WRIA 1 Nearshore & Estuarine Assessment and Restoration Prioritization

Prepared for: The City of Bellingham
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Coastal Geologic Services
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Executive Summary

Water Resource Inventory Area 1 (WRIA 1) has lacked a comprehensive assessment to strategically inform marine nearshore restoration and protection planning and implementation activities. Many opportunities exist to ameliorate conditions in the WRIA 1 marine and estuarine nearshore ecosystems, which could also provide substantial benefit to Nooksack salmon, other nonnatal salmon, and the larger nearshore ecosystem in WRIA 1. The goal of this project was to assess conditions and develop and apply a restoration and protection prioritization tool, the results of which would guide restoration and protection efforts for the estuarine and marine shores of WRIA 1.

WRIA 1 marine and estuarine nearshore conditions were assessed by reviewing literature, local and regional data, digital imagery such as LIDAR, and vertical and oblique aerial photography. Data sources, ranging in scale from regional analyses to site-specific local studies, were reviewed and brought into Geographic Information Systems (GIS) where spatial data was available to assess current conditions and for potential utility in the prioritization. Conceptual models, peer reviewed studies, and multiscaled maps and assessments produced by the Puget Sound Nearshore Ecosystem Restoration Project (PSNERP), Washington Department of Natural Resources (WDNR) and Washington Department of Fish and Wildlife (WDFW) were key data sources.

Assessment results highlighted the unique conditions in WRIA 1, particularly the diversity of coastal landforms and the interconnected nature of nearshore processes, structures, and vital habitats which communally support the nearshore ecosystem. The scale and magnitude of anthropogenic alterations to WRIA 1 nearshore and estuarine ecosystem processes were also assessed. Results showed that the most widespread changes since historical conditions were the loss of natural shorelines resulting from shoreline modifications and other stressors. A considerable length of the study area is considered “artificial” or so heavily degraded that it no longer functions or resembles the historical configuration. Numerous tidal barriers found in the Nooksack River Delta and marine nearshore were associated with coastal roads and the BNSF (Burlington Northern Santa Fe) rail causeway. The widespread nature of shore modifications and tidal barriers has resulted in considerable degradation to sediment supply and tidal flow processes along the WRIA 1 nearshore.

Following assessment, data gaps were identified and prioritized; this included recommendations to improve upon existing data sets and to complete data sets that did not cover the entire study area. The highest priority data gap to be filled is an assessment of juvenile salmonid utilization of the marine and estuarine shores throughout WRIA 1. Such an assessment should be stratified by coastal landforms following the same structure as a similar assessment conducted by Beamer and Fresh (*in prep* 2012). Additional recommendations for data collection and local assessments included a vulnerability assessment of nearshore habitat types to climate change impacts; detailed studies of coastal tributaries; compilation, analysis and augmentation of data on wave and erosion rates; and conduct of higher resolution pocket beach mapping (if necessary for the fish utilization assessment).

Prior to developing the restoration prioritization tool for WRIA 1, a review of 13 related efforts was conducted to identify the pros and cons associated with different approaches. The lessons learned from the review process were carried forward and applied in the development of the nearshore prioritization tool for WRIA 1. Each of the models that were selected for review was applied across areas that are similar in size to WRIA 1 with similar objectives, or included WRIA 1. Each study employed an ecosystem-based approach built on the fundamental linkages between nearshore ecosystem processes, structure and functions, and the impacts that nearshore stressors, such as shore armor, have on these

relationships and conditions over time. This review process showed the need to create a scalable tool that would accurately represent on-the-ground conditions, integrate best available science and data sets, and reduce subjectivity to the greatest extent practicable.

The overarching goal of the WRIA 1 Marine and Estuarine Assessment and Prioritization was to develop a science-based, user-friendly prioritization tool for estuarine and marine nearshore restoration and protection efforts in WRIA 1. Two different approaches were developed for the marine nearshore and the Nooksack River estuary (including the Lummi River estuary) due to the fundamental differences in fluvial and marine systems and the contrasting resolution of assessment and engineering studies that have been applied to the two areas.

Prioritization Methods – Marine Nearshore

The approach applied to nearshore conditions integrated local habitat data with coastal landform and nearshore ecosystem process data. The nested nature of these datasets resulted in a scalable tool that can be used to identify where to implement restoration and conservation projects throughout the marine shores of WRIA 1 with the greatest benefit to nearshore processes and species. The first step in the development of this GIS tool was to identify coarse-scaled priority areas throughout the WRIA 1 marine nearshore. The objective at this stage was to determine *what needs to be done where* to benefit the nearshore ecosystem and priority species. All data were first analyzed in each coastal landform and then scaled-up to drift-cells, as many coastal landforms function as part of an interconnected net shore-drift cell system.

Each coastal landform, also referred to as a “shoreform”, was assessed to measure the distribution of nearshore ecological resources (habitat functions) of several nearshore species (particularly salmonids) throughout the WRIA 1 nearshore. This assessment method, hereafter referred to as the “Ecological Value Criteria” (EVC), included nine resource parameters associated with nearshore ecosystem health, biodiversity and habitat structure and function to critical species such as juvenile salmon. The EVC metric parameters include the ecological communities highlighted by the Puget Sound Recovery Implementation Technical Team (RITT) as contributing to the key ecological attributes of estuaries and nearshore for support of juvenile salmonids. The nine parameters included presence of absence of surf smelt, sand lance, and herring spawning; emergent wetlands; submerged aquatic vegetation (eelgrass or bull kelp); marine riparian vegetation; freshwater input; proximity to chinook-bearing streams; and proximity to other salmon-bearing streams.

The next step in the assessment was to measure the degree to which nearshore processes were intact within each coastal landform in WRIA 1. A subset of PSNERP strategic needs assessment nearshore process degradation data that included sediment supply, tidal flow, and physical disturbance was linked with each coastal landform. Nearshore processes degradation categories (high, medium, low, none, NA) were then linked with the appropriate management strategies (protect, restore, enhance). Shoreforms were prioritized within each of the strategy based on the EVC scores and then scaled-out to prioritize net shore-drift cells. Therefore both shoreforms and drift cells were assigned both a management strategy and a priority ranking throughout the study area.

On-the-ground protection, restoration, and enhancement opportunities were compiled into a geodatabase from existing data sets and local entities and then augmented by CGS to assure comprehensive coverage throughout the study area. Supporting data were to compiled rank the opportunities and help practitioners advance opportunities toward implementation. Supporting data included strategy type (restoration, protection, enhancement), project source, benefit area, the number of impacts to limiting factors addressed, the management measures required for the project, project justification, and ownership data. Three additional queries were performed to identify priority opportunities: the strategy match, the process match, and the number of limiting factors addressed. The strategy match addresses how well matched the on-the-ground project strategy is with the shoreform or drift-cell strategies. Projects in which the strategy was a perfect match (i.e., protection project within a priority protection drift cell) were awarded 3 out of 3 points. The opportunities were then sorted into those that could be implemented in a 3- or 10-year timeframe. The driving factor for implementation time was landowner willingness based on ownership categories. Landowner willingness is a common constraint to implementing restoration on privately owned land. Therefore, projects that were on privately owned property (without current landowner willingness) were assumed to be too constrained to implement in a 3-year timeframe. However, the 10-year plan opportunities exclusively address nearshore process degradation in the areas that can most benefit from project implementation (regardless of ownership). The final project score was then calculated by summing all of the scoring criteria (benefit score, process match, strategy match, number of limiting factors addressed). The highest 30% of the scores were categorized as “top”, and the middle 30% were identified as “high” scoring opportunities. The lower scoring projects were seen as lesser priority actions, which would only be included in priority drift cells that lacked other opportunities.

Prioritization Methods – Nooksack Estuary

The Nooksack River Estuary area of analysis extended from where the Nooksack River and Lummi River currently diverge at river mile 4.5 on the mainstem of the Nooksack River. As there have been previous efforts to identify restoration opportunities in the Nooksack River estuary (US Army Corps of Engineers 2000, Smith 2002, Brown et al. 2005, Nooksack Natural Resource et al. 2005, Lummi Natural Resources and ESA 2008, ESA et al. 2011Smith), the approach taken in this project was to create a prioritized list of opportunities by compiling the opportunities previously identified and screening them to inform the prioritization.

Each project opportunity was examined to characterize the scale and logistics entailed and the status of restoration planning, as well as the anticipated benefits to ecological processes, habitats, and the achievement of restoration objectives. The scale and logistical information compiled consisted of the benefit area, estimated cost, sequencing considerations with other opportunities, and current known constraints to implementation. For each opportunity the status of the restoration planning was categorized, cost estimated, and the anticipated benefits to key ecological attributes for salmon recovery identified (RITT 2010). Each opportunity was also evaluated to characterize the level to which each of the five restoration objectives identified in the limiting factors report was addressed.

Results - Marine Nearshore

Prioritization results ranked shoreforms and drift cells for protection, restoration and enhancement as well as on-the-ground opportunities. Restoration and conservation practitioners can use the two data sets independently, although the final ranking of on-the-ground opportunities incorporates the results of all analyses.

The coarse-scaled assessment results ranked areas throughout WRIA 1 in which protection, restoration, and enhancement should be conducted. Areas in which nearshore processes are in a relatively pristine condition and had relatively high EVC scores were identified as high protection priorities (Map 13). In total, over 43 miles were identified as protection priority areas, including 16 shoreforms and 18 drift cells. Shores with moderate nearshore process degradation and relatively high EVC scores were ranked for restoration (Map 14). Restoration priority areas cumulatively encompassed just under 62 miles of WRIA 1 marine shoreline, including four individual shoreforms and nine drift cells. The areas with both high nearshore process degradation and high EVC scores were identified as enhancement priority areas (Map 15). Six shoreforms and 11 drift cells, across approximately 32 miles of shoreline, were mapped as enhancement priority areas.

Nearshore restoration/protection/enhancement opportunities are abundant throughout the WRIA 1 shores. In total 133 potential projects were compiled and identified: 19 protection, 60 restoration, and 54 enhancement opportunities (Map 16). Opportunities vary considerably in the nature and scale of benefits.

Ten protection priority projects were identified for implementation in the short-term, including four top-ranking and six high-ranking projects. Eight opportunities would benefit forage fish spawning areas, and most would aid in the conservation of down-drift habitats. Detailed information on each project is included in the project geodatabase. The 10-year protection priorities consist of nine additional opportunities; four top- and six high-ranking projects. All but three of these protection opportunities occur within areas prioritized for restoration, such as Drayton Harbor, Cherry Point, and the northeast and northwest shores of Bellingham Bay. Each of the 10-year protection opportunities offer off-site benefits to either the down-drift or down-stream shores, and several would directly benefit forage fish spawning areas.

The top and highest-ranking restoration opportunities were reduced to a total of nine opportunities (Table 26). Each opportunity has the potential to restore sediment or tidal processes and provide off-site benefits down-drift or up-stream. Most of these opportunities are located within restoration priority areas; however, two are located within areas identified for enhancement, where the action could ameliorate process degradation within the surrounding nearshore. Thirty opportunities were selected as 10-year priorities, eight of which were ranked as top priorities. All of these opportunities exist on private land, so landowner willingness will need to be a focused first effort in working towards implementing any of these valuable projects. Similar to the 3-year restoration priorities, all of these projects will restore nearshore processes, and have far-reaching benefits to down-drift shores or adjacent coastal wetlands.

Eleven enhancement opportunities were identified as 3-year priorities (see Table 28). Five enhancement projects have either conceptual or more fully developed designs and almost all are located on publicly owned land or have already worked out agreements with landowners. The benefits of these projects are typically more restricted to the project footprint, although two projects, including the top-ranking project along Lummi Shore Rd, would provide down-drift benefits. Most of the 3-year enhancement priority projects are located within the City of Bellingham’s shoreline, as it encompasses the greatest spatial extent of enhancement priority areas in the study area. Seven projects were identified as 10-year enhancement priorities (Table 29). At least three of these projects would have off-site benefits. Four have conceptual designs or are more fully developed. These opportunities are distributed throughout the more degraded areas of the WRIA 1 study area from the City of Blaine shoreline south into Skagit County.

Results – Nooksack Estuary

In total, 11 site-specific large-scale projects and two general project types were identified in the Nooksack River estuary. The project opportunities can be completed independently; however, given their spatial adjacency and overlap in desired functional outcomes, they can also be viewed as interrelated clusters of projects. Projects 1 through 4 address floodplain connectivity and side-channel habitats along the lower mainstem of the Nooksack River. Projects 5 and 6 target reestablishing historical connections between the Nooksack River and the Lummi River Delta. Projects 8 through 10 restore the Lummi River Delta and are linked to the reconnection of the Lummi River with the Nooksack River (Project 6). Projects 7 and 11 are independent actions. Projects 12 and 13 are not site-specific, but can be incorporated as design elements of other estuarine restoration projects.

With regard to the benefits analysis by processes, habitats, and restoration objectives, it is necessary that each of the identified opportunities provides meaningful estuary benefits. All projects provide valuable benefits that have strong individual merit and would collectively provide estuary restoration that is unmatched in Puget Sound and could significantly benefit not only important subpopulations of salmonids listed under the Endangered Species Act (ESA), but all communities reliant on a healthy estuary.

Based on the processes, habitat, and restoration objectives analysis, the following projects are recommended as initial priorities for the estuary:

- Project 1 – reconnection of the floodplain along the left bank of the mainstem of the Nooksack River
- Project 2 – reconnection of the floodplain along the right bank of the mainstem of the Nooksack River
- Project 5 – improvement of tidal exchange and passage along Smuggler’s Slough
- Project 6 – restoration of perennial surface water connection between the Nooksack River and Lummi River
- Project 8 – reconnection of the lower portion of Lummi River Delta between Lummi Aquaculture and the Lummi River mouth
- Project 9 – reconnection of the lower portion of Lummi River Delta north of the Lummi River mouth, and
- Project 10 – reconnection of the North Red River distributary channel.

Each of the projects provides many benefits to the estuary and achieves multiple restoration objectives. The Project 5 restoration work in Smuggler’s Slough is included as a priority despite slightly lesser benefit estimates because the project would restore a connection between the Lummi River Delta and the Nooksack River and is designed and ready for construction. The only other project that addresses this cross-connection is Project 6, Lummi River reconnection, but as described above there are major constraints to the project and a general lack of certainty regarding if and when the project could be completed, despite its significant anticipated benefits.

Table of Contents

Table of Tables

Table of Figures

Table of Maps

Glossary

Accretion	The gradual addition of sediment to a beach or to marsh surface as a result of deposition by flowing water or air. Accretion leads to increases in the elevation of a marsh surface, the seaward building of the coastline, or an increase in the elevation of a beach profile (the opposite of erosion) (Shipman 2008).
Anthropogenic	Caused or produced by humans.
Backshore	The upper zone of a beach beyond the reach of normal waves and tides, landward of the beach face. The backshore is subject to periodic flooding by storms and extreme tides, and is often the site of dunes and back-barrier wetlands (Clancy et al. 2009).
Barrier beach	A linear ridge of sand or gravel extending above high tide, built by wave action and sediment deposition seaward of the original coastline. Includes a variety of depositional coastal landforms, including spits, tombolos, cuspate forelands, and barrier islands (Shipman 2008).
Beach	The gently sloping zone of unconsolidated sediment along the shoreline that is moved by waves, wind, and tidal currents (Shipman 2008).
Bluff	A steep bank or slope rising from the shoreline, generally formed by erosion of poorly consolidated material such as glacial or fluvial sediments (Shipman 2008).
Conceptual model	A model, either numerical or diagrammatic, that summarizes and describes the relationships and interactions between specified model components.
Delta	A deposit of sediment formed at a stream or river mouth, or other location where the slowing of water flow results in sediment deposition (Clancy et al. 2009).
Detritus import and export	Import and deposition of particulate (dead) organic matter.
Drift cell	A littoral [drift] cell is a coastal compartment that contains a complete cycle of sedimentation including sources, transport paths, and sinks. The cell boundaries delineate the geographical area within which the budget of sediment is balanced, providing the framework for the quantitative analysis of coastal erosion and accretion. See Johannessen and MacLennan (2007) for further description of drift cells.
Ecosystem	A dynamic complex of plant, animal, and micro-organism communities and their nonliving environment interacting as a functional unit. An ecosystem can be of any size—from a log, pond, field, or forest, to the earth's biosphere—depending upon the organisms that are the frame of reference, but it always functions as a whole unit. Ecosystems are commonly described according to the major type of vegetation, for example, forest ecosystem, old-growth ecosystem, or marine ecosystem.

Ecosystem function	The specific mechanisms through which we benefit from Puget Sound, such as production of forage fish, or wave attenuation. Functions are roughly synonymous with goods and services. Ecosystem functions are delivered through the interaction of processes and structures (Simenstad et al. 2006).
Ecosystem structure	The position and character of the physical components of an ecosystem; the character or “state” of the system. Structures are created through the effects of ecosystem processes, and in turn provide ecosystem function goods and services.
Embayment	An indentation of the shoreline larger in size than a cove but smaller than a gulf.
Enhancement	Any improvement of a structural or functional attribute of an ecosystem (NRC 1992).
Erosion	The wearing away of land by the action of natural forces. On a beach, the carrying away of beach material by wave action, tidal currents, littoral currents, or deflation (wind action) (opposite of accretion) (Shipman 2008).
Estuary	A semi-enclosed coastal body of water that has a free connection with the open sea and within which sea water is measurably diluted with fresh water derived from land drainage. Sometimes defined more broadly to include other coastal inlets that connect coastal lagoons and swamps to the sea.
Freshwater inputs	Freshwater inflow from surface (streamflow) or groundwater (seepage) in terms of seasonal and event hydrography. Freshwater input affects the patterns of salinity and of sediment and soil moisture content across the nearshore.
Geomorphic system	As used here, four broad categories of coastline (rocky coasts, beaches, embayments, and river deltas) that reflect the relative influences of wind, tidal, and fluvial processes in controlling the transport and distribution of sediments and the resulting evolution of landforms (Shipman 2008). See Shipman (2008) for a full explanation of typology.
Habitat	The physical, biological, and chemical characteristics of a specific unit of the environment occupied by a specific plant or animal. Habitat is unique to specific organisms and provides all the physical, chemical and biological requirements of that organism within a specific location (Fresh et al. 2004).
Longshore transport	Transport of sediment parallel to the shoreline by waves and currents (Shipman 2008).
Meso-tidal	The middle tidal range of 2–4 m. Tidal action and wave activity both tend to be important in such areas.
Morphology	The shape or form of the land surface or of the seabed and the study of

	its change over time (Clancy et al. 2009).
Neap tide	A tide that occurs when the difference between high and low tide is least; the lowest level of high tide. Neap tide comes twice a month, in the first and third quarters of the moon
Nearshore	As defined by PSNERP, includes the area from the deepest part of the photic zone (approximately 10 meters below Mean Lower Low Water [MLLW]) landward to the top of shoreline bluffs, or in estuaries upstream to the head of tidal influence (Clancy et al. 2009).
Physical disturbance	Change of shoreline shape or character caused by exposure to local wind and wave energy input. Localized and chronic disturbance of biotic assemblages caused by large wood movement, scour, and overwash.
Pocket estuary	Term used in the Puget Sound region to describe small estuaries and lagoons (types of embayments) partially isolated by their configuration from the main body of Puget Sound (Shipman 2008).
Primary production	The in situ fixation of atmospheric carbon and energy into organic compounds that form the basis for all food chains. Nearshore primary production is supplemented by detritus import and export to determine the energetic budget for nearshore biota.
Progradation	Occurs on a shoreline that is being built forward or outward into a sea or lake by deposition and accumulation as in a delta.
Protection	Safeguarding ecosystems or ecosystem components from harm caused by human actions.
Process-based restoration	Intentional changes made to an ecosystem to allow natural processes such as erosion, accretion, accumulation of wood debris, etc., to occur. Process-based restoration aims to return the landscape to its predisturbance, self-sustaining state. Also defined as the restoration of processes that shape an ecosystem, such as sediment transport or erosion, rather than the restoration of ecosystem features, such as tidal marshes or species populations (Van Cleve et al. 2004).
Puget Sound Basin	Term used to mean the entire Puget Sound Nearshore General Investigation study area and all seven of its subbasins. Used in tables and figures to describe Puget Sound-wide conditions, rather than sub-basin conditions.
Restoration	Returning an ecosystem to a close approximation of its predisturbance state in terms of structure and function (NRC 1992). This includes measures needed to protect and preserve restored systems in perpetuity.
Sediment transport	Bedload and suspended transport of sediments and other matter by water and wind along (longshore) and across (cross-shore) the shoreline. The continuity of sediment transport strongly influences the longshore structure of beaches.

Sediment Input	Delivery of sediment from bluff, stream, and marine sources into the nearshore. Depending on landscape setting, inputs can vary in scale from acute, low-frequency episodes (hillslope mass wasting from bluffs) to chronic, high-frequency events (some streams and rivers). Sediment input interacts with sediment transport to control the structure of beaches.
Shoreform	A term often used in Puget Sound to describe a coastal landform. The term is generally used to describe landscape features on the scale of hundreds to thousands of meters, such as coastal bluffs, estuaries, barrier beaches, or river deltas.
Shoreform unit scale	The subject unit of analysis is the coastal landform.
Solar incidence	Exposure, absorption, and reflectance of solar radiation (e.g., radiant light and heat) and resulting effects. Solar incidence controls photosynthesis rates and temperature patterns in the nearshore.
Spring tides	The exceptionally high and low tides that occur at the time of the new moon or the full moon.
Stressors	Stressors are measureable changes to the structure of the ecosystem resulting from human activities such as filling of wetlands or construction of shoreline armor, groins, over-water structures, breakwater jetties, marinas, roads, tidal barriers, land cover, and impervious surfaces (Cereghino et al. 2012).
Tidal channel	Natural levee formation.Geomorphic processes, primarily tidally driven, form tidal channel geometry.
Tidal delta	Accumulations of sand and gravel deposited inside or outside of tidal inlets when tidal currents slow. Flood tide and ebb tide deltas can be distinguished and are commonly associated with barrier lagoons and estuaries (Shipman 2008).
Tidal flow	Localized tidal effects on water elevation and currents, differing significantly from regional tidal regime mostly in tidal freshwater and estuarine ecosystems.
Tidal prism	The change in the volume of water that flows into a tidal area between a low tide and the subsequent high tide.

Acronyms and Abbreviations

ART	artificial landform
BAB	barrier beach
BE	barrier estuary
BL	barrier lagoon
BLB	bluff-backed beach
BMPs	best management practices
BNSF	Burlington Northern Santa Fe railway
CAO	Critical Areas Ordinance
CFS	Cubic feet per second
CGS	Coastal Geologic Services
D	delta
DG	data gap
DOE	Washington Department of Ecology
EEW	estuarine emergent wetland
ELJ	engineered log jam
ESA	Endangered Species Act
ESRP	Estuary and Salmon Recovery Program
ESU	Evolutionarily Significant Unit
ESW	estuarine scrub-shrub wetland
EVC	ecological value criteria
GIS	geographic information systems
H	high
KEA	key ecological attribute
L	low
LWD	large woody debris
M	medium
MHHW	mean higher high water
MHW	mean high water
MLLW	mean lower low water
MRC	Marine Resources Committee
NA	not applicable
NAD	no appreciable drift
NRC	National Research Council
PB	pocket beach
PFW	palustrine forested wetland
PHS	Priority Habitats and Species
PL	plunging rocky shore

PSNERP	Puget Sound Nearshore Ecosystem Restoration Project
RITT	Puget Sound Recovery Implementation Technical Team
RM	river mile
ROW	right of way
RP	rocky platform shore
SAV	submerged aquatic vegetation
SMP	Shoreline Master Program
SNAR	Strategic Needs Assessment Report
TAG	technical advisory group
USGS	United States Geological Survey
WDFW	Washington Department of Fish and Wildlife
WDNR	Washington Department of Natural Resources (also noted as DNR)
WRIA	water resource inventory areas
USACE	United States Army Corps of Engineers
USFWS	United States Fish and Wildlife Service

1.0 Introduction

Water Resource Inventory Area 1 (WRIA 1) has lacked a comprehensive assessment of needs and threats to strategically inform marine nearshore restoration and protection planning and implementation activities. Salmon recovery in WRIA 1 is largely focused on upper reaches of the Nooksack River, with less attention devoted to the estuary and marine shorelines. Many opportunities exist to restore, enhance, and protect habitat structure and ecosystem processes that would benefit Nooksack salmon, other nonnatal salmon, and the larger marine ecosystem in WRIA 1; however, a thorough assessment has been needed to integrate, identify, and prioritize these potential projects.

The goal of this project was to review key datasets to assess conditions and to develop and apply a prioritization tool to guide restoration and protection efforts for the estuarine and marine shores of WRIA 1. The City of Bellingham and project manager Renee LaCroix hired the CGS team to achieve these goals and objectives. The project applied a phased approach. Phase 1 was a comprehensive literature review of existing data on WRIA 1 conditions, from which data gaps were identified. It also included a summary and comparison of various approaches to prioritizing nearshore restoration and protection projects throughout the region. The results of Phase 1 provided a rich foundation for the development of the Phase 2 prioritization model. Phase 2 efforts were focused on the development and application of the prioritization approach and the resulting population of a WRIA 1 nearshore project portfolio. Each of the major elements described as part of Phases 1 and 2 will be described in this report.

The suite of tasks associated with each project phase were accomplished with the guidance of a technical advisory group (TAG) composed of local experts and representatives from major stakeholder groups in WRIA 1 (Table 1). The TAG aided in the development of key objectives and contributed valuable input at critical junctures in the creation of the prioritization approach. Additional information relating to the TAG, including a summary of input from each meeting is included in the report Appendix.

Table 1. Members of the TAG and the entities they represent. Renee LaCroix managed this project.

Last name	First name	Entity
LaCroix	Renee	City of Bellingham (project manager)
Williams	Brian	Washington State Department of Fish and Wildlife (WDFW)
Thompson	Doug	WDFW
Grossman	Eric	US Geological Survey (USGS)
Carabba	Eric	Whatcom Land Trust
Stroebel	Erika	Whatcom County
Komoto	Jill	Lummi Nation
Thompson	John	Whatcom County
Hood	Steve	Washington State Department of Ecology
Coe	Treva	Nooksack Tribe

2.0 WRIA 1 Nearshore and Estuarine Conditions

A literature review was conducted to document the natural conditions within the marine and estuarine shores of WRIA 1 and the human-made modifications to these systems. There are several fundamental factors of influence that ultimately determine the character of the nearshore environment at a given location. These factors include geology, topography, oceanography, net shore-drift patterns, and fluvial systems. Natural conditions in many locations of the marine and estuarine shores of WRIA 1 have been substantially altered as a result of upland land use, modifications to water routing, agriculture, industry, and shoreline development. Each of these elements is briefly described in the following section.

2.1 General

The watersheds of WRIA 1 encompass over 1,410 square miles from sea level to the top of Mount Baker at 10,781 ft and roughly 160 miles of marine shoreline (Map 1). The marine shorelines of WRIA 1 extend from the U.S.-Canadian border north of Blaine to the northern portion of the Samish River Delta. In addition, Point Roberts is an isolated portion of the WRIA 1 marine shoreline. The WRIA 1 marine shoreline includes the entire shoreline of Whatcom County and the northernmost 8.7 miles of Skagit County. The geographic areas in the marine shoreline include Drayton Harbor, the Strait of Georgia, Lummi Bay, Portage Bay, Bellingham Bay, Chuckanut Bay and Samish Bay, as well as Lummi, Eliza, Portage and Chuckanut Islands. The marine shorelines are almost entirely located within Whatcom County. The southern 8.7 miles of WRIA 1 shoreline (and 21 square miles of watershed area) is located in Skagit County. Much of the Skagit County shoreline is encompassed within the historical delta of the Samish River.

Figure 1. Great Northern railway trestle waterward of historical shoreline along Chuckanut Road. HistoryLink.org (http://www.historylink.org/index.cfm?DisplayPage=output.cfm&file_id=9855).

Land along the shore is used primarily for residential, agricultural, and commercial/industrial development. Transportation corridors frequently occur adjacent to the shoreline. The Burlington Northern Santa Fe (formerly Great Northern) railway runs within 200 ft of the shoreline across roughly seven and a half miles of WRIA 1 (Simenstad et al. 2011). In several locations the railway was constructed waterward of the shoreline on trestles that were later in-filled, resulting in an expansive armored causeway spanning a considerable portion of the southern marine shorelines (Figure 1). Roads within 200 ft of the marine shoreline occur along 18.5 miles of WRIA 1 shoreline (Simenstad et al. 2011). In total,

Map 1. WRIA 1 geographically within the Salish Sea and Lummi Tribal Lands.

WRIA 1 Nearshore Assessment and Estuarine Restoration Prioritization

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approximately 26 miles (17%) of the marine shoreline of WRIA 1 has either railroad or roads parallel to the shoreline.

The aboriginal tribal people subsisted off the region's wealth of natural resources until Euro-American settlement. WRIA 1 encompasses both the Nooksack and the Lummi Indian Reservations, though only the latter includes marine and estuarine shoreline (Map 1). The Lummi Indian Reservation comprises the 5-mile-long Lummi Peninsula (with Lummi Bay on the west and Bellingham Bay on the east), Portage Island to the south, the Nooksack/Lummi River Delta, a northwestern upland area, the low-lying Sandy Point peninsula, and adjacent tidelands extending to extreme lower low water. Cumulatively, the Lummi Indian Reservation encompasses approximately 38 miles of WRIA 1 marine shoreline.

The cities of Bellingham (population 80,885 in 2010), Birch Bay (8,413 in 2010) and Blaine (4,684 in 2010) have greater population densities and more concentrated shoreline alterations than the more rural parts of the study area. With the longest history of commercial and industrial development, the shores of Bellingham Bay are the most heavily altered shorelines throughout WRIA 1.

2.2 The WRIA 1 Nearshore Ecosystem

Nearshore ecosystems are among the more complex ecosystem types and are critical parts of the Salish Sea. The nearshore encompasses the interface between terrestrial, freshwater, estuarine, and marine systems. Over the course of the past 150+ years, Euro-American settlement and development have profoundly altered nearshore ecosystems in the Salish Sea and in WRIA 1. Understanding the fundamental elements (processes, structure, and components) of nearshore ecosystems, the unique characteristics of WRIA 1, and the extent to which WRIA 1 nearshore ecosystems have been altered provides an integral foundation for restoration and conservation planning for the WRIA 1 nearshore.

The composition, shape, and characteristics of Puget Sound nearshore ecosystems are the net effect of the interactions of numerous ecosystem processes. Ecosystem processes are defined as the interactions among physiochemical and biological elements of an ecosystem that involve changes in character or "state" over time (Simenstad et al. 2006). Puget Sound ecosystem processes provide ecosystem structure, which is in turn responsible for ecosystem goods, services, and functions (Simenstad et al. 2006). The processes at work along a particular reach of shoreline are influenced by a number of controlling factors that occur at differing scales. Large-scale controlling factors (or regional influences) that make WRIA 1 unique within the Puget Sound region include oceanography, tides and currents, geology, and climate (Table 2).

Table 2. Controlling factors that drive regional nearshore ecosystem conditions in WRIA 1.

Oceanography
Oceanographic processes in WRIA 1 are characteristic of the normal circulation pattern in a fjordal estuary, with seaward flow at the surface and landward flow at depth. WRIA 1 is linked to the Pacific Ocean through Rosario, Haro, and Georgia Straits and through the Strait of Juan de Fuca. Due to proximity and the absence of sills, WRIA 1 is more influenced by oceanic conditions and has a shorter residence time of tidal flushing than the southern sub-basins of the Salish Sea..
Fluvial systems
Major sources of freshwater in WRIA 1 include the Fraser River, which enters the southern Strait of Georgia in British Columbia just north of Point Roberts, and the Nooksack River, which flows into Bellingham Bay. A detailed discussion of the Nooksack River Delta is found in *Section 2.3* The Fraser River is one of the greatest sources of freshwater in

the Salish Sea (formerly referred to as the Puget Sound–Georgia Basin). The outflow of the Fraser River and tidal currents create a large counterclockwise rotating gyre west of the Fraser River Delta. Freshwater from the Nooksack River enters the nearshore system and flows south, while a bottom inflow of saline waters from Rosario Strait enters the system from the south and flows north.
Tides
Ocean currents within the Strait of Georgia are primarily driven by tides, wind, and river flow. The combined forces of lunar influence, winds, and bathymetry determine the extent to which these layers are mixed. During neap tides, when the tide range is least, seawater intrusion and the influx of saltier water to the Straits is greatest. However, during spring tides, high-velocity tidal currents result in increased mixing of fresh and salt water. Tides in the Salish Sea and WRIA 1 are semidiurnal with two ebbs and two floods per lunar day. Successive ebbs and floods are of unequal strength and the tidal range in the study area is meso-tidal (6.5 –13 ft between spring high and low [maximum mean high and minimum mean low]).
Geology
The underlying geology of WRIA 1 is far from uniform, with variability in both bedrock and glacial deposits. Bedrock shores found in the southern extent of the study area are largely part of the Chuckanut Formation, an alluvial flood plain deposit that consists of sandstone conglomerate, shale, and coal. The southern portions of Lummi and Eliza Islands have exposures of Cretaceous or Jurassic siltstone and conglomerate. Much of the remaining shoreline comprises Quaternary, glacially derived geologic units including glacial outwash, glacial marine drift, and terrace deposits. These shorelines have been delineated into several alongshore sediment subsystems referred to as net shore-drift cells that range in length from five miles or more to just a few hundred feet (Map 2). All areas outside drift cells have No Appreciable Drift (NAD) either due to a lack of wave energy to transport sediment or a lack of sediment to be transported (e.g., along bedrock shores). Shore-drift does not occur within pocket beaches, which are definitively enclosed between two bedrock headlands; therefore these areas are also considered NAD shores.

Regional influences form the backdrop for broad physiographic processes and fine-scale, local geochemical and ecological processes (Simenstad et al. 2006). Broad physiographic processes are landscape-forming processes, which are nested in the regional context and exhibit considerable variability in their occurrence and intensity across Puget Sound shorelines (Table 3). These processes shape coastal landforms, and drive the formation of ecosystem structure that in turn supports nearshore habitats.

A list of valued ecosystem components (VECs) was created by the Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) to represent a cross section of organisms and physical structures that occupy and interact with the physical processes found in the nearshore (Table 4). The VECs are iconic, valued elements of Puget Sound, a subset of nearshore ecosystem components or biological communities that are considered to be among the most important due to their ecologic, economic, cultural, spiritual, or aesthetic value. Each VEC shares three characteristics: 1) it will benefit from nearshore restoration, 2) it has a direct or indirect benefit to humans socially, culturally, or environmentally, and 3) it is recognized as emblematic of a “healthy” Puget Sound. A schematic of the relationship of VECs to the nearshore and each other is shown in Figure 2. Most VECs have incurred considerable degradation or dramatic population declines (Gelfenbaum 2006, Simenstad et al. 2011). Nine of the 10 Puget Sound species identified as endangered or threatened rely on nearshore environments and are at least in part related to problems in the nearshore ecosystems.

Map 2. WRIA 1 Net shore drift and no appreciable drift shores.

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Table 3. Broad physiographic, landscape-forming processes embedded within regional controls and responsible for the creation and maintenance of the shoreforms and the energy regimes that characterize Puget Sound shorelines.

Sediment input
Delivery of sediment from bluff, stream, and marine sources into the nearshore. Depending on landscape setting, inputs can vary in scale from acute, low-frequency episodes (hillslope mass wasting from bluffs) to chronic, high-frequency events (some streams and rivers). Sediment input interacts with sediment transport to control the structure of beaches.
Sediment transport
Bedload and suspended transport of sediments and other matter by water and wind along (longshore) and across (cross-shore) the shoreline. The continuity of sediment transport strongly influences the longshore structure of beaches.
Erosion and accretion of sediments
Deposition (dune formation, delta building) of nonsuspended (e.g., bedload) sediments and mineral particulate material by water, wind, and other forces. Settling (accretion) of suspended sediment and organic matter on marsh and other intertidal wetland surfaces. These processes are responsible for creation and maintenance of barrier beaches (spits) and tidal wetlands.
Tidal flow
Localized tidal effects on water elevation and currents, differing significantly from regional tidal regime mostly in tidal freshwater and estuarine ecosystems.
Distributary channel migration
Change of distributary channel form and location caused by combined freshwater and tidal flow. Distributary channel migration affects the distribution of alluvial material across a river delta.
Tide channel formation and maintenance
Geomorphic processes, primarily tidally driven, that form and maintain tide channel geometry. Natural levee formation.
Freshwater input
Freshwater inflow from surface (stream flow) or groundwater (seepage) in terms of seasonal and event hydrography. Freshwater input affects the pattern of salinity and sediment and soil moisture content across the nearshore.
Detritus import and export
Import and deposition of particulate (dead) organic matter. Soil formation. Recruitment, disturbance, and export of large wood.
Exchange of aquatic organisms
Organism transport and movement driven predominantly by water (tidal, fluvial) movement.
Physical disturbance
Change of shoreline shape or character caused by exposure to local wind- and wave-energy input. Localized and chronic disturbance of biotic assemblages caused by large wood movement, scour, and overwash.
Solar incidence
Exposure, absorption, and reflectance of solar radiation (e.g., radiant light and heat) and resulting effects. Solar incidence controls photosynthesis rates and temperature patterns in the nearshore.

Table 4. Valued Ecosystem Components of the Salish Sea and WRIA 1.

Coastal forests or marine riparian vegetation
Marine riparian areas border marine or tidal waters and provide many functions as the interface or ecotone between terrestrial and marine ecosystems (Brennan and Culverwell 2004). Functions of marine buffers include the following (Parametrix et al. 2006): export of material to marine systems (detritus, terrestrial insects), shading the upper beach (moisture retention, microclimates), shoreline stabilization, nutrient/toxin/pathogen cycling, wildlife habitat, large woody debris (LWD) recruitment and storage, moderate storm water runoff, and enhanced infiltration (Brennan and Culverwell 2004).
Beaches and bluffs
Throughout areas mapped within drift cells, eroding coastal bluffs (commonly referred to as feeder bluffs) are the primary source of beach sediment, and their natural erosion is essential for maintaining down-drift beaches and nearshore habitats. Large woody debris is also recruited from eroding bluffs. The long-term driver of bluff erosion is wave erosion (also referred to as marine-induced erosion), which undercuts the toe of the bluff leading to bluff failure (Shipman 2004). Bulkheads reduce wave attack to the bluff toe but can accelerate erosion of the beach and typically only reduce marine-induced erosion, rather than erosion resulting from upland geology or poor land-use practices, which commonly interacts with wave erosion to initiate landslides.
Eelgrass and kelp
Submerged aquatic vegetation (SAV) most commonly refers to kelp (*Nereocystis luetkeana*) and eelgrass (*Zostera marina or japonica*). SAV performs a wide variety of ecological functions in nearshore ecosystems, from sequestering carbon that fuels nearshore food webs primarily through detrital processes to providing habitat structure for other organisms (Mumford 2007). Crabs and bivalves use eelgrass beds for nursery areas and feed indirectly on the carbon fixed by the plants, while fishes utilize the structure for protection from predation along their migratory corridors. Many species forage upon the epiphytic species found on SAV, such as algae, eggs, and invertebrates, while other predators forage upon juvenile fishes, larvae, and other species utilizing the habitat. Eelgrass is found in mud to clean sand and gravel throughout much of Puget Sound and WRIA 1. It occurs in areas with moderate to low wave or current energy and does not occur on exposed shorelines (Parametrix et al. 2006). Kelp is found where there is hard substrate in shallow water, including pilings and other artificial substrates. It prefers areas with adequate water movement that brings in nutrients and removes excess sediment.
Forage fish
In marine waters, the principal forage species for salmonids, marine mammals, and sea birds are surf smelt (*Hypomesium pretiosus*), Pacific sand lance (*Ammodytes hexapterus*), Pacific herring (*Clupea hargengus*), and juvenile salmonids such as pink (*Oncorhynchus gorbuscha*) and chum (*Oncorhynchus keta*) smolts. The maintenance of these forage species is considered one key to maintaining anadromous fish populations (Nooksack Natural Resources et al. 2005). Forage fish use a variety of shallow nearshore and estuarine habitats for spawning, feeding, and rearing (WDFW 2004a). Surf smelt spawn in the upper intertidal zone of beaches composed of coarse sand to pea gravel (1 to 7 mm diameter). Pacific sand lance rear in bays and nearshore waters, and move into estuarine waters for spring and summer feeding. They spawn over a wide range of substrates from fine sand to gravel up to 30 mm in size (Penttila 1995). Herring rely on eelgrass, and to a lesser extent on bull kelp and other macroalgae, as important spawning substrates. The adhesive herring eggs are deposited on leaf blades and algae in intertidal and shallow subtidal areas, at elevations between 0 and -10 feet mean lower low water (MLLW).

Table 4 Cont. Valued Ecosystem Components of the Salish Sea and WRIA 1.

Great Blue Heron
The Great Blue Heron (*Ardea herodias*) is found in its greatest concentrations here in the Salish Sea with some of the largest heronries in North America. Because herons are predators on nearshore species, heron populations are indicative of levels of environmental toxins, availability and connectivity of shoreline-upland habitat, and conditions of eelgrass and intertidal habitats (Eissinger 2007).
Juvenile salmon
Puget Sound salmon occupy the nearshore during their transition from freshwater to saltwater and upon their return to their natal streams in the region. The use of nearshore ecosystems varies considerably between and within species, with juvenile Chinook (*Oncorhynchus tshawytscha*) and chum salmon making the most extensive use of nearshore habitats. Population and life history are both relevant to how and when nearshore habitats are utilized (Fresh 2007). The ability of nearshore ecosystems to support or promote salmon population viability depends on both local attributes and the context of the habitat within the surrounding ecological system. The ability of nearshore habitats to support salmon population viability is a function of how well the habitat supports 1) feeding and growth, 2) avoidance of predators, 3) the physiological transition from freshwater to saltwater, and 4) the migration to ocean feeding habitats (Fresh 2007).
Orca whales
The southern resident and transient orca (*Orcinus orca*) populations are important to the region's ecosystem, economy, and recreation. These top predators use nearshore locations for foraging and travel and are very susceptible to human disturbance and ecosystem decline. The southern residents were recently (2005) listed as endangered under the Endangered Species Act (ESA). A combination of natural factors including the decline of prey (salmon populations), removal for public display, , disturbance from vessel traffic, and toxins likely contributed to the whales' decline (Kriete 2007) .
Native shellfish
Native shellfish in Washington State are of high ecological, economic, cultural, and recreational value. Shellfish beds perform numerous important ecological functions including nutrient cycling, substrate stabilization, habitat structure creation (e.g., oyster reefs), water quality enhancement (filtering and retention), and provision of food for a wide variety of marine invertebrates, birds, fish and mammals. Cobble to fine sand beaches and tidal sand and mud flats are important habitats for shellfish. Species include crabs (*Cancer magister*), numerous clams, the Olympia oyster (*Ostrea lurida*), mussels (*Mytilus spp*.), shrimp , abalone (*Haliotis kamtschatkana*), and various others. In Puget Sound, all major shellfish species, with the exception of shrimp, use nearshore ecosystems for part or all of their life histories (Dethier 2006).
Nearshore birds
The Salish Sea is home to a great number of birds closely associated with the marine environment. All of these birds use one or more of three habitat types – open water, rocky shoreline, and mud flats. The species associated with these habitats include: Surf Scoter (*Melanitta perspicillata*), Black Oystercatcher (*Haematompus bachmani*), and Dunlin (*Caridris alpine*). All three species use nearshore habitats for foraging and resting and Black Oystercatchers also nest in the nearshore. These species are important to the Salish Sea ecosystem for the value bring to wildlife observations, as indicators of contaminant loading (Surf Scoters), and for the relative rarity of the species and regional importance of these specialized habitats (Buchanan 2006).

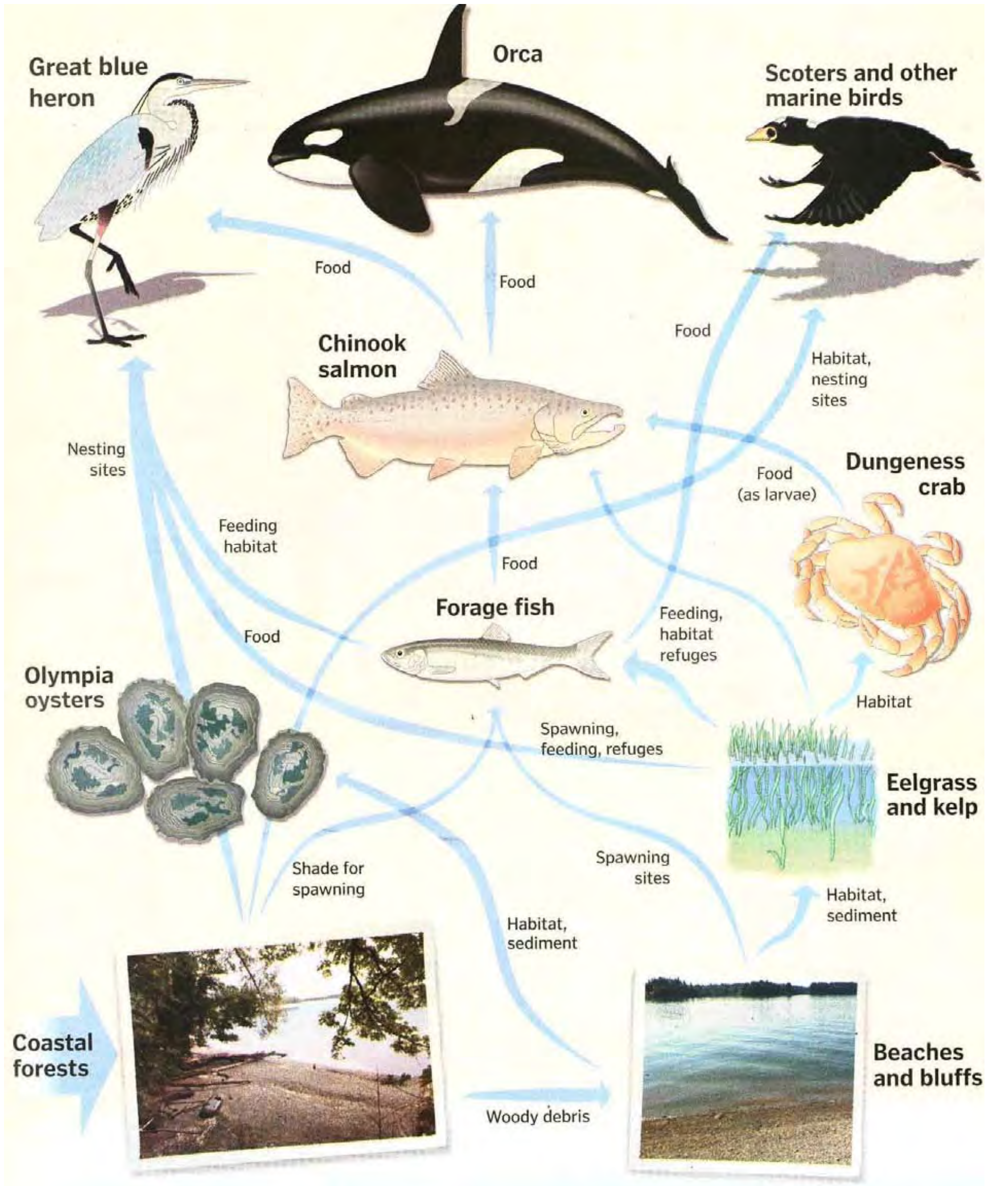


Figure 2. Displays the relationship of VECs to the nearshore and each other. (from Schlenger et al. 2011).

2.2.1 WRIA 1 Coastal Landforms

Coastal geomorphic shoreforms, or shoreline landforms, are the product of large-scale regional controls and landscape-scale processes which together define the overall character and ecological function of the shoreline. Each of the major shoreform types found throughout the Salish Sea occurs within the shorelines of WRIA 1. These include bedrock landforms such as plunging rocky shores and rocky platforms, pocket beaches, eroding bluff-backed beaches, barrier beaches, and several different kinds of coastal embayments. The Nooksack River estuary encompasses both an active and a historical delta, each of which is considerably altered from its historical configuration due to land-use conversion (wetlands to agriculture), hydraulics, and many levees and dikes.

Shoreforms have been mapped throughout the Puget Sound region using different shoreline-classification systems. Most recently, historical and current shoreforms were mapped by the PSNERP (Simenstad et al. 2011), which applied a shoreform-mapping approach developed by regional coastal geologist Hugh Shipman at the Washington State Department of Ecology (Map 3, Shipman 2008: http://pugetsoundnearshore.org/technical_papers/geomorphic_classification.pdf). Table 5 shows exemplary WRIA 1 shoreforms of each variety and some of the defining characteristics that result in the selected shoreform classification.

Table 5. Exemplary shoreforms of each type found in WRIA 1.

Artificial (ART) - Filled and armored. *Blaine Marina, 2006 Dept of Ecology (DOE).*

Barrier Beach (BAB) - Wave-dominated, depositional. *Cherry Point Reach, CGS photo.*

Barrier Estuary (BE) - Tide-dominated and leeward of barrier, with freshwater. *Terrell Creek, 2006 DOE.*

Barrier Lagoon (BL) - - Tide–dominated and leeward of barrier. *Portage Island, 2006 DOE.*

Bluff-backed Beach (BLB) - - Wave-dominated, erosional. *Point Whitehorn, CGS photo.*

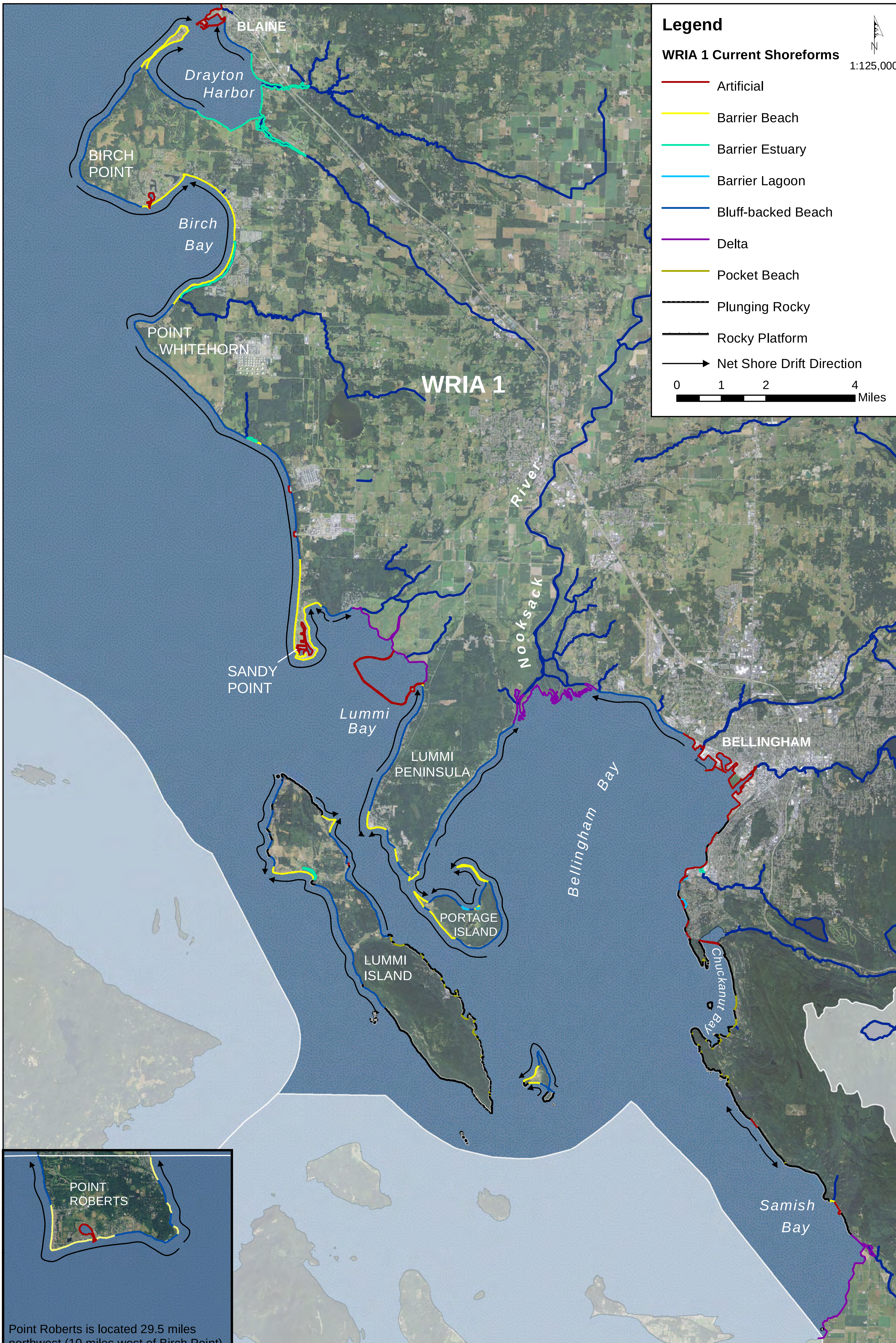
Delta (D) - - Fluvial-dominated, depositional. *Nooksack River Delta. 2006 DOE.*

Pocket Beach (PB) - Wave-dominated, contained by bedrock headlands*. Wildcat Cove, 2006 DOE.*

Plunging Rocky (PL) - Wave-dominated, high relief, bedrock. *South Lummi Island, 2006 DOE.*

Rocky Platform (RP) - Wave-dominated, low relief, bedrock *Clarks Point, 2006 DOE.*

Overall, 261 shoreforms comprise the WRIA 1 marine shoreline (Map 3). The most commonly occurring shoreform type by count is rocky platforms, while bluff-backed beaches compose the greatest length of WRIA 1 shoreline (43.2 miles, 27%, Table 6). The south half of the county, including Lummi Island, is largely composed of bedrock shores including pocket beaches, rocky platforms, and plunging rocky



Map 3. WRIA 1 current shoreforms (Simenstad 2011).

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shores, while the north county consists of far more bluff-backed and barrier beaches. Artificial shoreforms are abundant (by count) and make up a large portion (17%) of the WRIA 1 shoreline (26.9 miles, Table 6). Most artificial shoreforms occur along the Burlington Northern Santa Fe (BNSF) rail causeway and along more urbanized shorelines in the cities of Blaine and Bellingham. Pocket beaches are also abundant but cumulatively represent only a small portion of the WRIA 1 shoreline due to their relatively short average length. Similar to most bedrock shoreforms, pocket beaches most commonly occur where bedrock geology is prevalent: south of the City of Bellingham and intermittently along the shores of Lummi Island. Far fewer barrier estuaries (10%) and deltaic (11%) shoreforms occur within WRIA 1; however, they represent a large portion of the study area and are considerably complex shorelines. PSNERP shoreform mapping was reviewed by CGS staff prior to integrating it into this project work. Several mapping revisions were made based on local knowledge and known errors that resulted from the coarseness of the data relied upon in the original mapping effort. Revisions are described in the report Appendix.

Table 6. Shoreform composition of WRIA 1.

Shoreform	Count	Total length (miles)	Average length (miles)	% Length of WRIA 1 shoreline
Bluff-backed beach	46	43.2	0.9	27
Artificial	39	26.9	0.7	17
Barrier beach	33	25.3	0.8	16
Rocky platform	83	23.8	0.3	15
Delta	3	17.6	5.9	11
Barrier estuary	6	16.8	2.8	10
Pocket beach	36	3.1	0.1	2
Plunging rocky	11	2.7	0.2	2
Barrier lagoon	4	0.9	0.2	1
All shoreforms	261	160.2	0.6	100%

2.2.2 Coastal Landforms, Habitats, and Valued Ecosystem Components

As previously discussed, the distribution and character of coastal landforms is the result of numerous interacting variables, many of which are regional in nature such as geology, tides, topography, climate, and sea level rise history. However at a finer scale, a number of local factors contribute to the geomorphic character of a coastal landform, with subsequent effects on ecosystem structure and habitat function, such as shoreline orientation to waves, local heterogeneity in geology, availability of sediment, erosion and accretion patterns, and proximity to stream mouths (Shipman 2008). Similarly, wave energy, substrate composition, salinity, and elevation are fundamental factors of influence to nearshore ecology that are generally consistent within shoreforms (excluding elevation) and strongly affect species distributions and/or biological assemblages (Dethier 1990, Simenstad et al. 1991). Therefore the coastal landforms that compose the WRIA 1 nearshore are inherently linked with the occurrence of different habitat structures and are a main determinant of species distributions (Kruckeberg 2002). For example, kelp forests are limited to shoreforms with coarse-grained and rocky substrates at low elevations. These conditions are likely to occur within a limited number of shoreforms including plunging rocky shores, bedrock ramps, pocket beaches, bluff-backed beaches, and in some cases, artificial shoreforms. Artificial shoreforms are substantially altered by development by definition. In some cases artificial shores encompass habitat structures associated with the historical shoreform that have persisted after the degradation. The similarity of these characteristics among coastal landforms creates a valuable tool for shoreline planning and assessing the relative restoration potential of different locations. Patterns between coastal landforms and the distribution of valued nearshore species (VECs) were explored within WRIA 1.

Marine Riparian Areas

Residential development has modified marine riparian conditions along a majority of the WRIA 1 marine shoreline, most notably along the shores of Point Roberts, Birch Bay, Sandy Point, and the west shore of the Lummi Peninsula. Agricultural and commercial/industrial developments have altered nearshore riparian communities in other areas. Few areas of intact riparian cover remain along marine shores except for areas along Lummi Island and the Nooksack River Delta. Invasive species are abundant both in the Nooksack River Delta, although no detailed mapping has been conducted.

Marine riparian vegetation throughout WRIA 1 has been recently classified and mapped by Anchor QEA. Results showed that shrubs were the most abundant vegetation type along the northern portion of Whatcom County, followed by deciduous trees (Anchor QEA 2010, 2012). Deciduous and coniferous forests were the most dominant vegetation type in the southern county (Anchor QEA 2012). Residential and industrial developments along the marine shorelines are likely responsible for the bulk of riparian vegetation loss. Additionally, it is important to be mindful that some shoreforms, such as barrier beaches and certain bedrock shores, do not naturally sustain marine riparian vegetation.

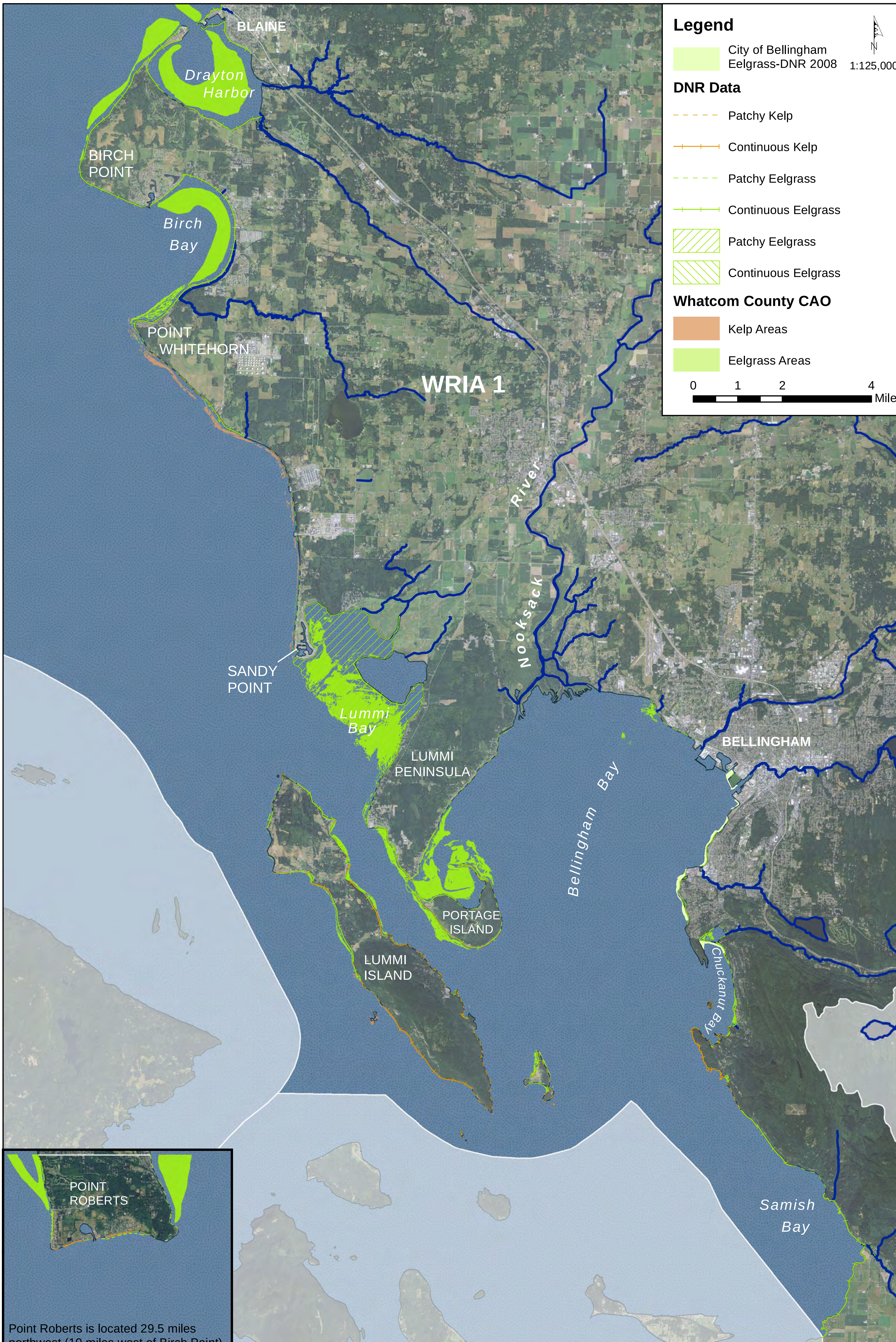
Eelgrass

In WRIA 1, the largest eelgrass meadows occur in four general areas (Map 4):

- Western and eastern shores of Point Roberts
- Semiahmoo Bay and Drayton Harbor to the Semiahmoo Spit and the northernmost part of Birch Point
- Birch Bay to Point Whitehorn
- Lummi Bay and around the end of the Lummi Peninsula into Portage Bay

Eelgrass beds in WRIA 1 were most abundant waterward of rocky platform and bluff-backed beaches. They did not occur within embayment or delta shoreforms. However, according to historical records, current eelgrass abundance and distribution has diminished considerably. A study conducted for the City of Bellingham documents eelgrass losses on the order of 92% since the 1800s in Bellingham Bay (Gaeckle 2009).

Other more scattered patches of eelgrass occur throughout WRIA 1, from Fairhaven to the southern extent of the WRIA, within Chuckanut Bay, near Marine Heritage Park Waterway (north), south of Post Point, within Post Point lagoon, east of Clark’s Point, the northern shores of Lummi Island, along the shore south of Cherry Point, and along the south shore of Point Roberts (Map 4). Eelgrass meadows are not present on the Nooksack River Delta, and are very small and patchy in the northeastern portion of Bellingham Bay and the outer shores of the southern portion of Lummi Island (Parametrix et al. 2006). Delta dynamics and changes in flow patterns with forthcoming changes to salinity and sedimentation rates have likely affected eelgrass distributions around the Nooksack River Delta (Gaeckle 2009).



Map 4. WRIA 1 Submerged aquatic vegetation (SAV) from City of Bellingham (DNR 2008), Whatcom County CAO (2005), and DNR (2001) data.

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Kelp Forests

Kelp can form dense, highly productive forests that support a diverse ecosystem including fish and marine mammals. Kelp forests are important habitat for rockfishes and lingcod (*Ophiodon elongates*). Dense kelp beds also dissipate wave energy and provide sheltered habitat within the kelp bed and in adjacent surface waters (e.g., for resting/rafting seabirds) or shorelines.

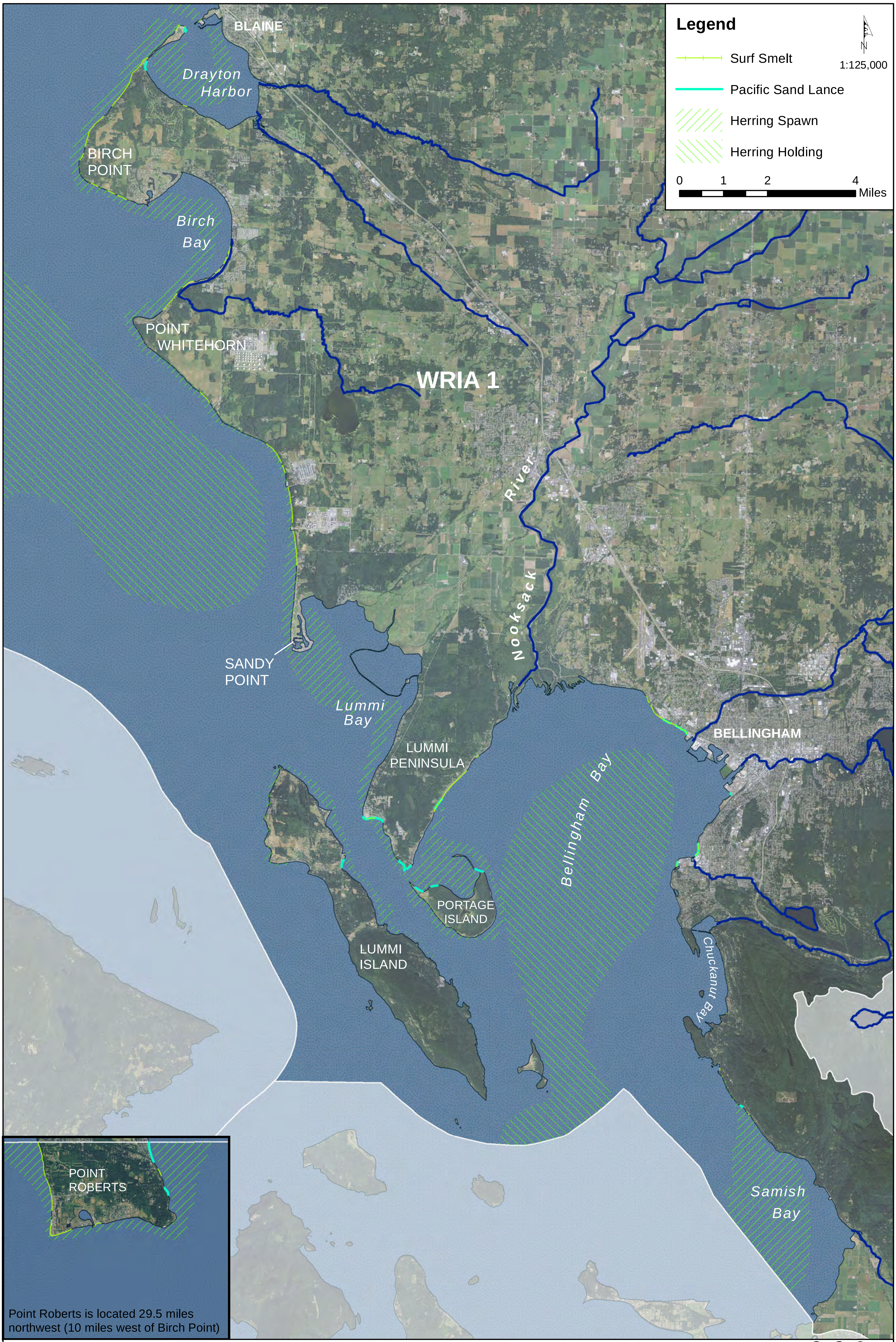
Kelp distribution in WRIA 1 is limited to the shoreforms with coarse-grained and rocky substrates at low elevations (Map 4, Table 7). Kelp is found primarily between Point Whitehorn and Neptune beach, and along the south shores of Point Roberts and Lummi Island.

Table 7. Eelgrass and bull kelp occurrence by geomorphic shoreform throughout WRIA 1.

Shoreform	Count	Number with SAV	Length with bull kelp (ft)	Percent of WRIA 1 with bull kelp	Length with eelgrass (ft)	Percent of WRIA 1 with eelgrass
Rocky platform	83	61	71,821	15	18,122	34
Bluff-backed beach	46	40	198,783	41	16,690	31
Plunging rocky	11	9	2,079	0	9,859	18
Barrier beach	33	29	106,344	22	7,279	14
Pocket beach	36	34	12,617	3	1,449	3
Artificial	39	22	37,191	8	-	0
Barrier estuary	6	4	34,963	7	-	0
Barrier lagoon	4	3	3,252	1	-	0
Delta	3	1	22,512	5	-	0
All shoreforms	261	203	489,563	100	53,400	100

Forage Fish

Forage fish spawning has been documented along close to 14 miles of WRIA 1 shoreline (Map 5). Sixty-seven percent of documented surf smelt spawning in WRIA 1 occurs along bluff-backed beaches (Table 8), followed by barrier beaches (26%), artificial shoreforms (5%), and pocket beaches (1%). Spawning has also been infrequently documented along the thin veneer of sediment found along rocky platform shoreforms, located in the southern reaches of WRIA 1 (Table 8, Map 5). Sand lance spawning primarily occurs along barrier beaches, where substrate is typically finer; it also occurs along bluff-backed beaches but to a much lesser degree (Map 5).



Map 5. WRIA 1 Forage fish spawning areas (WDFW data).

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Table 8. Distribution of surf smelt and sand lance spawning in WRIA 1 by geomorphic shoreform.

Shoreform	Count	Number with smelt spawning	Length with smelt spawning (ft)	Percent of WRIA 1 with smelt spawning	Number with sand lance spawning	Length with sand lance spawning (ft)	Percent of WRIA 1 with sand lance spawning
Barrier beach	33	5	18,931	26	10	10,319	51
Bluff-backed beach	46	12	48,467	67	8	5,607	28
Artificial	39	9	3,861	5	5	3,195	16
Rocky platform	83	4	1,012	1	2	1,042	5
Barrier estuary	6	0	0	0	0	0	0
Barrier lagoon	4	0	0	0	0	0	0
Delta	3	0	0	0	0	0	0
Pocket beach	36	2	406	1	0	0	0
Plunging rocky	11	0	0	0	0	0	0
All shoreforms	261	32	72,676	100	25	20,162	100

Herring spawning occurs in subtidal waters along a considerable portion of the WRIA 1 shoreline (Map 5, Table 9). There are three different herring stocks that spawn in WRIA 1 that are referred to by their general spawning locations: Semiahmoo Bay, Cherry Point, and Portage Bay. Maps that show spawning locations for all of the stocks are found in the Map folio. Spawning for individual stocks is location-specific and occurs generally from mid-January to March. Adult herring typically congregate and hold in deeper waters adjacent to spawning areas for three to four weeks prior to moving to spawning areas (Stick and Lindquist 2008, Parametrix et al. 2006).

Table 9. Herring spawning in WRIA 1 by geomorphic shoreform.

Shoreform	Count	Number with herring spawning	Percent of WRIA 1 with herring spawning
Bluff-backed beach	46	40	34
Barrier beach	33	31	26
Rocky platform	83	25	21
Artificial	39	13	11
Pocket beach	36	7	6
Delta	3	2	2
Barrier estuary	6	1	1
Barrier lagoon	4	0	0
Plunging rocky	11	0	0
All shoreforms	261	119	100

Shellfish Beds

Recreation shellfish areas occur along the beaches from Drayton Harbor and Semiahmoo Spit to Cherry Point, Birch Bay, Lummi Bay, Lummi Island, Chuckanut Bay, and Samish Bay. Ceremonial, subsistence, and commercial shellfish areas occur in Lummi tidelands in Lummi Bay and Portage Bay and along the Lummi Peninsula. Lummi Reservation shellfish areas are open only to enrolled members of the Lummi Nation. Commercial shellfish areas also occur in Drayton Harbor, Birch Bay, Eliza Island, and south of Oyster Creek.

Shellfish beds were associated with nearly all shoreform types in WRIA 1 (Table 10). Shellfish beds were not found in delta shoreforms and very few occur in artificial shoreforms. Tidal flats extending waterward of rocky platform shoreswere most commonly associated with shellfish areas. Bluff-backed beaches, barrier beaches and pocket beaches were also commonly associated with shellfish areas in WRIA 1.

Table 10. Shellfish bed occurrence by geomorphic shoreform.

Shoreform	Count	Number with shellfish	One shellfish species	> One shellfish species	Percent with shellfish
Barrier beach	33	22	12	10	2
Bluff-backed beach	46	26	15	11	18
Pocket beach	36	19	6	13	2
Rocky platform	83	42	28	14	2
Barrier lagoon	4	2	2	0	21
Plunging rocky	11	5	1	4	0
Barrier estuary	6	2	2	0	16
Artificial	39	3	3	0	4
Delta	3	0	0	0	35
All shoreforms	261	121	69	52	100

Juvenile Salmon Use of Estuarine and Marine Nearshore Habitats

The Nooksack River and the numerous independent tributaries of WRIA 1 support multiple species and stocks of salmonids whose life cycles include outmigration to the estuarine and marine waters. These include all five Pacific salmon species (*Oncorhynchus tschawtscha, keta, kisutch, gorbuscha, and nerka*), as well as steelhead (*Oncorhynchus mykiss)*, bull trout (Salvelinus confluentus), and sea-run cutthroat trout (*Oncorhynchus clarkii clarkia*). Among these species, Chinook salmon, bull trout, and steelhead are listed as threatened under the federal Endangered Species Act, and coho salmon are listed as a species of concern. Hood Canal summer chum salmon may occupy the marine nearshore waters of WRIA 1, and it is likely that salmon originating in the Fraser River system migrate into and utilize the marine nearshore waters of WRIA 1.

A thorough investigation of salmon utilization in WRIA 1 has not yet been conducted, however, limited sampling by Lummi Natural Resources has documented that multiple (wild) species of salmonids are present and utilize nearshore areas between Neptune Beach and Lummi Shore Road. Species caught include pink, chum, cutthroat, coho, and Chinook. Sampling data shows the highest average catch was of chum. Wild Chinook were caught more frequently across all sampling locations, documenting their presence in the WRIA 1 nearshore.

Estuaries and marine nearshore environments provide distinctly different conditions for outmigrating juvenile salmonids (and returning adults) than the freshwater portions of the watershed. The fish encounter changes in water salinity, typically cooler water temperatures, new prey items (often larger in size and caloric content), the ebb and flow of tides, new habitat configurations, and different predators and competitors.

Estuaries and the marine nearshore tend to be highly productive habitats where juvenile salmonids can grow rapidly. Juvenile salmon are opportunistic feeders that tend to forage on a wide diversity of prey types, including benthic/epibenthic prey (e.g., amphipods, copepods, and worms), planktonic/neritic prey (e.g., crab larvae and fish larvae), terrestrial/riparian prey (e.g., insects and spiders), and other fish (Fresh, 2006). Juvenile Chinook salmon, in particular, have been documented to rely upon a diverse prey base (Simenstad et al. 1982, Brennan et al. 2004, Toft et al. 2010). The availability of prey in these areas is related to the delicate balance of water flow, sediment transport, and organic matter in and through the nearshore. As observed by Fresh (2006), *"[n]earshore food webs are noteworthy in that they support abundant prey types that are especially important to small juvenile salmon and because they depend upon internally derived (i.e., from nearshore habitats) sources of organic matter (e.g., eelgrass)"* (Sibert et al. 1977).

Juvenile salmon face several types of predators in the estuary and marine nearshore. Larger fish, birds, and mammals all prey upon salmon (Parker 1971, Fresh 1997). The availability of shallow water to escape larger fish, deeper water to avoid birds/mammals, submerged vegetation, habitat structure (e.g., wood), and even turbidity, can help reduce predation (Simenstad et al. 1982). In addition, the availability of abundant and diverse prey allows juvenile salmon to grow rapidly and outgrow many potential predators.

A growing body of evidence shows that the early marine growth of juvenile salmon is important to the overall marine survival of salmon. Beamish and Mahnkens (2001) suggested that salmonid survival during the marine phase is regulated at two stages: first, the early marine stage in which increased size leads to decreased predation risk; second, the fall/winter of their first year in saltwater in which increased fitness leads to increased overwinter survival. At that life stage, fitness is linked to growth during the preceding stage. Saloniemi et al. (2004) documented that larger wild fish survive at higher rates. A study by Duffy and Beauchamp (2011) demonstrated the importance of early marine growth on hatchery-origin Chinook salmon. They reported that hatchery Chinook marine survival to adulthood was most strongly related to their average body size in July with larger fish experiencing higher survival rates. The highest survival was observed in fish that were greater than 17 grams (approximately 120 mm) by July and released before May. The authors acknowledge that the applicability of this study to wild fish is a question.

Prior to and during the transition of juvenile anadromous salmonids from freshwater habitats to brackish, then saltwater, then back again as adults, their bodies undergo a major physiological transition (called smoltification in juveniles) to enable the animals to survive. In large river systems such as the Nooksack River, the increasing salinity gradient occurs over an extended length of the lower river, typically several miles. It is understood that part of the smoltification process occurs after the juvenile salmon enter the marine nearshore (Fresh 2006). Fresh (2006) posits that habitat use in nearshore ecosystems may be partially driven by physiological needs. Recent data have documented the movement of juvenile Chinook, chum, and coho salmon from their natal estuary to nonnatal estuaries (Beamer et al. 2003, Hirschi et al.

2003). This demonstrates the close association of juvenile salmon with estuaries and the nearshore over extended distances.

The life cycle of anadromous salmonids includes migration to the ocean, and the availability of suitable migratory corridors is vital. For juvenile salmon that are dependent on the estuary and marine nearshore, the migratory corridor must provide the other ecological needs, either continuously as in the case of predator avoidance, or sufficiently to enable the fish to survive and grow. Recent research has documented that the migration of juvenile salmon from their natal estuaries does not always occur as a directed movement (at varied paces) toward the ocean. Instead, juvenile salmon distribute widely upon entering Puget Sound (Duffy 2003, Brennan et al. 2004, Fresh et al. 2006), including many that move away from the ocean, thus extending their residency in Puget Sound.

Studies have documented that a portion of the juvenile salmonids outmigrating from their natal rivers disperse among shorelines distributed throughout the Puget Sound region. In King County located approximately 70 miles south of WRIA 1, Brennan et al. (2004) reported capturing tagged hatchery-origin juvenile Chinook salmon from river systems to the north, south, and west, including as far away as the Lummi Bay Sea Ponds. Similarly, Beamer and Fresh (*in prep* 2012) captured juvenile salmon at shoreline sampling stations throughout the San Juan Islands where there are few to no naturally produced salmon from the islands' streams. These results indicate that an unknown portion of juvenile salmonids entering Puget Sound do not necessarily make directed movements to the ocean and instead choose to remain in Puget Sound for a period of rearing in the shallow water habitats of the marine nearshore.

Since juvenile salmonids utilize shallow marine nearshore habitats both near their natal river as well as far distances away (e.g., Brennan et al. 2004), the marine shorelines of WRIA 1 can be expected to be utilized by juvenile salmonids originating in other areas of Puget Sound and British Columbia. This is particularly likely given the presence of the large numbers of salmon from the Nooksack River, as well as the WRIA's proximity to the Skagit Fraser rivers.

Salt Marshes

Salt marshes typically occur at elevations at and above mean higher high water (MHHW) in areas where sediment supply and accretion are relatively high (depositional areas). Therefore, they predominantly occur in embayment shoreforms (barrier lagoons and barrier estuaries), at drift-cell termini, and in river deltas (Table 11). Salt marshes in WRIA 1 primarily occur in the Lummi River Delta and the Nooksack River Delta, on Cherry Point at Gulf Rd, along the south shore of Drayton harbor, and along the southwest shore of Eliza Island. In total, 826 acres of emergent wetlands have been mapped in WRIA 1 (Simenstad et al. 2011). In WRIA 1 salt marshes are also found within artificial shoreforms that were historically embayment shoreforms (Table 11).

Fringing salt marsh occurs in barrier estuaries and lagoons such as at the mouth of Chuckanut Creek and the northern shore of Portage Island. Salt marsh vegetation also occurs intermittently in the backshore between Padden Creek and Chuckanut Bay, particularly in areas that periodically flood during high tides or are wetted by backspray. In northern Bellingham Bay, near the Nooksack River Delta, salt marshes may be more abundant now than historically due to the rapid progradation of the delta and the increase in habitat available for salt marsh (Collins and Sheik 2003). In contrast, the Lummi River Delta has experienced a 95% reduction in salt-marsh habitat since the 1880s (Bortleson et al. 1980, Parametrix et al. 2006).

Table 11. Salt marshes and freshwater inputs by shoreform.

Shoreform	Count	Number with salt marsh	Percent with salt marsh	Length with salt marsh (ft)	Number with freshwater	Percent with freshwater
Artificial	39	9	23	17,128	19	49
Barrier beach	33	7	21	4,962	10	30
Barrier estuary	6	5	83	14,462	6	100
Barrier lagoon	4	4	100	3,773	0	0
Bluff-backed beach	46	1	2	933	10	22
Delta	3	3	100	56,984	3	100
Pocket beach	36	0	0	0	3	8
Plunging rocky	11	0	0	0	0	0
Rocky platform	83	2	2	1,619	7	8
All shoreforms	261	31	12	99,862	58	22

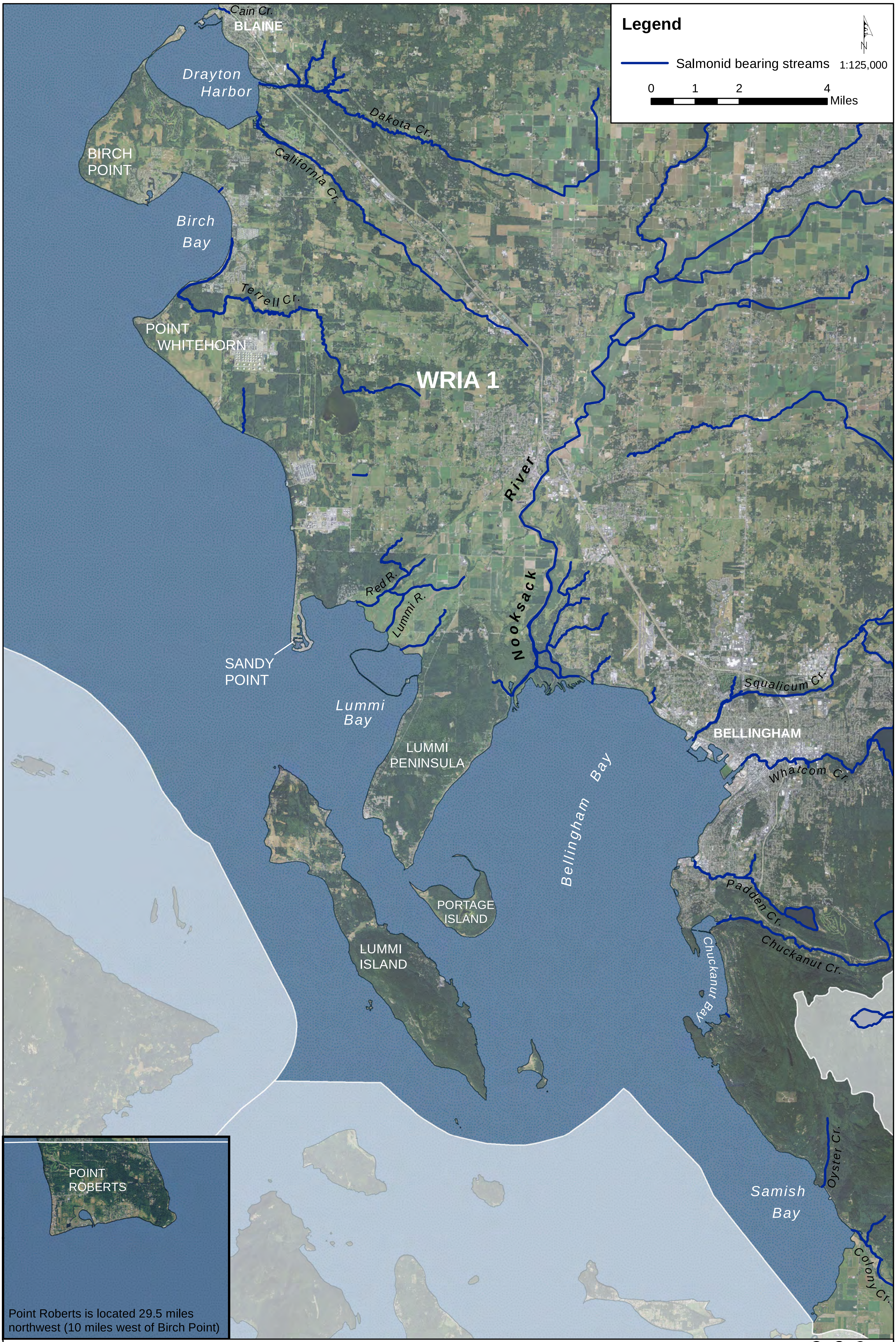
Salt marshes are among the most productive ecosystems in the world (Costanza et al. 1997). Ecological processes that are important for creating and maintaining salt-marsh habitat include sediment transport and deposition and tidal exchange. Sediment transport and deposition form the coastal landforms subject to tidal inundation that support salt-marsh vegetation. Tidal exchange supports nutrient and organic exchange, inundation regimes, salinity gradients, and sediment processes that support salt-marsh vegetation and associated faunal communities. Organic matter from salt-marsh vegetation supports macro-detritus-based food webs that provide food items for forage fish and salmonids in nearshore habitats adjacent to salt marshes (Mitsch and Gosselink 1993, Parametrix et al. 2006).

Freshwater Inputs

Several small fluvial systems occur in WRIA 1. From north to south these include California and Dakota Creeks in Drayton Harbor; several small unnamed creeks that flow into Birch Bay; and Terrell, Little Squalicum, Squalicum, Whatcom, Padden, Chuckanut, Oyster, and Colony Creeks (Map 6). The Lummi River is not included in this group because it is technically part of the Nooksack River system. Several smaller sources of freshwater also occur within WRIA 1 which are not mapped at high resolution

(Map 6). The extent of influence that small fluvial systems have on nearshore ecosystems is largely a function of the size and character of their watershed. Important factors include elevation, geology, vegetation, and climate (Komar 1976, Parametrix et al. 2006,). Sources of freshwater increase the diversity if not the quantity of shoreline functions through the presence of alluvial fans, variation in the salinity gradient, interaction with freshwater biota, and organic inputs from the contributing watershed. In addition, many creek mouths include small unmapped barrier estuary landforms and salt marshes (Cereghino et al. 2012).

Coarse-scale mapping shows that freshwater inputs are associated with 20% of the WRIA 1 coastal landforms (Table 11). Barrier estuaries and deltas are all associated with freshwater sources, as part of their defining characteristics. Freshwater sources were also commonly associated with bluff-backed beaches and barrier beaches, which typically embay or enclose barrier estuaries. Close to half of the artificial shoreforms in WRIA 1 are associated with freshwater inputs. Water quantity and quality are



Map 6. WRIA 1 Salmonid bearing streams (WDFW data).

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pervasive issues for many of these small streams (Smith 2002).

2.3 The Nooksack River

The major river system in WRIA 1 is the Nooksack River, which has three branches in its upper watershed: the North Fork, Middle Fork, and South Fork. Headwaters, originating on federally managed lands in the Cascade Mountain Range near Mount Baker, form streams that flow into the forks which combine just east of Deming. From Deming, the mainstem of the Nooksack River flows through the Lummi Indian Reservation and into Bellingham Bay (Map 1, Figure 3). Current land use transitions from forestry to agriculture, and the shift in land use has altered the fluvial landscape with substantial water withdrawals, levees, dikes, isolation of wetlands, and degradation of the floodplain and habitat-forming processes.

Prior to a sequence of systemic alterations that began around 1860; the Nooksack River had a broad delta that discharged water (and sediment) through distributary channels to both Lummi and Bellingham Bays, with the Lummi River side being the dominant outlet. In 1852 the US Army's Annual Report of the Chief Engineers describes the flow of the Nooksack River into Bellingham Bay as "only a small creek" (Deardorff 1992, Collins and Sheikh 2003). The flow ratios apparently shifted between the two outlets over time until the late 1800s, when the Lummi River connection was plugged (Smith 2002, Collins and Sheikh 2003,Smith). Between 1926 and 1934, a reclamation project was undertaken to provide protected agricultural land by diking the Nooksack River, disconnecting the Lummi River distributary, ditching to drain agricultural lands, and constructing a seawall along Lummi Bay. In 1951 a limited freshwater connection between the Nooksack River and Lummi River was established through a culvert. Currently, the Lummi River receives Nooksack flow through the culvert when discharge is greater than 9,600 cfs (Lummi Nation 2008).

Historical research has estimated that these activities decreased subaerial wetlands in the lower Lummi River watershed by approximately 95% (Bortelson et al. 1980). Historically, tidal wetlands were more extensive on the Lummi River side (Collins and Sheikh 2003). Collins and Sheikh posited that the less extensive wetland network on the Nooksack River side of the historical estuary may have been a reflection of the channel only being a small distributary to the Lummi River, so that it received less sediment to support progradation and wetland establishment along the Nooksack River.

Channel alterations have led to abandonment of old delta areas and formation of new delta areas closer to the Lummi Reservation. Large wood was removed from the channel in concentrated snagging operations. By 1910 the lower mainstem had been shortened through meander cutoffs and simplified with dikes and levees to a single channel, resulting in a major loss of slough, side-channel, and off-channel habitat (Smith 2002, Collins and Sheikh 2003). The loss of floodplain wetlands and distributary channels, coupled with the increase in agriculture, has also resulted in water quality and quantity issues in the estuary. In addition, land use higher in the watershed, most notably forestry and the channelization of the Nooksack River, has amplified sediment loading.

Together this suite of alterations to the Nooksack River has resulted in rapid progradation and accretion of the delta over the last 100 years. Sediment-accretion estimates in the delta are estimated at 21–25 feet in the last 150 years (Parametrix et al. 2006). Recent research by USGS across the delta and nearshore is finding evidence of significant amounts of sediment bypassing the delta and getting exported or lost. Floodplains and delta environments would benefit from this sediment, particularly in the face of sea level rise. A preliminary analysis of bathymetric change between 2010 and 2011 showed that more than 300,000 cubic meters accumulated along a very small portion of the delta front (Grossman, pers. comm).

Analyses (by USGS) are underway to determine a sediment budget for the delta that integrates short and long-term bathymetric change with continuous synoptic measurements of sediment transport at the USGS Ferndale stream gauge.

The sediment derived from the Nooksack River influences nearshore habitat well over a mile from the delta. The inflow of freshwater decreases the salinity of Bellingham Bay marine waters and provides large quantities of fine sediment (sand, silt, and clay) into Bellingham Bay, contributing to the development of valuable habitats including marshes, distributary channels, shallow-water deltaic habitats, eelgrass beds, and sand and mud flats (Parametrix et al. 2006). The historical Nooksack River Delta was comprised of a mosaic of estuarine habitats that were associated with strong and diverse salmon runs. Diking, draining of the estuarine wetlands, and loss of distributary and blind channel networks reduced the quality key habitat from 138 acres to 37 acres in the Nooksack estuary (Figure 3, Brown et al. 2005). Approximately 65% of the Nooksack floodplain has been converted to agriculture since the 1930s and over the past 150 years much of the habitat diversity has been lost from the Lummi Delta (Collins and Sheikh 2003, Brown et al. 2005). Habitat type has changed greatly over time as well. Where wetland areas have decreased over time, forested areas in the delta on the newly accreted land have greatly increased (Brown et al. 2005). However, the loss of channel complexity and loss of estuarine and riverine tidal wetlands has reduced the quality of remaining habitat and contributions to the food web (Peterson et al. 2010). Despite the slough of alterations that the Nooksack River Delta and watershed have incurred, recent research conducted by PSNERP reveals that it is in much better condition than all other large river systems located along the east shore of Puget Sound (Schlenger et al. 2011).

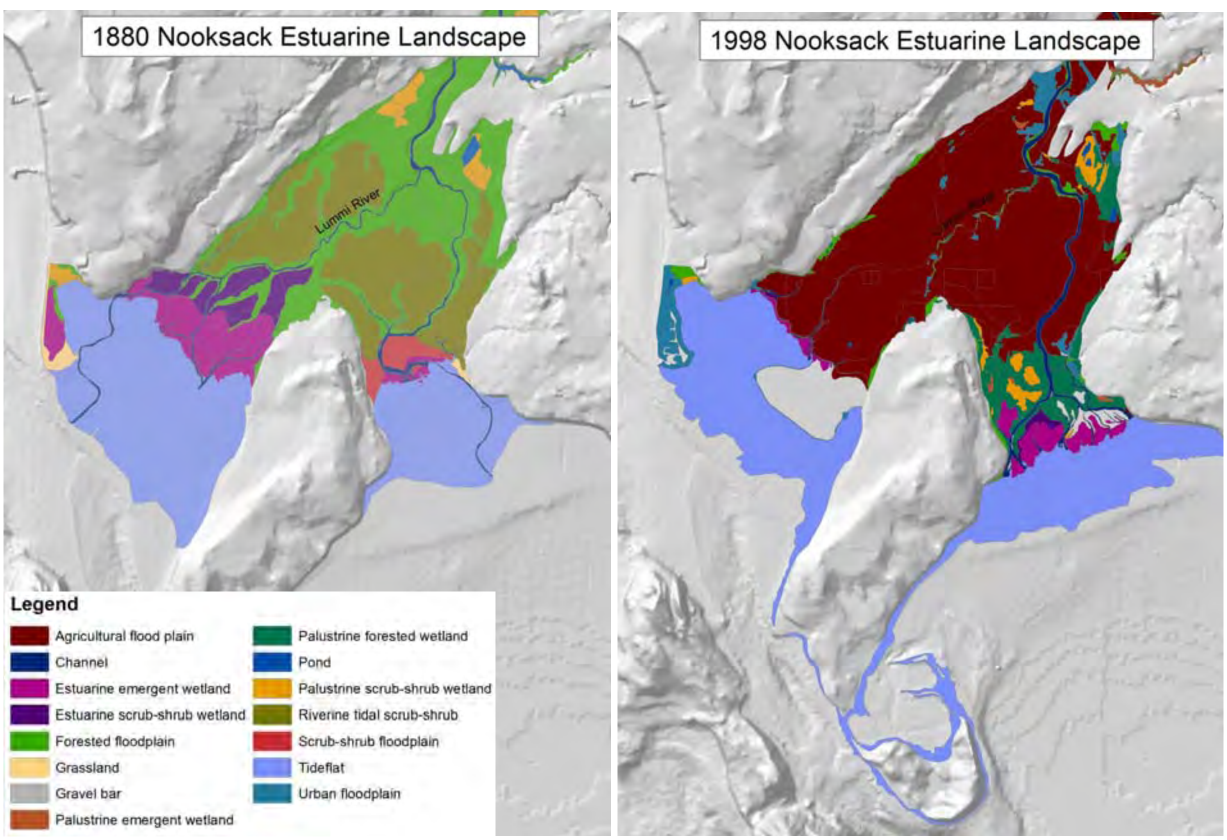

Figure 3. Changes to the historical Nooksack River estuarine landscape (Collins and Sheikh 2003).

2.4 WRIA 1 Limiting Factors Report – Nearshore and Estuary

The WRIA 1 Limiting Factors Report (Smith 2002) consolidated and rated salmonid habitat conditions from the freshwater to nearshore environments. The focus is greater on the smaller estuaries than on the adjacent marine/nearshore environment. However, this important reference document is commonly relied upon for developing coordinated efforts towards salmonid recovery, restoration and protection actions, and strategy development. This section summarizes nearshore and estuary conditions, data gaps, and the greatest impacts to these systems, as reported in the WRIA 1 Limiting Factors Report.

2.4.1 WRIA 1 Nearshore Limiting Factors

WRIA 1 nearshore shallow and subtidal habitats provide a critical migratory corridor for juvenile salmonids, which use the area for feeding, shelter from predators, and rearing (Smith 2002). From marine riparian forests to the shallow subtidal, the WRIA 1 nearshore provides a host of prey species important to juvenile salmonids, as well as critical refuge from avian and fish predators until they transition into deep-water habitats (Smith 2002). Several major impacts to these functions are documented in the WRIA 1 Limiting Factors Report, including the following:

- Shoreline modifications
- Overwater structures
- Boat ramps, slips, and piers (often associated with dredging)
- Loss of riparian areas/wetland loss
- Degraded water and sediment quality

Each of these impacts was characterized in the document and the need for specific actions to ameliorate conditions caused by these impacts was outlined. A summary of estuarine and nearshore conditions associated with several of these impacts is shown in Table 12. The table clearly demonstrates the extent of data gaps that exist for the nearshore but also for general areas in which restoration and protection could be targeted.

Impacts to WRIA 1 creeks that flow directly into the marine waters in WRIA 1 were also outlined in the Limiting Factors Report (Table 13). Several data gaps were identified as part of this assessment including a comprehensive understanding of floodplain conditions, sediment quantity and quality, and channel stability. Updated riparian and instream LWD quantity data may now be available for most of the streams shown in Table 13 (Anchor QEA 2010, 2012).

Table 12. Summary of estuarine and nearshore conditions in WRIA 1 (from Limiting Factors Report, Smith 2002). DG=Data Gap.

Region	Wetland loss[a]	Water and/or sediment quality	Shoreline modification[b]	Boat ramps, slips, piers[c]
Point Roberts	DG	DG	Poor	Poor
Peach Arch	DG	DG	Poor	Good
Blaine	DG	DG	Poor	Poor
Semiahmoo Spit	DG	DG	Fair	Good
Drayton Harbor	DG	Poor	Fair	Good
Birch Bay	DG	DG	Poor	Poor
Birch Point	DG	DG	Good	Good
Point Whitehorn	DG	DG	Good	Good
Cherry Point	DG	Questionable	Good	Good
Neptune Beach	DG	DG	Poor	Good
Sandy Point Shores	DG	DG	Good	Poor
Lummi Bay	Poor	DG	Poor	Good
Lummi Island	DG	DG	Good	Good
Portage Island	DG	DG	Good	Good
Eliza Island	DG	DG	Good	Good
Nooksack River Delta	Good	DG	Good	Good
North Bellingham Bay	Poor	Poor (inner)	Poor	Poor
South Bellingham Bay	Poor	Poor (inner)	Poor	Poor
Chuckanut Bay	DG	DG	Mixed	Poor
North Samish Bay (to Wendy Pt)	Poor	Fair	Poor	Good
Samish Bay (Wendy Pt south)	Poor	Fair	Poor	Good

a Poor conditions represented by high amounts of wetland loss

b Poor conditions represented by a highly modified shoreline

c Numerous structures earn a poor rating

Table 13. Summarized conditions of WRIA 1 streams from Smith (2002). DG=Data Gap.

Stream name	Fish passage barriers	Floodplain conditions	Water quality	Water quantity	Riparian wetland	Road density
Dakota Cr	Poor	Poor	Poor	Poor	Poor	Poor
California Cr	DG	Poor	Poor (DG)	Poor	Poor	Poor
Terrell Cr	DG	DG	DG	Poor	Poor	Poor
Squalicum Cr	Poor	Poor (DG)	Poor	Poor	Poor	Poor
Whatcom Cr	DG	DG	Poor	Poor	Poor	Poor
Padden Cr	DG	DG	Poor	Poor	Poor (DG)	Poor
Chuckanut Cr	DG	DG	Fair	Poor	Poor (low)	Poor
Oyster Cr	DG	DG	DG	Poor (DG)	Poor (DG)	Fair
Colony Cr	DG	DG	DG	Poor (DG)	Poor (DG)	Fair

2.4.2 Nooksack River Estuary Limiting Factors

Systemic alterations to the Nooksack River have resulted in changed conditions with consequent effects on habitats important to salmonids. Several assessments have characterized these impacts; including the WRIA 1 Limiting Factors Report (Smith 2002), the Nooksack estuary habitat assessment (Brown et al. 2005, and recent work by USGS [Grossman 2012 pers comm]). The following major alterations to the Nooksack River system have had negative implications on salmon habitats that should be addressed:

- *Disconnection of the Lummi River from the Nooksack River.* The disconnection of the Lummi River from the Nooksack has drastically reduced the size of the Nooksack River estuary. As a result, the amount of rearing habitat has been greatly reduced and the naturally high-productivity tidal wetlands that historically occurred throughout the Lummi River Delta side have been largely eliminated. Tidal channels, distributary channels, and sloughs provide productive rearing habitat for juvenile salmon that supports rapid growth and tends to prolong their estuarine residency (either because a high-flow refuge is provided that enables the fish to remain in the river or because they volitionally remain). The disconnection of the Lummi River reduced tidal wetland by more than half of its historical area (Collins and Sheikh 2003).
- *Disconnection of the floodplain and tidal wetlands in the estuary.* The network of dikes along the Nooksack River and the Lummi River, tide gates, ditches, and the seawall bordering the Lummi River Delta have reduced the flood storage and inundation capacity of the estuary. This type of disconnection impacts many of the natural ecological processes that occur in estuaries. Naturally shaped estuaries of large rivers, such as the Nooksack, typically have an extensive network of distributary and tidal channels across an extensive area. The modifications in the Nooksack estuary have isolated the mainstem from its floodplain, thereby greatly reducing the availability of habitats for juvenile salmonids and the maintenance of highly productive tidal wetlands.
- *Impairment of water quality, particularly water temperatures and salinity.* During the late summer months, temperatures in the estuary can achieve levels that are lethal to juvenile salmon or cause

them to relocate to avoid the conditions (Brown et al. 2005). The timing of the high temperatures generally does not coincide with the late winter and spring residency and outmigration of juvenile salmonids, but some life history strategies, particularly of Chinook, may be impacted. Salinity is an issue in the Nooksack estuary for the relatively short distance in which the salt wedge penetrates upstream. Brown et al. (2005) report that the salt wedge penetrates only a short distance up the Nooksack while on the Lummi side, it extends more than three miles. The extent of the salt wedge is an important component of the estuary because it indicates the upper extent of the salinity gradient habitat in which the transition from freshwater to saltwater occurs for out-migrating juvenile salmon.

- *Excess sedimentation rates in the delta.* In deltaic environments, excess sediment supply can be as harmful as reduced sediment supply, especially when the sediment composition (size) has also changed. Increased sedimentation rates in the Nooksack River Delta have led to habitat and species burial, abrasion, fragmentation, high turbidity, and poor water quality. The Nooksack River Delta in Bellingham Bay has one of the highest progradation rates (Brown et al. 2005, Grossman 2012 pers comm.) and continued excess delivery due to river-delta channelization and focusing. The effects of the increased sedimentation likely limit eelgrass distribution and benthic faunal diversity.

2.5 WRIA 1 Nearshore Degradation and Stressors

Nearshore process degradation and the occurrence of various stressors were mapped and analyzed as part of multiple PSNERP efforts, primarily the Change Analysis (Simenstad et al. 2011) and the Strategic Needs Assessment Report (SNAR, Schlenger et al. 2011). Data from these regional efforts were mapped and analyzed to better understand the scale and magnitude of impacts to the larger WRIA 1 nearshore ecosystem, and to form appropriate strategies and priorities. The results from these regional efforts will be summarized and interpreted for WRIA 1 in this section to highlight what actions to apply where across the WRIA 1 marine landscape.

The Change Analysis documented several different kinds of changes that have occurred to the Salish Sea since Euro-American settlement. The most substantial of these changes are referred to as Tier I impacts, in which shoreforms change character or are lost completely. Comparison of current and historical conditions in WRIA 1 shows that 41 shoreforms have been “lost”. A shoreform can be lost as the result of several stressors resulting in a shoreform transitioning to another shoreform or to an “Artificial” shoreform. In WRIA 1 most of the shoreform loss can be attributed to combined stressors that created 35 artificial shoreforms. The remaining shoreforms may have been lost as a result of stressors that entirely precluded the existence of the lost historical shoreform or less frequently due to contrasting mapping resolution. Shoreform loss is a contributing factor to the simplification and overall shortening of the Puget Sound or Salish Sea shoreline. Throughout the Salish Sea, the shoreline has cumulatively shortened 15% in length (Fresh et al. 2011). Much of the shoreform loss and artificial shoreforms that occur in WRIA 1 are associated with the BNSF rail causeway, which cumulatively covers almost 8 miles of WRIA 1 shoreline (Simenstad et al. 2011).

The following stressor summary of WRIA 1 is displayed spatially on Maps 7 and 8. Shoreline armor occurs along approximately 34 miles, or 22% of the WRIA 1 shoreline. Nearshore roads cumulatively occur along 18.4 miles of the WRIA, accounting for 12% of the shoreline. Over twelve miles of tidal barriers and approximately 1.2 miles of nearshore fill exist. In total, 15 breakwaters or jetties are found in

Map 7. WRIA 1 nearshore stressors - roads, railroads, tidal barriers, and overall armoring (PSNERP data).

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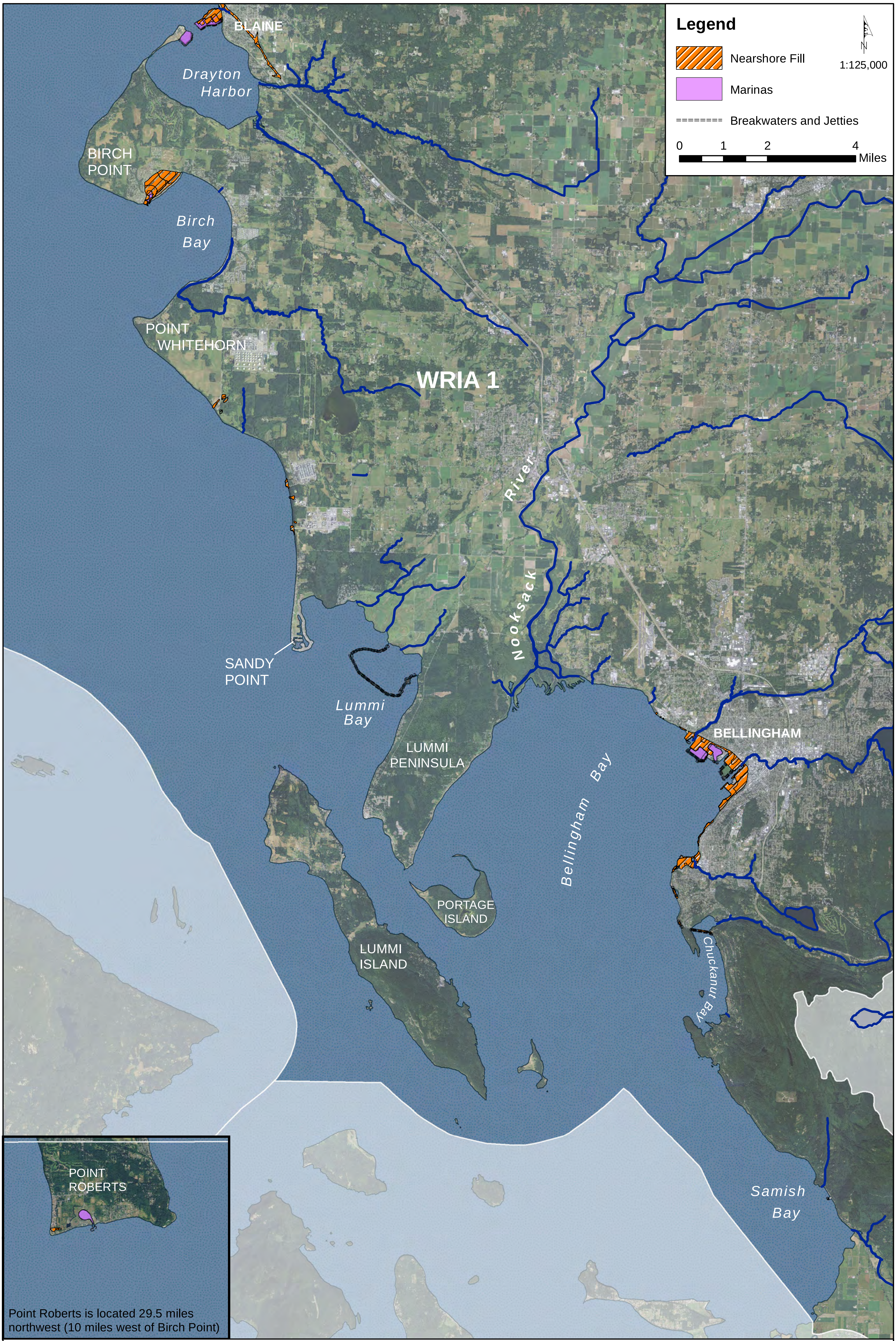

Map 8. WRIA 1 nearshore stressors - breakwaters & jetties, marinas, and fill (PSNERP data).

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WRIA 1, many of which are associated with one of the 10 different marinas. A total of 305 over-water structures were identified along the marine shorelines of WRIA 1.

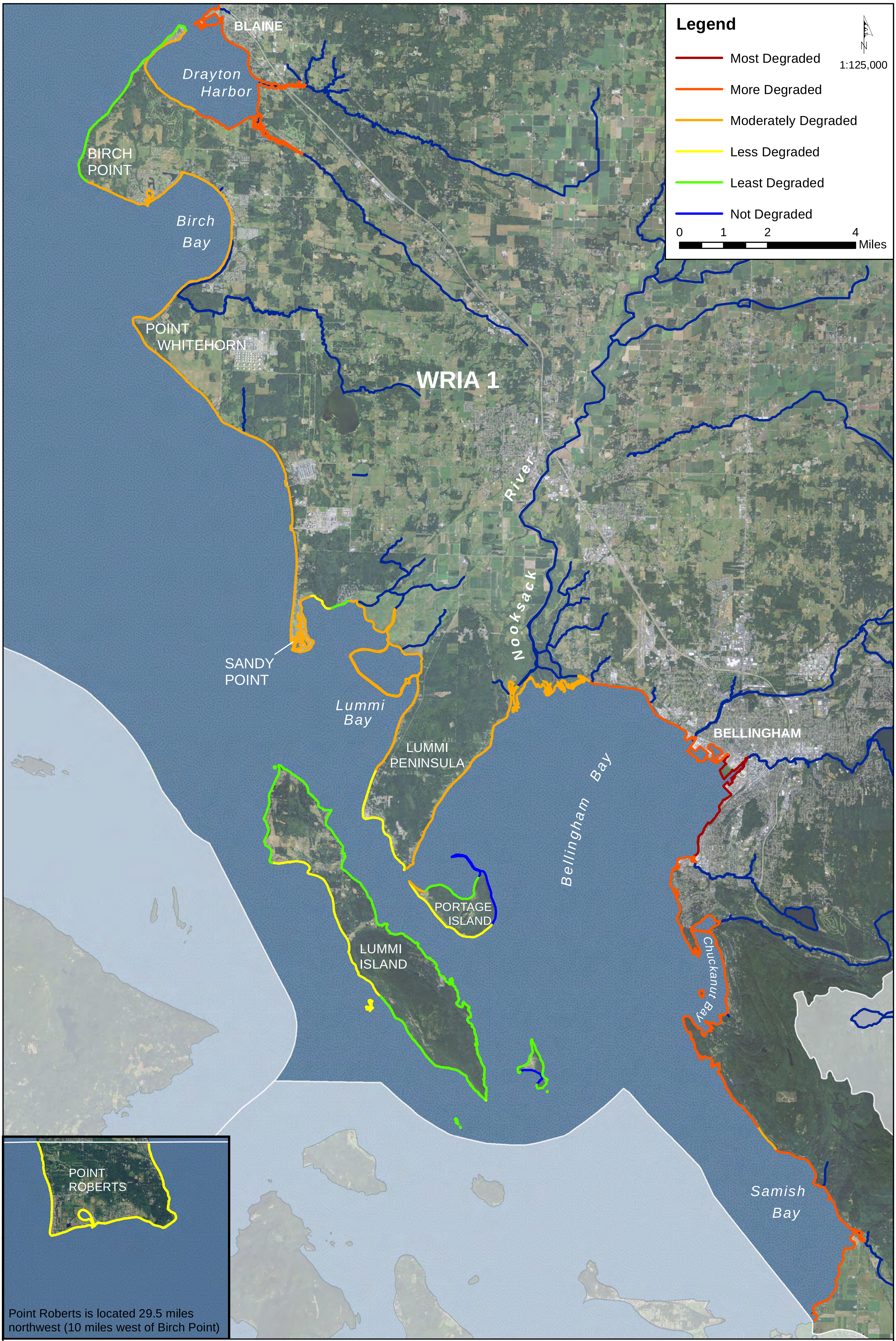
Linkages were drawn between each of the 12 stressors and the 11 nearshore ecosystem processes to document how the altered processes result in changes in ecosystem structure and habitat function (Table 14). The distribution of stressors was analyzed to specifically document the spatial co-occurrence of stressors along the same sections of shoreline, termed “co-located stressors”. Armoring is most commonly co-located with nearshore roads (23% of armored shores are also within close proximity to nearshore roads). Approximately 10% of all armored shores in WRIA 1 are also filled. Shoreline armor commonly comprises tidal barriers (61%), and many other tidal barriers were associated with roads (25%). Eighty-percent (80%) of the nearshore fill mapped in WRIA 1 was in association or co-located with the BNSF rail causeway (Schlenger et al. 2011, Simenstad et al. 2011).

Table 14. Linkages between PNSERP nearshore processes and stressors (Schlenger et al. 2011).

Stressor (Change Analysis Categories [Tiers])	**PSNERP Nearshore processes**										
	Sediment Input	Sediment Transport	Erosion/Accretion of Sediment	Tidal Flow	Tide Channel Formation and Maintenance	Distributary Channel Migration	Freshwater Input	Detritus Import and Export	Exchange of Aquatic Organisms	Physical Disturbance	Solar Incidence
Shoreline Armoring (2)	✓	✓	✓	o	o	✓	o	✓	✓	✓	o
Breakwaters and Jetties (2)	o	✓	✓			o		o	✓	✓	o
Tidal Barriers (2)		✓	✓	✓	✓	✓		✓	✓	o	
Nearshore Fill (2)	✓	✓	✓	✓	✓	✓	o	✓	✓	✓	o
Roads (2, 3, 4)	✓	o	✓	✓	o		o	✓	✓	✓	o
Overwater Structures (2)	o	o	o					o	✓	o	✓
Marinas (2)	o	✓	✓	o	o		o	o	✓	✓	✓
Railroads (2, 3, 4))	✓	o	✓	✓	o	o	o	✓	✓	✓	o
Land Cover Development(3, 4)	o		o			o	o	✓			✓
Impervious Surface (3, 4)	o						✓	o			✓
Stream Crossings (3, 4)			o					o	✓		✓
Dams (4)	✓	✓	o			✓	✓	o	✓	o	

Note: ✓denotes a direct connection, or impact on process resulting from stressor
o denotes indirect or partial impact on process resulting from stressor

The main drivers of overall nearshore process degradation are degradation to sediment supply and tidal-flow processes. These two nearshore processes predominate in different shoreform types and display contrasting results, even when summarized at the process unit (drift cell) scale (Maps 10 and 11). Shoreline armor along bluff-backed beaches is the main driver of degradation to sediment supply. Bluff-backed beaches are ubiquitous in the Salish Sea and homeowners commonly armor the toe of their bluffs to slow marine-induced erosion. Sediment supply is highly degraded in the east and leeward shores of Drayton Harbor, along the west shore of the Nooksack River Delta, and along the City of Bellingham shoreline south to near the Skagit-Whatcom county line. The areas with the most intact sediment supply occur along the shores of Eliza Island, northwest Portage Island, and a short reach of shoreline east of Sandy Point and west of the Lummi River Delta.



Map 9. WRIA 1 overall nearshore processes degradation (Schlenger et al. 2011).

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Map 10. WRIA 1 sediment supply degradation (Schlenger et al. 2011).

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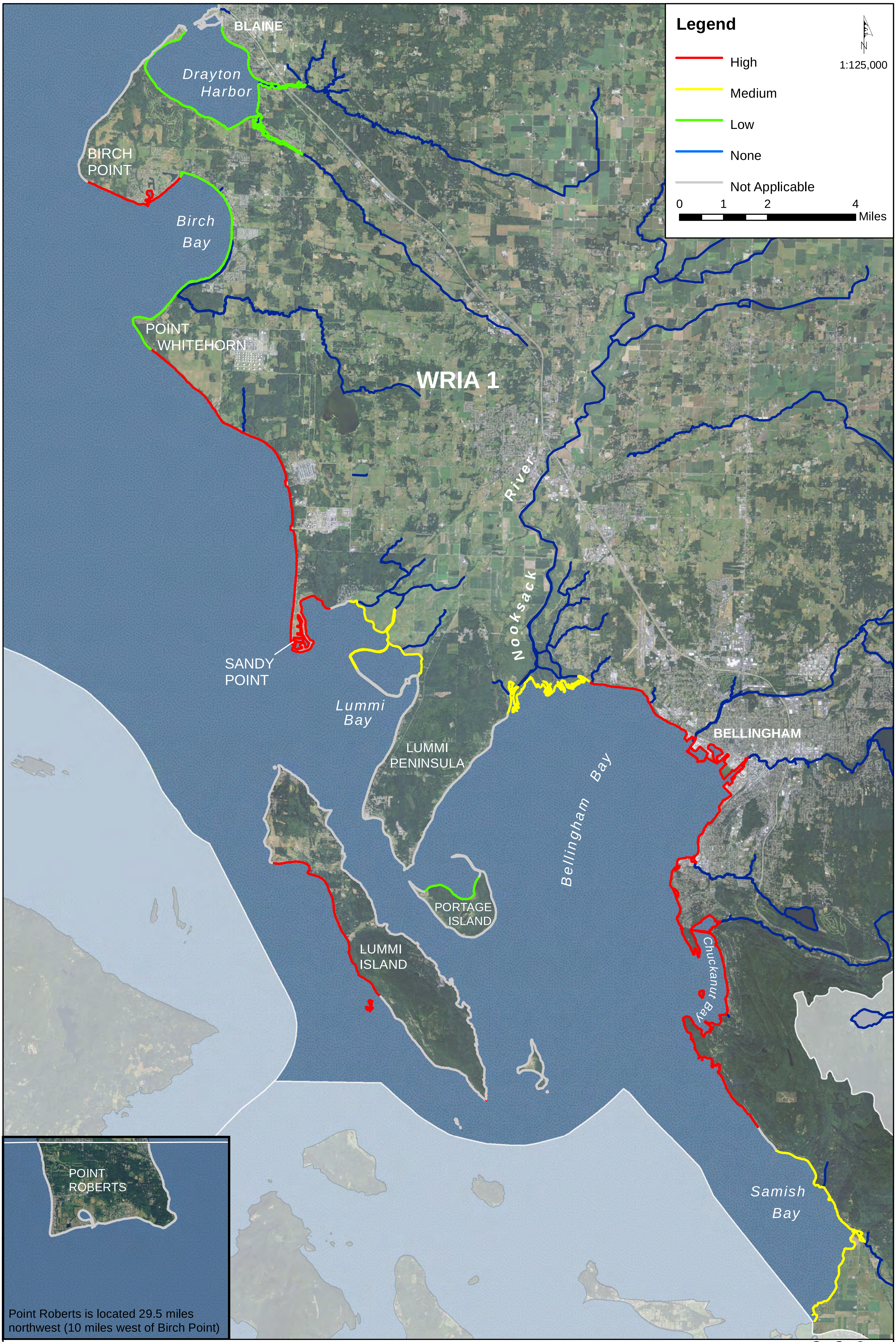

Map 11. WRIA 1 tidal flow degradation (Schlenger et al. 2011).

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Degradation to tidal flow commonly occurs as the result of nearshore fill reducing the extent of marine shoreline as well as restricting tidal flow into tidally inundated areas, such as embayments like barrier lagoons and estuaries. Considerable fill has occurred in Drayton Harbor, Birch Bay, the City of Bellingham, and other WRIA 1embayments. Tidal flow can be restricted into an embayment by constricting a tide channel or otherwise altering tide channel geometry. Such is the case with several lagoons in WRIA 1, particularly along the BNSF causeway. Tidal-flow degradation is greatest northwest of Birch Bay, from Cherry Point to Sandy Point, and along the central west shore of Lummi Island.

3.0 Critical Data Gaps

Several data gaps were identified during Phase I (literature review and synthesis) that span a range of disciplines and required spatial extent (full or only part of WRIA 1). Critical research on some specific topics could help to advance the understanding of the need for nearshore restoration in WRIA 1. The data gap that could provide the greatest value for nearshore restoration would be a WRIA 1-wide assessment of juvenile salmonid utilization of both the Nooksack estuary and the entire nearshore (stratified by shoreform), similar to the study recently conducted by Beamer and Fresh in WRIA 2 (Beamer and Fresh in prep. 2012). Greater understanding of salmonid residence time in the nearshore and the degree to which they rely on nearshore habitats will help to quantify how important nearshore habitats are specifically to juvenile Chinook, particularly where extensive estuarine habitat loss has occurred (Beamer et al. 2003). Additionally, linking salmonid utilization data to an assessment of the important biophysical processes (circulation, salinity gradients, food webs) that shape habitats along each shoreform is important to assess future change with land use and climate change. The timing of applying for grant funding for this type of research is prime and partnerships with Skagit County, tribes, or others could be beneficial for sharing match requirements.

Research should also be conducted to assess the vulnerability of WRIA 1 nearshore habitats to implications of climate change. Baseline understanding of background erosion rates and wave data are critical data gaps that could inform a higher resolution study of WRIA 1 nearshore vulnerability to sea level rise and other implications of climate change.

There are several existing datasets that are known to be lacking in resolution or complete coverage (Table 15). Improving these datasets should also be considered a priority. A greater understanding of overall watershed conditions as compared to historical conditions (floodplain and wetland loss) within each of the major tributary watersheds would be beneficial to bettering the management of the coastal watershed. The WRIA 1 Limiting Factors Report highlights the need for such a study (Smith 2002). Certain datasets that are known to be of coarse scale and could be improved upon include mapping of tide gates, nearshore fill, and pocket beaches. Higher resolution pocket beach mapping was completed for the WRIA 2 wild Chinook restoration assessment, which was integrated into the Beamer and Fresh (in prep 2012) juvenile Chinook utilization study of WRIA 2. For the Beamer and Fresh study, the regional pocket beach mapping was insufficient as the minimum mapping unit was too large (100 meters) to pick up on many pocket beaches that were shown to be the most heavily utilized shoreform (for wild juvenile Chinook) in the WRIA 2 nearshore (Beamer and Fresh in prep. 2012). Higher resolution mapping conducted for Beamer and Fresh included all pocket beaches that were 50 ft or longer in length across the Washington Department of Natural Resources (WDNR) high-tide shoreline. Similar to WRIA 2, many more pocket beaches likely occur in WRIA 1, which could be identified if higher resolution pocket beach mapping were conducted.

Table 15. Prioritized data gaps for WRIA 1 nearshore and estuary.

Priority	Data gap description	Additional information
1	WRIA-1 wide assessment of juvenile salmonid utilization	A study similar to that recently conducted by Beamer and Fresh in WRIA 2 is needed for both the Nooksack estuary and the entire nearshore (stratified by shoreform). Greater understanding of salmonid residence time in the nearshore and the degree to which they rely on shoreline habitats is the goal.
2	Vulnerability of WRIA 1 nearshore habitat types to climate change.	Baseline understanding of background erosion rates and wave data are critical data gaps that could inform a higher resolution study of WRIA 1 nearshore vulnerability to climate change implications, to provide understanding of the relative constraints/resilience of different habitats and shoreforms.
3	Detailed studies of coastal tributaries	Historical analysis of overall watershed conditions of coastal tributaries particularly with regard to floodplain and wetland loss would benefit the management of the coastal watershed
4	Baseline data on waves, erosion rates	Wave modeling has been done for Whatcom County and parts of the Lummi Indian Reservation and the City of Bellingham. Erosion rate work has been conducted for some areas in WRIA 1 and extensively for the Lummi Indian Reservation These data should be compiled, augmented, and assessed in a complete study.
5	Higher resolution pocket beach mapping	This may be required if the fish utilization study is conducted, as regional pocket beach mapping is too coarse to capture all those utilized by juvenile salmonids (Beamer and Fresh pers. comm., 2011).

4.0 Review of Restoration Prioritization Approaches

The WRIA 1 Nearshore Assessment and Restoration Prioritization effort builds on numerous other prioritization efforts in the Salish Sea region. Thirteen related efforts were reviewed in order to assess their overall approach and prioritization criteria, and identify the pros and cons associated with different applications. The lessons learned from the review process were carried forward and applied in the development of the nearshore prioritization tool for WRIA 1. Each of the models that were selected for review was applied across areas that are similar in size to WRIA 1 with similar objectives, or included WRIA 1. Each study employed an ecosystem-based approach built on the fundamental linkages between nearshore ecosystem processes, structure and functions, and the impacts that nearshore stressors such as shoreline modifications can have on these relationships and conditions over time (Figure 4).

Several approaches incorporated conceptual linkages between nearshore ecosystem conditions, habitat degradation, and benefit to nearshore species without extensive local data to document these relationships. Most studies incorporated standard datasets on where valuable habitats exist and the best resolution data available to assess the conditions of nearshore processes and habitat structure. The take-away message from this review process was the need to create a scalable tool that accurately represents on-the-ground conditions, integrates best available science and datasets, and reduces subjectivity to the extent practicable.

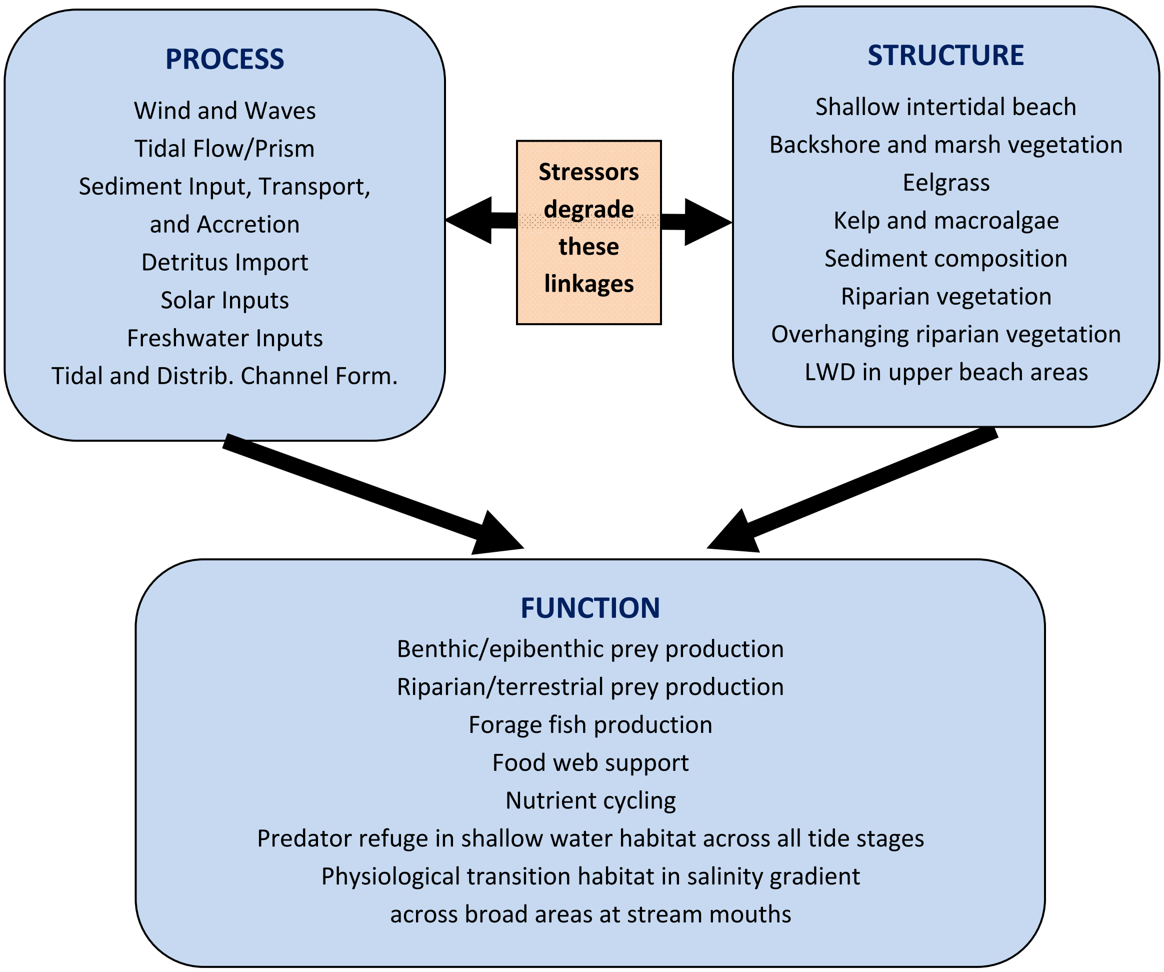

Figure 4. Conceptual linkages between nearshore ecosystem processes, structure and function and the degradation caused by stressors.

4.1 Puget Sound Nearshore Ecosystem Restoration Project (PSNERP)

PSNERP is a project led by the U.S. Army Corps of Engineers and Washington Department of Fish and Wildlife (WDFW) to plan for large-scale restoration in Puget Sound. The project entails characterizing the historical, current, and future conditions of Puget Sound, assessing the changes and major impacts of the changes, and strategically identifying and completing restoration projects to address the major problems of the study area. The evaluation of the impacts of the major changes and the identification of major problems were conducted in a “Strategic Needs Assessment of Puget Sound” (Schlenger et al. 2011).

The underlying conceptual model of PSNERP is the relationship between ecological processes, habitat structures, and biological functions. In this conceptual model, ecological processes form and maintain the habitat structures of Puget Sound. Habitat structures also influence the ecological processes that occur in an area. Ecological processes and habitat structures both control and drive biological function. With this conceptual model in mind, PSNERP emphasizes process-based restoration as the necessary approach to provide true restoration over the long-term.

In the Strategic Needs Assessment Report (SNAR), a framework was developed to characterize the degree to which the ecological processes of the marine nearshore and large river deltas were degraded by man-made modifications along the shore (e.g., shoreline armoring and tidal barriers). In total, 11 ecological processes were evaluated individually and as an overall composite for each assessment unit. The assessment unit used for the analysis was one “drift cell” or one large river delta, of which there were 812 and 16, respectively, Puget Sound-wide. The degradation of each process was evaluated based on the spatial distribution of a selected set of stressors. In addition, the degradation assessment was specific to the type of shoreform that the process applies to and the modifications that degrade processes in that shoreform. The degradation assessment was based on a Geographic Information System (GIS) and used the source datasets that document the discrete start and end points of the stressors used in the evaluation.

One of the “pros” of the SNAR approach is the novel framework for evaluating the degradation of ecological processes in drift cells. The technique was applied to the entire Puget Sound project area, including WRIA 1, and a subset of the results can be extracted for use outside of PSNERP.

The “cons” of the Strategic Needs Assessment approach are related to its development for a Sound-wide analysis using only datasets that were available throughout the area. This unfortunately excluded some useful datasets available for portions of Puget Sound; also, the data resolution acceptable for a Sound-wide analysis is often inadequate when applied to a smaller area.

4.2 Wild Salmon Recovery in San Juan County

The Wild Salmon Recovery restoration planning project in San Juan County was a project designed to apply existing information on fish use and shoreline conditions in a WRIA 2-wide prioritization for restoration and protection (Whitman et al. in prep. 2012). The outcome of the project will be incorporated into the San Juan chapter of the Puget Sound Salmon Recovery Plan. A technical advisory team was convened for the project and provided input at three meetings.

The Wild Salmon Recovery project took the PSNERP degradation framework and GIS database and applied them at the county scale. Instead of evaluating drift cells, the assessment of process degradation was conducted at the scale of shoreforms. The degradation framework was adapted to the available datasets in the WRIA and applied to evaluate the “Key Ecological Processes” identified by the Puget Sound Recovery Implementation Technical Team (RITT) as supporting juvenile salmon in the estuary. The degradation information was coupled with recently collected fish-use data to identify priority areas. Once priority areas were identified, finer scale information on restoration opportunities, ecological communities, and feasibility were applied.

The “pros” of the Wild Salmon Recovery project are that it built upon the PSNERP peer-reviewed work and addressed the “Key Ecological Processes and Attributes” identified by the RITT. The analysis was conducted on shoreforms which are subsets of the drift cells, thereby providing higher resolution analysis than did PSNERP. The project was conducted at a broad scale for screening based on fish use and degradation, and then fine-scale opportunities were identified. The “cons” of the Wild Salmon Recovery project are that it was a very labor-intensive approach for GIS and that the analysis relied upon an extensive survey of fish use in WRIA 2.

4.3 WRIA 9 Marine Nearshore Prioritization

In WRIA 9, the Green-Duwamish watershed in central Puget Sound, a marine nearshore prioritization was conducted to provide a science-based analysis of priority areas for restoration and protection (Anchor Environmental 2006). The project report was used to update the WRIA 9 chapter in the Puget Sound Salmon Recovery Plan because the marine nearshore prioritization was not complete at the time of the plan development.

The WRIA 9 prioritization evaluated habitat function conditions for juvenile salmon based on the presence or absence of beneficial habitat features (e.g., coastal bluffs and aquatic vegetation), as well as detrimental man-made modifications (e.g., shoreline armoring and overwater structures). Nearshore conditions were evaluated separately for three components of the nearshore: sediment supply, juvenile salmon migration corridor, and riparian corridor. The assessment was conducted in small-scale assessment units with a separate analysis of landscape-scale conditions. The assessment recommendations were provided at the drift-cell and site scales with specific opportunities identified.

The “pros” of the WRIA 9 prioritization are that it was salmon-focused and that recommendations were provided at multiple scales. The “cons” of the WRIA 9 prioritization are that it used nearshore inventory data collected through field and remote data collection projects, which could not be conducted as part of this study due to resource constraints, and that the project was not explicitly process-focused.

4.4 Whatcom County Nearshore Habitat Restoration Prioritization

The objective of the Whatcom County Nearshore Habitat Restoration Prioritization project, contracted by the Whatcom County Marine Resources Committee (MRC), was to prioritize a list of nearshore restoration opportunities within three target areas of Whatcom County: Point Roberts, Birch Bay, and Chuckanut Bay (MacLennan and Johannessen 2007). The approach integrated sustainability, risk, practicality, feasibility, and the projected benefit of the restoration opportunity’s ability to improve conditions for nearshore processes and the specific species identified within the MRC’s mandate: forage fish spawning areas, juvenile salmonid rearing/migration, and submerged aquatic vegetation. The project employed a process-based approach and relied upon a conceptual model built on the fundamental linkages established by PSNERP and outlined in Figure 5. The unit of analysis of this project was the individual restoration site. The datasets relied upon included the restoration points identified in the Whatcom County SMP update restoration plan. That list was augmented by the authors (CGS) by reviewing aerial photographs and surveying each target area on foot. Other datasets included WDFW Priority Habitats and Species (PHS) data, LIDAR imagery, historical T-sheets, feeder bluff mapping, drift-cell mapping, the WDNR ShoreZone database, parcel data, pictometry images, and Washington State Department of Ecology’s shoreline oblique images. Thirty-three attributes were scored, which were generally categorized into factors that influence sustainability, risk, ecological function, targeted response, and feasibility; the latter incorporated property-owner willingness and other socio-economic aspects of implementing nearshore restoration projects. The targeted response category was the most heavily weighted scoring category, followed by ecological function and feasibility.

Site visits were made to each opportunity and the dimensions were measured for each potential restoration/enhancement action; these were used to calculate benefit areas. Final scores ranged from 42 to 74 out of a total of 117 points possible. Planning-level cost estimates were provided and scoring data could be analyzed by category, target area, or feasibility (project readiness). The “pros” of this type of approach include the finer scale and the unique scoring categories that take into account real issues associated with project implementation that can help expedite the feasibility assessment process. The top-ranking project (Chuckanut Village marsh culvert removal) was implemented and is generally accepted as a successful restoration project in the WRIA 1 nearshore and for the Whatcom MRC and the City of Bellingham. The “cons” of this approach are largely associated with the subjectivity of the scoring process not being adequately defended or explained; the limited area (not countywide), which resulted in few projects that were feasible to implement; and the bias involved in identifying projects opportunistically rather than systematically based on where they are needed most (at a larger spatial scale). The opportunities identified for the Whatcom County Nearshore Habitat Restoration Prioritization project were included in the inventory of on-the-ground opportunities used in this project.

4.5 Jefferson County Marine Shoreline Restoration Prioritization

The Jefferson County Marine Shoreline Restoration Prioritization approach was developed by Battelle Pacific Northwest National Laboratory scientists and applied to east and west Kitsap County, Bainbridge Island, and some areas in Jefferson County (Diefenderfer et al. 2006). The approach was designed to target juvenile salmonid foraging, rearing, and migratory habitats and overall nearshore ecosystem processes. The units of analysis were the ShoreZone unit, the drift cell, and the watershed. The project aimed to meet the aforementioned objectives as well as fill data gaps identified by the lead entity strategy. Data used in the assessment included the WDNR ShoreZone database (2001) and local WDFW PHS data. The conceptual model that the assessment was built upon is displayed in Figure 5.

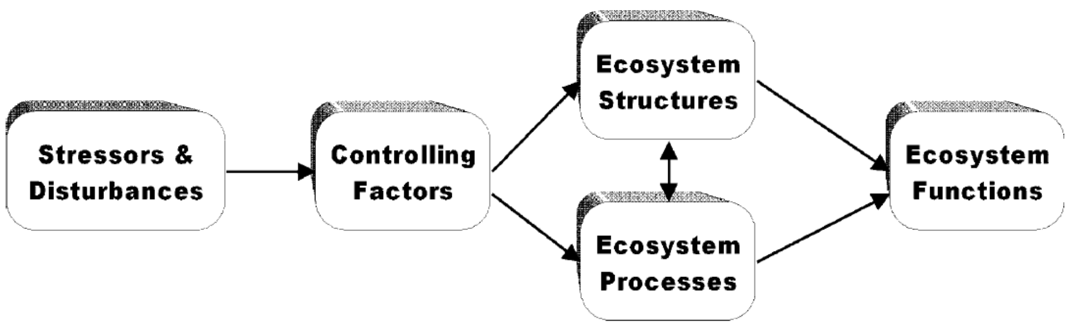

Figure 5. Conceptual model for the Jefferson County Marine Shoreline Restoration Prioritization (Diefenderfer et al. 2006).

The assessment approach entailed a scoring system that was applied at the ShoreZone unit scale. Stressor scores were assigned based on the spatial extent and frequency of the stressors present. A weighting factor was applied based on the impact that the stressors were thought to have on controlling factors. A geomorphic modifier was applied that reflected the variable impact that stressors have across different shoreforms. For example, if a stressor was to impact controlling factors within a given shoreform then it would have a geomorphic modifier =1. Function scores were then assigned scores (1-3-5) based the occurrence of WDFW PHS data including herring spawning, herring holding, surf smelt and sand lance spawning, geoducks, rare plants, wetlands, eelgrass, bull kelp, and intertidal macroalgae. Stressor scores (negative values) were multiplied by the controlling factor weighting plus the geomorphic modifier, and were then summed with the Function scores (positive values) for each unit. At the drift-cell scale, stressor values and function scores were averaged and weighted by length. Watersheds were scored only where perennial freshwater inputs occurred. These scores addressed riparian fragmentation, watershed-scale road density, the quality of riparian vegetation, watershed-scale percent of forest cover, and hydrologic alterations (using a score that addressed alterations to delivery, movement, and loss of water).

This early prioritization approach has several “pros”, most notably the nested units that allow users to scale up and down. The watershed stressors are particularly valuable for areas with perennial streams. The “cons” associated with this approach are 1) the very limited understanding of coastal processes applied to the stressors (armor is not properly linked with impacted processors among different shoreforms), 2) relation of the stressor scores to the extent/frequency across the larger study area (e.g., West Kitsap County) rather than the cumulative spatial extent of the unit of analysis, which means that many shoreforms are included in that measure that may not be impacted by the stressor, and 3) use of weighting factors that do not all make sense. For example, stairs and armor were of equal impact to sediment supply.

4.6 Strategies for Nearshore Protection and Restoration in Puget Sound

Cereghino et al. (2012) recently applied a Sound-wide analysis of numerous PSNERP products, including the Change Analysis and SNAR (Schlenger et al. 2011, Simenstad et al. 2011), that resulted in a suite of nearshore strategies to address the various sources of degradation and impairment to the greater Puget Sound nearshore ecosystem. Recommendations were made based on cluster analyses of a composite ranking of site potential, degradation, and risk. Site potential integrated landscape ecology and conservation biology principles based on the historical configuration and inherent potential of shoreforms. Degradation data were extracted from SNAR but focused only on degradation to sediment supply and tidal flow. Risk was based on future impacts projected to occur in the Puget Sound region based on trends associated with population growth and developmental pressure.

Results of the ranking were clustered and assigned one of three strategic approaches: protect, restore, or enhance. A set of sites within each of the strategies was then identified as providing a greater value of ecosystem services and therefore having higher site potential (protect versus protect high). Thus the final spectrum of recommended priorities was essentially two-tiered with protection priorities and high protection priorities, restoration priorities and high restoration priorities, and enhancement priorities and high enhancement priorities (Figure 6). Protection projects were considered the greatest priorities as they have the highest certainty of attaining the anticipated benefits, and protecting nearshore processes is the greatest way to assure ecosystem health. Areas ranked as “Protect High” were considered the greatest priority action areas, followed by areas ranked “Protect”. Similarly, restoration was ranked a higher priority than enhancement, because restoration projects generally have a higher certainty of success (achieving anticipated response) than enhancement projects; this is due to their greater overall ecosystem health as compared to the more degraded areas targeted for enhancement. Additionally, enhancement projects are typically very costly, highly constrained, and unlikely to fully recover historical ecosystem processes. Shoreforms ranked as “Restoration High” should be considered a higher priority than those ranked as “Restore” (and similarly with shoreforms ranked “Enhance High” and “Enhance”, respectively). Higher valued priority actions should be targeted first as they are more likely to provide larger scale benefits to nearshore ecosystem functions, goods, and services (Cereghino et al. 2012).

“Pros” of this assessment, in particular, are the individual metrics and GIS assessments that were integrated to make the final recommendations. Several of the assessments that helped to form the final recommendations were based on sound principles and can be utilized independently for other applications outside of restoration prioritization work. As for “cons”, the overall unit of analysis was the drift cell; therefore rocky shores (or those mapped as NAD) were not included and lumped as single areas despite the existence of valuable habitats such as pocket beaches. Additionally, the coarse scale of the assessment units, the lumping of all rocky shoreforms, and the all-inclusive composite resulted in recommendations that did not always agree with on-the-ground conditions. Additionally, the overlapping nature of the PSNERP process units (drift cells) resulted in duplicated recommendations for different areas, which again often did not concur with finer-scale local data.

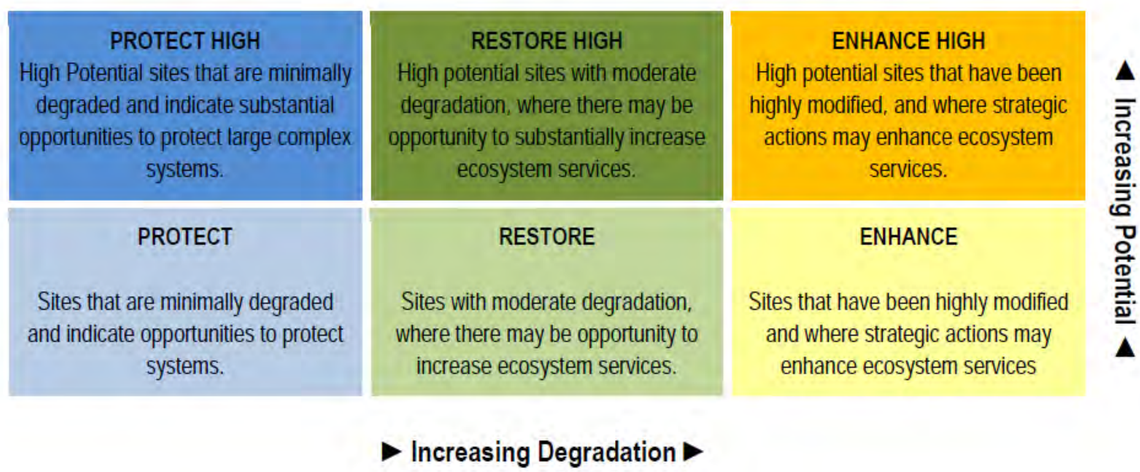

Figure 6. Relationship between nearshore process degradation and site potential associated with recommendations and strategies outlined by PSNERP (Cereghino et al. 2012).

5.0 Prioritization Methods

The overarching goal of the WRIA 1 Marine and Estuarine Assessment and Prioritization was to develop a science-based, user-friendly prioritization tool for estuarine and marine nearshore restoration and protection efforts in WRIA 1. Two different approaches were developed for the marine nearshore and the Nooksack River estuary (including the Lummi River estuary) due to the fundamental differences in fluvial and marine systems and the contrasting resolution of assessment and engineering studies that have been applied to the two areas. For example, more in-depth assessments have been completed for the Nooksack River estuary, which has a long history of systemic alteration. Previous work in the estuary has identified several major restoration project opportunity locations throughout the estuary to address one or more of the limiting factors. In contrast, the marine shorelines largely function in more linear alongshore nearshore subsystems (net shore-drift cells) with far less upland influence. For these reasons, addressing the Nooksack estuary and WRIA 1 marine shorelines separately was recommended and two different approaches were applied (Figure 7).

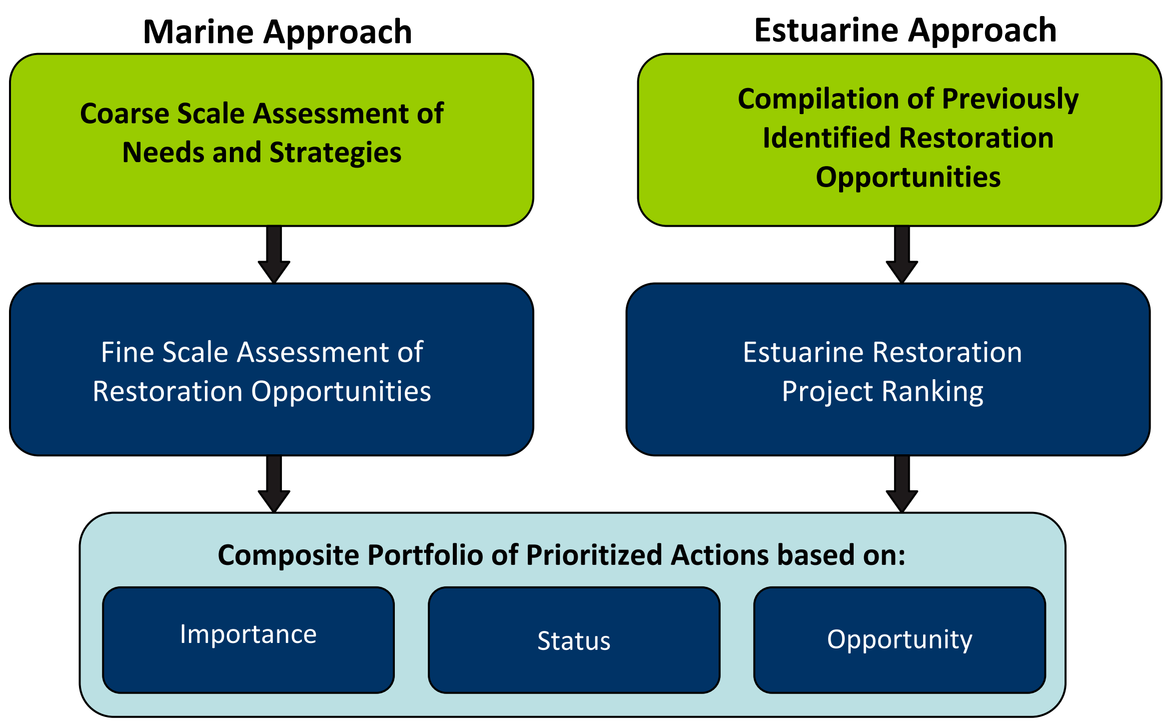

Figure 7. Combined conceptual approach to estuarine and marine shoreline prioritizations.

5.1 Prioritizing Restoration and Conservation for WRIA 1 Marine Shores

The approach applied to assess nearshore conditions and identify restoration and protection priorities in WRIA 1 integrated local habitat data with larger scale datasets (shoreform and drift cell) that address the condition of nearshore ecosystem processes as they relate to habitat and regional restoration priorities. The nested nature of the datasets results in a scalable tool that can be used to identify where to implement restoration and conservation projects throughout the marine shores of WRIA 1 with the greatest benefit to nearshore processes and species. The methods applied in this approach are detailed below. This GIS-based tool applies the key values identified in the restoration prioritization review (Section 4), Phase 1 assessment data, and fundamental principles of restoration and conservation from peer-reviewed literature, and includes PSNERP, best available science, and TAG input. Where necessary, local data were augmented to include additional project opportunities that exist within WRIA 1. A description of how to use the resulting geodatabase to meet the objectives of different user groups is included in Appendix B.

5.1.1 Coarse Scale

The coarse-scale assessment was the first step in the identification of priorities throughout the WRIA 1 marine nearshore. The objective at this stage was to develop a science-based approach from which to determine *what needs to be done where* to benefit the nearshore ecosystem and priority species. The fundamental unit of analysis was the geomorphic shoreform. All data were assembled and analyzed at the shoreform-unit scale; however, data were scaled-up to the drift-cell scale, as shoreforms are inherently linked with other shoreforms in the same alongshore system. Restoration and protection actions in a single shoreform can provide drift-cell-wide benefits. The ecological value of each geomorphic shoreform was assessed by applying a simple rank-sum approach described further below. The data were then linked with nearshore process degradation data to identify the appropriate action to apply: protection, restoration, or enhancement. Priorities, areas, and actions were then identified for the fine-scale assessment, from which the 3-year and 10-year portfolio of actions were assembled (Figure 8).

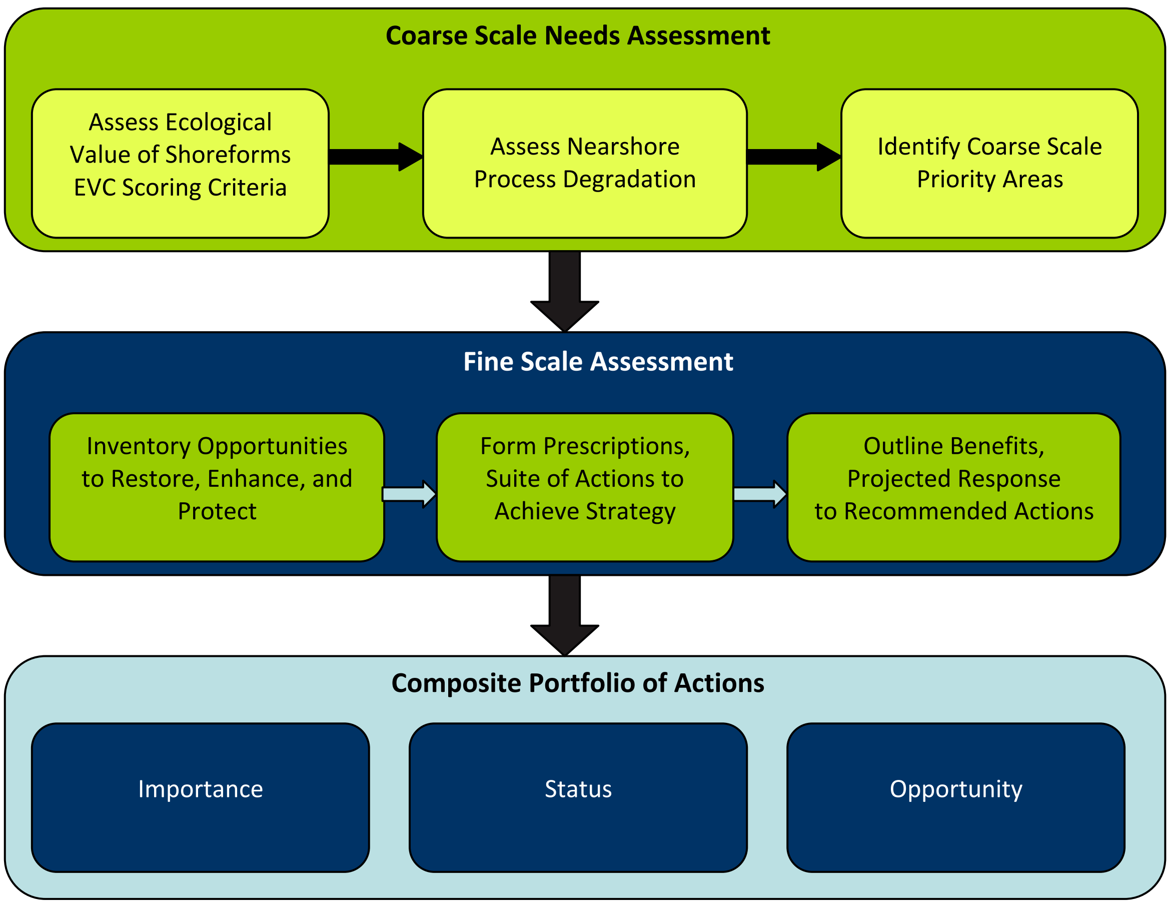

Figure 8. WRIA 1 marine prioritization conceptual approach to nearshore prioritization.

5.1.2 Ecological Value Criteria

A shoreform-scale assessment method of ecological value in relation to habitat functions of several nearshore species (particularly salmonids) was developed and applied throughout the WRIA 1 nearshore. The purpose of this assessment method, hereafter referred to as the "Ecological Value Criteria" (EVC), was to measure the distribution of ecological resources throughout the WRIA 1 nearshore, particularly those resources that are associated with nearshore ecosystem health, biodiversity, and habitat structure and function to critical species such as juvenile salmon. The metric also characterizes the likelihood of the area's use by salmon, including an emphasis on juvenile Chinook salmon. The EVC metric was developed with emphasis on juvenile Chinook salmon due to the species' listing under ESA and their dependence on the marine nearshore (see Healey 1982, Fresh 2006). In addition, the resources that support juvenile Chinook salmon survival and growth as they rear and migrate through the marine nearshore are a diverse suite of prey items and habitats that are more commonly available in naturally functioning areas than in modified shoreline areas. In this way, the EVC metric illustrates some of the inherent differences between resource distributions among different shoreforms as well as the relative function of the shoreline.

The EVC metric includes nine habitat and resource parameters. The resource parameters include the ecological communities highlighted by the Puget Sound Recovery Implementation Technical Team (RITT) as contributing to the key ecological attributes of estuaries and nearshore for support of juvenile salmonids. The nine parameters included in the EVC metric, and a statement about the rationale for their inclusion, are presented in Table 16. In addition to the ecological basis described in the table, the availability of GIS data throughout WRIA 1 was a necessary prerequisite.

Table 16. Overview of EVC parameters and links to salmonid function in WRIA 1 nearshore ecosystems.

EVC parameter	Overview of salmon link
Surf smelt spawning Sand lance spawning Herring spawning	These three species of "forage fish" or "bait fish" are preyed upon by salmon of multiple life stages. All three species spawn in the marine nearshore and have fairly specific spawning habitat requirements. Collectively, the presence of their spawning in an area indicates the availability of relatively fine-grained, naturally sloping, upper intertidal beaches and/or abundant submerged aquatic vegetation (macroalgae) in the subtidal zone. The species require different conditions for spawning: sand lance requires sandy mid- to upper intertidal habitats, surf smelt require fine to coarse sand mid- to upper intertidal habitats, and herring require specific types of subtidal vegetation. As a result of these species-specific requirements, there are often some differences in the spawning locations they use; therefore, the species were included in the EVC metric separately in order to assign higher scores to those areas with multiple species spawning.
Emergent wetlands	Emergent wetlands are highly productive areas supporting prey production, nutrient cycling, salmon habitat, and detritus inputs. The distribution of these habitats has been significantly reduced over the last 150 years.

Table 16 Cont. Overview of EVC parameters.

<table>
<tr><th>EVC parameter</th><th>Overview of salmon link</th></tr>
<tr><td>Submerged aquatic vegetation (eelgrass and bull kelp only)</td><td>Areas with SAV are also highly productive areas supporting prey production, nutrient cycling, salmon habitat, and detritus inputs. Like emergent wetlands, the distribution of eelgrass and bull kelp has been reduced from historical distributions.</td></tr>
<tr><td>Marine riparian vegetation</td><td>Terrestrial-origin insects are important components in the diets of several species of juvenile salmon. Marine riparian vegetation (MRV) in close proximity to the shoreline is important for supporting the input of terrestrial-origin insects into the aquatic system. In addition, MRV leads to large woody debris inputs to the shoreline which support lower trophic levels, provide habitat complexity, and retain sediment. The leaf litter and “small woody debris” from MRV also provide material for the detritus-based food web of estuaries and the marine nearshore.</td></tr>
<tr><td>Freshwater input</td><td>Freshwater inputs are anticipated to increase the diversity if not the quantity of shoreline functions through the presence of alluvial fans, variations in the salinity gradient, freshwater biota (Cereghino et al. 2012), and organic and inorganic material from the watershed, such as prey items for juvenile salmon, detritus, and sediment. The mouths of tributaries have also been documented to be highly utilized by juvenile salmon from other river systems (e.g., Beamer 2005, Hirschi et al. 2003. Freshwater inputs provide a salinity gradient that can provide a physiological refuge for salmon transitioning to the marine environment. . These areas also provide access to migration corridors, spawning, and rearing habitats, and can be highly productive in supporting macroalgae growth.</td></tr>
<tr><td>Close proximity to Chinook-bearing stream</td><td rowspan="2">Parameters associated with streams bearing Chinook and other salmonids provide an indication of the likelihood of use by juvenile salmon outmigrating from their natal streams. The use of a separate parameter for Chinook effectively serves to emphasize (or weight) shorelines near a Chinook-bearing river.

A score of 1 was assigned to areas within 5 miles of natal streams. This distance was identified by Redman et al. (2005) based on a general approximation of the distance a juvenile salmon can travel in a day. To further characterize the likelihood of use by juvenile Chinook, recently collected fish-use data were applied. Juvenile Chinook research in the marine nearshore off the Skagit River has documented higher numbers of juvenile Chinook in nonnatal pocket estuaries, such as barrier estuaries and barrier lagoons (Beamer et al. 2003). Recent work in the San Juan archipelago documented higher juvenile Chinook use in pocket beaches that occur among rocky shorelines (Beamer and Fresh in prep. 2012).</td></tr>
<tr><td>Close proximity to salmon-bearing stream</td></tr>
</table>

Each EVC parameter was scored a 0 or 1 based on presence (1) or absence (0). The assessment unit used in the evaluation was at the scale of the individual shoreforms. All scores were summed for each shoreform and normalized by the maximum scoring shoreform in the study area. All EVC parameter data were maintained in the database, and some parameters include higher resolution data that can be utilized for further analysis or for applying differing prioritization approaches. Shellfish data are included in the geodatabase despite not being included in the final EVC score. Eelgrass and bull kelp coverage qualifiers were included for the density of coverage (patchy or continuous). Similarly, qualification of marine riparian cover as high, medium, or low was maintained in the database, despite only scoring for high and medium coverage.

5.1.3 Assessing Degradation and Identifying Coarse-Scale Strategies and Priority Areas

The objective of this portion of the assessment and prioritization effort was to link nearshore process degradation results with appropriate management strategies. Early PSNERP efforts highlighted the importance of process-based restoration over efforts to restore only ecosystem structure (often referred to as *enhancement* projects). Goetz et al. (2004) reported that nearshore biota can only be conserved by managing those ecosystem processes responsible for structuring the landscape. The conceptual foundation of this approach integrates this fundamental assumption as well as the following recommendations by Cereghino et al (2012), Goetz et al. (2004), and Greiner (2010):

1. By restoring degraded physical processes we maximize the sustainability and resilience of a complex nearshore ecosystem structure similar to the historical template to which a diverse biota is best adapted.
2. A complex and dynamic nearshore ecosystem with intact physiographic processes is most likely to continue to provide functions, goods, and services into the future, as compared to systems with degraded processes. Both costs and risks are likely to increase as we attempt to restore historical conditions in more severely altered landscapes.
3. The management of nearshore processes most reliably occurs at the scale at which they operate—the landscape scale.
4. Protecting existing unimpaired systems is more effective and efficient than restoration of impaired systems, and protection and restoration must be used together to restore the larger Salish Sea nearshore ecosystem.

The PSNERP Strategic Needs Assessment Team assessed the extent to which shoreline and watershed alterations around Puget Sound have impacted natural nearshore processes (Schlenger et al. 2011). The assessment was conducted to characterize the relative degree of impacts, i.e., how impacted is one area relative to another. The authors developed an assessment framework to estimate how degraded nearshore processes are in an area based on how much of the shoreline and watershed area has been altered. The analysis was conducted at the drift-cell scale. The assessment of process degradation was conducted separately for 11 nearshore processes. The assessment technique for each nearshore process was different to account for differences in which alterations affect which process and how the impacts vary depending on the type of shoreline (e.g., beach, barrier estuary, and river delta). The results of the degradation analysis for each of the 11 individual nearshore processes were qualitatively reported in the following categories of degradation: None, Low, Medium, High, or Not Applicable (N/A; for shoreforms in which the process generally does not occur). The results of the degradation calculations for each of the 11 nearshore processes (Table 3) were combined to provide an overall assessment of process degradation in each drift-cell analysis unit.

To serve the purposes of this WRIA 1 study, the PSNERP framework for assessing degradation was simplified. This was justified because while the PSNERP approach successfully provided a comprehensive assessment tool for that project, there was considerable overlap in the analysis approach used for each of the nearshore processes. To simplify the approach while still retaining the quality of the analysis, PSNERP results were reviewed to identify a subset of processes that sufficiently characterize the overall degradation in each analysis area.

Results of this review showed that sediment supply and tidal flow were most indicative of the overall degradation. Therefore, this WRIA 1 analysis used the degradation results for sediment supply and tidal flow to assess restoration and protection needs at both the shoreform and drift-cell scale. The metric for measuring degradation to sediment input within a drift cell was the cumulative percent of the bluff-backed beach shoreline (within areas with sediment transport) where shoreline armor, fill, railroads, roads, and artificial shoreforms occur. Tidal flow degradation was determined by measuring the total percent of embayment shoreline (barrier estuaries, barrier lagoons, or open coastal inlets) with tidal barriers, nearshore fill, railroads, and artificial shoreforms. These stressors were selected to assess the condition of the nearshore processes within these shoreforms based on conceptual linkages documented in the PSNERP SNAR (Schlenger et al. 2011) and supporting materials (Shipman 2008, Clancy et al. 2009, Simenstad et al. 2011).

Tidal flow and sediment process degradation were integrated into the shoreform database at the shoreform scale to inform strategy recommendations. Each of these drivers of nearshore process degradation was paired to select those strategy recommendations appropriate for the entire drift cell. Table 17 displays how various combinations of tidal and sediment process degradation were interpreted to provide overall strategy recommendations. Areas with only low degradation or “not applicable” degradation (meaning the process does not occur in the shoreform) were recommended for protection. Areas with only high or “not applicable” degradation were recommended for enhancement, meaning true process-based restoration is deemed either unlikely to succeed or unlikely to be feasible based on the extent of development. All other combinations of degradation were recommended for restoration.

Table 17. Link between nearshore process degradation and strategy recommendations.

Sediment supply degradation	Tidal flow degradation	Strategy recommendation
Low	Low	Protect
Low	NA	Protect
NA	Low	Protect
High	Medium	Restore
High	Low	Restore
Medium	High	Restore
Medium	Medium	Restore
Medium	Low	Restore
Medium	NA	Restore
Low	High	Restore
Low	Medium	Restore
NA	Medium	Restore
High	High	Enhance
High	NA	Enhance
NA	High	Enhance
NA	NA	Enhance

In general, shoreforms grouped as rocky or bedrock shoreforms (Shipman 2008), including plunging rocky shores, bedrock ramps, and pocket beaches, are dominated by neither sediment nor tidal processes. These shoreforms are wave-dominated and degradation to wave processes typically occurs when stressors impact or alter wave energy via structures such as breakwaters, causeways, and jetties (Shipman 2008, Schlenger et al. 2011). A GIS metric was used to assess degradation to wave processes (referred to as physical disturbance) in the PSNERP SNAR; however, it was applied to broad reaches of shoreline that lumped several adjacent shoreforms together that are not functioning as a single unit like a drift cell. For this effort, we applied that same metric to assess degradation of this important process to these wave-dominated shoreforms at the individual-shoreform scale. The metric assessed the cumulative percent of the shoreform in which the following stressors occur along the shoreline: fill, armor, railroads, roads, marinas, breakwaters/jetties, and artificial shoreforms. These results were used to provide strategy recommendations for bedrock shores that do not occur within drift cells (Table 18).

Table 18. Link between physical disturbance (PD) degradation and strategy recommendations.

Cumulative % altered by PD Stressors	Physical disturbance degradation	Strategy recommendation
NA	NA	NA
0	None	Protect
1–32.9%	Low	Protect
33–62.9%	Medium	Restore
63–100%	High	Enhance

A similar approach was applied by Cereghino et al. (2012); they integrated degradation data with additional analysis that included measures of risk associated with development and inherent potential based on specific landscape ecology and conservation biology principles. The Cereghino et al (2012) strategy recommendations did not apply to all shoreform types and excluded bedrock shoreforms, including pocket beaches. These data have value and were incorporated into the shoreform geodatabase for planning purposes, even though the scale of the assessment is coarser and the lack of bedrock shoreforms (one of the most abundant shoreform types) in WRIA 1 made it insufficient to rely on for the WRIA 1 study area.

5.1.4 Linking strategies and defining priorities

Shoreform strategy recommendations were next linked with EVC scores and scaled-out to rank and prioritize drift-cell and NAD shoreforms for protection, restoration, and enhancement along the WRIA 1 marine shore. First, EVC scores were length-weighted by determining the percent of the total drift-cell length that was composed of each shoreform. That percentage was multiplied by the (normalized) EVC score for the shoreform. Each length-weighted EVC score was then summed for all shoreforms within each drift cell. The number of shoreforms within drift-cell units ranged from 1 to 14. Bedrock shoreform types (pocket beaches, plunging rocky shores, and bedrock ramps) were treated as individual units.

Strategy recommendations applied originally at the shoreform scale were scaled-up to the drift cell by applying a length-weighted approach where the strategy representing the largest portion of shoreline was selected and applied to the entire drift cell. Where recommendations were more or less equally distributed within the drift cell—e.g., 33% of the drift-cell protection, 33% restoration, 33% enhancement—the selected recommendation was selected so as to accurately reflect overall degradation within the drift cell. For the hypothetical example above, restoration would be selected because nearshore process degradation occurs throughout a larger portion of the drift cell. Circumstances such as the example described above occurred infrequently, but were carefully interpreted to provide consistent and accurate representation of on-the-ground conditions. Shoreform-scale strategy recommendations were maintained in the geodatabase so that they can be used to inform and guide finer scale actions.

Where shoreforms were matched in both strategy recommendations and EVC scores the same rank was applied. Therefore, it is important to be mindful when interpreting results that there are occasionally multiple drift cells of the same ranking for certain strategies.

5.1.5 Fine Scale

On-the-ground protection, restoration, and enhancement opportunities were compiled from existing datasets from various local entities including the following:

- The City of Blaine SMP Update Restoration Plan
- Whatcom County SMP Update Restoration Plan
- Whatcom County Restoration Prioritization
- Whatcom County Feeder Bluff Mapping
- The City of Bellingham SMP Update Restoration Plan

The list of opportunities was augmented by CGS staff using best available datasets to guide the identification of new opportunities. These datasets included nearshore process degradation datasets, stressor data (shoreline armoring, jetties/breakwaters, tidal barriers, fish passage barriers, etc.), feeder bluff mapping, and habitat data (all data included in the EVC model [Section 5.1.2, Figure 9]). Similar to shoreform mapping, each opportunity is numbered geographically from north to south and clockwise around the islands.

Within the opportunities geodatabase, supporting data were compiled to help practitioners advance opportunities to implementation. The original source of the opportunity was maintained in the attribute table to facilitate potential partnering. A general description of each opportunity and the general strategy of the project (protection, restoration, or enhancement) were included. If the opportunity entailed process-based restoration, the processes being addressed were identified. The benefit area of the project was generally characterized and scores were awarded to each category based on the anticipated spatial extent of the project benefit. The following categories were applied and scored:

- The project footprint (no substantial off-site benefits)
- Down-drift benefits (assumed benefits associated with project footprint also included)
- Down-drift barrier embayments
- Instream/wetlands for projects from which fluvial systems or fish passage would benefit

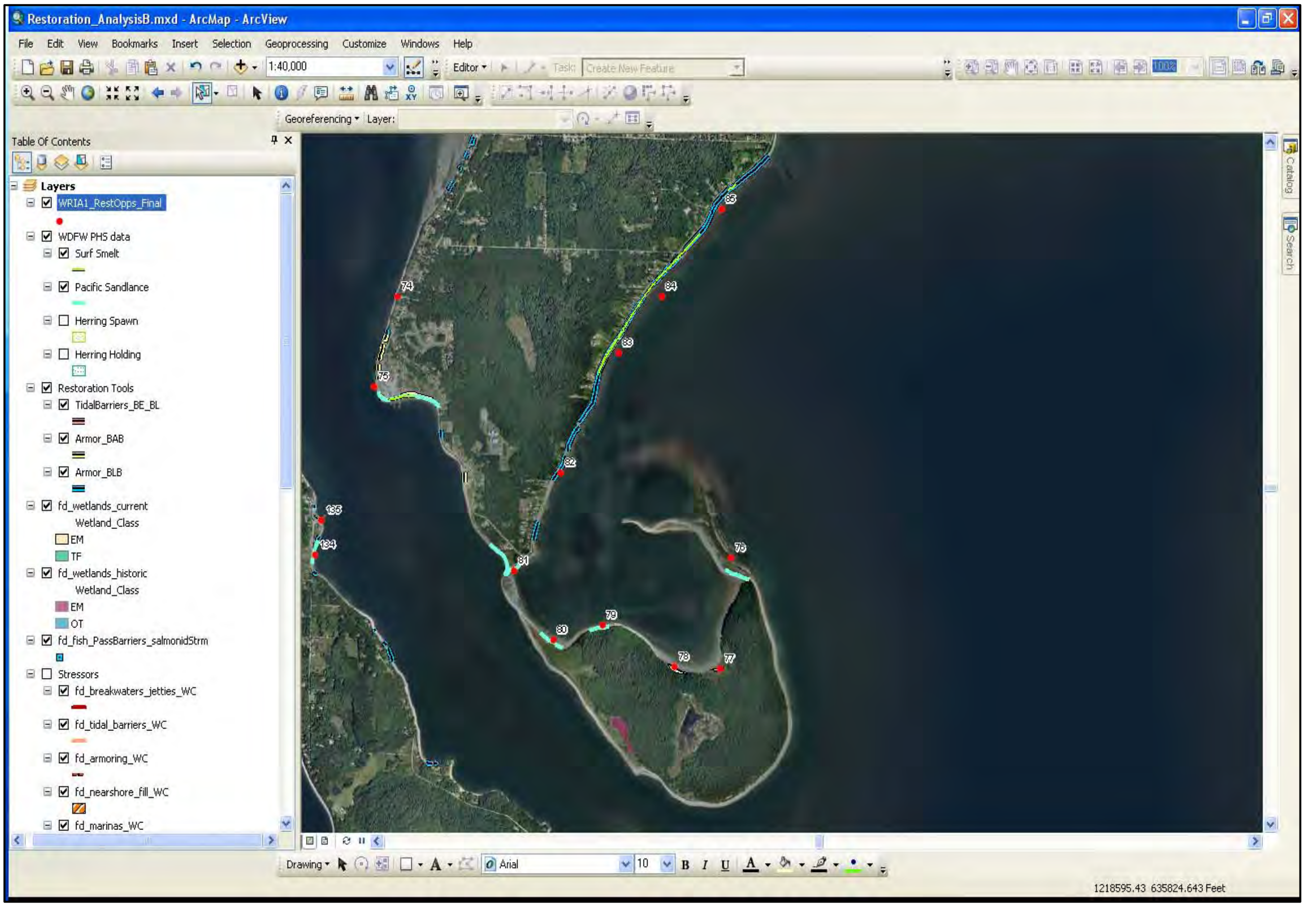

Figure 9. Screen shot of how data were used to guide identification of on-the-ground opportunities.

This metric was developed to highlight restoration projects that could result in down-drift benefits to adjacent shoreforms, especially those shown to be of regional importance (Beamer et al. 2003, Redman et al. 2005, Simenstad et al. 2011, Cereghino et al. 2012), in particular barrier beaches that protect landward embayment shoreforms and coastal wetlands.

The specific impacts to limiting factors in estuarine and nearshore areas of WRIA 1 were also documented to help identify specific benefits that these proposed projects would have upon salmonid migratory, rearing, and refuge habitats. A count of the number of limiting factor impacts was calculated for quick review. The general management measures required to achieve the project were also listed using a recent guidance document published by PSNERP, which provides a how-to manual on implementing each of these actions in the Puget Sound region (Table 19, Clancy et al. 2009). Practitioners are encouraged to refer to this guidance in moving forward with these projects to enhance the likelihood of project success. For example, to remove a tide gate and restore a natural tide channel, one would reference the chapter on Channel Rehabilitation/Creation. For all new projects identified as part of this project, additional justification was documented, such as benefits to surf smelt spawning or restoration of a historical wetland area. Ownership data were also integrated into the dataset to facilitate project planning; these data included the Whatcom County parcel numbers and general ownership categories (Private, Public [City of Bellingham, City of Blaine, State Parks, and right-of-ways—ROW, Whatcom County, Port of Bellingham, Whatcom Land Trust, Reserve], Private-undeveloped, Lummi Tribal Lands, and Unknown). Ownership data were used to inform the “opportunity to implement within 3-years” attribute, which was requested to follow a similar format as the Salmon Recovery Plan restoration matrices by the project's TAG (Table 20).

Table 19. Management measures and the relationship to nearshore ecosystem processes (Clancy et al. 2009).

No.	Management Measure[1]	Relationship to PSNERP Nearshore Ecosystem Processes ● = strong effect; ◗ = weak effect; blank = no relationship									
		Sediment Supply and Transport	Beach Erosion and Accretion	Distributary Channel Migration	Tidal Channel Formation and Maintenance	Freshwater Input	Tidal Hydrology	Detritus Recruitment and Retention	Exchange of Aquatic Organisms	Solar Radiation (Sunshine)	Wind and Waves
1	Armor (a) Removal	●	●			◗		●			●
	(b) Modification		◗			◗					
2	Beach Nourishment	●	●								
3	Dike or Berm (a) Removal	●		●	●	●	●	●	●		◗
	(b) Modification	◗			◗	◗	◗	◗	◗		
4	Channel (a) Rehabilitation	●		◗	◗	●	●	●	●		
	(b) Creation	◗			◗	●	◗	◗	◗		
5	Contaminant (a) Removal								◗		
	(b) Remediation								◗		
6	Debris Removal	◗	◗		◗						
7	Groin (a) Removal	●	●	◗	◗	◗	◗	◗	●		●
	(b) Modification	◗	◗	◗	◗	◗	◗	◗	◗		◗
8	Habitat Protection Policy or Regulations[2]	◗	◗	◗	◗	◗		◗	◗		◗
9	Hydraulic Modification	◗				◗	◗	◗	◗		◗
9	Invasive Species Control	◗	◗		◗	◗	◗	◗	◗	◗	◗
11	Large Wood Placement	◗	◗	◗	◗			◗	◗		◗
12	Overwater Structure (a) Removal	◗	◗							●	◗
	(b) Modification									◗	◗
13	Physical Exclusion								◗		
14	Pollution Control								◗		
15	Property Acquisition and Conservation[3]	●	●	●	●	●	●	●	●	●	●
16	Public Education and Involvement[4]	◗	◗	◗	◗	◗	◗	◗	◗	◗	◗
17	Revegetation	◗	◗	◗		◗		◗		◗	◗
18	Species Habitat Enhancement								◗		
19	Reintroduction of Native Animals (Non-Plant)								●		
20	Substrate Modification	◗	◗		◗	◗			●		◗
21	Topography Restoration	●	●	●	●	●	●	●	●		●

[1]Some management measures are broken out into separate rows labeled (a) and (b) to distinguish variation in the degree of process restoration between full removal of a stressor and partial removal/modification of the stressor.
[2] This measure influences process via specific regulations such as the Shoreline Management Act and Growth Management Act, which limit shoreline armoring, overwater structures and removal of riparian vegetation; stormwater regulations, which require management of runoff, infiltration, etc.; and other regulations that protect processes.
[3] Measure has the potential to influence all processes to some degree and is essential for the long-term protection of ecosystem processes.
[4] Public Education and Involvement potentially influences most processes, albeit mainly indirectly and with varying durability.

Table 20. Ownership category interpretations to 3-year implementation.

Ownership type	Opportunity to implement project in 3 years
Public ownership	Yes
Tribal and private undeveloped	Limited
Private corporations	No
Unknown ownership (not attributed in parcel data)	Unknown

Three additional queries were performed to identify priority opportunities: the strategy match, the process match, and the number of limiting factors addressed. The strategy match addresses how well matched the on-the-ground project strategy is with the shoreform or drift-cell strategies. Projects in which the strategy was a perfect match (e.g., protection project within a priority protection drift cell) were awarded 3 out of 3 points. However, restoration projects are also valued in reaches ranked for protection; therefore additional points were assigned to slightly mismatched project and larger scale strategies. Restoration projects that have been proposed in areas identified as enhancement priorities were treated slightly differently, as these projects would be ideal if restoration could be successfully achieved. A feasibility screen was applied to several opportunities that presented considerable risk and did not appear likely to meet project goals. Additional points were awarded to restoration projects that would ameliorate the driving sources of degradation in enhancement priority areas, as these projects could have substantial benefit. Each combination is accounted for in Table 21.

Table 21. Points awarded to project strategies that occur within different large-scale strategy areas.

Project Strategy in Reach Strategy	Strategy points awarded
Enhancement in Protection	1
Enhancement in Restoration	2
Enhancement in Enhancement	3
Restoration in Enhancement	3
Restoration in Enhancement where degraded processes would benefit	4
Restoration in Protection	2
Restoration in Restoration	3
Protection in Enhancement	1
Protection in Restoration	2
Protection in Protection	3

These data were used in combination to identify the top-ranking short-range (3-year) and midterm (10-year) opportunities to advance forward for funding and implementation in the coming years for WRIA 1. The guiding factors for the 3-year opportunities were first driven by landowner willingness based on ownership categories. Acquiring landowner willingness is commonly a time-intensive effort associated with implementing restoration on privately owned land. Therefore, projects that were on privately owned property (without current landowner willingness) were assumed to be constrained to implement in a 3-year timeframe. However, the 10-year plan opportunities exclusively address nearshore process degradation in the areas that need it most (regardless of ownership), while benefiting the larger nearshore ecosystem.

A project score was created that was a sum of the various scoring criteria (benefit score, process match, strategy match, number of limiting factors addressed). The highest 30% of the scores were categorized as “top”, and the middle 30% were identified as “high” scoring opportunities. The lower scoring projects were seen as lesser priority actions, which would only be included in priority drift cells that lacked other opportunities. Enhancement opportunities that occurred within drift cells identified as protection strategy areas were not considered top or high priority actions. Then each opportunity was sorted by project strategy, followed by priority drift cells, and the highest ranking opportunities within each drift cell were ranked (as top or high) for the 10-year portfolio. The 3-year portfolio essentially applied this same approach, but first applied a filter that addresses property ownership (public or tribal), which was inferred to be the greatest constraint to implementing projects in a 3-year timeframe. Projects in which landowner willingness has already been obtained (based on project status) were also included in the list of 3-year opportunities, where project quality was sufficient to do so.

5.2 Prioritizing Restoration and Conservation for the Nooksack Estuary

The Nooksack River estuary area of analysis extended from where the Nooksack River and Lummi River currently diverge at river mile 4.5 on the mainstem of the Nooksack River. The inclusion of the Lummi River estuary in the analysis was important to this analysis of restoration and protection priorities in the estuary given that historically until the mid-1800s the Lummi River had been the dominant outlet of the Nooksack River (Figure 10). As a result, the analysis area included both the lower Nooksack River and delta in Bellingham Bay, as well as the Lummi River and delta in Lummi Bay. This analysis area is herein referred to as the Nooksack River estuary and more specific references to locations on the Lummi River portion or mainstem of the Nooksack River portion are identified as such.

As there have been previous efforts to identify restoration opportunities in the Nooksack River estuary, the approach taken in this project was to create a prioritized list of opportunities by compiling the opportunities previously identified and screening them to inform the prioritization. Restoration opportunities were compiled from the following documents:

- WRIA 1 Near-term (10 Year) Actions, Appendix B in the WRIA 1 Salmonid Recovery Plan by Nooksack Natural Resources et al. (2005)
- Nooksack River Estuary Habitat Assessment by Brown et al. (2005)
- Nooksack River Estuary, Chapter 23 in the Strategic Restoration Conceptual Engineering – Final Design Report. Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) report by ESA et al. (2011).
- Lummi Nation Wetland and Habitat Mitigation Bank Prospectus by Lummi Nation Natural Resources Department and ESA Adolfson (2008)
- Nooksack River Estuary Recovery Project Section 22 Planning Study, Lummi Indian Reservation Final Report on Possible Restoration Alternatives, by the U.S. Army Corps of Engineers, Seattle District (2000)

- Salmon and Steelhead Habitat Limiting Factors in WRIA 1, the Nooksack Basin, Washington State Conservation Commission report by Smith (2002)

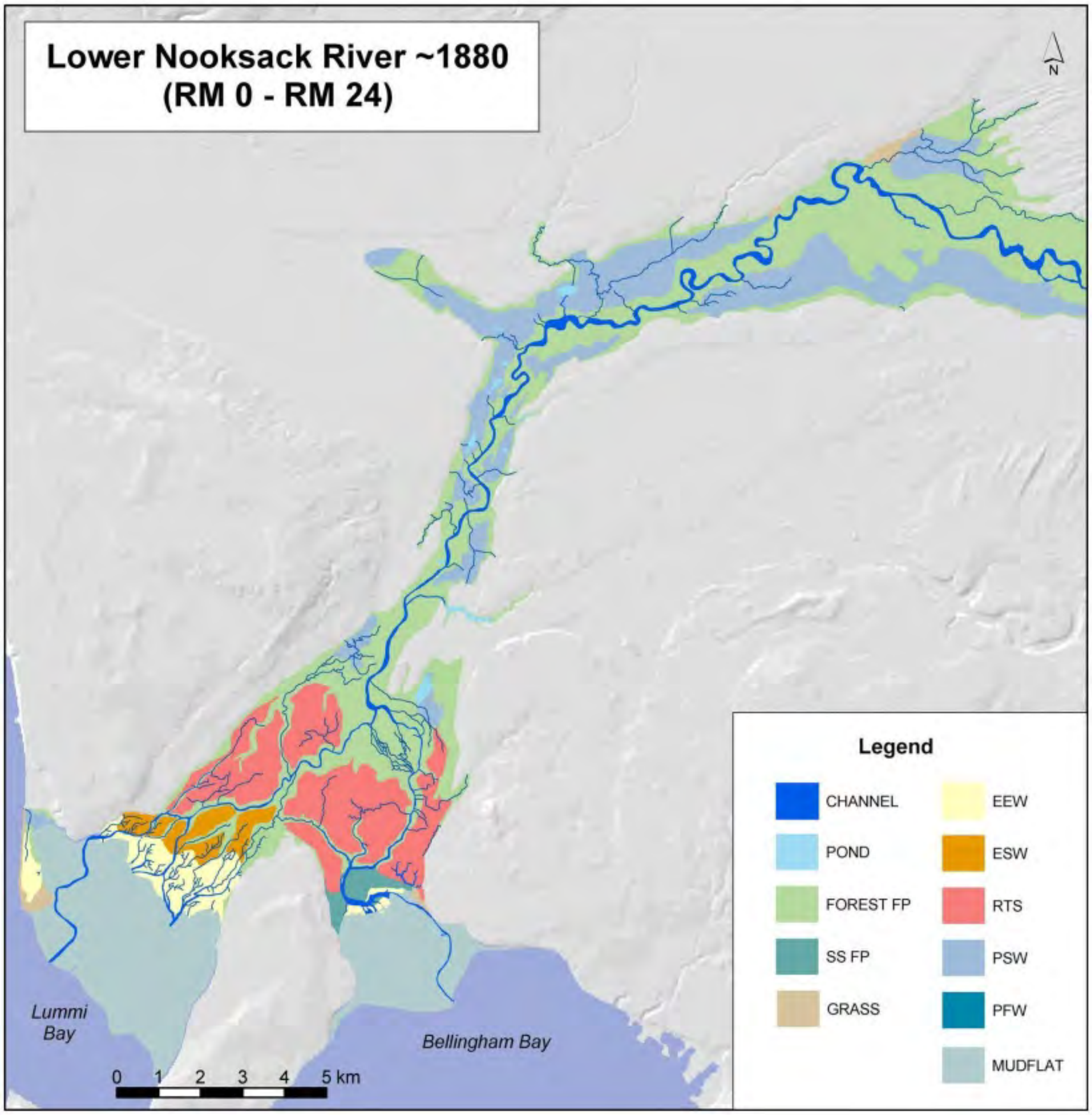

Figure 10. Map of historical Lower Nooksack River including Lummi River outflow to Lummi Bay and Nooksack River outflow to Bellingham Bay (Collins and Sheikh 2003) FP: Floodplain; EEW: estuarine emergent wetland, ESW: estuarine scrub-shrub wetland, RTS: riverine-tidal scrub-shrub wetland; PSW: palustrine scrub-shrub wetland; PFW: palustrine forested wetland.

Each project opportunity was examined to characterize the scale and logistics entailed and the status of restoration planning, as well as the anticipated benefits to ecological processes, habitats, and the achievement of restoration objectives. The scale and logistical information compiled consisted of the benefit area, generally estimated cost, sequencing considerations with other opportunities, and current known constraints to implementation. The status of restoration planning included a description of the status, as well as the identification of the completion of restoration status categories, as assigned in the Washington State Estuary and Salmon Restoration Program (ESRP):

- Feasibility Phase
- Early Design Phase: Assessment and Conceptual Design
- Late Design Phase: Permitting and Final Design
- Implementation

For each opportunity, the category description is either complete, ongoing, or left blank (to indicate not started at this time). The cost estimates are intended as ballpark costs considering design, permitting, public outreach, land acquisition, and construction. Because no additional design work other than that included in source documents was conducted, approximate costs were categorized as:

- Less than $100,000
- $100,000 to $500,000
- $500,000 to $1,000,000
- More than $1,000,000

The evaluation of anticipated benefits entailed qualitatively interpreting whether the benefit of each opportunity would be high, medium, low, or no effect. The evaluations were based on the completion of each individual project and the current understanding of the purpose and magnitude of the project. The anticipated benefits would change depending on project refinement that would occur through project design and the public process.

The anticipated benefits of the six key physical and ecological processes of major estuaries identified by the Puget Sound Regional Implementation Technical Team (RITT) were evaluated. These processes were identified by the RITT because of each process' contribution to providing key ecological attributes (KEAs) for salmon recovery (RITT 2010). The six ecological processes are identified below with an explanation of the KEAs associated with each process:

- *Fluvial sediment dynamics* refers to the delivery, deposition, and erosion of sediment and the impact of river discharge and hydrography on sediment movement. The volume and size of sediment in the estuary is an outcome of fluvial sediment dynamics. Fluvial sediment dynamics also affect whether submerged aquatic vegetation is buried or eroded.
- *Tidal hydrology* refers to the inundation of intertidal habitats and circulation of water masses. In estuaries, tides affect the structure and function of river deltas and tidal wetlands. Tidal circulation affects water salinity, sediment transport, detritus input, organism movements, and patterns in primary and secondary production.
- *Freshwater hydrology* introduces sediment, detritus, nutrients, pollutants, and water quality changes to estuaries.
- *Distributary channel formation and maintenance* refers to the network of channels upon which river deltas prograde. As a river delivers sediment to its delta, the delta progrades and the river progressively divides into distributaries. Distributary channel network affects the spatial distribution of estuarine salinity gradients and sedimentation patterns, which in turn affect vegetation distribution and aquatic organism—including salmon—distributions.

- *Tidal channel formation and maintenance* provides the conduits for water, sediment, nutrients, detritus, and aquatic organisms, thus linking highly productive tidal marshes in estuaries with the marine nearshore. Tidal channels affect hydrodynamics, sediment transport, and the distribution and production of plants and animals.

- *Detritus recruitment and retention* is important for the food webs of tidal marshes, which are largely based on detritus. Detritus consists of a variety of materials ranging from logs to leaves and terrestrial insects. Sources of detritus include river drainage basins, riparian vegetation, tidal marshes, and submerged aquatic vegetation.

The anticipated benefits to five types of habitats were evaluated for each opportunity:

- Mainstem of the Nooksack and Lummi rivers
- Tidal marshes
- Tidal channels, distributary channels, side channels
- Floodplains
- Riparian zones

Each opportunity was also evaluated to characterize the level to which each of the five restoration objectives identified above (and repeated here) rate in the limiting factors section:

- Reestablish connectivity of floodplain and deltaic habitats in the Nooksack and Lummi estuarine areas, including connectivity between Nooksack River Delta and Lummi River Delta
- Reestablish river flow to Lummi River Delta
- Restore fish passage between Lummi Bay and the mainstem of the Nooksack River, as well as in tributaries draining into the estuary
- Restore the quantity and quality of smaller channel habitats, including distributary channels, tidal channels, blind channels, and side channels
- Restore natural tidal inundation and tidal exchange in the Nooksack and Lummi estuarine areas

6.0 Results

Coarse-scale priority strategies were identified by linking EVC results with nearshore process degradation data as described in Section 5.0 (*Methods*) of this report. The EVC results demonstrate the contrasting conditions with relation to ecological conditions across the WRIA 1 shoreline landscape. Although relatively rare, barrier estuaries had the highest average EVC scores (Table 22); bluff-backed beaches, the most ubiquitous landform in WRIA 1, were also among the highest scoring shoreform in the study area. Bluff-backed beaches commonly encompass forage fish spawning areas; have marine riparian vegetation, LWD-recruitment, and waterward eelgrass beds; and provide several critical nearshore processes, functions, goods, and services (Map 12).

Table 22. Minimum, maximum, and average EVC scores by shoreform throughout WRIA 1.

Shoreform	Count	Average EVC score	Min	Max
Artificial	39	0.4	0.1	0.9
Barrier beach	33	0.5	0.1	0.8
Barrier estuary	6	0.6	0.5	0.9
Barrier lagoon	4	0.5	0.4	0.6
Bluff-backed beach	46	0.5	0.0	1.0
Delta	3	0.5	0.5	0.6
Pocket beach	36	0.4	0.1	0.6
Plunging rocky	11	0.1	0.1	0.3
Rocky platform	83	0.3	0.0	0.8
All shoreforms	261	0.4	0.0	1.0

Priority drift cells and bedrock shoreforms for each strategy were identified by linking EVC scores with nearshore process degradation based on the relationships shown in Table 23. The relationships between ecosystem conditions and management strategy have been discussed considerably throughout the duration of this project with the TAG as well as in the restoration science community, and the relationships shown below have been recommended for application throughout the Salish Sea by PSNERP (Cereghino et al. 2012). Nearshore process degradation was assessed by integrating data from Schlenger et al. (2011) as well as additional interpretation by CGS for physical disturbance for bedrock shoreforms only, as discussed in detail in the *Methods*. Maps 9 to 11 depict nearshore process degradation throughout the study area.

Map 12. WRIA 1 normalized ecological value criteria (EVC) scores.

WRIA 1 Nearshore Assessment and Estuarine Restoration Prioritization

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1711 Ellis St, suite 103
Bellingham, WA 98225
360-647-1845 - coastalgeo.com

Table 23. Ecological value and nearshore process degradation relationships that drive strategy assignments.

Recommended strategy	Ecological value	Process degradation
Protection	High-Moderate	Low
Restoration	High-Moderate	Low-Moderate
Enhancement	High-Moderate	High

Areas in which nearshore processes are in a relatively pristine condition (low or no degradation to physical disturbance tidal flow and sediment supply process processes), and had relatively high EVC scores, were identified as high protection priorities (Map 13). In total, over 43 miles were identified as protection priority areas; these include 16 shoreforms and 18 drift cells. Protection priorities exist along the shores of Point Roberts, from Birch Point to Semiahmoo Spit, on southern Lummi Island, along the west shore of the Lummi peninsula, on Portage and Eliza Islands, and in the intermittent shoreforms with rich habitats around Chuckanut Bay.

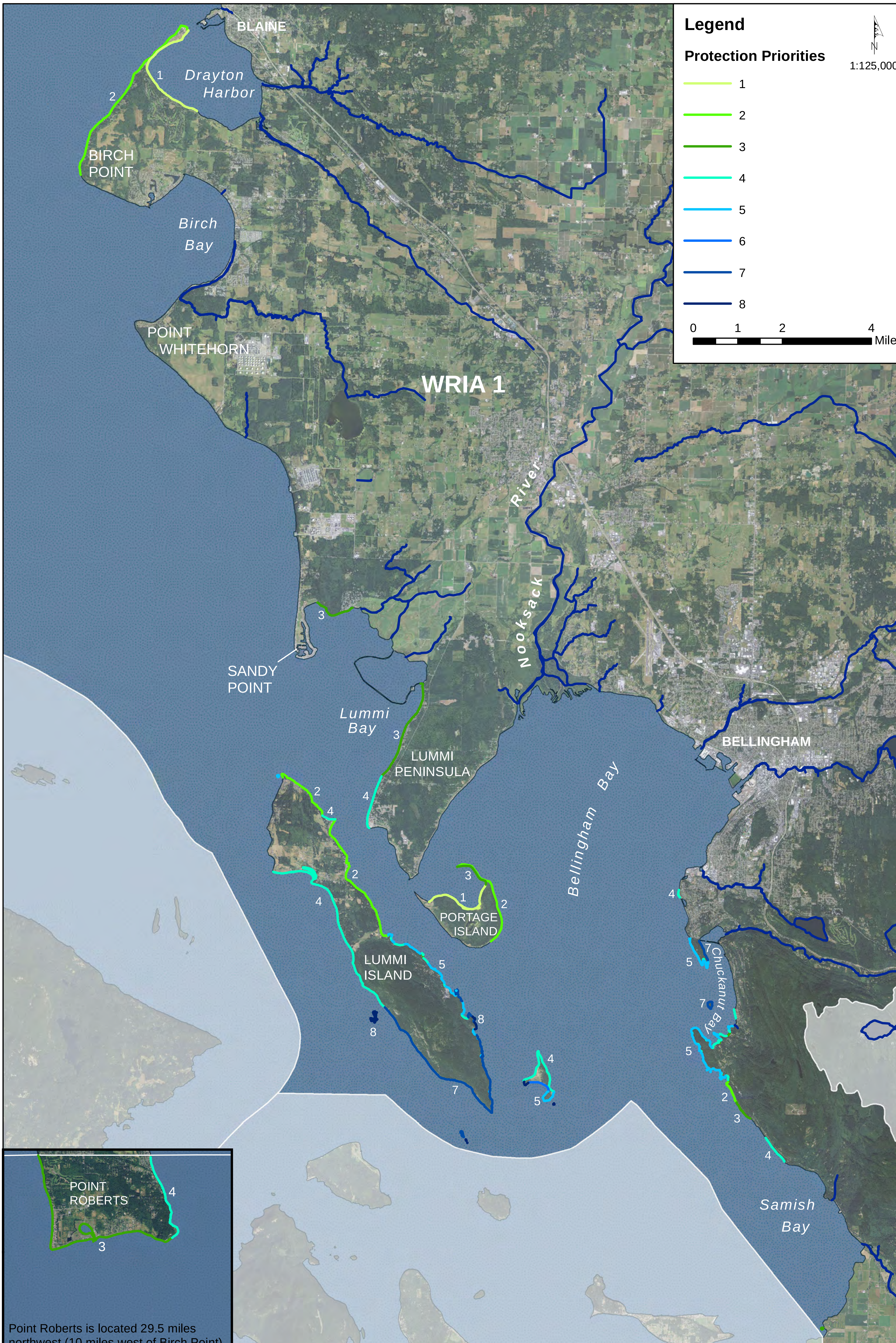
Shores in which moderate nearshore process degradation was mapped and relatively high EVC scores occurred were ranked for restoration (Map 14). Restoration priority areas cumulatively encompassed just under 62 miles of WRIA 1 marine shoreline, including four individual shoreforms and nine drift cells. Restoration priority areas included the inner shores of Drayton Harbor adjacent to Dakota and California Creeks, an extensive stretch of shoreline from Birch Point to Sandy Point, the south shore of the Lummi Peninsula, the northeast shore of Bellingham Bay, the northwest shore of Lummi Island, Mud Bay, and much of the shoreline south of the Skagit-Whatcom county line.

The areas in which nearshore process degradation was high with high EVC scores were identified as enhancement priority areas (Map 15). Six shoreforms and 11 drift cells, across approximately 32 miles of shoreline, were mapped as enhancement priority areas. Enhancement priority areas included the City of Blaine shoreline, the northwest shore of Bellingham Bay (adjacent to Lummi Shore Rd), much of the City of Bellingham, and intermittent shoreforms south of Mud Bay.

6.1 Marine shores

Identified nearshore restoration/protection/enhancement projects are abundant throughout the WRIA 1 shores. In total 133 potential projects were compiled and identified: 19 protection, 60 restoration, and 54 enhancement opportunities (Map 16). Opportunities vary considerably in the nature and scale of benefits. Some projects are more experimental in nature, such as the installation of "habitat benches" along marina shorelines, where shallow-water shorelines are recreated with artificial profile shapes to offset the loss of this habitat type. Other projects aim to enhance tidal flushing within the constraints of major infrastructure, such as the many crossings and artificial tidal embayments resulting from the BNSF rail causeway. Within the City of Bellingham, several contaminant removal areas were identified. Many bulkhead and groin removal projects were identified to restore sediment supply and transport processes. Each opportunity was sorted by strategy type and populated with supporting data to inform the ranking process (see *Methods* section).

The following section describes the top and highest ranking projects for protection, restoration, and enhancement on shorelines in which implementation could be conducted within the next three years. The



Map 13. WRIA 1 protection priority areas prioritized from 1 through 8.

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Map 14. WRIA 1 restoration priority areas prioritized from 1 through 6.

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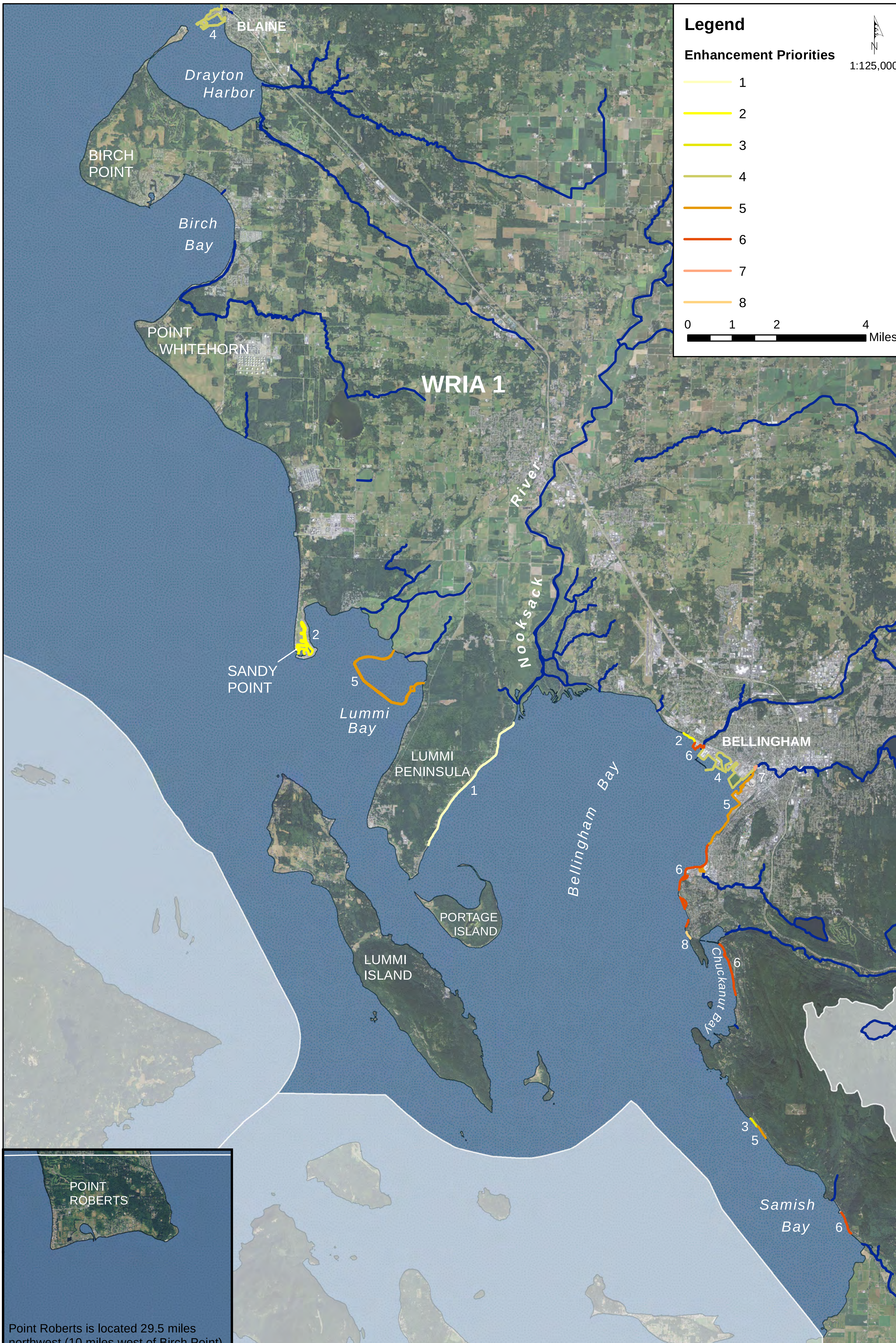

Map 15. WRIA 1 enhancement priority areas prioritized from 1 through 8.

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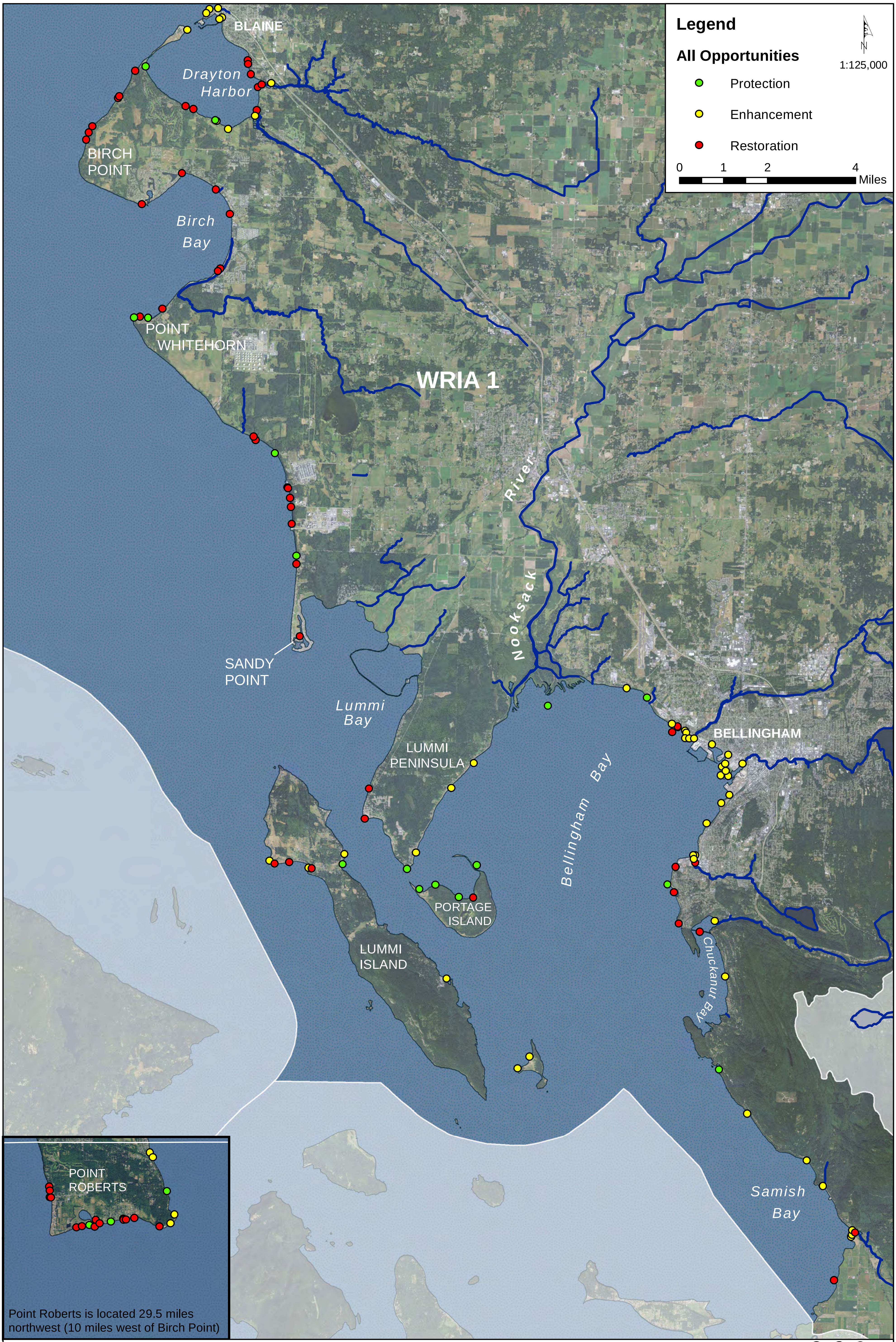

Map 16. All protection, enhancement, and restoration projects identified in WRIA 1.

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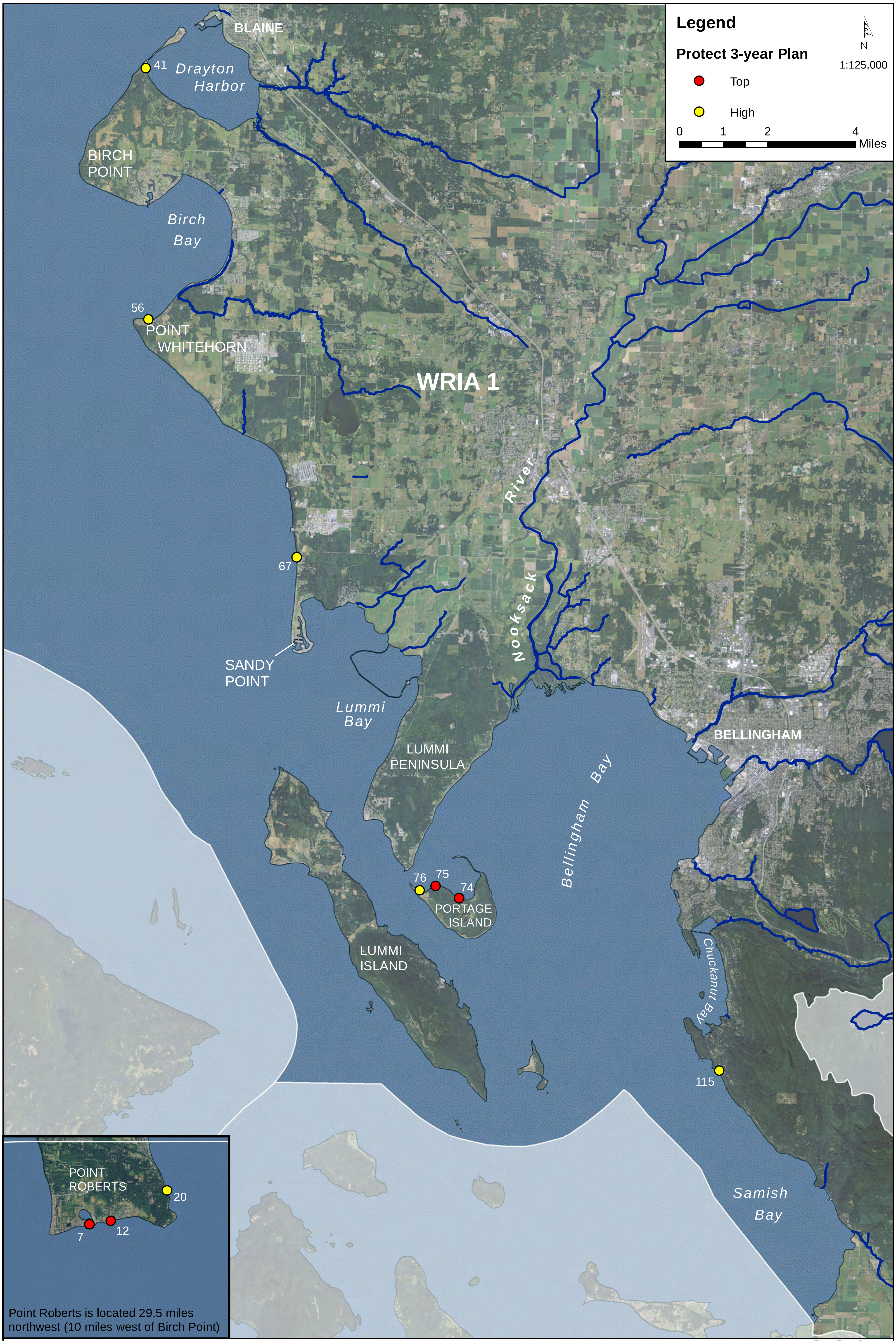
subsequent section similarly details priority projects for implementation within the next ten years. This latter list of priority projects would provide equal benefit to the WRIA 1 nearshore ecosystem as the 3-year list, but would require more time and engagement with landowners to achieve implementation. Several additional opportunities are included in the geodatabase that will not be described in this document, but could benefit the nearshore if landowner willingness was achieved.

6.1.1 3-Year Protection Priorities

Protection priority projects were organized into top- and high-priority categories that could be implemented across more immediate (3-year) and longer time spans. A total of ten protection priority projects were identified for implementation in the short-term, including four top-ranking and six high-ranking projects. Most of these opportunities (six) occur within drift cells and shoreforms that were identified in the coarse-scale assessment as priority areas for protection. Most of the protection projects exist within coarse-scale restoration priority areas, although three exist in restoration priority areas. Eight opportunities would benefit forage fish spawning areas, and most would aid in the conservation of down-drift habitats. Detailed information on each project is included in the project geodatabase. Unarmored, undeveloped sites could be acquisition targets or be flagged within Whatcom County files as conservation targets in which larger setback distances should be recommended to assure that potential future erosion does not necessitate shoreline armor. Of the nine protection projects identified for the short-term, three were ranked as top priorities, while the remaining six were ranked as high priorities. Map 17 displays these 3-year protection priorities; details are presented in Table 24.

Table 24. Top- and high-ranking 3-year protection priorities. LIBC=Lummi Indian Business Council.

ID	3-year protection priorities	Area	Ownership	Rank
7	Protect unarmored, undeveloped parcels along south shore of Pt Roberts west of the marina.	Lighthouse	Private-undeveloped	Top
12	Protect unarmored parcel along south shore of Pt Roberts east of marina.	Lilly Point	Private-undeveloped	Top
74	Protect wetland and marsh habitat, sand lance spawning down-drift, undeveloped parcels.	Portage Bay	Lummi Nation	Top
75	Protect sand lance spawning beach, undeveloped parcels.	Portage Bay	Lummi Nation	Top
20	Protect sand lance spawning beach.	Lilly Point	Whatcom County	High
41	Protect sand lance spawning habitat within Semiahmoo County Park boundary.	Drayton Shore	City of Blaine	High
56	Protect shoreline that delivers large amounts of sediment down-drift, undeveloped parcel.	Cherry Point	Private-undeveloped	High
67	Protect undeveloped coastal wetland and surf smelt spawning beach.	Sandy Point	Private-undeveloped/LIBC	High
76	Protect sand lance spawning beach, undeveloped parcels.	Portage Bay	Lummi Nation	High
115	Protect surf smelt spawning in Larrabee State Park, provide education to public users, and encourage BMPs.	Chuckanut	WA State Parks	High



Map 17. WRIA 1 Top and High Protection Priorities for 3-year plan.

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6.1.2 10-Year Protection Priorities

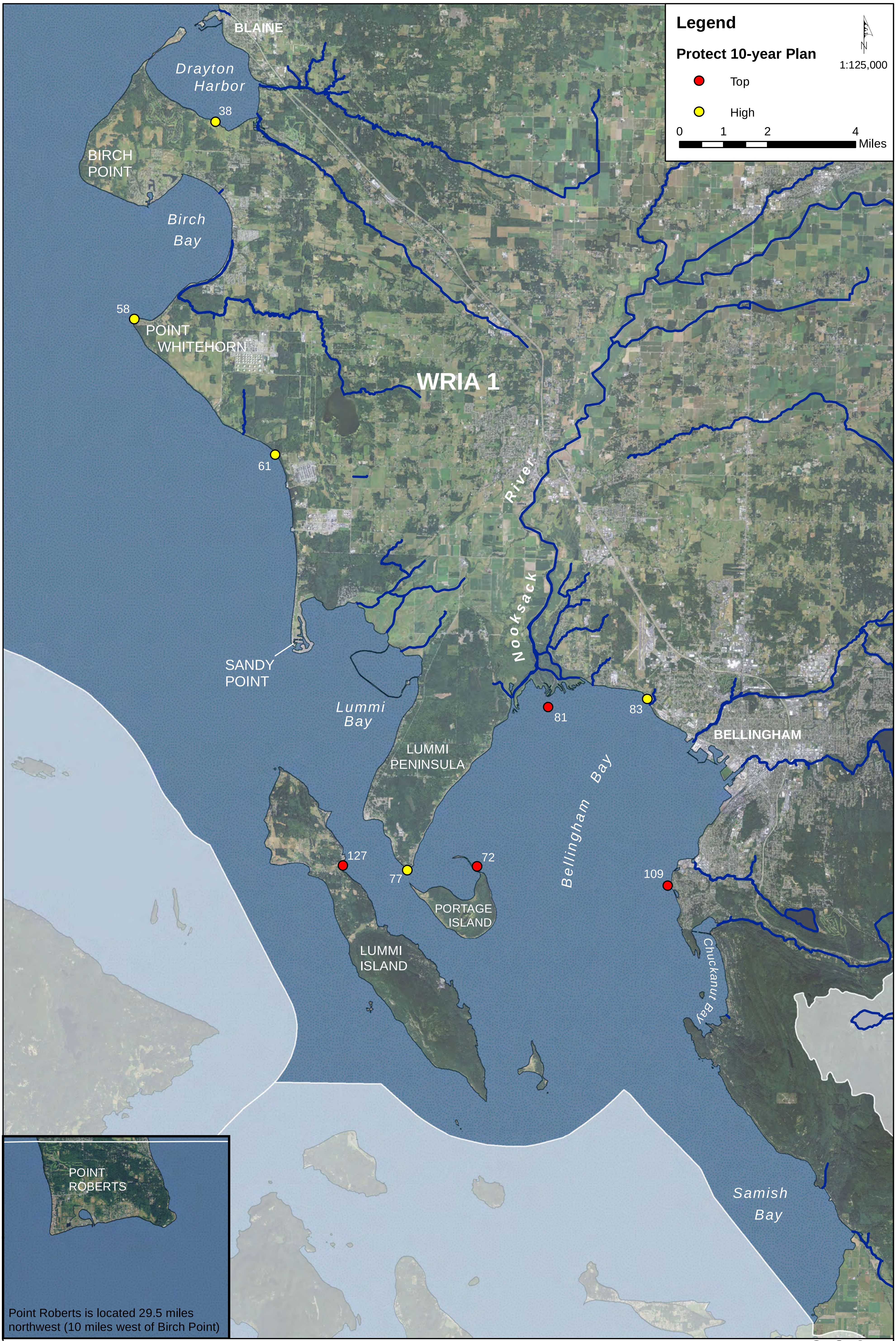
The 10-year protection priorities consist of nine additional opportunities: four top- and six high-ranking projects. All but three of these protection opportunities occur within areas prioritized for restoration, such as Drayton Harbor, Cherry Point, and the northeast and northwest shores of Bellingham Bay. Each of the 10-year protection opportunities offer off-site benefits to either the down-drift or down-stream shores, and several would directly benefit forage fish spawning areas. Map 18 displays each of these opportunities, Table 25 presents more detail, and additional supporting information is provided in the geodatabase.

Table 25. Top- and high-ranking 10-year protection priorities.

ID	10-year protection priorities	Area	Ownership	Rank
72	Portage Island Protection Area.	Portage Island	Lummi Nation	Top
81	Nooksack River Delta Protection Area.	Nooksack River Delta	Lummi Nation	Top
109	Post Point to Chuckanut Protection Area.	Edgemoor	Unknown	Top
127	Protect sand lance spawning beach and no apparent armor on Lummi Island.	Hale Passage	Private	Top
38	Protect valuable habitats along shoreline of undeveloped parcels.	Drayton Shore	Private	High
58	Protect intact, high-volume feeder bluffs along undeveloped parcels that support important habitats and down-drift shoreforms.	Cherry Point	Private	High
61	Protect surf smelt spawning beach.	Cherry Point	Private-Intalco	High
77	Protect shoreline, and limit any new armoring due to spawning areas; consider realigning southern end of Lummi Shore Road further inland.	Lummi Shore	Private-undeveloped	High
83	Protect shoreline (forage fish spawning habitat), and provide education to public users of "Locust Beach".	Fort Bellingham	Private	High

6.1.3 3-Year Restoration Priorities

The top- and highest-ranking restoration opportunities were reduced to a total of nine opportunities (Table 26). Each opportunity has the potential to restore sediment or tidal processes and provide off-site benefits down-drift or up-stream. Most of these opportunities are located within restoration priority areas; however, two are located within areas identified for enhancement, where the action could ameliorate process degradation within the surrounding nearshore. Three opportunities are located within Birch Bay, including one of the top-ranked opportunities, which is to remove groins and bulkheads and nourish the beach. The other top-ranking restoration opportunity is to open up a tide channel through the BNSF causeway in the Edgemoor area, which could provide fish access to an artificially enclosed barrier lagoon. A single restoration opportunity occurs at the largely pristine Portage Island, where a dike or drainage channel is



Map 18. WRIA 1 Top and High Protection Priorities for 10-year plan.

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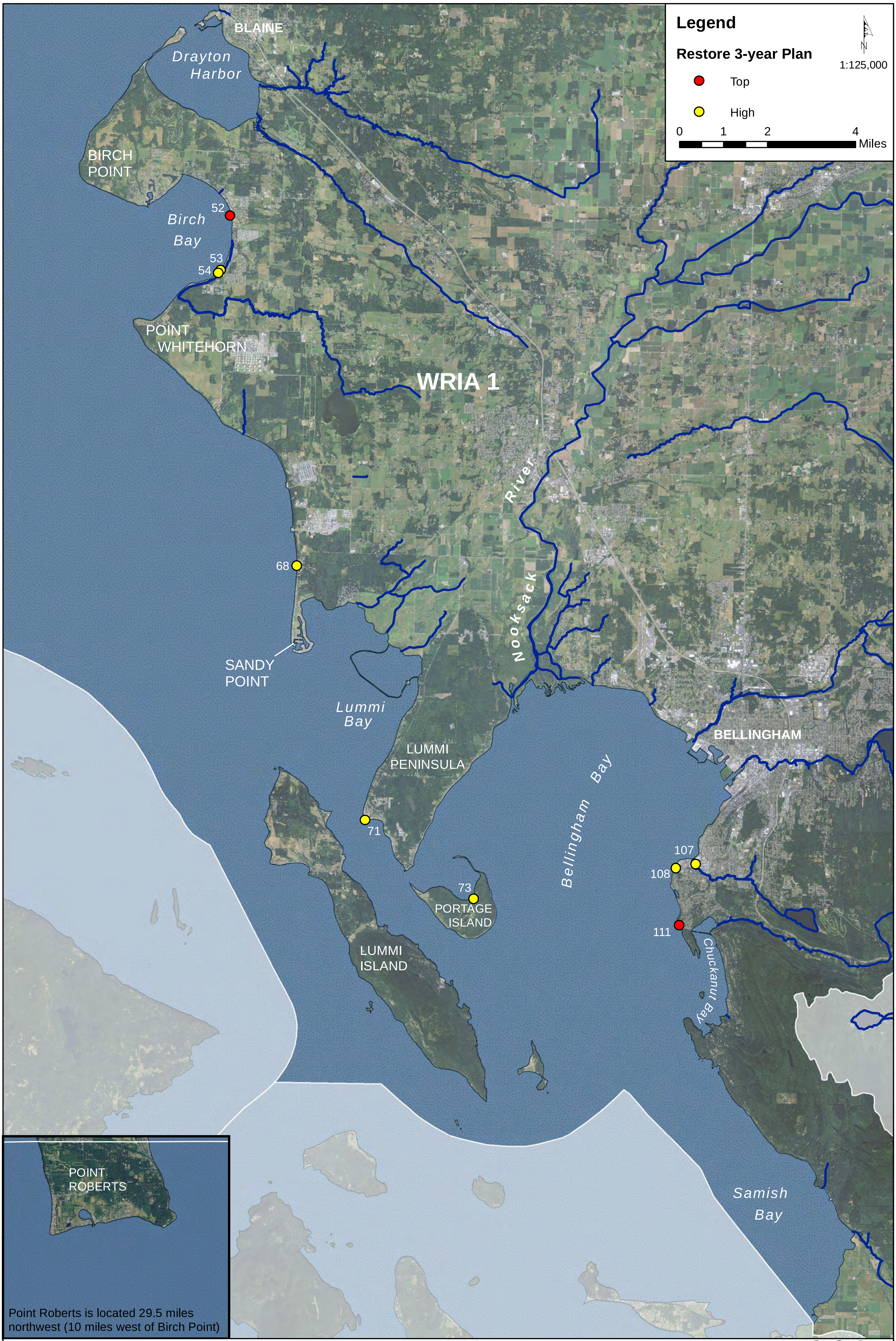
likely reducing the tidal prism of a barrier lagoon. Each opportunity is further described in the geodatabase and shown in Map 19.

Table 26. Top- and high-ranking 3-year restoration priorities.

ID	3-year restoration priorities	Area	Ownership	Rank
52	Remove groins and bulkheads and nourish upper beach along Birch Bay Drive to restore upper beach and backshore habitats.	Birch Bay	Private	Top
111	Replace or modify existing culvert (appears closed) under railroad to open up tidal channel at Chuckanut Spit.	Edgemoor	Whatcom Land Trust	Top
53	Remove or modify shore armoring.	Birch Bay	Whatcom County	High
54	Remove or modify shore armoring.	Birch Bay State Park	Whatcom County	High
68	Remove shoreline modification - concrete wall waterward of undeveloped property (parcel layer may be off by 50 ft to north).	Sandy Point	Lummi - undeveloped	High
71	Remove broken concrete bulkhead sections, primarily north of Gooseberry Point and near the tip and south shore.	Gooseberry Point	Private-Lummi Tribal	High
73	Remove dike or drainage channel from barrier lagoon.	Portage Bay	Private-Lummi Tribal	High
107	Remove fill and replace Harris Ave culvert with bridge to remove partial fish barrier to different parts of Padden Creek estuary.	Bellingham	City of Bellingham	High
108	Modify existing structure under railroad crossing to open up tide channel and remove toppled revetment rock from intertidal at Post Point Lagoon shore, up-drift of surf smelt spawning.	Edgemoor	City of Bellingham	High

6.1.4 10-Year Restoration Priorities

Thirty opportunities were selected as 10-year priorities, eight of which were ranked as top priorities. All of these opportunities exist on private land, so landowner willingness will need to be a focused first effort in working towards implementing any of these valuable projects. Three of the top-ranking opportunities occur within the Cherry Point shoreline (Table 27). Other top-ranking opportunities (which are displayed geographically from north-to-south, not individually prioritized) include restoring coastal wetlands at Rogers Slough in Birch Bay, expanding the Gulf Road wetland to its historical extent by removing fill and a failing road/parking lot, restoring an open tide channel at Little Squalicum Creek, reconnecting a tide channel at Colony Creek, expanding the BNSF causeway opening at Mud Bay to enhance tidal flushing, and removing dikes along the Samish River Delta flats. Similar to the 3-year restoration priorities, all of these projects will restore nearshore processes, and have far-reaching benefits to down-drift shores or adjacent coastal wetlands. Each opportunity can be further assessed by referring to Map 20, Table 27, or the geodatabase.



Map 19. WRIA 1 Top and High Restoration Priorities for 3-year plan.

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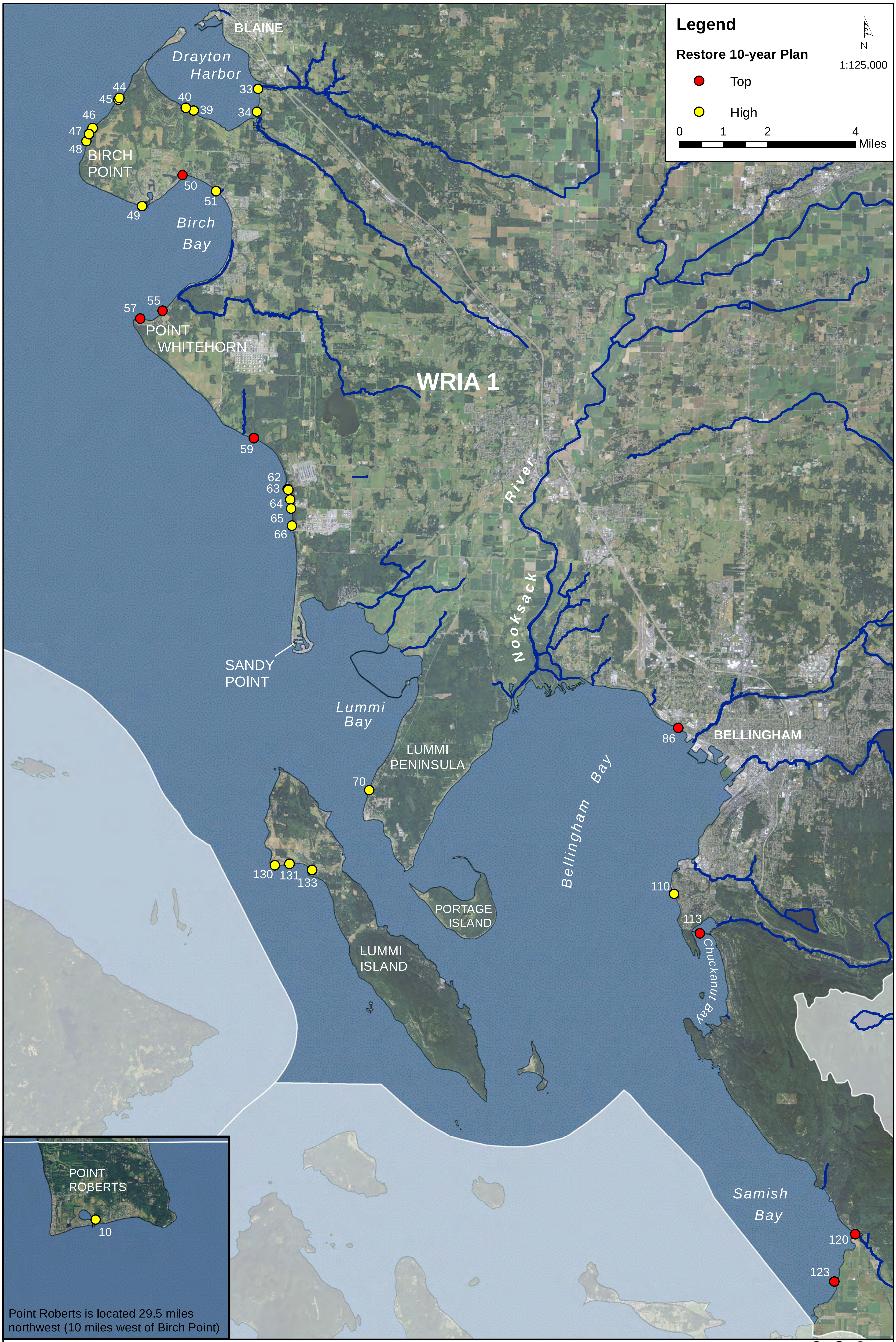

Map 20. WRIA 1 Top and High Restoration Priorities for 10-year plan.

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Table 27. Top- and high-ranking 10-year restoration priorities.

ID	10-year restoration priorities	Area	Ownership	Rank
50	Reconnect coastal wetland processes in Rogers Slough.	Birch Bay	Private-BBV Comm Club	Top
55	Remove or modify shore armoring along these bluffs; many of these bulkheads appear to be unpermitted.	Cherry Point	Private	Top
57	Remove or modify bulkheads along Pt Whitehorn bluffs, which are the sole sediment source for the miles of accretion shoreform and valuable habitat in Birch Bay.	Cherry Point	Private	Top
59	Expand and restore wetland to historical extent and remove/reduce road footprint at Gulf Rd coastal wetland (salmonids observed in tidal channel).	Cherry Point	Private-Pac Int Terminals	Top
86	Restore natural tide channel or replacement of current culvert with larger box culvert with foot bridge at mouth of Little Squalicum Creek for juvenile salmonid forage and refuge/rearing.	Fort Belling ham	Whatcom Co. BNSF	Top
113	Modify or replace existing causeway to allow greater tidal exchange between Mud Bay and Chuckanut Bay.	Edge moor	Unknown	Top
120	Reconnect tidal channel at Colony Creek.	Skagit County	PSE	Top
123	Remove dikes in Samish Delta—would entail acquiring farmland parcels.	Skagit County	Private	Top
10	Reconnect coastal wetland, remove shore armor and outfall which acts as groin.	Light house	Private-Pt Roberts Resort	High
33	Remove or modify bulkheads that protrude into the intertidal zone in Drayton Harbor north of Dakota Creek.	Drayton Shore	Private	High
34	Remove or modify bulkheads that protrude into the intertidal in eastern Drayton Harbor.	Drayton Shore	Private	High
39	Remove or partially remove shore armor in southern Drayton Harbor.	Drayton Shore	Private	High
40	Remove or modify bulkhead, consider land acquisition.	Drayton Shore	Private	High
44	Remove 6 rock groins and 2 concrete groins.	Birch Point	Private	High
45	Remove rock groin.	Birch Point	Private	High
46	Remove or modify shore armoring and failing creosoted wood wall.	Birch Point	Private	High

Table 27 Cont. Top- and high-ranking 10-year restoration priorities.

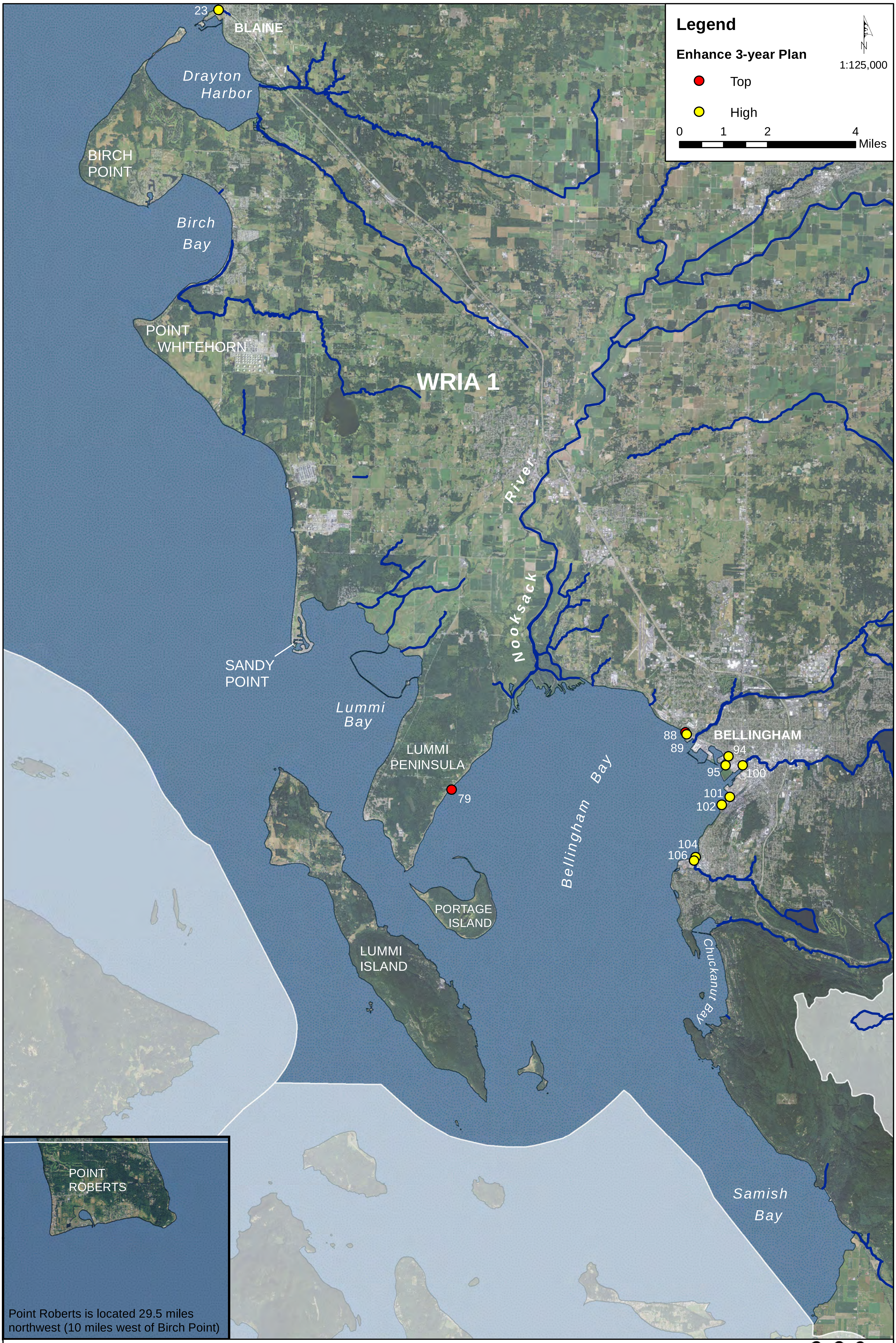
ID	10-year restoration priorities	Area	Ownership	Rank
47	Remove or modify shore armoring and failing creosoted wood wall at site with adequate structure setback at top of bluff.	Birch Point	Private	High
48	Remove concrete bulkhead 20-25 ft high and 15 ft waterward of bank.	Birch Point	Private	High
49	Remove or modify shore armoring; undeveloped parcel.	Birch Bay	Private-BBV Comm Club	High
51	Remove or modify shoreline armoring, old boat ramp.	Birch Bay	Unknown	High
62	By-pass sediment from artificially accreted backshore north of fill to down-drift (south) side of pier facility, as down-drift beach appears to be depleted.	Cherry Point	Private-Intalco	High
63	Remove culvert (with groin-like effects) from intertidal, daylight surface water connection, treat with bioswale if necessary.	Cherry Point	Private-Intalco	High
64	Remove or modify shore armoring (large rock along toe of bluff).	Cherry Point	Private-Intalco	High
65	Remove or modify shore armor (large rock along toe of bluff); no apparent structures on uplands and landsliding may be controlled by geology rather than wave-induced.	Cherry Point	Private-Phillips	High
66	Excavate sediment from landward of the active beach berm up-drift (north) of the pier and bypass to the down-drift (south) side of the pier fill area, which could also create coastal wetlands in the backshore.	Cherry Point	Private-Phillips	High
70	Remove sediment impoundments and alongshore drift impediments such as the failed concrete bulkhead owned by Lummi Nation.	Gooseberry Point	Lummi Nation	High
110	Modify existing structure under railroad crossing to open up tidal channel and intertidal nourishment to add complexity around tidal channel at Post Point south.	Edgemoor	BNSF	High
130	Remove or modify shore and road protection; this seawall is continually undermined and a maintenance issue for Whatcom County. Consider land acquisition, road realignment, or road closure as alternatives.	N Lummi Island	Private-Lummi Is Land Co	High
131	Remove failed solid filled pier, large rock groin, concrete debris, and derelict piles in the western portion of Legoe Bay.	N Lummi Island	Private	High
133	Reconnect coastal wetland leeward of Legoe Bay Road through restored tide channel or installation of larger box culvert.	N Lummi Island	Private-Lummi Is Land Co	High

6.1.5 3-Year Top- and High-Ranking Enhancement Priorities

Eleven enhancement opportunities were identified as 3-year priorities (see Table 28). Five enhancement projects have either conceptual or more fully developed designs and almost all are located on publically owned land or have already worked out agreements with landowners. The benefits of these projects are typically more restricted to the project footprint, although two projects, including the top-ranking project along Lummi Shore Rd, would provide down-drift benefits. Enhancing fish habitat at Cain Creek would also provide large-scale benefits. Most of the 3-year enhancement priority projects are located within the City of Bellingham's shoreline, as it encompasses the greatest spatial extent of enhancement priority areas in the study area. See Map 21 for additional detail and site locations.

Table 28. Top- and high-ranking 3-year enhancement priorities.

ID	3-year enhancement priorities	Status	Area	Ownership	Rank
79	Continue nourishment of beach substrate suitable for forage fish and monitoring, as begun under USACE-constructed revetment.	Design	Lummi Shore	Lummi Nation	Top
88	Remove large boulders and rocks, renourish naturalized beach at Mt Baker Plywood.	Design	Fort Bellingham	Port of Bellingham	Top
23	Naturalize channel, enhance fish habitat, and revegetate marine riparian near Cain Creek.	Unknown	City of Blaine	City of Blaine	High
89	Remove or modify fill at Mt. Baker Plywood, regrade for marine riparian buffer and possible salt marsh.	Design	Fort Bellingham	Private-commercial	High
94	Enhance naturalized marsh habitat area in I and J waterway.	Unknown	Bellingham	Port of Bellingham	High
95	Enhance naturalized pocket beach with surf smelt spawning.	Unknown	Bellingham	Port of Bellingham	High
100	Modify elevations and substrates to establish estuarine riparian, mudflat, and salt marsh at head of Whatcom Waterway.	Unknown	Bellingham	Port of Bellingham	High
101	Remove wood debris, modify elevations to provide shallow subtidal and intertidal habitats, potentially enhance eelgrass at the Port log raft.	Unknown	Bellingham	Port of Bellingham	High
102	Remove debris and regrade to create intertidal and possibly salt marsh with eelgrass habitats at the Cornwall Avenue Landfill.	Unknown	Bellingham	City of Bellingham	High
104	Remove debris and enhance habitat at Padden Creek.	Design	Bellingham	Port of Bellingham	High
106	Remove fill and debris and modify elevations to provide estuarine and riparian vegetation, mudflat, and marsh along the east shore of Padden Creek.	Design	Bellingham	City of Bellingham	High



Map 21. WRIA 1 Top and High Enhancement Priorities for 3-year plan.

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6.1.5 10-Year Top- and High-Ranking Enhancement Priorities

Seven projects were identified as 10-year enhancement priorities (Table 29). At least three of these projects would have off-site benefits. Four have conceptual designs or are more fully developed. The ownership of several opportunities was unclear from the Whatcom County parcel database. Such information will be required to reach out to landowners. These opportunities are distributed throughout the more degraded areas of the WRIA 1 study area from the City of Blaine shoreline south into Skagit County. Map 22 shows the location of each opportunity and additional information can be found in the project geodatabase.

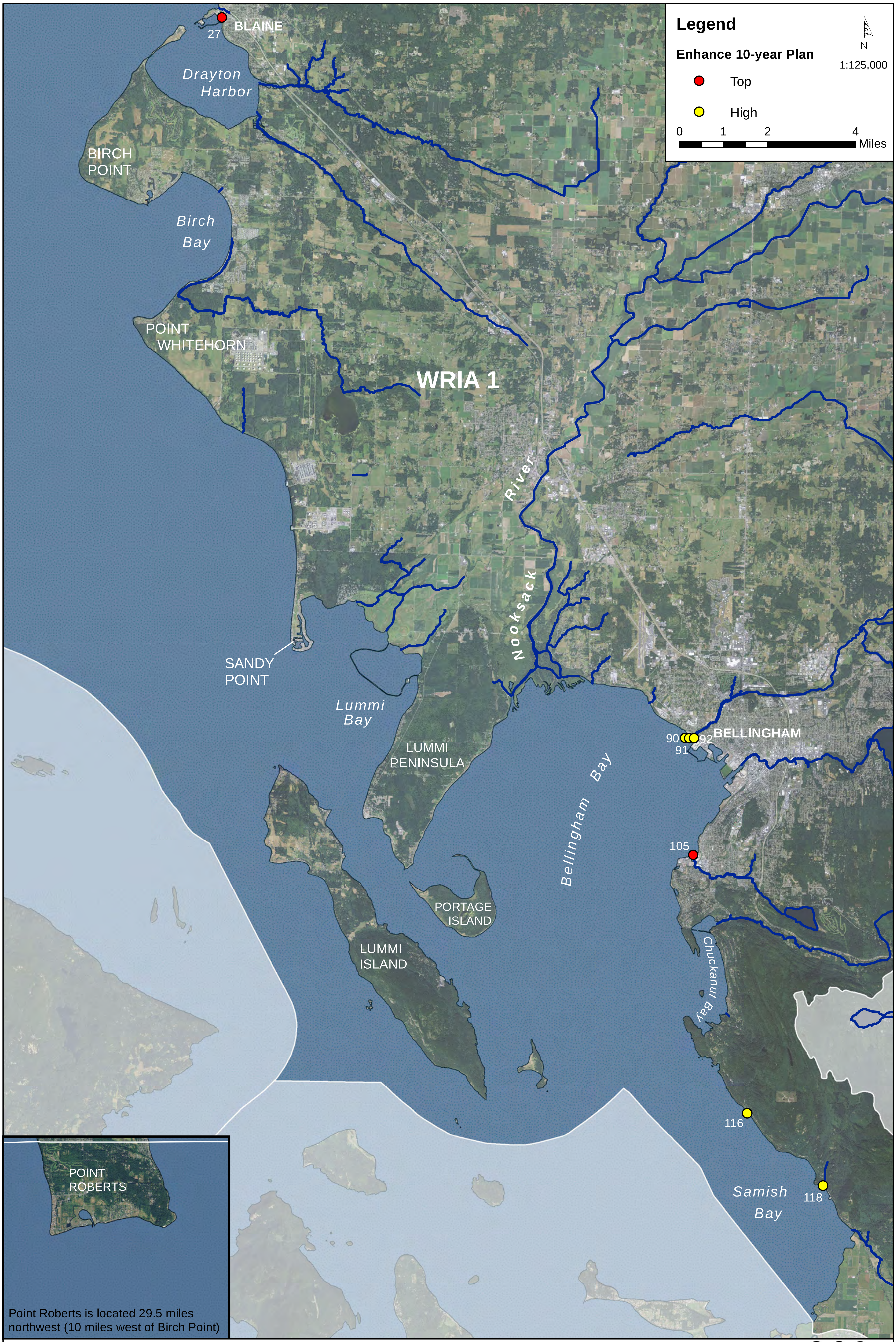
Table 29. Top- and high-ranking 10-year enhancement priorities.

ID	10-year enhancement priorities	Status	Area	Ownership	Rank
27	Enhance disturbed wetland near Blaine Marina, expand buffer adjacent to parking lot.	Unknown	City of Blaine	Unknown	Top
105	Remove treated wooden pier, creosote, and fill and possibly expand eelgrass beds at Padden Creek.	Design	Bellingham	Unknown	Top
90	Remove fill and regrade for potential salt marsh and marine riparian enhancement at Mt Baker Plywood.	Design	Fort Bellingham	Unknown	High
91	Raise elevations within estuary to provide intertidal and shallow water habitat for eelgrass and salt marsh with marine riparian zone enhancement at Squalicum Creek Waterway.	Design	Fort Bellingham	Unknown	High
92	Remove fill and regrade to provide estuarine habitat including intertidal, salt marsh, and marine riparian zone at Bellingham Cold Storage.	Design	Bellingham	Unknown	High
116	Enhance of beach sediment and remove debris—derelict pilings and rail structure—at forage fish spawning beach.	Unknown	Chuckanut	PSE	High
118	Remove tidal barrier or take related enhancement actions to increase tidal exchange in barrier estuary and emergent marsh.	Unknown	Skagit County	Private	High

6.2 The Nooksack Estuary

In total, 11 site-specific large-scale projects and two general project types were identified in the Nooksack River estuary. A description of these projects along with their location and possible sponsor is presented in Table 30. Map 23 shows the location of each of the 11 site-specific opportunities.

The project opportunities can be completed independently; however, given their spatial adjacency and overlap in desired functional outcomes, they can also be viewed as interrelated clusters of projects. Projects 1 through 4 address floodplain connectivity and side-channel habitats along the lower mainstem of the Nooksack River. Projects 5 and 6 target reestablishing historical connections between the Nooksack River and the Lummi River Delta. Projects 8 through 10 restore the Lummi River Delta and are linked to the reconnection of the Lummi River with the Nooksack River (Project 6). Projects 7 and 11 are independent actions. Projects 12 and 13 are not site-specific, but can be incorporated as design elements of other estuarine restoration projects.



Map 22. WRIA 1 Top and High Enhancement Priorities for 10-year plan.

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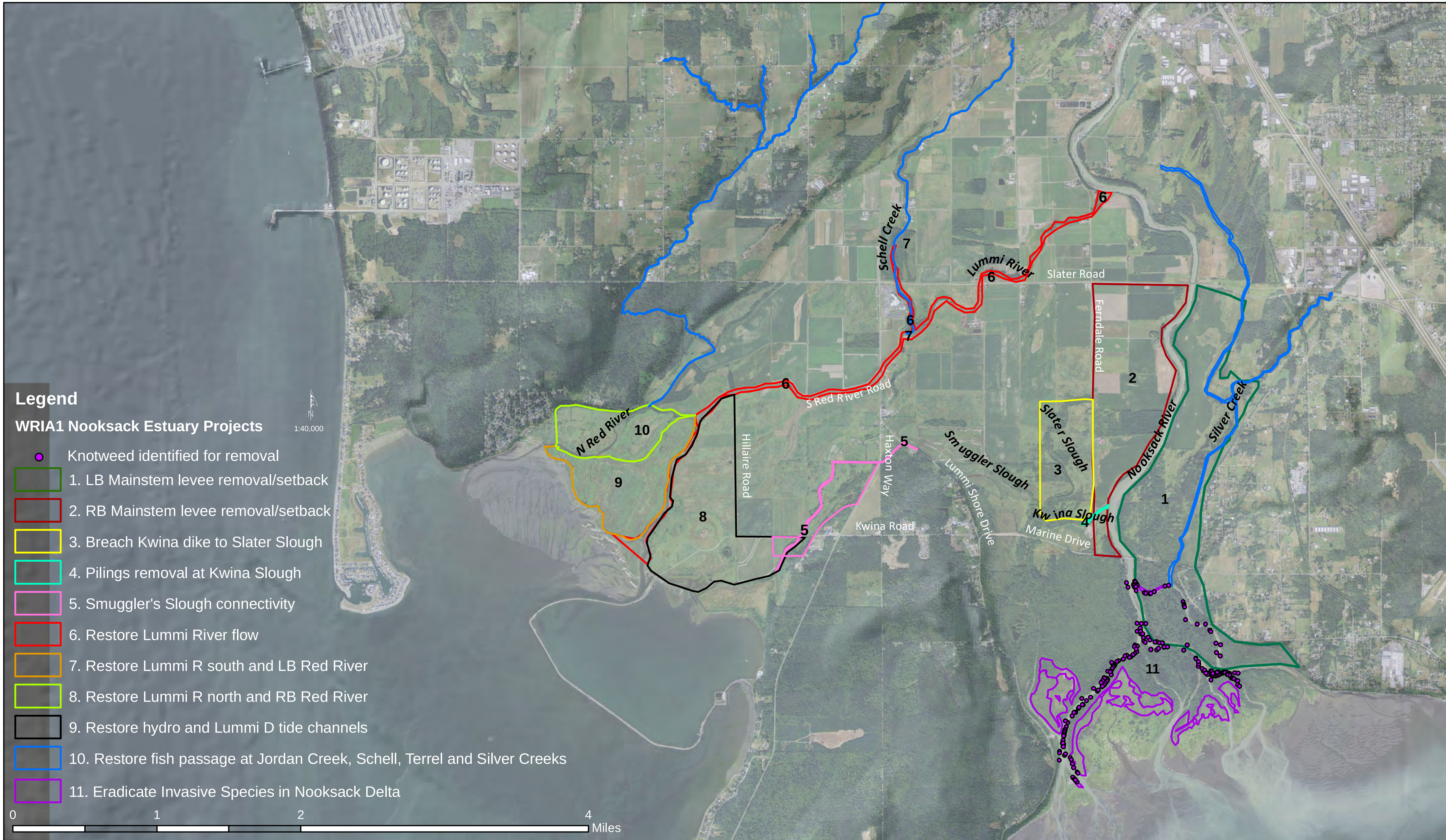

Map 23. Nooksack River estuary restoration opportunities.

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Table 30. Nooksack estuary restoration opportunities.

Project no.	Project description	Source report(s)	Possible sponsor
1	Breach or remove levee along the left bank of the mainstem of the Nooksack River between Slater Road and Marine Drive (RM 1.4 to 3.5) to reconnect floodplain.	• WRIA 1 Near-term Actions (10 years) • PSNERP Conceptual Designs • USACE Recovery Planning Study	Whatcom County
2	Breach or remove levee along the right bank of the mainstem of the Nooksack River between Slater Road and Marine Drive to reconnect floodplain.	• WRIA 1 Near-term Actions (10 years) • PSNERP Conceptual Designs • USACE Recovery Planning Study	Whatcom County
3	Reconnect Slater Slough with Nooksack River estuarine channel network by breaching Kwina Slough dike.	• Nooksack Estuary Habitat Assessment	Whatcom County
4	Restore connectivity of Kwina Slough and Nooksack River by removing pilings at head of Kwina Slough.	• Nooksack Estuary Habitat Assessment	Whatcom County
5	Improve tidal exchange and passage along Smuggler's Slough between Nooksack River and Lummi River by removing one culvert and replacing two culverts.	• Smuggler's Slough Restoration Project • USACE Recovery Planning Study	Lummi Nation
6	Restore perennial surface water connection (approximately 200 cfs) and fish passage between Nooksack River and Lummi River through culvert/levee removal and setback dike.	• Nooksack Estuary Habitat Assessment • PSNERP Conceptual Designs • USACE Recovery Planning Study	No known sponsor
7	Remove fish barriers on tributaries flowing into estuary, notably Schell Creek, Silver Creek, Tennant Creek, and Jordan Creek.	• Habitat Limiting Factors Report	City of Ferndale, Whatcom County
8	Remove/breach Lummi River Delta seawall/dike north of Lummi Aquaculture and south of the Lummi River mouth, including breaching the dike along the lower portion of Lummi River downstream of Hillaire Road. Restore tidal channels and salt marsh hydrology. Construct levee along Haxton Way.	• Lummi Mitigation Bank • Nooksack Estuary Habitat Assessment • USACE Recovery Planning Study	Lummi Nation

Table 30 Cont. Nooksack estuary restoration opportunities.

Project no.	Project description	Source report(s)	Possible sponsor
9	Remove/breach Lummi River Delta seawall/dike north of Lummi River mouth to restore northwest portion of Lummi River Delta between Lummi River mainstem and North Red River Distributary Channel.	• Nooksack Estuary Habitat Assessment • Lummi Mitigation Bank Prospectus • USACE Recovery Planning Study	Lummi Nation
10	Reconnect North Red River distributary channel.	• Nooksack Estuary Habitat Assessment • Lummi Mitigation Bank Prospectus • USACE Recovery Planning Study	Lummi Nation
11	Control invasive plants on Nooksack River Delta, including Japanese knotweed, cordgrass (*Spartina* spp.), English ivy, reed canarygrass, and yellow flag iris.	• Lummi Mitigation Bank Prospectus	Lummi Nation
12 (not on map)	Install engineered log jam (ELJ) to restore channel complexity and slow large woody debris transport.	• WRIA 1 Near-term Actions (10 years) • Nooksack Estuary Habitat Assessment • PSNERP Conceptual Designs	Lummi Nation, Whatcom County
13 (not on map)	Restore historical riparian stand vegetation.	• Nooksack Estuary Habitat Assessment	Lummi Nation, Whatcom County

The status of each opportunity is presented in Table 35 (see Appendix F). The feasibility and conceptual design of Projects 1 through 4 in the Nooksack River floodplain and sloughs are being developed by Whatcom County using a grant from ESRP. Project 5 at Smuggler's Slough is part of the overall Smuggler's Slough Restoration project and is in the design phase. As part of the Lummi Nation Wetland and Habitat Mitigation Bank and Lummi Restoration Division project activity Projects 8 and 9, in the Lummi River Delta, are in the early stages of feasibility and conceptual design. Project 6, the reconnection of the Lummi River with the Nooksack River, was a focus of conceptual design work completed by PSNERP. PSNERP plans to continue to advance the project in the coming years; no current work is being conducted on it.

The scale and logistics of each opportunity are also presented in Table 37 (Appendix F). The largest opportunities based on GIS estimates of the benefit area are Projects 1 (left bank Nooksack floodplain), 2 (right bank Nooksack floodplain), and 8 (Lummi River Delta seawall/dike breach west of Lummi aquaculture), with estimated acreages of 768, 461, and 425, respectively. The benefit area for Project 6 (Lummi River reconnection) was estimated as the channel area that would be created; however, it should be noted that the project could include a much larger footprint such as proposed in the PSNERP conceptual designs and it sets the stage to increase the benefits anticipated from the other project opportunities on the Lummi River Delta (Projects 8, 9, and 10).

Due to the complexity of the larger restoration opportunities in terms of land acquisition needs, restoration design, and community willingness, the costs and constraints tend to be greatest with the largest projects. Notably, Projects 1, 2, and 6 (Lummi River reconnection) are characterized as having the highest costs and major constraints. Each of the projects entails significantly altering water routing through the estuary, constructing a setback levee, elevating Ferndale Road, and converting remaining agricultural land to estuarine habitat. These projects will likely require extensive community dialogue to communicate the project goals and intended benefits. Likewise, funds will need to be secured to support community outreach, design, and construction.

The sequence in which the project opportunities are completed is an important consideration for the project designs and the ability to achieve the anticipated benefits. Project 6 (Lummi River reconnection) could achieve greater benefits if conducted before Project 10 (North Red River distributary reconnection). The sequence of these projects would enhance the restoration objectives and scale of benefits, which are to restore salt marsh habitat and the historical channel network of the Lummi River. In this way, the distributary channel reconnection should occur after the Lummi River reconnection or at least after it is certain that the Lummi River reconnection will be constructed. The Lummi River reconnection project would also significantly influence the anticipated benefits and design of Projects 8 and 9 which entail removing portions of the seawall/dike and restoring the Lummi River Delta. The seawall/dike projects would be beneficial regardless of whether the Lummi River reconnection occurs and therefore could be constructed before or after the Lummi River reconnection. However, some redesign of the seawall/dike removal and Lummi River Delta tidal channel restoration projects may be necessary if the Lummi River reconnection occurs at a later time. The restoration of Smuggler's Slough (Project 5) that is underway will improve connectivity and passage in the Lummi River Delta side of the estuary and increase the anticipated benefits of Project 8. Among the projects along the lower Nooksack River estuary, the ESRP analysis will inform the degree to which Projects 1 through 4 will be combined in the future. In particular, the area and design of Project 2 (reconnection of right bank floodplain) could result in it including Projects 3 (Slater Slough reconnection) or 4 (Kwina Slough connectivity). Setback levees would likely be required to protect adjacent lands for most of these projects.

The anticipated benefits of each opportunity with regard to ecological processes, habitats, and achievement of restoration objectives are summarized in Table 31 and presented in detail in Appendix F. The greatest amount of anticipated benefits to processes was estimated to be achieved by Projects 1 and 2 which reconnect the floodplain along the left and right banks of the Nooksack River, respectively. Both projects were estimated to have high benefits for 5 of the 6 processes. Projects 8 and 9, which would remove portions of the Lummi River Delta seawall/dike and restore tidal channels, were estimated to highly benefit three processes and offer medium benefits to the other three processes. The only other project with estimated high benefits for more than one process was Project 6, the Lummi River reconnection. That project is estimated to achieve high benefits for two processes, plus low benefit for one process. In addition, as described above the Lummi River reconnection would increase the benefits of other projects on the Lummi River Delta (#8, 9, and 10) and therefore would benefit additional processes through the opportunities the reconnection would support.

The estimate of the number of habitat types benefiting from each opportunity produces similar outcomes as the process evaluation in that many of the same projects would provide the greatest benefits. Projects 1, 2, 8, and 9 were determined to provide benefits to the most habitat types as each opportunity was estimated to provide high benefits to four out of the five habitat types. The only other project that was estimated to provide high benefits to more than one habitat type was Project 10, the North Red River distributary channel reconnection. As noted above for ecological processes, Project 6, the Lummi River reconnection would increase the benefits of other projects on the Lummi River Delta, thereby facilitating high benefits to additional habitat types other than the one assigned to the project.

The suite of restoration opportunities would collectively provide high achievement of each of the five restoration objectives. In fact, all restoration objectives would be highly achieved through two or more of the opportunities, except the objective of reestablishing perennial flow to the Lummi River which would only be achieved through Project 6. The projects estimated to highly achieve the greatest number of objectives (three out of five) are the same four projects that would restore the greatest number of habitat types. Project 6, the Lummi River reconnection, would also highly achieve three of the restoration objectives. The only other projects estimated to highly achieve any of the restoration objectives are Project 7, removal of fish passage barriers in tributaries, and Project 10, North Red River distributary channel reconnection. Both are estimated to highly achieve one objective.

With regard to the above benefits analysis by processes, habitats, and restoration objectives, it is necessary that each of the identified opportunities provides meaningful estuary benefits. The relative rankings of high, medium, and low are intended to help prioritize among projects, with additional consideration of sequencing requirements, rather than filter which projects should be pursued and which should not. All projects provide valuable benefits that have strong individual merit and would collectively provide estuary restoration that is unmatched in Puget Sound and could significant benefit not only important sub-populations of ESA-listed salmonids, but all communities reliant on a healthy estuary.

Based on the processes, habitat, and restoration objectives analysis presented above, the following projects are recommended as initial priorities for the estuary:

- Project 1 – reconnection of the floodplain along the left bank of the mainstem of the Nooksack River
- Project 2 – reconnection of the floodplain along the right bank of the mainstem of the Nooksack River
- Project 5 – improvement of tidal exchange and passage along Smuggler’s Slough
- Project 6 – restoration of perennial surface water connection between the Nooksack River and Lummi River
- Project 8 – reconnection of the lower portion of Lummi River Delta between Lummi Aquaculture and the Lummi River mouth
- Project 9 – reconnection of the lower portion of Lummi River Delta north of the Lummi River mouth
- Project 10 – reconnection of the North Red River distributary channel

Each of the projects provides many benefits to the estuary and achieves multiple restoration objectives. The Project 5 restoration work in Smuggler’s Slough is included as a priority despite slightly lesser benefit estimates because the project would restore a reconnection between the Lummi River Delta and the Nooksack River and is designed and ready for construction. The only other project that addresses this cross-connection is Project 6, Lummi River reconnection, but as described above there are major constraints to the project and a general lack of certainty regarding if/when the project could be completed, despite its significant anticipated benefits.

7.0 Conclusions

A portfolio of prioritized actions to improve conditions in the WRIA 1 estuary and nearshore has been compiled to achieve the objectives of this study. Ideally these protection, restoration, and enhancement actions can be incorporated into the WRIA 1 Salmon Recovery 3- and 10-year Implementation Plans. Currently, some long-term actions are outlined for the estuary; very few projects exist in the marine nearshore, particularly outside of Bellingham Bay, yet over 130 opportunities exist within the study area. Much of the Phase 2 prioritization tool and results were structured to follow a framework similar to the Salmon Recovery Plan restoration implementation matrices and utilize common terminology to rank projects for implementation. Excerpts from the current Salmon Recovery Implementation Plan are included in the Appendix of this report to provide context and display the need to expand the portfolio of actions. Actions were also linked with details that will help support forthcoming steps towards implementation, most notably specific terminology required for regional restoration grants. It is the hope of the authors' that the tools and prioritized actions resulting from this project will be prove to be valuable tools for regional restoration/protection practitioners and will aid in the development of a more comprehensive implementation plan for the WRIA 1 nearshore.

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Appendix A: Revisions to PSNERP Mapping in WRIA 1

The PSNERP mapping was reviewed for errors and potential misinterpretations, and several refinements were applied for this study (Table 31). Finer scale local datasets were used to quality check the data, including oblique imagery, LIDAR imagery, WDGR surface geology mapping, and Coastal Geologic Services (CGS) feeder-bluff mapping (Johannessen and Chase 2005). Many of the changes applied resulted from subjective interpretation of coarse datasets conducted by the original mappers, who were likely unfamiliar with local conditions. A few changes were applied due to fundamental disagreement with the shoreform typology: specifically the inclusion of pocket beaches within drift cells. Pocket beaches are definitively closed systems that are contained between two headlands and not within net shore-drift cells. Care was taken to not reinterpret all shoreform mapping and to largely comply with the original mapping typology (Map 3). Following review, all of the shoreforms were then split at the drift-cell boundaries so they could be cleanly nested within the drift-cell units to facilitate the Phase 2 prioritization effort.

Table 31. List of all changes applied to the PSNERP mapping during the QA/QC review process.

Original shoreform	Revised shoreform	Justification
Open Coastal Inlet (OCI)	Barrier Estuary (BE)	Drayton Harbor was mapped as an open coastal inlet, when it is protected by Semiahmoo spit and should be linked with that landform as a barrier estuary.
Bluff-Backed Beach (BLB)	Barrier Beach (BAB)	At Roger's Slough, in the northern corner of Birch Bay, a bluff-backed beach was mapped. This misinterpretation was likely caused by the landward relict shoreline, visible in the LIDAR imagery. Mapping was revised to a barrier beach as this depositional landform is an exemplary depositional "log-spiral beach" and in recent history was the opening of a large barrier estuary that extended landward into the Birch Bay village community.
Pocket Beach (PB)	Bluff-Backed Beach (BLB)	Several (approximately 7) pocket beaches mapped within drift cells were converted to bluff-backed beaches,
Delta (D)	Artificial (ART)	Not deltaic shore but artificial comprised of fill and armor.
Delta (D)	Plunging Rocky Shore (PL)	Not deltaic shore, mapped as NAD due to bedrock geology.
Delta (D)	Barrier Beach (BAB)	Not deltaic shore, barrier beach at mouth of Oyster Creek.

Appendix B: How to Use the WRIA 1 Project Geodatabase

The WRIA 1 nearshore assessment and prioritization (NAARP) geodatabase consists of two main layers, one of which consists of polyline features, the others as points. This document was compiled to summarize how each dataset can be used to analyze conditions, link with other data, and comprehensively use as a tool for identifying restoration, enhancement, and protection projects in WRIA 1.

The line layers are individual WRIA 1 shoreforms, consisting of 261 units. The Rvs_NAARP_ID is a unique geographic ID for the shoreform that is applied to all shoreforms from north to south and around each of the islands in the study area clockwise. Most data have been broken down to the shoreform scale; however, some larger scale datasets are also included such as drift cells, which are only referred to by name. The utility of this data is to be able to explore what resources occur throughout the WRIA 1 nearshore, and to use as a tool for identifying specific strategies for broader reaches of shoreline based on the occurrence of specific nearshore resources. EVC scores were created based on the resource data shown in Table 32. The “total score without shellfish” and the normalized_EVC score adhere to the final EVC scoring approach. The “total score” however, also includes shellfish presence/absence (P/A).

To identify strategies, EVC parameters can be explored and linked with degradation data. Degradation can be explored by only looking at the spatial extent of shoreline armor, or sediment supply, tidal flow, or physical disturbance degradation (applied to rocky shores and pocket beaches only). Cereghino et al. (2012) recommendations were also included, which can be joined with more detailed supporting data in the Change Analysis (Simenstad et al. 2011) using the C_ID attribute. CGS provided strategy recommendations at the shoreform and drift-cell scale. All drift cells (and the shoreforms nested within them) were then prioritized (CGS_DC_Prio) based for each strategy type (CGS_DC_Strat). These data can be easily sorted and displayed by applying definition queries and displaying multiple copies of the data.

The on-the-ground (OTG) project layer is a point file that consists of 133 proposed projects that will benefit the WRIA 1 nearshore. Considerable supporting information is included in the geodatabase that can support the development of these proposed projects (Table 33), from estimating benefit areas, identifying necessary management areas, and linking projects with the degraded nearshore processes that will improve as a result of the proposed action. Several of these parameters have not previously been applied as part of a restoration planning tool. These tools in particular, will help grant reviewers distinguish these projects from others that have not clearly identified these important linkages. Ownership data can be linked and updated with the Whatcom County parcel data easily by using the WCAGCODE attributes. These data can be used independently or in combination with the shoreform layer to identify optimal projects to implement in WRIA 1. The attribute table is included in Appendix B (Table 33).

Table 32. Attributes in WRIA 1 shoreforms layer.

Attribute	Definition	Utility
C_ID	PSNERP ID	This ID can be used to link with PSNERP data including the Change Analysis.
C_Type	Shoreform	Refined application of the Shipman typology (Shipman 2008).
SS_Spawn	Surf smelt spawn	Presence/Absence within shoreform based on WDFW PHS data (2012)
SS_Len	Surf smelt spawn	Linear extent within shoreform in feet (WDFW PHS 2012)
SL_Spawn	Sand lance spawn	Presence/Absence based on WDFW PHS data (2012)
SL_Len	Sand lance spawn	Linear extent within shoreform in feet (WDFW PHS 2012)
Herring	Herring off-shore of shoreform	All shoreforms tagged Presence/Absence where spawning documented off-shore. Based on WDFW PHS data (2012).
SAV	Eelgrass or Bull Kelp mapped	Linear extent within shoreform in feet (WDFW PHS 2012)
FW_Input	Freshwater input	Presence/Absence based on WDNR freshwater/hydro layer
Wetlands	Emergent wetlands	Current conditions, emergent wetlands in PSNERP Change Analysis (Simenstad et al. 2011).
Wet_Len	Emergent wetlands	Linear extent within shoreform in feet (Simenstad et al. 2011)
MarRip	LWD recruitment and MarRipVeg cover	Two different datasets used - Anchor QEA (2012) for all shores but Lummi and COB. LWD recruitment (High-Med-Low). Lummi and COB relied on shorezone RipVegCvr.
ChinStrDist	Distance to Nooksack RD	Measured by CGS along low-tide shoreline to avoid errors due to shoreline complexity.
SalmdStrDist	Distance to salmonid bearing stream	Measured by CGS along low-tide shoreline to avoid errors due to highly complex shorelines. Based on PHS data, but excluded resident Cutthroat.
SalmndStrName	Closest salmonid bearing stream name.	Based on PHS data, but excluded resident Cutthroat.
ChinScore	Chinook proximity	Shoreform within 5 miles of the Nooksack River Delta.
SalmndScore	Salmonid proximity	Shoreform within 5 miles of a salmonid bearing stream.
Shellfish	One or more species of shellfish	One species of shellfish (0.5), Two or more species of shellfish (1). No shellfish (0). Based on WDFW PHS Data (2012).
Total_Score	EVC criteria	Total EVC score with shellfish
Cerr_Rec	Cerreghino Recommended	Recommended strategies for preservation/ restoration/enhancement at the shoreform scale from Cereghino et al 2012.
Zoma_Len	Eelgrass length	Length of eelgrass (ft) within shoreform.

Table 32 Cont. Attributes in WRIA 1 shoreforms layer.

Attribute	Definition	Utility
Nelu_Len	Bull kelp length	Length of bull kelp (ft) within shoreform.
MarRip_Score	Marine riparian	Presence/Absence (greater than 30% cover by shoreform length)
Shellfish_Score	Shellfish	Presence/Absence of shellfish based on PHS data (2012)
Total_Score_No_ Shellfish	ECV score	EVC score total. Criteria described in methods section.
Armor_Len	Shoreline armor length	Linear extent within shoreform in feet (Simenstad et al. 2011)
FB_Len	Feeder bluff (ft)	Feeder bluffs mapped by CGS (2005). Only within Bluff-backed beaches (BLBs)
FB_Pct	Feeder bluff (%)	Feeder bluffs mapped by CGS (2005). Only within Bluff-backed beaches (BLBs)
Armor_Pct	Percent shoreline armor	Percent of shoreform length with shoreline armor (Simenstad et al. 2011)
DCELL_NR	Net shore-drift cell name	Drift cell name based on CGS drift-cell mapping
Nrmlz_EVC_Scr	Normalized EVC Score	Normalized by top scoring shoreform in WRIA 1. 0-1.
SS_Degradation	Sediment Supply degradation	Categorized sediment supply degradation (Schlenger et al. 2011)
TF_Degradation	Tidal Flow degradation	Categorized tidal flow degradation (Schlenger et al. 2011)
PD_Degradation	Physical disturbance degradation	Categorized physical disturbance degradation for bedrock and pocket beach shoreforms (CGS 2012).

Table 33. Attributes of OTG (on-the-ground) projects layer.

Attribute	Definition	Utility
FID	GIS ID	NA
Id	Project ID	Unique project ID numbered from north to south
ProcessRes	Nearshore process	Nearshore process addressed by restoration/protection action.
Source	Project Source	Document or data set from which the project originated.
Descr	Description	General description of the project.
Benefit_Ar	Benefit area	Characterization of the benefit area: footprint, down-drift, up-stream/wetland, down-drift embayment
Limited_Fa	Limited Factor	Limiting Factor Impact addressed by the project.
Opportunit	Opportunity	Opportunity to implement in 3-year time span.

Table 33 Cont. Attributes of OTG (on-the-ground) projects layer.

Attribute	Definition	Utility
Status	Status of project	Status of project - assessment, design, permitted, unknown.
Mgmt_Meas	Management measures	Management measures required to achieve objectives of project.
Justificat	Justification	For new opportunities only, the justification for the new project was described.
Strategy	Strategy	Overall strategy for the drift cell.
Mn_Reach	Marine Reach	Descriptor of geographic area in WRIA 1.
WCAGCODE	Parcel ID	Only for Whatcom County parcels.
Ownership	Ownership category	Public, Private, Tribal etc.
StratMatch	Strategy Match	How well matched are the drift-cell/shoreform strategies with the project strategy?
ProcMatch	Process Match	How well matched are the process degradation of the shoreform /drift cell with the processes addressed by the project?
LTF_Match	Limiting Factors	How many limiting factors are addressed by the project?
Proj_Strat	Project strategy.	Protect, Restore, or Enhance.
NAARP_ID	Shoreform ID	Shoreform ID encompassing the opportunity.
CGS_DC_Pri	Drift-cell priority	Drift-cell priority throughout WRIA 1.
Benft_Scr	Benefit score	Scores the relative spatial extent of the project benefit area categories.
Proj_Scr	Project Score	Sum of benefit score, strategy match, process match, and number of limiting factors addressed.
3yr_Scrn	3-year Screen	Can it be implemented in the next 3-years? Either public, undeveloped, tribal or projects in progress.
3Yr_Prio	3-year priorities	3-year priorities ranked top and high.
10Yr_Prio	10-year priorities	10-year priorities ranked top and high.
Proj_Cat	Project benefit category	Top, High, or Mod based on benefit score.
Feasible	Feasibility Screen	Some proposed projects are infeasible to implement.

Appendix C: Nearshore Restoration On-the-ground Projects

Attribute Table

Id	ProcessRes	Source	Shoreform Number	Description	Benefit_Ar	Limited_Fa	Status	Mgmt_Meas	Justificat	Strategy	Mn_Reach	WCAGCODE	Ownership	Strat Match	Proc Match	LTF Match	Proj Strat Match	NAARP ID	Opprtny	CGS_DC_Pri	Benft_Scr	Proj_Scr	3yr_Scrn	3Yr_Prio	10Yr_Prio	Proj_Cat	Feasible
1	sediment	Whatcom County SMP	1	Remove or modify rock bulkheads along west shore of Pt Roberts, where erosion does not appear to be substantial	down-drift	shoreline modification	Unknown	Armor removal or modification	N/A	Protect	Boundary Bluff	4.05304E+11	Private	2	1	1	Restoration	10	No	3	2	6	0	0	0	Moderate	
2	sediment	CGS_WRIA1_NAARP	1	Remove or modify rock bulkhead, where erosion does not appear to be substantial	down-drift	shoreline modification	Unknown	Armor removal or modification	armored BAB, surf smelt spawning	Protect	Boundary Bluff	4.05304E+11	Private	2	1	1	Restoration	8	No	3	2	6	0	0	0	Moderate	
3		Whatcom County SMP	2	Remove abandoned pilings (likely creosoted) near the west end of Gulf Road	footprint	contaminants	Unknown	Armor removal or modification, debris removal	N/A	Protect	Lighthouse	4.05304E+11	Private	1	0	1	Enhancement	8	No	3	1	3	0	0	0	Moderate	
4	sediment	CGS_RestoPrio	1	Remove or modify bulkhead and rock debris, structure being protected appears vacant	down-drift	shoreline modification	Unknown	Armor removal or modification	N/A	Protect	Lighthouse	4.05304E+11	Private	2	1	1	Restoration	8	No	3	2	6	0	0	0	Moderate	
5	sediment	CGS_WRIA1_NAARP	2	Remove or modify bulkhead and rock debris	down-drift	shoreline modification	Unknown	Armor removal or modification, debris removal	armored BAB, up-drift of BAB, undeveloped lot	Protect	Lighthouse	4.0531E+11	Private-undeveloped	2	1	1	Restoration	8	Ltd	3	2	6	1	0	0	Moderate	
6	sediment	CGS_WRIA1_NAARP	3	Remove or modify bulkhead and rock debris	down-drift	shoreline modification	Unknown	Armor removal or modification, debris removal	armored BAB, up-drift of BAB, undeveloped lot	Protect	Lighthouse	4.0531E+11	Private-undeveloped	2	1	1	Restoration	8	Ltd	3	2	6	1	0	0	Moderate	
7		CGS_WRIA1_NAARP	4	Protect unarmored parcel along south shore of Pt Roberts west of marina	down-drift	NA	Unknown	Aquisition and Conservation	BAB, undeveloped lots	Protect	Lighthouse	4.0531E+11	Private-undeveloped	3	0	0	Protection	8	Ltd	3	2	5	1	0	0	Top	
8	sediment	CGS_RestoPrio	2	Remove groin between jetty and armored shore at Pt Roberts marina	down-drift	shoreline modification	Unknown	Groin removal or modification	N/A	Protect	Lighthouse	4.0531E+11	Private-Pt Roberts Resort	2	1	1	Restoration	9	No	3	2	6	0	0	0	Moderate	
9	tidal	CGS_RestoPrio	3	Reconnect coastal wetland at Pt Roberts marina - TIDEGATE 1	in-stream/wetland	wetland loss	Unknown	Hydraulic modification	N/A	Protect	Lighthouse	4.0531E+11	Private-Pt Roberts Resort	2	0	1	Restoration	8	No	3	3	6	0	0	0	Moderate	
10	tidal/sediment	CGS_RestoPrio	4	Reconnect coastal wetland, remove shore armor, outfall also acts as groin - TIDEGATE 2	in-stream/wetland	wetland loss	Unknown	Hydraulic modification, groin removal	N/A	Protect	Lighthouse	4.0531E+11	Private-Pt Roberts Resort	2	1	1	Restoration	8	No	3	3	7	0	0	High	High	
11	sediment	CGS_WRIA1_NAARP	5	Remove or modify rock bulkhead, where erosion does not appear to be substantial	down-drift	shoreline modification	Unknown	Armor removal or modification	armored BAB, surf smelt spawning	Protect	Lighthouse	4.0531E+11	Private	2	1	1	Restoration	8	No	3	2	6	0	0	0	Moderate	
12		CGS_WRIA1_NAARP	6	Protect unarmored parcel along south shore of Pt Roberts east of marina	down-drift	NA	Unknown	Aquisition and Conservation	BAB, undeveloped lots	Protect	Lilly Point	4.05311E+11	Private-undeveloped	3	0	0	Protection	8	Ltd	3	2	5	1	Top	0	Top	
13	sediment	CGS_RestoPrio	5	Remove or modify bulkhead/gabion basket, large setback distance - GABION 3	down-drift	shoreline modification	Unknown	Armor removal or modification	N/A	Protect	Lilly Point		RESERVE	2	1	1	Restoration	7	Yes	3	2	6	1	0	0	Moderate	
14	sediment	CGS_RestoPrio	6	Remove groin in intertidal	down-drift	shoreline modification	Unknown	Groin removal or modification	N/A	Protect	Lilly Point	4.05311E+11	Private	2	1	1	Restoration	7	No	3	2	6	0	0	0	Moderate	
15	sediment	CGS_RestoPrio	7	Remove groin in intertidal	down-drift	shoreline modification	Unknown	Groin removal or modification	N/A	Protect	Lilly Point	4.05311E+11	Private	2	1	1	Restoration	7	No	3	2	6	0	0	0	Moderate	
16	sediment	Whatcom County SMP	3	Remove or modify revetments in front of houses/cabins west of Lilly Point, restore marine riparian vegetation	down-drift	shoreline modification	Unknown	Armor removal or modification	N/A	Protect	Lilly Point	4.05311E+11	Private	2	1	1	Restoration	7	No	3	2	6	0	0	0	Moderate	
17	sediment	CGS_RestoPrio	8	Remove or modify bulkhead-gabion basket	down-drift	shoreline modification	Unknown	Armor removal or modification	N/A	Protect	Lilly Point	4.05312E+11	Private	2	1	1	Restoration	7	No	3	2	6	0	0	0	Moderate	
18		CGS_RestoPrio	9	Remove debris in intertidal including derelict car parts at Lily Point	footprint	NA	Unknown	Debris removal	N/A	Protect	Lilly Point	4.05312E+11	Whatcom County	1	0	0	Enhancement	6	Yes	4	1	2	1	0	0	Moderate	
19		Whatcom County SMP	4	Remove debris in the intertidal from the old cannery including pilings, slag piles, and various debris such as concrete pieces from the intertidal and backshore	footprint	contaminants	Unknown	Debris removal	N/A	Protect	Lilly Point	4.05312E+11	Whatcom County	1	0	1	Enhancement	5	Yes	4	1	3	1	0	0	Moderate	
20		CGS_WRIA1_NAARP	7	Protect sand lance spawning beach	footprint	NA	Unknown	Aquisition or Conservation	sand lance spawning, WC land	Protect	Lilly Point	4.05301E+11	Whatcom County	3	0	0	Protection	3	Yes	4	1	4	1	High	0	High	
21		CGS_RestoPrio	10	Beach nourishment along Maple Beach seawall	down-drift embayment	shoreline modification	Unknown	Beach nourishment	surf smelt spawning, long-term erosion	Protect	Maple Beach		Whatcom County	1	0	1	Enhancement	1	yes	4	3	5	0	0	0	High	
22	sediment	Whatcom County SMP	5	Remove or partially remove of the outfall structure, short groin, and the old pilings (likely creosoted) could be at least partially removed to free up beach area and remove the foreign material	down-drift	shoreline modification/contaminants	Unknown	Hydraulic modification, contaminant removal	N/A	Protect	Maple Beach	4.15336E+11	County Parks	2	1	2	Enhancement	1	Yes	4	2	7	1	0	0	High	
23		City of Blaine SMP	1	Naturalize channel, enhance fish habitat and revegetate marine riparian near Cain Creek	in-stream/wetland	NA	Unknown	Revegetation	N/A	Enhance	City of Blaine	4.15136E+11	City of Blaine	3	0	0	Enhancement	12	Yes	4	3	6	1	High	0	High	
24		City of Blaine SMP	0	Beach nourishment along a portion of the shoreline for erosion control	footprint	shoreline modification	Enhance	Beach nourishment		Enhance	Blaine		Port of Blaine	3	0	1	Enhancement	12	yes	4	1	5	0	0	0	High	
25		City of Blaine SMP	0	Beach nourishment along a portion of the shoreline for erosion control	footprint	shoreline modification	Enhance	Beach nourishment, topography restoration		Enhance	Blaine		Port of Blaine	3	0	1	Enhancement	12	yes	4	1	5	0	0	0	High	
26		City of Blaine SMP	5	Enhance and expand salt marsh, remove fill, create marine riparian ecotone/buffer particularly adjacent to parking lots	footprint	wetland loss	Unknown	Channel rehabilitation	N/A	Enhance	City of Blaine	4.05101E+11	Port of Bellingham	3	0	1	Enhancement	12	Yes	4	1	5	1	0	0	High	
27		City of Blaine SMP	4	Enhance disturbed wetland near Blaine Marina, expand buffer adjacent to parking lot	footprint	wetland loss	Unknown	Channel rehabilitation	N/A	Enhance	City of Blaine		Railroad ROW	3	0	1	Enhancement	12	Unknown	4	1	5	0	0	Top	Top	
28	sediment	City of Blaine SMP	6	Remove or modify bulkheads; replace with alternative actions in Drayton Harbor	footprint	shoreline modification	Unknown	Armor removal or modification	N/A	Restore	City of Blaine		ROW	3	0	1	Restoration	14	Yes	1	1	5	1	0	0	Moderate	
29	sediment	City of Blaine SMP	7	Remove debris used for shore armoring and derelict pilings in Drayton Harbor	footprint	shoreline modification	Unknown	Debris removal	N/A	Restore	City of Blaine	4.00107E+11	Private	3	3	1	Restoration	14	No	1	1	8	0	0	0	Moderate	
30	sediment	City of Blaine SMP	8	Remove or modify bulkheads; replace with alternative actions and area-wide beach nourishment in Drayton Harbor	down-drift	shoreline modification	Unknown	Armor removal or modification, beach nourishment	N/A	Restore	City of Blaine	4.00107E+11	Private-Homestead	3	0	1	Restoration	14	No	1	2	6	0	0	0	Moderate	
31		City of Blaine SMP	9	Increase width of marine riparian buffer at Dakota Cr	footprint	NA	Unknown	Revegetation	N/A	Restore	Drayton Shore	4.00108E+11	Private-undeveloped	2	0	0	Enhancement	14	Ltd	1	1	3	1	0	0	Moderate	
32	tidal	Whatcom County SMP	6	Remove debris from the intertidal including the large platform and foundation to restore the beach and fringing marsh	footprint	NA	Unknown	Debris removal	N/A	Restore	Drayton Shore	4.00107E+11	Private-commercial	3	1	0	Restoration	14	No	1	1	5	0	0	0	Moderate	
33	sediment	Whatcom County SMP	7	Remove or modify bulkheads that protrude into the intertidal in Daryton Harbor north of Dakota Creek	down-drift	shoreline modification	Unknown	Armor removal or modification	N/A	Restore	Drayton Shore	4.00107E+11	Private	3	3	1	Restoration	14	No	1	2	9	0	0	High	High	

Id	ProcessRes	Source	Shoreform Number	Description	Benefit_Ar	Limited_Fa	Status	Mgmt_Meas	Justificat	Strategy	Mn_Reach	WCAGCODE	Ownership	Strat Match	Proc Match	LTF Match	Proj Strat Match	NAARP ID	Opprtny	CGS_DC_Pri	Benft_Scr	Proj_Scr	3yr_Scrn	3Yr_Prio	10Yr_Prio	Proj_Cat	Feasible
34	sediment	Whatcom County SMP	8	Remove or modify bulkheads that protrude into the intertidal in Drayton Harbor	down-drift	shoreline modification	Unknown	Armor removal or modification	N/A	Restore	Drayton Shore	4.00118E+11	Private	3	3	1	Restoration	14	No	1	2	9	0	0	High	High	
35		CGS_WRIA1_NAARP	8	Enhance tidal exchange at historic marsh	footprint	wetland loss	Unknown	Channel rehabilitation	tidal barrier, shore armor, historic marsh,	Restore	Drayton Shore	4.00118E+11	Private	2	0	1	Enhancement	14	No	1	1	4	0	0	0	Moderate	
36		CGS_WRIA1_NAARP	9	Enhance tidal exchange at culvert by replacing with larger culvert	footprint	wetland loss	Unknown	Hydraulic modification	tidal barrier	Restore	Drayton Shore	4.05114E+11	Private	2	0	1	Enhancement	14	No	1	1	4	0	0	0	Moderate	
37		Whatcom County SMP	9	Remove dilapidated dock from salt marsh habitat	footprint	shoreline modification	Unknown	Overwater structure removal, debris removal	N/A	Restore	Drayton Shore	4.05113E+11	Private	2	0	1	Enhancement	14	No	1	1	4	0	0	0	Moderate	
38		CGS_WRIA1_NAARP	10	Protect shoreline, especially along undeveloped parcels	down-drift	NA	Unknown	Aquisition or Conservation	high scoring	Restore	Drayton Shore	4.05113E+11	Private	2	0	0	Protection	14	No	1	2	4	0	0	High	High	
39	sediment	City of Blaine SMP	10	Remove or partially remove shore armor in Drayton Harbor	down-drift	shoreline modification	Unknown	Armor removal or modification	N/A	Restore	Drayton Shore	4.05113E+11	Private	3	1	1	Restoration	15	No	1	2	7	0	0	High	High	
40	sediment	CGS_WRIA1_NAARP	11	Remove or modifiy bulkhead, consider land acquisition	down-drift embayment	shoreline modification	Unknown	Armor removal or modification	armored BLB, FB, surf smelt spawning	Protect	Drayton Shore	4.05111E+11	Private	2	1	1	Restoration	15	No	1	3	7	0	0	High	High	
41		CGS_WRIA1_NAARP	12	Protect sand lance spawning habitat within Semiahmoo County Park boundary	footprint	NA	Unknown	Aquisition or Conservation	forage fish spawning, park land	Protect	Drayton Shore	4.05111E+11	City of Blaine	3	0	0	Protection	16	Yes	1	1	4	1	High	0	High	
42		City of Blaine SMP	11	Replace creosoted piles with non-toxic piles at Semiahmoo Spit	footprint	contaminants	Unknown	Contaminant removal	N/A	Protect	Drayton Shore	4.05103E+11	Private-DBW Whatcom LLC	1	0	1	Enhancement	16	No	1	1	3	0	0	0	Moderate	
43	sediment	CGS FB Mapping	6	Remove revetment and creosoted timber wall	footprint	shoreline modification/contaminants	Unknown	Armor removal or modification, contaminant removal	N/A	Protect	Birch Point	4.0511E+11	Private	2	1	2	Restoration	18	No	2	1	6	0	0	0	Moderate	
44	sediment	CGS FB Mapping	5	Remove 6 rock groins and 2 concrete groins	down-drift embayment	shoreline modification	Unknown	Groin removal	N/A	Protect	Birch Point	4.0511E+11	Private	2	1	1	Restoration	18	No	2	3	7	0	0	High	High	
45	sediment	CGS FB Mapping	4	Remove rock groin	down-drift embayment	shoreline modification	Unknown	Groin removal	N/A	Protect	Birch Point	4.0511E+11	Private	2	1	1	Restoration	18	No	2	3	7	0	0	High	High	
46	sediment	CGS FB Mapping	3	Remove or modify of shore armoring, failing creosoted wood wall	down-drift embayment	shoreline modification/contaminants	Unknown	Armor removal or modification, contaminant removal	N/A	Protect	Birch Point	4.05117E+11	Private	2	1	2	Restoration	18	No	2	3	8	0	0	High	High	
47	sediment	CGS_WRIA1_NAARP	13	Remove or modify shore armoring, failing creosoted wood wall, and adequate setback of structure at top of bluff	down-drift embayment	shoreline modification/contaminance	Unknown	Armor removal or modification, contaminant removal	armored BLB, FB, surf smelt spawning	Protect	Birch Point	4.05117E+11	Private	2	1	2	Restoration	18	No	2	3	8	0	0	High	High	
48	sediment	CGS FB Mapping	2	Remove concrete bulkhead 20-25 ft high and 15 ft waterward of bank	down-drift embayment	shoreline modification	Unknown	Armor removal or modification	N/A	Protect	Birch Point	4.05116E+11	Private	2	1	1	Restoration	18	No	2	3	7	0	0	High	High	
49	sediment	CGS_RestoPrio	11	Remove or modify shore armoring, undeveloped parcel	down-drift embayment	shoreline modification	Unknown	Armor removal or modification	N/A	Restore	Birch Bay	4.05126E+11	Private-BBV Comm Club	3	1	1	Restoration	20	No	2	3	8	0	0	High	High	
50	tidal	CGS_RestoPrio	12	Reconnect coastal wetland processes in Rogers Slough	in-stream/wetland	wetland loss	Unknown	Dike removal, hydraulic modification	N/A	Restore	Birch Bay	4.05124E+11	Private-BBV Comm Club	3	3	1	Restoration	20	No	2	3	10	0	0	Top	Top	
51	sediment	CGS_RestoPrio	13	Remove or modify shoreline armoring, old boat ramp	down-drift embayment	shoreline modification	Unknown	Armor removal or modification, groin removal	N/A	Restore	Birch Bay		Unknown	3	2	1	Restoration	22	Yes	2	3	9	1	0	High	High	
52	sediment	Whatcom County SMP	10	Remove groins and bulkheads and nourish upper beach along Birch Bay Drive to restore upper beach and backshore habitats	down-drift embayment	shoreline modification	Assessment	Armor removal or modification, groin removal	N/A	Restore	Birch Bay	4.0013E+11	Private	3	2	1	Restoration	22	No	2	3	9	0	Top		Top	
53	sediment	CGS_WRIA1_NAARP	14	Remove or modify shore armoring	down-drift embayment	shoreline modification	Unknown	Armor removal or modification	armored BAB, surf smelt spawning	Restore	Birch Bay		ROW	3	2	1	Restoration	23	Yes	2	3	9	1	High	0	High	
54	sediment	CGS_WRIA1_NAARP	15	Removal or modification of shore armoring	down-drift embayment	shoreline modification	Unknown	Armor removal or modification	armored BAB, surf smelt spawning	Restore	Birch Bay State Park		ROW	3	2	1	Restoration	23	Yes	2	3	9	1	High	0	High	
55	sediment	CGS_WRIA1_NAARP	16	Remove or modify shore armoring along these bluffs, many of these bulkheads appear to be un-permitted	down-drift embayment	shoreline modification	Unknown	Armor removal or modification	armored BLBs, FB, surf smelt spawning	Restore	Cherry Point	3.95102E+11	Private	3	2	1	Restoration	25	No	2	3	9	0	0	Top	High	
56		CGS_WRIA1_NAARP	17	Protect shoreline that delivers large amounts of sediment down-drift, undeveloped parcel	down-drift	NA	Unknown	Aquisition and Conservation	undeveloped parcel, no armor	Restore	Cherry Point	3.95102E+11	Private-undeveloped	2	0	0	Protection	25	Ltd	2	2	4	1	High	0	High	
57	sediment	Whatcom County SMP	11	Remove or modify bulkheads along Pt Whitehorn bluffs, which are the sole sediment source for the miles of accretionary shoreform and valuable habitat in Birch Bay	down-drift embayment	shoreline modification	Unknown	Armor removal or modification	N/A	Restore	Cherry Point	3.95102E+11	Private	3	2	1	Restoration	25	No	2	3	9	0	0	Top	High	
58		CGS_WRIA1_NAARP	18	Protect shoreline that delivers large amounts of sediment down-drift, undeveloped parcel	down-drift	NA	Unknown	Aquisition or Conservation	undeveloped parcel, no armor	Restore	Cherry Point	3.95102E+11	Private	2	0	0	Protection	25	No	2	2	4	0	0	High	High	
59	tidal	CGS_WRIA1_NAARP	19	Expand and restore wetland to historic extent and remove/reduce road footprint at Gulf Rd coastal wetland (salmondis observed in tidal channel)	in-stream/wetland	wetland loss	Unknown	Channel rehabilitation	tidal barrier, historic wetland	Restore	Cherry Point	3.90119E+11	Private-Pac Int Terminals	3	3	1	Restoration	28	No	2	3	10	0	0	Top	Top	
60	solar	CGS FB Mapping	1	Remove failed gravel pier	footprint	shading	Unknown	Overwater structure removal, debris removal	N/A	Restore	Cherry Point	3.90119E+11	Private-Pac Int Terminals	3	0	1	Restoration	27	No	2	1	5	0	0	0	Moderate	
61		CGS_WRIA1_NAARP	20	Protect surf smelt spawning beach, undeveloped parcels owned by Intalco	down-drift	NA	Unknown	Aquisition or Conservation	undeveloped parcel, surf smelt spawning, no armor	Restore	Cherry Point	3.9012E+11	Private-Intalco	2	0	0	Protection	29	No	2	2	4	0	0	High	High	
62	sediment	CGS_WRIA1_NAARP	21	Sediment by-pass at down-drift (south) end of pier facility, as down-drift beach appears to be depleted	down-drift embayment	shoreline modification	Unknown	Beach nourishment	armored BLB, surf smelt spawning	Restore	Cherry Point	3.90129E+11	Private-Intalco	3	1	1	Restoration	31	No	2	3	8	0	0	High	High	
63	sediment	CGS_WRIA1_NAARP	22	Remove culvert (with groin-like effects) from intertidal, daylight surface water connection, treat with bioswale if necessary	down-drift	shoreline modification/contaminance	Unknown	Hydraulic modification	surf smelt spawning, debris removal	Restore	Cherry Point	3.90129E+11	Private-Intalco	3	1	2	Restoration	31	No	2	2	8	0	0	High	High	
64	sediment	CGS_WRIA1_NAARP	23	Remove or modify shore armoring-large rock along toe of bluff	down-drift embayment	shoreline modification	Unknown	Armor removal or modification	armored BLB, surf smelt spawning	Restore	Cherry Point	3.90129E+11	Private-Intalco	3	1	1	Restoration	31	No	2	3	8	0	0	High	High	
65	sediment	CGS_WRIA1_NAARP	24	Remove or modify shore armoring-large rock along toe of bluff, no apparent structures on uplands and landliding likely controlled by geology rather than wave induced	down-drift embayment	shoreline modification	Unknown	Armor removal or modification	armored BLB, surf smelt spawning	Restore	Cherry Point	3.90132E+11	Private-Conoco Phillips	3	1	1	Restoration	31	No	2	3	8	0	0	High	High	

Nearshore Restoration On-the-ground Projects Attribute Table.

Id	ProcessRes	Source	Shoreform Number	Description	Benefit_Ar	Limited_Fa	Status	Mgmt_Meas	Justificat	Strategy	Mn_Reach	WCAGCODE	Ownership	Strat Match	Proc Match	LTF Match	Proj Strat Match	NAARP ID	Opprtny	CGS_DC_Pri	Benft_Scr	Proj_Scr	3yr_Scrn	3Yr_Prio	10Yr_Prio	Proj_Cat	Feasible
66	sediment	Whatcom County SMP	12	Excavate sediment from the up-drift (north) side of the pier and bypassed to the down-drift (south) side of the pier fill area in stages, which could also create coastal wetlands in the backshore	down-drift	shoreline modification	Unknown	Beach nourishment	N/A	Restore	Cherry Point	3.90132E+11	Private-Conoco Phillips	3	1	1	Restoration	31	No	2	2	7	0	0	High	High	
67		CGS_WRIA1_NAARP	25	Protect undeveloped coastal wetland and surf smelt spawning beach	down-drift	NA	Unknown	Aquisition or Conservation	surf smelt spawning, undevloped land	Restore	Sandy Point	3.80105E+11	Private-undeveloped	2	0	0	Protection	34	Ltd	2	2	4	1	High	0	High	
68	sediment	CGS_WRIA1_NAARP	26	Remove shoreline modification - concrete wall, undeveloped property (parcel layer may be off by 50' to north)	down-drift embayment	shoreline modification	Unknown	Aquisition or Conservation	surf smelt spawning, undevloped land	Restore	Sandy Point	3.80105E+11	Private-undeveloped	3	1	1	Restoration	34	Ltd	2	3	8	1	High	0	High	
69		Whatcom County SMP	13	Reduce intertidal slope, reduce impervious surfaces and create riparian buffer/dune habitat to aid with flood control issues. Portions of the undeveloped (filled) uplands could be restored to marsh where possible.	footprint	wetland loss/shoreline modification	Unknown	Topography restoration, revegetation	N/A	Enhance	Sandy Point Basin	3.80109E+11	Private-Sandy Pt Marina	2	3	2	Restoration	35	No	2	1	8	0	0	0	Moderate	
70	sediment	Whatcom County SMP	15	Remove sediment impoundments and alongshore drift impediments such as the failed concrete bulkhead owned by Lummi Tribal Realty Office	down-drift	shoreline modification	Unknown	Armor removal or modification	N/A	Protect	Gooseberry Point	3.80134E+11	Private-Lummi Realty	2	1	1	Restoration	46	No	4	2	6	0	0	High	High	
71	sediment	Whatcom County SMP	16	Remove broken concrete bulkhead sections, primarily north of Gooseberry Point and near the tip and south shore of the point	down-drift	shoreline modification	Unknown	Armor removal or modification	N/A	Restore	Gooseberry Point	3.80134E+11	Private-Lummi Tribal	3	2	1	Restoration	47	Ltd	4	2	8	1	High	0	High	
72		City of Bellingham	25	PORTAGE ISLAND PROTECTION AREA	down-drift	NA	Unknown	Aquisition or Conservation	N/A	Protect	Portage Island	3.70112E+11	Private-Lummi Tribal	3	0	0	Protection	224	Unknown	2	2	5	0	0	Top	Top	
73	tidal	CGS_WRIA1_NAARP	27	Remove dike or drainage channel from barrier lagoon	in-stream/wetland	wetland loss	Unknown	Channel rehabilitation	tidal barrier, historic wetland	Protect	Portage Bay	3.70207E+11	Private-Lummi Tribal	2	1	1	Restoration	237	Ltd	1	3	7	1	High	0	High	
74		CGS_WRIA1_NAARP	28	Protect wetland and marsh habitat, sand lance spawning down-drift, undeveloped parcels owned by Lummi Business Council	down-drift	NA	Unknown	Aquisition or Conservation	marsh, sand lance spawning down-drift	Protect	Portage Bay	3.70112E+11	Private-Lummi Tribal	3	0	0	Protection	234	Ltd	1	2	5	1	Top	0	Top	
75		CGS_WRIA1_NAARP	29	Protect sand lance spawning beach, undeveloped parcels owned by Lummi Business Council	down-drift	NA	Unknown	Aquisition or Conservation	undeveloped parcel, sand lance spawning, no armor	Protect	Portage Bay	3.70112E+11	Private-Lummi Tribal	3	0	0	Protection	232	Ltd	1	2	5	1	Top	0	Top	
76		CGS_WRIA1_NAARP	30	Protect sand lance spawning beach, undeveloped parcels owned by Lummi Business Council	down-drift	NA	Unknown	Aquisition or Conservation	undeveloped parcel, sand lance spawning, no armor	Restore	Portage Bay	3.70111E+11	Private-Lummi Tribal	2	0	0	Protection	239	Ltd	2	2	4	1	High	0	High	
77		CGS_WRIA1_NAARP	31	Protect shoreline and limit any new armoring related to the road, consider moving the road inland	down-drift	NA	Unknown	Aquisition or Conservation	sand lance spawning, BAB, high scoring	Restore	Lummi Shore	3.70111E+11	Private	2	0	0	Protection	53	No	2	2	4	0	0	High	High	
78		CGS_WRIA1_NAARP	0	Nourish beach substrate for forage fish spawning	down-drift	shoreline modification	Unknown	Beach nourishment	forage fish spawning	Restore	Lummi Shore		Private-Lummi Tribal	2	0	1	Enhancement	54	Ltd	2	2	5	0	0	0	High	
79		Whatcom County SMP	18	Nourishment of beach substrate suitable for forage fish and continued monitoring, as begun under USACE-constucted revetment	down-drift	shoreline modification	Designs	Beach nourish, Species habitat enhancement		Enhance	Lummi Shore		Private-Lummi Tribal	3	0	1	Enhancement	55	Ltd	1	2	6	0	Top	0	High	
80		Whatcom County SMP	18	Remove derelict drift nets, debris, and other foreign material from the beaches along Lummi Shore Road	footprint	NA	Unknown	Debris removal	N/A	Enhance	Lummi Shore	3.80126E+11	Private	3	0	0	Enhancement	55	No	1	1	4	0	0	0	Moderate	
81		City of Bellingham	26	NOOKSACK DELTA PROTECTION AREA	in-stream/wetland	NA	Unknown	Aquisition or Conservation	N/A	Restore	Nooksack River Delta		Private-Lummi Tribal	2	0	0	Protection	56	Unknown	3	3	5	0	0	Top	Top	
82		Whatcom County SMP	19	Remove abundant fine wood debris smothering nearshore sediments along the Cliffside Community beach	down-drift	NA	Assessed	Debris removal, substrate modification		Enhance	Fort Bellingham	3.80215E+11	DNR	2	0	1	Enhancement	57	Yes	1	2	4	0	0	0	Moderate	
83		CGS_WRIA1_NAARP	33	Protect shoreline and provide education to public users of "Locust Beach"	down-drift	NA	Unknown	Aquisition or Conservation	surf smelt spawning, BLB, high scoring	Restore	Fort Bellingham	3.80222E+11	Private	2	0	0	Protection	57	No	1	2	4	0	0	High	High	
84		CGS_WRIA1_NAARP	42	Protect forage fish spawning, enhance beach substrate and remove intertidal debris	down-drift	shoreline modification	Unknown	Beach nourish, aquisition, debris removal	forage fish spawning, armor and debris	Enhance	Fort Bellingham	3.80223E+11	Private-commercial	2	0	1	Enhancement	57	No	1	2	5	0	0	0	High	
85	solar	City of Bellingham	1	Remove creosoted wood piles at CEMENT CO. DOCK	footprint	shading/contaminants	Unknown	Overwater structure removal, contaminant removal	N/A	Enhance	Fort Bellingham	3.80223E+11	Private-commercial	3	0	2	Restoration	58	No	2	1	6	0	0	0	Moderate	
86	tidal	CGS_WRIA1_NAARP	35	Restoration of natural tide channel or replacement of current culvert with larger box culvert with foot bridge at mouth of Little Squalicum Creek for juvenile salmonid forage and refuge/rearing	in-stream/wetland	fish passage/wetland loss	Designs	Channel rehabilitation	forage fish spawning, fish barrier	Enhance	Fort Bellingham	3.80223E+11	Private-commercial-COB	4	3	2	Restoration	58	No	2	3	12	0	0	Top	Top	
87		Whatcom County SMP	20	Remove debris and exotic species and revegetate with native plants at Little Squalicum Creek mouth/estuary	footprint	NA	Unknown	Debris removal	N/A	Enhance	Fort Bellingham	3.80223E+11	Private-commercial-COB	3	0	0	Enhancement	58	No	2	1	4	0	0	0	Moderate	
88		City of Bellingham	2	Remove large boulders and rocks, renourish naturalized beach at MT. BAKER PLYWOOD WEST	footprint	shoreline modification	Designs	Beach nourishment, debris removal	N/A	Enhance	Fort Bellingham	3.80223E+11	Private-commercial-POB	3	3	1	Enhancement	58	No	2	1	8	0	Top	0	Top	
89		City of Bellingham	3	Remove or modify fill at MT. BAKER PLYWOOD NORTHWEST, regrade for marine buffer and possible salt marsh	footprint	shoreline modification/fish passage	Designs	Topographic restoration	N/A	Enhance	Fort Bellingham	3.80223E+11	Private-commercial-POB	3	0	2	Enhancement	58	No	2	1	6	0	High	0	High	
90		City of Bellingham	4	Remove fill and regrade for potential salt marsh and marine riparian enhancement at MT. BAKER PLYWOOD SOUTH	in-stream/wetland	shoreline modification/fish passage	Designs	Topographic restoration	N/A	Enhance	Fort Bellingham	3.80223E+11	Port of Bellingham	3	0	2	Enhancement	59	Unknown	6	3	8	0	0	High	High	
91		City of Bellingham	5	Raise elevations within estuary to provide intertidal and shallow water habitat for eelgrass and salt marsh with marine riparian enhancement at SQUALICUM CREEK WATERWAY - B	footprint	shoreline modification/fish passage	Designs	Substrate modification	N/A	Enhance	Fort Bellingham		Port of Bellingham	3	0	2	Enhancement	59	Unknown	6	1	6	0		High	High	
92		City of Bellingham	6	Remove fill and regrade to provide estuary habitat including intertidal, salt marsh, and marine riparian at BELLINGHAM COLD STORAGE	footprint	shoreline modification/fish passage	Designs	Topographic restoration	N/A	Enhance	Bellingham		Port of Bellingham	3	0	2	Enhancement	59	Unknown	6	1	6	0		High	High	
93		City of Bellingham	7	Remove or modify shore armor and enhance with beach sediment at SQUALICUM MARINA	footprint	shoreline modification/fish passage	Unknown	Substrate modification	N/A	Enhance	Bellingham	3.80225E+11	Port of Bellingham	3	0	2	Enhancement	61	Yes	4	1	6	1	0	0	High	No

Id	ProcessRes	Source	Shoreform Number	Description	Benefit_Ar	Limited_Fa	Status	Mgmt_Meas	Justificat	Strategy	Mn_Reach	WCAGCODE	Ownership	Strat Match	Proc Match	LTF Match	Proj Strat Match	NAARP ID	Opprtny	CGS_DC_Pri	Benft_Scr	Proj_Scr	3yr_Scrn	3Yr_Prio	10Yr_Prio	Proj_Cat	Feasible
94		CGS_WRIA1_NAARP	36	Enhance naturalized marsh habitat area in I and J waterway	footprint	shoreline modification	Unknown	Species habitat enhancement	naturalized marsh	Enhance	Bellingham	3.80225E+11	Port of Bellingham	3	0	1	Enhancement	61	Yes	4	1	5	1	High	0	High	
95		CGS_WRIA1_NAARP	37	Enhance naturalized pocket beach with surf smelt spawning	footprint	shoreline modification	Unknown	Species habitat enhancement	surf smelt spawning, naturalized pocket beach	Enhance	Bellingham	3.80225E+11	Port of Bellingham	3	0	1	Enhancement	61	Yes	4	1	5	1	High	0	High	
96		City of Bellingham	8	Raise elevations to create shallow water habitat, establish marine riparian and potentially eelgrass habitat at PORT-HILTON HARBOR	footprint	shoreline modification/fish passage	Unknown	Substrate modification	N/A	Enhance	Bellingham	3.80225E+11	Port of Bellingham	3	0	2	Enhancement	62	Yes	4	1	6	1	0	0	High	No
97		City of Bellingham	9	Remove contaminants, replace with clean sediment, and create habitat features at GP - ASB	footprint	shoreline modification/fish passage/contaminants	Unknown	Contaminant removal, substrate modification	N/A	Enhance	Bellingham	3.80225E+11	Port of Bellingham	3	0	3	Enhancement	62	Yes	4	1	7	1	0	0	Top	
98		City of Bellingham	10	Raise elevations to expand existing eelgrass habitat at G-P ASB - SOUTH	footprint	shoreline modification/fish passage	Unknown	Substrate modification	N/A	Enhance	Bellingham	3.80226E+11	Port of Bellingham	3	0	2	Enhancement	62	Yes	4	1	6	1	0	0	High	
99		City of Bellingham	11	Raise elevations to establish shallow water habitat, marine riparian enhancement at G-P ASB - EAST	footprint	shoreline modification/fish passage	Unknown	Substrate modification	N/A	Enhance	Bellingham	3.80226E+11	Port of Bellingham	3	0	2	Enhancement	62	Yes	4	1	6	1	0	0	High	
100		City of Bellingham	12	Modify elevations and substrates to establish estuarine riparian, mudflat, and salt marsh at HEAD OF WHATCOM WATERWAY	footprint	shoreline modification/fish passage	Unknown	Substrate modification	N/A	Enhance	Bellingham	3.80226E+11	Port of Bellingham	3	0	2	Enhancement	62	Yes	4	1	6	1	High	0	High	
101		City of Bellingham	13	Remove wood debris, modify elevations to provide shallow subtidal and intertidal habitats, potentially enhance eelgrass at PORT LOG RAFT	footprint	shoreline modification/fish passage	Unknown	Debris removal, substrate modification	N/A	Enhance	Bellingham	3.80236E+11	Port of Bellingham	3	0	2	Enhancement	65	Yes	5	1	6	1	High	0	High	
102		City of Bellingham	14	Remove debris and regrade to create intertidal and possibly salt marsh with and eelgrass habitat at CORNWALL AVE. LANDFILL - SHORELINE/UPLAND/IN-WATER	footprint	shoreline modification/fish passage	Unknown	Debris removal, topographic restoration	N/A	Enhance	Bellingham	3.80236E+11	City of Bellingham	3	0	2	Enhancement	66	Yes	5	1	6	1	High	0	High	
103		City of Bellingham	15	Remove or modify shore armor and remove excess concrete debris and potentially restore eelgrass at BOULEVARD PARK	footprint	shoreline modification	Designs	Armor removal or modification, debris removal	N/A	Enhance	Bellingham	3.70201E+11	City of Bellingham	3	0	1	Enhancement	69	Yes	5	1	5	1	0	0	High	
104		City of Bellingham	16	Remove debris and enhance habitat - PADDEN CREEK - NORTH SHORELINE	footprint	shoreline modification/fish passage	Designs	Debris removal, species habitat enhancement	N/A	Enhance	Bellingham	3.70201E+11	Port of Bellingham	3	0	2	Enhancement	76	Yes	6	1	6	1	High	0	High	
105		City of Bellingham	17	Remove treated wooden pier, creosote, and fill and possibly expand eelgrass beds at PADDEN CREEK - NORTH IN-WATER	footprint	shoreline modification/fish passage/contaminants	Designs	Contaminant removal, substrate modification	N/A	Enhance	Bellingham		Port of Bellingham	3	0	3	Enhancement	76	Unknown	6	1	7	0	0	Top	Top	
106		City of Bellingham	18	Remove fill and debris and modify elevations to provide estuarine and riparian vegetation, mudflat and marsh at EAST SHORE PADDEN CREEK	footprint	shoreline modification/fish passage	Designs	Topographic restoration	N/A	Enhance	Bellingham	3.70203E+11	City of Bellingham	3	0	2	Enhancement	77	Yes	5	1	6	1	High	0	High	
107	tidal	City of Bellingham	19	Remove fill and expand of Harris Ave bridge to reconnect tidally influenced brackish marsh with marine riparian enhancement at PADDEN CREEK - UPLAND	in-stream/wetland	wetland loss	Unknown	Channel rehabilitation	N/A	Enhance	Bellingham	3.70201E+11	City of Bellingham	4	3	1	Restoration	77	Yes	5	3	11	1	High	0	Top	
108	tidal	City of Bellingham	20	Modify existing structure under railroad crossing to open up tidal channel and replace concrete shore armor with rock at POST POINT - SHORELINE, up-drift of surf smelt spawning	in-stream/wetland	wetland loss	Unknown	Channel rehabilitation	N/A	Enhance	Edgemoor	3.70211E+11	City of Bellingham	4	3	1	Restoration	81	Yes	6	3	11	1	High	0	Top	
109		City of Bellingham	21	POST POINT TO CHUCKANUT - PROTECTION AREA	down-drift	NA	Unknown	Aquisition or Conservation	N/A	Protect	Edgemoor	3.70211E+11	Private-undeveloped	3	0	0	Protection	83	Unknown	4	2	5	0	0	Top	Top	
110	tidal	City of Bellingham	22	Modify existing structure under railroad crossing to open up tidal channel and intertidal nourishment to add complexity around tidal channel at POST POINT - SOUTH	in-stream/wetland	wetland loss	Unknown	Hydraulic modification, substrate modification	N/A	Enhance	Edgemoor		Railroad	4	3	1	Restoration	85	Unknown	6	3	11	0	0	High	Top	
111	tidal	City of Bellingham	23	Replace or modify existing culvert (appears closed) under railroad to open up tidal channel at CHUCKANUT SPIT	in-stream/wetland	wetland loss/fish passage	Unknown	Hydraulic modification	N/A	Enhance	Edgemoor	3.70214E+11	Whatcom Land Trust	4	3	2	Restoration	90	Yes	8	3	12	1	Top	0	Top	
112	sediment	CGS_WRIA1_NAARP	38	Remove jetty/boat basin at barrier estuary in Mud Bay	footprint	shoreline modification	Unknown	Channel rehabilitation	shore modification/jetty	Restore	Edgemoor	3.70213E+11	City of Bellingham	3	3	1	Enhancement	98	Yes	3	1	8	1	0	0	Moderate	
113	tidal	City of Bellingham	24	Modify or replace existing causeway to allow greater tidal exchange between Mud Bay and Chuckanut Bay at CHUCKANUT BREACH	in-stream/wetland	wetland loss	Unknown	Berm or dike removal	N/A	Restore	Edgemoor		Railroad	4	3	1	Restoration	99	Unknown	3	3	11	0	0	Top	Top	
114		CGS_RestoPrio	14	Remove old debris from Chuckanut Cannery	footprint	NA	Unknown	Debris removal	N/A	Enhance	Chuckanut	3.07224E+11	Private	3	0	0	Enhancement	100	No	6	1	4	0	0	0	Moderate	
115		CGS_WRIA1_NAARP	39	Protect surf smelt spawning in Larrabee State Park	footprint	NA	Unknown	Aquisition or Conservation	surf smelt spawning, publicly owned land	Protect	Chuckanut	3.70236E+11	State Parks	3	0	0	Protection	130	Yes	3	1	4	1	High	0	High	
116		CGS_WRIA1_NAARP	0	Enhancement of beach sediment, removal of debris - derelict pilings and rail structure at forage fish spawning beach	down-drift	shoreline modification	Unknown	Beach nourishment, debris removal	forage fish spawning	Enhance	Chuckanut		PSE	3	0	1	Enhancement	133	No	3	2	6	0	0	High	High	
117		CGS_WRIA1_NAARP	41	Enhancement of emergent marsh habitat area, remove toppled armor	footprint	wetland loss	Unknown	Species habitat enhancement	tidal barrier, emergent marsh	Restore	Skagit County	47935	Private-commercial	2	0	1	Enhancement	138	No	2	1	4	0	0	0	Moderate	
118		CGS_WRIA1_NAARP	42	Removal of tidal barrier or related enhancement actions to increase tidal exchange in barrier estuary and emergent marsh	in-stream/wetland	wetland loss	Unknown	Channel rehabilitation	tidal barrier, emergent marsh	Restore	Skagit County	47914	Private	2	0	1	Enhancement	139	No	2	3	6	0	0	High	High	
119		CGS_WRIA1_NAARP	43	Removal of derelict debris - apparent creosoted soldier pile wall into intertidal	footprint	contaminants	Unknown	Contaminant removal	debris and contaminants in intertidal	Restore	Skagit County		BLANK	2	0	1	Enhancement	143	Unknown	2	1	4	0	0	0	Moderate	
120	tidal	CGS_WRIA1_NAARP	45	Reconnection of tidal channel at Colony Creek	in-stream/wetland	wetland loss	Unknown	Channel rehabilitation	tidal barrier	Restore	Skagit County		PSE	3	2	1	Restoration	143	No	2	3	9	0	0	Top	High	
121		CGS_WRIA1_NAARP	46	Removal of derelict debris - apparent creosoted soldier pile wall into intertidal	footprint	contaminants	Unknown	Armor removal or modification	debris and contaminants in intertidal	Restore	Skagit County		Unknown	2	0	1	Enhancement	143	Unknown	2	1	4	0	0	0	Moderate	

Nearshore Restoration On-the-ground Projects Attribute Table.

Id	ProcessRes	Source	Shoreform Number	Description	Benefit_Ar	Limited_Fa	Status	Mgmt_Meas	Justificat	Strategy	Mn_Reach	WCAGCODE	Ownership	Strat Match	Proc Match	LTF Match	Proj Strat Match	NAARP ID	Opprtny	CGS_DC_Pri	Benft_Scr	Proj_Scr	3yr_Scrn	3Yr_Prio	10Yr_Prio	Proj_Cat	Feasible
122		CGS_WRIA1_NAARP	47	Removal of derelict debris - boat in intertidal Samish Bay	footprint	NA	Unknown	Debris removal	debris in intertidal	Restore	Skagit County	47970	Private	2	0	0	Enhancement	143	No	2	1	3	0	0	0	Moderate	
123	tidal	CGS_WRIA1_NAARP	48	Removal of dikes in Samish Delta - would entail acquiring farmland parcels	in-stream/wetland	wetland loss	Unknown	Berm or dike removal, acquisition or conservation	tidal barrier, farmland	Restore	Skagit County	48448	Private	3	2	1	Restoration	143	No	2	3	9	0	0	Top	High	
124		Whatcom County SMP	21	Remove derelict piles (likely creosoted) Eliza Island	footprint	contaminants	Unknown	Contaminant removal	N/A	Protect	Eliza Island	3.70232E+11	Private-Eliza Island Club	1	0	1	Enhancement	251	No	4	1	3	0	0	0	Moderate	
125		Whatcom County SMP	22	Remove derelict piles (likely creosoted) Eliza Island	footprint	contaminants	Unknown	Contaminant removal	N/A	Protect	Eliza Island	3.70232E+11	Private-Eliza Island Club	1	0	1	Enhancement	251	No	4	1	3	0	0	0	Moderate	
126		Whatcom County SMP	23	Enhance shoreline not being used by commercial/industry by removing fill and enhancing marine riparian to resemble the rocky shore prior to site development	footprint	shoreline modification	Unknown	Species habitat enhancement	N/A	Protect	S Lummi Island	3.70124E+11	Private-commercial	1	0	1	Enhancement	169	No	5	1	3	0	0	0	Moderate	
127		CGS_WRIA1_NAARP	49	Protect sand lance spawning beach and no apparent armor	down-drift	NA	Unknown	Aquisition or Conservation	sand lance spawning, no armor	Protect	Hale Pass	3.7011E+11	Private	3	0	0	Protection	152	No	2	2	5	0	0	Top	Top	
128		CGS_WRIA1_NAARP	50	Enhancement of marine riparian along artificial shore at ferry terminal	footprint	NA	Unknown	Revegetation	surf smelt spawning	Protect	Hale Pass	3.70105E+11	Whatcom County	1	0	0	Enhancement	150	Yes	2	1	2	1	0	0	Moderate	
129		Whatcom County SMP	24	Remove relict structures in backshore/marsh environments with marsh restoration	footprint	NA	Unknown	Debris removal, species habitat enhancement	N/A	Restore	N Lummi Island	3.70108E+11	Private-Lummi Is Land Co	2	0	0	Enhancement	208	No	5	1	3	0	0	0	Moderate	
130	sediment	CGS_WRIA1_NAARP	51	Removal or modification of shore and road protection; this seawall is continually undermined and a maintanence issue for Whatcom County, consider land acquistion or road closure as alternatives	down-drift	shoreline modification	Unknown	Armor removal or modification	armored BAB	Protect	N Lummi Island	3.70108E+11	Private-Lummi Is Land Co	2	1	1	Restoration	207	No	4	2	6	0	0	High	High	
131	sediment	Whatcom County SMP	25	Remove failed solid filled pier, large rock groin, concrete debris and derelict piles in the western portion of Legoe Bay	down-drift	shoreline modification	Unknown	Armor removal or modification, groin removal	N/A	Protect	N Lummi Island	3.70108E+11	Private	2	1	1	Restoration	207	No	4	2	6	0	0	High	Moderate	
132		Whatcom County SMP	26	Remove derelict piles (likely creosoted) south Lummi Island	footprint	contaminants	Unknown	Contaminant removal	N/A	Protect	N Lummi Island	3.70109E+11	Private-Lummi Is Land Co	2	0	1	Enhancement	207	No	4	1	4	0	0	0	Moderate	
133	tidal	CGS_WRIA1_NAARP	52	Reconnection of coastal wetland leeward of Legoe Bay Road through restored tide channel or installation of larger box culvert	in-stream/wetland	wetland loss	Unknown	Channel rehabilitation	tidal barrier, salmonid migratory pathway	Protect	N Lummi Island	3.70109E+11	Private-Lummi Is Land Co	2	3	1	Restoration	209	No	4	3	9	0	0	High	High	

Appendix D: Current Salmon Recovery Implementation Plan

WRIA 1 Watershed Restoration Strategy and Near-Term Actions

The WRIA 1 watershed recovery strategy aims to recover self-sustaining salmonid runs to harvestable levels through habitat restoration integrated with careful hatchery and harvest management. The near-term objectives for WRIA 1 are to (1) focus and prioritize salmon recovery efforts to maximize benefits to the two Nooksack early Chinook populations; (2) address late-timed Chinook through adaptive management; (3) facilitate recovery of WRIA 1 bull trout and steelhead by implementing actions that are mutually beneficial to early Chinook, bull trout, and steelhead; and (4) address other salmonid populations by protecting habitat-forming processes through regulatory and incentive-based programs and encouraging voluntary efforts that will not divert attention from early Chinook recovery.

Three of the nine Near-Term Actions that have been identified to address the objectives described above affect nearshore and estuarine areas:

Action 4. Habitat protection and restoration in estuarine and nearshore areas,

Action 7. Habitat protection through local land use regulations,

Action 9. Restore functioning riparian and water quality conditions and reconnect isolated habitats in lower mainstem tributaries and independent tributaries in WRIA 1.

WRIA 1 Salmon Recovery 3-year Implementation Plan

The 2011-2013 WRIA 1 3-year project plan includes actions to address each of the Near-Term Actions. The estuary and nearshore habitat actions identified in the 3-year plan include the following:

- Estuarine and Marine Nearshore Needs Assessment and Prioritization (this project) to compile existing data and research.
- Restoration of floodplain connectivity upstream of the Nooksack River Delta including preliminary steps that will lead to future modification or removal of the left bank levee between Slater Road and Marine Drive. Possible repairs or replacement of the head structure on the Lummi River near Ferndale Road may also be evaluated.
- Lower Nooksack River Restoration including acquisition of floodplain areas with elements identified in the U.S. Army Corps of Engineers and Washington Department of Fish and Wildlife Puget Sound Nearshore Ecosystem Restoration Project.
- Multiple riparian restoration projects and fish passage projects in independent coastal streams.
- Restoration of upstream and downstream connectivity and estuarine habitat quantity and quality on the Lummi Delta, including restoration work underway in Smuggler's Slough.
- Design, restoration, and creation of multiple nearshore and pocket estuary projects in Bellingham Bay.

WRIA 1 Salmon Recovery 10-year and Long-Term Actions

The WRIA 1 Salmonid Recovery Plan prepared in 2005 identified actions to be implemented over the next 10 years (i.e., 2006 through 2015) and over the long-term (i.e., over the next 25 to 100 years). A subset of the actions was focused on habitat conditions in the estuary and nearshore.

Nooksack Estuary 10-year Actions

- *Restore riverine-tidal blind channel network, Marietta Slough*: Set back levees on left bank (looking downstream) of river between mouth of river and Slater Road, and seaward dikes.
- *Restore riverine-tidal blind channel network, Tennant Wetland:* Project proposes to enhance floodplain tributary channels by redesigning the channel and introducing wood and planting riparian vegetation on Tennant Creek. This creek drains the wetlands on the eastern side of the floodplain of the mainstem downstream of Ferndale.
- *Setback/ remove levees on left bank of river between Slater Road and Ferndale:* Levee setback and removal will encourage floodwater and sediment deposition on the estuarine floodplain above Slater Road. Slater Road will be raised to accommodate flooding and infrastructure will be protected. It is expected that the project will enhance wetland functions on the floodplain and encourage more flow into the Tennant Creek area.
- *Restore channel complexity:* Wood will be placed along river margins and anchored to piling wing walls or other instream structures. Structures will be placed to increase channel complexity along the bank of the river at multiple locations. LWD will improve complexity along the edge of the channel and increase habitat quality for juvenile rearing.

Nooksack Estuary Long-Term Actions

- *Reconnect slough and floodplain habitat:* Reconnection of floodplain sloughs, such as Smuggler's Slough and Slater Slough, will provide enhanced freshwater rearing habitat for juvenile salmon. The project also provides a freshwater transit between the Bellingham Bay Delta and the Lummi Bay Delta.
- *Reconnect distributary habitat:* In places where tidal and distributary channels have been truncated by non-passable tide gates and levees, restoration opportunities exist to improve passage into these habitat areas by updating or removing the tide gates.

WRIA 1 Nearshore 10-year Actions

The 10-year actions identified were exclusive to the Bellingham Bay shoreline and did not address additional sources of habitat and nearshore process degradation in the larger WRIA 1 nearshore. The following opportunities were extracted directly from the list of 10-year actions.

- *Prioritize and implement relevant recommendations from the Bellingham Bay Pilot Project:* The Bellingham Bay Pilot Project developed a list of restoration and enhancement projects for the developed portion of Bellingham Bay. These projects could be evaluated and prioritized for their benefit to target species and implemented. Focus should be placed on projects that improve habitat diversity and quantity in the nearshore areas and non-natal estuaries of Padden Creek, Whatcom Creek, and Squalicum Creek.
- *From Appendix B:* 10-year actions: Estuarine and Nearshore Areas. Goal: Protect and restore quantity and quality of properly functioning habitat conditions in the estuarine and nearshore marine habitats that will lead to the recovery of the Nooksack stocks of Chinook and other salmonids. Objectives: The near-term objectives for the next 5-10 years are to
    - protect ecosystem processes essential to the productivity and abundance of Nooksack Chinook, bull trout, and other salmonids and the prey on which they depend;
    - provide incentives for the restoration of nearshore habitat structure and processes;

- develop and begin implementation of a prioritized list of actions for protection and restoration of habitats and ecosystem processes necessary to recover the productivity and abundance of Nooksack early Chinook, bull trout, and other salmonids;
- minimize water quality impacts to the marine environment from watershed and shoreline activities.

WRIA 1 Nearshore Long-Term Actions

- *Monitor Shorelines and Critical Areas Ordinance:* The Whatcom County Shorelines regulations and Critical Areas Ordinance will likely have a positive effect on reducing the impacts of shoreline development along the nearshore areas of Bellingham Bay and will need to be monitored for long-term effectiveness. Critical areas will include a geotechnical setback for bluffs and riparian protection, which are important to the recovery of habitat-forming processes such as sediment transport and natural beach protection in the nearshore.
- *Restore beach habitat-forming processes:* Restoring beach processes may include removing unnecessary bulkheads, or artificially nourishing the beach where bulkheads cannot be removed. Benefits include reducing beach scour, restoration of littoral sediment supply and movement, restoration of backshore vegetation, and the accumulation of driftwood.

Additional Actions to Protect and Restore Estuarine and Marine Nearshore Habitat

The following additional estuarine and nearshore actions to recover salmonids were identified:

- Address water quality degradation in streams and rivers flowing to WRIA 1 estuarine and nearshore marine waters.
- Protect and restore estuaries associated with coastal independent tributaries (especially in Bellingham Bay), especially those have been determined to provide important nonnatal estuary habitat to Nooksack River salmonids.
- Protect and restore, to the extent feasible, the processes regulating the supply, transport, and deposition of sediment, water, large wood, and nutrients in the estuarine and nearshore marine environment.
- Protect and restore nearshore marine habitat structure and function:
    - Ensure no net loss of eelgrass habitats, macroalgae habitats, intertidal forage fish spawning habitats (e.g. surf smelt and sandlance), intertidal wetlands, intertidal mudflats, and salt marsh.
    - Avoid or limit dredging activities, and minimize and fully mitigate for adverse impacts (eelgrass destruction, bathymetric changes, resuspension of contaminated sediments).
    - Avoid or limit placement of fill, and minimize and fully mitigate for adverse impacts.
    - Restore bathymetry where feasible (e.g., remove fill); the Cornwall Landfill has been identified as a high priority through the Bellingham Bay Demonstration Pilot.
    - Plant native vegetation.
- Protect and restore shoreline conditions.
    - Develop and enforce land use regulations (Shorelines Master Plan) to protect and restore marine bluffs (i.e., limit construction, removal of vegetation, new roadbuilding).

    - Prevent new shoreline modification.
    - Develop incentives and identify opportunities to remove, set back, or replace shoreline armoring and bulkheading with softer alternatives.
    - Identify opportunities to remove fill and overwater structures in the nearshore environment.
    - Restore vegetation along shorelines to provide shoreline stabilization, shading of upper intertidal, and inputs of organic matter and woody debris.
- Protect and restore forage fish spawning areas:
    - Prohibit development or activities that would adversely impact known forage fish spawning beaches.
    - Avoid destruction of eelgrass beds; where infeasible, minimize and fully mitigate for adverse impacts.
    - Minimize disturbance in herring prespawn holding areas to the extent possible.
    - Implement beach nourishment activities to restore forage fish spawning areas:
        - Although not process-based, this may be the only available option when restoration of the sediment regime is infeasible (e.g., inner Bellingham Bay, other highly modified shorelines).
        - Consider physical context (wave and current patterns) in site selection to minimize the need for costly, frequent maintenance.
        - Consider specific substrate size and tidal elevation requirements.
        - Secure funding for long-term maintenance.
- Improve migratory corridors in the estuarine and nearshore marine environments:
    - Maintain adequate flows through estuaries to ensure optimal and timely downstream migration for smolts.
    - Identify timing, location, and characteristics of migration routes for Chinook and other salmonids.
    - Identify existing structures and shoreline conditions that disrupt or otherwise adversely impact migrating salmonids.
    - Avoid adverse impacts of new activities and development on migratory corridors.
    - Restore or enhance conditions in migratory corridors, e.g., by placement of cover, grading to create shallow shelf habitats, and restoration of eelgrass and other intertidal and subtidal vegetation.
- Ensure coordination and cooperation with and among various organizations and committees working within the estuarine and nearshore marine environments of WRIA 1 (e.g., Whatcom Marine Resources Committee, Bellingham Bay Pilot Project, Puget Sound Nearshore Ecosystem Restoration Program, Waterfront Futures) to achieve recovery of estuarine and nearshore marine ecological functions beneficial to recovery of Chinook salmon and other salmonids.

- Work with the Burlington Northern railroad to seek solutions to reduce impacts to WRIA 1 shorelines (especially Chuckanut Bay).
- Reduce occurrence of treated wood structures in the nearshore:
    - Use less toxic alternatives to wood treatment.
    - Identify, prioritize, and remove or replace existing treated timber structures.
- Evaluate, address, and avoid or minimize impacts of industrial and municipal discharges in Cherry Point to water and sediment quality.
- Evaluate and remove creosote logs in WRIA 1 estuaries and nearshore marine habitats.
- Promote oil and hazardous substance spill prevention, contingency, and response planning to reduce risk, minimize exposures, remediate contaminated areas, and restore lost resource functions and services.
- Regularly monitor for presence of *Spartina* and other invasive species in WRIA 1, especially on the Lummi Bay and Bellingham Bay mudflats, and develop a plan to quickly respond with control efforts if detected.
- Continue to address the cleanup and disposal or appropriate capping of contaminated sediments in inner Bellingham Bay according to the prioritization by the Bellingham Bay Demonstration Pilot Project.

Appendix E: Summary of TAG Input

The group comprised nine individuals representing a variety of entities and areas of expertise. TAG members were selected based on specific criteria so that, *collectively,* the group reflected the following:

- o Geographic balance across WRIA 1 nearshore areas
- o Mix of urban and nonurban constituency interests
- o Nearshore restoration expertise including coastal geology, fisheries biology, shoreline ecology, and marine biology
- o Diverse range of interests in nearshore restoration, including recovery of species at risk, protection of wildlife, protection of shoreline landscapes and processes, and enhanced opportunities for recreation (including fishing) and commercial fishing
- o Representation across multiple governments including federal, state, local, and tribal
- o Nongovernment interests (environmental NGO)

The TAG met four times throughout the project's duration. These meetings coincided with the completion of key components and deliverables of the project, including the following:

<u>TAG Meeting 1:</u> Information Review/Synthesis, February 29, 2012

<u>TAG Meeting 2:</u> Draft Conceptual Approach: Marine Nearshore, April 24, 2012

<u>TAG Meeting 3:</u> Draft Conceptual Approach: Nooksack Estuary, May 29, 2012

<u>TAG Meeting 4:</u> Draft Prioritization Tool and Priority Projects, June 26, 2012

Table 34. Summary of the input provided by the TAG.

KEY WORK PRODUCT OR TOPIC	INFORMATION REQUESTED	SUMMARY OF TAG INPUT	HOW INPUT WAS ADDRESSED
Geographic Extent of the Study Area	*Upper extent of Nooksack and Lummi Rivers*	Review historical conditions mapping, consider upper extent of salt wedge.	Referred to Collins and Sheikh and the upstream extent of tidal fresh wetlands (Simenstad et al. 2011).
Information Review/ Synthesis	*Are there additional reports and studies that should be reviewed?*	Nooksack Recovery Team limiting factors report	All available requested reports and studies were reviewed and incorporated. The draft RITT report was reviewed and incorporated into both phases of the project; however, the final RITT report had not been published at the time this project was completed.
		WRIA 1 Salmon Recovery process restoration matrices	
		City of Bellingham Comprehensive Plan	
		City of Bellingham Park Master Plan	
		City of Bellingham SMP Restoration Plan	
		Whatcom County Comprehensive Plan	

		Recovery Implementation Technical Team (RITT) Framework for the Nearshore	
Stakeholder Engagement	*Key entities/individuals for inclusion in a broader stakeholder engagement strategy*	DNR; BBWARM; BNSF; Peter Gill at Whatcom County; Lindsay Taylor with RE Sources; Diking District 1; Port of Bellingham; Whatcom Conservation District; Farm Friends; Whatcom Agricultural Preservation; Birch Bay Shellfish District; Drayton Harbor Shellfish District	All entities/individuals were added to the distribution list for broader stakeholder engagement effort.
Prioritization Approach: Marine Shorelines	*General feedback on proposed approach for marine shorelines*	Cumulative benefits should be reflected in the ranking criteria.	This was done.
		It is important to explore broader ecological benefits, not just salmonid recovery.	Broader ecological elements will be addressed through the ranking criteria; users of the prioritization tool can turn "on" or "off" different criteria to focus in on specific aspects of the ecosystem.
		The approach should reflect the current status of a project/opportunity so that leverage points and collaborations can be easily identified.	This was done.
		Would like the capability to prioritize within and across the three main strategies (restoration, protection and enhancement)	The tool will allow for this.
		Historical and current shoreform maps should be made available to the TAG.	Done.
	Feedback on Ecological Valuation Criteria (EVC)	Additional attributes such as benthic invertebrates should be added so that it addresses additional species and reflects biological richness, rather than being mainly salmon focused.	There are some difficulties in adding additional species such as limited data and complexities in the tool. The consultant team will explore options for how best to add species.
		Include all relevant information on quantity or quality of each attribute in the attribute table; retain original data.	This will be done.
		Should refer to "natal streams for ESA ESU" rather than as "proximity to Chinook bearing streams".	This change will be made.
		Establish measures of quality and function of various attributes.	This will be done where data are available.
	Identifying High Priority Areas	Be sure to run the scoring with and without weighting factors.	This will be done.

	Fine scale priorities	Feasibility should be factored in as part of the opportunity analysis; it should be reassessed every 3 years because it can change over time.	This will be done.
Prioritization Approach: Nooksack Estuary	*Overall approach*	Include opportunities on Shell Creek (a culvert inventory was done that identifies barriers to implementation).	This will be done.
	Summary matrix	Tease apart processes and habitat to the degree possible (use "High, Medium and Low" rather than just marking with an X.	
		Benefit column: should try to capture the type of benefit (e.g., H, M or L in terms of timing).	
		Do not minimize the constraints; we need a realistic understanding of them, as well as some measure for bringing them into the tool.	Noted; constraints are an important consideration and will be incorporated into the final product.
		Sequencing and constraints are related; a summary describing how these pieces fit together is needed.	This will be addressed.
	Project list	Projects 1, 2, and 5 should be included as 1 linked project; flow issues need to be addressed.	Change made.
		Additional restoration opportunities identified by the Lummi Nation need to be included.	Consultant team met with Jill (Lummi) and John (Whatcom Co) to get relevant information to be included.
		A flow chart that illustrates linkages and sequencing between projects should be produced.	A flow chart was created.

Appendix F: Nooksack River Estuary Restoration Opportunities

Table 35. Restoration status, scale, and logistics of Nooksack Estuary restoration opportunities.

Table 36. Benefits to ecological processes and habitats and achievement of restoration objectives of the Nooksack River Estuary restoration opportunities.

Table 35. Restoration status, scale, and logistics of Nooksack Estuary restoration opportunities.

Project Number and Description	Status Description	Restoration Status Category				Scale and Logistics			
		Feasibility Phase	Early Design Phase: Assessment & Conceptual Design	Late Design: Permitting & Final Design	Implementation	Benefit Area (acres)	Cost	Sequencing	Constraints
1 Reconnect floodplain along left bank of the Mainstem of the Nooksack River	10% design from PSNERP, ESRP grant awarded to assess feasibility	ongoing	ongoing			768	More than $1,000,000	Prior to implementation, several acquisitions and demolitions in the Marietta community will be necessary	**MAJOR**: Requires acquisition and relocation of multiple landowners. In addition, the project entails conversion of agricultural land. The portion of the project area located upstream of Marine Drive is publically owned by WDFW. Given the sensitive community issues, implementation of this type of project at this scale will require extensive community dialogue throughout an extensive public process.
2 Reconnect floodplain along right bank of the Mainstem of the Nooksack River	10% design from PSNERP, ESRP grant awarded to assess feasibility	ongoing	ongoing			461	More than $1,000,000	Depending on restoration approach, may require constructing setback dikes prior to breaching. Will require replacing/retrofitting/removing roads and bridges to accommodate altered flow patterns	**MAJOR**: Requires a substantial amount of infrastructure improvements (e.g., setback dikes, roads, and bridge crossings) to accommodate the increased flows over the floodplain. Also requires the acquisition of multiple properties, possibly with relocation costs, as well as the conversion of agricultural lands. Given the sensitive community issues, implementation of this type of project at this scale will require extensive community dialogue throughout an extensive public process.
3 Reconnect Slater Slough by breaching Kwina Slough dike	will be included in ESRP grant awarded to assess feasibility; depending on early findings of that analysis this opportunity may not be part of later stages of ESRP grant	ongoing	ongoing			193	$100,000 to $500,000	If ultimately not part of ESRP project that is moved forward, then this opportunity could occur before or after that other work in the area, as long as projects are designed to be complementary	**MINOR**: Requires acquisition of multiple properties and will require the cooperation of the diking district.
4 Remove pilings at head of Kwina Slough	will be included in ESRP grant awarded to assess feasibility; depending on early findings of that analysis this opportunity may not be part of later stages of ESRP grant	ongoing	ongoing			1	Less than $100,000	If ultimately not part of ESRP project that is moved forward, then this opportunity could occur before or after that other work in the area, as long as projects are designed to be complementary	**MINOR**: Requires acquisition of multiple properties and will require the cooperation of the diking district.
5 Improve tidal exchange and passage along Smuggler's Slough	This project is in the design phase; considered Phase 2 of ongoing Smuggler's Slough restoration work	complete	complete	complete	ongoing	7	$100,000 to $500,000	Currently in the early design phase. Construction has not started.	

6 Restore perennial surface water connection between Nooksack River and Lummi River	10% design was prepared by PSNERP; PSNERP intends to continue working on opportunity in the coming years	ongoing	ongoing			110	$500,000 to $1,000,000	Prior to implementation, will require replacing/retrofitting/removing roads and bridges to accommodate altered flow patterns; should occur before of in conjunction with restoration of lower portions of Lummi River (opportunities #8, 9, and 10), although opportunities #9 and 10 could be altered later, if those opportunities are implemented first	**MAJOR**: Requires a substantial amount of infrastructure improvements (e.g., setback dikes, roads, and bridge crossings) to accommodate the increased flows through the historical channel. The preliminary target flow of 200 cfs (USACE 200) would be more than 10 percent of the average recorded flow in the Nooksack River during the late summer which is a major water reallocation issue that would need to be resolved. Also requires the willingness of multiple properties, and possibly the conversion of agricultural lands. Water quality and water quantity issues have been identified previously as concerns for this type of project. Long-standing concerns about water quality in Nooksack River that would be introduced to Lummi River have delayed previous work on this opportunity and would need to be resolved prior to implementation. There are water quantity issues that would need to be resolved including downstream water rights, fish passage conditions, and intended duration of flow during the year. Given the sensitive community issues, implementation of this type of project at this scale will require extensive community dialogue throughout an extensive public process. **MINOR**: Long-standing concerns about water quality in Nooksack River that would be introduced to Lummi River have delayed previous work on this opportunity and had to be resolved prior to implementation.
7 Remove fish barriers on tributaries flowing into estuary	barriers evaluated per WDFW fish passage barrier protocols					61	$100,000 to $500,000	Each of the 4 creeks has sequencing issues consider. The benefits of Schell Creek restoration is related to the reconnection of flow into the Lummi River (#6). The benefits of Jordan Creek restoration would be improved by the reconnection of the North Red River distributary channel (#10). The benefits of Silver Creek restoration would be improved by the reconnection of the left bank Nooksack River restoration (#1), although the limitation is lesser for Silver Creek than the other two creeks. Within each watershed, fish barriers should be removed in order from the downstream end to the upstream end.	**MINOR**: The greatest limitation to the projects is the ability to complete the prerequisite projects first (see sequencing).
8 Reconnect lower portion of Lummi River Delta between Lummi Aquaculture and Lummi River mouth	feasibility assessed, acquiring permits, establishing mitigation bank	complete	ongoing			425	More than $1,000,000	Project being advanced in Lummi Mitigation Bank activities. May entail additional land acquisitions; should occur after or in conjunction with the restoration of Lummi River and Delta (opportunities #5 and 6), although could occur before opportunity #5 if designed to accommodate additional flow from the restoration	**MODERATE**: Will require willingness of multiple landowners and stakeholders. Also requires the acquisition of multiple properties, possibly with relocation costs, as well as the conversion of agricultural lands. Given the sensitive community issues, implementation of this type of project at this scale will require extensive community dialogue throughout an extensive public process.

9	Reconnect lower portion of Lummi River Delta west of Lummi River mouth	considered Phase 4 of ongoing Lummi River restoration work	ongoing	ongoing			228	More than $1,000,000	Should occur after or in conjunction with the reconnection of the N. Red River distributary channel (opportunity #10). Would be greatly enhanced by the reconnection of the Lummi River with the Nooksack River (#6).	**MODERATE**: Will require willingness of multiple landowners and stakeholders. Also requires the acquisition of multiple properties, possibly with relocation costs, as well as the conversion of agricultural lands. Given the sensitive community issues, implementation of this type of project at this scale will require extensive community dialogue throughout an extensive public process.
10	Reconnect North Red River distributary channel	part of future plans for Lummi Mitigation Bank, but not currently underway					164	$500,000 to $1,000,000	Should occur before or in conjunction with the restoration of northwest portion of Lummi River Delta (opportunity #9) and the reconnection of the Lummi River (#6). Would be greatly enhanced by the reconnection of the Lummi River with the Nooksack River (#6).	**MODERATE**: Will require willingness of multiple landowners and stakeholders. Also requires the acquisition of multiple properties, possibly with relocation costs, as well as the conversion of agricultural lands. Given the sensitive community issues, implementation of this type of project at this scale will require extensive community dialogue throughout an extensive public process.
11	Control invasive plants on Nooksack River Delta	as of 2008, infested delta areas mapped for all species, but Spartina. Spartina surveys have been conducted but were conducted as part of different effort.					157	$100,000 to $500,000	Sequencing considerations most important for species carried downstream whose source population has not been addressed (e.g., Japanese knotweed). In this case, there would be a high risk of recontamination unless actively managed over time. Spartina and other species could be controlled immediately and long-term consideration of how to make the areas more suitable for native vegetation should be pursued (e.g., native vegetation planting, routine maintenance, and altered water routing)	**MINOR**: Long-term effectiveness would require routine maintenance indefinitely.
12	Install ELJs to restore channel complexity	incorporate opportunistically into other projects					N/A	Less than $100,000	Could be incorporated into other project designs; should not occur before ESRP project implementation	**MODERATE**: Could require willingness of multiple landowners and stakeholders, particularly tribal fisherman. Depending on the scale of action considered, extensive community dialogue may be necessary.
13	Restore historical riparian stand vegetation	incorporate opportunistically into other projects					N/A	Less than $100,000	Could be incorporated into other project designs; should not occur before other restoration opportunities in the area which may affect benefits and effectiveness of project	**MINOR**: Since this opportunity is envisioned as being incorporated into other projects, landowner willingness should already be established and few other limitations on including riparian vegetation should be expected.

Table 36. Benefits to Ecological Processes and Habitats and Achievement of Restoration Objectives of the Nooksack River Estuary Restoration Opportunities

Project Number and Description		Key Physical and Ecological Processes			Habitats			Restoration Objectives			Summary of Potential Benefits/ Importance
		High	Medium	Low	High	Medium	Low	High	Medium	Low	
1	Reconnect floodplain along left bank of the Mainstem of the Nooksack River	5			4		1	3			This project would reconnect a large portion of the lower Nooksack River floodplain. This would benefit the flood storage capacity of the lower river and reduce flooding. The project would support/entail process-based restoration at a large-scale which would benefit multiple estuarine processes and habitats. This restoration would improve the estuary's resilience in the event of sea level rise. The restoration would benefit outmigrating juvenile salmon, such as Chinook salmon, by increasing the amount of suitable side-channel and distributary channel habitats for rearing and high flow refuge.
2	Reconnect floodplain along right bank of the Mainstem of the Nooksack River	5			4		1	3			This project would reconnect a large portion of the lower Nooksack River floodplain. This would benefit the flood storage capacity of the lower river and reduce flooding. The project would support/entail process-based restoration at a large-scale which would benefit multiple estuarine processes and habitats. This restoration would improve the estuary's resilience in the event of sea level rise. The restoration would benefit outmigrating juvenile salmon, such as Chinook salmon, by increasing the amount of suitable side-channel and distributary channel habitats for rearing and high flow refuge. The project area could incorporate or benefit other opportunities, most notably the Slater Slough restoration (#3) and the Kwina Slough (#4) projects.
3	Reconnect Slater Slough by breaching Kwina Slough dike		1	2		1	2		2	1	This project would reconnect Slater Slough with the Nooksack River estuarine channel network. The project would support/entail process-based restoration which would benefit multiple estuarine processes and habitats. The project would increase the estuary's flood storage capacity which may reduce flooding depending on the design configuration. The restoration would benefit outmigrating juvenile salmon, such as Chinook salmon, by increasing the amount of suitable tidal channel and wetland habitat that is accessible for rearing and high flow refuge.
4	Remove pilings at head of Kwina Slough		1	2			1			1	This project will remove derelict pilings that restrict unimpeded flow from the mainstem of the Nooksack River to the Kwina Slough.
5	Improve tidal exchange and passage along Smuggler's Slough.		1	4		2	1		2	2	This project is an important early step in the restoring the connectivity between the Nooksack River and Lummi Delta as part of the larger Smuggler's Slough Restoration project.
6	Restore perennial surface water connection between Nooksack River and Lummi River	2		1	1			3			This project would restore a historical connection between the Nooksack River and the Lummi River and estuary. This is a major project that is a pre-requisite for several other restoration opportunities in the Lummi Delta. The project would restore freshwater transport and detritus through the Lummi River and support other proposed process-based restoration opportunities in the Lummi Delta (# 8, 9, and 10). As a result, the project is critical to other opportunities that would greatly expand the size and function of the estuary. Likewise, the benefits and significance of the Lummi River reconnection would be greatly increased by opportunities #8, 9, and 10. The project could increase habitat availability for juvenile salmon outmigration and rearing, as well as a possible upstream migratory corridor for adult salmon.
7	Remove fish barriers on tributaries flowing into estuary			3			1	1			The removal of would expand the amount of freshwater habitat accessible to salmon. Depending on the condition of the barriers, benefits to sediment and large wood transport may be possible.
8	Reconnect lower portion of Lummi River Delta between Lummi Aquaculture and Lummi River mouth	3	3		4			3			This project would reconnect a large portion of the lower Lummi River estuary. The project's benefits and significance would be improved by the reconnection of the Lummi River with the Nooksack River (#6). Likewise, the benefits of the Lummi River reconnection (#6) would be greatly expanded by this project. The project would support/entail process-based restoration at a large-scale which would benefit multiple estuarine processes and habitats. This restoration would improve the estuary's resilience in the event of sea level rise. In addition, raising Haxton Way for it to function as a levee addresses a flooding issue for a county road. The restoration would benefit outmigrating juvenile salmon, such as Chinook salmon, by increasing the amount of suitable side-channel and distributary channel habitats for rearing and high flow refuge.
9	Reconnect lower portion of Lummi River Delta north of Lummi River mouth	3	3		4			3			This project would reconnect a large portion of the lower Lummi River estuary. The project's benefits and significance would be improved by the reconnection of the Lummi River with the Nooksack River (#6). Likewise, the benefits of the Lummi River reconnection (#6) would be greatly expanded by this project. The project would support/entail process-based restoration at a large-scale which would benefit multiple estuarine processes and habitats. This restoration would improve the estuary's resilience in the event of sea level rise. The restoration would benefit outmigrating juvenile salmon, such as Chinook salmon, by increasing the amount of suitable side-channel and distributary channel habitats for rearing and high flow refuge.
10	Reconnect North Red River distributary channel	1	3		3	1		1	2		This project would reconnect a major distributary channel and a substantial portion of the lower Lummi River estuary. The project's benefits and significance would be improved by the reconnection of the Lummi River with the Nooksack River (#6) and the removal of the seawall dike (#9). Likewise, the benefits of the Lummi River reconnection (#6) would be greatly expanded by this project. The project would support/entail process-based restoration at a large-scale which would benefit multiple estuarine processes and habitats. This restoration would improve the estuary's resilience in the event of sea level rise. The restoration would benefit outmigrating juvenile salmon, such as Chinook salmon, by increasing the amount of suitable side-channel and distributary channel habitats for rearing and high flow refuge.

Project Number and Description	Key Physical and Ecological Processes			Habitats			Restoration Objectives			Summary of Potential Benefits/ Importance
	High	Medium	Low	High	Medium	Low	High	Medium	Low	
11 Control invasive plants on Nooksack River Delta	1		1	1	2	1			2	This project would remove invasive vegetation from the Nooksack River Delta and promote the reestablishment of native vegetation which would restore natural estuarine processes including tidal wetland establishment, and depending on location, large woody debris recruitment. Native riparian vegetation would benefit salmon by providing terrestrial-origin prey items and detritus inputs, as well as large woody debris inputs.
12 Install ELJs to restore channel complexity		2	1		2			2		This project would contribute to the reconnection and reestablishment of side channels and tidal channels, as well as improvements to mainstem habitat conditions. The wood structures would be designed to create pools to provide deep areas with cooler water and slower flows which are important areas for juvenile and adult salmon.
13 Restore historical riparian stand vegetation	1		1	2					2	This project would reestablish native vegetation in the estuary which would restore natural estuarine processes including large woody debris recruitment and detritus inputs. Unlike project #11 which is specifically located at the mouth of the Nooksack River, this opportunity is not location specific and will be included in other restoration projects in the estuary. Native riparian vegetation would benefit salmon by providing terrestrial-origin prey items and detritus inputs, as well as large woody debris inputs.