5'-2". Includes elements such as approach slab, abutment, barriers, and railinc	11.3
Bridge 1 - Foundation	LF		42	Drilled shaft foundation; depth 100-f	11.3
Bridge 2 - Foundation	LF		42	Drilled shaft foundation; depth 100-f	11.3
Rail	LF		100	Single track, mainline	11.3
Railway Bridge 1- Superstructure	SF		3,300	Bridge located at south limits. Prestressed box girder bridge, 200 lf in length; Constructed under traffic. Significant O&M costs associated with this bridge. Design elev of bridge deck is below the 100-yr flood elevati	11.3
Railway Bridge 1- Foundation	LF		75	HP 14x89 pile foundation, 100' deptl	11.3
Railway Bridge 2- Superstructure	SF		825	Replacement portion of existing at Hardscrabble Slough. Prestressed box girder bridge, 200 lf in length; Constructed under traffic Significant O&M costs associated with this bridge. Design elev of bridge deck is below the 100-yr flood elevati	11.3
Railway Bridge 2- Foundation	LF		60	HP 14x89 pile foundation, 100' deptl	11.3
Railway - Shoe fly	LF		NA		
Permanent Access Features					
Roads	Level		NA		
Utility Access Routes	L.F.		21,300	Dike top (12' width) all-weather gravel roa	11.3
Erosion Control Features	L.F.		21,300	Overtopping erosion protection of new collective new dike	11.3
Public Access or Recreation Features					
Trails	SF		50,000	Nature access tails (10,000 lf, 5 ft width assumed) - crushed rock surfacing (6" depth assume	11.3
Bridges	SF		NA		
Kiosk	EA		NA		
Restrooms	EA		NA		
Interpretive Signs	EA		4	Include # interpretive signs based on number of local public access point	11.3
Parking area	SF		NA		
Recreational Use Areas	EA		5	Grassed recreational use areas on graded pads at west perimeter of tidal restoration area - assume 1 acre in area each	11.3
Vegetation & Erosion Control					
Hydroseeding	AC		42	Native seed grass seed mix for removed dike and new dike side slope	11.3
Planting	AC		15	Plant created hummocks with native shrub/scrub specie	11.3
Vegetation Maintenance	AC-YR		15	Includes temporary irrigation, weeding, plant replacement for one ye	11.3
Erosion / sediment BMPs - Temp.	LS		1	Temporary erosion/sedimentation control and treatment BMPs for control of work area drainage located upstream of Marshland Canal pump station (use pump station for discharge of treated flows to Snohomish River). Assume compliance with Construction General NPDES include	11.3
Erosion / sediment BMPs - Permanent	AC		NA		
Waterside controls - Temporary	LF		600	Turbidity curtains at Marshland Canal outlet and two new bridge outle	11.3
Construction Management					
Construction oversight	weeks		50	Assume 6 month construction season for two construction seasons	11.3
Materials testing			NA		
Design and Detailed Site Investigations					
Survey & Property, Utility Research	LS		1	% of construction cost	11.8
35% Design	LS		1	35% x 25% x Engineer's Estimate	11.8
65% design	LS		1	65% x 25% x Engineer's Estimate less the cost for 35% PS&I	11.8
90% design	LS		1	35% x 25% x Engineer's Estimate less the cost for 35% + 65%PS&I	11.8
100% design	LS		1	25% x Engineer's Estimate less previous cost	11.8
Geotechnical Studies	LS		1	Geotech study needed to design new dikes and road. Significant peat deposits in marsh area are expected. Pre-load (1-yr assumed) should be added for all dikes and roads in estimating pending more definitive geotechnical findings.	11.8
Cultural Studies	LS		1	Cultural resources investigation need assumed for action area	11.8
HTWR Studies	LS		1	Simpson and prior creosote parcels in NW corner of action area assumed to require environmental site assessment; No RIFS or cleanup action assumed for partial restoratic	11.8
Project Agreement Activities				Unable to provide credible estimate at 10% design	
Site-Specific Adaptive Management Features & Activities				List if known	
Monitoring Activities				Assume 5 crew-days/year for each monitoring parameter in design report for 5 yrs	
Monitoring (Type_)	crew-days		150		
Operations & Maintenance				Unable to provide credible estimate at 10% design	

12. EVERETT RIVERFRONT WETLAND COMPLEXES (#1127)

Local Proponent	City of Everett
Delta Process Unit	Delta SNH
Shoreline Process Unit(s)	NA
Strategy(ies)	1 - River Delta
Restoration Objectives	Remove fill and culverts and install channels to improve connectivity between significant wetland complexes and the mainstem Snohomish River. This will restore tidal freshwater wetlands, a regionally rare ecosystem

12.1 Description of the Action

The Everett Riverfront action will improve connectivity between existing, altered, floodplain wetland complexes and the mainstem Snohomish River; reestablish tidal freshwater wetlands; and restore the lower portion of Bigelow Creek. The primary management measures include berm removal, armor removal, topography restoration, and channel rehabilitation. Please see the Introduction chapter for important information regarding PSNERP and for context related to this restoration project.

12.2 Action Area Description and Context

The Everett Riverfront action area is part of the Snohomish River delta in the Whidbey Subbasin of Puget Sound. The action area lies between an active railroad line (to the west) and the Snohomish River mainstem (to the east), east of I-5 in Everett. This land is within the Snohomish River floodplain in the upper portion of the estuary. Bigelow Creek drains the hillside to the west of the action area via several large freshwater wetlands. The action area wraps around the Simpson Pad, the fill pad associated with the former (now abandoned) Simpson lumber mill. Private developers intend to develop the 119-acre pad site with the support of the City of Everett planning department. The City's Master Plan describes the planned restoration and development of the Riverfront area (MacLeod Reckord 2009). The action area is shown in Figure 12-1.

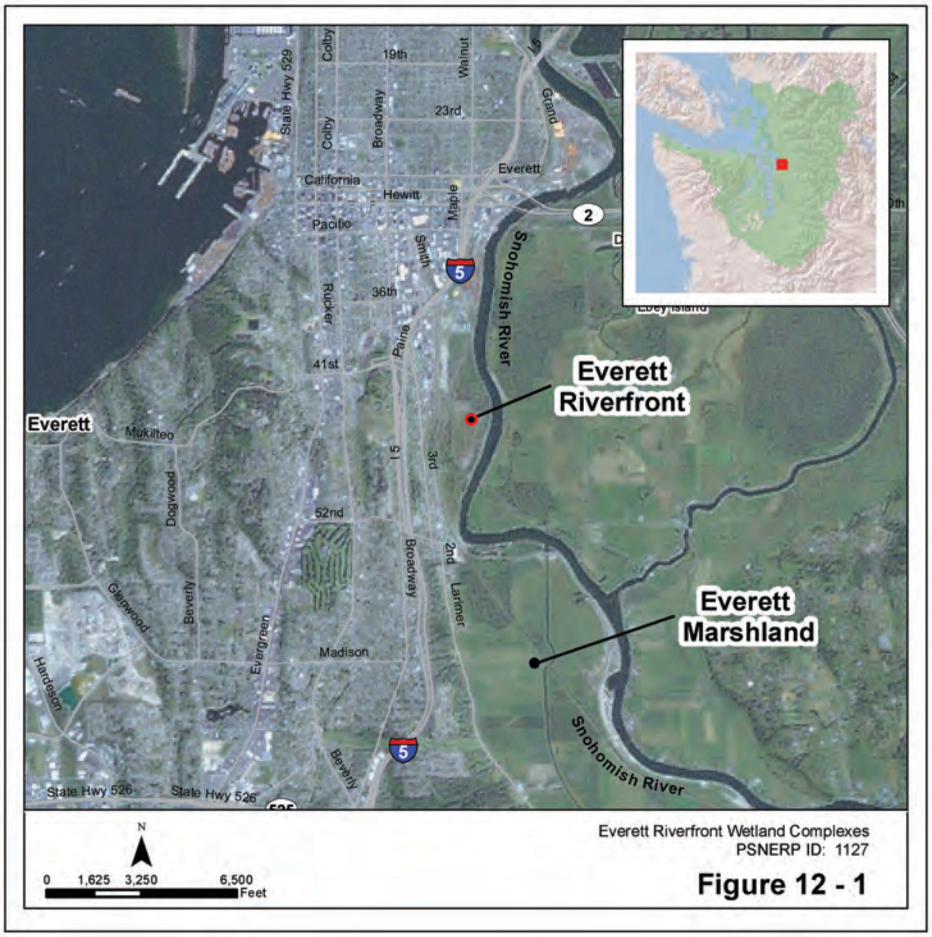


Figure 12-1. Action Area and Vicinity

12.2.1 Historic Condition

In the earliest mapping available (circa 1884-1885), much of the area is denoted as wooded marsh, with the remainder in grassland or fenced with no specific cover denoted (Figures 12-2A and 12-2B). The Bigelow Creek channel is not shown on the 1880s mapping. Early land clearing on what is now the Simpson Pad is apparent, and there are indications of a road corresponding with the point at which the Bigelow Creek valley broadens out onto the floodplain. The Bigelow Creek channel is apparent on the 1938 photo, flowing directly into the mainstem south of the existing Simpson Pad. By 1938, lower Bigelow Creek had been channelized and potentially incorporated as part of the mill operations.

The T-sheet mapping suggests that the Simpson Pad (former mill site) was originally relatively high ground, not intertidal wetland. This lack of historical wetland condition is the reason for not including more of the fill pad in either of the restoration alternatives.

The 1930s aerial photo shows a mill with associated railroads and other transportation infrastructure in the vicinity of the Riverfront site. The mill, associated outbuildings, and access roads effectively cover what is now referred to as the southern wetland complex.

The western wetland complex is apparent in the 1938 photo and appears generally similar to today's conditions in terms of layout and vegetation. A northern wetland complex is also apparent in the 1938 photograph. A linear ditch had been excavated by that time through the center of the wetland (and is still present).

Fill and active drainage are more apparent in the southern portion of the northern wetland complex. The rail line along the edge of the mainstem and associated buildings are apparent by 1938. The railroad along the mainstem appears to have broken the historical connections between the river and the floodplain in this location. Levees are also apparent along the mainstem on the opposite (east) side of the river by 1938.

12.2.2 Natural Environment

The Snohomish River mainstem flows alongside the action area. Ebey Slough branches from the mainstem approximately 7,100 feet upstream of the action area. Water levels in the Snohomish River are tidally dominated, but significant freshwater inflows can override tidal signals. Salinity levels are not well understood in this reach of the river, but are not expected to support salt marsh vegetation.

There are three main wetland complexes within the Everett Riverfront action area. The northern wetland complex, north of the Simpson Pad, is an approximately 32-acre Category I wetland (according to the Department of Ecology's rating system) that extends to the west bank of the Snohomish River. The western wetland complex, west of the Simpson Pad, is a large depression on valley alluvium alongside the railroad corridor. The southern wetland complex is a series of depressions that flow into the Snohomish River south of the Simpson Pad.

All of the wetland complexes have been altered by past land uses. Drainage to and through the wetlands has been modified with berms and artificial ditches. Historical aerial photographs indicate that portions of the complexes were cleared and graded, and portions were used as process water facilities. Non-native weed species, particularly reed canarygrass, dominate significant portions of the wetland complexes today.

The Simpson Pad is currently grassland. The surrounding wetland complexes are a mixture of open water, emergent, scrub-shrub, and forested vegetation communities.

Three listed fish species occur within the lower Snohomish River Estuary: Chinook, steelhead, and bull trout (the lower Snohomish River is listed as critical habitat for both Chinook salmon and bull trout). Fish currently have access to Bigelow Creek within the action area, extending up to a culvert under the BNSF railroad tracks. Chinook use of the mainstem channel is limited mainly to upstream migration of adults and downstream migration of juveniles, with some year-round rearing. The majority of the action area is within the 100-year (1% annual chance) floodplain of the Snohomish River. The northern wetland complex is mapped as within the floodway. The river inundates the wetland complexes and flows around the west side of the Simpson Pad during flood events (FEMA DFIRM 2010).

12.2.3 Human Environment

The Everett Riverfront action area has supported a number of industries and land uses since the 1850s. Most notable was the paper mill that operated on the site from the late 1800s to the 1970s (HistoryLink.org). A number of support industries to the mill occurred within the action area, including blacksmith shops and railroads. After the mill closed, the site was used as a refuse transfer station and animal shelter (MacLeod Reckord 2009).

The BNSF railroad mainline runs along the southwest edge of the action area. A northeast-trending abandoned spur line now used as a trail corridor forms the remainder of the west action area boundary. The trail corridor links municipal parks located north and south of the Everett Riverfront area. Another abandoned railroad embankment follows the riverbank for the majority of the action area; the railroad grade still exists in places but the track has been removed. Several gravel access roads, active rail lines, and a paved trail also cross the action area. The riverbank through much of the action area has been modified with wooden piers and riprap armoring.

South of the action area, WSDOT has recently installed a series of stormwater treatment wetlands that provide water quality treatment for runoff from I-5. These ponds discharge to the mainstem Snohomish River south of the southern wetland complex.

12.3 Restoration Design Concept

12.3.1 Restoration Overview and Key Design Assumptions

The restoration alternatives are illustrated in Figures 12-3 through 12-6. The overall intent of the Everett Riverfront restoration action is to provide greater connectivity between the mainstem Snohomish River and the large freshwater wetland complexes on the site. The full restoration alternative entails work within the northern, western, and southern wetland complexes, and realignment of Bigelow Creek. The key design elements of the full restoration alternative include (Figure 12-3):

- Excavating small distributary channels and installing new openings to the main river within the northern wetland complex.
- Removing a portion of the Simpson Pad.
- Excavating a new channel alignment for Bigelow Creek.
- Restoring intertidal elevations by removing fill and a culvert within the southern wetland complex.
- Installing compost planting areas within the western wetland complex.
- Removing existing wooden bulkheads and piles along the west bank of the main Snohomish River channel.

The partial restoration alternative, which is designed to be more consistent with the proponent's planned restoration activities in this location, only addresses the northern wetland complex (Figure 12-4). The partial restoration alternative includes new distributary channels, improved connectivity to the main river channel, and revegetation to promote establishment of complex freshwater tidal wetlands.

Table 12-1 summarizes the key design elements associated with full and partial restoration alternatives.

Table 12-1. Key Design Elements

Element	Full Restoration	Partial Restoration
Northern Wetland Complex		
New Distributary Channels	Install small distributary channels sized for an approximately 7-acre marsh surface drainage area. Excavate channels to match expected tidal prism.	Same as full restoration; less channel length to avoid impacts to a trail and access to overhead power line tower. Smaller "starter" channel section is proposed.
New Openings to Main Channel	Install four new openings from wetland complex to main channel.	Install three new openings from wetland complex to main channel.
Main Channel Rehabilitation	Minor fill removal from main channel within northern wetland complex.	Same as full restoration.
Planting Islands	Place excavation spoils from new channels in long, low berms. These berms will be discontinuous to allow tidal flux from the channels to the wetland surface. Plant densely with native tree and shrub species.	Same as full restoration.
Western Wetland Complex		
Planting Islands	Place imported compost in low berms. Plant with native tree and shrub species.	Not included.
Southern Wetland Complex		
Fill Removal	Remove southern portion of fill pad, berms, and trail alignment along river.	Not included.
New Bigelow Creek Channel	Align Bigelow Creek to flow directly to mainstem Snohomish River via southern wetland complex. Install large wood.	Not included.
New Bigelow Creek Channel	Install bed control logs within restored channel to prevent headcutting toward BNSF right-of-way.	Not included.
Planting	Plant native species within fill removal area, focused on transitions to neighboring uplands.	Not included.
Trail Alignment	Realign trail to western side of fill pad. Requires wetland fill and culvert in western wetland complex.	Not included.

12.3.2 Restoration Features – Primary Process-Based Management Measures

Armor Removal/Modification

Approximately 5,020 LF of discontinuous wooden bulkhead on the mainstem Snohomish River would be removed in the full restoration alternative (Figure 12-3). A portion of the bulkhead and pilings (approximately 2,439 LF along the northern wetland complex) would be removed in the partial restoration alternative (Figure 12-4).

Berm or Dike Removal/Modification - NA

Channel Rehabilitation/Creation

With both restoration alternatives, a system of distributary channels will be installed in the northern wetland complex (Figures 12-3 and 12-4). These channels will increase tidal flux through the wetland complex. Currently tides only enter the lower portion of the straightened main channel. The new system of channels would allow natural fluvial processes to operate, better connecting the wetland with the mainstem channel. The proposed channels in the full restoration alternative were developed to drain approximately equal portions of the wetland complex, using the regional regressions included in the *Applied Geomorphology Guidelines* (Appendix C). This approach likely results in an overestimate of channel size, since much of the northern wetland complex is higher than MHHW, limiting tidal flux through the channel system.

The northern wetland complex channel system will be installed in both restoration alternatives, and in generally the same alignment. The full restoration alternative includes overexcavated channels, assuming that sedimentation will occur (Figure 12-5). The partial restoration alternative (Figure 12-6) includes one less channel opening and less new channel length at the southern end of the wetland complex. Eliminating this opening allows an existing trail to remain, and retains an existing maintenance access to a BPA overhead power line. The partial restoration alternative also includes a smaller initial channel section to serve as starter channels. This approach acknowledges the likely overestimate of channel size resulting from the regional regressions and minimizes excavation quantities as well as overall disturbance to the existing wetland system.

In the full restoration alternative, the Bigelow Creek channel will be restored and realigned to flow through the southern wetland complex (Figure 12-5). Currently, Bigelow Creek flows through linear ditches with no shade or natural morphology along the railroad right-of-way as it flows north to the mainstem. The realigned creek will flow directly east to the Snohomish River mainstem through what will be an intertidal area (see the topography restoration described below). The restored Bigelow Creek alignment will generally follow an existing overflow route to the river that includes a corrugated metal pipe with flap gate. This culvert and other fill will be removed to allow a free-flowing creek mouth.

Large wood, including bed control logs, will be included along the restored Bigelow Creek channel. The bed control logs will be placed to avoid channel headcutting back toward the BNSF right-of-way.

None of the work in the southern wetland complex will occur in the partial restoration alternative.

Groin Removal/Modification - NA

Hydraulic Modification

In the full restoration alternative, a culvert in the southern wetland complex would be removed, and Bigelow Creek would be rerouted to avoid several other culvert crossings (Figure 12-3).

Overwater Structure Removal - NA

Topography Restoration

In the full restoration alternative, fill will be removed from a portion of the Simpson Pad directly north of the southern wetland complex. This will allow restoration of intertidal wetland at the restored mouth of Bigelow Creek, and provide greater freshwater tidal wetland area adjacent to the mainstem. This will require excavation depths of up to 14 feet, with additional depth required along the Bigelow Creek channel (Figure 12-5).

In the northern wetland complex, spoils from the channel excavations will be placed in low berms along the new channels for both alternatives (Figures 12-5 and 12-6). These berms will be planted with native shrub and tree species to provide greater complexity for the wetland system and shade for the channels.

In the full restoration alternative, a similar measure will be taken for the western wetland complex. Compost berms will be imported, placed, and densely planted. The current wetland is dominated by reed canarygrass and cattails, so these planting islands are intended to increase complexity.

12.3.3 Restoration Features – Additional Management Measures

Beach Nourishment - NA

Contaminant Removal/Remediation

Contaminated soils are likely to occur in much of the action area, particularly the southern wetland complex, as it was the former location of the mill and several subsidiary facilities including the blacksmith shop. Part of the topographic restoration would include the excavation and removal of these contaminants.

Debris Removal - NA

Invasive Species Control

Invasive species on the site include reed canarygrass and Himalayan blackberry. A long-term goal of the distributary channel system and associated berms in the northern wetland complex is reduced dominance by reed canarygrass. The dense plantings of shrubs and trees will eventually provide greater shade, favoring other plant species.

For the full restoration alternative, excavations to intertidal elevations would occur within the southern wetland complex. The depths of tidal water in these areas should allow for colonization by freshwater intertidal species, rather than reed canarygrass.

Large Wood Placement

Salvaged and imported large wood from site clearing will be placed on the surface of the northern wetland complex, and along the mainstem where armor has been removed in both the full and partial restoration alternatives (Figures 12-3 and 12-4). Within the wetlands, downed wood is intended to support colonization by native shrub and tree species. Large wood will also be placed along the mainstem where the wooden bulkhead is removed to provide edge habitat along the mainstem. Wood quantities are based on Fox and Bolton (2007), using the median density along channel length.

Physical Exclusion - NA

Pollution Control - NA

Revegetation

Plantings of native vegetation communities are proposed in a number of locations. In the northern wetland complex, the berms created from channel excavation spoils will be densely planted with native shrub species in both the full and partial restoration alternatives (Figures 12-3 and 12-4). Channel excavation quantities will be smaller in the partial restoration alternative, so the planting area will be similarly reduced.

In the western wetland complex for the full restoration alternative, installed compost berms will be densely planted with native shrub species to provide additional vertical strata and reduce the dominance of non-native, invasive weed species.

In the full restoration alternative, buffer and intertidal plantings will occur along the restored channel of Bigelow Creek. These will include freshwater tidal marsh emergent species.

Reintroduction of Native Animals - NA

Substrate Modification - NA

Species Habitat Enhancement - NA

12.3.4 Restoration Features – Other

In the full restoration alternative, an existing trail (Lowell Riverfront Trail) that runs along the riverbank from Lowell Riverfront Park to the northern wetland complex would be rerouted further west onto the Simpson Pad. The existing trail alignment would interfere with the bank sloping needed to allow for armor removal, and would require a substantial bridge over the restored Bigelow Creek area. The existing trail alignment would also interfere with one of the proposed distributary channels and new openings in the northern wetland complex.

In the partial restoration alternative, the trail could remain in its current alignment.

12.3.5 Land Requirements

Most of the action area is owned by the City of Everett and the remainder is privately held. The partial restoration alternative has been developed to stay within City property.

The full restoration alternative would require acquisition of a portion of the Simpson Pad to allow for greater intertidal area at the southern wetland complex.

The full restoration alternative would also require construction easements with BNSF Railway at the tie-in point to the existing Bigelow Creek alignment. Bigelow Creek flows below the BNSF rail line and along railroad right-of-way. The proposed alignment would require earthwork within the right-of-way to connect the new channel and plug the existing ditch.

12.3.6 Design Considerations

The potential for contamination exists throughout the site, but especially in the western and southern wetland complexes, given the historical land uses. There is a restrictive covenant on the western wetland complex that limits potential excavation and increases in flow velocity. A former landfill adjacent to the action area has an active remediation project designed to prevent groundwater flow toward the river. These factors have influenced the design to avoid all excavation in the western wetland complex, and minimize excavation within the northern wetland complex. Rerouting Bigelow Creek to the south would avoid having the creek interact with these areas, potentially reducing contaminant loading to the mainstem.

12.3.7 Construction Considerations

In the northern wetland complex, construction access to the channel excavations will be limited by very soft, saturated soils. It is anticipated that mats and low-ground-pressure equipment will be required to complete this work. Temporary berms or inflatable bladders at the new channel openings may be required to protect the work area during channel excavation and berm placement. The access considerations for excavation will require greater time for the channel excavation within the northern wetland complex, likely requiring 6 to 8 weeks to fully implement.

In the western wetland complex, the compost berms are anticipated to be blown in place, with no machine access to the wetland. Plantings would occur with hand labor only.

In the southern wetland complex, there is suitable access via gravel roads. Access can be developed that avoids crossing the BNSF rail lines. Excavations would need to be sequenced to complete the majority of fill removal prior to allowing full tidal inundation. The extent of fill removal will extend into saturated soils, so dewatering of excavation spoils would likely be necessary prior to offsite haul or placement. This will require a local stockpile. If the restoration occurs before site development, the Simpson Pad could be used for dewatering.

12.4 Extent of Stressor Removal

Table 12-2 describes the amount of stressors to be removed with this action.

Table 12-2. Stressor Removal

Stressor	Full Restoration	Partial Restoration
Tidal Barrier (LF)	550 LF along southern wetland complex, and new openings along northern wetland complex	150 LF along new openings along northern wetland complex
Fill (acres)	9.8 acres, primarily in southern wetland complex, and new openings in northern wetland complex	0.7 acres, new openings in the northern wetland complex
Armor (LF)	5,020	2,439

12.5 Expected Evolution of the Action Area

In the northern wetland complex, the goal of the new system of distributary channels is to increase tidal flux throughout the wetland area. This channel system is anticipated to be dynamic, and the excavated channels are intended to be a starting point for the formation of a self-sustaining channel system. It is likely that some channels will become blocked via beaver dams or sedimentation. It is expected that tidal flow would be transferred to other distributary channels, or new channels would form. The rate of channel development would depend on the flooding pattern and sediment loading from the mainstem. The excavation spoils berms would develop shrub and forest structure over time, increasing shade and habitat complexity within the wetland.

In the full restoration alternative, the channels will be excavated to larger dimensions to match expected tidal flux, so less initial adjustment is expected. In the partial restoration alternative, the channels will be excavated as starter channels, with a much smaller cross sectional area. Therefore, more substantial initial channel erosion is expected for this alternative.

In the southern wetland complex, the channel is expected to develop a stable profile to meet the mainstem. This area is expected to be net aggradational, but log and rock controls will be installed to prevent headcutting that might destabilize the railroad; the opening is designed to be wide enough to prevent significant vertical scour. Sedimentation may occur in this area during or after flood events. After initial excavation, there will be approximately 9 acres of new freshwater intertidal wetland at the mouth of Bigelow Creek.

12.6 Uncertainties and Risks

The site’s location within the floodplain and likely channel migration zone of the Snohomish River suggests that the action area can evolve via fluvial processes. The full restoration alternative would remove shoreline armoring, which could allow for greater rates of channel migration in this location. Flooding from the mainstem also has the potential to alter the functioning of the restored systems by erosion, sedimentation, or changing wetland hydroperiods.

As noted above, the presence of contaminated soils is likely throughout the site, especially in the southern wetland complex.

The long-term functioning of the proposed distributary channels within the northern wetland complex is uncertain. Beaver activity and sedimentation may reduce the extent of tidal influence within the wetland complex over time.

Bigelow Creek drains an urban residential area with little or no stormwater treatment or detention. This has the potential for pollutant loading to the action area. The City of Everett is currently designing a water quality retrofit project for this basin, which may include a constructed wetland for stormwater treatment.

Cultural resources have been identified in portions of the action area and are likely to be present throughout the action area. A cultural resources investigation would be advised.

12.6.1 Risks Associated with Projected Sea Level Change

Table 12-3 compares potential risks associated with projected sea level changes based on professional judgment.

Table 12-3. Risks of Sea Level Change

	Projected Sea Level Change		
	High (46 cm)	**Intermediate (4 cm)**	**Low (-8 cm)**
Full Restoration	This scenario may change the typical dominance of tidal ecosystems on the Riverfront site. Northern wetland complex: greater tidal inundation of the wetland surface, most of which is above existing MHHW. Potential tidal channel expansion, and greater dominance of emergent vegetation at higher elevations. Southern wetland complex: smooth side slopes at upper intertidal range allow the intertidal community to adjust upward. All locations: increase in still water levels at high tide may increase water stage at peak fluvial flows. Greater stage and/or duration of floodwaters may influence geomorphic development of wetlands and channels.	Minimal changes to existing conditions.	Minimal changes to existing conditions.

	Projected Sea Level Change		
	High (46 cm)	Intermediate (4 cm)	Low (-8 cm)
Partial Restoration	This scenario may change the typical dominance of tidal ecosystems on the Riverfront site. Northern wetland complex: greater tidal inundation of the wetland surface, most of which is above existing MHHW. Potential tidal channel expansion, and greater dominance of emergent vegetation at higher elevations. Higher tide heights alter high fluvial flow stage.	Minimal changes to existing conditions.	Minimal changes to existing conditions.

12.7 Potential Monitoring Opportunities

Monitoring is important for evaluating restoration success. A combination of field surveys and aerial photographs would be used to document biological and physical changes to the landscape. Monitoring data can be used to refine adaptive management and corrective actions, as needed. Some of the main monitoring needs and opportunities associated with this action are summarized in Table 12-4.

Table 12-4. Monitoring Needs and Opportunities

Monitoring Parameter	Key Performance Indicator	Note
Topographic Stability	X	Within northern wetland complex, and in excavated intertidal area
Sediment Accretion / Erosion	X	Within southern wetland complex
Wood Accumulation		
Soil / Substrate Conditions		
Vegetation Establishment	X	Effectiveness of compost and dredge spoil berms
Marsh Surface Evolution / Accretion	X	
Tidal Channel Cross-Section / Density	X	Channel evolution in the northern wetland complex
Water Quality (contaminants)		
Salinity		
Shellfish Production		
Extent of Invasive Species		
Animal Species Richness		

Monitoring Parameter	Key Performance Indicator	Note
Fish (salmonid) Access/Use	X	Edge habitats along mainstem (ongoing elsewhere in lower Snohomish Estuary)
Forage Fish Production		
Wildlife Species Use		
Effectiveness of Exclusion Devices		

12.8 Information Needed for Subsequent Design

This conceptual design report represents an initial step in the restoration design sequence. The design concepts described above were developed based on readily available information without the level of site-specific survey and investigation that is necessary to support subsequent design and implementation. Substantial additional information will be required at the preliminary and later design stages to confirm the design assumptions, refine quantity estimates, address property and regulatory issues, obtain stakeholder support, and fill in data gaps. The extent to which this information is collected for preliminary design (or a later design stage) will depend upon the available budget, schedule and other factors. This section attempts to define the most essential information needs for this action. Refer to the Introduction chapter for additional information.

- Property Investigation/Survey – More detailed information on parcel ownership, utility locations, and property boundary locations will be needed to finalize the design, confirm acquisition requirements, and support negotiations with property owners.
- Topographic/Bathymetric Survey –Restoration would require a topographic survey to confirm elevations and refine quantity estimates. Survey data would also be used as a baseline for pre- and post-construction modeling.
- Geotechnical Investigation – Borings are needed to assess subsurface conditions in the area proposed for intertidal excavation in the southern wetland complex.
- Cultural Resources Investigation – Surveys for archaeological and historic resources may be required for this action area. This is particularly important in areas proposed for excavation.
- Contaminant Survey – If preliminary investigations confirm that hazardous material are present in the action area, additional soil and sediment analysis may be needed.

12.9 Quantity Estimates

The quantity spreadsheets for the full and partial restoration alternatives are provided in Exhibits 12-1 and 12-2.

12.10 References

MacLeod Reckord, PLLC. 2009. *Riverfront Development Public Amenities Master Plan – Final Draft.* May. Seattle, WA. Prepared for City of Everett Engineering and Public Services Department and Parks and Recreation Department, Everett, WA.

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64

WDFW Contract # 100-000204 (CAPS No. 10-1461)

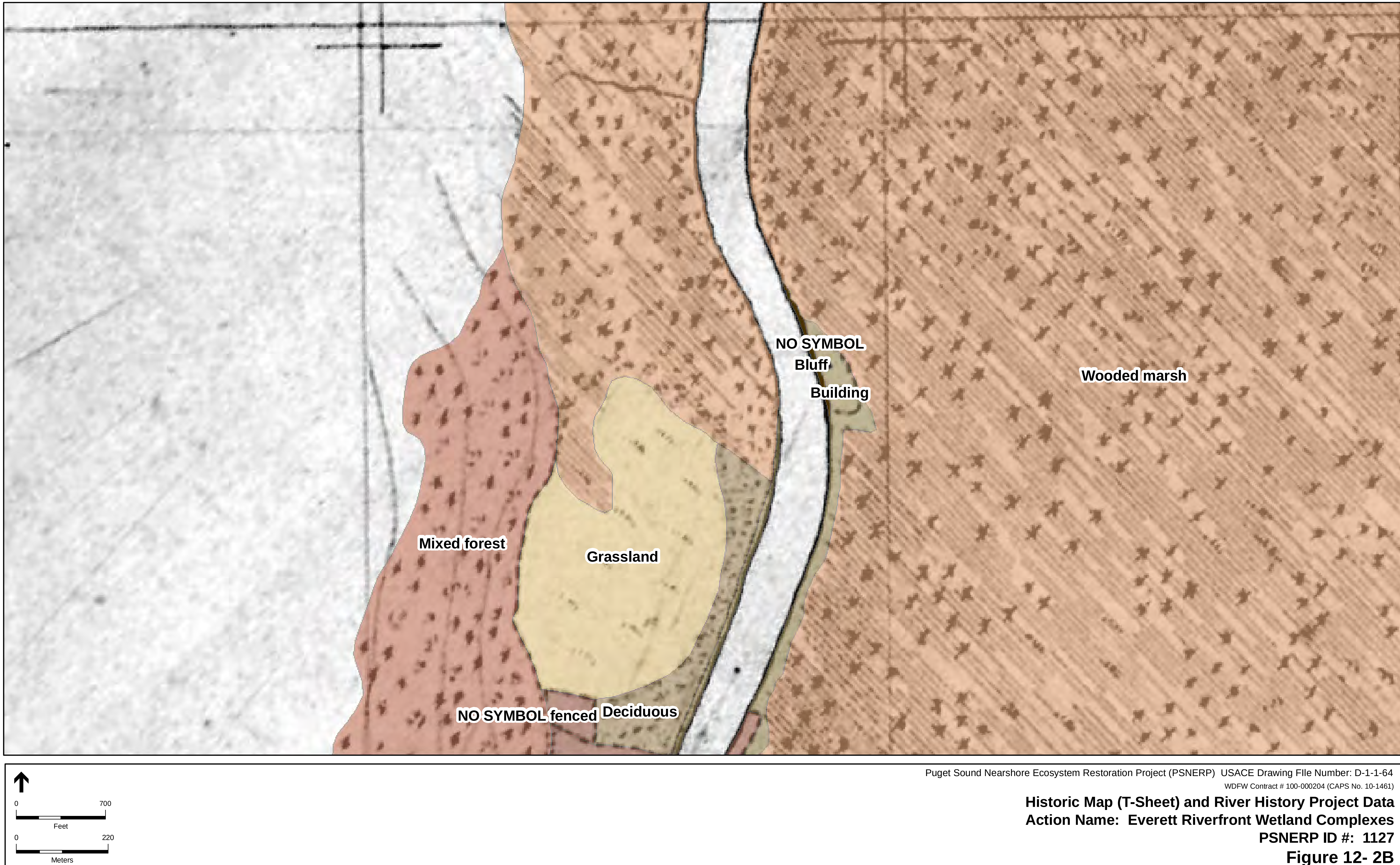
Historic Map (T-Sheet)

Action Name: Everett Riverfront Wetland Complexes

PSNERP ID #: 1127

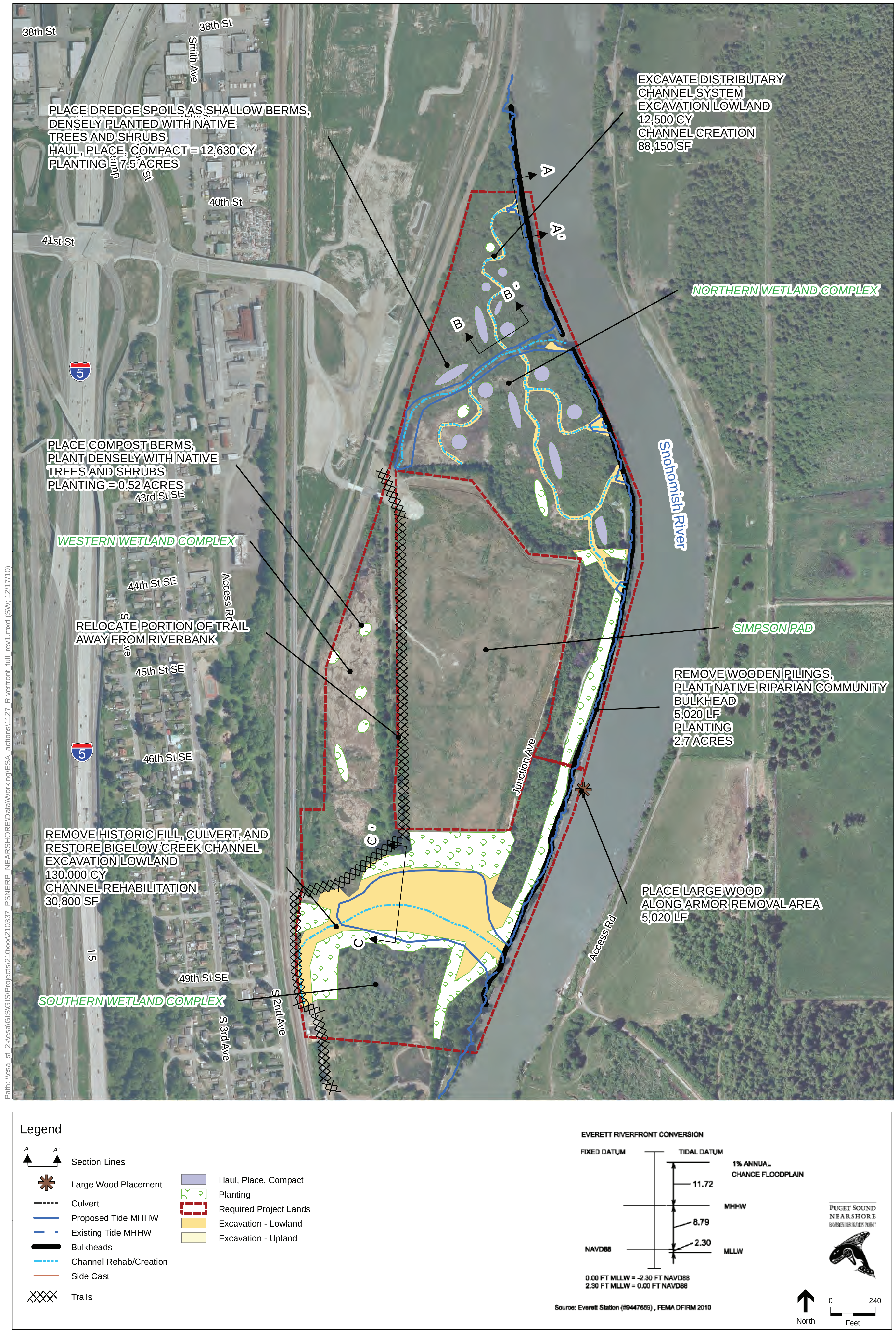
Figure 12- 2A

S:\GIS\Projects\210xxx\210337_PSNERP_NEARSHORE\Projects\2-TSheets_rev.mxd (DLP; 2/24/2011)



Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Historic Map (T-Sheet) and River History Project Data
Action Name: Everett Riverfront Wetland Complexes
PSNERP ID #: 1127
Figure 12- 2B



SOURCE: PSNERP (2011); Aerial (Bing, 2009)

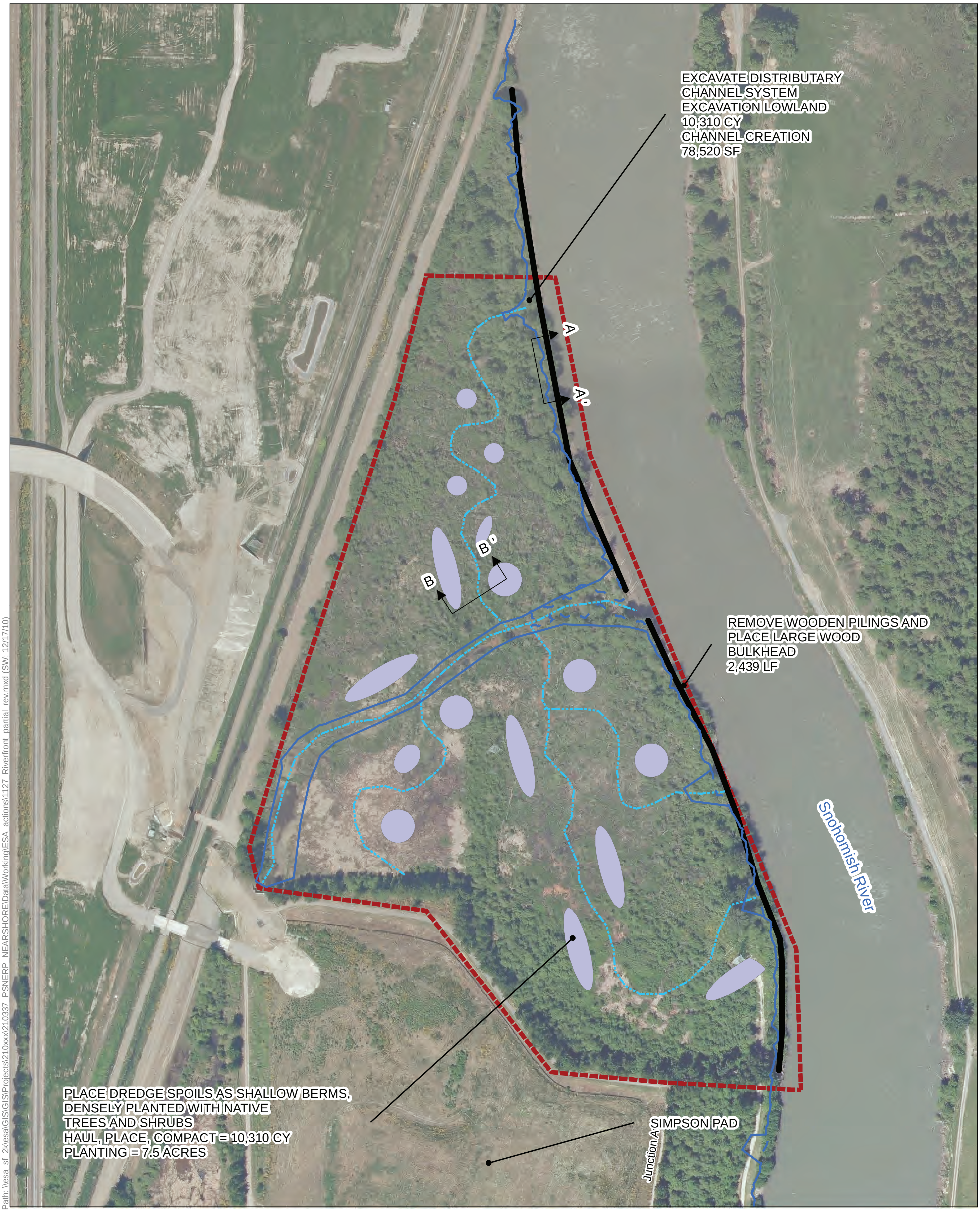
Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64

WDFW Contract # 100-000204 (CAPS No. 10-1461)

Lead Contractor: ESA
Design Lead: ESA
Date: 2/28/2011

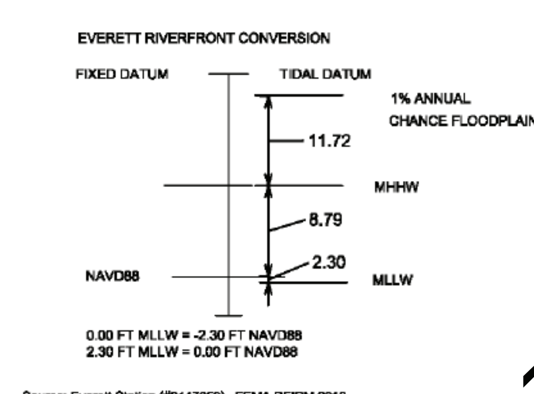
Conceptual Design Plan
Site Name: Snohomish River Delta
Action Name: Everett Riverfront Wetland Complexes
PSNERP ID #:1127
Full Restoration

Figure 12-3



Legend

A A' Section Lines
Proposed Tide MHHW
Existing Tide MHHW
Bulkheads
Channel Rehab/Creation
Required Project Lands
Haul, Place, Compact



PUGET SOUND NEARSHORE

North

0 120
Feet

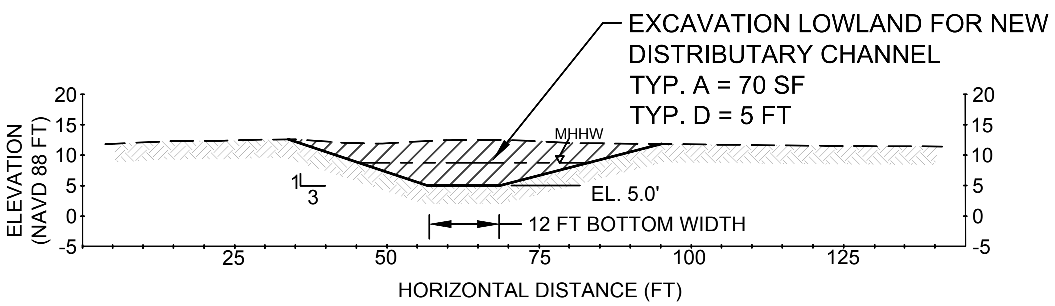
SOURCE: PSNERP (2011); Aerial (Bing, 2009)

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

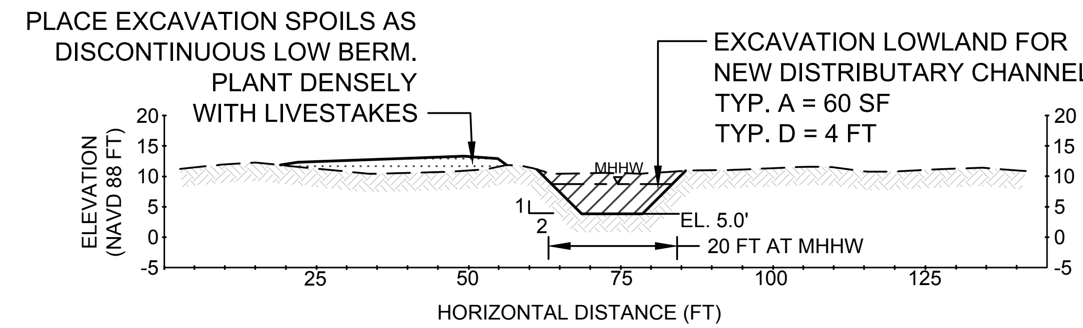
Conceptual Design Plan
Site Name: Snohomish Estuary
Action Name: Everett Riverfront Wetland Complexes
PSNERP ID #:1127
Partial Restoration

Lead Contractor: ESA
Design Lead: ESA
Date: 2/28/2011

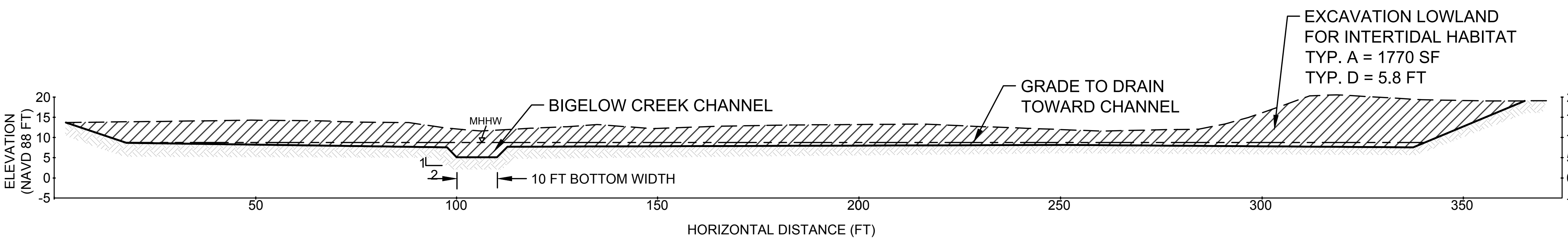
Figure 12-4



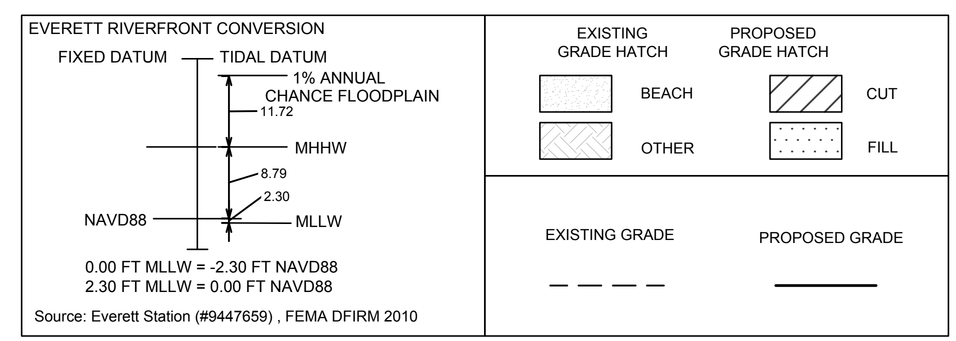
A NORTH WETLAND NEW OPENING TO MAINSTEM (TYP.)



B NORTH WETLAND DISTRIBUTARY CHANNEL (TYP.)



C SOUTH WETLAND COMPLEX FILL REMOVAL AREA (TYP.)



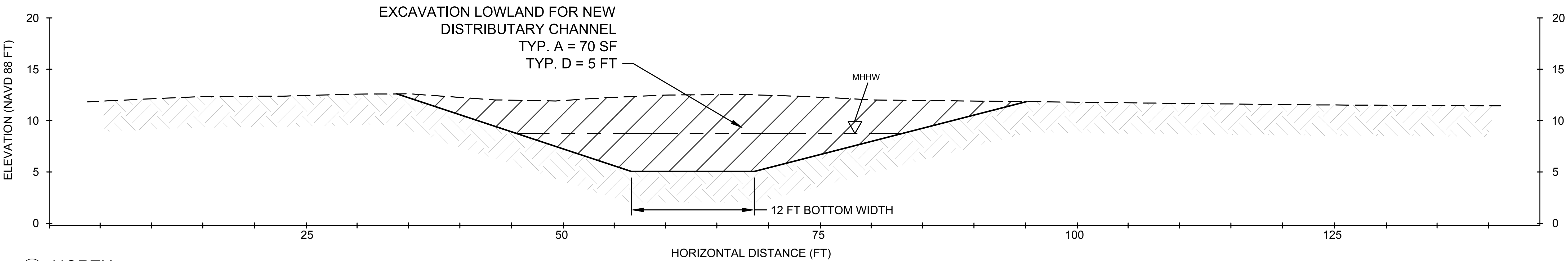
PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: ESA
Date: 3/2011

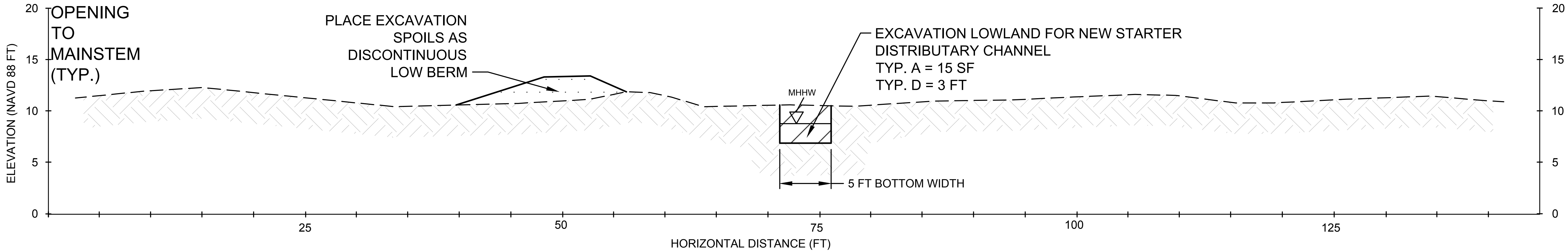
Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Section
SITE NAME: **Snohomish River Delta**
ACTION NAME: **Everett Riverfront Wetland Complexes**
PSNERP ID#: **1127**
Full Restoration

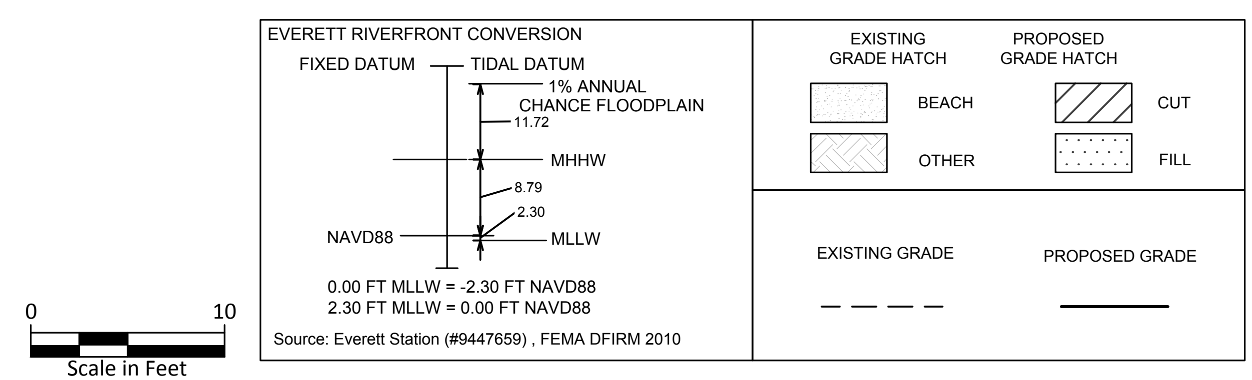
Figure 12-5



(A) NORTH WETLAND NEW OPENING TO MAINSTEM (TYP.)



(B) NORTH WETLAND STARTER DISTRIBUTARY CHANNEL (TYP.)



PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: ESA
Date: 3/2011

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Section
SITE NAME: **Snohomish River Delta**
ACTION NAME: **Everett Riverfront Wetland Complexes**
PSNERP ID#: **1127**
Partial Restoration

Figure 12-6

Full Restoration Quantity Estimate

Action Name:	Everett Riverfront Wetland Complexes				
Action #:	1127				
Date:	February 2011				
By:	ESA				

REMEDY: *Install distributary channel system within north wetland complex, restore estuary mouth and remove historical fill for Bigelow Creek in the South Wetland Complex*

Construction Period: Four Months

Item	Unit of Measure	Material Name	Qty	Description of Item		Indicate section of design report where item is described
ACQUISITION AND CONSERVATION				Based on available mapping information		
Required Project Lands	Acre		90.3	Total land required For action		12.3.5
Proponent / Partner-owned lands	Acre		82.1	Etimate of lands currently owned by Proponent (i.e., Public lands)		12.3.5
Lands To Be Acquired	Acre		8.2	Estimate land required to be acquired for action prior to implementation		12.3.5
Material Sites				Not Used: See Earthwork - Imported Fill.		
MOBILIZATION AND ACCESS for construction activities				Description required for each item to facilitate cost estimating		
Mobilization - Typical (Equipment, Personnel, Planning, Financial)	LS		1	Assume 8% of total		
Mobilization - Remote (Equipment, Personnel, Planning, Financial)	LS		NA			
Site Access	LS		1	Access can utilize existing surface roads to the site. No through traffic on site.		12.3.7
Site Access	LS		1	Work within wetland c will require mats and small low ground pressure equipment.		12.3.7
Barge Access	Days		NA			
Temporary Traffic Control (one of the following)						
none	LS		NA			
signs	LS		NA			
flags / spotters	LS		NA			
unique	LS		NA			
Temporary Roadway	LS		1	Regional trail may need to be re-routed during construction.		
Control of Water	LS		1	May need to block tidal action during breech in north and south wetland complexes.		
Control of Water	LS		1	Dredge from south wetland complex may require dewatering on site prior to haul.		
Relocation Activities						
Site Demolition Activities						
Clearing and Grubbing (one or more of following)						
Clear Vegetation - Local Disposal	AC		NA	Assume clearing integral to excavation, lowland		
Clear /Grub Vegetation - Local Disposal	AC		NA			
Clear /Grub Vegetation - Offsite Disposal	AC		NA			
Clear, stockpile - large woody debris	CY		400	Estimate		
Hydraulic Structures - Small	LS		1	Removal of existing culverts and tidegates - total length unknown.		
Hydraulic Structures - Large	LS		NA			
Utilities	LS		1	Utilities likely need to be relocated or buried deeper - type and extent unknown.		
Buildings	SF		NA			
Pavement	SF		NA			
Bulkheads	LF or SF		NA			
Rock revetments	LF, Ton or CY		NA			
Large Coastal Structures	LF, SF or CY		NA			
Demolition / Removal - Bridge	SF or CY		NA			
Removal - Misc. (e.g. angular rock from beach)	Ton		NA			
Demolition / Removal - Boat Ramp	SF		NA			
Haul - Offsite Disposal of Demolition Debris	Miles		20	Assumed.		
Hazardous/Contaminated Waste Removal						
Contaminated Earthwork	CY		65,000	Assume half of excavated sediments are contaminated in south wetland complex.		
Hazardous Earthwork	CY		0			
Construct Temporary Features						
EARTHWORK						
Excavation	CY					
Excavation - Upland	CY		NA			
Excavation - Lowland	CY		2,000	New channel mouths in north wetland complex, to be used on-site		12.3.1
Excavation - Lowland	CY		10,500	New channel excavation in north wetland complex, to be used on-site		12.3.1
Excavation - Lowland	CY		130	Minor sediment removal from main channel in north wetland complex, to be used on-site		12.3.1
Excavation - Lowland	CY		130,000	Fill removal at south wetland complex to be hauled		12.3.1
Excavation - Lowland	CY		6,000	Channel excavation in south wetland complex to be hauled		12.3.1
Dredging - Bucket - Land	CY		NA			
Dredging - Bucket - Marine	CY		NA			
Dredging - Hydraulic	CY		NA			
Fine Grading	AC		NA			
Fill Placement - local borrow						
Side cast	CY		NA			
Haul - uncontrolled placement	CY		NA			
Haul, place, compact	CY		12,630	Place all excavated materials from north wetland complex in low berms along new channels.		Table 12.1
Stockpile - uncontrolled placement	CY		NA			
Stockpile - controlled placement	CY		NA			
Conveyor placement from stockpile land/water	CY		NA			
Imported Fill						
Select Fill	CY		NA			
Select Fill	CY		NA			
Gravel Borrow, including haul	CY		NA			
Sand / Gravel for Beach Nourishment	CY		NA			
Cobble for Shore Nourishment	CY		NA			
Embankment Compaction	CY		NA			
Topsoil	CY		850	Compost import for Western Wetland Complex		Table 12.1
RESTORATION Features						
Channel Rehab / Creation	SF		88150	Minor fine grading and LWD placement in new channels in north wetland complex		12.3.2
Channel Rehab / Creation	SF		64050	Remove beaver dams and fine grading of main channel in north wetland complex		12.3.2
Channel Rehab / Creation	SF		30800	Minor fine grading and LWD placement in new channels in Bigelow Creek.		12.3.2
Large Wood Placement	EA		1632	Median number for W. Washington streams using the Fox and Bolton numbers (2007)		12.3.2
Invasive Species Control	Acre		NA			
Physical Exclusion Devices	LF or EA		NA			
Other Restoration Features/ Activities	LS		NA			
Structures	EA					
Water Control Structures - Culverts with Gates	EA		NA			
Water Control Structures - Weirs	EA		NA			
Rock Slope Protection	LF		NA			
Other	EA		NA			
Elevated Boat Ramp	EA		NA			
Fencing	SF		NA			
Utilities						
Water	LF		0			
Gas	LF		0			
Electric	LF		0			
Sewer	LF		0			
Telecommunications	LF		0			
Other	LF		0	Others = whatever is required (e.g.. power towers, petroleum, jet fuel, etc.)		
Roadway / Railway				KPFF expected to participate in these estimates		
Roadway (Type)	SF		NA			
Roadway - Traffic Signal	LS		NA			
Culvert (type)	LF		NA			
Culvert - Jacking	LF		NA			
Culvert - Horizontal Pile Driving	LF		NA			
Bridge - Foundations, Deck and Appurtenances	SF		NA			
Railway - Box Girder	SF		NA			
Railway - Foundation	LF		NA			
Railway - Shoe fly	LF		NA			
Permanent Access Features						
Roads	Level		0			
Utility Access Routes	varies		0			
Erosion Control Features	L.F.		0			
Public Access or Recreation Features						
Trails	SF		37900	Re-align trail to the west		12.3.4
Bridges	SF		0			
Kiosk	EA		0			
Restrooms	EA		0			
Interpretive Signs	EA		2			
Parking Area	SF		0			
Other	EA		0			
Vegetation & Erosion Control						
Hydroseeding	AC		0			
Planting	AC		7.5	Planting excavation spoil berms in north wetland complex		12.3.1
Planting	AC		2.7	Planting along main channel		
Planting	AC		5.6	Planting riparian area in south wetland complex.		
Planting	AC		0.52	Planting compost berms in west wetland complex.		
Vegetation Maintenance	AC-YR		81.6	Assume 5 years for total from above.		
Erosion / sediment BMPs - Temp.	AC		30			
Erosion / sediment BMPs - Permanent	AC		0			
Waterside controls - Temporary	EA, LF, LS		0			

Full Restoration Quantity Estimate

	Action Name:	Everett Riverfront Wetland Complexes					
	Action #:	1127					
	Date:	February 2011					
	By:	ESA					

REMEDY: ***Install distributary channel system within north wetland complex, restore estuary mouth and remove historical fill for Bigelow Creek in the South Wetland Complex***

Construction Period: Four Months

	Item	**Unit of Measure**	**Material Name**	**Qty**	**Description of Item**		**Indicate section of design report where item is described**
Construction Management							
	Construction oversight	weeks		16			
	Materials testing						
Design and Detailed Site Investigations							
	Survey & Property, Utility Research	LS		1	% of construction cost		
	35% Design	LS		1	35% x 25% x Engineer's Estimate		
	65% design	LS		1	65% x 25% x Engineer's Estimate less the cost for 35% PS&E		
	90% design	LS		1	35% x 25% x Engineer's Estimate less the cost for 35% + 65%PS&E		
	100% design	LS		1	25% x Engineer's Estimate less previous costs		
	Geotechnical Studies				Refer to design report for description of need		
	Cultural Studies				Refer to design report for description of need		
	HTWR Studies				Refer to design report for description of need		
Project Agreement Activities					Unable to provide credibale estimate at 10% design		
Site-Specific Adaptive Management Features & Activities					List if known		
Monitoring Activities					Assume 5 crew-days/year for each monitoring parameter in design report for 5 yrs		
	Monitoring (Type)	crew-days		150			
Operations & Maintenance					Unable to provide credible estimate at 10% design		

Partial Restoration Quantity Estimate

Action Name: Everett Riverfront Wetland Complexes
Action #: 1127
Date: February 2011
By: ESA

REMEDY: ***Install Distributary channel system within existing floodplain wetland (north wetland complex).***
Construction Period: Three Months

Item	Unit of Measure	Material Name	Qty	Description of Item	Indicate section of design report where item is described
ACQUISITION AND CONSERVATION				Based on available mapping information	
Required Project Lands	Acre		35.2	Total land required For action	12.3.5
Proponent / Partner-owned lands	Acre		35.2	Etimate of lands currently owned by Proponent (i.e., Public lands)	12.3.5
Lands To Be Acquired	Acre		0	Estimate land required to be acquired for action prior to implementation	12.3.5
Material Sites				Not Used: See Earthwork - Imported Fill.	
MOBILIZATION AND ACCESS for construction activities				Description required for each item to facilitate cost estimating	
Mobilization - Typical (Equipment, Personnel, Planning, Financial)	LS		1	Assume 8% of total	
Mobilization - Remote (Equipment, Personnel, Planning, Financial)	LS		NA		
Site Access	LS		1	Access can utilize existing surface roads to the site. No through traffic on site.	12.3.7
Site Access	LS		1	Work within north wetland complex will require mats and small low ground pressure equipment.	12.3.7
Barge Access	Days		NA		
Temporary Traffic Control (one of the following)					
none	LS		NA		
signs	LS		NA		
flags / spotters	LS		NA		
unique	LS		NA		
Temporary Roadway	LS		NA		
Control of Water	LS		1	May need to block tidal action during breech in north wetland complex.	
Relocation Activities					
Site Demolition Activities					
Clearing and Grubbing (one or more of following)					
Clear Vegetation - Local Disposal	AC		NA	Assume clearing integral to excavation, lowland	
Clear /Grub Vegetation - Local Disposal	AC		NA		
Clear /Grub Vegetation - Offsite Disposal	AC		NA		
Clear, stockpile - large woody debris	CY		400	Estimate	
Hydraulic Structures - Small	LS		NA		
Hydraulic Structures - Large	LS		NA		
Utilities	LS		1	Preserve access to BPA overhead powerlines	
Buildings	SF		NA		
Pavement	SF		NA		
Bulkheads	LF or SF		NA		
Rock revetments	LF, Ton or CY		NA		
Large Coastal Structures	LF, SF or CY		NA		
Demolition / Removal - Bridge	SF or CY		NA		
Removal - Misc. (e.g. angular rock from beach)	Ton		NA		
Demolition / Removal - Boat Ramp	SF		NA		
Haul - Offsite Disposal of Demolition Debris	Miles		20	Assumed.	
Hazardous/Contaminated Waste Removal					
Contaminated Earthwork	CY		0		
Hazardous Earthwork	CY		0		
Construct Temporary Features					
EARTHWORK					
Excavation	CY				
Excavation - Upland	CY		NA		
Excavation - Lowland	CY		2,000	New channel mouths in north wetland complex, to be used on-site	12.3.1
Excavation - Lowland	CY		2,200	New channel excavation in north wetland complex, to be used on-site	12.3.1
Excavation - Lowland	CY		130	Minor sediment removal from main channel in north wetland complex, to be used on-site	12.3.1
Dredging - Bucket - Land	CY		NA		
Dredging - Bucket - Marine	CY		NA		
Dredging - Hydraulic	CY		NA		
Fine Grading	AC		NA		
Fill Placement - local borrow					
Side cast	CY		NA		
Haul - uncontrolled placement	CY		NA		
Haul, place, compact	CY		4,330	Place all excavated materials from north wetland complex in low berms along new channels.	Table 12.1
Stockpile - uncontrolled placement	CY		NA		
Stockpile - controlled placement	CY		NA		
Conveyor placement from stockpile land/water	CY		NA		
Imported Fill					
Select Fill	CY		NA		
Select Fill	CY		NA		
Gravel Borrow, including haul	CY		NA		
Sand / Gravel for Beach Nourishment	CY		NA		
Cobble for Shore Nourishment	CY		NA		
Embankment Compaction	CY		NA		
Topsoil	CY		NA		
RESTORATION Features					
Channel Rehab / Creation	SF		19630	Minor fine grading and LWD placement in new channels in north wetland complex	12.3.2
Channel Rehab / Creation	SF		64050	Remove beaver dams and fine grading of main channel in north wetland complex	12.3.2
Large Wood Placement	EA		788	Median number for W. Washington streams using the Fox and Bolton numbers (2007)	12.3.2
Invasive Species Control	Acre		NA		
Physical Exclusion Devices	LF or EA		NA		
Other Restoration Features/ Activities	LS		NA		
Structures	EA				
Water Control Structures - Culverts with Gates	EA		NA		
Water Control Structures - Weirs	EA		NA		
Rock Slope Protection	LF		NA		
Other	EA		NA		
Elevated Boat Ramp	EA		NA		
Fencing	SF		NA		
Utilities					
Water	LF		0		
Gas	LF		0		
Electric	LF		0		
Sewer	LF		0		
Telecommunications	LF		0		
Other	LF		0	Others = whatever is required (e.g.. power towers, petroleum, jet fuel, etc.)	
Roadway / Railway				KPFF expected to participate in these estimates	
Roadway (Type)	SF		NA		
Roadway - Traffic Signal	LS		NA		
Culvert (type)	LF		NA		
Culvert - Jacking	LF		NA		
Culvert - Horizontal Pile Driving	LF		NA		
Bridge - Foundations, Deck and Appurtenances	SF		NA		
Railway - Box Girder	SF		NA		
Railway - Foundation	LF		NA		
Railway - Shoe fly	LF		NA		
Permanent Access Features					
Roads	Level		0		
Utility Access Routes	varies		0		
Erosion Control Features	L.F.		0		
Public Access or Recreation Features					
Trails	SF		0		
Bridges	SF		0		
Kiosk	EA		0		
Restrooms	EA		0		
Interpretive Signs	EA		2		
Parking Area	SF		0		
Other	EA		0		
Vegetation & Erosion Control					
Hydroseeding	AC		0		
Planting	AC		7.5	Planting excavation spoil berms in north wetland complex	12.3.1
Planting	AC		2.7	Planting along main channel	
Vegetation Maintenance	AC-YR		51	Assume 5 years for total from above.	
Erosion / sediment BMPs - Temp.	AC		15		
Erosion / sediment BMPs - Permanent	AC		0		
Waterside controls - Temporary	EA, LF, LS		0		
Construction Management					
Construction oversight	weeks		12		
Materials testing					

Partial Restoration Quantity Estimate

Action Name:	Everett Riverfront Wetland Complexes
Action #:	1127
Date:	February 2011
By:	ESA

REMEDY: ***Install Distributary channel system within existing floodplain wetland (north wetland complex).***

Construction Period: Three Months

	Item	Unit of Measure	Material Name	Qty	Description of Item		Indicate section of design report where item is described
Design and Detailed Site Investigations							
	Survey & Property, Utility Research	LS		1	% of construction cost		
	35% Design	LS		1	35% x 25% x Engineer's Estimate		
	65% design	LS		1	65% x 25% x Engineer's Estimate less the cost for 35% PS&E		
	90% design	LS		1	35% x 25% x Engineer's Estimate less the cost for 35% + 65%PS&E		
	100% design	LS		1	25% x Engineer's Estimate less previous costs		
	Geotechnical Studies				Refer to design report for description of need		
	Cultural Studies				Refer to design report for description of need		
	HTWR Studies				Refer to design report for description of need		
Project Agreement Activities					Unable to provide credibale estimate at 10% design		
Site-Specific Adaptive Management Features & Activities					List if known		
Monitoring Activities					Assume 5 crew-days/year for each monitoring parameter in design report for 5 yrs		
	Monitoring (Type)	crew-days		150			
Operations & Maintenance					Unable to provide credible estimate at 10% design		

13. HAMMA HAMMA CAUSEWAY REPLACEMENT AND ESTUARY RESTORATION (#1047)

Local Proponent	Hood Canal Salmon Enhancement Group (HCSEG)
Delta Process Unit	HAM
Shoreline Process Unit(s)	NA
Strategy(ies)	1 - River Delta
Restoration Objectives	Remove stressors and reconnect tidal channels to the mainstem to increase freshwater and sediment flow to the north channel and restore tidal hydrology, sediment supply and transport into the estuary, freshwater input, tidal channel formation and maintenance, detritus import and export, and exchange of aquatic organisms

13.1 Description of the Action

The proposed action would restore natural hydraulic and geomorphic processes in the Hamma Hamma River Estuary. The primary stressor in the estuary is the Highway 101 causeway that crosses the delta from north to south. Additional stressors include dikes, armoring, and dredging to direct the flow of the river through the delta. The restoration project proposes to restore tidal hydrology, sediment transport, freshwater input, and other hydrologic and geomorphic process by removing and replacing some or all of the existing Highway 101 roadway embankment, bridges, dikes, and armoring, and by placing an engineered log jam to divert flow to the north channel. Please see the Introduction chapter for important information regarding PSNERP and for context related to this restoration project.

13.2 Action Area Description and Context

The action area is located in the Hood Canal Subbasin on the west shoreline of Hood Canal at the mouth of the Hamma Hamma River. The Hamma Hamma River flows east from the Olympic Mountains to Hood Canal. The river delta formed at the mouth is one of the largest in Hood Canal. The area is in a rural location approximately 12 miles north of Hoodsport, Washington, on Highway 101. The action area includes mudflat, tidal marsh, remnants of a barrier beach, dikes, several residential structures, a commercial shellfish processing and retail facility, and the Highway 101 bridges and roadway embankment. Steep, heavily wooded hillsides rise to the north, west, and south of the action area.

Highway 101 bisects the action area from north to south. Highway 101 consists of roadway embankment fill and two bridges. Two primary distributary channels exist in the river delta, referred to as the south and north channels. Bridges span both channels, and road fill connects the two bridges and the north and south approaches to the bridges. Currently, the south channel is the primary conveyance for the Hamma Hamma River.

The south channel has been dredged and straightened. A dike was constructed on its north (left) bank and armored to direct the river away from the majority of the river delta used for shellfish aquaculture. Deposition of fine sediments and gravel from the watershed has been concentrated in the south channel and is not distributed across the delta due to channelization. This alteration has prevented the river from meandering through shellfish beds, but it has also starved most of the estuary of sediment. The action area is shown in Figure 13-1.

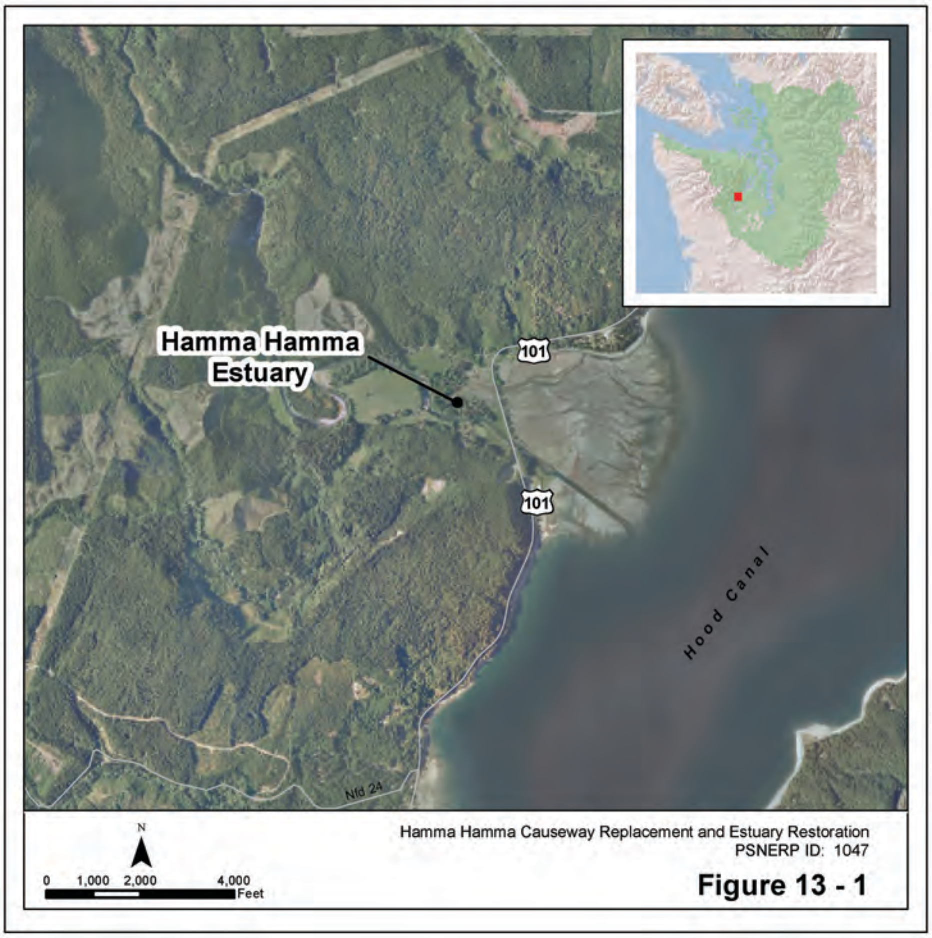


Figure 13-1. Action Area and Vicinity

13.2.1 Historic Condition

Prior to construction of Highway 101 in the 1920s and the river channel alterations, the estuary had two channels; however, the north channel was the primary channel of the river. Upon removal of a log jam in the 1950s, the dominant flow of the river channel switched to the south channel (Werner 2010). At or about that same time, the mouth of the south channel was channelized and hardened by the landowner. This channelization prevented the river channel from migrating over adjacent tidal flats and through oyster beds on the east side of Highway 101, and it diverted channel flow and sediment discharge to the south and deeper water in Hood Canal.

In addition to the south and north channels, historic maps (1883 T-sheets) show multiple and complex distributary and blind channels in the estuary (Figures 13-2A and 13-2B). The construction of the Highway 101 roadway embankment has truncated these channels. These channels still appear to be present upon review of aerial photos and LiDAR mapping and by visual inspection, and would be reactivated upon removal of the embankment fill. This alteration in historical channel water and sediment flows represents a significant habitat loss for juvenile salmon, and an additional loss of the delivery route for sediment to the northern two-thirds of the delta.

The historic and LiDAR maps also show a distinct barrier beach spit at the southern half of the delta that hooked toward the west at the terminus. This spit historically had a railroad and log dump at the terminus (Werner 2010). The piles and fill from this historic railroad and log dump are deteriorated but still visible.

13.2.2 Natural Environment

Most of the Hamma Hamma River watershed is in federal ownership, primarily managed by the Olympic National Forest, with a smaller portion on the north margin managed by the Olympic National Park. In addition, most of the upper watershed consists of roadless areas managed as wilderness. The lower 5 miles of the river and the largest downstream tributary, John Creek, are in private ownership and managed as commercial forestland that has been heavily logged. The estuary consists of a full gradient of habitat types with an extensive mudflat and marsh complex, and some forested and scrub-shrub wetland.

Historic tidal channels and marsh/mudflat habitats outside of the Highway 101 footprint and dredged/diked south river channel are largely intact. One important shift in vegetation, visible on the upstream and downstream sides of Highway 101, is likely caused by the partial tidal barrier constituted by the roadway prism. On the downstream side of the highway, marsh vegetation is dominated by salt-tolerant species such as pickleweed. On the upstream side of the highway, the marsh vegetation is dominated by brackish species such as Lyngby's sedge and cattails in blocked tidal channels. The fragmentation and lack of transition between these vegetation communities appears linked to the effects of the road fill on saltwater and freshwater circulation.

There are also distinct differences in the existing ground surface elevation of the south and north portions of the delta on the downstream (east) side of Highway 101. These differences in marsh plain and mudflat elevation appear to be associated with the channelization of the south channel, and the inactive nature of the north channel, affecting sediment distribution.

Finally, the presence of the former barrier beach spit and modifications for the past railroad and log dump are visible in the southeast sector of the marsh plain. A distinct elevated area exists, with some trees and shrubs, at the north terminus of this shoreform, resulting from the accretion of natural materials (sand and gravel) and the placement of fill and pilings. Loss of fine sediment and exposure of coarser gravel and cobble sediment is apparent as the barrier beach is cut off by the maintenance dredging of the south river channel.

13.2.3 Human Environment

Highway 101, a two-lane rural highway, crosses the Hamma Hamma River delta via an elevated roadway approximately 2,400 feet in length. The roadway is composed of an earth-filled embankment with two identical concrete arch bridge structures spanning the mainstem of the river (south channel) and a north distributary channel. The two bridges, each 154 feet in length, were constructed in 1923 and 1924 and are on the National Register of Historic Places. The posted speed limit is 50 miles per hour. The roadway includes two bridge approach embankment sections at the north and south ends of the bridges and estuary.

On the east side of Highway 101, an earthen dike lines the south (mainstem) channel along the left bank. This dike is protected from river channel erosion by rock armor. Rock armor is also located on the south bank of this river channel east of Highway 101. In the lower portion of the channel (downstream of the historic barrier beach spit), there are dikes on each bank constructed of rock fill. This channel was periodically dredged for maintenance (Werner 2010). The entire action area, other than the Highway 101 right-of-way, is within private ownership (Robbins family, owner of the Hamma Hamma Oyster Company) and the lower intertidal area is used for shellfish aquaculture (Werner 2010).

Modifications to the south channel (diking and dredging) of the Hamma Hamma River were accomplished to control freshwater inflow because of its negative effects on shellfish aquaculture. The dikes have no known flood control function and were privately constructed. However, this channelization of the river delta has reduced sediment input to a large area of the lower estuary. The changes have resulted in progradation of the south delta, artificially altering sediment size and substrate quality across the delta. The southernmost portion of the historic delta/estuary marsh has been filled to support land-based shellfish processing and retail operations.

Utilities in the action area include overhead power and telephone lines following the Highway 101 road alignment. More detailed information on existing utilities and the need for utility relocations will be required to support subsequent design phases.

13.3 Restoration Design Concept

13.3.1 Restoration Overview and Key Design Assumptions

The following key design assumptions and information apply to this action:

- Highway 101 is a two-lane highway (WSDOT designation R1) and is the primary route along Hood Canal on the Olympic Peninsula.
- The existing roadway will remain in service during construction, and the roadway prism and bridges will be removed upon completion.
- Right-of-way acquisition would be needed.

Figures 13-3 through 13-8 illustrate the restoration alternatives. The full restoration alternative would include: realignment of Highway 101 to the west for approximately 1.3 miles, installation of a new reinforced concrete bridge crossing the Hamma Hamma River upstream of tidal influence, removal of the existing roadway embankment and bridges, removal of dikes along the south channel of the river, diversion of the main flow of water and sediment from the south channel to the north channel using one or more engineered log jams, filling of the dredged south channel, diversion of the south channel to the relict historic channel, and restoration of the salt marsh and barrier beach spit (Figures 13-3, 13-5A, and 13-5B). This alternative also includes removal of nearshore fill that is not currently being used south of the south channel and adjacent to the oyster company operations.

The new roadway alignment for the full restoration alternative would follow two existing roadways to the maximum extent possible (Lonn Webb Road along the north and Eldon Road along the south) in order to minimize the associated earthwork, right-of-way acquisition, and wall construction. The new alignment would skirt the base of the hillsides along the edge of the valley floor. The new roadway alignment was selected as part of the full restoration alternative to remove the roadway from the tidally influenced estuary consistent with the *Hierarchy of Openings Memorandum* (Appendix C) and other guidance provided to the design team. The new roadway is intended to meet the goal of full stressor removal and is believed to be more cost-effective than replacement of the existing causeway with a bridge. The new roadway alignment may not have full support of the proponent. Additional analysis of the alignment and stakeholder coordination will be required during subsequent stages of design to determine a satisfactory alignment.

The proposed full restoration bridge span would be 180 feet in length with a single intermediate bent. Clearance from the design water surface to the low chord of the proposed bridge would be approximately 5 feet 6 inches. The bridge location was selected where the river channel appears to be well defined and stable. Aerial photography indicates little change in the river channel at this location during the last 20 years. Topography indicates that the river is constrained by an increasingly elevated area west of the bridge. However, analysis will be needed during subsequent design to confirm the adequacy of the bridge opening, length, and height to accommodate the full range of hydraulic and geomorphic processes. Culverts or short bridges would be installed along the new roadway where drainages from the steep slopes adjacent to the valley floor intersect the roadway alignment, as well as within the floodplain area west of the river to accommodate floods.

The partial restoration alternative would include replacement of the Highway 101 bridges and the roadway embankment between them with a new reinforced concrete elevated bridge adjacent to the present location of Highway 101 (Figures 13-4, 13-6A, and 13-6B). Bridge approaches would be modified slightly to match the alignment of the new bridge. The length and alignment of the bridge included in the partial restoration alternative were selected to minimize impacts to roadway function and address alignment and profile design complications, while removing the roadway from the most active part of the estuary. Flow into the north river channel would be encouraged to provide more freshwater and sediment input to the estuary using engineered log jams. The south channel would be restored as described in the full restoration alternative, but no fill would be removed south of the south channel in the vicinity of upland shellfish processing and retail facilities. The partial restoration alternative would remove most of the stressors, but it would not address all of them, including nearshore fill and addition of substantial new overwater structures associated with a new Highway 101 bridge parallel and adjacent to the current Highway 101 causeway.

Under the partial restoration alternative, the proposed bridge would span most of the delta with a length of 1,440 feet. The bridge would be constructed parallel to the existing roadway and at the same approximate elevation. Clearance between the bottom chord of the bridge and the design water surface elevation would be approximately 4 feet 6 inches. Traffic would be maintained on the existing Highway 101 roadway and bridges during construction. The new roadway bridge approach embankment would be constructed upon completion of the bridge as a transition to the existing alignment north and south of the action area. Once the new alignment is completed and can accommodate traffic, the existing bridges and roadway would be removed.

The key design elements of each alternative are summarized in Table 13-1.

Table 13-1. Key Design Elements

Element	Full Restoration	Partial Restoration
Roadway Embankment Fill	Remove roadway fill through estuary	Same as full restoration
Bridges	Remove existing bridges, reroute Highway 101, and construct new 180-foot-long bridge above tidal influence	Remove existing bridges, construct new 1,440-foot-long bridge adjacent to existing bridge spanning main channels and estuary between main channels
Dikes	Remove existing dikes on both sides of south channel	Same as full restoration
Armoring	Remove armoring on both sides of south channel	Same as full restoration
Barrier Beach	Restore barrier beach by placing fill in south channel	Same as full restoration
North Channel	Restore flow to north channel by placing an engineered log jam	Same as full restoration
South Channel	Fill in dredged channel and divert flow to historic relict channel	Same as full restoration
Fill	Remove nearshore fill south of south channel	Not included

13.3.2 Restoration Features – Primary Process-Based Management Measures

Armor Removal/Modification

Armoring was placed along the dikes on the north and south banks of the main channel (south channel) of the Hamma Hamma River downstream (east) of Highway 101 to protect against erosion. Both the full and partial restoration alternatives would include removal of approximately 4,450 LF of armoring along the dikes and banks on the north and south sides of the channel (Figures 13-3 and 13-4).

Berm or Dike Removal/Modification

The primary stressor within the action area is the Highway 101 roadway, including approximately 2,092 feet of roadway embankment and two bridges that are each approximately 154 feet in length. The roadway embankment disrupts tidal hydrology, sediment transport, and freshwater input to the estuary. The existing roadway embankment between the two bridges is typically about 28 to 34 feet wide on top, with a top elevation of approximately 23 feet MLLW and 2H:1V sideslopes. The bridge approach embankments are similar in geometry to the roadway embankment at the bridge, but the fill prism varies as the bridge approach embankments transition to the upland. The elevation of the roadway at the north end of the causeway is approximately26 feet MLLW. The elevation of the roadway at the south end of the causeway is approximately 23 feet MLLW.

The full restoration alternative would include removal of 2,839 feet of the Highway 101 roadway, including the entire embankment that crosses the estuary (Figure 13-3). The roadway would be rerouted to the west and would cross the river just upstream of the tidal influence. The volume of roadway fill material removed would be approximately 45,000 CY.

The partial restoration alternative would include removal of approximately 1,026 feet of the roadway embankment between the two existing bridges (Figure 13-4). The volume of roadway fill material removed would be approximately 22,200 CY.

Additional stressors within the estuary include dikes installed along the south channel to contain the river and limit freshwater input to shellfish beds. Both the full and partial restoration alternatives would include removal of the dikes along the north and south banks of the south channel, including approximately 3,250 feet of dike. The total volume of fill material removed would be approximately 4,400 CY.

Channel Rehabilitation/Creation

The main channel (south channel) through the river delta has been modified through the construction of dikes, placement of armoring, and dredging to direct freshwater input away from portions of the delta used for aquaculture. The north channel of the river was historically the main channel, but maintenance activities upstream and downstream and channelization of the delta have shifted most of the flow to the south channel, reducing sediment and freshwater input to the northern portion of the delta. Both the full and partial restoration alternatives propose to restore the channels and hydrology closer to the historic conditions. The dredged south channel will be partially filled in, and a new starter channel excavated to connect to the relict south channel in the estuary east of the restored barrier beach. An engineered log jam is proposed near the branch of the north and south channels to encourage flow to the north channel (Figures 13-3 and 13-4).

Groin Removal/Modification - NA

Hydraulic Modification

The full restoration alternative would include removal of the north Hamma Hamma River and south Hamma Hamma River bridges. Each bridge is 154 feet long. The bridges would be replaced with a single 180-foot-long bridge, spanning the Hamma Hamma River upstream of tidal influence (Figure 13-6). This action reduces 4,200 SF of overwater coverage.

Overwater Structure Removal - NA

Topography Restoration

In addition to fill placed in the south channel for channel rehabilitation, topographic restoration includes filling the existing dredged channel to restore the barrier beach that was bisected by channel modifications. Fill placement, along with additional grading, would result in restoration of natural pre-modification topography/bathymetry.

13.3.3 Restoration Features – Additional Management Measures

Beach Nourishment

Placement of suitable sand and gravel beach sediments is anticipated at the south river channel where the barrier beach is restored. These beach sediments may be of a different size range than the material used to fill in the south channel of the river.

Contaminant Removal/Remediation - NA

Debris Removal - NA

Invasive Species Control - NA

Large Wood Placement

As part of both the full and partial restoration alternatives, an engineered log jam would be placed at the point where the north and south branches of the river diverge. This engineered log jam would divert most of the flow to the north branch.

Physical Exclusion - NA

Pollution Control - NA

Revegetation

Limited revegetation is included in the project scope due to the extensive areas of bare ground that will result from road embankment, fill removal, and other topographic restoration in barrier beach and riparian areas. It is assumed that marsh areas will naturally recolonize due to the abundant seed and plant sources in the estuary; marsh revegetation is not included.

Reintroduction of Native Animals - NA

Substrate Modification - NA

Species Habitat Enhancement - NA

13.3.4 Restoration Features – Other

Additional restoration features that would be incorporated as part of the full restoration alternative would include rerouting Highway 101 to the west and constructing a bridge crossing the Hamma Hamma River just upstream of the tidal influence (Figure 13-3). The roadway would extend along the base of the hillside on the north side of the river, cross the river at a bridge approximately 0.5 mile west of the existing Highway 101 alignment, and run along the base of the hill on the south side of the river. The proposed highway improvements would include installation of 6,994 feet of new roadway, including a 180-foot-long, 33-foot-wide full-span reinforced concrete bridge over the Hamma Hamma River (Figure 13-6). The alignment of the new roadway would be optimized as much as possible to minimize earthwork, impacts to existing property, and removal of trees and other vegetation.

The partial restoration alternative would include replacement of the existing Highway 101 bridges and the roadway in between the two bridges, with a new elevated bridge structure constructed adjacent to the existing roadway (Figure 13-4). The bridge approaches would need to be modified to match the alignment of the proposed bridge. The new bridge and roadway would be just 45 feet upstream (west) of the existing highway. Construction of the bridge adjacent to the causeway would allow for continued use of Highway 101 during bridge construction. The proposed bridge would be a 1,440-foot-long, 28-foot-wide reinforced concrete elevated structure (Figure 13-8).

13.3.5 Land Requirements

As noted previously, the action area is privately held by the Robbins family (the owner of the Hamma Hamma Oyster Company), a commercial forestry operation (outside of the action area), and gravel mining. The primary activities on the property are an oyster and clam farm and processing plant, and private residences owned by Robbins family members. The north edge of the estuary includes many residential shoreline properties that are not owned by the Robbins family. The Robbins family has requested that restoration activities provide continued access to oyster beds and assurance that changes resulting from restoration activities will not be detrimental to shellfish growing operations. Fill removal at the south side of the main channel (south channel) also should not adversely affect the shellfish processing and retail facility adjacent to it. Effects of road realignment on private residences should also be minimized.

For the full restoration alternative, approximately 36 acres would be impacted by the restoration action. Approximately 5.1 of those acres are currently in the public right-of-way. Approximately 30.9 acres would need to be acquired or an easement granted from the Robbins family for access and implementation, including the following:

- Approximately 11.2 acres of new right-of-way for Highway 101 realignment.
- Approximately 19.7 acres to allow for removal of dikes, armoring, and placement of fill along the south channel.

For the partial restoration alternative, approximately 20.9 acres would be impacted by the restoration action. Approximately 3.9 of those acres are currently in the public right-of-way. Approximately 17.0 acres would need to be acquired from the Robbins family for access and implementation, including the following:

- Approximately 2.8 acres of new right-of-way for Highway 101 realignment.
- Approximately 14.2 acres to allow for removal of dikes, armoring, and placement of fill along the south channel.

13.3.6 Design Considerations

Highway 101 Operation and Design

Highway 101 is the major route of travel along the west side of Hood Canal between cities in the north Olympic Peninsula and south Puget Sound areas. Maintaining operation of the highway during construction is a primary design consideration. The design of both the full and partial restoration alternatives would include construction of new bridge structures and roadway facilities adjacent to or along a completely different alignment, so that the existing Highway 101 facilities can remain in operation during construction. The design would allow for the existing bridges and roadway to be removed after traffic is routed to the new bridges and roadway.

Old highway plans provided by WSDOT indicate that the original alignment of Olympic Highway, now Highway 101, extended west along the base of the hill on the north side of the Hamma Hamma River before turning south and crossing the river approximately 0.4 mile west of the existing causeway. Remnants of the old highway remain, including Lonn Webb Road on the north side of the river and Eldon Road on the south side of the river. The proposed highway realignment that would be incorporated as part of the full restoration alternative would follow approximately the same route, but with curves and geometry designed to meet current WSDOT and county highway design standards.

Improvements to Highway 101 would restore the highway to the current design standards. Highway 101 in this area is posted at 50 mph and has a design speed of 55 mph. For the full restoration alternative, the minimum roadway width would be 28 feet including shoulders, with additional widening along curves of minimum radii to accommodate truck trailer movements. Horizontal curves would have a super-elevated section of up to 6%. Several drainages from the adjacent steep hillsides would intersect the roadway alignment. Culverts would be installed to pass the design flows from these watersheds. A large-span culvert is proposed within the floodplain area to provide additional capacity during flood events of the Hamma Hamma River. Additional hydrologic studies would be needed to confirm appropriate size, placement and scour protection. Also, further evaluation would be needed to determine adequate sight distance at driveway accesses to the highway.

Bridge Design

For the full restoration alternative, the proposed bridge will be 180 feet long. The superstructure would consist of 95-foot-long spans made up of 3-foot-6-inch deep pre-cast concrete slab girders (Figure 13-6). The intermediate pier would consist of 30-inch-diameter cast-in-place concrete piles. The assumed embedment depth of the piles would be 100 feet. Other pile types, such as pre-cast concrete piles, should be considered during later stages of design.

For the partial restoration alternative, the proposed alignment of the new bridge would be parallel to the existing causeway in order to maintain traffic and minimize road closures during construction. The new bridge would be 1,440 feet long. The bridge superstructure would consist of 14 spans 90 feet long, made up of 3-foot-6-inch deep pre-cast concrete slab girders (Figure 13-8). The roadway would transition to the new alignment via reverse curves with sufficient tangent between. Pier bents would consist of 30-inch-diameter cast-in-place concrete piles. The assumed embedment depth of the piles is 100 feet. Other pile types, such as pre-cast concrete piles, should be considered during design.

Right-of-Way and Property Impacts

The existing Highway 101 right-of-way is narrow and cannot accommodate construction of a new structure adjacent to the existing roads and bridges. Additional right-of-way would be required for either the full or the partial restoration alternative to allow for construction of new facilities. Design of new facilities would need to consider existing land uses and the need to secure additional right-of-way. The design would need to include consultation with the private landowner or additional land acquisition to minimize impacts.

A requirement identified by the proponent for the property owner is access to the oyster beds on both sides of the south channel of the Hamma Hamma River. This access could be accomplished in either restoration alternative by restoring the coastal barrier beach, which could then be used to access tidal areas from the current oyster company building. The property owner wants to be assured that changes resulting from estuary restoration affecting channel morphology, freshwater input, and sediment distribution will not be detrimental to their shellfish growing operations.

Tides and Flooding

The design of improvements in the Hamma Hamma River delta needs to accommodate fluctuating tide levels and flooding. For the partial restoration alternative, the new bridge would be located entirely within the tidal influence. The design of the new bridge and roadway improvements requires a design water surface elevation (WSEL) to ensure that the bridge provides adequate clearance for flows and tidal exchange. The design WSEL developed for use in concept designs for the partial restoration alternative accounts for peak tide and potential sea level rise, as follows:

- Design WSEL = Peak Tide + Allowance for Sea Level Rise

The peak tide was estimated by reviewing tide predictions from NOAA. Tide predictions for Ayock Point, which is approximately 2.5 miles south of the action area, indicate that the extreme high tide during 2011 is predicted to be approximately 13.1 feet MLLW (10.5 feet NAVD 88). An allowance of 1.5 feet was added to account for predicted sea level rise, which represents the U.S. Army Corps of Engineers' current high estimate for sea level rise for the Strait of Juan de Fuca, as outlined later in this report (USACE 2010). The resulting design WSEL, 14.1 feet MLLW (11.5 feet NAVD 88), was used for evaluation of the partial restoration alternative. The proposed bridge would be designed with a deck elevation equal to the existing roadway elevation, 22.6 feet MLLW (20.0 feet NAVD 88). Based on review of possible bridge sections, the proposed bridge would have more than adequate clearance for flows and tidal exchange at that elevation, with no significant modification of the elevation of bridge approaches.

For the full restoration alternative, the new bridge would be located just upstream of tidal influence. FEMA floodplain mapping for the lower portion of the Hamma Hamma River (FEMA 1988) designates the floodplain within the action area as Zone A, which indicates that base flood elevations have not been determined. Because the proposed bridge crossing for the full restoration alternative is just upstream of tidal influence, it is anticipated that the influence of river flows on flooding would be small. It was determined that the evaluation of the bridge for the concept design would account for peak tide and sea level rise, or a design WSEL of 13.1 feet MLLW (11.5 feet NAVD 88), as outlined above. The proposed bridge would be designed with a deck elevation of 23.6 feet MLLW (21.0 feet NAVD). Based on review of possible bridge sections, it is anticipated that a proposed bridge at that elevation would have more than adequate clearance for flood flows and tidal conditions. Additional analysis will be needed during subsequent design to verify the impact of flooding on water surface elevations at the proposed bridge crossing.

Environmental Resources

Realignment of the highway, as outlined for the full restoration alternative, would follow local road alignments as much as possible. Where the alignment requires wider right-of-way, some clearing and earthwork may be required that could have a negative impact on local environmental resources. The design of the project would need to consider these impacts, in light of other considerations mentioned above, and include measures to minimize or prevent negative impacts.

13.3.7 Construction Considerations

Equipment

Construction of either restoration alternative would likely require heavy equipment, such as excavators and front end loaders, for fill excavation and placement of fill; dump trucks for hauling excess material; and graders and compactors for construction of roadway improvements. Use of equipment on soft soils in marsh areas and mudflats would be minimized by working from the existing roadway embankment or other local road surfaces or dike tops. Where this is not possible, low-ground-pressure tracked vehicles, wood lagging mats, or other measures could be used.

For the full restoration alternative, a pile driving rig and crane likely would be required for the bridge construction. Other bridge types such as a steel truss should be investigated during design to eliminate the need for intermediate piers while maintaining a shallow (below-grade) structure with adequate clearance over the river. Once the piles are placed (assuming one pile per day), the cast-in-place pilecaps and abutments would be constructed and the bridge girders would be set with a crane. Soils typical of areas such as the floodplain where the realigned roadway would cross are granular and sandy in nature. Any consolidation that may occur due to placement of fill on these soils is expected to be minimal and would occur during construction. No long-term settlement monitoring is anticipated.

For the partial restoration alternative, a pile driving rig and crane likely would be required for the bridge construction. This equipment would operate predominantly in the flats west of the existing roadway. Once the piles are placed (assuming one pile per day), the cast-in-place pilecaps would be constructed and the bridge girders would be set with a crane. After the new bridge is completed, traffic would be moved to the bridge and the roadway embankment excavated.

Haul and Disposal

Both restoration alternatives will require excavation, haul, and disposal of material from the existing roadway embankment, dikes, and armoring. Subsequent design efforts will need to identify specific disposal locations and haul routes. Materials would likely be hauled to disposal sites within 20 miles of the action area.

Timing and Duration

The construction of restoration improvements would require coordination with permitting agencies, including WSDOT. WSDOT would need to approve of road closures and other traffic control activities needed to complete construction of either restoration alternative. For the full restoration alternative, bridge construction of the two-span slab girder structure would be expected to last about 6 months. Construction of the roadway, removal of fill, and other restoration work would last 6 to 8 months. The total duration of the project would be approximately 12 to 14 months.

For the partial restoration alternative, bridge construction of the 14-span slab girder structure would be expected to last about 13 months. Construction of the roadway approaches, removal of fill, and other restoration would last 2 to 3 additional months. The overall duration of the project would be approximately 15 to 16 months.

Access

Access to most of the site would be available via local roads and from Highway 101. The contractor would need to work closely with the private property owner to improve access to work areas and maintain access to private facilities on or near the site. For bridge construction under the full restoration alternative, access would be provided via the existing local roadways on each side of the river, requiring new road construction to reach the bridge site. For bridge construction under the partial restoration alternative, access would be provided via land adjacent to the west end of the existing causeway.

Staging

There would be very little room to stage equipment and stockpile materials within the public right-of-way. Construction access will need to be negotiated in advance of final design and bidding and will require an easement for construction and staging. It is anticipated that a staging and stockpile area can be identified on the Robbins property through the easement negotiation process.

Diversion and Care of Water

Restoration work would require implementation of best management practices, such as silt curtains, silt fences, cofferdams, pumping, and temporary conveyance, to prevent pollution. In-water work would include removal and placement of fill, removal of armoring, placement of engineered log jams, and construction of new bridge supports.

Utilities

Known utilities include overhead power and telecommunications lines along the alignment of Highway 101. Overhead electrical and telephone share the utility poles along the existing roadway. For the full restoration alternative, the utilities would need to be relocated to follow the new roadway alignment. Relocation of utilities would require coordination with utility owners. For partial restoration, overhead electrical distribution and telephone would be relocated in advance of the bridge construction.

13.4 Extent of Stressor Removal

The full restoration alternative would include removal of all of the primary stressors in the area, including complete removal of the Highway 101 causeway. The partial restoration alternative would include removal of most of the Highway 101 causeway but not the bridges (existing bridges would be replaced with new bridges) or the nearshore fill south of the south channel. Table 13-2 provides the amount of stressor removal with the full and partial restoration alternatives.

Table 13-2. Stressor Removal

Stressor	Full Restoration	Partial Restoration
Tidal Barrier – Highway 101 Causeway (LF)	2,092	1,026
Fill – South Channel Dikes (LF)	3,250	3,250
Fill – Misc. Nearshore (CY)	35,600	0
Armor – South Channel (LF)	4,450	4,450

13.5 Expected Evolution of the Action Area

Following restoration, the main flow of fresh water and sediment will be to the north channel of the river delta. This change will result in a rebuilding of the middle and north portions of the river delta that are currently more subsided than the south portion of the delta. Tidal channels reconnected through the removal of the roadway embankment are expected to remain fairly stable depending on the stability of the main channel. If there are shifts in the main channel, then corresponding shifts in the blind and distributary channels are also anticipated.

Many bare areas will result from filling the south channel and removing the roadway embankment and other fills. Where these areas do not align with tidal channels, they will be graded to marsh plain elevations to encourage rapid recolonization by estuarine marsh vegetation. Some shifts in marsh vegetation distribution are anticipated resulting from several factors. First, the salinity gradient will become evenly distributed with the removal of the roadway embankment and will affect distributions of marsh species. Second, the salinity regime and the sediment inputs will be shifted to the central and north portions of the delta. Some increase in marsh vegetation is anticipated as grades rise in this area over time. Finally, the filling of the south channel and reactivation of the barrier beach on the south portion of the delta will result in changes in this area such as potential burial of some areas and a more saline marsh community on the west side of the barrier beach. Sea level rise effects are described below.

Restoration will improve the survival of juvenile salmon such as Chinook and summer chum by improving access to nursery habitat in the estuary and wetland, and improved acclimatization to increased salinity of Hood Canal. Smolts are now flushed out of the mainstem into deep water where they are subjected to a higher rate of predation. Under the restored conditions, juvenile salmon would have the opportunity to outmigrate through multiple tidal sloughs where they can rest, find refuge from predators, and feed during acclimatization. Removing the singular and channelized access to the estuary will also reduce predation rates on returning adult salmon by predators such as seals (Werner 2010).

13.6 Uncertainties and Risks

Uncertainties and risks may include the following:

- Goetechnical Conditions – No field investigations have been completed to characterize the subsurface soil conditions in the action area. Subsurface soil conditions could potentially have a significant impact on the feasibility and costs related to bridge construction for both the full and partial restoration alternatives.
- Sediment Transport – Because the delta has been extensively modified for more than 80 years by Highway 101, the ability to predict future sediment transport and shoreform dynamics in this area is limited. Sediment inputs in the delta depend on upstream watershed land use activities including the level of logging and road building.
- Property Issues – The proponent has indicated that the property owner requires access to existing shellfish beds and wants to ensure that changes do not negatively impact aquaculture operations. Potential impacts to shellfish aquaculture operations from changing freshwater and sediment input are not well understood and require further consideration, mapping, and analysis during subsequent design phases.
- Historic Preservation Issues – Both existing Hamma Hamma River bridges are on the National Register of Historic Places. In the case of their demolition, documentation of the existing bridges would be required. Projects that involve historic bridge structures must follow the guidelines set forth in the WSDOT Environmental Procedures Manual M31-11.09. If federal funding or federal permits are required, the project must also comply with Section 106 of the National Historic Preservation Act.
- Cultural Resources – Given the location of this action, there is a strong probability of cultural resources being present, which could substantially alter the design possibilities.

13.6.1 Risks Associated with Projected Sea Level Change

The risk of sea level rise for either restoration alternative is small because most of the physical barriers to flow into and out of the river and estuary would be removed. For the full restoration alternative, the proposed bridge would have a deck elevation of 23.6 feet MLLW (21.0 feet NAVD 88), which is much higher than the predicted high tide plus an allowance of 1.5 feet for sea level rise. For the partial restoration alternative, the proposed bridge would have a deck elevation of 22.6 feet MLLW (20.0 feet NAVD 88), which is also much higher than the predicted high tide plus allowance for sea level rise. These are assumed to have sufficient vertical clearance to allow for debris or flooding. These elevations should be verified as part of more detailed restoration design.

Finally, the estuary will be better able to respond to sea level rise if sediment deposition is more distributed across the delta than the current diked and dredged channel allows. The barrier beach that would be restored by filling a portion of the south channel would be prone to overtopping during extreme high tide events, which could result in reduced access to the estuary for aquaculture operations during limited periods of time.

Risks to habitat from sea level rise are primarily an upstream shift in habitat types, with potential conflicts to current agricultural land uses outside the project area. The risks of sea level change applicable to this action are listed in Table 13-3.

Table 13-3. Risks of Sea Level Change

	Projected Sea Level Change		
	High (46cm)	**Intermediate (4cm)**	**Low (-8cm)**
Full Restoration	Low risk to transportation and utility infrastructure. Moderate risk of habitat displacement upstream. Larger tidal prism would increase the tidal energy in the channels, cause localized erosion and channel migration.	Low risk to transportation and utility infrastructure and of habitat displacement upstream.	No risk to transportation and utility infrastructure and of habitat displacement upstream.
Partial Restoration	Low risk to transportation and utility infrastructure. Greater risk of scour effects and need for armor long term at abutments. Moderate risk of habitat displacement upstream.	Low risk to transportation and utility infrastructure and of habitat displacement upstream.	No risk to transportation and utility infrastructure and of habitat displacement upstream.

13.7 Potential Monitoring Opportunities

Monitoring is important for evaluating the success of the partial or full restoration alternative. A combination of field surveys and aerial photographs would be used to document biological and physical changes to the landscape. Monitoring data can be used to refine adaptive management and corrective actions, as needed. The monitoring needs and opportunities associated with this action are summarized in Table 13-4.

Table 13-4. Monitoring Needs and Opportunities

Monitoring Parameter	Key Performance Indicator	Note
Topographic Stability	X	See description of site evolution
Sediment Accretion / Erosion	X	See description of site evolution
Wood Accumulation		
Soil / Substrate Conditions		
Vegetation Establishment	X	See description of site evolution
Marsh Surface Evolution / Accretion	X	See description of site evolution
Tidal Channel Cross-Section / Density	X	See description of site evolution
Water Quality (contaminants)		
Salinity	X	See description of site evolution
Shellfish Production	X	Effects on nearby shellfish operation will need to be monitored
Extent Of Invasive Species		
Animal Species Richness		

Monitoring Parameter	Key Performance Indicator	Note
Fish (salmonid) Access/Use	X	See description of site evolution
Forage Fish Production		
Wildlife Species Use		
Effectiveness Of Exclusion Devices		

13.8 Information Needed for Subsequent Design

This conceptual design report represents an initial step in the restoration design sequence. The design concepts described above were developed based on readily available information without the level of site-specific survey and investigation that is necessary to support subsequent design and implementation. Substantial additional information will be required at the preliminary and later design stages to confirm the design assumptions, refine quantity estimates, address property and regulatory issues, obtain stakeholder support, and fill in data gaps. The extent to which this information is collected for preliminary design (or a later design stage) will depend upon the available budget, schedule, and other factors. This section attempts to define the most essential information needs for this action. Refer to the Introduction chapter for additional information.

- Subsurface Soil Information – A preliminary field investigation, including soil borings, sampling, and testing, would be needed to complete preliminary design of bridge supports and roadway improvements. Geotechnical recommendations would be needed for foundation type and potential for settlement from embankment construction through the floodplain.
- Property and Topographic/Bathymetric Survey – Property boundary and topographic/bathymetric surveys by a licensed surveyor would be necessary for locating facilities, utilities, and property lines. Survey data would be used in negotiating property acquisition for the restoration design. A more detailed survey of topographic/bathymetric features, including the existing river channel, would be useful in providing accurate preliminary designs and quantities for demolition, roadway improvements, bridges, engineered log jams, and removal of existing features.
- Additional As-built Information – Additional as-built information for the existing bridges, roadway, and overhead utilities would be needed to develop preliminary design details.
- Cultural Resources Investigation – Surveys for archaeological and historic resources may be required for this action area. This is particularly important for areas proposed for excavation or other ground disturbance.
- Hazardous Materials Assessment – If preliminary investigations suggest that hazardous material could be present in the action area, additional soil and sediment analysis related to demolition of utilities, roads, or buildings may be needed. The introductory chapter describes the Phase I site investigations that are occurring as part of this overall effort via a separate contract.
- Hydraulic and Hydrodynamic Analysis – Additional hydraulic analysis would be needed to provide recommendations for scour, minimum bridge clearance over water, minimum hydraulic opening in the floodplain, and mitigation for fill in the

floodplain. Additional hydrodynamic modeling of the movement of water through the estuary would be needed to more clearly understand the impact that the proposed restoration would have on tidal topography. This information would be particularly important for understanding potential impacts on aquaculture and on the barrier beach. The specific modeling approach/method needs to be determined. The need for a temporary tide gage should be considered in the early design stages to obtain site-specific tidal statistics.

13.9 Quantity Estimates

The design quantities are largely developed from LiDAR data sets lacking the resolution to accurately quantify all elements of construction. These are supplemented by unmeasured estimates made during one site visit at high tide and areal take-offs from available imagery. A detailed list of quantities for both restoration alternatives is provided in Exhibits 13-1 and 13-2.

13.10 References

ESA (Engineering Services Associates). 2003. *Highway 101 Causeway Study Revised Draft*. August 2003. Engineering Services Associates and Grant Solutions Technical Writing.

FEMA (Federal Emergency Management Agency). 1998. Flood Insurance Rate Map, Mason County, Washington (Unincorporated), Panel 530115 0050 C, Effective Date May 17, 1988.

USACE (U.S. Army Corps of Engineers). 2010. *Puget Sound Nearshore Ecosystem Restoration Study, Appendix C.* U.S. Army Corps of Engineers, February 2010.

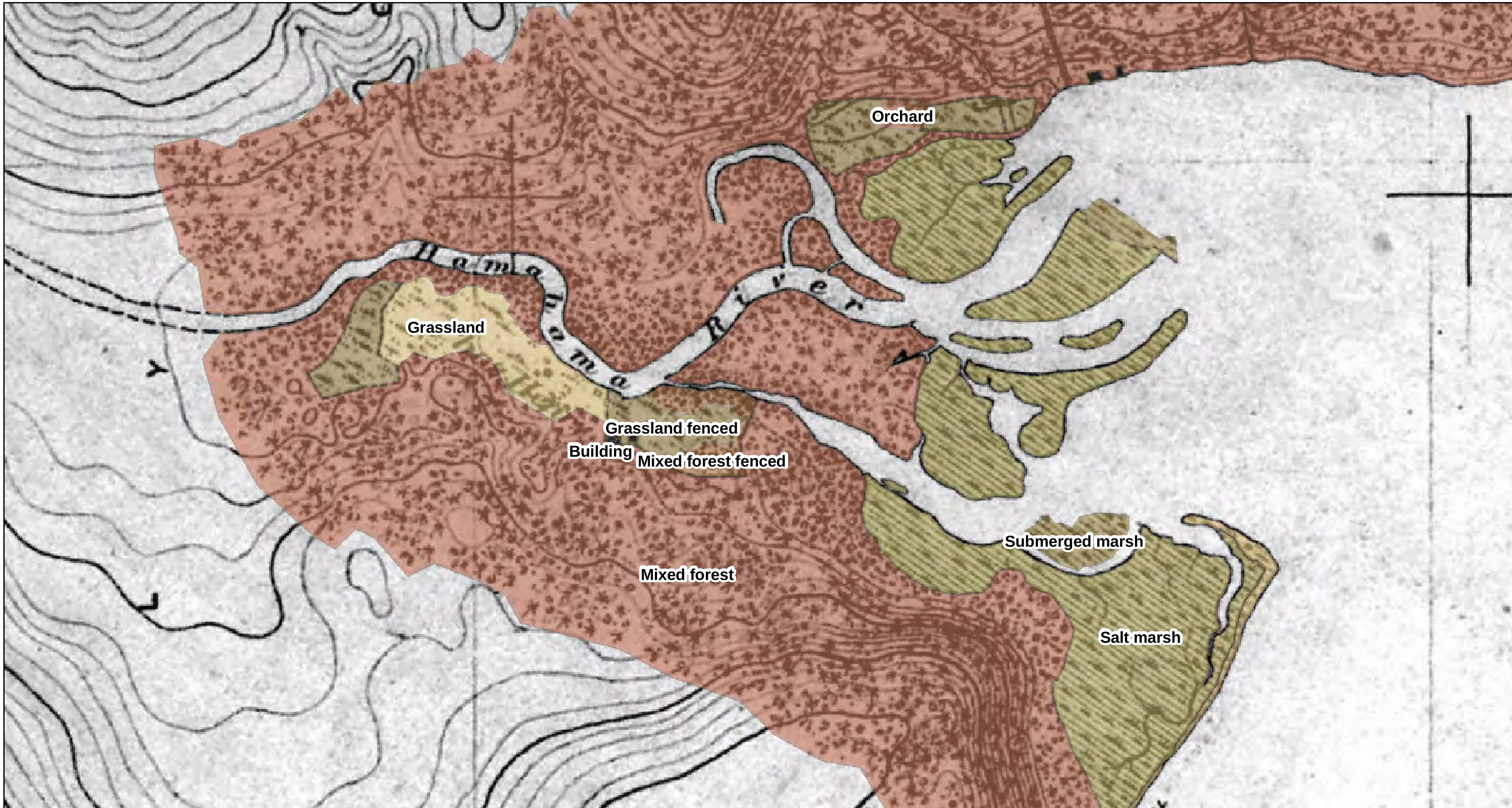
Werner, 2010. Personal communication with Neil Werner of the Hood Canal Salmon Enhancement Group at the PSNERP site visit, September, 2010.

S:\GIS\Projects\210xxx\210337_PSNERP_NEARSHORE\Projects\2-TSheets_rev.mxd (DLP; 2/24/2011)

0 420
Feet
0 120
Meters

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Historic Map (T-Sheet)
Action Name: Hamma Hamma Causeway Replacement and Estuary Restoration
PSNERP ID #: 1047
Figure 13- 2A



0 420
Feet
0 120
Meters

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64

WDFW Contract # 100-000204 (CAPS No. 10-1461)

Historic Map (T-Sheet) and River History Project Data

Action Name: Hamma Hamma Causeway Replacement and Estuary Restoration

PSNERP ID #: 1047

Figure 13- 2B

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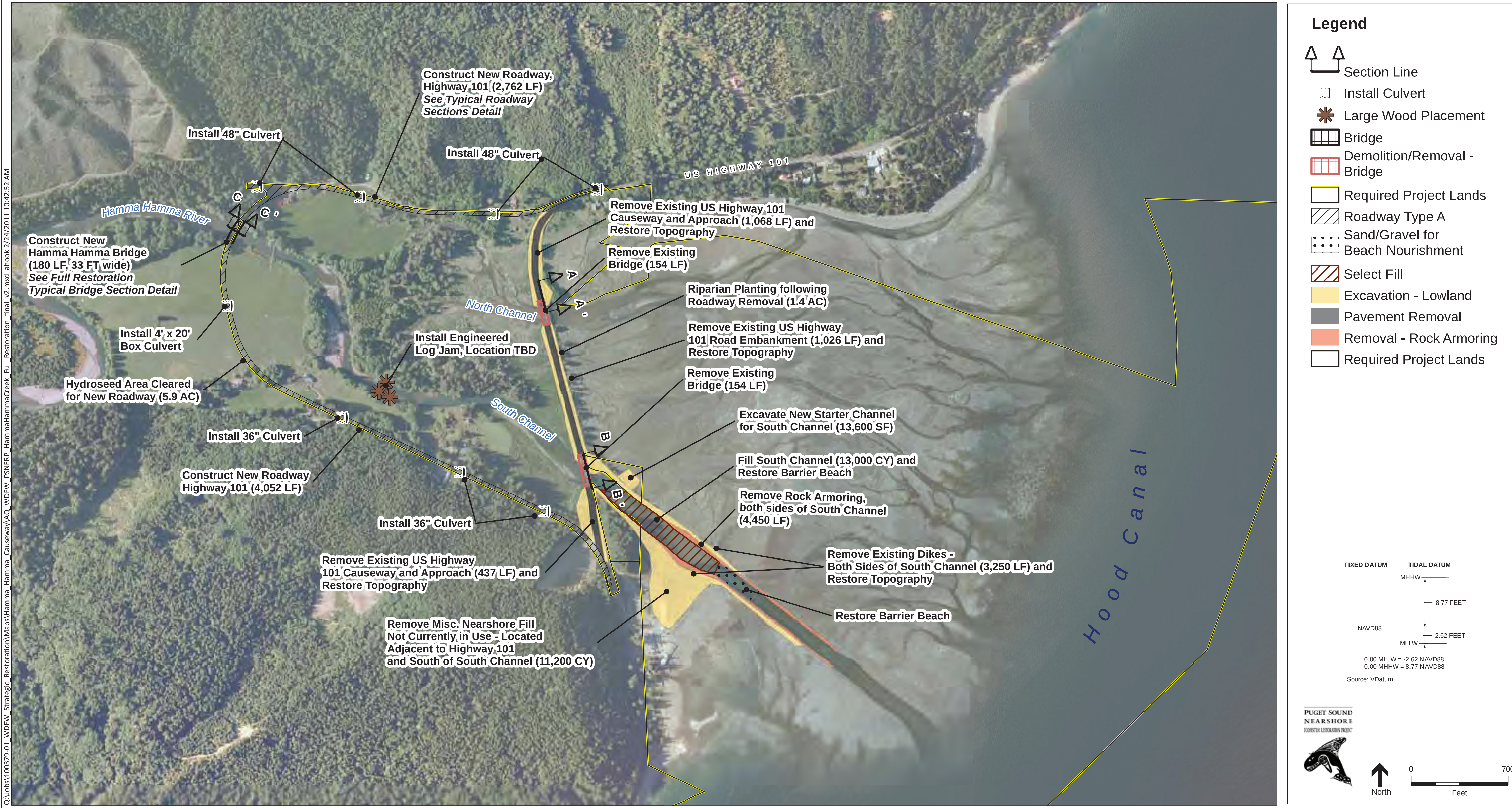


Q:\Jobs\100379-01_WDFW_Strategic_Restoration\Maps\Hamma_Hamma_Causeway\AQ_WDFW_PSNERP_HammaHammaCreek_Full_Restoration_final_v2.mxd ahook 2/24/2011 10:42:52 AM

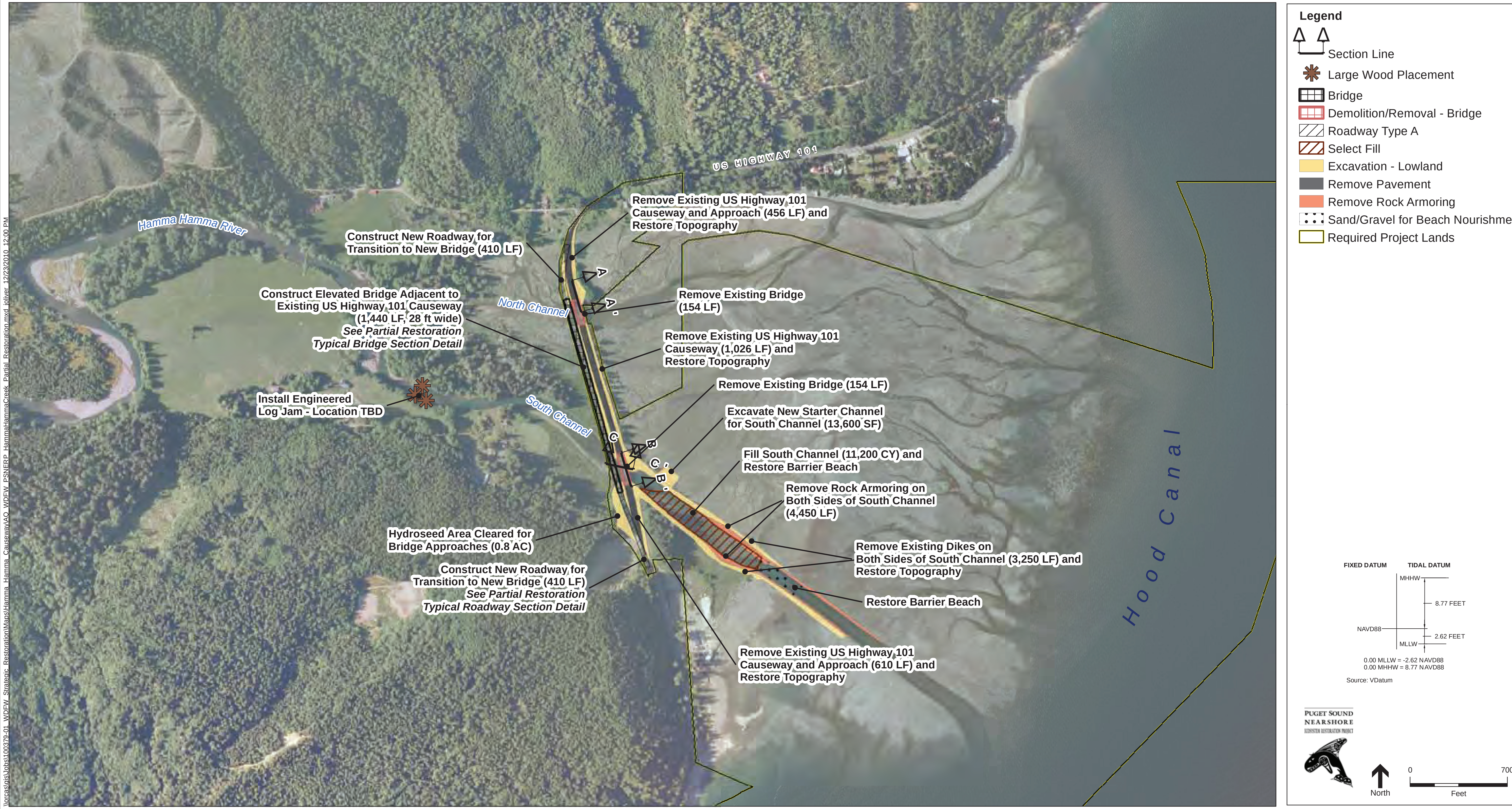
SOURCE: Washington Counties Parcels (2009); Action Area (PSNERP, 2010); High Resolution Orthoimagery (USGS, 2009)

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Lead Contractor: ESA
Design Lead: Anchor QEA, David Rice, with KPFF
Date: 02/23/2011

Conceptual Design Plan
Site Name: Hamma Hamma Causeway
Action Name: Hamma Hamma Causeway Replacement and Estuary Restoration
PSNERP ID #: 1047
Full Restoration

Figure 13-3



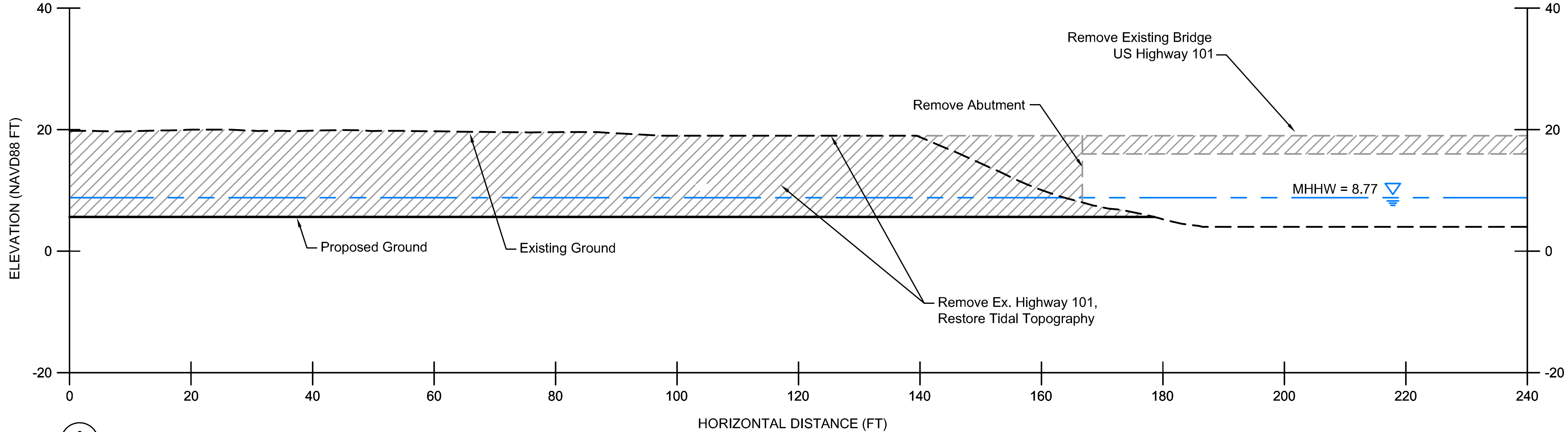
SOURCE: Washington Counties Parcels (2009); Action Area (PSNERP, 2010); High Resolution Orthoimagery (USGS, 2009)

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

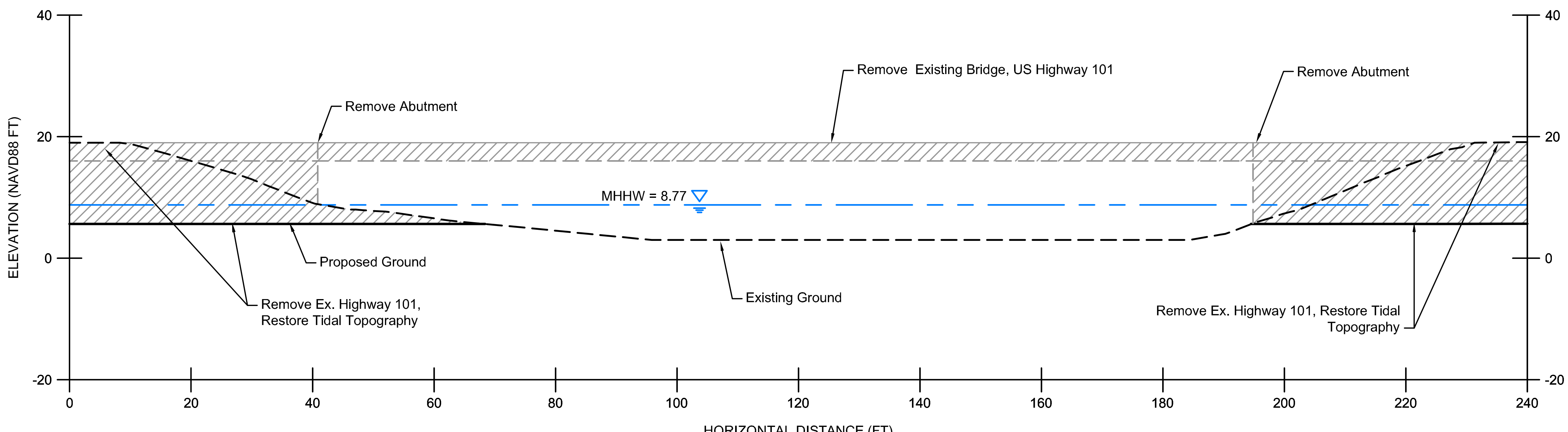
Lead Contractor: ESA
Design Lead: Anchor QEA, David Rice, with KPFF
Date: 2/2011

Conceptual Design Plan
Site Name: Hamma Hamma Causeway
Action Name: Hamma Hamma Causeway Replacement and Estuary Restoration
PSNERP ID #: 1047
Partial Restoration

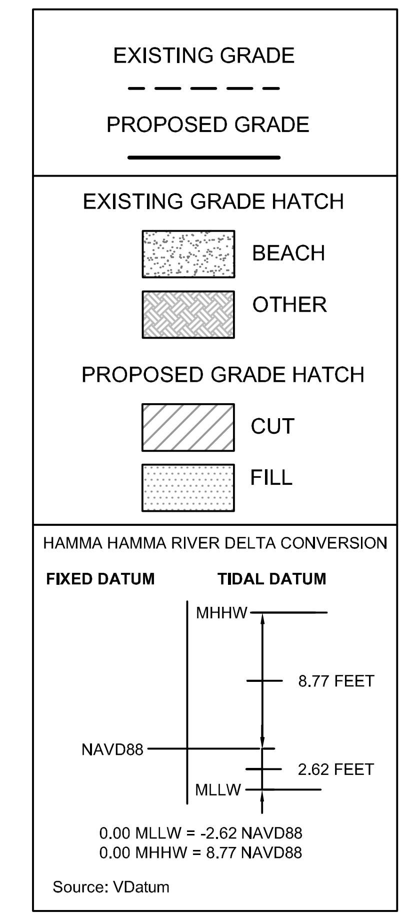
Figure 13-4

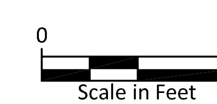


(A) FULL RESTORATION TYPICAL SECTION



(B) FULL RESTORATION TYPICAL SECTION



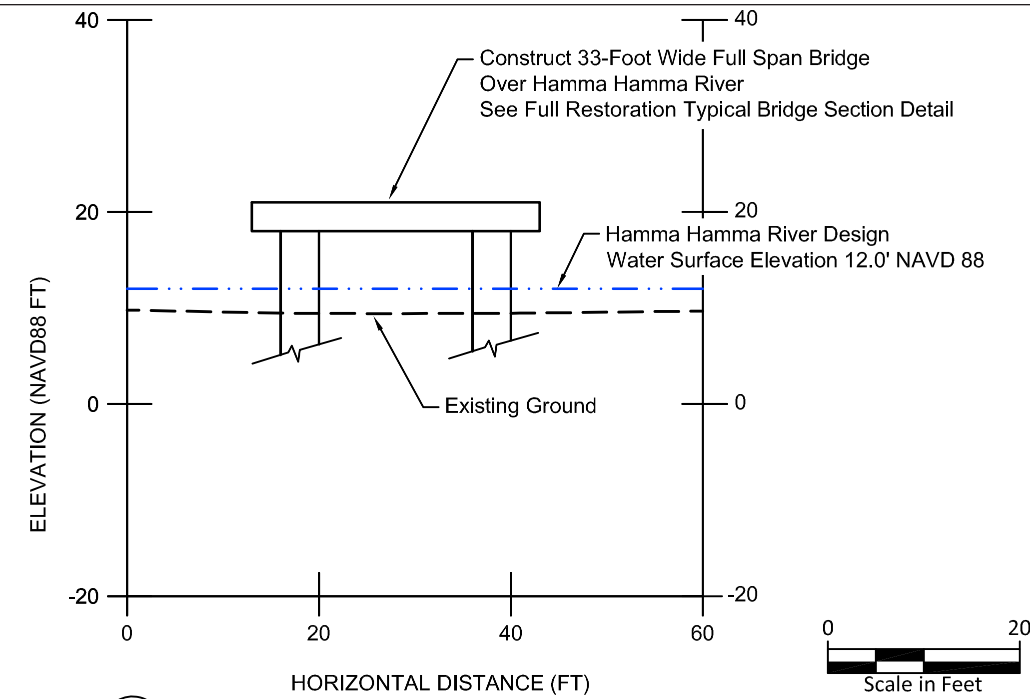


PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

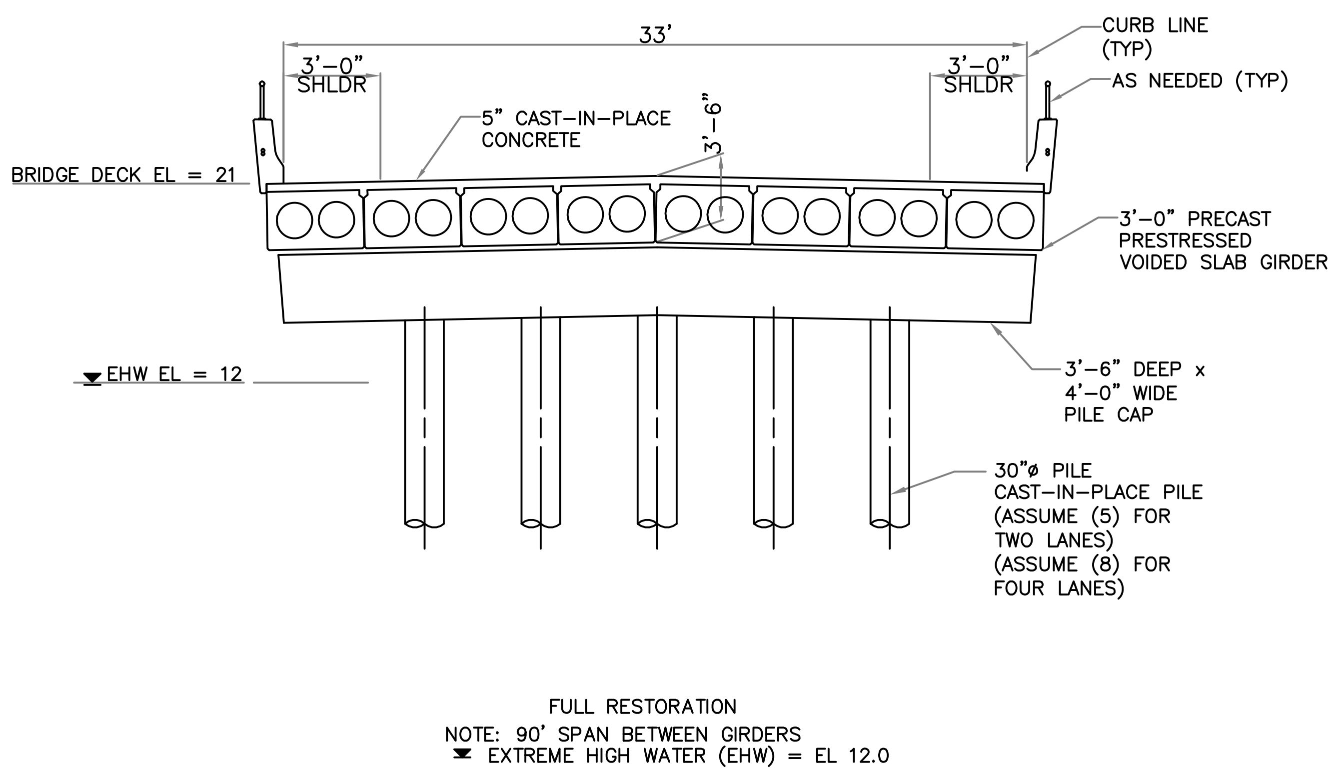
Lead Contractor: ESA
Design Lead: Anchor with KPFF
Date: 3/2011

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)
Conceptual Design Section
SITE NAME: **Hamma Hamma River Delta**
ACTION NAME: **Hamma Hamma Causeway Replacement and Estuary Restoration**
PSNERP ID#: **1047**
Full Restoration

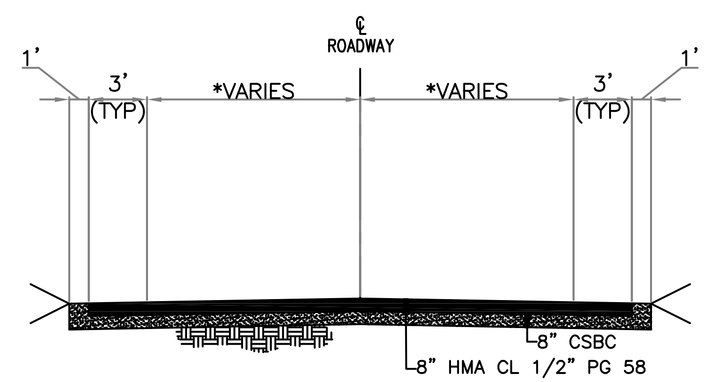
Figure 13-5



C FULL RESTORATION TYPICAL SECTION



SECTION/DETAIL
Typical Bridge
Not to Scale



*LANE WIDTHS:

11'-0"	STA 47+00 TO 67+63 STA 74+49 TO 76+28 STA 90+48 TO 94+44 STA 97+40 TO 101+96	TOTAL LENGTH = 3,094-LF
13'-6"	STA 40+00 TO 47+00 STA 67+63 TO 74+49 STA 76+28 TO 90+48 STA 101+96 TO 105+86	TOTAL LENGTH = 3,196-LF
14'-0"	STA 105+86 TO 109+94	TOTAL LENGTH = 408-LF

SECTION/DETAIL
Typical Roadway
Not to Scale

EXISTING GRADE

PROPOSED GRADE

EXISTING GRADE HATCH

BEACH

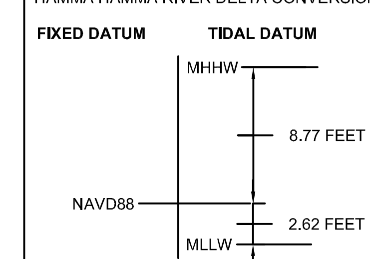
OTHER

PROPOSED GRADE HATCH

CUT

FILL

HAMMA HAMMA RIVER DELTA CONVERSION



0.00 MLLW = -2.62 NAVD88
0.00 MHHW = 8.77 NAVD88

Source: VDatum

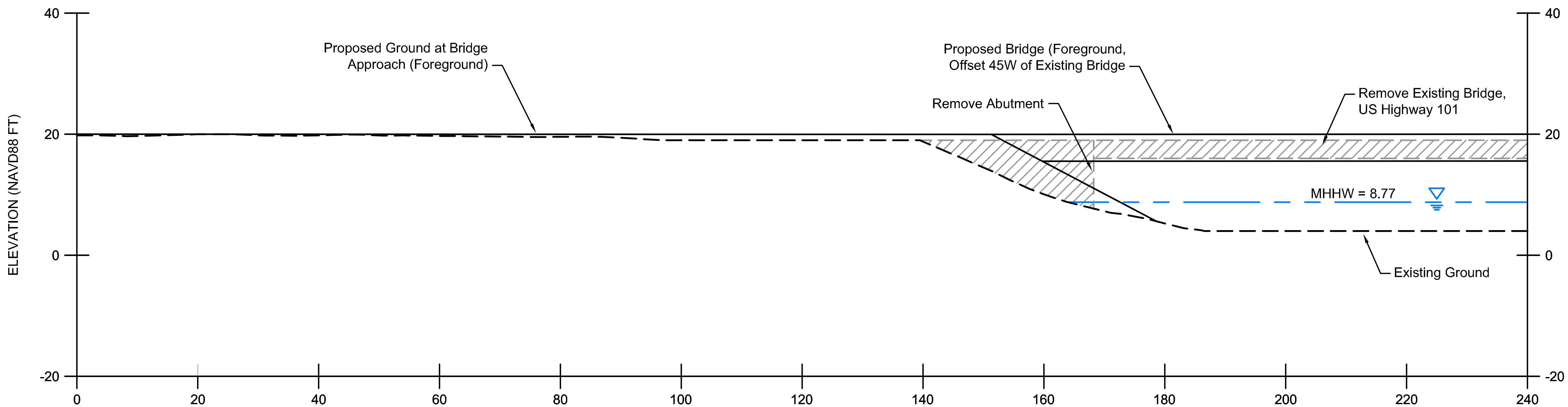
PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: Anchor with KPFF
Date: 3/2011

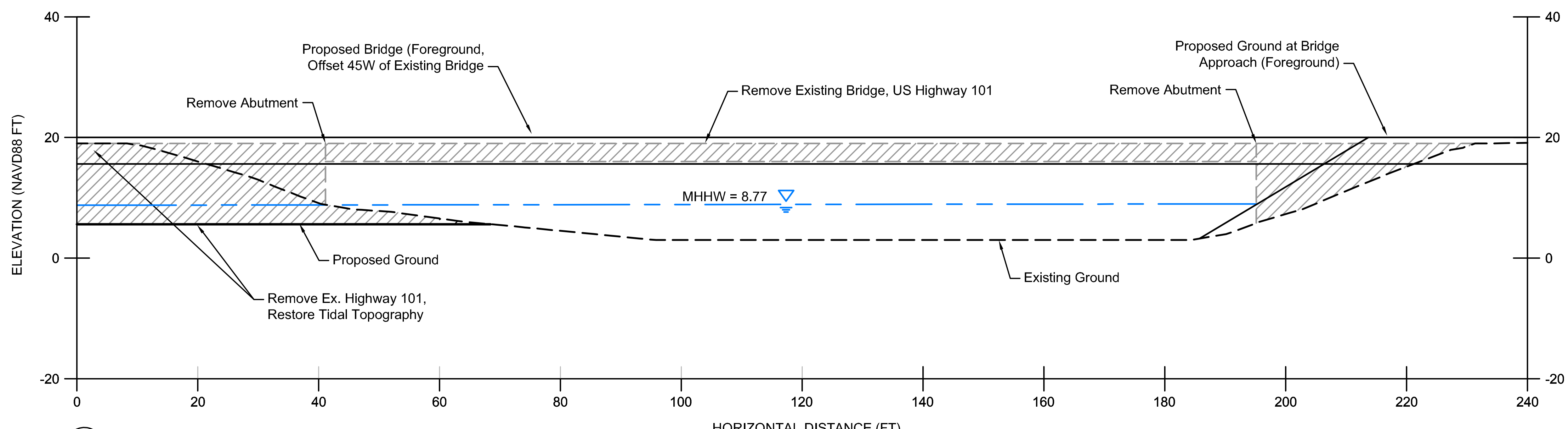
Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Section
SITE NAME: **Hamma Hamma River Delta**
ACTION NAME: **Hamma Hamma Causeway Replacement and Estuary Restoration**
PSNERP ID#: **1047**
Full Restoration

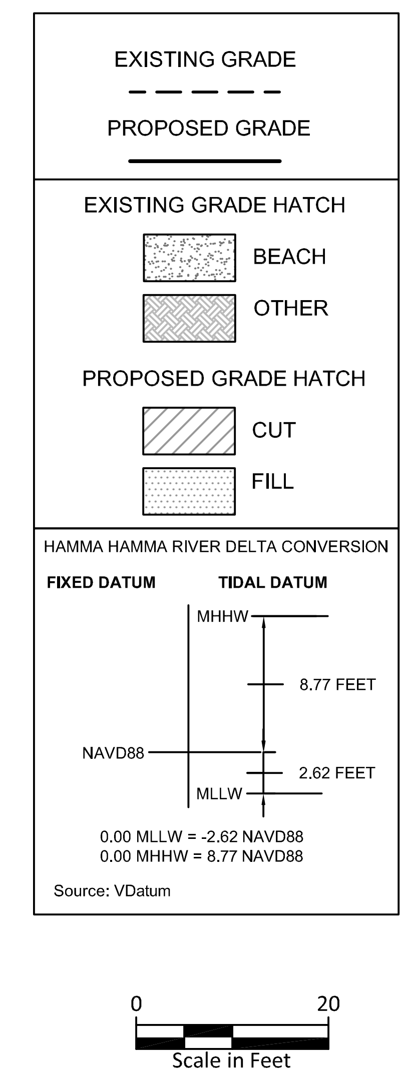
Figure 13-6



A PARTIAL RESTORATION TYPICAL SECTION



B PARTIAL RESTORATION TYPICAL SECTION



PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: Anchor with KPFF
Date: 3/2011

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

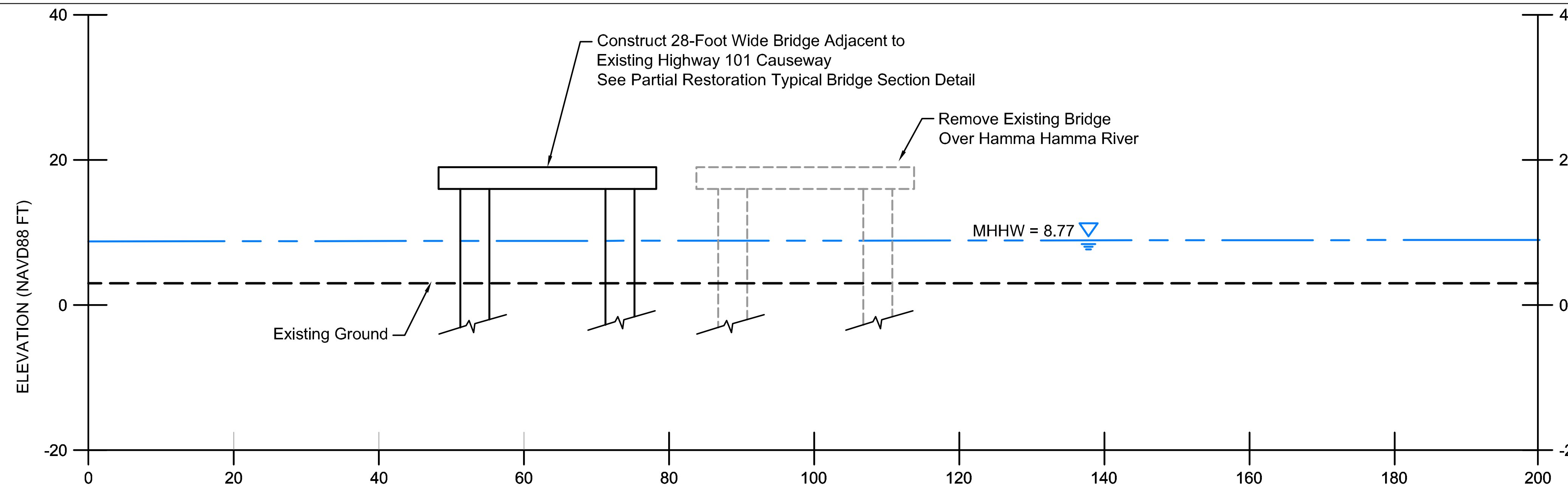
Conceptual Design Section

SITE NAME: **Hamma Hamma River Delta**

ACTION NAME: **Hamma Hamma Causeway Replacement and Estuary Restoration**

PSNERP ID#: **1047**

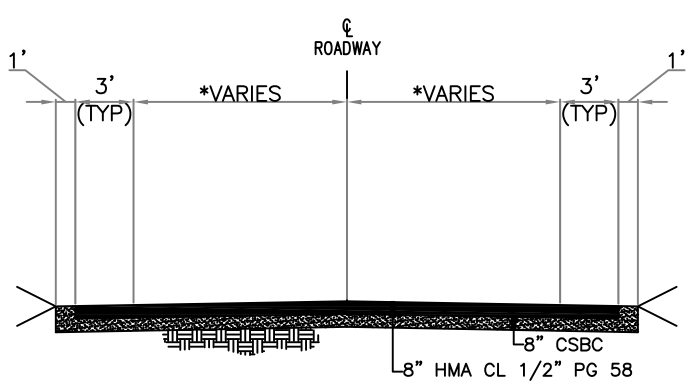
Partial Restoration



HORIZONTAL DISTANCE (FT)

(C) PARTIAL RESTORATION TYPICAL SECTION

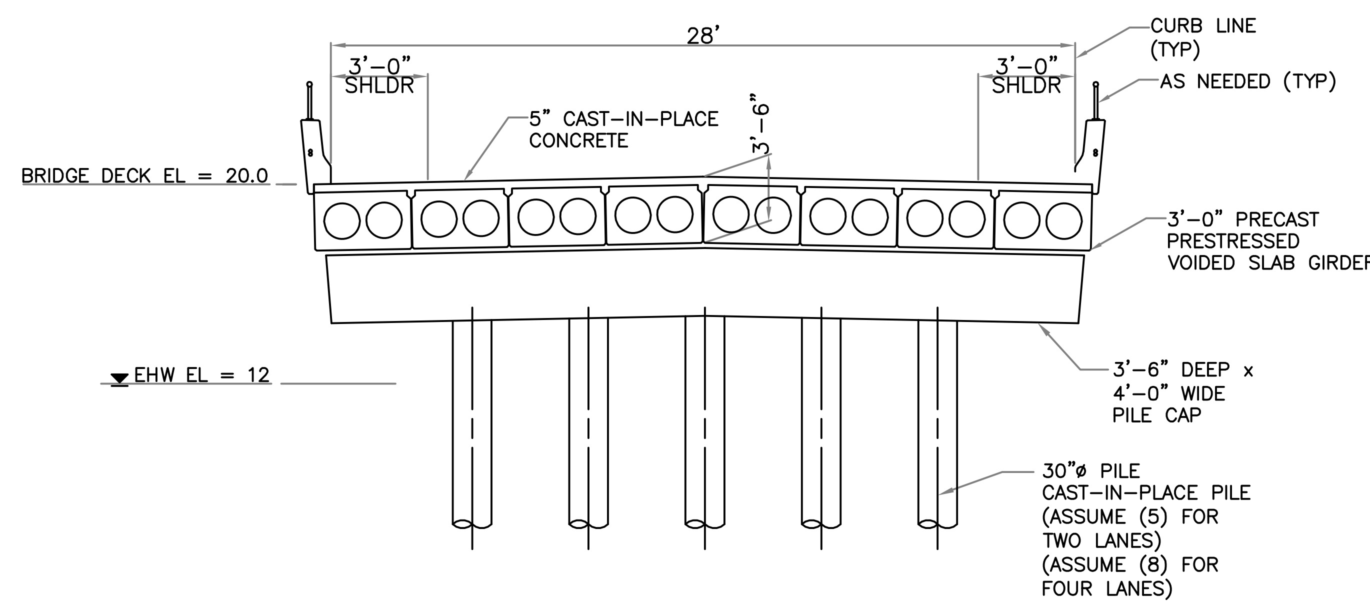
0 20
Scale in Feet



*LANE WIDTHS:

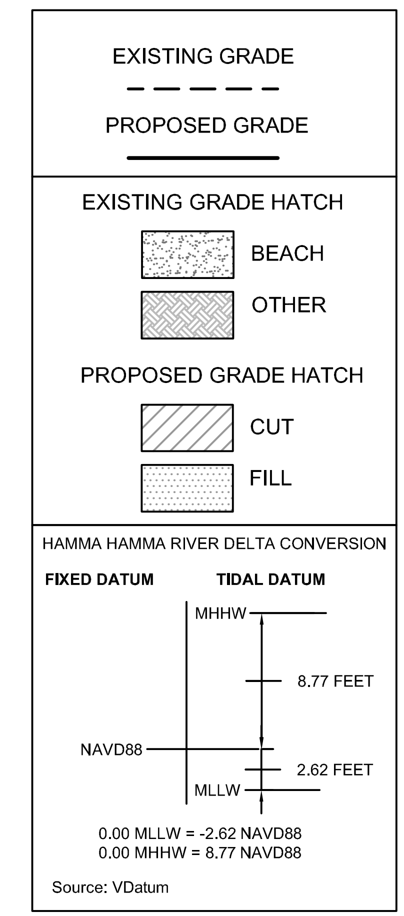
11'–0"		TOTAL LENGTH = 3,094–LF
	STA 47+00 TO 67+63	
	STA 74+49 TO 76+28	
	STA 90+48 TO 94+44	
	STA 97+40 TO 101+96	
13'–6"		TOTAL LENGTH = 3,196–LF
	STA 40+00 TO 47+00	
	STA 67+63 TO 74+49	
	STA 76+28 TO 90+48	
	STA 101+96 TO 105+86	
14'–0"		TOTAL LENGTH = 408–LF
	STA 105+86 TO 109+94	

SECTION/DETAIL
Typical Roadway
Not to Scale



PARTIAL RESTORATION
NOTE: 90' SPAN BETWEEN GIRDERS
EXTREME HIGH WATER (EHW) = EL 12.0

SECTION/DETAIL
Typical Bridge
Not to Scale



PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: Anchor with KPFF
Date: 3/2011

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)
Conceptual Design Section
SITE NAME: **Hamma Hamma River Delta**
ACTION NAME: **Hamma Hamma Causeway Replacement and Estuary Restoration**
PSNERP ID#: **1047**
Partial Restoration

Figure 13-8

Full Restoration Quantity Estimate

Action Name: Hamma Hamma River Delta
Action #: PSNERP ID #1047
Date: February 2011
By: David Rice, P.E.

REMEDY: ***Removal/relocation of Highway 101 causeway and bridges, Installation of new roadway, Construction of new bridge, Dike removal, Fill removal, Fill placement***
Construction Period: Approximately 60 Weeks

Item	Unit of Measure	Material Name	Qty	Description of Item	Indicate section of design report where item is described
ACQUISITION AND CONSERVATION				Based on available mapping information	
Required Project Lands	Acre		36	Portion of South River Channel and Overbanks + Existing Highway 101 ROW + New ROW	Section 13.3.5
Proponent / Partner-owned lands	Acre		5.1	Existing WSDOT Right-of-Way, Typically 70-feet Wide	Section 13.3.5
Lands To Be Acquired	Acre		15.3	Acquisition of Right-of-Way Needed for New Roadway and Bridge + 2 Parcels downstream of bridge, Assumes other actions would be completed on private property with construction/conservation easements	Section 13.3.5
Material Sites				Not Used: See Earthwork - Imported Fill.	
MOBILIZATION AND ACCESS for construction activities				Description required for each item to facilitate cost estimating	
Mobilization - Typical (Equipment, Personnel, Planning, Financial)	LS		1	Assume 8% of other Construction Cost Items	
Mobilization - Remote (Equipment, Personnel, Planning, Financial)	LS		0	Not Applicable	
Site Access	LS		0	Not Applicable	
Barge Access	Days		0	Not Applicable	
Temporary Traffic Control (one of the following)				Includes installation of traffic signals, signage, signmen, etc. There are 4 types as follows	
none	LS		0	Not Applicable	
signs	LS		1	Typical Construction Signage	
flags / spotters	LS		1	Flags and spotters only during roadway transition connection	
unique	LS		0	Not Applicable	
Temporary Roadway	SF		0	Not Applicable	
Control of Water	LS		1	Diversion of water for bridge construction, dewatering of excavations for roadway and culvert construction.	
Site Demolition Activities				Demolition and removal of structures (description required), temporary features and relocations, itemized separately); Clearing and grubbing of vegetation, and removal of minor debris (rocks, slabs) - description required.	
Clearing and Grubbing (one or more of following)					
Clear Vegetation - Local Disposal	AC		0	Not Applicable	
Clear /Grub Vegetation - Local Disposal	AC		21.7	Clear, Grub Proposed 60-foot width along proposed roadway, 15 feet on sides of causeway, south channel	
Clear /Grub Vegetation - Offsite Disposal	AC		0	Vegetation is taken offsite and disposed - use for noxious invasives, etc.	
Clear, stockpile - large woody debris	CY		0	Vegetation is segregated and stockpiled / prepared for reuse on site.	
Hydraulic Structures - Small	LS		0	Not Applicable	
Hydraulic Structures - Large	LS		0	Not Applicable	
Utilities	LS	OH Utilities	1	Remove and Relocate Overhead Power and Telephone Lines Along Highway 101	Section 13.3.7
Buildings	LS or SF		0	Not Applicable	
Pavement	SF	Pavement	147,672	Remove Pavement on SR101 & Lonn Webb Rd at new Allignment	Section 13.3.2
Bulkheads	LF or SF		0	Not Applicable	
Rock revetments	Ton	Rock	1,154	Remove Armoring Along South Channel Dikes	Section 13.3.2
Large Coastal Structures	LF, SF or CY		0	Not Applicable	
Demolition / Removal - Bridge	SF	Bridge	10,500	Remove (2) 150' Concrete Arch Bridges	Section 13.3.2
Removal - Misc. (e.g. angular rock from beach)	Ton		0	Not Applicable	
Demolition / Removal - Boat Ramp	SF		0	Not Applicable	
Demolition / Removal - in-water Piling	Number of Piles		244	Remove Timber Piling	
Haul - Offsite Disposal of Demolition Debris	Miles		20	Estimate distance (to nearest 10 miles) to disposal site for materials, veg clear and grub, etc.	Section 13.3.7
Hazardous/Contaminated Waste Removal				These items for earthwork of quality not compatible with wetlands, requiring special handling and disposal. Describe basis for classification as contaminated or hazardous. State known or suspected contamination, describe known similar work.	
Contaminated Earthwork	CY		0	Not Applicable	
Hazardous Earthwork	CY		0	Not Applicable	
Construct Temporary Features				Use as needed for unusual temporary features not included elsewhere (see TESC below)	
EARTHWORK				Expand to include equipment, etc. to facilitate cost estimating.	
Excavation	CY			Per yard excavation w/out expected haul	
Excavation - Upland - For New Roadway	CY	Fill	16,200	Cut for new roadway	Section 13.3.4
Excavation - Lowland - Causeway	CY	Fill	45,000	Removal of existing Highway 101 Causeway	Section 13.3.2
Excavation - Lowland - Dikes	CY	Fill	4,400	Removal of existing South Channel Dikes, 2 Dikes, Total Length~3,250 LF	Section 13.3.2
Excavation - Lowalnd - Misc Fill	CY	Fill	37,300	Removal of Misc Fill South of South Channel + South Channel Connection to Existing Tide Channel	Section 13.3.2
Dredging - Bucket - Land	CY		0	Not Applicable	
Dredging - Bucket - Marine	CY		0	Not Applicable	
Dredging - Hydraulic	CY		0	Not Applicable	
Fine Grading	AC		0	Not Applicable	
Fill Placement - local borrow				This is additive to Earthwork -Excavation	
Side cast	CY		0	Not Applicable	
Haul - uncontrolled placement	CY		0	Not Applicable	
Haul, place, compact - For New Roadway	CY	Fill	17,100	Placement of fill for new roadway	Section 13.3.4, 13.3.6
Stockpile - uncontrolled placement	CY		0	Not Applicable	
Stockpile - controlled placement	CY	Fill	86,700	Stockpile of Material for Placement as Roadway Fil	Section 13.3.4, 13.3.6
Conveyor placement from stockpile land/water	CY		0	Not Applicable	
Imported Fill				Includes purchase, delivery and placement or as noted / described	
Select Fill	CY	Select Fill	13,000	Fill south channel for restoration of barrier beach	Section 13.3.2
Gravel Borrow, including haul	CY		0	Not Applicable	
Sand / Gravel for Beach Nourishment	CY		0	Not Applicable	
Cobble for Shore Nourishment	CY		0	Not Applicable	
Embankment Compaction	CY		0	Not Applicable	
Topsoil	CY		0	Not Applicable	
RESTORATION Features					
Channel Rehab / Creation	SF	Fill	13,600	Removal of existing sediment for Connection of South Channel to Tidal Channels	Section 13.3.2
Large Wood Placement	EA	Log Jam	8	Assumes Engineered Log Jam Anchored into Bank With Approximately 8 Logs	Section 13.3.2
Invasive Species Control	Acre		0	Not Applicable	
Physical Exclusion Devices	LF or EA		0	Not Applicable	
Other Restoration Features/ Activities	LS		0	Not Applicable	
Structures	EA			KPFF to provide additional inputs	
Water Control Structures - Culverts with Gates	EA		0	Not Applicable	
Water Control Structures - Weirs	EA		0	Not Applicable	
Rock Slope Protection	LF		0	Not Applicable	
Other	EA		0	Not Applicable	
Elevated Boat Ramp	SF		0	Not Applicable	
Fencing	SF		0	Not Applicable	
Utilities				Replacement or relocation. Designer to provide size and material and have separate line item for each run. Incidentals include earthwork, testing, hook up fees, etc. These quantities do not include demolition of existing utilities, real estate / easements, design fees. Describe the owner if known, and whether utility franchise will install (e.g., electric is typically installed by electrical franchise)	
Water	LF		0		
Gas	LF		0		
Electric	LF	OH Power	6,994	Overhead Power to be Relocated Along New Alignment	Section 13.3.7
Sewer	LF		0		
Telecommunications	LF	OH Phone	6,994	Overhead Telephone to be Relocated Along New Alignment	Section 13.3.7
Other	LF	Poles	6,994	Utility Poles - For 6,994 Feet of Relocated Overhead Power and Telephone Along New Road Alignment	Section 13.3.7
Roadway / Railway				KPFF expected to participate in these estimates	
Roadway	SF	Pavement	82,892	Typical Roadway Varies Between 11' wide and 13'-6" Wide	Section 13.3.4, 13.3.6
Roadwat - Minor Intersections	SF	Pavement	14,898	Minor Intersection at Lonn Webb Rd	Section 13.3.4, 13.3.6
Roadway - Switch (potential)	LS			Street lights, etc. (Temporary traffic control handled under Temporary Facilities)	
Culvert 48"	LF	Culvert	400	48" Concrete Culvert 100' Length Each	Section 13.3.6
Culvert 36"	LF	Culvert	300	36" Concrete Culvert 100' Length Each	Section 13.3.6
Culvert Box	LF	Culvert	100	4' x 20' Concrete Box Culvert 100' Length	Section 13.3.6
Culvert - Jacking	LF			Not Applicable	
Culvert - Horizontal Pile Driving	LF			Not Applicable	
Bridge - Deck	SF	Bridge	6,300	Voided girder slab precast prestressed girders 90' Spans	Section 13.3.4, 13.3.6
Bridge - Foundation	LF	Foundation	99	(3) CIP Concrete Pile Caps w/ (5) 30" CIP Concrete Piles 100' Embedment Each Cap	Section 13.3.4, 13.3.6
Railway - Box Girder	SF		0	Not Applicable	
Railway - Foundation	LF		0	Not Applicable	
Railway - Shoe fly	LF		0	Not Applicable	
Permanent Access Features				KPFF expected to participate in these estimates	
Roads	Level	1	8	Level 1 direct access, Level 2 moderately difficult, Level 3 difficult access, Private Drive Connections	
Utility Access Routes	varies		0	Not Applicable	
Erosion Control Features	L.F.		0	Not Applicable	
Public Access or Recreation Features				KPFF expected to participate in these estimates	
Trails	SF		0	Not Applicable	
Bridges	SF		0	Not Applicable	
Kiosk	EA		0	Not Applicable	
Restrooms	EA		0	Not Applicable	
Interpretive Signs	EA		2	tbd	
Parking Area	SF		0	Not Applicable	
Other	EA		0	Not Applicable	
Vegetation & Erosion Control					
Hydroseeding	AC	Hydroseed	5.9	Hydroseed for cleared area along proposed roadway alignment	Section 13.3.3
Planting	AC	Plants	1.4	Marsh and riparian planting where existing causeway is removed	Section 13.3.3
Vegetation Maintenance	AC-YR		0	Not Applicable	
Erosion / sediment BMPs - Temp.	LS		1	Erosion/sediment control BMPs - Silt fences, cofferdams, temporary pumping and conveyance	
Erosion / sediment BMPs - Permanent	AC		0	Not Applicable	
Waterside controls - Temporary	LS		1	Erosion/sediment control BMPs - Silt curtains, cofferdams, other	
Construction Management					
Construction oversight	weeks		60	Quanity based on constructon duration/ # of construction seasons	Section 13.3.7
Materials testing				Included in cost of material - no separate quantity	

Full Restoration Quantity Estimate

Action Name: Hamma Hamma River Delta
Action #: PSNERP ID #1047
Date: February 2011
By: David Rice, P.E.

REMEDY: ***Removal/relocation of Highway 101 causeway and bridges, Installation of new roadway, Construction of new bridge, Dike removal, Fill removal, Fill placement***
Construction Period: Approximately 60 Weeks

	Item	Unit of Measure	Material Name	Qty	Description of Item		Indicate section of design report where item is described
Design and Detailed Site Investigations							
	Survey & Property, Utility Research	LS		1	Topographic and Property Boundary Survey		
	35% Design	LS		1	35% x 25% x Engineer's Estimate		
	65% design	LS		1	65% x 25% x Engineer's Estimate less the cost for 35% PS&E		
	90% design	LS		1	35% x 25% x Engineer's Estimate less the cost for 35% + 65%PS&E		
	100% design	LS		1	25% x Engineer's Estimate less previous costs		
	Geotechnical Studies			1	Borings, Test Pits, Testing, Geotech Report With Foundation Recommendations, Cut/Fill Slopes, Etc.		
	Cultural Studies			1	Cultral Resources Survey		
	HTWR Studies				Refer to design report for description of need		
Project Agreement Activities					Unable to provide credibale estimate at 10% design		
Site-Specific Adaptive Management Features & Activities					List if known		
Monitoring Activities					Assume 5 crew-days/acre/year for each monitoring parameter in design report		
	Monitoring (Type)	crew-days		200			
Operations & Maintenance					Unable to provide credible estimate at 10% design		

Partial Restoration Quantity Estimate

Action Name: Hamma Hamma River Delta
Action #: PSNERP ID #1047
Date: February 2011
By: David Rice, P.E.

REMEDY: ***Removal/relocation of Highway 101 causeway and bridges, Installation of new bridge adjacent to existing causeway, Dike removal, Fill removal, Fill placement***
Construction Period: Approximately 69 Weeks

Item	Unit of Measure	Material Name	Qty	Description of Item	Indicate section of design report where item is described
ACQUISITION AND CONSERVATION				Based on available mapping information	
Required Project Lands	Acre		20.9	Portion of South River Channel and Overbanks + Existing Highway 101 ROW + New ROW	Section 13.3.5
Proponent / Partner-owned lands	Acre		3.9	Existing WSDOT Right-of-Way, Typically 70-feet Wide	Section 13.3.5
Lands To Be Acquired	Acre		6.9	Acquisition of Right-of-Way Needed for New Roadway and Bridge + 2 Parcels downstream of bridge, Assumes other actions would be completed on private property with construction/conservation easements	Section 13.3.5
Material Sites				Not Used: See Earthwork - Imported Fill.	
MOBILIZATION AND ACCESS for construction activities				Description required for each item to facilitate cost estimating	
Mobilization - Typical (Equipment, Personnel, Planning, Financial)	LS		1	Assume 8% of other Construction Cost Items	
Mobilization - Remote (Equipment, Personnel, Planning, Financial)	LS		0	Not Applicable	
Site Access	LS		0	Not Applicable	
Barge Access	Days		0	Not Applicable	
Temporary Traffic Control (one of the following)				Includes installation of traffic signals, signage, signmen, etc. There are 4 types as follows:	
none	LS		0	Not Applicable	
signs	LS		1	Typical Construction Signage	
flags / spotters	LS		1	Flags and spotters only during roadway transition connection	
unique	LS		0	Not Applicable	
Temporary Roadway	SF		0	Not Applicable	
Control of Water	LS		1	Diversion of water for bridge construction, dewatering of excavations for roadway and culvert construction.	
Relocation Activities				Not Used: See Utilities, Structures	
Site Demolition Activities				Demolition and removal of structures (description required), temporary features and relocations, itemized separately); Clearing and grubbing of vegetation, and removal of minor debris (rocks, slabs) - description required.	
Clearing and Grubbing (one or more of following)					
Clear Vegetation - Local Disposal	AC		0	Not Applicable	
Clear /Grub Vegetation - Local Disposal	AC		8.4	Clear, Grub Proposed 60-foot width along proposed roadway, 15 feet on sides of causeway, south channel	
Clear /Grub Vegetation - Offsite Disposal	AC		0	Vegetation is taken offsite and disposed - use for noxious invasives, etc.	
Clear, stockpile - large woody debris	CY		0	Vegetation is segregated and stockpiled / prepared for reuse on site.	
Hydraulic Structures - Small	LS		0	Not Applicable	
Hydraulic Structures - Large	LS		0	Not Applicable	
Utilities	LS	OH Utilities	1	Remove and Relocate Overhead Power and Telephone Lines Along Highway 101	Section 13.3.7
Buildings	LS or SF		0	Not Applicable	
Pavement	SF		56,000	Remove Pavement on SR101	Section 13.3.2
Bulkheads	LF or SF		0	Not Applicable	
Rock revetments	Ton	Rock	1,154	Remove Armoring Along South Channel Dikes	Section 13.3.2
Large Coastal Structures	LF, SF or CY		0	Not Applicable	
Demolition / Removal - Bridge	SF		10,500	Remove (2) 150' Concrete Arch Bridges	Section 13.3.2
Removal - Misc. (e.g. angular rock from beach)	Ton		0	Not Applicable	
Demolition / Removal - Boat Ramp	SF		0	Not Applicable	
Demolition / Removal - in-water Piling	Number of Piles		244	Remove Timber Piling	
Haul - Offsite Disposal of Demolition Debris	Miles		20	Estimate distance (to nearest 10 miles) to disposal site for materials, veg clear and grub, etc.	Section 13.3.7
Hazardous/Contaminated Waste Removal				These items for earthwork of quality not compatible with wetlands, requiring special handling and disposal. Describe basis for classification as contaminated or hazardous. State known or suspected contamination, describe known similar work.	
Contaminated Earthwork	CY		0	Not Applicable	
Hazardous Earthwork	CY		0	Not Applicable	
Construct Temporary Features				Use as needed for unusual temporary features not included elsewhere (see TESC below)	
EARTHWORK				Expand to include equipment, etc. to facilitate cost estimating.	
Excavation	CY			Per yard excavation w/out expected haul	
Excavation - Lowland - Causeway	CY	Fill	22,200	Removal of existing Highway 101 Causeway	Section 13.3.2
Excavation - Lowland - Dikes	CY	Fill	4,400	Removal of existing South Channel Dikes, 2 Dikes, Total Length~3,260 LF	Section 13.3.2
Dredging - Bucket - Land	CY		0	Not Applicable	
Dredging - Bucket - Marine	CY		0	Not Applicable	
Dredging - Hydraulic	CY		0	Not Applicable	
Fine Grading	AC		0	Not Applicable	
Fill Placement - local borrow				This is additive to Earthwork -Excavation	
Side cast	CY		0	Not Applicable	
Haul - uncontrolled placement	CY		0	Not Applicable	
Haul, place, compact - For Bridge Approaches	CY	Fill	4,200	Placement of fill for new roadway	Section 13.3.4, 13.3.6
Stockpile - uncontrolled placement	CY		0	Not Applicable	
Stockpile - controlled placement	CY	Fill	26,600	Stockpile of Material for Placement as Roadway Fill	Section 13.3.4, 13.3.6
Conveyor placement from stockpile land/water	CY		0	Not Applicable	
Imported Fill				Includes purchase, delivery and placement or as noted / described	
Select Fill	CY	Select Fill	13,000	Fill south channel for restoration of barrier beach	Section 13.3.2
Gravel Borrow, including haul	CY		0	Not Applicable	
Sand / Gravel for Beach Nourishment	CY		0	Not Applicable	
Cobble for Shore Nourishment	CY		0	Not Applicable	
Embankment Compaction	CY		0	Not Applicable	
Topsoil	CY		0	Not Applicable	
RESTORATION Features					
Channel Rehab / Creation	SF	Fill	13,600	Removal of existing sediment for Connection of South Channel to Tidal Channels	Section 13.3.2
Large Wood Placement	EA	Log Jam	8	Assumes Engineered Log Jam Anchored into Bank With Approximately 8 Logs	Section 13.3.2
Invasive Species Control	Acre		0	Not Applicable	
Physical Exclusion Devices	LF or EA		0	Not Applicable	
Other Restoration Features/ Activities	LS		0	Not Applicable	
Structures	EA			KPFF to provide additional inputs	
Water Control Structures - Culverts with Gates	EA		0	Not Applicable	
Water Control Structures - Weirs	EA		0	Not Applicable	
Rock Slope Protection	LF		0	Not Applicable	
Other	EA		0	Not Applicable	
Elevated Boat Ramp	SF		0	Not Applicable	
Fencing	SF		0	Not Applicable	
Utilities				Replacement or relocation. Designer to provide size and material and have separate line item for each run. Incidentals include earthwork, testing, hook up fees, etc. These quantities do not include demolition of existing utilities, real estate / easements, design fees. Describe the owner if known, and whether utility franchise will install (e.g., electric is typically installed by electrical franchise).	
Water	LF		0		
Gas	LF		0		
Electric	LF	OH Power	2,471	Overhead Power to be Relocated Along New Alignment	Section 13.3.7
Sewer	LF		0		
Telecommunications	LF	OH Phone	2,471	Overhead Telephone to be Relocated Along New Alignment	Section 13.3.7
Other	LF	Poles	2,471	Utility Poles - For 2,471 Feet of Relocated Overhead Power and Telephone Along New Bridge	Section 13.3.7
Roadway / Railway				KPFF expected to participate in these estimates	
Roadway	SF		27,580	Typical Roadway 11' wide	Section 13.3.4, 13.3.6
Roadway - Switch (potential)	LS			Street lights, etc. (Temporary traffic control handled under Temporary Facilities)	
Culverts	LF		0	Not Applicable	
Culvert - Jacking	LF			Not Applicable	
Culvert - Horizontal Pile Driving	LF			Not Applicable	
Bridge - Deck	SF		43,200	Voided girder slab precast prestressed girders 90' Spans	Section 13.3.4, 13.3.6
Bridge - Foundation	LF		476	(17) CIP Concrete Pile Caps w/ (5) 30" CIP Concrete Piles 100' Embedment Each Cap	Section 13.3.4, 13.3.6
Railway - Box Girder	SF		0	Standard	
Railway - Foundation	LF		0	Standard	
Railway - Shoe fly	LF		0	Temporary alignment	
Permanent Access Features				KPFF expected to participate in these estimates	
Roads	Level		0	Not Applicable	
Utility Access Routes	varies		0	Not Applicable	
Erosion Control Features	L.F.		0	Not Applicable	
Public Access or Recreation Features				KPFF expected to participate in these estimates	
Trails	SF		0	Not Applicable	
Bridges	SF		0	Not Applicable	
Kiosk	EA		0	Not Applicable	
Restrooms	EA		0	Not Applicable	
Interpretive Signs	EA		2	tbd	
parking area	SF		0	Not Applicable	
Other	EA		0	Not Applicable	
Vegetation & Erosion Control					
Hydroseeding	AC	Hydroseed	0.8	Hydroseed bare cut/fill at bridge approaches	Section 13.3.3
Planting	AC		0	Not Applicable	
Vegetation Maintenance	AC-YR		0	Not Applicable	
Erosion / sediment BMPs - Temp.	LS		1	Erosion/sediment control BMPs - Silt fences, cofferdams, temporary pumping and conveyance	
Erosion / sediment BMPs - Permanent	AC		0	Not Applicable	
Waterside controls - Temporary	LS		1	Erosion/sediment control BMPs - Silt curtains, cofferdams, other	

Partial Restoration Quantity Estimate

Action Name: Hamma Hamma River Delta
Action #: PSNERP ID #1047
Date: February 2011
By: David Rice, P.E.

REMEDY: ***Removal/relocation of Highway 101 causeway and bridges, Installation of new bridge adjacent to existing causeway, Dike removal, Fill removal, Fill placement***
Construction Period: Approximately 69 Weeks

	Item	Unit of Measure	Material Name	Qty	Description of Item		Indicate section of design report where item is described
Construction Management							
	Construction oversight	weeks		69	Quanity based on constructon duration/ # of construction seasons		Section 13.3.7
	Materials testing				Included in cost of material - no separate quantity		
Design and Detailed Site Investigations							
	Survey & Property, Utility Research	LS		1	Topographic and Property Boundary Survey		
	35% Design	LS		1	35% x 25% x Engineer's Estimate		
	65% design	LS		1	65% x 25% x Engineer's Estimate less the cost for 35% PS&E		
	90% design	LS		1	35% x 25% x Engineer's Estimate less the cost for 35% + 65%PS&E		
	100% design	LS		1	25% x Engineer's Estimate less previous costs		
	Geotechnical Studies			1	Borings, Test Pits, Testing, Geotech Report With Foundation Recommendations, Cut/Fill Slopes, Etc.		
	Cultural Studies			1	Cultral Resources Survey		
	HTWR Studies				Refer to design report for description of need		
Project Agreement Activities					Unable to provide credibale estimate at 10% design		
Site-Specific Adaptive Management Features & Activities					List if known		
Monitoring Activities					Assume 5 crew-days/acre/year for each monitoring parameter in design report		
	Monitoring (Type)	crew-days		200			
Operations & Maintenance					Unable to provide credible estimate at 10% design		

14. HARPER ESTUARY RESTORATION DESIGN AND CONSTRUCTION (#1505)

Local Proponent	Kitsap County
Delta Process Unit	N/A
Shoreline Process Unit(s)	4039 and 4038
Strategy(ies)	4 - Coastal Inlet
Restoration Objectives	Remove roadway fill and undersized culvert to restore tidal processes and reclaim estuarine habitat

14.1 Description of the Action

The proposed action would increase tidal inundation to the Harper Estuary by removing the roadway fill of SE Olympiad Drive in its entirety, or constructing a bridge to increase the hydraulic opening. The action would restore historical estuarine areas, full tidal hydrology south of the road, nearshore beach processes, and sediment transport processes. Fragmentation of the shoreline would be reduced through the removal of a relict roadway embankment, bridge abutment and associated bulkhead, and a gravel boat launch. An undersized culvert that restricts tidal exchange and acts as a barrier to fish passage would be removed as a result of the road removal and bridge construction. Please see the Introduction chapter for important information regarding PSNERP and for context related to this restoration project.

14.2 Action Area Description and Context

Harper Estuary is located on the east shoreline of the Kitsap Peninsula, approximately 5.5 miles east of Port Orchard in the South Central Puget Sound Subbasin. The current estuary is bounded to the west by SE Southworth Drive (State Route 160), which was constructed through the historical estuary, and SE Olympiad Drive, which transverses the mouth of the historical outfall. The action area is shown in Figure 14-1.

Figure 14-1. Action Area and Vicinity

14.2.1 Historic Condition

A T-sheet dating from 1876-1877 indicates a barrier beach and estuary with a salt marsh (Figures 14-2A and 14-2B). Two creeks drain to the estuary from the south, forming into relatively wide channels in the tidally influenced areas, joining behind the barrier beach with a single outlet channel to the Sound. The historic sheets predate the roadways, bridges and the brick manufacturing plant that were constructed in the early 1900s. The T-sheet identifies a wooded marsh within the estuary and sand above shoreline in the northern portion of the action area.

The Harper Brick & Tile Co. had a mining and manufacturing facility located in the southwest of the estuary in the general area of the existing ball field. A wooden drawbridge that existed at this time was located at the northern shoreline of the barrier beach, providing access to the west side of the estuary. Remnants of the concrete abutment and walls associated with the bridge still exist today along the beach. When this bridge was removed, a roadway embankment was built along the western shore of the beach, but this too was abandoned and eventually replaced with SE Olympiad Drive. The abandoned roadway embankment and that of SE Olympiad Drive have created an isolated freshwater wetland over the historic beach.

Based on the T-sheets it appears as though SE Southworth Drive was constructed through the estuary and isolated a portion of the estuary where the ball field is today.

The creek draining from the southwest, as shown on the T-sheet, now enters the estuary through a 24-inch diameter culvert beneath the roadway. Flow from this tributary has been captured within a linear drainage ditch and directed east to the tidal mudflat.

Evidence of past fill and other land use modifications is abundant throughout the action area, with piles of abandoned brick throughout, including beneath the roadway embankment, and dispersed in areas of the salt marsh as evidenced by hummocks.

14.2.2 Natural Environment

The estuary encompasses an area of approximately 5 acres. The upland areas immediately surrounding the site are well forested. Development in the surrounding watershed is limited to low-density residential, with significant forest cover. Existing vegetation in the area south of the roadway embankment is typical of low salt marsh with pickleweed, salt grass, Pacific silverweed, and a mix of brackish grasses. Historically, there existed two distinct channels that appear separate in the 1876-1877 mapping. Today only one exists and is connected to the source of the former channel by a ditch that has been excavated from the aforementioned 24-inch culvert. The remaining channel near the east edge of the estuary is wide and shallow, likely due to the tidal barrier which has reduced the velocities in the channel, resulting in aggradation of sediments.

The freshwater wetland bounded by the abandoned roadway embankment and SE Olympiad Drive is dominated by cattails. Hillside runoff from the east is impounded by the embankments over what was likely a sand spit, with no apparent connection to the bay or the saltwater marsh.

The barrier beach is largely where it was mapped originally, with other areas of sediment deposits along the west shoreline and the boat launch, except that much of it has been converted to freshwater wetland due to the impoundment of surface runoff behind the roadway embankments. It is now bisected by an engineered channel from the 36-inch-diameter outfall.

The action area is within a mapped no appreciable drift area, but downdrift from adjacent drift cells to either side. Both adjacent drift cells have been altered with bulkheads and rockeries, reducing sediment delivery to this area. There are what appear to be accretionary shoreforms in the cove west of the boat ramp.

14.2.3 Human Environment

The action area has been altered over the years as described earlier. The existing roadway embankment through the estuary supports a two-lane roadway and is approximately 45 feet in width at the crest. The single 36-inch diameter culvert is undersized and restricts tidal exchange into the estuary and fish passage.

A boat launch for shallow-draft boats is located on the north side of SE Olympiad Drive. It appears to be over a portion of the historic beach, but additional gravel has likely been imported. There are degraded wood piles adjacent to the boat launch, likely from an abandoned pier. There are grant constraints associated with the boat launch, and any removal may require replacement in-kind elsewhere.

Existing utilities in the roadway include a water main, overhead power, and communications lines.

14.3 Restoration Design Concept

14.3.1 Restoration Overview and Key Design Assumptions

The restoration alternatives are illustrated in Figures 14-3 through 14-7. The full restoration alternative (Figure 14-3) entails complete removal of the existing SE Olympiad Drive roadway fill to allow full tidal influence into the estuary and restore sediment transport processes, tidal channel formation, and erosion/accretion of sediment. The full restoration alternative is designed to re-establish the historic inlet dimensions and allow unencumbered tidal access to the inlet. The removal of SE Olympiad Drive will remove an access point to a residential neighborhood, adding approximately 1 mile to local residents' access routes.

The partial restoration alternative (Figure 14-4) includes replacement of the existing SE Olympiad Drive roadway with an elevated structure approximately 140 feet in length spanning the historic outfall. This would remove the tidal barrier and restore many of the same processes.

The partial restoration alternative was developed to preserve both: (1) existing access along SE Olympiad Drive, and (2) some functionality of the existing boat launch. These elements require a span to complete the road while allowing full tidal access into the inlet. The 140-foot span length was selected based on the tidal prism volume and potential marsh area within the inlet, consistent with the *Applied Geomorphology and Hierarchy of Openings* guidelines presented in Appendix C. The opening was expanded beyond the minimum channel opening to allow for natural channel and marsh plain development below the span. This portion of the drift cell is mapped as no appreciable drift (NAD), and appears to be aggradational, so having a wider opening here addresses some of the risks of sedimentation reducing tidal flux into the inlet. The 140-foot span is as wide as is feasible to allow for continued functioning of the existing boat ramp.

Additional design elements include:

- Removal of brick piles throughout the site,
- Removal of the gravel boat launch in entirety (full), or approximately half (partial),
- Removal of the relict roadway embankment and the historic bridge abutment and associated bulkhead from the beach, and
- Filling of the ditch connecting the historic streams to allow a natural channel to develop.

Key design elements associated with full and partial restoration alternatives are shown in Table 14-1.

Table 14-1. Key Design Elements

Element	Full Restoration	Partial Restoration
Existing SE Olympiad Drive Roadway Fill	Full removal through estuary to improve tidal exchange and sediment transport and increase estuary habitat	Partial removal and replacement with bridge to remove tidal barrier

Element	Full Restoration	Partial Restoration
Relict Roadway Embankment	Full removal in action area to allow for tidal flow access to freshwater marshland	Same as full restoration
Relict Bulkhead	Full removal of bulkhead, abutment and associated wood piles that may exist to restore natural beach forming processes	Same as full restoration
Gravel Boat Launch	Full removal to regain beach and estuary habitat	Remove approximately half of the existing launch, leaving a turn-out single lane access to the shore
Existing Debris (Brick "Clinkers")	Full removal to improve beach and estuary habitat	Same as full restoration
Tidal Channels	Restore channels within estuary	Same as full restoration
Marine Riparian Vegetation	Plant marine riparian vegetation in upland portions of the site that are disturbed by earthwork	Same as full restoration

14.3.2 Restoration Features – Primary Process-Based Management Measures

Armor Removal/Modification

In both the full and partial restoration alternatives, the relict bridge abutment and bulkhead will be removed to allow for the return of additional beachfront and nearshore area (Figures 14-3 and 14-4). Approximately 140 LF will be removed to enhance beach and nearshore habitat.

Berm or Dike Removal/Modification

The full restoration alternative will remove approximately 425 feet of the SE Olympiad Drive roadway and embankment fill currently bisecting the freshwater marsh and saltwater estuarine area. The roadway embankment will be cut down approximately 5 to 7 feet to allow for greater tidal influx into the estuary (Figure 14-5). Complete removal of the boat launch is included in the full restoration alternative. Removal of the existing roadway embankment and boat launch will generate approximately 10,300 CY of material and reduce pollution-generating impervious surfaces in the action area by 14,100 SF or 0.32 acre.

The partial restoration alternative will remove approximately 140 feet of SE Olympiad Drive roadway and embankment fill, and replace it with a bridge structure of similar length (Figure 14-6). The partial restoration alternative includes partial removal of the existing boat launch. Removal of the existing roadway embankment and boat launch will generate approximately 4,000 CY of material.

Removal of the relict roadway embankment will occur for both the full and partial restoration alternatives. Removing the existing fill situated between the freshwater marsh and the shoreline will allow for the return of natural shoreline and beach habitat. Removal of the relict roadway embankment will generate 7,000 CY of material.

Channel Rehabilitation/Creation

Two portions of the new stream channel will be excavated to provide more sinuosity and enhance stream function within the estuarine area (Figure 14-6C). The first section will provide greater sinuosity for a straightened channel that has been dredged through the marsh. The existing ditch will be filled with excavated side cast. The second section is intended to provide a starter channel that will connect the existing channel to the new opening through the road fill. The starter channel will expedite natural channel development within the estuary/marsh system.

Groin Removal/Modification - NA

Hydraulic Modification

Removal of the existing SE Olympiad Drive roadway embankment and the existing 36-inch-diameter culvert will allow for full hydraulic influence into the marsh area and remove a barrier to fish passage into the estuary. Because the full restoration alternative removes the entire road embankment (Figures 14-3 and 14-5), the amount of tidal influx into the upper estuary and nearshore areas will be greater than for the partial restoration alternative, which involves spanning the Harper Creek channel with a bridge (Figure 14-4).

The full restoration alternative will provide an approximately 350-foot-wide opening, and partial restoration will provide a 140-foot-wide opening. Both opening widths are greater than the minimum opening required for tidal channel development in this location. The marsh behind the embankment covers approximately 3.8 acres, so using the regional regressions for the Seattle tide gage (Appendix C), the top width of a channel that drains that area would be about 17 feet. The Harper Estuary also conveys freshwater flows from a contributing basin. Therefore, the channel is anticipated to be larger than the tidal regression would suggest. Even conservatively doubling the top width would give about 35 feet wide. Therefore, both the full and partial restoration alternatives should provide for full tidal engagement of the historical estuary, and will provide for a channel and marsh plain to develop. Future design will need to validate the stability of the inlet width for the new tidal prism.

Overwater Structure Removal - NA

Topography Restoration

Topography restoration is addressed above. Refer to the description of removal of the brick "clinker" piles, and the relict and existing roadway prisms.

14.3.3 Restoration Features – Additional Management Measures

Beach Nourishment

No direct beach nourishment is included as part of these conceptual designs. The removal of the old road embankment north of Olympiad Drive will allow a beach to re-form in this location.

Contaminant Removal/Remediation - NA

Debris Removal

Removal of the brick "clinker" piles will occur for both the full and partial restoration alternatives to enhance the shoreline and nearshore habitat. Removal of the brick piles is expected to require overexcavation and will generate approximately 3,000 CY of material. Grade will be restored within these overexcavated limits with imported select fill or channel excavation spoils.

Invasive Species Control - NA

Large Wood Placement - NA

Physical Exclusion - NA

Pollution Control - NA

Revegetation

Much of the action area south of SE Olympiad Drive is already well vegetated with species native and common to Puget Sound salt marshes. Areas where brick piles are to be removed are expected to re-colonize naturally. Marine riparian vegetation (0.1 acre) will be installed in both restoration alternatives in a portion of the road to be removed.

Reintroduction of Native Animals - NA

Substrate Modification - NA

Species Habitat Enhancement - NA

14.3.4 Restoration Features – Other

NA

14.3.5 Land Requirements

The majority of the 13.4-acre action area is within public ownership. A 0.81-acre parcel at the south end of the restored estuary would need to be acquired via purchase, easement or other similar means to complete the channel excavation. Temporary construction access on public rights-of way would be required as well.

This action will potentially change flood risk to properties that border the area of required project lands previously described. The restoration of full tidal influence into the estuary will change the frequency and duration of inundation during high water events. Easements on private property, such as flowage or temporary construction access, may be required.

14.3.6 Design Considerations

Closure of SE Olympiad Drive, as proposed under full restoration, will require a traffic analysis to assess impacts to local residences and emergency services.

The proposed bridge for the partial restoration alternative will run along SE Olympiad Drive. The road will be closed during construction. The proposed bridge will be approximately 140 feet long single span, with 6-foot 6-inch-deep precast concrete girders. Abutments at the end of the proposed bridge will be pile supported (Figure 14-7).

The roadway elevation for the proposed bridge structure will near 20.0 feet. The existing roadway elevation is 17.5 feet at the west end of SE Southworth Drive and 13 feet on the east end of SE Olympiad Drive. The roadways adjacent to the new bridge will need to be raised and adjusted to accommodate the new bridge and clearance requirements. The limits of work are expected to be 200 feet north and 150 feet south of the intersection with SE Southworth Drive, and 250 feet to the east along SE Olympiad Drive. Final design will need to determine vertical control and stopping sight distance associated with the bridge elevation. The estimated quantity of gravel borrow to adjust the roadway grade is 1,550 CY.

Part of the existing boat launch will be maintained under the partial restoration alternative, with the access on the east side of the proposed span. Vehicle and boat trailer turning movements will need to be considered during the design process to determine geometry and sight distance with proximity to the bridge structure. Because the boat launch was apparently installed using grant funds, continued boat access will be required at this or some other nearby location. The future design will need to consider an alternate site for a replacement launch.

The full and partial restoration alternatives will impact existing underground and overhead utilities. A water main of unknown size will be impacted by removal of the roadway embankment. It is assumed that the water main will need to be replaced to maintain a loop for the service area. Under the full restoration alternative, it will need to be replaced by horizontal directional drilling beneath the estuary following the current alignment. A new water main will be supported from the bridge as part of the partial restoration alternative.

Overhead electrical and communication lines will need to be removed and relocated. It is assumed that the electrical could remain in the vicinity of the action area and span the estuary. The fiber optic communications will likely need to be routed in a different manner. The final configuration will be determined through coordination with service providers during design.

14.3.7 Construction Considerations

Most embankment and fill removal would be accomplished with heavy construction equipment including excavators and front-end loaders. Dump trucks will be used for hauling material from the site. Low-ground-pressure track excavators and wood lagging mats will be used for grading and excavation within the tidally influenced areas.

A pile driving rig will be needed for installation of the abutment foundations. A crane positioned on one end of the bridge will set the girders in place. Access and staging for the proposed bridge will be provided via SE Olympiad Drive and the land just adjacent to the road. Estimated construction duration for the bridge is 5 months. Total duration for the both restoration alternatives is 9 to 11 months.

Standard erosion control measures will be required to stabilize disturbed areas and prevent sediment-laden runoff from leaving the site and discharging to the Sound. Typical best management practices include stabilized construction entrance, silt fence, hydroseeding, or other stabilizing measures. The approximate area of disturbance is 3.5 acres.

14.4 Extent of Stressor Removal

Table 14-2 shows the amount of stressor removal with full and partial restoration alternatives.

Table 14-2. Stressor Removal

Stressor	Full Restoration	Partial Restoration
Tidal Barrier (LF)	Removal of bulkhead, 140 LF	Removal of bulkhead, 140 LF
Fill (area)	Removal of relict roadway and boat launch, 1.1 acres	Removal of relict roadway and portion of boat launch, 1.0 acre
Armor (LF)	Bulkhead removal noted above would also remove armoring.	Bulkhead removal noted above would also remove armoring.
Nearshore Roads (LF)	Removal of SE Olympiad Drive, 400 LF	Removal of SE Olympiad Drive, 140 LF
Marinas (area)	Boat Launch Removed	N/A

14.5 Expected Evolution of the Action Area

In both the full and partial restoration alternatives, the old road and bulkhead north of Olympiad Drive will be removed. This will allow the tide to reengage the currently freshwater wetland. The bulkhead removal will allow for beach formation in this area, with some retreat to the south likely. The freshwater wetland would transition to a salt marsh community, but it is already at high intertidal elevations and would not be dependent on aggradation. This elevation, combined with the existing seed source in the estuary to the south, should allow for relatively rapid transition to a salt marsh in this area.

In the estuary south of the embankment, the area is already dominated by a typical salt marsh vegetation community. The greater tidal flux into the area will result in development of more distinct, larger tidal channels, as anticipated by the channel excavation in both the full and partial restoration alternatives. These channels will adjust but likely within the existing drainage network within the estuary.

14.6 Uncertainties and Risks

The nature and extent of possible contamination associated with former land uses and the remnant clinker piles are unknown. Property owners within the vicinity of the action area have not been questioned about their opinion of the complete removal of SE Olympiad Drive, so the degree of community support for this element of the full restoration alternative is uncertain.

14.6.1 Risks Associated with Projected Sea Level Change

Table 14-3 compares potential risks associated with projected sea level changes based on professional judgment.

Table 14-3. Risks of Sea Level Change

	Projected Sea Level Change		
	High (65 cm)	**Intermediate (23 cm)**	**Low (13cm)**
Full Restoration	Potential to drown the lower portions of the existing salt marsh within the estuary. The topographic transition around the perimeter of the estuary is relatively abrupt, limiting the ability of vegetation communities to adjust laterally. The estuary is in a zone of no appreciable drift, and receives sediment from both the west and the east, which may help to aggrade the site with rising sea level. Increased wave energy on the site perimeter is also possible, but the site's north aspect protects it from typical winter storm tracks.	Less likely to drown the lower portion of the marsh, but the lower elevation band of intertidal vegetation may be affected. The slopes around the perimeter are relatively steep, but would allow adjustment.	See Intermediate.
Partial Restoration	Same as full restoration.	Same as full restoration.	Same as full restoration.

14.7 Potential Monitoring Opportunities

Monitoring is important for evaluating restoration success. A combination of field surveys and aerial photographs would be used to document biological and physical changes to the landscape. Monitoring data can be used to refine adaptive management and corrective actions, as needed. Some of the main monitoring needs and opportunities associated with this action are summarized in Table 14-4.

Table 14-4. Monitoring Needs and Opportunities

Monitoring Parameter	Key Performance Indicator	Note
Topographic Stability	X	Evolving beach in road removal section
Sediment Accretion / Erosion	X	Assess sedimentation and erosion rates
Wood Accumulation		
Soil / Substrate Conditions		
Vegetation Establishment	X	Salt marsh vegetation establishment in debris removal areas
Marsh Surface Evolution / Accretion		
Tidal Channel Cross-Section / Density	X	Channel development with full tidal restoration
Water Quality (contaminants)		
Salinity		
Shellfish Production		
Extent of Invasive Species		
Animal Species Richness		
Fish (salmonid) Access/Use	X	Increased access and rearing habitat
Forage Fish Production		
Wildlife Species Use		
Effectiveness of Exclusion Devices		

14.8 Information Needed for Subsequent Design

This conceptual design report represents an initial step in the restoration design sequence. The design concepts described above were developed based on readily available information without the level of site-specific survey and investigation that is necessary to support subsequent design and implementation. Substantial additional information will be required at the preliminary and later design stages to confirm the design assumptions, refine quantity estimates, address property and regulatory issues, obtain stakeholder support, and fill in data gaps. The extent to which this information is collected for preliminary design (or a later design stage) will depend upon the available budget, schedule, and other factors. This section attempts to define some of the most essential information needs for this action.

- Property Investigation/Survey – More detailed information on parcel ownership, utilities, and property boundary locations will be needed to finalize the design, confirm property agreement requirements (including boat launch replacement requirements), and support negotiations with property owners.
- Topographic/Bathymetric Survey – The survey data would be used to refine design of key project elements and develop detailed construction and demolition plans. Survey data could also be used as a baseline for pre- and post-construction monitoring and hydrodynamic modeling. A temporary tide gauge may be

required in the early design stages to obtain site-specific tidal statistics.

- Hydrodynamic and Hydraulic Analysis– Tidal circulation, flood, and wave modeling will be required to optimize the size of the opening in the partial restoration alternative. Site-specific data on seasonal freshwater flow to the action area may also be necessary during early stages of design.
- Additional As-built Information – As-constructed information is needed to assess requirements for relocation of utility infrastructure and to complete the site survey.
- Cultural Resource Survey – There are no known cultural resources within the action area, but there is a possibility that cultural resources exist. The origin and significance of the "clinker" piles may require further investigation. Additional investigation and/or survey may be required prior to final design.
- Geotechnical Investigation – Geotechnical investigations and recommendations for bridge foundation are needed. Hydraulic engineering recommendations for scour and minimum bridge clearance over water are needed based on modeling.
- Contaminant Survey - If preliminary investigations suggest that hazardous material could be present in the action area, additional soil and sediment analysis may be needed. The introductory chapter describes the Phase I site investigations that are occurring as part of this overall effort via a separate contract.
- Sea Level Change Projection – Estimates of sea level change for the conceptual design were based on calculations provided by the Washington Department of Fish and Wildlife and the Corps of Engineers using guidance in Corps' Engineering Circular No. 1165-2-211. Projections for each project area will be refined using localized tide gauge data during later design stages.

14.9 Quantity Estimates

The design quantities are largely developed from LiDAR data sets lacking the resolution to accurately quantify all elements of construction. These are supplemented by unmeasured estimates made during one site visit at high tide and areal take-offs from available imagery. The quantity spreadsheets for the full and partial restoration alternatives are provided in Exhibits 14-1 and 14-2.

14.10 References

Elliot, E., J.J. 1876-7. Topography of Puget Sound Wash. Ter. From Restoration – Alki Pts. To Robinsons Pt., U.S. Coast And Geodetic Survey.

GeoEngineers. Undated. Harper Estuary Culvert Replacement. Five plan sheets.

U.S. Army Corps of Engineers. 2002. *Preliminary Restoration Plan, Harper Estuary Section 206 Study*, 2010, Kitsap County, Washington.

0 260
Feet
0 80
Meters

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Historic Map (T-Sheet)
Action Name: Harper Estuary Restoration Design and Construction
PSNERP ID #: 1505
Figure 14- 2A

S:\GIS\Projects\210xxx\210337_PSNERP_NEARSHORE\Projects\2-TSheets_rev.mxd (DLP; 2/24/2011)

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64

WDFW Contract # 100-000204 (CAPS No. 10-1461)

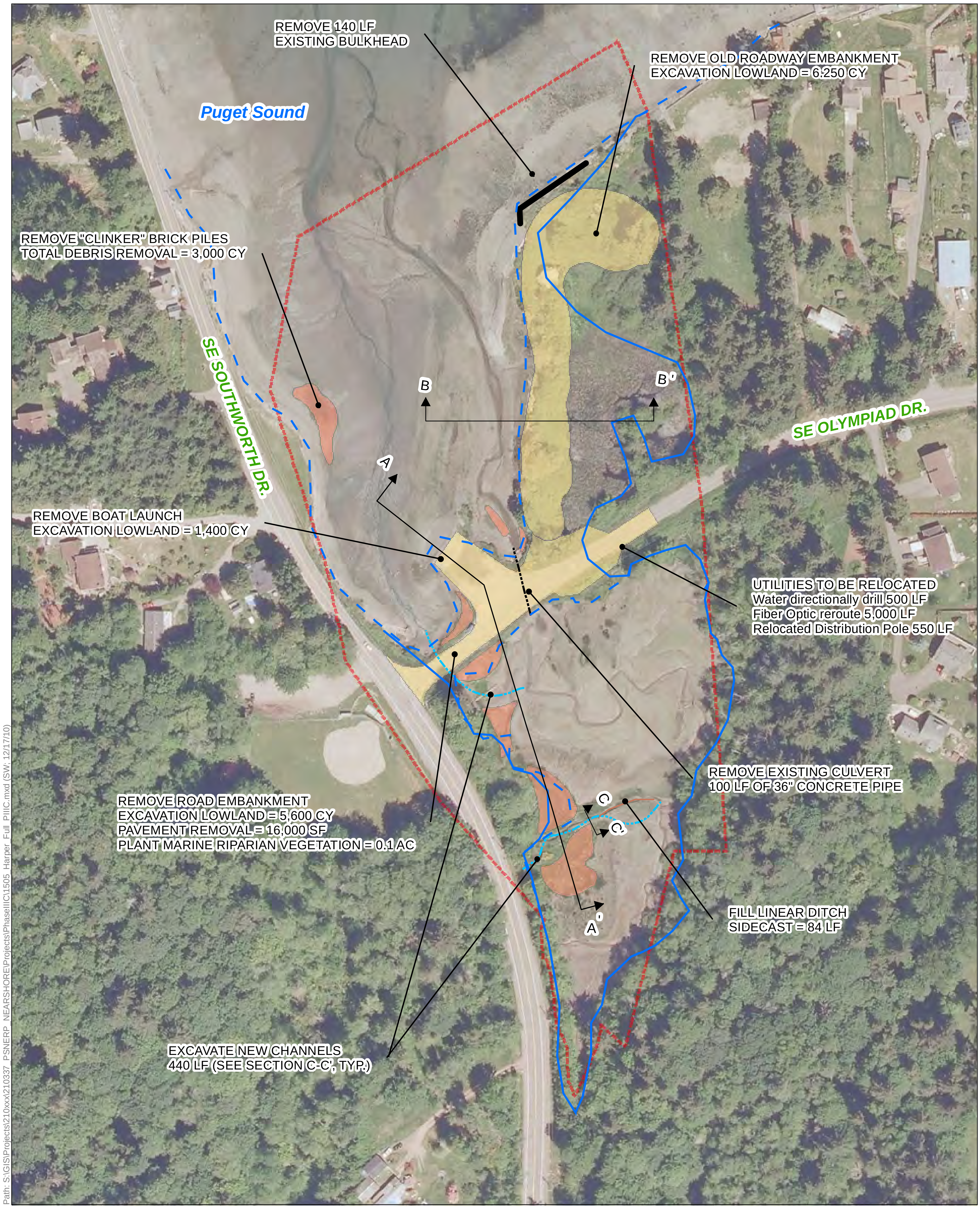
Historic Map (T-Sheet) and River History Project Data

Action Name: Harper Estuary Restoration Design and Construction

PSNERP ID #: 1505

Figure 14- 2B

S:\GIS\Projects\210xxx\210337_PSNERP_NEARSHORE\Projects\2-TSheets_rev.mxd (DLP; 2/24/2011)



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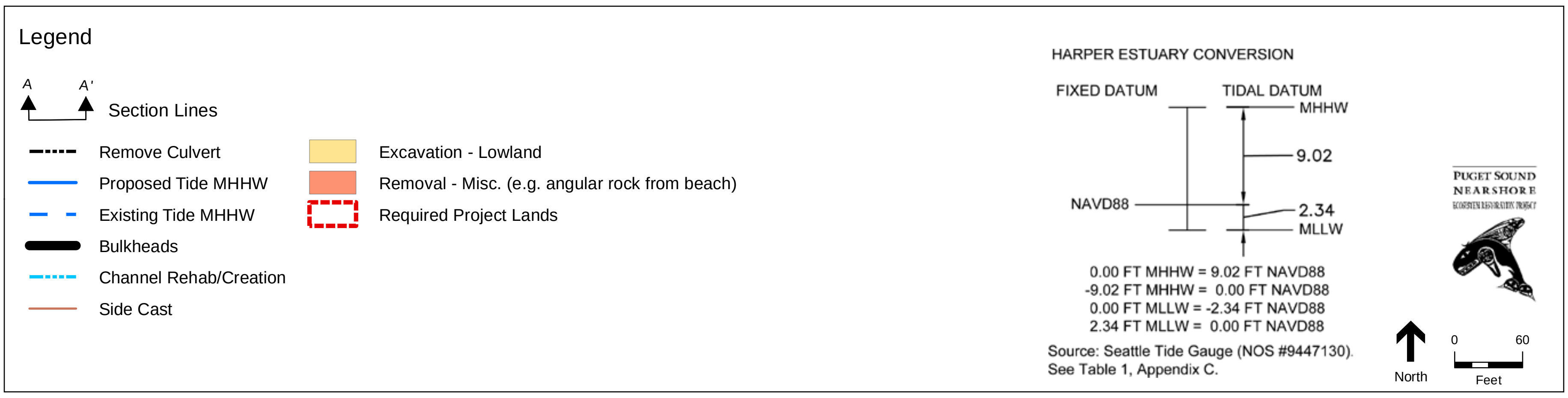


SOURCE: PSNERP (2011); Aerial (Bing, 2009)

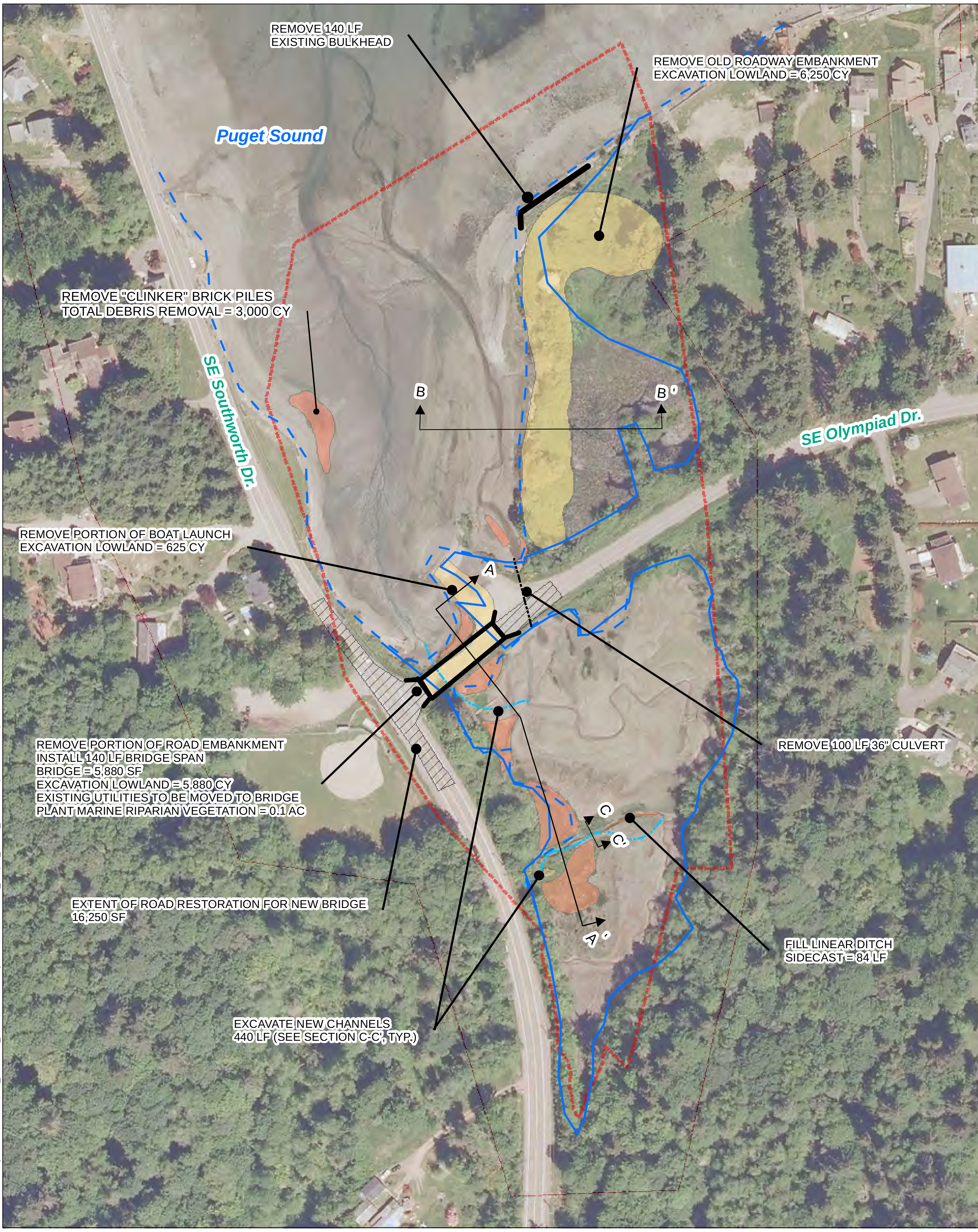
Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64

WDFW Contract # 100-000204 (CAPS No. 10-1461)

Lead Contractor: ESA
Design Lead: KPFF, P. Sloan, PE
Date: 05/2012

Conceptual Design Plan
Site Name: Harper Estuary
Action Name: Harper Estuary Restoration Design
PSNERP ID #:1505
Full Restoration

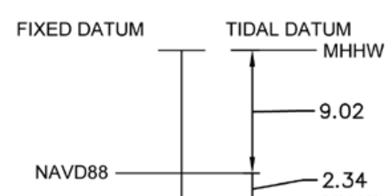
Figure 14-3



Legend

Section Lines (A — A')	Excavation - Lowland
Proposed bridge	Removal - Misc. (e.g. angular rock from beach)
Remove Culvert	Required Project Lands
Proposed Tide MHHW	Roadway Restoration
Existing Tide MHHW	
Bulkheads	
Channel Rehab/Creation	
Side Cast	

HARPER ESTUARY CONVERSION



0.00 FT MHHW = 9.02 FT NAVD88
-9.02 FT MHHW = 0.00 FT NAVD88
0.00 FT MLLW = -2.34 FT NAVD88
2.34 FT MLLW = 0.00 FT NAVD88

Source: Seattle Tide Gauge (NOS #9447130).
See Table 1, Appendix C.

PUGET SOUND NEARSHORE

North

0 60
Feet

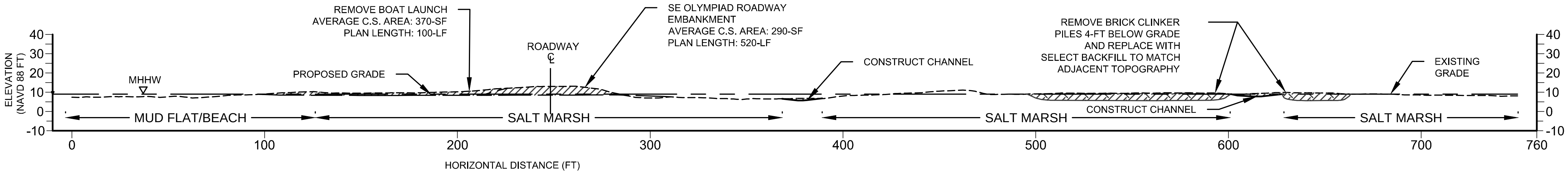
SOURCE: PSNERP (2011); Aerial (Bing, 2009)

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

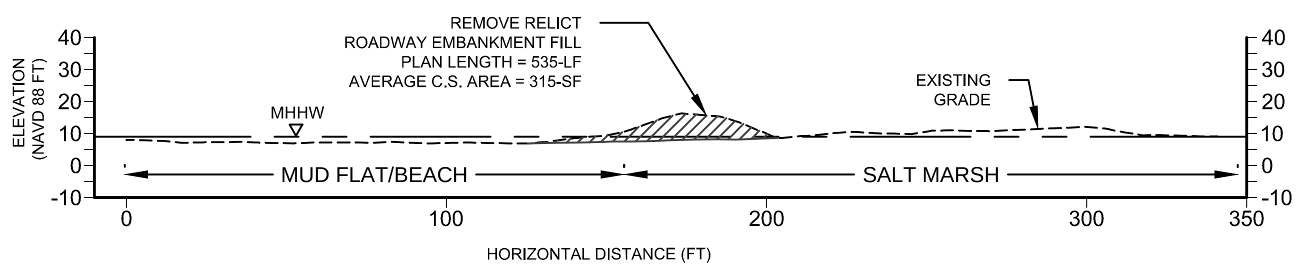
Conceptual Design Plan
Site Name: Harper Estuary
Action Name: Harper Estuary Restoration Design
PSNERP ID #:1505
Partial Restoration

Lead Contractor: ESA
Design Lead: KPFF, P. Sloan, PE
Date: 05/2012

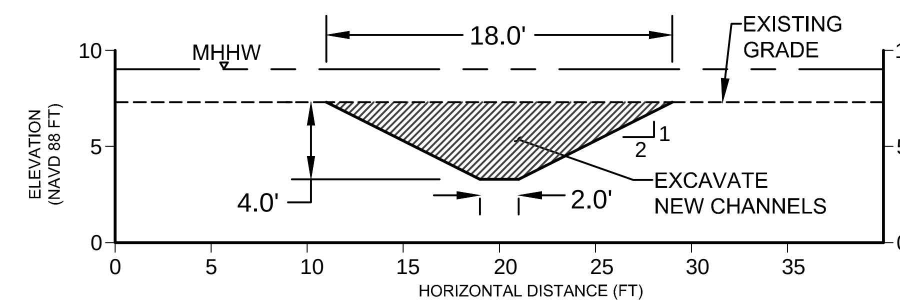
Figure 14-4



A TYPICAL SECTION A-A'

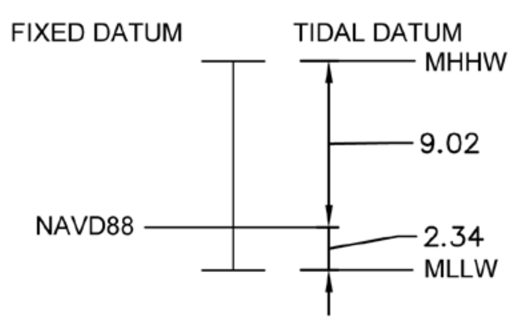


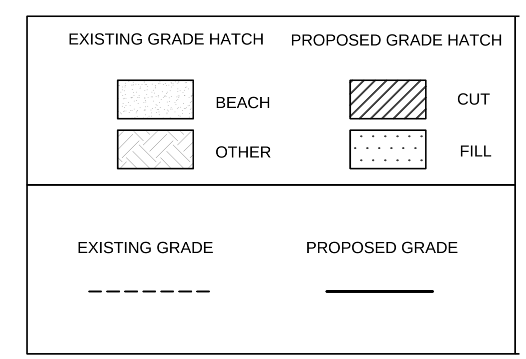
B TYPICAL SECTION B-B'



C TYPICAL CHANNEL SECTION
NTS

HARPER ESTUARY CONVERSION





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-9.02 FT MHHW = 0.00 FT NAVD88
0.00 FT MLLW = -2.34 FT NAVD88
2.34 FT MLLW = 0.00 FT NAVD88

Source: Seattle Tide Gauge (NOS #9447130).
See Table 1, Appendix C.

0 60
Scale in Feet

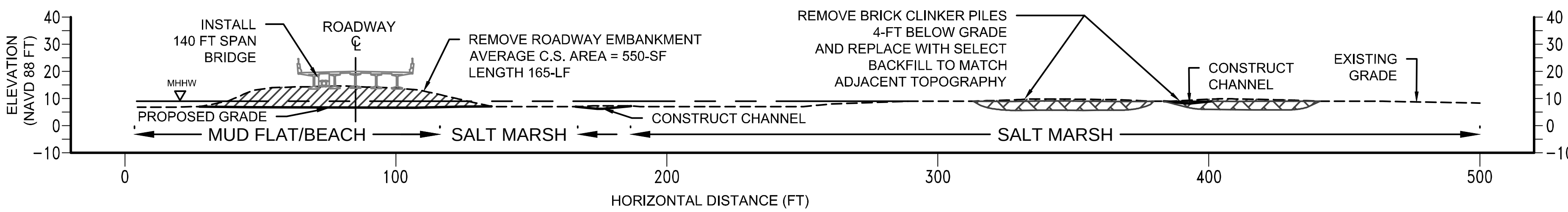
PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: KPFF, P. Sloan, PE
Date: 05/2012

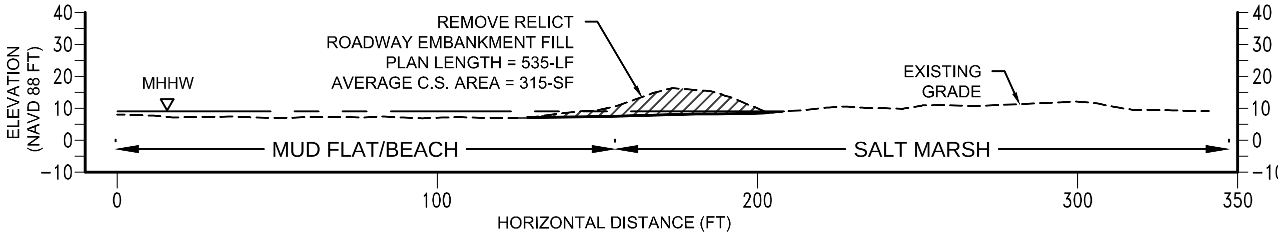
Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Section
SITE NAME: **Harper Estuary**
ACTION NAME: **Harper Estuary Restoration Design and Construction**
PSNERP ID#: **1505**
Full Restoration

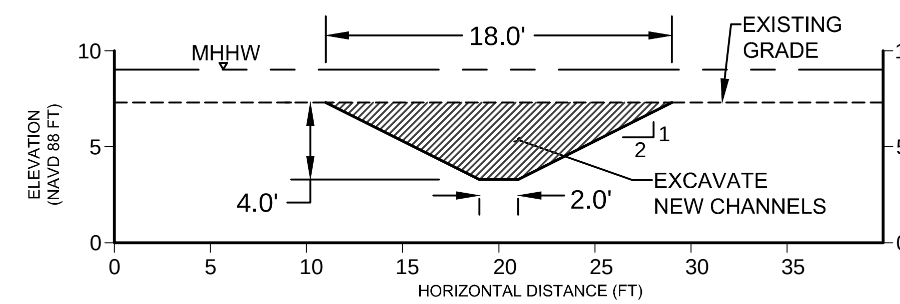
Figure 14-5



A TYPICAL SECTION A-A'



B TYPICAL SECTION B-B'



C TYPICAL CHANNEL SECTION
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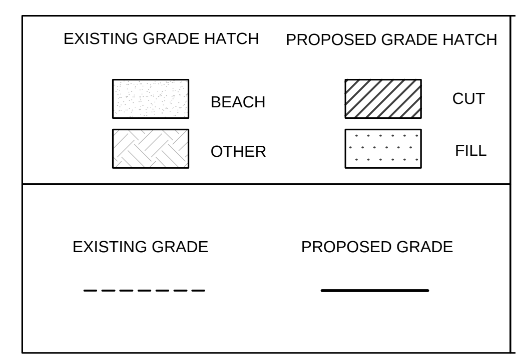
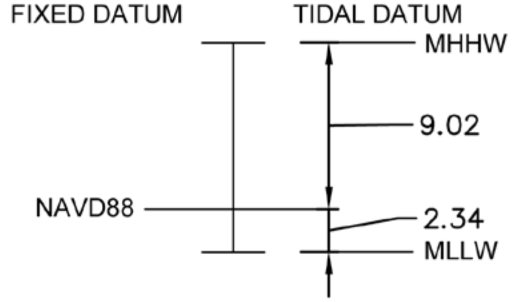


HARPER ESTUARY CONVERSION



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0.00 FT MLLW = -2.34 FT NAVD88
2.34 FT MLLW = 0.00 FT NAVD88

Source: Seattle Tide Gauge (NOS #9447130).
See Table 1, Appendix C.

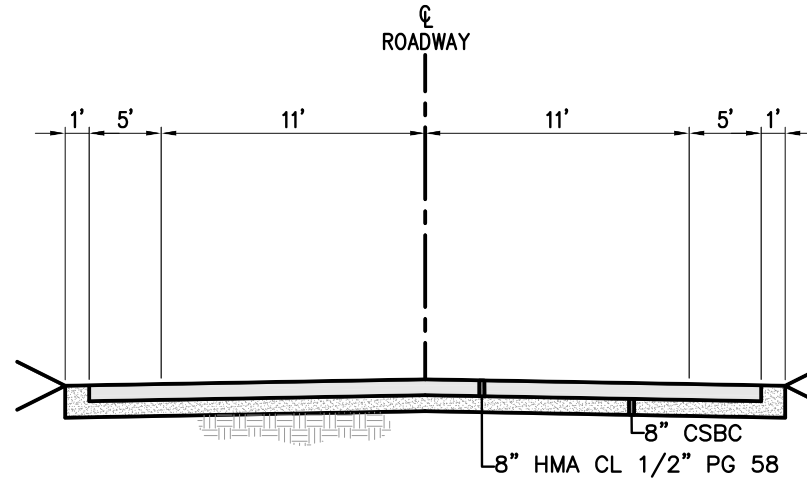
PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: KPFF, P. Sloan, PE
Date: 05/2012

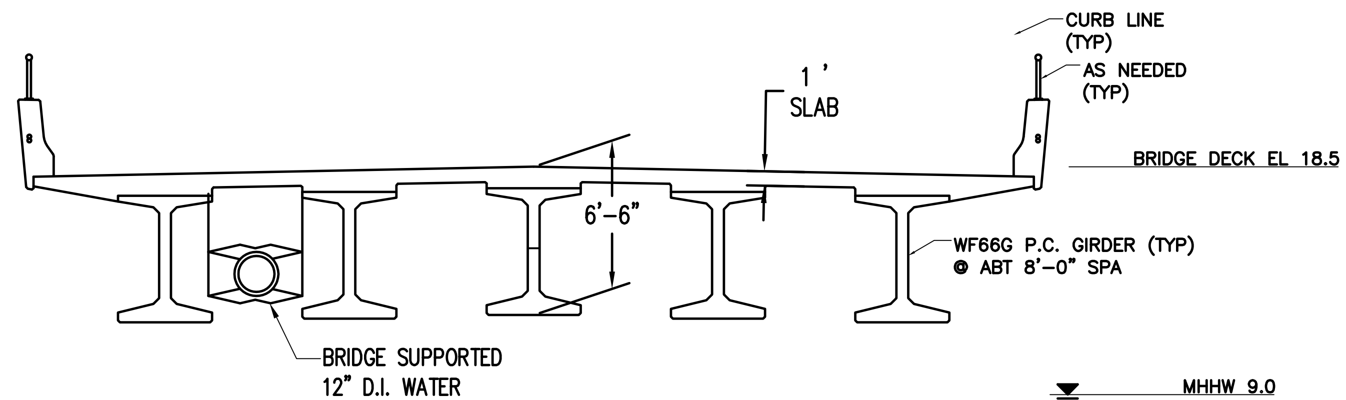
Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Section
SITE NAME: **Harper Estuary**
ACTION NAME: **Harper Estuary Restoration Design and Construction**
PSNERP ID#: **1505**
Partial Restoration

Figure 14-6

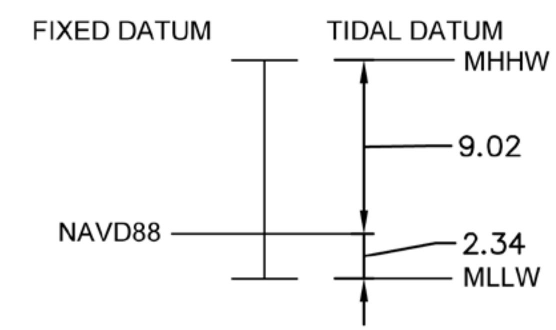


TYPICAL ROADWAY SECTION A–A
NTS



BRIDGE SECTION (B–B) – 140' SPAN
NTS

HARPER ESTUARY CONVERSION



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2.34 FT MLLW = 0.00 FT NAVD88

Source: Seattle Tide Gauge (NOS #9447130).
See Table 1, Appendix C.

PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: KPFF, P. Sloan, PE
Date: 05/2012

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Section
SITE NAME: **Harper Estuary**
ACTION NAME: **Harper Estuary Restoration Design and Construction**
PSNERP ID#: **1505**
Full & Partial Restoration

Figure 14-7

Full Restoration Quantity Estimate

Action Name: Harper Estuary
Action #:
Date: February 2011 Revised May 2012
By: KPFF

REMEDY: increase tidal inundation to the Harper Estuary by removing the roadway fill of SE Olympiad Drive in its entirety
Construction Period: 9-11 months

Item	Unit of Measure	Material Name	Qty	Description of Item	Indicate section of design report where item is described
ACQUISITION AND CONSERVATION				Based on available mapping information	
Required Project Lands	Acre		13.4	Total land required For action	14.3.5
Proponent / Partner-owned lands	Acre		12.6	Estimate of lands currently owned by Proponent (i.e., Public lands)	14.3.5
Lands To Be Acquired	Acre		0.8	Estimate land required to be acquired for action prior to implementation	
Material Sites				Not Used: See Earthwork - Imported Fill.	
MOBILIZATION AND ACCESS for construction activities				Description required for each item to facilitate cost estimating	
Mobilization - Typical (Equipment, Personnel, Planning, Financial)	LS		1	Up front costs such as bonding, planning and other staff time and financing. Typically, assume 8% to 10% of other items.	
Mobilization - Remote (Equipment, Personnel, Planning, Financial)	LS		NA		
Site Access	LS		NA		
Barge Access	Days		NA		
Temporary Traffic Control (one of the following)				Includes installation of traffic signals, signage, signmen, etc. There are 4 types as follows:	
none	LS		NA		
signs	LS		1	Construction Signage at both sites to alert of Construction & Lane shifting	
flags/spotters crews	LS		NA		
unique	LS		NA		
Temporary Roadway	SF		NA		
Control of Water	LS		NA		
Relocation Activities				Not Used: See Utilities, Structures	
Site Demolition Activities				Demolition and removal of structures (description required), temporary features and relocations, itemized separately); Clearing and grubbing of vegetation, and removal of minor debris (rocks, slabs) - description required.	
Clearing and Grubbing (one or more of following)				Use one or more of the following categories of clearing and grubbing	
Clear Vegetation - Local Disposal	AC		NA		
Clear /Grub Vegetation - Local Disposal	AC		NA		
Clear /Grub Vegetation - Offsite Disposal	AC		1.5	Vegetation is taken offsite and disposed - use for noxious invasives, etc.	
Clear, stockpile - large woody debris	CY		NA		
Hydraulic Structures - Small	LS		NA		
Hydraulic Structures - Large	LS		NA		
Power	LF		550	Overhead Distribution	14.3.6
Water	LF		500	Size Unknown	14.3.6
Fiber Optic Communications	LF		5000	Communication duct bank to be routed south to SE Southworth Drive due to roadway removal.	14.3.6
Culvert	LF		100	Remove 36" Culvert	14.3.2
Buildings	LS or SF		NA		
Pavement	SF		16,000	Removal of pavement along SE Olympiad Drive with in the action area.	14.3.2
Bulkheads	LF		140	Northeast area	14.3.2
Demolition/Removal - Armor on Railroad Berm	LF, Ton or CY		NA		
Demolition / Removal - Railroad Berm	LF, SF or CY		NA		
Removal - Misc. (e.g. angular rock from beach)	LF, SF or CY		NA		
Removal - in-water Piling	Number of Piles		NA		
Haul - Offsite Disposal of Demolition Debris	Miles		20	Estimate distance (to nearest 10 miles) to disposal site for materials, veg clear and grub, etc.	
Hazardous/Contaminated Waste Removal				These items for earthwork of quality not compatible with wetlands, requiring special handling and disposal. Describe basis for classification as contaminated or hazardous. State known or suspected contamination, describe known similar work.	
Contaminated Earthwork	CY		NA		
Hazardous Earthwork	CY		NA		
Construct Temporary Features				Use as needed for unusual temporary features not included elsewhere (see TESC below)	
EARTHWORK				Expand to include equipment, etc. to facilitate cost estimating.	
Excavation	CY			Per yard excavation w/out expected haul	
Excavation - Historic Road Embankment	CY		6250	Conducive for transitional earthwork equipment, including scrapers, with high production and low cost. Quantity estimated from footprint of area identified for removal and an estimated average depth based on LiDAR data.	14.3.2
Excavation - Brick Mounds	CY		3000	Excavation of brick mounds requires low ground pressure equipment and or mats; low production bucket methods, typically hydraulic excavator and front end loaders. Volume has been estimated from the footprint of areas identified in plan. Height of material based on LiDAR data with an assumed over excavation of 4 feet.	14.3.2
Excavation - Existing Road Embankment	CY		7000	Conducive for transitional earthwork equipment, including scrapers, with high production and low cost. Estimated from a typical roadway section based on available LiDAR data.	14.3.2
Excavation - Lowland	CY		720	Requires low ground pressure equipment and or mats; low production bucket methods, typically hydraulic excavator and front end loaders. Hydraulic excavator to truck or to pile with front end loader to truck. Offhaul to disposal site.	14.3.2
Dredging - Bucket - Land	CY		NA		
Dredging - Bucket - Marine	CY		NA		
Dredging - Hydraulic	CY		NA		
Fine Grading	AC		NA		
Fill Placement - local borrow				This is additive to Earthwork -Excavation	
Side cast	LF		84	Fill linear ditch adjacent to new channel excavation	
Haul - uncontrolled placement	CY		NA		
Haul, place, compact	CY		NA		
Stockpile - uncontrolled placement	CY		NA		
Stockpile - controlled placement	CY		NA		
Conveyor placement from stockpile land/water	CY		NA		
Imported Fill				Includes purchase, delivery and placement or as noted / described	
Select Fill	CY		2200	Imported select material to be placed in the marsh areas that will be over-excavated for removal of debris. Volume as based on the typical section identified in the report and the length of channels proposed in conceptual plan.	14.3.3
Gravel Borrow, including haul	CY		NA		14.3.6
Sand / Gravel for Beach Nourishment	CY		NA		
Cobble for Shore Nourishment	CY		NA		
Embankment Compaction	CY		NA		14.3.6
Topsoil	CY		NA		
RESTORATION Features					
Channel Rehab / Creation	SF		8790	Channel construction (SF) including imported sediment and habitat materials, excluding excavation	143.3
Large Wood Placement	EA		NA		

Full Restoration Quantity Estimate

Action Name:	Harper Estuary			
Action #:				
Date:	February 2011	Revised May 2012		
By:	KPFF			

REMEDY: increase tidal inundation to the Harper Estuary by removing the roadway fill of SE Olympiad Drive in its entirety
Construction Period: 9-11 months

Invasive Species Control	Acre		NA			
Physical Exclusion Devices	LF or EA		NA			
Other Restoration Features/ Activities	LS		NA			
Structures	EA					
Water Control Structures - Culverts with Gates	EA		NA			
Water Control Structures - Weirs	EA		NA			
Rock Slope Protection	LF		NA			
Other	EA		NA			
Elevated Boat Ramp	SF		NA			
Fencing	SF		NA			
Utilities				Replacement or relocation. Designer to provide size and material and have separate line item for each run. Incidentals include earthwork, testing, hook up fees, etc. These quantities do not include demolition of existing utilities, real estate / easements, design fees. Describe the owner if known, and whether utility franchise will install (e.g.. electric is typically installed by electrical franchise).		
Water	LF		500	To be installed by horizontally directional drilling. Estimated quantity is based on the length of roadway removed.		14.3.6
Gas	LF		NA			
Electric	LF		500	Overhead Distribution. Estimated quantity is based on length of roadway removal assuming some adjustment is necessary for the change in grade, or to span the width of the estuary.		14.3.6
Sewer	LF		NA			
Fiber Optic Telecommunications	LF		5500	Estimated length is to relocated fiber optic to south along SE Southworth Drive.		14.3.6
Other	LF					
Roadway / Railway						
Roadway	SF		NA			14.3.6
Roadway - Switch (potential)	LS		NA			
Culvert (type)	LF		NA			
Culvert - Jacking	LF		NA			
Culvert - Horizontal Pile Driving	LF		NA			
Railway - Box Girder	SF		NA			
Bridge - Foundation	LF		NA			
Railway - Shoe fly	LF		NA			
Permanent Access Features						
Roads	Level		NA			
Utility Access Routes	varies		NA			
Erosion Control Features	AC		NA			
Public Access or Recreation Features						
Trails	SF		NA			
Bridges	SF		NA			
Kiosk	EA		NA			
Restrooms	EA		NA			
Interpretive Signs	EA		NA			
Parking Area	SF		NA			
Other	EA		NA			
Vegetation & Erosion Control						
Hydroseeding	AC		NA			
Planting	AC		0.1	Marine Riparian Vegetation		
Vegetation Maintenance	AC-YR		0.5	Includes irrigation, weeding, plant replacement for five years		
Erosion / sediment BMPs - Temp.	AC		3.5	Stabilized Construction Entrances, Sediment Ponds, Hydro Seed to Stabilize Roadway Embankments, Silt Fence Compost Berm. Area based on the footprint of likely disturbance.		14.3.7
Erosion / sediment BMPs - Permanent	AC		NA			
Waterside controls - Temporary	EA, LF, LS		NA			
Construction Management						
Construction oversight	weeks		20	Quantity based on construction duration of a single construction season		
Quality Assurance With Testing	L.S.					
Design and Detailed Site Investigations						
Survey & Property, Utility Research	LS		1	% of construction cost		
35% Design	LS		1	35% x 25% x Engineer's Estimate		
65% design	LS		1	65% x 25% x Engineer's Estimate less the cost for 35% PS&E		
90% design	LS		1	35% x 25% x Engineer's Estimate less the cost for 35% + 65%PS&E		
100% design	LS		1	25% x Engineer's Estimate less previous costs		
Geotechnical Studies			1	Refer to design report for description of need		
Cultural Studies			1	Refer to design report for description of need		
HTRW Test Holes & Sampling	ea.					
Project Agreement Activities				Unable to provide credible estimate at 10% design		
Project site financial close-out	Man-Days		75			
Monitoring Activities				Assume 5 crew-days/year for each monitoring parameter in design report for 5 yrs		
Operations & Maintenance				Unable to provide credible estimate at 10% design		

Partial Restoration Quantity Estimate

Action Name: Harper Estuary
Action #:
Date: February 2011 Revised May 2012
By: KPFF

REMEDY: increase tidal inundation to the Harper Estuary by replacing roadway fill of SE Olympiad Drive with a bridge
Construction Period: 9-11 months

Item	Unit of Measure	Material Name	Qty	Description of Item	Indicate section of design report where item is described
ACQUISITION AND CONSERVATION				Based on available mapping information	
Required Project Lands	Acre		13.4	Total land required For action	14.3.5
Proponent / Partner-owned lands	Acre		12.6	Estimate of lands currently owned by Proponent (i.e., Public lands)	14.3.5
Lands To Be Acquired	Acre		0.8	Estimate land required to be acquired for action prior to implementation	
Material Sites				Not Used: See Earthwork - Imported Fill.	
MOBILIZATION AND ACCESS for construction activities				Description required for each item to facilitate cost estimating	
Mobilization - Typical (Equipment, Personnel, Planning, Financial)	LS		1	Up front costs such as bonding, planning and other staff time and financing. Typically, assume 8% to 10% of other items.	
Mobilization - Remote (Equipment, Personnel, Planning, Financial)	LS		NA		
Site Access	LS		NA		
Barge Access	Days		NA		
Temporary Traffic Control (one of the following)				Includes installation of traffic signals, signage, signmen, etc. There are 4 types as follows:	
none	LS		NA		
signs	LS		1	Construction Signage at both sites to alert of Construction & Lane shifting	
flags/spotters crews at both sides for transitions	LS		1	Flags and spotters only during roadway transition connection	
unique	LS		NA		
Temporary Roadway	SF		NA		
Control of Water	LS		NA		
Relocation Activities				Not Used: See Utilities, Structures	
Site Demolition Activities				Demolition and removal of structures (description required), temporary features and relocations, itemized separately); Clearing and grubbing of vegetation, and removal of minor debris (rocks, slabs) - description required.	
Clearing and Grubbing (one or more of following)				Use one or more of the following categories of clearing and grubbing	
Clear Vegetation - Local Disposal	AC		NA		
Clear /Grub Vegetation - Local Disposal	AC		NA		
Clear /Grub Vegetation - Offsite Disposal	AC		1.5	Vegetation is taken offsite and disposed - use for noxious invasives, etc.	
Clear, stockpile - large woody debris	CY		NA		
Hydraulic Structures - Small	LS		NA		
Hydraulic Structures - Large	LS		NA		
Power	LF		NA		14.3.6
Water	LF		300	Size Unknown	14.3.6
Fiber Optic Communications	LF		5000		14.3.6
Buildings	LS or SF		NA		14.3.2
Pavement	SF		15600	Includes removal of pavement along Southworth for restoration to transition to new grade on Olympiad. Limits of new roadway improvements described in the narrative	
Bulkheads	LF		140	Northeast area	14.3.2
Demolition/Removal - Armor on Railroad Berm	LF, Ton or CY		NA		14.3.2
Demolition / Removal - Railroad Berm	LF, SF or CY		NA		
Demolition / Removal - Bridge	SF or CY		NA		
Removal - Misc. (e.g. angular rock from beach)	LF, SF or CY		NA		
Demolition / Removal - in-water Piling	Number of Piles		NA		
Haul - Offsite Disposal of Demolition Debris	Miles		20	Distance (to nearest 10 miles) to disposal site for materials, veg clear and grub, etc.	
Hazardous/Contaminated Waste Removal				These items for earthwork of quality not compatible with wetlands, requiring special handling and disposal. Describe basis for classification as contaminated or hazardous. State known or suspected contamination, describe known similar work.	
Contaminated Earthwork	CY		NA		
Hazardous Earthwork	CY		NA		
Construct Temporary Features				Use as needed for unusual temporary features not included elsewhere (see TESC below)	
EARTHWORK				Expand to include equipment, etc. to facilitate cost estimating.	
Excavation	CY			Per yard excavation w/out expected haul	
Excavation - Historic Road Embankment	CY		6250	Conducive for transitional earthwork equipment, including scrapers, with high production and low cost. Quantity estimated from footprint of area identified for removal and an estimated average depth based on LiDAR data.	14.3.2
Excavation - Brick Mounds	CY		3000	Excavation of brick mounds requires low ground pressure equipment and or mats; low production bucket methods, typically hydraulic excavator and front end loaders. Volume has been estimated from the footprint of areas identified in plan. Height of material based on LiDAR data with an assumed over excavation of 4 feet.	14.3.2
Excavation - Existing Road Embankment	CY		4025	Conducive for transitional earthwork equipment, including scrapers, with high production and low cost. Estimated from a typical roadway section based on available LiDAR data.	14.3.2
Excavation - Lowland	CY		720	Requires low ground pressure equipment and or mats; low production bucket methods, typically hydraulic excavator and front end loaders. Hydraulic excavator to truck or to pile with front end loader to truck. Offhaul to disposal site.	14.3.2
Dredging - Bucket - Land	CY		NA		
Dredging - Bucket - Marine	CY		NA		
Dredging - Hydraulic	CY		NA		
Fine Grading	AC		NA		
Fill Placement - local borrow				This is additive to Earthwork -Excavation	
Side cast	LF		84	Fill linear ditch adjacent to new channel excavation	
Haul - uncontrolled placement	CY		NA		
Haul, place, compact	CY		NA		
Stockpile - uncontrolled placement	CY		NA		
Stockpile - controlled placement	CY		NA		
Conveyor placement from stockpile land/water	CY		NA		
Imported Fill				Includes purchase, delivery and placement or as noted / described	
Select Fill	CY		2200	Imported select material to be placed in the marsh areas that will be over-excavated for removal of debris. Volume as based on the typical section identified in the report and the length of channels proposed in conceptual plan.	14.3.3
Gravel Borrow, including haul	CY		1550	WSDOT standard item. Estimated volume based on average assumed change in grade over the length of roadway improvement by the standard width for that roadway.	14.3.6
Sand / Gravel for Beach Nourishment	CY		NA		
Cobble for Shore Nourishment	CY		NA		
Embankment Compaction	CY		1550	WSDOT standard item	14.3.6
Topsoil	CY				
RESTORATION Features					
Channel Rehab / Creation	SF		8790	Channel construction (SF) including imported sediment and habitat materials, excluding excavation	143.3
Large Wood Placement	EA		NA		
Invasive Species Control	Acre		NA		
Physical Exclusion Devices	LF or EA		NA		
Other Restoration Features/ Activities	LS		NA		
Structures	EA				
Water Control Structures - Culverts with Gates	EA		NA		
Water Control Structures - Weirs	EA		NA		
Rock Slope Protection	LF		NA		
Other	EA		NA		
Elevated Boat Ramp	SF		NA		
Fencing	SF		NA		
Utilities				Replacement or relocation. Designer to provide size and material and have separate line item for each run. Incidentals include earthwork, testing, hook up fees, etc. These quantities do not include demolition of existing utilities, real estate / easement	
Water	LF		300	To be attached to structure. Estimated quantity is based on the length of bridge plus some allowance to transition and connect to existing.	14.3.6
Gas	LF		NA		
Electric	LF		NA		14.3.6
Sewer	LF		NA		
Fiber Optic Communications	LF		500	To be attached to structure. Estimated quantity is based on the length of bridge plus some allowance to transition and connect to existing.	14.3.6
Other	LF		NA		
Roadway / Railway					
Roadway	SF		24500	Roadway 8" ASPH w/ 8" Base Width of 32'. Area based on proposed limits of roadway improvement.	14.3.6
Roadway - Switch (potential)	LS		NA		
Culvert (type)	LF		NA		
Culvert - Jacking	LF		NA		
Culvert - Horizontal Pile Driving	LF		NA		
Bridge - Deck	SF		5880	Prestressed Precast Girder Bridge with 140' Spans	14.3.6
Bridge 1 - Foundation	LF		NA		
Railway - Box Girder	SF		NA		
Bridge - Foundation	LF		NA		
Railway - Shoe fly	LF		NA		
Permanent Access Features					

Partial Restoration Quantity Estimate

	Action Name:	Harper Estuary					
	Action #:						
	Date:	February 2011	Revised May 2012				
	By:	KPFF					
	REMEDY: increase tidal inundation to the Harper Estuary by replacing roadway fill of SE Olympiad Drive with a bridge						
	Construction Period: 9-11 months						
	Roads	Level		NA			
	Utility Access Routes	varies		NA			
	Erosion Control Features	AC		NA			
Public Access or Recreation Features							
	Trails	SF		NA			
	Bridges	SF		NA			
	Kiosk	EA		NA			
	Restrooms	EA		NA			
	Interpretive Signs	EA		NA			
	Parking Area	SF		NA			
	Other	EA		NA			
Vegetation & Erosion Control							
	Hydroseeding	AC					
	Planting	AC		0.1	Marine riparian vegetation		
	Vegetation Maintenance	AC-YR		0.5	Includes irrigation, weeding, plant replacement for five years		
	Erosion / sediment BMPs - Temp.	AC		3.5	Stabilized Construction Entrances, Sediment Ponds, Hydro Seed to Stabilize Roadway Embankments, Silt Fence Compost Berm. Area based on the footprint of likely disturbance.		14.3.7
	Erosion / sediment BMPs - Permanent	AC		NA			
	Waterside controls - Temporary	EA, LF, LS		NA			
Construction Management							
	Construction oversight	weeks		40	Quantity based on construction duration/ # of construction seasons		
	Materials testing						
Design and Detailed Site Investigations							
	Survey & Property, Utility Research	LS		1	% of construction cost		
	35% Design	LS		1	35% x 25% x Engineer's Estimate		
	65% design	LS		1	65% x 25% x Engineer's Estimate less the cost for 35% PS&E		
	90% design	LS		1	35% x 25% x Engineer's Estimate less the cost for 35% + 65%PS&E		
	100% design	LS		1	25% x Engineer's Estimate less previous costs		
	Geotechnical Studies			1	Refer to design report for description of need		
	Cultural Studies			1	Refer to design report for description of need		
	HTWR Studies						
Project Agreement Activities					Unable to provide credible estimate at 10% design		
Site-Specific Adaptive Management Features & Activities					List if known		
Monitoring Activities					Assume 5 crew-days/year for each monitoring parameter in design report for 5 yrs		
	Monitoring (Type)	crew-days		75			
Operations & Maintenance					Unable to provide credible estimate at 10% design		

15. JOHN'S CREEK ESTUARY RESTORATION PROJECT (#1447)

Local Proponent	Cascade Land Conservancy (CLC)
Delta Process Unit	NA
Shoreline Process Unit(s)	3092
Strategy(ies)	4 - Coastal Inlet
Restoration Objectives	Restore tidal flow, freshwater inflow and other processes that are needed to sustain a coastal inlet and deltaic tidal channel system

15.1 Description of the Action

The action includes removing intertidal and supratidal dikes; planting native vegetation; restoring tidal inundation and nearshore function to 2,400 feet of shoreline and 1,600 feet of stream; and conserving 27 acres of salt marsh habitat in the John's Creek Estuary. Please see the Introduction chapter for important information regarding PSNERP and for context related to this restoration project.

15.2 Action Area Description and Context

The action area, within Oakland Bay in the South Puget Sound Subbasin, includes the Shelton Bayshore Golf Club, an adjacent salt marsh to the west, and associated tidelands to the south. The Cascade Land Conservancy has expressed an interest in purchasing the golf course and salt marsh from the owners, Shelton Bayshore Golf Company and Bayshore Inc., respectively (Mason County 2009). The tidelands are primarily owned by commercial shellfish growers or are publicly owned by WDNR. Some tidelands just north of the dike are part of individual parcels within the Bay Vista residential community. The golf course and homes are built on the delta of a late Vashon glaciation meltwater stream. The delta is several feet higher than the surrounding areas of Oakland Bay; the golf course and homes are at elevations ranging from 15 to 40 feet (NAVD 88). The action area is shown in Figure 15-1.

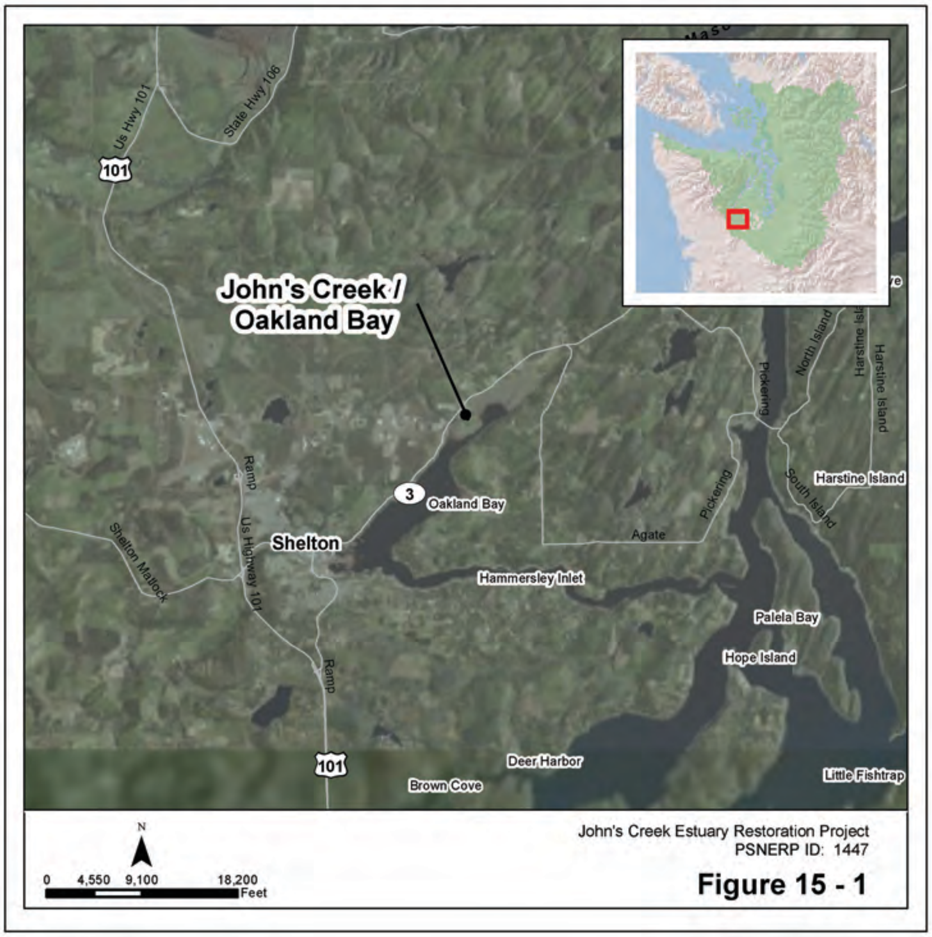

Figure 15-1. Action Area and Vicinity

15.2.1 Historic Condition

The area was an important source of Olympia oysters and other shellfish for the Squaxin Tribe and their ancestors. Portions of the current golf course were already cleared by settlers prior to the earliest identified map of the area (circa 1880). This map shows several structures near the mouth of John's Creek and in the area north of the existing golf course. The map also shows a dam (no longer present) across lower John's Creek about 500 feet downstream of State Route 3. In general, the historic locations of the shoreline, John's Creek, and the large salt marsh appear relatively similar to their current locations (Collins and Sheikh 2005). Therefore, it appears that only a small portion of the current golf course was historically a salt marsh. The level of detail on the available historic mapping (Figures 15-2A and 15-2B) is relatively coarse compared to other locations. For instance, tidal channels in the intertidal zone of John's Creek and Oakland Bay are not shown and do not provide a basis of comparison to the current diked intertidal creek channel.

15.2.2 Natural Environment

The golf course and Bay Vista residential community are built on the delta of a late Vashon glaciation meltwater stream that cut the channels, terminating into a glacial lake and forming clean, deltaic aggregate deposits (Polenz et al. 2010). These deposits were mapped as undifferentiated Vashon recessional outwash unit Qgo by Schasse and others (2003). The current stream—John's Creek—is much smaller than its Vashon glaciation predecessor that drained a much larger basin. John's Creek flows into Oakland Bay following the same general course as a historic stream, but it has eroded a smaller, slightly incised channel within that Vashon-era floodplain and outwash delta. This delta forms the demarcation between the extensive mudflat and tidal channel complex of upper Oakland Bay and the lower bay, which is generally subtidal. The eastern side of the site also includes an extensive salt marsh. A large and relatively deep tidal channel separates the delta from the eastern shore of Oakland Bay. The extensive tidal prism of upper Oakland Bay maintains this tidal channel.

15.2.3 Human Environment

The uplands of the site are dominated by a golf course and several single-family residences along the adjacent shore on the southwest side of the delta. The golf course has an irrigation system and the residences are served by typical utilities, such as water and power. There are two bridges over lower John's Creek—one at State Route 3 and another smaller bridge that serves the golf course and the Bay Vista community. Small amounts of rock riprap have been used to stabilize the channel in some locations through the golf course.

An intertidal dike is used to divert fresh water around shellfish beds owned by Taylor United Incorporated and others. The dike is about 1,500 feet long and varies in cross section. The cross sectional dimensions could not be estimated due to tidal elevation at the time of the site visit.

At least two supratidal dikes have been constructed just above MHHW along the edge of the golf course. These are located near the head of tidal channels and are likely intended to prevent tidal flooding of the golf course. These features are relatively small, about 5 feet high, 20 feet wide (at grade), and 100 feet long.

The action area is in private ownership. Currently, the Cascade Land Conservancy is in negotiation to purchase the golf course and salt marsh portions of the action area (this does not include the private residential parcels, private tidelands or state owned tidelands that are currently leased).

15.3 Restoration Design Concept

15.3.1 Restoration Overview and Key Design Assumptions

Dikes inhibit the free flow of tidal and fluvial water across the site, and impact the natural geomorphic processes that are responsible for creating and maintaining nearshore habitat. Removal of these dikes will likely have a significant impact on the shellfish production of the area, but will allow for natural transport of sediment and freshwater inputs across the intertidal portion of the John's Creek delta.

The proponents of this action see it largely as a nearshore upland restoration project, and consider acquisition of the site important to an overall conservation strategy for Oakland Bay. That strategy includes acquisition, restoration, and conservation of several other sites and has been largely successful to date. The principal opportunity for process-based restoration, however, lies in the removal of an intertidal dike (at a different location than the supratidal dikes) that is maintained to prevent fresh water from John's Creek from flowing across commercial clam beds. This differs significantly from the proponent's description in terms of the location and type of action.

This restoration requires property acquisition and cooperation from private landowners, resource agencies, and tideland leaseholders. WDFW manages shellfish harvest on tidelands, including those owned and leased to commercial shellfish operations by WDNR. The proposed restoration may be in conflict with current management of tidelands within the action area for shellfish aquaculture.

The restoration alternatives are illustrated in Figures 15-3 through 15-6. The full restoration alternative maximizes the width of the initial channel migration zone by creating new channels that fan out radially from the mouth of the creek. The primary constraint to process restoration is the potential impact on shellfish harvest from the migration of the restored channel. The partial restoration alternative does not include a new channel that flows to the southwest, initially limiting the anticipated channel migration zone. The removal of primary stressors (in this case intertidal dikes) makes it likely that over the long term (50 years), the outcome in terms of channel location would be similar for both alternatives. The full restoration alternative also includes more extensive restoration of the golf course fringing the shoreline and existing salt marsh.

The full restoration alternative would remove all artificial channel confinements, including the intertidal dike and modified channel (Figure 15-3). This amounts to removal of a tidal barrier that can also act—in a limited fashion—as a jetty. Removing the small dikes along the edge of the golf course would remove another tidal barrier and allow for the extension of some existing tidal channels. These dikes also constitute nearshore fill that alters processes and displaces vegetation communities. Other secondary stressors include land cover development in terms of the golf course and shoreline homes.

Channel reconstruction for this project is not proposed to fully connect the entire intertidal area. It is assumed that once the initial channels are excavated and stressors are removed, natural channel formation will occur in appropriate areas through the processes of sediment erosion, transport, and deposition.

These restoration actions would eliminate primary stressors on sediment transport, erosion/accretion of sediment, tidal flow, tidal channel formation and maintenance, freshwater input, exchange of aquatic organisms, and detritus import and export. Anticipated structural responses include a decrease in localized coarse sediment associated with the excavated channel, and an increase in the number and total area of tidal channels.

Table 15-1 summarizes key design elements associated with the full and partial restoration alternatives.

Table 15-1. Key Design Elements

Element	Full Restoration	Partial Restoration
John's Creek Intertidal Dike	Full removal; except as needed to prevent channel migration into residential areas	Partial removal to allow stream to meander freely to the south and east, but some restriction on migration toward homes and private tidelands to the west
Intertidal Channels	Restore tidal channels to create a wide deltaic fan of braided channels	Restore tidal channels within a more defined corridor

Element	Full Restoration	Partial Restoration
Supratidal Dike Along Golf Course	Full removal	Partial removal
Tidal Channels in Salt Marsh	Restore channels within areas of the existing golf course low enough to support salt marsh vegetation	None
Marsh Vegetation	Restore vegetation in all areas low enough to support salt marsh vegetation	Same as full restoration
Riparian Vegetation	Restore vegetation that supports nearshore habitat	Same as full restoration

15.3.2 Restoration Features – Primary Process-Based Management Measures

Armor Removal/Modification - NA

Berm or Dike Removal/Modification

Both of the alternatives include removal of the intertidal dike that was constructed to divert fresh water around shellfish beds (Figures 15-5A and 15-6A). The dike was constructed by excavating gravels from the channel and placing them to divert the flow of John's Creek, first to the southwest and then due west. Removal of the dike and channel could be accomplished by placing the dike material back into the excavated channel from which it was dredged until the grade matches the existing slope and contour of the surrounding tideflat. It is assumed that no excess material would be exported and that no additional material would be imported to restore grades. An additional survey will be required to determine if a net import or export is required. Over time, fine-grained sediments would be expected to fill in between any exposed gravels.

A small dike west of the channel at about elevation 7 feet (NAVD 88) would also be removed in the full restoration alternative. This dike appears to have limited effect on the course of the channels as it is located on the inside of a bend in the main channel of the creek. Both alternatives include complete removal of the larger dike (east and south of the John's Creek channel) estimated at 4,125 CY. Removal of the second, smaller dike on the other side of John's Creek (west of the John's Creek channel) is estimated at 1,010 CY. It is assumed that the excavated material will be used to fill the existing excavated channel to match the surrounding grade.

Both of the alternatives include removal of some or all of the supratidal dike along most of the boundary between the golf course and the salt marsh (Figures 15-6B and 15-7B). This structure appears to be intended to keep salt water off the golf course during extremely high tides. It also blocks the head of a few of the larger tidal channels through the marsh. Removing the dike would allow expansion of the salt-tolerant vegetation community. The dike is estimated to include about 1,100 CY of material that could be placed further upland on the site.

Channel Rehabilitation/Creation

The goal of the channel restoration around the mouth of John's Creek is to minimize the relict effects of the existing dike-supported single channel on future channel formation and migration. In the full restoration alternative, a series of braided channels will be created to allow delta-forming processes of deposition and erosion to affect the maximum area possible. In the partial restoration alternative, these channels are more limited in number and include leaving some of the existing channel in place; over time channels may form across generally the same areas.

The goal of the dike removal around the golf course is to allow the full tidal inundation of the area, and tidal channel formation is a likely result of the increase in intertidal area. Under both alternatives, it is assumed that the golf course will be abandoned and that additional tidal inundation of some areas will not interfere with complementary upland restoration efforts by the project sponsor. Under the full restoration alternative, the tidal channels would be restored to the extent warranted by the topography. Under the partial restoration alternative, areas of fill would be removed, where apparent, but the existing tidal channels would not generally be extended with restored or created channels.

Groin Removal/Modification - NA

Hydraulic Modification - NA

Overwater Structure Removal - NA

Topography Restoration

In the case of the full restoration alternative, an estimated 1,610 CY will be used to fill all existing dredged channels of John's Creek across the intertidal zone (these areas are also currently confined by intertidal diking). In the partial restoration alternative, 1,260 CY would be used to fill the upper portion of the dredged channel and disconnect the lower channels from the creek. It is assumed that the rest of the dredged channel would fill in naturally over time.

Under both restoration alternatives, areas of fill around the golf course would be restored to varying degrees. A site reconnaissance and review of LiDAR topography did not reveal extensive areas of likely fill. It is possible that some areas near the outer edge of the golf course have been raised slightly; these areas should be regraded to match the overall slope of the surrounding Vashon glaciation deposits. Material could be placed elsewhere on the golf course (e.g., in sand traps) prior to upland restoration planned by the local proponent.

15.3.3 Restoration Features – Additional Management Measures

Beach Nourishment - NA

Contaminant Removal/Remediation - NA

Debris Removal - NA

Invasive Species Control - NA

Large Wood Placement - NA

Physical Exclusion - NA

Pollution Control - NA

Revegetation

Most of the action area that is at an elevation appropriate to support salt marsh vegetation is already well vegetated with species native and common to Puget Sound salt marshes. Possible exceptions are some low-lying areas of the golf course that no longer receive regular tidal inundation by salt water due to the presence of the supratidal dike. These areas should be restored and as necessary replanted with salt-tolerant vegetation.

Much of the riparian area within the action area has a mix of mature widely spaced trees (mostly native species), but it is generally devoid of other vegetation aside from mowed turf grasses. These areas would be extensively revegetated to develop a closed canopy and multi-layered understory using a mix of typical Puget Sound shoreline riparian species for a minimum of 25 feet from the limit of marsh vegetation.

Separate from the nearshore project, Puget Sound prairie species will be restored to the former golf course by the proponent. A total of 6.2 acres of vegetation would be restored as part of this project. The local proponent would likely work to restore other upland and riparian areas.

Reintroduction of Native Animals - NA

Substrate Modification- NA

Species Habitat Enhancement - NA

15.3.4 Restoration Features – Other

NA.

15.3.5 Land Requirements

The project proponent and partners are already in discussion with the owners of the Shelton Bayshore Golf Company and Bayshore Inc. for the purchase of the two largest parcels (50 acres and 25 acres, respectively) in the action area. Areas where construction would take place also include tidelands that are privately owned or publicly owned and leased. These lands are actively managed for shellfish aquaculture. These areas comprise about 50 acres of private land. Under the full restoration alternative, the commercial viability of aquaculture in these 50 acres (and other public lands) could be adversely impacted by channel migration. Under the partial restoration alternative, there is no guarantee that over time the channel would not cross the entire area, but that alternative is intended to limit meander to the eastern two-thirds of the delta and would likely impact less than 30 acres of private tidelands in use for aquaculture. The total land requirement (private) for the full restoration alternative is 125 acres, and the requirement for the partial restoration alternative is 107 acres.

The dike may be located on both public and private tidelands. If the dike were removed, determination of ownership would be required.

15.3.6 Design Considerations

Most of the tidelands in the vicinity are privately owned and used for shellfish production and harvest. Removal or modification of the intertidal dike and formation of multiple channels may have negative impacts on shellfish harvest by introducing fresh water and higher nutrient loads to the shellfish beds, and allowing channel migration through and erosion of the shellfish beds. Therefore, removal of the intertidal dikes should only occur in areas where there are public tidelands, or where private tidelands are acquired.

WDFW shellfish managers have raised concerns about restoration of the John's Creek Estuary and its potential impact on shellfish resources in the action area, including potential impacts to Tribal and recreational shellfish use and resources (WDFW 2010). Portions of this area are currently under "single-entity" shellfish management by the Squaxin Tribe, and this management authority is expected to be extended by agreement through 2021.

15.3.7 Construction Considerations

Most of the earthwork would be done with low-ground-pressure equipment such as a tracked excavator during low tides. A temporary diversion of John's Creek would be necessary during some of the work to limit sediment loading of the adjacent waters. Earthwork would be limited to low tide hours, most likely during the summer, and may only be feasible during certain tidal cycles. Construction access is good, with multiple alternatives for temporary haul routes. Construction is anticipated to last 3 months for partial restoration and 4 months for the full restoration alternative. Property acquisition is already underway and could be complete prior to project planning. Design and permitting, including discussions with tideland owners and other aquaculture interests, is expected to take 1 to 2 years. No utilities are known that would be affected other than the irrigation system for the golf course, which could be repurposed as a temporary irrigation system for the riparian plantings.

15.4 Extent of Stressor Removal

Table 15-2 describes the amount of stressors to be removed with this action.

Table 15-2. Stressor Removal

Stressor	Full Restoration	Partial Restoration
Tidal Barrier (LF)	1,610	1,260
Fill (acres)	2.42	1.86
Breakwaters & Jetties (LF)	1,260[1]	1,260[1]

1) The intertidal dike acts as a jetty across various portions of its length at tidal ranges above about 3 3 feet MLLW, but due to the slope of the dike, the entire length does not act as a jetty at any one tidal stage.

15.5 Expected Evolution of the Action Area

The distributary channels across the intertidal areas near the mouth of John's Creek will continue to migrate, erode, and accrete as part of normal delta-forming processes. Processes beneficially impacted by the removal of these stressors include: sediment supply and transport, distributary channel migration, dispersed freshwater input and mixing across the delta, and restored exposure to wind and waves.

The removal of the supratidal dike provides an excellent opportunity to restore the natural resiliency of the salt marsh to sea level rise. The topography of the Vashon glaciation delta provides a broad, undeveloped area onto which the salt marsh vegetation can migrate inland and upward as sea level rises. This resiliency will limit losses of processes supported by tidal wetlands including: erosion and accretion of sediments, tidal channel formation and maintenance, detritus import and export, and the exchange of aquatic organisms.

Both the partial and full restoration alternatives will result in similar responses after 50 years, assuming that the identified stressors, which inhibit tidal flow and natural channel migration, are not reintroduced within that timeframe.

15.6 Uncertainties and Risks

The site has documented historical and archeological resources; therefore, a cultural resources assessment of the area of potential effect is warranted. There are no known sources of environmental contamination associated with the action area. An avulsion of John's Creek upstream of the mouth could result in redirection of the stream and could threaten residences. Such an event would not likely be related to the restoration, but could result in the installation of new dikes or levees to manage the flood risk. Allowing the mouth and lower reaches of John's Creek to meander could, but is not likely to, adversely impact adjacent residential properties. The channel is well defined, somewhat incised within a larger floodplain, and unlikely to migrate rapidly.

15.6.1 Risks Associated with Projected Sea Level Change

Projected sea level rise over the next 50 years would likely have three significant effects on the project. First, the increased tidal backwater effects on John's Creek would increase the risk of an avulsion of the creek through the residences on the shoreline when high flows back up against extremely high tides. Erosion of the streambank is already occurring in one particularly susceptible area.

Second, sea level rise could outpace the rate of sedimentation at the existing salt marsh. This would be mitigated—to a degree—if and when the golf course is removed, so that the marsh could "retreat" to higher elevations as sea level rises. Some grading to remove additional upland fill placed for the golf course may be needed to support this "retreat" across areas where the grade slopes up more steeply from the marsh. Areas around the golf course exhibit a low (1 meter) scarp, where waves at very high tides likely erode the Vashon glaciation delta formation that underlies the salt marsh. This process would accelerate, creating more area suitable for salt marsh vegetation west of the existing salt marsh. At the same time, greater tidal prism at the head of Oakland Bay would increase the force and velocity of water moving through the constriction caused by the Vashon glaciation delta. This would cause an increase in the rate of erosion of the lower fringe of the salt marsh.

Third, the increased inundation by tides would lead to an increased rate of migration of tidal channels due to increased influence of tidal flow, currents, and waves.

Table 15-3 provides a qualitative comparison of potential risks associated with projected sea level changes.

Table 15-3. Risks of Sea Level Change

	Projected Sea Level Change		
	High (65cm)	**Intermediate (21cm)**	**Low (13cm)**
Full Restoration	Increased risk of avulsion of John's Creek threatening homes. Salt marsh would likely be significantly eroded at lower elevations and replace upland non-halophytic vegetation in areas above the existing salt marsh. Increased migration of upper intertidal channels.	Minor increased risk of avulsion of John's Creek threatening homes. Salt marsh would likely be eroded at lower elevations and extend into higher areas.	Minor migration upward (west) of area dominated by salt marsh vegetation.
Partial Restoration	Increased risk of avulsion of John's Creek threatening homes. Salt marsh would likely be eroded at lower elevations and extend into higher areas. Increased migration of upper intertidal channels within confines of remaining dike.	Minor increased risk of avulsion of John's Creek threatening homes. Salt marsh would likely be eroded at lower elevations and extend into higher areas.	Minor migration upward (west) of area dominated by salt marsh vegetation.

15.7 Potential Monitoring Opportunities

Monitoring of John's Creek Estuary is important for evaluating the success of the restoration. A combination of field surveys and aerial photographs would be used to document biological and physical changes to the landscape. Monitoring data can be used to refine adaptive management and corrective actions, as needed. Some of the key performance indicators are shown in Table 15-4.

Table 15-4. Monitoring Needs and Opportunities

Monitoring Parameter	Key Performance Indicator	Note
Topographic Stability	X	Monitor shorelines adjacent to private property to ensure there are no negative impacts due to restoration activities
Sediment Accretion / Erosion	X	Same as topographic stability
Wood Accumulation		
Soil / Substrate Conditions		
Vegetation Establishment	X	Evaluate health of native plantings
Marsh Surface Evolution / Accretion	X	Evaluate changes in marsh
Tidal Channel Cross-Section / Density	X	Evaluate changes in tidal channels
Water Quality (contaminants)		
Salinity	X	Monitor salinity/temperature in the estuary
Shellfish Production	X	Monitor shellfish production
Extent of Invasive Species		
Animal Species Richness		
Fish (salmonid) Access/Use	X	Monitor salmonid use
Forage Fish Production	X	Monitor forage fish production
Wildlife Species Use		
Effectiveness of Exclusion Devices		

15.8 Information Needed for Subsequent Design

This conceptual design report represents an initial step in the restoration design sequence. The design concepts described above were developed based on readily available information without the level of site-specific survey and investigation that is necessary to support subsequent design and implementation. Substantial additional information will be required at the preliminary and later design stages to confirm the design assumptions, refine quantity estimates, address property and regulatory issues, obtain stakeholder support, and fill in data gaps.

Refinements for later design include defining the extent of dike removal in the intertidal and supratidal areas, and restoration actions for bordering areas that include land cover development stressors (shoreline homes and the golf course). For partial restoration, subsequent design will define the extent of intertidal dike removal and distributary channel formation. The extent to which this information is collected for preliminary design (or a later design stage) will depend upon the available budget, schedule, and other factors. This section attempts to define the most essential information needs for this action. Refer to the Introduction chapter for additional information.

- Property Investigation/Survey – More detailed information on parcel ownership, property boundary location, and utilities may be needed to finalize the design, confirm acquisition requirements, and support negotiations with property owners. If not readily available, a detailed survey to determine land ownership is likely required.
- Topographic/Bathymetric Survey – The survey data would be used to refine design of key project elements and develop detailed construction and demolition plans. Survey data could also be used as a baseline for pre- and post-construction modeling, including hydrodynamic modeling. A temporary tide gage may be required in the early design stages to obtain site-specific tidal statistics.
- Cultural Resources Investigation – Surveys for archaeological and historic resources may be required for this action area, as it has a high likelihood of having past use by Native Americans. This is particularly important in areas proposed for excavation and trenching. An historic bridge that crossed John's Creek and has been removed would be included in this investigation.
- Hydraulic Analysis – A study of the flows of John's Creek and the risk of avulsion of the channel upstream of the proposed dike construction may be warranted.
- Contaminant Survey – If preliminary investigations suggest that hazardous material could be present in the action area, additional soil and sediment analysis may be needed. The introductory chapter describes the Phase I site investigations that are occurring as part of this overall effort via a separate contract.
- Geotechnical Study - A characterization of the physical and chemical characteristics of onsite materials to be excavated or moved including the dikes, stream bed, and tide flats would be required to minimize the risk of creating a turbid plume or exposing or spreading contaminated materials.

15.9 Quantity Estimates

The design quantities are largely developed from LiDAR data sets lacking the resolution to accurately quantify all elements of construction. These are supplemented by unmeasured estimates made during one site visit at high tide and areal take-offs from available imagery. The quantities for both alternatives are provided in Exhibits 15-1 and 15-2.

15.10 References

Anchor Environmental. 2002. *Oakland Bay and Hammersley Inlet Nearshore Habitat Assessment.* Prepared for the Squaxin Island Tribe and Taylor United Shellfish. February 2002.

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Polenz, M., T.A. Contreras, J.L. Czajkowski, G.L. Paulin, B.A. Miller, M.E. Martin, T.J. Walsh, R.L. Logan, R.J. Carson, C.N. Johnson, R.H. Skov, S.A. Mahan, and C.R. Cohan. 2010. Supplement to Geologic Maps of the Lilliwaup, Skokomish Valley, and Union 7.5-minute Quadrangles, Mason County, Washington— Geologic Setting and Development Around the Great Bend of Hood Canal. Washington Division of Geology and Earth Resources, Open File Report June 5, 2010.

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0 500
Feet
0 150
Meters

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64

WDFW Contract # 100-000204 (CAPS No. 10-1461)

Historic Map (T-Sheet)

Action Name: John's Creek Estuary Restoration Project

PSNERP ID #: 1447

Figure 15- 2A

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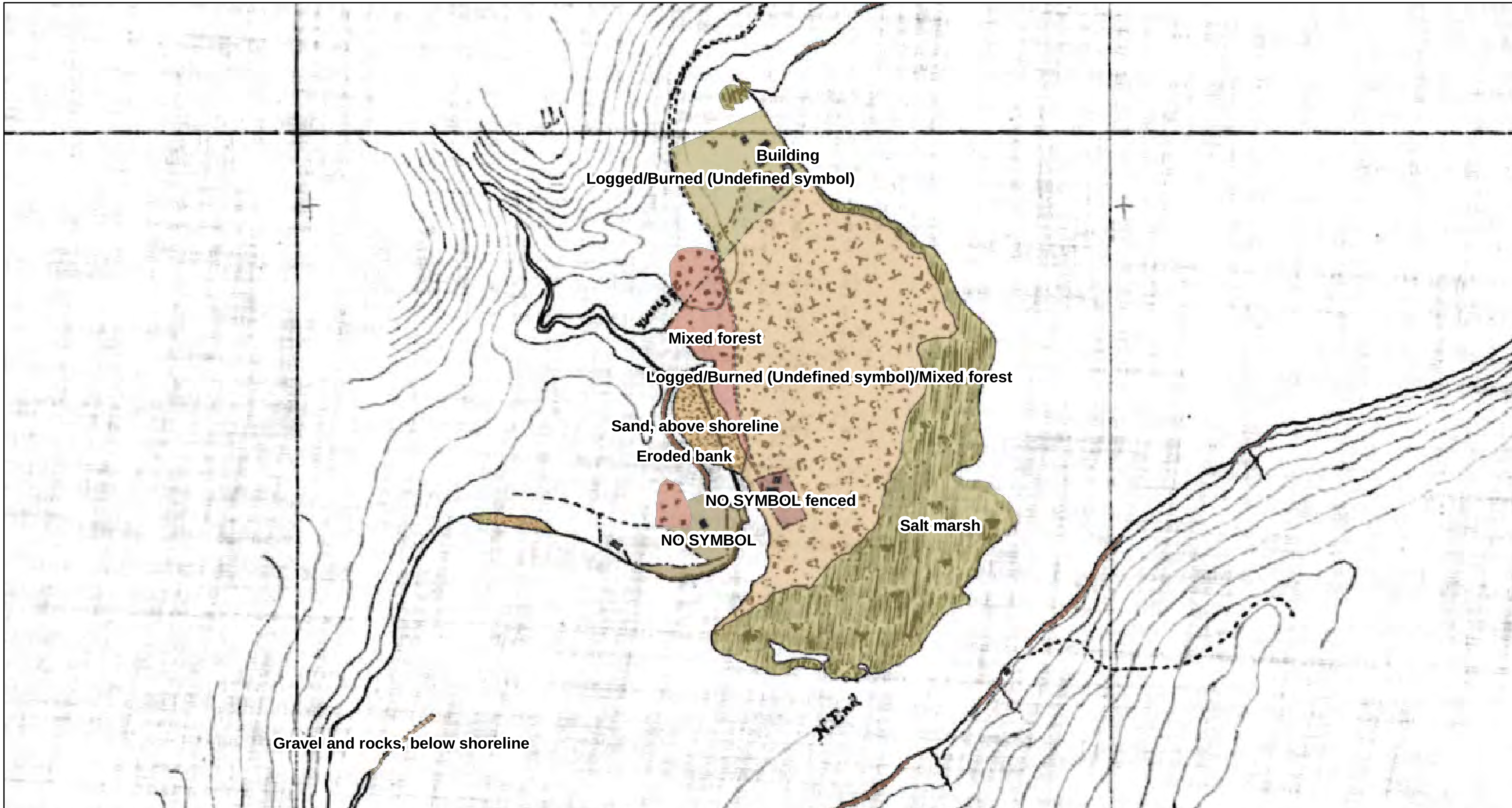

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64

WDFW Contract # 100-000204 (CAPS No. 10-1461)

Historic Map (T-Sheet) and River History Project Data

Action Name: John's Creek Estuary Restoration Project

PSNERP ID #: 1447

Figure 15- 2B

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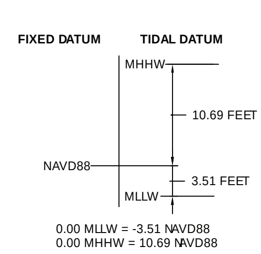
Legend

- Existing MHHW (10.69 ft)
- Proposed MHHW (10.69 ft)
- Existing MLLW (-3.51 ft)
- Channel Rehab/Creation
- Native Channel Development
- Section Lines
- 5ft Contour
- Excavation - Lowland
- Planting
- Fill from Lowland Excavation
- Required Project Lands



North

0 450
Feet

SOURCE: Washington Public Lands Database (2006); Washington Counties Parcels (2009)

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64

WDFW Contract # 100-000204 (CAPS No. 10-1461)

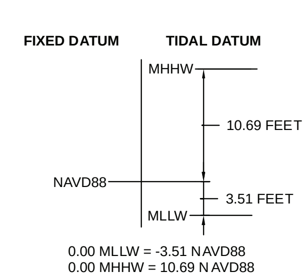
Lead Contractor: ESA
Design Lead: Anchor QEA, John Small
Date: 02/18/2010

Conceptual Design Plan
Site Name: John's Creek
Action Name: John's Creek Estuary Restoration Project
PSNERP ID #: 1447
Full Restoration

Figure 15-3

Legend

- Existing MHHW (10.69 ft)
- Proposed MHHW
- Existing MLLW (-3.51 ft)
- Channel Rehab/Creation
- Native Channel Development
- Section Lines
- 5ft Contour
- Excavation - Lowland
- Planting
- Fill from Lowland Excavation
- Required Project Lands



North

0 450
Feet

PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

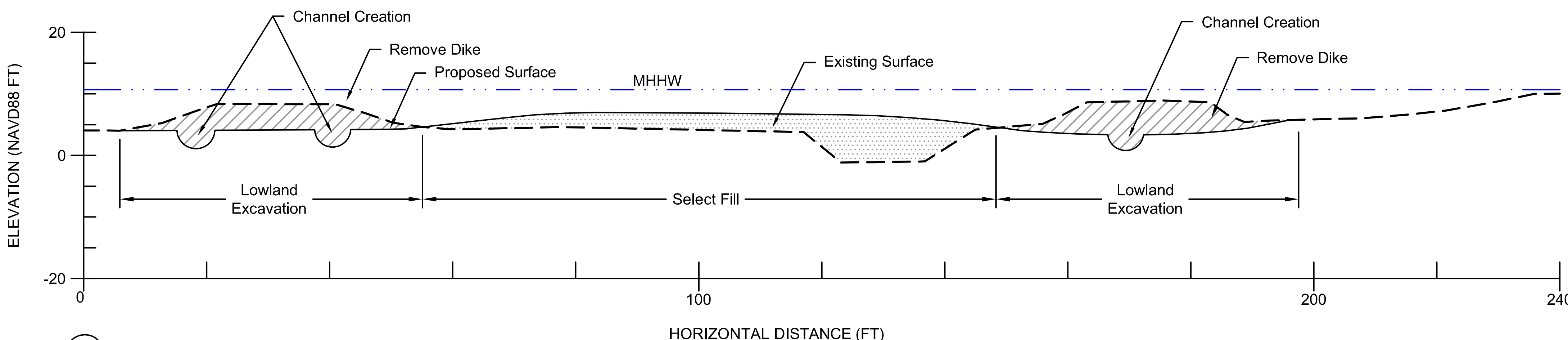
SOURCE: Washington Public Lands Database (2006);
Washington Counties Parcels (2009); Action Area (PSNERP, 2010)

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

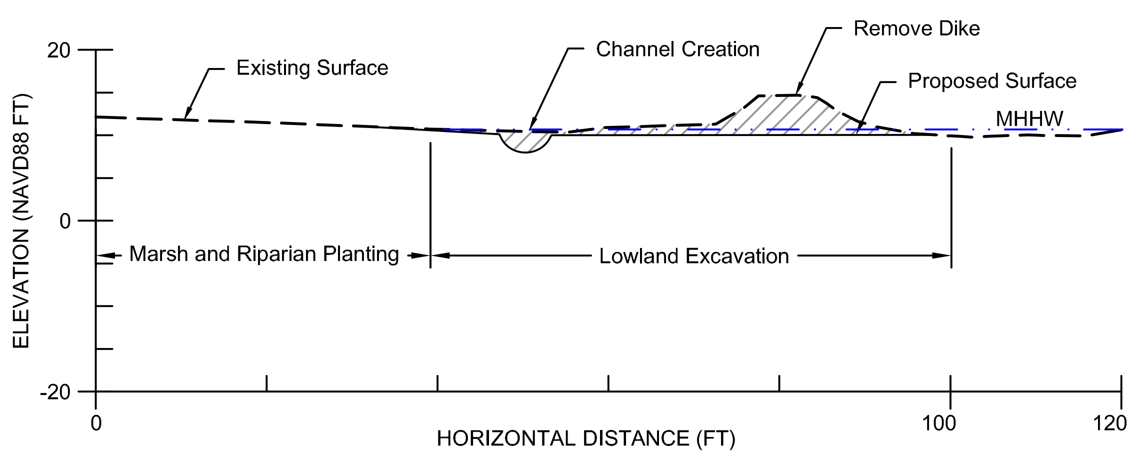
Conceptual Design Plan
Site Name: John's Creek
Action Name: John's Creek Estuary Restoration Project
PSNERP ID #:1447
Partial Restoration

Lead Contractor: ESA
Design Lead: Anchor QEA, John Small
Date: 02/16/2010

Figure 15-4

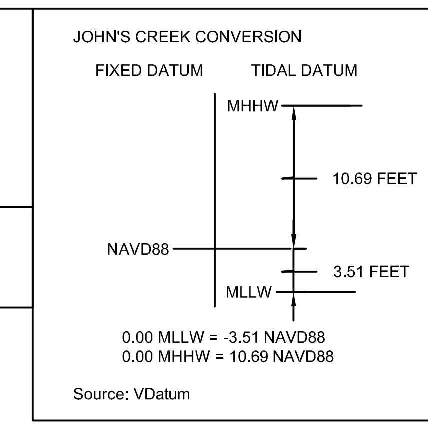


Ⓐ FULL RESTORATION TYPICAL SECTION



Ⓑ FULL RESTORATION TYPICAL SECTION

EXISTING GRADE HATCH	PROPOSED GRADE HATCH
BEACH	CUT
OTHER	FILL
EXISTING GRADE	PROPOSED GRADE



0 20
Scale in Feet

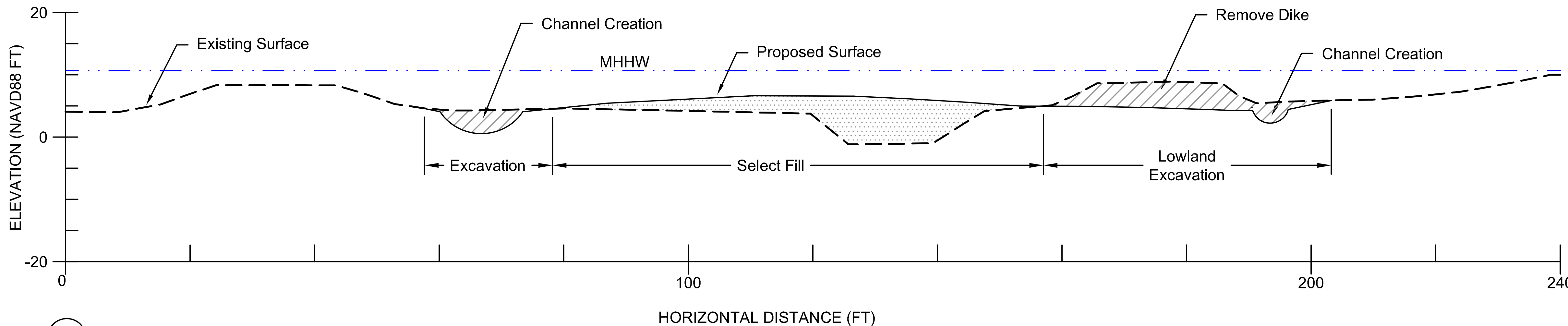
PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: Anchor
Date: 3/2011

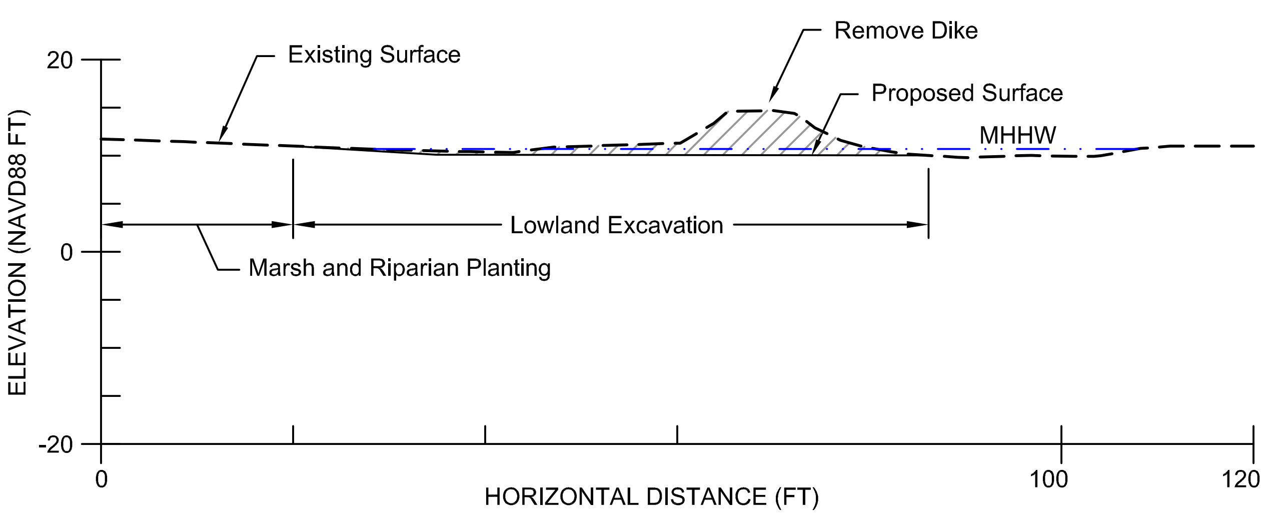
Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Section
SITE NAME: **Oakland Bay**
ACTION NAME: **John's Creek Estuary Restoration Project**
PSNERP ID#: **1447**
Full Restoration

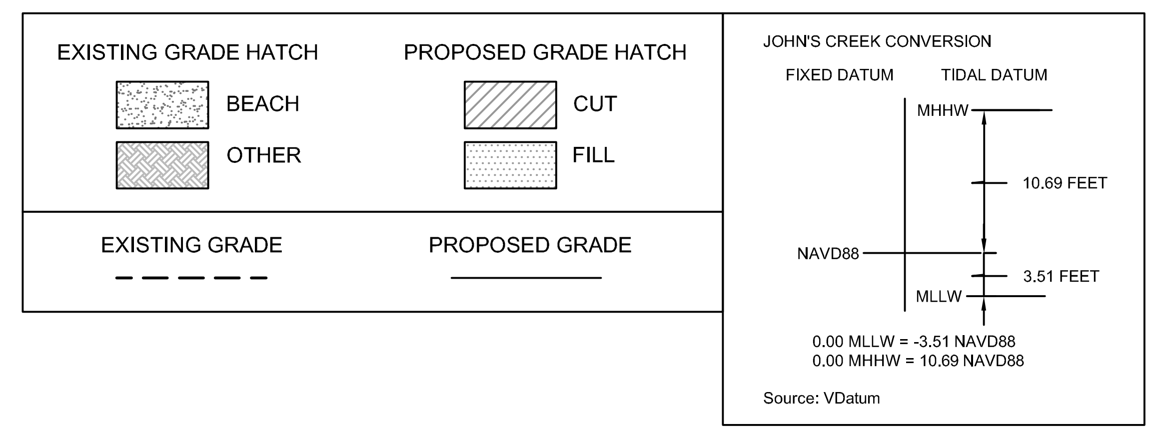
Figure 15-5

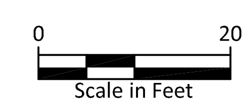


(A) PARTIAL RESTORATION TYPICAL SECTION



(B) PARTIAL RESTORATION TYPICAL SECTION





PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: Anchor
Date: 3/2011

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Section
SITE NAME: **Oakland Bay**
ACTION NAME: **John's Creek Estuary Restoration Project**
PSNERP ID#: **1447**
Partial Restoration

Figure 15-6

Full Restoration Quantity Estimate

Action Name:	John's Creek
Action #:	1447
Date:	February 2011
By:	John Small

REMEDY: *Dike removal, channel construction, restoration of vegetation*
Construction Period: 4 months, In water work 6 weeks

Item	Unit of Measure	Material Name	Qty	Description of Item	Indicate section of design report where item is described
ACQUISITION AND CONSERVATION					
Required Project Lands	Acre		124	Privately owned land only, project would also require changes to public land leased for aquaculture	1.3.5
Proponent / Partner-owned lands	Acre		0	Proponent is currently working to acquire the golf course and salt marsh	
Lands To Be Acquired	Acre		124		1.3.5
Material Sites					
MOBILIZATION AND ACCESS for construction activities					
Mobilization - Typical (Equipment, Personnel, Planning, Financial)	LS		1	Up front costs such as bonding, planning and other staff time and financing. Typically, assume 8% to 10% of other items.	1.3.7
Mobilization - Remote (Equipment, Personnel, Planning, Financial)	LS		0	Up front cost for nontypical or remote locations. Assume 12% of other items	
Site Access	LS		0	NA	
Barge Access	Days		0	NA	
Temporary Traffic Control (one of the following)				Includes installation of traffic signals, signage, signmen, etc. There are 4 types as follows:	
none	LS		0	No traffic control required	
signs	LS			Signs = signs only, costs typically around 1% of total roadway costs	
flags / spotters	LS			Flags and spotters = signs plus entails a greater level of effort. Describe the duration of this activity. This can be about 3% of total roadway costs.	
unique	LS			Unique = Greater effort than flags / spotters. Describe as basis for cost estimate.	
Temporary Roadway	SF			Includes construction of temporary adjacent roadway or bypass roadways and for vehicle and pedestrian travel through or around site.	
Control of Water	LS		1	Temporary diversion of John's creek to allow grading in the dry, pumped diversion unlikely.	1.3.7
Relocation Activities					
Site Demolition Activities					
Clearing and Grubbing (one or more of following)					
Clear Vegetation - Local Disposal	AC		0	NA	
Clear /Grub Vegetation - Local Disposal	AC		8.8	Strip turf	1.3.2
Clear /Grub Vegetation - Offsite Disposal	AC		0	NA	
Clear, stockpile - large woody debris	CY		0	NA	
Hydraulic Structures - Small	LS		0	NA	
Hydraulic Structures - Large	LS			Dam removal (describe and state whether this item includes water control and sediment removal or these are in separate items)	
Utilities	LS or LF				
Buildings	LS or SF				
Pavement	LS or SF				
Bulkheads	LF or SF			Use this for bulkheads…if large and difficult, consider using Large Coastal Structures.	
Rock revetments	LF, Ton or CY				
Large Coastal Structures	LF, SF or CY			Use this item for breakwaters, jetties, groins, reinforced concrete seawalls and any structure that requires larger equipment and power to break up and or remove	
Demolition / Removal - Bridge	SF or CY			Use this item for structures that require cranes or other special removal staging	
Removal - Misc. (e.g. angular rock from beach)	Ton			For loose rock scattered across intertidal.	
Demolition / Removal - Boat Ramp	SF			This is a special item but happens at least once…others can also be added as needed.	
Haul - Offsite Disposal of Demolition Debris	Miles			Estimate distance (to nearest 10 miles) to disposal site for materials, veg clear and grub, etc.	
Hazardous/Contaminated Waste Removal					
Contaminated Earthwork	CY		0	Excavation, off haul and disposal within a licensed landfill, complete	
Hazardous Earthwork	CY		0	Excavation, off haul and disposal within a licensed hazardous waste landfill, complete	
Construct Temporary Features					
EARTHWORK					
Excavation	CY			Per yard excavation w/out expected haul	
Excavation - Upland	CY		1100	Tracked excavator and standard dump truck (on or off hwy.)	1.3.2
Excavation - Lowland	CY	Remove Dike	1610	Requires low ground pressure equipment and or mats; low production bucket methods, typically hydraulic excavator and front end loaders. Tracked hauling equipment (Morooka)	1.3.2
Dredging - Bucket - Land	CY		0	NA	
Dredging - Bucket - Marine	CY		0	NA	
Dredging - Hydraulic	CY			Hydraulic cutter / suction dredge to slurry and pump sediments	
Fine Grading	AC		4.27	Small tolerance grading after rough grading in all areas subject to excavation except channels	1.3.2
Fill Placement - local borrow					
Side cast	CY	Existing Cha	2710	Excavated material placed within reach of excavator / dredge - assume includes some shaping by bucket	
Haul - uncontrolled placement	CY			Transportation and second handling - estimate distance.	
Haul, place, compact	CY			Transportation and second handling - estimate distance, placement in lifts, moisture conditioning, compaction testing.	
Stockpile - uncontrolled placement	CY			Intermediate step, for subsequent off haul or use elsewhere on site.	
Stockpile - controlled placement	CY			intermediate step, for subsequent off haul or use elsewhere on site. Can use this for drying material for subsequent controlled compacted fill	
Conveyor placement from stockpile land/water	CY		0	Some projects may require conveyor placement	
Imported Fill				Includes purchase, delivery and placement or as noted / described	
Select Fill	CY		0	Imported select material - describe use, e.g. levee, root base mix, etc;	
Gravel Borrow, including haul	CY		0	WSDOT standard item	
Sand / Gravel for Beach Nourishment	CY			special borrow and sorting required; identify material source	
Cobble for Shore Nourishment	CY			special borrow and sorting required; identify material source	
Embankment Compaction	CY			WSDOT standard item	
Topsoil	CY		3555	assumes 3" in planted areas	
RESTORATION Features					
Channel Rehab / Creation	SF		7231	Channel construction (SF) including imported sediment and habitat materials, excluding excavation	1.3.3
Large Wood Placement	EA		0	Per each log, Including drift logs, lower river log jams, etc.	
Invasive Species Control	Acre			Per acre control described in drawings and narrative	
Physical Exclusion Devices	LF or EA		0	Human or wildlife exclusions including fences, barriers, mooring buoys, etc	
Other Restoration Features/ Activities	LS		0	Describe other items not included elsewhere	
Structures	EA				
Water Control Structures - Culverts with Gates	EA			Describe type, number of openings (e.g. pipes), expected materials, dimensions	
Water Control Structures - Weirs	EA			Describe, length, type, anticipated materials	
Rock Slope Protection	LF			Describe slope, rock size, layering, use of fabric, back up quantities per foot.	
Other	EA			NA	
Elevated Boat Ramp	SF			Pile or pier supported to allow sediment drift	
Fencing	SF			Describe, type, height etc.	
Utilities					
Water	LF			NA	
Gas	LF			NA	
Electric	LF			NA	
Sewer	LF			NA	
Telecommunications	LF			NA	
Other	LF			Others = whatever is required (e.g.. power towers, petroleum, jet fuel, etc.)	
Roadway / Railway					
Roadway (Type)	SF			Typical roadway, not including earthwork and temporary or permanent traffic controls. Provide a description. Assume a standard pavement section or describe if special section anticipated.• Pavement• Base Course• Storm Drainage Collection and Conveyance (incl. trenching, backfill, etc.)• Stormwater Treatment	
Roadway - Traffic Signal	LS			Street lights, etc. (Temporary traffic control handled under Temporary Facilities)	
Culvert (type)	LF			Provide specific culver size and type	
Culvert - Jacking	LF			Through railway	
Culvert - Horizontal Pile Driving	LF			Through railway	
Bridge - Deck and appurtenances	SF				
Bridge - Foundations, Deck and Appurtenances	SF			Include elements such as approach slab, abutment, barriers, railings, etc. to conform to one of three or four types to be developed	
Railway - Box Girder	SF			Standard	
Railway - Foundation	LF			Standard	
Railway - Shoe fly	LF			Temporary alignment	
Permanent Access Features					
Roads	Level			Level 1 direct access, Level 2 moderately difficult, Level 3 difficult access	
Utility Access Routes	varies			NA	
Erosion Control Features	L.F.			NA	
Public Access or Recreation Features					
Trails	SF			NA	
Bridges	SF			Describe bridge feature, such as wooden pedestrian, or H20 vehicle.	
Kiosk	EA			Describe kiosk feature, such as size, material.	
Restrooms	EA			Describe restroom feature, such as size, material.	
Interpretive Signs	EA			Include # interpretive signs based on number of local public access points	
Parking Area	SF			Describe parking area, such as size, material.	
Other	EA			NA	

Full Restoration Quantity Estimate

Action Name:	John's Creek
Action #:	1447
Date:	February 2011
By:	John Small

REMEDY: ***Dike removal, channel construction, restoration of vegetation***
Construction Period: 4 months, In water work 6 weeks

	Item	Unit of Measure	Material Name	Qty	Description of Item		Indicate section of design report where item is described
Vegetation & Erosion Control							
	Hydroseeding	AC		8.8	Underseeding in addition to container planting		Not described in text
	Planting	AC		8.8	container planting of native treess and shrubs (1 gal, 4' o.c. typ.and 10 cu. in. 1' o.c. typ.)		Not described in text
	Vegetation Maintenance	AC-YR		26.4	Planted area for three years		Not described in text
	Erosion / sediment BMPs - Temp.	AC		8.8	Planted areas, not intertidal or existing saltmarsh.		Not described in text
	Erosion / sediment BMPs - Permanent	AC		0	NA		
	Waterside controls - Temporary	EA, LF, LS		0	NA (work in dry)		
Construction Management							
	Construction oversight	weeks		14	Quanity based on constructon duration/ # of construction seasons		
	Materials testing			NA	Included in cost of material - no separate quantity		
Design and Detailed Site Investigations							
	Survey & Property, Utility Research	LS		3	% of construction cost (includes property boundary determination)		1.3.6, 1.8
	35% Design	LS		6.25%	% of construction cost		1.3.6, 1.8
	65% design	LS		6.25%	% of construction cost		1.3.6, 1.8
	90% design	LS		6.25%	% of construction cost		1.3.6, 1.8
	100% design	LS		6.25%	% of construction cost		1.3.6, 1.8
	Geotechnical Studies			1	test pits in areas of earthwork to confrim physical and chemical properties of materials to be handle		Not described in text
	Cultural Studies			1	Historic and archaeological use of the site is known, detail study and UDP required		1.6
	HTWR Studies			1	Determine stream and tidal flow dynamics, design channels to appropriate geomorphic config.		Not described in text
Project Agreement Activities							
Site-Specific Adaptive Management Features & Activities					List if known		
Monitoring Activities					Assume 5 crew-days/year for each monitoring parameter in design report for 5 yrs		
	All monitoring activities	crew-days		225			1.7
Operations & Maintenance					Unable to provide credible estimate at 10% design		

Partial Restoration Quantity Estimate

Action Name: John's Creek
Action #: 1447
Date: February 2011
By: John Small

REMEDY: Dike removal, channel construction, restoration of vegetation
Construction Period: 3 months, In water work 6 weeks

Item	Unit of Measure	Material Name	Qty	Description of Item	Indicate section of design report where item is described
ACQUISITION AND CONSERVATION					
Required Project Lands	Acre		107	Privately owned land only, project would also require changes to public land leased for aquaculture	1.3.5
Proponent / Partner-owned lands	Acre		0	Proponent is currently working to acquire the golf course and salt marsh	
Lands To Be Acquired	Acre		107		1.3.5
Material Sites					
MOBILIZATION AND ACCESS for construction activities					
Mobilization - Typical (Equipment, Personnel, Planning, Financial)	LS		1	Up front costs such as bonding, planning and other staff time and financing. Typically, assume 8% to 10% of other items.	1.3.7
Mobilization - Remote (Equipment, Personnel, Planning, Financial)	LS		0	Up front cost for nontypical or remote locations. Assume 12% of other items	
Site Access	LS		0	NA	
Barge Access	Days		0	NA	
Temporary Traffic Control (one of the following)				Includes installation of traffic signals, signage, signmen, etc. There are 4 types as follows:	
none	LS		1	None = no traffic control	
signs	LS				
flags / spotters	LS				
unique	LS				
Temporary Roadway	SF				
Control of Water	LS		1	Temporary diversion of John's creek to allow grading in the dry, pumped diversion unlikely.	1.3.7
Relocation Activities					
Site Demolition Activities					
Clearing and Grubbing (one or more of following)					
Clear Vegetation - Local Disposal	AC		0	NA	
Clear /Grub Vegetation - Local Disposal	AC		6.2	Strip turf	1.3.2
Clear /Grub Vegetation - Offsite Disposal	AC		0	NA	
Clear, stockpile - large woody debris	CY		0	NA	
Hydraulic Structures - Small	LS		0	NA	
Hydraulic Structures - Large	LS		0	NA	
Buildings	LS or SF		0	NA	
Pavement	LS or SF		0	NA	
Bulkheads	LF or SF		0	NA	
Rock revetments	LF, Ton or CY		0	NA	
Large Coastal Structures	LF, SF or CY		0	NA	
Demolition / Removal - Bridge	SF or CY		0	NA	
Removal - Misc. (e.g. angular rock from beach)	Ton		0	NA	
Demolition / Removal - Boat Ramp	SF		0	NA	
Haul - Offsite Disposal of Demolition Debris	Miles		0	NA	
Hazardous/Contaminated Waste Removal					
Contaminated Earthwork	CY		0	Excavation, off haul and disposal within a licensed landfill, complete	
Hazardous Earthwork	CY		0	Excavation, off haul and disposal within a licensed hazardous waste landfill, complete	
Construct Temporary Features					
EARTHWORK					
Excavation	CY				
Excavation - Upland	CY		600	Per yard excavation w/out expected haul	1.3.2
Excavation - Lowland	CY		1260	Tracked excavator and standard dump truck (on or off hwy.)	1.3.2
Dredging - Bucket - Land	CY		0	Requires low ground pressure equipment and or mats; low production bucket methods, typically hydraulic excavator and front end loaders. Tracked hauling equipment (Morooka)	
Dredging - Bucket - Marine	CY		0	NA	
Dredging - Hydraulic	CY		0	NA	
Fine Grading	AC		0.45	Small tolerance grading after rough grading in all areas subject to excavation except channels	1.3.2
Fill Placement - local borrow					
Side cast	CY		1860	Excavated material placed within reach of excavator / dredge - assume includes some shaping by bucket	1.3.2
Haul - uncontrolled placement	CY			Transportation and second handling - estimate distance.	
Haul, place, compact	CY				
Stockpile - uncontrolled placement	CY			Intermediate step, for subsequent off haul or use elsewhere on site.	
Stockpile - controlled placement	CY			intermediate step, for subsequent off haul or use elsewhere on site. Can use this for drying material for subsequent controlled compacted fill	
Conveyor placement from stockpile land/water	CY		0	Some projects may require conveyor placement	
Imported Fill				Includes purchase, delivery and placement or as noted / described	
Select Fill	CY			Imported select material - describe use, e.g. levee, root base mix, etc;	
Gravel Borrow, including haul	CY			WSDOT standard item	
Sand / Gravel for Beach Nourishment	CY				
Cobble for Shore Nourishment	CY				
Embankment Compaction	CY				
Topsoil	CY		2511	assumes 3" in planted areas	1.3.2
RESTORATION Features					
Channel Rehab / Creation	SF		5194	Channel construction (SF) including imported sediment and habitat materials, excluding excavation	1.3.3
Large Wood Placement	EA		0	Per each log, Including drift logs, lower river log jams, etc.	
Invasive Species Control	Acre		0	Per acre control described in drawings and narrative	
Physical Exclusion Devices	LF or EA		0	Human or wildlife exclusions including fences, barriers, mooring buoys, etc	
Other Restoration Features/ Activities	LS		0	Describe other items not included elsewhere	
Structures	EA				
Water Control Structures - Culverts with Gates	EA				
Water Control Structures - Weirs	EA				
Rock Slope Protection	LF				
Other	EA				
Elevated Boat Ramp	SF				
Fencing	SF				
Utilities					
Water	LF				
Gas	LF				
Electric	LF				
Sewer	LF				
Telecommunications	LF				
Other	LF				
Roadway / Railway					
Roadway (Type)	SF				
Roadway - Traffic Signal	LS				
Culvert (type)	LF				
Culvert - Jacking	LF				
Culvert - Horizontal Pile Driving	LF				
Bridge - Deck and appurtenances	SF				
Bridge - Foundations	LF				
Railway - Box Girder	SF				
Railway - Foundation	LF				
Railway - Shoe fly	LF				
Permanent Access Features					
Roads	Level				
Utility Access Routes	varies				
Erosion Control Features	L.F.				
Public Access or Recreation Features					
Trails	SF				
Bridges	SF				
Kiosk	EA				
Restrooms	EA				
Interpretive Signs	EA				
Parking Area	SF				
Other	EA				
Vegetation & Erosion Control					
Hydroseeding	AC		6.2	Underseeding in addition to container planting	Not described in text
Planting	AC		6.2	container planting of native treess and shrubs (1 gal, 4' o.c. typ.and 10 cu. in. 1' o.c. typ.)	Not described in text
Vegetation Maintenance	AC-YR		18.6	Planted area for three years	Not described in text
Erosion / sediment BMPs - Temp.	AC		6.2	Planted areas, not intertidal or existing saltmarsh.	Not described in text
Erosion / sediment BMPs - Permanent	AC		0	NA	
Waterside controls - Temporary	EA, LF, LS		0	NA (work in dry)	
Construction Management					
Construction oversight	weeks		11	Quanity based on constructon duration/ # of construction seasons	
Materials testing			1	Included in cost of material - no separate quantity	
Design and Detailed Site Investigations					
Survey & Property, Utility Research	LS		3	% of construction cost (includes property boundary determination)	1.3.6, 1.8
35% Design	LS		6.25%	% of construction cost	1.3.6, 1.8
65% design	LS		6.25%	% of construction cost	1.3.6, 1.8
90% design	LS		6.25%	% of construction cost	1.3.6, 1.8
100% design	LS		6.25%	% of construction cost	1.3.6, 1.8
Geotechnical Studies			1	test pits in areas of earthwork to confrim physical and chemical properties of materials to be handled	Not described in text
Cultural Studies			1	Historic and archaeological use of the site is known, detail study and UDP required	1.6
HTWR Studies			1	Determine stream and tidal flow dynamics, design channels to appropriate geomorphic config.	Not described in text
Project Agreement Activities					

Partial Restoration Quantity Estimate

Action Name: John's Creek
Action #: 1447
Date: February 2011
By: John Small

REMEDY: Dike removal, channel construction, restoration of vegetation
Construction Period: 3 months, In water work 6 weeks

	Item	Unit of Measure	Material Name	Qty	Description of Item		Indicate section of design report where item is described
Site-Specific Adaptive Management Features & Activities					List if known		
Monitoring Activities					Assume 5 crew-days/acre/year for each monitoring parameter in design report		
	All monitoring activities	crew-days		225			1.7
Operations & Maintenance					Unable to provide credible estimate at 10% design		

16. KILISUT HARBOR/OAK BAY RECONNECTION (#1552)

Local Proponent	Jamestown S'Klallam Tribe
Delta Process Unit	NA
Shoreline Process Unit(s)	5007, 5012, 5036
Strategy(ies)	3 - Barrier Embayment
Restoration Objectives	Remove the barrier to full tidal exchange posed by the filled roadway and reconnect the salt marsh, and hence southern Kilisut Harbor, to Oak Bay to increase flushing and improve water quality, and to recreate connectivity during high tide periods

16.1 Description of the Action

The proposed restoration action would modify State Route 116 to restore natural tidal flow from Kilisut Harbor to the salt marsh south of the road and reopen the tide channel to Oak Bay. This would allow for tidal exchange, restoring natural hydrology and sediment transport processes in the area. Please see the Introduction chapter for important information regarding PSNERP and for context related to this restoration project.

16.2 Action Area Description and Context

Oak Bay / Kilisut Harbor is located in the North Puget Sound Subbasin between Marrowstone and Indian Islands in Jefferson County, Washington. Construction of State Route 116 has altered tidal hydrology between Indian and Marrowstone Islands. The through-fill road and twin 5-foot-diameter culverts built for State Route 116 have severely constrained natural tidal exchange between Kilisut Harbor and Oak Bay to the south. Salt marsh and intertidal channels exist on both the north and south sides of the State Route 116 causeway. The action area is shown in Figure 16-1.

Figure 16-1. Action Area and Vicinity

16.2.1 Historic Condition

The 1880 H-sheet and similar year T-sheet pre-dated the installation of the road. These maps show two distinct channels through the area where the road is now located (Figures 16-2A through 16-2B). These channels connected the ecologically rich Kilisut Harbor to Oak Bay in the south. George Vancouver's crew described the channels as "navigable for small boats only at half flood to half ebb and was dry at low water" (Moore 1975). Both channels were mapped in 1871 at roughly +6 feet MLLW (+4.9 feet NAVD88) through lead line soundings (and only generally referenced to the plane of MLLW), such that the tide channels were apparently dry at mid and low waters. A large salt marsh island was present under the middle section of the present road causeway. There was documentation of cattle scows and boats up to 30 feet in length transiting this area at higher tides (Moore 1975). In the early 1900s, the road causeways were constructed with bridges sufficiently high to allow small boats to continue traveling between Kilisut Harbor and Oak Bay (Johnson 2010).

A barrier beach with overwash fans and salt marsh were mapped south of the road, with a tide channel that extended through the south beach west of the road area in the 1871 T-sheet. Extensive areas below the approximate MHW line were mapped between the causeway and the south beach/spit. Much of the southern end of Kilisut Harbor (Scow Bay) was also below MHW, with marsh areas that were likely between MHW and MHHW. The tide channel extending westward to Oak Bay was generally 140 to 200 feet wide at MHW, with a minimum width of 140 feet as measured from MHW to MHW in 1871.

In 1908 and 1912, two bridges were constructed across each of the channels with clearance for small boats (Moore 1975). Decades after the causeway was installed, the tide channel appeared to be approximately 60 feet wide in a low-resolution 1942 aerial photo mosaic, and was closed by the 1970s. Reduced tidal flushing appears to have caused partial filling of the tide channels south and north of the road. The historic tide channel that was present to Oak Bay has completely closed, basically eliminating tidal exchange between Kilisut Harbor and the intertidal area south of the road, as well as to Oak Bay. Saltwater exchange from Oak Bay to the marsh system in recent decades has been limited to waves overtopping the barrier beach during storm events.

16.2.2 Natural Environment

Indian and Marrowstone Islands are at the northeast corner of the Olympic Peninsula, and extend north-south for a maximum length of 7 miles. The islands and other features in the vicinity were scoured from glacial deposits and are long and narrow in the north-south direction. Admiralty Inlet, the entrance to Puget Sound, is immediately east of Marrowstone Island. On the west side of Marrowstone Island is Kilisut Harbor, with Mystery Bay and Scow Bay in the south, within the action area. Marrowstone Island contains high-bluff shores and long spits, with rural land uses, scattered residences, and Fort Flagler State Park. Indian Island on the west side of Kilisut Harbor is owned by the U.S. Navy and is not open to the public.

Northwestward net shore-drift was mapped along the barrier beach at the southern, Oak Bay shore (Johannessen 1992). A moderately high volume of net shore-drift sediment is transported in this littoral cell from high feeder bluffs on southwest Marrowstone Island (Johannessen 1999). The bayhead of southern Kilisut Harbor has no appreciable drift due to insufficient wave energy. Wave energy is considerably greater along the Oak Bay shore, which is exposed to the prevailing southerly winds and waves, with maximum fetch of 12.5 miles.

Kilisut Harbor has had a large herring spawn density, and has extensive surf smelt and sandlance spawning beaches. Eelgrass has been mapped along both sides of Scow Bay, with large beds further north in the rest of Kilisut Harbor. The Indian Island shore and large portions of the Marrowstone Island shores are forested.

This marsh appears to have been aggrading, especially on the western side which is the area more distant from the twin road culverts. During the field review on September 27, 2010, the team observed 10 to 12 inches of very soft sediment in the old western channel over a firmer layer on the north side of the road causeway. Surface sediments were primarily sand and silt, with finer gravel in areas. The southern barrier beach was composed of larger gravel, especially at higher elevations, with overwash fans along the leeward side of the spit. Down-drift of the action area to the west is an intact tidal lagoon with extensive salt marsh. This approximately 21-acre lagoon appears to have sufficient tidal prism to maintain an opening to the west.

There is a tidal elevation and phase difference between Kilisut Harbor and Oak Bay. Using predicted tides from NOAA's Port Townsend and Kilisut water level stations, it appears that high tides to the south (Oak Bay) are approximately 0.9 foot higher than in Kilisut Harbor. This tidal head difference creates strong tidal currents in adjacent Admiralty Inlet and the Port Townsend Ship Canal, and presumably would create enough tidal current through the proposed recreated tidal channels to keep them open.

16.2.3 Human Environment

State Route 116 was first constructed with two bridges in the early 1900s. Additional fill was added to the roadway in the 1940s, with large culverts which were apparently replaced with smaller culverts in 1958 (Moore 1975). The roadway is approximately 450 feet long where it crosses the tidelands, with a surface elevation generally +14 to +15 feet MLLW. The road causeway is 60 to 70 feet wide. Two 60-inch-diameter culverts are present near the east end of the fill area.

Existing utilities appear to consist of overhead power and a buried water line. Indian Island (on the west side of the road) is currently a Navy ordnance facility. There are limited developments and public access in this area. Marrowstone Island includes a state park at the northwest end and low-density residential housing. Additional information on existing utilities and the need for utility relocations will be required to support subsequent design phases.

The road is east of a navigation channel excavated by the U.S. Army Corps of Engineers in approximately 1915 that now separates Indian Island from the mainland. This approximately 400-foot-wide navigation channel, known as the Port Townsend Ship Canal, is actively maintained. The channel provides a more sheltered passage from Hood Canal and Puget Sound to Port Townsend Bay, as compared to Admiralty Inlet.

Extensive fish kills were reported in Kilisut Harbor in the early 1970s due to very low dissolved oxygen levels caused by limited flushing (Moore 1975).

16.3 Restoration Design Concept

16.3.1 Restoration Overview and Key Design Assumptions

Restoration focuses on natural tidal exchange between Kilisut Harbor and Oak Bay. Two actions are required to achieve the restoration goal: creation of a tide channel through the barrier beach on the Oak Bay side, and replacement of the undersized concrete culverts of the causeway with an open channel(s). Figures 16-3 through 16-6 illustrate the restoration alternatives.

Both alternatives include excavation of starter channels through the existing salt marsh down to +5 feet NAVD88 (+6.1 feet MLLW) (Figures 16-5 and 16-6). The channels would extend westward and connect to Oak Bay through the barrier beach at the western end of the marsh. This was the location of the channel in historic maps and is still the location of relict channels today, although they have been reduced to only 1 to 3 feet wide. This would also appear to be the most stable natural location due to the northwestward net shore-drift at the Oak Bay shore. This would remove the dominant stressor in this location and reestablish historical processes. Both restoration alternatives include two tidal channels through the existing State Route 116 causeway to connect with the remnants of the two channels immediately south and north of the roadway.

In addition to channel creation, the full restoration alternative involves removing the entire 45o LF of road causeway and replacing it with a multi-span bridge (Figure 16-3). Three 150-foot bridge spans with two mid-channel supports would allow full water and sediment exchange below the structure.

Partial restoration entails construction of two shorter bridges with 175 feet of causeway between them (Figure 16-4). The eastern bridge, a single 125-foot span, would be placed atop the current location of the culverts. The western bridge, a single 140-foot span, would be constructed in the location of the western historic tidal channel. Existing utilities, water and electric, would be relocated to the bridge and new causeway. The two spans would facilitate nearly unrestricted water and sediment flow. The two bridges would be an immense improvement over existing conditions but will not quite achieve full process restoration, as the connection will still be constricted by the central causeway.

The key design elements associated with full and partial restoration alternatives are shown in Table 16-1.

Table 16-1. Key Design Elements

Element	Full Restoration	Partial Restoration
Marsh Causeway	Remove 450 feet of causeway	Same as full restoration
Roadway (at grade)	Remove and rebuild 1,150 feet of road (including bridge section)	Same as full restoration
Bridge	One 450-foot bridge	Two bridges separated by 175 feet of new causeway
Tide Channel Excavation	Excavate/recreate 1,750 feet of channels in intertidal zone	Same as full restoration
Utilities	Relocate power and water to new alignment	Same as full restoration

16.3.2 Restoration Features – Primary Process-Based Management Measures

Armor Removal/Modification - NA

Berm or Dike Removal/Modification

The causeway on State Route 116, between Scow Bay at the south end of Kilisut Harbor and Oak Bay, acts as a berm that impedes natural tidal exchange between these two water bodies. For the full restoration alternative, the existing causeway would be completely removed (10,000 CY) and replaced with a 450 LF bridge to open up the historic channels and marsh plain (Figure 16-3). Partial restoration includes removing two sections of the causeway (7,500 CY) and installing 125 LF and 140 LF bridge spans on either side of the shortened causeway (Figure 16-4).

Channel Rehabilitation/Creation

Recreated tide channels near the causeway and a tidal inlet from Oak Bay are to be excavated to restore the historic connection between Kilisut Harbor and Oak Bay (Figures 16-3 and 16-4). On the north side of the State Route 116 causeway, two starter channels would be enlarged to emulate historic conditions. Excavation from the starter channels includes approximately 20,000 SF on the west side of Kilisut Harbor and 13,400 SF on the east side of the harbor, which is the current location of the culverts and limited tidal exchange. The remnant of the old tide channel south of the causeway would be excavated westward through the sandy marsh plain, and a new inlet would be excavated to connect to Oak Bay through the barrier (104,000 SF). All channels will be excavated to +6.1 feet MLLW (+5 feet NAVD88) except the one to the north and east of the road, which will be slightly lower at +5.1 feet MLLW (+4 feet NAVD88). The depths are based on limited H-sheet data and observations of the existing channels. The eastern channel appears to have been historically deeper and remains that way at present.

Restoration actions for channel rehabilitation are the same for full and partial restoration alternatives. However, the two bridge spans would require slightly less overall excavation for the partial restoration alternative. The excavated tide channels would restore exchange of aquatic organisms, sediment supply and transport, and detritus recruitment and retention within the barrier lagoon and adjacent Scow Bay, as well as improving water quality in southern Kilisut Harbor.

Groin Removal/Modification - NA

Hydraulic Modification

Removal and disposal of two side-by-side, 50-foot-long concrete culverts (60-inch diameter) would be required for both full and partial restoration alternatives.

Overwater Structure Removal - NA

Topography Restoration

The removal of all (full restoration) or most (partial restoration) of the road causeway would restore the topography of the marsh plain for process restoration (discussed in more detail in *Channel Rehabilitation/Creation*, above).

16.3.3 Restoration Features – Additional Management Measures

Beach Nourishment - NA

Contaminant Removal/Remediation - NA

Debris Removal - NA

Invasive Species Control - NA

Large Wood Placement - NA

Physical Exclusion - NA

Pollution Control - NA

Revegetation - NA

Reintroduction of Native Animals - NA

Substrate Modification - NA

Species Habitat Enhancement - NA

16.3.4 Restoration Features – Other

Both restoration alternatives call for relocation of State Route 116 approximately 30 feet south of its present alignment (Figures 16-3 and 16-4). All utilities are to be relocated to the new alignment; only overhead power and underground water lines are known.

16.3.5 Land Requirements

Most land needed for the project is existing road right-of-way that is already in public ownership (approximately 29 acres). However, additional right-of-way (approximately 1 acre) would need to be acquired since the proposed alignment is located just south of the current alignment and extends a little beyond the right-of-way. The new alignment is required to avoid complete road closures during construction.

The local proponent is chiefly interested in improving habitat conditions in the Kilisut Harbor area. There are no known constraints from the local proponent or others, such as the need for preserving existing features or adding certain recreation features, which are very limited at this site. Utilities and other infrastructure are the primary issues which would need to be addressed through additional discussions with WSDOT and other entities.

Overhead power would be relocated onto the proposed bridge structure. The water main would be relocated under the bridge deck.

16.3.6 Design Considerations

Under both full and partial restoration alternatives, the proposed alignment would run along the south side of the current causeway to maintain traffic along State Route 116 and minimize road closures during construction (Figures 16-3 and 16-4). This is the only road to Marrowstone Island. The north lane would be maintained in a one-way configuration, with either flagger or stoplight traffic control, and the south lane would be for construction access. The new alignment would overlap the current south road shoulder.

Full Restoration Alternative

Under full restoration, the new bridge would be 450 feet long, with spans spaced at 150 feet with an approximate depth of 6.5 feet (Figures 16-5 and 16-6). For this study, the bottom elevation of the bridge girders is calculated at MHHW plus 3 feet. Concrete bridge elements are preferred over steel given the highly corrosive coastal environment. One means of supporting the bridge would consist of concrete columns on drilled shafts. The assumed embedment depth of the drilled shafts is 100 feet. Other foundation types including pre-cast piles and concrete shell piles should be considered during design.

A ballast/fill section would be needed to transition from the bridge structure to the existing roadway. The proposed roadway section will meet current WSDOT design standards and meet or exceed equivalent capacity. The road will include two 10.5-foot lanes and two 3-foot shoulders.

The proposed roadway geometry includes vertical and horizontal alignment considerations with respect to the proposed bridges. The existing roadway geometry on the east end of the alignment is substandard. To minimize property acquisition, the alignment has been built as close as possible to the existing road. Although the proposed alignment would be an improvement, it still will not meet current WSDOT design standards. To meet WSDOT road design standards, additional property acquisition will be required. The total length of improvements (bridge and road structures) is approximately 1,150 LF.

Partial Restoration Alternative

For partial restoration, the proposed alignment would be parallel to the existing causeway to maintain traffic and minimize road closures during construction (Figure 16-4). The new bridges will include a 125-foot bridge span on the east side, and a 140-foot bridge span on the west side of the alignment, both with an approximate depth of 5.17 feet. For this study, the bottom elevation of the bridge girders is calculated at MHHW plus 3 feet. New causeway will be built between the new bridge spans. Concrete bridge elements are preferred over steel given the highly corrosive coastal environment. Pile-supported finger piers would be required for installing the abutments at each bridge.

A ballast/fill section would be placed between the two bridge structures. Ballast and fill could be recycled from the existing causeway. The abutments and wing walls at each bridge end would retain the soil. Construction would require stabilized construction entrances, sediment ponds, and hydroseeding on the compacted road embankment to stabilize the new section of embankment.

The proposed roadway geometry includes vertical and horizontal alignment considerations with respect to the new bridge structures. The existing roadway geometry on the east end of the alignment is substandard. To minimize property acquisition, the alignment has been built as close as possible to the existing road. Although the proposed alignment would be an improvement, it still would not meet current WSDOT design standards. To meet WSDOT road design standards, additional property acquisition will be required. The total length of improvements (bridge and road structures) is approximately 1,600 LF.

16.3.7 Construction Considerations

A temporary construction trestle consisting of pile-supported finger piers at each bent location would need to be constructed to facilitate the installation of the drilled shafts and placement of bridge girders. Heavy machinery such as a drilled-shaft oscillator and crane could be moved between finger piers via the existing causeway at night. If the alignment is moved to the waterward side (south side) of the causeway, a full length temporary construction trestle would be necessary. This option should be considered during design.

It is assumed that the contractor would install one shaft per week. Large-diameter casing shoring would be required to keep out water and allow access to the top of the shaft for column form placement and removal.

Once the shafts are installed, the columns are cast inside the shoring casing. After the casing is removed, the cast-in-place pilecaps and bridge superstructure are constructed. Construction access and staging would be provided via finger piers and the existing causeway.

The duration of construction for the bridges and road work is estimated at 7 months, with excavation of the tidelands occurring simultaneously and likely requiring less time.

Concrete bridges require very little maintenance. The current standard is to inspect bridges every 2 years.

A portion of the tide channels are to be constructed in the existing salt marsh in an area of extremely soft ground. North of State Route 116 the marsh surface is likely much too soft to allow excavator access. These areas could be accessed by a low-draft barge at high tide, which could be allowed to ground at low tide. A bucket dredge could then be used to excavate the channel from the barge.

South of State Route 116, the ground is likely firm enough to allow excavator access, although some type of weight-distributing equipment such as a swamp pad may be required in the eastern portion of the excavation area. The central and western portions have firm soils consisting of coarse and very coarse sand with pebble. This area is the bulk of the excavation in terms of volume.

16.4 Extent of Stressor Removal

Table 16-2 describes the amount of stressors to be removed with this action.

Table 16-2. Stressor Removal

Stressor	Full Restoration	Partial Restoration
Tidal Barrier (LF)	450	265
Fill (area)	(tidal barrier used)	(tidal barrier used)

16.5 Expected Evolution of the Action Area

Without restoration of full tidal flushing at Kilisut Harbor, sedimentation rates would likely continue to increase and remnant tide channels continue to fill in. Mudflats would likely continue to accrete and transition to low marsh. The barrier beach located along the southern shore would likely incur overwash events with increasing frequency as sea level rises, with deposition of sand likely offsetting any potential increase in tidal prism south of State Route 116. Sea level change would result in the south shoreline migrating landward (northward), as well as increased delivery of large wood to the harbor. The increased water levels within the harbor would result in increased flooding of the road and adjacent properties.

Following restoration of tidal exchange between Kilisut Harbor and Oak Bay, the area would be expected to undergo significant and rapid change. Tide channels are not expected to remain in their excavated configurations, and instead would shift elevation and position, especially during spring tides as large amounts of water flow through them. Net sediment transport through the marsh may be northward, resulting in deposition of flood tidal deltas north of State Route 116.

Since net shore-drift on the Oak Bay barrier beach is to the northwest, the new tide channel may experience periodic shoaling or closure as waves transport sediment into the mouth. While these closures are expected to be temporary, some amount of intervention may be required. This would entail the use of an excavator to dig out the mouth during low tide. Excavated sediment could be deposited on the beach immediately northwest of the inlet. This may be slightly more prevalent with the partial restoration alternative, as the hydraulic reconnection would not be complete.

16.6 Uncertainties and Risks

The primary risk factors include a limited ability to predict future sediment transport and shoreform dynamics in this area, and the potential for changes to the spit at the mouth of Kilisut Harbor to affect shoreform processes at this site. The degree of risk from these factors can be further evaluated through the use of hydrodynamic modeling.

In general, the risk factors are slightly greater for the partial restoration alternative. By limiting the width of the openings at the road, there is less room for dynamic processes and for the system to readjust. However, it does not appear it is the width as much as the depth of the channels that would limit flow.

The uncertainty that drives these risk factors may be constrained with the use of a hydrodynamic model. However, the resolution of the models would be limited, especially in terms of sediment transport. Understanding sediment transport is critical to answering the main design questions posed by this site.

16.6.1 Risks Associated with Projected Sea Level Change

Sea level and climate change would likely *enhance* the sustainability of the restoration action by increasing water depths, thereby enhancing tidal exchange and currents, and tide channel formation and maintenance processes.

One potential future risk to infrastructure associated with sea level and climate change is the elevation of the road and the risk of overtopping during storm events. However, the roadway would be raised, a clear improvement over current conditions. Future sea level change analysis will assist in refining the design elevation for the bridge.

Table 16-3 compares potential risks associated with projected sea level changes based on professional judgment.

Table 16-3. Risks of Sea Level Change

	Projected Sea Level Change		
	High (46 cm)	**Intermediate (4 cm)**	**Low (-8 cm)**
Full Restoration	Higher sea levels will reach farther up the new bridge deck, although the surrounding marsh will likely provide enough protection from waves to disallow overtopping. The restored channel and marsh will be able to adapt to rising sea levels with reconnected tidal flow through marsh providing additional sediment to raise marsh floor.	Negligible	None
Partial Restoration	Higher sea levels will reach farther up the new bridge decks, although the surrounding marsh will likely provide enough protection from waves to disallow overtopping. The restored channel and marsh will be able to adapt to rising sea levels with reconnected tidal flow through marsh providing additional sediment to raise marsh floor, despite not being opened completely.	Negligible	None

16.7 Potential Monitoring Opportunities

Monitoring is important for evaluating restoration success. A combination of field surveys and aerial photographs would be used to document biological and physical changes to the landscape. Monitoring data can be used to refine adaptive management and corrective actions, as needed. Some of the main monitoring needs and opportunities associated with this action are summarized in Table 16-4.

Table 16-4. Monitoring Needs and Opportunities

Monitoring Parameter	Key Performance Indicator	Note
Topographic Stability		
Sediment Accretion / Erosion		
Wood Accumulation	X	Monitor for increased delivery of large wood to the harbor
Soil / Substrate Conditions		
Vegetation Establishment		
Marsh Surface Evolution / Accretion		
Tidal Channel Cross-Section / Density	X	Check for shifting, shoaling, or closure as waves transport sediment into the mouth
Water Quality (contaminants)	X	
Salinity		
Shellfish Production		
Extent of Invasive Species		
Animal Species Richness	X	
Fish (salmonid) Access/Use	X	Document improvements in access and production
Forage Fish Production		
Wildlife Species Use		
Effectiveness of Exclusion Devices		

16.8 Information Needed for Subsequent Design

This conceptual design report represents an initial step in the restoration design sequence. The design concepts described above were developed based on readily available information without the level of site-specific survey and investigation that is necessary to support subsequent design and implementation. Substantial additional information will be required at the preliminary and later design stages to confirm the design assumptions, refine quantity estimates, address property and regulatory issues, obtain stakeholder support, and fill in data gaps. The extent to which this information is collected for preliminary design (or a later design stage) will depend upon the available budget, schedule and other factors. This section attempts to define the most essential information needs for this action.

- Property Investigation/Survey – More detailed information on parcel ownership and property boundary location will be needed to finalize the design, confirm acquisition requirements, and support negotiations with property owners. Locating and identifying existing utilities and the need for utility relocations will be required to support subsequent design phases.
- Topographic/Bathymetric Survey – Survey is needed for the core of the action area where work is proposed. The LiDAR is old (2001) and out of date for this area. It also lacks accuracy for the vegetated marsh areas and areas below approximately +7 feet MLLW, which was underwater. A boundary survey will also be required.
- Geotechnical Investigation – Geotechnical investigation and recommendations will be required for selection of bridge foundation type and design. Hydraulic engineering recommendations will be required for scour and minimum bridge clearance over water.
- Cultural Resources Investigation – A cultural resources survey is not anticipated to be required, as the entire excavation area was below the level of high tide during early mapping. However, these historic channels may have been used for transit and may be of concern to the local Tribes.
- Hydraulic Analysis/Modeling – The development of a hydrodynamic model is required to better assess the stability of several alternative tide channel and inlet designs for this multi-inlet site, and to assess changes in water circulation. This action area is not like most other 10% design sites, in that the system has a large but distant opening at the north end of Kilisut Harbor (one with its own dynamics) and the recommended restored tidal inlet to Oak Bay. The general information produced for channel sizing in this stage of the larger design project is not applicable to this multi-inlet system. A site-specific hydrodynamic model is needed to handle the different tidal phasing and sediment transport issues at this site. This includes addressing the contribution of the dredged Port Townsend Ship Canal to the west.
- Contaminant Survey – If preliminary investigations suggest that hazardous material could be present in the action area, additional soil and sediment analysis may be needed. The introductory chapter describes the Phase I site investigations that are occurring as part of this overall effort via a separate contract.

16.9 Quantity Estimates

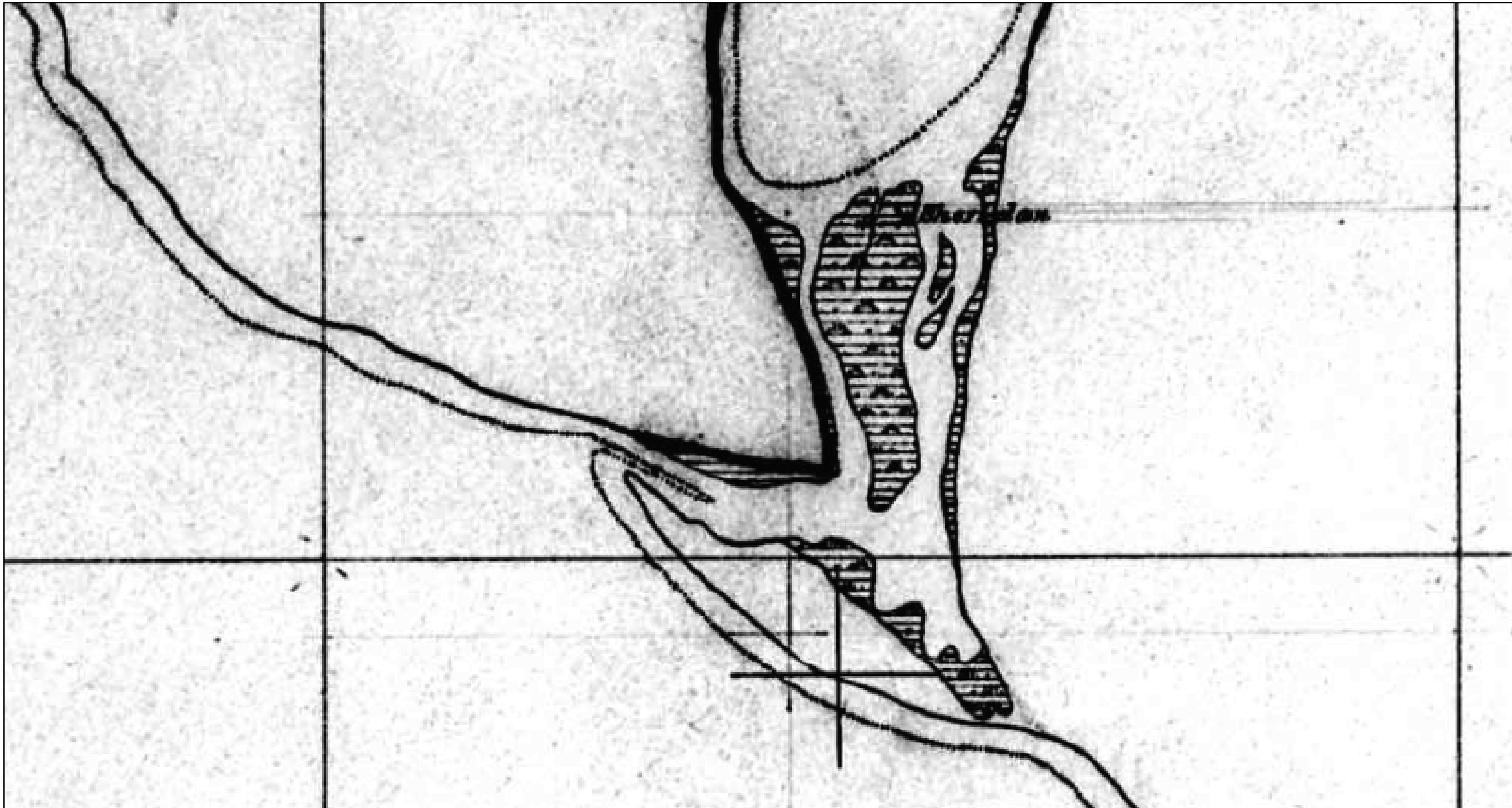
The design quantities are largely developed from LiDAR data sets lacking the resolution to accurately quantify all elements of construction. These are supplemented by unmeasured estimates made during one site visit at high tide and areal take-offs from available imagery. The quantity spreadsheets for the full and partial restoration alternatives are provided in Exhibits 16-1 and 16-2.

16.10 References

Johannessen, J. W. 1992. *Net shore-drift in San Juan County and parts of Jefferson, Island, and Snohomish counties, Washington: final report.* Western Washington University, for Shorelands and Coastal Zone Management Program, Washington Department of Ecology, Olympia.

Johannessen, J. W. 1999. *Critical Shoreline Areas Relative to Critical Nearshore Habitats at Tala Point to Kala Point, Eastern Jefferson County, WA*. Prepared for Jefferson County Planning Department.

Johnson, R. 2010. *Kilisut Harbor/Oak Bay Reconnection Project*. Memo prepared for Hans Hals, Jamestown S'Kallam Tribe.



0 350
Feet
0 100
Meters

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64

WDFW Contract # 100-000204 (CAPS No. 10-1461)

Historic Map (T-Sheet)

Action Name: Kilisut Harbor / Oak Bay Reconnection

PSNERP ID #: 1552

Figure 16- 2A

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0 350
Feet
0 100
Meters

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Historic Map (T-Sheet) and River History Project Data
Action Name: Kilisut Harbor / Oak Bay Reconnection
PSNERP ID #: 1552
Figure 16- 2B

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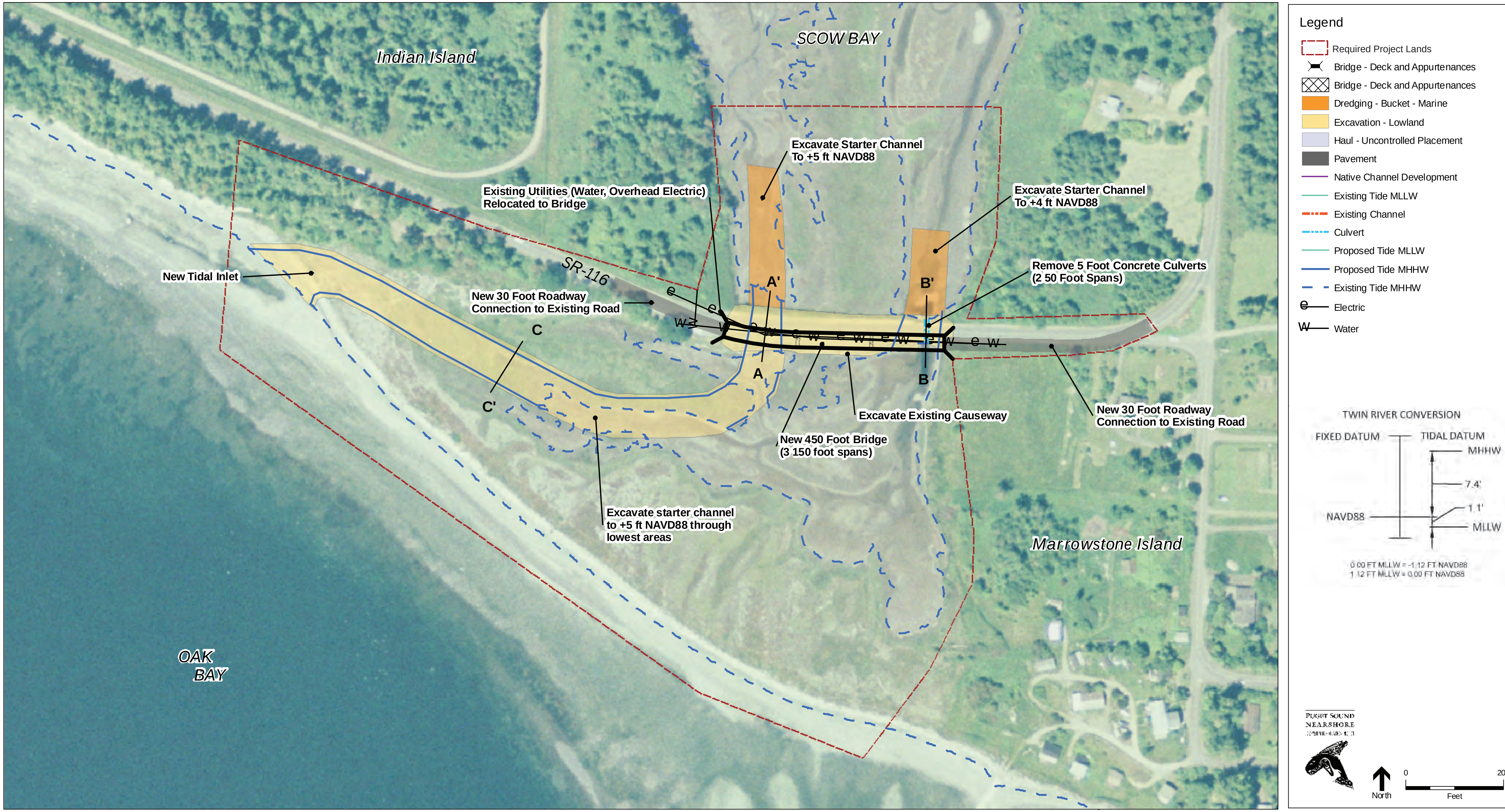


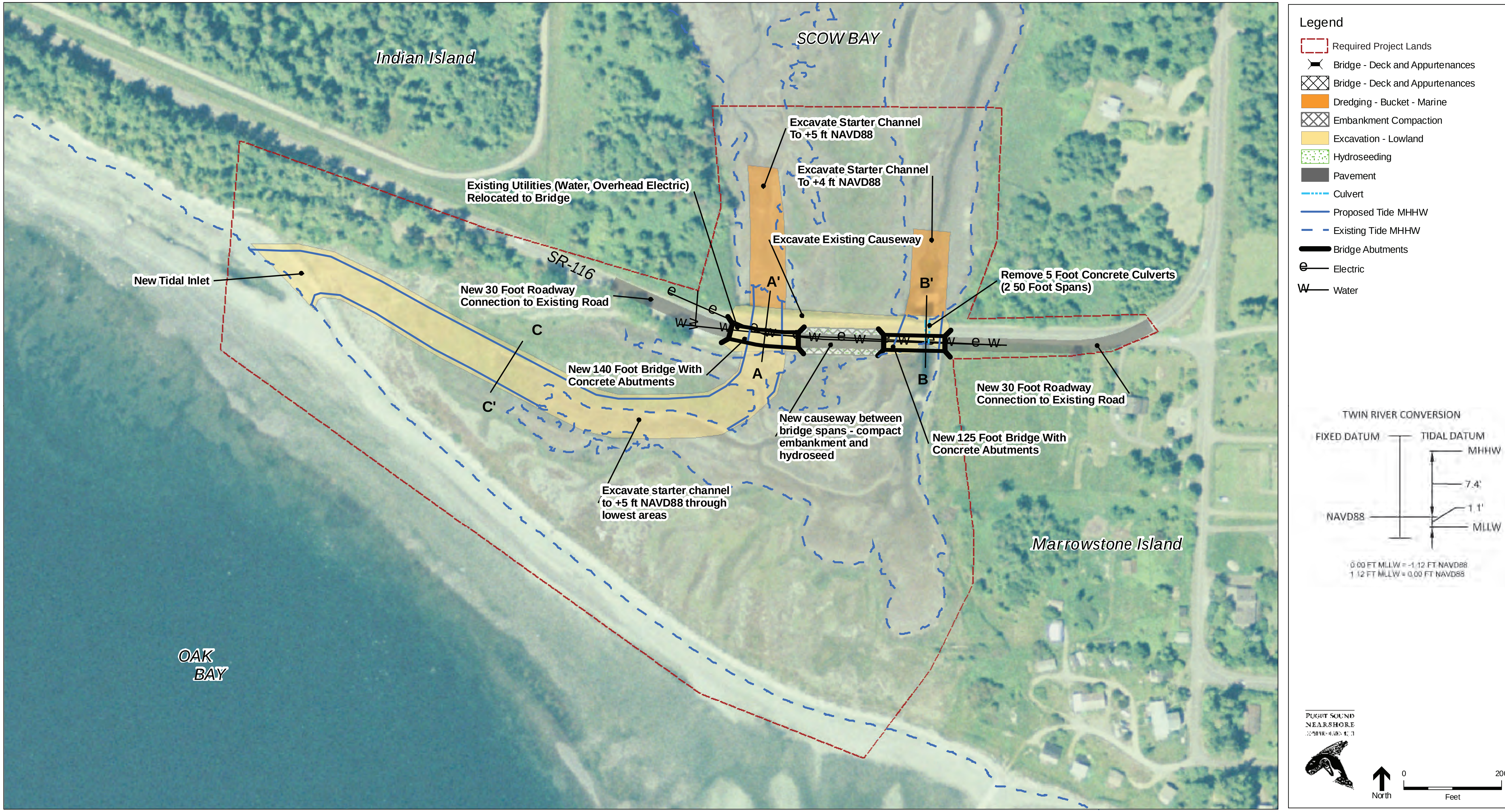
SOURCE: Washington Public Lands Database (2006); Washington Counties Parcels (2009); Action Area (PSNERP, 2010); Aerial Photo (Jefferson County 2005)

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Lead Contractor: ESA
Design Lead: CGS, Jim Johannessen
Date: 2/2011

Conceptual Design Plan
Site Name: Oak Bay
Action Name: Kilisut Harbor / Oak Bay Reconnection
PSNERP ID #:1552
Full Restoration

Figure 16-3



SOURCE: Washington Public Lands Database (2006); Washington Counties Parcels (2009); Action Area (PSNERP, 2010)

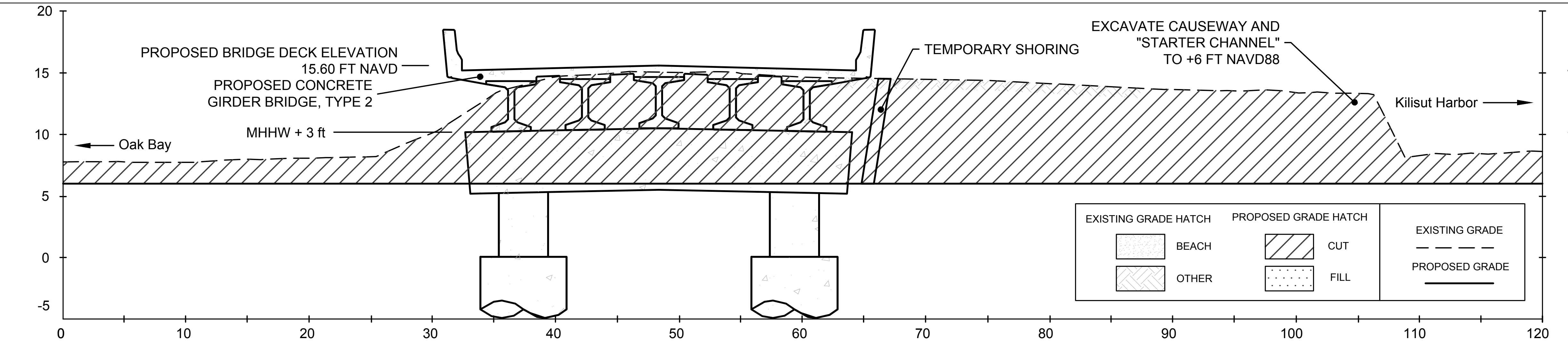
Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64

WDFW Contract # 100-000204 (CAPS No. 10-1461)

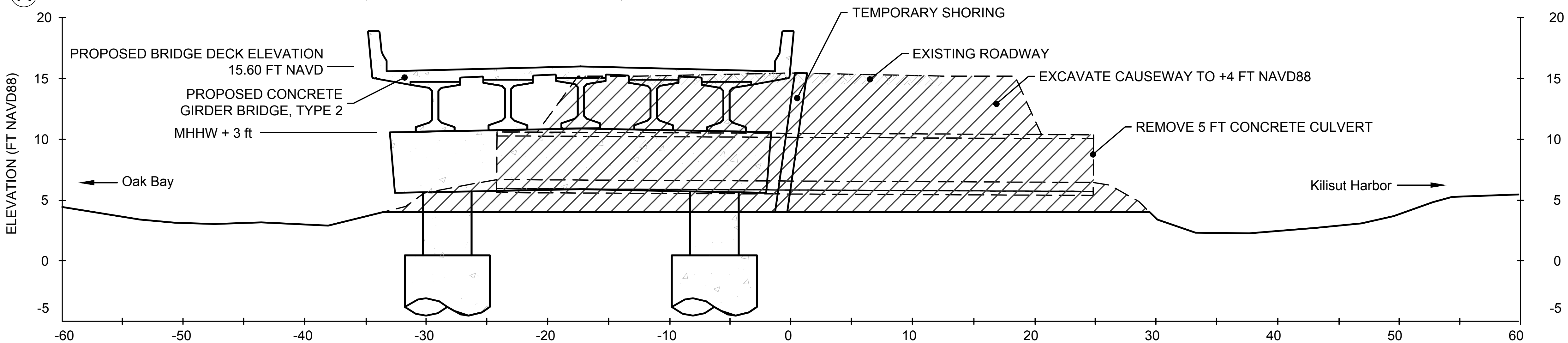
Lead Contractor: ESA
Design Lead: CGS, Jim Johannessen
Date: 2/2011

Conceptual Design Plan
Site Name: Oak Bay
Action Name: Kilisut Harbor / Oak Bay Reconnection
PSNERP ID #:1552
Partial Restoration

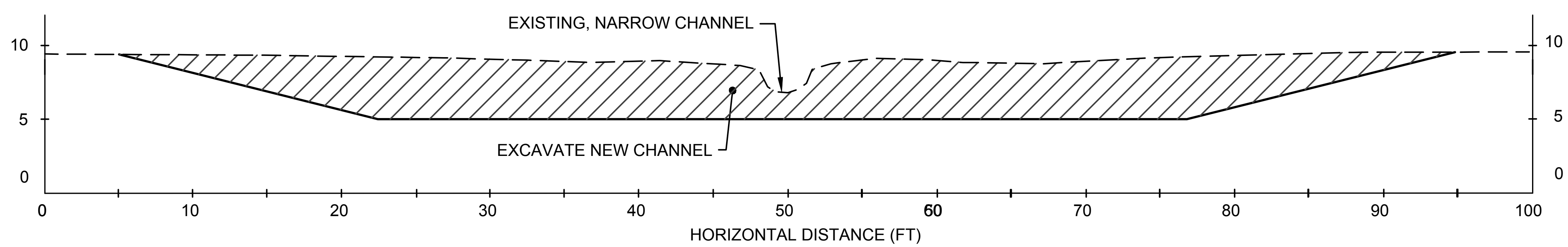
Figure 16-4



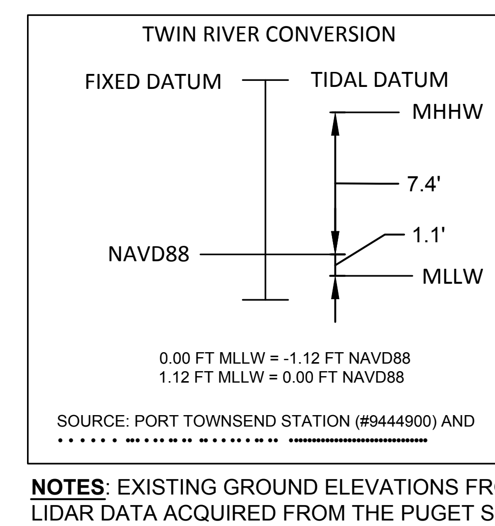
Ⓐ TRANSECT 1. WEST END CAUSEWAY, BRIDGE ON CONCRETE PILES, FULL RESTORATION TYPICAL SECTION



Ⓑ TRANSECT 2. EAST END CAUSEWAY, BRIDGE ON CONCRETE PILES, FULL RESTORATION TYPICAL SECTION



Ⓒ STARTER CHANNEL, FULL RESTORATION TYPICAL SECTION



NOTES: EXISTING GROUND ELEVATIONS FROM 2002 LIDAR DATA ACQUIRED FROM THE PUGET SOUND LIDAR CONSORTIUM

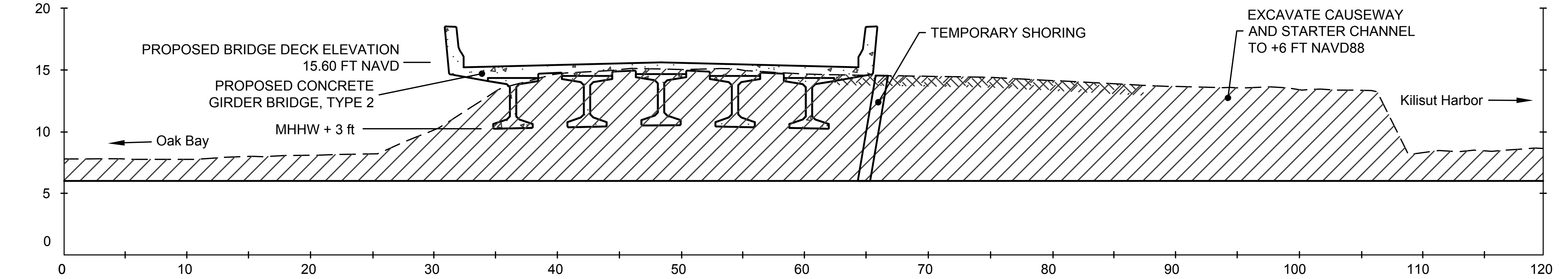
PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: CGS
Date: 3/2011

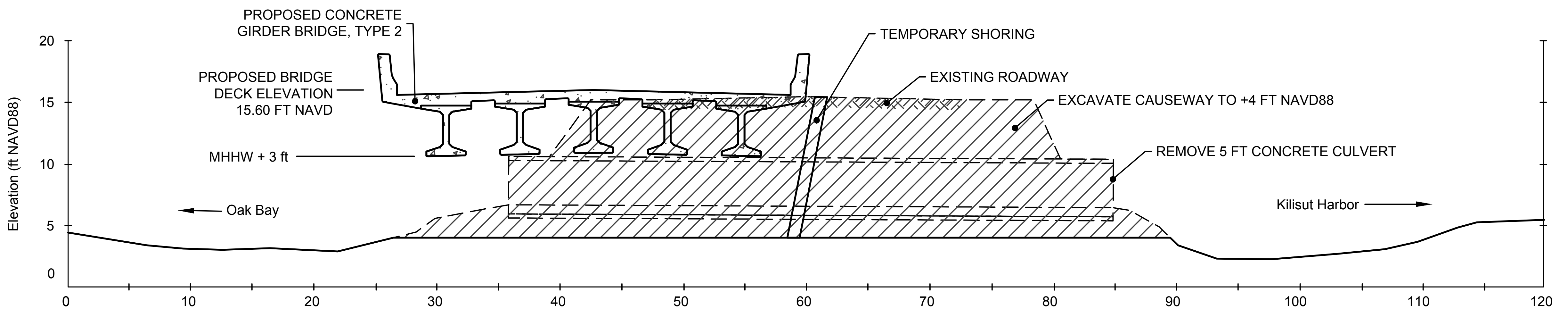
Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Section
SITE NAME: **Oak Bay**
ACTION NAME: **Kilisut Harbor / Oak Bay Reconnection**
PSNERP ID#: **1552**
Full Restoration

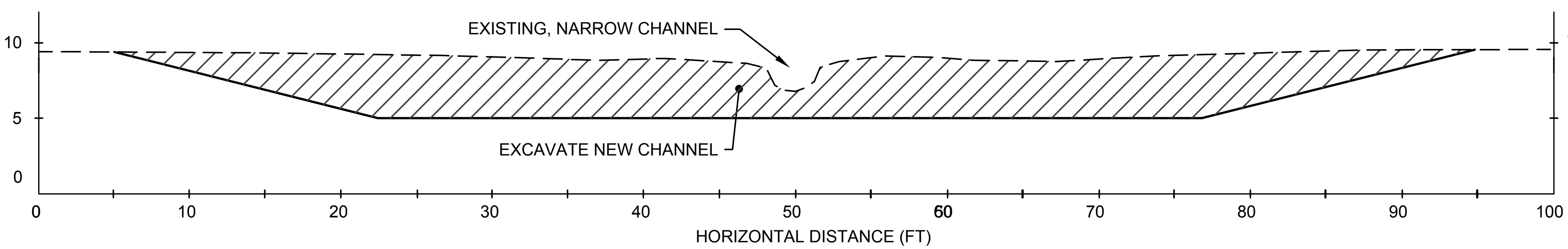
Figure 16-5



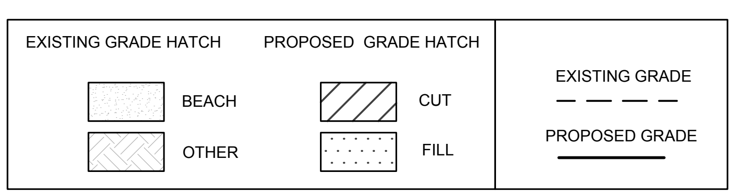
Ⓐ TRANSECT 1. WEST END CAUSEWAY, BRIDGE ON CONCRETE ABUTMENTS, PARTIAL RESTORATION TYPICAL SECTION

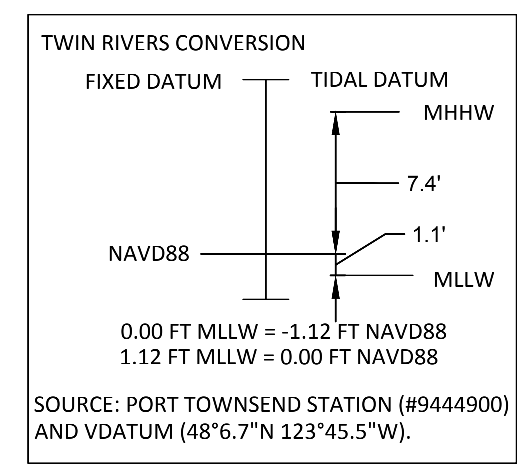


Ⓑ TRANSECT 2. EAST END CAUSEWAY, BRIDGE ON CONCRETE ABUTMENTS, PARTIAL RESTORATION TYPICAL SECTION



Ⓒ STARTER CHANNEL, PARTIAL RESTORATION TYPICAL SECTION





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Scale in Feet

NOTES: EXISTING GROUND ELEVATIONS FROM 2002 LIDAR DATA ACQUIRED FROM THE PUGET SOUND LIDAR CONSORTIUM

PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: CGS
Date: 3/2011

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Section
SITE NAME: **Oak Bay**
ACTION NAME: **Kilisut Harbor / Oak Bay Reconnection**
PSNERP ID#: **1552**
Partial Restoration

Figure 16-6

Full Restoration Quantity Estimate

Action Name: Killisut Harbor/ Oak Bay Reconnection
Action #: 1552
Date: February 2011
By: Coastal Geologic Services

REMEDY: Modify State Route 116 by excavating the causeway and installing a 450 ft bridge, excavate to recreate tide channels to restore natural tidal flow from Kilisut Harbor to to Oak Bay.
Construction Period: 7 months to demolish road and culverts, build 450 ft bridge while simultaneously excavating channels

Item	Unit of Measure	Material Name	Qty	Description of Item		Indicate section of design report where item is described
ACQUISITION AND CONSERVATION						
Required Project Lands	Acre		30	Total area of marsh and road		2.3.5 Land Requirements
Proponent / Partner-owned lands	Acre		29	Estimate of lands currently owned by Proponent (i.e., Public lands)		2.3.5 Land Requirements
Lands To Be Acquired	Acre		1	Realignment of right-of-way to south		2.3.5 Land Requirements
Material Sites						
MOBILIZATION AND ACCESS for construction activities						
Mobilization - Typical (Equipment, Personnel, Planning, Financial)	LS		10%	Up front costs such as bonding, planning and other staff time and financing. Typically, assume 8% to 10% of other items.		
Mobilization - Remote (Equipment, Personnel, Planning, Financial)	LS			Not Applicable to This Action		
Site Access	LS			Not Applicable to This Action		
Barge Access	Days		10	Barge-based excavation of tide channels north of SR-116 due to extremely soft soils, located in upper-middle intertidal		2.3.7 Construction considerations
Temporary Traffic Control (one of the following)				Includes installation of traffic signals, signage, sign men, etc. There are 4 types as follows:		
none	LS		1	None = no traffic control		
signs	LS		1	Typical Construction Signage		
flags / spotters	LS		1	Flags and spotters only during roadway transition connection		
unique	LS		0	Not Applicable to This Action		
Temporary Roadway	SF		0	Not Applicable to This Action		
Control of Water	LS		0	Not Applicable to This Action		
Relocation Activities						
Site Demolition Activities						
Clearing and Grubbing (one or more of following)				Use one or more of the following categories of clearing and grubbing		
Clear Vegetation - Local Disposal	AC		0.5	Remove grasses, and mostly native brush and dispose/replant locally		2.3.2 Restoration Features - Management Measures: Berm or Dike Removal
Clear /Grub Vegetation - Local Disposal	AC		0	Not Applicable to This Action		
Clear /Grub Vegetation - Offsite Disposal	AC		0	Not Applicable to This Action		
Clear, stockpile - large woody debris	CY		0	Not Applicable to This Action		
Hydraulic Structures - Culverts	LS		4000	Removal of 2 by 50' by 60" concrete culverts		2.3.3 Restoration Features - Management Measures: Debris removal
Hydraulic Structures - Large	LS		0	Not Applicable to This Action		
Utilities	LF		3200	overhead power and water (assume 1600 lf each)		2.3.2 Restoration Features - Management Measures: Berm or dike removal
Buildings	LS or SF		0	Not Applicable to This Action		
Pavement	SF		48000	Removal of 30' Roadway		2.3.2 Restoration Features - Management Measures: Berm or dike removal
Bulkheads	LF or SF		0	Not Applicable to This Action		
Demolition/Removal - Armor on Railroad Berm	LF, Ton or CY		0	Not Applicable to This Action		
Demolition / Removal - Railroad Berm	LF, SF or CY		0	Not Applicable to This Action		
Demolition / Removal - Bridge	SF		0	Not Applicable to This Action		
Removal - Misc. (e.g. angular rock from beach)	Ton		0	Not Applicable to This Action		
Demolition / Removal - in-water Piling	Number of Piles		0	Not Applicable to This Action		
Haul - Offsite Disposal of Demolition Debris	Miles		20	Placeholder distance, all non-hazardous debris and fill		
Hazardous/Contaminated Waste Removal						
Contaminated Earthwork	CY			Not Applicable to This Action		
Hazardous Earthwork	CY			Not Applicable to This Action		
Construct Temporary Features						
Temporary construction trestle	LS		1	For pile installation		
Temporary shoring	LS		1	For bridge construction		
EARTHWORK						
Excavation	CY			Per yard excavation w/out expected haul		
Excavation - Upland	CY		0	Not Applicable to This Action		
Excavation - Lowland	CY		22,500	Excavation of tide channels south of SR-116 (12,500 CY) and causeway (10,000 CY)		2.3.2 Restoration Features - Management Measures: Channel Rehabilitation
Dredging - Bucket - Land	CY		0	Not Applicable to This Action		
Dredging - Bucket - Marine	CY		2500	Excavation of 2 starter tide channels north of SR-116 (1,500 CY west, 1,000 CY east)		2.3.2 Restoration Features - Management Measures: Channel Rehabilitation
Dredging - Hydraulic	CY		0	Not Applicable to This Action		
Fine Grading	AC		0	Not Applicable to This Action		
Fill Placement - local borrow				This is additive to Earthwork -Excavation		
Side cast	CY		0	Not Applicable to This Action		
Haul - uncontrolled placement	CY		0	Not Applicable to This Action		
Haul, place, compact	CY		0	Not Applicable to This Action		
Stockpile - uncontrolled placement	CY		0	Not Applicable to This Action		
Stockpile - controlled placement	CY		0	Not Applicable to This Action		
Conveyor placement from stockpile land/water	CY		0	Not Applicable to This Action		
Imported Fill				Includes purchase, delivery and placement or as noted / described		
Select Fill	CY		0	Not Applicable to This Action		
Gravel Borrow, including haul	CY		0	Not Applicable to This Action		
Sand / Gravel for Beach Nourishment	CY		0	Not Applicable to This Action		
Cobble for Shore Nourishment	CY		0	Not Applicable to This Action		
Embankment Compaction	CY		0	Not Applicable to This Action		
Topsoil	CY		0	Not Applicable to This Action		
RESTORATION Features						
Channel Rehab / Creation	SF		137,400	Surface treatment only - grading and contouring		2.3.2 Restoration Features - Management Measures: Channel Rehabilitation
Large Wood Placement	EA		0	Not Applicable to This Action		
Invasive Species Control	Acre		0	Not Applicable to This Action		
Physical Exclusion Devices	LF or EA		0	Not Applicable to This Action		
Other Restoration Features/ Activities	LS		0	Not Applicable to This Action		
Structures	EA					
Water Control Structures - Culverts with Gates	EA		0	Not Applicable to This Action		
Water Control Structures - Weirs	EA		0	Not Applicable to This Action		
Rock Slope Protection	LF		0	Not Applicable to This Action		
Other	EA		0	Not Applicable to This Action		
Elevated Boat Ramp	SF		0	Not Applicable to This Action		
Fencing	SF		0	Not Applicable to This Action		
Utilities						
Water	LF		1600	hang from bridge		2.3.1 Restoration overview
Gas	LF		0	Not Applicable to This Action		
Electric	LF		1600	Overhead power onto bridge		2.3.1 Restoration overview
Sewer	LF		0	Not Applicable to This Action		
Telecommunications	LF		0	Not Applicable to This Action		
Other	LF		0	Not Applicable to This Action		
Roadway / Railway				KPFF expected to participate in these estimates		
Roadway	SF		18750	Typical Roadway 30' wide		2.3.6 Design Considerations
Roadway - Switch (potential)	LS		0	Not Applicable to This Action		
Culvert (type)	LF		0	Not Applicable to This Action		
Culvert - Jacking	LF		0	Not Applicable to This Action		
Culvert - Horizontal Pile Driving	LF		0	Not Applicable to This Action		
Bridge Deck	SF		16150	Precast Concrete Girder Bridge with (3) 150' Spans		2.3.6 Design Considerations
Bridge -Foundation	LF		64	(2) 32' CIP Concrete pile caps w/ (2) 7' Dia Drilled Shafts 100' Embed At Each Pile Cap		2.3.6 Design Considerations
Railway - Shoe fly	LF		0	Not Applicable to This Action		
Permanent Access Features						
Roads	Level		0%	Not Applicable to This Action		
Utility Access Routes	varies		0	Not Applicable to This Action		
Erosion Control Features	AC		2.4	Stabilized Construction Entrances, Sediment Ponds, Hydro Seed to Stabilize Roadway Embankments		2.3.6 Design Considerations
Public Access or Recreation Features						
Trails	SF		0	Not Applicable to This Action		
Bridges	SF		0	Not Applicable to This Action		
Kiosk	EA		0	Not Applicable to This Action		

Full Restoration Quantity Estimate

Action Name: Killisut Harbor/ Oak Bay Reconnection
Action #: 1552
Date: February 2011
By: Coastal Geologic Services

REMEDY: Modify State Route 116 by excavating the causeway and installing a 450 ft bridge, excavate to recreate tide channels to restore natural tidal flow from Kilisut Harbor to to Oak Bay.
Construction Period: 7 months to demolish road and culverts, build 450 ft bridge while simultaneously excavating channels

	Item	Unit of Measure	Material Name	Qty	Description of Item		Indicate section of design report where item is described
	Restrooms	EA		0	Not Applicable to This Action		
	Interpretive Signs	EA		1	tbd		
	Parking Area	SF		0	Not Applicable to This Action		
	Other	EA		0	Not Applicable to This Action		
Vegetation & Erosion Control							
	Hydroseeding	AC		0	Not Applicable to This Action		
	Planting	AC		0	Not Applicable to This Action		
	Vegetation Maintenance	AC-YR		0	Not Applicable to This Action		
	Erosion / sediment BMPs - Temp.	AC		0	Not Applicable to This Action		
	Erosion / sediment BMPs - Permanent	AC		0	Not Applicable to This Action		
	Waterside controls - Temporary	LF		1000	Silt fencing around causeway during construction		2.3.6 Design Considerations
Construction Management							
	Construction oversight	weeks		32	Quantity based on construction duration/ # of construction seasons		2.3.7 Construction considerations
	Materials testing			0	Included in cost of material - no separate quantity		
Design and Detailed Site Investigations							
	Survey & Property, Utility Research	LS		1	% of construction cost		2.8 Information Needed for Preliminary Design
	35% Design	LS		1	35% x 25% x Engineer's Estimate		
	65% design	LS		1	65% x 25% x Engineer's Estimate less the cost for 35% PS&E		
	90% design	LS		1	35% x 25% x Engineer's Estimate less the cost for 35% + 65%PS&E		
	100% design	LS		1	25% x Engineer's Estimate less previous costs		
	Geotechnical Studies			1	Refer to design report for description of need		2.8 Information Needed for Preliminary Design
	Cultural Studies			0	Refer to design report for description of need		2.8 Information Needed for Preliminary Design
	Hydrodynamic Modeling			1	Refer to design report for description of need		2.8 Information Needed for Preliminary Design
Project Agreement Activities					Unable to provide credible estimate at 10% design		
Site-Specific Adaptive Management Features & Activities					List if known		
Monitoring Activities					Assume 5 crew-days/year for each monitoring parameter in design report for 5 yrs		
	Monitoring (Type)	crew-days		125			
Operations & Maintenance					Unable to provide credible estimate at 10% design		

Partial Restoration Quantity Estimate

Action Name: Killisut Harbor/ Oak Bay Reconnection
Action #: 1552
Date: February 2011
By: Coastal Geologic

REMEDY: Modify State Route 116 by excavating the causeway and installing two 125-140 LF single span bridges, excavate to recreate tide channels to restore natural tidal flow from Kilisut Harbor to to Oak Bay.
Construction Period: 7 months to demolish road and culverts, build two 125-140 ft single span bridges while simultaneously excavating channels

	Item	Unit of Measure	Material Name	Qty	Description of Item	Indicate section of design report where item is described
ACQUISITION AND CONSERVATION						
	Required Project Lands	Acre		30	Total area of marsh and road	2.3.5 Land Requirements
	Proponent / Partner-owned lands	Acre		29	Estimate of lands currently owned by Proponent (i.e., Public lands)	2.3.5 Land Requirements
	Lands To Be Acquired	Acre		1	Realignment of right-of-way to south	2.3.5 Land Requirements
Material Sites						
MOBILIZATION AND ACCESS for construction activities						
	Mobilization - Typical (Equipment, Personnel, Planning, Financial)	LS		10%	Up front costs such as bonding, planning and other staff time and financing. Typically, assume 8% to 10% of other items.	
	Mobilization - Remote (Equipment, Personnel, Planning, Financial)	LS		0	Not Applicable to This Action	
	Site Access	LS		0	Not Applicable to This Action	
	Barge Access	Days		10	Barge-based excavation of tide channels north of SR-116 due to extremely soft soils, located in upper-middle intertidal	2.3.7 Construction considerations
	Temporary Traffic Control (one of the following)				Includes installation of traffic signals, signage, signmen, etc. There are 4 types as follows:	
	none	LS		1	None = no traffic control	
	signs	LS		1	Typical Construction Signage	
	flags / spotters	LS		1	Flags and spotters only during roadway transition connection	
	unique	LS		0	Not Applicable to This Action	
	Temporary Roadway	SF		0	Not Applicable to This Action	
	Control of Water	LS		0	Not Applicable to This Action	
Relocation Activities						
Site Demolition Activities						
	Clearing and Grubbing (one or more of following)				Use one or more of the following categories of clearing and grubbing	
	Clear Vegetation - Local Disposal	AC		0.5	Remove grasses, and mostly native brush and dispose/replant locally	2.3.2 Restoration Features - Management Measures: Berm or dike removal
	Clear /Grub Vegetation - Local Disposal	AC		0	Not Applicable to This Action	
	Clear /Grub Vegetation - Offsite Disposal	AC		0	Not Applicable to This Action	
	Clear, stockpile - large woody debris	CY		0	Not Applicable to This Action	
	Hydraulic Structures - Culverts	LS		4000	Removal of 2 by 50' by 60" concrete culverts	2.3.3 Restoration Features - Management Measures: Debris removal
	Hydraulic Structures - Large	LS		0	Not Applicable to This Action	
	Utilities	LF		3200	overhead power and water (assume 1600 lf each)	2.3.2 Restoration Features - Management Measures: Berm or dike removal
	Buildings	LS or SF		0	Not Applicable to This Action	
	Pavement	SF		48000	Removal of 30' Roadway	2.3.2 Restoration Features - Management Measures: Berm or dike removal
	Bulkheads	LF or SF		0	Not Applicable to This Action	
	Demolition/Removal - Armor on Railroad Berm	LF, Ton or CY		0	Not Applicable to This Action	
	Demolition / Removal - Railroad Berm	LF, SF or CY		0	Not Applicable to This Action	
	Demolition / Removal - Bridge	SF		0	Not Applicable to This Action	
	Removal - Misc. (e.g. angular rock from beach)	Ton		0	Not Applicable to This Action	
	Demolition / Removal - in-water Piling	Number of Piles		0	Not Applicable to This Action	
	Haul - Offsite Disposal of Demolition Debris	Miles		20	Non-hazardous debris and fill	
Hazardous/Contaminated Waste Removal						
	Contaminated Earthwork	CY		0	Not Applicable to This Action	
	Hazardous Earthwork	CY		0	Not Applicable to This Action	
Construct Temporary Features						
	Temporary construction trestle	LS		1	For pile installation	
	Temporary shoring	LS		1	For bridge installation	
EARTHWORK						
	Excavation	CY		0	Per yard excavation w/out expected haul	
	Excavation - Upland	CY		0	Not Applicable to This Action	
	Excavation - Lowland	CY		20,000	Excavation of tide channels south of SR-116 (12,500 CY) and causeway (7,500 CY)	2.3.2 Restoration Features - Management Measures: Berm or dike removal
	Dredging - Bucket - Land	CY		0	Not Applicable to This Action	
	Dredging - Bucket - Marine	CY		2,500	Excavation of 2 starter tide channels north of SR-116 (1,500 CY west, 1,000 CY east)	2.3.2 Restoration Features - Management Measures: Channel Rehabilitation; 2.3.7
	Dredging - Hydraulic	CY		0	Not Applicable to This Action	
	Fine Grading	AC		0	Not Applicable to This Action	
	Fill Placement - local borrow				This is additive to Earthwork -Excavation	
	Side cast	CY		0	Not Applicable to This Action	
	Haul - uncontrolled placement	CY		0	Not Applicable to This Action	
	Haul, place, compact	CY		0	Not Applicable to This Action	
	Stockpile - uncontrolled placement	CY		0	Not Applicable to This Action	
	Stockpile - controlled placement	CY		0	Not Applicable to This Action	
	Conveyor placement from stockpile land/water	CY		0	Not Applicable to This Action	
	Imported Fill				Includes purchase, delivery and placement or as noted / described	
	Select Fill	CY		0	Not Applicable to This Action	
	Gravel Borrow, including haul	CY		0	Not Applicable to This Action	
	Sand / Gravel for Beach Nourishment	CY		0	Not Applicable to This Action	
	Cobble for Shore Nourishment	CY		0	Not Applicable to This Action	
	Embankment Compaction	CY		250	New re-aligned (middle) causeway section embankment compaction	2.3.2 Restoration Features - Management Measures: Channel Rehabilitation
	Topsoil	CY		0	Not Applicable to This Action	
RESTORATION Features						
	Channel Rehab / Creation	SF		137,400	Surface treatment only - grading and contouring	2.3.2 Restoration Features - Management Measures: Channel Rehabilitation
	Large Wood Placement	EA		0	Not Applicable to This Action	
	Invasive Species Control	Acre		0	Not Applicable to This Action	
	Physical Exclusion Devices	LF or EA		0	Not Applicable to This Action	
	Other Restoration Features/ Activities	LS		0	Not Applicable to This Action	
Structures		EA				
	Water Control Structures - Culverts with Gates	EA		0	Not Applicable to This Action	
	Water Control Structures - Weirs	EA		0	Not Applicable to This Action	
	Rock Slope Protection	LF		0	Not Applicable to This Action	
	Other	EA		0	Not Applicable to This Action	
	Elevated Boat Ramp	SF		0	Not Applicable to This Action	
	Fencing	SF		0	Not Applicable to This Action	
Utilities						
	Water	LF		1600	hang from bridge	2.3.1 Restoration overview
	Gas	LF		0	Not Applicable to This Action	
	Electric	LF		1600	Overhead power onto bridge	2.3.1 Restoration overview
	Sewer	LF		0	Not Applicable to This Action	
	Telecommunications	LF		0	Not Applicable to This Action	
	Other	LF		0	Not Applicable to This Action	
Roadway / Railway					KPFF expected to participate in these estimates	
	Roadway	SF		33,750	Typical Roadway 30' wide	2.3.6 Design Considerations
	Roadway - Switch (potential)	LS		0	Not Applicable to This Action	
	Culvert (type)	LF		0	Not Applicable to This Action	
	Culvert - Jacking	LF		0	Not Applicable to This Action	
	Culvert - Horizontal Pile Driving	LF		0	Not Applicable to This Action	
	Bridge Deck	SF		8480	(2) Precast Concrete Girder Bridges with 140' Span (140'x32')& 125' (125'x32) Span	2.3.6 Design Considerations
	Bridge - Foundation Drilled Shafts	LF		0	(Abutments included in bridge deck above)(0) 32' CIP Concrete pile caps w/ (2) 7' Dia Drilled Shafts 100' Embed At Each Pile Cap	2.3.6 Design Considerations
	Railway - Shoe fly	LF		0	Not Applicable to This Action	
Permanent Access Features					KPFF expected to participate in these estimates	
	Roads	Level		0%	Not Applicable to This Action	
	Utility Access Routes	varies		0	Not Applicable to This Action	
	Erosion Control Features	AC		2.4	Stabilized Construction Entrances, Sediment Ponds, Hydro Seed to Stabilize Roadway Embankments	2.3.6 Design Considerations
Public Access or Recreation Features					KPFF expected to participate in these estimates	
	Trails	SF		0	Not Applicable to This Action	

Partial Restoration Quantity Estimate

Action Name: Killisut Harbor/ Oak Bay Reconnection
Action #: 1552
Date: February 2011
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REMEDY: Modify State Route 116 by excavating the causeway and installing two 125-140 LF single span bridges, excavate to recreate tide channels to restore natural tidal flow from Kilisut Harbor to to Oak Bay.
Construction Period: 7 months to demolish road and culverts, build two 125-140 ft single span bridges while simultaneously excavating channels

	Item	Unit of Measure	Material Name	Qty	Description of Item		Indicate section of design report where item is described
	Bridges	SF		0	Not Applicable to This Action		
	Kiosk	EA		0	Not Applicable to This Action		
	Restrooms	EA		0	Not Applicable to This Action		
	Interpretive Signs	EA		1	tbd		
	Parking Area	SF		0	Not Applicable to This Action		
	Other	EA		0	Not Applicable to This Action		
Vegetation & Erosion Control							
	Hydroseeding	AC		0.5	Standard road embankment mix		
	Planting	AC		0	Not Applicable to This Action		
	Vegetation Maintenance	AC-YR		0	Not Applicable to This Action		
	Erosion / sediment BMPs - Temp.	AC		0	Not Applicable to This Action		
	Erosion / sediment BMPs - Permanent	AC		0	Not Applicable to This Action		
	Waterside controls - Temporary	LF		1000	Silt fencing around causeway during construction		
Construction Management							
	Construction oversight	weeks		32	Quantity based on construction duration/ # of construction seasons		2.3.7 Construction considerations
	Materials testing				Included in cost of material - no separate quantity		
Design and Detailed Site Investigations							
	Survey & Property, Utility Research	LS		1	% of construction cost		2.8 Information Needed for Preliminary Design
	35% Design	LS		1	35% x 25% x Engineer's Estimate		
	65% design	LS		1	65% x 25% x Engineer's Estimate less the cost for 35% PS&E		
	90% design	LS		1	35% x 25% x Engineer's Estimate less the cost for 35% + 65%PS&E		
	100% design	LS		1	25% x Engineer's Estimate less previous costs		
	Geotechnical Studies			1	Bridge design		2.8 Information Needed for Preliminary Design
	Cultural Studies			0	Refer to design report for description of need		2.8 Information Needed for Preliminary Design
	Hydrodynamic Modeling			1	Refer to design report for description of need		2.8 Information Needed for Preliminary Design
Project Agreement Activities					Unable to provide credible estimate at 10% design		
Site-Specific Adaptive Management Features & Activities					List if known		
Monitoring Activities					Assume 5 crew-days/year for each monitoring parameter in design report for 5 yrs		
	Monitoring (Type)	crew-days		125			
Operations & Maintenance					Unable to provide credible estimate at 10% design		

17. LILLIWAUP CAUSEWAY REPLACEMENT AND ESTUARY RESTORATION (#1346)

Local Proponent	Hood Canal Coordinating Council
Delta Process Unit	NA
Shoreline Process Unit(s)	2034, 2035
Strategy(ies)	4 – Coastal Inlet (could be characterized as Strategy 1 River Deltas, and includes elements of shore restoration)
Restoration Objectives	Restore processes by removing obstruction formed by roadway that changes hydraulics and sediment transport

17.1 Description of the Action

The action will restore tidal connectivity in the Lilliwaup Estuary by replacing the existing causeway with an elevated structure that spans the entire delta to restore hydraulics, sediment transport, and geomorphology. Aggraded stream channel sediments and floodplain fill will be removed to restore fluvial hydrology processes. Please see the Introduction chapter for important information regarding PSNERP and for context related to this restoration project.

17.2 Action Area Description and Context

The Lilliwaup Estuary is on the western side of Hood Canal in the Hood Canal Subbasin. Lilliwaup Creek is the largest creek in the southern portion of the Hamma Hamma watershed. The Lilliwaup drainage contains significant wetlands and lakes, and the lower reaches provide important habitat for salmonids. A large falls (Lilliwaup Falls) 0.7 mile upstream of the mouth prevents anadromous fish passage. Approximately 80% of the watershed is publically owned forest land. A few residential homes/farms are located next to the creek near the mouth. Long Live the Kings (LLTK), a private enhancement group, maintains a small hatchery on Lilliwaup Creek. They collect summer chum entering Lilliwaup Creek, spawn them at the hatchery, and release the offspring. A private owner operates a small hydroelectric power plant below Lilliwaup Falls and sells the electricity generated to the local PUD. The action area is shown in Figure 17-1.

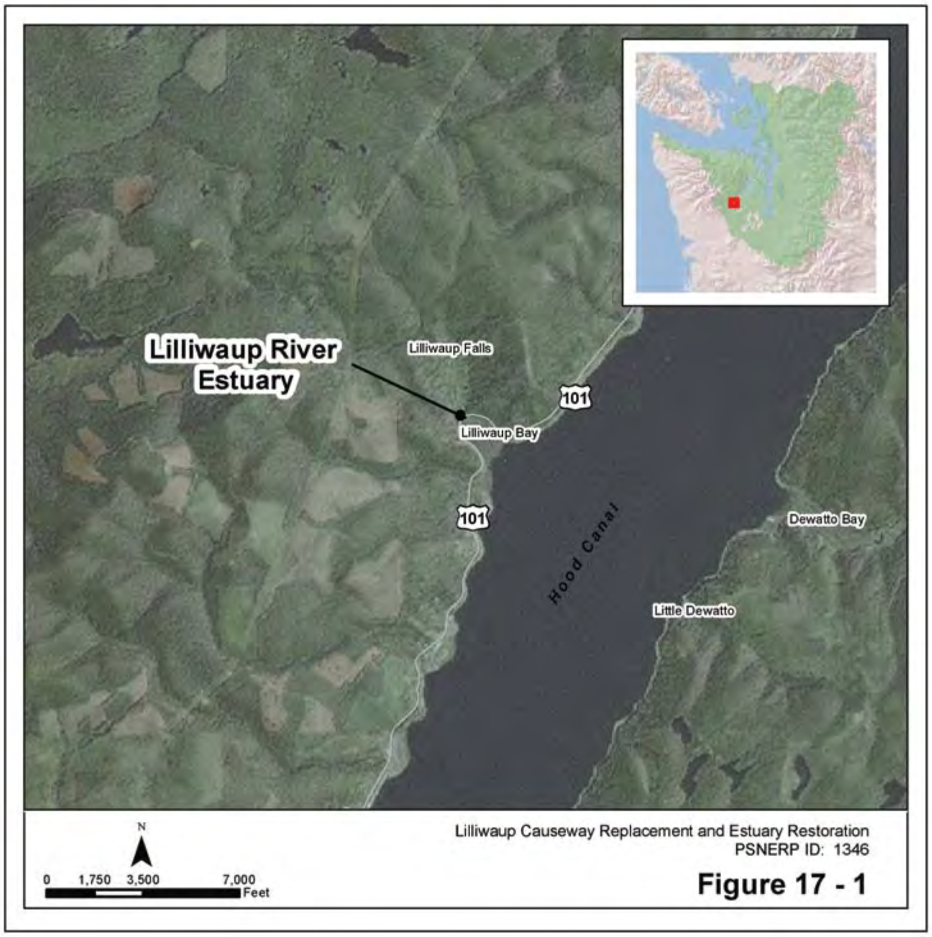

Figure 17-1. Action Area and Vicinity

17.2.1 Historic Condition

The 1884 T-sheet shows two tidal channels at the mouth of the creek extending out into Lilliwaup Bay (Figures 17-2A and 17-2B). Additionally, a few small marsh islands are shown at the upstream end of the estuary. The creek shows some minor sinuosity upstream of its mouth. A small area north of the creek is shown to be fenced grassland, but the T-sheet does not show any roadways or other signs of settlement at the Lilliwaup Estuary. A small back barrier lagoon is present on the western shore, and gravel shorelines are indicated on both sides of Lilliwaup Bay. The vegetation transitions from mixed forest and grassland upstream, to salt marsh at the edge of the estuary near the mouth of Lilliwaup Creek.

A 1925 WSDOT roadway and bridge drawing (provided by Carl Ward, WSDOT, Olympic Region) shows an existing “pile trestle” crossing just east of the new road. It also shows three distributary channels for Lilliwaup Creek: South Fork South Channel (along the south bank in a position similar to that shown in the 1884 map), South Fork North Channel (in the middle, crossing southeasterly from north fork to south fork), and North Fork Channel (along the north bank similar to position in 1884 map). The new bridge was aligned near the middle channel (South Fork North), and the road embankment blocked the other two. Excess material was disposed west of the north abutment. The WSDOT drawing shows road and lot lines in Lilliwaup Bay; apparently there were plans to fill and develop. A wharf (probably fill) about 300 feet long extended from Helen Street into the bay just east of the proposed roadway on the south bank. The south shore had been filled or accreted to the end of this feature, with residences and bulkheads, and a boat house at the end of the historic wharf structure.

Tides reportedly reached upstream on Lilliwaup Creek to the vicinity of the waterfall prior to aggradation of the streambed (Moore 2010).

17.2.2 Natural Environment

The creek has two defined channels upstream of the Highway 101 bridge. The eastern channel is currently the primary flow path. Some braiding is present within the marsh and mudflats just upstream of the Highway 101 crossing. The channel deepens near the bridge, indicating hydraulic constriction. The aerial photograph shows a shoal under the bridge, perhaps indicating that a slug of coarse sediment is passing the mouth. However, the morphology appears to be altered by the roadway. Downstream of the bridge, the channel rapidly widens into the bay, with several distributary channels extending to the east and south.

The watershed is small, narrow and steep sided, with a waterfall (Lilliwaup Falls) approximately 0.7 mile upstream. Human modifications include a weir-like concrete structure at the waterfall, a sluiceway that enters the canyon from the northeast, and a culvert that enters from the west (reported but not field verified). The sluiceway was reportedly for a power plant, but it is not currently operating due to several structural failures farther upstream. A large slide is apparent on the west side where a culvert reportedly plugged. Lilliwaup Creek upstream of the site was significantly altered by large gravel slide events in 2005 (flume failure) and 2007 (culvert blockage). The upstream channel between Highway 101 and the waterfall (within the anadromous reach) is heavily aggraded as a result of these events. At the upstream bridge, photographs indicate the creek has aggraded on the order of 10 feet. Sediment deposition and progradation of marsh have also occurred. A 2008 rehabilitation project removed approximately 5,000 CY of this aggraded gravel and sediment between the falls and approximately 1,000 feet downstream of the falls (LLTK 2010).

LLTK staff working at the fish hatchery report that gravel slides have raised stream groundwater levels to the point that trees are dying due to drowned roots.

17.2.3 Human Environment

The mouth of Lilliwaup Estuary is partially blocked by the roadway embankment for Highway 101. A single-span bridge (150 feet) spans the channel of Lilliwaup Creek at the mouth of the estuary. The bridge is located in the center of the estuary and directs all of the flow from Lilliwaup Creek through a single opening (compared to two channels historically). The downstream roadway embankments are heavily armored with concrete rubble and concrete sack armoring. Utilities other than overhead power and telecommunication lines are not known at this time. More detailed information on existing utilities and the need for utility relocations will be required to support subsequent design phases.

Properties on the east and west sides of the bay have concrete bulkheads. Large concrete rubble is located within the marsh upstream of the bridge in the western side of the estuary. The western banks of the estuary are armored with concrete rubble to protect the adjacent roadway. The western bank has been filled and developed on the east side of the roadway.

Lilliwaup Street runs along the western bank upstream of Highway 101 and crosses the creek at the upstream bridge, providing access to the LLTK hatchery and a private residence. The entire area is private property except for Highway 101. However, the upstream property owner is supporting the LLTK hatchery and stream restoration plans, and therefore may be amenable to the proposed restoration actions. The perspectives and interests of the property owners along the shore near Highway 101 are unknown.

17.3 Restoration Design Concept

17.3.1 Restoration Overview and Key Design Assumptions

Both the full and partial restoration alternatives would remove the existing Highway 101 bridge and roadway embankments and replace them with a longer multi-span bridge (Figures 17-3 through 17-7). The full restoration alternative bridge spans the estuary between hillside controls and provides complete removal of the stressors. The partial restoration alternative includes a shorter bridge, which minimizes impacts to the properties and structures on the western shore downstream of the crossing.

Under the partial restoration alternative, the morphology at the creek mouth is restricted (based on the guidance in Appendix C) and the western bank is not restored, which reduces the benefits. The roadway alignment will be parallel to the existing causeway but located to the north to allow continued use of Highway 101 during construction. The widened opening will increase the tidal prism and restore unrestricted tidal exchange to the area upstream of the causeway. The existing Lilliwaup Street will be rebuilt to conform to the new roadway alignment in both restoration alternatives.

For the full restoration alternative, the aggraded sediment deposited by the two slide events (2005 flume failure and 2007 culvert blockage and flooding) will be removed from the channel over the entire length of the anadromous reach and the adjacent overbanks upstream of the existing marsh. The aggraded overbanks would be excavated to marsh plain elevation in areas that were historically marsh (based on the 1884 T-sheet) (Figure 17-3). For the partial restoration alternative, the aggraded sediment will be removed from the channel only. Removal of aggraded channel sediments would prevent future migration of this large deposit into the estuary, which would adversely impact estuary function. The sediment removal also directly restores the extent of tidal exchange that existed historically in Lilliwaup Creek.

New channels would be excavated beginning at the mudflats downstream of the causeway to the main channel split upstream of the existing marsh (Figure 17-4). The hardened banks and shoreline development on the downstream side of the causeway would undergo varying extents of demolition, grading, and beach reconstruction under both the full and partial restoration alternatives.The action area is on private property with the exception of the WSDOT right-of-way at Highway 101, and land within the area may require purchase.

Key design elements associated with full and partial restoration alternatives are summarized in Table 17-1.

Table 17-1. Key Design Elements

Element	Full Restoration	Partial Restoration
Bridge	Replace roadway embankment with 600-foot-long bridge	Replace roadway embankment with 500-foot-long bridge
In-Channel Accumulated Sediment	Remove sediment	Remove sediment
Overbank Sediment	Excavate to marsh plain elevation Construct a small tidal pool at the downstream western shore of the estuary	Not included
Beach Nourishment	9,200 CY of placement	5,000 CY of placement
Residences and Buildings	Remove 7 structures	Remove 2 structures

17.3.2 Restoration Features – Primary Process-Based Management Measures

Armor Removal/Modification

The existing rock revetment and concrete-sack-armored banks will be removed from the downstream side of the eastern and western abutments of the existing causeway. The total length of the removal is approximately 240 feet. The concrete bulkheads at the western development on the western downstream shore will be removed. Both structures will be demolished (400 feet) for the full restoration alternative, while only the northern structure will be removed for the partial restoration alternative (150 feet).

Berm or Dike Removal/Modification

The existing earth roadway embankment and surface roads will be removed for both the full and partial restoration alternatives. The roadway embankment would be excavated to an average elevation of 7.8 feet MLLW (5 feet NAVD88) at the new bridge openings. The remaining existing roadway would be removed following the construction of the new approaches. The quantity of excavation at the existing abutments and roadway (25o feet each) is approximately 20,800 CY.

Channel Rehabilitation/Creation

The existing eastern and western channels of Lilliwaup Creek will be deepened and widened as part of both alternatives (Figures 17-5 and 17-6). The western channel of Lilliwaup Creek was nearly completely filled by the 2005 and 2007 landslide events, and the primary flow pathway is now the eastern channel. It appears that the western channel was the dominant channel around 1939 (aerial photo date) but it also appears that this was due to dredging. The main channels would be excavated to an elevation of approximately -4 feet NAVD88, which is about 1 foot below MLLW. The most downstream portions of the channels would still hold water at the most extreme low tides. The channel sizes depicted in the design alternatives were based on review of historic channels and the *Applied Geomorphology Guidelines* (Appendix C), but further analysis is required to determine the level of excavation needed to restore estuarine processes.

Channel alignments would be modified following the removal of the existing causeway. Both channels would be moved away from the center of the estuary and closer to their historic alignments. The two channels join the mainstem of Lilliwaup Creek approximately 1,700 feet upstream of the existing Highway 101 bridge.

A constant channel slope was assumed for the Lilliwaup Creek channels based on a recent draft analysis conducted by Mertig Engineering for LLTK (2010). This draft report was provided by LLTK for use in the PSNERP conceptual design. Mertig reported that the historic gradient of Lilliwaup Creek was approximately 2.3%. This slope was used to define the profile of the new/restored channels of Lilliwaup Creek, with a starting invert elevation of -1 foot MLLW (-3.8 feet NAVD88) and a channel length of 3,750 feet. The new upstream channel invert (near the falls) would be 8.2 feet MLLW (5.4 feet NAVD88). The new top width (at MHHW) of the each channel will be 40 feet. The top widths will narrow, moving upstream to the point where the two branches join and the channel width will be 30 feet. This dimension was based on the results of the hydraulic geometry analysis, as well as review of available aerial photographs.

The blind tidal channels would be excavated in each of the newly restored tidal marsh areas. The restored tidal marsh will require channels to allow tidal inundation in what is presently fill and/or aggraded sediments. The channels are an important component of the tidal marsh system. Two new channels (with a total length of 660 feet) would be excavated for both restoration alternatives. The hydraulic geometry analysis yielded a design top width of 12 feet for these channels.

Groin Removal/Modification - NA

Hydraulic Modification

The existing 150-foot-long bridge would be replaced with either a 600-foot-long bridge (full restoration) or a 500-foot-long bridge (partial restoration), with new approaches on both ends of the bridge resulting in realignment of 1,200 feet of Highway 101.

Overwater Structure Removal - NA

Topography Restoration

Two areas between the existing eastern and western channels of Lilliwaup Creek will be excavated to marsh plain elevation for both the full and partial restoration alternatives (Figures 17-5 and 17-6). The total area of this fill is approximately 5 acres (218,500 SF) and has an average existing elevation of 10.8 to 11.8 feet MLLW (8 to 9 feet NAVD88). The fill, which consists primarily of aggraded sediments from the landslides, would be excavated to an average elevation of 8.8 feet MLLW (6 feet NAVD88). The total excavation volume is estimated to be 22,000 CY. This area was divided into two subbasins (2 acres each). A new blind tidal channel would be excavated within each subbasin.

In the full restoration alternative, a small tidal pool will be constructed at the downstream western shore of the estuary. The T-sheet depicts a back barrier lagoon in this location. This small feature may have been transitory and associated with shore accretion or related to wave overwash. The area is presently filled and developed.

Therefore, a back beach tidal pool will be excavated to provide a more complex shore form and replicate historic conditions. The pool would be excavated to approximate elevation 0 feet MLLW (-3 feet NAVD88), with gentle side slopes (5:1) and a surface area of approximately 4,000 SF. Approximately 750 CY of material would be excavated to create this feature. Following excavation, the slopes of the pool would be lined with gravel excavated during the upstream fill removal activities.

17.3.3 Restoration Features – Additional Management Measures

Beach Nourishment

Gravel and sediments excavated from the channel and aggraded marsh plain will be used to reconstruct a natural beach at the western shore of the estuary near the new bridge. The 1884 T-sheet shows gravel beaches along both shores of the Lilliwaup Estuary, and this shoreform would be restored under both alternatives. The sediments would be placed to a depth of 3 feet and from an elevation of approximately 4.3 to 13.3 feet MLLW (1.5 feet to 10.5 feet NAVD88). The upper limit was set using a typical beach berm elevation of 13.3 feet MLLW (1.5 feet above MHHW).

The length of new beach will vary between the full and partial restoration alternatives. Much of the development downstream of the highway will be removed as part of the full restoration alternative. The western beach length will be approximately 850 feet for the full restoration alternative, and 350 feet for the partial restoration alternative. Similarly, a new beach and gravel shore will be constructed at the eastern side of the estuary at the location of the existing bridge abutment. The length of the new beach is approximately 250 feet.

A typical cross section was developed to estimate the volume of gravel to be placed for each alternative (Figures 17-5 and 17-6). The total volume of gravel for beach nourishment is approximately 9,200 CY for the full restoration alternative and 5,000 CY for the partial restoration alternative.

Contaminant Removal/Remediation - NA

Debris Removal

Large boulders and concrete chunks scattered across the western portion of the estuary would be removed for both alternatives. It was assumed that approximately 100 pieces of rock are present and that each is approximately 1 CY, resulting in an estimate of approximately 150 tons of rock and rubble to be removed from the estuary.

Invasive Species Control - NA

Large Wood Placement

Both alternatives will include placement of large wood within the channel and adjacent marsh plain (Figures 17-3 and 17-4). The wood is intended to provide habitat complexity for anadromous fish, as well as structure to maintain the excavated channels. It is estimated that five large wood structures, consisting of three to four logs each, would be placed in the main channel of Lilliwaup Creek. Additionally, three pieces of large wood would be placed on the restored gravel beaches to provide enhanced shoreform structure and erosion protection to the restored beaches, and for stability following construction.

Physical Exclusion - NA

Pollution Control - NA

Revegetation

In the full restoration alternative, the upland extent of the beaches at the downstream western shore of the estuary would be planted with upland vegetation (above MHHW). The total area of the upland shore planting is approximately 0.6 acre.

Both the full and partial restoration alternatives include riparian planting in areas that are impacted by the channel excavation activities upstream of the eastern and western channel split. The total area of planting for channel rehabilitation is approximately 1 acre.

Reintroduction of Native Animals - NA

Substrate Modification - NA

Species Habitat Enhancement - NA

17.3.4 Restoration Features – Other

The full restoration alternative will remove all of the structures from the water side of the western shore downstream from the Highway 101 bridge. A total of seven structures will be removed from this area, with a total surface area of approximately 16,500 SF. For the partial restoration alternative, only the northernmost building downstream of Highway 101 would be demolished (1,000 SF). The abandoned buildings located at the western abutment of the existing bridge will be removed in both alternatives (2,200 SF). The removal of these structures will restore natural shore conditions and remove encroachment into the historic alignment of the western channel.

The overhead power, telephone, and telecommunications lines that currently pass along the existing causeway would be relocated to the new bridge and roadway alignment. It is unknown if a water line or other utilities exist at the bridge crossing.

17.3.5 Land Requirements

The action area is composed of private property with the exception of the WSDOT right-of-way. It is assumed that the land to be modified by the restoration activities will need to be purchased for both restoration alternatives.

Additional right-of-way may need to be acquired along the southwest edge of the new road to allow for the new roadway alignment. The proposed alignment is located northwest of the current alignment in order to avoid complete road closures during construction.

Utilities are expected to exist in the developed parcels to be acquired and demolished. Further investigation of utilities is required.

17.3.6 Design Considerations

The proposed bridge alignment will be shifted just north of the existing alignment to maintain traffic during construction. With the full restoration alternative, the bridge will be approximately 600 feet long with six spans; with the partial restoration alternative it will be approximately 500 feet long with five spans. The spans will be approximately 100 feet and consist of 5-foot-2-inch-deep pre-cast concrete girders. The bridge substructure will consist of columns supported on drilled shafts (Figure 17-7). The assumed embedment depth of the drilled shafts is 100 feet.

A ballast/fill section will be needed to transition from the bridge structure to the existing roadway. The proposed roadway will meet current design standards and will meet or exceed equivalent capacity. The road will include two 12-foot lanes and 3-foot and 10-foot shoulders.

The proposed roadway geometry includes vertical and horizontal alignment considerations. The existing roadway geometry at the intersection of Lilliwaup Street may require a design deviation from WSDOT. To minimize property acquisition, the new alignment would be built as close as possible to the existing road. The total length of improvements (bridge and road structures) is approximately 1,350 LF.

Boats tied up on the right (south) bank of the estuary, which appears to be partly sheltered by the existing road embankment, may be affected by increased wave and currents resulting from embankment removal. However, this constraint appears minor as the beaches used to haul out small craft should remain.

17.3.7 Construction Considerations

Roadway

Pre-cast concrete girders are not ideal for tight-radius bridge alignments. Other bridge types, such as curved steel I-girders or box girders, should be considered during later design phases to minimize the number of spans and foundations.

A drilled-shaft oscillator likely would be used to install the drilled shafts. Where the new alignment runs adjacent to the existing bridge, local access via filling in from the shore or temporary platforms will be required for shaft installation. It is assumed that the contractor will be able to install one shaft per week. Large-diameter casing shoring would be required to keep out water and allow access to the top of the shaft for column form placement and removal. Once the shafts are installed, the columns are cast inside the shoring casing. After the casing is removed, the cast-in-place pilecaps and bridge superstructure are constructed. Concrete bridges require very little maintenance. The current standard is to inspect bridges every 2 years.

Earthwork

The project will require removal of a large volume of earth and gravel from the site. Further analysis of disposal sites as well as opportunities to reuse earth and gravel onsite is recommended. The gravel deposits in the upper reaches should be useful for shore restoration within this project, but should also have value for other projects. Use of local sediments for roadway fill should be seriously considered in subsequent design phases.

17.4 Extent of Stressor Removal

Table 17-2 provides the amount of stressor removal with the full and partial restoration alternatives.

Table 17-2. Stressor Removal

Stressor	Full Restoration	Partial Restoration
Tidal Barrier (LF)	500	400
Fill (area)	5 acres	5 acres
Armor (LF)	640	390

17.5 Expected Evolution of the Action Area

The restored site will evolve toward a dynamic equilibrium consistent with historic conditions. This equilibrium will include a greater extent of defined channels, and a diversity of salinity and vegetation regimes spanning from riparian to estuarine to littoral. The landscape will be resilient, with fluctuations in hydraulic and sediment processes. Without restoration, degradation of habitats can be expected due to an abnormally large sediment pulse and blockage by Highway 101.

17.6 Uncertainties and Risks

The most significant uncertainties revolve around sediment transport. The watershed above the falls (outside the project area) has been disturbed, resulting in significant deposition of gravels in the lower 0.5 mile of Lilliwaup Creek. Mobilization of additional sediment inputs, similar to the 2005 and 2007 slides, from upstream of the falls appears unlikely to occur (LLTK 2010). However, the sediments already deposited below the falls but upstream of the estuary could migrate downstream and pose a risk to estuarine processes in the future, affecting both morphology and habitat. A pulse of sediment could impede tidal exchange and degrade functions.

The severity or importance of this risk factor has not been fully evaluated. The risk is greatly reduced if the creek restoration proposed by LLTK is implemented either as part of the PSNERP action or separately. The full restoration alternative reduces this risk substantially by removing sediment and “resetting” the system. Removing the Highway 101 embankment also reduces this risk by facilitating sediment passage into Hood Canal. Changes to sediment transport and creek channel locations may affect private shorelines along the south side near Highway 101. Given the significant changes to the watershed, the natural hydrology and sediment processes may be difficult to define and use as a basis of restoration.

17.6.1 Risks Associated with Projected Sea Level Change

The residences located on the western side of the Lilliwaup Estuary are at an elevation of approximately 14.8 feet MLLW (12 feet NAVD88). This elevation is only 3 feet above MHHW, and these areas may be subject to flood risk now and in the future. Table 17-3 provides a qualitative comparison of sea level change risks associated with this action.

Table 17-3. Risks of Sea Level Change

	Projected Sea Level Change		
	High (46cm)	**Intermediate (4cm)**	**Low (-8cm)**
Full Restoration	The Highway 101 bridge clearances may be reduced to below standards. Habitat mix may change but overall the natural environment should be fairly resilient. Nearshore properties will be subject to increased flood and erosion risk, and any armoring will impede shore migration and cause a loss of intertidal beaches.	Negligible impact.	Negligible impact.
Partial Restoration	The Highway 101 bridge clearances may be reduced to below standards. Habitat mix may change but overall the natural environment should be fairly resilient. Nearshore properties will be subject to increased flood and erosion risk, and any armoring will impede shore migration and cause a loss of intertidal beaches. This is a greater risk with partial restoration because more coastal development remains.	Negligible impact.	Negligible impact.

17.7 Potential Monitoring Opportunities

Monitoring is important for evaluating the success of the restoration. A combination of field surveys and aerial photographs would be used to document biological and physical changes to the landscape. Monitoring data can be used to refine adaptive management and corrective actions, as needed. Some of the key monitoring needs and opportunities associated with this action are summarized in Table 17-4.

Table 17-4. Monitoring Needs and Opportunities

Monitoring Parameter	Key Performance Indicator	Note
Topographic Stability	X	Monitor beach morphology to inform restoration success
Sediment Accretion / Erosion	X	Monitor sediment accumulation and effects on estuary morphology and habitat
Wood Accumulation		
Soil / Substrate Conditions		
Vegetation Establishment	X	Monitor riparian plantings
Marsh Surface Evolution / Accretion	X	Monitor excavated areas to document marsh plain evolution
Tidal Channel Cross-Section / Density	X	Check stability of tidal channel modifications
Water Quality (contaminants)		
Salinity		
Shellfish Production		
Extent of Invasive Species		
Animal Species Richness		
Fish (salmonid) Access/Use		
Forage Fish Production		
Wildlife Species Use		
Effectiveness of Exclusion Devices		

17.8 Information Needed for Preliminary Design

This conceptual design report represents an initial step in the restoration design sequence. The design concepts described above were developed based on readily available information without the level of site-specific survey and investigation that is necessary to support subsequent design and implementation. Substantial additional information will be required at the preliminary design stage to confirm the design assumptions, refine quantity estimates, address property and regulatory issues, obtain stakeholder support, and fill in data gaps. The extent to which this information is collected for preliminary design (or a later design stage) will depend upon the available budget, schedule and other factors. This section attempts to define the most essential information needs for this action.

- Property Investigation/Survey – More detailed information on parcel ownership, utilities and property boundary locations will be needed to finalize the design, confirm acquisition requirements, and support negotiations with property owners.
- Topographic/Bathymetric Survey – The survey data would be used to refine design of key project elements and develop detailed construction and demolition plans. Survey data could also be used as a baseline for pre- and post-construction

modeling, including hydrodynamic modeling. A temporary tide gage may be required in the early design stages to obtain site-specific tidal statistics.

- Geotechnical Investigation – Additional geotechnical study will be required to finalize design and address questions of slope stability related to the slide area.
- Cultural Resources Investigation – Surveys for archaeological and historic resources may be required for this action area as it has a high likelihood of having past use by Native Americans. This is particularly important in areas proposed for excavation.
- Hydraulic Analysis/Modeling – Tidal circulation, flood, and hydrodynamic modeling will be required for foundation type and to evaluate impacts to infrastructure and adjacent properties following restoration. Hydraulic engineer recommendations will be needed for scour and minimum bridge clearance over water.
- Contaminant Survey – If preliminary investigations suggest that hazardous material could be present in the action area, additional soil and sediment analysis may be needed. The introductory chapter describes the Phase I site investigations that are occurring as part of this overall effort via a separate contract.
- Sediment Transport Study – Assessment of sediment transport dynamics may be needed to refine the design.

17.9 Quantity Estimates

The quantity spreadsheets for the full and partial restoration alternatives are provided in Exhibits 17-1 and 17-2.

17.10 References

LLTK (Long Live the Kings). 2010. *Draft Lilliwaup Creek Watershed Assessment and Project Design Evaluation.*

Moore, Jed. 2010. Long Live the Kings, personal communication.

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64

WDFW Contract # 100-000204 (CAPS No. 10-1461)

Historic Map (T-Sheet)

Action Name: Lilliwaup Causeway Replacement and Estuary Restoration

PSNERP ID #: 1346

Figure 17- 2A

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Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64

WDFW Contract # 100-000204 (CAPS No. 10-1461)

Historic Map (T-Sheet) and River History Project Data

Action Name: Lilliwaup Causeway Replacement and Estuary Restoration

PSNERP ID #: 1346

Figure 17- 2B

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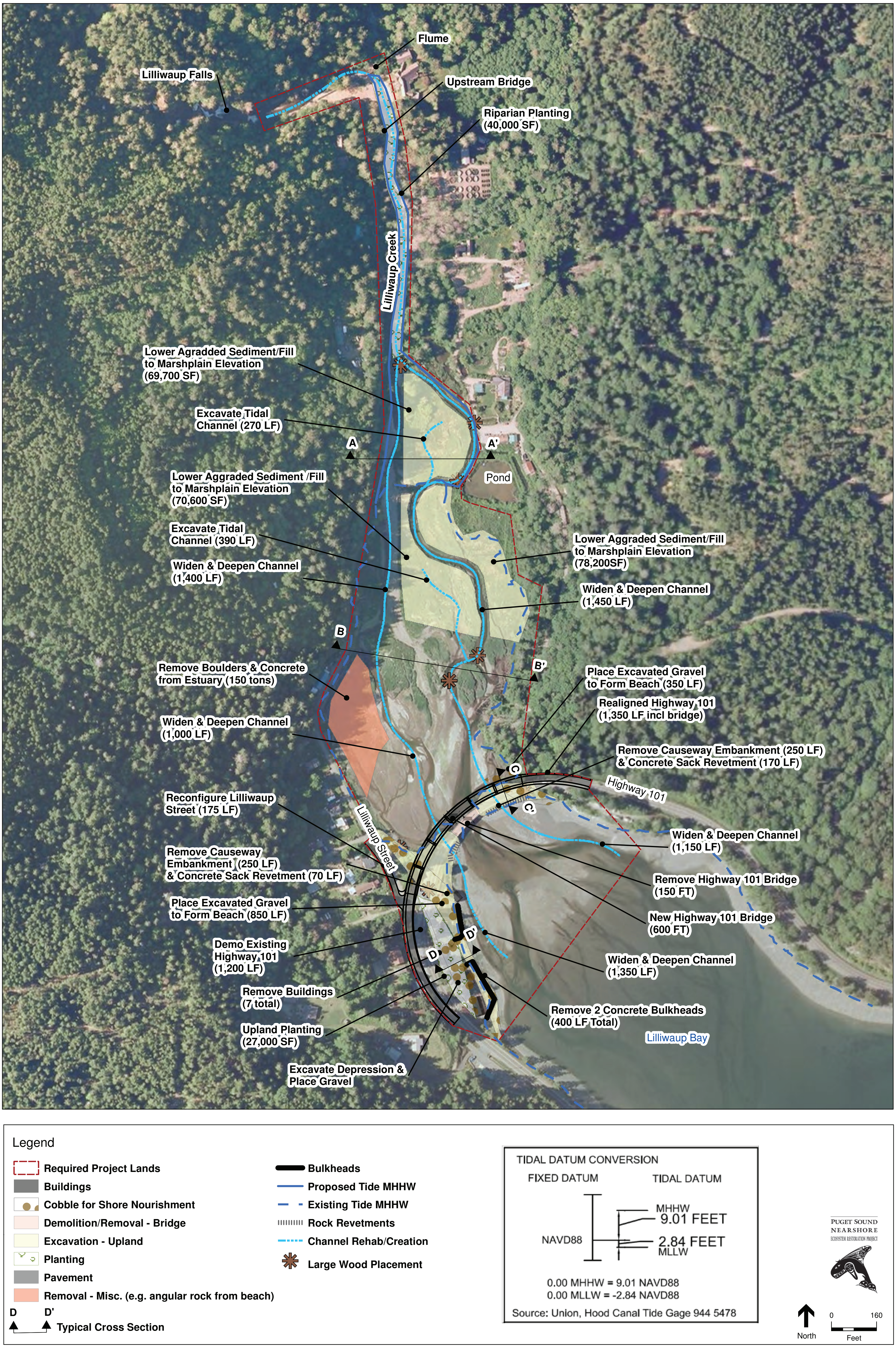


SOURCE: Washington Public Lands Database (2006); Washington Counties Parcels (2009); AEX (image, 2009)

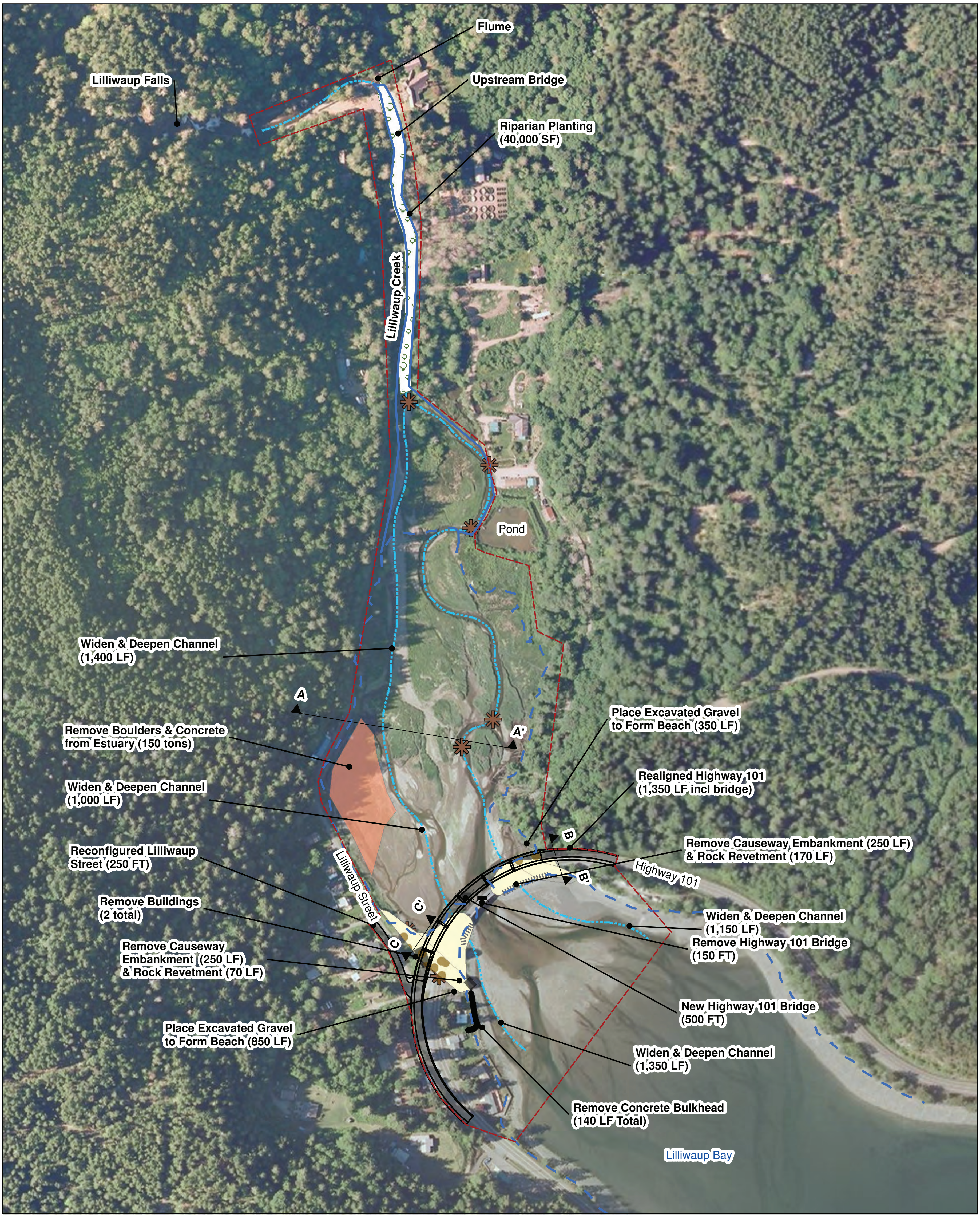
Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64

WDFW Contract # 100-000204 (CAPS No. 10-1461)

Lead Contractor: ESA
Design Lead: ESA PWA, Bob Battalio
Date: 2/2011

Conceptual Design Plan
Site Name: Lilliwaup River and Sund Creek Estuaries
Action Name: Lilliwaup Causeway Replacement and Estuary Restoration
PSNERP ID #:1346
Full Restoration

Figure 17-3



Legend

- Required Project Lands
- Buildings
- Cobble for Shore Nourishment
- Excavation - Lowland
- Excavation - Upland
- Pavement
- Removal - Misc. (e.g. angular rock from beach)
- D D' Typical Cross Section
- Bulkheads
- Existing Tide MHHW
- Proposed Tide MHHW
- Rock Revetments
- Channel Rehab/Creation
- Large Wood Placement

TIDAL DATUM CONVERSION

FIXED DATUM — TIDAL DATUM

NAVD88 — MHHW 9.01 FEET — 2.84 FEET MLLW

0.00 MHHW = 9.01 NAVD88
0.00 MLLW = -2.84 NAVD88

Source: Union, Hood Canal Tide Gage 944 5478

North 0 160 Feet

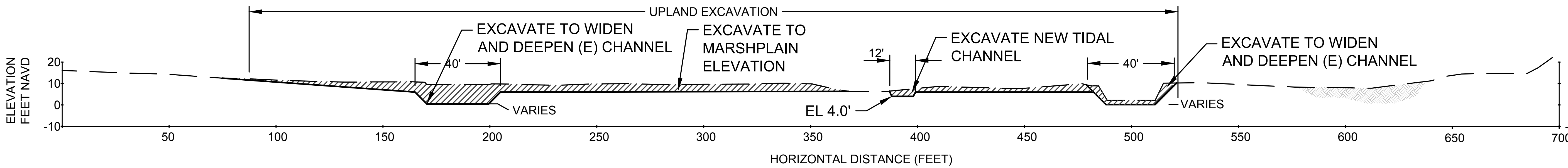
SOURCE: Washington Public Lands Database (2006);
Washington Counties Parcels (2009); Action Area (PSNERP, 2010)

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

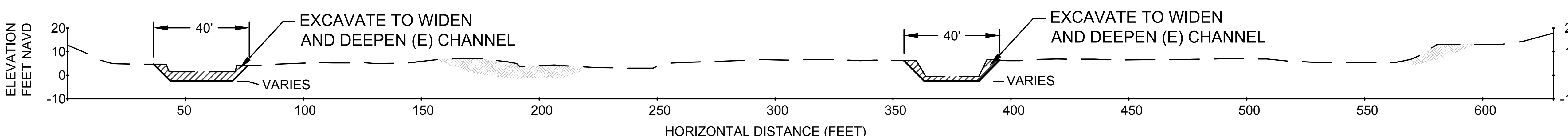
Lead Contractor: ESA
Design Lead: ESA PWA, Bob Battalio
Date: 2/2011

Conceptual Design Plan
Site Name: Lilliwaup River and Sund Creek Estuaries
Action Name: Lilliwaup Causeway Replacement and Estuary Restoration
PSNERP ID #:1346
Partial Restoration

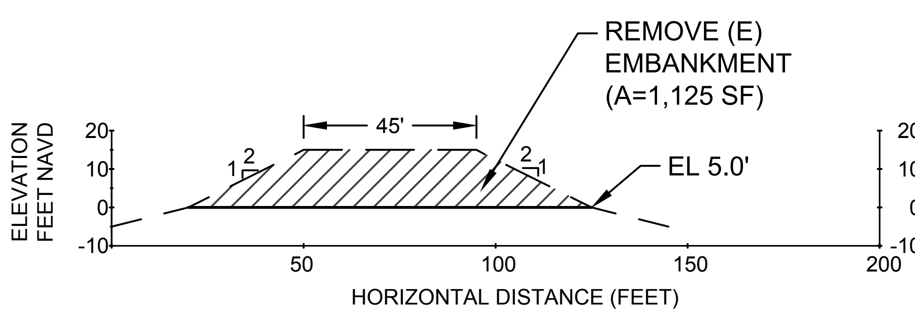
Figure 17-4



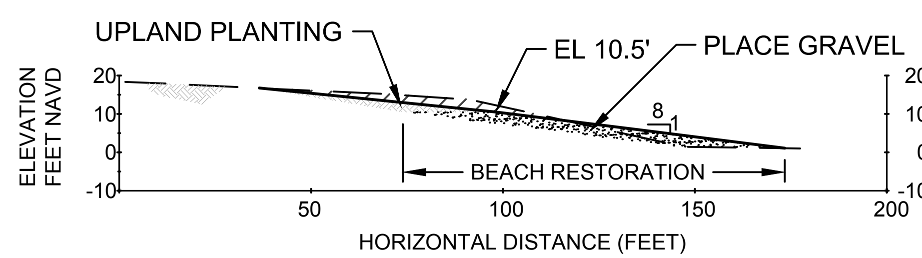
A CHANNEL AND MARSHPLAIN EXCAVATION - TYPICAL SECTION



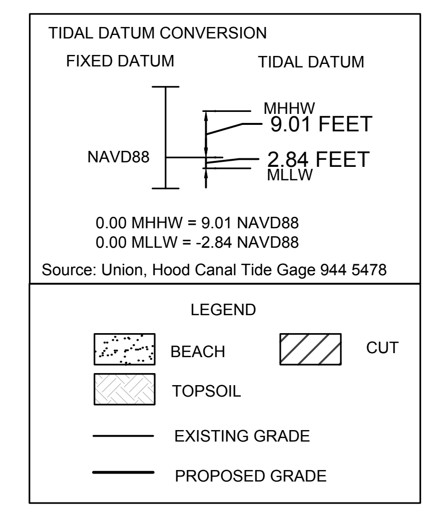
B CHANNEL EXCAVATION - TYPICAL SECTION



C CAUSEWAY EMBANKMENT - TYPICAL SECTION



D OUTBOARD BEACH - TYPICAL SECTION

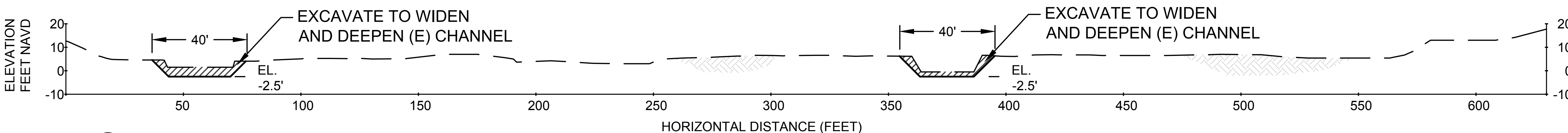


PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

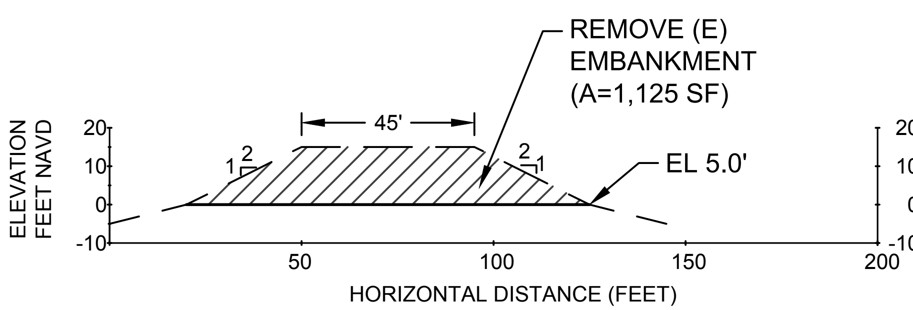
Lead Contractor: ESA
Design Lead: ESA PWA with KPFF
Date: 3/2011

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)
Conceptual Design Section
SITE NAME: **Lilliwaup River and Sund Creek Estuaries**
ACTION NAME: **Lilliwaup Causeway Replacement and Estuary Restoration**
PSNERP ID#: **1346**
Full Restoration

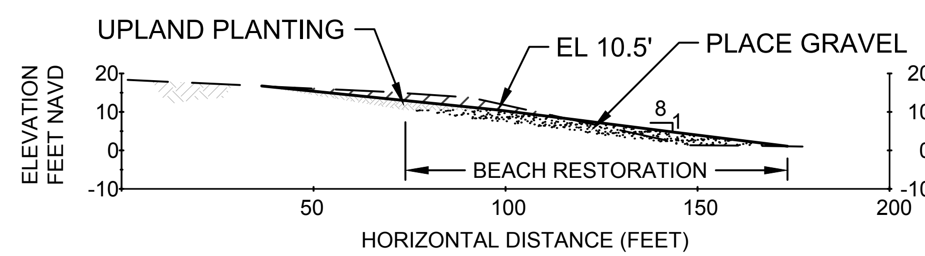
Figure 17-5



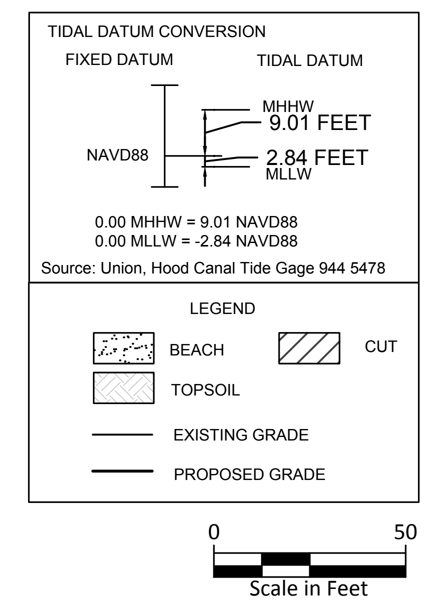
(B) CHJANNEL EXCAVATION - TYPICAL SECTION



(C) CAUSEWAY EMBANKMENT - TYPICAL SECTION



(D) OUTBOARD BEACH - TYPICAL SECTION



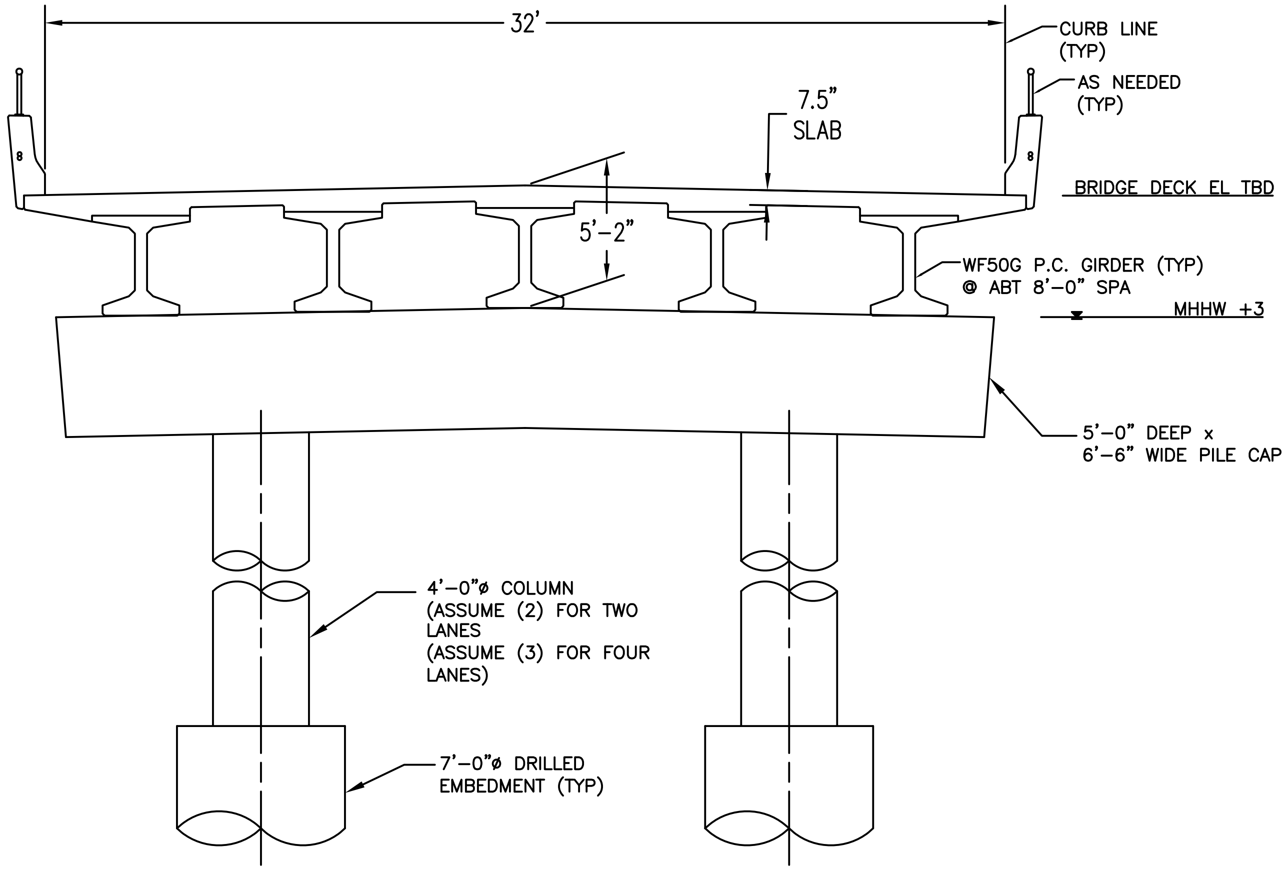
PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: ESA PWA with KPFF
Date: 3/2011

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

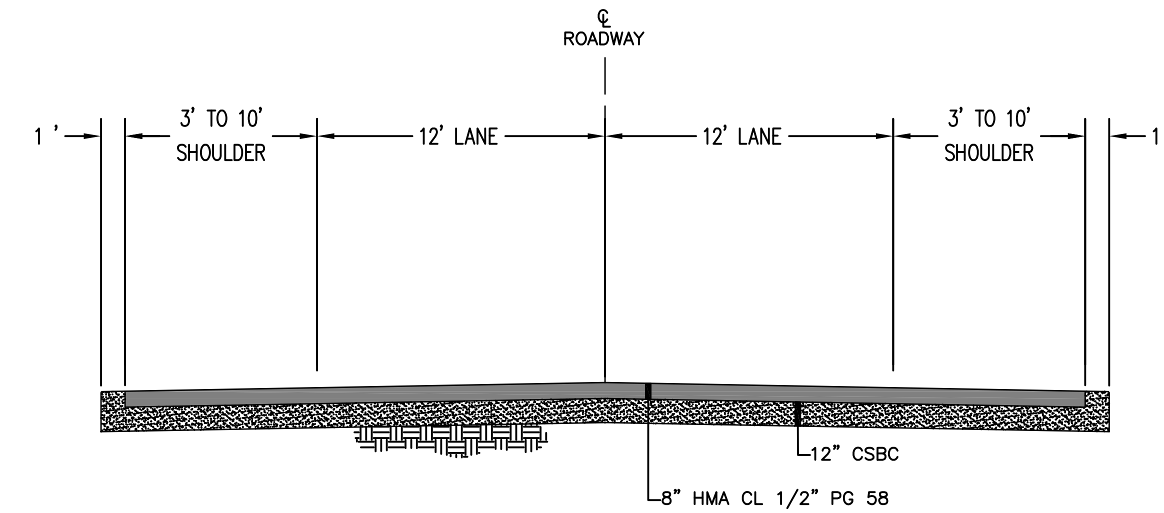
Conceptual Design Section
SITE NAME: **Lilliwaup River and Sund Creek Estuaries**
ACTION NAME: **Lilliwaup Causeway Replacement and Estuary Restoration**
PSNERP ID#: **1346**
Partial Restoration

Figure 17-6



BRIDGE SECTION

NOTE: TEMPORARY FALSEWORK REQUIRED TO SUPPORT GIRDER SEGMENTS PRIOR TO SPLICING.



ROADWAY SECTION
NTS

PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: ESA PWA with KPFF
Date: 3/2011

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Section
SITE NAME: **Lilliwaup River and Sund Creek Estuaries**
ACTION NAME: **Lilliwaup Causeway Replacement and Estuary Restoration**
PSNERP ID#: **1346**
Full & Partial Restoration

Figure 17-7

Full Restoration Quantity Estimate

	Action Name:	Lilliwaup Causeway Replacement and Estuary Restoration	
	Action #:	1346	
	Date:	February 2011	
	By:	ESA PWA with KPFF	

REMEDY: ***restore tidal connectivity in the Lilliwaup Estuary by replacing the existing causeway with an elevated structure that spans the entire delta***

Construction Period:

	Item	Unit of Measure	Material Name	Qty	Description of Item		Indicate section of design report where item is described
ACQUISITION AND CONSERVATION					Based on available mapping information		
	Required Project Lands	Acre		35.4	Total land required For action		17.3
	Proponent / Partner-owned lands	Acre		7.6	WSDOT		17.3
	Lands To Be Acquired	Acre		32.1	Estimate land required to be acquired for action prior to implementation		17.3
Material Sites					Not Used: See Earthwork - Imported Fill.		
MOBILIZATION AND ACCESS for construction activities					Description required for each item to facilitate cost estimating		
	Mobilization - Typical (Equipment, Personnel, Planning, Financial)	LS		1	Up front costs such as bonding, planning and other staff time and financing. Typically, assume 8% to 10% of other items.		17.3
	Mobilization - Remote (Equipment, Personnel, Planning, Financial)	LS		0			
	Site Access	LS		0			
	Barge Access	Days		0			
	Temporary Traffic Control (one of the following)						
	none	LS		0			
	signs	LS		1	Typical Construction Signage		17.3
	flags / spotters	LS		1	Flags and spotters only during roadway transition connection		17.3
	unique	LS		0			
	Temporary Roadway	SF		0			
	Control of Water	LS		1	Creek channel excavation will require bypassing of bse flow plus allowance for storm flows during construction period. Anticipate that a temporary dam to a pipe in a temporary channel will be sufficient. Assume 1000 lf of 48" diam HDPE pipe with metal post pipe anchors every 50 feet. Inlet and outletwill require earthwork, rock, and sand bags. Expect 4 installations of one month each (resuse bypass equipment)		17.3
Relocation Activities					Not Used: See Utilities, Structures		
Site Demolition Activities					Demolition and removal of structures (description required), temporary features and relocations, itemized separately); Clearing and grubbing of vegetation, and removal of minor debris (rocks, slabs) - description required.		
	Clearing and Grubbing (one or more of following)				Use one or more of the following categories of clearing and grubbing		
	Clear Vegetation - Local Disposal	AC		7	light vegeation clearing as part fo excavation		17.3
	Clear /Grub Vegetation - Local Disposal	AC		0			
	Clear /Grub Vegetation - Offsite Disposal	AC		0			
	Clear, stockpile - large woody debris	CY		0			
	Hydraulic Structures - Culverts	LS		0			
	Hydraulic Structures - Large	LS		0			
	Utilities	LF		1000	Electric & Telephone at existing bridge to be relocated to new bridge		17.3
	Buildings	SF		16,500	Western outboard shore development (7 structures)		17.3
	Pavement	SF		42250	Removal of 30' Roadway		17.3
	Bulkheads	LF		400	Remove 2 bulkheads at western outboard shore		17.3
	Demolition/Removal - Rock Revetments	LF		240	Rock and sackrete revetement at downstream face of existing causeway		17.3
	Demolition / Removal - Railroad Berm	LF, SF or CY		0			
	Demolition / Removal - Bridge	SF		4500	150'x30'		17.3
	Removal - Misc. (e.g. angular rock from beach)	Ton		150	Boulders and concrete scatttered over western area of existing estuary		17.3
	Demolition / Removal - in-water Piling	Number of Piles		0			
	Haul - Offsite Disposal of Demolition Debris	Miles		40	Round trip haul distance for local disposal assumed		17.3
Hazardous/Contaminated Waste Removal					These items for earthwork of quality not compatible with wetlands, requiring special handling and disposal. Describe basis for classification as contaminated or hazardous. State known or suspected contamination, describe known similar work.		
	Contaminated Earthwork	CY		0			
	Hazardous Earthwork	CY		0			
Construct Temporary Features					Use as needed for unusual temporary features not included elsewhere (see TESC below)		
EARTHWORK					Expand to include equipment, etc. to facilitate cost estimating.		
	Excavation	CY			Per yard excavation w/out expected haul		
	Excavation - Upland	CY		22000	Lower upland to marshplain, causeway removal		17.3
	Excavation - Lowland	CY		9000	Highway 101 roadway embankment excavation and tidal depression		17.3
	Dredging - Bucket - Land	CY		48600	Channel Excavation - (6350 LF main channel + 660 LF blind tidal channel)		17.3
	Dredging - Bucket - Marine	CY		0			
	Dredging - Hydraulic	CY		0			
	Fine Grading	AC		0			
	Fill Placement - local borrow				This is additive to Earthwork -Excavation		
	Side cast	CY		0	Excavated material placed within reach of excavator / dredge - assume includes some shaping by bucket		
	Haul - uncontrolled placement	CY		9200	Placement of excavated gravel at eastern and western shore for beach		17.3
	Haul - uncontrolled placement	CY		8	5 riparian structures, 3 beach structures		17.3
	Haul, place, compact	CY		0			
	Stockpile - uncontrolled placement	CY		0			
	Stockpile - controlled placement	CY		0			
	Conveyor placement from stockpile land/water	CY		0			
	Imported Fill				Includes purchase, delivery and placement or as noted / described		
	Select Fill	CY		0			
	Gravel Borrow, including haul	CY		0			
	Sand / Gravel for Beach Nourishment	CY		0			
	Cobble for Shore Nourishment	CY		0			
	Embankment Compaction	CY		0			
	Topsoil	CY		0			
RESTORATION Features							
	Channel Rehab / Creation	SF		40000	Riparian vegetation at upstream reach of reconstructed channel		17.3
	Large Wood Placement	EA		8	5 riparian structures, 3 beach structures		17.3
	Invasive Species Control	Acre		0	Per acre control described in drawings and narrative		
	Physical Exclusion Devices	LF or EA		0	Human or wildlife exclusions including fences, barriers, mooring buoys, etc		
	Other Restoration Features/ Activities	LS		0	Describe other items not included elsewhere		
Structures		EA			KPFF to provide additional inputs		
	Water Control Structures - Culverts with Gates	EA		0	Describe type, number of openings (e.g. pipes), expected materials, dimensions		
	Water Control Structures - Weirs	EA		0	Describe, length, type, anticipated materials		
	Rock Slope Protection	LF		0	Describe slope, rock size, layering, use of fabric, back up quantities per foot.		
	Other	EA		0	Describe		
	Elevated Boat Ramp	SF		0	Pile or pier supported to allow sediment drift		
	Fencing	SF		0	Describe, type, height etc.		
Utilities					Replacement or relocation. Designer to provide size and material and have separate line item for each run. Incidentals include earthwork, testing, hook up fees, etc. These quantities do not include demolition of existing utilities, real estate / easemen		
	Water	LF		1600	Hang from bridge		17.3
	Gas	LF		0	unknown		
	Electric	LF		1000	Existing overhead power at Highway 101 bridge to be relocated to new bridge alignment		17.3
	Sewer	LF		0	unknown		
	Telecommunications	LF		1000	Existing overhead power at Highway 101 bridge to be relocated to new bridge alignment		17.3
	Other	LF					
Roadway / Railway					KPFF expected to participate in these estimates		
	Roadway	SF		27861	Typical Roadway 37' wide, includes Lilliwaup St (250'x25')		17.3
	Roadway - Switch (potential)	LS		0			
	Culvert (type)	LF		0			
	Culvert - Jacking	LF		0			
	Culvert - Horizontal Pile Driving	LF		0			
	Bridge Deck	SF		25200	Precast Concrete Girder Bridge with 100' spans		17.3
	Bridge -Foundation	LF		200	(5) 40' CIP Concrete pile caps with (2) 7' drilled shafts 100' embed at each pile cap		17.3
	Railway - Shoe fly	LF		0			

Full Restoration Quantity Estimate

	Action Name:	Lilliwaup Causeway Replacement and Estuary Restoration					
	Action #:	1346					
	Date:	February 2011					
	By:	ESA PWA with KPFF					

REMEDY: ***restore tidal connectivity in the Lilliwaup Estuary by replacing the existing causeway with an elevated structure that spans the entire delta***

Construction Period:

	Item	Unit of Measure	Material Name	Qty	Description of Item		Indicate section of design report where item is described
Permanent Access Features					KPFF expected to participate in these estimates		
	Roads	Level		2%	Level 1 direct access, Level 2 moderately difficult, Level 3 difficult access		17.3
	Utility Access Routes	varies		0			
	Erosion Control Features	AC		0.72	Stabilized Construction Entrances, Sediment Ponds, Hydro Seed to Stabilize Roadway Embankments		17.3
Public Access or Recreation Features					KPFF expected to participate in these estimates		
	Trails	SF		0			
	Bridges	SF		0			
	Kiosk	EA		0			
	Restrooms	EA		0			
	Interpretive Signs	EA		1	TBD		
	Parking Area	SF		0			
	Other	EA		0			
Vegetation & Erosion Control							
	Hydroseeding	AC		0			
	Planting	AC		0.6	Upland vegetation at western outboard shore		17.3
	Vegetation Maintenance	AC-YR		0			
	Erosion / sediment BMPs - Temp.	AC		0.72	BMPs for control of drainage - describe. Assume compliance with Construction General NPDES included		17.3
	Erosion / sediment BMPs - Permanent	AC		0	May want to separate slopes over 25% into separate category		
	Waterside controls - Temporary	EA, LF, LS		0	Silt curtain or other water based temporary actions		
Construction Management							
	Construction oversight	weeks		40	Assume 10 months. Quanity based on constructon duration/ # of construction seasons		17.3
	Materials testing				Included in cost of material - no separate quantity		
Design and Detailed Site Investigations							
	Survey & Property, Utility Research	LS		1	% of construction cost		17.8
	35% Design	LS		1	35% x 25% x Engineer's Estimate		17.8
	65% design	LS		1	65% x 25% x Engineer's Estimate less the cost for 35% PS&E		17.8
	90% design	LS		1	35% x 25% x Engineer's Estimate less the cost for 35% + 65%PS&E		17.8
	100% design	LS		1	25% x Engineer's Estimate less previous costs		17.8
	Geotechnical Studies	LS		1	Refer to design report for description of need		17.8
	Cultural Studies	LS		1	Refer to design report for description of need		17.8
	Soil sampling and testing for contamination	LS		1	check for contaminated material in fill areas		17.8
	Hydraulics and sediment trasnport analyses	LS		1	Evaluate flood risk and fluvial sediment transport		17.8
	HTWR Studies				Refer to design report for description of need		
Project Agreement Activities					Unable to provide credibale estimate at 10% design		
Site-Specific Adaptive Management Features & Activities					List if known		
Monitoring Activities					Assume 5 crew-days/year for each monitoring parameter in design report for 5 yrs		
	Monitoring (Type_)	crew-days		125			
Operations & Maintenance					Unable to provide credible estimate at 10% design		

Partial Restoration Quantity Estimate

Action Name: Lilliwaup Causeway Replacement and Estuary Restoration
Action #: 1346
Date: February 2011
By: ESA PWA with KPFF

REMEDY: restore tidal connectivity in the Lilliwaup Estuary by replacing the existing causeway with an elevated structure that spans the entire delta
Construction Period:

Item	Unit of Measure	Material Name	Qty	Description of Item	Indicate section of design report where item is described
ACQUISITION AND CONSERVATION				Based on available mapping information	
Required Project Lands	Acre		35.4	Total land required For action	17.3
Proponent / Partner-owned lands	Acre		7.6	WSDOT	17.3
Lands To Be Acquired	Acre		18.5	Estimate land required to be acquired for action prior to implementation	17.3
Material Sites				Not Used: See Earthwork - Imported Fill.	
MOBILIZATION AND ACCESS for construction activities				Description required for each item to facilitate cost estimating	
Mobilization - Typical (Equipment, Personnel, Planning, Financial)	LS		1	Up front costs such as bonding, planning and other staff time and financing. Typically, assume 8% to 10% of other items.	17.3
Mobilization - Remote (Equipment, Personnel, Planning, Financial)	LS				
Site Access	LS		0		
Barge Access	Days		0		
Temporary Traffic Control (one of the following)					
none	LS		0		
signs	LS		1	Typical Construction Signage	17.3
flags / spotters	LS		1	Flags and spotters only during roadway transition connection	17.3
unique	LS		0		
Temporary Roadway	SF		0		
Control of Water	LS		1	Creek channel excavation will require bypassing of bse flow plus allowance for storm flows during construction period. Anticipate that a temporary dam to a pipe in a temporary channel will be sufficient. Assume 1000 lf of 48" diam HDPE pipe with metal post pipe anchors every 50 feet. Inlet and outletwill require earthwork, rock, and sand bags. Expect 4 installations of one month each (resuse bypass equipment)	17.3
Relocation Activities				Not Used: See Utilities, Structures	
Site Demolition Activities				Demolition and removal of structures (description required), temporary features and relocations, itemized separately); Clearing and grubbing of vegetation, and removal of minor debris (rocks, slabs) - description required.	
Clearing and Grubbing (one or more of following)				Use one or more of the following categories of clearing and grubbing	
Clear Vegetation - Local Disposal	AC		2	light vegetation clearing as part of excavation	17.3
Clear /Grub Vegetation - Local Disposal	AC		0		
Clear /Grub Vegetation - Offsite Disposal	AC		0		
Clear, stockpile - large woody debris	CY		0		
Hydraulic Structures - Culverts	LS		0		
Hydraulic Structures - Large	LS		0		
Utilities	LF		1000	Electric & Telephone at existing bridge to be relocated to new bridge	17.3
Buildings	LS or SF		3200	Western outboard shore development (2 structures)	17.3
Pavement	SF		42250	Removal of 30' Roadway and portion of Lilliwaup St (250'x25')	17.3
Bulkheads	LF		150	Remove 1 concrete bulkhead at western outboard shore	17.3
Demolition/Removal - Rock Revetments	LF		240	Rock and sackrete revetement at downstream face of existing causeway	17.3
Demolition / Removal - Railroad Berm	LF, SF or CY				
Demolition / Removal - Bridge	SF		4500	150'x30'	17.3
Removal - Misc. (e.g. angular rock from beach)	Ton		150	Boulders and concrete scatttered over western area of existing estuary	17.3
Demolition / Removal - in-water Piling	Number of Piles		0		
Haul - Offsite Disposal of Demolition Debris	Miles		40	Round trip haul distance for local disposal assumed	17.3
Hazardous/Contaminated Waste Removal				These items for earthwork of quality not compatible with wetlands, requiring special handling and disposal. Describe basis for classification as contaminated or hazardous. State known or suspected contamination, describe known similar work.	
Contaminated Earthwork	CY		0		
Hazardous Earthwork	CY		0		
Construct Temporary Features				Use as needed for unusual temporary features not included elsewhere (see TESC below)	
EARTHWORK				Expand to include equipment, etc. to facilitate cost estimating.	
Excavation	CY			Per yard excavation w/out expected haul	
Excavation - Upland	CY		0		
Excavation - Lowland	CY		8200	Highway 101 roadway embankment excavation	17.3
Dredging - Bucket - Land	CY		48000	Channel Excavation - (6350 LF main channel)	17.3
Dredging - Bucket - Marine	CY		0		
Dredging - Hydraulic	CY		0		
Fine Grading	AC		0		
Fill Placement - local borrow				This is additive to Earthwork -Excavation	
Side cast	CY		0	Excavated material placed within reach of excavator / dredge - assume includes some shaping by bucket	
Haul - uncontrolled placement	CY		5000	Placement of excavated gravel at eastern and western shore for beach	17.3
Haul - uncontrolled placement	CY		51200	Offsite disposal of excavated material	17.3
Haul, place, compact	CY		0		
Stockpile - uncontrolled placement	CY		0		
Stockpile - controlled placement	CY		0		
Conveyor placement from stockpile land/water	CY		0		
Imported Fill				Includes purchase, delivery and placement or as noted / described	
Select Fill	CY		0		
Gravel Borrow, including haul	CY		0		
Sand / Gravel for Beach Nourishment	CY		0		
Cobble for Shore Nourishment	CY		0		
Embankment Compaction	CY		0		
Topsoil	CY		0		
RESTORATION Features					
Channel Rehab / Creation	SF		40000	Riparian vegetation at upstream reach of reconstructed channel	17.3
Large Wood Placement	EA		8	5 riparian structures, 3 beach structures	
Invasive Species Control	Acre		0	Per acre control described in drawings and narrative	
Physical Exclusion Devices	LF or EA		0	Human or wildlife exclusions including fences, barriers, mooring buoys, etc	
Other Restoration Features/ Activities	LS		0	Describe other items not included elsewhere	
Structures	EA			KPFF to provide additional inputs	
Water Control Structures - Culverts with Gates	EA		0	Describe type, number of openings (e.g. pipes), expected materials, dimensions	
Water Control Structures - Weirs	EA		0	Describe, length, type, anticipated materials	
Rock Slope Protection	LF		0	Describe slope, rock size, layering, use of fabric, back up quantities per foot.	
Other	EA		0	Describe	
Elevated Boat Ramp	SF		0	Pile or pier supported to allow sediment drift	
Fencing	SF		0	Describe, type, height etc.	
Utilities				Replacement or relocation. Designer to provide size and material and have separate line item for each run. Incidentals include earthwork, testing, hook up fees, etc. These quantities do not include demolition of existing utilities, real estate / easements, design fees. Describe the owner if known, and whether utility franchise will install (e.g., electric is typically installed by electrical franchise).	
Water	LF		1600	Hang from bridge	17.3
Gas	LF		0	unknown	
Electric	LF		1000	Existing overhead power at Highway 101 bridge to be relocated to new bridge alignment	17.3
Sewer	LF		0	unknown	
Telecommunications	LF		1000	Existing overhead power at Highway 101 bridge to be relocated to new bridge alignment	17.3
Other	LF			Others = whatever is required (e.g.. power towers, petroleum, jet fuel, etc.)	
Roadway / Railway				KPFF expected to participate in these estimates	
Roadway	SF		31,561	Typical Roadway 37' wide, includes Lilliwaup St.	17.3
Roadway - Switch (potential)	LS		0		
Culvert (type)	LF		0		
Culvert - Jacking	LF		0		
Culvert - Horizontal Pile Driving	LF		0		
Bridge Deck	SF		21000	Precast Concrete Girder Bridge with 100' spans	
Bridge - Foundation Drilled Shafts	LF		160	(4) 40' CIP Concrete pile caps with (2) 7' drilled shafts 100' embed at each pile cap	17.3
Railway - Shoe fly	LF		0	Temporary alignment	17.3

Partial Restoration Quantity Estimate

Action Name: Lilliwaup Causeway Replacement and Estuary Restoration
Action #: 1346
Date: February 2011
By: ESA PWA with KPFF

REMEDY: restore tidal connectivity in the Lilliwaup Estuary by replacing the existing causeway with an elevated structure that spans the entire delta
Construction Period:

	Item	Unit of Measure	Material Name	Qty	Description of Item		Indicate section of design report where item is described
Permanent Access Features					KPFF expected to participate in these estimates		
	Roads	Level		2%	Level 1 direct access, Level 2 moderately difficult, Level 3 difficult access		17.3
	Utility Access Routes	varies		0	Describe utility access feature, such as boardwalk or all-weather gravel road		
	Erosion Control Features	AC		0.72	Stabilized Construction Entrances, Sediment Ponds, Hydro Seed to Stabilize Roadway Embankments		17.3
Public Access or Recreation Features					KPFF expected to participate in these estimates		
	Trails	SF		0			
	Bridges	SF		0			
	Kiosk	EA		0			
	Restrooms	EA		0			
	Interpretive Signs	EA		1			
	Parking Area	SF		0	TBD		
	Other	EA		0			
Vegetation & Erosion Control							
	Hydroseeding	AC		0			
	Planting	AC		0.6	Upland vegetation at western outboard shore		17.3
	Vegetation Maintenance	AC-YR		0			
	Erosion / sediment BMPs - Temp.	AC		0.72	BMPs for control of drainage - describe. Assume compliance with Construction General NPDES included		17.3
	Erosion / sediment BMPs - Permanent	AC		0	May want to separate slopes over 25% into separate category		
	Waterside controls - Temporary	EA, LF, LS		0	Silt curtain or other water based temporary actions		
Construction Management							
	Construction oversight	weeks		40	(Assume 10 mo.) Quanity based on construction duration/ # of construction seasons		
	Materials testing				Included in cost of material - no separate quantity		
Design and Detailed Site Investigations							
	Survey & Property, Utility Research	LS		1	% of construction cost		17.8
	35% Design	LS		1	35% x 25% x Engineer's Estimate		17.8
	65% design	LS		1	65% x 25% x Engineer's Estimate less the cost for 35% PS&E		17.8
	90% design	LS		1	35% x 25% x Engineer's Estimate less the cost for 35% + 65%PS&E		17.8
	100% design	LS		1	25% x Engineer's Estimate less previous costs		17.8
	Geotechnical Studies			1	Refer to design report for description of need		17.8
	Cultural Studies				Refer to design report for description of need		
	Soil sampling and testing for contamination	LS		1	check for contaminated material in fill areas		17.8
	Hydraulics and sediment trasnport analyses	LS		1	Evaluate flood risk and fluvial sediment transport		17.8
	HTWR Studies				Refer to design report for description of need		
Project Agreement Activities					Unable to provide credible estimate at 10% design		
Site-Specific Adaptive Management Features & Activities					List if known		
Monitoring Activities					Assume 5 crew-days/year for each monitoring parameter in design report for 5 yrs		
	Monitoring (Type_)	crew-days		125			
Operations & Maintenance					Unable to provide credible estimate at 10% design		

18. LIVINGSTON BAY - DIKED FARMLAND AND NEARSHORE HABITAT (#1618)

Local Proponent	Whidbey Camano Land Trust
Delta Process Unit	NA
Shoreline Process Unit(s)	6049, 6050
Strategy(ies)	3 - Barrier Embayment (Lost Embayment)
Restoration Objectives	Removal of dikes that prevent tidal inundation and restore tidal marsh, marsh channel network and associated processes

18.1 Description of the Action

This action entails breaching of a closed barrier embayment and the restoration of tidal flow to diked farmland. The action also entails the construction of a flood protection dike, creation of a breach to Livingston Bay, removal of dikes, and reestablishment of a marsh channel network. Please see the Introduction chapter for important information regarding PSNERP and for context related to this restoration project.

18.2 Action Area Description and Context

Livingston Bay is within the Whidbey Subbasin of Puget Sound. The bay is located within the Stillaguamish River delta on the southeast side of Camano Island. The Whidbey Camano Land Trust and The Nature Conservancy own more than 6,000 acres of tidelands in the adjacent Port Susan Bay. The Land Trust is seeking funding to acquire 300 acres of diked farmland at the head of Port Susan Bay. The proposed restoration action is to restore tidal flow to 250 acres of the diked farmland to create nearshore habitat. This restoration would require the creation of a breach, removal of dikes, and reestablishment of a marsh channel network. The sloping topography surrounding the site would allow the full gradient of habitats to be established. The action area is shown in Figure 18-1.

Figure 18-1. Action Area and Vicinity

18.2.1 Historic Condition

The site had already been diked for agricultural fields by the time of the 1886 topographic sheet (T-sheet) survey (Figures 18-2A and 18-2B). Prior to 1886, the entire embayment was likely converted to agricultural use by the construction of a dike across the entrance channel and diversion of drainage to the perimeter of the site.

The Livingston Bay action area comprises the entire footprint of what was once a salt marsh formed behind a full barrier beach that developed across a broad arcuate embayment. The bay sits at the head of extensive mudflats fed by sediment from the Stillaguamish River and from bluffs to the east and west. The bay is formed in a natural amphitheatre, with the upland rising steeply away from the former salt marsh. A natural barrier beach berm ran across the mouth of the bay, built by wave action, resulting in a predominantly swash-aligned beach fed from the bluffs to the east and west. Reworking by waves of the finer sediments in the mudflats resulted in the accretion of salt marshes in the sheltered area behind the natural beach berm. The berm appears to have been quite wide, built by storm surge overwash events pushing both coarser sediment and woody debris into the salt marsh behind. Today these overwash features are evident in the hummocky topography behind the present beach.

It would appear that the salt marsh drained to the west through a tidal channel system that ran close to the western edge of the action area. Imprints of the relict system can be seen in aerial photographs. The location and width of the entrance channel through the barrier beach are also indicated in these photos. The remains of a jetty can be seen at this location; it was probably aligned with the subtidal channel draining the embayment.

18.2.2 Natural Environment

Livingston Bay is a critical stop on the Pacific Flyway for waterfowl and other migratory birds. The bay provides vital rearing habitat for salmon, steelhead, and other fish species due to its proximity to the mouth of Skagit River. The berm and beach appear to have been relatively undisturbed by diking as the dike was constructed to landward. However, the massive present accumulation of woody debris may indicate that wood has been blocked from moving into the salt marsh. The hummocky area between the dike and berm is poorly drained, with marsh vegetation. Landward of the dike the historic salt marsh has been drained and used for agriculture, both grazing and crops. Initially the elevation of the salt marsh would have allowed passive drainage of diked farmlands by gravity drains; however, as the peat subsided, a pump station was constructed halfway along the berm. As well as being subsided, the soils have probably been compacted by farm machinery.

There is no significant freshwater inflow into the site. Runoff has been diverted by dikes and channels that run north-south close to the western and eastern edges of the site, discharging directly to the bay. More recently, these drainage channels have been used to drain some of the farmland on the eastern side of the site, which has led to some water quality issues.

The supply of estuarine fine sediment appears plentiful, being derived from the Stillaguamish River and recirculated by wave action from the extensive mudflats in Livingston Bay. The river is also the primary source of large amounts of woody debris that accumulates on the beaches and marshes around Livingston Bay. Eroding bluffs on either side of Livingston Bay likely provide a continuous supply of coarser sediments to the barrier beach at the site.

18.2.3 Human Environment

Most of the area is used for agriculture. Apart from agricultural fields and drainage, there has been little development within the former salt marsh. State Route 532, access roads, and residential areas have all been built on higher ground that surrounds the bay; the only utilities crossing the site appear to be related to agricultural activities. More detailed information on existing utilities and the need for utility relocations will be required to support subsequent design phases.

The Livingston Bay Community, located at the southeast portion of the site, is a residential neighborhood with more than 50 homes. The community is accessed from State Route 532, which runs east-west at the northern boundary of the action area, and by Fox Trot Way and East Livingston Bayshore Drive. The houses have been constructed on elevated pads.

Drainage District 5 drains the entire Livingston Bay basin, from Utsalady Road to the north, Hanstead Road to the west, and to Utsalady School (about 2,000 acres), through ditches and a pump system which discharges to Livingston Bay. The Livingston Bay East culvert drains the entire basin from Hanstead Road to the west, Utsalady Road to the north, and Good Road to the east and discharges directly onto the Livingston Bay tidal flats.

18.3 Restoration Design Concept

18.3.1 Restoration Overview and Key Design Assumptions

The lack of development within the former salt marsh would allow for the restoration of almost all of the processes and functions that sustain a complete barrier bay ecosystem. Restoration of tidal inundation to Livingston Bay is a relatively straightforward proposition, particularly since the watershed area and runoff are small. The adjacent rising land should minimize post-restoration flooding and sea level rise issues.

Although the site is subsided, there appears to be a plentiful supply of fine sediment in the existing mudflats that would allow rapid accretion and colonization of the marsh surface, and which would help sustain the marsh in the future with rising sea level. High sedimentation rates would assist in the rapid evolution of a tidal drainage network.

The restoration alternatives are illustrated in Figures 18-3 through 18-6. Both alternatives include breaching the barrier beach in the historic location at the western end of the beach and excavating a tidal channel network. Both alternatives include lowering internal dikes to marsh plain elevations and filling internal drainage ditches and excavation of a tidal channel system. The partial alternative only differs in the amount of channel to be excavated and the extent of dike lowering.

The breach will be located at the approximate historic location at the western end of the bay. The dike, woody material, and scattered rock debris will be removed to create a breach 300 feet wide. The western 200 feet forming the initial inlet will be lowered to an elevation of -4.7 feet MLLW (-7 feet NAVD88, based on the Everett tide gage). The eastern 100 feet will be lowered to 6.3 feet MLLW (4 feet NAVD88) to allow the breach to erode and the inlet to migrate as required. The breach was sized according to the *Applied Geomorphology Guidelines and Hierarchy of Openings* (Appendix C) and compared to an adjacent analog site to the west of Livingston Bay at Barnum Point. The design assumes that inlet will naturally resize to accommodate the tidal prism.

A tidal channel network will be excavated based upon the relict channel pattern to expedite evolution of the marsh channel system. Approximately 12,500 feet of channel will be excavated; between 45 and 115 feet wide, and 5 to 10 feet deep. The channels were sized according to the *Applied Geomorphology Guidelines* (Appendix C). Approximately 4,000 feet of starter channels will be cut for the lower order channels. Material from the channels will be sidecast as low, unconsolidated berms with elevations below MHHW to create heterogeneity on the marsh plain and reduce costs associated with double handling. Gaps will be left in the berms to allow small channels to develop naturally. The existing drainage network would be modified to filter all flows from upslope into the wetland and out through the breach. Ditch blocks would be used to modify the existing straight drainage channels, and the existing pump station would be demolished. Both ditch blocks and sidecast berms will be constructed with material excavated from the channels and lowered dikes. The berms are sidecast mostly within reach of excavator. Low height (e.g., around MHHW), flat sloped geometry is used. Typically, the berms are "dressed" by dragging an excavator bucket or timber mat across them to increase density without compaction. The ditch blocks are earth embankments that extend across the ditches and are similar in final elevation as the berms.

Inundation of Livingston Bay Community would be prevented by 2,000 feet of new flood protection dike constructed along the north side of East Livingston Bay Shore Drive. The crest elevation of the new dike will be 13.3 feet MLLW (11 feet NAVD88). The new dike would grade into rising ground to the south and the east. Flood protection dikes would not be required elsewhere as the setback area grades into rising land.

The partial restoration alternative (Figure 18-4) has the same area of tidal inundation as the full restoration alternative. The breach located at the western end of the bay would be about 300 feet wide. The primary difference with the partial alternative is that starter channels will be excavated for the main channels (about 5 feet deep excavated to MLLW, and about 15 feet to 30 feet wide). This approach reduces initial earthwork efforts and assumes that the channel network will develop gradually based on natural tidal circulation processes.

The evolution of the channel system, and the site in general, would be expected to be slower in the partial restoration alternative. The existing drainage network would be modified to filter all flows from upslope into the wetland and out through the breach. Ditch blocks would be used to modify the existing straight drainage channels, and the existing pump station would be demolished. A new flood protection dike, 2,000 feet long, would be constructed on the north side of East Livingston Bay Shore Drive with a crest elevation of 11 feet MLLW (8.7 feet NAVD88) grading into rising ground to the south and the east.

The key design elements associated with full and partial restoration alternatives are shown in Table 18-1.

Table 18-1. Key Design Elements

Element	Full Restoration	Partial Restoration
Dike Lowering	Lower existing dikes to grade in eastern portion of site and near existing pump station	Dike lowering only occurring in eastern portion and not near pump station
Build New Dike	Construct new flood protection dike along East Livingston Bay Shore Drive (2,000 LF)	Same as full restoration
Revegetation	Plant riparian vegetation along slopes of new dike (120,000 SF)	Same as full restoration
Dike Breach	Excavate breach at western end of barrier beach. Lower existing barrier berm and remove woody debris and rock	Same as full restoration
Beach Nourishment	Nourish existing beach downdrift of breach using sand from excavation (50,000 SF)	Same as full restoration
Tidal Channels	Excavate tidal channel network (12,500 LF) and starter channels (4,000 LF)	Excavate starter channels (8,000 LF)
Existing Drainage Channels	Sidecast material to block existing drainage channels and create low natural berms adjacent to channels	Block existing drainage channels

Element	Full Restoration	Partial Restoration
Pump Station	Remove existing pump station and associated power poles and power lines	Same as full restoration

18.3.2 Restoration Features – Primary Process-Based Management Measures

Armor Removal/Modification

Berm or Dike Removal/Modification

The full and partial restoration alternatives include lowering internal dikes to marsh plain elevations and filling internal drainage ditches (Figure 18-3). Internal dikes would be removed to facilitate marsh restoration at lengths of 7,750 LF for the full restoration and 1,400 LF for the partial restoration.

Channel Rehabilitation/Creation

Both the full and partial restoration alternatives include breaching the barrier beach in the historic location at the western end of the beach. The breach would include lowering the barrier beach berm and removing wood and rock debris along a corridor of about 700 LF. This corridor would provide an area for the breach to migrate across the shore. The breach excavation would extend to about 5 feet below MLLW and provide a channel about 200 feet wide.

The full restoration alternative includes an interior channel network with a 12,500 LF main channel (Figures 18-3 and 18-5). The main channel would range from about 200 feet wide with an invert 5 feet below MLLW near the breach, to about 80 feet wide with an invert at MLLW about two-thirds of the way into the site. Approximately 4,000 LF of starter channels will be cut for the lower order channels. Material generated from channel excavation would be used to block nearby drainage ditches and to create berms that resemble natural dikes adjacent to the channels at or just above marsh plain elevations. Lower order side channels would be excavated off the main channel, and gaps would be left in the low berms to facilitate tidal circulation and drainage of areas away from the main channel.

The partial restoration alternative includes only cutting starter channels (Figures 18-4 and 18-6). The main channel would be about 8,000 LF. Excavated material would be used to fill drainage ditches.

Groin Removal/Modification - NA

Hydraulic Modification - NA

Overwater Structure Removal - NA

Topography Restoration - NA

18.3.3 Restoration Features – Additional Management Measures

Beach Nourishment

Sandy fill generated from breach excavation will be used to nourish the existing beach downdrift of the breach. Both the full and partial restoration alternatives would lower the barrier beach and excavate a breach in the beach, providing sand for beach nourishment activities. Over time, littoral processes would rework the sand, rebuilding the beach berm and depositing sand within the excavated breach to develop an equilibrium between tidal forces and wave action. The designs assumes a 10-foot high shore profile (-0' to +10' MLLW) which creates about 50,000 SF of new beach with excavation from breach.

Contaminant Removal/Remediation - NA

Debris Removal

Both the full and partial restoration alternatives include removal of woody debris and rock along a 700 LF corridor at the western end of the barrier beach (Figures 18-3 and 18-4). The material must be removed so that excavation of the tidal inlet can occur and provide a corridor for the breach to migrate across the shore. It is assumed that the material will be placed on adjacent beaches.

Invasive Species Control - NA

Large Wood Placement - NA

Physical Exclusion - NA

Pollution Control - NA

Revegetation

Under both alternatives, the new dike will be planted with riparian vegetation for erosion control. Native tree and/or shrub species will be planted and the area will be hydroseeded. The marsh will not be planted as vegetation is expected to colonize naturally.

Reintroduction of Native Animals - NA

Substrate Modification - NA

Species Habitat Enhancement - NA

18.3.4 Restoration Features – Other

In both alternatives, the existing pump system used to dewater the agricultural fields would need to be abandoned and removed from the site. The Livingston Bay East culvert will be closed off. All the runoff from Drainage District 5 will be filtered through the restored salt marsh and into Livingston Bay. Electric power lines, power poles or other utilities associated with the existing pump station would also be removed (Figures 18-3 and 18-4).

18.3.5 Land Requirements

Construction of this action will affect of 287 acres of agricultural land and shoreline. There are several landowners within the action area whose holdings run perpendicular to the shoreline. For both the full and partial restoration alternatives, all the land in the action area would have to be acquired via purchase, easement or other similar means. If the pump station is relocated rather than removed permanently, additional land would also have to be acquired. The Land Trust is seeking funding to acquire about 300 acres of diked farmland.

18.3.6 Design Considerations

The main constraint may be the degree of subsidence on the site. The large amount of sediment available from the adjacent mudflats should result in high sedimentation rates.

The proposed tidal inlet should be evaluated further to determine the appropriate depth, width, and section to maintain an open tidal system. Tidal channel sizing and locations for smaller channels will need to be analyzed for the full restoration alternative.

The size of the main channel cross section may need to be optimized to provide adequate fill to create low berms that mimic natural dikes adjacent to the excavated channels. Expanding the excavated channels to short-term equilibrium sections (or larger) would provide additional fill to create low, natural berms to support salt marsh vegetation. Short-term equilibrium sections are made larger to provide adequate capacity for full tidal circulation, as expected with an increased tidal prism associated with the subsided site.

18.3.7 Construction Considerations

The present diked and drained nature of the site would allow for construction of the interior tidal channel network year-round. The upper portions of the tidal channel network could be constructed primarily with upland equipment. Portions of the tidal channel network may require excavators due to high groundwater levels.

Internal dikes may be lowered with upland equipment; however, placement of fill within the existing drainage ditches would require work with dozers or front end loaders. The existing barrier beach may be lowered primarily with dozers. Removal of large woody debris would require work with dozers. The woody debris and rock may be redistributed along the fringe of the restored marsh site. The breach would require work with excavators.

18.4 Extent of Stressor Removal

Table 18-2 describes the amount of stressors to be removed with this action.

Table 18-2. Stressor Removal

Stressor	Full Restoration	Partial Restoration
Tidal Barrier (LF)	Lower 700 LF of barrier beach and about 7,800 LF of dikes to restore tidal action to the site	Lower 700 LF of barrier beach and about 6,400 LF of dikes to restore tidal action to the site
Fill (area)	Remove 0.46 acre of fill along barrier beach to restore tidal action	Remove 0.46 acre of fill along barrier beach to restore tidal action

18.5 Expected Evolution of the Action Area

Without restoration, the site will remain isolated from tidal action by a dike across the entrance channel. The site will continue to be drained and farmed for agricultural purposes. Runoff from the surrounding watershed will continue to be drained to the perimeter of the site. Washover processes on the barrier will be limited due to the massive wood on the beach and by the secondary dike running parallel to the barrier.

Both the full and partial restoration alternatives would lower the barrier beach and excavate a breach in the beach to restore the topography to quasi-historic conditions. Both alternatives would include excavation of a main tidal channel following the path of the relict tidal channel within the historic salt marsh. It is expected that the channel network would equilibrate to the enlarged tidal prism when the channels will become self-maintaining; this will take longer for the partial restoration alternative when starter channels only will be excavated.

There are few constraints in the project area that would inhibit full restoration of the ecological functions. Although the site is subsided, there appears to be a plentiful supply of fine sediment in the existing mudflats that would allow rapid accretion and colonization of the marsh surface, and which would help sustain the marsh in the future with rising sea level. High sedimentation rates, together with the blockage of existing drainage channels, should assist in the rapid evolution of a tidal drainage network. The low berms formed adjacent to excavated channels would provide opportunities for revegetation with native high-marsh and salt marsh species. Areas around the perimeter of the restoration site would also support high-marsh transitional species and riparian species.

With the removal of the dikes around the inlet, lateral movement of the mouth should be unconstrained. The inlet would be overexcavated in anticipation of achieving full tidal range in the site. If wave action builds a sill which prevents full draining, then the breach and channels may fill with sediment, reducing their depth. In addition, the secondary dike would be removed to allow the beach barrier to be overwashed.

18.6 Uncertainties and Risks

The greatest uncertainty is related to the inlet. If wave action is significant, then a sill will develop which may reduce the tidal range within the site, leading to some ponding and retarding the site's evolution. Another uncertainty will be the behavior of the large amounts of woody debris that are presently on the beach. The wood may become more mobile and accumulate within the site, as has occurred in similar sites to the southwest. Large wood may also cause partial blockages in the inlet, restricting tidal inflows of water and sediment and slowing the evolution of the site. Another uncertainty is possible flooding risks to private properties associated with the restoration, particularly to the properties located on the eastern shoreline.

18.6.1 Risks Associated with Projected Sea Level Change

Table 18-3 compares potential risks associated with projected sea level changes based on professional judgment.

Table 18-3. Risks of Sea Level Change

	Projected Sea Level Change		
	High (46cm)	Intermediate (4cm)	Low (-8cm)
Full Restoration	Low risk due to natural amphitheatre with the upland rising steeply away from the former salt marsh.	Negligible	Negligible
Partial Restoration	Low risk due to natural amphitheatre with the upland rising steeply away from the former salt marsh.	Negligible	Negligible

18.7 Potential Monitoring Opportunities

Monitoring is important for evaluating restoration success. A combination of field surveys and aerial photographs would be used to document biological and physical changes to the landscape. Monitoring data can be used to refine adaptive management and corrective actions, as needed. Some of the key monitoring needs and opportunities associated with this action are summarized in Table 18-4.

Table 18-4. Monitoring Needs and Opportunities

Monitoring Parameter	Key Performance Indicator	Note
Topographic Stability	X	Monitor beach and inlet stability
Sediment Accretion / Erosion	X	Document accretion rates
Wood Accumulation	X	
Soil / Substrate Conditions		
Vegetation Establishment	X	
Marsh Surface Evolution / Accretion	X	Document colonization of the marsh surface
Tidal Channel Cross-Section / Density	X	Monitor sedimentation rates and evolution of a tidal drainage network
Water Quality (contaminants)		
Salinity	X	
Shellfish Production		
Extent of Invasive Species		
Animal Species Richness	X	
Fish (salmonid) Access/Use	X	
Forage Fish Production		
Wildlife Species Use		
Effectiveness of Exclusion Devices		

18.8 Information Needed for Subsequent Design

This conceptual design report represents an initial step in the restoration design sequence. The design concepts described above were developed based on readily available information without the level of site-specific survey and investigation that is necessary to support subsequent design and implementation. Substantial additional information will be required at the preliminary and later design stages to confirm the design assumptions, refine quantity estimates, address property and regulatory issues, obtain stakeholder support, and fill in data gaps. The extent to which this information is collected for preliminary design (or a later design stage) will depend upon the available budget, schedule and other factors. This section attempts to define some of the most essential information needs for this action.

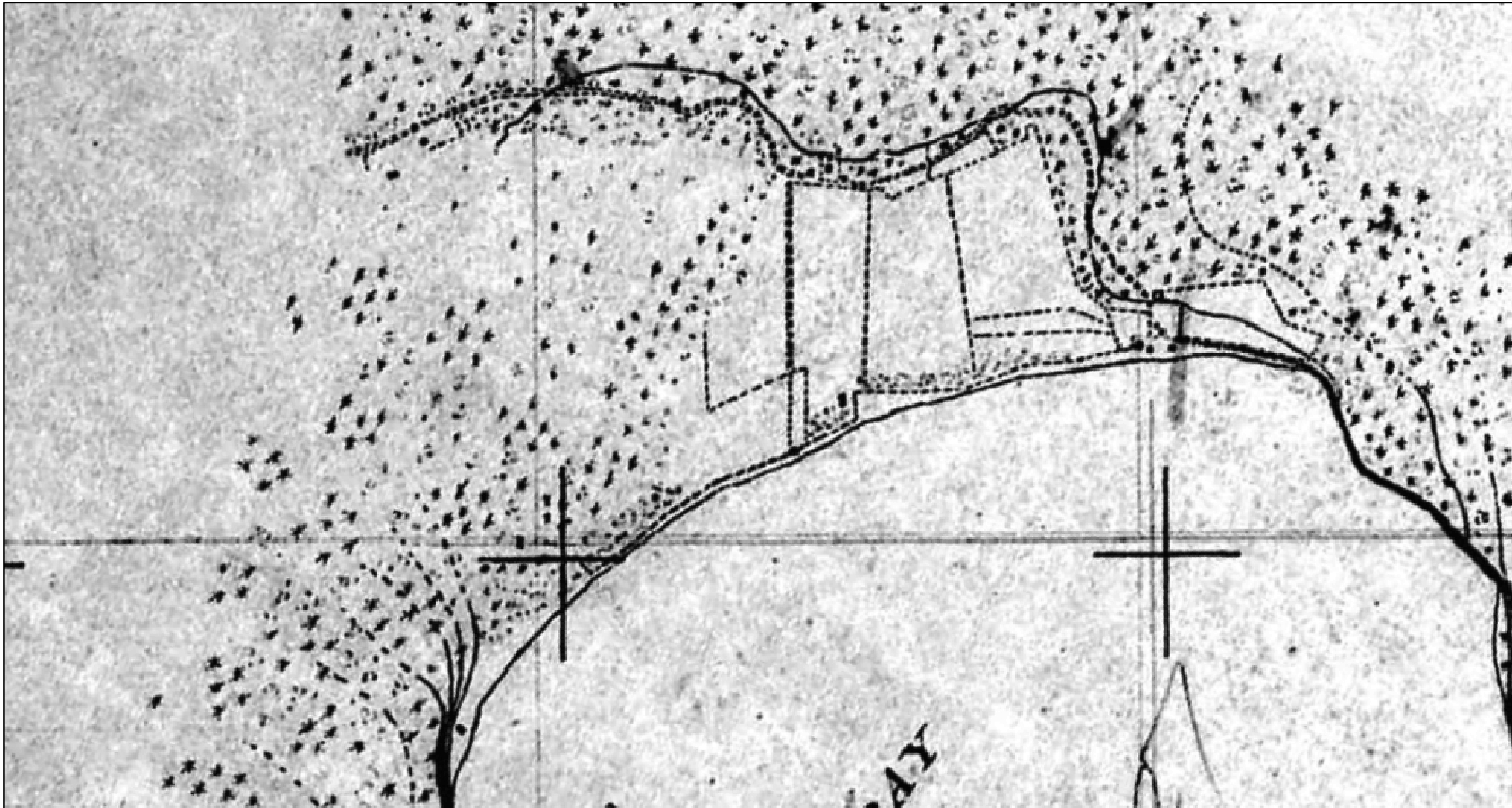
- Property Investigation/Survey – More detailed information on parcel ownership, utilities, and property boundary locations will be needed to finalize the design, confirm acquisition requirements, and support negotiations with property owners.
- Topographic/Bathymetric Survey – Surveys will be required along the tidal channel alignment including the breach location, interior channel profile, outboard mudflat profile, and sections of existing drainage channel along the west end of the site. Surveys should also include drainage ditch sections, existing structures, etc. The survey data would be used to refine design of key project elements and develop detailed construction and demolition plans. Survey data could also be used as a baseline for pre- and post-construction modeling and to understand tidal durations (how many hours a day will the marsh be flooded) for plant survival. A temporary tide gauge may be required in the early design stages to obtain site-specific tidal statistics.
- Cultural Resources Investigation – Surveys for archaeological and historic resources may be required for this action area This is particularly important in areas proposed for excavation.
- Hydraulic Analysis/Modeling – Tidal circulation, flood, and hydrodynamic modeling will be required to evaluate impacts to infrastructure and adjacent properties following restoration, and to optimize the size and confirm the stability of the breaches, inlet opening and channels. This information would also be used to identify flood risks to adjacent properties.
- Contaminant Survey – If preliminary investigations suggest that hazardous material could be present in the action area, additional soil and sediment analysis may be needed. The introductory chapter describes the Phase I site investigations that are occurring as part of this overall effort via a separate contract.
- Geotechnical Investigation – Geotechnical investigations may be needed to identify the size of armor to be removed.
- Sediment Analysis – More detailed investigation of sediment characteristics is needed to confirm assumptions about the site's sediment budget and expected site evolution following restoration.
- Sea Level Change Projection – Estimates of sea level change for the conceptual design were based on calculations provided by the Washington Department of Fish and Wildlife and the Corps of Engineers using guidance in Corps'

Engineering Circular No. 1165-2-211. Projections for each project area will be refined using localized tide gauge data during later design stages.

- Other – Species that use the area as a critical stop on the Pacific Flyway may require further documentation. The characteristics of the excavated sediment of the proposed tidal inlet for use onsite may also require evaluation.

18.9 Quantity Estimates

The quantity spreadsheets for the full and partial restoration alternatives are provided in Exhibits 18-1 and 18-2.



0 660
Feet
0 200
Meters

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Historic Map (T-Sheet)
Action Name: Livingston Bay - Diked Farmland & Nearshore Habitat
PSNERP ID #: 1618
<FNT name="Arial" size="14">Figure 18- 2A</FNT>

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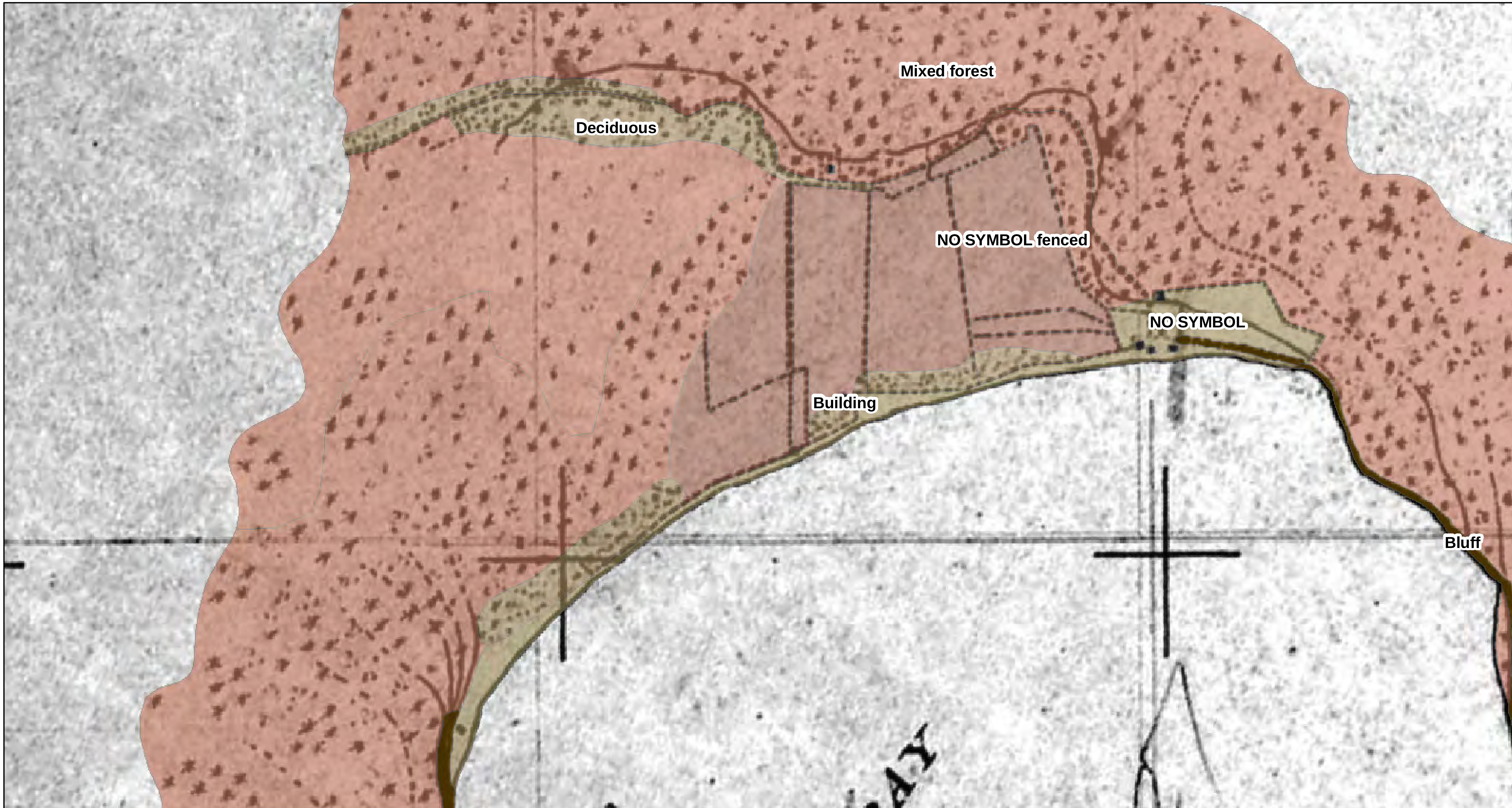

0 660
Feet
0 200
Meters

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64

WDFW Contract # 100-000204 (CAPS No. 10-1461)

Historic Map (T-Sheet) and River History Project Data
Action Name: Livingston Bay - Diked Farmland & Nearshore Habitat
PSNERP ID #: 1618
<FNT name="Arial" size="14">Figure 18- 2B</FNT>

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Legend

- Buildings
- Dredging - Bucket - Land
- Excavation - Lowland
- Haul - Uncontrolled Placement
- Haul, Place, Compact
- Removal - Misc. (e.g. angular rock from beach)
- Side Cast
- Required Project Lands
- Proposed Tide MHHW
- Existing Tide MHHW
- Channel Rehab/Creation
- A A' Typical Cross Section

LIVINGSTON BAY CONVERSION

FIXED DATUM TIDAL DATUM

MHHW 8.79 NAVD88 2.30 MLLW

0.00 FT MHHW = 8.79 FT NAVD88
-8.79 FT MHHW = 0.00 FT NAVD88
0.00 FT MLLW = -2.30 FT NAVD88
2.30 FT MLLW = 0.00 FT NAVD88

Source: Everett Tide Gauge (NOS #9447659)
See Table 1, Appendix C.

PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

North 0 500 Feet

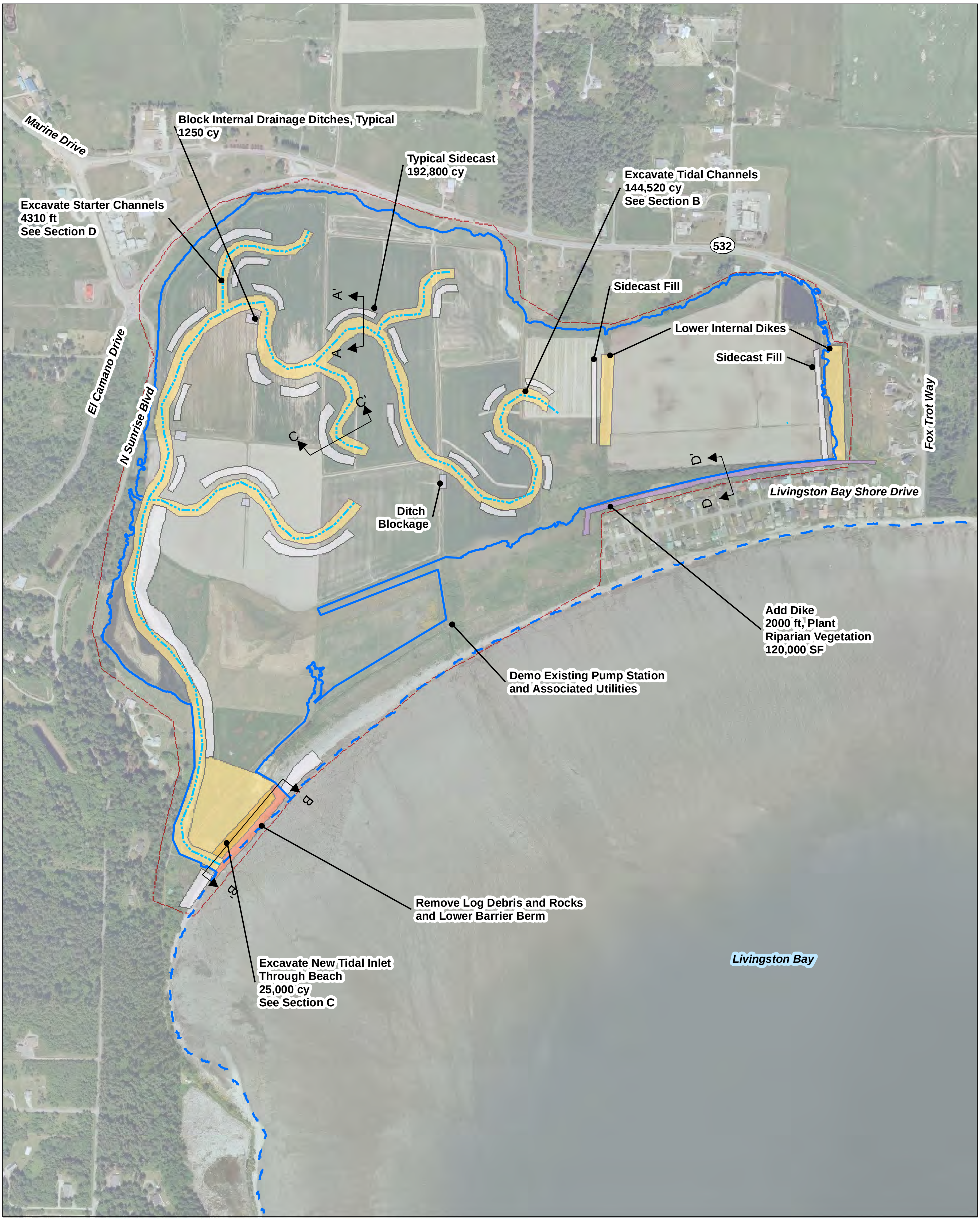
SOURCE: Washington Public Lands Database (2006);
Washington Counties Parcels (2009); Action Area (PSNERP, 2010)

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Plan
Site Name: Livingston Bay
Action Name: Livingston Bay - Dike Farmland and Nearshore Habitat
PSNERP ID #: 1618
Full Restoration

Lead Contractor: ESA
Design Lead: ESA PWA, L. White, PE
Date: 05/2012

Figure 18-3



Legend

- Buildings
- Dredging - Bucket - Land
- Excavation - Lowland
- Haul, Place, Compact
- Haul - Uncontrolled Placement
- Removal - Misc. (e.g. angular rock from beach)
- Side Cast
- Required Project Lands
- Proposed Tide MHHW
- Existing Tide MHHW
- Channel Rehab/Creation
- A A' Typical Cross Section

LIVINGSTON BAY CONVERSION

FIXED DATUM — TIDAL DATUM

MHHW
8.79
NAVD88
2.30
MLLW

0.00 FT MHHW = 8.79 FT NAVD88
-8.79 FT MHHW = 0.00 FT NAVD88
0.00 FT MLLW = -2.30 FT NAVD88
2.30 FT MLLW = 0.00 FT NAVD88

Source: Everett Tide Gauge (NOS #9447659).
See Table 1, Appendix C.

PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

North — 0 500 Feet

SOURCE: Washington Public Lands Database (2006);
Washington Counties Parcels (2009); Action Area (PSNERP, 2010)

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

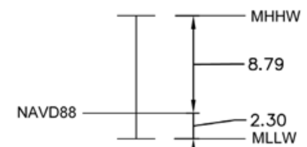
Conceptual Design Plan
Site Name: Livingston Bay
Action Name: Livingston Bay - Dike Farmland and Nearshore Habitat
PSNERP ID #: 1618
Partial Restoration

Lead Contractor: ESA
Design Lead: ESA PWA, L. White, PE
Date: 05/2012

Figure 18-4

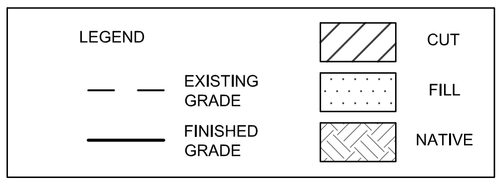
LIVINGSTON BAY CONVERSION

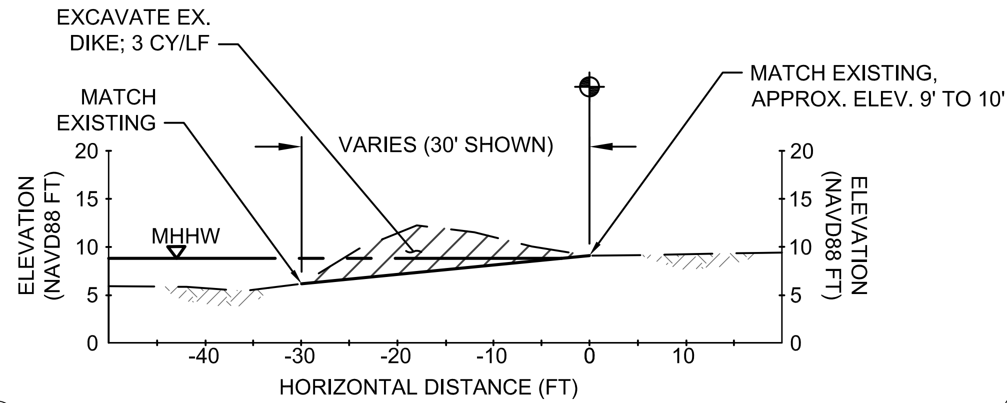
FIXED DATUM TIDAL DATUM



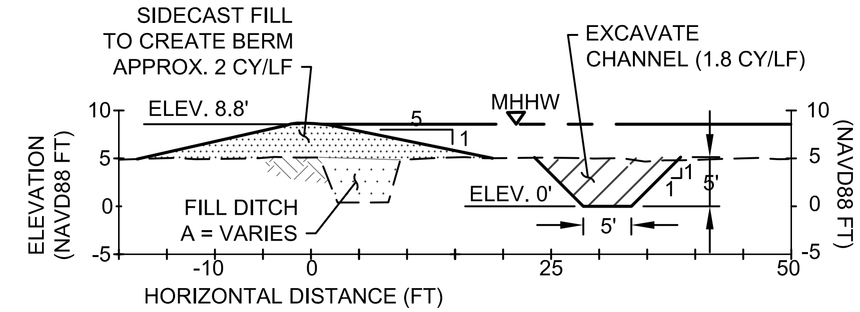
0.00 FT MHHW = 8.79 FT NAVD88
-8.79 FT MHHW = 0.00 FT NAVD88
0.00 FT MLLW = -2.30 FT NAVD88
2.30 FT MLLW = 0.00 FT NAVD88

Source: Everett Tide Gauge (NOS #9447659)
See Table 1, Appendix C.

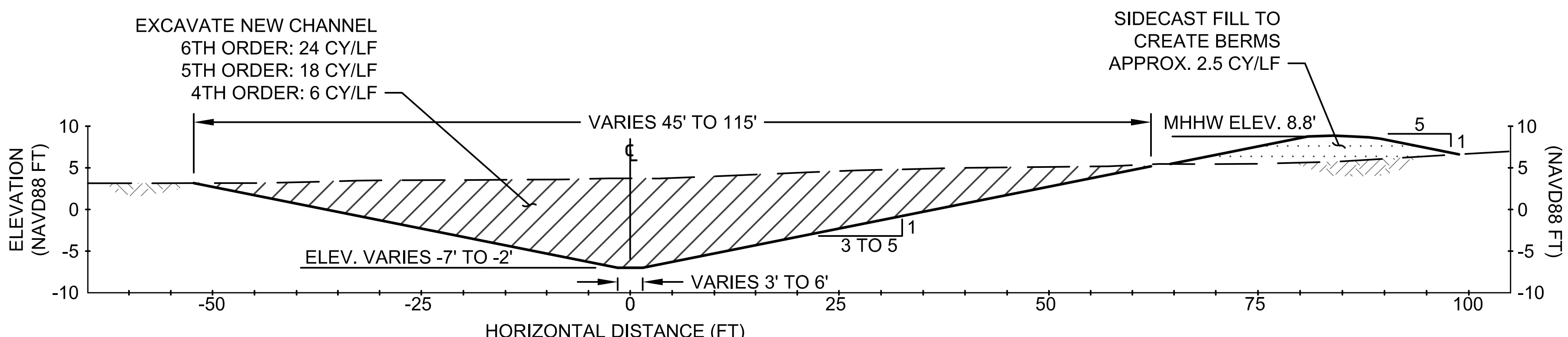




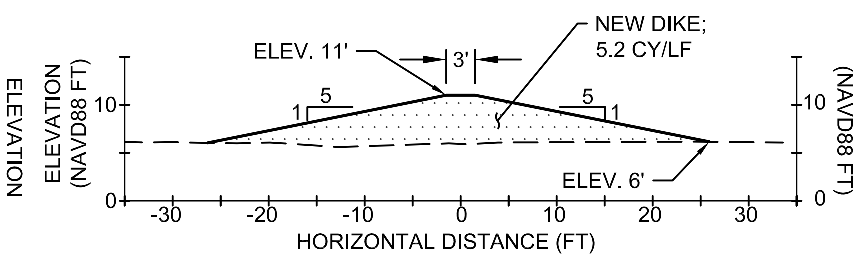
A FULL RESTORATION TYPICAL SECTION - DIKE REMOVAL



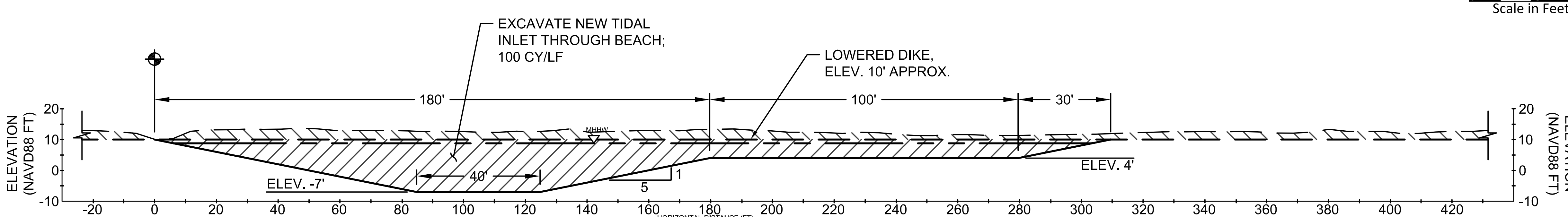
D STARTER CHANNEL - TYPICAL SECTION



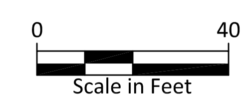
B FULL RESTORATION TYPICAL SECTION - TIDAL (4TH, 5TH, AND 6TH ORDER) CHANNEL



E DIKE - TYPICAL SECTION



C FULL RESTORATION TYPICAL SECTION - TIDAL INLET



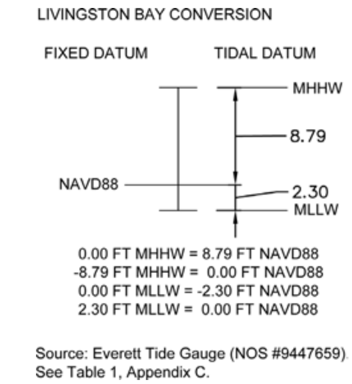
PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

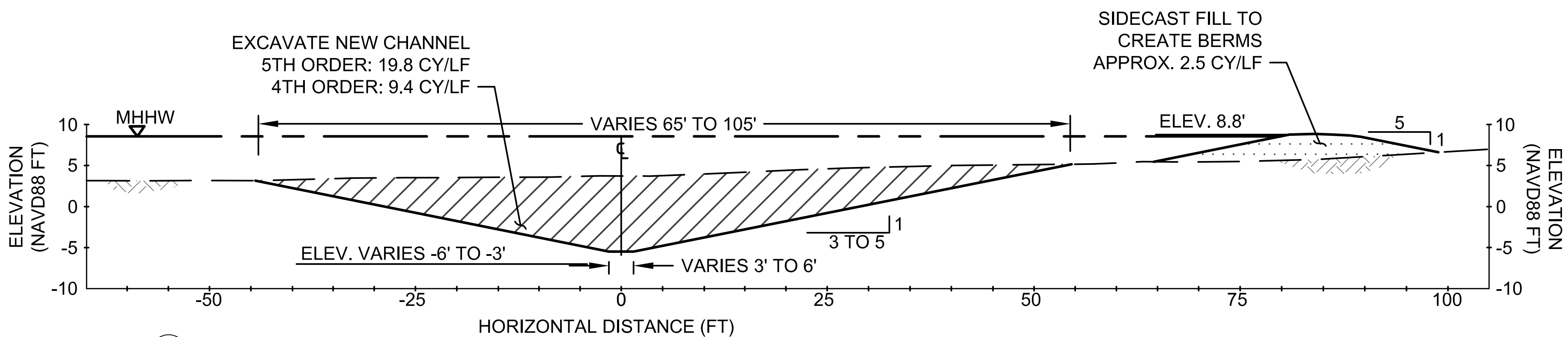
Lead Contractor: ESA
Design Lead: ESA PWA, L. White, PE
Date: 07/2012

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

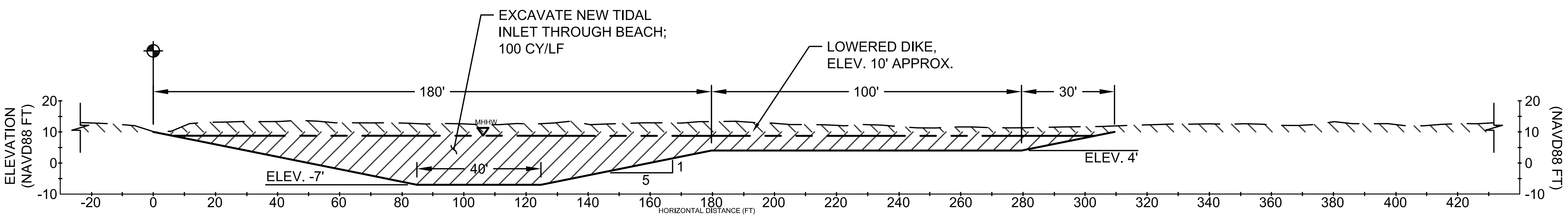
Conceptual Design Section
SITE NAME: **Livingston Bay**
ACTION NAME: **Livingston Bay - Diked Farmland & Nearshore Habitat**
PSNERP ID#: **1618**
Full Restoration

Figure 18-5

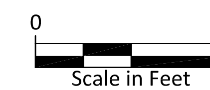


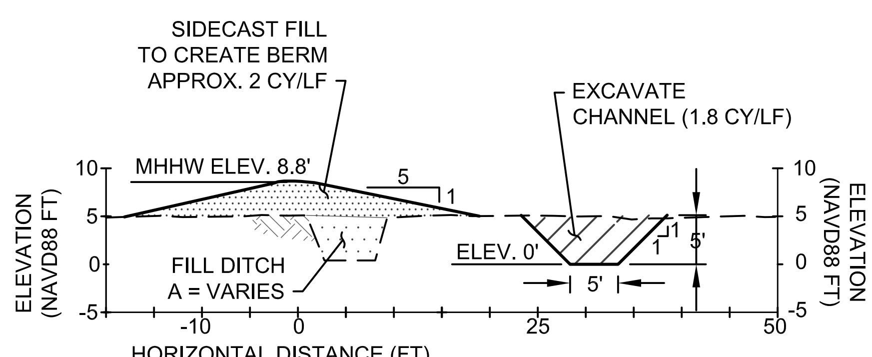


Ⓐ PARTIAL RESTORATION TYPICAL SECTION - TIDAL (4TH AND 5TH ORDER) CHANNEL

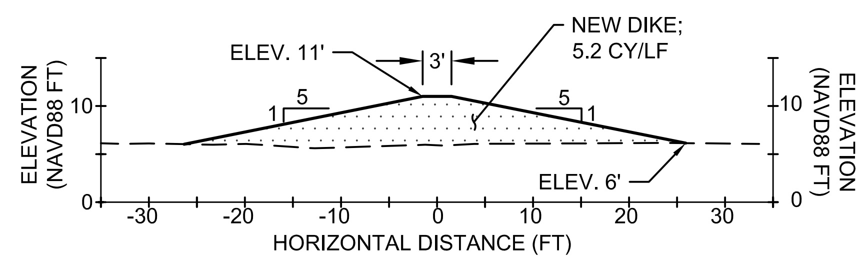


Ⓑ PARTIAL RESTORATION TYPICAL SECTION - TIDAL INLET

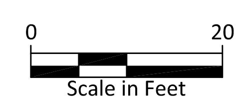


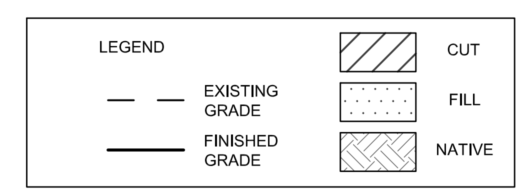


Ⓒ STARTER CHANNEL - TYPICAL SECTION



Ⓓ DIKE - TYPICAL SECTION





PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: ESA PWA, L. White, PE
Date: 07/2012

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Section
SITE NAME: **Livingston Bay**
ACTION NAME: **Livingston Bay - Diked Farmland & Nearshore Habitat**
PSNERP ID#: **1618**
Partial Restoration

Figure 18-6

Full Restoration Quantity Estimate

Action Name:	Livingston Bay		
Action #:	1618		
Date:	February 2011	**Revised with backcheck updates: 30 June 2011**	
By:	L. White	Revised May 2012, July 2012	

REMEDY: ***Remove dikes, construct tidal inlet and channels through subsided site***
Construction Period: 24 weeks

Item	Unit of Measure	Qty	Description of Item	Indicate section of design report where item is described
ACQUISITION AND CONSERVATION			Based on available mapping information	
Required Project Lands	Acre	287	Total land required For action	18.3
Proponent / Partner-owned lands	Acre	NA	Estimate of lands currently owned by Proponent (i.e., Public lands)	
Lands To Be Acquired	Acre	NA	Estimate land required to be acquired for action prior to implementation	
Material Sites			Not Used: See Earthwork - Imported Fill.	
MOBILIZATION AND ACCESS for construction activities			Description required for each item to facilitate cost estimating	
Mobilization - Typical (Equipment, Personnel, Planning, Financial)	LS	1	Up front costs such as bonding, planning and other staff time and financing. Typically, assume 8% to 10% of other items.	18.3
Mobilization - Remote (Equipment, Personnel, Planning, Financial)	LS	NA		
Site Access	LS	NA		
Barge Access	Days	NA		
Temporary Traffic Control (one of the following)				
none	LS	NA		
signs	LS	NA		
flags / spotters	LS	NA		
unique	LS	NA		
Temporary Roadway	SF	NA		
Control of Water	LS	NA		
Relocation Activities			Not Used: See Utilities, Structures	
Site Demolition Activities			Demolition and removal of structures (description required), temporary features and relocations, itemized separately); Clearing and grubbing of vegetation, and removal of minor debris (rocks, slabs) - description required.	
Clearing and Grubbing (one or more of following)			Use one or more of the following categories of clearing and grubbing	
Clear Vegetation - Local Disposal	AC	NA		
Clear /Grub Vegetation - Local Disposal	AC	37.6	Vegetation roots also removed and disposed locally. Assume also log and rock debris removed at breach location to facilitate excavation.	18.3
Clear /Grub Vegetation - Offsite Disposal	AC	NA		
Clear, stockpile - large woody debris	CY	NA		
Hydraulic Structures - Small	LS	NA		
Hydraulic Structures - Large	LS	NA		
Utilities	LS or LF	NA		18.3
Buildings	LS or SF	5644	Demo pump station	
Pavement	LS or SF	NA		
Bulkheads	LF or SF	NA		
Rock revetments	LF, Ton or CY	NA		
Large Coastal Structures	LF, SF or CY	NA		
Demolition / Removal - Bridge	SF or CY	NA		
Removal - Misc. (e.g. angular rock from beach)	Ton	NA		
Demolition / Removal - Boat Ramp	SF	NA		
Haul - Offsite Disposal of Demolition Debris	Miles	NA		
Hazardous/Contaminated Waste Removal			These items for earthwork of quality not compatible with wetlands, requiring special handling and disposal. Describe basis for classification as contaminated or hazardous. State known or suspected contamination, describe known similar work.	
Contaminated Earthwork	CY	NA		
Hazardous Earthwork	CY	NA		
Construct Temporary Features			Use as needed for unusual temporary features not included elsewhere (see TESC below)	
EARTHWORK			Expand to include equipment, etc. to facilitate cost estimating.	
Excavation	CY		Per yard excavation w/out expected haul	
Excavation - Upland	CY	NA		
Excavation - Lowland	CY	236500	Requires low ground pressure equipment and or mats; low production bucket methods, typically hydraulic excavator and front end loaders.	18.3
Dike Lowering	*CY*	*23280*	*LGP Excavators. Assumes 3 cy/lf. Approximately 7,750 LF total in eastern portion of site and near existing pump station*	18.3
Channels	*CY*	*213220*	*Channel excavation using LGP excavators*	18.3
Dredging - Bucket - Land	CY	25000	Breach Excavation	18.3
Dredging - Bucket - Marine	CY	NA		
Dredging - Hydraulic	CY	NA		
Fine Grading	AC	NA		
Fill Placement - local borrow			This is additive to Earthwork -Excavation	
Side cast	CY	261500	Excavated material placed within reach of excavator / dredge - assume includes some shaping by bucket	18.3
Dike Lowering	*CY*	*23280*	*LGP Excavators. Assumes 3 cy/lf. Approximately 7,750 LF total in eastern portion of site and near existing pump station*	18.3
Channels	*CY*	*213220*	*Channel excavation using LGP excavators*	18.3
Tidal Inlet	*CY*	*25000*	*Breach Excavation*	18.3
Haul - uncontrolled placement	CY	1270	Ditch Blocks	18.3
Haul, place, compact	CY	10370	New dike	18.3
Stockpile - uncontrolled placement	CY	NA		
Stockpile - controlled placement	CY	NA		
Conveyor placement from stockpile land/water	CY	NA		
Imported Fill			Includes purchase, delivery and placement or as noted / described	
Select Fill	CY	NA		
Gravel Borrow, including haul	CY	NA		
Sand / Gravel for Beach Nourishment	CY	NA		
Cobble for Shore Nourishment	CY	NA		
Embankment Compaction	CY	NA		
Topsoil	CY	NA		
RESTORATION Features				
Channel Rehab / Creation	SF	NA		
Large Wood Placement	EA	NA		
Invasive Species Control	Acre	NA		
Physical Exclusion Devices	LF or EA	NA		
Other Restoration Features/ Activities	SF	50000	Beach nourishment using 25,000 CY of fill from excavation of tidal inlet. Assumes 10' high shore profile (-0' to +10' MLLW) which gives about 0.4 cy/sf of beach. 25,000 cy / 0.4 cy/sf = 62,500 sf. Approximately 50,000 sf of new beach created with excavation from breach.	
Structures	EA			
Water Control Structures - Culverts with Gates	EA	NA		
Water Control Structures - Weirs	EA	NA		
Rock Slope Protection	LF	NA		
Other	EA	1	Pump station	
Elevated Boat Ramp	SF	NA		
Fencing	SF	NA		

Full Restoration Quantity Estimate

Action Name:	Livingston Bay
Action #:	1618
Date:	February 2011 — **Revised with backcheck updates: 30 June 2011**
By:	L. White — Revised May 2012, July 2012

REMEDY: ***Remove dikes, construct tidal inlet and channels through subsided site***
Construction Period: 24 weeks

	Item	Unit of Measure	Qty	Description of Item	Indicate section of design report where item is described
Utilities				Replacement or relocation. Designer to provide size and material and have separate line item for each run. Incidentals include earthwork, testing, hook up fees, etc. These quantities do not include demolition of existing utilities, real estate / easements, design fees. Describe the owner if known, and whether utility franchise will install (e.g.. electric is typically installed by electrical franchise).	
	Water	LF	NA		
	Gas	LF	NA		
	Electric	LF	2600	Power to pump station through site includes 10 power poles	
	Sewer	LF	NA		
	Telecommunications	LF	NA		
	Other	LF	NA		
Roadway / Railway					
	Roadway (Type_)	SF	NA		
	Roadway - Traffic Signal	LS	NA		
	Culvert (type)	LF	NA		
	Culvert - Jacking	LF	NA		
	Culvert - Horizontal Pile Driving	LF	NA		
	Bridge - Foundations, Deck and Appurtenances	SF	NA		
	Railway - Box Girder	SF	NA		
	Railway - Foundation	LF	NA		
	Railway - Shoe fly	LF	NA		
Permanent Access Features					
	Roads	Level	NA		
	Utility Access Routes	varies	NA		
	Erosion Control Features	L.F.	NA		
Public Access or Recreation Features					
	trails	SF	NA		
	bridges	SF	NA		
	kiosk	EA	NA		
	restrooms	EA	NA		
	Interpretive Signs	EA	NA		
	parking area	SF	NA		
	Other	EA	NA		
Vegetation & Erosion Control					
	Hydroseeding	AC	2.75	Riparian vegetation planting and hydroseeding along dike 60' width x 2,000 LF	
	Planting	AC	2.75	Riparian vegetation planting and hydroseeding along dike 60' width x 2,000 LF	
	Vegetation Maintenance	AC-YR	NA		
	Erosion / sediment BMPs - Temp.	AC	NA		
	Erosion / sediment BMPs - Permanent	AC	NA		
	Waterside controls - Temporary	EA, LF, LS	NA		
Construction Management					
	Construction oversight	weeks	24	Quantity based on construction duration/ # of construction seasons	18.3
	Materials testing				
	Quality Assurance With Testing	L.S.			
Design and Detailed Site Investigations					
	Survey & Property, Utility Research	LS	1	% of construction cost	18.8
	35% Design	LS	1	35% x 25% x Engineer's Estimate	18.8
	65% design	LS	1	65% x 25% x Engineer's Estimate less the cost for 35% PS&E	18.8
	90% design	LS	1	35% x 25% x Engineer's Estimate less the cost for 35% + 65%PS&E	18.8
	100% design	LS	1	25% x Engineer's Estimate less previous costs	18.8
	Geotechnical Studies			Refer to design report for description of need	
	Cultural Studies			Refer to design report for description of need	
	HTWR Studies			Refer to design report for description of need	
Project Agreement Activities				Unable to provide credible estimate at 10% design	
Site-Specific Adaptive Management Features & Activities				List if known	
Monitoring Activities				Assume 5 crew-days/year for each monitoring parameter in design report for 5 yrs	
	Monitoring (Type_)	crew-days	150		
Operations & Maintenance				Unable to provide credible estimate at 10% design	

Partial Restoration Quantity Estimate

	Action Name:	Livingston Bay			
	Action #:	1618			
	Date:	February 2011	**Revised with backcheck updates: 30 June 2011**		
	By:	L. White	Revised May 2012, July 2012		
	REMEDY: ***Remove dikes, construct tidal inlet and channels through subsided site***				
	Construction Period: 19 weeks				

	Item	Unit of Measure	Qty	Description of Item	Indicate section of design report where item is described
ACQUISITION AND CONSERVATION				Based on available mapping information	
	Required Project Lands	Acre	244	Total land required For action	18.3
	Proponent / Partner-owned lands	Acre	NA	Estimate of lands currently owned by Proponent (i.e., Public lands)	
	Lands To Be Acquired	Acre	NA	Estimate land required to be acquired for action prior to implementation	
Material Sites				Not Used: See Earthwork - Imported Fill.	
MOBILIZATION AND ACCESS for construction activities				Description required for each item to facilitate cost estimating	
	Mobilization - Typical (Equipment, Personnel, Planning, Financial)	LS	1	Up front costs such as bonding, planning and other staff time and financing. Typically, assume 8% to 10% of other items.	18.3
	Mobilization - Remote (Equipment, Personnel, Planning, Financial)	LS	NA		
	Site Access	LS	NA		
	Barge Access	Days	NA		
	Temporary Traffic Control (one of the following)				
	none	LS	NA		
	signs	LS	NA		
	flags / spotters	LS	NA		
	unique	LS	NA		
	Temporary Roadway	SF	NA		
	Control of Water	LS	NA		
Relocation Activities				Not Used: See Utilities, Structures	
Site Demolition Activities				Demolition and removal of structures (description required), temporary features and relocations, itemized separately); Clearing and grubbing of vegetation, and removal of minor debris (rocks, slabs) - description required.	
	Clearing and Grubbing (one or more of following)			Use one or more of the following categories of clearing and grubbing	
	Clear Vegetation - Local Disposal	AC	NA		
	Clear /Grub Vegetation - Local Disposal	AC	24.8	Vegetation roots also removed and disposed locally. Assume also log and rock debris removed at breach location to facilitate excavation.	18.3
	Clear /Grub Vegetation - Offsite Disposal	AC	NA		
	Clear, stockpile - large woody debris	CY	NA		
	Hydraulic Structures - Small	LS	NA		
	Hydraulic Structures - Large	LS	NA		
	Utilities	LS or LF	5644	Demo pump station	
	Buildings	LS or SF	NA		
	Pavement	LS or SF	NA		
	Bulkheads	LF or SF	NA		
	Rock revetments	LF, Ton or CY	NA		
	Large Coastal Structures	LF, SF or CY	NA		
	Demolition / Removal - Bridge	SF or CY	NA		
	Removal - Misc. (e.g. angular rock from beach)	Ton	NA		
	Demolition / Removal - Boat Ramp	SF	NA		
	Haul - Offsite Disposal of Demolition Debris	Miles	NA		
Hazardous/Contaminated Waste Removal				These items for earthwork of quality not compatible with wetlands, requiring special handling and disposal. Describe basis for classification as contaminated or hazardous. State known or suspected contamination, describe known similar work.	
	Contaminated Earthwork	CY	NA		
	Hazardous Earthwork	CY	NA		
Construct Temporary Features				Use as needed for unusual temporary features not included elsewhere (see TESC below)	
EARTHWORK				Expand to include equipment, etc. to facilitate cost estimating.	
	Excavation	CY	NA		
	Excavation - Upland	CY	NA		
	Excavation - Lowland	CY	167800	Requires low ground pressure equipment and or mats; low production bucket methods, typically hydraulic excavator and front end loaders.	18.3
	Dike Lowering	*CY*	*19170*	*LGP Excavators. Assumes 3 cy/lf. Approximately 6,400 LF total in eastern portion of site.*	18.3
	Channels	*CY*	*144520*	*Channel excavation using LGP excavators*	18.3
	Dredging - Bucket - Land	CY	25000	Excavation below ground water or underwater; reach limited low production.	18.3
	Tidal Inlet	*CY*	*25000*	*Breach Excavation*	18.3
	Dredging - Bucket - Marine	CY			
	Dredging - Hydraulic	CY			
	Fine Grading	AC			
	Fill Placement - local borrow			This is additive to Earthwork -Excavation	
	Side cast	CY	192800	Excavated material placed within reach of excavator / dredge - assume includes some shaping by bucket	18.3
	Dike Lowering	*CY*	*19170*	*LGP Excavators. Assumes 3 cy/lf. Approximately 6,400 LF total in eastern portion of site.*	18.3
	Channels	*CY*	*144520*	*Channel excavation using LGP excavators*	18.3
	Tidal Inlet	*CY*	*25000*	*Breach Excavation*	18.3
	Haul - uncontrolled placement	CY	1250	Ditch blocks	18.3
	Haul, place, compact	CY	10370	New dike	18.3
	Stockpile - uncontrolled placement	CY	NA		
	Stockpile - controlled placement	CY	NA		
	Conveyor placement from stockpile land/water	CY	NA		
	Imported Fill			Includes purchase, delivery and placement or as noted / described	
	Select Fill	CY	NA		
	Gravel Borrow, including haul	CY	NA		
	Sand / Gravel for Beach Nourishment	CY	NA		
	Cobble for Shore Nourishment	CY	NA		
	Embankment Compaction	CY	NA		
	Topsoil	CY	NA		
RESTORATION Features					
	Channel Rehab / Creation	SF	NA		
	Large Wood Placement	EA	NA		
	Invasive Species Control	Acre	NA		
	Physical Exclusion Devices	LF or EA	NA		
	Other Restoration Features/ Activities	SF	50000	Beach nourishment using 25,000 CY of fill from excavation of tidal inlet. Assumes 10' high shore profile (-0' to +10' MLLW) which gives about 0.4 cy/sf of beach. 25,000 cy / 0.4 cy/sf = 62,500 sf. Approximately 50,000 sf of new beach created with excavation from breach.	
Structures		EA			
	Water Control Structures - Culverts with Gates	EA	NA		
	Water Control Structures - Weirs	EA	NA		
	Rock Slope Protection	LF	NA		
	Other	EA	NA		
	Elevated Boat Ramp	SF	NA		
	Fencing	SF	NA		
Utilities				Replacement or relocation. Designer to provide size and material and have separate line item for each run. Incidentals include earthwork, testing, hook up fees, etc. These quantities do not include demolition of existing utilities, real estate / easements, design fees. Describe the owner if known, and whether utility franchise will install (e.g., electric is typically installed by electrical franchise).	
	Water	LF	NA		
	Gas	LF	NA		
	Electric	LF	2600	Power to pump station through site includes 10 power poles	
	Sewer	LF	NA		
	Telecommunications	LF	NA		
	Other	LF	NA		
Roadway / Railway					
	Roadway (Type_)	SF	NA		

Partial Restoration Quantity Estimate

	Action Name:	Livingston Bay			
	Action #:	1618			
	Date:	February 2011	**Revised with backcheck updates: 30 June 2011**		
	By:	L. White	Revised May 2012, July 2012		

REMEDY: ***Remove dikes, construct tidal inlet and channels through subsided site***
Construction Period: 19 weeks

	Item	Unit of Measure	Qty	Description of Item	Indicate section of design report where item is described
	Roadway - Traffic Signal	LS	NA		
	Culvert (type)	LF	NA		
	Culvert - Jacking	LF	NA		
	Culvert - Horizontal Pile Driving	LF	NA		
	Bridge - Foundations, Deck and Appurtenances	SF	NA		
	Railway - Box Girder	SF	NA		
	Railway - Foundation	LF	NA		
	Railway - Shoe fly	LF	NA		
Permanent Access Features					
	Roads	Level	NA		
	Utility Access Routes	varies	NA		
	Erosion Control Features	L.F.	NA		
Public Access or Recreation Features					
	trails	SF	NA		
	bridges	SF	NA		
	kiosk	EA	NA		
	restrooms	EA	NA		
	Interpretive Signs	EA	NA		
	parking area	SF	NA		
	Other	EA	NA		
Vegetation & Erosion Control					
	Hydroseeding	AC	2.75	riparian vegetation planting and hydroseeding along dike 60' width x 2,000 LF	
	Planting	AC	2.75	riparian vegetation planting and hydroseeding along dike 60' width x 2,000 LF	
	Vegetation Maintenance	AC-YR	NA		
	Erosion / sediment BMPs - Temp.	AC	NA		
	Erosion / sediment BMPs - Permanent	AC	NA		
	Waterside controls - Temporary	EA, LF, LS	NA		
Construction Management					
	Construction oversight	weeks	19	Quantity based on construction duration/ # of construction seasons	18.3
	Materials testing				
Design and Detailed Site Investigations					
	Survey & Property, Utility Research	LS	1	% of construction cost	18.8
	35% Design	LS	1	35% x 25% x Engineer's Estimate	18.8
	65% design	LS	1	65% x 25% x Engineer's Estimate less the cost for 35% PS&E	18.8
	90% design	LS	1	35% x 25% x Engineer's Estimate less the cost for 35% + 65%PS&E	18.8
	100% design	LS	1	25% x Engineer's Estimate less previous costs	18.8
	Geotechnical Studies			Refer to design report for description of need	
	Cultural Studies			Refer to design report for description of need	
	HTWR Studies			Refer to design report for description of need	
Project Agreement Activities				Unable to provide credible estimate at 10% design	
Site-Specific Adaptive Management Features & Activities				List if known	
Monitoring Activities				Assume 5 crew-days/year for each monitoring parameter in design report for 5 yrs	
	Monitoring (Type_)	crew-days	150		
Operations & Maintenance				Unable to provide credible estimate at 10% design	

19. MCGLINN ISLAND CAUSEWAY (#1092)

Local Proponent	Skagit River System Cooperative
Delta Process Unit	SKG
Shoreline Process Unit(s)	NA
Strategy(ies)	1 – River Delta
Restoration Objectives	Primary restoration objectives are to: 1) restore freshwater inputs to lower salinity levels in Padilla Bay, and 2) recreate estuarine marsh habitat and connectivity

19.1 Description of the Action

This action seeks to improve the hydraulic connection between the North Fork Skagit River and the Swinomish Channel by removing both physical and physiological barriers to fish migration. The project entails lowering existing jetty elevations and creating a new distributary channel. The partial restoration alternative includes a new bridge. Please see the Introduction chapter for important information regarding PSNERP and for context related to this restoration project.

19.2 Action Area Description and Context

The McGlinn Island Causeway action area is located in Skagit Bay, near the mouth of the North Fork Skagit River in the Whidbey Subbasin of Puget Sound. McGlinn Island lies between Dunlap Bay and the Swinomish Channel just south of LaConner.

The Skagit River system is the largest river system contributing to Puget Sound and supports some of the most important and productive salmon runs. Over time, the North Fork Skagit River has migrated and created an extensive delta, which historically supported vast wetland complexes. McGlinn Island sits in the context of a large distributary network that provides linkages between Samish, Padilla, and Skagit Bays. The action area is shown in Figure 19-1.

Figure 19-1. Action Area and Vicinity

19.2.1 Historic Condition

Historically, Swinomish Slough, a large distributary channel connecting Skagit and Padilla Bays, was a significant migratory corridor for juvenile Skagit River Chinook salmon seeking rearing habitat in Padilla Bay. Mixing of fresh water from the North Fork Skagit River with marine water from Padilla Bay and Skagit Bay presumably resulted in a salinity gradient in the Swinomish Slough that allowed juvenile salmon opportunity to seek out appropriate habitat while undergoing transition from a freshwater to a saltwater physiology. Engineering works between 1892 and 1935 changed the complex, braided deltaic distributary system into a simplified navigation channel and diverted river flow away from the Swinomish Slough, which changed the salinity gradient. Figures 19-2A and 19-2B provide historic maps of the area.

19.2.2 Natural Environment

Fish catch data indicate that juvenile salmon abundance is very low in the Swinomish Channel compared with other areas in the North Fork Skagit River tidal marshes (Yates 2001). Juvenile Chinook show a steady decline to zero northward along the Swinomish Channel.

The dredging of the navigation channel and construction of dikes, causeway, and jetty have created barriers to fish use of the Swinomish Channel. There is the physical barrier of the jetties and causeways that block movement of fish, particularly at lower tidal stages, requiring them to swim farther to gain access to the rearing habitat of Padilla Bay (14 miles as opposed to 7 miles). Present fish access is limited to a single narrow passage (the “fish hole”) through the rock jetties, accessible only at higher tide stages.

There is also the physiological barrier of a sharp salinity gradient between the Skagit River and the Swinomish Channel. This is particularly a problem for the physiologically sensitive Chinook salmon (Skagit River System Cooperative 2008). Fresh water discharged from the North Fork is currently restricted from entering the Swinomish Channel by the McGlinn Island Causeway and Jetty, and is either transported to the south away from Skagit Bay during the ebb tide, or to the north end of the bay around the jetty during the flood tide.

Yates (2001) shows that the North Fork Skagit River discharge east of the jetty is fresh (0 ppt) throughout the water column. On the west side of the jetty, there is a small area of mixing between fresh river water seeping through the rock jetty and marine water in the Swinomish Channel. North and south of this mixing area, salinity becomes relatively uniform along the channel, ranging from 15 ppt to 25 ppt, which is higher than the desired salinity for juvenile Chinook migration. The actual salinity is dependent upon tide stage and freshwater inputs such as streams to the west of the Swinomish Channel, agricultural drainage adjacent to the channel, and North Fork Skagit River discharge.

19.2.3 Human Environment

The confluence of the North Fork Skagit River and Swinomish Slough has been extensively altered by human impacts related to dredging and diking the Swinomish Channel for navigation.

In the later 19th century, boats began to use Swinomish Slough to travel between Skagit and Padilla Bays, thereby avoiding Deception Pass and Rosario Strait. The mudflats and shifting channels at the mouth of the North Fork Skagit River made navigation difficult. The Rivers and Harbors Act of 1892 authorized a 100-foot-wide navigation channel dredged to -4 feet MLLW (-5.5 feet NAVD88, based on the La Conner tide gage) running from Goat Island to the railroad bridge at the north end of Swinomish Slough. This channel was subsequently deepened to -12 feet MLLW (-13.5 feet NAVD88) and extended from Padilla Bay to the Saratoga Passage in 1935.

To help reduce sedimentation in the navigation channel, a series of dikes, causeways, and jetties were constructed. A 5,700-foot-long jetty from the south end of the Swinomish Reservation to Goat Island, called the McGlinn Island Jetty, was constructed by 1894. In the same year the dike between McGlinn Island and the mainland was built with a crest at 13 feet MLLW (11.5 feet NAVD88), separating Dunlap Bay from Swinomish Slough. This latter dike became a disposal area for sediments dredged from the navigation channel, creating the present McGlinn Causeway.

In 1908, to prevent further sedimentation in the slough, the South Jetty was constructed from the west end of Goat Island westward toward Saratoga Passage. Subsequent wave action lowered the crest of the McGlinn Island Jetty, allowing water and fine sediment to pass from the Skagit River to the Swinomish Channel, depositing in the lee of the structure. The McGlinn Island Jetty was later repaired to 14 feet MLLW (12.5 feet NAVD88) in 1973; a 30-foot-wide fish gap in the jetty was also constructed at that time.

The presence of the boat yard at the end of McGlinn Island Lane suggests there may be electrical, water, sewage, and telephone utilities in the vicinity of the site. More detailed information on existing utilities and the need for utility relocations will be required to support subsequent design phases.

19.3 Restoration Design Concept

19.3.1 Restoration Overview and Key Design Assumptions

The goal is to increase freshwater flow between the North Fork Skagit River and Swinomish Channel/Padilla Bay for the reasons previously stated. The restoration action would allow additional freshwater discharge to the Swinomish Channel from the North Fork Skagit River, either by lowering the McGlinn Island Jetty or by creating a new distributary channel from Dunlap Bay to the Swinomish Channel connected to an existing tidal slough. The proposed action differs from others as its benefits are the restoration of a process that reestablishes a significant migratory corridor for juvenile Skagit River Chinook salmon seeking rearing habitat in Padilla Bay (a distance of about 6 miles). The design recognizes, as the proponents do, that full restoration of historic conditions is virtually impossible given the geomorphic changes and the present use of the Swinomish Channel for navigation purposes. Nevertheless, the proposed action seeks to restore hydraulics and geomorphology to the extent practicable.

The primary stressors are the combination of physical and physiological barriers created by dredging and training the navigation channel. Improved connectivity through the jetties and causeway would allow direct access of fish from the North Fork Skagit River to the Swinomish Channel. It would make available low-salinity water (5 to 10 ppt) to juvenile Chinook salmon, which is essential to their physiological adaptation to marine conditions during the early phases of seaward migration.

Reconnecting the North Fork Skagit River with the Swinomish Channel would allow fish access to significant current habitat within the channel and in Padilla Bay, and to future restoration sites such as Telegraph Slough. The full restoration alternative lowers the McGlinn Island Jetty from McGlinn Island to Goat Island. The partial restoration alternative constructs a new channel through the McGlinn Causeway. The alternatives are shown on Figures 19-3 through 19-7.

The full restoration alternative consists of lowering the entire length of rock jetty running between McGlinn Island and Goat Island (Figures 19-3 and 19-5). The elevation of the surrounding mudflat is about MLLW (-1.51 feet NAVD88). About 5,700 LF of rock jetty will be lowered from a crest elevation of about 14 feet MLLW (12.5 feet NAVD88) to an elevation of about -2 feet MLLW (-3.5 feet NAVD88). The average cross section unit volume of the jetty is about 20.2 CY per linear foot; the total volume of the jetty to be removed is about 115,140 CY. The rock will be transported offsite; options for reuse will need to be identified in later design stages. Removing the rock jetty is likely to remobilize sediment deposited in its lee. The fate of this sediment, together with changes in sedimentation patterns in the Swinomish Channel and Skagit River, will need to be investigated prior to implementation.

The partial restoration alternative would breach the McGlinn Causeway, creating a shallow distributary channel from Dunlap Bay to the Swinomish Channel, connected to an existing tidal slough in Dunlap Bay (Figures 19-4 and 19-6). The causeway breach channel would be about 500 feet long with a bottom width of about 130 feet. The channel would be excavated to about 2.5 to 3.5 feet MLLW (1 to 2 feet NAVD 88) and allowed to erode naturally. The channel size was determined by comparison with the existing tidal slough channel in Dunlap Bay. The blind tidal channel would be excavated following the existing sinuous alignment to increase channel width and depth, facilitating the connection between the North Fork Skagit River and the Swinomish Channel.

To maintain access along McGlinn Island Lane, a bridge would be constructed across the causeway breach. Approximately 800 feet of existing roadway on the causeway would be removed, together with 8,400 SF of landscaping along the new alignment. The roadway would be replaced with a bridge approximately 270 feet long, and 265 feet of new roadway would be constructed at either end of the bridge. Channel side slopes within 50 feet of the abutments on both sides of the bridge would be armored with riprap boulders with underlying bedding and filter fabric to prevent scour around the structure (Figure 19-6). The rock will be buried beneath a “habitat surface” that is more gently sloping and revegetated. Slopes of the channel are shallow, and the bridge longer than the width of the excavated channel, to reduce the need for a fully armored channel.

The key design elements associated with full and partial restoration alternatives are shown in Table 19-1.

Table 19-1. Key Design Elements

Element	Full Restoration	Partial Restoration
Swinomish/North Fork Skagit River Distributary Channel	Lower McGlinn Island Jetty. Rock transport and disposal – either onsite to raise existing low areas or for beneficial uses nearby.	Construct channel through McGlinn Island Causeway. Expand natural channel connecting to tidal slough in Dunlap Bay marsh. Soil transport and disposal – either onsite to raise existing low areas or for beneficial uses nearby.
Roadway/Bridge	Not included.	Construct new 270-foot-long bridge over channel. Reconstruct portion of roadway and armor 50 feet of channel slopes adjacent to bridge abutments. Plant channel slopes with native riparian species.

19.3.2 Restoration Features – Primary Process-Based Management Measures

Armor Removal/Modification – NA

Berm or Dike Removal/Modification

The full restoration alternative would allow additional freshwater discharge to the Swinomish Channel during all tidal stages by lowering the McGlinn Island Jetty (Figure 19-5). Approximately 5,700 feet of the jetty would be lowered to about -2 feet MLLW (about -3.5 feet NAVD88) by removing the existing rock armor (Figure 19-3). The actual elevation of the lowering would be determined following detailed survey of the existing structure.

The partial restoration alternative would breach the McGlinn Causeway, creating a shallow distributary channel from Dunlap Bay to the Swinomish Channel, connected to an existing tidal slough (Figure 19-4). The causeway channel would be about 500 feet long with a bottom width of about 130 feet. The breach channel would be excavated to about 2.5 to 3.5 feet MLLW (1 to 2 feet NAVD 88) (Figure 19-6).

Channel Rehabilitation/Creation

The partial restoration alternative would expand an existing blind tidal channel to connect the McGlinn Causeway breach to the main tidal slough channel in Dunlap Bay that connects to the North Fork Skagit River. The blind tidal channel would be excavated following the existing sinuous alignment, to increase channel width and depth and facilitate the connection between the North Fork Skagit River and the Swinomish Channel. The conceptual design shows relatively flat side slopes with a 130-foot-wide base at about 2.5 to 3.5 feet MLLW (1 to 2 feet NAVD 88).

Groin Removal/Modification – NA

Hydraulic Modification – NA

Overwater Structure Removal – NA

Topography Restoration – NA

19.3.3 Restoration Features – Additional Management Measures

Beach Nourishment – NA

Contaminant Removal/Remediation – NA

Debris Removal

The partial restoration alternative would include some removal of large woody debris that has deposited along the east side of the McGlinn Causeway. The large woody debris may be redistributed along the fringes of Dunlap Bay or transported offsite.

Invasive Species Control – NA

Large Wood Placement – NA

Physical Exclusion – NA

Pollution Control - NA

Revegetation

The partial restoration alternative includes shallow channel slopes that could support riparian corridors. These channel slopes will be planted with native riparian species.

Reintroduction of Native Animals – NA

Substrate Modification – NA

Species Habitat Enhancement – NA

19.3.4 Restoration Features – Other

For the partial restoration alternative, access along McGlinn Island Lane would need to be maintained. The restoration plan includes the removal of approximately 800 feet of existing roadway on the causeway and an additional 8,400 SF of landscaping along the new alignment. The roadway would be replaced with a bridge approximately 270 feet long, together with 265 feet of new roadway at either end of the bridge (Figure 19-7).

19.3.5 Land Requirements

Additional right-of-way may need to be acquired along the new McGlinn Lane alignment to allow for new roadway and bridge construction. The proposed bridge alignment is located parallel to the current alignment in order to avoid complete road closures during construction.

19.3.6 Design Considerations

The causeway and jetty were constructed to prevent river-borne sediment from filling the Swinomish Channel. Lowering the jetty or breaching the causeway to allow freshwater mixing and fish passage must account for sediment transport and its effect on current maintenance dredging schedules.

In both alternatives, key considerations would include salinity gradients between the freshwater discharge from the North Fork Skagit River and the more saline Swinomish Channel, and sediment transport from the Skagit River to the navigable waters of the Swinomish Channel. Sufficient fresh water must enter the Swinomish Channel to allow Chinook salmon to take advantage of a salinity gradient. Simultaneously, the existing tidal velocity asymmetry needs to be maintained to assist the northward migration.

In the full restoration alternative, the lowering of the jetty offers a more direct connection between the Skagit River and Swinomish Channel, with the potential for increased sediment transport. In the Skagit River System Cooperative report (2008) two jetty elevations were considered (MSL versus MHW) to limit sediment transport. Lowering the jetty to below MLLW would need to be closely examined to balance fish passage requirements while limiting sediment transport from the Skagit River into the Swinomish Channel.

In the partial restoration alternative, routing flows from the sediment-laden North Fork Skagit River through Dunlap Bay prior to discharge into Swinomish Channel offers opportunities for deposition within the tidal marshes of Dunlap Bay. The channel bottom elevations would need to be closely examined to balance ease of fish passage with sediment transport and potential trapping within Dunlap Bay.

In the partial restoration alternative, the proposed elevated roadway alignment is parallel to the existing alignment to maintain traffic during construction. The proposed bridge would be approximately 270 feet long and would consist of two 135-foot spans with 6-foot-6-inch-deep pre-cast concrete girders. The bridge substructure consists of columns supported on drilled shafts. The assumed embedment depths of the drilled shafts are 100 feet. A ballast/fill section would be needed to transition from bridge structure to the existing roadway. The proposed roadway would meet current design standards and would meet or exceed equivalent capacity. The road would include two 11-foot lanes and two 3-foot shoulders. The proposed roadway geometry includes vertical and horizontal alignment considerations. The total length of improvements (bridge and road structures) is approximately 800 LF.

19.3.7 Construction Considerations

The full restoration alternative would require marine access for barge-mounted excavators. Rock material excavated from the jetty via barge would be hauled offsite.

The partial restoration alternative would be constructed primarily with tracked excavators during low tides. Summer construction would be ideal to limit earthwork and sedimentation during the rainy season and to take advantage of lower astronomical tides.

One consideration is disposal of excavated material from the channel. Approximately 64,000 CY of material would be generated in the implementation of the partial restoration alternative. This material may be utilized locally to build up grades along the McGlinn Causeway or on McGlinn Island itself, while imported select material is assumed for bridge approaches. Local disposal would limit costs associated with the project. This fill material may also have beneficial uses on other nearby restoration projects.

The McGlinn Lane bridge in the partial restoration alternative would require special construction considerations. The drilled shafts would be installed directly from the ground surface with a drilled-shaft oscillator prior to excavation. Large-diameter casing shoring would be required to keep out water and allow access to the top of the shaft for column form placement and removal. It is assumed that the contractor would be able to install one shaft per week. Once the shafts are installed, the columns would be cast inside the shoring casing. After the casing is removed, the cast-in-place pilecaps and bridge superstructure would be constructed. Concrete bridges require very little maintenance. The current standard is to inspect bridges every 2 years.

19.4 Extent of Stressor Removal

Table 19-2 describes the amount of stressors to be removed with this action.

Table 19-2. Stressor Removal

Stressor	Full Restoration	Partial Restoration
Tidal Barrier (LF)	NA	Removal/breaching of 175 LF of the McGlinn Causeway
Fill (area)	NA	21.26 acres of fill removed from McGlinn Causeway (overlaps with tidal barrier)
Breakwaters & Jetties (LF)	Lowering of about 5,700 LF of the McGlinn Island Jetty	NA

19.5 Expected Evolution of the Action Area

Without restoration, the physical barrier of the causeway and jetty would continue to impede migration of fish from the North Fork Skagit River into the Swinomish Channel. The steep salinity gradient between the two channels would remain as a physiological barrier. The causeway is unlikely to alter over time. The jetty is likely to continue to sustain damage along its length, lowering the crest elevation of the structure. A reduced crest elevation would result in greater exchange of water between the Skagit River and the Swinomish Channel, and more sediment entering the Swinomish Channel. This would be especially true during high discharge/high sediment load events in the Skagit River, when water elevations are highest and damage to the jetty crest is most likely.

The restoration alternatives, connecting the Skagit River and Swinomish Channel, and coupled with future restoration of habitat at sites such as Telegraph Slough, should reestablish a significant migratory corridor for juvenile Skagit River Chinook salmon migrating to rearing habitat in Padilla Bay. Connection of the causeway channel to the existing tidal slough in Dunlap Bay would increase the tidal flow through the slough, eroding the channel and increasing its width and depth. During high discharge events in the North Fork Skagit River, there is potential for a large proportion of this flow to be captured in the new channel. It is unlikely that the North Fork Skagit River would avulse due to the restriction of the rock armored channel. However, the channel could become a significant distributary channel of the North Fork Skagit River; in this case, management of the accompanying sediment load would become an issue.

Increased maintenance dredging may be required if the Swinomish Channel is to be maintained. The amount and frequency of future dredging is unknown and should be investigated further.

19.6 Uncertainties and Risks

There are considerable uncertainties with the proposed action. The action requires a detailed understanding of sediment transport and freshwater/saltwater mixing patterns for the Skagit/Swinomish/Padilla Bay system. Numerical modeling of sediment transport, tidal and riverine currents, and freshwater/saltwater mixing patterns is essential to determine whether reconnecting the Swinomish Channel, and ultimately Padilla Bay, to the North Fork Skagit River is feasible (Skagit River System Cooperative 2008).

One major concern would be the potential during a large flood event for the North Fork Skagit River flow to be captured and directed into the Swinomish Channel. This would radically alter the existing flow, salinity, and sedimentation patterns of the Skagit-Swinomish system.

19.6.1 Risks Associated with Projected Sea Level Change

Table 19-3 compares potential risks associated with projected sea level changes based on professional judgment.

Table 19-3. Risks of Sea Level Change

	Projected Sea Level Change		
	High (46cm)	**Intermediate (4cm)**	**Low (-8cm)**
Full Restoration	Flows over the lowered jetty would increase as sea level rises. Freshwater/saltwater mixing patterns may vary with sea level rise. Modeling needs to include sea level rise.	Negligible impact.	Negligible impact.
Partial Restoration	Fixed structures such as the bridge would need to be designed to accommodate the anticipated sea level rise within the project life. Freshwater/saltwater mixing patterns may vary with sea level rise. Modeling needs to include sea level rise.	Negligible impact.	Negligible impact.

19.7 Potential Monitoring Opportunities

Monitoring is important for evaluating restoration success. A combination of field surveys and aerial photographs would be used to document biological and physical changes to the landscape. Monitoring data can be used to refine adaptive management and corrective actions, as needed. Some of the main monitoring needs and opportunities associated with this action are summarized Table 19-4.

Table 19-4. Monitoring Needs and Opportunities

Monitoring Parameter	Key Performance Indicator	Note
Topographic Stability		Monitor stability of jetty and causeway
Sediment Accretion / Erosion	X	Monitor amount of sediment entering Swinomish Channel
Wood Accumulation	X	Monitor amount of wood entering Swinomish Channel
Soil / Substrate Conditions		
Vegetation Establishment		
Marsh Surface Evolution / Accretion		
Tidal Channel Cross-Section / Density	X	Monitor breached channel cross section to ensure adequate size for tidal range
Water Quality (contaminants)		
Salinity	X	Assess salinity gradient between the two channels
Shellfish Production		
Extent of Invasive Species		
Animal Species Richness	X	
Fish (salmonid) Access/Use	X	
Forage Fish Production		
Wildlife Species Use		
Effectiveness of Exclusion Devices		

19.8 Information Needed for Subsequent Design

This conceptual design report represents an initial step in the restoration design sequence. The design concepts described above were developed based on readily available information without the level of site-specific survey and investigation that is necessary to support subsequent design and implementation. Substantial additional information will be required at the preliminary design stage to confirm the design assumptions, refine quantity estimates, address property and regulatory issues, obtain stakeholder support, and fill in data gaps. The extent to which this information is collected for preliminary design (or a later design stage) will depend upon the available budget, schedule and other factors. This section attempts to define the most essential information needs for this action.

- Property Investigation/Survey – More detailed information on parcel ownership,utilities, and property boundary locations will be needed to finalize the design, confirm acquisition requirements, and support negotiations with property owners.
- Topographic/Bathymetric Survey – Detailed survey of the jetty and causeway are required. The survey data would be used to refine design of key project elements

and develop detailed construction and demolition plans. Survey data could also be used as a baseline for pre- and post-construction modeling, including hydrodynamic modeling. A temporary tide gage may be required in the early design stages to obtain site-specific tidal statistics.

- Geotechnical Investigation – Additional geotechnical study will be required toinform bridge designs (pilings, foundations, etc.). In addition, hydraulic engineering would be required to provide scour estimates for bridge footings and recommendations for bridge elevations for clearance over design water surface elevations.
- Cultural Resources Investigation – Surveys for archaeological and historic resources may be required for this action area.
- Hydraulic Analysis/Modeling – Tidal circulation, flood, and hydrodynamic modeling will be required to analyze the effects of each design option on flows, velocities, and salinity gradients along the North Fork Skagit River and Swinomish Channel to assess the impact on fish passage. The balance between navigational requirements related to sedimentation and dredging and fish passage issues needs to be addressed. The type of model used will be determined in a later design stage.
- Contaminant Survey – If preliminary investigations suggest that hazardous material could be present in the action area, additional soil and sediment analysis may be needed. The introductory chapter describes the Phase I site investigations that are occurring as part of this overall effort via a separate contract.
- Sediment Transport Study – Assessment of sediment transport dynamics may be needed to evaluate design options against U.S. Army Corps of Engineers criteria for navigation dredging along the Swinomish Channel.

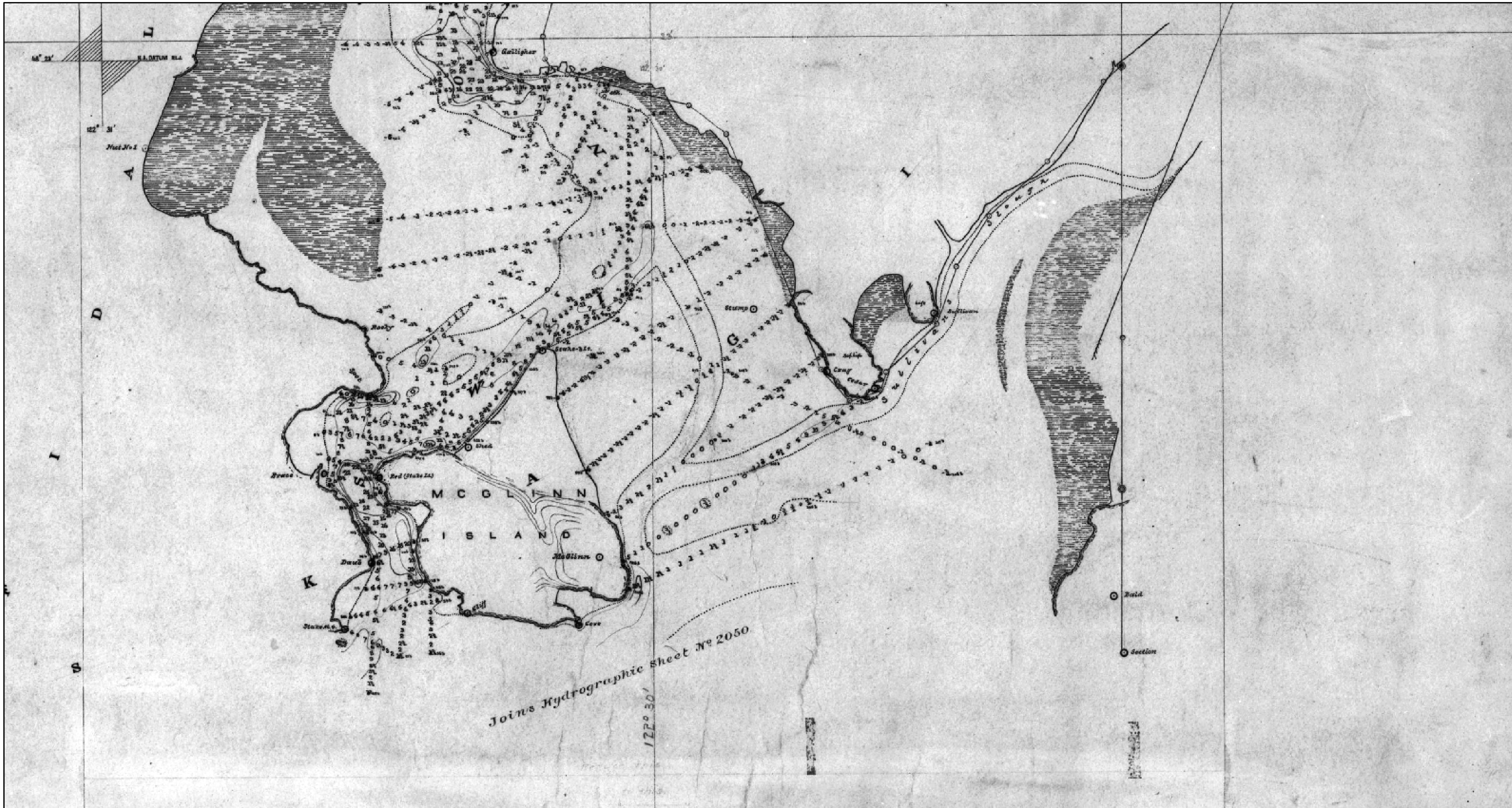
19.9 Quantity Estimates

The quantity spreadsheets for the full and partial restoration alternatives are provided in Exhibits 19-1 and 19-2.

19.10 References

Skagit River System Cooperative. 2008. *Habitat Restoration Feasibility Phase 1: Establishing the Viability of Hydraulic Connectivity between Skagit and Padilla Bays*. Skagit River System Cooperative, Battelle PNL and USGS.

Yates S. 2001. *Effects of Swinomish Channel Jetty and Causeway on Outmigrating Chinook Salmon (Oncorhynchus tshawytscha) from the Skagit River Washington.* MSc Thesis, Western Washington University.



0 700
Feet
0 220
Meters

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Historic Map (T-Sheet)
Action Name: McGlinn Island Causeway
PSNERP ID #: 1092
Figure 19- 2A

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Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64

WDFW Contract # 100-000204 (CAPS No. 10-1461)

Historic Map (T-Sheet) and River History Project Data

Action Name: McGlinn Island Causeway

PSNERP ID #: 1092

Figure 19- 2B

SOURCE: Washington Public Lands Database (2006); Washington Counties Parcels (2009); Action Area (PSNERP, 2010)

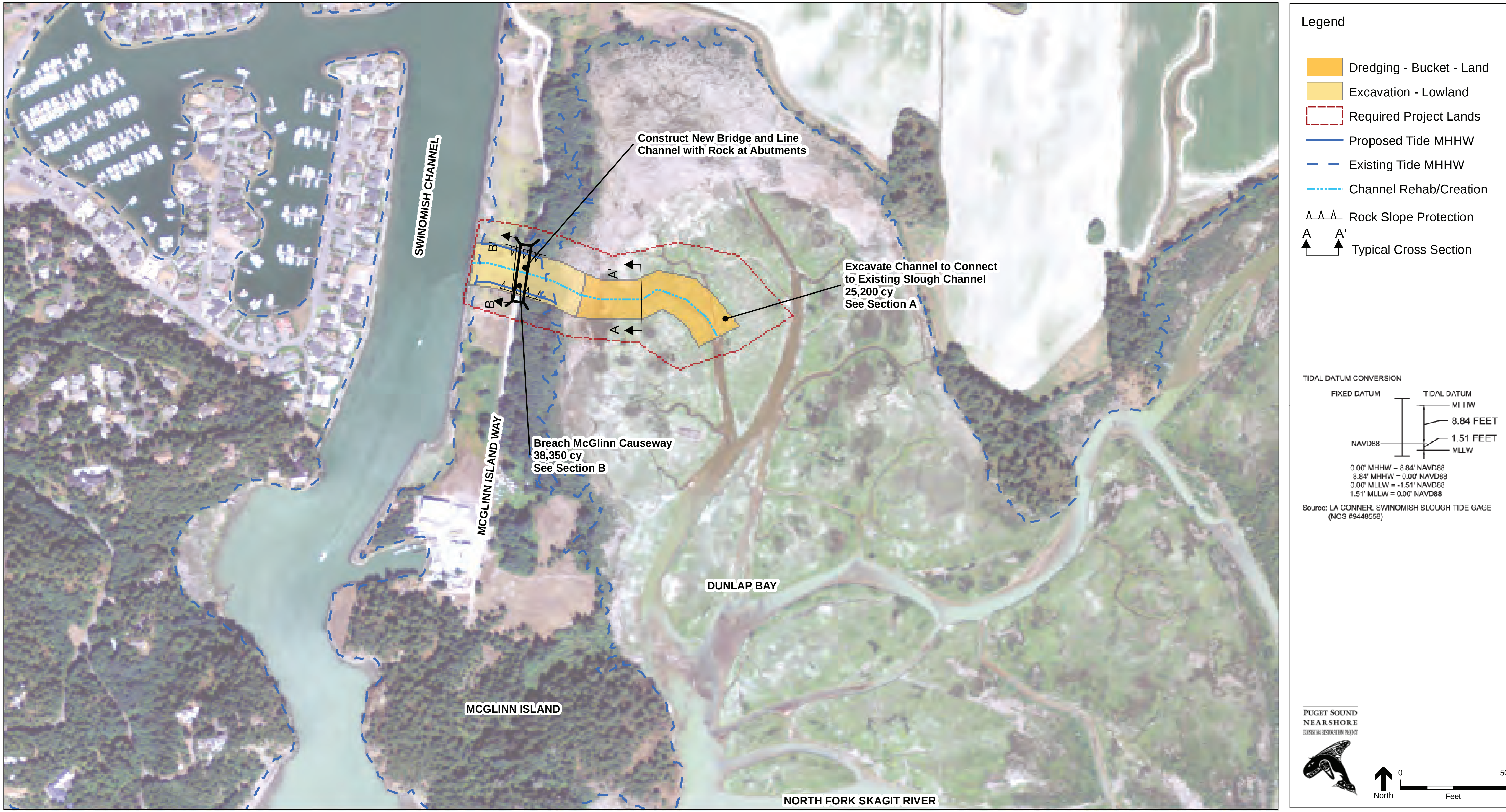
Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64

WDFW Contract # 100-000204 (CAPS No. 10-1461)

Lead Contractor: ESA
Design Lead: ESA PWA
Date: 2/2011

Conceptual Design Plan
Site Name: Skagit River Delta
Action Name: McGlinn Island Causeway
PSNERP ID #: 1092
Full Restoration

Figure 19-3



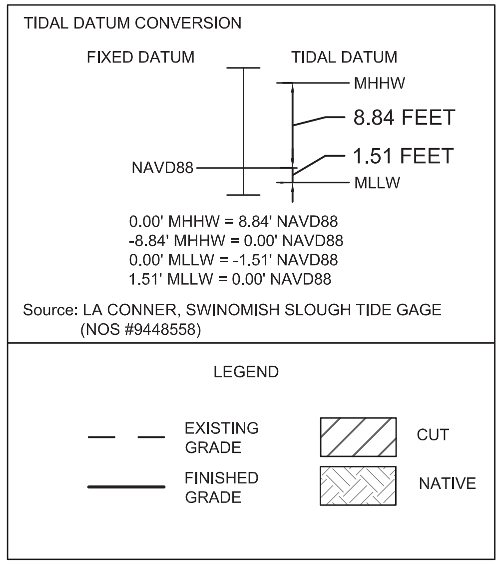
SOURCE: Washington Public Lands Database (2006); Washington Counties Parcels (2009); Action Area (PSNERP, 2010)

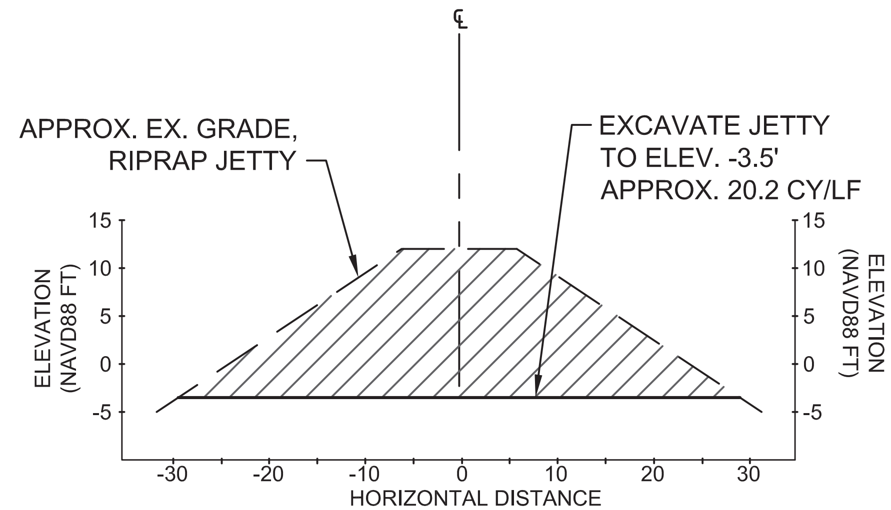
Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Plan
Site Name: Skagit River Delta
Action Name: McGlinn Island Causeway
PSNERP ID #: 1092
Partial Restoration

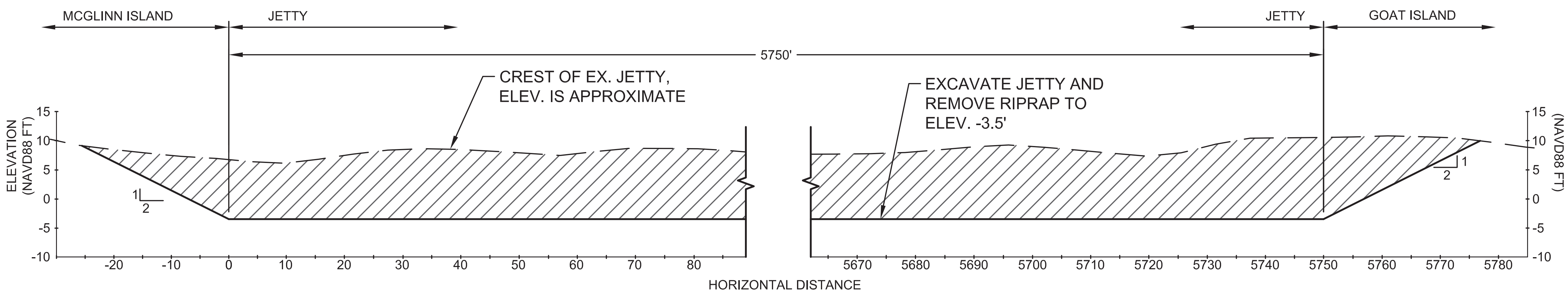
Lead Contractor: ESA
Design Lead: ESA PWA
Date: 2/2011

Figure 19-4





Ⓐ FULL RESTORATION TYPICAL SECTION
SECTION ACROSS JETTY CREST



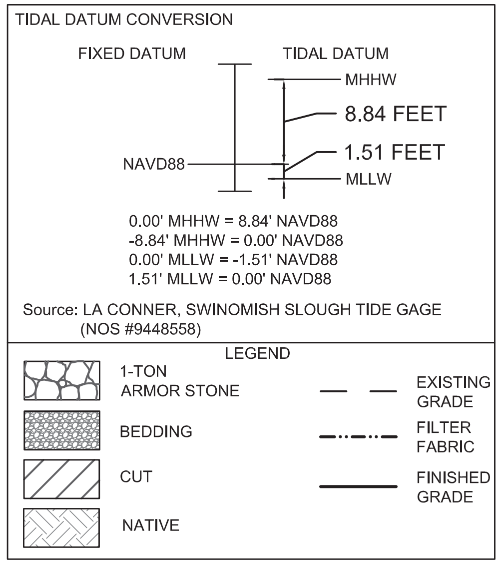
Ⓑ FULL RESTORATION TYPICAL SECTION
PROFILE ALONG JETTY CREST, NORTH TO SOUTH

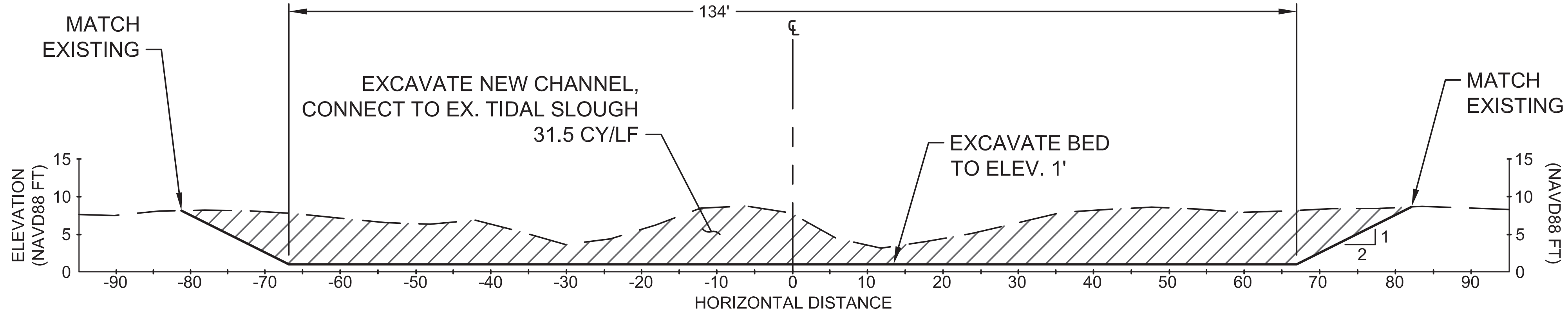
PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: ESA PWA
Date: 3/2011

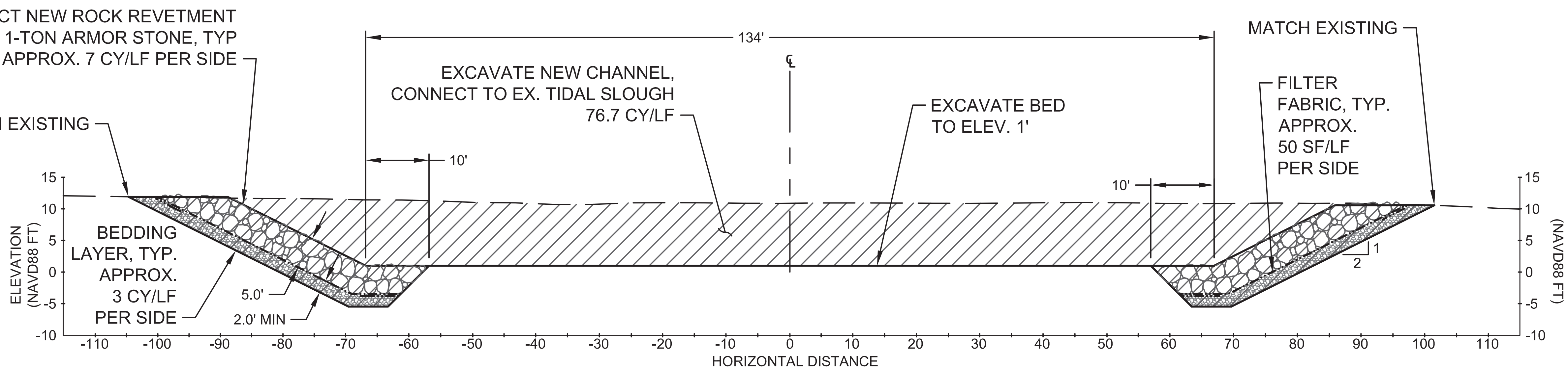
Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)
Conceptual Design Section
SITE NAME: **Skagit River Delta**
ACTION NAME: **McGlinn Island Causeway**
PSNERP ID#: **1092**
Full Restoration

Figure 19-5





Ⓐ PARTIAL RESTORATION TYPICAL SECTION
MCGLINN CAUSEWAY BREACH CHANNEL, APPROX. 1200 LF TOTAL



Ⓑ PARTIAL RESTORATION TYPICAL SECTION
MCGLINN CAUSEWAY BREACH CHANNEL, APPROX. 100 LF AT NEW BRIDGE

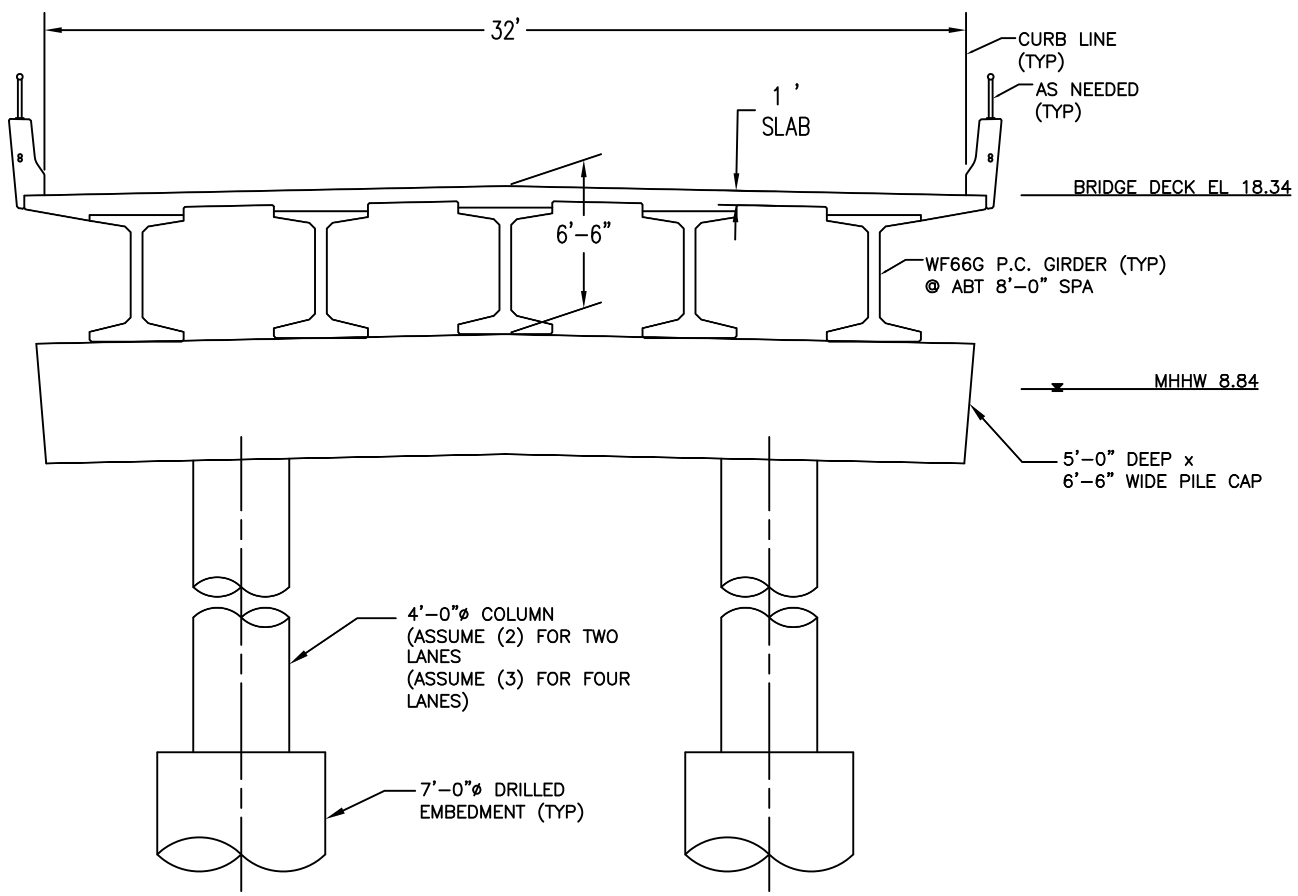
0 20
Scale in Feet

PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

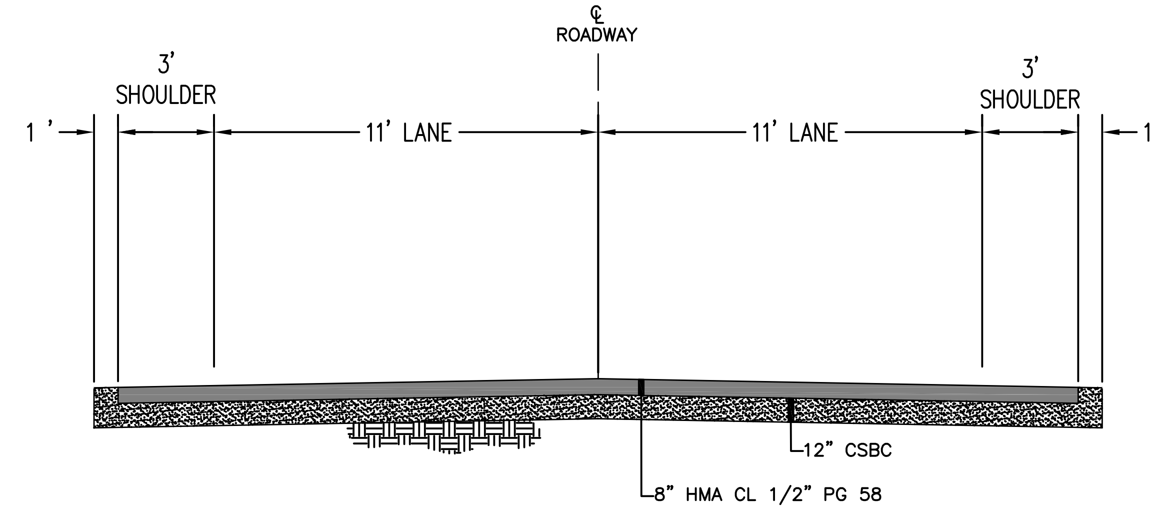
Lead Contractor: ESA
Design Lead: ESA PWA
Date: 3/2011

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Section
SITE NAME: **Skagit River Delta**
ACTION NAME: **McGlinn Island Causeway**
PSNERP ID#: **1092**
Partial Restoration



BRIDGE SECTION
NTS



ROADWAY SECTION
NTS

PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: ESA PWA
Date: 3/2011

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)
Conceptual Design Section
SITE NAME: **Skagit River Delta**
ACTION NAME: **McGlinn Island Causeway**
PSNERP ID#: **1092**
Full & Partial Restoration

Figure 19-7

Full Restoration Quantity Estimate

Action Name:	McGlinn Island Causeway			
Action #:	1092			
Date:	February 2011			
By:	L. White			

REMEDY: ***Lower McGlinn Island Jetty***

Construction Period: Assume 2 week construction duration to lower jetty

Item	Unit of Measure	Qty	Description of Item	Indicate section of design report where item is described
ACQUISITION AND CONSERVATION			Based on available mapping information	
Required Project Lands	Acre	56	Total land required For action	19.3
Proponent / Partner-owned lands	Acre	56	Etimate of lands currently owned by Proponent (i.e., Public lands	19.3
Lands To Be Acquired	Acre	NA	Estimate land required to be acquired for action prior to implementation	
Material Sites			Not Used: See Earthwork - Imported Fill.	
MOBILIZATION AND ACCESS for construction activities			Description required for each item to facilitate cost estimating	
Mobilization - Typical (Equipment, Personnel, Planning, Financial)	LS	1	Up front costs such as bonding, planning and other staff time and financing. Typically, assume 8% to 10% of other items.	19.3
Mobilization - Remote (Equipment, Personnel, Planning, Financial	LS	NA	Up front cost for nontypical or remote locations. Assume 12% of other items	
Site Access	LS	NA	Use for special situations (e.g.. new bridge, new access roads) for the purposes of construction access Include description.	
Barge Access	Days	10	Excavate jetty using hydraulic excavator from barge	19.3
Temporary Traffic Control (one of the following)			Includes installation of traffic signals, signage, signmen, etc. There are 4 types as follows	
none	LS	NA	None = no traffic control	
signs	LS	NA	Typical Construction Signage (KPFF)	
flags / spotters	LS	NA	Flags and spotters only during roadway transition connection (KPFF	
unique	LS	NA	Unique = Greater effort than flags / spotters. Describe as basis for cost estimate	
Temporary Roadway	SF	NA	Includes construction of temporary adjacent roadway or bypass roadways and for vehicle and pedestrian travel through or around site	
Control of Water	LS	NA	Use for special situations that require draining the site using pumps or water control structures, and bypassing water during construction. Can also be used for multi-year projects. Description required, including estimate duration.	
Relocation Activities			Not Used: See Utilities, Structures	
Site Demolition Activities			Demolition and removal of structures (description required), temporary features and relocations, itemized separately); Clearing and grubbing of vegetation, and removal of minor debris (rocks, slabs) - description required.	
Clearing and Grubbing (one or more of following)			Use one or more of the following categories of clearing and grubbing	
Clear Vegetation - Local Disposal	AC	NA	Vegetation removed above grade and disposed locally	
Clear /Grub Vegetation - Local Disposal	AC	NA	Vegetation roots also removed and disposed locally. Assume entire width and length of channel	
Clear /Grub Vegetation - Offsite Disposal	AC	NA	Vegetation is taken offsite and disposed - use for noxious invasives, etc	
Clear, stockpile - large woody debris	CY	NA	Vegetation is segregated and stockpiled / prepared for reuse on site	
Hydraulic Structures - Small	LS	NA	Removal of tide control and significant drainage structures that require excavation, cofferdam and or water control. Describe type of structure, elevation etc. For major structures (dam, diversion), use different line	
Hydraulic Structures - Large	LS	NA	Dam removal (describe and state whether this item includes water control and sediment removal or these are in separate items)	
Utilities	LS or LF	NA		
Buildings	LS or SF	NA		
Pavement	SF	1650	Excavate 250 LF Weir in existing jetty. Likely to use large hydraulic excavator from barge	19.3
Bulkheads	LF or SF	NA	Use this for bulkheads…if large and difficult, consider using Large Coastal Structures	
Rock revetments	LF, Ton or CY	NA		
Large Coastal Structures	CY	NA	Use this item for breakwaters, jetties, groins, reinforced concrete seawalls and any structure that requires larger equipment and power to break up and or remove	
Demolition / Removal - Bridge	SF or CY	NA	Use this item for structures that require cranes or other special removal staging	
Removal - Misc. (e.g. angular rock from beach)	Ton	NA	For loose rock scattered across intertidal	
Demolition / Removal - Boat Ramp	SF	NA	This is a special item but happens at least once…others can also be added as needed	
Haul - Offsite Disposal of Demolition Debris	Miles	10	Assume jetty material is transported less than 10 miles for reuse or disposal	19.3
Hazardous/Contaminated Waste Removal			These items for earthwork of quality not compatible with wetlands, requiring special handling and disposal. Describe basis for classification as contaminated or hazardous. State known or suspected contamination, describe known similar work	
Contaminated Earthwork	CY	NA	Excavation, off haul and disposal within a licensed landfill, complete	
Hazardous Earthwork	CY	NA	Excavation, off haul and disposal within a licensed hazardous waste landfill, complete	
Construct Temporary Features			Use as needed for unusual temporary features not included elsewhere (see TESC below)	
EARTHWORK			Expand to include equipment, etc. to facilitate cost estimating.	
Excavation	CY		Per yard excavation w/out expected haul	
Excavation - Upland	CY	NA	Conducive for transitional earthwork equipment, including scrapers, with high production and low cost	
Excavation - Lowland	CY	NA	Requires low ground pressure equipment and or mats; low production bucket methods, typically hydraulic excavator and front end loaders.	
Dredging - Bucket - Land	CY	NA	Excavation below ground water or underwater; reach limited low production	
Dredging - Bucket - Marine	CY	NA	Floating or amphibious equipment with excavator, clamshell or dragline bucket	
Dredging - Hydraulic	CY	NA	Hydraulic cutter / suction dredge to slurry and pump sediment	
Fine Grading	AC	NA	Small tolerance grading after rough grading	
Fill Placement - local borrow			This is additive to Earthwork -Excavation	
Side cast	CY	NA	Excavated material placed within reach of excavator / dredge - assume includes some shaping by bucket	
Haul - uncontrolled placement	CY	NA	Transportation and second handling - estimate distance	
Haul, place, compact	CY	NA	Transportation and second handling - estimate distance, placement in lifts, moisture conditioning, compaction testing.	
Stockpile - uncontrolled placement	CY	NA	Intermediate step, for subsequent off haul or use elsewhere on site	
Stockpile - controlled placement	CY	NA	intermediate step, for subsequent off haul or use elsewhere on site. Can use this for drying material for subsequent controlled compacted fill	
Conveyor placement from stockpile land/water	CY	NA	Some projects may require conveyor placement	
Imported Fill			Includes purchase, delivery and placement or as noted / described	
Select Fill	CY	NA	Bridge approaches	
Gravel Borrow, including haul	CY	NA	WSDOT standard item	
Sand / Gravel for Beach Nourishment	CY	NA	special borrow and sorting required; identify material source	
Cobble for Shore Nourishment	CY	NA	special borrow and sorting required; identify material source	
Embankment Compaction	CY	NA	WSDOT standard item - compaction of bridge approaches	
Topsoil	CY	NA		
RESTORATION Features				
Channel Rehab / Creation	SF	NA	Channel construction (SF) including imported sediment and habitat materials, excluding excavation	
Large Wood Placement	EA	NA	Per each log, Including drift logs, lower river log jams, etc	
Invasive Species Control	Acre	NA	Per acre control described in drawings and narrative	
Physical Exclusion Devices	LF or EA	NA	Human or wildlife exclusions including fences, barriers, mooring buoys, etc	
Other Restoration Features/ Activities	LS	NA	Describe other items not included elsewhere	
Structures	EA		KPFF to provide additional inputs	
Water Control Structures - Culverts with Gates	EA	NA	Describe type, number of openings (e.g. pipes), expected materials, dimensions	
Water Control Structures - Weirs	EA	NA	Describe, length, type, anticipated materials	
Rock Slope Protection	LF	NA	Not applicable to action	
RSP on North Bank	*LF*	NA	Not applicable to action	
RSP on North Bank	*LF*	NA	Not applicable to action	
Other	EA	NA	Describe	
Elevated Boat Ramp	SF	NA	Pile or pier supported to allow sediment drift	
Fencing	SF	NA	Describe, type, height etc	
Utilities			Replacement or relocation. Designer to provide size and material and have separate line item for each run. Incidentals include earthwork, testing, hook up fees, etc. These quantities do not include demolition of existing utilities, real estate / easements, design fees. Describe the owner if known, and whether utility franchise will install (e.g.. electric is typically installed by electrical franchise	
Water	LF	NA		
Gas	LF	NA		
Electric	LF	NA		
Sewer	LF	NA		
Telecommunications	LF	NA		
Other	LF	NA	Others = whatever is required (e.g.. power towers, petroleum, jet fuel, etc.	
Roadway / Railway			KPFF expected to participate in these estimates	
Roadway	SF	14840	Typical Roadway 28' wide (KPFF)	19.3
Roadway - Traffic Signal	LS	NA	Street lights, etc. (Temporary traffic control handled under Temporary Facilities	
Culvert (type)	LF	NA	Provide specific culver size and type	
Culvert - Jacking	LF	NA	Through railway	
Culvert - Horizontal Pile Driving	LF	NA	Through railway	
Bridge Deck	SF	8640	Precast Concrete Girder Bridge with 135' Spans (KPFF)	19.3
Bridge -Foundation	LF	32	(1) 32' CIP Concrete pile caps w/ (2) 7' Dia Drilled Shafts 100' Embed At Each Pile Cap (KPFF	19.3
Railway - Box Girder	SF	NA	Standard	
Railway - Foundation	LF	NA	Standard	
Railway - Shoe fly	LF	NA	Temporary alignment	
Permanent Access Features			KPFF expected to participate in these estimates	
Roads	Level	2%	Level 1 direct access, Level 2 moderately difficult, Level 3 difficult access (KPFF)	19.3
Utility Access Routes	varies	NA	Describe utility access feature, such as boardwalk or all-weather gravel road	
Erosion Control Features	AC	0.6	Stabilized Construction Entrances, Sediment Ponds, Hydro Seed to Stabilize Roadway Embankments (KPFF)	19.3
Public Access or Recreation Features			KPFF expected to participate in these estimates	
trails	SF	NA	Describe trail feature, such as gravel, mulch, asphalt concrete	

Full Restoration Quantity Estimate

	Action Name:	McGlinn Island Causeway			
	Action #:	1092			
	Date:	February 2011			
	By:	L. White			

REMEDY: *Lower McGlinn Island Jetty*

Construction Period: Assume 2 week construction duration to lower jetty

	Item	Unit of Measure	Qty	Description of Item	Indicate section of design report where item is described
	bridges	SF	NA	Describe bridge feature, such as wooden pedestrian, or H20 vehicle.	
	kiosk	EA	NA	Describe kiosk feature, such as size, material	
	restrooms	EA	NA	Describe restroom feature, such as size, material	
	Interpretive Signs	EA	NA	Include # interpretive signs based on number of local public access points	
	parking area	SF	NA	Describe parking area, such as size, material	
	Other	EA	NA	Describe other recreational features (see Corps criteria, ER 1105-2-100 for compatibility with ecosystem objectives)	
Vegetation & Erosion Control					
	Hydroseeding	AC	NA	Describe desired seed mix (e.g.. native plants cost more)	
	Planting	AC	NA	Describe, provide breakdown on unit area basis	
	Vegetation Maintenance	AC-YR	NA	Includes irrigation, weeding, plant replacement for one yea	
	Erosion / sediment BMPs - Temp.	AC	0.6	BMPs for control of drainage - describe. Assume compliance with Construction General NPDES included (KPFF)	19.3
	Erosion / sediment BMPs - Permanent	AC	NA	May want to separate slopes over 25% into separate category	
	Waterside controls - Temporary	EA, LF, LS	NA	Silt curtain or other water based temporary actions	
Construction Management					
	Construction oversight	weeks	2	Quantity based on construction duration/# of construction seasons	19.3
	Materials testing			Included in cost of material - no separate quantity	
	Proponent in-kind Services	Man-Days		Describe services to be provided by Proponent during construction, such as site night securit	
	Government Oversight	Man-Days		Describe length of construction period(s) for on-site inspection	
	Quality Control & Testing	L.S.		Describe types and quantities of required contractor QC	
	Quality Assurance With Testing	L.S.		Describe types and quantities of government QA associated with QC	
Design and Detailed Site Investigations					
	Survey & Property, Utility Research	LS	1	% of construction cost	19.8
	35% Design	LS	1	35% x 25% x Engineer's Estimate	19.8
	65% design	LS	1	65% x 25% x Engineer's Estimate less the cost for 35% PS&E	19.8
	90% design	LS	1	35% x 25% x Engineer's Estimate less the cost for 35% + 65%PS&E	19.8
	100% design	LS	1	25% x Engineer's Estimate less previous costs	19.8
	Geotechnical Studies			Refer to design report for description of need	
	Cultural Studies			Refer to design report for description of need	
	HTWR Studies			Refer to design report for description of need	
	Land Survey Documentation	pages		Describe types and quantities of expected documentation	
Project Agreement Activities				Unable to provide credibale estimate at 10% design	
Site-Specific Adaptive Management Features & Activities				List if known	
	Adaptive Science and Technology Implementatio	L.S.		Describe level of effort expected to implement AT&T at site	
Monitoring Activities				Assume 5 crew-days/year for each monitoring parameter in design report for 5 yrs	
	Monitoring (Type)	crew-days	150		
Operations & Maintenance				Unable to provide credible estimate at 10% design	

Partial Restoration Quantity Estimate

Action Name: McGlinn Island Causeway
Action #: 1092
Date: February 2011
By: L. White

REMEDY: ***Excavate channel through Dunlap Bay to connect water from the North Fork Skagit River to Swinomish Channel. Install bridge.***
Construction Period: Assume 38 weeks for construction - includes approx. 40 days excavation, 32 weeks bridge, 2 weeks rock revetment, 1 week clear and grub

Item	Unit of Measure	Qty	Description of Item	Indicate section of design report where item is described
ACQUISITION AND CONSERVATION			Based on available mapping information	
Required Project Lands	Acre	15	Total land required For action	19.3
Proponent / Partner-owned lands	Acre	NA	Etimate of lands currently owned by Proponent (i.e., Public lands)	
Lands To Be Acquired	Acre	NA	Estimate land required to be acquired for action prior to implementation	
Material Sites			Not Used: See Earthwork - Imported Fill.	
MOBILIZATION AND ACCESS for construction activities			Description required for each item to facilitate cost estimating	
Mobilization - Typical (Equipment, Personnel, Planning, Financial)	LS	1	Up front costs such as bonding, planning and other staff time and financing. Typically, assume 8% to 10% of other items.	19.3
Mobilization - Remote (Equipment, Personnel, Planning, Financial)	LS	NA	Up front cost for nontypical or remote locations. Assume 12% of other items	
Site Access	LS	NA	Use for special situations (e.g.. new bridge, new access roads) for the purposes of construction access. Include description.	
Barge Access	Days	NA	Not applicable to action	
Temporary Traffic Control (one of the following)			Includes installation of traffic signals, signage, signmen, etc. There are 4 types as follows	
none	LS	NA	None = no traffic control	
signs	LS	1	Typical Construction Signage (KPFF)	19.3
flags / spotters	LS	1	Flags and spottersonly during roadway transition connection (KPFF)	19.3
unique	LS	NA	Unique = Greater effort than flags / spotters. Describe as basis for cost estimate.	
Temporary Roadway	SF	NA	Includes construction of temporary adjacent roadway or bypass roadways and for vehicle and pedestrian travel through or around site.	
Control of Water	LS	NA	Use for special situations that require draining the site using pumps or water control structures, and bypassing water during construction. Can also be used for multi-year projects. Description required, including estimate duration.	
Relocation Activities			Not Used: See Utilities, Structures	
Site Demolition Activities			Demolition and removal of structures (description required), temporary features and relocations, itemized separately); Clearing and grubbing of vegetation, and removal of minor debris (rocks, slabs) - description required.	
Clearing and Grubbing (one or more of following)			Use one or more of the following categories of clearing and grubbing	
Clear Vegetation - Local Disposal	AC	NA	Vegetation removed above grade and disposed locally	
Clear /Grub Vegetation - Local Disposal	AC	5.8	Vegetation roots also removed and disposed locally. Assume entire width and length of channel	19.3
Clear /Grub Vegetation - Offsite Disposal	AC	NA	Vegetation is taken offsite and disposed - use for noxious invasives, etc.	
Clear, stockpile - large woody debris	CY	NA	Vegetation is segregated and stockpiled / prepared for reuse on site.	
Hydraulic Structures - Small	LS	NA	Removal of tide control and significant drainage structures that require excavation, cofferdam and or water control. Describe type of structure, elevation etc. For major structures (dam, diversion), use different line.	
Hydraulic Structures - Large	LS	NA	Dam removal (describe and state whether this item includes water control and sediment removal or these are in separate items)	
Utilities	LS or LF	NA		
Buildings	LS or SF	NA		
Pavement	LS or SF	22400	Removal of 28' Roadway (KPFF)	19.3
Bulkheads	LF or SF	NA	Use this for bulkheads…if large and difficult, consider using Large Coastal Structures.	
Rock revetments	LF, Ton or CY	NA		
Large Coastal Structures	CY	NA		
Excavate 250 LF Weir in Jetty	*CY*	NA		
Demolition / Removal - Bridge	SF or CY	NA	Use this item for structures that require cranes or other special removal staging	
Removal - Misc. (e.g. angular rock from beach)	Ton	NA	For loose rock scattered across intertidal.	
Demolition / Removal - Boat Ramp	SF	NA	This is a special item but happens at least once…others can also be added as needed.	
Haul - Offsite Disposal of Demolition Debris	Miles	10	Estimate distance (to nearest 10 miles) to disposal site for materials, veg clear and grub, etc.	19.3
Disposal of Jetty Materials	*Miles*	*10*	*Assume jetty material is transported less than 10 miles for reuse or disposal*	19.3
Hazardous/Contaminated Waste Removal			These items for earthwork of quality not compatible with wetlands, requiring special handling and disposal. Describe basis for classification as contaminated or hazardous. State known or suspected contamination, describe known similar work.	
Contaminated Earthwork	CY	NA	Excavation, off haul and disposal within a licensed landfill, complete	
Hazardous Earthwork	CY	NA	Excavation, off haul and disposal within a licensed hazardous waste landfill, complete	
Construct Temporary Features			Use as needed for unusual temporary features not included elsewhere (see TESC below)	
EARTHWORK			Expand to include equipment, etc. to facilitate cost estimating.	
Excavation	CY		Per yard excavation w/out expected haul	
Excavation - Upland	CY	NA	Conducive for transitional earthwork equipment, including scrapers, with high production and low cost.	
Excavation - Lowland	CY	38350	Excavation of Section B through (E) road. May be able to utilize higher production equipment	19.3
Dredging - Bucket - Land	CY	25200	Excavation of Section A through (E) marsh.	19.3
Dredging - Bucket - Marine	CY	NA	Floating or amphibious equipment with excavator, clamshell or dragline bucket	
Dredging - Hydraulic	CY	NA	Hydraulic cutter / suction dredge to slurry and pump sediments	
Fine Grading	AC	NA	Small tolerance grading after rough grading.	
Fill Placement - local borrow			This is additive to Earthwork -Excavation	
Side cast	CY	NA	Excavated material placed within reach of excavator / dredge - assume includes some shaping by bucket	
Haul - uncontrolled placement	CY	63550	Haul all excavated material approximately 20 miles	19.3
Haul, place, compact	CY	NA	Transportation and second handling - estimate distance, placement in lifts, moisture conditioning, compaction testing.	
Stockpile - uncontrolled placement	CY	NA	Intermediate step, for subsequent off haul or use elsewhere on site.	
Stockpile - controlled placement	CY	NA	intermediate step, for subsequent off haul or use elsewhere on site. Can use this for drying material for subsequent controlled compacted fill	
Conveyor placement from stockpile land/water	CY	NA	Some projects may require conveyor placement	
Imported Fill			Includes purchase, delivery and placement or as noted / described	
Select Fill	CY	2800	Bridge approaches - assume 6 ft elevation change over 300 LF, 30 ft top width, @:1 sideslopes	19.3
Gravel Borrow, including haul	CY	NA	WSDOT standard item	
Sand / Gravel for Beach Nourishment	CY	NA	special borrow and sorting required; identify material source	
Cobble for Shore Nourishment	CY	NA	special borrow and sorting required; identify material source	
Embankment Compaction	CY	2800	Bridge Approaches (2 each)	19.3
Topsoil	CY	NA		
RESTORATION Features				
Channel Rehab / Creation	LF	1300	New channel	19.3
Large Wood Placement	EA	NA	Per each log, Including drift logs, lower river log jams, etc	
Invasive Species Control	Acre	NA	Per acre control described in drawings and narrative	
Physical Exclusion Devices	LF or EA	NA	Human or wildlife exclusions including fences, barriers, mooring buoys, etc	
Other Restoration Features/ Activities	LS	NA	Describe other items not included elsewhere	
Structures	EA		KPFF to provide additional inputs	
Water Control Structures - Culverts with Gates	EA	NA	Describe type, number of openings (e.g. pipes), expected materials, dimensions	
Water Control Structures - Weirs	EA	NA	Describe, length, type, anticipated materials	
Rock Slope Protection	LF	1000	2 layers of 1-ton armor (7 CY/LF) over filter fabric (50 SF/LF) over bedding material (3 CY/LF)	19.3
RSP on North Bank	*LF*	*500*		19.3
RSP on South Bank	LF	*500*		19.3
Other	EA	NA	Describe	
Elevated Boat Ramp	SF	NA	Pile or pier supported to allow sediment drift	
Fencing	SF	NA	Describe, type, height etc.	
Utilities			Replacement or relocation. Designer to provide size and material and have separate line item for each run. Incidentals include earthwork, testing, hook up fees, etc. These quantities do not include demolition of existing utilities, real estate / easements, design fees. Describe the owner if known, and whether utility franchise will install (e.g., electric is typically installed by electrical franchise)	
Water	LF	NA		
Gas	LF	NA		
Electric	LF	NA		
Sewer	LF	NA		
Telecommunications	LF	NA		
Other	LF	NA	Others = whatever is required (e.g.. power towers, petroleum, jet fuel, etc.)	
Roadway / Railway			KPFF expected to participate in these estimates	
Roadway (Type)	SF	14840	Typical roadway 28' wide (KPFF)	19.3
Roadway - Traffic Signal	LS	NA	Street lights, etc. (Temporary traffic control handled under Temporary Facilities)	
Culvert (type)	LF	NA	Provide specific culver size and type	
Culvert - Jacking	LF	NA	Through railway	
Culvert - Horizontal Pile Driving	LF	NA	Through railway	
Bridge Deck	SF	8640	Precast Concrete Girder Bridge with 135' Spans (KPFF)	19.3
Bridge Foundation	LF	32	(1) 32' CIP Concrete pile caps w/ (2) 7' Dia Drilled Shafts 100' Embed At Each Pile Cap (KPFF)	19.3
Railway - Box Girder	SF	NA	Standard	
Railway - Foundation	LF	NA	Standard	
Railway - Shoe fly	LF	NA	Temporary alignment	
Permanent Access Features			KPFF expected to participate in these estimates	
Roads	Level	2%	Level 1 direct access, Level 2 moderately difficult, Level 3 difficult access (KPFF)	19.3
Utility Access Routes	varies	NA	Describe utility access feature, such as boardwalk or all-weather gravel road	
Erosion Control Features	AC	0.6	Stabilized Construction Entrances, Sediment Ponds, Hydro Seed to Stabilize Roadway Embankments (KPFF)	19.3
Public Access or Recreation Features			KPFF expected to participate in these estimates	
trails	SF	NA	Describe trail feature, such as gravel, mulch, asphalt concrete.	
bridges	SF	NA	Describe bridge feature, such as wooden pedestrian, or H20 vehicle.	
kiosk	EA	NA	Describe kiosk feature, such as size, material.	
restrooms	EA	NA	Describe restroom feature, such as size, material.	
Interpretive Signs	EA	NA	Include # interpretive signs based on number of local public access points	
parking area	SF	NA	Describe parking area, such as size, material.	
Other	EA	NA	Describe other recreational features (see Corps criteria, ER 1105-2-100 for compatibility with ecosystem objectives)	
Vegetation & Erosion Control				
Hydroseeding	AC	NA	Describe desired seed mix (e.g.. native plants cost more)	
Planting	AC	NA	Describe, provide breakdown on unit area basis.	
Vegetation Maintenance	AC-YR	NA	Includes irrigation, weeding, plant replacement for one year	

Partial Restoration Quantity Estimate

Action Name: McGlinn Island Causeway
Action #: 1092
Date: February 2011
By: L. White

REMEDY: ***Excavate channel through Dunlap Bay to connect water from the North Fork Skagit River to Swinomish Channel. Install bridge.***
Construction Period: Assume 38 weeks for construction - includes approx. 40 days excavation, 32 weeks bridge, 2 weeks rock revetment, 1 week clear and grub

	Item	Unit of Measure	Qty	Description of Item	Indicate section of design report where item is described
	Erosion / sediment BMPs - Temp.	AC	0.6	BMPs for control of drainage - describe. Assume compliance with Construction General NPDES included (KPFF)	19.3
	Erosion / sediment BMPs - Permanent	AC	NA	May want to separate slopes over 25% into separate category	
	Waterside controls - Temporary	EA, LF, LS	NA	Silt curtain or other water based temporary actions	
Construction Management					
	Construction oversight	weeks	38	Assume construction oversight occuring simultaneous to bridge and additional 6 weeks	19.3
	Constructino oversight - Bridge	weeks	32	*(8 mo) Quantity based on construction duration/# of construction seasons (KPFF)*	19.3
	Construction oversight - Additional/ concurrent	weeks	6	*Assume Construction oversight occuring simultaneous toBridge and additional 6 weeks*	19.3
	Materials testing	weeks		Included in cost of material - no separate quantity	
	Proponent in-kind Services	Man-Days		Describe services to be provided by Proponent during construction, such as site night security	
	Government Oversight	Man-Days		Describe length of construction period(s) for on-site inspection	
	Quality Control & Testing	L.S.		Describe types and quantities of required contractor QC.	
	Quality Assurance With Testing	L.S.		Describe types and quantities of government QA associated with QC.	
Design and Detailed Site Investigations					
	Survey & Property, Utility Research	LS		% of construction cost	
	35% Design	LS		35% x 25% x Engineer's Estimate	
	65% design	LS		65% x 25% x Engineer's Estimate less the cost for 35% PS&E	
	90% design	LS		35% x 25% x Engineer's Estimate less the cost for 35% + 65%PS&E	
	100% design	LS		25% x Engineer's Estimate less previous costs	
	Geotechnical Studies			Refer to design report for description of need	
	Cultural Studies			Refer to design report for description of need	
	HTWR Studies			Refer to design report for description of need	
Project Agreement Activities				Unable to provide credibale estimate at 10% design	
Site-Specific Adaptive Management Features & Activities				List if known	
Monitoring Activities				Assume 5 crew-days/year for each monitoring parameter in design report for 5 yrs	
	Monitoring (Type_)	crew-days	150		
Operations & Maintenance				Unable to provide credible estimate at 10% design	

20. MILLTOWN ISLAND (#1091)

Local Proponent	Skagit River Systems Cooperative
Delta Process Unit	Delta SKG
Shoreline Process Unit(s)	NA
Strategy(ies)	1 – River Delta
Restoration Objectives	Remove perimeter and cross dikes to restore higher density distributary channel formation and associated processes that link tidal marsh habitats to adjacent South Fork Skagit River sloughs

20.1 Description of the Action

This action would breach additional sections of Milltown Island perimeter dikes and create supplemental marsh pilot channels to restore combined tidal/freshwater (low salinity) hydrology to the island's interior marsh area habitats. The restored tidal and riverine processes will form, scour, and expand the dike breaches and marsh channels within the island's former agricultural areas. The full gradient of habitats across the island would be restored, particularly the scrub-shrub wetland habitat that was eradicated by past agricultural uses. Please see the Introduction chapter for important information regarding PSNERP and for context related to this restoration project.

20.2 Action Area Description and Context

Milltown Island, located along the east periphery of the South Fork Skagit River Delta within the Whidbey Subbasin, is part of WDFW's 17,000-acre Skagit Wildlife Area. The island is not accessible by road. The middle and north sections of Milltown Island (the portions with current and historic dikes) total about 216 acres. Of that total, the marsh area totals approximately 173 acres (the remaining area is higher elevation forested habitat at the north end of the island). This area historically had agricultural use after construction of perimeter dikes, a central cross dike, and drainage channels. The southerly portion of Milltown Island, consisting of approximately 100 acres of tidal marsh, has not been previously diked, and is considered the reference site for targeted marsh channel density to be achieved through full restoration. The action area is shown in Figure 20-1.

Figure 20-1. Action Area and Vicinity

20.2.1 Historic Condition

Review of historic topographic sheet (T-sheet) documentation and other historic mapping and aerial photographs suggests that the diked portions of Milltown Island were in agricultural use dating back to at least the late 1800s. Historical maps are provided in Figures 20-2A and 20-2B. Prior records of the pre-diked conditions showing historic channel networks and vegetation distribution across the island have not been located at this time. There is evidence that the northern (currently forested) portion of the island had a cross-island distributary channel providing connectivity between the two perimeter sloughs (Google Earth 2010). However, no direct evidence has been found of further distributary channels that extended across the island prior to agricultural use. The blind tidal channel density in the north diked area, consisting of five tidal channels totaling 5.3 acres of habitat area (pre-2005), is much lower than expected in comparison with the south Milltown Island reference site, which supports 10 tidal channels with 3.9 acres of habitat area (SRSC and WDFW 2005). The north end island dike was damaged (understood to be partially breached) by flooding in the 1970s and was never repaired (Hinton 2010). Dredging of Tom Moore Slough occurred in the past to facilitate log rafting, with spoils apparently placed along the east perimeter dike, which is reported to be significantly higher than other dikes on the west side (Hinton 2010). The site was acquired by WDFW after farming was deemed impractical in this area.

20.2.2 Natural Environment

The Milltown Island site is defined by two major distributary river channels—Steamboat Slough to the west and Tom Moore Slough to the east. The predominant flow is reported to occur in the Steamboat Slough channel (Hinton 2010). Tom Moore Slough is comparatively narrower and shallower, although channel widths are still appreciable (approximately 90 feet minimum). The north, upstream end of the island contains a significant stand of forested wetland habitat subject to riverine flooding; it is dominated by red alder with occasional black cottonwood and Sitka spruce. The south, downstream end of the island consists of emergent marsh with an extensive tidal channel network and was never diked. In the central portion of the island, vegetation has lain fallow since the cessation of agricultural practices. These diked portions of Milltown Island are understood to have been scrub-shrub wetland historically, but are currently dominated by emergent reed canarygrass and cattail marsh growing in relatively monotypic stands. The dikes themselves support deciduous trees (red alder typical) in riparian corridors along the adjacent sloughs. Localized communities of emergent sedges, bulrush, willow, and small alder are also evident near recently restored blind dendrite channel connections to Steamboat Slough (Anchor QEA 2010). An active beaver population is reported to exist in the east island interior within willow scrub-shrub habitat north and south of the mid-island cross dike (Hinton 2010).

Sediment characteristics are not fully known, but based on available soils mapping and site observations, surficial soils are expected to consist primarily of sands and silts. The predominant surficial soil type on Milltown Island (diked portion) is classified as Tacoma silt loam (NRCS 2009). Normal tidal fluctuation ranges from -1.90 feet MLLW to +9.15 feet MHHW NAVD 88 (NOAA 2010), compared to interior marsh elevations that typically range between approximately 5 to 8 feet NAVD 88. Although typically obscured by vegetative cover, perimeter and cross dike top elevations (except where breached) are estimated to range from approximately 10 to 13 feet NAVD 88. Tidal influence in recently created marsh channels occurs at lower levels (estimated to range down to about elevation 0 to 3 feet NAVD 88) as controlled by the dike breach elevations.

Targeted dike breaching and marsh channel development on the island have been in progress since 2005. The proponent designed and implemented process-based restoration on Milltown Island in partnership with WDFW from 2005 to 2007, removing and lowering selected segments of perimeter dike along Steamboat Slough totaling approximately 1,380 feet using explosives blasting techniques (Hinton 2010). Two sections of the mid-island cross dike were also partially removed as part of this work, and localized dendrite blind channels, totaling approximately 3,420 feet, were created in selected estuarine marsh habitats using similar techniques. Documentation of this work was provided to Anchor QEA by the proponent in the form of GIS shape files (SRSC 2010). Some reed canarygrass suppression with native species (sedges, rushes, and alder) has also occurred in and near the created channels. More work has been done in the northern portion of the diked area than in the southern portion, although more existing marsh channels are present in the southern section. Restoration efforts prior to 2005 were minimal, consisting of five ad hoc dike breaches in 2000 by Navy SEALS (Hinton 2010).

20.2.3 Human Environment

Aside from construction of the perimeter and cross dikes and historic agricultural activities, Milltown Island has had little anthropogenic activity over the past century. Having no road access to the island has enabled that condition. Interior to the dikes is a borrow ditch that was likely used as a source of material to construct perimeter dikes. Other linear excavated drainage channels were likely installed to provide adequate interior drainage for past agricultural practices. WDFW currently owns all of the properties comprising Milltown Island (Hinton 2010). There is a residence on the southwest edge of the island, along Steamboat Slough and outside of the action area. No known structures, utility corridors, or other infrastructure exist across the island. A boat launch is located on the east side of Tom Moore Slough adjacent to the island and accessible from State Route 530 (Pioneer Highway), which runs along the adjacent shore to the east. Milltown Island is not actively managed for waterfowl habitat, as is the adjacent Deepwater (Erickson) Island to the west across Steamboat Slough.

20.3 Restoration Design Concept

20.3.1 Restoration Overview and Key Design Assumptions

Anthropogenic dikes are key stressors that inhibit the free flow of tidal and fluvial waters across the middle and north sections of Milltown Island. They impact the natural geomorphic processes that would otherwise create and maintain nearshore habitat. Full removal of these dikes would be intrusive and would remove large areas of functional slough bank riparian habitat. Partial removal of strategically located and adequate lengths of existing dikes (beyond those sections already removed) is anticipated to have significantly less negative effect on riparian habitats and provide substantial benefits for restoring tidal channel area. The restoration alternatives are illustrated in Figures 20-3 through 20-5.

A key metric of the Skagit Chinook Recovery Plan (SRSC and WDFW 2005) to be achieved through removal of existing stressors is marsh channel area in proportion to restored marsh area. The marsh channel area density is targeted to be comparable to the south (undiked) Milltown Island reference site. The proponent has achieved as much as 50% of that restoration objective already through completion of dike breaches and creation of marsh pilot channels since 2000, and more extensively since 2005 (Hinton 2010). Past dike breaches were implemented successfully using controlled blasting. These breaches and related pilot channels are referenced as “existing” on the full and partial restoration figures.

Full restoration will meet the Skagit Chinook Recovery Plan metric and the PSNERP process-based restoration objectives by:

- Removing additional sections of perimeter dike, which is a primary stressor under existing conditions (Figure 20-3).
- Creating a higher density of active marsh channel habitats through excavation, resulting in improved perimeter slough connectivity.
- Improving connectivity of perimeter sloughs to interior marsh channels and water bodies and associated landscape habitats, which will facilitate habitat

adjustments through renewed processes including freshwater input, tidal flow and channel formation/maintenance, and erosion/accretion of sediments.

- Locally modifying topography within the marsh plain associated with marsh channel excavation/blasting and creation of hummocks, resulting in greater diversity in and functionality of created landscape habitats.

The primary objectives of restoring freshwater/tidal hydrology are to facilitate channel development to reference site densities, and to reestablish the pre-settlement gradient and diversity of habitat types across the island. In particular, this includes restoring scrub-shrub wetland community habitat in abandoned agriculture areas, and facilitating habitat forming processes including widespread beaver colonization. Beaver activity on the island is showing a strong connection to restoration of this habitat type (Hinton 2010). Due to the larger extent of new created marsh channel included with full restoration, a key design assumption is that dike breaches and pilot marsh channels in the full restoration alternative would be completed using barged-in, tracked, low-pressure excavating equipment.

The partial restoration alternative would differ from the full restoration alternative by limiting the extent of additional dike breaches to the west side of Milltown Island (Figure 20-4). This alternative focuses on blind dendrite marsh channel creation, primarily without added connectivity to existing interior marsh channels. For partial restoration, the resulting marsh channel area density will be lower, and may not fully achieve the Skagit Chinook Recovery Plan metric. This alternative will focus on the areas with a low density of existing or recently created marsh channels (north end of island, from Steamboat Slough) and where additional dike breaches are needed to increase the freshwater/tidal prism to the existing marsh channel network (south of cross dike, from Steamboat Slough).

For partial restoration, no dike breaching along Tom Moore Slough on the east side of the island would occur. Dike breaching on the east portion of the island is deemed more difficult due to the width and height of the dikes in that location. Under the partial restoration alternative, a key design assumption is that marsh channel creation at dike breaches would primarily be by natural processes, with irregular dike breaches and pilot channels assumed to be created through blasting, similar to construction techniques used for recent west side restoration actions.

For both the full and partial restoration alternatives, it is assumed that marsh channels will be created at approximately mid-tide level (elevation 4.5 feet NAVD 88), allowing natural erosion processes to deepen and widen channels with added freshwater/tidal prism exchange at dike breaches (Figure 20-5).

Dike breaches and marsh channel construction for this action are not intended or assumed to fully connect the entire intertidal area. It is assumed that once adequate dike removal occurs and more extensive pilot channels are constructed through marsh vegetation communities, the natural geomorphic processes of erosion, sediment transport, and deposition will further restore targeted habitats and habitat complexity.

Existing linear drainage channels are assumed to remain open for both the full and partial restoration alternatives because they maximize marsh channel habitat area and connectivity (in the full restoration alternative), thus also minimizing fish stranding potential. Those channels would be difficult to effectively fill due to limited site access for construction equipment, in particular, equipment for hauling large volumes of soils around the action area. Construction of temporary access roads across the marsh to transport excavated materials was assumed to be undesirable and too disruptive to existing habitats. Alternatively, use of excavated or blasted marsh channel soils to form irregular hummocks along the created channels was assumed to provide more benefit through improved landscape habitat diversity (Beamer 2010).

The key design elements associated with the full and partial restoration alternatives are shown in Table 20-1.

Table 20-1. Key Design Elements

Element	Full Restoration Alternative	Partial Restoration Alternative
West Perimeter Dike Breaches	Remove dike sections at three additional locations with connectivity to Steamboat Slough	Same as full restoration, except that controlled blasting would be used instead of excavation
East Perimeter Dike Breaches	Remove dike sections at two additional locations with connectivity to Tom Moore Slough	Not included
Channel Creation	Create more extensive network of pilot marsh channels connected to existing and prior created marsh channels through excavation; three additional connectivity points on Steamboat Slough west side and two additional connectivity points on Tom Moore Slough east side Create 9,500 LF and 2.6 acres of marsh pilot channels (assuming channels develop as expected, target channel density would increase to 95% of reference site density) Plant periphery and raised areas with native vegetation	Create additional blind dendrite pilot channels focused on new dike breaches on west side of island through blasting; three additional connectivity points on Steamboat Slough west side Create 2,500 LF and 0.7 acre of marsh pilot channels (assuming channels develop as expected, target channel density would increase to 60% of reference site density)
Excavated/Blasted Soils	Place excavated soils from dike breaches and marsh plain pilot channel construction onsite as uniformly as possible along fringes of marsh and excavated channels to support scrub-shrub habitat development	Blast dike breaches and marsh plain pilot channels using buried explosives, with blasted soils more uniformly distributed on adjacent marsh plain (not manipulated)

20.3.2 Restoration Features – Primary Process-Based Management Measures

Armor Removal/Modification - NA

Berm or Dike Removal/Modification

Selected removal/breaching of existing perimeter dikes is proposed for both the full and partial restoration alternatives at targeted locations where historic connectivity may have existed along the west and east perimeter of Milltown Island. The primary goals of implementing this management measure are to improve freshwater and tidal prism exchange with the island marsh plain, and increase hydraulic and habitat connectivity of the perimeter South Fork Skagit River sloughs to interior marsh channels (existing and created). The proposed lengths of dike breaches are shown on Figures 20-3 and 20-4, with assumed breach geometry and sizes shown on Figure 20-5.

Computed areas and estimated quantities (volumes) of earthwork to achieve targeted perimeter dike removals/modifications are included in later sections of this report. In general, dike breaches are proposed to range from 200 to 400 feet in length, with a cumulative length for the full restoration alternative of 1,200 feet, and they would extend down in elevation to the adjacent marsh plain. A smaller pilot channel (averaging 12 feet in top width and 3 feet in depth) would be cut through the lower section of the dike breach (below the marsh level), and would be connected to the marsh channels (Figures 20-3 and 20-4). The total dike breach length under the partial restoration alternative is limited to the Steamboat Slough side of the island and is a cumulative length of 600 feet.

Selected dike removal/breaching will support blind channel development to Milltown Island marsh habitat through enlarged riverine and tidal prism exchange with the adjacent Skagit River South Fork sloughs. The proposed dike breach geometries targeted to achieve that hydraulic modification are shown on Figure 20-5.

The larger restored riverine and tidal prism volume (expected to be roughly 460 acre-feet between the marsh and MHHW tidal elevations, averaging 2.65 feet in depth) would require an average flow of approximately 920 cfs to enter and exit the marsh area within a 6-hour (diurnal tide) exchange period. Using an assumed average velocity of 1 foot per second (conservative, because velocities would be variable, but generally higher velocities are expected) and assuming 50% of the breach cross section area within that depth range is effective to flow over the 6-hour tidal flood and ebb conditions, approximately 1,840 SF of dike breach hydraulic area would then be required to exchange that tidal prism volume (between average marsh and MHHW tidal elevations). The required breach area using regression curves for the LaConner Swinomish Slough tide gage station in the *Applied Geomorphology Guidelines and Hierarchy of Openings* (Appendix C) is approximately 50% lower at approximately 900 SF, and the hydraulic geometries are predicted to be deeper and narrower than what is proposed for the multiple, shallower dike breaches. For the lower average depths from marsh plain to MHHW tidal elevation (plus added depth in marsh pilot channels), riverine and tidal exchange velocities are expected to be comparatively lower, and consequently more cross sectional area would be required, as provided by the estimated value above.

Under full restoration, the proposed dike breach effective length (1,000 feet of 1,200-foot total that fronts the marsh area) at the 2.65-foot average depth equates to a breach cross sectional area of 2,650 SF, thus exceeding the computed hydraulic cross section area need of 1,840 SF. In addition, existing dike breaches (full extent and area unknown) are assumed to contribute significantly to tidal prism exchange. Similar calculations can be applied to the partial restoration alternative using the smaller number of dike breaches and resulting smaller cross section area, but uncertainties associated with blasting described below need to be considered.

Dike breach geometries are expected to self-adjust through erosive action, particularly in the excavated pilot channels, resulting in channel enlargement and deepening to geometries that are in equilibrium for the actual riverine and tidal prism exchange. For full restoration, there will be more certainty in initial hydraulic control at dike breaches due to those breaches being created by excavation to specified design drawing grades. Alternatively, for the partial restoration alternative with assumed use of explosives for irregular breaching of perimeter dikes, there will be reduced certainty in achieving and maintaining the targeted tidal prism exchange.

Channel Rehabilitation/Creation

Tidal marsh plain channel creation is proposed under both the full and partial restoration alternatives. As shown on Figure 20-3, the full restoration alternative would increase tidal channel density on the currently diked portion of Milltown Island to 13 channels (with perimeter slough connectivity) totaling approximately 36,000 feet and 9.9 acres (existing plus created channels, assuming a 12-foot average channel width), within a composite marsh area of approximately 173 acres (less north forested community), or approximately 0.057 channel acre per marsh acre. The full restoration alternative includes five new connectivity points to existing slough channels: three on Steamboat Slough and two on Tom Moore Slough.

The partial restoration alternative includes three new connectivity points to existing slough channels on Steamboat Slough. None are proposed on Tom Moore Slough. As shown on Figure 20-4, the partial restoration alternative would include 11 channels totaling approximately 29,100 feet and 8.0 acres (existing plus created channels, assuming a 12-foot average channel width) within the 173-acre marsh area, or approximately 0.046 channel acre per marsh acre. The total length of created marsh pilot channels in the full restoration alternative (9,500 feet and 2.6 acres) far exceeds the equivalent value under the partial restoration alternative (2,500 feet and 0.7 acre). Connectivity of created channels (13 locations total) to existing channels and previously created dendrite channels would be much greater under full restoration, with blind dendrite channels connections (four locations total) proposed under partial restoration.

Groin Removal/Modification - NA

Hydraulic Modification -NA

Overwater Structure Removal - NA

Topography Restoration

The full restoration alternative includes the placement of excavated materials in adjacent marsh areas, effectively creating small raised areas extending above the marsh plain. These raised areas are intended to be as uniformly graded as possible and support the colonization of scrub-shrub wetland vegetation. Use of excavation spoils is an effective method of initiating conditions that support this habitat type (Beamer 2010) while also providing opportunities for onsite soil reuse. An added benefit relates to invasive species control, as the raised areas can effectively break up large lower elevation areas favored by reed canarygrass and cattails, allowing native scrub-shrub species to outcompete these invasive plants. For created channels, those raised areas would be placed alternately along both sides of the channel, resulting in gaps between them, allowing unconstrained interchange of flows between the created channels and marsh plain. The size of created raised areas is expected to be irregular, typically ranging up to approximately 2 feet in height and 15 feet in base width to achieve a materials balance with the volume of excavated material.

For blasted dike and channel sections as assumed for partial restoration, material will be dispersed over the marsh plain in a random manner, and will not be adjusted because no use of excavation equipment is proposed for that alternative.

20.3.3 Restoration Features – Additional Management Measures

Beach Nourishment - NA

Contaminant Removal/Remediation - NA

Debris Removal - NA

Invasive Species Control

Invasive species are known to be present within the diked sections of Milltown Island, on the fallow, previously agricultural lands. Reed canarygrass and cattails on the marsh plain form dense mats of vegetation that prevent colonization of other species and suppress the evolution of the emergent marsh to a scrub-shrub marsh. Prior restoration efforts associated with marsh channel creation (by use of explosives) since 2005 have relied primarily on natural processes to recolonize disturbed ground. The result has been a beneficial diversification of native species (emergent and scrub-shrub communities) in combination with these disruptions of the dense root mats of invasive species. This diversification is supported by the increased influx of tidally influenced (low salinity) waters at dike breaches, and the ability of native seed banks in the disturbed soils to outcompete invasive species (Hinton 2010). Although early in the restoration process, there is observed evidence of the success of this approach, but reed canarygrass and cattails are still present in undisturbed areas.

The presence of a significant beaver population along the east side of the island marsh area, where scrub-shrub willow habitats are present (Hinton 2010), also influences invasive species control through created beaver dam inundation. For full and partial restoration, it is expected that invasive species control will continue using similar natural processes, considering native seed banks combined with increased tidal prism exchange. In addition, the topographic restoration technique (mentioned above) of creating hummocks for scrub-shrub habitat development will also aid in invasive species control.

Large Wood Placement

Placement of large woody debris is generally not expected as part of this action, as long-term restoration will rely more on natural recruitment of existing trees along perimeter dikes. However, in defined areas of dike breaches associated with full restoration, where trees are typically present, excavation equipment can be used to remove trees within the breach limits and relocate that large woody debris to optimal locations such as on the adjacent marsh plain and in proposed marsh channels. For the blasting approaches to dike breaches associated with partial restoration, trees will be cut down and cut into smaller lengths prior to blasting. Vegetation dispersal resulting from that action would otherwise be random, as use of excavation equipment with this approach is not expected.

Physical Exclusion – NA

Pollution Control – NA

Revegetation

Use of limited supplemental native plantings to enhance natural revegetation is also assumed, but only for the created marsh channels periphery and raised areas in the full restoration alternative where it would be possible to use equipment to distribute plant materials. Planting densities and areas are assumed to be low and would be implemented by hand.

Reintroduction of Native Animals – NA

Substrate Modification – NA

Species Habitat Enhancement – NA

20.3.4 Restoration Features – Other

Because the area is owned and managed by WDFW, with process-based habitat restoration being the targeted objective, and with no land-based access to the island provided, no public or recreational use proposals or facilities are envisioned.

20.3.5 Land Requirements

Construction of this action will affect of 173 acres of recreational lands that were previously used for agriculture. The entire restoration area is currently owned and managed by WDFW as part of the Skagit Wildlife Area. Therefore, no land acquisition is required for this action area. No utilities are known to exist on Milltown Island that would require relocation (nor are they presumed to be present due to the lack of public access and use).

20.3.6 Design Considerations

Physical design considerations are primarily associated with the lack of access to the action area. Marsh plain elevations, soil conditions, and shallow groundwater elevations under tidal influence also affect design criteria. Because dike breaches have already occurred, it will be important to document the extent of tidal and groundwater level fluctuation that currently occurs. These considerations affect the restoration design approach in terms of how improvements can be constructed (see *Construction Considerations* below), as well as the extent of and certainty in hydraulic modification that can be achieved. The extent of perimeter dike removed would be limited to only that required to achieve a fully functional tidal prism exchange.

Another consideration is cultural resources that may be present through the action area. For the partial restoration alternative, the effects of blasting on existing species and chemical residuals potentially released as contaminants should also be evaluated in future design/permitting project phases.

Social, legal, and institutional design considerations are generally not present for this action area. Public use of the adjacent Deepwater (Erickson) Island for waterfowl hunting is seasonally provided by WDFW, but since no such access to Milltown Island has historically been provided, nor is envisioned, wildlife management for this purpose is not expected to be a design consideration.

20.3.7 Construction Considerations

There are significant constructability limitations for this action. Because no bridged road access exists to the island, barging of materials and equipment to the island is required. Barge access is expected to be primarily from Steamboat Slough, with more limited barge access from Tom Moore Slough. A low draft barge will be needed, and barge access timing may be limited to approximately mid-tide level and above. A temporary (Bailey) bridge crossing Tom Moore Slough may also be possible to provide equipment access and import/export of construction materials. However, given the required span (likely 120 feet minimum) and challenges/effects of installing and removing such a temporary bridge, construction access via barge has been assumed for purposes of 10% design. A recreational boat launch is located on the east side of Tom Moore Slough across from Milltown Island. This boat launch has good county road access.

For full restoration, it is assumed that a track hoe excavator (low-ground-pressure type) will be used to complete dike breaches, for marsh pilot channel excavations, to locally place excavated materials for hummock creation, to down and place any trees requiring removal as large woody debris in restored marsh areas, and to distribute supplemental plantings. Creation of construction access roads is not envisioned due to material import and disposal needs. It is assumed that excavator access will occur mainly along created marsh channel alignments, and will likely be limited to mid- to lower tide periods, and during summer months. For temporary equipment storage during higher tides, it was assumed that a series of small embankment fill pads (10 total are assumed) would be constructed along the created marsh channels using the excavated marsh channel material. Construction activities within the marsh area are envisioned to occur in the dry, prior to additional dike breaches, as equipment access likely will not be possible under full riverine and tidal prism exchange. Construction of the additional dike breaches is assumed to be made last from perimeter dikes by barging of equipment to those perimeter dike access points.

For partial restoration, it is assumed that explosives would be used to blast perimeter dike breaches and create marsh pilot channels, and that no excavation equipment would be used. This follows from the past construction techniques that have been used by the proponent in coordination with WDFW since work was initiated in 2000. Using explosives rather than an excavator to implement the breach will result in less certainty about the depth and width of the resulting opening. A key limitation with this approach is the extent of soils removal achieved through blasting as compared to excavation (especially at dike breaches). Construction using this approach is assumed for the more limited dike breaches and marsh channel lengths associated with partial restoration. It would not be practicable for construction of the more extensive targeted actions associated with full restoration.

20.4 Extent of Stressor Removal

Table 20-2 describes the amount of stressors to be removed with this action.

Table 20-2. Stressor Removal

Stressor	Full Restoration Alternative	Partial Restoration Alternative
Tidal Barrier (LF)	1,200	600
Fill (area)	30,000 square feet (0.69 ac)	15,000 square feet (0.34 acre)

20.5 Expected Evolution of the Action Area

After freshwater and tidal prism exchange is fully achieved, the dike breaches and marsh channels are expected to adjust in geometry/size. Habitat communities will evolve consistent with the site's landscape position within the larger Skagit River system processes. Geomorphic processes will undergo ongoing changes due to external basin-wide actions and tidal level changes (see *Risks Associated with Projected Sea Level Change* below). Under current conditions, a larger proportion of Skagit River flood flows are apparently adjusting from the South Fork to the North Fork channel. Although potentially cyclic, this type of external influence could effect changes in geomorphic processes restored to the action area.

Sea level change could also affect habitat communities. Emergent marsh and scrub-shrub communities could shift toward mudflat and deeper emergent marsh communities over time. Salinity changes may also influence development of plant communities. Another, more local effect could be changes in flow and sediment distribution in the action area perimeter sloughs associated with nearby restoration actions on Deepwater (Erickson) Island and in the Wiley Slough area.

Both the partial and full restoration alternative areas will likely respond in a similar fashion to these types of external influences through the assumed 50-year evolution period. However, the full restoration alternative is anticipated to have a more rapid developmental trajectory than the partial restoration alternative due to the larger tidal prism.

20.6 Uncertainties and Risks

Uncertainties and risks for this action area include following factors:

- External Skagit River system and delta geomorphic response changes.
- Ability to maintain a workable balance in the desired higher density of active marsh channels across the island while not excessively impacting existing riparian slough habitat (tree canopy) established on perimeter dikes targeted for removal.
- Effectiveness for freshwater/tidal prism exchange, considering the extent of existing and created marsh drainage channels.
- Ability to successfully reestablish scrub-shrub habitats using the limited approaches associated with dike removals, channel construction, and beaver colonization in areas where monotypic stands of emergent invasive species exist.
- Higher uncertainties of obtaining target tidal prism exchange at each dike breach location using controlled blasting compared with excavation.

20.6.1 Risks Associated with Projected Sea Level Change

Projected sea level change over the next 50 years ranges from 1.51 feet to -0.13 feet (Anchor QEA 2010). Table 20-3 compares potential risks associated with projected sea level changes based on professional judgment.

Table 20-3. Risks of Sea Level Change

	Projected Sea Level Change		
	High (46 cm)	**Intermediate (4 cm)**	**Low (-8 cm)**
Full Restoration Alternative	Upstream shift in emergent and scrub-shrub restored habitats across the middle and north sections of island Creation of more extensive mudflat habitat in the south section of Milltown Island Increased inundation by a larger tidal prism would lead to an increased rate of migration of tidal channels Increased salinity of freshwater dominated habitats and loss or reduction of forested riverine habitat on the north section of island Sea level change rate could outpace the rates of sedimentation, particularly if flow and sedimentation rates shift further to the North Fork Potential lowering of Chinook smolt production from Skagit Chinook Recovery Plan target	No appreciable change	No appreciable change
Partial Restoration Alternative	Similar to full restoration, except that sea level change would result in more extensive modification of island habitats from those to be achieved with the full restoration alternative	No appreciable change	No appreciable change

20.7 Potential Monitoring Opportunities

Monitoring is important for evaluating restoration success. A combination of field surveys and aerial photographs would be used to document biological and physical changes to the island. Monitoring data can be used to refine adaptive management and corrective actions, as needed. Some of the main monitoring needs and opportunities associated with this action are summarized in Table 20-4.

Table 20-4. Monitoring Needs and Opportunities

Monitoring Parameter	Key Performance Indicator	Note
Topographic Stability		
Sediment Accretion / Erosion		
Wood Accumulation		
Soil / Substrate Conditions		
Vegetation Establishment	X	Document establishment of scrub-shrub communities
Marsh Surface Evolution / Accretion	X	
Tidal Channel Cross-Section / Density	X	Assess if target densities are achieved
Water Quality (contaminants)		
Salinity		
Shellfish Production		
Extent of Invasive Species	X	Document changes in extent of invasive species
Animal Species Richness	X	
Fish (salmonid) Access/Use	X	
Forage Fish Production		
Wildlife Species Use		
Effectiveness of Exclusion Devices		

20.8 Information Needed for Subsequent Design

This conceptual design report represents an initial step in the restoration design sequence. The design concepts described above were developed based on readily available information without the level of site-specific survey and investigation that is necessary to support subsequent design and implementation. Substantial additional information will be required at the preliminary and later design stages to confirm the design assumptions, refine quantity estimates, address property and regulatory issues, obtain stakeholder support, and fill in data gaps. The extent to which this information is collected for preliminary design (or a later design stage) will depend upon the available budget, schedule and other factors. This section attempts to define the most essential information needs for this action. Refer to the Introduction chapter for additional information.

- Topographic/Bathymetric Survey – A more detailed survey of site features including existing island habitat types and limits would be useful for potential adjustment in dike removal lengths and locations to minimize adverse impacts. This work could yield improved mapping of existing marsh channels and their profile elevations, including those potentially existing channels (possibly obscured by marsh vegetation) along proposed newly created channel alignments; better mapping of slough edge habitats (along existing dikes) to be affected by dike breaches; and better information on slough bathymetry.

- Contractor Consultation – Consultation with marine contractor would help assess the practicability of barge transport of construction equipment and materials access.

- Geotechnical Studies – Geotechnical investigation and evaluation of shallow subsurface soils to be manipulated with restoration actions would help determine shallow groundwater elevation response to tidal effects. These studies would help to assess effects on the buried gas pipeline, verify slope stability of the proposed levee, and evaluate impacts to levees along Tom Moore slough.

- Hydrodynamic and Hydraulic Analysis – Additional hydraulic modeling may be needed to more precisely inform geomorphic evaluation under restored conditions including adjacent slough flow, water level, and sediment erosion, transport, and deposition characteristics. Prior hydrodynamic model analysis datasets and report findings may need further analysis in support of preliminary design. The specific approach/method of any future modeling will need to be determined. The need for a temporary tide station to obtain a more accurate depiction of tidal datums at the site will be evaluated during preliminary design.

- Hazardous Materials Assessment – If preliminary investigations suggest that hazardous material could be present in the action area, additional soil and sediment analysis related to utility and road relocation and demolition of buildings may be needed. The introductory chapter describes the Phase I site investigations that are occurring as part of this overall effort via a separate contract.

- Cultural Resources Investigation – Surveys for archaeological and historic resources may be required for this action area. This is particularly important for areas proposed for excavation or other ground disturbance.
- Sea Level Change Projection – Estimates of sea level change for the conceptual design were based on calculations provided by the Washington Department of Fish and Wildlife and the Corps of Engineers using guidance in Corps' Engineering Circular No. 1165-2-211. Projections for each project area will be refined using localized tide gauge data during later design stages.

- Other - Additional studies may include an evaluation of potential methods for breaching of the east dike (e.g., small breaches created with explosives; scalp top of dike to allow a more natural failure of the dike); evaluation effects of channel reactivation on logjams present in the head of the sloughs and along the left bank; and, further evaluation and refinement of the sizing of channels and breaches post-construction.

20.9 Quantity Estimates

The quantity spreadsheets for the full and partial restoration alternatives are provided in Exhibits 20-1 and 20-2.

20.10 References

Anchor QEA. 2010. Site observations during October 7, 2010 PSNERP field visit to Milltown Island.

Beamer. 2010. Personal communication with Eric Beamer on December 3, 2010, at the ESRP River Delta Workshop, Seattle, Washington.

Google Earth. 2010. Historic Topographic Maps Coverage, United States Geologic Survey (USGS), Topography, Mount Vernon, Washington Quadrangle. January 1911 Edition.

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NOAA (National Oceanic and Atmospheric Administration). 2010. Vertical Datum Transformation (Vdatum) software (v2.3.3); http://vdatum.noaa.gov/; November 2010.

NRCS (U.S. Department of Agriculture, Natural Resource Conservation Service). 2009. Web Soil Survey, Skagit County, Washington. Updated November 2009.

SRSC (Skagit River System Cooperative). 2010. GIS Shapefiles for Milltown Island including existing channels, prior dike breaches and removals, and created marsh channels. November 2010.

SRSC and WDFW (Skagit River System Cooperative and Washington Department of Fish and Wildlife). 2005. *Skagit Chinook Recovery Plan*. Chapter 11 and Appendix D.

0 1,300
Feet
0 400
Meters

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Historic Map (T-Sheet)
Action Name: Milltown Island
PSNERP ID #: 1091
Figure 20- 2A

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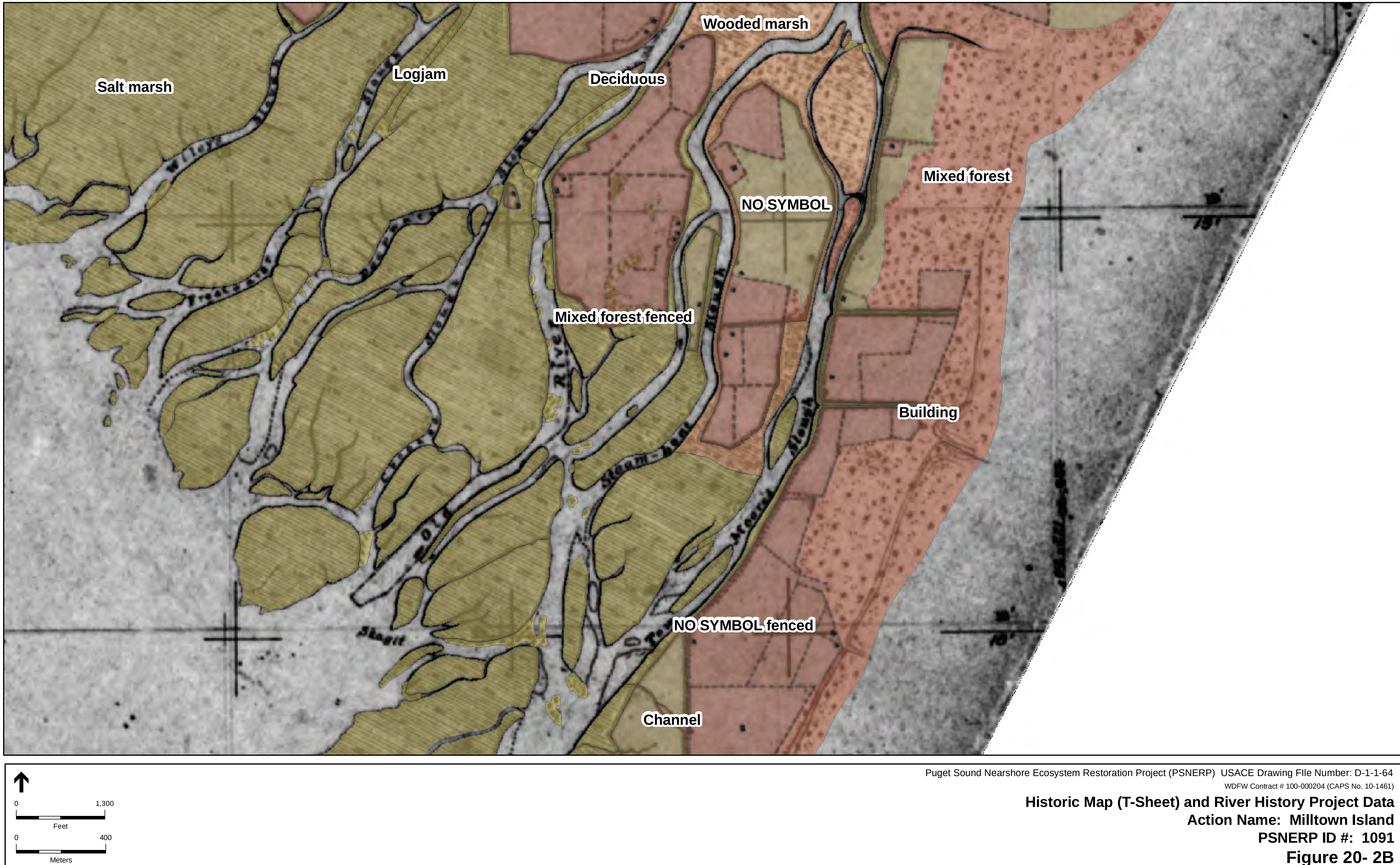

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64

WDFW Contract # 100-000204 (CAPS No. 10-1461)

Historic Map (T-Sheet) and River History Project Data

Action Name: Milltown Island

PSNERP ID #: 1091

Figure 20- 2B

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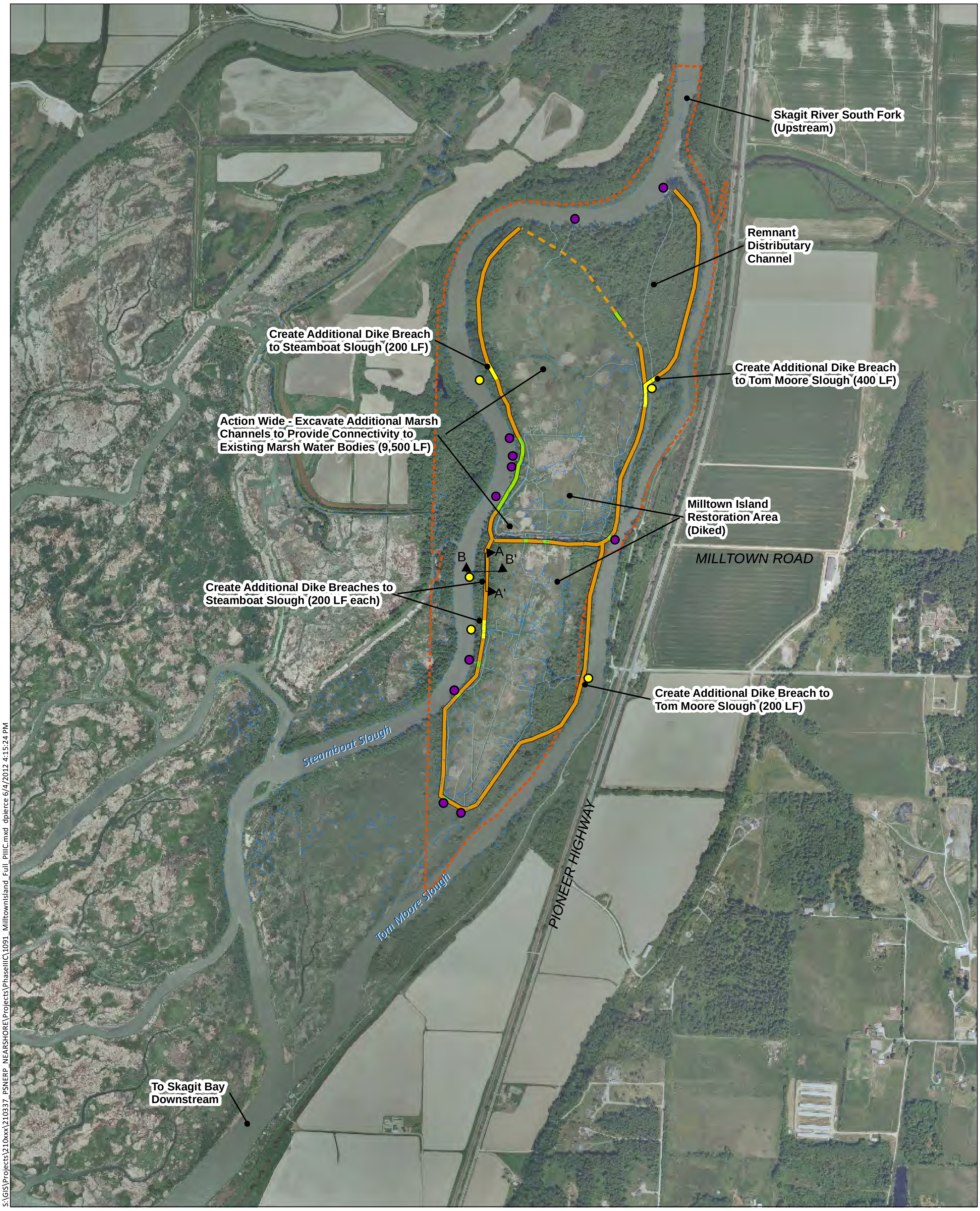

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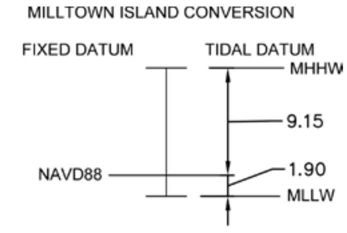
Legend

- Existing Connectivity
- Proposed Connectivity
- Existing Channel/Ditch
- Proposed Channel
- Existing Dike
- Existing Dike - Damaged
- Existing Dike Breach
- Proposed Dike Breach
- Proposed Tide MHHW
- Existing Tide MHHW
- Required Project Lands
- Section Line

MILLTOWN ISLAND CONVERSION



0.00 FT MHHW = 9.15 FT NAVD88
-9.15 FT MHHW = 0.00 FT NAVD88
0.00 FT MLLW = -1.90 FT NAVD88
1.90 FT MLLW = 0.00 FT NAVD88

Source:
VDATUM (LAT. 48.307571, LONG. -122.356783)

PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

North

0 500
Feet

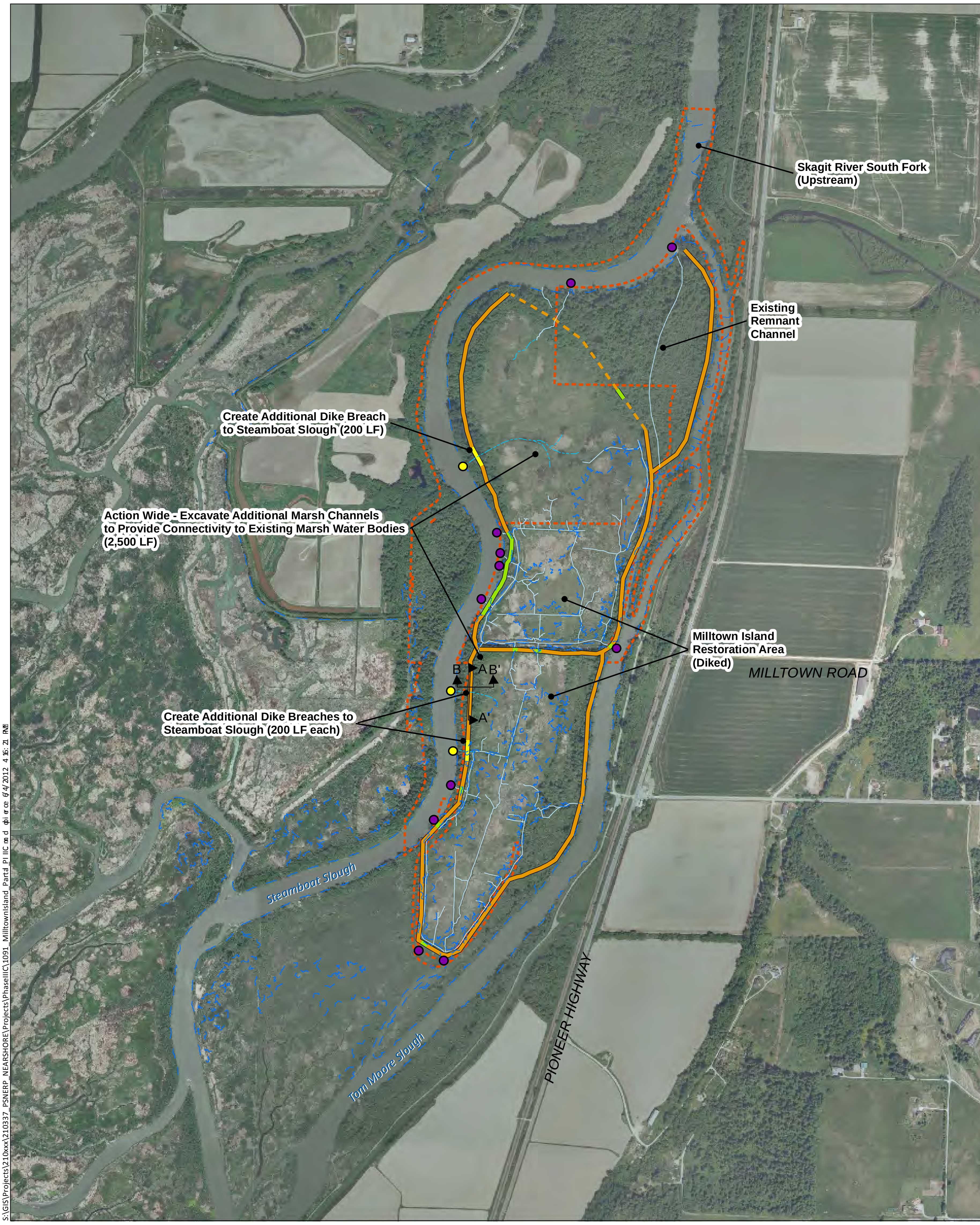
SOURCE: NAIP Orthoimagery (USDA, 2009); Action Area (PSNERP, 2010)

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP)   USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Plan
Site Name: Skagit River Delta
Action Name: Milltown Island
PSNERP ID #: 1091
Full Restoration

Lead Contractor: ESA
Design Lead: Anchor QEA, J. Bibee, P.E.
Date: 05/2012

Figure 20-3



Legend

- Existing Connectivity
- Proposed Connectivity
- Existing Tide MHHW
- Existing Channel/Ditch
- Proposed Channel
- Existing Dike
- Existing Dike - Damaged
- Existing Dike Breach
- Proposed Dike Breach
- Required Project Lands
- Section Line

MILLTOWN ISLAND CONVERSION

FIXED DATUM — TIDAL DATUM

MHHW
9.15
NAVD88
1.90
MLLW

0.00 FT MHHW = 9.15 FT NAVD88
-9.15 FT MHHW = 0.00 FT NAVD88
0.00 FT MLLW = -1.90 FT NAVD88
1.90 FT MLLW = 0.00 FT NAVD88

Source:
VDATUM (LAT. 48.307571, LONG. -122.356783)

North

0 500
Feet

PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

SOURCE: NAIP Orthoimagery (USDA, 2009);
Action Area (PSNERP, 2010)

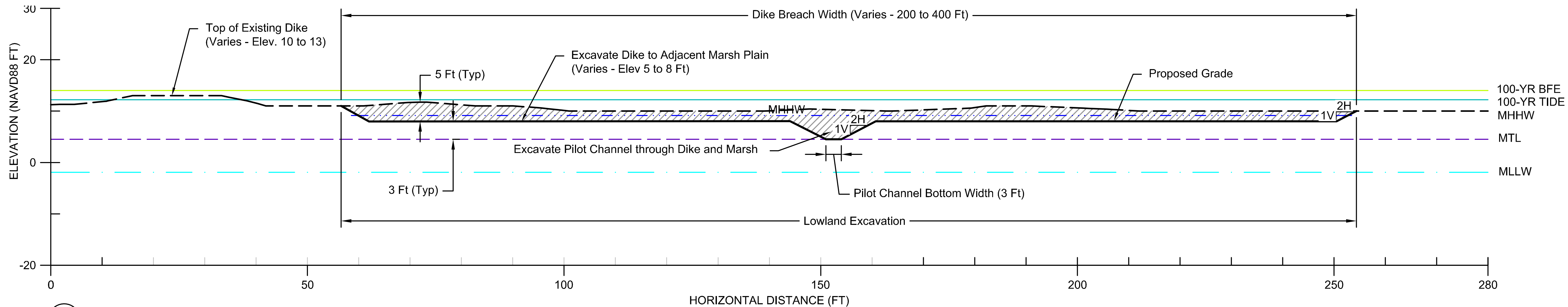
Puget Sound Nearshore Ecosystem Restoration Project (PSNERP)   USACE Drawing FIle Number: D-1-1-64

WDFW Contract # 100-000204 (CAPS No. 10-1461)

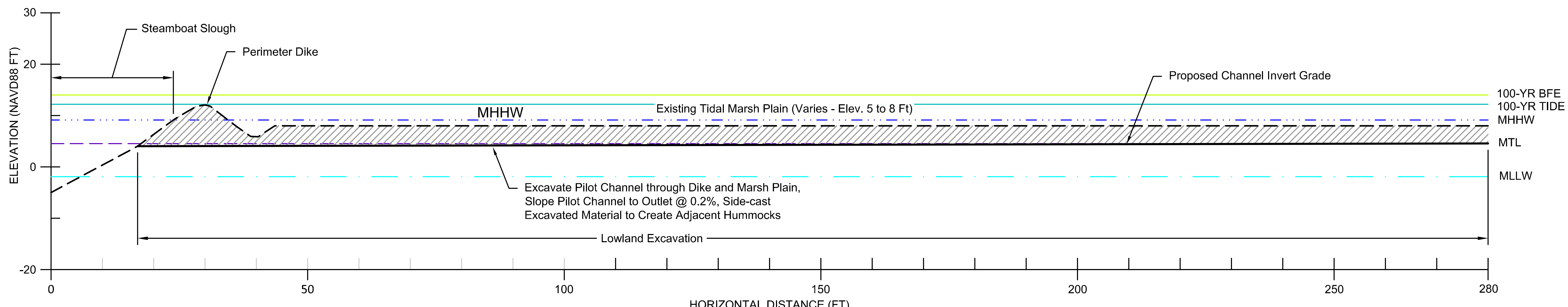
Conceptual Design Plan
Site Name: Skagit River Delta
Action Name: Milltown Island
PSNERP ID #: 1091
Partial Restoration

Lead Contractor: ESA
Design Lead: Anchor QEA, J. Bibee, P.E.
Date: 05/2012

Figure 20-4



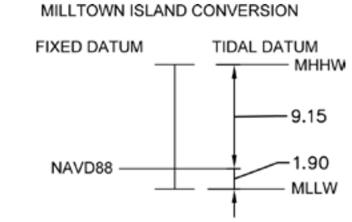
A DIKE BREACH AND MARSH CHANNEL SECTION, TYPICAL



B DIKE BREACH AND CREATED MARSH CHANNEL PROFILE, TYPICAL

EXISTING GRADE HATCH	PROPOSED GRADE HATCH
BEACH	CUT
OTHER	FILL
EXISTING GRADE	PROPOSED GRADE

MILLTOWN ISLAND CONVERSION



0.00 FT MHHW = 9.15 FT NAVD88
-9.15 FT MHHW = 0.00 FT NAVD88
0.00 FT MLLW = -1.90 FT NAVD88
1.90 FT MLLW = 0.00 FT NAVD88

Source:
VDATUM (LAT. 48.307571,
LONG. -122.356783)

0 20
Scale in Feet

PUGET SOUND
NEARSHORE
ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: Anchor QEA, J. Bibee, PE; with KPFF, P. Sloan, PE
Date: 05/2012

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Section
SITE NAME: **Skagit River Delta**
ACTION NAME: **Milltown Island**
PSNERP ID#: **1091**
Full Restoration / Partial Restoration

Figure 20-5

Full Restoration Quantity Estimate

Action Name: Milltown Island
Action #: 1091
Date: Revised July 2011 | Revised May 2012
By: Jerry Bibee, Anchor QEA

REMEDY: ***Full restoration - breaching 1,200 feet of perimeter dike to creation of 9.500 feet of new marsh channel with 11 points of outfall connection to perimeter slough channels; low-pressure tracked excavation equipment, no transport of materials; equipment/materials transported/staged from barge; other items: LWD placement, invasive species control, and limited revegetation***
Construction Period: 3 months (90 days) during the summer months

Item	Unit of Measure	Material Name	Qty	Description of Item	Indicate section of design report where item is described
ACQUISITION AND CONSERVATION				Based on available mapping information	
Required Project Lands	Acre		173	Total land required For action	1.3.5
Proponent / Partner-owned lands	Acre		316	Estimate of lands currently owned by Proponent (i.e., Public lands)	1.2
Lands To Be Acquired	Acre		0	Estimate land required to be acquired for action prior to implementation	1.3.5
Material Sites				Not Used: See Earthwork - Imported Fill.	
MOBILIZATION AND ACCESS for construction activities				Description required for each item to facilitate cost estimating	
Mobilization - Typical (Equipment, Personnel, Planning, Financial)	LS		NA		
Mobilization - Remote (Equipment, Personnel, Planning, Financial)	LS		1	Up front cost for nontypical or remote locations. Assume 12% of other items; Assume high mobilization for staging of equipment/materials by barge	1.3.7
Site Access	LS		NA		
Barge Access	Days		90	Describe need for barge access - Assume 1 barge needed for 3 months during summer construction season	1.3.6, 1.3.7
Temporary Traffic Control (one of the following)				Includes installation of traffic signals, signage, signmen, etc. There are 4 types as follows:	
none	LS		NA		
signs	LS		NA		
flags / spotters	LS		NA		
unique	LS		NA		
Temporary Roadway	SF		NA		
Control of Water	LS		1	Use for special situations that require draining the site using pumps or water control structures, and bypassing water during construction. Can also be used for multi-year projects. Description required, including estimate duration.	Not discussed - localized sump dewatering for dike breaches and channel excavations may be needed
Relocation Activities				Not Used: See Utilities, Structures	
Site Demolition Activities				Demolition and removal of structures (description required), temporary features and relocations, itemized separately); Clearing and grubbing of vegetation, and removal of minor debris (rocks, slabs) - description required.	
Clearing and Grubbing (one or more of following)				Use one or more of the following categories of clearing and grubbing	
Clear Vegetation - Local Disposal	AC		9.5	Vegetation removed above grade and disposed locally. Clearing/stripping of vegetation assumed for area of proposed perimeter dike breaches and marsh channel creation inclusive of sidecast hummock creation areas with sidecast disposal (40 ft width along created channel length)	1.3.2
Clear /Grub Vegetation - Local Disposal	AC		NA		
Clear /Grub Vegetation - Offsite Disposal	AC		NA		
Clear, stockpile - large woody debris	EA		48	Vegetation is segregated and stockpiled / prepared for reuse on site. Assume 48 trees with rootwads removed with dike breaches for placement in marsh restoration area (assumes 25 ft spacing along 1,200 ft dike breaches)	1.3.3
Hydraulic Structures - Small	LS		NA		
Hydraulic Structures - Large	LS		NA		
Utilities	LS or LF		NA		
Buildings	LS or SF		NA		
Pavement	LS or SF		NA		
Bulkheads	LF or SF		NA		
Rock revetments	LF, Ton or CY		NA		
Large Coastal Structures	LF, SF or CY		NA		
Demolition / Removal - Bridge	SF or CY		NA		
Removal - Misc. (e.g. angular rock from beach)	Ton		NA		
Demolition / Removal - Boat Ramp	SF		NA		
Haul - Offsite Disposal of Demolition Debris	Miles		NA		
Hazardous/Contaminated Waste Removal				These items for earthwork of quality not compatible with wetlands, requiring special handling and disposal. Describe basis for classification as contaminated or hazardous. State known or suspected contamination, describe known similar work.	
Contaminated Earthwork	CY		NA		
Hazardous Earthwork	CY		NA		
Construct Temporary Features	EA		10	Use as needed for unusual temporary features not included elsewhere (see TESC below); Construct elevated pads for excavation equipment placement during high tides; assume located every 1,000 ft along marsh channels; assume use of excavated native soils to create)	
EARTHWORK				Expand to include equipment, etc. to facilitate cost estimating.	
Excavation	CY		NA		
Excavation - Upland	CY		NA		
Excavation - Lowland	CY		11,040	Requires low ground pressure equipment and or mats; low production bucket methods, typically hydraulic excavator and front end loaders. Dike breach and marsh channel excavation quantities assume geometries per design report Figures (assumes average existing grades; dike breach quantity = 4,000 CY; marsh channel excavation quantity = 7,040 CY	1.3.2
Dredging - Bucket - Land	CY		NA		
Dredging - Bucket - Marine	CY		NA		
Dredging - Hydraulic	CY		NA		
Fine Grading	AC		NA		
Fill Placement - local borrow				This is additive to Earthwork -Excavation	
Side cast	CY		11,040	Excavated material placed within reach of excavator / dredge - assume includes some shaping by bucket; Assume sidecast of excavated material along sides of excavated marsh channels (for hummock creation and along marsh fringe at protected toe of perimeter dikes removed with breaching - minor shaping with bucket required	1.3.2
Haul - uncontrolled placement	CY		NA		
Haul, place, compact	CY		NA		
Stockpile - uncontrolled placement	CY		NA		
Stockpile - controlled placement	CY		NA		
Conveyor placement from stockpile land/water	CY		NA		
Imported Fill					
Select Fill	CY		NA		
Gravel Borrow, including haul	CY		NA		
Sand / Gravel for Beach Nourishment	CY		NA		
Cobble for Shore Nourishment	CY		NA		
Embankment Compaction	CY		NA		
Topsoil	CY		NA		
RESTORATION Features					
Channel Rehab / Creation	SF		123,500	Channel construction (SF) including imported sediment and habitat materials, excluding excavation; See excavation/fill above	1.3.3
Large Wood Placement	EA		48	Per each log, Including drift logs, lower river log jams, etc.; See Clearing above	1.3.3
Invasive Species Control	Acre		8.7	Per acre control described in drawings and narrative; Assumes 40 ft width control area along created marsh channel length of 9.500 ft (excavation plus sidecast hummock creation width; 20 feet each side of channel centerline)	1.3.3
Physical Exclusion Devices	LF or EA		NA		
Other Restoration Features/ Activities	LS		NA		
Structures	EA				
Water Control Structures - Culverts with Gates	EA		NA		
Water Control Structures - Weirs	EA		NA		
Rock Slope Protection	LF		NA		

Full Restoration Quantity Estimate

Action Name: Milltown Island
Action #: 1091
Date: Revised July 2011 | Revised May 2012
By: Jerry Bibee, Anchor QEA

REMEDY: ***Full restoration - breaching 1,200 feet of perimeter dike to creation of 9.500 feet of new marsh channel with 11 points of outfall connection to perimeter slough channels; low-pressure tracked excavation equipment, no transport of materials; equipment/materials transported/staged from barge; other items: LWD placement, invasive species control, and limited revegetation***
Construction Period: 3 months (90 days) during the summer months

	Item	Unit of Measure	Material Name	Qty	Description of Item	Indicate section of design report where item is described
	Other	EA		NA		
	Elevated Boat Ramp	SF		NA		
	Fencing	SF		NA		
Utilities					Replacement or relocation. Designer to provide size and material and have separate line item for each run. Incidentals include earthwork, testing, hook up fees, etc. These quantities do not include demolition of existing utilities, real estate / easements, design fees. Describe the owner if known, and whether utility franchise will install (e.g.. electric is typically installed by electrical franchise).	
	Water	LF		NA		
	Gas	LF		NA		
	Electric	LF		NA		
	Sewer	LF		NA		
	Telecommunications	LF		NA		
	Other	LF		NA		
Roadway / Railway						
	Roadway (Type)	SF		NA		
	Roadway - Traffic Signal	LS		NA		
	Culvert (type)	LF		NA		
	Culvert - Jacking	LF		NA		
	Culvert - Horizontal Pile Driving	LF		NA		
	Bridge - Foundations, Deck and Appurtenances	SF		NA		
				NA		
	Railway - Box Girder	SF		NA		
	Railway - Foundation	LF		NA		
	Railway - Shoe fly	LF		NA		
Permanent Access Features						
	Roads	Level		NA		
	Utility Access Routes	varies		NA		
	Erosion Control Features	L.F.		NA		
Public Access or Recreation Features						
	Trails	SF		NA		
	Bridges	SF		NA		
	Kiosk	EA		NA		
	Restrooms	EA		NA		
	Interpretive Signs	EA		NA		
	Parking Area	SF		NA		
	Other	EA		NA		
Vegetation & Erosion Control						
	Hydroseeding	AC		NA		
	Planting	AC		8.7	Describe, provide breakdown on unit area basis; Supplement natural recruitment with limited-scale native scrub-scrub planting along marsh channel - assume plantings at 10' oc	1.3.3
	Vegetation Maintenance	AC-YR		8.7	Includes irrigation, weeding, plant replacement for one year	Not described in text - irrigation not feasible
	Erosion / sediment BMPs - Temp.	AC		9.5	BMPs for control of drainage - describe. Assume compliance with Construction General NPDES	Not described in text - standard measures
	Erosion / sediment BMPs - Permanent	AC		NA		
	Waterside controls - Temporary	LF		1,200.0	Silt curtain or other water based temporary actions: along dike breach length	Not described in text - turbidity curtain along perimeter dike breach length to control sediment delivery from marsh work areas to perimeter sloughs
Construction Management						
	Construction oversight	weeks		12	Quantity based on construction duration/ # of construction seasons	Not described in text - limited oversight required
	Materials testing			NA		
Design and Detailed Site Investigations						
	Survey & Property, Utility Research	LS		1	% of construction cost	1.3.6, 1.8
	35% Design	LS		1	35% x 25% x Engineer's Estimate	1.3.6, 1.8
	65% design	LS		1	65% x 25% x Engineer's Estimate less the cost for 35% PS&E	1.3.6, 1.8
	90% design	LS		1	35% x 25% x Engineer's Estimate less the cost for 35% + 65%PS&E	1.3.6, 1.8
	100% design	LS		1	25% x Engineer's Estimate less previous costs	1.3.6, 1.8
	Geotechnical Studies			1	Refer to design report for description of need	1.3.6, 1.8
	Cultural Studies			1	Refer to design report for description of need	1.3.6, 1.8
	HTWR Studies					
Project Agreement Activities					Unable to provide credible estimate at 10% design	
Site-Specific Adaptive Management Features & Activities					List if known	
Monitoring Activities					Assume 5 crew-days/year for each monitoring parameter in design report for 5 yrs	
	All monitoring activities	crew-days		150		1.7
Operations & Maintenance					Unable to provide credible estimate at 10% design	

Partial Restoration Quantity Estimate

Action Name: Milltown Island
Action #: 1091
Date: Revised July 2011 Revised May 2012
By: Jerry Bibee, Anchor QEA

REMEDY: ***Partial restoration includes: breaching approximately 600 feet of perimeter dike, creation of approximately 2,500 feet of new interconnected marsh channel with 9 points of outfall connection to perimeter slough channels; use of blasting (AMFO) for excavation is assumed; equipment/materials transported/staged from barge; other items include: LWD placement, invasive species control, and limited revegetation***

Construction Period: 2 months (60 days) during the summer months

Item	Unit of Measure	Material Name	Qty	Description of Item	Indicate section of design report where item is described
ACQUISITION AND CONSERVATION				Based on available mapping information	
Required Project Lands	Acre		173	Total land required For action	1.3.5
Proponent / Partner-owned lands	Acre		316	Estimate of lands currently owned by Proponent (i.e., Public lands)	1.2
Lands To Be Acquired	Acre		0	Estimate land required to be acquired for action prior to implementation	1.3.5
Material Sites				Not Used: See Earthwork - Imported Fill.	
MOBILIZATION AND ACCESS for construction activities				Description required for each item to facilitate cost estimating	
Mobilization - Typical (Equipment, Personnel, Planning, Financial)	LS		NA		
Mobilization - Remote (Equipment, Personnel, Planning, Financial)	LS		1	Up front cost for nontypical or remote locations. Assume 12% of other items; Assume high mobilization for staging of equipment/materials by barge	1.3.7
Site Access	LS		NA		
Barge Access	Days		60	Describe need for barge access; assume 1 barge needed for 2 months during summer construction season for explosives transport for blasting operations	1.3.6, 1.3.7
Temporary Traffic Control (one of the following)				Includes installation of traffic signals, signage, signmen, etc. There are 4 types as follows:	
none	LS		NA		
signs	LS		NA		
flags / spotters	LS		NA		
unique	LS		NA		
Temporary Roadway	SF		NA		
Control of Water	LS		NA		Not discussed - for blasting approach, no localized dewatering needed
Relocation Activities				Not Used: See Utilities, Structures	
Site Demolition Activities				Demolition and removal of structures (description required), temporary features and relocations, itemized separately); Clearing and grubbing of vegetation, and removal of minor debris (rocks, slabs) - description required.	
Clearing and Grubbing (one or more of following)				Use one or more of the following categories of clearing and grubbing	
Clear Vegetation - Local Disposal	AC		1.1	Vegetation removed by hand above grade and disposed locally; Clearing/stripping of vegetation assumed for area of proposed perimeter dike breaches and marsh channel creation for blasting	1.3.2
Clear /Grub Vegetation - Local Disposal	AC		NA		
Clear /Grub Vegetation - Offsite Disposal	AC		NA		
Clear, stockpile - large woody debris	EA		24	Vegetation is segregated and stockpiled / prepared for reuse on site; Assume 24 trees with rootwads removed with dike breaches for placement in marsh restoration area (assumes 25 ft spacing along 60 ft dike breaches). As these will be placed by hand, cutting large logs may be necessary	1.3.3
Hydraulic Structures - Small	LS		NA		
Hydraulic Structures - Large	LS		NA		
Utilities	LS or LF		NA		
Buildings	LS or SF		NA		
Pavement	LS or SF		NA		
Bulkheads	LF or SF		NA		
Rock revetments	LF, Ton or CY		NA		
Large Coastal Structures	LF, SF or CY		NA		
Demolition / Removal - Bridge	SF or CY		NA		
Removal - Misc. (e.g. angular rock from beach)	Ton		NA		
Demolition / Removal - Boat Ramp	SF		NA		
Haul - Offsite Disposal of Demolition Debris	Miles		NA		
Hazardous/Contaminated Waste Removal				These items for earthwork of quality not compatible with wetlands, requiring special handling and disposal. Describe basis for classification as contaminated or hazardous. State known or suspected contamination, describe known similar work.	
Contaminated Earthwork	CY		NA		
Hazardous Earthwork	CY		NA		
Construct Temporary Features	EA			Use as needed for unusual temporary features not included elsewhere (see TESC below)	
EARTHWORK				Expand to include equipment, etc. to facilitate cost estimating.	
Excavation	CY		NA		
Excavation - Upland	CY		NA		
Excavation - Lowland	CY		NA		
Dredging - Bucket - Land	CY		NA		
Dredging - Bucket - Marine	CY		NA		
Dredging - Hydraulic	CY		NA		
Fine Grading	AC		NA		
Excavation - Blasting (AMFO) - Dike Breach	SF		16,800	Required blasting depth of 5 feet; Use of explosives for blasting consistent with prior dike breaching actions; estimated volume of soils to be displaced by blasting is 2,000 CY	1.3.2
Excavation - Blasting (AMFO) - Marsh Channels	SF		32,500	Required blasting depth of 2.5 feet typical; Use of explosives for blasting consistent with prior marsh channels creation actions; estimated volume of soils to be displaced by blasting is 1,850 CY	1.3.2
Fill Placement - local borrow				This is additive to Earthwork -Excavation	
Side cast	CY		NA		
Haul - uncontrolled placement	CY		NA		
Haul, place, compact	CY		NA		
Stockpile - uncontrolled placement	CY		NA		
Stockpile - controlled placement	CY		NA		
Conveyor placement from stockpile land/water	CY		NA		
Imported Fill					
Select Fill	CY		NA		
Gravel Borrow, including haul	CY		NA		
Sand / Gravel for Beach Nourishment	CY		NA		
Cobble for Shore Nourishment	CY		NA		
Embankment Compaction	CY		NA		
Topsoil	CY		NA		
RESTORATION Features					
Channel Rehab / Creation	SF		32,500	Channel construction (SF) including imported sediment and habitat materials, excluding excavation; see excavation by blasting above	1.3.3
Large Wood Placement	EA		24	Per each log, Including drift logs, lower river log jams, etc.; see Clearing above	1.3.3
Invasive Species Control	Acre		2.3	Per acre control described in drawings and narrative; Assumes 40 ft width control area along created marsh channel length (assumed primary blasting zone; 20 feet each side of channel centerline)	1.3.3
Physical Exclusion Devices	LF or EA		NA		
Other Restoration Features/ Activities	LS		NA		
Structures	EA				
Water Control Structures - Culverts with Gates	EA		NA		
Water Control Structures - Weirs	EA		NA		
Rock Slope Protection	LF		NA		
Other	EA		NA		
Elevated Boat Ramp	SF		NA		
Fencing	SF		NA		

Partial Restoration Quantity Estimate

Action Name: Milltown Island
Action #: 1091
Date: Revised July 2011 — Revised May 2012
By: Jerry Bibee, Anchor QEA

REMEDY: ***Partial restoration includes: breaching approximately 600 feet of perimeter dike, creation of approximately 2,500 feet of new interconnected marsh channel with 9 points of outfall connection to perimeter slough channels; use of blasting (AMFO) for excavation is assumed; equipment/materials transported/staged from barge; other items include: LWD placement, invasive species control, and limited revegetation***

Construction Period: 2 months (60 days) during the summer months

	Item	Unit of Measure	Material Name	Qty	Description of Item	Indicate section of design report where item is described
Utilities					Replacement or relocation. Designer to provide size and material and have separate line item for each run. Incidentals include earthwork, testing, hook up fees, etc. These quantities do not include demolition of existing utilities, real estate / easements, design fees. Describe the owner if known, and whether utility franchise will install (e.g.. electric is typically installed by electrical franchise).	
	Water	LF		NA		
	Gas	LF		NA		
	Electric	LF		NA		
	Sewer	LF		NA		
	Telecommunications	LF		NA		
	Other	LF		NA		
Roadway / Railway						
	Roadway (Type)	SF		NA		
	Roadway - Traffic Signal	LS		NA		
	Culvert (type)	LF		NA		
	Culvert - Jacking	LF		NA		
	Culvert - Horizontal Pile Driving	LF		NA		
	Bridge - Foundations, Deck and Appurtenances	SF		NA		
	Railway - Box Girder	SF		NA		
	Railway - Foundation	LF		NA		
	Railway - Shoe fly	LF		NA		
Permanent Access Features						
	Roads	Level		NA		
	Utility Access Routes	varies		NA		
	Erosion Control Features	L.F.		NA		
Public Access or Recreation Features						
	Trails	SF		NA		
	Bridges	SF		NA		
	Kiosk	EA		NA		
	Restrooms	EA		NA		
	Interpretive Signs	EA		NA		
	Parking Area	SF		NA		
	Other	EA		NA		
Vegetation & Erosion Control						
	Hydroseeding	AC		NA		Not described in text - hydroseed equipment access not feasible
	Planting	AC		2.3	Describe, provide breakdown on unit area basis; Supplement natural recruitment with limited-scale native scrub-scrub hand-planting along marsh channel - assume plantings at 10' oc	1.3.3
	Vegetation Maintenance	AC-YR		2.3	Includes irrigation, weeding, plant replacement for one year	Not described in text - irrigation not feasible
	Erosion / sediment BMPs - Temp.	AC		1.1	BMPs for control of drainage - describe. Assume compliance with Construction General NPDES	Not described in text - assume doesn't apply for blasting approach to excavation
	Erosion / sediment BMPs - Permanent	AC		NA	May want to separate slopes over 25% into separate category	
	Waterside controls - Temporary	LF		600		Not described in text - turbidity curtain along perimeter dike breach length to control sediment delivery from marsh work areas to perimeter sloughs
Construction Management						
	Construction oversight	weeks		8	Quantity based on construction duration/ # of construction seasons	Not described in text - limited oversight required
	Materials testing			NA		
Design and Detailed Site Investigations						
	Survey & Property, Utility Research	LS		1	% of construction cost	1.3.6, 1.8
	35% Design	LS		1	35% x 25% x Engineer's Estimate	1.3.6, 1.8
	65% design	LS		1	65% x 25% x Engineer's Estimate less the cost for 35% PS&E	1.3.6, 1.8
	90% design	LS		1	35% x 25% x Engineer's Estimate less the cost for 35% + 65%PS&E	1.3.6, 1.8
	100% design	LS		1	25% x Engineer's Estimate less previous costs	1.3.6, 1.8
	Geotechnical Studies			1	Refer to design report for description of need	1.3.6, 1.8
	Cultural Studies			1	Refer to design report for description of need	1.3.6, 1.8
	HTWR Studies					
Project Agreement Activities					Unable to provide credible estimate at 10% design	
Site-Specific Adaptive Management Features & Activities					List if known	
Monitoring Activities					Assume 5 crew-days/year for each monitoring parameter in design report for 5 yrs	
	All monitoring activities	crew-days		150		1.7
Operations & Maintenance					Unable to provide credible estimate at 10% design	

21. MISSION CREEK ESTUARY RECONNECTION (#1457)

Local Proponent	Port of Olympia
Delta Process Unit	NA
Shoreline Process Unit(s)	3041
Strategy(ies)	3 - Barrier Embayment
Restoration Objectives	Remove road fill and drainage structures to allow full tidal hydrology and sediment processes to operate within the Mission Creek Estuary

21.1 Description of the Action

The action for Mission Creek will be to remove a road embankment and related drainage structures to allow full tidal hydrology and sediment processes to operate within the Mission Creek Estuary. The existing road embankment has been abandoned, and can be fully removed with no replacement. This will restore a coastal embayment along the east side of Budd Inlet. Please see the Introduction chapter for important information regarding PSNERP and for context related to this restoration project.

21.2 Action Area Description and Context

The Mission Creek Estuary lies in the South Puget Sound Subbasin in Budd Inlet. The action area is within Priest Point Park, a 314-acre City of Olympia-managed park that includes approximately 1 mile of the Budd Inlet shoreline. Mission Creek drains a relatively small area (approximately 0.32 square mile) of the northern portion of the City of Olympia. The nearshore areas of Budd Inlet are heavily armored and modified with bulkheads, tidal culverts, and other developments, which have caused extensive loss of nearshore and estuarine habitat. The action area is shown in Figure 21-1.

Figure 21-1. Action Area and Vicinity

21.2.1 Historic Condition

Mission Creek once flowed unobstructed into Budd Inlet, as shown on the 1873 U.S. Coast Survey map of Budd Inlet. This area likely had a meandering channel through salt marsh in this small embayment. The historic shoreline appears to have been located about 150 feet landward of its current location. The construction of the road embankment and outlet control has resulted in the deposition of approximately 2 to 5 feet of soft silt sediments within the historical limits of the estuary (Coast and Harbor 2006). The historic maps show a road to Mission Creek and a building south of the creek, indicating that this location has long been an access point to the shoreline (Figures 21-2A and 21-2B). The relatively steep topography of the hillside to the east limited the extent of tidal hydrology in this location.

21.2.2 Natural Environment

The Mission Creek Estuary is directly south of the outlet of Ellis Creek. Net shore-drift in this area is south to north. The estuary is part of a long drift cell along the east side of Budd Inlet that extends to the Boston Harbor Lighthouse.

The contributing drainage area has been mapped as pre-Frazier continental glacial drift (WDNR 1:100,000 scale mapping). The Mission Creek valley is incised into these glacial sediments, resulting in a relatively narrow valley. The grade of the floodplain is flat behind the roadway embankment, but rises steeply east away from the shore, rising to 4 feet above MHHW within 200 feet of the road embankment.

The tide range for Budd Inlet has been well described as part of the hydrodynamic work performed by the Lacey-Olympia-Tumwater-Thurston (LOTT) Alliance. This work included bathymetric and velocity measurements to quantify tidal and freshwater dynamics within the inlet. This work found that the diurnal tide range is 14.4 feet, and the overall flushing time for Budd Inlet ranges from 8.4 days in January to 11.3 days in September.

Vegetation on the landward side of the road embankment is a mix of salt-tolerant marsh species and freshwater wetland species. This mix may reflect the ongoing degradation of the wooden weir that had been used to isolate the area from the tides. The crest elevation of the inlet is 10.5 feet (MLLW) and the culvert invert is at 8.5 feet (MLLW), based on the Coast and Harbor Engineering survey. The top of the weir is therefore 4 feet below MHHW.

21.2.3 Human Environment

The area surrounding Priest Point Park is predominantly residential, supported by a number of roads. The main arterial road in the area is East Bay Drive NE, which is a through-fill road through the Mission Creek valley. The road appears to be above the extent of historic intertidal area, but additional survey would be needed to confirm this.

The action area appears to have been used for agriculture in the past. Linear drainage ditches have been excavated through the old marsh, replacing the meandering channel planform. The road embankment is actively eroding on the shore side, exposing the mix of materials that were used to construct the embankment. The road surface is a thin veneer of asphalt.

21.3 Restoration Design Concept

21.3.1 Restoration Overview and Key Design Assumptions

The action at Mission Creek consists of earthwork to remove a road embankment and restore more natural channel alignments and morphology. In general, both restoration actions are consistent with previous plans developed for the site by Coast and Harbor Engineering in 2007. The restoration alternatives are illustrated in Figures 21-3 through 21-6.

The site behind the road embankment is currently at elevations below MHHW, so the area is expected to return to salt marsh habitat with no additional planting. There is one main difference between the full and partial restoration alternatives for this action, related to embankment fill, as shown in Table 21-1.

Table 21-1. Key Design Elements

Element	Full Restoration	Partial Restoration
Road Removal	Remove road fill and install 10H:1V slope Remove pavement	Remove fill and install sand and gravel to form barrier beach Remove pavement
Sediment Removal	Excavate surface sediments impounded behind road embankment to below MHHW	Excavate surface sediments impounded behind road embankment to below MHHW
Linear Ditches	Fill ditches with local borrow Excavate new sinuous channel alignment	Same as full restoration
Slope Protection	Install soft shore armoring to protect southern slope and adjacent residential properties	Install rock slope protection to protect southern slope and adjacent residential properties

21.3.2 Restoration Features – Primary Process-Based Management Measures

Armor Removal/Modification - NA

Berm or Dike Removal/Modification

The existing road embankment at the mouth of Mission Creek acts as a berm, preventing full tidal inundation of the estuary and lower reach of Mission Creek. Removing the road embankment will allow for full tidal inundation of the site, similar to the historical condition (Figures 21-3, 21-4, 21-5A and 21-6A).

It is likely that some type of slope protection will be required at the exposed slope on the south end of the proposed embankment removal. This location will be an exposed point with fetch to the northwest, so it will have potential for erosion, as evidenced by erosion of the existing road embankment. Soft shore armoring is proposed for the full restoration alternative, and rock slope protection is included for the partial restoration alternative. It is possible that some of the debris to be removed from the beach could be reused as slope protection (Coast and Harbor 2006).

Channel Rehabilitation/Creation

At its mouth, Mission Creek flows through a series of linear ditches and a 36-inch-diameter concrete culvert prior to entering Puget Sound. The ditches will be filled with local borrow from the roadway excavation, and a new channel will be excavated to mimic likely historical conditions (Figures 21-3, 21-4, 21-5B and 21-6B). The new channel will be allowed to self-adjust within the site over time. The action will restore natural channel morphology to the lower reach of Mission Creek and remove the restriction at the road embankment.

Groin Removal/Modification - NA

Hydraulic Modification

Removing the existing 36-inch-diameter culvert and failing weir will allow for full tidal inundation of the inlet. These features allow some level of muted tidal influence now that the weir has partially failed.

Overwater Structure Removal - NA

Topography Restoration

In both restoration alternatives, surface sediments will be removed from the area behind the road embankment. The removal is intended to reduce the potential for sedimentation on the beach, and accelerate the development of a salt marsh after the embankment is removed.

In the partial restoration alternative, sand and gravel will be placed on the outboard side of the excavated road embankment to create a barrier beach (Figures 21-4 and 21-6). This is intended to prevent an initial retreat of the marsh face, and partially compensate for the reduction in up-drift sediment supply resulting from shoreline armoring up-drift of the park. The barrier beach creation is intended as a one-time measure to provide more time for the marsh to develop and stabilize without having the tide wash over the entire site. This element was included in the partial restoration alternative as a strategy for mitigating the potentially rapid changes that would occur in the estuary once the road embankment is removed.

21.3.3 Restoration Features – Additional Management Measures

Beach Nourishment - NA

Contaminant Removal/Remediation - NA

Debris Removal

Concrete rubble will be removed from the beach adjacent to the existing road embankment (Figures 21-3 and 21-4). Some of this material may be reusable onsite to protect the slope on the southern edge of the action area.

Invasive Species Control

Invasive species on the site include reed canarygrass. The reintroduction of salt water to the site is expected to control this species in the intertidal area, but no direct control measures are proposed in either restoration alternative. Reed canarygrass, a non-native and invasive species, would continue to be dominant in areas above tidal influence.

Large Wood Placement - NA

Physical Exclusion - NA

Pollution Control - NA

Revegetation - NA

Reintroduction of Native Animals - NA

Substrate Modification - NA

Species Habitat Enhancement - NA

21.3.4 Restoration Features – Other

NA

21.3.5 Land Requirements

The Mission Creek action area is located within Priest Point Park and is in public ownership. No property would need to be acquired for the action, though a temporary construction easement across the property to the south of the park (accessed via Mission Drive NE) would allow for more flexibility during construction, especially when placing the southern rock slope protection.

21.3.6 Design Considerations

The primary design consideration for Mission Creek is the presence of residential properties directly south of the action area. Removing the berm would expose the southern slope to greater tidal inundation and wave action. Rock slope armor is proposed in this location to prevent erosion that may impact those properties (Figures 21-3 and 21-4).

21.3.7 Construction Considerations

The removal of the road at the mouth of Mission Creek will require an excavator and dump trucks to be mobilized to the site. A small, low-ground-pressure excavator would be necessary to complete the channel work in the existing wetland. Access to the site could occur via an existing paved, but currently unused, access road from the north. Minor clearing would be necessary to prepare the road for use, and traffic control would be necessary where the road meets East Bay Drive.

Channel excavation and pavement removal would occur prior to full removal of the berm. Rubble removal from the beach would also occur in a low tide cycle prior to berm removal. The existing culvert could be blocked and the stream temporarily bypassed to allow more flexibility for timing. Once the channel system is completed, the berm could be removed in one low tide cycle. The partial restoration alternative may require one additional low tide cycle to complete the placement of the sand and gravel barrier berm.

21.4 Extent of Stressor Removal

Table 21-2 describes the amount of stressors to be removed with this action.

Table 21-2. Stressor Removal

Stressor	Full Restoration	Partial Restoration
Tidal Barrier (LF)	140	140
Fill (SF)	14,000	14,000
Nearshore Roads (LF)	Road acts as tidal barrier, so it is counted above	Road acts as tidal barrier, so it is counted above

21.5 Expected Evolution of the Action Area

Once the tidal barrier is removed and channels restored on the site, a salt marsh is expected to re-form at the mouth of Mission Creek. This will include the formation and sorting of the transition zone from the freshwater stream through the salt marsh to the beach. Through the next 50 years, the vegetation community on the site is expected to transition to salt-tolerant native species. Some trees that have established along the perimeter of the diked site may not survive the greater salt concentrations.

The marsh to beach transition is expected to be dynamic, altered by storms and high tides. This transition would be left to natural processes in the full restoration alternative, and may include an initial retreat of the marsh front. In the partial restoration alternative, the placed barrier beach materials would be intended to avoid or minimize initial retreat and allow faster formation of the salt marsh. The perimeter of the site may retreat over time, if the placed material is exported from the site. No additional placement would be necessary over time at this location.

21.6 Uncertainties and Risks

The evolution of the vegetation community at the Mission Creek site is expected to take several years to decades, but a precise rate cannot be determined. The evolution of the beach to marsh transition is another uncertain aspect. The up-drift portion of the drift cell has been armored, which has reduced sediment supply to the action area and may accelerate erosion, precluding the development of historical conditions.

Rock slope armor has been proposed to protect the southern slope that would be exposed after berm removal. The armor would protect a residential structure and property directly adjacent to the action area. The slope protection would need to be monitored for effectiveness.

21.6.1 Risks Associated with Projected Sea Level Change

Table 21-3 compares potential risks associated with projected sea level changes based on professional judgment.

Table 21-3. Risks of Sea Level Change

	Projected Sea Level Change		
	High (65cm)	**Intermediate (21cm)**	**Low (13cm)**
Full Restoration	This scenario may drown the expected salt marsh in the lower (western) portion of the site and extend the beach further inland in this location.	This scenario also has the potential to alter the composition of the marsh, but with limited potential for significant change in areal extent of the marsh in this location (e.g., it may adjust inland, but in a limited lateral area).	Same as Intermediate, with lower potential.
Partial Restoration	This scenario may drown the expected salt marsh and accelerate erosion of the placed beach materials.	This scenario also has the potential to alter the composition of the marsh, but with limited potential for significant change in areal extent of the marsh in this location (e.g., it may adjust inland, but in a limited lateral area).	Same as Intermediate, with lower potential.

21.7 Potential Monitoring Opportunities

Monitoring is important for evaluating restoration success. A combination of field surveys and aerial photographs would be used to document biological and physical changes to the landscape. Monitoring data can be used to refine adaptive management and corrective actions, as needed. Some of the monitoring needs and opportunities associated with this action are summarized in Table 21-4.

Table 21-4. Monitoring Needs and Opportunities

Monitoring Parameter	Key Performance Indicator	Note
Topographic Stability	X	Monitor beach face and new channel
Sediment Accretion / Erosion	X	Assess beach face stability
Wood Accumulation		
Soil / Substrate Conditions		
Vegetation Establishment	X	Assess changes in native salt marsh species
Marsh Surface Evolution / Accretion		
Tidal Channel Cross-Section / Density	X	Monitor channel evolution
Water Quality (contaminants)		
Salinity		
Shellfish Production		
Extent of Invasive Species	X	Assess changes in dominance of reed canarygrass
Animal Species Richness		
Fish (salmonid) Access/Use		
Forage Fish Production		
Wildlife Species Use		
Effectiveness of Exclusion Devices		

21.8 Information Needed for Subsequent Design

This conceptual design report represents an initial step in the restoration design sequence. The design concepts described above were developed based on readily available information without the level of site-specific survey and investigation that is necessary to support subsequent design and implementation. Substantial additional information will be required at the preliminary and later design stages to confirm the design assumptions, refine quantity estimates, address property and regulatory issues, obtain stakeholder support, and fill in data gaps. The extent to which this information is collected for preliminary design (or a later design stage) will depend upon the available budget, schedule and other factors. This section attempts to define the most essential information needs for this action. Refer to the Introduction chapter for additional information.

- Property Investigation/Survey – More detailed information on parcel ownership, utility locations, and property boundary locations will be needed to finalize the design, confirm acquisition requirements, and support negotiations with property owners.
- Topographic/Bathymetric Survey –Restoration would require a topographic survey including slopes on the reference beach to the north. Survey data would also be used as a baseline for pre- and post-construction modeling.
- Geotechnical Investigation – Borings are needed to assess subsurface conditions in the area proposed for intertidal excavation in the southern wetland complex.
- Cultural Resources Investigation – Surveys for archaeological and historic resources may be required for this action area. This is particularly important in areas proposed for excavation.
- Contaminant Survey – If preliminary investigations suggest that hazardous material could be present in the action area, additional soil and sediment analysis may be needed. The introductory chapter describes the Phase I site investigations that are occurring as part of this overall effort via a separate contract.

21.9 Quantity Estimates

The quantity spreadsheets for the full and partial restoration alternatives are provided in Exhibits 21-1 and 21-2.

21.10 References

City of Olympia. 2007. *City of Olympia's Response to Climate Change, Volumes 1 and 2*. City of Olympia Washington, Public Works Department, Water Resources. September, 2007.

Coast and Harbor Engineering. 2006. *Priest Point Park Nearshore Restoration Feasibility Study*. Prepared for South Sound Salmon Enhancement Group.

0 200
Feet
0 60
Meters

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Historic Map (T-Sheet)
Action Name: Mission Creek Estuary Reconnection
PSNERP ID #: 1457
Figure 21- 2A

S:\GIS\Projects\210xxx\210337_PSNERP_NEARSHORE\Projects\2-TSheets_rev.mxd (DLP; 2/24/2011)

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64

WDFW Contract # 100-000204 (CAPS No. 10-1461)

Historic Map (T-Sheet) and River History Project Data
Action Name: Mission Creek Estuary Reconnection
PSNERP ID #: 1457
Figure 21- 2B

S:\GIS\Projects\210xxx\210337_PSNERP_NEARSHORE\Projects\2-TSheets_rev.mxd (DLP; 2/24/2011)

Path: \\esa_sf_2k\esa\GIS\GIS\Projects\210xxx\210337_PSNERP_NEARSHORE\Data\Working\ESA_actions\1457_mission_full_rev1.mxd (SW; 12/17/10)

SOURCE: PSNERP (2010); Aerials Express (2009)

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Lead Contractor: ESA
Design Lead: ESA
Date: 2/28/11

Conceptual Design Plan
Site Name: Budd Inlet
Action Name: Mission Creek Estuary Reconnection
PSNERP ID #1457
Full Restoration

Figure 21-3

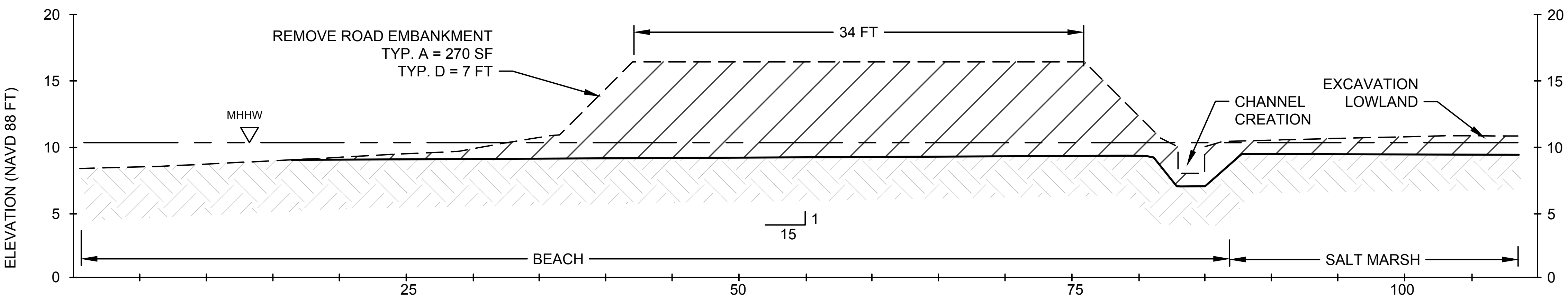
SOURCE: PSNERP (2010); Aerials Express (2009)

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

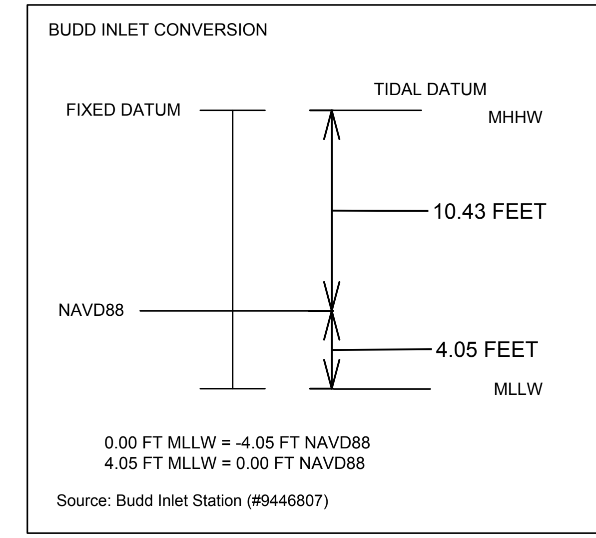
Conceptual Design Plan
Site Name: Budd Inlet
Action Name: Mission Creek Estuary Reconnection
PSNERP ID #1457
Partial Restoration

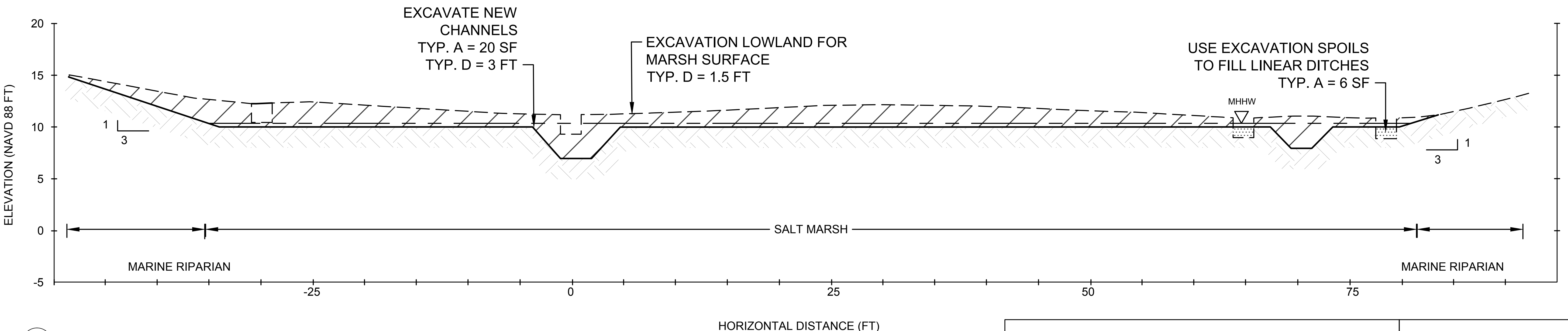
Lead Contractor: ESA
Design Lead: ESA
Date: 2/28/11

Figure 21-4

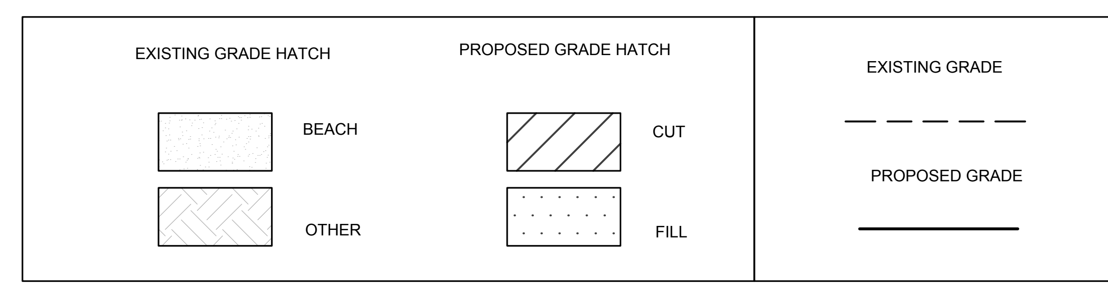


A ROAD REMOVAL (TYP.)





B NEW CHANNEL AND MARSH EXCAVATION (TYP.)



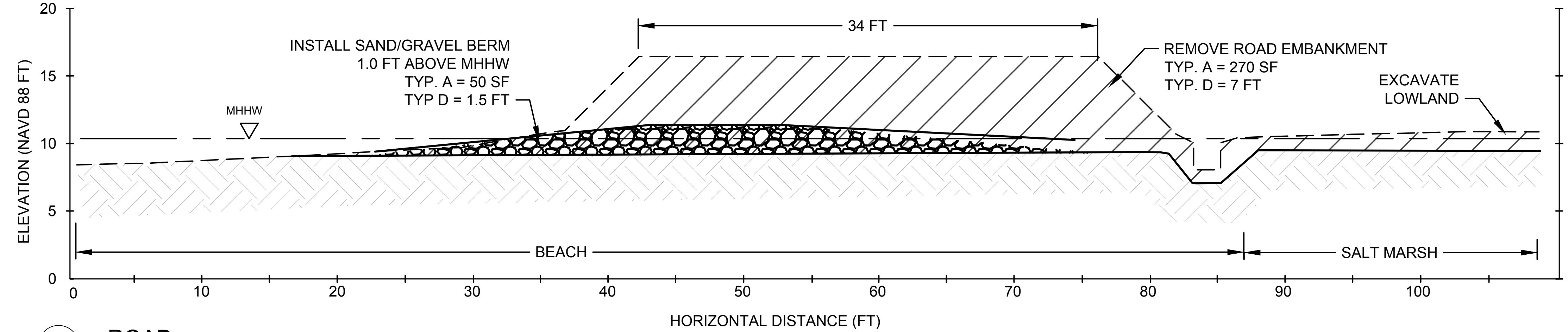
PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: ESA
Date: 3/2011

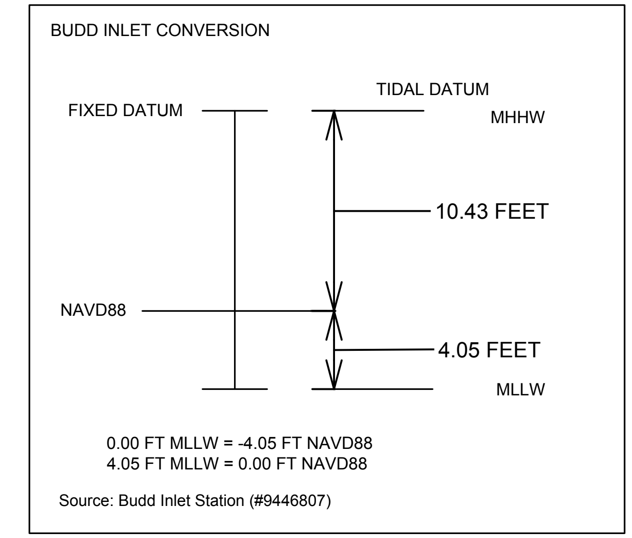
Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

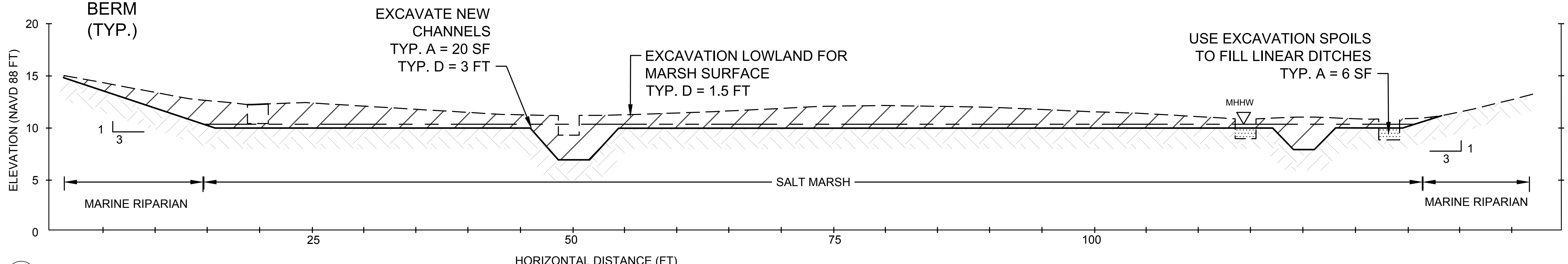
Conceptual Design Section
SITE NAME: **Budd Inlet**
ACTION NAME: **Mission Creek Estuary Reconnection**
PSNERP ID#: **1457**
Full Restoration

Figure 21-5

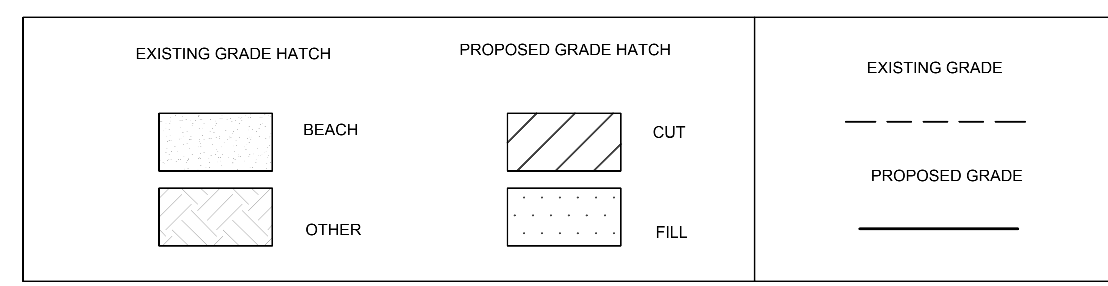


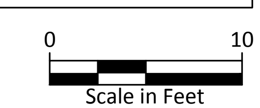
A ROAD REMOVAL WITH BEACH BERM (TYP.)





B NEW CHANNEL AND MARSH EXCAVATION (TYP.)





PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: ESA
Date: 3/2011

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Section
SITE NAME: **Budd Inlet**
ACTION NAME: **Mission Creek Estuary Reconnection**
PSNERP ID#: **1457**
Partial Restoration

Figure 21-6

Full Restoration Quantity Estimate

Action Name:	Mission Creek
Action #:	1456
Date:	February 2011
By:	ESA

REMEDY: ***Remove road embankment and restore natural channel morphology***

Construction Period: Four Weeks

Item	Unit of Measure	Material Name	Qty	Description of Item	Indicate section of design report where item is described
ACQUISITION AND CONSERVATION				Based on available mapping information	
Required Project Lands	Acre		5.7	Total land required For action	21.3.5
Proponent / Partner-owned lands	Acre		5.7	Etimate of lands currently owned by Proponent (i.e., Public lands)	21.3.5
Lands To Be Acquired	Acre		0	Estimate land required to be acquired for action prior to implementation	21.3.5
Material Sites				Not Used: See Earthwork - Imported Fill.	
MOBILIZATION AND ACCESS for construction activities				Description required for each item to facilitate cost estimating	
Mobilization - Typical (Equipment, Personnel, Planning, Financial)	LS		1	Assume 8% of total	
Mobilization - Remote (Equipment, Personnel, Planning, Financial)	LS		NA		
Site Access	LS		1	Minimal clearing needed to utilize existing paved access road from the north.	
Barge Access	Days		NA	Describe need for barge access	
Temporary Traffic Control (one of the following)				Includes installation of traffic signals, signage, signmen, etc. There are 4 types as follows:	
none	LS		NA	None = no traffic control	
signs	LS		1	Signs = signs only, costs typically around 1% of total roadway costs	
flags / spotters	LS		NA		
unique	LS		NA		
Temporary Roadway	SF		NA		
Control of Water	LS		1	May be necessary to block existing culvert to allow more flexibility in channel excavation behind the berm.	
Relocation Activities					
Site Demolition Activities					
Clearing and Grubbing (one or more of following)					
Clear Vegetation - Local Disposal	AC		NA		
Clear /Grub Vegetation - Local Disposal	AC		NA		
Clear /Grub Vegetation - Offsite Disposal	AC		NA		
Clear, stockpile - large woody debris	CY		NA		
Hydraulic Structures - Small	LS		1	Remove existing 36" culvert through road embankment and beach	
Hydraulic Structures - Large	LS		NA		
Utilities	LS or LF		NA		
Buildings	LS or SF		NA		
Pavement	SF		4800	Pavement removal from road embankment, measured in geodatabase. Pavement is very thin veneer.	
Pavement	SF		10,064	Pavement removal from access road, measured from geodatabase. Pavement isthin veneer.	
Bulkheads	LF or SF		NA		
Rock revetments	LF, Ton or CY		NA		
Large Coastal Structures	LF, SF or CY		NA		
Demolition / Removal - Bridge	SF or CY		NA		
Removal - Misc. (e.g. angular rock from beach)	Ton		260	Remove concrete rubble from beach. Assumed removal area was 50% rubble, and 1.5 tons/CY.	
Demolition / Removal - Boat Ramp	SF		NA		
Haul - Offsite Disposal of Demolition Debris	Miles		20	Assumed.	
Hazardous/Contaminated Waste Removal					
Contaminated Earthwork	CY		0		
Hazardous Earthwork	CY		0		
Construct Temporary Features					
EARTHWORK					
Excavation	CY				
Excavation - Upland	CY		NA		
Excavation - Lowland	CY		1400	Remove roadway embankment. Area and length reported in geodatabase, area shown on typical sections.	21.3.1
Excavation - Lowland	CY		240	Excavate new channel alignments. Will require smaller, low ground pressure, equipment. Length from geodatabase, xs on sections, developed from regional regressions.	21.3.1
Excavation - Lowland	CY		3300	Remove accumulated sediments. Will require smaller low ground pressure equipment. Volume developed using surface differencing in ACAD Civil 3D using LiDAR topography for existing.	21.3.1
Dredging - Bucket - Land	CY		NA		
Dredging - Bucket - Marine	CY		NA		
Dredging - Hydraulic	CY		NA		
Fine Grading	AC		NA		
Fill Placement - local borrow					
Side cast	CY		130	Use excavation, lowland spoils from channel excavation to fill ditches. Length from geodatabase, area estimated from field observations.	21.3.1
Haul - uncontrolled placement	CY		NA		
Haul, place, compact	CY		NA		
Stockpile - uncontrolled placement	CY		NA		
Stockpile - controlled placement	CY		NA		
Conveyor placement from stockpile land/water	CY		NA		
Imported Fill					
Select Fill	CY		NA		
Gravel Borrow, including haul	CY		NA		
Sand / Gravel for Beach Nourishment	CY		NA		
Cobble for Shore Nourishment	CY		NA		
Embankment Compaction	CY		NA		
Topsoil	CY		NA		
RESTORATION Features					
Channel Rehab / Creation	SF		490	Realigned channels through marsh.	21.3.2
Large Wood Placement	EA		1	Shown on plan - see Structures - Other for detail.	
Invasive Species Control	Acre		NA		
Physical Exclusion Devices	LF or EA		NA		
Other Restoration Features/ Activities	LS		NA		
Structures	EA				
Water Control Structures - Culverts with Gates	EA		NA		
Water Control Structures - Weirs	EA		NA		
Rock Slope Protection	LF		NA		
Other	EA		80	Provide soft shore stabilization on southern end of road embankment removal. This item is assumed to include LWD.	12.3.2
Elevated Boat Ramp	SF		NA		
Fencing	SF		NA		
Utilities				Replacement or relocation. Designer to provide size and material and have separate line item for each run. Incidentals include earthwork, testing, hook up fees, etc. These quantities do not include demolition of existing utilities, real estate / easements, design fees. Describe the owner if known, and whether utility franchise will install (e.g., electric is typically installed by electrical franchise).	
Water	LF		0		
Gas	LF		0		
Electric	LF		0		
Sewer	LF		0		
Telecommunications	LF		0		
Other	LF		0	Others = whatever is required (e.g.. power towers, petroleum, jet fuel, etc.)	
Roadway / Railway				KPFF expected to participate in these estimates	
Roadway (Type)	SF		0		
Roadway - Traffic Signal	LS		0		
Culvert (type)	LF		0		
Culvert - Jacking	LF		0		
Culvert - Horizontal Pile Driving	LF		0		
Bridge - Foundations, Deck and Appurtenances	SF		0		
Railway - Box Girder	SF		0		
Railway - Foundation	LF		0		
Railway - Shoe fly	LF		0		
Permanent Access Features					
Roads	Level		0		
Utility Access Routes	varies		0		
Erosion Control Features	L.F.		0		
Public Access or Recreation Features					
Trails	SF		0		
Bridges	SF		0		
Kiosk	EA		0		
Restrooms	EA		0		
Interpretive Signs	EA		1		
Parking Area	SF		0		
Other	EA		0		
Vegetation & Erosion Control					
Hydroseeding	AC		0		
Planting	AC		0.23	Underplant conifers along access road corridor at project completion	
Vegetation Maintenance	AC-YR		1.15	Assume 5 years	
Erosion / sediment BMPs - Temp.	AC		1		
Erosion / sediment BMPs - Permanent	AC		0		
Waterside controls - Temporary	EA, LF, LS		0		
Construction Management					
Construction oversight	weeks		4		
Materials testing					
Design and Detailed Site Investigations					
Survey & Property, Utility Research	LS		1	% of construction cost	

Full Restoration Quantity Estimate

Action Name: Mission Creek
Action #: 1456
Date: February 2011
By: ESA

REMEDY: ***Remove road embankment and restore natural channel morphology***
Construction Period: Four Weeks

	Item	Unit of Measure	Material Name	Qty	Description of Item		Indicate section of design report where item is described
	35% Design	LS		1	35% x 25% x Engineer's Estimate		
	65% design	LS		1	65% x 25% x Engineer's Estimate less the cost for 35% PS&E		
	90% design	LS		1	35% x 25% x Engineer's Estimate less the cost for 35% + 65%PS&E		
	100% design	LS		1	25% x Engineer's Estimate less previous costs		
	Geotechnical Studies				Refer to design report for description of need		
	Cultural Studies				Refer to design report for description of need		
	HTWR Studies				Refer to design report for description of need		
Project Agreement Activities					Unable to provide credibale estimate at 10% design		
Site-Specific Adaptive Management Features & Activities					List if known		
Monitoring Activities					Assume 5 crew-days/year for each monitoring parameter in design report for 5 yrs		
	Monitoring (Type_)	crew-days		125	Very small site - cross-sections can easily be surveyed quickly.		
Operations & Maintenance					Unable to provide credible estimate at 10% design		

Partial Restoration Quantity Estimate

Action Name:	Mission Creek
Action #:	1457
Date:	February 2011
By:	ESA

REMEDY: ***Remove road embankment and restore natural channel morphology***

Construction Period: Four Weeks

Item	Unit of Measure	Material Name	Qty	Description of Item	Indicate section of design report where item is described
ACQUISITION AND CONSERVATION				Based on available mapping information	
Required Project Lands	Acre		5.7	Total land required For action	21.3.5
Proponent / Partner-owned lands	Acre		5.7	Etimate of lands currently owned by Proponent (i.e., Public lands)	21.3.5
Lands To Be Acquired	Acre		0	Estimate land required to be acquired for action prior to implementation	21.3.5
Material Sites				Not Used: See Earthwork - Imported Fill.	
MOBILIZATION AND ACCESS for construction activities				Description required for each item to facilitate cost estimating	
Mobilization - Typical (Equipment, Personnel, Planning, Financial)	LS		1	Assume 8% of total	
Mobilization - Remote (Equipment, Personnel, Planning, Financial)	LS		NA		
Site Access	LS		1	Minimal clearing needed to utilize existing paved access road from the north.	
Barge Access	Days		NA	Describe need for barge access	
Temporary Traffic Control (one of the following)				Includes installation of traffic signals, signage, signmen, etc. There are 4 types as follows:	
none	LS		NA	None = no traffic control	
signs	LS		1	Signs = signs only, costs typically around 1% of total roadway costs	
flags / spotters	LS		NA		
unique	LS		NA		
Temporary Roadway	SF		NA		
Control of Water	LS		1	May be necessary to block existing culvert to allow more flexibility in channel excavation behind the berm.	
Relocation Activities					
Site Demolition Activities					
Clearing and Grubbing (one or more of following)					
Clear Vegetation - Local Disposal	AC		NA		
Clear /Grub Vegetation - Local Disposal	AC		NA		
Clear /Grub Vegetation - Offsite Disposal	AC		NA		
Clear, stockpile - large woody debris	CY		NA		
Hydraulic Structures - Small	LS		1	Remove existing 36" culvert through road embankment and beach	
Hydraulic Structures - Large	LS		NA		
Utilities	LS or LF		NA		
Buildings	LS or SF		NA		
Pavement	SF		4800	Pavement removal from road embankment, measured in geodatabase. Pavement is very thin veneer.	
Pavement	SF		4800	Pavement removal from access road, measured from geodatabase. Pavement isthin veneer.	
Bulkheads	LF or SF		NA		
Rock revetments	LF, Ton or CY		NA		
Large Coastal Structures	LF, SF or CY		NA		
Demolition / Removal - Bridge	SF or CY		NA		
Removal - Misc. (e.g. angular rock from beach)	Ton		260	Remove concrete rubble from beach. Assumed removal area was 50% rubble, and 1.5 tons/CY.	
Demolition / Removal - Boat Ramp	SF		NA		
Haul - Offsite Disposal of Demolition Debris	Miles		20	Assumed.	
Hazardous/Contaminated Waste Removal					
Contaminated Earthwork	CY		0		
Hazardous Earthwork	CY		0		
Construct Temporary Features					
EARTHWORK					
Excavation	CY				
Excavation - Upland	CY		NA		
Excavation - Lowland	CY		1400	Remove roadway embankment. Area and length reported in geodatabase, area shown on typical sections.	21.3.1
Excavation - Lowland	CY		240	Excavate new channel alignments. Will require smaller, low ground pressure, equipment. Length from geodatabase, xs on sections, developed from regional regressions.	21.3.1
Excavation - Lowland	CY		3300	Remove accumulated sediments. Will require smaller low ground pressure equipment. Volume developed using surface differencing in ACAD Civil 3D using LiDAR topography for existing.	21.3.1
Dredging - Bucket - Land	CY		NA		
Dredging - Bucket - Marine	CY		NA		
Dredging - Hydraulic	CY		NA		
Fine Grading	AC		NA		
Fill Placement - local borrow					
Side cast	CY		130	Use excavation, lowland spoils from channel excavation to fill ditches	21.3.1
Haul - uncontrolled placement	CY		NA		
Haul, place, compact	CY		NA		
Stockpile - uncontrolled placement	CY		NA		
Stockpile - controlled placement	CY		NA		
Conveyor placement from stockpile land/water	CY		NA		
Imported Fill					
Select Fill	CY		NA		
Gravel Borrow, including haul	CY		NA		
Sand / Gravel for Beach Nourishment	CY		290	Placement to +1.0 ft MHHW to create barrier beach. Minimal shaping after embankment is removed.	21.3.2
Cobble for Shore Nourishment	CY		NA		
Embankment Compaction	CY		NA		
Topsoil	CY		NA		
RESTORATION Features					
Channel Rehab / Creation	SF		490	Realigned channel through marsh	21.3.2
Large Wood Placement	EA		NA		
Invasive Species Control	Acre		NA		
Physical Exclusion Devices	LF or EA		NA		
Other Restoration Features/ Activities	LS		NA		
Structures	EA				
Water Control Structures - Culverts with Gates	EA		NA		
Water Control Structures - Weirs	EA		NA		
Rock Slope Protection	LF		80	Provide protection for southern slope adjacent to residential properties. Existing rubble to be removed from beach may be suitable for re-use as slope protection.	
Other	EA		NA		12.3.2
Elevated Boat Ramp	SF		NA		
Fencing	SF		NA		
Utilities				Replacement or relocation. Designer to provide size and material and have separate line item for each	
Water	LF		NA		
Gas	LF		NA		
Electric	LF		NA		
Sewer	LF		NA		
Telecommunications	LF		NA		
Other	LF		NA		
Roadway / Railway					
Roadway (Type)	SF		NA		
Roadway - Traffic Signal	LS		NA		
Culvert (type)	LF		NA		
Culvert - Jacking	LF		NA		
Culvert - Horizontal Pile Driving	LF		NA		
Bridge - Foundations, Deck and Appurtenances	SF		NA		
Railway - Box Girder	SF		NA		
Railway - Foundation	LF		NA		
Railway - Shoe fly	LF		NA		
Permanent Access Features					
Roads	Level		NA		
Utility Access Routes	varies		NA		
Erosion Control Features	L.F.		NA		
Public Access or Recreation Features					
Trails	SF		NA		
Bridges	SF		NA		
Kiosk	EA		NA		
Restrooms	EA		NA		
Interpretive Signs	EA	1			
Parking Area	SF		NA		
Other	EA		NA		
Vegetation & Erosion Control					
Hydroseeding	AC		NA		
Planting	AC		0.23	Underplant conifers along access road corridor at project completion	
Vegetation Maintenance	AC-YR		1.15	Assume 5 years	
Erosion / sediment BMPs - Temp.	AC		1		
Erosion / sediment BMPs - Permanent	AC		NA		
Waterside controls - Temporary	EA, LF, LS		NA		
Construction Management					
Construction oversight	weeks		4		
Materials testing					

Partial Restoration Quantity Estimate

Action Name: Mission Creek
Action #: 1457
Date: February 2011
By: ESA

REMEDY: ***Remove road embankment and restore natural channel morphology***
Construction Period: Four Weeks

	Item	Unit of Measure	Material Name	Qty	Description of Item		Indicate section of design report where item is described
Design and Detailed Site Investigations							
	Survey & Property, Utility Research	LS		1	% of construction cost		
	35% Design	LS		1	35% x 25% x Engineer's Estimate		
	65% design	LS		1	65% x 25% x Engineer's Estimate less the cost for 35% PS&E		
	90% design	LS		1	35% x 25% x Engineer's Estimate less the cost for 35% + 65%PS&E		
	100% design	LS		1	25% x Engineer's Estimate less previous costs		
	Geotechnical Studies				Refer to design report for description of need		
	Cultural Studies				Refer to design report for description of need		
	HTWR Studies				Refer to design report for description of need		
Project Agreement Activities					Unable to provide credibale estimate at 10% design		
Site-Specific Adaptive Management Features & Activities					List if known		
Monitoring Activities					Assume 5 crew-days/year for each monitoring parameter in design report for 5 yrs		
	Monitoring (Type_)	crew-days		125	Very small site - cross-sections can easily be surveyed quickly.		
Operations & Maintenance					Unable to provide credible estimate at 10% design		

22. NEARSHORE RESTORATION STRATEGY FOR TWIN RIVERS (#1190)

Local Proponent	Lower Elwha Klallam Tribe
Delta Process Unit	NA
Shoreline Process Unit(s)	1027
Strategy(ies)	2 - Beach
Restoration Objectives	Remove barriers to littoral transport and restore sediment supply and transport processes

22.1 Description of the Action

The proposed action is to remove the rock revetment and sheet pile wall surrounding a derelict 5.6-acre fill area (termed a “mole”) to remove the barrier to littoral transport and sediment delivery, and also to uncover the intertidal zone. Please see the Introduction chapter for important information regarding PSNERP and for the context related to this restoration project.

22.2 Action Area Description and Context

This action area is located along the high-energy coast of the Strait of Juan de Fuca, in the subbasin of the same name. Although it is outside of mapped net shore-drift cells, it does have considerable littoral transport on the shore platform. The mole and associated armor and fill considerably hinder eastward littoral transport as the mole extends into the subtidal to supratidal zone. The mole and access road down the face of the bluff have altered sediment delivery at this location as well. Therefore, the mole not only limits sediment input from the bluff at this location, but it also traps sediment, acting as a groin, and may disrupt salmonid migration alongshore or to and from the East and West Twin Rivers, located just east of the site. The action area is shown in Figure 22-1.

Figure 22-1. Action Area and Vicinity

22.2.1 Historic Condition

Historic maps are provided in Figures 22-2A and 22-2B. The historic topographic sheet (T-sheet) mapping showed a relatively linear bluff shore at the site with mixed forest above. The bluff at the site appeared very steep and erosional, with a narrow beach at the time of earliest T-sheet mapping in 1908 (T-sheet 2907). T-sheet 4182 from 1926 appears to show a broad intertidal area extending approximately 500 feet waterward of the bluff toe. Over 5 acres of this area was filled between 1965 and 1967. Extensive large boulders were present in the intertidal zone with kelp further offshore. The West Twin River mouth is approximately 1,900 feet east of the fill area, and East Twin River is approximately 3,300 feet east of the fill area. Each of these rivers had built a delta that extended to the subtidal zone, and a relatively fine-grained beach was present between the two rivers.

East of the mole, the PSNERP change analysis mapped areas of barrier beach at both Twin River deltas with bluff-backed beach between. The shore west of the deltas was mapped as rocky platform. Construction of the mole and associated fill resulted in a transition to an artificial shoreform along the entire fill area.

22.2.2 Natural Environment

The site is located along the west-central portion of the high-energy northern shore of the Olympic Peninsula. This area has a broad shore platform and unstable bluffs composed primarily of marine sedimentary deposits. Large deep-seated landslides are fairly common from high bluffs in this area (Parks 2005), forming a major source of littoral sediment. An old slide complex at the site was reactivated in the winter of 2009-2010. Intermittent, relatively steep-gradient rivers and streams drain to the coast, forming a secondary source of littoral sediment. Beaches are typically limited to intermittent, narrow supratidal deposits with extensive, broad shore platforms containing varying amounts of fine-grained sediment and lag deposit boulders. The site is exposed to swell from the west-northwest and moderate wave energy from the east.

Although the site was originally mapped as a “no appreciable drift” area, this mapping is currently being revised for the Clallam County Shoreline Master Program update, and this area is mapped within a net shore-drift cell. There is clearly both moderate rates of bluff sediment input and gross littoral transport at the site. Apparent net eastward littoral transport occurs on the shore platform, where a broad but thin expanse of sand and lesser amounts of gravel are in transport, along with transport along a narrow high tide beach.

Kelp was mapped offshore of the mole in a large patch and occurs intermittently elsewhere between 400 and 2,000 feet waterward of the shore. Patchy eelgrass occurs near the mole. Eelgrass recolonization has reportedly begun in the formerly dredged channel (Parks 2010) that extends north from the east side of the mole.

Collectively the East and West Twin Rivers support a number of salmon stocks including Chinook, coho, cutthroat, chum, and steelhead (Roni et al. 2008, Kramer 1952; cited in Shaffer et al. 2009). Surf smelt spawning is documented a short distance east of the mole. Potential surf smelt spawning habitat is mapped starting approximately 400 feet from the eastern end of the fill.

22.2.3 Human Environment

The site is located approximately 25 linear miles west of Port Angeles and 15 miles southeast of Clallam Bay. The site is accessed by nearby State Route 112. The 3.8-acre mole was constructed over tidelands leased from WDNR to allow direct barge loading from the Twin Rivers clay quarry. The quarry site covered approximately 214 acres in the uplands owned by LaFarge in North America (LaFarge). The tideland where the mole rests still has an active lease by LaFarge, although the company apparently is not planning more mining at the site (Parks 2010).

The mole extends approximately 600 feet waterward of the bank and is approximately 275 feet wide. The mole was filled up to approximately +16.5 feet MLLW. There has been no documentation of the composition of fill material, but erosional exposures at the north end of the mole were composed of sand and fine gravel. There is also unsubstantiated record of a variety of fill types being used including clay (Parks 2010). Additionally, a large rock revetment is present along the western side and most of the northern side of the mole, which extends an additional 30 to 45 feet into nearshore waters (0.8 acre). A 425-foot-long steel sheet pile wall with concrete cap is located on the northeast and east shores of the mole, which contains tie rods that reportedly connect to buried creosote-treated wood. An additional, smaller fill area runs alongshore to the east, extending approximately 420 feet along the shore and 100 feet from the toe of the bluff (1.0 acre). The mole and fill areas total approximately 5.6 acres.

A dredged channel for barge access measuring up to 1,600 feet long by 250 feet wide was present immediately east of the mole. Dredging records indicated that approximately 102,000 CY of dredged sediment was removed between 1982 and 1985 (Parks 2005). No utilities are apparent at the site.

22.3 Restoration Design Concept

22.3.1 Restoration Overview and Key Design Assumptions

The primary restoration element is removal of shoreline armor from the Twin Rivers mole (Figures 22-3 through 22-6). Site access and project staging areas are available via State Highway 112 and through the upland mine at the site. Prior to demolition, the mole access road would need to be rehabilitated to allow for large equipment use. This will involve possible regrading, as the maximum grade of the road is 26%, and portions of the adjacent slopes have been actively sliding. However, Parks (2010) stated that the road rehabilitation should not require an excessive amount of work. Rock revetments at the mole consist of large rock (3 to 6 feet in diameter) down to approximately MLLW, with portions of the north end revetment extending into the subtidal zone. All rock will be removed from the shore. The 425-foot sheet pile wall will require initial excavation behind the wall to remove the tie rods and creosote-treated timbers. The wall will then be removed with a crane for disposal.

Once the shore armor and associated debris have been removed, the partial restoration alternative will be complete. Fill left behind in the mole and adjacent fill area, which is understood to have been derived from adjacent native deposits, will be allowed to naturally redistribute to the nearshore. The full restoration alternative would remove the armor and then actively remove the fill for disposal offsite. Since the site was once actively used by heavy equipment to mine materials, some amount of soil contamination may be possible. Contamination, if found, would require remediation or disposal at an approved upland facility (to be determined in a later design stage).

It is unlikely that a barge could be used for site access as the deepwater channel on the east side of the mole appears to have largely been filled through littoral transport. Initial eelgrass colonization has begun near the northeast corner of the mole (Parks 2010). Access to the mole has historically been via a steep road down the bluff that has not been maintained in recent years. Restoration assumes that one of the two means of access can be utilized, with the road through the mine the planned access route.

The key design elements associated with full and partial restoration alternatives are shown in Table 22-1.

Table 22-1. Key Design Elements

Element	Full Restoration	Partial Restoration
Armor Removal	Remove rock revetments and sheet pile wall	Same as full restoration
Fill Removal/Release	Remove fill for offsite disposal or reshape into landscape feature	Expose fill to allow natural redistribution alongshore
Debris Removal	Remove concrete, creosote wood and misc debris	Same as full restoration

22.3.2 Restoration Features – Primary Process-Based Management Measures

Armor Removal/Modification

The full and partial restoration alternatives both include full removal of armor, including all rock revetments and the sheet pile wall. In this case the armor serves as a jetty or very large groin. Rock revetments are located on the northwest and west sides of the mole, the southeast corner of the mole, and along the fill area east of the mole for access road stabilization (Figures 22-3 through 22-6). A total of approximately 8,100 CY of rock would be removed. The sheet pile wall is located along the entire east side of the mole; it continues along a portion of the north side of the mole that formerly facilitated barge loading and transport of mined material at the site. The full 425 LF of the approximately 30-foot-high sheet pile wall will be removed, including the concrete cap tie rods and creosote-treated wood anchors and accessories (e.g., steel cleats).

Berm or Dike Removal/Modification - NA

Channel Rehabilitation/Creation - NA

Groin Removal/Modification

The mole acts as a groin and partial barrier to littoral transport. Full restoration includes excavation and disposal of all fill (approximately 130,000 CY) associated with the mole following armor removal (Figure 22-5). Following partial restoration, the fill will be left in place where it will be exposed to wave attack and allowed to naturally redistribute in the nearshore (Figure 22-6). Both restoration alternatives are expected to achieve similar results, although the full restoration alternative will achieve the objectives more quickly.

Hydraulic Modification - NA

Overwater Structure Removal - NA

Topography Restoration

The fill and associated shore armor are situated over the intertidal zone and represent the primary stressor at this site. As outlined under *Groin Removal/Modification* and *Armor Removal/Modification*, the topography of the beach and shore platform would be restored through application of those management measures. Topography would be restored right away with full restoration, and over time with partial restoration.

22.3.3 Restoration Features – Additional Management Measures

Beach Nourishment - NA

Contaminant Removal/Remediation – NA

Contaminants are not documented at the action area. However some amount of contaminated soils, such as contamination by diesel fuel, may be present at the site. Further investigation would be required to determine if this is the case.

Debris Removal - NA

Invasive Species Control - NA

Large Wood Placement - NA

Physical Exclusion - NA

Pollution Control - NA

Revegetation - NA

Reintroduction of Native Animals - NA

Substrate Modification - NA

Species Habitat Enhancement - NA

22.3.4 Restoration Features – Other

NA

22.3.5 Land Requirements

The mole and the associated upland mine are owned by LaFarge. The tidelands on which the mole was constructed are owned by WDNR and actively leased to LaFarge. The removal of the mole would likely be supported by WDNR. However, there are complications related to this (see *Design Considerations* section, below). Permission to use the upland mine for access must be acquired prior to restoration.

22.3.6 Design Considerations

The tidelands are owned by WDNR and therefore appear to be available for restoration; however, the land is managed by the Surface Mining Group and has an active lease. Due to the recent reactivation of a large landslide complex immediately landward of the mole, WDNR issued an agreed emergency order. Geotechnical studies and other work are underway to determine slope stability constraints and how they pertain to the use and management of the lease. This work is not yet complete, but the geotechnical analysis may recommend leaving the mole in place in order to reduce the instability of the uplands. This would obviously be contradictory to the goals of environmental restoration and allowing naturally unstable and undeveloped bluffs to function as feeder bluffs for the benefit of the nearshore system. The uplands at the site do not contain any permanent improvements, nor are there plans to continue mining operations. Therefore, slope instability is unlikely to have detrimental impacts.

Access to the site appears available through rehabilitating the old road down from the mine, although the degree of degradation of the roadbed due to landslides and erosion is not known. Parks (2010) thought this option would be feasible, as the road is currently passable by pickup truck. However, the current maximum grade on the road is 26%, which must be considered for access by large equipment. A known deep-seated landslide hazard in the uplands could cause the loss of a rehabilitated upland road at any time. Winter is generally the time of greatest slope instability in this region.

The amount of sedimentation in the old barge channel and the presence of intermittent small patches of eelgrass may preclude the use of barges for removal of armor and possibly other material from the site.

The presence or absence of contaminants in the fill soil has not been determined. However, there is a clear risk of contaminants such as diesel and possibly other material related to past industrial use.

22.3.7 Construction Considerations

The current understanding of the site and its constraints suggest that upland based access and work would be best, although additional information would allow for a better determination of whether barge-based access would be more efficient. The site is accessible from State Route 112 through the now-closed upland mine. The mole access road will first require rehabilitation to allow heavy equipment to pass safely. Due to the much greater number of dump truck loads required by the full restoration alternative, the access road will require a higher level of rehabilitation than for partial restoration.

The majority of demolition is expected to require the use of large excavators, loaders, and dump trucks. Removal of the steel sheet pile wall may require a crane. Clearing of bank vegetation with local disposal will be required to allow equipment to access the revetment.

The rock revetment is composed of angular and subangular basalt boulders up to 5 feet in length. This material may be of some value for reuse by contractors or others. Removal and disposal may be feasible at a significantly lower cost than if the material was treated as waste. Another possibility is to use a portion of the upland mine for disposal of the armor rock.

Demolition will likely commence on the north side of the mole and progress landward. Under the full restoration alternative, all fill will be removed along with the armor, so both armor and fill removal must planned to ensure access to any given demolition area. Some areas of the rock revetment contain up to 8 feet of near-vertical slope above the top of the revetment. The fill inside the revetment will need to be cut down in stages to provide access to the rock for removal. At this stage it was estimated that 50% of the fill removal will require upland excavation methods and equipment, and 50% will require lowland excavation.

No detailed investigation of the sheet pile wall was completed as part of this work. Estimates of quantities are based on limited exposure of the tie rods at the north end. Steel tie rods appear to be spaced at approximately 4-foot intervals alongshore at the exposed areas, and extend at least 10 feet landward of the wall. The anchors are reportedly creosote-treated timbers or piles, although no investigation into their location, size, or extent was made as part of this study and no documentation was available.

The upland mine site could be used for staging of excavated materials prior to haul offsite. The mine contains a large, flat area that could be used for this purpose. Given the recent landslides at the property, the geotechnical work currently underway or additional stability analysis will be required prior to placement of any staging materials on the site.

A preliminary cost estimate was prepared by Phil Jensen of WDFW in 2005 (Shaffer et al. 2009). The estimated $391,000 (2005 dollars) total included costs for mobilization, access road rehabilitation, armor removal, and site closeout, along with a 30% contingency. This cost estimate did not include fill removal, engineering, project administration, sales tax, or permitting. However, this cost estimate was preliminary and in need of updating.

22.4 Extent of Stressor Removal

Table 22-2 describes the amount of stressors to be removed with this action.

Table 22-2. Stressor Removal

Stressor	Full Restoration	Partial Restoration
Fill (acres)	5.6	5.6 over time
Breakwaters & Jetties (LF)	1,800	1,800

22.5 Expected Evolution of the Action Area

Without restoration, the site is expected to continue to degrade in the short to long term. Both the revetment and sheet pile wall would be expected to gradually fail over time, but they would remain in the nearshore and provide some amount of continued groin effect for at least another 30 to 50 years. As the growing forest expands onto the mole, the tree root network will provide further stability to the mole fill, extending its effective ecological footprint. Some amount of impounded fill soil would gradually be entrained into the littoral transport system as the armor is gradually degraded.

Following partial restoration (armor removal only), wave action is expected to begin eroding the mole fill immediately. The sediment will initially be redistributed on the low-tide terrace, followed by alongshore and onshore transport. Potential contamination of portions of the fill would need to be addressed prior to implementation. Transient accretion features may form, such as a spit extending eastward from the tip of the mole. An older study estimated the length of time required for full redistribution of the sediment was on the order of 3 to 10 years (Parks 2005). Following distribution of the fill sediment, bluff erosion will begin again. This is likely to involve a number of small landslides as wave-induced erosion reaches the base of the mole, and the bluff returns to equilibrium with the marine environment.

The full restoration alternative, which includes complete removal of mole fill, will accelerate the above processes. Removal of the fill from the bluff toe will cause it to be immediately exposed to wave attack. Several large slides are possible as the bluff trends toward the new dynamic equilibrium. Natural sediment transport processes will then be able to distribute the landslide colluvium alongshore. However, the removal of the mole fill would result in a net decrease of available sediment for the nearshore system, and the higher cost of this alternative appears not to be justified.

22.6 Uncertainties and Risks

The rate of transport and dispersal of fill sediment is uncertain. The likely fate of transported sediment is also not well understood, and will need further analysis as salmon-bearing rivers are present a short distance east of the site. Preliminary analysis by others (Parks 2005) concluded that there is minimal hazard of blocking fish access to the rivers, but this was based on preliminary work. With the apparently high rate of wave energy and littoral transport, it appears that if negative impacts do occur they will be limited in duration, as stream outflow is likely to overcome any blockage of the channel.

There is a risk of encountering contaminants such as diesel and possibly other material related to past industrial use. Such materials will require offsite disposal prior to completion of the restoration.

22.6.1 Risks Associated with Projected Sea Level Change

Table 22-3 compares potential risks associated with projected sea level changes based on professional judgment.

Table 22-3. Risks of Sea Level Change

	Projected Sea Level Change		
	High (46cm)	**Intermediate (4cm)**	**Low (-8cm)**
Full Restoration	Risk of increased bluff instability following removal of mole fill, which may further destabilize the uplands	Very minor risk to uplands due to bluff instability	No increased risk
Partial Restoration	Risk of increased bluff instability following removal of mole fill, which may further destabilize the uplands	Very minor risk to uplands due to bluff instability	No increased risk

22.7 Potential Monitoring Opportunities

Monitoring is important for evaluating the success of the partial or full restoration alternative. A combination of field surveys and aerial photographs would be used to document biological and physical changes to the landscape. Monitoring data can be used to refine adaptive management and corrective actions, as needed. Some of the monitoring needs and opportunities associated with this action are summarized in Table 22-4.

Table 22-4. Monitoring Needs and Opportunities

Monitoring Parameter	Key Performance Indicator	Note
Topographic Stability	X	Monitor bluff toe
Sediment Accretion / Erosion	X	Monitoring needs may vary depending on which restoration alternative is used
Wood Accumulation		
Soil / Substrate Conditions		
Vegetation Establishment	X	Monitor long-term variation in eelgrass beds
Marsh Surface Evolution / Accretion		
Tidal Channel Cross-Section / Density		
Water Quality (contaminants)	X	Monitor if fill material found to be contaminated
Salinity		
Shellfish Production		
Extent of Invasive Species		
Animal Species Richness		
Fish (salmonid) Access/Use	X	Document salmonid migration patterns when mole is removed
Forage Fish Production	X	Monitor known populations nearby
Wildlife Species Use		
Effectiveness of Exclusion Devices		

22.8 Information Needed for Preliminary Design

This conceptual design report represents an initial step in the restoration design sequence. The design concepts described above were developed based on readily available information without the level of site-specific survey and investigation that is necessary to support subsequent design and implementation. Substantial additional information will be required at the preliminary design stage to confirm the design assumptions, refine quantity estimates, address property and regulatory issues, obtain stakeholder support, and fill in data gaps. The extent to which this information is collected for preliminary design (or a later design stage) will depend upon the available budget, schedule and other factors. This section attempts to define the most essential information needs for this action.

- Property Investigation/Survey – More detailed information on parcel ownership and property boundary location will be needed to finalize the design, confirm acquisition requirements, and support negotiations with property owners.
- Sediment Transport Studies – Studies may be needed to determine the fate of the sediments and their impacts on adjacent habitats (eelgrass beds, forage fish spawning grounds, and fish access at West and East Twin Rivers) once the site is restored.

- Topographic/Bathymetric Survey – The survey, focused on the beach, toe of revetments, and adjacent in-water areas, along with mole topography, would be used to refine design of key project elements and develop detailed construction and demolition plans.
- Subsurface Investigations – Subsurface investigations should be carried out to determine the composition of the mole fill sediment, as well as possible soil contamination. This will be particularly important under the partial restoration alternative in order to prevent chemical contamination of the nearshore as well as to help determine possible impacts to nearby forage fish spawning beaches.
- Other – The extent to which the access road can be rehabilitated compared to the feasibility of barge access must be determined prior to deciding on the means of access to the mole.

22.9 Quantity Estimates

The quantity spreadsheets for the full and partial restoration alternatives are provided in Exhibits 22-1 and 22-2.

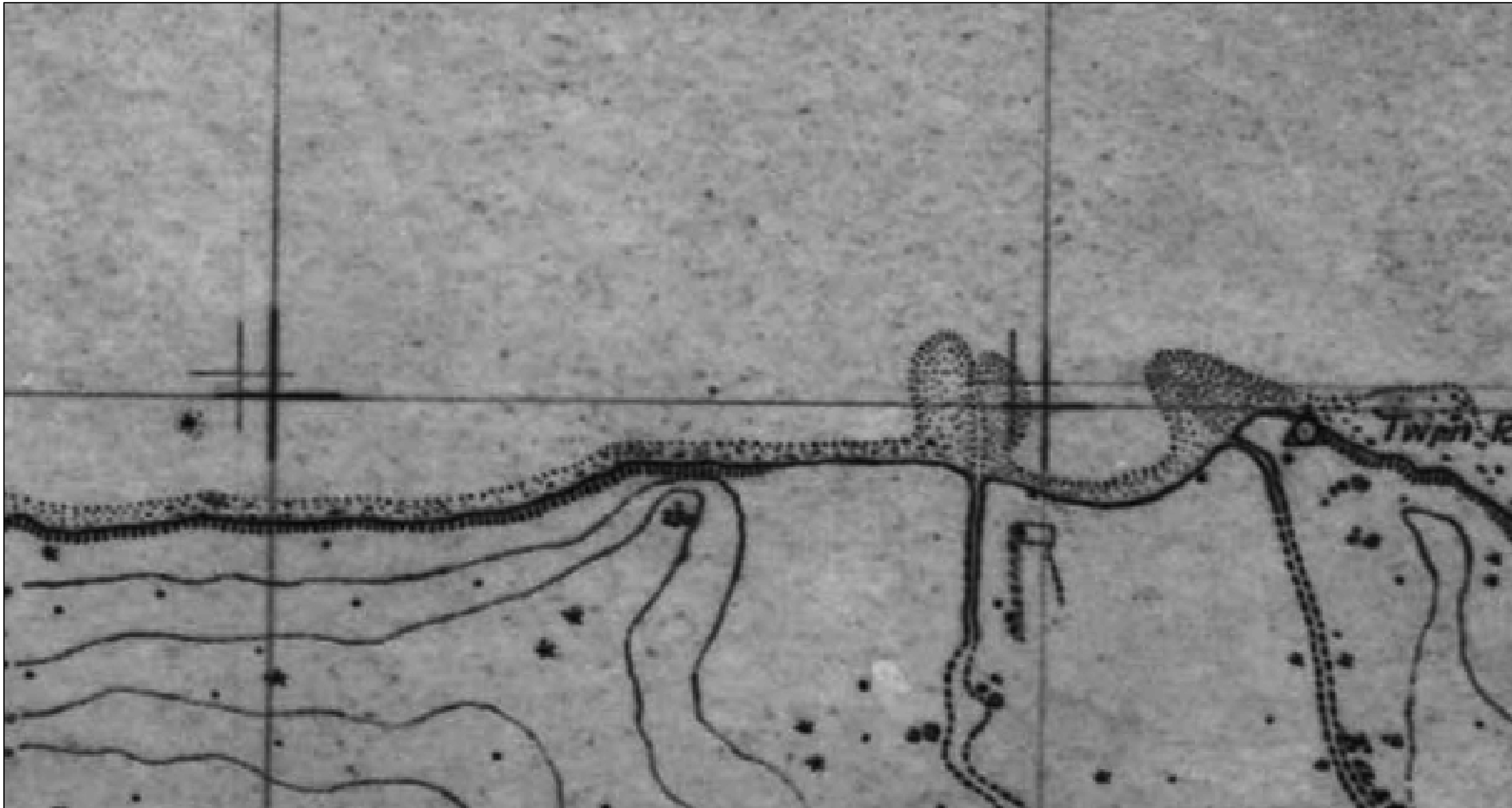
22.10 References

Parks, D. 2005. *Preliminary assessment of sediment transport processes resulting from decommissioning of the Twin River clay quarry loading facility, Clallam County, Washington.* WDNR, Port Angeles, WA.

Parks, D. 2010. Personal communication, WDNR staff, Port Angeles, WA.

Roni, P., R. Holland, T. Bennett, G. Pess and R. Moses. 2008. *Straits intensively monitored watershed contract report: Results of FY07 PIT tagging on east and west Twin rivers.* Northwest Fisheries Science Center, NMFS, Seattle.

Shaffer, A., J. Paul, P. Cain, M. McHenry, P. Jensen, T. Whitey, D. Parks and A Schouten. 2009. *Nearshore restoration strategy for Twin Rivers: A revised proposal by the Twins nearshore restoration work group* (2004, revised 2009).



0 520
Feet
0 160
Meters

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Historic Map (T-Sheet)
Action Name: Nearshore Restoration Strategy for Twin Rivers
PSNERP ID #: 1190
Figure 22- 2A

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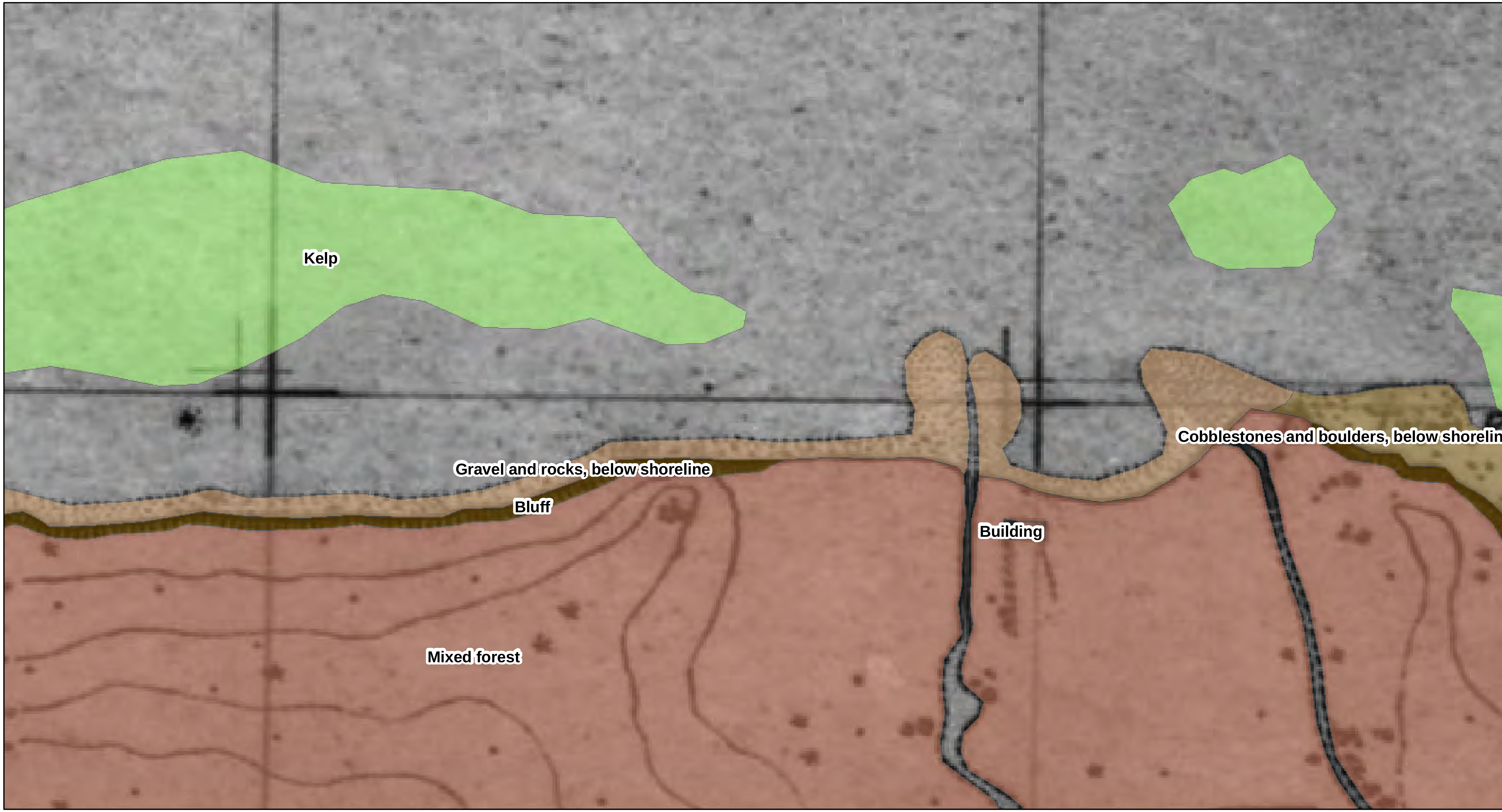

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Feet
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Meters

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Historic Map (T-Sheet) and River History Project Data
Action Name: Nearshore Restoration Strategy for Twin Rivers
PSNERP ID #: 1190
Figure 22- 2B

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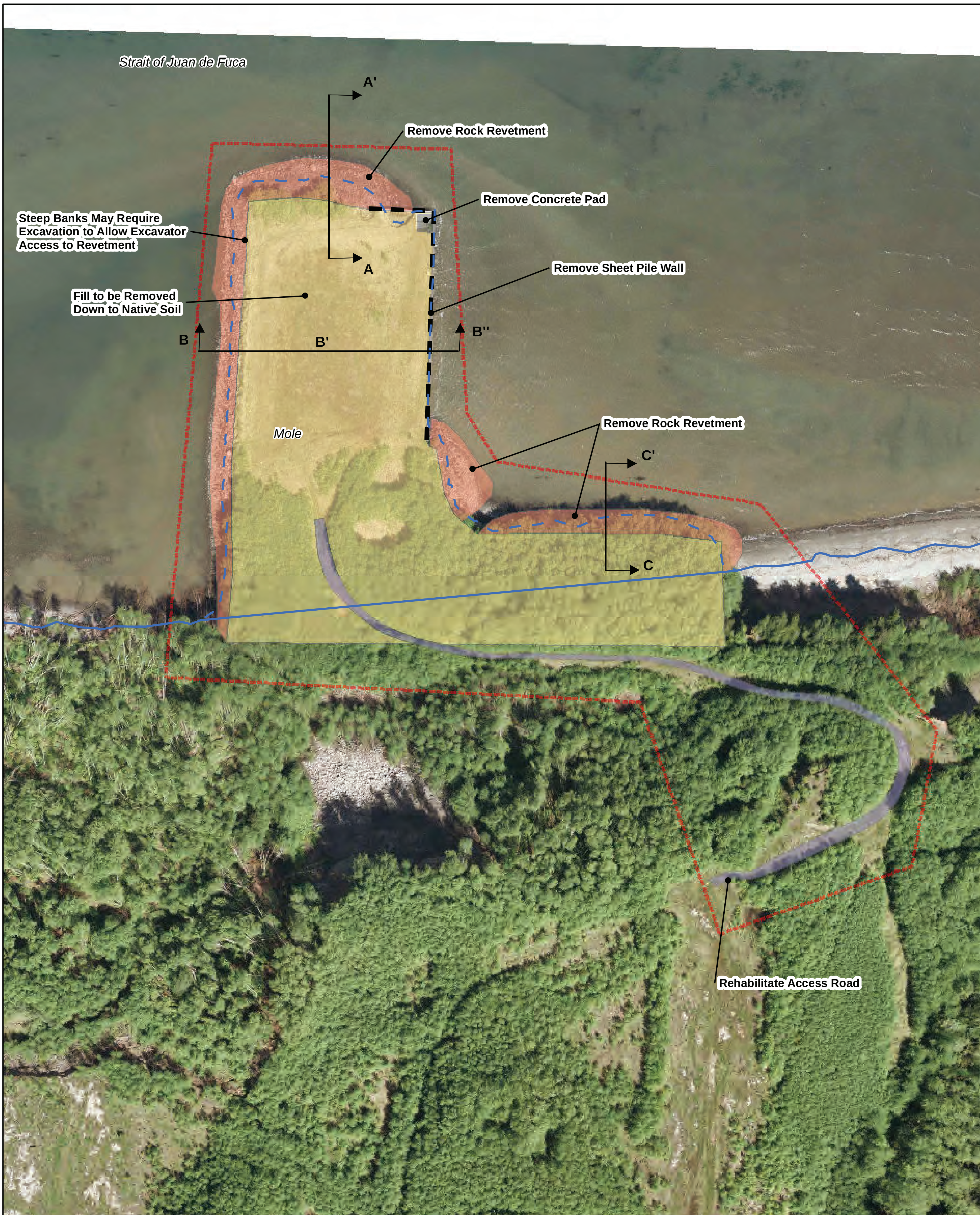
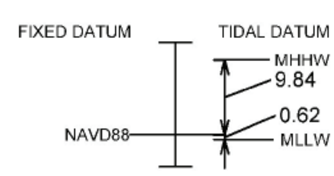


Legend

- Required Project Lands
- Remove Concrete Pad
- Excavation - Lowland
- Remove Rock Revetment
- Temporary Roadway Improvements
- Proposed Tide MHHW
- Existing Tide MHHW
- Large Coastal Structures

TWIN RIVERS CONVERSION



0.00 FT MLLW = -0.42 FT NAVD88
0.42 FT MLLW = 0.00 FT NAVD88

Source: Crescent Bay Station (#9443826) and

PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

North

0 150 Feet

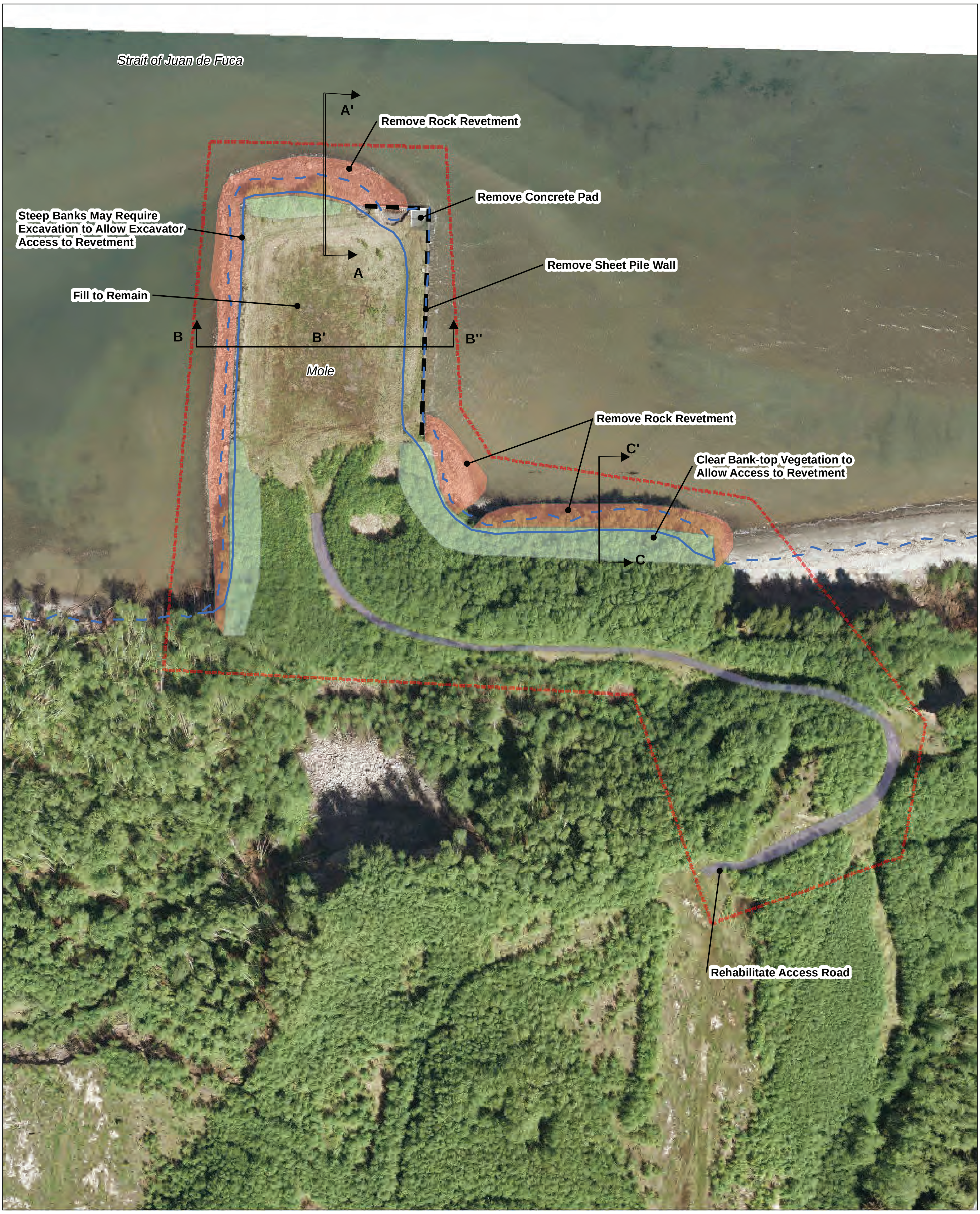
SOURCE:
Washington Public Lands Database (2006); Washington Counties Parcels (2009);
Action Area (PSNERP, 2010); 2005 Aerial Photograph (Jefferson County)

Lead Contractor: ESA
Design Lead: CGS
Date: 2/25/2011

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

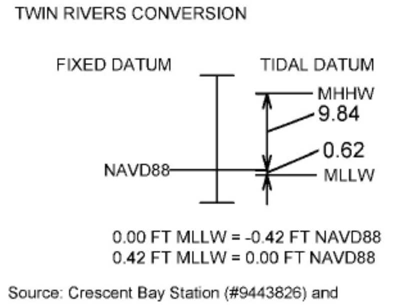
Conceptual Design Plan
Site Name: Twin Rivers Fill Removal
Action Name: Nearshore Restoration Strategy for Twin Rivers
PSNERP ID #:1190
Full Restoration

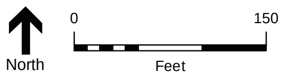
Figure 22-3



Legend

- Required Project Lands
- Clear Vegetation - Local Disposal
- Remove Concrete Pad
- Excavation - Lowland
- Remove Rock Revetment
- Temporary Roadway Improvements
- Existing Tide MHHW
- Large Coastal Structures
- Proposed Tide MHHW





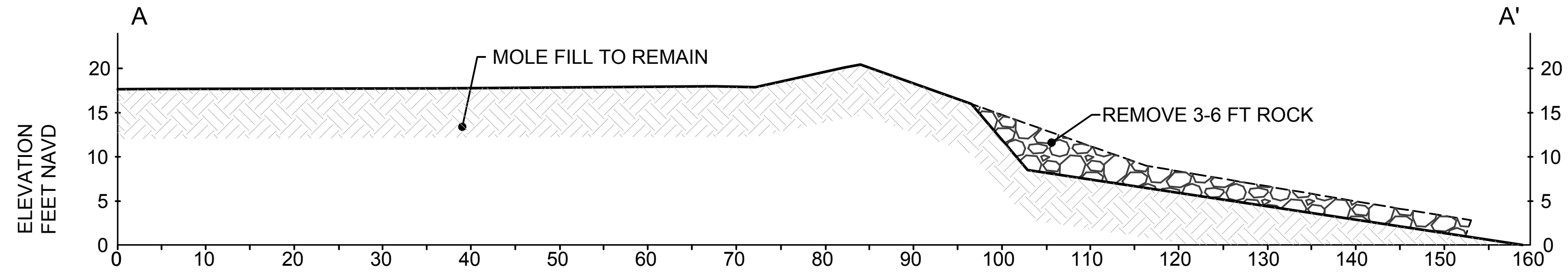
SOURCE:
Washington Public Lands Database (2006); Washington Counties Parcels (2009);
Action Area (PSNERP, 2010); 2010 Aerial Photograph (LaFarge)

Lead Contractor: ESA
Design Lead: CGS
Date: 2/25/2011

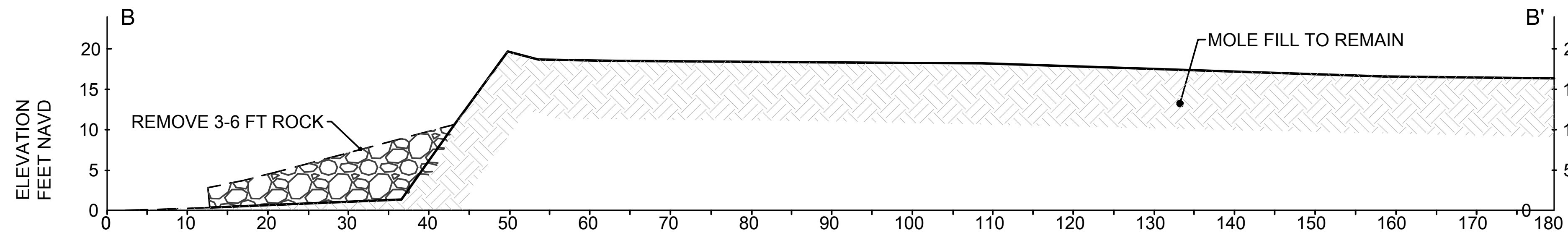
Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Plan
Site Name: Twin Rivers Fill Removal
Action Name: Nearshore Restoration Strategy for Twin Rivers
PSNERP ID #:1190
Partiall Restoration

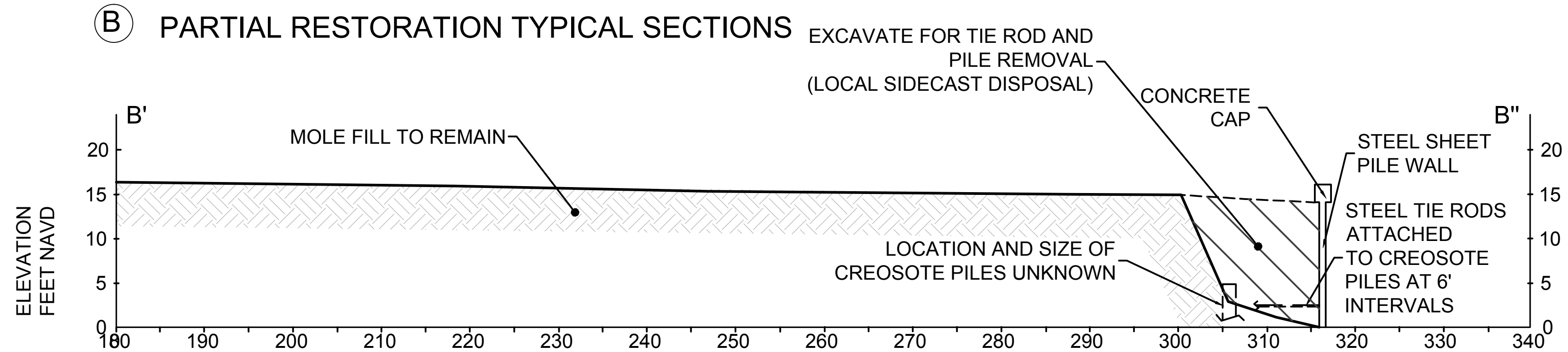
Figure 22-4



Ⓐ PARTIAL RESTORATION TYPICAL SECTIONS



Ⓑ PARTIAL RESTORATION TYPICAL SECTIONS



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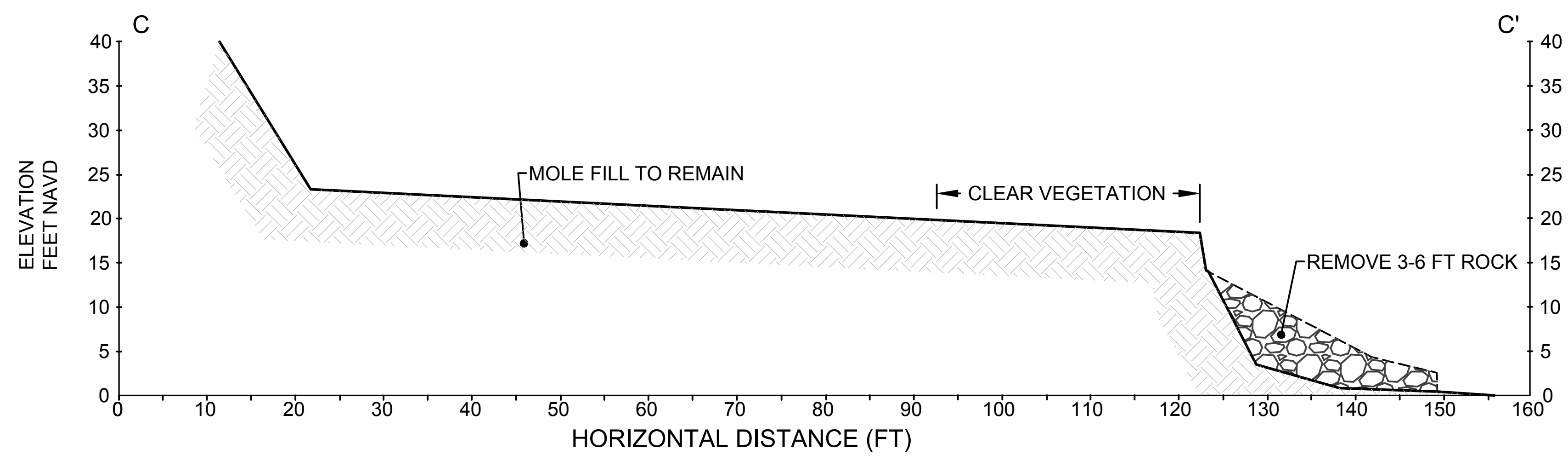
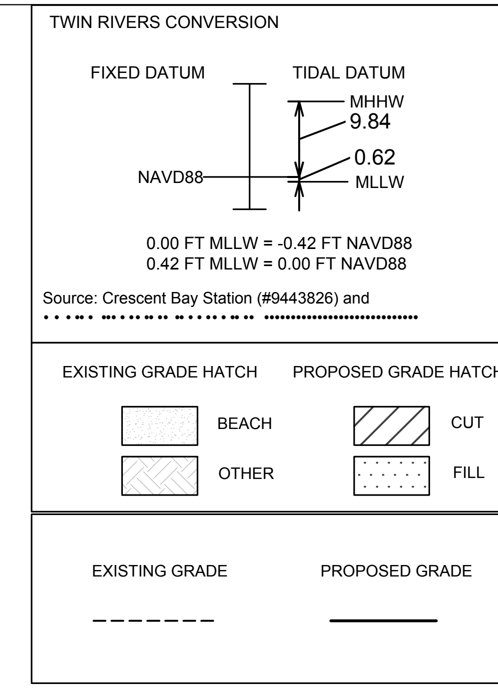
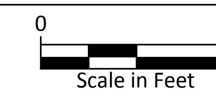
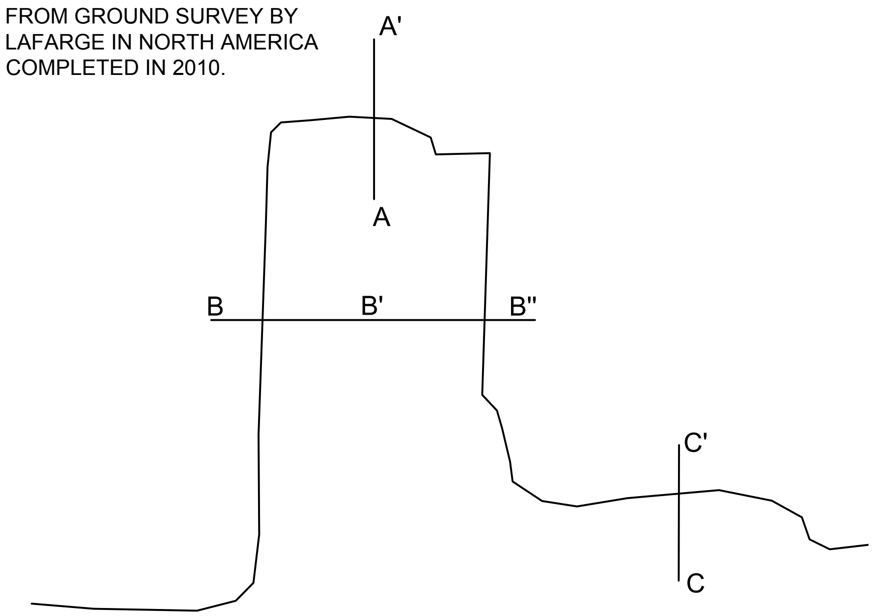


Ⓒ PARTIAL RESTORATION TYPICAL SECTIONS





NOTES
TIDAL DATUMS BASED ON NOAA CRESCENT BAY STATION (#9443826). NAVD88 TO TIDAL CONVERSION BASED ON VDATUM (V. 2.2.7) FOR COORDINATES
MLLW = -0.42 FT NAVD88
MHHW = +6.64 FT NAVD88
EXISTING GROUND ELEVATIONS FROM GROUND SURVEY BY LAFARGE IN NORTH AMERICA COMPLETED IN 2010.



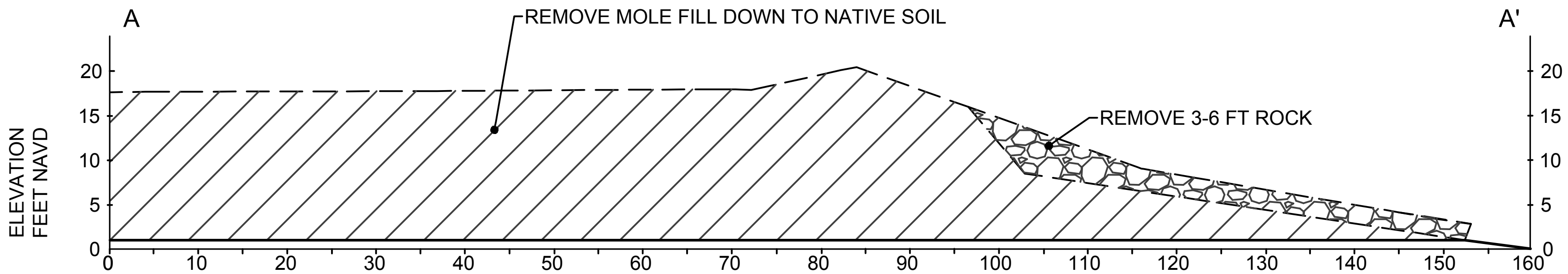
Cross Section Location Schematic (NTS)

PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

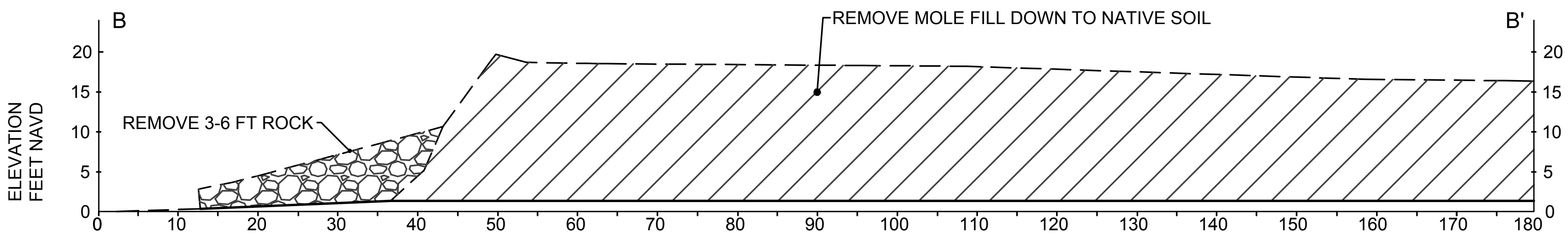
Lead Contractor: ESA
Design Lead: CGS
Date: 3/2011

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

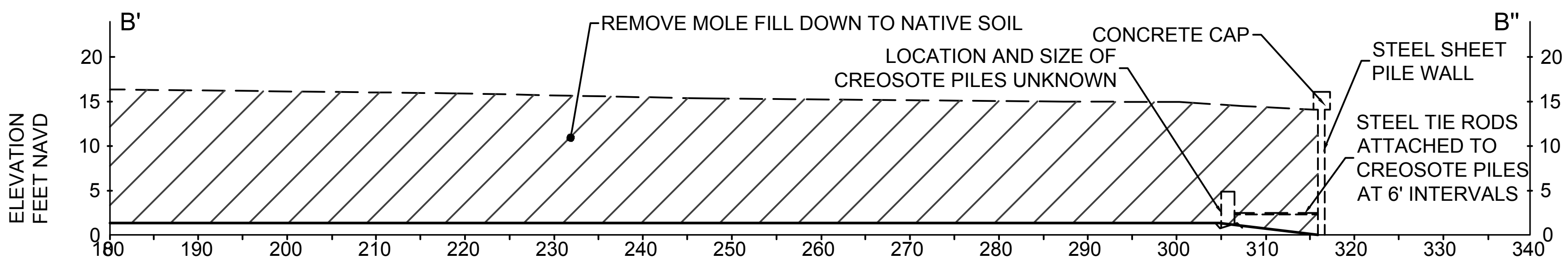
Conceptual Design Section
SITE NAME: **Twin Rivers**
ACTION NAME: **Nearshore Restoration Strategy for Twin Rivers**
PSNERP ID#: **1190**
Full Restoration



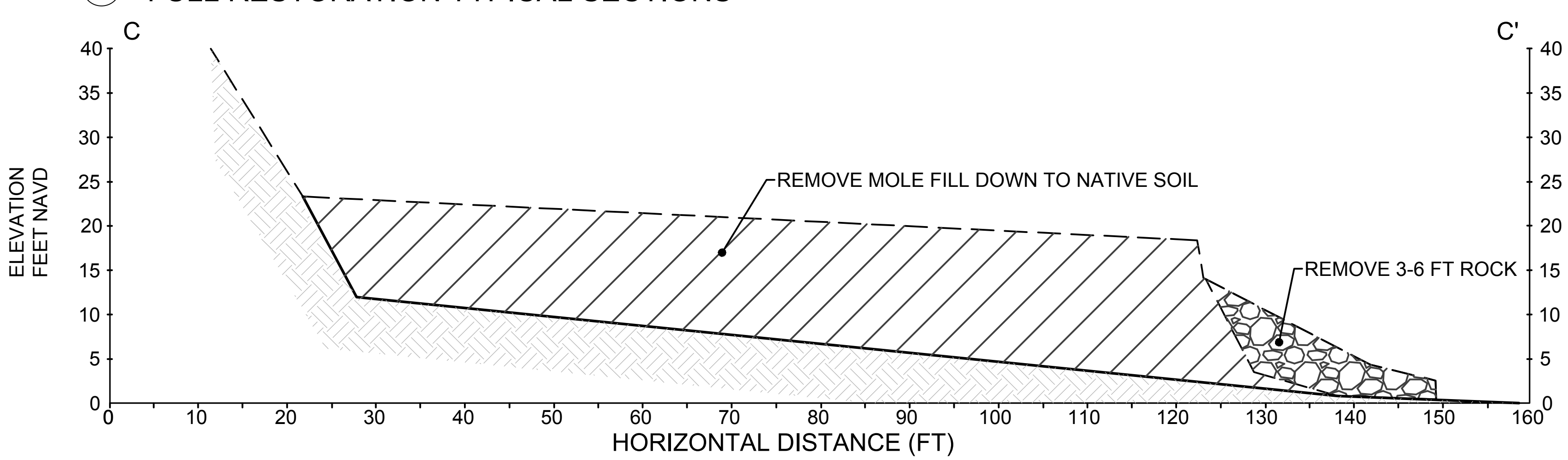
(A) FULL RESTORATION TYPICAL SECTIONS



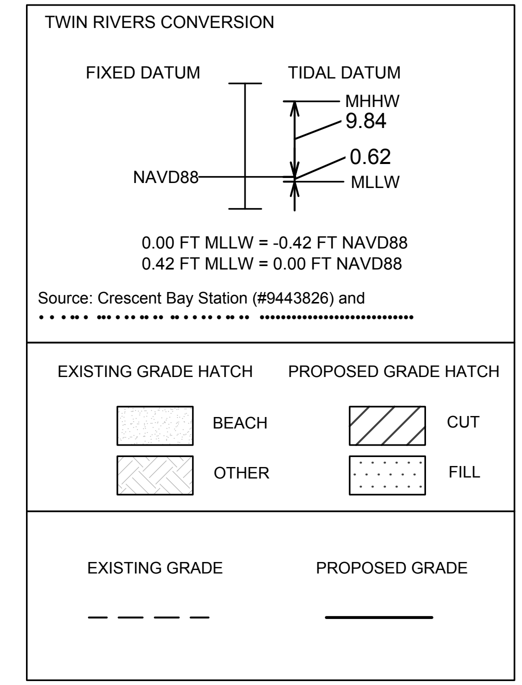
(B) FULL RESTORATION TYPICAL SECTIONS



(B) FULL RESTORATION TYPICAL SECTIONS

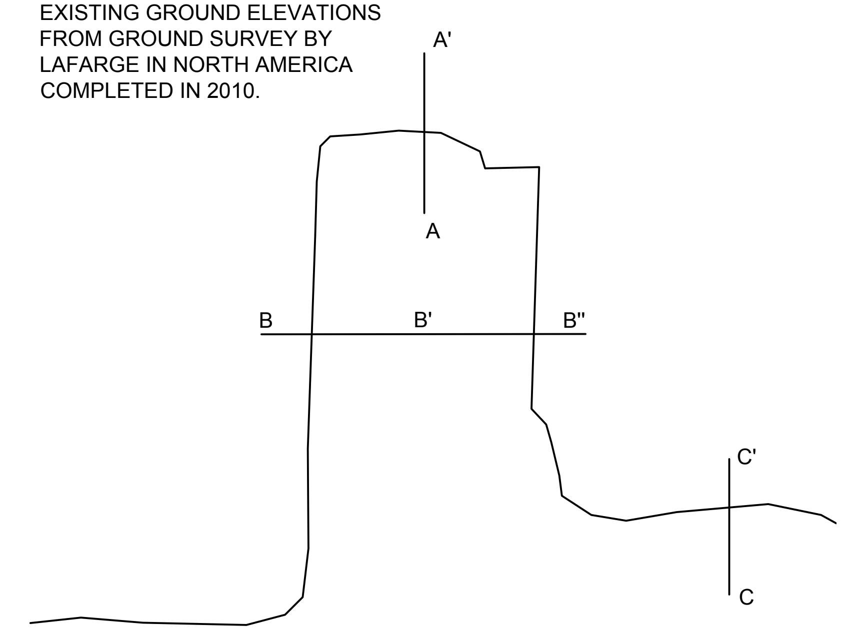


(C) FULL RESTORATION TYPICAL SECTIONS



NOTES
TIDAL DATUMS BASED ON NOAA CRESCENT BAY STATION (#9443826). NAVD88 TO TIDAL CONVERSION BASED ON VDATUM (V. 2.2.7) FOR COORDINATES
MLLW = -0.42 FT NAVD88
MHHW = +6.64 FT NAVD88
EXISTING GROUND ELEVATIONS FROM GROUND SURVEY BY LAFARGE IN NORTH AMERICA COMPLETED IN 2010.

0 20
Scale in Feet



Cross Section Location Schematic (NTS)

PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: CGS
Date: 3/2011

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Section
SITE NAME: **Twin Rivers**
ACTION NAME: **Nearshore Restoration Strategy for Twin Rivers**
PSNERP ID#: **1190**
Partial Restoration

Figure 22-6

Full Restoration Quantity Estimate

Action Name: Twin Rivers
Action #: 1190
Date: February 2011
By: Coastal Geologic Services

REMEDY: ***Remove the rock revetment, sheet pile wall, and approximately 130,000 CY at a derelict 5.6 acre fill area (termed a "mole") to remove the barrier to littoral transport and sediment delivery and also to uncover the interdial***

Construction Period: 22 weeks estimated, however, total time could vary from 14-35 weeks based on size & amount of equipment, also if clay pit could be used for fill and armor disposal, if not haul distance

Item	Unit of Measure	Material Name	Qty	Description of Item	Indicate section of design report where item is described
ACQUISITION AND CONSERVATION				Based on available mapping information	
Required Project Lands	Acre		9	Includes uplands required for site access, staging, and stockpiling	22.2
Proponent / Partner-owned lands	Acre		0	Includes the tidelands under the mole, owned by WA DNR - note that this land overlaps a portion of the lands to be acquired	22.2
Lands To Be Acquired	Acre		9	Includes the mole and uplands	22.2
Material Sites				Not Used: See Earthwork - Imported Fill.	
MOBILIZATION AND ACCESS for construction activities				Description required for each item to facilitate cost estimating	
Mobilization - Typical (Equipment, Personnel, Planning, Financial)	LS		1	Up front costs such as bonding, planning and other staff time and financing. Typically, assume 8% to 10% of other items.	
Mobilization - Remote (Equipment, Personnel, Planning, Financial)	LS		1	Up front cost for nontypical or remote locations. Assume 12% of other items	
Site Access	LS		0	Use for special situations (e.g.. new bridge, new access roads) for the purposes of construction access. Include description.	22.3.1
Barge Access	Days		0	Barge access problemmatic due to appaernet need for dredging over borad shore platform, but could likely be used if deemed advantagous	22.3.1
Temporary Traffic Control (one of the following)					
none	LS				
signs	LS		1%	Very minimal need for signage indicating trucks entering and leaving site	22.3.7
flags / spotters	LS				
unique	LS				
Temporary Roadway	SF		26000	Rehabilitate damaged access road for construction access-Steep road (up to 26%) in wet area that has not been maintained in 15 years	22.3.7
Control of Water	LS		$ 15,000	Water control on steep access road with ditche, culverts, check dams, etc	22.3.7
Relocation Activities				Not Used: See Utilities, Structures	
Site Demolition Activities				Demolition and removal of structures (description required), temporary features and relocations, itemized separately); Clearing and grubbing of vegetation, and removal of minor debris (rocks, slabs) - description required.	
Clearing and Grubbing (one or more of following)					
Clear Vegetation - Local Disposal	AC		0		22.3.7
Clear /Grub Vegetation - Local Disposal	AC		0		
Clear /Grub Vegetation - Offsite Disposal	AC		0		
Clear, stockpile - large woody debris	CY		0		
Hydraulic Structures - Small	LS		0		
Hydraulic Structures - Large	LS		0		
Utilities	LS or LF		0		
Buildings	LS or SF		0		
Pavement	SF		710	Concrete Pad on northeast corner of mole - approximately 6 inches thick	22.3.7
Bulkheads	LF or SF		0		
Rock revetments	CY		8100	Revetments comprised of 3-4+ ft rock in good condition	22.3.7
Large Coastal Structures	LF		425	Approximately 30 ft high steel sheet pile wall with concrete cap. Two inch steel tie-backs to unknown anchor. Stressor: 425 LF of armor	22.3.7
Demolition / Removal - Bridge	SF or CY				
Removal - Misc. (e.g. angular rock from beach)	Ton		0		
Demolition / Removal - Boat Ramp	SF		0		
Haul - Offsite Disposal of Demolition Debris	Miles		20	Placeholder distance, however disposal in clay pit or salvage/re-use may be available.	22.3.7
Hazardous/Contaminated Waste Removal				These items for earthwork of quality not compatible with wetlands, requiring special handling and disposal. Describe basis for classification as contaminated or hazardous. State known or suspected contamination, describe known similar work.	
Contaminated Earthwork	CY		0	Data is missing on presence/absence of contaminated soils for the site	22.6
Hazardous Earthwork	CY		0	Not likely at site	
Construct Temporary Features				Use as needed for unusual temporary features not included elsewhere (see TESC below)	
EARTHWORK					
Excavation				Per yard excavation w/out expected haul	
Excavation - Upland	CY		65500	Remove entire volume of fill from bluff toe waterward, reportedly comprised of clay, sand, and pea gravel in unknown proportion. Upper half of fill will require low ground pressure equipment	22.3.7
Excavation - Lowland	CY		65500	Remove entire volume of fill from bluff toe waterward, reportedly comprised of clay, sand, and pea gravel in unknown proportion. Lower half of fill will require low ground pressure equipment	22.3.7
Dredging - Bucket - Land	CY		0		
Dredging - Bucket - Marine	CY		0		
Dredging - Hydraulic	CY		0		
Fine Grading	AC		0		
Fill Placement - local borrow			0		
Side cast	CY		0		
Haul - uncontrolled placement	CY		0		
Haul, place, compact	CY		0		
Stockpile - uncontrolled placement	CY		0		
Stockpile - controlled placement	CY		0		
Conveyor placement from stockpile land/water	CY		0		
Imported Fill					
Select Fill	CY		0		
Gravel Borrow, including haul	CY		0		
Sand / Gravel for Beach Nourishment	CY		0		
Cobble for Shore Nourishment	CY		0		
Embankment Compaction	CY		0		
Topsoil	CY		0		
RESTORATION Features					
Channel Rehab / Creation	SF		0		
Large Wood Placement	EA		0		
Invasive Species Control	Acre		0		
Physical Exclusion Devices	LF or EA		0		
Other Restoration Features/ Activities	LS		0		
Structures	EA			KPFF to provide additional inputs	
Water Control Structures - Culverts with Gates	EA		0		
Water Control Structures - Weirs	EA		0		
Rock Slope Protection	LF		0		
Other	EA		0		
Elevated Boat Ramp	SF		0		
Fencing	SF		0		
Utilities					
Water	LF		0		
Gas	LF		0		
Electric	LF		0		
Sewer	LF		0		
Telecommunications	LF		0		
Other	LF		0		
Roadway / Railway					
Roadway (Type_)	SF		0		
Roadway - Traffic Signal	LS		0		
Culvert (type)	LF		0		
Culvert - Jacking	LF		0		
Culvert - Horizontal Pile Driving	LF		0		
Bridge - Foundations, Deck and appurtenances	SF		0		
Railway - Box Girder	SF		0		
Railway - Foundation	LF		0		
Railway - Shoe fly	LF		0		
Permanent Access Features					
Roads	Level		0		
Utility Access Routes	varies		0		
Erosion Control Features	L.F.		0		
Public Access or Recreation Features					
Trails	SF		0		
Bridges	SF		0		
Kiosk	EA		0		
Restrooms	EA		0		
Interpretive Signs	EA		0		
Parking Area	SF		0		
Other	EA		0		
Vegetation & Erosion Control					
Hydroseeding	AC		0	NOTE: we want the mole (fill soils) to erode	
Planting	AC		0		
Vegetation Maintenance	AC-YR		0		
Erosion / sediment BMPs - Temp.	AC		0		
Erosion / sediment BMPs - Permanent	AC		0		
Waterside controls - Temporary	EA, LF, LS		0		
Construction Management					
Construction oversight	weeks		22	Total time could vary from 14-35 weeks based on size & amount of equipment, also if clay pit could be used for fill and armor disposal, if not haul distance	
Materials testing				Included in cost of material - no separate quantity	
Design and Detailed Site Investigations					
Survey & Property, Utility Research	LS		1	% of construction cost	22.8
35% Design	LS		1	35% x 25% x Engineer's Estimate	22.8
65% design	LS		1	65% x 25% x Engineer's Estimate less the cost for 35% PS&E	22.8
90% design	LS		1	35% x 25% x Engineer's Estimate less the cost for 35% + 65%PS&E	22.8
100% design	LS		1	25% x Engineer's Estimate less previous costs	22.8
Geotechnical Studies			1	Refer to design report for description of need	22.8
Cultural Studies			0		
Contaminated sediment study			1	Refer to design report for description of need	22.8
Project Agreement Activities				Unable to provide credibale estimate at 10% design	
Site-Specific Adaptive Management Features & Activities				List if known	
Monitoring Activities				Assume 5 crew-days/year for each monitoring parameter in design report for 5 yrs	
Monitoring (Type_)	crew-days		150		
Operations & Maintenance				Unable to provide credible estimate at 10% design	

Partial Restoration Quantity Estimate

Action Name: Twin Rivers
Action #: 1190
Date: February 2011
By: Coastal Geologic Services

REMEDY: Remove the rock revetment and sheet pile wall surrounding a derelict 5.6 acre fill area (termed a "mole") to remove the barrier to littoral transport and sediment delivery, and also to uncover intertidal
Construction Period: 6 weeks estimated for full armor excavation, and haul off site, however, total time could vary from 4-12 weeks based on size & amount of equipment, also if clay pit could be used for armor disposal, and if not haul distance

Item	Unit of Measure	Material Name	Qty	Description of Item	Indicate section of design report where item is described
ACQUISITION AND CONSERVATION				Based on available mapping information	
Required Project Lands	Acre		9	Includes uplands required for site access, staging, and stockpilir	22.2
Proponent / Partner-owned lands	Acre		0	Includes the tidelands under the mole, owned by WDNR - note that this land overlaps a portion of the lands to be acquired	22.2
Lands To Be Acquired	Acre		9	Includes the mole and upland:	22.2
Material Sites				Not Used: See Earthwork - Imported Fill.	
MOBILIZATION AND ACCESS for construction activities				Description required for each item to facilitate cost estimating	
Mobilization - Typical (Equipment, Personnel, Planning, Financial)	LS		0	Up front costs such as bonding, planning and other staff time and financing. Typically, assume 8% to 10% of other items.	
Mobilization - Remote (Equipment, Personnel, Planning, Financia	LS		1	Up front cost for nontypical or remote locations. Assume 12% of other items	
Site Access	LS		0		22.3.1
Barge Access	Days		0	Barge access problemmatic due to appaernet need for dredging over borad shore platform, but could likely b used if deemed advantagous	22.3.1
Temporary Traffic Control (one of the following)					
none	LS				
signs	LS		1	Very minimal need for signage indicating trucks entering and leaving site	22.3.7
flags / spotters	LS		0		
unique	LS		0		
Temporary Roadway	SF		26000	Rehabilitate damaged access road for construction access-Steep road (up to 26%) in wet area that has not been maintained in 15 years	22.3.7
Control of Water	LS		$ 12,000	Water control on steep access road with ditche, culverts, check dams, etc	22.3.7
Relocation Activities				Not Used: See Utilities, Structures	
Site Demolition Activities				Demolition and removal of structures (description required), temporary features and relocations, itemized separately); Clearing and grubbing of vegetation, and removal of minor debris (rocks, slabs) - description required.	
Clearing and Grubbing (one or more of following)					not discussed, but shown on plans
Clear Vegetation - Local Disposa	AC		1		22.3.7
Clear /Grub Vegetation - Local Disposal	AC		0		
Clear /Grub Vegetation - Offsite Disposal	AC		0		
Clear, stockpile - large woody debris	CY		0		
Hydraulic Structures - Smal	LS		0		
Hydraulic Structures - Large	LS		0		
Utilities	LS or LF		0		
Buildings	LS or SF		0		
Pavement	SF		710	Concrete Pad on northeast corner of mole - approximately 6 inches thic	
Bulkheads	LF or SF		0		22.3.7
Rock revetments	CY		8100	Revetments comprised of 3-4+ ft rock in good condition, could liely be reused/salvage sale; volume approximate based on field measurements and ground survey. Stressor: 1,375 LF of armor remov	22.3.7
Large Coastal Structures	LF		425	Approximately 30 ft high steel sheet pile wall with concrete cap. Two inch steel tie-backs to unknown anchor, reprtedely creosoted wood. Stressor 425 LF of Armor remova	22.3.7
Demolition / Removal - Bridge	SF or CY				
Removal - Misc. (e.g. angular rock from beach)	Ton		0		
Demolition / Removal - Boat Ramp	SF		0		
Haul - Offsite Disposal of Demolition Debris	Miles		30	Approximate distance, however closer disposeal/slavage may be availab	22.3.7
Hazardous/Contaminated Waste Removal					
Contaminated Earthwork	CY		0	Data is missing on presence/absence of contaminated soils for the sit	22.6
Hazardous Earthwork	CY		0	Not likely at site	1.3.3
Construct Temporary Features				Use as needed for unusual temporary features not included elsewhere (see TESC below)	
EARTHWORK				Expand to include equipment, etc. to facilitate cost estimating.	
Excavation				Per yard excavation w/out expected haul	
Excavation - Uplanc	CY		0		
Excavation - Lowlanc	CY		0		
Dredging - Bucket - Land	CY		0		
Dredging - Bucket - Marine	CY		0		
Dredging - Hydraulic	CY		0		
Fine Grading	AC		0		
Fill Placement - local borrow			0		
Side cast	CY		0		
Haul - uncontrolled placement	CY		0		
Haul, place, compact	CY		0		
Stockpile - uncontrolled placement	CY		0		
Stockpile - controlled placemen	CY		0		
Conveyor placement from stockpile land/water	CY		0		
Imported Fill				Includes purchase, delivery and placement or as noted / described	
Select Fill	CY		0		
Gravel Borrow, including haul	CY		0		
Sand / Gravel for Beach Nourishment	CY		0		
Cobble for Shore Nourishment	CY		0		
Embankment Compaction	CY		0		
Topsoil	CY		0		
RESTORATION Features					
Channel Rehab / Creatior	SF		0		
Large Wood Placement	EA		0		
Invasive Species Control	Acre		0		
Physical Exclusion Devices	LF or EA		0		
Other Restoration Features/ Activities	LS		0		
Structures	EA				
Water Control Structures - Culverts with Gates	EA		0		
Water Control Structures - Weirs	EA		0		
Rock Slope Protection	LF		0		
Other	EA		0		
Elevated Boat Ramp	SF		0		
Fencing	SF		0		
Utilities					
Water	LF		0		
Gas	LF		0		
Electric	LF		0		
Sewer	LF		0		
Telecommunications	LF		0		
Other	LF		0		
Roadway / Railway					
Roadway (Type_)	SF		0		
Roadway - Traffic Signal	LS		0		
Culvert (type)	LF		0		
Culvert - Jacking	LF		0		
Culvert - Horizontal Pile Driving	LF		0		
Bridge - Foundations, Deck and appurtenances	SF		0		
Railway - Box Girder	SF		0		
Railway - Foundation	LF		0		
Railway - Shoe fly	LF		0		
Permanent Access Features					
Roads	Level		0		
Utility Access Routes	varies		0		
Erosion Control Features	L.F.		0		
Public Access or Recreation Features					
Trails	SF		0		
Bridges	SF		0		
Kiosk	EA		0		
Restrooms	EA		0		
Interpretive Signs	EA		0		
Parking Area	SF		0		
Other	EA		0		
Vegetation & Erosion Control					
Hydroseeding	AC		0	NOTE: we want the mole (fill soils) to erode	
Planting	AC		0		
Vegetation Maintenance	AC-YR		0		
Erosion / sediment BMPs - Temp	AC		0		
Erosion / sediment BMPs - Permanent	AC		0		
Waterside controls - Temporary	EA, LF, LS		0		
Construction Management					
Construction oversight	weeks		6	Total time could vary from 4-12 weeks based on size & amount of equipment, also if clay pit could be used fo armor disposal, and if not haul distance	
Materials testing					
Design and Detailed Site Investigations					
Survey & Property, Utility Research	LS		1	% of construction cost	22.8
35% Design	LS		1	35% x 25% x Engineer's Estimate	22.8
65% design	LS		1	65% x 25% x Engineer's Estimate less the cost for 35% PS&E	22.8
90% design	LS		1	35% x 25% x Engineer's Estimate less the cost for 35% + 65%PS&E	22.8
100% design	LS		1	25% x Engineer's Estimate less previous costs	22.8
Geotechnical Studies			1	Determine mole fill composition and possible fate in the nearshore, possibility of access road rehabilitation	22.8
Cultural Studies			0		
Contaminated sediment study			1	Needed to determine if fill soils is clean or contaminated	22.8
Project Agreement Activities				Unable to provide credibale estimate at 10% design	
Site-Specific Adaptive Management Features & Activities				List if known	
Monitoring Activities				Assume 5 crew-days/year for each monitoring parameter in design report for 5 yrs	
Monitoring (Type_)	crew-days		150		
Operations & Maintenance				Unable to provide credible estimate at 10% design	

23. NOOKSACK RIVER DELTA (#1055)

Local Proponent	Whatcom Action Area Local Integrating Organization
Delta Process Unit	Delta NKS
Shoreline Process Unit(s)	SPUs 7175, 7146
Strategy(ies)	1 – River Delta
Restoration Objectives	Remove levees and roads to restore hydrologic and sediment processes to a substantial portion of the historical Nooksack River delta

23.1 Description of the Action

This action removes levees, roads and other barriers to restore water and sediment processes throughout the historical Nooksack River delta. Project elements would restore fluvial processes and enhance tidal hydrology to both the east (Nooksack River) and the west (Lummi River) sides of the delta; restore formerly drained and filled channels and sloughs through excavation; remove and/or relocate levees and berms to increase floodplain inundation and allow for channel migration, and restore sediment dynamics; and modify existing roads and other infrastructure such as bridges. Please see the Introduction chapter for important information regarding PSNERP and for context related to this restoration project.

23.2 Action Area Description and Context

This action area is centered on the Lummi Reservation north of Bellingham in the San Juan/Georgia Strait Subbasin. It encompasses nearly all of the Nooksack and Lummi River Estuaries below Ferndale, Washington. The action area is shown in Figure 23-1.

Figure 23-1. Action Area and Vicinity

23.2.1 Historic Condition

The Nooksack River delta is relatively young in geologic terms. The current course of the Nooksack River probably follows the alignment a former avulsion channel of the Fraser River system, with the Nooksack's capture of this alignment likely occurring in the Holocene epoch. The Nooksack River has progressively built its delta toward and around the Lummi Peninsula, and included distributary channels that discharged water to both Lummi and Bellingham Bays. The distributary channel flowing to the west of the Lummi Peninsula into Lummi Bay is termed the Lummi River, and the mainstem Nooksack River flows along the east side of the peninsula into Bellingham Bay. The course of the main river has alternated to either side of the Lummi Peninsula, altering the balance of freshwater and sediment delivery over time (Collins and Sheikh 2003).

Historical maps are provided in Figures 23-2A and 23-2B. Prior to 1860, most fresh water flowed west of the Lummi Peninsula through the Lummi River, with the split moderated to some extent by the presence of a significant log jam (the Portage Jam). The dominant westerly flow path is captured in mapping (circa 1856-1858) of the boundary between the United States and British possessions (Collins and Sheikh 2003). Active removal of large wood, draining, diking, and levee construction forced almost all flow to the east side of the delta. The diversion of flow from Lummi Bay to Bellingham Bay occurred around 1860, when a log jam near what is now the City of Ferndale blocked the Nooksack River and diverted it to a small stream that flowed into Bellingham Bay. Since around 1860, the Nooksack River has flowed to Bellingham Bay because of the construction of a dam across the headwaters of the Lummi River (Collins and Sheikh 2003). This shift of the lower Nooksack River virtually eliminated migration of stream channels over the Lummi delta (Bortleson et al. 1980).

The mainstem Nooksack River currently flows into Bellingham Bay on the east side of the Lummi Peninsula, and the alignment is enforced with levees. Substantial progradation of the delta has occurred since the 1880s mapping.

Early General Land Office mapping (circa 1887-1888) shows that significant meandering channels and intertidal habitats existed on both sides of the Lummi Peninsula. Estuarine wetlands were much more extensive on the Lummi River side, potentially reflecting the progradation of the west side when the main channel aligned to the west (Collins and Sheikh 2003). Bearing tree data suggest that red alder was the most common tree on the historical delta, followed by willow and crab apple. Sitka spruce was less common, but larger diameters suggest that this species had the most basal area on the delta (Collins and Sheikh 2003).

Collins and Sheikh (2003) estimated general losses of wetland types using mapping from 1880 and 1998. These estimates indicate substantial losses of palustrine (freshwater) and estuarine wetlands. The modern “winter inundation area” is around 5% of the historical condition, and “summer inundation” about 1% of the historical area. The area of estuarine wetland is estimated to be about 30% of the historical condition (Collins and Sheikh 2003).

23.2.2 Natural Environment

The Nooksack River drains approximately 825 square miles from Mount Baker to Bellingham Bay within WRIA 1. The mainstem Nooksack River has three major forks that converge as they exit the Cascade Mountain foothills. The Nooksack River formerly divided into distributary channels in the delta; however, the mainstem is now directed to flow east of the Lummi Peninsula, and is constrained by levees for much of its length. Freshwater flow into the Lummi River distributary channel is essentially eliminated except for flow through a culvert (above 9,600 cfs). The river’s mainstem occasionally overtops the levees. Several smaller tributary channels join the Nooksack River on its left bank within the delta. Most of these connections have been altered by channelization, but previous restoration efforts to improve habitat conditions have occurred.

The west side of the delta currently receives much less freshwater flow from the Nooksack River and has also been separated from tidal influence by the levee system. The Lummi River has full tidal access but is essentially a blind channel because it is separated from the mainstem Nooksack River by a levee, and only receives intermittent mainstem flow through the aforementioned culvert. The Lummi River receives freshwater inflows from Shell Creek, which drains portions of the City of Ferndale to the north. Most of the former western delta wetlands are separated from tidal influence by a levee system along the Lummi River and levees and tide gates in other areas. Forest cover has been almost entirely eliminated from the western delta. Riparian forest along the mainstem and forested areas within the progradating delta occur on the eastern portion of the delta.

The Nooksack River system supports nine species of salmonids, including three listed under the Endangered Species Act: early Chinook, steelhead, and bull trout. Only three of the 25 salmonid stocks in WRIA 1 are currently considered healthy (Smith 2002). The Nooksack River is one of five geographic areas considered essential for recovery of the Puget Sound Environmentally Significant Unit.

23.2.3 Human Environment

Significant human changes to the Nooksack River delta action area include:

1. A road network, with the major roads including Slater Road, Ferndale Road, North Red River Road, South Red River Road, Marine Drive, Kwina Road, Hillaire Road, and Haxton Way.
2. Conversion to agriculture (field crops, poplar plantations, and pasture).
3. Low-density residential development.
4. Levees constructed along the mainstem Nooksack River and Lummi River.
5. A seawall and berm system in the west delta.
6. Tide gates installed on channels and the Lummi River in the west delta.
7. Land use conversion to commercial (gas station/minimart, Silver Reef Hotel, Casino, Spa).

The results of these changes are altered land cover throughout the majority of the historical delta; tidal and fluvial processes (related to both flow and sediment) that are muted and eliminated, respectively; and altered sediment delivery to river floodplains and the nearshore.

The Lummi Indian Reservation is composed of a northwestern upland area (which includes the Sandy Point Peninsula), the Lummi River and Nooksack River floodplain, a southern upland area known as the Lummi Peninsula, Portage Island, and the surrounding tidelands extending to extreme lower low water. Portions of the floodplain located adjacent to the Reservation boundary are owned by private individuals, the Lummi government, Washington State, or Whatcom County government.

Substantial surface water diversions, groundwater withdrawals, and drainage activities within the Nooksack River watershed impact the magnitude, timing, and duration of surface water flows in the Nooksack River. The primary diversions that transfer water out of basin are the Middle Fork diversion operated by the City of Bellingham, and two points of diversion in the lower river that are operated by Whatcom County PUD No. 1 to supply the three major industries (two petroleum oil refineries and an aluminum smelter) within the Heavy Impact Industrial Zone of Cherry Point. There are also numerous consumptive water uses by the agricultural community during the summer months when flows in the river are also typically at the lowest levels.

Water quality problems in the Nooksack River and/or its tributaries include elevated fecal coliform levels, elevated water temperatures, and high sediment loads. Overbank flooding is common on the lower Nooksack River delta. Numerous flood events within the delta have resulted in transportation delays and damaged residences, notably in the Marietta community. The existing levees in the lower Nooksack River delta typically provide less than a 10-year level of protection. The low lying roads, particularly Marine Drive, Kwina Road, Haxton Way, Hillaire Road, and Slater Road, are susceptible to flooding. These roads provide the only access to portions of the Lummi Indian Reservation, and the only access to the Lummi Island ferry terminal located on the Lummi Peninsula.

The Lummi Nation has operated an aquaculture facility along the west side of the Lummi Peninsula since the early 1970s. The 750-acre Seaponds Aquaculture Facility extending into Lummi Bay is clearly evident on aerial photographs and USGS topographic maps of the area. The original purpose of the enclosure was to support a pan-sized salmon production facility, but this operation was unsuccessful due to temperature extremes that characterize the site. The Seaponds Aquaculture Facility is now used for a salmon hatchery, a shellfish hatchery, shellfish rearing, and to support ceremonial, subsistence, and commercial shellfish harvests by Lummi Tribal members.

The Marietta community consists of residential homes at the southeastern corner of the Nooksack River delta, south of Marine Drive. This community has experienced repetitive losses during past flood events. Many potential restoration measures would change the timing and stage of flood events in this area.

23.3 Restoration Design Concept

23.3.1 Restoration Overview and Key Design Assumptions

The conceptual restoration plan for the Nooksack River delta has the following main elements (Figures 23-3 through 23-11):

- Levee removal.
- Channel creation and rehabilitation.
- Hydraulic modifications.
- Substantial property acquisition.
- Alterations to bridges and other transportation elements.
- Underplanting of conifer trees.
- Invasive weed control/management.

The overall intent of both the full and partial restoration alternatives is to restore natural hydrologic, sediment, and ecological processes to a substantial portion of the Nooksack delta. In the full restoration alternative, this goal is to be accomplished by removal of levees, and regrading the Lummi River to allow for a more dynamic flow and sediment split between the two rivers. The full restoration alternative will also include removing a number of existing roads and replacing existing bridges with longer spans. Substantial property acquisition would be required to implement the full restoration alternative.

The partial restoration alternative is intended to build upon the past and ongoing efforts of the local proponents to the extent possible. The partial restoration alternative includes project elements previously designed by others, including:

- Slater Road Improvements (DEA 2007)

- Hillaire Road Improvements (nhc and RH2 2009)
- Marine Drive Reconstruction (nhc and RH2 2010)

Partial restoration is also intended to allow for the implementation of the proposed Lummi Nation Wetland and Habitat Bank (Lummi Nation 2008). For completeness and to show all of the ecosystem changes that would occur, elements of the proposed bank are included here, shown on the plans, and captured in the quantities. It is understood that these elements would need to be performed by the Lummi Nation, and would not be implemented as part of a federally funded restoration project.

Levee Removal and Levee Breaches

The levees/berms along the Nooksack River and the plugging of the Lummi River channel have eliminated important floodplain slough and distributary channel habitats, and eliminated or greatly reduced key geomorphic processes. The removal and setback of levees along the Nooksack River would restore these geomorphic processes (Figures 23-7 and 23-8). In the short term, this includes the connection of the river and tidal areas to the floodplain/marsh. In the longer term, the removal/setback of the levees would decrease the relative amount of stream power constricted within the presently leveed reach of the river, with a resultant increase in sediment deposition in the channel and floodplain. Sediment deposition—in conjunction with engineered log jams that would cause hydraulic constrictions—would increase stage relative to discharge. This is desirable in increasing the connection of the Lummi River to the Nooksack River at progressively decreasing discharge levels through time. Optimally, the Lummi River would become connected to the Nooksack River at all discharge levels.

Levee removal (full restoration alternative) and levee setback (partial restoration alternative) on the *right* bank (when facing downstream) of the Nooksack River would achieve similar hydrologic and hydraulic outcomes. However, the magnitude of the outcomes (hydraulic and geomorphic; short- and long-term) is not well understood because of the lack of hydrodynamic modeling for these alternatives. Alignment of the levee setback for the partial restoration alternative would be optimized during subsequent modeling. In the absence of modeling data, the design concept assumes a setback alignment along Ferndale Road, which is consistent with the local proponents' existing plans. Figures 23-19 and 23-10 provide cross sections of levee removal and channel excavation for each alternative.

Levee removal (full restoration alternative) and strategic levee breaches (partial restoration alternative) on the *left* bank of the Nooksack River have issues and outcomes similar to that of the right-bank measures. However, the magnitude of the desired hydraulic response and the rate of longer term evolution of the river and floodplain are difficult to assess without modeling.

There is some risk that the levee breaching identified in the partial restoration alternative may not provide the hydraulic response needed to restore geomorphic processes. Thus the volume estimates conservatively assume that nearly 60% of the levee length must be removed, even though some hydraulic studies (Whatcom County Department of Public Works 1999) suggest that floodwaters access the left-bank floodplain upstream of the action area. Subsequent design may determine that removing and/or breaching the levees in phases may be beneficial in balancing the need to connect the water surface elevation of the Nooksack River to the Lummi River channel with the need to aggrade the Nooksack River channel to engage the Lummi distributary channel at progressively lower discharge levels. Such balancing would be assessed via later modeling.

Removing the levees from the Lummi River delta would restore tidal flux to the western portion of the delta. In the full restoration alternative, all levees west of the seapond would be removed (Figure 23-5). The seapond is assumed to remain in both alternatives. In the full restoration alternative, access would be supported by one access road from the east, and the partial restoration alternative would maintain existing access from Hillaire and Kwina Roads. In the partial restoration alternative, portions of the levee system west of the Lummi River would be breached, and the existing tide gates on the levee east of the Lummi River would be replaced with self-regulating tide gates or similar (Figure 23-6). The self-regulating tide gates would be designed to allow substantial tidal flux during normal flow conditions, but would remain closed during storm events. Under the full restoration alternative, the golf course west of the Lummi River would be decommissioned. A setback levee to protect the golf course would be installed in the partial restoration alternative.

Channel Creation and Rehabilitation

The Lummi River would be regraded to allow for much more frequent engagement by fluvial flows from the upper watershed. The existing Lummi River appears to be perched on “delta cone” sediments remnant from when most of the flow was directed west to Lummi Bay. Further, the mainstem Nooksack River has been leveed, and flow into the Lummi River is via a relatively small culvert.

Connecting the Nooksack River with the Lummi River would enable distributary flow into the Lummi River at essentially all discharge levels to provide a sustained freshwater connection to enhance water quality and increase habitat. Because the head of the Lummi River channel is substantially disconnected from the Nooksack River channel, the connection to the river includes rehabilitation of the Lummi River channel to more closely approximate that of the Nooksack River. If actions to include flow into the Lummi River distributary channel at lower discharge levels are not taken, the restoration benefits would be much more transitory and limited to periods when the Nooksack River is flooding. This may or may not coincide with times when water quality in the Lummi River would be substantially improved by upstream inputs of fresh water.

The full restoration alternative (Figure 23-7) would include a full breach in the right bank of the Nooksack River sufficient to open an unobstructed connection to the Lummi River channel. The partial restoration alternative (Figure 23-8) would include an engineered side weir (or similar) structure in the right-bank levee of the Nooksack River to allow some flow into the Lummi River. To account for potential future changes in the stage/discharge relationship of the Nooksack River at this location, the weir structure would likely include some level of adjustment so that only the allowable discharge levels for which the downstream channel is designed are conveyed into the Lummi River.

The full restoration alternative’s breach in the right bank of the Nooksack River would need to connect to the Lummi River in a manner that allows flows to pass down the Lummi River at times of lower discharge levels. This would likely require excavating the upper reaches of the Lummi River (from approximately Slater Road upstream to the head of Lummi River) to lower the channel invert to achieve connectivity at lower discharges.

The existing Lummi River has been highly modified in the last 150 years, including straightening and narrowing the channel. In its upstream extent the Lummi River is very small (the field estimates suggest it may only convey approximately 150 cfs or less) and would be rehabilitated (enlarged) for either the partial or full restoration alternative. The full restoration alternative would therefore include channel expansion and floodplain grading to promote geomorphic processes and create habitat; at higher discharge levels flows would exceed this channel capacity and flood across the delta. The partial restoration alternative would also include lowering the Lummi River channel in its upper reaches, as well as grading and channel expansion to increase geomorphic processes and create habitat. The key difference is that the partial restoration alternative would include setback levees and floodplain grading sized to confine Nooksack River overflow to within the Lummi River floodway without flooding across the delta.

Modifications to the Transportation System

Roads through the Nooksack River delta provide key transportation connections to portions of the Lummi Indian Reservation, and the only access to the ferry to Lummi Island. It is necessary to modify much of the existing system of bridges and roads through the delta to allow for successful restoration of water and sediment processes. Modifications to roads and bridges on the delta east of Ferndale Road include: Ferndale Road at the Lummi River, Slater Road at the Lummi River and Nooksack River, and Marine Drive between the Nooksack River and the Lummi Peninsula (Figures 23-7 and 23-8). Modifications on the west side of the delta include Hillaire Road at the Lummi River, Imhoff Road at the Lummi River, Haxton Way at Smuggler's Slough, and Kwina Road at Smuggler's Slough (Figures 23-5 and 23-6).

In general, bridges with larger spans would be added to allow for channel migration and greater flood flow conveyance and transfer. New bridges would be 44 feet wide, with two to six span lengths ranging from 110 to 150 feet, and 6-foot-6 inch-deep pre-cast concrete girders (Figure 23-11). Typical bridge lengths range from 220 to 800 LF. New roadways would have two 12-foot lanes with two 8-foot shoulders (Figure 23-11).

For the full restoration alternative, bridge spans over the Lummi River (Ferndale, Imhoff, Slater Roads, and Haxton Way) were sized to allow full avulsion of the Nooksack River into the new channel. Bridges over sloughs (Haxton Way and Kwina Road) were sized to achieve a free-flowing condition to achieve the highest level in the hierarchy of openings (Appendix C).

In the partial restoration alternative, bridge spans over the Lummi River were sized to match the proposed levee setback and channel geometry to be controlled by the engineered weir on the mainstem Nooksack River. For partial restoration, the bridge spans and box culverts on Tennant Creek and Kwina Slough on Marine Drive were developed based on previous plans, which are assumed to be based on site-specific hydraulic investigations (DEA 2007, nhc and RH2 2010). In partial restoration, the Kwina Slough bridge span was assumed to be half the width of the full restoration alternative. Key design elements associated with the full and partial restoration alternatives are identified below in Table 23-1. The differences between the two alternatives relate to the level of protection in relation to flooding. The full alternative would subject the entire Nooksack delta to flooding. This includes active businesses, residences, farms, and critical transportation infrastructure. Much of the floodplain is within the boundaries of the Lummi Indian Nation's reservation. For these reasons, the full restoration alternative was determined to be not socially acceptable. The partial restoration alternative achieves significant restoration benefits without the high social/economic costs of the full alternative.

The full alternative effectively pulls the perimeter of flood protection from its existing position back to approximately Slater Road. In the full alternative, the number of transportation corridors from the surrounding uplands to the peninsula is reduced to two: Marine Drive and Haxton Way, but these would be designed to provide access during major flood events. The full alternative would also re-engage dynamic channel processes within the Lummi River, and would remove controls that now prevent channel avulsion from the mainstem.

The partial alternative sets back the flood protection perimeter, but preserves flood protection for a significant portion of the central delta. The partial alternative preserves the existing transportation corridors. The Lummi River would receive more flow than under current conditions, but controls would be installed to prevent full channel avulsion from the mainstem.

Table 23-1. Key Design Elements

Element	Full Restoration Alternative	Partial Restoration Alternative
Levee Modification		
Right Bank Nooksack River	Full removal from the head of the Lummi River to near Kwina Slough	Levee setback to Ferndale Road alignment between Slater Road and Marine Drive Strategic (approximately 60%) removal from the head of the Lummi River to near Kwina Slough
Left Bank Nooksack River	Full removal from near Slater Road to Marine Drive	Strategic removal/breaching of approximately 60% of the length from near Slater Road to Marine Drive
Lummi River (both banks)	Full removal; channel and floodplain rehabilitation to increase fluvial and tidal processes	Strategic removal and setback, with channel and floodplain reconfiguration to enhance channel capacity and improve geomorphic processes
Golf Course Setback Levee	Not included- golf course is decommissioned	Install setback levee to protect golf course on west side of Lummi delta
Channel Rehabilitation		
Upstream Lummi River Connection	Remove levee and culvert; install engineered log jam	Engineered connection to be regulated via weir (with or without operable gates)

Element	Full Restoration Alternative	Partial Restoration Alternative
Lummi River	Dredging to better match invert to water surface elevation of the Nooksack River Rehabilitate channel to remove fill and create surface to encourage geomorphic processes	Similar to full restoration; levees set back to contain flood flows through the Lummi River and preclude flooding of the delta
Tidal Channels in Former Lummi Delta	Comprehensive - fill linear ditches and connect relict channels	Focused in area west of Hillaire Road to Lummi River
Hydraulic Modifications		
Smuggler’s Slough Tide Gates	Remove tide gates at aquaculture pen	Convert flap gate to self-regulating tide gate
Property Acquisition		
Marietta Community	Quantities assume that residential property in the floodplain is purchased outright	Same as full restoration
Transportation Modifications		
Ferndale Road at Lummi River	Remove 900 feet of roadway. Add 400 feet of new roadway New 500-foot-long bridge (four 125-foot spans) Construction Duration: 12 months	Remove 650 feet of roadway. Add 400 feet of new roadway New 250-foot-long bridge (two 125-foot spans) Construction Duration: 10 months
Slater Road at Lummi River	Remove 700 feet of existing road. Add 200 feet of new roadway New 500-foot-long bridge (four 125-foot spans) Construction Duration: 12 months	Remove 450 feet of existing road. Add 200 feet of new roadway New 250-foot-long bridge (two 125-foot spans) Construction Duration: 10 months
Slater Road at Nooksack River	Remove existing road – 6,400 LF. Add 5,600 feet of new road New 800-foot-long bridge (six 133-foot spans) Construction Duration: 18 months	Raise Slater Road per DEA (2007) plans and add 387-foot span on Tennant Creek to allow 100-year flow to pass below the two bridges Include temporary detour route Construction Duration: 18 months

Element	Full Restoration Alternative	Partial Restoration Alternative
Marine Drive	Remove 4,275 feet of existing road. Add 3,500 LF new causeway plus 125 feet of roadway New 650-foot-longbridge (five 130-foot spans) at Nooksack mainstem New 220-foot-long bridge (two 110-foot spans) at Kwina Slough. Construction Duration: 26 months	Raise road and add box culverts per nhc and RH2 plans
Hillaire Road at Lummi River	Remove existing crossing and road (26,000 SF) Construction Duration: 5 months	Remove 40,600 SF of roadway. Add 200 feet of new roadway New 450-foot bridge (three 150-foot spans) Construction Duration: 12 months
Imhoff Road at Lummi River	Remove 650 feet of existing road. Add 150 feet of new roadway New 500-foot-long bridge (four 125-foot spans) Construction Duration: 12 months	Remove 400 feet of existing road. Add 400 feet of new roadway New 250-foot-long bridge (two 125-foot spans). Construction Duration: 10 months
Haxton Way	Remove existing road (2,900 LF) New 450-foot-long bridge (three 150-foot spans) over Lummi River Add 1,200-foot-long causeway New 500-foot-long bridge (four 125-foot spans) over Smuggler's Slough Construction Duration: 20 months	Remove 1,300 feet of existing road. Add 200 feet of new road New 450-foot-long bridge (three 150-foot spans) over Lummi River No change at Smuggler's Slough Construction Duration: 10 months
Kwina Road at Smuggler's Slough	Remove 700 feet of existing road. Add 200 feet of new roadway New 500-foot-long bridge (four 125-foot spans) Construction Duration: 12 months	Remove 650 feet of existing road. Add 400 feet of new roadway New 250-foot-long bridge (two 125-foot spans) Construction Duration: 10 months

23.3.2 Restoration Features – Primary Process-Based Management Measures

Armor Removal/Modification

Rock armoring is part of the seaward levee on the Lummi River delta. Under both alternatives, this rock would be removed as part of levee removal. In the partial alternative, although not all of the levee is proposed for removal, all of the rock armoring will be removed to allow for more rapid site evolution.

Berm or Dike Removal/Modification

Levees are proposed to be removed from both the mainstem Nooksack River and the Lummi River and delta. For the mainstem Nooksack River, removal of levees would increase connectivity between channel and floodplain, and encourage natural channel processes. The full restoration alternative would remove the entire levee from the head of the Lummi River to Marine Drive (Figures 23-7 and 23-9). The partial restoration alternative would remove approximately 60% of the levee system from Slater Road to Marine Drive (Figures 23-8 and 23-10).

To assist the development of the Nooksack to Lummi River transition, engineered log jams would be added to increase water surface elevations in the channel at any particular discharge, and to force flows out onto the floodplain to decrease channel efficiency and encourage sediment deposition in the channel and floodplain.

On the Lummi River and delta, levee removal is intended to provide for full tidal flux into the delta. The full restoration alternative would include removal of the entire levee system, which would require substantial excavation and haul (Figure 23-5). It is likely that, if suitable, some or all of the material could be placed on the subsided fields, to accelerate marsh plain development. In the partial restoration alternative, levee breaches and self-regulating tide gates or similar would be installed to allow substantial tidal influence into the delta, with openings sized to allow full tidal channel development (Figure 23-6).

Channel Rehabilitation/Creation

In the full restoration alternative, the Lummi River would be reconnected to the mainstem Nooksack River. This would require levee removal, and grading the existing Lummi River channel to increase conveyance capacity from the head to approximately Slater Road. This channel would be sized to match the conveyance capacity of the lower Lummi River – generally 20 to 25% of the cross sectional area of the mainstem Nooksack River (Figure 23-9).

In the partial restoration alternative, channel excavation would be required in the same reach of the Lummi River, but the volume removed would be smaller (Figure 23-10). The channel connection to the mainstem would take the form of a weir that would increase conveyance over existing conditions, but would limit the high flow volumes that could reach the Lummi River.

On the Lummi River delta, the historical tidal and distributary channel network evident in the topographic sheets has largely been subsumed within a linear ditch system. In both the full and partial restoration alternatives, ditches would be filled and channels excavated along or near historical alignments. Channel creation would be more extensive in the full restoration alternative, and would not include any regulation at the mouth. The tidal channels excavated between Hillaire Road and the Lummi River would be less extensive, and would require tide gates through the remaining levee (nhc and RH2 2009).

Groin Removal/Modification – NA

Hydraulic Modification

The primary hydraulic modification would occur on the Lummi River side of the Nooksack delta. In the full restoration alternative, levee removal would result in full tidal access to the delta. In the partial restoration alternative, self-regulating tide gates or similar (e.g., side-hinge gates) would be required at the end of the slough system to prevent flood damage, but restore tidal action during most conditions.

Access roads and self-regulating tide gates would be installed and upgraded near Hillaire and Kwina Roads to provide ongoing access to the seapond and provide flood protection. Access to the seapond would be provided from the Lummi Peninsula via Kwina Road in the full restoration alternative. For the partial restoration alternative, access to the seapond could occur via Kwina Road and via the relocated North Red River Road to Hillaire Road.

On the Nooksack River, addition of a span at Tennant Creek along Slater Road is intended to allow the 100-year flow to pass unimpeded into the levee removal and setback area downstream.

Overwater Structure Removal – NA

Topography Restoration

Both the full and partial restoration alternatives would require substantial volumes of excavation. Some land subsidence has likely occurred in the diked agricultural lands. Excess excavated materials could be applied in subsided areas and/or in existing borrow ditches to accelerate marsh development. The quantities and areas have not been specified here, but would be determined after geotechnical review to assess the suitability of these materials for reuse in setback levees and road raising, and/or fill of borrow ditches.

23.3.3 Restoration Features – Additional Management Measures

Beach Nourishment – NA

Contaminant Removal/Remediation – NA

Debris Removal – NA

Invasive Species Control

The action area has extensive coverage by reed canarygrass. The reintroduction of salt water to the site is expected to suppress this species in the intertidal area, but no direct measures are proposed. Weed control would be implemented within the revegetation areas.

Additional weed management elements are included in the Lummi Nation Wetland and Habitat Mitigation Bank proposal.

Large Wood Placement

Placement of large wood, in the form of habitat structures and engineered log jams, would be included in the full and partial restoration alternatives. Full restoration would include 350 habitat structures, with 200 structures for partial restoration. Habitat structures would range from 3 to 20 logs per structure (assuming an 18-inch diameter at breast height and a length of 30 feet). Quantity estimates assume an average log count of 12 logs per structure. Sizing and placement of habitat structures would be completed at a subsequent stage of design.

Engineered log jams would be used as a hydraulic obstruction within the rehabilitated river. The log jams would increase upstream water surface elevations to encourage out-of-bank flow and floodplain inundation, and sort sediment and create scour holes (for juvenile rearing and adult holding). In both alternatives, 50 log jams would be placed almost exclusively on the mainstem Nooksack River and grouped in clusters to achieve desired hydraulic effects. Each engineered log jam averages 40 logs (24-inch diameter at breast height and length ranges from 25 to 40 feet); plus an optional 200 logs of racking material (average 9-inch diameter at breast height and a length of 20 feet).

Physical Exclusion – NA

Pollution Control – NA

Revegetation

Portions of the Nooksack River delta would be planted with native tree, shrub, and herbaceous species in both the full and partial restoration alternatives. These locations would be focused on areas where plantings provide a buffer to remaining infrastructure, and in active floodplain areas. The goal would be to achieve more rapid restoration of the riparian floodplain forest.

Reintroduction of Native Animals – NA

Substrate Modification – NA

Species Habitat Enhancement – NA

23.3.4 Restoration Features – Other

In the partial restoration alternative, several measures would be included to preserve access to locations throughout the delta. Setback levees are proposed to preserve lands that are currently used for agriculture. This includes installation of a berm along Hillaire Road, and raising a portion of the access road from Kwina Road to the seapond.

Both the full and partial restoration alternatives involve changing the levee and road system along the Nooksack River in ways that are likely to impact flood stage, timing, and duration. The Marietta community is currently within the floodplain. Changes recommended in either restoration effort have the potential to increase flooding in the area. Therefore, significant property acquisition is proposed for this area. The buildings and street would be removed and replanted to forest.

23.3.5 Land Requirements

Land within the Nooksack River delta is currently held by a variety of public, Tribal, and private entities. Substantial acquisition will be required throughout the delta for either the full or partial restoration alternative. The full restoration alternative would cover approximately 5,552 acres to encompass all of the project elements discussed above. The full restoration alternative would require acquisition of approximately 2,100 acres, primarily in agricultural fields, structures, and the Marietta community.

The partial restoration alternative would cover approximately 3,100 acres. Of that area, 1,085 acres are estimated to be in private ownership.

The Washington Public Lands database did not provide adequate resolution for this analysis, as it considered the entire Lummi Nation Reservation as "public." A Whatcom County dataset labeled "public lands" from 2006 was used as a basis for the acquisition area estimates, but this would need to be refined in future design phases.

23.3.6 Design Considerations

The restoration actions developed for the Nooksack River delta cover a substantial area in a complex hydrologic and hydraulic portion of a large river. The two design alternatives presented here represent two potential approaches to the overall restoration of the delta, but there are many other combinations of approaches that have merit in this situation.

The full restoration alternative represents a robust approach that would allow natural processes to dominate the form and function of both the Nooksack and Lummi Rivers. The partial restoration alternative would allow for much greater extents of aquatic and floodplain habitats, but would retain a level of engineering control that would limit the changes necessary to land use on much of the delta.

A network of transportation corridors has developed over the delta, and much of the area supports active agricultural operations. The full restoration alternative would impact every transportation route within the action area south of, and including, Slater Road. Construction could be phased to allow for continuously available routes to the Lummi Peninsula, but there would be impacts to travel for a significant period of time during construction.

Four roads (Hillaire Road, North Red River Road west of Haxton Way, South Red River Road from Slater Road to Hillaire Road, and Ferndale Road between Slater Road and Marine Drive) would be completely removed in the full restoration alternative. Currently, the seapond access road is used as an emergency access road during significant flood events, allowing access to high ground to the north and west. This route would be removed in the full restoration alternative, and upgrades to other portions of the transportation network would need to be made to preserve emergency access.

The partial restoration alternative has been developed to retain agricultural area, reduce the efforts and costs of changing transportation infrastructure, and be consistent with the existing proposals for the Lummi Nation Wetland and Habitat Mitigation Bank. The existing infrastructure system would remain intact, with the most significant change being realignment of Ferndale Road south of Slater Road. Substantial property acquisition would still be required, especially along the mainstem Nooksack River south of Slater Road. Access to the northwest would be maintained via Kwina Road to a setback berm along Hillaire Road, then to the realigned North Red River Road.

Water quality from the Nooksack River watershed presents a significant design consideration. Fecal coliform bacteria loading from the Nooksack River adversely impacted Portage Bay to the point that shellfish harvesting was halted over the 1996 to 2006 period. A recent increasing trend of fecal coliform densities may argue against sending additional water into the Lummi River, and thence Lummi Bay, due to the resultant potential closure of Lummi Bay shellfish beds to ceremonial, subsistence, and commercial harvest.

Transportation Infrastructure Modifications

At least one route to the Lummi Peninsula would be maintained for traffic. Traffic can be staged to minimize road closure. Bridges with two spans or greater would have a substructure consisting of columns supported on drilled shafts (Figure 23-11). The assumed embedment depths of the drilled shafts are 100 feet. The bridge approaches would have pile-supported abutments. Approaches to bridges will require design to allow for overtopping.

A ballast/fill section would be needed to transition from bridge structure to the existing roadway. The proposed roadways/causeways would meet current design standards and would meet or exceed equivalent capacity.

23.3.7 Construction Considerations

Earthwork would require mobilizing heavy equipment to the site. Access to the site can occur via the existing system of county and farm access roads. Temporary traffic control would be necessary during mobilization and fill removal.

All aspects of the projects would need to be carefully phased to avoid elevated flood risks and in-water work windows. Notably, the setback levee system would need to be in place on both sides of the delta before both: (1) levee removal on the mainstem, (2) allowing additional flow to enter the Lummi River channel, and (3) removing or modifying tidegates on the Lummi delta. Road and bridge elements would need to be phased in a manner that allows for continuous access to and from the Lummi Peninsula.

For bridge construction, a crane positioned on one end of the bridge would be required to set the girders in place. A drilled-shaft oscillator would be used to install the drilled shafts. It is assumed that the contractor would be able to install one shaft per week. In areas near the slough, a large-diameter casing shoring would be required to keep out water and allow access to the top of the shaft for column form placement and removal. Once the shafts are installed, the columns are cast inside the shoring casing. After the casing is removed, the cast-in-place pilecaps and bridge superstructure are constructed.

Concrete bridges require very little maintenance. The current standard is to inspect bridges every 2 years.

23.4 Extent of Stressor Removal

Table 23-2 shows the amount of stressor removal with the full and partial restoration alternatives.

Table 23-2. Stressor Removal

Stressor	Full Restoration Alternative	Partial Restoration Alternative
Tidal Barrier (LF)	30,000 (Lummi delta levees)	11,600 (portions of Lummi delta levees)
Fill (acres)	99 (assumed to be areas excavated for levee removal)	33 (assumed to be areas excavated for levee removal)
Armor (LF)	19,308	19,308
Nearshore Roads (LF)	24,400 (Ferndale Road, Hillaire Road, North and South Red River Roads)	0 (roads are removed, but are relocated to setback levees or similar)

23.5 Expected Evolution of the Action Area

Without restoration, it is anticipated that the Nooksack River would continue to hydraulically simplify (see recent trends documented in Collins and Sheikh 2004). The Lummi River would be hydraulically connected only during flows above approximately 9,600 cfs. The benefits of those flows may be precluded when freshwater inputs to the Lummi River would have the greatest benefits to improving water quality. Tidal channels and floodplain areas would remain leveed and separated from adjacent water bodies. The natural geomorphic and ecologic processes of floodplain inundation would continue to be substantially reduced or eliminated.

Both the full and partial restoration alternatives are expected to rehabilitate channel and floodplain sediment deposition processes, slowly reversing the channel simplification of the last approximately 150 years. This would rehabilitate floodplain inundation processes and improve the connection with Lummi River at progressively lower discharge levels. As mentioned above, subsequent design phases may determine that partial and/or phased breaching of the left-bank levees on the Nooksack River may be beneficial in balancing the need to connect the water surface elevation of the Nooksack River to the Lummi River with the need to aggrade the channel of the Nooksack River to engage the Lummi distributary channel at progressively lower discharge levels.

23.6 Uncertainties and Risks

A LiDAR-based topographic surface model was used in developing these restoration concepts. However, in areas obscured by thick vegetation and for smaller features, the accuracy and precision of the elevations in that surface model are questionable (e.g., the invert elevation of small channels). Furthermore, the LiDAR does not include bathymetry. Accurate and precise measurements of certain elevations are critical to generating restoration concepts. The feasibility of these concepts may be at risk if the error/uncertainty in those elevations exceeds the range of feasibility of the proposed management measures. This is particularly important at the head of the Lummi River where accurate elevation data for the existing culvert and channel invert at the head of the Lummi River are unavailable; only an approximate elevation is observable from the LiDAR. Higher-resolution field topographic surveys would be required to complete numerical modeling and proceed with the development of restoration designs. Similarly, topographic information for roads and bridges is limited for this effort.

Sediment yield and transport through the reach is only understood at a general level. Quantifying the magnitude and timing of the response to levee removal on channel and floodplain sedimentation processes is difficult at this time. Hydrodynamic and sediment transport modeling would assist in gaining certainty during subsequent design phases.

Two-dimensional hydrodynamic modeling of flood routing through the delta is not currently available. The available studies that have examined these issues are either limited in geographic scope or only examined flooding in a one-dimensional model. Further, those studies were not examining aquatic habitat restoration, and as such their findings are not necessarily focused on the technical issues and management measures contemplated in this action. The concepts for the full and partial restoration alternatives have not been examined using robust numerical modeling tools that are commonly employed to examine the potential effects of floodwater routing through the delta and how that relates to geomorphic processes.

23.6.1 Risks Associated with Projected Sea Level Change

A significant advantage of implementing restoration at the scale of the Nooksack River delta is that the action would restore a long gradient from Puget Sound up the entire deltaic transition zone. By restoring and preserving this connection, external shifts such as sea level change would be expected to have minimal influence on the functioning of the overall system. Certainly changes in sea level would affect ongoing geomorphic processes, but the system should be able to adjust to that type of change.

Table 23-3 gives a comparison of sea level change risks for the full and partial restoration alternatives.

Table 23-3. Risks of Sea Level Change

	Projected Sea Level Change		
	High (46cm)	Intermediate (4cm)	Low (-8cm)
Full Restoration	Accretion in the mainstem may occur faster than under existing conditions; this may accelerate geomorphic processes, including potential channel movement	Minimal impacts	Minimal impacts to overall system
Partial Restoration	Minimal impacts expected; flood protection along setback levees would be reduced	Minimal impacts	Minimal impacts to overall system

23.7 Potential Monitoring Opportunities

Monitoring is important for evaluating restoration success. A combination of field surveys and aerial photographs would be used to document biological and physical changes to the landscape. Monitoring data can be used to refine adaptive management and corrective actions, as needed. Some of the main monitoring needs and opportunities associated with this action are summarized in Table 23-4.

Table 23-4. Monitoring Needs and Opportunities

Monitoring Parameter	Key Performance Indicator	Note
Topographic Stability	X	Delta and floodplain topographic development
Sediment Accretion / Erosion	X	Longitudinal channel profile
Wood Accumulation	X	In mainstem Nooksack to determine functioning of installed wood
Soil / Substrate Conditions		
Vegetation Establishment	X	Development of native riparian forest, recolonization of salt marsh in Lummi delta
Marsh Surface Evolution / Accretion	X	
Tidal Channel Cross-Section / Density	X	Distributary channel development and evolution
Water Quality (contaminants)	X	With special attention to fecal coliform and temperature
Salinity	X	
Shellfish Production/Harvest	X	Link to water quality
Extent of Invasive Species		

Monitoring Parameter	Key Performance Indicator	Note
Ability to Navigate And Harvest Salmon	X	Treaty-protected right of the Lummi Nation
Animal Species Richness		
Fish (salmonid) Access/Use		
Forage Fish Production		
Wildlife Species Use		
Effectiveness Of Exclusion Devices		

23.8 Information Needed for Subsequent Design

This conceptual design report represents an initial step in the restoration design sequence. The design concepts described above were developed based on readily available information without the level of site-specific survey and investigation that is necessary to support subsequent design and implementation. Substantial additional information will be required at the preliminary and later design stages to confirm the design assumptions, refine quantity estimates, address property and regulatory issues, obtain stakeholder support, and fill in data gaps. The extent to which this information is collected for preliminary design (or a later design stage) will depend upon the available budget, schedule and other factors. This section attempts to define the most essential information needs for this action. Refer to the Introduction chapter for additional information.

- Property Investigation/Survey – More detailed information on parcel ownership, utilities, and property boundary locations will be needed to finalize the design, confirm acquisition requirements, and support negotiations with property owners. The survey would also be useful in providing more accurate preliminary designs and quantities for roadways, utilities, bridges, and removal of existing features.
- Topographic/Bathymetric Survey – The survey data would be used to refine design of key project elements and develop detailed construction and demolition plans. Survey data could also be used as a baseline for pre- and post-construction modeling, including hydrodynamic modeling. A temporary tide gauge may be required in the early design stages to obtain site-specific tidal statistics.
- Geotechnical Investigation – Additional geotechnical study and recommendations will be required to finalize design of dikes, levees, and bridge, road, and rail infrastructure, and to address questions of slope stability of setback dikes.
- Hydrodynamic and Hydraulic Analysis – Adapt the existing FEQ hydraulic model developed by Whatcom County and Lummi Nation (or other 2D model) to investigate WSELs under different restoration scenarios. This investigation would assist in sizing channel openings, ensure that significant high flow conveyances are accounted for, optimize levee setbacks and removals, and investigate upstream and downstream impacts to peak flood stages (e.g., Hovander Road, BNSF rail line). Hydraulic engineer recommendations are needed for scour analysis, large wood designs, Lummi River diversion design, Lummi River channel sizing, and minimum bridge clearance over water.

- Channel Migration Analysis. As a compliment to the hydraulic analysis, geomorphic analysis of channel migration potential would be required to consider channel response to levee setback and increased tidal influence.
- Contaminant Survey – If preliminary investigations suggest that hazardous material could be present in the action area, additional soil and sediment analysis related to demolition of utilities, roads, or buildings may be needed. The introductory chapter describes the Phase I site investigations that are occurring as part of this overall effort via a separate contract.
- Cultural Resources Investigation – Surveys for archaeological and historic resources may be required for this action area as it has a high likelihood of having past use by Native Americans. This is particularly important in areas proposed for excavation.
- This work would need to be coordinated with the Lummi Nation.
- Sediment Transport Studies – Sediment transport evaluations should be conducted to decrease uncertainty about floodplain sedimentation processes and sustainability.
- Sea Level Change Projection – Estimates of sea level change for the conceptual design were based on calculations provided by the Washington Department of Fish and Wildlife and the Corps of Engineers using guidance in Corps' Engineering Circular No. 1165-2-211. Projections for each project area will be refined using localized tide gauge data during later design stages.
- Other – The location, extent, and character of wetlands require further documentation.

23.9 Quantity Estimates

The quantity spreadsheets for the full and partial restoration alternatives are provided in Exhibits 23-1 and 23-2.

23.10 References

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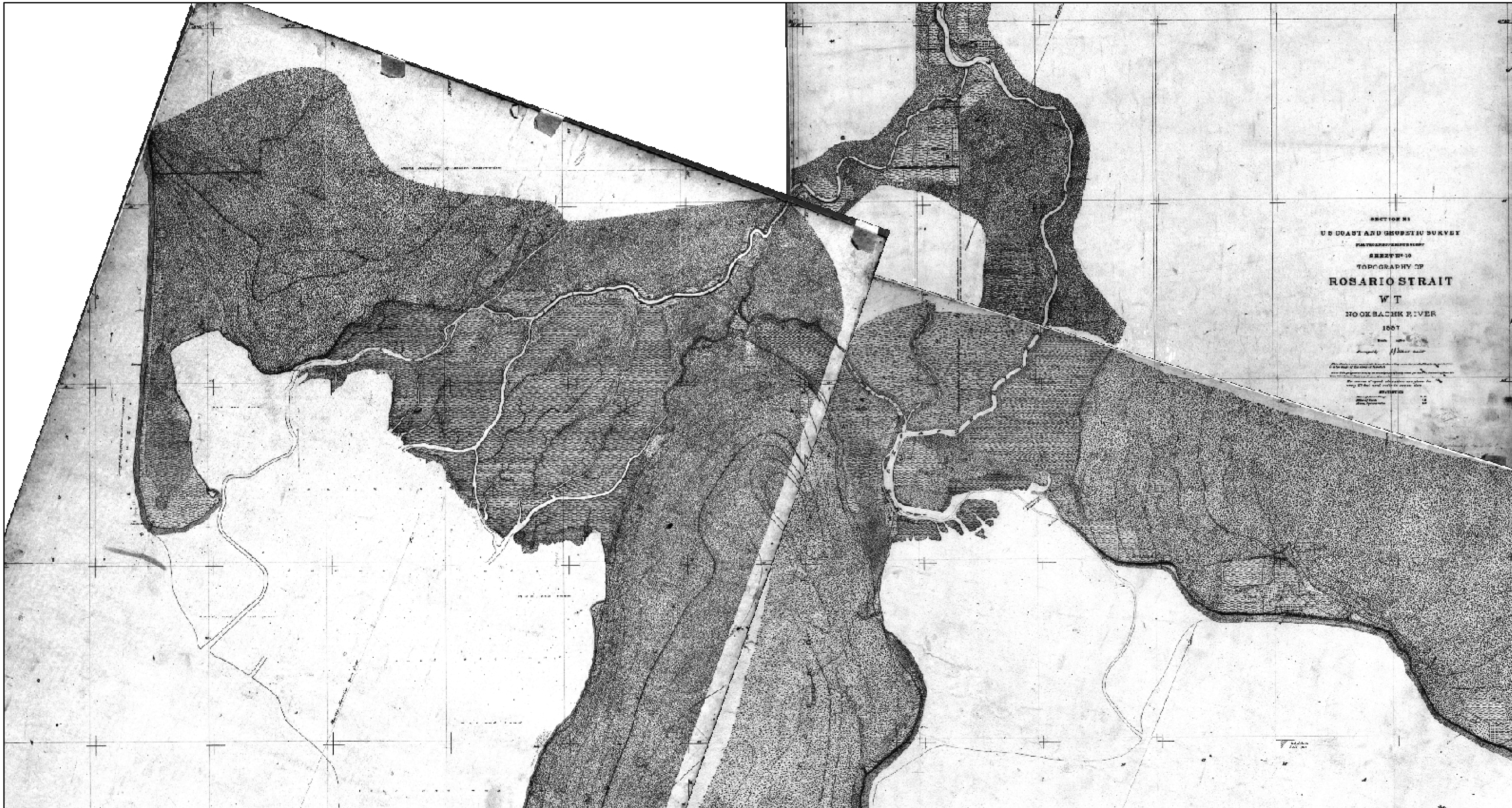

0 3,200
Feet
0 1,000
Meters

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64

WDFW Contract # 100-000204 (CAPS No. 10-1461)

Historic Map (T-Sheet)

Action Name: Nooksack River Estuary

PSNERP ID #: 1055

Figure 23- 2A

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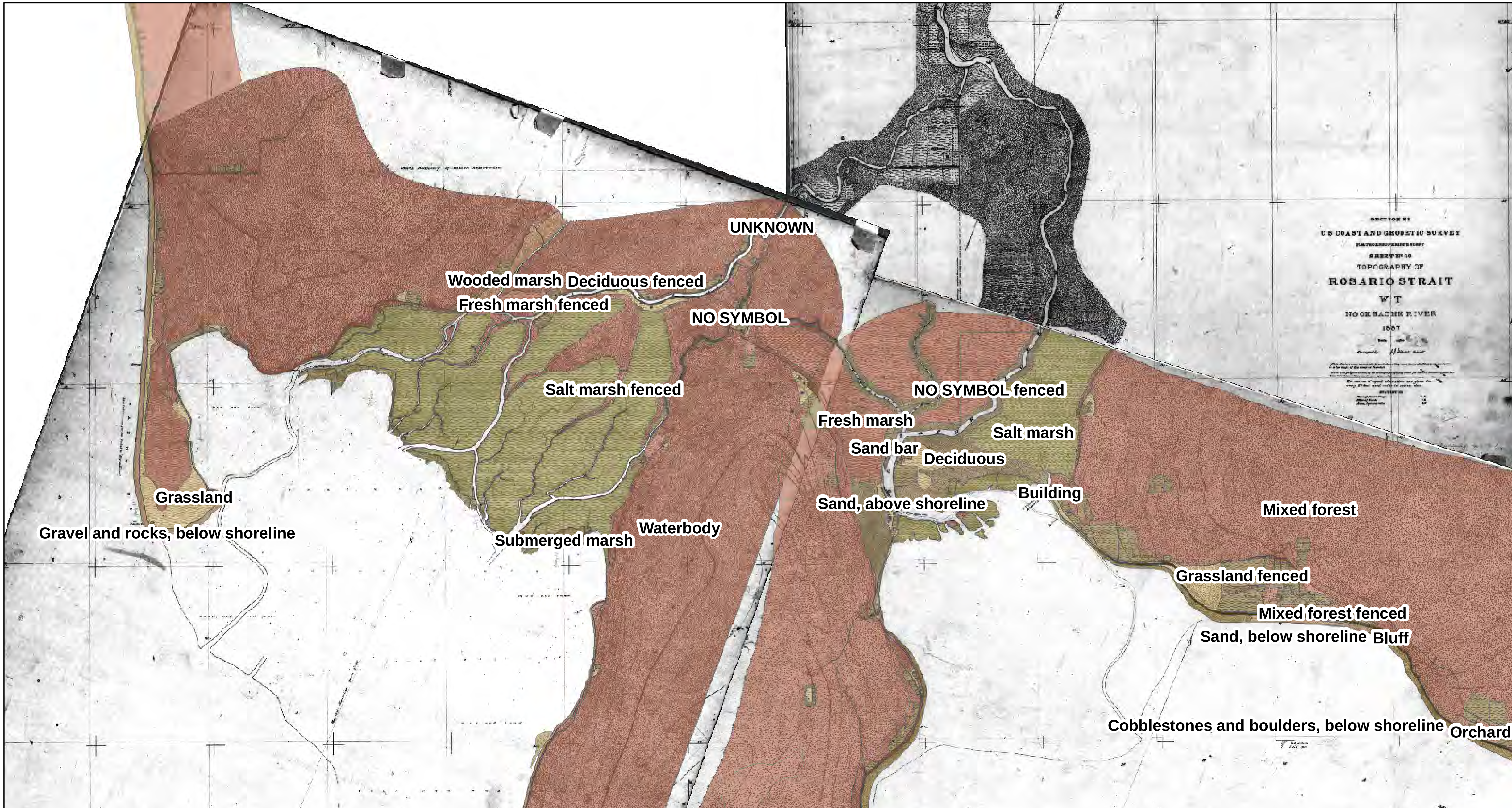

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0 3,200
Feet

0 1,000
Meters

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64

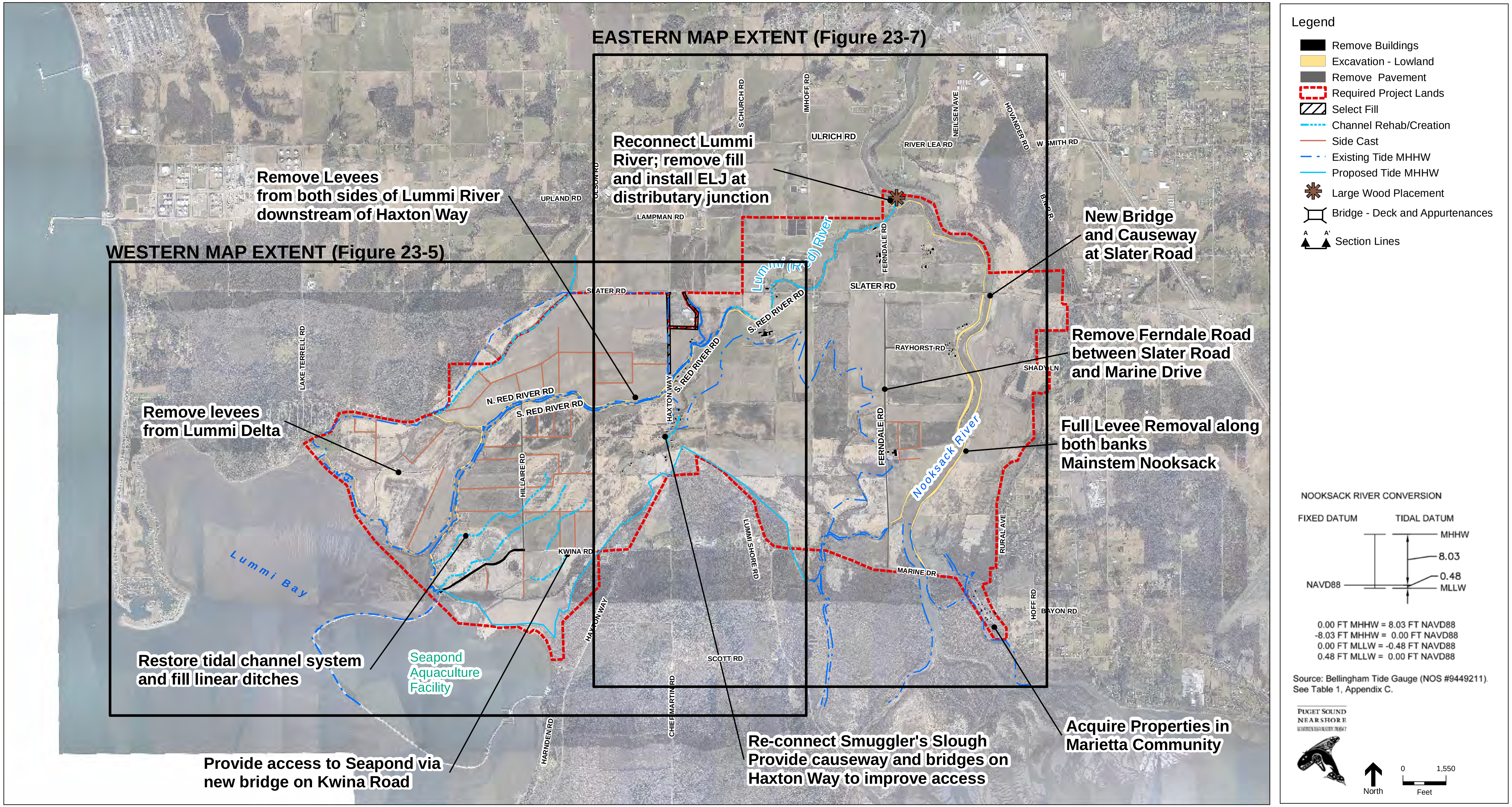
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Historic Map (T-Sheet) and River History Project Data

Action Name: Nooksack River Estuary

PSNERP ID #: 1055

Figure 23- 2B



SOURCE: PSNERP (2011); Aerial (2009, NAIP)

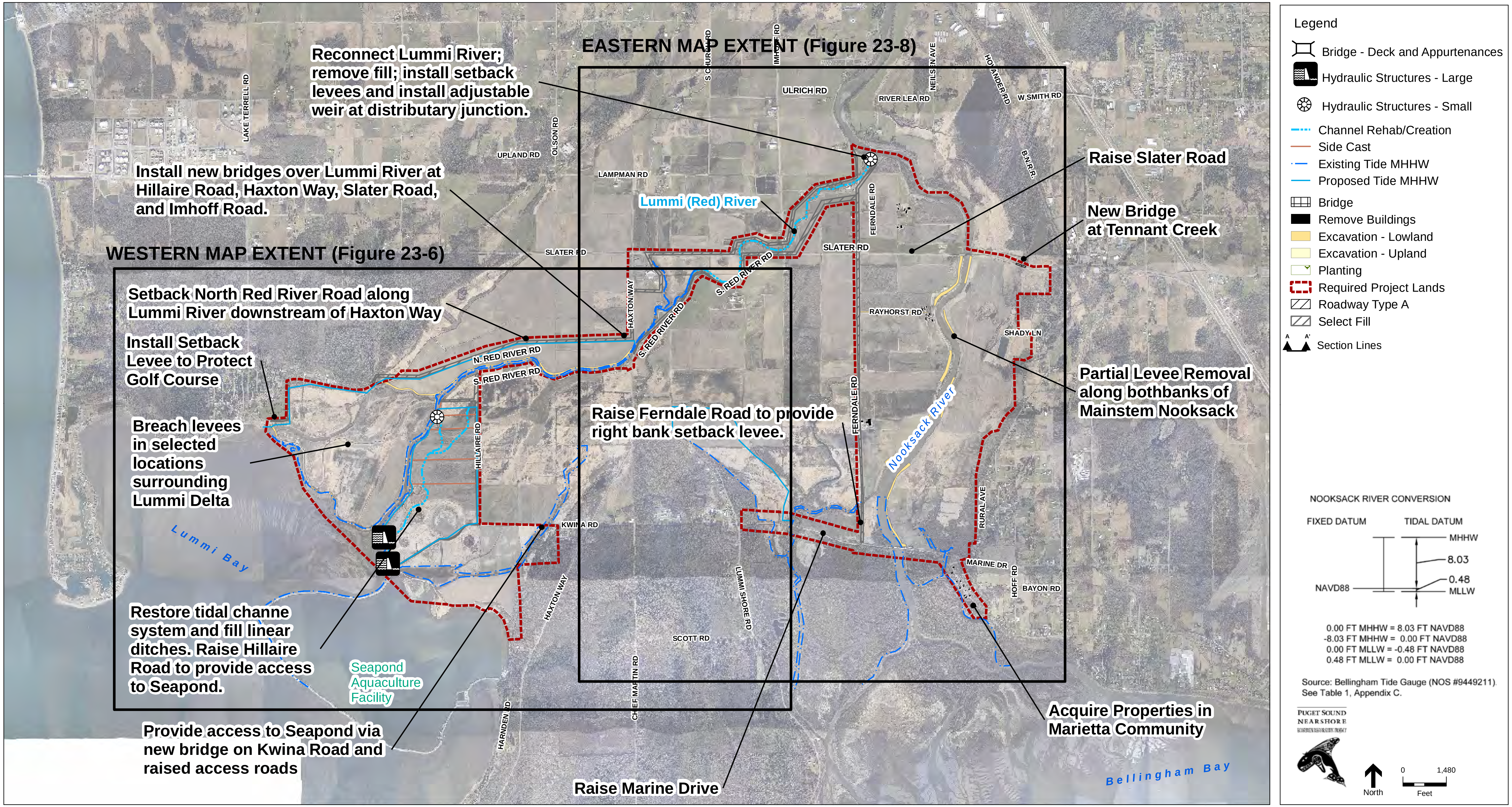
Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64

WDFW Contract # 100-000204 (CAPS No. 10-1461)

Lead Contractor: ESA
Design Lead: ESA, S. Winter, PH
Date: 05/2012

Conceptual Design Plan
Site Name: Nooksack River Delta
Action Name: Nooksack River Estuary – Index Map
PSNERP ID #:1055
Full Restoration

Figure 23-3



SOURCE: PSNERP (2011); Aerial (2009, NAIP)

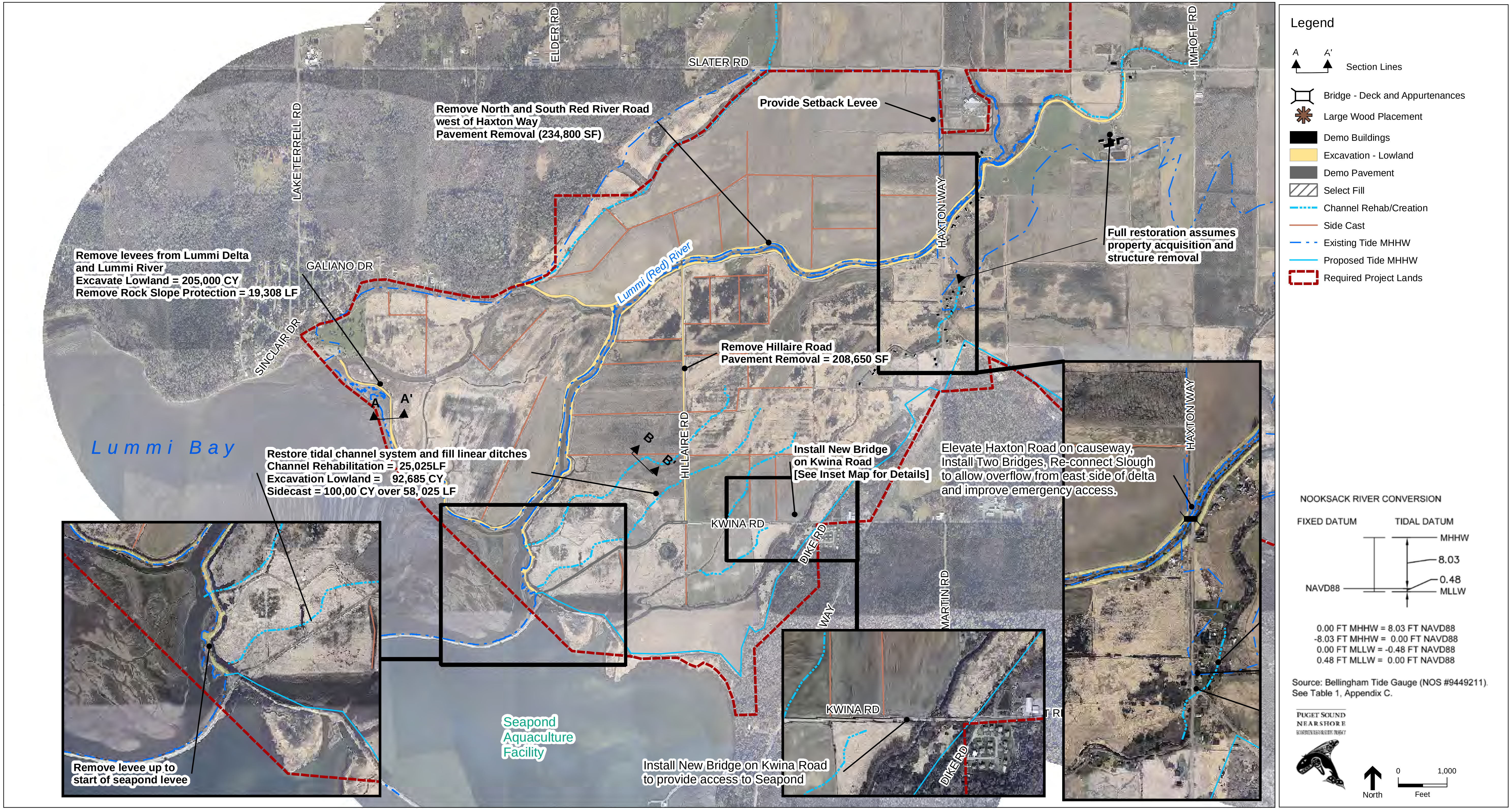
Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64

WDFW Contract # 100-000204 (CAPS No. 10-1461)

Lead Contractor: ESA
Design Lead: ESA, S. Winter, PH
Date: 05/2012

Conceptual Design Plan
Site Name: Nooksack River Delta
Action Name: Nooksack River Estuary – Index Map
PSNERP ID #:1055
Partial Restoration

Figure 23-4



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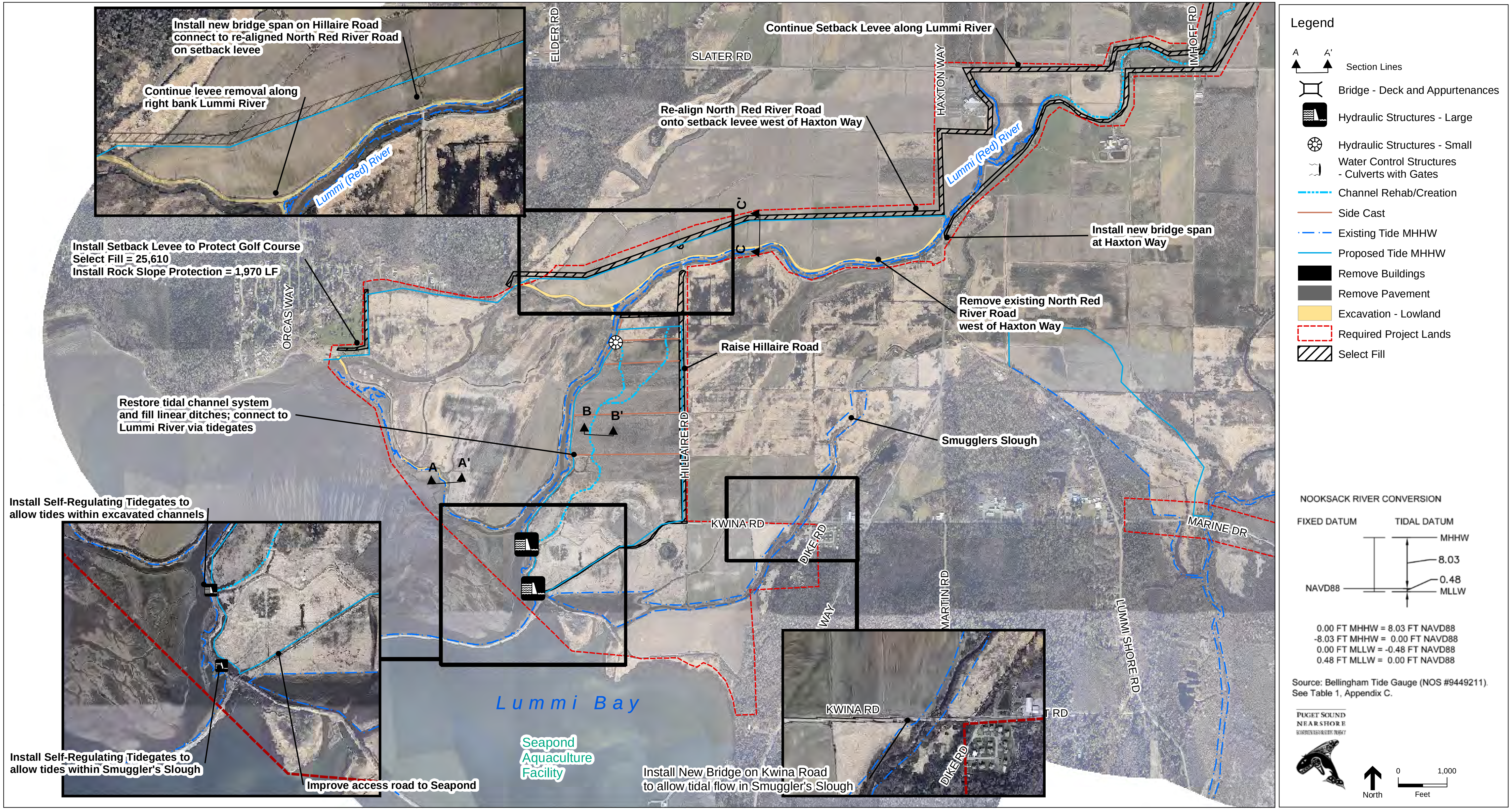
SOURCE: PSNERP (2011); Aerial(NAIP, 2009)

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Plan
Site Name: Nooksack River Delta
Action Name: Nooksack River Estuary – West View
PSNERP ID #:1055
Full Restoration

Lead Contractor: ESA
Design Lead: ESA, S. Winter, PH
Date: 05/2012

Figure 23-5



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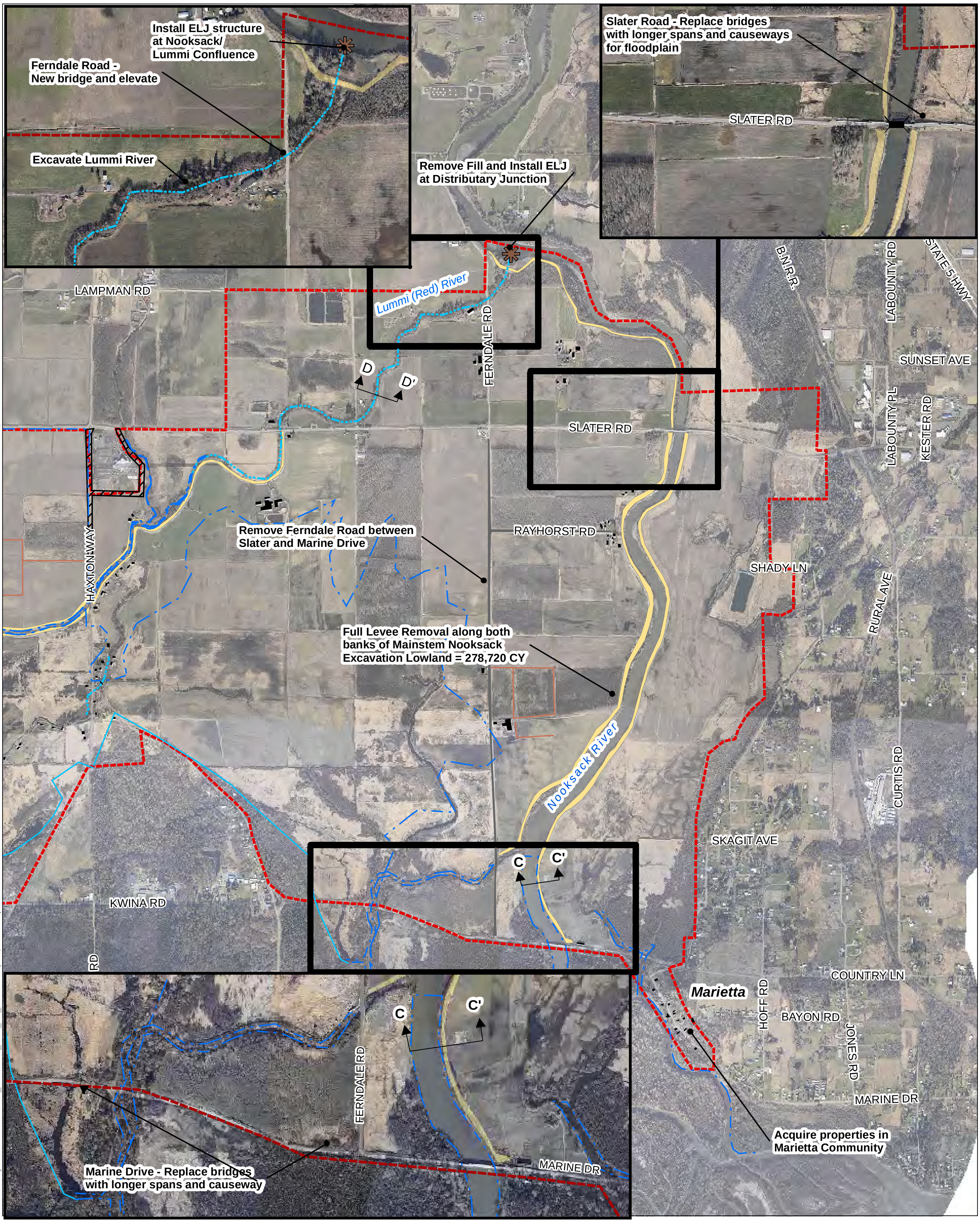
SOURCE: PSNERP (2011); Aerial (NAIP, 2009)

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Plan
Site Name: Nooksack River Delta
Action Name: Nooksack River Estuary – West View
PSNERP ID #:1055
Partial Restoration

Lead Contractor: ESA
Design Lead: ESA, S. Winter, PH
Date: 05/2012

Figure 23-6



Legend

- Bridge - Deck and Appurtenances
- Large Wood Placement
- Channel Rehab/Creation
- Side Cast
- Existing Tide MHHW
- Proposed Tide MHHW
- Section Lines
- Remove Buildings
- Remove Pavement
- Excavation - Lowland
- Required Project Lands
- Select Fill

NOOKSACK RIVER CONVERSION

FIXED DATUM — TIDAL DATUM

NAVD88 — MHHW 8.03 — MLLW 0.48

0.00 FT MHHW = 8.03 FT NAVD88
-8.03 FT MHHW = 0.00 FT NAVD88
0.00 FT MLLW = -0.48 FT NAVD88
0.48 FT MLLW = 0.00 FT NAVD88

Source: Bellingham Tide Gauge (NOS #9449211).
See Table 1, Appendix C.

North — 0 — 2,000 Feet

PUGET SOUND NEARSHORE

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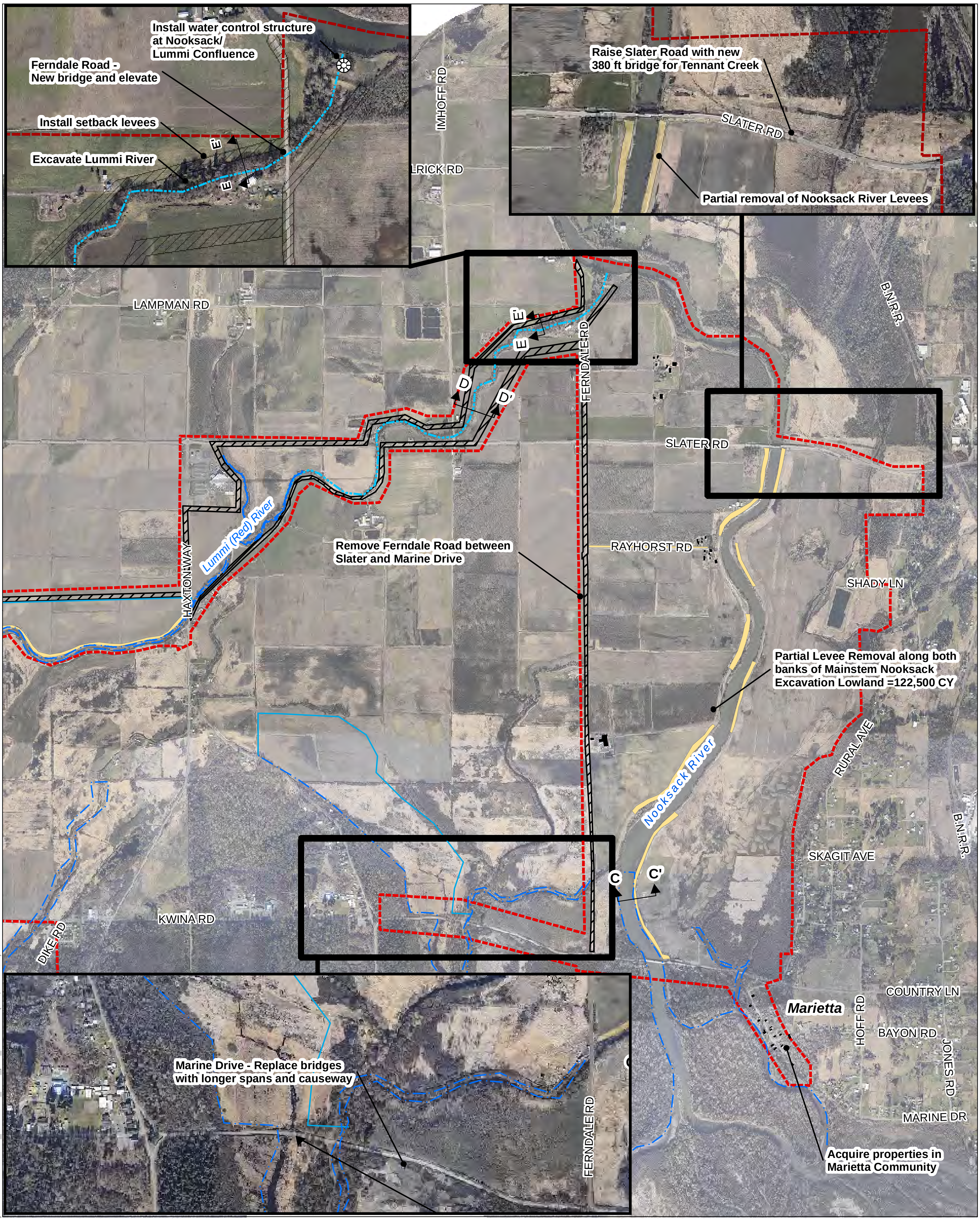
SOURCE: PSNERP (2011); Aerial (NAIP 2009)

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Lead Contractor: ESA
Design Lead: ESA, S. Winter, PH
Date: 05/2012

Conceptual Design Plan
Site Name: Nooksack River Delta
Action Name: Nooksack River Estuary – East View
PSNERP ID #:1055
Full Restoration

Figure 23-7



Legend

- Bridge - Deck and Appurtenances
- Large Wood Placement
- Channel Rehab/Creation
- Side Cast
- Existing Tide MHHW
- Proposed Tide MHHW
- Section Lines
- Demo Buildings
- Excavation - Lowland
- Required Project Lands
- Select Fill

NOOKSACK RIVER CONVERSION

FIXED DATUM — TIDAL DATUM

MHHW 8.03; NAVD88 0.48 MLLW

0.00 FT MHHW = 8.03 FT NAVD88
-8.03 FT MHHW = 0.00 FT NAVD88
0.00 FT MLLW = -0.48 FT NAVD88
0.48 FT MLLW = 0.00 FT NAVD88

Source: Bellingham Tide Gauge (NOS #9449211).
See Table 1, Appendix C.

North

0 2,000 Feet

PUGET SOUND NEARSHORE

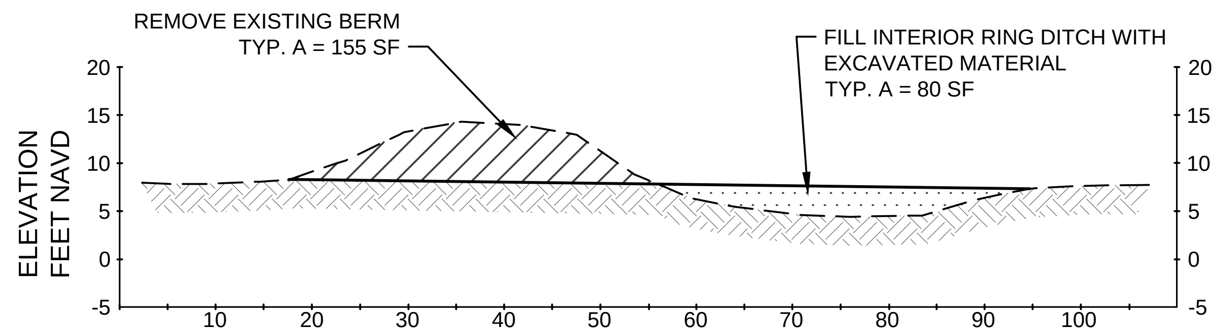
SOURCE: Washington Public Lands Database (2006);
Washington Counties Parcels (2009); Action Area (PSNERP, 2010)

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

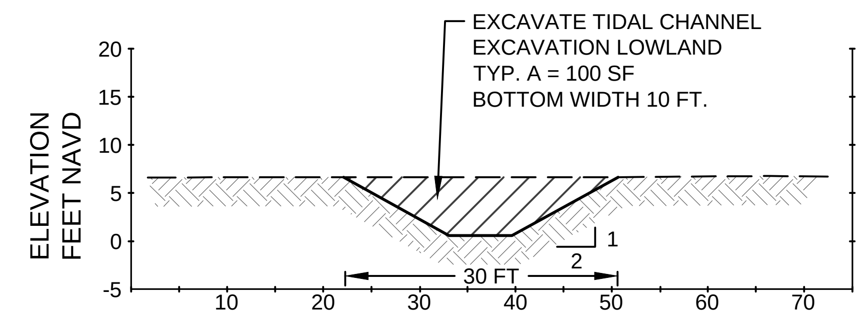
Lead Contractor: ESA
Design Lead: ESA, S. Winter, PH
Date: 05/2012

Conceptual Design Plan
Site Name: Nooksack River Delta
Action Name: Nooksack River Estuary – East View
PSNERP ID #:1055
Partial Restoration

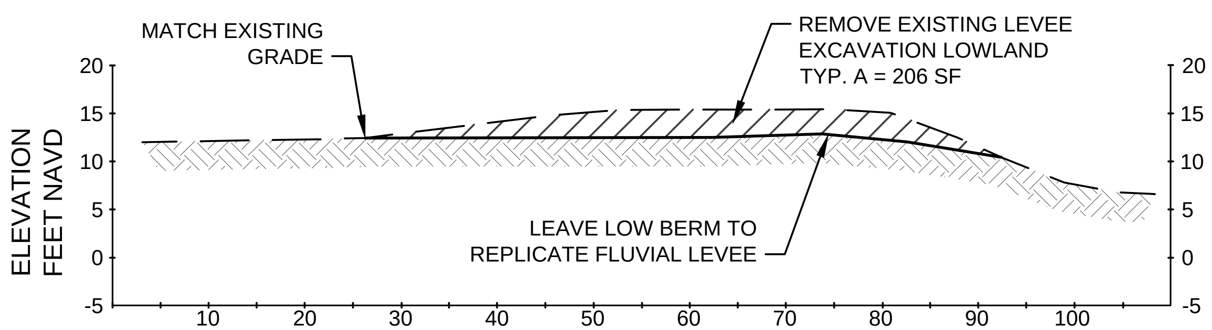
Figure 23-8



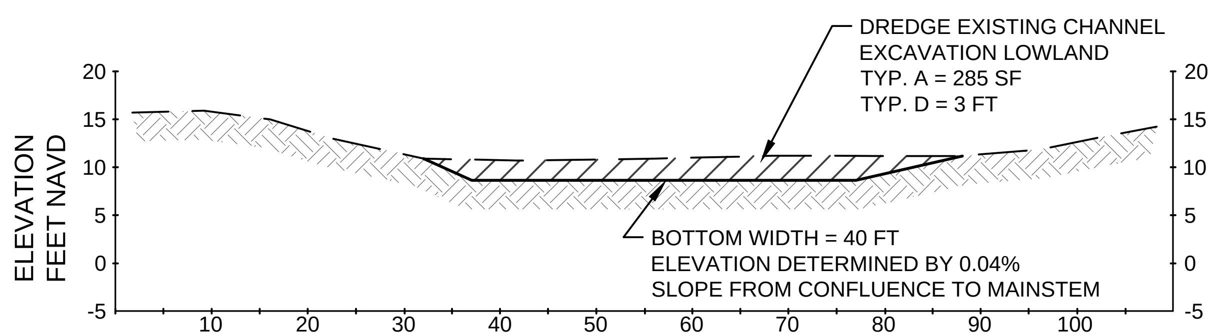
Ⓐ LEVEE REMOVAL FROM LUMMI DELTA (TYP.)



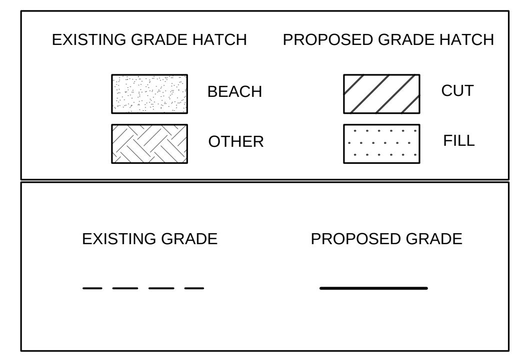
Ⓑ TIDAL CHANNEL EXCAVATION IN WESTERN DELTA (TYP.)



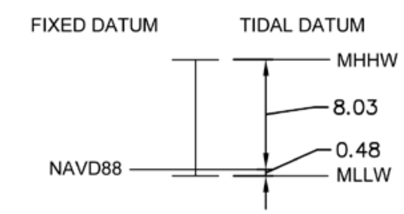
Ⓒ LEVEE REMOVAL FROM LEFT BANK NOOKSACK (TYP.)



Ⓓ LUMMI RIVER CHANNEL EXCAVATION (TYP.)



NOOKSACK RIVER CONVERSION



0.00 FT MHHW = 8.03 FT NAVD88
-8.03 FT MHHW = 0.00 FT NAVD88
0.00 FT MLLW = -0.48 FT NAVD88
0.48 FT MLLW = 0.00 FT NAVD88

Source: Bellingham Tide Gauge (NOS #9449211).
See Table 1, Appendix C.

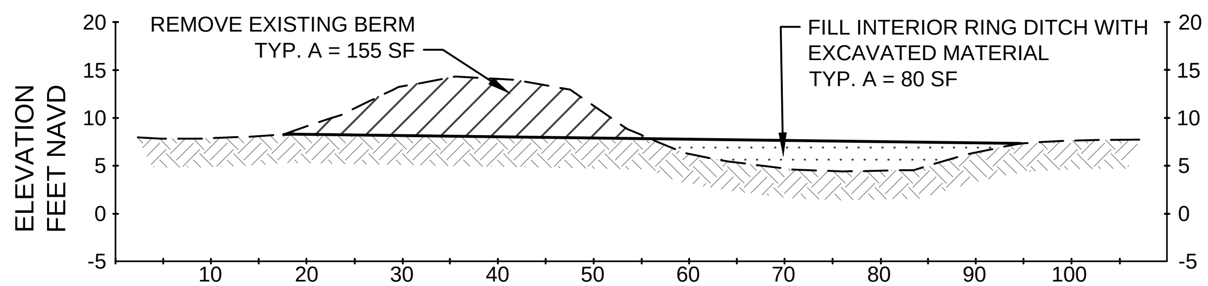
PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: ESA, S. Winter, PH
Date: 05/2012

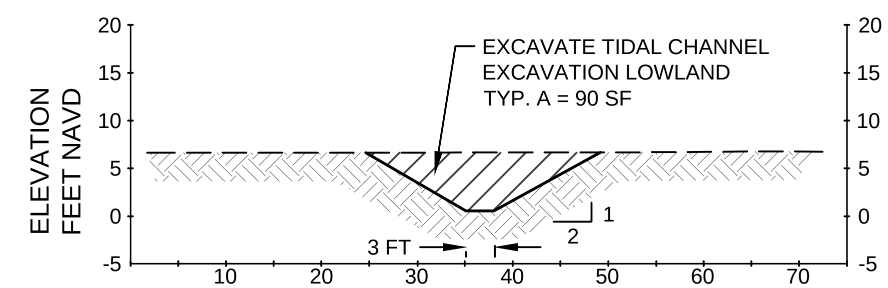
Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Section
SITE NAME: **Nooksack River Delta**
ACTION NAME: **Nooksack River Estuary**
PSNERP ID#: **1055**
Full Restoration

Figure 23-9

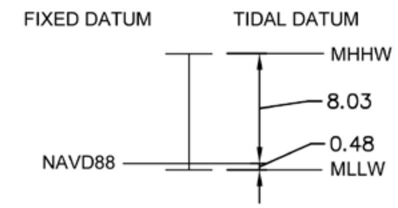


(A) LEVEE REMOVAL FROM LUMMI DELTA (TYP.)



(B) TIDAL CHANNEL EXCAVATION IN WESTERN DELTA (TYP.)

NOOKSACK RIVER CONVERSION



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0.00 FT MLLW = -0.48 FT NAVD88
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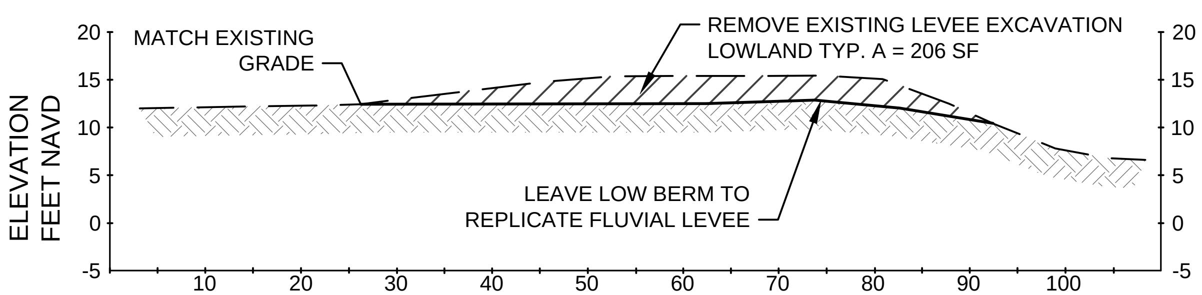
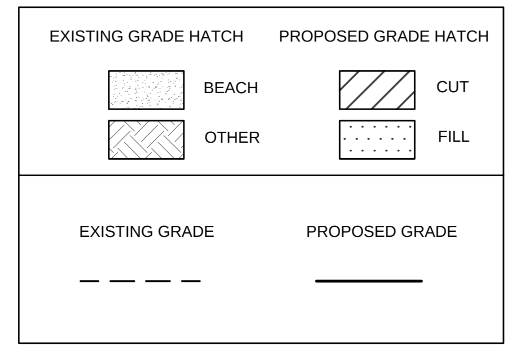
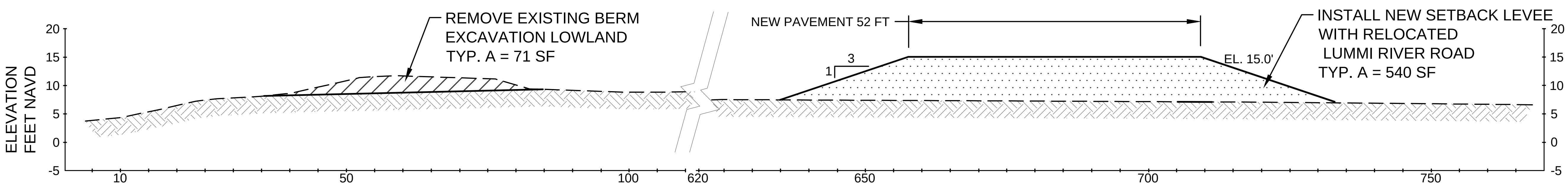
Source: Bellingham Tide Gauge (NOS #9449211).
See Table 1, Appendix C.

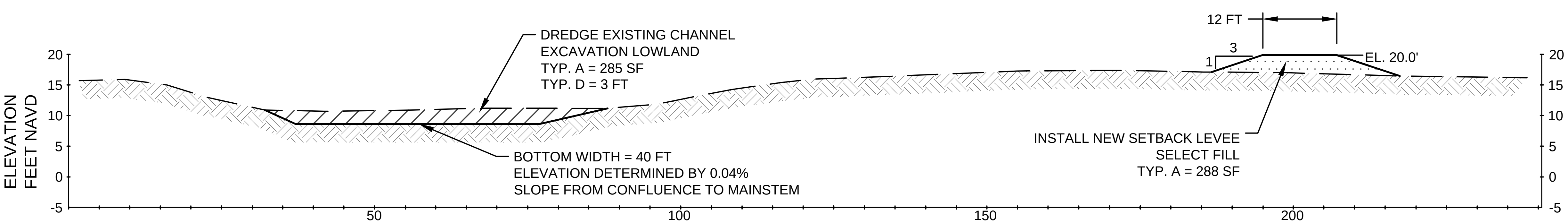


(C) LEVEE REMOVAL FROM LEFT BANK NOOKSACK (TYP.)





(D) LUMMI RIVER RIGHT BANK LEVEE SETBACK (TYP.)



(E) LUMMI RIVER CHANNEL EXCAVATION (TYP.)

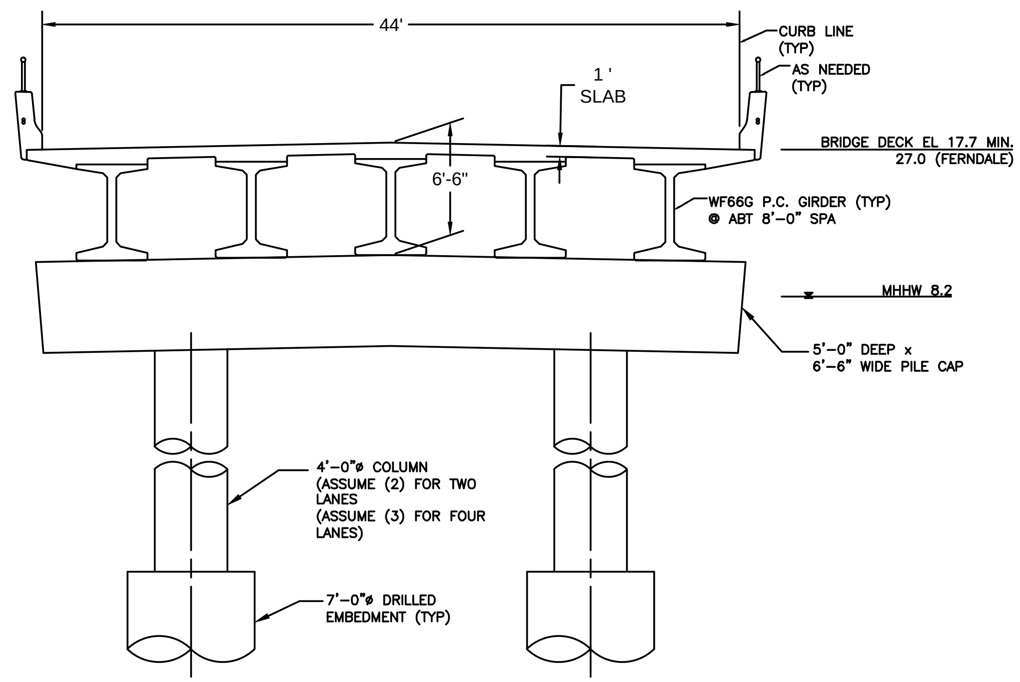
PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: ESA, S. Winter, PH
Date: 05/2012

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

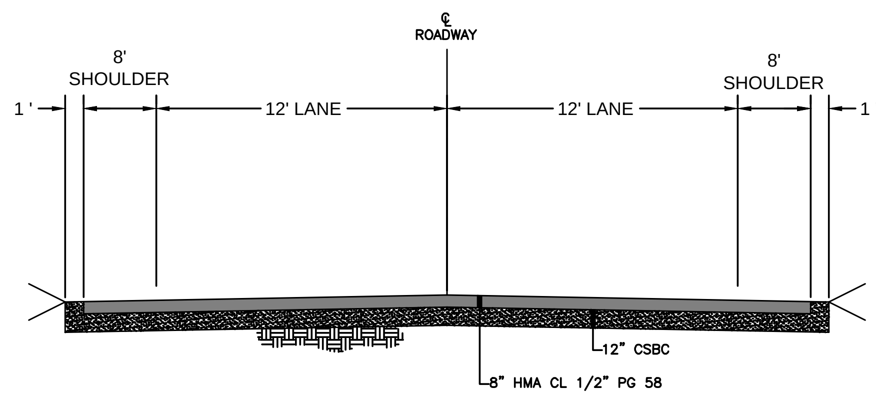
Conceptual Design Section
SITE NAME: **Nooksack River Delta**
ACTION NAME: **Nooksack River Estuary**
PSNERP ID#: **1055**
Partial Restoration

Figure 23-10



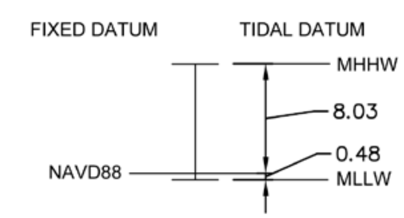
BRIDGE SECTION
NTS

TYPICAL FOR:
KWINA (FULL 500' SPAN AND PARTIAL 250' SPAN)
HAXTON WAY (FULL 450' SPAN, 500' SPAN, & 1200' CAUSEWAY AND PARTIAL 450' SPAN)
HILLAIRE (PARTIAL 450' SPAN)
IMHOFF (FULL 500' SPAN AND PARTIAL 250' SPAN)
FERNDALE (FULL 500' SPAN AND PARTIAL 250' SPAN)
SLATER (FULL 500' SPAN)



ROADWAY SECTION
NTS

NOOKSACK RIVER CONVERSION



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-8.03 FT MHHW = 0.00 FT NAVD88
0.00 FT MLLW = -0.48 FT NAVD88
0.48 FT MLLW = 0.00 FT NAVD88

Source: Bellingham Tide Gauge (NOS #9449211).
See Table 1, Appendix C.

PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: ESA, S. Winter, PH
Date: 05/2012

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Section
SITE NAME: **Nooksack River Delta**
ACTION NAME: **Nooksack River Estuary**
PSNERP ID#: **1055**
Full & Partial Restoration

Figure 23-11

Full Restoration Quantity Estimate

Action Name: Nooksack Delta
Action #: 1055
Date: February 2011 **Revised with backcheck updates: 30 June 2011**
By: ESA Revised April 2012

REMEDY: ***Remove levees, reconnect channels, linear ditches, and modify transporation infrastructure.***
Construction Period: 2 Years

Item	Unit of Measure	Material Name	Qty	Description of Item	Indicate section of design report where item is described
ACQUISITION AND CONSERVATION				Based on available mapping information	
Required Project Lands	Acre		5552	Total land required For actior	
Proponent / Partner-owned lands	Acre		3387	Estimate of lands currently owned by Proponent (i.e., Public lands	
Lands To Be Acquired	Acre		2098	Estimate land required to be acquired for action prior to implementatio	
Material Sites				Not Used: See Earthwork - Imported Fill.	
MOBILIZATION AND ACCESS for construction activities				Description required for each item to facilitate cost estimating	
Mobilization - Typical (Equipment, Personnel, Planning, Financial)	LS		1	Assume 10% of total	
Mobilization - Remote (Equipment, Personnel, Planning, Financia	LS		NA		
Site Access	LS		1	Access can utilize existing paved and gravel surface roads to the majority of the site.	
Barge Access	Days		NA		
Temporary Traffic Control (one of the following)					
none	LS		NA		
signs	LS		1	Ferndale	
flags / spotters	LS		1	Ferndale	
signs	LS		1	Slater at Nooksack	
flags / spotters	LS		1	Slater at Nooksack	
signs	LS		1	Slater at Lummi River	
flags / spotters	LS		1	Slater at Lummi River	
signs	LS		1	Marine Drive at Silver Creek	
flags / spotters	LS		1	Marine Drive at Silver Creek	
signs	LS		1	Marine Drive at Nooksack	
flags / spotters	LS		1	Marine Drive at Nooksack	
signs	LS		1	Hillaire Road at Lummi	
flags / spotters	LS		1	Hillaire Road at Lummi	
signs	LS		1	Imhoff Road at Lummi	
flags / spotters	LS		1	Imhoff Road at Lummi	
signs	LS		1	Haxton at Lummi and Slough	
flags / spotters	LS		1	Haxton at Lummi and Slough	
signs	LS		1	Kwina at Slough	
flags / spotters	LS		1	Kwina at Slough	
Control of Water	LS		1	Significant levee removal on Nooksack mainstem will need to be staged to coordinate with high fluvial flows and	
Control of Water	LS		1	Significant levee removal on Lummi River will need to be staged to coordinate with high fluvial flows and tides.	
Relocation Activities					
Site Demolition Activities					
Clearing and Grubbing (one or more of following)					
Clear Vegetation - Local Disposa	AC		99	Assume same area as total coverage of "excavation, lowlanc	23.3.1
Clear /Grub Vegetation - Local Disposa	AC		NA		23.3.1
Clear /Grub Vegetation - Offsite Disposal	AC		NA		23.3.1
Clear, stockpile - large woody debris	CY		NA		23.3.1
Hydraulic Structures - Small	LS		NA	Unknown number of structures to be removec	23.3.1
Hydraulic Structures - Large	LS		NA		23.3.1
Utilities	LF		21,120	This is a significant unknown. As a general estimate, the distance from the edge of the floodplain to the Lummi Delta is 4 miles along a major road. This would provide a mechanism to estimate costs for relocation of major utilities along this alignment	23.3.1
Buildings	SF		270,000	Building removal within floodplain based on geodatabase, removing 84 structure	23.3.1
Pavement	SF		39,600	Ferndale Road at Lummi River (L = 900 ft, W = 44 ft	23.3.1
Pavement	SF		281,600	Slater Road at Nooksack (L = 6,400 ft, W = 44 ft)	23.3.1
Pavement	SF		30,800	Slater Road at Lummi River (L=700 ft, W = 44 ft)	23.3.1
Pavement	SF		19,360	Marine Drive at Silver Creek (L = 440, W =44	23.3.1
Pavement	SF		188,100	Marine Drive at Nooksack (L = 4,275, W = 44	23.3.1
Pavement	SF		208,650	Hillaire Road Removal (L = 5,230, W = 40	23.3.1
Pavement	SF		28,600	Imhoff Road at Lummi (L = 650, W = 44)	23.3.1
Pavement	SF		127,600	Haxton at Lummi (L = 2,900, W = 44)	23.3.1
Pavement	SF		30,800	Kwina at Slough (L = 700, W = 44)	23.3.1
Pavement	SF		234,800	RemoveNorth Lummi Road west of Haxton (L = 9783, W = 24	23.3.1
Pavement	SF		459,730	Remove Ferndale between Slater and Marine Drive	23.3.1
Pavement	SF		140,040	Remove South Lummi (red) River Road between Haxton and Hillaire (L = 5835, W = 24	23.3.1
Bulkheads	LF or SF		NA		23.3.1
Rock revetments	LF		19308	On outside of Lummi Delta levee (largest rock is approx 4 ft diameter) rock is discontinuous along face of levee, and depth is unknowr	23.3.1
Large Coastal Structures	LF, SF or CY		NA		23.3.1
Demolition / Removal - Bridge	SF or CY		NA	See pavement removal	
Removal - Misc. (e.g. angular rock from beach)	LS		1	Decommission Golf Course on west end of Lummi Delta	
Demolition / Removal - Boat Ramp	SF		NA		
Haul - Offsite Disposal of Demolition Debris	Miles		20	Assumed.	
Hazardous/Contaminated Waste Removal					
Contaminated Earthwork	CY		0		
Hazardous Earthwork	CY		0		
Construct Temporary Features					
EARTHWORK					
Excavation	CY				
Excavation - Uplanc	CY		NA		
Excavation - Lowland	CY		214,561	Removal of levee along Lummi River	23.3.1
Excavation - Lowland	CY		92685	New channel excavation on west side of delta	23.3.1
Excavation - Lowland	CY		20,400	Channel excavation at Haxton Way	23.3.1
Excavation - Lowland	CY		67300	Lummi River regrade	23.3.1
Excavation - Lowland	CY		278720	Nooksack River full berm removal - total length 21,040 f	23.3.1
Excavation - Lowland	CY		22290	Remove Ferndale Road between Slater and Marine Drive (12,033 ft long, xs =50 sq ft	23.3.1
Dredging - Bucket - Land	CY		NA		
Dredging - Bucket - Marine	CY		NA		
Dredging - Hydraulic	CY		NA		
Fine Grading	AC		NA		
Fill Placement - local borrow					
Side cast	CY		100,000	Fill linear ditches on west side of delta total length = 58,024	23.3.1
Side cast	CY		9,000	Fill linear ditches on east side of delta total length = 4,867	23.3.1
Haul - uncontrolled placement	CY		NA		23.3.1
Haul, place, compact	LS		1	Assume fill placement in subsided areas - volumes to be determined after new roadways complete	23.3.1
Stockpile - uncontrolled placement	CY		NA		
Stockpile - controlled placemen	CY		NA		

Full Restoration Quantity Estimate

Action Name:	Nooksack Delta
Action #:	1055
Date:	February 2011 **Revised with backcheck updates: 30 June 2011**
By:	ESA Revised April 2012

REMEDY: ***Remove levees, reconnect channels, linear ditches, and modify transporation infrastructure.***
Construction Period: 2 Years

	Item	Unit of Measure	Material Name	Qty	Description of Item		Indicate section of design report where item is described
	Conveyor placement from stockpile land/water	CY		NA			
	Imported Fill						
	Select Fill	CY		NA			
	Gravel Borrow, including haul	CY		NA			
	Sand / Gravel for Beach Nourishment	CY		NA			
	Cobble for Shore Nourishment	CY		NA			
	Embankment Compaction	CY		NA			
	Topsoil	CY		NA			
RESTORATION Features							
	Channel Rehab / Creation	SF		750,750	New channel excavation on west side of delta, total length 25,025 linear feet. Alignments based on T-Shee		23.3.1
	Channel Rehab / Creation	SF		45,900	Lummi River channel enhancements/excavation at Haxton Way - 1311 linear fe		23.3.1
	Channel Rehab / Creation	SF		593,400	Lummi River regrade in upper 9,890 feet of channel		23.3.1
	Large Wood Placement	EA		1	ELJ structure at head of Lummi River, assume 50 key logs, 100 racking logs, include foundatic		23.3.1
	Large Wood Placement	EA		350	Habitat structures in Mainstem, assume 12 logs/structure at 18" DBH and 30' lor		
	Large Wood Placement	EA		50	ELJ structures in Mainstem, assume 40 logs/structure at 24 DBH and 30' lor		
	Invasive Species Control	Acre		NA			
	Physical Exclusion Devices	LF or EA		NA			
	Other Restoration Features/ Activities	LS		NA			
Structures		EA					
	Water Control Structures - Culverts with Gates	EA		NA			23.3.1
	Water Control Structures - Weirs	EA		NA			23.3.1
	Rock Slope Protection	LF		NA			23.3.1
	Other	EA		NA			
	Elevated Boat Ramp	SF		NA			
	Fencing	SF		NA			
Utilities							
	Water	LF		0			
	Gas	LF		0			
	Electric	LF		0			
	Sewer	LF		0			
	Telecommunications	LF		0			
	Other	LF		0			
Roadway / Railway							
	Roadway (Type A)	SF		0	Ferndale Road Replacement		23.3.1
	Roadway (Type A)	SF		246400	Slater Road, new causeway @5600 LF		23.3.1
	Roadway (Type A)	SF		8800	Slater Road at Lummi River		23.3.1
	Roadway (Type A)	SF		8800	Marine Drive at Silver Creek		23.3.1
	Roadway (Type A)	SF		159500	Marine Drive at Nooksack		23.3.1
	Roadway (Type A)	SF		6600	Imhoff Road at Lummi		23.3.1
	Roadway (Type A)	SF		118400	Haxton new causeway and road between Kwina and Lummi River		23.3.1
	Roadway (Type A)	SF		8800	Kwina at Slough		23.3.1
	Roadway - Traffic Signal	LS		0			
	Culvert (type)	LF		0			
	Culvert - Jacking	LF		0			
	Culvert - Horizontal Pile Driving	LF		0			
	Bridge Deck	SF		22000	Ferndale Road 500' bridge, 44' wide. 4 spans w/ 6.5' Precast Concrete Girder Bridge		23.3.1
	Bridge Foundation	LF		132	Ferndale Road (3) 44' CIP Concrete pile caps with (2) 7' drilled shafts 100' embed at each pile ca		23.3.1
	Bridge Deck	SF		35200	Slater Road 800' x 44 wide bridge. Six spans w/ 6.5' Precast Concrete Girder Bridge		23.3.1
	Bridge Foundation	LF		220	Slater Road (5) 44' CIP Concrete pile caps with (2) 7' drilled shafts 100' embed at each pile ca		23.3.1
	Bridge Deck	SF		22000	Slater at Lummi 500' bridge 44' wide. Four spans w/ 6.5' deep precast concrete girder		23.3.1
	Bridge Foundation	LF		132	Slater at Lummi (3) 44' CIP Concrete pile caps with (2) 7' drilled shafts 100' embed at each pile ca		23.3.1
	Bridge Deck	SF		9680	Marine at Silver 220' bridge 44' wide. Two spans w/ 5.17' deep Precast Concrete Girder Bridge		23.3.1
	Bridge Foundation	LF		44	Marine at Silver (1) 44' CIP Concrete pile caps with (2) 7' drilled shafts 100' embed at each pile ca		23.3.1
	Bridge Deck	SF		28600	Marine at Nooksack 650' bridge 44' wide. Five spans w/ 6.5' deep precast concrete girder		23.3.1
	Bridge Foundation	LF		176	Marine at Nooksack (4) 44' CIP Concrete pile caps with (2) 7' drilled shafts 100' embed at each pile ca		23.3.1
	Bridge Deck	SF		22000	Imhoff at Lummi 500' bridge 44' wide. Four spans w/ 6.5' deep Precast Concrete Girder Bridge		23.3.1
	Bridge Foundation	LF		132	Imhoff at Lummi (3) 44' CIP Concrete pile caps with (2) 7' drilled shafts 100' embed at each pile ca		23.3.1
	Bridge Deck	SF		22000	Haxton at Lummi 500' bridge 44' wide. Four spans w/ 6.5' deep Precast Concrete Girder Bridge		23.3.1
	Bridge Foundation	LF		132	Haxton at Lummi (3) 44' CIP Concrete pile caps with (2) 7' drilled shafts 100' embed at each pile ca		23.3.1
	Bridge Deck	SF		22000	Haxton at Slough 500' bridge 44' wide. Four spans w/ 6.5' deep Precast Concrete Girder Bridge		23.3.1
	Bridge Foundation	LF		132	Haxton at Slough (3) 44' CIP Concrete pile caps with (2) 7' drilled shafts 100' embed at each pile ca		23.3.1
	Bridge Deck	SF		22000	Kwina at Slough 500' bridge 44' wide. Four spans w/ 6.5' deep Precast Concrete Girder Bridge		23.3.1
	Bridge Foundation	LF		132	Kwina at Slough (3) 44' CIP Concrete pile caps with (2) 7' drilled shafts 100' embed at each pile ca		23.3.1
	Bridge Deck	SF		NA			
	Railway - Box Girder	SF		NA			
	Railway - Foundation	LF		NA			
	Railway - Shoe fly	LF		NA			
Permanent Access Features							
	Roads	Level		NA	Ferndale (No level assigned at this stage of design: Level 1 direct access, Level 2 moderately difficult, Level 3 difficult access)		
	Roads	Level		NA	Slater at Nooksack (No level assigned at this stage of design: Level 1 direct access, Level 2 moderately difficult, Level 3 difficult access)		
	Roads	Level		NA	Slater at Lummi (No level assigned at this stage of design: Level 1 direct access, Level 2 moderately difficult, Level 3 difficult access)		
	Roads	Level		NA	Marine at Silver (No level assigned at this stage of design: Level 1 direct access, Level 2 moderately difficult, Level 3 difficult access)		
	Roads	Level		NA	Marine at Nooksack (No level assigned at this stage of design: Level 1 direct access, Level 2 moderately difficult, Level 3 difficult access)		
	Roads	Level		NA	Imhoff Road at Lummi River (No level assigned at this stage of design: Level 1 direct access, Level 2 moderately difficult, Level 3 difficult access		
	Roads	Level		NA	Haxton at Lummi (No level assigned at this stage of design: Level 1 direct access, Level 2 moderately difficult, Lev 3 difficult access)		
	Roads	Level		NA	Kwina at Slough (No level assigned at this stage of design: Level 1 direct access, Level 2 moderately difficult, Level 3 difficult access)		
	Utility Access Routes	varies		0			
	Erosion Control Features	L.F.		0.5	Ferndale		
	Erosion Control Features	L.F.		6.5	Slater at Nooksack		
	Erosion Control Features	L.F.		0.5	Slater at Lummi		
	Erosion Control Features	L.F.		0.22	Marine at Silver		
	Erosion Control Features	L.F.		3.5	Marine at Nooksack		
	Erosion Control Features	L.F.		0.5	Imhoff Road at Lummi River		
	Erosion Control Features	L.F.		1.3	Haxton at Lummi		
	Erosion Control Features	L.F.		0.5	Kwina at Slough		
	Erosion Control Features	L.F.					
Public Access or Recreation Features							
	Trails	SF		0			

Full Restoration Quantity Estimate

Action Name: Nooksack Delta
Action #: 1055
Date: February 2011 **Revised with backcheck updates: 30 June 2011**
By: ESA Revised April 2012

REMEDY: ***Remove levees, reconnect channels, linear ditches, and modify transporation infrastructure.***
Construction Period: 2 Years

	Item	Unit of Measure	Material Name	Qty	Description of Item		Indicate section of design report where item is described
	Bridges	SF		0			
	Kiosk	EA		0			
	Restrooms	EA		0			
	Interpretive Signs	EA		0			
	Parking Area	SF		0			
	Other	EA		0			
Vegetation & Erosion Control							
	Hydroseeding	AC		0			
	Planting	AC		830	Assume planting areas along nooksack mainstem, north of slater road to lummi river, and along lummi river to haxton.		
	Vegetation Maintenance	AC-YR		4150	Assum 5 years		
	Erosion / sediment BMPs - Temp	AC		0.5	Ferndale		
	Erosion / sediment BMPs - Temp	AC		6.5	Slater at Nooksack		
	Erosion / sediment BMPs - Temp	AC		0.5	Slater at Lummi		
	Erosion / sediment BMPs - Temp	AC		0.22	Marine at Silver		
	Erosion / sediment BMPs - Temp	AC		3.5	Marine at Nooksack		
	Erosion / sediment BMPs - Temp	AC		0.5	Imhoff at Lummi		
	Erosion / sediment BMPs - Temp	AC		0.5	Haxton at Lummi		
	Erosion / sediment BMPs - Temp	AC		0.5	Kwina at Slough		
	Erosion / sediment BMPs - Permanent	AC		0			
	Waterside controls - Temporary	EA, LF, LS		0			
Construction Management							
	Construction oversight	weeks		36	Ferndale		
	Construction oversight	weeks		72	Slater at Nooksack		
	Construction oversight	weeks		36	Slater at Lummi		
	Construction oversight	weeks		40	Marine at Silver		
	Construction oversight	weeks		64	Marine at Nooksack		
	Construction oversight	weeks		20	Hillaire Road Removal		
	Construction oversight	weeks		36	Imhoff Road at Lummi		
	Construction oversight	weeks		36	Haxton at Lummi		
	Construction oversight	weeks		36	Kwina at Slough		
	Construction oversight	weeks					
	Construction oversight	weeks					
	Materials testing						
Design and Detailed Site Investigations							
	Survey & Property, Utility Research	LS		1	% of construction cost		
	35% Design	LS		1	35% x 25% x Engineer's Estimate		
	65% design	LS		1	65% x 25% x Engineer's Estimate less the cost for 35% PS&E		
	90% design	LS		1	35% x 25% x Engineer's Estimate less the cost for 35% + 65%PS&E		
	100% design	LS		1	25% x Engineer's Estimate less previous costs		
	Geotechnical Studies				Refer to design report for description of need		
	Cultural Studies				Refer to design report for description of need		
	HTWR Studies				Refer to design report for description of need		
Project Agreement Activities					Unable to provide credible estimate at 10% design		
Site-Specific Adaptive Management Features & Activities					List if known		
Monitoring Activities					Assume 5 crew-days/year for each monitoring parameter in design report for 5 yrs		
	Monitoring (Type_)	crew-days		250			
Operations & Maintenance					Unable to provide credible estimate at 10% design		

Partial Restoration Quantity Estimate

Action Name: Nooksack Delta
Action #: 1055
Date: February 2011 **Revised with backcheck updates: 30 June 2011**
By: ESA Revised April 2012

REMEDY: ***Remove levees, reconnect channels, linear ditches, and modify transporation infrastructure.***
Construction Period: 2-4 Years

	Item	**Unit of Measure**	**Material Name**	**Qty**	**Description of Item**	**Indicate section of design report where item is described**
ACQUISITION AND CONSERVATION					Based on available mapping information	
	Required Project Lands	Acre		3107	Total land required For actior	
	Proponent / Partner-owned lands	Acre		1938	Etimate of lands currently owned by Proponent (i.e., Public lands	
	Lands To Be Acquired	Acre		1086	Estimate land required to be acquired for action prior to implementatio	
Material Sites					Not Used: See Earthwork - Imported Fill.	
MOBILIZATION AND ACCESS for construction activities					Description required for each item to facilitate cost estimating	
	Mobilization - Typical (Equipment, Personnel, Planning, Financial)	LS		1	Assume 10% of total	
	Mobilization - Remote (Equipment, Personnel, Planning, Financia	LS		NA		
	Site Access	LS		1	Access can utilize existing paved and gravel surface roads to the majority of the site.	
	Barge Access	Days		NA		
	Temporary Traffic Control (one of the following)					
	none	LS		NA		
	signs	LS		1	Ferndale	
	flags / spotters	LS		1	Ferndale	
	signs	LS		1	Slater at Nooksack	
	flags / spotters	LS		1	Slater at Nooksack	
	signs	LS		1	Slater at Lummi River	
	flags / spotters	LS		1	Slater at Lummi River	
	signs	LS		1	Marine Drive at Silver Creek	
	flags / spotters	LS		1	Marine Drive at Silver Creek	
	signs	LS		1	Marine Drive at Nooksack	
	flags / spotters	LS		1	Marine Drive at Nooksack	
	signs	LS		1	Hillaire Road at Lummi	
	flags / spotters	LS		1	Hillaire Road at Lummi	
	signs	LS		1	Imhoff Road at Lummi	
	flags / spotters	LS		1	Imhoff Road at Lummi	
	signs	LS		1	Haxton at Lummi and Slough	
	flags / spotters	LS		1	Haxton at Lummi and Slough	
	signs	LS		1	Kwina at Slough	
	flags / spotters	LS		1	Kwina at Slough	
	Control of Water	LS		1	Significant levee removal on Nooksack mainstemwill need to be staged to coordinate with high fluvial flows and tides.	
	Control of Water	LS		1	Significant levee removal on Lummi River will need to be staged to coordinate with high fluvial flows and tides.	
Relocation Activities						
Site Demolition Activities						
	Clearing and Grubbing (one or more of following)					
	Clear Vegetation - Local Disposa	AC		33	Assume same area as total coverage of "excavation, lowlanc	23.3.1
	Clear /Grub Vegetation - Local Disposa	AC		NA		23.3.1
	Clear /Grub Vegetation - Offsite Disposal	AC		NA		23.3.1
	Clear, stockpile - large woody debris	CY		NA		23.3.1
	Hydraulic Structures - Small	LS		NA	Unknown number of structures to be removec	23.3.1
	Hydraulic Structures - Large	LS		NA		23.3.1
	Utilities	LF		21,120	This is a significant unknown. As a general estimate, the distance from the edge of the floodplain to the Lummi Delta is 4 miles along a major road. This would provide a mechanism to estimate costs for relocation of major utilities along this alignment	23.3.1
	Buildings	SF		102,700	Building removal within floodplain based on geodatabase, removing 34 structure	23.3.1
	Pavement	SF		28,600	Ferndale Road at Lummi River (L = 650 ft, W = 44 ft	23.3.1
	Pavement	SF		44,000	Slater Road at Nooksack (L = 1,000 ft, W = 44 ft)	23.3.1
	Pavement	SF		19,800	Slater Road at Lummi River (L = 450 ft, W = 44 ft)	23.3.1
	Pavement	SF		37,400	Marine Drive at Nooksack (L = 850 ft, W = 44 ft	23.3.1
	Pavement	SF		40,600	Hillaire Road Removal (L = 575 ft, W = 44 plus misc vertical adjustments at intersections	23.3.1
	Pavement	SF		17,600	Imhoff Road at Lummi (L = 400, W = 44)	23.3.1
	Pavement	SF		57,200	Haxton at Lummi (L = 1,300, W = 44)	23.3.1
	Pavement	SF		28,600	Kwina at Slough (L = 650 ft, W = 44 ft)	23.3.1
	Pavement	SF		234,800	Remove North Lummi (Red) River Road west of Haxton (L = 9783, W = 24	23.3.1
	Pavement	SF		459,730	Remove Ferndale between Slater and Marine Drive	23.3.1
	Bulkheads	LF or SF		NA		23.3.1
	Rock revetments	LF		19,308	On outside of Lummi Delta levee (largest rock approx. 4 ft diameter, depth unknown) This assumes full removal of armor, not just at breach locations	23.3.1
	Large Coastal Structures	LF, SF or CY		NA		23.3.1
	Demolition / Removal - Bridge	SF or CY		NA	See pavement removal	23.3.1
	Removal - Misc. (e.g. angular rock from beach)	Ton		NA		
	Demolition / Removal - Boat Ramp	SF		NA		
	Haul - Offsite Disposal of Demolition Debris	Miles		20	Assumed.	
Hazardous/Contaminated Waste Removal						
	Contaminated Earthwork	CY		0		
	Hazardous Earthwork	CY		0		
Construct Temporary Features						
EARTHWORK						
	Excavation	CY				
	Excavation - Uplanc	CY		NA		
	Excavation - Lowland	CY		9,950	Selective removal of levee along Lummi Rive	23.3.1
	Excavation - Lowland	CY		48,938	Remove berm from north side of Lummi River west of Haxtor	23.3.1
	Excavation - Lowland	CY		67300	Lummi River regrade	23.3.1
	Excavation - Lowland	CY		122500	Nooksack River ,mainstem partial berm removal - total length 13,225 '	23.3.1
	Excavation - Lowland	CY		6225	Remove portion of access road in Nooksack levee setback area	23.3.1
	Excavation - Lowland	CY		25850	Starter channels west of Hillaire	23.3.1
	Dredging - Bucket - Land	CY		NA		
	Dredging - Bucket - Marine	CY		NA		
	Dredging - Hydraulic	CY		NA		
	Fine Grading	AC		NA		
	Fill Placement - local borrow					
	Side cast	CY		19,950	Fill linear ditches on west side of Hillaire total length = 10,766	23.3.1
	Haul - uncontrolled placement	CY		NA		23.3.1
	Haul, place, compact	LS		1	Assume fill placement in subsided areas - volumes to be determined after new roadways complete	23.3.1
	Haul, place, compact	CY		18,250	Place fill on access road to aquaculture area	23.3.1
	Stockpile - uncontrolled placement	CY		NA		
	Stockpile - controlled placemen	CY		NA		
	Conveyor placement from stockpile land/wate	CY		NA		

Partial Restoration Quantity Estimate

Action Name: Nooksack Delta
Action #: 1055
Date: February 2011 **Revised with backcheck updates: 30 June 2011**
By: ESA Revised April 2012

REMEDY: ***Remove levees, reconnect channels, linear ditches, and modify transporation infrastructure.***
Construction Period: 2-4 Years

	Item	Unit of Measure	Material Name	Qty	Description of Item		Indicate section of design report where item is described
	Imported Fill						
	Select Fill	CY		25610	Golf Course Setback Levee		23.3.1
	Select Fill	CY		131,600	Lummi River North Setback levee west of Haxton Way		23.3.1
	Select Fill	CY		121,600	Lummi River North Setback levee east of Haxton Way		23.3.1
	Select Fill	CY		72,800	Lummi River south setback from Haxton to Ferndale		23.3.1
	Select Fill	CY		280733	Ferndale Road Realignment and setback levee		23.3.1
	Select Fill	CY		39150	Hillaire Road Berm		23.3.1
	Gravel Borrow, including haul	CY		NA			
	Sand / Gravel for Beach Nourishment	CY		NA			
	Cobble for Shore Nourishment	CY		NA			
	Embankment Compaction	CY		25610	Golf Course Setback Levee		23.3.1
	Embankment Compaction	CY		72,800	Lummi River Setback levee west of Haxton Way		23.3.1
	Embankment Compaction	CY		NA			
	Topsoil	CY		NA			
RESTORATION Features							
	Channel Rehab / Creation	SF		255850	New channel excavation on west side of Hillaire total length 7,753 linear fee		23.3.1
	Channel Rehab / Creation	SF		593,400	Lummi River regrade in upper 9,890 feet of channel		23.3.1
	Large Wood Placement	EA		1	ELJ structure at head of Lummi River		23.3.1
	Large Wood Placement	EA		3	ELJ structures in Mainstem		23.3.1
	Invasive Species Control	Acre		NA			
	Physical Exclusion Devices	LF or EA		NA			
	Other Restoration Features/ Activities	LS		NA			
Structures		EA					
	Water Control Structures - Culverts with Gates	EA		3	Self Regulating Tidegates (SRT) at the mouth of the Smuggler Slough system		23.3.1
	Water Control Structures - Weirs	EA		1	Weir at head of Lummi River		23.3.1
	Rock Slope Protection	LF		1970	Protection for Golf Course setback levee		23.3.1
	Other	EA		NA			
	Elevated Boat Ramp	SF		NA			
	Fencing	SF		NA			
Utilities							
	Water	LF		0			
	Gas	LF		0			
	Electric	LF		0			
	Sewer	LF		0			
	Telecommunications	LF		0			
	Other	LF		0			
Roadway / Railway							
	Roadway (Type A)	SF		540000	Ferndale Road Replacement on setback levee		23.3.1
	Roadway (Type A)	SF		8800	Slater Road, new causeway @5600 LF		23.3.1
	Roadway (Type A)	SF		8800	Slater Road at Lummi River		23.3.1
	Roadway (Type A)	SF		26400	Marine Drive Raise		23.3.1
	Roadway (Type A)	SF		8800	Hillaire Road at Lummi		23.3.1
	Roadway (Type A)	SF		6600	Imhoff Road at Lummi		23.3.1
	Roadway (Type A)	SF		17600	Kwina Road at Slough		23.3.1
	Roadway (Type A)	SF		8800	Haxton new causeway and road		23.3.1
	Roadway (Type A)	SF		276480	North Red River Road on new setback levee		23.3.1
	Roadway - Traffic Signal	LS		0			
	Culvert (type)	LF		90	New culvert with flap gate to drain golf course and surrounding neighborhood through setback leve		23.3.1
	Culvert (type)	LF		85	New culvert with flap gate to drain ag field through Lummi River Road setback leve		23.3.1
	Culvert - Jacking	LF		NA			
	Culvert - Horizontal Pile Driving	LF		NA			
	Bridge Deck	SF		11000	Ferndale Road 250' bridge, 44' wide. 2 spans w/ 6.5' Precast Concrete Girder Bridge		23.3.1
	Bridge Foundation	LF		44	Ferndale Road (1) 44' CIP Concrete pile caps with (2) 7' drilled shafts 100' embed at each pile ca		23.3.1
	Bridge Deck	SF		35200	Slater Road at Tennant Creek 390' x 44 wide bridge. 12" Precast voided slab with 5" C.I.P. Concrete Deck Continuous for Live Load (DEA, 2007		23.3.1
	Bridge Foundation	LF		308	Slater Road at Tennant Creek (7) 44' CIP Concrete pile caps with (2) 7' drilled shafts 100' embed at each pile cap (DEA, 2007)		23.3.1
	Bridge Deck	SF		11000	Slater at Lummi 250' bridge 44' wide. Two spans w/ 6.5' deep precast concrete girder		23.3.1
	Bridge Foundation	LF		44	Slater at Lummi (1) 44' CIP Concrete pile caps with (2) 7' drilled shafts 100' embed at each pile ca		23.3.1
	Bridge Deck	SF		19800	Hillaire at Lummi 450' bridge 44' wide. Five spans w/ 6.5' deep precast concrete girder		23.3.1
	Bridge Foundation	LF		88	Hillaire at Lummi (2) 44' CIP Concrete pile caps with (2) 7' drilled shafts 100' embed at each pile ca		23.3.1
	Bridge Deck	SF		11000	Imhoff at Lummi 250' bridge 44' wide. Two spans w/ 6.5' deep Precast Concrete Girder Bridge		23.3.1
	Bridge Foundation	LF		44	Imhoff at Lummi (1) 44' CIP Concrete pile caps with (2) 7' drilled shafts 100' embed at each pile ca		23.3.1
	Bridge Deck	SF		19800	Haxton Way at Lummi River 450' bridge 44' wide. Five spans w/ 6.5' deep precast concrete girder		23.3.1
	Bridge Foundation	LF		88	Haxton Way at Lummi River (2) 44' CIP Concrete pile caps with (2) 7' drilled shafts 100' embed at each pile ca		23.3.1
	Bridge Deck	SF		11000	Kwina at Smuggler Slough 250' bridge 44' wide. Two spans w/ 6.5' deep Precast Concrete Girder Bridge		23.3.1
	Bridge Foundation	LF		44	Kwina at Slough (1) 44' CIP Concrete pile caps with (2) 7' drilled shafts 100' embed at each pile ca		23.3.1
	Bridge Deck	SF		NA			
	Railway - Box Girder	SF		NA			
	Railway - Foundation	LF		NA			
	Railway - Shoe fly	LF		NA			
Permanent Access Features							
	Roads	Level		NA	Ferndale (No level assigned at this stage of design: Level 1 direct access, Level 2 moderately difficult, Level 3 difficult access)		
	Roads	Level		NA	Slater at Nooksack (No level assigned at this stage of design: Level 1 direct access, Level 2 moderately difficult, Level 3 difficult access		
	Roads	Level		NA	Slater at Lummi (No level assigned at this stage of design: Level 1 direct access, Level 2 moderately difficult, Level 3 difficult access)		
	Roads	Level		NA	Marine Drive (No level assigned at this stage of design: Level 1 direct access, Level 2 moderately difficult, Level 3 difficult access)		
	Roads	Level		NA	Imhoff Road at Lummi River (No level assigned at this stage of design: Level 1 direct access, Level 2 moderately difficult, Level 3 difficult access		
	Roads	Level		NA	Haxton at Lummi (No level assigned at this stage of design: Level 1 direct access, Level 2 moderately difficult, Level 3 difficult access)		
	Roads	Level		NA	Kwina at Slough (No level assigned at this stage of design: Level 1 direct access, Level 2 moderately difficult, Level 3 difficult access)		
	Utility Access Routes	varies		0			
	Erosion Control Features	L.F.		0.25	Ferndale		
	Erosion Control Features	L.F.		0.8	Slater at Nooksack		
	Erosion Control Features	L.F.		0.25	Slater at Lummi		
	Erosion Control Features	L.F.		0.87	Marine Drive		
	Erosion Control Features	L.F.		0.5	Hillaire Road at Lummi		
	Erosion Control Features	L.F.		0.25	Imhoff Road at Lummi River		
	Erosion Control Features	L.F.		0.25	Haxton at Lummi		
	Erosion Control Features	L.F.		0.25	Kwina at Slough		
	Erosion Control Features	L.F.					

Partial Restoration Quantity Estimate

Action Name:	Nooksack Delta
Action #:	1055
Date:	February 2011 **Revised with backcheck updates: 30 June 2011**
By:	ESA Revised April 2012

REMEDY: ***Remove levees, reconnect channels, linear ditches, and modify transporation infrastructure.***

Construction Period: 2-4 Years

	Item	Unit of Measure	Material Name	Qty	Description of Item		Indicate section of design report where item is described
Public Access or Recreation Features							
	Trails	SF		0			
	Bridges	SF		0			
	Kiosk	EA		0			
	Restrooms	EA		0			
	Interpretive Signs	EA		0			
	Parking Area	SF		0			
	Other	EA		0			
Vegetation & Erosion Control							
	Hydroseeding	AC		0			
	Planting	AC		830	Assume planting areas along Nooksack mainstem, north of Slater road to Lummi river, and along Lummi river to haxton.		
	Vegetation Maintenance	AC-YR		4150	Assum 5 years		
	Erosion / sediment BMPs - Temp	AC		0.25	Ferndale		
	Erosion / sediment BMPs - Temp	AC		0.8	Slater at Nooksack		
	Erosion / sediment BMPs - Temp	AC		0.25	Slater at Lummi		
	Erosion / sediment BMPs - Temp	AC		0.87	Marine Drive		
	Erosion / sediment BMPs - Temp	AC		0.5	Hillaire Road at Lumm		
	Erosion / sediment BMPs - Temp	AC		0.25	Imhoff at Lummi		
	Erosion / sediment BMPs - Temp	AC		0.25	Haxton at Lummi		
	Erosion / sediment BMPs - Temp	AC		0.25	Kwina at Slough		
	Erosion / sediment BMPs - Permanent	AC		0			
	Waterside controls - Temporary	EA, LF, LS		0			
Construction Management							
	Construction oversight	weeks		40	Ferndale		
	Construction oversight	weeks		40	Slater at Nooksack		
	Construction oversight	weeks		40	Slater at Lummi		
	Construction oversight	weeks		100	Marine at Nooksack		
	Construction oversight	weeks		36	Hillaire Road at Lummi		
	Construction oversight	weeks		40	Imhoff Road at Lummi		
	Construction oversight	weeks		40	Haxton at Lummi		
	Construction oversight	weeks		40	Kwina at Slough		
	Construction oversight	weeks					
	Construction oversight	weeks					
	Materials testing						
Design and Detailed Site Investigations							
	Survey & Property, Utility Research	LS		1	% of construction cost		
	35% Design	LS		1	35% x 25% x Engineer's Estimate		
	65% design	LS		1	65% x 25% x Engineer's Estimate less the cost for 35% PS&E		
	90% design	LS		1	35% x 25% x Engineer's Estimate less the cost for 35% + 65%PS&E		
	100% design	LS		1	25% x Engineer's Estimate less previous costs		
	Geotechnical Studies				Refer to design report for description of need		
	Cultural Studies				Refer to design report for description of need		
	HTWR Studies				Refer to design report for description of need		
Project Agreement Activities					Unable to provide credible estimate at 10% design		
Site-Specific Adaptive Management Features & Activities					List if known		
Monitoring Activities					Assume 5 crew-days/year for each monitoring parameter in design report for 5 yrs		
	Monitoring (Type_)	crew-days		250			
Operations & Maintenance					Unable to provide credible estimate at 10% design		

24. NORTH FORK LEVEE SETBACK (#1102)

Local Proponent	Skagit Watershed Council
Delta Process Unit	SKG
Shoreline Process Unit(s)	NA
Strategy(ies)	1 – River Delta
Restoration Objectives	Specific process-based restoration objectives include: (1) tidal channel formation and maintenance; (2) tidal flow; (3) distributary channel migration; (4) erosion and accretion of sediments; and (5) exchange of aquatic organisms

24.1 Description of the Action

The proposed action will restore the riverine floodplain and tidal connectivity along the lower reach of the North Fork of the Skagit River. This will require constructing a new flood protection dike further inland. The existing dike would be lowered and selectively breached to allow inundation of the estuarine emergent marsh and sustain back channel habitat. Forested floodplain habitat would be created along the lowered dike adjacent to the mainstem river channel. Please see the Introduction chapter for important information regarding PSNERP and for context related to this restoration project.

24.2 Action Area Description and Context

Extensive diking of the North Fork Skagit River has caused substantial loss of estuarine connectivity. The proposed restoration would set back flood protection dikes on both sides of the North Fork, from the former inlet of Dry Slough to the western terminus of the dike system near Rawlins Road. The action seeks to restore natural levees and create additional emergent marsh and riverine wetlands.

A brief description of the project is included in the Skagit Chinook Recovery Plan (SRSC and WDFW 2005). The plan lists this action as a project with a "long-term restoration horizon," meaning that it is generally less well developed and has uncertainties that must be addressed before implementation. The same plan includes a number of other setback projects proposed along the North Fork at Thein Farm, Rawlins Road Dike, and Blake's Bottleneck. A feasibility study of the Rawlins Road project has been conducted (Yang and Khangaonkar 2006). Given their geographical proximity, there is potential synergy between the North Fork levee setback and these other projects. The full restoration alternative presented here is a combination of the North Fork at Thein Farm, Rawlins Road Dike, and Blake's Bottleneck projects. The partial restoration alternative is based on the North Fork project alone. The action area is shown in Figure 24-1.

Figure 24-1. Action Area and Vicinity

24.2.1 Historic Condition

Estuarine wetlands were extensive in the floodplains of the Skagit River, accounting for at least 27% of land area (Collins 1998, p.7). The Skagit River delta also had extensive freshwater wetlands covering a further 22% of the land area (freshwater wetlands include riverine tidal areas in which tidal backwater augmented the effects of flooding). The delta had numerous distributary and blind tidal channels which, because of the delta's diverging-spreading form, were dominated by estuarine channels. Deposition patterns associated with these channels created topographic gradients. The highest areas occur upstream where there was initial deposition of coarser material from fluvial sources. Elevations lowered and the sediment became finer southward as estuarine processes dominated. There was also an elevation gradient laterally with distance from the distributary channels. Coarser, better drained soils were found in the natural levees that line the banks of the distributary channels, creating distinctive riparian corridors in the deltas. Typically small channels would have run parallel to the main channel behind the natural levee.

Since 1860, land development on the delta has removed a large proportion of the estuary from the landscape, fundamentally altering the geomorphic processes that form and sustain delta ecosystems. The diking of distributary channels has had a significant impact on estuarine wetlands and tidal channels in the delta (Collins 1998). The 1886 topographic sheet (T-sheet) already showed extensive diking on the North Fork and on Fir Island (Figures 24-2A and 24-2B). Despite the extensive diking, the total area of distributary channel has remained reasonably constant as the North Fork delta continues to prograde and creates smaller emergent marshes and associated channels at its seaward edges. However, the loss of large distributary channels and associated wetlands in the estuarine-fluvial zone has been significant. These areas provide a critical transition zone for juvenile salmonids as they migrate downstream from freshwater habitats to Puget Sound. Diking eliminated these pathways and drained or isolated large areas of emergent marsh on the bay front of Fir Island that had sustained the estuarine food web. Blocking of distributary channels fragmented the remnant bayfront marshes and reduced use by juvenile salmon migrating down mainstem river channels. Diking of emergent marshes eliminated parallel drainage systems landward of the natural levees, and reduced the size and complexity of remnant channels on the outboard side.

24.2.2 Natural Environment

The North Fork levee action area lies on a salinity gradient from estuarine-emergent marsh, to estuarine-scrub-shrub, to forested floodplain zones (Collins 2000). While salinity and elevation gradients still exist in the action area, much of the associated habitat has been lost. Only a discontinuous narrow strip of riparian floodplain now lies between the channel and the dike. This strip is about 500 feet wide on either side of the North Fork bridge but narrows significantly downstream. The floodplain disappears altogether for long stretches where the dike is adjacent to the channel. In several of these locations the dike has been armored with riprap. The remnant riparian floodplain has been significantly narrowed and fragmented. The only remaining channels associated with the floodplain are found adjacent to the North Fork bridge and appear to have been truncated by diking.

There are significant areas of emergent marsh, scrub-shrub and forested floodplain west of Rawlins Road. Continuing this band of habitat eastward through the site would significantly improve the ecosystem connectivity within North Fork floodplains, tidal channels, and estuarine wetlands. This would increase the migratory conditions for salmonids between the Skagit River and nearshore marsh habitats eliminated with the construction of the dikes. It would also restore landscape-scale ecological processes on Fir Island as the health of a coastal marshland habitat is dependent upon an adequate supply of sediment and nutrients, which was eliminated with construction of the dikes.

24.2.3 Human Environment

Fir Island is intensively farmed. Fields and farm buildings lie immediately adjacent to the dikes, and several farm residences are located within the site boundary. The agricultural land is all low lying due to 2 to 4 feet of subsidence associated with drainage and farming activities. A former garbage dump to the west of Brown Slough Road, operated by Skagit County, is reported to lie within the site; however, this is anecdotal and its exact location and its contents will need to be determined (Diking District 26 representative, pers. comm.). To the west, adjacent to the North Fork channel, is Blake's Resort, an RV park and marina. Providing access and maintaining flood protection to the resort will be a challenge given its location between the main channel and proposed restoration areas.

Highway 534 (Fir Island Road, Brown Slough Road, or Best Road) crosses the North Fork in the middle of the site and is a primary access to Fir Island, connecting it with

Interstate 5 and State Route 20. The southern approach of the North Fork bridge crosses the site. The inland boundary of the site is delimited by Rawlins Road and Moore Road. At the eastern end of the site, Moore Road runs adjacent to the existing dike and dwellings within the proposed levee setback area.

24.3 Restoration Design Concept

24.3.1 Restoration Overview and Key Design Assumptions

The primary stressors are armored dikes preventing deltaic estuarine processes from occurring. Hydraulic processes related to frequency and depth of inundation are eliminated. Similarly, geomorphic processes such as sedimentation, channel alvusion and channel migration are prevented. This, combined with agricultural practices, has resulted in significant subsidence (2 to 4 feet) of the former emergent marsh/scrub-shrub habitat. Breaching and lowering of the dikes to suitable elevations is intended to restore combined tidal/freshwater (low salinity) hydrology to support channel formation, emergent marsh, forested floodplains and scrub-shrub wetland community development. Specific process-based restoration objectives to be achieved with this action include: (1) tidal channel formation and maintenance; (2) tidal flow; (3) distributary channel migration; (4) erosion and accretion of sediments; and (5) exchange of aquatic organisms.

The action provides an opportunity to restore estuarine emergent marsh, scrub-shrub and forested floodplain along the North Fork Skagit River. Such restoration would improve connectivity of the North Fork and reduce fragmentation along the channel. If the setback is sufficiently wide, there is also the opportunity for recreating the elevation gradient landward of the lowered dike and restoring back channels parallel to the North Fork. Widening the floodplain by setting back the flood protection dikes may also reduce flood risks and reduce the need for armoring of the dike face.

The full restoration alternative would create a continuous floodplain corridor along the length of the south bank of the North Fork, and an area of floodplain along the north bank of the North Fork (Figure 24-3) by setting back the flood protection dike. The project area includes the existing site footprint, the adjacent Rawlins Road setback project area, and Blake's Resort – a total project area of 310 acres. These expanded floodplains would increase flood capacity along the North Fork, and potentially lower flood levels in the project vicinity and to some extent upstream of the project site.

Inundation of Fir Island would be prevented by 12,600 LF of new flood protection dikes constructed along the southern edge of the site on the north side of Rawlins Road. The crest elevation of the new dikes will be 21.5 feet MLLW (20 feet NAVD88 based on the La Conner tide gage), the same crest elevation as the dike it replaces. On the north side of the river, no new flood protection levees are required as the setback area grades into rising land.

The existing dikes (approximately 16,100 LF) would be lowered to elevations similar to that of the natural levees (about 13.5 feet MLLW, 12 feet NAVD88), which are formed during flood events and exist further downstream. This would restore the natural overtopping processes that occur during floods. Buildings, roads, utilities, and other hard structures/surfaces within the setback area, including Blake's Resort, will be removed. The material excavated during the lowering of the crest of the dike would be placed on the landward side of the existing dike to create a forested floodplain berm 100 to 150 feet wide. The width of the berm will be determined by the amount of material available. The berm will be constructed up to a maximum elevation of about 13.5 feet MLLW (12 feet NAVD88).

Breaches through the lowered dikes would allow unimpeded tidal inundation of the estuarine emergent marsh in the setback area. These breaches would be about 120 feet wide, with an additional 100 feet of the adjacent dike on either side lowered to 8.5 feet MLLW (7 feet NAVD88) to provide additional capacity at higher water levels. Channels running parallel to the mainstem river channel would drain the setback area through the breaches and create back channel habitat. Such habitat may take several decades to evolve unassisted. To accelerate their evolution, these breaches and channels will be excavated to equilibrium dimensions as described in the *Applied Geomorphology Guidelines* (Appendix C). Excavating the channels will also reduce the possibility of channel migration and the erosion of the flood protection dike. Channel top widths would vary between 30 and 100 feet, with depths between 4 and 8 feet below existing grade. Approximately 20,400 LF of channel would be excavated: 2,400 LF of second-order; 7,800 LF of third-order; 7,600 LF of fourth-order; and 2,600 LF of fifth-order. Material generated by channel excavation will be sidecast to increase heterogeneity of the setback area, help establish forested floodplain, and reduce handling and hauling costs.

The partial restoration alternative would restore a portion of the corridor based on a smaller footprint (Figure 24-4). The dike would be set back on only the southern side of the river between Blake's Resort and North Fork bridge – an area of 130 acres. Inundation of Fir Island would be prevented by 10,700 LF of new flood protection dikes constructed along the southern edge of the site, along the north side of Rawlins Road and along the access road to Blake's Resort. The existing dikes (approximately 7,600 LF) would be lowered to elevations similar to that of the natural levees. Buildings, roads, utilities, and other hard structures within the setback area will be removed. The material excavated during the lowering of the crest of the dike would be placed on the landward side of the existing dike to create a wider forested floodplain berm. Channels running parallel to the mainstem river channel would drain the setback area through breaches and create back channel habitat. These breaches and channels will be excavated to equilibrium dimensions as described in the *Applied Geomorphology Guidelines* (Appendix C). Breach width would be about 120 feet, with an additional 100 feet of the adjacent dike lowered on either side. Channel top widths would vary between 30 and 50 feet, with depths between 4 and 8 feet below existing grade. Approximately 7,900 LF of channel would be excavated: 6,400 LF of third-order and 1,500 LF of fourth-order. Material generated by channel excavation will be sidecast.

There would be limited benefit in setting back the dike adjacent to the North Fork bridge. The existing alignment is not impeding ecosystem processes, and a setback would have minimal hydraulic impact while impacting the existing riparian corridor. The proposed setbacks will increase the flood conveyance downstream of the North Fork bridge, which in turn is likely to reduce upstream flood levels. The issue of blockage by large woody debris could be addressed via normal maintenance.

Table 24-1 describes the key design elements associated with full and partial restoration alternatives. The alternatives are illustrated in Figures 24-3 through 24-5.

Table 24-1. Key Design Elements

Element	Full Restoration	Partial Restoration
Lower Dike	Create low, natural levee adjacent to North Fork Skagit (16,140 LF) to support riparian woodland corridor	Create low, natural levee adjacent to North Fork Skagit (7,580 LF) to support riparian woodland corridor
Revegetation	Plant riparian vegetation along low natural levee to expand riparian corridor	Plant riparian vegetation along low natural levee to expand riparian corridor
Breaches	Breach lowered dike in 4 locations	Breach lowered dike in 2 locations
Tidal Channels	About 20,400 LF of tidal channels excavated in restored floodplain	About 7,850 LF of tidal channels excavated in restored floodplain
Build New Dike	Construct new flood protection dike along Rawlins Road, Browns Slough Road, and Moore Road (12,640 LF)	Construct new flood protection dike along Rawlins Road, Blake's Resort Road, and Browns Slough Road (10,680 LF)
Revegetation	Plant riparian vegetation along slopes of new dike	Plant riparian vegetation along slopes of new dike
Demolish Existing Buildings	Remove Blake's Resort, 6 buildings	Remove 5 buildings

24.3.2 Restoration Features – Primary Process-Based Management Measures

Armor Removal/Modification

The full restoration alternative would remove armoring, in the form of riprap, along both the north and south banks of the North Fork Skagit River. The design of the new flood protection dikes does not include riprap. Armoring would be removed from up to 13,000 LF of the south bank and up to 3,140 LF of the north bank (Figure 24-5).

The partial restoration alternative would remove armoring from up to 7,580 LF of the south bank of the North Fork Skagit River (Figure 24-5).

Berm or Dike Removal/Modification

The existing dikes along the North Fork Skagit River would be lowered or removed, and a natural levee would be created adjacent to the channel. The crest elevation of the natural levee would be low enough to allow periodic flooding but high enough to retain a riparian corridor.

The full restoration alternative would lower the existing dikes along both the north and south banks of the North Fork Skagit River. The dikes along up to 13,000 LF of the south bank and up to 3,140 LF of the north bank would be lowered.

The partial restoration alternative would lower up to 7,580 LF of the south bank of the North Fork Skagit River.

Channel Rehabilitation/Creation

In the setback area between the existing dike and the new flood protection dike, parallel drainage systems will be created. Each drainage system would include a breach and sinuous tidal channel network to allow tidal inundation from the North Fork Skagit River to flow onto the restored floodplain. Breaches and tidal channels would be sized based on contributing watershed area and estimated tidal prism. Material excavated to create the tidal channels would be sidecast adjacent to the channels to create low berms to support a riparian corridor.

In the full restoration alternative, four breaches and tidal channel networks would be created, including about 20,400 LF of tidal channels ranging in size from second-order (about 4 feet deep and 30 feet top width) to fifth-order (about 100 feet wide and 8 feet deep) (Figure 24-5).

The partial restoration alternative would include two breaches. Tidal channel networks would be created with about 7,850 LF of third- and fourth-order channels (30 to 50 feet wide and 4 to 8 feet deep (Figure 24-5)).

Groin Removal/Modification - NA

Hydraulic Modification - NA

Overwater Structure Removal - NA

Topography Restoration

The full and partial restoration alternatives involve grading along the inside of the lowered dike of the North Fork to support a riparian corridor. Breaches in the lowered dike will allow emergent marsh to form on the restored floodplain.

24.3.3 Restoration Features – Additional Management Measures

Beach Nourishment - NA

Contaminant Removal/Remediation - NA

Debris Removal - NA

Invasive Species Control - NA

Large Wood Placement - NA

Physical Exclusion - NA

Pollution Control – NA

Revegetation

Both the full and partial restoration alternatives include lowering of existing dikes to mimic natural levees with a low, wide crest and flat slopes to support riparian corridors. Along excavated channels, the low berms created with the sidecast material will be at riparian elevations. These lowered natural levee and sidecast berms will be planted with native riparian species.

The realigned levee along Rawlins Road, Brown's Slough Road, and Moore Road will have a gradual transitional slope from the riparian elevations down into the floodplain. This slope will also support riparian plantings.

Reintroduction of Native Animals - NA

Substrate Modification - NA

Species Habitat Enhancement - NA

24.3.4 Restoration Features – Other

The existing dike along the North Fork would be realigned, and new flood protection dikes would need to be constructed along the landward edge of the site. The new flood protection dike would have a crest elevation of 21.5 feet MLLW (20 feet NAVD88) to maintain the current level of flood protection. The flood protection dike would incorporate a relatively flat transitional slope from riparian elevations down to the restored floodplain to support a riparian corridor and to increase stability. Depending upon geotechnical properties of the soils, the flood protection dike may incorporate a stability berm adjacent to Rawlins Road.

In the full restoration alternative, about 12,640 LF of new flood protection dike would be constructed. In most cases, the new dike alignment would be adjacent to Rawlins Road and Brown Slough Road. Under the full restoration alternative presented, the restoration plan follows the Moore Road alignment. The dike alignment will need to account for the location of any identified landfills.

In the partial restoration alternative, about 10,680 LF of new flood protection dike would be constructed. The new flood protection dike would protect the western boundary of Blake's Resort Road, and run along the northern boundary of Rawlins Road and along Brown Slough Road.

24.3.5 Land Requirements

This action would require acquisition of several privately owned properties. Numerous buildings located along Rawlins Road would need to be removed under the full and partial restoration alternatives. In the full restoration alternative, Blake's Resort and six buildings would need to be removed. In the partial restoration alternative, five buildings would be removed. The only known utilities in the area are related to the existing buildings.

A dike high enough to provide adequate flood protection, including allowance for subsidence, requires a corridor of at least 150 to 200 feet, which could take a substantial proportion of the setback area depending upon other property constraints.

24.3.6 Design Considerations

There are significant constraints for this site. Most of the land appears to be approximately MHHW or below in elevation (less than 10.4 feet MLLW, 8.8 feet NAVD88). For riparian habitat, the elevation would need to be higher (10.5 feet to 13.5 feet MLLW, 9 feet to 12 feet NAVD88). Adjacent to the North Fork, the existing dike provides a source of fill to create a broad natural levee to support a wide riparian corridor. Along the tidal channel network, excavated material would be used to create low berms at natural riparian levee elevations.

Flood protection for Fir Island would be provided by a new flood protection dike running beside the present road alignment in both alternatives. Blake's Resort would require access and protection from erosion and flooding in the partial restoration alternative.

A large quantity of material would be required for construction of the new dike. In the full restoration alternative, more than 506,000 CY of material is required. By comparison, about 439,000 CY of material would be excavated to lower the existing dike and to excavate channels. The partial restoration alternative has a larger deficit between cut and fill, with about 427,000 CY of material required to construct the new dike and 169,000 CY of excavated material onsite.

Ideally, most of the excavated material would be used to create low levees to support riparian corridors. This excavated material may not be suitable for dike core fill. Some of the excavated material may be used to create stability berms and transitional slopes along the new, realigned dike, but competent, structural fill will need to be imported for the dike core.

24.3.7 Construction Considerations

The present diked nature of the site would allow for construction of the tidal channel network and the new dike year-round. The new dike would be constructed first with imported material. The new flood protection dike and upper portions of the tidal channel network could be constructed primarily with upland equipment, including scrapers and end dumps. Excavators may be needed to create portions of the tidal channel network due to high groundwater levels.

Following construction of the new flood protection dike, the existing dike adjacent to the North Fork may be lowered and widened primarily with upland equipment, provided this work occurs during the dry season. Breaches would require work with excavators. Final dike lowering and breaching should be coordinated, including a plan for access as tidal waters enter the site.

24.4 Extent of Stressor Removal

Table 24-2 describes the amount of stressors to be removed with this action.

Table 24-2. Stressor Removal

Stressor	Full Restoration	Partial Restoration
Tidal Barrier (LF)	Lower existing dike (16,140 LF)	Lower existing dike (7,580 LF)
Armor (LF)	16,140 LF of armor on dike along North Fork	7,580 LF of armor on dike along North Fork
Marinas (area)	Blake's Resort ~ 7.5 acres	NA

24.5 Expected Evolution of the Action Area

Without restoration, erosion of the flood protection dike will continue, requiring more armoring along its length. Over time, the dike footprint will increase, most likely on the channel side. As a consequence, the remaining riparian floodplain will be reduced in area and become increasingly fragmented. Rising sea levels will impact both the dike and the floodplain. As sea level rises, the crest elevation of the dike will have to be raised to maintain the same level of protection from flooding. In addition there is likely to be loss of floodplain as habitats are "squeezed" against the dike slope.

Lowering the existing dike and allowing it to function as a "natural levee," with frequent overtopping, together with breaching and creation of a tidal channel system, will increase the area of emergent marsh and scrub-shrub floodplain. By providing a buffer to flood flows, erosion and overtopping of the realigned flood protection dike will be reduced, requiring less maintenance and future armoring.

The site is intended to evolve toward a mature state to provide similar ecologic functions to those in the historic emergent marsh. However, the mature restored marsh may differ from, or take a very long time to achieve, the same functions as the historic marsh. Within the project site there has been considerable subsidence relative to the tidal frame. This will likely result in more intertidal emergent marsh and less scrub-shrub and forested wetland than existed prior to diking.

In a restored marsh, floodwater transports suspended sediments that deposit in the slack waters of the flooded site. As the emergent marsh/mudflat rises in elevation, the period of inundation decreases and the rate of sedimentation declines. The elevation of the subsided site is anticipated to evolve, in response to estuarine sedimentation processes, to intertidal emergent marsh between 7.1 and 11.3 feet MLLW.

The rate at which the elevation of mudflat and marsh accretes depends on the amount of sediment carried into the site by floodwater, the rate of relative sea level rise, the amount of resuspension of deposited sediments, and the rate of organic accretion. The balance between sea level rise and net accretion will determine the ultimate equilibrium of the emergent marsh elevation.

Concurrent with the physical evolution of the marsh, the tidal drainage system running parallel to the natural levee will evolve. The higher order channels will be excavated before breaching. Lower order channels will be allowed to develop naturally. As the marsh evolves from primary colonized mudflat to low emergent marsh and then to high emergent marsh, the density of tidal drainage channels changes. In the young marsh, marsh elevations are low, tidal prism is large, and drainage density high. As sediments accrete beyond a certain point, tidal prism is reduced and drainage density decreases. Channel density therefore varies with elevation and hence age of restoration. A low marsh restoration will tend to have more small channels in complex drainage patterns, while a higher or older marsh will tend to have a less complex drainage pattern with fewer small channels. Borrow ditches or drains will be blocked to prevent them from capturing and dominating the evolution of the tidal drainage system.

24.6 Uncertainties and Risks

Significant uncertainties exist in the ability to acquire property within the project area. The project concept is based upon restoring a contiguous corridor and so requires the cooperation of a number of land owners. Another uncertainty is the location of a landfill adjacent to the North Fork bridge, which could restrict the degree of dike setback at the eastern end of the project area.

Uncertainty also exists in the long-term evolution of the site. There have been major shifts in flow and sediment load between the South and North Fork channels in the past. Such a shift in the future could reduce the supply of sediment to the restored wetlands, reducing accretion rates and the ability to respond to accelerated sea level rise.

One significant risk is that the setback of the present dike may lead to the avulsion of a new distributary channel. To the west of the North Fork bridge is the imprint of Brown Slough, a historic distributary channel which can be seen in aerial photos. It is possible that this channel could be reoccupied during a high flood event. To reduce this possibility, fill could be placed in the historic channel between the flood protection dike and natural levee to redirect the flow into the main channel.

24.6.1 Risks Associated with Projected Sea Level Change

Table 24-3 compares potential risks associated with projected sea level changes based on professional judgment.

Table 24-3. Risks of Sea Level Change

	Projected Sea Level Change		
	High (46 cm)	**Intermediate (4 cm)**	**Low (-8 cm)**
Full Restoration	Changes to the salinity gradient of the Skagit River in response to climate change and other factors influencing freshwater discharges could affect habitat distribution. Levee design (in particular the levee footprint) needs to allow for the projected increase in relative sea level. Emergent marsh will transgress up natural levee slope if marsh accretion does not keep pace with sea level rise.	Negligible	Negligible

	Projected Sea Level Change		
	High (46 cm)	Intermediate (4 cm)	Low (-8 cm)
Partial Restoration	Changes to the salinity gradient in response to climate change and other factors influencing freshwater discharges could affect habitat distribution. Levee design (in particular the levee footprint) needs to allow for the projected increase in relative sea level. Emergent marsh will transgress up natural levee slope if marsh accretion does not keep pace with sea level rise.	Negligible	Negligible

24.7 Potential Monitoring Opportunities

Monitoring is important for evaluating restoration success. A combination of field surveys and aerial photographs would be used to document biological and physical changes to the landscape. Monitoring data can be used to refine adaptive management and corrective actions, as needed. Some of the main monitoring needs and opportunities associated with this action are summarized in Table 24-4.

Table 24-4. Monitoring Needs and Opportunities

Monitoring Parameter	Key Performance Indicator	Note
Topographic Stability		
Sediment Accretion / Erosion	X	Sediment rates will affect vegetation establishment
Wood Accumulation		
Soil / Substrate Conditions		
Vegetation Establishment	X	Assess riparian and marsh plant establishment
Marsh Surface Evolution / Accretion	X	Assess changes from mudflat to low, and then high marsh
Tidal Channel Cross-Section / Density	X	Monitor increase in channel density
Water Quality (contaminants)		
Salinity	X	
Shellfish Production		

Monitoring Parameter	Key Performance Indicator	Note
Extent of Invasive Species		
Animal Species Richness	X	
Fish (salmonid) Access/Use	X	
Forage Fish Production		
Wildlife Species Use		
Effectiveness of Exclusion Devices		

24.8 Information Needed for Subsequent Design

This conceptual design report represents an initial step in the restoration design sequence. The design concepts described above were developed based on readily available information without the level of site-specific survey and investigation that is necessary to support subsequent design and implementation. Substantial additional information will be required at the preliminary design stage to confirm the design assumptions, refine quantity estimates, address property and regulatory issues, obtain stakeholder support, and fill in data gaps. The extent to which this information is collected for preliminary design (or a later design stage) will depend upon the available budget, schedule, and other factors. This section attempts to define the most essential information needs for this action.

- Property Investigation/Survey – More detailed information on parcel ownership, utilities, and property boundary locations will be needed to finalize the design, confirm acquisition requirements, and support negotiations with property owners.
- Topographic/Bathymetric Survey – The survey data would be used to refine design of key project elements and develop detailed construction and demolition plans. Survey data could also be used as a baseline for pre- and post-construction modeling, including hydrodynamic modeling. Additional tidal information is necessary for the design; the installation of a tide gage should be evaluated against other approaches.
- Geotechnical Investigation – Geotechnical investigations of existing subsoils and potential fill sources for new levees are needed. Geotechnical recommendations are required for new levee design.
- Cultural Resources Investigation – Surveys for archaeological and historic resources may be required for this action area. This is particularly important in areas proposed for excavation and trenching.
- Hydraulic Analysis/Modeling – Hydrologic and hydraulic modeling of flood flows along the North Fork Skagit River is needed to inform setback levee heights to contain the design 100-year flood flow and to determine riparian berm. Two-dimensional modeling will be required to capture the complex flow patterns during large flood events.
- Contaminant Survey – If preliminary investigations suggest that hazardous material could be present in the action area, additional soil and sediment analysis

may be needed. The introductory chapter describes the Phase I site investigations that are occurring as part of this overall effort via a separate contract.

24.9 Quantity Estimates

The quantity spreadsheets for the full and partial restoration alternatives are provided in Exhibits 24-1 and 24-2.

24.10 References

Collins, B. 1998. *Preliminary assessment of historic conditions of the Skagit River in the Fir Island area: Implications for salmonid habitat restoration*. Prepared for the Skagit River System Cooperative.

Collins, B. 2000. *Mid-19th century stream channels and wetlands interpreted from archival sources for three north Puget Sound estuaries*. Prepared for Skagit System Cooperative, Bullitt Foundation and Skagit Watershed Council.

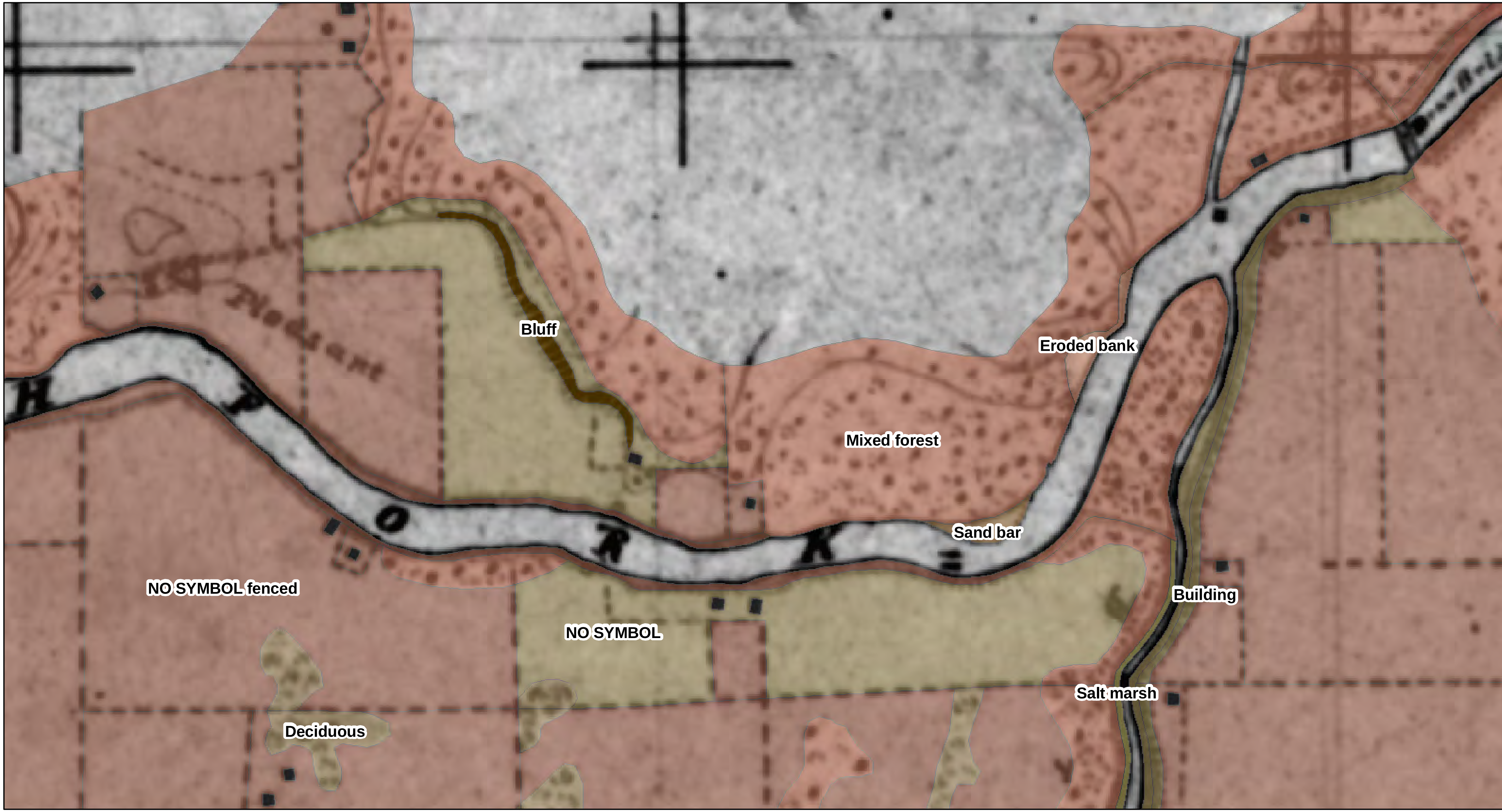
SRSC (Skagit River System Cooperative and Washington Department of Fish and Wildlife). 2005. *Skagit Chinook Recovery Plan*.

Yang, Z. and T. Khangaonkar. 2006. *Rawlins Road Restoration Feasibility Study*. Prepared by Battelle for the Skagit Watershed Council.

0 600
Feet
0 180
Meters

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Historic Map (T-Sheet)
Action Name: North Fork Levee Setback
PSNERP ID #: 1102
Figure 24- 2A

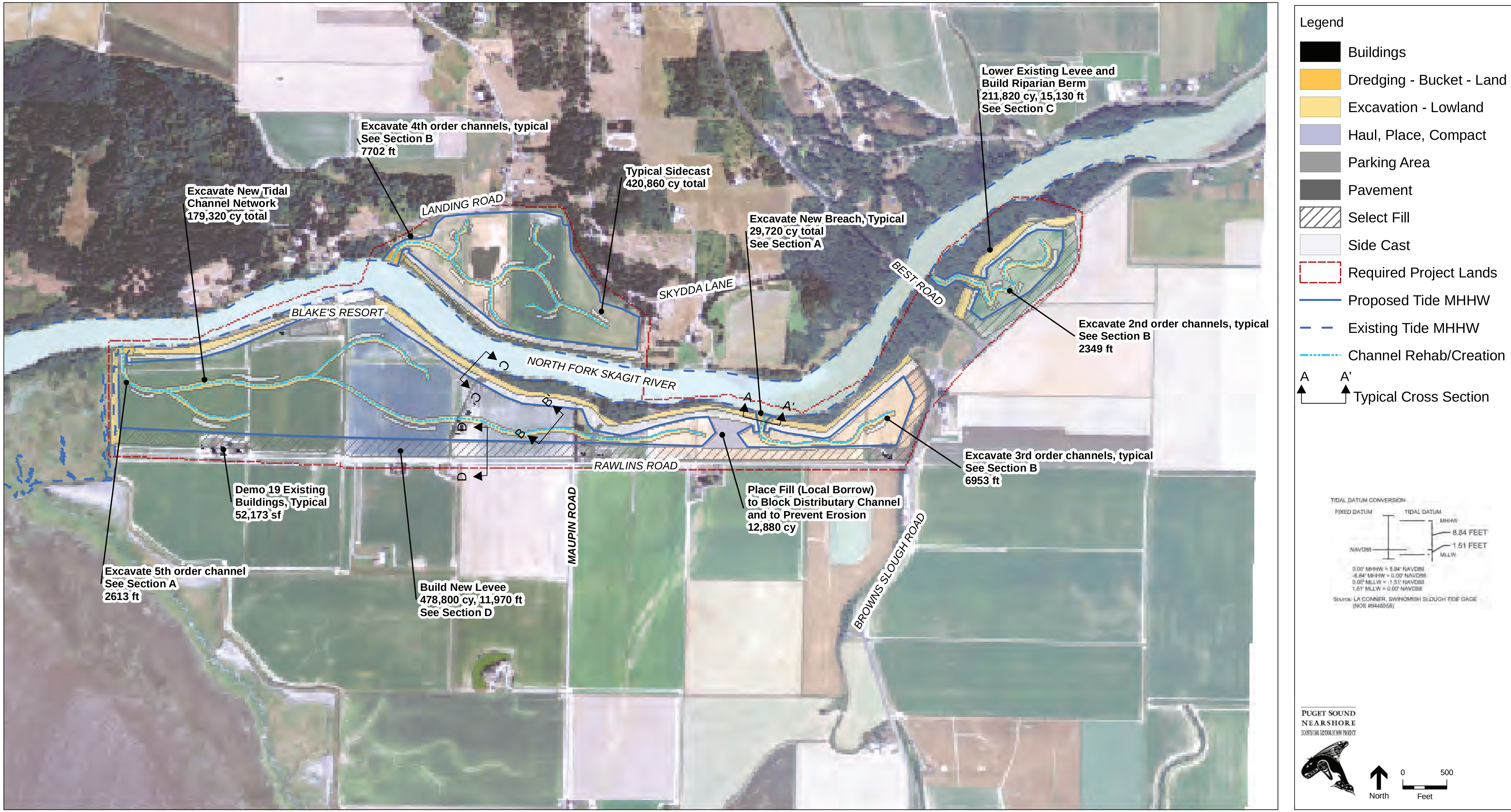


0 600
Feet
0 180
Meters

S:\GIS\Projects\210xxx\210337_PSNERP_NEARSHORE\Projects\2-TSheets_rev.mxd (DLP; 2/24/2011)

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Historic Map (T-Sheet) and River History Project Data
Action Name: North Fork Levee Setback
PSNERP ID #: 1102
Figure 24- 2B



SOURCE: Washington Public Lands Database (2006); Washington Counties Parcels (2009); Action Area (PSNERP, 2010)

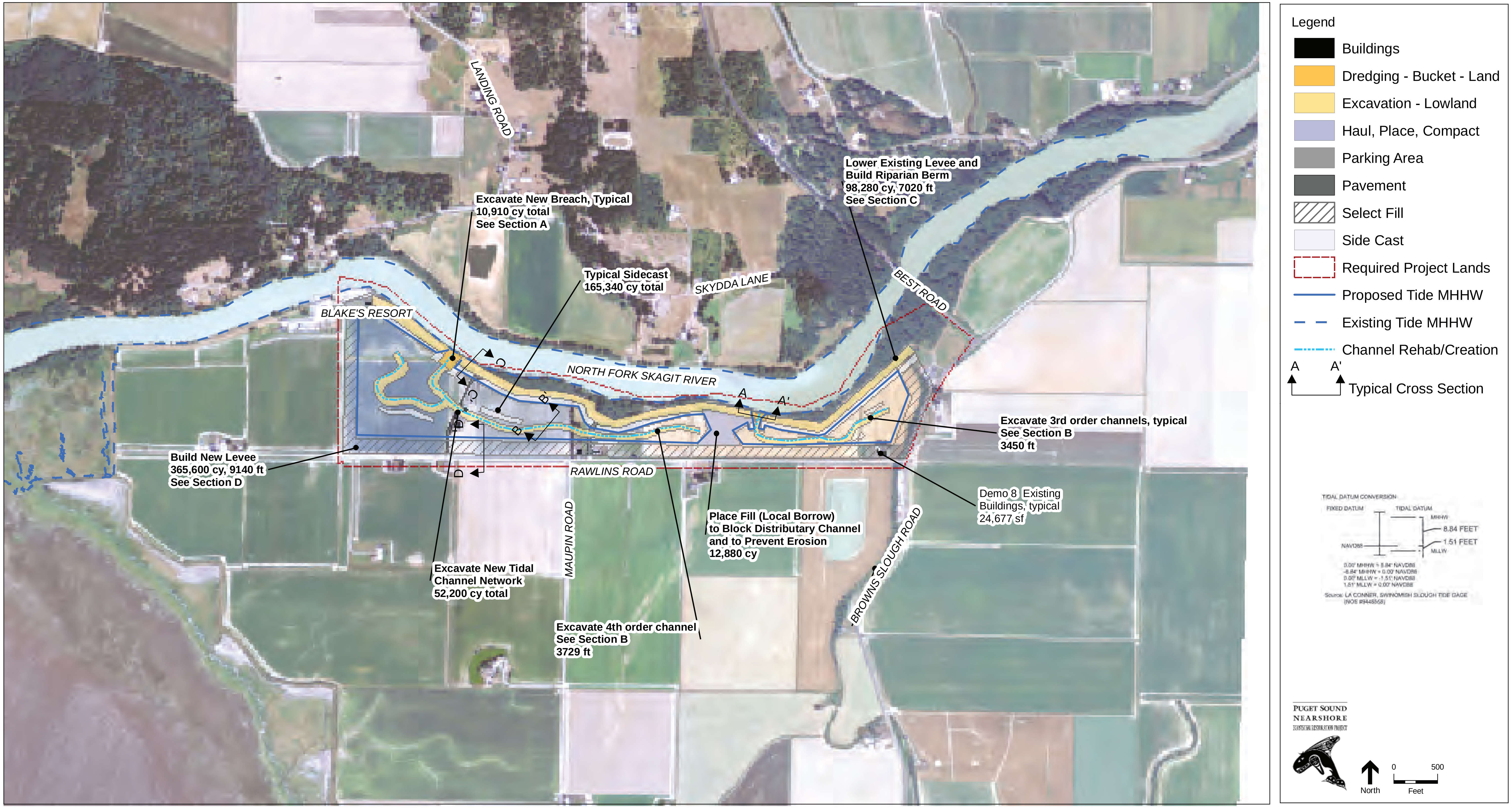
Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64

WDFW Contract # 100-000204 (CAPS No. 10-1461)

Lead Contractor: ESA
Design Lead: ESA PWA
Date: 2/2011

Conceptual Design Plan
Site Name: Skagit River Delta
Action Name: North Fork Levee Setback
PSNERP ID #: 1102
Full Restoration

Figure 24-3



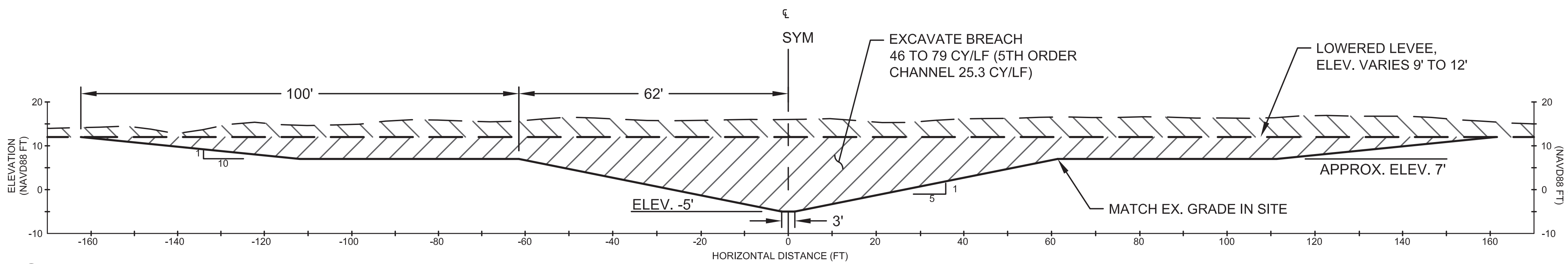
SOURCE: Washington Public Lands Database (2006); Washington Counties Parcels (2009); Action Area (PSNERP, 2010)

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

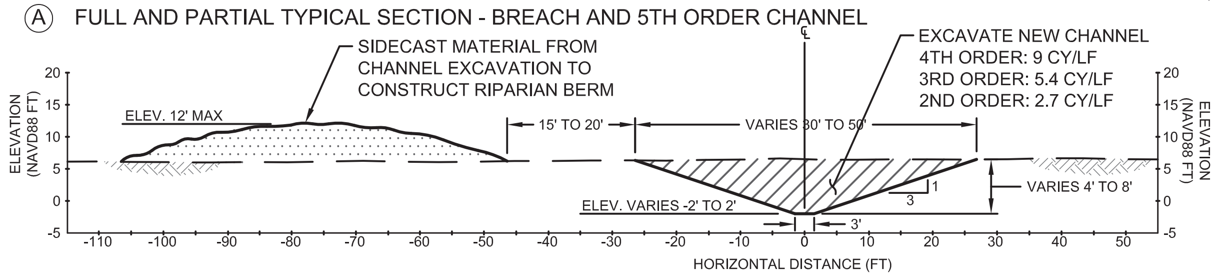
Lead Contractor: ESA
Design Lead: ESA PWA
Date: 2/2011

Conceptual Design Plan
Site Name: Skagit River Delta
Action Name: North Fork Levee Setback
PSNERP ID #: 1102
Partial Restoration

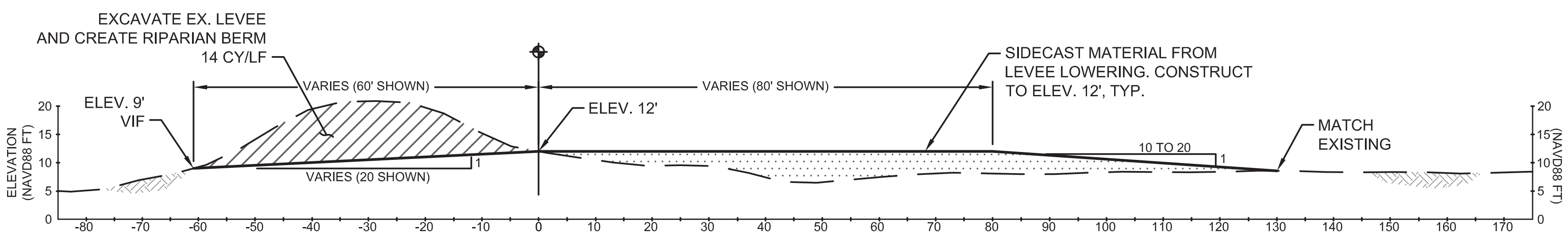
Figure 24-4



Ⓐ FULL AND PARTIAL TYPICAL SECTION - BREACH AND 5TH ORDER CHANNEL

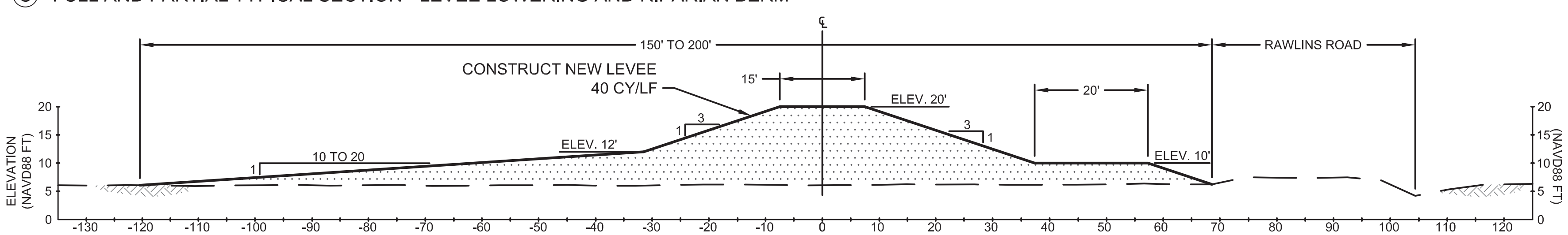


Ⓑ FULL AND PARITAL TYPICAL CHANNEL SECTION - 2ND, 3RD, AND 4TH ORDER (SHOWN)

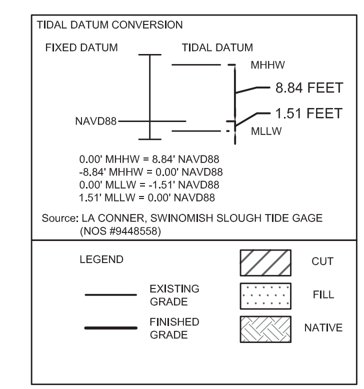


Ⓒ FULL AND PARTIAL TYPICAL SECTION - LEVEE LOWERING AND RIPARIAN BERM

HORIZONTAL DISTANCE (FT)



Ⓓ FULL AND PARTIAL TYPICAL SECTION - NEW LEVEE



0 30
Scale in Feet

PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: ESA PWA with KPFF
Date: 3/2011

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Section
SITE NAME: **Skagit River Delta**
ACTION NAME: **North Fork Levee Setback**
PSNERP ID#: **1102**
Full Restoration & Partial Restoration

Figure 24-5

Full Restoration Quantity Estimate

Action Name: North Fork Levee Setback
Action #: 1102
Date: February 2011
By: L. White

REMEDY: ***Remove levee, construct new flood levee, construct channels to develop riparian tidal habitat***
Construction Period: 56 week construction phased over 2 or 3 seasons

Item	Unit of Measure	Qty	Description of Item	Indicate section of design report where item is described
ACQUISITION AND CONSERVATION			Based on available mapping information	
Required Project Lands	Acre	555	Total land required For action	24.3
Proponent / Partner-owned lands	Acre	0	Etimate of lands currently owned by Proponent (i.e., Public lands)	
Lands To Be Acquired	Acre	555	Estimate land required to be acquired for action prior to implementation	24.3
Material Sites			Not Used: See Earthwork - Imported Fill.	
MOBILIZATION AND ACCESS for construction activities			Description required for each item to facilitate cost estimating	
Mobilization - Typical (Equipment, Personnel, Planning, Financial)	LS	1		24.3
Mobilization - Remote (Equipment, Personnel, Planning, Financial)	LS	NA	Up front cost for nontypical or remote locations. Assume 12% of other items	
Site Access	LS	NA	Use for special situations (e.g.. new bridge, new access roads) for the purposes of construction access. Include description.	
Barge Access	Days	NA	Describe need for barge access	
Temporary Traffic Control (one of the following)			Includes installation of traffic signals, signage, signmen, etc. There are 4 types as follows	
none	LS	NA	None = no traffic control	
signs	LS	NA	Signs = signs only, costs typically around 1% of total roadway costs	
flags / spotters	LS	NA	Flags and spotters = signs plus entails a greater level of effort. Describe the duration of this activity. This can be about 3% of total roadway costs.	
unique	LS	NA	Unique = Greater effort than flags / spotters. Describe as basis for cost estimate.	
Temporary Roadway	SF	NA	Includes construction of temporary adjacent roadway or bypass roadways and for vehicle and pedestrian travel through or around site.	
Control of Water	LS	NA	Use for special situations that require draining the site using pumps or water control structures, and bypassing water during construction. Can also be used for multi-year projects. Description required, including estimate duration.	
Relocation Activities			Not Used: See Utilities, Structures	
Site Demolition Activities			Demolition and removal of structures (description required), temporary features and relocations, itemized separately); Clearing and grubbing of vegetation, and removal of minor debris (rocks, slabs) - description required.	
Clearing and Grubbing (one or more of following)			Use one or more of the following categories of clearing and grubbing	
Clear Vegetation - Local Disposal	AC	NA	Vegetation removed above grade and disposed locally	
Clear /Grub Vegetation - Local Disposal	AC	56.0	Vegetation roots also removed and disposed locally	24.3
Clear /Grub Vegetation - Offsite Disposal	AC	NA	Vegetation is taken offsite and disposed - use for noxious invasives, etc.	
Clear, stockpile - large woody debris	CY	NA	Vegetation is segregated and stockpiled / prepared for reuse on site.	
Hydraulic Structures - Small	LS	NA		
Hydraulic Structures - Large	LS	NA	Dam removal (describe and state whether this item includes water control and sediment removal or these are in separate items)	
Utilities	LS or LF	NA		
Buildings	SF	45024	Remove 17 buildings	24.3
Pavement	SF	244259		24.3
Marina	*SF*	*139906*	*Remove pavement at Marina.*	24.3
Roads	*SF*	*104353*	*Remove pavement along roads.*	24.3
Bulkheads	LF or SF	NA	Use this for bulkheads…if large and difficult, consider using Large Coastal Structures.	
Rock revetments	LF, Ton or CY	NA		
Large Coastal Structures	LF, SF or CY	NA	Use this item for breakwaters, jetties, groins, reinforced concrete seawalls and any structure that requires larger equipment and power to break up and or remove	
Demolition / Removal - Bridge	SF or CY	NA	Use this item for structures that require cranes or other special removal staging	
Removal - Misc. (e.g. angular rock from beach)	Ton	NA	For loose rock scattered across intertidal.	
Demolition / Removal - Boat Ramp	SF	30000	Assume 100 ft by 300 ft; Need to verify	24.3
Haul - Offsite Disposal of Demolition Debris	Miles	20		
Hazardous/Contaminated Waste Removal			These items for earthwork of quality not compatible with wetlands, requiring special handling and disposal. Describe basis for classification as contaminated or hazardous. State known or suspected contamination, describe known similar work.	
Contaminated Earthwork	CY	NA	Excavation, off haul and disposal within a licensed landfill, complete	
Hazardous Earthwork	CY	NA	Excavation, off haul and disposal within a licensed hazardous waste landfill, complete	
Construct Temporary Features			Use as needed for unusual temporary features not included elsewhere (see TESC below)	
EARTHWORK			Expand to include equipment, etc. to facilitate cost estimating.	
Excavation	CY		Per yard excavation w/out expected haul	
Excavation - Upland	CY	211820	Levee lowering; assume scapers	24.3
Excavation - Lowland	CY	179320	Channel excavation using LGP excavators	24.3
Dredging - Bucket - Land	CY	29720	Breach excavation	24.3
Dredging - Bucket - Marine	CY	NA	Floating or amphibious equipment with excavator, clamshell or dragline bucket	
Dredging - Hydraulic	CY	NA	Hydraulic cutter / suction dredge to slurry and pump sediments	
Fine Grading	AC	NA	Small tolerance grading after rough grading.	
Fill Placement - local borrow			This is additive to Earthwork -Excavation	
Side cast	CY	420860	Excavated material placed within reach of excavator / dredge - assume includes some shaping by bucket	24.3
Levee Lowering	*CY*	*211820*		24.3
Channels	*CY*	*179320*		24.3
Breaches	*CY*	*29720*		24.3
Haul - uncontrolled placement	CY	NA	Transportation and second handling - estimate distance.	
Haul, place, compact	CY	10260	Block distributary channel and prevent erosion	24.3
Stockpile - uncontrolled placement	CY	NA	Intermediate step, for subsequent off haul or use elsewhere on site.	
Stockpile - controlled placement	CY	NA	intermediate step, for subsequent off haul or use elsewhere on site. Can use this for drying material for subsequent controlled compacted fill	
Conveyor placement from stockpile land/water	CY	NA	Some projects may require conveyor placement	
Imported Fill			Includes purchase, delivery and placement or as noted / described	
Select Fill	CY	478800	New Levee - Imported select material	24.3
Gravel Borrow, including haul	CY	NA	WSDOT standard item	
Sand / Gravel for Beach Nourishment	CY	NA	special borrow and sorting required; identify material source	
Cobble for Shore Nourishment	CY	NA	special borrow and sorting required; identify material source	
Embankment Compaction	CY	478800		24.3
Topsoil	CY	NA		
RESTORATION Features				
Channel Rehab / Creation	SF	19617		24.3
Large Wood Placement	EA	NA	Per each log, Including drift logs, lower river log jams, etc.	
Invasive Species Control	Acre	NA	Per acre control described in drawings and narrative	
Physical Exclusion Devices	LF or EA	NA	Human or wildlife exclusions including fences, barriers, mooring buoys, etc	
Other Restoration Features/ Activities	LS	NA	Describe other items not included elsewhere	
Structures	EA		KPFF to provide additional inputs	
Water Control Structures - Culverts with Gates	EA	NA	Describe type, number of openings (e.g. pipes), expected materials, dimensions	
Water Control Structures - Weirs	EA	NA	Describe, length, type, anticipated materials	
Rock Slope Protection	LF	NA	Describe slope, rock size, layering, use of fabric, back up quantities per foot.	
Other	EA	NA	Describe	
Elevated Boat Ramp	SF	NA	Pile or pier supported to allow sediment drift	
Fencing	SF	NA	Describe, type, height etc.	
Utilities			Replacement or relocation. Designer to provide size and material and have separate line item for each run. Incidentals include earthwork, testing, hook up fees, etc. These quantities do not include demolition of existing utilities, real estate / easements, design fees. Describe the owner if known, and whether utility franchise will install (e.g., electric is typically installed by electrical franchise).	
Water	LF	NA		
Gas	LF	NA		
Electric	LF	NA		
Sewer	LF	NA		
Telecommunications	LF	NA		
Other	LF	NA	Others = whatever is required (e.g.. power towers, petroleum, jet fuel, etc.)	
Roadway / Railway			KPFF expected to participate in these estimates	
Roadway (Type_)	SF	NA	Typical roadway, not including earthwork and temporary or permanent traffic controls. Provide a description. Assume a standard pavement section or describe if special section anticipated.• Pavement• Base Course• Storm Drainage Collection and Conveyance (incl. trenching, backfill, etc.)• Stormwater Treatment	
Roadway - Traffic Signal	LS	NA	Street lights, etc. (Temporary traffic control handled under Temporary Facilities)	
Culvert (type)	LF	NA	Provide specific culver size and type	
Culvert - Jacking	LF	NA	Through railway	
Culvert - Horizontal Pile Driving	LF	NA	Through railway	
Bridge - Foundations, Deck and Appurtenances	SF	NA	Include elements such as approach slab, abutment, barriers, railings, etc. to conform to one of three or four types to be developed	
Railway - Box Girder	SF	NA	Standard	
Railway - Foundation	LF	NA	Standard	
Railway - Shoe fly	LF	NA	Temporary alignment	
Permanent Access Features			KPFF expected to participate in these estimates	
Roads	Level	NA	Level 1 direct access, Level 2 moderately difficult, Level 3 difficult access	
Utility Access Routes	varies	NA	Describe utility access feature, such as boardwalk or all-weather gravel road	
Erosion Control Features	L.F.	NA	Describe quantity of expected erosion control measures	
Public Access or Recreation Features			KPFF expected to participate in these estimates	
Trails	SF	NA	Describe trail feature, such as gravel, mulch, asphalt concrete.	
Bridges	SF	NA	Describe bridge feature, such as wooden pedestrian, or H20 vehicle.	
Kiosk	EA	NA	Describe kiosk feature, such as size, material.	
Restrooms	EA	NA	Describe restroom feature, such as size, material.	
Interpretive Signs	EA	NA	Include # interpretive signs based on number of local public access points	
Parking Area	SF	NA	Describe parking area, such as size, material.	
Other	EA	NA	Describe other recreational features (see Corps criteria, ER 1105-2-100 for compatibility with ecosystem objectives)	
Vegetation & Erosion Control				
Hydroseeding	AC	NA	Describe desired seed mix (e.g.. native plants cost more)	
Planting	AC	NA	Describe, provide breakdown on unit area basis.	
Vegetation Maintenance	AC-YR	NA	Includes irrigation, weeding, plant replacement for one year	
Erosion / sediment BMPs - Temp.	AC	NA	BMPs for control of drainage - describe. Assume compliance with Construction General NPDES included	
Erosion / sediment BMPs - Permanent	AC	NA	May want to separate slopes over 25% into separate category	
Waterside controls - Temporary	EA, LF, LS	NA	Silt curtain or other water based temporary actions	

Full Restoration Quantity Estimate

Action Name:	North Fork Levee Setback
Action #:	1102
Date:	February 2011
By:	L. White

REMEDY: ***Remove levee, construct new flood levee, construct channels to develop riparian tidal habitat***

Construction Period: 56 week construction phased over 2 or 3 seasons

	Item	Unit of Measure	Qty	Description of Item		Indicate section of design report where item is described
Construction Management						
	Construction oversight	weeks	56	Quanity based on constructon duration/ # of construction seasons		24.3
	Materials testing			Included in cost of material - no separate quantity		
	Proponent in-kind Services	Man-Days		Describe services to be provided by Proponent during construction, such as site night security		
	Government Oversight	Man-Days		Describe length of construction period(s) for on-site inspection		
	Quality Control & Testing	L.S.		Describe types and quantities of required contractor QC.		
	Quality Assurance With Testing	L.S.		Describe types and quantities of government QA associated with QC.		
Design and Detailed Site Investigations						
	Survey & Property, Utility Research	LS	1	% of construction cost		24.8
	35% Design	LS	1	35% x 25% x Engineer's Estimate		24.8
	65% design	LS	1	65% x 25% x Engineer's Estimate less the cost for 35% PS&E		24.8
	90% design	LS	1	35% x 25% x Engineer's Estimate less the cost for 35% + 65%PS&E		24.8
	100% design	LS	1	25% x Engineer's Estimate less previous costs		24.8
	Geotechnical Studies			Refer to design report for description of need		
	Cultural Studies			Refer to design report for description of need		
	HTWR Studies			Refer to design report for description of need		
				Describe level of effort		
Project Agreement Activities						
Site-Specific Adaptive Management Features & Activities				List if known		
		L.S.				
Monitoring Activities				Assume 5 crew-days/year for each monitoring parameter in design report for 5 yrs		
	Monitoring (Type_)	crew-days	175			
Operations & Maintenance				Unable to provide credible estimate at 10% design		

Partial Restoration Quantity Estimate

Action Name:	North Fork Levee Setback
Action #:	1102
Date:	February 2011
By:	ESA PWA

REMEDY: ***Remove levee, construct new flood levee, construct channels to develop riparian tidal habitat***

Construction Period: 47 week construction phased over 2 or 3 seasons

Item	Unit of Measure	Qty	Description of Item	Indicate section of design report where item is described
ACQUISITION AND CONSERVATION			Based on available mapping information	
Required Project Lands	Acre	188	Total land required For action	24.3
Proponent / Partner-owned lands	Acre	0	Etimate of lands currently owned by Proponent (i.e., Public lands)	
Lands To Be Acquired	Acre	188	Estimate land required to be acquired for action prior to implementation	24.3
Material Sites			Not Used: See Earthwork - Imported Fill.	
MOBILIZATION AND ACCESS for construction activities			Description required for each item to facilitate cost estimating	
Mobilization - Typical (Equipment, Personnel, Planning, Financial)	LS	1	Up front costs such as bonding, planning and other staff time and financing. Typically, assume 8% to 10% of other items.	24.3
Mobilization - Remote (Equipment, Personnel, Planning, Financial)	LS	NA	Up front cost for nontypical or remote locations. Assume 12% of other items	
Site Access	LS	NA	Use for special situations (e.g.. new bridge, new access roads) for the purposes of construction access. Include description.	
Barge Access	Days	NA	Describe need for barge access	
Temporary Traffic Control (one of the following)			Includes installation of traffic signals, signage, signmen, etc. There are 4 types as follows:	
none	LS	NA	None = no traffic control	
signs	LS	NA	Signs = signs only, costs typically around 1% of total roadway costs	
flags / spotters	LS	NA	Flags and spotters = signs plus entails a greater level of effort. Describe the duration of this activity. This can be about 3% of total roadway costs.	
unique	LS	NA	Unique = Greater effort than flags / spotters. Describe as basis for cost estimate.	
Temporary Roadway	SF	NA	Includes construction of temporary adjacent roadway or bypass roadways and for vehicle and pedestrian travel through or around site.	
Control of Water	LS	NA	Use for special situations that require draining the site using pumps or water control structures, and bypassing water during construction. Can also be used for multi-year projects. Description required, including estimate duration.	
Relocation Activities			Not Used: See Utilities, Structures	
Site Demolition Activities			Demolition and removal of structures (description required), temporary features and relocations, itemized separately); Clearing and grubbing of vegetation, and removal of minor debris (rocks, slabs) - description required.	
Clearing and Grubbing (one or more of following)			Use one or more of the following categories of clearing and grubbing	
Clear Vegetation - Local Disposal	AC	NA	Vegetation removed above grade and disposed locally	
Clear /Grub Vegetation - Local Disposal	AC	28.7	Vegetation roots also removed and disposed locally	24.3
Clear /Grub Vegetation - Offsite Disposal	AC	NA	Vegetation is taken offsite and disposed - use for noxious invasives, etc.	
Clear, stockpile - large woody debris	CY	NA	Vegetation is segregated and stockpiled / prepared for reuse on site.	
Hydraulic Structures - Small	LS	NA	Unknown	
Hydraulic Structures - Large	LS	NA	Dam removal (describe and state whether this item includes water control and sediment removal or these are in separate items)	
Utilities	LS or LF	NA	Unknown	
Buildings	SF	24677	Remove 8 buildings	24.3
Pavement	SF	48937		24.3
Marina	*SF*	*40412*	*Remove pavement at Marina.*	24.3
Roads	*SF*	*38525*	*Remove pavement along roads.*	24.3
Bulkheads	LF or SF	NA	Use this for bulkheads…if large and difficult, consider using Large Coastal Structures.	
Rock revetments	LF, Ton or CY	NA		
Large Coastal Structures	LF, SF or CY	NA	Use this item for breakwaters, jetties, groins, reinforced concrete seawalls and any structure that requires larger equipment and power to break up and or remove	
Demolition / Removal - Bridge	SF or CY	NA	Use this item for structures that require cranes or other special removal staging	
Removal - Misc. (e.g. angular rock from beach)	Ton	NA	For loose rock scattered across intertidal.	
Demolition / Removal - Boat Ramp	SF	NA	This is a special item but happens at least once…others can also be added as needed.	
Haul - Offsite Disposal of Demolition Debris	Miles	20		24.3
Hazardous/Contaminated Waste Removal			These items for earthwork of quality not compatible with wetlands, requiring special handling and disposal. Describe basis for classification as contaminated or hazardous. State known or suspected contamination, describe known similar work.	
Contaminated Earthwork	CY	NA	Excavation, off haul and disposal within a licensed landfill, complete	
Hazardous Earthwork	CY	NA	Excavation, off haul and disposal within a licensed hazardous waste landfill, complete	
Construct Temporary Features			Use as needed for unusual temporary features not included elsewhere (see TESC below)	
EARTHWORK			Expand to include equipment, etc. to facilitate cost estimating.	
Excavation	CY		Per yard excavation w/out expected haul	
Excavation - Upland	CY	98280	Levee lowering, assume scrapers	24.3
Excavation - Lowland	CY	52200	Channel excavation using LGP excavators	24.3
Dredging - Bucket - Land	CY	14860	Breacg excavation	24.3
Dredging - Bucket - Marine	CY	NA	Floating or amphibious equipment with excavator, clamshell or dragline bucket	
Dredging - Hydraulic	CY	NA	Hydraulic cutter / suction dredge to slurry and pump sediments	
Fine Grading	AC	NA	Small tolerance grading after rough grading.	
Fill Placement - local borrow			This is additive to Earthwork -Excavation	
Side cast	CY	165340	Excavated material placed within reach of excavator / dredge - assume includes some shaping by bucket	24.3
Levee Lowering	*CY*	*96280*		24.3
Channels	*CY*	*52200*		24.3
Breaches	*CY*	*14860*		24.3
Haul - uncontrolled placement	CY		Transportation and second handling - estimate distance.	
Haul, place, compact	CY	10910	Transportation and second handling - estimate distance, placement in lifts, moisture conditioning, compaction testing.	24.3
Stockpile - uncontrolled placement	CY	NA	Intermediate step, for subsequent off haul or use elsewhere on site.	
Stockpile - controlled placement	CY	NA	intermediate step, for subsequent off haul or use elsewhere on site. Can use this for drying material for subsequent controlled compacted fill	
Conveyor placement from stockpile land/water	CY	NA	Some projects may require conveyor placement	
Imported Fill			Includes purchase, delivery and placement or as noted / described	
Select Fill	CY	365600	New Levee - Imported select material - describe use, e.g. levee, root base mix, etc;	24.3
Gravel Borrow, including haul	CY	NA	WSDOT standard item	
Sand / Gravel for Beach Nourishment	CY	NA	special borrow and sorting required; identify material source	
Cobble for Shore Nourishment	CY	NA	special borrow and sorting required; identify material source	
Embankment Compaction	CY	365600		24.3
Topsoil	CY	NA		
RESTORATION Features				
Channel Rehab / Creation	SF	7179		24.3
Large Wood Placement	EA	NA	Per each log, Including drift logs, lower river log jams, etc.	
Invasive Species Control	Acre	NA	Per acre control described in drawings and narrative	
Physical Exclusion Devices	LF or EA	NA	Human or wildlife exclusions including fences, barriers, mooring buoys, etc	
Other Restoration Features/ Activities	LS	NA	Describe other items not included elsewhere	
Structures	EA		KPFF to provide additional inputs	
Water Control Structures - Culverts with Gates	EA	NA	Describe type, number of openings (e.g. pipes), expected materials, dimensions	
Water Control Structures - Weirs	EA	NA	Describe, length, type, anticipated materials	
Rock Slope Protection	LF	NA	Describe slope, rock size, layering, use of fabric, back up quantities per foot.	
Other	EA	NA	Describe	
Elevated Boat Ramp	SF	NA	Pile or pier supported to allow sediment drift	
Fencing	SF	NA	Describe, type, height etc.	
Utilities			Replacement or relocation. Designer to provide size and material and have separate line item for each run. Incidentals include earthwork, testing, hook up fees, etc. These quantities do not include demolition of existing utilities, real estate / easements, design fees. Describe the owner if known, and whether utility franchise will install (e.g.. electric is typically installed by electrical franchise).	
Water	LF	NA		
Gas	LF	NA		
Electric	LF	NA		
Sewer	LF	NA		
Telecommunications	LF	NA		
Other	LF	NA	Others = whatever is required (e.g.. power towers, petroleum, jet fuel, etc.)	
Roadway / Railway			KPFF expected to participate in these estimates	
Roadway (Type_)	SF	NA	Typical roadway, not including earthwork and temporary or permanent traffic controls. Provide a description. Assume a standard pavement section or describe if special section anticipated.• Pavement• Base Course• Storm Drainage Collection and Conveyance (incl. trenching, backfill, etc.)• Stormwater Treatment	
Roadway - Traffic Signal	LS	NA	Street lights, etc. (Temporary traffic control handled under Temporary Facilities)	
Culvert (type)	LF	NA	Provide specific culver size and type	
Culvert - Jacking	LF	NA	Through railway	
Culvert - Horizontal Pile Driving	LF	NA	Through railway	
Bridge - Foundations, Deck and Appurtenances	SF	NA	Include elements such as approach slab, abutment, barriers, railings, etc. to conform to one of three or four types to be developed	
Railway - Box Girder	SF	NA	Standard	
Railway - Foundation	LF	NA	Standard	
Railway - Shoe fly	LF	NA	Temporary alignment	
Permanent Access Features			KPFF expected to participate in these estimates	
Roads	Level	NA	Level 1 direct access, Level 2 moderately difficult, Level 3 difficult access	
Utility Access Routes	varies	NA	Describe utility access feature, such as boardwalk or all-weather gravel road	
Erosion Control Features	L.F.	NA	Describe quantity of expected erosion control measures	
Public Access or Recreation Features			KPFF expected to participate in these estimates	
trails	SF	NA	Describe trail feature, such as gravel, mulch, asphalt concrete.	
bridges	SF	NA	Describe bridge feature, such as wooden pedestrian, or H20 vehicle.	
kiosk	EA	NA	Describe kiosk feature, such as size, material.	
restrooms	EA	NA	Describe restroom feature, such as size, material.	
Interpretive Signs	EA	NA	Include # interpretive signs based on number of local public access points	
parking area	SF	NA	Describe parking area, such as size, material.	
Other	EA	NA	Describe other recreational features (see Corps criteria, ER 1105-2-100 for compatibility with ecosystem objectives)	
Vegetation & Erosion Control				
Hydroseeding	AC	NA	Describe desired seed mix (e.g.. native plants cost more)	
Planting	AC	NA	Describe, provide breakdown on unit area basis.	
Vegetation Maintenance	AC-YR	NA	Includes irrigation, weeding, plant replacement for one year	
Erosion / sediment BMPs - Temp.	AC	NA	BMPs for control of drainage - describe. Assume compliance with Construction General NPDES included	
Erosion / sediment BMPs - Permanent	AC	NA	May want to separate slopes over 25% into separate category	
Waterside controls - Temporary	EA, LF, LS	NA	Silt curtain or other water based temporary actions	

Partial Restoration Quantity Estimate

Action Name: North Fork Levee Setback
Action #: 1102
Date: February 2011
By: ESA PWA

REMEDY: ***Remove levee, construct new flood levee, construct channels to develop riparian tidal habitat***
Construction Period: 47 week construction phased over 2 or 3 seasons

Item	Unit of Measure	Qty	Description of Item	Indicate section of design report where item is described
Construction Management				
Construction oversight	weeks	47	Quanity based on constructon duration/ # of construction seasons	24.3
Design and Detailed Site Investigations				
Survey & Property, Utility Research	LS	1	% of construction cost	24.8
35% Design	LS	1	35% x 25% x Engineer's Estimate	24.8
65% design	LS	1	65% x 25% x Engineer's Estimate less the cost for 35% PS&E	24.8
90% design	LS	1	35% x 25% x Engineer's Estimate less the cost for 35% + 65%PS&E	24.8
100% design	LS	1	25% x Engineer's Estimate less previous costs	24.8
Geotechnical Studies			Refer to design report for description of need	
Cultural Studies			Refer to design report for description of need	
HTWR Studies			Refer to design report for description of need	
Project Agreement Activities			Unable to provide credibale estimate at 10% design	
Site-Specific Adaptive Management Features & Activities			List if known	
Monitoring Activities			Assume 5 crew-days/year for each monitoring parameter in design report for 5 yrs	
Monitoring (Type_)	crew-days	175		
			Describe types and quantities of expected monitoring contracts	
Operations & Maintenance			Unable to provide credible estimate at 10% design	

25. POINT WHITNEY (#1379)

Local Proponent	Washington Department of Fish and Wildlife (WDFW)
Delta Process Unit	NA
Shoreline Process Unit(s)	2052
Strategy(ies)	3 – Barrier Embayment
Restoration Objectives	Remove fill to restore tidal hydrology and full tidal prism to lagoon, and also remove barriers to littoral sediment transport

25.1 Description of the Action

The proposed restoration entails removal of earthern dikes and fill that has aggraded over time in the Point Whitney lagoon. In addition, roads, paved parking areas, and buildings would be removed from the barrier beach. Please see the Introduction chapter for important information regarding PSNERP and for context related to this restoration project.

25.2 Action Area Description and Context

The Point Whitney Lagoon is located in the northern section of Hood Canal called Dabob Bay. The action area consists of the lagoon and the spit, and extends along the shoreline of the bay. The removal of fill within the historic lagoon footprint would restore lagoon hydraulics and morphology, increasing tidal prism, helping to maintain the entrance channel, and improving tidal exchange. The removal of fill and armoring on the gravel spit (shore and crest) would restore natural sediment transport in the cross-shore direction and provide additional habitat area. The action area is shown in Figure 25-1.

Figure 25-1. Action Area and Vicinity

25.2.1 Historic Condition

The 1883 topographic sheet (T-sheet) shows a well-formed spit with a narrow inlet at the northwest corner of the lagoon (Figures 25-2A and 25-2B). The T-sheet indicates that the spit was historically grassland with mixed forest on the relatively steep hillsides surrounding the lagoon. There is no evidence of any constructed features at the spit or immediately adjacent to the lagoon at the time of the T-sheet survey.

25.2.2 Natural Environment

The Point Whitney Lagoon was partially filled to create ponds used for shellfish rearing. The western lagoon is open to tidal flows, while the two ponds are controlled by tide gated culverts. Drift is from east to west. By inspection, it appears that longshore transport is driven northward until the tip of a hillside control is reached, at which point sediment transport slows, forming a spit across the mouth of the drowned drainage between hillside controls. The tidal prism appears to be sufficient to maintain a tidal inlet, probably because of low wave exposure and low littoral transport rates. Eroding hillslopes east and south of the existing facilities appear to be the source of sediment and cobble for the shore and beach at the spit. An intermittent stream, with a drainage area of approximately 100 acres, delivers fresh water to the southern end of the lagoon.

Another small drainage to the west includes a small deltaic deposition of sediments that appears to be larger than shown on the 1883 T-sheet. Some development exists, with signs of shore access and modification. The effect of the inlet extends westward to this property.

Eelgrass is present in the northern rearing pond. Oysters and clams are present in the ponds, the lagoon, and on the outboard side of the spit.

The shore is gravel and cobble with oyster shells with the outer beach transitioning to sand below MLLW. The outer beach has an approximate slope of 6:1. Shells are found on all shores within the site, and are integrated with the inlet mouth on the north side. The north side of the paving on the spit shows signs of wave-induced erosion. WDFW staff confirmed wave runup to the crest of the spit (parking lot).

Lagoon tides lag behind those on the Sound by about 1 to 1.5 hours. The inlet sill is reportedly at about elevation +5 feet MLLW, limiting tidal exchange to the upper part of the tidal frame (Bradbury, 2010).

It is reported that the inlet was excavated in the 1950s (WDFW, with reference to Westley, 1955 – not available at the time of this report). The excavation deepened the inlet 2 feet to elevation +6 feet MLLW, and it has reportedly deepened another foot to the existing +5 feet MLLW. A comparison with the *Applied Geomorphology Guidelines and Hierarchy of Openings* (Appendix C) indicates that the inlet is deeper than would be expected based on tidal prism, and that further scour is unlikely and infill may occur.

25.2.3 Human Environment

The Point Whitney Lagoon was partially filled by WDFW to create ponds used for shellfish rearing and for construction of buildings. The ponds are currently controlled by three tide gated culverts and used as intakes for a private, commercial fish-rearing operation (under lease from WDFW until 2020). There are concrete tanks/ponds, pumps, and additional structures located on fill placed near the eastern end of the spit. Two large buildings, currently used by the WDFW Shellfish Laboratory, are located at the eastern end of the spit. Point Whitney Road provides access to the structures. An overhead power line runs adjacent to the roadway. A former, abandoned road grade at the eastern edge of the lagoon rises in elevation from south to north. The surface of the spit has been hardened by placement of concrete, asphalt, and gravel for vehicle parking and beach access for recreational shellfish harvest. A boat ramp is located on the north side of the spit across from the end of Point Whitney Road to provide additional off-shore access. Shore armoring riprap and concrete are present at the northeast corner of the spit, immediately below a portable building structure.

25.3 Restoration Design Concept

25.3.1 Restoration Overview and Key Design Assumptions

The restoration alternatives are illustrated in Figures 25-3 through 25-5. The full restoration alternative would restore the full tidal prism to the lagoon and reestablish the historic configuration. The size of the inlet opening in the full restoration alternative was designed to match the historic inlet dimensions. The main components are removal of earthen dikes, several buildings and structures, paved areas, and compacted fill. The full restoration elements of dike removal, topography restoration, and debris removal would proceed concurrently.

The partial restoration alternative was designed to allow for continued use of the site as a shellfish facility and as a public beach. The partial alternative has many of the same elements as the full alternative, but the work would be phased to maintain the on-site operations and the construction activity would be focused on the west side of the site. The scaled-down strategy for the partial alternative retains several of the buildings and some of the parking areas to accommodate the existing lease and the interests of the local community. The partial alternative was developed in a way that would allow the full action to be completed in the future, if desired. Key design elements associated with full and partial restoration alternatives are summarized in Table 25-1.

Table 25-1. Key Design Elements

Element	Full Restoration	Partial Restoration
Earthen Dikes	Remove dikes concurrently	Remove dikes in two phases (1 and 2)
Rock Revetment	Remove rock revetment (240 LF)	No removal
Dike and Structural Fill	Remove fill	Remove fill (Phase 2)
Buildings	Remove all buildings (15)	Remove fewer buildings (9) (Phase 2)
Paving and Hardened Surfaces	Remove all surfaces	Remove surfaces on western side of spit (Phase 2)
Uptake Pipes	Remove pipes	Remove pipes (Phase 2)
Upland Fill Placement	Place portion of excavated dike material on site (3,000 CY) Plant northeastern area of spit (0.34 AC) and southeast corner of ponds (0.44 AC)	Fill placement same as full. Plant near southeast corner of ponds (0.2 AC)

25.3.2 Restoration Features – Primary Process-Based Management Measures

Armor Removal/Modification

Under the full restoration alternative, approximately 240 LF of rock revetment consisting of concrete rubble, boulders, and riprap (2 to 3 feet in diameter) would be removed from the northeastern corner of the spit. This material is currently in place to protect the adjacent structures and parking area. This armoring would be left in place under the partial restoration alternative to continue to provide protection to the adjacent buildings and parking area.

Berm or Dike Removal/Modification

For the full restoration alternative, the earthen dikes that were constructed to create the north and south ponds within the lagoon would be removed (Figure 25-3). All of the vegetation (mature trees and shrubs) would be removed from the dikes and transported offsite prior to excavation work. The dikes would be excavated to an elevation of approximately 5.1 feet MLLW (2.5 feet NAVD88) (Figure 25-5), which is the approximate bottom elevation of the ponds. The total length of the dikes for removal is approximately 925 feet with an excavation volume of approximately 11,800 CY. Approximately 3,000 CY of this would be placed onsite, with the remaining 8,800 CY to be hauled offsite. The three corrugated metal pipe (CMP) culverts with tide gates located within the earth dikes would be removed and disposed of offsite (disposal site to be determined later in the design process).

For the partial restoration alternative, the earth dikes and control structures would be removed in a phased approach, with the south pond berm removed immediately and the north pond berm removed after a lease agreement has been reached (Figure 25-4). The excavated volume for the south pond dike is approximately 5,100 CY. Approximately 3,000 CY of this would be placed onsite, with the remaining 2,100 CY to be hauled offsite. When it occurs, the entire 6,700 CY volume of the north pond dike would be hauled offsite.

Channel Rehabilitation/Creation – NA

Groin Removal/Modification – NA

Hydraulic Modification – NA

Overwater Structure Removal – NA

Topography Restoration

The south side of the western end of the spit would be regraded to restore the spit and lagoon (Figure 25-5). A 5:1 slope would be graded from elevation 14.1 feet MLLW (11.5 feet NAVD88) to elevation 5.1 feet MLLW (2.5 feet NAVD88) over a distance of approximately 300 feet (measured along the spit). The top width of the spit would be approximately 55 feet after grading. Approximately 1,000 CY of material would be excavated from the western portion of the spit.

The fill at the central portion of the spit would be removed, and a new shore would be graded on the south side of the spit under both alternatives (Figure 25-5). The fill placed in this area would be excavated to restore the geometry of the lagoon to historic dimensions (based on the 1883 T-sheet; Figures 25-2A and 25-2B). The surface elevation of this area is approximately 14.6 feet MLLW (12 feet NAVD88) and would be lowered to elevation 5.1 feet MLLW (2.5 feet NAVD88) to restore the lagoon bed. A slope of 5:1 was chosen based on existing slopes at the lagoon currently open to tidal fluctuation, as well as the *Applied Geomorphology Guidelines* (Appendix C). The top width of the restored spit would be approximately 65 feet. The total volume of excavation required for removal of fill at the central portion of the spit is approximately 6,400 CY.

The beach on the eastern end of the spit is oversteepened at 2+:1 slope. Under the full restoration alternative, it would be reconstructed to match the less impacted geometry on the main part of the spit. The length of the reconstructed section of beach is approximately 240 feet. No changes are proposed to this section of the spit under the partial restoration alternative.

The surface of the spit would be overexcavated by 2 feet following pavement removal to allow for native sediment placement. The overexcavation volume would be 3,100 CY for the full restoration alternative and 2,200 CY for the partial restoration alternative. New select fill native sediment would be placed to a depth of 3 feet at all locations where the pavement and asphalt are to be removed from the spit, as well as the regraded or newly created back slope of the spit. The surface area of the native sediment placement is 60,100 SF for the full restoration alternative and 48,300 SF for the partial restoration alternative. The total volume of native sediment would be 6,700 CY for the full restoration alternative and 5,400 CY for the partial restoration alternative.

The total excavated volume for the full restoration alternative is approximately 22,300 CY (dike removal and topography restoration). The total excavated volume for the partial restoration alternative is approximately 21,400 CY (dike removal and topography restoration). A portion of this excavated material could be placed onsite near the southeast corner of the south pond. This area is relatively flat with an elevation of approximately 15.6 feet MLLW (13 feet NAVD88). Soil disposal in this area would reduce the total volume of offsite disposal and could help reduce erosion of the hillside.

An upland area of approximately 14,000 SF would be created by placing excavated material to a depth of 12 feet with a 3:1 side slope facing the southern end of the lagoon. Temporary erosion and sediment control measures and other best management practices would be employed to stabilize the excavation area and a portion would be planted with native upland species. This would allow for the disposal of approximately 3,000 CY of material within the action area. The remaining volume of excavated soil would require offsite hauling and disposal under both alternatives. In addition to providing an opportunity for onsite soil disposal, a portion of the upland fill area would also be used to provide parking. A new parking surface would be constructed on top of the fill with access to Point Whitney Road. The total surface area of the parking is approximately 10,000 SF and would be included under both alternatives.

25.3.3 Restoration Features – Additional Management Measures

Beach Nourishment –

Beach gravel would be placed to reconstruct the beach at the eastern end of the spit in the full alternative. Approximately 580 CY of beach gravel would be imported and placed on the shore to reconstruct the beach at a 6:1 slope, with a berm elevation of approximately 13 feet and a width of approximately 40 feet.

Contaminant Removal/Remediation – NA

Debris Removal –

A number of wooden piles on the north side of the spit, within Dabob Bay, would be removed under both alternatives.

Invasive Species Control – NA

Large Wood Placement – NA

Physical Exclusion - NA

Pollution Control – NA

Revegetation

Two areas would be revegetated under the full restoration alternative. The northeastern area of the spit (approximately 0.34 acre) would require fine grading, erosion control, and planting with native upland species following removal of the WDFW buildings. At the southeast end of the action area, a portion of the upland fill area (0.44 acre) would be planted with native upland species. In the partial alternative, a small amount (0.2 acre) of this upland fill placement area would be planted.

Reintroduction of Native Animals – NA

Substrate Modification – NA

Species Habitat Enhancement – NA

25.3.4 Restoration Features – Other

A total of 15 buildings and structures are located on the central and eastern portions of the spit. There are four buildings further inland that will not be impacted by either alternative. Nine structures are located on the central portion of the spit, including three tanks, two aquaculture structures (concrete basins), and four additional buildings that have a combined footprint of approximately 6,800 SF. There are six buildings and structures used by WDFW Shellfish Laboratory staff for offices and operations with a footprint of approximately 7,900 SF. The two larger buildings are two stories while the other four buildings are single-story structures of varying size.

The full restoration alternative would remove all 15 of the buildings (14,700 SF) concurrently. The partial restoration alternative would remove only the nine structures on the central portion of the spit (6,800 SF) during Phase 2 of the project. The remaining six structures at the eastern portion of the spit would remain in place.

In addition to the buildings, the existing hardened surface of the spit would be removed and disposed of offsite. The asphalt paving and gravel would be removed from the spit to a depth of 1 foot (Figure 25-5). The hardened surface removal area is 46,500 SF for the full restoration alternative and 29,000 SF for the partial restoration alternative. The eastern portion of the spit would remain paved as part of the partial restoration alternative.

Following pavement removal and building demolition at the eastern end of the spit, the area would be regraded to transition to the upland slope immediately south of the existing structures as part of the full restoration alternative.

Two intake pipes from the north pond to the aquaculture basins would also be removed under both alternatives. These pipes would likely be removed during Phase 2 of the partial restoration alternative.

The excavated material could be hauled using an existing, abandoned access road at the eastern side of the ponds. This road would require some initial work, including vegetation clearing, gravel placement and minor grading, to make it suitable for heavy trucks.

The overhead electric/telephone line that runs along the access road would be removed following demolition of the buildings for the full restoration alternative. It is estimated that 320 feet of this utility would be removed. Other utilities including water and telecommunications lines would be capped or cut and abandoned in place.

Additionally, it is understood that the shellfish lab has an intake or discharge pipe on the north side of the spit that connects to Dabob Bay. This pipe would be capped or removed under both alternatives (part of Phase 2 of the partial restoration alternative).

25.3.5 Land Requirements

Construction of this action will require 12.9 acres, 5.7 acres of which is upland that includes buildings and aquaculture infrastructure. The required project lands are publically owned and managed by WDFW (some lands are leased to a commercial shellfish company). There are no additional land requirements to complete the restoration.

This action will potentially change flood risk to properties that border the required project lands. The restoration of the full tidal prism to the historic lagoon will change the frequency and duration of inundation during high water events. Easements on private property, such as flowage or temporary construction access, may be required.

25.3.6 Design Considerations

The amount of fill removal within the historic lagoon footprint was determined based on the need to restore hydraulics and morphology and maintain the channel entrance. The opportunity to reuse or otherwise place this excavated material onsite should be evaluated during future design. Other design considerations include the effect of the restoration on the shellfish operations (as considered in the phasing and scaling of the partial restoration alternative) and the degree of public access that should be incorporated into the restoration design. At present, the public can access the area using parking located on the beach barrier. The removal of parking would reduce public access.

25.3.7 Construction Considerations

A significant difference between the full and partial restoration alternatives is the duration of the restoration activities. Under the full restoration alternative, all demolition and construction activities would occur concurrently in a single phase. For the partial restoration, the activities are phased, with the south pond berm removed immediately and the north pond berm and central and western spit excavation in a second phase after conclusion of a lease agreement. The building removal and regrading of the western side of the spit would also occur during the second phase.

25.4 Extent of Stressor Removal

Table 25-2 identifies the amount of stressor removal with full and partial restoration alternatives.

Table 25-2. Stressor Removal

Stressor	Full Restoration	Partial Restoration
Tidal Barrier (LF)	925	925
Fill (SF)	81,590	81,590 (Total) 17,650 (Phase 1) 63,940 (Phase 2)
Armor (LF)	240	NA

25.5 Expected Evolution of the Action Area

Without restoration, the lagoon and barrier beach would be constrained by the presence of structures and hardened surfaces, fill would continue to reduce tidal prism, and the response to sea level rise would be retarded. The likely evolution of the site is uncertain. The uncertainty is increased by reports that the inlet was previously excavated to enhance drainage (Blake, WDFW, pers. comm., with reference to Westley 1955). The likely response to overexcavation of the inlet and filling of the lagoon is sediment deposition and shrinkage of the inlet. Given that the fill in the lagoon reduces the tidal prism, the future equilibrium inlet channel would likely be smaller than the pre-disturbance inlet section. Sea level rise would tend to increase the tidal prism and increase the inlet section, but could be countered by increased sediment deposition in the lagoon. The existing armoring and fill on the spit (the parking lot) would inhibit transgression (inland and upward movement of the spit in response to sea level rise and increased sediment overwash), causing a narrowing of the beach and impacts to the inlet geometry.

The restoration alternatives would increase the tidal prism, allowing the restoration of the lagoon hydraulics and morphology. The tidal channel may still shrink but its equilibrium would likely be larger than with existing development, and with an incrementally larger equilibrium tidal prism. A larger equilibrium inlet can be expected to allow a larger tidal prism, improved flushing and water quality, and increased likelihood of an open inlet. Whether the new equilibrium inlet would be larger than the existing excavated inlet requires further analysis. An assessment of water quality would require consideration of discharges related to the existing WDFW facility, if any, as well as tidal flushing. Natural sediment transport in the cross-shore direction, and additional habitat area, would be reestablished with the removal of fill and armoring on the gravel spit.

25.6 Uncertainties and Risks

A significant uncertainty that may affect the timing and phasing of the project is the continued use of the WDFW buildings. Removing these buildings would necessitate relocating the State's shellfish management operations. The ponds and rearing buildings are currently being leased to Trout Lodge for rearing black cod. The present lease runs out in 2020 and should be reviewed in detail to determine any restrictions on restoration. The current lease may delay implementation of the design. The ponds themselves are not currently being used for rearing, although they are used for water intake and discharge buffering. There is new construction underway adjacent to the buildings and rearing tanks, which could indicate an expectation of future use that would affect the timing of the barrier spit restoration.

WDFW shellfish managers have raised concerns about restoration of the Point Whitney tidelands and its potential impact on Tribal and recreational shellfish use and resources (WDFW 2010). The potential impacts to the uses and access to this site, including Tribal treaty rights, will require further evaluation during subsequent design phases and may affect the restoration options at this site.

25.6.1 Risks Associated with Projected Sea Level Change

Table 25-3 compares potential risks associated with projected sea level changes based on professional judgment.

Table 25-3. Risks of Sea Level Change

	Projected Sea Level Change		
	High (46cm)	**Intermediate (4cm)**	**Low (-8cm)**
Full Restoration	With the removal of all structures, an adequate sediment supply and the removal of constraints to barrier overwash, the site should be able to evolve in response to sea level rise.	Negligible	Negligible
Partial Restoration	The restored system is expected to be resilient to sea level rise after Phase 2 removal of all fill along the west and central portions of the spit. However, without removal of the parking lot and armoring on the east portion of the spit, the beach would become narrower and steeper as the offshore portion migrated but the armored/ fill portion remained fixed in space. Ultimately, the beach would be largely degraded, assuming the fill is adequately armored to withstand erosion and wave overtopping. The beach degradation would result in a narrower intertidal area, higher wave reflection and alongshore currents, scour in front of armoring, and conditions not suitable for fish spawning and bird use.	Negligible	Negligible

25.7 Potential Monitoring Opportunities

Monitoring is important for evaluating restoration success. A combination of field surveys and aerial photographs would be used to document biological and physical changes to the lagoon and beach. Monitoring data can be used to refine adaptive management and corrective actions, as needed. Some of the primary monitoring needs and opportunities associated with this action are summarized in Table 25-4.

Table 25-4. Monitoring Needs and Opportunities

Monitoring Parameter	Key Performance Indicator	Note
Topographic Stability	x	Monitor inlet stability
Sediment Accretion / Erosion	x	Monitor cross-shore sediment transport with the removal of fill and armoring on the gravel spit
Wood Accumulation		
Soil / Substrate Conditions		
Vegetation Establishment		
Marsh Surface Evolution / Accretion		
Tidal Channel Cross-Section / Density	x	Monitor changes to tidal channel dimensions
Water Quality (contaminants)	x	Monitor changes in lagoon water quality
Salinity		
Shellfish Production	x	Monitor effects on clam and oyster production
Extent of Invasive Species		
Animal Species Richness		
Fish (salmonid) Access / Use		
Forage Fish Production		
Wildlife Species Use		
Effectiveness of Exclusion Devices		
Effects on Public Access / Recreation	x	Track changes due to reduction in parking and habitat changes

25.8 Information Needed for Subsequent Design

This conceptual design report represents an initial step in the restoration design sequence. The design concepts described above were developed based on readily available information without the level of site-specific survey and investigation that is necessary to support subsequent design and implementation. Substantial additional information will be required at the preliminary and later design stages to confirm the design assumptions, refine quantity estimates, address property and regulatory issues, obtain stakeholder support, and fill in data gaps. The extent to which this information is collected for preliminary design (or a later design stage) will depend upon the available budget, schedule and other factors. This section attempts to define the most essential information needs for this action.

- Property Investigation – Terms of the property lease would need to be investigated prior to future design efforts.
- Topographic/Bathymetric Survey – The survey data would be used to refine design of key project elements and develop detailed construction and demolition plans. Survey data could also be used as a baseline for pre- and post-construction

monitoring and hydrodynamic modeling. A temporary tide gauge may be required in the early design stages to obtain site-specific tidal statistics.

- Cultural Resources Investigation – Surveys for archaeological and historic resources may be required for this action area as it has a high likelihood of having past use by Native Americans. This is particularly important in areas proposed for excavation.
- Hydraulic Analysis/Modeling – Tidal circulation, flood, and hydrodynamic modeling may be desired to help refine the design and confirm that the target inlet dimensions are stable.
- Contaminant Survey – If preliminary investigations suggest that hazardous material could be present in the action area, additional soil and sediment analysis may be needed. The introductory chapter describes the Phase I site investigations that are occurring as part of this overall effort via a separate contract.
- Sea Level Change Projection – Estimates of sea level change for the conceptual design were based on calculations provided by the Washington Department of Fish and Wildlife and the Corps of Engineers using guidance in Corps' Engineering Circular No. 1165-2-211. Projections for each project area will be refined using localized tide gauge data during later design stages.
- Other – A sediment grain size survey may be needed to determine the size/gradation of the material selected for beach nourishment (to match with existing and nearby beach sediment).

25.9 Quantity Estimates

The quantity spreadsheets for the full and partial restoration alternatives are provided in Exhibits 25-1 and 25-2.

25.10 References

Bradbury, A. WDFW. 2010. Personal communication. September 28.

WDFW (Washington Department of Fish and Wildlife). 2010. Memorandum to C. Tanner. Shellfish Review of PSNERP Candidate Restoration Proposals. September 29.

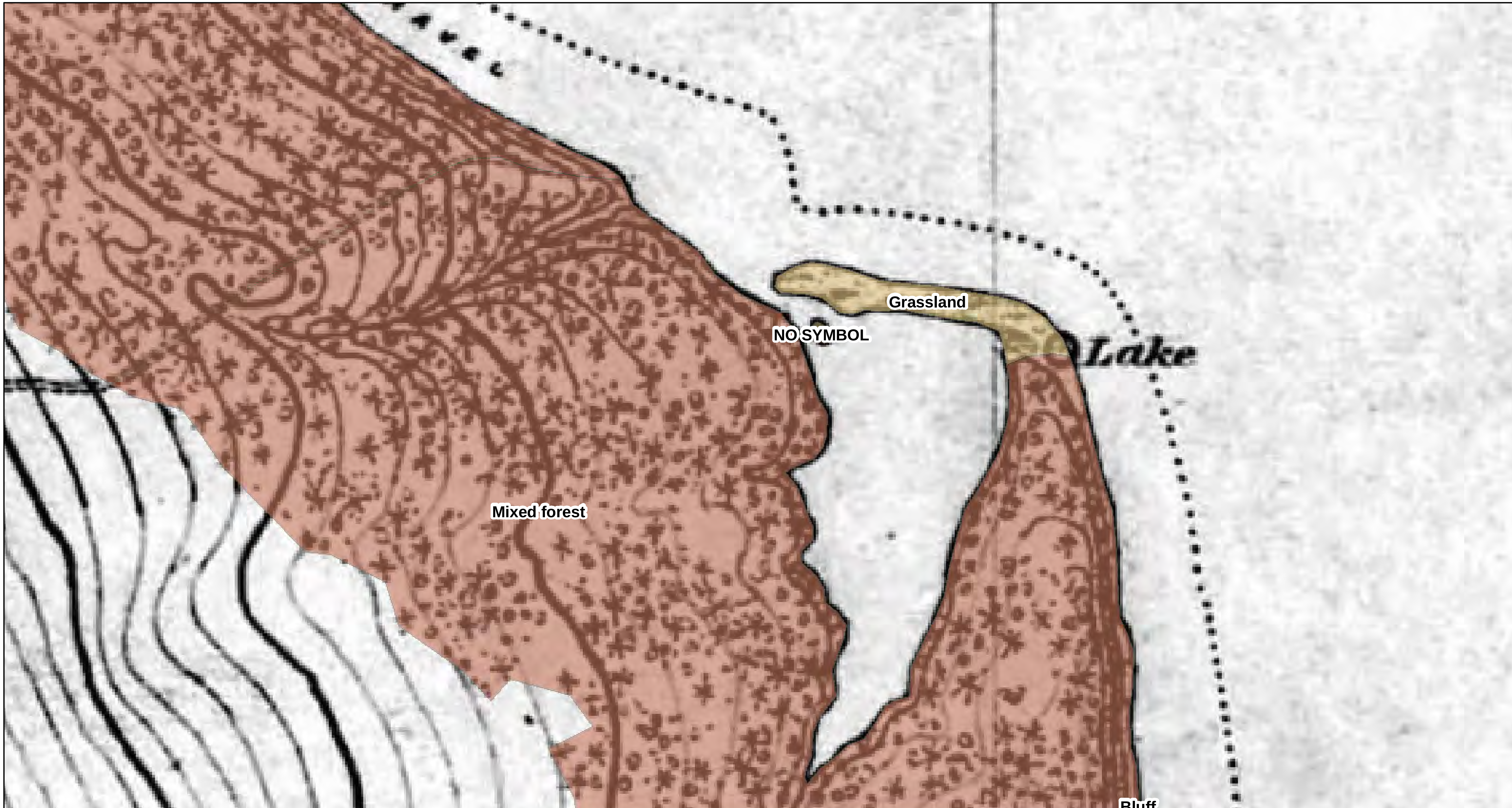
Westley, R.E. 1955. Point Whitney Historical Report (full citation unavailable).

0 240
Feet
0 60
Meters

S:\GIS\Projects\210xxx\210337_PSNERP_NEARSHORE\Projects\2-TSheets_rev.mxd (DLP; 2/24/2011)

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Historic Map (T-Sheet)
Action Name: Point Whitney
PSNERP ID #: 1379
Figure 25- 2A



Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64

WDFW Contract # 100-000204 (CAPS No. 10-1461)

Historic Map (T-Sheet) and River History Project Data

Action Name: Point Whitney

PSNERP ID #: 1379

Figure 25- 2B

S:\GIS\Projects\210xxx\210337_PSNERP_NEARSHORE\Projects\2-TSheets_rev.mxd (DLP; 2/24/2011)

SOURCE: Washington Public Lands Database (2006);
Washington Counties Parcels (2009); AEX (image 2009)

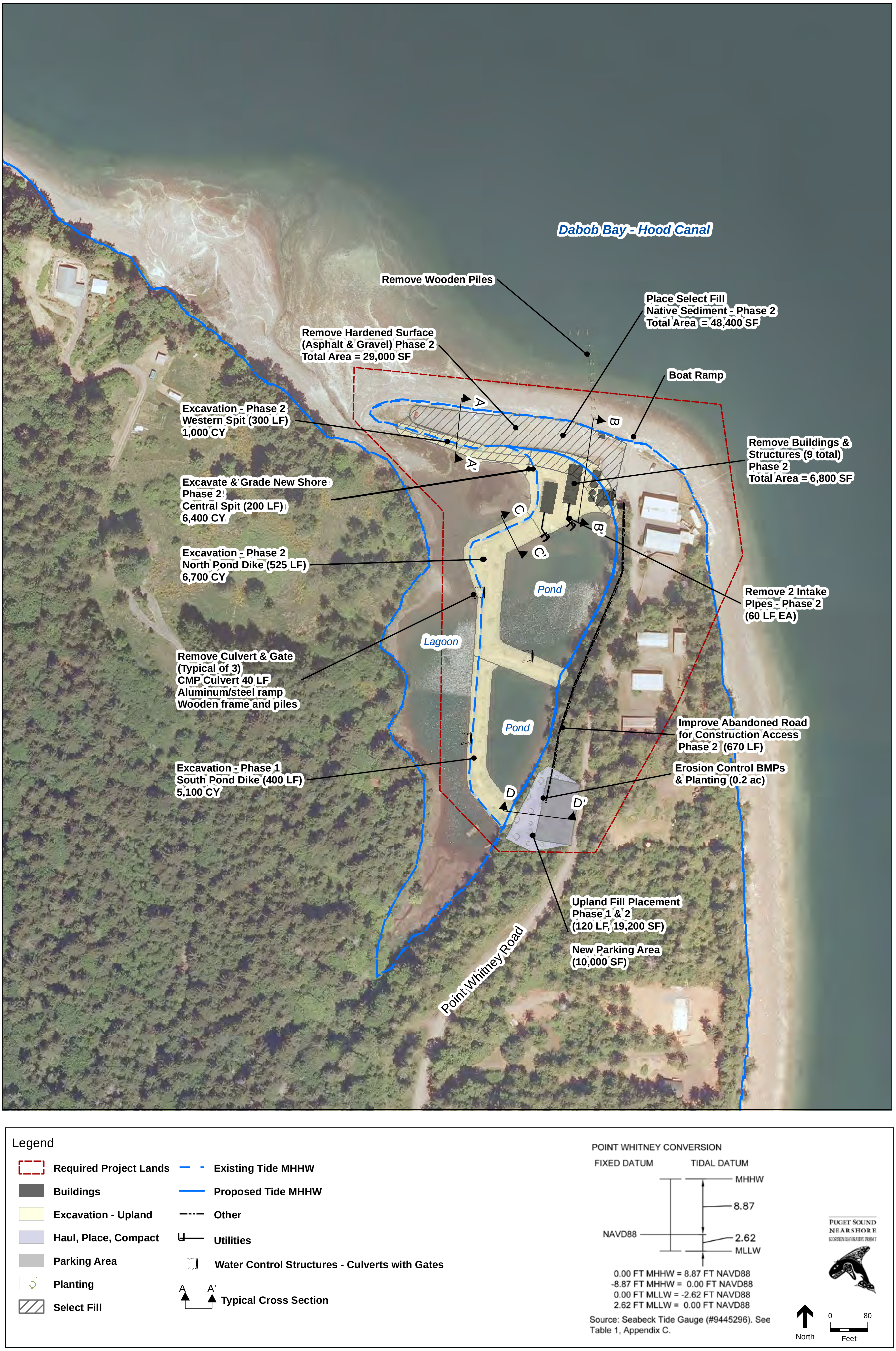
Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64

WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Plan
Site Name: Point Whitney
Action Name: Point Whitney
PSNERP ID #:1379
Full Restoration

Lead Contractor: ESA
Design Lead: ESA PWA, P. Leucking, PE
Date:05/2012

Figure 25-3



SOURCE: Washington Public Lands Database (2006); Washington Counties Parcels (2009); AEX (image 2009)

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP)

USACE Drawing FIle Number: D-1-1-64

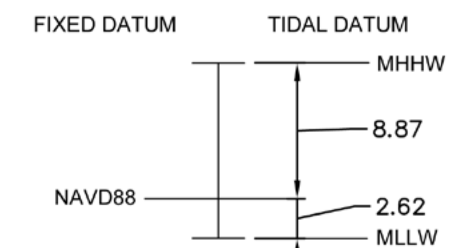
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Plan
Site Name: Point Whitney
Action Name: Point Whitney
PSNERP ID #:1379
Partial Restoration

Lead Contractor: ESA
Design Lead: ESA PWA, P. Leucking, PE
Date:05/2012

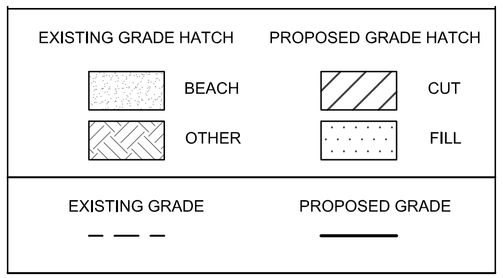
Figure 25-4

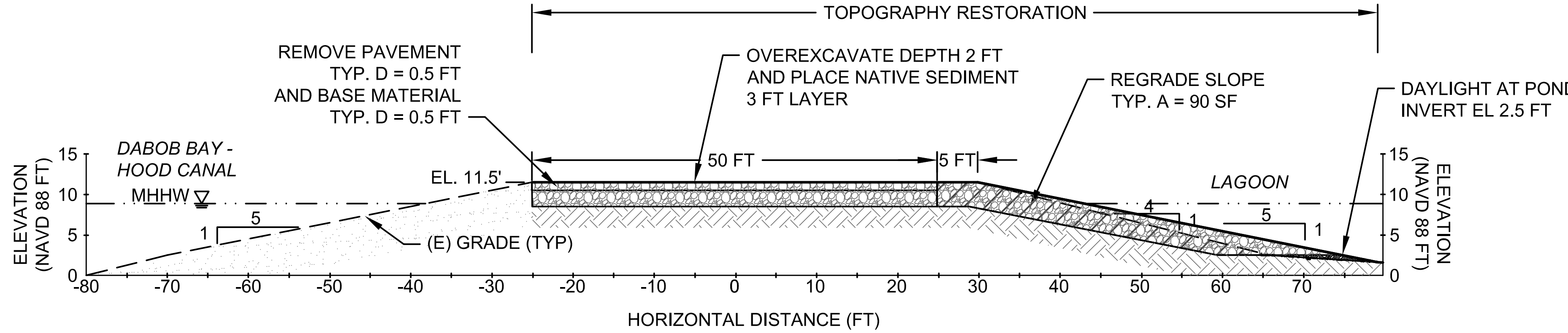
POINT WHITNEY CONVERSION



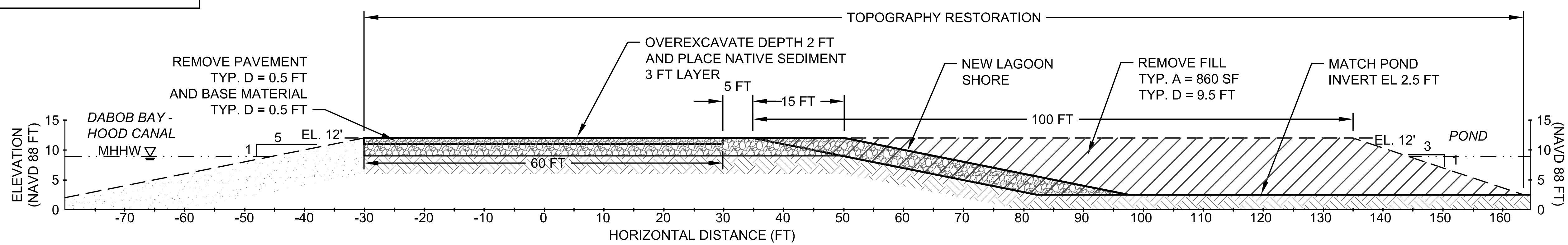
0.00 FT MHHW = 8.87 FT NAVD88
-8.87 FT MHHW = 0.00 FT NAVD88
0.00 FT MLLW = -2.62 FT NAVD88
2.62 FT MLLW = 0.00 FT NAVD88

Source: Seabeck Tide Gauge (#9445296). See Table 1, Appendix C.

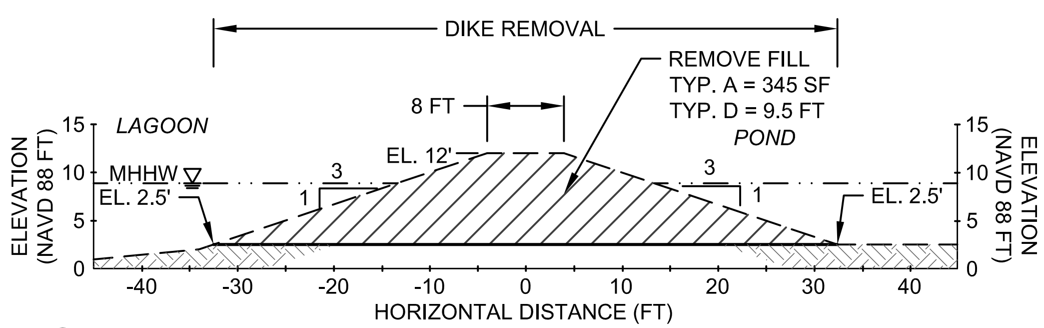




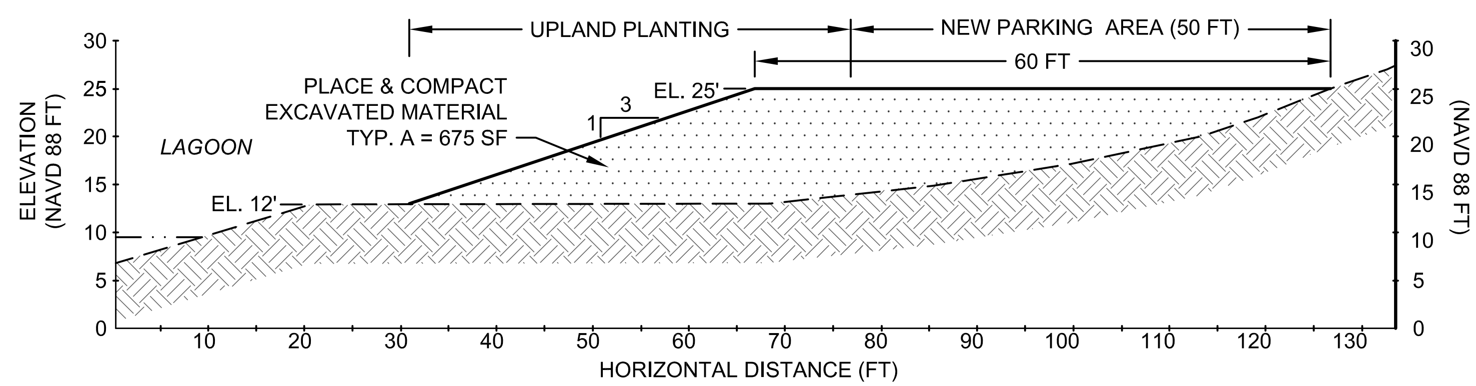
Ⓐ FULL & PARTIAL (PHASE 2) TYPICAL SECTION - WESTERN END OF SPIT



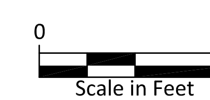
Ⓑ FULL & PARTIAL (PHASE 2) TYPICAL SECTION - CENTRAL SPIT



Ⓒ FULL & PARTIAL (PHASE 1 & 2) TYPICAL SECTION - NORTH AND SOUTH POND DIKES



Ⓓ FULL & PARTIAL (PHASE 1 & 2) TYPICAL SECTION - UPLAND FILL PLACEMENT AT SOUTHEAST CORNER OF SOUTH POND



PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: ESA PWA, P. Leucking, PE
Date: 05/2012

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Section
SITE NAME: **Point Whitney Lagoon**
ACTION NAME: **Point Whitney**
PSNERP ID#: **1379**
Full Restoration & Partial Restoration

Figure 25-5

Full Restoration Quantity Estimate

Action Name:	Point Whitney Lagoon
Action #:	1379
Date:	February 2011 Revised May 2012
By:	ESA PWA

REMEDY: ***restore tidal influence and increase tidal prism to the lagoon at Point Whitney. The restoration entails removal of dikes, aggraded area, hardened features and buildings***

Construction Period: one phase/ construction season (10-16 weeks)

	Item	Unit of Measure	Material Name	Qty	Description of Item	Indicate section of design report where item is described
ACQUISITION AND CONSERVATION					Based on available mapping information	
	Required Project Lands	Acre		12.9	Total land required for action (12.9 ac total area, 5.7 ac is land)	
	Proponent / Partner-owned lands	Acre		6	All lands required for action are owned by WDFW.	
	Lands To Be Acquired	Acre		NA		
Material Sites					Not Used: See Earthwork - Imported Fill.	
MOBILIZATION AND ACCESS for construction activities					Description required for each item to facilitate cost estimating	
	Mobilization - Typical (Equipment, Personnel, Planning, Financial)	LS		1	Typically, assume 8% to 10% of other items.	
	Mobilization - Remote (Equipment, Personnel, Planning, Financial)	LS		NA		
	Site Access	LS		1	Improve existing earth road running at eastern edge of ponds (clear vegetation, place gravel) to provide access to on-site disposal location (L = 670 ft). No other special access required.	25.3.4
	Barge Access	Days		NA		
	Temporary Traffic Control (one of the following)					
	none	LS		None		
	signs	LS		NA		
	flags / spotters	LS		NA		
	unique	LS		NA		
	Temporary Roadway	SF		NA		
	Control of Water	LS		NA		
Relocation Activities					Not Used: See Utilities, Structures	
Site Demolition Activities					Demolition and removal of structures (description required), temporary features and relocations, itemized separately); Clearing and grubbing of vegetation, and removal of minor debris (rocks, slabs) - description required.	
	Clearing and Grubbing (one or more of following)					
	Clear Vegetation - Local Disposal	AC		NA		
	Clear /Grub Vegetation - Local Disposal	AC		1.3	Remove Vegetation (trees, shrubs, grasses) from pond dikes	25.3.2
	Clear /Grub Vegetation - Offsite Disposal	AC		NA		
	Clear, stockpile - large woody debris	CY		NA		
	Hydraulic Structures - Small	LS		1	Remove 3 - 40' CMP culverts with flap gates, wooden piles (2 per structure), wooden frame, aluminum/steel ramp. Remove or cap water intake/discharge pipe on north side of spit	25.3.2, 25.3.4
	Hydraulic Structures - Large	LS		1	Remove wooden piles at Dabob Bay side of spit	25.3.4
	Utilities - Overhead Electric	LF		320	Remove overhead electric/telephone line	25.3.4
	Utilities - Water	LF		?	Location unknown, but will be removed or capped with building demolition	25.3.4
	Utilities - Telecom	LF		?	Location unknown, but will be removed or capped with building demolition	25.3.4
	Buildings	SF		14,700	15 total structures, 10 single story bldgs, 2 two story buildings, 3 tanks	25.3.4
	Pavement	SF		46,500	Asphalt and gravel paving at the spit and near Shellfish lab buildings	25.3.4
	Bulkheads	LF or SF		NA		
	Rock revetments	LF		240	Concrete and rock revetment at east end of spit	25.3.2 Armor Removal
	Large Coastal Structures	LF, SF or CY		NA		
	Demolition / Removal - Bridge	SF or CY		NA		
	Removal - Misc. (e.g. angular rock from beach)	Ton		NA		
	Demolition / Removal - Boat Ramp	SF		NA		
	Haul - Offsite Disposal of Demolition Debris	Miles		40	Assumed suitable location is available within 40 miles of site.	25.3.4
Hazardous/Contaminated Waste Removal					These items for earthwork of quality not compatible with wetlands, requiring special handling and disposal. Describe basis for classification as contaminated or hazardous. State known or suspected contamination, describe known similar work.	
	Contaminated Earthwork	CY		NA		
	Hazardous Earthwork	CY		NA		
Construct Temporary Features					Use as needed for unusual temporary features not included elsewhere (see TESC below)	
EARTHWORK					Expand to include equipment, etc. to facilitate cost estimating.	
	Excavation	CY				
	Excavation - Upland	CY		11,800	North and south pond dike Removal (925 FT x 345 SF). Land based bucket excavator for removal of dikes and loading of trucks	25.3.2 Dike or Berm Removal
	Excavation - Upland	CY		7,400	Includes western & central spit excavation (300 FT x 90 FT) + (200FT x 860 SF)	25.3.2 Topography Restoration
	Excavation - Upland	CY		3,100	Overexcavation of spit prior to allow for native sediment placement. (2 FT x 41,400 SF)	25.3.2 Topography Restoration
	Excavation - Lowland	CY		NA		
	Dredging - Bucket - Land	CY		NA		
	Dredging - Bucket - Marine	CY		NA		
	Dredging - Hydraulic	CY		0		
	Fine Grading	AC		0.34	Upland transition grading at east end of spit	25.3.4
	Fill Placement - local borrow					
	Side cast	CY		NA		
	Haul - uncontrolled placement	CY		19,300	Transportation and second handling off-site (22,300 CY - 3,000 CY)	25.3.4
	Haul, place, compact	CY		3,000	Placement at southeast corner of southern pond via existing access road. Haul distance = 670 ft (120 FT x 675 SF)	25.3.2 Dike or Berm Removal, 25.3.4
	Stockpile - uncontrolled placement	CY		NA		
	Stockpile - controlled placement	CY		NA		
	Conveyor placement from stockpile land/water	CY		NA		
	Imported Fill				Includes purchase, delivery and placement or as noted / described	
	Select Fill	CY		7,700	Imported native soil, gravel mix for placement at top surface of the spit and back slope of spit (3 FT x 57,200 SF)	25.3.2 Topography Restoration
	Gravel Borrow, including haul	CY		NA		
	Sand / Gravel for Beach Nourishment	CY		NA		
	Cobble for Shore Nourishment	CY		580	Reconstruct beach slope after revetment removal (240 FT x 65 SF)	25.3.3 Beach Nourishment
	Embankment Compaction	CY		NA		
	Topsoil	CY		NA		
RESTORATION Features						
	Channel Rehab / Creation	SF		NA		
	Large Wood Placement	EA		NA		
	Invasive Species Control	Acre		NA		
	Physical Exclusion Devices	LF or EA		NA		
	Other Restoration Features/ Activities	LS		NA		
Structures		EA				
	Water Control Structures - Culverts with Gates	EA		NA		
	Water Control Structures - Weirs	EA		NA		
	Rock Slope Protection	LF		NA		
	Other	EA		NA		
	Elevated Boat Ramp	SF		NA		
	Fencing	SF		NA		
Utilities					Replacement or relocation. Designer to provide size and material and have separate line item for each run. Incidentals include earthwork, testing, hook up fees, etc. These quantities do not include demolition of existing utilities, real estate / easements, design fees. Describe the owner if known, and whether utility franchise will install (e.g., electric is typically installed by electrical franchise).	
	Water	LF		NA		
	Gas	LF		NA		
	Electric	LF		320	Line along access road to be removed after demolition of buildings	25.3.4 Restoration Features
	Sewer	LF		NA		
	Telecommunications	LF		320	Line along access road to be removed after demolition of buildings	25.3.4 Restoration Features
	Other	LF		NA	Others = whatever is required (e.g.. power towers, petroleum, jet fuel, etc.)	
Roadway / Railway						
	Roadway (Type)	SF		NA		
	Roadway - Traffic Signal	LS		NA		
	Culvert (type)	LF		NA		
	Culvert - Jacking	LF		NA		
	Culvert - Horizontal Pile Driving	LF		NA		
	Bridge - Deck and appurtenances	SF		NA		
	Bridge - Foundations	LF		NA		
	Railway - Box Girder	SF		NA		
	Railway - Foundation	LF		NA		
	Railway - Shoe fly	LF		NA		
Permanent Access Features						
	Roads	Level		NA		
	Utility Access Routes	varies		NA		
	Erosion Control Features	L.F.		NA		
Public Access or Recreation Features						
	Trails	SF		NA		
	Bridges	SF		NA		
	Kiosk	EA		NA		
	Restrooms	EA		NA		
	Interpretive Signs	EA		1	TBD	
	Parking Area	SF		10000	New parking area at upland fill placement, southeast corner of south pond	25.3.4
	Other	EA		NA		
Vegetation & Erosion Control						
	Hydroseeding	AC		NA		
	Planting	AC		0.78	Upland planting at transitional slope area at northeastern corner of the spit and upland fill placement at southeast corner of ponds	25.3.4

Full Restoration Quantity Estimate

	Action Name:	Point Whitney Lagoon					
	Action #:	1379					
	Date:	February 2011	Revised May 2012				
	By:	ESA PWA					

REMEDY: ***restore tidal influence and increase tidal prism to the lagoon at Point Whitney. The restoration entails removal of dikes, aggraded area, hardened features and buildings***

Construction Period: one phase/ construction season (10-16 weeks)

	Item	Unit of Measure	Material Name	Qty	Description of Item		Indicate section of design report where item is described
	Vegetation Maintenance	AC-YR		NA			
	Erosion / sediment BMPs - Temp.	AC		0.78	Northeastern corner of the spit and upland fill placement at southeast corner of ponds.		25.3.4
	Erosion / sediment BMPs - Permanent	AC		NA			
	Waterside controls - Temporary	EA, LF, LS		NA			
Construction Management							
	Construction oversight	weeks			Quantity based on construction duration/ # of construction seasons		
	Materials testing				Included in cost of material - no separate quantity		
Design and Detailed Site Investigations							
	Survey & Property, Utility Research	LS		1	% of construction cost		
	35% Design	LS		1	% of construction cost		
	65% design	LS		1	% of construction cost		
	90% design	LS		1	% of construction cost		
	100% design	LS		1	% of construction cost		
	Geotechnical Studies				Refer to design report for description of need		
	Cultural Studies				Refer to design report for description of need		
	HTWR Studies				Refer to design report for description of need		
Project Agreement Activities					Unable to provide credible estimate at 10% design		
Site-Specific Adaptive Management Features & Activities					List if known		
Monitoring Activities					Assume 5 crew-days/year for each monitoring parameter in design report for 5 yrs		
	Monitoring (Type_)	crew-days		150			
Operations & Maintenance					Unable to provide credible estimate at 10% design		

Partial Restoration Quantity Estimate

Action Name:	Point Whitney Lagoon
Action #:	1379
Date:	February 2011 — Revised May 2012
By:	ESA PWA

REMEDY: ***restore tidal influence and increase tidal prism to the lagoon at Point Whitney. The restoration entails removal of dikes, aggraded area, hardened features and buildings***

Construction Period: Phased construction over 2 seasons (10 - 16 weeks)

Item	Unit of Measure	Material Name	Qty	Description of Item		Indicate section of design report where item is described
ACQUISITION AND CONSERVATION				Based on available mapping information		
Required Project Lands	Acre		12.9	Total land required for action (12.9 ac total area, 5.7 ac is land)		
Proponent / Partner-owned lands	Acre		6	All lands required for action are owned by WDFW.		
Lands To Be Acquired	Acre		NA			
Material Sites				Not Used: See Earthwork - Imported Fill.		
MOBILIZATION AND ACCESS for construction activities				Description required for each item to facilitate cost estimating		
Mobilization - Typical (Equipment, Personnel, Planning, Financial)	LS		1	Typically, assume 8% to 10% of other items.		
Mobilization - Remote (Equipment, Personnel, Planning, Financial)	LS		NA			
Site Access	LS		1	Improve existing earth road running at eastern edge of ponds (clear vegetation, place gravel) to provide access to on-site disposal location (L = 670 ft). No other special access required.		25.3.4
Barge Access	Days		NA			
Temporary Traffic Control (one of the following)						
none	LS		None			
signs	LS		NA			
flags / spotters	LS		NA			
unique	LS		NA			
Temporary Roadway	SF		NA			
Control of Water	LS		NA			
Relocation Activities				Not Used: See Utilities, Structures		
Site Demolition Activities				Demolition and removal of structures (description required), temporary features and relocations, itemized separately); Clearing and grubbing of vegetation, and removal of minor debris (rocks, slabs) - description required.		
Clearing and Grubbing (one or more of following)						
Clear Vegetation - Local Disposal	AC		NA			
Clear /Grub Vegetation - Local Disposal	AC		1.3	Phase 1 = 0.4 ac, Phase 2 = 0.9 ac. Remove Vegetation (trees, shrubs, grasses) from pond dikes		25.3.2
Clear /Grub Vegetation - Offsite Disposal	AC		NA			
Clear, stockpile - large woody debris	CY		NA			
Hydraulic Structures - Small	LS		1	Phase 1 - remove one from south pond.		25.3.2
Hydraulic Structures - Small	LS		1	Phase 2 remove two from north pond. In total, remove 3, 40' CMP culverts with flap gates, wooden piles (2 per structure), wooden frame, aluminum/steel ramp. Remove or cap water intake/discharge pipe on north side of spit		25.3.2, 25.3.4
Hydraulic Structures - Large	LS		1	Remove wooden piles at Dabob Bay side of spit		25.3.4
Utilities - Overhead Electric	LF		NA			
Buildings	SF		6,800	Phase 2, 9 total structures, 6 single story buildings, 3 tanks		25.3.4
Pavement	SF		29,000	Phase 2, Asphalt and gravel paving at the spit		25.3.4
Bulkheads	LF or SF		0			
Rock revetments	LF		NA			
Large Coastal Structures	LF, SF or CY		NA			
Demolition / Removal - Bridge	SF or CY		NA			
Removal - Misc. (e.g. angular rock from beach)	Ton		NA			
Demolition / Removal - Boat Ramp	SF		NA			
Haul - Offsite Disposal of Demolition Debris	Miles		40	Assumed suitable location is available within 40 miles of site		25.3.4
Hazardous/Contaminated Waste Removal				These items for earthwork of quality not compatible with wetlands, requiring special handling and disposal. Describe basis for classification as contaminated or hazardous. State known or suspected contamination, describe known similar work.		
Contaminated Earthwork	CY		NA			
Hazardous Earthwork	CY		NA			
Construct Temporary Features				Use as needed for unusual temporary features not included elsewhere (see TESC below)		
EARTHWORK				Expand to include equipment, etc. to facilitate cost estimating.		
Excavation						
Excavation - Upland	CY		5,100	Phase 1 includes only the south dike removal. (400 FT x 345 SF) Land based bucket excavator for removal of dikes and loading of trucks.		25.3.2 Dike or Berm Removal
Excavation - Upland	CY		6,700	Phase 2 includes north dike removal (400 FT x 345 SF)		25.3.2 Dike or Berm Removal
Excavation - Upland	CY		7,400	Phase 2 includes western & central spit excavation (300 FT x 90 FT) + (200FT x 860 SF)		25.3.2 Topography Restoration
Excavation - Upland	CY		2,200	Phase 2 - overexcavation of spit prior to allow for native sediment placement. (2 FT x 29,600 SF)		25.3.2 Topography Restoration
Excavation - Lowland	CY		NA			
Dredging - Bucket - Land	CY		NA			
Dredging - Bucket - Marine	CY		NA			
Dredging - Hydraulic	CY		NA			
Fine Grading	AC		NA			
Fill Placement - local borrow						
Side cast	CY		NA			
Haul - uncontrolled placement	CY		18,400	Transportation and second handling off-site (21,400 CY - 3,000 CY)		25.3.4
Haul, place, compact	CY		3,000	Placement at southeast corner of southern pond via existing access road. Haul distance = 670 ft (120 FT x 675 SF)		25.3.4
Stockpile - uncontrolled placement	CY		NA			
Stockpile - controlled placement	CY		NA			
Conveyor placement from stockpile land/water	CY		NA			
Imported Fill				Includes purchase, delivery and placement or as noted / described		
Select Fill	CY		6,400	Imported native soil, gravel mix for placement at top surface of the spit and back slope of spit (3 FT x 57,200 SF)		25.3.2 Topography Restoration
Gravel Borrow, including haul	CY		NA			
Sand / Gravel for Beach Nourishment	CY		NA			
Cobble for Shore Nourishment	CY		NA			
Embankment Compaction	CY		NA			
Topsoil	CY		NA			
RESTORATION Features						
Channel Rehab / Creation	SF		NA			
Large Wood Placement	EA		NA			
Invasive Species Control	Acre		NA			
Physical Exclusion Devices	LF or EA		NA			
Other Restoration Features/ Activities	LS		NA			
Structures	EA					
Water Control Structures - Culverts with Gates	EA		NA			
Water Control Structures - Weirs	EA		NA			
Rock Slope Protection	LF		NA			
Other	EA		NA			
Elevated Boat Ramp	SF		NA			
Fencing	SF		NA			
Utilities				Replacement or relocation. Designer to provide size and material and have separate line item for each run. Incidentals include earthwork, testing, hook up fees, etc. These quantities do not include demolition of existing utilities, real estate / easements, design fees. Describe the owner if known, and whether utility franchise will install (e.g., electric is typically installed by electrical franchise)		
Water	LF		NA			
Gas	LF		NA			
Electric	LF		NA			
Sewer	LF		NA			
Telecommunications	LF		NA			
Other	LF		NA	Others = whatever is required (e.g., power towers, petroleum, jet fuel, etc.)		
Roadway / Railway						
Roadway (Type)	SF		NA			
Roadway - Traffic Signal	LS		NA			
Culvert (type)	LF		NA			
Culvert - Jacking	LF		NA			
Culvert - Horizontal Pile Driving	LF		NA			
Bridge - Deck and appurtenances	SF		NA			
Bridge - Foundations	LF		NA			
Railway - Box Girder	SF		NA			
Railway - Foundation	LF		NA			
Railway - Shoe fly	LF		0			
Permanent Access Features						
Roads	Level		NA			
Utility Access Routes	varies		NA			
Erosion Control Features	L.F.		NA			
Public Access or Recreation Features						
Trails	SF		NA			
Bridges	SF		NA			
Kiosk	EA		NA			
Restrooms	EA		NA			
Interpretive Signs	EA		1	TBD		
Parking Area	SF		10,000	New parking area at upland fill placement, southeast corner of south pond		25.3.4
Other	EA		NA			
Vegetation & Erosion Control						
Hydroseeding	AC		NA			
Planting	AC		0.2	Upland planting at upland fill placement		25.3.4
Vegetation Maintenance	AC-YR		NA			
Erosion / sediment BMPs - Temp.	AC		0.2	Upland fill placement area		25.3.4
Erosion / sediment BMPs - Permanent	AC		NA			
Waterside controls - Temporary	EA, LF, LS		NA			

Partial Restoration Quantity Estimate

	Action Name:	Point Whitney Lagoon					
	Action #:	1379					
	Date:	February 2011	Revised May 2012				
	By:	ESA PWA					

REMEDY: ***restore tidal influence and increase tidal prism to the lagoon at Point Whitney. The restoration entails removal of dikes, aggraded area, hardened features and buildings***

Construction Period: Phased construction over 2 seasons (10 - 16 weeks)

	Item	Unit of Measure	Material Name	Qty	Description of Item		Indicate section of design report where item is described
Construction Management							
	Construction oversight	weeks		NA	Quantity based on construction duration/ # of construction seasons		
	Materials testing			NA	Included in cost of material - no separate quantity		
Design and Detailed Site Investigations							
	Survey & Property, Utility Research	LS		1	% of construction cost		
	35% Design	LS		1	% of construction cost		
	65% design	LS		1	% of construction cost		
	90% design	LS		1	% of construction cost		
	100% design	LS		1	% of construction cost		
	Geotechnical Studies				Refer to design report for description of need		
	Cultural Studies				Refer to design report for description of need		
	HTWR Studies				Refer to design report for description of need		
Project Agreement Activities					Unable to provide credible estimate at 10% design		
Site-Specific Adaptive Management Features & Activities					List if known		
Monitoring Activities					Assume 5 crew-days/year for each monitoring parameter in design report for 5 yrs		
	Monitoring (Type_)	crew-days		150			
Operations & Maintenance					Unable to provide credible estimate at 10% design		

26. QUILCEDA ESTUARY RESTORATION (#1136)

Local Proponent	Tulalip Tribes
Delta Process Unit	Delta SNH
Shoreline Process Unit(s)	NA
Strategy(ies)	1 - River Delta
Restoration Objectives	Restore natural tidal hydrology and marsh morphology to a disturbed portion of the Quilceda Estuary

26.1 Description of the Action

This action includes the removal of artificial berms, fill, bulkheads, and related drainage structures to restore full tidal hydrology and sediment processes within 5 to 10 acres of the Quilceda Creek Estuary. Please see the Introduction chapter for important information regarding PSNERP and for context related to this restoration project.

26.2 Action Area Description and Context

The Quilceda Creek action area covers 14 acres within the lower Snohomish River Estuary at the eastern edge of the Tulalip Indian Reservation near Marysville. The Tribes' Hibulb Cultural Center and Natural History Preserve is located just north of the action area. The mainstem of Quilceda Creek is approximately 11 miles long, with the headwaters located east of State Route 9 on Getchell Plateau. The creek drains approximately 36 square miles to Ebey Slough. The watershed includes the Marysville Trough, a flat alluvial plain that separates the Snohomish and Stillaguamish River basins. The Trough includes highly permeable alluvial soils, as well as significant areas with high seasonal groundwater (Snohomish County 2002). The contributing basin includes broad areas of glacial till and outwash. The contributing area is predominantly rural and agricultural, but there are significant infrastructure and medium-density residential and commercial areas. The action area is shown in Figure 26-1.

Figure 26-1. Action Area and Vicinity

26.2.1 Historic Condition

Historical mapping (circa 1884-1885) indicates that the Quilceda Creek Estuary graded into the lower Snohomish River Estuary via a series of meandering channels flowing through an extensive salt marsh (Figures 26-2A and 26-2B). Much of this salt marsh is still present in the Quilceda Estuary. Within the action area, greater areas of salt marsh are mapped than currently exist. The 1938 aerial photo shows that the boat basin was at least partially in place, and the beginnings of the agricultural berms and ditches. The 1938 photo also shows a dense network of tidal channels within the unfilled portion of the site.

26.2.2 Natural Environment

The Quilceda Estuary action area is surrounded by salt marsh that extends to Ebey Slough to the south, and continues on the south side of Ebey Slough in the “Big Flats” portion of North Ebey Island. Sturgeon Creek flows into the west bank of Quilceda Creek within the action area.

The Quilceda Creek basin supports several runs of anadromous salmonid species. The WDFW Salmonscape database indicates that Quilceda Creek supports fall Chinook, summer Chinook, coho, fall chum, bull trout, summer steelhead, and winter steelhead.

26.2.3 Human Environment

Large infrastructure development within the Quilceda Creek basin includes I-5, a portion of the Arlington Airport, and commercial development east of I-5. Near the action area are residential and commercial buildings, and two major bridges for Marine View Drive. There is direct access to the site via established roads south of Marine View Drive.

The action area has been altered through past conversion to agriculture and to support water access. In the northern portion of the action area, berms have been constructed along the mainstem and drainage ditches excavated, likely in an attempt to reclaim the area for agriculture. This portion of the action area drains to the creek via a small square culvert (8 inches by 12 inches). This culvert may allow muted tidal influx to the bermed portion of the site, based on the presence of salt-tolerant vegetation along portions of the linear ditches.

The southern portion of the action area has been filled, raising the surface elevation above tidal influence. A log bulkhead and pier have been constructed, and a portion of the marsh was excavated to create a boat basin. The upland area is currently used for construction material storage and laydown. This area has underground electrical service.

26.3 Restoration Design Concept

26.3.1 Restoration Overview and Key Design Assumptions

The restoration alternatives are illustrated in Figures 26-3 through 26-6. Full restoration of the action area would include removing shoreline armoring, nearshore fill, and the artificial berms (Figure 26-3). The linear agricultural ditches would be filled and new small blind channels excavated in their place. Intertidal elevations and channel morphology, similar to historical conditions (based on the historic maps and 1938 photograph), will be reestablished on the site. A buffer of marine riparian upland vegetation would be planted in the full restoration alternative. The partial restoration alternative would include the same elements but would also include a boat launch, as requested by the proponent (Figure 26-4).

The key design elements associated with full and partial restoration alternatives are shown in Table 26-1.

Table 26-1. Key Design Elements

Element	Full Restoration	Partial Restoration
Fill Removal	Remove fill to intertidal elevations, including a small pond. 3H:1V slope to match surrounding grade	Same as full restoration
Berm Removal	Remove berms along channel to match surrounding grade	Same as full restoration

Element	Full Restoration	Partial Restoration
Bulkhead Removal	Remove entire wooden bulkhead	Remove eastern portion of bulkhead
Building Removal	Remove two storage/workshop buildings from site	Same as full restoration
Pavement Removal	Remove gravel, old pavement, and old foundations from fill area	Same as full restoration
Electric Line Removal	Remove underground electric line from where it undergrounds to the buildings	Remove underground electric line, leaving spur to the remaining bulkhead, if necessary
Fill of Linear Ditches	Fill ditches with sidecast local borrow from channel excavation or berm removal	Same as full restoration
New Channels	Divide exposed marsh into roughly equal 1.5- to 2-acre drainage basins and excavate starter channel sized to regional curves. Starter channel mouths based on faint channels in 1938 photo and reference channels on the other side of Quilceda Creek	Same as full restoration
Inlet	Haul, place, and compact local borrow within the dredge inlet to restore intertidal marsh habitat. Morphology based on T-sheets and 1938 photo	No fill placement
Marine Riparian Planting	Plant buffer around fill removal area	Plant smaller buffer around removal area, leaving access to boat launch

26.3.2 Restoration Features – Primary Process-Based Management Measures

Armor Removal/Modification

The existing wooden bulkhead would be fully or partially removed in the full and partial restoration alternatives, respectively. The full restoration alternative would remove 570 LF of armor, and the partial restoration alternative would remove 310 LF (Figures 26-3 and 26-4).

Berm or Dike Removal/Modification

Berms have been constructed along the main channel of Quilceda Creek. These berms will be removed to allow full tidal inundation of the site to approximate historical extents (Figures 26-3 and 26-4).

Channel Rehabilitation/Creation

Linear ditches will be filled, and new sinuous marsh channels will be excavated. The location of these channels is based on traces on the 1938 photo, targets 1.5- to 2.0-acre drainage basins, and mimics the alignments of the reference channels in the surrounding marsh (Figures 26-3 and 26-4).

Groin Removal/Modification - NA

Hydraulic Modification

The small culvert that extends through the berm would be removed. This, along with removal of the berm, would allow full tidal access to the site.

Overwater Structure Removal - NA

Topography Restoration

In both restoration alternatives, fill will be removed to lower the elevation of the site from between 9.5 to 12 feet MLLW (12 and 14 feet NAVD 88) to intertidal elevations generally 2 feet below MHHW (Figures 26-5 and 26-6). In general, the 2009 LiDAR topography was used as a guide to the extent of topographic restoration, matching intertidal elevations on either side of the fill area.

26.3.3 Restoration Features – Additional Management Measures

Beach Nourishment - NA

Contaminant Removal/Remediation - NA

Debris Removal - NA

Invasive Species Control

Invasive plant species on the site include reed canarygrass, Spartina, and Himalayan blackberry. The reintroduction of salt water to the site is expected to eradicate reed canarygrass and blackberry, or at least reduce the extent of infestation in the intertidal area. Limited excavation (stripping) is proposed to reduce the initial dominance of those species.

Specific measures will be necessary to control Spartina as part of an integrated pest management approach. The infestations appear to be localized, so the primary control measure will be to excavate the areas as part of the topographic restoration of the site. Followup treatments with mechanical clearing and/or application of an approved aquatic herbicide may be necessary.

Large Wood Placement

Salvaged large wood from site clearing will be placed on the restored marsh surface to support colonization by native shrub and tree species.

Physical Exclusion - NA

Pollution Control - NA

Revegetation

Portions of the marine riparian area surrounding the site will be planted with native tree, shrub, and herbaceous species.

Reintroduction of Native Animals - NA

Substrate Modification - NA

Species Habitat Enhancement - NA

26.3.4 Restoration Features – Other

In the partial restoration alternative, the dredged inlet would remain, and the western portion would be left with bulkhead to support a boat launch (Figure 26-3). Additional site improvements may be required to support this land use.

26.3.5 Land Requirements

The Quilceda Creek restoration area is within the control of the Tulalip Tribes. Work on the western portion of the action area abuts private property, so construction easements may be necessary to complete the work in this area.

26.3.6 Design Considerations

Minimal design considerations exist for Quilceda Creek. The restored area would need to function within the overall upland land uses of the site, cultural center, and surrounding properties. The necessity for continued use of the area to launch boats is the largest consideration, and it is addressed with the partial restoration alternative.

Removing the laydown area and bulkhead creates the potential to encounter contamination. The bulkhead includes creosote-treated timbers, which would need to be properly removed and disposed of.

There are underground power lines in portions of the action area. This and any other utilities would need to be identified and mapped prior to final design.

26.3.7 Construction Considerations

Earthwork will require mobilizing heavy equipment to the site. Access to the site can occur via Marine View Drive and existing gravel access roads. Temporary traffic control would be necessary during mobilization and fill removal.

Channel excavation and fill removal would need to be sequenced to preclude tidal inundation of the site until excavation is complete. For the full restoration alternative, placement of excavated materials within the existing dredged inlet may require special construction measures and timing. Specific measures may include sediment curtains or other means of temporarily separating the work area from tidal influence.

26.4 Extent of Stressor Removal

Table 26-2 describes the amount of stressors to be removed with this action.

Table 26-2. Stressor Removal

Stressor	Full Restoration	Partial Restoration
Tidal Barrier (LF)	700	700
Fill (SF)	321,032	245,875
Armor (LF)	510	310
Marinas (acre)	0.6	0.3

26.5 Expected Evolution of the Action Area

Once the tidal barriers, site features, and fill are removed and channels restored on the site, a salt marsh and channel system is expected to re-form. A forested marine riparian community would develop on the upland immediately adjacent to the fill removal area.

The extensive surrounding area of intact marsh is expected to support the recolonization of native marsh species in the restored area. The perimeter of the fill in the existing dredged inlet may retreat over time, if sufficient fluvial energy is available to scour this area.

26.6 Uncertainties and Risks

The design would need to allow for connection to existing, functioning salt marsh to the west and to the north at the mouth of Sturgeon Creek. This may result in changes in channel morphology on the adjacent northern marsh. The rapidity of recolonization of the marsh surface by salt-tolerant species is also uncertain.

The area has a long history of human use, including Tribal use. Cultural resources may be present in the vicinity. The use of the upland fill area for construction material laydown also introduces the potential for contamination. Creosote contamination from the bulkhead may occur. Past use of the site would need to be investigated further to resolve these uncertainties.

26.6.1 Risks Associated with Projected Sea Level Change

Table 26-3 compares potential risks associated with projected sea level changes based on professional judgment.

Table 26-3. Risks of Sea Level Change

	Projected Sea Level Change		
	High (46 cm)	Intermediate (4 cm)	Low (-8 cm)
Full Restoration	This scenario may drown the expected salt marsh until/unless the site can aggrade	No change anticipated	No change anticipated
Partial Restoration	This scenario may drown the expected salt marsh until/unless the site can aggrade	No change anticipated	No change anticipated

26.7 Potential Monitoring Opportunities

Monitoring is important for evaluating restoration success. A combination of field surveys and aerial photographs would be used to document biological and physical changes to the landscape. Monitoring data can be used to refine adaptive management and corrective actions, as needed. Some of the monitoring needs and opportunities associated with this action are summarized in Table 26-4.

Table 26-4. Monitoring Needs and Opportunities

Monitoring Parameter	Key Performance Indicator	Note
Topographic Stability	X	Monitor longitudinally across beach face and for new channel
Sediment Accretion / Erosion	X	Monitor beach face stability
Wood Accumulation	X	
Soil / Substrate Conditions		
Vegetation Establishment	X	Monitor increased dominance of native salt marsh species; establishment of marine riparian plants
Marsh Surface Evolution / Accretion	X	
Tidal Channel Cross-Section / Density	X	Assess channel evolution
Water Quality (contaminants)		
Salinity		
Shellfish Production		
Extent of Invasive Species	X	Monitor effectiveness of Spartina removal
Animal Species Richness		
Fish (salmonid) Access/Use		
Forage Fish Production		
Wildlife Species Use		
Effectiveness of Exclusion Devices		

26.8 Information Needed for Subsequent Design

This conceptual design report represents an initial step in the restoration design sequence. The design concepts described above were developed based on readily available information without the level of site-specific survey and investigation that is necessary to support subsequent design and implementation. Substantial additional information will be required at the preliminary and later design stages to confirm the design assumptions, refine quantity estimates, address property and regulatory issues, obtain stakeholder support, and fill in data gaps. The extent to which this information is collected for preliminary design (or a later design stage) will depend upon the available budget, schedule and other factors. This section attempts to define the most essential information needs for this action. Refer to the Introduction chapter for additional information.

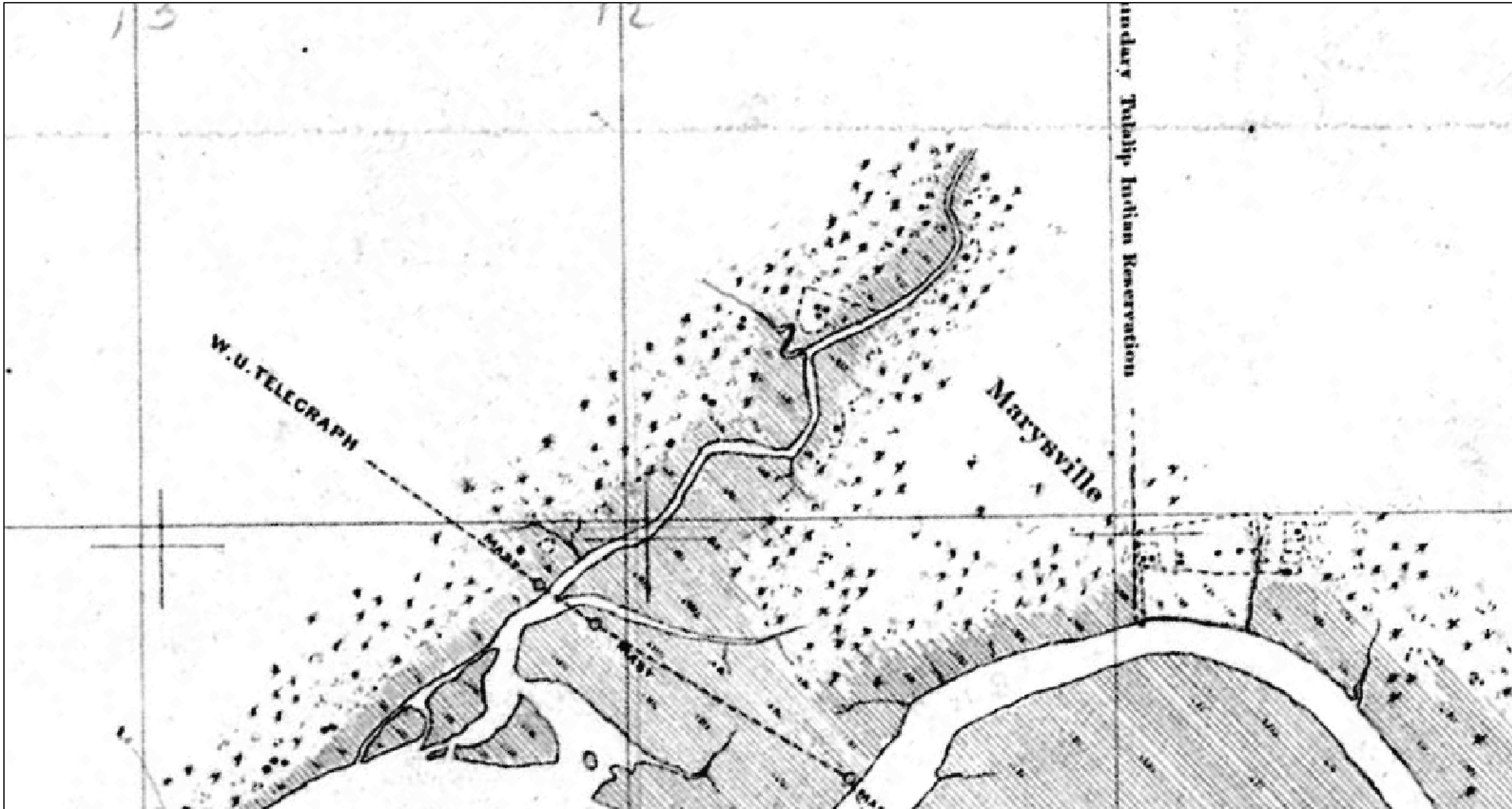
- Property Investigation/Survey – More detailed information on parcel ownership, utility locations, and property boundary locations will be needed to finalize the design, confirm acquisition requirements, and support negotiations with property owners.
- Topographic/Bathymetric Survey –Restoration would require a topographic survey. Survey data would also be used as a baseline for pre- and post-construction modeling.
- Geotechnical Investigation – Borings are needed to characterize the fill to be removed and determine suitability for placement within the dredged inlet.
- Cultural Resources Investigation – Surveys for archaeological and historic resources may be required for this action area. This is particularly important in areas proposed for excavation.
- Contaminant Survey – If preliminary investigations suggest that hazardous material could be present in and around the laydown area, additional soil and sediment analysis may be needed. The introductory chapter describes the Phase I site investigations that are occurring as part of this overall effort via a separate contract.
- Other - Coordination with the Tulalip Tribes will be necessary to determine requirements for the type of boat launch included in the partial restoration alternative.

26.9 Quantity Estimates

The quantity spreadsheets for the full and partial restoration alternatives are provided in Exhibits 26-1 and 26-2.

26.10 References

Snohomish County. 2002. *Quilceda Creek Drainage Needs Report DNR No. 1.* Snohomish County Public Works Surface Water Management Division. December 2002.



0 840
Feet
0 250
Meters

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Historic Map (T-Sheet)

Action Name: Quilceda Estuary Restoration

PSNERP ID #: 1136

Figure 26- 2A

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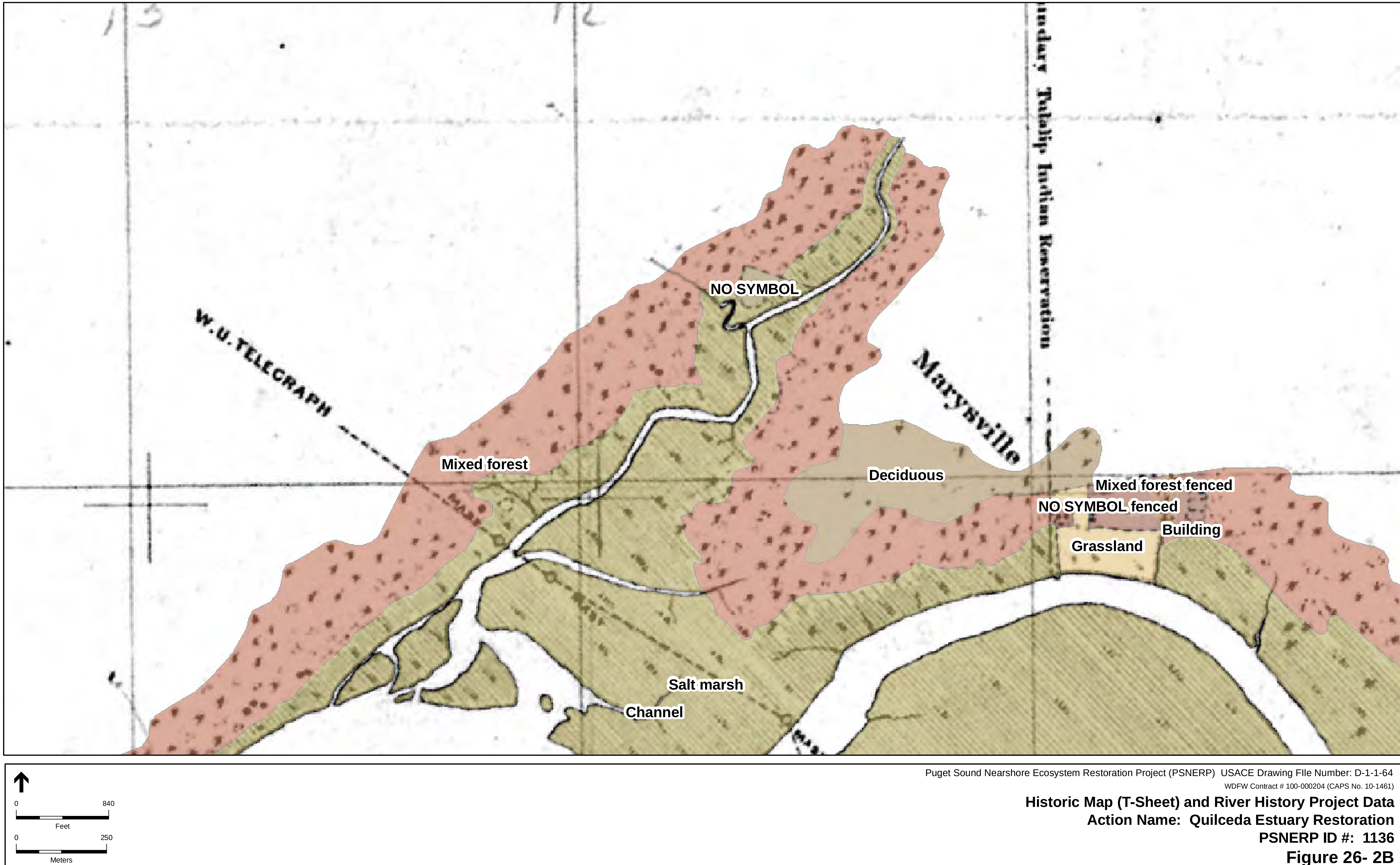
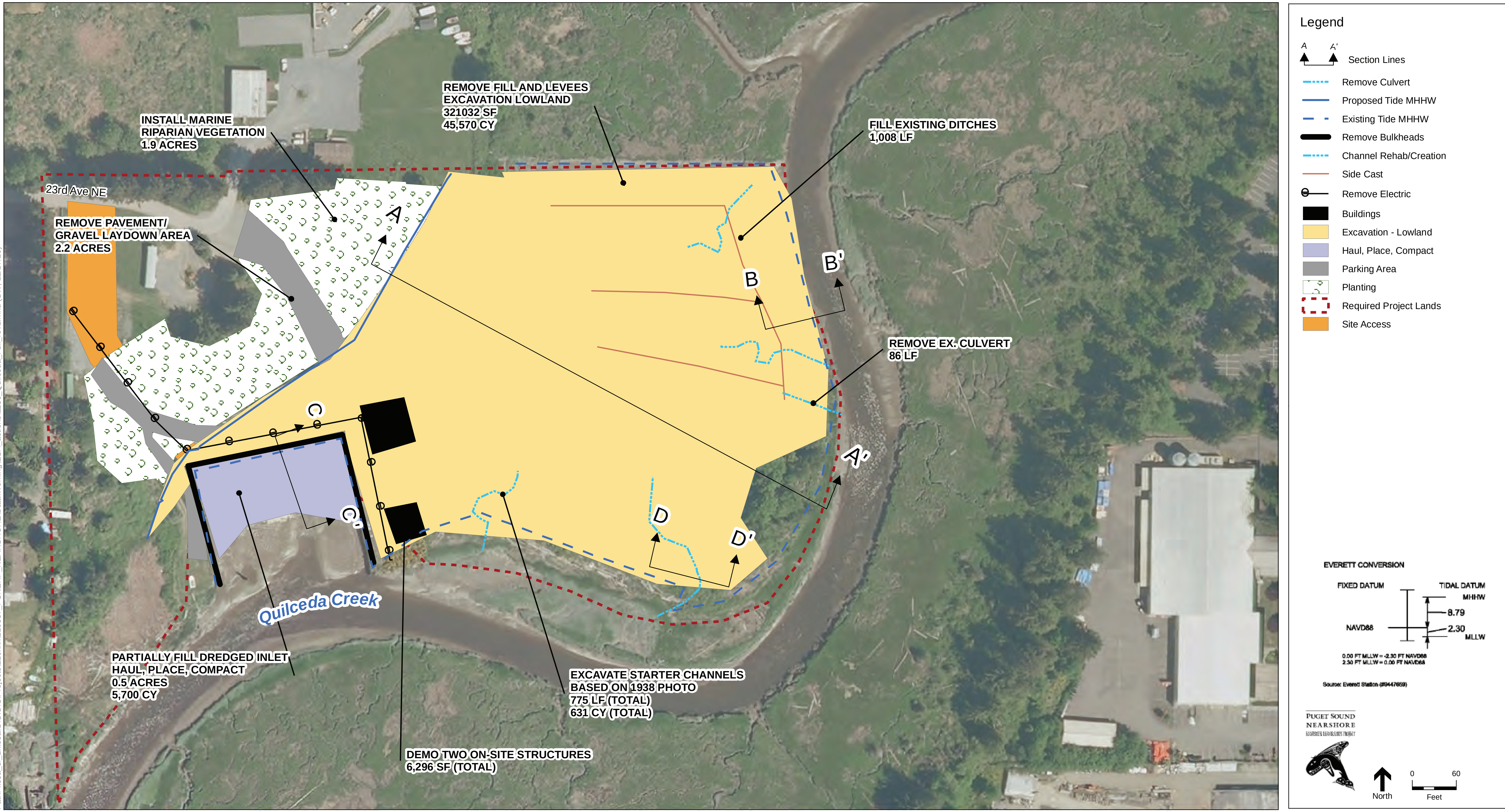


Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64

WDFW Contract # 100-000204 (CAPS No. 10-1461)

Historic Map (T-Sheet) and River History Project Data
Action Name: Quilceda Estuary Restoration
PSNERP ID #: 1136
Figure 26- 2B



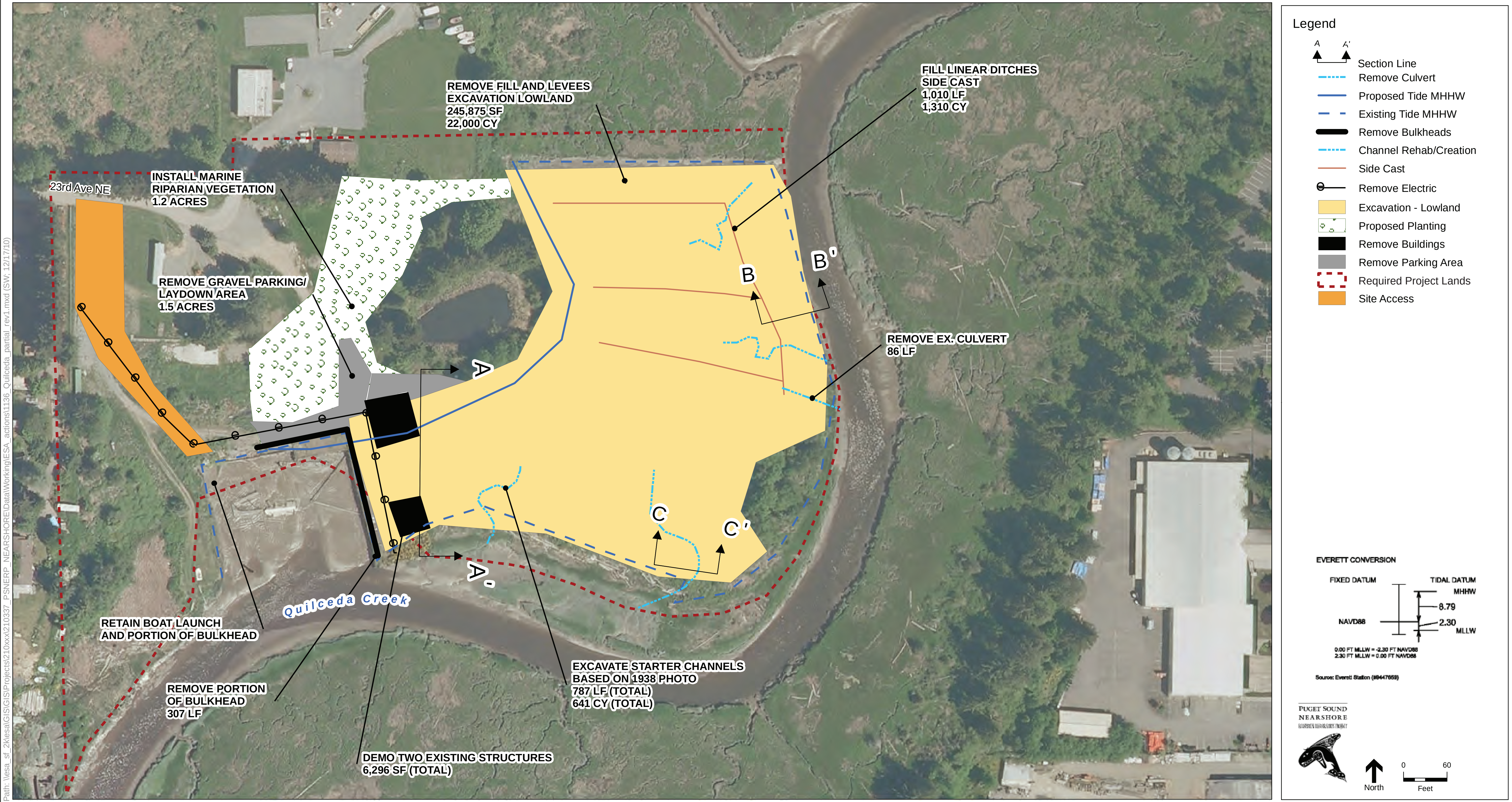
SOURCE: PSNERP (2011); Aerial (BING, 2009)

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Plan
Site Name: Snohomish River Delta
Action Name: Quilceda Estuary Restoration
PSNERP ID #:1136
Full Restoration

Lead Contractor: ESA
Design Lead: ESA
Date: 2/28/11

Figure 26-3



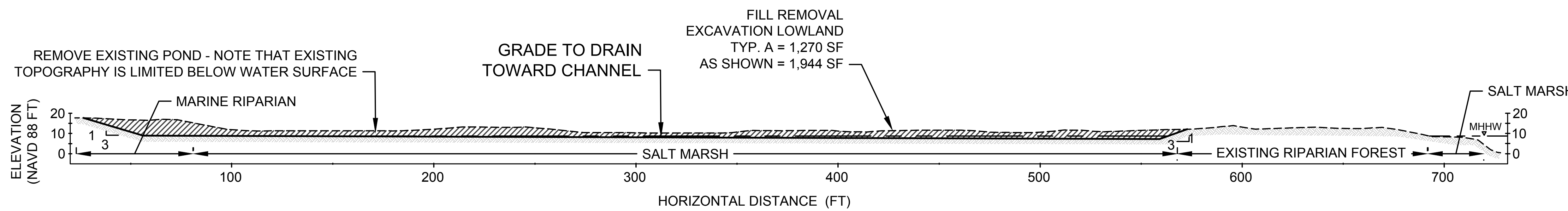
SOURCE: PSNERP (2011); Aerial (BING, 2009)

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

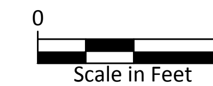
Conceptual Design Plan
Site Name: Snohomish River Delta
Action Name: Quilceda Estuary Restoration
PSNERP ID #:1136
Partial Restoration

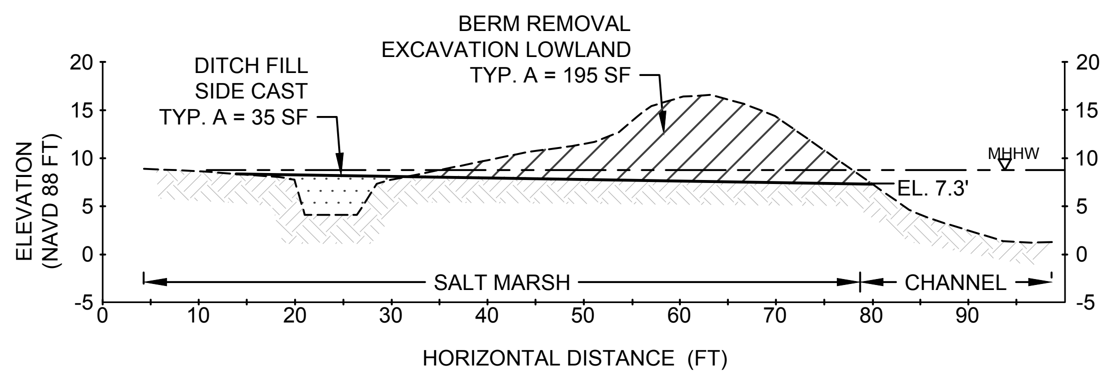
Lead Contractor: ESA
Design Lead: ESA
Date: 2/28/11

Figure 26-4

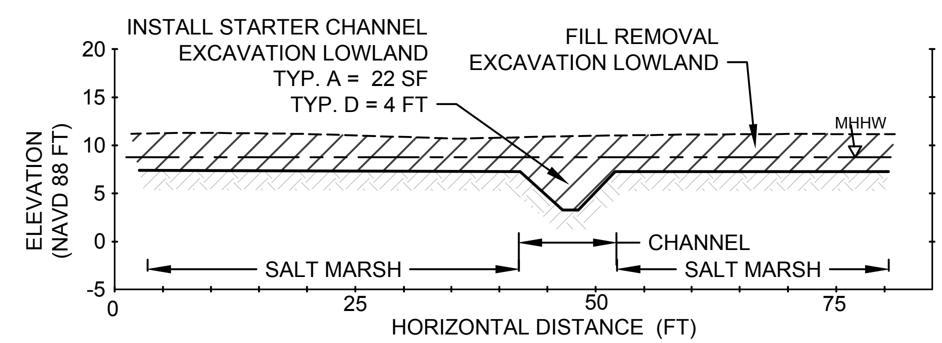


Ⓐ FILL REMOVAL AREA (TYP.)

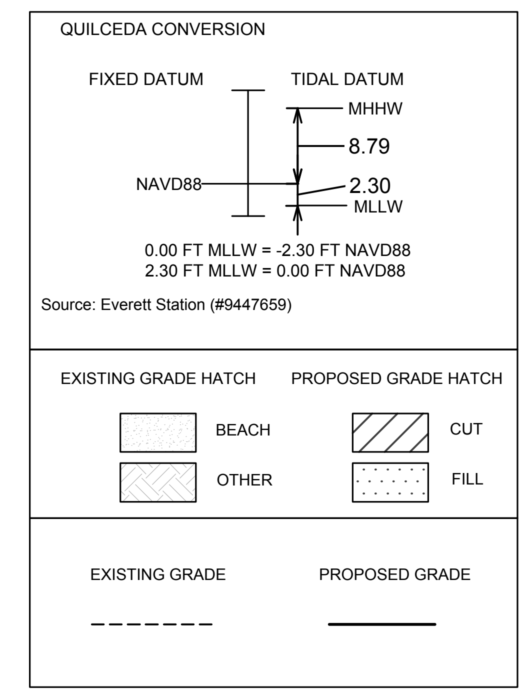


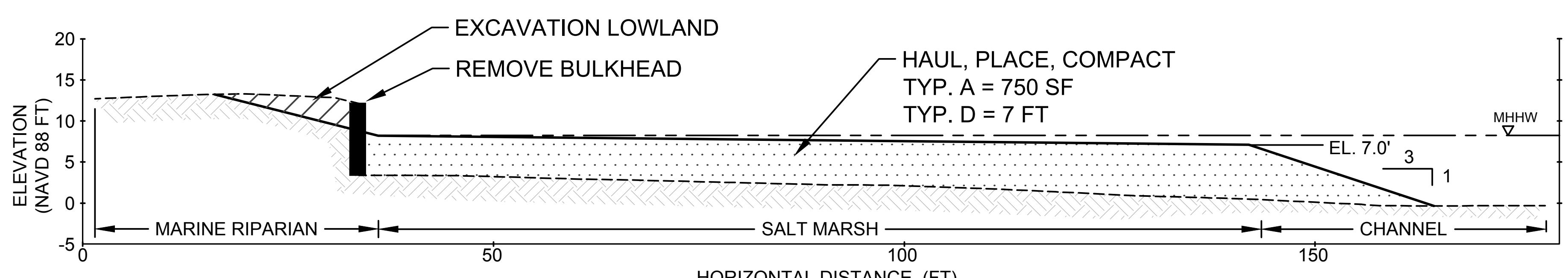


Ⓑ BERM REMOVAL (TYP.)



Ⓒ FILL REMOVAL AND STARTER CHANNEL (TYP.)





Ⓓ FILL EXISTING DREDGED INLET (TYP.)

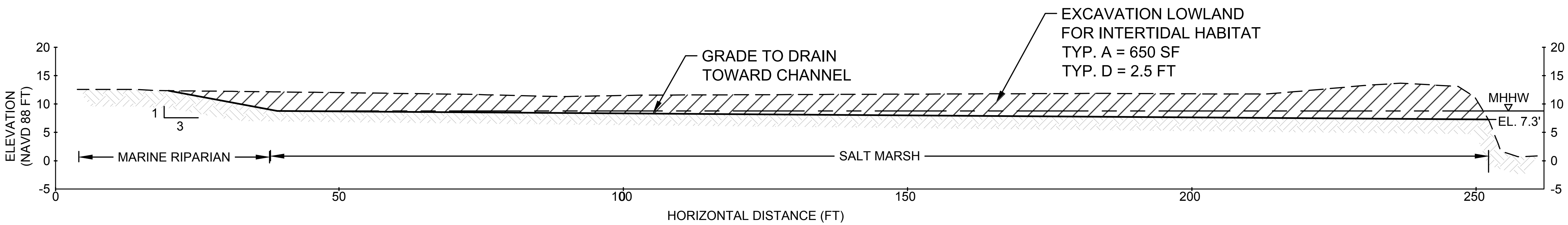
PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: ESA
Date: 3/2011

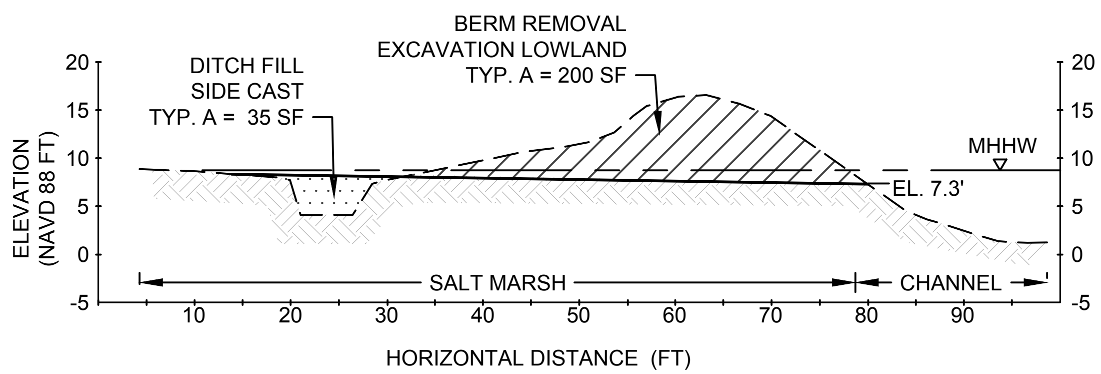
Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Section
SITE NAME: **Snohomish River Delta**
ACTION NAME: **Quilceda Estuary Restoration**
PSNERP ID#: **1136**
Full Restoration

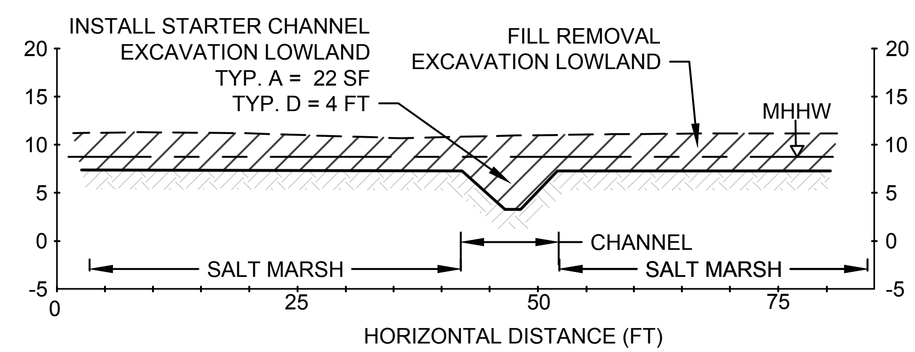
Figure 26-5



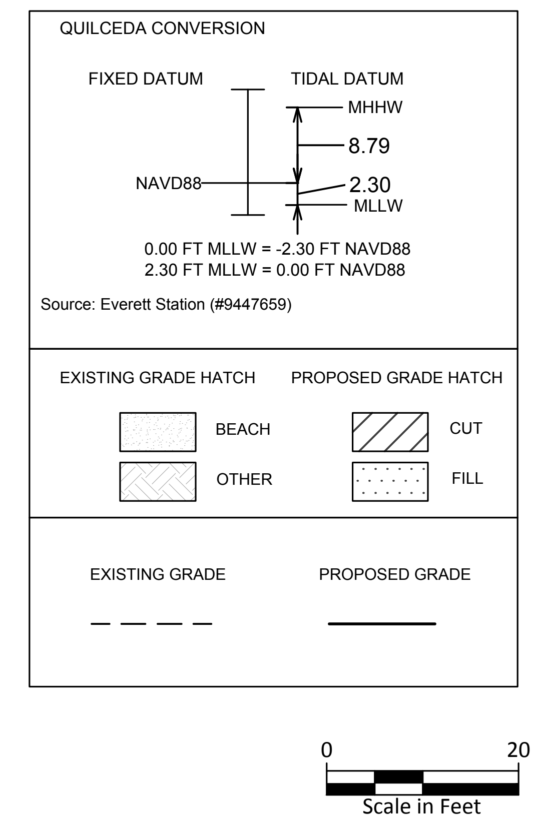
Ⓐ FILL REMOVAL AREA (TYP.)



Ⓑ BERM REMOVAL (TYP.)



Ⓒ FILL REMOVAL AND STARTER CHANNEL (TYP.)



PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: ESA
Date: 3/2011

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Section
SITE NAME: **Snohomish River Delta**
ACTION NAME: **Quilceda Estuary Restoration**
PSNERP ID#: **1136**
Partial Restoration

Figure 26-6

Full Restoration Quantity Estimate

Action Name: Quilceda Estuary
Action #: 1136
Date: February 2011
By: ESA

REMEDY: ***Remove historic fill, berms, bulkheads and fill linear channels. embankment and restore natural channel morphology***
Construction Period: 20 to 40 days

Item	Unit of Measure	Material Name	Qty	Description of Item	Indicate section of design report where item is described
ACQUISITION AND CONSERVATION				Based on available mapping information	
Required Project Lands	Acre		14.3	Total land required For action	26.3.5
Proponent / Partner-owned lands	Acre		14.3	Etimate of lands currently owned by Proponent (i.e., Public lands)	26.3.5
Lands To Be Acquired	Acre		0	Estimate land required to be acquired for action prior to implementation	26.3.5
Material Sites				Not Used: See Earthwork - Imported Fill.	
MOBILIZATION AND ACCESS for construction activities				Description required for each item to facilitate cost estimating	
Mobilization - Typical (Equipment, Personnel, Planning, Financial)	LS		1	Assume 8% of total	
Mobilization - Remote (Equipment, Personnel, Planning, Financial)	LS		NA		
Site Access	LS		1	Access can utilize existing gravel surface roads to the site.	
Barge Access	Days		NA		
Temporary Traffic Control (one of the following)					
none	LS		NA		
signs	LS		1	Signs = signs only, costs typically around 1% of total roadway costs	
flags / spotters	LS		NA		
unique	LS		NA		
Temporary Roadway	SF		NA		
Control of Water	LS		1	May be necessary to block existing culvert and/or retain earthen berms to allow more flexibility in excavation within intertidal area.	
Control of Water	LS		1	Placement of fill within existing dredged inlet. May require sediment curtains, inflatable bladders, etc.	
Relocation Activities					
Site Demolition Activities					
Clearing and Grubbing (one or more of following)					
Clear Vegetation - Local Disposal	AC		3.9	Selective clearing to retain some existing trees.	
Clear /Grub Vegetation - Local Disposal	AC		NA		
Clear /Grub Vegetation - Offsite Disposal	AC		NA		
Clear, stockpile - large woody debris	CY		NA		
Hydraulic Structures - Small	LS		1	Remove existing 8" x 12" culvert through berm (86 LF)	26.3.1
Hydraulic Structures - Large	LS		NA		
Utilities	LF		700	Buried electric - full extent unknown, measured by last overhead pole to most distant light.	26.3.1
Buildings	SF		6,296	Two on-site structures	26.3.1
Pavement	SF		70,900	Pavement removal from existing laydown area, mainly gravel and older paved surfaces. Includes what may be old foundations.	26.3.1
Bulkheads	LF or SF		570	Wooden bulkheads 5-10 feet tall; includes creosote treated timbers that will require proper disposal	26.3.1
Rock revetments	LF, Ton or CY		NA		
Large Coastal Structures	LF, SF or CY		NA		
Demolition / Removal - Bridge	SF or CY		NA		
Removal - Misc. (e.g. angular rock from beach)	Ton		NA		
Demolition / Removal - Boat Ramp	SF		NA	Subsumed within bulkhead removal	
Haul - Offsite Disposal of Demolition Debris	Miles		20	Assumed.	
Hazardous/Contaminated Waste Removal					
Contaminated Earthwork	CY		0		
Hazardous Earthwork	CY		0		
Construct Temporary Features					
EARTHWORK					
Excavation	CY				
Excavation - Upland	CY		NA		
Excavation - Lowland	CY		45,570	Remove historical fill to expose intertidal elevations. Slope to drain toward main channel.	26.3.2
Excavation - Lowland	CY		631	Excavate new channel alignments. Will require smaller, low ground pressure, equipment.	26.3.2
Dredging - Bucket - Land	CY		NA		
Dredging - Bucket - Marine	CY		NA		
Dredging - Hydraulic	CY		NA		
Fine Grading	AC		NA		
Fill Placement - local borrow					
Side cast	CY		1,310	Use excavation, lowland spoils from channel excavation to fill ditches	26.3.2
Haul - uncontrolled placement	CY		NA		
Haul, place, compact	CY		5,700	Place dredge spoils within the inlet to intertidal elevations.	
Stockpile - uncontrolled placement	CY		NA		26.3.2
Stockpile - controlled placement	CY		NA		
Conveyor placement from stockpile land/water	CY		NA		
Imported Fill					
Select Fill	CY		NA		
Gravel Borrow, including haul	CY		NA		
Sand / Gravel for Beach Nourishment	CY		NA		
Cobble for Shore Nourishment	CY		NA		
Embankment Compaction	CY		NA		
Topsoil	CY		NA		
RESTORATION Features					
Channel Rehab / Creation	SF		7750	Realigned channel through marsh (7750 ft[geodatabase] * 10 ft top width from regresssions). This effort is minimal - the starter channels require fine grading only with no variation in cross-section	26.3.2
Large Wood Placement	EA		NA		
Invasive Species Control	Acre		NA		
Physical Exclusion Devices	LF or EA		NA		
Other Restoration Features/ Activities	LS		NA		
Structures	EA				
Water Control Structures - Culverts with Gates	EA		NA		
Water Control Structures - Weirs	EA		NA		
Rock Slope Protection	LF		NA		
Other	EA		NA		
Elevated Boat Ramp	SF		NA		
Fencing	SF		NA		
Utilities					
Water	LF		0		
Gas	LF		0		
Electric	LF		0		
Sewer	LF		0		
Telecommunications	LF		0		
Other	LF		0	Others = whatever is required (e.g.. power towers, petroleum, jet fuel, etc.)	
Roadway / Railway				KPFF expected to participate in these estimates	
Roadway (Type)	SF		0		
Roadway - Traffic Signal	LS		0		
Culvert (type)	LF		0		
Culvert - Jacking	LF		0		
Culvert - Horizontal Pile Driving	LF		0		
Bridge - Foundations, Deck and Appurtenances	SF		0		
Railway - Box Girder	SF		0		
Railway - Foundation	LF		0		
Railway - Shoe fly	LF		0		
Permanent Access Features					
Roads	Level		0		
Utility Access Routes	varies		0		
Erosion Control Features	L.F.		0		
Public Access or Recreation Features					
trails	SF		0		
bridges	SF		0		
kiosk	EA		0		
restrooms	EA		0		
Interpretive Signs	EA		1		
parking area	SF		0		
Other	EA		0		
Vegetation & Erosion Control					
Hydroseeding	AC		0		
Planting	AC		1.9	Marine Riparian Community around perimeter of grading area.	
Vegetation Maintenance	AC-YR		9.5	Assume 5 years	
Erosion / sediment BMPs - Temp.	AC		7		
Erosion / sediment BMPs - Permanent	AC		0		
Waterside controls - Temporary	EA, LF, LS		0		
Construction Management					
Construction oversight	weeks		6		
Materials testing					
Design and Detailed Site Investigations					
Survey & Property, Utility Research	LS		1	% of construction cost	
35% Design	LS		1	35% x 25% x Engineer's Estimate	
65% design	LS		1	65% x 25% x Engineer's Estimate less the cost for 35% PS&E	
90% design	LS		1	35% x 25% x Engineer's Estimate less the cost for 35% + 65%PS&E	

Full Restoration Quantity Estimate

	Action Name:	Quilceda Estuary					
	Action #:	1136					
	Date:	February 2011					
	By:	ESA					

REMEDY: ***Remove historic fill, berms, bulkheads and fill linear channels. embankment and restore natural channel morphology***

Construction Period: 20 to 40 days

	Item	Unit of Measure	Material Name	Qty	Description of Item		Indicate section of design report where item is described
	100% design	LS		1	25% x Engineer's Estimate less previous costs		
	Geotechnical Studies				Refer to design report for description of need		
	Cultural Studies				Refer to design report for description of need		
	HTWR Studies				Refer to design report for description of need		
Project Agreement Activities					Unable to provide credibale estimate at 10% design		
Site-Specific Adaptive Management Features & Activities					List if known		
Monitoring Activities					Assume 5 crew-days/year for each monitoring parameter in design report for 5 yrs		
	Monitoring (Type_)	crew-days		175			
Operations & Maintenance					Unable to provide credible estimate at 10% design		

Partial Restoration Quantity Estimate

Action Name:	Quilceda Estuary
Action #:	1136
Date:	February 2011
By:	ESA

REMEDY: ***Remove historic fill, berms, bulkheads and fill linear channels. embankment and restore natural channel morphology***

Construction Period: 20 to 40 days

Item	Unit of Measure	Material Name	Qty	Description of Item	Indicate section of design report where item is described
ACQUISITION AND CONSERVATION				Based on available mapping information	
Required Project Lands	Acre		14.3	Total land required For action	26.3.5
Proponent / Partner-owned lands	Acre		14.3	Etimate of lands currently owned by Proponent (i.e., Public lands)	26.3.5
Lands To Be Acquired	Acre		0	Estimate land required to be acquired for action prior to implementation	26.3.5
Material Sites					
MOBILIZATION AND ACCESS for construction activities				Description required for each item to facilitate cost estimating	
Mobilization - Typical (Equipment, Personnel, Planning, Financial)	LS		1	Assume 8% of total	
Mobilization - Remote (Equipment, Personnel, Planning, Financial)	LS		NA		
Site Access	LS		1	Access can utilize existing gravel surface roads to the site.	
Barge Access	Days		NA		
Temporary Traffic Control (one of the following)					
none	LS		NA		
signs	LS		1	Signs = signs only, costs typically around 1% of total roadway costs	
flags / spotters	LS		NA		
unique	LS		NA		
Temporary Roadway	SF		NA		
Control of Water	LS		1	May be necessary to block existing culvert and/or retain earthen berms to allow more flexibility in excavation within intertidal area.	
Relocation Activities					
Site Demolition Activities					
Clearing and Grubbing (one or more of following)					
Clear Vegetation - Local Disposal	AC		3.9	Surface clearing prior to fill removal. Selective clearing to retain some existing trees.	
Clear /Grub Vegetation - Local Disposal	AC		NA		
Clear /Grub Vegetation - Offsite Disposal	AC		NA		
Clear, stockpile - large woody debris	CY		40	Estimate of trees to be salvaged from on site.	
Hydraulic Structures - Small	LS		1	Remove existing culvert through berm (86 LF)	26.3.1
Hydraulic Structures - Large	LS		NA		
Utilities	LF		700	Buried electric - full extent unknown, measured by last overhead pole to most distant light. Relocate portion to new boat launch	26.3.1
Buildings	SF		6296	Demolish two on-site structures	26.3.1
Pavement	SF		70,900	Pavement removal from existing laydown area, mainly gravel and older paved surfaces. Includes what may be old foundations.	26.3.1
Bulkheads	LF or SF		310	Wooden bulkheads 5-10 feet tall - partial removal, leave western portion for boat launch; Includes creosote treated timbers that will require proper disposal.	26.3.1
Rock revetments	LF, Ton or CY		NA		
Large Coastal Structures	LF, SF or CY		NA		
Demolition / Removal - Bridge	SF or CY		NA		
Removal - Misc. (e.g. angular rock from beach)	Ton		NA		
Demolition / Removal - Boat Ramp	SF		NA	Subsumed within bulkhead removal	
Haul - Offsite Disposal of Demolition Debris	Miles		20	Assumed.	
Hazardous/Contaminated Waste Removal					
Contaminated Earthwork	CY		0		
Hazardous Earthwork	CY		0		
Construct Temporary Features					
EARTHWORK					
Excavation	CY				
Excavation - Upland	CY		NA		
Excavation - Lowland	CY		22,000	Remove historical fill to expose intertidal elevations. Slope to drain toward main channel.	26.3.2
Excavation - Lowland	CY		1250	Excavate new channel alignments. Will require smaller, low ground pressure, equipment.	26.3.2
Dredging - Bucket - Land	CY		NA		
Dredging - Bucket - Marine	CY		NA		
Dredging - Hydraulic	CY		NA		
Fine Grading	AC		NA		
Fill Placement - local borrow					
Side cast	CY		1,310	Use excavation, lowland spoils from channel excavation to fill ditches	26.3.2
Haul - uncontrolled placement	CY		NA		
Haul, place, compact	CY		NA		
Stockpile - uncontrolled placement	CY		NA		26.3.2
Stockpile - controlled placement	CY		NA		
Conveyor placement from stockpile land/water	CY		NA		
Imported Fill					
Select Fill	CY		NA		
Gravel Borrow, including haul	CY		NA		
Sand / Gravel for Beach Nourishment	CY		NA		
Cobble for Shore Nourishment	CY		NA		
Embankment Compaction	CY		NA		
Topsoil	CY		NA		
RESTORATION Features					
Channel Rehab / Creation	SF		7750	Realigned channel through marsh (775 ft * 10 ft top width from regresssions). Additional channel effort is anticipated to be minimal. Includes fine grading with constant cross-section for starter channels.	26.3.2
Large Wood Placement	EA		NA		
Invasive Species Control	Acre		NA		
Physical Exclusion Devices	LF or EA		NA		
Other Restoration Features/ Activities	LS		NA		
Structures	EA				
Water Control Structures - Culverts with Gates	EA		NA		
Water Control Structures - Weirs	EA		NA		
Rock Slope Protection	LF		NA		
Other	EA		NA		
Elevated Boat Ramp	EA		1	Intended to capture additional improvements to support a boat launch in this location. Type and location of launch undetermined at this time.	
Fencing	SF		NA		
Utilities					
Water	LF		0		
Gas	LF		0		
Electric	LF		0		
Sewer	LF		0		
Telecommunications	LF		0		
Other	LF		0	Others = whatever is required (e.g.. power towers, petroleum, jet fuel, etc.)	
Roadway / Railway					
Roadway (Type)	SF		0		
Roadway - Traffic Signal	LS		0		
Culvert (type)	LF		0		
Culvert - Jacking	LF		0		
Culvert - Horizontal Pile Driving	LF		0		
Bridge - Foundations, Deck and Appurtenances	SF		0		
Railway - Box Girder	SF		0		
Railway - Foundation	LF		0		
Railway - Shoe fly	LF		0		
Permanent Access Features					
Roads	Level		0		
Utility Access Routes	varies		0		
Erosion Control Features	L.F.		0		
Public Access or Recreation Features					
Trails	SF		0		
Bridges	SF		0		
Kiosk	EA		0		
Restrooms	EA		0		
Interpretive Signs	EA		1		
Parking Area	SF		0		
Other	EA		0		
Vegetation & Erosion Control					
Hydroseeding	AC		0		
Planting	AC		1.2	Marine Riparian Community around perimeter of grading area.	
Vegetation Maintenance	AC-YR		6	Assume 5 years	
Erosion / sediment BMPs - Temp.	AC		4		
Erosion / sediment BMPs - Permanent	AC		0		
Waterside controls - Temporary	EA, LF, LS		0		
Construction Management					
Construction oversight	weeks		6		
Materials testing					
Design and Detailed Site Investigations					
Survey & Property, Utility Research	LS		1	% of construction cost	
35% Design	LS		1	35% x 25% x Engineer's Estimate	
65% design	LS		1	65% x 25% x Engineer's Estimate less the cost for 35% PS&E	

Partial Restoration Quantity Estimate

Action Name: Quilceda Estuary
Action #: 1136
Date: February 2011
By: ESA

REMEDY: ***Remove historic fill, berms, bulkheads and fill linear channels. embankment and restore natural channel morphology***
Construction Period: 20 to 40 days

	Item	Unit of Measure	Material Name	Qty	Description of Item		Indicate section of design report where item is described
	90% design	LS		1	35% x 25% x Engineer's Estimate less the cost for 35% + 65%PS&E		
	100% design	LS		1	25% x Engineer's Estimate less previous costs		
	Geotechnical Studies				Refer to design report for description of need		
	Cultural Studies				Refer to design report for description of need		
	HTWR Studies				Refer to design report for description of need		
Project Agreement Activities					Unable to provide credibale estimate at 10% design		
Site-Specific Adaptive Management Features & Activities					List if known		
Monitoring Activities					Assume 5 crew-days/year for each monitoring parameter in design report for 5 yrs		
	Monitoring (Type_)	crew-days		175			
Operations & Maintenance					Unable to provide credible estimate at 10% design		

27. SEQUALITCHEW CREEK CULVERT (#1467)

Local Proponent	South Puget Sound Salmon Enhancement Group
Delta Process Unit	NA
Shoreline Process Unit(s)	3006
Strategy(ies)	4: Coastal Inlet
Restoration Objectives	Restore an open coastal inlet with full tidal hydrology and alluvial sediment supply to the nearshore

27.1 Description of the Action

This action includes removing a tidal barrier formed by the BNSF railroad embankment, along with associated shoreline armoring and nearshore fill. This would allow for restoration of the stream mouth and open coastal inlet morphology. Please see the Introduction chapter for important information regarding PSNERP and for context related to this restoration project.

27.2 Action Area Description and Context

This action is within the South Puget Sound Subbasin. Sequalitchew Creek flows from its headwaters near Joint Base Lewis-McChord to Puget Sound, passing through a culvert in the BNSF railway corridor near the mouth. The BNSF railway follows the Puget Sound shoreline from the mouth of the Nisqually River to the mouth of the Puyallup River. The railway is cut into a bench on the bluff above Puget Sound along most of this stretch of shoreline and is armored with large, loose riprap to prevent erosion. The areas north and south of the mouth of Sequalitchew Creek are consistent with this pattern. However, at the mouth of Sequalitchew Creek, a large ravine has been filled with a high embankment to support the railroad. In addition, just north of the creek mouth on the water side and below the railroad embankment are the remains of fill from a former narrow-gauge railroad (described below) and wharf abutment. This historic fill now supports a wider beach and supratidal shelf below the railway embankment.

Upstream of the culvert and railway embankment is a brackish marsh at an elevation of 6 to 10 feet NAVD 88. Vegetation in the marsh is salt-tolerant and shows clear zonation of communities based on elevation and proximity to the stream. There is evidence that the stream has been straightened and channelized through the marsh, presumably in an effort to minimize erosion of the ravine walls and railroad berm. North of the marsh is a wide bench between the marsh and ravine wall where a second railway used to pass. This railway was used to transport munitions from the E.I. DuPont de Nemours and Company plant near the town of DuPont down the ravine to a wharf situated just north of the creek's mouth. A tunnel was built for this railway under the BNSF railway, presumably when the trestle of the BNSF railway was filled in with gravel and the culvert installed to allow the creek to drain to Puget Sound. The action area is shown in Figure 27-1.

Figure 27-1. Action Area and Vicinity

27.2.1 Historic Condition

When the first Euro-Americans arrived in the late 18th and early 19th centuries, they found a Nisqually village located at the mouth of Sequalitchew Creek. There, the creek had formed a deltaic projection against the steep bluff that afforded space for two cedar longhouses. A population of approximately 50 persons comprising five or six extended families lived there in 1832 when fur traders of the Hudson's Bay Company arrived at Sequalitchew Creek. The original "Nisqually House" or Fort Nisqually was situated on the beach near the mouth of Sequalitchew Creek. A year later it was moved inland about 1 mile to an area near the top of Sequalitchew Creek ravine. The ravine remained a vital link between the Fort Nisqually settlement and Puget Sound (Anchor QEA and Aspect 2010).

A sawmill operated at the mouth of Sequalitchew Creek from the 1850s to at least 1870. In 1906 the E.I. DuPont de Nemours Company built a munitions plant on some of the former holdings of the Hudson Bay Company centered on Sequalitchew Creek. The plant generated hydroelectric power on the south side of the creek near the mouth until about the 1930s. A photograph shows the aftermath of a penstock failure that left the powerhouse filled above the window casings with gravel from the side of the ravine. A narrow-gauge rail line along the north side of the creek connected the plant to the wharf on Puget Sound. This line passed under the Northern Pacific Railway (now BNSF) which was constructed in 1912. This line crossed the mouth of the creek on a trestle which is now buried beneath the fill that forms the embankment at the mouth of the creek.

Examination of the topographic sheet (T-sheet) from the late 19th century indicates that the creek mouth was an open coastal inlet (Figures 27-2A and 27-2B). The mapping indicates the presence of a marsh, but shows a low tide line seaward of the inlet and bluff face, indicating that the inlet was intertidal. The railway crossing was originally a wooden trestle, portions of which are still visible along the side of the tracks. The trestle is now buried in an embankment approximately 400 feet long, 180 feet wide at the base, and 40 feet high.

27.2.2 Natural Environment

Sequalitchew Creek is a small spring-fed stream that originates in the forested Sequalitchew Creek ravine about 1 mile upstream of the mouth. The BNSF railway runs adjacent to the shore of Puget Sound and crosses the mouth of the creek on an approximately 40-foot-high embankment. This earthen embankment separates Puget Sound from an estuarine emergent marsh through which Sequalitchew Creek flows. A concrete box culvert, 5 feet by 5 feet by 180 feet, connects the marsh to Puget Sound and conveys both tidal and creek flows.

The majority of the brackish marsh, approximately 0.5 acre in size, is situated on the southwest side of the main Sequalitchew Creek channel landward of the railroad embankment/berm. The marsh is connected to Puget Sound through a 5-foot by 5-foot-wide box culvert under the railroad embankment/berm. One main tidal channel with dendritic fingers cuts through the marsh and connects with the creek near the mouth of the culvert. When the tide is below about +8 feet MLLW, Sequalitchew Creek flows within its channel and bypasses the marsh. Portions of the main tidal channel remain wetted while the fingers are dry with scattered ponding. As the tide rises to about +9 feet MLLW, fresh water from the creek is diverted into the main tidal channel. This is followed with salt water as the tide rises above +10 feet MLLW, inundating the marsh.

The shoreline is dominated by a wide gravel beach that is armored near MHHW with large rock. The riparian area is well forested above the railway, but along and below the railway it is dominated by invasive shrubs (e.g., Scot's broom). An eelgrass bed exists on the delta offshore and a large, tidally influenced, nearshore spring exists a few hundred yards north of the mouth of the creek.

27.2.3 Human Environment

The railway that separates the marsh from Puget Sound is considered to be one of the busiest sections of railway on the West Coast. The railway sits on a fill prism about 50 feet above and parallel to the shore of Puget Sound through the area. The shoreline is armored in many places with large rock to prevent erosion from undermining the tracks.

Remnants of the DuPont wharf and associated bulkhead are still visible along the shoreline north of the creek, as is the tunnel under the BNSF railway that accommodated the smaller rail connection between the E.I. DuPont de Nemours Company facilities and the DuPont wharf. A consent decree between the Washington State Department of Ecology and both the Weyerhaeuser Company and E.I. DuPont De Nemours was reached in 2003 to remediate the former munitions plant under the state Model Toxics Control Act. The remediation included soil removal and remediation upstream and just north of the marsh, and along the Puget Sound shoreline.

The area around the marsh was previously used as a storage area by the DuPont Company. The railroad along the creek was once used to transport chemicals and munitions to the DuPont wharf, just north of the mouth of Sequalitchew Creek. Observations of spoil mounds and construction debris in the field indicate that portions of the marsh have been filled, and that perhaps portions of the creek through the marsh have been dredged. Vegetation on the mounds indicates that these modifications took place at least several years ago. Aboveground storage tanks were used to store bunker fuel just upstream of the marsh.

The railway is owned by BNSF and is a double mainline track. Utilities in the action area include those necessary for operation of the railroad. No other utilities in the action area are documented.

27.3 Restoration Design Concept

27.3.1 Restoration Overview and Key Design Assumptions

The restoration alternatives are illustrated in Figures 27-3 through 27-7. The full restoration design concept involves removing the armor and nearshore fill around the mouth of the Sequalitchew Creek ravine. The partial restoration design concept involves installing a second culvert through the railroad embankment/berm to lessen the effect of the tidal constriction and allow more dynamic channel migration to occur.

Full restoration of the action area (Figure 27-3) would remove all intertidal and nearshore fill; build a pier- or pile-supported bridge to support the railway lines; remove all shoreline armoring at the mouth of the creek; regrade the area under the railway to connect the marsh and delta with a series of tidal channels; and remove fill and obstructions in the marsh that prevent the stream from meandering. A new bridge would be constructed on the existing rail track alignment. A temporary shoofly (railroad bypass tracks) would be constructed on the waterward side of the existing track to reroute rail traffic around the new bridge construction and avoid interruption of BNSF rail service. The existing railroad embankment across the mouth of Sequalitchew Creek would be removed.

The partial restoration alternative (Figure 27-4) would install an additional culvert capable of supporting several tidal channels (or a series of culverts each capable of supporting at least one channel) under the railway. Fill along the north side of the marsh would be removed, along with as much shoreline armoring and former wharf pad fill as possible without jeopardizing the stability of the railway. This alternative could also include grading of new tidal channels and stream channels through the marsh and expansion of the marsh to the north. The partial restoration alternative would not achieve the primary objective of restoring an open coastal inlet with full tidal hydrology and alluvial sediment supply to the nearshore. Partial restoration would lead to improved tidal exchange and tidal channel formation in the existing estuarine marsh, but would not restore the wave energy, erosion and accretion, and tidal circulation processes of an open coastal inlet.

Under partial restoration, one additional 48-inch-diameter culvert approximately 200 LF would be jack-and-bored under the existing railway embankment at a location south of the existing culvert (Figure 27-4). Concrete end walls would be provided at both ends of the culvert, with rock erosion protection on the waterward side. This would be done without the use of a temporary shoofly and would require monitoring of the track alignment during and immediately following construction. The invert elevations of the new culvert would be very similar to those of the existing culvert that would remain. The partial restoration alternative would require some grading, channel restoration, and marsh restoration in the brackish marsh near the mouth of the new culvert to restore channel connectivity and mitigate for temporary construction impacts.

Table 27-1 summarizes key design elements associated with full and partial restoration alternatives.

Table 27-1. Key Design Elements

Element	Full Restoration	Partial Restoration
Railroad Berm / Embankment	Full removal of armor across mouth of coastal inlet. Replace berm with 1,000-foot-long bridge opening across mouth of open coastal inlet and ravine	Increase tidal connection by adding a second 48-inch-diameter culvert adjacent to existing culvert. Remove 659 LF of shoreline armoring on the northwest side of the embankment
Channel Rehabilitation	Restore channel in area currently buried by berm/embankment	Create second channel at new culvert and restore associated dendritic network in the intertidal zone waterward of the new culvert
Topographic Restoration	Restore areas impacted by fill east of railroad embankment	Same as full restoration

27.3.2 Restoration Features – Primary Process-Based Management Measures

Armor Removal/Modification

The full restoration alternative would include removal of all shoreline armoring between the two proposed bridge abutments. Both the full and partial restoration alternatives would include armor removal where armor has been placed but is no longer needed north of the stream mouth, adjacent to a section of wider beach and backshore. This northern portion of armor is approximately 660 feet long.

Berm or Dike Removal/Modification

The full restoration alternative would include removal of all material associated with the existing approximately 900-foot-long railroad berm/embankment, which acts as a tidal barrier (Figure 27-5)y. The partial restoration alternative would not include berm/embankment removal.

Channel Rehabilitation/Creation

The full restoration alternative would include restoration of the channels between the existing brackish marsh across the restored inlet (where the berm/embankment is removed) to and across the beach waterward of the berm removal. This alternative would allow formation of natural (based on stressor removal) tidal channel connections to existing dendritic channels in the marsh. This would allow the new channels to migrate naturally, and allow native vegetation and wave processes to establish a new equilibrium.

The partial restoration alternative would include the natural creation of new channels in the lower intertidal zone waterward of the proposed new culvert. This alternative would also include connections to existing dendritic channels in the marsh. Those channels would be restored by removing minor fills and debris.

Groin Removal/Modification - NA

Hydraulic Modification

The full restoration alternative would remove the hydraulic restrictions of the tidal barrier and culvert, and restore the tidal flow processes as well as wind and wave processes to the action area. This is accomplished in full restoration by replacing the tidal barrier/railroad embankment with a 31,000 SF (1,000-foot-long) railroad bridge (Figures 27-5 and 27-6). The partial restoration alternative would increase the existing culvert capacity and improve tidal flow processes by adding a second culvert. This culvert would be 48 inches in diameter and 200 feet long Figure 27-7).

Overwater Structure Removal - NA

Topography Restoration

The full restoration alternative includes removing minor fills and debris on the east side of the railroad embankment/berm associated with the former narrow-gauge railway in the ravine bottom. Topographic restoration would also occur at the ravine walls where the embankment is removed. This topographic restoration is shown as "upland excavation" on Figure 27-4.

Under the partial restoration alternative, similar fill removal to full restoration is proposed east of the railroad embankment/berm. In addition, some material would be removed from certain areas of the marsh to facilitate a more dynamic and complex two-culvert system.

27.3.3 Restoration Features – Additional Management Measures

Beach Nourishment

Full restoration includes placement of 10,000 CY of gravel and cobble material where railroad berm/embankment and armor material is removed and the inlet is restored. This material is included due to a lack of information about the type of material that would be exposed after the embankment and armor are removed. This area will be fully exposed to high wind/wave energy when restored.

In partial restoration, 1,318 CY of gravel and cobble material is proposed where armor is removed along the northwest portion of the shoreline. This material is included due to a lack of information about the type of material that would be exposed after the armor is removed. This area will be fully exposed to high wind/wave energy when restored.

Contaminant Removal/Remediation – NA

Debris Removal

At some time in the past, the channel of Sequalitchew Creek appears to have followed the toe of the slope that forms the southern edge of the brackish marsh. This would have forced the stream to turn abruptly at the railroad berm and again at the culvert. This alignment may have resulted in erosion of the railroad berm. The channel in this area shows evidence of fill and the placement of railroad ties and other debris. This was likely done in an effort to redirect the creek to its current alignment, which cuts straight through the marsh to the culvert. Both restoration alternatives would include removal of the debris, consisting of approximately 2 tons of railroad ties and 100 CY of fill and miscellaneous debris.

Invasive Species Control – NA

Large Wood Placement – NA

Physical Exclusion – NA

Pollution Control – NA

Revegetation

The full restoration alternative includes 0.87 acre of salt marsh restoration, and the partial restoration alternative includes 0.4 acre of marsh restoration. This would be facilitated by fill removal, and the species used would be consistent with those already present in the marsh system.

Reintroduction of Native Animals – NA

Substrate Modification – NA

Species Habitat Enhancement – NA

27.3.4 Restoration Features – Other

A public trail along the north side of the marsh uses the tunnel under the BNSF railway to provide public access to the Puget Sound shoreline. It should be assumed that the project would need to include a trail facility connecting the Sequalitchew Creek trail to Puget Sound. However, this trail may not need to extend as far west, as the shoreline would not extend as far west after restoration.

27.3.5 Land Requirements

According to Pierce County assessor's data, the site is under three separate ownerships. The City of DuPont owns the southern part of the site (the left bank of Sequalitchew Creek). A holding company owns the parcel to the north (the right bank of Sequalitchew Creek). This parcel is under the same ownership as adjacent land, which is leased to CalPortland and contains an active gravel mine. There are no parcel records for the corridor along the track; presumably, this is BNSF right-of-way.

27.3.6 Design Considerations

The railroad is a significant regional transportation facility accommodating much of the West Coast with freight and passenger traffic. The line is owned by BNSF but is shared with Union Pacific and has a very high traffic volume. Therefore, removal of the nearshore railroad was not considered a practicable alternative at this site. There are currently two sets of tracks which would need to remain, and rail traffic would need to be accommodated during implementation.

BNSF has indicated that any down time associated with construction on the railroad is a major concern. As a result, any structure or culvert would need to be constructed without major interruption of service. This would complicate the process of designing and building a new bridge structure that allows for the complete removal of the railroad embankment. In partial restoration, railroad operations could limit the size of any new culverts installed.

The site is exposed to a 4-mile fetch from the west. The abutments and foundations of any structure that supports the railway need to be designed to resist wind, waves, and beach erosion. This could include burying armor under more natural materials, which would act as a failsafe in the event that the stream or tidal channels migrate toward the abutments, or it could include setting back or burying abutments and foundations deeply enough to account for erosional forces.

The action area is designated open space under the City of DuPont's comprehensive plan. The trail from town hall to Puget Sound through the site is part of the City of DuPont's overall trail system. When designing for removal of fill material for topography restoration and tidal barrier/railroad berm removal, the ability to access the restored shoreline via trail will need to be addressed.

The crossing was originally a wooden trestle, which still exists but is now buried in the existing railroad embankment. The embankment is approximately 180 feet wide at the base and 40 feet high, and would provide a potential staging and access area for construction of the new bridge.

With full embankment removal, the height required for a new structure would be approximately 50 feet. BNSF standard pile bents (H-pile) are limited to 30 feet above ground to top of tie. Therefore, a non-standard bridge may be required. The conceptual design is based on a pre-stressed girder bridge with modified WSDOT girders (Figure 27-6). Steel bridge options should also be considered during design. One means of supporting the bridge structure would be drilled shaft foundations. The assumed embedment depth of the drilled shafts is 120 feet.

Bridges and culverts would require annual inspection, along with occasional cleaning of dirt and stray ballast from the bridge seats. Brush, vegetation, and any collected drift underneath the bridge and at culvert end walls should be cleared on an annual basis.

The 48-inch size for the culvert in the partial restoration alternative was chosen due to cost considerations and the potential limitations of jack-and-bore technology. More than one culvert, a larger culvert, or multiple culverts could be considered depending on the final hydraulic analysis in subsequent design phases. Microtunneling would allow for a larger culvert to be installed, but at significantly higher cost.

The main consideration not addressed by the restoration is the lack of flow of Sequalitchew Creek. Currently, creek flows are less than 20% of the historic discharge, and the creek lacks a surface water connection to the marsh. This severely limits the amount of habitat accessible to anadromous species; coho salmon are particularly affected, as conditions under the historic flow regime would provide excellent spawning and rearing habitat (Anchor QEA and Aspect 2010).

The site has a history of industrial uses dating back to the 18th century. These uses include munitions production; therefore, excavations need to consider exposure of potentially contaminated soils. The brackish marsh is the site of a former hydropower plant and wood stave pipelines used to transport bunker fuel between the wharf and storage tanks just upstream of the marsh. The site is a known Native American village site, which was likely inhabited for several centuries. Project-specific archaeological and environmental studies would need to occur and could strongly influence the final design alternative.

27.3.7 Construction Considerations

Under the full restoration alternative, it is assumed that the contractor would be able to install one shaft per week. It is likely that the contractor would excavate partially down the embankment, approximately 10 feet above MHHW tide levels, in order to reduce the required drilling length of shaft installation. Large-diameter casing shoring would be required to allow access to the top of the shaft for column form placement and removal.

Once the shafts are installed, the columns are cast inside the shoring casing. After the shoring casing is removed, the cast-in-place pilecaps and bridge superstructure would be constructed. Other foundation types, installation sequences, and construction methods should be considered during design.

At the bridge abutments, retaining structures would likely be required to stabilize the ravine slope during and after embankment removal.

Track connections for the temporary shoofly to the existing rail would be required to be constructed by BNSF union workers. The contractor would provide construction for the balance of the project.

Under the partial restoration alternative, the jack-and-boring of the new culvert would be initiated from the landward side of the existing embankment, with the receiving end on the waterward side of the embankment. The construction site would require temporary shoring for the jack-and-bore equipment and for final concrete endwall construction on both ends of the culvert.

Access and Staging

Under both restoration alternatives, access and staging would be accommodated from the landward side of the existing railroad embankment. There are limited opportunities for staging in the ravine and marsh, but additional areas exist about 1 mile upstream in the City of DuPont. Upgrades may be required to the existing trail, which would likely be used to provide vehicle and equipment access to the site. The upgrades may include new cross culverts and temporary or permanent shoring resurfacing. Access from the water should also be considered during later design.

Timing and Duration

Under the full restoration alternative, an allowable work window of 4 to 8 hours is estimated, with prior coordination and scheduling through BNSF for most work. Construction of the shoofly is anticipated to take about 24 months and construction of the mainline about 20 months. Demolition of the shoofly would take an additional 6 months, resulting in a total construction duration of approximately 50 months.

Under the partial restoration alternative, the jack-and-bore installation of the new culvert could occur without interruption of BNSF rail traffic or prior construction window scheduling. Construction is anticipated to take about 2 months.

Other Considerations

The shoofly will be a single track with a 30-inch box girder and 80-foot span, similar to the permanent rail bridge structure, with transition connections made to the existing track. Switching coordination north and south of the shoofly will be required to allow only one train to pass through the shoofly at any given time, and reduced speeds will also need to be enforced through the shoofly transitions. The embankment may or may not be useful for the contractor, but it will likely be partially excavated to construct elements of the bridge. The embankment can be fully removed after the bridge is in place. This should be left up to the contractor as much as possible.

A permanent realigned bridge could be used instead of an interim shoofly bridge, but would require construction of two tracks rather than the one shown for the shoofly. A realigned permanent bridge would also require a longer permanent bridge and longer transitions than currently shown for the shoofly, as design speeds will be higher for the permanent condition than for the temporary shoofly condition. A realigned permanent bridge would require additional separation from the existing rail, pushing it farther into the bay. The longer transitions for a realigned bridge may also require additional nearshore excavation impacts.

27.4 Extent of Stressor Removal

Nearshore fill and armoring for the railroad berm act as a partial tidal barrier and constrict a stream crossing. Additional nearshore fill and armoring exists on the Puget Sound side of the railroad where a fill pad was built to access the former wharf. The access through the ravine and under the railroad via a tunnel (former rail line to the former wharf, now a road bed) also resulted in placement of nearshore fill on the land side of the railroad. Removing intertidal and nearshore fill by putting the railway lines on a bridge would remove the tidal barrier, the fill, and most or all shoreline armoring at the mouth of the creek.

Table 27-2 shows the amount of stressor removal with the full and partial restoration alternatives.

Table 27-2. Stressor Removal

Stressor	Full Restoration	Partial Restoration
Tidal Barrier (LF)	900 (overlaps fill)	4 (new culvert)
Fill (area)	3 acres	10,000 SF
Armor (LF)	1,147 (488 feet overlaps fill)	659

27.5 Expected Evolution of the Action Area

Under the full restoration alternative, portions of the action area, such as the brackish marsh, would likely erode significantly over time due to exposure to wind waves that are currently blocked by the railroad embankment. Other changes to the action area include sorting and redistribution of nearshore sediments at the restored inlet. Over time, the action area is expected to reach a dynamic equilibrium of erosional and depositional features based on the local wave patterns and site-specific nearshore drift processes. The ravine walls and inlet edges would develop into vegetated habitats ranging from upland forest and marine riparian to supratidal beach backshore in higher energy areas, and potentially a reconfigured brackish marsh at the upper extent of tidal influence.

27.6 Uncertainties and Risks

Opening the inlet to the full force of wind waves and currents could reduce the size of the marsh due to erosion. Sequalitchew Creek currently lacks sufficient flow to transport sediment to the delta at the rate that it did historically. As a result, the overall morphology and function of the system may differ from pre-development conditions.

Remediation of hydrocarbon contamination is known to have recently occurred in the vicinity of the project. It is possible that excavation for the project or erosion after the project could expose additional, previously unidentified areas of contamination that present toxicity risk to the nearshore ecosystem.

The site has documented historical and archeological resources; a cultural resources assessment of the area of potential effect is warranted. The potential for the discovery of historical or cultural resources is high given the site's long history of human use.

Along the embankment, the original trestle is assumed to have been abandoned and not removed. Existing pile locations should be verified by examining as-builts and/or potholing. Removal of timber piles is typically accomplished by full removal in the marine nearshore. If breakage occurs during removal, cutting the broken pile 1 foot or more below the mud line is typically required by permitting agencies. A geotechnical investigation would be required for design of the bridge abutments and foundations. This investigation would include borings and potentially test pits.

An evaluation and analysis of the railway soils within the berm and slopes via potholing should be conducted prior to bridge or culvert jack-and-boring construction. A soils analysis would ensure a stable foundation and that culvert installation would not create soil settlement issues or stability issues within the berm supporting the rail track.

27.6.1 Risks Associated with Projected Sea Level Change

Sea level rise is not considered a significant risk to restored habitat at this site given the morphology of the ravine (habitat would shift up the ravine). Due to the railroad's elevated alignment, there is no known infrastructure risk or risk to existing development from sea level rise. However, there is some uncertainty and risk associated with the effects of increased wave energy and erosion from restoration actions, coupled with sea level rise, on the potential disturbance of cultural resources and potential areas of buried contaminated soils. Under full restoration, there is also a risk that with rising sea level and increased storminess, the marsh could become severely eroded and smaller than it is now, or the lower ravine walls could erode, widening the mouth of the coastal embayment and allowing the marsh to move inland, but also necessitating shoreline armor at the bridge abutments. Under partial restoration, the increased tidal prism would increase velocity (and depth) in the culverts, which could reduce fish passage and could limit the effectiveness of restoration.

Risks of sea level change are summarized in Table 27-3.

Table 27-3. Risks of Sea Level Change

	Projected Sea Level Change		
	High (65 cm)	**Intermediate (21 cm)**	**Low (13 cm)**
Full Restoration	Increase in erosion of ravine walls near bridge abutments	Minimal	Minimal
Partial Restoration	Increase in velocity in culvert	Minimal	Minimal

27.7 Potential Monitoring Opportunities

Monitoring is important for evaluating the success of the restoration. A combination of field surveys and aerial photographs would be used to document biological and physical changes to the landscape. Monitoring data can be used to refine adaptive management and corrective actions, as needed. Some of the key monitoring needs and opportunities associated with this action are summarized in Table 27-4.

Table 27-4. Monitoring Needs and Opportunities

Monitoring Parameter	Key Performance Indicator	Note
Topographic Stability	X	Monitor inlet stability
Sediment Accretion / Erosion	X	Monitor sorting and redistribution of nearshore sediments at the restored inlet
Wood Accumulation		
Soil / Substrate Conditions		
Vegetation Establishment		
Marsh Surface Evolution / Accretion	X	Monitor loss of marsh due to erosion
Tidal Channel Cross-Section / Density		
Water Quality (contaminants)		
Salinity		
Shellfish Production		
Extent of Invasive Species		
Animal Species Richness		
Fish (salmonid) Access/Use	X	
Forage Fish Production		
Wildlife Species Use		
Effectiveness of Exclusion Devices		

27.8 Information Needed for Subsequent Design

This conceptual design report represents an initial step in the restoration design sequence. The design concepts described above were developed based on readily available information without the level of site-specific survey and investigation that is necessary to support subsequent design and implementation. Substantial additional information will be required at the preliminary and later design stages to confirm the design assumptions, refine quantity estimates, address property and regulatory issues, obtain stakeholder support, and fill in data gaps. The extent to which this information is collected for preliminary design (or a later design stage) will depend upon the available budget, schedule, and other factors. This section attempts to define the most essential information needs for this action. Refer to the Introduction chapter for additional information.

- Property Investigation/Survey – More detailed information on parcel ownership, utilities, and property boundary location will be needed to finalize the design, confirm acquisition requirements, and support negotiations with property owners.
- Topographic/Bathymetric Survey – The survey data would be used to refine design of key project elements and develop detailed construction and demolition plans. Survey data could also be used as a baseline for pre- and post-construction modeling, including hydrodynamic modeling. A temporary tide gage should be considered in the early design stages to obtain site-specific tidal statistics.

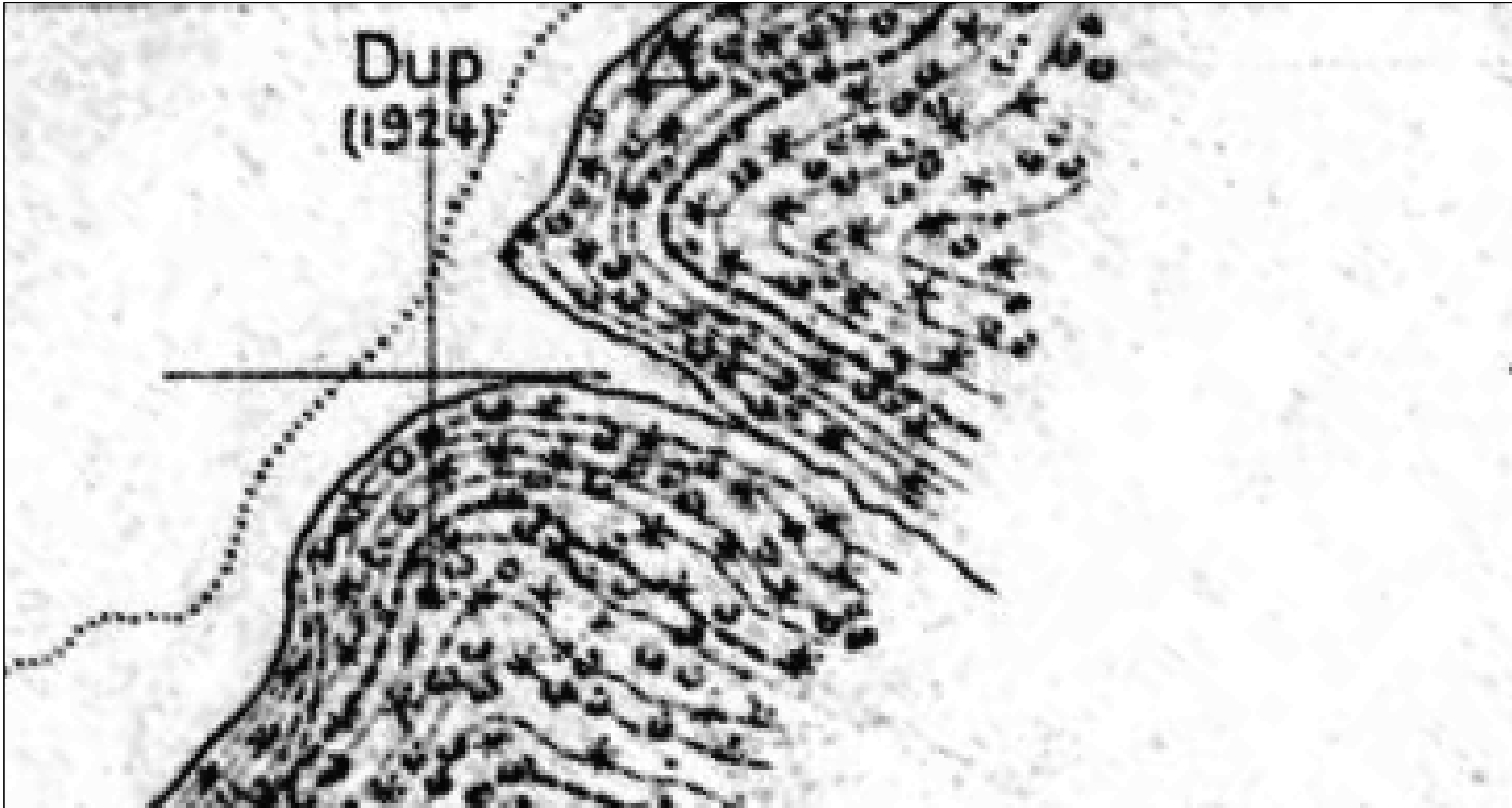
- Geotechnical Investigation – Additional geotechnical study will be required to determine the appropriate bridge foundation type and to design the retaining structure for the abutments. An analysis of the stability of the existing slopes is warranted for bridge or culvert construction.
- Cultural Resources Investigation – Surveys for archaeological and historic resources may be required for this action area, as it has a high likelihood of having past use by Native Americans. This is particularly important in areas proposed for excavation and trenching. An historic bridge that crossed the creek and has been removed would be included in this investigation.
- Hydrodynamic Analysis – A hydraulic analysis of potential scour from stream flows and wind waves is needed to evaluate impacts to infrastructure and adjacent properties following restoration, and to optimize the size of the bridge and culvert openings and determine if armor can be removed from the shoreline in the partial restoration alternative without jeopardizing the stability of railway.
- Contaminant Survey – If preliminary investigations suggest that hazardous material could be present in the action area, additional soil and sediment analysis may be needed. The introductory chapter describes the Phase I site investigations that are occurring as part of this overall effort via a separate contract.
- Coordination with BNSF – Consultation with the railroad will be required to evaluate feasibility, timing, and other issues.

27.9 Quantity Estimates

The design quantities are largely developed from LiDAR data sets lacking the resolution to accurately quantify all elements of construction. These are supplemented by unmeasured estimates made during one site visit at high tide and information from aerial photographs and other available imagery. The quantity spreadsheets for the full and partial restoration alternatives are provided in Exhibits 27-1 and 27-2.

27.10 References

Anchor QEA LLC and Aspect Consulting. 2010. *Pioneer Aggregates Gravel Mine Expansion – Sequalitchew Creek Ecosystem and Watershed Restoration Final Feasibility Study*. Prepared for CalPortland. July 2010.



0 300
Feet
0 80
Meters

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64

WDFW Contract # 100-000204 (CAPS No. 10-1461)

Historic Map (T-Sheet)

Action Name: Sequalitchew Creek Culvert

PSNERP ID #: 1467

Figure 27- 2A

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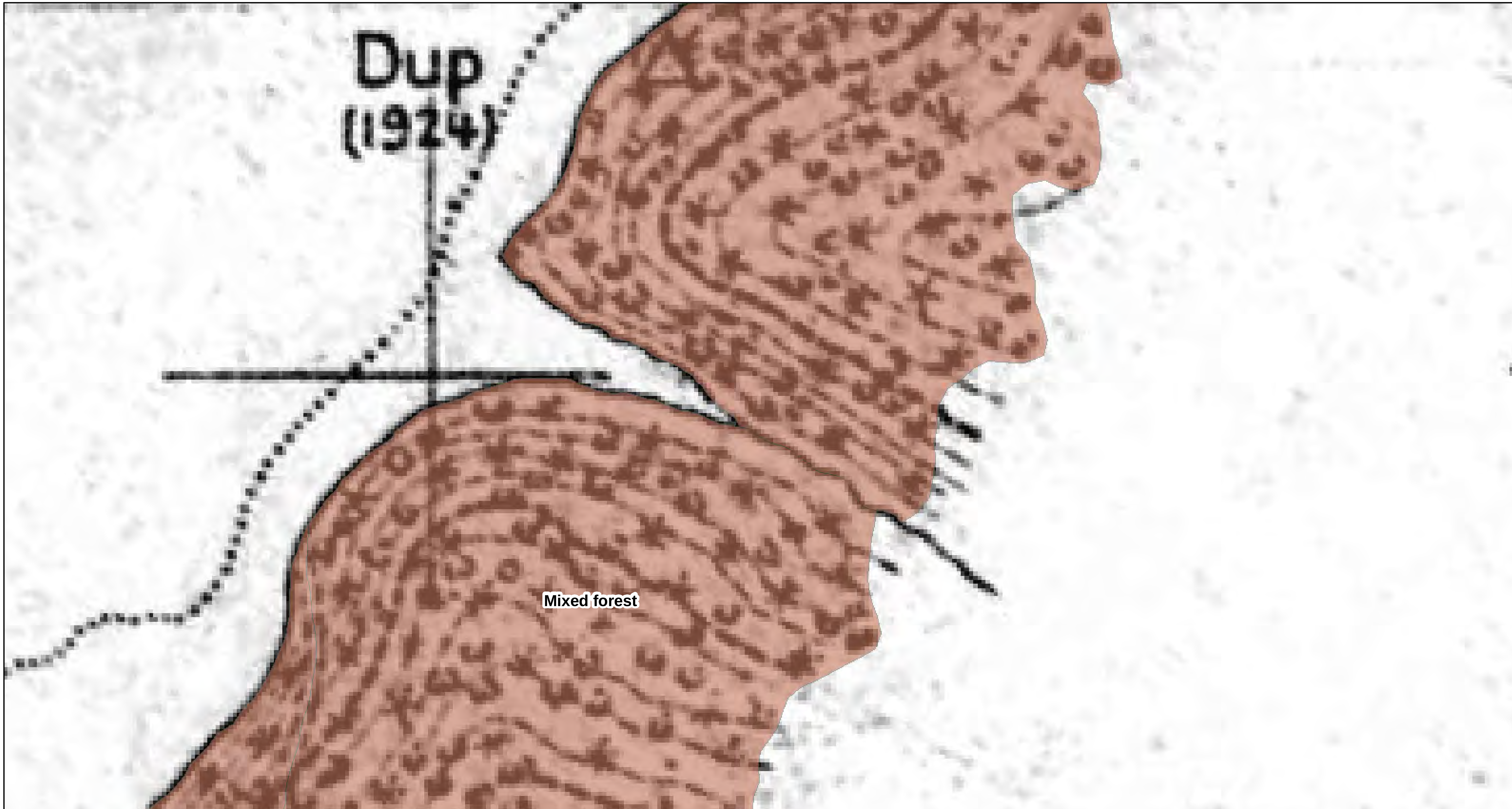

0 300
Feet
0 80
Meters

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Historic Map (T-Sheet) and River History Project Data
Action Name: Sequalitchew Creek Culvert
PSNERP ID #: 1467
Figure 27- 2B

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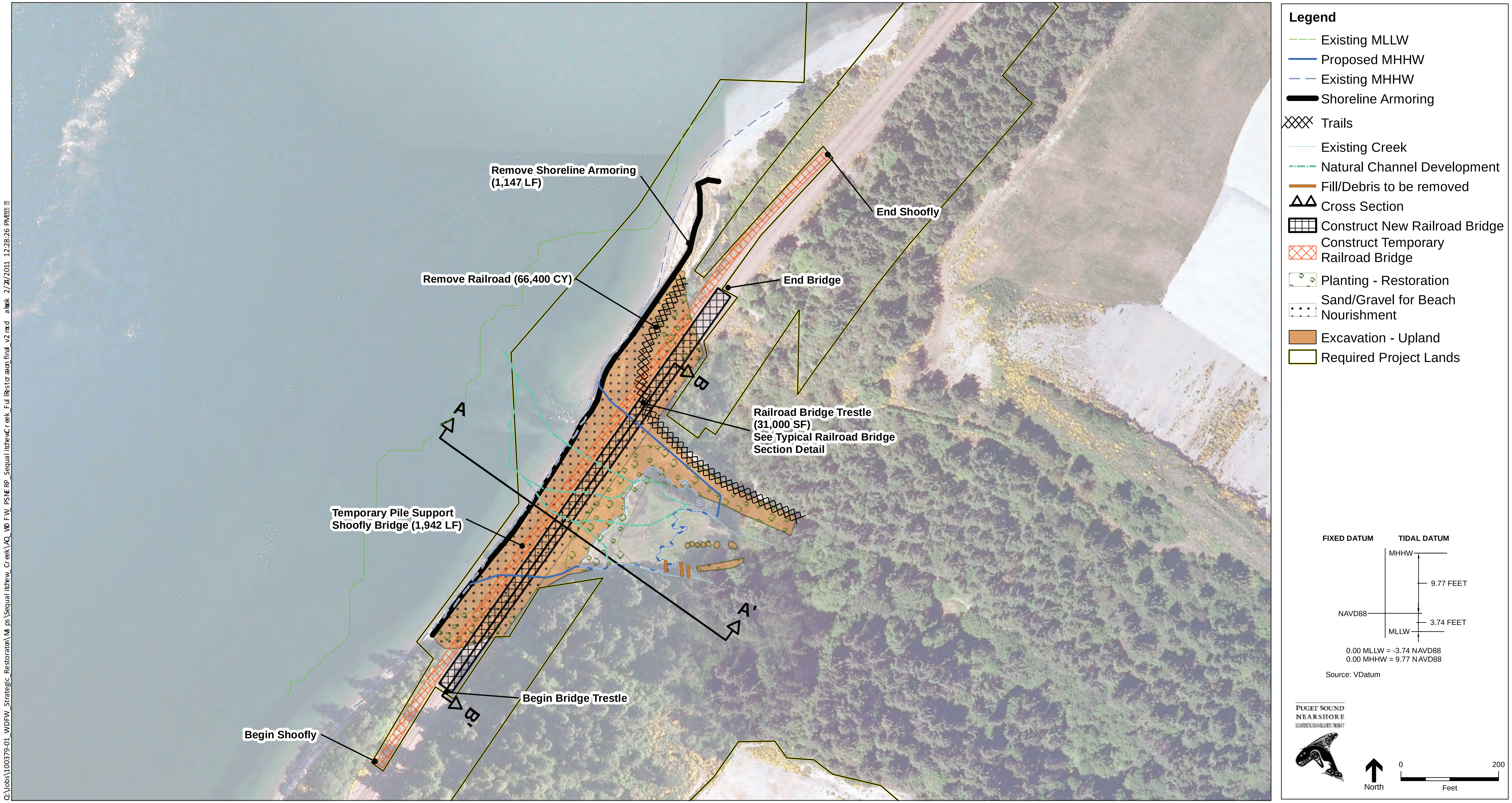


SOURCE: High Resolution Orthoimagery (USGS, 2009); Action Area (PSNERP, 2010)

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64

WDFW Contract # 100-000204 (CAPS No. 10-1461)

Lead Contractor: ESA
Design Lead: Anchor QEA, John Small
Date: 02/22/2011

Conceptual Design Plan
Site Name: Sequalitchew Creek
Action Name: Sequalitchew Creek Culvert
PSNERP ID #: 1467
Full Restoration

Figure 27-3

SOURCE: High Resolution Orthoimagery (USGS, 2009); Action Area (PSNERP, 2010)

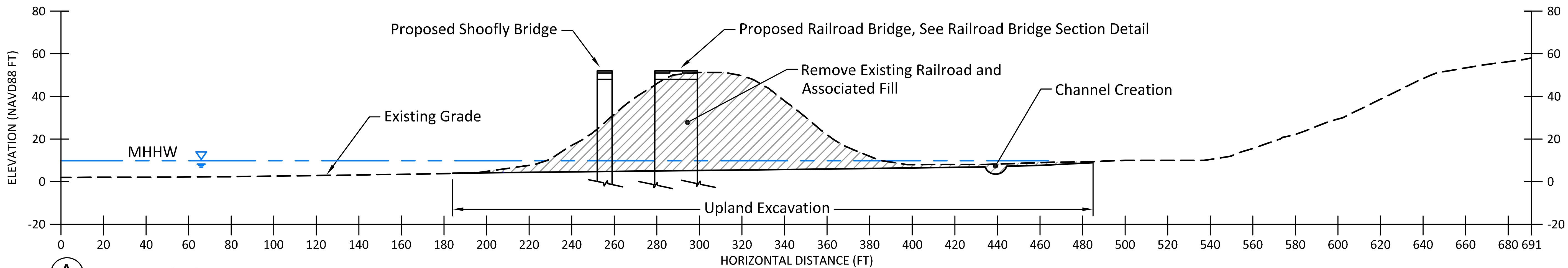
Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64

WDFW Contract # 100-000204 (CAPS No. 10-1461)

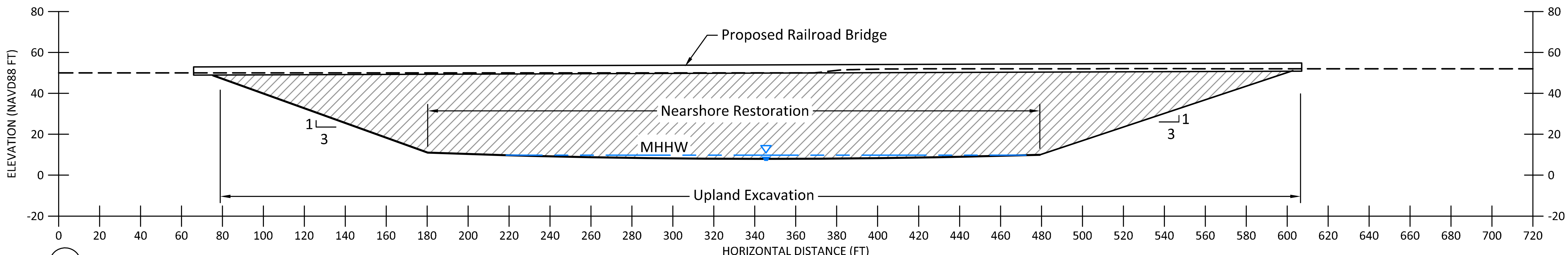
Lead Contractor: ESA
Design Lead: Anchor QEA, John Small
Date: 02/22/2011

Conceptual Design Plan
Site Name: Sequalitchew Creek
Action Name: Sequalitchew Creek Culvert
PSNERP ID #: 1467
Partial Restoration

Figure 27-4



Ⓐ FULL RESTORATION TYPICAL SECTION

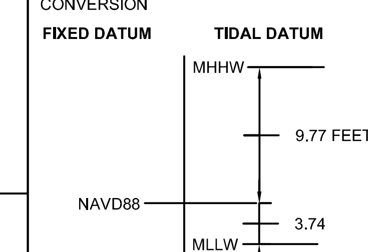


Ⓑ FULL RESTORATION TYPICAL SECTION

EXISTING GRADE HATCH	PROPOSED GRADE HATCH
BEACH	CUT
OTHER	FILL
EXISTING GRADE	PROPOSED GRADE

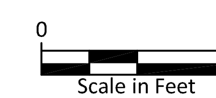
NOTES: Anticipated Marsh Vegetation Zone Elevation 9.0-12.0'

SEQUALITCHEW CREEK ESTUARY CONVERSION



0.00 MLLW = -3.74 NAVD88
0.00 MHHW = 9.77 NAVD88

Source: VDatum



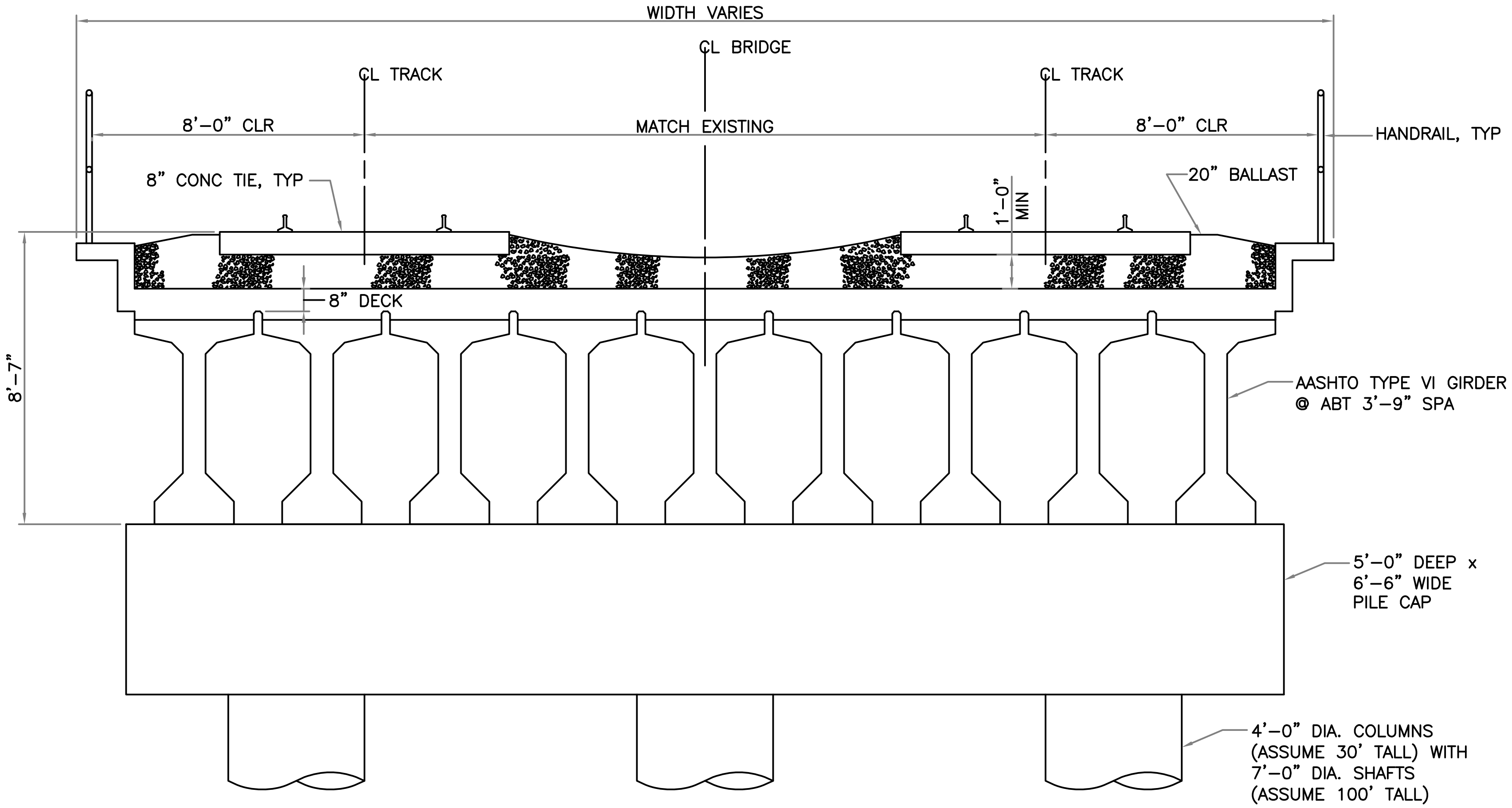
PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: Anchor with KPFF
Date: 3/2011

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Section
SITE NAME: **Sequalitchew Creek Estuary**
ACTION NAME: **Sequalitchew Creek Culvert**
PSNERP ID#: **1467**
Full Restoration

Figure 27-5

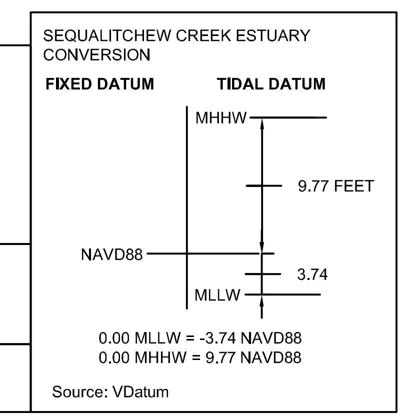


TYPICAL RAILROAD BRIDGE
SECTION DETAIL
Not to Scale
Section Provided by KPFF

NOTE: 80' SPAN BETWEEN GIRDERS

EXISTING GRADE HATCH	PROPOSED GRADE HATCH
BEACH	CUT
OTHER	FILL
EXISTING GRADE	PROPOSED GRADE

NOTES: Anticipated Marsh Vegetation Zone Elevation 9.0-12.0'

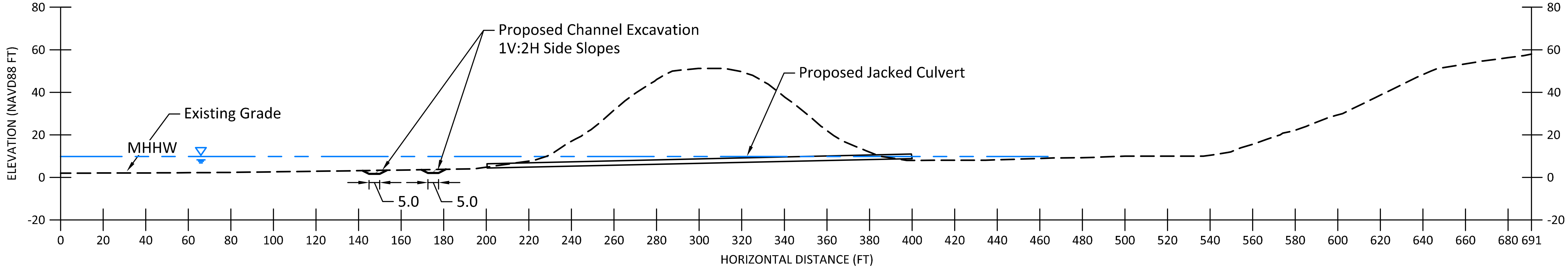


PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: Anchor with KPFF
Date: 3/2011

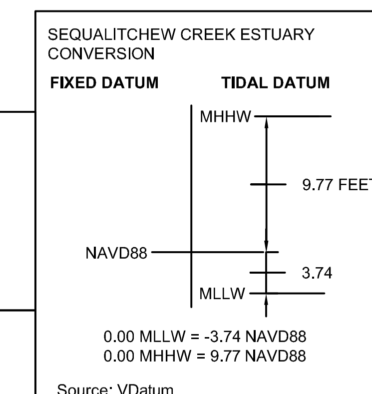
Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

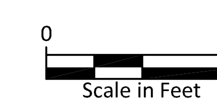
Conceptual Design Section
SITE NAME: **Sequalitchew Creek Estuary**
ACTION NAME: **Sequalitchew Creek Culvert**
PSNERP ID#: **1467**
Full Restoration



A PARTIAL RESTORATION TYPICAL SECTION

EXISTING GRADE HATCH		PROPOSED GRADE HATCH	
	BEACH		CUT
	OTHER		FILL
EXISTING GRADE		PROPOSED GRADE	





PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: Anchor with KPFF
Date: 3/2011

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Section
SITE NAME: **Sequalitchew Creek Estuary**
ACTION NAME: **Sequalitchew Creek Culvert**
PSNERP ID#: **1467**
Partial Restoration

Figure 27-7

Full Restoration Quantity Estimate

Action Name: Squalitchew Creek
Action #: 4167
Date: February 2011
By: John Small

REMEDY: <Restore an open coastal inlet with full tidal hydrology and alluvial sediment supply to the nearshore
Construction Period: 50 months

Item	Unit of Measure	Material Name	Qty	Description of Item		Indicate section of design report where item is described
ACQUISITION AND CONSERVATION				Based on available mapping information		
Required Project Lands	Acre		10.4323	Estmate is based on short plat of existing parcels - does not include other private lands needed for access and staging. Does not include ROW. All lands are currently in conservancy zoning		27.3
Proponent / Partner-owned lands	Acre		0	BNSF Right of Way is not included - construction easement would be required		
Lands To Be Acquired	Acre		10.4323	Estmate is based on short plat of existing parcels - does not include other private lands needed for access and staging. Does not include ROW. All lands are currently in conservancy zoning		27.3
MOBILIZATION AND ACCESS for construction activities				Description required for each item to facilitate cost estimating		
Mobilization - Typical (Equipment, Personnel, Planning, Financial)	LS		0	Up front costs such as bonding, planning and other staff time and financing. Typically, assume 8% to 10% of other items.		
Mobilization - Remote (Equipment, Personnel, Planning, Financial)	LS		1	May require upgardes to the existing, one lane, access road/trail including replacement culverts and new shoring of embankment. Staging and laydown are very constrained at project site, most likely areas are off of Center Drive at top of ravine.		27.3
Site Access	LS		1	Upgrades to existing narrow gage rail tunnel to allow		27.3
Barge Access	Days		0	Barge access may be required if larger equipment is required and cannot be brought in by road or rail.		
Temporary Traffic Control (one of the following)				Includes installation of traffic signals, signage, signmen, etc. There are 4 types as follows:		
Control of Water	LS		1	A bypass of Sequalitchew creek would be needed at some point in the excavation of the railroad prism.		27.3
Relocation Activities				Not Used: See Utilities, Structures		
Site Demolition Activities				Demolition and removal of structures (description required), temporary features and relocations, itemized separately); Clearing and grubbing of vegetation, and removal of minor debris (rocks, slabs) - description required.		
Clearing and Grubbing (one or more of following)				Use one or more of the following categories of clearing and grubbing		
Clear Vegetation - Local Disposal	AC		0	Vegetation removed above grade and disposed locally		
Clear /Grub Vegetation - Local Disposal	AC		0	Vegetation roots also removed and disposed locally		
Clear /Grub Vegetation - Offsite Disposal	AC			Vegetation is taken offsite and disposed - use for noxious invasives, etc.		
Clear, stockpile - large woody debris	CY		0	Vegetation is segregated and stockpiled / prepared for reuse on site.		
Bulkheads	LF or SF		1147	large rock, 3 man and up.		27.3
Debris	Ton		2	Treated railroad ties		27.3
Large Coastal Structures	CY		100	Remove existing culvert; 5X5 foot concrete box, approx 180 feet long		27.3
Haul - Offsite Disposal of Demolition Debris	Miles		30	City of Tacoma Landfill in Graham		27.3
Hazardous/Contaminated Waste Removal				These items for earthwork of quality not compatible with wetlands, requiring special handling and disposal. Describe basis for classification as contaminated or hazardous. State known or suspected contamination, describe known similar work.		
Contaminated Earthwork	CY		10	Placeholder due to probability of contamination.		27.3
Hazardous Earthwork	CY					
Construct Temporary Features				Use as needed for unusual temporary features not included elsewhere (see TESC below)		
EARTHWORK				Expand to include equipment, etc. to facilitate cost estimating.		
Excavation	CY			Per yard excavation w/out expected haul		
Excavation - Upland	CY		66400	Material will have to be removed from under the active rail line after the new bridge is completed		27.3
Excavation - Lowland	CY		10311			27.3
Fine Grading	AC		3	All excavation areas		27.3
Fill Placement - local borrow				This is additive to Earthwork -Excavation		
Conveyor placement from stockpile land/water	CY			Some projects may require conveyor placement		
Imported Fill				Includes purchase, delivery and placement or as noted / described		
Sand / Gravel for Beach Nourishment	CY		3330	1 foot top dress over new beach (excavation footprint) - note short haul from Pioneer Agregates		27.3
Cobble for Shore Nourishment	CY		6670	3 foot depth typical, new beach under existing fill - note short haul from Pioneer Agregates		27.3
Embankment Compaction	CY			WSDOT standard item		
Topsoil	CY		704	6" in planting areas		27.3
RESTORATION Features						
Channel Rehab / Creation	SF		6330	Channel construction (SF) including imported sediment and habitat materials, 6-foot width typical		27.3
Large Wood Placement	EA		0	Per each log, Including drift logs, lower river log jams, etc.		
Physical Exclusion Devices	AC		0			
Other Restoration Features/ Activities	AC			Describe other items not included elsewhere		
Structures	EA			KPFF to provide additional inputs		
Other	EA			Describe		
Utilities				Replacement or relocation. Designer to provide size and material and have separate line item for each run. Incidentals include earthwork, testing, hook up fees, etc. These quantities do not include demolition of existing utilities, real estate / easements, design fees. Describe the owner if known, and whether utility franchise will install (e.g., electric is typically installed by electrical franchise).		
Water	LF					
Gas	LF					
Electric	LF					
Sewer	LF					
Telecommunications	LF					
Other	LF			Others = whatever is required (e.g., power towers, petroleum, jet fuel, etc.)		
Roadway / Railway				KPFF expected to participate in these estimates		
Railway - Box Girder Bridge	SF		31000	Include in Railway Bridge Section (31' x 1,000')		27.3
Railway - Foundation	LF		420	30' X 6.5' Pile Cap, 80' spacing/ Pile Depth = 100'		27.3
Railway - Shoo fly	LF		1942	Temporary alignment		27.3
Permanent Access Features				KPFF expected to participate in these estimates		
Erosion Control Features	L.F.			Describe quantity of expected erosion control measures		
Public Access or Recreation Features				KPFF expected to participate in these estimates		
trails	SF		2400	Gravel base for asphalt paving by others		27.3
Other	EA			Describe other recreational features (see Corps criteria, ER 1105-2-100 for compatibility with ecosystem objectives)		
Vegetation & Erosion Control						
Hydroseeding	AC		1	Disturbed areas not directly under bridge		27.3
Planting	AC		0.87	Salt marsh and riparian areas, 4" and 1 gallon specimens 2-3' O.C.		27.3
Vegetation Maintenance	AC-YR		3	3 years, no irrigation hook up available on site.		27.3
Erosion / sediment BMPs - Temp.	AC		0.87	BMPs for control of drainage - describe. Assume compliance with Construction General NPDES included		27.3
Erosion / sediment BMPs - Permanent	AC			May want to separate slopes over 25% into separate category		
Waterside controls - Temporary	LF		3884	Silt curtain or other water based temporary shoring actionas (full length X2 to cover both sides of const.)		27.3
Construction Management						
Construction oversight	weeks		216	Quanity based on constructon duration/ # of construction seasons		27.3
Materials testing				Included in cost of material - no separate quantity		
Design and Detailed Site Investigations						
Survey & Property, Utility Research	LS		3	% of construction cost		27.8
35% Design	LS		0.0625	% of construction cost		27.8
65% design	LS		0.0625	% of construction cost		27.8
90% design	LS		0.0625	% of construction cost		27.8
100% design	LS		0.0625	% of construction cost		27.8
Geotechnical Studies			1	Potholing		27.8
Cultural Studies			1	Refer to design report for description of need		27.8
HTWR Studies			1	Refer to design report for description of need		27.8
Project Agreement Activities				Unable to provide credibale estimate at 10% design		
Site-Specific Adaptive Management Features & Activities				List if known		
Monitoring Activities				Assume 5 crew-days/acre/year for each monitoring parameter in design report		
Monitoring (Type_)	crew-days		100			
Operations & Maintenance				Unable to provide credible estimate at 10% design		

Partial Restoration Quantity Estimate

Action Name: Squalitchew Creek
Action #: 4167
Date: February 2011
By: John Small

REMEDY: <*Restore an open coastal inlet with full tidal hydrology and alluvial sediment supply to the nearshore*
Construction Period: 50 months

	Item	Unit of Measure	Material Name	Qty	Description of Item		Indicate section of design report where item is described
ACQUISITION AND CONSERVATION					Based on available mapping information		
	Required Project Lands	Acre		10.4323	Estmate is based on short plat of existing parcels - does not include other private lands needed for access and staging. Does not include ROW. All lands are currently in conservancy zoning		27.3
	Proponent / Partner-owned lands	Acre		0	Etimate of lands currently owned by Proponent (i.e., Public lands)		
	Lands To Be Acquired	Acre		10.4323	Estmate is based on short plat of existing parcels - does not include other private lands needed for access and staging. Does not include ROW. All lands are currently in conservancy zoning		27.3
Material Sites					Not Used: See Earthwork - Imported Fill.		
MOBILIZATION AND ACCESS for construction activities					Description required for each item to facilitate cost estimating		
	Mobilization - Typical (Equipment, Personnel, Planning, Financial)	LS		0	Up front costs such as bonding, planning and other staff time and financing. Typically, assume 8% to 10% of other items.		
	Mobilization - Remote (Equipment, Personnel, Planning, Financial)	LS		1	May require upgardes to the existing, one lane, access road/trail including replacement culverts and new shoring of embankment. Staging and laydown are very constrained at project site, most likely areas are off of Center Drive at top of ravine.		27.3
	Site Access	LS		1	May require upgardes to the existing, one lane, access road/trail including replacement culverts and new shoring of embankment. Staging and laydown are very constrained at project site, most likely areas are off of Center Drive at top of ravine.		27.3
	Temporary Traffic Control (one of the following)				Includes installation of traffic signals, signage, signmen, etc. There are 4 types as follows:		
	none	LS		1	None = no traffic control		27.3
	signs	LS			Signs = signs only, costs typically around 1% of total roadway costs		
	flags / spotters	LS			Flags and spotters = signs plus entails a greater level of effort. Describe the duration of this activity. This can be about 3% of total roadway costs.		
	unique	LS			Unique = Greater effort than flags / spotters. Describe as basis for cost estimate.		
	Temporary Roadway	SF			Includes construction of temporary adjacent roadway or bypass roadways and for vehicle and pedestrian travel through or around site.		
	Control of Water	LS		1	May require confinement of work area during jack and bore to prevent tidal inundation.		27.3
Relocation Activities					Not Used: See Utilities, Structures		
Site Demolition Activities					Demolition and removal of structures (description required), temporary features and relocations, itemized separately); Clearing and grubbing of vegetation, and removal of minor debris (rocks, slabs) - description required.		
	Clearing and Grubbing (one or more of following)				Use one or more of the following categories of clearing and grubbing		
	Clear Vegetation - Local Disposal	AC		0	Vegetation removed above grade and disposed locally		
	Clear /Grub Vegetation - Local Disposal	AC		0	Vegetation roots also removed and disposed locally		
	Clear /Grub Vegetation - Offsite Disposal	AC			Vegetation is taken offsite and disposed - use for noxious invasives, etc.		
	Clear, stockpile - large woody debris	CY		0	Vegetation is segregated and stockpiled / prepared for reuse on site.		
	Bulkheads	LF or SF		659	large rock, 3 man and up.		27.3
	Debris	Ton		2	Treated railroad ties		27.3
	Haul - Offsite Disposal of Demolition Debris	Miles		30	City of Tacoma Landfill in Graham		27.3
Hazardous/Contaminated Waste Removal					These items for earthwork of quality not compatible with wetlands, requiring special handling and disposal. Describe basis for classification as contaminated or hazardous. State known or suspected contamination, describe known similar work.		
	Contaminated Earthwork	CY		10	Placeholder due to probability of contamination.		27.3
Construct Temporary Features					Use as needed for unusual temporary features not included elsewhere (see TESC below)		
EARTHWORK					Expand to include equipment, etc. to facilitate cost estimating.		
	Excavation	CY			Per yard excavation w/out expected haul		
	Excavation - Upland	CY		2593	Some work will extend below MLLW, but can be done at low tide.		27.3
	Excavation - Lowland	CY		0	Requires low ground pressure equipment and or mats; low production bucket methods, typically hydraulic excavator and front end loaders.		
	Fill Placement - local borrow				This is additive to Earthwork -Excavation		
	Imported Fill				Includes purchase, delivery and placement or as noted / described		
	Cobble for Shore Nourishment	CY		1318	Back fill shoreline armor areas.		27.3
	Embankment Compaction	CY			WSDOT standard item		
	Topsoil	CY		324	6" depth in excavation area		27.3
RESTORATION Features							
	Channel Rehab / Creation	SF		600	Localized at inlet to new culvert		27.3
	Physical Exclusion Devices	AC		0			
	Other Restoration Features/ Activities	LS			Describe other items not included elsewhere		
Structures		EA			KPFF to provide additional inputs		
	Other	EA		2	48" culvert end walls (both ends, both sides)		27.3
Utilities					Replacement or relocation. Designer to provide size and material and have separate line item for each run. Incidentals include earthwork, testing, hook up fees, etc. These quantities do not include demolition of existing utilities, real estate / easements, design fees. Describe the owner if known, and whether utility franchise will install (e.g., electric is typically installed by electrical franchise).		
Roadway / Railway					KPFF expected to participate in these estimates		
	Culvert - RCP	LF		200	48" RCP		27.3
	Culvert - Jacking	LF		200	Through railway 48" RCP		27.3
Permanent Access Features					KPFF expected to participate in these estimates		
	Erosion Control Features	L.F.		0	Describe quantity of expected erosion control measures		
Public Access or Recreation Features					KPFF expected to participate in these estimates		
	trails	SF			Gravel base for asphalt paving by others		
	Other	EA			Describe other recreational features (see Corps criteria, ER 1105-2-100 for compatibility with ecosystem objectives)		
Vegetation & Erosion Control							
	Hydroseeding	AC		0.25	misc. temporary disturbed areas		27.3
	Planting	AC		0.4	Salt marsh and riparian areas, 4" and 1 gallon specimens 2-3' O.C.		27.3
	Vegetation Maintenance	AC-YR		1.2	3 years, no irrigation hook up available on site.		27.3
	Erosion / sediment BMPs - Temp.	AC		GIS	BMPs for control of drainage - describe. Assume compliance with Construction General NPDES included		27.3
	Erosion / sediment BMPs - Permanent	AC			May want to separate slopes over 25% into separate category		
	Waterside controls - Temporary	LF		40	Silt Curtain and dewatering at Puget sSound end of bore.		27.3
Construction Management							
	Construction oversight	weeks		8	Quanity based on constructon duration/ # of construction seasons		27.3
	Materials testing				Included in cost of material - no separate quantity		
Design and Detailed Site Investigations							
	Survey & Property, Utility Research	LS		3	% of construction cost		27.8
	35% Design	LS		0.0625	% of construction cost		27.8
	65% design	LS		0.0625	% of construction cost		27.8
	90% design	LS		0.0625	% of construction cost		27.8
	100% design	LS		0.0625	% of construction cost		27.8
	Geotechnical Studies			1	Refer to design report for description of need		27.8
	Cultural Studies			1	Refer to design report for description of need		27.8
	HTWR Studies			1	Refer to design report for description of need		27.8
Project Agreement Activities					Unable to provide credibale estimate at 10% design		
Site-Specific Adaptive Management Features & Activities					List if known		
Monitoring Activities					Assume 5 crew-days/year for each monitoring parameter in design report for 5 yrs		
	Monitoring (Type_)	crew-days		100			
Operations & Maintenance					Unable to provide credible estimate at 10% design		

28. SMITH ISLAND ESTUARY RESTORATION (#1142)

Local Proponent	Snohomish County
Delta Process Unit	Delta SNH
Shoreline Process Unit(s)	NA
Strategy(ies)	1 – River Delta
Restoration Objectives	Remove hydrologic barriers to restore estuarine linkages and processes between fresh and saltwater environments. Restore connectivity between Union Slough and disconnected tidal blind channels currently isolated by perimeter dikes. Improve connectivity to adjacent estuarine restoration areas. Maximize the exchange of water, wood, sediment, nutrients, and fish between the action area and Union Slough. Expand and improve juvenile Chinook rearing habitat and smolt production, and reestablish a range of tidal to freshwater vegetation communities

28.1 Description of the Action

The Smith Island Estuary restoration action proposes to restore tidal estuarine marsh habitats (emergent, scrub-shrub, and forested) through reconnection to Union Slough. The action would remove perimeter dike and existing tide gates, create additional marsh pilot dendritic channels, and fill linear agricultural drainage ditches. Sections of existing dike would remain to minimize Union Slough edge habitat disruption and protect a major natural gas pipeline. Construction of a setback dike is required to protect I-5, the gas pipeline, and other utility infrastructure. Please see the Introduction chapter for important information regarding PSNERP and for context related to this restoration project.

28.2 Action Area Description and Context

Smith Island is located east of I-5, north of the City of Everett, and south of the City of Marysville, in the Whidbey Subbasin of Puget Sound. It lies south and west of Union Slough and north of the City of Everett WWTP lagoons. It is part of numerous restoration actions by various agencies, targeted or in progress within the Snohomish River Estuary, with a combined restoration area ranging from 1,200 to 2,000 acres.

The Smith Island restoration area represents one of the largest and best opportunities for process-based restoration of a mid-estuary river delta site within the Snohomish Estuary. It has a central position in the estuary and is characterized by a complete absence of tidal hydrology and a low level of infrastructure constraints. Historically, tidal barrier dikes were installed along Union Slough, and agricultural drainage ditches were installed within the Smith Island action area to reclaim the land for agricultural use. Two large remnant (disconnected) blind tidal slough channels are still present on Smith Island. They extend primarily in a north-south orientation. The east channel connects to Union Slough at its outlet via a tide gate. The west channel connection to Union Slough historically followed an alignment that now crosses I-5. For conceptual design, it was assumed that a culvert does not exist under I-5 at this historic channel. The portion of the channel west of I-5 that remains and passes through an active lumber mill is connected to Union Slough via a tide gate.

The action area totals approximately 580 acres. It is currently accessed from the 12th Street NE overcrossing of I-5 near the southern limit of the action area. South of this road is the City of Everett-owned property including the WWTP and the Union Slough restoration site on the east side of the WWTP. These two areas are separated from the action area by an east-west dike.

The action is an important component in achieving federally listed Chinook salmon recovery, consistent with the 10-year estuary habitat benchmarks identified in the Snohomish River Basin Salmon Conservation Plan (SBSRF 2005). The action area's location between the City of Everett's Union Slough restoration project to the south, Spencer Island to the southeast, and the Blue Heron Slough Mitigation Bank to the north illustrates its importance for ecological connectivity.

The proponent (Snohomish County) has made significant progress towards design development of this action area over the past 8 to 10 years, including conceptual design, feasibility evaluation, environmental review assessment, and affected property acquisition.

Otter Island, located approximately 0.25 mile east of the action area across Union Slough and Steamboat Slough, has been identified by the proponent as the reference site for targeted Smith Island mid-estuary marsh restoration. Otter Island is considered an appropriate reference site for several reasons. First, it is located in a similar position with the Snohomish Estuary landscape and is nearby. Second, Otter Island has never been diked and has a complex blind tidal channel system, along with a mosaic of tidal marsh vegetation communities that have not been modified by past agricultural use or other anthropengic modifications. However, the T-sheets and interpretations of historic vegetation communities show that there were some differences in vegetation between the action area and Otter Island. The action area is shown in Figure 28-1.

Figure 28-1. Action Area and Vicinity

28.2.1 Historic Condition

Prior to the mid 19th century, the Snohomish Estuary contained about 10,000 acres of tidal marsh. The estuary area was likely historically used by Native Americans for hunting, fishing and gathering. Historic mid-estuary marsh conditions are best represented by Otter Island. Beginning in approximately 1860, extensive timber harvesting, levee/dike construction, ditching and draining of marsh areas, and farming/livestock grazing by early settlers degraded the quality of estuarine marsh habitat. Extensive removal of riparian forests and more than 10,000 pieces of large woody debris from the estuary system significantly reduced juvenile salmonid acclimation, flood refuge, and rearing areas. These activities also reduced edge habitat complexity and fragmented habitats, affecting the productivity of the main river and distributary slough channels.

The topographic sheets for this site document that a network of blind channels (two primary) existed within the Smith Island action area (Figures 28-2A and 28-2B). The easterly of the two channels is and was connected to Union Slough, although its current connection is modified by diking and tide gates. The westerly channel was historically connected to Union Slough and to the Old River (Snohomish River mainstem) channel west of the current I-5 corridor. It is now connected only to Union Slough. This channel is degraded by I-5 embankment fill, and diking and fill activities associated with commercial property uses west of I-5. These land uses have cut off or restricted the direct tidal flow into this channel reaching the action area. The cross-island distributary channel linking Union Slough and the Snohomish River mainstem has been filled in at several locations, most notably on the southern end at the Dagmar's Landing facility. Other modifications to the Smith Island action area include an extensive drainage channel network within the proponent-owned land, a continuous dike along Union Slough on the north and east sides of the action area, I-5, agricultural land (nursery and horse farm) on the west, and 12th Street NE on the south.

28.2.2 Natural Environment

The Snohomish Estuary discharges to Port Gardner Bay, Puget Sound, and is connected by the Snohomish River to the Snoqualmie and Skykomish Rivers. The Snohomish River watershed is the second largest watershed draining into Puget Sound. Remnant tidal marsh channels between I-5 and Union Slough have reverted primarily to open water or freshwater emergent and scrub-shrub (primarily edge) habitats, with a few smaller groupings of mature trees (Sitka spruce and other conifers, red alder, black cottonwood, and Pacific willow near the slough channels). Only limited hydraulic connectivity exists through tide gates between freshwater in remnant blind channels in the action area, and tidally influenced higher salinity water in Union Slough. The majority of the action area that was once in agricultural use now lies fallow. Invasive species (primarily reed canarygrass and Himalayan blackberry and some Japanese knotweed) were observed in the action area during the site investigation (Anchor QEA 2010). Smith Island is not actively managed for waterfowl habitat.

Sediment characteristics are not fully known. Based on available soils mapping and site observations, surficial soils are expected to consist primarily of sands, silts, and clays (closest to the marine environment). The predominant surficial soil types are reported to be Puget silty clay loam (more than 75% of the action area), with Snohomish silt loam and Mukilteo muck also present (NRCS 2009). Evidence of significant subsidence exists on Smith Island (Wahl 2010), assumed to be caused primarily by agricultural drainage modifications over compressible underlying soils.

Normal tidal fluctuation ranges from approximately -1.83 feet MLLW elevation to +9.07 feet MHHW elevation at the NAVD 88 vertical datum (NOAA 2010). Based on available LiDAR mapping (NOAA and PSLC 2009), Smith Island marsh elevations typically range between approximately 0 and 3 feet NAVD 88 in the marsh channels, and between approximately 3 and 8 feet NAVD 88 in the adjacent marsh areas. The entire action area is within the Snohomish River 100-year floodplain. The Snohomish County Flood Insurance Study Draft Digital Flood Insurance Rate Map Update (FEMA 2010) reports the 100-year tidally influenced stillwater elevation (100-year flood frequency tide elevation plus surge) for Smith Island to be approximately elevation 15.0 feet NAVD 88. Protection provided by existing dikes is reported to be in the 5-year event plus range. The proponent recommends that proposed setback dikes be constructed to a higher standard of 10-year event protection plus 2 feet of freeboard (Garric 2010 and FEMA 2010).

28.2.3 Human Environment

The primary anthropogenic features within or bounding Smith Island are listed below.

- The I-5 fill embankment corridor at its west limit.
- The perimeter dikes along the east side of Union Slough.
- Dikes, access roads, and the City of Everett WWTP along the southern limit of the action area.
- A directionally-drilled 15-inch natural gas pipeline that extends across the southeast (Williams NW) property, with continuation parallel to 12th Street NE, then north along to its crossing of I-5.
- The A-1 Landscaping tree farm between I-5 and the west remnant tidal channel.
- A horse boarding/agricultural facility in the southwest action area parcel.

Utilities affecting the action area include the Williams NW gas pipeline, a buried telecommunications line along I-5, and drainage infrastructure associated with the current and former diked agriculture land. Some local utilities are assumed to support the horse farm in the southwest portion of the site. More detailed information on existing utilities and the need for utility relocations will be required to support subsequent design phases. The WWTP is considered an adjacent use and not part of the action area.

28.3 Restoration Design Concept

28.3.1 Restoration Overview and Key Design Assumptions

Dikes along the south and east sides of Union Slough are key stressors that inhibit the free flow of tidal and fluvial waters across Smith Island. The I-5 embankment near the west side of Smith Island is also a primary stressor. These barriers to riverine and tidal flows impact the natural geomorphic processes that would otherwise create and maintain nearshore habitat. Full removal of these dikes would be intrusive and would remove large areas of functional slough bank riparian habitat. Partial removal of strategically located and adequate lengths of existing dikes is anticipated to have significantly less negative effect on riparian habitats, and to restore tidal marsh channels cut through the lowered slough bank.

Figures 28-3 through 28-6 illustrate the restoration alternatives. The proponent (Snohomish County) has made significant progress towards design development of this action area over the past 8 to 10 years, including conceptual design, feasibility evaluation, environmental review assessment, and affected property acquisition. With this in mind, the full restoration alternative is similar to but more extensive than the proponent's most extensive restoration proposal (Alternative 1). The full restoration alternative is being developed by PSNERP for planning purposes to identify the restoration potential of the site. The full restoration alternative is not supported by the proponent and may not be consistent with certain Snohomish County land use policies.

For full restoration, more property would be added to the action area along the western side bordering the I-5 right-of-way. Under the full restoration alternative, the restoration area benefited would be approximately 483 acres.

The full restoration alternative includes the removal of the majority of existing Union Slough dikes adjacent to Smith Island and the existing tide gates, and construction of a setback dike along the west periphery of the restoration area. These actions will wholly connect Union Slough with the tidal marsh and remnant blind tidal channels, and with predominant freshwater inputs at the upstream end of the action area. The full restoration alternative would include the A-1 Landscaping parcel to the west and the Buse parcel to the northwest, along with elimination of the horse boarding/agricultural use on the southwest area parcel. These actions will maximize marsh area and distributary channel reconnection. The full restoration alternative is also proposed to include the City of Everett parcel south of 12th Street NE, as bounded by the City of Everett WWTP facilities, and the east/west dike.

Two new clear-span pedestrian bridges are included in the full restoration alternative along the east-west dike to allow hydraulic connectivity to the City of Everett's existing restoration project to the south and provide pedestrian trail access between the action area and the City's existing restoration site (Figure 28-3). Construction of the west setback dike is assumed to be required for the full restoration alternative to provide required levels of flood protection to I-5 and properties to the west of I-5. Along the southwest and southeast limits of the action area, the setback dike, combined with sections of Union Slough dike proposed to remain, would protect critical underground utilities (buried natural gas pipeline and telecommunications cable along I-5), a horse boarding farm, and the City of Everett WWTP lagoons. Filling in all existing drainage ditches and regrading excess soils onsite are proposed, using soils from dike removal and marsh channel excavation.

Under the partial restoration alternative, the restoration area benefited would decrease to approximately 414 acres. Partial restoration will provide the equivalent of the proponent's Dike Alignment Alternative 1 (Snohomish County 2009) and associated west setback dike alignment. The partial restoration alternative would differ from the full restoration alternative primarily by moving the proposed setback dike farther east to avoid two commercial properties along I-5. This would eliminate one of the two remnant dendritic channels from inclusion in the restoration area. The existing dike between the southeast portion of the action area and the City of Everett's restoration site is left in place in partial restoration. Since greater setback dike lengths are proposed and fewer agricultural ditches will be filled in partial restoration, more of the excess soil from this action will need to be regraded onsite. All other management measures and features of the full restoration alternative are assumed to be similar (Figure 28-4). Key design elements associated with the full and partial restoration alternatives are identified in Table 28-1.

Table 28-1. Key Design Elements

Element	Full Restoration Alternative	Partial Restoration Alternative
Dike Removal	Remove approximately 6,600 feet of the Union Slough dike. Southern breaches are for hydraulic connectivity to City of Everett restoration site and are therefore smaller than breaches adjacent to Union Slough	Remove approximately 4,850 feet of the Union Slough dike. No breaches in dikes at southeastern portion of action area and no hydraulic connection to City of Everett restoration site
New Setback Dike	Construct 8,260 feet of new setback dike	Construct 8,825 feet of new setback dike
Marsh Channel Creation	Create 13,100 feet of extended/new marsh channels; 0.034 channel-acres per marsh-acre	Create 7,600 feet of marsh channels; 0.026 channel-acres per marsh-acre
Fill of Agricultural Drainage Channels	Regrade and fill approximately 27,700 feet of existing agricultural drainage channels	Regrade and fill approximately 9,200 feet of existing agricultural drainage channels
Hydraulic Modification	Increase off-channel riverine and tidal prism exchange to remnant and new tidal marsh channels with dike and tide gate removals Slough hydraulic connectivity cross-section area of 2,300 SF below MHHW	Increase off-channel riverine and tidal prism exchange to remnant and new tidal marsh channels with dike and tide gate removals Slough hydraulic connectivity cross-section area of 2,000 SF below MHHW
Access Road Removal	Remove 2,700 feet of existing unimproved access road (assumed 15-foot top width) Restore road footprint to match adjacent marsh grade	Same as for full restoration

28.3.2 Restoration Features – Primary Process-Based Management Measures

Armor Removal/Modification – NA

Berm or Dike Removal/Modification

Selected removal of existing sections of dike on Smith Island along Union Slough is proposed for both the full and partial restoration alternatives at three primary locations: north, to reestablish connectivity to two primary remnant dendritic marsh channels (one of which historically connected to the west under I-5); east, to a newly-created dendritic marsh channel; and south (two locations), where connections to upstream riverine geomorphic processes would be restored.

For the full restoration alternative, a total of 6,600 LF of dike would be removed, including north (3,600 LF), east (2,700 LF), and south at two locations for footbridges (300 LF collectively). For the partial restoration alternative, a total of 4,850 LF of dike would be removed, including north (1,850 LF), east (2,700 LF), and south at two locations for footbridges (300 LF collectively). The project assumes removal of slough dikes to base elevation 7.2 feet NAVD 88 from average top elevation of 14 feet NAVD 88 (approximately 1 foot below MHW and 1 foot above average marsh elevation). The locations of dike removals are shown on Figures 28-3 and 28-4. Assumed dike removal geometries and elevations are shown on Figures 28-5 and 28-6.

Beyond the proposed dike removals, the restored marsh channels would be cut through the lower portion of the removed dike sections (below the marsh level). Under the partial restoration alternative, there would be a reduction of approximately 1,450 LF of dike removed as compared to the full restoration alternative. In partial restoration, no dike removal is proposed at southeast portion of the action area, and no hydraulic connection to the existing City of Everett restoration site is proposed.

Setback dike construction would be required for both the full and partial restoration alternatives to protect I-5, regional utilities, the City of Everett WWTP lagoons to the south, and existing commercial properties along the east side of I-5 (if not acquired). The setback dike is assumed to be constructed to a top elevation of approximately 16 feet NAVD 88 to meet the proponent's 10-year flood protection standard for these improvements (plus 2 feet of freeboard and potential sea level change effects). The lengths of setback dike required range from approximately 8,260 LF to 8,825 LF for the full and partial restoration alternatives, respectively.

Selected dike removal/breaching will provide increased off-channel riverine and tidal prism exchange with the adjacent Union Slough. For the full restoration alternative, the larger restored riverine and tidal prism volume (expected to be roughly 1,700 acre-feet between the marsh and MHHW tidal elevations, averaging 3.5 feet in depth) would require an average flow of approximately 3,400 cfs to enter and exit the marsh area within a 6-hour (diurnal tide) exchange period. Using an assumed average velocity of 1.5 foot per second (conservative because variable but generally higher velocities are expected), and assuming 50% of the breach cross section area within that depth range is effective to flow over the 6-hour tidal flood and ebb conditions, roughly 4,500 SF of dike removal/marsh channel section hydraulic area would then be required to exchange that tidal prism volume (between average marsh and MHHW tidal elevations).

The required breach area using regression curves for the Everett tide gage station in the *Applied Geomorphology Guidelines* (Appendix C) is approximately 50% lower at approximately 2,300 SF, and the hydraulic geometries are predicted to be deeper and narrower than what is proposed for the multiple, shallower dike removals and remnant marsh channel connection. For the lower average depths from marsh plain to MHHW tidal elevation (plus added depth in marsh channels), riverine and tidal exchange velocities are expected to be comparatively lower, and consequently, more cross sectional area would be required, as provided by the estimated value above.

Under partial restoration, the comparable tidal prism volume would be lower (approximately 1,450 acre-feet), resulting in an estimated average tidal exchange flow of approximately 2,900 cfs, and the need for roughly 3,900 SF of dike removal/marsh channel section hydraulic area. The comparable cross-sectional area shown in the *Applied Geomorphology Guidelines* (Appendix C) is approximately 2,000 SF for the 410 acres of restored marsh under partial restoration. Dike removal and marsh channel geometries are expected to self-adjust through erosive action, particularly in the excavated channels, resulting in channel enlargement and deepening to geometries that are in equilibrium for the actual riverine and tidal prism exchange.

Excess excavated materials suitable for fill placement (after setback dike construction and agricultural channel filling) are proposed to be regraded onsite away from existing and proposed channels. This material will be spread as uniformly as possible.

Channel Rehabilitation/Creation

This management measure would increase the density and complexity of tidal marsh blind channels consistent with their historic abundance, and similar to the undiked reference site (Otter Island to the east). The full restoration alternative would increase the tidal channel density on Smith Island to approximately 37,000 feet and 16.3 acres (existing plus created channels, assuming a 20-foot average width for primary channels, and a 12-foot average width for secondary channels), within a composite marsh area of approximately 483 acres, or approximately 0.034 channel-acres per marsh-acre.

The partial restoration alternative would result in less channel length, area, and density, totaling approximately 24,500 feet and 10.6 acres (for the same assumptions as with the full restoration alternative) within the restored marsh area, or approximately 0.026 channel-acres per marsh-acre.

Considering new channels only, the full and partial restoration alternatives propose approximately 13,000 feet and 7,600 feet of created marsh tidal channel, respectively. Both alternatives include three restored primary marsh channel connectivity points to the Union Slough channel.

The total length of created marsh blind channels in the full restoration alternative (13,000 feet and 5.2 acres) far exceeds the equivalent value under the partial restoration alternative (7,600 feet and 2.8 acres). Also, interior connectivity of created channels to existing channels would be greater for the full restoration alternative (12 locations) compared to the partial restoration alternative (7 locations). In general, the objective of channel excavation is to provide pilot or starter channels that through natural processes can increase in length. These starter channels are proposed due to presence of dense mats of reed canarygrass that inhibit starter channel development of larger remanent channels.

In the full restoration alternative, a new channel is proposed to connect the two larger remnant blind channels. This connection is proposed based on the assumption that the western blind channel does not have a functioning connection to Union Slough under I-5, and that west of I-5 this channel is blocked by a tide gate and impacted by an active lumber mill. This western remnant blind channel is not included in the partial restoration alternative.

Filling of existing, linear agricultural channels on Smith Island is proposed for the full and partial restoration alternatives (Figures 28-3 and 28-4). The length of existing channels proposed for filling under the full and partial restoration alternatives is 27,700 feet and 9,200 feet, respectively. Fill material is assumed to be supplied by excavation for dike removals and marsh channels.

Groin Removal/Modification – NA

Hydraulic Modification

A tide gate at the north end of the larger remanent blind channel (east of two larger blind channels within action area) will be removed in full and partial restoration. Currently, the Union Slough dike and tide gate in this location prevents tidal exchange to this blind channel. Removal of this tide gate would occur in conjunction with dike removal and would allow for full tidal exchange with Union Slough. In full restoration, two pedestrian bridges are proposed in the dike at the southeast portion of the action area to establish a hydraulic connection with the City of Everett restoration site to the south.

Overwater Structure Removal – NA

Topography Restoration – NA

28.3.3 Restoration Features – Additional Management Measures

Beach Nourishment – NA

Contaminant Removal/Remediation – NA

Debris Removal – NA

Invasive Species Control

Invasive species are known to be present within the diked sections of Smith Island, on the fallow lands previously used for agriculture. Reed canarygrass and cattail typically form dense mats of vegetation that prevent colonization of other species, and can suppress the evolution of the emergent marsh to scrub-shrub marsh vegetation. The extent of Japanese knotweed infestation within the action area has not been documented. This species can spread rapidly and complicate restoration efforts.

Habitats in the action area will be diversified through invasive vegetation control and reestablishment of native emergent and scrub-shrub communities (in intermediate to higher marsh elevations, beyond created lower elevation mudflats). The increased influx of tidally influenced waters will support a transition to a native vegetation community. The ability of native seed banks in the disturbed soils to outcompete invasive species will also be important. Excess soils from dike removal (in excess of those needed for channel filling) will be regraded as uniformly as possible onsite to suppress invasive species and aid in the colonization of the action area by a more diverse assemblage of estuarine marsh species.

Large Wood Placement - NA

Physical Exclusion – NA

Pollution Control – NA

Revegetation

Limited supplemental native plantings would be installed in both the full and partial restoration alternatives to enhance natural revegetation, but only for the created marsh channel periphery and regraded areas. Planting densities are assumed to be low. The proponent is gathering vegetative monitoring data from other local restoration sites to provide further insight regarding expected native vegetation colonization. Revegetation management is part of a coordinated monitoring and adaptive management strategy currently under development by the proponent (Snohomish County 2010).

Reintroduction of Native Animals – NA

Substrate Modification – NA

Species Habitat Enhancement – NA

28.3.4 Restoration Features – Other

Other restoration features include the removal of fill materials associated with approximately 2,700 feet of 12th Street NE and other unimproved roads currently servicing the existing Union Slough dike. Access to this dike would be provided in the full and partial restoration alternatives with a rerouted road access along the top of the proposed setback dike (Figures 28-3 and 28-4). This proposed road segment provides access to the north side of the City of Everett WWTP, and the remaining segment of Union Slough dike. In full restoration, the two pedestrian bridges in the southeast dike will provide public access for recreation.

28.3.5 Land Requirements

Most of the action area is in Snohomish County ownership. Based on review of PSNERP action area field maps and input from the proponent (Garric 2010), a few key parcels of City of Everett and private property ownership exist within the action area. These include the Buse and A-1 Landscaping properties between the west tidal channel and I-5, the Williams NW property, and the City of Everett property between 12th Street NE and the WWTP. These public and private properties are being included for the full restoration alternative. The proponent pursued acquisition of remaining properties on the west side of the island (A-1 Landscaping, Buse), but negotiations have been unsuccessful to date (Garric 2010). These two parcels would need to be acquired to implement the full restoration alternative.

In addition, the proponent proposes to reserve portions of the site for mitigation (these areas would likely be excluded from any federally funded restoration project). The actual area encumbered by agreements with other entities is relatively small (approximately 14 acres). Mitigation agreements with WSDOT and BNSF Railway will raise approximately $2.5 million for the overall restoration project (Garric 2010).

28.3.6 Design Considerations

Primary design considerations for the full restoration alternative include:

- Commitment to compliance with the Snohomish River Basin Salmon Conservation Plan goals and objectives.
- Use limitations on Snohomish County-owned properties proposed for restoration.
- The limitations imposed by Williams NW on protection and access needs for the natural gas pipeline.

- The conditions imposed in various agreements between Snohomish County and the City of Everett pertaining to south end properties.

- Proposed mitigation within the action area to satisfy WSDOT and BNSF Railway agreements with the proponent.

- Invasive species control approaches and adaptive management practices to be integrated with design.

- Requirements to ensure protection of the City of Everett WWTP lagoon facilities to the south.

- Public access requirements to connect the action area to the City of Everett's restoration area south of the east/west dike.

For the partial restoration alternative, additional design considerations include:

- The existing Union Slough dikes presumed as needing to be retained at the north end for tie-in of the proposed setback dike further to the east.

- Private property ownership along the western portion of the action area (A-1 Landscaping and Buse).

- The horse boarding facility in the southwest action area.

28.3.7 Construction Considerations

For the full and partial restoration alternatives, it is assumed that multiple track-hoe excavators (low-ground-pressure type) will be used to complete marsh channel excavations and to regrade excavated materials onsite from channel creation and dike removal spoils. Loaders, dump trucks, soil compaction equipment, dewatering wells, pumps, piping, and construction water quality treatment devices will also be needed to prepare the site for excavation and move the significant amounts of earthwork involved. Controlled placement and compaction of suitable embankment fill materials will also be needed for setback dike construction and filling of agricultural channels.

Overexcavation is assumed at the base of the setback dike embankment fill to dispose of clear and grub vegetation/soils and unsuitable subgrade materials prior to embankment placement. Dependent on geotechnical investigation findings during preliminary or subsequent design, pre-load of the dike embankment area may be required over a 1-year period to reduce long-term embankment settlement.

Temporary construction access roads would be used to maximize the efficiency of earthwork operations, import materials, and dispose of unsuitable materials offsite. It is assumed that construction access will typically follow the existing Union Slough dike and proposed marsh channel creation alignments, but further evaluation will be needed.

Construction for a site of this scale is envisioned to occur over at least two summer construction seasons. In-water work is typically limited to July through September by WDFW and the U.S. Army Corps of Engineers through permitting approvals; however, work could occur over a longer duration, primarily earlier in the growing season. Work interior to the Union Slough dikes needs to occur as a first phase (prior to dike removal) to maximize the work that can be accomplished beyond the ordinary high water limits, and minimize disruption to aquatic habitats. For the succeeding phases, the dikes are assumed to be sequentially removed, working from the remaining dikes. A portion of that work may also need to be accomplished from barge access along Union Slough if access along the slough dikes becomes impracticable in the later stages of dike removal.

28.4 Extent of Stressor Removal

Table 28-2 describes the amount of stressors to be removed with this action.

Table 28-2. Stressor Removal

Stressor	Full Restoration	Partial Restoration
Tidal Barrier (LF)	6,600 (Union Slough dikes)	4,550 (Union Slough dikes)
Fill (acres)	5.3 (Union Slough dikes)	3.9 (Union Slough dikes)
Armor (LF)	None is known to exist	None is known to exist
Nearshore Roads (LF)	2,700	2,700

28.5 Expected Evolution of the Action Area

After freshwater and tidal prism exchange is fully achieved for Smith Island, it is expected that the geometry of the marsh channels will adjust to the flow, sediment, and tidal regimes of the restored action area. Habitat and native vegetation communities will develop consistent with the site's landscape position, and in response to geomorphic processes within the larger Snohomish River Estuary system. Those ongoing changes will also be affected by external basin-wide actions and changes. Processes beneficially restored by the removal of stressors include tidal channel formation and maintenance, tidal flow, distributary channel migration, erosion and accretion of sediments, and exchange of aquatic organisms. Sea level change, as discussed below, could also affect created habitat communities through changes from emergent marsh and scrub-shrub communities to mudflat and deeper emergent marsh communities over time.

Both the partial and full restoration alternatives will likely respond in a similar fashion to external influences through the assumed 50-year evolution period. However, the full restoration alternative is anticipated to develop more quickly due to the larger tidal prism.

28.6 Uncertainties and Risks

Uncertainties and risks for this action area include:

- Sediment Supply – The Snohomish River mainstem is believed to carry most of the sediment and water volume in the estuary (Wahl 2010). The level of sediment supply to locations not located on the mainstem, including the action area, is less certain. The proponent is conducting a separate modeling study to investigate this issue at various restoration sites near the action area.

- Infrastructure Concerns – Reactivation of the distributary channel tidal prism and modification or realignment of dikes could put critical utility infrastructure at increased risk of erosion (exposure), damage or flooding.
- Ecological Evolution – There is uncertainty related to sediment supply and subsidence that will affect ecological evolution toward the types of habitat found at the reference site, Otter Island. The ability to achieve the desired active marsh channel density across the island without excessively impacting riparian slough habitat (tree canopy) established on perimeter dikes targeted for removal is uncertain. It is also unclear how much freshwater/tidal prism exchange will occur, considering the extent of existing and created marsh drainage channels.

28.6.1 Risks Associated with Projected Sea Level Change

Sea level change could potentially exceed sediment delivery rates through the Snohomish River Estuary that contribute to rebuilding of estuary marsh areas. This change may be most severe for locations such as the action area along the Union Slough distributary channel that are not directly adjacent to the Snohomish River mainstem. Riverine processes such as sediment delivery will be less pronounced in distributary channels such as Union Slough (Wahl 2010).

Projected sea level change risks are qualitatively summarized in Table 28-3.

Table 28-3. Risks of Sea Level Change

	Projected Sea Level Change		
	High (46 cm)	**Intermediate (8 cm)**	**Low (– 4 cm)**
Full Restoration	Upstream shift in emergent and scrub-shrub restored habitats Creation of more extensive mudflat habitat throughout Smith Island Increased inundation by a larger tidal prism would lead to an increased rate of migration of tidal channels Increased salinity of tidal marsh inundation affecting habitat creation, vegetation establishment, and habitat functions Sea level change rate could outpace the rates of sedimentation Potential lowering of Chinook smolt production	No appreciable change	No appreciable change

	Projected Sea Level Change		
	High (46 cm)	Intermediate (8 cm)	Low (– 4 cm)
Partial Restoration	Similar to the full restoration alternative, but smaller area of affected habitat modification	No appreciable change	No appreciable change

28.7 Potential Monitoring Opportunities

Monitoring is important for evaluating restoration success. A combination of field surveys and aerial photographs would be used to document biological and physical changes to the landscape. Monitoring data can be used to refine adaptive management and corrective actions, as needed. Some of the key monitoring needs and opportunities associated with this action are summarized in Table 28-4.

Table 28-4. Monitoring Needs and Opportunities

Monitoring Parameter	Key Performance Indicator	Note
Topographic Stability		
Sediment Accretion / Erosion	X	Assess sediment supply
Wood Accumulation		
Soil / Substrate Conditions		
Vegetation Establishment	X	Assess changes from emergent marsh and scrub-shrub communities to mudflat and deeper emergent marsh communities
Marsh Surface Evolution / Accretion	X	
Tidal Channel Cross-Section / Density	X	Evaluate balance in density of active marsh channels and impacts on riparian slough habitat
Water Quality (contaminants)		
Salinity		
Shellfish Production		
Extent of Invasive Species		
Animal Species Richness		
Fish (salmonid) Access/Use	X	Document desired improvements in salmonid production
Forage Fish Production		
Wildlife Species Use		
Effectiveness of Exclusion Devices		

28.8 Information Needed for Subsequent Design

This conceptual design report represents an initial step in the restoration design sequence. The design concepts described above were developed based on readily available information without the level of site-specific survey and investigation that is necessary to support subsequent design and implementation. Substantial additional information will be required at the preliminary and later design stages to confirm the design assumptions, refine quantity estimates, address property and regulatory issues, obtain stakeholder support, and fill in data gaps. The extent to which this information is collected for preliminary design (or a later design stage) will depend upon the available budget, schedule, and other factors. This section attempts to define the most essential information needs for this action. Refer to the Introduction chapter for additional information.

- Property and Topographic/Bathymetric Survey – A more detailed survey of site features including existing island habitat types and limits would be useful for potential adjustment in dike removal lengths and locations to minimize adverse impacts. This work could yield improved mapping of existing marsh channels and their profile elevations, including those potentially existing channels (possibly obscured by marsh vegetation) along proposed newly created channel alignments, better mapping of slough edge habitats (along existing dikes) to be affected by dike breaches, and better information on Union Slough bathymetry. The mapping should identify the presence or absence of stressors such as armor on the Union Slough dike. The mapping should also determine the presence or absence of a culvert connection under I-5 for the west remnant blind channel.

- Contractor Consultation – Consultation with marine contractor would help assess the practicability and extent of use of barge construction equipment as may be needed for selected dike removals.

- Geotechnical Studies – Geotechnical investigation and hydrogeology evaluation of shallow subsurface soils to be manipulated with restoration actions would help determine shallow groundwater elevation response to tidal effects, assess effects on the buried gas pipeline, and verify slope stability of the proposed levee.

- Hydrodynamic and Hydraulic Analysis – Additional hydraulic modeling may be needed to more precisely inform geomorphic evaluation under restored conditions including adjacent slough flow, water level, and sediment erosion, transport, and deposition characteristics. Prior hydrodynamic model analysis datasets and report findings may need further analysis in support of preliminary design. The specific approach/method of any future modeling will need to be determined. A temporary tide gage may be needed in the early design stages to obtain site-specific tidal statistics.

- Hazardous Materials Assessment – If preliminary investigations suggest that hazardous material could be present in the action area, additional soil and sediment analysis related to demolition of utilities, roads, or buildings may be needed. The introductory chapter describes the Phase I site investigations that are occurring as part of this overall effort via a separate contract.

- Cultural Resources Investigation – Surveys for archaeological and historic resources may be required for this action area. This is particularly important for areas proposed for excavation or other ground disturbance.

28.9 Quantity Estimates

The design quantities are largely developed from LiDAR data sets lacking the resolution to accurately quantify all elements of construction. These are supplemented by unmeasured estimates made during one site visit at high tide and areal take-offs from available imagery. The quantity spreadsheets for the full and partial restoration alternatives are provided in Exhibits 28-1 and 28-2.

28.10 References

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0 800
Feet
0 240
Meters

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64

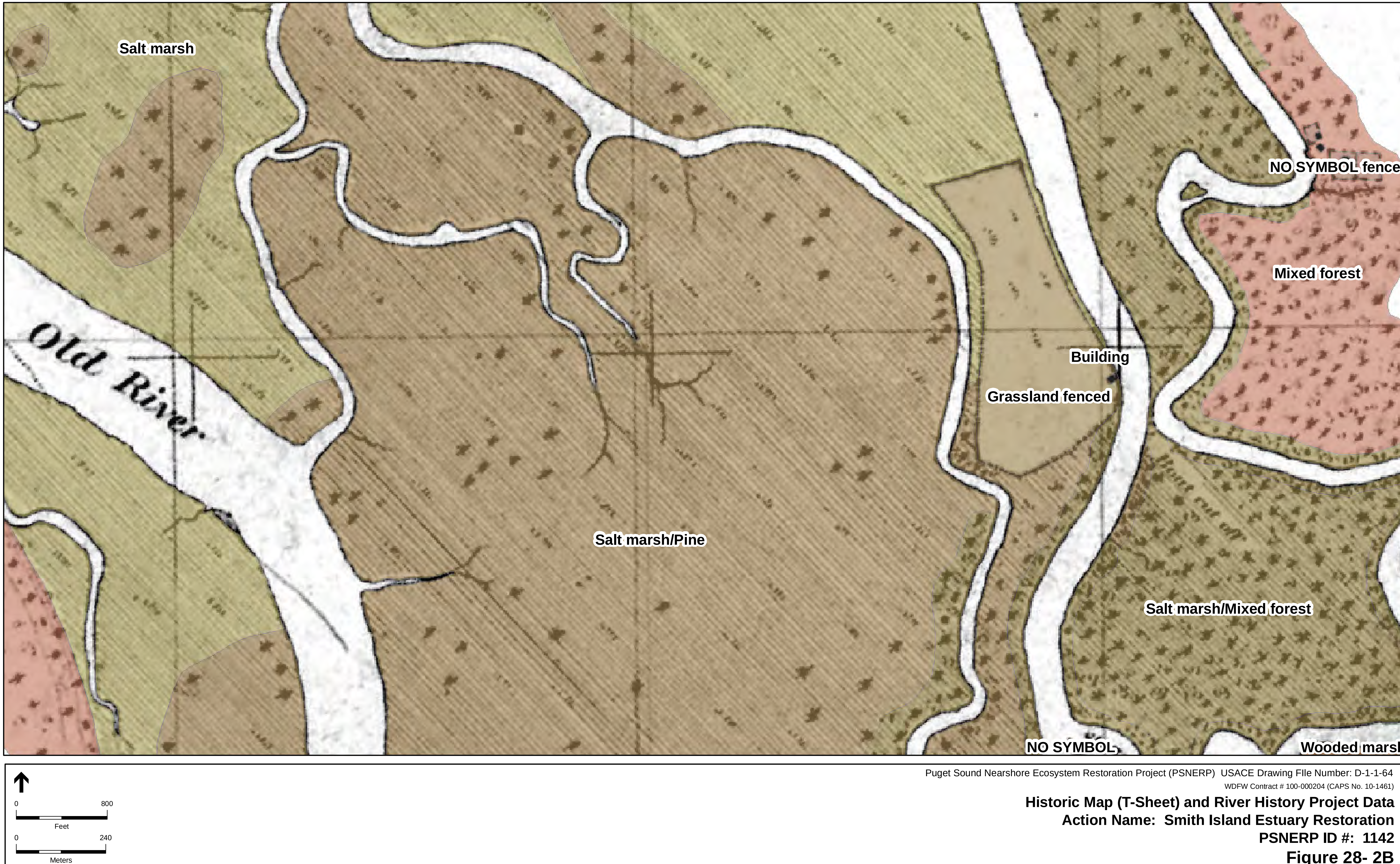
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Historic Map (T-Sheet)

Action Name: Smith Island Estuary Restoration

PSNERP ID #: 1142

Figure 28- 2A



Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64

WDFW Contract # 100-000204 (CAPS No. 10-1461)

Historic Map (T-Sheet) and River History Project Data

Action Name: Smith Island Estuary Restoration

PSNERP ID #: 1142

Figure 28- 2B

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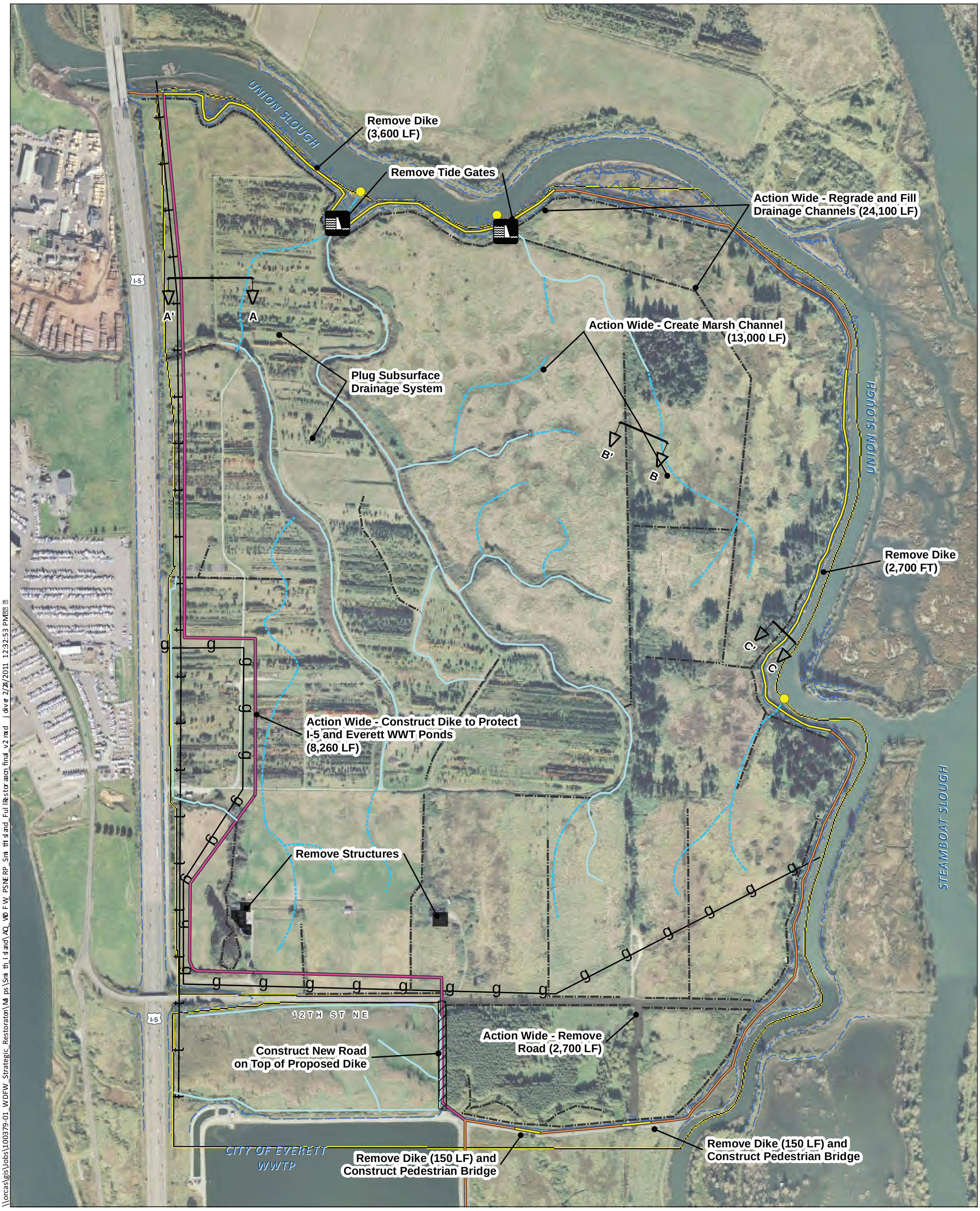
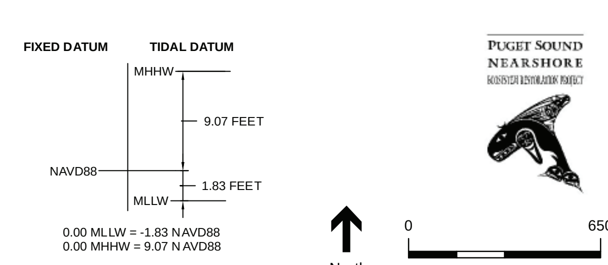


Legend

- Proposed Connectivity
- Hydraulic Structures - Large
- Buildings
- Pavement
- Roadway Type A
- Required Project Lands
- Existing Dike
- Dike Construction
- Dike Removal
- Existing Channel
- Fill Existing Channel
- Create Marsh Channel
- Natural Gas Line
- Telecom Line
- Existing MHHW



SOURCE: NAIP Orthoimagery (USDA, 2009); Action Area (PSNERP, 2010)

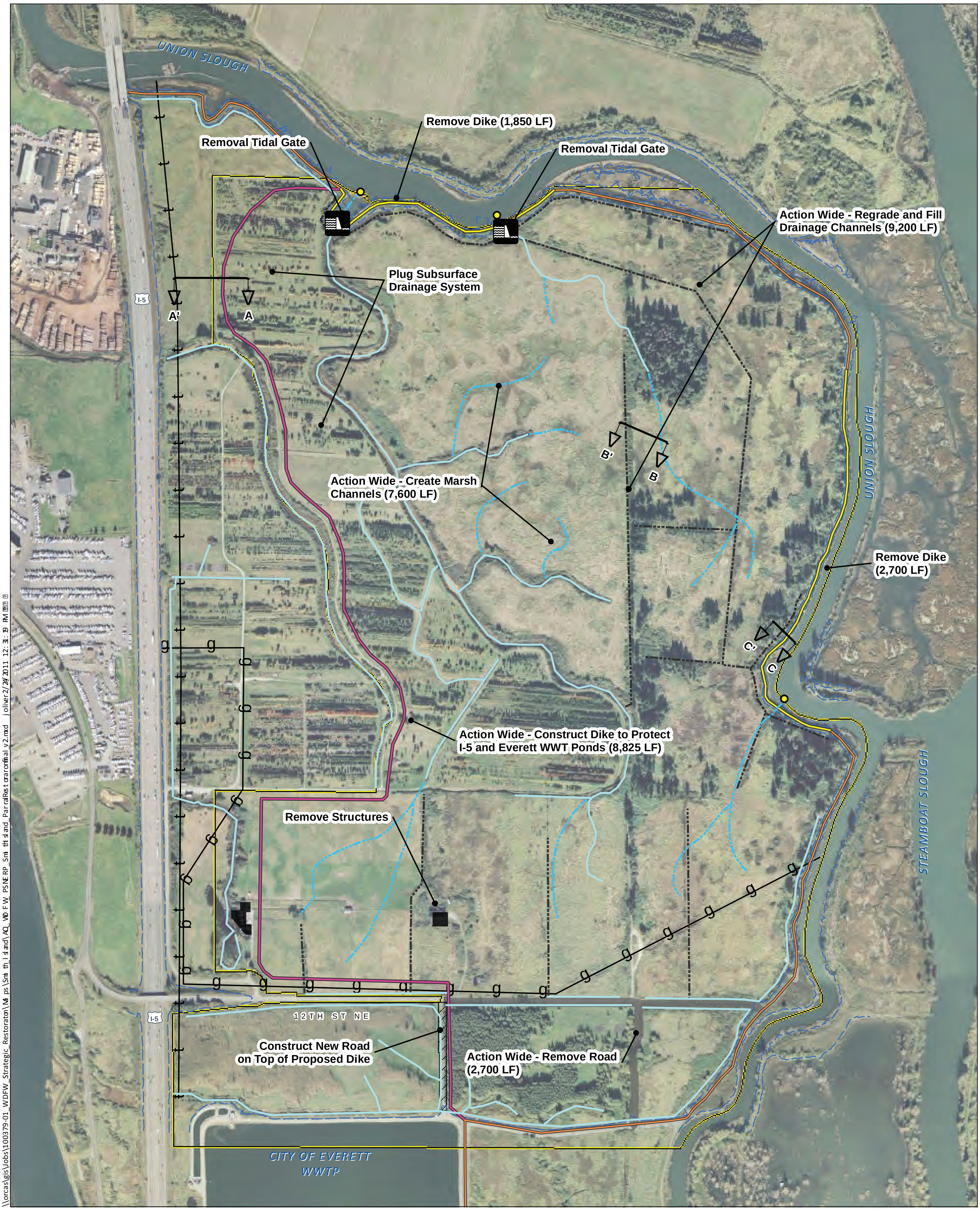
Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64

WDFW Contract # 100-000204 (CAPS No. 10-1461)

Lead Contractor: ESA
Design Lead: Anchor QEA, J. Bibee P.E.
Date: 02/18/2011

Conceptual Design Plan
Site Name: Smith Island
Action Name: Smith Island Estuary Restoration
PSNERP ID #: 1142
Full Restoration

Figure 28-3



Legend

- Proposed Connectivity
- Hydraulic Structures - Large
- Buildings
- Pavement
- Roadway Type A
- Required Project Lands
- Existing Dike
- Dike Construction
- Dike Removal
- Existing Channel
- Fill Existing Channel
- Create Marsh Channel
- Natural Gas Line
- Telecom Line
- Existing MHHW

FIXED DATUM | TIDAL DATUM
MHHW
9.07 FEET
NAVD88
1.83 FEET
MLLW
0.00 MLLW = -1.83 NAVD88
0.00 MHHW = 9.07 NAVD88
Source: VDatum

North

0 650
Feet

PUGET SOUND NEARSHORE

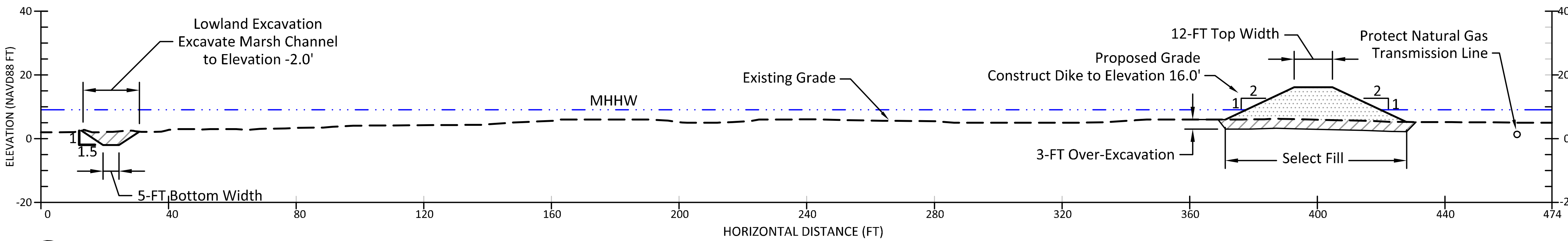
SOURCE: NAIP Orthoimagery (USDA, 2009);
Action Area (PSNERP, 2010)

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

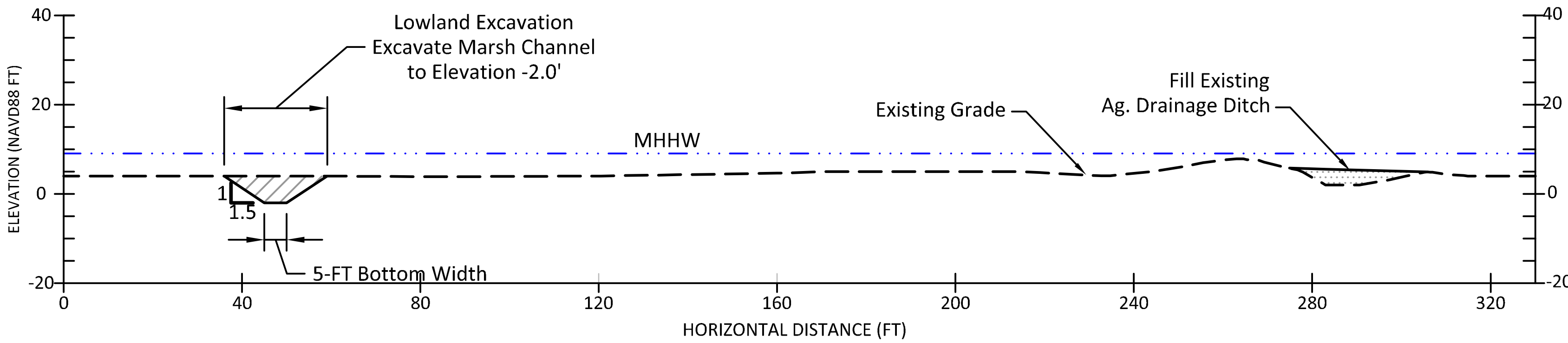
Lead Contractor: ESA
Design Lead: Anchor QEA, J Bilbee P.E.
Date: 02/18/2011

Conceptual Design Plan
Site Name: Smith Island
Action Name: Smith Island Estuary Restoration
PSNERP ID #: 1142
Partial Restoration

Figure 28-4



A FULL RESTORATION TYPICAL SECTION



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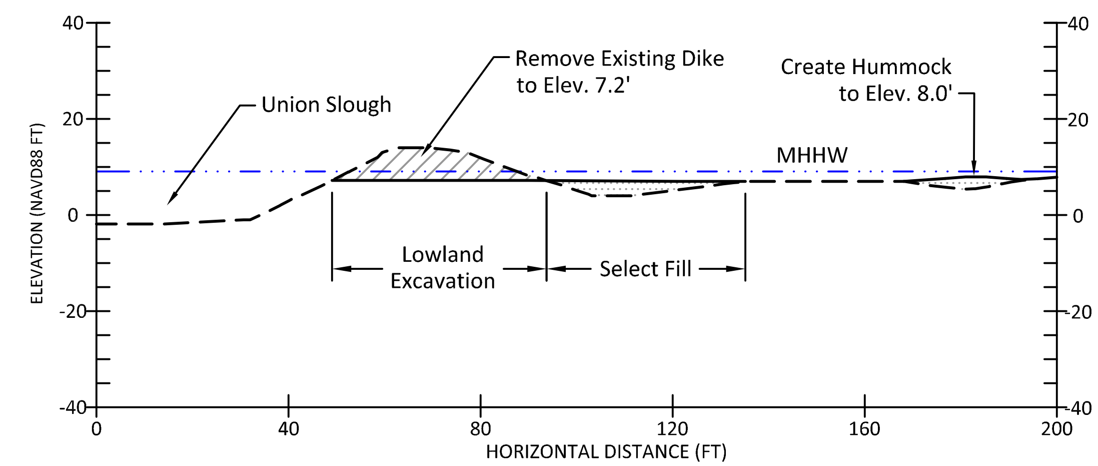
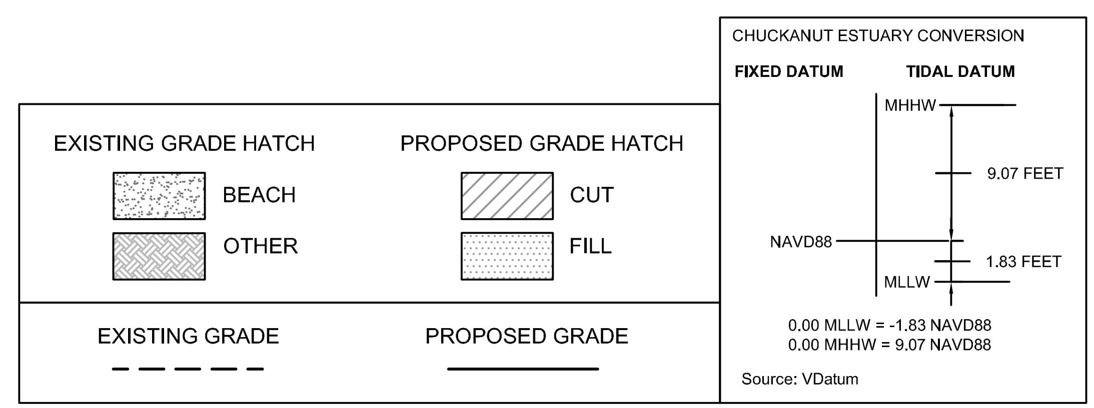
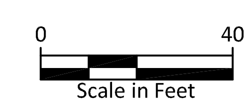


C FULL RESTORATION TYPICAL SECTION





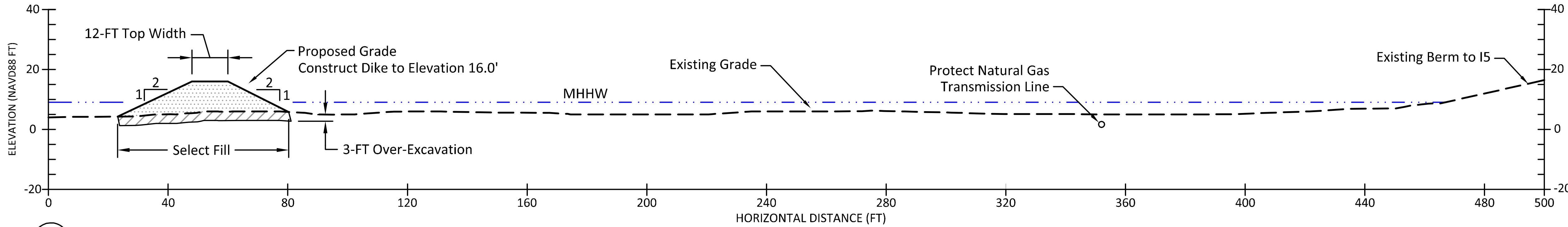
PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: Anchor
Date: 3/2011

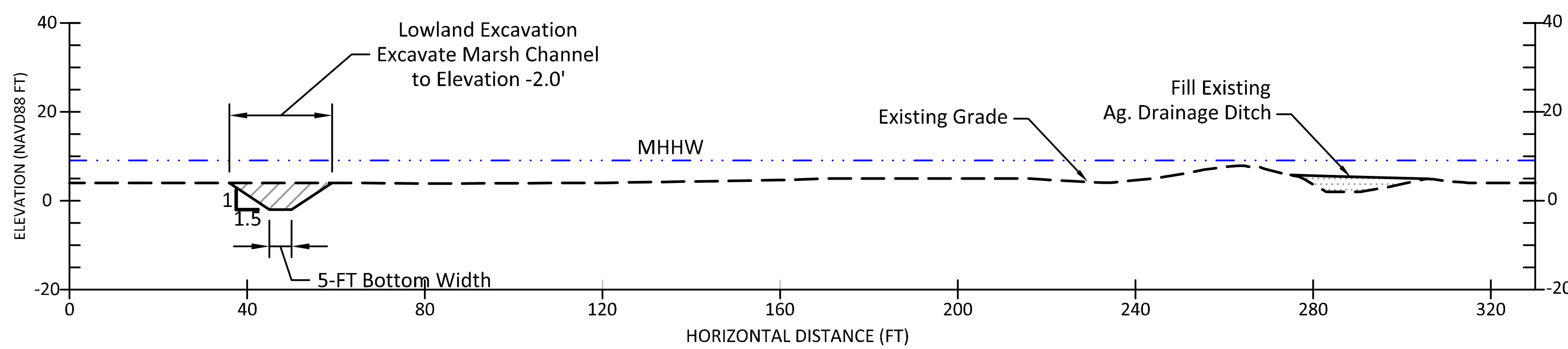
Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Section
SITE NAME: **Snohomish River Delta**
ACTION NAME: **Smith Island Estuary Restoration**
PSNERP ID#: **1142**
Full Restoration

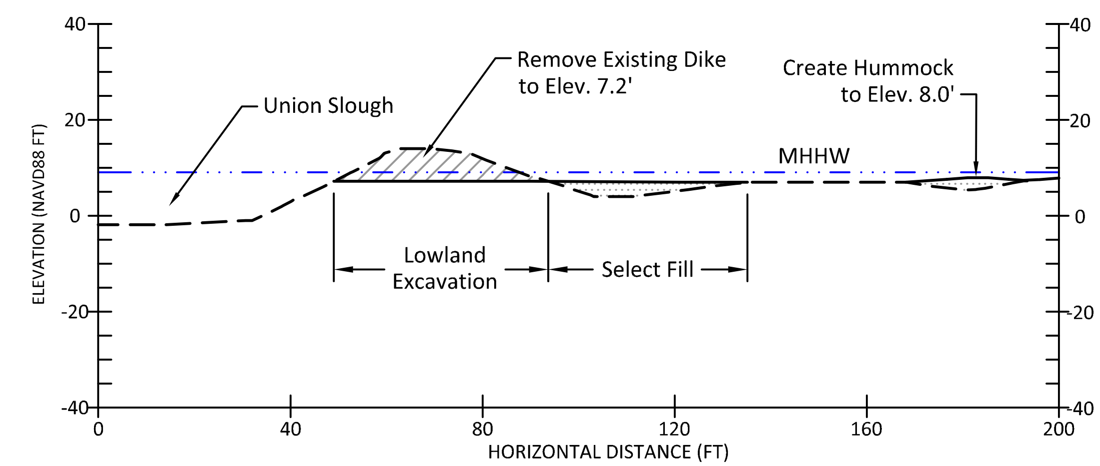
Figure 28-5



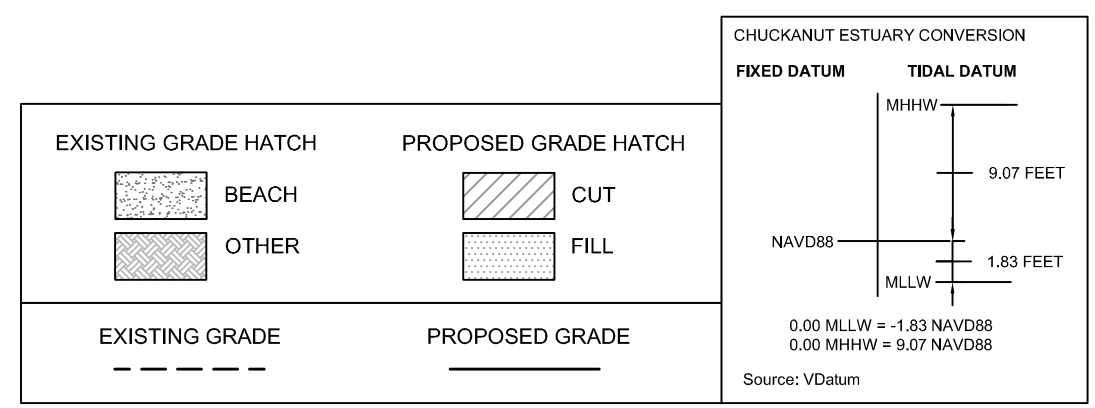
A PARTIAL RESTORATION TYPICAL SECTION

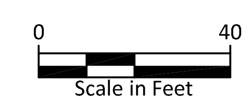


B PARTIAL RESTORATION TYPICAL SECTION



C PARTIAL RESTORATION TYPICAL SECTION





PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: Anchor
Date: 3/2011

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Section
SITE NAME: **Snohomish River Delta**
ACTION NAME: **Smith Island Estuary Restoration**
PSNERP ID#: **1142**
Partial Restoration

Figure 28-6

Full Restoration Quantity Estimate

Action Name: Smith Island
Action #: 1142
Date: February 2011
By: S. Page and J. Bibee, Anchor

REMEDY: ***Restore 483 acres of priority tidal estuarine marsh habitats through its reconnection to Union Slough; primary management measures required include removal of stressors including 1 mile of perimeter dike and existing tide gates ; sections of existing dike are proposed to remain, and construction of a setback dike is required to protect I-5*** **and major utility infrastructure; interior remnant agricultural drainage ditches are proposed to be filled with the dike removal spoils including areas of upland regrading.**
Construction Period: Estimate two construction summer seasons plus limited upland work over winter - estimated 8 to 14 months total

Item	Unit of Measure	Material Name	Qty	Description of Item		Indicate section of design report where item is described
ACQUISITION AND CONSERVATION				Based on available mapping information		
Required Project Lands	Acre		580	Total land required for action - Total area within action area. Approx. 483 ac. of that area would be restored to beneficial fish use through tidal/freshwater connection		28.3
Proponent / Partner-owned lands	Acre		149	Estimate of lands currently owned by Proponent (i.e., Public lands) - Government or quasi-government ownerships within the action area		28.3
Lands To Be Acquired	Acre		390	Estimate land required to be acquired for action prior to implementation - Total of 21 affected private parcels with 15 individual owners		28.3
Material Sites				Not Used: See Earthwork - Imported Fill.		
MOBILIZATION AND ACCESS for construction activities				Description required for each item to facilitate cost estimating		
Mobilization - Typical (Equipment, Personnel, Planning, Financial)	LS		1	Up front costs such as bonding, planning and other staff time and financing. Typically, assume 8% to 10% of other items.		28.3
Mobilization - Remote (Equipment, Personnel, Planning, Financial)	LS			Up front cost for nontypical or remote locations. Assume 12% of other items		
Site Access	LS			Use for special situations (e.g.. new bridge, new access roads) for the purposes of construction access. Include description.		
Barge Access	Days		40	May need barge access for a portion of the dike removal activities		28.3
Temporary Traffic Control (one of the following)				Includes installation of traffic signals, signage, signmen, etc. There are 4 types as follows:		
none	LS			None = no traffic control		
signs	LS		1	Signs = signs only, costs typically around 1% of total roadway costs		28.3
flags / spotters	LS		1	Flags and spotters = signs plus entails a greater level of effort. May need flaggers and spotters for 4 months to facilitate trucks entering and exiting the site. This can be about 3% of total roadway costs.		28.3
unique	LS			Unique = Greater effort than flags / spotters. Describe as basis for cost estimate.		
Temporary Roadway	SF			Includes construction of temporary adjacent roadway or bypass roadways and for vehicle and pedestrian travel through or around site.		
Control of Water	LS		1	May need to de-water footings of new set back dike. Maybe required for during the duration of the dike construction. Not possible to estimate with confidence at the 10% design as geotechnical evaluations are not available.		28.3
Relocation Activities				Not Used: See Utilities, Structures		
Site Demolition Activities				Demolition and removal of structures (description required), temporary features and relocations, itemized separately); Clearing and grubbing of vegetation, and removal of minor debris (rocks, slabs) - description required.		
Clearing and Grubbing (one or more of following)				Use one or more of the following categories of clearing and grubbing		
Clear Vegetation - Local Disposal	AC			Vegetation removed above grade and disposed locally		
Clear /Grub Vegetation - Local Disposal	AC			Vegetation roots also removed and disposed locally		
Clear /Grub Vegetation - Offsite Disposal	AC		5.85	Strip existing dike in areas for removal; assume 42.4 sf/lf of removal and 6,625 lf of dike.		28.3
Clear /Grub Vegetation - Offsite Disposal	AC		13.65	Strip footprint for new dike: assume 72 sf/lf of removal and 8,260 lf of dike		28.3
Clear /Grub Vegetation - Offsite Disposal	AC		12.83	Strip vegetation for new channels: assume 43 sf/lf of removal and 13,000 lf of channels		28.3
Clear /Grub Vegetation - Offsite Disposal	AC		13.99	Strip vegetation to fill old channels: assume 22 sf/lf of removal and 27,700 lf of drainage channels		28.3
Clear, stockpile - large woody debris	CY			Vegetation is segregated and stockpiled / prepared for reuse on site.		
Hydraulic Structures - Small	LS		1	Remove tide gate on Union Slough		28.3
Hydraulic Structures - Large	LS			Dam removal (describe and state whether this item includes water control and sediment removal or these are in separate items)		
Utilities	LF		826	OHP service to properties		28.3
Buildings	SF		5510	Permanent structures. Based on aerial there appears to be numerous containers that are assumed to be removed by the property owner		28.3
Pavement	LF or SF					
Bulkheads	LF or SF			Use this for bulkheads…if large and difficult, consider using Large Coastal Structures.		
Rock revetments	LF, Ton or CY		1	Unknown if rock revetment is present along existing dikes.		28.3
Large Coastal Structures	LF, SF or CY			Use this item for breakwaters, jetties, groins, reinforced concrete seawalls and any structure that requires larger equipment and power to break up and or remove		
Demolition / Removal - Bridge	SF or CY			Use this item for structures that require cranes or other special removal staging		
Removal - Misc. (e.g. angular rock from beach)	Ton			For loose rock scattered across intertidal.		
Demolition / Removal - Boat Ramp	SF			This is a special item but happens at least once…others can also be added as needed.		
Haul - Offsite Disposal of Demolition Debris	Miles		15	North County Recycling and Transfer Station 19600 63rd Avenue NE Arlington, WA		28.3
Hazardous/Contaminated Waste Removal				These items for earthwork of quality not compatible with wetlands, requiring special handling and disposal. Describe basis for classification as contaminated or hazardous. State known or suspected contamination, describe known similar work.		
Contaminated Earthwork	CY			Excavation, off haul and disposal within a licensed landfill, complete		
Hazardous Earthwork	CY			Excavation, off haul and disposal within a licensed hazardous waste landfill, complete		
Construct Temporary Features				Use as needed for unusual temporary features not included elsewhere (see TESC below)		
EARTHWORK				Expand to include equipment, etc. to facilitate cost estimating.		
Excavation	CY			Per yard excavation w/out expected haul		
Excavation - Upland	CY		31707	Excavate existing dike: assume 5.28 cy/lf and 6,625 lf, may require some in water work to remove segments of dikes at channel openings		28.3
Excavation - Upland	CY		44053	Over-excavation for new dike: assume 5.33 cy/lf and 8,260 lf		28.3
Excavation - Lowland	CY		30092	Excavation of new channels		28.3
Dredging - Bucket - Land	CY			Excavation below ground water or underwater; reach limited low production.		
Dredging - Bucket - Marine	CY			Floating or amphibious equipment with excavator, clamshell or dragline bucket		
Dredging - Hydraulic	CY			Hydraulic cutter / suction dredge to slurry and pump sediments		
Fine Grading	AC			Small tolerance grading after rough grading.		
Fill Placement - local borrow				This is additive to Earthwork -Excavation		
Side cast	CY			Excavated material placed within reach of excavator / dredge - assume includes some shaping by bucket		
Haul - uncontrolled placement	CY		105852	Haul stockpiled materials to fill locations- less than 1 mile.		28.3
Haul, place, compact	CY			Transportation and second handling - estimate distance, placement in lifts, moisture conditioning, compaction testing.		
Stockpile - uncontrolled placement	CY		105852	Temporary stockpile of excavated materials for channel filling		28.3
Stockpile - controlled placement	CY			intermediate step, for subsequent off haul or use elsewhere on site. Can use this for drying material for subsequent controlled compacted fill		
Conveyor placement from stockpile land/water	CY			Some projects may require conveyor placement		
Imported Fill				Includes purchase, delivery and placement or as noted / described		
Select Fill	CY		192733	Imported select material - Dike construction		28.3
Gravel Borrow, including haul	CY			WSDOT standard item		
Sand / Gravel for Beach Nourishment	CY			special borrow and sorting required; identify material source		
Cobble for Shore Nourishment	CY			special borrow and sorting required; identify material source		
Embankment Compaction	CY		192733	WSDOT standard item		28.3
Topsoil	CY					
RESTORATION Features						
Channel Rehab / Creation	SF			Channel construction (SF) including imported sediment and habitat materials, excluding excavation		

Full Restoration Quantity Estimate

Action Name: Smith Island
Action #: 1142
Date: February 2011
By: S. Page and J. Bibee, Anchor

REMEDY: ***Restore 483 acres of priority tidal estuarine marsh habitats through its reconnection to Union Slough; primary management measures required include removal of stressors including 1 mile of perimeter dike and existing tide gates ; sections of existing dike are proposed to remain, and construction of a setback dike is required to protect I-5*** **and major utility infrastructure; interior remnant agricultural drainage ditches are proposed to be filled with the dike removal spoils including areas of upland regrading.**
Construction Period: Estimate two construction summer seasons plus limited upland work over winter - estimated 8 to 14 months total

Item	Unit of Measure	Material Name	Qty	Description of Item		Indicate section of design report where item is described
Large Wood Placement	EA			Per each log, Including drift logs, lower river log jams, etc.		
Invasive Species Control	Acre			Per acre control described in drawings and narrative		
Physical Exclusion Devices	LF or EA			Human or wildlife exclusions including fences, barriers, mooring buoys, etc		
Other Restoration Features/ Activities	LS			Describe other items not included elsewhere		
Structures	EA			KPFF to provide additional inputs		
Water Control Structures - Culverts with Gates	EA			Describe type, number of openings (e.g. pipes), expected materials, dimensions		
Water Control Structures - Weirs	EA			Describe, length, type, anticipated materials		
Rock Slope Protection	LF			Describe slope, rock size, layering, use of fabric, back up quantities per foot.		
Other	EA			Describe		
Elevated Boat Ramp	SF			Pile or pier supported to allow sediment drift		
Fencing	SF			Describe, type, height etc.		
Utilities				Replacement or relocation. Designer to provide size and material and have separate line item for each run. Incidentals include earthwork, testing, hook up fees, etc. These quantities do not include demolition of existing utilities, real estate / easements, design fees. Describe the owner if known, and whether utility franchise will install (e.g.. electric is typically installed by electrical franchise).		
Water	LF					
Gas	LF		1	Locate and protect existing natural gas transmission pipeline		28.3
Electric	LF					
Sewer	LF					
Telecommunications	LF		1	Locate and protect existing telecommunications lines		28.3
Other	LF		1	Williams NG Transmission Line. Unable to provide credible estimate at 10% design. Line is regulated by USDOT. Likely additional engineering studies will be required by Williams the demonstrate that line meets standards.		
Roadway / Railway				KPFF expected to participate in these estimates		
Roadway (Type_)	SF			Typical roadway, not including earthwork and temporary or permanent traffic controls. Provide a description. Assume a standard pavement section or describe if special section anticipated.• Pavement• Base Course• Storm Drainage Collection and Conveyance (incl. trenching, backfill, etc.)• Stormwater Treatment		
Roadway - Traffic Signal	LS			Street lights, etc. (Temporary traffic control handled under Temporary Facilities)		
Culvert (type)	LF			Provide specific culver size and type		
Culvert - Jacking	LF			Through railway		
Culvert - Horizontal Pile Driving	LF			Through railway		
Bridge - Foundations, Deck and Appurtenances	SF			Include elements such as approach slab, abutment, barriers, railings, etc. to conform to one of three or four types to be developed		
Railway - Box Girder	SF			Standard		
Railway - Foundation	LF			Standard		
Railway - Shoe fly	LF			Temporary alignment		
Permanent Access Features				KPFF expected to participate in these estimates		
Roads	Level			Level 1 direct access, Level 2 moderately difficult, Level 3 difficult access		
Utility Access Routes	L.F.		8260	Dike top all-weather gravel road		28.3
Erosion Control Features	L.F.			Describe quantity of expected erosion control measures		
Public Access or Recreation Features				KPFF expected to participate in these estimates		
Trails	SF			Describe trail feature, such as gravel, mulch, asphalt concrete.		
Bridges	SF		4,200	Pedestrian bridge type H20 vehicle bridges (2 at 150 lf)		28.3
Kiosk	EA			Describe kiosk feature, such as size, material.		
Restrooms	EA			Describe restroom feature, such as size, material.		
Interpretive Signs	EA		2	Include # interpretive signs based on number of local public access points		28.3
Parking Area	SF			Describe parking area, such as size, material.		
Other	EA			Describe other recreational features (see Corps criteria, ER 1105-2-100 for compatibility with ecosystem objectives)		
Vegetation & Erosion Control						
Hydroseeding	AC		12.7	Native seed grass seed mix for new dike slopes.		28.3
Planting	AC		1.4	Plant with native shrub/scrub species		28.3
Vegetation Maintenance	AC-YR			Includes irrigation, weeding, plant replacement for one year		
Erosion / sediment BMPs - Temp.	AC		0.25	Generally drainage is controled by onsite ditch network and perimeter dikes. Need entrance / exit controls to prevent track out.		28.3
Erosion / sediment BMPs - Permanent	AC			May want to separate slopes over 25% into separate category		
Waterside controls - Temporary	EA, LF, LS			Silt curtain or other water based temporary actions		
Construction Management						
Construction oversight	weeks		27	3 month construction season for two seasons.		28.3
Materials testing				Included in cost of material - no separate quantity		
Design and Detailed Site Investigations						
Survey & Property, Utility Research	LS		1	% of construction cost		28.8
35% Design	LS		1	35% x 25% x Engineer's Estimate		28.8
65% design	LS		1	65% x 25% x Engineer's Estimate less the cost for 35% PS&E		28.8
90% design	LS		1	35% x 25% x Engineer's Estimate less the cost for 35% + 65%PS&E		28.8
100% design	LS		1	25% x Engineer's Estimate less previous costs		28.8
Geotechnical Studies	LS		1	Geotech study needed to design new dike. Refer to design report for detailed description of need.		28.8
Cultural Studies	LS		1	May require additional survey as "Full Restoration" incorporates more area than that evaluated by local sponser. Refer to design report for description of need.		28.8
HTWR Studies	LS		1	Parcels included in full restoration may have stored pretoleum products and pesticides. These may not have been investigated by local sponser. Refer to design report for description of need.		28.8
Project Agreement Activities				Unable to provide credibale estimate at 10% design		
Site-Specific Adaptive Management Features & Activities				List if known		
Monitoring Activities				Assume 5 crew-days/year for each monitoring parameter in design report for 5 yrs		
Monitoring (Type_)	crew-days		125			
Operations & Maintenance				Unable to provide credible estimate at 10% design		

Partial Restoration Quantity Estimate

Action Name: Smith Island
Action #: 1142
Date: February 2011
By: S. Page and J. Bibee

REMEDY: ***Restore from 410 to more than 483 acres (depending on the alternative) of priority tidal estuarine marsh habitats through its reconnection to Union Slough; primary management measures required include removal of stressors including 1 mile of perimeter dike and existing tide gates ; sections of existing dike are proposed to remain, and construction of a setback dike is required to protect I-5 and major utility infrastructure; interior remnant agricultural drainage ditches are proposed to be filled with the dike removal spoils including areas of upland regrading.***
Construction Period: Estimate two construction summer seasons plus limited upland work over winter - estimated 8 to 14 months total

Item	Unit of Measure	Material Name	Qty	Description of Item	Indicate section of design report where item is described
ACQUISITION AND CONSERVATION				Based on available mapping information	
Required Project Lands	Acre			Total land required For action	
Proponent / Partner-owned lands	Acre			Etimate of lands currently owned by Proponent (i.e., Public lands)	
Lands To Be Acquired	Acre			Estimate land required to be acquired for action prior to implementation	
Material Sites				Not Used: See Earthwork - Imported Fill.	
MOBILIZATION AND ACCESS for construction activities				Description required for each item to facilitate cost estimating	
Mobilization - Typical (Equipment, Personnel, Planning, Financial)	LS		1	Up front costs such as bonding, planning and other staff time and financing. Typically, assume 8% to 10% of other items.	28.3
Mobilization - Remote (Equipment, Personnel, Planning, Financial)	LS			Up front cost for nontypical or remote locations. Assume 12% of other items	
Site Access	LS			Use for special situations (e.g.. new bridge, new access roads) for the purposes of construction access. Include description.	
Barge Access	Days		40	May need barge access for a portion of the dike removal activities	28.3
Temporary Traffic Control (one of the following)				Includes installation of traffic signals, signage, signmen, etc. There are 4 types as follows:	
none	LS			None = no traffic control	
signs	LS		1	Signs = signs only, costs typically around 1% of total roadway costs	28.3
flags / spotters	LS		1	Flags and spotters = signs plus entails a greater level of effort. May need flaggers and spotters for 4 months to facilitate trucks entering and exiting the site. This can be about 3% of total roadway costs.	28.3
unique	LS		1	Unique = Greater effort than flags / spotters. Describe as basis for cost estimate.	28.3
Temporary Roadway	SF			Includes construction of temporary adjacent roadway or bypass roadways and for vehicle and pedestrian travel through or around site.	
Control of Water	LS		1	May need to de-water footings of new set back dike. Maybe required for during the duration of the dike construction. Not possible to estimate with confidence at the 10% design as geothechnical evaluations are not available.	28.3
Relocation Activities				Not Used: See Utilities, Structures	
Site Demolition Activities				Demolition and removal of structures (description required), temporary features and relocations, itemized separately); Clearing and grubbing of vegetation, and removal of minor debris (rocks, slabs) - description required.	
Clearing and Grubbing (one or more of following)				Use one or more of the following categories of clearing and grubbing	
Clear Vegetation - Local Disposal	AC			Vegetation removed above grade and disposed locally	
Clear /Grub Vegetation - Local Disposal	AC			Vegetation roots also removed and disposed locally	
Clear /Grub Vegetation - Offsite Disposal	AC		4.67	Strip existing dike in areas for removal; assume 42.4 sf/lf of removal and 4,825 lf of dike.	28.3
Clear /Grub Vegetation - Offsite Disposal	AC		14.58	Strip footprint for new dike: assume 72 sf/lf of removal and 8,825 lf of dike	28.3
Clear /Grub Vegetation - Offsite Disposal	AC		7.5	Strip vegetation for new channels: assume 43 sf/lf of removal and 7,600 lf of channels	28.3
Clear /Grub Vegetation - Offsite Disposal	AC		4.65	Strip vegetation to fill old channels: assume 22 sf/lf of removal and 9,200 lf of drainage channels	28.3
Clear, stockpile - large woody debris	CY			Vegetation is segregated and stockpiled / prepared for reuse on site.	
Hydraulic Structures - Small	LS		1	Remove tide gate on Union Slough	28.3
Hydraulic Structures - Large	LS			Dam removal (describe and state whether this item includes water control and sediment removal or these are in separate items)	
Utilities	LF				
Buildings	SF			Permanent structures. Based on aerial there appears to be numerous containers that are assumed to be removed by the property owner	
Pavement	LF or SF				
Bulkheads	LF or SF			Use this for bulkheads…if large and difficult, consider using Large Coastal Structures.	
Rock revetments	LF, Ton or CY		1	Unknown if rock revetment is present along existing dikes.	28.3
Large Coastal Structures	LF, SF or CY			Use this item for breakwaters, jetties, groins, reinforced concrete seawalls and any structure that requires larger equipment and power to break up and or remove	
Demolition / Removal - Bridge	SF or CY			Use this item for structures that require cranes or other special removal staging	
Removal - Misc. (e.g. angular rock from beach)	Ton			For loose rock scattered across intertidal.	
Demolition / Removal - Boat Ramp	SF			This is a special item but happens at least once…others can also be added as needed.	
Haul - Offsite Disposal of Demolition Debris	Miles		15	North County Recycling and Transfer Station 19600 63rd Avenue NE Arlington, WA	28.3
Hazardous/Contaminated Waste Removal				These items for earthwork of quality not compatible with wetlands, requiring special handling and disposal. Describe basis for classification as contaminated or hazardous. State known or suspected contamination, describe known similar work.	
Contaminated Earthwork	CY			Excavation, off haul and disposal within a licensed landfill, complete	
Hazardous Earthwork	CY			Excavation, off haul and disposal within a licensed hazardous waste landfill, complete	
Construct Temporary Features				Use as needed for unusual temporary features not included elsewhere (see TESC below)	
EARTHWORK				Expand to include equipment, etc. to facilitate cost estimating.	
Excavation	CY			Per yard excavation w/out expected haul	
Excavation - Upland	CY		25,344	Excavate existing dike: assume 5.28 cy/lf and 4,825 lf	28.3
Excavation - Upland	CY		47,037	Over-excavation for new dike: assume 5.33 cy/lf and 8,825 lf	28.3
Excavation - Lowland	CY		17,480	Excavation of new channels	28.3
Dredging - Bucket - Land	CY			Excavation below ground water or underwater; reach limited low production.	
Dredging - Bucket - Marine	CY			Floating or amphibious equipment with excavator, clamshell or dragline bucket	
Dredging - Hydraulic	CY			Hydraulic cutter / suction dredge to slurry and pump sediments	
Fine Grading	AC			Small tolerance grading after rough grading.	
Fill Placement - local borrow				This is additive to Earthwork -Excavation	
Side cast	CY			Excavated material placed within reach of excavator / dredge - assume includes some shaping by bucket	
Haul - uncontrolled placement	CY		89,861	Haul stockpiled materials to fill locations- less than 1 mile.	28.3
Haul, place, compact	CY			Transportation and second handling - estimate distance, placement in lifts, moisture conditioning, compaction testing.	
Stockpile - uncontrolled placement	CY		89,861	Temporary stockpile of excavated materials for channel filling	28.3
Stockpile - controlled placement	CY			intermediate step, for subsequent off haul or use elsewhere on site. Can use this for drying material for subsequent controlled compacted fill	
Conveyor placement from stockpile land/water	CY			Some projects may require conveyor placement	
Imported Fill				Includes purchase, delivery and placement or as noted / described	
Select Fill	CY		205,622	Imported select material - Dike construction	28.3
Gravel Borrow, including haul	CY			WSDOT standard item	
Sand / Gravel for Beach Nourishment	CY			special borrow and sorting required; identify material source	
Cobble for Shore Nourishment	CY			special borrow and sorting required; identify material source	
Embankment Compaction	CY		205622	WSDOT standard item	28.3
Topsoil	CY				
RESTORATION Features					
Channel Rehab / Creation	SF			Channel construction (SF) including imported sediment and habitat materials, excluding excavation	
Large Wood Placement	EA			Per each log, Including drift logs, lower river log jams, etc.	
Invasive Species Control	Acre			Per acre control described in drawings and narrative	
Physical Exclusion Devices	LF or EA			Human or wildlife exclusions including fences, barriers, mooring buoys, etc	

Partial Restoration Quantity Estimate

Action Name: Smith Island
Action #: 1142
Date: February 2011
By: S. Page and J. Bibee

REMEDY: ***Restore from 410 to more than 483 acres (depending on the alternative) of priority tidal estuarine marsh habitats through its reconnection to Union Slough; primary management measures required include removal of stressors including 1 mile of perimeter dike and existing tide gates ; sections of existing dike are proposed to remain, and construction of a setback dike is required to protect I-5 and major utility infrastructure; interior remnant agricultural drainage ditches are proposed to be filled with the dike removal spoils including areas of upland regrading.***

Construction Period: Estimate two construction summer seasons plus limited upland work over winter - estimated 8 to 14 months total

Item	Unit of Measure	Material Name	Qty	Description of Item	Indicate section of design report where item is described
Other Restoration Features/ Activities	LS			Describe other items not included elsewhere	
Structures	EA			KPFF to provide additional inputs	
Water Control Structures - Culverts with Gates	EA			Describe type, number of openings (e.g. pipes), expected materials, dimensions	
Water Control Structures - Weirs	EA			Describe, length, type, anticipated materials	
Rock Slope Protection	LF			Describe slope, rock size, layering, use of fabric, back up quantities per foot.	
Other	EA			Describe	
Elevated Boat Ramp	SF			Pile or pier supported to allow sediment drift	
Fencing	SF			Describe, type, height etc.	
Utilities				Replacement or relocation. Designer to provide size and material and have separate line item for each run. Incidentals include earthwork, testing, hook up fees, etc. These quantities do not include demolition of existing utilities, real estate / easements, design fees. Describe the owner if known, and whether utility franchise will install (e.g.. electric is typically installed by electrical franchise)	
Water	LF				
Gas	LF		1	Locate and protect existing natural gas transmission pipeline	28.3
Electric	LF				
Sewer	LF				
Telecommunications	LF		1	Locate and protect existing telecommunications lines	28.3
Other	LF		1	Williams NG Transmission Line. Unable to provide credible estimate at 10% design. Line is regulated by USDOT. Likely additional engineering studies will be required by Williams the demonstrate that line meets standards	28.3
Roadway / Railway				KPFF expected to participate in these estimates	
Roadway (Type_)	SF			Typical roadway, not including earthwork and temporary or permanent traffic controls. Provide a description. Assume a standard pavement section or describe if special section anticipated.• Pavement• Base Course• Storm Drainage Collection and Conveyance (incl. trenching, backfill, etc.)• Stormwater Treatment	
Roadway - Traffic Signal	LS			Street lights, etc. (Temporary traffic control handled under Temporary Facilities)	
Culvert (type)	LF			Provide specific culver size and type	
Culvert - Jacking	LF			Through railway	
Culvert - Horizontal Pile Driving	LF			Through railway	
Bridge - Foundations, Deck and Appurtenances	SF			Include elements such as approach slab, abutment, barriers, railings, etc. to conform to one of three or four types to be developed	
Railway - Box Girder	SF			Standard	
Railway - Foundation	LF			Standard	
Railway - Shoe fly	LF			Temporary alignment	
Permanent Access Features				KPFF expected to participate in these estimates	
Roads	Level			Level 1 direct access, Level 2 moderately difficult, Level 3 difficult access	
Utility Access Routes	L.F.		8,825	Dike top all-weather gravel road	28.3
Erosion Control Features	L.F.			Describe quantity of expected erosion control measures	
Public Access or Recreation Features				KPFF expected to participate in these estimates	
Trails	SF			Describe trail feature, such as gravel, mulch, asphalt concrete.	
Bridges	SF		0	Pedestrian bridge type H20 vehicle bridges	
Kiosk	EA			Describe kiosk feature, such as size, material.	
Restrooms	EA			Describe restroom feature, such as size, material.	
Interpretive Signs	EA		2	Include # interpretive signs based on number of local public access points	28.3
Parking Area	SF			Describe parking area, such as size, material.	
Other	EA			Describe other recreational features (see Corps criteria, ER 1105-2-100 for compatibility with ecosystem objectives)	
Vegetation & Erosion Control					
Hydroseeding	AC		13.57	Native seed grass seed mix for new dike slopes.	28.3
Planting	AC		10.5	Plant with native shrub/scrub species	28.3
Vegetation Maintenance	AC-YR			Includes irrigation, weeding, plant replacement for one year	
Erosion / sediment BMPs - Temp.	AC		0.25	Generally drainage is controled by onsite ditch network and perimeter dikes. Need entrance / exit controls to prevent track out.	28.3
Erosion / sediment BMPs - Permanent	AC			May want to separate slopes over 25% into separate category	
Waterside controls - Temporary	EA, LF, LS			Silt curtain or other water based temporary actions	
Construction Management					
Construction oversight	weeks		27	3 month construction season for two seasons.	28.3
Materials testing				Included in cost of material - no separate quantity	
Design and Detailed Site Investigations					
Survey & Property, Utility Research	LS		1	% of construction cost	28.8
35% Design	LS		1	35% x 25% x Engineer's Estimate	28.8
65% design	LS		1	65% x 25% x Engineer's Estimate less the cost for 35% PS&E	28.8
90% design	LS		1	35% x 25% x Engineer's Estimate less the cost for 35% + 65%PS&E	28.8
100% design	LS		1	25% x Engineer's Estimate less previous costs	28.8
Geotechnical Studies	LS		1	Geotech study needed to design new dike. Refer to design report for detailed description of need.	28.8
Cultural Studies	LS			Refer to design report for description of need.	
HTWR Studies	LS			Refer to design report for description of need.	
Project Agreement Activities				Unable to provide credibale estimate at 10% design	
Site-Specific Adaptive Management Features & Activities				List if known	
Monitoring Activities				Assume 5 crew-days/year for each monitoring parameter in design report for 5 yrs	
Monitoring (Type_)	crew-days		125		
Operations & Maintenance				Unable to provide credible estimate at 10% design	

29. SNOHOMISH ESTUARY MAINSTEM CONNECTIVITY PROJECTS (#1805)

Local Proponent	Tulalip Tribes
Delta Process Unit	Delta SNH
Shoreline Process Unit(s)	NA
Strategy(ies)	1 - River Delta
Restoration Objectives	Restore tidal hydrology and channel morphology along the mainstem Snohomish River. Restore and enhance connectivity between the mainstem of the river and distributary channels of the lower Snohomish Estuary

29.1 Description of the Action

This action will restore and enhance connectivity between the Snohomish River mainstem and distributary channels of the lower Snohomish Estuary. This action involves recreating a former distributary channel near Dagmar's Marina and reengaging a blind slough north of Langus Riverfront Park.

29.2 Action Area Description and Context

The Snohomish River Estuary is the second largest estuary in Puget Sound. The estuary includes the mainstem Snohomish River, and the distributaries of Ebey, Steamboat, and Union Sloughs. The estuary provides critically important spawning and rearing habitat for salmonids including: Chinook, coho, chum, pink, and sockeye salmon; steelhead and rainbow trout; cutthroat trout; and bull trout.

Estuarine habitat restoration is a cornerstone of the Snohomish Basin salmon recovery strategy. Projects are underway to restore hundreds of acres located primarily in the northeast estuary along Union, Steamboat, and Ebey Sloughs. The Salmon Recovery Plan indicates the importance of improving habitat along the Snohomish River mainstem in the estuary, given its high proportion of flow relative to the sloughs, high densities of juvenile salmonids, and substantial habitat degradation.

Two potential locations for enhancing mainstem connectivity were selected from a number of potential locations identified by the local proponent. These locations are referred to here as the Distributary Channel and the Blind Slough. Both locations provide sound opportunities to increase habitat complexity because of their relatively clear historical condition. These locations were selected because of the potential to reestablish features of the historical channel environment by restoring tidal hydrology along the mainstem.

The two locations selected for the mainstem connectivity action are located in relatively highly altered and urbanized environments. The Blind Slough connection is located on the right (east) bank of the mainstem, just north of the I-5 river crossing, on the west side of Smith Island and the Everett Water Pollution Control Facility (WPCF). The Distributary Channel is located a short distance downstream, near Dagmar's Marina on the north bank of the mainstem channel between I-5 and State Route 529. The action area is shown in Figure 29-1.

Figure 29-1. Action Area and Vicinity

29.2.1 Historic Condition

The lower Snohomish River Estuary historically included a number of distributary channels and extensive intertidal habitats. Historical mapping (ca. 1884-1885) of the estuary shows similar lengths of the mainstem and major distributary channels as exist today, but also greater densities of tidal channels and more interconnections between the larger channels. Haas and Collins (2001) provide a detailed description of the historical Snohomish River valley.

For the Distributary Channel, the 1938 photo shows a free-flowing channel approximately 200 feet wide that connects the mainstem to Union Slough. By that time, one bridge had been constructed at the southern end of the slough. This southern area has subsequently been completely filled, and the northern slough connection has been disconnected by a levee. The slough channel remains throughout much of its length, but it has become dominated by weeds and has been filled in places. The surrounding area was once salt marsh and tidally influenced pine forest, based on the T-sheets, but portions have been filled to support other activities in the area (Figures 29-2A and 29-2B).

The Blind Slough formed as the most significant drainage in the southern portion of Smith Island. Based on the 1938 photo, a channel system more than 5,800 feet long drained at least 190 acres of the floodplain. Only the lower 1,500 feet of the channel still exists. The remainder of the drainage network was filled for the installation of the Everett WPCF and I-5.

29.2.2 Natural Environment

The Snohomish River drains roughly 1,860 square miles in King and Snohomish Counties. The lower Snohomish Estuary is a broad alluvial plain that covers around 25 square miles, where tidal influence dominates most low flow water levels. Flood flows from the watershed can dominate water levels for up to 2 weeks during significant events.

Distributary Channel

The Distributary Channel is shown on the T-sheets and on the 1938 aerial photograph (Figures 29-2A and 29-2B). The T-sheets suggest that the channel was part of a tidal drainage system extending into Smith Island. By 1938, it appears that levees had been installed and agriculture was the dominant land use, but the channel still was connected to the mainstem under a bridge span.

Currently, the Distributary Channel functions as a freshwater wetland, providing drainage from the interior of Smith Island to Union Slough. The connection to the Snohomish River is completely blocked by fill. Drainage is focused in a tide gate located at the north end of the former slough channel. The tide gate provides drainage through a levee that blocks the mouth of the former channel. The existing wetland has open water components in the former channel, and is otherwise dominated by reed canarygrass.

Blind Slough

Only a small portion of the former Blind Slough system currently exists as an open water wetland near the former mouth. The surrounding area functions as either wetland (to the north), or as vegetated upland (to the west). The connection from the open water wetland to the Snohomish River is unknown. Several tide-gated culverts in the general area may provide drainage to the river.

29.2.3 Human Environment

Distributary Channel

The former Distributary Channel has been completely disconnected from tidal action by a levee with tide gate to the north, and through road fill (Ross Avenue/Smith Island Road) to the south. Portions of the former marsh surface within the levees have been converted to agriculture and/or filled to support development. A number of active operations (Buse Lumber Mill, Glacier Facility, Dagmar's Marina) are located in the former tidal drainage area.

Blind Slough

The former Blind Slough tidal drainage network has been significantly altered with the installation of Smith Island Road, I-5, the Everett WPCF, and portions of Langus Riverfront Park. This location has also been used as a dredge disposal site for materials removed from the Snohomish River. These alterations limit the ability of restoration actions to achieve the historical condition.

29.3 Restoration Design Concept

29.3.1 Restoration Overview and Key Design Assumptions

The mainstem connectivity action has two elements: (1) restoring the Distributary Channel to the north, and (2) reengaging the Blind Slough north of Langus Riverfront Park. The restoration alternatives are illustrated in Figures 29-3 through 29-11. At each location, there is a full and partial restoration alternative as described below.

Distributary Channel

The Distributary Channel action is located between I-5 and State Route 529. A relict channel in this location once connected the mainstem Snohomish River to Union Slough, as documented in the T-sheets and the 1938 aerial photograph. The channel has been completely filled at the southern connection to the mainstem, and leveed at the northern connection to Union Slough. A road crossing at 28th Place provides access to the Buse Lumber Mill. Ross Avenue is the only surface access to the southern portion of Smith Island.

The Distributary Channel will be reconnected at the north and south ends, and flood protection levees installed in both the full and partial restoration alternatives. In the full restoration alternative, the flood protection levees will be set back from the relict channel where possible. This will allow for greater fill removal and restoration of fringing intertidal marsh, similar to, but smaller than, the historical condition. The channel would be dredged to approximately MLLW elevation to allow for full tidal flux through the restored channel immediately after construction. Minimal rock slope protection would be required since the levees would be set back from concentrated flow.

The full restoration alternative (Figure 29-3) would eliminate the 28th Place crossing, relocating the access road to the eastern setback levee along the restored slough channel. A new 330-foot span bridge would be installed on Ross Avenue. This span was selected to allow for an opening similar to the historical condition.

In the partial restoration alternative (Figure 29-4), the flood protection levees will be constructed along the sides of the relict slough channel. Therefore the width of the intertidal area would be less than the full restoration alternative, and continuous rock slope protection would be required along the levee. The width of the levees in the partial restoration alternative was selected to provide for a channel that at a minimum would be able to adjust to the tidal prism within the channel, using regional regressions provided in Appendix C. Tidal volumes were adjusted up by 50% to account for some of the uncertainty in how fluvial flows influence channel form in this location. In general this width is larger than the existing Union Slough on the east side of Smith Island, but is smaller than Union Slough directly downstream of the action area.

Both existing road crossings (28th Place and Ross Avenue) would remain for the partial restoration alternative, replaced with bridges sufficient to span the setback levee width.

Key design elements associated with the full and partial restoration alternatives for the Distributary Channel are shown in Table 29-1.

Table 29-1. Key Design Elements for the Distributary Channel

Element	Full Restoration	Partial Restoration
Distributary Channel		
Fill Removal	Remove through fill road to reconnect the slough to the south to replicate 1938 alignment. Remove fill placed within former tidal marsh.	Remove fill to reconnect the slough to the south to provide minimum opening size.
Levee Removal	Remove portion of levee to connect to Union Slough.	Same as full restoration.
Flood Protection Levees	Provide flood protection (10-year plus 2, plus 1) with levees opportunistically routed to provide fringing marsh habitat in addition to distributary channel.	Provide flood protection (10-year plus 2, plus 1) with levees along either side of the distributary slough channel.
Dredge Existing Channel	Excavate slough to -2 feet NAVD 88 (approximately MLLW).	Minor removal of fill in slough.
Rock Slope Protection	Potentially required along southern opening.	Proposed along length of levee face.
Ross Avenue/Smith Island Road		
Roadway Pavement	Remove 1,030 feet, add 700 feet new pavement.	Remove 860 feet, add 700 feet new pavement.
Bridge	Add one 330-foot bridge (three spans).	Add one 160-foot bridge (single span).
28th Place		
Pavement	Remove 1,075 feet, add 2,150 feet new pavement.	Remove 690 feet, add 500 feet new pavement.
Culvert	Remove box culvert.	Remove box culvert.
Bridge	No new crossing proposed.	One 190-foot bridge (single span).

Blind Slough

The Blind Slough action is located along Smith Island Road, between I-5 and the mainstem. A small portion of a remnant channel system that once drained a significant portion of southern Smith Island still exists in this location. The drainage area has been substantially modified from the historic condition with the installation of agricultural levees, I-5, and the Everett WPCF. This area has also apparently been used as a dredge spoil disposal site for sediments removed from the mainstem.

The overall objective in this area is to remove fill associated with Smith Island Road to allow tides to enter the area, remove fill within the former Distributary Channel system to maximize intertidal area within the footprint, and plant a marine riparian vegetation community around the perimeter of the project. Both full and partial restoration alternatives require the installation of a bridge to allow continued access to the south end of Smith Island. Both alternatives would also include a berm with a drainage culvert that would represent the extent of tidal influence. This berm is necessary to prevent tides and high river flows from reaching the access road to the WPCF and portions of the facility itself.

The full restoration alternative (Figure 29-5) includes a 220-foot span that would allow for dynamic processes to function at the mouth of the blind channel. This width was selected based on the historical opening width, which had adjusted to a much larger drainage area. Fill removal would occur in two areas, one directly east of Smith Island Road, and one south of the Everett Animal Shelter. The full restoration alternative would extend tidal influence to a narrow area below I-5.

The partial restoration alternative (Figure 29-6) includes an 80-foot span, which was determined from the tidal prism in the fill removal/Distributary Channel area. The setback berm for the partial restoration alternative is proposed at a narrow area due east from the Everett Animal Shelter, providing approximately half the length of the full restoration alternative. The fill removal area and volume are similarly reduced.

Key design elements associated with the full and partial restoration alternatives for the Blind Slough are shown in Table 29-2.

Table 29-2. Key Design Elements for the Blind Slough

Element	Full Restoration	Partial Restoration
Blind Slough		
Fill Removal	Remove fill to provide single opening at 1938 location and approximate width.	Remove fill to provide single opening at 1938 location with minimum width for anticipated tidal prism.
Fill Removal	Remove dredge spoils north of Everett Animal Shelter to restore intertidal area along slough channel.	Remove dredge spoils north of Everett Animal Shelter to restore intertidal area along slough channel.
Fill Removal	Remove dredge spoils south of Everett Animal Shelter to restore intertidal area along slough channel.	Not included.
Berm and Culvert Placement	Install berm, culvert, and flapgate in existing channel below I-5 to provide flood control for WPCF. Culvert necessary to provide drainage from portion of WPCF.	Install berm, culvert, and flapgate in existing channel adjacent to Everett Animal Shelter to provide flood control for WPCF. Culvert necessary to provide drainage from portion of WPCF facility.

Element	Full Restoration	Partial Restoration
Smith Island Road Bridge		
Pavement	Remove 710 feet, add 500 feet new pavement.	Remove 480 feet, add 400 feet new pavement.
Bridge	Add one 220-foot bridge (two spans).	Add one 80-foot voided slab bridge (single span).

29.3.2 Restoration Features – Primary Process-Based Management Measures

Armor Removal/Modification

Distributary Channel

A limited amount of armor would be removed at the breach locations on the mainstem and Union Slough. The extent of armor removal varies with the restoration alternative, based on the differing widths of opening (Figures 29-3 and 29-4).

Blind Slough

A limited amount of armor would be removed from the mainstem at the breach location at Smith Island Road. The extent of armor removal varies with the restoration alternative, based on the differing widths of opening (Figures 29-5 and 29-6).

Berm or Dike Removal/Modification

Distributary Channel

Portions of levees would be removed to provide full tidal and fluvial flux between the mainstem and Union Slough (Figures 29-7 and 29-8). New levees would be constructed to provide flood control on either side of the restored channel.

Blind Slough

Smith Island Road in this location is part of the berm that provides flood protection for Smith Island. A portion of that protection will be removed at the breach to provide full tidal flux into the historical tidal slough. The size of opening varies for the full and partial restoration alternatives (Figures 29-9 and 29-10). A setback levee would be provided to tie to existing high ground and avoid exacerbating flood risk for I-5 and the WPCF.

Channel Rehabilitation/Creation

Distributary Channel

The overall objective of this action is to restore a functioning distibutary channel between the mainstem and Union Slough. Smaller marsh channels would be excavated within the levee setback area in the full restoration alternative. The alignments are based on the 1938 aerial photograph. No additional channels would be excavated in the partial restoration alternative.

Blind Slough

The overall objective of this action is to restore a blind tidal channel with direct connection to the mainstem Snohomish River.

Groin Removal/Modification - NA

Hydraulic Modification - NA

Overwater Structure Removal - NA

Topography Restoration

Distributary Channel

The greater levee setback widths in the full restoration alternative, ranging between 60 and 900 feet from the channel, provide the opportunity to remove fill to restore intertidal areas along the slough (Figure 29-3). The partial restoration alternative would include minor fill removals within the relict slough channel (Figure 29-8, Section C) to ensure initial conveyance capacity in the slough channel.

Blind Slough

Dredge spoils would be removed to restore intertidal areas along the historical slough. The volume and spatial extent would be greater in the full restoration alternative.

29.3.3 Restoration Features – Additional Management Measures

Beach Nourishment - NA

Contaminant Removal/Remediation - NA

Debris Removal - NA

Invasive Species Control

Invasive species on both sites include reed canarygrass. The reintroduction of tidal flux and salt water to the site is expected to eradicate this species in the intertidal area, but no direct control measures are proposed.

Large Wood Placement - NA

Physical Exclusion - NA

Pollution Control - NA

Revegetation

Distributary Channel

Isolated high areas (approximately 2 feet above MHHW) within the levees in the full restoration alternative would be planted with native marine riparian species.

Blind Slough

An approximately 75-foot-wide buffer along the west side of the intertidal area would be planted with native marine riparian species. The east side is in WSDOT right-of-way, and likely could not be planted.

Reintroduction of Native Animals - NA

Substrate Modification - NA

Species Habitat Enhancement -NA

29.3.4 Restoration Features – Other

NA

29.3.5 Land Requirements

Distributary Channel

With the exception of public rights-of-way, the Distributary Channel is proposed entirely on privately held lands. This action would cover approximately 110 acres for the full restoration alternative, and 50 acres for the partial restoration alternative. All of the area would need to be acquired for either restoration alternative. Additional temporary construction easements would be necessary for access along the Buse Lumber Mill, the Glacier facility, and the BMC West building.

Blind Slough

This action covers approximately 34 acres for the full restoration alternative, and 27 acres in the partial restoration alternative. The entire area is proposed on lands that are owned by the City of Everett or in public rights-of-way. The project would require coordination with WSDOT, as work is proposed within the I-5 right-of-way.

29.3.6 Design Considerations

Distributary Channel

The primary design considerations for the Distributary Channel project include the need to provide road access from State Route 529 to the southern end of Smith Island. This action would impact the City of Everett's only road access to the WPCF, so continuous access will need to be provided during construction.

Flood protection is another design consideration. The former slough and surrounding area are currently protected by levees that provide variable levels of protection, but the proposed project would need to provide a consistent level of protection. A minimum elevation was selected to be the FEMA 10-year plus 2 feet stage, to ensure that the new levee would meet U.S. Army Corps of Engineers PL 84-99 standards. One foot was added to the "10 year plus 2" level to provide some freeboard for sea level rise. This relatively limited freeboard was selected as this will already be higher than the surrounding remaining levees.

The alignments of the setback levees and roads should also be revisited in future design phases. At this point, they have been developed to allow existing land uses to continue to the extent possible. Greater property acquisition would allow for greater restoration of channels and salt marsh habitat between I-5 and State Route 529.

Drainage from the surrounding areas will also need to be addressed. Currently, drainage from the local area, and a portion of the historical drainage basin east of I-5, flows into the relict slough where it is stored then discharged north to Union Slough via a culvert and tide gate. Additional culverts with tide gates will be necessary to allow drainage through the proposed setback levees. We have identified three preliminary locations where these drains will be required (Figures 29-3 and 29-4).

Ross Avenue Full and Partial Restoration

Traffic can likely be routed around the new bridge construction area. The proposed bridges will be approximately 330 feet for full restoration and 160 feet for partial restoration, with three spans and one span (respectively). The full restoration bridge will consist of three 110-foot spans with 5-foot-2-inch-deep pre-cast concrete girders (Figure 29-9). The partial restoration alternative will consist of one single 160-foot span with 7-foot-11-inch-deep spliced pre-cast concrete girders (Figure 29-11).

The three-span bridge substructure consists of columns supported on drilled shafts. The assumed embedment depth of the drilled shafts is 100 feet. The single-span bridge will have pile-supported abutments.

A ballast/fill section will be needed to transition from bridge structure to the existing roadway. The proposed roadway will meet current design standards and will meet or exceed equivalent capacity. The road will include two 16-foot lanes and two 8-foot shoulders. The proposed roadway geometry includes vertical and horizontal alignment considerations.

28th Place Full and Partial Restoration

Traffic can likely be routed around the construction area for both alternatives. The full restoration alternative consists of a new access road only (Figure 29-11). The partial restoration alternative consists of a new 190-foot single-span bridge with 7-foot-11-inch-deep spliced pre-cast concrete girders (Figure 29-11). The single-span bridge will have pile-supported abutments.

For partial restoration, a ballast/fill section will be needed to transition from bridge structure to the existing roadway. The proposed roadway will meet current design standards and will meet or exceed equivalent capacity. The road will include two 16-foot lanes and two 8-foot shoulders. The proposed roadway geometry includes vertical and horizontal alignment considerations.

Blind Slough

Providing continuing access to the WPCF, the Everett Animal Shelter, and Langus Riverfront Park and shellhouse is a key consideration. A temporary detour over the WPCF ring levee may provide sufficient temporary access to avoid the need for a temporary road during bridge construction.

Flood protection at the slough site is necessary to protect Smith Island Road, I-5, and the WPCF. This requires the installation of berms in both the full and partial restoration alternatives. These berms will need to be evaluated with site-specific topographic data to confirm their flood protection function.

The proximity of the WPCF and I-5 also requires that geotechnical and hydrogeologic issues be investigated during future design phases. Reintroducing tidal flux into this area could destabilize fill or change water quality near the aeration ponds.

Smith Island Road Full and Partial Restoration

Traffic can likely be routed around the construction area for both alternatives. The full restoration alternative consists of a new 210-foot structure with two 110-foot spans consisting of 5-foot-2-inch-deep pre-cast concrete girders (Figure 29-11). The partial restoration alternative consists of an 80-foot single-span (voided slab) bridge with pile-supported abutments (Figure 29-11).

A ballast/fill section will be needed to transition from bridge structure to the existing roadway. The proposed roadway will meet current design standards and will meet or exceed equivalent capacity. The road will include two 16-foot lanes and two 8-foot shoulders. The proposed roadway geometry includes vertical and horizontal alignment considerations.

29.3.7 Construction Considerations

Distributary Channel

Sequencing is the primary construction consideration for the Distributary Channel. Getting the fill removed, channels excavated, and bridge installed, all while providing continuous road access to the south, will need to occur prior to breaching the levee to the north and the south.

Dewatering is likely to be necessary for dredging the slough and potentially for new channel excavation. Additional control of water may be necessary to prevent tides from inundating the site while the levee is being breached to both the north and the south.

Blind Slough

The primary construction considerations for this area are to define the haul routes and stockpile areas to allow for export of the material. Site access is good from existing roads, but sequencing would need to be developed to allow construction to move forward during bridge construction. The bridge installation could be accomplished by leaving a portion of the existing road in place to prevent access by tides during construction. Construction access would also need to consider ongoing operations at the Everett Animal Shelter, and access to Langus Riverfront Park.

Bridge Installations

A crane positioned on one end of the bridge is required to set the girders in place. A drilled-shaft oscillator would be used to install the drilled shafts. It is assumed that the contractor will be able to install one shaft per week. In areas near the slough, a large-diameter casing shoring would be required to keep out water and allow access to the top of the shaft for column form placement and removal. Once the shafts are installed, the columns are cast inside the shoring casing. After the casing is removed, the cast-in-place pilecaps and bridge superstructure are constructed.

Concrete bridges require very little maintenance. The current standard is to inspect bridges every 2 years.

29.4 Extent of Stressor Removal

Table 29-3 describes the amount of stressors to be removed with the Distributary Channel.

Table 29-3. Stressor Removal – Distributary Channel

Stressor	Full Restoration	Partial Restoration
Tidal Barrier (LF)	600	300
Fill (Acres)	13 from levee breaches and fill removal area	2.5 from levee breaches
Armor (LF)	600	300

Table 29-4 describes the amount of stressors to be removed with the Blind Slough.

Table 29-4. Stressor Removal – Blind Slough

Stressor	Full Restoration	Partial Restoration
Tidal Barrier (LF)	210	130
Fill (acres)	8.5	6.4
Armor (LF)	210	130

29.5 Expected Evolution of the Action Area

Distributary Channel

Under the full restoration alternative, the Distributary Channel will have been dredged to dimensions that approximate the historical condition. Therefore, limited channel change would be expected within the slough channel. Aggradation may occur in this area, as the local tidal prism volume will be limited by the setback levees, and therefore lower than it was in the historical condition. However, it may be that the form of the Distributary Channel is governed more by high freshwater flows, which would not suggest aggradation. Scour is also a possibility, especially if hydraulics allow for greater transfer of high fluvial flows from the mainstem to Union Slough.

The marsh plain and channel systems within the setback levees would evolve with recolonization by salt marsh vegetation communities. These channels were aligned based on the 1938 photo, but their drainage basins will be altered from those historical conditions.

Under the partial restoration alternative, limited initial removal of material from the slough channel will occur. Therefore, the channel would be expected to erode the bed in the years following reopening. The width of the levees was set to be greater than the top width of a tidal channel that would drain the volume held within the slough. Therefore, erosion beyond the levees is not expected. Rock slope protection is also included in the partial restoration alternative, and would need to be designed and installed to be deformable in case the channel erodes laterally more than expected. The levees are not set back sufficiently in the partial restoration alternative to form marsh plain and channels, but vegetated benches are likely to form, similar to the surrounding leveed channels (e.g., Union Slough).

Blind Slough

The primary evolution for the Blind Slough location is the development of a marsh plain in the fill removal areas. Portions of the site that are currently dominated by weeds would slowly become dominated by species that favor tidal conditions. This location is further upstream in the system, where salinities are expected to be less than the lower estuary, so the location may not support a classic salt marsh vegetation community. The channel had formed under a much larger tidal drainage basin (192 acres) compared to the proposed condition (around 80 acres). Therefore, some aggradation may occur as the channel adjusts to a new tidal regime.

29.6 Uncertainties and Risks

Distributary Channel

The geomorphic response of the Distributary Channel is the greatest uncertainty for this action. Conditions in the mainstem and on the floodplain are substantially different than when the Distributary Channel had formed naturally. In the full restoration alternative, levees are set back from the channel, allowing some degree of channel migration and adjustment. The partial restoration alternative essentially locks the channel planform in place, so if channel erosion were to occur, it could destabilize the proposed flood protection levees. Therefore, this alternative will likely require some level of additional stabilization on the inner slopes of the flood protection levee. In both alternatives, the channel has been sized based on regional regression equations, plus some buffer, so the channel is expected to function within the area given for the channel. However, the Snohomish River is capable of substantial fluvial flows, which could alter the form of that channel.

There is the potential to encounter either contaminated materials or cultural resources during excavation. The design of the flood protection levees and bridge supports will be highly dependent on subsurface soil conditions which have not been fully investigated.

Blind Slough

The speed of the evolution of the marsh plain is the primary uncertainty for the Blind Slough action. The lower salinities with greater freshwater influence in this area may result in slower evolution and greater numbers and densities of non-native vegetation communities. The amount of sediment being contributed from the mainstem is another uncertainty for both actions along the mainstem.

Moving the flood protection levee further into the interior of Smith Island could also change flood risks for I-5 and the Everett WPCF.

There is the potential to encounter either contaminated materials or cultural resources during excavation. The design of the flood protection levees and bridge supports will be highly dependent on subsurface soil conditions which have not been fully investigated.

29.6.1 Risks Associated with Projected Sea Level Change

Table 29-5 compares sea level change risks based on professional judgment for the Distributary Channel.

Table 29-5. Risks of Sea Level Change – Distributary Channel

	Projected Sea Level Change		
	High (46 cm)	**Intermediate (4 cm)**	**Low (-8 cm)**
Full Restoration	Potential to drown salt marsh within the setback levee. Marsh expected to aggrade and re-form, but sediment supply and depositional patterns are not known. Increasing the static base level may also reduce effectiveness of proposed flood protection levees due to upward shift of flood stage during high tide.	Minimal changes expected.	Minimal changes expected.
Partial Restoration	Potential for greater depths of scour through the channel and reduced effectiveness of proposed flood protection measures.	Minimal changes expected.	Minimal changes expected.

Table 29-6 compares sea level change risks based on professional judgment for the Blind Slough.

Table 29-6. Risks of Sea Level Change – Blind Slough

	Projected Sea Level Change		
	High (46 cm)	**Intermediate (4 cm)**	**Low (-8 cm)**
Full Restoration	Potential to drown salt marsh within the setback levee. Marsh expected to aggrade and re-form, but sediment supply and depositional patterns are not known. Increasing the static base level may reduce effectiveness of proposed flood protection levees due to upward shift of flood stage during high tide.	Minimal changes expected.	Minimal changes expected.
Partial Restoration	Potential for greater depths of scour at the channel opening to the mainstem and reduced effectiveness of proposed flood protection measures.	Minimal changes expected.	Minimal changes expected.

29.7 Potential Monitoring Opportunities

Monitoring is important for evaluating restoration success. A combination of field surveys and aerial photographs would be used to document biological and physical changes to the landscape. Monitoring data can be used to refine adaptive management and corrective actions, as needed. Some of the key monitoring needs and opportunities associated with this action (both locations) are summarized in Table 29-7.

Table 29-7. Monitoring Needs and Opportunities

Monitoring Parameter	Key Performance Indicator	Note
Topographic Stability	X	Within new channel and marsh areas, especially along proposed flood protection levees
Sediment Accretion / Erosion	X	Channel stability
Wood Accumulation		
Soil / Substrate Conditions		
Vegetation Establishment	X	Increased dominance of native salt marsh species
Marsh Surface Evolution / Accretion		
Tidal Channel Cross-Section / Density	X	Channel evolution
Water Quality (contaminants)		
Salinity		
Shellfish Production		
Extent of Invasive Species	X	Monitor existing areas of non-native vegetation for transition post tide reintroduction
Animal Species Richness		
Fish (Salmonid) Access/Use		
Forage Fish Production		
Wildlife Species Use		
Effectiveness of Exclusion Devices		

29.8 Information Needed for Subsequent Design

This conceptual design report represents an initial step in the restoration design sequence. The design concepts described above were developed based on readily available information without the level of site-specific survey and investigation that is necessary to support subsequent design and implementation. Substantial additional information will be required at the preliminary and later design stages to confirm the design assumptions, refine quantity estimates, address property and regulatory issues, obtain stakeholder support, and fill in data gaps.

- Survey - Property survey and additional topographic survey are needed for both sites. A traffic study may be required to determine the most effective temporary traffic routing measures at Ross Avenue and Smith Island Road during construction. Utilities will need to be identified and located in both action areas.

- Hydraulic Modeling - A 2D hydraulic model would be especially useful to test the design assumptions about the Distributary Channel. Developing this type of hydrodynamic model would allow for sensitivity analysis of potential future velocities, which would be especially useful for final sizing of the partial restoration alternative. This may need to be expanded to investigate the cumulative system-wide adjustments to channel systems in the lower Snohomish resulting from several proposed restoration projects. Hydraulic engineer recommendations are needed for scour and minimum bridge clearance over water.
- Flood Protection - A decision will need to be made regarding the level of protection provided by the levees. The 10-year plus 2 standard assumed here is consistent with past plans, but may not be desirable for future conditions.
- Drainage Study - Detailed interior drainage study will be required to properly assess and size the proposed culverts that drain into the restored areas.
- Contaminant Surveys – Phase 1 and 2 studies are recommended to assess the potential for contaminated soils, especially in the boat yard area. The introductory chapter describes the Phase I site investigations that are occurring as part of this overall effort via a separate contract.
- Geotechnical Analysis -Detailed geotechnical work will be required to assess subsurface conditions, especially for the Blind Slough near the WPCF and I-5. Geotechnical investigations would be required to develop recommendations for bridge foundations.

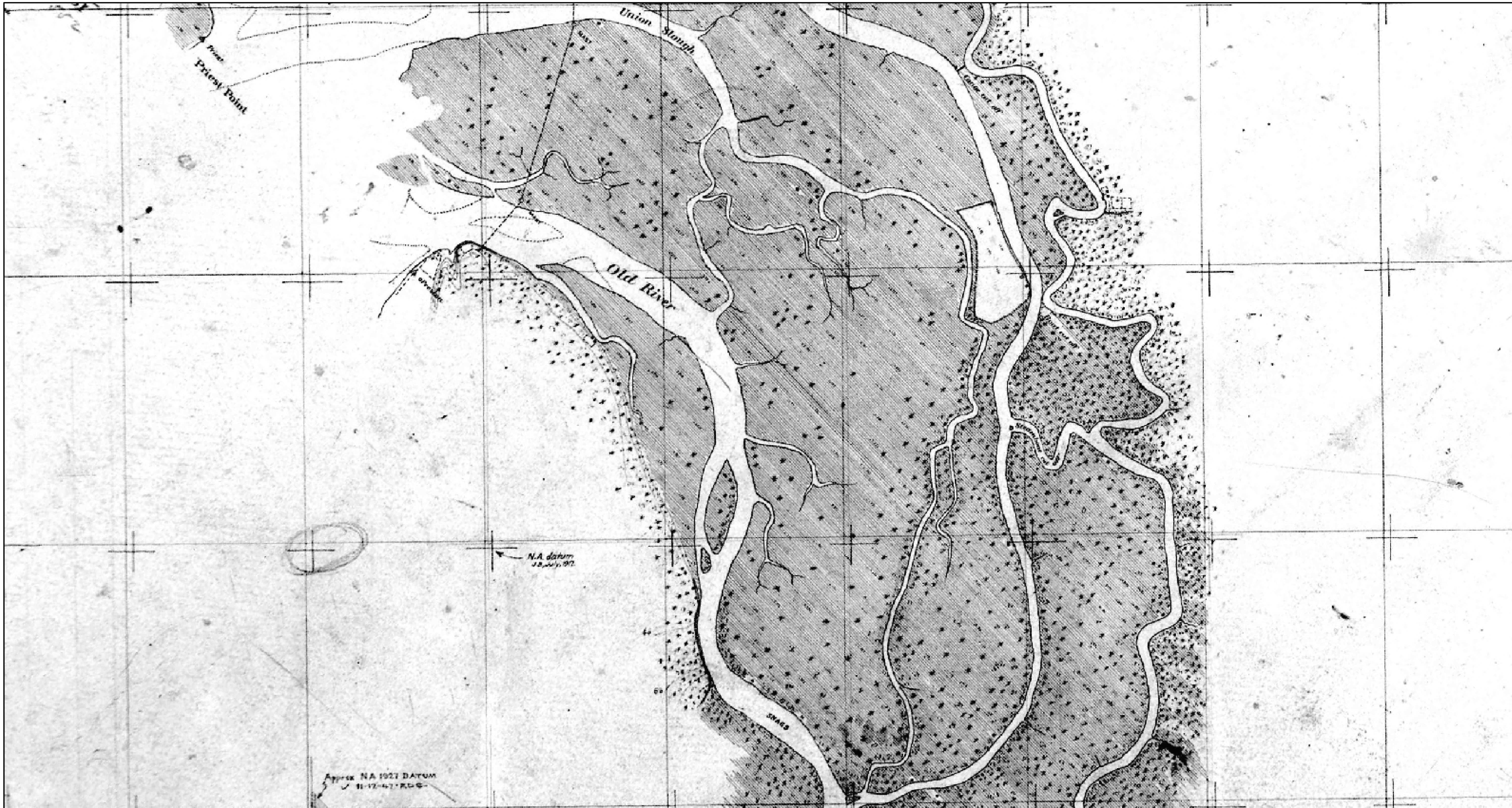
29.9 Quantity Estimates

The design quantities are largely developed from LiDAR data sets lacking the resolution to accurately quantify all elements of construction. These are supplemented by unmeasured estimates made during one site visit at high tide and areal take-offs from available imagery. The quantity spreadsheets for the full and partial restoration alternatives are provided in Exhibits 29-1a, 29-1b, 29-2a, and 29-2b.

29.10 References

Haas, A.D., and B.D. Collins, 2001. *An historical analysis of habitat alterations in the Snohomish River valley, Washington since the mid-19th century: implications for Chinook and coho salmon.* Prepared for the Tulalip Tribes and Snohomish County Department of Public Works.

Snohomish Basin Salmon Recovery Forum. 2005. Snohomish River Basin Salmon Conservation Plan. June 2005. http://www1.co.snohomish.wa.us/Departments/Public_Works/Divisions/SWM/Work_Areas/Habitat/Salmon/Snohomish/Snohomish_Basin_Salmon_Conservation_Plan.htm



0 2,200
Feet
0 680
Meters

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64

WDFW Contract # 100-000204 (CAPS No. 10-1461)

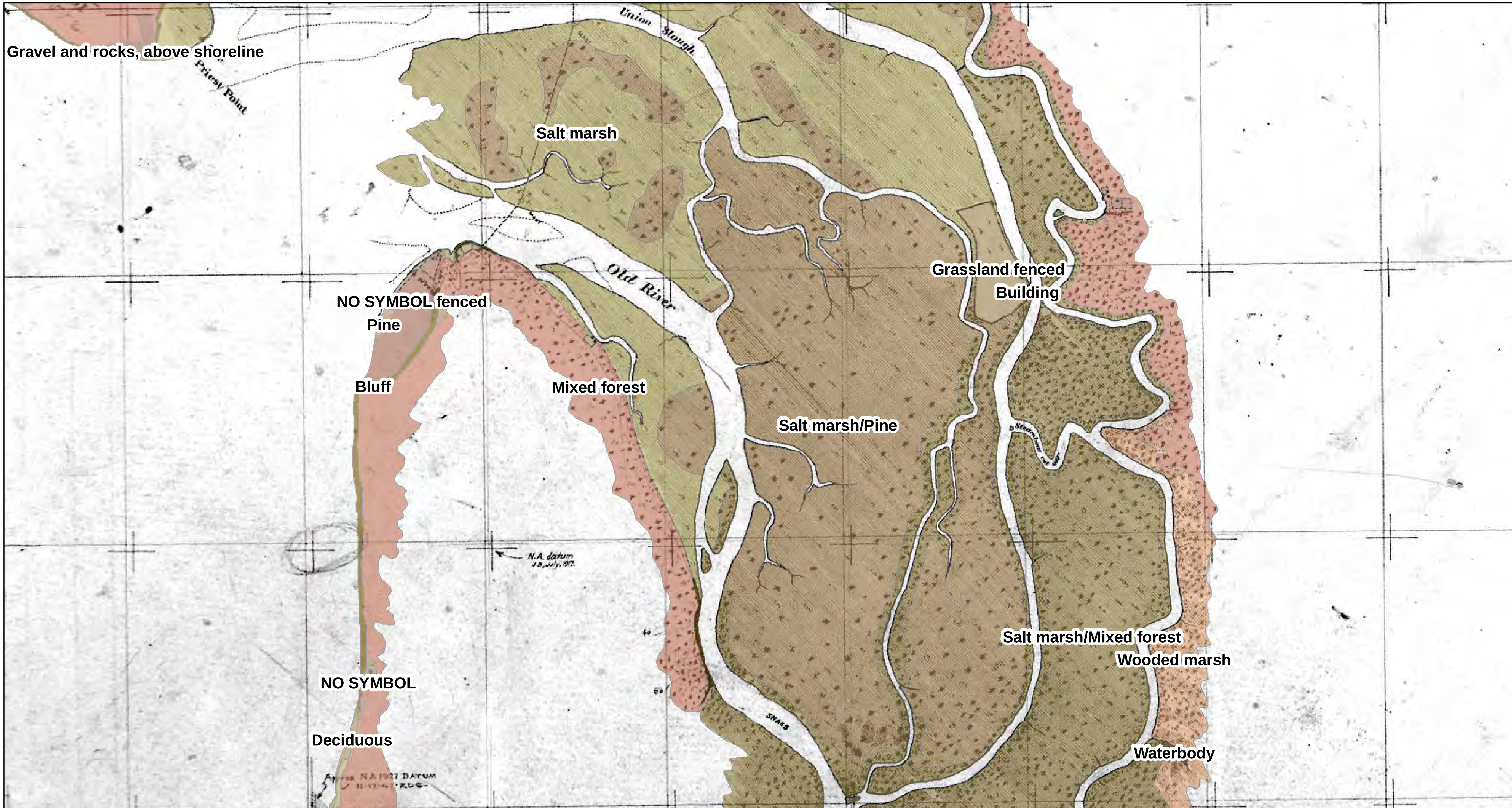
Historic Map (T-Sheet)

Action Name: Snohomish Estuary Main Stem Connectivity

PSNERP ID #: 1805

Figure 29- 2A

S:\GIS\Projects\210xxx\210337_PSNERP_NEARSHORE\Projects\2-TSheets_rev.mxd (DLP; 2/24/2011)



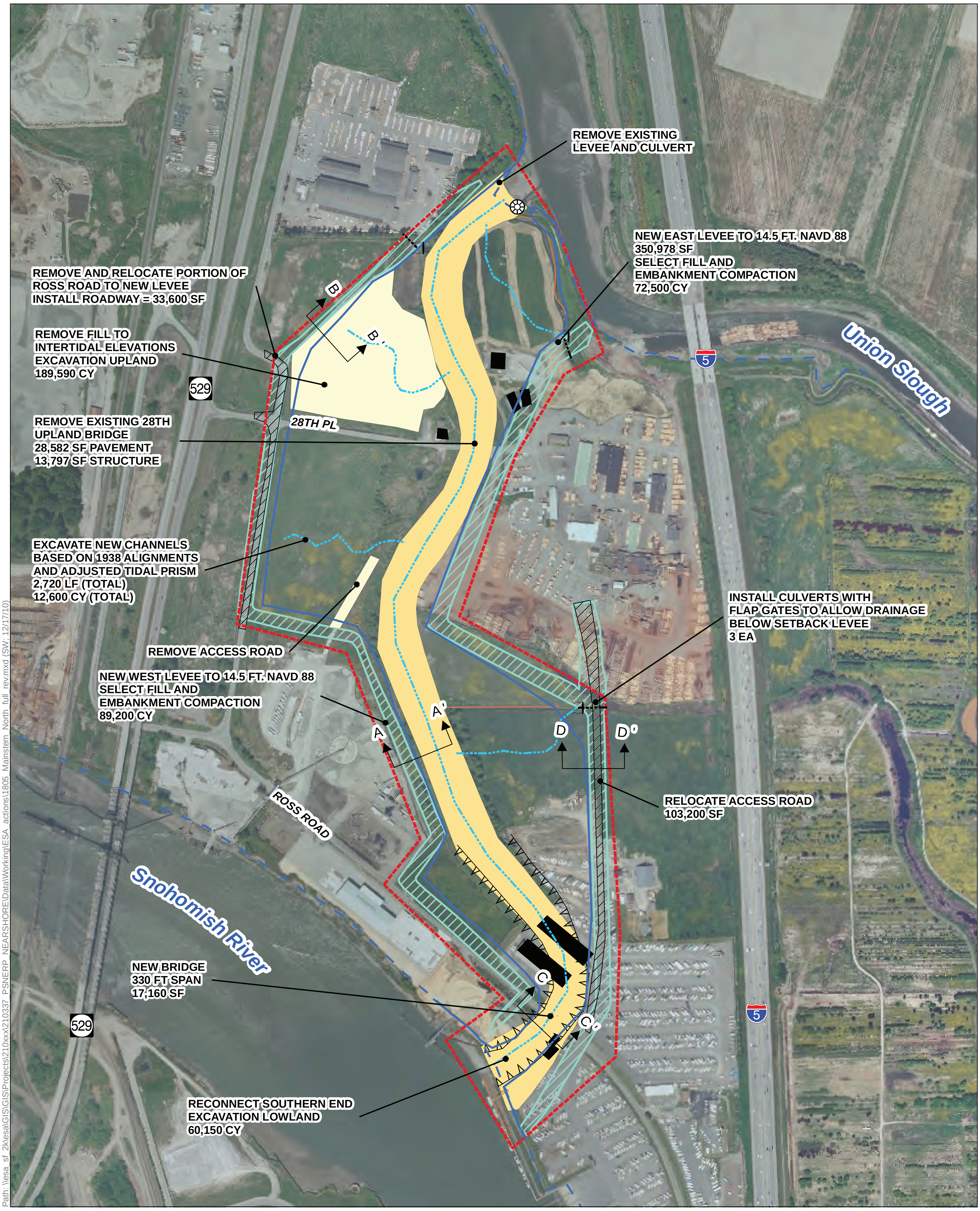
0 2,200
Feet
0 680
Meters

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64

WDFW Contract # 100-000204 (CAPS No. 10-1461)

Historic Map (T-Sheet) and River History Project Data
Action Name: Snohomish Estuary Main Stem Connectivity
PSNERP ID #: 1805
Figure 29- 2B

S:\GIS\Projects\210xxx\210337_PSNERP_NEARSHORE\Projects\2-TSheets_rev.mxd (DLP; 2/24/2011)



Path: \\esa_sf_2k\esa\GIS\GIS\Projects\210xxx\210337_PSNERP_NEARSHORE\Data\Working\ESA_actions\1805_Mainstem_North_full_rev.mxd (SW; 12/17/10)

Legend

- Bridge
- Hydraulic Structures - Small
- Water Control Structures - Culverts with Gates
- Section Lines
- Culvert
- Proposed Tide MHHW
- Existing Tide MHHW
- Channel Rehab/Creation
- Side Cast
- Rock Slope Protection
- Remove Buildings
- Dock
- Excavation - Lowland
- Excavation - Upland
- Haul, Place, Compact
- Required Project Lands
- Roadway Type A
- Select Fill
- Site Access

EVERETT CONVERSION

FIXED DATUM — TIDAL DATUM

NAVD88 — MHHW 8.79 — 2.30 MLLW

0.00 FT MLLW = -2.30 FT NAVD88
2.30 FT MLLW = 0.00 FT NAVD88

Source: Everett Station (#9447659)

North

0 240 Feet

SOURCE: PSNERP (2011); Aerials Express (2009)

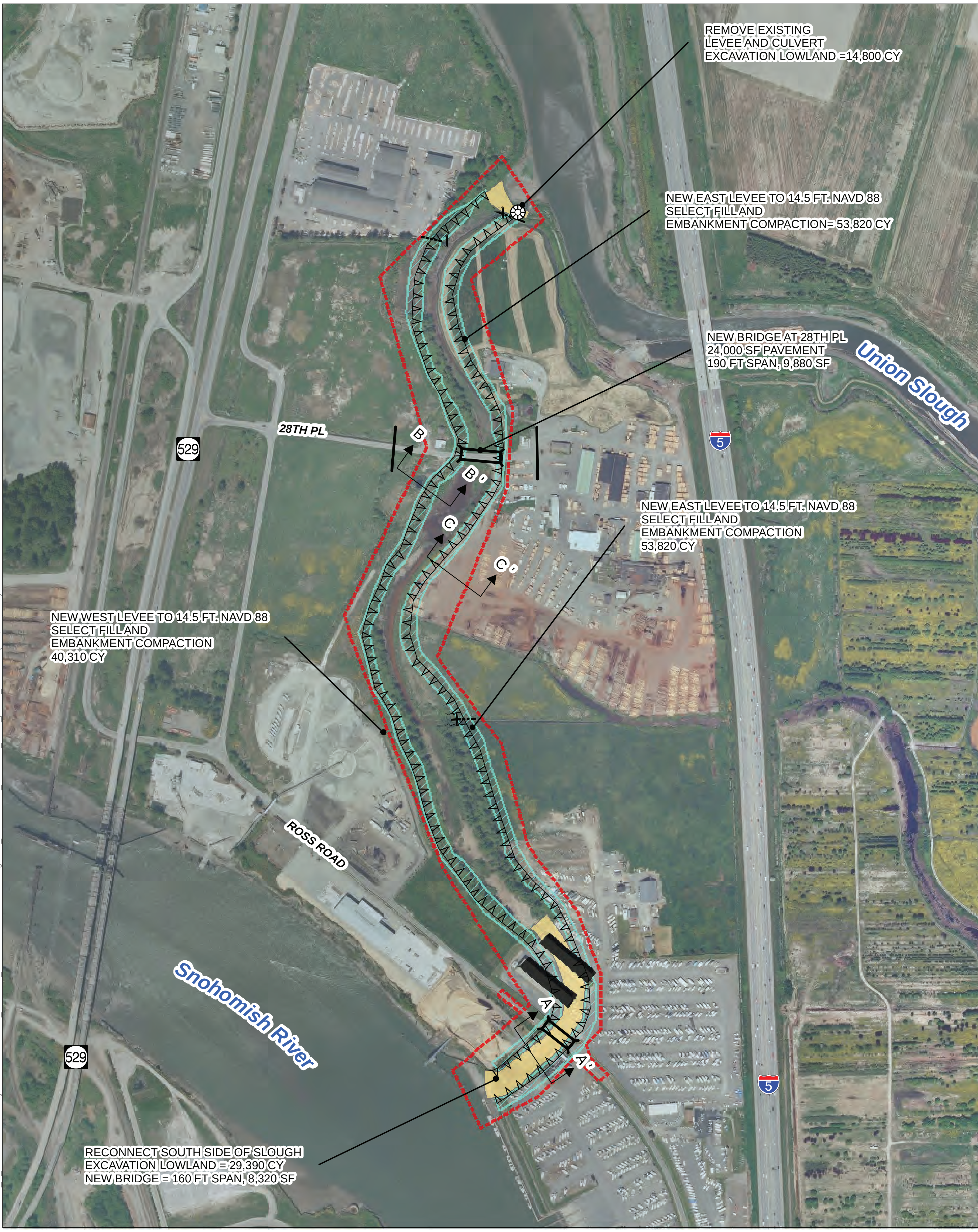
Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64

WDFW Contract # 100-000204 (CAPS No. 10-1461)

Lead Contractor: ESA
Design Lead: ESA
Date: 2/28/2011

Conceptual Design Plan
Site Name: Snohomish River Delta
Action Name: Snohomish Estuary Main Stem Connectivity – Distributary Channel
PSNERP ID #:1805
Full Restoration

Figure 29-3



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Legend

- A A' Section Lines
- Bridge
- Hydraulic Structures - Small
- Water Control Structures - Culverts with Gates
- Culvert
- Rock Slope Protection
- Remove Buildings
- Required Project Lands
- Excavation - Lowland
- Haul, Place, Compact
- Place Select Fill

EVERETT CONVERSION

FIXED DATUM | TIDAL DATUM

MHHW 8.79

NAVD88 2.30 MLLW

0.00 FT MLLW = -2.30 FT NAVD88
2.30 FT MLLW = 0.00 FT NAVD88

Source: Everett Station (#9447659)

PUGET SOUND NEARSHORE

North

0 240 Feet

SOURCE: PSNERP (2011);Aerials Express, 2009

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Plan
Site Name: Snohomish River Delta
Action Name: Snohomish Estuary Main Stem Connectivity – Distributary Channel
PSNERP ID #:1805
Partial Restoration

Lead Contractor: ESA
Design Lead: ESA
Date: 2/28/2011

Figure 29-4

Path: \\esa_sf_2k\esa\GIS\GIS\Projects\210xxx\210337_PSNERP_NEARSHORE\Data\Working\ESA_actions\1805_Mainstem_Middle_full_rev.mxd (SW; 12/17/10)

Legend

- A A' Section Lines
- Bridge
- Water Control Structures - Culverts with Gates
- Install Culvert
- Proposed Tide MHHW
- Existing Tide MHHW
- Pavement
- Required Project Lands
- Planting
- Site Access
- Haul, Place, Compact
- Clear/Grub Vegetation - Local Disposal
- Excavation - Lowland

EVERETT CONVERSION

FIXED DATUM | TIDAL DATUM

MHHW

8.79

NAVD88

2.30

MLLW

0.00 FT MLLW = -2.30 FT NAVD88
2.30 FT MLLW = 0.00 FT NAVD88

Source: Everett Station (#9447659)

PUGET SOUND NEARSHORE

North

0 160 Feet

SOURCE: PSNERP (2011); Aerial (BING

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64

WDFW Contract # 100-000204 (CAPS No. 10-1461)

Lead Contractor: ESA
Design Lead: ESA
Date: 2/28/2011

Conceptual Design Plan
Site Name: Snohomish River Delta
Action Name: Snohomish Estuary Main Stem Connectivity – Blind Slough
PSNERP ID #:1805
Full Restoration

Figure 29-5

Path: \\esa_sf_2k\esa\GIS\GIS\Projects\210xxx\210337_PSNERP_NEARSHORE\Data\Working\ESA_actions\1805_Mainstem_Middle_partial_rev.mxd (SW, 12/17/10)

SOURCE: PSNERP (2011); Aerials Express (2009)

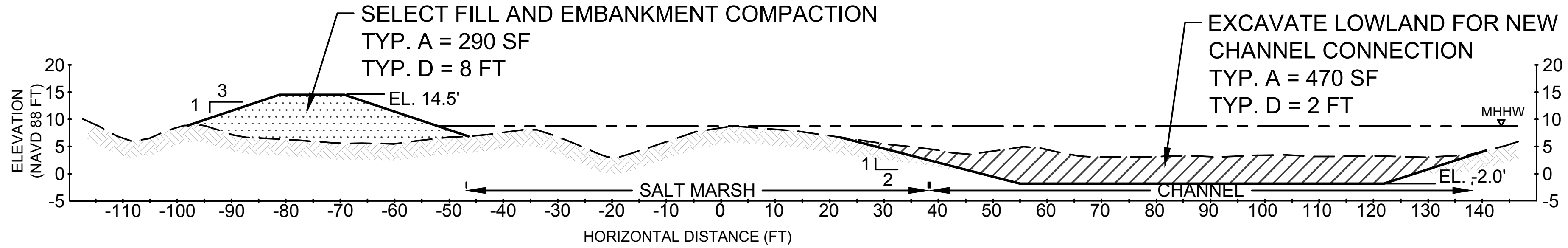
Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64

WDFW Contract # 100-000204 (CAPS No. 10-1461)

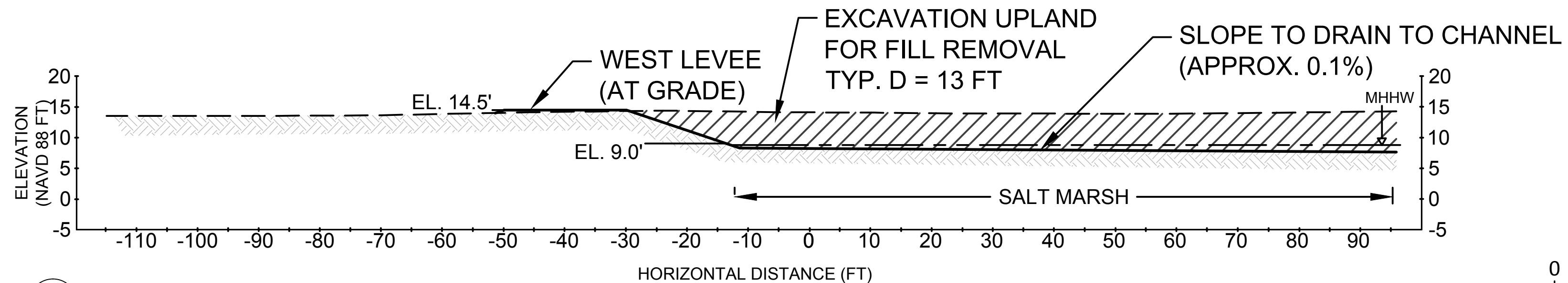
Conceptual Design Plan
Site Name: Snohomish River Delta
Action Name: Snohomish Estuary Main Stem Connectivity – Blind Slough
PSNERP ID #:1805
Partial Restoration

Lead Contractor: ESA
Design Lead: ESA
Date: 2/28/2011

Figure 29-6

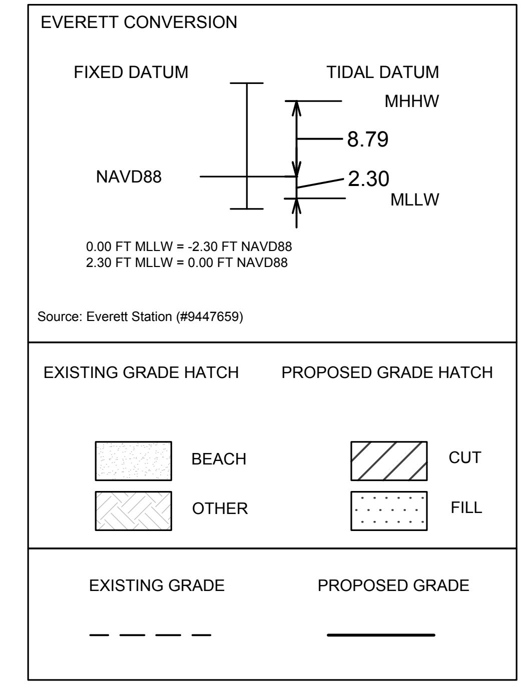


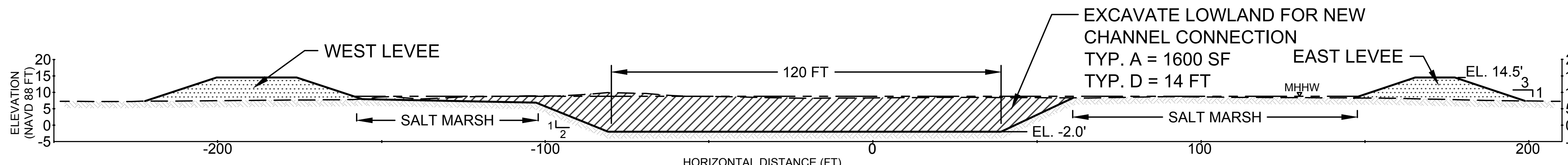
Ⓐ WEST LEVEE AND CHANNEL EXCAVATION (TYP.)



Ⓑ WEST LEVEE AND FILL REMOVAL (TYP.)

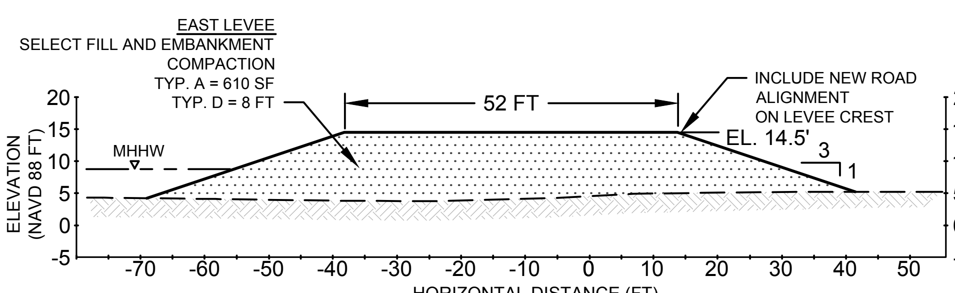
0 30
Scale in Feet





Ⓒ NEW SOUTHERN CHANNEL CONNECTION (TYP.)

0 40
Scale in Feet



Ⓓ NEW EAST LEVEE AND RELOCATED ACCESS ROAD (TYP.)

0 30
Scale in Feet

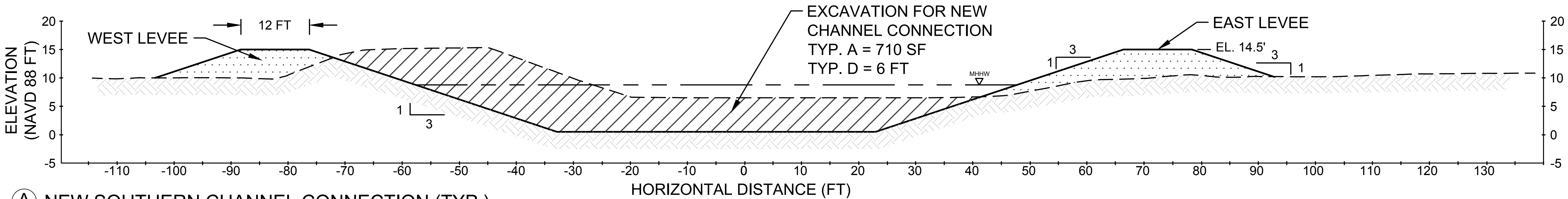
PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: ESA
Date: 3/2011

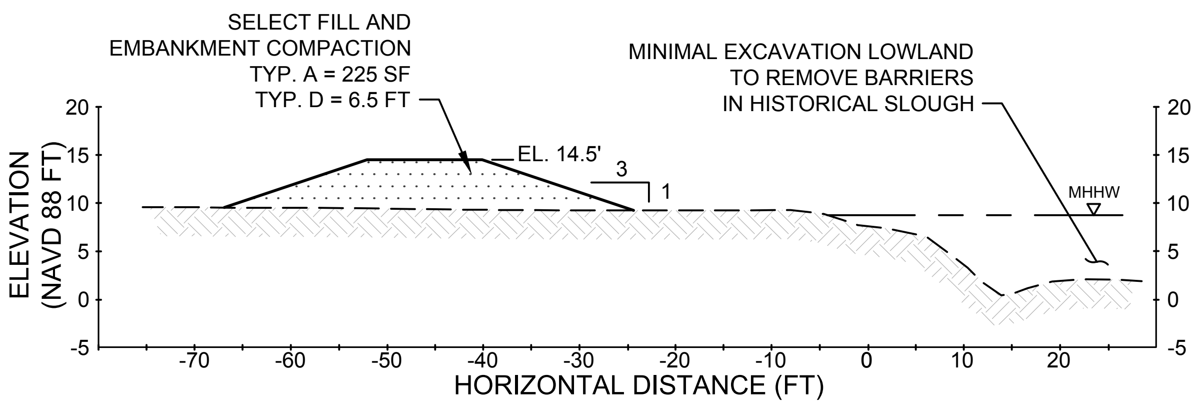
Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Section
SITE NAME: **Snohomish River Delta**
ACTION NAME: **Snohomish Estuary Main Stem Connectivity- Distributary**
PSNERP ID#: **1805**
Full Restoration

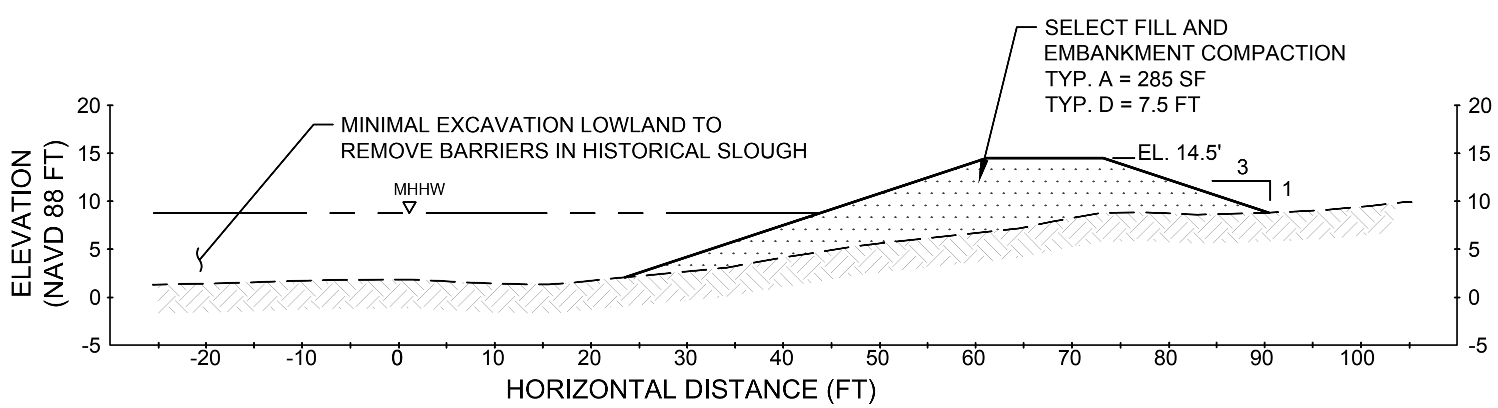
Figure 29-7



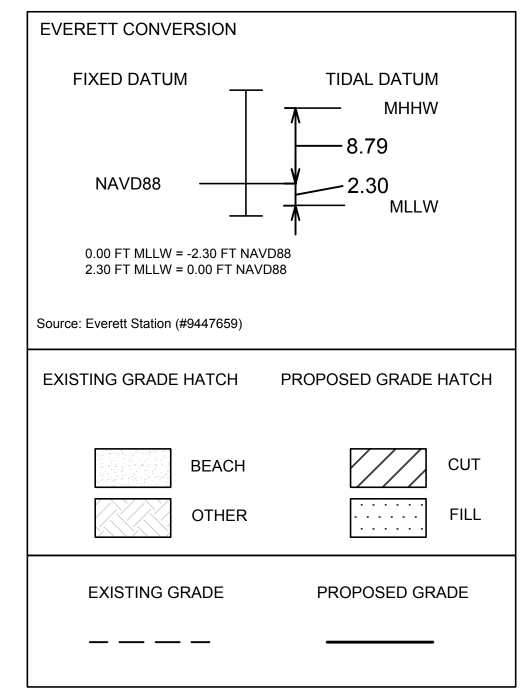
Ⓐ NEW SOUTHERN CHANNEL CONNECTION (TYP.)



Ⓑ NEW WEST LEVEE (TYP.)



Ⓒ NEW EAST LEVEE (TYP.)

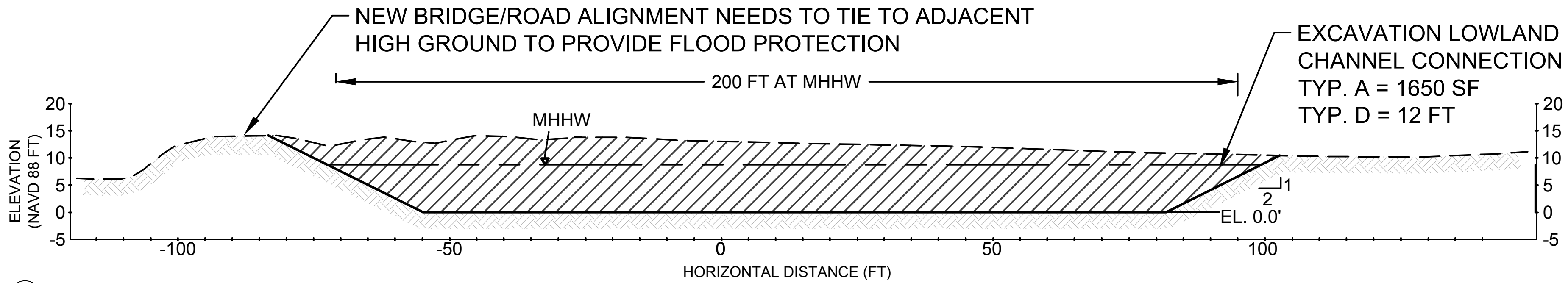


PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

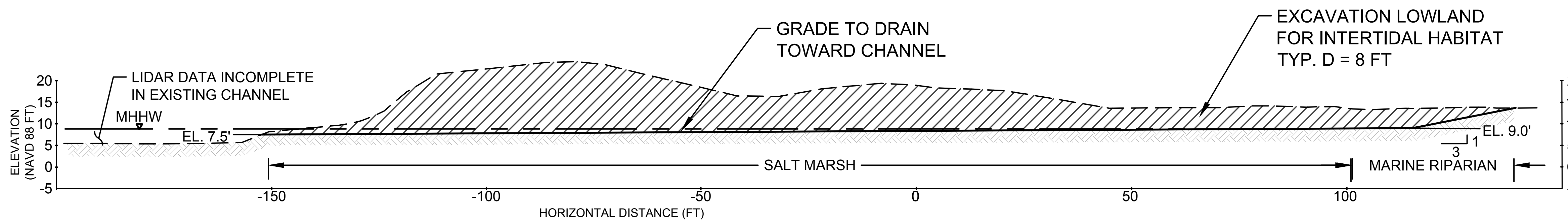
Lead Contractor: ESA
Design Lead: ESA
Date: 3/2011

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)
Conceptual Design Section
SITE NAME: **Snohomish River Delta**
ACTION NAME: **Snohomish Estuary Main Stem Connectivity- Distributary**
PSNERP ID#: **1805**
Partial Restoration

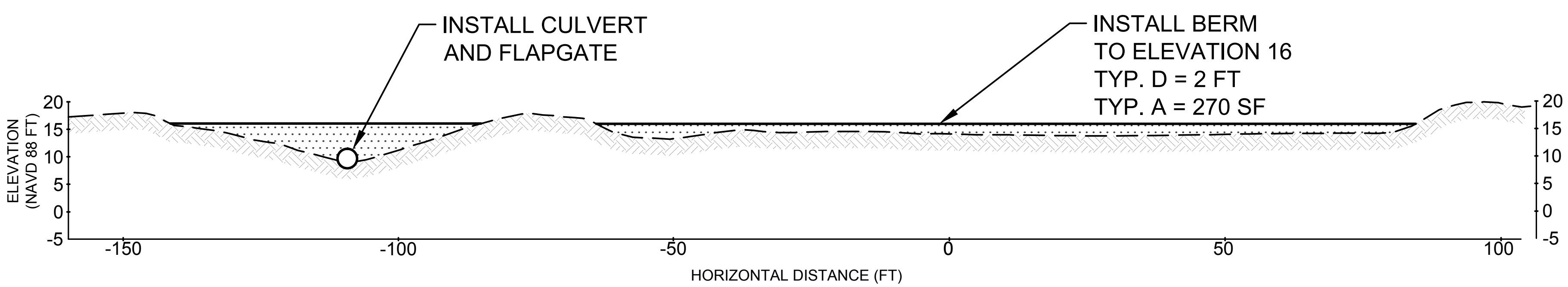
Figure 29-8



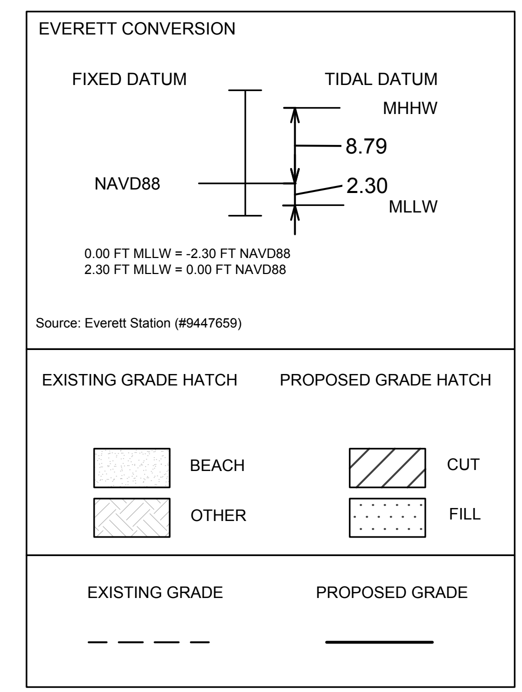
Ⓐ NEW CHANNEL OPENING (TYP.)



Ⓑ NORTH FILL REMOVAL AREA (TYP.)



Ⓒ NEW BERM WITH CULVERT (TYP.)



0 30
Scale in Feet

PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: ESA
Date: 3/2011

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Section

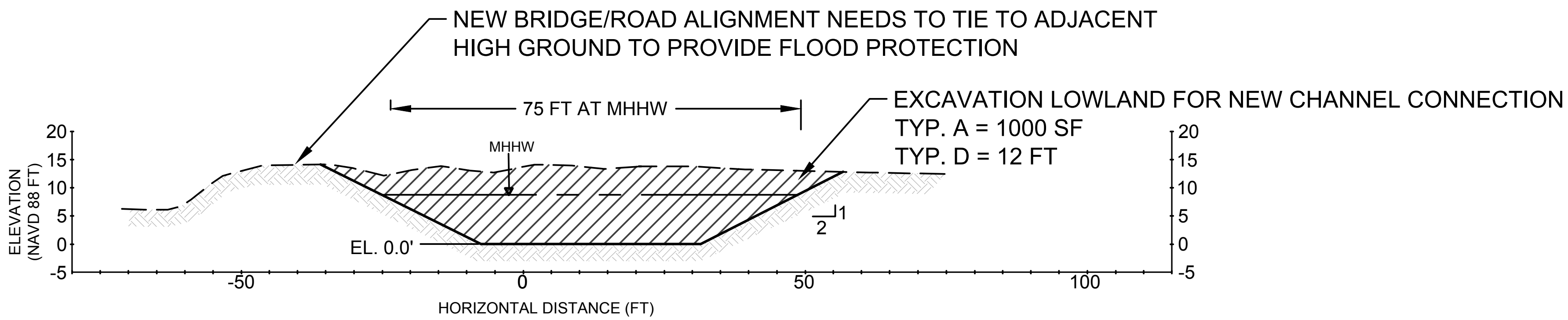
SITE NAME: **Snohomish River Delta**

ACTION NAME: **Snohomish Estuary Main Stem Connectivity- Blind**

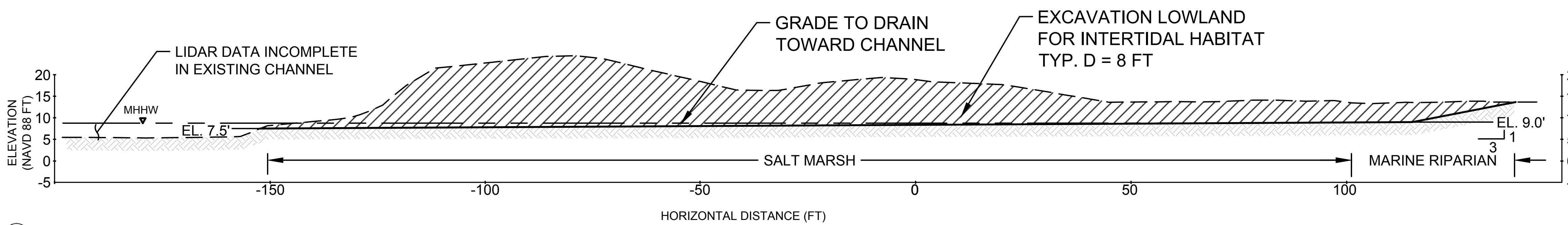
PSNERP ID#: **1805**

Full Restoration

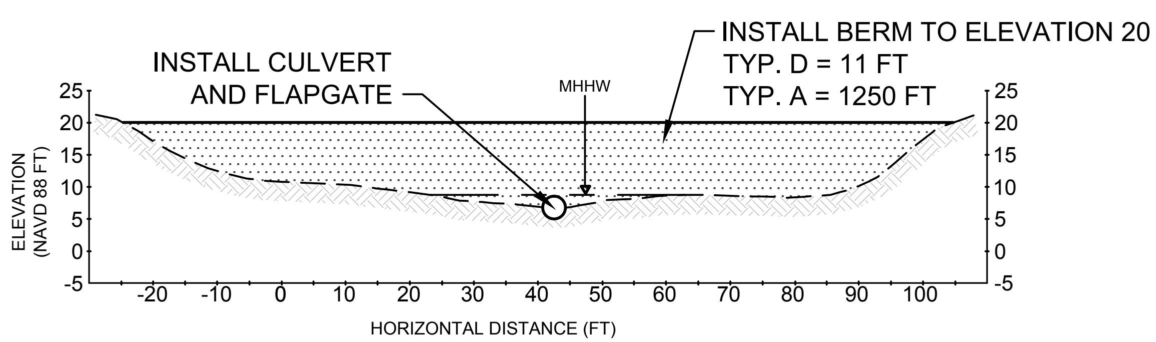
Figure 29-9



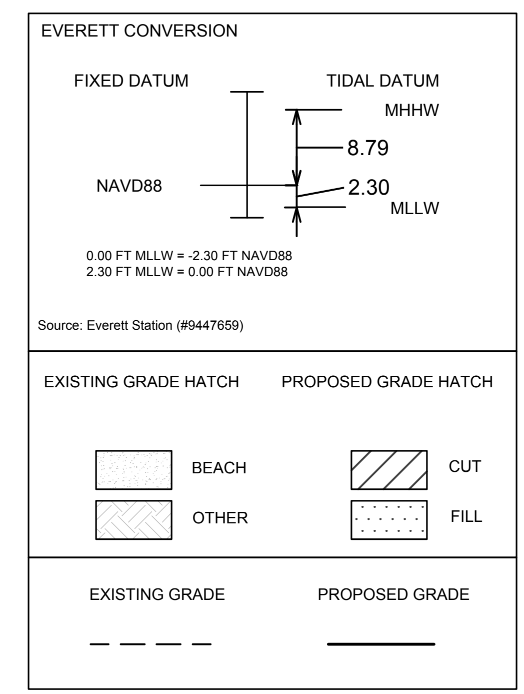
Ⓐ NEW CHANNEL OPENING (TYP.)



Ⓑ NORTH FILL REMOVAL AREA (TYP.)



Ⓒ SETBACK LEVEE AND CULVERT (TYP.)



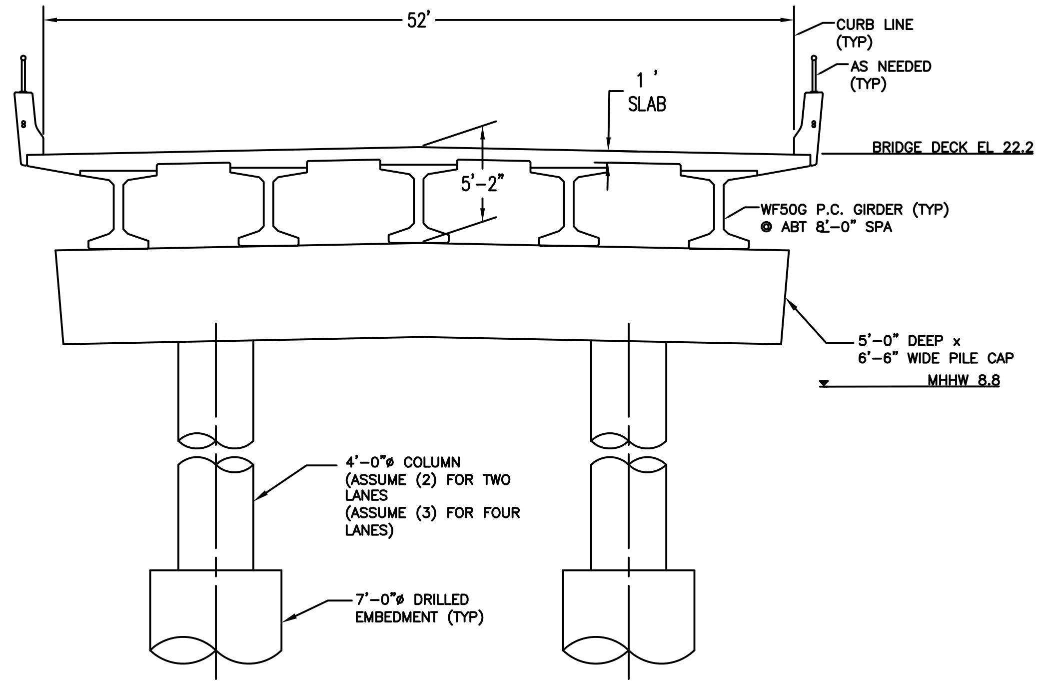
PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: ESA
Date: 3/2011

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

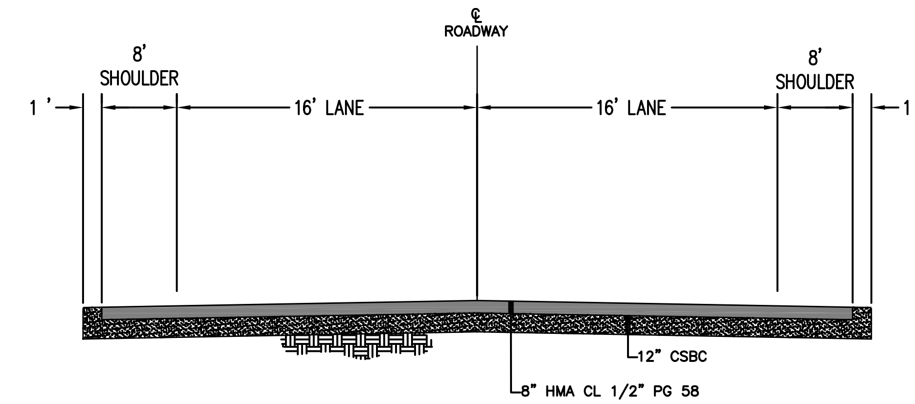
Conceptual Design Section
SITE NAME: **Snohomish River Delta**
ACTION NAME: **Snohomish Estuary Main Stem Connectivity- Blind**
PSNERP ID#: **1805**
Partial Restoration

Figure 29-10

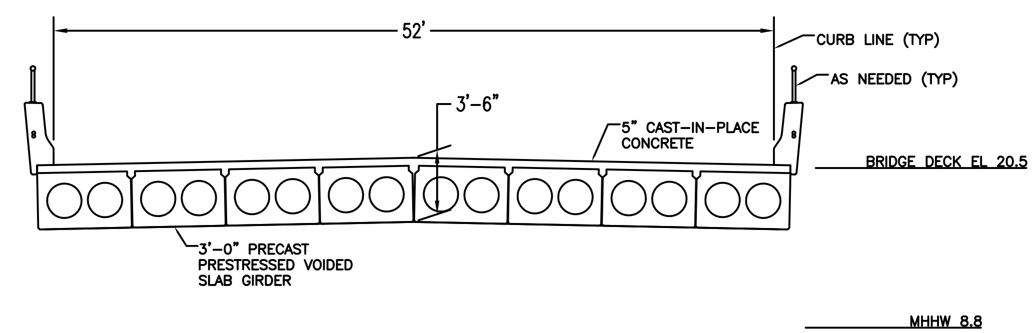


BRIDGE SECTION – ALT. 1
NTS

FOR ROSS ROAD (DISTRIBUTARY CHANNEL – FULL ALTERNATIVE), AND SMITH ISLAND ROAD (BLIND SLOUGH – FULL ALTERNATIVE).



ROADWAY SECTION
NTS



BRIDGE SECTION – ALT. 2
NTS

NOTE: SINGLE SPAN BRIDGES WILL HAVE PILE-SUPPORTED ABUTMENTS.
FOR 28TH PLACE (DISTRIBUTARY CHANNEL – PARTIAL ALTERNATIVE), ROSS ROAD (DISTRIBUTARY CHANNEL – PARTIAL ALTERNATIVE), AND SMITH ISLAND ROAD (BLIND SLOUGH – PARTIAL ALTERNATIVE).

PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: KPFF
Date: 3/2011

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Section
SITE NAME: **Snohomish River Delta**
ACTION NAME: **Snohomish Estuary Main Stem Connectivity**
PSNERP ID#: **1805**
Full & Partial Restoration

Figure 29-11

Full Restoration Quantity Estimate

Action Name: Snohomish Mainstem Connectivity: Slough
Action #: 1805
Date: February 2011
By: ESA

REMEDY: ***Remove historic fill to reconnect a historical blind slough channel to the Snohomish Mainstem***

Construction Period: Five Months

Item	Unit of Measure	Material Name	Qty	Description of Item		Indicate section of design report where item is described
ACQUISITION AND CONSERVATION				Based on available mapping information		
Required Project Lands	Acre		34.2	Total land required For action		29.3.5
Proponent / Partner-owned lands	Acre		34.2	Etimate of lands currently owned by Proponent (i.e., Public lands)		29.3.5
Lands To Be Acquired	Acre		0	Estimate land required to be acquired for action prior to implementation		29.3.5
Material Sites				Not Used: See Earthwork - Imported Fill.		
MOBILIZATION AND ACCESS for construction activities				Description required for each item to facilitate cost estimating		
Mobilization - Typical (Equipment, Personnel, Planning, Financial)	LS		1	Assume 8% of total		
Mobilization - Remote (Equipment, Personnel, Planning, Financial)	LS		1	Significant coordination will be necessary, especially for temporary roads and traffic control.		
Site Access	LS		1	Access can utilize existing surface roads to the site. During bridge construction, traffic may need to be routed to WPCF berms.		
Barge Access	Days		NA			
Temporary Traffic Control (one of the following)						
none	LS		NA			
signs	LS		1			
flags / spotters	LS		1			
unique	LS		NA			
Temporary Roadway	LS		1	Divert traffic to 12th Street/ WPCF levees during bridge installation		29.3.7
Control of Water	LS		1	May need to block tidal action during breach.		
Relocation Activities						
Site Demolition Activities						
Clearing and Grubbing (one or more of following)						
Clear Vegetation - Local Disposal	AC		9.1	Selective clearing to retain some existing trees.		
Clear /Grub Vegetation - Local Disposal	AC		NA			
Clear /Grub Vegetation - Offsite Disposal	AC		NA			
Clear, stockpile - large woody debris	CY		400	Estimate		
Hydraulic Structures - Small	LS		1	Removal of existing culverts and tidegates - total length unknown.		
Hydraulic Structures - Large	LS		NA			
Utilities	LS		1	Utilities likely need to be relocated or buried deeper - type and extent unknown.		
Buildings	SF		NA			
Pavement	SF		34,080	Removal of 48' wide roadway		
Bulkheads	LF or SF		NA			
Rock revetments	LF, Ton or CY		NA			
Large Coastal Structures	LF, SF or CY		NA			
Demolition / Removal - Bridge	SF or CY		NA			
Removal - Misc. (e.g. angular rock from beach)	Ton		NA			
Demolition / Removal - Boat Ramp	SF		NA			
Haul - Offsite Disposal of Demolition Debris	Miles		20	Assumed.		
Hazardous/Contaminated Waste Removal						
Contaminated Earthwork	CY		0			
Hazardous Earthwork	CY		0			
Construct Temporary Features						
EARTHWORK						
Excavation	CY					
Excavation - Upland	CY		NA			
Excavation - Lowland	CY		80,570	Northern fill removal to intertidal elevations		29.3.1
Excavation - Lowland	CY		47,090	Southern fill removal to intertidal elevations		29.3.1
Excavation - Lowland	CY		6,375	breach at new channel connection.		29.3.1
Dredging - Bucket - Land	CY		NA			
Dredging - Bucket - Marine	CY		NA			
Dredging - Hydraulic	CY		NA			
Fine Grading	AC		NA			
Fill Placement - local borrow						
Side cast	CY		NA			
Haul - uncontrolled placement	CY		NA			
Haul, place, compact	CY		400	Use excavated materials to create berm to prevent tidal inundation near Everett WPCF		29.3.1
Stockpile - uncontrolled placement	CY		NA			
Stockpile - controlled placement	CY		NA			
Conveyor placement from stockpile land/water	CY		NA			
Imported Fill						
Select Fill	CY		NA			
Select Fill	CY		NA			
Gravel Borrow, including haul	CY		NA			
Sand / Gravel for Beach Nourishment	CY		NA			
Cobble for Shore Nourishment	CY		NA			
Embankment Compaction	CY		400	Compact Berm		29.3.1
Topsoil	CY		NA			
RESTORATION Features						
Channel Rehab / Creation	SF		NA			
Large Wood Placement	EA		NA			
Invasive Species Control	Acre		NA			
Physical Exclusion Devices	LF or EA		NA			
Other Restoration Features/ Activities	LS		NA			
Structures	EA					
Water Control Structures - Culverts with Gates	EA		1	Total 65 LF new culvert to allow drainage through new berm.		Table 29-1
Water Control Structures - Weirs	EA		NA			
Rock Slope Protection	LF		NA			
Other	EA		NA			
Elevated Boat Ramp	EA		NA			
Fencing	SF		NA			
Utilities				**Utilities represent a signficant unknown for the quantity/cost estimate.**		
Water	LF		0			
Gas	LF		0			
Electric	LF		0			
Sewer	LF		0			
Telecommunications	LF		0			
Other	LF		0	Others = whatever is required (e.g.. power towers, petroleum, jet fuel, etc.)		
Roadway / Railway						
Roadway	SF		34080	Install new roadway along Smith Island Road		
Roadway - Traffic Signal	LS		0			
Culvert (type)	LF		0			
Culvert - Jacking	LF		0			
Culvert - Horizontal Pile Driving	LF		0			
Bridge Deck	SF		11440	Precast Concrete Girder Bridge with (2) 110' spans (52' wide)		29.3.6
Bridge Foundation Drilled Shafts	LF		52	(1) 52' CIP Concrete pile caps with (2) 7' drilled shafts 100' embed at each pile cap		29.3.6
Railway - Box Girder	SF		0			
Railway - Foundation	LF		0			
Railway - Shoe fly	LF		0			
Permanent Access Features						
Roads	Level		2			
Utility Access Routes	varies		0			
Erosion Control Features	AC		0.78	Stabilized Construction Entrances, Sediment Ponds, Hydro Seed to Stabilize Roadway Embankments		
Public Access or Recreation Features						
Trails	SF		0			
Bridges	SF		0			
Kiosk	EA		0			
Restrooms	EA		0			
Interpretive Signs	EA		0			
Parking Area	SF		0			
Other	EA		0			
Vegetation & Erosion Control						
Hydroseeding	AC		0			
Planting	AC		2.93	Marine Riparian Community to provide buffer around fill removal areas.		
Vegetation Maintenance	AC-YR		14.65	Assume 5 years		
Erosion / sediment BMPs - Temp.	AC		15			
Erosion / sediment BMPs - Permanent	AC		0			
Waterside controls - Temporary	EA, LF, LS		0			
Construction Management						
Construction oversight	weeks		20			
Materials testing						

Full Restoration Quantity Estimate

Action Name: Snohomish Mainstem Connectivity: Slough
Action #: 1805
Date: February 2011
By: ESA

REMEDY: ***Remove historic fill to reconnect a historical blind slough channel to the Snohomish Mainstem***

Construction Period: Five Months

	Item	Unit of Measure	Material Name	Qty	Description of Item		Indicate section of design report where item is described
Design and Detailed Site Investigations							
	Survey & Property, Utility Research	LS		1	% of construction cost		
	35% Design	LS		1	35% x 25% x Engineer's Estimate		
	65% design	LS		1	65% x 25% x Engineer's Estimate less the cost for 35% PS&E		
	90% design	LS		1	35% x 25% x Engineer's Estimate less the cost for 35% + 65%PS&E		
	100% design	LS		1	25% x Engineer's Estimate less previous costs		
	Geotechnical Studies				Refer to design report for description of need		
	Cultural Studies				Refer to design report for description of need		
	HTWR Studies				Refer to design report for description of need		
Project Agreement Activities					Unable to provide credibale estimate at 10% design		
Site-Specific Adaptive Management Features & Activities					List if known		
Monitoring Activities					Assume 5 crew-days/year for each monitoring parameter in design report for 5 yrs		
	Monitoring (Type)	crew-days		125			
Operations & Maintenance					Unable to provide credible estimate at 10% design		

Full Restoration Quantity Estimate

	Action Name:	Snohomish Mainstem Connectivity: Distributary					
	Action #:	1805					
	Date:	February 2011					
	By:	SMW					
	REMEDY: Remove fill to reconnect a historical distributary channel between the Snohomish Mainstem and Union Slough						
	Construction Period: Six Months						
	Item	**Unit of Measure**	**Material Name**	**Qty**	**Description of Item**		**Indicate section of design report where item is described**
ACQUISITION AND CONSERVATION					Based on available mapping information		
	Required Project Lands	Acre		108.7	Total land required For action		29.3.5
	Proponent / Partner-owned lands	Acre		0	Etimate of lands currently owned by Proponent (i.e., Public lands)		29.3.5
	Lands To Be Acquired	Acre		108.7	Estimate land required to be acquired for action prior to implementation		29.3.5
Material Sites					Not Used: See Earthwork - Imported Fill.		
MOBILIZATION AND ACCESS for construction activities					Description required for each item to facilitate cost estimating		
	Mobilization - Typical (Equipment, Personnel, Planning, Financial)	LS		1	Assume 8% of total		
	Mobilization - Remote (Equipment, Personnel, Planning, Financial)	LS		1	Significant coordination will be necessary, especially for temporary roads and traffic control.		
	Site Access	LS		1	Access can utilize existing surface roads to the site. Temporary roads may be needed for some portions of the setback levee.		
	Barge Access	Days		NA			
	Temporary Traffic Control (one of the following)						
	none	LS		NA			
	signs	LS		1			
	flags / spotters	LS		1			
	unique	LS		NA			
	Temporary Roadway	SF		15000	Divert Ross Road during bridge construction.		
	Control of Water	LS		1	Dewatering may be necessary to support channel excavation.		
	Control of Water	LS		1	Additional control may be necessary to preclude tidal inundation during the breech of the north and south connections.		
Relocation Activities							
Site Demolition Activities							
	Clearing and Grubbing (one or more of following)						
	Clear Vegetation - Local Disposal	AC		40	Selective clearing to retain some existing trees.		
	Clear /Grub Vegetation - Local Disposal	AC		NA			
	Clear /Grub Vegetation - Offsite Disposal	AC		NA			
	Clear, stockpile - large woody debris	CY		1000	Estimate		
	Hydraulic Structures - Small	LS		1	Removal of existing culverts and tidegates - total length unknown.		
	Hydraulic Structures - Large	LS		NA			
	Utilities	LS		1	Utilities likely need to be relocated or buried deeper - type and extent unknown.		
	Buildings	SF		66215	Demolish five structures within levee footprint or setback area.		
	Pavement	SF		280,360	Pavement removal from access roads, laydown areas, and parking lots.		
	Pavement	SF		49,440	Pavement removal from Ross Road		
	Pavement	SF		103,200	Pavement Removal from 28th Pl.		
	Bulkheads	LF or SF		NA			
	Rock revetments	LF, Ton or CY		NA			
	Large Coastal Structures	LF, SF or CY		NA			
	Demolition / Removal - Bridge	SF or CY		NA			
	Removal - Misc. (e.g. angular rock from beach)	Ton		NA			
	Demolition / Removal - Boat Ramp	SF		8070	One dock at south end to be removed		
	Haul - Offsite Disposal of Demolition Debris	Miles		20	Assumed.		
Hazardous/Contaminated Waste Removal							
	Contaminated Earthwork	CY		0			
	Hazardous Earthwork	CY		0			
Construct Temporary Features							
EARTHWORK							
	Excavation	CY					
	Excavation - Upland	CY		189,590	Remove historical fill to expose intertidal elevations. Slope to drain toward main channel.		29.3.1
	Excavation - Lowland	CY		74,860	Dredge existing slough channel to -2 ft NAVD 88		29.3.1
	Excavation - Lowland	CY		60,150	Excavation of historical fill to restore southern channel connection.		29.3.1
	Excavation - Lowland	CY		470	Remove portion of access road within levee setback.		29.3.1
	Excavation - Lowland	CY		13,520	Excavate new channels within levee setback area.		29.3.1
	Dredging - Bucket - Land	CY		NA			
	Dredging - Bucket - Marine	CY		NA			
	Dredging - Hydraulic	CY		NA			
	Fine Grading	AC		NA			
	Fill Placement - local borrow						
	Side cast	CY		1,680	Use excavation, lowland spoils from channel excavation to fill ditches		29.3.1
	Haul - uncontrolled placement	CY		NA			
	Haul, place, compact	CY		NA			
	Stockpile - uncontrolled placement	CY		NA			
	Stockpile - controlled placement	CY		NA			
	Conveyor placement from stockpile land/water	CY		NA			
	Imported Fill						
	Select Fill	CY		72500	Fill for eastern setback levee.		29.3.1
	Select Fill	CY		89200	Fill for western setback levee.		29.3.1
	Gravel Borrow, including haul	CY		NA			
	Sand / Gravel for Beach Nourishment	CY		NA			
	Cobble for Shore Nourishment	CY		NA			
	Embankment Compaction	CY		72500	Compact eastern setback levee		29.3.1
	Embankment Compaction	CY		89200	Compact western setback levee		29.3.1
	Topsoil	CY		NA			
RESTORATION Features							
	Channel Rehab / Creation	SF		95200	Realigned channels in levee setback area (2720 ft [geodatabase] *35 ft top width from regressions)		29.3.1
	Large Wood Placement	EA		NA			
	Invasive Species Control	Acre		NA			
	Physical Exclusion Devices	LF or EA		NA			
	Other Restoration Features/ Activities	LS		NA			
Structures		EA					
	Water Control Structures - Culverts with Gates	EA		3	Total 370 LF new culvert to allow drainage through setback levee.		29.3.1
	Water Control Structures - Weirs	EA		NA			
	Rock Slope Protection	LF		2900	Only at southern end to protect bridge.		29.3.1
	Other	EA		NA			
	Elevated Boat Ramp	EA		1	Replace Dock at South End - size/type to be determined		29.3.1
	Fencing	SF		NA			
Utilities							
	Water	LF		0			
	Gas	LF		0			
	Electric	LF		0			
	Sewer	LF		0			
	Telecommunications	LF		0			
	Other	LF		0	Others = whatever is required (e.g.. power towers, petroleum, jet fuel, etc.)		
Roadway / Railway					KPFF expected to participate in these estimates		
	Roadway	SF		33600	Replace Ross Road on Levee		29.3.6
	Roadway	SF		103200	Relocated 28th Pl east of slough.		29.3.6
	Roadway - Traffic Signal	LS		0			
	Culvert (type)	LF		0			
	Culvert - Jacking	LF		0			
	Culvert - Horizontal Pile Driving	LF		0			
	Bridge Deck	SF		17160	Ross Road: Precast Concrete Girder Bridge with (3) 110' spans (52' wide)		29.3.6
	Bridge - Foundation Drilled Shafts	LF		104	Ross Road: (2) 52' CIP Concrete pile caps with (2) 7' drilled shafts 100' embed at each pile cap		29.3.6
	Bridge - Foundations, Deck and Appurtenances	SF		0			
	Railway - Box Girder	SF		0			
	Railway - Foundation	LF		0			
	Railway - Shoe fly	LF		0			
Permanent Access Features							
	Roads	Level		0			
	Utility Access Routes	varies		0			
	Erosion Control Features	AC		1.14	Ross Road: Stabilized Construction Entrances, Sediment Ponds, Hydro Seed to Stabilize Roadway Embankments		
	Erosion Control Features			2.4	28th Place: Stabilized Construction Entrances, Sediment Ponds, Hydro Seed to Stabilize Roadway Embankments		
Public Access or Recreation Features							
	Trails	SF		0			
	Bridges	SF		0			
	Kiosk	EA		0			
	Restrooms	EA		0			
	Interpretive Signs	EA		0			
	Parking Area	SF		0			
	Other	EA		0			

Full Restoration Quantity Estimate

	Action Name:	Snohomish Mainstem Connectivity: Distributary					
	Action #:	1805					
	Date:	February 2011					
	By:	SMW					

REMEDY: Remove fill to reconnect a historical distributary channel between the Snohomish Mainstem and Union Slough

Construction Period: Six Months

	Item	Unit of Measure	Material Name	Qty	Description of Item		Indicate section of design report where item is described
Vegetation & Erosion Control							
	Hydroseeding	AC		0			
	Planting	AC		1.75	Marine Riparian Community within high spots within levee setback area.		
	Vegetation Maintenance	AC-YR		8.75	Assume 5 years		
	Erosion / sediment BMPs - Temp.	AC		30			
	Erosion / sediment BMPs - Temp.	AC		1.14	Ross Road: BMPs for control of drainage - describe. Assume compliance with Construction General NPDES included		
	Erosion / sediment BMPs - Temp.	AC		2.4	28th Place: BMPs for control of drainage - describe. Assume compliance with Construction General NPDES included		
	Erosion / sediment BMPs - Permanent	AC		0			
	Waterside controls - Temporary	EA, LF, LS		0			
Construction Management							
	Construction oversight	weeks		64			
	Materials testing						
Design and Detailed Site Investigations							
	Survey & Property, Utility Research	LS		1	% of construction cost		
	35% Design	LS		1	35% x 25% x Engineer's Estimate		
	65% design	LS		1	65% x 25% x Engineer's Estimate less the cost for 35% PS&E		
	90% design	LS		1	35% x 25% x Engineer's Estimate less the cost for 35% + 65%PS&E		
	100% design	LS		1	25% x Engineer's Estimate less previous costs		
	Geotechnical Studies				Refer to design report for description of need		
	Cultural Studies				Refer to design report for description of need		
	HTWR Studies				Refer to design report for description of need		
Project Agreement Activities					Unable to provide credibale estimate at 10% design		
Site-Specific Adaptive Management Features & Activities					List if known		
Monitoring Activities					Assume 5 crew-days/year for each monitoring parameter in design report for 5 yrs		
	Monitoring (Type)	crew-days		125			
Operations & Maintenance					Unable to provide credible estimate at 10% design		

Partial Restoration Quantity Estimate

Action Name:	Snohomish Mainstem Connectivity: Slough
Action #:	1805
Date:	February 2011
By:	ESA

REMEDY: ***Remove historic fill to reconnect a historical blind slough channel to the Snohomish Mainstem Embankment and restore natural channel morphology.***

Construction Period: 6 Months

	Item	**Unit of Measure**	**Material Name**	**Qty**	**Description of Item**	**Indicate section of design report where item is described**
ACQUISITION AND CONSERVATION					Based on available mapping information	
	Required Project Lands	Acre		27.8	Total land required For action	29.3.5
	Proponent / Partner-owned lands	Acre		27.8	Etimate of lands currently owned by Proponent (i.e., Public lands)	29.3.5
	Lands To Be Acquired	Acre		0	Estimate land required to be acquired for action prior to implementation	29.3.5
Material Sites					Not Used: See Earthwork - Imported Fill.	
MOBILIZATION AND ACCESS for construction activities					Description required for each item to facilitate cost estimating	
	Mobilization - Typical (Equipment, Personnel, Planning, Financial)	LS		1	Assume 8% of total	
	Mobilization - Remote (Equipment, Personnel, Planning, Financial)	LS		1	Significant coordination will be necessary, especially for temporary roads and traffic control.	
	Site Access	LS		1	Access can utilize existing surface roads to the site. During bridge construction, traffic may need to be routed to WPCF berms.	
	Barge Access	Days		NA		
	Temporary Traffic Control (one of the following)					
	none	LS		NA		
	signs	LS		1		
	flags / spotters	LS		1		
	unique	LS		NA		
	Temporary Roadway	LS		1	Divert traffic to 12th Street/ WPCF levees during bridge installation	29.3.7
	Control of Water	LS		1	May need to block tidal action during breech.	
Relocation Activities						
Site Demolition Activities						
	Clearing and Grubbing (one or more of following)					
	Clear Vegetation - Local Disposal	AC		9.1		
	Clear /Grub Vegetation - Local Disposal	AC		NA		
	Clear /Grub Vegetation - Offsite Disposal	AC		NA		
	Clear, stockpile - large woody debris	CY		400	Estimate	
	Hydraulic Structures - Small	LS		1	Removal of existing culverts and tidegates - total length unknown.	
	Hydraulic Structures - Large	LS		NA		
	Utilities	LS		1	Utilities likely need to be relocated or buried deeper - type and extent unknown.	
	Buildings	SF		NA		
	Pavement	SF		23040	Smith Island Road: Removal of 30' Roadway and portion of Lilliwaup St (250'x25')	
	Bulkheads	LF or SF		NA		
	Rock revetments	LF, Ton or CY		NA		
	Large Coastal Structures	LF, SF or CY		NA		
	Demolition / Removal - Bridge	SF or CY		NA		
	Removal - Misc. (e.g. angular rock from beach)	Ton		NA		
	Demolition / Removal - Boat Ramp	SF		NA		
	Haul - Offsite Disposal of Demolition Debris	Miles		20	Assumed.	
Hazardous/Contaminated Waste Removal						
	Contaminated Earthwork	CY		0		
	Hazardous Earthwork	CY		0		
Construct Temporary Features						
EARTHWORK						
	Excavation	CY				
	Excavation - Upland	CY		NA		
	Excavation - Lowland	CY		83,000	Northern fill removal to intertidal elevations	29.3.1
	Excavation - Lowland	CY		2,790	Breech at new channel connection.	29.3.1
	Dredging - Bucket - Land	CY		NA		
	Dredging - Bucket - Marine	CY		NA		
	Dredging - Hydraulic	CY		NA		
	Fine Grading	AC		NA		
	Fill Placement - local borrow					
	Side cast	CY		NA		
	Haul - uncontrolled placement	CY		NA		
	Haul, place, compact	CY		2,100	Use excavated materials to create berm to prevent tidal inundation near Everett WPCF	29.3.1
	Stockpile - uncontrolled placement	CY		NA		
	Stockpile - controlled placement	CY		NA		
	Conveyor placement from stockpile land/water	CY		NA		
	Imported Fill					
	Select Fill	CY		NA		
	Select Fill	CY		NA		
	Gravel Borrow, including haul	CY		NA		
	Sand / Gravel for Beach Nourishment	CY		NA		
	Cobble for Shore Nourishment	CY		NA		
	Embankment Compaction	CY		2100	Compact Berm	29.3.1
	Topsoil	CY		NA		
RESTORATION Features						
	Channel Rehab / Creation	SF		NA		
	Large Wood Placement	EA		NA		
	Invasive Species Control	Acre		NA		
	Physical Exclusion Devices	LF or EA		NA		
	Other Restoration Features/ Activities	LS		NA		
Structures		EA				
	Water Control Structures - Culverts with Gates	EA		1	Total 170 LF new culvert to allow drainage through new berm.	Table 29-1
	Water Control Structures - Weirs	EA		NA		
	Rock Slope Protection	LF		410	Provide at new mouth.	29.3.1
	Other	EA		NA		
	Elevated Boat Ramp	EA		NA		
	Fencing	SF		NA		
Utilities					**Utilities represent significant unknown for quantities.**	
	Water	LF		0		
	Gas	LF		0		
	Electric	LF		0		
	Sewer	LF		0		
	Telecommunications	LF		0		
	Other	LF		0	Others = whatever is required (e.g.. power towers, petroleum, jet fuel, etc.)	
Roadway / Railway					KPFF expected to participate in these estimates	
	Roadway	SF		19,200	Smith: Typical Roadway 48' wide	
	Roadway - Traffic Signal	LS		0		
	Culvert (type)	LF		0		
	Culvert - Jacking	LF		0		
	Culvert - Horizontal Pile Driving	LF		0		
	Bridge Deck	SF		4160	Voided Slab Bridge with (1) 80' span (52' wide)	29.3.6
	Bridge - Foundation Drilled Shafts	LF		52	(1) 52' CIP Concrete pile caps with (2) 7' drilled shafts 100' embed at each pile cap	29.3.6
	Railway - Box Girder	SF		0		
	Railway - Foundation	LF		0		
	Railway - Shoe fly	LF		0		
Permanent Access Features						
	Roads	Level		2		
	Utility Access Routes	varies		0		
	Erosion Control Features	L.F.		0.72	Stabilized Construction Entrances, Sediment Ponds, Hydro Seed to Stabilize Roadway Embankments	
Public Access or Recreation Features						
	Trails	SF		0		
	Bridges	SF		0		
	Kiosk	EA		0		
	Restrooms	EA		0		
	Interpretive Signs	EA		0		
	Parking Area	SF		0		
	Other	EA		0		
Vegetation & Erosion Control						
	Hydroseeding	AC		0		
	Planting	AC		1.95	Marine Riparian Community to provide buffer around fill removal areas.	
	Vegetation Maintenance	AC-YR		9.75	Assume 5 years	
	Erosion / sediment BMPs - Temp.	AC		16		
	Erosion / sediment BMPs - Permanent	AC		0		
	Waterside controls - Temporary	EA, LF, LS		0		
Construction Management						
	Construction oversight	weeks		24		
	Materials testing					

Partial Restoration Quantity Estimate

Action Name: Snohomish Mainstem Connectivity: Slough
Action #: 1805
Date: February 2011
By: ESA

REMEDY: ***Remove historic fill to reconnect a historical blind slough channel to the Snohomish Mainstem Embankment and restore natural channel morphology.***
Construction Period: 6 Months

	Item	Unit of Measure	Material Name	Qty	Description of Item		Indicate section of design report where item is described
Design and Detailed Site Investigations							
	Survey & Property, Utility Research	LS		1	% of construction cost		
	35% Design	LS		1	35% x 25% x Engineer's Estimate		
	65% design	LS		1	65% x 25% x Engineer's Estimate less the cost for 35% PS&E		
	90% design	LS		1	35% x 25% x Engineer's Estimate less the cost for 35% + 65%PS&E		
	100% design	LS		1	25% x Engineer's Estimate less previous costs		
	Geotechnical Studies				Refer to design report for description of need		
	Cultural Studies				Refer to design report for description of need		
	HTWR Studies				Refer to design report for description of need		
Project Agreement Activities					Unable to provide credibale estimate at 10% design		
Site-Specific Adaptive Management Features & Activities					List if known		
Monitoring Activities					Assume 5 crew-days/year for each monitoring parameter in design report for 5 yrs		
	Monitoring (Type)	crew-days		125			
Operations & Maintenance					Unable to provide credible estimate at 10% design		

Partial Restoration Quantity Estimate

Action Name:	Snohomish Mainstem Connectivity: Distributary
Action #:	1805
Date:	February 2011
By:	ESA

REMEDY: ***Remove fill to reconnect a historical distributary channel between the Snohomish Mainstem and Union Slough***

Construction Period: Three months

Item	Unit of Measure	Material Name	Qty	Description of Item		Indicate section of design report where item is described
ACQUISITION AND CONSERVATION				Based on available mapping information		
Required Project Lands	Acre		48	Total land required For action		29.3.5
Proponent / Partner-owned lands	Acre		0	Etimate of lands currently owned by Proponent (i.e., Public lands)		29.3.5
Lands To Be Acquired	Acre		48	Estimate land required to be acquired for action prior to implementation		29.3.5
Material Sites				Not Used: See Earthwork - Imported Fill.		
MOBILIZATION AND ACCESS for construction activities				Description required for each item to facilitate cost estimating		
Mobilization - Typical (Equipment, Personnel, Planning, Financial)	LS		1	Assume 8% of total		
Mobilization - Remote (Equipment, Personnel, Planning, Financial)	LS		1	Significant coordination will be necessary, especially for temporary roads and traffic control.		
Site Access	LS		1	Access can utilize existing surface roads to the site. Temporary roads may be needed for some portions of the setback levee.		
Barge Access	Days		NA			
Temporary Traffic Control (one of the following)						
none	LS		NA			
signs	LS		1	Levee Construction		
signs	LS		1	Ross Road		
signs	LS		1	28th Pl		
flags / spotters	LS		1	Levee Construction		
flags / spotters	LS		1	Ross Road		
flags / spotters	LS		1	28th Pl		
unique	LS		NA			
Temporary Roadway	SF		15000	Divert Ross Road during bridge construction.		
Control of Water	LS		1	Additional control may be necessary to preclude tidal inundation during the breech of the north and south connections.		
Relocation Activities						
Site Demolition Activities						
Clearing and Grubbing (one or more of following)						
Clear Vegetation - Local Disposal	AC		13.7	Selective clearing to retain some existing trees.		
Clear /Grub Vegetation - Local Disposal	AC		NA			
Clear /Grub Vegetation - Offsite Disposal	AC		NA			
Clear, stockpile - large woody debris	CY		400	Estimate		
Hydraulic Structures - Small	LS		1	Removal of existing culverts and tidegates - total length unknown.		
Hydraulic Structures - Large	LS		NA			
Utilities	LS		1	Utilities likely need to be relocated or buried deeper - type and extent unknown.		
Buildings	SF		NA			
Pavement	SF		117,538	Pavement removal from existing access roads, laydown areas, and parking lots.		
Pavement	SF		41,280	Ross Road: Removal of 30' Roadway and portion of Lilliwaup St (250'x25')		
Pavement	SF		33,120	28th Place: Removal of 48' Roadway		
Bulkheads	LF		160	Ross Road Armor Removal		
Rock revetments	LF, Ton or CY		NA			
Large Coastal Structures	LF, SF or CY		NA			
Demolition / Removal - Bridge	SF or CY		NA			
Removal - Misc. (e.g. angular rock from beach)	Ton		NA			
Demolition / Removal - Boat Ramp	SF		NA			
Haul - Offsite Disposal of Demolition Debris	Miles		20	Assumed.		
Hazardous/Contaminated Waste Removal						
Contaminated Earthwork	CY		0			
Hazardous Earthwork	CY		0			
Construct Temporary Features						
EARTHWORK						
Excavation	CY					
Excavation - Upland	CY		NA			29.3.1
Excavation - Lowland	CY		29,390	Excavation of historical fill to restore southern channel connection.		29.3.1
Excavation - Lowland	CY		14,800	Breech northern levee		29.3.1
Dredging - Bucket - Land	CY		NA			29.3.1
Dredging - Bucket - Marine	CY		NA			29.3.1
Dredging - Hydraulic	CY		NA			
Fine Grading	AC		NA			
Fill Placement - local borrow						
Side cast	CY		NA			
Haul - uncontrolled placement	CY		NA			
Haul, place, compact	CY		NA			
Stockpile - uncontrolled placement	CY		NA			
Stockpile - controlled placement	CY		NA			
Conveyor placement from stockpile land/water	CY		NA			
Imported Fill						
Select Fill	CY		40310	Fill for western setback levee.		29.3.1
Select Fill	CY		53820	Fill for eastern setback levee.		29.3.1
Gravel Borrow, including haul	CY		NA			
Sand / Gravel for Beach Nourishment	CY		NA			
Cobble for Shore Nourishment	CY		NA			
Embankment Compaction	CY		40310	Compact western setback levee		29.3.1
Embankment Compaction	CY		53820	Compact eastern setback levee		29.3.1
Topsoil	CY		NA			
RESTORATION Features						
Channel Rehab / Creation	SF		NA			29.3.1
Large Wood Placement	EA		NA			
Invasive Species Control	Acre		NA			
Physical Exclusion Devices	LF or EA		NA			
Other Restoration Features/ Activities	LS		NA			
Structures	EA					
Water Control Structures - Culverts with Gates	EA		3	Total 225 LF new culvert to allow drainage through setback levee.		29.3.1
Water Control Structures - Weirs	EA		NA			
Rock Slope Protection	LF		5050	East Side		29.3.1
Rock Slope Protection	LF		4925	West Side		
Other	EA		NA			29.3.1
Elevated Boat Ramp	EA		NA			
Fencing	SF		NA			
Utilities						
Water	LF		0			
Gas	LF		0			
Electric	LF		0			
Sewer	LF		0			
Telecommunications	LF		0			
Other	LF		0	Others = whatever is required (e.g.. power towers, petroleum, jet fuel, etc.)		
Roadway / Railway				KPFF expected to participate in these estimates		
Roadway	SF		33,600	Ross Road at southern channel connection		29.3.6
Roadway - Traffic Signal	LS		0			29.3.6
Culvert (type)	LF		0			
Culvert - Jacking	LF		0			
Culvert - Horizontal Pile Driving	LF		0			
Bridge Deck	SF		8320	Ross Road: Precast Concrete Girder Bridge with (1) 160' span (52' wide)		
Bridge Foundation Drilled Shafts	SF		52	Ross Road: (1) 52' CIP Concrete pile caps with (2) 7' drilled shafts 100' embed at each pile cap		29.3.6
Railway - Box Girder	SF		0			
Railway - Foundation	LF		0			
Railway - Shoe fly	LF		0			
Permanent Access Features						
Roads	Level		2	Ross Road		
Roads	Level		2	28th Pl		
Utility Access Routes	varies		0			
Erosion Control Features	AC		0.95	Ross Road: Stabilized Construction Entrances, Sediment Ponds, Hydro Seed to Stabilize Roadway Embankments		
Erosion Control Features	AC		0.72	28th Place: Stabilized Construction Entrances, Sediment Ponds, Hydro Seed to Stabilize Roadway Embankments		
Public Access or Recreation Features						
Trails	SF		0			
Bridges	SF		0			
Kiosk	EA		0			
Restrooms	EA		0			
Interpretive Signs	EA		0			
Parking Area	SF		0			
Other	EA		0			

Partial Restoration Quantity Estimate

Action Name: Snohomish Mainstem Connectivity: Distributary
Action #: 1805
Date: February 2011
By: ESA

REMEDY: ***Remove fill to reconnect a historical distributary channel between the Snohomish Mainstem and Union Slough***

Construction Period: Three months

	Item	Unit of Measure	Material Name	Qty	Description of Item		Indicate section of design report where item is described
Vegetation & Erosion Control							
	Hydroseeding	AC		NA			
	Planting	AC		NA			
	Vegetation Maintenance	AC-YR		NA			
	Erosion / sediment BMPs - Temp.	AC		12	Levee setback		
	Erosion / sediment BMPs - Temp.	AC		0.95	Ross Road: BMPs for control of drainage - describe. Assume compliance with Construction General NPDES included		
	Erosion / sediment BMPs - Temp.	AC		0.76	28th Place BMPs for control of drainage - describe. Assume compliance with Construction General NPDES included		
	Erosion / sediment BMPs - Permanent	AC		NA			
	Waterside controls - Temporary	EA, LF, LS		NA			
Construction Management							
	Construction oversight	weeks		20			
	Materials testing						
Design and Detailed Site Investigations							
	Survey & Property, Utility Research	LS		1	% of construction cost		
	35% Design	LS		1	35% x 25% x Engineer's Estimate		
	65% design	LS		1	65% x 25% x Engineer's Estimate less the cost for 35% PS&E		
	90% design	LS		1	35% x 25% x Engineer's Estimate less the cost for 35% + 65%PS&E		
	100% design	LS		1	25% x Engineer's Estimate less previous costs		
	Geotechnical Studies				Refer to design report for description of need		
	Cultural Studies				Refer to design report for description of need		
	HTWR Studies				Refer to design report for description of need		
Project Agreement Activities					Unable to provide credibale estimate at 10% design		
Site-Specific Adaptive Management Features & Activities					List if known		
Monitoring Activities					Assume 5 crew-days/year for each monitoring parameter in design report for 5 yrs		
	Monitoring (Type)	crew-days		125			
Operations & Maintenance					Unable to provide credible estimate at 10% design		

30. SNOW CREEK AND SALMON CREEK ESTUARY RESTORATION (#1230)

Local Proponent(s)	Hood Canal Coordinating Council, Jefferson County Conservation District, North Olympic Salmon Coalition
Delta Process Unit	NA
Shoreline Process Unit(s)	1010, 1011
Strategy(ies)	4 - Coastal Inlet
Restoration Objectives	Remove barriers formed by abandoned railroad fill, retarded deltaic deposits, and roadways to restore tidal hydrology, freshwater input and alluvial sediment supply, sediment supply and transport, beach erosion / accretion, and tidal flow

30.1 Description of the Action

The proposed action will remove obstructions formed by abandoned railroad, fill, retarded deltaic deposits and roadways to restore the Snow Creek-Salmon Creek Estuary. This will include replacing existing sections of Highway 101 with a bridge, removal of the railroad grade, reconfiguration of tidal channels, and removal of fill. Please see the Introduction chapter for important information regarding PSNERP and for context related to this restoration project.

30.2 Action Area Description and Context

The action area encompasses the mouths of Salmon and Snow Creeks, which form a low-gradient riparian area transitioning to wetland and sediment flats in Discovery Bay. Agriculture and limited development have impacted the riparian area, channelized and separated creek channels, and caused habitat loss. Highway 101 crosses the site in the zone of brackish to salt marsh with bridges at each of the creeks. Farther downstream (north), an abandoned railroad grade crosses the wetland delta, further channelizing the creeks and impacting hydraulics, sediment, and morphology. The railroad continues northward at low elevations within the historic footprint of Discovery Bay, resulting in a range of modified shore habitat including a lagoon that supports Olympia oyster beds. The railroad right-of-way is also targeted for public access, which may conflict with restoration. WDFW owns much of the property and has restored some areas. The action area is shown in Figure 30-1.

Figure 30-1. Action Area and Vicinity

30.2.1 Historic Condition

Figures 30-2A and 30-2B provide historic maps of the action area. An interpretation of the historic creek channel alignments using historic maps, including Government Land Office (GLO) maps, was provided by the Hood Canal Coordinating Council (JCCD 2004). The maps show that Salmon Creek was historically located at the western edge of the valley, while Snow Creek was located near the center of the valley. Snow Creek joined Salmon Creek well upstream (south) of the current Highway 101 alignment, and the two systems discharged to Discovery Bay as a single channel. What appears to be the mouth of Snow Creek would have been a tidal slough which could have been the remnant of an older creek alignment. Based on these historic maps, it appears the historic conditions have been significantly altered over time.

The low tide limit on the historic maps was approximately at the mouth of the estuary with westward-reaching, open spits on the north and south banks (visible on the plans sheets in Figures 30-23 and 30-4). The 1870 topographic sheet (T-sheet) shows a road or causeway across the estuary with tidal marsh upstream of the road. The 1890 hydrographic sheet (H-sheet) shows the road at the boundary of salt marsh (north) and freshwater marsh (south). This implies that the roadway affected sediment transport between 1870 and 1890, and the boundary between the marshes was the result of the causeway.

30.2.2 Natural Environment

The Salmon-Snow Estuary is located at the convergence of two drift cells (both originate outside of the study area and therefore are not shown on the figures included here). One originates to the north of Mill Point and flows south and southwest along the western shore of Discovery Bay, while the other originates at Adelma Beach and flows to the south and southeast along the eastern side of the bay. According to Shipman (2008), lower Discovery Bay is classified as a coastal embayment with a typical elongated, glacial trough estuary. The bay ends in a tide-dominated river delta system with alluvial floodplain, salt marsh, tidal and subtidal flats, distributary channels, and tidal channels (Shreffler 2010 citing Brocksmith 2010). Salmon and Snow Creeks have distinct distributary channels through the mudflats to the outer delta. The adjacent shores are dominated by fine-grained sediments with beach berm, beach face, and low-tide terrace landforms. Interspersed in these beach systems are small embayments with barrier estuary and lagoon landforms (Shreffler 2010 citing Brocksmith 2010).

The historic northern spit has been partially closed by the railroad grade to form the Mill Pond Lagoon and Cherry Tree Pond. The Mill Pond Lagoon is connected to Discovery Bay via a creosote trestle bridge at the railroad grade. There are two cells of the lagoon with an open connection to allow tidal flows. A network of tidal channels is visible within the larger (northern) cell, while the southern cell has a deeper pool to the north and mudflats to the south. The Cherry Tree Pond is disconnected from the tides and receives freshwater input from local hillside runoff west of Highway 101. A small cobble and gravel beach is present on the outboard side of the railroad grade levee.

Salmon Creek is sinuous through the action area, with large wood present at several bend locations. The railroad grade bisects an historical tidal channel to form two dead-end channels. The Salmon Creek tidal channel is joined by a remnant of its historic meander, which was cut off by the railroad. Two recent tidal restoration sites totaling approximately 11 acres are located adjacent to Salmon Creek. One tidal restoration site, approximately 6 acres, is located immediately east of Salmon Creek and south of Highway 101. The other recently restored site, approximately 5 acres, is located northwest of the mouth of Salmon Creek, immediately east of Highway 101. In 2007 these parcels were lowered by approximately 3 feet to the tide range. Tidal channels were excavated and emergent species such as rushes are currently establishing within the marsh.

Snow Creek is largely linear through the action area, and is contained by embankments adjacent to the eastern edge of the site. Snow Creek is primarily fresh water through the action area to a point downstream of the railroad grade. Snow Creek is channelized by openings at Highway 101, State Route 20, and the railroad corridor. Sediment has accumulated and been dredged onto the banks, and the tidal portion of the creek is largely disconnected from the adjacent delta wetland floodplain.

Discovery Bay supports a small population of rare native Olympia oysters. The bay is one of the largest and most important commercial shellfish harvesting areas in Washington state.

30.2.3 Human Environment

Highway 101, State Route 20, and a railroad grade embankment cross the estuary of Salmon and Snow Creeks. The railroad grade is parallel to, and north of, Highway 101 and is presently used as an informal trail and conduit for a private water line. Highway 101 is a two-lane state highway (designation R1) and is the primary north-south route along Hood Canal on the Olympic

Peninsula. State Route 20, also a two-lane highway which continues north to Port Townsend, intersects Highway 101 at the eastern limits of the action area.

WDFW owns most of the land in the action area; parcels between Highway 101 and the railroad grade east of Salmon Creek are mostly privately owned. Several buildings are present at the western edge of the action area along Highway 101 and include private residences, outbuildings, and commercial buildings. These structures are situated on higher ground than much of the action area. The local community is considering conversion of the railroad grade to a regional trail. An overhead telephone/power line crosses Discovery Bay from the southern spit to the embankment between the two cells of the lagoon and continues westward across Highway 101. A private 2-inch water line is located in the railroad grade through the entire action area. This water line is supplied by nearby upslope springs and serves approximately 25 local residences. More detailed information on existing utilities and the need for utility relocations will be required to support subsequent site designs.

Olympia oysters are grown in the muted intertidal lagoon area formed by the abandoned railroad. The restoration alternatives maintain this area to support the native oyster population in Discovery Bay.

30.3 Restoration Design Concept

30.3.1 Restoration Overview and Key Design Assumptions

Removal of major stressors presents a significant opportunity for process-based restoration at this location. The restoration will remove the Highway 101 concrete bridges at Salmon Creek and Snow Creek (120-foot and 68-foot-long, respectively) and one 104-foot timber treated structure over Snow Creek at State Route 20. The new bridge crossings and channel dimensions were determined using the methodologies of the *Applied Geomorphology Guidelines and Hierarchy of Openings* (Appendix C). The restoration also removes the abandoned railroad grade and structures which are significant stressors that effectively convert 2.5 acres of intertidal wetland to upland of limited ecolgocial value; inhibit hydraulics; and limit other natural dynamics including wave action. These stressors also disrupt migratory pathways and serve as a vector for human disturbances. Removal of the railway embankment will reverse these effects, restore high-water inundation and sedimentation patterns, allow more natural movements of nutrients and animals, and allow development of larger, longer blind channels which may benefit fish. ISE Consultants (2009) indicated that wave action should not be a problem due to railway removal.

The full restoration alternative will extend the restoration of tidal marsh to the area south of Highway 101. The partial restoration alternative will limit the extent of tidal marsh restoration to the area north of Highway 101. The restoration alternatives are shown in Figures 30-3 through 30-7.

The removal of fill and delta deposits would also significantly improve habitat. Upstream of Highway 101, the Snow Creek channel is in an unnatural position, disconnected from floodplains and wetlands. Reconnection to Salmon Creek, under the full alternative, would enhance floodplain and wetland connectivity. The mouth of Snow Creek is captured within levee-like deposits that extend from Highway 101 well into Discovery Bay. Reconfiguring the channel outside this “delta cone” deposit will connect the tidal river channel with adjacent wetlands.

The full restoration alternative will realign Highway 101 to the north of the existing alignment. A bridge is proposed to elevate the highway across the entire estuary, generally delineated by Snow Creek to the east and Salmon Creek to the west (Figure 30-3). The partial restoration alternative will construct a new long-span bridge at Salmon Creek, with no changes to the roadway crossings at Snow Creek (Figure 30-4).

The existing roadway will remain in service during construction. The roadway prism and bridges will be removed upon completion for both alternatives. Right-of-way acquisition is required for both alternatives. Intersection improvements also will be required at State Route 20 and West Uncas Road for the full restoration alternative. The key design elements associated with full and partial restoration alternatives are shown in Table 30-1.

Table 30-1. Key Design Elements

Element	Full Restoration	Partial Restoration
Bridges	Remove Hwy 101 bridges and remove SR 20 bridge, construct single long-span bridge (1,175 feet long). New pedestrian bridge along railroad grade at Mill Pond Lagoon (125 feet). Three creosote log structures (2 trestles, 1 bridge) to be removed along railroad grade	Remove Hwy 101 bridge at Salmon Creek, replace with a 600-foot-long bridge providing higher clearance. New pedestrian bridges along railroad grade at Cherry Tree Pond (45 feet) and Mill Pond Lagoon (125 feet). Three creosote log structures (2 trestles, 1 bridge) to be removed along railroad grade
Roadway Embankment	Remove Hwy 101 and SR 20 embankment fill within estuary limits	Similar to full restoration except that removed portions of embankment fill will largely be replaced with fill for new roadway alignment
Utilities	Relocate overhead transmission line at roadway and water line in railroad grade	Same as full restoration
Abandoned Railroad	Remove abandoned railroad grade across delta wetlands and western shore of Discovery Bay	Same as full restoration
Lowland Excavation (Wetland and Tidal Channel Restoration)	Acquire lands, demolish and remove buildings, and excavate down to MHHW in areas north and south of Hwy 101 to restore historic tidal wetland area Reconnect wetlands to lower Snow Creek by excavating through delta cone created by Snow Creek Expand Salmon Creek at Hwy 101 crossing Restore delta distributary and tidal channels by excavating imported fill Excavate Cherry Tree Pond	Same as full restoration except areas south of Hwy 101 are not included for wetland and tidal channel restoration and Salmon Creek will not be expanded at Hwy 101 crossing

Element	Full Restoration	Partial Restoration
Upland Excavation (Reconnect Creeks)	Reconnect Snow Creek to Salmon Creek Plant riparian vegetation and place large wood structures	Not included
Beach Restoration	Remove existing armor and grade 1,000 LF of western shore of Discovery Bay	Same as full restoration
Trail	Construct trail from Mill Pond Lagoon, along Hwy 101, to southeast shore of Discovery Bay	Same as full restoration

30.3.2 Restoration Features – Primary Process-Based Management Measures

Armor Removal/Modification

Along with the removal of the abandoned railroad embankment, shore armor will be removed along 1,000 feet on the west side of Discovery Bay, from Salmon Creek to the south end of Mill Pond Lagoon in both alternatives. The slope will be graded back and filled with clean beach gravel as shown in Figures 30-5 and 30-6.

Berm or Dike Removal/Modification

The full restoration alternative will result in complete reconstruction of Highway 101 at the Discovery Bay crossing. The new highway will be elevated on piles across the delta (Figure 30-7). The intersection with State Route 20 will be reconfigured and located at the east side of the action area, east of what is now Snow Creek. This alignment will require purchasing a portion of the property for the State Route 20 right-of-way, adjacent to the shore. In addition, road access to properties between Salmon and Snow Creeks would be lost, and it will be necessary to purchase these properties. The full restoration alternative includes a combined-use (bicycle and pedestrian) access trail (12-feet wide) adjacent to, and part of, the elevated Highway 101 roadway structure.

The partial restoration alternative will replace the existing Salmon Creek bridge with a longer bridge. A new roadway will be constructed immediately north and adjacent to the existing Highway 101 grade. A new roadway embankment will be constructed to transition (both vertically and horizontally) from the end of the new bridge to match the existing grade near the State Route 20 intersection. A portion of the existing roadway east of the new Salmon Creek bridge will be maintained to provide access to the private properties south of Highway 101. Only minor changes will be made to the State Route 20 intersection, with no changes to the Highway 101 and State Route 20 roadway crossings at Snow Creek under the partial restoration alternative.

In both the full and partial restoration alternatives, the abandoned railroad embankment will be removed from east of Snow Creek to west of Salmon Creek, completely removing this stressor from the delta wetlands. The portion of the railroad grade along the western shore of Discovery Bay will be used to accommodate a public access trail (12-feet wide) as described below under *Restoration Features- Other*.

Channel Rehabilitation/Creation

The full restoration alternative will connect Snow Creek to Salmon Creek with a new channel located about 1,900 feet upstream of Highway 101. The new channel is located within property owned by WDFW. In the partial alternative, Snow Creek will not be reconnected to Salmon Creek.

The downstream (northerly) section of Snow Creek will become a tidal slough for both restoration alternatives. The downstream part of Salmon Creek will be excavated at the Highway 101 crossing, but otherwise will be allowed to scour as it expands to accommodate the flow from Snow Creek.

The historic main channel of Salmon Creek will be reconnected just north of Highway 101 on the right bank of the existing channel, where the railroad embankment had previously blocked the channel and caused infill by sediment deposition. Farther north and east, a small remnant of a channel will be expanded, reestablishing a delta wetland island that had prematurely melded with the adjacent marsh. A new distributary channel branch will extend southward to the lower portion of Snow Creek through the delta cone deposits. Also, a new lower Snow Creek channel system will be constructed by excavating several short segments that loop through the deltaic deposits.

The removal of fill and excavation of new channels will result in the creation of several individual tidal marsh basins within the existing tidal marsh, outboard of the railroad grade. Second and third order channels will be excavated to drain these small basins (on the order of 1 to 3 acres) (Figures 30-5 and 30-6). The second- and third-order channels will be connected to the distributary channels to enhance the drainage of the tidal marsh. Channel alignments will be located to breach the deltaic deposits along lower Snow Creek and extend tidal action into areas with unnaturally high elevations. Some higher ground will remain after channel excavation.

The full restoration alternative extends tidal marsh restoration into the private properties within the Snow-Salmon delta wetland complex. The partial restoration alternative does not include the private properties south of Highway 101.

Groin Removal/Modification - NA

Hydraulic Modification

The culvert in the railroad grade at Cherry Tree Pond would be removed and the opening widened under both restoration alternatives. This widened opening would be spanned by a new pedestrian bridge (45 feet long) under the partial restoration alternative. The full restoration alternative does not include a bridge span at this location; the opening would be allowed to modify over time naturally.

Overwater Structure Removal

Three creosote timber structures associated with the abandoned railroad grade would be removed under both restoration alternatives. The creosote railroad trestles at the Mill Pond Lagoon (125 feet) and at Salmon Creek (110 feet) will be demolished. The creosote timber railroad bridge at Snow Creek (40 feet) will also be demolished.

Topography Restoration

Surface grading is proposed to lower areas of high ground due to sedimentation and fill as well as a portion of the "delta cone." Removal of all delta cone/deposits above marsh elevation would increase volumes of earthwork excavation and offhaul, and was not judged to have incremental benefits in proportion to the incremental costs. Further analysis could refine the extent of delta cone excavation.

The full restoration alternative restores approximately 17 acres of salt and brackish marsh by excavating lowland areas down to the vicinity of MHHW and excavating tidal channels. Much of the topographic modification will require purchase of private property and removal of buildings, paving, and utilities. Cherry Tree Pond will also be excavated.

The partial restoration alternative includes approximately 8 acres of new and enhanced salt and brackish marsh. The lowland excavation area and treatment are the same as the full restoration alternative, except that areas south of Highway 101 are not included in the partial restoration alternative. Cherry Tree Pond will also be excavated.

30.3.3 Restoration Features – Additional Management Measures

Beach Nourishment

Approximately 1,000 LF of shoreline will be created as described under *Armor Removal/Modification.*

Contaminant Removal/Remediation

Topographic modification at Cherry Tree Pond and elsewhere may require removal of contaminated materials, although quantities are unknown at this time.

Debris Removal - NA

Invasive Species Control - NA

Large Wood Placement

In both alternatives, large wood will be placed on the left bank of Salmon Creek, downstream of the new Highway 101 crossing, to prevent erosion of the bank and protect the property and structures immediately adjacent to the channel. In the full restoration alternative, large wood placement will be included in the newly constructed creek channel that connects Snow Creek to Salmon Creek. The wood will be placed at the channel bends to provide structural integrity to the channel that may otherwise move laterally across the floodplain. Each large wood structure will consist of three logs.

Physical Exclusion - NA

Pollution Control - NA

Revegetation

Vegetation planting will be included at the new creek channel between Snow and Salmon Creeks to provide riparian vegetation to an area that is currently open floodplain.

Reintroduction of Native Animals - NA

Substrate Modification

Creek sediment (gravels) will be placed in the new channel between Snow and Salmon Creeks. Gravel sizes have not yet been determined.

Species Habitat Enhancement - NA

30.3.4 Restoration Features – Other

Roadways

Under the full restoration alternative, the proposed bridge will be a 1,175-foot-long, 6-feet-6-inch-deep, pre-cast concrete girder bridge with eight spans at a maximum spacing of 150 feet. The design elevation of the bridge will be set higher than the existing, consistent with passing the combined flow of Snow and Salmon Creeks (WDFW 2007) and includes an additional 3 feet plus sea level rise. The bridge will be supported by concrete columns with drilled shaft foundations (Figure 30-7). The assumed embedment depth of the drilled shafts is 100 feet.

For the partial restoration alternative, a smaller bridge crossing lower Salmon Creek is proposed in lieu of spanning the full width of the estuary. The proposed bridge is the same type as for the full restoration except it is 600 feet in length with four spans. Based on comments from local sponsors, the partial restoration does not include changes to the Snow Creek bridges. An option for further consideration is removal or modification of these crossings.

The proposed alignment of Highway 101 will parallel the existing alignment to the north in order to maintain traffic during construction. The proposed bridge will terminate in a similar location, but not utilize the existing bridge abutments. For both restoration alternatives, the new roadway will be approximately 3 to 10 feet higher than the existing roadway along the bridge opening. This allows the potential reuse of the existing embankment and reduces the volume to be removed.

Highway 101 in this area is posted at 45 mph and has the same design speed. The minimum roadway width is 40 feet including shoulders. State Route 20 has a design speed of 50 mph but due to the stop condition at the intersection with Highway 101, the geometry can be based on slower design speeds on the approach.

Public Access

An important local requirement is construction of the Olympic Discovery Trail along the bay. Under both restoration alternatives, the trail follows the railroad alignment along the east and west shores of the bay, but is realigned to the north side of the Highway 101/State Route 20 causeway across the estuary. The roadway section across the estuary will accommodate a 12-foot-wide combined-use trail along the north side. AASHTO requirements include 5-foot separation between the travel lane and the path. Use of the railroad embankment for access was rejected based on local proponent concerns but could be a viable option, depending on the extent of pile-supported versus fill-supported area.

Pedestrian bridges are required for the channel crossings at Mill Pond Lagoon for both restoration alternatives. A pedestrian bridge is also required for the channel crossing at Cherry Tree Pond for the partial alternative but the trail alignment in this area neglects the need for a bridge for the full alternative.. These relatively short spans can be accomplished using pre-engineered and pre-fabricated trusses, or a 2-foot-7-inch slab girder superstructure of 50-foot spans supported on 24-inch octagonal concrete piles. Assumed embedment depth is 100 feet.

Oyster Beds

Oyster beds in Mill Pond Lagoon will remain unless and until new oyster beds establish on the delta deposits in Discovery Bay. An option not included here is to attempt oyster bed restoration by construction of a coarse sediment substrate in the correct elevation band on the north side of the Salmon-Snow Creek delta.

Utilities

An overhead transmission line running along the south side of Highway 101 may be relocated to be closer to the new roadway alignment under both alternatives. The full restoration alternative requires more extensive relocation of the transmission line to follow the new alignment of State Route 20.

A privately owned 2-inch water line located beneath the existing railroad embankment will require relocation under both restoration alternatives. The water line will be relocated following the new trail alignment and be attached to the bridge structure.

30.3.5 Land Requirements

Construction of the full alternative will affect of 211 acres of public and privately held lands that support agricultural and residential uses. The partial alternative will affect approximately 174 acres of land. Approximately 15 acres (8 acres for partial alternative) are private lands that will need to be acquired via purchase, easement or other similar means. Several small parcels of land are affected north of Highway 101 under both alternatives, where the existing high ground will be lowered to marsh elevation. The properties south of Highway 101 and land required for realignment of State Route 20 east of Snow Creek are also recommended for purchase under the full restoration alternative. The lands owned by WDNR may require a lease or other agreement, but outright purchase is assumed to not be necessary.

30.3.6 Design Considerations

The private property needed for restoration is in or near the floodplain. Therefore the effect of restoration on flood risk should be considered as part of the subsequent design efforts unless the properties are purchased for restoration.

The cost of elevating Highway 101 is a consideration. However, the roadway provides only marginal clearance at the Salmon Creek bridge and the clearance will be reduced over time by sea level rise. Hence, the roadway will likely require some level of modification within the planning period. The planned improvements to Highway 101 and State Route 20 will upgrade the highway to the current design standards for the roadway classifications. The reconfiguration of State Route 20 to the east will require additional analysis of surface drainage following construction of the new roadway embankment.

The Olympic Discovery Trail will pass through this area of the bay. Replacing the embankment with the elevated, or partially elevated, trail options proposed in the full or partial restoration alternatives will require community support.

30.3.7 Construction Considerations

Temporary trestle structure and/or local filling will be required along portions of the proposed bridge alignment to provide access for heavy equipment during construction while leaving Highway 101 open to traffic. Alternatively, some revisions to the channelization may be possible with minor widening to provide access from the existing roadway prism for construction.

In the partial alternative, the existing Highway 101 roadway and embankment will be utilized during construction of the new Salmon Creek bridge (600 feet in length). A new roadway and embankment will be constructed from the new Salmon Creek bridge to tie into the existing Highway 101 roadway alignment just west of the Highway 101/SR 20 intersection. Because the new bridge will be higher than the existing bridge and the road will match existing grade at the highway 101/SR 20 intersection, a new roadway embankment will be constructed to transition both vertically and laterally over this section of Highway 101. The new roadway (2 12-foot-wide lanes with 8-foot-wide shoulders) embankment in not specifically shown on Figure 30-4, but is represented in plan view by the symbology for the new roadway.

A drilled-shaft oscillator will be used to install the drilled shafts. It is assumed that the contractor will be able to install one shaft per week. Large-diameter casing shoring would be required to keep out water and allow access to the top of the shaft for column form placement and removal. Once the shafts are installed, the columns are cast inside the shoring casing. After the casing is removed, the cast-in-place pilecaps and bridge superstructure are constructed. A crane will be required to set the girders in place. The temporary trestle or earth fill would then be removed.

Material from the excavated portions of the roadway can likely be used for the fill required in the new roadway approaches. However, much of the earthwork will be excavation of lowland areas, requiring substantial bucket dredging to form channels. Substantial offhaul and offsite disposal is required as no beneficial reuse onsite was identified.

Staging areas for construction are assumed to be available in the upland area just south of Highway 101 and SR 20. Additionally, some portion of the existing railroad grade may be used for staging and to provide access to the excavation sites within the estuary. Access to the site is readily available using the Highway 101 and SR 20 corridors. These roadways will remain open during construction but are will be used for construction access and off haul.

30.4 Extent of Stressor Removal

Table 30-2 describes the amount of stressors to be removed with this action.

Table 30-2. Stressor Removal

Stressor	Full Restoration	Partial Restoration
Tidal Barrier (LF)	Approximately 4,000 LF (1,200 LF of Hwy 101 and SR 20, and 2,800 LF of railroad embankment)	Approximately 3,400 SF (600 LF of Hwy 101 and SR 20, and 2,800 LF of railroad embankment)
Fill (area)	17 acres	8 acres

Stressor	Full Restoration	Partial Restoration
Armor (LF)	1,000 LF at west shore of Discovery Bay (at beach profile restoration)	Same as full restoration
Nearshore Roads (LF)	1,200 LF (included in tidal barrier removal)	600 LF (included in tidal barrier removal)
Railroad (LF)	1,200 LF (included in tidal barrier removal)	Same as full restoration

30.5 Expected Evolution of the Action Area

Without restoration, the site is expected to essentially maintain its existing condition. With restoration, sediment will deposit on new marsh plains and vegetation will establish. Channel banks will likely slough until vegetation establishes, stabilizes banks, and induces scour of the thalwegs. Some expansion of higher salinity levels in the marshes south of Highway 101 is expected.

30.6 Uncertainties and Risks

The restoration alternatives will remove barriers to inundation. This will tend to increase the range of tidal inundation, which could increase flood risk to properties in the floodplain that are not acquired. However, removal of barriers could reduce the extent of fluvial flooding during high creek flows.

Contaminated soils were found at the previous restoration area near Mill Pond Lagoon. Therefore, it is possible that contaminated soils will require special treatment within the restoration area.

Acquisition of private property is also a risk that could impact the extent of high ground areas that are lowered to marsh elevation north and south of Highway 101. Additional property may require acquisition due to impacts of removing flow from Snow Creek on the properties immediately east of the current channel alignment.

Community support for trail alignments is uncertain and could significantly impact the restoration if support for removal of the railroad grade is not achieved.

30.6.1 Risks Associated with Projected Sea Level Change

Table 30-3 compares potential risks associated with projected sea level changes based on professional judgment.

Table 30-3. Risks of Sea Level Change

	Projected Sea Level Change		
	High (46 cm)	**Intermediate (4 cm)**	**Low (-8 cm)**
Full Restoration	Low: Railway bridge and sections of highway to be replaced by bridge that would be designed to accommodate sea level change	Negligible	Negligible
Partial Restoration	Low: Railway bridge and sections of highway to be replaced by bridge that would be designed to accommodate sea level change	Negligible	Negligible

30.7 Potential Monitoring Opportunities

Monitoring is important for evaluating restoration success. A combination of field surveys and aerial photographs would be used to document biological and physical changes to the landscape. Monitoring data can be used to refine adaptive management and corrective actions, as needed. Some of the key monitoring needs and opportunities associated with this action are summarized in Table 30-4.

Table 30-4. Monitoring Needs and Opportunities

Monitoring Parameter	Key Performance Indicator	Note
Topographic Stability	X	Monitor stability of west shore and Snow- Salmon connection
Sediment Accretion / Erosion	X	Monitor delta area
Wood Accumulation		
Soil / Substrate Conditions		
Vegetation Establishment	X	Monitor changes in marsh assemblages
Marsh Surface Evolution / Accretion	X	Monitor sediment deposition on marsh plain above and below Hwy 101
Tidal Channel Cross-Section / Density	X	Document new channel establishment in delta
Water Quality (contaminants)	X	Monitor during Mill Pond Lagoon excavation
Salinity	X	Monitor salinity changes in marshes south of Hwy 101
Shellfish Production	X	Monitor Olympia oyster production

Monitoring Parameter	Key Performance Indicator	Note
Extent of Invasive Species		
Animal Species Richness		
Fish (salmonid) Access/Use		
Forage Fish Production		
Wildlife Species Use		
Effectiveness of Exclusion Devices		

30.8 Information Needed for Subsequent Design

This conceptual design report represents an initial step in the restoration design sequence. The design concepts described above were developed based on readily available information without the level of site-specific survey and investigation that is necessary to support subsequent design and implementation. Substantial additional information will be required at the preliminary design stage to confirm the design assumptions, refine quantity estimates, address property and regulatory issues, obtain stakeholder support, and fill in data gaps. The extent to which this information is collected for preliminary design (or a later design stage) will depend upon the available budget, schedule and other factors. This section attempts to define the most essential information needs for this action.

- Property Investigation/Survey – More detailed information on parcel ownership, utilities, and property boundary locations will be needed to finalize the design, confirm acquisition requirements, and support negotiations with property owners.
- Topographic/Bathymetric Survey – The survey data would be used to refine design of key project elements and develop detailed construction and demolition plans. Survey data could also be used as a baseline for pre- and post-construction modeling, including hydrodynamic modeling. A temporary tide gauge may be required in the early design stages to obtain site-specific tidal statistics.
- Geotechnical Investigation – Additional geotechnical study will be required for pile foundations, slope stability, and settlement. Subsurface exploration will also be required.
- Cultural Resources Investigation – Surveys for archaeological and historic resources may be required for this action area. This is particularly important in areas proposed for excavation or ground disturbance.
- Hydraulic Analysis/Modeling – Tidal circulation, flood, and hydrodynamic modeling will be required to evaluate impacts to infrastructure and adjacent properties following restoration, to optimize the size of the bridge openings and determine minimum bridge clearances, and to size the coastal inlet and channels for the Salmon Creek/Snow Creek Estuary.
- Sediment Transport Stud y – Assessment of sediment transport dynamics may be needed to optimize the channel openings.
- Contaminant Survey – If preliminary investigations suggest that hazardous material could be present in the action area, additional soil and sediment analysis may be needed. The introductory chapter describes the Phase I site investigations that are occurring as part of this overall effort via a separate contract.

- Sea Level Change Projection – Estimates of sea level change for the conceptual design were based on calculations provided by the Washington Department of Fish and Wildlife and the Corps of Engineers using guidance in Corps' Engineering Circular No. 1165-2-211. Projections for each project area will be refined using localized tide gauge data during later design stages.
- Other – Sites for disposal and trucking routes will need to be evaluated further during later stages of design.

30.9 Quantity Estimates

The quantity spreadsheets for the full and partial restoration alternatives are provided in Exhibits 30-1 and 30-2.

30.10 References

Engineering Services Associates. 2010. Salmon Creek Estuary Restoration, Preliminary Drawings, May, 2010.

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North Olympic Salmon Coalition. 2010. Salmon Recovery Project Application, 10-1611, September 10, 2010.

Shipman, H. 2008. *A Geomorphic Classification of Puget Sound Nearshore Landforms*. Puget Sound Nearshore Partnership Report No. 2008-01. Published by Seattle District, U.S. Army Corps of Engineers, Seattle, Washington. Available at: http://pugetsoundnearshore.org/technical_papers/geomorphic_classification.pdf

Shreffler, D. 2010. Memorandum to Rebecca Benjamin, North Olympic Salmon Coalition, Re: Salmon-Snow Estuary Railroad Grade Removal vs. Breaching. July 30, 2010.

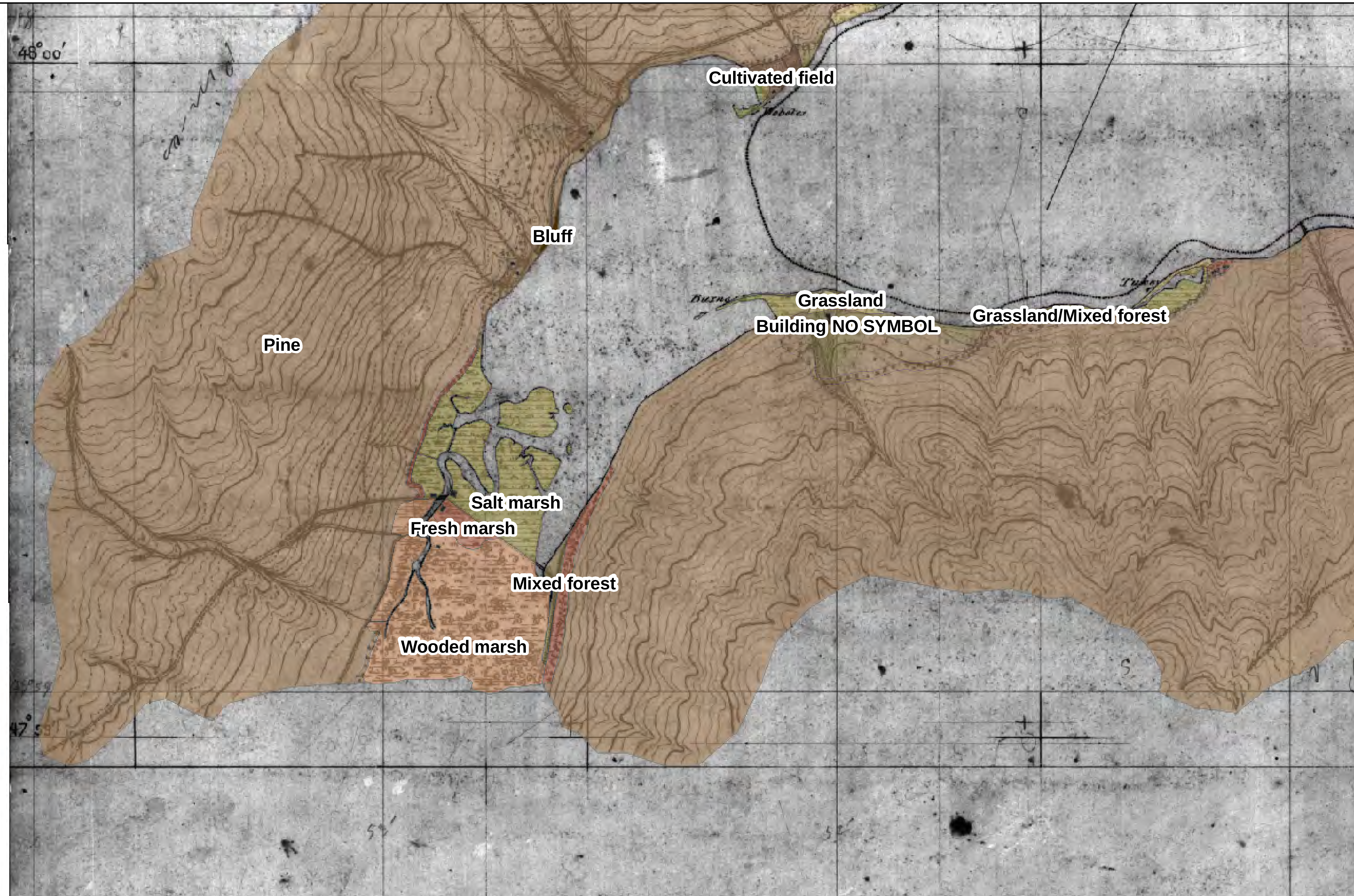
WDFW (Washington Department of Fish and Wildlife). 2007. *US 101 at Salmon Ck. Estuary Restoration and Snow Ck. Reconnection Hydraulic Report*. Region 6, Habitat Program. September 17, 2007.

0 950
Feet
0 300
Meters

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Historic Map (T-Sheet)
Action Name: Snow Creek and Salmon Creek Estuary Restoration
PSNERP ID #: 1230
Figure 30- 2A

S:\GIS\Projects\210xxx\210337_PSNERP_NEARSHORE\Projects\2-TSheets_rev.mxd (DLP; 2/24/2011)

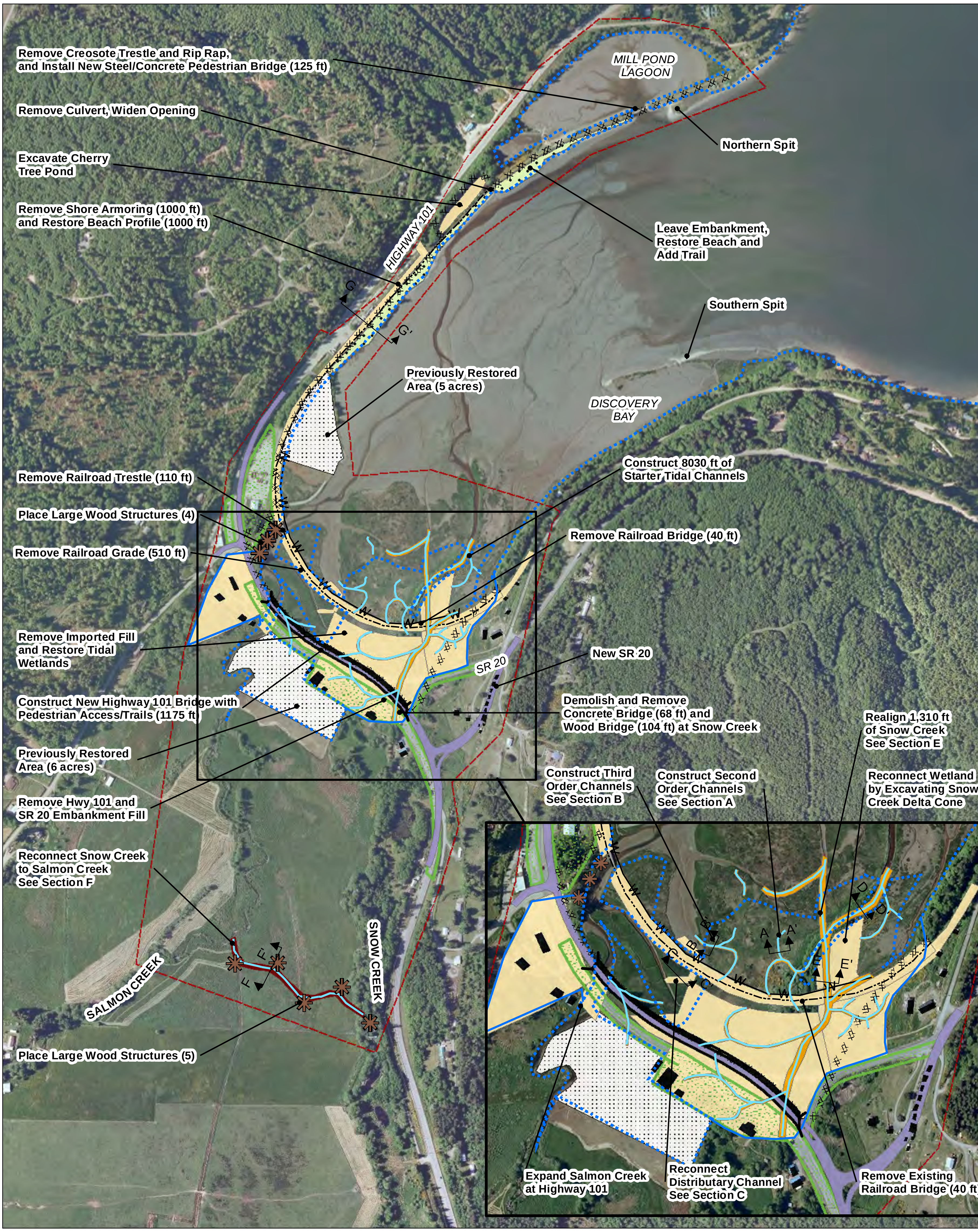


0 950
Feet
0 300
Meters

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Historic Map (T-Sheet) and River History Project Data
Action Name: Snow Creek and Salmon Creek Estuary Restoration
PSNERP ID #: 1230
Figure 30- 2B

S:\GIS\Projects\210xxx\210337_PSNERP_NEARSHORE\Projects\2-TSheets_rev.mxd (DLP; 2/24/2011)



Legend

- Large Wood Placement
- Proposed Tide MHHW
- Existing Tide MHHW
- Channel Rehab/Creation
- Trails
- Water
- Other
- Typical Cross Section
- Bridge
- Buildings
- Dredging - Bucket - Land
- Excavation - Lowland
- Excavation - Upland
- Hydroseeding
- Previously Restored
- Roadway
- Sand/Gravel for Beach Nourishment
- Required Project Lands

SNOW & SALMON CREEK ESTUARY CONVERSION

FIXED DATUM TIDAL DATUM

MHHW 7.41 1.11 MLLW NAVD88

0.00 FT MHHW = 7.41 FT NAVD88
-7.41 FT MHHW = 0.00 FT NAVD88
0.00 FT MLLW = -1.11 FT NAVD88
1.11 FT MLLW = 0.00 FT NAVD88

Source:
Port Townsend Tide Gauge (NOS #9444900).
See Table 1, Appendix C.

North 0 500 Feet

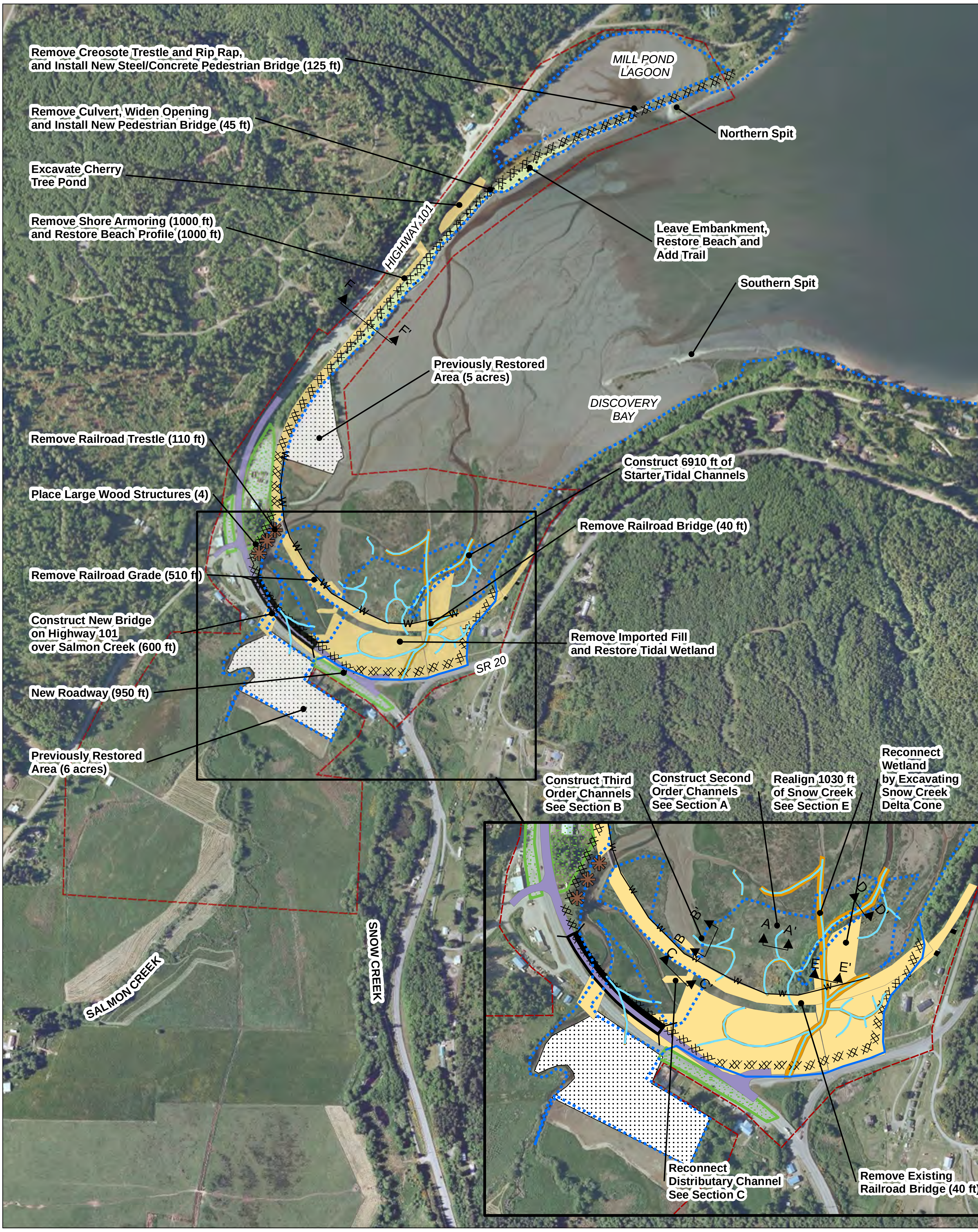
SOURCE: Washington Public Lands Database (2006); Washington Counties Parcels (2009); Action Area (PSNERP, 2012).
Service Layer Credits: Source: Esri, i-cubed, USDA, USGS, AEX, GeoEye, Getmapping, Aerogrid, IGN, IGP, and the GIS User Community

Lead Contractor: ESA
Design Lead: ESA PWA, Phil Leucking, PE
Date: 11/2012

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Plan
Site Name: Discovery Bay
Action Name: Snow Creek and Salmon Creek Estuary Restoration
PSNERP ID #:1230
Full Restoration

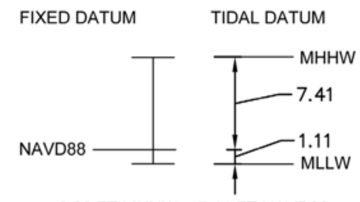
Figure 30-3



Legend

- Large Wood Placement
- Proposed Tide MHHW
- Existing Tide MHHW
- Channel Rehab/Creation
- Trails
- Water
- Other
- Typical Cross Section
- Bridge
- Buildings
- Dredging - Bucket - Land
- Excavation - Lowland
- Hydroseeding
- Previously Restored
- Roadway
- Sand/Gravel for Beach Nourishment
- Required Project Lands

SNOW & SALMON CREEK ESTUARY CONVERSION



0.00 FT MHHW = 7.41 FT NAVD88
-7.41 FT MHHW = 0.00 FT NAVD88
0.00 FT MLLW = -1.11 FT NAVD88
1.11 FT MLLW = 0.00 FT NAVD88

Source:
Port Townsend Tide Gauge (NOS #9444900).
See Table 1, Appendix C.

PUGET SOUND NEARSHORE

North 0 500 Feet

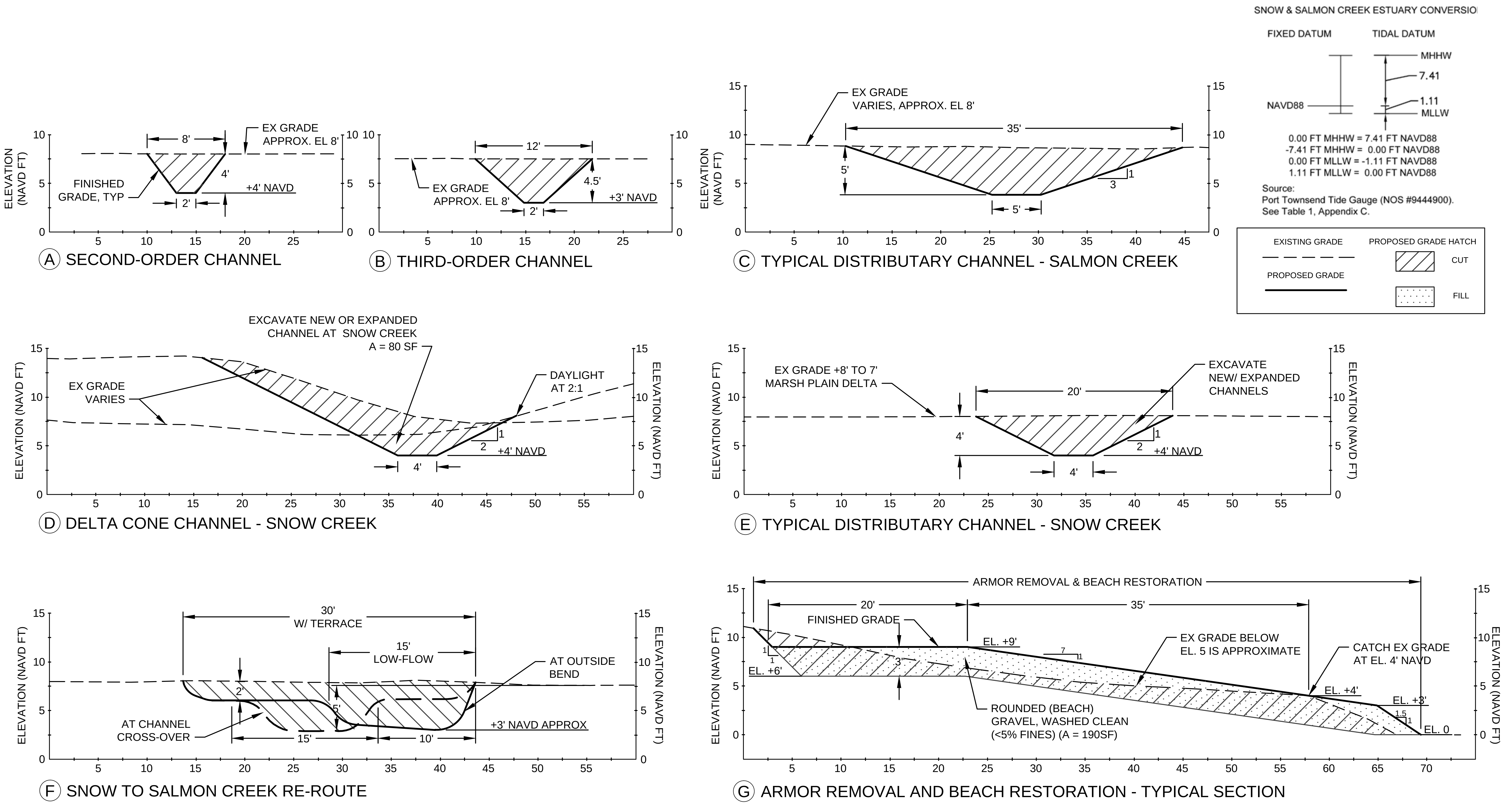
SOURCE: Washington Public Lands Database (2006); Washington Counties Parcels (2009); Action Area (PSNERP, 2012).
Service Layer Credits: Source: Esri, i-cubed, USDA, USGS, AEX, GeoEye, Getmapping, Aerogrid, IGN, IGP, and the GIS User Community

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Plan
Site Name: Discovery Bay
Action Name: Snow Creek and Salmon Creek Estuary Restoration
PSNERP ID #:1230
Partial Restoration

Lead Contractor: ESA
Design Lead: ESA PWA, Phil Leucking, PE
Date: 11/2012

Figure 30-4



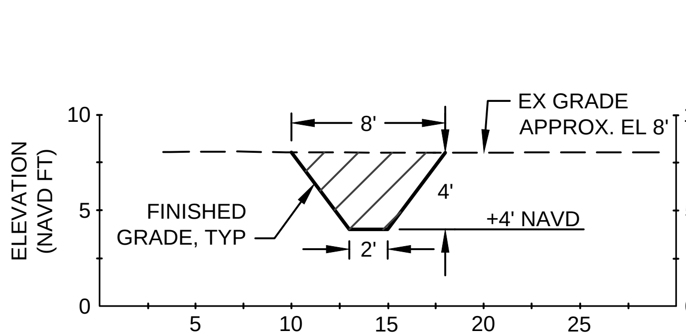
PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: ESA PWA, Phil Leucking, PE
Date: 05/2012

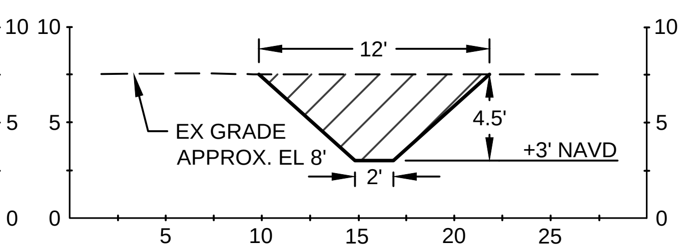
Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Section
SITE NAME: **Discovery Bay**
ACTION NAME: **Snow Creek and Salmon Creek Estuary Restoration**
PSNERP ID#: **1230**
Full Restoration

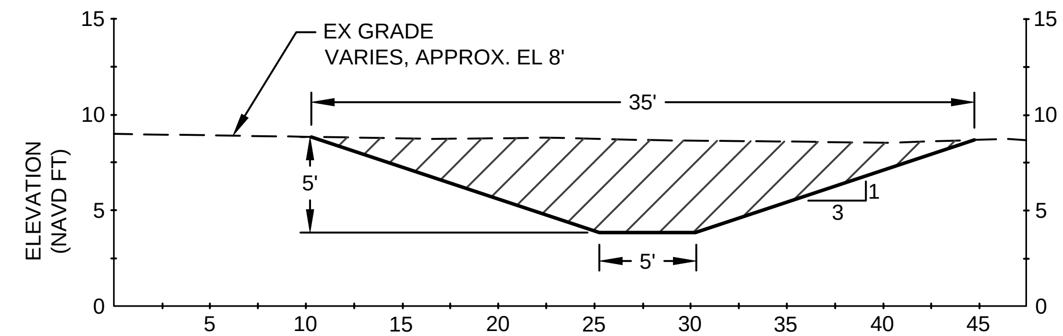
Figure 30-5



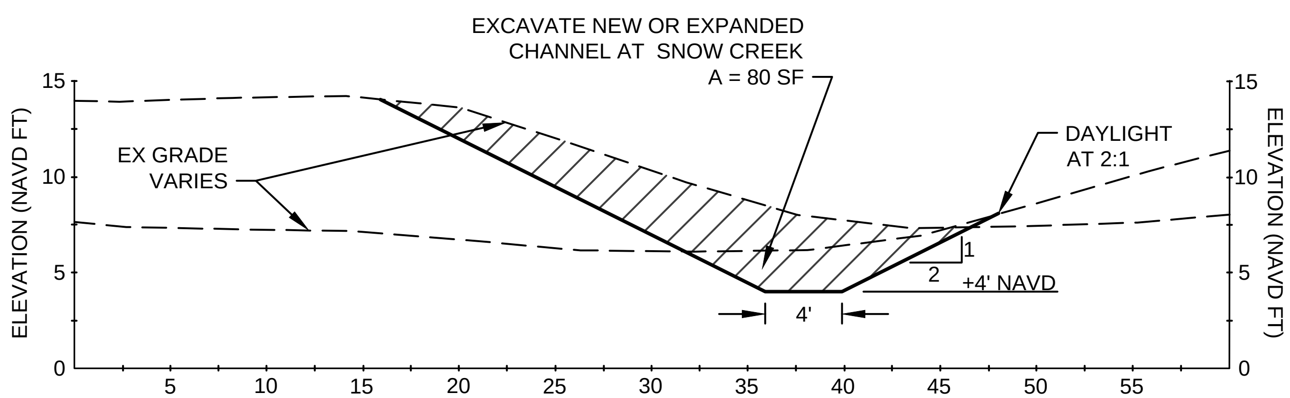
Ⓐ SECOND-ORDER CHANNEL



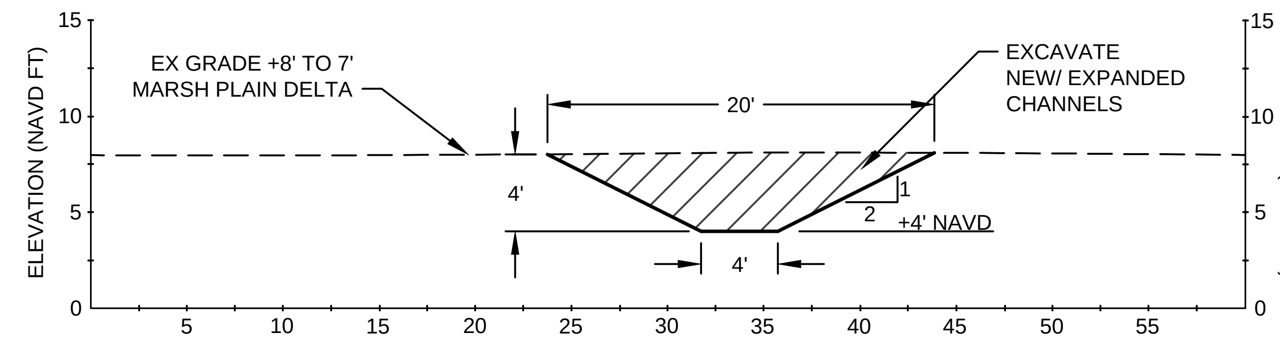
Ⓑ THIRD-ORDER CHANNEL



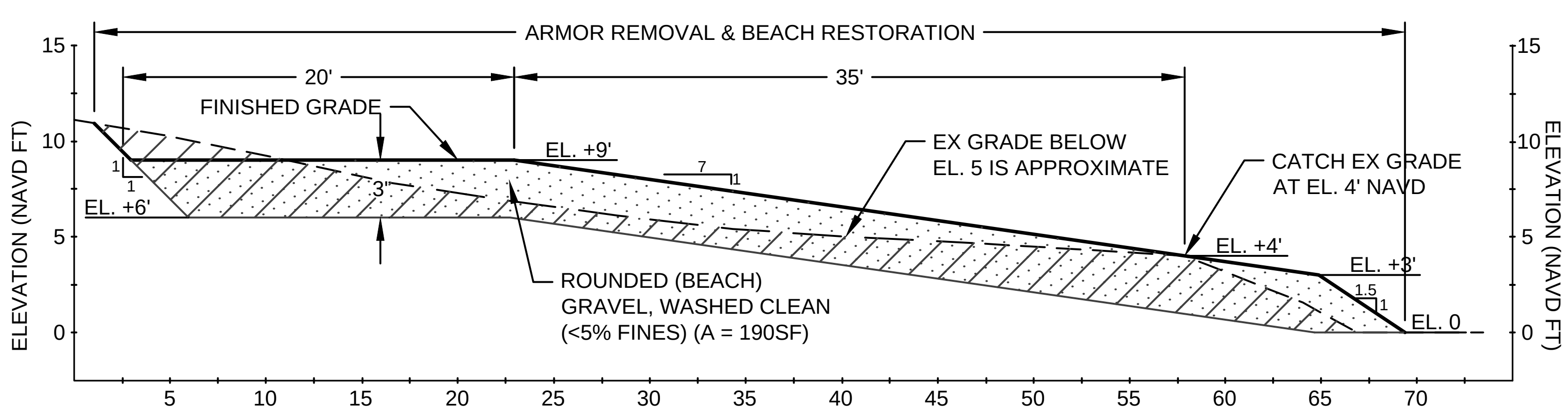
Ⓒ TYPICAL DISTRIBUTARY CHANNEL - SALMON CREEK



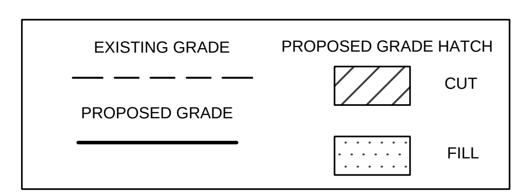
Ⓓ DELTA CONE CHANNEL - SNOW CREEK

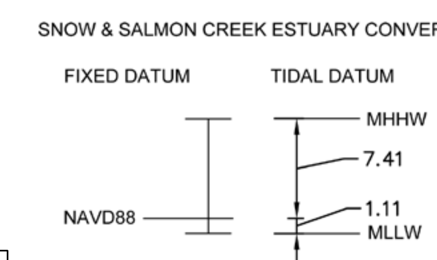


Ⓔ TYPICAL DISTRIBUTARY CHANNEL - SNOW CREEK



Ⓕ ARMOR REMOVAL AND BEACH RESTORATION - TYPICAL SECTION





0.00 FT MHHW = 7.41 FT NAVD88
-7.41 FT MHHW = 0.00 FT NAVD88
0.00 FT MLLW = -1.11 FT NAVD88
1.11 FT MLLW = 0.00 FT NAVD88

Source:
Port Townsend Tide Gauge (NOS #9444900).
See Table 1, Appendix C.

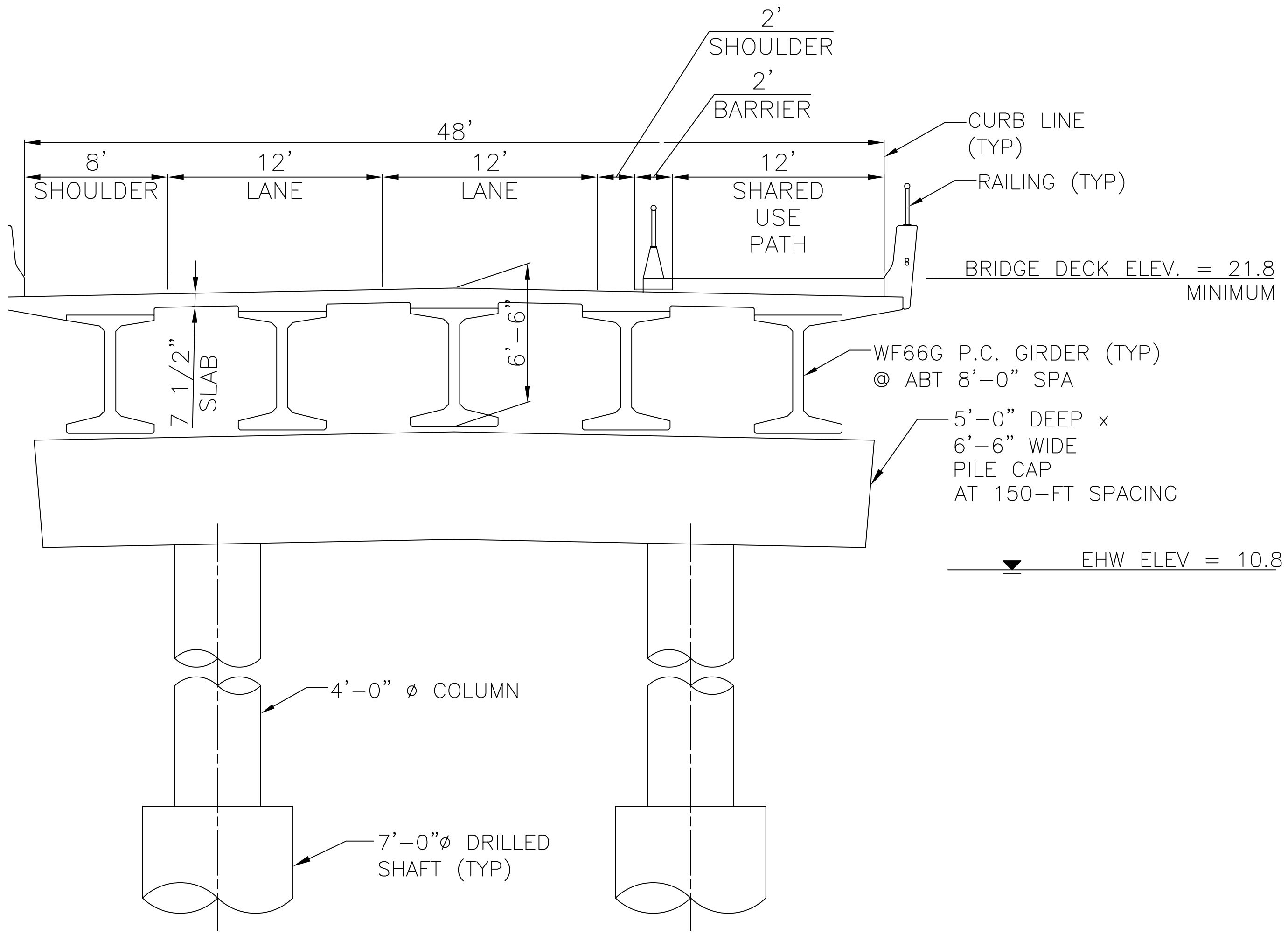
PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: ESA PWA, Phil Leucking, PE
Date: 05/2012

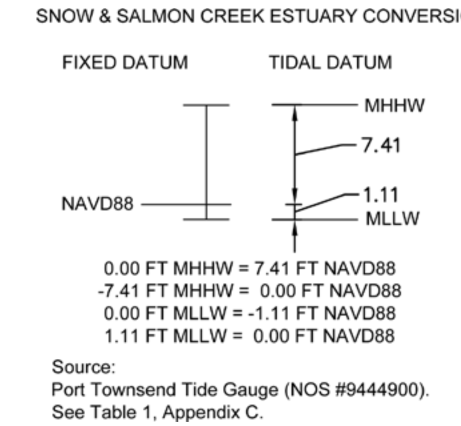
Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

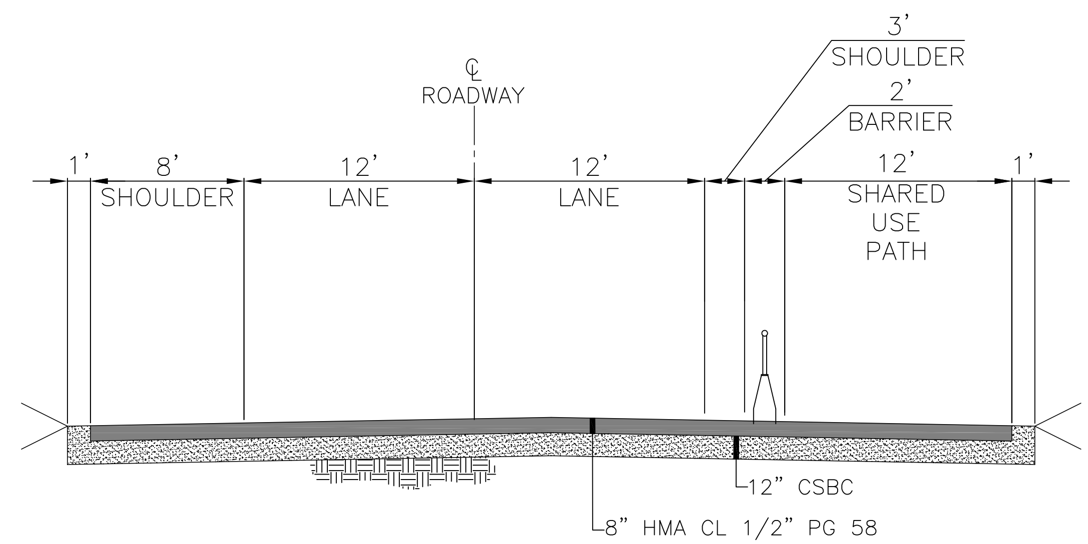
Conceptual Design Section
SITE NAME: **Discovery Bay**
ACTION NAME: **Snow Creek and Salmon Creek Estuary Restoration**
PSNERP ID#: **1230**
Partial Restoration

Figure 30-6



CONCRETE GIRDER BRIDGE
NTS
FULL & PARTIAL RESTORATION





TYPICAL ROADWAY SECTION
NTS
FULL AND PARTIAL RESTORATION

PUGET SOUND
NEARSHORE
ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: ESA PWA, Phil Leucking, PE
Date: 05/2012

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)
Conceptual Design Section
SITE NAME: **Discovery Bay**
ACTION NAME: **Snow Creek and Salmon Creek Estuary Restoration**
PSNERP ID#: **1230**
Full Restoration & Partial Restoration

Figure 30-7

Full Restoration Quantity Estimate

Action Name:	Snow Creek Salmon Creek	
Action #:	1230	Revised May 2012, Revised July 2012
Date:	February 2011	Revised with backcheck updates: 08 August 2011
By:	ESA PWA with KPFF	

REMEDY: ***Restore processes by removing obstructions formed by abandoned railroad, fill, retarded deltaic deposits and roadways. Reconnect Snow Creek and Salmon Creek.***

Construction Period: 40 weeks

Item	Unit of Measure	Material Name	Qty	Description of Item	Indicate section of design report where item is described
ACQUISITION AND CONSERVATION				Based on available mapping informatior	
Required Project Lands	Acre		211	Total land required For action (this is the action area polygon which includes open water	30.3
Proponent / Partner-owned lands	Acre		187	Estimate of lands currently owned by Proponent (i.e., Public lands	30.3
Lands To Be Acquired	Acre		15	Estimate land required to be acquired for action prior to implementation	30.3
Material Sites				Not Used: See Earthwork - Imported Fill.	
MOBILIZATION AND ACCESS for construction activities				Description required for each item to facilitate cost estimating	
Mobilization - Typica (Equipment, Personnel, Planning, Financial)	LS		1	Up front costs such as bonding, planning and other staff time and financing. Typically, assume 8% to 10% of other items.	30.3
Mobilization - Remote (Equipment, Personnel, Planning, Financial`	LS		NA		
Site Access	LS		NA		
Barge Access	Days		NA		
Temporary Traffic Control (one of the following)					
none	LS		NA		
signs	LS		1	Signage will be required for temporary rerouting duration ~ 4 months for the work on the new SR20 and Highway 101 intersections.	30.3
flags / spotters	LS		1	Flagger and spotters will be required for transition work to make connection to existing highway, for an estimated duration of 4 months.	30.3
unique	LS		NA		
Temporary Roadway	SF		NA		
Control of Water	LS		NA		
Relocation Activities				Not Used: See Utilities, Structures	
Site Demolition Activities				Demolition and removal of structures (description required), temporary features and relocations, itemized separately); Clearing and grubbing of vegetation, and removal of minor debris (rocks, slabs) - description required.	
Clearing and Grubbing (one or more of following)				Use one or more of the following categories of clearing and grubbing	
Clear Vegetation - Local Disposal	AC		20	Vegetation removed above grade and disposed locally	30.3
Clear /Grub Vegetation - Local Disposal	AC		NA		
Clear /Grub Vegetation - Offsite Disposal	AC		NA		
Clear, stockpile - large woody debris	CY		NA		
Hydraulic Structures - Smal	LS		NA		
Hydraulic Structures - Large	LS		NA		
Culverts	LF		70	Cherry Tree Pond culvert, diameter unknown	30.3
Water	LF		3000	2" privately-owned water main located in railroad grade	30.3
Electric	LF		1300	Overhead along existing Highway 101 & SR 20	30.3
Buildings	SF		34,958	Building removal associated with acquired lands and excavation of high ground to marsh plain and new SR 20 alignment	30.3
Pavement	SF		164000	Removal of existing Highway 101 and SR 20 roadway	30.3
Bulkheads	LF or SF		NA		
Rock revetments	CY		1000	Sparse and spotty armor along abandoned railway embankment to be removed. Assumes 1CY/LF (1,000 LF)	30.3
Large Coastal Structures	LF, SF or CY		NA		
Demolition / Removal - Bridge 1	SF		5640	Remove 120-ft concrete bridge over Salmon Creek (47 ft wide`	30.3
Demolition / Removal - Bridge 2	SF		3876	Remove 68-ft concrete bridge over Snow Creek (57 ft wide`	30.3
Demolition / Removal - Bridge 3	SF		3744	Remove 104-ft timber and concrete bridge over Snow Creek (36 ft wide`	30.3
Demolition / Removal - Bridge 4	SF		1500	Remove125-ft railroad creosote timber trestle at Mill Pond Lagoon (12 ft wide	30.3
Demolition / Removal - Bridge 5	SF		1320	Remove 110-ft railroad creosote timber trestle at Salmon Creek (12 ft wide	30.3
Demolition / Removal - Bridge 6	SF		480	Remove 40-ft railroad creosote timber bridge at Snow Creek (12 ft wide	
Removal - Misc. (e.g. angular rock from beach)	Ton		NA		
Demolition / Removal - Boat Ramp	SF		NA		
Haul - Offsite Disposal of Demolition Debris	Miles		20		30.3
Hazardous/Contaminated Waste Removal				These items for earthwork of quality not compatible with wetlands, requiring special handling and disposal Describe basis for classification as contaminated or hazardous. State known or suspected contamination, describe known similar work.	
Contaminated Earthwork	CY		NA		
Hazardous Earthwork	CY		NA		
Construct Temporary Features				Use as needed for unusual temporary features not included elsewhere (see TESC below	
EARTHWORK				Expand to include equipment, etc. to facilitate cost estimating	
Excavation	CY		NA	Per yard excavation w/out expected haul	
Excavation - Upland	CY		3750	Conducive for transitional earthwork equipment, including scrapers, with high production and low cost. 3.4 sf x 1106 ft. (Reconnect Snow and Salmon Creeks)	30.3
Excavation - Lowland	CY		132000	Requires low ground pressure equipment and or mats; low production bucket methods, typically hydraulic excavator and front end loaders. Hydraulic excavator to truck or to pile with front end loader to truck. Offhaul to disposal site. Some upland excavation in upper elevations of fill areas which are several feet above tide range. However, lower portion of excavation in high moisture low bearing soils	30.3
Cherry Tree Pond	CY		*1620*	*29,145 sf x 1.5 ft*	30.3
Railroad Embankment	CY		*14180*	*109,388 sf x 3.5 ft*	30.3
West Land to Acquire	CY		*15670*	*169,208 sf x 2.5 ft*	30.3
East Land to Acquire	CY		*94500*	*566,973 sf x 4.5 ft*	30.3
Salmon Creek at Bridge	CY		*270*	*14,774 sf x 0.5 ft*	30.3
Reconnect Distributary Channel	CY		*1240*	*3.6 cy/ft x 346 ft*	30.3
Beach Profile	CY		*4555*	*1000 LF x 123 sf*	30.3
Dredging - Bucket - Land	CY		8600	Excavation below ground water or underwater; reach limited low production. Track mounted hydraulic excavator with small bucket. Swinging 180 degrees to trucks backed up on mats. Truck offhaul to washdown location and then to offsite disposal. All low ground pressure and or on mats.	30.3
Delta cone	CY		*3870*	*3.0 cy/ft x 1307 ft*	30.3
3rd order channels	CY		*3610*	*0.7 cy/ft x 3094 ft*	30.3
2nd order channels	CY		*1130*	*0.4 cy/ft x 1529 ft*	30.3
Dredging - Bucket - Marine	CY		NA		
Dredging - Hydraulic	CY		NA		
Fine Grading	AC		NA		
Fill Placement - local borrow					
Side cast	CY		NA		
Haul - uncontrolled placement	CY		144350	Offsite disposal of excavated material includes upland and lowland sediment	30.3
Haul, place, compact	CY		NA		
Stockpile - uncontrolled placement	CY		NA		
Stockpile - controlled placement	CY		NA		
Conveyor placement from stockpile land/water	CY		NA		
Imported Fill				Includes purchase, delivery and placement or as noted / described	
Select Fill	CY		22900	Imported fill for Hwy 101 and SR 20 roadway embankments	
Gravel Borrow, including haul	CY		NA		30.3
Sand / Gravel for Beach Nourishment	CY		7040	1000 LF x 190 sf	30.3
Cobble for Shore Nourishment	CY		NA		
Embankment Compaction	CY		22900	WSDOT standard item compaction	30.3
Topsoil	CY		NA		
RESTORATION Features					
Channel Rehab / Creation	LF		NA		
Large Wood Placement	EA		6	Log structures at the new Snow Creek to Salmon Creek channel, at the western bank of Salmon Creek at Highway 101. For cost estimating purposes, it could be assumed preliminarily that each structure/element would consist of 3 logs.	30.3

Full Restoration Quantity Estimate

Action Name:	Snow Creek Salmon Creek
Action #:	1230 — Revised May 2012, Revised July 2012
Date:	February 2011 — Revised with backcheck updates: 08 August 2011
By:	ESA PWA with KPFF

REMEDY: ***Restore processes by removing obstructions formed by abandoned railroad, fill, retarded deltaic deposits and roadways. Reconnect Snow Creek and Salmon Creek.***

Construction Period: 40 weeks

	Item	Unit of Measure	Material Name	Qty	Description of Item	Indicate section of design report where item is described
	Invasive Species Control	Acre		NA		
	Physical Exclusion Devices	LF or EA		NA		
	Other Restoration Features/ Activities	LS		NA		
Structures		EA				
	Water Control Structures - Culverts with Gates	EA		NA		
	Water Control Structures - Weirs	EA		NA		
	Rock Slope Protection	LF		NA		
	Other	EA		NA		
	Elevated Boat Ramp	SF		NA		
	Fencing	SF		NA		
Utilities					Replacement or relocation. Designer to provide size and material and have separate line item for each run. Incidentals include earthwork, testing, hook up fees, etc. These quantities do not include demolition of existing utilities, real estate / easements, design fees. Describe the owner if known, and whether utility franchise will install (e.g.. electric is typically installed by electrical franchise).	
	Water	LF		2750	2-in diameter privately owned water main. Rerouted along length of trail and attached to bridge crossin	30.3
	Gas	LF		NA		
	Electric	LF		4000	Overhead power rerouted along new Highway 101 and SR 20 alignment	30.3
	Sewer	LF		NA		
	Telecommunications	LF		NA		
	Other	LF		NA		
Roadway / Railway						
	Roadway (2 12-ft lanes with 8 ft shoulders)	SF		152024	Two-lane roadway with 8-ft shoulders. Includes a shared use path on north side of Highway 101 for a length of 950 lf. Refer to Plans for pavement sectior	30.3
	Roadway - Traffic Signal	LS		NA		
	Roadway - Drainage	LS		1	Drainage patterns at the new SR 20 roadway will need to be reconfigurec	30.3
	Culvert (type)	LF		NA		
	Culvert - Jacking	LF		NA		
	Culvert - Horizontal Pile Driving	LF		NA		
	Bridge 1 - Superstructure	SF		56140	1,175-lf, 8-span precast concrete girder bridge. Depth of girder is 6'-6". Bridge on horizontal curve. Includes elements such as approach slab, abutment, barriers, and railings	30.3
	Bridge 1 - Foundation	LF		336	7-ft diameter drilled shafts, 100-ft embedment. Measurement is along the length of pile caps	30.3
	Railway - Box Girder	SF		NA		
	Railway - Foundation	LF		NA		
	Railway - Shoo fly	LF		NA		
Permanent Access Features						
	Roads	Level		NA		
	Utility Access Routes	varies		NA		
	Erosion Control Features	L.F.		NA		
Public Access or Recreation Features						
	trails	SF		31440	12-ft trail; 4-in HMA over 4-in base course. Length for that portion not adjacent to roadway (2620 lf	30.3
	bridges	SF		1500	Mill Pond Lagoon pedestrian bridge. Prefab steel with concrete deck 125' long . 12' wide	30.3
	kiosk	EA		NA		
	restrooms	EA		NA		
	Interpretive Signs	EA		1	Include # interpretive signs based on number of local public access points	30.3
	parking area	SF		NA		
	Other	EA		NA		
Vegetation & Erosion Control						
	Hydroseeding	AC		10	Describe desired seed mix (e.g.. native plants cost more	30.3
	Planting	AC		NA		
	Vegetation Maintenance	AC-YR		NA		
	Erosion Control Features	AC		15.5	Stabilized Construction Entrances, Sediment Ponds, Hydro Seed to Stabilize Roadway Embankments, Silt Fence Compost Berm.	30.3
	Erosion / sediment BMPs - Permanent	AC		NA		
	Waterside controls - Temporary	EA, LF, LS		NA		
Construction Management						
	Construction oversight	weeks		40	Quantity based on construction duration/ # of construction seasons	30.3
	Materials testing			NA	Included in cost of material - no separate quantity	
Design and Detailed Site Investigations						
	Survey & Property, Utility Research	LS		1	% of construction cost	30.8
	35% Design	LS		1	35% x 25% x Engineer's Estimate	30.8
	65% design	LS		1	65% x 25% x Engineer's Estimate less the cost for 35% PS&E	30.8
	90% design	LS		1	35% x 25% x Engineer's Estimate less the cost for 35% + 65%PS&E	30.8
	100% design	LS		1	25% x Engineer's Estimate less previous costs	30.8
	Geotechnical Studies	LS		1	Refer to design report for description of need	30.8
	Cultural Studies			NA	Refer to design report for description of need	
	Hydraulic Modeling	LS		1	flood risk assessment	30.8
	Soil tests for contamination	LS		1	Contamination found in adjacent restored areas	30.8
	HTWR Studies				Refer to design report for description of need	
Project Agreement Activities					Unable to provide credible estimate at 10% desigr	
Site-Specific Adaptive Management Features & Activities					List if known	
Monitoring Activities					Assume 5 crew-days/year for each monitoring parameter in design report for 5 yr	
	Monitoring (Type)	crew-days		200		
Operations & Maintenance					Unable to provide credible estimate at 10% design	

Partial Restoration Quantity Estimate

Action Name:	Snow Creek Salmon Creek	
Action #:	1230	Revised May 2012, Revised July 2012
Date:	February 2011	Revised with backcheck updates: 08 August 2011
By:	ESA PWA with KPFF	

REMEDY: ***Restore processes by removing obstructions formed by abandoned railroad, fill, retarded deltaic deposits and roadways***

Construction Period: 40 weeks

Item	Unit of Measure	Material Name	Qty	Description of Item	Indicate section of design report where item is described
ACQUISITION AND CONSERVATION				Based on available mapping information	
Required Project Lands	Acre		174	Total land required For action	30.3
Proponent / Partner-owned lands	Acre		166	Estimate of lands currently owned by Proponent (i.e., Public lands)	30.3
Lands To Be Acquired	Acre		8	Estimate land required to be acquired for action prior to implementation	30.3
Material Sites				Not Used: See Earthwork - Imported Fill.	
MOBILIZATION AND ACCESS for construction activities				Description required for each item to facilitate cost estimating	
Mobilization - Typical (Equipment, Personnel, Planning, Financial)	LS		1	Up front costs such as bonding, planning and other staff time and financing. Typically, assume 8% to 10% of other items.	30.3
Mobilization - Remote (Equipment, Personnel, Planning, Financial)	LS		NA		
Site Access	LS		NA		
Barge Access	Days		NA		
Temporary Traffic Control (one of the following)					
none	LS		NA		
signs	LS		NA		
flags / spotters	LS		NA		
unique	LS		NA		
Temporary Roadway	SF		NA		
Control of Water	LS		NA		
Relocation Activities				Not Used: See Utilities, Structures	
Site Demolition Activities				Demolition and removal of structures (description required), temporary features and relocations, itemized separately); Clearing and grubbing of vegetation, and removal of minor debris (rocks, slabs) - description required.	
Clearing and Grubbing (one or more of following)				Use one or more of the following categories of clearing and grubbing	
Clear Vegetation - Local Disposal	AC		12.5	Vegetation removed above grade and disposed locally	30.3
Clear /Grub Vegetation - Local Disposal	AC		NA		
Clear /Grub Vegetation - Offsite Disposal	AC		NA		
Clear, stockpile - large woody debris	CY		NA		
Hydraulic Structures - Small	LS		NA		
Hydraulic Structures - Large	LS		NA		
Culverts	LF		70	Cherry Tree Pond culvert, diameter unknown	30.3
Water	LF		3000	2" privately-owned water main located in railroad grade	30.3
Electric	LF		1300	Overhead along existing Highway 101 & SR 20	30.3
Buildings	LS or SF		1,036	Building removal at east side of site where higher ground will be lowered to marsh elevation	30.3
Pavement	SF		110400	Removal of 2400 LF of Highway 101	30.3
Bulkheads	LF or SF		NA		
Rock revetments	CY		1000	Sparse and spotty armor along abandoned railway embankment to be removed. Assumes 1CY/LF (1,000 LF)	30.3
Large Coastal Structures	LF, SF or CY		NA		
Demolition / Removal - Bridge - 1	SF		5640	Remove 120-ft concrete bridge at Highway 101 over Salmon Creek (47 ft wide)	30.3
Demolition / Removal - Bridge - 2	SF		1500	Remove125-ft railroad creosote timber trestle at Mill Pond Lagoon (12 ft wide)	30.3
Demolition / Removal - Bridge - 3	SF		1320	Remove 110-ft railroad creosote timber trestle at Salmon Creek (12 ft wide)	30.3
Demolition / Removal - Bridge - 4	SF		480	Remove 40-ft railroad creosote timber bridge at Snow Creek (12 ft wide)	30.3
Removal - Misc. (e.g. angular rock from beach)	Ton		NA		
Demolition / Removal - Boat Ramp	SF		NA		
Haul - Offsite Disposal of Demolition Debris	Miles		20		30.3
Hazardous/Contaminated Waste Removal				These items for earthwork of quality not compatible with wetlands, requiring special handling and disposal. Describe basis for classification as contaminated or hazardous. State known or suspected contamination, describe known similar work.	
Contaminated Earthwork	CY		NA		
Hazardous Earthwork	CY		NA		
Construct Temporary Features				Use as needed for unusual temporary features not included elsewhere (see TESC below	
EARTHWORK				Expand to include equipment, etc. to facilitate cost estimating.	
Excavation	CY		NA		
Excavation - Upland	CY		0		30.3
Excavation - Lowland	CY		89500	Requires low ground pressure equipment and or mats; low production bucket methods, typically hydraulic excavator and front end loaders. Hydraulic excavator to truck or to pile with front end loader to truck. Offhaul to disposal site. Some upland excavation in upper elevations of fill areas which are several feet above tide range. However, lower portion of excavation in high moisture low bearing soils.	30.3
Cherry Tree Pond	*CY*		*1620*	*29,145 sf x 1.5 ft*	30.3
Railroad Embankment	*CY*		*14180*	*109,388 sf x 3.5 ft*	30.3
East Land to Acquire	*CY*		*67580*	*405,506 sf x 4.5 ft*	30.3
Salmon Creek at Bridge	*CY*		*270*	*14,774 sf x 0.5 ft*	30.3
Reconnect Distributary Channel	*CY*		*1240*	*3.6 cy/ft x 346 ft*	30.3
Beach Profile	*CY*		*4555*	*1000 LF x 123 sf*	30.3
Dredging - Bucket - Land	CY		7000	Excavation below ground water or underwater; reach limited low production. Track mounted hydraulic excavator with small bucket. Swinging 180 degrees to trucks backed up on mats. Truck offhaul to washdown location and then to offsite disposal. All low ground pressure and or on mats.	30.3
Delta cone	*CY*		*3050*	*3.0 cy/ft x 1031 ft*	30.3
3rd order channels	*CY*		*3010*	*0.7 cy/ft x 2578 ft*	30.3
2nd order channels	*CY*		*890*	*0.4 cy/ft x 1205 ft*	30.3
Dredging - Bucket - Marine	CY		NA		
Dredging - Hydraulic	CY		NA		
Fine Grading	AC		NA		
Fill Placement - local borrow					
Side cast	CY		NA		
Haul - uncontrolled placement	CY		96500	Offsite disposal of excavated material includes upland and lowland sediments	30.3
Haul, place, compact	CY		NA		
Stockpile - uncontrolled placement	CY		NA		
Stockpile - controlled placement	CY		NA		
Conveyor placement from stockpile land/water	CY		NA		
Imported Fill				Includes purchase, delivery and placement or as noted / described	
Select Fill	CY		30000	Imported fill for Hwy 101 roadway embankments	
Gravel Borrow, including haul	CY		NA		30.3
Sand / Gravel for Beach Nourishment	CY		7040	1000 LF x 190 sf	30.3
Cobble for Shore Nourishment	CY		NA		
Embankment Compaction	CY		30000	WSDOT standard item compaction of roadway embankment	30.3
Topsoil	CY		NA		
RESTORATION Features					
Channel Rehab / Creation	LF		NA		
Large Wood Placement	EA		3	Log structures at the western bank of Salmon Creek at Highway 101. For cost estimating purposes, it could be assumed preliminarily that the structure/element would consist of 3 logs.	30.3
Invasive Species Control	Acre		NA		
Physical Exclusion Devices	LF or EA		NA		
Other Restoration Features/ Activities	LS		NA		
Structures	EA				
Water Control Structures - Culverts with Gates	EA		NA		
Water Control Structures - Weirs	EA		NA		

Partial Restoration Quantity Estimate

Action Name:	Snow Creek Salmon Creek		
Action #:	1230		Revised May 2012, Revised July 2012
Date:	February 2011		Revised with backcheck updates: 08 August 2011
By:	ESA PWA with KPFF		

REMEDY: ***Restore processes by removing obstructions formed by abandoned railroad, fill, retarded deltaic deposits and roadways***

Construction Period: 40 weeks

	Item	Unit of Measure	Material Name	Qty	Description of Item		Indicate section of design report where item is described
	Rock Slope Protection	LF		NA			
	Other	EA		NA			
	Elevated Boat Ramp	SF		NA			
	Fencing	SF		NA			
Utilities					Replacement or relocation. Designer to provide size and material and have separate line item for each run. Incidentals include earthwork, testing, hook up fees, etc. These quantities do not include demolition of existing utilities, real estate / easements, design fees. Describe the owner if known, and whether utility franchise will install (e.g.. electric is typically installed by electrical franchise).		
	Water	LF		2750	2-in diameter privately owned water main. Rerouted along length of trail and attached to bridge crossing		30.3
	Gas	LF		NA			
	Electric	LF		2400	Overheard power realigned with new SR 101 alignment		30.3
	Sewer	LF		NA			
	Telecommunications	LF		NA			
	Other	LF		NA			
Roadway / Railway							
	Roadway (2 12-ft lanes with 8 ft shoulders)	SF		90000	Two-lane roadway with 8-ft shoulders. Includes a combined-use path on north side of Highway 101 for a length of 950 lf. Refer to Plans for pavement section		30.3
	Roadway - Traffic Signal	LS		NA			
	Culvert (type)	LF		NA			
	Culvert - Jacking	LF		NA			
	Culvert - Horizontal Pile Driving	LF		NA			
	Bridge - Superstructure	SF		28533	600-lf, 4-span, 48-ft wide precast concrete girder bridge. Depth of girder is 6'-6". Bridge on a horizontal curve. Item Includes elements such as approach slab, abutment, barriers, and railings.		30.3
	Bridge - Foundation	LF		144	7-ft diameter drilled shafts, 100-ft embedment. Measurement is along the length of pile caps.		30.3
	Bridge 1 - Foundation	LF		NA			
	Railway - Box Girder	SF		NA			
	Railway - Foundation	LF		NA			
	Railway - Shoo fly	LF		NA			
Permanent Access Features							
	Roads	Level		NA			
	Utility Access Routes	varies		NA			
	Erosion Control Features	L.F.		NA			
Public Access or Recreation Features							
	trails	SF		31440	12-ft trail; 4-in HMA over 4-in base course. Length for that portion not adjacent to roadway (2620 lf)		30.3
	bridges	SF		1500	Mill Pond Lagoon pedestrian bridge. Prefab steel with concrete deck 125' long . 12' wide.		
	bridges	SF		540	Cherry Tree Pond pedestrian bridge. Prefab steel with concrete deck 45' long . 12' wide.		
	kiosk	EA		NA			
	restrooms	EA		NA			
	Interpretive Signs	EA		4	Include # interpretive signs based on number of local public access points		30.3
	parking area	SF		NA			
	Other	EA		NA			
	Boardwalk Superstructure	SF		NA			
	Boardwalk Foundation	LF		NA			
Vegetation & Erosion Control							
	Hydroseeding	AC		10	Native upland erosion control mix		30.3
	Planting	AC		NA			
	Vegetation Maintenance	AC-YR		NA			
	Erosion Control Features	AC		15.5	Stabilized Construction Entrances, Sediment Ponds, Hydro Seed to Stabilize Roadway Embankments, Silt Fence Compost Berm.		30.3
	Erosion / sediment BMPs - Permanent	AC		NA			
	Waterside controls - Temporary	EA, LF, LS		NA			
Construction Management							
	Construction oversight	weeks		40	Quantity based on construction duration/ # of construction seasons		30.3
	Materials testing			NA	Included in cost of material - no separate quantity		
Design and Detailed Site Investigations							
	Survey & Property, Utility Research	LS		1	% of construction cost		30.8
	35% Design	LS		1	35% x 25% x Engineer's Estimate		30.8
	65% design	LS		1	65% x 25% x Engineer's Estimate less the cost for 35% PS&E		30.8
	90% design	LS		1	35% x 25% x Engineer's Estimate less the cost for 35% + 65%PS&E		30.8
	100% design	LS		1	25% x Engineer's Estimate less previous costs		30.8
	Geotechnical Studies	LS		1	Refer to design report for description of need		30.8
	Cultural Studies			NA	Refer to design report for description of need		
	HTWR Studies			1	Refer to design report for description of need		30.8
	Hydraulic Modeling	LS		1	flood risk assessment		30.8
	Soil tests for contamination	LS		1	Contamination found in adjacent restored areas		30.8
Project Agreement Activities					Unable to provide credible estimate at 10% design		
Site-Specific Adaptive Management Features & Activities					List if known		
Monitoring Activities					Assume 5 crew-days year for each monitoring parameter in design report for 5 years		
	Monitoring (Type)	crew-days		200			
Operations & Maintenance					Unable to provide credible estimate at 10% design		

31. SPENCER ISLAND RESTORATION (#1149)

Local Proponent	Snohomish County, Ducks Unlimited Inc.
Delta Process Unit	DPU SHN
Shoreline Process Unit(s)	NA
Strategy(ies)	1 – River Delta
Restoration Objectives	Remove tidal barriers to restore tidal flow and sediment process and provide greater representation of delta ecosystem components including tidal freshwater wetland, distributary channel, tidal channel and riparian forest

31.1 Description of the Action

The proposed action will restore full estuarine processes and seasonal riverine flooding to the interior of Spencer Island through dike breaching, dike lowering, and channel network enhancements. The restoration action would restore historic tidal freshwater habitat and habitat connectivity. Please see the Introduction chapter for important information regarding PSNERP and the context of this restoration project.

31.2 Action Area Description and Context

Spencer Island is located between Union and Steamboat Sloughs near Everett, Washington, in the Snohomish River Estuary at approximately river mile 3.8. This action is within the Whidbey Subbasin of Puget Sound. The action area is about 350 acres and is shown in Figure 31-1.

Past restoration on Spencer Island has restored tidal action to about 80 acres of tidal marsh habitat in the southern part of the island. A series of designed breaches in the 1990s and the construction of a cross dike allowed tidal inundation to restore estuarine processes in the southern part of the island. In 2005, an accidental breach occurred in the northern part of the island, restoring tidal action. Since the breaches occurred, many studies have highlighted the importance of removing dikes in estuary systems. Dike removal promotes higher densities of tidal channels, increased edge complexity, and higher habitat diversity.

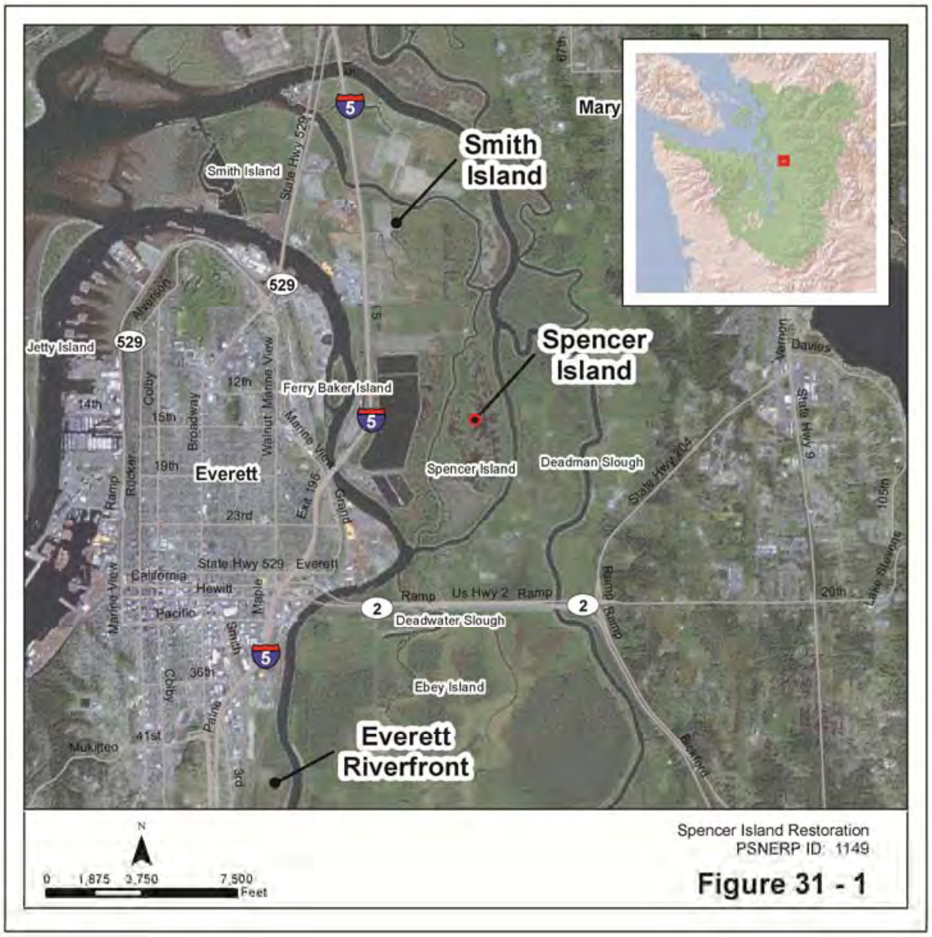


Figure 31-1. Action Area and Vicinity

31.2.1 Historic Condition

Spencer Island lies on the salinity gradient from estuarine scrub-shrub to riverine tidal forested wetland zones (Collins 2002). Historically the Snohomish River had extensive freshwater wetlands, more than four times the amount of tidal wetlands, due to the broad, gently sloping valley eroded by continental ice sheets (Figures 31-2A and 31-2B). Unlike the Skagit River, the Snohomish River does not have a divergent delta and this reduces the amount of estuarine channel (Collins 2002).

Deposition patterns associated with the distributary channels created natural levees. Coarser, better drained soils are found in the natural levees that line the banks of the distributary channels and create distinctive riparian corridors in the deltas.

The island was diked in the early 1900s and used primarily for grazing. During this period, drainage practices and lack of tidal inundation resulted in up to 4 feet of subsidence which alters the effectiveness of creating the historic type and range of habitats. These practices also altered the restored drainage patterns.

31.2.2 Natural Environment

Tidal inundation, with a maximum diurnal tide range of approximately 12 feet, was restored to part of the site in the 1990s. Tanner et al. (2002) describe the vegetation prior to breaching and its subsequent evolution. Before restoration, the site was characterized by dense monotypic stands of the invasive reed canarygrass. Large patches of cattail occurred in some lower elevation areas. Vegetation in higher elevation habitats (i.e., spoil piles and dikes) was composed primarily of non-native blackberries. In the east and southern third of the site, reed canarygrass and blackberry grade into a forested wetland area composed of canopy- forming red alder and willow, black cottonwood and Sitka spruce, and an understory of mixed shrubs and emergent plants.

The evolution of the site subsequent to breaching in the 1990s is described by Tanner et al. (2002). The site was colonized by a plant assemblage characteristic of tidal freshwater wetlands, a habitat that has become uncommon in our region due to human impacts in estuaries. Invertebrate assemblages and densities were similar to those found at reference sites just to the south of the island. Breaching of the dikes resulted in access by several species of juvenile salmon.

Since the northern dike breached in 2005, it appears that mudflat sedimentation and vegetation colonization are occurring within the site. However, the preexisting field drain system appears to have captured tidal flows, precluding the development of a dendritic channel network.

31.2.3 Human Environment

The island was jointly purchased in 1989 by Snohomish County Parks and Recreation Department and WDFW. The County manages the south half of the island for recreation, including hiking trails and bird watching. Prior to accidental breaching, WDFW managed the north half of the island for waterfowl breeding and wildlife-oriented recreation. Because dike breach restoration was not consistent with waterfowl management activities conducted by WDFW in northern sections of the island, a 2,500-foot internal cross dike was constructed to restrict tidal influence to just the southern portion of the island and avoid flooding of WDFW property. After construction of the cross dike, three dike breaches were excavated by the County in November 1994 to connect the southern portion of the island to the tidal sloughs.

The island is designated as the Spencer Island Regional Park. Public access to the island is provided by a pedestrian bridge over Union Slough. The island has a series of dike-top trails that run along the perimeter and cross the island.

31.3 Restoration Design Concept

31.3.1 Restoration Overview and Key Design Assumptions

The location of the site on the estuary salinity gradient provides an opportunity to restore tidal freshwater habitat which has been lost due to development. In addition, it appears that the island is located close enough to the mudflats at the mouth of the Snohomish River to allow for resuspended estuarine sediments to reach the island and deposit on flood tides.

The primary stressors at Spencer Island are the combination of tidal barriers and their associated drainage networks. Breaching and lowering of dikes to suitable elevations is intended to restore tidal freshwater (low salinity) hydrology to support channel formation and the development of a tidal forested wetland community. Specific process-based restoration objectives to be achieved with this action include: (1) tidal channel formation and maintenance; (2) tidal flow; (3) distributary channel migration; (4) erosion and accretion of sediments; and (5) exchange of aquatic organisms.

Creation and enhancement of breaches and improvements in the connectivity of the channel network will restore the ecosystem processes associated with the distributary channels by restoring habitat connectivity, estuarine habitat and channels. The full restoration will restore delta ecosystem components including tidal freshwater wetland, distributary channel, tidal channel and riparian forest to the area north of the cross dike. A partial restoration will restore the same components, but the evolution of the channels will be slower.

An important outcome of the proposed action is that Chinook salmon juveniles coming down the river would have full access to rearing habitat inside Spencer Island. At present, the majority of these outmigrants travel down Steamboat Slough rather than Union Slough. Enhancing the existing breach and tidal channel system associated with Steamboat Slough would therefore be advantageous. In addition, the creation of a new rearing habitat on the west may increase juvenile use of Union Slough. Historically a tidal channel network drained to the east, and this action would restore this connection. However, further consideration of the Chinook outmigrant distribution in Union and Steamboat Sloughs is needed in later design stages.

The restoration alternatives are illustrated in Figures 31-3 through 31-6. The full restoration alternative would include expanding two existing breaches and adding a third breach, and excavating a tidal channel network within the site to improve tidal circulation. Existing dikes along Steamboat and Union Sloughs would be lowered to create a low berm adjacent to the sloughs to support development of a riparian woodland corridor (Figures 31-3 and 31-5). The partial restoration alternative includes the dike lowering and dike breaches, but would not include excavation of an interior tidal channel network (Figures 31-4 and 31-6).

Under the full alternative, the existing 70-foot-wide breach on the east side of the island, adjacent to Steamboat Slough, will be widened to approximately 160 feet and deepened by about 8 feet to an elevation of -5.7 feet MLLW (-8 feet NAVD88, based on the Everett tide gage). This larger breach is designed according to the *Applied Geomorphology Guidelines* and *Hierarchy of Openings* (Appendix C) to accommodate a larger tidal prism. A marsh area of approximately 145 acres was assumed for the east side of the island. In addition, about 6,100 feet of dike adjacent to the breach will be lowered by about 3 feet to between 11.3 and 14.3 feet MLLW (9 and 12 feet NAVD88), to increase the frequency of inundation during high flow events and to support a riparian woodland corridor.

On the western side of the island, adjacent to Union Slough, an existing breach at the northern end of the island will be similarly expanded and a second breach will be created near the center of the island. The dimensions of the both the expanded and new breaches will be the same as for the Steamboat Slough breach and the assumed marsh area is also approximately 145 acres. A 180-foot-long wooden pedestrian bridge will be constructed across the new breach on Union Slough to maintain public access along the crest of the dike. About 3,100 feet of dike will be lowered at the northern end of the island. To restore a historical tidal channel network, a total of about 8,500 feet of channel, between 30 and 90 feet wide and about 5 to 10 feet below existing grade, will be excavated.

The existing agricultural drainage ditches, consisting of straight channels, are capturing much of the tidal drainage. Channel blocks and excavation will be used to increase the sinuosity of the existing drainage channels and reduce short-circuiting. A tidal channel network may take several decades to evolve unassisted. To accelerate development and evolution of the channel network, these breaches and new channels will be excavated to equilibrium dimensions as described in the *Applied Geomorphology Guidelines* and *Hierarchy of Openings* (Appendix C). A total of about 4,700 feet of channel, between 30 and 90 feet wide and about 5 to 10 feet below existing grade, will be excavated.

The partial restoration alternative would enhance and create new breaches and lower existing dikes, as with full restoration. The breaches and levee lowering are proposed at the same dimensions as the full restoration action. The primary difference is that the partial restoration does not include the modification or creation of drainage networks within the island. The partial restoration alternative allows for natural development of channel drainages adjusting to the new and expanded breach locations. Under the partial alternative, evolution of the site will be slower, and an alternative channel system may develop based on the existing manmade channel system and the greater subsidence of more peaty areas.

Active revegetation of the lowered levees is proposed to accelerate the development of native riparian forest. A forest community may not re-establish without planting due to significant potential for weeds to dominate at these elevations.

Key design elements associated with full and partial restoration alternatives are shown in Table 31-1.

Table 31-1. Key Design Elements

Element	Full Restoration	Partial Restoration
Lower Existing Dikes	Lower dike adjacent to Union Slough (3,075 LF) and Steamboat Slough (6,075 LF) to support riparian woodland corridor	Same as full restoration
Revegetation	Plant riparian vegetation along low natural levee to expand riparian corridor	Same as full restoration
Breaches	Expand one existing breach adjacent to Steamboat Slough, expand one existing breach adjacent to Union Slough in the northern portion of island, and excavate one new breach adjacent to Union Slough	Same as full restoration

Element	Full Restoration	Partial Restoration
Tidal Channels	Excavate tidal channel network and add sinuous bends to existing drainage channel network. About 13,200 LF of tidal channels excavated Sidecast material to block existing drainage channels and create low natural berms adjacent to channels	Not included

31.3.2 Restoration Features – Primary Process-Based Management Measures

Armor Removal/Modification - NA

Berm or Dike Removal/Modification

Both the full and partial restoration alternatives include lowering the existing dikes along Union Slough (3,075 LF) and Steamboat Slough (6,075 LF). The dikes would be lowered to create a wide, low berm similar to the natural levees that line the banks of sloughs in the region. At nearby Otter Island, riparian habitat is found between 11.3 and 14.3 feet MLLW (about 9 to 12 feet NAVD88). These lowered dikes would allow high flows to discharge overbank onto Spencer Island, potentially lowering flood flow depths along Union and Steamboat Sloughs.

Channel Rehabilitation/Creation

The partial and full restoration alternatives include expanding the existing dike breaches to the west on Union Slough and to the east on Steamboat Slough. The existing breaches would be expanded to accommodate the tidal prism associated with the subsided site. Both alternatives also include excavation of an additional breach in the northern portion of the site to reconnect a remnant tidal channel to Union Slough.

The full restoration alternative also includes excavation of an interior tidal channel network to facilitate tidal circulation within the site (Figure 31-3). For the expanded breach and new breach on Union Slough, the excavated tidal channel network would follow a remnant tidal channel. These channels would include side channels to allow lower areas behind natural levees to drain. The existing drainage ditch network connected to the east breach on Steamboat Slough would be modified. A number of bends would be added to the existing drainage channel network, and ditch blocks would be located within the bends to add sinuosity. Excavated material from all interior channels would be sidecast adjacent to the channels to create low berms at elevations suitable to support a riparian woodland corridor. The berms would have occasional breaks to facilitate drainage and circulation to lower areas away from the channels.

The partial restoration alternative would not include an interior tidal channel network (Figure 31-4).

Groin Removal/Modification - NA

Hydraulic Modification - NA

Overwater Structure Removal - NA

Topography Restoration - NA

31.3.3 Restoration Features – Additional Management Measures

Beach Nourishment - NA

Contaminant Removal/Remediation - NA

Debris Removal - NA

Invasive Species Control - NA

Large Wood Placement - NA

Physical Exclusion - NA

Pollution Control - NA

Revegetation

The dikes along Union Slough and Steamboat Slough would be lowered to match the natural levees that line the banks of sloughs in the region. These low, natural levees would be planted with riparian woodland vegetation between 11.3 and 14.3 feet MLLW (about 9 to 12 feet NAVD88).

Under the full restoration alternative, the interior channels would include low, natural levees designed to support riparian vegetation. These areas will be planted with native riparian species.

Reintroduction of Native Animals - NA

Substrate Modification - NA

Species Habitat Enhancement - NA

31.3.4 Restoration Features – Other

Both the full and partial restoration alternatives include a bridge across the west breach on Union Slough to maintain the existing public access trail. The restoration plan includes the removal of approximately 160 feet of existing public access path, which is incidental to the breach excavation, to be replaced by a 180 LF prefabricated pedestrian bridge approximately 10 to 15 feet wide. The bridge will be sized for final channel dimensions, including abutments, and installed during primary construction phase.

31.3.5 Land Requirements

Construction of this action will affect of 378 acres of public land managed for passive recreation. The land is co-owned by Snohomish County Parks and Recreation and WDFW, so there are no private properties to be acquired.

31.3.6 Design Considerations

The existing drainage channel network consisting of straight channels to efficiently drain the site is capturing much of the tidal drainage. The excavated tidal channel network included in the full restoration alternative addresses this problem by adding sinuous bends to the existing drainage channel network. During detailed design, filling of the existing drainage channel network and excavation of a more natural tidal channel network should be examined.

Existing public access at the site limits the amount of dike lowering possible. In the full and partial restoration alternatives, dikes that do not support improved access trails are identified for lowering. During detailed design, lowering of additional dikes should be evaluated against the requirements for public access.

The available sediment supply may not be adequate to make up for the amount of subsidence (about 4 feet) at the site in combination with sea level changes. However, recent experience since the breach in the northern part of the site occurred in 2005 indicates that sedimentation is occurring. With expanded breaches and the interior tidal channel network included in the full restoration alternative, sedimentation within the site may be maximized.

31.3.7 Construction Considerations

The existing dikes adjacent to Union and Steamboat Sloughs may be lowered primarily with upland equipment, provided this work occurs during the dry season. Access to the areas north of the existing west and east breaches would require marine access for equipment (i.e., via barge).

Breaches would require work with excavators. Final dike lowering and breaching should be coordinated, including a plan for access as additional tidal waters enter the site.

For the full restoration alternative, excavation of the interior tidal channel network and filling of the existing drainage channels would require amphibious or marine based equipment because part of the site is already tidal. Depending upon site conditions, it may be possible to excavate the sinuous interior tidal channels connecting to the west breaches on Union Slough with low-ground-pressure hydraulic excavators on mats; ditch blocks and riparian berms will be formed by sidecasting the material excavated from these channels. The partial restoration alternative would not require amphibious or marine based work.

31.4 Extent of Stressor Removal

Table 31-2 shows the amount of stressor removal with the full and partial restoration alternatives.

Table 31-2. Stressor Removal

Stressor	Full Restoration	Partial Restoration
Tidal Barrier (LF)	Lower existing dikes adjacent to Union Slough (3,075 LF) and Steamboat Slough (6,075 LF) to support riparian woodland corridor	Lower existing dikes adjacent to Union Slough (3,075 LF) and Steamboat Slough (6,075 LF) to support riparian woodland corridor
Fill (area)	Breach dikes on Union Slough to restore historic tidal connection to site (0.84 acre)	Breach dikes on Union Slough to restore historic tidal connection to site (0.84 acre)

31.5 Expected Evolution of the Action Area

Without restoration, portions of the site will still be subject to tidal inundation. The area is currently drained by straight drainage ditches, and this network will evolve to accommodate the larger tidal prism. The eastern breach to Steamboat Slough appears to be capturing most of the drainage area, and the breach has widened considerably to accommodate the large tidal prism. As the channel network evolves and the tidal prism increases, it would be expected that this breach will continue to widen. However, not all parts of the site are served by the existing drainage network, and ponding may continue to occur in these areas.

The breaching and lowering of dikes and the creation of a drainage network will restore tidal freshwater hydrology to the site. This will restore the ecosystem processes associated with the adjacent distributary channels by restoring habitat connectivity, estuarine habitat and channels. The increased tidal prism will result in erosion of the portions of the existing distributary channels that connect to outside the project site. In addition to these morphological changes, the salinity and sedimentation patterns will change as a result of the increased tidal prism.

Within the island there has been considerable subsidence since diking, and land elevations have lowered considerably relative to the tidal frame. This will likely result in more intertidal emergent marsh and less scrub-shrub and forested wetland than existed prior to diking.

31.6 Uncertainties and Risks

Uncertainty exists in the long-term evolution of the site. Reduced sediment supply from the watershed of the Snohomish River, coupled with proposed restoration projects creating upstream sediment sinks, may hamper the evolution of the subsided site and reduce its ability to keep up with a high level of sea level rise (see next section).

The project site already has a number of breaches and channels which allow some tidal inundation. An uncertainty is how the additional breaches, ditch blocks and excavated channels in the proposed project interact with the existing drainage pattern. There may be additional tidal scour along the downstream banks of Union Slough as the channel adjusts to the larger tidal prism.

31.6.1 Risks Associated with Projected Sea Level Change

Table 31-3 compares potential risks associated with projected sea level changes based on professional judgment.

Table 31-3. Risks of Sea Level Change

	Projected Sea Level Change		
	High (46 cm)	**Intermediate (4 cm)**	**Low (-8 cm)**
Full Restoration	Changes to the salinity gradient of the Snohomish River in response to climate change and other factors influencing freshwater discharges could affect habitat distribution Sediment supply may be insufficient for wetlands to keep up with relative sea level rise	Negligible	Negligible
Partial Restoration	Changes to the salinity gradient of the Snohomish River in response to climate change and other factors influencing freshwater discharges could affect habitat distribution Sediment supply may be insufficient for wetlands to keep up with relative sea level rise	Negligible	Negligible

31.7 Potential Monitoring Opportunities

Monitoring is important for evaluating restoration success. A combination of field surveys and aerial photographs would be used to document biological and physical changes to the landscape. Monitoring data can be used to refine adaptive management and corrective actions, as needed. Some of the main monitoring needs and opportunities associated with this action are summarized in Table 31-4.

Table 31-4. Monitoring Needs and Opportunities

Monitoring Parameter	Key Performance Indicator	Note
Topographic Stability	X	
Sediment Accretion / Erosion	X	
Wood Accumulation		
Soil / Substrate Conditions		
Vegetation Establishment	X	Assess shifts from scrub-shrub and

Monitoring Parameter	Key Performance Indicator	Note
		forested wetland to emergent marsh
Marsh Surface Evolution / Accretion		
Tidal Channel Cross-Section / Density	X	Monitor density and development of tidal channel network
Water Quality (contaminants)		
Salinity	X	
Shellfish Production		
Extent of Invasive Species		
Animal Species Richness		
Fish (salmonid) Access/Use	X	
Forage Fish Production		
Wildlife Species Use		
Effectiveness of Exclusion Devices		

31.8 Information Needed for Subsequent Design

This conceptual design report represents an initial step in the restoration design sequence. The design concepts described above were developed based on readily available information without the level of site-specific survey and investigation that is necessary to support subsequent design and implementation. Substantial additional information will be required at the preliminary design stage to confirm the design assumptions, refine quantity estimates, address property and regulatory issues, obtain stakeholder support, and fill in data gaps. The extent to which this information is collected for preliminary design (or a later design stage) will depend upon the available budget, schedule and other factors. This section attempts to define the most essential information needs for this action.

- Topographic/Bathymetric Survey – The survey data would be used to refine design of key project elements and develop detailed construction and demolition plans. Survey data could also be used as a baseline for pre-and post-construction modeling, including hydrodynamic modeling. A temporary tide gauge may be required in the early design stages to obtain site-specific tidal statistics.
- Geotechnical Investigation – Geotechnical studies and recommendations may be required to inform design of the proposed bridge at the new western breach. Pile footing depths and bearing loads are key site-specific geotechnical factors that will be required for preliminary and final designs. Additional, geotechnical input on the stability of soils along the restored historic tidal channel network and the sinuous additions to the existing drainage channel network will be helpful to define the type of construction equipment that maybe utilized to construct those interior features.
- Cultural Resources Investigation – Surveys for archaeological and historic resources may be required for this action area. This is particularly important in areas proposed for excavation.

- Hydraulic Analysis/Modeling – Hydrodynamic modeling will be necessary to inform the design of natural levee elevations particularly during flood events. Ideally, elevations can be based on local natural analogs. Hydrodynamic modeling may also be useful to optimize channel sizes and network to balance restoration goals with funding limitations.
- Contaminant Survey – If preliminary investigations suggest that hazardous material could be present in the action area, additional soil and sediment analysis may be needed. The introductory chapter describes the Phase I site investigations that are occurring as part of this overall effort via a separate contract.
- Sea Level Change Projection – Estimates of sea level change for the conceptual design were based on calculations provided by the Washington Department of Fish and Wildlife and the Corps of Engineers using guidance in Corps' Engineering Circular No. 1165-2-211. Projections for each project area will be refined using localized tide gauge data during later design stages.
- Other - Surveys at major project elements will be required to refine designs and quantities. Future design will need to examine the balance between public access, habitat considerations, and costs. Maintaining public access along the western dike north of the new breach will require a bridge that will raise project costs. Maintaining the dike and public trail above flood elevations will also limit habitat functions. It may be possible to maintain a public access trail at natural levee elevations, if occasional overtopping of access features is acceptable.

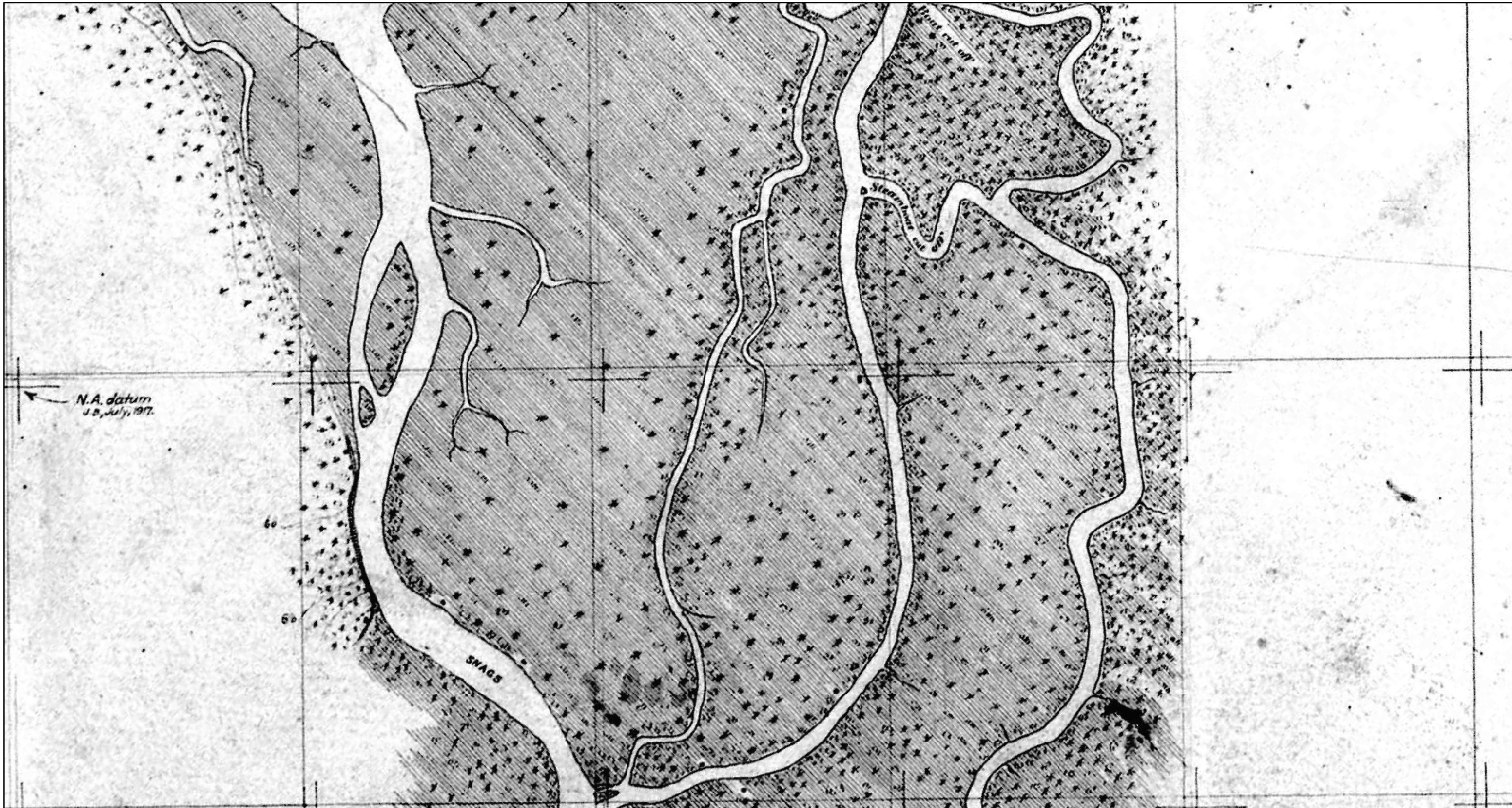
31.9 Quantity Estimates

The quantity spreadsheets for the full and partial restoration alternatives are provided in Exhibits 31-1 and 31-2.

31.10 References

Collins, B. 2002. *Mid-19th century stream channels and wetlands interpreted from archival sources for three north Puget Sound estuaries*. Skagit River System Cooperative.

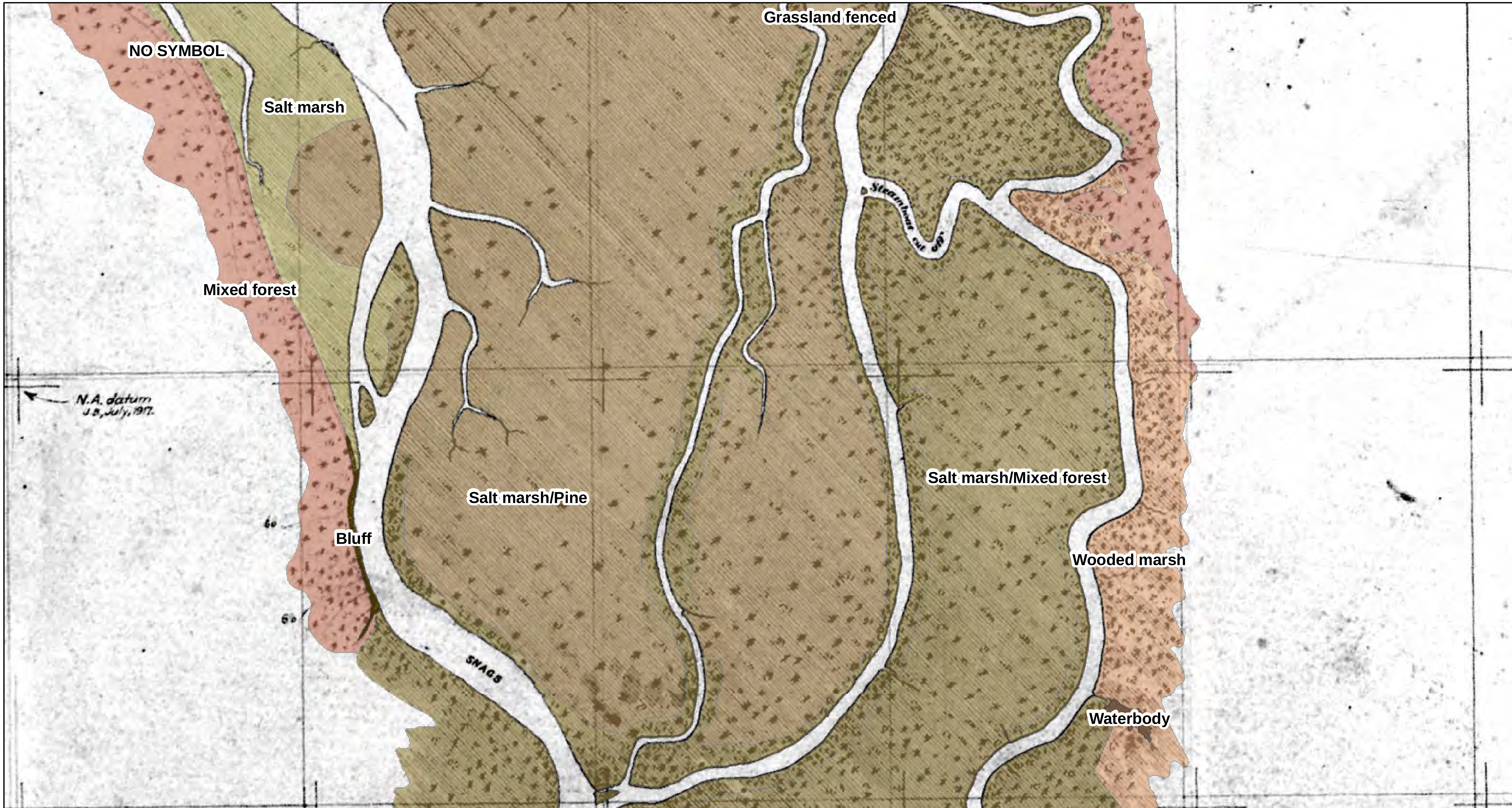
Tanner, C.D., Cordell, J. R., Rubey, J, and Tear L M. 2002. Restoration of freshwater intertidal habitat functions at Spencer Island, Everett, Washington. *Restoration Ecology* Vol. 10 No. 3, pp. 564–576.



0 1,320
Feet
0 420
Meters

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Historic Map (T-Sheet)
Action Name: Spencer Island Restoration
PSNERP ID #: 1149
Figure 31- 2A



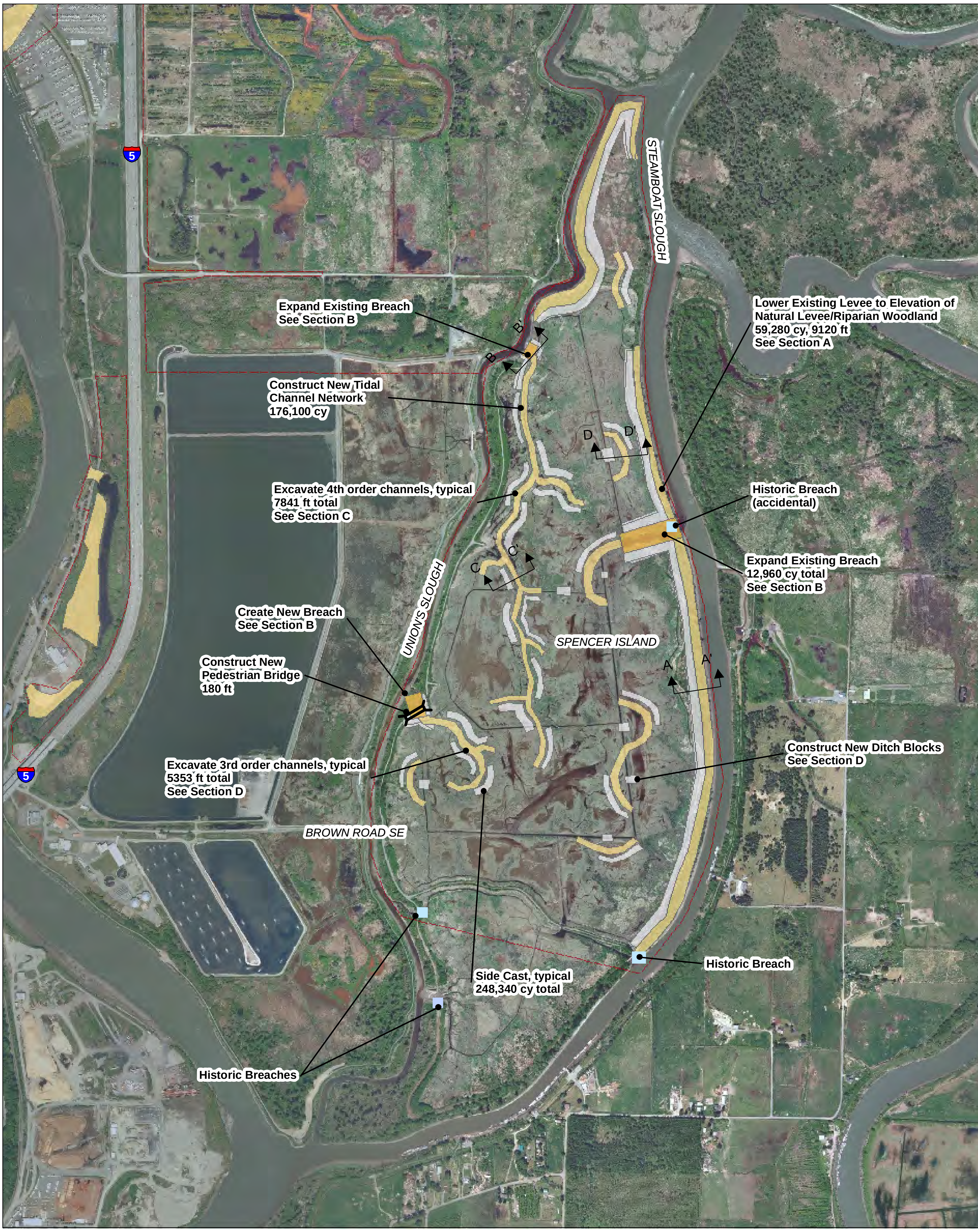
0 1,320
Feet
0 420
Meters

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64

WDFW Contract # 100-000204 (CAPS No. 10-1461)

Historic Map (T-Sheet) and River History Project Data
Action Name: Spencer Island Restoration
PSNERP ID #: 1149
Figure 31- 2B

S:\GIS\Projects\210xxx\210337_PSNERP_NEARSHORE\Projects\2-TSheets_rev.mxd (DLP; 2/24/2011)



Legend

Dredging - Bucket - Land	Proposed Tide MHHW
Excavation - Lowland	Existing Tide MHHW
Side Cast	Channel Rehab/Creation
Required Project Lands	A A' Typical Cross Section

SPENCER ISLAND CONVERSION

FIXED DATUM — TIDAL DATUM

MHHW, 8.79, NAVD88, 2.30, MLLW

0.00 FT MHHW = 8.79 FT NAVD88
-8.79 FT MHHW = 0.00 FT NAVD88
0.00 FT MLLW = -2.30 FT NAVD88
2.30 FT MLLW = 0.00 FT NAVD88

Source: Everett Tide Gauge (NOS #9447659).
See Table 1, Appendix C.

PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

North 0 500 Feet

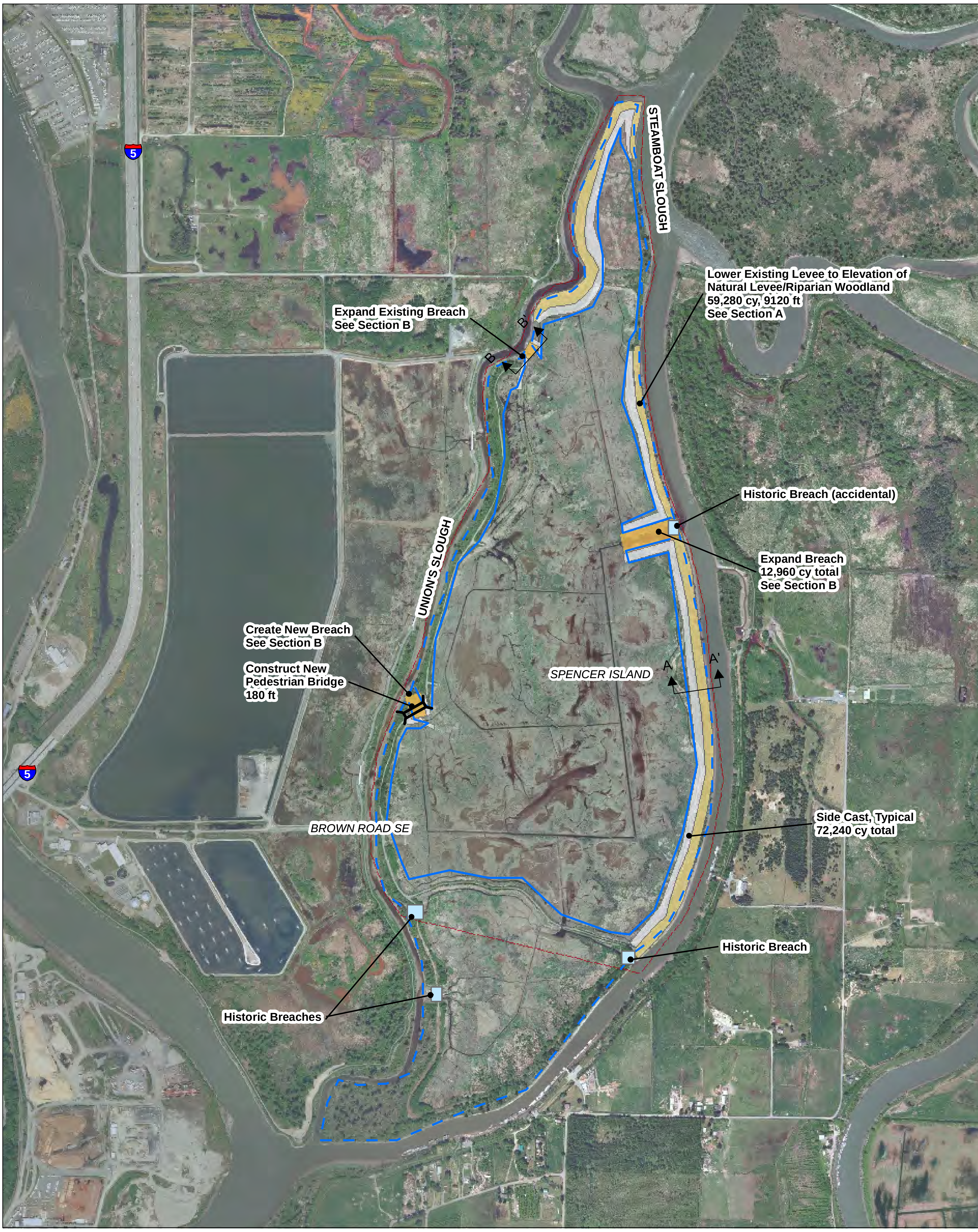
SOURCE: Washington Public Lands Database (2006);
Washington Counties Parcels (2009); Action Area (PSNERP, 2010)

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Plan
Site Name: Snohomish River Delta
Action Name: Spencer Island Restoration
PSNERP ID #: 1149
Full Restoration

Lead Contractor: ESA
Design Lead: ESA PWA, L. White, PE
Date: 05/2012

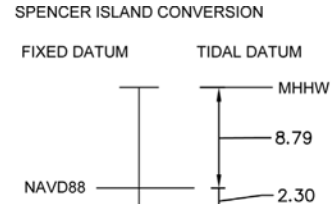
Figure 31-3



Legend

- Dredging - Bucket - Land
- Excavation - Lowland
- Side Cast
- Required Project Lands
- Proposed Tide MHHW
- Existing Tide MHHW
- Channel Rehab/Creation
- A A' Typical Cross Section

SPENCER ISLAND CONVERSION



0.00 FT MHHW = 8.79 FT NAVD88
-8.79 FT MHHW = 0.00 FT NAVD88
0.00 FT MLLW = -2.30 FT NAVD88
2.30 FT MLLW = 0.00 FT NAVD88

Source: Everett Tide Gauge (NOS #9447659).
See Table 1, Appendix C.

PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

North 0 500 Feet

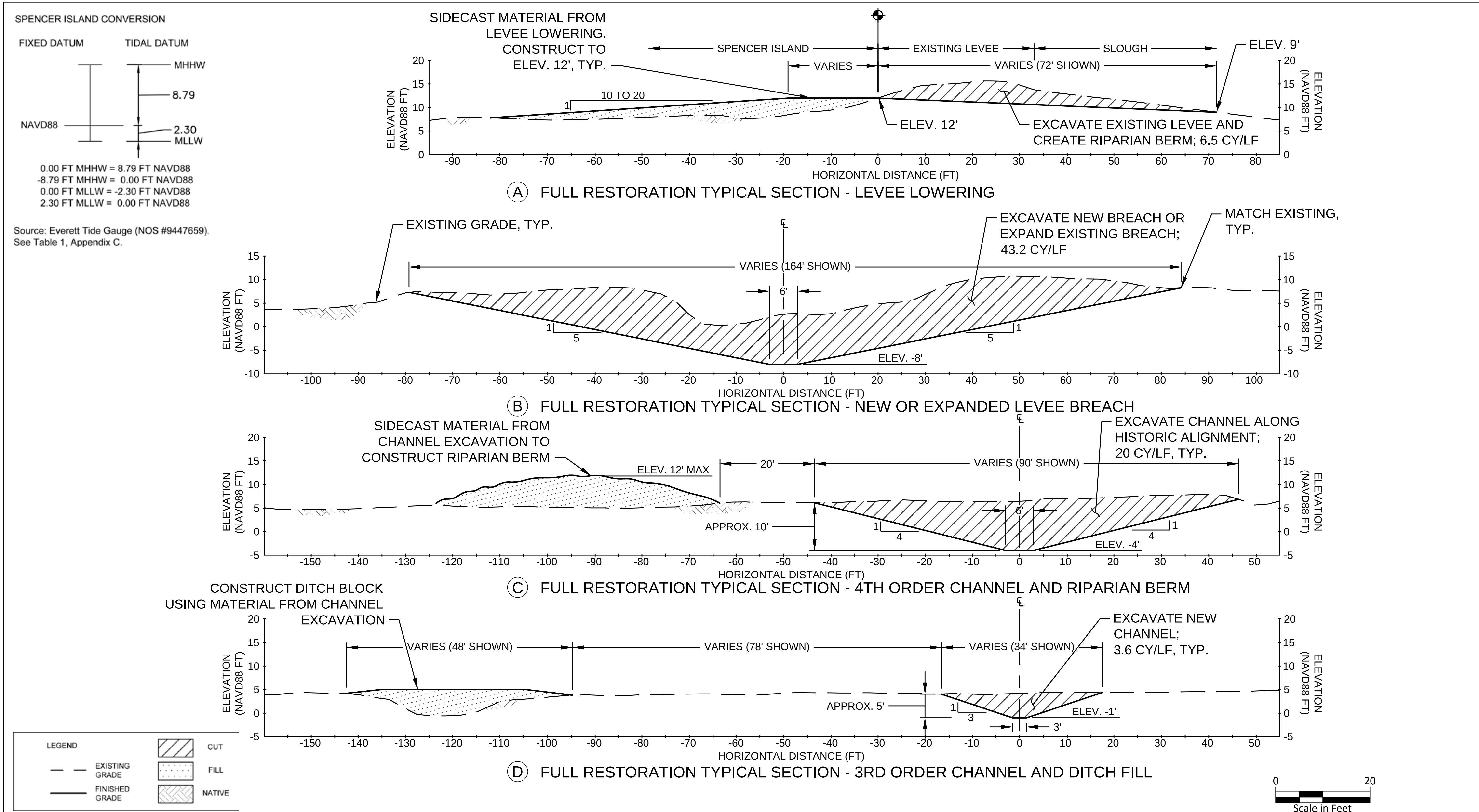
SOURCE: Washington Public Lands Database (2006);
Washington Counties Parcels (2009); Action Area (PSNERP, 2010)

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Lead Contractor: ESA
Design Lead: ESA PWA, L. White, PE
Date: 05/2012

Conceptual Design Plan
Site Name: Snohomish River Delta
Action Name: Spencer Island Restoration
PSNERP ID #: 1149
Partial Restoration

Figure 31-4



PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

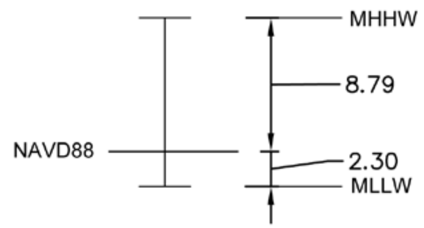
Lead Contractor: ESA
Design Lead: ESA PWA, L. White, PE
Date: 05/2012

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Section
SITE NAME: **Snohomish River Delta**
ACTION NAME: **Spencer Island Restoration**
PSNERP ID#: **1149**
Full Restoration

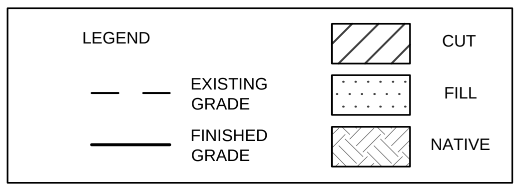
Figure 31-5

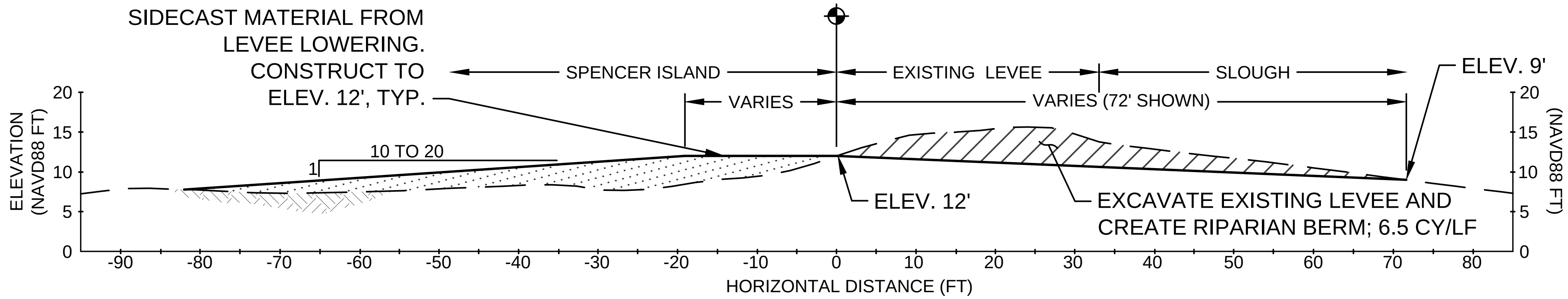
SPENCER ISLAND CONVERSION



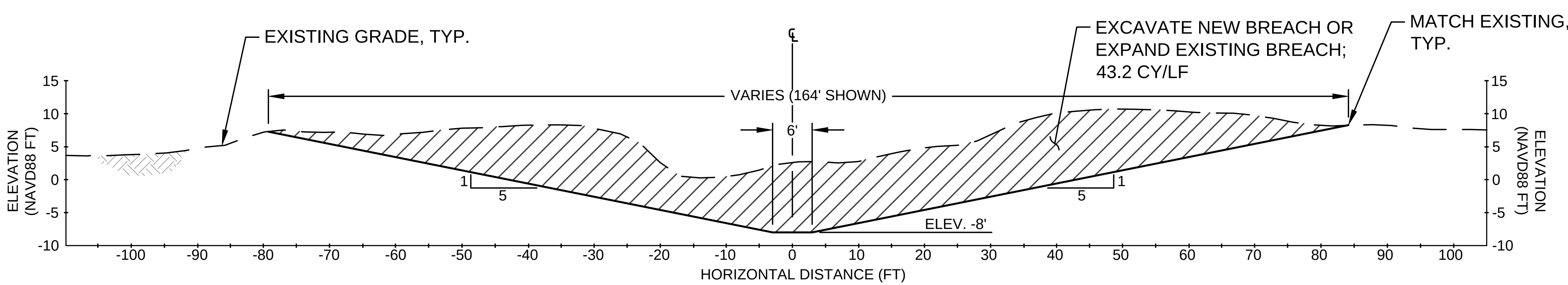
0.00 FT MHHW = 8.79 FT NAVD88
-8.79 FT MHHW = 0.00 FT NAVD88
0.00 FT MLLW = -2.30 FT NAVD88
2.30 FT MLLW = 0.00 FT NAVD88

Source: Everett Tide Gauge (NOS #9447659).
See Table 1, Appendix C.





Ⓐ PARTIAL RESTORATION TYPICAL SECTION - LEVEE LOWERING



Ⓑ PARTIAL RESTORATION TYPICAL SECTION - NEW OR EXPANDED LEVEE BREACH

PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: ESA PWA, L. White, PE
Date: 05/2012

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Section

SITE NAME: **Snohomish River Delta**

ACTION NAME: **Spencer Island Restoration**

PSNERP ID#: **1149**

Partial Restoration

Figure 31-6

Full Restoration Quantity Estimate

	Action Name:	Spencer Island Restoration			
	Action #:	1149			
	Date:	February 2011	Revised May 2012		
	By:	L. White			

REMEDY: ***Remove levee, construct channels, block ditches, expand and construct breaches to enhance wetland development***
Construction Period: 23 Weeks

	Item	Unit of Measure	Qty	Description of Item	Indicate section of design report where item is described
ACQUISITION AND CONSERVATION				Based on available mapping information	
	Required Project Lands	Acre	378	Total land required For action	31.3
	Proponent / Partner-owned lands	Acre	378	Estimate of lands currently owned by Proponent (i.e., Public lands)	31.3
	Lands To Be Acquired	Acre	NA	Estimate land required to be acquired for action prior to implementation	
Material Sites				Not Used: See Earthwork - Imported Fill.	
MOBILIZATION AND ACCESS for construction activities				Description required for each item to facilitate cost estimating	
	Mobilization - Typical (Equipment, Personnel, Planning, Financial)	LS	1	Up front costs such as bonding, planning and other staff time and financing. Typically, assume 8% to 10% of other items.	31.3
	Mobilization - Remote (Equipment, Personnel, Planning, Financial)	LS	NA		
	Site Access	LS	NA		
	Barge Access	Days	NA		
	Temporary Traffic Control (one of the following)				
	none	LS	NA		
	signs	LS	NA		
	flags / spotters	LS	NA		
	unique	LS	NA		
	Temporary Roadway	SF	NA		
	Control of Water	LS	NA		
Relocation Activities				Not Used: See Utilities, Structures	
Site Demolition Activities				Demolition and removal of structures (description required), temporary features and relocations, itemized separately); Clearing and grubbing of vegetation, and removal of minor debris (rocks, slabs) - description required.	
	Clearing and Grubbing (one or more of following)			Use one or more of the following categories of clearing and grubbing	
	Clear Vegetation - Local Disposal	AC	NA		
	Clear /Grub Vegetation - Local Disposal	AC	40.0	Vegetation roots also removed and disposed locally	31.3
	Clear /Grub Vegetation - Offsite Disposal	AC	NA		
	Clear, stockpile - large woody debris	CY	NA		
	Hydraulic Structures - Small	LS	NA		
	Hydraulic Structures - Large	LS	NA		
	Utilities	LS or LF	NA		
	Buildings	LS or SF	NA		
	Pavement	LS or SF	NA		
	Bulkheads	LF or SF	NA		
	Rock revetments	LF, Ton or CY	NA		
	Large Coastal Structures	LF, SF or CY	NA		
	Demolition / Removal - Bridge	SF or CY	NA		
	Removal - Misc. (e.g. angular rock from beach)	Ton	NA		
	Demolition / Removal - Boat Ramp	SF	NA		
	Haul - Offsite Disposal of Demolition Debris	Miles	NA		
Hazardous/Contaminated Waste Removal				These items for earthwork of quality not compatible with wetlands, requiring special handling and disposal. Describe basis for classification as contaminated or hazardous. State known or suspected contamination, describe known similar work.	
	Contaminated Earthwork	CY	NA		
	Hazardous Earthwork	CY	NA		
Construct Temporary Features				Use as needed for unusual temporary features not included elsewhere (see TESC below)	
EARTHWORK				Expand to include equipment, etc. to facilitate cost estimating.	
	Excavation	CY		Per yard excavation w/out expected haul	
	Excavation - Upland	CY	NA		
	Excavation - Lowland	CY	235380	Requires low ground pressure equipment and or mats; low production bucket methods, typically hydraulic excavator and front end loaders.	31.3
	Levee Lowering	*CY*	*59280*	*LGP Excavators*	31.3
	Channels	*CY*	*176100*	*Channel excavation using LGP excavators*	31.3
	Dredging - Bucket - Land	CY	12960	Breach excavation'	31.3
	Dredging - Bucket - Marine	CY	NA		
	Dredging - Hydraulic	CY	NA		
	Fine Grading	AC	NA		
	Fill Placement - local borrow			This is additive to Earthwork -Excavation	
	Side cast	CY	248540	Excavated material placed within reach of excavator / dredge - assume includes some shaping by bucket	31.3
	Levee Lowering	*CY*	*59480*	*LGP Excavators*	31.3
	Channels	*CY*	*176100*	*Channel excavation using LGP excavators*	31.3
	Breaches	*CY*	*12960*	*Breach Excavation*	31.3
	Haul - uncontrolled placement	CY	NA		
	Haul, place, compact	CY	NA		
	Stockpile - uncontrolled placement	CY	NA		
	Stockpile - controlled placement	CY	NA		
	Conveyor placement from stockpile land/water	CY	NA		
	Imported Fill				
	Select Fill	CY	NA		
	Gravel Borrow, including haul	CY	NA		
	Sand / Gravel for Beach Nourishment	CY	NA		
	Cobble for Shore Nourishment	CY	NA		
	Embankment Compaction	CY	NA		
	Topsoil	CY	NA		
RESTORATION Features					
	Channel Rehab / Creation	SF	13194		31.3
	Large Wood Placement	EA	NA		
	Invasive Species Control	Acre	NA		
	Physical Exclusion Devices	LF or EA	NA		
	Other Restoration Features/ Activities	LS	NA		
Structures		EA			
	Water Control Structures - Culverts with Gates	EA	NA		
	Water Control Structures - Weirs	EA	NA		
	Rock Slope Protection	LF	NA		
	Other	EA	NA		
	Elevated Boat Ramp	SF	NA		
	Fencing	SF	NA		
Utilities				Replacement or relocation. Designer to provide size and material and have separate line item for each run. Incidentals include earthwork, testing, hook up fees, etc. These quantities do not include demolition of existing utilities, real estate / easements, design fees. Describe the owner if known, and whether utility franchise will install (e.g.. electric is typically installed by electrical franchise).	
	Water	LF	NA		
	Gas	LF	NA		

Full Restoration Quantity Estimate

Action Name:	Spencer Island Restoration		
Action #:	1149		
Date:	February 2011	Revised May 2012	
By:	L. White		

REMEDY: ***Remove levee, construct channels, block ditches, expand and construct breaches to enhance wetland development***

Construction Period: 23 Weeks

	Item	Unit of Measure	Qty	Description of Item	Indicate section of design report where item is described
	Electric	LF	NA		
	Sewer	LF	NA		
	Telecommunications	LF	NA		
	Other	LF	NA		
Roadway / Railway					
	Roadway (Type_)	SF	NA		
	Roadway - Traffic Signal	LS	NA		
	Culvert (type)	LF	NA		
	Culvert - Jacking	LF	NA		
	Culvert - Horizontal Pile Driving	LF	NA		
	Bridge - Foundations, Deck and Appurtenances	SF	NA		
	Railway - Box Girder	SF	NA		
	Railway - Foundation	LF	NA		
	Railway - Shoe fly	LF	NA		
Permanent Access Features					
	Roads	Level	NA		
	Utility Access Routes	varies	NA		
	Erosion Control Features	L.F.	NA		
Public Access or Recreation Features					
	Trails	SF	NA		
	Bridges	SF	2700	Wooden Pedestrian bridge, 15 ft by 180 ft	31.3
	Kiosk	EA	NA		
	Restrooms	EA	NA		
	Interpretive Signs	EA	NA		
	Parking Area	SF	NA		
	Other	EA	NA		
Vegetation & Erosion Control					
	Hydroseeding	AC	NA		
	Planting	AC	NA		
	Vegetation Maintenance	AC-YR	NA		
	Erosion / sediment BMPs - Temp.	AC	NA		
	Erosion / sediment BMPs - Permanent	AC	NA		
	Waterside controls - Temporary	EA, LF, LS	NA		
Construction Management					
	Construction oversight	weeks	23	Quantity based on construction duration/ # of construction seasons	31.3
	Materials testing		NA		
	Proponent in-kind Services	Man-Days	NA		
	Government Oversight	Man-Days	NA		
	Quality Control & Testing	L.S.	NA		
	Quality Assurance With Testing	L.S.	NA		
Design and Detailed Site Investigations					
	Survey & Property, Utility Research	LS	1	% of construction cost	31.8
	35% Design	LS	1	35% x 25% x Engineer's Estimate	31.8
	65% design	LS	1	65% x 25% x Engineer's Estimate less the cost for 35% PS&E	31.8
	90% design	LS	1	35% x 25% x Engineer's Estimate less the cost for 35% + 65%PS&E	31.8
	100% design	LS	1	25% x Engineer's Estimate less previous costs	31.8
	Geotechnical Studies			Refer to design report for description of need	
	Cultural Studies			Refer to design report for description of need	
	HTWR Studies			Refer to design report for description of need	
Project Agreement Activities				Unable to provide credible estimate at 10% design	
Site-Specific Adaptive Management Features & Activities				List if known	
Monitoring Activities				Assume 5 crew-days/year for each monitoring parameter in design report for 5 yrs	
		crew- days	125		
Operations & Maintenance				Unable to provide credible estimate at 10% design	

Partial Restoration Quantity Estimate

	Action Name:	Spencer Island Restoration			
	Action #:	1149			
	Date:	February 2011	Revised May 2012		
	By:	L. White			
	REMEDY: ***Remove levee, expand and construct breaches to enhance wetland development***				
	Construction Period: 9 Weeks				

	Item	**Unit of Measure**	**Qty**	**Description of Item**	**Indicate section of design report where item is described**
ACQUISITION AND CONSERVATION				Based on available mapping information	
	Required Project Lands	Acre	378	Total land required For action	31.3
	Proponent / Partner-owned lands	Acre	378	Estimate of lands currently owned by Proponent (i.e., Public lands	31.3
	Lands To Be Acquired	Acre	NA	Estimate land required to be acquired for action prior to implementatio	
Material Sites				Not Used: See Earthwork - Imported Fill.	
MOBILIZATION AND ACCESS for construction activities				Description required for each item to facilitate cost estimating	
	Mobilization - Typica (Equipment, Personnel, Planning, Financial)	LS	1	Up front costs such as bonding, planning and other staff time and financing. Typically, assume 8% to 10% of other items.	31.3
	Mobilization - Remote (Equipment, Personnel, Planning, Financial	LS	NA		
	Site Access	LS	NA		
	Barge Access	Days	NA		
	Temporary Traffic Control (one of the following)				
	none	LS	NA		
	signs	LS	NA		
	flags / spotters	LS	NA		
	unique	LS	NA		
	Temporary Roadway	SF	NA		
	Control of Water	LS	NA		
Relocation Activities				Not Used: See Utilities, Structures	
Site Demolition Activities				Demolition and removal of structures (description required), temporary features and relocations, itemized separately); Clearing and grubbing of vegetation, and removal of minor debris (rocks, slabs) - description required.	
	Clearing and Grubbing (one or more of following)			Use one or more of the following categories of clearing and grubbing	
	Clear Vegetation - Local Disposal	AC	NA		
	Clear /Grub Vegetation - Local Disposal	AC	22	Vegetation roots also removed and disposed locally	31.3
	Clear /Grub Vegetation - Offsite Disposal	AC	NA		
	Clear, stockpile - large woody debris	CY	NA		
	Hydraulic Structures - Smal	LS	NA		
	Hydraulic Structures - Large	LS	NA		
	Utilities	LS or LF	NA		
	Buildings	LS or SF	NA		
	Pavement	LS or SF	NA		
	Bulkheads	LF or SF	NA		
	Rock revetments	LF, Ton or CY	NA		
	Large Coastal Structures	LF, SF or CY	NA		
	Demolition / Removal - Bridge	SF or CY	NA		
	Removal - Misc. (e.g. angular rock from beach)	Ton	NA		
	Demolition / Removal - Boat Ramp	SF	NA		
	Haul - Offsite Disposal of Demolition Debris	Miles	NA		
Hazardous/Contaminated Waste Removal				These items for earthwork of quality not compatible with wetlands, requiring special handling and disposal. Describe basis for classification as contaminated or hazardous. State known or suspected contamination, describe known similar work.	
	Contaminated Earthwork	CY	NA		
	Hazardous Earthwork	CY	NA		
Construct Temporary Features				Use as needed for unusual temporary features not included elsewhere (see TESC below)	
EARTHWORK				Expand to include equipment, etc. to facilitate cost estimating.	
	Excavation	CY		Per yard excavation w/out expected haul	
	Excavation - Upland	CY	NA		
	Excavation - Lowland	CY	59280	Levee lowering, LGP excavators	31.3
	Dredging - Bucket - Land	CY	12960	Breach excavation	31.3
	Dredging - Bucket - Marine	CY	NA		
	Dredging - Hydraulic	CY	NA		
	Fine Grading	AC	NA		
	Fill Placement - local borrow			This is additive to Earthwork -Excavatio	
	Side cast	CY	72240	Excavated material placed within reach of excavator / dredge - assume includes some shaping by buck	31.3
	Levee Lowering	*CY*	*59280*		31.3
	Breaches	*CY*	*12960*		31.3
	Haul - uncontrolled placement	CY	NA		
	Haul, place, compact	CY	NA		
	Stockpile - uncontrolled placement	CY	NA		
	Stockpile - controlled placement	CY	NA		
	Conveyor placement from stockpile land/water	CY	NA		
	Imported Fill				
	Select Fill	CY	NA		
	Gravel Borrow, including haul	CY	NA		
	Sand / Gravel for Beach Nourishment	CY	NA		
	Cobble for Shore Nourishment	CY	NA		
	Embankment Compaction	CY	NA		
	Topsoil	CY	NA		
RESTORATION Features					
	Channel Rehab / Creation	SF	NA		
	Large Wood Placement	EA	NA		
	Invasive Species Control	Acre	NA		
	Physical Exclusion Devices	LF or EA	NA		
	Other Restoration Features/ Activities	LS	NA		
Structures		EA			
	Water Control Structures - Culverts with Gates	EA	NA		
	Water Control Structures - Weirs	EA	NA		
	Rock Slope Protection	LF	NA		
	Other	EA	NA		
	Elevated Boat Ramp	SF	NA		
	Fencing	SF	NA		
Utilities				Replacement or relocation. Designer to provide size and material and have separate line item for each run. Incidentals include earthwork, testing, hook up fees, etc. These quantities do not include demolition of existing utilities, real estate / easements, design fees. Describe the owner if known, and whether utility franchise will install (e.g., electric is typically installed by electrical franchise	
	Water	LF	NA		
	Gas	LF	NA		
	Electric	LF	NA		
	Sewer	LF	NA		
	Telecommunications	LF	NA		
	Other	LF	NA		
Roadway / Railway					
	Roadway (Type_)	SF	NA		
	Roadway - Traffic Signal	LS	NA		
	Culvert (type)	LF	NA		
	Culvert - Jacking	LF	NA		
	Culvert - Horizontal Pile Driving	LF	NA		
	Bridge - Foundations, Deck and Appurtenances	SF	NA		
	Railway - Box Girde	SF	NA		

Partial Restoration Quantity Estimate

Action Name:	Spencer Island Restoration		
Action #:	1149		
Date:	February 2011	Revised May 2012	
By:	L. White		

REMEDY: ***Remove levee, expand and construct breaches to enhance wetland development***
Construction Period: 9 Weeks

	Item	Unit of Measure	Qty	Description of Item	Indicate section of design report where item is described
	Railway - Foundation	LF	NA		
	Railway - Shoe fly	LF	NA		
Permanent Access Features					
	Roads	Level	NA		
	Utility Access Routes	varies	NA		
	Erosion Control Features	L.F.	NA		
Public Access or Recreation Features					
	Trails	SF	NA		
	Bridges	SF	2700	Wooden Pedestrian bridge, 15 ft by 180 ft	31.3
	Kiosk	EA	NA		
	Restrooms	EA	NA		
	Interpretive Signs	EA	NA		
	Parking Area	SF	NA		
	Other	EA	NA		
Vegetation & Erosion Control					
	Hydroseeding	AC	NA		
	Planting	AC	NA		
	Vegetation Maintenance	AC-YR	NA		
	Erosion / sediment BMPs - Temp.	AC	NA		
	Erosion / sediment BMPs - Permanent	AC	NA		
	Waterside controls - Temporary	EA, LF, LS	NA		
Construction Management					
	Construction oversight	weeks	9	Quantity based on construction duration/ # of construction seasons	31.3
	Materials testing				
	Proponent in-kind Services	Man-Days	NA		
	Government Oversight	Man-Days	NA		
	Quality Control & Testing	L.S.	NA		
	Quality Assurance With Testing	L.S.	NA		
Design and Detailed Site Investigations					
	Survey & Property, Utility Research	LS	1	% of construction cost	31.8
	35% Design	LS	1	35% x 25% x Engineer's Estimate	31.8
	65% design	LS	1	65% x 25% x Engineer's Estimate less the cost for 35% PS&E	31.8
	90% design	LS	1	35% x 25% x Engineer's Estimate less the cost for 35% + 65%PS&E	31.8
	100% design	LS	1	25% x Engineer's Estimate less previous costs	31.8
	Geotechnical Studies			Refer to design report for description of need	
	Cultural Studies			Refer to design report for description of need	
	HTWR Studies			Refer to design report for description of need	
Project Agreement Activities				Unable to provide credible estimate at 10% design	
Site-Specific Adaptive Management Features & Activities				List if known	
Monitoring Activities				Assume 5 crew-days/year for each monitoring parameter in design report for 5 yrs	
	Monitoring (Type_)	crew-days	125		
Operations & Maintenance				Unable to provide credible estimate at 10% design	

32. TAHUYA CAUSEWAY REPLACEMENT AND ESTUARY RESTORATION (#1404)

Local Proponent	Mason County
Delta Process Unit	NA
Shoreline Process Unit(s)	2013, 2084
Strategy(ies)	4 - Coastal Inlet
Restoration Objectives	Remove barriers to tidal flow and sediment transport to restore historic distributary channel system, exchange of aquatic organisms, and detritus import and export

32.1 Description of the Action

The proposed action would restore natural tidal flow and sediment transport to the Tahuya River Estuary, allowing the restoration of a distributary channel system. Restoration would include replacement the existing bridge with a longer bridge to span the inlet, removal of roadway embankment fill (NE North Shore Road), and removal of fill in nearshore areas southwest of the road bridge. Please see the Introduction chapter for important information regarding PSNERP and for context related to this restoration project.

32.2 Action Area Description and Context

The action area is located in the Hood Canal Subbasin. The Tahuya River inlet is near the head of Hood Canal and generally sheltered from high waves. NE North Shore Road is built on an embankment across the mouth of the Tahuya River Estuary, with a short bridge where it crosses the Tahuya River channel. Large estuarine marshes are located between the main channels, which are largely unconstrained except at the bridge. Despite residential development along the Hood Canal shoreline, the area is largely undeveloped with limited impacts to coastal processes outside the project site. The action area is shown in Figure 32-1.

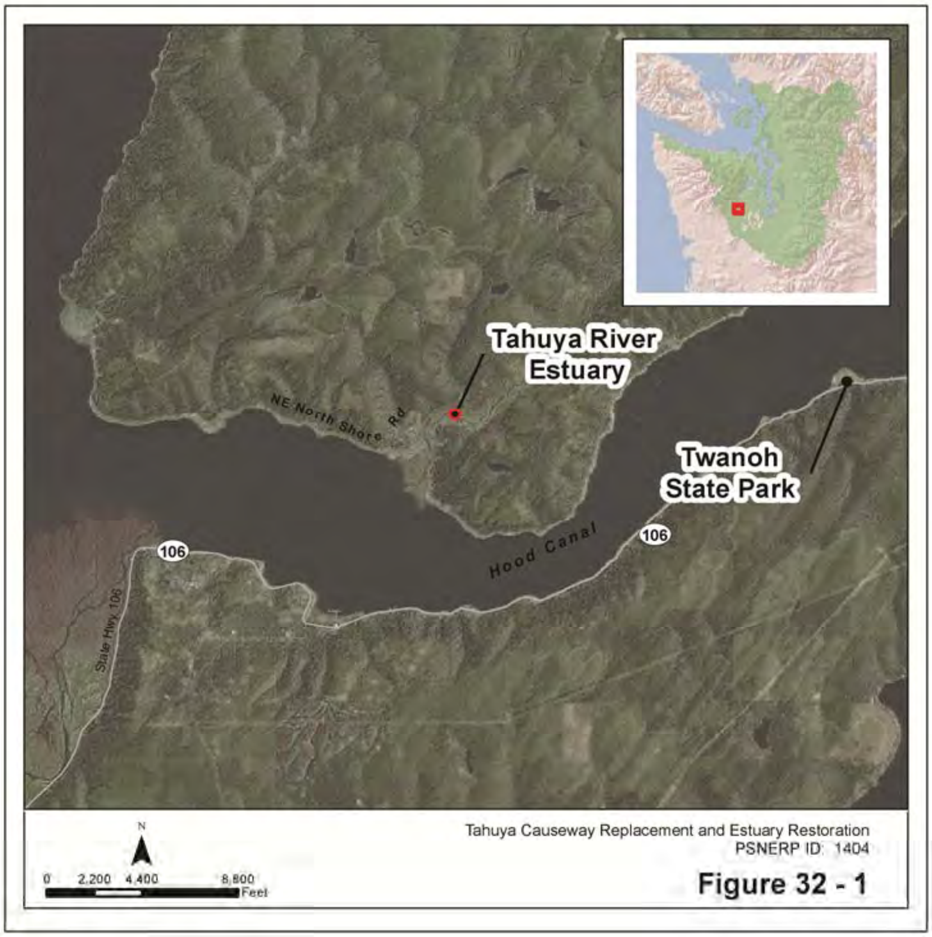


Figure 32-1. Action Area and Vicinity

32.2.1 Historic Condition

Figures 32-2A and 32-2B provide historic maps of the action area. At the time of the earliest known cartographic survey (Gilbert 1884), the inlet supported a larger estuarine wetland complex than exists currently. The former estuarine areas appear to have been filled by the roadway embankment and for other land uses (Collins and Sheikh 2005). In 1884, the stream had at least two distinct distributary channels that have been constrained to a single channel at the bridge. This has reduced the number and complexity of braided channels in the inlet.

32.2.2 Natural Environment

The upland areas of the site—and much of the surrounding watershed—are forested and mostly in timber production. There is extensive high marsh and low marsh vegetation, much of it in more or less the same location as when it was originally mapped. An extensive freshwater wetland exists contiguous to the upstream end of the estuarine wetland complex. With the exception of the bridge and roadway embankment, there are no structures and few other alterations that restrict channel migration. Harbor seals use floats in the inlet for haulout.

Southwest of the bridge, bare-earth LiDAR maps show that ancient mass wasting (probably a rotational block approximately 2,000 feet wide) resulted in the valley wall collapsing into, and slightly constricting the mouth of, the inlet just downstream of the project area.

32.2.3 Human Environment

The site was originally altered to accommodate a mill site and other logging activity, principally in the area northeast of the existing bridge. A 500-foot-long earthen embankment and 150-foot-long wood trestle bridge were later installed on nearly the same alignment as the contemporary bridge. The current bridge was built adjacent to that bridge. As a result, the embankment is quite wide (60 feet) given the level of use of the road. NE North Shore Road is a two-lane secondary arterial owned and maintained by Mason County. The roadway is posted today with a speed advisory sign. The design speed for this roadway classification is 35 mph.

Along the west side of the road, overhead utilities include power and communication lines. Along the east side of the road and attached to the side of the bridge are buried communication lines. A filled gravel lot has been constructed on historic tidelands southwest of the bridge and serves as a helipad for emergency medical transport. A rural residence with several outbuildings exists to the northeast of the bridge, at the site of a historic sawmill. Numerous piles in the marsh and in the water are probably related to historic log rafting and log haulout activities at the mill site.

Ownership of the estuary is private except for the road right-of-way and some tidelands. WDFW also owns approximately 20 acres of land downstream of the NE North Shore Road bridge (WDFW 2010) and the action area. These lands include upland and intertidal habitat.

32.3 Restoration Design Concept

32.3.1 Restoration Overview and Key Design Assumptions

Figures 32-3 through 32-7 illustrate the restoration alternatives. The full restoration alternative includes replacing the existing bridge and entire roadway embankment within the footprint of the historic estuary with a longer bridge to facilitate channel migration and tidal flow (Figure 32-3). The full restoration alternative would realign the roadway west of the existing alignment and span the entire limits of tidal influence along the Tahuya River. The alignment for the full restoration alternative would be improved to the design speed (35 mph).

The new bridge would be approximately 700 feet long with eight spans of about 90 feet, consisting of 3-foot-6-inch-deep slab girders (Figures 32-5A and 32-5B). The scour hole under the existing bridge would not be filled to match the adjacent grade, but is anticipated to fill naturally in less than 2 years. The exact dimensions of the scour hole are unknown and should be determined by a survey for the subsequent design phase. Fill would be removed and tidal marsh restored in the vicinity of the existing embankment and helipad.

The partial restoration alternative addresses some of the constraints associated with the full restoration by reducing the length of the new bridge (Figures 32-6A and 32-6B). This alternative is smaller in scope and requires less roadway realignment. The existing 123-foot-6-inch-long concrete slab bridge would be removed and replaced along the same alignment with a 560-foot, multi-span, slab girder bridge. Much of the roadway embankment and other fill would be removed, and some tidal marsh restoration would also occur.

The primary difference between the full and partial alternatives is the extent of fill removal on the north side of the channel. The full removes essentially all fill from the intertidal and replaces with a long span, and the partial leaves approximately 200 LF of embankment on the north side. The partial alignment was selected to remove the bulk of the hydraulic impact of the historical fill, but reduces project costs and avoids having to reconfigure road connections on the north side of the bridge.

The proposed restoration is anticipated to improve shellfish productivity in the lower estuary by allowing increased sediment transport, in particular coarser sediments beneficial to shellfish (WDFW 2010).

The key design elements associated with full and partial restoration alternatives are summarized in Table 32-1.

Table 32-1. Key Design Elements

Element	Full Restoration	Partial Restoration
Bridge Replacement	Remove existing bridge (123 LF) and replace with longer bridge (700 LF)	Remove existing bridge (123 LF) and replace with longer bridge (560 LF)
Existing Roadway Fill	Remove roadway approach fill (9,550 CY)	Remove partial extent of roadway and embankment fill (4,770 CY)
Embankment and Other Nearshore Fill	Remove roadway and fill north of bridge (4,525 CY) Remove roadway and helipad fill (12,025 CY) south of bridge Remove four areas of debris and miscellaneous derelict pilings	Same as full restoration
Tidal Marsh	Restore areas where fill is removed or temporary impacts occur through decompaction, soil amendment and revegetation	Same as full restoration
Utility Relocation	Relocate overhead and buried utilities on embankment	Same as full restoration

32.3.2 Restoration Features – Primary Process-Based Management Measures

Armor Removal/Modification

Shoreline armor is limited to the abutments of the existing bridge. This armor would be removed with the full restoration alternative, but it may become needed in the partial restoration alternative if channel migration threatens to undermine one or both of the abutments in the future. The existing armor is primarily light loose riprap (2 man and smaller) with some sack concrete. This armor is less than 6 feet high and does not extend very far beyond the bridge abutments. A short section (30 feet) of older, creosote treated, wooden pile and lagging bulkhead forms the abandoned abutment of a previous bridge west of and contiguous to the existing south abutment.

Berm or Dike Removal/Modification

The roadway embankment acts as a primary stressor on tidal flow, sediment transport, and channel formation and maintenance (see below). By eliminating or substantially reducing the size of this embankment, these habitat-forming processes would be restored.

Channel Rehabilitation/Creation

The presence of the roadway embankment and channel confinement over several decades appears to have resulted in slight aggradation upstream from the bridge (about 1 foot or less in most areas) and a deep scour hole under the bridge. Removal of the roadway embankment would remove the primary stressor on channel migration in the action area. The site is naturally dominated by tidal – not fluvial – hydrology, so natural recovery of the system is dependent on tidal cycles and not high stream flows. However, the channel does experience flood events. It is anticipated that with the restoration of the full (or nearly full) tidal prism, the scour hole will fill in less than 1 year and the natural tidal channel patterns will begin to reestablish. Additional study of the need to augment natural process by filling the scour hole, excavating channels, or promoting meander with engineered log jams is recommended in subsequent design phases, but the use of these techniques is not anticipated to be necessary.

Groin Removal/Modification - NA

Hydraulic Modification - NA

Overwater Structure Removal - NA

Topography Restoration

Areas of fill would be fully or partially removed to allow restoration of tidal marsh and channel formation and maintenance. Existing roadway embankments would be excavated from their current elevation of approximately 18 feet MLLW to the elevation of the surrounding delta flat – approximately 6 feet MLLW.

32.3.3 Restoration Features – Additional Management Measures

Beach Nourishment - NA

Contaminant Removal/Remediation - NA

Debris Removal

Several areas of the shoreline have scattered or concentrated debris. In some cases, this debris may have historic significance. Debris is mostly surficial and consists of domestic garbage illegally dumped, car parts, old machinery, and a collapsed shack. Derelict piles, presumably related to the mill site, would be removed. Many of these piles appear to be creosote treated, but they are extremely weathered and could not be accessed to verify that assumption. The presence of creosote piles should be verified in subsequent design phases.

Invasive Species Control - NA

Large Wood Placement - NA

Physical Exclusion - NA

Pollution Control - NA

Revegetation

Nearshore fill in areas identified as estuarine marsh on historic maps would be removed as described above and the areas restored. Restoration would include decompaction, soil amendment, and planting with appropriate species. The extent of revegetation is greater in the full restoration alternative than in the partial restoration alternative, in part due to the increased disturbance associated with modifying the roadway alignment.

Reintroduction of Native Animals - NA

Substrate Modification - NA

Species Habitat Enhancement - NA

32.3.4 Restoration Features – Other

NA

32.3.5 Land Requirements

Construction of this action will affect of 2.5 acres of tidelands and uplands. Three landowners are affected by the project. WDNR owns most of the tidelands affected, and WDFW owns salt marsh and other lands just downstream of the action area. Under the full restoration alternative, additional right-of-way would be required to accommodate the new bridge alignment. It is possible that this could be offset by vacating right-of-way that would no longer be required. The southern portion of the site is owned by Manke Lumber Company, who has indicated a willingness to work with the project proponent to facilitate the restoration. Further discussions with this landowner are needed to investigate alternatives such as property acquisition, easement or other similar means. A private rural residential parcel exists northwest of the bridge. A small portion of the roadway embankment fill scheduled for removal appears to be on this parcel. Additional survey would be required to determine the extent of such fill.

32.3.6 Design Considerations

Road and bridge design will conform to WSDOT standards and will be reviewed and approved by Mason County Public Works prior to implementation.

Existing overhead power and communication distribution lines located along the west side of NE North Shore Road, and buried communication lines located along the east side of the road, would be relocated prior to construction. Transformers on the overhead power lines would be relocated to outside the fill removal area, but within the same general vicinity (just north or south of the construction limits). The proposed bridge would be supported on 30-inch-diameter cast-in-place piles under both alternatives. The assumed embedment depth of the piles is 100 feet. Other foundation types such as pre-cast concrete piles should be considered during later phases of design.

The local proponent has indicated that if use of the helipad at this location is eliminated, a new location may need to be identified in the vicinity. The exact requirements of a new facility are not known, but the current helipad is a simple graded gravel area approximately 100 feet in diameter.

Removal of the roadway entirely from the nearshore area was considered, but it is not included in these alternatives. Abandonment of the existing nearshore portion of the road would leave many residents in the area with only one route for access to their homes and could add significantly to travel times. NE North Shore Road provides the only access to many residences, and is within a county designated landslide hazard area for nearly the entire 10-mile length from NE Belfair Tahuya Road to the site at the mouth of the Tahuya River (Mason County 2010). The road is susceptible to closure at many locations by landslides, and has been closed recently due to a landslide near NE Bel Air Drive. Abandonment of the road at the Tahuya River crossing would make access to residences west of a landslide potentially impossible until debris is cleared. For this reason, abandonment is not considered practicable.

In order to move the roadway out of the nearshore at the crossing of the Tahuya River, a replacement roadway would need to be constructed farther inland. Due to the steep topography of the area, this would likely involve new roads on either side of the lower Tahuya River valley connected by a new bridge farther upstream. Such an alignment would either cross the extensive freshwater wetland complex that is contiguous with the estuary, or require siting the new bridge more than 1.5 miles upstream. Such a new alignment would result in significantly more overall road length on both sides of the upper estuary/inlet, with potentially severe impacts to the forest ecosystem bordering it.

Improvements to NE North Shore Road would restore the roadway to the current design standards. The minimum roadway width varies between a minimum of 30 feet widening to 35 feet along the horizontal curve to accommodate truck trailer movements. Horizontal curves have a super-elevated section of 6%.

The existing bridge would be closed and demolished prior to construction of the new bridge along the existing alignment.

32.3.7 Construction Considerations

Methods and Equipment

Land-based drilling augers or pile driving rigs will be used to install the foundations at the portion of the roadway adjacent to the existing embankment. Where the new alignment runs adjacent to the existing bridge, local access via filling in from the shore or temporary platforms would be required to drive piles. Another possibility would be to use a barge-based pile-driving rig, but this would require dredging an access channel from Hood Canal; this may have greater temporary construction impacts. During the next design phases, consideration should be given to increasing the span length of the proposed bridge to expedite construction and reduce costs. At this time, work is anticipated to require land-based pile driving rigs or large augers, excavators, cranes, concrete trucks, and dump trucks.

Once piles are placed (assuming one pile per day), the cast-in-place pilecaps and abutments would be constructed and the bridge girders set with a crane.

Access and Staging

Access would be provided via the existing roadway embankment and additional filling/temporary platforms as required for pile installation adjacent to the existing bridge. A temporary access road for the residence on the north side at the roadway transition will need to be provided by the contractor to NE Belfair Tahuya Road. Staging and laydown would occur on the existing helipad; this area would be retained until other construction was complete and then excavated near the end of the project sequence. Other fill removal could be coordinated with new roadway embankment construction to facilitate reuse onsite where possible. Earthwork will not require dredging or water based equipment, and could be accomplished with larger tracked excavators or similar equipment. Some excavation could only be accomplished at tidal elevations above approximately 7 feet MLLW. Access to the residences on the north side of the action area will be provided during construction.

Timing and Duration

Mason County Public Works has confirmed that full closure of NE North Shore Road for the duration of construction is acceptable. NE Belfair-Tahuya Road would be the detour route, with signage provided near the town of Belfair nearly 20 miles to the east.

Bridge construction of the multi-span voided slab structure can be expected to require up to 11 months for the full restoration alternative and up to 9 months for the partial restoration alternative. Additional crews can be added to accelerate the construction, which may be desirable due to the inconvenience that shutdown of the roadway would cause. This would have to be weighed against the additional cost of mobilizing the necessary equipment.

32.4 Extent of Stressor Removal

The primary stressor in the action area is the fill associated with the nearshore road. The replacement of the existing roadway embankment (nearshore fill) with an elevated roadway (e.g., pile- or pier-supported structure) would eliminate the partial tidal barrier, allow removal of all or most of the nearshore fill, and allow the removal of all of the shoreline armoring now used to protect the bridge abutments. Additional nearshore fill could be removed in adjacent areas northwest and southeast of the roadway embankment. Removal of piles would also partially address overwater structure stressors. The amounts of stressor removal are provided in Table 32-2.

Table 32-2. Stressor Removal

Stressor	Full Restoration	Partial Restoration
Tidal Barrier (LF)	575	435
Fill (CY)	26,100	21,320
Armor (LF)	210	210

32.5 Expected Evolution of the Action Area

The site is expected to develop new tidal channels (in both alternatives) as natural regimes of erosion and sedimentation are restored. Estuarine marsh vegetation may eventually be flooded in some lower areas and would replace palustrine vegetation in some higher areas. Under the partial restoration alternative, it is possible that tidal channel migration may reach the new bridge abutments, causing scour and/or requiring new bank hardening.

32.6 Uncertainties and Risks

There is a relatively high probability of encountering historic and archaeological resources at this locale; therefore, a cultural resources assessment of the area of potential effect is warranted. For both alternatives, construction of a bridge includes concrete piles installed within the tidally inundated area of the inlet. The concrete piles create some potential risk for localized scour, but the extent of these effects is uncertain at 10% design. These effects could be better understood at later stages of design using hydrodynamic modeling. There are no known sources of environmental contamination associated with the project area.

32.6.1 Risks Associated with Projected Sea Level Change

The bridge abutment armor was damaged by velocity scour associated with the riverine floods of 2008. With rising sea levels and increased tidal prism, this risk would increase. The potential for occasional flooding also exists due to the low elevation of the roadway. Risks to habitat from sea level rise are primarily an upstream shift in habitat types, potentially conflicting with current agricultural land uses outside the project area. A rise in sea level under the high change scenario would result in a larger tidal prism, which would increase the tidal energy in the channels at the site. This could increase localized erosion and channel migration, and in the case of the partial restoration alternative, may necessitate shoreline armor around the bridge abutments. A maximum design water elevation for the project of 14.60 feet NAVD 88 (17.45 feet MLLW) was determined by interpolating the maximum tidal elevation from adjacent NOAA datum stations and adding the high sea level change, 18 inches (46 cm). Risks of sea level change are summarized in Table 32-3.

Table 32-3. Risks of Sea Level Change

	Projected Sea Level Change		
	High (46 cm)	Intermediate (4 cm)	Low (-8 cm)
Full Restoration	Low risk to transportation and utility infrastructure. Moderate risk of habitat displacement upstream	Low risk to transportation and utility infrastructure and habitat displacement upstream	No risk to transportation and utility infrastructure and habitat displacement upstream
Partial Restoration	Low risk to transportation and utility infrastructure; greater risk of scour effects and need for armor long term at abutments in this alternative; moderate risk of habitat displacement upstream	Low risk to transportation and utility infrastructure and habitat displacement upstream	No risk to transportation and utility infrastructure and habitat displacement upstream

32.7 Potential Monitoring Opportunities

Monitoring is important for evaluating the success of the restoration. A combination of field surveys and aerial photographs would be used to document biological and physical changes to the landscape. Monitoring data can be used to refine adaptive management and corrective actions, as needed. Some of the key monitoring needs and opportunities associated with this action are summarized in Table 32-4.

Table 32-4. Monitoring Needs and Opportunities

Monitoring Parameter	Key Performance Indicator	Note
Topographic Stability	X	Monitor tidal channel migration and effects on new bridge abutments
Sediment Accretion / Erosion	X	Monitor sediment transport
Wood Accumulation		Monitor deposition of large wood, log jams, and bars
Soil / Substrate Conditions		
Vegetation Establishment	X	Monitor changes in estuarine marsh vegetation in lower areas and palustrine vegetation in higher areas
Marsh Surface Evolution / Accretion	X	Assess if natural erosion and sedimentation regimes are restored. Monitor for erosion of the valley wall

Monitoring Parameter	Key Performance Indicator	Note
Tidal Channel Cross-Section / Density	X	Document new tidal channel development
Water Quality (contaminants)		
Salinity		
Shellfish Production	X	
Extent of Invasive Species		
Animal Species Richness		
Fish (salmonid) Access/Use	X	
Forage Fish Production		
Wildlife Species Use		
Effectiveness of Exclusion Devices		

32.8 Information Needed for Subsequent Design

This conceptual design report represents an initial step in the restoration design sequence. The design concepts described above were developed based on readily available information without the level of site-specific survey and investigation that is necessary to support subsequent design and implementation. Substantial additional information will be required at the preliminary and later design stages to confirm the design assumptions, refine quantity estimates, address property and regulatory issues, obtain stakeholder support, and fill in data gaps. The extent to which this information is collected for preliminary design (or a later design stage) will depend upon the available budget, schedule, and other factors. This section attempts to define the most essential information needs for this action:

- Property Investigation/Survey – More detailed information on parcel ownership, utilities, and property boundary location will be needed to finalize the design, confirm acquisition requirements, and support negotiations with property owners.
- Topographic/Bathymetric Survey – The survey data would be used to refine design of key project elements and develop detailed construction and demolition plans. Survey data could also be used as a baseline for pre- and post-construction modeling. A temporary tide gauge may be required in the early design stages to obtain site-specific tidal statistics.
- Geotechnical Investigation – Geotechnical investigations and recommendations for bridge foundation are needed. Additional investigations may be needed to identify the size of armor to be removed.
- Cultural Resources Investigation – Surveys for archaeological and historic resources may be required for this action area. This is particularly important for areas proposed for excavation.
- Hydraulic Analysis/Modeling – Additional hydrologic and hydraulic study will be required to optimize the design and determine minimum bridge clearances and scour recommendations. Geomorphic study will be required to understand the rate of natural channel formation and filling of the existing scour hole. This study

should be used to determine if channel excavation or the installation of engineered log jams is warranted.

- Contaminant Survey – If preliminary investigations suggest that hazardous material could be present in the action area, additional soil and sediment analysis may be needed. The Introduction chapter describes the Phase I site investigations that are occurring as part of this overall effort via a separate contract. This survey would include testing of derelict piling for creosote. Sea Level Change Projection – Estimates of sea level change for the conceptual design were based on calculations provided by the Washington Department of Fish and Wildlife and the Corps of Engineers using guidance in Corps' Engineering Circular No. 1165-2-211. Projections for each project area will be refined using localized tide gauge data during later design stages.

32.9 Quantity Estimates

The design quantities are largely developed from LiDAR data sets lacking the resolution to accurately quantify all elements of construction. These are supplemented by unmeasured estimates made during one site visit at high tide and areal take-offs from available imagery. The quantity spreadsheets for the full and partial restoration alternatives are provided in Exhibits 32-1 and 32-2.

32.10 References

Gilbert, J.J. 1884. Map of Hood's Canal, Washington Territory, Sheet No 10. U.S. Coast and Geodetic Survey.

Collins, B. D., and A. J. Sheikh. 2005. *Historical Reconstruction, Classification and Change Analysis of Puget Sound Tidal Marshes.* Washington Department of Natural Resources, Aquatic Lands Division.

Mason County. 2010. *Mason County Natural Hazard Mitigation Plan.* Mason County Division of Emergency Management. Adopted by the Mason County commission July 27, 2010.

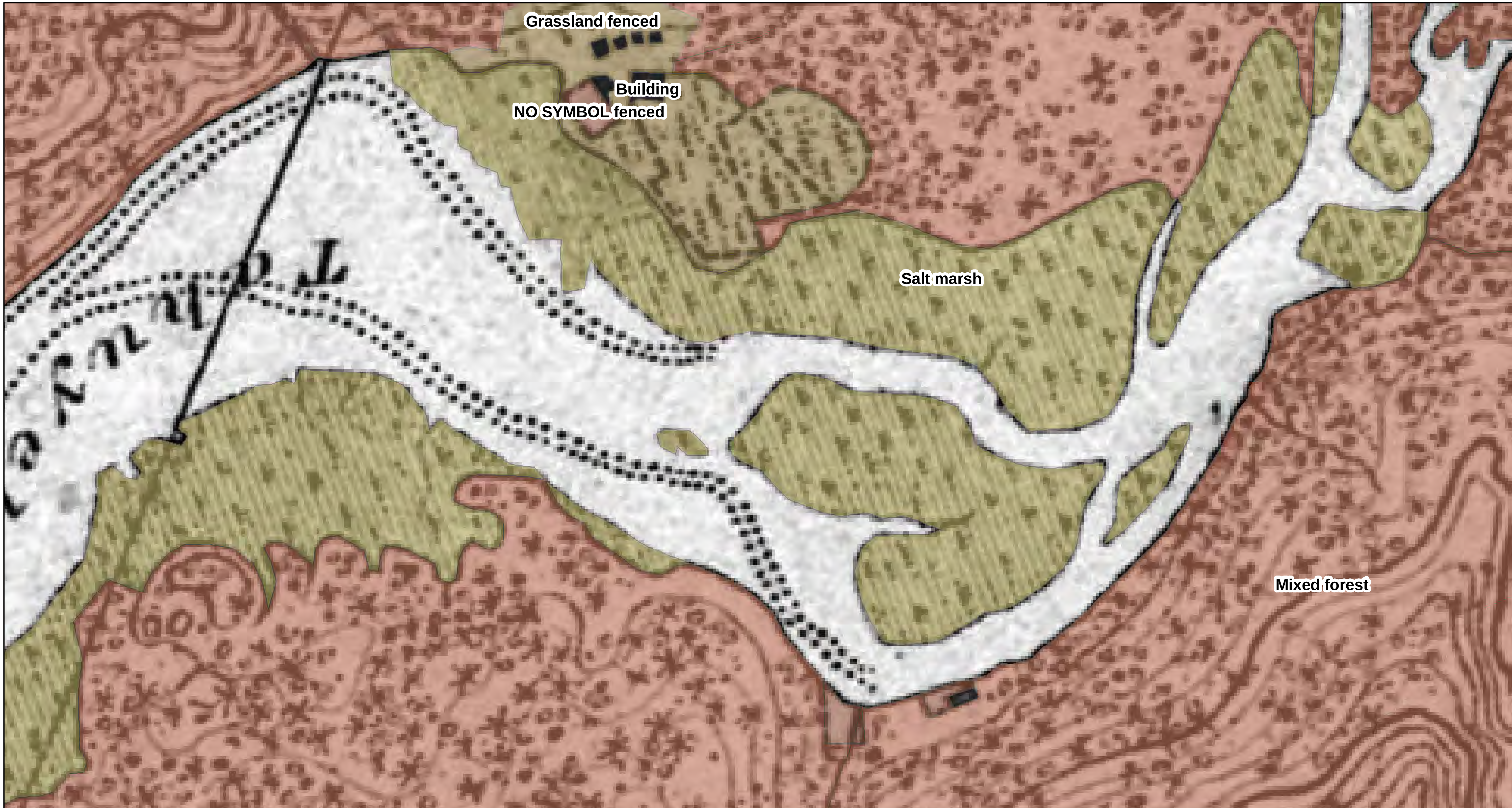
WDFW (Washington Department of Fish and Wildlife). 2010. WDFW PSNERP Strategic Restoration Project Action Characterization Report comments. Comment provided by Curtis Tanner, WDFW. November, 2010.

0 200
Feet
0 60
Meters

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Historic Map (T-Sheet)
Action Name: Tahuya Causeway Replacement and Estuary Restoration
PSNERP ID #: 1404
Figure 32- 2A

S:\GIS\Projects\210xxx\210337_PSNERP_NEARSHORE\Projects\2-TSheets_rev.mxd (DLP; 2/24/2011)

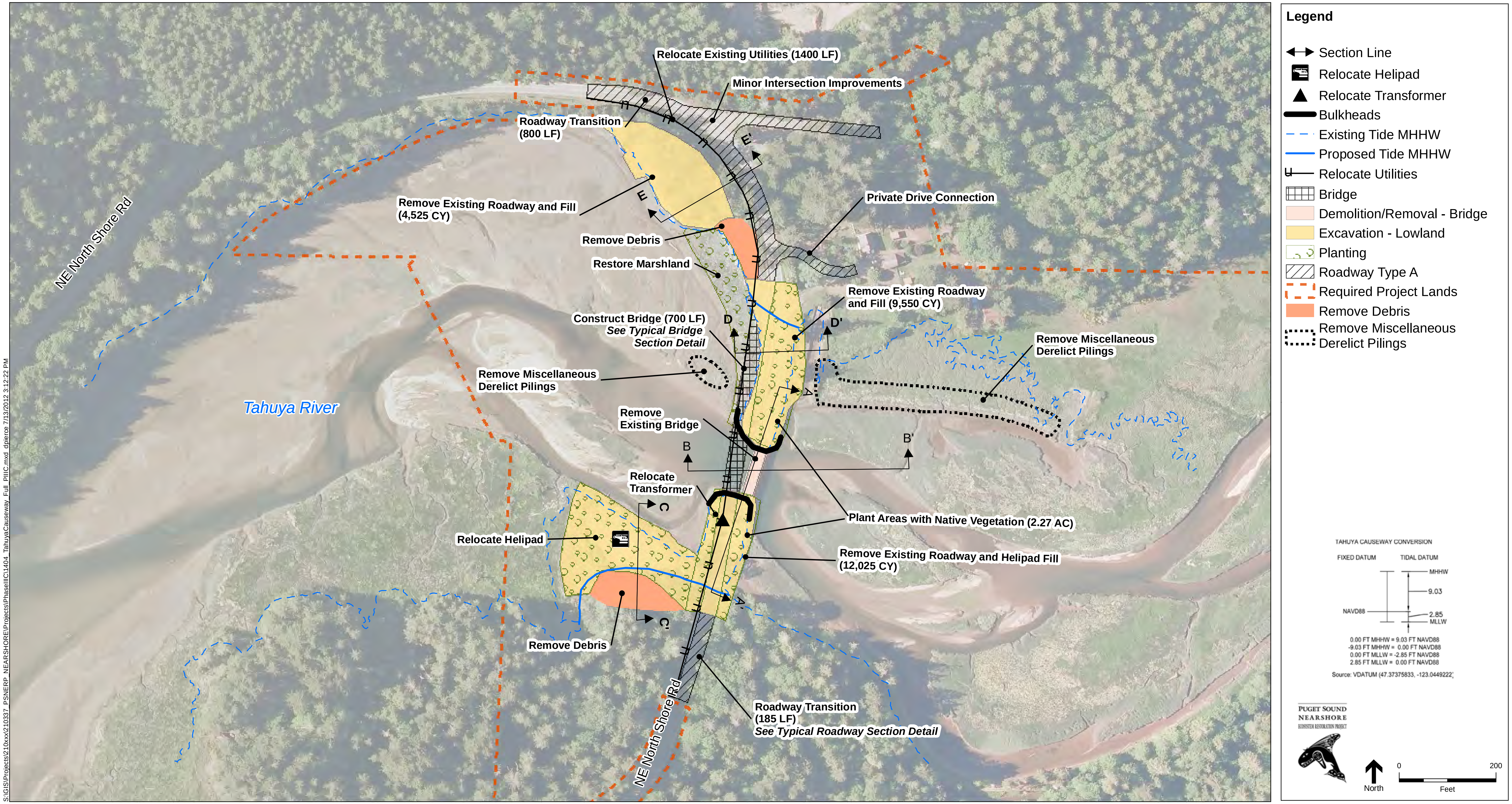


0 200
Feet
0 60
Meters

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Historic Map (T-Sheet) and River History Project Data
Action Name: Tahuya Causeway Replacement and Estuary Restoration
PSNERP ID #: 1404
Figure 32- 2B

S:\GIS\Projects\210xxx\210337_PSNERP_NEARSHORE\Projects\2-TSheets_rev.mxd (DLP; 2/24/2011)



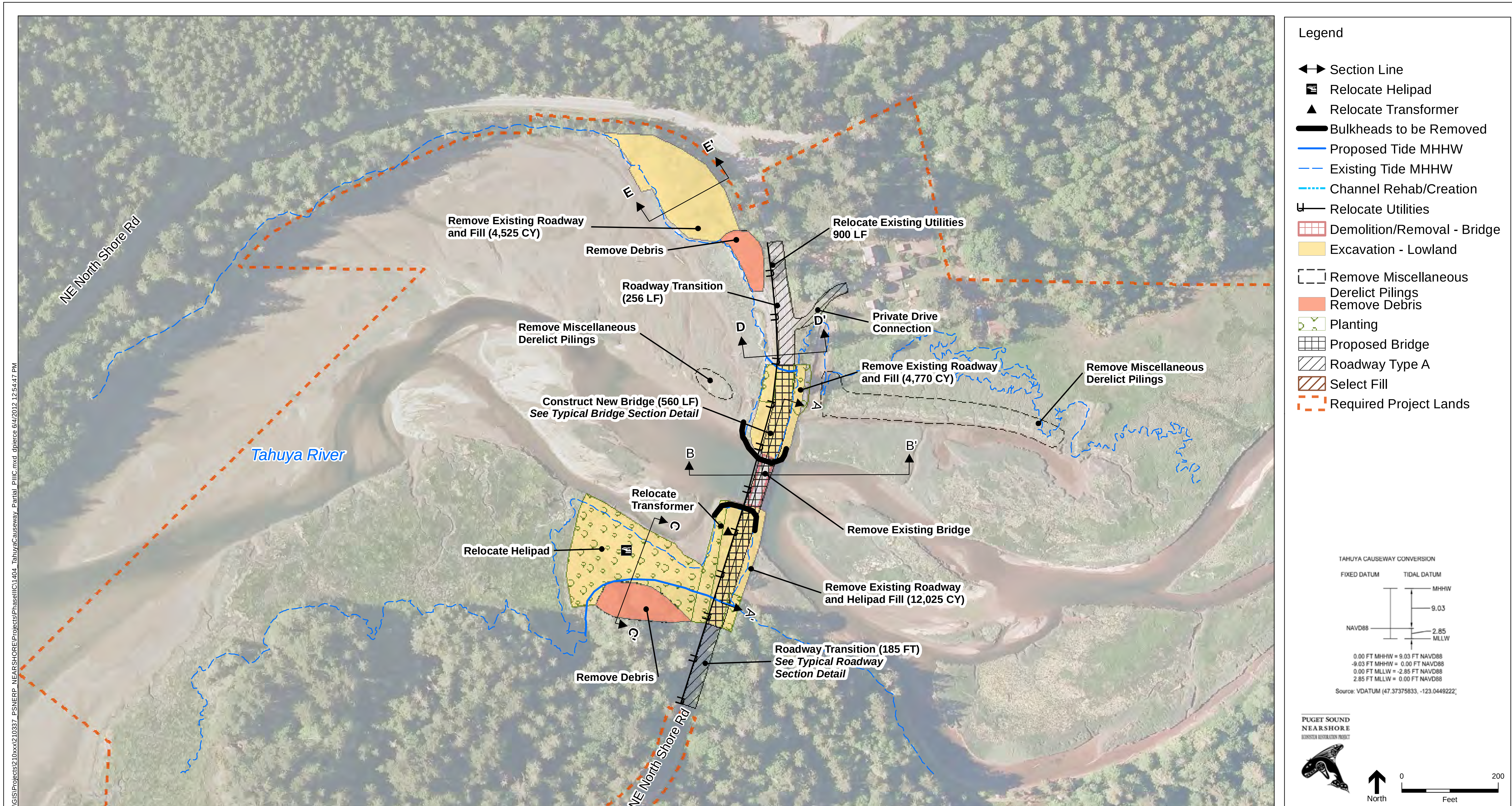
SOURCE: Mason County Parcels (2009); Action Area (PSNERP, 2010); High Resolution Orthoimagery (USGS, 2009)

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Lead Contractor: ESA
Design Lead: Anchor QEA, J. Small
Date: 07/2012

Conceptual Design Plan
Site Name: Tahuya Causeway
Action Name: Tahuya Causeway Replacement and Estuary Restoration
PSNERP ID #: 1404
Full Restoration

Figure 32-3



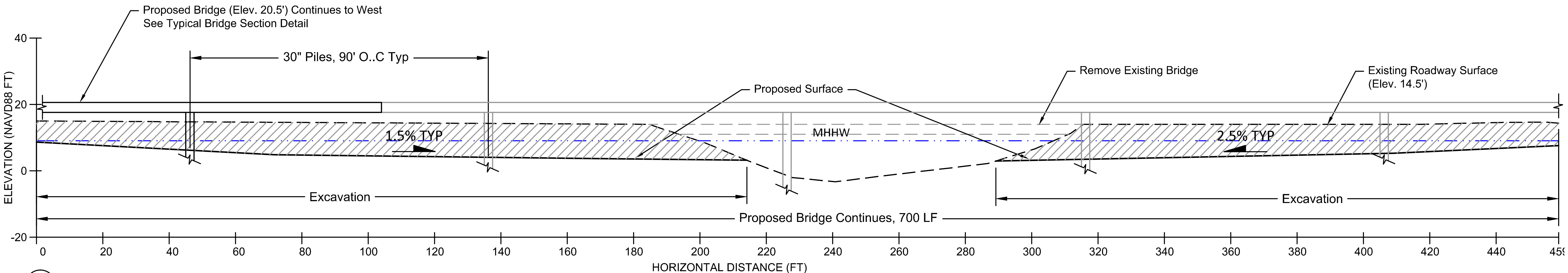
SOURCE: Mason County Parcels (2009); Action Area (PSNERP, 2010); High Resolution Orthoimagery (USGS, 2009)

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

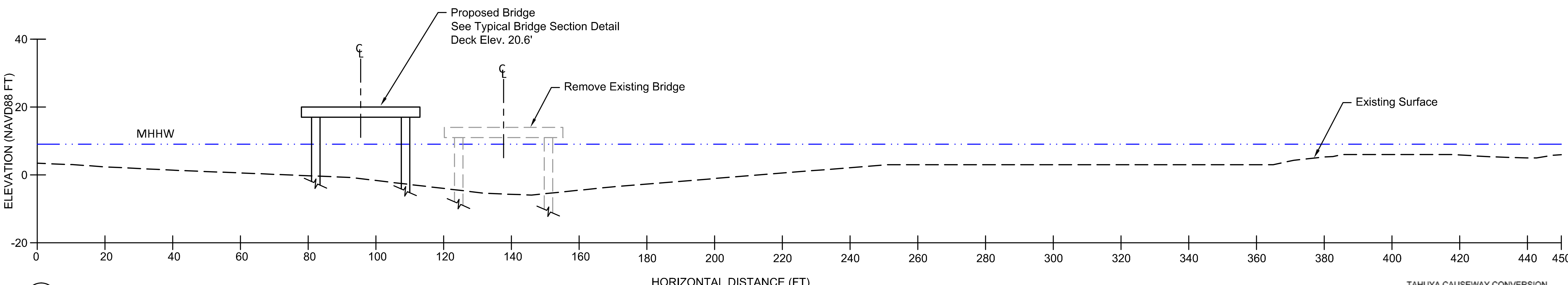
Lead Contractor: ESA
Design Lead: Anchor QEA, J. Small
Date: 05/2012

Conceptual Design Plan
Site Name: Tahuya Causeway
Action Name: Tahuya Causeway Replacement and Estuary Restoration
PSNERP ID #: 1404
Partial Restoration

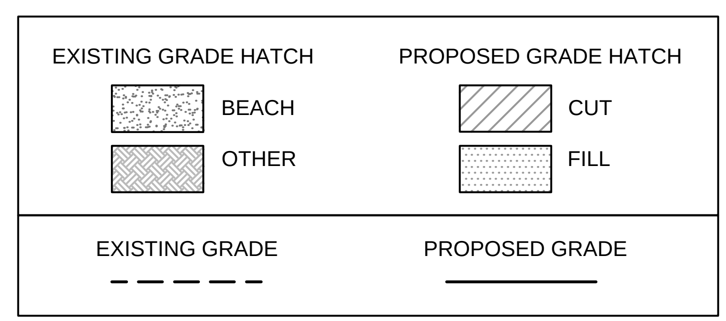
Figure 32-4

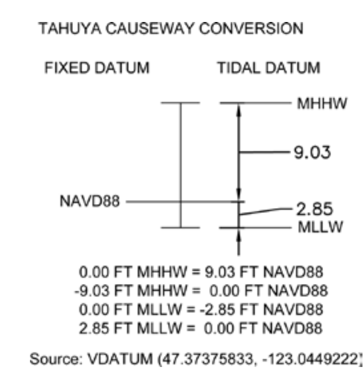


(A) FULL RESTORATION TYPICAL SECTION



(B) FULL RESTORATION TYPICAL SECTION





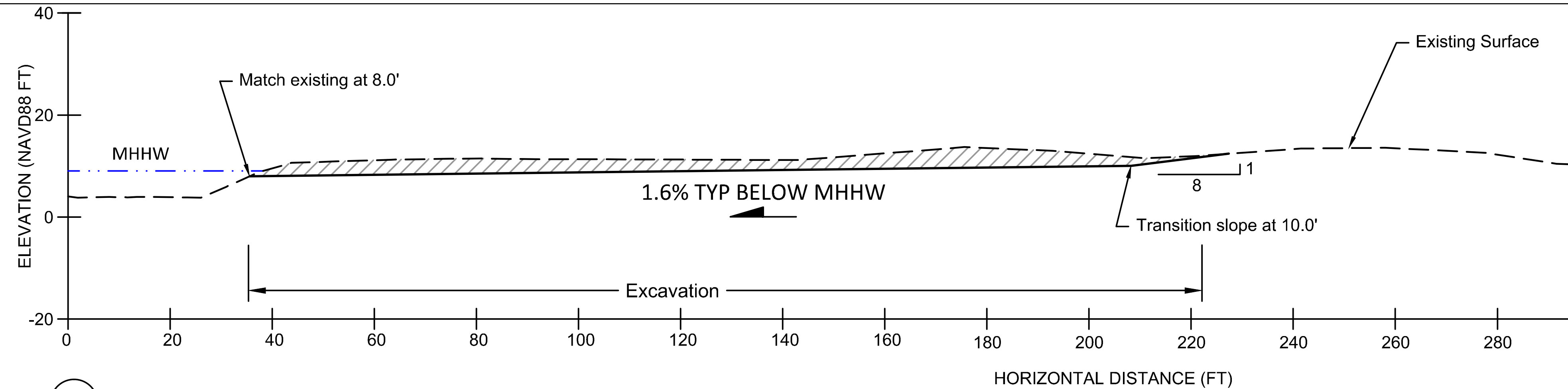
PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: Anchor QEA, J. Small
Date: 05/2012

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Section
SITE NAME: **Tahuya River Estuary**
ACTION NAME: **Tahuya Causeway Replacement and Estuary Restoration**
PSNERP ID#: **1404**
Full Restoration

Figure 32-5



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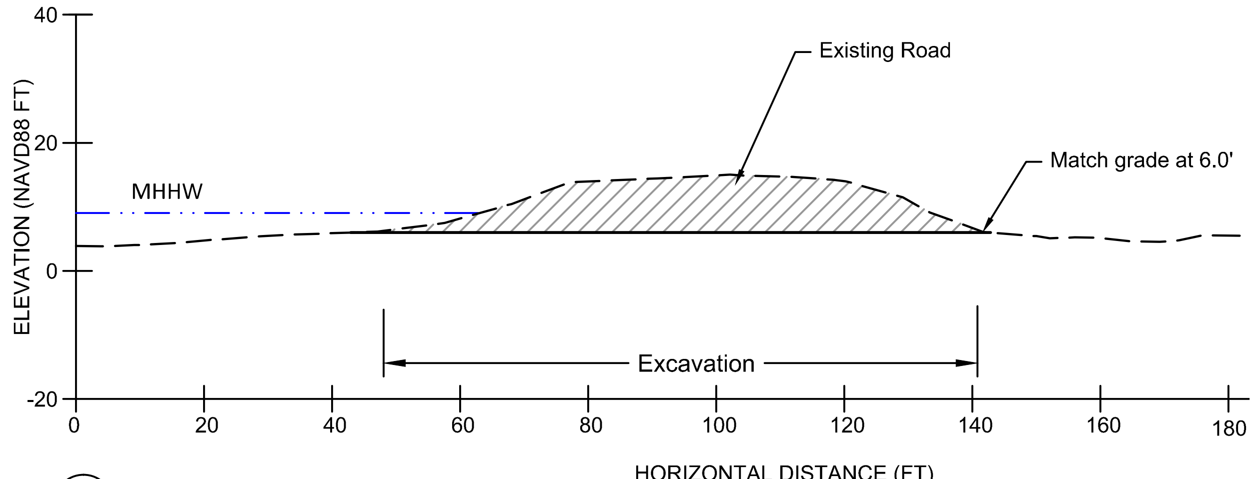
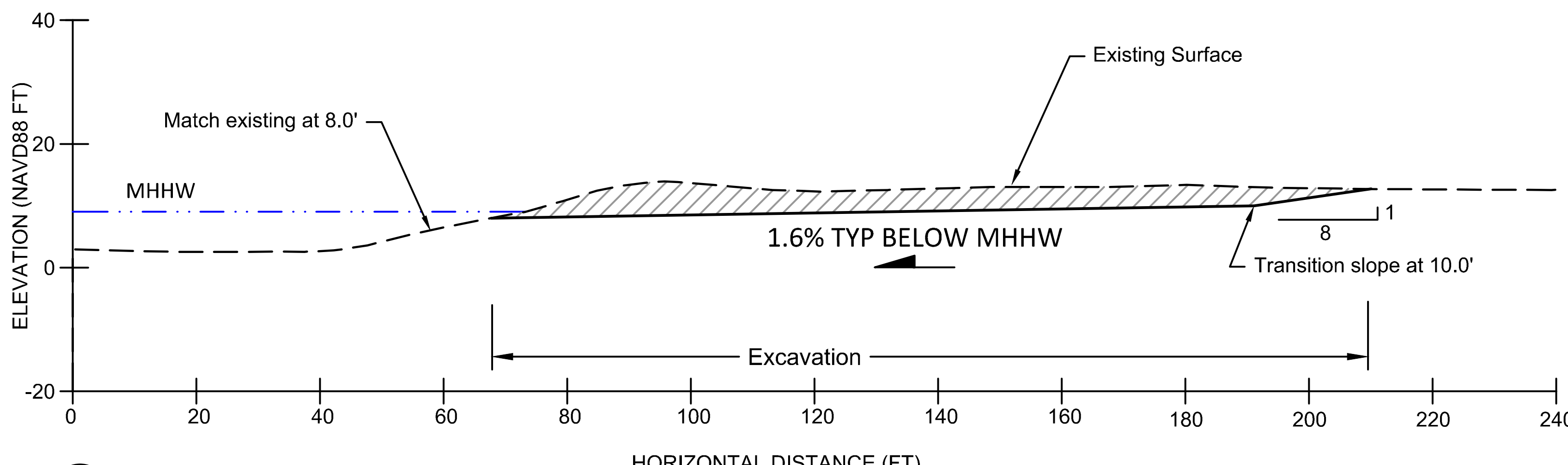
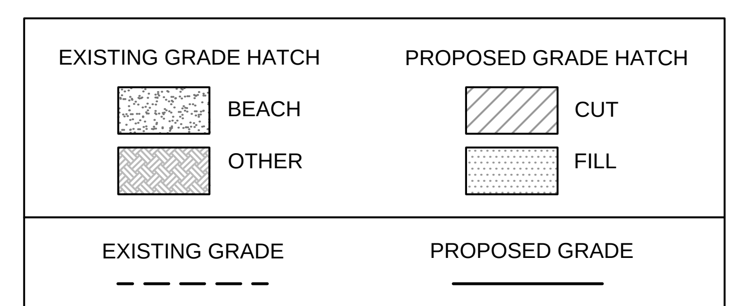
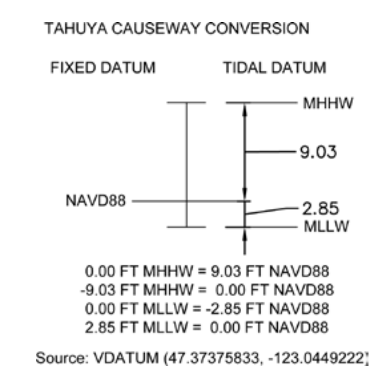


D FULL RESTORATION TYPICAL SECTION



E FULL RESTORATION TYPICAL SECTION





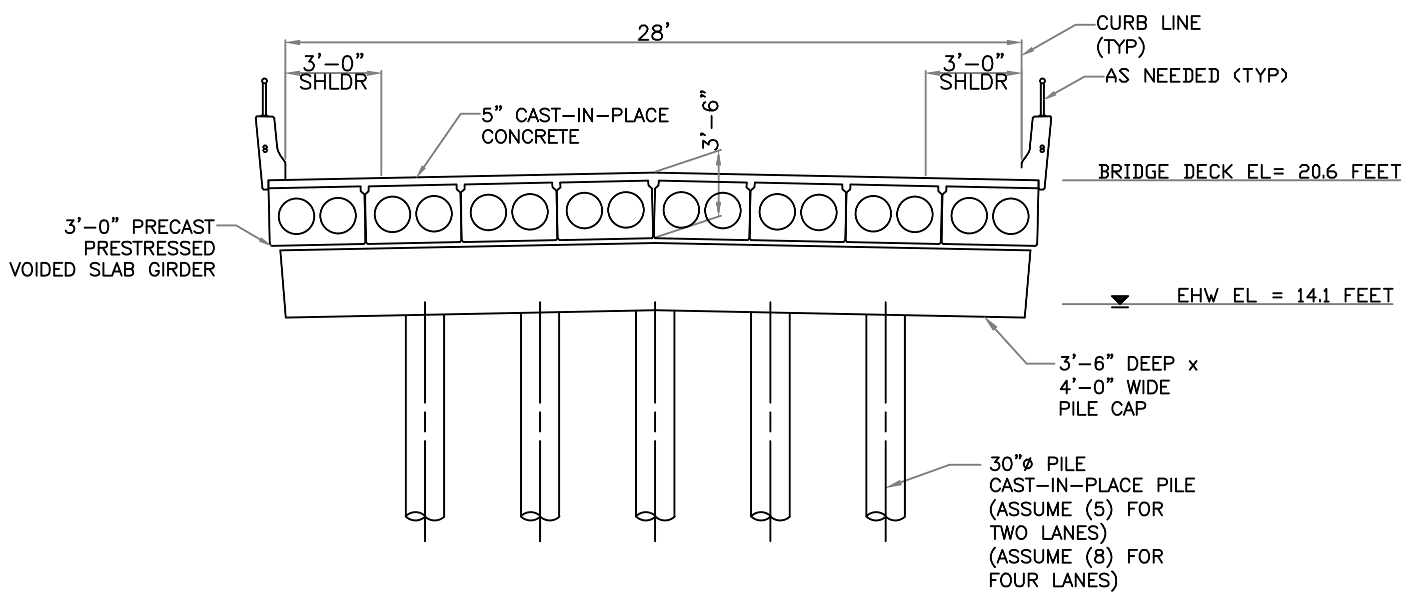
PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

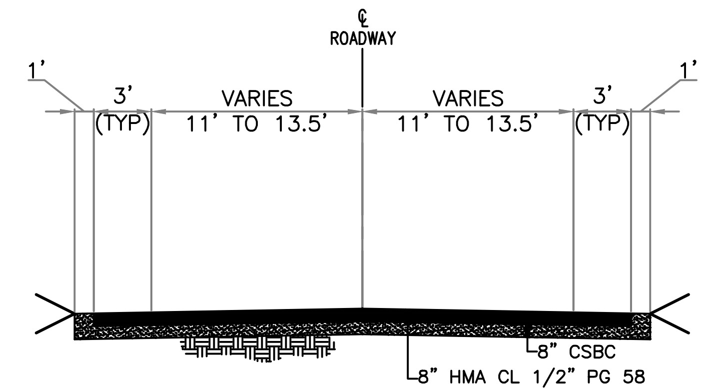
Lead Contractor: ESA
Design Lead: Anchor QEA, J. Small
Date: 05/2012

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Section
SITE NAME: **Tahuya River Estuary**
ACTION NAME: **Tahuya Causeway Replacement and Estuary Restoration**
PSNERP ID#: **1404**
Full Restoration

Figure 32-6



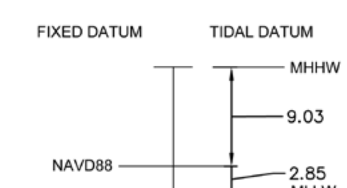


SECTION/DETAIL
Typical Roadway
Not to Scale
Section Provided by KPFF

NOTE: 90' SPAN (FULL RESTORATION)
80' SPAN (PARTIAL RESTORATION)
EXTREME HIGH WATER (EHW) = EL 14.1

SECTION/DETAIL
Typical Bridge
Not to Scale
Section Provided by KPFF

TAHUYA CAUSEWAY CONVERSION



0.00 FT MHHW = 9.03 FT NAVD88
-9.03 FT MHHW = 0.00 FT NAVD88
0.00 FT MLLW = -2.85 FT NAVD88
2.85 FT MLLW = 0.00 FT NAVD88

Source: VDATUM (47.37375833, -123.0449222)

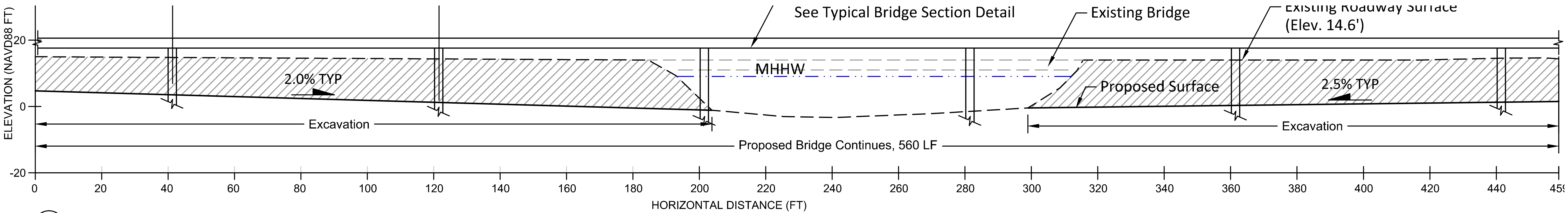
PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: Anchor QEA, J. Small
Date: 05/2012

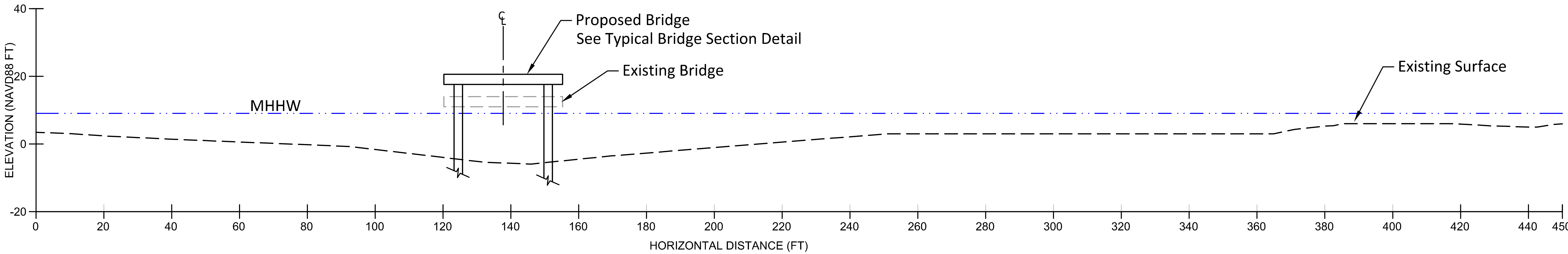
Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Section
SITE NAME: **Tahuya River Estuary**
ACTION NAME: **Tahuya Causeway Replacement and Estuary Restoration**
PSNERP ID#: **1404**
Full Restoration

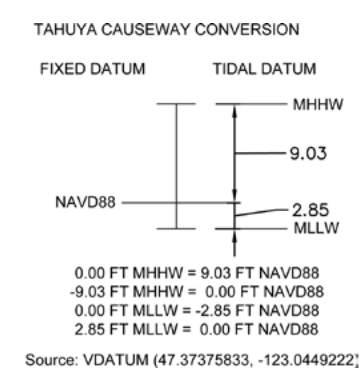
Figure 32-7



(A) FULL RESTORATION TYPICAL SECTION



(B) FULL RESTORATION TYPICAL SECTION



EXISTING GRADE HATCH		PROPOSED GRADE HATCH	
	BEACH		CUT
	OTHER		FILL
EXISTING GRADE		PROPOSED GRADE	

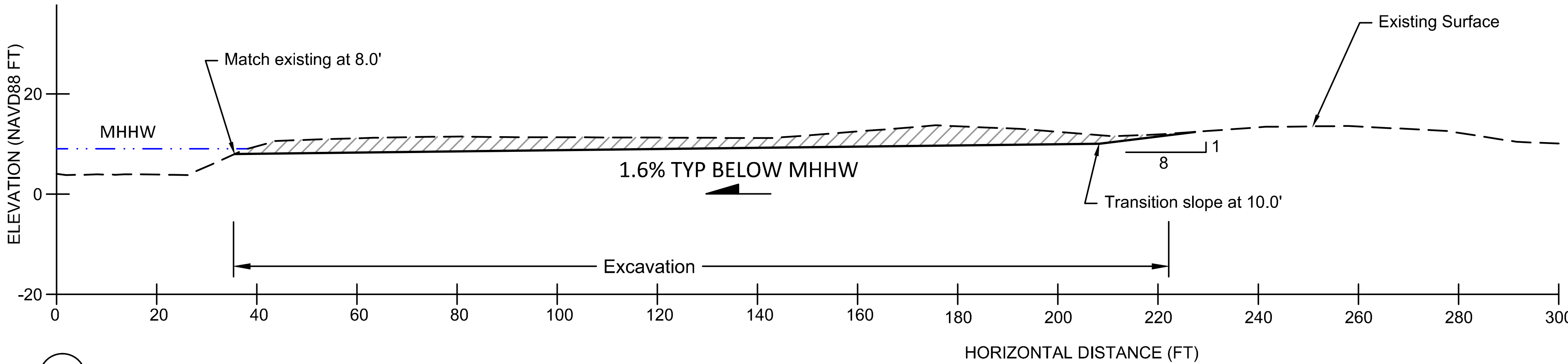
0 30
Scale in Feet

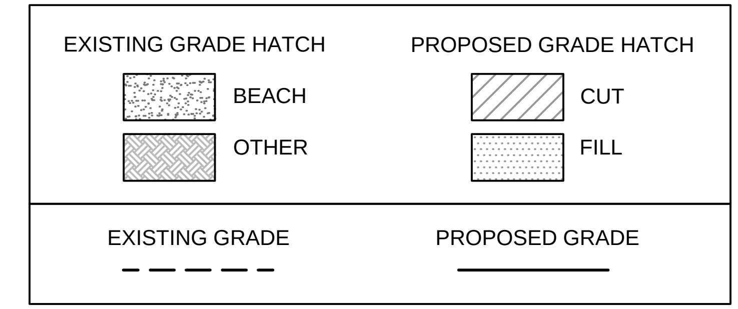
PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

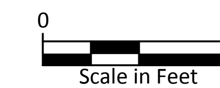
Lead Contractor: ESA
Design Lead: Anchor QEA, J. Small
Date: 05/2012

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

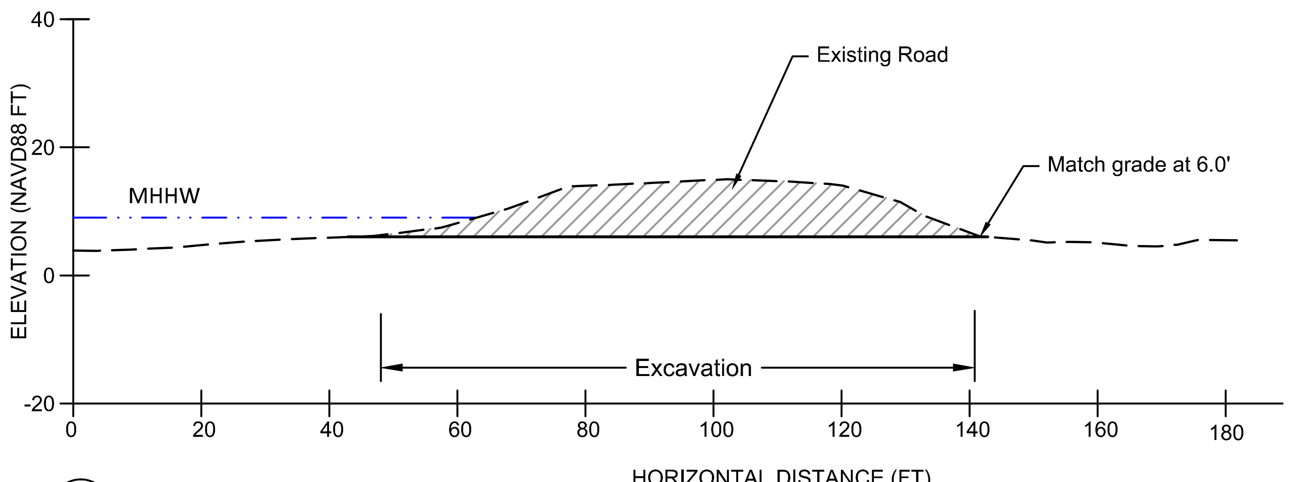
Conceptual Design Section
SITE NAME: **Tahuya River Estuary**
ACTION NAME: **Tahuya Causeway Replacement and Estuary Restoration**
PSNERP ID#: **1404**
Partial Restoration



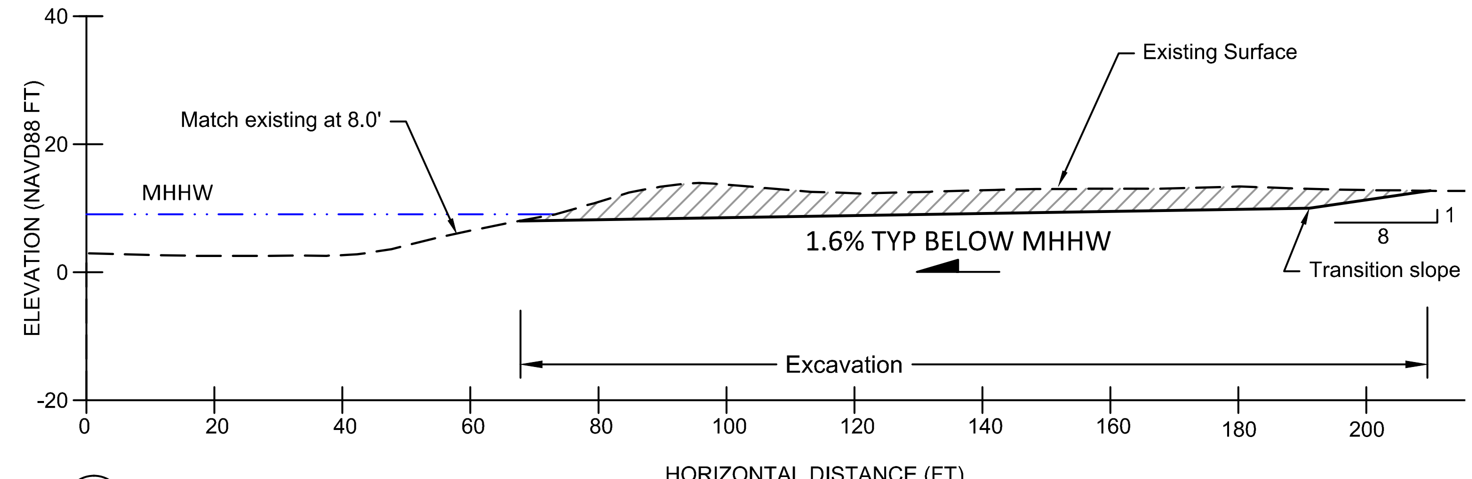




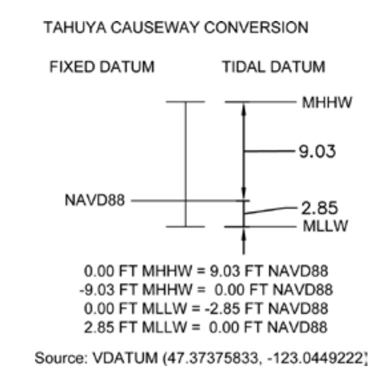
C PARTIAL RESTORATION TYPICAL SECTION



D PARTIAL RESTORATION TYPICAL SECTION



E PARTIAL RESTORATION TYPICAL SECTION



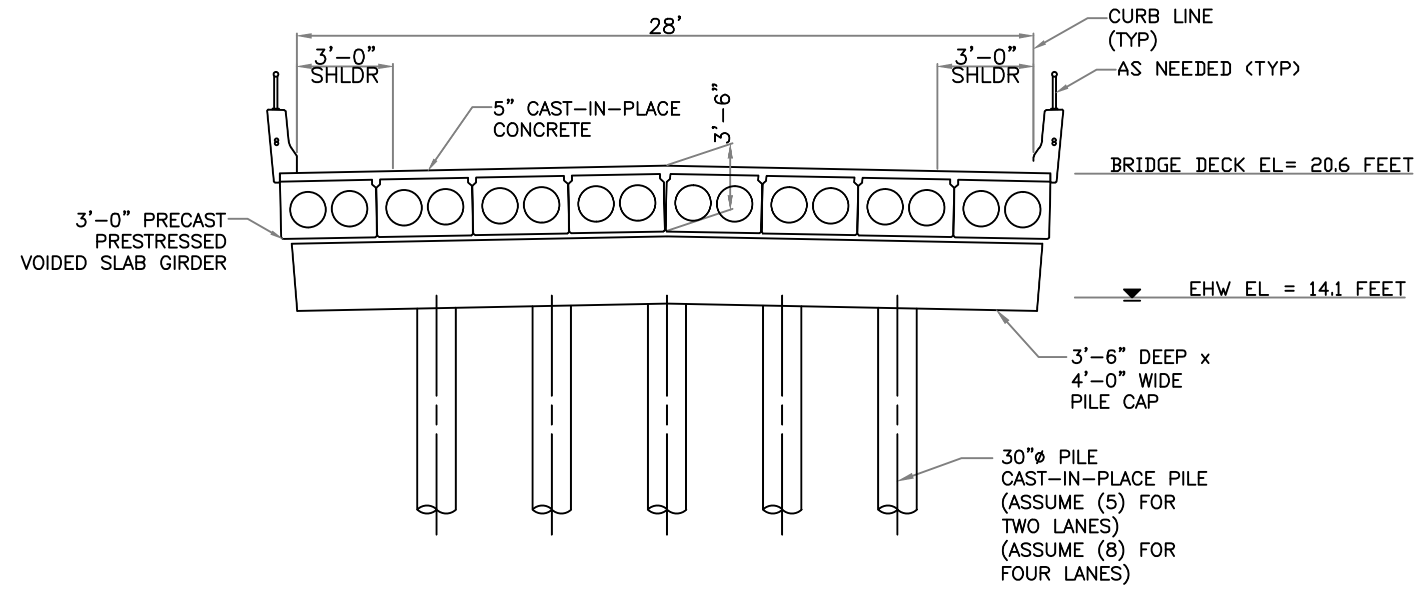
PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: Anchor QEA, J. Small
Date: 05/2012

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

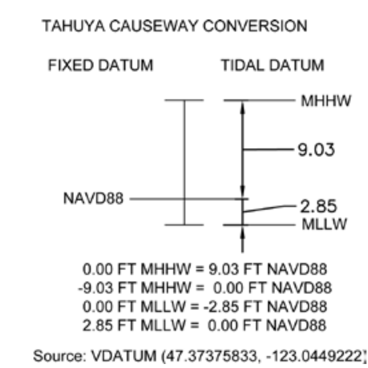
Conceptual Design Section
SITE NAME: **Tahuya River Estuary**
ACTION NAME: **Tahuya Causeway Replacement and Estuary Restoration**
PSNERP ID#: **1404**
Partial Restoration

Figure 32-9



NOTE: 90' SPAN (FULL RESTORATION)
80' SPAN (PARTIAL RESTORATION)
EXTREME HIGH WATER (EHW) = EL 14.1

SECTION/DETAIL
Typical Bridge
Not to Scale
Section Provided by KPFF



PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: Anchor QEA, J. Small
Date: 05/2012

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Section
SITE NAME: **Tahuya River Estuary**
ACTION NAME: **Tahuya Causeway Replacement and Estuary Restoration**
PSNERP ID#: **1404**
Partial Restoration

Figure 32-10

Full Restoration Quantity Estimate

Action Name:	Tahuya		
Action #:	1404		Revised May 2012
Date:	February 2011		Revised with backcheck updates: 25 July 2011
By:	John Small, Anchor QEA		

REMEDY: *Remove existing roadway embankment fill and helipad fill, build new road bridge*
Construction Period: 11 months

Item	Unit of Measure	Material Name	Qty	Description of Item	Indicate section of design report where item is described
ACQUISITION AND CONSERVATION				Based on available mapping information	
Required Project Lands	Acre		2.49	Total land required For action	32.3
Proponent / Partner-owned lands	Acre		NA	WDFW owns 10 acres downstream, WDNR land required for new ROW (equivalent existing ROW could be abandoned)	
Lands To Be Acquired	Acre		2.49	Estimate land required to be acquired for action prior to implementation	32.3
Material Sites				Not Used: See Earthwork - Imported Fill.	
MOBILIZATION AND ACCESS for construction activities				Description required for each item to facilitate cost estimating	
Mobilization - Typical (Equipment, Personnel, Planning, Financial)	LS		1	Up front costs such as bonding, planning and other staff time and financing. Typically, assume 8% to 10% of other items.	32.3
Mobilization - Remote (Equipment, Personnel, Planning, Financial)	LS		NA		
Site Access	LS		NA		
Barge Access	Days		1	Barge may be used at high tide to facilitate filling of scour hole.	32.3
Temporary Traffic Control (one of the following)				Includes installation of traffic signals, signage, signmen, etc. There are 4 types as follows:	
none	LS		NA		
signs	LS		NA		
flags / spotters	LS		NA		
unique	LS		1	Long term detour route around project area, include community outreach and communication	32.3
Temporary Roadway	SF		4000	Gravel access to private residence, 10' wide typ.	32.3
Control of Water	LS		NA		
Relocation Activities				Not Used: See Utilities, Structures	
Site Demolition Activities				Demolition and removal of structures (description required), temporary features and relocations, itemized separately); Clearing and grubbing of vegetation, and removal of minor debris (rocks, slabs) - description required.	
Clearing and Grubbing (one or more of following)				Use one or more of the following categories of clearing and grubbing	
Clear Vegetation - Local Disposal	AC		0.25	roadside vegetation, minimal	32.3
Clear /Grub Vegetation - Local Disposal	AC		NA		
Clear /Grub Vegetation - Offsite Disposal	AC		NA		
Clear, stockpile - large woody debris	CY		NA		
Hydraulic Structures - Small	LS		NA		
Hydraulic Structures - Large	LS		NA		
Overhead Power	LF		1400		32.3
Overhead Communication	LF		1400		32.3
Buried Fiber Optic	LF		1400		32.3
Buildings	LS or SF		NA		
Pavement	SF		27790	Remove Pavement	32.3
Bulkheads	LF		30	10 foot high wooden bulkhead (assume creosote)	32.3
Rock revetments	LF		210	Rock armor at bridge abutments. The existing armor is primarily light loose riprap (2 man and smaller) with some sack concrete. This armor is less than 6 feet high and does not extend very far beyond the bridge abutments.	32.3
Large Coastal Structures	LF, SF or CY		NA		
Demolition / Removal - Bridge	SF		6300	Remove 5 Span Concrete Bridge	32.3
Removal - Misc. (Electrical transformers on poles)	EA		3	Remove for reuse	32.3
Removal - buried debris	CY		158	Estimated area of removal 1' depth X 17,021 SF X 25% coverage (debris is scattered).	32.3
Demolition / Removal - in-water Piling	Number of Piles		24	Remove Concrete Piling	32.3
Demolition / Removal - in-water Piling	Number of Piles		30	Remove Derelict wood Piling	32.3
Haul - Offsite Disposal of Demolition Debris	Miles		30	Union, WA	32.3
Hazardous/Contaminated Waste Removal				These items for earthwork of quality not compatible with wetlands, requiring special handling and disposal. Describe basis for classification as contaminated or hazardous. State known or suspected contamination, describe known similar work.	
Contaminated Earthwork	CY		NA		
Hazardous Earthwork	CY		NA		
Construct Temporary Features				Use as needed for unusual temporary features not included elsewhere (see TESC below)	
EARTHWORK				Expand to include equipment, etc. to facilitate cost estimating.	
Excavation					
Excavation - Upland	CY		NA		32.3
Excavation - Lowland	CY		26100	Amount includes 4,525 CY (north side ex) + 9,550 CY (north side bridge approach) + 12,025CY (south side	32.3
Dredging - Bucket - Land	CY		NA		
Dredging - Bucket - Marine	CY		NA		
Dredging - Hydraulic	CY		NA		
Fine Grading	AC		2.27	Small tolerance grading after rough grading.	32.3
Fill Placement - local borrow				This is additive to Earthwork -Excavation	
Side cast	CY		NA		
Haul - uncontrolled placement	CY		NA		
Haul, place, compact	CY		NA		
Stockpile - uncontrolled placement	CY		NA		
Stockpile - controlled placement	CY		NA		
Conveyor placement from stockpile land/water	CY		8444	Placement only: to fill scour hole under existing bridge, may be facilitated by use of barge at high tide.	32.3
Imported Fill				Includes purchase, delivery and placement or as noted / described	
Select Fill	CY		NA		
Gravel Borrow, including haul	CY		NA		
Sand / Gravel for Beach Nourishment	CY		NA		
Cobble for Shore Nourishment	CY		NA		
Embankment Compaction	CY		NA		
Topsoil	CY		1499	Planting areas (except existing beach)	32.3
RESTORATION Features					
Channel Rehab / Creation	SF		NA		
Large Wood Placement	EA		NA		
Invasive Species Control	Acre		NA		
Physical Exclusion Devices	SF		NA		
Other Restoration Features/ Activities	LS		NA		
Structures	EA				
Water Control Structures - Culverts with Gates	EA		NA		
Water Control Structures - Weirs	EA		NA		
Rock Slope Protection	LF		NA		
Other	EA		NA		
Elevated Boat Ramp	SF		NA		
Fencing	SF		NA		
Utilities				Replacement or relocation. Designer to provide size and material and have separate line item for each run. Incidentals include earthwork, testing, hook up fees, etc. These quantities do not include demolition of existing utilities, real estate / easements, design fees. Describe the owner if known, and whether utility franchise will install (e.g.. electric is typically installed by electrical franchise).	
Water	LF		NA		
Gas	LF		NA		
Electric	LF		1400	Overhead: replace poles with towers at new bridge	32.3
Reinstall existing transformers	LS		1		32.3
Telecommunications	LF		1400	Overhead	32.3
Telecommunications	LF		1400	Buried	32.3
Roadway / Railway					
Roadway	SF		27790	Typical roadway varies between 11' wide and 13'-6' wide. Approximately 750 linear feet of guardrail will be needed.	32.3
Roadway - Minor Intersections	SF		5049	Minor Intersection at NE Belfair Tahuya Rd	32.3

Full Restoration Quantity Estimate

	Action Name:	Tahuya					
	Action #:	1404		Revised May 2012			
	Date:	February 2011		Revised with backcheck updates: 25 July 2011			
	By:	John Small, Anchor QEA					
	Culvert (type)	LF		NA			
	Culvert - Horizontal Pile Driving	LF		NA			
	Bridge - Deck	SF		21000	Voided girder slab precast prestressed girders with 90' Spans		32.3
	Bridge - Foundation	LF		252	(9) CIP concrete pile caps w/ (5) 30' CIP concrete piles 100' embedment each cap		32.3
	Railway - Foundation	LF		NA			
	Railway - Shoe fly	LF		NA			
Permanent Access Features							
	Utility Access Routes	varies		1	Private drive connection		32.3
	Erosion Control Features	L.F.		NA			
	Replacement Helipad	LS		NA			
	bridges	SF		NA			
	kiosk	EA		NA			
	restrooms	EA		NA			
	Interpretive Signs	EA		NA			
	parking area	SF		NA			
	Other	EA		NA			
Vegetation & Erosion Control							
	Hydroseeding	AC		0.5	Temporarily disturbed upland areas		32.3
	Planting	AC		2.27	Use 4" container stock - 2' O.C., some areas may be too low to plant in final grading.		32.3
	Vegetation Maintenance	AC-YR		2.27	weeding, plant replacement for one year		32.3
	Erosion / sediment BMPs - Temp.	AC		0.75	BMPs for control of drainage - describe. Assume compliance with Construction General NPDES included		32.3
	Erosion / sediment BMPs - Permanent	AC		NA			
	Waterside controls - Temporary	LF		2200	Silt fence, silt curtain or similar		32.3
Construction Management							
	Construction oversight	weeks		39	Quantity based on construction duration/ # of construction seasons		32.3
	Materials testing						
Design and Detailed Site Investigations							
	Survey & Property, Utility Research	LS		2	% of construction cost, including wetland delineation and OHWM delineation		32.8
	35% Design	LS		6.25	35% x 25% x Engineer's Estimate		32.8
	65% design	LS		6.25	65% x 25% x Engineer's Estimate less the cost for 35% PS&E		32.8
	90% design	LS		6.25	35% x 25% x Engineer's Estimate less the cost for 35% + 65%PS&E		32.8
	100% design	LS		6.25	25% x Engineer's Estimate less previous costs		32.8
	Geotechnical Studies			1	Refer to design report for description of need		32.8
	Cultural Studies			1	Refer to design report for description of need		32.8
	H&H Studies			1	Refer to design report for description of need		32.8
Project Agreement Activities					Unable to provide credible estimate at 10% design		
Site-Specific Adaptive Management Features & Activities					List if known		
Monitoring Activities					Assume 5 crew-days/year for each monitoring parameter in design report for 5 yrs		
	Monitoring (Type_)	crew-days		175			
Operations & Maintenance					Unable to provide credible estimate at 10% design		

Partial Restoration Quantity Estimate

Action Name: Tahuya
Action #: 1404 — Revised May 2012
Date: February 2011 — Revised with backcheck updates: 25 July 2011
By: John Small, Anchor QEA

REMEDY: ***Remove existing roadway embankment fill and helipad fill, build new road bridge***
Construction Period: 9 months

Item	Unit of Measure	Material Name	Qty	Description of Item	Indicate section of design report where item is described
ACQUISITION AND CONSERVATION				Based on available mapping information	
Required Project Lands	Acre		2.49	Total land required For action	32.3
Proponent / Partner-owned lands	Acre		NA	WDFW owns 10 acres downstream, WDNR land required for new ROW (equivalent existing ROW could be abandoned)	
Lands To Be Acquired	Acre		2.49	Estimate land required to be acquired for action prior to implementation	32.3
Material Sites				Not Used: See Earthwork - Imported Fill.	
MOBILIZATION AND ACCESS for construction activities				Description required for each item to facilitate cost estimating	
Mobilization - Typical (Equipment, Personnel, Planning, Financial)	LS		1	Up front costs such as bonding, planning and other staff time and financing. Typically, assume 8% to 10% of other items.	32.3
Mobilization - Remote (Equipment, Personnel, Planning, Financial)	LS		NA	Up front cost for nontypical or remote locations. Assume 12% of other items	
Site Access	LS		NA		
Barge Access	Days		NA		
Temporary Traffic Control (one of the following)					
none	LS		NA		
signs	LS		NA		
flags / spotters	LS		NA		
unique	LS		1	Long term detour route around project area, include community outreach and communication	32.3
Temporary Roadway	SF		4000	Gravel access to private residence 10' wide typ.	32.3
Control of Water	LS		NA		
Relocation Activities				Not Used: See Utilities, Structures	
Site Demolition Activities				Demolition and removal of structures (description required), temporary features and relocations, itemized separately); Clearing and grubbing of vegetation, and removal of minor debris (rocks, slabs) - description required.	
Clearing and Grubbing (one or more of following)				Use one or more of the following categories of clearing and grubbing	
Clear Vegetation - Local Disposal	AC		0.25	roadside vegetation, minimal	32.3
Clear /Grub Vegetation - Local Disposal	AC		NA		
Clear /Grub Vegetation - Offsite Disposal	AC		NA		
Clear, stockpile - large woody debris	CY		NA		
Hydraulic Structures - Small	LS		NA		
Hydraulic Structures - Large	LS		NA		
Overhead Power	LF		900		32.3
Overhead Communication	LF		900		32.3
Buried Fiber Optic	LF		900		32.3
Buildings	LS or SF		NA		
Pavement	SF		14000	Remove Pavement	32.3
Bulkheads	LF		30	10 foot high wooden bulkhead (assume creosote)	32.3
Rock revetments	LF		210	Rock armor at bridge abutments. The existing armor is primarily light loose riprap (2 man and smaller) with some sack concrete. This armor is less than 6 feet high and does not extend very far beyond the bridge abutments.	32.3
Large Coastal Structures	LF, SF or CY		NA		
Demolition / Removal - Bridge	SF		6300	Remove 5 Span Concrete Bridge	32.3
Removal - Misc. (Electrical transformers on poles)	EA		3	Remove for reuse	32.3
Removal - buried debris	CY		158	Estimated area of removal 1' depth X 17,021 SF X 25% coverage (debris is scattered).	32.3
Demolition / Removal - in-water Piling	Number of Piles		24	Remove Concrete Piling	32.3
Demolition / Removal - in-water Piling	Number of Piles		30	Remove Derelict wood Piling	32.3
Haul - Offsite Disposal of Demolition Debris	Miles		30	Union, WA	32.3
Hazardous/Contaminated Waste Removal				These items for earthwork of quality not compatible with wetlands, requiring special handling and disposal. Describe basis for classification as contaminated or hazardous. State known or suspected contamination, describe known similar work.	
Contaminated Earthwork	CY		NA		
Hazardous Earthwork	CY		NA		
Construct Temporary Features				Use as needed for unusual temporary features not included elsewhere (see TESC below)	
EARTHWORK				Expand to include equipment, etc. to facilitate cost estimating.	
Excavation					
Excavation - Upland	CY		NA		32.3
Excavation - Lowland	CY		21320	Amount includes 4,525 CY (north side ex) + 4,770 CY (north side bridge approach) + 12,025CY (south side	32.3
Dredging - Bucket - Land	CY		NA		
Dredging - Bucket - Marine	CY		NA		
Dredging - Hydraulic	CY		NA		
Fine Grading	AC		1.85	Small tolerance grading after rough grading.	32.3
Fill Placement - local borrow				This is additive to Earthwork -Excavation	
Side cast	CY		NA		
Haul - uncontrolled placement	CY		NA		
Haul, place, compact	CY		NA		
Stockpile - uncontrolled placement	CY		NA		
Stockpile - controlled placement	CY		NA		
Conveyor placement from stockpile land/water	CY		2098	Placement only: to fill scour hole under existing bridge, may be facilitated by use of barge at high tide.	32.3
Imported Fill				Includes purchase, delivery and placement or as noted / described	
Select Fill	CY		0	Material only: to fill scour hole under existing bridge	
Gravel Borrow, including haul	CY		NA		
Sand / Gravel for Beach Nourishment	CY		NA		
Cobble for Shore Nourishment	CY		NA		
Embankment Compaction	CY		NA		
Topsoil	CY		210	Planting areas (except existing beach)	32.3
RESTORATION Features					
Channel Rehab / Creation	SF		NA		
Large Wood Placement	EA		NA		
Invasive Species Control	Acre		NA		
Physical Exclusion Devices	SF		NA		
Other Restoration Features/ Activities	LS		NA		
Structures	EA				
Water Control Structures - Culverts with Gates	EA		NA	Describe type, number of openings (e.g. pipes), expected materials, dimensions	
Water Control Structures - Weirs	EA		NA	Describe, length, type, anticipated materials	
Rock Slope Protection	LF		NA	Describe slope, rock size, layering, use of fabric, back up quantities per foot.	
Other	EA		NA	Describe	
Elevated Boat Ramp	SF		NA	Pile or pier supported to allow sediment drift	
Fencing	SF		NA	Describe, type, height etc.	
Utilities				Replacement or relocation. Designer to provide size and material and have separate line item for each run. Incidentals include earthwork, testing, hook up fees, etc. These quantities do not include demolition of existing utilities, real estate / easements, design fees. Describe the owner if known, and whether utility franchise will install (e.g.. electric is typically installed by electrical franchise).	
Water	LF		NA		
Gas	LF		NA		
Electric	LF		900	Overhead: replace poles with towers at new bridge	32.3
Reinstall existing transformers	LS		1		32.3
Telecommunications	LF		900	Overhead	32.3
Telecommunications	LF		900	Buried	32.3
Roadway / Railway					

Partial Restoration Quantity Estimate

	Action Name:	Tahuya					
	Action #:	1404		Revised May 2012			
	Date:	February 2011		Revised with backcheck updates: 25 July 2011			
	By:	John Small, Anchor QEA					
	Roadway	SF		14000	Typical Roadway Varies Between 11' wide and 13'-6" Wide. Approximately 550 linear feet of guardrail should be needed.		32.3
	Roadway - Minor Intersections	SF		0	Minor Intersection at NE Belfair Tahuya Rd		
	Culvert (type)	LF		NA			
	Culvert - Jacking	LF		NA			
	Culvert - Horizontal Pile Driving	LF		NA			
	Bridge - Deck	SF		16800	Voided girder slab precast prestressed girders with 90' Spans		32.3
	Bridge - Foundation	LF		224	(9) CIP Concrete Pile Caps w/ (5) 30" CIP Concrete Piles 100' Embedment Each Cap		32.3
	Railway - Foundation	LF		NA			
	Railway - Shoe fly	LF		NA			
Permanent Access Features							
	Roads	Level	1	1	Private Drive Connection		32.3
	Utility Access Routes	varies		NA			
	Erosion Control Features	L.F.		NA			
	Replacement Helipad	LS		NA			
Public Access or Recreation Features							
	Trails	SF		NA			
	Bridges	SF		NA			
	Kiosk	EA		NA			
	Restrooms	EA		NA			
	Interpretive Signs	EA		NA			
	Parking Area	SF		NA			
	Other	EA		NA			
Vegetation & Erosion Control							
	Hydroseeding	AC		0.5	Temporarily disturbed upland areas		32.3
	Planting	AC		1.15	Use 4" container stock - 2' O.C., some areas may be too low to plant in final grading.		32.3
	Vegetation Maintenance	AC-YR		1.15	weeding, plant replacement for one year		32.3
	Erosion / sediment BMPs - Temp.	AC		0.32	BMPs for control of drainage - describe. Assume compliance with Construction General NPDES included		32.3
	Erosion / sediment BMPs - Permanent	AC		NA			
	Waterside controls - Temporary	LF		3200	Silt fence, silt curtain or similar		32.3
Construction Management							
	Construction oversight	weeks		48	Quantity based on construction duration/ # of construction seasons		32.3
	Materials testing			NA			
Design and Detailed Site Investigations							
	Survey & Property, Utility Research	LS		2	% of construction cost, including wetland delineation and OHWM delineation		32.8
	35% Design	LS		6.25	35% x 25% x Engineer's Estimate		32.8
	65% design	LS		6.25	65% x 25% x Engineer's Estimate less the cost for 35% PS&E		32.8
	90% design	LS		6.25	35% x 25% x Engineer's Estimate less the cost for 35% + 65%PS&E		32.8
	100% design	LS		6.25	25% x Engineer's Estimate less previous costs		32.8
	Geotechnical Studies			1	Refer to design report for description of need		32.8
	Cultural Studies			1	Refer to design report for description of need		32.8
	H&H Studies			1	Refer to design report for description of need		32.8
Project Agreement Activities					Unable to provide credible estimate at 10% design		
Site-Specific Adaptive Management Features & Activities					List if known		
Monitoring Activities					Assume 5 crew-days/year for each monitoring parameter in design report for 5 yrs		
	Monitoring (Type)	crew-days		175			
Operations & Maintenance					Unable to provide credible estimate at 10% design		

33. TELEGRAPH SLOUGH PHASE 1 AND 2 (#1633 AND 1635)

Local Proponent	Skagit River System Cooperative (Phase 1) Skagit Watershed Council (Phase 2) Washington Department of Fish and Wildlife (Phase 2)
Delta Process Unit	Delta SKG
Shoreline Process Unit(s)	7165
Strategy(ies)	1 – River Delta
Restoration Objectives	Remove multiple dikes and tide gates to restore connectivity and diversity of tidal slough/distributary channel system; provide for natural sediment erosion/accretion processes in historic tidal marsh estuary; recreate estuarine marsh habitat and connectivity; restore freshwater inputs to lower salinity levels in Padilla Bay

33.1 Description of the Action

The proposed restoration would remove coastal and inland dikes, existing tide gates and culverts, and construct setback dikes and bridges. This action aims to restore tidal hydrology and channel-forming processes to historic distributary slough channels connecting Swinomish Channel to Padilla Bay, restore tidal hydrology to diked farmland that was historically estuarine marsh, and increase freshwater inputs to Padilla Bay. The degree to which the latter objective is achieved may depend partly on whether other actions, specifically the McGlinn Island Causeway Action (#1092), are implemented. Please see the Introduction chapter for important information regarding PSNERP and for context related to this restoration project.

33.2 Action Area Description and Context

The 1,240-acre action area, in the Whidbey Subbasin of Puget Sound, is bounded by Padilla Bay on the north, Telegraph Slough on the east and south, and the Swinomish Channel on the west. The Swinomish Channel is a federally maintained navigation channel. Major regional transportation and utility infrastructure bisects the action area in an east/west direction. Tidal influence at Telegraph Slough is limited to the portion north of State Route 20. South of this highway, Telegraph Slough and three other distributary channels to the west are blocked by the BNSF railroad and State Route 20. In addition, the lands north and south of State Route 20 within the action area are protected by dikes bordering Padilla Bay, the Swinomish Channel, and the portion of Telegraph Slough north of State Route 20. A series of tide gates drains the south portion of Telegraph Slough to the Swinomish Channel. Most of the land outside public road rights-of-way is private and in agricultural use. In addition, a commercial marina and dry stack boat storage facility (Twin Bridges Marina) is located in the northwest portion of the action area bordering the Swinomish Slough and the north side of State Route 20. The action area is shown in Figure 33-1.

Figure 33-1. Action Area and Vicinity

33.2.1 Historic Condition

Review of the 1886 topographic sheet (T-sheet) and proponent's descriptions (Hinton 2010; Warriner 2010) shows that an extensive distributary and blind channel system connected to the North Fork Skagit River and emptied into Padilla Bay (Figures 33-2A and 33-2B). The main distributary channel split into four main distributary slough channels approximately 1.5 miles south of the current diked shoreline of Padilla Bay. The two largest distributary channels were the centrally located Swinomish Slough and Telegraph Slough on the east.

An extensive network of distributary channels and blind tidal channels drained a large historic salt marsh estuary and provided tidal hydrology and freshwater input. This marsh was approximately 2 miles wide (east to west) by 1.5 miles long (north to south) in 1886. In addition, extensive mudflats and eelgrass beds were presumed to exist, and still exist, to the north of this historic marsh in Padilla Bay. However, the T-sheet shows extensive modifications of the area south and east of this salt marsh, indicating diking and agriculture in 1886. Therefore, the full extent of the historic estuary habitat between Padilla Bay and North Fork Skagit River is not shown on the 1886 T-sheet, and is expected to have covered a much larger area.

Beginning in the 1860s, and continuing into the early 1900s (exact date unknown), the estuary was reclaimed for agricultural use through the installation of approximately 3 miles of tidal dikes along the Padilla Bay shoreline (north of the State Route 20 causeway), and about 2 miles of riverine dikes along the east side of the Swinomish Channel. The U.S. Army Corps of Engineers fully converted the Swinomish Channel from a natural slough to an 11-mile-long dredged navigation channel in 1937 (Historylink.org 2004). It is unclear how this channel construction affected tidal inundation of Telegraph Slough.

Construction of State Route 20 in the early 1970s severed the tidal connection between the north and south portions of Telegraph Slough (WDFW 2010). Other modifications along the State Route 20 alignment at Telegraph Slough include the installation of a railroad and various utilities (date of installation unknown). These actions, combined with diking along the west side of the Swinomish Channel, effectively isolated approximately 7 miles of former salt marsh distributary channels within the action area from combined tidal and freshwater flows. Associated salmonid rearing habitats were also lost.

33.2.2 Natural Environment

The historic tidal marsh area east of the Swinomish Channel and south of State Route 20 is mostly in agricultural use, with a few farmhouses near the highway frontage. Remnant estuarine marsh channels south of State Route 20 and west of Telegraph Slough (those not filled or otherwise modified) now exhibit mostly freshwater habitats and contain emergent and scrub-shrub vegetation communities. However, the portion of Telegraph Slough adjoining State Route 20 on the south side has a well-developed salt marsh plant community in the channel bottom. It is possible that this vegetation is supported by seepage under the highway and railroad and not via this culvert.

The upstream (southern) portion of Telegraph Slough has freshwater characteristics east of the tide gates. Some sections of the historic Swinomish Slough channel also remain as open water habitat (e.g., oxbow channel on east side of the Swinomish Channel dike). The presence of invasive species such as reed canarygrass was also noted during the site investigation.

On the north side of the State Route 20 highway and frontage road, the primary land use is a commercial poplar plantation, which generally extends north to the tidal dike. Three historic slough distributary channels west of Telegraph Slough and east of the Swinomish Channel also exist, but they lack tidal connectivity and are used as agricultural drainage channels. The westerly channel is blocked by a tide dike at the north end and by State Route 20. The central channel appears to terminate at State Route 20, and was historically connected to the westerly channel in the vicinity of State Route 20. The easterly channel has a tide gate through the tidal dike and is blocked by State Route 20. The main Telegraph Slough channel north of State Route 20 is open to tidal exchange and has primarily tidal mudflat habitat, with some smaller areas of salt marsh fringe.

Only very limited connectivity currently exists between Telegraph Slough and the Swinomish Channel. Based on site observations, that connectivity is through a series of five large culverts (with conventional flap-type tide gates) located within the Swinomish Channel east dike near the upstream (south) end of Telegraph Slough.

Sediment characteristics are not fully known, but based on available soils mapping and site observations, surficial soils are expected to consist primarily of sands, silts, and clays (closest to the marine environment). The predominant surficial soil types are Sumas silt loam, located primarily in the higher elevation (farmed) areas of the slough, and Tacoma silt loam (drained and undrained), located in the poplar plantation area and along the remnant tidal marsh channels (NRCS 2009).

Based on available LiDAR mapping (USGS et al. 2006), the elevations of Telegraph Slough marsh/agriculture fields south of State Route 20 typically range between approximately 4 and 7 feet NAVD 88, with some hummock areas up to approximately 9 feet NAVD 88. However, the elevations of the Telegraph Slough channel and other historic distributary channels are 1 to 3 feet NAVD 88 south of State Route 20.

North of State Route 20, LiDAR data show that marsh/agriculture field elevations protected by tidal dikes range between approximately 0 and 6 feet NAVD 88. This area generally appears to have subsided several feet lower than the areas south of State Route 20 (or farm field areas south of State Route 20 have been filled above historic slough levels). Historic slough channels behind the tidal dikes north of State Route 20 are currently in the 0 to 4 feet NAVD 88 elevation range.

Telegraph Slough north of State Route 20 is considerably higher than the portion south of the highway. This may be because tidal hydrology and wave energy on this northern portion of the slough have allowed sediment to build up there, while the presence of State Route 20 has blocked the historic tidal and freshwater channel maintenance processes. It is also possible that the slough channel south of State Route 20 has subsided.

Top of dike elevations range between approximately 12 and 15 feet NAVD 88. The State Route 20 road surface elevations east of the Swinomish Channel bridge are typically lower, ranging from approximately 9 to 12 feet NAVD 88.

33.2.3 Human Environment

The primary anthropogenic features within the action area include:

- State Route 20, a divided four-lane highway, and associated frontage roads.
- The BNSF railroad (on the north side of State Route 20).
- Major utilities such as a liquid petroleum pipeline and regional power, and waterlines along the highway and railroad corridor.
- Existing tidal and riverine dikes described above with access roads.
- A few residential and commercial structures associated with the farming activities and poplar plantation.
- Dike-protected agriculture.
- A marina and dry stack boat storage facility on the northeast side of the Swinomish Channel and State Route 20 bridge.
- The gated culverts (tide gates) connecting Telegraph Slough to the Swinomish Channel (through the east dike) at the south limit of the slough.

Residential development also exists along the Swinomish Channel south of the tide gates and action area.

State Route 20 (WSDOT designation R1) within the action area is a four-lane divided highway. It serves as the only access from the mainland to Fidalgo Island and the north access point for Whidbey Island. It has a total roadway width in each direction of 28 feet, with a 60-foot median between the eastbound and westbound lanes.

Several regional utility lines were observed along both sides of State Route 20 during the site investigation. These include an overhead electrical transmission line corridor on the north side of State Route 20 and the BNSF railroad (assumed to be operated by Puget Sound Energy), and a liquid petroleum pipeline and water main on the south side of State Route 20. The water main was noted by the U.S. Army Corps of Engineers representative at the site investigation as being critical infrastructure for Whidbey Naval Air Station. All of these utilities are regional in nature, serving Anacortes and Whidbey Island and in most cases connecting to much larger areas. More detailed information on existing utilities and the need for utility relocations will be required to support subsequent design phases.

According to readily available information, three major private property ownerships exist within the Telegraph Slough action area: the Hsueh, Bell, and Nelson properties. The willingness of these property owners to support restoration or sell their property is mixed (Warinner 2010). Property acquisition or conservation agreements would be required to implement this action. In addition, agreements with WSDOT, the BNSF Railway, major utility providers, and the Whidbey Naval Air Station would be required to cross and modify that infrastructure. The marina and boat storage facility are owned and operated by Twin Bridges Marina. This business has not been contacted about any restoration actions affecting their property.

A 30-acre parcel owned by WDNR on Telegraph Slough south of State Route 20 is managed by the WDFW as the Telegraph Slough Unit of the 17,000-acre Skagit Wildlife Area. This portion of the action area is managed for waterfowl and wildlife hunting. It includes a small parking area accessible from the eastbound lanes of State Route 20 (WDFW 2010).

33.3 Restoration Design Concept

33.3.1 Restoration Overview and Key Design Assumptions

The restoration alternatives are illustrated in Figures 33-3 through 33-8. In general, there does not appear to be a significant difference between the proponent’s combined Phase 1 and 2 restoration projects and the PSNERP formulation for the full restoration alternative. The main difference is the addition of diked farmland on the north side of State Route 20 to the full restoration alternative. Therefore, it is recommended that the two separate actions (#1633 and 1635), representing the proponent’s Phases 1 and 2, should be combined into a single and expanded PSNERP action.

The full restoration alternative includes removal of most of the existing dikes along Telegraph Slough, Padilla Bay, and Swinomish Channel (east), removal of existing tide gates, and bridging of Telegraph Slough at the State Route 20 and BNSF railroad within the action area. This alternative would restore tidal hydrology to nearly all of the action area. A new setback dike along the east and south sides of Telegraph Slough, south of State Route 20 and connecting to the east Swinomish Channel dike, would provide containment of flood flows and extreme tides coming into the action area from the Swinomish Channel and flooding areas to the south and east.

The full restoration alternative also would raise State Route 20 and the railroad and install bridge structures to provide a hydraulic connection of Telegraph Slough to its historic limits. Removal of dikes necessitates raising the railroad to an elevation of 18.5 feet NAVD 88 to keep it above the limits of inundation and wave action. A new dike would be constructed north of the existing rail grade from a point east of Telegraph Slough west to the Swinomish Channel. The rail line would be relocated atop this dike. As the rail alignment approaches the existing swing bridge at the channel crossing, the rail line would transition off of the dike to the bridge, which is at an elevation of 15.0 feet NAVD 88. The dike would continue up to the abutment.

The roadway would also be raised throughout these limits to a minimum elevation of 17 feet NAVD 88 to protect the highway from inundation and provide adequate freeboard. The design water surface elevations are discussed in more detail below.

Culverts are proposed at two locations beneath State Route 20 (Sta. 209+50 and Sta. 236+00) to provide hydraulic connectivity to additional smaller tidal drainages. The westernmost culvert would be installed on a skew to provide connectivity to the historic channel to the south. The eastern culvert would be installed along the current alignment of the channel. The culverts could be installed using jack-and-bore methods and countersunk to provide a natural channel bed within the culvert.

Two additional culverts are proposed beneath the new setback dike to be constructed to the south. These culverts are proposed as 6-foot by 6-foot, pre-cast concrete box culverts and are needed to drain agricultural land south of the action area.

The full restoration alternative also includes relocation of major utility infrastructure to facilitate unconstrained tidal and freshwater inputs and connectivity between Padilla Bay and the Swinomish Channel. Full restoration would need to maintain a manageable but functional flow split between the Swinomish Channel and Telegraph Slough at their confluence. Installation of large culverts under State Route 20 and the BNSF railroad would reconnect the two additional historic tidal distributary channels west of Telegraph Slough to Padilla Bay. A third channel would be reconnected to the west distributary channel south of State Route 20 (Figure 33-3).

The partial restoration alternative would focus on restoring the connectivity and diversity of the tidal slough/distributary channel system between Swinomish Channel and Padilla Bay, via the Telegraph Slough channel. The partial alternative would not restore tidal processes to the area bracketed by HWY 20, Telegraph Slough, and Swinomish Slough. This alternative would require removal of existing tide gates and culverts at the Swinomish Channel east dike. It would also require construction of setback dikes along the south, east, and west sides of the Telegraph Slough channel connected to the east Swinomish Channel dike south of State Route 20. The partial alternative span over Telegraph Slough for HWY 20 and BNSF railroad would be approximately 340 feet shorter than the span for the full restoration alternative as it would tie into the proposed set back levee. This would provide a more limited tidal and freshwater connection between the Swinomish Channel and Padilla Bay (Figure 33-4).

Under the partial restoration alternative, the extent of roadway improvements would be limited because the coastal and inland dikes would remain and continue to protect the roadway and railroad. The highway and railroad would be raised only in the area of Telegraph Slough as necessary to provide a hydraulic connection to the slough. The bridges would be constructed at an elevation sufficient to provide clearance from the design water surface elevation. Imported fill would be placed on the approaches to the bridges to accommodate the revised grade.

No culverts are proposed beneath State Route 20 under the partial restoration alternative. The 6-foot by 6-foot pre-cast concrete box culverts at the south end of Telegraph Slough, however, are part of the partial restoration alternative.

The partial restoration alternative would not fully restore tidal hydrology to the entire action area, and would allow limited tidal and freshwater connectivity to the main Telegraph Slough channel. It would also result in a more limited hydraulic connection under BNSF railroad and State Route 20 due to the reduced tidal prism from the smaller restored area. This alternative would significantly reduce the amount of restored distributary channel habitat (compared with the full restoration alternative).

Design Water Surface Elevation

The design water surface elevation is based on the following assumptions. Mean tidal elevations within the estuary should not change significantly for either full or partial restoration alternative. However, storm tide elevations may increase slightly within the estuary due to removal of the tidal barrier. Predicted (astronomical) tides for this action area based on the Vdatum program (NOAA 2010) relative to the MLLW datum and to the fixed NAVD 88 datum are as follows:

	MLLW	NAVD 88
MHHW	8.39 feet	7.82 feet
MHW	7.62 feet	7.08 feet
MTL	5.06 feet	4.52 feet
MLW	2.50 feet	1.96 feet
MLLW	0.00 feet	-0.51 feet

The Skagit County Flood Insurance Study Draft Digital Flood Insurance Rate Map Update (FEMA 2010) reports the 100-year stillwater elevation (100-year flood frequency tide plus surge) for Padilla Bay to be elevation 11.3 feet NAVD 88. Wind wave setup from the north exposed fetch is not uncommon and can increase local sea level above the tidal elevation.

The FEMA study predicted 100-year tidal elevations including surge. The probability of that elevation coinciding with additional wind waves caused by north winds would be much more remote than once in 100 years. An additional 1.0 foot of elevation was added to account for the possibility of some wind waves caused by north winds occurring at the same time as the 100-year tide level (elevation 12.3 feet NAVD 88).

The future design water level, which takes into account estimated sea level change for the action area, is 1.5 feet higher than the existing conditions predicted level, or elevation 13.8 feet NAVD 88. This future predicted water level (with high sea level change scenario) was used for 10% design of the new Telegraph Slough bridges and restoration actions inside the estuary (e.g., marsh restoration).

For evaluation of the proposed railroad bridge under the full restoration alternative (where the existing tidal dike is proposed to be removed), an additional allowance of 2.5 feet was added to take into account the potential influence of wave run-up on the new railroad embankment (that could coincide with a large coastal flooding event). Therefore, the minimum required railroad replacement berm elevation under full restoration was estimated to be 16.3 feet NAVD 88. With an additional freeboard of 2.3 feet above that estimated wave runup design water surface, the top of rail dike design grade of 18.6 feet NAVD 88 was established.

The key design elements associated with full and partial restoration alternatives are shown in Table 33-1.

Table 33-1. Key Design Elements

Element	Full Restoration	Partial Restoration
State Route 20 and BNSF Railroad	Bridge Telegraph Slough at State Route 20 and BNSF railroad full channel width Raise State Route 20 and railroad west to Swinomish Channel bridges to address tidal dike removal and sea level change	Bridge Telegraph Slough at State Route 20 and BNSF railroad partial channel width Transition State Route 20 and railroad to existing grades east and west of bridges
Tidal and Riverine Dikes	Remove all tidal and riverine dikes in action area New setback dike for BNSF railroad, and along south and east sides of Telegraph Slough south of State Route 20 Raise State Route 20 above flood levels Plant portions of dike with riparian vegetation Dike removal will effectively restore approximately 780 acres to tidal influence	Dike removal at south end of Telegraph Slough/Swinomish Channel only New setback dikes on east, west, and south sides of Telegraph Slough south of State Route 20 Plant portions of dike with riparian vegetation Dike removal will effectively restore approximately 125 acres to tidal influence
Tidal Channels (including Telegraph Slough)	Reconnect Telegraph Slough and three distributary channels (west of Telegraph Slough) to Padilla Bay and tidal hydrology Approximately 15,200 LF of tidal channels restored including Telegraph Slough	Reconnect Telegraph Slough to Padilla Bay and tidal hydrology only; three distributary channels (west of Telegraph Slough) not included Approximately 5,200 LF of tidal channel restored at Telegraph Slough
Utility Relocations (Electrical, Communications, Water, and Petroleum)	Relocate all utilities at proposed Telegraph Slough bridge Relocate water and petroleum pipelines as needed west of the bridge and at bridge transition to the east	Same as full restoration

Element	Full Restoration	Partial Restoration
Private Lands and Structures	Acquire all private lands in action area and remove all residential and commercial structures.	Acquire private lands or easements needed for setback dikes and utilities, bridge, road, and railroad modifications No residential or commercial structure removal required
Channel Regrading	Excavate channel at proposed Telegraph Slough bridge and north and south to elevation 4 feet NAVD 88	Same as full restoration
Hydraulic Structures	Remove culverts and tide gates at south end of Telegraph Slough/Swinomish Channel Construct new culvert and tide gate in southeast portion of setback dike to convey drainage from two channels southeast of action area boundary Provide new connecting channel between these two existing channels Construct two culverts under State Route 20 and railroad to reconnect three distributary channels to Padilla Bay Construct channel to connect middle to west distributary channel	Remove culverts and tide gates at south end of Telegraph Slough/Swinomish Channel Construct new culvert and tide gate in southeast portion of setback dike to convey drainage from two channels southeast of action area boundary Provide new connecting channel between these two existing channels

33.3.2 Restoration Features – Primary Process-Based Management Measures

Armor Removal/Modification

Armor exists on portions of the dikes to be removed along the Swinomish Channel and along Padilla Bay. The shoreline around the Twin Bridges Marina also contains armor. For the full restoration option, all of this armor rock will be removed. There is no armor removal for the partial restoration alternative.

Berm or Dike Removal/Modification

Full restoration entails removal of all the tidal dikes on the north side of State Route 20 and the BNSF railroad, except for a short segment north of the proposed Telegraph Slough bridge. A new dike is proposed in conjunction with the new elevated railroad to address tidal flooding concerns with full restoration. In addition, State Route 20 would be raised between the proposed bridge and the existing bridge approach over the Swinomish Channel to address tidal flooding concerns. The entire dike along the Swinomish Channel would also be removed. New setback dikes are proposed to connect from the existing Swinomish Channel dike in the southwest corner of the action area, around the south and east sides of Telegraph Slough to State Route 20 (Figures 33-3 and 33-5).

For partial restoration, more limited dike removal is proposed at the south end of Telegraph Slough in conjunction with tide gate removal. Removal of the State Route 20 roadway and BNSF railroad berm is proposed at a shorter bridge across Telegraph Slough (Figures 33-4 and 33-6). Setback dikes would be constructed on the north, west, south, and east sides of Telegraph Slough in partial restoration to limit tidal hydrology to the channel itself.

Channel Rehabilitation/Creation

Channel rehabilitation would restore tidal hydrology to Telegraph Slough and three smaller distributary channels extending north to Padilla Bay with the full restoration alternative. A new channel is proposed to connect the centrally located restored distributary channel to the westernmost channel and a proposed culvert under State Route 20 and railroad (Figure 33-3). These two channels were historically connected in the vicinity of the current State Route 20. The *Applied Geomorphology Guidelines and Hierarchy of Openings* (Appendix C, Figure 8) were applied at the existing Telegraph Slough under State Route 20 to size the required breach opening cross section area, top width, and depth below MHHW.

For Telegraph Slough, fill and accumulated sediments would be removed at the proposed State Route 20 roadway and BNSF railroad bridge, and areas north and south of these bridges, to restore the slough channel, particularly north of the proposed bridges within the existing channel. Excavation to lower the grade in Telegraph Slough at this location is needed to allow for a full tidal connection to restored areas south of the bridge. The extent of excavation is substantial (approximately 75,000 CY) due to the amount of sediment buildup in this location as compared to channel elevations at the north and south ends of the slough.

Partial restoration would be limited to channel rehabilitation (excavation of sediment) of Telegraph Slough's main channel only (Figure 33-4).

Groin Removal/Modification - NA

Hydraulic Modification

Hydraulic modifications are required at the Telegraph Slough/Swinomish Channel confluence area where a series of culverts with tide gates would be removed. A hydraulic structure that controls the split of water between Telegraph Slough and Swinomish Slough may be needed at this location. The need for this type of structure and, if included in the project, its potential effect on sediment and hydrology will be determined in subsequent design phases. Southeast of that location, a new culvert and tide gate would be needed to pass drainage flows from two channels (connected by a new drainage channel) located on the south side of the proposed setback dike described above (Figures 33-3 and 33-4).

Removal of the State Route 20 and BNSF railroad fills from the historic Telegraph Slough channel would require new 680-foot-long bridges in full restoration and 340-foot-long bridges in partial restoration(Figures 33-5, 33-6 and 33-7) (See *Channel Rehabilitation/Creation* for removal of sediments in the Telegraph Slough channel). Construction of the bridges would provide a new hydraulic opening under both the full and partial restoration alternatives. The full restoration alternative would also restore hydraulic connectivity to three smaller distributary channels west of Telegraph Slough by installation of two 10-foot-diameter culverts. Two of the channels would be joined with a proposed connecting channel on the south side of State Route 20. The two culverts are proposed under State Route 20 and the BNSF railroad to convey and hydraulically connect these two distributary channels to Padilla Bay following tidal dike removal (Figures 33-3 and 33-4).

It is assumed in full restoration that three other small culverts and/or tide gates would be removed. Two culverts with tide gates would be removed as part of the Padilla Bay dike removal at the north end of two existing historic distributary channels. One additional culvert would also be removed under State Route 20 as part of the demolition and excavation to construct the new bridge. This culvert is small (8-inch diameter) and appears to convey only local drainage.

Overwater Structure Removal - NA

Topography Restoration

Full restoration would consist of placing soils from the dike removal activity in areas of low topography north of State Route 20 to raise grades outside of distributary channels. These areas would be raised to the target marsh plain elevations found in nearby reference sites. These elevations are assumed to be approximately 7.85 feet ± 1 foot (NAVD88), though further evaluation of design elevations in subsequent design phases will be necessary.

33.3.3 Restoration Features – Additional Management Measures

Beach Nourishment - NA

Contaminant Removal/Remediation - NA

Debris Removal - NA

Invasive Species Control

This management measure is expected to be a minor component of the restoration action. Invasive species in the action area consist primarily of reed canarygrass and cattails in south portions of Telegraph Slough and in the other former distributary channels to the west. These species, which currently inhabit areas dominated by fresh water, are anticipated to be eradicated by restoring tidal hydrology, which increases salinity, wave energy, and tidal prism. However, some strategic removal of these invasive species may be warranted to avoid large mats of displaced vegetation clogging restored channels. Invasive species control may also be needed on road or dike slopes where weedy upland species could become established.

Large Wood Placement - NA

Physical Exclusion - NA

Pollution Control - NA

Revegetation

Revegetation is anticipated to be a very limited effort for this restoration action. Revegetation would be limited primarily to dike and road embankments that would need to be vegetated with native species to protect them from erosion, and to inhibit establishment of invasive species. A combination of hydroseeding and limited live staking and bare root plantings would be used. Live stakes and bare root plantings of riparian species such as willows, red alder, and black hawthorne are anticipated toward the lower end of these embankments. These plantings would also diversify habitat for fish and wildlife and speed the restoration trajectory.

Reintroduction of Native Animals - NA

Substrate Modification - NA

Species Habitat Enhancement - NA

33.3.4 Restoration Features – Other

Continued access to the Skagit Wildlife Area on the south side of State Route 20 at Telegraph Slough is anticipated to be required by WDNR and WDFW. This access would include a spur road and small gravel parking area adjacent to the south side of State Route 20.

33.3.5 Land Requirements

Construction of this action will affect of 1,240 acres of land previously used for agricultural and commerical purposes. Land requirements include: (1) property acquisitions or conservation easement agreements with affected private property owners, and (2) agreements with WSDOT, BNSF Railway, and affected utility owners (see design considerations below).

The full restoration alternative is anticipated to necessitate the acquisition of 785 acres on 57 privately owned parcels. For the partial restoration alternative, conservation and construction easements are likely feasible to address dike and hydraulic structure facilities on private lands. This is because lands affected are not in active use for agriculture or commercial activities, but are primarily used for drainage. For the partial restoration alternative, conservation and construction easements are assumed necessary on 130 acres of private property on 19 parcels.

33.3.6 Design Considerations

Major Infrastructure Modifications

The proposed State Route 20 vehicle bridge for the full restoration alternative would be 680 feet long, with six spans of approximately 113 feet with 6-foot-6-inch-deep pre-cast concrete girders. The proposed State Route 20 vehicle bridge for the partial restoration alternative would be 340 feet long, with three spans of approximately 113 feet with 6-foot-6-inch-deep pre-cast concrete girders (Figure 33-8). The bridge substructure assumes columns supported on drilled shafts. The assumed embedment depth of the drilled shafts is 100 feet.

The proposed BNSF rail bridge for both the full and partial restoration alternatives would consist of 30-inch-deep pre-stressed box girders with bents spaced at 36 feet. Each concrete bent (pilecap) would be supported by four steel piles with an assumed embedment of 100 feet.

Substantial modifications to utility infrastructure (electrical transmission, petroleum pipeline, and water main, as well as possibly communication lines) would be required at the proposed Telegraph Slough bridge in both alternatives, and along the State Route 20/BNSF corridor west of the bridge in the full restoration alternative.

Running parallel to State Route 20 along the south side are a major water transmission line and a petroleum pipeline. The former serves as the primary supply to Whidbey Island and the naval station. The latter utility serves the oil refinery near Anacortes. Excavation proposed for both alternatives within the slough would necessitate the lowering of both pipelines to provide adequate cover. The sizes of these facilities are unknown, but the presumption is that service cannot be interrupted. The full restoration alternative would impact the utilities in a similar fashion where culverts would be installed.

Three aerial transmission lines are located on the north side of the railroad alignment. One is located between the highway and BNSF lines. Two are located along the north side of the railroad. Under the full restoration alternative, all three lines would be relocated to the north of the future rail alignment. The catenary wires would be raised to maintain adequate vertical clearance from the roadway and railroad, which would be higher in elevation. The electrical lines would cross over the BNSF tracks where the rail curves to the northwest, and connect to the existing lines along Josh Green Lane. Under the partial restoration alternative, only the lines to the north would be relocated to make way for the shoofly (a temporary railroad bypass structure). Upon completion of construction of the rail bridge, it is assumed that the lines would be relocated back to their original locations. All three transmission lines would be adjusted vertically adjacent to the elevated portions of the highway to maintain adequate vertical separation.

Approvals from transportation and utility infrastructure government and private entities including WSDOT, BNSF Railway, Puget Sound Energy, and petroleum pipeline and water main owners would be need to be obtained to modify or move these facilities.

Hydrology and Hydraulic Considerations

Hydrology and hydraulic considerations are of two types: (1) protecting infrastructure and adjacent properties from normal tidal high water and flooding, and (2) designing suitable conditions for the full restoration of tidal exchange in the restored slough channels. Additional considerations are the potential flow split between the Swinomish Channel and Telegraph Slough when the slough is opened, and the handling of offsite drainage at the southeast corner of the project area, where it would discharge into Telegraph Slough.

Ecological Considerations

The full restoration alternative proposes the maximum connectivity and diversity of restored habitat through significant dike removal and setback and infrastructure modifications. Process restoration effectiveness with full restoration would be achieved by restoring all historic distributary channels and all of the historic marsh plain within the action area, with the exception of the transportation infrastructure footprint. Full tidal hydrology, channel development, and sediment transport processes would be restored. Areas of subsidence north of State Route 20 are a consideration, given that sediment supply to these areas may not raise them sufficiently to historic marsh plain elevations.

The partial restoration alternative would result in significantly less connectivity of distributary channels (main Telegraph Slough channel only). The partial restoration alternative would lack a diverse assemblage of contributing habitat types, provide limited area for marsh habitat development, and lack channel complexity due to the dikes on both sides and separation from the three smaller historic distributary channels extending north.

33.3.7 Construction Considerations

Hauling and offsite disposal areas for excavated and demolished materials need to be identified during subsequent design phases, but are assumed to occur within 20 miles of the action area. However, due to the low topography of the area north of State Route 20, soils from the dike removal in full restoration could be used to raise grades outside of distributary channels. This approach would reduce offsite haul and disposal, and improve habitat restoration performance in subsided areas.

A staging and stockpile area for full restoration could be located at the Twin Bridges Marina. For partial restoration, the staging and stockpile area would be located outside of the action area. A suitable location would need to be identified during final design and prior to bidding.

Construction would include the phased removal of sections of existing dike, along with construction of new setback dikes, potentially over compressible soils. In general, all restoration improvements within existing dikes (e.g., railroad and road bridges and reconstruction work, setback dikes, etc.) should be completed within the initial phase of construction, prior to any dike breaches or removal of the existing tide gate at the Telegraph Slough/Swinomish Channel confluence to eliminate external water flow through the work areas (beyond work area runoff flow diversions and dewatering). The sequencing of dike removals (including the tidal dike) would need to be closely orchestrated to maintain acceptable flow control and required diversions between the Swinomish Channel and the restored Telegraph Slough marsh. Dike removals would need to be made progressively from points of upland access and in consideration of tidal elevations (work would need to be primarily accomplished during mid to low tide periods).

Vehicle Bridges

A drilled-shaft oscillator would be used to install the drilled shafts. It is assumed that the contractor would be able to install one shaft per week. Large-diameter casing shoring would be required to keep out water and allow access to the top of the shaft for column form placement and removal. Once the shafts are installed, the columns are cast inside the shoring casing. After the casing is removed, the cast-in-place pilecaps and bridge superstructure are constructed.

Rail Bridges

Because this location is part of the coastal saltwater environment, a coating system for steel piles and/or sacrificial thickness would be required to ensure satisfactory long-term performance. Other pile types such as pre-cast concrete piles should also be considered during later design stages.

Both rail and vehicular traffic must be maintained during construction. A concept for construction phasing for the proposed work is as follows:

Full Restoration

Rail construction would be the first order of work. The existing alignment would remain in operation while the new railroad berm/dike and rail bridge are constructed. Transition sections would be installed at the east and west limits. Rail traffic would be shifted to the new alignment and the existing rail removed.

Traffic on State Route 20 would be maintained by reducing traffic in each direction to a single lane, and shifting traffic from the westbound lanes to the eastbound lanes for the first phase and vice versa for the second phase. The bridge and highway improvements would be constructed for the westbound lanes first. Once completed, all traffic would be shifted to the north side and the eastbound lanes constructed.

Dike removals cannot begin until the rail and highway are raised. Culverts beneath State Route 20 would likely be constructed using jack-and-bore methods. An alternative to this approach would be to construct them in phases. While the westbound lanes are closed to traffic, the north half of the culvert could be installed by conventional excavation and installation methods. The south half would then be constructed with the southbound lanes. The wide median makes this approach feasible by providing space for the necessary excavations and clear zones from the travel lanes. It is more complicated at the railroad. Here, the jack-and-bore method may be the only feasible solution given the limited space for excavation between the existing rail line and the proposed rail line alignment. Further evaluation is needed during design.

Partial Restoration

Rail construction would also be the first order of work for the partial restoration alternative. A shoofly is proposed to the north of the existing alignment, with a total length of 3,500 LF to span the entire distance of bridge installation and vertical transition. The shoofly would be constructed with fill. Once rail traffic is routed to the shoofly, construction of the rail bridge and approaches can begin. The shoofly would be removed upon completion.

Phasing for work on State Route 20 is the same as for the full restoration alternative.

33.4 Extent of Stressor Removal

Table 33-2 describes the amount of stressors to be removed with this action.

Table 33-2. Stressor Removal

Stressor	Full Restoration	Partial Restoration
Tidal Barrier (LF)	21,055	1,080
Fill (area-acres)	26.9	3.8
Armor (LF)	8,450	0
Nearshore Roads (LF)	680	340
Railroad (LF)	680	340

Stressor	Full Restoration	Partial Restoration
Marinas (area-acres)	1.8	0

33.5 Expected Evolution of the Action Area

The full restoration alternative would result in a rapid change upon completion of the restoration of tidal hydrology to this large action area. The Telegraph Slough channel would see rapid changes in vegetation, and both gradual and episodic sediment distribution changes as the large tidal prism establishes an equilibrium channel. It is anticipated that sediment would be displaced within the channel south of State Route 20 and redistributed to the Padilla Bay side of the slough channel and out into the bay itself.

During Skagit River flood events, more substantial channel morphology and sediment transport changes are anticipated, as well as some distribution of woody debris in the slough channel and elsewhere. In the three smaller distributary channels, similar changes are anticipated, but with less substantial channel morphology and sediment transport implications. This is primarily because these smaller channels are currently lower in elevation than the northern portion of Telegraph Slough.

In addition to these primary distributary channels, a network of blind channels is expected to develop, branching off into the restored marsh plain. On the restored former marsh plain, initially elevations in many areas, particularly north of State Route 20, would be below the range that is suitable for marsh vegetation establishment. The restoration of tidal hydrology to these areas, combined with sediment from flood events, would support the gradual aggradation of many of these areas, particularly south of State Route 20, to elevations suitable for marsh establishment.

A similar evolution of the main Telegraph Slough channel is anticipated for the partial restoration alternative. However, the speed of channel development to the equilibrium condition is expected to be slower due to the significantly reduced tidal prism represented by partial restoration. The volume of sediment distribution from the channel to the bay is expected to be significantly reduced and to occur over a longer time. Vegetation changes in the restored slough channel would occur rapidly with the influx of higher salinity tidal hydrology.

Operation and maintenance issues associated with the restoration include removal of debris from beneath the bridge and the box culverts under State Route 20 and the railroad and after major floods. Woody debris from these maintenance operations can be placed within the action area to support habitat structure and complexity.

33.6 Uncertainties and Risks

Uncertainties and risks for this action area include:

- Property Concerns – There are significant uncertainties with the full restoration alternative regarding the willingness of the private landowners to sell or grant easements for restoration of their property. This uncertainty is significantly lower for partial restoration because the affected area is limited to the slough channel, which is not actively used for agriculture or other land uses (other than some recreation use).

- Transportation and Utility Issues – There are uncertainties regarding the design and construction requirements needed to satisfy the BNSF Railway, WSDOT, Puget Sound Energy, and the petroleum and water pipeline owners. The railroad and State Route 20 are currently at risk of damage from seismic events, particularly where crossing potentially liquefiable slough channel soils. Bridging and otherwise reinforcing these areas (potentially pile-supported box culverts for smaller distributary slough channels) would reduce this risk. Additional engineering studies, including civil, geotechnical, and hydraulic studies, would be needed to determine design issues and constraints. Restoration may put critical utility infrastructure at risk due to erosion (exposure) or damage associated with the distributary channels' tidal prism and the reactivation of Swinomish Channel flow to Telegraph Slough. Negotiation and reaching agreements with the infrastructure owners may be protracted and outcomes are uncertain.
- Freshwater Inflow – There is uncertainty that this action would substantially increase freshwater flow to Padilla Bay. Increased freshwater flow to the Swinomish Channel depends upon the increased freshwater flow in the McGlinn Island action. If the McGlinn Island action is not achieved, the ability to provide increased freshwater flow is uncertain and potentially unachievable. However, this is not the primary restoration objective.
- Geomorphic Changes – Potential river system and delta geomorphic response changes include major shifts in flow and sediment load between the South and North Fork Skagit River channels, affecting Swinomish Channel flows, salinity, and sediment levels.

33.6.1 Risks Associated with Projected Sea Level Change

This action would require sufficient sediment loads to maintain habitat types in the face of sea level change. This is due to the relatively flat condition of most of the action area, and the substantial portions of the area that have subsided (as stated above). The action does not provide an area for restored habitats to migrate to if sedimentation rates do not keep pace with sea level change.

Increased risks to critical utility infrastructure include erosion (exposure) or damage associated with the distributary channels' tidal prism and Swinomish Channel flow connectivity in the absence of, and combined with, sea level change. The high sea level change scenario would increase tidal prism and erosion forces, particularly in distributary channels and at structures such as bridges. Risks to critical infrastructure (State Route 20, the BNSF railroad, and major utilities) would be mitigated by designing for projected sea level change. There is a significant and greater risk to the transportation and utility infrastructure under a no action scenario, since much of this area is low now and minimally protected from a high sea level change scenario.

Table 33-3 compares potential risks associated with projected sea level changes based on professional judgment.

Table 33-3. Risks of Sea Level Change

	Projected Sea Level Change		
	High (46 cm)	Intermediate (4 cm)	Low (-8 cm)
Full Restoration	Low to Moderate: Infrastructure risks mitigated by design for projected sea level change Moderate to High: Risk of sediment supply not keeping pace with sea level change and conversion of restored marsh habitats to lower elevation (mudflat) Moderate to High: Increased tidal prism from sea level change increasing channel erosion, particularly at bridges and culverts	Low: Infrastructure risks partially mitigated by design for projected sea level change Low: Risk of sediment supply not keeping pace with sea level change and conversion of restored marsh habitats to lower elevation (mudflat) Low: Increased tidal prism from sea level change increasing channel erosion, particularly at bridges and culverts	None
Partial Restoration	Low to Moderate: Infrastructure risks mitigated by design for projected sea level change Low to Moderate: Risk of sediment supply not keeping pace with sea level change and conversion of restored marsh habitats to lower elevation (mudflat) Moderate: Increased tidal prism from sea level change increasing channel erosion, particularly at bridges	Low: Infrastructure risks mitigated by design for projected sea level change Low: Risk of sediment supply not keeping pace with sea level change and conversion of restored marsh habitats to lower elevation (mudflat) Low: Increased tidal prism from sea level change increasing channel erosion, particularly at bridges	None

33.7 Potential Monitoring Opportunities

Monitoring is important for evaluating restoration success. A combination of field surveys and aerial photographs would be used to document biological and physical changes to the landscape. Monitoring data can be used to refine adaptive management and corrective actions, as needed. Some of the main monitoring needs and opportunities associated with this action are summarized in Table 33-4.

Table 33-4. Monitoring Needs and Opportunities

Monitoring Parameter	Key Performance Indicator	Note
Topographic Stability		
Sediment Accretion / Erosion	X	Monitor sediment load between the South and North Fork Skagit River channels as the amount of sediment in North Fork potentially affects sediment in Swinomish Slough. Sediment delivery is needed to reestablish marsh plain within action area
Wood Accumulation		
Soil / Substrate Conditions		
Vegetation Establishment	X	Assess effects of changes in tidal hydrology on marsh establishment
Marsh Surface Evolution / Accretion	X	Monitor rate of marsh development south of State Route 20
Tidal Channel Cross-Section / Density	X	Monitor channel changes throughout action area
Water Quality (contaminants)		
Salinity	X	Monitor to assess changes in freshwater inflow to Padilla Bay
Shellfish Production		
Extent of Invasive Species		
Animal Species Richness		
Fish (salmonid) Access/Use		
Forage Fish Production		
Wildlife Species Use		
Effectiveness of Exclusion Devices		

33.8 Information Needed for Subsequent Design

This conceptual design report represents an initial step in the restoration design sequence. The design concepts described above were developed based on readily available information without the level of site-specific survey and investigation that is necessary to support subsequent design and implementation. Substantial additional information will be required at the preliminary and later design stages to confirm the design assumptions, refine quantity estimates, address property and regulatory issues, obtain stakeholder support, and fill in data gaps. The extent to which this information is collected for preliminary design (or a later design stage) will depend upon the available budget, schedule, and other factors. This section attempts to define the most essential information needs for this action. Refer to the Introduction chapter for additional information.

- Property Investigation/Survey – More detailed information on parcel ownership, utilities, and property boundary locations will be needed to finalize the design, confirm acquisition requirements, and support negotiations for designing transportation and utility infrastructure.
- Topographic/Bathymetric Survey – The survey would be useful in providing more accurate preliminary designs and quantities for roadways, utilities, bridges, and removal of existing features including the extent of armoring. Survey data could also be used as a baseline for pre- and post-construction monitoring and hydrodynamic modeling. A temporary tide gauge may be required in the early design stages to obtain site-specific tidal statistics.
- Subsurface Soil Information – A preliminary field investigation, including soil borings, sampling, and testing, would be needed to complete preliminary design of bridge supports and roadway improvements. A geotechnical report would be needed with recommendations regarding foundation types for bridges.
- Additional As-built Information – Additional as-built information for the existing bridges, roadways, and existing utilities would be needed to understand demolition and removal requirements and develop preliminary design details for new facilities.
- Geotechnical Investigation – Additional geotechnical study will be required to finalize design of dikes, levees, and bridge, road, and rail infrastructure, to address questions of slope stability of setback dikes, and to determine the size of required armor rock.
- Hydrodynamic and Hydraulic Analysis – Tidal circulation, flood, and wave modeling would be required to evaluate impacts to the estuary and adjacent properties following restoration. The models would also be used to optimize the size of the opening in the partial restoration alternative, and to provide design criteria for proposed roadway and utility improvements for both restoration alternatives. Results from the modeling would be used by a hydraulic engineer to provide recommendations for culvert sizing (for partial restoration) and scour and minimum deck/bridge elevations for State Route 20 and BNSF bridges (both full and partial restoration). Sediment transport evaluations should be conducted (based on modeling results) to optimize the channel opening and other planned excavation activities to reduce the risk of infilling of the constructed channel and restored estuary over time. The specific modeling approach/method needs to be determined. A temporary tide gage may be needed in the early design stages to obtain site-specific tidal statistics.
- Hazardous Materials Assessment – If preliminary investigations suggest that hazardous material could be present in the action area, additional soil and sediment analysis related to demolition of utilities, roads, or buildings may be needed. The introductory chapter describes the Phase I site investigations that are occurring as part of this overall effort via a separate contract.
- Cultural Resources Investigation – Surveys for archaeological and historic resources may be required for this action area. This is particularly important for areas proposed for excavation or other ground disturbance.
- Sea Level Change Projection – Estimates of sea level change for the conceptual design were based on calculations provided by the Washington Department of Fish and Wildlife and the Corps of Engineers using guidance in Corps'

Engineering Circular No. 1165-2-211. Projections for each project area will be refined using localized tide gauge data during later design stages.

33.9 Quantity Estimates

The design quantities are largely developed from LiDAR data sets lacking the resolution to accurately quantify all elements of construction. These are supplemented by unmeasured estimates made during one site visit at high tide and areal take-offs from available imagery. The quantity spreadsheets for the full and partial restoration alternatives are provided in Exhibits 33-1 and 33-2.

33.10 References

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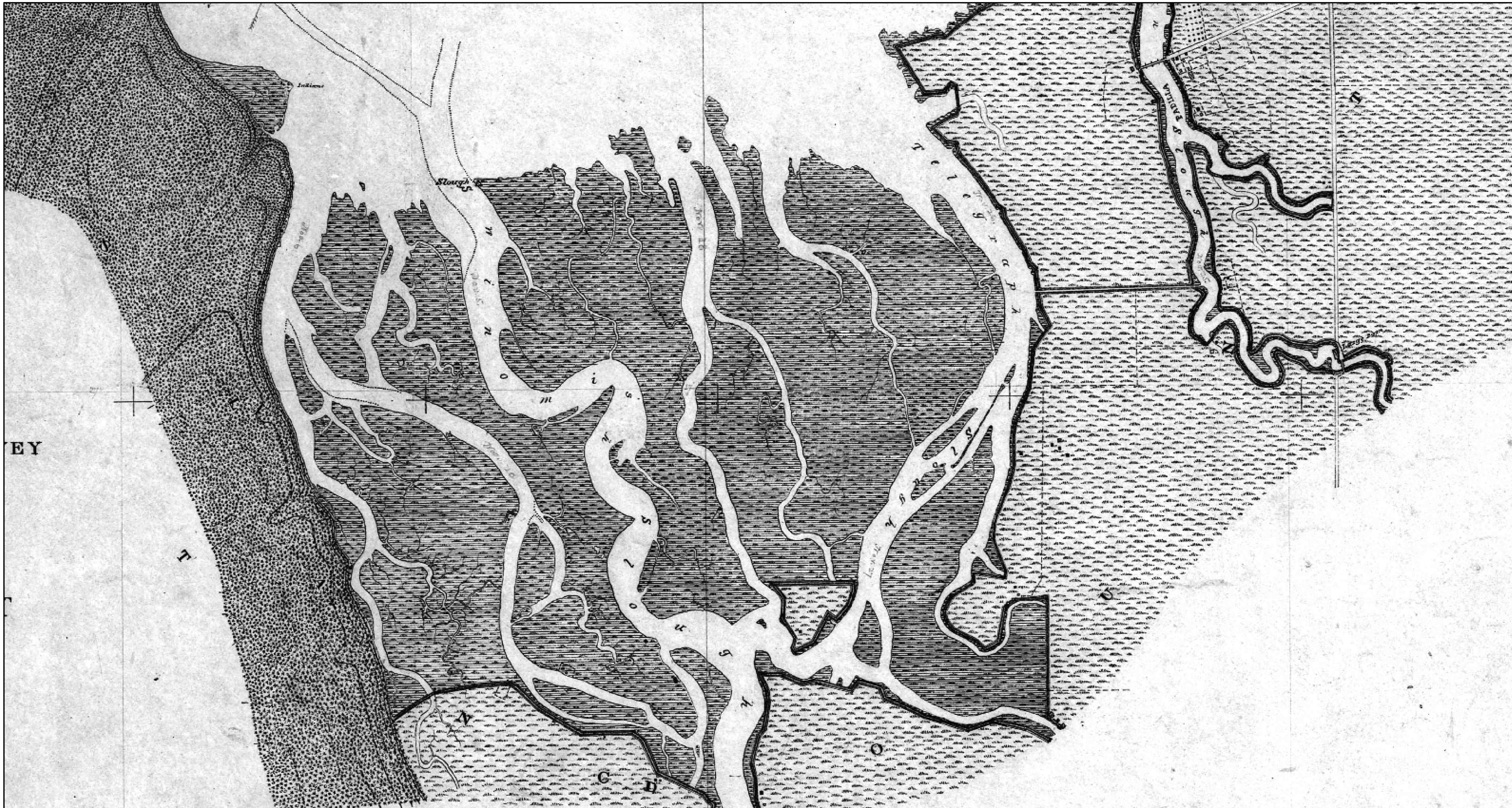

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0 1,320
Feet
0 420
Meters

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64

WDFW Contract # 100-000204 (CAPS No. 10-1461)

Historic Map (T-Sheet)

Action Name: Telegraph Slough - Phase 1/2

PSNERP ID #: 1633

Figure 33- 2A

0 1,320
Feet
0 420
Meters

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64

WDFW Contract # 100-000204 (CAPS No. 10-1461)

Historic Map (T-Sheet) and River History Project Data

Action Name: Telegraph Slough - Phase 1/2

PSNERP ID #: 1633

Figure 33- 2B

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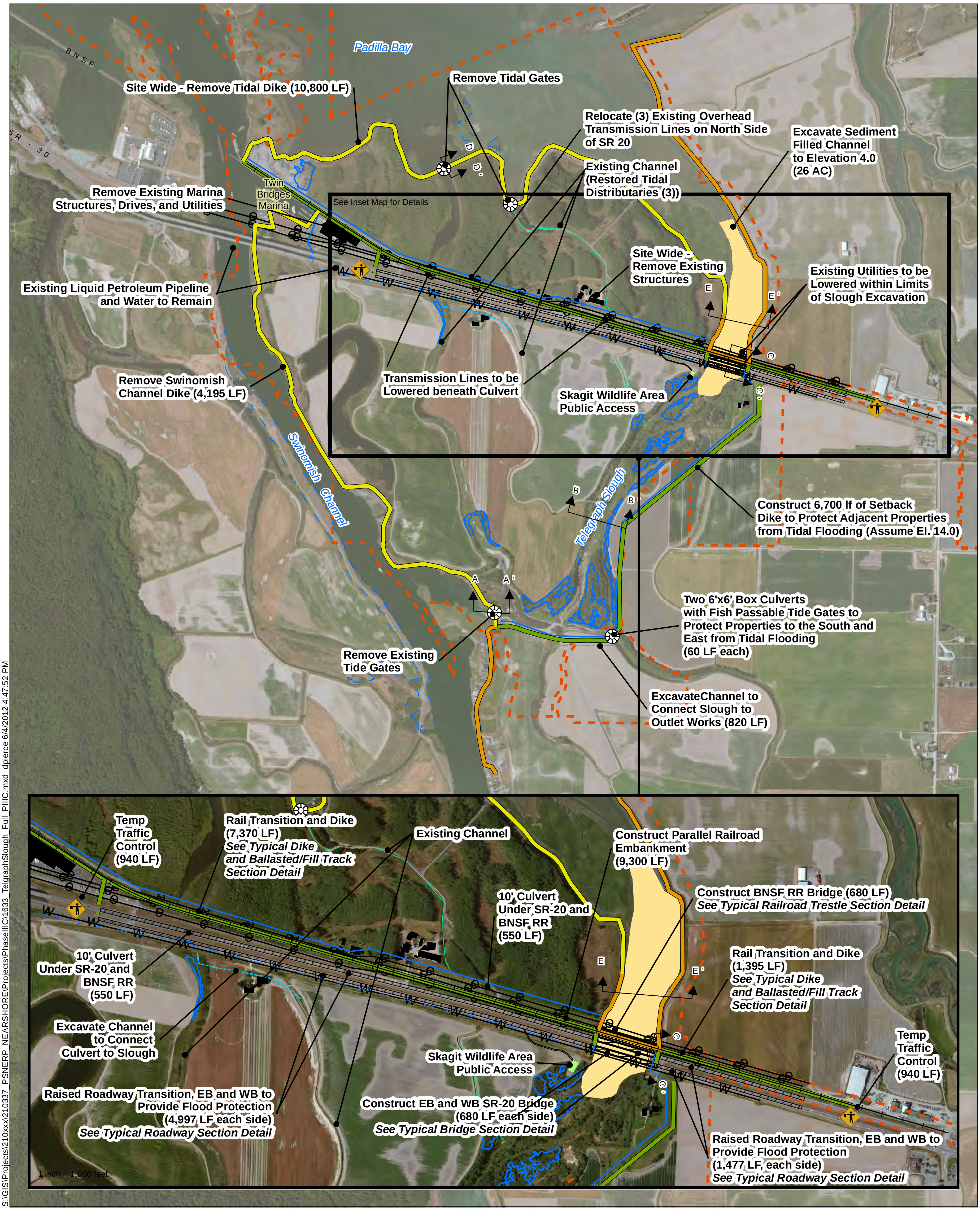


S:\GIS\Projects\210xxx\210337_PSNERP_NEARSHORE\Projects\PhaseIIIC\1633_TelegraphSlough_Full_PIIIC.mxd dpierce 6/4/2012 4:47:52 PM

Legend

- Hydraulic Structures - Small
- Other
- Proposed Shoofly
- Existing Rail Alignment
- Existing Dike
- Dike Removal
- Dike Construction
- Existing Channel
- Culvert
- Proposed Tide MHHW
- Existing Tide MHHW
- Channel Rehab/Creation
- Electric
- Gas
- Sewer
- Water
- Section Lines
- Excavation - Lowland
- Remove Structures
- Recreation Public Access
- Required Project Lands

TELEGRAPH SLOUGH CONVERSION

FIXED DATUM — TIDAL DATUM

MHHW 7.82; NAVD88 0.51; MLLW

0.00 FT MHHW = 7.82 FT NAVD88
-7.82 FT MHHW = 0.00 FT NAVD88
0.00 FT MLLW = -0.51 FT NAVD88
0.51 FT MLLW = 0.00 FT NAVD88

Source: VDATUM (48.45621944, -122.4923083)

North — 0 — 680 Feet

PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

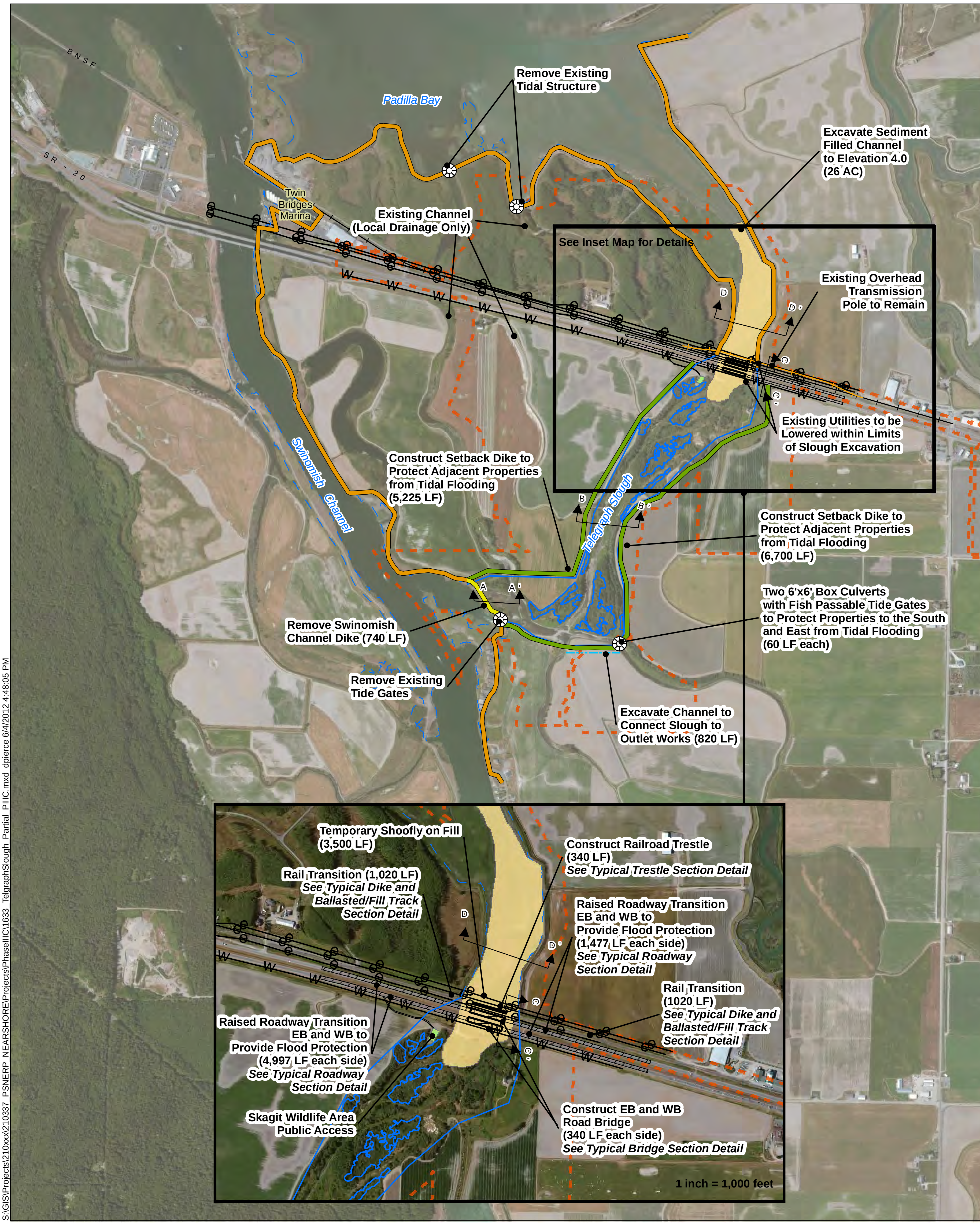
SOURCE: Skagit County GIS(2007); Bing Maps (2011)

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Plan
Site Name: Telegraph Slough
Action Name: Telegraph Slough – Phase 1 & 2
PSNERP ID #: 1633, 1635
Full Restoration

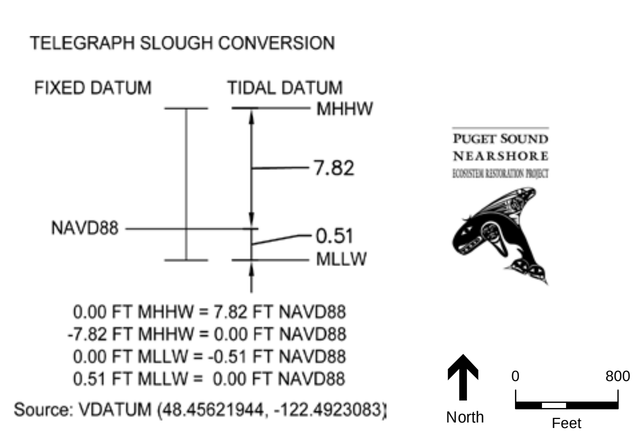
Lead Contractor: ESA
Design Lead: Anchor QEA, J. Bibee P.E.
Date: 05/2012

Figure 33-3



Legend

Hydraulic Structures - Small	Proposed Tide MHHW	Section Lines
Proposed Shoofly	Existing Tide MHHW	Bridge
Existing Rail Alignment	Channel Rehab/Creation	Roadway Modifications
Existing Dike	Electric	Excavation - Lowland
Dike Removal	Gas	Recreation Public Access
Dike Construction	Sewer	Required Project Lands
Existing Channel	Water	
Culvert		



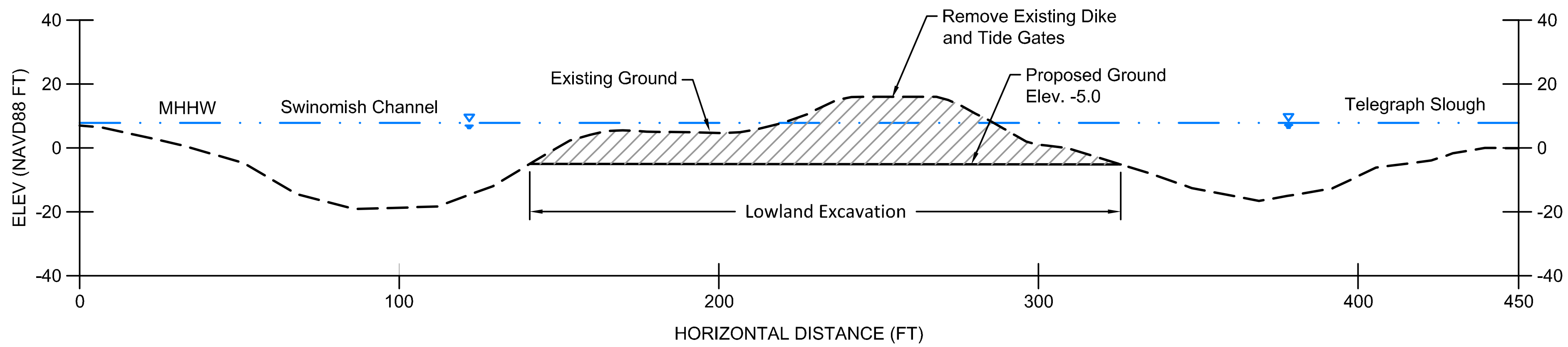
SOURCE: Skagit County GIS(2007); Action Area (PSNERP, 2010)

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

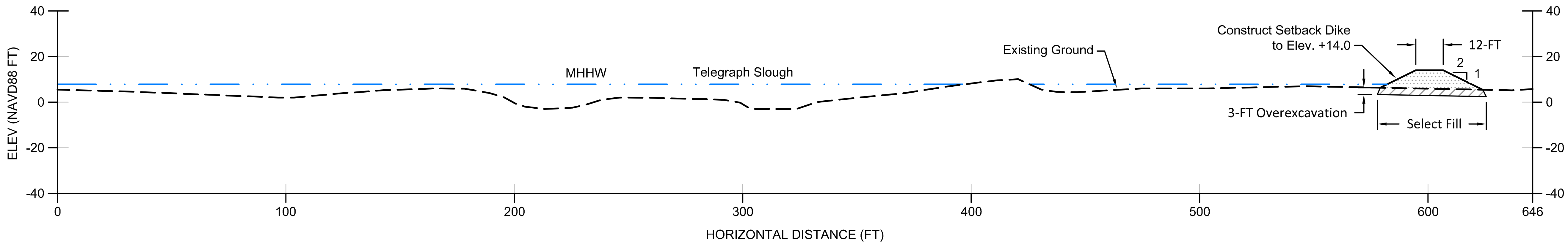
Conceptual Design Plan
Site Name: Telegraph Slough
Action Name: Telegraph Slough – Phase 1 & 2
PSNERP ID #: 1633, 1635
Partial Restoration

Lead Contractor: ESA
Design Lead: Anchor QEA, J. Bibee P.E.
Date: 05/2012

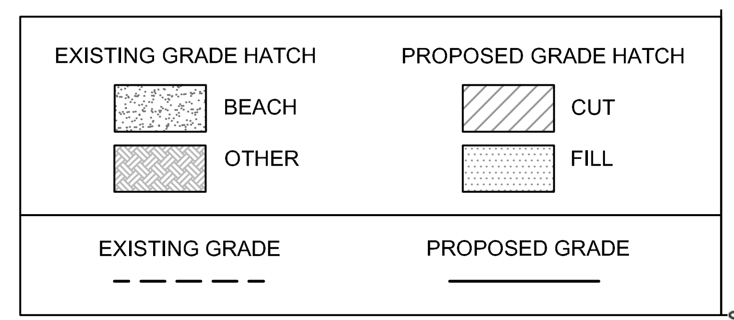
Figure 33-4

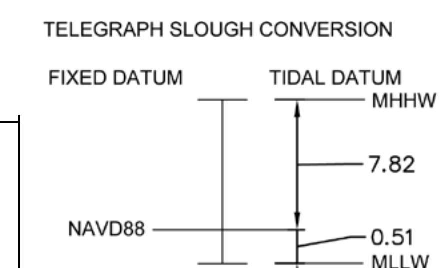


A FULL RESTORATION TYPICAL SECTION

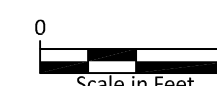


B FULL RESTORATION TYPICAL SECTION





0.00 FT MHHW = 7.82 FT NAVD88
-7.82 FT MHHW = 0.00 FT NAVD88
0.00 FT MLLW = -0.51 FT NAVD88
0.51 FT MLLW = 0.00 FT NAVD88
Source: VDATUM (48.45621944, -122.4923083)



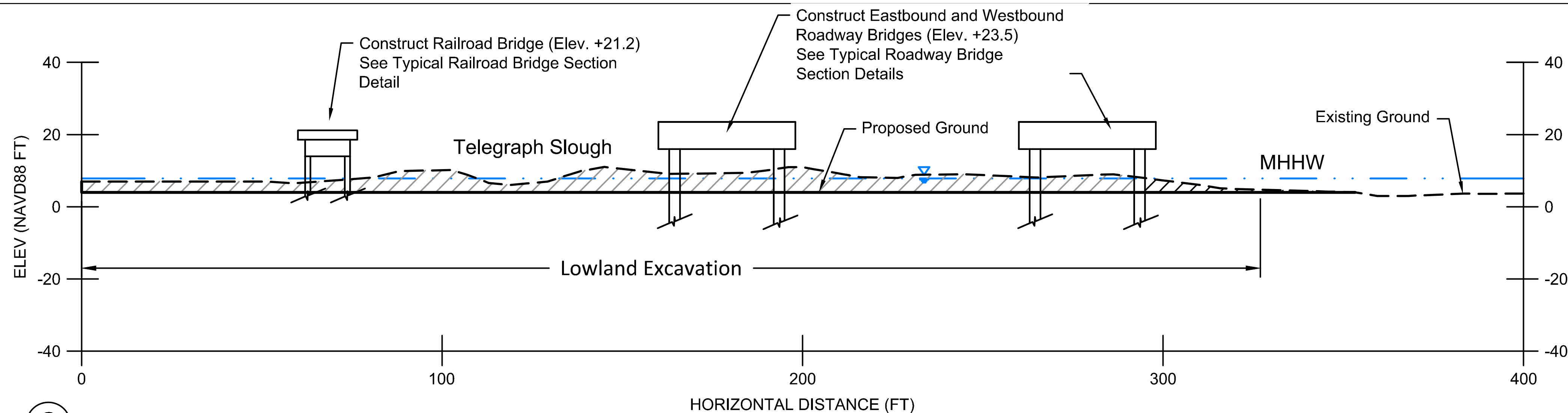
PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: Anchor, Jerry Bibee, PE
Date: 5/2012

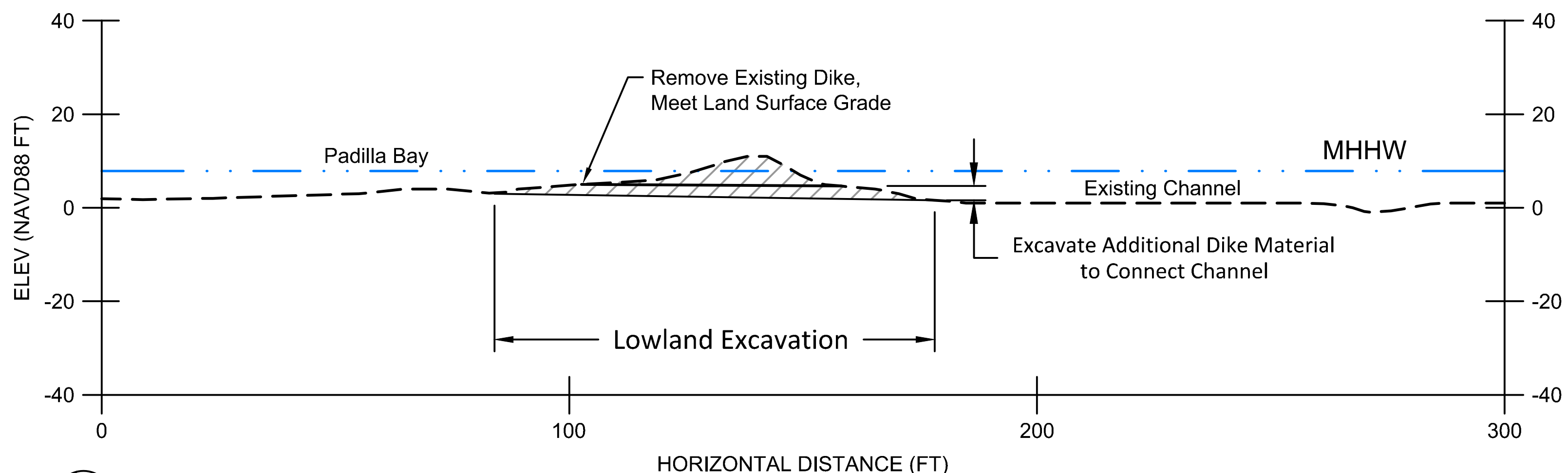
Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Section
SITE NAME: **Skagit River Delta**
ACTION NAME: **Telegraph Slough Phase 1**
PSNERP ID#: **1633**
Full Restoration

Figure 33-5



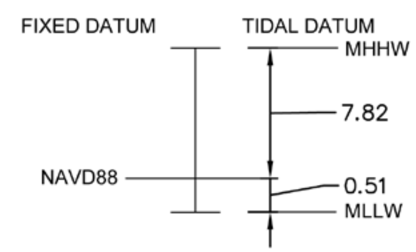
C FULL RESTORATION TYPICAL SECTION



D FULL RESTORATION TYPICAL SECTION

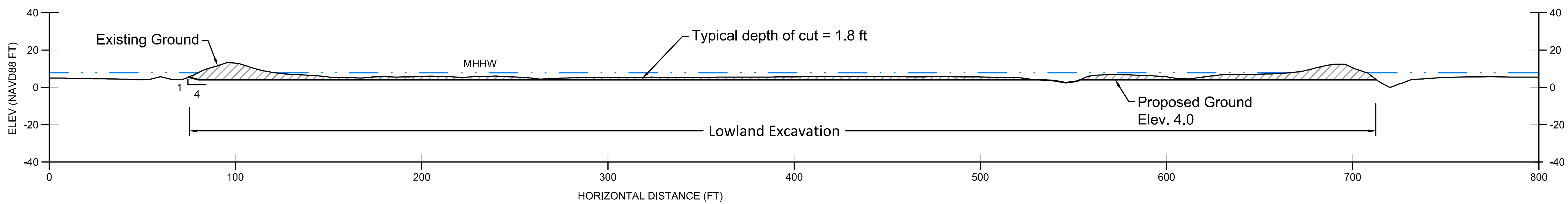
EXISTING GRADE HATCH		PROPOSED GRADE HATCH	
	BEACH		CUT
	OTHER		FILL
EXISTING GRADE		PROPOSED GRADE	

TELEGRAPH SLOUGH CONVERSION



0.00 FT MHHW = 7.82 FT NAVD88
-7.82 FT MHHW = 0.00 FT NAVD88
0.00 FT MLLW = -0.51 FT NAVD88
0.51 FT MLLW = 0.00 FT NAVD88

Source: VDATUM (48.45621944, -122.4923083)



E FULL RESTORATION TYPICAL SECTION

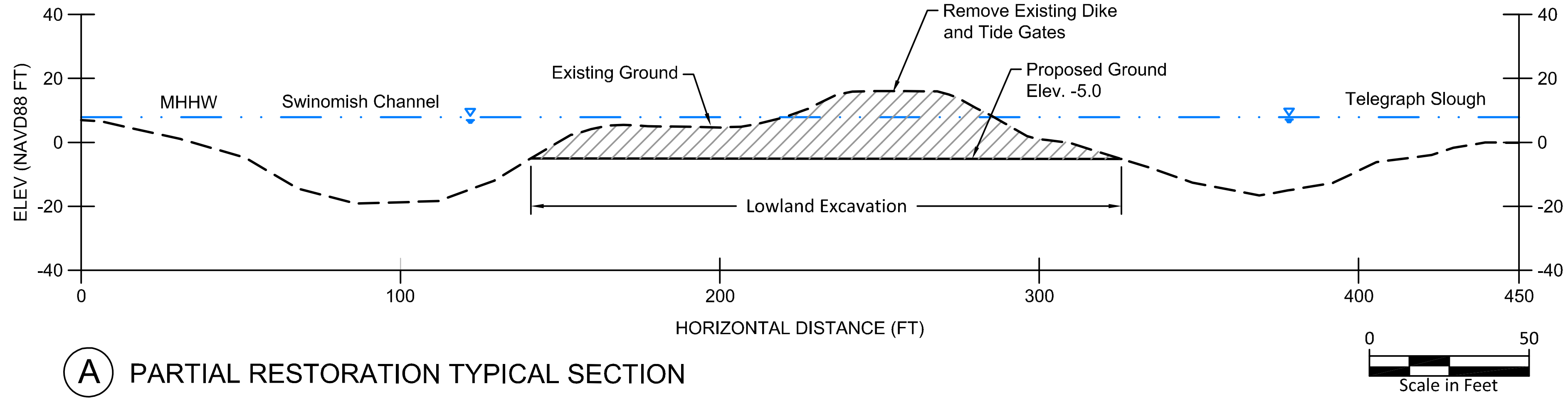
PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: Anchor, Jerry Bibee, PE
Date: 5/2012

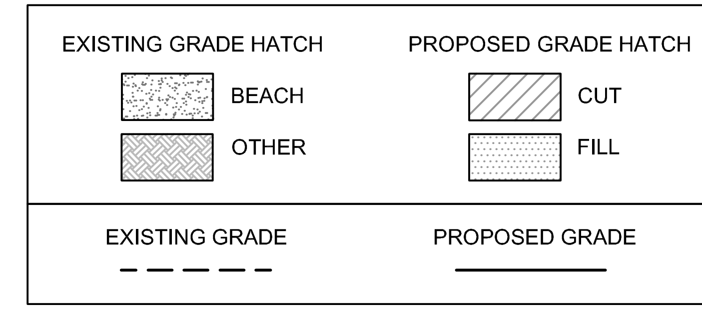
Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

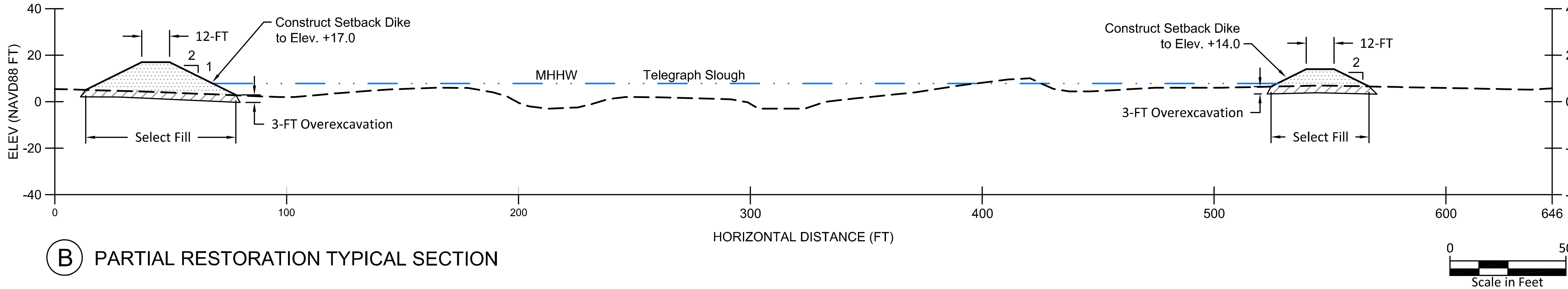
Conceptual Design Section
SITE NAME: **Skagit River Delta**
ACTION NAME: **Telegraph Slough Phase 1**
PSNERP ID#: **1633**
Full Restoration

Figure 33-6

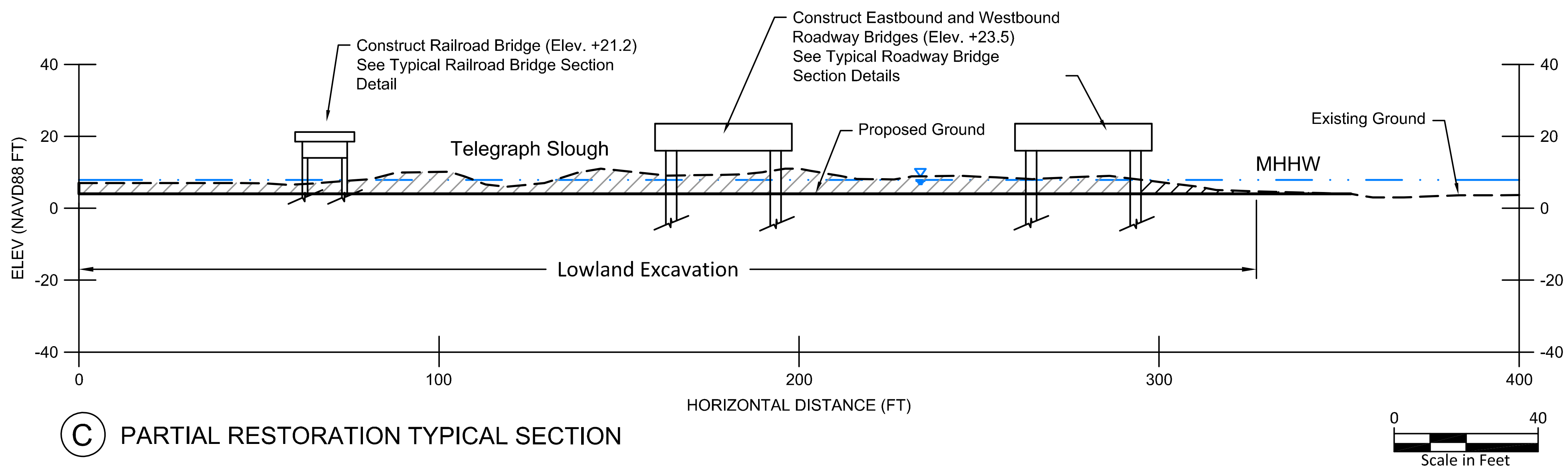


(A) PARTIAL RESTORATION TYPICAL SECTION

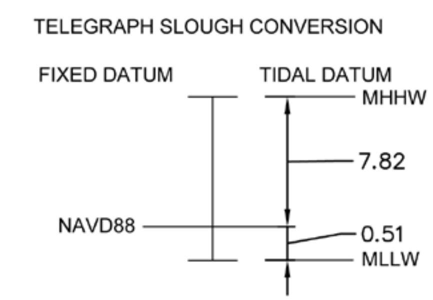




(B) PARTIAL RESTORATION TYPICAL SECTION



(C) PARTIAL RESTORATION TYPICAL SECTION



0.00 FT MHHW = 7.82 FT NAVD88
-7.82 FT MHHW = 0.00 FT NAVD88
0.00 FT MLLW = -0.51 FT NAVD88
0.51 FT MLLW = 0.00 FT NAVD88

Source: VDATUM (48.45621944, -122.4923083)

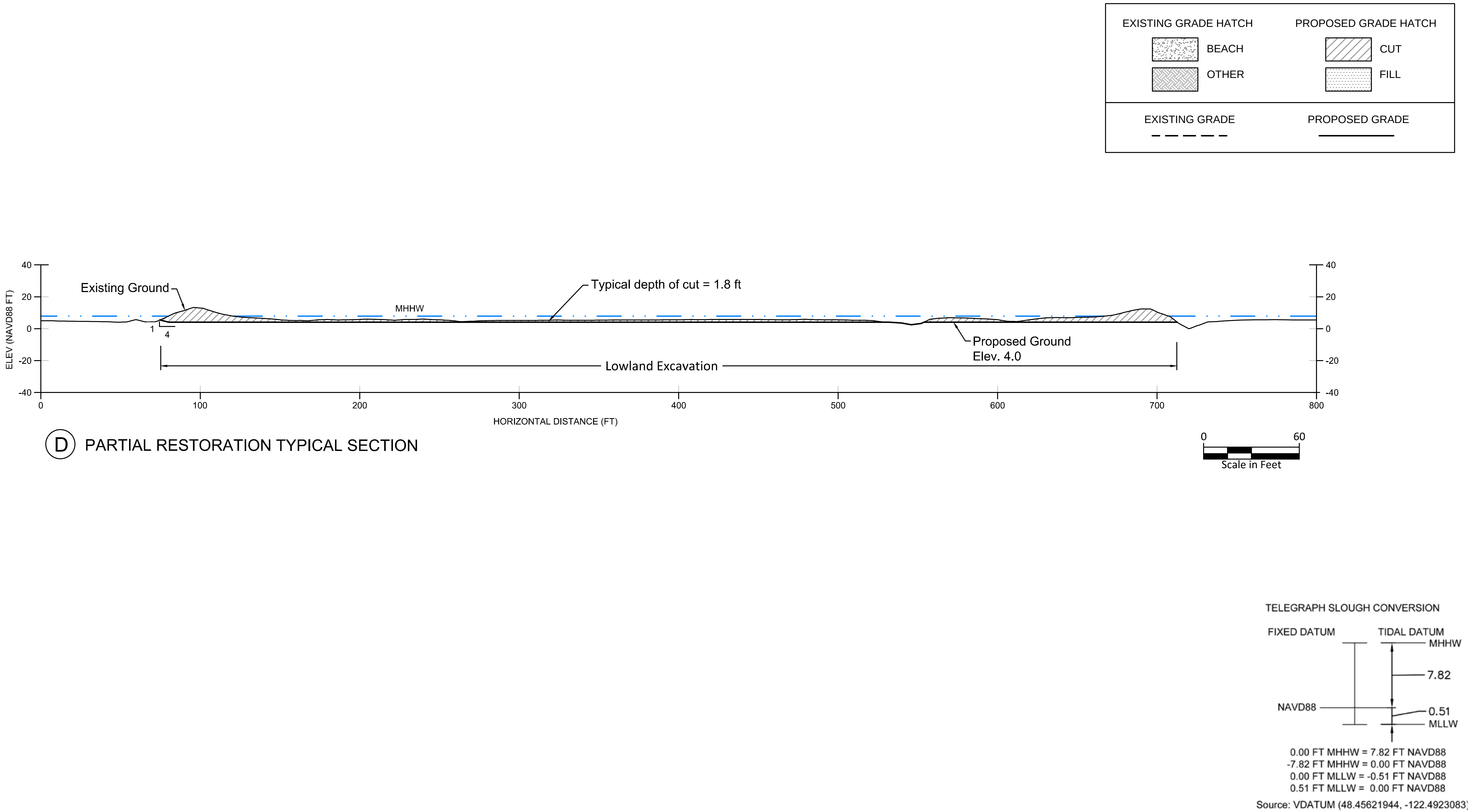
PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: Anchor, Jerry Bibee, PE
Date: 5/2012

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Section
SITE NAME: **Skagit River Delta**
ACTION NAME: **Telegraph Slough Phase 1**
PSNERP ID#: **1633**
Partial Restoration

Figure 33-7



D PARTIAL RESTORATION TYPICAL SECTION

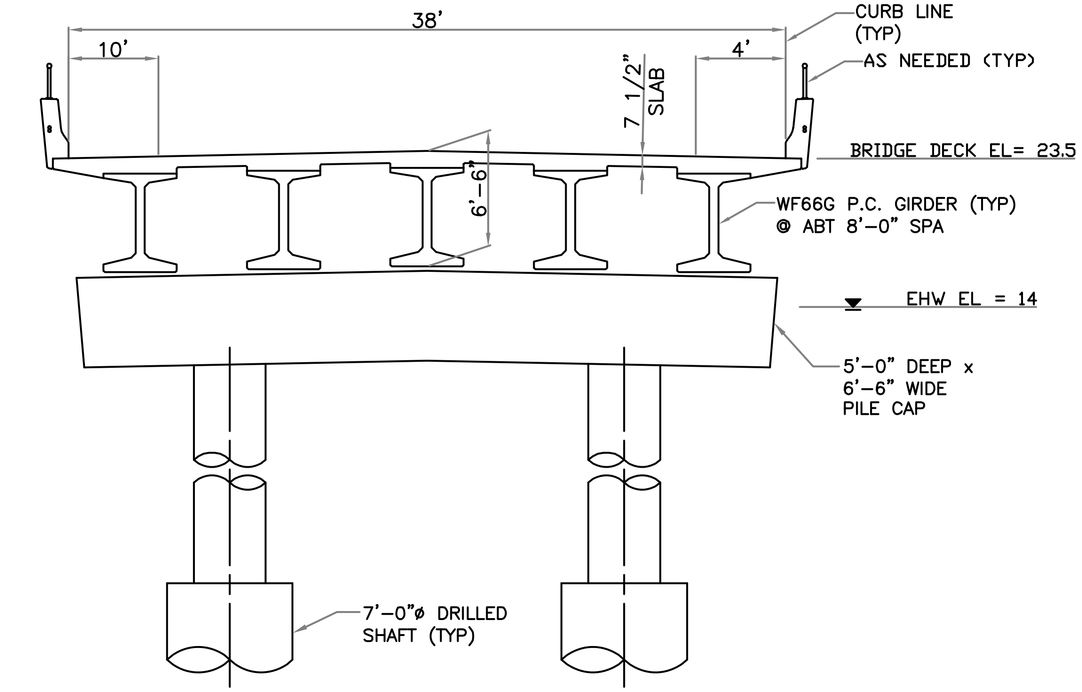
PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: Anchor, Jerry Bibee, PE
Date: 5/2012

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

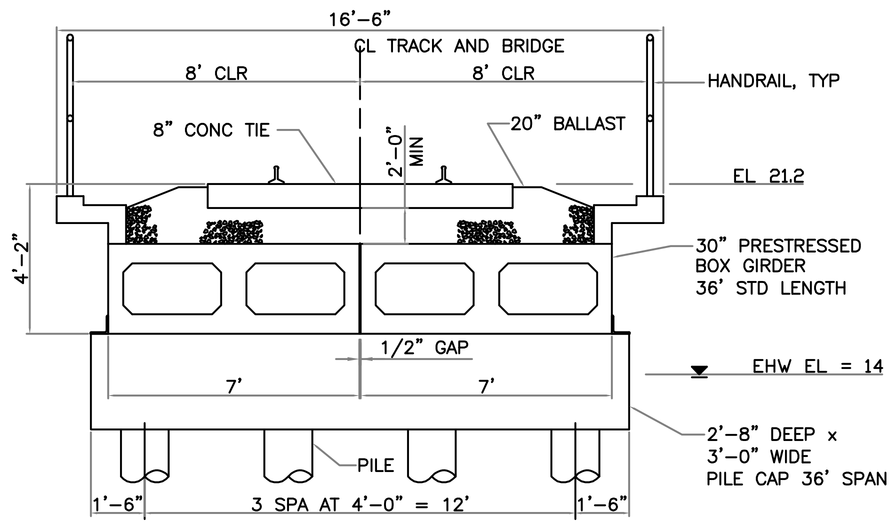
Conceptual Design Section
SITE NAME: **Skagit River Delta**
ACTION NAME: **Telegraph Slough Phase 1**
PSNERP ID#: **1633**
Partial Restoration

Figure 33-8



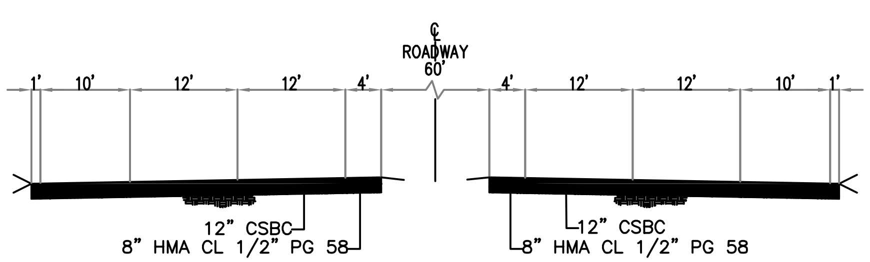
NOTE: 136' SPAN (FULL), 113' SPAN (PARTIAL)
EXTREME HIGH WATER (EHW) EL = 14

TYPICAL ROADWAY BRIDGE
Section Detail
Note to Scale
Provided by KPFF

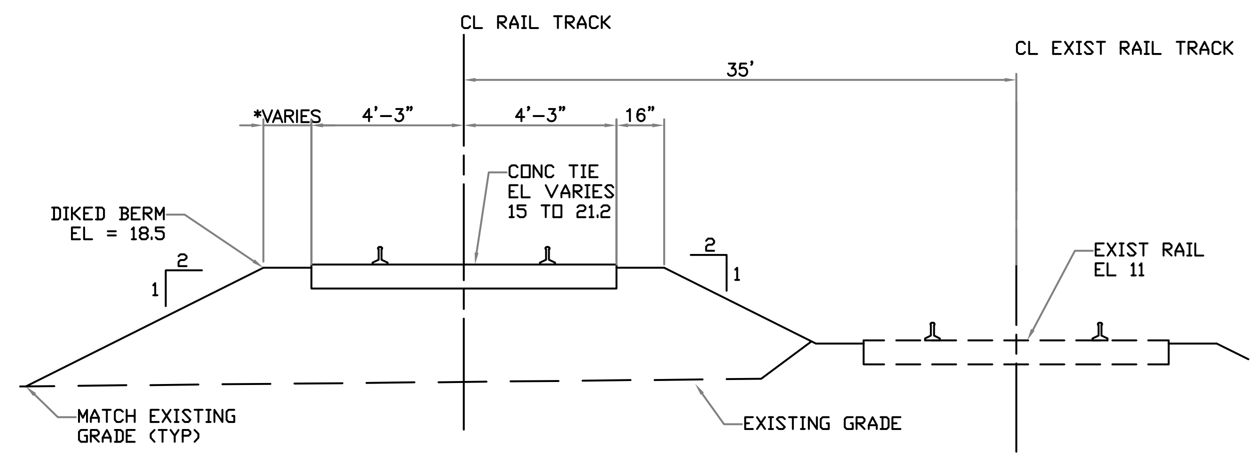


NOTE: 36' SPAN
EXTREME HIGH WATER (EHW) EL = 14

TYPICAL RAILROAD BRIDGE
Section Detail
Note to Scale
Provided by KPFF



TYPICAL ROADWAY
Section Detail
Note to Scale
Provided by KPFF

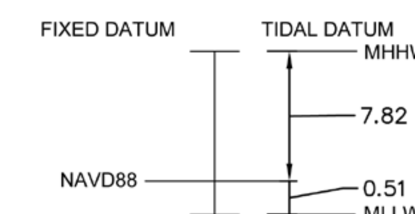


FULL RESTORATION
TRACK ELEVATION VARIES FROM EL 15 TO THE WEST AND 21.2
AT THE BRIDGE CROSSING.

* 2' TO 9.5'

TYPICAL DIKE AND BALLASTED FILL TRACK
Section Detail
Note to Scale

TELEGRAPH SLOUGH CONVERSION



0.00 FT MHHW = 7.82 FT NAVD88
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0.51 FT MLLW = 0.00 FT NAVD88

Source: VDATUM (48.45621944, -122.4923083)

PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: Anchor, Jerry Bibee, PE
Date: 5/2012

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Section
SITE NAME: **Skagit River Delta**
ACTION NAME: **Telegraph Slough Phase 1**
PSNERP ID#: **1633**
Full & Partial Restoration

Figure 33-9

Full Restoration Quantity Estimate

Action Name: Telegraph Slough
Action #: 1633 and 1635
Date: February 2011 — Revised May 2012
By: S. Page and J. Bibee — Revised with backcheck updates: 30 June 2011

REMEDY: Full restoration includes removal of the majority of the existing Telegraph Slough, Tidal (Padilla Bay), and Swinomish Channel (east) dikes, existing tide gates, and bridging of Telegraph Slough at the SR 20 and BNSF railroad within the action area. It includes re-construction of the an elevated replacement rail line on a newly-constructed tidal dike on the north side of the existing railroad berm, with tie in at the Swinomish Channel swing bridge and east of the new Telegraph Slough trestle bridge. SR 20 westbound and eastbound lanes would be raised on either side of the new Telegraph Slough bridge to be above tidal flood stage (plus freeboard), extending to nearly the existing Swinomish Channel bridge to the west, and east to a transition tie to existing road grade. Secondary distributary channel crossings of SR-20 and the BNRR would require large diameter horizontally-driven pipe culverts for north-south channel habitats connection. The existing tide gate at the Swinomish Channel would be removed, and new setback dikes would be constructed along the SE limit of the action area along the Telegraph Slough Channel. A new fish-passable culvert and tide gate would be constructed at the SE corner of the action area to connect the existing distributary channel to the SE. Major utilities (buried liquid petroleum, water [serves Whidbey Island], and OHP transmission lines require relocation at multiple locations.

Construction Period: Estimate three construction summer seasons plus limited upland work over winter - estimated 36 to 48 months total

Item	Unit of Measure	Material Name	Qty	Description of Item	Indicate section of design report where item is described
ACQUISITION AND CONSERVATION				Based on available mapping information	
Required Project Lands	Acre		1,240	Total land required For actioi	33.3
Proponent / Partner-owned lands	Acre		NA	Estimate of lands currently owned by Proponent (i.e., Public land	
Lands To Be Acquired	Acre		785	Estimate land required to be acquired for action prior to implementation - Estimate 57 private parcels totaling 785 acres required for acquisitioi	33.3
Material Sites				Not Used: See Earthwork - Imported Fill.	
MOBILIZATION AND ACCESS for construction activities				Description required for each item to facilitate cost estimating	
Mobilization - Typica (Equipment, Personnel, Planning, Financial)	LS		1	Up front costs such as bonding, planning and other staff time and financing. Typically, assume 8% to 10% other items.	33.3
Mobilization - Remote (Equipment, Personnel, Planning, Financial	LS		NA		
Site Access	LS		NA		
Barge Access	Days		60	May need barge access to excavate portions of the Swinomish Channel Dik	33.3
Temporary Traffic Control (one of the following)				Includes installation of traffic signals, signage, signmen, etc. There are 4 types as follov	
none	LS		NA		
signs	LS		NA		
flags / spotters	LS		NA		
unique	LS		1	Maintenance of traffic would require reducing traffic on SR 20 to a single lane in each direction, shifting traf from west bound lanes to east bound in order to construct the bridge and improvements to west bound lanes. Process would be repeated for construction of eastbound lanes. Elements of work would include temporary paving across median, construction signage, truck-mounted variable message signs.	33.3
Temporary Roadway	SF		88,000	Includes construction of temporary adjacent roadway or bypass roadways and for vehicle and pedestrian travel through or around site	33.3
Control of Water	LS		1	May need to control water for construction of new set back dikes.	33.3
Relocation Activities				Not Used: See Utilities, Structures	
Site Demolition Activities				Demolition and removal of structures (description required), temporary features and relocations, itemized separately); Clearing and grubbing of vegetation, and removal of minor debris (rocks, slabs) - description required.	
Clearing and Grubbing (one or more of following)				Use one or more of the following categories of clearing and grubbing	
Clear /Grub Vegetation - Offsite Disposa	AC		30	Vegetation removed from SR-20 and RR corridor, assumed to remove vegetation and 1 foot of topsoil to remove vegetative root mas:	33.3
Clear /Grub Vegetation - Local Disposa	AC		NA		
Clear /Grub Vegetation - Offsite Disposa	AC		NA		
Clear /Grub Vegetation - Offsite Disposa	AC		NA	Strip existing Swinomish dike in areas for removal; assume 36 sf/lf of removal and 7,833 lf of di	
Clear /Grub Vegetation - Offsite Disposa	AC		NA	Strip existing Swinomish dike for channel connections; assume 80 sf/lf of removal and 1,740 lf of dil	
Clear /Grub Vegetation - Offsite Disposa	AC		NA		
Clear, stockpile - large woody debris	CY		NA	Vegetation is segregated and stockpiled / prepared for reuse on si	
Hydraulic Structures - Small	LS		3	Remove culverts and tide gate	33.3
Hydraulic Structures - Large	LS		1	Remove large multi-barrel tide gate syste	33.3
Utilities	LF		1,000	OHP service to propertie:	33.3
Buildings	SF		173,296	Permanent structures. Based on aerial there appears to be numerous containers that are assumed to be removed by the property owne	33.3
Pavement	LF or SF		88,000	Accounts for removal of temporary pavement only. Existing pavement would not need to be removed. It should be broken in place and roadway fill placed on to	33.3
Bulkheads	LF or SF			Use this for bulkheads...if large and difficult, consider using Large Coastal Structure:	
Rock revetments	LF		8450	Remove rock revetment at Twin harbors marina	33.3
Large Coastal Structures	LF, SF or CY		NA		
Demolition / Removal - Bridge	SF or CY		NA		
			NA		
Removal - Misc. (e.g. angular rock from beach)	Ton		NA		
Demolition / Removal - Boat Ramp	SF		NA		
Haul - Offsite Disposal of Demolition Debris	Miles		20	Unknown location. Could be packed into containers and picked up by Waste Management Ii	33.3
Hazardous/Contaminated Waste Removal				These items for earthwork of quality not compatible with wetlands, requiring special handling and disposal. Describe basis for classification as contaminated or hazardous. State known or suspected contamination, describe known similar work	
Contaminated Earthwork	CY		NA		
Hazardous Earthwork	CY		NA		
Construct Temporary Features				Use as needed for unusual temporary features not included elsewhere (see TESC below)	
EARTHWORK				Expand to include equipment, etc. to facilitate cost estimating.	
Excavation	CY		NA		
Excavation - Upland	CY		NA		
Excavation - Upland	CY		44,667	Over-excavation for new east side dike: assume 6.6 cy/lf and 6,700	33.3
Excavation - Lowland	CY		115,200	Removal of exiting Padilla Bay dikes: Assume 10.67 cy/lf, and 10,800	33.3
Excavation - Lowland	CY		75,000	Excavate approximately 26 acres of accumulated sediment to elevation 4 (average excavation depth = 1.8 ft) to reconnect Telegraph Slough	33.3
Excavation - Lowland	CY		41,749	Removal of exiting Swinomish Channel dikes: Assume 5.33 cy/lf, and 7,833	33.3
Dredging - Bucket - Land	CY		6,800	Excavation below ground water or underwater; reach limited low production. Excavate new drainage char 850lf x 48' TW X 6 ft Depth	33.3
Dredging - Bucket - Marine	CY		50,390	Removal of Swinomish Channel Dike to -5 to connect relic channel and Telegraph Slough. 28.96 cy/lf ar 1,740 lf	33.3
Dredging - Hydraulic	CY		NA		
Fine Grading	AC		NA		
Fill Placement - local borrow				This is additive to Earthwork -Excavatio	
Side cast	CY		NA		
Haul - uncontrolled placement	CY		NA		
Haul, place, compact	CY		NA		
Stockpile - uncontrolled placement	CY		276,616	Temporary stockpile of excavated materials for dike construction, road fill, or other onsite fill to spread in l lying areas north of SR 20 outside of channels.	33.3
Stockpile - controlled placement	CY		57,190	Temporary stockpile of excavated wet materials for dike construction, road fill, or other onsite fill to cre hummocks	33.3
Conveyor placement from stockpile land/water	CY		NA		
Imported Fill					
Select Fill	CY		107,200	Imported select material - East Dike construction Assume 16 cy/lf and 6,700	33.3
Select Fill	CY		236,534	Imported select material - Road constructic	33.3
Select Fill	CY		191,603	Imported select material - RR berm construction. Assume 21.9 cy/lf 8,765	33.3
Gravel Borrow, including haul	CY		NA		
Sand / Gravel for Beach Nourishment	CY		NA		
Cobble for Shore Nourishment	CY		NA		
Embankment Compaction	CY		345650	WSDOT standard iten	33.3
Topsoil	CY		NA		
RESTORATION Features					
Channel Rehab / Creation	SF		NA		
Large Wood Placement	EA		NA		
Invasive Species Control	Acre		NA		
Physical Exclusion Devices	LF or EA		NA		
Other Restoration Features/ Activities	LS		1	Fill and raise low lying areas north of SR 20 outside of channel areas with surplus materials. Unknown if existing materials are suitable for construction of new dikes and road/rail f	33.3
Structures	EA				
Water Control Structures - Culverts with Gates	EA		1	2 60 ft long 6'x6' concrete box culverts with fish passable tide gat	33.3
Water Control Structures - Weirs	EA		NA	Describe, length, type, anticipated materia	
Rock Slope Protection	LF		NA		
Other	EA		NA		
Elevated Boat Ramp	SF		NA		
Fencing	SF		NA		

Full Restoration Quantity Estimate

Action Name: Telegraph Slough
Action #: 1633 and 1635
Date: February 2011 — Revised May 2012
By: S. Page and J. Bibee — Revised with backcheck updates: 30 June 2011

REMEDY: Full restoration includes removal of the majority of the existing Telegraph Slough, Tidal (Padilla Bay), and Swinomish Channel (east) dikes, existing tide gates, and bridging of Telegraph Slough at the SR 20 and BNSF railroad within the action area. It includes re-construction of the an elevated replacement rail line on a newly-constructed tidal dike on the north side of the existing railroad berm, with tie in at the Swinomish Channel swing bridge and east of the new Telegraph Slough trestle bridge. SR 20 westbound and eastbound lanes would be raised on either side of the new Telegraph Slough bridge to be above tidal flood stage (plus freeboard), extending to nearly the existing Swinomish Channel bridge to the west, and east to a transition tie to existing road grade. Secondary distributary channel crossings of SR-20 and the BNRR would require large diameter horizontally-driven pipe culverts for north-south channel habitats connection. The existing tide gate at the Swinomish Channel would be removed, and new setback dikes would be constructed along the SE limit of the action area along the Telegraph Slough Channel. A new fish-passable culvert and tide gate would be constructed at the SE corner of the action area to connect the existing distributary channel to the SE. Major utilities (buried liquid petroleum, water [serves Whidbey Island], and OHP transmission lines require relocation at multiple locations.

Construction Period: Estimate three construction summer seasons plus limited upland work over winter - estimated 36 to 48 months total

Item	Unit of Measure	Material Name	Qty	Description of Item	Indicate section of design report where item is described
Utilities				Replacement or relocation. Designer to provide size and material and have separate line item for each run. Incidentals include earthwork, testing, hook up fees, etc. These quantities do not include demolition of existing utilities, real estate / easements, design fees. Describe the owner if known, and whether utility franchise will install (e.g., electric is typically installed by electrical franchise	
Water	LF		860 minimum	Major supply line to Whidbey Island of unknown size. Unable to provide credible estimate at 10% design. Li may be able to be incorporated into revised road prism and bridge structu	33.3
Gas	LF		NA		
Electric	LF		6,450	Three sets of overhead transmission lines located north of SR-20. Unable to provide credible estimate at 1(design. Although it is anticipated that the corridor can largely be avoided, there may be vertical clearance concerns with relocated rail line passing under the lines. Additionally several structures are located within the reactivated Telegraph Slough and may need to be relocated or reconstructed to withstand hydrodynamic loading.	33.3
Sewer	LF		NA		
Telecommunications	LF		NA		
Petroleum Pipeline	LF		860 minimum	Unable to provide credible estimate at 10% design. Major pipeline serving the refineries in Anacortes. Additional engineering studies will be required by Owner/Operator. It is likely that a parallel segment will need to installed by directional drilling methods below the potential scour depth of the reactivated channels and tied b to the existing pipeline to avoid interruptions in servic	33.3
Roadway / Railway					
Roadway (4-lane Divided Highway)	SF		486,500	4-lane divided highway with median. Refer to plans for pavement sectic	33.3
Roadway - Traffic Signal	LS			Street lights, etc. (Temporary traffic control handled under Temporary Facilitie	
Culvert (6'x6' Precast Conc. Box)	LF		120	6'x6' Precast Conc. Box	33.3
Culvert (10' Diam. Steel or RCC Jacking Pipe)	LF		850	10' Diam. Steel or RCC Jacking Pipe	33.3
Culvert - Jacking	LF				
Culvert - Horizontal Pile Driving	LF		850	Through railway	33.3
Bridge Superstructure	SF		40,800	Two 6'-6" precast concrete girder bridges, each 680 feet in lengt	33.3
Bridge - Foundations	LF		380	Drilled shaft foundation; depth 100 feet	33.3
Rail	LF		9,445	Single track, main line	33.3
Railway - Box Girder	SF		11,220	Prestressed box girder bridge, 680 feet in lengt	33.3
Railway - Foundation	LF		270	Concrete pile foundatior	33.3
Railway - Shoe fly	LF			Temporary alignment	
Permanent Access Features					
Roads	Level		NA		
Utility Access Routes	LF		6,700	Dike top all-weather gravel roa	33.3
Erosion Control Features	LF		NA		
Public Access or Recreation Features					
Trails	SF		NA		
Bridges	SF		NA		
Kiosk	EA		NA		
Restrooms	EA		NA		
Interpretive Signs	EA		NA		
Parking Area	SF		NA		
Other	EA		NA		
Vegetation & Erosion Control					
Hydroseeding	AC		9.2	Native seed grass seed mix for new dike slope	33.3
Planting	AC		1	Not possible to estimate at 10% design, but anticipate planting hummocks created from surplus materials w scrub/shrub species	33.3
Vegetation Maintenance	AC-YR		NA		
Erosion / sediment BMPs - Temp.	AC		39.4	Typical BMPs used for this project may include stabilized construction entrances, sediment ponds or settlement tanks, hydroseed or mulch to stabilize roadway embankments and dikes, and silt fen	33.3
Erosion / sediment BMPs - Permanent	AC		NA		
Waterside controls - Temporary	EA, LF, LS		NA		
Construction Management					
Construction oversight	weeks		150	Anticipated that construction may take several (3 to 4) yea	33.3
Materials testing			NA		
Design and Detailed Site Investigations					
Survey & Property, Utility Research	LS		1	% of construction cost	33.8
35% Design	LS		1	35% x 25% x Engineer's Estimate	33.8
65% design	LS		1	65% x 25% x Engineer's Estimate less the cost for 35% PS&I	33.8
90% design	LS		1	35% x 25% x Engineer's Estimate less the cost for 35% + 65%PS&I	33.8
100% design	LS		1	25% x Engineer's Estimate less previous cost	33.8
Geotechnical Studies	LS		1	Geotech study needed to design new dikes and railroad/road . Refer to design report for detailed descriptior need.	33.8
Cultural Studies	LS		1		33.8
HTWR Studies	LS		1	Parcels included in full restoration may have stored petroleum products and pesticides. These may not ha been investigated by local sponsor. Refer to design report for description of nee	33.8
Project Agreement Activities				Unable to provide credible estimate at 10% design	
Site-Specific Adaptive Management Features & Activities				List if known	
Monitoring Activities				Assume 5 crew-days/year for each monitoring parameter in design report for 5 yrs	
Monitoring (Type_)	crew-days		125		
Operations & Maintenance				Unable to provide credible estimate at 10% design	

Partial Restoration Quantity Estimate

Action Name: Telegraph Slough
Action #: 1633 and 1635 — Revised May 2012
Date: February 2011 — Revised with backcheck updates: 30 June 2011
By: S. Page and J. Bibee

REMEDY: This alternative would require removal of existing tide gates at the Swinomish Channel east dike. It would also require construction of setback dikes along the south, east, and west sides of the Telegraph Slough channel connected to the east Swinomish Channel dike south of SR 20. It would require a smaller bridge than full restoration at SR 20 and the BNSF railroad to provide a more limited tidal and freshwater connection between the Swinomish channel and Padilla Bay.
The BNSF and SR-20 would be elevated at the bridge crossings, then transition back to existing rail and road grades to the west and east. A new fish-passable culvert and tide gate would be constructed at the SE corner of the action area to connect the existing distributary channel to the SE.
Construction Period: Estimate two construction summer seasons plus limited upland work over winter - estimated 24 to 30 months total

Item	Unit of Measure	Material Name	Qty	Description of Item	Indicate section of design report where item is described
ACQUISITION AND CONSERVATION				Based on available mapping information	
Required Project Lands	Acre		130	Total land required For actioı	33.3
Proponent / Partner-owned lands	Acre		NA	Estimate of lands currently owned by Proponent (i.e., Public lands	
Lands To Be Acquired	Acre		10	Estimate land required to be acquired for action prior to implementation - Assumes 5 acres required either side of BNRR and SR-20 for larger embankment fill with locally raised rail and ro	33.3
Conservation Easements to be Secured	Acre		130	Conservation easement assumed along Telegraph Slough Alignme	33.3
Material Sites				Not Used: See Earthwork - Imported Fill.	
MOBILIZATION AND ACCESS for construction activities				Description required for each item to facilitate cost estimating	
Mobilization - Typica (Equipment, Personnel, Planning, Financial)	LS		1	Up front costs such as bonding, planning and other staff time and financing. Typically, assume 8% t 10% of other items.	33.3
Mobilization - Remote (Equipment, Personnel, Planning, Financia	LS		NA		
Site Access	LS		NA		
Barge Access	Days		20	May need barge access to excavate portions of the Swinomish Channel Dike.	33.3
Temporary Traffic Control (one of the following)				Includes installation of traffic signals, signage, signmen, etc. There are 4 types as follows:	
none	LS		NA		
signs	LS		NA		
flags / spotters	LS		NA		
unique	LS		1	Maintenance of traffic would require reducing traffic on SR 20 to a single lane in each direction, shifting traffic from west bound lanes to east bound in order to construct the bridge and improvements to west bound lanes. Process would be repeated for construction of eastbound lanes. Elements of work would include temporary paving across median, construction signage, truck-mounted variable message signs	33.3
Temporary Roadway	SF		88,000	Includes construction of temporary adjacent roadway or bypass roadways and for vehicle and pedestrian travel through or around site	33.3
Control of Water	LS		1	May need to control water for construction of new set back dikes.	33.3
Relocation Activities				Not Used: See Utilities, Structures	
Site Demolition Activities				Demolition and removal of structures (description required), temporary features and relocations, itemized separately); Clearing and grubbing of vegetation, and removal of minor debris (rocks, slabs) - description required	
Clearing and Grubbing (one or more of following)				Use one or more of the following categories of clearing and grubbing	
Clear Vegetation - Local Disposal	AC		NA	Vegetation removed above grade and disposed local	
Clear /Grub Vegetation - Local Disposal	AC		13.5	Vegetation roots also removed and disposed locally -Road/R	33.3
Clear /Grub Vegetation - Offsite Disposal	AC		1.4	Strip existing dike in areas for removal; assume 80 sf/lf of removal and 740 lf of dik	33.3
Clear /Grub Vegetation - Offsite Disposal	AC		NA		
Clear, stockpile - large woody debris	CY		NA	Vegetation is segregated and stockpiled / prepared for reuse on site	
Hydraulic Structures - Small	LS		1	Remove multi-barrel tide gate to Swinomish Chann	33.3
Hydraulic Structures - Large	LS		1	Dam removal (describe and state whether this item includes water control and sediment removal or these are in separate items	33.3
Utilities	LF		NA		
Buildings	SF		NA	Permanent structures. Based on aerial there appears to be numerous containers that are assumed to be removed by the property owne	
Pavement	LF or SF		88,000	Accounts for removal of temporary pavement only. Existing pavement would not need to be removed. It should be broken in place and roadway fill placed on to	33.3
Bulkheads	LF or SF		NA		
Rock revetments	LF, Ton or CY		NA		
Large Coastal Structures	LF, SF or CY		NA		
Demolition / Removal - Bridge	SF or CY		NA		
Removal - Misc. (e.g. angular rock from beach)	Ton		NA		
Demolition / Removal - Boat Ramp	SF		NA		
Haul - Offsite Disposal of Demolition Debris	Miles		20	Unknown location. Could be packed into containers and picked up by Waste Management In	33.3
Hazardous/Contaminated Waste Removal				These items for earthwork of quality not compatible with wetlands, requiring special handling and disposal. Describe basis for classification as contaminated or hazardous. State known or suspected contamination, describe known similar work	
Contaminated Earthwork	CY		NA		
Hazardous Earthwork	CY		NA		
Construct Temporary Features				Use as needed for unusual temporary features not included elsewhere (see TESC below)	
EARTHWORK				Expand to include equipment, etc. to facilitate cost estimating.	
Excavation	CY			Per yard excavation w/out expected haul	
Excavation - Upland	CY		41,800	Over-excavation for new west dike: assume 8 cy/lf and 5,225	33.3
Excavation - Upland	CY		44,667	Over-excavation for new east dike: assume 6.6 cy/lf and 6,700	33.3
Excavation - Lowland	CY		75,000	Excavate approximately 26 acres of accumulated sediment to elevation 4 (average excavation depth = 1.8 ft) to reconnect Telegraph Slough	33.3
Dredging - Bucket - Land	CY		6,800	Excavation below ground water or underwater; reach limited low production. Excavate new draina channel 850lf x 48' TW X 6 ft Depth	33.3
Dredging - Bucket - Marine	CY		21,430	Excavation of Swinomish Channel Dike to connect Telegraph Slough. Floating or amphibious equipme with excavator, clamshell or dragline bucket. 740 lf of dike to -5	33.3
Dredging - Hydraulic	CY		NA		
Fine Grading	AC		NA		
Fill Placement - local borrow				This is additive to Earthwork -Excavation	
Side cast	CY		NA		
Haul - uncontrolled placement	CY		NA		
Haul, place, compact	CY		NA		
Stockpile - uncontrolled placement	CY		86,467	Temporary stockpile of excavated materials for dike, road and rail fill	33.3
Stockpile - controlled placement	CY		28,230	intermediate step, for subsequent off haul or use elsewhere on site. Can use this for drying material for subsequent controlled compacted fi	33.3
Conveyor placement from stockpile land/water	CY		NA		
Imported Fill				Includes purchase, delivery and placement or as noted / described	
Select Fill	CY		107,200	Imported select material - East Dike construction. 16 cy/lf and 6,700	33.3
Select Fill	CY		121,917	Imported select material - West Dike construction. 23.3 cy/lf and 5,225 l	33.3
Select Fill	CY		236,534	Imported select material - SR-20 constructioı	33.3
Select Fill	CY		44,594	Imported select material - RR Berm constructioı	33.3
Gravel Borrow, including haul	CY		NA		
Sand / Gravel for Beach Nourishment	CY		NA		
Cobble for Shore Nourishment	CY		NA		
Embankment Compaction	CY		510,245	WSDOT standard item	33.3
Topsoil	CY		NA		
RESTORATION Features					
Channel Rehab / Creation	SF		NA		
Large Wood Placement	EA		NA		
Invasive Species Control	Acre		NA		
Physical Exclusion Devices	LF or EA		NA		
Other Restoration Features/ Activities	LS		0	Unknown if existing materials are suitable for construction of new dikes and road/rail fi	
Structures	EA				
Water Control Structures - Culverts with Gates	EA		1	2 - 60 ft long 6'x6' concrete box culverts with fish passable tide gate	
Water Control Structures - Weirs	EA		NA		
Rock Slope Protection	LF		NA		
Other	EA		NA		
Elevated Boat Ramp	SF		NA		
Fencing	SF		NA		
Utilities				Replacement or relocation. Designer to provide size and material and have separate line item for each run. Incidentals include earthwork, testing, hook up fees, etc. These quantities do not include demolition of existing utilities, real estate / easements, design fees. Describe the owner if known, and whether utility franchise will install (e.g., electric is typically installed by electrical franchise	

Partial Restoration Quantity Estimate

Action Name: Telegraph Slough
Action #: 1633 and 1635 — Revised May 2012
Date: February 2011 — Revised with backcheck updates: 30 June 2011
By: S. Page and J. Bibee

***REMEDY:** This alternative would require removal of existing tide gates at the Swinomish Channel east dike. It would also require construction of setback dikes along the south, east, and west sides of the Telegraph Slough channel connected to the east Swinomish Channel dike south of SR 20. It would require a smaller bridge than full restoration at SR 20 and the BNSF railroad to provide a more limited tidal and freshwater connection between the Swinomish channel and Padilla Bay.*
The BNSF and SR-20 would be elevated at the bridge crossings, then transition back to existing rail and road grades to the west and east. A new fish-passable culvert and tide gate would be constructed at the SE corner of the action area to connect the existing distributary channel to the SE.
Construction Period: Estimate two construction summer seasons plus limited upland work over winter - estimated 24 to 30 months total

Item	Unit of Measure	Material Name	Qty	Description of Item	Indicate section of design report where item is described
Water	LF		440 minimum	Major supply line to Whidbey Island of unknown size. Unable to provide credible estimate at 10' design. Line may be able to be incorporated into revised road prism and bridge structu	33.3
Gas	LF		NA		
Electric	LF		2000	Three sets of overhead transmission lines located north of SR-20. Unable to provide credible estima at 10% design. Although it is anticipated that the corridor can largely be avoided, there may be vertical clearance concerns with relocated rail line passing under the lines. Additionally several structures are located within the reactivated Telegraph Slough and may need to be relocated or reconstructed to withstand hydrodynamic loading.	33.3
Sewer	LF		NA		
Telecommunications	LF		NA		
Petroleum Pipeline	LF		440 minimum	Unable to provide credible estimate at 10% design. Major pipeline serving the refineries in Anacortes. Additional engineering studies will be required by Owner/Operator. It is likely that a parallel segment will need to installed by directional drilling methods below the potential scour depth of the reactivated channels and tied back to the existing pipeline to avoid interruptions in service.	33.3
Roadway / Railway					
Roadway (4-lane divided highway)	SF		233,920	4-lane divided highway with median. Refer to plans for pavement secti	33.3
Roadway - Traffic Signal	LS		NA	Street lights, etc. (Temporary traffic control handled under Temporary Faciliti	
Culvert (Precast 6' x 6' Concrete Box)	LF		120	6' x 6' precast box	33.3
Culvert - Jacking	LF		NA	Through railway	
Culvert - Horizontal Pile Driving	LF		NA	Through railway	
Bridge Superstructure	SF		25,840	Two 6'-6" precast concrete girder bridges, each 680 feet in length. Included elements such as approach slab, abutment, barriers, and railings	33.3
Bridge - Foundations	LF		152	Drilled shaft foundation; depth 100 fee	33.3
Rail	LF		9,445	Single track, main line	33.3
Railway - Box Girder	SF		5,610	Prestressed box girder bridge, 680 feet in lengt	33.3
Railway - Foundation	LF		135	Concrete pile foundation Standar	33.3
Railway - Shoe fly	LF		3,500	Temporary alignment	33.3
Permanent Access Features					
Roads	Level		NA		
Utility Access Routes	L.F.		11,925	Dike top all-weather gravel roa	33.3
Erosion Control Features	L.F.			Describe quantity of expected erosion control measure	
Public Access or Recreation Features					
Trails	SF		NA		
Bridges	SF		NA		
Kiosk	EA		NA		
restrooms	EA		NA		
Interpretive Signs	EA		NA		
Parking Area	SF		NA		
Other	EA		NA		
Vegetation & Erosion Control					
Hydroseeding	AC		17.8	Native seed grass seed mix for new dike slopes	33.3
Planting	AC		1	Not possible to estimate at 10 % design, but anticipate planting hummocks created from surplu materials with scrub/shrub species	33.3
Vegetation Maintenance	AC-YR			Includes irrigation, weeding, plant replacement for one ye	
Erosion / sediment BMPs - Temp.	AC		31.36	Typical BMPs used for this project may include stabilized construction entrances, sediment ponds or settlement tanks, hydroseed or mulch to stabilize roadway embankments and dikes, and silt fence.	33.3
Erosion / sediment BMPs - Permanent	AC		NA		
Waterside controls - Temporary	EA, LF, LS		NA		
Construction Management					
Construction oversight	weeks		100	Anticipated that construction may take several year	33.3
Materials testing			NA	Included in cost of material - no separate quantit	
Design and Detailed Site Investigations					
Survey & Property, Utility Research	LS		1	% of construction cost	33.8
35% Design	LS		1	35% x 25% x Engineer's Estimate	33.8
65% design	LS		1	65% x 25% x Engineer's Estimate less the cost for 35% PS&E	33.8
90% design	LS		1	35% x 25% x Engineer's Estimate less the cost for 35% + 65%PS&E	33.8
100% design	LS		1	25% x Engineer's Estimate less previous costs	33.8
Geotechnical Studies	LS		1	Geotech study needed to design new dike. Refer to design report for detailed description of nee	33.8
Cultural Studies	LS		1	Refer to design report for description of need	33.8
HTWR Studies	LS		1	Refer to design report for description of need	33.8
Project Agreement Activities				Unable to provide credible estimate at 10% design	
Site-Specific Adaptive Management Features & Activities				List if known	
Monitoring Activities				Assume 5 crew-days/year for each monitoring parameter in design report for 5 yrs	
Monitoring (Type_)	crew-days		125		
Operations & Maintenance				Unable to provide credible estimate at 10% design	

34. TWANOH STATE PARK BEACH RESTORATION (#1421)

Local Proponent	Washington State Parks
Delta Process Unit	NA
Shoreline Process Unit(s)	2028, 2029
Strategy(ies)	3 - Barrier Embayment
Restoration Objectives	Remove armor and fill and restore historic barrier embayment

34.1 Description of the Action

The action would remove nearshore armor and fill. Full restoration would restore a barrier embayment that was converted to a saltwater pool when the state park was created, and remove and reconfigure the existing recreational boat ramp to benefit nearshore processes. Full restoration includes actions taken along the entire park shore. Partial restoration would focus on the western and northern beaches without restoring the embayment. Please see the Introduction chapter for important information regarding PSNERP and for context related to this restoration project.

34.2 Action Area Description and Context

This action is located at Twanoh State Park on the south side of Hood Canal near Union. The Twanoh Creek watershed, which is in the Hood Canal Subbasin, is mostly undeveloped forest land. The portion within the state park is well forested, while adjacent areas are a mix of recently logged and regenerating forestland. The park is bisected by State Route 106, which runs parallel to shore. The action area is shown in Figure 34-1.

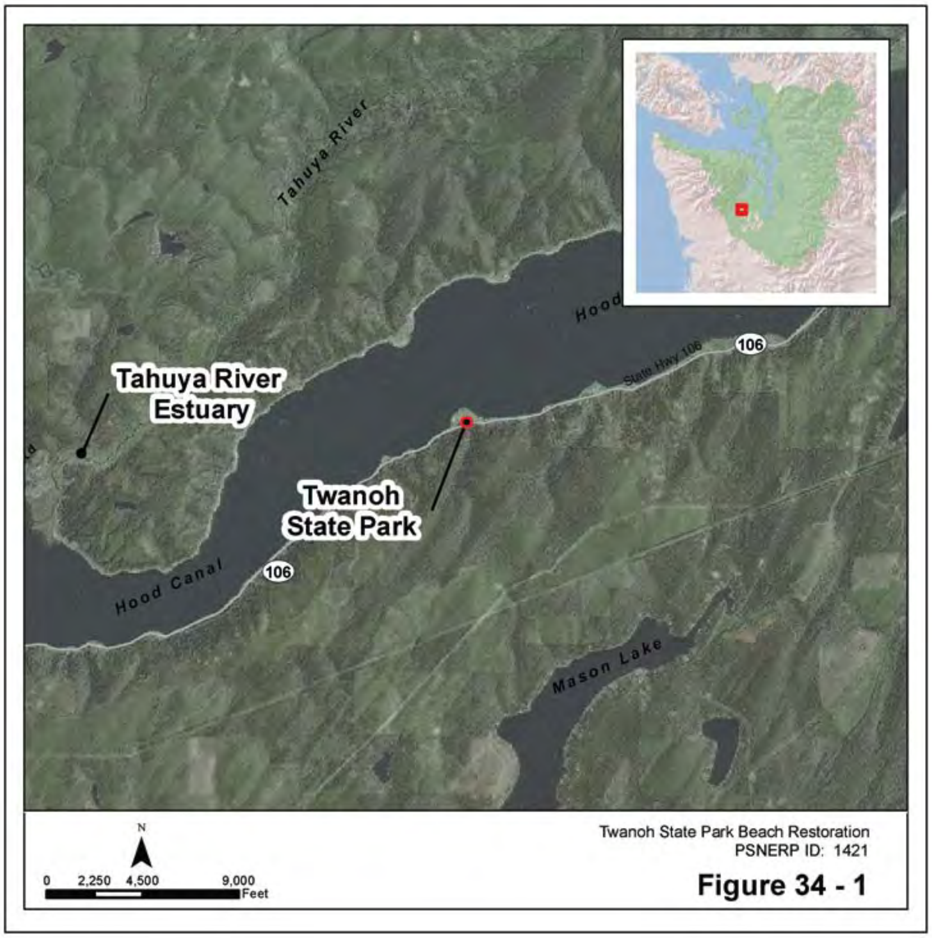


Figure 34-1. Action Area and Vicinity

34.2.1 Historic Condition

The topographic sheets (T-sheets from 1884) show a pronounced barrier spit along the east shoreline of the park (Figures 34-2A and 34-2B). The spit embayed a narrow lagoon along the shore of the larger Twanoh Creek delta. The bottom of the lagoon appeared to have gravel substrate with fringing salt marsh, from the T-sheet vegetation interpretations. A band of salt marsh extending east from the creek mouth varied in width from 50 to 200 feet. This marsh area mapped in the T-sheet extended beyond the current east boundary of the park.

West of the creek mouth, there was an additional small patch of marsh and most of the adjacent upland was labeled as "grassland." It is unclear if this was a disturbed area or a higher salt marsh plant community at the time T-sheets were prepared.

The intertidal zone was characterized as a gravel beach varying in width from 100 to 300 feet. The stream is generally in the same location now as was shown in the T-sheet. A comparison of the historic T-sheets and current LiDAR indicates that the parking, boat launch, and lawn areas are displacing much of the former salt marsh, "grassland," and the upper portion of the intertidal gravel beach and backshore.

34.2.2 Natural Environment

The Twanoh Creek delta and the historic spit on the east are the dominant shoreforms at this location. The creek delta was raised by seismic activity approximately 1,000 years ago (Shipman 2010). This “perched” delta has an extensive upland forest that is above current extreme high water elevations. Net shore-drift, although now diminished by shore armoring and reduced sediment supply, converges at the park, but overall wind/wave energy is fairly low at this location (Schwartz and Blankenship 1982, Shipman 2010). One example of the low-energy conditions is the existence of salt marsh vegetation on the upper beachface. Extensive shoreline armoring associated with residential development exists east and west of the action area.

The Twanoh Creek watershed is mostly undeveloped forest land. The portion within the state park is well forested, with recently logged and regenerating forestland in other areas. The uplands of the state park site are vegetated with sparse to dense native vegetation, including mature conifers and other native trees at the delta and on the south side of State Route 106. Parking lots directly above the armored shoreline interrupt the otherwise continuous patch of upland forests extending landward, except in two locations. These two locations are the narrow creek mouth (between armor segments) and the more extensive saltwater wading pool area. The shoreline in some areas, particularly at the stream mouth, has a narrow fringing marsh consisting largely of pickleweed and gumweed. Very little of the natural upper intertidal and supratidal zone is intact; most areas are either armored or filled.

The intertidal substrate reflects the shoreline conditions. To the east the beach is composed of pebbles, but below the armored areas, the substrate is coarse and contains significant amounts of angular rock. The sources of this rock are the toppling revetments found waterward of the parking and lawn areas on the east and west sides of the creek mouth. Surf smelt eggs were observed and identified by the WDFW area habitat biologist at the creek mouth and west of the boat launch on the intertidal gravel substrate.

Twanoh State Park tidelands support clams, oysters, and mussels with recreational shellfish harvesting of oysters and clams (Lantz 2010). The tidelands contain Olympia oysters at moderate density. Shellfish resources include enhancements by WDFW and the Skokomish Tribe, and represent an important commercial, ceremonial, and subsistence resource for Tribal members. The shellfish beds are also an important recreational resource for other, non-Tribal park users (WDFW 2010).

34.2.3 Human Environment

The development of this park dates back to the early 20th century and was implemented by the Civilian Conservation Corps (CCC). This development includes several historic park structures and view corridors. On the east side of the action area, the spit and embayment have been modified by a partially buried, vertical concrete wall, and the historic tide channel has been filled to create an enclosed, shallow, saltwater bathing area or wading pool. The concrete wall helps to contain water within the wading pool along with a manually operated tide gate, drain, and culvert. Washington State Parks cultural resource staff consider the wading pool, view corridors, and historic structures as part of the park’s CCC-era cultural landscape (Lantz 2010).

The central and western portions of the park are dominated by parking areas that drain directly to the shore and are protected by rock armor. The stream is also armored between the two parking areas. A concrete boat ramp blocks eastward net shore-drift and includes an overwater dock and float. In 1982, Schwartz and Blankenship noted a

2-meter vertical offset in the beach on either side of the boat launch as evidence of this effect (Schwartz and Blankenship 1982). A similar offset was observed in 2010. A separate pile-supported dock with moorage floats is located at the far east end of the park within the action area. Portions of the parking, lawn areas, boat launch, boat dock, and rock shoreline armor were built subsequent to the CCC era and are not considered part of the CCC-era cultural landscape (Lantz 2010). The area on the north side of State Route 106 is for day use only.

State Route 106 bisects the park and results in some intertidal fill on the west side of the park. The highway and adjacent residential development fragment the marine riparian forest from the gravel beach on the east and west ends of the park. Filling occurred along the creek banks upstream of the highway where the campground is located. The creek is conveyed under State Route 106 by a single concrete culvert that appears undersized for the range of flow and capacity of the creek. The area on the south side of the highway includes a campground. The forested area on the delta remains very similar to the historic extent.

34.3 Restoration Design Concept

34.3.1 Restoration Overview and Key Design Assumptions

The objective of the project is to restore the historic barrier embayment and ameliorate degradation of the historic beaches resulting from extensive nearshore fill and shore armor. The restoration alternatives are illustrated in Figures 34-3 through 34-6.

Full restoration would entail removal of armor from the entire shoreline, excavation of fill, and beach nourishment to restore a natural beach profile with substrate, orientation, and gradient similar to the historic shore (Figure 34-3). Partial restoration would include removal or setback of all existing armor from the western and northern beaches, as well as fill removal and beach nourishment (Figure 34-4). For both the full and partial restoration alternatives, the northeastern portion of the north beach would have a slightly more sheltered configuration with a lower gradient beach of relatively finer sediment composition, which together would facilitate the establishment of salt marsh vegetation and enhance sediment accretion processes.

The full restoration alternative at the east shore entails removal of the vertical concrete bulkhead, tide gate, and drain pipe associated with the saltwater pool. The historic tide channel and lagoon would be restored by excavating fill and regrading the lagoon bathymetry to a configuration similar to the historic extent. The southern limit of the restored lagoon would be slightly further north than the historic lagoon shore, to avoid threatening adjacent park infrastructure and cultural resources. Partial restoration at the eastern beach would maintain the current condition and use of the tidal wading pool. State Parks could consider repairing the tide gate that controls the water level within the saltwater pool to restore the function of this culturally significant feature.

Along the western shore in the partial restoration alternative, some armor would be set back and reconstructed waterward of the parking lot. This parking lot would also be raised (via fill) to prevent frequent flooding (reported by Parks staff) and to provide a sub-base for permeable paving. The key design elements associated with the full and partial restoration alternatives are summarized in Table 34-1.

Table 34-1. Key Design Elements

Element	Full Restoration	Partial Restoration
Armor Removal	Remove all armor along shore and creek mouth.	Remove shore armor along north shore and set back armor on west shore.
Barrier Beach and Lagoon	Excavate fill areas and regrade to recreate natural beach profiles throughout the park. Remove fill, historic tide gate, and culvert and excavate and restore natural tide channel and lagoon.	Excavate fill areas and regrade to restore natural beach profiles with narrower than natural beach at western shore.
Beach Nourishment	Beach nourishment to recreate a similar profile, substrate, gradient and orientation to historic conditions.	Beach nourishment to recreate a sustainable beach profile; with appropriate substrate, gradient, and orientation.
Debris Removal	Remove paving and lawn to restore beach profile and recreate marine riparian buffer. Remove broken concrete culvert from west beach and loosely dispersed rock that has fallen from armor structures.	Remove most paving and lawn to restore beach profile and recreate marine riparian buffer. Remove broken concrete culvert from west beach and loosely dispersed rock that has fallen from armor structures.
Creek Mouth	Remove fill and armor, widen and replant riparian vegetation along creek mouth.	Remove most fill and armor, widen and replant riparian vegetation along creek mouth.
Boat Ramp	Remove boat ramp that currently obstructs sediment transport along the west shore of the action area and replace with raised boat ramp.	Not included.
Twanoh Creek Culvert	Replace the culvert that conveys Twanoh Creek beneath Hwy 106 with a larger culvert (or bridge).	Not included.
Large Wood Placement	Place large woody debris along the berm crest at multiple locations.	Same as full restoration.
Revegetation	Restore marsh/dune vegetation and marine riparian upland buffer vegetation.	Same as full restoration.

34.3.2 Restoration Features – Primary Process-Based Management Measures

Armor Removal/Modification

Full restoration would entail removal of 1,253 LF of rock revetment from the waterward portions of the western and northern beaches, and approximately 260 LF of concrete bulkhead associated with the historic saltwater wading pool (Figures 34-3 and 34-5). Partial restoration would include removal of only the 1,253 LF of rock revetment from the western and northern beaches (Figures 34-4 and 34-6). Rock armor along the toe of the concrete boat ramp is recommended for removal in the full restoration alterative (approximately 180 CY).

The partial restoration alternative would also entail placement of 189 LF of vertical rockery (set back from present location along the waterward extent of the west parking lot near the boat ramp). The parking lot would be raised to 12.25 feet (NAVD88) to prevent frequent flooding and allow for sea level change. Approximately 142 feet of rock slope protection would be placed at the toe of the bank along the westernmost shore that abuts State Route 106 to prevent erosion of the road prism for both the full and partial restoration alternatives.

Berm or Dike Removal/Modification - NA

Channel Rehabilitation/Creation

Under the full restoration alternative, approximately 20,700 SF would be excavated to restore the tide channel as part of restoring the historic barrier lagoon along the eastern shore of the park (Figure 34-3). The tide gate, culvert, and drain would also be removed. With both alternatives, fill and armor around the creek mouth would be excavated and the channel area widened to slightly different extents.

Groin Removal/Modification

Full restoration would entail removal of the boat ramp located along the western shore of the park, which would be replaced with an elevated boat ramp. This would remove the groin effect and allow littoral transport to occur beneath the structure, as well as recovering beach area that is currently buried beneath the existing structure. Additional detail on this measure is provided below.

Hydraulic Modification

Installation of a larger culvert or small bridge at the State Route 106 Twanoh Creek crossing is recommended as part of full restoration. The 3-foot concrete box culvert should be replaced by a 12-foot pre-cast concrete bottomless box culvert or larger opening. Removal of the tide gate in the wading pool/lagoon is recommended for full restoration. The partial restoration does not include changes to the tide gate, but repair of the tide gate could be considered as part of a future action.

Overwater Structure Removal – NA

Topography Restoration

Fill would be excavated to recreate a natural beach profile and gradient, similar to historic conditions, for both the full and partial restoration alternatives. Full restoration would require excavation of 27,500 CY from park lowlands. Partial restoration would entail excavation of 12,000 CY from park lowlands. Topography restoration of the northeast corner of the park would also aid in the recreation of the distal end of the spit and tide channel opening elements of lagoon restoration.

For full restoration, the western parking area would be raised and paved with permeable pavement, requiring approximately 1,700 CY of material. Partial restoration would entail the addition of 2,000 CY to raise the parking lot by approximately 2.25 feet to reduce flooding, and to provide adequate sub-base for permeable paving to aid in treatment of parking lot runoff. This would also raise the (smaller) parking lot and reduce inundation periods, benefitting water quality. Some rough regrading will also be required to achieve design elevations. Partial restoration would entail regrading of approximately 200 CY of material, while rough regrading with the full restoration alternative would be approximately 300 CY.

34.3.3 Restoration Features – Additional Management Measures

Beach Nourishment

The western and northern beaches would be nourished as part of setting back the shoreline closer to the historic position, slope, substrate, and orientation in support of both full and partial restoration alternatives. Full restoration would entail 5,700 CY of beach nourishment. Partial restoration would entail 4,800 CY of beach nourishment. It is assumed that the native substrate will be suitable for the tide channel and lagoon. Subgrade soils should be evaluated to determine whether additional beach nourishment is required in these areas.

Contaminant Removal/Remediation - NA

Debris Removal

A broken, concrete culvert will be removed from the west beach as part of both the full and partial restoration alternatives. An estimated 250 tons of toppled revetment rock is loosely dispersed over the upper beach along the western and northern shores. This material is recommended for removal in both alternatives.

Invasive Species Control - NA

Large Wood Placement

Large woody debris pieces would be placed along the berm crest at the western and northern beaches. It would increase structural complexity of the barrier beaches and provide substrate for colonizing vegetation, insects, and other invertebrates (Figures 34-3 and 34-4). With the full restoration alternative, 34 pieces of large wood would be placed at 17 locations. With the partial restoration alternative, 28 pieces would be placed in 13 locations. Large wood will also be used as exclusionary devices for planting areas, where possible.

Physical Exclusion

Temporary exclusionary devices will be used around vegetation plantings to prevent trampling by humans and animals that utilize the park. Exclusion of waterfowl from the restored tidal marsh proposed as part of the full restoration alternative may also be necessary. Large woody debris will be used to create footpaths to focused access points, such as the shore of the tidal wading pool or lagoon. In total, 400 LF of physical exclusion will be utilized for both the full and partial restoration alternatives. Two interpretive signs will be placed along gravel trails and adjacent to planting areas to educate visitors about the value and objectives of the restoration.

Pollution Control - NA

Revegetation

Paving, nearshore fill, and lawn would be removed to allow for recreation of the historic salt marsh areas and to recreate a marine riparian buffer. The waterward extent of the revegetation effort along the northeast shore will consist of salt marsh vegetation assemblages (0.14 acre). A narrow band of dune/backshore vegetation would be planted slightly landward of the berm crest (0.4 acre). Riparian forest vegetation would be planted further landward along the western and northern shore (0.7 acre).

Full restoration would entail removal of 82,900 SF of pavement, and 1.24 total acres of revegetation. Partial restoration would entail removal of 52,000 SF of pavement and revegetation of approximately 1.1 acres, which includes 0.8 acre of forested marine riparian vegetation and 0.3 acres of dune/backshore vegetation assemblages.

Reintroduction of Native Animals - NA

Substrate Modification - NA

Species Habitat Enhancement - NA

34.3.4 Restoration Features – Other

Full restoration includes an elevated boat ramp (also described as groin removal) which would enable sediment transport beneath it. The adjacent floating docks would be changed to include open decking to allow light transmission. The boat ramp demolition and removal would encompass 10,000 SF.

Additional features associated with both alternatives include gravel trails that extend from the parking lots to the beach and creek mouth (Figures 34-3 and 34-4). Additional trails along the northern beach would lead visitors to the shoreline and provide access to picnic areas, the tide channel, and lagoon shore. Approximately 5,100 SF of trails will be created as part of the full restoration alternative and 3,760 SF of trails for the partial restoration alternative.

34.3.5 Land Requirements

The entire action area is owned by Washington State Parks, so no additional acquisition of private property will be required. No utilities appear to be in the area where the restoration measures would take place, although this will need to be confirmed.

34.3.6 Design Considerations

The site is owned by Washington State Parks and actively used as a recreation facility. The boat ramp is used year-round. Washington State Parks has indicated an interest in restoring the site and moving some uses (such as parking) away from the nearshore. Washington State Parks has also indicated that the wading pool is inoperable and that there are no current plans to restore it to use. The boat ramp is one of only a few in the area, and the complete removal of the ramp (and associated parking) would not be supported by Washington State Parks, although Parks stated that the ramp does not get high use. The site is considered a historic landscape, and Parks would have concerns about alteration of the historic character. Alterations will need to be done consistently with applicable historic preservation regulations. This cultural landscape includes the wading pool, many buildings, and view corridors through the site.

WDFW shellfish managers have documented specific concerns about restoration of the Twanoh Creek mouth and its potential impact on shellfish resources in the action area, including potential impacts to Skokomish Tribe Usual and Accustomed (U&A) shellfish resources and recreational shellfish use and resources (WDFW 2010). Setting back the shoreline would provide the opportunity to restore the beach profile without waterward infringement on the shellfish beds.

34.3.7 Construction Considerations

For both full and partial restoration alternatives, construction, staging, and access could be conducted from the paved park uplands. Most armor removal can be conducted with excavators from the adjacent uplands. Limited work such as removing scattered rock on the tidelands will need to be conducted from the upper beach; however, in-water work will not be required as construction could be timed to occur only during low tides.

One of the more challenging access points will be removal of the structures associated with the wading pool in the full restoration alternative, such as the eastern concrete bulkhead, which will need to be broken into pieces with a concrete hammer or saw cut and excavated in pieces. The removal of the tide gate structure and outfall pipe will also require access across the beach. Work on the beach should be avoided during the surf smelt spawning period. Sampling of forage fish spawn will likely be required to identify spawn timing and assure that spawn is not present during the construction period.

Timing and sequencing of work should progress from the shoreline moving landward, with demolition and removal of pavement and parking lots last. The existing parking lot paving will be removed, and appropriate sub-base placed to support permeable paving. Removal of loosely dispersed rock from the intertidal zone could be conducted manually in important shellfish areas. For installation of a much larger culvert to convey Twanoh Creek at State Route 106 in the full restoration alternative, work will likely need to occur in late summer when streamflow is low. A temporary flow diversion will likely be required.

34.4 Extent of Stressor Removal

Table 34-2 describes the amount of stressors to be removed with this action.

Table 34-2. Stressor Removal

Stressor	Full Restoration	Partial Restoration
Tidal Barrier (LF)	95	NA
Fill (SF)	107,000	55,400
Armor (LF)	1,513	1,442

34.5 Expected Evolution of the Action Area

The expected evolution of the Twanoh beaches without restoration would likely include additional beach erosion and narrowing as the result of the artificial (waterward) position of the shore, presence of armor, and sea level change. Sea level change along these armored shores will result in habitat loss and an overall reduction in the effectiveness of shore armor. Beach narrowing will result in decreased forage fish spawning areas and further degraded salmonid migration corridors. Paved fill areas will also be subject to increasing wave attack and will suffer continued damage.

For low-elevation areas such as the west beach, as the upper beach narrows, eventually the parking area will become inundated regularly at higher high tides. Similar impacts will likely occur along the northern beach; however, the uplands and parking lot are at slightly higher elevation and will not likely be threatened with inundation until years after the west parking lot. Parking lot runoff will continue to drain directly to the intertidal zone. The east shore will likely translate landward. The existing concrete bulkhead associated with the wading pool will likely cause additional vertical offset between the waterward and leeward sides of the spit, as natural barrier overwash and translation processes are degraded by the structure.

Full restoration would enhance the sustainability of the western shore to the greatest degree. Partial restoration would enable the west shoreline to migrate landward until it abuts the rock revetment waterward of the parking lot. The area will likely still be flooded during extreme high water events. Additionally, as the shoreline translates further landward, the western parking area could be relocated south of State Route 106 to allow for additional beach area. Restored marine riparian areas could help to reduce erosion and absorb floodwaters.

Full and partial restoration would enable full translation of the beach profile along the north shore. The full restoration alternative would allow the east beach to translate landward. Sea level change will increase the tidal prism within the lagoon to naturally sustain processes and associated habitats.

34.6 Uncertainties and Risks

It is unclear whether current sediment supply is adequate to maintain the north beach if it were nourished and moved northward. Nearshore armor is prevalent in the net shore-drift of the area.

The extent of Tribal cultural resources is not well understood at the Park and could hinder some of the planned excavation. The depth and composition of native substrate is unknown, which could alter quantities associated with beach nourishment and excavation.

34.6.1 Risks Associated with Projected Sea Level Change

Table 34-3 compares potential risks associated with projected sea level changes based on professional judgment.

Table 34-3. Risks of Sea Level Change

	Projected Sea Level Change		
	High (46cm)	**Intermediate (4cm)**	**Low (-8cm)**
Full Restoration	Landward translation of the barrier beaches with erosion of the upper beach. Increased tidal heights in lagoon could threaten park structures.	Minimal risk of landward translation of barrier beaches.	Negligible
Partial Restoration	Reduced adaptive capacity of east beach due to concrete bulkhead. Flooding of north and west parking lots possible. Upper beach loss along west shore.	Reduced adaptive capacity of east beach due to concrete bulkhead. Periodic flooding of north and west parking lots during high water events.	Negligible

34.7 Potential Monitoring Opportunities

Monitoring is important for evaluating restoration success. A combination of field surveys and aerial photographs would be used to document biological and physical changes in and around the action area. Monitoring data can be used to refine adaptive management and corrective actions, as needed. The monitoring needs and opportunities associated with this action are summarized in Table 34-4.

Table 34-4. Monitoring Needs and Opportunities

Monitoring Parameter	Key Performance Indicator	Note
Topographic Stability		
Sediment Accretion / Erosion	X	Monitor north beach and other areas as appropriate
Wood Accumulation		
Soil / Substrate Conditions		
Vegetation Establishment	X	
Marsh Surface Evolution / Accretion		
Tidal Channel Cross-Section / Density		
Water Quality (contaminants)		
Salinity		
Shellfish Production	X	Monitor effects on Tribal shellfish resources
Extent of Invasive Species		
Animal Species Richness		
Fish (salmonid) Access/Use		
Forage Fish Production	X	Monitor use of beach by surf smelt and other species
Wildlife Species Use		
Effectiveness of Exclusion Devices		

34.8 Information Needed for Preliminary Design

This conceptual design report represents an initial step in the restoration design sequence. The design concepts described above were developed based on readily available information without the level of site-specific survey and investigation that is necessary to support subsequent design and implementation. Substantial additional information will be required at the preliminary design stage to confirm the design assumptions, refine quantity estimates, address property and regulatory issues, obtain stakeholder support, and fill in data gaps. The extent to which this information is collected for preliminary design (or a later design stage) will depend upon the available budget, schedule and other factors. This section attempts to define the most essential information needs for this action.

- Topographic/Bathymetric Survey – The survey data would be used to refine design of key project elements, locate utilities, and develop detailed construction and demolition plans. Survey data could also be used as a baseline for pre- and post-construction modeling.

- Cultural Resources Investigation – Surveys for archaeological and historic resources may be required for this action area.
- Hydraulic Analysis/Modeling – Additional information on Twanoh Creek flow will need to be acquired for proper sizing of an improved crossing at State Route 106.
- Contaminant Survey – If preliminary investigations suggest that hazardous material could be present in the action area, additional soil and sediment analysis may be needed. The introductory chapter describes the Phase I site investigations that are occurring as part of this overall effort via a separate contract.
- Other - Determination of native substrate composition and depth of fill material will be required in the future, as will the depth of structures proposed for removal such as the concrete bulkhead, the tide gate, and the outfall pipe associated with the wading pool, the boat ramp footings, and the rock revetments along most of the west and north shores of the site.

34.9 Quantity Estimates

The quantity spreadsheets for the full and partial restoration alternatives are provided in Exhibits 34-1 and 34-2.

34.10 References

Lantz, 2010. Personal communication with Lisa Lantz of Washington State Parks and Recreation Commission at PSNERP Twanoh site visit, October, 2010.

Shipman, H. 2010. Personal communication with Hugh Shipman of the Department of Ecology at PSNERP Twanoh site visit, October 2010.

Schwartz and Blankenship. 1982. *Mason County Washington Net Shore Drift.* Published by Washington Department of Ecology under the name: Net Shore Drift in Washington State, Volume 4, Hood Canal Region, June 1991, Publication 00-06-033.

WDFW (Washington Department of Fish and Wildlife). 2010. Shellfish Review of PSNERP Candidate Restoration Proposals. WDFW Fish Program Memorandum from Bradbury, A. Blake, B. and C. Speck. September 2010.

0 180
Feet
0 50
Meters

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Historic Map (T-Sheet)
Action Name: Twanoh State Park Beach Restoration
PSNERP ID #: 1421
Figure 34- 2A

S:\GIS\Projects\210xxx\210337_PSNERP_NEARSHORE\Projects\2-TSheets_rev.mxd (DLP; 2/24/2011)

0 180
Feet
0 50
Meters

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64

WDFW Contract # 100-000204 (CAPS No. 10-1461)

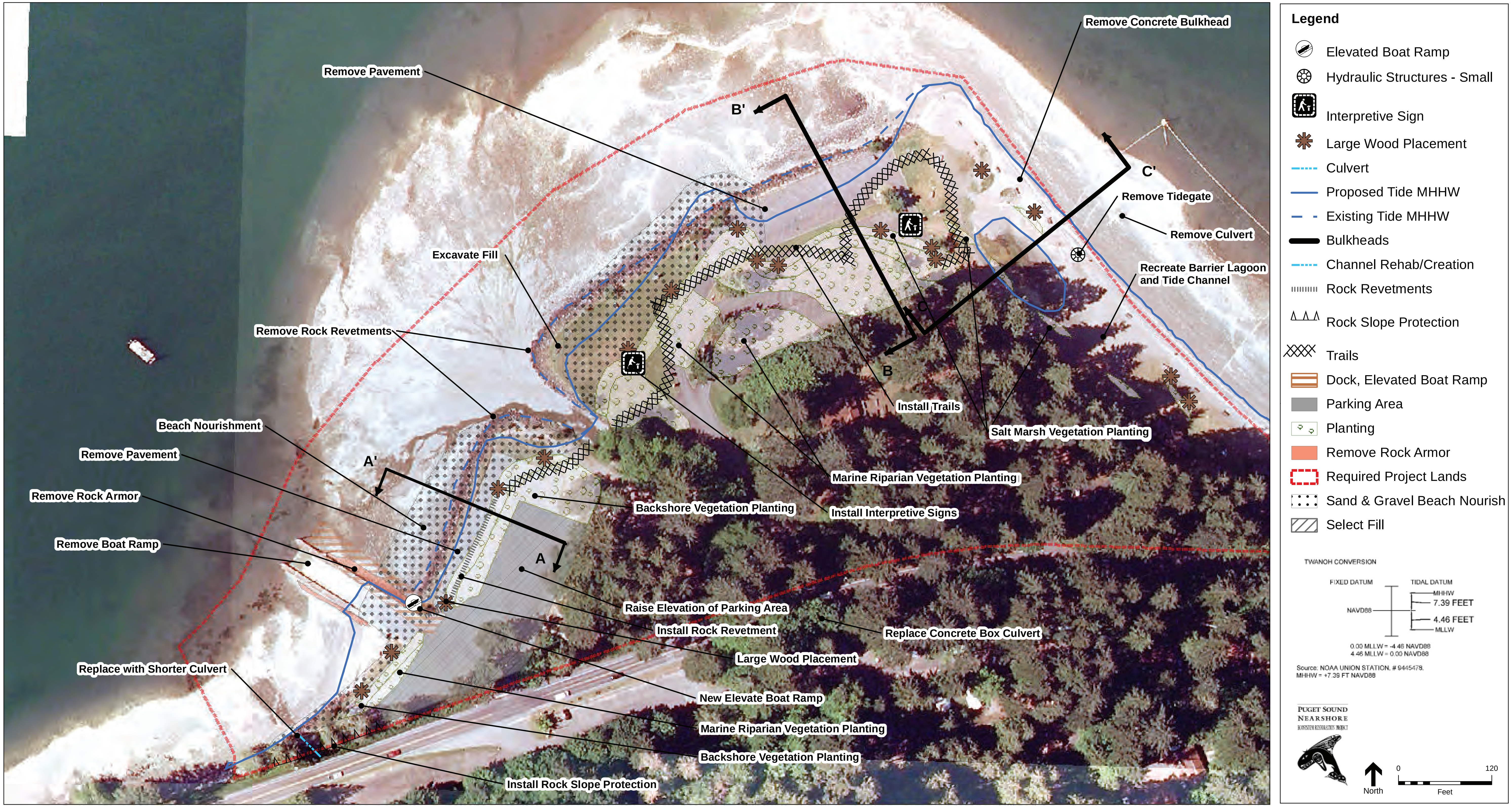
Historic Map (T-Sheet) and River History Project Data

Action Name: Twanoh State Park Beach Restoration

PSNERP ID #: 1421

Figure 34- 2B

S:\GIS\Projects\210xxx\210337_PSNERP_NEARSHORE\Projects\2-TSheets_rev.mxd (DLP; 2/24/2011)



SOURCE: Washington Public Lands Database (2006); Washington Counties Parcels (2009); Action Area (PSNERP, 2010); USGS (2009)

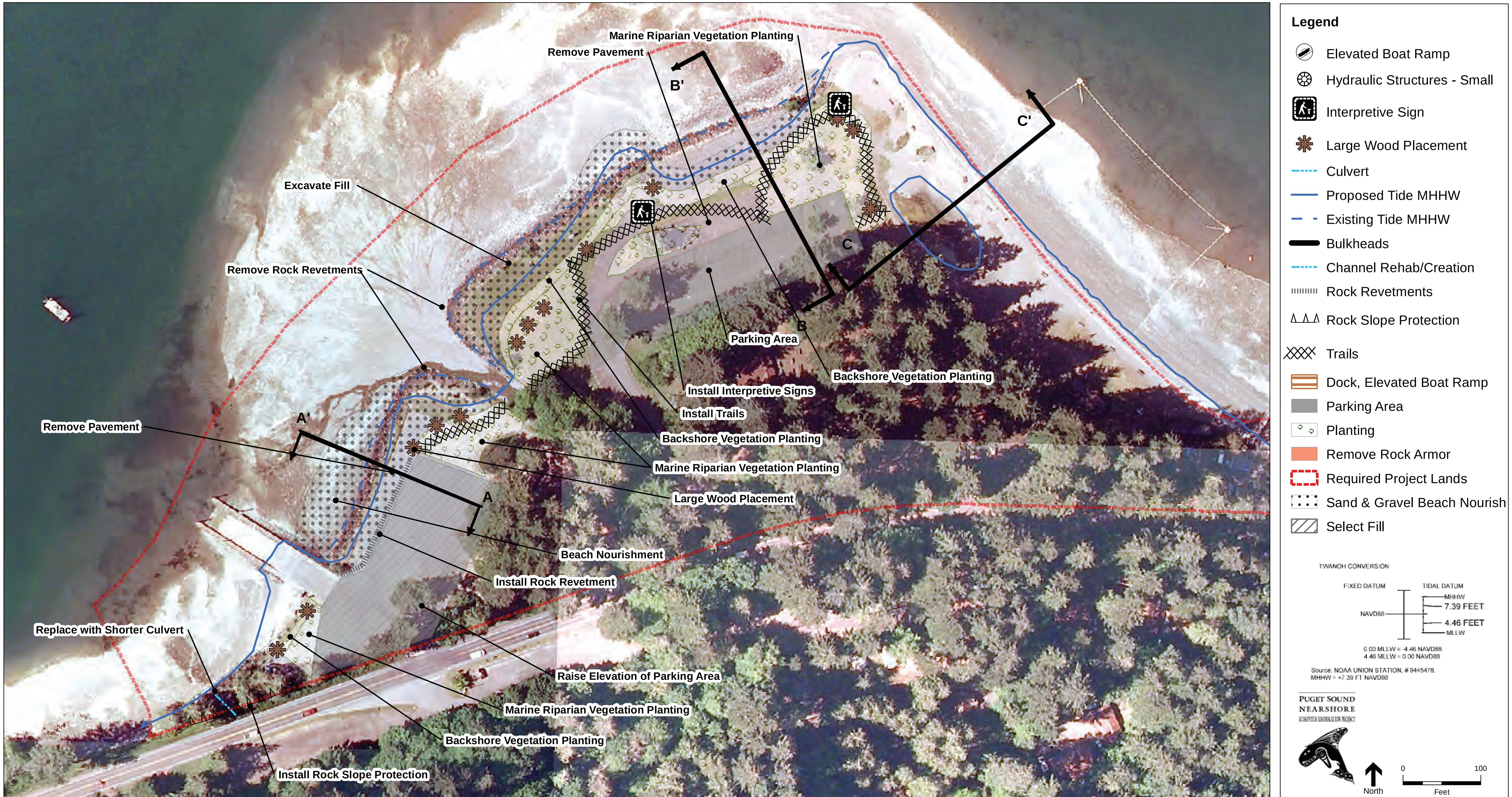
Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64

WDFW Contract # 100-000204 (CAPS No. 10-1461)

Lead Contractor: ESA
Design Lead: CGS, Jim Johannessen
Date: 2/2011

Conceptual Design Plan
Site Name: Twanoh Drift Cell
Action Name: Twanoh State Park Beach Restoration
PSNERP ID #:1421
Full Restoration

Figure 34-3



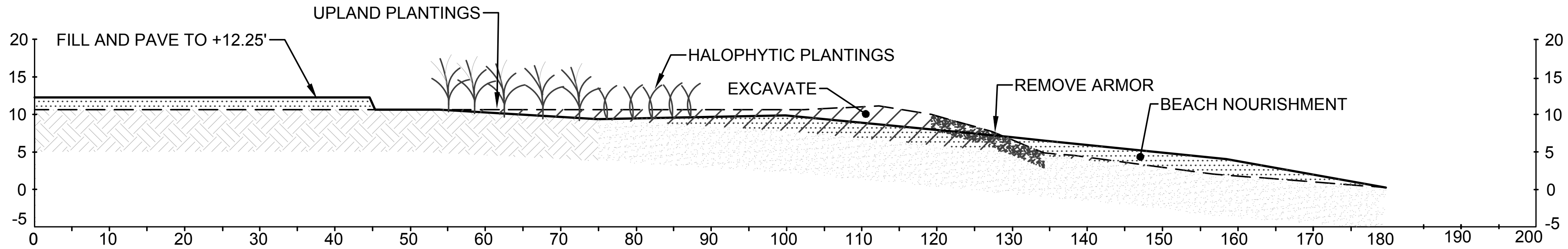
SOURCE: Washington Public Lands Database (2006); Washington Counties Parcels (2009); Action Area (PSNERP, 2010); USGS (2009)

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

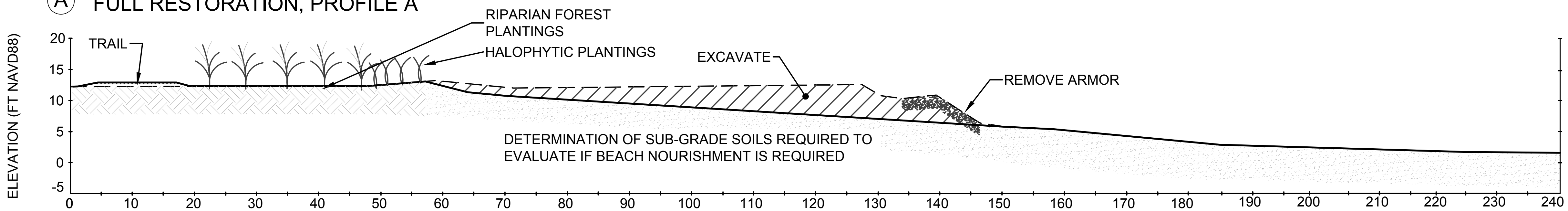
Lead Contractor: ESA
Design Lead: CGS, Jim Johannessen
Date: 2/2011

Conceptual Design Plan
Site Name: Twanoh Drift Cell
Action Name: Twanoh State Park Beach Restoration
PSNERP ID #:1421
Partial Restoration

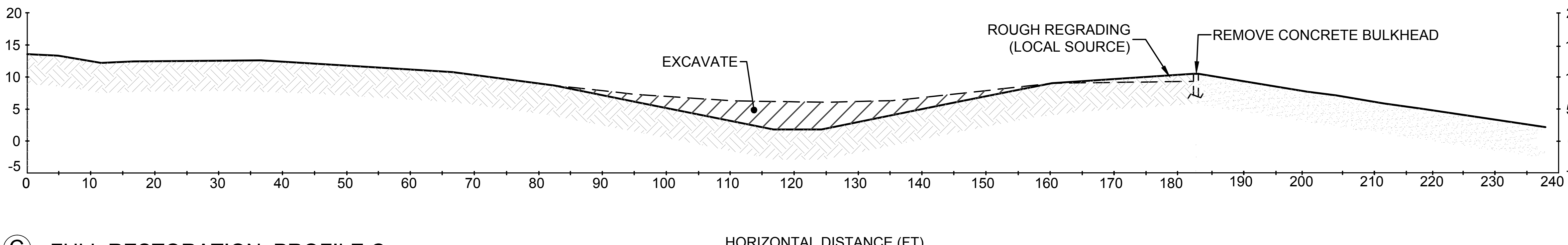
Figure 34-4



Ⓐ FULL RESTORATION, PROFILE A



Ⓑ FULL RESTORATION, PROFILE B



Ⓒ FULL RESTORATION, PROFILE C

TWANOH CONVERSION

FIXED DATUM — TIDAL DATUM

NAVD88 — MHHW 7.39 FEET; 4.46 FEET MLLW

0.00 MLLW = -4.46 NAVD88
4.46 MLLW = 0.00 NAVD88

Source: NOAA UNION STATION, # 9445478.
MHHW = +7.39 FT NAVD88

EXISTING GRADE HATCH: BEACH, OTHER

PROPOSED GRADE HATCH: CUT, FILL

EXISTING GRADE ------- PROPOSED GRADE ———

0 20
Scale in Feet

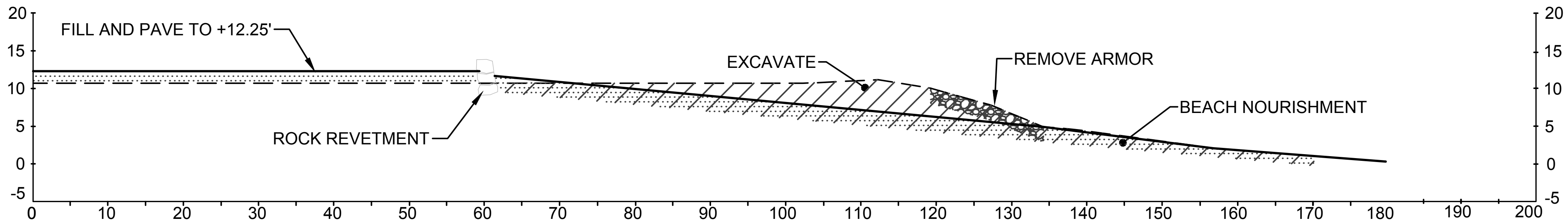
PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: CGS
Date: 3/2011

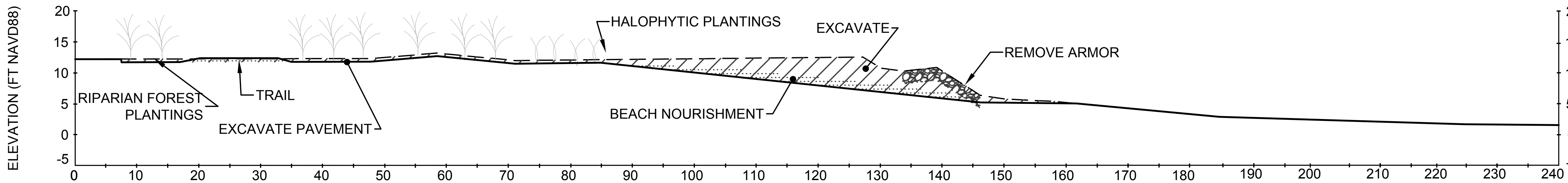
Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Section
SITE NAME: **Twanoh Drift Cell**
ACTION NAME: **Twanoh State Park Beach Restoration**
PSNERP ID#: **1421**
Full Restoration

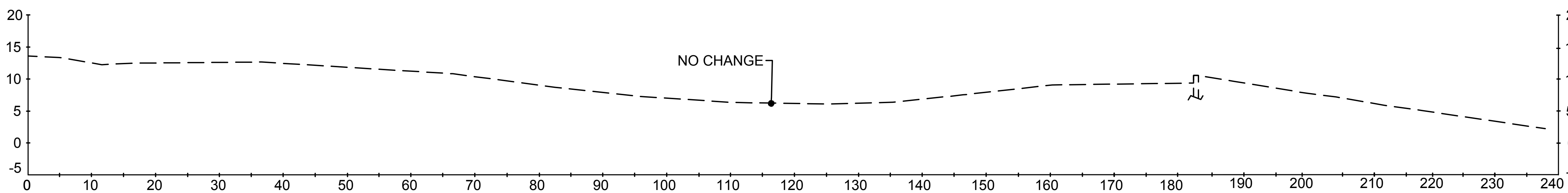
Figure 34-5



Ⓐ PARTIAL RESTORATION, PROFILE A

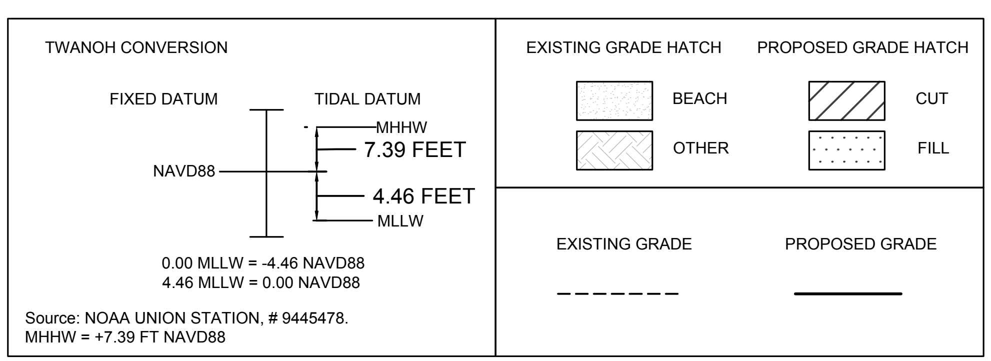


Ⓑ PARTIAL RESTORATION, PROFILE B



Ⓒ PARTIAL RESTORATION, PROFILE C

HORIZONTAL DISTANCE (FT)



PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: CGS
Date: 3/2011

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Section
SITE NAME: **Twanoh Drift Cell**
ACTION NAME: **Twanoh State Park Beach Restoration**
PSNERP ID#: **1421**
Partial Restoration

Figure 34-6

Full Restoration Quantity Estimate

Action Name: Twanoh State Park Beach Restoration
Action #: 1421
Date: February 2011
By: Coastal Geologic Services, Inc.

REMEDY: ***Removal of boat ramp, rock revetments, fill, concrete bulkhead and tide gate and installation of a new elevated boat ramp, beach nourishment, revegetation of salt marsh, backshore, and marine riparian vegetation. Some additional park features will be added, including trails, interpretive signs, and a new elevated parking area to alleviate innudation during winter storms.***

Construction Period: 15 weeks for demolition and haul out, beach reshaping and nourishment, and construction of restoration features

	Item	Unit of Measure	Material Name	Qty	Description of Item	Indicate section of design report where item is described
ACQUISITION AND CONSERVATION						
	Required Project Lands	Acre		16	Required Project Lands are owned by Washington State Parks.	34.3.5 Land Requirements
	Proponent / Partner-owned lands	Acre		16	Washington State Parks is owner of the land where restoration will occur and is a willing landowner.	34.3.5 Land Requirements
	Lands To Be Acquired	Acre		NA	Not Applicable to Action	
Material Sites						
MOBILIZATION AND ACCESS for construction activities						
	Mobilization - Typical (Equipment, Personnel, Planning, Financial)	LS		1	Up front costs such as bonding, planning and other staff time and financing. Typically, assume 8% to 10% of other items.	
	Mobilization - Remote (Equipment, Personnel, Planning, Financial)	LS		0	Up front cost for nontypical or remote locations. Assume 12% of other items	
	Site Access	LS		0	Use for special situations (e.g.. new bridge, new access roads) for the purposes of construction access. Include description.	
	Barge Access	Days		0	Not Applicable to Action	
	Temporary Traffic Control (one of the following)				Includes installation of traffic signals, signage, signmen, etc. There are 4 types as follows:	
	none	LS		0	Not Applicable to Action	
	signs	LS		0	Not Applicable to Action	
	flags / spotters	LS		1	Flags and spotters = signs plus entails a greater level of effort. Describe the duration of this activity. This can be about 3% of total roadway costs.	
	unique	LS		0	Not Applicable to Action	
	Temporary Roadway	SF		0	Not Applicable to Action	
	Control of Water	LS		0	Not Applicable to Action	
Relocation Activities						
Site Demolition Activities						
	Clearing and Grubbing (one or more of following)				Use one or more of the following categories of clearing and grubbing	
	Clear Vegetation - Local Disposal	AC		0	Not Applicable to Action	
	Clear /Grub Vegetation - Local Disposal	AC		0	Not Applicable to Action	
	Clear /Grub Vegetation - Offsite Disposal	AC		0	Not Applicable to Action	
	Clear, stockpile - large woody debris	CY		0	Not Applicable to Action	
	Hydraulic Structures - Small	LS		3000	Removal of tide gatem drain, and associated culvert from east beach at approximately 10 ft elevation NAVD 88	
	Hydraulic Structures - Large	LS		0	Not Applicable to Action	
	Utilities	LS or LF			Not Applicable to Action	
	Buildings	LS or SF			Not Applicable to Action	
	Pavement	SF		82,900	Pavement for parking lot overlies fill material.	34.3.3 Restoration Features - Additional Management Measures: Revegetation
	Bulkheads	LF		260	Concrete bulkhead along east shore of park.	34.3.3 Restoration Features - Additional Management Measures: Armor Removal
	Rock revetments	CY		1,300	Rock revetment at waterward edge of fill area alongnorth and west shore.	34.3.3 Restoration Features - Additional Management Measures: Armor Removal
	Large Coastal Structures	LF, SF or CY		0	Not Applicable to Action	
	Demolition / Removal - Bridge	SF or CY		0	Not Applicable to Action	
	Removal - Misc. (e.g. angular rock from beach)	Ton		250	Loose rock scattered across intertidal waterward of the rock revetment.	34.3.3 Restoration Features - Additional Management Measures: Debris Removal
	Demolition / Removal - Boat Ramp	SF		10,000	Remove boat ramp and surrounding rock armor, replace with elevated boat ramp	34.3.3 Restoration Features - Additional Management Measures: Groin Removal
	Haul - Offsite Disposal of Demolition Debris	Miles		20	Placeholder distance (to nearest 10 miles) to disposal site for materials, veg clear and grub, etc.	
Hazardous/Contaminated Waste Removal						
	Contaminated Earthwork	CY		0	Not Applicable to Action	
	Hazardous Earthwork	CY		0	Not Applicable to Action	
Construct Temporary Features						
EARTHWORK						
	Excavation	CY		300	Rough grading of fill material if adequate	34.3.2 Restoration Features - Primary Management Measures: Topographic Restoration
	Excavation - Upland	CY		0	Not Applicable to Action	
	Excavation - Lowland	CY		27,500	Excavate fill retained behind rock revetment to restore the natural beach profile and re-create historic lagoon and tide channel.	34.3.2 Restoration Features - Primary Management Measures: Topographic Restoration
	Dredging - Bucket - Land	CY		0	Not Applicable to Action	
	Dredging - Bucket - Marine	CY		0	Not Applicable to Action	
	Dredging - Hydraulic	CY		0	Not Applicable to Action	
	Fine Grading	AC		0	Not Applicable to Action	
	Fill Placement - local borrow				This is additive to Earthwork -Excavation	
	Side cast	CY		0	Not Applicable to Action	
	Haul - uncontrolled placement	CY		0	Not Applicable to Action	
	Haul, place, compact	CY		0	Not Applicable to Action	
	Stockpile - uncontrolled placement	CY		0	Not Applicable to Action	
	Stockpile - controlled placement	CY		0	Not Applicable to Action	
	Conveyor placement from stockpile land/water	CY		0	Not Applicable to Action	
	Imported Fill				Includes purchase, delivery and placement or as noted / described	
	Select Fill	CY		1,700	Imported select material to fill parking lot and raise to 12.25 ft elevation and reduce innudation during winter storms.	34.3.2 Restoration Features - Primary Management Measures: Topographic Restoration
	Gravel Borrow, including haul	CY		0	Not Applicable to Action	
	Sand / Gravel for Beach Nourishment	CY		5,700	Pebbly sand pit run from local gravel pit	34.3.3 Restoration Features - Additional Management Measures: Beach Nourishment
	Cobble for Shore Nourishment	CY		0	Not Applicable to Action	
	Embankment Compaction	CY		0	Not Applicable to Action	
	Topsoil	CY		0	Not Applicable to Action	
RESTORATION Features						
	Channel Rehab / Creation	SF		20,700	Re-create barrier lagoon and tide channel, calculation taken from plan view area GIS of excavation-low	34.3.2 Restoration Features - Primary Management Measures: Channel Rehabilitation
	Large Wood Placement	EA		34	17 groups of logs with 2-3 per group, using as physical exclusion and erosion control	34.3.3 Restoration Features - Additional Management Measures: Large Wood Placement
	Invasive Species Control	Acre		0	Not Applicable to Action	
	Physical Exclusion Devices	LF or EA		400 LF	Fencing placed around vegetation plantings	34.3.3 Restoration Features - Additional Management Measures: Physical Exclusion
	Other Restoration Features/ Activities	LS		0	Not Applicable to Action	
Structures		EA			KPFF to provide additional inputs	
	Water Control Structures - Culverts with Gates	EA			Not Applicable to Action	
	Water Control Structures - Weirs	EA			Not Applicable to Action	
	Rock Slope Protection	LF		140	Install rock slope protection near Hwy 106 using large boulders	
	Other	EA		0	Not Applicable to Action	
	Elevated Boat Ramp	SF		7,100	Pier supported elevated boat ramp to allow sediment drift	34.3.4 Restoration Features - Other
	Fencing	SF			Not Applicable to Action	
Utilities						
	Water	LF		0	Not Applicable to Action	
	Gas	LF		0	Not Applicable to Action	
	Electric	LF		0	Not Applicable to Action	
	Sewer	LF		0	Not Applicable to Action	
	Telecommunications	LF		0	Not Applicable to Action	
	Other	LF		0	Not Applicable to Action	
Roadway / Railway						
	Roadway (Type)	SF			Not Applicable to Action	
	Roadway - Traffic Signal	LS			Not Applicable to Action	

Full Restoration Quantity Estimate

	Action Name:	Twanoh State Park Beach Restoration					
	Action #:	1421					
	Date:	February 2011					
	By:	Coastal Geologic Services, Inc.					

REMEDY: ***Removal of boat ramp, rock revetments, fill, concrete bulkhead and tide gate and installation of a new elevated boat ramp, beach nourishment, revegetation of salt marsh, backshore, and marine riparian vegetation. Some additional park features will be added, including trails, interpretive signs, and a new elevated parking area to alleviate innudation during winter storms.***

Construction Period: 15 weeks for demolition and haul out, beach reshaping and nourishment, and construction of restoration features

	Item	Unit of Measure	Material Name	Qty	Description of Item		Indicate section of design report where item is described
	Culvert (concrete-broken)			45	Replace 18" HDPE (or shorten) culvert at southwest end of park near SR 106		34.3.3 Restoration Features - Additional Management Measures: Debris Removal
	Culvert (tide gate)			110	Remove culvert associated with tide gate		
	Culvert (box culvert)	LF		32	Remove 3 ft concrete box culvert and install 12 ft pre-cast concrete bottomless box culvert		34.3.2 Restoration Features - Primary Management Measures: Hydraulic Modification
	Culvert - Jacking	LF			Not Applicable to Action		
	Culvert - Horizontal Pile Driving	LF			Not Applicable to Action		
	Bridge - Foundations, Deck and appurtenances	SF			Not Applicable to Action		
	Railway - Box Girder	SF			Not Applicable to Action		
	Railway - Foundation	LF			Not Applicable to Action		
	Railway - Shoe fly	LF			Not Applicable to Action		
Permanent Access Features							
	Roads	Level			Not Applicable to Action		
	Utility Access Routes	varies			Not Applicable to Action		
	Erosion Control Features	L.F.			Not Applicable to Action		
Public Access or Recreation Features							
	Trails	SF		5,100	Gravel or mulch trails approximately 5 ft wide.		34.3.4 Restoration Features - Other
	Bridges	SF			Not Applicable to Action		
	Kiosk	EA			Not Applicable to Action		
	Restrooms	EA			Not Applicable to Action		
	Interpretive Signs	EA		2	2 interpretive signs intsalled near trails and beach		
	Parking Area	SF		29,000	The parking areas are reduced to recover more natural backshore, potentially made of asphalt or permeable concrete.		
	Other	EA			Not Applicable to Action		
Vegetation & Erosion Control							
	Hydroseeding	AC			Not Applicable to Action		
	Planting	AC		1.24 (total), 0.14 (SM), 0.40 (BK), 0.70 (MR)	Salt marsh (SM), backshore (BK) vegetation unit area and marine riparian (MR) vegetation unit areas will be planted in the restoration area.		34.3.3 Restoration Features - Additional Management Measures: Revegetation
	Vegetation Maintenance	AC-YR		0	Not Applicable to Action		
	Erosion / sediment BMPs - Temp.	AC		0	Not Applicable to Action		
	Erosion / sediment BMPs - Permanent	AC		0	Not Applicable to Action		
	Waterside controls - Temporary	EA, LF, LS		0	Not Applicable to Action		
Construction Management							
	Construction oversight	weeks		15	demolition and haul out, beach reshaping and nourishment, and construction of restoration features		
	Materials testing				Included in cost of material - no separate quantity		
Design and Detailed Site Investigations							
	Survey & Property, Utility Research	LS		1	% of construction cost		
	35% Design	LS		1	35% x 25% x Engineer's Estimate		
	65% design	LS		1	65% x 25% x Engineer's Estimate less the cost for 35% PS&E		
	90% design	LS		1	35% x 25% x Engineer's Estimate less the cost for 35% + 65%PS&E		
	100% design	LS		1	25% x Engineer's Estimate less previous costs		
	Geotechnical Studies				Refer to design report for description of need		
	Cultural Studies			1	Refer to design report for description of need		
	HTWR Studies				Refer to design report for description of need		
Project Agreement Activities					Unable to provide credibale estimate at 10% design		
Site-Specific Adaptive Management Features & Activities					List if known		
Monitoring Activities					Assume 5 crew-days/year for each monitoring parameter in design report for 5 yrs		
	Monitoring (Type_)	crew-days		100			
Operations & Maintenance					Unable to provide credible estimate at 10% design		

Partial Restoration Quantity Estimate

Action Name: Twanoh State Park Beach Restoration
Action #: 1421
Date: February 2011
By: Coastal Geologic Services, Inc.

REMEDY: ***Removal of rock revetment, fill, and beach nourishment, revegetation of backshore, and marine riparian vegetation. Some additional park features will also be added, including trails, interpretive signs, and a new elevated parking area to alleviate innudation during winter storms.***

Construction Period: 11 weeks for demolition and haul out, beach reshaping and nourishment, and construction of restoration features

	Item	Unit of Measure	Material Name	Qty	Description of Item		Indicate section of design report where item is described
ACQUISITION AND CONSERVATION					Based on available mapping information		
	Required Project Lands	Acre		16	Required Project Lands are owned by Washington State Parks.		34.3.5 Land Requirements
	Proponent / Partner-owned lands	Acre		16	Washington State Parks is owner of the land where restoration will occur and is a willing landowner.		34.3.5 Land Requirements
	Lands To Be Acquired	Acre		NA	Not Applicable to Action		
Material Sites					Not Used: See Earthwork - Imported Fill.		
MOBILIZATION AND ACCESS for construction activities					Description required for each item to facilitate cost estimating		
	Mobilization - Typical (Equipment, Personnel, Planning, Financial)	LS		0	Up front costs such as bonding, planning and other staff time and financing. Typically, assume 8% to 10% of other items.		
	Mobilization - Remote (Equipment, Personnel, Planning, Financial)	LS		0	Up front cost for nontypical or remote locations. Assume 12% of other items		
	Site Access	LS		0	Use for special situations (e.g.. new bridge, new access roads) for the purposes of construction access. Include description.		
	Barge Access	Days		0	Not Applicable to Action		
	Temporary Traffic Control (one of the following)				Includes installation of traffic signals, signage, signmen, etc. There are 4 types as follows:		
	none	LS		0	None = no traffic control		
	signs	LS		0	Signs = signs only, costs typically around 1% of total roadway costs		
	flags / spotters	LS		1	Flags and spotters = signs plus entails a greater level of effort. Describe the duration of this activity. This can be about 3% of total roadway costs.		
	unique	LS		0	Not Applicable to Action		
	Temporary Roadway	SF		0	Not Applicable to Action		
	Control of Water	LS		0	Not Applicable to Action		
Relocation Activities					Not Used: See Utilities, Structures		
Site Demolition Activities					Demolition and removal of structures (description required), temporary features and relocations, itemized separately); Clearing and grubbing of vegetation, and removal of minor debris (rocks, slabs) - description required.		
	Clearing and Grubbing (one or more of following)				Use one or more of the following categories of clearing and grubbing		
	Clear Vegetation - Local Disposal	AC		0	Not Applicable to Action		
	Clear /Grub Vegetation - Local Disposal	AC		0	Not Applicable to Action		
	Clear /Grub Vegetation - Offsite Disposal	AC		0	Not Applicable to Action		
	Clear, stockpile - large woody debris	CY		0	Not Applicable to Action		
	Hydraulic Structures - Small	LS		0	Not Applicable to Action		
	Hydraulic Structures - Large	LS		0	Not Applicable to Action		
	Utilities	LS or LF		0	Not Applicable to Action		
	Buildings	LS or SF		0	Not Applicable to Action		
	Pavement	SF		52000	Pavement for parking lot overlies fill material.		34.3.3 Restoration Features - Additional Management Measures: Revegetation
	Bulkheads	LF or SF		0	Not Applicable to Action		
	Rock revetments	CY		1300	Rock revetments at waterward edge of fill at north and majority of the west shore.		34.3.2 Restoration Features - Primary Management Measures: Armor Removal
	Large Coastal Structures	LF, SF or CY		0	Not Applicable to Action		
	Demolition / Removal - Bridge	SF or CY		0	Not Applicable to Action		
	Removal - Misc. (e.g. angular rock from beach)	Ton		250	Loose rock scattered across intertidal waterward of the rock revetment.		34.3.3 Restoration Features - Additional Management Measures: Debris Removal
	Demolition / Removal - Boat Ramp	SF		0	Not Applicable to Action		
	Haul - Offsite Disposal of Demolition Debris	Miles		20	Placeholder distance (to nearest 10 miles) to disposal site for materials, veg clear and grub, etc.		
Hazardous/Contaminated Waste Removal							
	Contaminated Earthwork	CY		0	Not Applicable to Action		
	Hazardous Earthwork	CY		0	Not Applicable to Action		
Construct Temporary Features							
EARTHWORK							
	Excavation	CY		200	Rough grading of fill material if adequate		34.3.2 Restoration Features - Primary Management Measures: Topographic Restoration
	Excavation - Upland	CY		0	Not Applicable to Action		
	Excavation - Lowland	CY		12,000	Excavate fill retained behind rock revetment to restore the natural beach profile.		34.3.2 Restoration Features - Primary Management Measures: Beach Nourishment
	Dredging - Bucket - Land	CY		0	Not Applicable to Action		
	Dredging - Bucket - Marine	CY		0	Not Applicable to Action		
	Dredging - Hydraulic	CY		0	Not Applicable to Action		
	Fine Grading	AC		0	Not Applicable to Action		
	Fill Placement - local borrow				This is additive to Earthwork -Excavation		
	Side cast	CY		0	Not Applicable to Action		
	Haul - uncontrolled placement	CY		0	Not Applicable to Action		
	Haul, place, compact	CY		0	Not Applicable to Action		
	Stockpile - uncontrolled placement	CY		0	Not Applicable to Action		
	Stockpile - controlled placement	CY		0	Not Applicable to Action		
	Conveyor placement from stockpile land/water	CY		0	Not Applicable to Action		
	Imported Fill				Includes purchase, delivery and placement or as noted / described		
	Select Fill	CY		2,000	Imported select material to fill parking lot and raise to 12.25 ft elevation and reduce innudation during winter storms.		2.3.2 Restoration Features - Primary Management Measures: Topographic Restoration
	Gravel Borrow, including haul	CY		0	Not Applicable to Action		
	Sand / Gravel for Beach Nourishment	CY		4,800	Pebbly sand pit run from local gravel pit		2.3.3 Restoration Features - Additional Management Measures: Beach Nourishment
	Cobble for Shore Nourishment	CY		0	Not Applicable to Action		
	Embankment Compaction	CY		0	Not Applicable to Action		
	Topsoil	CY		0	Not Applicable to Action		
RESTORATION Features							
	Channel Rehab / Creation	SF		0	Channel construction (SF) including imported sediment and habitat materials, excluding excavation		
	Large Wood Placement	EA		28	13 groups of logs with 2-3 per group, using as physical exclusion and erosion control		2.3.3 Restoration Features - Additional Management Measures: Large Wood Placement
	Invasive Species Control	Acre		0	Not Applicable to Action		
	Physical Exclusion Devices	LF		400	Fencing placed around vegetation plantings		2.3.3 Restoration Features - Additional Management Measures: Physical Exclusion
	Other Restoration Features/ Activities	LS		0	Describe other items not included elsewhere		
Structures		EA					
	Water Control Structures - Culverts with Gates	EA		0	Not Applicable to Action		
	Water Control Structures - Weirs	EA		0	Not Applicable to Action		
	Rock Slope Protection	LF		140	Install rock slope protection near Hwy 106 using large boulders		
	Other	EA		190	Install rock revetment on waterward side of boat ramp parking area using large boulders stacked 3 high.		
	Elevated Boat Ramp	SF		0	Not Applicable to Action		
	Fencing	SF		0	Not Applicable to Action		
Utilities							
	Water	LF		0	Not Applicable to Action		
	Gas	LF		0	Not Applicable to Action		
	Electric	LF		0	Not Applicable to Action		
	Sewer	LF		0	Not Applicable to Action		

Partial Restoration Quantity Estimate

Action Name: Twanoh State Park Beach Restoration
Action #: 1421
Date: February 2011
By: Coastal Geologic Services, Inc.

REMEDY: ***Removal of rock revetment, fill, and beach nourishment, revegetation of backshore, and marine riparian vegetation. Some additional park features will also be added, including trails, interpretive signs, and a new elevated parking area to alleviate innudation during winter storms.***

Construction Period: 11 weeks for demolition and haul out, beach reshaping and nourishment, and construction of restoration features

	Item	Unit of Measure	Material Name	Qty	Description of Item		Indicate section of design report where item is described
	Telecommunications	LF		0	Not Applicable to Action		
	Other	LF		0	Not Applicable to Action		
Roadway / Railway							
	Roadway (Type)	SF		0	Not Applicable to Action		
	Roadway - Traffic Signal	LS		0	Not Applicable to Action		
	Culvert (concrete-broken)	LF		45	Replace 18" HDPE (or shorten) culvert at southwest end of park near SR 106		34.3.3 Restoration Features - Additional Management Measures: Debris Removal
	Culvert - Jacking	LF		0	Not Applicable to Action		
	Culvert - Horizontal Pile Driving	LF		0	Not Applicable to Action		
	Bridge - Foundations, Deck and appurtenances	SF		0	Not Applicable to Action		
	Railway - Box Girder	SF		0	Not Applicable to Action		
	Railway - Foundation	LF		0	Not Applicable to Action		
	Railway - Shoe fly	LF		0	Not Applicable to Action		
Permanent Access Features							
	Roads	Level			Not Applicable to Action		
	Utility Access Routes	varies			Not Applicable to Action		
	Erosion Control Features	L.F.			Not Applicable to Action		
Public Access or Recreation Features							
	trails	SF		3,500	Gravel or mulch trails approximately 5 ft wide.		34.3.4 Restoration Features - Other
	bridges	SF		0	Not Applicable to Action		
	kiosk	EA		0	Not Applicable to Action		
	restrooms	EA		0	Not Applicable to Action		
	Interpretive Signs	EA		2	2 interpretive signs intsalled near trails and beach		
	parking area	SF		64,450	The parking areas are reduced and removed to recover more natural backshore, potentially made of asphalt or permeable concrete.		
	Other	EA		0	Not Applicable to Action		
Vegetation & Erosion Control							
	Hydroseeding	AC		0	Not Applicable to Action		
	Planting	AC		1.08 (total), 0.30 (BK), 0.79 (MR)	Backshore (BK) vegetation unit area and marine riparian (MR) vegetation unit areas will be planted in the restoration area.		34.3.3 Restoration Features - Additional Management Measures: Revegetation
	Vegetation Maintenance	AC-YR		0	Not Applicable to Action		
	Erosion / sediment BMPs - Temp.	AC		0	Not Applicable to Action		
	Erosion / sediment BMPs - Permanent	AC		0	Not Applicable to Action		
	Waterside controls - Temporary	EA, LF, LS		0	Not Applicable to Action		
Construction Management							
	Construction oversight	weeks		11	demolition and haul out, beach reshaping and nourishment, and construction of restoration features		
	Materials testing				Included in cost of material - no separate quantity		
Design and Detailed Site Investigations							
	Survey & Property, Utility Research	LS		1	% of construction cost		
	35% Design	LS		1	35% x 25% x Engineer's Estimate		
	65% design	LS		1	65% x 25% x Engineer's Estimate less the cost for 35% PS&E		
	90% design	LS		1	35% x 25% x Engineer's Estimate less the cost for 35% + 65%PS&E		
	100% design	LS			25% x Engineer's Estimate less previous costs		
	Geotechnical Studies				Refer to design report for description of need		
	Cultural Studies			1	Refer to design report for description of need		
	HTWR Studies				Refer to design report for description of need		
Project Agreement Activities					Unable to provide credibale estimate at 10% design		
Site-Specific Adaptive Management Features & Activities					List if known		
Monitoring Activities					Assume 5 crew-days/year for each monitoring parameter in design report for 5 yrs		
	Monitoring (Type)	crew-days		100			
Operations & Maintenance					Unable to provide credible estimate at 10% design		

35. WASHINGTON HARBOR TIDAL HYDROLOGY RESTORATION PROJECT (#1237)

Local Proponent	Jamestown S'Klallam Tribe
Delta Process Unit	NA
Shoreline Process Unit(s)	1020, 1021
Strategy(ies)	4 – Coastal Inlet
Restoration Objectives	Remove fill, dikes, and armoring to restore tidal hydrology and sediment transport processes and reconnect historic salt marsh, tidal channel, and barrier beach habitats

35.1 Description of the Action

This action would enhance tidal exchange and fish passage through Washington Harbor by removing a sewer maintenance access road and road embankment fill that cross the harbor. A sewer pipe located within the access road would be replaced with either an underground or a bridge-mounted pipe. Dikes at the north end of the action area would also be removed. Please see the Introduction chapter for important information regarding PSNERP and for context related to this restoration project.

35.2 Action Area Description and Context

Washington Harbor (also known as the Bell Creek Estuary) is the largest tidal wetland complex in the vicinity of Sequim Bay. Most of the historic mudflat, tidal marsh, and barrier beach (Gibson Spit) remain. However, significant stressors in the form of a nearshore road and dikes have degraded ecosystem processes including tidal hydrology, sediment supply, and tidal channel formation and maintenance.

The Washington Harbor action area is located on the shoreline of the Strait of Juan de Fuca near the mouth of Sequim Bay. The action area is approximately 5 miles east of Sequim and includes tidal marsh, tidal channels, barrier beach, mudflat, forested bluff, dikes, and an access road. Bell Creek discharges to Washington Harbor from the west. A steep, heavily wooded bluff rises on the west side of Washington Harbor north of Bell Creek. Gibson Spit provides a barrier beach between Washington Harbor and the Strait of Juan de Fuca on the east. The entrance to Washington Harbor from the Strait of Juan de Fuca is located between Gibson Spit and another barrier beach at the southeast corner of the action area.

Nearby features include county roads, a shoreline access road and boat launch, and the City of Sequim (City) wastewater treatment plant. The wastewater treatment plant is approximately 0.5 mile west of Washington Harbor. The primary stressor in the action area is a sewer maintenance access road located above an 18-inch-diameter sewer outfall pipe. The pipe extends east from the treatment plant to the Strait of Juan de Fuca through Washington Harbor. At Washington Harbor, an access road was constructed to cover the sewer outfall pipe and enable access for maintenance. Two 72-inch-diameter reinforced concrete culverts were constructed under the sewer outfall pipe near the low point in the tidal channel to allow for limited tidal exchange and movement of water across the access road embankment. The sewer outfall continues approximately 1,900 feet beyond Gibson Spit and discharges to the Strait of Juan de Fuca at a depth of approximately 53 feet (Gray and Osborne 2003) .The action area is shown in Figure 35-1.

Figure 35-1. Action Area and Vicinity

35.2.1 Historic Condition

The 1870 topographic sheet (T-sheet) for this site shows the extent of the spit and marsh as generally similar to what currently exists, but without more recent modifications (Figures 35-2A and 35-2B). It does not show the extent of tidal channels within the interior of Washington Harbor. A historical change analysis for the Strait and Hood Canal included the action area and found that Gibson Spit changed very little between 1870 and 2006. The analysis also found that the combined lagoon and marsh area of Washington Harbor decreased by 11%, with most of the change in the lagoon area (Todd et al. 2006).

The most significant change from historic conditions included installation of the sewer outfall and access road, which bisect the action area in the northern portion of Washington Harbor. In addition, a dike was installed at the north end of the action area, converting 4 acres of former salt marsh to drained and ditched pasture. A smaller dike located just to the south encloses a smaller area of former marsh. Sewer outfall and dike construction occurred independently and at different times (Todd et al. 2006). Noticeable changes in sediment transport and tidal channel morphology have occurred since the sewer line and access road were constructed (Johnson 2010a). These include changes to two larger tidal channels in the mudflat and two smaller tidal channels in the salt marsh that are bisected by the sewer maintenance access road, scouring at ends of the existing culverts that cross the access road, and interruption of sediment transport between the south and north sides of the harbor.

35.2.2 Natural Environment

Washington Harbor is the largest tidal marsh/mudflat/lagoon complex in the vicinity of Sequim Bay, with more than half the total habitat of this type (Todd et al. 2006). Washington Harbor is formed by two barrier beach spit formations, one originating from the south within Sequim Bay, and the other (Gibson Spit) originating from the north outside the entrance to Washington Harbor. The only freshwater input to Washington Harbor is Bell Creek. Bell Creek discharges fresh water to the southern lobe of the harbor from the west. Bell Creek is a minor remnant stream occupying a paleo-channel of the Dungeness River. The contributing Bell Creek basin provides flood discharge, limited wood recruitment, organism dispersal, and limited sediment supply to support the restored system. Most of the wood and sediments that support Washington Harbor are transported from other sources via the marine environment (Johnson 2010b).

Overall, Washington Harbor is rated as moderately impaired, based largely on the previously described nearshore stressors within the action area. Gibson Spit encloses the action area on the east side. This barrier beach is the terminus of a drift cell that originates at Kulakala Point on the Strait of Juan de Fuca to the northwest with a southeast net shore drift (Schwartz and Bubnick 1985; Todd et al. 2006) .Material for the drift cell originates from erosion of a feeder bluff north of Gibson Spit near Kulakala Point .This drift cell is minimally impacted by shoreline armoring, with less than 2% of the shoreline armored. Northwest of Gibson Spit, the shoreline consists of extensive bluff-backed beaches with agricultural land uses extending inland above the bluffs.

The spit consists of a well developed sand and gravel beach with a minimal backshore at the north end, and a progressively wider sandy/gravelly backshore at the southern terminus. These areas support a well developed native plant community consisting of beach grasses, sedges, and herbaceous perennials tolerant of backshore, dune, and dune swale conditions. A hooked spit feature is located at the entrance to Washington Harbor. The west side of Washington Harbor contains a well developed forested riparian zone with some fragmentation (a single-lane, unpaved road) separating some of the forest from the harbor. The beach and spit enclose an extensive mudflat, tidal channel lagoon, and salt marsh complex.

Water depths and channel morphology, particularly in the mudflat, are noticeably different on the north and south sides of the sewer maintenance access road. Large scoured depressions from the twin culverts are located on both the north and south sides of the access road. The larger of the two diked areas at the north end of the harbor supports mostly reed canarygrass and stands of Himalayan blackberry at the spoils berm along the drainage ditch. The nearshore habitat of Washington Harbor provides important pocket estuaries for juvenile salmon, including Hood Canal summer chum salmon, which is listed as threatened under the federal Endangered Species Act.

35.2.3 Human Environment

The primary anthropogenic changes in the action area have included construction of the sewer outfall pipeline and the 1,367-foot-long access road embankment. This facility is operated by the City and was originally constructed as the primary conveyance for effluent discharge from the City wastewater treatment plant, which is located just west of the action area near Bell Creek. The City upgraded the wastewater treatment plant to provide tertiary treatment and allow for reclamation and reuse of treated water. Treated water is now distributed through the City's water reuse system to selected sites for irrigation and other non-potable uses. Reuse locations include a 29-acre demonstration site at the east end of Sequim.

During winter, when wastewater flows are high and demand at reuse sites is low, the City does not always have the ability to effectively use or disperse all of the treated wastewater through its reuse system and discharges effluent through the outfall pipeline to the Strait of Juan de Fuca (Tjemsland 2010). The City's National Pollutant Discharge Elimination System (NPDES) permit allows for discharge of effluent from the treatment plant to Bell Creek, or through the outfall pipeline to the Strait of Juan de Fuca (Gray and Osborne 2003). The City intends to expand reuse and is currently working on a grant project that would identify and develop opportunities for using reclaimed water to recharge groundwater supplies and supplement instream flows. The City hopes to expand reuse so that use of the outfall would be limited to emergencies, such as a failure of the tertiary treatment system.

The existing access road over the outfall pipe is one lane and unpaved. Varying amounts of rock armor have been placed on the south side and at the west end of the access road, where wave action from Sequim Bay can enter Washington Harbor. Design drawings for the sewer outfall (Roats Engineering 1965) indicate that the 18-inch-diameter concrete sewer line is buried within the fill placed for the access road and is typically above the natural bottom of the harbor. The design drawings indicate that manholes provide access to the sewer line at the west (upland) and east (Gibson Spit) ends of the access road and at three locations in between. The road also provides private landowner beach access. The existing outfall extends approximately 1,900 feet beyond the easternmost manhole at Gibson Spit, discharging through a diffuser offshore at a depth of approximately 53 feet.

Tidal exchange between the north and south sides of the access road is conveyed by two 72-inch-diameter reinforced concrete pipe culverts. These culverts, which may have been originally constructed at the low point in the tidal channel, are now perched above the bottom of Washington Harbor as a result of scour in the tidal channel near the ends of the culverts. The ends of the culverts are supported by cables anchored to the access road embankment. Tidal exchange is limited by the size and configuration of the culverts. When tidal conditions create differential head across the culverts, high velocity conditions in the culverts can be detrimental to fish access (Salmon Recovery Funding Board 2010).

Other modifications in the action area include the two diked areas at the north end. These dikes were apparently built for agricultural purposes. The larger diked area does not appear to support any current agricultural use. Other modifications up-drift from the barrier beach include a private well and bulkhead north of the harbor and spit, and a public shoreline access area at Port Williams that includes a parking area and boat launch. Both of these constructed features include shoreline armor extending into the active beach foreshore area in front of bluff-backed beaches.

35.3 Restoration Design Concept

35.3.1 Restoration Overview and Key Design Assumptions

Figures 35-3 through 35-7 illustrate the restoration alternatives. The full restoration alternative (Figure 35-3) would include removal of the sewer maintenance access road embankment and reinstallation of the sewer line below the surface of the mudflat, marsh, and spit. Reinstallation of the sewer line would require directional drilling techniques to minimize trenching (Figure 35-5).

Access to the sewer line for maintenance would occur at the east (Gibson Spit) end of the sewer line via Port Williams Road and the Gibson Spit beach connecting to the north. The west end of the sewer line would also be accessible for maintenance via the existing dirt road, which would be terminated and removed from the edge of the harbor to Gibson Spit. All nearshore fill, rock armor, and culverts would be removed and topography would be restored. The dikes at the north end of the action area and the shoreline armoring and fill extending onto the beach north of Gibson Spit (Port Williams public access and private well) would also be removed, relocated as needed, and the area would be topographically restored.

Public access to the beach from Port Williams for recreational use (walking) and maintenance vehicles would also be provided. It is also recommended that the full restoration alternative seek to protect the undeveloped feeder bluffs that supply Gibson Spit. This could occur through conservation easements as opposed to outright acquisition.

The partial restoration alternative (Figure 35-4) would replace a portion of the access road with a bridge. The sewer could be attached to the structure between the girders, but this would require replacing the sewer line farther upstream in the system to adjust the vertical profile because the bridge-supported sewer would be approximately 8 feet higher in elevation. Approximately 570 feet of the existing embankment would be removed and replaced with a bridge across Washington Harbor. Manholes would be replaced near the east and west ends of the bridge to provide access. The bridge opening would be designed to optimize tidal hydrology restoration, sediment transport, and tidal channel formation and maintenance.

The proponent has studied three bridge lengths: 78 feet, 562 feet, and 762 feet (Johnson 2010a). In order to maximize the hydrologic benefits, while minimizing impacts to existing infrastructure and the environment, it is recommended that a mid-length bridge be used (570 feet) (Figure 35-6A).

Specific instances where the partial restoration alternative achieves less stressor reduction compared to full restoration are as follows:

1. Lack of habitat processes and functions in the northern 6 acres of diked wetland.
2. Reduction of minor sediment transport processes along the western shoreline of the restored 37-acre area.
3. Reduction in wave energy, wood distribution, and channel formation and maintenance within the vegetated portion of Gibson Spit north of the existing access road.

Key design elements associated with full and partial restoration alternatives are shown in Table 35-1.

Table 35-1. Key Design Elements

Element	Full Restoration	Partial Restoration
Sewer Line	Remove/relocate sewer line through harbor; replace with directionally drilled underground sewer line	Remove/relocate a portion of sewer line through harbor; replace with bridge-mounted sewer line
Access Road	Remove entire access road through harbor, two culverts through road, and road armoring	Remove a portion of access road, two culverts through road and road armoring; replace with bridge
Northern Dikes and Ditches	Remove dikes and fill ditch	Not included
Nearshore Armoring	Remove armoring along beach up-drift of Gibson Spit	Not included
Well	Abandon/relocate well at beach	Not included
Nearshore Fill	Remove nearshore fill at Port Williams shoreline access	Not included
Feeder Bluffs	Protect undeveloped feeder bluffs that supply spit	Not included

35.3.2 Restoration Features – Primary Process-Based Management Measures

Armor Removal/Modification

Armored areas within Washington Harbor include the south side of the sewer maintenance access road embankment and adjacent shoreline. Two armored areas have also been identified on the beach near the north end of Gibson Spit and at the Port Williams public shoreline access facility up-drift of Gibson Spit.

The full restoration alternative (Figure 35-3) would remove approximately 1,450 LF of armoring along the access road embankment and adjacent shoreline. It would also remove approximately 200 LF of armoring on the beach at the north end of Gibson Spit, and 250 LF of armoring up-drift of Gibson Spit at the Port Williams public shoreline access facility.

The partial restoration alternative (Figure 35-4) would remove approximately 570 LF of armoring along the portion of the access road embankment that would be removed. However, armoring would remain along the rest of the access road.

Berm or Dike Removal/Modification

The access road embankment creates a tidal barrier and impacts 37 acres of the action area. The existing access road embankment is approximately 14 feet wide on top, with a top elevation ranging from approximately 11 feet NAVD 88 (12 feet MLLW) at Gibson Spit to 16 feet NAVD 88 (17 feet MLLW) at the west end of the access road. The access road fill prism has 3 horizontal to 1 vertical (H:V) side slopes from the top to the existing ground at the bottom of Washington Harbor.

The full restoration alternative (Figure 35-3) would remove the 1,367-foot-long access road embankment through Washington Harbor. Access road fill would be removed to match adjacent existing grades (Figure 35-4). The volume of material removed would be approximately 13,200 CY. The partial restoration alternative (Figure 35-4) would remove approximately 570 feet of the embankment through the deepest portion of Washington Harbor, within the historic limits of tidal influence. The volume of material removed would be approximately 9,000 CY. Under the partial restoration alternative, the access road embankment would be replaced by a 570-foot-long bridge.

The full restoration alternative would remove approximately 960 feet of dikes at the north end of the harbor. The dikes impact approximately 6 acres of the action area. The dikes are typically 12 to 16 feet wide on top, with top elevations ranging from 10 to 12 feet NAVD88 (11 to 13 feet MLLW), and 3:1 average side slopes. The total volume of material removed would be approximately 2,900 CY.

Channel Rehabilitation/Creation

The full restoration alternative would involve complete removal of the access road fill and dikes within Washington Harbor. Fill removal would include excavation of material down to adjacent elevations at the bottom of Washington Harbor, to rehabilitate historic tidal channels that have been cut off by the access road and dikes (Figures 35-3 and 35-5). It is anticipated that scour holes created by the two existing culverts would fill in quickly following restoration of natural tidal cycles. Additional bathymetry information may indicate that filling of these areas is warranted as part of access road removal because these areas could result in juvenile salmon stranding and susceptibility to excessive predation once tidal hydrology is restored.

It is anticipated that full restoration would result in the rehabilitation of two primary tidal channels near the west side of Washington Harbor, and at least one smaller tidal channel closer to Gibson Spit. The partial restoration alternative includes partial removal of access road fill and removal of dikes. Removal of fill and associated grading would also result in rehabilitation of the primary tidal channel through the harbor, and filling of scour holes through sediment deposition during tide cycles.

Groin Removal/Modification – NA

Hydraulic Modification

The access road embankment acts as a breakwater, blocking wave energy and sediment transport into the north portion of Washington Harbor. Two 100-foot-long parallel culverts constructed through the road embankment provide the only hydraulic connection between the north and south sides of the harbor. The 72-inch-diameter culverts have limited hydraulic capacity and are perched above the bottom of the harbor. As a result, tidal exchange is restricted, and stressful thermal conditions result as the residual water is trapped and becomes excessively heated. In addition, high velocities occur when tidal conditions create differential head across the culverts, resulting in detrimental conditions for fish passage.

The full restoration alternative would include complete removal of the access road embankment and the 100-foot-long culverts, completely removing the barrier between the north and south portions of the harbor and restoring hydrologic and hydraulic processes (Figure 35-3). The partial restoration alternative would also include removal of the 100-foot-long culverts; however, only 570 feet of the existing access road embankment would be removed (Figure 35-4). A bridge would be designed to span the removed portion of the access road embankment (Figures 35-6A and 35-6B). The bridge opening would be designed to optimize hydrologic and hydraulic processes.

Overwater Structure Removal – NA

Topography Restoration

The full restoration alternative would include filling a manmade ditch at the north end of the harbor (Figure 35-3). Fill placement (from onsite dike removal described above), along with additional grading, would result in restoration of pre-ditch topography and bathymetry. In addition, some minor topography restoration may occur north of Gibson Spit where the bulkheads and fill are removed.

Additional Management Measures - NA

35.3.3 Restoration Features – Other

Additional restoration features that would be incorporated as part of the full restoration alternative include replacement of the existing sewer outfall pipeline with a pipeline buried below the harbor bottom, abandonment and relocation of an existing well drilled into the beach at the north end of Gibson Spit, and improvements to maintain walking access and access for maintenance vehicles at the Port Williams shoreline access facility. The replacement sewer outfall pipeline would be installed via directional drilling (Figure 35-5) to avoid the impact of trenching and backfill activities on ecological and cultural resources within the harbor. Replacement of about 75 LF of pipe would be needed west of Washington Harbor upstream of the directional drill to transition the profile of the existing sewer line to the directionally drilled outfall. Abandonment of the well drilled into the beach at the north end of the spit would likely require drilling a replacement well at a nearby upland location. Additional information is needed to determine the purpose of the existing well, and requirements for replacement of the water supply generated by the well.

Removal of fill and armoring at Port Williams would impact the existing public access facilities. The full restoration alternative would maintain public access to the beach for recreational use (walking) and for maintenance vehicles.

The partial restoration alternative would include installation of a 570-foot-long, 16-foot-wide pre-cast concrete bridge to span the removed portion of the access road. Approximately 1,880 feet of sewer outfall pipeline would be replaced with 18-inch-diameter pipe, including 590 feet of pipe supported by the bridge (Figures 36-5A and 36-5B). Six new sewer manholes would also be installed. The partial restoration alternative would include installation of an elevated bridge and modifications to the roadway needed to match the proposed elevation of the bridge. The bridge would allow for continued maintenance access along the sewer outfall pipeline and provide local (private) access to the beach.

For partial restoration, the replacement sewer outfall pipeline would be attached to the bottom of the bridge between two girders. Buried pipeline would also be constructed beyond the extents of the bridge to accommodate the change in the pipeline profile. A second option has been considered, which would include burial of the pipeline under the harbor via directional drilling, rather than installation of the pipeline on the bridge. However, it is anticipated that hanging the pipe from the bridge would cost less, provide better access for maintenance, and avoid creation of a siphon in the pipeline under the harbor. The proponent wants to satisfy the requirements of the City and property owners to implement the project, which would require having a bridge to maintain access along the sewer line and to the beach.

35.3.4 Land Requirements

The action area is privately owned, primarily by two main landowners. The southern portion of the action area, including the southern end of Gibson Spit, the upland area west of the sewer maintenance access road, and properties south of Washington Harbor, is owned by Burrows Properties, LLC. The primary property owner has expressed support for restoration of tidal hydrology. Because neither restoration alternative would have a significant permanent impact on the upland portions of this property, either alternative could be completed through construction and conservation easements, without property acquisition.

The property north and west of Washington Harbor, including the diked area at the north end of Washington Harbor, is owned by Steven Clapp. This property owner has not been responsive to the proponent's attempts to make contact. A small parcel extending along Gibson Spit north of the sewer maintenance access road is owned by the Pitship Duck Club.

For the full restoration alternative, use of approximately 15.1 acres of private property would need to be granted through conservation and construction easements for access and implementation, or the property would need to be acquired. This includes the following areas:

- Approximately 3.5 acres owned by Burrows Properties LLC, to allow for removal of the existing sewer maintenance access roadway and sewer replacement.
- Approximately 11.6 acres owned by Steven Clapp at the north end of the action area to allow access for dike removal, fill, and restoration at the north end of Washington Harbor.

Restoration work completed at the Port Williams public access as part of the full restoration alternative would be done on public property.

For the partial restoration alternative, the actions would take place entirely within parcels owned by the primary property owner, Burrows Properties, LLC. As noted above, this property owner has indicated support for the project, and it is anticipated that access to the property would be granted for partial restoration actions. Partial restoration would require use of approximately 3.5 acres of the property for sewer maintenance access roadway modifications and sewer replacement.

35.3.5 Design Considerations

Sewer Outfall Operations

The City indicated that the sewer outfall is still used to discharge excess effluent from the wastewater treatment plant to the Strait of Juan de Fuca, particularly during the winter when treatment flows exceed the demand for reclaimed water. Although the City's goal is to minimize use of the outfall by expanding the use of reclaimed water, replacement of the sewer outfall pipeline would be required to maintain the ability to discharge according to the City's NPDES permit. Additional coordination with the City would be required to determine the timing of construction relative to the City's operational and maintenance needs.

Tides and Wave Action

Improvements constructed in Washington Harbor would need to accommodate tides and wave and wind setup. Long fetch distances to the north and east across the Strait of Juan de Fuca create the potential for wave runup on beaches and road embankments.

The design of the bridge and sewer outfall needed to replace a portion of the road embankment with the partial restoration alternative requires a design water surface elevation (WSEL) to ensure that the bridge and sewer pipe mounted on the bridge have appropriate protection against tides and wave action. The design WSEL developed as part of this evaluation is as follows:

- Design WSEL = Peak Tide + Wave/Wind Setup + Allowance for Sea Level Rise

The peak tide was estimated by reviewing NOAA's 2011 tide predictions. Tide predictions for the mouth of Sequim Bay indicate that the high tide during 2011 is predicted to be approximately 8.5 feet NAVD88 (9.1 feet MLLW). An allowance of 1.5 feet was added to account for wave and wind setup. Another 1.5 feet was added to account for predicted sea level rise, which represents the U.S. Army Corps of Engineers' current high estimate for sea level rise for the Strait of Juan de Fuca. The resulting design WSEL, 11.5 feet NAVD88 (12.1 feet MLLW), was used for evaluation of the potential design alternatives.

Bridge Design

The partial restoration alternative would require a new bridge to span the harbor and provide continued access to the sewer outfall pipeline (Figure 35-4). The new bridge would be approximately 570 feet long and replace the same amount of causeway. The bridge superstructure would consist of 95-foot-long spans made up of 5-foot-2-inch-deep pre-cast concrete girders supported by concrete columns on drilled shafts (Figure 35-6B). The assumed embedment depth of the drilled shafts is 100 feet. Other foundation types, including pre-cast piles, should be considered during preliminary design.

Sewer Outfall Alignment and Profile

The existing sewer line is located within the road prism; once the road prism is removed, it would be exposed. For the full restoration alternative, the existing 18-inch-diameter sanitary sewer would require replacement at a lower elevation. The sewer would be buried by directional drilling methods below the harbor bottom. The new sewer profile would need to be sufficiently deep to provide adequate cover from any possible changes in grade that would occur naturally within the harbor from tidal influence and wave action. It has been assumed that a minimum depth of 5 feet to the top of the pipe would be required from the lowest point along the path of the new sewer alignment. This is approximately 14 feet lower than the existing outfall at the manhole nearest the Strait of Juan de Fuca (Figure 35-5).

The existing sewer outfall operates by gravity. The full restoration concept would include abandoning the existing 1,900-foot-long outfall pipe in the Strait of Juan de Fuca and extending the replacement pipe, via directional drilling, to daylight at a new outfall location (Figure 35-5). This would allow for a constant positive slope in the profile of the pipe toward the outfall. If the existing marine outfall pipe has to be maintained in its current condition, the replacement sewer line across the harbor would have to be installed as an inverted siphon, with the ends of the pipe matching the elevation of the existing pipeline and the center of the pipe sagging below the bottom of Washington Harbor, to the depth described above. The pipe would remain full and would flow based on the differential in WSEL between the manholes at the ends of the pipe.

For the partial restoration alternative, the replacement sewer line would be installed by attaching the pipe to the bottom of the new bridge (Figure 35-6A). It is anticipated that installation of the pipe on the bridge would reduce the cost of the project. In order to prevent impacts to the bottom of the bridge deck and the pipeline by tides and wave action, the bottom of the pipeline and the bridge deck would be above the design WSEL. The bridge-supported sewer and the bridge deck would be up to 8 feet higher in elevation than the existing sewer line and road surface (Figure 35-6A). The project would require replacing the sewer line farther upstream to adjust the vertical profile of the sewer line to allow for continued gravity flow operation. The existing sewer main increases in elevation west of the action area .The wastewater treatment plant, located approximately 0.5 mile west of the action area, is at an elevation of approximately 40 feet MLLW.

For both alternatives, the design of the sewer replacement would need to consider hydraulic operation carefully to ensure that outfall capacity is maintained. The City of Sequim would need to confirm that the pipe alignment, profile, and hydraulic operating conditions meet their requirements.

Sewer Outfall Access and Maintenance

Under the full restoration alternative, access to the sewer outfall pipeline would be limited to a manhole on the west side of Washington Harbor. The pipe beyond that manhole would be installed via directional drilling at an elevation that is several feet below the existing sewer to a new outfall location in the Strait of Juan de Fuca. The partial restoration alternative would provide access at additional manholes near the ends of the proposed bridge. The design would need to consider access and the ability for the City to clean and maintain the sewer line.

Cultural Resources

Cultural resources are anticipated to be present on Gibson Spit, according to the Jamestown S'Klallam Tribe's cultural resource staff (Johnson 2010a). Therefore, trenching to install the sewer line would be avoided for the full restoration alternative. Design of the partial restoration alternative would require some trenching in what is assumed to be access road fill to replace segments of the existing sewer line beyond the extents of the bridge.

35.3.6 Construction Considerations

Equipment

Under the full restoration alternative, the sanitary sewer outfall replacement would be installed by horizontal directional drilling (Figure 35-5). An entry pit would be located at the west edge of the access road, at a depth approximately 20 feet below the existing grade of the access road. An 18-inch-diameter HDPE pipe would be installed via drilling to extend a total length of 1,725 LF. The receiving pit would be located off the shoreline with a cofferdam. A manhole would be installed at the upstream end of the line, and a connection would be made to the nearest existing manhole upstream by conventional trenching methods.

For the partial restoration alternative, a bridge would be constructed to replace a portion of the access road (Figure 35-4). A drilled-shaft oscillator could be used to install the drilled shafts directly from the existing causeway. It is assumed that the contractor would be able to install one shaft per week. Large-diameter casing shoring would be required to keep out water and allow access to the top of the shaft for column form placement and removal. Once the shafts are installed, the columns would be cast inside the shoring casing. After the casing is removed, the cast-in-place pilecaps and bridge superstructure would be constructed.

Construction of either alternative would likely include heavy equipment, such as excavators and front end loaders, for fill excavation and placement of fill; dump trucks for hauling excess material; and other miscellaneous equipment for installation of the bridge (for the partial restoration alternative) and pipeline. Use of heavy equipment on soft soils would require appropriate low-ground-pressure tracked vehicles, timber lagging, or other protection required by permits.

Haul and Disposal

The full restoration alternative would remove approximately 17,050 CY of fill, the partial restoration alternative approximately 9,000 CY of fill. Construction would require identification of stockpile and disposal locations and haul routes. All disposal would be offsite. The specific location will be determined later in the design process but is assumed to be within 20 miles of the action area.

Timing and Duration

Construction of restoration improvements would require coordination with the City to minimize impacts to outfall operation. Summer construction would likely have the least impact on the City's outfall operation. For the full restoration alternative, installation of the new sewer line would be the critical item for scheduling. Directional drilling of the sewer line could proceed relatively quickly once the equipment is set up and material put in place. Removal of the access roadway, dikes, and other miscellaneous restoration work would require 3 to 4 months.

Installation of the sewer line would take approximately 1 to 1.5 months. The duration of work, including sewer replacement, would be approximately 5.5 months. For the partial restoration alternative, removal of a portion of the access road and other work would require an estimated 2 months. Construction of the six-span concrete girder bridge would require up to 8 months. Total duration of work including removal of the access road and replacement of the sanitary sewer outfall is expected to be 12 months.

Access

Access would be provided via the existing access road from Schmuck Road. Access to the north end of the harbor for removal of dikes, placement of ditch fill, and removal of fill and armoring at the north end of Gibson Spit would require access along the beach, either from the east end of the existing sewer maintenance access road or from the Port Williams shoreline access road. Temporary access facilities would be removed upon completion of the installation of the sanitary sewer main. For the full restoration alternative, a cofferdam would be constructed at the new sewer outfall location from a barge in the Strait of Juan de Fuca equipped with a crane and pile driving rig. For the partial restoration alternative, it is anticipated that access for bridge and sewer construction would be via the existing road embankment.

Staging

Onsite space for staging of construction equipment and stockpiling of materials above the ordinary high water line would be limited. Staging and stockpiling is anticipated to require an offsite location.

Construction planning would require a construction easement on the private land in advance of construction. It is assumed that the contractor would identify a staging and stockpiling area offsite, and this cost would be included as part of bidding and construction.

Dewatering

Restoration work would require implementation of best management practices, such as silt curtains, silt fences, cofferdams, pumping, and temporary conveyance to prevent pollution. In-water work would include removal and placement of fill, removal of culverts and sewer pipe, and removal of armoring. Removal of fill and installation of sewer pipe would likely include dewatering of excavations.

35.4 Extent of Stressor Removal

Table 35-2 describes the amount of stressors to be removed with this action.

Table 35-2. Stressor Removal

Stressor	Full Restoration	Partial Restoration
Tidal Barrier – Access Road (LF)	1,367	570
Fill - Dikes (LF)	960	NA
Armor (LF)	1,900	570
Utilities – Sewer Lines (LF)	1,800	1,880
Culverts (LF)	200	200
Fill – Misc. Nearshore (CY)	1,000	NA

35.5 Expected Evolution of the Action Area

The full restoration alternative would restore tidal exchange to the north half of the harbor. Restoration of tidal exchange would rehabilitate tidal channels that are currently cut off by the access road fill, including two larger tidal channels and at least one smaller tidal channel. In addition, scour holes that have formed at the ends of the existing culverts would fill through sediment deposition during tidal cycles. Sediment transport resulting from restored tidal hydrology would replenish mudflats in the north part of the harbor. Tidal hydrology would restore salt marshes and potentially eelgrass in the north part of the harbor.

The removal of dikes and ditches at the north end of the harbor would restore the tidal prism and allow for recolonization of estuarine marsh vegetation and tidal channel development and maintenance. Removal of the access culverts and access road would eliminate the stressful thermal conditions that occur when water temperatures rise on the north side of the access road during the summer. Removal of the culverts and access road would also eliminate the primary barrier to fish passage to the north end of the harbor. Removal of armoring and fill at the north end of Gibson Spit and up-drift of the spit would improve beach sediment transport. Removal of the access road fill and armoring footprint would restore approximately 68,000 SF of intertidal area.

The expected evolution would be similar for the partial restoration alternative, but some stressors would remain and process restoration would be muted. Tidal exchange between the north and south portions of the harbor would improve. Restoration of tidal exchange to the north side of the bridge would result in the rehabilitation of at least one large tidal channel and one smaller tidal channel. Mudflats would be replenished, salt marshes and eelgrass (potentially) would be restored, and fish passage and thermal conditions would improve. Removal of a portion of the access road fill and armoring footprint would restore approximately 46,000 SF of intertidal area. The partial restoration alternative would not include removal of stressors on the east side of the harbor, limiting tidal channel development and maintenance, or at the beach or up-drift of Gibson Spit. Therefore, no improvement to beach sediment transport would be expected. In addition, no dike removal or fill of existing ditches would occur at the north end of the harbor, which would limit benefits to the estuarine marsh and maintenance of tidal channels.

35.6 Uncertainties and Risks

Uncertainties and risks associated with the proposed restoration may include the following:

- Geotechnical Conditions – No field investigations have been conducted to characterize the subsurface soil conditions in the action area. Subsurface soil conditions could potentially have a significant impact on the feasibility and costs related to bridge construction, for the partial restoration alternative, and directional drilling for sewer pipe installation, as part of the full restoration alternative.
- Cultural Resources – The Jamestown S'Kallam Tribe has indicated that there may likely be cultural resources in the action area. Additional surveys would be needed to more clearly outline potential impacts to cultural resources for permitting.
- Property Issues – The owner of the parcels at the north end of Washington Harbor has not been responsive to the proponent's efforts to contact him about the project. Cooperation of the property owner, either through support of the project or through property transaction, would be crucial to completing the dike removal, ditch fill, armor removal, well relocation, and other measures.
- Sewer Maintenance and Operation – Operation and maintenance of the sewer line would change by changing the profile of the sewer line through the harbor. For both the full and partial restoration alternatives, the design would include a pipeline that would flow by gravity to the outfall location. Additional analysis would be needed to ensure that pipeline design and operation meets the City's operational and maintenance requirements. For the full restoration alternative, access to the buried pipe would be more limited.

35.6.1 Risks Associated with Projected Sea Level Change

The risk from sea level rise on the full restoration alternative is minimal, given the removal of the road and reinstallation of the outfall pipe at depth. The risk from sea level rise to the partial restoration alternative is an important consideration. The elevation of the access road ranges from 16 feet NAVD88 (17 feet MLLW) at the west end, to just over 11 feet NAVD88 (12 feet MLLW) at the east end, approximately 1 to 2 feet above the level of the beach backshore. Gibson Spit is subject to periodic overwash from extreme high tides. In the "high" sea level change scenario, the amount of sea level rise would limit use of the access road during extreme high tides with minimal waves of 1 foot. The barrier beach is exposed to significant wave energy from the Strait of Juan de Fuca in the easterly and northerly wave fetches. Although the new bridge could be raised, access would need to be modified (including potentially increasing armoring) to maintain the current level of vehicular access in the long term. This would also be an issue with the status quo. However, it is likely that temporary access limitations during extreme tidal events would be acceptable to the landowner and the City.

The risk of sea level rise and wave and wind setup was factored into the design of the bridge proposed with the partial restoration alternative. An allowance of 46 centimeters, or 1.5 feet, was added to the peak predicted tide to account for future sea level rise. An allowance of 1.5 feet was also added to account for wave and wind setup.

Accommodating the design WSEL 11.5 feet NAVD88 (12.1 feet MLLW) would require that the proposed bridge and sewer line be higher than the existing road and sewer line. The surface of the bridge is proposed to be at elevation 19.7 feet NAVD88 (20.3 feet MLLW), which is more than 6 feet higher than the existing road at the west end, and more than 7.5 feet above the existing road at the east end. The bottom chord on the bridge would be approximately 3 feet above the design WSEL. Modification to existing road fill would be required to make the transition from the existing road to the proposed bridge. Additional sewer line beyond the extents of the bridge would also need to be replaced to maintain a positive slope on the replacement sewer line toward the outfall at the Strait of Juan de Fuca. If the proposed bridge were designed for a lower estimate of sea level rise (intermediate or low), the impact to the existing road and sewer line would be reduced.

Additional risks that could result from sea level rise under either alternative include increased overwash of the barrier beach at Gibson Spit, increased tidal area and depth within the harbor, or increased tidal prism. This increased tidal prism would result in higher velocities of tidal exchange, would affect channel formation and maintenance, and would affect the distribution of aquatic and estuarine marsh vegetation.

Table 35-3 compares potential risks associated with projected sea level changes based on professional judgment.

Table 35-3. Risks of Sea Level Change

	Projected Sea Level Change		
	High	**Intermediate**	**Low**
Full Restoration	Low to no risks to the sewer outfall. Low to moderate risks to mudflat and estuarine marsh habitats.	No risks to the sewer outfall. Low to no risks to the mudflat and estuarine marsh vegetation communities.	No risks to the sewer outfall or mudflat and estuarine marsh vegetation communities.
Partial Restoration	Low to no risks to the sewer outfall and bridge. Low to moderate risks to the mudflat and estuarine marsh habitats.	Low to no risks to the sewer outfall and bridge. Low risks to the mudflat and estuarine marsh vegetation communities.	No risks to the sewer outfall, bridge, or mudflat and estuarine marsh vegetation communities.

35.7 Potential Monitoring Opportunities

Monitoring is important for evaluating restoration success. A combination of field surveys and aerial photographs would be used to document biological and physical changes to the lagoon and beach. Monitoring data can be used to refine adaptive management and corrective actions, as needed. Some of the primary monitoring needs and opportunities associated with this action are summarized in Table 35-4.

Table 35-4. Monitoring Needs and Opportunities

Monitoring Parameter	Key Performance Indicator	Note
Topographic Stability		
Sediment Accretion / Erosion	X	Document effects of sediment transport via restored tidal hydrology on mudflats in the north part of the harbor Monitor beach sediment transport at the north end of Gibson Spit and up-drift
Wood Accumulation		
Soil / Substrate Conditions		
Vegetation Establishment	X	Eelgrass surveys
Marsh Surface Evolution / Accretion	X	Assess recolonization of estuarine marsh vegetation
Tidal Channel Cross-Section / Density	X	Assess effects of tidal prism on tidal channel development and maintenance
Water Quality (contaminants)		
Salinity		
Shellfish Production		
Extent of Invasive Species		
Animal Species Richness		
Fish (salmonid) Access/Use	X	Monitor thermal conditions and fish passage to the north end of the harbor
Forage Fish Production		
Wildlife Species Use		
Effectiveness of Exclusion Devices		

35.8 Information Needed for Subsequent Design

This conceptual design report represents an initial step in the restoration design sequence. The design concepts described above were developed based on readily available information without the level of site-specific survey and investigation that is necessary to support subsequent design and implementation. Substantial additional information will be required at the preliminary and later design stages to confirm the design assumptions, refine quantity estimates, address property and regulatory issues, obtain stakeholder support, and fill in data gaps. The extent to which this information is collected for preliminary design (or a later design stage) will depend upon the available budget, schedule, and other factors. This section attempts to define the most essential information needs for this action.

- Subsurface Soil Information – A preliminary field investigation, including soil borings, sampling, and testing, would be needed to complete preliminary design of the sewer line to be installed using directional drilling techniques for the full restoration alternative, and design of bridge supports for the partial restoration alternative. Preliminary bridge design would require geotechnical recommendations for foundation type and drilling recommendations to prevent hydrofracture (or the seepage of the drilling slurry into the waters due to the drilling pressures).

- Bathymetry – Additional underwater topography is needed to determine the depth of sewer line burial, the extent of fill removal and grading needed to restore tidal topography, the location of the new sewer outfall and cofferdam needed to construct the outfall, the configuration of bridge supports, the placement of fill for road modifications, and the extent of fill removal and grading needed to restore tidal topography.
- Property and Topographic Survey – The location of property lines and survey of topographic features would be useful in providing accurate preliminary designs and quantities, and in working out property agreements and transactions. However, preliminary design could move forward for the full restoration alternative using LiDAR topography for upland features because the full restoration alternative does not require as much detailed construction as the partial restoration alternative.
- Additional As-built Information – Additional as-built information for the sewer outfall line would be needed to provide an accurate alignment and profile for the replacement sewer line.
- Cultural Resource Survey – A preliminary survey of cultural resources would be needed to determine potential impacts.
- Additional Hydrodynamic and Hydraulic Analysis – Additional analysis would be needed to provide recommendations for scour and minimum bridge clearance over water for the partial restoration alternative. Additional modeling of the movement of water through the harbor may also be needed to optimize the size of the bridge opening proposed for the partial restoration alternative. However, analysis already completed by the proponent may be sufficient for preliminary design.
- Existing Well Information – Additional information is needed to understand the use of the existing well at the north end of Gibson Spit and requirements for its replacement.

35.9 Quantity Estimates

The design quantities are largely developed from LiDAR data sets lacking the resolution to accurately quantify all elements of construction. These are supplemented by unmeasured estimates made during one site visit at high tide and information from available aerial photography and imagery. The quantity spreadsheets for the full and partial restoration alternatives are provided in Exhibits 35-1 and 35-2.

35.10 References

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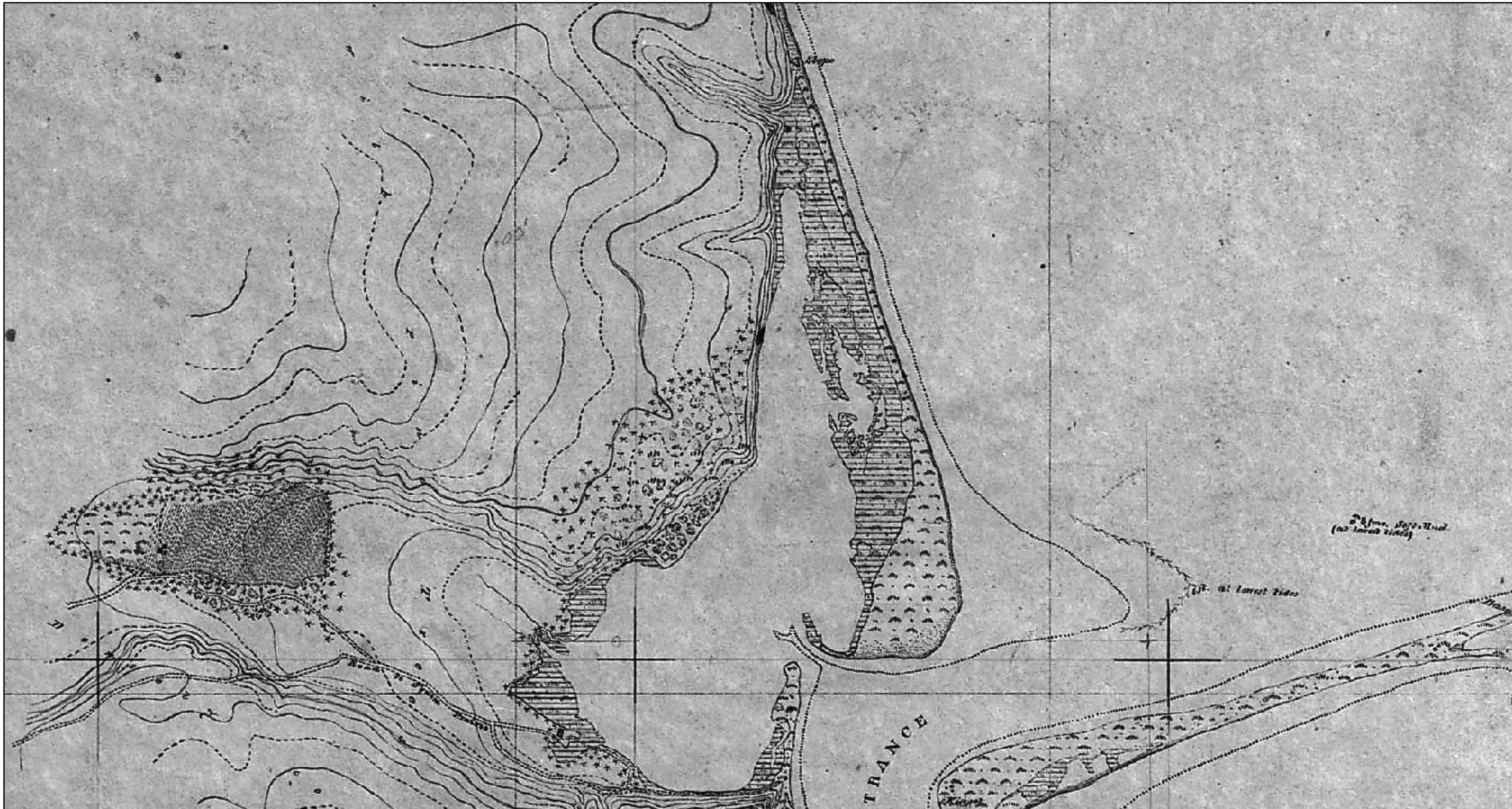

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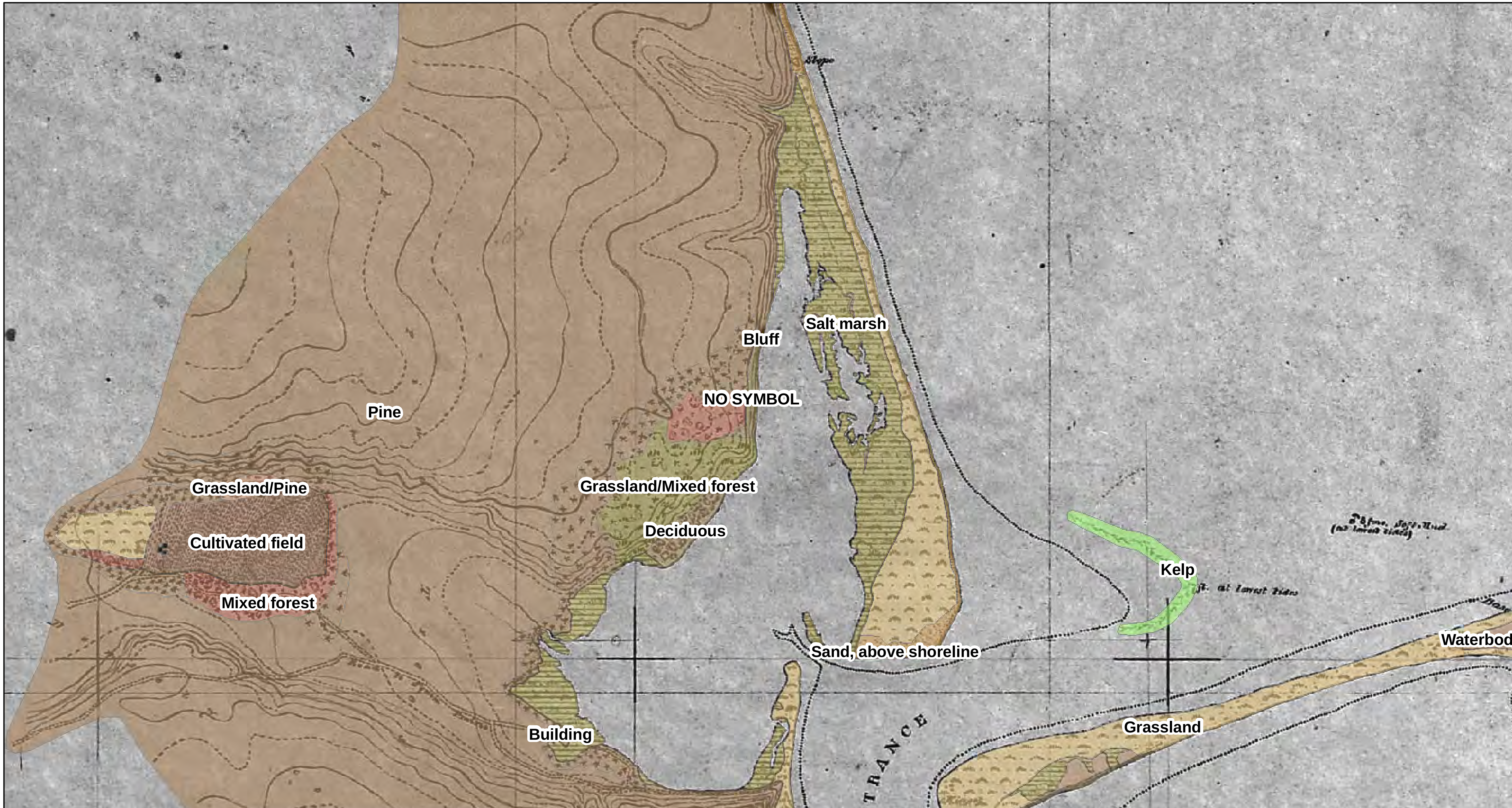
0 750
Feet
0 240
Meters

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Historic Map (T-Sheet)
Action Name: Washington Harbor TIdal Hydrology Restoration Project
PSNERP ID #: 1237
Figure 35- 2A

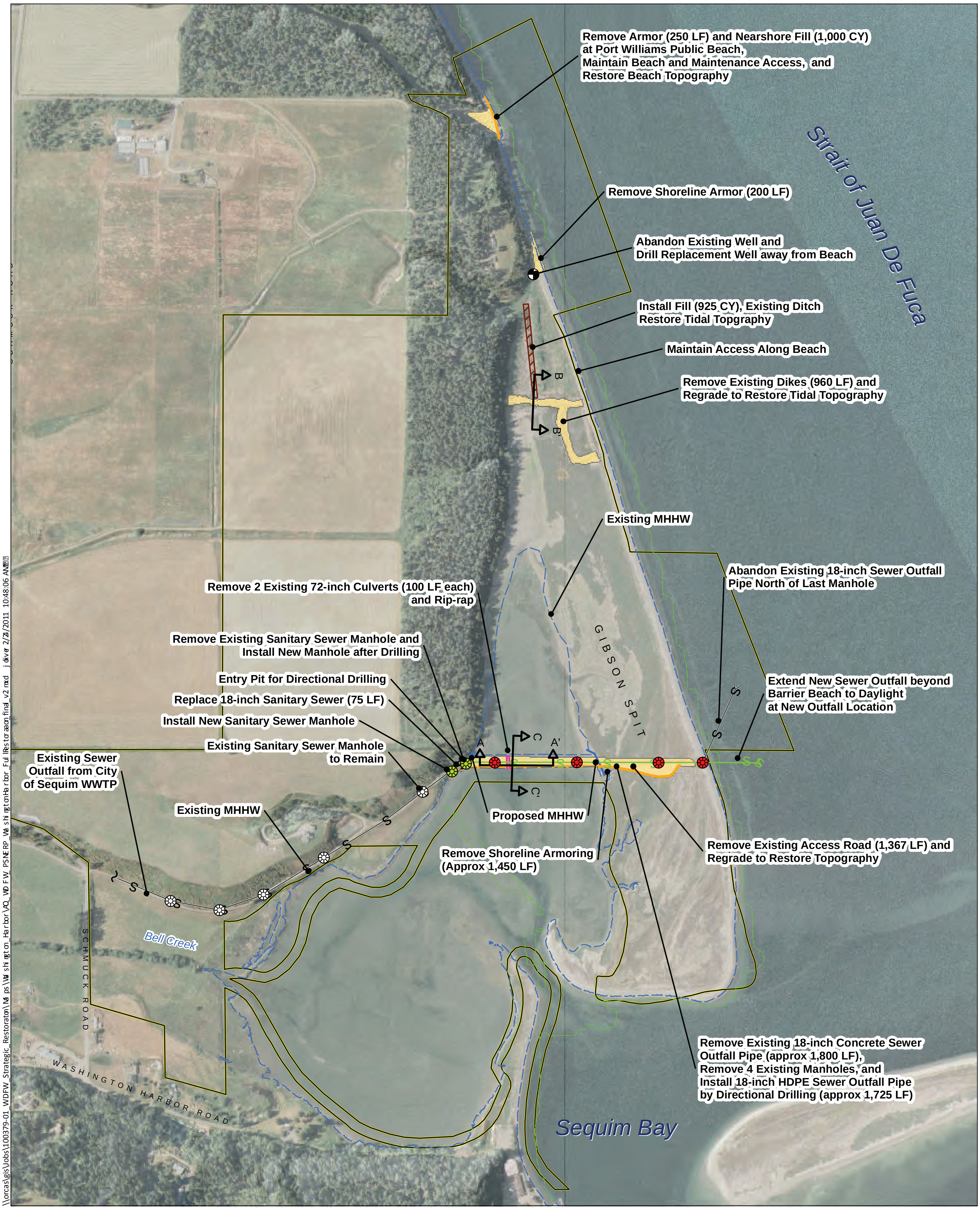


0 750
Feet
0 240
Meters

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

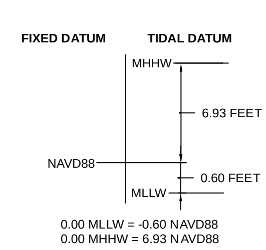
Historic Map (T-Sheet) and River History Project Data
Action Name: Washington Harbor TIdal Hydrology Restoration Project
PSNERP ID #: 1237
Figure 35- 2B

S:\GIS\Projects\210xxx\210337_PSNERP_NEARSHORE\Projects\2-TSheets_rev.mxd (DLP; 2/24/2011)



Legend

- Remove Existing Manhole
- Remove Existing Well
- Existing Sanitary Sewer Manhole
- New Sanitary Sewer Manhole
- Excavation - Lowland
- Select Fill
- Required Project Lands
- Existing Tide MHHW
- Proposed Tide MHHW
- Existing Tide MLLW
- Remove Bulkheads
- Remove Culvert
- Existing Sewer
- Replace/Proposed Sewer
- Section Line



North

0 600 Feet

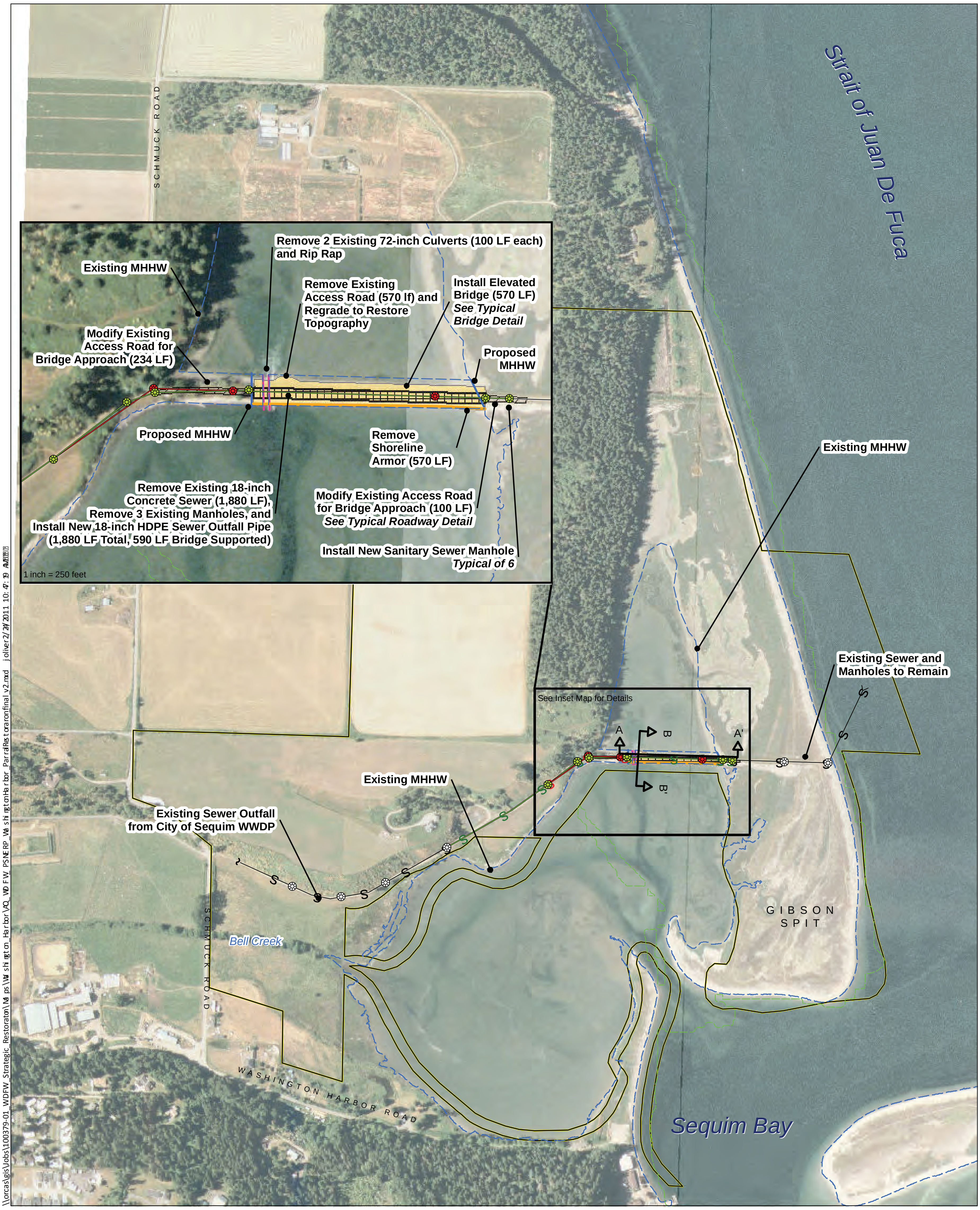
SOURCE: High Resolution Orthoimagery (USGS, 2009);
Washington Counties Parcels (2009); Action Area (PSNERP, 2010)

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Plan
Site Name: Washington Harbor
Action Name: Washington Harbor Tidal Hydrology Restoration Project
PSNERP ID #: 1237
Full Restoration

Lead Contractor: ESA
Design Lead: Anchor QEA, David Rice
Date: 02/23/2011

Figure 35-3



Legend

- Existing Sanitary Sewer Manhole
- New Sanitary Sewer Manhole
- Remove Sanitary Sewer Manhole
- Bridge
- Excavation - Lowland
- Roadway Type A
- Required Project Lands
- Remove Bulkheads
- Proposed Tide MHHW
- Existing Tide MHHW
- Existing Tide MLLW
- Remove Culvert
- Existing Sewer
- Proposed/Replace Sewer
- Remove Sewer
- SectionLines Legend

FIXED DATUM — TIDAL DATUM: MHHW, NAVD88, MLLW; 6.93 FEET; 0.60 FEET

0.00 MLLW = -0.60 NAVD88
0.00 MHHW = 6.93 NAVD88

Source: VDatum

North

0 600 Feet

PUGET SOUND NEARSHORE

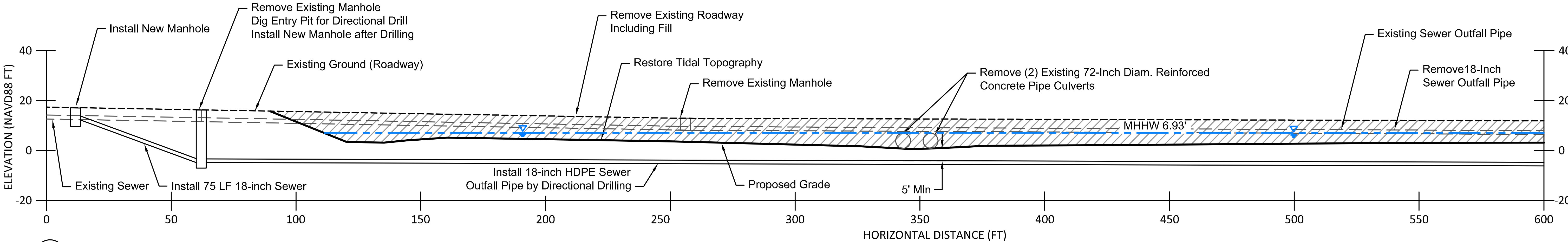
SOURCE: High Resolution Orthoimagery (USGS, 2009);
Washington Counties Parcels (2009); Action Area (PSNERP, 2010)

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

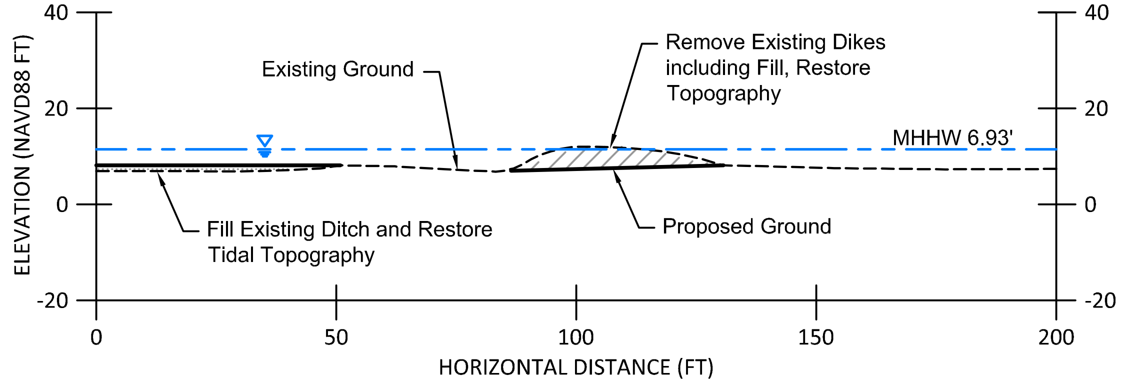
Conceptual Design Plan
Site Name: Washington Harbor
Action Name: Washington Harbor Tidal Hydrology Restoration Project
PSNERP ID #: 1237
Partial Restoration

Lead Contractor: ESA
Design Lead: Anchor QEA, David Rice
Date: 02/23/2011

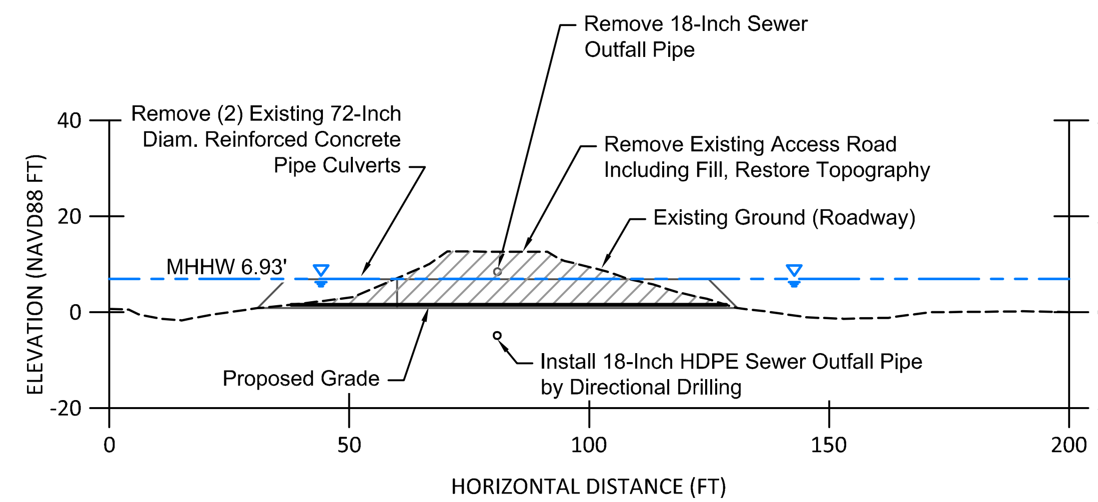
Figure 35-4



A FULL RESTORATION TYPICAL SECTION



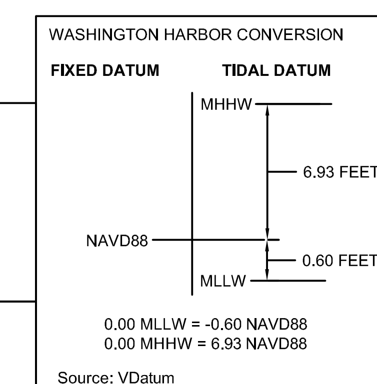
B FULL RESTORATION TYPICAL SECTION



C FULL RESTORATION TYPICAL SECTION

0 40
Scale in Feet

EXISTING GRADE HATCH		PROPOSED GRADE HATCH	
	BEACH		CUT
	OTHER		FILL
EXISTING GRADE		PROPOSED GRADE	



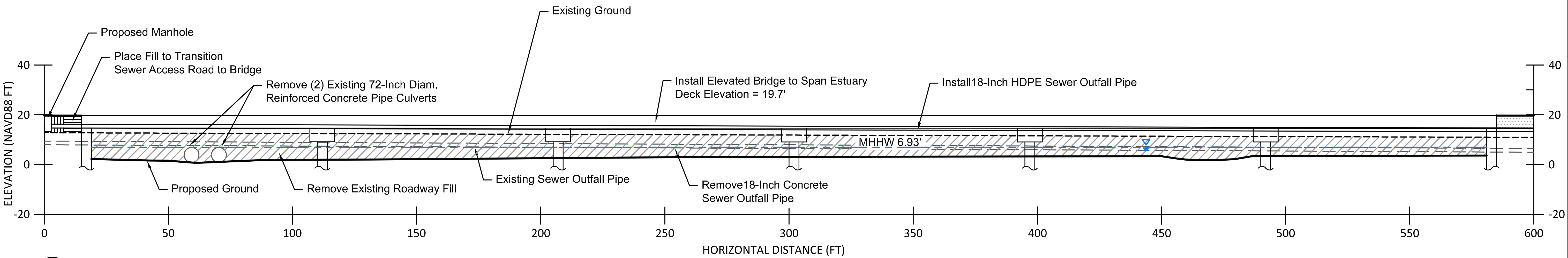
PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: Anchor with KPFF
Date: 3/2011

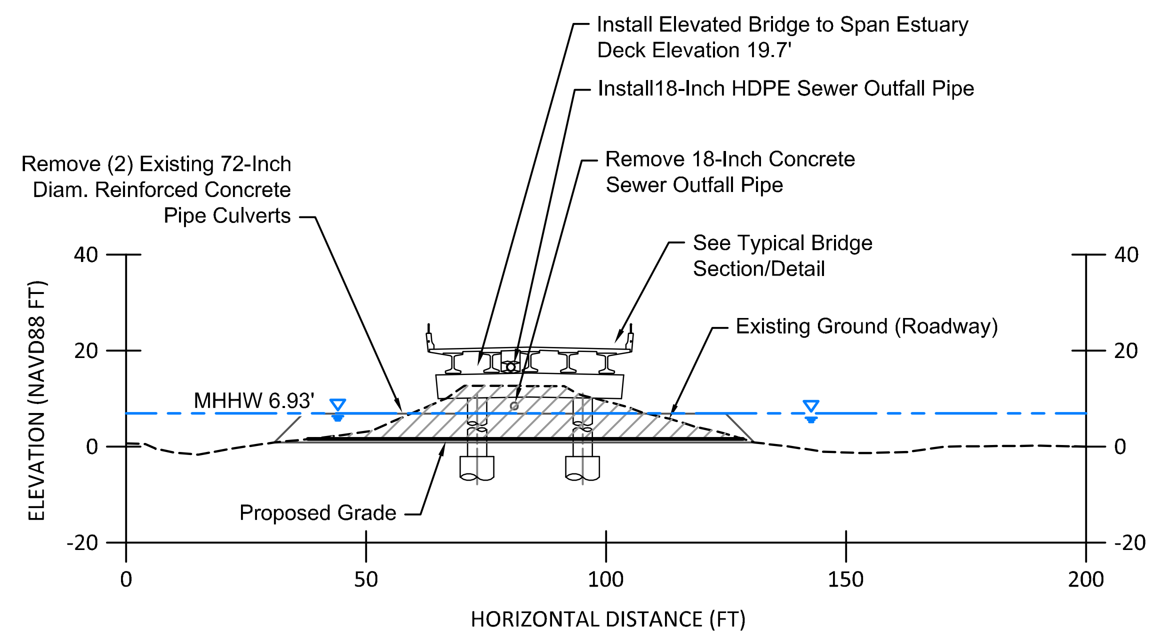
Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Section
SITE NAME: **Sequim Bay**
ACTION NAME: **Washington Harbor Tidal Hydrology Restoration Project**
PSNERP ID#: **1237**
Full Restoration

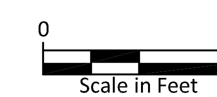
Figure 35-5

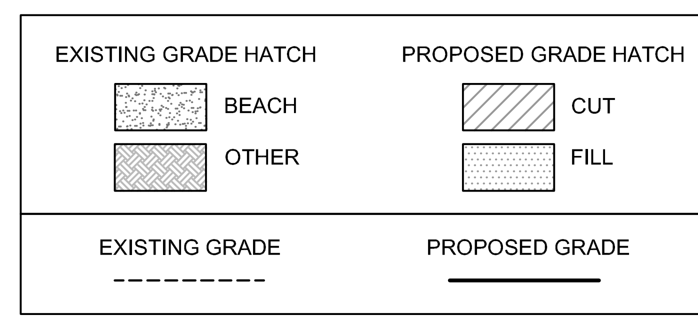


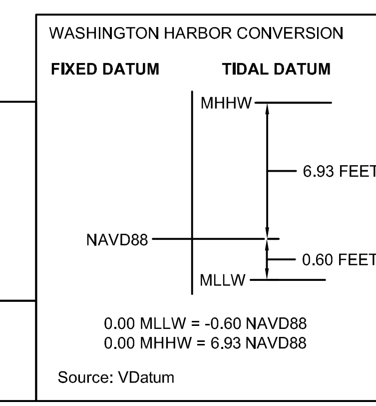
A PARTIAL RESTORATION TYPICAL SECTION



B PARTIAL RESTORATION TYPICAL SECTION







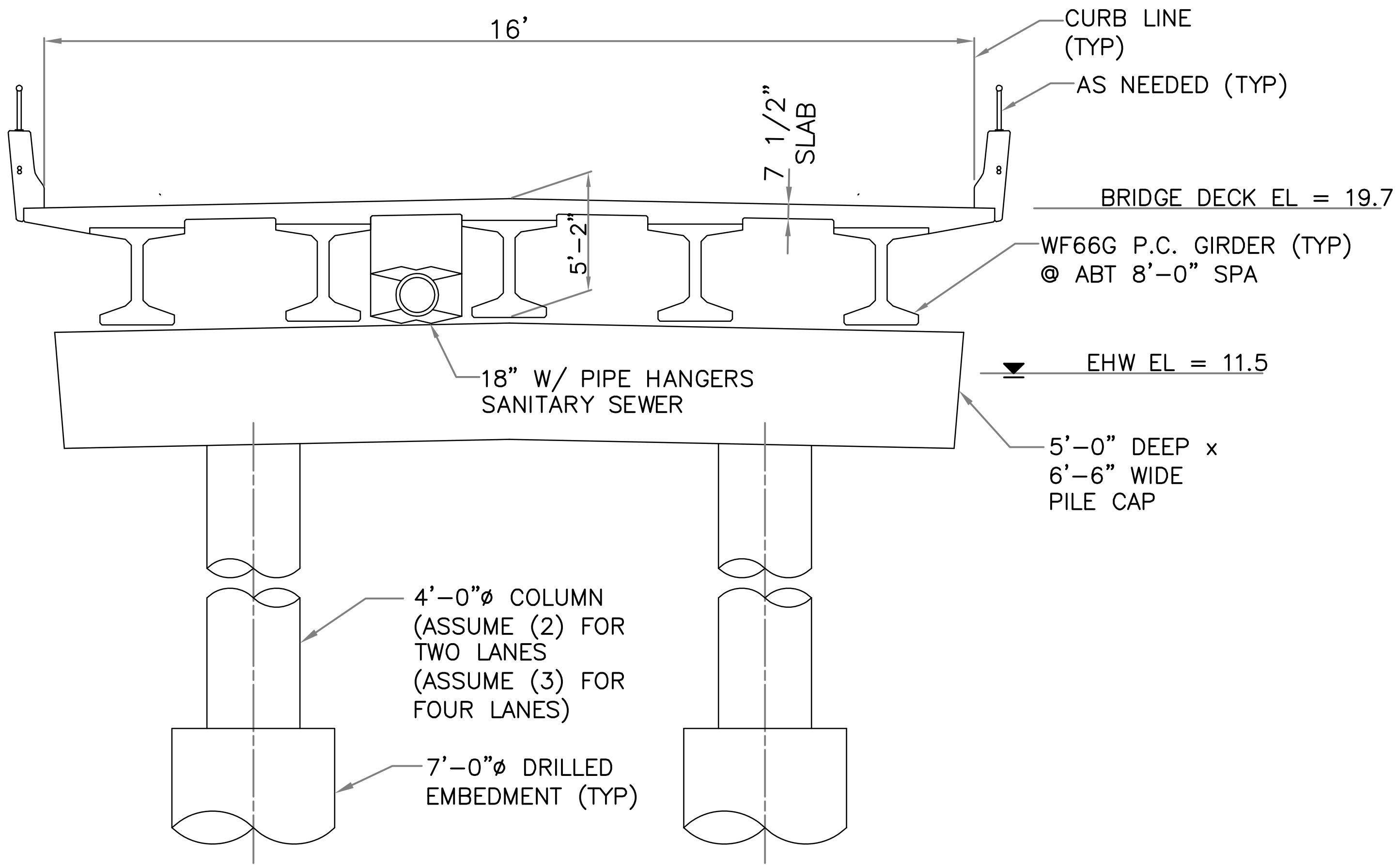
PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: Anchor with KPFF
Date: 3/2011

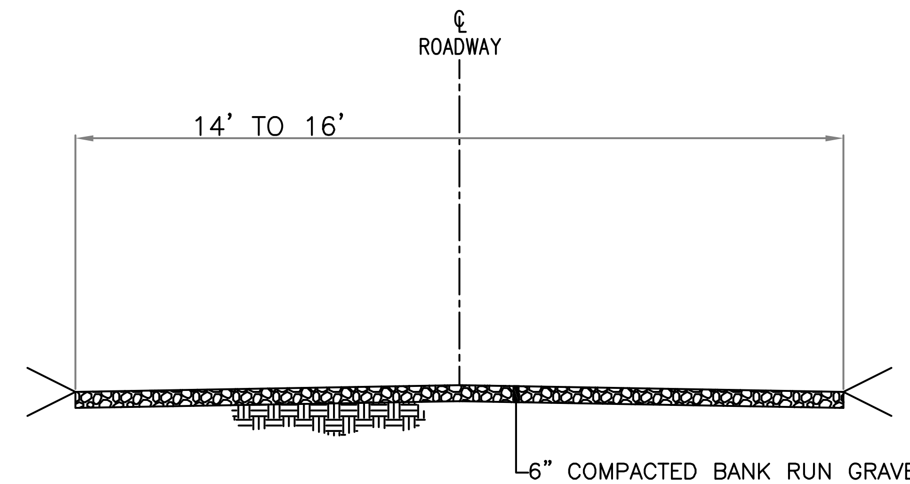
Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Section
SITE NAME: **Sequim Bay**
ACTION NAME: **Washington Harbor Tidal Hydrology Restoration Project**
PSNERP ID#: **1237**
Partial Restoration

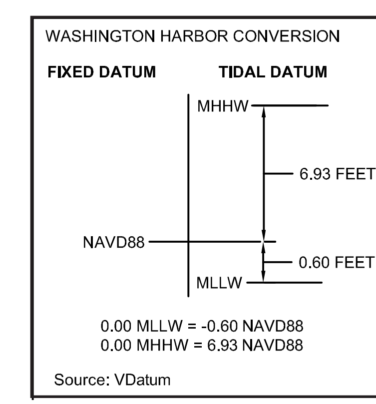
Figure 35-6



SECTION/DETAIL
Typical Bridge
Not to Scale
Section Provided by KPFF



SECTION/DETAIL
Typical Roadway
Not to Scale
Section Provided by KPFF



PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: Anchor with KPFF
Date: 3/2011

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Section
SITE NAME: **Sequim Bay**
ACTION NAME: **Washington Harbor Tidal Hydrology Restoration Project**
PSNERP ID#: **1237**
Partial Restoration

Figure 35-7

Full Restoration Quantity Estimate

Action Name: Washington Harbor
Action #: PSNERP ID #1237
Date: February 2011
By: David Rice, P.E., Anchor QEA

REMEDY: ***Access roadway removal, sewer outfall relocation, culvert removal, dike removal, armoring removal, ditch fill***
Construction Period: Approximately 24 Weeks

	Item	Unit of Measure	Material Name	Qty	Description of Item	Indicate section of design report where item is described
ACQUISITION AND CONSERVATION					Based on available mapping information	
	Required Project Lands	Acre		16.3	Includes 100-foot width along access roadway, beach and nearshore area to Port Williams	1.3.5
	Proponent / Partner-owned lands	Acre		1.2	1.22 Acre Parcel at Port Williams Owned by Clallam County	
	Lands To Be Acquired	Acre		0	Assumes construction/conservation easements will be granted by private property owners	
Material Sites					Not Used: See Earthwork - Imported Fill.	
MOBILIZATION AND ACCESS for construction activities					Description required for each item to facilitate cost estimating	
	Mobilization - Typical (Equipment, Personnel, Planning, Financial)	LS		1	Assume 8% of other Construction Cost Items	
	Mobilization - Remote (Equipment, Personnel, Planning, Financial)	LS		0	Not Applicable	
	Site Access	LS		0	Not Applicable	
	Barge Access	Days		30	Barge access required for installation of new outfall	1.3.7
	Temporary Traffic Control (one of the following)				Not Applicable	
	none	LS		0	Not Applicable	
	signs	LS		1	Typical construction signage. Minimal impacts to traffic since this is an access road.	
	flags / spotters	LS		0	Not Applicable	
	unique	LS		0	Not Applicable	
	Temporary Roadway	SF		0	Not Applicable	
	Control of Water	LS		1	Cofferdams, or other dewatering will be required for roadway and sewer removal, maintenance of entray pit and installation of new outfall for directional drilling of sewer line	1.3.7
Relocation Activities					Not Used: See Utilities, Structures	
Site Demolition Activities					Demolition and removal of structures (description required), temporary features and relocations, itemized separately); Clearing and grubbing of vegetation, and removal of minor debris (rocks, slabs) - description required.	
	Clearing and Grubbing (one or more of following)				Use one or more of the following categories of clearing and grubbing	
	Clear Vegetation - Local Disposal	AC		0	Not Applicable	
	Clear /Grub Vegetation - Local Disposal	AC		1.9	Clear and Grub, 50-FT Width Along Roadway, 30-FT Width for Dike Removal, 12,500 SF at Port Williams	
	Clear /Grub Vegetation - Offsite Disposal	AC		0	Not Applicable	
	Clear, stockpile - large woody debris	CY		0	Not Applicable	
	Hydraulic Structures - Small	LS	Culverts	1	Removal of (2) 72" 100 LF Culverts	1.3.7, 1.4
	Hydraulic Structures - Large	LS		0	Not Applicable	
	Utilities - Sewer	LF		1,650	18" sanitary sewer and 3 manholes	
	Buildings	LS or SF		0	Not Applicable	
	Pavement	LS or SF		0	Not Applicable	
	Bulkheads	LF or SF		0	Not Applicable	
	Rock revetments - Along Roadway	Ton	Armoring	380	Shoreline Armoring…1,450 LF Along Roadway	1.3.1, 1.3.2
	Rock revetments - N End of Gibson Spit	Ton	Armoring	105	Shoreline Armoring…200 LF Along N Spit	1.3.1, 1.3.2
	Rock revetments - Port Williams Public Access	Ton	Armoring	130	Shoreline Armoring…250 LF at Port Williams	1.3.1, 1.3.2
	Large Coastal Structures	LF, SF or CY		0	Not Applicable	
	Demolition / Removal - Bridge	SF or CY		0	Not Applicable	
	Removal - Misc. (e.g. angular rock from beach)	Ton		0	Not Applicable	
	Demolition / Removal - Boat Ramp	SF		0	Not Applicable	
	Haul - Offsite Disposal of Demolition Debris	Miles		20	Estimate distance (to nearest 10 miles) to disposal site for materials, veg clear and grub, etc.	
	Abandon/Relocate Existing Well	LS		1	Abandon existing well in beach at north end of Gibson Spit, Replace with well away from beach (upland)	
Hazardous/Contaminated Waste Removal					These items for earthwork of quality not compatible with wetlands, requiring special handling and disposal. Describe basis for classification as contaminated or hazardous. State known or suspected contamination, describe known similar work.	
	Contaminated Earthwork	CY		0	Not Applicable	
	Hazardous Earthwork	CY		0	Not Applicable	
Construct Temporary Features					Use as needed for unusual temporary features not included elsewhere (see TESC below)	
EARTHWORK					Expand to include equipment, etc. to facilitate cost estimating.	
	Excavation	CY			Per yard excavation w/out expected haul	
	Excavation - Upland	CY		0	Not Applicable	
	Excavation - Lowland - Roadway Removal	CY		13,200	Includes Roadway removal	
	Excavation - Lowland - Dike Removal	CY		2,900	Includes dike removal at north end of estuary	
	Excavation - Lowland - Misc Fill Removal	CY		950	Includes miscellaneous fill removal at Port Williams	
	Dredging - Bucket - Land	CY		0	Not Applicable	
	Dredging - Bucket - Marine	CY		0	Not Applicable	
	Dredging - Hydraulic	CY		0	Not Applicable	
	Fine Grading	AC		0	Not Applicable	
	Off-site Haul and Disposal - Excavated Material	Miles		20	Off-site haul/waste of excess excavated fill, Total Excavated Fill (17,050 CY) - Fill used on-site (925 CY)	
	Fill Placement - local borrow				This is additive to Earthwork -Excavation	
	Side cast	CY		0	Not Applicable	
	Haul - uncontrolled placement	CY		0	Not Applicable	
	Haul, place, compact - Fill Existing Ditch	CY		925	Transportation and second handling - estimate distance, placement in lifts, moisture conditioning, compaction testing.	
	Stockpile - uncontrolled placement	CY		0	Not Applicable	
	Stockpile - controlled placement	CY		17,050	intermediate step, for subsequent off haul or use elsewhere on site. Can use this for drying material for subsequent controlled compacted fill	
	Conveyor placement from stockpile land/water	CY		0	Not Applicable	
	Imported Fill				Not Applicable	
	Select Fill	CY		0	Not Applicable	
	Gravel Borrow, including haul	CY		0	Not Applicable	
	Sand / Gravel for Beach Nourishment	CY		0	Not Applicable	
	Cobble for Shore Nourishment	CY		0	Not Applicable	
	Embankment Compaction	CY		0	Not Applicable	
	Topsoil	CY		0	Not Applicable	
RESTORATION Features						
	Channel Rehab / Creation	SF		16,000	Grading for restoration of tidal channels where roadway fill will be removed.	1.3.2
	Large Wood Placement	EA		0	Not Applicable	
	Invasive Species Control	Acre		0	Not Applicable	
	Physical Exclusion Devices	LF or EA		0	Not Applicable	
	Other Restoration Features/ Activities	LS		0	Not Applicable	
Structures		EA			KPFF to provide additional inputs	
	Water Control Structures - Culverts with Gates	EA		0	Not Applicable	
	Water Control Structures - Weirs	EA		0	Not Applicable	
	Rock Slope Protection	LF		0	Not Applicable	
	Other	EA		0	Not Applicable	
	Elevated Boat Ramp	SF		0	Not Applicable	
	Fencing	SF		0	Not Applicable	
Utilities					Replacement or relocation. Designer to provide size and material and have separate line item for each run. Incidentals include earthwork, testing, hook up fees, etc. These quantities do not include demolition of existing utilities, real estate / easements, design fees. Describe the owner if known, and whether utility franchise will install (e.g., electric is typically installed by electrical franchise).	
	Water	LF		0	Not Applicable	
	Gas	LF		0	Not Applicable	
	Electric	LF		0	Not Applicable	
	Sewer - Pipe (Directionally Drilled)	LF	Sewer	1,650	Horizontal directionally drilled 18" SS	1.3.4
	Sewer - Pipe (Trenched and Backfilled)	LF	Sewer	75	Average Burial Depth (To bottom of pipe) = 5 Feet, With 6 inches Bedding, Select Backfill to 6 inches above pipe	
	Sewer - Manhole	EA	Manhole	1	New Manhole installed at upstream end of directionally drilled pipe	
	Sewer - Outfall Diffuser	LS	1	1	New outfall with diffuser installed where directionally drilled pipe daylights under Strait of Juan de Fuca	
	Telecommunications	LF		0	Not Applicable	
	Other	LF		0	Not Applicable	
Roadway / Railway					KPFF expected to participate in these estimates	
	Roadway (Type)	SF		0	Not Applicable	
	Roadway - Traffic Signal	LS		0	Not Applicable	
	Culvert (type)	LF		0	Not Applicable	
	Culvert - Jacking	LF		0	Not Applicable	
	Culvert - Horizontal Pile Driving	LF		0	Not Applicable	
	Bridge - Foundations, Deck and Appurtenances	SF		0	Not Applicable	
	Railway - Box Girder	SF		0	Not Applicable	
	Railway - Foundation	LF		0	Not Applicable	
	Railway - Shoe fly	LF		0	Not Applicable	
Permanent Access Features					KPFF expected to participate in these estimates	
	Roads	Level		0%	Not Applicable	
	Utility Access Routes	LF		3,800	Maintenance access along beach to sewer outfall location from Port Williams	
	Erosion Control Features	L.F.		0	Not Applicable	
Public Access or Recreation Features					KPFF expected to participate in these estimates	
	trails	SF		0	Not Applicable	
	bridges	SF		0	Not Applicable	
	kiosk	EA		0	Not Applicable	
	restrooms	EA		0	Not Applicable	
	Interpretive Signs	EA		0	Not Applicable	
	parking area	SF		0	Not Applicable	
	Other	EA		0	Not Applicable	

Full Restoration Quantity Estimate

	Action Name:	Washington Harbor					
	Action #:	PSNERP ID #1237					
	Date:	February 2011					
	By:	David Rice, P.E., Anchor QEA					
Vegetation & Erosion Control							
	Hydroseeding	AC		0	Not Applicable		
	Planting	AC		0	Not Applicable		
	Vegetation Maintenance	AC-YR		0	Not Applicable		
	Erosion / sediment BMPs - Temp.	LS		1	Erosion/sediment control BMPs - Silt fences, cofferdams, temporary pumping and conveyance		
	Erosion / sediment BMPs - Permanent	AC		0	Not Applicable		
	Waterside controls - Temporary	LS		1	Erosion/sediment control BMPs - Silt curtains, cofferdams, other		
Construction Management							
	Construction oversight	weeks		15	Estimated construction duration of 3+ Months		
	Materials testing				Included in cost of material - no separate quantity		
Design and Detailed Site Investigations							
	Survey & Property, Utility Research	LS		1	Topographic and Property Boundary Survey		
	35% Design	LS		1	35% x 25% x Engineer's Estimate		
	65% design	LS		1	65% x 25% x Engineer's Estimate less the cost for 35% PS&E		
	90% design	LS		1	35% x 25% x Engineer's Estimate less the cost for 35% + 65%PS&E		
	100% design	LS		1	25% x Engineer's Estimate less previous costs		
	Geotechnical Studies	LS		1	Borings, Soil Info for Direction Drill		
	Cultural Studies	LS		1	Cultural Resource Survey of Estuary		
	HTWR Studies				Refer to design report for description of need		
Project Agreement Activities					Unable to provide credibale estimate at 10% design		
Site-Specific Adaptive Management Features & Activities					List if known		
Monitoring Activities					Assume 5 crew-days/year for each monitoring parameter in design report for 5 yrs		
	Monitoring (Type)	crew-days		125			
Operations & Maintenance					Unable to provide credible estimate at 10% design		

Partial Restoration Quantity Estimate

Action Name: Washington Harbor
Action #: PSNERP ID #1237
Date: February 2011
By: David Rice, P.E., Anchor QEA

REMEDY: *Access roadway replacement with bridge, sewer outfall relocation, culvert removal, armoring removal*
Construction Period: Approximately 52 Weeks

Item	Unit of Measure	Material Name	Qty	Description of Item	Indicate section of design report where item is described
ACQUISITION AND CONSERVATION				Based on available mapping information	
Required Project Lands	Acre		3.5	Includes 100-foot width along access roadway	1.3.5
Proponent / Partner-owned lands	Acre		0	Not Applicable	
Lands To Be Acquired	Acre		0	Assumes construction/conservation easements will be granted by private property owners	
Material Sites				Not Used: See Earthwork - Imported Fill.	
MOBILIZATION AND ACCESS for construction activities				Description required for each item to facilitate cost estimating	
Mobilization - Typical (Equipment, Personnel, Planning, Financial)	LS		1	Assume 8% of other Construction Cost Items	
Mobilization - Remote (Equipment, Personnel, Planning, Financial)	LS		0	Not Applicable	
Site Access	LS		0	Not Applicable	
Barge Access	Days		0	Not Applicable	
Temporary Traffic Control (one of the following)				Not Applicable	
none	LS		0	Not Applicable	
signs	LS		1	Typical construction signage. Minimal impacts to traffic since this is an access road.	
flags / spotters	LS		0	Not Applicable	
unique	LS		0	Not Applicable	
Temporary Roadway	SF		0	Not Applicable	
Control of Water	LS		1	Cofferdams, or other dewatering will be required for roadway and sewer removal	1.3.7
Relocation Activities				Not Used: See Utilities, Structures	
Site Demolition Activities				Demolition and removal of structures (description required), temporary features and relocations, itemized separately); Clearing and grubbing of vegetation, and removal of minor debris (rocks, slabs) - description required.	
Clearing and Grubbing (one or more of following)				Use one or more of the following categories of clearing and grubbing	
Clear Vegetation - Local Disposal	AC		0	Not Applicable	
Clear /Grub Vegetation - Local Disposal	AC		0.4	Clear and Grub, 50-FT Width Along Roadway to be Modified	
Clear /Grub Vegetation - Offsite Disposal	AC		0	Not Applicable	
Clear, stockpile - large woody debris	CY		0	Not Applicable	
Hydraulic Structures - Small	LS	Culverts	1	Removal of (2) 72" 100 LF Culverts	1.3.7, 1.4
Hydraulic Structures - Large	LS		0	Not Applicable	
Utilities - Sewer Pipe	LF	Sewer	1,880	Removal of existing 18-inch concrete sewer pipe in access road and up road 2 manholes from causeway	
Utilities - Sewer Manholes	EA	Manhole	3	Removal of existing pre-cast (48-inch) concrete sewer manholes	
Buildings	LS or SF		0	Not Applicable	
Pavement	LS or SF		0	Not Applicable	
Bulkheads	LF or SF		0	Not Applicable	
Rock revetments - Along Roadway	Ton	Armoring	148	Shoreline Armoring...570 LF Along Roadway	1.3.1, 1.3.2
Large Coastal Structures	LF, SF or CY		0	Not Applicable	
Demolition / Removal - Bridge	SF or CY		0	Not Applicable	
Removal - Misc. (e.g. angular rock from beach)	Ton		0	Not Applicable	
Demolition / Removal - Boat Ramp	SF		0	Not Applicable	
Haul - Offsite Disposal of Demolition Debris	Miles		20	Estimate distance (to nearest 10 miles) to disposal site for materials, veg clear and grub, etc.	
Hazardous/Contaminated Waste Removal				These items for earthwork of quality not compatible with wetlands, requiring special handling and disposal. Describe basis for classification as contaminated or hazardous. State known or suspected contamination, describe known similar work.	
Contaminated Earthwork	CY		0	Not Applicable	
Hazardous Earthwork	CY		0	Not Applicable	
Construct Temporary Features				Use as needed for unusual temporary features not included elsewhere (see TESC below)	
EARTHWORK				Expand to include equipment, etc. to facilitate cost estimating.	
Excavation	CY			Per yard excavation w/out expected haul	
Excavation - Upland	CY		0	Not Applicable	
Excavation - Lowland - Roadway Removal	CY		9,000	Includes Roadway removal	1.3.2
Dredging - Bucket - Land	CY		0	Not Applicable	
Dredging - Bucket - Marine	CY		0	Not Applicable	
Dredging - Hydraulic	CY		0	Not Applicable	
Fine Grading	AC		0	Not Applicable	
Off-site Haul and Disposal - Excavated Material	Miles		20	Off-site haul/waste of excess excavated fill, Total Excavated Fill (9,000 CY)-Fill Used for Roadway (2,000 CY)	
Fill Placement - local borrow				This is additive to Earthwork -Excavation	
Side cast	CY		0	Not Applicable	
Haul - uncontrolled placement	CY		0	Not Applicable	
Haul, place, compact - For Approach to Bridge	CY		2,000	Use of fill excavted for bridge construction for construction of roadway modifications for bridge approaches	
Stockpile - uncontrolled placement	CY		0	Not Applicable	
Stockpile - controlled placement	CY		9,000	intermediate step, for subsequent off haul or use elsewhere on site. Can use this for drying material for subsequent controlled compacted fill	
Conveyor placement from stockpile land/water	CY		0	Not Applicable	
Imported Fill				Not Applicable	
Select Fill	CY		0	Not Applicable	
Gravel Borrow, including haul	CY		0	Not Applicable	
Sand / Gravel for Beach Nourishment	CY		0	Not Applicable	
Cobble for Shore Nourishment	CY		0	Not Applicable	
Embankment Compaction	CY		2,000	Compaction of Additional Fill Placed for Roadway Embankment Modifications	
Topsoil	CY		0	Not Applicable	
RESTORATION Features					
Channel Rehab / Creation	SF		12,000	Grading for restoration of tidal channels where roadway fill will be removed.	1.3.2
Large Wood Placement	EA		0	Not Applicable	
Invasive Species Control	Acre		0	Not Applicable	
Physical Exclusion Devices	LF or EA		0	Not Applicable	
Other Restoration Features/ Activities	LS		0	Not Applicable	
Structures	EA			KPFF to provide additional inputs	
Water Control Structures - Culverts with Gates	EA		0	Not Applicable	
Water Control Structures - Weirs	EA		0	Not Applicable	
Rock Slope Protection	LF		0	Not Applicable	
Other	EA		0	Not Applicable	
Elevated Boat Ramp	SF		0	Not Applicable	
Fencing	SF		0	Not Applicable	
Utilities				Replacement or relocation. Designer to provide size and material and have separate line item for each run. Incidentals include earthwork, testing, hook up fees, etc. These quantities do not include demolition of existing utilities, real estate / easements, design fees. Describe the owner if known, and whether utility franchise will install (e.g., electric is typically installed by electrical franchise).	
Water	LF		0	Not Applicable	
Gas	LF		0	Not Applicable	
Electric	LF		0	Not Applicable	
Sewer - Pipe (Installed on Bridge)	LF	Sewer	590	Pipe - installed on bridge, Include pipe supports installed between girders on bridge	1.3.4
Sewer - Pipe (Trenched and Backfilled)	LF	Sewer	1,290	Average Burial Depth (To bottom of pipe) = 5 Feet, With 6 inches Bedding, Select Backfill to 6 inches above pipe	
Sewer - Manhole	EA	Manhole	6	New SS Maholes	
Telecommunications	LF		0	Not Applicable	
Other	LF		0	Not Applicable	
Roadway / Railway				KPFF expected to participate in these estimates	
Roadway - Gravel Surface	SF	Gravel	5,143	Typical Roadway Varies Between 14' wide and 16' Wide, 6 inch Bank Run Gravel Surface	
Roadway - Traffic Signal	LS		0	Not Applicable	
Culvert (type)	LF		0	Not Applicable	
Culvert - Jacking	LF		0	Not Applicable	
Culvert - Horizontal Pile Driving	LF		0	Not Applicable	
Bridge - Superstructure	SF	Bridge	10,620	Concrete Girder Bridge with 95' Spans	
Bridge -Foundation	LF	Foundation	112	(7) CIP pile caps w/ (2) 7' Dia drilled shafts 100' Embedment at each pile cap	
Railway - Box Girder	SF		0	Not Applicable	
Railway - Foundation	LF		0	Not Applicable	
Railway - Shoe fly	LF		0	Not Applicable	
Permanent Access Features				KPFF expected to participate in these estimates	
Roads	Level		0%	Not Applicable	
Utility Access Routes	LF		0	Not Applicable	
Erosion Control Features	L.F.		0	Not Applicable	
Public Access or Recreation Features				KPFF expected to participate in these estimates	
Trails	SF		0	Not Applicable	
Bridges	SF		0	Not Applicable	
Kiosk	EA		0	Not Applicable	
Restroom	EA		0	Not Applicable	
Interpretive Signs	EA		0	Not Applicable	
Parking Area	SF		0	Not Applicable	
Other	EA		0	Not Applicable	
Vegetation & Erosion Control					
Hydroseeding	AC		0	Not Applicable	
Planting	AC		0	Not Applicable	
Vegetation Maintenance	AC-YR		0	Not Applicable	
Erosion / sediment BMPs - Temp.	LS		1	Erosion/sediment control BMPs - Silt fences, cofferdams, temporary pumping and conveyance	
Erosion / sediment BMPs - Permanent	AC		0	Not Applicable	

Partial Restoration Quantity Estimate

Action Name: Washington Harbor
Action #: PSNERP ID #1237
Date: February 2011
By: David Rice, P.E., Anchor QEA

	Waterside controls - Temporary	LS		1	Erosion/sediment control BMPs - Silt curtains, cofferdams, other		
Construction Management							
	Construction oversight	weeks		52	Estimated construction duration of 15 Months		
	Materials testing				Included in cost of material - no separate quantity		
Design and Detailed Site Investigations							
	Survey & Property, Utility Research	LS		1	Topographic and Property Boundary Survey		
	35% Design	LS		1	35% x 25% x Engineer's Estimate		
	65% design	LS		1	65% x 25% x Engineer's Estimate less the cost for 35% PS&E		
	90% design	LS		1	35% x 25% x Engineer's Estimate less the cost for 35% + 65%PS&E		
	100% design	LS		1	25% x Engineer's Estimate less previous costs		
	Geotechnical Studies	LS		1	Borings, Soil Info for Direction Drill		
	Cultural Studies	LS		1	Cultural Resource Survey of Estuary		
	HTWR Studies				Refer to design report for description of need		
Project Agreement Activities					Unable to provide credibale estimate at 10% design		
Site-Specific Adaptive Management Features & Activities					List if known		
Monitoring Activities					Assume 5 crew-days/year for each monitoring parameter in design report for 5 yrs		
	Monitoring (Type_)	crew-days		125			
Operations & Maintenance					Unable to provide credible estimate at 10% design		

36. WDNR MARINE LAB BULKHEAD SOFTENING (#1684)

Local Proponent	Washington Department of Natural Resources (WDNR)
Delta Process Unit	DES
Shoreline Process Unit(s)	3039
Strategy(ies)	2 - Beach
Restoration Objectives	Restore sediment supply and transport at historic beach, bluff, and barrier lagoon, to 1 mile of shore including down-drift barrier estuary

36.1 Description of the Action

This proposed action entails restoration of sections of barrier and bluff-backed beach, which will alleviate degradation of sediment supply and transport, tidal flow, and other nearshore processes. Proposed restoration actions include armor/groin removal, topographic restoration, debris removal, contaminant removal, beach nourishment, large woody debris placement, and revegetation. Please see the Introduction chapter for important information regarding PSNERP and the context of this restoration project.

36.2 Action Area Description and Context

The action area is located in the South Puget Sound Subbasin within shoreline process unit 3039, which exhibits northward net shore-drift from Ellis Cove to Gull Harbor, along the east shore of Budd Inlet in southern Puget Sound. The area includes approximately 780 feet of publicly and privately owned shoreline. The WDNR marine lab is built on a large fill area that encompasses the central portion of the site. Several structures, including an artesian well with pump house, outfalls, and a large shed, are part of the facility. An old office building was removed from the south end of the site in 2003, as was a garage (year of removal unknown). The fill is contained by two L-shaped soldier-pile bulkheads constructed of creosote-treated wood piles and timbers, and a rock revetment. The fill area infringes on the beach considerably and appears to have a groin-like effect on littoral transport along much of the high tide beach. The fill has retained a good amount of net shore-drift sediment supplied from bluffs up-drift of the structure, but also now appears to bypass most sediment in the lower intertidal zone to beaches down-drift of the structure, which includes the large barrier estuary of Gull Harbor located at the drift cell terminus.

The armored, low-elevation shore north of the WDNR property is a private access beach for the adjacent mobile home park. This site appears to have undergone many changes since historic times, largely due to the placement of nearshore fill and construction of a bulkhead, which extends both waterward and landward into a narrow ravine. At least one culvert currently controls the hydrology of the wetland/historic lagoon. Access to the northern properties was not granted for a field visit, so it is not known whether a tide gate was installed at the site or if marine waters inundate the wetland. In addition, south of the WDNR property is a concrete bulkhead at what appears to be a publicly owned shore. Removing this bulkhead provides an opportunity to further restore sediment supply and transport processes in the action area. The action area is shown in Figure 36-1.

Figure 36-1. Action Area and Vicinity

36.2.1 Historic Condition

Change analysis (Simenstad et al. 2009) mapped much of this area including the WDNR property as bluff-backed beach. Historically, a small barrier lagoon extended from the northern beach landward into a ravine, which currently encompasses a wetland and a small stream. A 1950s aerial photograph shows the northern site prior to what appears to be most of the filling. A broad stream delta was present on the intertidal zone in the 1950s. The 1873 mapping showed what appeared to be a barrier that curved waterward at the barrier mapped lagoon location. A small stream channel was mapped that extended approximately 1,400 feet through a small ravine, extending through the berm (Collins and Sheikh 2005).

The T-sheet (Figures 36-2A and 36-2B) does not appear to show a tide channel but instead shows a survey monument in this location. The barrier shape was much more indented than the historic (1873) mapping by the time of the 1950s aerial photo. Currently the site is mapped as “artificial” due to the number of co-located stressors that have together substantially altered the historic character of the site (Simenstad et al.

2009). Stressors and other impacts to the action area include filling of the barrier lagoon and beach to the north, and the combined effects of armor, fill, and dredging of the tidelands on the WDNR-owned property.

36.2.2 Natural Environment

The WDNR property encompasses roughly 3 acres, much of which extends into the uplands. Shallow landslides occur on the bluffs that bound the access road on both sides of the ravine. At the highest elevation, the bluffs measure approximately 80 feet high and are relatively high gradient. The uplands are mapped as glacial till overlying outwash sand, followed by the Kitsap Formation, and penultimate drift. The exposed lower bluff at the site appeared to consist of coarser sand mixed with medium pebbles. The exposure of the site is classified as “protected” (WDNR 2001) with a maximum fetch of approximately 5 miles to the northeast. A local NOAA water level station specified +14.4 feet MLLW as local MHHW.

36.2.3 Human Environment

Most stressors on the WDNR property were constructed around 50 years ago by the Maritime Administration. This early owner of the parcel constructed the fill, armor, and creosote-treated wood pier and dredged the tidelands as far back as 1956. The Maritime Administration used the facility to maintain more than 100 ships referred to as the “Mothball Fleet” or “Reserve Fleet.” The ships were largely veterans of World War II and other conflicts. They were stationed in Budd Inlet from 1946-1972. During the 1950s many ships were used as storehouses for wheat.

This site is currently owned and operated by the WDNR. The facility is used to stage dive operations, as well as store and maintain marine equipment from boats to diving equipment for agency use. Plans are currently underway to remove the derelict pier at the site and several of the creosote-treated piles on the adjacent WDNR-held tidelands. The pier and all associated structures are scheduled to be removed by March 14, 2011. The remaining stressors include a creosote-treated wood, vertical bulkhead that extends from the upland edge in an L-shape, around but not completely across the waterward face of the fill area. The central (waterward) face of the structure is contained and fortified by a rock revetment composed of densely piled 2- to 3-foot-diameter riprap that extends to approximately +6 to +8 feet MLLW or 7 to 8 feet below MHHW. The ground surface of the fill area is largely gravel and asphalt, and a large warehouse, storage shed and well, and pump house are located on the fill area. Two fire hydrants and several outfalls are also found within the fill area.

This area was originally filled with dredged material from the tidelands which reportedly consisted of silty sand. However, some of this material was removed due to contamination that resulted from the catastrophic failure of an old heating oil tank buried in the fill. The excavated area was backfilled with pit-run sandy gravel with silt (Landau Associates 2003, 2009). Some contamination of the remaining fill material exists, which is actively being bioremediated. This *in situ* treatment of the contaminated material is effective for capped sediment only. Some contamination of the tidelands also exists; however the source, magnitude, and spatial extent of the contamination are not yet known.

The fill area is flat and extends 223 feet from the base of the bluff. The aerial extent of the fill measures 32,276 SF. An additional 6,475 SF of intertidal area is covered with riprap waterward of the fill area.

The northern properties, which appear to be owned by the same family, currently function as private beach access for “Seashore Villa,” the mobile home park located in the adjacent uplands. A picnic shelter, parking lot, and two other small structures are found in the filled, partially paved area landward of the bulkhead. The first fill and hydrologic alterations appear to have taken place sometime between the 1950s and 1977, as the site was little developed in the 1950s aerial photograph.

36.3 Restoration Design Concept

36.3.1 Restoration Overview and Key Design Assumptions

Figures 36-3 through 36-5 illustrate the alternatives. The full restoration alternative entails actions taken on both the WDNR marine lab property as well as the adjacent properties to the north and south. The partial restoration alternative would occur only on the WDNR marine lab property and the adjacent publicly owned lands.

Proposed actions for the full restoration alternative on the properties to the north of the WDNR facility include: property acquisition, armor removal, topographic restoration, debris removal, beach nourishment, channel rehabilitation, large woody debris placement, and revegetation. Proposed restoration actions in support of both the full and partial restoration alternatives on the WDNR and adjacent publicly owned property to the south include: armor/groin removal, topographic restoration, debris removal, contaminant removal, beach nourishment, large woody debris placement, and revegetation.

The partial restoration alternative entails removing and regrading the fill area, which is contained by a creosote-treated wood bulkhead and rock armor. The armor and fill extend over most of the high tide beach, resulting in a groin-like effect on nearshore sediment transport processes. The removal of this material would ameliorate degraded sediment supply and transport to approximately 1 mile of down-drift shore. An additional concrete bulkhead south of the WDNR site would also be removed as it does not appear to be within a privately held parcel but on publicly owned lands.

Previous investigation showed that contamination of fill material reached as deep as 13 to 16 feet below the ground surface, which is approximately 3 to 6 feet below the historic beach grade. It is assumed that the backfill or other historic fill material would not be appropriate for regrading the beach following excavation of contaminated material, and that clean sediment of coarser grain size would be brought in to recreate a natural beach profile. It is also assumed that there may be additional contamination in the fill, which may have originated in fuel, the heavily creosote-treated timbers that contain the fill, and/or the numerous buried creosote-treated piles that were used as structural support for the buildings.

The heavily creosote-treated piles, timbers, and pier are likely contributors to cPAH contamination. More than 230 creosote-treated piles and 10,462 SF of overwater structure will be removed by March 14, 2011. WDNR currently has no plans to further characterize sediment at this site. Contaminants identified through previous sampling were found at depth (Landau Associates 2003, 2009). Remediation would most likely not be required for site restoration if surface levels remain below cleanup standards. Further characterization of sediment will be needed. The sampling plan would focus on the sediment surface level that would be created and exposed to future transport. A sediment transport assessment should be completed to assess whether contaminated sediment may be impacted by reestablished littoral drift processes. The data would then be shared with Ecology to determine whether removal is required to protect human health and the environment.

Key design elements associated with full and partial restoration alternatives are shown in Table 36-1.

Table 36-1. Key Design Elements

Element	Full Restoration	Partial Restoration
Acquisition	Potentially acquire the tidelands adjacent to parcel 1292640300, dependent on results of ownership survey	Not included
Armor Removal	Remove concrete bulkhead along northern and southern adjacent shore, creosote and rock armor on WDNR property	Remove concrete bulkhead along southern adjacent shore, creosote and rock armor on WDNR property
Debris Removal	Remove buildings from northern property, rock rubble from northern property, remove buildings from WDNR fill area and buried creosote piles in fill. Remove debris from tidelands and adjacent bedlands	Remove buildings from WDNR fill area and buried creosote piles in fill. Remove debris from tidelands and adjacent bedlands
Fill	Remove fill from northern property, dredge to recreate tidal lagoon, remove fill from WDNR fill area	Remove fill from WDNR fill area
Excavation	Excavate and dispose of hazardous material in fill area adjacent to bulkhead, and any contaminated intertidal or subtidal sediments that would be exposed to littoral drift	Same as full restoration
Beach Profile	Recreate barrier that embays the lagoon; recreate beach profile following excavation of hazardous material	Recreate beach profile following excavation of hazardous material
Tidal Channel	Excavate/recreate a tide channel to restore/create connectivity between lagoon and marine water	Not included
Revegetation	Reestablish backshore and riparian vegetation on 1.73 acres	Reestablish backshore and riparian vegetation on 0.65 acres
Large Woody Debris	Distribute 8 to 9 large wood groupings	Distribute 3 large wood groupings

36.3.2 Restoration Features – Primary Process-Based Management Measures

Armor Removal/Modification

The full restoration alternative entails removal of all armoring in the nearshore on the WDNR site as well as the properties to the north and south, to allow full restoration of sediment transport and supply processes. Armor slated for removal from the properties to the north includes a concrete bulkhead (250 LF) and small volume (39 CY) of rubble (Figures 36-3 and 36-5).

The partial restoration alternative includes removal of armor only from the WDNR site and the adjacent publicly owned land to the south (Figures 36-4 and 36-5). Armor on the WDNR site consists of 370 LF of creosote-treated wood, soldier pile, and timber bulkhead and 1,050 CY of rock revetment. The concrete bulkhead on the publicly owned property to the south (115 LF) would also be removed.

Berm or Dike Removal/Modification - NA

Channel Rehabilitation/Creation

As part of the full restoration alternative, a tide channel would be excavated to connect the restored barrier lagoon with Budd Inlet along the properties north of the WDNR facility. The tide channel would extend from several feet vertically below the proposed MHHW line into the lagoon basin (Figure 36-3). It would have an average depth of approximately 5 feet. The approximate excavation volume to create the tide channel is 3,500 CY. The proposed channel would measure approximately 25 feet in width and be composed of native material.

Groin Removal/Modification

The WDNR armor and fill area functions similarly to a groin by limiting littoral transport along the beach face. Thus, the fill area can be considered a large groin measuring approximately 100 feet cross-shore, with a total volume of approximately 10,600 CY. The removal of this groin-like structure is included as part of both the partial and full restoration alternatives (Figures 36-3 and 36-4).

Hydraulic Modification - NA

Overwater Structure Removal - NA

Topography Restoration

Both the full and partial restoration alternatives include fill removal, excavation, and rough grading to recreate the beach at the WDNR property. Partial restoration would include removal of 10,600 CY of fill material, with 3,000 CY of fill requiring handling and disposal as hazardous material. It is assumed that at least 250 CY of suitable uncontaminated sediment from the fill excavation can be reused for beach nourishment with partial restoration, and 450 CY for full restoration.

Only minor clearing and grubbing will be required (0.4 acre in full restoration alternative, with slightly less in partial restoration alternative). The full restoration alternative would also include 3,500 CY of excavation to recreate the barrier lagoon and tide channel complex at the north properties. The berm at the lagoon was designed at this level using the guidance in Appendix C and is intended to be dynamically stable with overwash only during extreme high water, which will ensure that invasive species do not colonize it.

36.3.3 Restoration Features – Additional Management Measures

Beach Nourishment

Beach nourishment would expand and increase the elevation of the north-trending historic barrier beach that embays the lagoon along the northern property. The full restoration alternative would require 1,770 CY of material to adequately restore these features to a sustainable configuration (Figure 36-3).

The partial restoration alternative entails beach nourishment as a means of recreating the beach profile following excavation of hazardous material (Figure 36-4). The partial restoration alternative will require 820 CY of nourishment material.

Contaminant Removal/Remediation

Previous research by Landau Associates (in prep.) estimated that approximately 3,000 CY of contaminated sediment exists within the WDNR fill area. Both partial and full restoration alternatives include excavation and disposal of this hazardous material as part of restoring the natural beach profile and nearshore processes. Further assessment is needed to determine quantities of contaminated sediment that may need to be removed. A layer of clean sediment may need to be added to reestablish the shoreline to proper elevation following contaminated sediment removal.

Debris Removal

Creosote-treated wood planks and piles that help to contain the WDNR fill area will be removed, hauled away, and disposed in an appropriate location. Soil adjacent to piles will be evaluated for contamination and removed if necessary. Debris removal of approximately 350 CY of creosote-treated wood will occur for both restoration alternatives (Figures 36-3 and 36-4).

The removal of additional non-hazardous debris is recommended under both the full and partial restoration alternatives. Full restoration would require the removal of a total of seven buildings from all properties, with a cumulative area of 6,640 SF. Also, 42,530 SF of pavement would be removed in full restoration. The partial restoration alternative entails removal of four buildings from the WDNR property, totaling 5,530 SF, and 36,880 SF of pavement.

Invasive Species Control

Scot's broom and Himalayan blackberry (0.1 acre) would be removed for both full and partial restoration at the south end of the WDNR property as well as the adjacent (south) property. Small areas of similar invasive vegetation would need to be removed from the northern properties (approximately 0.2 acre).

Large Wood Placement

Large woody debris would be placed along the berm crest to increase the structural complexity of the barrier beach by providing additional substrate for colonizing vegetation, insects, and other invertebrates. Twelve large wood pieces would be placed at three different locations along the berm crest for the partial restoration alternative (Figure 36-4). An additional 16 large wood pieces would be placed at six locations along the northern property as part of the full restoration alternative (Figure 36-3).

Physical Exclusion - NA

Pollution Control - NA

Revegetation

Full restoration would entail reestablishing 1 acre of backshore and 0.73 acre of riparian vegetation at the WDNR fill area (1.73 acres total) and along the lawn areas to the north and south of the fill area (Figure 36-3). The full restoration alternative would install backshore/dune vegetation plantings along an approximately 15-foot-wide band adjacent to the tide channel, along the berm crest of the barrier and southern shore of the lagoon, north of the WDNR site. On the WDNR site, backshore/dune vegetation would be installed along a similar approximately 15-foot band. Marine riparian vegetation planting would extend landward of the backshore/dune riparian plantings.

Partial restoration would entail revegetation of a total of 0.65 acre of the WDNR fill area (0.1 acre of backshore vegetation and 0.55 acre of marine riparian vegetation) (Figure 36-4). On the WDNR site, backshore/dune vegetation would be installed along an approximately 15-foot band. Marine riparian vegetation planting would extend landward of the backshore dune riparian plantings. Soil should be augmented along all planting areas to increase the success of plantings.

Reintroduction of Native Animals - NA

Substrate Modification - NA

Species Habitat Enhancement - NA

36.3.4 Restoration Features – Other

NA

36.3.5 Land Requirements

The partial restoration alternative would require land on two parcels owned by WDNR and land outside of parcel ownership, which appears to be public, totaling 6.3 acres. The full restoration alternative includes the same land as needed for partial restoration, as well as portions of two privately owned parcels north of the WDNR-owned land, totaling 7.6 acres.

WDNR is a willing partner and open to relocating the current operations elsewhere, making the partial restoration alternative free of landowner constraints. The WDNR-owned parcel includes 5.5 acres of land. All restoration actions included in both the partial and full restoration alternatives could be administered from the uplands, using the existing roads for access.

Lands that would need to be acquired in support of the full restoration alternative include the narrow parcel north of the WDNR land (approximately 0.5 acre) and a portion of the property directly north of that parcel (approximately 0.7 acre). In lieu of purchasing the property, conservation easements could be acquired to conserve the property while maintaining it as a private beach for the mobile home park.

36.3.6 Design Considerations

Both restoration alternatives present uncertainties relating to contamination of the fill and native soils at the WDNR site and in the tidelands. This has potential water quality implications. It is likely that additional dredge and disposal of contaminated material will be required in the area surrounding the WDNR pier, to complete restoration of the site.

Cultural resources (presence or absence) are not documented at the site. The degree of risk could not be addressed using the level of information available for either restoration alternative.

The northern properties may be very difficult to obtain, as they provide community shore access and improvements at this location. Access could still be accommodated as well as a relocated storage facility in a limited area with full restoration; however, giving up the large, level filled area may be unacceptable to the landowners.

36.3.7 Construction Considerations

Site access is good with a direct road to the main portion of the site and a private drive to the north area. Building and bulkhead removal will be a large portion of the work for both restoration alternatives. Creosote-treated bulkhead removal will include targeted excavation of tie rods and creosote-treated tie backs. Creosote-treated building pile foundations will also need to be removed individually. Excavating and hauling out fill will be large tasks. Testing for contamination may need to occur during excavation if not completed in advance. All contaminants and fill will likely need to be removed prior to restoration work and surface treatments. Restoration features and grading are relatively minor compared to the removal stages.

Excavation and removal of the known, remaining hazardous material found in the fill is included in both the full and partial restoration alternatives. This action will require additional considerations during removal due to the material being located down to approximate mean sea level and below original beach grade. Land-based equipment is recommended for use in the removal. The area would need to be dewatered and excavation timed appropriately to occur during the lowest tides possible. To prevent tidal inundation during removal, a temporary sheet pile wall or similar measure may need to be installed. Maneuvering around an exclusion area can present challenges, so double handing may be required to move the material offsite. A containment barrier such as an oil boom or silt curtain should also be employed to reduce the transport of resuspended contaminated sediment released during dredging. A placement of clean material will most likely be required.

36.4 Extent of Stressor Removal

Table 36-2 describes the amount of stressors to be removed with this action.

Table 36-2. Stressor Removal

Stressor	Full Restoration	Partial Restoration
Tidal Barrier (LF)	18,911 SF	NA
Fill (area)	36,000 SF	36,000 SF
Armor (LF)	735	485

36.5 Expected Evolution of the Action Area

Without restoration of the WDNR site, partial interruption of sediment transport and delivery would continue, and there would be increasing beach narrowing and gradual loss of intertidal habitats. The existing fill and armor that infringe on the intertidal beach would continue to impact the remaining beach with increasing sea level, and less sediment transport would occur waterward of the WDNR site. Littoral transport from the southern to the northern beaches would therefore be further degraded by the groin-like effects of the fill structure.

With full and partial restoration alternatives, the beaches would likely reestablish an equilibrium, and sediment from the southern shore would once again nourish the northern beaches. The sediment that has accumulated on the south shore directly adjacent to the WDNR fill area will likely slowly erode and redistribute along the down-drift shore. The bluff-backed beaches that are currently armored would again become vulnerable to wave-induced erosion and landslides. This restored sediment supply will help sustain the adjacent restored beaches and aid in the natural development of forage fish spawning habitat and large wood recruitment.

Upper beach habitats that are currently beneath fill would provide surf smelt spawning habitat (forage fish spawning is documented along the adjacent shores). Restored marine riparian areas and large wood could benefit forage fish spawning and juvenile salmonid migratory habitats by providing shade and forage, as well as retaining moisture in the beach substrate. Beach wrack, driftwood, and large wood input would also once again occur along these shores, as restored cross-shore connectivity facilitates the import and exchange of detritus.

At the northern properties, the full restoration alternative would recreate the upper beach that is currently beneath fill and armor in some areas. Farther north, it would restore tidal flow, tide channel processes, detritus import and exchange, exchange of aquatic species, sediment supply, erosion and accretion, transport and wave processes to the action area. Beach nourishment and armor removal would restore elevations and processes to enhance adaptive capacity to sea level rise, in contrast to the current armored, sediment-deprived condition. The barrier beach will likely adapt to the restored condition, and the tide channel location will likely shift based on modern littoral transport rates, wave climate, and freshwater input.

The small restored tide channel would allow for utilization of the complex, shallow water lagoon habitat by aquatic species such as migrating juvenile salmonids and forage fish.

Restored tidal inundation within the lagoon will allow establishment of emergent (halophytic) vegetation and deposition of large wood, which will increase habitat structure and function within the lagoon.

36.6 Uncertainties and Risks

The presence of contaminants in the fill and tidelands are key uncertainties that could cause negative impacts and affect habitat quality and aquatic species for both full restoration and partial restoration. WDNR is actively continuing site remediation, and the larger cleanup effort is part of an ongoing phased approach.

It is unlikely, but not well researched at this point, that armor removal will exacerbate erosion along the north and south shores to the degree that structures located on the bluff top are threatened.

The stability of the proposed tide channel for the north end in the full restoration alternative is not at all certain. The tidal prism is quite small and the freshwater input has not been adequately explored. The historic condition of the barrier estuary in the north end remains unclear due to the limited early mapping and long period of development at the site. Nevertheless, the full restoration alternative includes a tide channel which would be simple to grade at this scale.

36.6.1 Risks Associated with Projected Sea Level Change

Table 36-3 compares potential risks associated with projected sea level changes based on professional judgment.

Table 36-3. Risks of Sea Level Change

	Projected Sea Level Change		
	High (65cm)	**Intermediate (21cm)**	**Low (13cm)**
Full Restoration	The barrier protecting the lagoon will likely translate landward as will the landward extent of tidal inundation. Marine-induced bluff erosion will increase sediment supply, which will help the barrier to naturally adapt to rise in sea level, but may threaten upland development.	Minor translation of barrier beach shore landward. Potential shifts in tide channel location. Marine-induced bluff erosion will increase along bluff-backed beaches, which will aid in the translation of the local beaches upward and landward.	Minor translation of barrier beach shore upward and landward. Potential shifts in tide channel location. Marine-induced bluff erosion will increase slightly along bluff-backed beaches, which will aid in the translation process of adjacent beaches.

	Projected Sea Level Change		
	High (65cm)	Intermediate (21cm)	Low (13cm)
Partial Restoration	Shoreline translation will lead to inland barrier migration and erosion of bluff-backed beaches. Some beach erosion and narrowing may occur where barriers are not able to migrate landward due to decreased sediment supply, with reduced backshore vegetation areas.	Shoreline translation will occur. Bluff-backed beaches will recede at an accelerated pace, which will help sustain down-drift beaches.	Minor shoreline translation will occur. Bluff-backed beaches will recede gradually.

36.7 Potential Monitoring Opportunities

Monitoring is important for evaluating the success of the partial or full restoration alternative. A combination of field surveys and aerial photographs would be used to document biological and physical changes to the landscape. Monitoring data can be used to refine adaptive management and corrective actions, as needed. The monitoring needs and opportunities associated with this action are summarized in Table 36-4.

Table 36-4. Monitoring Needs and Opportunities

Monitoring Parameter	Key Performance Indicator	Note
Topographic Stability	X	Monitoring beach morphology will inform restoration success
Sediment Accretion / Erosion	X	
Wood Accumulation	X	
Soil / Substrate Conditions	X	Check status of beach and lagoon area substrates
Vegetation Establishment	X	
Marsh Surface Evolution / Accretion		
Tidal Channel Cross-Section / Density	X	Check stability of created tidal channel
Water Quality (contaminants)		
Salinity		
Shellfish Production		
Extent of Invasive Species		
Animal Species Richness	X	
Fish (salmonid) Access/Use		
Forage Fish Production	X	Adjacent beaches are documented surf smelt spawning habitat

Monitoring Parameter	Key Performance Indicator	Note
Wildlife Species Use		
Effectiveness of Exclusion Devices		

36.8 Information Needed for Subsequent Design

This conceptual design report represents an initial step in the restoration design sequence. The design concepts described above were developed based on readily available information without the level of site-specific survey and investigation that is necessary to support subsequent design and implementation. Substantial additional information will be required at the preliminary and later design stages to confirm the design assumptions, refine quantity estimates, address property and regulatory issues, obtain stakeholder support, and fill in data gaps. The extent to which this information is collected for preliminary design (or a later design stage) will depend upon the available budget, schedule and other factors. This section attempts to define the most essential information needs for this action.

- Property Investigation/Topographic Survey – A detailed topographic and boundary survey of the site would be required to advance restoration designs. Utility locations should be verified. The exact status of the southern property was not entirely clear at the end of the preliminary design phase and needs to be resolved. Detailed engineering design drawings (USACE 1956) were received from the project proponent as this report was finalized. This information should inform later stages of restoration design to gain a higher level of accuracy in design specifications associated with the WDNR property. The historic condition of the barrier estuary in the north end remains unclear. Other sources of pre-1956 mapping should be explored to better document wetland/estuary conditions and better inform design work.
- Contaminant Survey – The suitability of fill soils for use outside the known contaminated area in the WDNR property needs to be further explored. The extent and source of contamination of the tidelands should be investigated and cleanup plans determined, if required.
- Cultural Resources Survey - The results of an existing cultural resources survey, completed in June 2008, should be integrated into design recommendations.
- Utilities - Any other utilities (e.g., gas line) should be identified.
- Other - Determine if dredging of tidelands occurred to support moorage of large ships.

36.9 Quantity Estimates

The quantity spreadsheets for the full and partial restoration alternatives are provided in Exhibits 36-1 and 36-2.

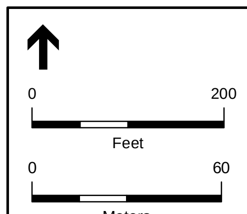
36.10 References

Collins, B. D. and A. J. Sheikh. 2005. *Historical reconstruction, classification, and change analysis of Puget Sound tidal marshes.* Final project report to

Washington Department of Natural Resources Aquatic Resources Division, Olympia, WA.

Landau Associates. 2003. *Soil and groundwater investigation report, Marine Research Center, Olympia, WA*. Prepared for the Washington State Department of Natural Resources.

Landau Associates. 2009. *Supplemental Site Investigation Report, Remedial Investigation Summary and Focused Feasibility Study, Marine Station Redevelopment Project, Olympia, WA*. Prepared for Washington State Department of Natural Resources. April 27.



Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64

WDFW Contract # 100-000204 (CAPS No. 10-1461)

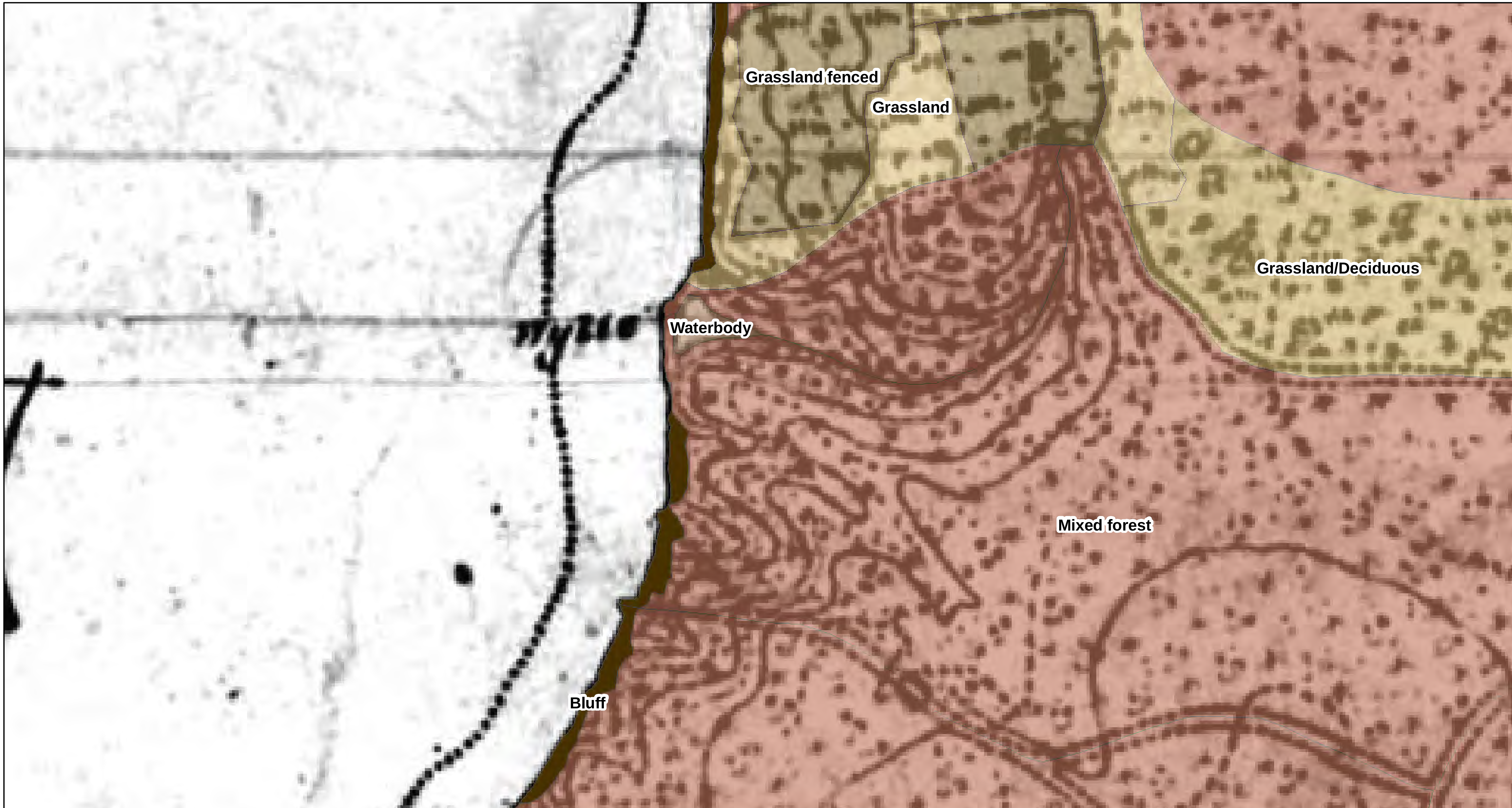
Historic Map (T-Sheet)

Action Name: WDNR Marine Lab Bulkhead Softening

PSNERP ID #: 1684

Figure 36- 2A

S:\GIS\Projects\210xxx\210337_PSNERP_NEARSHORE\Projects\2-TSheets_rev.mxd (DLP; 2/24/2011)

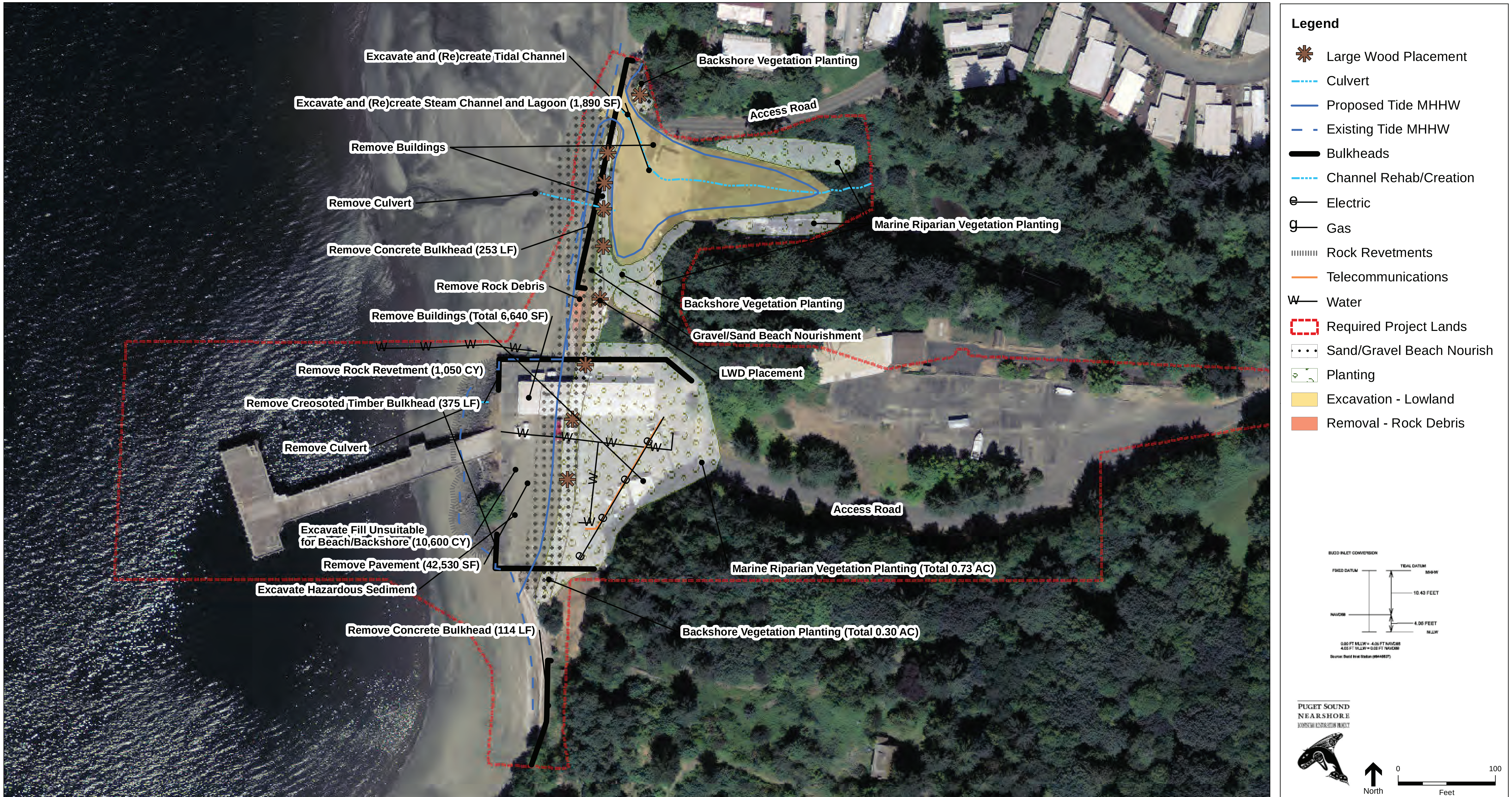


0 200
Feet
0 60
Meters

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Historic Map (T-Sheet) and River History Project Data
Action Name: WDNR Marine Lab Bulkhead Softening
PSNERP ID #: 1684
Figure 36- 2B

S:\GIS\Projects\210xxx\210337_PSNERP_NEARSHORE\Projects\2-TSheets_rev.mxd (DLP; 2/24/2011)



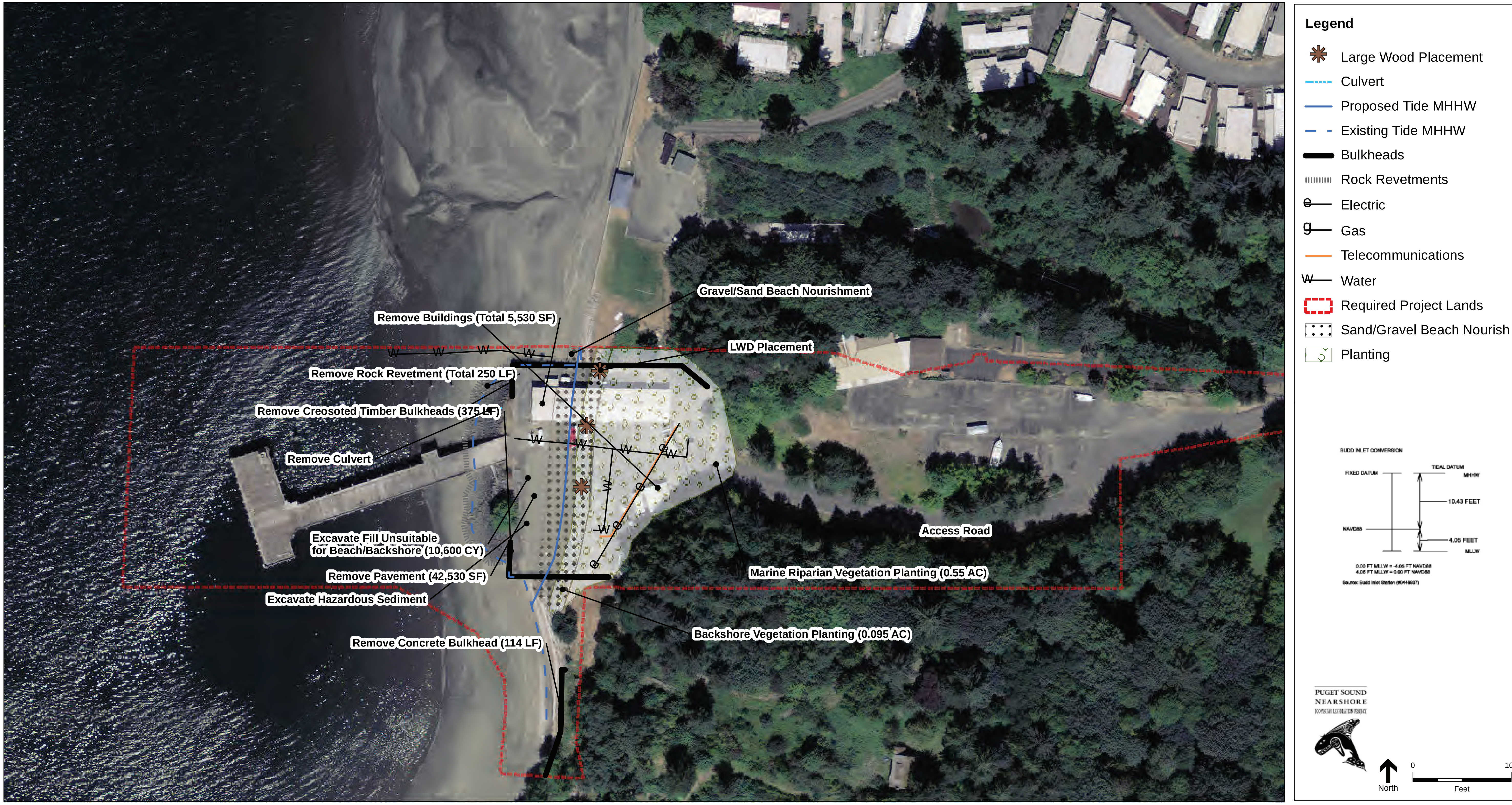
SOURCE: Washington Public Lands Database (2006); Washington Counties Parcels (2009); Action Area (PSNERP, 2010), Thurston County Aerial (2009)

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Lead Contractor: ESA
Design Lead: CGS, Jim Johannessen
Date: 2/2011

Conceptual Design Plan
Site Name: Budd Inlet
Action Name: WDNR Marine Lab Bulkhead Softening
PSNERP ID #:1684
Full Restoration

Figure 36-3



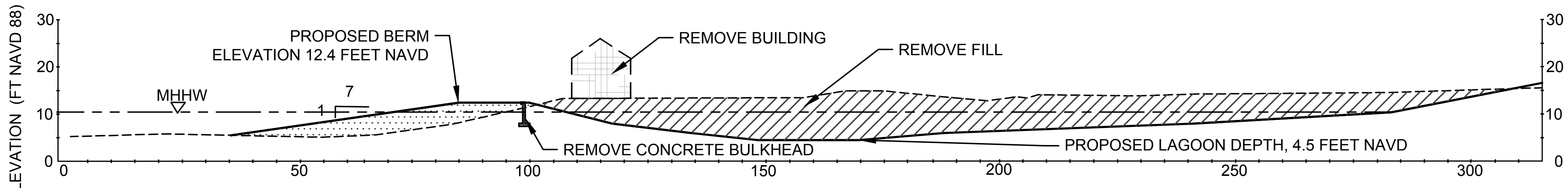
SOURCE: Washington Public Lands Database (2006); Washington Counties Parcels (2009); Action Area (PSNERP, 2010), Thurston County Aerial (2009)

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

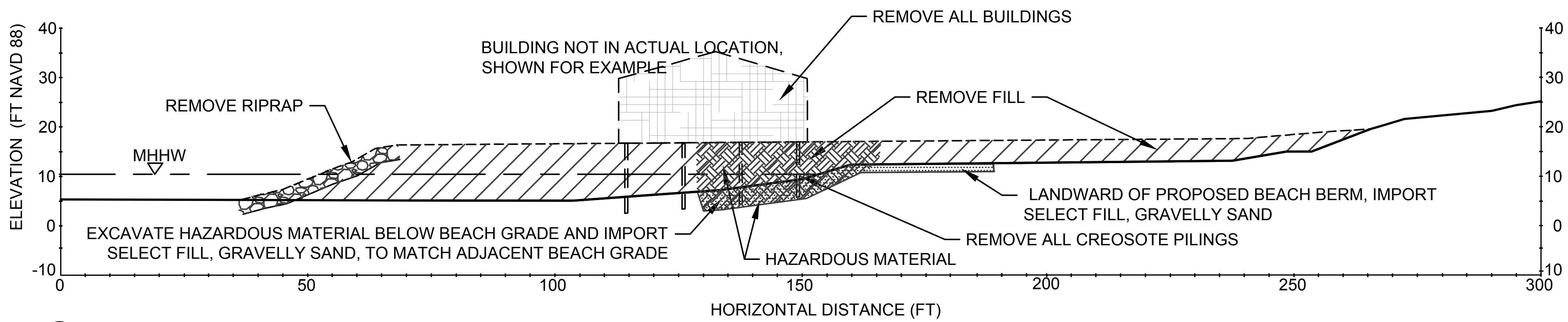
Lead Contractor: ESA
Design Lead: CGS, Jim Johannessen
Date: 2/2011

Conceptual Design Plan
Site Name: Budd Inlet
Action Name: WDNR Marine Lab Bulkhead Softening
PSNERP ID #:1684
Partial Restoration

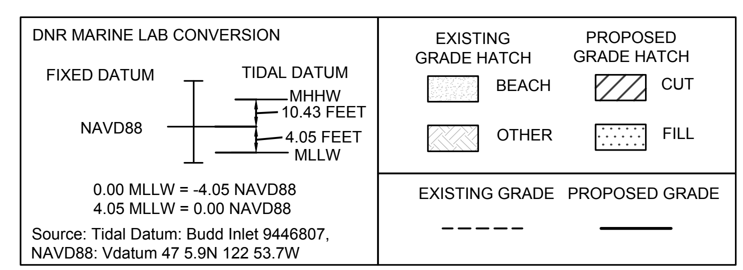
Figure 36-4



Ⓐ FULL RESTORATION TYPICAL SECTION



Ⓑ FULL AND PARTIAL RESTORATION TYPICAL SECTION



PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: CGS
Date: 3/2011

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Section
SITE NAME: **Budd Inlet**
ACTION NAME: **WDNR Marine Lab Bulkhead Softening**
PSNERP ID#: **1684**
Full &Partial Restoration

Figure 36-5

Full Restoration Quantity Estimate

Action Name: WDNR Marine Lab Bulkhead Softening
Action #: 1684
Date: February 2011
By: Coastal Geologic Services

REMEDY: Removal of hazardous fill and creosote and rock revetment armoring at the DNR site, and revegetation of backshore and marine riparian vegetation.
Construction Period: 18 weeks total (Building, fill, contaminent, & armor removal WDNR and south sites: 10 weeks; Building, fill, & armor removal north site: 4 weeks; Grading and restoration features both sites 4 week

Item	Unit of Measure	Material Name	Qty	Description of Item	Indicate section of design report where item is described
ACQUISITION AND CONSERVATION					
Required Project Lands	Acre		7.6	Required project lands includes the 2 WDNR owned parcels (93022600000 and 12926450200) as well as land outside of parcel ownership to the south and portions of two privately owned parcels to the north of the proponent owned land.	2.3.5 Land Requirements
Proponent / Partner-owned lands	Acre		5.5	Proponent owned lands include 2 WDNR parcels (93022600000 and 12926450200) that encompass the entire partial restoration area.	2.3.5 Land Requirements
Lands To Be Acquired	Acre		1.3	Parcels 83400200402 and 83400200400, owned by Hagglund family LTD Partnership and Carl D Hagglund (respectively) would need to be acquired in order for the full restoration to be completed.	2.3.1 Restoration Overview Table X, 2.3.5 Land Requirements
MOBILIZATION AND ACCESS for construction activities					
Mobilization - Typical (Equipment, Personnel, Planning, Financial)	LS		1	Up front costs such as bonding, planning and other staff time and financing. Typically, assume 8% to 10% of other items.	
Site Access	LS		0	Site access will remain as the roads to the WDNR site and north parcel will remain in place through restoration.	
Barge Access	Days		0	Not Applicable to Action	
Temporary Traffic Control (one of the following)					
none	LS		0	Not Applicable to Action	
signs	LS		0	Not Applicable to Action	
flags / spotters	LS		0	Not Applicable to Action	
unique	LS		0	Not Applicable to Action	
Temporary Roadway	SF		0	Not Applicable to Action	
Control of Water	LS		0	Not Applicable to Action	
Relocation Activities					
Site Demolition Activities					
Clearing and Grubbing (one or more of following)				Use one or more of the following categories of clearing and grubbing	
Clear Vegetation - Local Disposal	AC		0	Not Applicable to Action	
Clear /Grub Vegetation - Local Disposal	AC		0.3	Clear isolated trees from all areas-very limeted number	
Clear /Grub Vegetation - Offsite Disposal	AC		0.2	clear small areas of invasive species south of WDNR uplands	
Clear, stockpile - large woody debris	CY		20	Drift logs on south site and south portion of north property	
Hydraulic Structures - Small	LS		0	Not Applicable to Action	
Hydraulic Structures - Large	LS		0	Not Applicable to Action	
Utilities	LF		855 LF	All identified utilities will be removed from the site. Utilities, including electric, gas, water lines, telecommunications, and stormwater outfalls, were identified from background documents Landau Report Figure 5 and WDNR marine lab debris map.	
Buildings	SF	7 buildings	6,640 SF	Buildings include shops and warehouse, storage shed on south fill area, small storage shed on south fill area, and pump house water supply well. On the north parcel a covered picnic shelter, storage for electircal housing, and a stroage shed will be removed.	2.3.3 Restoration Features - Additional Management Measures
Pavement	SF		42,530 SF	Pavement on top of fill area at the DNR site.	2.3.3 Restoration Features - Additional Management Measures
Bulkheads	LF		735 LF	A) Creosote bulkhead at DNR site has apx total of 600 LF of creo piles and 360 LF of 6x12" creo timber lagging, ht varies between 5-15 ft, B) concrete bulkhead south of the fill area, estimated to be 4 ft tall and buried below beach level, C) concrete bulkhead north property estimated to be 4 ft tall and buried below beach leve	2.3.2 Restoration Features - Primary Management Measures; 2.4 Extent of Stressor Removal
Rock revetments	CY		1,050	Sloped angular rock armoring located at waterward edge of fill area of the WDNR site.	2.3.2 Restoration Features - Primary Management Measures; 2.4 Extent of Stressor Removal
Large Coastal Structures	LF, SF or CY		0	Not Applicable to Action	
Demolition / Removal - Bridge	SF or CY		0	Not Applicable to Action	
Removal - Misc. (e.g. angular rock from beach)	CY		39	Angular rock and concrete debris piled for shore protection. Assumed thickness of 1.5 ft multiplied by 700 SF	2.3.2 Restoration Features - Primary Management Measures; 2.4 Extent of Stressor Removal
Demolition / Removal - Boat Ramp	SF		0	Not Applicable to Action	
Haul - Offsite Disposal of Demolition Debris	Miles		20	placeholder; Landfill site in Yelm, Thurston County	
Hazardous/Contaminated Waste Removal				These items for earthwork of quality not compatible with wetlands, requiring special handling and disposal. Describe basis for classification as contaminated or hazardous. State known or suspected contamination, describe known similar work.	
Contaminated Earthwork	CY		350	Creosoted bulkhead and croesote logs potentially in fill material (based on Landau Report) will be be disposed of in a licensed landfill. Calculations for CY of contaminated material does not include creosote in fill.	2.3.2 Restoration Features - Primary Management Measures
Hazardous Earthwork	CY		3000	Hazardous materials in sediment include Gasoline-range petroleum hydrocarbon and Diesel petroleum hydrocarbons as indicated by Landau Report Figure 5. Excavation, off haul and disposal within a licensed hazardous waste landfill will ensue.	2.3.2 Restoration Features - Primary Management Measures
Construct Temporary Features					
EARTHWORK					
Excavation	CY	pebbly sand	450	Rough grading of retained sediment behind armor	2.3.2 Restoration Features - Primary Management Measures.
Excavation - Upland	CY		10,600	Excavate fill material at WDNR site. Some of the fill material is hazardous (see above section) and has been delineated in the Landau Report. Other nocontaminated fill may be reusable based on materials analysis. 3,000 CY of Hazardous materials from above section is included in this quantity.	2.3.2 Restoration Features - Primary Management Measures; 2.4 Extent of Stressor Removal
Excavation - Lowland	CY		3600	Excavate inlet and lagoon just outside of proposed MHHW line and assume average 5 ft depth. CY from CAD cross section drawings is approx 3,600.	2.3.2 Restoration Features - Primary Management Measures; 2.4 Extent of Stressor Removal
Dredging - Bucket - Land	CY		0	Not Applicable to Action	
Dredging - Bucket - Marine	CY		0	Not Applicable to Action	
Dredging - Hydraulic	CY		0	Not Applicable to Action	
Fine Grading	AC		0	Not Applicable to Action	
Fill Placement - local borrow				This is additive to Earthwork -Excavation	
Side cast	CY		0	Not Applicable to Action	
Haul - uncontrolled placement	CY		0	Not Applicable to Action	
Haul, place, compact	CY		0	Not Applicable to Action	
Stockpile - uncontrolled placement	CY		0	Not Applicable to Action	
Stockpile - controlled placement	CY		0	Not Applicable to Action	
Conveyor placement from stockpile land/water	CY		0	Not Applicable to Action	
Imported Fill				Includes purchase, delivery and placement or as noted / described	
Select Fill	CY		0	Not Applicable to Action	
Gravel Borrow, including haul	CY		0	Not Applicable to Action	
Sand / Gravel for Beach Nourishment	CY		1770	Pebbly sand pit run from local gravel pit	2.3.3 Restoration Features - Additional Management Measures
Cobble for Shore Nourishment	CY		0	Not Applicable to Action	
Embankment Compaction	CY		0	Not Applicable to Action	
Topsoil	CY		0	Not Applicable to Action	
RESTORATION Features					
Channel Rehab / Creation	SF		18900	Channel rehab calculations are based on the SF of lowland excavation for the channel and lagoon	2.3.2 Restoration Features - Primary Management Measures.
Large Wood Placement	EA		28	28 logs placed in groups	2.3.1 Restoration Overview Table X, 2.3.3 Restoration Features - Additional Management Measures
Invasive Species Control	Acre		0	Not Applicable to Action	
Physical Exclusion Devices	LF or EA		0	Exclusion around marien riparian planting areas	
Other Restoration Features/ Activities	LS		0	Not Applicable to Action	
Structures	EA				
Water Control Structures - Culverts with Gates	EA		0	Not Applicable to Action	
Water Control Structures - Weirs	EA		0	Not Applicable to Action	
Rock Slope Protection	LF		0	Not Applicable to Action	
Other	EA		0	Not Applicable to Action	
Elevated Boat Ramp	SF		0	Not Applicable to Action	
Fencing	SF		0	Not Applicable to Action	
Utilities					
Water	LF		0	Not Applicable to Action	
Gas	LF		0	Not Applicable to Action	
Electric	LF		0	Not Applicable to Action	
Sewer	LF		0	Not Applicable to Action	
Telecommunications	LF		0	Not Applicable to Action	
Other	LF		0	Not Applicable to Action	
Roadway / Railway					
Roadway (Type)	SF		0	Not Applicable to Action	
Roadway - Traffic Signal	LS		0	Not Applicable to Action	
Culvert (type)	LF		0	Not Applicable to Action	
Culvert - Jacking	LF		0	Not Applicable to Action	
Culvert - Horizontal Pile Driving	LF		0	Not Applicable to Action	
Bridge - Foundations, Deck and appurtenances	SF		0	Not Applicable to Action	
Railway - Box Girder	SF		0	Not Applicable to Action	
Railway - Foundation	LF		0	Not Applicable to Action	
Railway - Shoe fly	LF		0	Not Applicable to Action	
Permanent Access Features					
Roads	Level		0	Not Applicable to Action	
Utility Access Routes	varies		0	Not Applicable to Action	
Erosion Control Features	L.F.		0	Not Applicable to Action	
Public Access or Recreation Features					
Trails	SF		0	Not Applicable to Action	
Bridges	SF		0	Not Applicable to Action	
Kiosk	EA		0	Not Applicable to Action	
Restrooms	EA		0	Not Applicable to Action	
Interpretive Signs	EA		0	Not Applicable to Action	
Parking Area	SF		0	Not Applicable to Action	
Other	EA		0	Not Applicable to Action	
Vegetation & Erosion Control					
Hydroseeding	AC		0	Not Applicable to Action	
Planting	AC		1.03 total, 0.30 (BK) 0.73 (MR)	Backshore (BK) vegetation unit area and marine riparian (MR) vegetation unit areas will be planted in the restoration area	2.3.3 Restoration Features - Additional Management Measures
Vegetation Maintenance	AC-YR		0	Not Applicable to Action	
Erosion / sediment BMPs - Temp.	AC		0	Not Applicable to Action	
Erosion / sediment BMPs - Permanent	AC		0	Not Applicable to Action	
Waterside controls - Temporary	EA, LF, LS		0	Not Applicable to Action	
Construction Management					
Construction oversight	weeks		18	Building, fill, contaminent, & armor removal at WDNR and south sites: 10 weeks; Building, fill, & armor removal at north site: 4 weeks; Grading and restoration features both sites 4 weeks.	
Materials testing				Included in cost of material - no separate quantity	

Full Restoration Quantity Estimate

Action Name: WDNR Marine Lab Bulkhead Softening
Action #: 1684
Date: February 2011
By: Coastal Geologic Services

REMEDY: Removal of hazardous fill and creosote and rock revetment armoring at the DNR site, and revegetation of backshore and marine riparian vegetation.
Construction Period: 18 weeks total (Building, fill, contaminent, & armor removal WDNR and south sites: 10 weeks; Building, fill, & armor removal north site: 4 weeks; Grading and restoration features both sites 4 week

	Item	Unit of Measure	Material Name	Qty	Description of Item		Indicate section of design report where item is described
Design and Detailed Site Investigations							
	Survey & Property, Utility Research	LS		1	% of construction cost		
	35% Design	LS		1	35% x 25% x Engineer's Estimate		
	65% design	LS		1	65% x 25% x Engineer's Estimate less the cost for 35% PS&E		
	90% design	LS		1	35% x 25% x Engineer's Estimate less the cost for 35% + 65%PS&E		
	100% design	LS		1	25% x Engineer's Estimate less previous costs		
	Geotechnical Studies			1	Additonal on-site contamination, sediment, and determination of type and quantitiy of debris below grade all required, stabiltiy analysis not required.		
	Cultural Studies			1	Unclear as to need, but possible old historic use site		
	HTWR Studies			0	Not Applicable to Action		
Project Agreement Activities					Unable to provide credibale estimate at 10% design		
Site-Specific Adaptive Management Features & Activities					List if known		
Monitoring Activities					Assume 5 crew-days/year for each monitoring parameter in design report for 5 yrs		
	Monitoring (Type)	crew-days		200			
Operations & Maintenance					Unable to provide credible estimate at 10% design		

Partial Restoration Quantity Estimate

Action Name: WDNR Marine Lab Bulkhead Softening
Action #: 1684
Date: February 2011
By: Coastal Geologic Services

REMEDY: Removal of hazardous fill and creosote and rock revetment armoring at the DNR site, and revegetation of backshore and marine riparian vegetation.
Construction Period: 11.5 weeks (Building, fill, contaminent, & armor removal at WDNR and south sites: 10 weeks; Grading and restoration features both sites 1.5 weeks).

Item	Unit of Measure	Material Name	Qty	Description of Item		Indicate section of design report where item is described
ACQUISITION AND CONSERVATION						
Required Project Lands	Acre		6.3	Required project lands includes the 2 WDNR owned parcels (93022600000 and 12926450200) as well as land outside of parcel ownership to the south.		2.3.5 Land Requirements
Proponent / Partner-owned lands	Acre		5.5	Proponent owned lands include 2 WDNR parcels (93022600000 and 12926450200) that encompass the entire partial restoration area.		2.3.5 Land Requirements
Lands To Be Acquired	Acre		0	Not Applicable to Action		
Material Sites						
MOBILIZATION AND ACCESS for construction activities						
Mobilization - Typical (Equipment, Personnel, Planning, Financial)	LS		1	Up front costs such as bonding, planning and other staff time and financing. Typically, assume 8% to 10% of other items.		
Mobilization - Remote (Equipment, Personnel, Planning, Financial)	LS		0	Not Applicable to Action		
Site Access	LS		0	Site access will remain as the roads to the DNR site will remain in place through restoration.		
Barge Access	Days		0	Not Applicable to Action		
Temporary Traffic Control (one of the following)						
none	LS		0	Not Applicable to Action		
signs	LS		0	Not Applicable to Action		
flags / spotters	LS		0	Not Applicable to Action		
unique	LS		0	Not Applicable to Action		
Temporary Roadway	SF		0	Not Applicable to Action		
Control of Water	LS		0	Not Applicable to Action		
Relocation Activities						
Site Demolition Activities						
Clearing and Grubbing (one or more of following)				Use one or more of the following categories of clearing and grubbing		
Clear Vegetation - Local Disposal	AC		0	Not Applicable to Action		
Clear /Grub Vegetation - Local Disposal	AC		0.2	Clear isolated trees from all areas-very limeted number		
Clear /Grub Vegetation - Offsite Disposal	AC		0.1	Clear small areas of invasive species south of WDNR uplands		
Clear, stockpile - large woody debris	CY		10	Drift logs on south site		
Hydraulic Structures - Small	LS		0	Not Applicable to Action		
Hydraulic Structures - Large	LS		0	Not Applicable to Action		
Utilities	LF		775 LF	All identified utilities will be removed from the site. Utilities, including electric, gas, water lines, telecommunications, and stormwater outfalls, were identified from background documents Landau Report Figure 5 and DNR marine lab debris map.		
Buildings	SF	4 buildings	5,530 SF	Exact SF taken from assessors data where ever possible, otherwise taken from digitized SF measurements. Buildings include shops and warehouse, storage shed on south fill area, small storage shed on south fill area, and pump house water supply well.		2.3.3 Restoration Features - Additional Management Measures
Pavement	SF		36,880 SF	Pavement on top of fill area at the WDNR site.		2.3.3 Restoration Features - Additional Management Measures
Bulkheads	LF		485 LF	Creosote bulkhead at DNR site has apx total of 600 LF of creo piles and 360 LF of 6x12" creo timber lagging, ht varies between 5-15 ft and concrete bulkhead south of the fill area, estimated to be 4 ft tall and buried below beach level.		2.3.2 Restoration Features - Primary Management Measures, 2.4 Extent of Stressor Removal
Rock revetments	LF		250 LF, 1050 CY	Sloped angular rock armoring located at waterward edge of fill area of the DNR site.		2.3.2 Restoration Features - Primary Management Measures; 2.4 Extent of Stressor Removal
Large Coastal Structures	LF, SF or CY			Not Applicable to Action		
Demolition / Removal - Bridge	SF or CY			Not Applicable to Action		
Removal - Misc. (e.g. angular rock from beach)	CY			Not Applicable to Action		
Demolition / Removal - Boat Ramp	SF			Not Applicable to Action		
Haul - Offsite Disposal of Demolition Debris	Miles		20	placeholder; Landfill site in Yelm, Thurston County		
Hazardous/Contaminated Waste Removal						
Contaminated Earthwork	CY		350	Creosote bulkhead will be be disposed of in a licensed landfill. Include apx 600 LF of creo piles and 360 LF of 6x12" creo timber lagging, ht varies between 5-15 ft. Calculations for CY of contaminated material does not include creosote foundation piles under buildings in fill (gaunt unknown).		2.3.3 Restoration Features - Additional Management Measures
Hazardous Earthwork	CY		3000	Hazardous materials in sediment include Gasoline-range petroleum hydrocarbon and Diesel petroleum hydrocarbons as indicated by Landau Report Figure 5. Excavation, off haul and disposal within a licensed hazardous waste landfill will ensue.		2.3.3 Restoration Features - Additional Management Measures
Construct Temporary Features				Use as needed for unusual temporary features not included elsewhere (see TESC below)		
EARTHWORK				Expand to include equipment, etc. to facilitate cost estimating.		
Excavation	CY	pebbly sand	250	Rough grading of non-contaminated and appropriately sized sediment retained behind armor		2.3.2 Restoration Features - Primary Management Measures.
Excavation - Upland	CY		10,600	Excavate fill material at WDNR site. Some of the fill material is hazardous (see above section) and has been delineated in the Landau Report. Other nocontaminated fill may be reusable based on materials analysis.		2.3.2 Restoration Features - Primary Management Measures; 2.4 Extent of Stressor Removal.
Excavation - Lowland	CY		0	Not Applicable to Action		
Dredging - Bucket - Land	CY		0	Not Applicable to Action		
Dredging - Bucket - Marine	CY		0	Not Applicable to Action		
Dredging - Hydraulic	CY		0	Not Applicable to Action		
Fine Grading	AC		0	Not Applicable to Action		
Fill Placement - local borrow				This is additive to Earthwork -Excavation		
Side cast	CY		0	Not Applicable to Action		
Haul - uncontrolled placement	CY		0	Not Applicable to Action		
Haul, place, compact	CY		0	Not Applicable to Action		
Stockpile - uncontrolled placement	CY		0	Not Applicable to Action		
Stockpile - controlled placement	CY		0	Not Applicable to Action		
Conveyor placement from stockpile land/water	CY		0	Not Applicable to Action		
Imported Fill				Includes purchase, delivery and placement or as noted / described		
Select Fill	CY		0	Not Applicable to Action		
Gravel Borrow, including haul	CY		0	Not Applicable to Action		
Sand / Gravel for Beach Nourishment	CY		820	Pebbly sand pit run from local gravel pit		2.3.3 Restoration Features - Additional Management Measures
Cobble for Shore Nourishment	CY		0	Not Applicable to Action		
Embankment Compaction	CY		0	Not Applicable to Action		
Topsoil	CY		0	Not Applicable to Action		
RESTORATION Features						
Channel Rehab / Creation	SF		0	Not Applicable to Action		
Large Wood Placement	EA		12	12 logs placed in groups		2.3.1 Restoration Overview Table X, 2.3.3 Restoration Features - Additional Management Measures
Invasive Species Control	Acre		0	Not Applicable to Action		
Physical Exclusion Devices	LF		0	Exclusion around marien riparian planting areas		
Other Restoration Features/ Activities	LS		0	Not Applicable to Action		
Structures	EA					
Water Control Structures - Culverts with Gates	EA		0	Not Applicable to Action		
Water Control Structures - Weirs	EA		0	Not Applicable to Action		
Rock Slope Protection	LF		0	Not Applicable to Action		
Other	EA		0	Not Applicable to Action		
Elevated Boat Ramp	SF		0	Not Applicable to Action		
Fencing	SF		0	Not Applicable to Action		
Utilities						
Water	LF		0	Not Applicable to Action		
Gas	LF		0	Not Applicable to Action		
Electric	LF		0	Not Applicable to Action		
Sewer	LF		0	Not Applicable to Action		
Telecommunications	LF		0	Not Applicable to Action		
Other	LF		0	Not Applicable to Action		
Roadway / Railway						
Roadway (Type)	SF		0	Not Applicable to Action		
Roadway - Traffic Signal	LS		0	Not Applicable to Action		
Culvert (type)	LF		0	Not Applicable to Action		
Culvert - Jacking	LF		0	Not Applicable to Action		
Culvert - Horizontal Pile Driving	LF		0	Not Applicable to Action		
Bridge - Foundations, Deck and appurtenances	SF		0	Not Applicable to Action		
Railway - Box Girder	SF		0	Not Applicable to Action		
Railway - Foundation	LF		0	Not Applicable to Action		
Railway - Shoe fly	LF		0	Not Applicable to Action		
Permanent Access Features						
Roads	Level		0	Not Applicable to Action		
Utility Access Routes	varies		0	Not Applicable to Action		
Erosion Control Features	L.F.		0	Not Applicable to Action		
Public Access or Recreation Features						
trails	SF		0	Not Applicable to Action		
bridges	SF		0	Not Applicable to Action		
kiosk	EA		0	Not Applicable to Action		
restrooms	EA		0	Not Applicable to Action		
Interpretive Signs	EA		0	Not Applicable to Action		
parking area	SF		0	Not Applicable to Action		
Other	EA		0	Not Applicable to Action		

Partial Restoration Quantity Estimate

Action Name: WDNR Marine Lab Bulkhead Softening
Action #: 1684
Date: February 2011
By: Coastal Geologic Services

REMEDY: Removal of hazardous fill and creosote and rock revetment armoring at the DNR site, and revegetation of backshore and marine riparian vegetation.
Construction Period: 11.5 weeks (Building, fill, contaminent, & armor removal at WDNR and south sites: 10 weeks; Grading and restoration features both sites 1.5 weeks).

Item	Unit of Measure	Material Name	Qty	Description of Item	Indicate section of design report where item is described
Vegetation & Erosion Control					
Hydroseeding	AC		0	Not Applicable to Action	
Planting	AC		0.65 total, 0.095 (BK) 0.55 (MR)	Backshore (BK) vegetation unit area and marine riparian (MR) vegetation unit areas will be planted in the restoration area	2.3.3 Restoration Features - Additional Management Measures
Vegetation Maintenance	AC-YR		0	Not Applicable to Action	
Erosion / sediment BMPs - Temp.	AC		0	Not Applicable to Action	
Erosion / sediment BMPs - Permanent	AC		0	Not Applicable to Action	
Waterside controls - Temporary	EA, LF, LS		0	Not Applicable to Action	
Construction Management					
Construction oversight	weeks		11.5	rough estimation of construction period:P Building, fill, contaminent, & armor removal at WDNR and south sites: 10 weeks; Grading and restoration features both sites 1.5 weeks.	
Materials testing				Included in cost of material - no separate quantity	
Design and Detailed Site Investigations					
Survey & Property, Utility Research	LS		1	% of construction cost	
35% Design	LS		1	35% x 25% x Engineer's Estimate	
65% design	LS		1	65% x 25% x Engineer's Estimate less the cost for 35% PS&E	
90% design	LS		1	35% x 25% x Engineer's Estimate less the cost for 35% + 65%PS&E	
100% design	LS		1	25% x Engineer's Estimate less previous costs	
Geotechnical Studies			1	Additonal on-site contamination, sediment, and determination of type and quantitiy of debris below grade all required, stabiltiy analysis not required.	
Cultural Studies			1	Unclear as to need, but possible old historic use site	
HTWR Studies			0	Not Applicable to Action	
Project Agreement Activities				Unable to provide credibale estimate at 10% design	
Site-Specific Adaptive Management Features & Activities				List if known	
Monitoring Activities				Assume 5 crew-days/year for each monitoring parameter in design report for 5 yrs	
Monitoring (Type_)	crew-days		200		
Operations & Maintenance				Unable to provide credible estimate at 10% design	

Puget Sound Nearshore Ecosystem Restoration Project

Strategic Restoration Conceptual Engineering – Design Report

Appendix A: Action Characterization Report Results

March 2011

	Action Name	Big Beef Causeway Replacement and Estuary Restoration	Black Point Lagoon	Cattail Causeway Replacement and Estuary Restoration	Devil's Hole Creek	Duckabush Causeway Replacement and Estuary Restoration	Hamma Hamma Causeway Replacement and Estuary Restoration	Lilliwaup Causeway Replacement and Estuary Restoration	Point Whitney	Big Quilcene Delta Cone Removal
	Action ID #	**1256**	**1261**	**1271**	**1286**	**1012**	**1047**	**1346**	**1379**	**1074, 1076, 1077, 1078**
1	**Flata Flaw Criteria**									
1a	The local proponent has not precluded PSNERP's involvement in the concept design.	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes
1b	The candidate action is sufficiently described and spatially defined to enable us to design restoration alternatives and determine quantity estimates.	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes
1c	The candidate action is consistent w/ one or more PSNERP restoration strategy, and an alternative can be described which addresses one or more of the associated restoration objectives.	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Fatal Flaw		**Yes**	**Yes**	**Yes**					
2	**Additional Criteria**									
2a	There is an alternative for this action that could restore ecosystem processes to a substantial portion of their historic (less degraded) state.	Yes	No			Yes	Yes	Yes	Yes	Yes
2b	The restored action area will support a broad representation of nearshore ecosystem components appropriate for that geomorphic setting.	Yes	No			Yes	Yes	Yes	Yes	Yes
2c	There are no obvious and significant problems external to the action area that would jeopardize the restoration outcome.	Yes	Yes			Yes	No	No	Yes	No
2d	The contributing basin provides for flood discharge, wood recruitment, organism dispersal and sediment supply to support the restored system.	Yes	Yes			Yes	Yes	Yes	Yes	Yes
2e	The restored action area will form a contiguous large patch that is well connected to a surrounding terrestrial and marine landscape.	Yes	No			Yes	Yes	Yes	Yes	Yes
2f	The restored ecosystem components within the action area will be internally connected in a way that allows for the unconstrained movement of organisms, water, and sediments.	Yes	Yes			Yes	Yes	Yes	Yes	Yes
	Recommendation	**Go**	**No Go**	**No Go**	**No Go**	**Go**	**Go**	**Go**	**Go**	**Go**

Dec. 8, 2010 (Rev. Nov. 10, 2011 - to show proper status of Smith Island)

	Action Name	Tahuya Causeway Replacement and Estuary Restoration	Twanoh State Park Beach Restoration	Kilisut Harbor / Oak Bay Reconnection	Chuckanut Estuary Restoration	Deer Harbor Estuary Restoration	Nooksack River Estuary	Harper Estuary Restoration Design and Construction	Beaconsfield Feeder Bluff Restoration	Deschutes River Estuary Restoration
	Action ID #	**1401**	**1421**	**1552**	**1642**	**1648**	**1055**	**1505**	**1499**	**1003**
1	**Flata Flaw Criteria**									
1a	The local proponent has not precluded PSNERP's involvement in the concept design.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
1b	The candidate action is sufficiently described and spatially defined to enable us to design restoration alternatives and determine quantity estimates.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
1c	The candidate action is consistent w/ one or more PSNERP restoration strategy, and an alternative can be described which addresses one or more of the associated restoration objectives.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Fatal Flaw									
2	**Additional Criteria**									
2a	There is an alternative for this action that could restore ecosystem processes to a substantial portion of their historic (less degraded) state.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2b	The restored action area will support a broad representation of nearshore ecosystem components appropriate for that geomorphic setting.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2c	There are no obvious and significant problems external to the action area that would jeopardize the restoration outcome.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2d	The contributing basin provides for flood discharge, wood recruitment, organism dispersal and sediment supply to support the restored system.	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
2e	The restored action area will form a contiguous large patch that is well connected to a surrounding terrestrial and marine landscape.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
2f	The restored ecosystem components within the action area will be internally connected in a way that allows for the unconstrained movement of organisms, water, and sediments.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Recommendation	**Go**	**Go**	**Go**	**Go**	**Go**	**Go**	**Go**	**Go**	**Go**

	Action Name	Garfield Creek Delta Restoration	Indian/Moxlie Creek Delta Restoration	Mission Creek Estuary Reconnection	WDNR Marine Lab Bulkhead Softening	Chambers Bay Estuarine and Riparian Enhancement	John's Creek Estuary Restoration Project	Sequalitchew Creek Culvert	Snow Creek and Salmon Creek Estuary Restoration	Washington Harbor Tidal Hydrology Restoration Project
	Action ID #	**1004**	**1005**	**1457**	**1684**	**1801**	**1447**	**1467**	**1230**	**1237**
1	**Flata Flaw Criteria**									
1a	The local proponent has not precluded PSNERP's involvement in the concept design.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
1b	The candidate action is sufficiently described and spatially defined to enable us to design restoration alternatives and determine quantity estimates.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
1c	The candidate action is consistent w/ one or more PSNERP restoration strategy, and an alternative can be described which addresses one or more of the associated restoration objectives.	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Fatal Flaw	**Yes**								
2	**Additional Criteria**									
2a	There is an alternative for this action that could restore ecosystem processes to a substantial portion of their historic (less degraded) state.	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2b	The restored action area will support a broad representation of nearshore ecosystem components appropriate for that geomorphic setting.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2c	There are no obvious and significant problems external to the action area that would jeopardize the restoration outcome.	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2d	The contributing basin provides for flood discharge, wood recruitment, organism dispersal and sediment supply to support the restored system.	No	No	Yes	Yes	Yes	Yes	No	Yes	No
2e	The restored action area will form a contiguous large patch that is well connected to a surrounding terrestrial and marine landscape.	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
2f	The restored ecosystem components within the action area will be internally connected in a way that allows for the unconstrained movement of organisms, water, and sediments.	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
	Recommendation	**NoGo**	**No Go**	**Go**	**Go**	**Go**	**Go**	**Go**	**Go**	**Go**

Dec. 8, 2010 (Rev. Nov. 10, 2011 - to show proper status of Smith Island)

	Action Name	Nearshore Restoration Strategy for Twin Rivers	Dugualla Bay Restoration	Livingston Bay - Diked Farmland & Nearshore Habitat	Deepwater Slough Phase 2	McGlinn Island Causeway	Milltown Island	North Fork Levee Setback	Telegraph Slough 1 & 2	Everett Marshland Tidal Wetland Restoration
	Action ID #	**1190**	**1609**	**1618**	**1101**	**1092**	**1091**	**1102**	**1633, 1635**	**1126**
1	**Flata Flaw Criteria**									
1a	The local proponent has not precluded PSNERP's involvement in the concept design.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
1b	The candidate action is sufficiently described and spatially defined to enable us to design restoration alternatives and determine quantity estimates.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
1c	The candidate action is consistent w/ one or more PSNERP restoration strategy, and an alternative can be described which addresses one or more of the associated restoration objectives.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Fatal Flaw									
2	**Additional Criteria**									
2a	There is an alternative for this action that could restore ecosystem processes to a substantial portion of their historic (less degraded) state.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2b	The restored action area will support a broad representation of nearshore ecosystem components appropriate for that geomorphic setting.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2c	There are no obvious and significant problems external to the action area that would jeopardize the restoration outcome.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
2d	The contributing basin provides for flood discharge, wood recruitment, organism dispersal and sediment supply to support the restored system.	Yes	No	Yes	Yes	Yes	No	Yes	Yes/No	Yes
2e	The restored action area will form a contiguous large patch that is well connected to a surrounding terrestrial and marine landscape.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2f	The restored ecosystem components within the action area will be internally connected in a way that allows for the unconstrained movement of organisms, water, and sediments.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Recommendation	**Go**	**Go**	**Go**	**Go**	**Go**	**Go**	**Go**	**Go**	**Go**

Dec. 8, 2010 (Rev. Nov. 10, 2011 - to show proper status of Smith Island)

	Action Name	Everett Riverfront Wetland Complexes	Maulsby Swamp Mudflats/Enhanced Connection	Quilceda Estuary Restoration Hibulb Natural History Preserve	Smith Island Estuary Restoration	Snohomish Estuary Main Stem Connectivity	Spencer Island Restoration
	Action ID #	**1127**	**1131**	**1136**	**1142**	**1805**	**1149**
1	**Flata Flaw Criteria**						
1a	The local proponent has not precluded PSNERP's involvement in the concept design.	Yes	Yes	Yes	Yes	Yes	Yes
1b	The candidate action is sufficiently described and spatially defined to enable us to design restoration alternatives and determine quantity estimates.	Yes	Yes	Yes	Yes	Yes	Yes
1c	The candidate action is consistent w/ one or more PSNERP restoration strategy, and an alternative can be described which addresses one or more of the associated restoration objectives.	Yes	Yes	Yes	Yes	Yes	Yes
	Fatal Flaw						
2	**Additional Criteria**						
2a	There is an alternative for this action that could restore ecosystem processes to a substantial portion of their historic (less degraded) state.	Yes	No	Yes	Yes	Yes	Yes
2b	The restored action area will support a broad representation of nearshore ecosystem components appropriate for that geomorphic setting.	Yes	No	Yes	Yes	Yes	Yes
2c	There are no obvious and significant problems external to the action area that would jeopardize the restoration outcome.	Yes	Yes	Yes	Yes	Yes	Yes
2d	The contributing basin provides for flood discharge, wood recruitment, organism dispersal and sediment supply to support the restored system.	Yes	No	Yes	Yes	Yes	Yes
2e	The restored action area will form a contiguous large patch that is well connected to a surrounding terrestrial and marine landscape.	Yes	Yes	Yes	Yes	No	Yes
2f	The restored ecosystem components within the action area will be internally connected in a way that allows for the unconstrained movement of organisms, water, and sediments.	Yes	Yes	Yes	Yes	Yes	Yes
	Recommendation	**Go**	**No Go**	**Go**	**Go**	**Go**	**Go**

Dec. 8, 2010 (Rev. Nov. 10, 2011 - to show proper status of Smith Island)

Puget Sound Nearshore Estuary Restoration Project

10% Conceptual Design Contract – Go/ No Go Summary

DRAFT
December, 2010

South Puget Sound

Site Name: Budd Inlet

Action Name: Garfield Creek Delta Restoration (PSNERP ID #1004)

Summary

Garfield Creek is a degraded stream located in a heavily urbanized area. The stream flows are affected by the surrounding urban watershed. Flows are very low to intermittent during the late summer and fall. Garfield Creek conveys untreated stormwater to Puget Sound. The forested ravine and open stream channel west of West Bay Drive may provide some buffering and pollutant removal; however, typical contaminants from single family urban development are a concern. . These factors contributed to a NO response on Criteria 2c.

The small and urbanized watershed, seasonally low stream flows, and long culvert under the former lumber mill site and West Bay Drive is not conducive supporting salmon spawning and rearing, and prevents downstream movement of wood and sediment. As a result, the coastal inlet and nearshore zone do not receive the benefit of these inputs from the surrounding watershed. Justifiably, the response to Criteria 2d is NO.

In addition, the total restored area would be limited to roughly one acre, meaning that the contribution of this action to the health of Budd Inlet and Puget Sound would be small. Thus, the response to Criteria 2e is NO.

Garfield Creek has minimal direct ecological connection to the Deschutes Estuary, so it does not have a strong tie to PSNERP's river delta strategy. This fatal flaw along with three NO responses, means we cannot recommend that this action move forward to 10% design. Restoration of the Garfield Creek lower reach and delta may be consistent with other local or regional restoration objectives, but does not fit PSNERP's process-based restoration strategy.

Site: Normandy Park Shoreline

Action: Beaconsfield Feeder Bluff Restoration (#1499)

Summary

The Beaconsfield property is encompassed within a long drift cell with dense residential development of the shore. The PSNERP Strategic Needs Assessment evaluated this process unit as most degraded in the process evaluation framework. Many properties are armored, making the restoration of sediment supply that much more necessary, although this appears to make the

site not part of “contiguous large patch that is well connected to a surrounding terrestrial and marine landscape”. This action meets the criteria and is recommended for 10% design.

Site Name: Budd Inlet

Action: Indian/Moxlie Creek Delta Restoration (PSNERP ID # 1005)

Summary

The action could restore some ecosystem processes within a portion of the historic footprint of the head of the bay, but would not restore a substantial portion. The long culvert and huge volume of fill over the head of the historic bay constitute a significant interruption in the continuity of habitat structure and habitat forming processes. Portions of the contributing basin, including the entire lower basin are highly urbanized and are not anticipated to provide flood discharge, wood recruitment, organism dispersal and sediment supply to the restoration area. The restoration site is surrounded by urban areas that fragment the upland habitat. The aquatic and nearshore habitat is fragmented by a dredged channel and a marina. Riparian habitat is generally low quality. We believe the full restoration option could meet the criteria, but the partial restoration alternative would not. Lack of support for the full restoration option would tend to indicate a No Go recommendation.

Site Name: Oakland Bay

Action: John's Creek Estuary Restoration Project (PSNERP ID #1447)

Summary

This action meets the criteria. We recommend that this action move forward to 10% design.

Site Name: Budd Inlet

Action: Deschutes River Estuary Restoration (1003)

Summary

This action meets the criteria thus we are recommending it for 10% design.

Site Name: Budd Inlet

Action Name: Mission Creek Estuary Restoration (PSNERP ID #1457)

Summary

The Mission Creek action area is relatively small, so it did not pass the ‘large patch’ criterion. Since this small site is directly adjacent to a contiguous large patch that includes Priest Point

Park and Ellis Cove, we recommend that this action move forward to 10% design.

Site Name: Chambers Bay

Action: Chambers Bay Estuarine and Riparian Enhancement (PSNERP ID #1801)

Summary

In response to the "contributing basin" criterion: The Chambers Creek watershed is the contributing watershed basin for this action. This basin is extensively modified by urban residential land use modifications, within the cities of Tacoma, Lakewood and Fircrest. Urban stormwater runoff from impervious surfaces is widespread in this watershed. Fortunately, the lower portion of the creek runs through a forested ravine that is in public ownership. This ravine provides most of the ecological processes mentioned in this criterion. We recommend that this action move forward to 10% design.

Site Name: Budd Inlet

Action: WDNR Marine Lab Bulkhead Softening (1684)

Summary

We recommend this action move forward to 10 % design. Note that Go determination for this action is based upon shifting the strategy from an embayment restoration to a sediment transport restoration. The merit of the new strategy is high as the down-drift barrier estuary is likely degraded as the result of limited sediment supply resulting from the groin-like effect of the armored fill area.

South Central Puget Sound

Site Name: Harper Estuary

Action: Harper Estuary Restoration Design and Construction (PSNERP ID # 1505)

Summary

This action meets the criteria. We recommend that this action move forward to 10% design.

Site Name: Sequalitchew Creek Estuary

Action: Sequalitchew Creek Culvert (PSNERP ID # 1467)

Summary

In response the "contributing basin" criterion: The contributing basin has been highly modified with respect to stream flows in Sequalitchew Creek. Most of the historic stream flow is diverted out of the ravine where the action is as a result of Fort Lewis operations. For the "continguous patch" criterion: The partial restoration alternative is not well connected to the marine landscape. However the full restoration is well connected. The full and partial restoration are well connected to the terrestrial landscape of the ravine. The patch size of the action area is relatively small, particularly for partial restoration. We recommend that this action move forward to 10% design.

Hood Canal

Site Name: Cattail Creek and Devil's Hole Estuaries

Action: Cattail Causeway Replacement and Estuary Restoration (1271)

Summary

The owner, the US NAVY, has indicated that they plan to implement the project as without participation by PSNERP and suggested that the site visit was not necessary. Therefore, this project is a directed "No Go" without a detailed Phase 1 evaluation.

Site Name: Devil's Hole Estuary (#1286)

Action: Devil's Hole Creek

Summary

The owner, the US Navy, has indicated that they plan to implement the project as without participation by PSNERP and suggested that the site visit was not necessary. Therefore, this project is a directed "No Go" due to the "fatal flaws" of lack of participation with the local proponent and also the lack of a well defined alternative and the site has not been considered for a full evaluation.

Site: Lilliwaup River and Sund Creek Estuaries

Action: Lilliwaup Causeway Replacement and Estuary Restoration (1346)

Summary

Explanation for NO Answer to Criterion 2c: The watershed and upstream 0.5 mile of Lilliwaup Creek has experienced significant aggradation due to deposition of gravels resulting from landslides, which were caused by watershed disturbances. The concern is that the excess sediment may move as a slug and affect the restored area, and there is a possibility of additional events. The severity or importance of this risk factor has not been evaluated. The risk is greatly reduced if the creek restoration proposed by LLTK is implemented either as part of the PSNERP action or separately. We therefore recommend that this action move forward to 10% design, with the caveat that upstream restoration may be required and or that a sediment study be conducted.

Site Name: Black Point Lagoon

Action: Black Point Lagoon (1261)

Summary

The proposed restoration action may not substantially change the existing conditions. This is because the feature behind the barrier is an unusual deep lagoon, and therefore the level of stress resulting from the obstruction may not be great. However, the historic condition is not clear due to the unique (odd) morphology resulting from the geologic formation (kettle) and the apparent disturbance as early at the time of the 1883 map. Therefore, it is not clear this action is appropriate from a restoration standpoint, other than the roadway and culvert are clearly unnatural.

The feature is not large and the connection to the sound is narrow due to the geology, with private property immediately adjacent on both sides. We do not recommend that the project move forward through 10% design.

Site Name: Twanoh Drift Cell

Action: Twanoh State Park Beach Restoration (PSNERP ID #1421)

Summary:

The action is consistent with the criteria. We recommend that this action move forward to 10% design.

Site: Quilcene River

Action: Quilcene River Delta (ID #s 1074, 1076, 1077, 1078)

Summary

The main external issue (also within the action area) is shellfish aquaculture issues raised by WDFW and proponent particular on the south side of the existing main channel. Many of these issues are in conflict with processes this action is intended to restore. Nevertheless, we recommend this action move forward to 10% design.

Site Name: Point Whitney

Action: Point Whitney Lagoon (1379)

Summary

The action is consistent with the criteria. We recommend that this action move forward to 10% design.

Site Name: Hamma Hamma River

Action: Hamma Hamma River Delta (PSNERP ID #1047)

Summary:

The main external issue (2c) (also within the action area) is shellfish aquaculture issues raised by proponent and landowner. These issues may conflict with processes this action is intended to restore. Nevertheless, we recommend this action for 10% design.

Site Name: Big Beef Creek Estuary

Action: Big Beef Causeway Replacement and Estuary Restoration (#1256)

Summary

The Big Beef causeway replacement and estuary arrest rate in action meets the criteria and is recommended as a GO for development of the 10% design.

Site Name: Tahuya River Estuary

Action: Tahuya Causeway Replacement and Estuary Restoration (PSNERP ID # 1404)

Summary:

We recommend that this action move forward to 10% design.

Site Name: Duckabush River Delta

Action: Duckabush Causeway Replacement and Estuary Restoration (#1012)

Summary

The action is consistent with the criteria. We recommend that this action move forward to 10% design.

Whidbey

Site Name: Skagit River Delta

Action: Deepwater Slough Phase 2 (1101)

Summary
The action is consistent with the criteria. We recommend that this action move forward to 10% design.

Site Name: Snohomish River delta

Action: Maulsby Swamp Mudflats/Enhanced Connection (1131)

Summary
Maulsby Swamp receives a “no” for three of the screening criteria. These negative responses are related to Maulsby Swamp’s proximity to other ecosystem stressors that would not be addressed as part of a restoration project at this action area. As stated in the ACR, “given the overall alteration to the area, and larger scale changes to the Lower Snohomish Estuary, we are unlikely to achieve a full restoration of pre-disturbance processes in this location.” Although this one of very few opportunities to restore intertidal marsh in this portion of the nearshore, Maulsby Swamp is located in a highly degraded, long, drift cell in a highly urbanized area of Puget Sound. The only way to potentially achieve process-based restoration at this location is to acquire the Port of Everett property located on the waterward side of Marine Drive. Acquiring the Port property could create greater interaction with the nearshore and provide a larger, more contiguous habitat patch at this location, but full restoration of processes is unlikely. Also, because acquisition of Port land was not part of the proponent’s vision for this action, we do not know if it is feasible. Also, current landowners in the southern portion of the project area have specifically indicated unwillingness to participate in restoration planning for the site. Requests for site access here were denied, and the conceptual design team was unable to gain access to the preferred location for restoring tidal connectivity to the site. For these reasons, we recommend this action not move forward as part of PSNERP’s 10% design effort. Restoration of Maulsby Swamp likely has merit according to other criteria, but does not fit with PSNERP’s restoration objectives.

Site Name: Snohomish River Delta

Action: Quilceda Estuary Restoration Hibulb Natural History Preserve (1136)

Summary

The action is consistent with the criteria. We recommend that this action move forward to 10% design.

Site Name: Snohomish River Delta

Action: Spencer Island Restoration (1149)

Summary

The action is consistent with the criteria. We recommend that this action move forward to 10% design.

Site Name: Livingston Bay

Action: Livingston Bay – Dike Farmland & Nearshore Habitat (1618)

Summary

The action is consistent with the criteria. We recommend that this action move forward to 10% design.

Site Name: Skagit River Delta

Action: Milltown Island (PSNERP ID #1091)

Summary

In response to fatal flaw second criterion, additional evaluation is needed in coordination with the proponent during the Phase II 10% design to define the full (and partial) restoration limits for quantities definition. This will include defining the optimum limits of dike breaching and the most feasible methods of implementation to provide the targeted increase in density of sustainable tidal dendritic channels consistent with nearby reference sites. For the partial restoration alternative, the fifth and sixth additional criteria (2e and 2f) may not be fully satisfied from a process mitigation perspective. That said, we recommend that this action move forward to 10% design.

Site Name: Skagit River Delta

Action: McGlinn Island Causeway (1092)

Summary

This action is linked to actions restoring habitat in Padilla Bay, in particular the Telegraph Slough projects.

Criterion 2C, the success of the McGlinn Island Causeway Action depends on the implementation of the Telegraph Slough Action. The Telegraph Slough Action will distribute that freshwater flow to secondary distributary channels beyond the Swinomish Channel achieving the process-based objective of distribution of tidally-influenced freshwater inputs across the historic tidal marsh to Padilla Bay. In addition Telegraph Slough itself will provide additional rearing habitat in Padilla Bay for juvenile Skagit River Chinook benefiting from the McGlinn Island Causeway Action. We recommend that this action move forward to 10% design.

Site Name: Skagit River Delta

Action: North Fork Levee Setback (1102)

Summary

This action meets the criteria and should move forward to 10% design.

Site Name: Everett Riverfront

Action: Everett Riverfront Wetland Complexes (1127)

Summary

This action meets the criteria. We recommend that this action move forward to 10% design.

Site Name: Lower Snohomish Estuary

Action: Snohomish River Mainstem Connectivity Project (1805)

Summary

Taken individually, the mainstem connectivity actions meet all criteria except for the "large patch" metric. When viewed as a project intended to provide connectivity between regionally significant restoration projects, this action appears to meet the overall intent of the PSNERP effort. Several of the potential action areas appear to overlap with other PSNERP or other ongoing projects, so these are not recommended to proceed ahead under this action. Some of the projects are small scale, and highly constrained, so these appear to be a lower priority.

The remaining actions (historical slough on the north side of Smith Island, historical slough north of Langus Park, south side of Smith Island) are recommended to proceed to 10% design.

Site Name: Snohomish River Delta

Action: Everett Marshland Tidal Wetland Restoration (PSNERP ID #1126)

Summary

This action meets the criteria and we recommend it move forward to 10% design.

Site Name: Snohomish River Delta

Action: Smith Island Estuary Restoration (PSNERP ID #1142)

Summary

This action meets the criteria. We recommend it move forward for 10% design.

Site Name: Dugualla Bay

Action: Dugualla Bay Restoration (PSNERP ID #1609)

Summary

The contributing basin including Whidbey NAS has had significant removal of forest cover and wood recruitment will be very limited. Wood recruitment is more likely to occur from marine environment including Skagit River discharges that affect the area. Nevertheless, we recommend this action move forward to 10% design.

Site Name: Skagit River Delta

Action: Telegraph Slough Phases 1 and 2 (PSNERP ID #1633 and 1635)

Summary

This action is interdependent on McGlinn Island Causeway Action (1092) to satisfy the primary objection of increased freshwater input to Padilla Bay.

Under Criterion 2C, the obvious or significant problem external to the action area is the important linkage to the McGlinn Island Causeway Action to provide added freshwater inputs to the Swinomish Channel (as noted above). The Telegraph Slough Action on its own will not accomplish that objective. If improved freshwater input can be achieved external to this action area, then the Telegraph Slough Action will distribute that flow to secondary distributary channels beyond the Swinomish Channel including the primary Telegraph Slough (easterly) distributary channel, achieving the process-based objective of added connectivity and distribution of tidally-influenced freshwater inputs across the historic tidal marsh to Padilla Bay.

The response to Criterion 2D is listed as both Yes and No since that objective would primarily be achieved by McGlinn Island Causeway Action, and if so, the Telegraph Slough Action will distribute those inputs to the restored marsh area, but likely would only partially emulate the historic processes due to the Swinomish Channel management that occurs between those actions. It is not anticipated that wood recruitment would occur from the Swinomish Channel, and conveyance of adequate sediment supply to Telegraph Slough is questionable. The local Telegraph Slough watershed is likely not robust enough to provide those inputs either.

The response to Criterion 2F is listed as Yes, but the SR 20 highway and BNSR railroad barriers across the Telegraph Slough estuary, even if restored at distributary channel crossings, would not fully restore the internal connectivity for movement of organisms, water, and sediment within the historic estuary. Full restoration of those processes would require a re-route of the highway and railroad, which are constraints along with regionally-significant buried and underground utilities along that corridor. We recommend that the action be carried forward to 10 percent design.

Strait of Juan de Fuca

Site Name: Discovery Bay

Action: Snow Creek and Salmon Creek Estuary Restoration (1230)

Summary

The action is consistent with the criteria. We recommend that this action move forward to 10% design.

Site Name: Sequim Bay

Action Name: Washington Harbor Tidal Hydrology Restoration (PSNERP ID #1237)

Summary

The Bell Creek watershed is the contributing watershed basin for Washington Harbor. This basin is extensively modified by agricultural and urban land use modifications, including some of the City of Sequim (Todd et al, 2006). Clearing, urban stormwater runoff, and stream channelization are widespread in this watershed. The lower portion of this watershed is less developed than some of the upper portion, allowing for some of the ecological processes this criterion is targeting. We recommend that this action move forward to 10% design.

Site Name: Twin Rivers Fill Removal (#1190)

Action: Nearshore Restoration Strategy for Twin Rivers

Summary

The Twin Rivers fill removal meets the criteria and is recommended to be brought forward into the 10% design phase.

San Juan/Georgia Strait

Site Name: Deer Harbor, Orcas Island

Action: Deer Harbor Estuary Restoration (#1648)

Summary

This action meets the criteria. We recommend it move forward to 10% design.

Site: Nooksack River

Action: Nooksack River Estuary (#1055)

This action meets the criteria. We recommend that the Nooksack action be carried forward to 10 percent design.

Site Name: Chuckanut Estuary

Action: Chuckanut Estuary Restoration (PSNERP ID #1642)

Summary

In response to the "contributing basin" criterion: The Chuckanut Creek watershed is the contributing watershed basin for this action. This basin is modified by Interstate 5 and residential development. Urban stormwater runoff from impervious surfaces is widespread in this watershed. Fortunately, the lower portion of the creek runs through a forested ravine. This ravine provides most of the ecological processes mentioned in this criterion. We recommend that this action move forward to the 10% design phase.

North Puget Sound

Site Name: Oak Bay

Action: Kilisut Harbor/ Oak Bay Reconnection (#1552)

Summary

The site is recommended for a GO for development of the 10% design as there are no fatal flaws or other No responses to additional criterion.

South Puget Sound

Site Name: Budd Inlet

Action Name: Garfield Creek Delta Restoration (PSNERP ID #1004)

Local Proponent	City of Olympia
Delta Process Unit	Delta DES
Strategy(ies)	1: River Delta
Restoration Objectives	Remove barrier to tidal hydrology and freshwater input to restore intertidal area and allow stream delta processes to support development of mosaic marsh habitats along a salinity and elevation gradient
Process-based Management Measures	Topography Restoration; Hydraulic Modification; Channel Rehabilitation/Creation
Additional Management Measures	Debris Removal; Revegetation; Contaminant Removal/Remediation

Description of the Action

The action entails reintroducing tidal inundation to a portion of the Deschutes Estuary mudflats that were previously filled for a now abandoned industrial facility and railroad. Through topographic restoration, the action will restore tidal hydrology and freshwater inputs to the southern portion of the nearshore fill. Restoration will support development of estuarine marsh, which is scarce in Lower Budd Inlet. In addition, Garfield Creek will be "daylighted" as will a smaller stream and seeps, providing conditions for the development of a new stream and more complex tidal channel network. This action differs from the proponent's description in that it would not include filling the mudflat to create a stream delta and salt marsh. Instead, the proposed action is more inclusive of all freshwater sources, and expanded to remove fill to restore intertidal area and allow stream delta processes to support development of mosaic marsh habitats along a salinity and elevation gradient. The proponent's proposal focuses on daylighting a stream channel, and does not emphasize the range and gradation of habitats that could develop through restoring tidal hydrology, topography, and channel development in this setting. However, the proponent stated at the site visit that their objective is to restore a pocket estuary near the mouth of the Deschutes Estuary, which accomplishes a similar objective as PSNERP's process-based objectives.

Figure 1 - Garfield Creek Action Area

Status in Design Process

Restoration planning and design for the Garfield Creek Delta is in the assessment stage. The most recent work at the Budd Inlet scale includes some incremental progress toward a Budd Inlet habitat restoration plan by the Squaxin Island Tribe working with other stakeholders (NWIFC 2010).

Consideration of some limited daylighting at the existing Garfield Creek culvert outfall was included in early planning for West Bay Park Phase 1. However, the scope of Phase 1 did not include this portion of the undeveloped park property.

West Bay Park Phase 1 is located immediately north of the Garfield Creek restoration action. West Bay Park Phase I was completed in summer of 2010. Phase I included upland and sediment remediation, and intertidal habitat restoration. The intertidal habitat restoration actions included limited topographic restoration, piling removal, debris removal, salt marsh habitat restoration, riparian habitat restoration, and placement of large woody debris (Anchor QEA 2009).

Site Description and Context

Historic Conditions

Topographic sheet (T-sheet) maps from the late 19th century show Garfield Creek emerging from a wooded ravine into a small, narrow coastal inlet that opened to the mudflats and tidal channels of the Deschutes River. Subsequent land use changes included construction of a railroad spur; extensive fill placement to support industrial development for a sawmill and other forest products manufacturing; and regrading of the hillside to support construction of West Bay Drive (Anchor 2007; Parametrix 2004a, 2004b, 2007; U.S. Coast and Geodetic Survey 1873). These activities also resulted in culverting of Garfield Creek under West Bay Drive and the adjacent industrial land.

Natural Environment

Garfield Creek is a perennial stream that flows through a steep, approximately half-mile-long, wooded ravine surrounded by residential development. The stream's watershed is heavily modified by urbanization and urban stormwater runoff; however, the entire ravine maintains a forested condition except at one road crossing. A smaller ravine approximately one-third the length of Garfield Creek is located immediately to the south, and the two drainages are separated by a narrow ridge. The south ravine appears to support a smaller creek, whose outlet is also visible along undeveloped park shoreline (USGS 1994; Duncanson Company 2007). Other groundwater seeps from the hillsides along West Bay Drive also support small freshwater wetlands at the south end of the undeveloped West Bay Park site. These wetlands are interspersed with stands of more xeric weedy vegetation such as Scot's broom and Himalayan blackberry.

The eastern shore of the undeveloped park site consists of an intertidal mudflat and tidal channels formed by the Deschutes River. Above this mudflat is a gravel/cobble beach resulting from erosion of fill materials placed for railroad and industrial development. Salt marsh vegetation has colonized a narrow band of the upper intertidal zone above this beach. On the south side of the action area, a more extensive salt marsh is well established in an embayment with mudflats and tidal channels. This embayment is artificial and is separated from the main estuary/mudflat by the abandoned railroad bed. This salt marsh was restored as part of the mitigation for the 4th Avenue Bridge construction (Haub 2010, pers. comm.). Tidal hydrology is provided by gaps in the railroad bed. Fish use in Garfield Creek has not been documented and the culvert outfall is perched due to erosion of an escarpment above the beach. This condition represents at least a partial barrier to fish access during low tides. The surface of the fill appears to be above the 100-year floodplain on Federal Emergency Management Agency (FEMA) maps within the action area (FEMA 1982). However, the City of Olympia has identified elevation 18 feet (mean lower low water [MLLW] datum) as the highest observed tide, and some areas of existing fill surface in the action area may be in this elevation range (City of Olympia 2007; Duncanson Company 2007).

Human Environment

This 16-acre former industrial site, railroad bed, and mudflat are now owned by the City of Olympia Parks, Arts, and Recreation Department. The southern extent of this ownership needs to be verified. The action area has been extensively filled as previously mentioned to support a now abandoned railroad, and former industrial site. In addition West Bay Drive is an important arterial road now serving mostly residential and some commercial areas along the west side of Budd Inlet. Numerous dolphins (piling structures) occur along the east side of the action area in the mudflat. These appear to be associated with past log rafting in conjunction with lumber mills.

As mentioned previously, the area north of Garfield Creek culvert has been developed into Phase I of West Bay Park and includes a two-lane access drive, small parking lot, paved pathways, and lawn and viewing areas, with access to the beach in two locations.

A 36-inch concrete culvert conveys Garfield Creek from the bottom of the ravine under the West Bay Drive fill prism and undeveloped park site to Budd Inlet (Duncanson Company 2007). The culvert sections have separated at the outfall, and the asphalt and fill have eroded a 9-foot vertical escarpment. Other utilities in West Bay Drive include overhead power, a water main, and a sewer force main.

Opportunities for Process-based Restoration

The action area contains the following primary stressors: nearshore fill, impervious surfaces, and stream crossing (culvert). The remnant railroad bed is also a stressor and will be discussed under constraints below. Removal of the stressors would result in a benefit area of approximately 7 acres, and would support the following habitat-forming processes: tidal hydrology and freshwater input. Other processes restored would include tidal channel formation and maintenance, detritus import and export, exchange of aquatic organisms, and solar incidence. Some limited sediment input, as well as sediment erosion and accretion, may also result. Other secondary stressors include land cover development, and overwater structures (piles/dolphins). Land cover development is addressed by removal of the other stressors. Piling and dolphin removal would provide some limited benefits to the mudflat in a spatially separate area (east side of action area).

Design refinements for 10% design include confirmation of the culvert invert on the upstream side of West Bay Drive.

Potential Design Alternatives

Full restoration entails extensive topographic restoration that will allow for routing a daylighted Garfield Creek to the existing salt marsh and mudflat at the south end of the action area. This alternative also allows for intercepting the maximum amount of seepage and small stream freshwater inputs available in the action area. These freshwater inputs support marsh development and channel formation and saltwater/freshwater mixing in mudflat to the south. The general approach to topographic restoration would entail fill removal beginning at existing salt marsh and mudflat and gradually rising up to the invert elevation of the culvert where it emerges from under the West Bay Drive road fill prism. In addition, the full restoration includes removing all piles/dolphins from the east side of the action area. The full restoration alternative removes the stressors of nearshore fill, stream crossing (culvert in former industrial fill), impervious area, and overwater structures (piles/dolphins) and land cover development within the action area. No changes to the culvert under the West Bay Drive fill prism are proposed.

Partial restoration results in a smaller area of topographic restoration to intertidal stream delta and marsh on the east shore of the undeveloped park. This topographic restoration would occur in the vicinity of the location where the current culvert outfalls to the mudflat, and would extend into the industrial fill area. No changes to the culvert under the West Bay Drive fill prism are proposed. The restored area would improve tidal hydrology and freshwater input to a larger area that is now filled. The restoration of these processes would support marsh development and tidal channel formation, but channel length and total area would be significantly smaller (estimated at approximately a quarter the length and area of the full restoration alternative). However, this alternative provides opportunity to directly connect shore restoration from the park north to the restored stream mouth. The partial restoration alternative removes the stressors of nearshore fill, stream crossing (culvert industrial fill), impervious area, and land cover development, but to a much lesser extent than the full restoration alternative.

Local Proponent Requirements

The West Bay trail is being planned through the park, extending to downtown Olympia and further north along the west side of Budd Inlet. Waterfront access has strong public support in Olympia and 8.6 acres of the park site are designated as “open space” for the West Bay trail corridor (City of Olympia 2010). The trail may follow the railroad alignment, but some alignment for the trail through the restored area is a proponent requirement.

Potential Design Constraints

The ownership of the property by the City of Olympia Parks, Arts, and Recreation Department is a constraint in that the property was purchased for park and recreation purposes. No master plan for the site has been completed yet; however, such a master plan is identified in the City of Olympia’s new park and recreation plan (City of Olympia 2010).

The abandoned railroad bed is not a constraint in the existing former industrial fill area, as long as another trail alignment is provided in a north/south direction through this area. However, south of the industrial fill pad, where the railroad bed extends over the existing mudflat, it is a constraint because of its intended use for trail purposes. However, this constraint exists primarily south of the action area.

West Bay Drive and the culvert beneath it are constraints because the culvert sets the upstream elevation of topographic restoration. Bridging this road crossing was not considered because the stream bed on the upstream side of the road appears to be significantly higher than the intertidal range.

The topography of the hillside above West Bay Drive is also a constraint on the size of the project.

Uncertainties and Risks

The action is vulnerable to the risk of sea level rise due to the limited area available, the topographic constraints, and other uncertainties. It is uncertain whether the creek's sediment supply would be substantial enough to offset sea level rise in this location. The Olympia area's sea level rise risk is exacerbated in part due to subsidence occurring there (City of Olympia 2007).

There are uncertainties concerning the need for contaminate removal /remediation at this site. Past use of the site and the need for remediation work on the adjacent West Bay Park properties suggest that there is a reasonable likelihood of encountering soil or groundwater contamination during the restoration implementation.

The affects of sediment discharges from the Deschutes River restoration have been modeled and appear to affect the west side of Lower Budd Inlet very little (George et al. 2006). However, there is some uncertainty about the actual results of this action on the Garfield Creek restoration.

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Criteria For Go / No Go Determination

Fatal Flaws: A No on any question results in a No Go determination. Otherwise the action is recommended for 10% design

1	**Criterion**	**Yes**	**No**
1a	The local proponent has not precluded PSNERP's involvement in the concept design.	x	
1b	The candidate action is sufficiently described and spatially defined to enable us to design restoration alternatives and determine quantity estimates.	x	
1c	The candidate action is consistent w/ one or more PSNERP restoration strategy, and an alternative can be described which addresses one or more of the associated restoration objectives.		x

Additional Criteria: A No response one or more questions means the action may not be suitable for 10% design and requires a more detailed explanation and rationale by the CDT. If the action has no No responses, the determination is Go.

2	**Criterion**	**Yes**	**No**
2a	There is an alternative for this action that could restore ecosystem processes to a substantial portion of their historic (less degraded) state.	x	
2b	The restored action area will support a broad representation of nearshore ecosystem components appropriate for that geomorphic setting.	x	
2c	There are no obvious and significant problems external to the action area that would jeopardize the restoration outcome.		x
2d	The contributing basin provides for flood discharge, wood recruitment, organism dispersal and sediment supply to support the restored system.		x
2e	The restored action area will form a contiguous large patch that is well connected to a surrounding terrestrial and marine landscape.		x
2f	The restored ecosystem components within the action area will be internally connected in a way that allows for the unconstrained movement of organisms, water, and sediments.	x	

Summary

Garfield Creek is a degraded stream located in a heavily urbanized area. The stream flows intermittently-- generally during rainy periods, and like many urban streams conveys contaminated stormwater to Puget Sound. These factors contributed to a NO response on Criteria 2c.

The culvert under West Bay Drive blocks salmon from migrating upstream and prevents downstream movement of wood and sediment. As a result, the costal inlet and nearshore zone do not receive the benefit of these inputs from the surrounding watershed. Justifiably, the response to Criteria 2d is NO.

In addition, the total restored area would be limited to roughly one acre, meaning that the contribution of this action to the health of Budd Inlet and Puget Sound would be small. Thus, the response to Criteria 2e is NO.

Garfield Creek has minimal direct ecological connection to the Deschutes Estuary, so it does not have a strong tie to PSNERP's river delta strategy. This fatal flaw along with three NO responses, means we cannot recommend that this action move forward to 10% design. Restoration of the Garfield Creek lower reach and delta may be consistent with other local or regional restoration objectives, but does not fit PSNERP's process-based restoration strategy.

South Puget Sound

Site Name: Budd Inlet

Action: Indian/Moxlie Creek Delta Restoration (PSNERP ID # 1005)

Local Proponent	City of Olympia
Delta Process Unit	DES
Shoreline Process Unit(s)	NA
Strategy(ies)	4: Coastal Inlets (River Delta?)
Restoration Objectives	Remove fill to partially restore tidal hydrology, freshwater input, tidal channel formation and maintenance, and solar incidence and create estuarine marsh terrace to support the detritus import and export
Process-based Management Measures	Topography Restoration; Armor Removal/Modification, Hydraulic Modification
Additional Measures	Revegetation, Large Wood Placement; Substrate Modification; Debris Removal

Description of the Action

Most of the historic estuarine marsh habitat at the Deschutes River Estuary/Lower Budd Inlet has been lost to a combination of urbanization, dredging, and filling, as well as construction of the Capitol Lake dam. This project would attempt to restore some of the estuarine marsh habitat in Lower Budd Inlet. The proposed action would include removing fill, a short portion of local road, and culvert between two city blocks south of the existing mudflat. It would also include filling mudflat areas at the head of East Bay to raise the grade and create a marsh terrace and improved riparian zone. Removing any streets and upland fill is not consistent with the local sponsor's description of the action. Placing dredged material to create a marsh terrace and riparian area is consistent with the proponent's description of the action and could be a companion project to the Deschutes River Estuary Restoration action. The Deschutes River Estuary action is anticipated to produce a large quantity of sediment suitable for beneficial re-use in a locale such as this.

Status in Design Process

No design work has been completed to date.

Figure 1 - Indian/Moxlie Action Area

Site Description and Context

Historic Conditions

Lower Budd Inlet has been significantly altered by dredging, filling, and urbanization dating back to the initial platting in 1850 (NWAA 2008). Early maps from 1856 show a peninsula that has marsh on the east and roads and buildings on the west separating the East and West Bay portions of Lower Budd Inlet. Historically, East Bay extended about 2,000 feet further south than its current location and was fed by two streams: Indian Creek and Moxlie Creek. The 1873 topographic sheet (T-sheet) shows the presence of a distributary channel system in West Bay from the Deschutes River and a sinuous, convoluted shoreline around East Bay with a mixture of urban area, salt marsh, and deciduous forest. The action area is part of a historic mudflat formed by the Deschutes River that extended approximately 0.75 mile north and 1 mile west of the action area, with the peninsula described above separating East and West Bay. In the intervening years, the landscape around the action area has been transformed, and downtown Olympia has grown out over much of the historic mudflat and all of the historic marsh, and the lower portion of Indian and Moxlie Creek have been culverted under the eastern edge of downtown. The peninsula separating East Bay and West Bay has grown 0.75 mile to the north, and is 2,000 feet wide. Significant dredging and marina construction has occurred in East Bay. The sediment supply from the Deschutes River that created the mudflat and historic marsh has been cut off by the dam to create Capitol Lake. Historically Budd Inlet supported a large native oyster population (WDFW, 2010).

Natural Environment

Indian and Moxlie Creeks extend south and east of the action area. Moxlie Creek originates south of I-5 in a wooded ravine. Indian Creek begins in a plateau east of East Bay at a small lake and wetland complex. It has a much larger watershed than Moxlie Creek and runs south and then west, crossing I-5 twice before its confluence with Moxlie Creek at the southeast edge of downtown Olympia. The site has an extensive lower, intertidal mudflat with a complex channel network. The tidal channel system consists of a braided channel carrying low tide stream flows and an extensive network of dendritic blind channels. The edges of the mudflat consist of dredged channel to the north, and steep fill slopes on the east, south, and west. Marsh vegetation has colonized a narrow elevation band on the fill slopes showing some minor erosion around the edge of East

Bay. Upland vegetation includes mature street trees on the south and west, and a combination of mostly invasive trees and shrubs on the east side with a few native deciduous trees. Stream flows from the connection to Indian Creek and Moxlie Creek provide freshwater, nutrient, and detritus import. East Bay has water quality issues connected with poor tidal circulation resulting in anaerobic conditions (Haub 2010). Native oysters are being reintroduced to Budd Inlet but the locations relative to this action are unclear (WDFW 2010).

Human Environment

The action is on downtown Olympia waterfront and the surrounding landscape is highly urbanized. Fill depths are in the 20-foot range (Haub 2010). The majority of the uplands are dominated by impervious surfaces with little vegetation canopy; this is especially true to the west and south of the site. The open channel reaches of Indian and Moxlie creeks are connected to the site by a 3700-foot-long, 72 to 84inch diameter culvert. This structure does allow fish passage under certain conditions but is a major stressor on nearshore process. Eleven abandoned wood piles are located in the mudflat. Contamination of the mudflat sediments is anticipated due to contamination of the fill surrounding the mudflat (Haub 2010).

The tidelands are owned by Washington Department of Natural Resources (WDNR). The uplands consist of a combination of public street rights-of-way and private parcels.

It is anticipated that in addition to stormwater, there are other utilities in Olympia Avenue NE, which delineates the south edge of the action area. These utilities are expected to include water, sewer, electrical, communication, and storm drainage.

Opportunities for Process-based Restoration

Opportunities for process-based restoration are limited at this site. The stressors at this action area include nearshore fill, nearshore roads, impervious surfaces, stream crossings, and land cover development. Removing these stressors would restore tidal hydrology and freshwater input. However, in this location, it would also disrupt urban infrastructure in the downtown area. The local proponent's proposal would create a sediment bench for marsh colonization using clean dredged material from the Deschutes River and Capitol Lake. This approach is expected to be successful given the presence of this marsh vegetation around the relatively steep fill slopes surrounding East Bay. The successful establishment of this estuarine marsh vegetation would support the process of detritus import and export, but would not remove the primary stressors.

Refinements in the 10% design would include determining with the City of Olympia if any upland fill removal, including a short segment of Olympia Avenue NE and land to the south, is possible. It is also anticipated that this fill removal would involve adjacent parcels whose owners have not been identified. The second issue to be determined in 10% design is permitting and landowner feasibility issues associated with placing clean dredged material on WDNR tidelands in this location.

Potential Design Alternatives

Full restoration would include removal of a limited amount of fill and stream culvert from Olympia Avenue NE south to State Avenue NE. This fill and culvert removal would occur along the Chestnut Street right-of-way but, due to the depths of fill, would likely involve adjacent parcels on the east and west sides to provide space for transitional slopes. Olympia Avenue NE is not proposed to be rebuilt as a bridge over this restored channel because State Avenue NE is located one block away to the south and traffic could be rerouted to it. This restoration action would remove the stressors of nearshore fill, impervious surface, a stream crossing, and land cover development from a small portion of the former mudflat. The processes of tidal hydrology, freshwater input, tidal channel formation and maintenance, and solar incidence would be restored to a small area that is now covered.

In addition, the full restoration alternative would include piling removal and placement of clean dredged material from the Deschutes River Estuary restoration on the upper eastern side of the mudflat to create a marsh terrace. This action depends on the Deschutes River Estuary restoration action for this dredged material supply. The marsh terrace could also be designed to create a more natural transition to upland elevations and include riparian vegetation restoration. The marsh terrace and fill placement action would restore detritus import and export processes.

The partial restoration alternative would include only piling removal and placement of the clean dredged material to create a marsh terrace and riparian habitat. It would not address the primary stressors of nearshore fill, impervious area, stream crossings, and land cover development. It would not restore the target processes of tidal hydrology or freshwater inputs, but would improve detritus import and export.

Local Proponent Requirements

Stormwater drainage and conveyance capacity must be maintained and the risk of flooding cannot be increased. The proponent is interested in exploring how the project could be used to address local flooding risks associated with sea level rise. While not a definite requirement, the proponent is not endorsing removal of streets and upland fill to support restoration in this location.

Potential Design Constraints

The site is in a highly urbanized area. Removing fill, roads, and utilities is expected to be disruptive and is not expected to be supported by the local proponent, the City of Olympia. Without removing these stressors, the ability to restore processes at this location is very limited.

The water quality issues (anaerobic conditions) in East Bay limit the potential ecological benefits of performing restoration in this location.

Native oyster restoration efforts in Budd Inlet should be considered prior to implementing this action.

Uncertainties and Risks

The willingness of both public (City of Olympia and WDNR) and private landowners to allow fill removal in the uplands and fill placement in the tidelands is uncertain. Permitting associated with fill placement to create marsh terraces has some uncertainties.

The site is located in a low-lying area of Olympia that is subject to coastal flooding over time in response to sea level rise. Sea level rise could require continued placement of dredged material to adjust grades for target marsh and riparian habitats. Conversely, sea level rise could also adversely impact much of downtown Olympia over a 50- to 100-year timeframe, putting many of the roads, utilities, and urban development at risk.

The risk of encountering contaminants in the uplands is high according to the local proponent. There is also a likelihood of encountering contaminants in the sediments. However, placement of clean dredge material may provide a net ecological benefit if existing mudflats are contaminated.

Recontamination of clean dredge material with urban stormwater runoff from the 84-inch outfall is also a risk, depending on the City of Olympia's source control program within the Indian Moxlie Watershed.

Lower Budd Inlet and present day Olympia have an extensive pre-Euroamerican settlement history of Native American use (NWAA 2008). Encountering cultural resources is a risk with any excavation below the hydraulic fill placement-native sediment interface.

References

NWAA, 2008. Preliminary Cultural Resources Assessment for Percival Landing Major Rehabilitation, Olympia Washington, NWAA Report # WA07-118. Northwest Archeological Associates, October, 2008.

Haub, 2010. Personal communication with Andy Haub of the City of Olympia at the PSNERP site visit. October, 2010.

WDFW, 2010. Shellfish Review of PSNERP Candidate Restoration Proposals. WDFW Fish Program Memorandum by Bradbury, A., Blake, B., and C. Speck. . September 29, 2010.

Criteria For Go / No Go Determination

Fatal Flaws: A No on any question results in a No Go determination. Otherwise the action is recommended for 10% design

1	**Criterion**	**Yes**	**No**
1a	The local proponent has not precluded PSNERP's involvement in the concept design.	X	
1b	The candidate action is sufficiently described and spatially defined to enable us to design restoration alternatives and determine quantity estimates.	X	
1c	The candidate action is consistent w/ one or more PSNERP restoration strategy, and an alternative can be described which addresses one or more of the associated restoration objectives.	X	

Additional Criteria: A No response one or more questions means the action may not be suitable for 10% design and requires a more detailed explanation and rationale by the CDT. If the action has no No responses, the determination is Go.

2	**Criterion**	**Yes**	**No**
2a	There is an alternative for this action that could restore ecosystem processes to a substantial portion of their historic (less degraded) state.		X
2b	The restored action area will support a broad representation of nearshore ecosystem components appropriate for that geomorphic setting.	X	
2c	There are no obvious and significant problems external to the action area that would jeopardize the restoration outcome.		X
2d	The contributing basin provides for flood discharge, wood recruitment, organism dispersal and sediment supply to support the restored system.		X
2e	The restored action area will form a contiguous large patch that is well connected to a surrounding terrestrial and marine landscape.		X
2f	The restored ecosystem components within the action area will be internally connected in a way that allows for the unconstrained movement of organisms, water, and sediments.	X	

Summary

The action could restore some ecosystem processes within a portion of the historic footprint of the head of the bay, but would not restore a substantial portion. The long culvert and huge volume of fill over the head of the historic bay constitute a significant interruption in the continuity of habitat structure and habitat forming processes. Portions of the contributing basin, including the entire lower basin are highly urbanized and are not anticipated to provide flood discharge, wood recruitment, organism dispersal and sediment supply to the restoration area. The restoration site is surrounded by urban areas that fragment the upland habitat. The aquatic and nearshore habitat is fragmented by a dredged channel and a marina. Riparian habitat is generally low quality. We believe the full restoration option could meet the criteria, but the partial restoration alternative would not. Lack of support for the full restoration option would tend to indicate a No Go recommendation.

Whidbey

Site Name: Snohomish River delta

Action: Maulsby Swamp Mudflats/Enhanced Connection (1131)

Local Proponent	City of Everett
Delta Process Unit	Delta SNH
Shoreline Process Unit(s)	SPU 8055
Strategy(ies)	1: River Delta
Restoration Objectives	Remove barriers to tidal action to enhance connection(s) between Maulsby Swamp and the Lower Snohomish Estuary
Process-based Management Measures	Armor Removal or Modification; Channel Rehabilitation/Creation; Hydraulic Modification; Topography Restoration; Contaminant Removal/Remediation
Additional Management Measures	Debris Removal; Property Acquisition/Conservation

Description of the Action

The action will be to remove artificial fill and allow for greater tidal flux into and out of a wetland that is separated from surrounding mudflats by a road and railroad embankment. The PSNERP action appears to be very similar to the project proponent's vision for the site.

Status in Design Process

No formal design work has been completed to-date.

Site Description and Context

Historic Conditions

Historical mapping from the early GLO surveys is minimal in this area. The mapping with the most detail in this area (ca. 1884) shows the surrounding bluff topography, and there is a thin area designated as 'Pine' near the current road alignment. The area of the swamp is designated as fenced, but has no specific land cover denoted. The earliest aerial photos of the area (ca. 1938) show significant log rafting, and the beginnings of piers and intertidal fill on the shore side of the railroad. Within the swamp, the 1938 aerial photo shows relict tidal channels, along with the roads and linear drainage ditches. The orientation of the channels is not immediately apparent, and no distinct openings below the railroad are visible.

Figure 1 - Maulsby Swamp Action Area

Natural Environment

The Maulsby Swamp action area covers approximately 30 acres within the Lower Snohomish Estuary, on the mainland side facing Jetty Island. Maulsby Swamp occurs in a low area from the toe of the bluff to a road embankment. Maulsby Swamp is currently connected to the nearshore via a 36 inch concrete pipe with the outlet partially buried on the mudflat. The wetland appears to get muted tidal action, but water levels are likely seasonal, rather than tidally, dominated. There is limited tributary area to Maulsby Swamp, consisting only of the steep forested hillsides on the bluff that surrounds the Swamp. The wetland includes linear drainage ditches around the interior and perimeter of the site. No outlet on the northern portion of the Swamp is apparent.

The overall sediment dynamics of the nearshore have been altered from the historical condition. The action area is mapped as part of a long right to left drift cell that extends from Seattle north to Everett. In this area, net shore drift has been interrupted by the elements of the Port of Everett that extend into the nearshore. Jetty Island, which has been created using placed dredge materials, is located adjacent to the action area. The Snohomish River also delivers sediment to this location, and the overall sediment load has been reduced via maintenance dredging that occurs within the mainstem.

Human Environment

The nearshore has undergone a number of human alterations in the area surrounding Maulsby Swamp. The Swamp is separated from the nearshore by West Marine Drive (a state highway) and a BNSF rail line. The road alignment also includes a separated paved trail along the waterfront. Erosion along the shoreline is apparent along portions of the trail.

The nearshore has been filled to create upland area with water access. This has resulted in two generally rectangular platforms extending over the mudflat extending out to the navigation channel. The southerly area is owned by Jen-Weld, and the northern area is owned by the Port of Everett.

As noted above, the main facilities of the Port of Everett are located south (updrift) from the action area. Port facilities at this location include marinas and fill within the historical nearshore.

Opportunities for Process-based Restoration

The primary stressors in this area include: (1) shoreline armoring, (2) nearshore fill, (3) tidal barriers at the culvert connection to the Swamp, and (4) impervious surfaces. There are opportunities for process-based restoration in this location to partially address these stressors at Maulsby Swamp. However, given the overall alteration to the area, and larger scale changes to the Lower Snohomish Estuary, we are unlikely to achieve a full restoration of pre-disturbance processes in this location.

Potential Design Alternatives

The full restoration alternative for this area was developed with the assumption that both the Jen-Weld property and the BNSF and West Marine Drive will remain in their current locations.

A full restoration alternative for this area restores tidal hydrology/exchange to the maximum extent feasible and includes:

1. Hydraulic modification by increasing the size of the existing opening below the road and railroad embankment.
2. Hydraulic modification by installing a new opening on the north side of the Swamp.
3. Topographic restoration by removing and reshaping fill from the Port of Everett site to re-create mudflat and marsh.
4. Channel rehabilitation by filling the interior drainage ditches and connecting historical channels.
5. Armor modification and potentially beach nourishment to stabilizing the existing eroding shoreline near the outlet south of the Jen-Weld site.

A partial restoration alternative would include elements 1, 4, and 5 of the full restoration alternative. The partial project would result in only one opening from the Swamp to the nearshore, and would not include work on the Port of Everett site.

Local Proponent Requirements

There is public access (parking lot and trail) to the shoreline near the existing opening that the proponent needs to maintain.

Potential Design Constraints

Soil contamination within the action area has been detected as part of ongoing sampling in Port Gardener by the Department of Ecology. This contamination would need to be addressed prior to restoration work in this area. The length of time required to clean up the site and the feasibility of the remediation effort would need to be better understood to fully evaluate constraints at this location.

Property acquisition and/or easements would be required to accomplish either restoration alternative.

The BNSF rail line and West Marine Drive will influence the design of the new or upgraded openings between the Swamp and the nearshore. The Jen-Weld site is not currently part of the action area, so this fill is assumed to remain adjacent to the site. The project would need to avoid adverse impacts to that property.

Uncertainties and Risks

The historical condition for Maulsby Swamp is not well documented. Given the alterations to overall sediment dynamics in this area, both updrift and in the Lower Snohomish, the trajectory of a restored site will be more difficult to predict.

For the full restoration alternative, design judgment will be required to determine the initial grading for the Port of Everett location.   The habitats (mudflat and marsh) created there would need to function within an altered nearshore environment, so simply recreating historical conditions may not be sustainable.

Shoreline erosion is a current issue, and there a likely reduction in sediment delivery to this area. Restoration design can partially address this issue, but may require ongoing maintenance to achieve project goals.

Criteria For Go / No Go Determination

Fatal Flaws: A No on any question results in a No Go determination. Otherwise the action is recommended for 10% design

1	Criterion	Yes	No
1a	The local proponent has not precluded PSNERP's involvement in the concept design.	x	
1b	The candidate action is sufficiently described and spatially defined to enable us to design restoration alternatives and determine quantity estimates.	x	
1c	The candidate action is consistent w/ one or more PSNERP restoration strategy, and an alternative can be described which addresses one or more of the associated restoration objectives.	x	

Additional Criteria: A No response one or more questions means the action may not be suitable for 10% design and requires a more detailed explanation and rationale by the CDT. If the action has no No responses, the determination is Go.

2	Criterion	Yes	No
2a	There is an alternative for this action that could restore ecosystem processes to a substantial portion of their historic (less degraded) state.		x
2b	The restored action area will support a broad representation of nearshore ecosystem components appropriate for that geomorphic setting.		x
2c	There are no obvious and significant problems external to the action area that would jeopardize the restoration outcome.	x	
2d	The contributing basin provides for flood discharge, wood recruitment, organism dispersal and sediment supply to support the restored system.		x
2e	The restored action area will form a contiguous large patch that is well connected to a surrounding terrestrial and marine landscape.	x	
2f	The restored ecosystem components within the action area will be internally connected in a way that allows for the unconstrained movement of organisms, water, and sediments.	x	

Summary

Maulsby Swamp receives a "no" for three of the screening criteria. These negative responses are related to Maulsby Swamp's proximity to other ecosystem stressors that would not be addressed as part of a restoration project at this action area. As stated in the ACR, "given the overall alteration to the area, and larger scale changes to the Lower Snohomish Estuary, we are unlikely to achieve a full restoration of pre-disturbance processes in this location." Although this one of very few opportunities to restore intertidal marsh in this portion of the nearshore, Maulsby Swamp is located in a highly degraded, long, drift cell in a highly urbanized area of Puget Sound. The only way to potentially achieve process-based restoration at this location is to acquire the Port of Everett property located on the waterward side of Marine Drive. Acquiring the Port property could create greater interaction with the nearshore and provide a larger, more contiguous habitat patch at this location, but full restoration of processes is unlikely. Also, because acquisition of Port land was not part of the proponent's vision for this action, we do not know if it is feasible. For these reasons, we recommend this action not move forward as part of PSNERP's 10% design effort. Restoration of Maulsby Swamp may have merit according to some other criteria, but does not fit with PSNERP's restoration objectives.

Hood Canal

Site Name: Black Point Lagoon

Action: Black Point Lagoon (1261)

Local Proponent	Hood Canal Coordinating Council, Jefferson County Public Works
Delta Process Unit	NA
Shoreline Process Unit(s)	2098
Strategy(ies)	4 – Coastal Inlet (lost embayment)
Restoration Objectives	Restore processes by removing obstruction formed by roadway that changes hydraulics and sediment transport, and other processes
Process-based Management Measures	Berm or Dike Removal or Modification, Hydraulic Modification
Additional Measures	Property Acquisition/Conservation

Description of the Action

Reestablish historic tidal connection to lagoon by replacing undersized culvert with bridge or other opening. This description is the same as the sponsors. In addition, other modifications will be considered: (1) grading to change the channel connecting the lagoon and (2) modification of the inlet.

Status in Design Process

A description of the proposed action reportedly exists but was not available. The description is expected to be very conceptual at this stage, without design.

Site Description and Context

Historic Conditions

Lagoon may be a glacial kettle (large glacial ice chunk that slowly melted, leaving a depression behind). This results in an odd morphology, defined by the hillsides.

The 1883 T-sheet shows that the lagoon was being used, presumably for transport of logs with a road accessing the western side of the lagoon. At the time of the survey, a linear channel connected the lagoon to Hood Canal. A marsh or wetland was clearly present on either sides of the channel with mixed forest at higher elevations. It is not clear if the channel was created or modified following settlement of the area, but it is evident that the lagoon was being used at the time of the survey. Trails led to the lagoon bank (now called Fulton Lake), and it appears that water was then used as an access to hood canal, possibly explaining a straight channel cut through the marsh. The area outboard of the channel inlet was characterized a gravel and boulders.

Figure 1- Black Point Lagoon Action Area

Natural Environment

The lagoon and channel connecting to Hood Canal are currently tidal with the tidal inundation at the lagoon limited by the existing culvert and roadway embankment. Tidal marsh vegetation (pickle weed and salt grasses) is currently present on the north and south sides of the channel. This connecting linear channel passes through a narrow, hardened opening before opening to a sinous channel through the beach adjacent to Hood Canal.

The mouth is tidal with an intertidal sill about 12' wide composed of course shore sediments. It is not clear whether modifications have allowed or have maintained the opening and tidal channel, or if the tidal prism and runoff are sufficient to scour through the littoral ridge naturally. The 1883 map shows a smaller kettle-formation to the north, with an intact barrier ridge and back-ridge marsh and open water lagoon. An analysis of the watershed discharge and effective tidal prism may provide a better easement as to whether the feature was a perched, non-tidal fresh brackish lagoon with an ephemeral or perennial drainage outlet or a tidal salt lagoon.

The lagoon is reportedly about 40 ft deep with a thermocline typically around 10' below the surface.

Salinities measured with a refractometer were at 21 ppt just east of the roadway, rising to 24 ppt near the outlet and 26 ppt in Hood Canal. This indicates tidal salt water conditions.

Human Environment

A county roadway embankment separates the lagoon from the tidal inlet channel. A culvert (approx. 6 ft nominal diameter, about 5.5 ft internal diameter) through the roadway allows flow in and out of the lagoon. The land at the action site is privately owned; one owner owns the lagoon and channel and a separate owner owns the land near the inlet at Hood Canal. The lagoon is presently used for commercial seed oyster operation. A home and outbuildings are located immediately adjacent to the both banks of the inlet at Hood Canal.

Opportunities for Process-based Restoration

Replacement of the existing culvert with a larger opening would potentially increase tidal prism and ecologic connection between the lagoon and the elongated marsh-channel. To the extent the existing tide is muted, tide range would increase, resulting in an incremental increase in the inlet and water and nutrient exchange.

Potential Design Alternatives

There are two design alternatives for this area:

1) Restoration as a salty tidal lagoon and salt marsh: Remove road or replace with bridge or arch culvert that allows large wood debris to migrate through opening. Grade marsh to develop more sinuous and complex main and tributary channels.

2) Restoration as a non-tidal, back barrier lagoon and fresh / brackish wetland: Remove road or replace with bridge or arch culvert that allows large wood debris to migrate through opening. Grade shore to have a higher, closed beach berm consistent with fluvial drainage. Restore channel to natural morphology, which will probably consist of several smaller distributary channels.

Local Proponent Requirements

The primary local requirements are that Black Point Road must remain functional and the oyster operations in the lagoon must be maintained.

Potential Design Constraints

There are minimal design constraints at this site. The main issue would be maintaining vehicular access during constructions.

Uncertainties and Risks

The primary uncertainty is the natural condition to restore to. An assessment of likely equilibrium condition (either salty tidal or on-tidal, fresh-brackish drainage) as well as desired habitat should lead to one of the two design alternatives. Other areas of uncertainty are:

- Is the lagoon / lake hydraulically constricted? This can be evaluated approximately by comparing the estimated runoff and tidal discharges to the culvert dimensions and elevation.
- Will the property owners support restoration actions outside county road right of way?
- Are there archeological resources in the action are as suggested by the disturbance shown in 1883 map?

References

None.

Criteria For Go / No Go Determination

Fatal Flaws: A No on either question results in a No Go determination. Otherwise the action is recommended for 10% design

1	Criterion	Yes	No
1a	The local proponent has not precluded PSNERP's involvement in the concept design.	X	
1b	The candidate action is sufficiently described and spatially defined to enable us to design restoration alternatives and determine quantity estimates.	X	
1c	The candidate action is consistent w/ one or more PSNERP restoration strategy, and an alternative can be described which addresses one or more of the associated restoration objectives.		X

Additional Criteria: A No response one or more questions means the action may not be suitable for 10% design and requires a more detailed explanation and rationale by the CDT. If the action has no No responses, the determination is Go.

2	Criterion	Yes	No
2a	There is an alternative for this action that could restore ecosystem processes to a substantial portion of their historic (less degraded) state.		X
2b	The restored action area will support a broad representation of nearshore ecosystem components appropriate for that geomorphic setting.		X
2c	There are no obvious and significant problems external to the action area that would jeopardize the restoration outcome.	X	

2	**Criterion**	**Yes**	**No**
2d	The contributing basin provides for flood discharge, wood recruitment, organism dispersal and sediment supply to support the restored system.	X	
2e	The restored action area will form a contiguous large patch that is well connected to a surrounding terrestrial and marine landscape.		X
2f	The restored ecosystem components within the action area will be internally connected in a way that allows for the unconstrained movement of organisms, water, and sediments.	X	

Summary

The proposed restoration action may not substantially change the existing conditions. This is because the feature behind the barrier is an unusual deep lagoon, and therefore the level of stress resulting from the obstruction may not be great. However, the historic condition is not clear due to the unique (odd) morphology resulting from the geologic formation (kettle) and the apparent disturbance as early at the time of the 1883 map. Therefore, it is not clear this action is appropriate from a restoration standpoint, other than the roadway and culvert are clearly unnatural.

The feature is not large and the connection to the sound is narrow due to the geology, with private property immediately adjacent on both sides. We do not recommend that the project move forward through 10% design.

Hood Canal

Site Name: Cattail Creek and Devil's Hole Estuaries

Action: Cattail Causeway Replacement and Estuary Restoration (1271)

Local Proponent	Hood Canal Coordinating Council
Delta Process Unit	NA
Shoreline Process Unit(s)	2001
Strategy(ies)	4 – Coastal Inlet
Restoration Objectives	Restore processes by removing obstruction formed by roadway that changes hydraulics and sediment transport, and other processes
Process-based Management Measures	Berm or Dike Removal or Modification, Hydraulic Modification,
Additional Measures	NA

Description of the Action

The goal of this action is to restore salt marsh and lagoon habitat and restore fish passage at the mouth of Cattail Creek by removing the existing roadway and replacing it with an elevated structure.

Status in Design Process

The US Navy recently reported that they are pursuing design and plan to implement the project without participation by PSNERP (Wall, 2010).

Site Description and Context

Historic Conditions

The 1878 T-Sheet shows a small open water and marsh basin behind a coastal barrier. The coastal barrier is a littoral spit / beach ridge that extends from the northeast shore to the southern hillside control, with a very small inlet: The inlet is so small that it could have been an ephemeral tidal inlet or drainage outlet. The map symbology appears to be salt marsh. A small creek discharges into the lagoon / estuary.

Figure 1- Cattail Causeway Action Area

Natural Environment

A site visit was not conducted.

Human Environment

Maps and photographs show a road crossing near the historic beach barrier.

Opportunities for Process-based Restoration

No evaluation has been made, but it is presumed that removal of the road or installation of a bridge would enhance the shore form by reestablishing hydraulics and geomorphology, and restore the beach and inlet processes.

Potential Design Alternatives

No evaluation has been made.

Local Proponent Requirements

Potential Design Constraints

Navy has indicated that the project is moving forward without PSNERP involvement.

Uncertainties and Risks

No evaluation.

References

Wall, Lynn CIV NAVFAC NW, EV1, email to Tanner, Curtis D (DFW), Subject:FW: 46 projects Lynn Wall, September 24, 2010

Criteria For Go / No Go Determination

Fatal Flaws: A No on either question results in a No Go determination. Otherwise the action is recommended for 10% design

1	**Criterion**	**Yes**	**No**
1a	The local proponent has not precluded PSNERP's involvement in the concept design.		X
1b	The candidate action is sufficiently described and spatially defined to enable us to design restoration alternatives and determine quantity estimates.		X
1c	The candidate action is consistent w/ one or more PSNERP restoration strategy, and an alternative can be described which addresses one or more of the associated restoration objectives.	X	

Additional Criteria: A No response one or more questions means the action may not be suitable for 10% design and requires a more detailed explanation and rationale by the CDT. If the action has no No responses, the determination is Go.

2	**Criterion**	**Yes**	**No**
2a	There is an alternative for this action that could restore ecosystem processes to a substantial portion of their historic (less degraded) state.	X	
2b	The restored action area will support a broad representation of nearshore ecosystem components appropriate for that geomorphic setting.	X	
2c	There are no obvious and significant problems external to the action area that would jeopardize the restoration outcome.		X
2d	The contributing basin provides for flood discharge, wood recruitment, organism dispersal and sediment supply to support the restored system.	X	
2e	The restored action area will form a contiguous large patch that is well connected to a surrounding terrestrial and marine landscape.	X	
2f	The restored ecosystem components within the action area will be internally connected in a way that allows for the unconstrained movement of organisms, water, and sediments.	X	

Summary

The owner, the US NAVY, has indicated that they plan to implement the project as without participation by PSNERP and suggested that the site visit was not necessary. Therefore, this project is a directed “No Go” without a detailed Phase 1 evaluation.

Hood Canal

Site Name: Devil's Hole Estuary (#1286)

Action: Devil's Hole Creek

Local Proponent	Hood Canal Coordinating Council
Delta Process Unit	NA
Shoreline Process Unit(s)	2002
Strategy(ies)	3 – Barrier Embayment
Restoration Objectives	Restore processes by removing obstruction formed by roadway that precludes natural tidal flow, sediment transport, and other processes.
Process-based Management Measures	Berm or Dike Removal or Modification, Topographic Restoration, Armor Removal
Additional Measures	Revegetation

Description of the Action

The goal of this action is to restore tidal flushing into a barrier embayment by removing the existing causeway and replacing it with an elevated structure.

Status in Design Process

The US Navy recently reported that they are pursuing full design development and plan to implement the project without participation by PSNERP (Wall 2010).

Site Description and Context

Historic Conditions

Devil's Hole Creek flows into Bangor Lake or Devil's Hole Lake, which was created in the 1940s when Sea Lion Road was constructed. Historically the lake was an estuarine embayment created by two converging barrier spits bisected by a narrow tide channel (USCGS 1878). Currently the primary outlet is a vertical, rectangular concrete shaft, approximately 9 feet high, which is connected to a concrete bulkhead on shore. The surface area of the lake or embayment measures approximately 6.4 acres. A fishway was constructed at the lake outlet in 1979 to provide access for salmonids (Volkhardt et al. 2000).

Figure 1- Devil's Hole Action Area

Natural Environment

A site visit was not conducted.

Anadromous salmonids are known to utilize Devil's Hole Lake and Creek and the five unnamed tributaries that flow into the creek. WDFW concluded that the single largest impact on salmonid use in the Devil's Hole watershed is the dam/fishway at the mouth of the embayment (Volkhardt et al. 2000).

Devil's Hole Estuary

Human Environment

Maps and photographs show Sea Lion Road crossing over the top of both of the historic spits that extended from each side of the embayment mouth, and also crossing the historic tidal channel.

Opportunities for Process-based Restoration

No evaluation has been conducted, but it is presumed that removal of the road or removal and installation of a bridge over the center of the embayment mouth would enhance the embayment by reestablishing tidal flow, tide channel formation and maintenance, detritus import and exchange, exchange of aquatic organisms, erosion and accretion of sediments as well as beach and inlet processes.

Potential Design Alternatives

No evaluation has been conducted.

Local Proponent Requirements

Potential Design Constraints

The Navy has indicated that the project is moving forward through design and implementation without PSNERP involvement.

Uncertainties and Risks

No evaluation has been conducted.

References

US Coast and Geodetic Survey, 1878. T-sheet No. 1556 Hood's Canal: Port Gamble to Hazel Pt, Washington Territory.

Volkhardt, G., P. Topping, and D. Seiler, 2000. Assessment of Factors Limiting Salmon Production in Devil's Hole Creek. Prepared for The Department of the Navy Submarine Base, Bangor, Washington. Science Division, Fish Program, Washington Department of Fish and Wildlife, Olympia, Washington. 72p.

Wall, Lynn CIV NAVFAC NW, EV1, email to Tanner, Curtis D (WDFW), Subject: FW: 46 projects Lynn Wall, September 24, 2010.

Criteria For Go / No Go Determination

Fatal Flaws: A No on either question results in a No Go determination. Otherwise the action is recommended for 10% design

1	**Criterion**	**Yes**	**No**
1a	The local proponent has not precluded PSNERP's involvement in the concept design.		X
1b	The candidate action is sufficiently described and spatially defined to enable us to design restoration alternatives and determine quantity estimates.		X
1c	The candidate action is consistent w/ one or more PSNERP restoration strategy, and an alternative can be described which addresses one or more of the associated restoration objectives.	X	

Summary

The owner, the US Navy, has indicated that they plan to implement the project as without participation by PSNERP and suggested that the site visit was not necessary. Therefore, this project is a directed "No Go" due to the "fatal flaws" of lack of participation with the local proponent and also the lack of a well defined alternative and the site has not been considered for a full evaluation.

Puget Sound Nearshore Ecosystem Restoration Project

Strategic Restoration Conceptual Engineering – Design Report

Appendix B: Guidelines for Estimating Quantities

March 2011

Quantity Estimate Memorandum

PSNERP Strategic Restoration Site Conceptual Engineering

Contract No. 100-000204

CAPS No. 10-1461

Scope Exhibit 2

A key component of the 10% designs is the estimate of construction quantities. The USACE will rely on the quantity estimates as a basis for estimating likely construction costs. This memorandum describes our proposed approach, and the Quantity Estimate Template.

Approach

The overall approach is to use items and unit quantities, with quantities measured in "rolled up" units (e.g., linear foot, square foot, cubic yard). Each line item will have a description that provides additional information to the audience, which is assumed to be either the cost estimator or a reviewer. Lump sums or units of "each" can be used, but require more detailed descriptions.

Accuracy, precision and record keeping are required. Accuracy should be consistent with a 10%-level-of-completion. We anticipate a level of accuracy that requires a contingency of about +50% as follows.

Design Contingency – 30% to be added to the pre-tax subtotal. Taxes will be applied to this number

Construction Contingency – 20%. This is applied to the total construction costs (below the tax line). But since the tax is in that subtotal, it would be built-in and accounted for.

Precision will be achieved by standardization of the quantity estimate format: A Quantity Estimate Template is provided for review and refinement. The template includes items that are categorized and described in general. The estimator will use those items that best apply to the action, insert the estimated quantity, and populate the other columns with descriptive information. For example, 1,200 LF of New Water Line would be under Utilities, and the description would clarify it is a 6-inch transmission line with no distribution lines and typical burial depth.

Record Keeping will consist of backup for each item. The backup can be a drawing with the basic dimensions (e.g., length and location of new water line). Backup will also include digital files used to create the plan and cross-section drawings. , The quantity estimates can be derived from the plan and section figures to be included in the 10% description of each action. Ideally, hard copy backup will be on a sheet size that will facilitate scanning and digital records (i.e. 11"x17" or 8-1/2" x 11").

Other – Units: Ideally, the quantity estimate will be in units that are compliant with cost-benefit analysis. For example, linear feet of bulkhead removal with a description of bulkhead height and material may be preferred over quantities in square feet. Use of linear feet would allow a more direct adjustment of action effort to change cost-benefit (e.g., adjust to 500 lf of bulkhead removal instead of 800 lf). Similarly with bridges and roadways..

Other – Earthwork: There are multiple earthwork items. This is because many restoration projects are mostly earthwork, and therefore the unit costs estimated greatly affect the total estimate. Also, a range of earthwork types may be needed, with different equipment and unit costs. For example, roadway earthwork is very different from excavation of marsh channels: Roadway earthwork could use scrapers where as marsh channel excavation might require low-ground-pressure equipment on timber mats. Line items for bucket and hydraulic suction / cutter dredging are provided. Only a couple of these will be needed for any particular action.

Other – Descriptions: We have drafted descriptions for each item in the Quantity Template. Some of these can probably be used 'as is'. This helps standardize the estimates, but also is intended to save time for those estimating quantities and costs. Therefore, we request that a review of the descriptions (see template column "Explanation…."). For example, we propose that every action have a *Mobilization* item as described, which might typically amount to 8% or 10% of the total construction estimate, unless the site is remote, in which case the percentage would be greater. Special items such as building a road to access the site would be additional to typical *Mobilization* and included in *Site Access*.

Other – Materials: Material testing is built in to unit costs for the estimates we develop. Suppliers provide the material and testing requirements in the specifications.

Descriptions of Estimate Items

Descriptions for each item are provided in the Template. Additional explanation is provided here.

Acquisition and Conservation: Estimated total Required Project Lands will be the sum of Partner / Proponent Owned Lands (i.e., those that do not require purchasing) and Lands to be Acquired (i.e., those lands that may need to be purchased, easements acquired or other costs). We expect these quantities to be approximate based on existing, publically available parcel and landownership information

Mobilization and Access: Mobilization and Access includes those items of work that are preparatory to major improvements, and are required prior to and or during of construction, but may not be permanent of physical elements.

Mobilization for each action area would include the movement of equipment and materials to the action location and construction site, demobilization and site cleanup. Additional activities included under this heading include development of the staging area, general site access, project office setup and erection of any fencing required at the site and staging areas. Mobilization also includes any up-front costs such as bonding, financing, planning, and other staff time not specifically associated with physical construction site preparation.

Site Access entails construction of new site access (e.g. roadways, bridges) rather than typical minor actions associated with existing access. A description of the work required to develop and maintain construction access to the site should be included.

Barger Access would account for sites that require use of a barge for construction or demolition.

Temporary Traffic Control is temporary traffic control measures that will need to be in-place during construction at the Action site. A range of intensity of traffic control is provided:

- None: none required

- Signs: passive control.
- Flags / Spotters: active control; requires estimate of duration due to manpower.
- Unique: Define as needed.

Temporary Roadway may be required at sites that will otherwise fully disrupt the current vehicular traffic through or adjacent to the action area. This line item should be used to estimate the work required to construct any roadways, shoe-flys (railway shoe-flys are under Roadway/Railway), bypasses, or similar that will be used only during construction. Units would be lump sum. A description will be provided.

Control of Water*:* The proximity of the sites to both fluvial and tidal water systems will require control of water during construction. This line item should include any temporary placement of coffer dams, bypass channels, pumping, water control structures, or other that would be necessary to allow construction to proceed at the site without interference from surface or groundwater. A complete description of the planned approach for control of water should be provided, including the level of protection (i.e. storm event capacity if known or estimated dimensions of conveyance feature).

Site Demolition Activities: Many of the actions will require the demolition and removal of existing structures, roadways, buildings, utilities, revetments, bridges, and other material from both land and marine settings. Clearing and grubbing items are also included, and typically include minor demolition and debris removal. The quantities will include the demolition of the element and in most cases removal of the waste material from the action area. It may be advantageous to dispose of some vegetation, topsoil and large wood within the action area for permanent disposal or reuse. In these cases, the quantities should be separated to reflect onsite or local disposal. Also, invasive non-native plants may exist and require off haul. The haul distance is assumed to be 20miles.

Hazardous / Contaminated Waste Removal: Earth and other materials that are not compatible with exposure to water and habitat areas shall be considered contaminated and removed and disposed offsite. Given the conceptual nature of the project, we have greatly simplified the possibilities to either (a) *contaminated* (not compatible with wetlands but ok for upland or standard landfills) or (b) *hazardous* (requires special excavation, handling, testing and disposal). The estimator can provide more specific information in the description, especially if there are specifics about the contamination and prior remediation efforts.

Earthwork – Excavation & Grading: This category includes activities associated with the removal, transport, and placement of earth and rock material. The action areas will require excavation of earth and removal of rock from both land and marine environments. We have defined a range of earthwork categories that require different equipment and access. These construction line items will be based on volumetric or areal measurements.

Excavation – Upland involves traditional earthwork equipment and would likely include scrapers that provide high production rates at a low cost. This type of excavation is appropriate for higher ground locations that are dry and do not pose much potential for equipment to become stuck or have areas with limited access.

Excavation – Lowland is appropriate for locations that require low ground pressure equipment due to softened soil conditions and higher water levels. Typical methods would include low production bucket excavation methods with equipment such as hydraulic excavators and front end loaders with material being hauled from the site in trucks.

Dredging – Bucket – Land is appropriate for land based equipment but beneath the groundwater table or underwater. This work is typically associated with equipment that has limited reach and a low production (i.e. bucket methods). Low ground pressure equipment with mats (for bearing) are typically used.

Dredging – Bucket – Marine is appropriate for any excavation to be completed using floating or amphibious equipment with an excavator, clamshell, or drag-line bucket. This equipment is more suited for excavation in below the water line and will typically have a higher production rate than land-based dredging, but not as high as a hydraulic dredge operation.

Dredging – Hydraulic is appropriate for any excavation to be using a hydraulic cutter and suction dredge to slurry and pump marine sediments. This method allows for higher production rates but also requires some method for removing water (decanting) from the slurried sediment and requires special mobilization. A description of the method and location for decanting the slurry should be included, and confirmation that the cost of mobilization is spread or is a separate item.

Fine Grading is small tolerance grading to be completed following rough grading. This work would typically be required for embankments, levees, and grading prior to placement of any vegetation. This does not include any fine grading associated for vehicular roadways, which will be included in the roadway line item estimates. This is typically an area based estimate.

Earthwork Fill Placement: Placement of fill at the Action sites should be presented as an additive item to excavation. Three basic methods for fill placement are anticipated for the Actions. Excavated material may be side-cast, hauled and placed, or stockpiled and placed. Material to be placed will either be uncontrolled or controlled (requirements for placement and grades).

Fill Placement – Side Cast material will be placed within reach of the excavator or dredge without intermediate handling. It should be assumed that any some shaping and minor compaction would be conducted with the excavator bucket.

Haul – Uncontrolled Placement material would be loaded into trucks and hauled to another location within the Action area to be placed. The estimate should include the haul distance required between the excavation and placement locations.

Haul – Controlled Placement material would be loaded into trucks and hauled to another location within the Action area to be placed. The estimate should include the haul distance required between the excavation and placement locations. Additional handling is required to place soil in lifts, compact or track walk, moisture condition, and compaction testing.

Stockpile – Uncontrolled Placement material would be loaded into trucks and hauled to another location within the Action area to be temporarily stockpiled. This is an intermediate step required for drying of material, or storage prior to placement elsewhere at the Action site. The estimate should include the haul distance required between the excavation and stockpile locations.

Stockpile – Controlled Placement material would be loaded into trucks and hauled to another location within the Action area to be temporarily stockpiled. This is an intermediate step required for drying of material, or long-term storage prior to another phase or later off-haul. The estimate should include the haul distance required between the excavation and stockpile. Additional handling that is required for placement at the stockpile site is included in this line item: Additional handling may require site prep, grading, erosion control and drainage control activities.

Earthwork - Imported Fill: The use of imported fill may be required for the construction of specific design elements such as levees, planting base, and soil blending for structural enhancement. Additionally, special materials are required to restore beach morphology. Each type of material to be imported to the Action area should be specified based on its intended purpose. The imported material for shore nourishment should be separated by material type, (sand, gravel, cobble). Includes all costs complete and in place (purchase, transport, placement).

Restoration Features: Restoration Features are specialty items such as stream channels, biotechnical structures, large wood debris / log complexes, animal fences, etc. Descriptions are key for these items.

Structures: The actions will require a variety of structures to control and direct water, provide vehicular and pedestrian access, and realign or relocated utilities. It is anticipated that the structures will be presented based on the number of a similar type. Additional descriptions of the structures (dimensions, material types, other) will be provided

Water Control Structures – Culverts with Gates: A description of each culvert requiring control gates should be provided. Information should include the number of openings, culvert material and dimensions, type of gate. If an Action requires multiple configurations, a separate line item for each unique configuration should be provided.

Water Control Structures – Weirs: A description of each weir structure water control should be provided. Information should include the number of weir dimensions, type, construction material, as well as the purpose of the weir (i.e., diversion, emergency overflow, etc). If an action requires multiple configurations, a separate line item for each unique configuration should be provided.

Rock Slope Protection: A description of the extent of rock slope protection should be provided that clearly describes the slope, rock size, layering, and use of underlying fabric. It is desirable to convert this line item into a linear estimate and provide backup of the quantities estimate used to determine the linear quantity.

Other structures will be required as a part of one or two actions. One example is a boat launch ramp. A description will be provided.

Utilities: It is anticipated that some existing utilities will require replacement or relocation as a result of construction activities. Each impacted utility should be included in the estimate as a separate line item. Note that there is a separate line item for demolition. A detailed description of the utility should be provided including type, size, length, and owner. Utility estimates should be provided as a linear foot estimates including incidentals such as earthwork, excavation control, materials, testing, service switching.

Roadway / Railway: Multiple actions include modification to major road and rail crossings to allow restoration of processes. Roadways consisting of earth embankments and short bridges will be removed and replaced with longer bridges. New routes may be used. Railways will be converted from embankments to trestles (like bridges but with multiple pipes and framing to support train loads) or have culverts inserted using trenchless technology.

Roadway refers to new surface street roadway of a standardized pavement section, with appurtenant drainage. A unit of Square Feet is proposed. *Roadway – Traffic Signal* is an add-on for powered intersection traffic control.

Culverts come in multiple types. The type will be specified (e.g., *Arch culvert* ,pre-cast concrete arch, large, bottomless span); *Culvert-jacking* (steel pipe is pushed through embankment) and *Culvert – Horizontal Pile Driving* (steel pipe is hammered through embankment). Descriptions of appurtenances, materials, dimensions and numbers are required.

Bridges will each be comprised of *Bridge – Superstructure, Foundation and Appurtenances*. This item will include elements such as approach slab, abutment, barriers, railings, etc. to conform to one of three or four types to be developed. Unit of measurement will be Square Feet:

Railway Trestles will be treated as comprised of the Superstructure and Foundation, with shoefly. The Superstructure will consist of Precast concrete box girders. The Foundations will consist of steel piles with precast concrete caps. We will provide an assumed depth for the piles and would measure per linear foot as described for the roadway pile foundations above. The only variance might be with a higher structure such as the case at Sequalitchew Creek, longer spans may be used than the standard 26-foot. A shoefly, if needed could be of the same construction if it was to remain as permanent. If temporary there is some flexibility with the materials that can be used.

Permanent Access Features: We anticipate the need for access to and within some sites for the public and utilities.

Public Access and Recreation Features: Many actions will include local requirements for public access. A range of items are listed, but additional items may be required for one or more action. Since each may be somewhat unique, a description is important. Some examples:

Bridge - Pedestrian Traffic: A description of the pedestrian bridge should be provided with information including owner, material, length, span, width and level of use.

Boardwalk: A description of the boardwalk pedestrian bridge should be provided with information including owner, material, length, span, width and level of use.

Interpretive signage: An estimate of the number of signs based on the number of primary public access locations within the Action site will pro provided.

Vegetation and Erosion Control: Each Action will require some level of erosion control during and following construction. Some Actions may also require vegetation following construction activities.

Hydroseeding may be required for temporary or permanent site stabilization. Include a description of the purpose of the hydroseeding application as well as a description of the desired seed mix, noting that native mixes may have a higher cost. The quantity estimate should be based on the area to receive hydroseeding. If multiple applications are planned, this should be noted and accounted for as necessary.

Planting will be required at several sites to restore plants disturbed or removed during construction, or enhance the reestablishment of new vegetation, or provide new vegetation to the site. A general description of the proposed planting palette (riparian, intertidal, upland, etc) should be provided and quantities estimated by unit area of each unique planting regime.

Vegetation Maintenance is necessary to ensure that young plants are able to establish as planned and repair any areas damaged due to flooding or dry periods. Maintenance would also include periodic watering, weeding, thinning, and plant replacement for the course of a year. The estimate for vegetation maintenance should be provided on a acre-year basis.

Erosion & Sediment Control BMPs are required to protect the sites from erosion during and following construction activities. These measures protect work that has been completed and prevent off-site migration of air and water borne sediments. A general description of BMPs likely to be used at the site should be included. This line item estimate should be presented as area based on the total area of the site to be protected by the BMPs. Waterside Controls are a special case, typically consisting of a floating silt curtain with anchors and cabling to the banks.

Construction Management: Each Action will require construction management during implementation. The level of effort will be based on the expected duration of construction in teems of weeks or construction seasons.

Design and Detailed Site Investigations: Each Action will require additional study and assessment as part of the subsequent design phases. Estimates of cost for 35%, 60%, 90% and 100% design are typical reported as a percentage of construction costs:

- 35% PS&E = 35% x 25% x Engineer's Estimate
- 65% PS&E = 65% x 25% x Engineer's Estimate less the cost for 35% PS&E
- 90% PS&E = 35% x 25% x Engineer's Estimate less the cost for 35% + 65%PS&E
- 100% PS&E = 25% x Engineer's Estimate less previous costs

Typical studies required during the design process include property research and surveys, geotechnical investigation, hazardous materials investigations, and cultural resources surveys. The need for these studies will be described in the design report but it is not possible to provide a credible quantity estimate at 10 percent design.

Project Agreement Activities includes activities such as scoping and administering design agreements and certifying lands available for construction. It is not possible to provide a credible quantity estimate at 10 percent design.

Site-Specific Adaptive Management Features & Activities may be required at one or more action sites in order to ensure that the restoration benefits accrue over time. Adaptive management involving the re-application of a management measure or re-construction of a design features that can be reasonably foreseen will be described and the quantity estimated based on the units appropriate for that item.

Monitoring Activities will be performed at each Action site to assess site performance compliance with design parameters and for regulatory compliance purposes. Specific monitoring needs will be identified in the design report and an estimate will be provided based on the number of parameters to be monitored.

Operations & Maintenance (O & M) includes activities such as maintaining bridges, levees and other infrastructure. Most sites have infrastructure that needs ongoing maintenance. Future O&M quantities are difficult to credibly estimate at 10 percent design.

Puget Sound Nearshore Ecosystem Restoration Project

Strategic Restoration Conceptual Engineering – Design Report

Appendix C: Applied Geomorphology Guidelines and Hierarchy of Openings

March 2011

Applied Geomorphology Guidelines – Revised Draft Phase 2 Document
PSNERP Conceptual Design

December 20 2010

These Applied Geomorphology Guidelines will be used by the ESA team's conceptual designs. The Guidelines will be used as needed in the designs and to aid in quality control review. These guidelines may be revised to account for lessons learned during Phase 2 and for subsequent use.

The guidelines are intended only for conceptual design by the PSNERP team. These guidelines are established partly to provide a means of developing uniform designs, for quality control and precision, but also to facilitating future refinements. Further research and data collection are required to develop guidelines for broader application.

These guidelines use empirical models calibrated with data collected from field sites. Therefore, these guidelines are most useful when the site parameters lie within the range of the calibration data. Parameters include tide range, sediment and vegetation, fluvial effects, salinity (which affects plant types and geomorphology), and in some cases wave and littoral climate. Comprehensive data sets are not presently available for Puget Sound. The guidelines are based on both local data sets and data sets from other locations, with some adjustments, primarily for tide range. Therefore, the accuracy of the regressions provided here can be considered approximate. Historic data from the site (e.g. channel width from a T-Sheet) or nearby reference data (e.g. Hood's data for the Skagit, Barnard's data for Discovery Bay marshes) may be used instead of these guidelines.

The Guidelines are organized as follows:

1. Tides: Tide design parameters are identified for NOS tide stations selected to represent the varying tides in Puget Sound. Tide ranges are tabulated. Tidal datum conversion from Mean Lower Low Water (MLLW) to North American Vertical Datum (NAVD88) are provided at each tide station.

2. Tidal Marsh Channels: Regression lines and graphs are provided to relate channel geometry (channel cross-sectional area, width and depth) to marsh area and tidal prism. A set of regressions and graphs are provided for each tide station identified in (1), based on the tide range. A procedure is provided to estimate channel geometry with combined tidal and stream discharge.

3. Tidally-Influenced Fluvial Channels: Guidance for tidally influenced fluvial channels is to use historic data, remnant channel geometry and available published data on a site-specific basis.

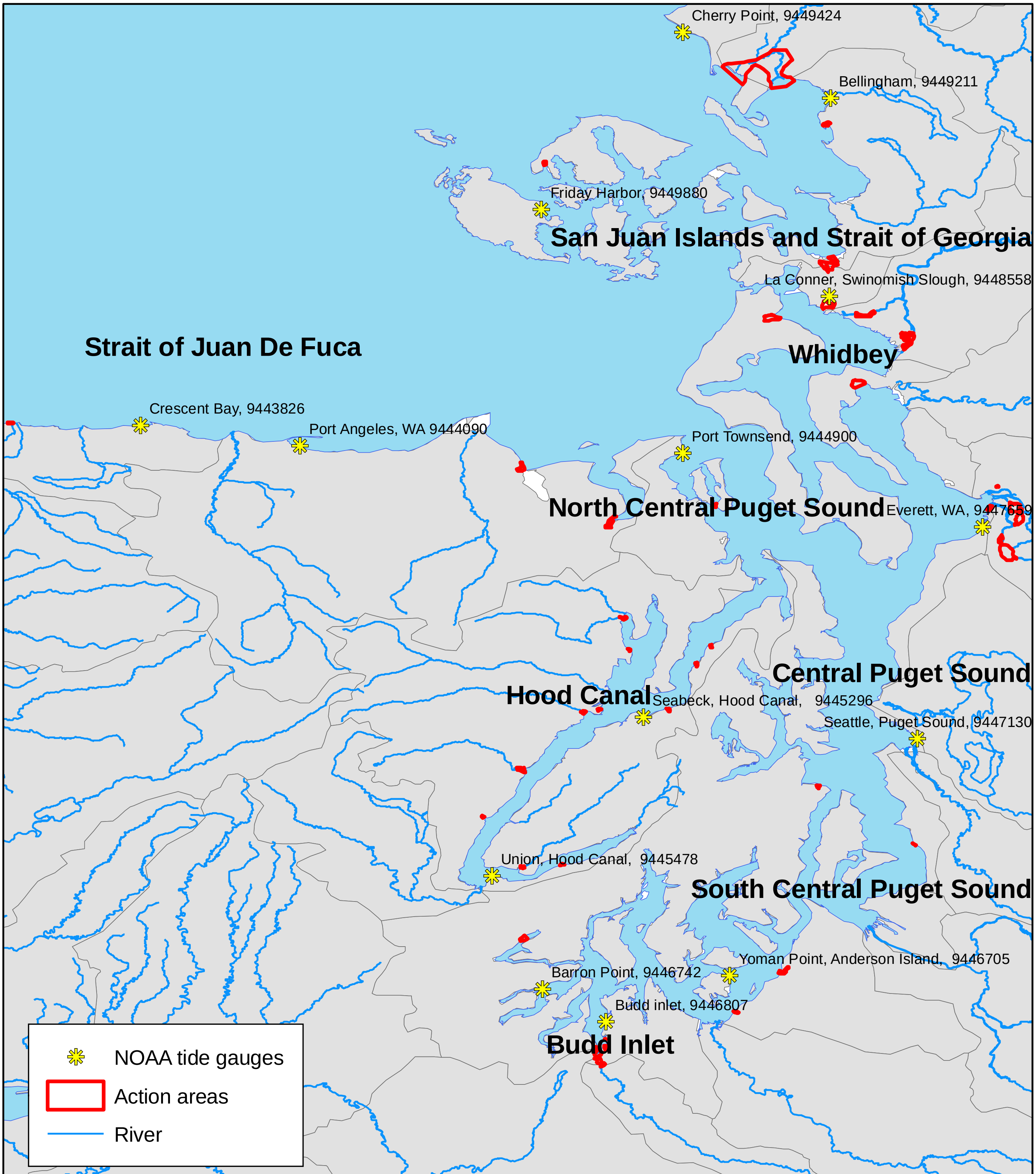
4. Tidal Inlets: A set of graphs are provided for tidal inlets where wave action and littoral drift affect the channel geometry and, in particular, limit the tide range. The graphs allow prediction of the tidal prism necessary for an open inlet and the size of the inlet cross section for a given tidal prism.

5. Beach Geometry: Guidance is provided to estimate the berm elevation of coarse sediment beaches.

1. Tides:

The Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) has defined sub basins of Puget Sound (Figure 1). Tide stations have been selected to characterize the tidal regime for each sub basin. Since the tides vary along each arm of Puget Sound (for example, the tide is amplified with distance south through Hood Canal), several tide stations are indentified for each sub basin, as shown in Figure 1. Table 1 lists the tide stations and their tidal datums published by the National Ocean Service (NOS). A conversion between tidal datums and the project vertical datum (NAVD88) are provided. The conversions are those published by the NOS or are based on a review of the tidal benchmarks and provided by Pacific Surveying and Engineering (PSE) and ESA PWA as part of this project. The sources of the conversion and level of confidence are provided.

Each action should define the tidal datums and NAVD conversion used and the sources.



Source: NOAA

Note: Subregion names are bold with NOAA tide gauge reference number.

N

0 10 20 40 Miles

figure X

PSNERP

NOAA Tide Gauge Locations

PWA Ref# -

PWA

G:\2036_PSNERP\mxds\base_map

Table 1: Tides Stations, tidal datums and NAVD conversions.

2036.01 Puget Sound
D.Kunz (PWA)
11/22/2010
Modfied B.Battalio, 12/9/2010
Puget Sound Tide Gages

				ft MLLW							ft NAVD							
Station	**NOS #**	**Start of Record**	**End of Record**	**MLLW**	**MLW**	**MSL**	**MTL**	**MHW**	**MHHW**	**MLLW to NAVD Conversion (ft)**	**MLLW**	**MLW**	**MSL**	**MTL**	**MHW**	**MHHW**	**Source of Datum Conversion**	**Conversion Level of Confidence***
Cherry Point	9449424	Nov-71	present	0.00	2.61	5.28	5.47	8.32	9.15	-0.96	-0.96	1.65	4.32	4.51	7.36	8.19	PSE Verrified	2
Bellingham	9449211	Mar-73	Jul-75	0.00	2.35	4.95	5.07	7.79	8.51	-0.48	-0.48	1.87	4.47	4.59	7.31	8.03	NOS Tidal Datums	4
Friday Harbor	9449880	Jan-32	present	0.00	2.29	4.55	4.70	7.11	7.76	-0.53	-0.53	1.76	4.02	4.17	6.58	7.23	PSE, WSDOT data	3
La Conner, Swinomish Slough	9448558	Jun-35	Feb-73	0.00	2.70	5.96	5.18	9.43	10.35	-1.51	-1.51	1.19	4.45	3.67	7.92	8.84	PSE Verrified	4
Crescent Bay	9443826	Sep-78	Nov-78	0.00	2.16	4.22	4.32	6.47	7.06	-0.42	-0.42	1.74	3.80	3.90	6.05	6.64	PSE Verrified	4
Port Angeles, WA	9444090	Aug-75	present	0.00	1.93	4.25	4.23	6.52	7.07	-0.43	-0.43	1.50	3.82	3.80	6.09	6.64	NOS Tidal Datums	4
Port Townsend	9444900	Dec-71	present	0.00	2.50	4.99	5.17	7.84	8.52	-1.11	-1.11	1.39	3.88	4.06	6.73	7.41	PSE Verrified	3
Everett, WA	9447659	Dec-76	Feb-96	0.00	2.80	6.48	6.51	10.21	11.09	-2.30	-2.30	0.50	4.18	4.21	7.91	8.79	NOS Tidal Datums	4
Seabeck, Hood Canal	9445296	Mar-35	Mar-78	0.00	2.99	6.75	6.76	10.54	11.49	-2.62	-2.62	0.37	4.13	4.14	7.92	8.87	PSE, VDATUM ONLY!!	1
Seattle, Puget Sound	9447130	Jan - 1899	Sep-88	0.00	2.83	6.64	6.66	10.49	11.36	-2.34	-2.34	0.49	4.30	4.32	8.15	9.02	NOS Tidal Datums	4
Union, Hood Canal	9445478	Mar-73	Mar-78	0.00	3.01	6.96	6.94	10.87	11.85	-2.84	-2.84	0.17	4.12	4.10	8.03	9.01	NOS Tidal Datums	4
Yoman Point, Anderson Island	9446705	Feb-78	Nov-96	0.00	2.94	7.71	7.75	12.55	13.48	-3.78	-3.78	-0.84	3.93	3.97	8.77	9.70	PSE, VDATUM ONLY!!	1
Barron Point	9446742	Sep-88	Mar-89	0.00	3.02	8.29	8.28	13.55	11.52	-4.08	-4.08	-1.06	4.21	4.20	9.47	7.44	PSE, VDATUM ONLY!!	1
Budd Inlet	9446807	Apr-96	Dec-96	0.00	3.07	8.31	8.30	13.53	14.48	-4.05	-4.05	-0.98	4.26	4.25	9.48	10.43	PSE, VDATUM ONLY!!	1

* Level of Confidence: 4 highest, 1 lowest.

"\\Mars\Projects\2036.01_PSNERP_Phase_1_Conceptual_Engineering\Applied Geomorphology Guidelines\NAVD MLLW Conversions\PSE Survey PSNERP_DATUM_CONVERSIONS 113010.pdf"

2. Tidal Salt Marsh Channels (Channel Modification, Dike Removal, Hydraulic Connection)

Tidal marsh channels are often sized based on applied geomorphology, typically using hydraulic geometry or allometry (Williams et al, 2002; Hood, 2002). Unfortunately, existing data sets are not adequate to develop guidelines for Puget Sound, and research indicates large variation between systems and locations (Hood, 2007; 2002). Still, some basis is needed to size channels in the conceptual designs as these are key drivers of quantity and cost estimates. Therefore, the guidelines presented here can be considered more of an engineering method and not vetted from a scientific perspective.

Hydraulic geometry has been used primarily in the study of fluvial and tidal systems, where channel parameters such as stream width or depth are regressed with area of the watershed (used as a surrogate for tidal prism and discharge). The form of the equation is typically a power function:

$$Y = a*x^n,$$

Where x is a independent variable (eg marsh area or watershed area),Y is the dependent variable (tidal channel width or stream depth), a and n are empirically derived coefficients determined from a regression of the log-transformed independent and dependent variables.

The hydraulic geometry of tidal channel parameters has been investigated in Washington at the Chehalis estuary by Hood (2002) and at the Skagit delta by Hood (2007). In the Chehalis work, log-transformed slough outlet width and outlet depth are shown to scale tightly (r^2 >0.95 for both) with outlet length for the Chehalis river sloughs. However, when three other nearby systems are analyzed in a similar fashion, there are significant differences (95% confidence level) in the regression estimates for nearly all of the systems analyzed. Hood (2002) indicates that these differences are likely a result of watershed processes, such as run off or soils, and that these differences must be integrated into the development of a restoration project. Furthermore, two of the systems investigated (Willapa River and South Fork Willapa River sloughs) undergo the same tidal regime, but have somewhat differing hydraulic geometry scaling relations.

Similar scaling regressions were performed in the Skagit delta, but in this work, outlet channel depth was not included in the analyses (Hood, 2007). As above, there are significant differences in the scaling relationships between channel outlet width and marsh island area for similar, nearby locations. In the Skagit delta area, these differences are likely driven by sedimentation and discharge from the Skagit river (Hood, 2007).

Approximate Hydraulic Geometry for Puget Sound, Extrapolating San Francisco Bay Regressions

The most expeditious means of developing guidelines for sizing tidal marsh channels is to modify the guidelines for San Francisco Bay (Williams et al, 2002; PWA, 1995). San Francisco Bay data sets are large and have been used successfully in design of marshes from a few acres to thousands of acres. While Puget Sound marshes should have different geometry due to different sediments, salinities and plants and greater rainfall effects, the primary difference is believed to be driven by the larger tide ranges.

These regressions are intended to represent future equilibrium conditions. In most cases, these dimensions are recommended for construction, with modification for constructability and slope stability if important. Overall, channels can be expected to evolve along with the marsh and take decades to reach an equilibrium condition, largely depending on sediment supply and vegetation establishment.

To account for the larger tide range in the Puget Sound area (diurnal range 7' to 16' with an average of about 10.5'), we adjusted the regression lines for San Francisco Bay data. First, we compared the large San Francisco bay data set (typical diurnal tide range about 5.8ft) with the subset from southern San Francisco Bay where the tides are much larger (range about 8.8ft). We then calculated the change in regression lines between the two data sets, and related the differences to percent increase in tide range. We then prorated this increase based on the tide ranges in Puget Sound.

Figures 2, 3 and 4 show data from San Francisco Bay (Williams et al, 2002) and Discovery Bay (Barnard, project worksheets, 2010), and regression lines by Hood (2002) and PWA (2003). The recommended regressions are those in red. These are example regressions for one tide station.

The above methodology was applied to 14 tide ranges defined at tide gauges distributed throughout the study area. This resulted in adjusted regression lines for each of the tide stations that are listed in section 1. Fourteen graphs (one for each tide station) are provided in the Appendix. Each graph includes three lines:

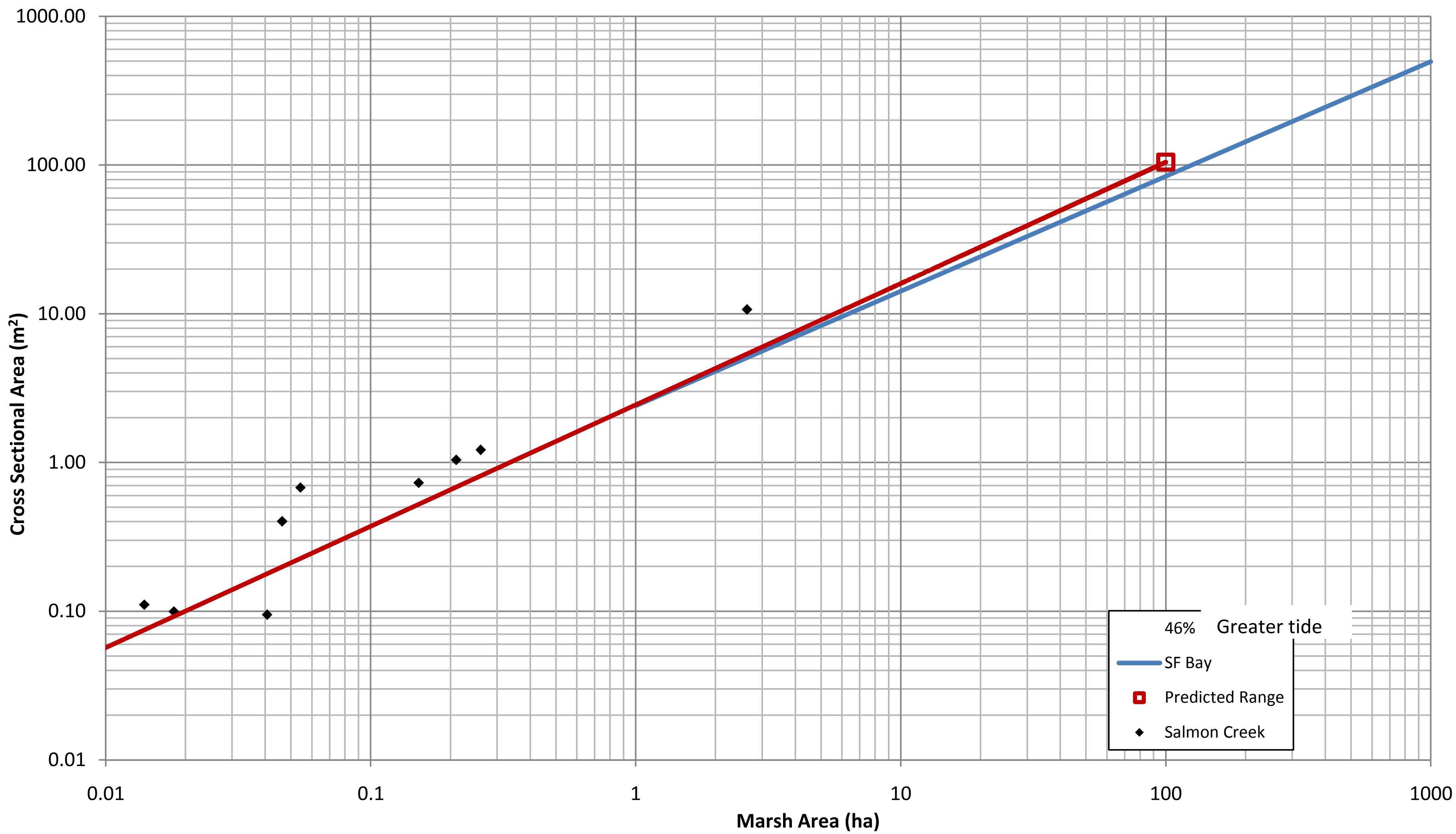
- Channel Cross section area (feet squared) vs. Marsh Area (acres);
- Channel Width (feet) vs. Marsh Area (acres); and,
- Channel Depth (feet) vs. Marsh Area (acres).

Upsizing to include stream discharge effects and additional tidal prism

The above discussion is based on tidal prism being the primary channel forming parameter, and uses marsh area as surrogate for tidal prism. Many Puget Sound marshes have significant freshwater inputs which add to the scouring power during ebb tides and therefore can be expected to increase the size of larger channels. To calculate the hydraulic geometry of a channel that incorporates fluvial discharge, the following methods are proposed. First, calculate the volume of water associated with fluvial discharge over the ebb period. Second, calculate the channel cross-sectional area from the marsh area. Third, using the Williams et al (2002) graph of tidal prism versus cross-sectional area:

a) locate the initial estimated cross-sectional area,

b) estimate the associated tidal prism,



Notes: Predicted width regressions are pro-rated based upon the depth and marsh area hydraulic geometry regressions of South SF bay and SF bay and tide range at given location. % greater tide refers to % greater than SF bay tides and is used to determine predicted range.
Source: Regression equations modified from Williams et al. (2002).

figure **2**

PSNERP

Channel area hydraulic geometry

PWA Ref #: 2036.00

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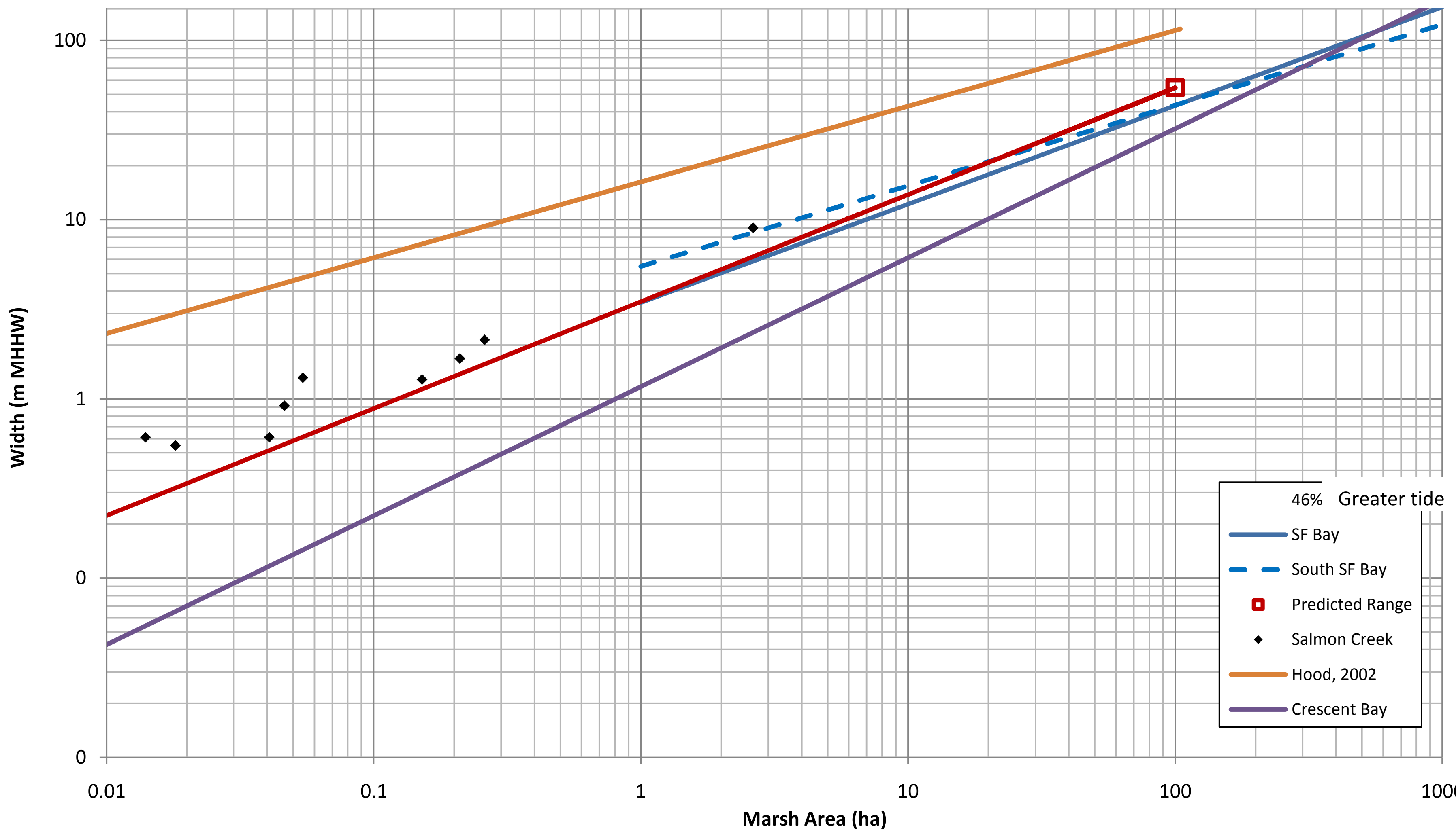

Notes: Predicted width regressions are pro-rated based upon the depth and marsh area hydraulic geometry regressions of South SF bay and SF bay and tide range at predicted location.% greater tide refers to % greater than SF bay tides and is used to determine predicted range.
Source: Regression equations modified from Williams et al. (2002).

figure **3**

PSNERP

Channel Width hydraulic geometry

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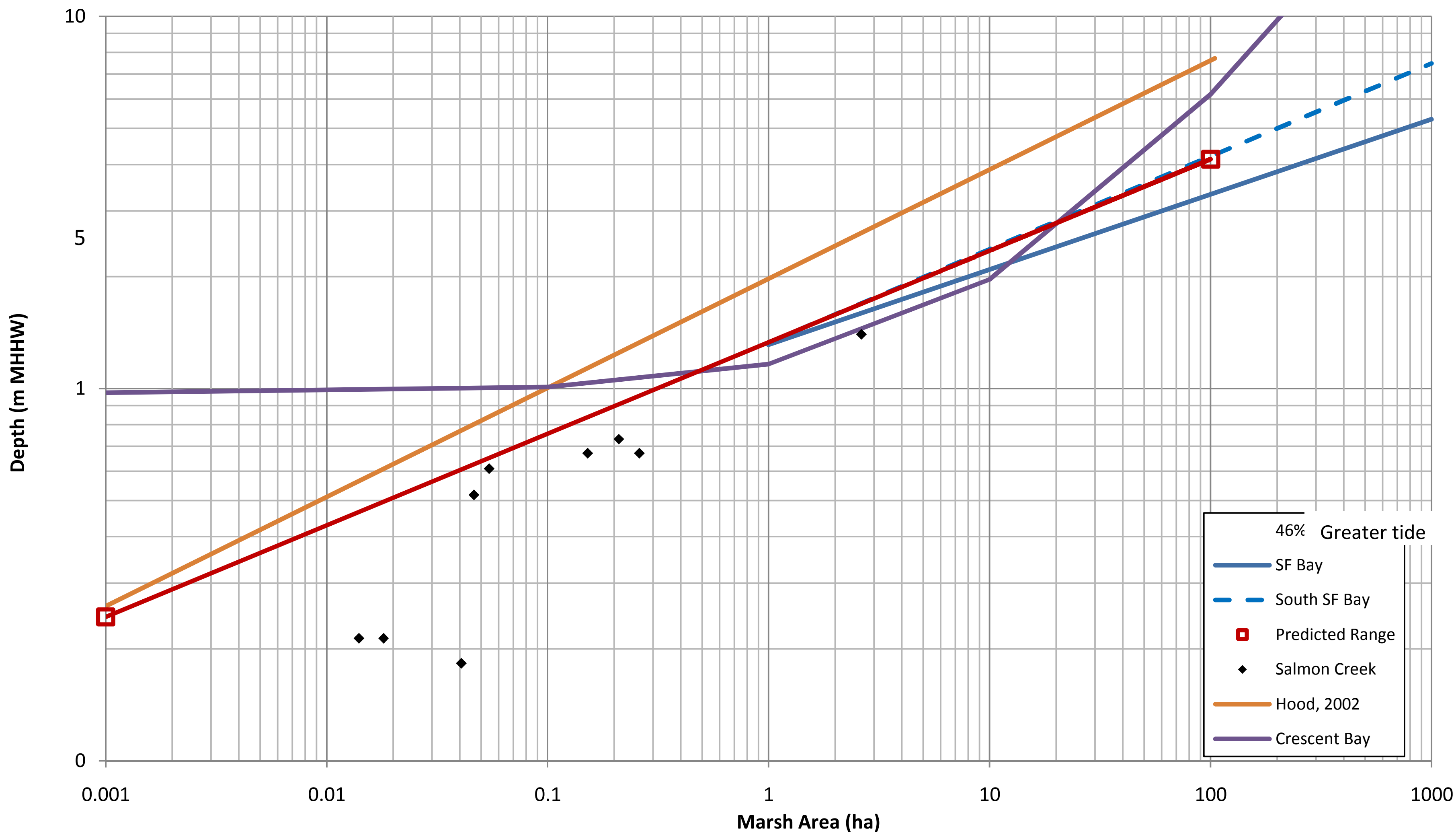

Notes: % greater tide refers to % greater than SF bay tides and is used to determine predicted range.
Source: Regression equations modified from Williams et al. (2002).

figure 4
PSNERP

Channel depth hydraulic geometry

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PWA

c) add the fluvial volume to the tidal prism to get the increased effective tidal prism c,

d) and e) locate the corresponding adjusted cross-sectional area.

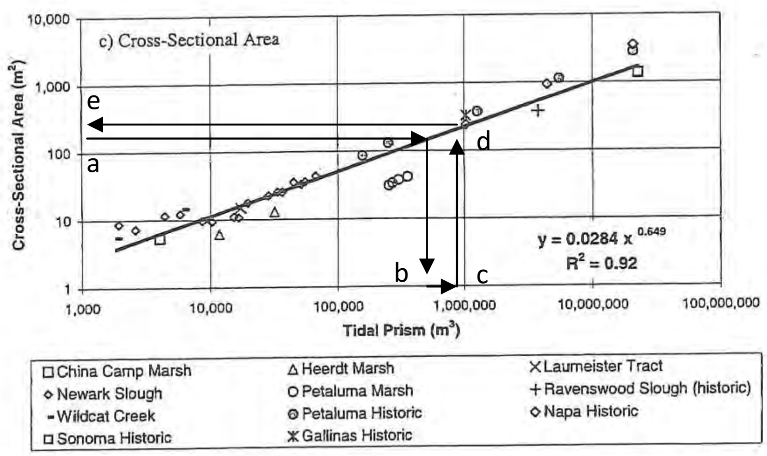


Figure 5: Tidal Prism vs. cross-section area (Williams et al, 2002); with example for adding minor drainage to increase effective tidal prism

The adjusted cross-sectional area can be accomplished by increasing the channel width, and assuming the depth does not increase.

The fluvial flow rate used in the calculation is selected by the designer. For summer conditions, this would be base flow. Otherwise, the estimated channel-forming flow, perhaps in the range of annual to 5 –year recurrence, can be used.

This procedure for increasing channel section for stream discharge can also be used to estimate the size of larger channels to convey the initial (post restoration) tidal prism of subsided sites. Typically, the future equilibrium tidal prism and channel dimensions are adequate and practical for restoration. However, the additional tidal prism for subsided sites can be estimated approximately as the site area times the difference between site grade and the MHHW elevation. This additional tidal prism can be added to get the expanded tidal prism “c”, and the expanded channel dimensions estimated.

It should be noted that these are approximate dimensions intended to accommodate site evolution toward equilibrium, rather than equilibrium geometries.

Channel Order and Drainage Area

Channel order is a means of comparing the number of channels of different size within and between drainage networks. The hierarchy of channel segments starts with the smallest channels and increases in order when two channels of the same order connect. For example, when two first order channels join, the downstream segment is classed as second order. When two second order channels join, the downstream segment becomes third order. A first order channel joining a third order channel does not change the order of the downstream segment. The system is defined by the highest order of channel; for instance a tidal drainage network may be described as ‘third order’.

Horton (1945) found that channel order is related to a number of metrics describing the channel network:

- number of channel segments;
- segment length;
- drainage area.

Generally these relations are semi-logarithmic as seen Figure 6 that plots drainage area with channel order for marshes in Snow Creek and Salmon Creek (Barnard, pers comm.).

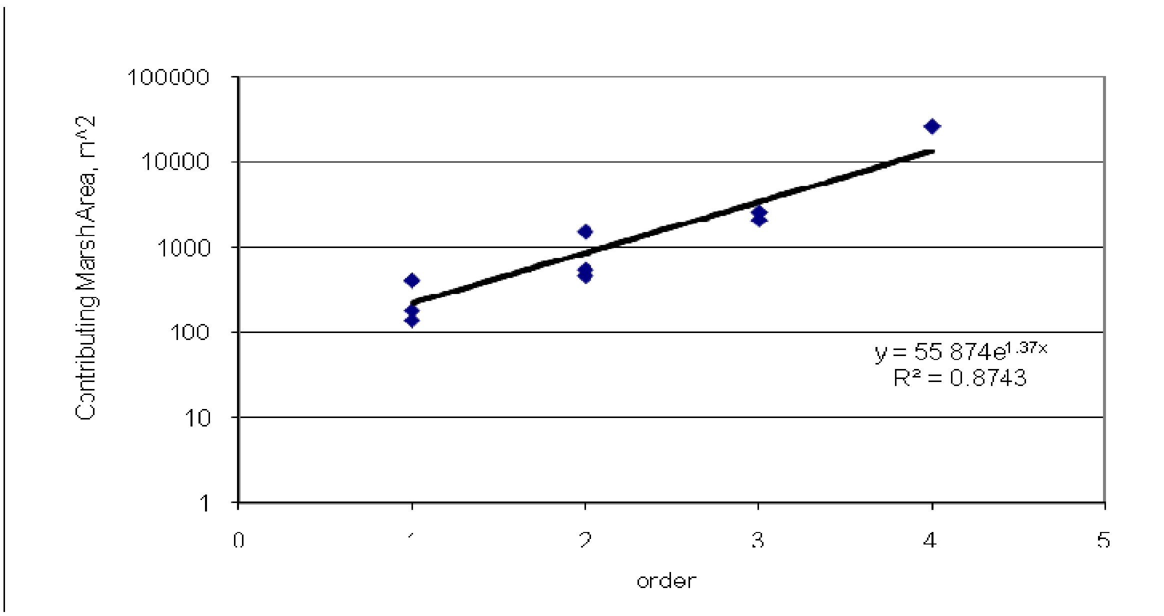


Figure 6: Regression of tidal channel order and marsh drainage area. Source: Salmon Creek data and analysis by Bob Barnard, WDFW.

General guidance can be provided from observations of natural channel systems of similar area; use should be made of local reference sites where possible. The following guidance is based upon marsh channel data and experience in constructing marsh channels:

a) Use the historical channel patterns, if it exists;
b) For drainage areas of 10 to 50 acres, a third or fourth order channel system should be adequate;
c) Second, third and fourth order channels should be excavated to equilibrium depth;

d) First order channels may not be practical to cut, especially if the site is subsided and expected to accrete sediment;
e) If the site is being graded, the marsh slope should be graded down below MHHW and sloped towards the channels to allow drainage and encourage channel network development.

3. Intertidal - Fluvial (channel modification, dike removal)

Given the paucity of data available, design guidelines for tidally-influenced fluvial channels is not practical within the time and budget constraints of this project. Hence, we recommend use of historic maps of the site, dimensions of remnant channels, and measurements at nearby reference sites if available.

4. Tidal Inlet (coarse sediment) (Channel Modification, Dike Removal, Hydraulic Connection)

Hydraulic geometry relationships between tidal prism and the cross-sectional area of the inlet channel are perhaps the most common criteria applied to predict the stability of tidal inlets (Battalio, et al, 2006). These are empirical relationships based on surveys of stable inlets and take the form:

$$A_e = C\,\Sigma^n$$

where A_e is the minimum cross-sectional area, Σ is the tidal prism, and C and n are empirically derived parameters. Jarrett (1976) examined earlier work by O'Brien (1931) for Pacific Coast inlets, and established relationships for sites along the Gulf, Pacific and Atlantic coasts. His results were further divided among inlets with and without jetties. Although the expressions established by Jarrett are considered the best available predictors for equilibrium cross-sectional areas, small inlets (small inlets can be defined as those with thalwegs near or above MLLW) tend to exhibit equilibrium area much larger than predicted by these tidal prism relationships (Hughes, 2002).

The cross-sectional area of the inlet channel, A_e, is related to the effective tidal prism by:

$$A_e = 0.65 k_a (C_I P)^{8/9}$$

where

$$C_I = \frac{W^{1/8}}{[g(S_S - 1)]^{1/2} d_e^{3/8} T}$$

W is the inlet width at mean tide level (meters), T is the tidal period (typically use semi-diurnal 12.4 hours, which is 44,640 seconds), d_e is the median grain size (in meters), g gravitational acceleration (9.81 m/sec^2), k_a is an empirical coefficient (with a best-fit value of 1.34), and P is the effective tidal prism (cubic meters). S_s is the specific gravity of the sediment (ρ_s/ρ_w) which is often taken to be around 2.6 for quartz and other rock.

The highest point in the channel thalweg typically occurs as the channel crosses the flood shoal and controls the low water elevation in the marsh. Relatively large wave events can induce a control at the receiving water side (eg. the ebb shoal or spit in Puget Sound) as well. Due to the complexities of ebb and flood shoal geometries and the difficulty in field data collection, the narrowest, deepest section of the inlets (aka "throat") are typically used as the reference section. Figure 7 shows the general relationships measured at the Crissy Field Lagoon "throat" in San Francisco Bay. The key parameter is the lagoon low water, which controls the effective tidal prism of the lagoon. The lagoon low water is variable, as it results from the sill elevation formed bay wave transport of littoral sediments against the scour of ebb tides. Inlet morphology also has an effect, which is greatly influenced by littoral drift parameters including structural controls such as reefs and jetties.

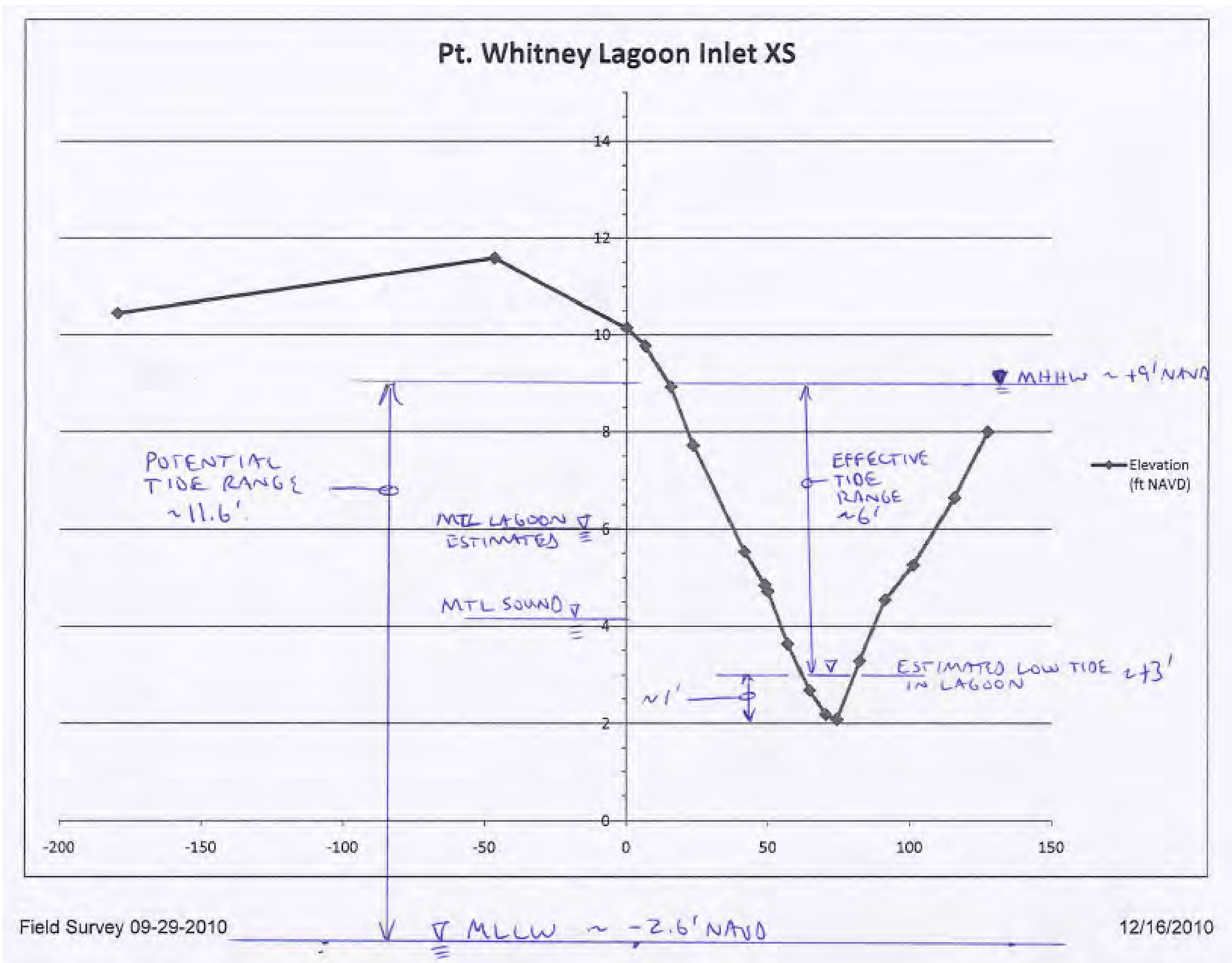


Figure 7. Effective tide range and inlet cross-section.

Considerable scatter in the data suggest that not all of the relevant processes are included in these simple relationships. Therefore, they should only be used as a first approximation and interpreted as representative of long-term average conditions. Significant variations in inlet cross-section can occur over the spring-neap tide cycle, during storms when wave attack is more intense, or following large flood events (DeTemple, 1999). This is especially true for small dynamic systems. A process-based tidal prism relationship developed by Hughes (2002) shows better agreement between small and large tidal inlets, and more promise for application to Puget Sound lagoons (Figure 8).

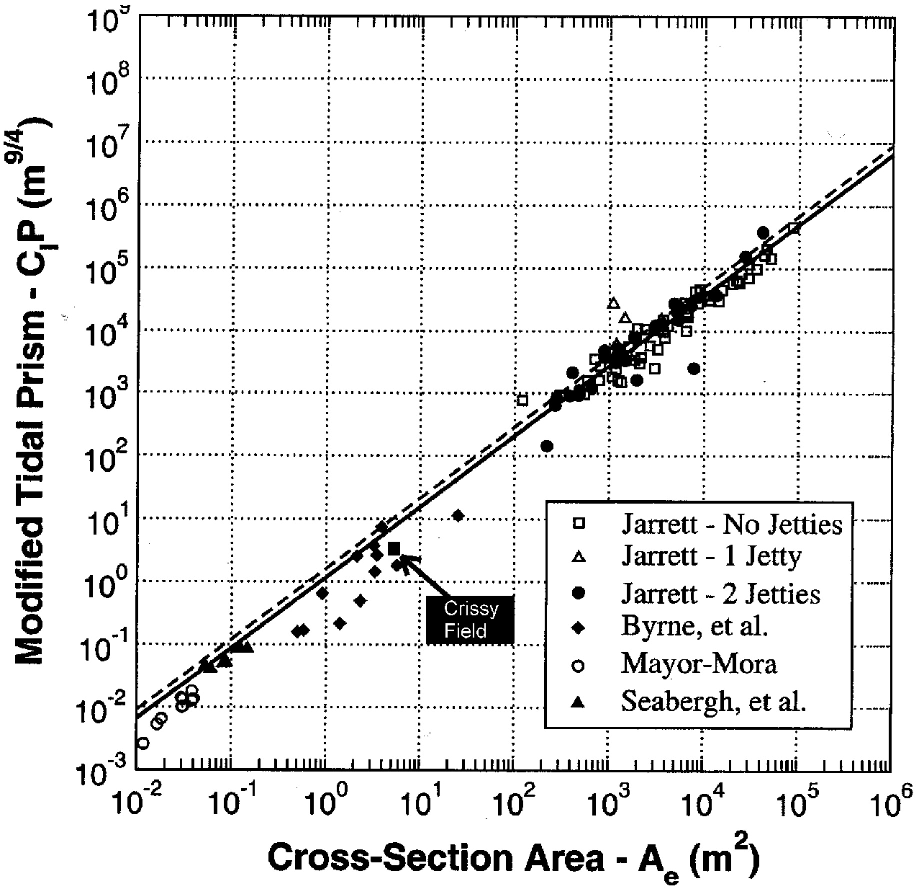


Figure 8. Hughes (2002) tidal prism and inlet cross-section relationship.

It should be noted that the sediments in Puget Sound are typically much coarser than those used to develop these empirical relationships. Coarser sediments tend to have greater porosity and hence can allow greater discharge through the berm, indicating smaller inlets may be likely. Coarser sediments also tend to form higher, steeper beach berms under wave action, which tend to resist deep thalwegs and hence shallower inlets can be expected. Finally, coarse sediments do not move as quickly for a given wave climate, and hence Puget Sound inlets will likely be more stable. In summary, we expect Puget Sound inlets to be shallower and more stable, with greater outflow through the littoral barrier.

Applications of the O'Brien and Johnson methods can be improved with accurate estimates of wave and tidal power. Figure 9 shows the corrected data in the form previously reported by Williams & Cuffe (1994) for California lagoons. We believe the version shown below can be used generally with contemporary wave power values (prior published versions had wave power values about 200 times too high (PWA, 1999)).

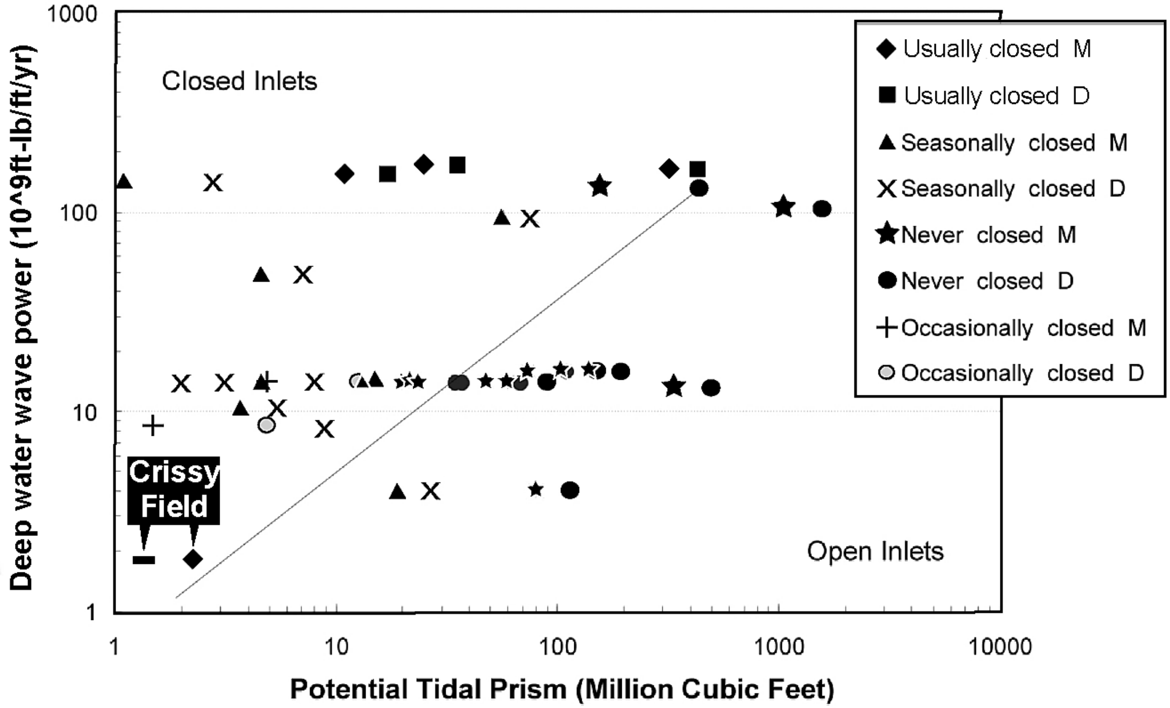


Figure 9. Power-based index of inlet closure potential with corrected annualized wave power. “M”=Mean tidal prism and “D”= diurnal tidal prism.

Ideally wave power would be calculated from the wave climate. Since much of the Sound is relatively deep with short fetches, relatively short wave periods can be expected. Exceptions are the Straits of and Juan De Fuca and Georgia where swell (Juan De Fuca)and large wind waves can occur (Strait of Georgia, Coulton et al, 2001): For these locations, more detailed calculations are recommended. For the Strait of Juan De Fuca, wave data are available. In most sites, wind wave hindcast using fetch limited parametric equations and wind climate is sufficient to define the deepwater wave climate. Simplified wave refraction using Snell’s law and diffraction using the methods of Goda (1985) are adequate. These data exist for some sub basins but otherwise may be beyond the scope of the PSNERP conceptual designs.

Wave power can then be used to estimate the minimum tidal prism needed to maintain an open inlet, using Figure 9. Note that Figure 9 is based on the potential tidal prism, which is typically the lagoon size multiplied by the potential tide range. Dividing by the tide range can then give an estimate of minimum lagoon size required for an open inlet. However, the actual tidal prism, often called the effective tidal prism, will be reduced by the littoral ridge built by waves. The effective tidal prism and tide range are “implicit” within inlet equations and can be the most challenging parameters to estimate. For open lagoons, a first estimate can be made by multiplying the lagoon area times the depth below MHHW (assuming the site bed is above MLLW). Note that the littoral sill often prevents full drainage, so using the existing grade as an estimate of the low tide may lead to an over-estimate of effective tidal prism and inlet area. For marshes, a first approximation can be based on the methods in Section 2 of this document. Also, like marshes, fluvial discharge tributary to the site can increase inlet size above that based on tidal prism alone. Once the effective tidal prism is estimated, it will be used to estimate the required inlet cross section geometry using Figure 8 and selected aspect ratios (width to depth).

The best available relationship for small tidal inlets in littoral systems is Hughes (2002; Figure 8). A review of this equation indicates that it is very sensitive to grain size, with larger grain sizes resulting in smaller predicted inlet cross sections. We recommend using a default of 1 mm which will help keep the equation within the range of data sources and bias the area calculation to the high side: In general, over-excavation of the inlet results in less risk of subsequent closure. Further research is needed to inform use for coarse sediment shores.

It should be noted that over-excavation will induce a perturbation that can reduce sediment supply to adjacent shores. Excavated sediment compatible with the littoral sediment should be placed down drift to mitigate the subsequent interruption of longshore transport during inlet evolution. For new inlets, placement of littoral sediments should be considered to mitigate the sediment deficit induced by flood and ebb shoal formation. The effect can extend updrift as well but to a lesser extent.

Once area is calculated, width and depth are selected. Ideally, an estimate of one of these parameters will be available. For example, the inlet width from an historic map can be used, and then the depth can calculated based on an assumed shape (see below).

The equation for a channel with a parabolic shape is as follows:

$$W=1.5A/d$$

Where W = width, A = area and d = depth.

Deepening of an existing inlet due to increased tidal prism can be estimated by prorating the existing depth using the square root of the estimated increase in cross-sectional area. Assuming that the width-to-depth ratio of the inlet throat remains the same, changes in depth of the throat can be estimated from:

$$\frac{d_{new}}{d_{old}} = \sqrt{\frac{A_{e\,new}}{A_{e\,old}}}$$

where d is the maximum depth at the throat, measured below $MTL_{lagoon,}$, and Ae is the area defined above for the Hughes (2002) relationship.

The depth of the inlet channel below Mean Tide Level (MTL) has been approximated using the relationship between depth and inlet area devised by Vincent and Corson (1981):

$$D_m = 0.5579(A_c)^{0.38}$$

where D_m is the depth at the throat of the inlet below MTL (ft) and A_c is the inlet below MTL (ft^2). This relationship was developed from data in Chesapeake Bay (Virginia, USA) which has a much smaller tide range, a semi-diurnal tide, and much finer sediment. Hence, this relationship should be used as an indicator to inform design judgment. For smaller systems, this equation may under-predict the depth due to its derivation with data from areas with smaller tide ranges. If this equation is used and predicts depths significantly above MLLW, over-excavation is recommended.

Reference site data can be used instead of or in addition to the methods proposed here.

5. Beach (coarse sediment) (bulkhead removal, groin removal)

The morphology of coarse sediment beaches includes a steep foreshore (swash zone) leading up to a flat terrace or berm (Bauer, 1974; Lorang, 2002). The profile morphology and terms are shown by the example in Figure 9 (Birch Bay, Whatcom County, Bauer, 1975). The swash zone slope is affected by sediment size and wave climate. For most Puget Sound locations, the swash zone has a typical slope around 7:1 with a range between 5:1 and 10:1 (horizontal: vertical). Steeper slopes can be expected for coarser and more uniform sized sediments, and higher wave exposure. The berm elevation is typically considered the result of wave runup that builds the berm to a level just below the annual maximum total water level (total water level is defined as the Puget Sound water level plus wave runup).

Figure 10 shows a conceptual profile of coarse beach dynamics (Bauer, 1975). Note that Figure 10 shows a berm configured to provide protection to inland development and includes extra volume as a "storm buffer," with the berm crest elevation about 6.5' above MHHW. Given PSNERP's focus on restoration, berm heights should typically not be over-built for protective purposes. Figures 11 and 12 provide an example of a reference site in Whatcom County (PWA, 2002). The berm crest is around 11.3' to 12.8' NAVD (converted from NGVD by adding 3.8'), and about 4 feet above MHHW. Note the wood above the berm indicating that the total water level exceeds the berm crest in natural conditions. Therefore, we recommend under-building the berm slightly to allow shaping by wave action. Slight under-building avoids the potential adverse effects of unnatural morphology and while limiting sediment demand to fill the "void" resulting removal of fill or armoring.

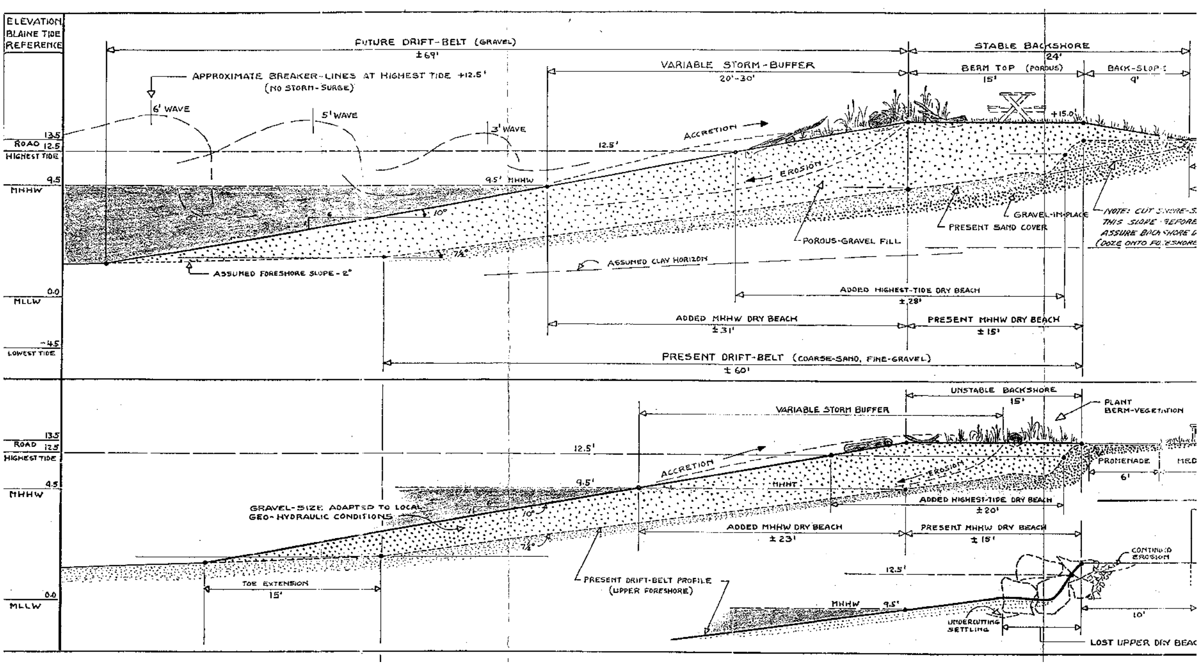
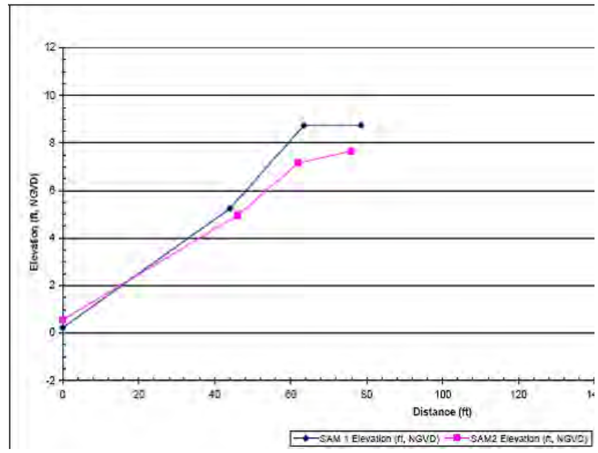


Figure 10. Description of coarse sediment beach profile morphology, for a protective berm (Bauer, 1975).



Figures 11 and 12. Semi-Ah-Moo Beach. Photograph of beach swash zone and berm (left); Elevation cross sections of swash zone slope and berm (right). Source, PWA, 1975.

For PSNERP conceptual designs, the geometry of nearby reference sites can be used to develop the restored profile and estimate quantities. Alternatively, some basic parameters should be sufficient. A slope of around 5:1 to 10:1 with a typical of 7:1 is recommended. This should be checked and adjusted based on consideration of local geometry, reference sites, size of sediment and wave exposure. The berm elevation can be estimated as the height of the annual wave runup (R) on the profile using the following equation:

$$R_{2\%} = \text{Static Setup} + \text{Runup}$$

$$= 0.2\, H_0 \qquad + 0.6r\, (m/(H_0/L_0)^{1/2})H_0$$

The above equation is based on the surf similarity parameter / Iriabarren number; m is the beach slope, r is an empirical coefficient, H_0 is the significant deep water wave height and L_0 is the deep water wave length . The wave values used should be on the order of an annual to 5 year return period. (Note that the term "2%" for the runup does not refer to annual frequency, but rather the exceedance within an event, e.g. the significant exceedance is typically considered 33% and the rms 50%).

It is recommended that a composite slope of about 10:1 (m=0.1) is used to account for larger waves breaking offshore of the swash formed foreshore. Also, the result should be adjusted downward to account for the permeability of the coarse sediment and a factor of about r=0.8 is recommended.

Wave runup on natural beaches does not typically exceed about three times the wave height. For steeper waves on porous (gravel, cobble) sediments, the runup is reduced and a maximum of about two times the wave height can be expected. We therefore recommend that a reasonable range for runup in sheltered waters (not exposed to ocean swell) is between 0.5 and 2 times the wave height, and on coarse sediment shores (gravels and cobble) will not typically exceed 1 times the wave height.

Since the berm is formed by the total water level with an approximate annual exceedance, the more extreme wave runup value (1 to 5 year recurrence) should be added to a typical high tide, on the order of MHHW or MHHW with a surge / setup added: A setup due to meteorological effects can be on the order of 1 foot. Alternatively, an annual high water level can be combined with a smaller, nominal wave height likely to occur simultaneously with the high tide.

For cases where much larger waves break far offshore of the berm, wave setup for the larger offshore waves should be added. A static wave set up can be approximately estimated as 0.2 times incident wave height (FEMA, 2005). The groupiness and randomness of the waves also results in longer-period dynamics often called dynamic setup. Accounting for dynamic setup and combining with static setup and runup can be complex. However, for the conditions associated with PSNERP it is recommended that a total wave setup of about 0.3 times the deepwater wave height is a reasonable estimate of total setup due to larger waves breaking offshore.

We recommend a minimum beach berm elevation of 1.5 ft above MHHW.

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Appendix A: NAVD Conversions from Pacific Survey and Engineering, 2010

Bob Battalio

From: Adam Morrow [AMorrow@psesurvey.com]
Sent: Tuesday, November 30, 2010 9:35 AM
To: Margaret Clancy
Cc: Bob Battalio
Subject: PSNERP Datum Conversions
Attachments: PSNERP_DATUM_CONVERSIONS.pdf

Margaret,

In an effort to wrap up our work on this project to date and provide you with an item that had been discussed in some detail over the past few months, we have attached a spreadsheet that details our Tidal-NAVD 88 vertical datum conversions that can be used for pre-selected sites. The spreadsheet includes conversions for areas that were noted as not available in Bob Battalio's previously emailed spreadsheet.

With a few exceptions, we were able to find consistent datum conversions for tidal regions throughout Puget Sound. Where we could not, we listed the applicable VDATUM conversion related to the reference tidal gauge. For your use, we also included a column that indicates our level of confidence for each conversion, based on the availability of published benchmark information and/or conflicts between published data and VDATUM results.

We hope that this proves useful for the design team in the continued efforts to provide 10% design documents for the project. We are ready and willing to respond to questions about this information as needed to help you complete your Phase 2 work.

I look forward to hearing from you in the near future about opportunities to continue to provide services on this project. From our research work to date, I suspect that we now have a good database of information from which we can provide cost estimates for necessary survey and base mapping work at each site if that is deemed necessary.

Thanks.

-Adam

Adam Morrow, PLS
Pacific Surveying and Engineering
1812 Cornwall Avenue
Bellingham, WA 98225
(360) 671-7387
(360) 671-4685 (fax)

	NOAA TIDAL REGION	POINTS IN COMMON (NGS)	Station Lat.	Station Long.	SEPARATION NAVD-TIDAL* US FEET	SEPARATION VDATUM** RESULT	TIDAL EPOCH	CONFIDENCE LEVEL***
Cherry Point	9449424	1	48 51.8 N	122 45.5 W	**0.96**	0.96	83-01	2
Friday Harbor	9449880	3 (WSDOT)	48 32.8 N	123 0.6 W	**0.53**	0.38	83-01	3
LaConner, SS	9448558	1	48 23.5 N	122 29.8 W	**1.51**	1.51	83-01	4
Crescent Bay	9443826	1	48 9.7 N	123 43.5 W	**0.42**	0.42	83-01	4
Pt Townsend	9444900	2	48 6.7' N	122 45.5' W	**1.11**	1.12	83-01	4
Seabeck, HC	9445296	0	47 38.5' N	122 49.7' W		**2.62**	83-01	1
Yoman Pt, AI	9446705	0	47 10.8' N	122 40.5' W		**3.78**	83-01	1
Barron Pt	9446742	0	47 9.4' N	123 0.5' W		**4.08**	83-01	1
Budd Inlet	9446807	0	47 5.9' N	122 53.7' W		**4.05**	83-01	1

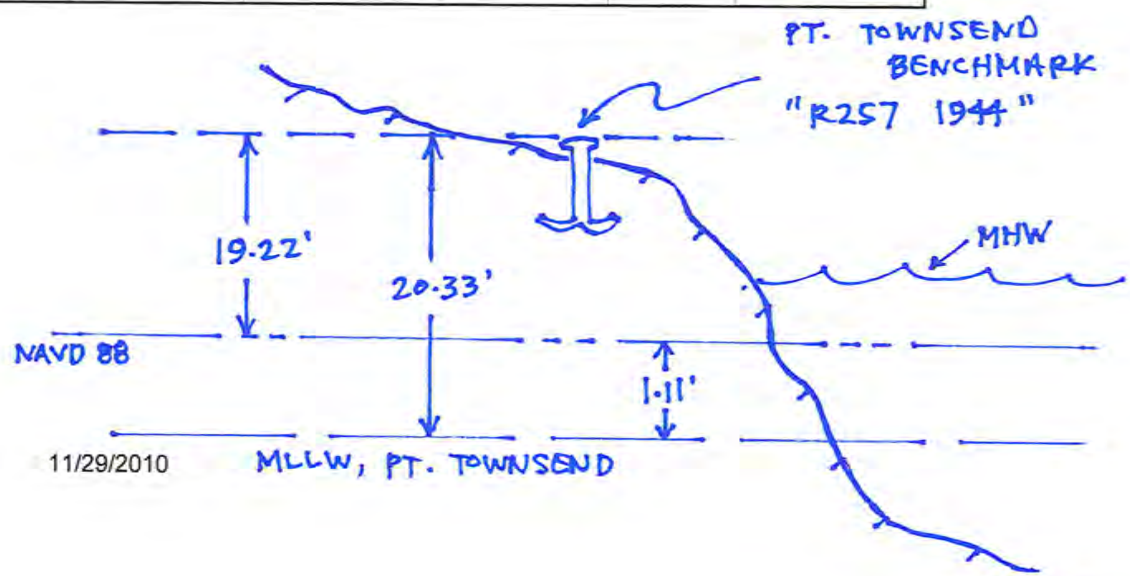
* Conversions determined from published elevations on benchmarks in common between NOAA, WSDOT and NGS.

** Conversions determined using VDATUM, a software tool developed jointly by NOAA's NGS, OCS and CO-OPS.

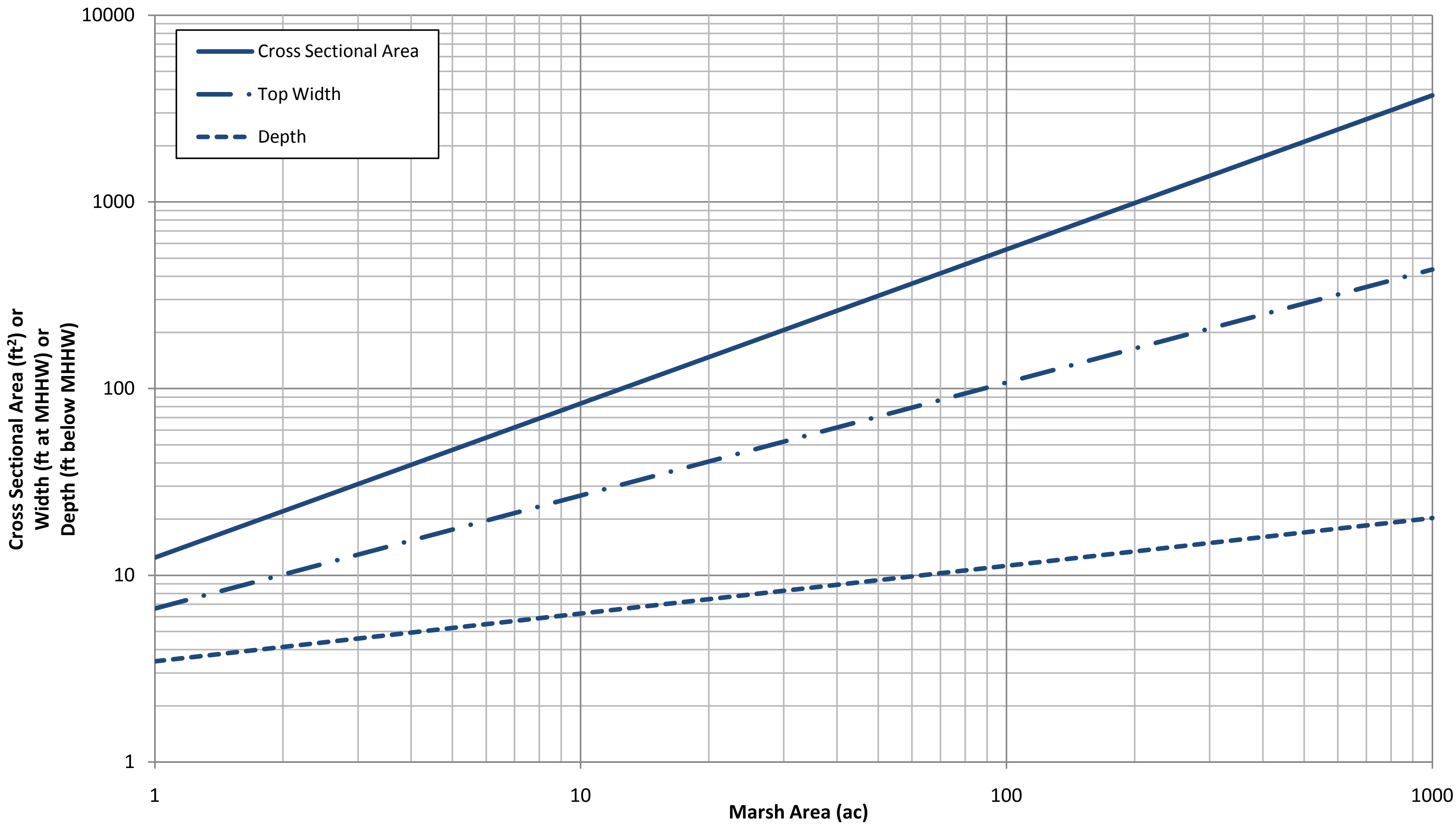
*** Level of confidence in conversion values based on # of sources found and agreement between sources. 4=highest, 1=lowest.

HOW TO APPLY CONVERSION:

Throughout the region, the 0 elevation plane of NAVD88 is above the 0 elevation plane of the various tidal datums. As a result, the NAVD88 elevation at any given point should reflect a smaller value than the local tidal datum elevation at the same point. To convert from tidal to NAVD88, subtract the separation value noted above in any given region. To convert from NAVD88 to local tidal datum, add the separation value. See sketch below:



Appendix B: Graphs of Tidal Wetland Channel Dimensions vs. Marsh Area



Tide Gage Station: Cherry Point # 9449424
For 10% PSNERP design use only.

Source: Williams et al. (2002). Regression equations adjusted based on percent increase in diurnal tide range relative to San Francisco Bay.

figure **1**

Puget Sound Nearshore Ecosystem Restoration Project

Hydraulic Geometry for Cherry Point

PWA Ref #: 2036.00

PWA

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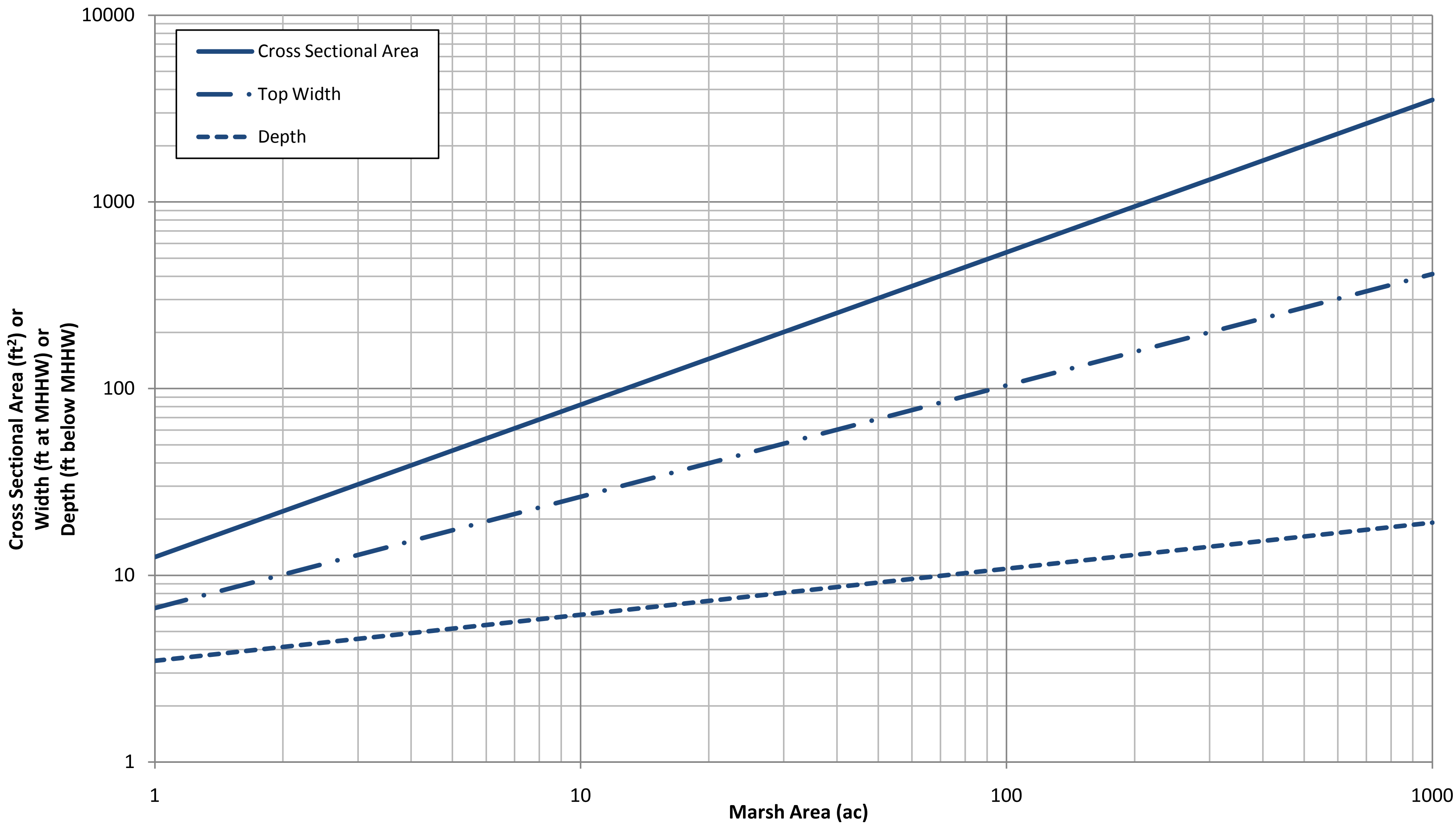

Tide Gage Station: Bellingham # 9449211
For 10% PSNERP design use only.

Source: Williams et al. (2002). Regression equations adjusted based on percent increase in diurnal tide range relative to San Francisco Bay.

figure **2**

Puget Sound Nearshore Ecosystem Restoration Project

Hydraulic Geometry for Bellingham

PWA Ref #: 2036.00

PWA

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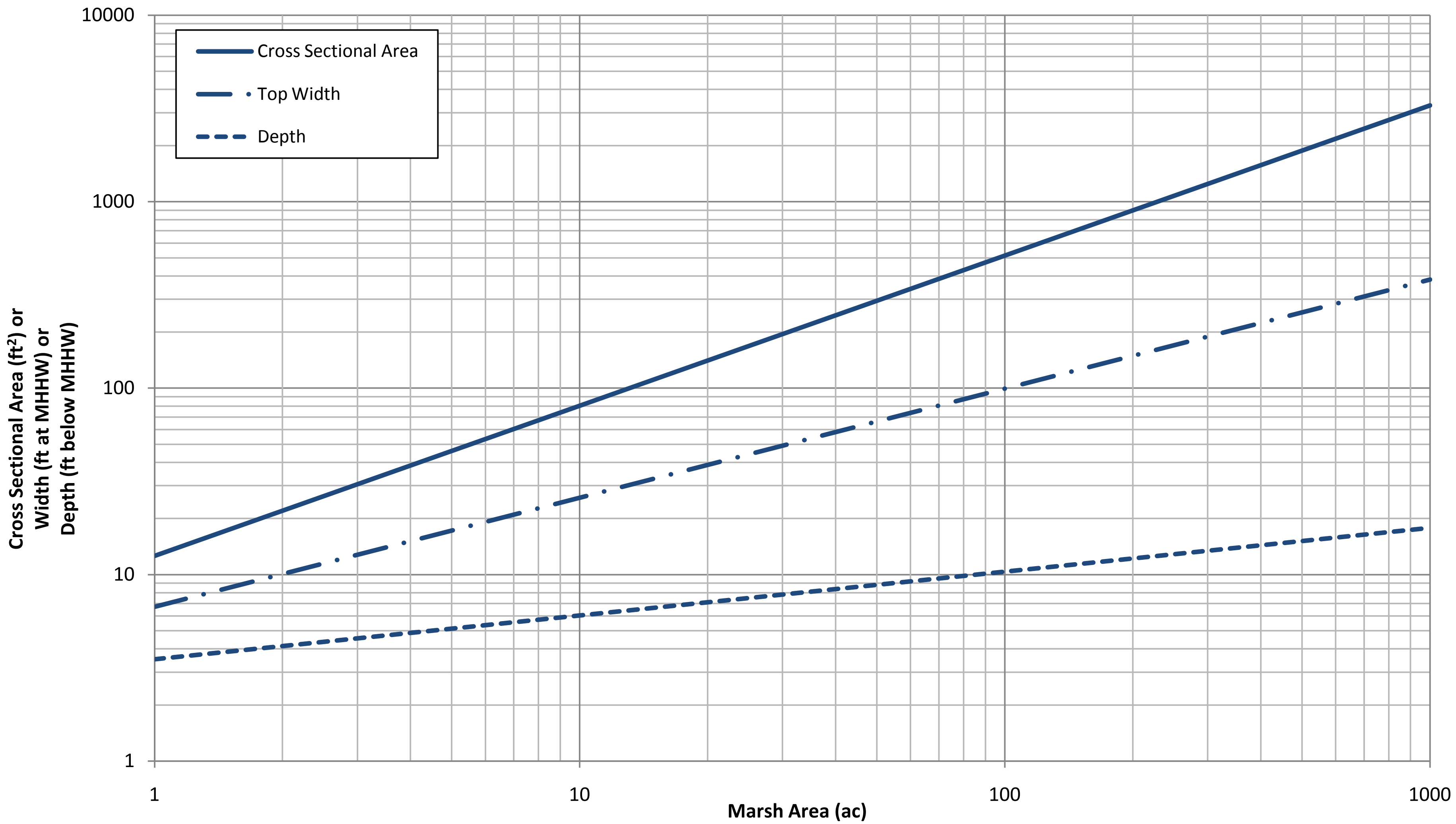

Tide Gage Station: Friday Harbor # 9449880
For 10% PSNERP design use only.

Source: Williams et al. (2002). Regression equations adjusted based on percent increase in diurnal tide range relative to San Francisco Bay.

figure **3**

Puget Sound Nearshore Ecosystem Restoration Project

Hydraulic Geometry for Friday Harbor

PWA Ref #: 2036.00

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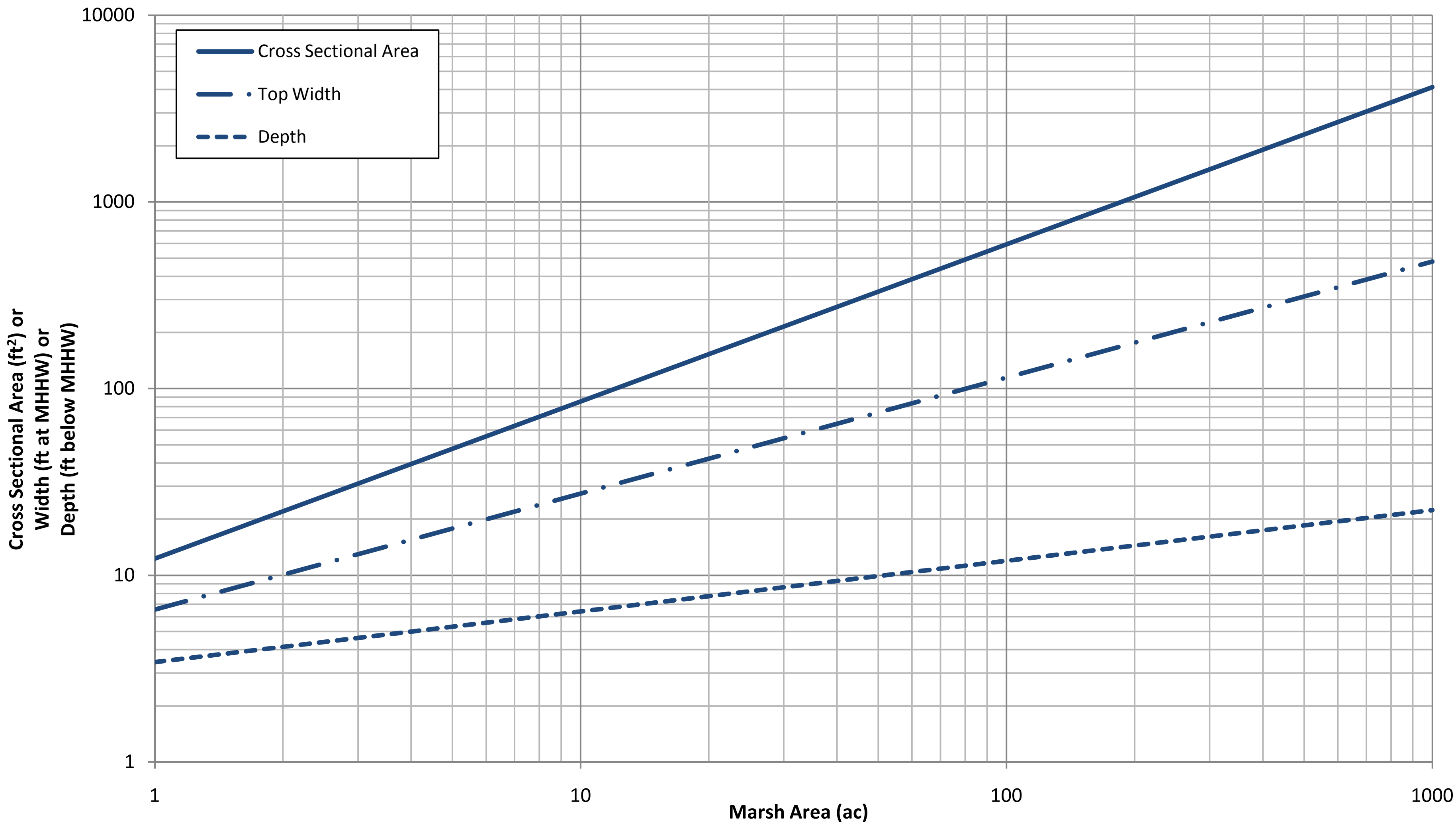

Tide Gage Station: La Conner, Swinomish Slough # 9448558
For 10% PSNERP design use only.

Source: Williams et al. (2002). Regression equations adjusted based on percent increase in diurnal tide range relative to San Francisco Bay.

figure **4**

Puget Sound Nearshore Ecosystem Restoration Project

Hydraulic Geometry for La Conner, Swinomish Slough

PWA Ref #: 2036.00

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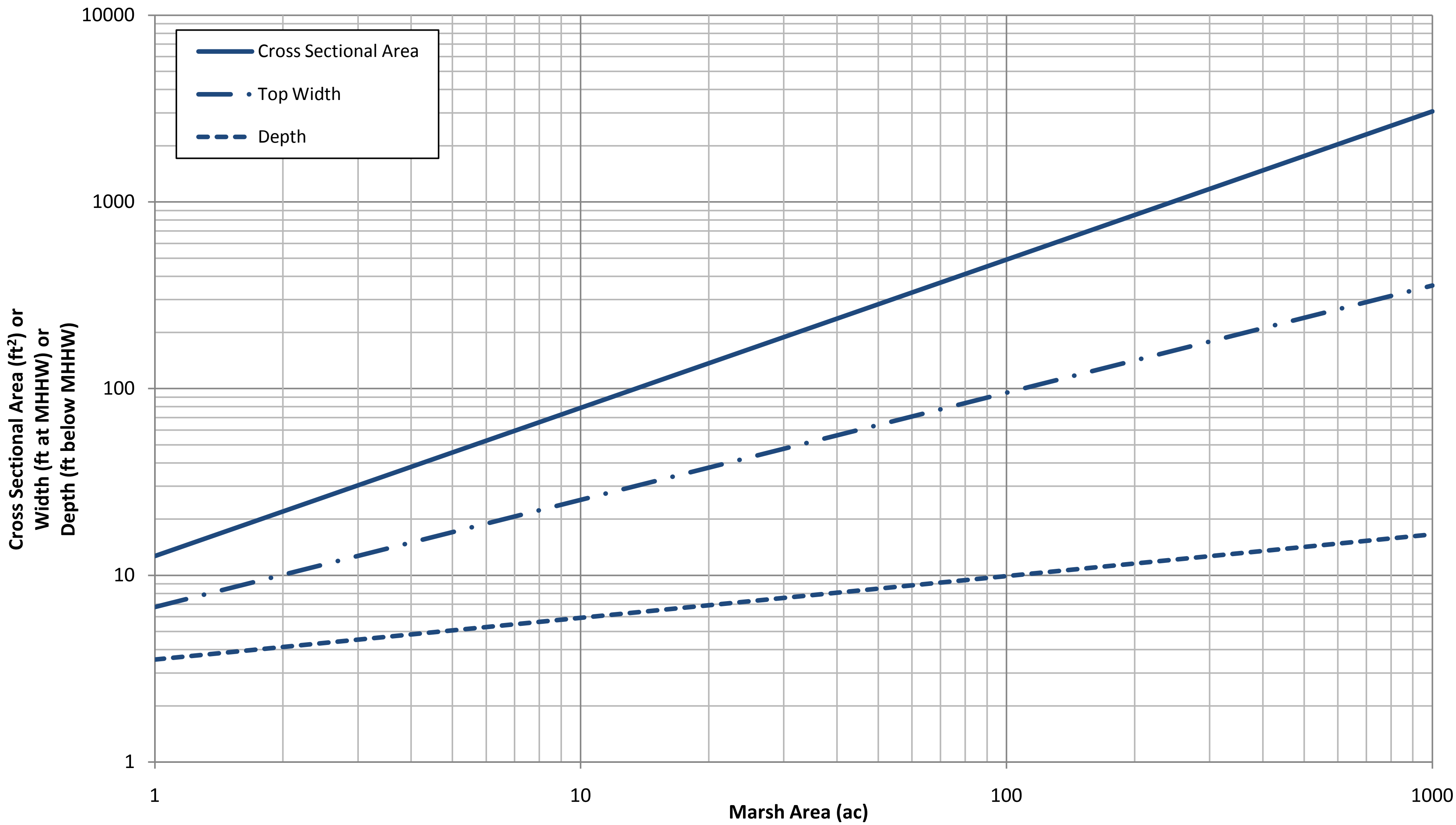

Tide Gage Station: Crescent Bay # 9443826
For 10% PSNERP design use only.

Source: Williams et al. (2002). Regression equations adjusted based on percent increase in diurnal tide range relative to San Francisco Bay.

figure **5**

Puget Sound Nearshore Ecosystem Restoration Project

Hydraulic Geometry for Crescent Bay

PWA Ref #: 2036.00

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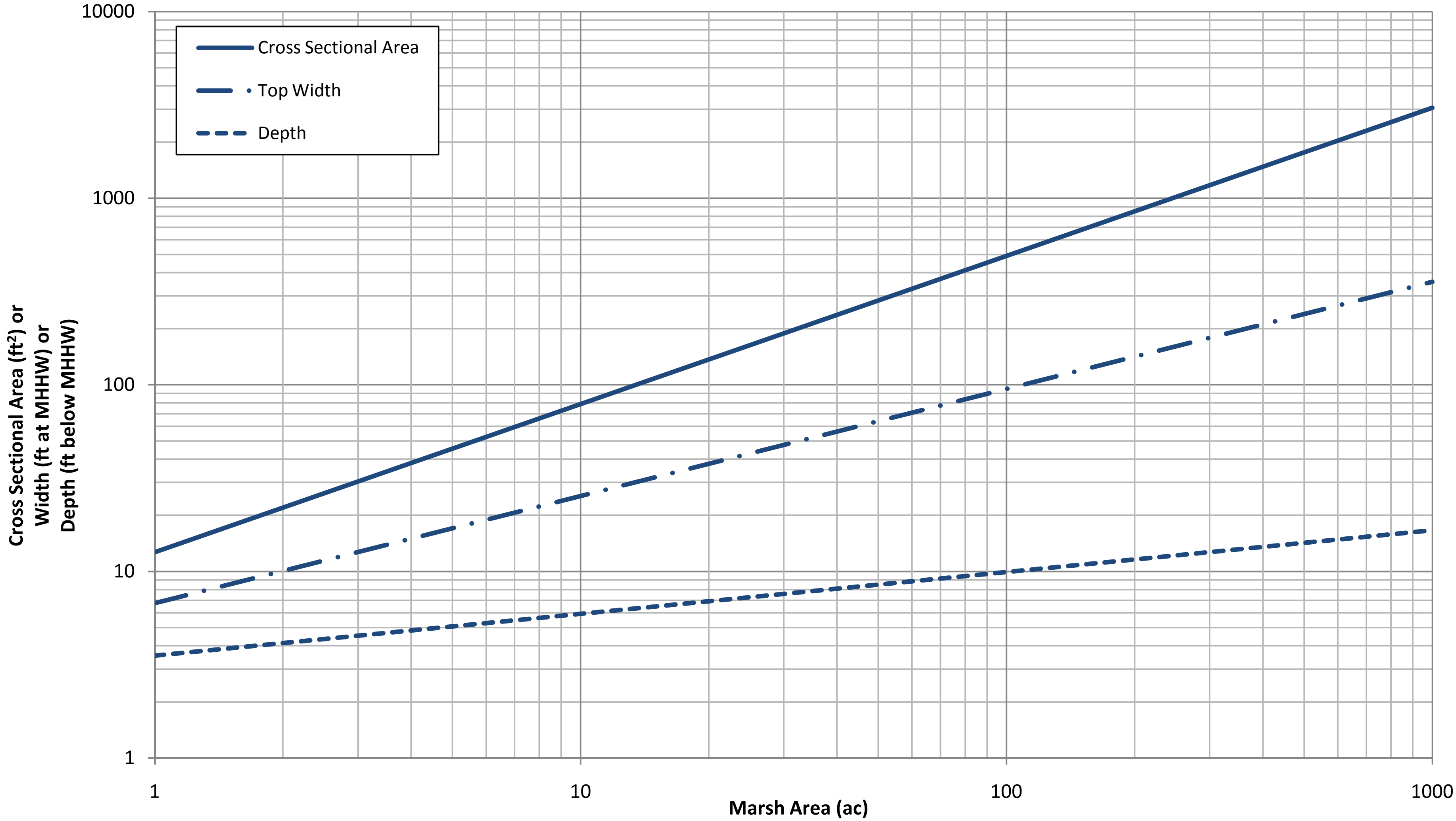

Tide Gage Station: Port Angeles, WA # 9444090
For 10% PSNERP design use only.

Source: Williams et al. (2002). Regression equations adjusted based on percent increase in diurnal tide range relative to San Francisco Bay.

figure **6**

Puget Sound Nearshore Ecosystem Restoration Project

Hydraulic Geometry for Port Angeles, WA

PWA Ref #: 2036.00

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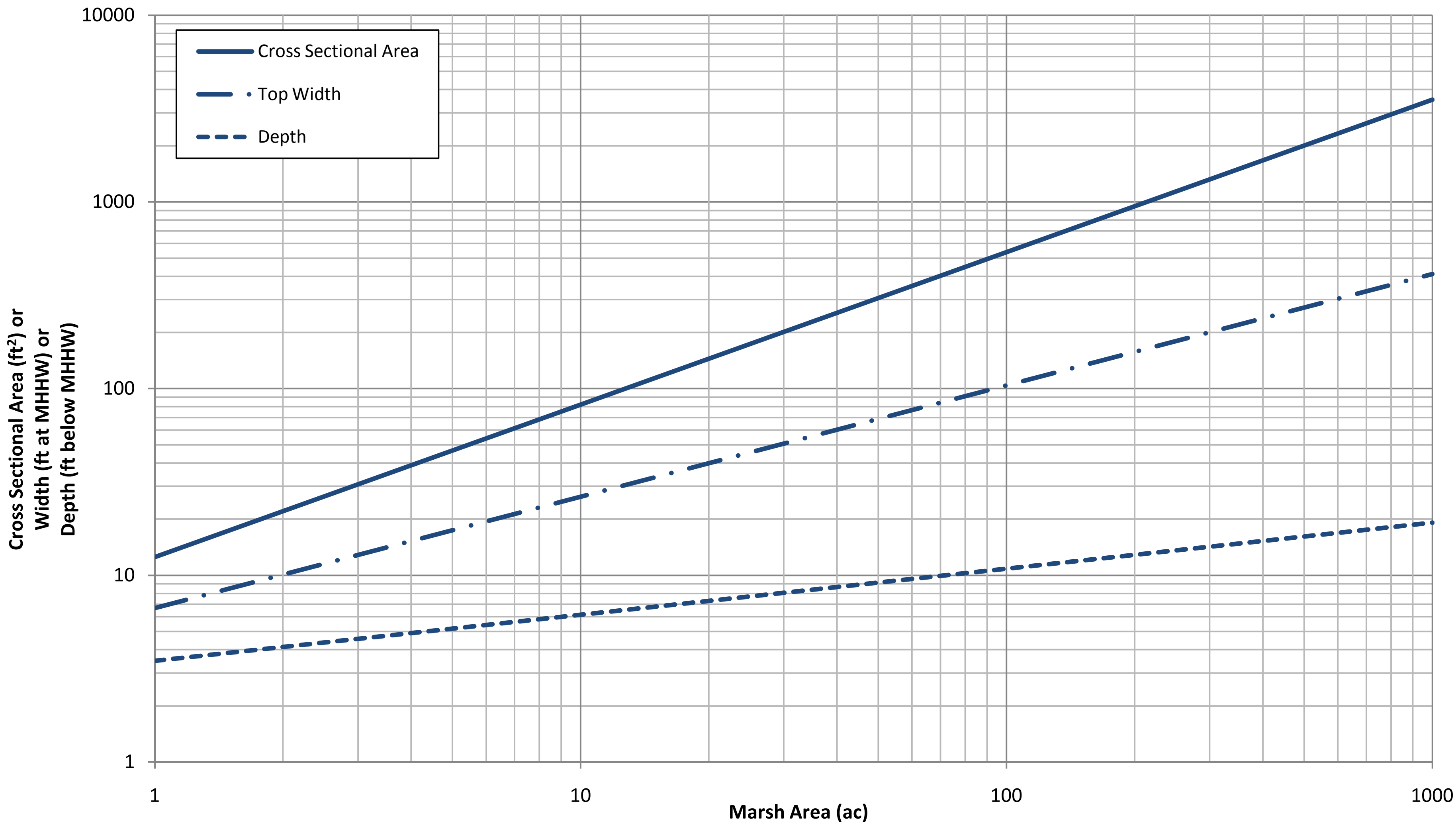

Tide Gage Station: Port Townsend # 9444900
For 10% PSNERP design use only.

Source: Williams et al. (2002). Regression equations adjusted based on percent increase in diurnal tide range relative to San Francisco Bay.

figure **7**

Puget Sound Nearshore Ecosystem Restoration Project

Hydraulic Geometry for Port Townsend

PWA Ref #: 2036.00

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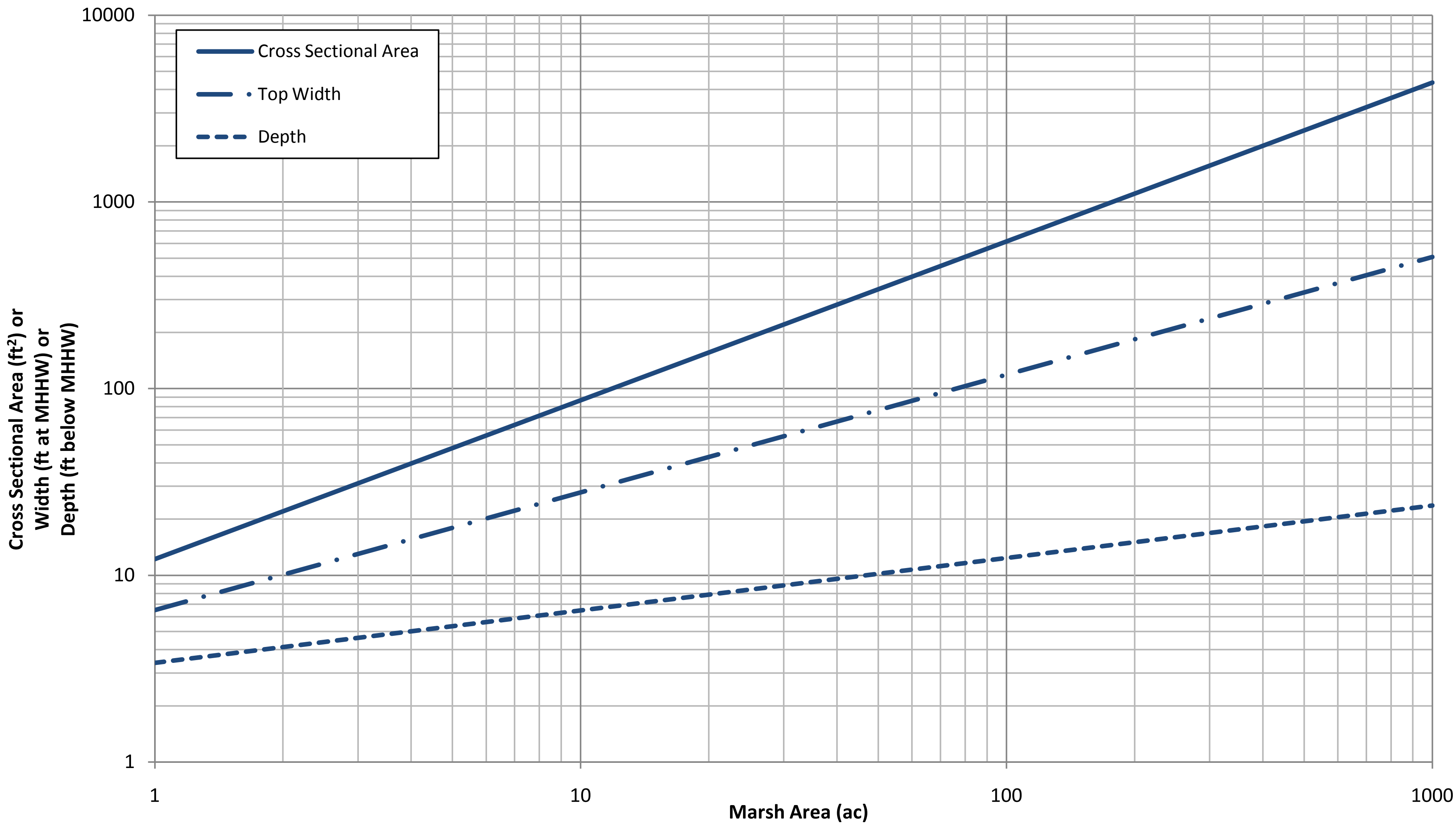

Tide Gage Station: Everett, WA # 9447659
For 10% PSNERP design use only.

Source: Williams et al. (2002). Regression equations adjusted based on percent increase in diurnal tide range relative to San Francisco Bay.

figure **8**

Puget Sound Nearshore Ecosystem Restoration Project

Hydraulic Geometry for Everett, WA

PWA Ref #: 2036.00

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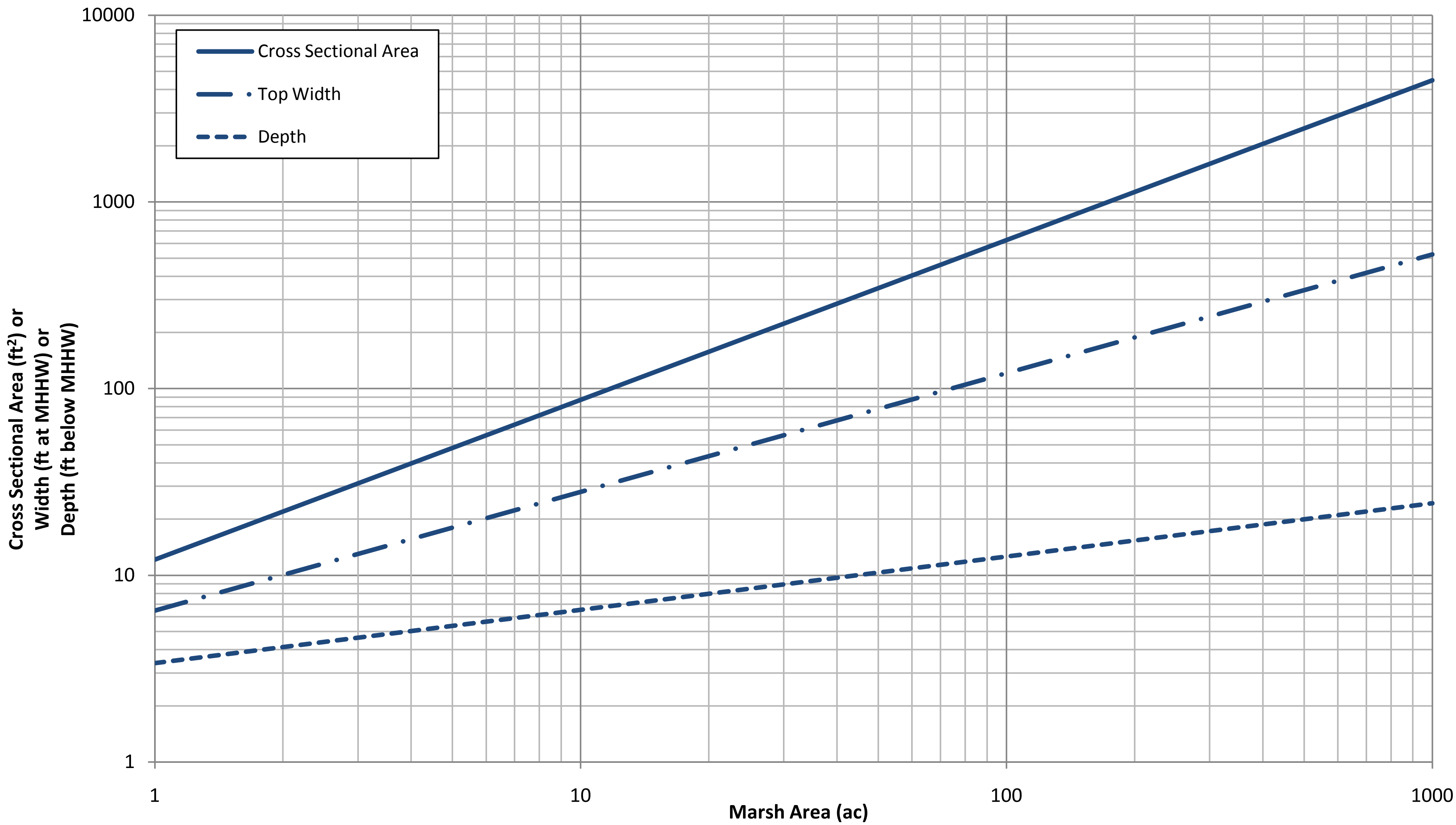

Tide Gage Station: Seabeck, Hood Canal # 9445296
For 10% PSNERP design use only.

Source: Williams et al. (2002). Regression equations adjusted based on percent increase in diurnal tide range relative to San Francisco Bay.

figure **9**

Puget Sound Nearshore Ecosystem Restoration Project

Hydraulic Geometry for Seabeck, Hood Canal

PWA Ref #: 2036.00

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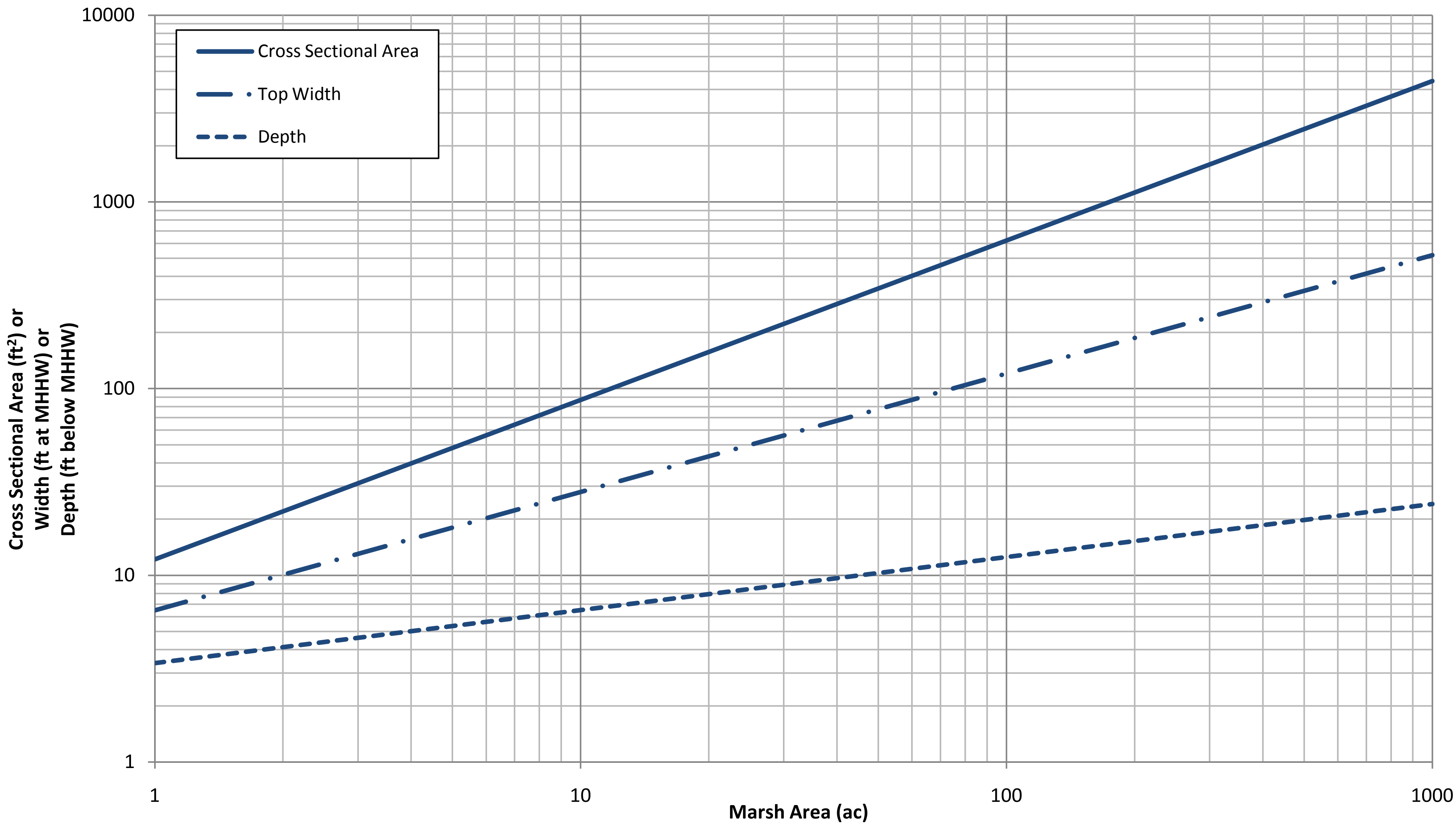

Tide Gage Station: Seattle, Puget Sound # 9447130
For 10% PSNERP design use only.

Source: Williams et al. (2002). Regression equations adjusted based on percent increase in diurnal tide range relative to San Francisco Bay.

figure **10**

Puget Sound Nearshore Ecosystem Restoration Project

Hydraulic Geometry for Seattle, Puget Sound

PWA Ref #: 2036.00

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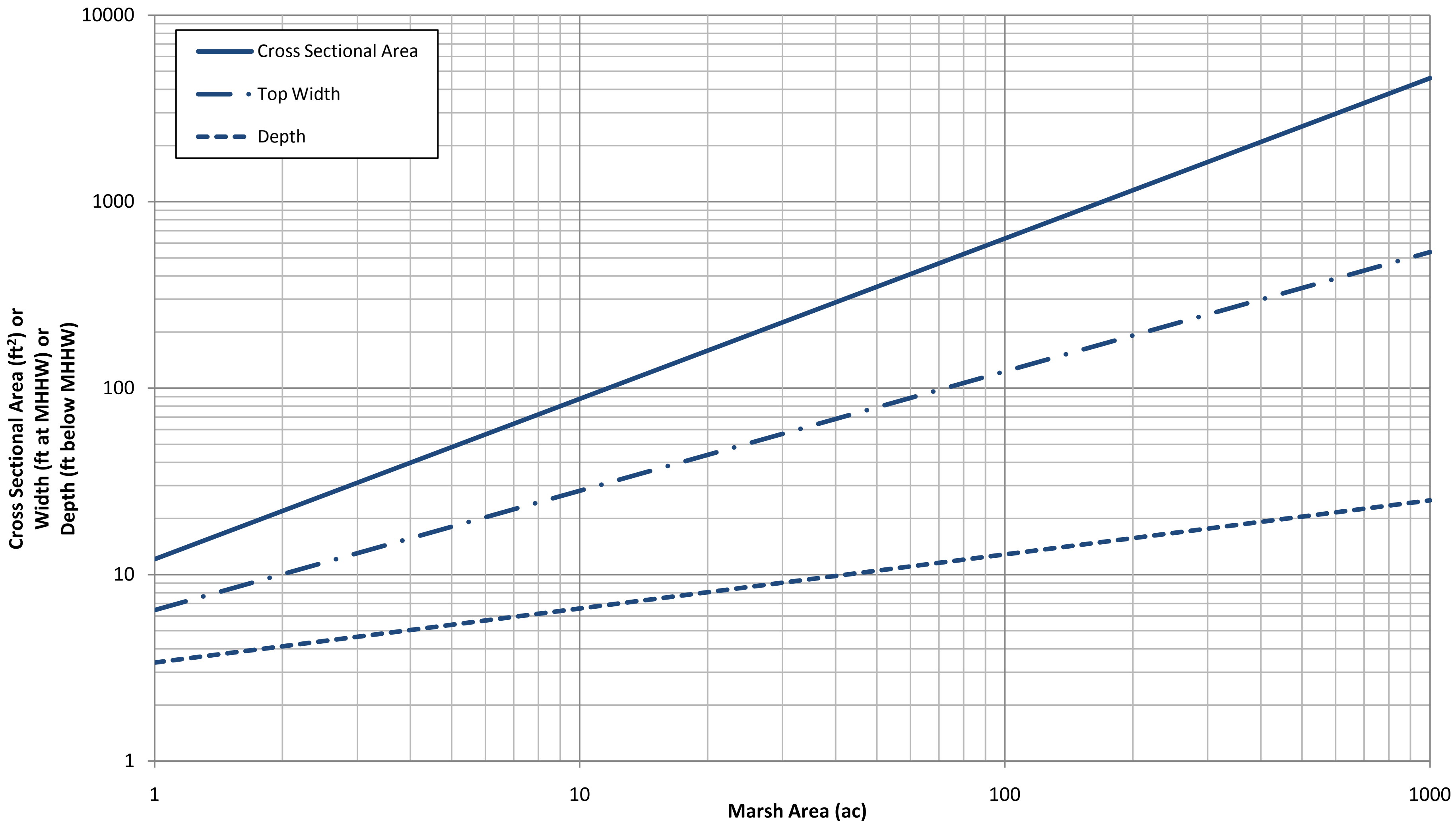

Tide Gage Station: Union, Hood Canal # 9445478
For 10% PSNERP design use only.

Source: Williams et al. (2002). Regression equations adjusted based on percent increase in diurnal tide range relative to San Francisco Bay.

figure ***11***

Puget Sound Nearshore Ecosystem Restoration Project

Hydraulic Geometry for Union, Hood Canal

PWA Ref #: 2036.00

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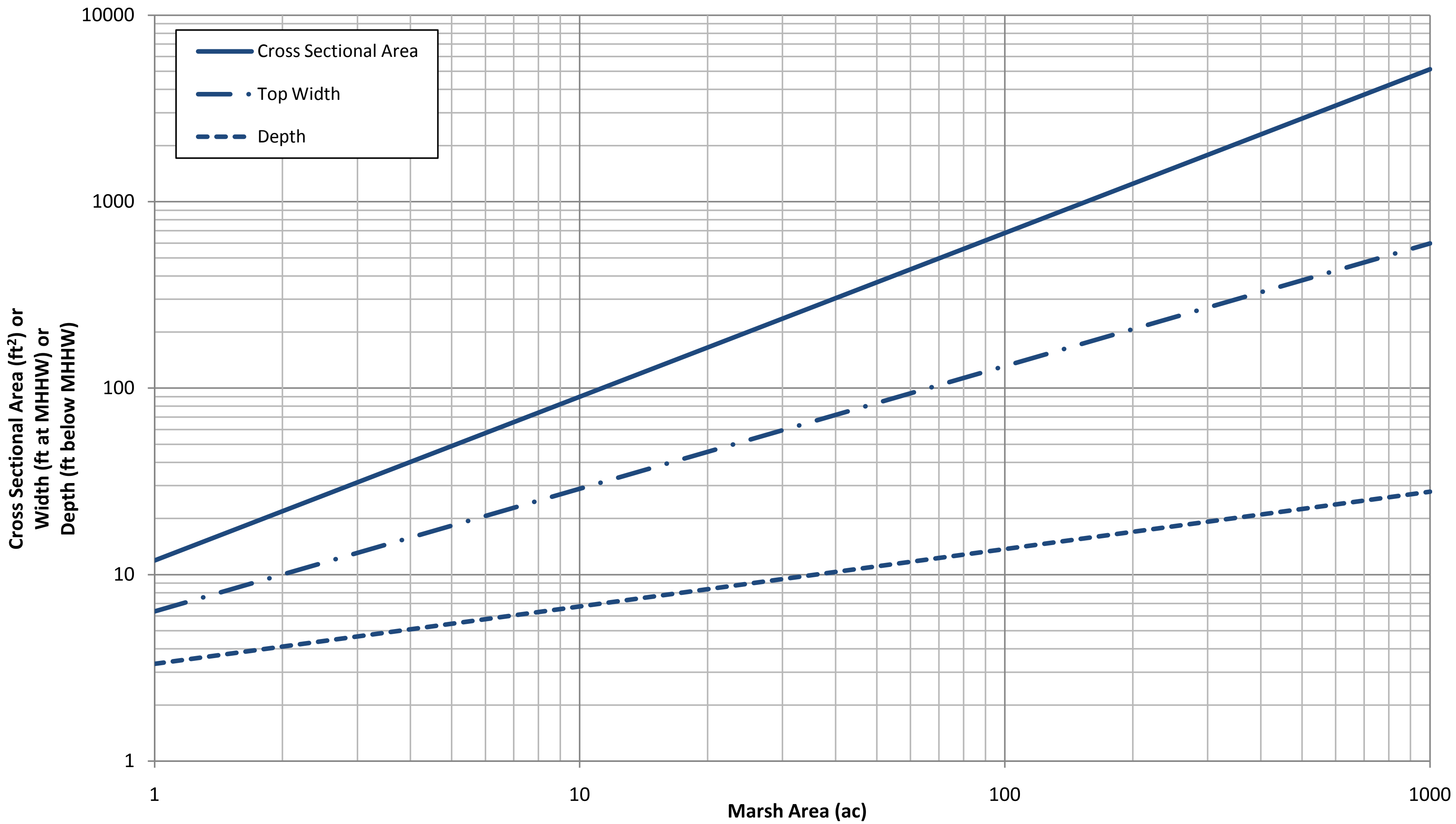
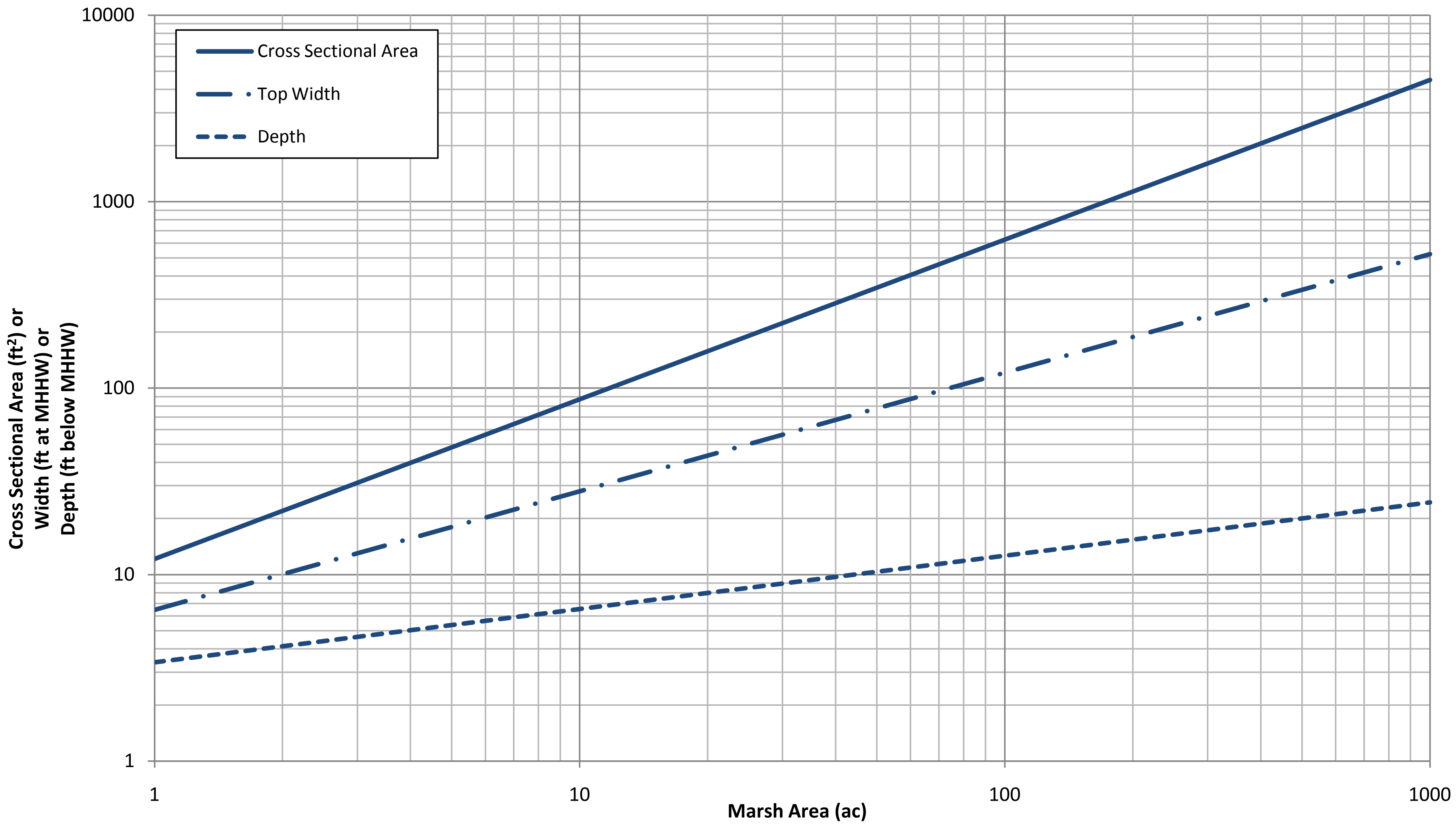


Tide Gage Station: Yoman Point, Anderson Island # 9446705 For 10% PSNERP design use only. Source: Williams et al. (2002). Regression equations adjusted based on percent increase in diurnal tide range relative to San Francisco Bay.	*figure* **12** *Puget Sound Nearshore Ecosystem Restoration Project* Hydraulic Geometry for Yoman Point, Anderson Island PWA Ref #: 2036.00



Tide Gage Station: Barron Point # 9446742
For 10% PSNERP design use only.

Source: Williams et al. (2002). Regression equations adjusted based on percent increase in diurnal tide range relative to San Francisco Bay.

figure **13**

Puget Sound Nearshore Ecosystem Restoration Project

Hydraulic Geometry for Barron Point

PWA Ref #: 2036.00

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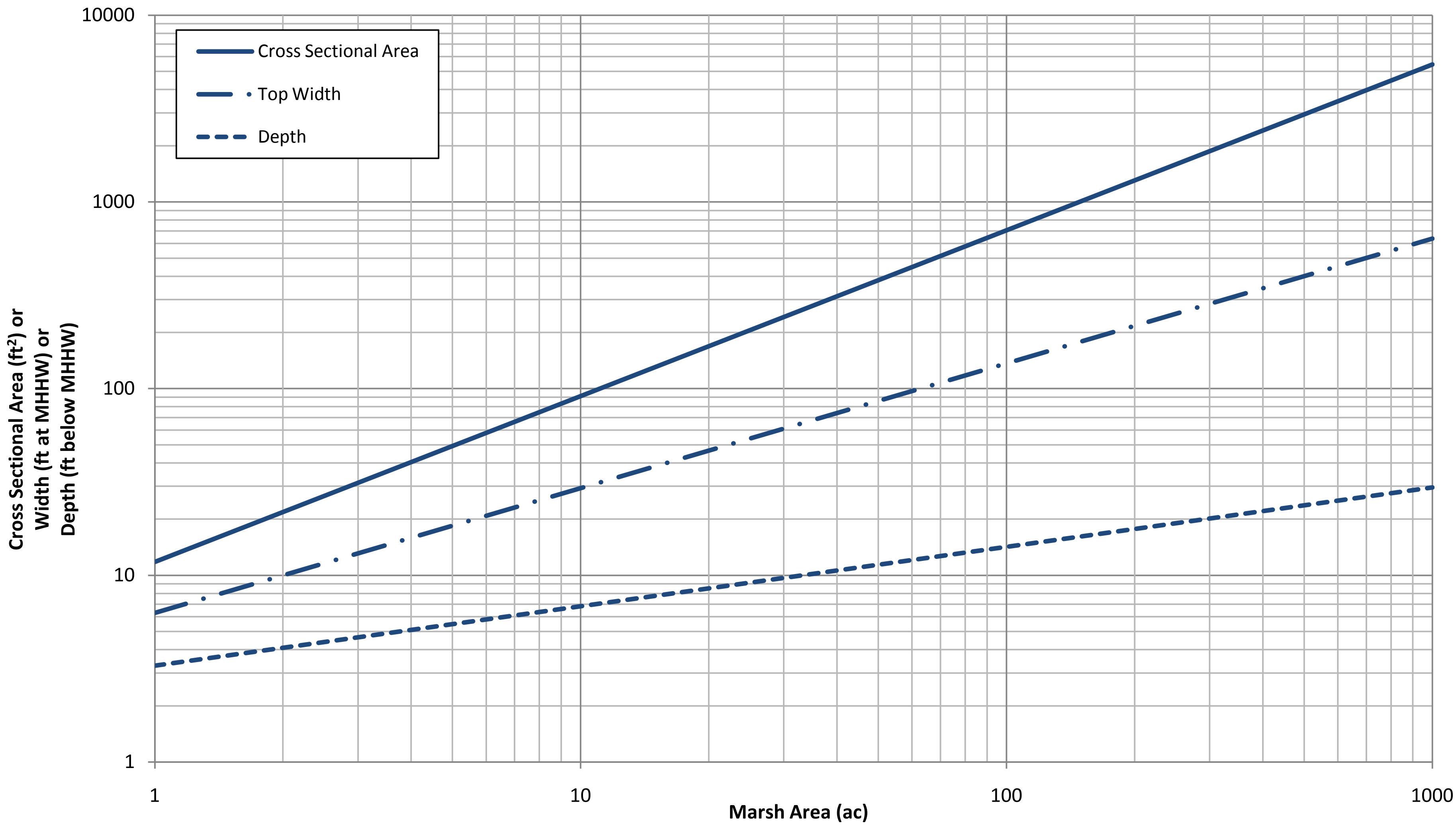

Tide Gage Station: Budd Inlet # 9446807
For 10% PSNERP design use only.

Source: Williams et al. (2002). Regression equations adjusted based on percent increase in diurnal tide range relative to San Francisco Bay.

figure **14**

Puget Sound Nearshore Ecosystem Restoration Project

Hydraulic Geometry for Budd Inlet

PWA Ref #: 2036.00

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memorandum

date December 22, 2010

to Bob Barnard, Curtis Tanner, PSNERP
Conceptual Design Team

from Phil Williams and Jeremy Lowe

subject PSNERP - Hierarchy of Benefits

1. INTRODUCTION

The purpose of this memo is to describe a hierarchy of benefits that will likely accrue to the natural processes, structure, and function of an ecosystem for variously located and sized openings in crossings of tidal and tidally influenced fluvial channels. We describe benefits in terms of ecosystem process, structure and function. By understanding what these benefits are, and how they impact the nearshore system crossings can be designed to provide maximum benefits more efficiently.

There is a dearth of information regarding the ecological impacts of constructing bridges or culverts across tidally influenced areas in the scientific literature. While hydrological and hydraulic impacts, such as amount and extent of anticipated scouring and longshore transport of sediment, are carefully considered during crossing design, impacts to overall geomorphology and ecological function are not. This may be because many decisions establishing culvert or bridge crossing design practice were made prior to 1969, before the passage of federal and state statutes that require inclusion of environmental impacts. Almost all tidal channel crossings were, and sometimes still are, designed to simply optimize hydraulic conveyance for drainage or design floods at least cost.

The loss of connectivity that occurs when dikes are constructed across wetlands and floodplains is well documented. Embanked bridge crossings can generate similar environmental impacts because they too may restrict the flow of animals, water, sediment, organic plant material and detritus. Today, however, there is an opportunity to assess and rectify the impacts of existing structures through restoration. The question that will need to be addressed is:

> *‘what are the tradeoffs between enhanced ecologic benefits and restoration costs for breaches or bridges larger than those required for hydraulic conveyance?’*

The hierarchy of benefits represents a new approach to crossing design by expanding its view from the minimum opening size that the hydraulics requires to one that considers how location and size of openings will impact the morphology and ecology of the ecosystem. This hierarchy of benefits will aid PSNERP decision makers by shedding light on whether a dike removal or a dike modification, and associated construction and monitoring costs, is warranted given particular parameters. It is a tool devised for this specific project, and its development was constrained by existing information and a short time horizon. It can be considered a starting place for cost-benefit analyses that incorporate the geomorphic and ecological aspects of ecosystem function.

2. CONCEPTUAL MODELS OF OPENINGS

PSNERP has described 21 management measures that that can be used to develop and evaluate Puget Sound nearshore restoration alternatives at individual sites. Management Measure 3 (MM3) (Clancy et al. 2009), describes in detail the need for and expected outcomes of dike removal or modification. One expected outcome is higher growth and survival of juvenile salmon in nearshore habitats. The connection between the restoration action (reintroducing the full tidal prism, flooding frequency and duration) and the goal (higher juvenile salmon survival rates) is expressed in a conceptual model that shows how the restoration action will likely restore processes and create structural changes that make the goal possible (see Figure 1).

Similarly, Management Measure 9 (MM9) (PSNERP 2009) describes the need for and expected outcomes of hydraulic modification. MM9 has comparable expected outcomes, and its conceptual model expresses how the restoration action (replace tide gate with open breach) will likely restore processes and create structural changes to improve salmon production and enhance other nearshore functions (see Figure 2).

Both dike removal or modification and hydraulic modification will result in a different type of opening across a tidally influenced area, such as a marsh or delta, than the constricted openings that currently exist. The impacts of the width, location and size of the new opening needs to be considered not only on the tidal and fluvial hydrology, but also on the geomorphic and ecologic processes of the tidally influenced area. This adds an additional dimension to the conceptual model because the rate at which the restoration goals can be achieved will be impacted by breach size.

3. IMPACTS OF CROSSING SIZE ON BARRIER ESTUARIES

Ecologic functioning of a number of barrier estuaries in the Puget Sound is constrained by road crossings. Typically, a road embankment has been constructed that follows the alignment of the natural barrier beach (Figure 3). The connection to tidal waters is often restricted to a single culvert or constricted bridge crossing. In addition, the inlet is fixed in location and high tide storm surge flows across the barrier beach are prevented by the embankment acting as a dike, reducing general flow over the marsh surface toward the bay front and eliminating wave action in the interior of the estuary.

The potential impacts of crossings on barrier estuaries are listed in Table 1 in terms of hydraulic and sedimentary processes and geomorphic and water quality impacts. The size of the inlet is often limited, which may partially or completely block the flow of water and mute the tide. This has implications for the location of head of tide and tidal prism volume. Small inlets may partially or completely block detritus, and large woody debris, and organic plant material from entering the estuary. Intertidal habitats inside the causeway may aggrade at a higher rate than areas outside due to the capture of sediment conveyed by floods from the watershed, or degrade when isolated from deposition of estuarine sediments brought in on the flood tide making these marshes more susceptible to the effects of sea level rise and geologic subsidence.

However these impacts do not occur in isolation. For example, within a barrier estuary alteration of the tidal signal has multiple hydrodynamic and geomorphic impacts including lowering of high tide elevations, raising low tide elevations, raising mean tide elevations, reducing the tidal frame, reducing the tidal prism in the marsh and reducing the tidal excursion. The structural and functional responses include isolation of marsh plains and conversion to fresher water habitats, a reduction in area of intertidal mudflat and sandflat habitat, siltation of tidal channels, an elevated water table affecting marsh to forest transition, a limited fluctuating water table affecting plant growth, atrophy of the channel system due to sedimentation and reduced channel connectivity, and passive advective transport of organisms into the estuary through baroclinic circulation.

The combination of embankment and reduced inlet size reduce both the area of habitat and habitat connectivity which in turn impacts all aspects of ecosystem function: distribution and abundance of species, community dynamics, productivity, and invasive species.

In restoring the ecosystem functions of these estuaries, the main tool is to decrease the hydraulic constriction due to the crossing and increase the habitat connectivity. The size of the opening will determine the type and amount of ecosystem processes that are impacted. The largest possible opening size will eliminate these impacts, while a small opening size will likely produce all of them. Intermediately sized openings will have impacts between these two endpoints.

3.1 Benefits of Increasing Bridge Crossing Size

To illustrate how much ecological benefits increase as opening size increases, we have carried out a first-cut qualitative assessment of five general categories of crossings as described below (see Figure 5):

1. Existing conditions. This assumes a raised embankment along the barrier beach and tidal flow restricted to a single culvert or narrow bridge crossing sized to drain the area landward of the barrier. Tidal regime will be strongly muted. All flows over the barrier beach will be blocked by the embankment.

2. Expand the inlet size with large culverts or bridge crossing to allow regular tidal inundation of the area landward of the barrier. The inlet crossing is designed to be the minimum size to allow the full average diurnal tidal range within the estuary based on the hydraulic geometry for tidal channels. However, tidal velocities will be greater than naturally occurring at the inlet requiring armoring to prevent scour and lateral migration. In addition storm surge tides will still be constricted. All flows over the barrier beach will be blocked by the embankment.

3. Expand the inlet size to allow for a naturally adjusting channel inlet to form. This would require a clear span bridge designed wide enough to allow a natural convex sided inlet channel that can adjust to storm surge tides. All flows over the barrier beach are blocked by the embankment.

4. Expand the inlet crossing to allow for lateral migration of the inlet channel. A bridge would be sized not only for the appropriate inlet channel morphology but also for historic migration width. Laterally meandering inlets have a tendency to ‘reset’ the estuarine drainage system and marsh habitats through bank erosion and migrating flood tide shoals All flows over the barrier beach are blocked by the embankment.

5. Complete removal of tidal barriers. This would include a bridge crossing to allow inlet migration and replacement of the embankment with an elevated causeway on pilings. The former road embankment would be graded down to natural beach crest elevations to allow for storm surge inundation and transport of large woody debris (LWD) into the estuary. The input of LWD creates habitat structure for all trophic levels from algae to invertebrates to fishes and wildlife; it allows for various species to seek shelter, find food, spawn, roost or nest. LWD also impacts sediment movement, potentially creating beach berms. More recently, LWD has been cited in facilitating tidal marsh succession acts by providing a nursery habitat for salt-intolerant species (Maser and Sedell).

Table 1 shows in detail how various process alterations impact ecosystem structure and function. Figures 5 uses this information to qualitatively assign values to restored processes according to opening size.

4. IMPACTS OF CROSSING SIZE AND LOCATION ON RIVER DELTAS

River deltas are dynamic geomorphic landscapes, with river distributary channels that evolve and migrate in response to major floods. They sustain a gradient of wetland habitat types from forested floodplains to forested tidal wetland to tidal marsh and mudflat. Roadways traverse river deltas at many locations in Puget Sound (Figure 4). Typically these have been constructed for convenience on embankments on the flat intertidal areas across the delta front and have concentrated river flows at a single bridge crossing location. Fixing the river channel in this way can significantly reduce the area of active delta. Upstream the river is restrained from avulsing into different distributary channels, resulting in a reduced variety of habitat types, and because of increased sediment deposition, the floodplain and former intertidal habitats aggrade. Downstream, single bridge crossings may partially or completely block the flow of sediment that sustains marsh habitats. Channelizing the outflow of riverine sediment along a single alignment forces delta progradation, changes salinity distribution and causes impacts to natural systems.

For instance, the size and location of bridge crossings are factors that will ultimately determine the viability of a salmon population. A population will become more viable if the size and location of the new opening adds new habitat, connects habitat and increases habitat capacity. New tidal or distributary channels will help to increase all three of these criteria, which alter the distribution and composition of life history strategies and result in an increase in viability.

4.1 Benefits of Increasing Bridge Crossing Size

To illustrate how ecologic benefits of river delta habits could be restored with increasing the size of bridge crossings we have conducted a first cut qualitative assessment of the four alternatives described below (see Figure 6):

1. Existing conditions. Assumes the roadway has been constructed on an elevated embankment that prevents tidal and river flows, and the bridge crossing itself has been sized to the typical design flood. Channel avulsions and distributary channel formation are restricted to the area downstream of the crossing. Elsewhere downstream of the embankment, tidal marshes are not replenished by sedimentation and relict distributary channels silt in. Upstream former intertidal wetlands convert to floodplains and the river channel is prevented from migrating or avulsing with river training structures that simplify habitat structure within the river channel.

2. Additional bridge crossing. The existing bridge crossing is duplicated at a location where a major distributary channel had been blocked off by the embankment. This would encourage a channel avulsion upstream and permit the main river to switch its course between two crossings, doubling the size of the active delta.

3. Extended bridge crossings allow for channel migration. Bridge spans are widened to allow for historic rates of lateral channel migration. Laterally meandering channels ‘reset’ the fluvial system through bank erosion and subsequent deposition in point bars. This introduces sediment and LWD into channels from stream banks, and promotes the exchange of nutrient-rich soils into the fluvial system. The erosion of banks, and subsequent deposition, results in a dynamic system with a mosaic of habitat types.

4. Extended bridge crossings with road on pilings. This would allow for restoring complete tidal exchange across the delta front. In addition it would allow removal of upstream river embankments allowing for restoration of fluvial processes acting across the delta.

Table 2 shows in detail how various process alterations impact ecosystem structure and function. Figures 6 uses this information to qualitatively assign values to restored processes according to opening size.

4.2 Benefits of Changing Bridge Crossing Location

The amount of ecological benefits derived from restoration efforts is not only influenced by the size of the opening, but also by its location within a watershed. The location of a crossing will be impacted by the tides (Figure 7). A qualitative assessment of tidal effects can be accomplished by expanding upon an approach published in Hydraulic Engineering Circular (Richardson, 2001) that is used to evaluate hydrological processes at crossings. This is, in large part, a measure of the distance from the head of tide to the crossing location. As the distance increases, the volume of tidal prism increases and, in turn, the discharge associated with each tidal cycle. Discharge drives the transport of fluvial and marine sediment in the estuary and scour at crossings. The distance from head of tide is also a measure of the crossing's effect on estuarine processes. Estuarine development (fill, dikes, land use) modifies the level of impact.

Qualitative categories of impact include (see Figure 7):

1. Low impact– the crossing is located near to the head of tide where tidal inundation occurs within the main channel banks, or where the tidally inundated marsh area is small.

2. Medium impact – this category encompasses most of the cases where the road embankment is built in the middle of the delta.

3. High impact– the crossing is located at the marine edge of a marsh, or encloses a large area principally below mean high water. These are cases where tidal volume is large and that significant inundated areas are funneled through a single opening, cutting off flow into distributary channels and over the marsh edge.

5. REFERENCES

Maser, C. and Sedell, J.R., 1994. From the Forest to the Sea: the Ecology of Wood in Streams, Rivers, Estuaries, and Oceans. St. Lucie Press, Delray Beach, FL, 200 pp.

Clancy et al., 2009. Management Measures for Protecting and Restoring the Puget Sound Nearshore. Technical Report 2009-01.

Richardson, 2001. Hydraulic Engineering Circular.

Table 1. POTENTIAL ADVERSE IMPACTS OF CROSSINGS ON BARRIER ESTUARIES

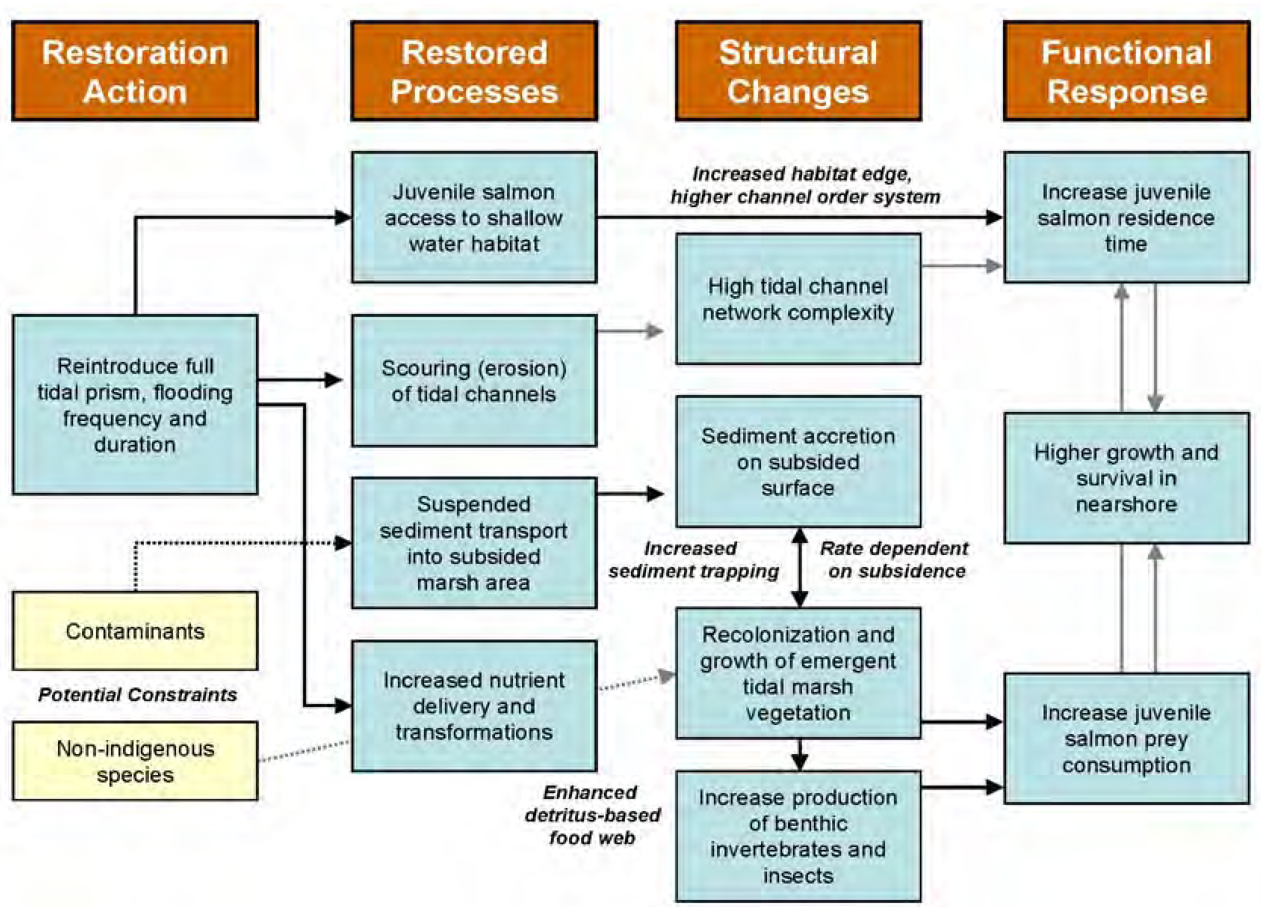
BARRIER ESTUARIES - Assumes culverted entrance, road embankment along beach alignment, watershed relatively small relative to estuary.

<u>**BARRIER ESTUARIES**</u>	**Process**	**Structural Impact**	**Functional Response**
HYDRAULIC/ HYDRODYNAMIC PROCESS IMPACTS	Alteration of tidal stage characteristics **(#2)**	Lowering of high tide elevations	Isolation of marsh plains, conversion to fresher habitats
		Raising low tide elevations	Reduction in area of intertidal mudflat/sandflat habitat
		Raising mean tide elevations	Water table elevated affecting marsh to forest transition
		Reduction in tidal frame	Water table fluctuation limited affecting plant growth
		Reduction in tidal prism in marsh	Channel system atrophies through sedimentation; reduced channel connectivity
		Reduced tidal excursion	Passive advective transport of organisms in and out of estuary diminished
	Alteration of salinity distribution **(#5)**	Vertical salinity stratification degraded through mixing	Reduction of passive transport of organisms into estuary through baroclinic circulation
		Salinity mixing zone length truncated	'Squeezing'and reduction of brackish zone habitats
	Elimination of storm surge overwash across beach **(#3, 4)**	Transport of large woody debris into marsh	Habitat heterogeneity reduced
		Mobilization of detritus due to storm surge wave action eliminated	Export of nutrients to estuary reduced
SEDIMENTARY PROCESS IMPACTS	Alluvial sedimentation altered by backwater affects	Fine sediment accumulates on marsh plain	Shift to upland habitats
		Coarse sediment accumulates in tidal channels	Loss of blind channel habitat
	Estuarine sedimentation limited by reduction in tidal flows **(#1)**	Reduced tidal prism reduces sediment delivery to marsh plain, causes lowering relative to tidal frame	Reduced productivity of marsh vegetation
		Increased turbidity in tidal channels due to loss of marsh plain sediment sink	Adverse affect on benthic organisms and eelgrass
GEOMORPHIC IMPACTS	Alteration of entrance channel morphology from broad shallow to narrow	Increased tidal velocity through entrance creates scour holes	Increased fish mortality
		Channel location fixed instead of lateral migration affecting ebb and flood shoal extent	Adverse affect on benthic organisms
		Fixed channel location may lead to permanent closure of confined marsh by longshore drift	Eliminates exchange of water, sediment, nutrients and organisms
	Atrophied tidal drainage system	Tidal channels shallower	Degraded estuarine habitat
		Dendritic tidal channel system becomes disconnected	Estuarine habitat degraded
	Marsh plain elevations changed	Lowered marsh plain	Reduced marsh productivity
		Areas raised by alluvial sedimentation	Change to freshwater or upland species
WATER QUALITY IMPACTS	Increased residence time **(#6)**	Reduction in tidal exchange	Algal blooms in marsh channels, anoxic in poorly drained holes
		Reduction in tidal excursion	Export of water column productivity to larger estuary limited
	Accumulation of toxics	Reduced tidal scouring allows accumulation of polluted sediments from watershed	Toxic affects on organisms
		Reduced residence time means concentration of dissolved pollutants in water column is higher	Toxic affects on organisms

Table 2. POTENTIAL ADVERSE IMPACTS OF CROSSINGS ON RIVER DELTAS

RIVER DELTAS - Assumes single bridge crossing across main river sized for major river flood on piers, road embankment across rest of delta.

RIVER DELTAS			
HYDRAULIC/ HYDRODYNAMIC PROCESS IMPACTS	Alteration of fluvial flows	Concentration of flood flows at one discharge point raises flood stages upstream	Shift from marshplain to floodplain ecologic processes
		Elimination of out of bank flows upstream increases discharge, scouring and flood velocities in main channel	Reduction of fish refuge habitat and shallow water habitat
	Alteration of estuarine tidal flows	Deeper main channel can extend tidal influence further upstream	Introduction of predators upstream
	Alteration of estuarine salinity distribution	Extension of single channel into deeper waters creates abrupt fresh to salt water mixing zone	Adverse impacts on anadramous migration
		Elimination of distributary channels alters spatial distribution of mixing zones across delta front.	Reduction in brackish zone, adverse impact on shellfish
		Elimination of distributary channels reduces linear extent of salinity transition zones	Reduction in anadramous fish habitat
SEDIMENTARY PROCESS IMPACTS	Alluvial sedimentation	Increased sedimentation on marshplain/floodplain upstream	Conversion from tidal marsh to floodplain habitats
		Reduced sediment delivery and erosion where distributary channels have been blocked	Loss of intertidal habitats
		Coarse sedimentation concentrated at mouth of single channel, instead of being distributed along multiple channels across delta front	Loss of habitat heterogeneity
	Estuarine sedimentation	Estuarine mudflats not replenished during flood events –fine alluvial sediments lost to deep water	Loss of intertidal mudflat/sandflat habitat
		Reduced flood tide suspended sediment concentrations reduce marshplain sedimentation rates	Loss of productivity and area of marshplain habitat
	Large wood accumulation	More export of large woody debris	Reduction in complexity of channel habitat
GEOMORPHIC IMPACTS	Spatial reduction of active delta	Reduction in area	Loss of benefits of large scale ecologic processes
		Simplification of deltaic system	Reduction in heterogeneity of habitats, loss of alternate migratory routes
		Disruption of natural gradient of wetland habits from floodplain to mudflat	Loss of connectivity of habitats, fragmentation of habitats
		Delinking of river channel from marshes	Adverse affect on migrating fish
	Main river channel changes	Deeper river channel	Simplification of fish habitat
		Channel location fixed	Reduction in habitat complexity derived from meandering processes
		Extension of delta lobe to deeper water reducing channel slope, increasing in-channel sediment deposition	Loss of watershed derived nutrients to estuarine system
	Distributary channel changes	Remnant distributary channel atrophies	Loss of channel edge habitat and migration routes
	Marshplain system changes	Marshplain erosion	Loss of marsh area, conversion to mud/sand flat
		Marshplain lowering	Reduction of productivity
	Mudflat changes	Mudflat lowering	Loss of mudflat habitat



Source: PSNERP Management Measures (2009)

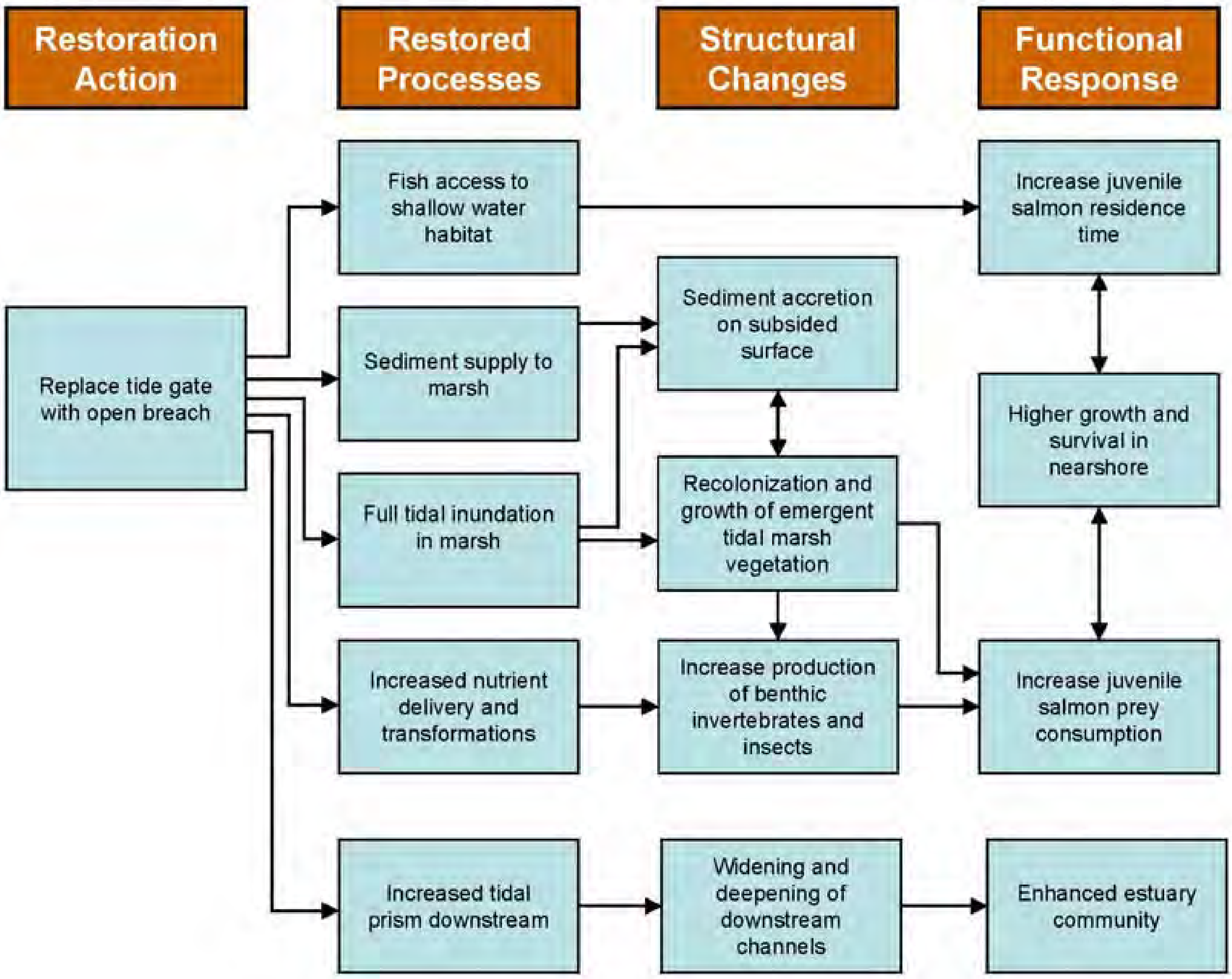
figure **1**
PSNERP Concept Engineering

Conceptual model of dike removal or modification

PWA Ref# 2036.01

PWA

\\Mars\Projects\2036.01_PSNERP_Phase_1_Conceptual_Engineering\Applied Geomorphology Guidelines\Hierarchy of Openings\Fig 1 Dike Removal CM.doc



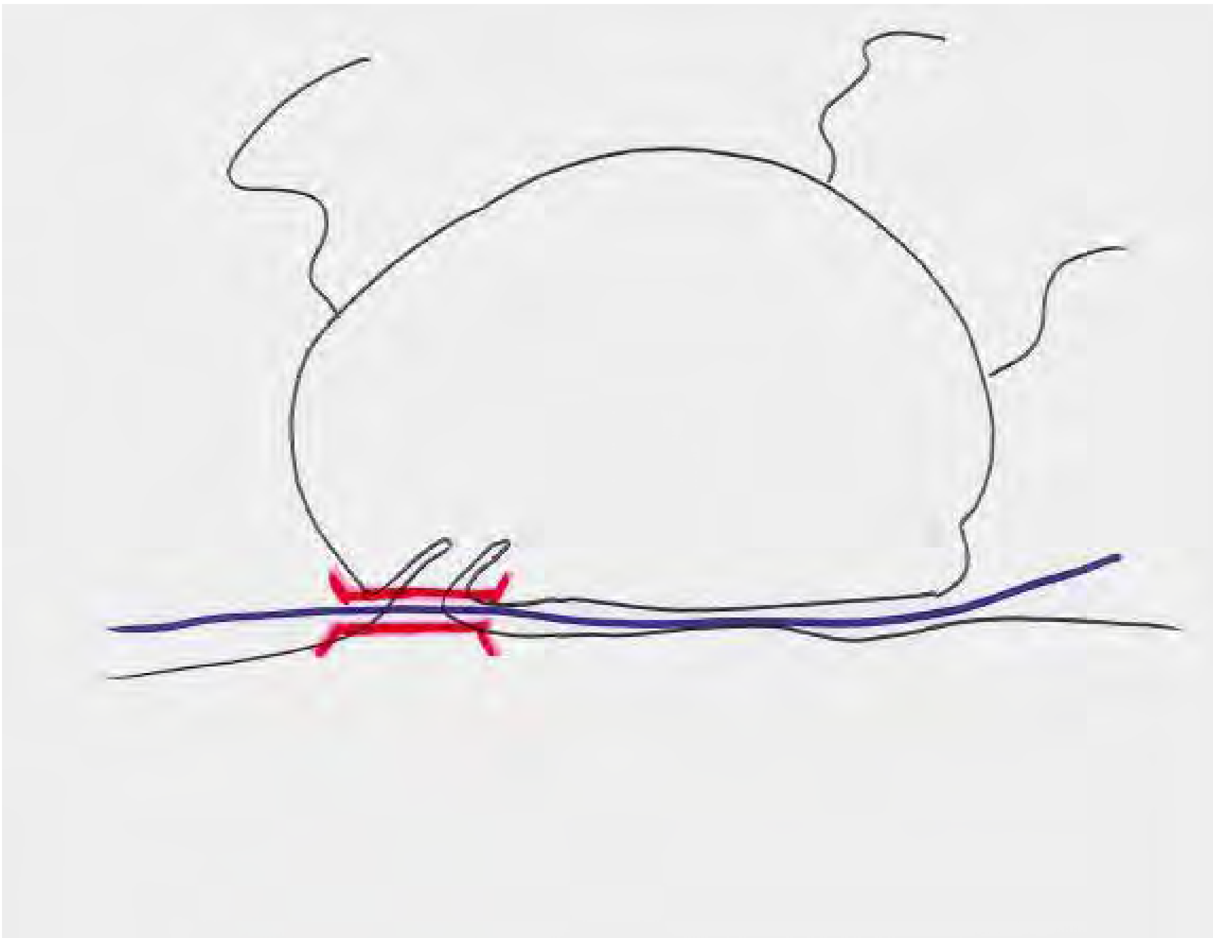
Source: PSNERP Management Measures (2009)

figure **2**
PSNERP Concept Engineering

Conceptual model of hydraulic modification

PWA Ref# 2036.01

PWA



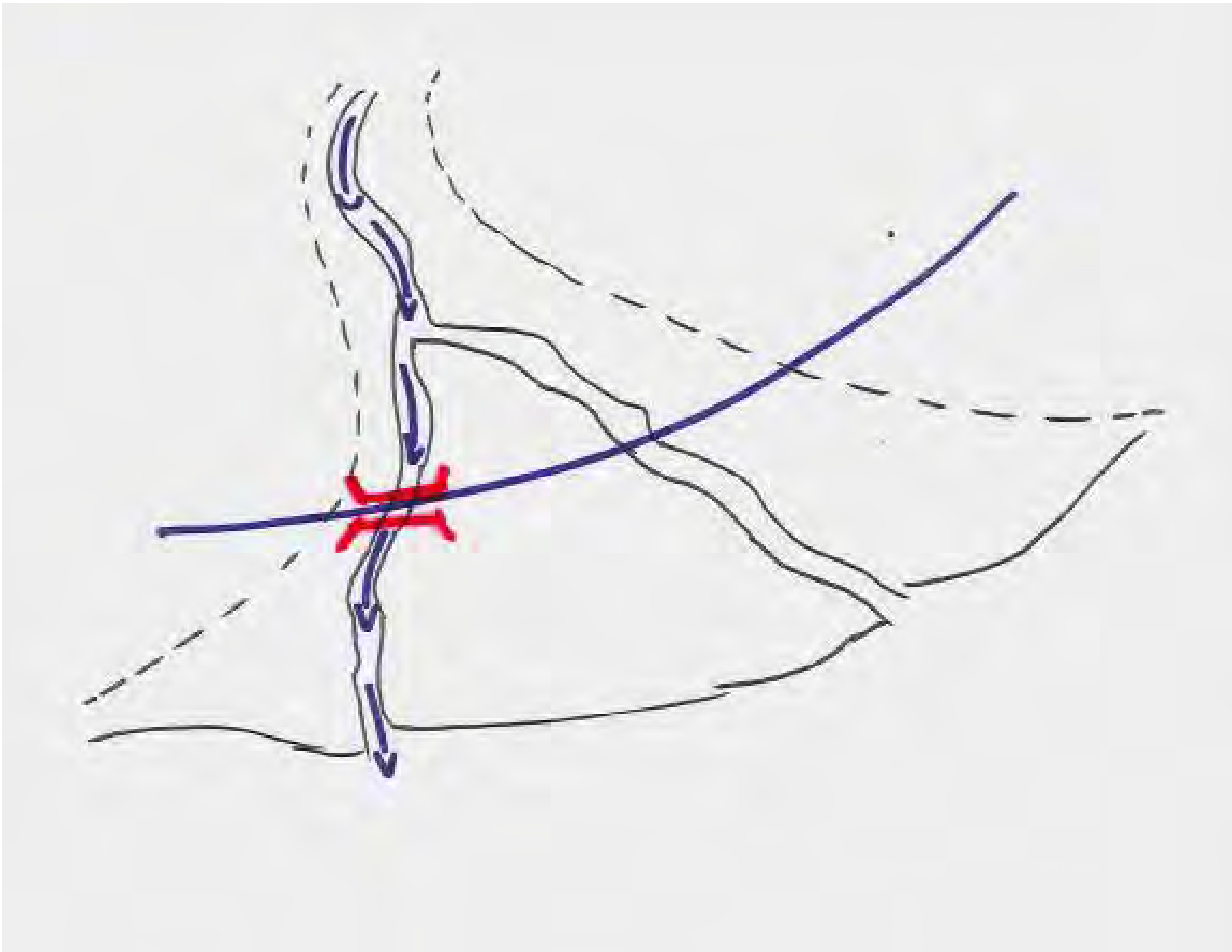
Source:

figure ***3***
PSNERP Concept Engineering

General layout of barrier estuary crossing

PWA Ref# 2036.01

PWA

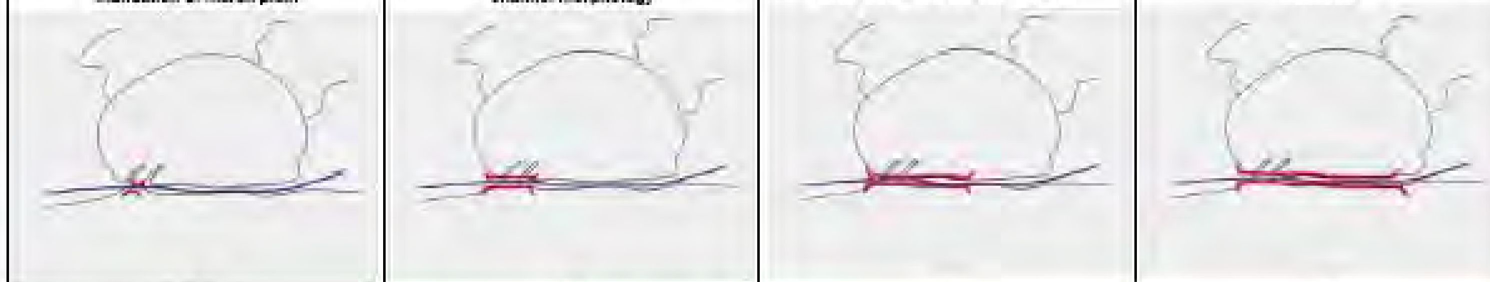


Source:

figure ***3***
PSNERP Concept Engineering

General layout of river delta crossing

PWA Ref# 2036.01



BARRIER ESTUARIES		Culvert	Culvert sized to allow inundation of marsh plain	Bridge sized to inlet channel morphology	Bridge sized for migration width	Causeway
	Restored Process					
	Fish Access to Shallow Water Habitat / Connectivity		0.6	0.8	1.0	1.0
1	Estuarine Sediment Supply to Marsh		0.8	0.9	0.9	1.0
2	Full Tidal Inundation in Marsh		0.7	1.0	1.0	1.0
3	Increased Nutrient Delivery to the Bay		0.4	0.7	0.8	1.0
	Increased Tidal Prism Downstream		0.7	1.0	1.0	1.0
4	Disturbance Regimes (LWD)/ Habitat Heterogeneity		0.0	0.2	0.4	1.0
5	Salt Water Mixing		0.4	0.9	1.0	1.0
6	Tidal Exchange Processes over Time		0.6	0.7	0.8	1.0
	Total Benefit		4.2	6.2	6.9	8.0

Source:

figure **5**
PSNERP Concept Engineering

Benefits of widening crossings of a barrier estuary

PWA Ref# 2036.01

PWA

Restored Process	Culvert not feasible	Bridge sized to 10-100 year flood	Two Bridges	Two Bridges sized for migration width	Two Bridges and Causeway
					
Fish Access to Shallow Water Habitat / Connectivity		0.1	0.4	0.6	0.8
Estuarine Sediment Supply to Marsh		0.1	0.3	0.5	1.0
Distributary Channel Formation		0.1	0.4	0.6	0.8
Increased Nutrient Delivery to the Bay		0.2	0.4	0.6	[illegible]
Channel Migration		0.0 0.0	0.1	0.4	0.8
Salt Water Mixing		0.2	0.6	0.6	0.8
	Total Benefit	0.7	2.2	3.3	6.2

Source:

figure **6**

PSNERP Concept Engineering

Benefits of widening crossings of a river delta

PWA Ref# 2036.01

PWA

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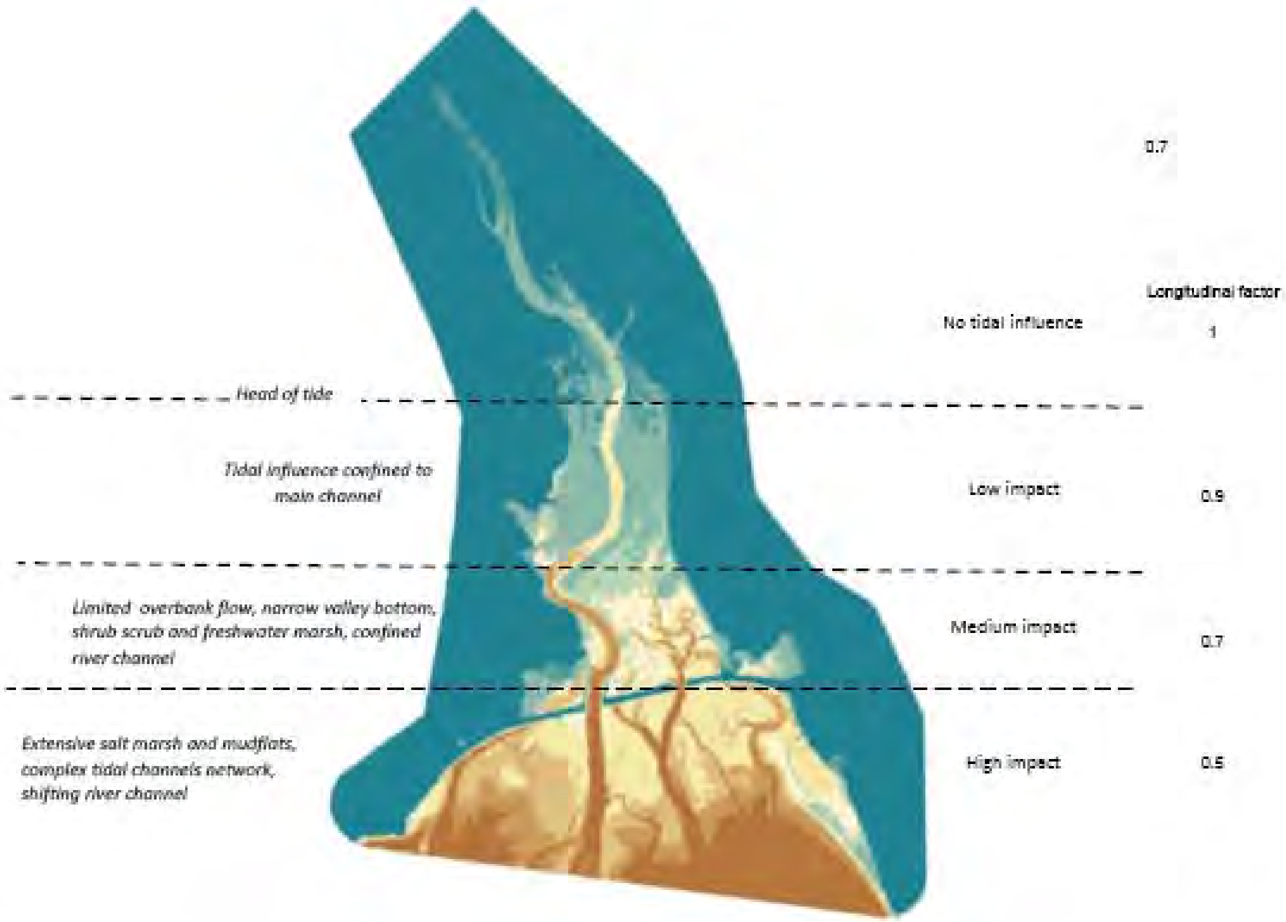

Source:

figure ***7***

PSNERP Concept Engineering

Location of crossing

PWA Ref# 2036.01

PWA

Puget Sound Nearshore Ecosystem Restoration Project

Strategic Restoration Conceptual Engineering – Design Report

Appendix D: Field Maps

March 2011

Aerial Image and Shoreform Change

PSNERP ID: 1256

Candidate Restoration Site: Big Beef Creek Estuary

1,000 Feet

500 Meters

Legend

Ownership
- Public Land
- Tribal Land

PSNERP Historic Shoreform Type
- Artificial
- Barrier Beach
- Barrier Estuary
- Barrier Lagoon
- Bluffed-Backed Beach
- Closed Lagoon Marsh
- Delta
- Open Coastal Inlet
- Pocket Beach
- Pocket Lagoon
- Rocky Platform

PSNERP Shoreform Change Type
- Artificial
- Barrier Beach
- Barrier Estuary
- Barrier Lagoon
- Bluff-backed beach
- Closed Lagoon Marsh
- Delta
- Open Coastal Inlet
- Pocket Beach
- Pocket Lagoon
- Rocky Platform

N

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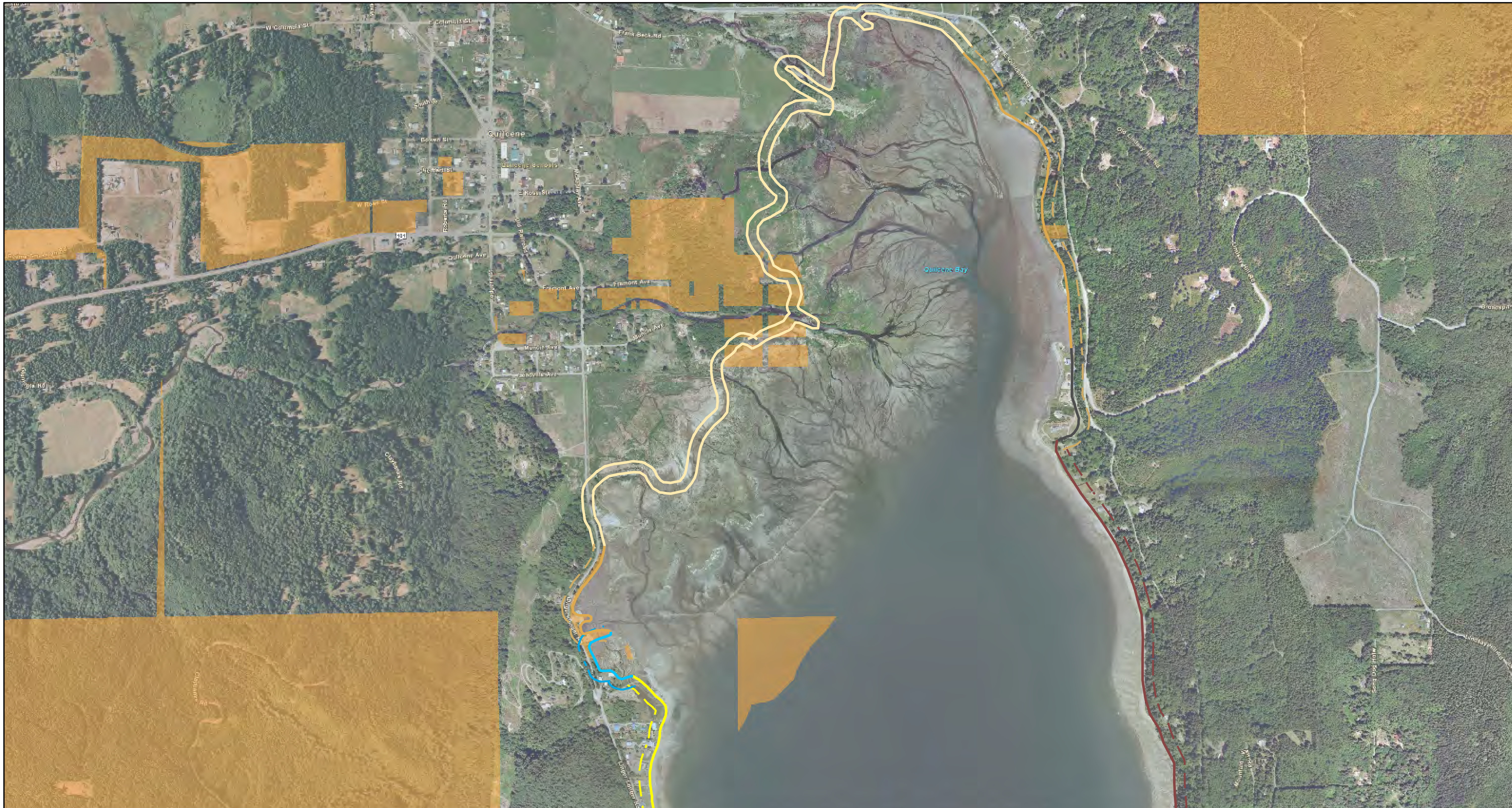

Aerial Image and Shoreform Change

PSNERP ID: 1074

Candidate Restoration Site: Quilcene River Delta

1,000 Feet

500 Meters

Legend

Ownership
- Public Land
- Tribal Land

PSNERP Historic Shoreform Type
- Artificial
- Barrier Beach
- Barrier Estuary
- Barrier Lagoon
- Bluffed-Backed Beach
- Closed Lagoon Marsh
- Delta
- Open Coastal Inlet
- Pocket Beach
- Pocket Lagoon
- Rocky Platform

PSNERP Shoreform Change Type
- Artificial
- Barrier Beach
- Barrier Estuary
- Barrier Lagoon
- Bluff-backed beach
- Closed Lagoon Marsh
- Delta
- Open Coastal Inlet
- Pocket Beach
- Pocket Lagoon
- Rocky Platform

N

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Aerial Image and Shoreform Change

PSNERP ID: 1801

Candidate Restoration Site: Chambers Bay

1,000 Feet

500 Meters

Legend

Ownership
- Public Land
- Tribal Land

PSNERP Historic Shoreform Type
- Artificial
- Barrier Beach
- Barrier Estuary
- Barrier Lagoon
- Bluffed-Backed Beach
- Closed Lagoon Marsh
- Delta
- Open Coastal Inlet
- Pocket Beach
- Pocket Lagoon
- Rocky Platform

PSNERP Shoreform Change Type
- Artificial
- Barrier Beach
- Barrier Estuary
- Barrier Lagoon
- Bluff-backed beach
- Closed Lagoon Marsh
- Delta
- Open Coastal Inlet
- Pocket Beach
- Pocket Lagoon
- Rocky Platform

N

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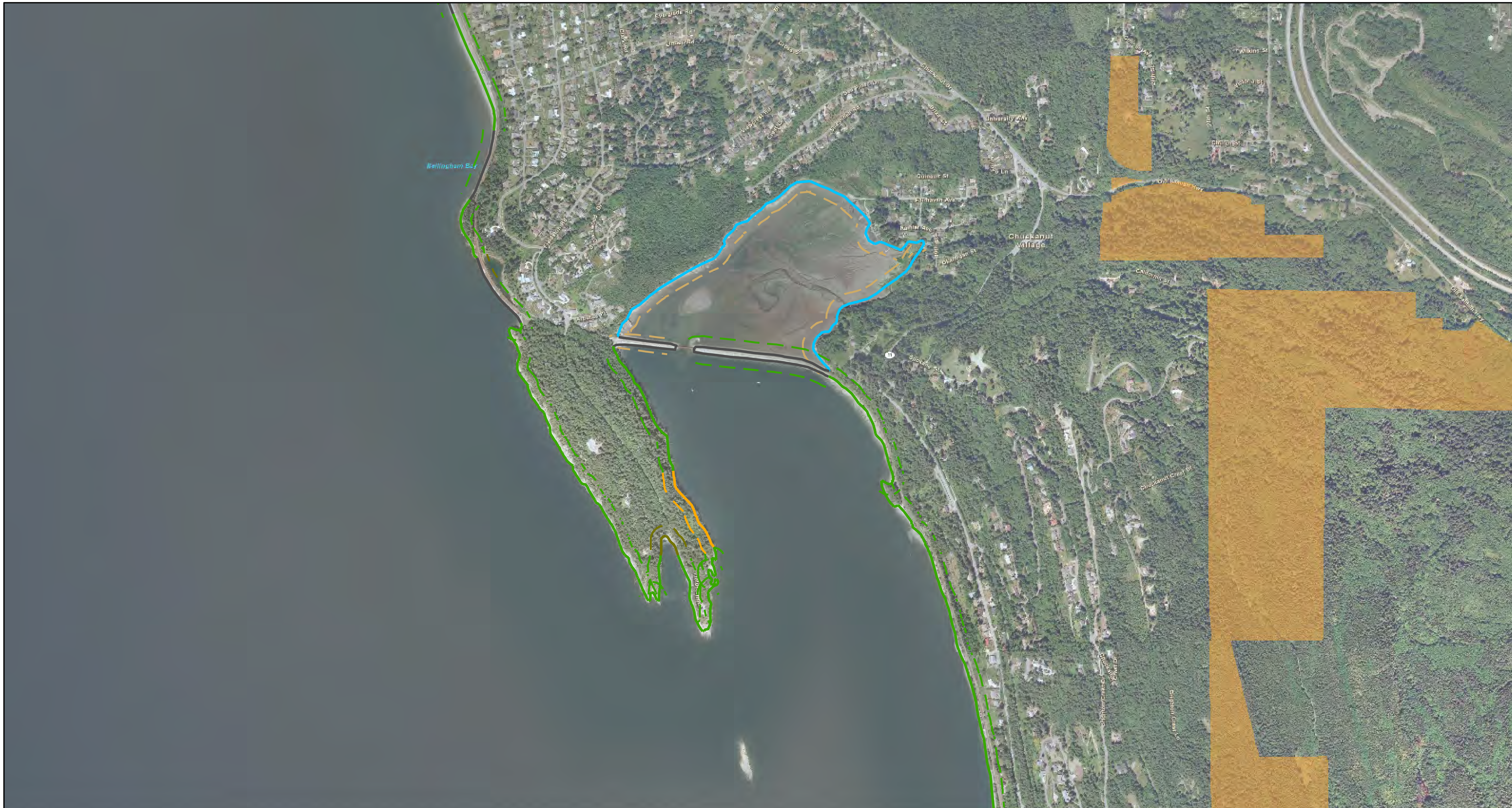

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Aerial Image and Shoreform Change
PSNERP ID: 1642
Candidate Restoration Site: Chuckanut Estuary

1,000 Feet
500 Meters

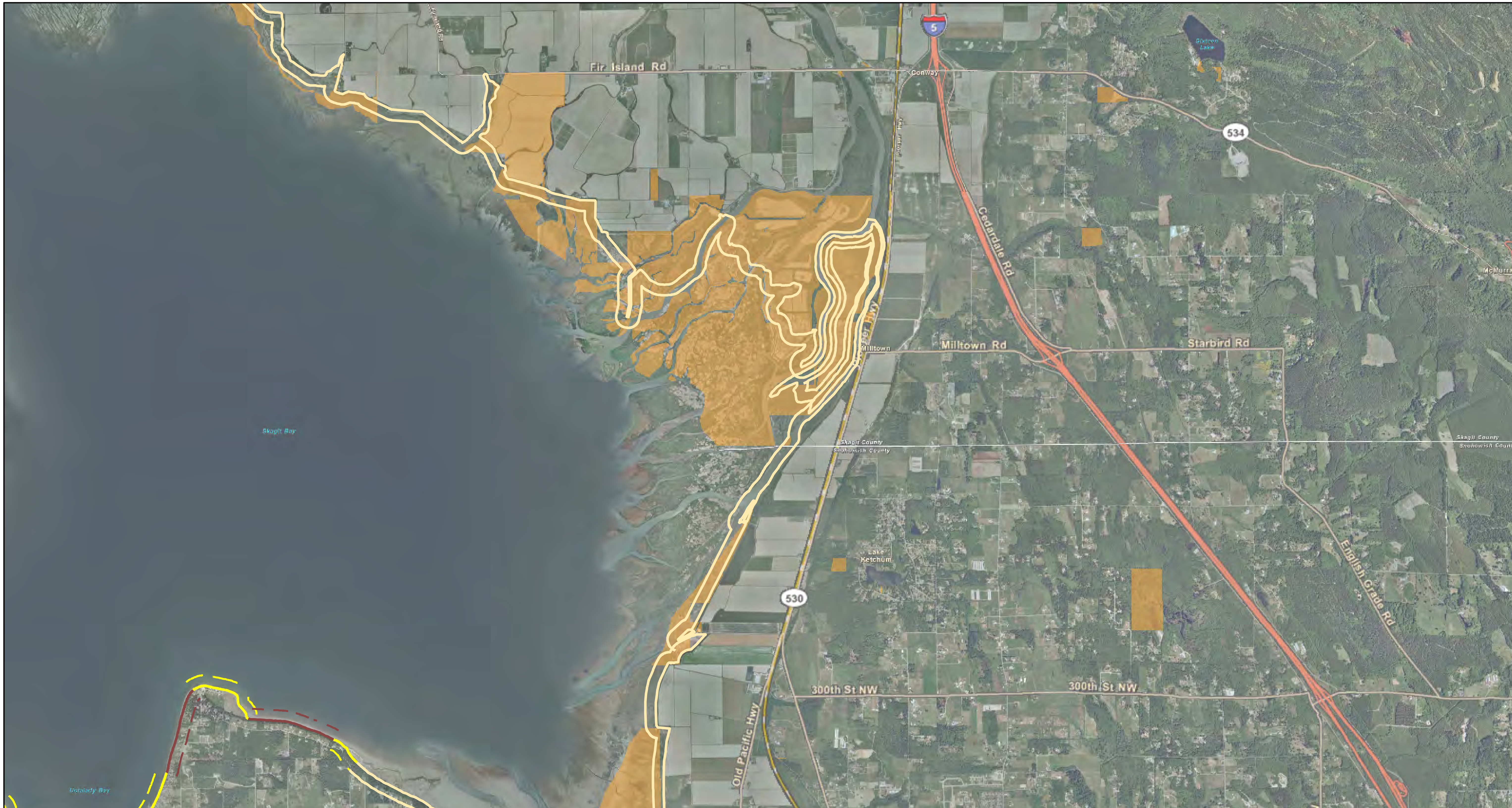
Legend

Ownership
- Public Land
- Tribal Land

PSNERP Historic Shoreform Type
- Artificial
- Barrier Beach
- Barrier Estuary
- Barrier Lagoon
- Bluffed-Backed Beach
- Closed Lagoon Marsh
- Delta
- Open Coastal Inlet
- Pocket Beach
- Pocket Lagoon
- Rocky Platform

PSNERP Shoreform Change Type
- Artificial
- Barrier Beach
- Barrier Estuary
- Barrier Lagoon
- Bluff-backed beach
- Closed Lagoon Marsh
- Delta
- Open Coastal Inlet
- Pocket Beach
- Pocket Lagoon
- Rocky Platform

N



Aerial Image and Shoreform Change

PSNERP ID: 1091, 1101

Candidate Restoration Site: Milltown Island, Deepwater Slough Phase 2

1,000 Feet

500 Meters

Legend

Ownership
- Public Land
- Tribal Land

PSNERP Historic Shoreform Type
- Artificial
- Barrier Beach
- Barrier Estuary
- Barrier Lagoon
- Bluffed-Backed Beach
- Closed Lagoon Marsh
- Delta
- Open Coastal Inlet
- Pocket Beach
- Pocket Lagoon
- Rocky Platform

PSNERP Shoreform Change Type
- Artificial
- Barrier Beach
- Barrier Estuary
- Barrier Lagoon
- Bluff-backed beach
- Closed Lagoon Marsh
- Delta
- Open Coastal Inlet
- Pocket Beach
- Pocket Lagoon
- Rocky Platform

N

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Aerial Image and Shoreform Change

PSNERP ID: 1648

Candidate Restoration Site: Deer Harbor Estuary

1,000
Feet
500
Meters

Legend

Ownership
- Public Land
- Tribal Land

PSNERP Historic Shoreform Type
- Artificial
- Barrier Beach
- Barrier Estuary
- Barrier Lagoon
- Bluffed-Backed Beach
- Closed Lagoon Marsh
- Delta
- Open Coastal Inlet
- Pocket Beach
- Pocket Lagoon
- Rocky Platform

PSNERP Shoreform Change Type
- Artificial
- Barrier Beach
- Barrier Estuary
- Barrier Lagoon
- Bluff-backed beach
- Closed Lagoon Marsh
- Delta
- Open Coastal Inlet
- Pocket Beach
- Pocket Lagoon
- Rocky Platform

N

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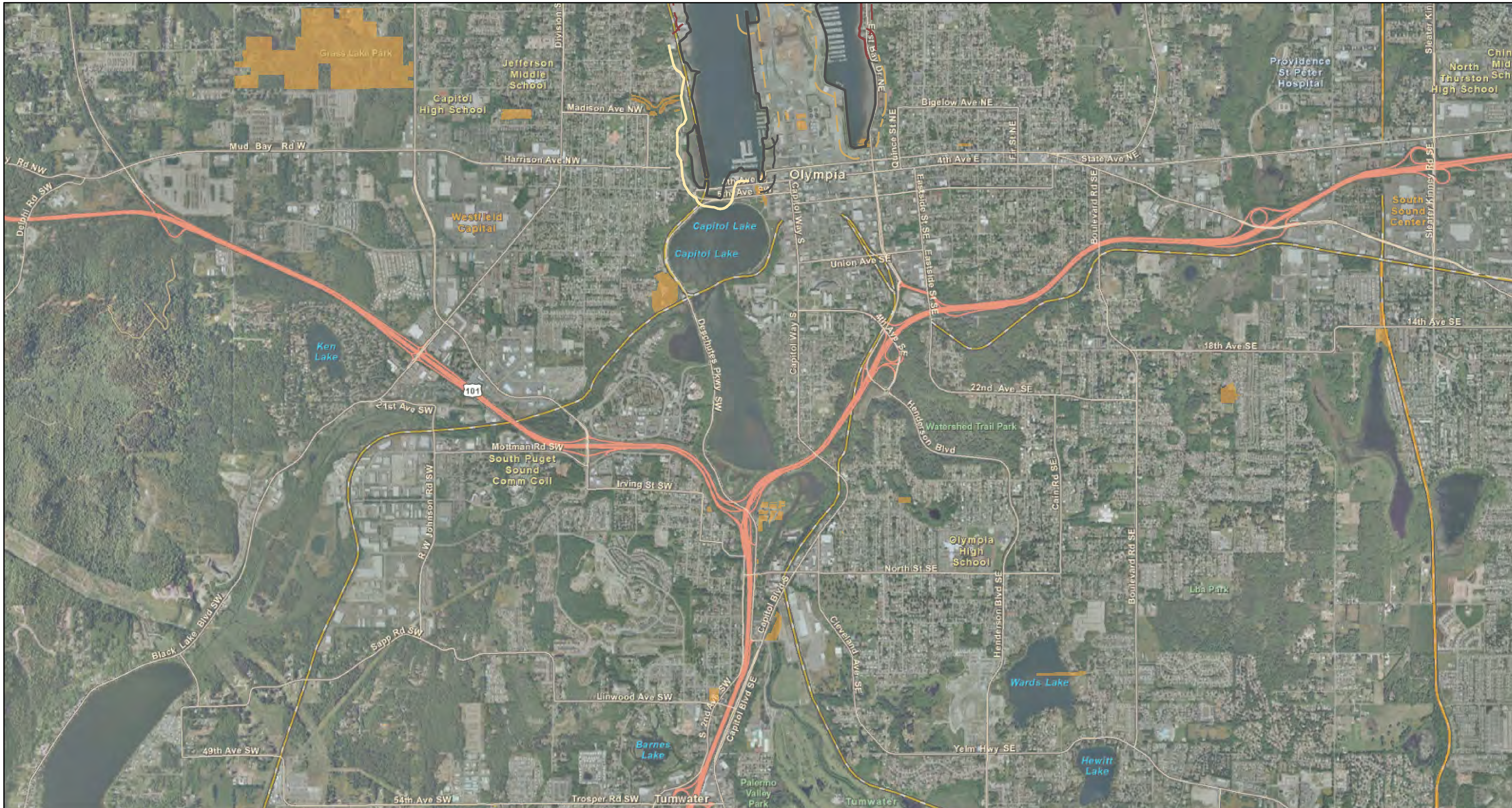

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Aerial Image and Shoreform Change
PSNERP ID: 1003
Candidate Restoration Site: Deschutes River Estuary

1,000 Feet
500 Meters

Legend

Ownership
- Public Land
- Tribal Land

PSNERP Historic Shoreform Type
- Artificial
- Barrier Beach
- Barrier Estuary
- Barrier Lagoon
- Bluffed-Backed Beach
- Closed Lagoon Marsh
- Delta
- Open Coastal Inlet
- Pocket Beach
- Pocket Lagoon
- Rocky Platform

PSNERP Shoreform Change Type
- Artificial
- Barrier Beach
- Barrier Estuary
- Barrier Lagoon
- Bluff-backed beach
- Closed Lagoon Marsh
- Delta
- Open Coastal Inlet
- Pocket Beach
- Pocket Lagoon
- Rocky Platform

N

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Aerial Image and Shoreform Change
PSNERP ID: 1012
Candidate Restoration Site: Duckabush River Delta

1,000 Feet

500 Meters

Legend

Ownership	PSNERP Historic Shoreform Type		PSNERP Shoreform Change Type	
Public Land	Artificial	Closed Lagoon Marsh	Artificial	Closed Lagoon Marsh
Tribal Land	Barrier Beach	Delta	Barrier Beach	Delta
	Barrier Estuary	Open Coastal Inlet	Barrier Estuary	Open Coastal Inlet
	Barrier Lagoon	Pocket Beach	Barrier Lagoon	Pocket Beach
	Bluffed-Backed Beach	Pocket Lagoon	Bluff-backed beach	Pocket Lagoon
		Rocky Platform		Rocky Platform

N

Aerial Image and Shoreform Change

PSNERP ID: 1609

Candidate Restoration Site: Dugualla Bay

1,000
Feet
500
Meters

Legend

Ownership
- Public Land
- Tribal Land

PSNERP Historic Shoreform Type
- Artificial
- Barrier Beach
- Barrier Estuary
- Barrier Lagoon
- Bluffed-Backed Beach
- Closed Lagoon Marsh
- Delta
- Open Coastal Inlet
- Pocket Beach
- Pocket Lagoon
- Rocky Platform

PSNERP Shoreform Change Type
- Artificial
- Barrier Beach
- Barrier Estuary
- Barrier Lagoon
- Bluff-backed beach
- Closed Lagoon Marsh
- Delta
- Open Coastal Inlet
- Pocket Beach
- Pocket Lagoon
- Rocky Platform

N

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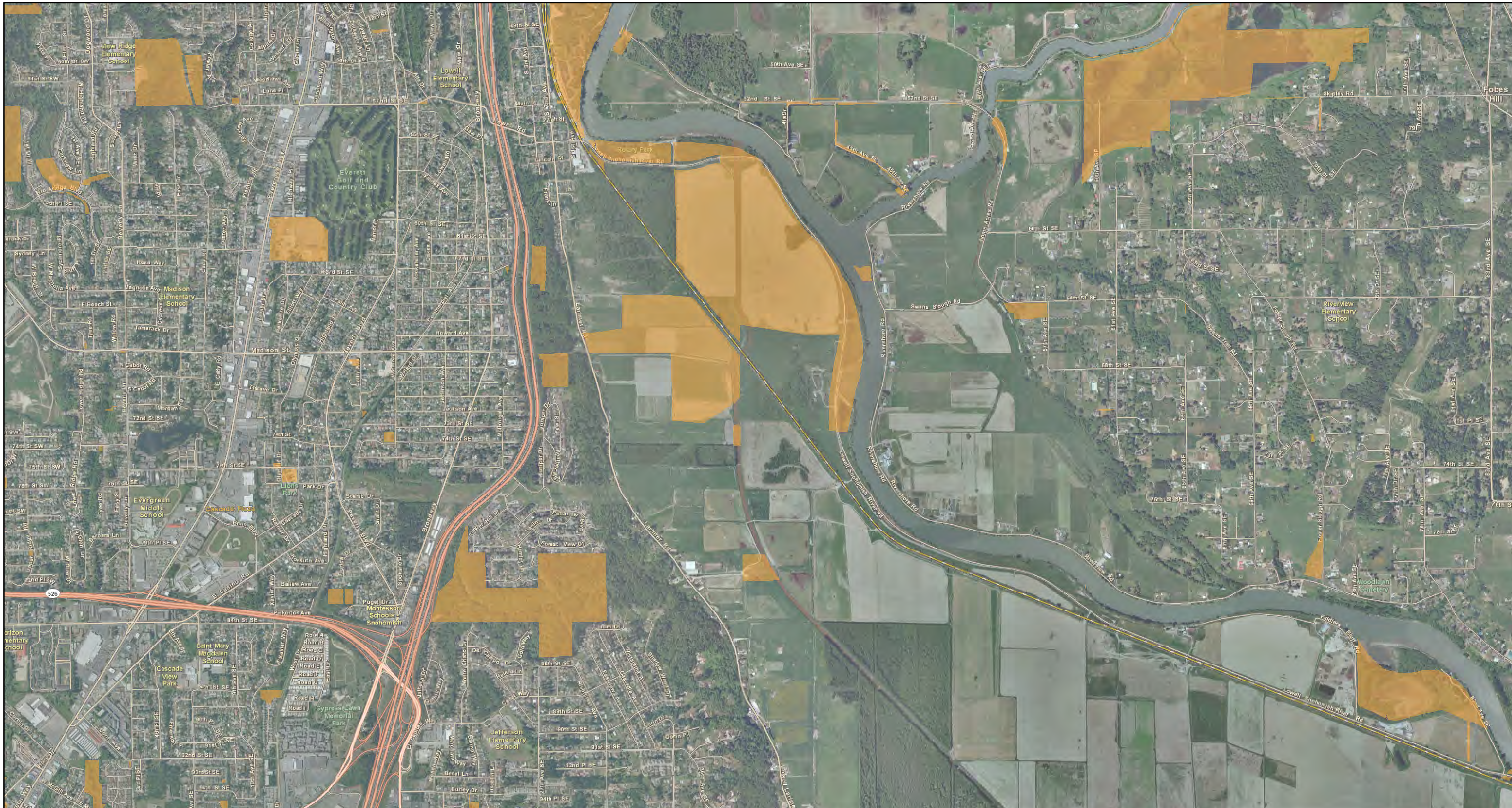

Aerial Image and Shoreform Change

PSNERP ID: 1126

Candidate Restoration Site: Everett Marshland

1,000 Feet

500 Meters

Legend

Ownership
- Public Land
- Tribal Land

PSNERP Historic Shoreform Type
- Artificial
- Barrier Beach
- Barrier Estuary
- Barrier Lagoon
- Bluffed-Backed Beach
- Closed Lagoon Marsh
- Delta
- Open Coastal Inlet
- Pocket Beach
- Pocket Lagoon
- Rocky Platform

PSNERP Shoreform Change Type
- Artificial
- Barrier Beach
- Barrier Estuary
- Barrier Lagoon
- Bluff-backed beach
- Closed Lagoon Marsh
- Delta
- Open Coastal Inlet
- Pocket Beach
- Pocket Lagoon
- Rocky Platform

N

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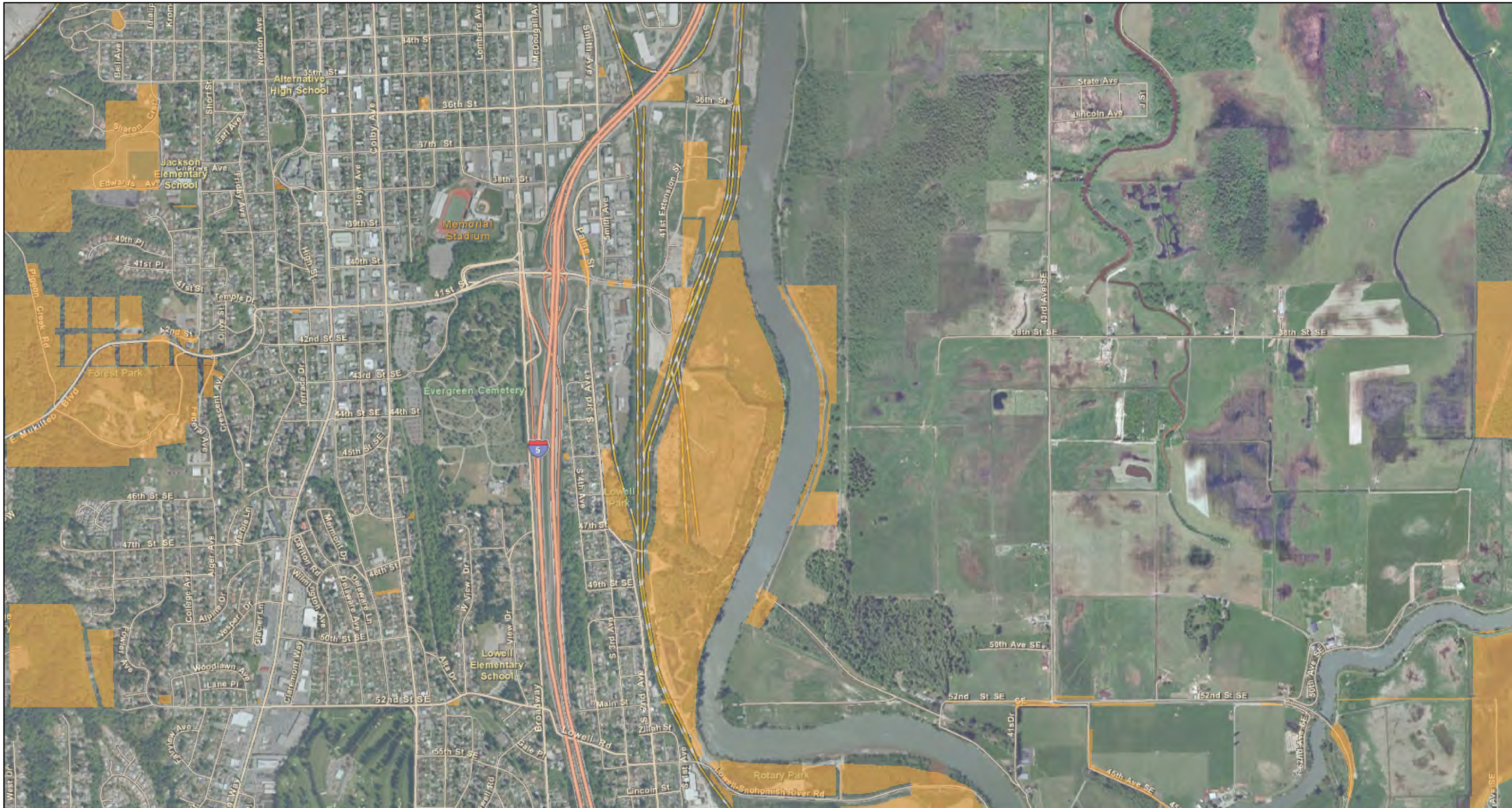

Aerial Image and Shoreform Change

PSNERP ID: 1127

Candidate Restoration Site: Everett Riverfront Wetland

1,000 Feet

500 Meters

Legend

Ownership
- Public Land
- Tribal Land

PSNERP Historic Shoreform Type
- Artificial
- Barrier Beach
- Barrier Estuary
- Barrier Lagoon
- Bluffed-Backed Beach
- Closed Lagoon Marsh
- Delta
- Open Coastal Inlet
- Pocket Beach
- Pocket Lagoon
- Rocky Platform

PSNERP Shoreform Change Type
- Artificial
- Barrier Beach
- Barrier Estuary
- Barrier Lagoon
- Bluff-backed beach
- Closed Lagoon Marsh
- Delta
- Open Coastal Inlet
- Pocket Beach
- Pocket Lagoon
- Rocky Platform

N

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Aerial Image and Shoreform Change

PSNERP ID: 1047

Candidate Restoration Site: Hamma Hamma River Delta

1,000 Feet

500 Meters

Legend

Ownership
- Public Land
- Tribal Land

PSNERP Historic Shoreform Type
- Artificial
- Barrier Beach
- Barrier Estuary
- Barrier Lagoon
- Bluffed-Backed Beach
- Closed Lagoon Marsh
- Delta
- Open Coastal Inlet
- Pocket Beach
- Pocket Lagoon
- Rocky Platform

PSNERP Shoreform Change Type
- Artificial
- Barrier Beach
- Barrier Estuary
- Barrier Lagoon
- Bluff-backed beach
- Closed Lagoon Marsh
- Delta
- Open Coastal Inlet
- Pocket Beach
- Pocket Lagoon
- Rocky Platform

N

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Aerial Image and Shoreform Change

PSNERP ID: 1505

Candidate Restoration Site: Harper Estuary

1,000 Feet

500 Meters

Legend

Ownership
- Public Land
- Tribal Land

PSNERP Historic Shoreform Type
- Artificial
- Barrier Beach
- Barrier Estuary
- Barrier Lagoon
- Bluffed-Backed Beach
- Closed Lagoon Marsh
- Delta
- Open Coastal Inlet
- Pocket Beach
- Pocket Lagoon
- Rocky Platform

PSNERP Shoreform Change Type
- Artificial
- Barrier Beach
- Barrier Estuary
- Barrier Lagoon
- Bluff-backed beach
- Closed Lagoon Marsh
- Delta
- Open Coastal Inlet
- Pocket Beach
- Pocket Lagoon
- Rocky Platform

N

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Aerial Image and Shoreform Change
PSNERP ID: 1447
Candidate Restoration Site: John's Creek Estuary

1,000
Feet
500
Meters

Legend

Ownership
- Public Land
- Tribal Land

PSNERP Historic Shoreform Type
- Artificial
- Barrier Beach
- Barrier Estuary
- Barrier Lagoon
- Bluffed-Backed Beach
- Closed Lagoon Marsh
- Delta
- Open Coastal Inlet
- Pocket Beach
- Pocket Lagoon
- Rocky Platform

PSNERP Shoreform Change Type
- Artificial
- Barrier Beach
- Barrier Estuary
- Barrier Lagoon
- Bluff-backed beach
- Closed Lagoon Marsh
- Delta
- Open Coastal Inlet
- Pocket Beach
- Pocket Lagoon
- Rocky Platform

N

Aerial Image and Shoreform Change
PSNERP ID: 1552
Candidate Restoration Site: Oak Bay

1,000
Feet
500
Meters

Legend

Ownership
Public Land
Tribal Land

PSNERP Historic Shoreform Type
Artificial
Barrier Beach
Barrier Estuary
Barrier Lagoon
Bluffed-Backed Beach
Closed Lagoon Marsh
Delta
Open Coastal Inlet
Pocket Beach
Pocket Lagoon
Rocky Platform

PSNERP Shoreform Change Type
Artificial
Barrier Beach
Barrier Estuary
Barrier Lagoon
Bluff-backed beach
Closed Lagoon Marsh
Delta
Open Coastal Inlet
Pocket Beach
Pocket Lagoon
Rocky Platform

N

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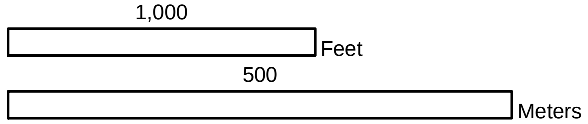
Aerial Image and Shoreform Change

PSNERP ID: 1552

Candidate Restoration Site: Oak Bay



Legend

Ownership
- Public Land
- Tribal Land

PSNERP Historic Shoreform Type
- Artificial
- Barrier Beach
- Barrier Estuary
- Barrier Lagoon
- Bluffed-Backed Beach
- Closed Lagoon Marsh
- Delta
- Open Coastal Inlet
- Pocket Beach
- Pocket Lagoon
- Rocky Platform

PSNERP Shoreform Change Type
- Artificial
- Barrier Beach
- Barrier Estuary
- Barrier Lagoon
- Bluff-backed beach
- Closed Lagoon Marsh
- Delta
- Open Coastal Inlet
- Pocket Beach
- Pocket Lagoon
- Rocky Platform

N

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Aerial Image and Shoreform Change

PSNERP ID: 1346

Candidate Restoration Site: Lilliwaup River and Sund Creek Estuaries

1,000 Feet

500 Meters

Legend

Ownership
- Public Land
- Tribal Land

PSNERP Historic Shoreform Type
- Artificial
- Barrier Beach
- Barrier Estuary
- Barrier Lagoon
- Bluffed-Backed Beach
- Closed Lagoon Marsh
- Delta
- Open Coastal Inlet
- Pocket Beach
- Pocket Lagoon
- Rocky Platform

PSNERP Shoreform Change Type
- Artificial
- Barrier Beach
- Barrier Estuary
- Barrier Lagoon
- Bluff-backed beach
- Closed Lagoon Marsh
- Delta
- Open Coastal Inlet
- Pocket Beach
- Pocket Lagoon
- Rocky Platform

N

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Aerial Image and Shoreform Change

PSNERP ID: 1618

Candidate Restoration Site: Livingston Bay

1,000 Feet

500 Meters

Legend

Ownership

- Public Land
- Tribal Land

PSNERP Historic Shoreform Type

- Artificial
- Barrier Beach
- Barrier Estuary
- Barrier Lagoon
- Bluffed-Backed Beach
- Closed Lagoon Marsh
- Delta
- Open Coastal Inlet
- Pocket Beach
- Pocket Lagoon
- Rocky Platform

PSNERP Shoreform Change Type

- Artificial
- Barrier Beach
- Barrier Estuary
- Barrier Lagoon
- Bluff-backed beach
- Closed Lagoon Marsh
- Delta
- Open Coastal Inlet
- Pocket Beach
- Pocket Lagoon
- Rocky Platform

N

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Aerial Image and Shoreform Change

PSNERP ID: 1092

Candidate Restoration Site: McGlinn Island

1,000 Feet

500 Meters

Legend

Ownership
- Public Land
- Tribal Land

PSNERP Historic Shoreform Type
- Artificial
- Barrier Beach
- Barrier Estuary
- Barrier Lagoon
- Bluffed-Backed Beach
- Closed Lagoon Marsh
- Delta
- Open Coastal Inlet
- Pocket Beach
- Pocket Lagoon
- Rocky Platform

PSNERP Shoreform Change Type
- Artificial
- Barrier Beach
- Barrier Estuary
- Barrier Lagoon
- Bluff-backed beach
- Closed Lagoon Marsh
- Delta
- Open Coastal Inlet
- Pocket Beach
- Pocket Lagoon
- Rocky Platform

N

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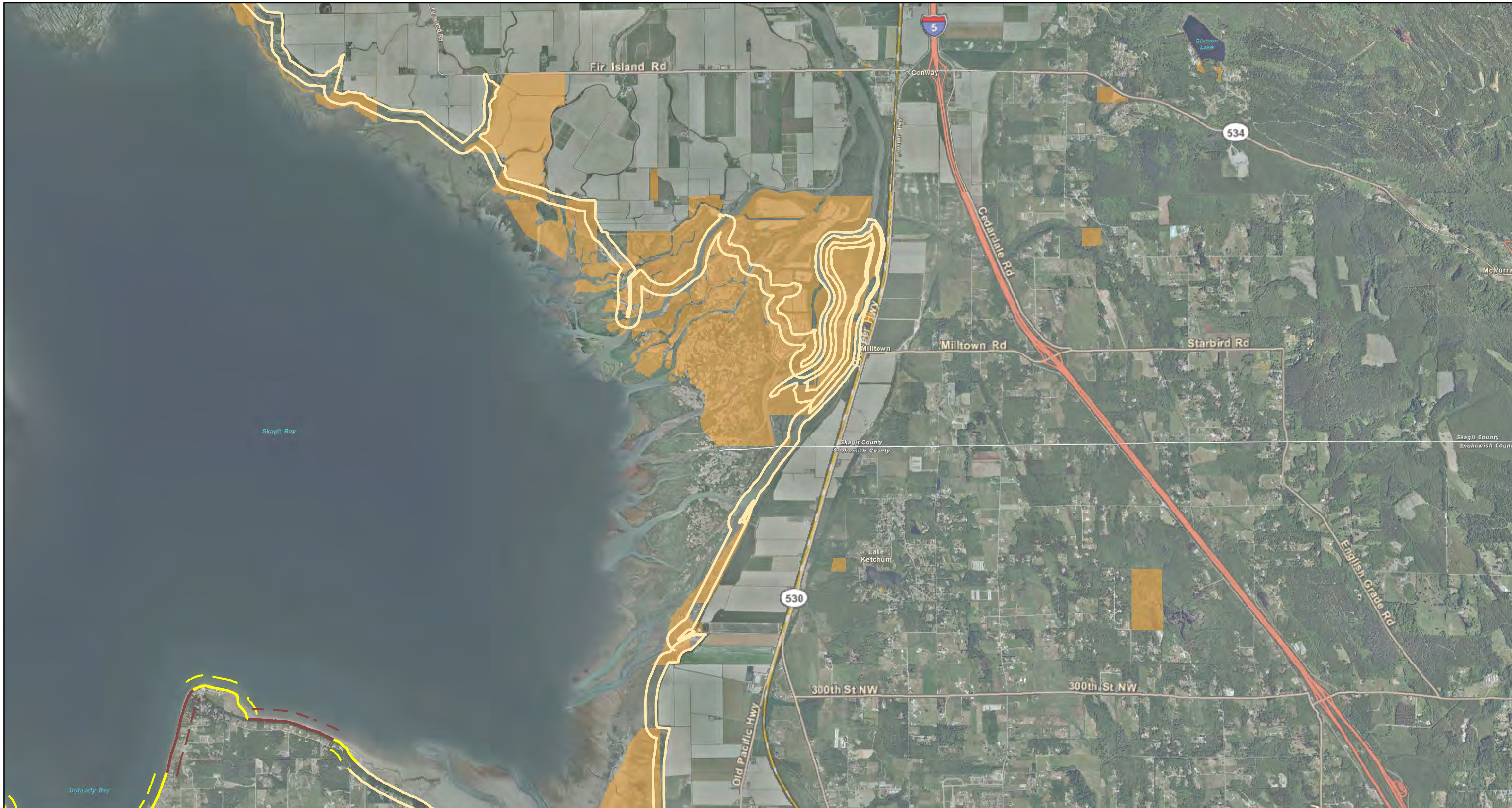

Aerial Image and Shoreform Change

PSNERP ID: 1091, 1101

Candidate Restoration Site: Milltown Island, Deepwater Slough Phase 2

1,000 Feet
500 Meters

Legend

Ownership
- Public Land
- Tribal Land

PSNERP Historic Shoreform Type
- Artificial
- Barrier Beach
- Barrier Estuary
- Barrier Lagoon
- Bluffed-Backed Beach
- Closed Lagoon Marsh
- Delta
- Open Coastal Inlet
- Pocket Beach
- Pocket Lagoon
- Rocky Platform

PSNERP Shoreform Change Type
- Artificial
- Barrier Beach
- Barrier Estuary
- Barrier Lagoon
- Bluff-backed beach
- Closed Lagoon Marsh
- Delta
- Open Coastal Inlet
- Pocket Beach
- Pocket Lagoon
- Rocky Platform

N

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Aerial Image and Shoreform Change

PSNERP ID: 1457

Candidate Restoration Site: Mission Creek Estuary

1,000 Feet

500 Meters

Legend

Ownership
- Public Land
- Tribal Land

PSNERP Historic Shoreform Type
- Artificial
- Barrier Beach
- Barrier Estuary
- Barrier Lagoon
- Bluffed-Backed Beach
- Closed Lagoon Marsh
- Delta
- Open Coastal Inlet
- Pocket Beach
- Pocket Lagoon
- Rocky Platform

PSNERP Shoreform Change Type
- Artificial
- Barrier Beach
- Barrier Estuary
- Barrier Lagoon
- Bluff-backed beach
- Closed Lagoon Marsh
- Delta
- Open Coastal Inlet
- Pocket Beach
- Pocket Lagoon
- Rocky Platform

N

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Aerial Image and Shoreform Change
PSNERP ID: 1190
Candidate Restoration Site: Twin Rivers

1,000
Feet
500
Meters

Legend

Ownership
Public Land
Tribal Land

PSNERP Historic Shoreform Type
Artificial
Barrier Beach
Barrier Estuary
Barrier Lagoon
Bluffed-Backed Beach
Closed Lagoon Marsh
Delta
Open Coastal Inlet
Pocket Beach
Pocket Lagoon
Rocky Platform

PSNERP Shoreform Change Type
Artificial
Barrier Beach
Barrier Estuary
Barrier Lagoon
Bluff-backed beach
Closed Lagoon Marsh
Delta
Open Coastal Inlet
Pocket Beach
Pocket Lagoon
Rocky Platform

N

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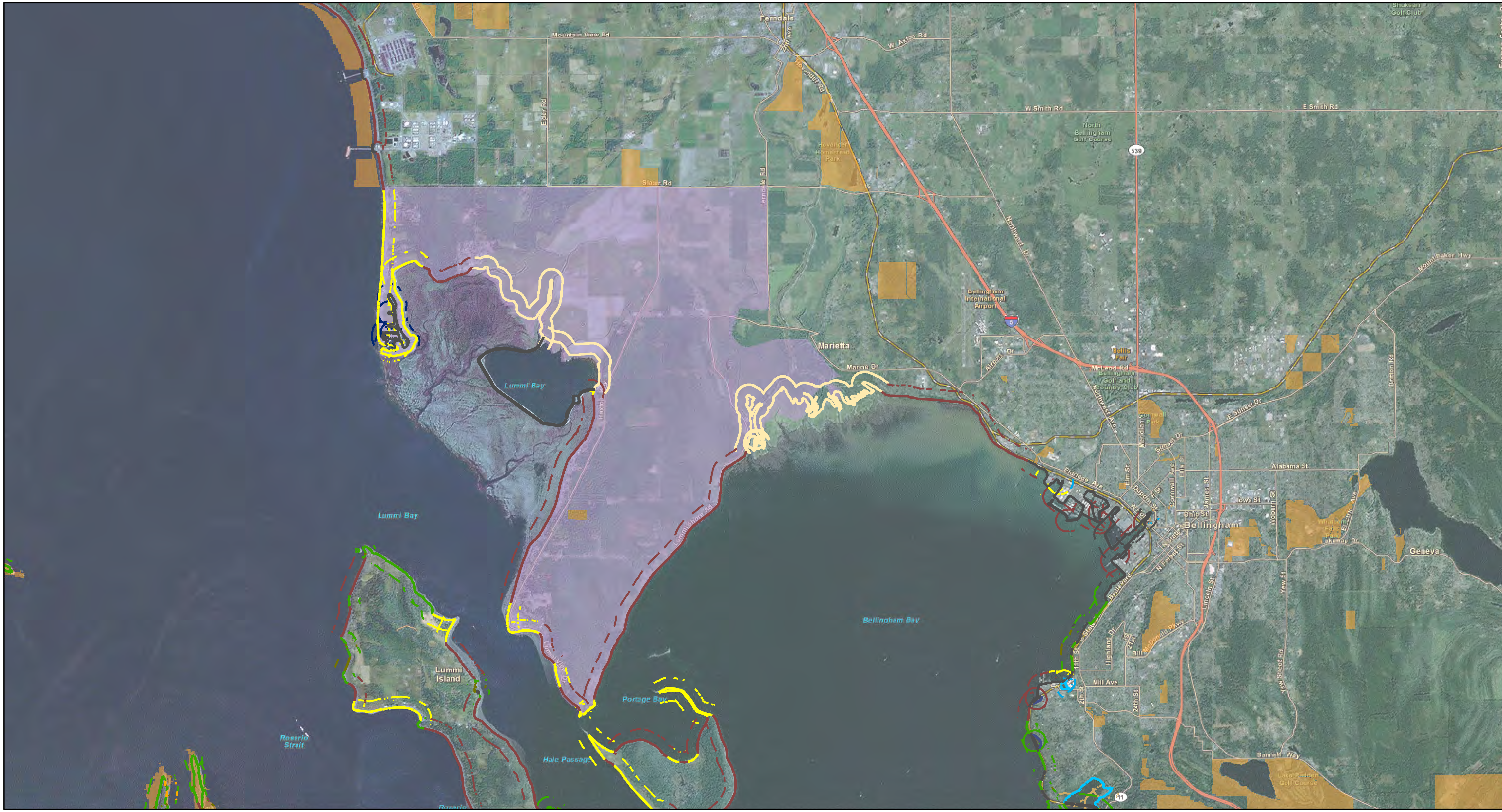

Aerial Image and Shoreform Change
PSNERP ID: 1055
Candidate Restoration Site: Nooksack River Delta

1,000 Feet
500 Meters

Legend

Ownership
- Public Land
- Tribal Land

PSNERP Historic Shoreform Type
- Artificial
- Barrier Beach
- Barrier Estuary
- Barrier Lagoon
- Bluffed-Backed Beach
- Closed Lagoon Marsh
- Delta
- Open Coastal Inlet
- Pocket Beach
- Pocket Lagoon
- Rocky Platform

PSNERP Shoreform Change Type
- Artificial
- Barrier Beach
- Barrier Estuary
- Barrier Lagoon
- Bluff-backed beach
- Closed Lagoon Marsh
- Delta
- Open Coastal Inlet
- Pocket Beach
- Pocket Lagoon
- Rocky Platform

N

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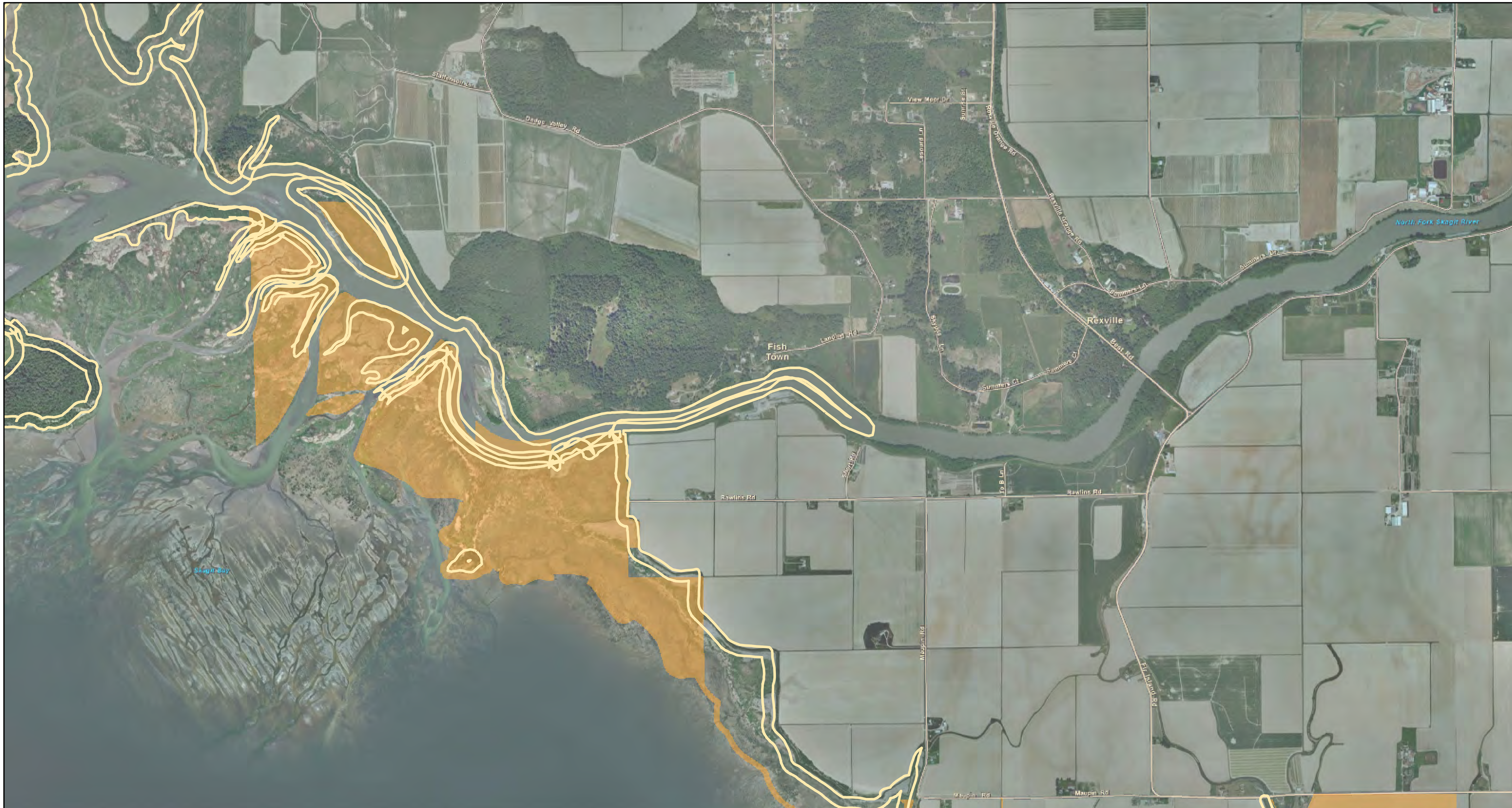

Aerial Image and Shoreform Change

PSNERP ID: 1102

Candidate Restoration Site: Skagit

1,000 Feet

500 Meters

Legend

Ownership
- Public Land
- Tribal Land

PSNERP Historic Shoreform Type
- Artificial
- Barrier Beach
- Barrier Estuary
- Barrier Lagoon
- Bluffed-Backed Beach
- Closed Lagoon Marsh
- Delta
- Open Coastal Inlet
- Pocket Beach
- Pocket Lagoon
- Rocky Platform

PSNERP Shoreform Change Type
- Artificial
- Barrier Beach
- Barrier Estuary
- Barrier Lagoon
- Bluff-backed beach
- Closed Lagoon Marsh
- Delta
- Open Coastal Inlet
- Pocket Beach
- Pocket Lagoon
- Rocky Platform

N

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Aerial Image and Shoreform Change

PSNERP ID: 1379

Candidate Restoration Site: Point Whitney Lagoon

1,000 Feet

500 Meters

Legend

Ownership
- Public Land
- Tribal Land

PSNERP Historic Shoreform Type
- Artificial
- Barrier Beach
- Barrier Estuary
- Barrier Lagoon
- Bluffed-Backed Beach
- Closed Lagoon Marsh
- Delta
- Open Coastal Inlet
- Pocket Beach
- Pocket Lagoon
- Rocky Platform

PSNERP Shoreform Change Type
- Artificial
- Barrier Beach
- Barrier Estuary
- Barrier Lagoon
- Bluff-backed beach
- Closed Lagoon Marsh
- Delta
- Open Coastal Inlet
- Pocket Beach
- Pocket Lagoon
- Rocky Platform

N

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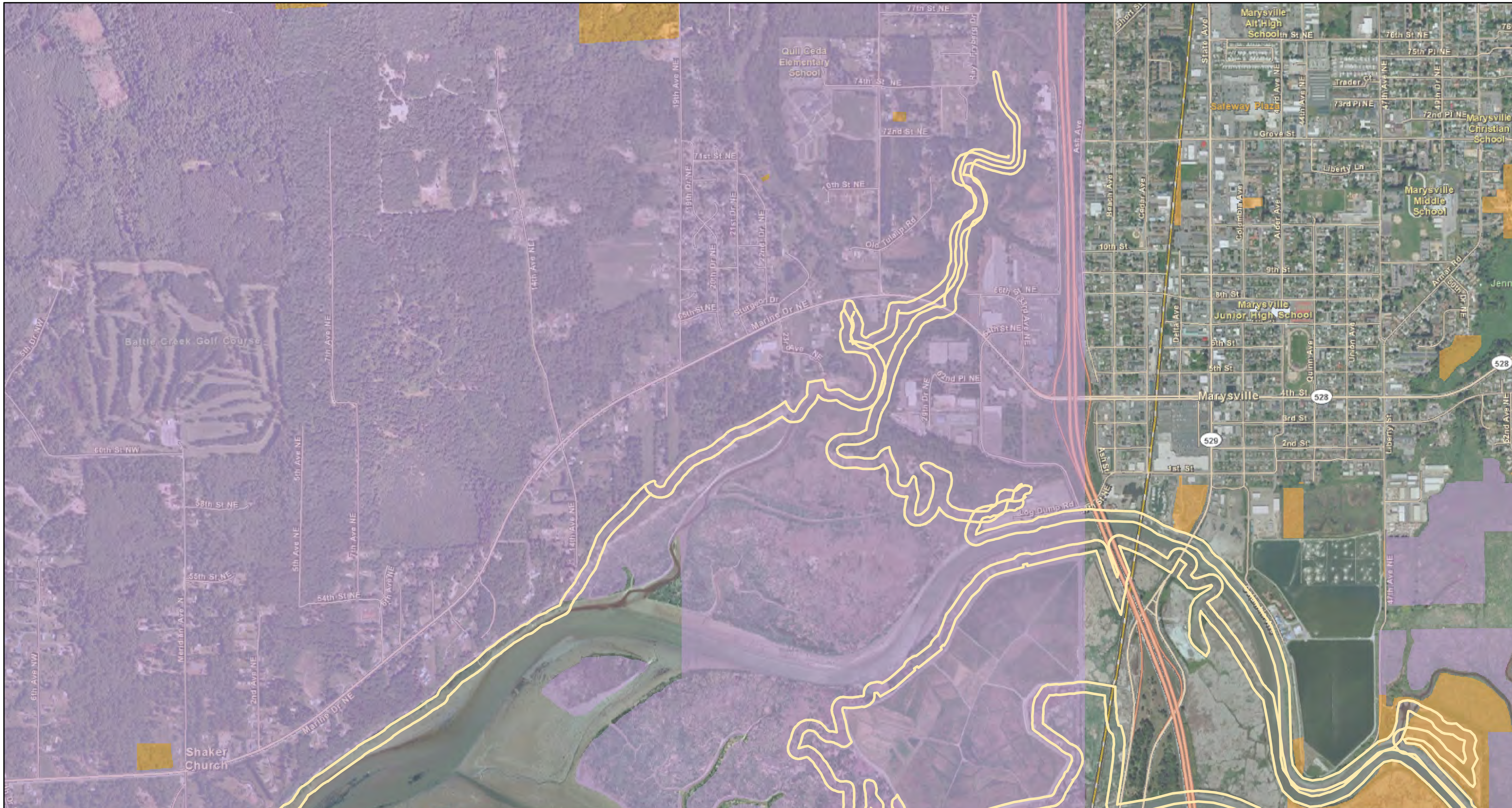

Aerial Image and Shoreform Change

PSNERP ID: 1136

Candidate Restoration Site: Quilceda Estuary

1,000

Feet

500

Meters

Legend

Ownership
- Public Land
- Tribal Land

PSNERP Historic Shoreform Type
- Artificial
- Barrier Beach
- Barrier Estuary
- Barrier Lagoon
- Bluffed-Backed Beach
- Closed Lagoon Marsh
- Delta
- Open Coastal Inlet
- Pocket Beach
- Pocket Lagoon
- Rocky Platform

PSNERP Shoreform Change Type
- Artificial
- Barrier Beach
- Barrier Estuary
- Barrier Lagoon
- Bluff-backed beach
- Closed Lagoon Marsh
- Delta
- Open Coastal Inlet
- Pocket Beach
- Pocket Lagoon
- Rocky Platform

N

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Aerial Image and Shoreform Change
PSNERP ID: 1467
Candidate Restoration Site: Sequalitchew Creek Estuary

1,000 Feet
500 Meters

Legend

Ownership
- Public Land
- Tribal Land

PSNERP Historic Shoreform Type
- Artificial
- Barrier Beach
- Barrier Estuary
- Barrier Lagoon
- Bluffed-Backed Beach
- Closed Lagoon Marsh
- Delta
- Open Coastal Inlet
- Pocket Beach
- Pocket Lagoon
- Rocky Platform

PSNERP Shoreform Change Type
- Artificial
- Barrier Beach
- Barrier Estuary
- Barrier Lagoon
- Bluff-backed beach
- Closed Lagoon Marsh
- Delta
- Open Coastal Inlet
- Pocket Beach
- Pocket Lagoon
- Rocky Platform

N

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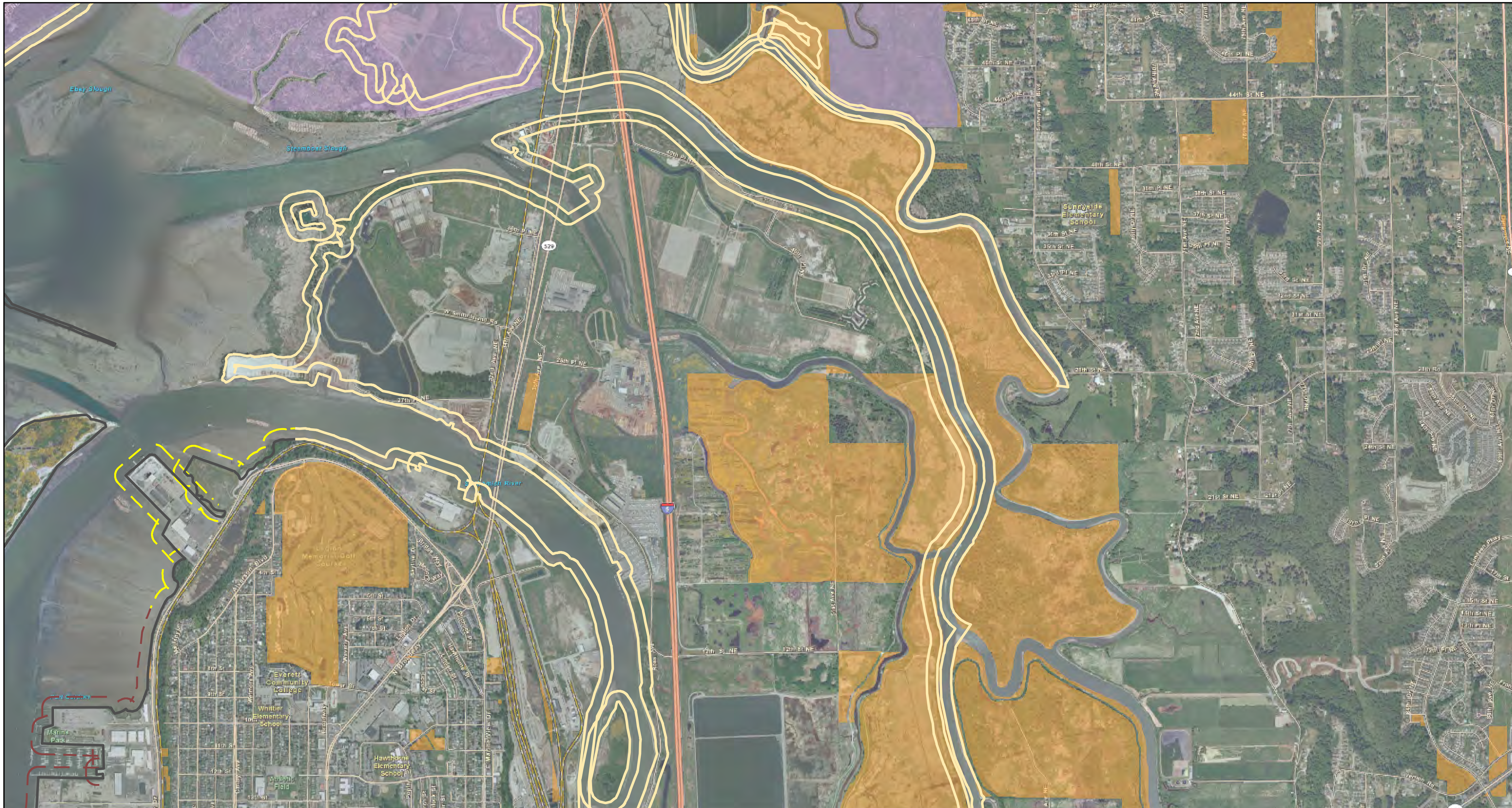

Aerial Image and Shoreform Change

PSNERP ID: 1142

Candidate Restoration Site: Smith Island

1,000 Feet

500 Meters

Legend

Ownership
- Public Land
- Tribal Land

PSNERP Historic Shoreform Type
- Artificial
- Barrier Beach
- Barrier Estuary
- Barrier Lagoon
- Bluffed-Backed Beach
- Closed Lagoon Marsh
- Delta
- Open Coastal Inlet
- Pocket Beach
- Pocket Lagoon
- Rocky Platform

PSNERP Shoreform Change Type
- Artificial
- Barrier Beach
- Barrier Estuary
- Barrier Lagoon
- Bluff-backed beach
- Closed Lagoon Marsh
- Delta
- Open Coastal Inlet
- Pocket Beach
- Pocket Lagoon
- Rocky Platform

N

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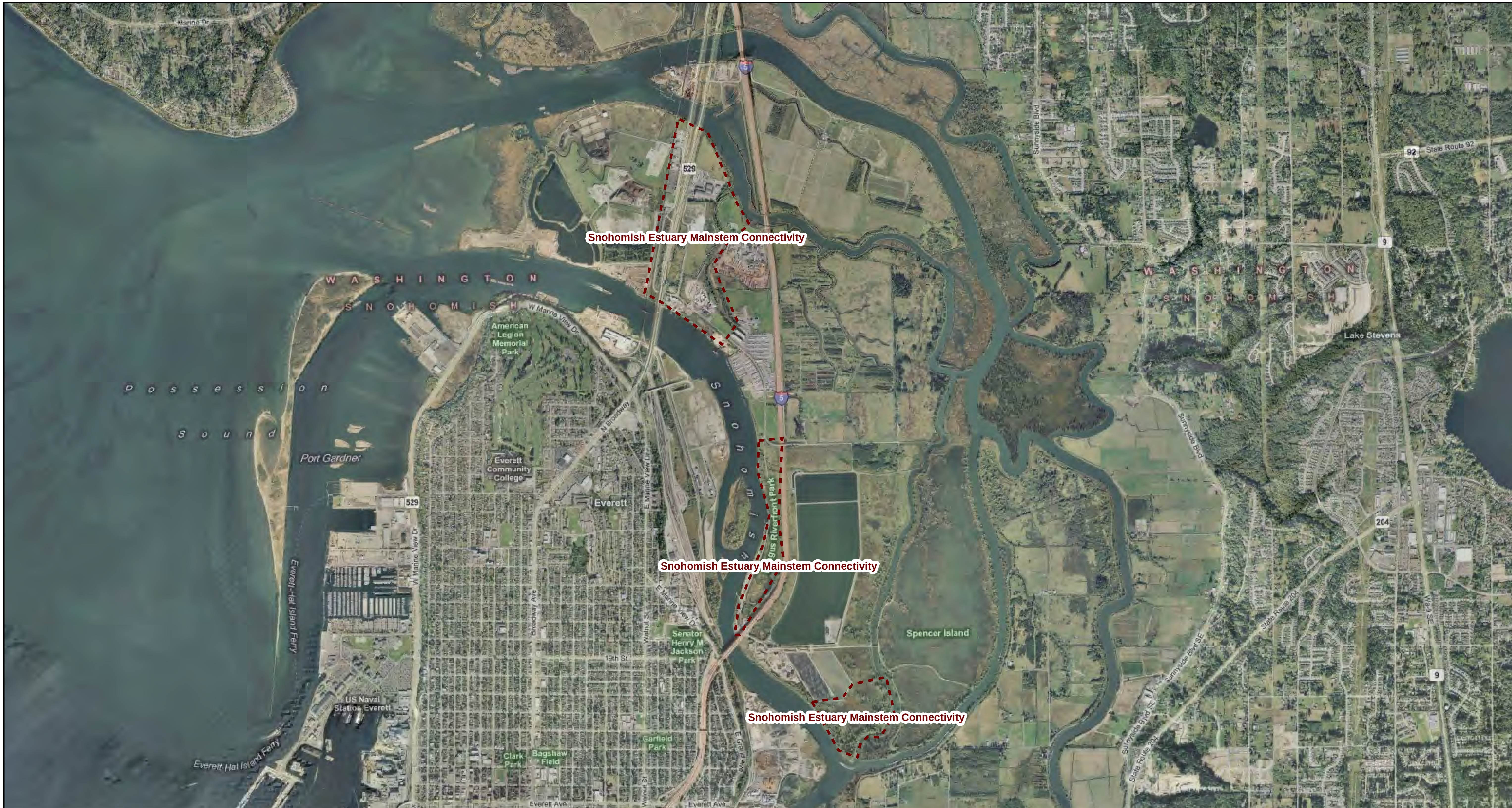

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PSNERP Action Area
PSNERP ID: N/A
Candidate Restoration Site: Snohomish Estuary Mainstem Connectivity

Legend
PSNERP Action Area

0 625 1,250 2,500 Feet

N

Aerial Image and Shoreform Change

PSNERP ID: 1230

Candidate Restoration Site: Discovery Bay

1,000 Feet

500 Meters

Legend

Ownership
- Public Land
- Tribal Land

PSNERP Historic Shoreform Type
- Artificial
- Barrier Beach
- Barrier Estuary
- Barrier Lagoon
- Bluffed-Backed Beach
- Closed Lagoon Marsh
- Delta
- Open Coastal Inlet
- Pocket Beach
- Pocket Lagoon
- Rocky Platform

PSNERP Shoreform Change Type
- Artificial
- Barrier Beach
- Barrier Estuary
- Barrier Lagoon
- Bluff-backed beach
- Closed Lagoon Marsh
- Delta
- Open Coastal Inlet
- Pocket Beach
- Pocket Lagoon
- Rocky Platform

N

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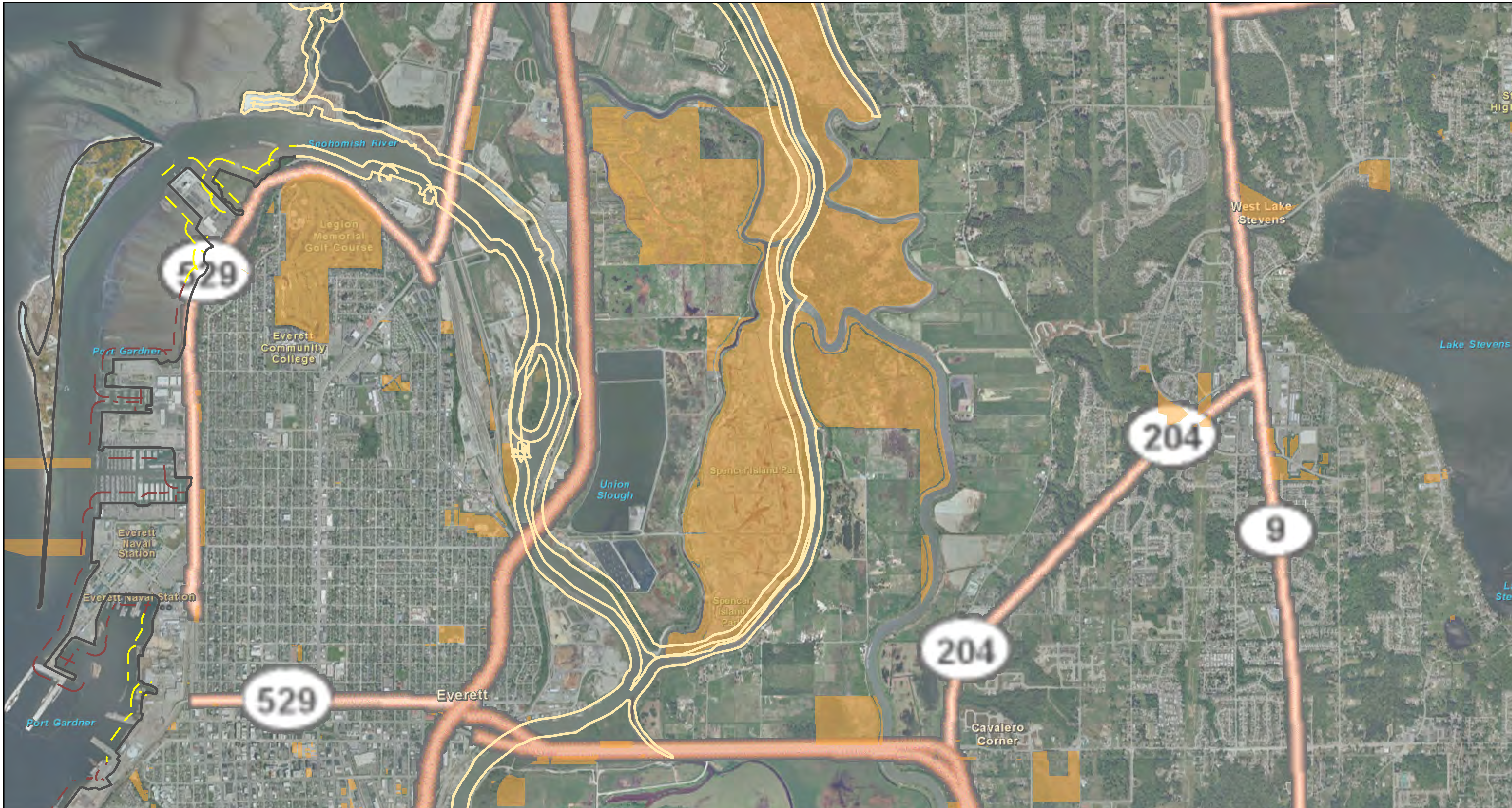

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Aerial Image and Shoreform Change

PSNERP ID: 1149

Candidate Restoration Site: Spencer Island

1,000 Feet

500 Meters

Legend

Ownership
- Public Land
- Tribal Land

PSNERP Historic Shoreform Type
- Artificial
- Barrier Beach
- Barrier Estuary
- Barrier Lagoon
- Bluffed-Backed Beach
- Closed Lagoon Marsh
- Delta
- Open Coastal Inlet
- Pocket Beach
- Pocket Lagoon
- Rocky Platform

PSNERP Shoreform Change Type
- Artificial
- Barrier Beach
- Barrier Estuary
- Barrier Lagoon
- Bluff-backed beach
- Closed Lagoon Marsh
- Delta
- Open Coastal Inlet
- Pocket Beach
- Pocket Lagoon
- Rocky Platform

N

Aerial Image and Shoreform Change
PSNERP ID: 1404
Candidate Restoration Site: Tahuya River Estuary

1,000 Feet

500 Meters

Legend

Ownership
- Public Land
- Tribal Land

PSNERP Historic Shoreform Type
- Artificial
- Barrier Beach
- Barrier Estuary
- Barrier Lagoon
- Bluffed-Backed Beach
- Closed Lagoon Marsh
- Delta
- Open Coastal Inlet
- Pocket Beach
- Pocket Lagoon
- Rocky Platform

PSNERP Shoreform Change Type
- Artificial
- Barrier Beach
- Barrier Estuary
- Barrier Lagoon
- Bluff-backed beach
- Closed Lagoon Marsh
- Delta
- Open Coastal Inlet
- Pocket Beach
- Pocket Lagoon
- Rocky Platform

N

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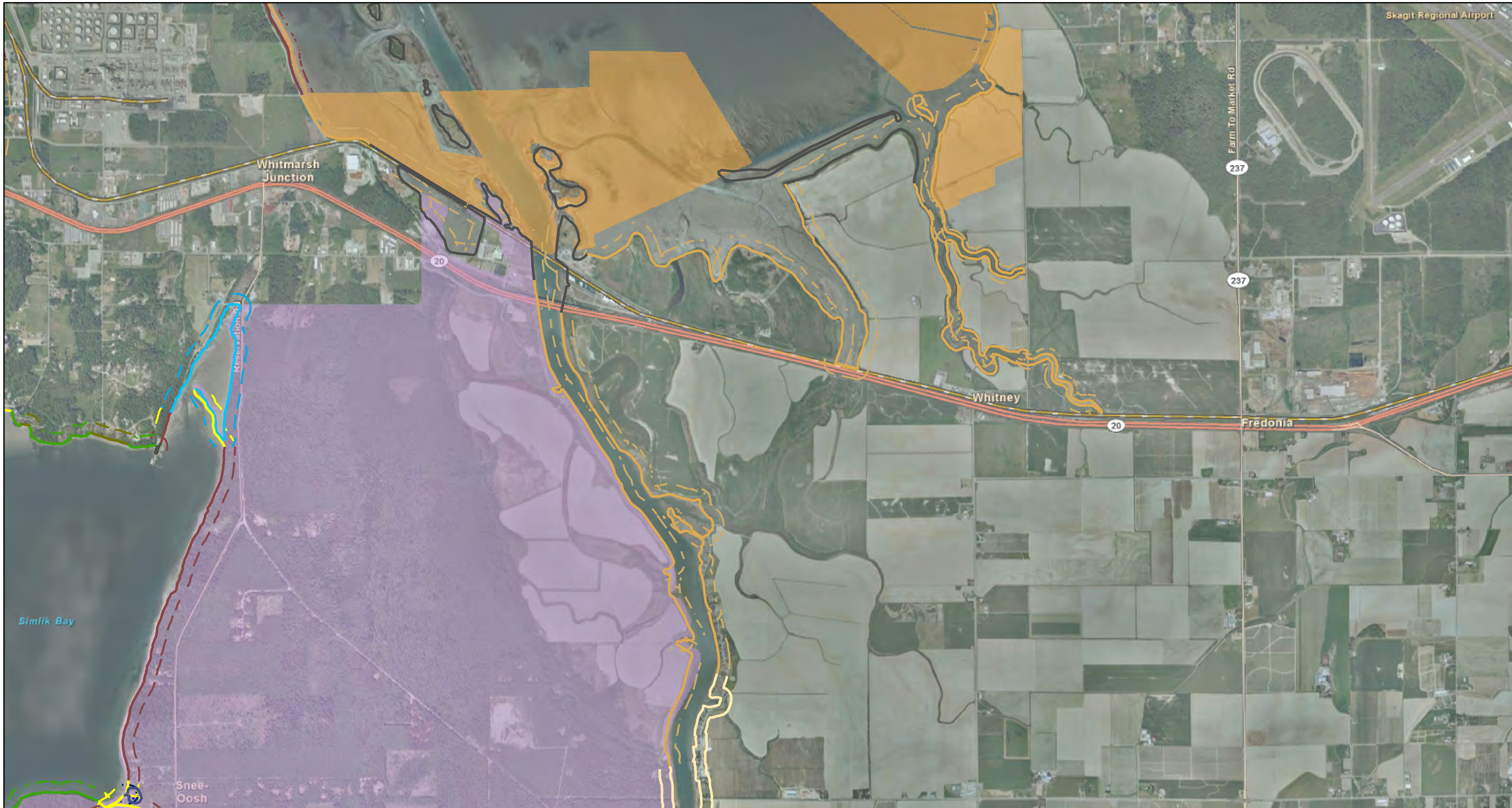

Aerial Image and Shoreform Change

PSNERP ID: 1633, 1635

Candidate Restoration Site: Telegraph Slough

1,000 Feet

500 Meters

Legend

Ownership
- Public Land
- Tribal Land

PSNERP Historic Shoreform Type
- Artificial
- Barrier Beach
- Barrier Estuary
- Barrier Lagoon
- Bluffed-Backed Beach
- Closed Lagoon Marsh
- Delta
- Open Coastal Inlet
- Pocket Beach
- Pocket Lagoon
- Rocky Platform

PSNERP Shoreform Change Type
- Artificial
- Barrier Beach
- Barrier Estuary
- Barrier Lagoon
- Bluff-backed beach
- Closed Lagoon Marsh
- Delta
- Open Coastal Inlet
- Pocket Beach
- Pocket Lagoon
- Rocky Platform

N

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Aerial Image and Shoreform Change

PSNERP ID: 1421

Candidate Restoration Site: Twanoh Drift Cell

1,000 Feet

500 Meters

Legend

Ownership
- Public Land
- Tribal Land

PSNERP Historic Shoreform Type
- Artificial
- Barrier Beach
- Barrier Estuary
- Barrier Lagoon
- Bluffed-Backed Beach
- Closed Lagoon Marsh
- Delta
- Open Coastal Inlet
- Pocket Beach
- Pocket Lagoon
- Rocky Platform

PSNERP Shoreform Change Type
- Artificial
- Barrier Beach
- Barrier Estuary
- Barrier Lagoon
- Bluff-backed beach
- Closed Lagoon Marsh
- Delta
- Open Coastal Inlet
- Pocket Beach
- Pocket Lagoon
- Rocky Platform

N

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Aerial Image and Shoreform Change
PSNERP ID: 1237
Candidate Restoration Site: Sequim Bay

1,000 Feet
500 Meters

Legend

Ownership
- Public Land
- Tribal Land

PSNERP Historic Shoreform Type
- Artificial
- Barrier Beach
- Barrier Estuary
- Barrier Lagoon
- Bluffed-Backed Beach
- Closed Lagoon Marsh
- Delta
- Open Coastal Inlet
- Pocket Beach
- Pocket Lagoon
- Rocky Platform

PSNERP Shoreform Change Type
- Artificial
- Barrier Beach
- Barrier Estuary
- Barrier Lagoon
- Bluff-backed beach
- Closed Lagoon Marsh
- Delta
- Open Coastal Inlet
- Pocket Beach
- Pocket Lagoon
- Rocky Platform

N

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Aerial Image and Shoreform Change

PSNERP ID: 1684

Candidate Restoration Site: WDNR Marine

1,000 Feet

500 Meters

Legend

Ownership
- Public Land
- Tribal Land

PSNERP Historic Shoreform Type
- Artificial
- Barrier Beach
- Barrier Estuary
- Barrier Lagoon
- Bluffed-Backed Beach
- Closed Lagoon Marsh
- Delta
- Open Coastal Inlet
- Pocket Beach
- Pocket Lagoon
- Rocky Platform

PSNERP Shoreform Change Type
- Artificial
- Barrier Beach
- Barrier Estuary
- Barrier Lagoon
- Bluff-backed beach
- Closed Lagoon Marsh
- Delta
- Open Coastal Inlet
- Pocket Beach
- Pocket Lagoon
- Rocky Platform

N

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