Final

PRIORITIZATION OF PILINGS FOR REMOVAL IN THE SNOHOMISH RIVER ESTUARY

Prepared for Snohomish County Marine Resources Committee

September 2020

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Snohomish Estuary Pilings Prioritization

Introduction

The Snohomish County Marine Resources Committee (MRC) initiated a project to develop a prioritized list of independent pilings in the Snohomish River estuary to target for future removal. The MRC is interested in facilitating piling removal as a habitat action primarily due to the water quality and sediment quality impacts that creosote-treated pilings can have in the aquatic environment. Independent pilings are single or clustered pilings in the estuary that are not associated with a dock, marina, or bulkhead.

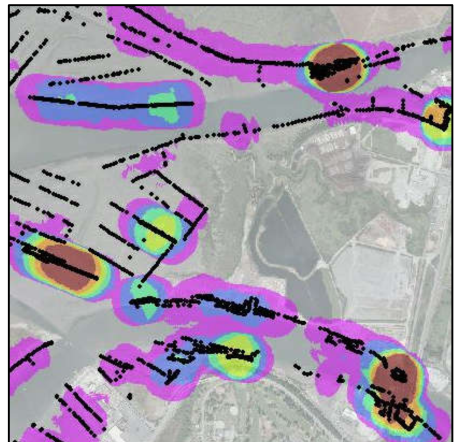
Multiple agencies have jurisdictions within the Snohomish River estuary. Because of the complex nature of this area, the MRC convened a stakeholder committee consisting of representatives from the Washington State Department of Natural Resources (WDNR), Snohomish County, Tulalip Tribes, City of Everett, Port of Everett, and City of Marysville. The MRC's objective was to create a shared understanding of the numbers and distribution of pilings in the Snohomish River estuary and identify those pilings determined to be high priority for removal. Ultimately, the goal of this information gathering and analysis process is to enable the appropriate agency to address pilings within their own jurisdiction.

To support this prioritization project, the MRC hired Environmental Science Associates (ESA). The goal of this effort is to identify piling removal opportunities in the Snohomish River estuary that are most ecologically beneficial and readily implementable by the WDNR Creosote Piling Removal Program. The project area is the Snohomish River estuary downstream of the Highway 2 crossing located just upstream of where Steamboat Slough splits from the river mainstem.

This report describes the steps taken to prepare a spatial database of piling locations in the project area and a prioritization framework for evaluating pilings and identifying the highest priority pilings for removal. The database development included desktop and field components. The prioritization was conducted using a point-based scoring system developed in a manner consistent with other past prioritizations in Puget Sound and the Columbia River. Each of these steps, including methods and results, are described in the report.

Identification of Pilings in the Project Area

Snohomish County GIS staff provided ESA with an initial geospatial database inventory of pilings in the Snohomish River estuary downstream of the Highway 2 crossing. The initial inventory was prepared by the Tulalip Tribes using remote sensing datasets (e.g., aerial photography) and Snohomish County added land ownership information. The inventory focused on independent pilings, not those clearly associated with providing structural support for adjacent infrastructure (e.g., no wood bulkheads or marina pilings included). This initial database included 9,760 pilings.



Example of Point Density Analysis

To supplement the database and prepare a comprehensive dataset of pilings, ESA conducted a piling location confirmation effort in three steps. The first two entailed desktop analysis using GIS tools and the third step was a field verification. All GIS steps described below were completed using ESRI's ArcGIS program.

The first step was a visual review of Snohomish County's high resolution imagery (Snohomish_Estuary_Mosaic.sid) supported by a GIS-based point density analysis. Using the original pilings dataset provided by Snohomish County, the Point Density tool was run in ArcGIS with a buffer search radius of 500 feet to estimate the density of pilings. This aided the visual search by customizing the scale at which the search could most efficiently occur. In the areas where there are more pilings close together, a more zoomed in view was necessary to conduct the visual review to identify additional pilings, whereas in less dense areas a broader view of the tidal areas could more effectively locate pilings that had not previously been included in the database. This analysis identified approximately 5,100 additional pilings, nearly 3,000 of which were within dense walls of pilings.

The second step was a slope analysis conducted to identify locations in the project area where the slope quickly changes. The rationale was that pilings will stand out as an outlier to the slope of the surrounding area. The analysis was used to identify likely areas with pilings, thereby streamlining the effort required to complete the piling confirmation. The slope analysis was based on Light Detection and Ranging (LiDAR) that was clipped to only include the aquatic areas in the project area. The LIDAR image was clipped using the WDNR hydrology polygon GIS layer with modifications to ensure it contained all of the pilings study area as close to the shoreline as possible. By limiting the analysis area to this extent, we were attempting to exclude trees and shoreline features with steep slopes that would interfere with the next step. Next, ArcGIS's Slope Spatial Analyst tool was then run to differentiate between areas with greater than 60 degree

Example of Slope Analysis

slopes and areas less than 60 degree slopes. The 60-degree threshold was identified by looking at slope values on a stretch color ramp and comparing it to known piling locations. The 60-degree threshold was selected as effective in distinguishing the apparent piling from other structures around it. The greater than 60 degree slopes were visually checked for pilings that had not previously been included in the database. This analysis identified approximately 400 additional pilings.

The third step was field verification of the pilings identified through steps one and two. A survey team of Snohomish County and ESA staff conducted the field verification by boat in four days. The main purposes of the field verification were to confirm the presence of all pilings in the database and evaluate whether the pilings were creosote-treated or not. Additional piling observations were recorded during the field effort, including whether they were currently in use, presence of wildlife, condition, and whether the pilings were clustered together. New pilings that were not previously identified through steps one and two, but observed in the field, were also recorded during the field effort. The presence of creosote was evaluated visually using indicators recommended in discussions with Chris Robertson, Aquatic Restoration Manager for the WDNR Creosote Piling Removal Program. The indicators included: visual presence of black creosote covering, pilings rotted from the inside out, appearance of milled lumber rather than knots increased likelihood of creosote, odor, and in some cases a small piece was cut off and examined to detect creosote treatment.

A total of 15,564 independent pilings were identified in the project area after the desktop analysis and subsequent field verification was complete (Figure 1). This count does not include pilings associated with docks, marinas, or bulkheads. Using parcel ownership data provided by Snohomish County, an overview of piling ownership is presented in Table 1. Those pilings located outside of delineated parcels were assumed to be on State-owned aquatic lands. Of the pilings on privately-owned parcels, 89% are owned by ten private owners. Table 2 shows the private owners and number of pilings among the top-ten private owners.

FIGURE 1. MAP OF PILINGS

TABLE 1
SUMMARY OF PILING OWNERSHIP

Ownership Type	Number of Pilings	Percentage of Total Number of Pilings
State of Washington	6,268	40%
Private	4,474	29%
Port of Everett	3,708	24%
City of Everett	356	2%
Snohomish County	316	2%
City of Marysville	267	2%
Tulalip Tribes	175	1%
TOTAL	15,564	100%

Note: Ownership information based on Snohomish County parcel database and not independently confirmed.

TABLE 2
TOP TEN PRIVATE LANDOWNERS BY COUNT OF PILINGS

Owner Name	Number of Pilings
Hook Investments	933
Kimberly-Clark Worldwide, Inc.	782
Dunlap Towing Co.	666
B&B-SI-1 LLC	507
Wildlands of Washington, LLC	435
Cedar Grove Composting, Inc.	158
BNSF Railway Co.	156
Delta Tidelands, LLC	152
M A P #2 LLC	134
Dagmars Marina, LLC	61

Note: Ownership information based on Snohomish County parcel database and not independently confirmed.

Of the 15,564 pilings in the project area, 2,456 or nearly 16% were identified in the field as being creosote-treated (Figure 2). Using parcel ownership data provided by Snohomish County, an overview of ownership of creosote-treated pilings is presented in Table 3. The 300 creosote-treated pilings on privately-owned parcels are owned by 18 different owners.

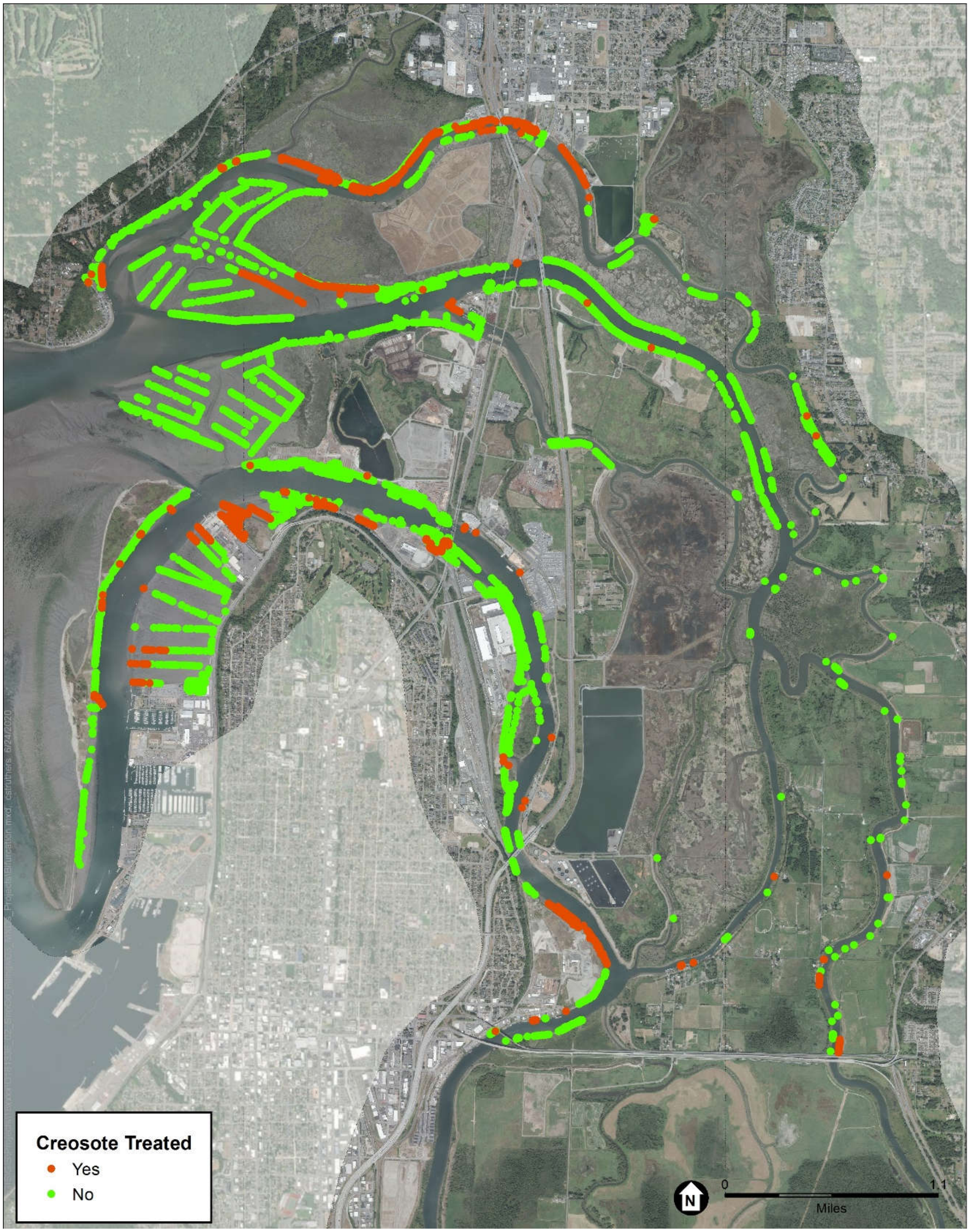


FIGURE 2. MAP OF CREOSOTE-TREATED PILINGS

TABLE 3
SUMMARY OF CREOSOTE-TREATED PILING OWNERSHIP

Ownership Type	Number of Pilings	Percentage of Total Number of Pilings
Port of Everett	976	40%
State	969	39%
Private	300	12%
City of Everett	110	4%
City of Marysville	68	3%
Tulalip Tribes	33	1%
Snohomish County	0	0%
TOTAL	2,456	100%

Prioritization Framework

A prioritization framework was developed to provide a systematic, science-based approach to evaluating pilings in the project area and identifying the highest priority pilings for removal. To inform the development of the prioritization framework, five other prioritization projects were reviewed. A brief summary of the other prioritizations reviewed is presented in Appendix A.

The prioritization framework was developed to inform the project goal of identifying piling removal opportunities in the Snohomish River estuary that are most ecologically beneficial and readily implementable by the WDNR Creosote Piling Removal Program, as well as high priority pilings throughout the estuary. The prioritization framework has two components: ecological benefits of removal and feasibility of removing the piling. For each component, scores were assigned to a selected set of parameters. The number of points possible varies among the parameters. This was done as a way to weight the scoring such that the parameters considered most important can have the greatest influence on the total score. Scores of each component were added separately to arrive at an overall ecological benefit score and a removal feasibility score for each piling. Prioritization tiers were assigned based on both of those scores.

Methods

Ecological Benefits

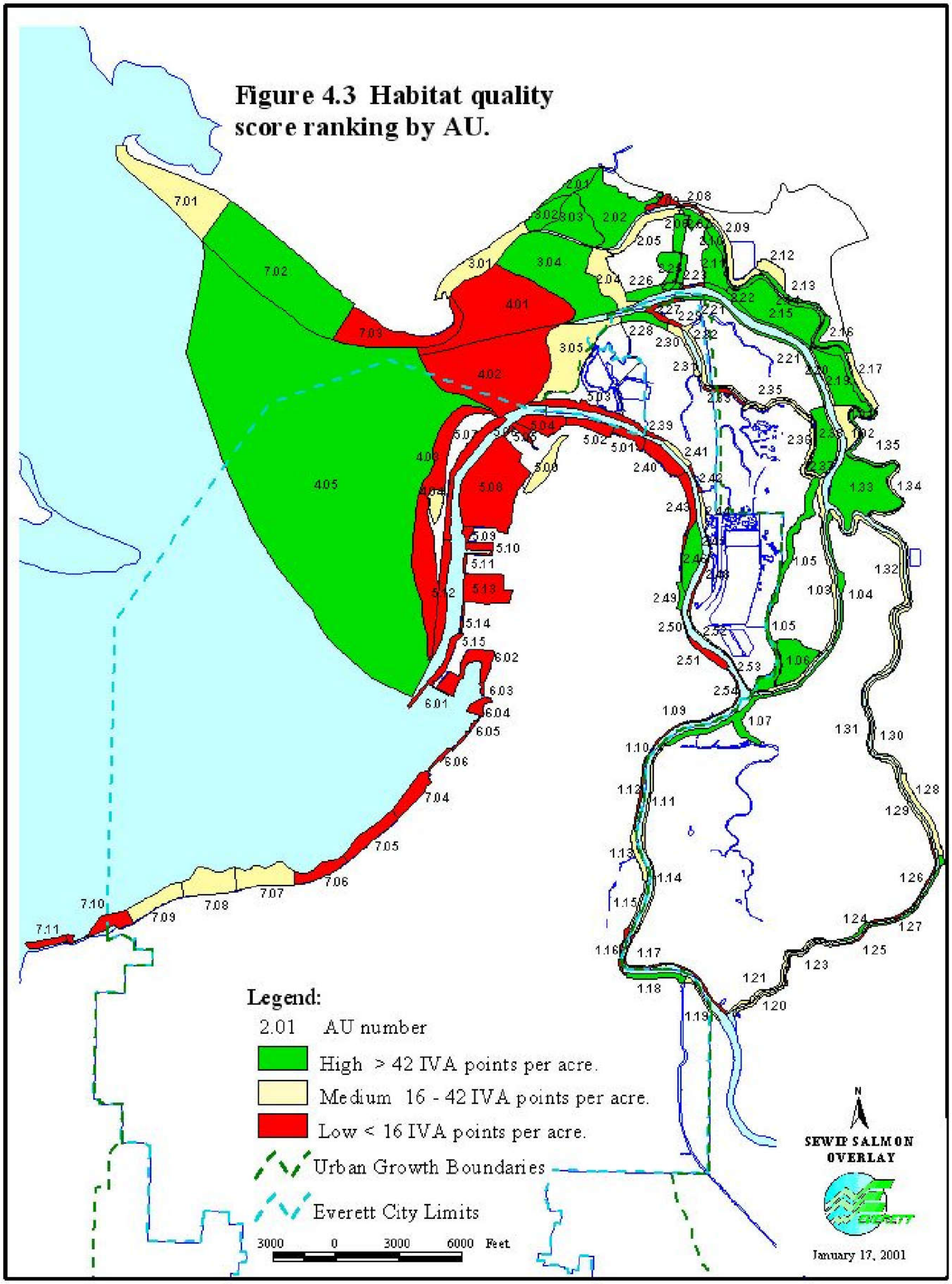
The ecological benefits of removal of each piling were characterized using seven parameters: creosote-treated, habitat type, salt marsh vegetation impacts, habitat function, landscape connectivity for outmigrating juvenile salmon, whether it is a single piling or part of a cluster of multiple pilings, and wildlife use. Table 4 describes the scoring system and rationale for each ecological benefits parameter.

The habitat function score is based on the Salmon Overlay to the Snohomish Estuary Wetland Integration Plan (SEWIP) (City of Everett and Pentec, 2001) which characterized habitat function for chinook salmon, coho salmon, and bull trout. The SEWIP habitat function scores are provided in Figure 3. The landscape connectivity score is an interpretation of a 1 to 9 bifurcation order system developed by the Skagit River Systems Cooperative (Beamer 2005). To support interpretation of the scoring assignments included in the prioritization framework, the bifurcation rating scores for the estuary are provided in Figure 4.

TABLE 4
ECOLOGICAL BENEFITS PARAMETERS

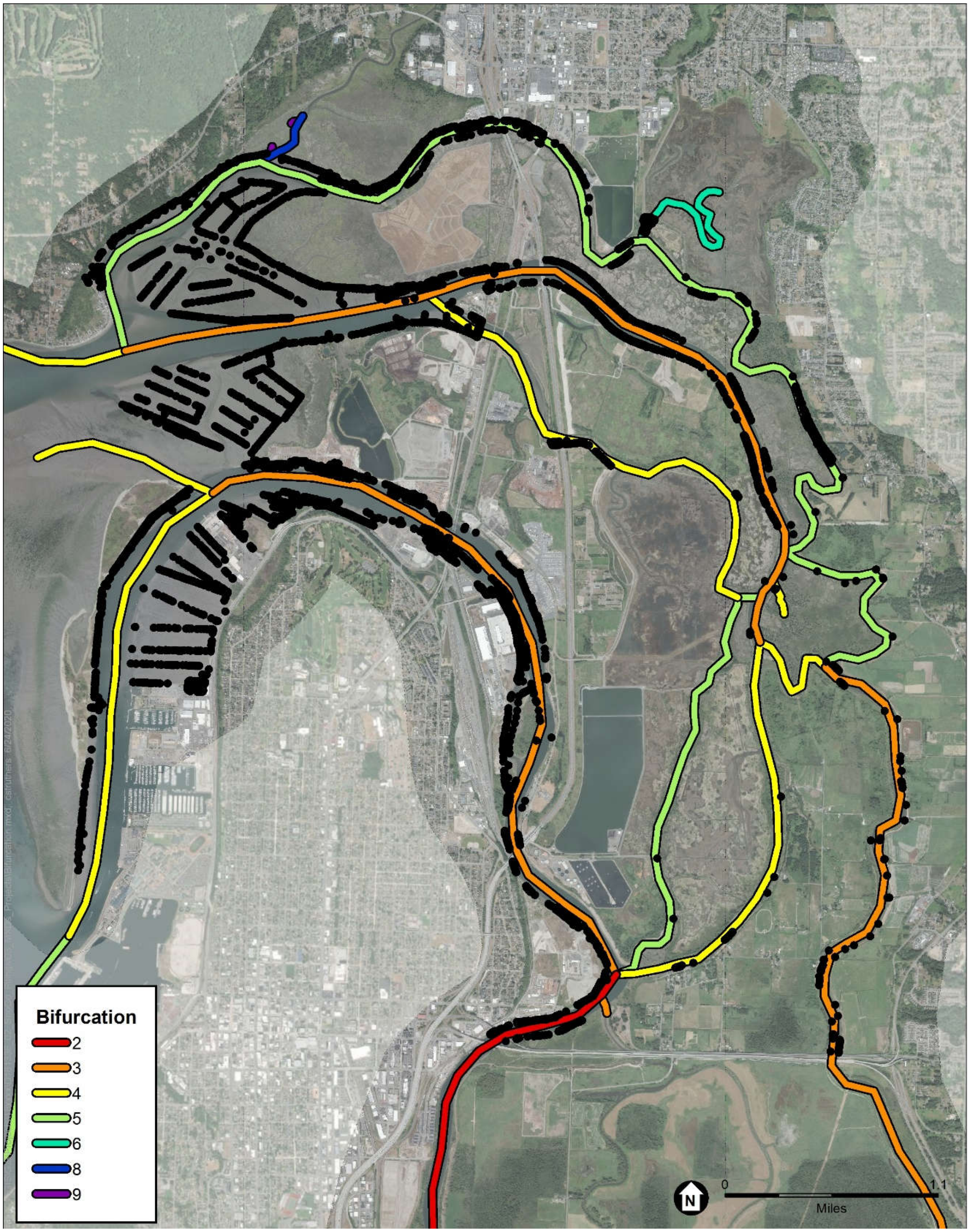
Parameter	Scores	Rationale	Data Source
Creosote-treated	Creosote-treated or other treatment = 10 pts Not treated = 0 pts	Highest possible score assigned to this parameter because removing creosote from the environment is a main focus of project.	Field survey using multiple on-site techniques recommended by WDNR
Habitat type	> +13 ft mean lower low water (MLLW) = 2 pts Supratidal (mean higher high water [MHHW] [+11 ft MLLW] to +13 ft MLLW) = 3 pts MLLW to MHHW = 5 pts -10 ft MLLW to MLLW = 3 pts Deep (<-10 ft MLLW) = 0 pts	Higher scores for those habitats along shoreline that juvenile salmon are generally considered to prefer. Intertidal habitats that are most commonly accessible to juvenile salmonids are the highest value. Supratidal habitats are less frequently inundated, but are used by juvenile salmon who tend to stay in upper portion of water column and along water's edge.	Tulalip Tribes' 2020 multibeam bathymetry data
Salt marsh or eelgrass vegetation	Following scores assigned to pilings in the elevation zone supporting marsh vegetation (estimated as +5.5 ft MLLW to +13 ft MLLW) if marsh vegetation is documented. If eelgrass, then no elevation limits applied. In area identified as continuous salt marsh, low marsh, or eelgrass = 5 pts In area identified as patchy salt marsh, low marsh, or eelgrass = 3 pts In area identified as no salt marsh, low marsh, or eelgrass = 0 pts	Higher scores for those pilings present in areas that could support marsh vegetation. Pilings often restrict growth of emergent vegetation in footprint as well as a halo around each piling. Removing a piling in an area that would otherwise support salt marsh vegetation will support expansion of the marsh vegetation. Salt marsh vegetation serves many beneficial functions including supporting production of invertebrate prey for juvenile salmon, cover habitat for the fish, and adding shoreline stability.	Elevation screen for salt marshes based on Tulalip Tribes' 2020 multibeam bathymetry data and LIDAR data. WDNR (2001) ShoreZone Inventory data on salt marsh and low marsh distributions, coupled with aerial photo interpretation of vegetation in immediately adjacent areas of similar elevation.
Landscape connectivity for outmigrating juvenile salmon	Bifurcation order 1 to 3 = 4 pts Bifurcation order 4 to 5 = 2 pts Bifurcation order 6 to 9 = 0 pts	Higher scores provided for the lower bifurcation order, which indicates the fewer possible flow paths there are for outmigrating juvenile salmon to use. Lower order indicates higher likelihood of use by juvenile salmon.	Beamer (2005) method for determining bifurcation order; see Figure 4 for results.

Parameter	Scores	Rationale	Data Source
Habitat function	High SEWIP habitat quality score = 3 pts Medium SEWIP habitat quality score = 2 pts Low SEWIP habitat quality score = 0 pts	Higher scores are assigned to areas with better existing habitat. Piling removal would enhance the condition of the area.	The Salmon Overlay to the Snohomish Estuary Wetland Integration Plan (SEWIP) (City of Everett and Pentec, 2001); see Figure 3.
Single or clustered pilings	Cluster of more than 25 pilings = 3 pts 6 to 25 pilings = 2 pts 2 to 5 pilings = 1 pt 1 piling = 0 pts	Multiple pilings are more likely to contribute to elevated levels of creosote-related contamination and to impact sediment transport processes. Higher scores are assigned to clusters of pilings.	GIS spatial density analysis
Wildlife use of pilings	Observed wildlife use = -5 pts No observed wildlife use= -5 pts	Pilings with documented use by wildlife have more habitat function than other pilings, therefore, should be scored lower for ecological benefit of removal.	Osprey data from ORCA program (Canright 2018) and purple martin nesting from Washington Department of Fish and Wildlife Priority Habitats and Species Database. Additional observations made during field survey.



SOURCE: Salmon Overlay to the Snohomish Estuary Wetland Integration Plan (SEWIP) (City of Everett and Pentec, 2001).

FIGURE 3. HABITAT FUNCTION SCORES IN SEWIP



SOURCE: Bifurcation order based on Beamer (2005). Pilings locations (circles) provided by Snohomish County and supplemented in this project.

Figure 4. Bifurcation Order Used in Landscape Connectivity Scoring

Removal Feasibility

To characterize the feasibility of removal, each piling was evaluated for the following three parameters: ownership, use and risk of contamination. Table 5 describes the scoring system and rationale of each removal feasibility parameter.

TABLE 5
REMOVAL FEASIBILITY PARAMETERS

Parameter	Scores	Rationale	Data Source
Ownership	State-Owned Aquatic Lands = 5 pts Other Public Ownership (i.e., City, County, Port) = 3 pts Tribal Ownership = 3 pts Private Ownership = 0 pts	Scored based on assumptions about the ease in which a piling removal action can be taken depending on the type of ownership.	Snohomish County parcel database; all areas not in delineated parcels are assumed to be State-owned Aquatic Lands. Leases of State-owned Aquatic Lands were not considered when evaluating ownership.
Pilings in Use	Piling with no identified use = 5 pts Piling used for log rafting at some time since 2000, but not currently = 2 pts Piling with use noted during field survey = 0 pts	Lower feasibility for pilings used for log rafting.	Current use based on observations made during field survey. Recent historic use interpreted based on aerial imagery. Google Earth imagery provides snapshots of use over time. Google Earth imagery since 2000 was reviewed to identify pilings used to raft logs.
Risk of Contamination	Sites "Awaiting Cleanup" = -5 pts All other locations, including sites in categories "Cleanup Action Complete," "Cleanup started," and "Other' = 0 pts	Lower feasibility for sites with known potential to re-suspend contaminated sediments through piling removal. Working at future cleanup sites would also require more agency approvals than other sites.	Data contamination was reviewed using Washington Department of Ecology "What's in My Neighborhood?" web map (https://apps.ecology.wa.gov/neighborhood/) and Port of Everett documents. The sites identified in this report need further investigation into sediment contamination and are not conclusive.

Other parameters considered, but not included were site accessibility and whether pilings were single or clustered. Site accessibility was not included because WDNR indicated they have been able to access pilings in any location and access has not limited where they have removed pilings previously. Whether a piling was single or clustered can inform the efficiency with which removal can be completed because it assumes that a piling can be removed quicker if in close proximity to another piling. This parameter was not included because it was factored into the ecological benefits component and because it does not inform feasibility as much as removal efficiency.

Assigning Prioritization Tiers

Prioritization tiers were assigned based on consideration of the ecological benefit scores and the removal feasibility scores. A two-axis approach was implemented to interpret the component results such that the highest priority was assigned to those piling receiving the highest scores in each component.

Separately for both components, three tiers were defined using ArcGIS natural breaks analysis of distribution of scores among the 15,564 pilings evaluated. These natural breaks were assigned tiers of High, Medium, and Low for each component. The tiers of ecological benefits and removal feasibility were both considered in assigning the prioritization tiers shown in Table 6.

TABLE 6
PRIORITIZATION TIERS FOR PILINGS

Removal Feasibility Tier	Ecological Benefits Tier: **Low (0 – 7)**	Ecological Benefits Tier: **Medium (8 – 16)**	Ecological Benefits Tier: **High (17 – 28)**
High (8 – 10)	Medium	High	High
Medium (4 – 7)	Low	Medium	High
Low (-3 – 3)	Low	Low	Medium

Results

Ecological Benefits Scores

Ecological benefit scores ranged from 0 to 28. The distribution of scores among the pilings is shown in order from highest to lowest in Figure 5. The scores were well distributed across the range.

The contribution of individual parameters to the total ecological benefits score is presented in Figure 6. As intended in developing the prioritization framework, pilings with creosote were among the highest scoring for ecological benefit (shown in dark blue). Conversely, many of the pilings with documented wildlife use (shown in black), the only negative scoring parameter, were among the lowest scores assigned.

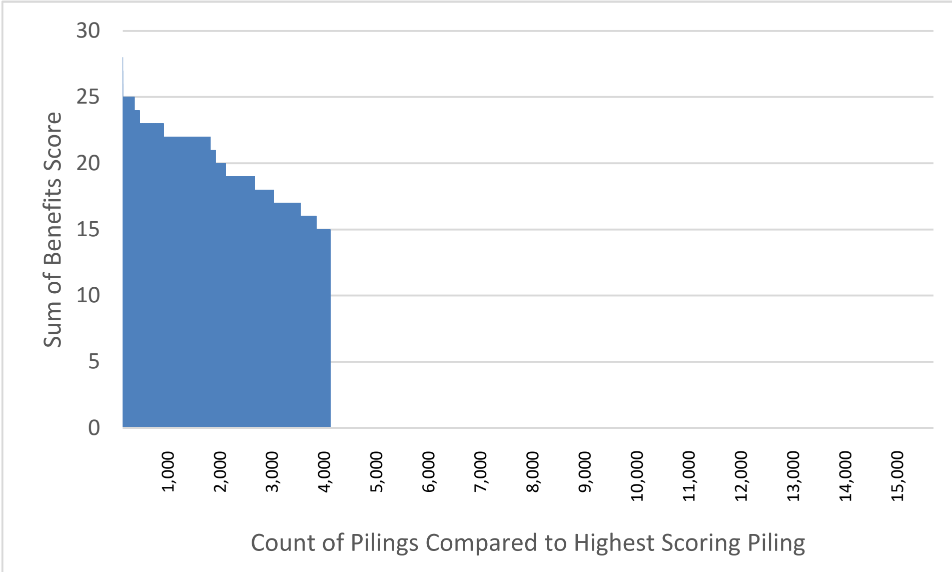


Figure 5. Ecological Benefits Scores from Highest to Lowest

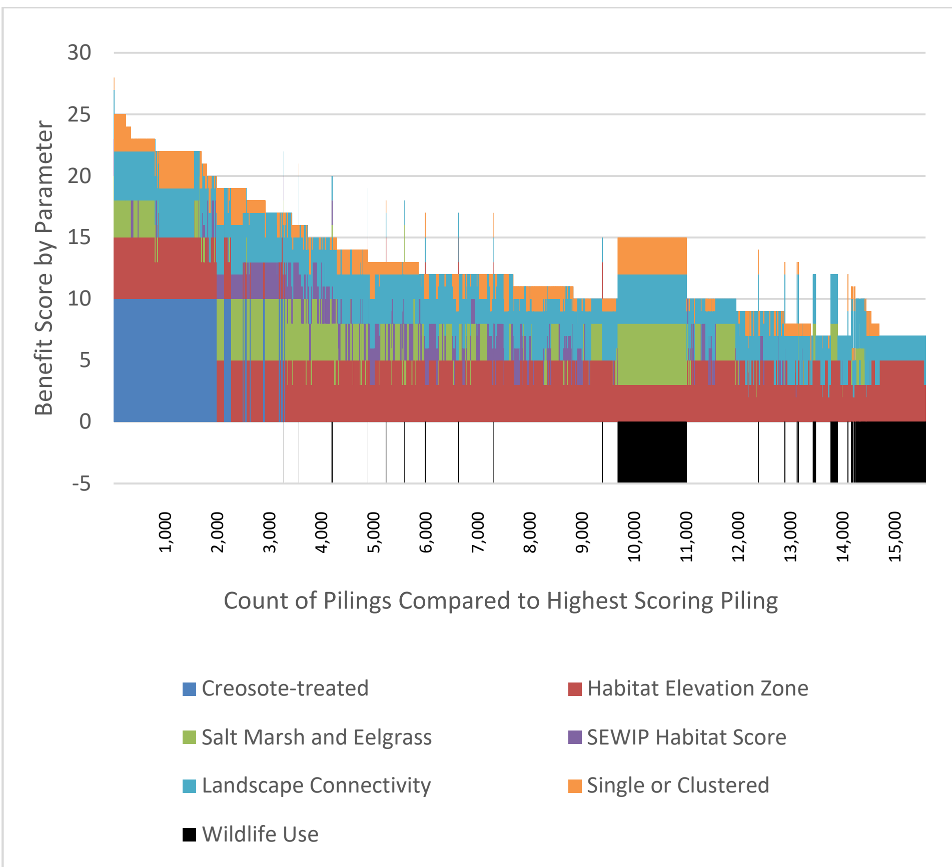


Figure 6. Ecological Benefits Parameter Scores from Highest to Lowest

Removal Feasibility Scores

Removal feasibility scores ranged from -3 to 10. The distribution of scores is shown in Figure 7. The contribution of each parameter to the removal feasibility score is presented in Figure 8.

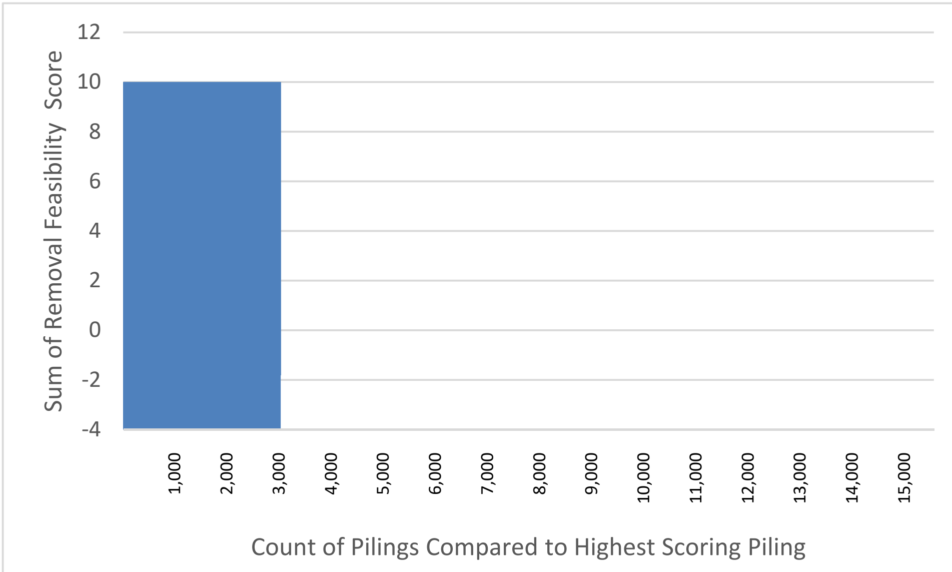


FIGURE 7. REMOVAL FEASIBILITY SCORES FROM HIGHEST TO LOWEST

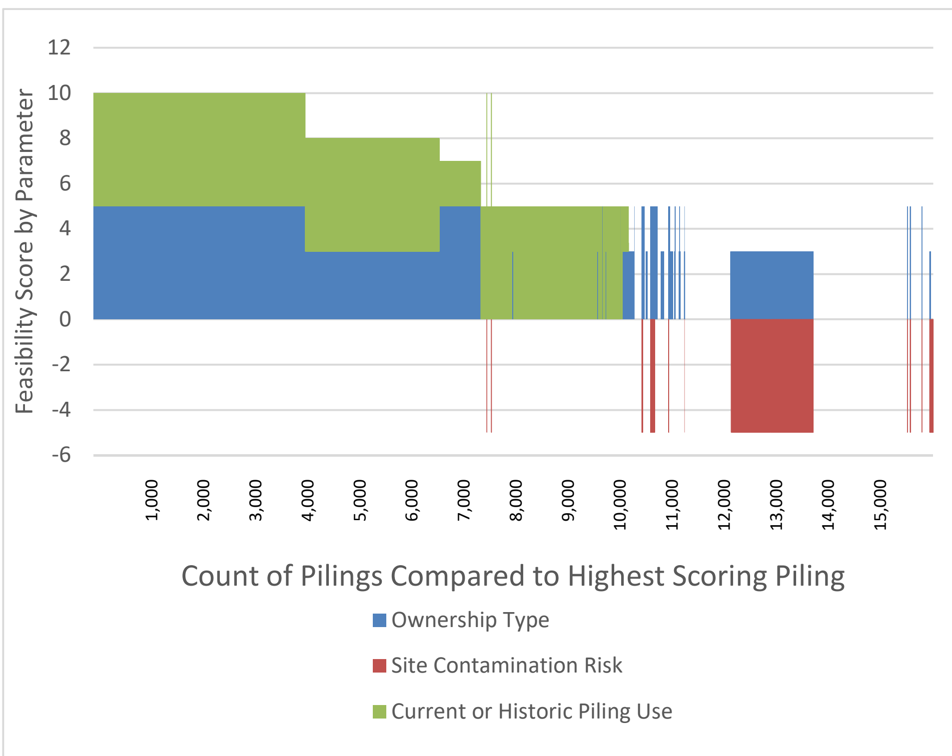


FIGURE 8. REMOVAL FEASIBILITY PARAMETER SCORES FROM HIGHEST TO LOWEST

Piling Prioritization

The natural breaks bin assignments for ecological benefit were 0-7, 8-16, and 17-28. The natural breaks bin assignments for removal feasibility were -5-3, 4-7, and 8-10. Using these scoring breaks and the prioritization bins described previously, Table 7 shows the number of pilings in each component tier combination. The table cells are color-coded such that blue = High Priority, orange = Medium Priority, and yellow = Low Priority.

A total of 6,982 pilings were assigned to the High Priority tier. This corresponds to 45% of all of the pilings. Medium Priority was assigned to 4,198 or 27%, and Low Priority was assigned to 4,384 or 28%. Table 8 shows the number of piling in each priority tier by ownership type. A map of the piling priorities is presented in Figure 9. Concentrations of high priority pilings are located throughout Ebey Slough downstream of Highway 2, the northern shoreline of Steamboat Slough along and downstream of the Snohomish River Estuary Park, the western bank of the mainstem Snohomish River from Highway 2 downstream to the northern end of Ferry Baker Island (due west of Everett Wastewater Treatment Lagoons), and the tideflat between the mainstem Snohomish River and Steamboat Slough. Medium and low priority pilings are distributed throughout the project area.

Among the 2,456 creosote-treated piling, 1,597 or 65% are identified as high priorities for removal. Another 844 are medium priority and 15 are low priority. The medium and low priority tier assignments of creosote-treated piling were almost entirely due to low feasibility of removal.

TABLE 7
COUNT OF PILINGS IN EACH PRIORITIZATION BIN

Removal Feasibility Tier	Ecological Benefits Tier: Low (0 – 7)	Ecological Benefits Tier: Medium (8 – 16)	Ecological Benefits Tier: High (17 – 28)
High (8 – 10)	349	4,375	1,683
Medium (4 – 7)	1,441	3,043	924
Low (-3 – 3)	418	2,525	806

TABLE 8
SUMMARY OF PILING OWNERSHIP BY PRIORITY TIER

Ownership Type	High Priority	Medium Priority	Low Priority	TOTAL
State of Washington	4,107	714	1,447	6,268
Private	503	2,018	1,953	4,474
Port of Everett	1,537	1,235	936	3,708
City of Everett	356	0	0	356
Snohomish County	315	0	1	316
City of Marysville	93	166	8	267
Tulalip Tribes	71	65	39	175
TOTAL	6,982	4,198	4,384	15,564

Note: Ownership information based on Snohomish County parcel database and not independently confirmed

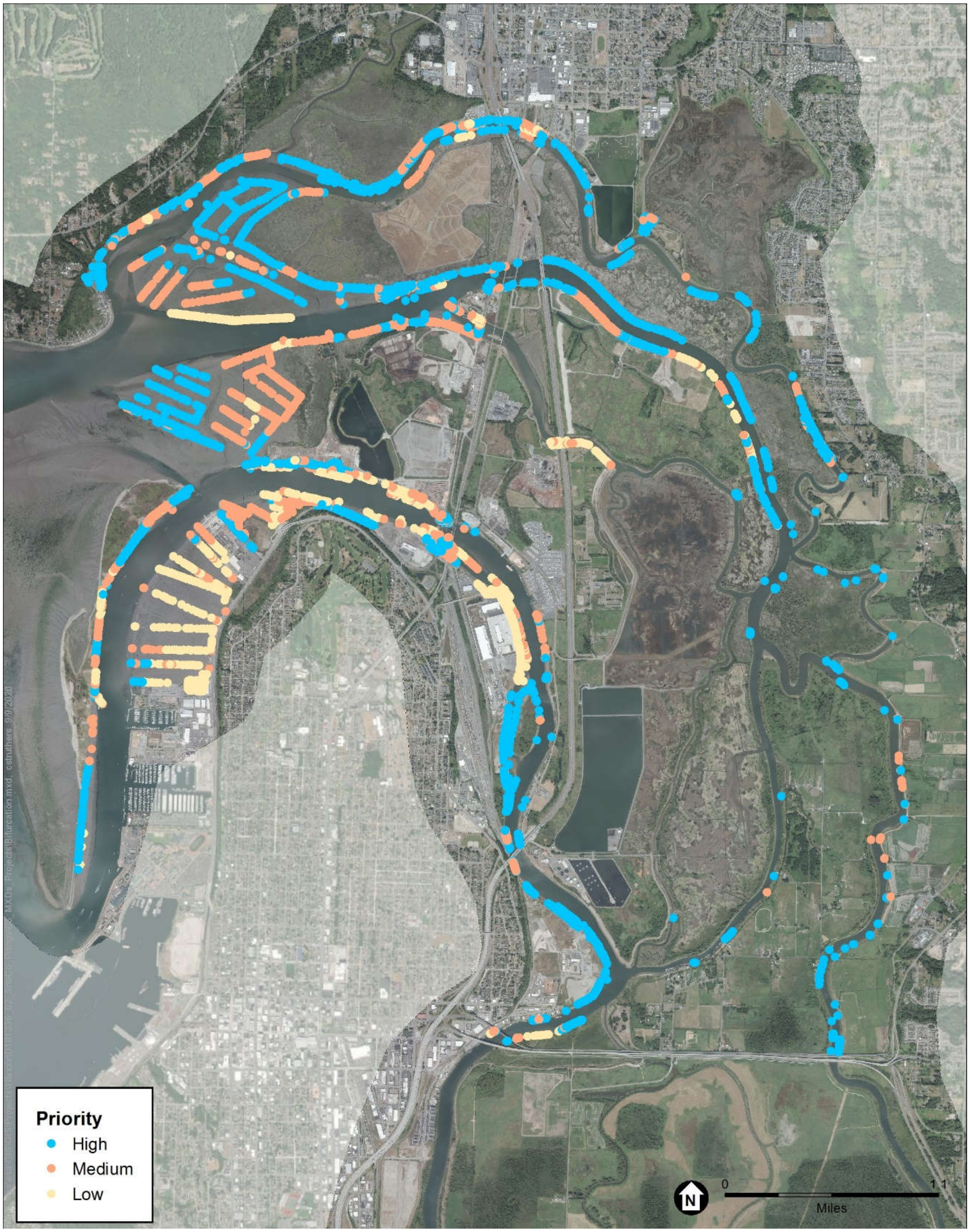


FIGURE 9. MAP OF PRIORITY TIER ASSIGNMENTS

Summary and Expected Uses

This project took an initial database of piling locations in the Snohomish River estuary and used GIS tools and field reconnaissance to conduct a comprehensive review and refinement of the database and document additional piling locations with relevant descriptive information for each piling. The number of pilings in the estuary –15,564 – is an exceptionally high number considering this analysis did not include pilings associated with docks, marinas, and bulkheads. Historically, conventional wisdom was that pilings needed to be treated with creosote in order to maintain the pilings' integrity in the marine environment, but this project found that only 16% (2,456) pilings were creosote treated. However, this finding is consistent with the expectations and observations of others who have worked on creosote wood removal, most notably Chris Robertson of WDNR's Creosote Piling Removal Program. Additionally, local knowledge from partners and longtime residents of the area noted that many pilings were untreated fir logs placed as short-term infrastructure for log-rafting without the intent of long term use. This is one explanation for why there are so many untreated pilings in the Snohomish River estuary.

While most of the pilings are single, isolated pilings, there are many that occur in clusters that are assumed to have more substantial effects on fish movements, sediment transport, and aquatic vegetation growth compared to single pilings. The calculation of the spatial density of pilings included in the database documents several areas, especially lines of piling, with more than 25 pilings clustered with less than 2 feet between them. In considering piling removal, there are efficiencies in effort and increases in ecological benefit in concentrating efforts to remove multiple pilings in selected areas rather than single or low numbers of pilings scattered across the estuary.

Given the goal of the project, it is hoped that this prioritization will help inform WDNR's piling removal efforts, as well as the Snohomish County MRC, local jurisdictions and other stakeholders to identify high priority piling removal opportunities with other landowners. The piling removal opportunities include several private landowners. Piling removal, particularly those treated with creosote, can generate mitigation credit for private landowners as well as public landowners. It is expected that responsible stakeholders will evaluate nearby pilings for removal. However, pilings should also be evaluated for potential benefit. For example, some pilings may increase woody debris and vegetation. In cases where pilings are a low priority for removal and are evaluated to be beneficial, those pilings should stay in place. All data identified in this report has been compiled into a geodatabase that the MRC has shared with partners of this project. If you would like to request copies of the complete database, please contact the Snohomish MRC. Next, the MRC will be starting a Phase 2 of this project which will focus on identifying specific high-priority areas using the data from this report. In 2021, the MRC will be meeting with stakeholders who have been identified as landowners of areas with high priority piles to discuss these areas in further detail and consider opportunities for pile removal.

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Appendix A
Previous Prioritizations Reviewed

ESA

Appendix A. Previous Prioritization Projects

This appendix summarizes five examples of previous estuary and marine nearshore prioritization projects. One of the projects focuses on piling removal in the Columbia River estuary. The other four projects are from locations around Puget Sound. The five examples reviewed are:

- Port of Vancouver Derelict Pile and In-Water Structure Removal Strategy Memorandum (ICF, 2019)
- Coastal Streams and Embayments Prioritization along Puget Sound Shores with a Railroad Prioritization Framework Technical Report (Confluence Environmental Company, 2019)
- Salmon Overlay to the Snohomish Estuary Wetland Integration Plan (City of Everett and Pentec Environmental, 2001)
- West Sound Nearshore Integration and Synthesis of Chinook Salmon Recovery Priorities (Confluence Environmental Company, Coastal Geologic Service, Wild Fish Conservancy, and Kitsap County, 2017)
- WRIA 1 Nearshore & Estuarine Assessment and Restoration Prioritization (Coastal Geologic Services, 2013)

Port of Vancouver Derelict Pile and In-Water Structure Removal Strategy (2019)

The objective of the Port of Vancouver (Port) Derelict Pile and In-Water Structure Removal Strategy project was to evaluate opportunities for removing existing derelict piles, other structures, and debris from the Columbia River within Port property as mitigation credit for future Port projects with potential impacts to aquatic resources. The project approach included an inventory and mapping of existing in-water structures for removal, followed by applying the Habitat Equivalency Analysis (HEA) model to calculate the credits associated with their removal. The HEA model calculates habitat credits which result from the alteration of one type of habitat to another over time (ICF, 2019). The model produces a unit of measurement, Discounted Service Acre Year (DSAY), that represents the value of all the ecosystem services provided by one acre of habitat in one year.

The project's inventory resulted in the mapping of 1,681 in-water piles and four overwater structures at three different water elevations (or habitat zones) for potential removal. The habitat zones were: Active Channel Margin (11.1 feet to 0 feet Columbia River Datum [CRD]), Shallow Water (0 feet to -20 feet CRD), and Deep Water (below -20 feet CRD). To employ the HEA model, distinct habitat polygons were first delineated around mapped piles according to pile density, and existing and future habitat characteristics (e.g. habitat zone, slope, substrate), and then given a habitat code. The model was then applied by inserting the value of the starting habitat (existing conditions) and value of the ending habitat (e.g. after derelict pile removal) (ICF, 2019). All the functions provided by the improvement over a modeling period of 30 years and 300 years were then added together (ICF, 2019).

<u>Port of Vancouver Overview</u>

- Science-based evaluation of pile removal opportunities for future mitigation credits within Port property on the Columbia River
- Habitat Equivalency Analysis (HEA) model used to calculate potential mitigation credits from removing all piles
- Relied on field inventory and mapping data
- Application of HEA model did not account for site specific conditions

The project applied the HEA model as if all the mapped piles were removed, and resulted in a net increase of 8.10 DSAYs gained after 30 years. ICF noted that the project's direct application of the HEA model did not include modifications for site specific conditions that could have better evaluated existing habitat conditions.

Coastal Streams and Embayments Prioritization along Puget Sound Shores with a Railroad Prioritization Framework Technical Report (2019)

The objective of the Coastal Streams and Embayments Prioritization along Puget Sound Shores with a Railroad project was to evaluate the benefit to Chinook salmon from restoration efforts at coastal streams and embayments impacted by BNSF railway crossings using a prioritization framework. The project area included the length of BNSF operated railway along the Puget Sound shoreline and 200 feet landward of the shoreline. The project involved three main stages: collecting GIS and field culvert data, developing a prioritization framework, and evaluating framework score results. The goal of the first stage was to create a comprehensive inventory of stream crossings, structures, and embayments in the project area based on field work and aerial photo review (Confluence Environmental Company [CEC] et al., 2019).

<u>Coastal Streams with Railroad Overview</u>

- Chinook-focused science-based evaluation of coastal stream and embayment restoration opportunities impacted by BSNF railway along Puget Sound shoreline
- Evaluated specific project opportunities
- Scoring framework developed to inform project prioritization
- Relied on field culvert data collection and available data across project area
- Projects assigned into three bins of priority

The second stage involved using the inventory data as well as other available data sources to develop a framework for rating the current ecological value of streams and embayments in the project area. The framework criteria for stream crossings were based on two categories: 1) the likelihood of juvenile Chinook salmon use and 2) the quality of upstream habitat. Factors influencing whether juvenile Chinook salmon used a stream were included in the scoring framework, which metrics were then applied to and resulted in a relative score. The framework for embayments followed the same process and structure as stream crossings, but with additional priority assigned to wetland total area. Scores were then summed within the two stream categories and translated into three prioritization bins: low, moderate, and high. Prioritization bins were not used for embayments since conditions were site-specific and difficult to simplify into categories (CEC et al., 2019).

The third stage of the project used the prioritization framework scores as a screening tool for stream and embayment restoration efforts most beneficial to juvenile Chinook salmon along the BNSF operated railway. As a project focused on habitat in the lowermost portion of the streams and estuaries, the framework did not integrate restoration objectives for entire stream systems. Restoration feasibility (e.g., landowner support, community support, funding availability, etc.) was not included in the prioritization. The project also noted that restoration efforts should consider climate change, especially sea level rise, in a further analysis of each site's existing conditions and future restoration need/opportunity (CEC et al., 2019).

Salmon Overlay to the Snohomish Estuary Wetland Integration Plan (2001)

The Salmon Overlay to the Snohomish Estuary Wetland Integration Plan (SEWIP) project was a second, revised phase of a previously established SEWIP that included a new "Salmon Overlay" to help jurisdictions respond to newly listed ESA species (Chinook salmon and bull trout) at the time. The objective of the project was to develop a basin-wide management strategy for listed species recovery that identified and categorized habitat quality across seven ecological management units (EMUs) of the planning area.

SEWIP Overview

- Chinook and bull trout focused basin-wide management strategy for the Snohomish River Estuary
- Developed science-based model to evaluate habitat functions and quality
- Model results used to prioritize project opportunities
- Relied on available data and only those datasets that extended across entire planning area

The planning area spanned the marine shorelines and nearshore areas of Port Gardner and Possession Sound from Mukilteo to the southern entrance to Tulalip Bay and upriver to Ebey Slough. The EMUs included: fluvial fresh water, fluvial brackish water, river and slough mouths, delta sandflats, lower Snohomish channel, Everett Harbor, and Port Gardner nearshore/Tulalip nearshore (City of Everett and Pentec, 2001). The objective of the project also included identifying opportunities for habitat restoration and/or preservation for listed species across the EMUs.

Several products and outcomes resulted from the project, including: a science based Tidal Habitat Model to characterize indicators of habitat functions for listed species; an inventory, based on the Tidal Habitat Model, of habitat quality currently available to listed species; the identification of high-value habitats for preservation; a ranked list of projects and opportunities for habitat restoration; methods for evaluating potential development impacts within the urban growth areas (UGAs) of nearby cities; and suggested mitigation and restoration policies for development (City of Everett and Pentec, 2001).

The Tidal Habitat Model followed the indicator value assessment (IVA) method which describes existing habitat conditions using evident pathways, stressors, and indicators for salmonids. In total, the Tidal Habitat Model delineated and scored 132 discrete habitat assessment units (AUs) within the seven EMUs. Close to half of the 132 AUs were determined to provide only low-quality habitat functions for listed species (City of Everett and Pentec, 2001), and were primarily located in three EMUs: river and slough mouths, delta sandflats, and the lower Snohomish channel.

West Sound Nearshore Integration and Synthesis of Chinook Salmon Recovery Priorities (2017)

This project focused on the eastern portion of Water Resource Inventory Area (WRIA) 15 known as the West Sound Watershed. The project area included the eastern portion of Kitsap County shoreline in Puget Sound, as well as the portion of Pierce County north of Gig Harbor. The objective of the West Sound Nearshore Integration and Synthesis of Chinook Salmon Recovery Priorities project was to develop a science-based prioritized list of nearshore project areas and opportunities for juvenile Chinook salmon within the West Sound (project area) (CEC et al., 2017). The approach of the project included three main stages. The first stage was integrating results from prior assessments conducted in the project area to develop a comprehensive map of priority areas. The second stage involved compiling a list of established restoration and protection project opportunities and integrating them with the mapped priority areas. The last stage included developing a prioritization framework based on the integrated priority areas as criteria for protection and restoration project evaluation.

West Sound Overview

- Chinook-focused science-based evaluation of nearshore restoration and conservation opportunities
- Evaluated specific project opportunities
- Scoring framework developed to inform project prioritization
- Relied on available data and only those datasets that extended across entire analysis area
- Projects assigned into four tiers of priority

A process-based approach was used during development of the prioritization framework, which relied upon the conceptual model of nearshore fundamental linkages (process, structure, and function) provided by MacLennan et al. (2013), the ecological needs of juvenile Chinook salmon (e.g. foraging, growth, avoidance of predators, etc.), and available data for the project area. Input from an Advisory Group was also considered during initial iterations of the prioritization framework, which helped refine the scoring system. The unit of analysis for the prioritization framework was individual parcels. Four components were selected for the framework scoring, including: benefits to process, site suitability, benefits to structure and function, and size. These components were then placed into the following scoring formula: [(Process x Suitability) + (Structure and Function)] x Size = Score. Each component included several contributing metrics, and the formula differed depending on the project type.

The datasets primarily used for the project included management recommendations from nearshore inventories specific to the project area. A total of 420 projects in the project area were scored using the prioritization framework and ranged 1.1 to 197.7 in score. Based on the average scores for each project type, protection projects generally scored higher than restoration projects of the same type, mostly because the project area was larger in size. In addition, the majority of highest score projects included tidal flow restoration or protection. Framework scores were further used to organize projects into four tiers based on anticipated benefits to juvenile Chinook salmon (CEC, 2019): 1 (highest, 2, 3, and 4. Tier 1 was fairly selective and consisted of the top 50 scoring projects considered to be the most beneficial. The remaining 370 projects were divided into the last three tiers evenly.

WRIA 1 Nearshore & Estuarine Assessment and Restoration Prioritization (2013)

For WRIA 1, the Nooksack River watershed in north Puget Sound, a marine nearshore and estuarine assessment and prioritization was conducted to develop a science-based analysis of priority areas for restoration and protection efforts (Coastal Geologic Services [CGS], 2013). A phased approach was used for the project: Phase 1 assessed existing nearshore and estuarine conditions within WRIA 1; and Phase 2 developed and applied a prioritization tool based on the results of the assessment conducted in Phase 1. No field work or site visits were conducted for the project. Local and regional prioritization efforts were also reviewed. This review demonstrated that the prioritization tool must be scalable, incorporate best available science, and reduce subjectivity as much as possible.

WRIA 1 Overview

- Science-based evaluation of nearshore and Nooksack River estuary restoration and protection opportunities
- Ecological Value Criteria assessment used to inform project prioritization in nearshore
- Screening methods used to prioritize multi-beneficial projects in Nooksack River estuary
- Relied on available data and only those datasets that extended across entire analysis area

Using the assessment information from Phase 1, Phase 2 implemented two different approaches to applying a prioritization tool for the marine nearshore and the Nooksack River estuary. The approach used for the marine nearshore incorporated local habitat data with coastal landform and nearshore ecosystem process data, which provided scalability to identify priority areas for projects. An "Ecological Value Criteria" (EVC) assessment was then applied to these priority areas. The EVC included nine resource metric parameters related to nearshore ecosystem health, biodiversity, and habitat structure and function. Priority areas were then ranked based on the resulting EVC score and appropriate management strategy before they were ultimately prioritized using three additional queries. The queries included strategy match, process match, and number of limiting factors addressed. Once the queries were applied, the priority areas were then sorted in a 3- or 10-year timeframe. A total of 133 potential opportunities/projects were compiled, identified, and prioritized in the marine nearshore using this approach.

The approach used for the Nooksack Estuary involved generating a prioritized list of restoration and protection opportunities identified during Phase 1 and screening them. Several aspects of the identified opportunities were screened, including: the scale and logistics required; the status of restoration planning as well as anticipated benefits to ecological processes, habitats, and achievement of restoration objectives (CGS, 2013). Based on the screening results, a total of 11 site-specific large-scale opportunities/projects were identified that would result in multiple restoration objectives.

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