Similik Tidal Marsh Restoration Project

Basis of Design Report

Prepared for
Skagit River System Cooperative

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1 Purpose

The Skagit River System Cooperative contracted with Blue Coast Engineering LLC (Blue Coast) to develop a preliminary design to restore tidal inundation to the historic Similk tidal marsh area (project site). The design team for the project also includes KPFF Consulting Engineers (KPFF), Aspect Consulting (Aspect) and Wilson Engineering (Wilson) to provide transportation engineering, geotechnical/water resources engineering and site survey services for the project, respectively.

This work builds on previous feasibility studies and conceptual design work completed by others (Anchor QEA 2015, Tuttle Engineering 2016, and Mickelson and Smith 2022). As a result of this previous work, a preferred option was selected and moved forward into preliminary design. The selection process for the preferred alternative is documented in the Project Scoping Report developed by SRSC (Mickelson and Smith, 2022). In addition to restoration of the historic tidal marsh at the project site, roadway and drainage modifications on Satterlee Road have been proposed to support the restoration effort and increase the resiliency of Satterlee Road to flooding.

This report outlines the basis of design at the preliminary design level (60%) for the proposed tidal marsh restoration, and at the conceptual level for roadway and drainage modifications.

2 Site Description

The Similk Tidal Marsh is a historic 17-acre barrier embayment (Shipman 2008) located on the margin of Similk Bay, part of the southern shoreline of Fidalgo Island in Skagit County (County), Washington (Figure 1). The site is located within a single day's migration from the Skagit River delta by migrant fry Chinook salmon (Beamer et. al., 2005), and has been isolated from tidal processes and fish access by the construction of both a county road (Satterlee Road) and berm along the beachfront. Property ownership within the limits of work for the project include parcels owned by the Swinomish Indian Tribal Community (SITC), including adjacent tidelands within Similk Bay and Skagit County Right-of-Way for Satterlee Road (see Figure 2). SITC owns and operates a commercial shellfish operation (Swinomish Shellfish Company or SSC) that operates on the tideland parcels owned by SITC in Similk Bay to the south and west of the project area. SITC currently accesses the shellfish beds through the project area over the beach berm.

Adjacent parcels to the west, east and south-east (tidelands) are privately owned by others. The Similk Beach Golf Course, also owned by SITC, is located directly to the north of the project area. The project is bounded to the east by Christianson Road and to the west by private residential homes.

The length of Satterlee Road adjacent to the project site is in a low-lying area prone to flooding from surface and groundwater inflow from adjacent uplands (see Photograph 1, Appendix A). The project site has several drainage ditches (see Photograph 3, Appendix A) that converge at a pump house located adjacent to Satterlee Road. The pumphouse is maintained by Skagit County and periodically pumps water from the adjacent drainage ditches through the beach berm to the south and into Similk Bay (see Photograph 4, Appendix A). There are two tide gate structures on the project site that are not maintained, and their current level of function is unknown. Active septic systems are located around the permitter of the project area (but not within the project site) with a suspected inactive septic system identified on the southwestern corner of the project area. Figure 3 provides an overview of known drainage features within the project site (SRSC, 2021).

The majority of the site north of Satterlee Road is relatively flat, with elevations within the interior of the historic marsh ranging from 7 feet North American Vertical Datum of 1988 (NAVD88) to 8 feet NAVD88 (see Photographs 1 and 2, Appendix A). Along the perimeter of the project area to the east and west, the site slopes upward steeply from 8 feet NAVD88 to 16 feet NAVD88 and 19 feet NAVD88, respectively. To the north, the site slopes upward more gradually. South of Satterlee Road, the site is flat and relatively low lying to the west (7 to 8 feet NAVD88) and higher in elevation to the east (13 to 14 feet NAVD88). Satterlee Road has similar elevations; lower to the west (7 to 8 feet NAVD88) (see Photograph 7, Appendix A), sloping up to about 16 feet NAVD88 at the intersection with Christianson Road. The beach berm along the shoreline, which is characterized by significant large wood accumulation and a few discrete areas of armor rock, has a variable crest elevation of 11 feet NAVD88 to 13 feet NAVD88 (see Photographs 9 and 10, Appendix A). The toe of the beach berm is at elevation 6 feet NAVD88 and is mildly sloping waterward of the toe (see Photograph 11, Appendix A). Figure 4 shows an overview of topography of the project site and adjacent area.

Satterlee Road is currently protected from tidal inundation by the presence of the beach berm. Surface water runoff from the golf course and surrounding uplands flows into the project area and would flood Satterlee Road as well as large portions of the project area if the county pump station were not operable. Figure 5 shows the approximate area of the project site that flooded during a storm in December 2020 when the pumphouse was inoperable.

3 Background and Proposed Project Elements

An initial feasibility study to evaluate the potential of restoring tidal inundation to the historic tidal marsh at Similk was completed by Anchor QEA (Anchor QEA, 2015). Blue Coast staff were involved in that initial work. Additional design work was completed by Tuttle Engineering (Tuttle Engineering, 2016). In 2021, SRSC and SITC conducted a series of design charettes to reimagine the function of the proposed project to support habitat restoration, improve flood resiliency for Satterlee Road, and retain existing use of the site by SITC for ongoing shellfish operations located in the tidelands to the south of the project location. The results of the charette meetings were documented in a project scoping report developed by SRSC (Mickelson and Smith, 2022) This document is provided in Appendix B. Goals for the project identified in that report are listed below:

- Sustainably restore natural processes, conditions, functions, and biological responses to approximately 17 acres of historic tidal marsh habitat along the northern shoreline of Similk Bay.
- Restore critical estuarine rearing habitat for ESA-listed juvenile Chinook salmon during the early phases of their oceanward migration.
- Restore estuarine habitat for other fish species, including other juvenile native salmonids and forage fish, as well as for other wildlife species (particularly marsh birds).
- Implement restoration actions that are compatible with adjacent land uses, including private residences to the east and west, a shellfish farm on the tide flats to the south, a golf course to the north, and adjacent transportation and utility corridors.

In addition, specific design decisions were developed during the charette meetings that were used to drive development of the preliminary design described in this report. These decisions are listed below, and are documented in detail in Mickelson and Smith, 2022:

- Satterlee Road cannot be abandoned as it is the only other road (besides Route 20) that connects Fidalgo Island to the mainland.
- Satterlee Road will be elevated above flood elevations and a bridge will be constructed over the restored tidal channel. Some utility modifications will be required to accommodate these transportation improvements.
- Access to the shoreline from the uplands to accommodate ongoing shellfish operations by SSC will need to be incorporated into the design. The preliminary design should be reviewed by representatives from SSC to ensure that the design adequately meets the needs of their operations.
- A single larger primary tidal channel is preferred over multiple smaller tidal channels based on geomorphic and habitat considerations.
- Despite a general lack of information about the historical conditions at the project site prior to anthropogenic influence, tidal marsh restoration at the site would provide significant benefit to juvenile Chinook and other salmonids.
- Minimum excavation in the interior of the project site will provide habitat benefit for restoration at the project site.
- A bridge opening of approximately 105 feet will be adequate to meet hydraulic and habitat restoration criteria for the project.
- The pump station may be removed as part of the proposed project.
- A berm may be required along the western edge of the outlet tidal channel in order to protect areas to the west of the channel from tidal inundation.

4 Data and Standards Used in Design

This section summarizes data sets and design standards used to facilitate the preliminary design for tidal marsh restoration at the project site.

4.1 Compiled and Collected Data

Data used to develop the basemap, design drawings, and conduct engineering calculations for the project are summarized in this section of the report.

4.1.1 Data Overview

A list of primary data, including source information, used to inform preliminary design for the tidal marsh restoration work is provided in Table 1. Other data sources specific to technical studies completed by others as part of the preliminary design are documented in technical memoranda included with this report as appendices.

Table 1: Overview of Data Used in Design

Date(s)	Date Set	Source	Purpose of Data
May 6, 2021	Topography and Site Survey within Satterlee Road right-of-way	Wilson	Develop basemap for use in preliminary design
2021	Topography (LiDAR)	OCM Partners	Hydrodynamic modeling and basemap within tidal marsh area
Various	Bathymetry	USGS (CoNED)	Hydrodynamic modeling and basemap within intertidal area
Various	Digital Elevation Model (DEM) of Topography (LiDAR) and Bathymetry	Blue Coast	Hydrodynamic Modeling
2021	Point Elevation Data within tidal marsh area	Blue Coast	Check LiDAR elevations within project area
N/A	Tidal Datums, Turner Bay NOAA # 9448657	NOAA[1]	Hydrodynamic modeling, restoration design, transportation improvements concepts, and permitting
2021	OWHM and HTL designation	Blue Coast	Permitting
2021	Sediment Test Pits	Aspect	Characterize sediments to be excavated to create tidal channels
April 5 & 6, 2022	Traffic Count Data	Skagit County	Roadway conceptual design

Notes:
NOAA – National Oceanic and Atmospheric Administration

4.1.2 Basemap Information

The basemap for the project site was developed based on various sources for topography, bathymetry, and site survey. Wilson completed a survey for the project area within the Satterlee Road right-of-way. That survey included topography (1-foot contours), extent of the right-of-way, edge of road, utilities and stormwater infrastructure including drainage ditches along the roadway, and the pump house location. Topography for the rest of the site was taken from a LiDAR elevation dataset (OCM Partners, 2021). The LiDAR elevations were validated with field data collection by Blue Coast staff using real-time kinematic (RTK) survey equipment. Multiple transects throughout the project site were measured and compared to the LiDAR information. The survey elevations showed agreement with the LiDAR data within the project area. Bathymetry information within Similk Bay, beyond the extent of the LiDAR data set, was taken from a data set developed by USGS (see Table 2).

4.2 Design Standards

Design standards and guidance documents used to develop the preliminary and conceptual design at the Project site are listed below:

- Coastal Protection Manual, United States Army Corps of Engineers (USACE), 2006
- A Primer for Selecting Sea Level Rise Projects for Washington State, WA Sea Grant, 2020
- Determining the Ordinary High-Water Mark for Shoreline Management Act Compliance in Washington State, Washington Department of Ecology, 2016
- Marine Shoreline Design Guidelines, Washington Department of Ecology, 2014
- 2010 Americans with Disabilities Act (ADA) standards for accessible design
- Whatcom County Development Standards
- Washington Department of Transportation, Standard Specifications (for materials)
- The American Standard for Nursery Stock (ANSI Z60.1-2014)
- U.S. Environmental Protection Agency (EPA), National Recommended Water Quality Criteria
- Skagit County Road Standards (2000)
- WSDOT Design Manual (2021)
- WSDOT Bridge Design Manual (2020)
- AASHTO Policy on Geometric Design of Highways and Streets (2018)
- AASHTO LRFD Bridge Design Specifications, 9th Edition AASHTO Guide (2020)
- Flood Insurance Study, Federal Emergency Management Agency (FEMA)
- Department of Ecology Stormwater Management Manual for Western Washington (as amended 2019)

5 Technical Evaluation and Basis of Design

Project elements summarized in Section 3 of this report were moved forward into preliminary design through a series of coordinated technical evaluations. Previous work completed at this site by others (Anchor QEA 2015, Tuttle 2016) was used to inform current work to the extent practical. Evaluations included a geotechnical evaluation of sediments within the proposed tidal marsh, surface water hydrology, tidal hydrodynamic modeling and analysis, coastal geomorphology, and water quality study for incoming surface water runoff from the SITC golf course.

The results of these studies were used to refine proposed project elements and to develop a preliminary (60%) design for the tidal channel network and a conceptual design for transportation improvements. The results of these studies are briefly summarized below with additional detail provided in appendices.

A groundwater evaluation and septic risk study are currently in progress; results of those studies will be documented in the final Basis of Design Report.

5.1 Geotechnical Evaluation

Aspect conducted a site reconnaissance and first-phase exploration program consisting of six excavator test pits located within the upland area of the project site between the SITC golf course and Satterlee Road (see Figure 1, Appendix C). The locations of the test pits were chosen to inform geotechnical analysis and recommendations for the tidal channel excavation, as well as to inform surface water infiltration and groundwater evaluations (in progress).

5.1.1 Sediment Characterization (Test Pits)

Test pits were excavated on June 29, 2021, using a small track-mounted excavator down to a depth ranging between 3 and 6 feet below ground surface (bgs). Exploration logs showing sediment horizons and location of groundwater table is provided in Appendix C, along with more detailed description of the study and study conclusions.

Peat was encountered in the near-surface for all test pit locations ranging from 0.25 to 4 feet bgs. Below the peat was a layer of silty sand with gravel down to the extent of the test pit exploration. This material consisted primarily of fine- to medium-grained sand with fine rounded gravels. Clam and other seashell fragments were also located within this layer. These were characterized as nearshore deposits by Aspect. Sediments at depth in cores 5 and 6, which were the farthest upland from Similk Bay, were characterized as glacial deposits by Aspect (see Appendix C).

Groundwater was encountered around 2 to 3 feet below ground surface. The groundwater table elevation was approximately 5 to 6 feet NAVD88 closer to the shoreline and 4 to 5 feet NAVD88 farther from the shoreline (see Table 1, Figure 1, Appendix C).

The location of characterized nearshore sediments within the upper few feet of the test pit locations implies that the area was a historic tidal marsh as opposed to a deeper estuary or upland freshwater marsh. In addition, sediments found within the excavated area for the tidal marsh are appropriate bed material for the proposed restored tidal channels.

5.1.2 Grading and Construction Recommendations

From the results of the Geotechnical Evaluation (Appendix C), Aspect recommends permanent channel side slopes be constructed no steeper than 4H:1V (horizontal:vertical). Similarly, fill mounds that will be inundated by high tidal water should be constructed with 4H:1V slopes. The fill mounds should be planted with erosion resistant vegetation that are able to withstand tidal inundation. The fill mounds should be located sufficiently far from the tidal finger channels to reduce the potential for erosion and sloughing into the excavated channels.

Excavations that extend below groundwater could be completed without dewatering without construction dewatering. Ideally, channel excavations would be completed by working from the beach on the south end towards the golf course on the north end. This would allow groundwater to drain more readily out to Similk Bay during construction.

5.2 Coastal Processes

Blue Coast completed a coastal processes evaluation for the project site which included evaluation of water levels, wind-waves, sediment sources, and net littoral drift. This information was used to inform the design of the primary tidal channel opening and to identify impacts, if any, of the proposed project on existing coastal processes at the site.

5.2.1 Water Levels

Tidal datums and tidal predictions for the project site were taken from a NOAA tidal station at Turner Bay, NOAA Station #9448657 (NOAA, 2022), located approximately 1 mile to the east from the project site. Relevant tidal datums for the project site relative to NAVD88 (North American Vertical Datum 1988) for the project area are listed in Table 1. The FEMA 100-year flood elevation for the site is 11.8 feet NAVD88 and is attributed to coastal flooding, not surface water flow into the project site (FEMA, 1985).

The location of the High Tide Line (HTL) is defined by the United States Army Corps of Engineers (USACE) in 33 C.F.R. § 328.3. The HTL for this site was determined as the 10-year average high tide elevation based on the highest estimated tide for each year from 2021 to 2030 at the Turner Bay NOAA station (#9446807). The HTL elevation for the project site is 10.5 feet NAVD88.The OHWM was evaluated on site by Blue Coast staff following Washington State Department of Ecology (Ecology) guidelines (Ecology 2016, WAC 173-22-03(5) and is located along the toe of the large wood rack along the entire length of the project shoreline. Additional information regarding determination for the HTL and OHWM by Blue Coast are documented in separate memoranda (Blue Coast, 2022(a)(b)).

Design water levels for the project are summarized in Table 2.

Table 2. Design Water Levels (NOAA Station 9448657, FEMA)

Tidal Datum	Elevation (feet, NAVD88)	Elevation (feet, MLLW)
FEMA 100-yr Flood Elevation[1]	11.8	13.3
HTL: High Tide Line	10.5	12.5
MHHW: Mean Higher-High Water	8.8	10.4
MHW: Mean High Water	8.0	9.5
MTL: Mean Tide Level	4.5	6.0
MLW: Mean Low Water	2.4	2.5
NAVD88: North American Vertical Datum 1988	0.0	1.5
MLLW: Mean Lower-Low Water	-1.5	0

Notes: 1. Flood elevation is due to coastal flooding (high tide, storm surge and wave run-up) at the project site

Long-term mean sea level in Puget Sound is predicted to increase versus historical rates of sea level rise (SLR) because of climate change related impacts. Miller et al. (2018) provides projections of local SLR at coastal locations in Puget Sound and Washington for various planning horizons. The estimate for SLR used for preliminary design at the site were selected as the 50% exceedance, RCP 8.5 (high greenhouse scenario) value. The median estimate (50% exceedance) for SLR in year 2100 for Similk Bay is 1.9 feet. Based on this value, MHHW at the project site would increase to 10.7 feet NAVD88 and the HTL to 12.4 feet NAVD88 by the year 2100.

Transportation improvements to Satterlee Road, including an elevated roadway prism and bridge, should account for the current FEMA 100-year flood elevation and median predicted SLR values over the design life of the transportation work. Recommended or required clearance heights above the flood elevation for the bridge (FEMA, WA Department of Ecology) should also be considered in design. For the purposes of preliminary design, this roadway/bridge design water level is 11.8 feet NAVD88, which is the 100-year FEMA floodplain elevation and is also 1.3 feet higher than current high tide elevations. The height of the bridge lowest structural member was assumed to be 3 feet above this water level (11.8 feet NAVD88), which is 14.8 feet NAVD88. This provides just over 2 feet of freeboard between the predicted future HTL (12.4 feet NAVD88 by the year 2100 and the bottom of the proposed bridge. The elevation of the roadway should be at or above the current 100-year FEMA elevation (11.8 feet NAVD88) and should use adaptation measures (such as increasing local roadway heights or curbing) to provide resilience for the roadway to climate change. The heights of the roadway and bridge will be revisited in final design.

5.2.2 *Wind Waves*

Wind-waves are formed in response to the force of the wind acting over the water surface. The height and period of wind-generated waves depends on both wind duration (i.e., time period of the windstorm) and fetch (i.e., distance over which wind is acting). Generally, the longer the windstorm lasts and the larger the fetch distance, the larger the height and period of the wave generated.

In areas with little topographic influence, wave direction is generally aligned with the wind direction unless the waves are in shallow water and refract to align with localized bathymetric contours (underwater topography). In areas where topographic effects are significant, such as Puget Sound and surrounding area, the wind, and therefore the wave direction becomes aligned with the maximum fetch length. At the project location, wind-waves align themselves with the north-south direction because the fetch to the south of the site is the longest.

The prevailing wind direction over the Whidbey sub-basin is from the south and southwest in the winter, and west and northwest during the summer (Overland and Walter 1983). The strongest winds are typically from the south during winter storm events. The wind climate within Similk Bay, where waves are generated that impact the project shoreline, was characterized using hourly wind records from the long-term meteorological station at West Point (1975 to 2019).

A joint probability plot for wind direction and wind speed is shown in Figure 6 for the West Point wind data after filtering for suspect records (based on the quality code indicator for suspect or erroneous values) and 0 value wind speeds. The joint probability plot shows the frequency of occurrence of combined wind speed and wind direction. The data are binned in 5 mph speed bins and 10° directional bins and shown as a heat map with warmer colors indicating a higher frequency of occurrence. The heat map shows that the most frequently occurring wind directions at the West Point station are southeasterly (160° to 170°; 12.5 mph bin center) and northeasterly (30° to 40°; 7.5 mph bin center). The strongest winds measured are from the south (160° to 240°), consistent with the broader regional wind patterns in western Washington.

An extreme value analysis of the wind record from the westerly sector was completed following the methods of Goda (1988) and Leenknecht et al. (1992). The analysis was completed for the southerly (90^0 to 270^0) sector for the West Point wind record, which represent wind directions that could develop wind-waves that would impact the Similk shoreline. Based on the best fit extreme value probability density function, return value wind speeds were estimated for return intervals ranging from 1 year to 100 years. The return value wind speeds from the extreme value analysis are summarized in Table 3 along with the 95% confidence interval wind speeds for directions of interest for the project site.

Wind statistics shown in Table 3 were used to estimate storm wave heights along the project shoreline. The shoreline at the project site is open to a relatively small fetch to the south across

Similk Bay due to the location of Kikit Island to the south. Using wind-wave hindcast methods outlined in the Coastal Engineering Manual (USACE, 2006), the 100-year return period significant wave height is 2.5 feet. Since the spread in predicted wind speeds between the 1-year and 100-year wind speed are not great, the 1-year return period significant wave height is not much smaller than the 100-year value - 2.0 feet. That said, relative to other locations within Puget Sound, the project shoreline at Similk is a lower energy wave environment due to the short fetch distance to the south and the presence of the wide, shallow (just below sea level) mudflat fronting the shoreline at the project location.

Table: 3 Extremal wind speeds at the West Point meteorological station.

	West Point (winds from the south)		
Return Period (years)	Wind Speed (mph[1])	95% confidence interval, lower (mph)	95% confidence interval, upper (mph)
1	43	42	44
2	46	44	47
5	49	47	51
10	51	50	53
25	54	52	57
50	56	53	59
100	58	55	61

mph – miles per hour

5.2.3 Sediment Sources and Net Littoral Drift

The shoreline adjacent to the project site is located along the northern shoreline of Similk Bay. It is characterized in the WA Department of Ecology Coastal Atlas (WA Dept. of Ecology, 2020) as an accretion shoreform (see Figure 7), where littoral drift originates from the west on the western side of the site and from the east on the eastern side of the site (see Figure 8). Feeder bluffs have also been identified in the coastal atlas to the south and west of the project shoreline (see Figure 7). These designations are consistent with site conditions along the shoreline, which are characterized by a wide lower intertidal beach (see Photograph 11, Appendix A). In addition, the shoreline along the project site has a significant volume of natural large wood accumulation (see Figures 9 and 10, Appendix A), which is consistent with the designation of the shoreline as an accretion zone.

However, despite feeder bluffs being located updrift of the project site, the shoreline does not appear to have accreted significantly over time based on review of the T-sheet and historic aerial and oblique photographs of the project shoreline. Reasons for this are likely (1) wave energy at the project site is low due to the small fetch distance between the Similk project site and Kiket Island to the south (about 1.7 miles); (2) sediments in the bay are fine grained silty sands which can be transported away from the project area due to tidal currents (not just along the shore due to littoral drift).

5.3 Channel Geomorphology and Habitat Evaluation

Blue Coast, with assistance from SRSC, conducted a geomorphic and habitat evaluation of the project site to identify the size of the primary tidal channel through the beach berm, under the proposed bridge, and into the project area, as well as the size and total length of the interior tidal channels within the restored Similk salt marsh. Previous work completed by Anchor QEA (Anchor QEA, 2015) was used as a starting point for this evaluation. However, sizing for the entrance and interior tidal channels was reevaluated based on new research led by Blue Coast (Cote, et. al, 2018) and SRSC (Beamer, 2022).

5.3.1 Primary Channel Width

Jessica Cote of Blue Coast is leading a research project funded through the Estuary and Salmon Restoration Program (ESRP) learning program entitled *Puget Sound Channel Guidelines for Barrier Embayment Restoration*. This research effort aims to establish design guidelines for sizing the primary tidal channel for tidal embayments, also known as barrier estuaries or pocket estuaries. These are systems in which the hydrodynamics and geomorphology of the system are driven by tidal and other coastal forces (i.e., waves). The research also included input from the Washington State Department of Fish and Wildlife and SRSC. The Phase 1 report for the project has been completed (Cote, et. al, 2018). The final report for the project is underway and will be finalized this year.

The results of this research project include a set of empirical relationships that define a relationship between the size of the primary tidal channel and the tidal prism of the system. The tidal prism is the volume of water that is moved into and out of the embayment over a typical tidal cycle. These relationships were used to establish the width of the primary tidal channel at MHHW elevation for the project.

The tidal prism for the restored project site at MHHW was estimated to be 43.7 acre-feet (53,900 cubic meters) based on predictions from a numerical model of the site. Using the regression equations developed by Cote et. al. (in preparation), the width of the channel at MHHW elevation should be approximately 75 feet in order to be geomorphically stable.

5.3.2 Interior Tidal Channel Network

SRSC (Beamer, 2022) used an allometric approach developed by Greg Hood (Hood, 2007), as well as a pocket estuary census in the Whidbey Basin (Beamer et al 2018) to develop a guidance document that includes a series of regression equations to be applied to predict interior channel patterns at

Similk. This guidance document is provided as Appendix D. These equations were used to assist in the design of the lengths of tidal channels and channel order for the Similk project site.

The relationships developed for the Similk project site also relied heavily on information developed by Eric Beamer as part of an ESRP Learning Grant completed in 2018 entitled *Puget Sound Channel Guidelines for Barrier Embayment Restoration* (Beamer, 2018) which identified channel geometry within intact systems with known fish use. In this way, the relationships developed in Beamer, 2022 combine geomorphology and habitat considerations into empirical equations for sizing the tidal channel networks that are geomorphically stable and provide appropriate habitat for fish. Blue Coast used the relationships in SRSC, 2022 to develop the length of the primary tidal channel, total length of interior tidal channels, and sinuosity of the channel network as described below.

Regression equations for mean channel length (MCL) and total channel length (TCL) from SRSC (2022) are provided in Equations 1 and 2, respectively, where all units are in meters.

The MCL is estimated as a function of the system length, which is the length of the project area at Similk measured in the north south direction (244 meters/735 feet). Using the measured system length and Equation 1, the length of the main channel between Similk Bay and the interior of the restored tidal marsh should be at least 480 feet.

The total channel length (TCL) is estimated as a function of the area of the inundated area at MHHW (7.1 hectares/17.5 acres). Using the measured inundated area and Equation 2, the total length of tidal channels within the restored tidal marsh should be at least 4,110 feet.

Main channel sinuosity values suggested in SRSC, 2022, (1.25 to 1.4) were also taken into consideration in the design of the primary tidal channel into the restored marsh.

$$Ln(MCL) = 1.345 * Ln(System\ Length) - 2.405 \qquad \text{Equation 1}$$
$$Ln(MCL) = 1.345 * Ln(244) - 2.405$$
$$Ln(MCL) = 4.99\ m$$
$$MCL = e^{4.99} = 146.4\ m = 480.3\ feet$$

$$Ln(TCL) = 0.979 * Ln(Area) + 5.786 \qquad \text{Equation 2}$$
$$Ln(TCL) = 7.1\ ha$$
$$TCL = e^{7.1} = 1{,}253\ m = 4{,}110.8\ feet$$

5.3.3 Habitat Benefits of Proposed Tidal Channel Design

There is no historic data available that illustrates what the tidal channel network at Similk looked like before anthropogenic influences on the project area began. There was significant discussion during the charette meetings led by SRSC prior to the start of preliminary design for the project regarding what type of habitat at the Similk project site would be most sustainable and beneficial to fish. After extensive discussion during those charette meetings, it was agreed that it is not necessary to design only according to historic conditions (which are uncertain) "*as long as the project concept is beneficial to juvenile Chinook and other salmonids and will be naturally sustainable over time*" (Mickelson and Smith, 2022).

Therefore, the design of the primary tidal channel and interior channel networks at the Similk project site were based on the following requirements taken from Cote et. el. (2018), SRSC (2022) and Mickelson and Smith (2022):

- From a biological perspective, having a single larger channel outlet would be more accessible to juvenile Chinook than multiple small outlets as conjectured to have occurred historically.
- The width of the primary tidal channel through the beach berm (and under the proposed Satterlee Road bridge) should be 75 feet at MHHW (see Section 5.2.1). This results in a bridge span of about 105 feet.
- The length of the primary tidal channel into the restored site should be about 480 feet (see Section 5.2.2).
- The total length of the tidal channels within the restored site should be at least 4,100 linear feet (see Section 5.2.2).
- Minimal excavation within the project area is required to restore tidal marsh habitat within the project site (SRSC, 2022).

5.4 Hydrologic Evaluation

Aspect conducted several hydrologic evaluations to support the preliminary design work for the project. These studies included evaluation of surface water hydrology (i.e., runoff), a groundwater hydrology study, and a septic risk evaluation. A summary of these studies is provided below (see Appendix E).

Aspect utilized a hydrologic model to evaluate the surface water inputs to the project area from the surrounding drainage basin. The evaluation was performed using the Western Washington Hydrology Model (WWHM). The goal of the analysis was to identify the seasonal variations in surface runoff and shallow subsurface (i.e., interflow) contributions to the Project Area as well as peak flows during significant storm events.

The total drainage basin tributary to the project site is about 272 acres, of which 42 percent is in the golf course subbasin. The predicted 2-year, 10-year, and 100-year total peak flow into the project area are about 8, 16 and 32 cubic feet per second (cfs), respectively.

The groundwater evaluation included development of a preliminary hydrogeological conceptual model based on review existing data, regional studies, and project test pit observations. The evaluation was used to formulate a preliminary risk assessment of flooding to nearby septic systems and saltwater intrusion to nearby water supply wells from the project design. A total of 25 nearby septic systems and one potential private water supply well were identified and mapped in the vicinity of the project area. The supply well was identified from a 1974 water right claim for domestic and irrigation uses on a parcel east of Christianson Road (no well logs were found). However, a utility service area map indicates the parcels around the project area are all on public water supply from Skagit County Public Utilities. Thus, saltwater intrusion to private supply wells is not likely a risk factor for the project – though the status of the parcel with the 1974 water right claim should be verified as part of final design for the project.

Records and as-builts were reviewed from 15 of the 25 mapped septic system and the elevations of the drain fields are all higher than the projected maximum inundation level. Thus, our preliminary analysis did not identify any specific risks to the septic systems using the available data. Additional field data collection and analysis is recommended as part of final design to finalize the risk assessment to septic systems.

5.5 Tidal Hydrodynamic Modeling

Blue Coast developed a tidal hydrodynamic model of the project site to inform design of the tidal channels for the project, to assess the upland extent of inundation over various tidal conditions (including onto the SITC golf course) and develop design criteria for the transportation improvements (bridge and elevated roadway at Satterlee Road). The model was also used to identify potential changes to sediment transport along the nearshore and within the proposed tidal marsh that could impact adjacent shellfish beds or result in changes to physical and geological coastal processes in the nearshore region of the Project site. Model development and model results are summarized in this section of the basis of design report.

5.5.1 Model Development

The model selected for the project was the open-source HEC-RAS model version 6.1 developed by the United States Army Corps of Engineers (USACE). This model is a finite element hydrodynamic model that is well suited to computing the two-dimensional flows that will occur within the proposed tidal channels at the site.

The model grid was developed using a combined bathymetry/topography DEM developed by Blue Coast for the project (see Table 2) and consists of 72,388 cells with a variable resolution. To accurately capture the small-scale topographic and bathymetric features in the project area, the model resolution (i.e., grid cell size) within the project area is 5 feet. As the model extends away from the project area, the model resolution increases to 15 feet. Figure 10 shows the extent of the model domain and the location and extent of the 15-foot and 5-foot model resolution areas. Figure 11 shows the grid resolution relative to the proposed tidal channel size.

The hydrodynamic model is driven by two boundary conditions: (1) upstream inflow at the northern (upstream) boundary of the model and (2) water surface elevation at the southern (ocean) boundary of the site (see Figure 10). Upstream inflows predicted by Aspect (see Section 5.2.1) are relatively small even for large return period events (i.e., 30 cfs). Compared to the tidal prism (volume of water exchanged over each tide cycle) expected once the project area is reconnected to Similk Bay, the surface and groundwater flows are very small. Therefore, the hydrodynamics of the site, including sediment transport and geomorphology, are expected to be driven by tidal hydrodynamics and upstream inflows were not considered in the hydrodynamic modeling completed as part of preliminary design. Instead, the model was driven at the southern (ocean) boundary using water levels from the Turner Bay NOAA Station.

Model roughness is a model parameter that considers the land cover and substrate type within the flow area, sinuosity of the channel, and other characteristics of the flow path that can impede flow in the system. For example, a channel with the same geometry will have different flow velocities if the channel bed is mud or if it consists of large boulders. For the model of the proposed tidal marsh at Similk, a constant value for roughness was assigned across the entire domain. (Manning's roughness coefficient set to 0.02)

The model was not calibrated or validated because, at present, there is no tidal inundation into the project site and therefore it is not possible to measure current water levels or velocities within the project area north of the beach berm.

5.5.2 Model Simulations and Results

Design information on channel and estuary/marsh characteristics for the restoration project from Beamer, 2022, Mickelson and Smith, 2022 and calculations discussed in Section 5.3 were used to develop a digital elevation model (DEM) of the proposed restoration (tidal channels) for the project site (See Figure 10). The channel thalweg elevation of the primary tidal channel is 5.0 feet NAVD88 and slopes upward mildly into the site to an elevation of about 6.5 feet NAVD88. Channel widths vary from 75 feet at MHHW at the entrance to 10 feet at the most landward finger channels.

Hydrodynamic model simulations focused on a king tide event from January 2021 predicted at the NOAA Turner Bay tidal gage. A plot of this tidal time series is provided in Figure 12.

Results from the model simulations, including depth averaged current velocities and water depths, are presented in Figures 13 through 18 as described below:

- Figure 13: Peak Flood Tide Velocities

- Figure 14: Peak Flood Tide Velocities, Channel Detail
- Figure 15: Peak Ebb Tide Velocities
- Figure 16: Peak Ebb Tide Velocities, Channel Detail
- Figure 17: Low Tide Velocities on Adjacent Shoreline
- Figure 18: Water Depth at High Tide (~11.5 feet MLLW)

Peak flood tide velocities are slightly higher than peak ebb velocities; 1.8 feet per second (f/s) compared to 1.2 f/s. Velocities above 1 ft/s are able to mobilize sand. Given the peak velocities shown in Figures 13 through 15, sand that deposits within the channel will most likely be moved out of the channel during peak flood or ebb tide. Since flood tide velocities are higher than ebb tide velocities, sediment is likely to move preferentially into the restored marsh as opposed to out onto the adjacent nearshore area.

Velocities on the adjacent shorelines reach approximately 0.5 ft/s during ebb tide. The model shows that the restored tidal estuary is almost fully drained by the time the tide reaches the shellfish beds. Therefore, higher velocities are not expected to occur in the area where shellfish beds are located at the project site.

In addition, the channels will be constructed to expected equilibrium widths and depths based on the geomorphic analysis conducted as part of this design effort (See Section 5.3). This combined with predicted relatively low velocities in the proposed tidal channels and on the adjacent nearshore area imply that no significant erosion is expected within the restored tidal marsh or along the shoreline following restoration of the site. Subsequently, no significant sedimentation within the shellfish bed areas is expected to occur as a result of the proposed restoration at the project site.

5.6 Transportation Evaluation

KPFF conducted a transportation evaluation to develop a conceptual (~10%) level of design for roadway improvements and new bridge at Satterlee Road to accommodate the proposed tidal channel and tidal marsh restoration proposed for the site. The evaluation included consideration and conceptual design for the following proposed transportation elements:

- Satterlee Road Improvements (not including proposed bridge):
  - Elevate existing roadway along current alignment above design flood elevations
  - Evaluate ROW and property impacts
  - Coordinate with Skagit County on assumptions for roadway conceptual design
  - Evaluate constructability and develop estimated costs
- Proposed Bridge at Satterlee Road
  - Evaluate a fish-passable bridge over the proposed tidal channel at the project site
  - Meet minimum clearance to high tide elevation

- Evaluate structural depth requirements
- Evaluate constructability and develop estimated costs

The results of this evaluation are provided in a Technical Memorandum developed by KPFF and are provided as Appendix F.

A high-level summary of assumptions used to develop the roadway improvement concepts are provided below and documented in detail in Appendix F. Assumptions will be verified and potentially updated during final design for the transportation improvements.

- Roadway is currently classified as an Urban Local Access. A more appropriate classification per conversations with Skagit County Public Works would be a Rural Major or Minor Collector.
- Average daily traffic (ADT) is greater than 400 vehicles per day per traffic count data collected by Skagit County specific to this project.
- Rural roadway section without sidewalk, curb, and gutter.
- Hydraulic assumptions to support tidal channel design.
  - Minimum channel width – 75 feet at MHHW
  - Minimum clear span between bridge abutments – 100 feet (see Michelson and Smith, 2022)
  - Bottom of channel – 4 feet NAVD88
  - FEMA 100-year flood elevation – 11.8 feet NAVD88
  - Minimum vertical clearance – 3 feet between bridge low chord and 100-year water level (WDFW)
  - Resilience to predicted sea level rise (climate change); see Section 5.2.1
- Assume that a driven pile foundation will be required for the bridge, no geotechnical information available for the concept development.
- Roadway posted for a 25-mph speed limit.

Based on these assumptions and stated design standards in Appendix F, a concept for the elevated roadway alignment along Satterlee road using was developed with a minimum elevation of 10.8 feet NAVD88. During final design, the roadway elevation will be increased to above the FEMA floodplain elevation. It may be necessary to incorporate grade breaks greater than currently assumed in the concept development and/or to move the roadway alignment north to provide additional clearance for adjacent properties.

The bridge concept includes a clear span between abutments of 106 feet, a top of deck elevation of approximately 20 feet NAVD88 to accommodate required clearance above the flood elevation, and the required structural depth of the bridge. The deck elevation for the final bridge design may differ somewhat from this concept based on additional data review (e.g., geotechnical borings) data and other considerations.

5.7 Golf Course Stormwater Evaluation

Aspect conducted an evaluation to characterize water quality in runoff from the golf course into the project site. This task also included a high-level review of potential changes to permit requirements of current storm water flows into the project area post-restoration (see Appendix G).

A stormwater grab sample was collected from the primary north-south drainage ditch on the golf course that drains into the project site on October 15, 2021. Evaluation of water quality from that sample showed that the only elevated constituents were fecal and total coliforms which were attributed to bird activity on the golf course. Once the restoration project is completed, the stormwater will be greatly diluted in the much larger tidal prism that inundates the project site compared to the inflow from the ditch into the project area. Therefore, the concentrations of fecal and total coliforms are unlikely to be elevated or impact shellfish operations. No pesticides, herbicides, or elevated metal concentrations were found in the grab sample.

Since operation of a golf course does not require a National Pollutant Discharge Elimination System (NPDES) or State Waste Disposal (SWD) permit, there are unlikely to be any significant considerations to stormwater permitting as a result of the proposed restoration project.

6 Preliminary Design

Based on previous technical work (Anchor QEA 2015, Tuttle Engineering 2016), design charette meetings with project stakeholders (Mickelson and Smith, 2022), and technical evaluations summarized in Section 5 of this report, a preliminary (60%) design for the tidal marsh and a conceptual (10%) design for the transportation improvements associated with restoration design have been developed for the Similk Tidal Marsh Restoration Project.

Design drawings for the design have been developed by Blue Coast and KPFF and are provided in Appendix H. A narrative description of the project elements is provided in Section 6.1 and an Engineers estimate of construction cost for the project is provided in Section 6.2 of this report.

6.1 Project Description

The Similk Tidal Marsh Restoration Project includes creation of a tidal channel network within the project site, connection of that network to Similk Bay through the existing beach berm, improvements to Satterlee Road to provide flood protection to the roadway, removal of the County maintained pump house on the project site, drainage modifications (as needed), and construction of an access corridor from the improved Satterlee Road to the beach berm to retain existing access to SSC for their commercial shellfish operations south of the site. Design drawings for the project are provided in Appendix H which illustrate the details for all of these project elements. A narrative summary of proposed project elements is provided in Table 4.

Table 4: Summary of Project Elements

Project Element	Description
Excavate tidal channels to restore tidal inundation to the historic tidal marsh	• Excavate a primary tidal channel through the beach berm and into the project area to restore tidal inundation to the site. • Excavate additional smaller channels stemming from the primary tidal channel. • Channels should be sized based on restoration of tidal marsh habitat requiring limited interior excavation. • Excavate all tidal channels to the widths and depths that they would have been historically. Do not use pilot channels. • Place 1 foot of streambed sediment in the lower 200 feet of the primary tidal channel. • Use excavated material from the tidal channels to develop discrete locations of higher ground to provide for variation in elevations to facilitate recruitment of different types of vegetation at the site once it is restored.
Improve resiliency of Satterlee Road to flooding	• Based on conversations with Skagit County, Satterlee Road cannot be abandoned as it is the only other road (besides Route 20) that connects between Fidalgo Island and the mainland (Mickelson and Smith, 2022). • Construct a bridge over the primary tidal channel that is resilient to coastal flooding based on County requirements and other relevant design standards. • Increase the elevation of Satterlee Road to be resilient to coastal flooding and flooding from upland run-off based on County requirements and other relevant design standards. The elevated roadway and bridge will also be resilient to climate change over the design life of both structures (see Section 5.2.1) • Remove the County maintained pumphouse and associated infrastructure from the site.
Retain existing onsite SITC access corridor to shellfish beds to the south	• Develop an elevated area to the south of the new Satterlee Road prism that can be used by SITC to maintain access to the commercial shellfish beds located in tidelands to the south and west of the site. • The size and location of the area will be dependent on the specific needs of SITC for use of the area.
Drainage Modifications	• Modify drainage pathways, as needed, to maintain drainage from adjacent upland areas into Similk Bay.
Golf Course Modifications	• Identify areas along the southern perimeter of the SITC golf course (located to the north of the project area) that may be inundated at higher tides due to the proposed restoration at the project site. • Design of specific golf course modifications to address expected inundation was not conducted as part of preliminary design.

6.2 Engineer's Opinion of Construction Cost

Based on design elements illustrated in the design drawings in Appendix H, the narrative in Table 4, the level of design for the tidal marsh excavation (~60%) and transportation improvements (~10%), an engineer's opinion of construction cost has been developed for the project as provided in Table 5.

Table 5: Summary of Probable Construction Costs

Project Element	Unit	Unit Cost[8,9]	Total[8,9] (rounded)
Transportation Improvements[1] (mobilization in lump sum costs)			
Construct ~105-ft span roadway bridge[1]	1 lump sum (LS)	$2,600,000	$2,600,000
Roadway and utility improvements[1].	1 LS	$960,000	$960,000
Mobilization and Design Contingencies[1]			*$1,415,000*
Subtotal			***$4,975,000***
Tidal Marsh Restoration[2]			
Channel excavation, re-use on site[3]	5,000 Cubic Yards (cy)	$45/cy	$225,000
Channel excavation, dispose of offsite[3]	1,500 CY	$90	$135,000
Place fish mix substrate in channel under bridge and to beach connection[4]	400 CY	$113	$45,000
Golf Course Improvements[5]	1 LS	$150,000	$150,000
Marsh Plantings[6]	40,000 square feet	$2/square foot	$80,000
Shellfish Access Area Fill[7]	2,000 CY	$60	$120,000
Drainage Improvements[7]	1 LS	$40,000	$40,000
Mobilization (10%) and Contingency (10%)			$160,000
Subtotal			***$955,000***
		Total Cost	***$5,930,000***

Notes:

1. Input on potential ROM costs for transportation improvements provided by KPFF, see Appendix F
2. Costs for tidal marsh restoration project elements developed by Blue Coast Engineering
3. Quantities based on Preliminary Design Drawings provided as Appendix H
4. Quantity based on placing a 1-foot-thick layer of stream bed sediment along the lower 200 linear feet of the primary tidal channel (see Appendix H)
5. ROM costs based on basic changes to impacted tee and green areas, no significant redesign.
6. Planting plan to be designed by others (likely SRSC staff) as part of final design of the restoration project. Cost estimate assumes a planting corridor at the upper ends of the marsh about 2,000 linear feet around the outside of the marsh and 20 feet wide.

Table 5 Notes, continued

7. Costs based on conceptual design. Details to be determined during final design for the project.
8. All costs are in 2022 dollars.
9. In providing opinions of probable construction cost, SRSC understands that Blue Coast and it's subconsultants (KPFF) have no control over the cost or availability of labor, equipment or materials, or over market condition or the Contractor's method of pricing, and the consultant's opinions of probable construction costs are made on the basis of the Consultant's professional judgment and experience. The Consultant makes no warranty, expressed or implied, that the bids or the negotiated cost of the work will not vary from the Consultant's opinion of probable construction cost.

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FIGURES

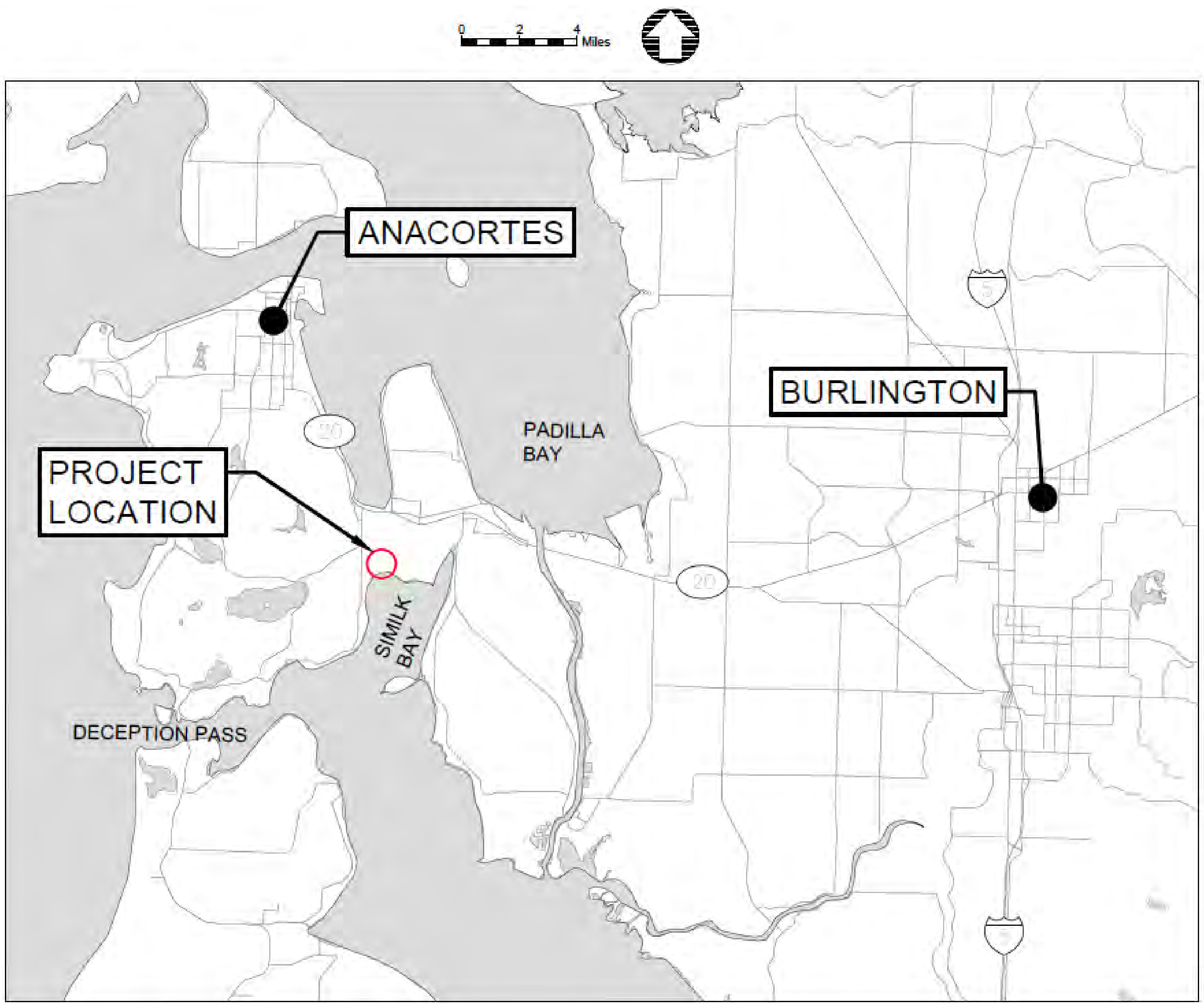

Figure 1: Project Site Vicinity Map

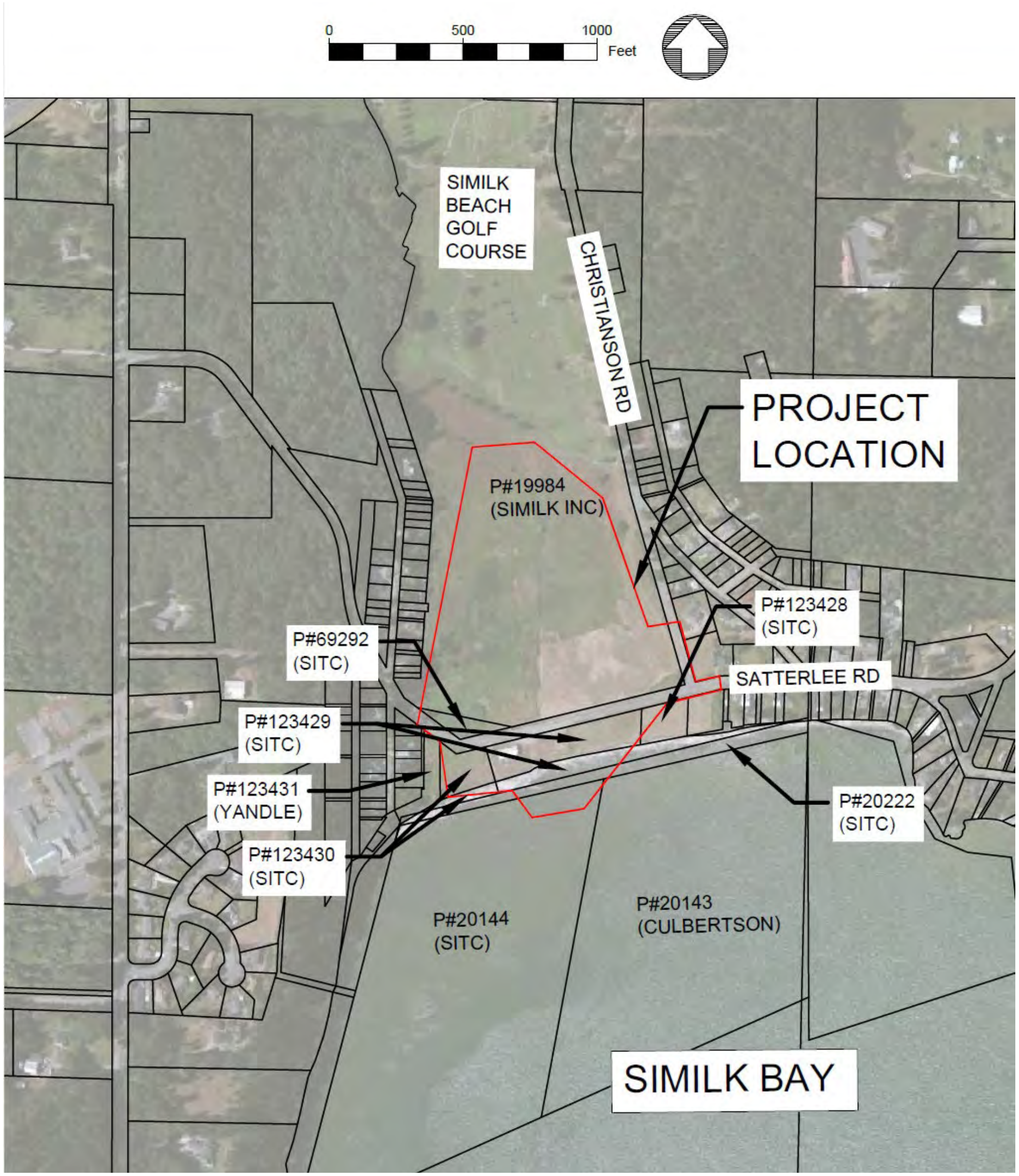

Figure 2: Project Site Location Map and Property Ownership

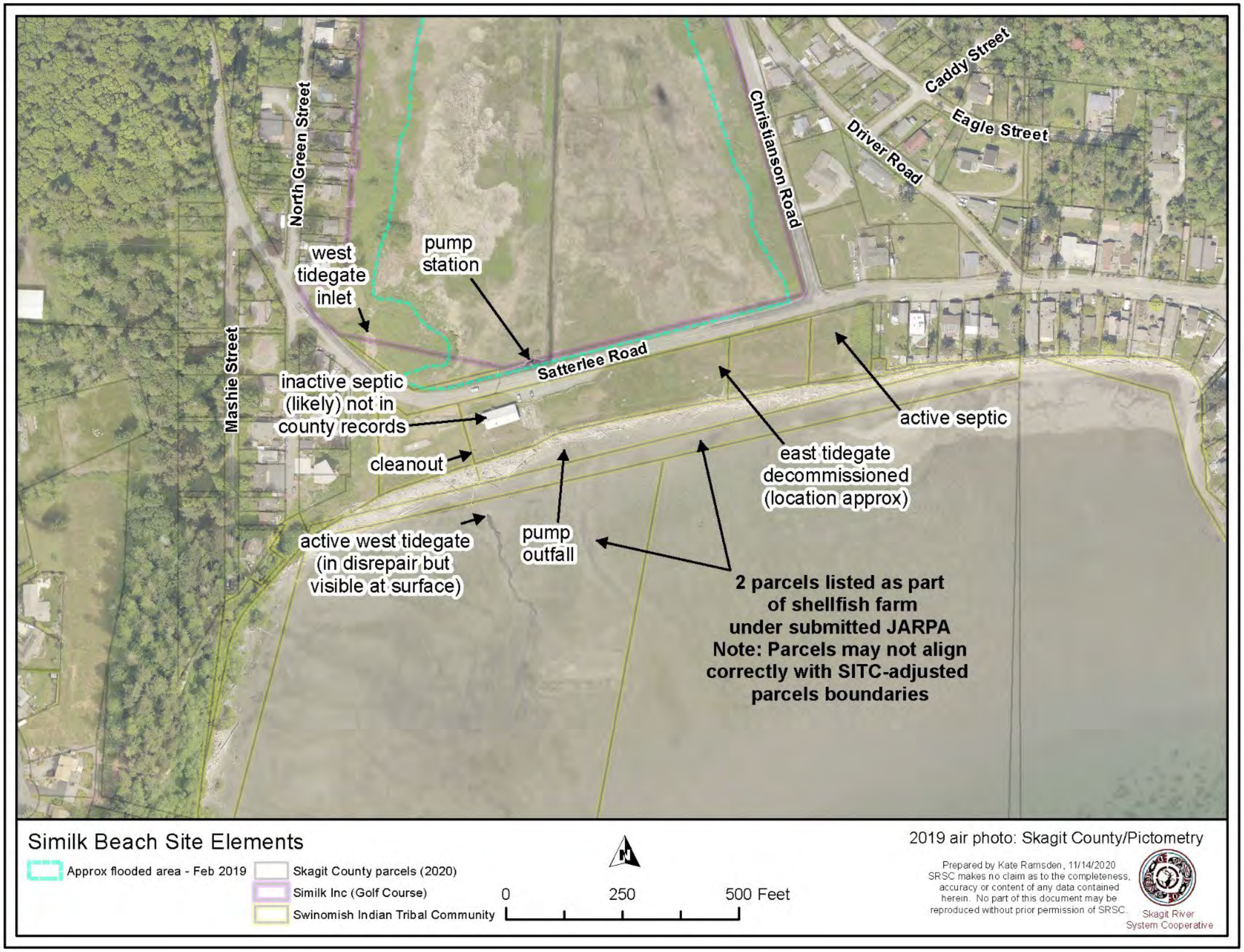

Figure 3: Roads and Known Drainage Infrastructure at Project Site (Figure developed by SRSC)

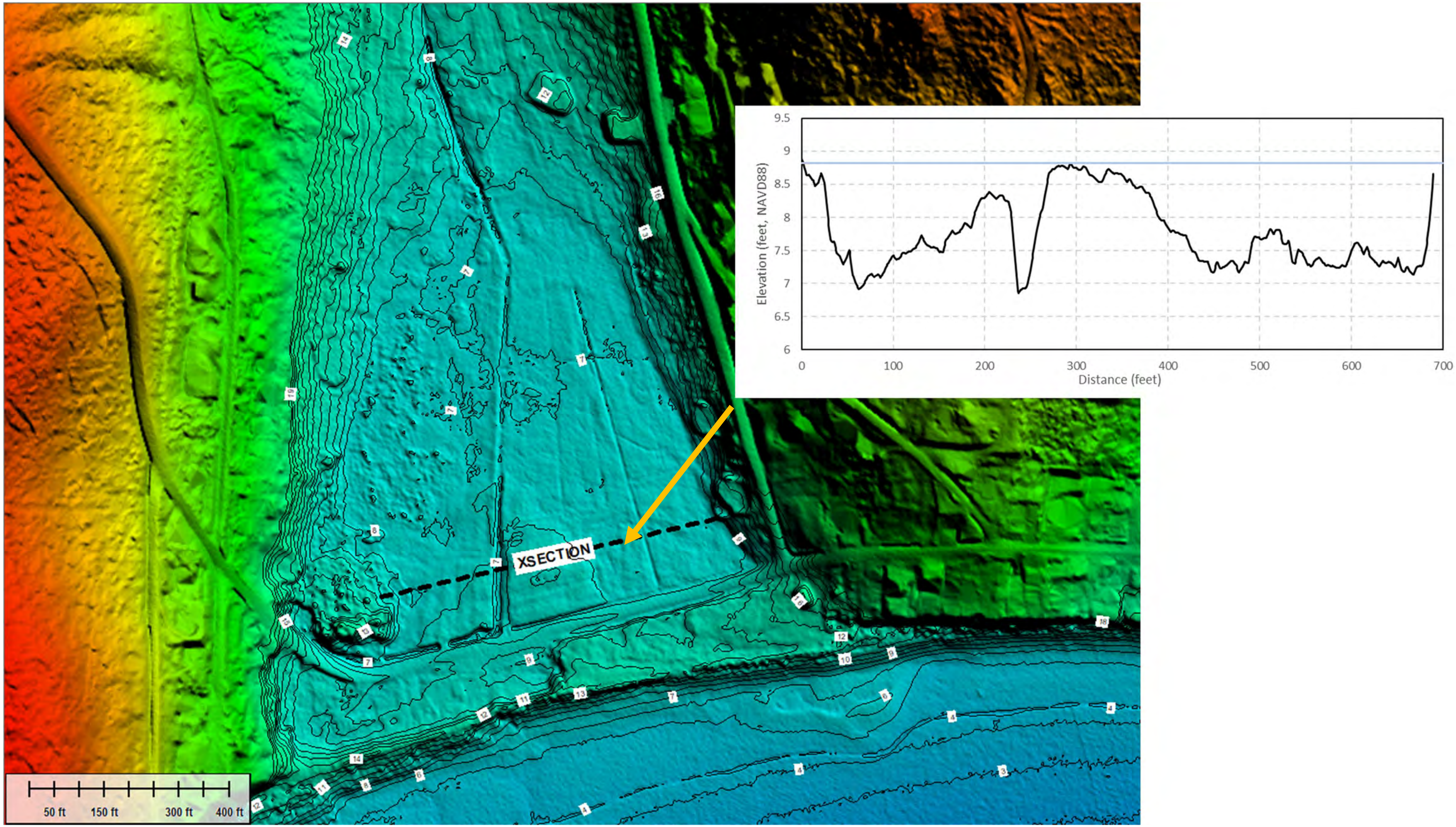

Figure 4: Project Site Topography (LiDAR only)

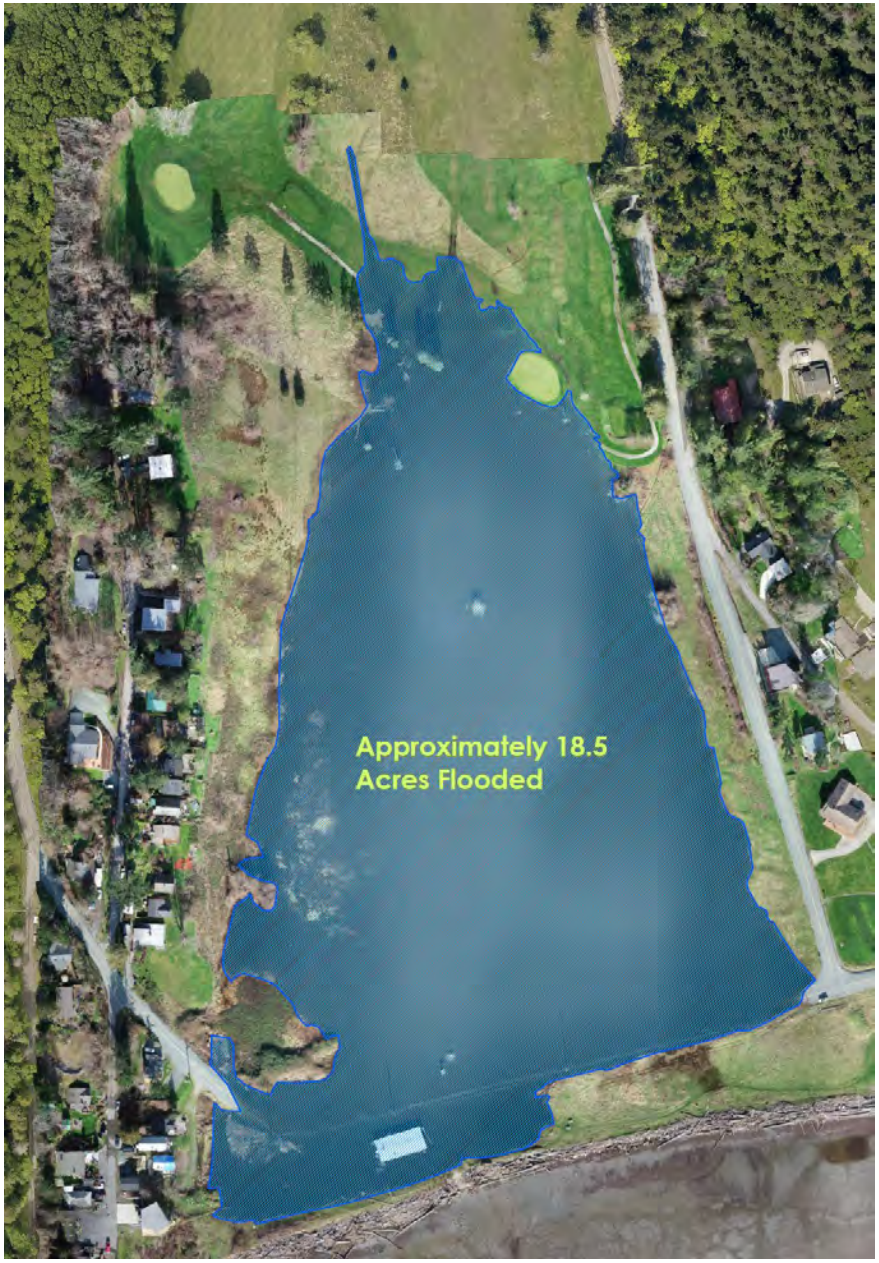

Figure 5: Extent of Flooding due to Pump House Failure, December 2020 (Image Provided by SRSC)

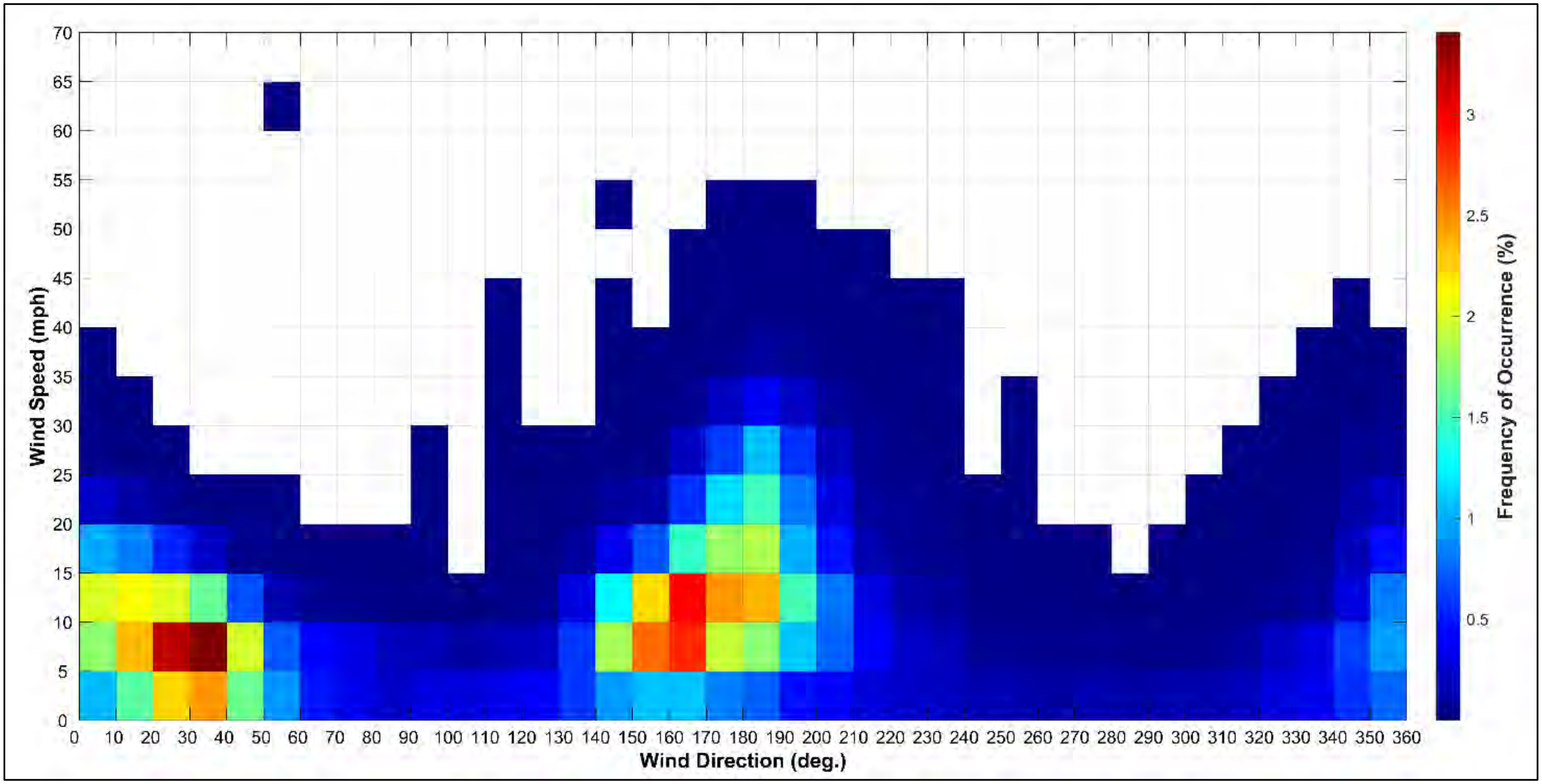

Figure 6: Joint probability plot of wind speed versus wind direction for the West Point meteorological station from 1975 to 2019.

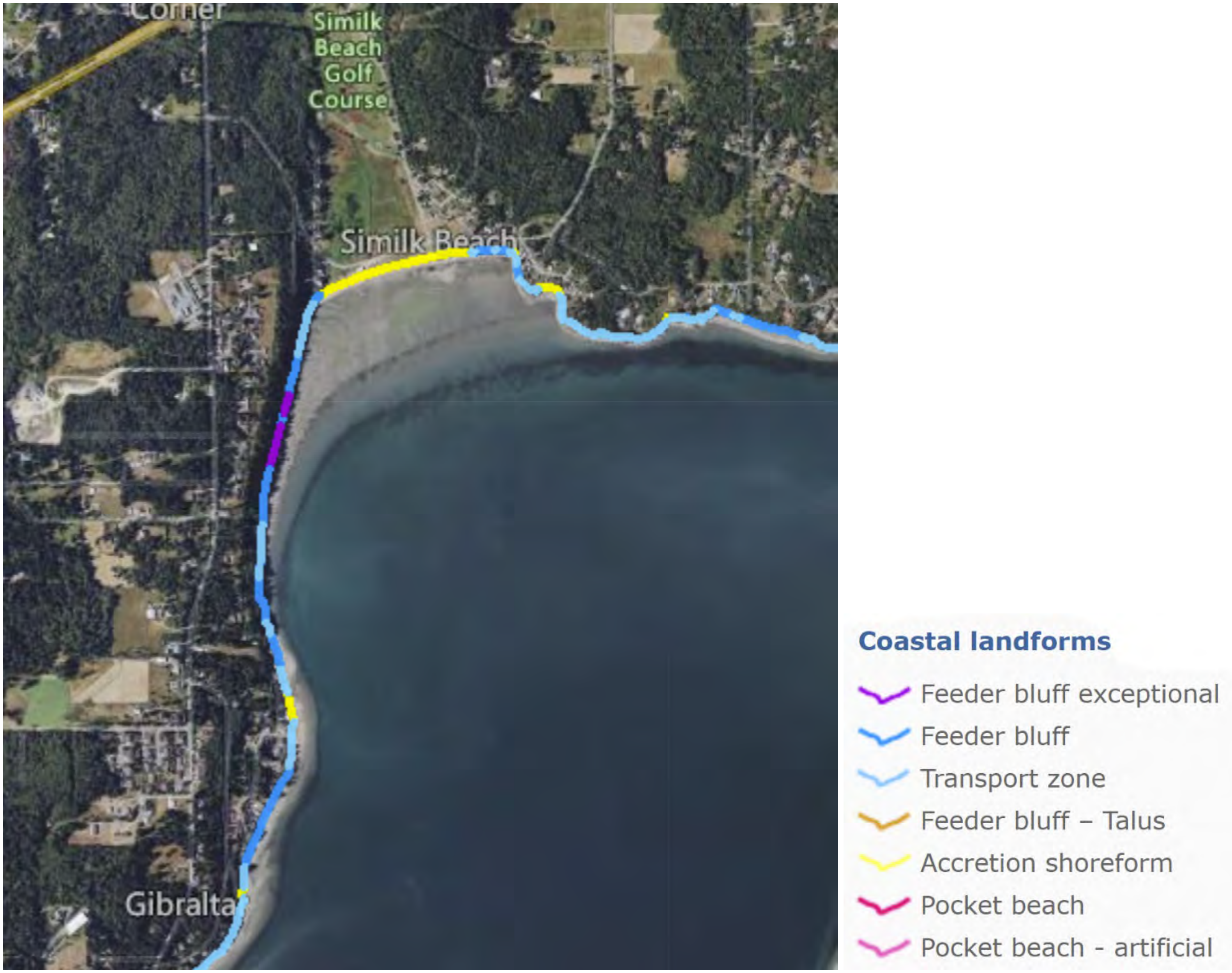

Figure 7: Coastal Landform Mapping at Project Shoreline (WA Department of Ecology Coastal Atlas)

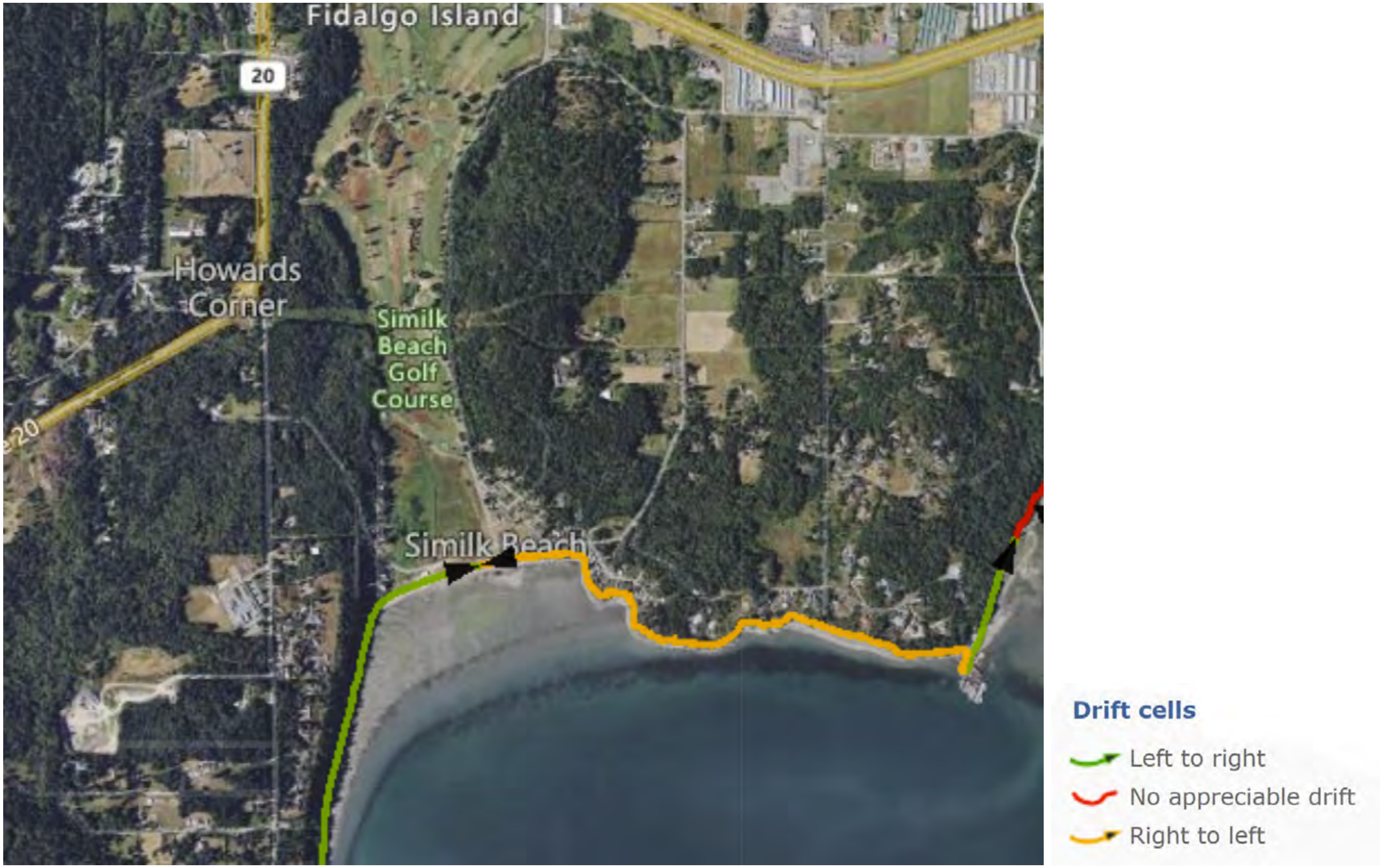

Figure 8: Net Littoral Drift Direction at Shoreline Location (WA Department of Ecology Coastal Atlas)

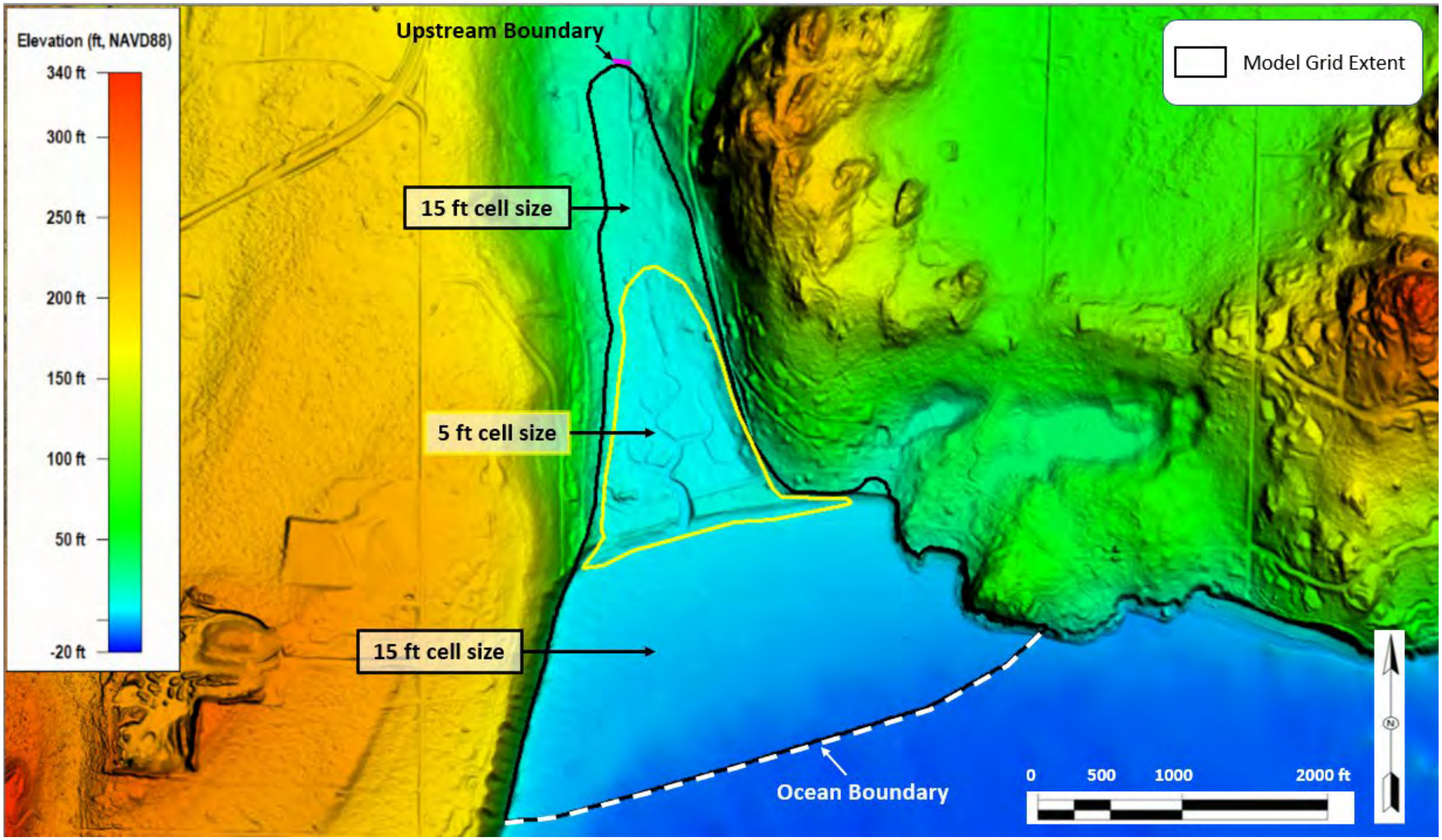

Figure 9: Hydrodynamic Model Grid Resolution.

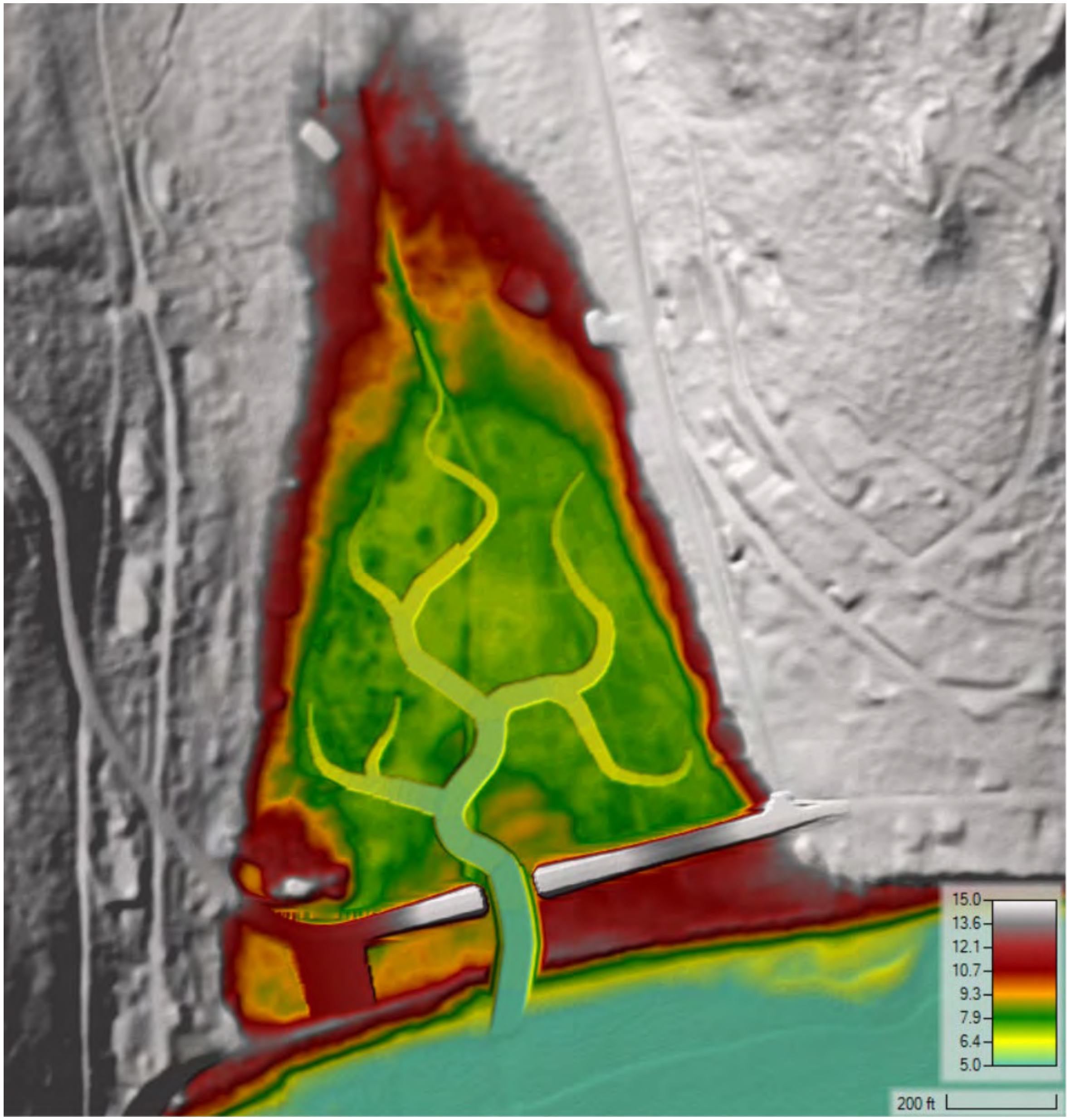

Figure 10: Digital Elevation Model (DEM) of Proposed Restoration (Tidal Channels) Used in Model

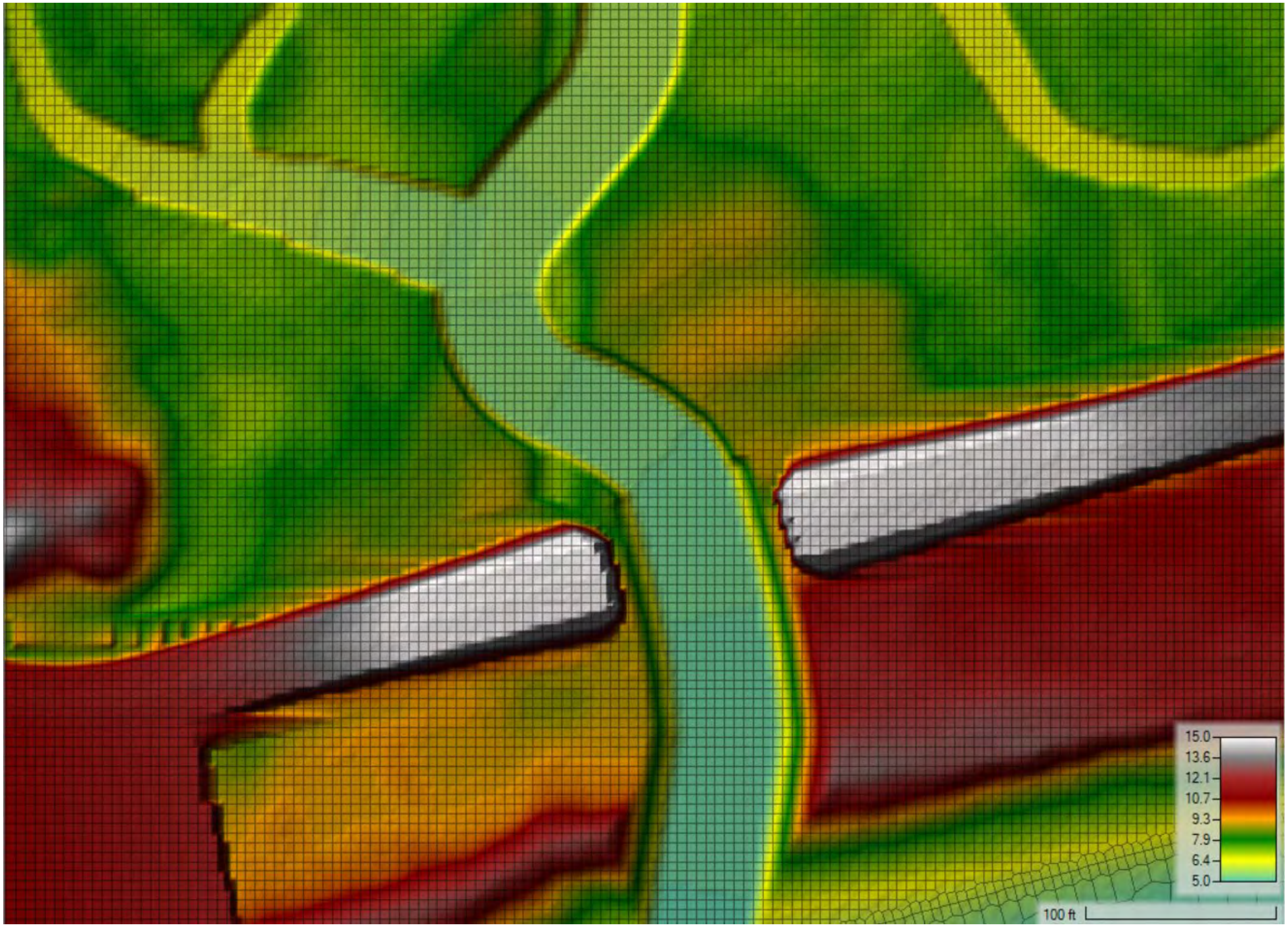

Figure 11: Grid Resolution Relative to Channel Size

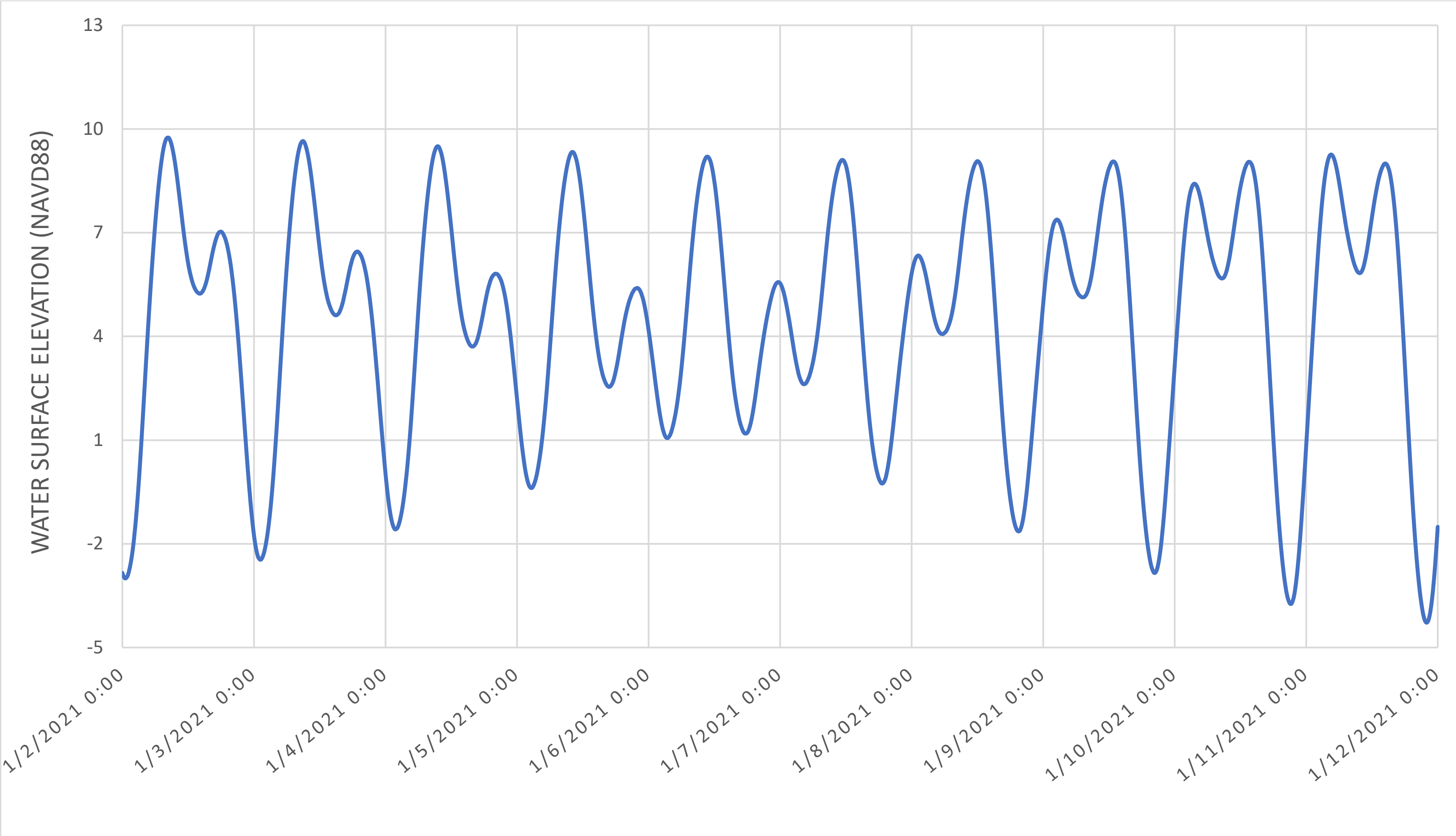

Figure 12: Tidal Time Series at Turner Bay used in Model Simulations

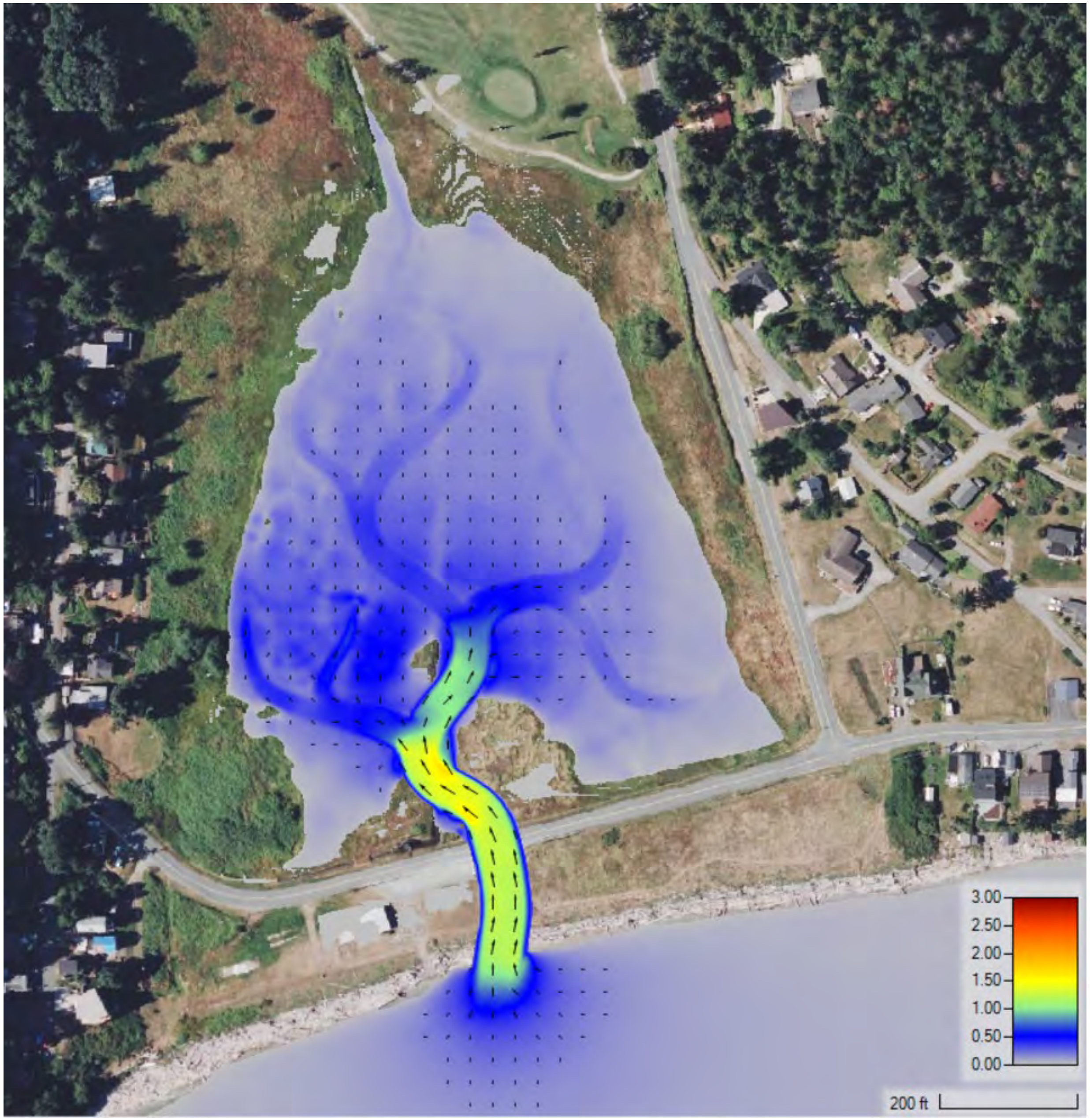

Figure 13: Peak Flood Tide Velocities in Restored Salt March

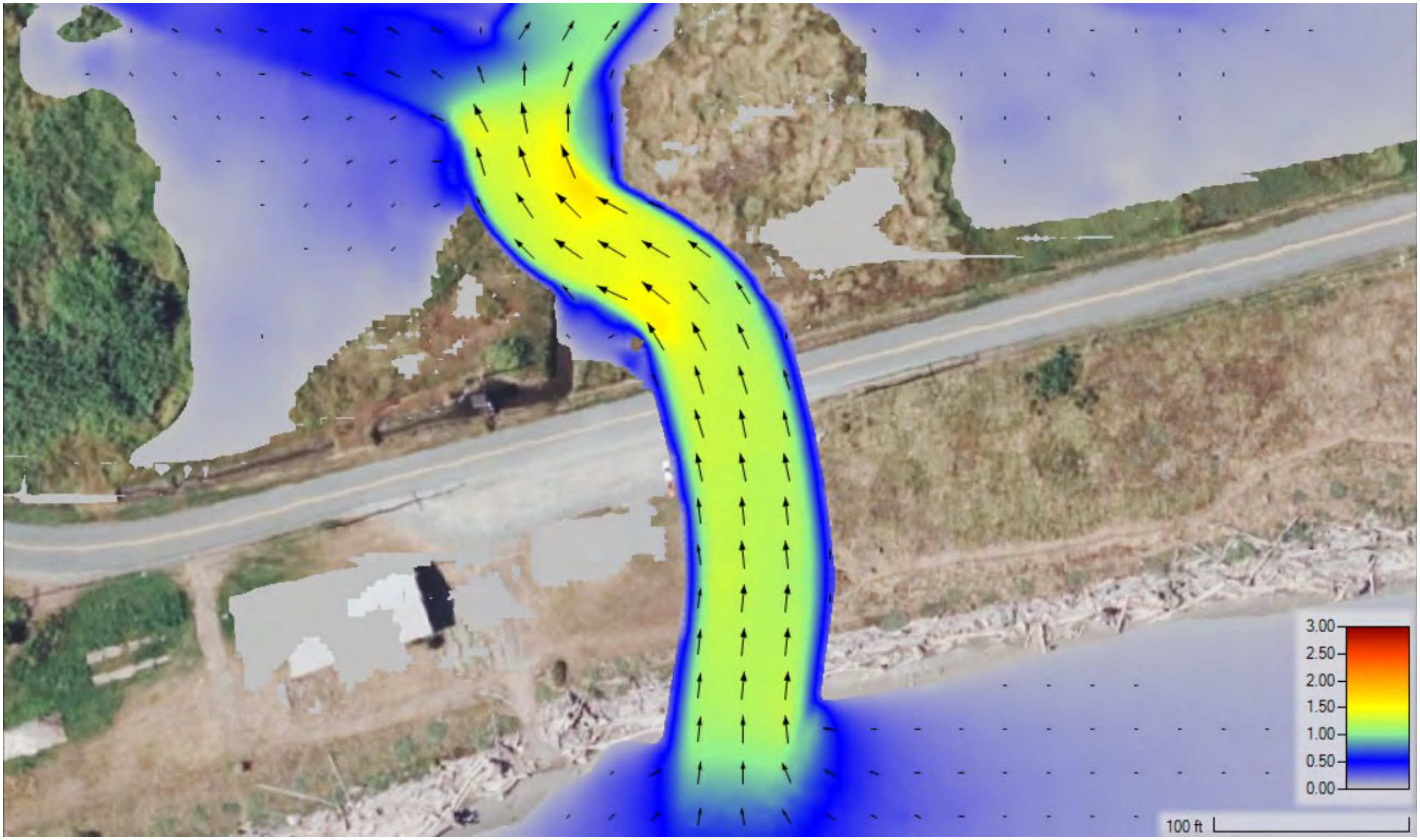

Figure 14: Peak Flood Tide Velocities in Restored Salt March (Channel Detail)

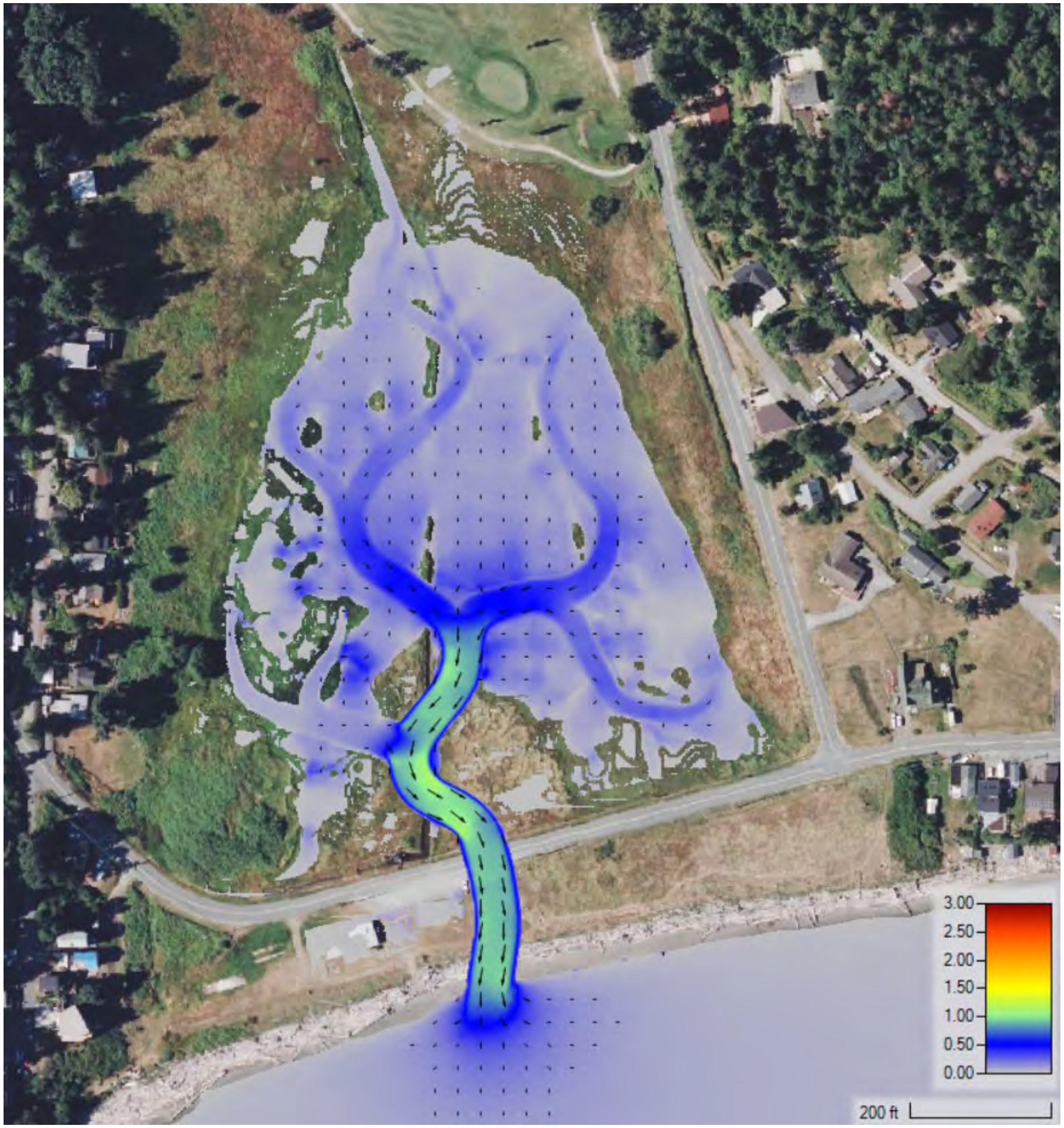

Figure 15: Peak Ebb Tide Velocities in Restored Tidal Marsh

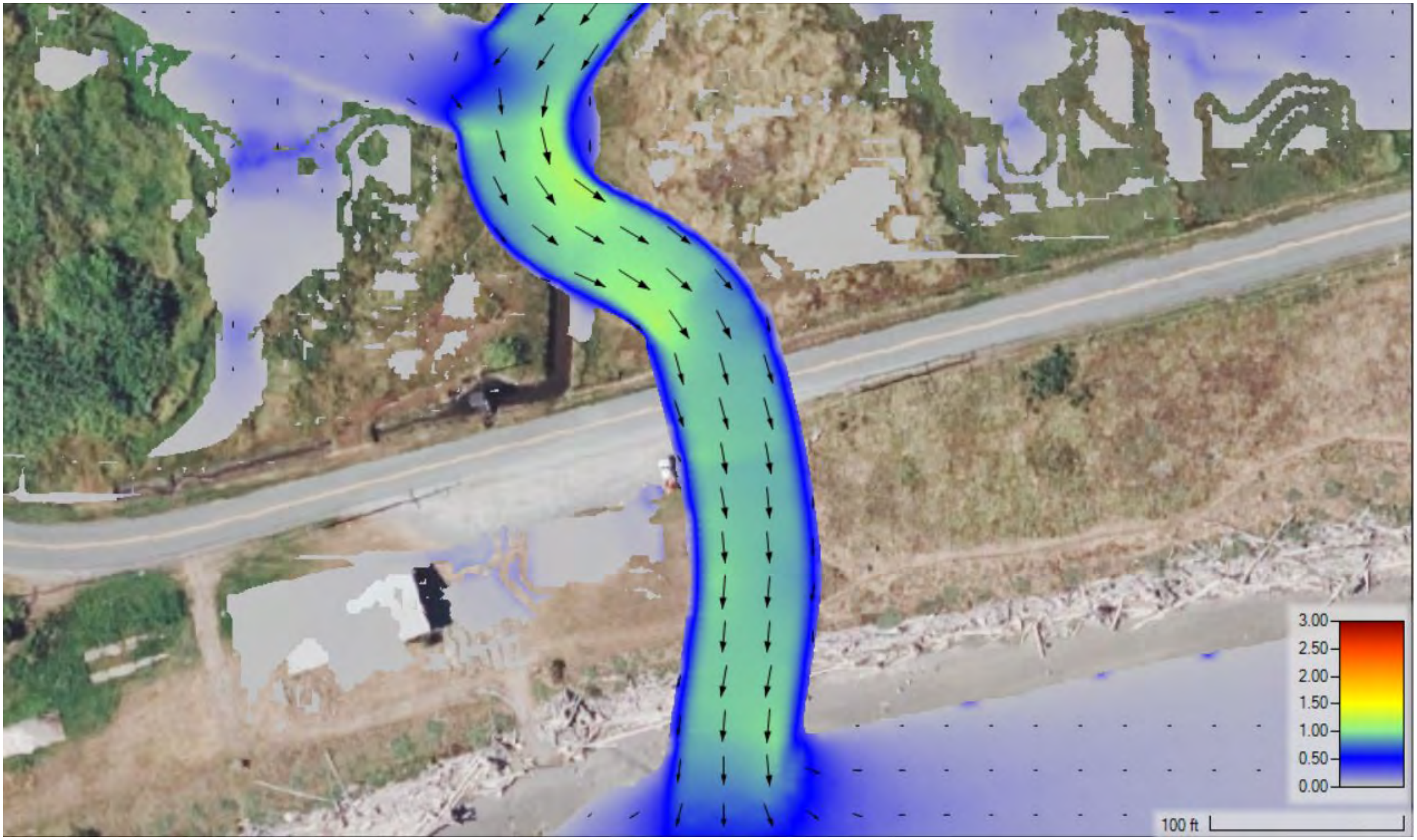

Figure 16 Peak Ebb Tide Velocities in Restored Salt March (Channel Detail)

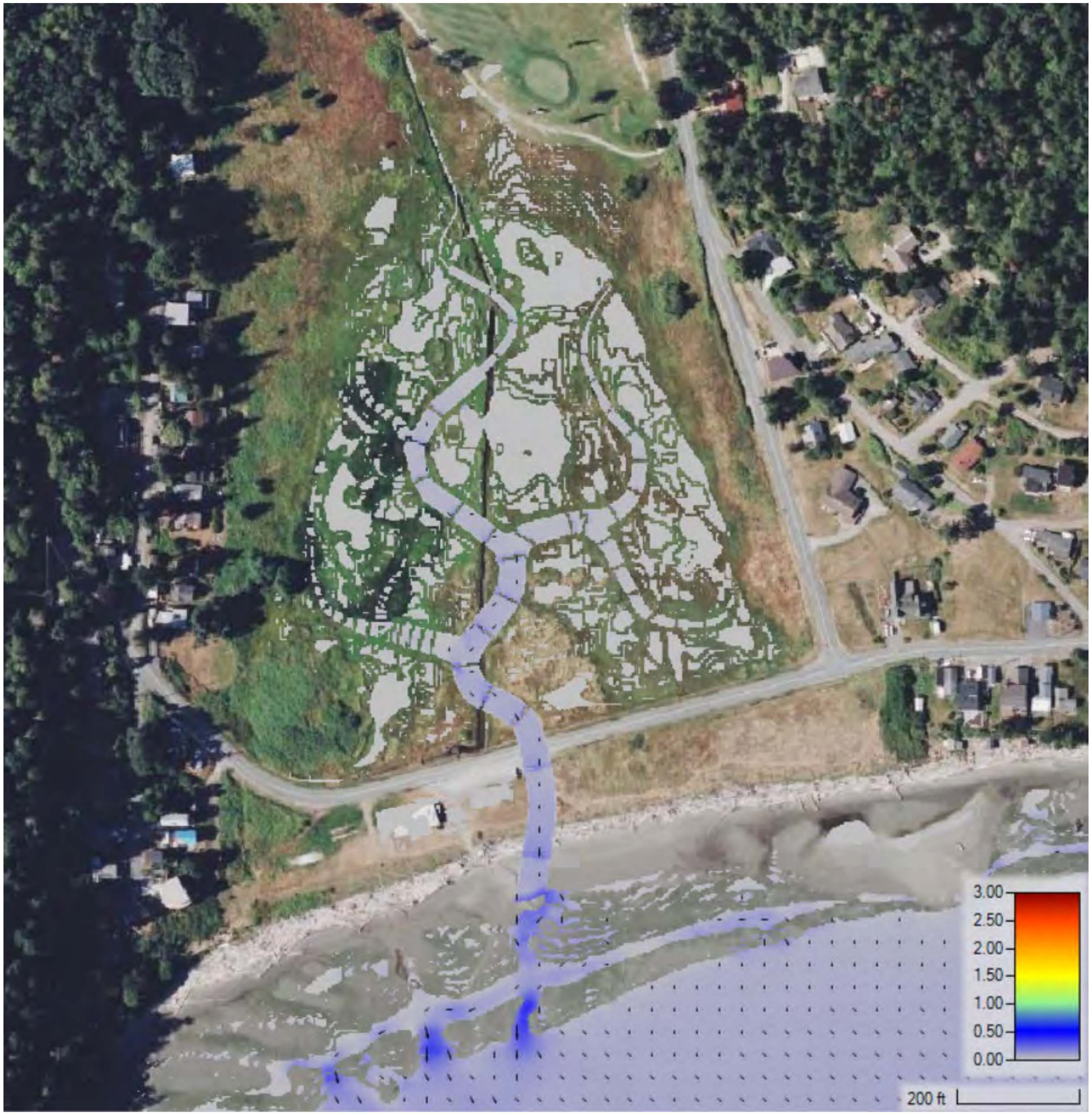

Figure 17: Velocities at Low Tide on Adjacent Shoreline

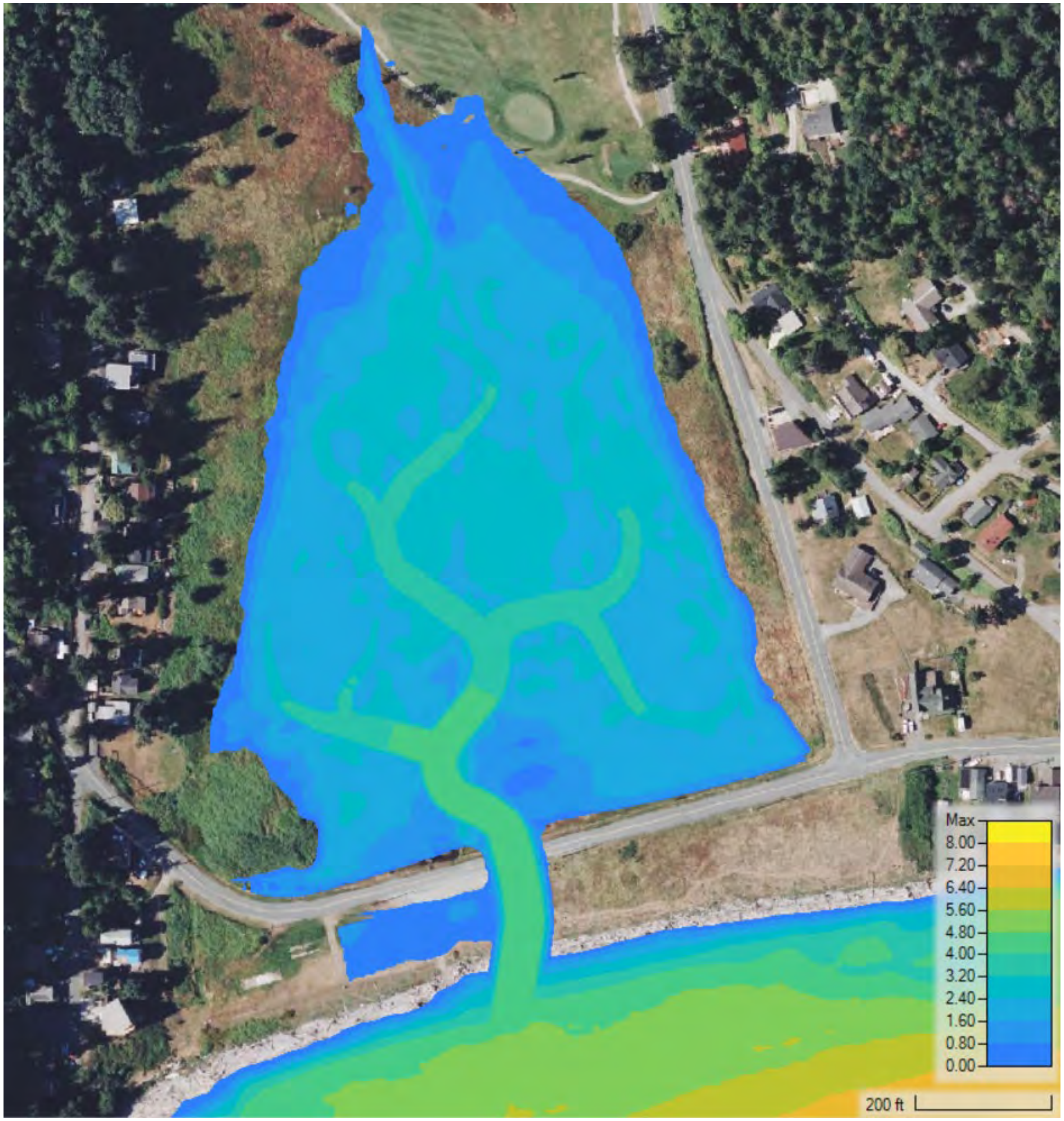

Figure 18: Water Depth in Restored Salt Marsh at High Tide (~11.5 feet MLLW)

Appendix A
Site Photographs

Photograph 1 – Upland Area (Historic Tidal Marsh) Looking North

Photograph 2 – Upland Area (Historic Tidal Marsh) Looking South West

Photograph 3 – Central Drainage Ditch Looking North Across Satterlee Road

Photograph 4 – Pumphouse and Adjacent Drainage Ditches Looking West

Photograph 5 – Upland Area of Site (including Satterlee Road) Looking North

Photograph 6 – Upland Area South of Satterlee Road Looking South

Photograph 7 – Upland Area South of Satterlee Road Looking North West

Photograph 8 – Power Lines Along Satterlee Road Looking North

Photograph 9 – Shoreline at Project Site Looking South West

Photograph 10 – Shoreline at Project Site Looking South East

Photograph 11– Intertidal Beach Adjacent to Site Looking South

Appendix B
Project Scoping Report (Mickelson and Smith, 2022)

SIMILK TIDAL MARSH RESTORATION

Project Scoping Report

Skagit River System Cooperative

Eric Mickelson and Devin Smith

La Conner, WA

March 22, 2022

INTRODUCTION

Overview

The Similk Tidal Marsh is a historic 17-acre barrier embayment (Shipman 2008), located on the margin of Similk Bay, part of the southern shoreline of Fidalgo Island in Skagit County, Washington (Figure 1). The site is located within a single day's migration from the Skagit River delta by fry migrant Chinook salmon (SRSC and WDFW 2005) and has been isolated from tidal processes and fish access by the construction of a County road and berm along the beachfront. The purpose of this report is to document the process by which our design team has evaluated the feasibility of restoring tidal inundation and access for juvenile Chinook and other salmon to the project site. This process has occurred in stages over time, and has included two previous studies to evaluate opportunities, constraints, and risks, and to assess alternative restoration concepts. We summarize the findings from these studies here, although they are also available as full reports for greater detail. We have sought input from a variety of project partners and design team members throughout the feasibility and conceptual design process, and we document the concerns and suggestions gathered during several meetings within this report. This document is intended to provide context and support for our selection of a preferred restoration alternative, which will be described in detail in a separate report and which will serve as the basis for the preliminary design phase of the project.

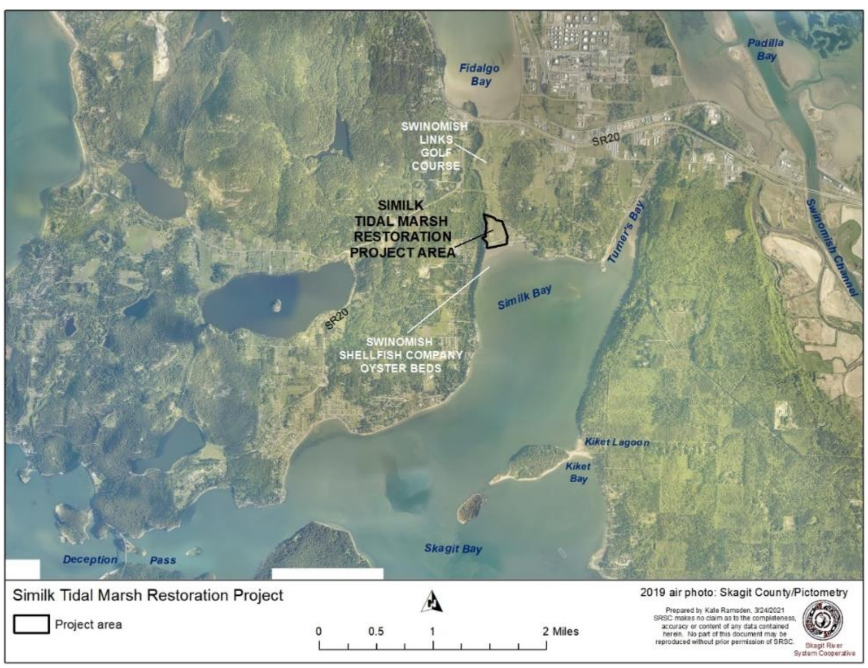

Figure 1. Similk Tidal Marsh Restoration Project location.

Project Goals and Objectives

This report documents the process by which our design team reviewed previous feasibility work, incorporated design team and partner input, and selected a preferred restoration action to achieve the following goals:

1. Sustainably restore natural processes, conditions, functions, and biological responses to approximately 17 acres of historic tidal marsh habitat along the northern shoreline of Similk Bay.
2. Restore critical estuarine rearing habitat for ESA-listed juvenile Chinook salmon during the early phases of their oceanward migration.
3. Restore estuarine habitat for other fish species, including other juvenile native salmonids and forage fish, as well as for other wildlife species (particularly marsh birds).
4. Implement restoration actions that are compatible with adjacent land uses, including private residences to the east and west, a shellfish farm on the tide flats to the south, a golf course to the north, as well as with adjacent transportation and utility corridors.

To do this, we have completed the following objectives:

1. Evaluate alternatives for removing, relocating, or elevating Satterlee Road to facilitate excavation of a tidal channel connecting Similk Bay to interior marsh habitat.
2. Assess geomorphic and hydrodynamic factors, including geology, topography, wind-wave energy, shoreline orientation, sediment supply, tidal elevations, and current velocities, to help evaluate likely channel location, dimensions, sustainability, inundation footprint, and site evolution.
3. Conduct a risk assessment to determine the effects of restoration actions on adjacent properties and land uses, such as the nearby shellfish farm, golf course, and private residences (including on wells and septics) as well as impacts to transportation and utility corridors.
4. Solicit and incorporate input from project partners, including representatives from SITC government, the Swinomish Shellfish Company, Skagit County, and Similk, Inc (Swinomish Golf Links).

Review of Conceptual Design

In 2018, SITC and SRSC submitted a preliminary design proposal to the Washington State Recreation and Conservation Office Salmon Recovery Board (SRFB). The project was successfully funded, but the SRFB review team noted that little justification was provided for dismissing restoration alternatives involving road relocation as too expensive, even though such a design would “allow for more complete restoration of the tidal connection between the marsh and Puget Sound” in addition to providing flood protection and debris passage benefits (SRFB 2018). The reviewers also questioned the proposed use of riprap in the outlet channel at the bridge crossing and suggested moving the outlet channel location away from the edges of the site to avoid potential impacts to neighboring beaches and properties.

Members of the design team agreed with these critiques, and also had some reservations about the proposed use of a soldier pile wall along much of the length of Satterlee Road, which was a component of the conceptual design outlined in an earlier feasibility and design report (Tuttle 2016). Although it would likely be an effective method of limiting the road fill footprint, it would also be expensive to install and maintain, would require ongoing pumping to drain the road corridor, and would create an unappealing sightline for visitors to the newly completed restoration project. Additionally, the sinuous tidal channels proposed by the 2016 Tuttle report did not appear to be representative of the dimensions and configuration of channels found in similar reference marshes or what was mostly likely present on the site historically

As a result, the design team opted to revisit the conceptual design phase to more fully evaluate the feasibility of relocating or altogether removing Satterlee Road at the mouth of the historic estuary, and to reconsider some of the other assumptions carried through the initial feasibility studies, including the outlet channel location. This work included a design charrette and series of meetings with project partners and the design team that was intended to evaluate and refine the restoration project concepts. We summarize the discussions and decisions from these meetings below, following an overview of site conditions and a review of previous feasibility and design work.

BACKGROUND

Site Description and Land Use

The project area is located on the southern portion of a 103-acre parcel owned by Similk Inc, a Swinomish Indian Tribal Community (SITC) -owned corporation. The historic barrier embayment is located on the shoreline of Similk Bay, and is bounded to the east and west by uplands that are currently occupied primarily by residential neighborhoods. To the north of the project site, the topography remains relatively flat, with elevations not much greater than those within the estuary until it meets Fidalgo Bay 0.9 miles to the north. The majority of the area north of the project site is occupied by the Swinomish Golf Links golf course, which is owned by SITC. Much of the course is fringed by forested uplands, and interior drainage networks convey water from these uplands through the golf course towards the project site or to a pump station at Fidalgo Bay. Christensen Road runs from north to south along the east edge of the golf course and the project site before intersecting with Satterlee Road, which runs east-west along the Similk Bay shoreline. Both roads are owned by Skagit County.

Tidal exchange between Similk Bay and the historic estuary is blocked by Satterlee Road and a berm along Similk Beach. The site was ditched and drained for agricultural purposes, and a remnant north-south ditch conveys fresh water draining to the site towards a discharge point at Satterlee Road. This ditch and tile network currently links to a pump station operated by Skagit County (Figure 2). No tide gates or channels connect Similk Bay to the historic estuary area. As a result, the site is occupied by a mosaic of noxious weeds, reed canarygrass (*Phalaris arundinacea)* and cattail (*Typha spp.*) wetland, with scattered trees and Himalayan blackberry (*Rubus armeniacus*) throughout. Occasional problems with the pump station during the winter months have led to flooding of Satterlee Road and the interior of the project site. Recent flooding events occurred over several months during winter 2019/2020 and again in November through January 2021/2022.

The tidelands adjacent to the beach and to the southwest of the project site are owned by SITC and are the site of shellfish beds owned and managed by the Swinomish Shellfish Company (SSC) while the tidelands to the southwest are privately owned. SSC utilizes a concrete pad along Satterlee Road at the southwest edge of the project site for shellfish harvest operations.

Figure 2. *Washington Department of Ecology Oblique. August 18, 2016. Satterlee Road runs east-west along the shoreline, and a north-south ditch (center of photo) drains upland water to a Skagit County-owned pump station.*

Habitat

Embayments such as the Similk Tidal Marsh, known as pocket estuaries, are attractive to juvenile Chinook and other salmon because freshwater inputs mixing with tide waters measurably reduce salinity compared to the adjacent nearshore, allowing fish to more gradually acclimate to the saltwater environment as they migrate oceanward from their natal rivers (Beamer et al. 2003, Beamer et al. 2005). Such habitats also serve as refuges from predators that may inhabit deeper waters adjacent to nearshore habitat (Beamer et al. 2003), and the detrital food webs associated with tidal salt marshes offer increased prey opportunities for juvenile salmon (Hood 2009). Combined, these factors have been shown to lead to growth and survival advantages for fish utilizing pocket estuaries compared to fish in adjacent nearshore habitat (SRSC and WDFW 2005). In the Whidbey Basin, 89% of historic pocket estuaries are now inaccessible to juvenile Chinook (SRSC and WDFW 2005).

Previous studies (Beamer et al. 2003 and Beamer et al. 2006) have demonstrated that fry migrant and nearshore refuge-rearing wild Chinook fry typically utilize pocket estuary habitat from February through May each year, and fish densities within pocket estuary habitat can be up to 20 times higher than in adjacent nearshore areas. The studies noted that these patterns have been observed in sites up to 25 km away from natal Chinook rivers. At the Similk Tidal Marsh, roughly 17 acres of habitat are expected to be inundated during high tides, while at lower tides inundation will be limited to tidal channels within the site.

At other pocket estuary restoration sites, juvenile Chinook have been found to utilize small streams entering the estuaries in addition to the restored estuary habitat (Beamer et al. 2009, Beamer et al. 2013). At the Similk restoration site, freshwater enters the site via drainage pathways that pass through the golf course located to the north of the estuary; some of these would likely be accessible to juvenile Chinook following restoration of tidal inundation to the site.

PREVIOUS FEASIBILITY AND DESIGN WORK

Anchor QEA, 2015. Coastal Engineering Evaluation and Risk Assessment- Similk Bay Estuary Restoration.

In 2015, the Skagit River System Cooperative (SRSC) contracted Anchor QEA, LLC to conduct a preliminary coastal engineering assessment and risk assessment for the Similk Tidal Marsh Project (Anchor QEA 2015). The stated purpose of this work was to support a feasibility analysis and to identify potential risks to private property and public infrastructure resulting from a range of potential restoration actions. The analyses completed by Anchor QEA also included preliminary evaluation of the resiliency of the proposed restoration actions to predicted sea level rise impacts.

For the assessment, SRSC and SITC, with input from Anchor QEA, proposed five initial restoration concepts for evaluation, including:

1. Remove the road and remove the berm along the beach to allow tidal inundation in the historic estuary (no channel excavation).
2. Remove the road and remove the berm along the beach to allow tidal inundation in the historic estuary; excavate one or more channels into the estuary.

3. Remove the road and remove the berm along the beach to allow tidal inundation in the historic estuary; excavate one or more channels into the estuary and excavate some areas inside the estuary to lower existing grade.
4. Relocate the road upland at the boundary of the project site and the golf course and remove the berm along the beach to allow tidal inundation in the historic estuary; excavate one or more channels into the estuary
5. Remove the berm along the beach, retain the existing road alignment and increase the height of the road to raise its elevation to avoid flooding due to coastal storms. Construct a bridge along the road alignment to allow for a single excavated channel into the estuary.

Of these, alternatives 1 and 5 were selected for coastal engineering evaluation because, of the range of potential concepts, these were the most different in terms of post-restoration hydraulic conditions. Alternatives 3 and 4 were thought to be too costly to construct unless necessitated by site constraints, so these were evaluation of these was deferred pending the results of the initial analysis.

For Alternative 1, Anchor QEA assumed that the Satterlee Road and berm fill was removed to match the existing grade in surrounding areas (roughly 8.0 feet NAVD88). This was expected to allow restoration of tidal inundation to the site at higher tides, and sediment deposition within the site was expected to lead to create marsh or mudflats with eventual natural formation of shallow tidal channels.

Alternative 5 was modeled with an 80 foot wide channel from Similk Bay into the project site to allow greater tidal interchange with the bay and a deeper entrance channel. Thalweg elevation was assumed to be 7.0 feet NAVD88. While the modeled thalweg elevation was within the observed range for reference estuaries, width for the modeled channel is larger than the 10-50 foot range of channel widths observed in similarly-sized sites; this was done to maximize flooding potential within the site to allow for a more conservative assessment of risk.

Coastal Engineering Evaluation

The coastal engineering evaluation involved compiling and reviewing long-term hourly wind data, topography and bathymetry data at the site and throughout Skagit and Similk Bay, and tidal datum information. Hydrodynamic conditions were determined for existing and future conditions using 2-D hydrodynamic (Delft3D-FLOW) and wave transformation (Delft3D-WAVE) models for which model grids were extended into the project site as part of this work. Model results include water levels, depth-averaged velocities, significant wave heights and wave periods in the nearshore area and within the estuary. Tides from July 2000, which include king tide elevations as well as smaller tidal swings, were used to ensure that a wide range of hydraulic conditions were represented in model results. Wind speeds for the 20-year storm event at directions that could create waves that might impact the site (130 and 180 degrees) were selected. An existing conditions tidal simulation was used as validation for the model; these were compared to NOAA tidal stations at several locations.

The hydrodynamic model results indicated that tidal inundation within the site for Alternative 1 was controlled by the elevation of the fill remaining between the interior of the site and Similk Bay, and results in overtopping at high tides and then interior ponding as the tide recedes. Conversely, tidal inundation for Alternative 5 was controlled by the channel thalweg elevation, resulting in less interior ponding. For Alternative 5, current velocities were large enough at some tides to limit sedimentation within the channel long-term. For Alternative 1, current velocities were potentially large enough at some tides to allow small tidal channels to naturally form, but these are anticipated to take a long time to develop, and might be more likely to fill and close over time. The wave transformation model results indicated that waves within the estuary are likely to be minimal and only occur during high winds at higher tides.

Risk Assessment

Fine-grained, consolidated soil conditions surrounding the project site indicated minimal likely influence to groundwater from tidal inundation. An open channel connection to the bay limits risk of flooding from upland drainage, and similarly tidal inundation was not expected to flood adjacent residences. More detailed information was required to fully assess risk to septic systems, but most residences with identified septic systems were high enough above the project site that risk was thought to be minimal. A small number of properties at lower elevations will be looked at more closely to ensure that restoration actions will not adversely affect septic system function. Management of groundwater and drainage adjacent to the site was not expected to require major infrastructure upgrades, though some small improvements may be necessary in some locations.

Anchor QEA recommended collecting data on septic system elevations for properties adjacent to the project site to help refine assessment of risk. Additional recommended work included surveying and collecting information on public infrastructure within the site and a drainage analysis to quantify surface and groundwater volumes.

Tuttle Engineering and Management. 2016. Feasibility Design Report: Similk Bay Estuary- Satterlee Road Bridge Project.

Following the 2015 coastal engineering and risk assessment, SRSC contracted with Tuttle Engineering and Management (TEAM) to develop a conceptual-level (10%) design for restoration at the project site (Tuttle 2016). The design developed by TEAM most closely aligned with Alternative 5 from the previous study, with a bridge over an 80 foot wide channel, but TEAM proposed a lower thalweg elevation (6.0 feet NAVD88) and also moved the outlet channel from the center of the project site toward the eastern edge in an effort to minimize fill needed for bridge approaches. Similarly, a soldier-pile wall was proposed along the north side of Satterlee Road (except for the bridge area) instead of elevating the entire roadway. This was intended to prevent backwatering of the road from the marsh interior while minimizing habitat impacts to the estuary associated with the greater fill footprint required for an elevated road. They note that this method would require continued operation of the County-owned pump station as a means to remove water accumulating within the road corridor.

TEAM also proposed a sinuous inlet channel rather than a straight one "to mimic natural pocket estuary geomorphology, encourage erosion and sedimentation in the channel, and to facilitate protection of the bridge, bridge abutments and pocket estuary opening from wind and wave action." The design also included riprap slopes beneath the bridge to protect against scour. Sinuous blind channels were also proposed for excavation within the interior of the site. The design called for dikes on either side of the outlet channel between the bridge and Similk Bay, to decrease risk of overtopping from the Similk Bay side during high tide events. These dikes were proposed to be set back from the edge of the channel to allow for lateral channel migration. Finally, the TEAM report made preliminary recommendations for performance and design criteria, dike design, geotechnical considerations, bridge foundations, bridge type, size, and location, roadway design, drainage and stormwater changes, utility and septic improvements, construction sequencing, and permitting.

REVIEW AND SCOPING PROCESS

Design Charrette

In November 2020, the design team convened a design charrette meeting to begin a more detailed look at design alternatives. The following individuals and organizations took part in the meeting:

Swinomish Department of Environmental Protection

- Todd Mitchell, Environmental Director
- Catey Ritchie, Shoreline Specialist

Swinomish Department of Land Management

- Karen Mitchell, Hydrogeologist

Swinomish Shellfish Company

- Stuart Thomas, Director

Natural Systems Design

- Steve Winter, Principal Hydrologist

Blue Coast Engineering

- Jessica Côté, Principal Engineer
- Kathy Ketteridge, Principal Engineer

Skagit River System Cooperative

- Devin Smith, Restoration Director
- Eric Beamer, Research Director
- Eric Mickelson, Restoration Ecologist

The goals for the meeting were to 1) review available information about the project site, 2) identify a project concept supported by a strong technical foundation, 3) determine additional information that will be needed, and 4) evaluate the design charrette process. The discussion was kept at a broad level, avoiding design details that could be addressed in future steps and focusing on the information most relevant to choosing a project concept. Participants reviewed the site history, pocket estuary fish use, hydraulic modeling of existing conditions and restoration alternatives, geomorphology and coastal processes, and restoration project history (Anchor QEA and TEAM studies).

The group also discussed shellfish farm and golf course operations, the County pump station and Satterlee Road flooding, adjacent land use (private residences and septic systems), transportation/utility concerns, and considered the critiques of the existing design concept. These included outlet channel location and configuration, interior marsh excavation, engineering challenges related to the beach berm, road protection, and other factors. Potential restoration concepts that were discussed included 1) full road removal, 2) a freshwater-dominated system (limited channel excavation) with multiple bridge crossings, and 3) a saltwater-dominated system (more extensive channel excavation) with a single bridged outlet channel. The group discussed criteria for evaluating alternatives, including biological benefits, sustainability, constraints, engineering considerations, and costs, and agreed that these criteria should not necessarily be used to rank projects, but rather to provide a framework for thinking about opportunities and constraints.

Particular attention was paid to the potential effects of the project on the adjacent shellfish farm operations. SSC is currently farming oysters on the tide flats outside of the project site using bag-on-bottom techniques that are sensitive to changes in sedimentation; there were concerns that construction of an outlet channel could alter patterns of sediment deposition or erosion at the project site, which could bury the bags and impact shellfish survival and growth. Other concerns centered around the need for parking and processing space along the beach, the potential for expanding operations to include Pacific geoduck and Manila clam, and potential space for sales. The project engineers (Blue Coast) felt that short term negative impacts to the shellfish beds are possible as the site adjusts, but that the outlet channel will probably become more stable over time. It may be possible to mitigate for temporary effects through project design or other means.

The group also discussed in detail the question of road removal or relocation. Channel design would likely remain the same regardless of whether Satterlee Road was removed/relocated or elevated/bridged. The roadway is likely used for emergency access, bus routes for school, and local transportation. It also likely contains a buried 6” water line and possibly a gas main, and overhead utility lines are present. These would all have to be relocated if the roadway was removed or relocated, which is likely a very expensive proposition. Modifications to utilities would also be necessary with the bridge option. Preliminary discussions with Skagit County staff have indicated that they may be amenable to changes if it helped lessen or eliminate the need to operate the pump station during winter months.

Record of Decision: Although the group agreed that the existing conceptual design had enough drawbacks that a closer look at other restoration alternatives was warranted, the group elected to continue discussions before selecting pathway forward. In particular, further conversations with SSC about shellfish operations and potential impacts as well as a meeting with Skagit County Engineering and Public works staff about the road corridor and the pump station were agreed to be necessary before making a decision about next steps.

Project Partner Outreach

Swinomish Shellfish Company

In December 2020, the SRSC and Blue Coast Engineering design team met with Stuart Thomas, the Director of the Swinomish Shellfish Company, to discuss specifics about shellfish farm operational needs in terms of access points, space for operations, equipment usage, and how the restoration project might be configured to accommodate. The shellfish farm staff currently use an existing concrete pad towards the western edge of the beach south of Satterlee Road for vehicle parking, loading and unloading an ATV and a truck, and for transferring products. SSC staff access the shellfish plots via a small beach access, located between the concrete pad and the existing pump outfall just to the east. They have acquired permits to clear driftwood that frequently accumulates at this access point. SSC staff typically work on the tide flats during low tides and are on foot with support from an ATV (quad).

Mr. Thomas shared a list of seven items important to existing or potential future shellfish farm operations that should be considered when developing a restoration design:

1. Access, both to property and beach, is critical.
2. Space for operations: SSC requires room to load and unload their ATV at their vehicles, which include 2 pickup trucks, a small box truck, and one or two more staff vehicles. Space to turn the vehicles around is important.
3. A ramp is needed for loading the ATV.
4. Storage space: a few hundred to a thousand square feet are needed.
5. SSC is considering a building or structure for shelter or gear storage, so space in which to build this is necessary.
6. Processing space: SSC can use the existing concrete pad, may need power and water.

7. Space for sales: Future plans for a location from which to do direct sales, perhaps with a picnic area. Need to ensure enough parking space for visitors as well.

Per Mr. Thomas, one to two acres would likely be sufficient for SSC needs, and no matter whether the restoration project involves elevating or removing the road, the approaches to SSC parking, processing, and future sales spaces will need to be modified as well to provide continued access. Development of a sales/picnic space could potentially have the benefit of deterring vandalism and trash dumping that currently occur regularly at the site and could be a good location to incorporate signage to educate visitors about the restoration project. It is preferable to keep the sales/picnic space separate from the operations space, perhaps even on the east side of the new restoration channel, but at the very least a gate or fence to separate public from private space.

The group also discussed in greater detail anticipated changes to the site and potential impacts to shellfish beds. It is likely that the largest changes will occur in the first year, as the site adjusts to the new channel, but once it adjusts, it is likely to stabilize. Modeling can be done to allow prediction of how velocities within the site and adjacent nearshore will change from current conditions, which will allow short-term site-level adjustments to be planned for.

Record of Decision: The design team proposed delineating SSC spaces on a conceptual site plan once a restoration alternative has been selected. This would allow SSC to review to ensure whether the concept is meeting requirements.

Skagit County

SRSC and Blue Coast Engineering design team also met in December 2020 with Skagit County Public Works and Engineering staff, including:

- Dan Berentson, Public Works Director
- Paul Randall-Grutter, County Engineer
- Michael See, Natural Resources Division Manager
- Forrest Jones, Transportation Program Section Manager
- Kara Symonds, Natural Resource Lands Program Coordinator
- Emily Derrenne, Habitat Restoration Specialist

The design team presented County staff with an overview of the project, including the Satterlee Road nexus, Swinomish Golf Links and Swinomish Shellfish Company operations, pump station operations, and potential restoration alternatives. The design team solicited feedback and information from County staff on several topics, including school district and bus routes, emergency access and evacuation routes, traffic studies, and pump station operations.

A primary concern with road abandonment raised by County staff was that although Satterlee Road is not designated as an official evacuation route, it is the only way for traffic to get onto Fidalgo

Island should State Route 20 be inaccessible for any reason. Given this, staff thought it extremely unlikely that Skagit County will be supportive of road abandonment at the project site. Further, given public comments that the County received during road closures due to winter 2019/2020 flooding during a pump station failure, staff did not expect that the surrounding neighborhoods would be very supportive of this option either.

Discussion then turned towards other road options, including a Satterlee Road bridge, elevating the road versus constructing a soldier pile wall along the north side of the road at the estuary crossing, and rerouting around the top of the estuary. The group elected to discuss the bridge and road fill alternatives further as work progressed on developing those alternatives, though County staff expressed that they would prefer to not continue maintaining and operating the pump station indefinitely if possible, as might be the case with the soldier pile wall concept developed by TEAM.

Initial analysis of the road reroute alternative by Blue Coast indicated a number of challenges, foremost of which is the very tight turning angles at the junction with Christensen road and the reconnection to the existing Satterlee Road on the west side of the project site. At that location in particular, westbound traffic would need to travel up a steep grade, down a short residential street, and then make a more than 90 degree turn uphill onto the existing section of Satterlee Road. This would make for challenging and potentially dangerous travel, particularly for longer vehicles such as school buses and fire trucks. The route would also be slightly longer, would require drainage adjustments at the golf course, and would require rerouting of utilities including a 6-inch water line, potentially a natural gas main, and some aboveground utilities that run along the existing Satterlee Road corridor. Per Skagit County, 2019 and 2020 traffic counts are around 600 vehicles per day along Satterlee Road. County staff concurred with the Blue Coast assessment.

The County provided the design team with details about the Satterlee Road pump station outage that occurred during the winter months of 2019/2020: The County Drainage Utility is responsible for replacing the pump. It took the County some time to research and secure the appropriate replacement, resulting in a closure of several months, during which time SITC supplied a temporary pump to reopen Satterlee Road. During the closure, County staff received more than 100 calls from the public. The main message to the County was that the road closure was a significant disruption to school and work access for residents in the surrounding area.

Moving forward, the County Engineer requested to be involved closely with any decisions and developments related to roads and bridges in the project site. SRSC proposed to work directly with him to develop a communication pathway that meets the County's needs and to keep other relevant County staff informed of progress.

Record of Decision: The design team will convey to stakeholders and funders that Skagit County is unsupportive of abandoning Satterlee Road, would strongly prefer a bridge crossing at the existing Satterlee Road alignment over rerouting Satterlee Road around the upper end of the project site, and prefer restoration alternatives that do not require continued operation of the pump station.

The design team will work with the County Engineer to identify staff and develop a process for communicating about project progress.

Conceptual Design Meeting

In February 2021, the attendees from the November charrette meeting reconvened to make decisions about which restoration alternative to advance for preliminary design. SRSC staff first summarized for the group the meetings with SSC and with Skagit County staff and the design charrette.

Initial discussion centered around whether the site would have historically been freshwater-dominated (multiple small channels) or saltwater-dominated (single large opening) tidal marsh: Per Blue Coast, the site closely resembles many barrier embayment systems in terms of site elevations and likely channel excavation depths, so the site seems a good candidate for a single opening saltwater-dominated system. Based on regressions of channel outlet width versus estuary area by Blue Coast, the likely channel opening width is 83', which could fit under a single bridge span. From a biological perspective, having a single outlet system would be more accessible to juvenile Chinook than multiple small outlets, although fish will use both.

There was also discussion as to whether the design objective needed to recreate what was there historically. There is not strong evidence in historical documentation (including US Coast and Geodetic Survey T-Sheets) to indicate the past presence of extensive tidal marsh habitat at the site, although it is also possible that such habitat may have once been present. After extensive discussion, the design team agreed that it might not be necessary to design only to historic conditions as long as the project concept is beneficial to juvenile Chinook and other salmonids and will be naturally sustainable over time.

Natural barrier embayments fall into three general categories: impoundments (large areas that stay wet), mudflats (silty sites that dry out and have shallower channels than marsh-dominated system), and marsh dominated (vegetated with a complex channel network). There is a large volume of available sediment so the site could lend itself to a mudflat system, but more information about freshwater volumes is needed to inform design. The site will either be marsh-dominated or mudflat. There is not much data about differences in fish use between these two habitat types, but there likely are some differences. There is evidence to indicate that a large, single outlet channel will be capable of sustaining itself over time.

Based on this discussion the group was supportive of the large single opening concept, so Blue Coast presented an overview of two conceptual designs:

Concept #1: Increase height of the roadway along the existing alignment and excavate a channel at the natural drainage point in the center of the beach.

- Limited interior excavation.
- Maximum 100' opening.

- No significant regrading of upland area.
- Orient ridge abutments to direct channel to the east to limit shellfish risk.
- Remove pump station.
- Some utility improvements will be required.
- Design will include flood/drainage protection for SSC operations areas.
- Bridge deck 16-18’ NAVD88; road 11.7’ NAVD88 (FEMA 100 year flood elevation) at minimum.
- May need a berm at the west edge of the outlet channel or this entire area could be elevated.

Concept #2: Site bridge at the high point in road, channel east of the natural drainage point. A portion of roadway will be elevated above 100-year flood (including sea level rise), but the western end of roadway will remain lower than 100-year flood, protected by a sheet pile wall.

- Same road elevations as concept 1.
- The pump station and/or beach berm improvements may be needed to protect the road from flooding.
- Some utility improvements will be required.
- Design will include flood/drainage protection for SSC operations areas.
- Maximum 100’ opening.
- Significant regrading of upland area is required.

Discussion of these concepts first revolved around the location of the outlet channel opening: the natural topographic drainage point is at the western edge of the tidal marsh, but putting a channel there would direct flows towards shellfish beds. It would also require more interior grading. The central and eastern alternatives would likely require some work to protect low-lying properties at the western end of the beach, but both offer better protection for shellfish operations. The eastern location of the channel Concept #2 possibly offers slightly greater shellfish protection than that of Concept #1 because it is further away. However, a raised area in the tide flats just east of the Concept #2 channel could potentially direct the channel back towards the shellfish beds, which is undesirable; more information will be required to determine this. Both concepts offer similar fish benefits.

In terms of maintenance, Concept #1 offers significant advantages in that it requires no pump station, has no sheet pile wall to maintain, and requires no upland excavation. The chosen project concept will need to be evaluated to determine if there are potential impacts to neighboring private properties, but no substantial risks were identified and the design team did not think the two concepts under consideration differed in this regard. Concept #1 is likely more desirable in terms of overall aesthetics (i.e. landowner perception).

Record of Decision: The group elected to pursue a preliminary design based on Concept #1 based on its greater overall simplicity, likely lower maintenance requirements, similar fish benefits, likely sustainability, and similar potential risks to shellfish operations and neighboring properties.

Restoration alternatives involving full road abandonment and road relocation were deemed not feasible based on the feedback received from Skagit County. The project design team will develop a proposal for completing preliminary design work for the chosen restoration concept, will begin to look in more detail at water quality and habitat availability in the freshwater drainage entering the site from the uplands and golf course adjacent to the project site.

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Appendix C
Geotechnical Evaluation Memorandum
(Aspect Consulting)

Aspect CONSULTING

MEMORANDUM

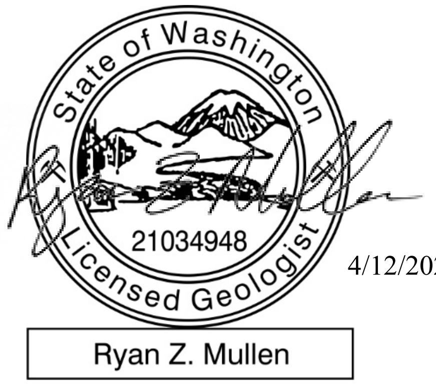
Project No. 210105-A-001-03

April 12, 2022

To: Kathy Ketteridge, Blue Coast Engineering, LLC

From:

4/12/2022



4/12/2022

Erik O. Andersen, PE
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Re: **Geotechnical Engineering Evaluation**
Similk Tidal Marsh Restoration Project
Skagit County, Washington

This technical memorandum presents the results of Aspect Consulting, LLC's (Aspect) geotechnical engineering investigation for the Similk Tidal Marsh Restoration (Project). The Project will restore tidal inundation to an historical 17-acre tidal marsh area (Site; Figure 1). Natural tide exchange between the pre-existing pocket estuary and Similk Bay was removed by the construction of the earthen embankment dike that is Satterlee Road. The Project will remove part of the roadway embankment dike and replace it with a single-span bridge along Satterlee Road. It will also include excavation of a primary tidal channel and finger channels to allow free tidal exchange between the estuary and Similk Bay.

The objectives of our geotechnical investigation were to characterize near-surface soil and groundwater conditions and provide generalized conclusions and recommendations in support of preliminary design of the tidal marsh restoration. Geotechnical engineering evaluations in support of the new bridge and roadway modifications are excluded from the current scope of work.

Aspect also completed a companion surface and groundwater evaluation that is provided under separate cover (Aspect, 2022).

Observations and Interpretations

Surface Conditions and Topography

The Site is comprised of a single property (Skagit County Parcel No. 057-340205-0-039-0008) located near the north end of Similk Bay along the southern shoreline of Fidalgo Island in Skagit County, Washington. It consists of approximately 17 acres of low-lying wetland area and is generally flat. Satterlee Road is an earthen embankment dike extending east/west parallel to Similk Beach and the shoreline, isolating the pre-existing pocket estuary from Similk Bay. Immediately to the north of the Site is the Swinomish Golf Links golf course.

Currently, surface water within the estuary Site drains toward a constructed north-south oriented ditch which then drains southward to an east-west constructed ditch along the north side of the Satterlee Road embankment dike. A pump station within the Satterlee ditch pumps water to the other side of the embankment to discharge into Similk Bay. Aspect understands there is also an existing tide gate which is no longer operational. During large runoff events into the estuary, the current drainage conveyance system underperforms, and flooding has been a problem.

Geologic Setting

The Site is located within the Puget Lowland, a broad area of tectonic subsidence flanked by two mountain ranges: the Cascades to the east and the Olympics to the west. The sediments within the Puget Lowland are the result of repeated cycles of glacial and nonglacial deposition and erosion. The most recent cycle, the Vashon State of the Fraser Glaciation (about 13,000 to 16,000 years ago), is responsible for most of the present day geologic and topographic conditions. During the Vashon Stade, the approximately 3,000-foot-thick Cordilleran Ice Sheet advanced into the Puget Lowland.

As the Cordilleran Ice Sheet advanced southward, lacustrine and fluvial sediments were deposited in front of the moving ice front. Preglacial and proglacial sediments were overridden and consolidated by the advancing ice, creating dense and hard soil deposits. At the interface between the advance soils and the glacial ice, the Cordilleran Ice Sheet sculped and smoothed the surface, and then deposited a consolidated basal till. As the Cordilleran Ice Sheet retreated northward from the Puget Lowland to British Columbia, it left an unconsolidated sediment veneer over glacially consolidated deposits.

The Site is located in the low-lying region of Similk Bay, a northern extension of Skagit Bay. As a result, much of the near-surface sediment in the area consists of younger, Quaternary-age nonglacial deposits. The most recent available geologic mapping (Dragovich et al., 2000) indicates that subsurface conditions at the Site predominantly consist of nonglacial deposits. These deposits are mapped as Holocene-age nearshore deposits (map unit Qn) and are defined as estuarine or tidal flats composed of sand, silt, and clay, and may contain marsh or peat deposits. Our observations of surface conditions at the Site are consistent with this description.

Glacial deposits Qgl(v) and Qgdm(e) are mapped along the valley slopes parallel and directly west and east of the Site and near the intersection of Satterlee and Christianson Road. We interpret the glacially derived deposits to be underlying the flat, nearshore deposits; however, it is unknow which unit is underlying. Glacially derived deposits consist of mixture of clay, silt, sand, and gravel. A detailed description of our subsurface findings is presented in the sections below.

Undivided surficial deposits Qs are mapped along the base of much of the slope west of the Site. It is unknown how the undivided surficial deposits were deposited and if they are younger or older than the glacial deposits Qgl(v).

Subsurface Exploration

Aspect completed six test pit explorations, designated ATP-01 through ATP-06, at the Site on June 29, 2021. Excavation was performed by Skagit River System Cooperative (SRSC) personnel using a small track-mounted excavator. The locations of the explorations were chosen to inform geotechnical analyses and recommendations for the proposed Project improvements and to investigate stormwater infiltration feasibility while also informing our conceptual hydrogeologic model of the Site. The locations the test pits are shown on Figure 1.

The test pits were spaced approximately 250 feet apart. Each test pit was dug to the maximum possible depth before groundwater seepage caused sloughing of test pit walls and no further downward progress was possible. The depth ranged from 3.3 to 6.8 feet below ground surface (bgs). We collected representative soil samples from certain depths in each test pit for further observation soil classification. Detailed logs of each test pit, including soil and groundwater observations, are provided in Appendix A.

Stratigraphy

Subsurface conditions at the Site were inferred from the completed field investigations, a review of applicable geologic literature, and our local geologic experience. The stratigraphy exposed in the walls of the test pits is generally as follows and is separated by nonglacial and glacial deposits.

Nearshore Deposits (nonglacial)

We interpret the upper few feet of soil in the test pits as nearshore deposits identified in the Washington State Department of Natural Resources (DNR) geologic map (Dragovich et al., 2000).

Peat was encountered in the near-surface in all test pits ranging from approximately 0.25 feet bgs in ATP-02 to 4 feet bgs in ATP-06. The peat was reddish brown, soft to medium stiff, moist, and contained disintegrated woody fragments. Plant roots were observed penetrating down through the entirety of the peat layer. Remnant intact cedar branches were also observed in this layer.

Below the peat, we encountered a layer of silty sand with gravel down to the maximum explored depth in ATP-01 through ATP-04 and at approximately 4 and 6 feet bgs in ATP-06 and ATP-05, respectively. This layer was light gray in color, generally loose, moist to wet, and consisted predominantly of fine- to medium-grained sand and fine subrounded gravel. Traces of disintegrated woody debris and abundant clam and other seashell fragments were observed. In the upper 1 foot of this layer in ATP-03 and in ATP-05, the fine-grained sediment appeared to consist of clay rather than silt; we therefore classified this as a sandy clay with gravel. In general, the contact between the upper peat layer and this layer exhibited a gradual transition with decreasing organic content.

Glacial Deposits

We interpret the soils in test pit explorations ATP-05 and ATP-06 underlying the nearshore deposits to be glacially derived based on our observations and the mapping of glacially derived units near the Site (Dragovich et al., 2000).

Glacial deposits were encountered at a depth below 6 feet bgs in ATP-05 and below 4 feet bgs in ATP-06. These soils were light gray in color, loose to medium dense, and composed of fine-grained sand overlying a stiff and wet sandy clay with gravel. We differentiated between nonglacial (recent nearshore deposits) and glacially derived soils in ATP-05 and ATP-06 by the absence of organic material/woody debris and increased density/consistency.

Groundwater Seepage

Groundwater seepage was encountered in the test pits between 1.3 and 3.3 feet bgs. The encountered groundwater seepage in each test pits is indicated in Table 1.

Table 1. Summary of Groundwater Seepage During Field Investigation

Exploration Number	Ground Surface Elevation (ft NAVD88)[1]	Depth to Groundwater Seepage (ft bgs)	Approximate Water Elevation (ft NAVD88)[2]	Date/Time of Water Level Elevation Measurement
ATP-01	7.3 ft	2.0 ft	5.3 ft	6/29/2021 / 8:00am
ATP-02	7.6 ft	1.3 ft	6.3 ft	6/29/2021 / 10:00am
ATP-03	7.0 ft	1.8 ft	5.2 ft	6/29/2021 / 8:30am
ATP-04	7.1 ft	1.3 ft	5.8 ft	6/29/2021 / 10:30am
ATP-05	6.8 ft	2.2 ft	4.6 ft	6/29/2021 / 9:00am
ATP-06	7.2 ft	3.3 ft	4.0 ft	6/29/2021 / 11:00am

Notes:
(1) – Ground surface elevations are based on Site topographic survey by Wilson Engineering.
(2) – Water level elevation is based on observations of seepage during test pit logging and surveyed ground surface elevation. Observations of seepage may be affected by presence of lenses of higher conductivity soils and potential perching.
ATP = Aspect Test Pit; ft bgs = feet below ground surface; ft NAVD88 = feet North American Vertical Datum of 1988.

Conclusions and Recommendations

Preliminary (60%) Design Plans by Blue Coast Engineering (Plans; 2022) show the estuary restoration will include removal of a portion of the roadway embankment dike, the stormwater pump station, and the tide gate. It will include excavation and establishment of a primary tidal channel with smaller finger-channels, collectively resembling a tree branch in plan view. An approximately 100-foot-long, single-span bridge will be constructed along Satterlee Road over the approximately 50-foot-wide primary tidal channel. Grading plans show excavations for the primary tidal and finger channels will vary from 2 to 5 feet deep. The Plans show that soil derived from channel excavations will be placed on site in compact mounds.

In our opinion, there are no significant geotechnical issues associated with this proposed grading plan. Excavations that extend below groundwater can be completed in the wet without construction dewatering. Ideally, channel excavations would be completed in a sequence working from the beach on the south end, toward the golf course on the north end. This should allow groundwater to more freely drain out to Similk Bay.

We recommend permanent channel side slopes be constructed no steeper than 4H:1V (horizontal:vertical). Similarly, fill mounds that will be inundated by high tidal water should be constructed with 4H:1V slopes. The fill mounds should be planted with erosion resistant vegetation that can handle tidal inundation. The fill mounds should be located sufficiently far from the tidal finger channels to reduce the potential for erosion and sloughing into the excavated channels.

References

Aspect Consulting LLC (Aspect), Surface Water, Groundwater, and Septic Risk and Seawater Intrusion Evaluations for Similk Tidal Marsh Restoration Project, dated April 12, 2022.

Blue Coast Engineering, Similk Estuary Tidal Restoration Preliminary Design, 14-sheet plan set, April 6, 2022.

Dragovich, J. D., M. L. Troost, D. K. Norman, G. Anderson, J. Cass, L. A. Gilbertson, D. T. McKay Jr., and K. G. Ikerd, 2006, Geology Map of the Anacortes South and La Conner 7.5-minute Quadrangles, Skagit and Island Counties, Washington. DNR Open File Report 2000-6.

Limitations

Work for this project was performed for Blue Coast Engineering (Client), and this report was prepared consistent with recognized standards of professionals in the same locality and involving similar conditions, at the time the work was performed. No other warranty, expressed or implied, is made by Aspect Consulting, LLC (Aspect).

Recommendations presented herein are based on our interpretation of site conditions, geotechnical engineering calculations, and judgment in accordance with our mutually agreed-upon scope of work. Our recommendations are unique and specific to the project, site, and Client. Application of this report for any purpose other than the project should be done only after consultation with Aspect.

Variations may exist between the soil and groundwater conditions reported and those actually underlying the site. The nature and extent of such soil variations may change over time and may not be evident before construction begins. If any soil conditions are encountered at the site that are different from those described in this report, Aspect should be notified immediately to review the applicability of our recommendations.

The scope of work does not include services related to construction safety precautions. Site safety is typically the responsibility of the contractor, and our recommendations are not intended to direct the contractor's site safety methods, techniques, sequences, or procedures. The scope of our work also does not include the assessment of environmental characteristics, particularly those involving potentially hazardous substances in soil or groundwater.

All reports prepared by Aspect for the Client apply only to the services described in the Agreement(s) with the Client. Any use or reuse by any party other than the Client is at the sole risk of that party, and without liability to Aspect. Aspect's original files/reports shall govern in the event of any dispute regarding the content of electronic documents furnished to others.

Please refer to Appendix B titled "Report Limitations and Guidelines for Use" for additional information governing the use of this report.

We appreciate the opportunity to perform these services. If you have any questions please call Erik Andersen, PE, Principal Geotechnical Engineer, at 360.746.8964.

Attachments: Figure 1 – Exploration Locations
Appendix A – Test Pit Logs
Appendix B – Report Limitations and Guidelines for Use

V:\210105 Similk Beach Site\Deliverables\Geotechnical Investigations\Similk Geotechnical Investigation_20220412.docx

GIS Path: T:\projects_8\SimilkBeach_210105\Working\01 Exploration locations.mxd || Coordinate System: NAD 1983 StatePlane Washington North FIPS 4601 Feet || Date Saved: 8/27/2021 || User: rmullen || Print Date: 8/27/2021

Test Pit

LiDAR 2-foot Contour

LiDAR 10-foot Contour

Exploration Locations

Geotechnical Assessment
Similk Estuary Rehabilitation
Skagit County, Washington

Aspect CONSULTING	AUG-2021	BY: RM/	FIGURE NO.
	PROJECT NO. 120105	REVISED BY: - - -	1

Basemap Layer Credits || Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
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APPENDIX A

Test Pit Logs

Major Divisions		Fines	Group Symbol	Group Name
Coarse-Grained Soils - More than 50%[1] Retained on No. 200 Sieve	Gravels - More than 50%[1] of Coarse Fraction Retained on No. 4 Sieve	≤5% Fines	GW	Well-graded GRAVEL Well-graded GRAVEL WITH SAND
			GP	Poorly-graded GRAVEL Poorly-graded GRAVEL WITH SAND
		≥15% Fines	GM	SILTY GRAVEL SILTY GRAVEL WITH SAND
			GC	CLAYEY GRAVEL CLAYEY GRAVEL WITH SAND
	Sands - 50%[1] or More of Coarse Fraction Passes No. 4 Sieve	≤5% Fines	SW	Well-graded SAND Well-graded SAND WITH GRAVEL
			SP	Poorly-graded SAND Poorly-graded SAND WITH GRAVEL
		≥15% Fines	SM	SILTY SAND SILTY SAND WITH GRAVEL
			SC	CLAYEY SAND CLAYEY SAND WITH GRAVEL
Fine-Grained Soils - 50%[1] or More Passes No. 200 Sieve	Silts and Clays Liquid Limit Less than 50%		ML	SILT SANDY or GRAVELLY SILT SILT WITH SAND SILT WITH GRAVEL
			CL	LEAN CLAY SANDY or GRAVELLY LEAN CLAY LEAN CLAY WITH SAND LEAN CLAY WITH GRAVEL
			OL	ORGANIC SILT SANDY or GRAVELLY ORGANIC SILT ORGANIC SILT WITH SAND ORGANIC SILT WITH GRAVEL
	Silts and Clays Liquid Limit 50% or More		MH	ELASTIC SILT SANDY or GRAVELLY ELASTIC SILT ELASTIC SILT WITH SAND ELASTIC SILT WITH GRAVEL
			CH	FAT CLAY SANDY or GRAVELLY FAT CLAY FAT CLAY WITH SAND FAT CLAY WITH GRAVEL
			OH	ORGANIC CLAY SANDY or GRAVELLY ORGANIC CLAY ORGANIC CLAY WITH SAND ORGANIC CLAY WITH GRAVEL
Highly Organic Soils			PT	PEAT and other mostly organic soils

"WITH SILT" or "WITH CLAY" means 5 to 15% silt and clay, denoted by a "-" in the group name; e.g., SP-SM • "SILTY" or "CLAYEY" means >15% silt and clay • "WITH SAND" or "WITH GRAVEL" means 15 to 30% sand and gravel. • "SANDY" or "GRAVELLY" means >30% sand and gravel. • "Well-graded" means approximately equal amounts of fine to coarse grain sizes • "Poorly graded" means unequal amounts of grain sizes • Group names separated by "/" means soil contains layers of the two soil types; e.g., SM/ML.

Soils were described and identified in the field in general accordance with the methods described in ASTM D2488. Where indicated in the log, soils were classified using ASTM D2487 or other laboratory tests as appropriate. Refer to the report accompanying these exploration logs for details.

1. Estimated or measured percentage by dry weight
2. (SPT) Standard Penetration Test (ASTM D1586)
3. Determined by SPT, DCPT (ASTM STP399) or other field methods. See report text for details.

GEOTECHNICAL LAB TESTS

MC	=	Natural Moisture Content
PS	=	Particle Size Distribution
FC	=	Fines Content (% < 0.075 mm)
GH	=	Hydrometer Test
AL	=	Atterberg Limits
C	=	Consolidation Test
Str	=	Strength Test
OC	=	Organic Content (% Loss by Ignition)
Comp	=	Proctor Test
K	=	Hydraulic Conductivity Test
SG	=	Specific Gravity Test

CHEMICAL LAB TESTS

Organic Chemicals

BTEX	=	Benzene, Toluene, Ethylbenzene, Xylenes
TPH-Dx	=	Diesel and Oil-Range Petroleum Hydrocarbons
TPH-G	=	Gasoline-Range Petroleum Hydrocarbons
VOCs	=	Volatile Organic Compounds
SVOCs	=	Semi-Volatile Organic Compounds
PAHs	=	Polycyclic Aromatic Hydrocarbon Compounds
PCBs	=	Polychlorinated Biphenyls

Metals

RCRA8	=	As, Ba, Cd, Cr, Pb, Hg, Se, Ag, (d = dissolved, t = total)
MTCA5	=	As, Cd, Cr, Hg, Pb (d = dissolved, t = total)
PP-13	=	Ag, As, Be, Cd, Cr, Cu, Hg, Ni, Pb, Sb, Se, Tl, Zn (d=dissolved, t=total)

FIELD TESTS

PID	=	Photoionization Detector
Sheen	=	Oil Sheen Test
SPT[2]	=	Standard Penetration Test
NSPT	=	Non-Standard Penetration Test
DCPT	=	Dynamic Cone Penetration Test

COMPONENT DEFINITIONS

Descriptive Term		*Size Range and Sieve Number*
Boulders	=	Larger than 12 inches
Cobbles	=	3 inches to 12 inches
Coarse Gravel	=	3 inches to 3/4 inches
Fine Gravel	=	3/4 inches to No. 4 (4.75 mm)
Coarse Sand	=	No. 4 (4.75 mm) to No. 10 (2.00 mm)
Medium Sand	=	No. 10 (2.00 mm) to No. 40 (0.425 mm)
Fine Sand	=	No. 40 (0.425 mm) to No. 200 (0.075 mm)
Silt and Clay	=	Smaller than No. 200 (0.075 mm)

ESTIMATED[1] PERCENTAGE

% by Weight		*Modifier*	*% by Weight*		*Modifier*
<1	=	Subtrace	15 to 25	=	Little
1 to <5	=	Trace	30 to 45	=	Some
5 to 10	=	Few	>50	=	Mostly

MOISTURE CONTENT

Dry	=	Absence of moisture, dusty, dry to the touch
Slightly Moist	=	Perceptible moisture
Moist	=	Damp but no visible water
Very Moist	=	Water visible but not free draining
Wet	=	Visible free water, usually from below water table

RELATIVE DENSITY

Non-Cohesive or Coarse-Grained Soils

Density[3]		*SPT[2] Blows/Foot*	*Penetration with 1/2" Diameter Rod*
Very Loose	=	0 to 4	≥ 2'
Loose	=	5 to 10	1' to 2'
Medium Dense	=	11 to 30	3" to 1'
Dense	=	31 to 50	1" to 3"
Very Dense	=	> 50	< 1"

CONSISTENCY

Cohesive or Fine-Grained Soils

Consistency[3]		*SPT[2] Blows/Foot*	*Manual Test*
Very Soft	=	0 to 1	Penetrated >1" easily by thumb. Extrudes between thumb & fingers.
Soft	=	2 to 4	Penetrated 1/4" to 1" easily by thumb. Easily molded.
Medium Stiff	=	5 to 8	Penetrated >1/4" with effort by thumb. Molded with strong pressure.
Stiff	=	9 to 15	Indented ~1/4" with effort by thumb.
Very Stiff	=	16 to 30	Indented easily by thumbnail.
Hard	=	> 30	Indented with difficulty by thumbnail.

GEOLOGIC CONTACTS

Observed and Distinct

Observed and Gradual

Inferred

Aspect CONSULTING

Exploration Log Key

AI Path: Q:_ACAD Standards\FIELD REFERENCE\MASTERS\Exploration Log Key-2018.ai // user: jinman // last saved: 12/31/2018

Aspect CONSULTING	Similk Tidal Marsh Restoration - 210105			Geotechnical Exploration Log	
	Project Address & Site Specific Location			*Coordinates (Lat,Lon WGS84)*	*Exploration Number*
	Satterlee Road, Anacortes, WA, West side of Estuary			48.4478, -122.5757 (est)	**ATP-01**
Contractor	*Equipment*	*Sampling Method*		*Ground Surface Elev. (NAVD88)*	
SRSC	Excavator or Backhoe	Grab		7' (est)	
Operator	*Exploration Method(s)*	*Work Start/Completion Dates*		*Top of Casing Elev. (NAVD88)*	*Depth to Water (Below GS)*
Matt E	Backhoe or trackhoe	6/29/2021		NA	2' (Seep)

Depth (feet)	Elev. (feet)	Exploration Notes and Completion Details	Sample Type/ID	Blows/foot ▲ Water Content (%)● 0 10 20 30 40 50	Blows/6"	Tests	Material Type	Description	Depth (ft)
								Nearshore Deposits PEAT (PT); soft, moist, red to dark brown; slight organic sheen; disentegraded woody fragments.	
1	6		S-1					Plant/vegetation roots encountered down to 1.0 ft	1
								Nearshore Deposits SILTY SAND WITH GRAVEL (SM); loose, moist becoming wet, light gray; fine to medium sand; fine, subrounded gravel; trace disentegraded woody debris; mostly clam and other seashell fragments	
2	5	6/29/2021	S-2					Rapid groundwater seepage at 2.0 ft	2
3	4		S-3					Layer of abundant broken seashells mixed with some wood fragments and bark pieces Severe sidwall caving below 3.0 ft	3
								Bottom of exploration at 3.3 ft. bgs.	
4	3								4
5	2								5
6	1								6
7	0								7

Legend

Plastic Limit ├──┤ Liquid Limit

Sample Type: Grab sample

Water Level: Water Level (Seepage)

See Exploration Log Key for explanation of symbols

Logged by: Ryan M
Approved by: EA

Exploration Log
ATP-01
Sheet 1 of 1

Similk Tidal Marsh Restoration - 210105

Geotechnical Exploration Log

Project Address & Site Specific Location	Coordinates (Lat,Lon WGS84)	Exploration Number
Satterlee Road, Anacortes, WA, East side of Estuary	48.4479, -122.5745 (est)	ATP-02

Contractor	Equipment	Sampling Method	Ground Surface Elev. (NAVD88)
SRSC	Excavator or Backhoe	Grab	8' (est)

Operator	Exploration Method(s)	Work Start/Completion Dates	Top of Casing Elev. (NAVD88)	Depth to Water (Below GS)
Matt E	Backhoe or trackhoe	6/29/2021	NA	1.3' (Seep)

Depth (feet)	Elev. (feet)	Exploration Notes and Completion Details	Sample Type/ID	Blows/foot ▲ Water Content (%)● 0 10 20 30 40 50	Blows/6"	Tests	Material Type	Description	Depth (ft)
			S-4					**Nearshore Deposits** PEAT (PT); soft to medium stiff, moist, red to dark brown; slight organic sheen; disentegraded woody fragments.	
								Nearshore Deposits SILTY SAND WITH GRAVEL (SM); loose, moist becoming wet, light gray; fine to medium sand; fine, subrounded gravel; trace disentegraded woody debris; mostly clam and other seashell fragments	
1	7								1
		6/29/2021						Rapid groundwater seepage at 1.3 ft	
2	6							**Nearshore Deposits** GRAVEL (GP); loose, wet, blue gray to dark gray; fine, rounded to subrounded gravel	2
			S-5						
3	5							Severe sidewall caving below 3.0 ft	3
								Bottom of exploration at 3.4 ft. bgs.	
4	4								4
5	3								5
6	2								6
7	1								7

Legend

Sample Type: Grab sample

Plastic Limit ├──┤ Liquid Limit

Water Level: Water Level (Seepage)

See Exploration Log Key for explanation of symbols

Logged by: Ryan M
Approved by: EA

Exploration Log ATP-02

Sheet 1 of 1

NEW STANDARD EXPLORATION LOG TEMPLATE P:\GINTW\PROJECTS\210105-SIMILK.GPJ April 11, 2022

Aspect CONSULTING	Similk Tidal Marsh Restoration - 210105			Geotechnical Exploration Log	
	Project Address & Site Specific Location			Coordinates (Lat,Lon WGS84)	Exploration Number
	Satterlee Road, Anacortes, WA, West side of Estuary			48.4485, -122.5756 (est)	ATP-03
Contractor	Equipment	Sampling Method		Ground Surface Elev. (NAVD88)	
SRSC	Excavator or Backhoe	Grab		7' (est)	
Operator	Exploration Method(s)	Work Start/Completion Dates		Top of Casing Elev. (NAVD88)	Depth to Water (Below GS)
Matt E	Backhoe or trackhoe	6/29/2021		NA	1.8' (Seep)

Depth (feet)	Elev. (feet)	Exploration Notes and Completion Details	Sample Type/ID	Blows/foot ▲ Water Content (%)● 0 10 20 30 40 50	Blows/6"	Tests	Material Type	Description	Depth (ft)
								Nearshore Deposits PEAT (PT); soft, moist, red to dark brown; slight organic sheen; disentegraded woody fragments.	
			S-8						
1	6								1
			S-6					2in-diameter cedar branches encountered	
		6/28/2021						Moderate groundwater seepage at 1.8 ft	
2	5							**Nearshore Deposits** SANDY CLAY WITH GRAVEL (CH); medium stiff to stiff, moist, dark gray; fine to medium sand; fine, subrounded gravel; some disentegraded woody debris; subtrace clam and other seashell fragments	2
			S-9						
								Nearshore Deposits SILTY SAND WITH GRAVEL (SM); loose, moist becoming wet, light gray; fine to medium sand; fine, subrounded gravel; trace disentegraded woody debris; mostly clam and other seashell fragments	
3	4								3
4	3							**Nearshore Deposits** SAND WITH GRAVEL (SP); loose, wet, light gray; fine sand; trace, subrounded fine gravel; trace seashell fragments	4
			S-7						
								Bottom of exploration at 4.55 ft. bgs.	
5	2								5
6	1								6
7	0								7

Legend

Plastic Limit ⊢—⊣ Liquid Limit

Sample Type: Grab sample

Water Level: Water Level (Seepage)

See Exploration Log Key for explanation of symbols

Logged by: Ryan M
Approved by: EA

Exploration Log ATP-03

Sheet 1 of 1

NEW STANDARD EXPLORATION LOG TEMPLATE P:\GINTW\PROJECTS\210105-SIMILK.GPJ April 11, 2022

Similk Tidal Marsh Restoration - 210105

Geotechnical Exploration Log

Aspect CONSULTING

Project Address & Site Specific Location	Coordinates (Lat,Lon WGS84)	Exploration Number
Satterlee Road, Anacortes, WA, East side of Estuary	48.4485, -122.5746 (est)	ATP-04

Contractor	Equipment	Sampling Method	Ground Surface Elev. (NAVD88)
SRSC	Excavator or Backhoe	Grab	7' (est)

Operator	Exploration Method(s)	Work Start/Completion Dates	Top of Casing Elev. (NAVD88)	Depth to Water (Below GS)
Matt E	Backhoe or trackhoe	6/29/2021	NA	1.3' (Seep)

Depth (feet)	Elev. (feet)	Exploration Notes and Completion Details	Sample Type/ID	Blows/foot ▲ Water Content (%) ● 0 10 20 30 40 50	Blows/6"	Tests	Material Type	Description	Depth (ft)
0	7						PT	**Nearshore Deposits** PEAT (PT); soft, moist, red to dark brown; slight organic sheen; disentegraded woody fragments.	
1	6								1
1.3		6/29/2021 (water level)						Moderate groundwater seepage at 1.3 ft	
2	5		Grab S-10						2
2.3							SM	**Nearshore Deposits** SILTY SAND WITH GRAVEL (SM); loose, moist becoming wet, light gray; fine to medium sand; fine, subrounded gravel; trace disentegraded woody debris; mostly clam and other seashell fragments	
3	4								3
3.5			Grab S-11						
4	3								4
5	2							Severe sidewall caving below 5.0 ft	5
5.3								Bottom of exploration at 5.3 ft. bgs.	
6	1								6
7	0								7

Legend

Plastic Limit ├──┤ Liquid Limit

Sample Type: Grab sample

Water Level: Water Level (Seepage)

See Exploration Log Key for explanation of symbols

Logged by: Ryan M
Approved by: EA

Exploration Log ATP-04

Sheet 1 of 1

NEW STANDARD EXPLORATION LOG TEMPLATE P:\GINTW\PROJECTS\210105-SIMILK.GPJ April 11, 2022

Aspect CONSULTING	Similk Tidal Marsh Restoration - 210105			Geotechnical Exploration Log	
	Project Address & Site Specific Location			*Coordinates (Lat,Lon WGS84)*	*Exploration Number*
	Satterlee Road, Anacortes, WA, West side of Estuary			48.4495, -122.5756 (est)	ATP-05
Contractor	*Equipment*	*Sampling Method*		*Ground Surface Elev. (NAVD88)*	
SRSC	Excavator or Backhoe	Grab		7' (est)	
Operator	*Exploration Method(s)*	*Work Start/Completion Dates*		*Top of Casing Elev. (NAVD88)*	*Depth to Water (Below GS)*
Matt E	Backhoe or trackhoe	6/29/2021		NA	2.2' (Seep)

Depth (feet)	Elev. (feet)	Exploration Notes and Completion Details	Sample Type/ID	Blows/foot ▲ Water Content (%)● 0 10 20 30 40 50	Blows/6"	Tests	Material Type	Description	Depth (ft)
0	7						PT	**Nearshore Deposits** PEAT (PT); soft, moist, red to dark brown; slight organic sheen; some disentegraded woody fragments.	
1	6								1
			S-14 (Grab)						
2	5							Plant/vegetation roots encountered down to 2.0 ft	2
		6/29/2021 (Water Level)						Moderate groundwater seepage at 2.2 ft	
							CH	**Nearshore Deposits** SANDY CLAY WITH GRAVEL (CH); medium stiff to stiff, moist, dark gray; fine to medium sand; fine, subrounded gravel; some disentegraded woody debris; trace charcol; subtrace clam and other seashell fragments	
3	4								3
4	3		S-12 (Grab)						4
5	2								5
6	1		S-13 (Grab)				SP	**Glacial Deposits** SAND (SP); loose to medium dense, wet, light gray; fine sand	6
							CL	**Glacial Deposits** SANDY CLAY WITH GRAVEL (CL); stiff, wet, light gray; fine sand; fine, subrounded gravel	
								Bottom of exploration at 6.5 ft. bgs.	
7	0								7

Legend

Sample Type: Grab sample

Plastic Limit ├──┤ Liquid Limit

Water Level: Water Level (Seepage)

See Exploration Log Key for explanation of symbols

Logged by: Ryan M
Approved by: EA

Exploration Log ATP-05

Sheet 1 of 1

NEW STANDARD EXPLORATION LOG TEMPLATE P:\GINTW\PROJECTS\210105-SIMILK.GPJ April 11, 2022

Aspect CONSULTING	Simlik Tidal Marsh Restoration - 210105			Geotechnical Exploration Log	
	Project Address & Site Specific Location			*Coordinates (Lat,Lon WGS84)*	*Exploration Number*
	Satterlee Road, Anacortes, WA, East side of Estuary			48.4496, -122.5748 (est)	**ATP-06**
Contractor	*Equipment*	*Sampling Method*		*Ground Surface Elev. (NAVD88)*	
SRSC	Excavator or Backhoe	Grab		7' (est)	
Operator	*Exploration Method(s)*	*Work Start/Completion Dates*		*Top of Casing Elev. (NAVD88)*	*Depth to Water (Below GS)*
Matt E	Backhoe or trackhoe	6/29/2021		NA	3.3' (Seep)

Depth (feet)	Elev. (feet)	Exploration Notes and Completion Details	Sample Type/ID	Blows/foot ▲ Water Content (%) ● 0 10 20 30 40 50	Blows/6"	Tests	Material Type	Description	Depth (ft)
0	7						PT	**Nearshore Deposits** PEAT (PT); soft, moist, red to dark brown; slight organic sheen; some disentegraded woody fragments.	
1	6		Grab S-15						1
2	5							Layer of abundant broken seashells mixed with some wood fragments and bark pieces	2
3	4	6/29/2021 (Water Level)						Moderate groundwater seepage at 3.25 ft	3
4	3		Grab S-16				SP	**Glacial Deposits** SAND (SP); loose to medium dense, wet, light gray; fine sand	4
5	2								5
6	1		Grab S-17				CL	**Glacial Deposits** SANDY CLAY WITH GRAVEL (CL); stiff, wet, light gray; fine sand; fine, subrounded gravel	6
7	0							Bottom of exploration at 6.78 ft. bgs.	7

Legend

Sample Type: Grab sample

Plastic Limit ├──┤ Liquid Limit

Water Level: Water Level (Seepage)

See Exploration Log Key for explanation of symbols

Logged by: Ryan M
Approved by: EA

Exploration Log ATP-06

Sheet 1 of 1

NEW STANDARD EXPLORATION LOG TEMPLATE P:\GINTW\PROJECTS\210105-SIMILK.GPJ April 11, 2022

APPENDIX B

Report Limitations and Guidelines for Use

REPORT LIMITATIONS AND GUIDELINES FOR USE

This Report and Project-Specific Factors

Aspect Consulting, LLC (Aspect) considered a number of unique, project-specific factors when establishing the Scope of Work for this project and report. You should not rely on this report if it was:

- Not prepared for you
- Not prepared for the specific purpose identified in the Agreement
- Not prepared for the specific real property assessed
- Completed before important changes occurred concerning the subject property, project or governmental regulatory actions

Geoscience Interpretations

The geoscience practices (geotechnical engineering, geology, and environmental science) require interpretation of spatial information that can make them less exact than other engineering and natural science disciplines. It is important to recognize this limitation in evaluating the content of the report. If you are unclear how these "Report Limitations and Use Guidelines" apply to your project or site, you should contact Aspect.

Reliance Conditions for Third Parties

This report was prepared for the exclusive use of the Client. No other party may rely on the product of our services unless we agree in advance to such reliance in writing. This is to provide our firm with reasonable protection against liability claims by third parties with whom there would otherwise be no contractual limitations. Within the limitations of scope, schedule, and budget, our services have been executed in accordance with our Agreement with the Client and recognized geoscience practices in the same locality and involving similar conditions at the time this report was prepared.

Property Conditions Change Over Time

This report is based on conditions that existed at the time the study was performed. The findings and conclusions of this report may be affected by the passage of time, by events such as a change in property use or occupancy, or by natural events, such as floods, earthquakes, slope instability, or groundwater fluctuations. If any of the described events may have occurred following the issuance of the report, you should contact Aspect so that we may evaluate whether changed conditions affect the continued reliability or applicability of our conclusions and recommendations.

Discipline-Specific Reports Are Not Interchangeable

The equipment, techniques, and personnel used to perform a geotechnical or geologic study differ significantly from those used to perform an environmental study and vice versa. For that reason, a geotechnical engineering or geologic report does not usually address any environmental findings, conclusions, or recommendations (e.g., about the likelihood of encountering underground storage tanks or regulated contaminants). Similarly, environmental reports are not used to address geotechnical or geologic concerns regarding the subject property.

We appreciate the opportunity to perform these services. If you have any questions please contact the Aspect Project Manager for this project.

Appendix D
Tidal Channel Design Guidance for Similk Restoration Project (SRSC) - Memorandum

Skagit River System Cooperative
11426 Moorage Way • P.O. Box 368 LaConner, WA 98257-0368
Phone: 360-466-7228 • Fax: 360-466-4047 • www.skagitcoop.org

***To*:** Devin Smith (SRSC Restoration), Kathy Ketteridge (Blue Coast Engineering)
***Cc*:** Greg Hood and Mike LeMoine (SRSC Research)

From: Eric Beamer (SRSC Research)

Date: April 8, 2022

Re: Tidal Channel Design Guidance for the Similk Beach Estuary Restoration Project

Historical tidal wetlands located in Similk Bay are being considered for restoration as a barrier embayment (http://skagitcoop.org/programs/restoration/similk-beach/). At the November 2021 Similk Beach Estuary Restoration Project (herein, Similk Restoration Project) design review meeting I was asked to provide input to the design team regarding tidal channel habitat. Specifically, the questions are:

1. How much channel habitat is appropriate?
2. What patterns of channel habitat is appropriate?
3. What elevation/dimension should channels be?

Additionally, I was asked about tidal marsh vegetation dynamics at the restored site. Specifically, the questions are:

4. Should the restored Similk Restoration site be planted with native marsh vegetation?
5. Is there an elevation dynamic between channels and predicted marsh surface that should be considered to foster low shear stress values on the predicted marsh surface thus enabling seeds to successfully establish into viable plants rather than be washed away?
6. Are there non-native marsh plant concerns?

This technical memo addresses all six questions.

Contents

Channel pattern guidance

Methods

I generally used an allometric approach (e.g, Hood 2007) to identify norms observed in nature for selected barrier embayments channel metrics. A system is allometric when the relative rate of change of one part of a system (*y*) is proportional to the relative rate of change of another part of the system (*x*), or of the whole system. Allometric models are described by power functions, $y = ax^b$, which can be linearized through log transformation. Similar allometric scaling in different systems suggest similar processes are occurring that give rise to similar forms.

The channel metrics selected for allometric analysis are thought to be ecological relevant because they represent metrics often correlated with fish abundance, biological hotspots, or are linked to productivity pathways across marsh to channel environments (see Simenstad et al. 2000). Naturally occurring norms represent sustainable conditions and reflect the interaction of landscape controls and natural processes acting on a site within an ecosystem (Beechie et al. 2003, 2010). Thus, designing restoration projects consistent within natural norms are likely more sustainable than not following natural norms. Additionally, biota responding to habitat conditions are likely adapted to natural norms.

Metrics

Table 1 shows the independent and response variables used to predict channel metrics for barrier embayments using an allometry analysis approach (.e.g, Hood 2007). Most variables are commonly known and/or have been discussed already during Similk Restoration Project meetings, so I only offer brief definitions for each within the table and/or cite where they are more clearly defined/used. However, 3 independent variables (embayment length, width, and length/width ratio) and 4 response variables (system channel order & branching; main channel length & sinuosity) were not discussed so I created Figures 1 and 2 to help describe them. Additionally, I offer some additional details how some metrics were calculated using GIS data which are found in Table 1.

Data sources

Barrier embayment polygon data from a recent GIS census of pocket estuaries in the Whidbey Basin and western shore of Whidbey Island were used as the basis for analysis (Beamer et al. 2018). I used 23 embayment sites for analyses of total channel area and length. Each site had natural outlet conditions (i.e., not armored or dredged; appears to be at equilibrium with tidal processes) and are within drift cell shoreline systems (not rocky shoreline system). Because the Similk Restoration Project site will be restored to a ‘flat’ or ‘marsh’ embayment system I used only flat (n=8) and marsh (n=10) sites out of the original 23 sites for analyses of main channel length and sinuosity, channel branching, and channel order. In addition to using the polygons from Beamer et al. (2018) I also counted or measured in GIS the following: channel branching within each embayment (count of bifurcations, i.e, # nodes), embayment system channel order, length and sinuosity of the embayment system’s main channel, and geometric length and width of each embayment.

Analysis approach

I used a multiple regression approach because independently embayment tidal area, embayment tidal volume, and watershed area associated with the embayment often have statistically significant correlations with channel metrics within embayments. Intertidal area and volume are surrogates for the same variable (i.e., potential tidal energy, which creates and maintains channels). Watershed area represents fluvial hydrology which is also capable of forming and maintaining channels. Thus, I wanted to include within analyses the possibility of both hydrologic forces helping to explain channel metric patterns. Lastly, embayment system geometric length and length to width ratio were also included as possible independent variables within models. Best models were selected based on Akaike's Information Criterion (AIC), which scores models higher as predictive power increases, but penalizes models as the number of estimated parameters increases (Burnham and Anderson 2002). The statistical correlations described above are often significant as linear or power functions but often are stronger as power functions so I natural logarithm transformed all numeric variables in order analyze data within a linear model construct. Lastly, embayment system type may influence channel metrics independently of numeric variables, so the linear models included 'system type' as a factor. Additionally, since allometry analyses are power functions their prediction of central tendency is skewed and usually has large confidence intervals. Application of model predictions need to keep these facts in mind. Additionally, the smallest tidal channels that could be resolved in the airphotos were 30 cm wide so GIS-based results for all channel metrics will be an underestimate from 'on the ground truth." The metrics most influenced by this issue are Total Channel Length, System Channel Branching, and System Channel Order. Total Channel is less influenced by this issue because the total area of the unidentified channels is very small compared to larger mapped channels. The main channel attributes are not influenced by this issue.

Table 1. Summary of variables with definitions.

Type	Variable	Definition
Independent variables	Embayment system type	The 3 system types correspond to the embayment's intertidal area being dominated (≥40% of the total intertidal area) by a single habitat type: lagoon systems – impoundment habitat; flat systems – low tide terrace habitat; and marsh system – tidal marsh habitat (see Beamer 2018). Categorical variable.
	Watershed area	Area of watershed (acres) associated with the embayment. Numeric variable.
	Embayment intertidal area	Area (ha) within embayment between MHHW and elevation of hydraulic control of system. Numeric variable.
	Embayment intertidal volume	Volume (m^3) within embayment between MHHW and elevation of hydraulic control of system. Numeric variable.
	Embayment length	Geometric mean length of intertidal portion of embayment (see Figure 1). Numeric variable.
	Embayment width	Geometric mean of intertidal portion of embayment (see Figure 1). Numeric variable.
	Embayment length/width ratio	Embayment length / Embayment width (see Figure 1). Numeric variable.
Response variables	Total Channel Area (TCA)[1]	Total area of channel within embayment. The sum area of channel and impoundment polygons by embayment was used to estimate TCA for each embayment.
	Total Channel Length (TCL)[1]	Total length of channels within embayment. The perimeter of GIS channel and impoundment polygons were divided by 2 to calculate their length. The sum of all channel and impoundment polygon lengths by embayment was used to estimate TCL for each embayment.
	System Channel Order (SCO)	Whole embayment system channel order (see Figure 2).
	System Channel Branching (SCB)	Number of channel bifurcations (nodes) within the embayment system (see Figure 2).
	Main Channel Length (MCL)	Meandering length of the highest order channel segment in embayment (see Figure 2).
	Main Channel Sinuosity (MCS)	Sinuosity has several definitions. I adapted the simplest one (the ratio of stream length to valley length) to a tidal environment as: meandering length of main channel / straight line (reach) length of main channel.

[1] I included impoundment polygons in with channel polygons in my calculation of TCA and TCL because (a) impoundments are often part of the channel network (i.e., not isolated from the channel system) and (b) are wetted areas within embayments known to be utilized by juvenile salmon.

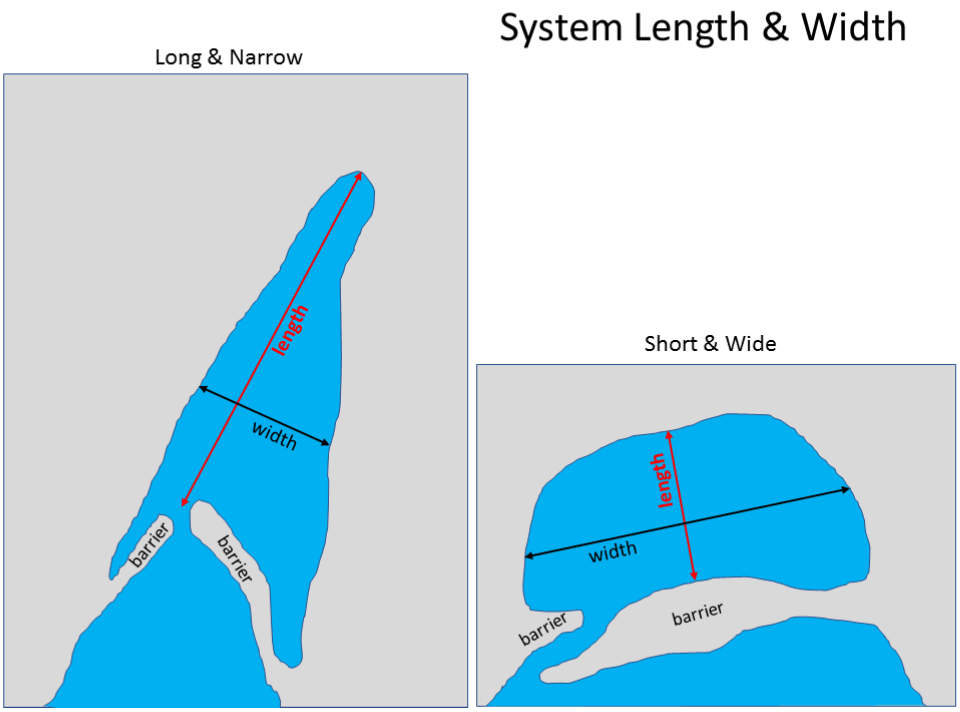


Figure 1. Cartoon of two embayments showing their contrasting geometric length to width ratios.

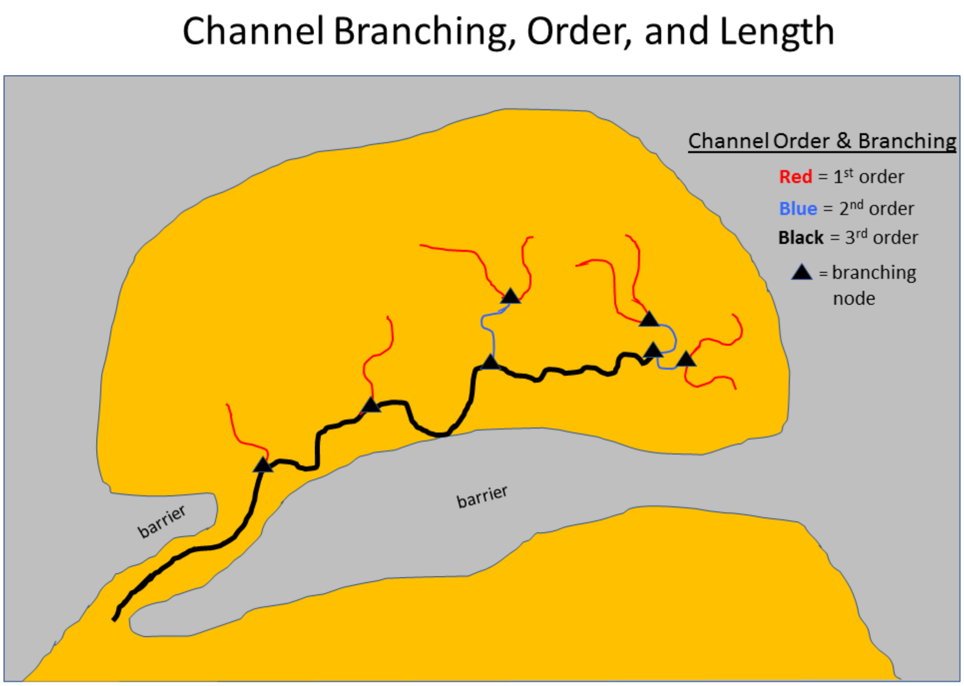


Figure 2. Cartoon of channel order and branching within a barrier embayment. This system is a 3rd order system and has 7 channel bifurcations (nodes). The main channel is the segment shown in black, which is a third order channel.

Results & Recommendations

Total Channel Area (TCA)

Model results: The analysis finds the best model for TCA includes intertidal area, watershed area, and system type (Table 2, Figures 3 & 4). TCA within marsh and flat systems have proportionally less than lagoon systems. This is caused by the high degree of impoundment habitat found in lagoon systems (which was included in my metric for TCA (see Table 1 definition of TCA). Although the model detected significant differences between system types (Table 2C and 2D) there appears to be no difference between TCA central tendency predictions for flat and marsh systems when the model coefficients are applied (Figure 4). I recommend using the marsh system equation from the best model (Table 2) as guidance to help determine an appropriate TCA within the Smilk Bay Restoration Project area. The equation is:

> Step 1. Natural log transformed TCA (in hectares) = (0.627*log intertidal area in ha)+(0.292*log watershed area in acres)-2.512.
>
> Step 2. Back transform [i.e, exp(x)] 'Natural log transformed TCA' to 'TCA.' Units are hectares.

Table 2. Best model outputs for predicting TCA.

A. Overall model performance and observations

Dependent Variable = log transformed TCA

N	23
Multiple R	0.928
Squared Multiple R	0.861

B. Model coefficients

CONSTANT		-2.512
System type	marsh	0.000
System type	flat	-0.019
System type	lagoon	0.853
Log intertidal area		0.627
Log watershed area		0.292

C. Analysis of Variance Statistics

Source	Type III SS	df	Mean Squares	F-Ratio	p-Value
System type	8.024	2	4.012	9.349	0.002
Log intertidal area	9.840	1	9.840	22.931	0.000
Log watershed area	3.306	1	3.306	7.704	0.012
Error	7.724	18	0.429		

D. Tukey's Honestly-Significant-Difference Test.

Post Hoc Test of log transformed TCA using least squares means for the model with MSE of 0.429 and 18 df.

TYPE$(i)	TYPE$(j)	Difference	p-Value	Lower 95% Confidence	Upper Interval
flat	lagoon	-0.871	0.118	-1.825	0.082
flat	marsh	0.815	0.048	0.022	1.608
lagoon	marsh	1.687	0.002	0.771	2.602

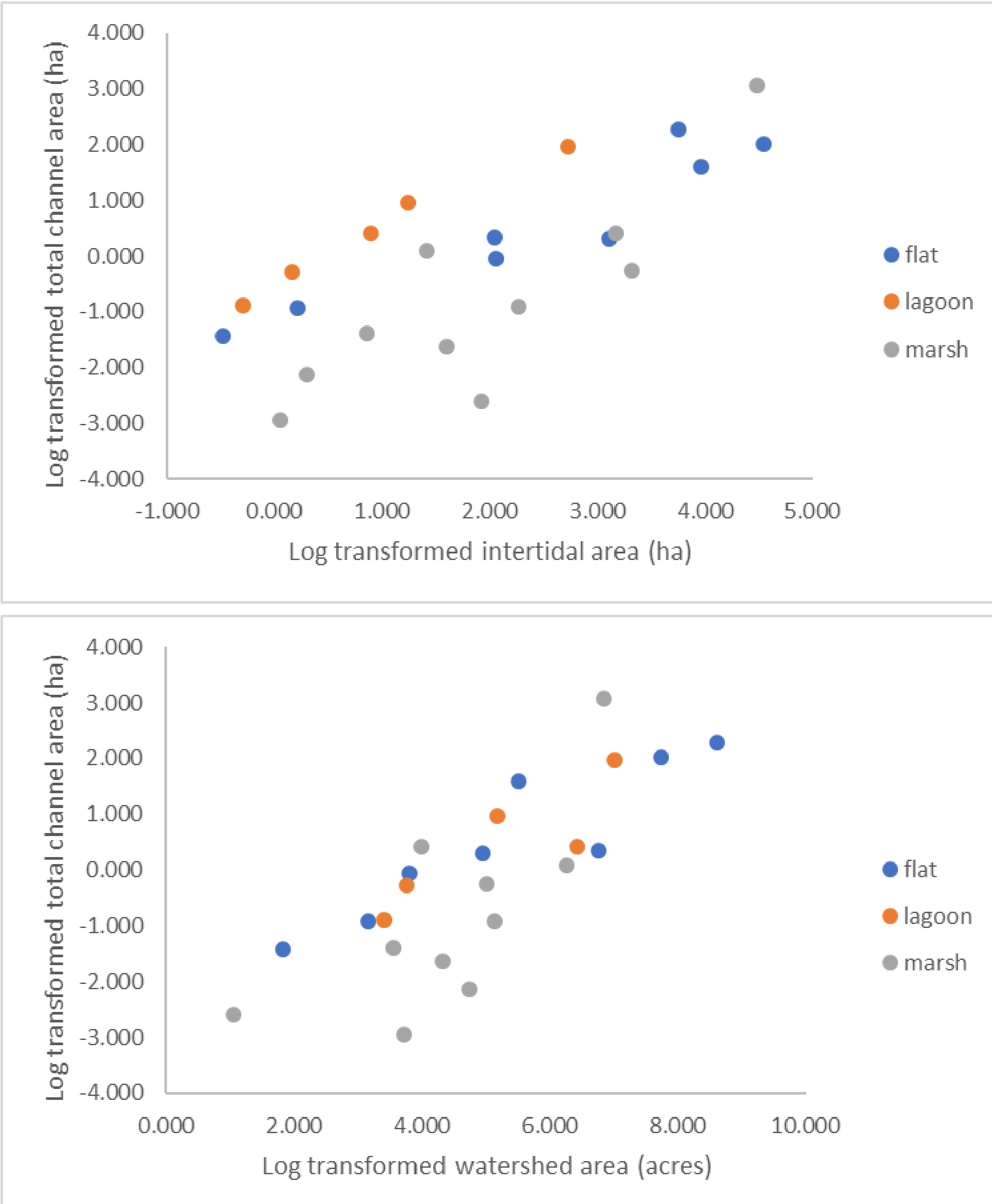


Figure 3. Scatterplot of intertidal area (top panel) and watershed area (bottom panel) and TCA by system type.

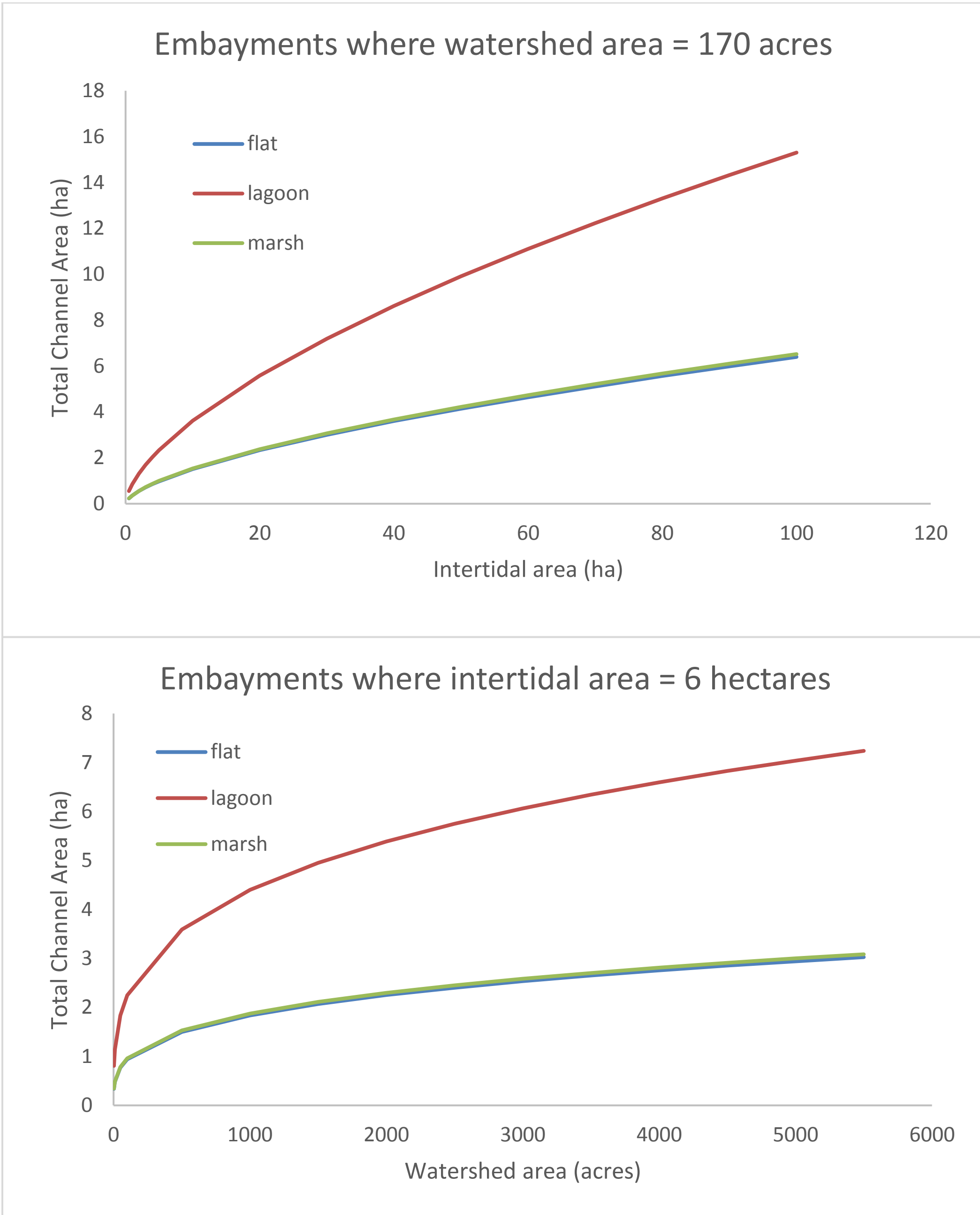


Figure 4. Predictions of TCA using best model which uses three variables: intertidal area, watershed area, and system type. *Top panel* shows the relationship as a function of intertidal area and system type with watershed area set at a constant 170 acres (rough approx. of watershed area to the Similk Restoration Project site). *Bottom panel* shows the relationship as a function of watershed area and system type with intertidal area set at a constant 6 hectares (rough approx. of potential intertidal area to the restored Similk Restoration Project site).

Total Channel Length (TCL)

Embayment intertidal area, embayment intertidal volume, and watershed area all independently have statistically significant positive correlations with TCL. Interestingly, system type has no influence on TCL. The analysis finds the best supported model using AIC was a single variable linear regression with intertidal area (Figure 5. Table 3). I recommend using the linear regression equation of Table 3 as guidance to help determine an appropriate TCL within the Smilk Bay Restoration Project area.

Step 1. The equation is: Natural log TCL (in meters) = (0.797*natural log Intertidal Area in hectare) + 5.786

Step 2. Back transform [i.e, exp(x)] 'Natural log transformed TCL' to 'TCL.' Units are meters.

Table 3. Best model outputs for predicting TCL.

A. Overall model performance and observations

Dependent Variable = log transformed TCL

N	23
Multiple R	0.951
Squared Multiple R	0.905
Adjusted Squared Multiple R	0.900
Standard Error of Estimate	0.409

B. Model coefficients

Effect	Coefficient	Standard Error	Std. Coefficient	Tolerance	t	p-Value
CONSTANT	5.786	0.136	0.000	.	42.468	0.000
Log Intertidal Area	0.797	0.056	0.951	1.000	14.122	0.000

C. Analysis of Variance Statistics

Source	Type III SS	df	Mean Squares	F-Ratio	p-Value
Regression	33.337	1	33.337	199.431	0.000
Residual	3.510	21	0.167		

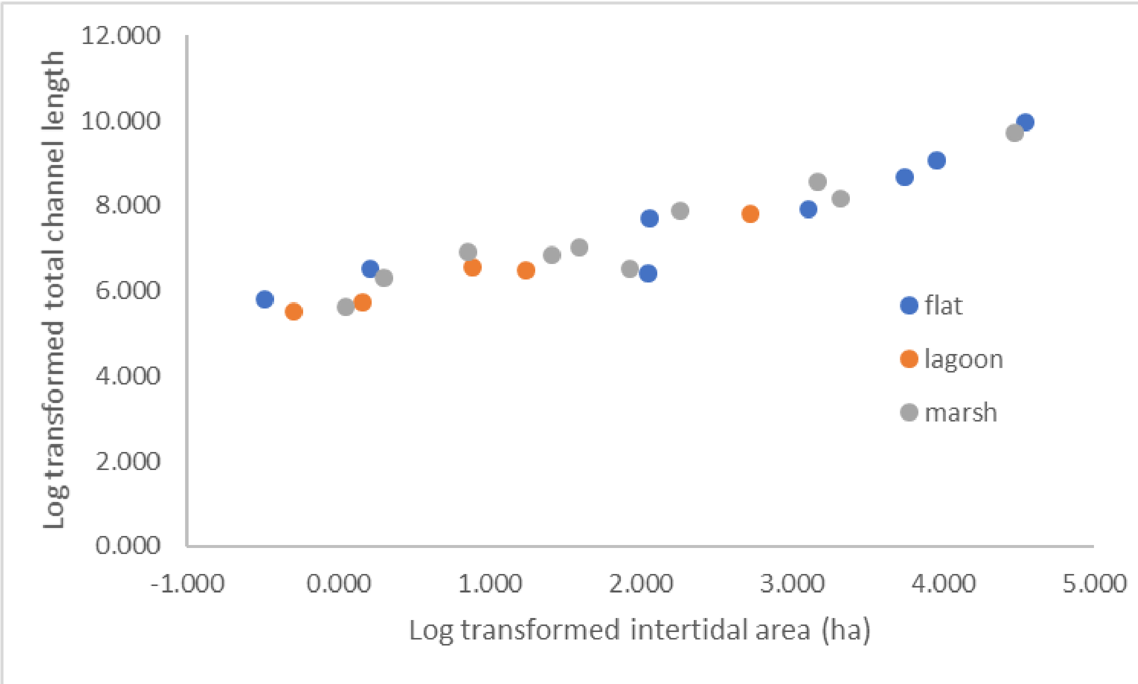


Figure 5. Relationship between embayment system intertidal area and TCL within embayment.

System Channel Branching (SCB)

Model results: The analysis finds the best model for SCB includes intertidal area and system type (Table 4, Figure 6). The relationship is a power function so I natural logarithm transformed the data. I recommend using the marsh system equation from the best model as guidance to help determine an appropriate level of SCB within the Smilk Bay Restoration Project area.

The equation is:

Step 1. Natural log transformed TCA (count of channel branch nodes) = (0.758*log intertidal area in ha)+ 1.064.

Step 2. Back transform [i.e, exp(x)] ‘Natural log transformed SCB’ to ‘SCB.’ Units are count of channel branch nodes.

Table 4. Best model outputs for predicting the number of SCB within an embayment.

A. Overall model performance and observations

Dependent Variable	Log # of nodes
N	18
Multiple R	0.910
Squared Multiple R	0.829

B. Model coefficients

CONSTANT		1.064
System type	flat	-0.328
Log intertidal area		0.758

C. Analysis of Variance Statistics

Source	Type III SS	df	Mean Squares	F-Ratio	p-Value
System type	1.867	1	1.867	5.726	0.030
Log intertidal area	23.262	1	23.262	71.346	0.000
Error	4.891	15	0.326		

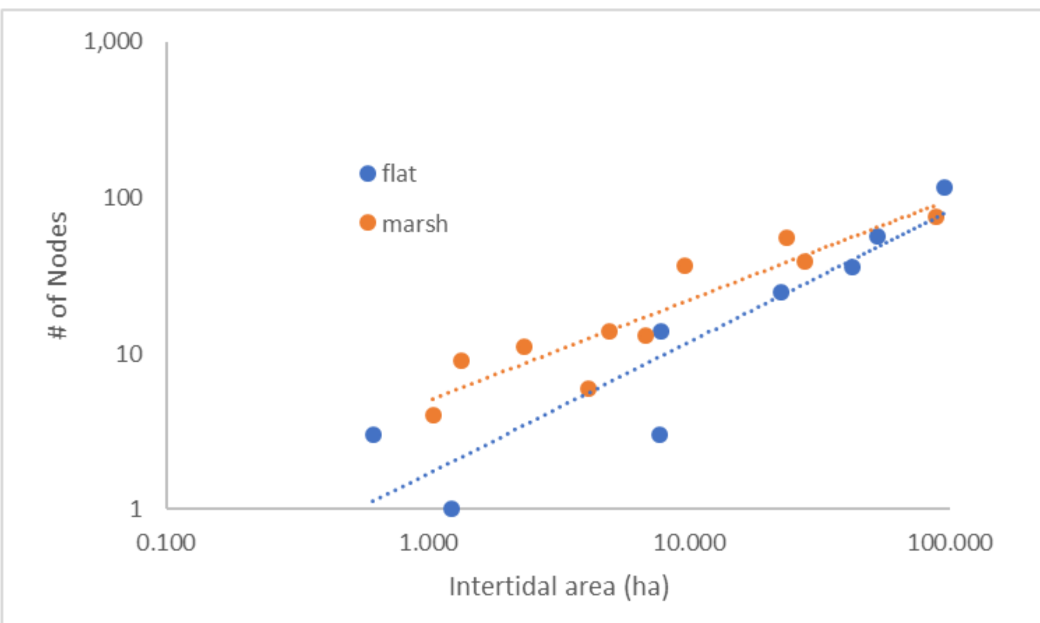


Figure 6. Relationship between embayment system intertidal area and SCB.

System Channel Order (SCO)

SCO scales with the size and shape of embayments. Larger embayments tend to have higher SCO while long skinny embayments tend to have lower SCO. However, I didn't find any model that is highly predictive of embayment SCO. The best model only has an $r^2 = 0.48$ and uses intertidal area without system type to predict SCO (Table 5, Figure 7). SCO only varied between 2 and 4 over the dataset of 18 embayment sites. Four of the five 2nd SCO systems have intertidal areas less than 4.1 hectares. Third Order systems varied greatly but three of the ten systems ranged from 5 to7 hectare in their intertidal area. Assuming the Similk Restoration Project site has an approximate 6-hectare intertidal area, I recommend it be designed as a 3rd order channel system.

Table 5. Best model outputs for predicting the SCO within an embayment.

A. Overall model performance and observations

Dependent Variable	SCO
N	18
Multiple R	0.696
Squared Multiple R	0.484
Adjusted Squared Multiple R	0.452
Standard Error of Estimate	0.537

B. Model coefficients

Effect	Coefficient	Standard Error	Coefficient	Tolerance	t	p-Value
CONSTANT	2.562	0.161	0.000		15.954	0.000
Intertidal area (ha)	0.017	0.004	0.696	1.000	3.872	0.001

C. Analysis of Variance Statistics

Source	Type III SS	df	Mean Squares	F-Ratio	p-Value
Regression	4.327	1	4.327	14.995	0.001
Residual	4.617	16	0.289		

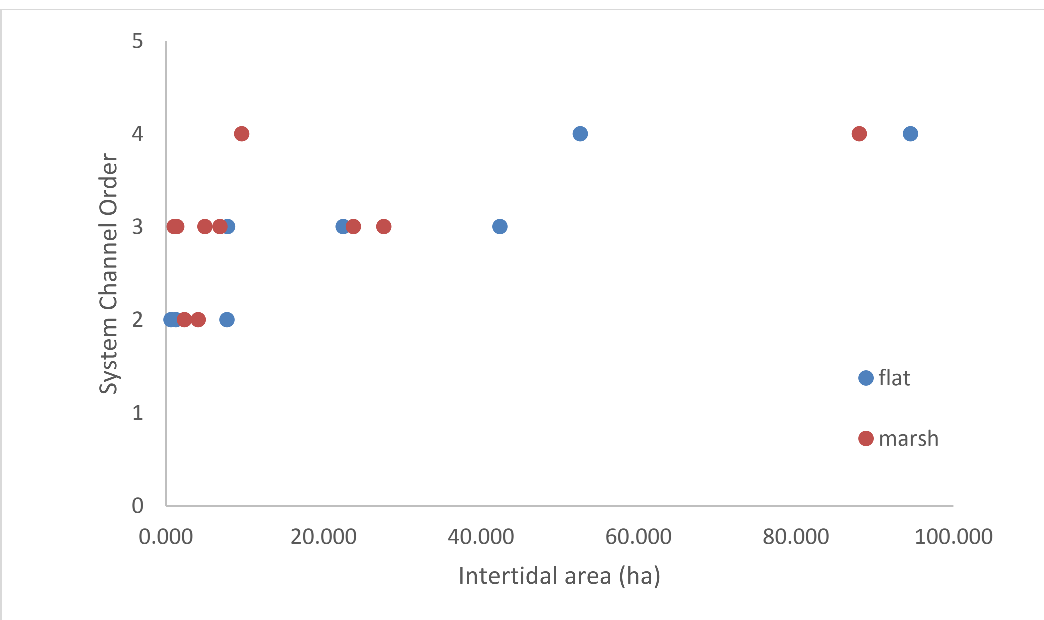


Figure 7. Relationship between embayment system intertidal area and SCO.

Main Channel Length (MCL)

MCL scales with the length of embayments. Longer embayments have longer main channels. The best model supported model using AIC has an r^2 = 0.82 and uses geometric system length without system type to predict MCL (Table 6, Figure 8). I recommend using the linear regression equation of Table 6 as guidance to help determine an appropriate MCL within the Smilk Bay Restoration Project area.

Step 1. The equation is: Natural log MCL (in meters) = (1.345*natural log geometric mean system length) -2.405

Step 2. Back transform [i.e, exp(x)] 'Natural log transformed MCL' to 'MCL.' Units are meters.

Table 6. Best model outputs for predicting the MCL within an embayment.

A. Overall model performance and observations

Dependent Variable	log of MCL
N	18
Multiple R	0.903
Squared Multiple R	0.815
Adjusted Squared Multiple R	0.804
Standard Error of Estimate	0.464

B. Model coefficients

Effect	Coefficient	Standard Error	Std. Coefficient	Tolerance	t	p-Value
CONSTANT	-2.405	0.993	0.000		-2.422	0.028
Log of Geometric mean length	1.345	0.160	0.903	1.000	8.404	0.000

C. Analysis of Variance Statistics

Source	Type III SS	df	Mean Squares	F-Ratio	p-Value
Regression	15.232	1	15.232	70.631	0.000
Residual	3.450	16	0.216		

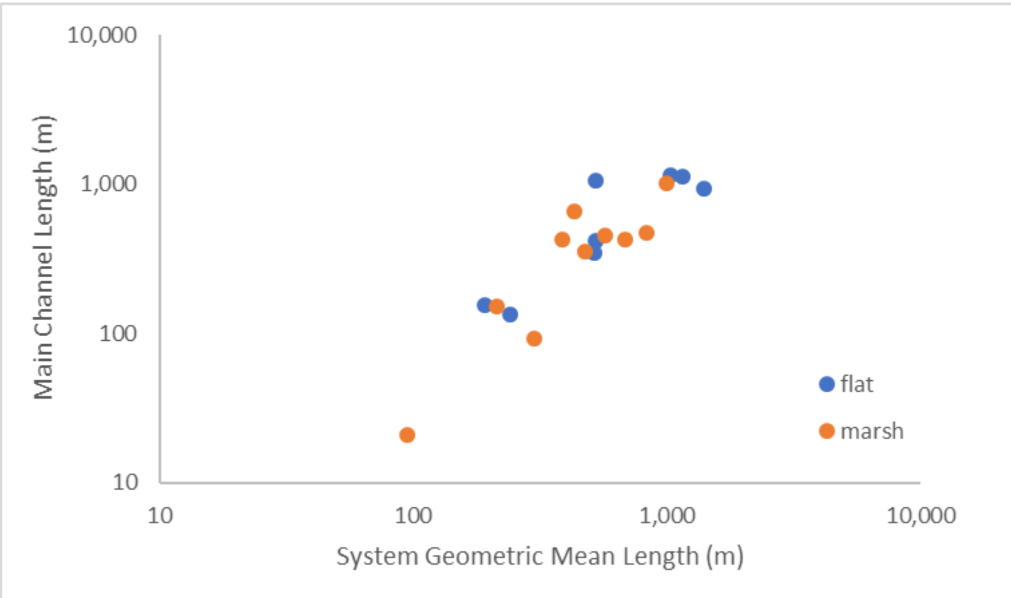


Figure 7. Relationship between embayment system length and MCL.

Main Channel Sinuosity (MCS)

Valley (in our case embayment) slope, bed resistance, and disturbance regime are controlling factors thought to influence channel sinuosity variation coupled with the hydraulic processes influencing channel meander wavelength and migration across a floodplain which are well known to be controlled by valley width. Lazarus et al. (2013) proposed universally (all systems: fluvial, tidal, etc.) that “flow resistance (representing landscape roughness attributable to topography or vegetation density) relative to surface slope exerts a fundamental control on channel sinuosity that is effectively independent of internal flow dynamics. Resistance-dominated surfaces produce channels with higher sinuosity than those of slope-dominated surfaces because increased resistance impedes downslope flow.” I lack some of the specific data used in typical geomorphic sinuosity, meander, or bank erosion models but I did use landscape data related to the fundamental hypotheses of channel sinuosity to predicted MCS for embayments. These data are: main channel reach gradient (surrogate for valley gradient), embayment geometric mean length/width ratio (surrogate for valley constraint), and system type (surrogate for bed resistance and disturbance regime).

The two best models support hypotheses of sinuosity theory (Tables 7 & 8, Figures 8 & 9). Specifically, steeper systems have straighter main channels (Figure 8, top panel) and systems where the landform constrains embayment valley width also have straighter main channels (Figure 8, bottom panel). While system type is not statistically significant (p is not < 0.05, see Table 7) the analysis hints of an effect by system type supporting the bed resistance part of sinuosity theory. Thus, I went ahead and used the model with system type to illustrate the small effect of system type (Figure 9) where marsh systems should be more resistant than flat systems, and thus have higher sinuosity, due to the root strength and roughness of marsh plants. Flat system embayments also may reflect systems with higher and more frequent disturbance regimes, which in theory increases sinuosity. I did notice that flat system embayments with the larger fetch values seemed to have an indication of prior channel pathways in their historic photo series which may be due to the recent disturbance history of the sites due to wave and drift cell sediment dynamics.

Overall, I have imperfect data (i.e., poor resolution gradient results from LiDAR, few sites overall, few sites with length/width ratios < 1 or > 3.5) to really develop a predictive sinuosity model for embayments. The models are bias low for sinuosity values higher than 2.0. The model including system type predicts impossible values for systems with length/width ratios >6.0 for flat systems and >10.0 for marsh systems (Figure 9, bottom panel). The Similk Restoration Project site likely has a valley slope in the ~0.2% to ~0.3% range, and system length/width ratio in the ~1.7 range so it is doubtful to expect Similk’s MCS to be in the high value range that is poorly predicted by my models. Most likely Similk’s MCS should be in the range between 1.25-1.4.

Table 7. Best model outputs for predicting the MCS within an embayment when including system type with covariates.

A. Overall model performance and observations

Dependent Variable	Log of MCS
N	15
Multiple R	0.783
Squared Multiple R	0.614

B. Model coefficients

Factor	Level	Log of MCS
CONSTANT		-0.854
TYPE$	flat	-0.100
LNGEOLW		-0.206
LNREACHGRAD		-0.213

C. Analysis of Variance Statistics

Source	Type III SS	df	Mean Squares	F-Ratio	p-Value
System type	0.105	1	0.105	1.796	0.207
Log of Geo L/W	0.478	1	0.478	8.150	0.016
Log of reach gradient	0.420	1	0.420	7.173	0.021
Error	0.645	11	0.059		

Table 8. Overall best supported model outputs for predicting the MCS within an embayment

A. Overall model performance and observations

Dependent Variable	Log of MCS
N	15
Multiple R	0.742
Squared Multiple R	0.551
Adjusted Squared Multiple R	0.476
Standard Error of Estimate	0.250

B. Model coefficients

Effect	Coefficient	Standard Error	Std. Coefficient	Tolerance	t	p-Value
CONSTANT	-0.484	0.486	0.000		-0.997	0.338
Log of reach Gradient	-0.163	0.073	-0.435	0.999	-2.247	0.044
Log of Geo L/W	-0.229	0.072	-0.615	0.999	-3.174	0.008

C. Analysis of Variance Statistics

Source	Type III SS	df	Mean Squares	F-Ratio	p-Value
Regression	0.919	2	0.460	7.352	0.008
Residual	0.750	12	0.063		

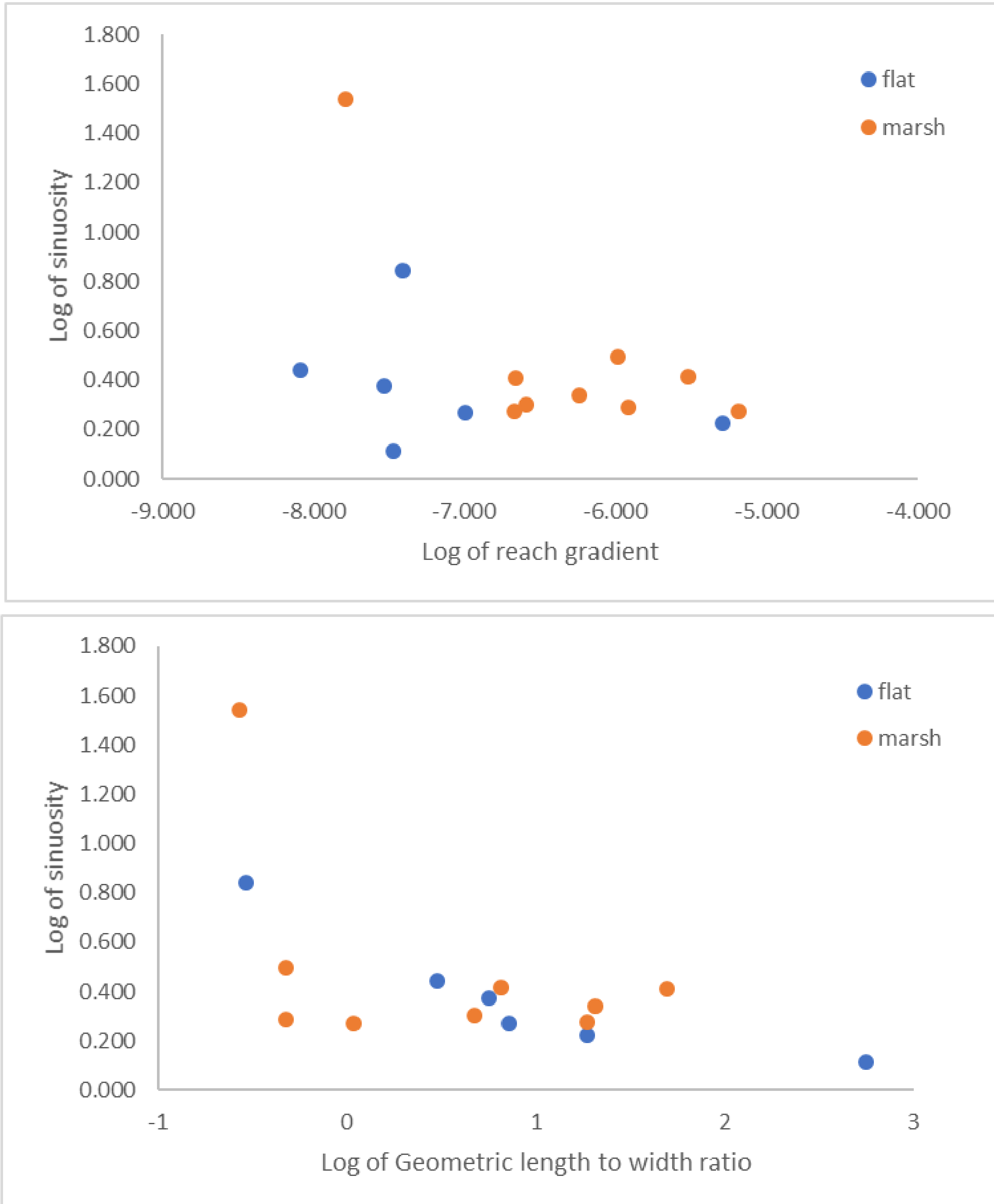


Figure 8. Relationship between main channel reach gradient (top panel) and embayment system length to width ratio (bottom panel) and MCS.

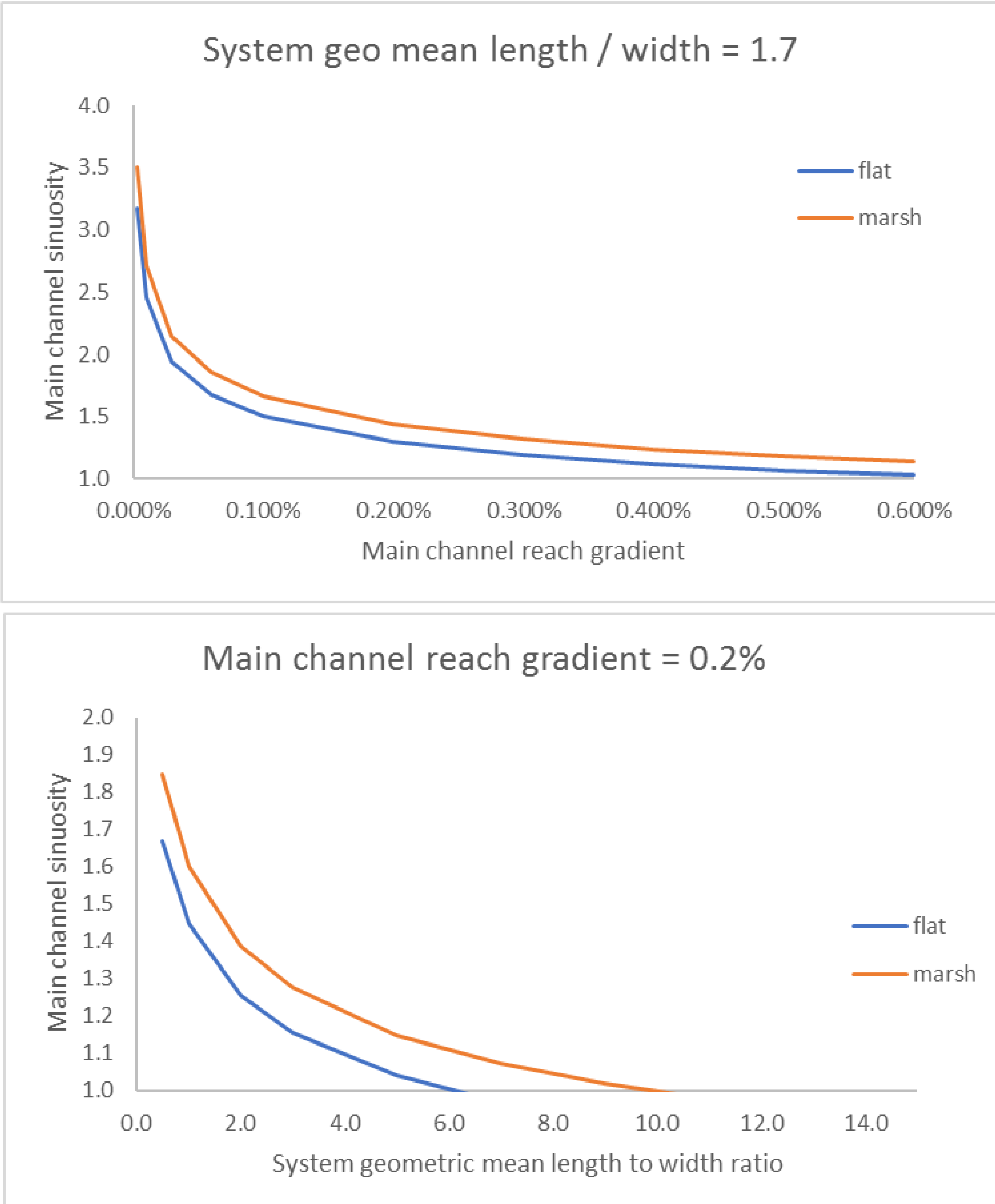


Figure 9. Predictions of MCS using best model (Table 7). Top panel shows the relationship as a function of main channel reach gradient and system type with system geometric length to width ratio set at a constant 1.7 (rough approx. of the Similk Restoration Project site). Bottom panel shows the relationship as a function of system geometric length to width ratio and system type with main channel reach gradient set at a constant 0.2% (rough approx. of the Similk Restoration Project site).

Channel elevation

To identify elevation norms for tidal channel habitat within barrier embayments I used over 600 polygons from the Beamer et al. (2018) dataset for channel and marsh habitat at 23 sites. Each polygon was associated with high resolution LiDAR (1 m^3 pixel size) flown in 2012 and 2014, depending on the site. There are 100s to 1000s of LiDAR pixels associated with each polygon yielding elevation results for each. I plotted the mean elevation results for channel and marsh habitat polygon by embayment site, system type, and system size (tidal volume and intertidal area). Overall, I found tidal volume is a much better predictor than intertidal area for elevation, so all results presented below are for tidal volume only. I queried the data to figure out what elevation channels should be but I found results for channel habitat unreliable (highly variable and biased high in elevation) so I looked at the marsh elevation data thinking an approach to design guidance could be to subtract channel depth from marsh elevation to obtain channel thalweg elevation. Below I describe what I found and follow up with some recommendations.

<u>LiDAR-based channel elevation</u>: I attempted to calculate elevation norms for channel habitat within barrier embayments based on the LiDAR results for channel polygons. I concluded channel elevation results based on LiDAR are highly variable, biased high in elevation, and therefore are not singularly useful for restoration design guidance. The bias is possibly due to the LiDAR based elevation results of channel polygons includes polygons that are dewatered and watered. The dewatered polygons would reflect a more accurate result (per the limitations of using LiDAR elevation results) while the watered polygons would be biased high from the channel's true thalweg elevation. I did not attempt to sort out which LiDAR pixels were associated with dry compared to wet channels because the task would require a large amount of effort. Thus, I don't think the channel habitat results from the current state of GIS data are immediately useful to present a norm for channel elevation design guidance for the Similk Restoration Project.

<u>LiDAR-based marsh elevation</u>: Embayment system size is negatively associated with average marsh elevation for a system (Figure 10). The top panel of Figure 10 shows no evidence of a relationship for lagoon systems whereas flat and marsh systems do show a functional relationship. I was thinking system marsh elevation would be reflected as a distribution not a function, so I was surprised by the result. Greg Hood and I briefly discussed if the results are spurious. The reasons we came up with are speculative and include the following two ideas: (1) there is a mismatch in elevation and habitat results and/or (2) I used the wrong elevation datum.

1. The results are a poor representation of elevation due to mismatches in the GIS polygons and LiDAR pixels compared to actual elevation. The mismatch is due to edge effects from linking the marsh polygon designations with the "blocky" representation of topography created by LiDAR which not only has poorer than ground truthed elevation but may include elevation results for adjacent habitats. In thinking this possible cause through I don't think the mismatch should result in a spurious correlation. It should result in a more uncertain correlation, which may make the result somewhat useless for restoration design guidance. Figure 10 used all 600+ polygons (even really small ones) so the mismatch issue described above may be more real for those polygons averaged for each system.
2. The results might be spurious because the analysis was completed using the wrong datum. This is a valid issue although the effect of not converting NAVD88 results to Tidal Datum results across the dataset analyzed is likely not enough to cause a spurious correlation (i.e., there isn't

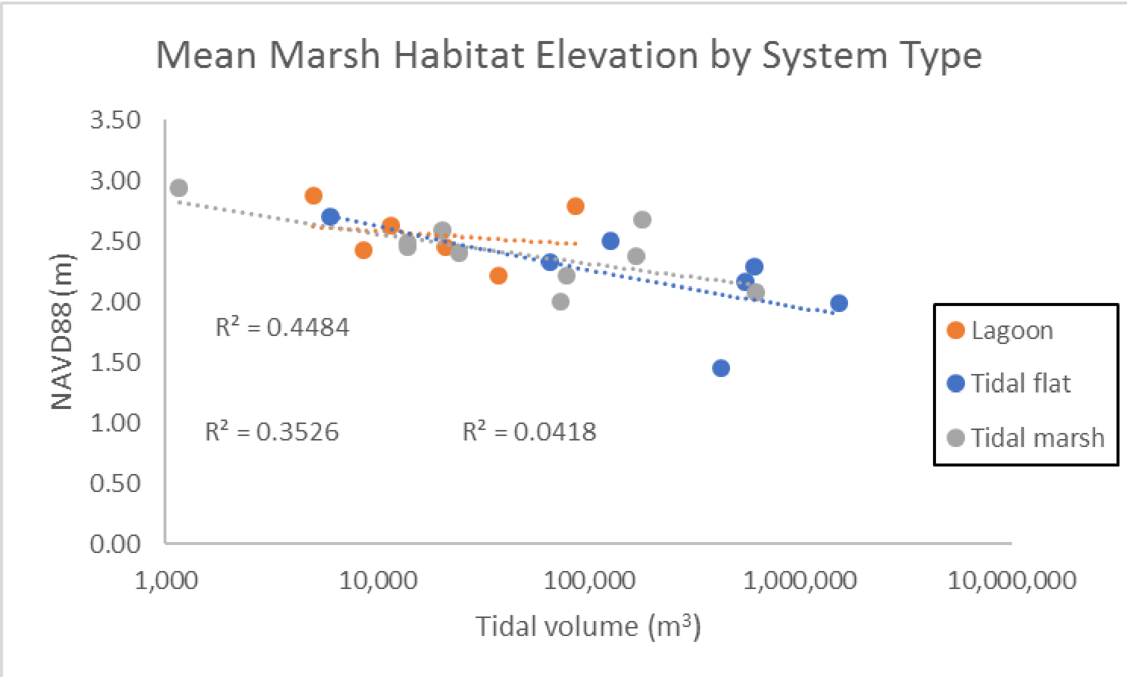
that big of a difference in tidal range within the Whidbey Basin). Additionally, it is doubtful using NAVD88 instead of tidal datum would result in a systematic bias across the dataset (i.e., the sites that benefit from tidal datum correction also are the largest sites).

Recommendation: If system size influences marsh elevation it should be considered when designing the Similk Restoration Project site. It also may be an important issue between developing the site as a marsh or flat system. If elevation datum is an important issue to determine marsh elevation results across the geography of the dataset (Whidbey Basin), then sites nearby to the Similk Restoration Project site should represent the most appropriate marsh elevations expressed as NAVD88 results. Sites located nearby to Similk are Turners Bay, Kiket Lagoon, and Lone Tree Lagoon have mean marsh elevation results of 1.46, 2.42, and 2.45 meters NAVD88 (or 4.79, 7.94, and 8.04 feet NAVD88), respectively (Table 9). Each of these sites have well known extensive juvenile Chinook salmon use.

I recommend designing the Similk Restoration Project site within the marsh elevation norms of these nearby sites. Channel habitat would be excavated to appropriate widths and depths based on the marsh elevation plain.

Table 9. Summary of marsh elevation and embayment system size for five embayment sites in close proximity to the Smilk Restoration Project site.

Site name	mean marsh elevation		Tidal volume (m^3)	System type
	NAVD88 m	NAVD88 ft		
Kiket Lagoon	2.42	7.95	8,636	Lagoon
Lone Tree Lagoon	2.45	8.02	20,914	Lagoon
Turners Bay	1.46	4.77	419,659	Tidal flat
English Boom Lagoon	2.94	9.63	1,163	Tidal marsh
Arrowhead Lagoon	2.49	8.17	13,899	Tidal marsh



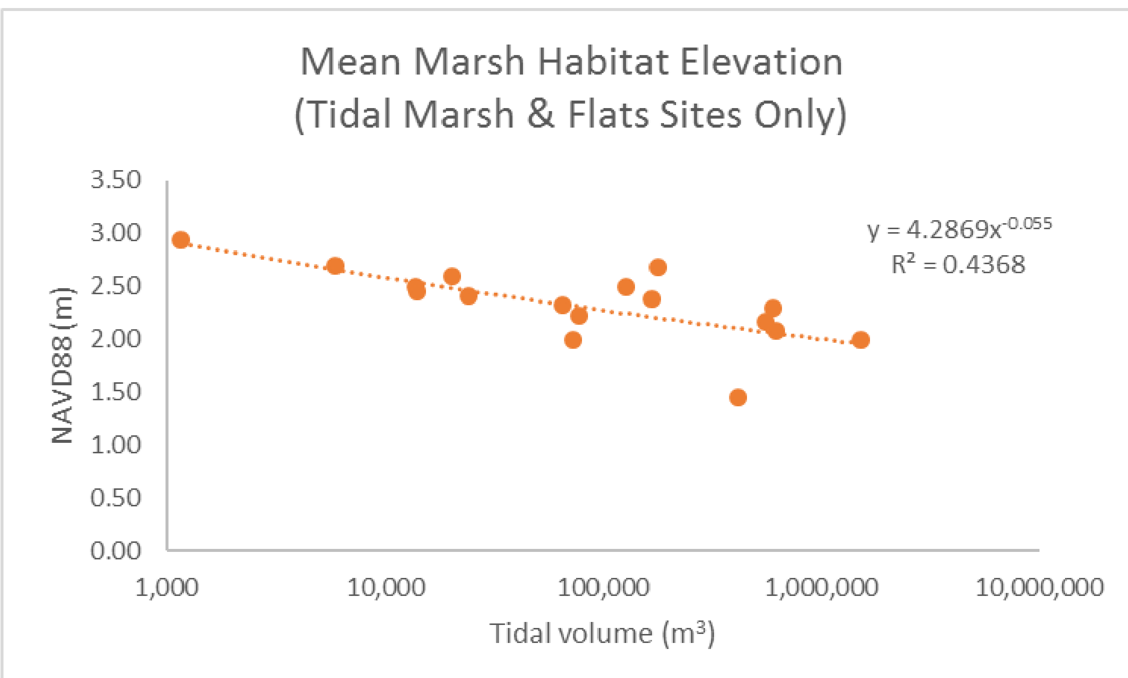


Figure 10. Relationship of mean marsh elevation by embayment system type and system intertidal volume.

Channel dimensions

It is well known that channel dimensions scale by channel order. The barrier embayment polygon dataset (Beamer et al. 2018) is not sufficiently detailed to extract channel dimension results by channel order. Thus, we don't have true barrier embayment channel dimension results to use for restoration design guidance at the Similk Restoration Project site.

An alternative is to use available tidal channel dimension (width and depth) results derived from GIS and field-based measurements from nearby Skagit tidal delta marshes that are tidally dominated and shadowed from river hydrology. Data from these channels have more similar hydrology to embayment channels than delta channels that are also influence heavily by river hydrology. Thus, I used a dataset from the 2004 Skagit Tidal Delta, including data attributes measured remotely using GIS tools and field-based measurements. The dataset is part of SRSC's Habitat Status and Trends Program (Hood et al 2019) and was initially developed and used to describe channel characteristics for estuarine habitat as part of the Skagit Chinook Recovery Plan (Beamer et al. 2005). I used these data to calculate tidal channel norms for (1) channel top width located at the channel's mouth by channel order and (2) channel depth located at the channel's mouth. These are described in more detail below.

Width by order

This section describes results for blind tidal channel top width located at the channel's mouth by channel order.

I trimmed the 2004 Skagit tidal delta dataset to 500+ observations to include adequate observation for each channel order by spatial bin within the Skagit tidal delta. Only three of the five spatial bins had adequate observations and only observations for 1-4 order channels were adequate across all three spatial bins. Thus, the analysis can only look at the influence of channel order and spatial bin for 4 channel order by 3 spatial bins. The three spatial bins are: Central Fir Island (Central Fir Is) which is the bayfront of Fir Island, North Fork delta (NF delta), and South Fork delta (SF delta). The Central Fir Is area is more tidally dominated than the other two bins which are roughly equal to each other having a strong mix of tidal and river hydrologic influence.

The best supported model includes spatial bin and channel order to predict blind tidal channel top width (Figure 11., Table 10A-C). The relationship is best expressed as a power function so I natural log transformed channel width and channel order for the analysis. Blind channels within Central Fir Is are wider than both SF and NF delta channels of the same channel order (Table 10D). NF delta and SF delta channels are not significantly different in their width by channel order.

<u>Recommendation</u>: Since the Central Fir Is area has the least riverine and most tidal influence of the three Skagit tidal delta spatial bins, blind tidal channel characteristics from that area are likely more similar to barrier embayment channel characteristics than NF delta or SF delta channels. I recommend using the Central Fir Is channel width by channel order results as a surrogate for channel widths for design guidance at the Similk Restoration Project site (Table 11).

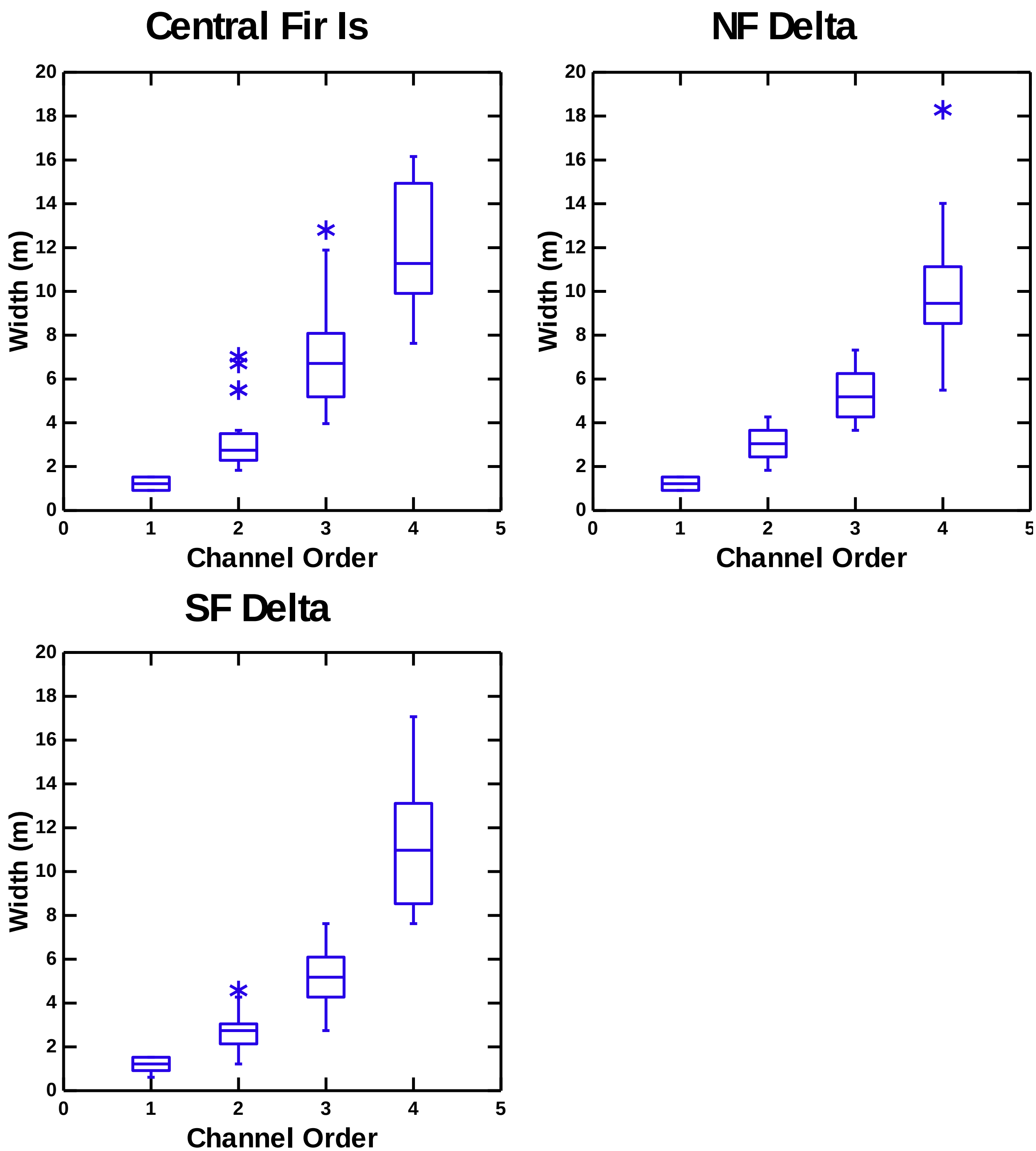


Figure 11. Boxplot of blind tidal channel top width in meters by channel order by three spatial strata within the Skagit tidal delta. The Central Fir Island results (top left panel) is most representative of barrier embayments.

Table 10. Best model outputs for predicting blind tidal channel top width.

A. Overall model performance and observations

Dependent Variable	LNGWIDTH_M
N	507
Multiple R	0.936
Squared Multiple R	0.875

B. Model coefficients

CONSTANT		0.162
PATHWAY_P$	Central Fir Is	0.088
PATHWAY_P$	NF Delta	-0.016
LNORDER		1.443

C. Analysis of Variance Statistics

Source	Type III SS	df	Mean Squares	F-Ratio	p-Value
PATHWAY_P$	1.415	2	0.708	9.375	0.000
LNORDER	255.482	1	255.482	3,384.464	0.000
Error	37.970	503	0.075		

D. Tukey's Honestly-Significant-Difference Test.

Post Hoc Test of LNGWIDTH_M using least squares means for the model MSE of 0.075 with 503 df.

PATHWAY P$(i)	PATHWAY P$(j)	Difference	p-Value	Lower 95% Confidence Interval	Upper Interval
Central Fir Is	NF Delta	0.105	0.056	-0.002	0.211
Central Fir Is	SF Delta	0.161	0.000	0.072	0.249
NF Delta	SF Delta	0.056	0.200	-0.020	0.132

Table 11. The distribution of channel width in meters by channel order for Central Fir Island dataset shown in Figure 11. The number of observations are 15, 19, 16, and 12 for 1^{st}, 2^{nd}, 3^{rd}, and 4^{th} order channels, respectively.

Distribution	Channel Order			
	1^{st}	2^{nd}	3^{rd}	4^{th}
Minimum	0.91	1.83	3.96	7.62
5%	0.91	1.83	4.05	7.71
25%	0.91	2.21	5.18	9.91
50% (median)	1.22	2.74	6.71	11.28
75%	1.52	3.58	8.08	14.94
95%	1.52	6.87	12.53	16.03
Maximum	1.52	7.01	12.80	16.15

Depth by order

This section describes results for blind tidal channel depth located at the channel's mouth.

I used 81 measured in the field observations of blind tidal channel top width and depth (measured at the channel's mouth. Only 31 of the 81 observation also have channel order assignments so I did not conduct the analysis to include channel order as a possible influence on channel depth. Regression analysis finds channel width predicts channel depth (Figure 12, Table 12). The relationship is a power function so data were natural log transformed. I recommend using the regression equation for channel depth applied to the channel widths by order shown in Table 11 for design guidance for the Similk Restoration Project channels.

The equation is:

> Step 1. Natural log transformed blind tidal channel depth (in meters) = (0.477*log channel width in meters)-0.436.
>
> Step 2. Back transform [i.e, exp(x)] 'Natural log transformed blind tidal channel depth' to 'blind tidal channel depth.' Units are meters.

Likely, the channel depths predicted by this equation are deeper than channels in barrier embayments because the dataset used are primarily from the NF and SF delta areas which are thought to have lower width to depth ratios than barrier embayments because of their river hydrology influence. It may be prudent to add a "fudge" factor to the regression result to reduce predicted depths. However, there may be little downside to over excavating channel depths (see comments on over excavating channels later in this memo).

Table 12. Best model outputs for predicting blind tidal channel depth.

A. Overall model performance and observations

Dependent Variable	LNDEPTH
N	81
Multiple R	0.756
Squared Multiple R	0.572
Adjusted Squared Multiple R	0.566
Standard Error of Estimate	0.388

B. Model coefficients

Effect	Coefficient	Standard Error	Coefficient	Tolerance	t	p-Value
CONSTANT	-0.436	0.062	0.000	.	-7.023	0.000
LNWIDTH	0.477	0.046	0.756	1.000	10.271	0.000

C. Analysis of Variance Statistics

Source	Type III SS	df	Mean Squares	F-Ratio	p-Value
Regression	15.882	1	15.882	105.491	0.000
Residual	11.894	79	0.151		

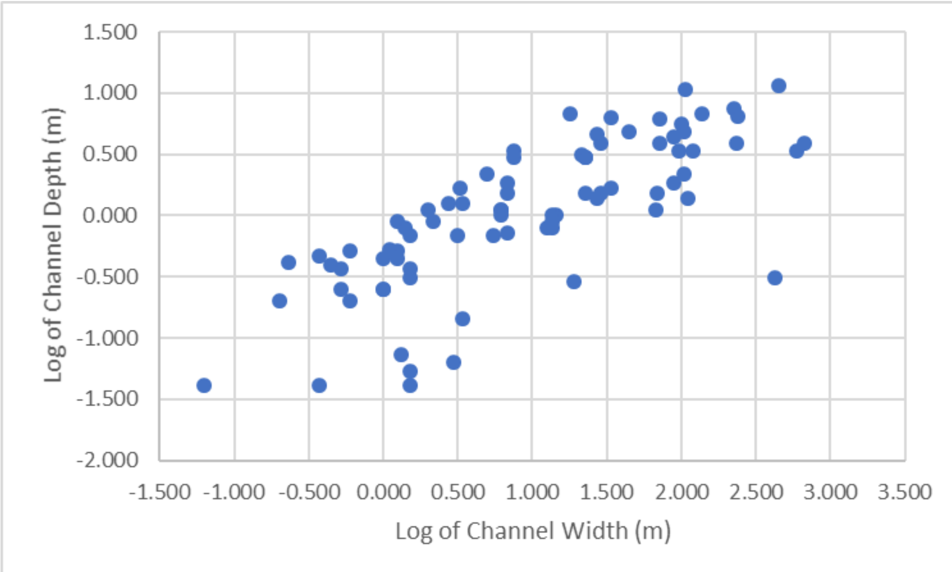


Figure 12. Relationship of top width and depth for blind tidal channels within the Skagit tidal delta.

Additional channel dimension comments:

1. Using nearby tidally dominated Skagit delta channel dimensions is a good starting point for design guidance (i.e., Figures 11 and 12, and Table 11), but ultimately a better solution is to go to nearby barrier embayment sites (e.g., sites in Table 9) and field measure channel width and depth dimensions by channel order. Then use the marsh elevation results (possibly the functional relationship shown in Figure 10) and subtract the existing channel depth by corresponding channel order.

2. In general, I recommend slight over excavation of the channels. If the channels accrete to an equilibrium depth and width, then there are no negative habitat consequences – it has only been an inefficient construction effort. If they do not accrete then fish will have more water to rear within. However, I highlight my thoughts on three possible negative issues with the idea of over excavation. They are: a) water temperature dynamics, b) set up of an inundation environment conducive to invasive plant species, and c) cost of excavation.
    a. <u>Water temperature</u>. I don't think there's a high risk of creating adverse water temperature condition due to over excavation of channels. Barrier embayments already get hot in late spring and the juvenile salmon egress from the systems on their way to the ocean. Barrier embayment habitat for juvenile salmon is a transient rearing opportunity during late winter and spring. Unsuitable water temperature will happen whether the channels were deep or shallow. Temperature dynamics will likely not change much due to small over excavation in channel depth because the overall volume of water subject to heating is small. The water will still all heat seasonally, and in its diurnal tidal pattern to a point in late spring when the fish need to leave. Excavation should set up channel conditions where they do not fully mix through tidal forces.
    b. <u>Invasive species</u>. Over excavation of channel depths may set up hydrologic characteristics conducive to invasive vegetation species rather than native species. This phenomenon has been observed in subsided river delta environments (Clifton et al. 2018).

However, Greg Hood and I are not aware of a similar paradigm of risk for embayments. We recommend that vegetation monitoring be done and invasive species control mitigation if needed.

c. Construction cost. It is unwise to over excavate the site to the point where you are greatly increasing construction costs. However, a plan to slightly over excavate might be smart to provide a safety factor in channel depth because it is more likely that the channels will passively fill in than passive down cut, based on monitoring results from other tidal channel sites. Additionally, much of the cost of excavation is absorbed by already being on site with an excavator. It would be much more costly to return to the site and dig the channels bigger/deeper.

Marsh vegetation guidance

Planting

The Similk Restoration Project site is proposed to be restored into a barrier embayment condition, and the topic of vegetation colonization of restored barrier embayments has not been studied/monitored rigorously to our knowledge. It is unknown whether there is sufficient seed source for native marsh vegetation to passively colonize the restored site. We hypothesize that native marsh seed source is sufficiently available to Similk Bay because of (a) the large amount of tidal flushing within Skagit Bay capable of dispersing seed, and (b) nearby native marsh seed sources. The seed source sites include nearby barrier embayments (Turners Bay, Lone Tree and Kiket Lagoons), as well as the large bay fringe of the Skagit tidal delta that include the salt tolerant plants common to barrier embayments. However, we recommend the question of native vegetation colonization within the restored site be incorporated into the site's monitoring plan. The site's monitoring plan should include adaptive management triggers to plant the site if native vegetation does not colonize as predicted. Further, a predictive vegetation model would need to be developed for Whidbey Basin (or Skagit Bay) barrier embayments to use as the basis for monitoring vegetation at the Similk Restoration Project site. The model would follow the concepts of existing predictive vegetation models for tidal delta habitat (e.g., Hood 2013).

Channel pattern and vegetation dynamics

Recent monitoring of restored sites in the Skagit and Stillaguamish deltas indicates that extensive channel excavation (matching reference conditions) appears to dramatically accelerate vegetation development while insufficient channel excavation strongly inhibited vegetation colonization. The hypothesized basis for inhibited vegetation colonization is insufficient channel development produces high sheet flow velocities and sheer stress over the marsh surface, thereby inhibiting seed recruitment and germination. This issue is currently being studied by SRSC (Greg Hood) as the funded ESRP Learning Project "Tidal Channel Excavation & Vegetation Development" (PRISM #20-1939). Specifically, the study measures sheet flow velocities and seed retention on four restoration sites in the Skagit and Stillaguamish deltas: zis-a-ba, Fir Island Farms, Leque Island (WDFW), and Port Susan Bay (The Nature Conservancy [TNC]). Results of this study are not yet available, but the hypothesized relationship between channel pattern and vegetation also apply to barrier embayment. Thus, restoring the Similk Restoration Project site to channel norms for reference barrier embayments is prudent for natural vegetation colonization.

Non-native marsh vegetation concerns

Colonization of non-native marsh vegetation after restoration of the Similk Restoration Project site may be a concern but is likely manageable with diligent monitoring and control efforts. Non-native cattail spread is common in nearby river tidal deltas (Skagit, Stillaguamish) but barrier embayments are saltier than river deltas so it is unlikely cattail spread will be a concern for the Similk's restored condition. More salt tolerant invasive species may be a concern, such as Spartina and Common Reed (*Phragmites australis*). Both were recently observed within a restored site in the Stillaguamish estuary but were apparently successfully eliminated by weed control (Hood 2021).

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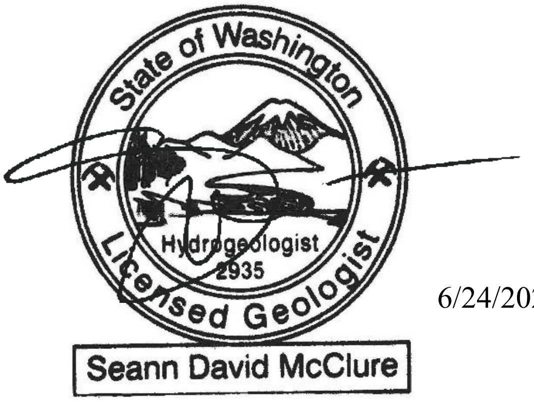
Appendix E
Surface Water, Groundwater, and Septic Risk and Saltwater Intrusion Evaluation (Aspect)

Project No. 210105-A-001-03

June 24, 2022

To: Kathy Ketteridge, Blue Coast Engineering, LLC

From:



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Re: **Surface Water, Groundwater, and Septic Risk and Saltwater Intrusion Evaluations for Similk Tidal Marsh Restoration Project**

Aspect Consulting, LLC (Aspect) prepared this Technical Memorandum to present the results of surface water hydrology, groundwater, and septic risk and saltwater intrusion evaluations in support of the proposed Similk Tidal Marsh Restoration project for the Skagit River System Cooperative (SRSC). These evaluations were completed as a consultant to Blue Coast Engineering, LLC (Blue Coast) under Subtasks 4.1 and 4.5 of Master Services Agreement Task Order #0103-2021-1.

Executive Summary

The following results summarize the key findings of this study:

Tidal exchange will be the dominant source of water entering the Similk Tidal Marsh Restoration project; however, surface water runoff during storm events are also important for informing project design. Surface water runoff rates to the project area were evaluated using the Western Washington Hydrology Model for the 262-acre drainage area. The results indicate an average flow of 40 gallons per minute (gpm) with flows ranging from zero during dry periods to as high as 14,400 gpm (or 32 cubic-feet-per-second) during the 100-year storm event.

The groundwater evaluation included development of a preliminary hydrogeological conceptual model based on review existing data, regional studies, and project test pit observations. The evaluation was used to formulate a preliminary risk assessment of flooding to nearby septic systems and saltwater intrusion to nearby water supply wells from the project design. A total of 25 nearby septic systems and one potential private water supply well were identified and mapped in the vicinity of the project area. The supply well was identified from a 1974 water right claim for domestic and irrigation uses on a parcel east of Christianson Road (no well logs were found). However, a utility service area map indicates the parcels around the project area are all on public water supply from Skagit County Public Utilities. Thus, saltwater intrusion to private supply wells is not likely a risk factor for the project – though the status of the parcel with the 1974 water right claim should be verified.

Records and as-builts were reviewed from 15 of the 25 mapped septic system and the elevations of the drain fields are all higher than the projected maximum inundation level. Thus, our preliminary analysis did not identify any specific risks to the septic systems using the available data. However, the conceptual model of groundwater flow and hydraulics between the estuary and adjacent hillslopes is preliminary and based on limited available data, so expected impacts to groundwater conditions from the proposed project remain uncertain. Therefore, additional field data collection and analysis is recommended to finalize the risk assessment to septic systems. The status of the private well identified from the water right claim should also be verified and if present evaluated for risk to saltwater intrusion.

Introduction

Aspect understands SRSC is evaluating a project that would restore tidal inundation to the historical 17-acre Similk tidal marsh area (Site; Figure 1). Natural tide exchange between the pre-existing pocket estuary and Similk Bay has been removed by the construction of a road (Satterlee Road) and an earthen dike. Currently, drainage of surface water from the wetlands occurs through a north-south ditch that conveys water southward to an east-west ditch along Satterlee Road. A pumpstation within the Satterlee ditch then pumps the water across an earthen dike to discharge into Similk Bay. Aspect also understands there is an existing (but inoperable) tide gate that provides limited drainage.

The proposed restoration site is a rectangular-shaped pocket estuary bordered to the north, east, and west by uplands and to the south by Satterlee Road and earthen embankment paralleling Similk Beach. The project includes roadway improvements and bridge design at Satterlee Road and formation of a channel to allow free tidal exchange between the estuary and Similk Bay.

Project Objectives

The objectives of this study are to evaluate the current surface water and groundwater interactions and inputs to the proposed restoration site, including:

- Assess potential project risks of flooding to underground septic systems
- Assess induced saltwater intrusion to neighboring groundwater supply wells near the base of the hillslopes

Our groundwater evaluation, which follows discussion of the surface water evaluation, relies primarily on review of existing data supplemented with project field work conducted for the preliminary design phase of the project, which included excavation of test pits across the estuary (see Aspect, 2022) and site observations during flooding events (Appendix A). These assessments are used to develop a preliminary site conceptual model, identify key data gaps, and and provide recommendations for proceeding with the next the phase of the project.

Aspect completed subsurface explorations (test pits) and prepared a companion technical memo with geologic interpretations and engineering conclusions and recommendations to support the preliminary design (Aspect, 2022).

Surface Water Evaluation

Tidal exchange will be the dominant source of water to the Similk Tidal Marsh Restoration project; however, surface water inputs are also important for informing the design of the tidal marsh restoration. The Site receives channelized surface water runoff from the Swinomish Golf Links golf course and a portion of Christianson Road, as well as a drainage basin along Satterlee Road with a less defined conveyance network, this basin also includes precipitation falling directly on the marsh. These three drainage basins are shown in Figure 1. These subbasins were delineated based primarily on topography from a Light Imaging, Detection, and Ranging (LiDAR) survey, with confirmation of key features on the golf course and Christianson Road during a site visit on October 15, 2021.

Surface water flows in each subbasin were evaluated using the Western Washington Hydrology Model 2012 (WWHM), version 4.2.17. WWHM is a continuous simulation hydrologic model based on the U.S. Environmental Protection Agency's (EPA) Hydrologic Simulation Program – Fortran (HSPF) that was developed by the Washington State Department of Ecology (Ecology) specifically for stormwater evaluations in Western Washington. The key inputs to WWHM are weather and land characteristics.

Weather inputs to WWHM are pre-selected based on the site location. WWHM uses time series of historical precipitation from a nearby weather station and applies a scaling factor to adjust the precipitation to represent the site. WWHM also uses pan evaporation from the Puyallup 2 W Experimental Station for all of the 19 Western Washington counties nearby weather stations. Based on the Site location, WWHM selected the Burlington station as the nearest station to the Site for precipitation. The precipitation records from the Burlington station were adjusted to the Site location by applying a scaling factor of 0.833 selected by the WWHM program. WWHM uses a period of record of 61 years (water years 1949 to 2009) for the Burlington station based on the length of historical observations.

Site-specific land characteristics are inputs to WWHM by the modeler and represent the amount of area in the drainage basin of interest that fall into different categories of soil type, slope, vegetative cover, or impervious cover.

WWHM simulates surface runoff, shallow subsurface flow (also known as interflow), and discharge from groundwater. Surface runoff and interflow are commonly considered stormwater runoff. The primary output from WWHM is a timeseries of stormwater on an hourly basis over the full 61-year period of record that can be statistically evaluated in WWHM or through post-processing (Appendix B).

Land characteristics for the three drainage subbasins connected to the Site were determined using soils information from the Natural Resource Conservation Service (NRCS) Web Survey, slopes measured from the LiDAR survey, and land cover digitized from aerial photos. The resulting soils and slope information are shown on Figure 2. Land cover is shown on Figure 3. The resulting land characteristics for each subbasin are shown in Table 1.

The total drainage basin tributary to the Site is about 261.7 acres, of which 42 percent is in the golf course subbasin, 8 percent is in the Christianson Road subbasin. The most prevalent land uses in the basin are flat, forested areas on well-draining soils (A/B-Forest-Flat) at 29 percent of the basin, followed by moderately sloping forests on well-draining soils (A/B-Forest-Moderate), and relatively flat grass areas of the golf course on lower permeability soils (C/D-Lawn-Flat) at 13 percent of the basin each. Impervious areas comprise, 8 percent of the basin.

The resulting predictions for monthly average surface water flows from WWHM for each subbasin are summarized in Table 2. In total, the basin generates an average annual flow of 0.09 cubic feet per second (cfs) or about 40 gallons per minute (gpm). Average monthly flows range from a low of 0.02 cfs (8.6 gpm) in July and August to a high of 0.2 cfs (88 gpm) in December. The Golf Course and Estuary subbasins each contribute about 47.5 percent of the flow, and the Christianson Road subbasin contributes the remaining 5 percent.

Peak flows from each subbasin are shown in Table 3. Peak flows represent the maximum 15-minute flow rates that occur during infrequent storm events. These infrequent storm events are described by their annual exceedance probability, which is the probability that a flow of that magnitude will be exceeded in any given year. Annual exceedance probability is the inverse of return interval. For example, a peak flow with an annual exceedance probability of 0.5 has a recurrence interval of 2 years, meaning that it has a 50 percent chance of being exceeded in any given year, or will be exceeded about every other year on average.

Peak flows with a 100-year recurrence interval range from 14.7 cfs from the golf course, 1.3 cfs from the Christianson Road culvert, and 15.8 cfs from the estuary subbasin.

Groundwater Evaluation

Our groundwater evaluation included review of geologic maps, reports of previous studies to support the project provided by SRSC and SITC (Anchor, 2015 and Tuttle, 2016), review of nearby well logs obtained from Ecology's online Well Report Viewer, and geologic evaluation provided in the Geotechnical Engineering Evaluation Memo (Aspect, 2022). Based on our review, a preliminary hydrogeologic conceptual model of shallow groundwater was developed. The conceptual model was developed to assess potential project risks of flooding to underground septic systems and utilities and inducing saltwater intrusion to neighboring groundwater supply wells near the base of the hillslopes.

The Geotechnical Engineering Evaluation Memo (Aspect, 2022) provides documentation of the geologic investigation, observations, and geologic interpretations. The discussion below presents a hydrogeologic conceptual model which organizes observations and interpretations of geology and soil texture with consideration to how it may affect groundwater occurrence and flow.

Hydrostratigraphy

The hydrostratigraphy at the Site is developed from observations and geologic interpretations provided in our Geotechnical Engineering Evaluation Memo (Aspect, 2022), which are based on observations from six test pits excavated to depths ranging from 3.3 to 6.8 feet in June 2021, a review of applicable geologic literature which includes the most recent available geologic mapping in the area (Dragovich et al., 2000; Figure 4), and local geologic experience in similar settings. Ecology's online Well Report Viewer was queried for nearby (within 1,000 feet) well logs;

however, the search did not return any logs located near the site with soil descriptions of sufficient detail to help inform the conceptual model.

The hydrostratigraphy at the Site consists of the following units from shallowest to deepest:

- Nearshore Peat Deposits
- Nearshore Silty Sand with Gravel Deposits
- Beach Deposits
- Recent Glacial Coarse-Grained Deposits
- Recent Glacial Fine-Grained Deposits
- Olympia Non-Glacial Deposits
- Metasedimentary Bedrock

The stratigraphy observed in the walls of the test pits (Figure 5) consisted of shallow nearshore and beach deposits underlain by glacial deposits of unknown origin (Aspect, 2022). A summary of the hydrostratigraphic units is provided below.

Nearshore and Beach Deposits (non-glacial)

Aspect (2022) interpreted the upper few feet of soil in the test pits as "Nearshore Deposits" identified as "Quaternary Alluvium" in the DNR geologic map (Dragovich et al., 2000; Figure 4). For the purposes of the hydrogeologic conceptual model, nearshore deposits observed in test pits are further divided into peat, and silty sand with gravel or sandy clay with gravel underlying the peat.

Peat of variable thickness occurs at the surface extending to a maximum observed depth of 4 feet below ground surface (bgs) at ATP-06. Below the peat, a silty sand with gravel occurs to a maximum depth of 6 feet bgs at ATP-05. The sand and gravel also contained traces of woody debris and abundant seashell fragments in all test pits and had more clay content at locations ATP-03 and ATP-05. A poorly graded gravel was encountered in one test pit (TP-02) from a depth of 1.8 feet bgs to the bottom of the test pit at 3.4 feet bgs. Based on the low silt content and proximity to the shoreline, the gravel may be older beach deposits.

Soils located south of Satterlee Road along Similk are mapped as beach deposits (Qb, though not differentiated from Qn in Figure 4) consisting of well-sorted sand and gravel (Dragovich et al., 2000). The thickness of the beach deposits is unknown – no explorations were performed in that area.

Recent Glacial Deposits

Glacial deposits are mapped at the surface on the hillslopes adjacent to the Site (Figure 4) and were encountered in test pits below nearshore deposits within the Site (Aspect, 2022). The thickness of glacial soils beneath the Site is unknown.

In the southeast, near the intersection of Satterlee and Christianson roads, surficial deposits are mapped as glaciomarine drift (Qgdm(e)) (Dragovich et al., 2000; Figure 4). Qgdm(e) are described as submarine deposits mostly consisting of clayey silt, silty clay, and clay which were deposited during the most recent Evanston Interstade following the Vashon Glaciation, and locally contain lenses and layers of sandy or gravelly outwash. Qgdm(e) glacial deposits may extend beneath the south part of the Site near Satterlee Road but may be absent at locations beneath the Site where glacial and post-glacial scouring and erosion has removed the unit.

Surficial deposits on the slope west of the Site are mapped as fine-grained lacustrine glacial deposits (Qgl(v)) consisting of clay, clayey silt, silt, and silty sand (Dragovich et al., 2000; Figure 4). The unit is described as consisting of early Vashon and pre-Vashon glacial sediments that commonly underly Vashon Advance Outwash, and if present, could act as a low-permeability strata perching groundwater in overlying sediments. The Qgl(v) deposits may extend beneath some or all of the Site, it may be absent where eroded from glacial and post-glacial scouring. However, undivided surficial deposits (mapped as Qs) are mapped along the base of much of the slope west of the site to North Green Street (Figure 4). It is unknown how the Qs was deposited and if it is younger or older than the Qgl(v). If older, it would suggest the Qgl(v) overlies the Qs and does not extend beneath the side. If younger, the Qs potentially obscures the lower contact of Qgl(v) projected beneath the Site, therefore the potential for Qgl(v) to underly nearshore deposits beneath the Site is uncertain.

Glacial deposits of unknown origin were encountered below the nearshore deposits within the Site in test pits ATP-05 (6 feet bgs) and ATP-06 (4 feet bgs) (Aspect 2022). For the purposes of the hydrogeologic conceptual model, the glacial soils are divided into a coarse-grained deposit characterized as light gray, loose to medium dense, clean fine-grained sand and sand with gravel, and glacial a fine-grained deposit characterized as a stiff wet sandy clay with gravel which underly the glacial coarse-grained deposits. The glacial deposits extend to at least 6.8 feet bgs (the maximum depth of the test pit excavations).

Olympia Nonglacial Deposits

Olympia nonglacial deposits (Qco) up to 100 feet thick are mapped as occurring beneath the Qgl(v) 3,000 feet southwest of the site (cross-section B-B’ in Dragovish et al., 2000). The Qco is described as sandy clay and clay with wood and shells in the two closest borings to the Site.

Based on extrapolation from the cross section, the Qco likely underlies the glacial deposits beneath the Site and may occur beneath the nearshore deposits where scoured erosional windows in glacial deposits occur. The Qco was not observed in the test pits.

Metasedimentary Bedrock

Metasedimentary bedrock is mapped at the surface along the slope east of Christianson Road, north of its intersection with Satterlee Road (Figure 4), and beneath Qco deposits west of the Site (cross-section B-B’ in Dragovich et al., 2000). The bedrock surface likely extends below the site from the ground surface contact along the base of the slope east of the site, dipping to the west, and underlying the Qco. The depth to bedrock beneath the Site is unknown.

Groundwater Occurrence and Flow

Very little data is available on the occurrence of groundwater in the project area. Therefore, the preliminary conceptual model of groundwater is based on inferences from local topography and surface water features, regional hydrostratigraphy, groundwater seepage observations from test pit explorations on June 29, 2021, and flooding conditions observed during a site visit on January 13,

2022. Conceptually, we also present a qualitative summary of soil properties and discussion of potential hydraulic continuity between shallow groundwater in the Site and the adjacent hillslopes.

Groundwater Flow

Shallow groundwater is inferred to flow from the topographically high hillslopes located east and west of the Site and converge towards the topographic low of the estuary and then southwards towards Similk beach with discharge to the drainage ditch running north-south along the center of the estuary and along Satterlee Road (Figure 1), and to Puget Sound. A groundwater divide likely occurs near the south end of the golf course north of the Site, dividing groundwater flow to the north towards Fidalgo Bay and to the south towards the Site and Similk Bay. The presence of the divide is inferred based on the assumption that groundwater discharges to both bays.

Groundwater levels and shallow groundwater flow directions beneath the Site are likely highly variable over time due to changing tide levels, precipitation, and local flooding events.

Recharge to shallow groundwater beneath the Site is assumed to be predominantly from infiltration of precipitation, and infiltration from stormwater runoff and flooding entering the Site from adjacent hillslopes during large storm events. Groundwater discharge is assumed to include discharge to the ditch, to Similk Bay, and through evapotranspiration. The potential for the ditch to act as an area of groundwater discharge or groundwater recharge is dependent on the elevations of the water level in the ditch relative to the elevation of the adjacent water table, which in turn is dependent on the balance of stormwater inflows and the pumpstation outflows that drain the ditch and is likely variable over time. Such relationships are complex and require monitoring of surface water and groundwater levels under a variety of conditions to understand the relationships at the Site. Irrigation on the golf course south of the groundwater divide may also be an important source of recharge that contributes to shallow groundwater beneath the Site.

Groundwater seepage was observed in test pits at depths ranging from 1.3 to 3.3 feet bgs (Aspect, 2022) and can be used to provide some estimates of groundwater levels. The depths and approximate elevations of seepage observed in the test pits are presented in Table 4 along with time-corresponding tide elevations in Similk Bay. The average tide elevation in Turner Bay[1] over the preceding 72 hours was 4.0 ft as calculated by the method of Serfes (1991) and is presented at the bottom of Table 4. Test pit observations were made on June 29, 2021, during the dry season, and following a high tide, while the tide was falling. Test pit locations were surveyed by Blue Coast Engineering using GPS and the corresponding ground surface excavations were estimated from the LIDAR-derived project digital elevation model (DEM). Accuracy of estimated test pit elevations is estimated to be +/- 0.25 feet.

The elevations of groundwater seepage observations in test pits ranged from 4.0 to 6.3 feet NAVD88 and were highest near the shoreline. The higher seepage elevations in test pits located closest to the shoreline does not support the conceptual model of discharge to Similk Bay. However, observations of groundwater seepage in test pits are not precise measurements of hydraulic head elevations in shallow groundwater because they potentially may represent perched groundwater conditions or confined flow within lenses of higher permeability soil. Furthermore, the observed depths were noted from an uneven ground surface adjacent to the test pits adding to

[1] Tidal predictions for Turner Bay, Station ID9448657 provided by National Oceanic and Atmospheric Administration

uncertainty when converting to elevations. Conceptually, shallow groundwater discharge from the Site is most likely towards the ditch and Similk Bay but further data collection from monitoring stations and further evaluation is required to better understand the transient dynamics of the system.

During a site visit on January 13, 2022, standing water was observed over much of the Site and parts of Satterlee Road adjacent to the Site (Appendix A). The flooding on January 13, 2022, is inferred to result from back up of stormwater flow (i.e., runoff) and limited ability to drain through the pump station and tide gate (Figure 1). Photos of another flooding event on February 19, 2019 (which was caused by a failure of the pump station), were provided by Blue Coast Engineering (Appendix A). Periodic flooding from stormwater flow during the wet season and limited ability to drain through the pumphouse station and tide gate likely results in periodic elevated groundwater elevations and inundation of the wetland under current conditions.

There is potential for upward gradients and inflows from deeper continuous aquifer sources beneath the Site given its setting between the two adjacent uplands. However, additional field investigations would be required to confirm and quantify the presence of upward gradients from deeper sources. Details on the occurrence of groundwater in the hillslopes adjacent to the Site where septic systems are located are also unknown.

Hydraulic Properties and Hydraulic Connectivity

The hydraulic properties and hydraulic connectivity of Site soils is discussed below. In the absence of onsite monitoring wells and hydraulic test data (such as slug tests or pump tests), the discussion is qualitative and based on soil texture descriptions provided in our Geotechnical Engineering Evaluation Memo (Aspect, 2022). In general, much of soils encountered beneath the Site consist of large portions of silt and/or clay and so are likely relatively restrictive to groundwater flow and may reduce the degree which changes in hydraulic and salinity conditions caused by the proposed project to impact groundwater offsite. However, layers of relatively clean sand observed in test pits may provide pathways for preferential flow. Hydraulic connectivity between shallow groundwater beneath the Site and groundwater beneath adjacent hillslopes where septic systems are located is uncertain.

The shallow nearshore deposits consist of silty sand with gravel and sandy clay with gravel below a layer of peat. This unit likely has relatively low permeability given the presence of silt and clay.

The glacial soils underlying the nearshore deposits consist of a layer of wet clean sand up to 2 feet thick (Recent Glacial Coarse Grain Deposits), underlain by stiff sandy clay with gravel to a depth of at least 6.8 feet (Recent Glacial Fine Grain Deposits). If the layer is widespread, it may provide a shallow zone of higher permeability and ability to exchange water with Puget Sound and adjacent hillslopes. However, given its variable thickness, it may not be continuous across the Site. The relatively low permeability of the overlying nearshore deposits may also limit its connectivity with surface sources of water.

The hydraulic connectivity of shallow groundwater beneath the Site to groundwater beneath adjacent hillslopes remains uncertain. Based on general textural descriptions of mapped geologic units, we can make some general observations. Qgdm(e) soils mapped on the hillslope southeast of the Site are generally described as clayey or silty (Dragovich et al., 2000) (Figure 4), and so likely do not readily transmit groundwater flow. Therefore, groundwater flow may be focused along localized coarser-grained lenses of sand and gravel. Perched groundwater with potential seepage along hillslopes may be another important pathway of inflow to the Site. Similarly, along the slope west of the Site where soils are mapped as Qfl(v), soils are expected to be restrictive to groundwater flow based on their fine-grained textures – thus, localized preferential flow zones and or perching may also be an important pathway for groundwater inflow from the west. Immediately west of the Site to approximately North Green Street, soils are mapped as undifferentiated (Qs) and so textural information to qualitatively evaluate hydraulic properties and potential connectivity pathways are not available (Figure 4).

In general, descriptions of soils along the hillslopes are based on generalized regional textural descriptions of geologic units. Glacial deposits are commonly highly variable thus investigation of local geologic conditions with exploratory borings and wells would be needed to assess hydraulic properties and connectivity of shallow groundwater with adjacent hillslopes.

Septic Risk and Saltwater Intrusion Evaluation

A preliminary study of potential groundwater-related impacts from the proposed project design was conducted by evaluating publicly available groundwater supply well and septic information in the context of the preliminary conceptual groundwater model discussed above and the following projected project inundation levels provided by Blue Coast (2022):

- High Astronautical Tide (HAT) of 10.8 feet NAVD88 + the fifty percent exceedance probability for the Representative Concentration Pathway (RCP) 8.5 climate scenario of 2 feet for year 2100 (12.8 feet NAVD88)
- FEMA 100-year flood level of 11.8 feet NAVD88 plus the fifty percent exceedance probability for RCP 8.5 climate scenario of 2 feet for year 2100 (13.8 feet NAVD88)

Following project completion, the new estuary outlet channel is not expected to significantly restrict flow and so inundation levels are assumed to closely follow tide elevations (Blue Coast, 2022). Therefore, the *frequency* of seawater inundation of the Site is expected to increase following completion of the proposed project. However, compared to current drainage conditions during times of Site flooding, the *duration* of inundation events is expected to decrease.

Frequent inundation of the estuary with seawater has the potential to both change shallow groundwater levels and increase salinity beneath the Site. If groundwater levels below the Site rise, they have the potential to back up groundwater flow to the Site, causing groundwater levels in the adjacent hillslopes to rise (although the rise may be relatively small). These changes, if large enough, could pose risks to the functionality of nearby septic systems and/or to water quality of nearby supply wells. Therefore, these risks were evaluated using available data as discussed in the following sections.

In summary, the evaluation of the available data did not identify any risks that were likely to occur due to the project. However, additional data collection and evaluation would be necessary to rule out potential for any risks with confidence. The conceptual model of current groundwater conditions is preliminary and based on limited available data. Therefore, the expected impact from the proposed project to shallow groundwater levels is difficult to evaluate without monitoring and collection of additional site data and possible modeling of future scenarios. Details of the evaluations are discussed in the subsections below. Recommendations for additional data collection and evaluation are listed below following the subsections discussing the septic risk and saltwater intrusion risk evaluations.

Septic Risk Evaluation

Increases in shallow groundwater levels may have the potential to flood and/or impact nearby septic system functionality, depending on the elevation at which septic systems were installed and the magnitude of groundwater level changes as a result of the project. To evaluate this potential impact, records from Skagit County's on-line septic system were searched and septic system as-builts were obtained for parcels located within 100 feet of the inundation contour and parcels located immediately adjacent to inundated portions of the estuary (Skagit County, 2022). As-builts were reviewed for information on drain field location and depth. Figure 6 shows the locations of drain fields identified during the search, as well as the HAT inundation contour, and the parcels that were included in the search. Information from as-builts is summarized in Table 5. Locations were cross referenced with the project DEM to estimate ground surface elevation and convert drain field depths to elevations. These elevations are also shown on Table 5.

Of the 25 septic systems identified in Skagit County's database and located within the search area, records for 16 of those systems included As-built information. The septic As-built records that we were able to obtain indicated drain fields were installed above the project's maximum expected inundation level (13.8 feet NAVD88). Drain field bottom elevations estimated from the 16 As-built records are all at or above 20 feet NAVD88 with the exception of one drain field at 15 feet NAVD88 (Parcel P69251 located on the east side of South Green Street) and one drain field at 16 feet NAVD88 (Parcel P69238 located south of the intersection of Satterlee and Christianson Roads)[2] – see Table 5 and Figure 6.

The evaluation of the available data did not identify any risks to septic infrastructure that were likely to occur due to the project. However, additional data collection and evaluation is recommended to finalize assessment of risk to nearby septic systems because expected changes in shallow groundwater adjacent to the Site remain uncertain without further data collection and study. Changes in Site shallow groundwater levels as a result of the project have the potential to propagate upgradient along the lower hillslopes and cause changes to water levels below septic systems in these parcels depending on the degree of hydraulic connection between shallow groundwater in the uplands and shallow Site groundwater. However, expected changes to average Site groundwater levels as a result of the proposed project are uncertain because observations of current Site groundwater conditions are limited and variation in groundwater conditions in response to changes in precipitation, tide, and surface water flow are not well understood.

Additionally, as noted above in the discussion of the preliminary groundwater conceptual model, current depths to groundwater beneath the adjacent hillslopes and septic systems are unknown, and the hydraulic connectivity between shallow Site groundwater and groundwater beneath the hillslopes is not well understood. Recommendations for additional data collection and evaluation to address these data gaps are listed below following the section discussing the septic risk evaluation.

[2] The drain field filed under parcel P69238 in Skagit County septic records is located on a separate parcel (P123427).

Saltwater Intrusion Risk Evaluation
To evaluate risk of saltwater intrusion impacts to groundwater supplies, a search for groundwater supply wells located within 1,000 feet of the HAT inundation contour was undertaken. The evaluation included searches Washington State Department of Natural Resources (DNR) online Geologic Information Portal, Ecology's online Well Report Viewer, and Ecology's online Water Rights Tracking System (WRTS).

One groundwater supply source was identified within 1,000 feet of the HAT in the WRTS database. The well was identified as a source of domestic and irrigation water supply in a water right claim dated 1974 (Water Right Document ID 2246787). Records indicate the well is located on the slope east of Eagle Street and North of Caddy Street on plot 9 of Parcel P69365, which corresponds to a ground surface elevation of approximately 60 to 70 feet (Figure 6). No information on the well construction was found in the WRTS database and a search to obtain the corresponding well log was unsuccessful, thus the well depth, static water level and well construction are unknown.

A map of Skagit PUD's water system distribution system provided on their on-line water system viewer shows water system mains extending along the roads adjacent to each of the residences in the developments adjacent to the Site (Skagit PUD, 2022). Therefore, it is likely that water is supplied to the residences by Skagit PUD. However, as a precaution, we recommend additional outreach to the well owner/operator to obtain additional information about the well including its depth and current use. Depending on current use and well depth, additional hydrogeologic data collection and analysis may be recommended to evaluate the likelihood of hydraulic connection to the estuary and risk of impact from saltwater intrusion.

Key Data Gaps and Recommendations for Additional Study
Limited data were available to adequately evaluate current groundwater and hydraulic interconnectivity within the Site and adjacent hillslopes. Additional evaluation and data collection is therefore recommended to refine the hydrogeologic conceptual model and further evaluate risk to local infrastructure:

- Install approximately three or more borings with monitoring wells, and approximately four to six hand driven piezometers at the Site and along the hillslopes, and one or more surface monitoring location in the ditches, and perform water level monitoring to evaluate horizontal and vertical hydraulic gradients, tidal influences, and hydraulic connection to uplands and surface water inundation. Install most wells and piezometers in the first shallow groundwater zone and at least one deeper well adjacent to a shallow well to evaluate vertical groundwater gradients. Water levels should be monitored continuously with data loggers in the surface monitoring location and in a subset or all of the groundwater monitoring locations. Monitoring should take place at least through the wet season (October through March) if possible, due to the potential to capture flooding conditions.
- Survey the monitoring locations so that surface and groundwater levels can be converted to elevations.
- Measure salinity concentrations in the ditches and monitoring wells to evaluate current baseline conditions of saltwater influence. A continuous salinity meter could be deployed at

key monitoring stations and supplemented with spot measurements at other locations during site visits.

- Conduct grain size analysis, slug tests, or short-term pumping tests in monitoring wells to estimate aquifer properties of the shallow aquifer.
- Aquifer properties together with gradients and observed interactions with the existing ditches can be used to refine the conceptual model and predict future impacts to groundwater due to the proposed project.
- Anchor (2015) and Tuttle (2016) document the presence of buried and overhead utilities near the restoration site. We recommend utilities located near the Site be inventoried to evaluate risk from changing groundwater conditions due to the proposed project,
- Conduct outreach to obtain well construction and use information for the water supply well (Figure 6) as well as septic system info for parcels that didn't include As-builts (Table 5). If local owners are willing, monitor water levels in the water supply well to evaluate influence with the estuary.

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Limitations

Work for this project was performed for Blue Coast Engineering, LLC (Client), and this memorandum was prepared in accordance with generally accepted professional practices for the nature and conditions of work completed in the same or similar localities, at the time the work was performed. This memorandum does not represent a legal opinion. No other warranty, expressed or implied, is made.

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Attachments:
Table 1 – WWHM Model Input
Table 2 – Monthly Flows by Subbasin
Table 3 – Stormwater Peak Flows
Table 4 – Test Pit Groundwater Summary
Table 5 – Septic As-built Summary
Figure 1 – Drainage Basin and Subbasins
Figure 2 – Soils and Slopes
Figure 3 – Cover Map
Figure 4 – Geologic Map
Figure 5 – Exploration Location Map
Figure 6 – Septic Risk Evaluation
Appendix A – Photographs documenting flooding on 2/19/2019 and 1/13/2022
Appendix B – WWHM Model Output

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TABLES

Table 1. Hydrologic Model Input

Project No. 210105-A-001-04, Skagit County, Washington

Soil-Cover-Slope Category	Area in Each Subbasin in Acres			Total Area in acres
	Golf Course Subbasin	Christianson Road Subbasin	Estuary Subbasin	
Impervious Areas				
Roads/Parking	4.04	1.15	10.43	15.6
Roofs	0.44	0.15	4.22	4.8
Total Impervious	4.48	1.30	14.66	20.44
Pervious Areas				
A/B-Forest-Flat	30.28	0.10	45.55	75.9
A/B-Forest-Moderate	23.43	6.68	4.13	34.2
A/B-Forest-Steep		8.58	9.06	17.6
A/B-Lawn-Flat	4.63		8.15	12.8
A/B-Lawn-Moderate	0.91		0.29	1.2
A/B-Lawn-Steep			0.24	0.2
C/D-Forest-Flat	2.68	2.57	2.80	8.0
C/D-Forest-Moderate	2.37	1.07	1.85	5.3
C/D-Forest-Steep		0.03	0.13	0.2
C/D-Lawn-Flat	31.55		2.28	33.8
C/D-Lawn-Moderate	0.40		2.08	2.5
C/D-Lawn-Steep			0.03	0.0
Saturated-Pasture-Flat	1.55		24.31	25.9
Saturated-Pasture-Moderate	1.90		0.96	2.9
Saturated-Pasture-Steep			0.20	0.2
Total Pervious	99.71	19.03	102.07	220.81
Total	108.67	21.64	131.39	261.7

Table 2. Monthly Surface Water Flows by Subbasin

Project No. 210105-A-001-04, Skagit County, Washington

Month	Monthly Average Surface Water Flow in cubic feet per second (cfs)						Total	
	Golf Course Subbasin		Christianson Road Subbasin		Estuary Subbasin			
	Average	Range	Average	Range	Average	Range	Average	Range
January	0.10	0.00-0.34	0.01	0.00-0.03	0.08	0.00-0.26	0.19	0.00-0.64
February	0.07	0.00-0.54	0.01	0.00-0.06	0.06	0.00-0.42	0.14	0.00-1.02
March	0.05	0.00-0.12	0.00	0.00-0.01	0.04	0.00-0.09	0.09	0.00-0.22
April	0.03	0.00-0.09	0.00	0.00-0.01	0.03	0.00-0.09	0.06	0.00-0.18
May	0.02	0.00-0.11	0.00	0.00-0.01	0.03	0.00-0.09	0.04	0.00-0.21
June	0.01	0.00-0.11	0.00	0.00-0.01	0.02	0.00-0.09	0.03	0.00-0.21
July	0.01	0.00-0.04	0.00	0.00-0.00	0.01	0.00-0.04	0.02	0.00-0.08
August	0.01	0.00-0.04	0.00	0.00-0.00	0.02	0.00-0.06	0.02	0.00-0.10
September	0.01	0.00-0.07	0.00	0.00-0.01	0.02	0.00-0.08	0.03	0.00-0.15
October	0.03	0.00-0.15	0.00	0.00-0.01	0.04	0.00-0.13	0.08	0.00-0.30
November	0.08	0.00-0.47	0.01	0.00-0.04	0.08	0.00-0.34	0.17	0.00-0.86
December	0.10	0.01-0.26	0.01	0.00-0.02	0.09	0.01-0.19	0.20	0.02-0.47
Total	0.04		0.004		0.04		0.09	

Note:
Totals may not match the sum of their components due to rounding.

Table 3. Stormwater Peak Flows

Project No. 210105-A-001-04, Skagit County, Washington

Storm Event		Peak Flow in cfs by Subbasin			Total Peak Flow in cfs
Annual Exceedance Probability	Recurrence Interval	Golf Course	Christianson Road Culvert	Remaining Basin	
0.5	2-year	2.7	0.5	5.1	8.2
0.2	5-year	4.7	0.6	7.3	12.6
0.1	10-year	6.4	0.8	9.0	16.2
0.04	25-year	9.1	1.0	11.5	21.6
0.02	50-year	11.7	1.1	13.6	26.4
0.01	100-year	14.7	1.3	15.8	31.8

Table 4. Test Pit Groundwater Summary

Project No. 210105, Skagit County, Washington

Exploration Number	Ground Surface Elevation (ft NAVD88)[1]	Depth to Groundwater Seepage (ft bgs)	Approximate Water Elevation (ft NAVD88)[2]	Date/Time of Groundwater Observation	Tide Elevation (ft NAVD88)[3]
West Transect (arranged with increasing distance from the shoreline)					
ATP-01	7.3	2.0	5.3	6/29/21 8:00 AM	5.97
ATP-03	7.0	1.8	5.2	6/29/21 8:30 AM	6.05
ATP-05	6.8	2.2	4.6	6/29/21 9:00 AM	5.99
East Transect (arranged with increasing distance from the shoreline)					
ATP-02	7.6	1.3	6.3	6/29/21 10:00 AM	5.34
ATP-04	7.1	1.3	5.8	6/29/21 10:30 AM	4.73
ATP-06	7.2	3.3	4.0	6/29/21 11:00 AM	3.94
				Serfes Average[4]	4.02

Notes

1 - Groundsurface elevations are based on estimated horizontal location and lidar digital elevation model, error for groundsurface elevation is estimated at +/- 0.25 ft.

2 - Water level elevation is based on observations of seepage during test pit logging and estimated groundsurface elevation (see note 1). Observations of seepage may be affected by presence of lenses of higher conductivity soils and potential perching and may not be representive of water table elevation.

3 - Tide predictions provided for Turner Bay, Station ID 9448657 by National Ocianic and Atmospheric Administration

4- Serfes average of tide elevations from preceding 72 hours calculated by the method of Serfes (1991)

Table 5. Septic As-Built Summary

Project No. 210105, Skagit County, Washington

Parcel Number	Drain Field Depth	Ground Surface Elevation at Drain field Location	Drain Field Elevation
P69229	1	23	22
P69231	1	23	22
P69236	0.75	25	24
P69237	1	21	20
P69242	2	29	27
P69243	2	24	22
P69244	1.5	27	25
P69246	2	25	23
P69251	2	17	15
P69255	2	35	33
P69325	0.75	24	23
P69330	0.5	34	33
P69332	0.75	34	33
P69356	1.17	37	36
P69378	1.25	28	26
P69238(1)	2.5	18(2)	16
P69232	No As-Built Available		
P69239	No depth Information on As-Built		
P69247	No As-Built Available		
P69249	No As-Built Available		
P69250	No depth Information on As-Built		
P69253	No As-Built Available		
P69328	No depth Information on As-Built		
P69351	No As-Built Available		
P69379	No As-Built Available		

Notes:

All depths are in feet.

All elevations are in feet NAVD88.

Approximate location of septic features are mapped on Figure 5.

Drain field depths are from septic records obtained from Skagit County's Septic Database (Skagit County, 2022).

Ground surface elevations are estimated based on approximate location and the project DEM.

1- Drain field is located on separate parcel (P123427).

2 - Drain field is installed within a mound 1 to 1.5 feet above groundsurface at the base of the mound.

FIGURES

GIS Path: G:\projects\SimilkBeach_210105\Delivered\HydroEvalTechMemo\01 Drainage Basin and Subbasins.mxd || Coordinate System: NAD 1983 StatePlane Washington North FIPS 4601 Feet || Date Saved: 3/29/2022 || User: nkochie || Print Date: 3/29/2022

Stormwater Sample Location

Primary Stormwater Conveyance (Ditches and Culverts)

Site Boundary

Watershed Boundary

Subbasin Boundary

10-ft. LiDAR Contour

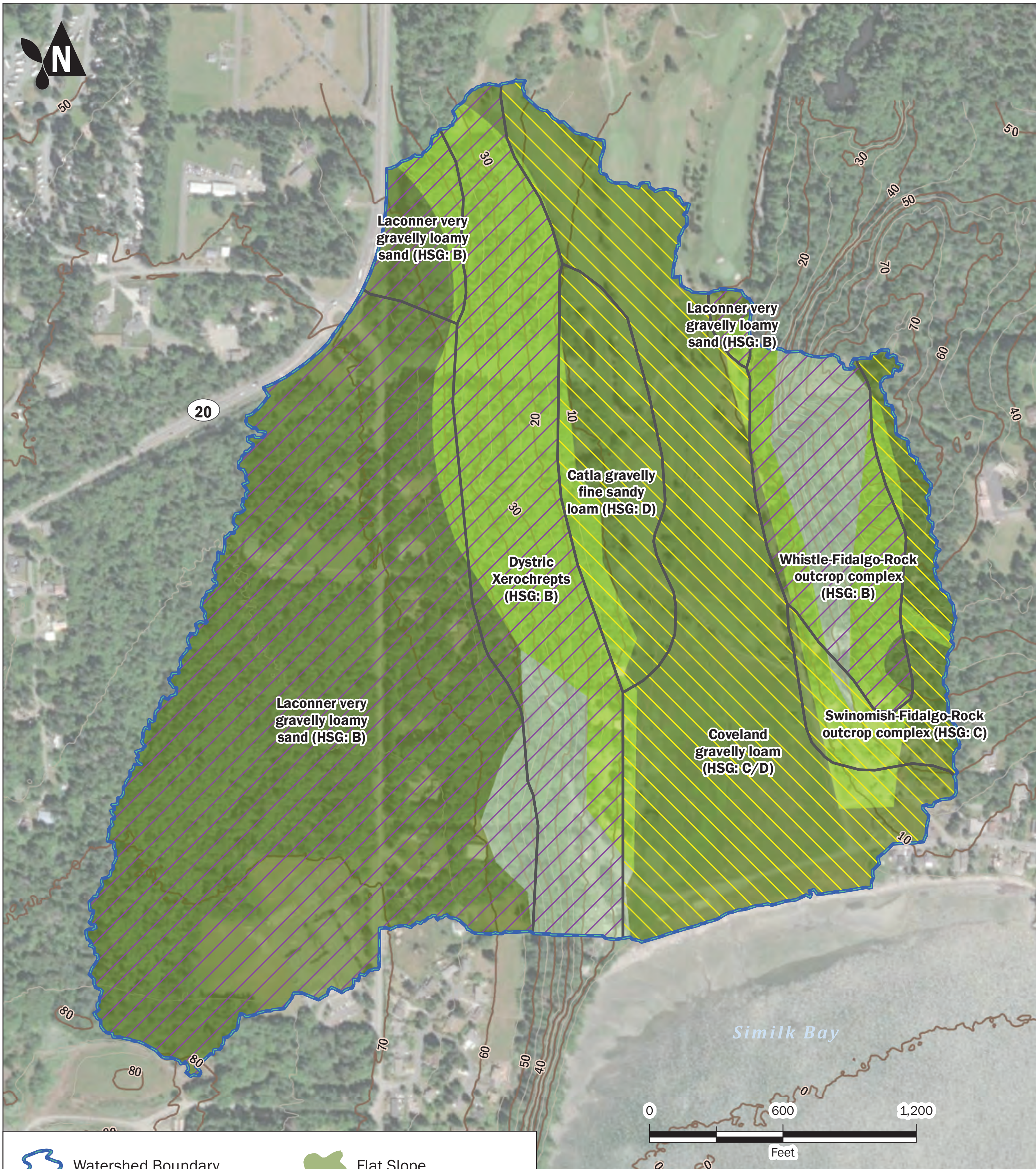
5-ft. LiDAR Contour

Drainage Basin and Subbasins

Hydrologic Evaluation Technical Memorandum
Similk Tidal Marsh Restoration Project
Skagit County, Washington

Aspect CONSULTING

MAR-2022	BY: OGR / WEG	FIGURE NO. 1
PROJECT NO. 210105-A-001-4	REVISED BY: NLK	



Watershed Boundary

NRCS Web Soil Survey

Hydrologic Soil Group A and B

Hydrologic Soil Group C and D

Flat Slope

Moderate Slope

Steep Slope

10-ft. LiDAR Contour

5-ft. LiDAR Contour

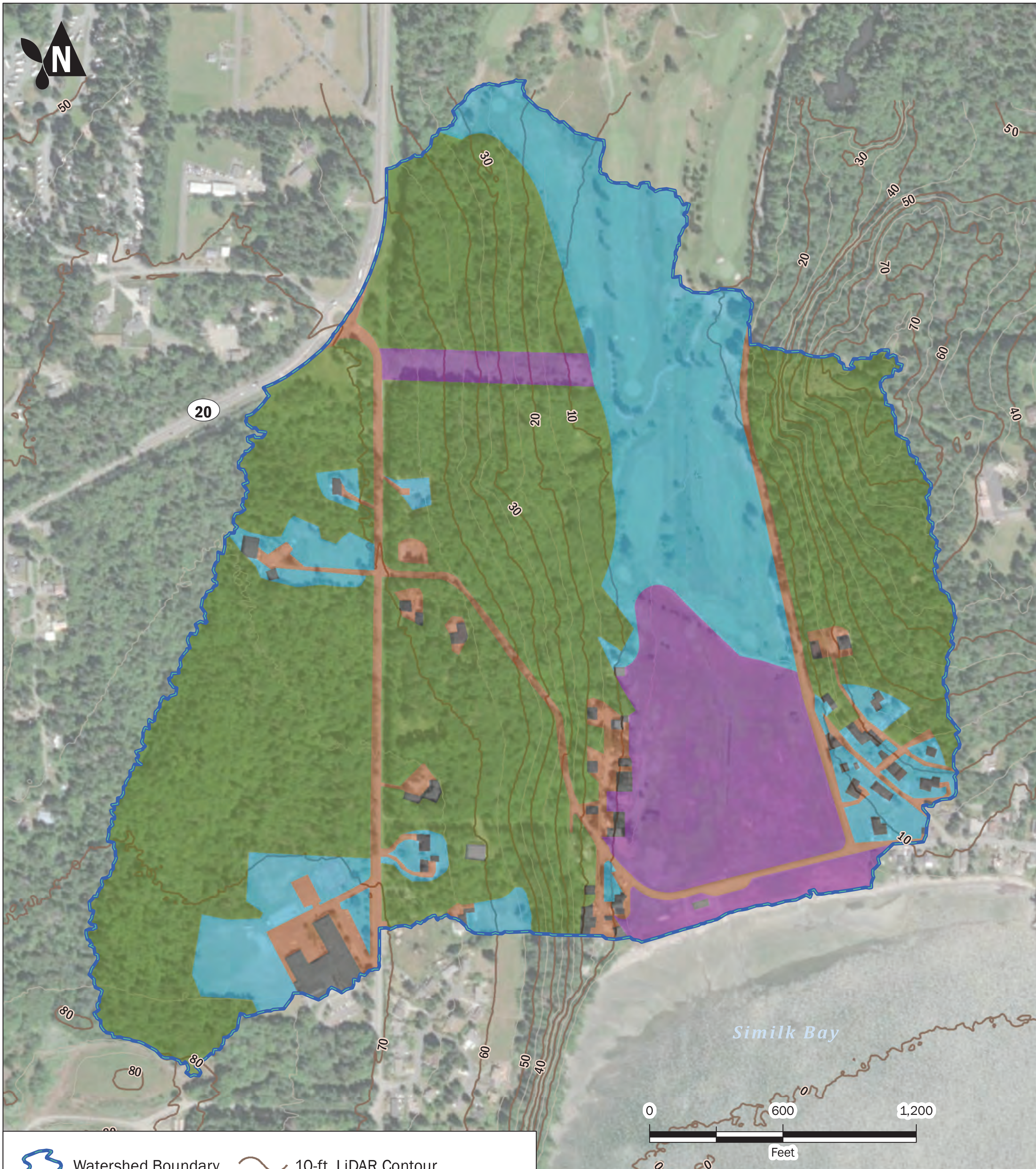
Soils and Slopes

Hydrologic Evaluation Technical Memorandum
Similk Tidal Marsh Restoration Project
Skagit County, Washington

Aspect CONSULTING	MAR-2022	BY: OGR / WEG	FIGURE NO. 2
	PROJECT NO. 210105-A-001-4	REVISED BY: NLK	

GIS Path: G:\projects\SimilkBeach_210105\Delivered\HydroEvalTechMemo\02 Soils and Slopes.mxd || Coordinate System: NAD 1983 StatePlane Washington North FIPS 4601 Feet || Date Saved: 3/29/2022 || User: nkochie || Print Date: 3/29/2022

Basemap Layer Credits || Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



Watershed Boundary
Forest
Grass
Pasture
Building
Roads/Parking
10-ft. LiDAR Contour
5-ft. LiDAR Contour

Cover

Hydrologic Evaluation Technical Memorandum
Similk Tidal Marsh Restoration Project
Skagit County, Washington

Aspect CONSULTING	FEB-2022	BY: OGR / WEG	FIGURE NO. 3
	PROJECT NO. 210105-A-001-4	REVISED BY: NLK	

GIS Path: G:\projects\SimilkBeach_210105\Delivered\HydroEvalTechMemo\03 Cover.mxd || Coordinate System: NAD 1983 StatePlane Washington North FIPS 4601 Feet || Date Saved: 2/10/2022 || User: nkochie || Print Date: 2/10/2022

Basemap Layer Credits || Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Surficial Geologic Unit (WA DNR 1:24,000)

Quaternary Rocks and Deposits

- Quaternary alluvium (Qn)
- Pleistocene continental glacial drift (Qgdm(e), Qga(v))
- Pleistocene glaciolacustrine deposits (Qgl(v))
- Pleistocene glacial and nonglacial deposits (Qs)

Mesozoic Rocks

- Mesozoic metasedimentary rocks (KJms(fas))

Water

- Water (wtr)

Geologic Contact (WA DNR 1:24,000)

- Contact, certain accurate
- Shoreline

Fault (WA DNR 1:24,000)

- Thrust, questionable concealed

Site Boundary

Geologic Map

Hydrologic Evaluation Technical Memorandum
Similk Tidal Marsh Restoration Project
Skagit County, Washington

Aspect CONSULTING	APR-2022	BY: SDM / WEG	FIGURE NO.
	PROJECT NO. 210105-A-001-4	REVISED BY: SDM / WEG	4

GIS Path: G:\projects\SimilkBeach_210105\Delivered\HydroEvalTechMemo\05 Geologic Map.mxd || Coordinate System: NAD 1983 StatePlane Washington North FIPS 4601 Feet || Date Saved: 4/5/2022 || User: bgrimm || Print Date: 4/5/2022

Test Pit

10-foot LiDAR Contour

2-foot LiDAR Contour

Exploration Locations

Hydrologic Evaluation Technical Memorandum
Similk Tidal Marsh Restoration Project
Skagit County, Washington

Aspect CONSULTING	APR-2022	BY: RM	FIGURE NO.
	PROJECT NO. 210105-A-001-4	REVISED BY: SDM / WEG	5

GIS Path: G:\projects\SimilkBeach_210105\Delivered\HydroEvalTechMemo\04 Exploration Locations.mxd || Coordinate System: NAD 1983 StatePlane Washington North FIPS 4601 Feet || Date Saved: 4/1/2022 || User: bgrimm || Print Date: 4/1/2022

Basemap Layer Credits || Esri, HERE, Garmin, (c) OpenStreetMap contributors, and the GIS user community
Copyright:(c) 2014 Esri
Sources: Esri, Garmin, USGS, NPS

GIS Path: G:\projects\SimilkBeach_210105\Delivered\HydroEvalTechMemo\06 Septic Risk Evaluation.mxd || Coordinate System: NAD 1983 StatePlane Washington North FIPS 4601 Feet || Date Saved: 6/24/2022 || User: bgrimm || Print Date: 6/24/2022

- Approximate location of septic drainfield, tank, and/or pump intake identified from available sources*
- Approximate location of septic drainfield, tank, and/or pump intake identified from available sources* (available sources do not include depth information and/or as-builts)
- High Astronomical Tide Contour
- Parcel of Interest for Septic Study
- Skagit County Tax Parcel

Note:
* Septic tank, drainfield, and pump tank locations obtained from following sources:
1. https://www.skagitcounty.net/Search/Septics/Search.aspx?SearchType=2
2. https://www.onlinerme.com/(S(2zpm0ty4cdqjbxswmziz2ncz))/contractorsearchproperty.aspx
3. "Septic Exhibit Plan," Similk Bay Estuary-Satterlee Road Bridge Project, Tuttle Engineering and Management, 2016.

Septic Risk Evaluation

Hydrologic Evaluation Technical Memorandum
Similk Tidal Marsh Restoration Project
Skagit County, Washington

Aspect CONSULTING	JUN-2022	BY: SDM / WEG	FIGURE NO.
	PROJECT NO. 210105	REVISED BY: SDM / WEG	6

APPENDIX A

Photographs documenting flooding on 2/19/2019 and 1/13/2022

Description: Flooding on January 13, 2022

(Photo Credits: Aspect Consulting)

Description: Flooding on January 13, 2022

(Photo Credits: Aspect Consulting)

Description: Flooding on January 13, 2022

(Photo Credits: Aspect Consulting)

Description: Flooding on February 19, 2019

(Photo Credits: Blue Coast Engineering)

Description: Flooding on February 19, 2019

(Photo Credits: Blue Coast Engineering)

APPENDIX B

WWHM Model Output

WWHM2012
PROJECT REPORT

Project Name: Similk
Site Name: Similk Tidal Marsh Restoration Project
Site Address: Similk Beach
City : Snohomish County, WA
Report Date: 2/20/2022
Gage : Burlington
Data Start : 1948/10/01
Data End : 2009/09/30
Precip Scale: 0.83
Version Date: 2019/09/13
Version : 4.2.17

Low Flow Threshold for POC 1 : 50 Percent of the 2 Year

High Flow Threshold for POC 1: 50 year

Low Flow Threshold for POC 2 : 50 Percent of the 2 Year

High Flow Threshold for POC 2: 50 year

Low Flow Threshold for POC 3 : 50 Percent of the 2 Year

High Flow Threshold for POC 3: 50 year

PREDEVELOPED LAND USE

Name : Golf Course
Bypass: No

GroundWater: No

Pervious Land Use	acre
A B, Forest, Flat	30.28
A B, Forest, Steep	23.43
A B, Lawn, Flat	4.63
A B, Lawn, Mod	.91
C, Forest, Flat	2.68
C, Forest, Mod	2.37
C, Lawn, Flat	31.55
C, Lawn, Mod	.4
SAT, Pasture, Flat	1.55
SAT, Pasture, Mod	1.9

Pervious Total 99.7

Impervious Land Use	acre

ROADS FLAT	4.04
ROOF TOPS FLAT	0.44

Impervious Total 4.48

Basin Total 104.18

Element Flows To:

Surface	Interflow	Groundwater

Name : Christianson Road Subbasin
Bypass: No

GroundWater: No

Pervious Land Use	acre
A B, Forest, Flat	.1
A B, Forest, Steep	8.58
A B, Forest, Mod	6.68
C, Forest, Flat	2.57
C, Forest, Mod	1.07
C, Forest, Steep	.03

Pervious Total 19.03

Impervious Land Use	acre
ROADS FLAT	1.15
ROOF TOPS FLAT	0.15

Impervious Total 1.3

Basin Total 20.33

Element Flows To:

Surface	Interflow	Groundwater

Name : Estuary Subbasin
Bypass: No

GroundWater: No

Pervious Land Use	acre
A B, Forest, Flat	45.55
A B, Forest, Steep	9.06
A B, Forest, Mod	4.13

A B, Lawn, Flat	8.15
A B, Lawn, Mod	.29
A B, Lawn, Steep	.24
C, Forest, Flat	2.8
C, Forest, Steep	.13
C, Forest, Mod	1.85
C, Lawn, Flat	2.28
C, Lawn, Mod	2.08
C, Lawn, Steep	.03
SAT, Pasture, Flat	24.31
SAT, Pasture, Mod	.96
SAT, Pasture, Steep	.2

Pervious Total 102.06

Impervious Land Use	acre
ROADS FLAT	10.43
ROOF TOPS FLAT	4.22

Impervious Total 14.65

Basin Total 116.71

Element Flows To:

Surface	Interflow	Groundwater

MITIGATED LAND USE

Name : Golf Course
Bypass: No

GroundWater: No

Pervious Land Use	acre
A B, Forest, Flat	30.28
A B, Forest, Steep	23.43
A B, Lawn, Flat	4.63
A B, Lawn, Mod	.91
C, Forest, Flat	2.68
C, Forest, Mod	2.37
C, Lawn, Flat	31.55
C, Lawn, Mod	.4
SAT, Pasture, Flat	1.55
SAT, Pasture, Mod	1.9

Pervious Total 99.7

Impervious Land Use	acre
ROADS FLAT	4.04
ROOF TOPS FLAT	0.44

Impervious Total **4.48**

Basin Total **104.18**

Element Flows To:

Surface	**Interflow**	**Groundwater**

Name **:** Christianson Road Subbasin
Bypass: No

GroundWater: No

Pervious Land Use	**acre**
A B, Forest, Flat	**.1**
A B, Forest, Steep	**8.58**
A B, Forest, Mod	**6.68**
C, Forest, Flat	**2.57**
C, Forest, Mod	**1.07**
C, Forest, Steep	**.03**

Pervious Total **19.03**

Impervious Land Use	**acre**
ROADS FLAT	**1.15**
ROOF TOPS FLAT	**0.15**

Impervious Total **1.3**

Basin Total **20.33**

Element Flows To:

Surface	**Interflow**	**Groundwater**

Name **:** Estuary Subbasin
Bypass: No

GroundWater: No

Pervious Land Use	**acre**
A B, Forest, Flat	**45.55**
A B, Forest, Steep	**9.06**
A B, Forest, Mod	**4.13**
A B, Lawn, Flat	**8.15**
A B, Lawn, Mod	**.29**
A B, Lawn, Steep	**.24**

C, Forest, Flat	2.8
C, Forest, Steep	.13
C, Forest, Mod	1.85
C, Lawn, Flat	2.28
C, Lawn, Mod	2.08
C, Lawn, Steep	.03
SAT, Pasture, Flat	24.31
SAT, Pasture, Mod	.96
SAT, Pasture, Steep	.2

Pervious Total **102.06**

Impervious Land Use	acre
ROADS FLAT	10.43
ROOF TOPS FLAT	4.22

Impervious Total **14.65**

Basin Total **116.71**

Element Flows To:

Surface	Interflow	Groundwater

ANALYSIS RESULTS

Stream Protection Duration

Predeveloped Landuse Totals for POC #1
Total Pervious Area:99.7
Total Impervious Area:4.48

Mitigated Landuse Totals for POC #1
Total Pervious Area:99.7
Total Impervious Area:4.48

Flow Frequency Return Periods for Predeveloped. POC #1

Return Period	Flow(cfs)
2 year	2.714299
5 year	4.671965
10 year	6.393172
25 year	9.142643
50 year	11.670149
100 year	14.664598

Flow Frequency Return Periods for Mitigated. POC #1

Return Period	Flow(cfs)
2 year	2.714299
5 year	4.671965
10 year	6.393172
25 year	9.142643
50 year	11.670149
100 year	14.664598

Stream Protection Duration
Annual Peaks for Predeveloped and Mitigated. POC #1

Year	Predeveloped	Mitigated
1949	6.413	6.413
1950	1.903	1.903
1951	6.171	6.171
1952	4.792	4.792
1953	5.470	5.470
1954	3.146	3.146
1955	1.530	1.530
1956	1.388	1.388
1957	5.638	5.638
1958	2.490	2.490
1959	1.788	1.788
1960	3.311	3.311
1961	2.091	2.091
1962	2.075	2.075
1963	2.260	2.260
1964	1.531	1.531
1965	5.089	5.089
1966	1.937	1.937
1967	2.564	2.564
1968	3.472	3.472
1969	1.961	1.961
1970	5.700	5.700
1971	3.971	3.971
1972	1.637	1.637
1973	2.529	2.529
1974	2.795	2.795
1975	12.707	12.707
1976	8.377	8.377
1977	2.166	2.166
1978	2.538	2.538
1979	2.364	2.364
1980	3.983	3.983
1981	1.860	1.860
1982	3.071	3.071
1983	2.828	2.828
1984	4.305	4.305
1985	1.784	1.784
1986	1.697	1.697
1987	1.850	1.850
1988	7.364	7.364
1989	1.787	1.787
1990	3.296	3.296
1991	5.220	5.220
1992	2.147	2.147
1993	1.579	1.579

1994	1.072	1.072
1995	1.183	1.183
1996	5.816	5.816
1997	17.202	17.202
1998	1.971	1.971
1999	1.182	1.182
2000	2.131	2.131
2001	1.400	1.400
2002	1.189	1.189
2003	1.539	1.539
2004	8.620	8.620
2005	2.191	2.191
2006	4.234	4.234
2007	2.924	2.924
2008	3.613	3.613
2009	3.737	3.737

Stream Protection Duration
Ranked Annual Peaks for Predeveloped and Mitigated. POC #1

Rank	Predeveloped	Mitigated
1	17.2018	17.2018
2	12.7065	12.7065
3	8.6201	8.6201
4	8.3771	8.3771
5	7.3635	7.3635
6	6.4127	6.4127
7	6.1712	6.1712
8	5.8160	5.8160
9	5.7002	5.7002
10	5.6382	5.6382
11	5.4703	5.4703
12	5.2202	5.2202
13	5.0889	5.0889
14	4.7919	4.7919
15	4.3047	4.3047
16	4.2338	4.2338
17	3.9826	3.9826
18	3.9712	3.9712
19	3.7374	3.7374
20	3.6129	3.6129
21	3.4724	3.4724
22	3.3106	3.3106
23	3.2962	3.2962
24	3.1462	3.1462
25	3.0708	3.0708
26	2.9245	2.9245
27	2.8279	2.8279
28	2.7945	2.7945
29	2.5641	2.5641
30	2.5380	2.5380
31	2.5285	2.5285
32	2.4897	2.4897
33	2.3636	2.3636
34	2.2604	2.2604
35	2.1910	2.1910
36	2.1659	2.1659

37	2.1470	2.1470
38	2.1310	2.1310
39	2.0909	2.0909
40	2.0748	2.0748
41	1.9706	1.9706
42	1.9610	1.9610
43	1.9366	1.9366
44	1.9033	1.9033
45	1.8596	1.8596
46	1.8497	1.8497
47	1.7879	1.7879
48	1.7867	1.7867
49	1.7843	1.7843
50	1.6970	1.6970
51	1.6368	1.6368
52	1.5787	1.5787
53	1.5389	1.5389
54	1.5309	1.5309
55	1.5298	1.5298
56	1.3999	1.3999
57	1.3884	1.3884
58	1.1892	1.1892
59	1.1827	1.1827
60	1.1818	1.1818
61	1.0719	1.0719

Stream Protection Duration
POC #1
The Facility PASSED

The Facility PASSED.

Flow(cfs)	Predev	Mit	Percentage	Pass/Fail
1.3571	0	0	0	Pass
1.4613	0	0	0	Pass
1.5655	0	0	0	Pass
1.6697	0	0	0	Pass
1.7738	0	0	0	Pass
1.8780	0	0	0	Pass
1.9822	0	0	0	Pass
2.0864	0	0	0	Pass
2.1905	0	0	0	Pass
2.2947	0	0	0	Pass
2.3989	0	0	0	Pass
2.5030	0	0	0	Pass
2.6072	0	0	0	Pass
2.7114	0	0	0	Pass
2.8156	0	0	0	Pass
2.9197	0	0	0	Pass
3.0239	0	0	0	Pass
3.1281	0	0	0	Pass
3.2322	0	0	0	Pass
3.3364	0	0	0	Pass
3.4406	0	0	0	Pass
3.5448	0	0	0	Pass
3.6489	0	0	0	Pass

3.7531	0	0	0	Pass
3.8573	0	0	0	Pass
3.9614	0	0	0	Pass
4.0656	0	0	0	Pass
4.1698	0	0	0	Pass
4.2740	0	0	0	Pass
4.3781	0	0	0	Pass
4.4823	0	0	0	Pass
4.5865	0	0	0	Pass
4.6906	0	0	0	Pass
4.7948	0	0	0	Pass
4.8990	0	0	0	Pass
5.0032	0	0	0	Pass
5.1073	0	0	0	Pass
5.2115	0	0	0	Pass
5.3157	0	0	0	Pass
5.4198	0	0	0	Pass
5.5240	0	0	0	Pass
5.6282	0	0	0	Pass
5.7324	0	0	0	Pass
5.8365	0	0	0	Pass
5.9407	0	0	0	Pass
6.0449	0	0	0	Pass
6.1490	0	0	0	Pass
6.2532	0	0	0	Pass
6.3574	0	0	0	Pass
6.4616	0	0	0	Pass
6.5657	0	0	0	Pass
6.6699	0	0	0	Pass
6.7741	0	0	0	Pass
6.8783	0	0	0	Pass
6.9824	0	0	0	Pass
7.0866	0	0	0	Pass
7.1908	0	0	0	Pass
7.2949	0	0	0	Pass
7.3991	0	0	0	Pass
7.5033	0	0	0	Pass
7.6075	0	0	0	Pass
7.7116	0	0	0	Pass
7.8158	0	0	0	Pass
7.9200	0	0	0	Pass
8.0241	0	0	0	Pass
8.1283	0	0	0	Pass
8.2325	0	0	0	Pass
8.3367	0	0	0	Pass
8.4408	0	0	0	Pass
8.5450	0	0	0	Pass
8.6492	0	0	0	Pass
8.7533	0	0	0	Pass
8.8575	0	0	0	Pass
8.9617	0	0	0	Pass
9.0659	0	0	0	Pass
9.1700	0	0	0	Pass
9.2742	0	0	0	Pass
9.3784	0	0	0	Pass
9.4825	0	0	0	Pass
9.5867	0	0	0	Pass

9.6909	0	0	0	Pass
9.7951	0	0	0	Pass
9.8992	0	0	0	Pass
10.0034	0	0	0	Pass
10.1076	0	0	0	Pass
10.2117	0	0	0	Pass
10.3159	0	0	0	Pass
10.4201	0	0	0	Pass
10.5243	0	0	0	Pass
10.6284	0	0	0	Pass
10.7326	0	0	0	Pass
10.8368	0	0	0	Pass
10.9409	0	0	0	Pass
11.0451	0	0	0	Pass
11.1493	0	0	0	Pass
11.2535	0	0	0	Pass
11.3576	0	0	0	Pass
11.4618	0	0	0	Pass
11.5660	0	0	0	Pass
11.6701	0	0	0	Pass

Water Quality BMP Flow and Volume for POC #1
On-line facility volume: 0 **acre-feet**
On-line facility target flow: 0 **cfs.**
Adjusted for 15 min: 0 **cfs.**
Off-line facility target flow: 0 **cfs.**
Adjusted for 15 min: 0 **cfs.**

LID Report

LID Technique	Used for Treatment?	Total Volume Needs Treatment (ac-ft)	Volume Through Facility (ac-ft)	Infiltration Volume (ac-ft.)	Cumulative Volume Infiltration Credit	Percent Volume Infiltrated	Water Quality	Percent Water Quality Treated	Comment
Total Volume Infiltrated		0.00	0.00	0.00		0.00	0.00	0%	No Treat. Credit

Compliance with LID Standard 8
Duration Analysis Result = Passed

Stream Protection Duration

Predeveloped Landuse Totals for POC #2
Total Pervious Area:19.03
Total Impervious Area:1.3

Mitigated Landuse Totals for POC #2
Total Pervious Area:19.03
Total Impervious Area:1.3

Flow Frequency Return Periods for Predeveloped. POC #2

Return Period	Flow(cfs)
2 year	0.451785
5 year	0.638872
10 year	0.780421
25 year	0.980518
50 year	1.14576
100 year	1.325518

Flow Frequency Return Periods for Mitigated. POC #2

Return Period	Flow(cfs)
2 year	0.451785
5 year	0.638872
10 year	0.780421
25 year	0.980518
50 year	1.14576
100 year	1.325518

Stream Protection Duration
Annual Peaks for Predeveloped and Mitigated. POC #2

Year	Predeveloped	Mitigated
1949	0.652	0.652
1950	0.354	0.354
1951	0.640	0.640
1952	0.587	0.587
1953	0.669	0.669
1954	0.329	0.329
1955	0.308	0.308
1956	0.263	0.263
1957	0.656	0.656
1958	0.321	0.321
1959	0.306	0.306
1960	0.495	0.495
1961	0.302	0.302
1962	0.510	0.510
1963	0.340	0.340
1964	0.377	0.377
1965	0.928	0.928
1966	0.402	0.402
1967	0.731	0.731
1968	0.579	0.579
1969	0.297	0.297
1970	0.726	0.726
1971	0.514	0.514
1972	0.301	0.301
1973	0.481	0.481
1974	0.424	0.424
1975	0.954	0.954
1976	0.814	0.814
1977	0.381	0.381
1978	0.656	0.656
1979	0.408	0.408
1980	0.500	0.500
1981	0.413	0.413

1982	0.434	0.434
1983	0.401	0.401
1984	0.461	0.461
1985	0.516	0.516
1986	0.329	0.329
1987	0.307	0.307
1988	0.738	0.738
1989	0.457	0.457
1990	0.449	0.449
1991	0.594	0.594
1992	0.465	0.465
1993	0.267	0.267
1994	0.309	0.309
1995	0.272	0.272
1996	0.641	0.641
1997	1.444	1.444
1998	0.442	0.442
1999	0.238	0.238
2000	0.615	0.615
2001	0.404	0.404
2002	0.297	0.297
2003	0.372	0.372
2004	1.418	1.418
2005	0.492	0.492
2006	0.518	0.518
2007	0.469	0.469
2008	0.432	0.432
2009	0.485	0.485

Stream Protection Duration
Ranked Annual Peaks for Predeveloped and Mitigated. POC #2

Rank	**Predeveloped**	**Mitigated**
1	1.4435	1.4435
2	1.4183	1.4183
3	0.9540	0.9540
4	0.9280	0.9280
5	0.8145	0.8145
6	0.7382	0.7382
7	0.7314	0.7314
8	0.7255	0.7255
9	0.6691	0.6691
10	0.6561	0.6561
11	0.6555	0.6555
12	0.6520	0.6520
13	0.6412	0.6412
14	0.6401	0.6401
15	0.6148	0.6148
16	0.5940	0.5940
17	0.5875	0.5875
18	0.5786	0.5786
19	0.5175	0.5175
20	0.5164	0.5164
21	0.5143	0.5143
22	0.5104	0.5104
23	0.5003	0.5003
24	0.4946	0.4946

25	0.4924	0.4924
26	0.4850	0.4850
27	0.4811	0.4811
28	0.4688	0.4688
29	0.4652	0.4652
30	0.4614	0.4614
31	0.4570	0.4570
32	0.4493	0.4493
33	0.4423	0.4423
34	0.4336	0.4336
35	0.4319	0.4319
36	0.4243	0.4243
37	0.4134	0.4134
38	0.4078	0.4078
39	0.4035	0.4035
40	0.4016	0.4016
41	0.4013	0.4013
42	0.3814	0.3814
43	0.3774	0.3774
44	0.3724	0.3724
45	0.3543	0.3543
46	0.3399	0.3399
47	0.3289	0.3289
48	0.3288	0.3288
49	0.3207	0.3207
50	0.3091	0.3091
51	0.3080	0.3080
52	0.3065	0.3065
53	0.3057	0.3057
54	0.3018	0.3018
55	0.3015	0.3015
56	0.2973	0.2973
57	0.2970	0.2970
58	0.2717	0.2717
59	0.2667	0.2667
60	0.2629	0.2629
61	0.2383	0.2383

Stream Protection Duration
POC #2
The Facility PASSED

The Facility PASSED.

Flow(cfs)	Predev	Mit	Percentage	Pass/Fail
0.2259	1546	1546	100	Pass
0.2352	1348	1348	100	Pass
0.2445	1180	1180	100	Pass
0.2538	1052	1052	100	Pass
0.2631	908	908	100	Pass
0.2724	785	785	100	Pass
0.2816	688	688	100	Pass
0.2909	600	600	100	Pass
0.3002	515	515	100	Pass
0.3095	461	461	100	Pass
0.3188	407	407	100	Pass

0.3281	353	353	100	Pass
0.3374	324	324	100	Pass
0.3467	295	295	100	Pass
0.3560	270	270	100	Pass
0.3653	245	245	100	Pass
0.3746	221	221	100	Pass
0.3838	205	205	100	Pass
0.3931	186	186	100	Pass
0.4024	174	174	100	Pass
0.4117	153	153	100	Pass
0.4210	142	142	100	Pass
0.4303	135	135	100	Pass
0.4396	122	122	100	Pass
0.4489	116	116	100	Pass
0.4582	110	110	100	Pass
0.4675	103	103	100	Pass
0.4768	97	97	100	Pass
0.4861	93	93	100	Pass
0.4953	87	87	100	Pass
0.5046	85	85	100	Pass
0.5139	79	79	100	Pass
0.5232	64	64	100	Pass
0.5325	63	63	100	Pass
0.5418	61	61	100	Pass
0.5511	59	59	100	Pass
0.5604	55	55	100	Pass
0.5697	54	54	100	Pass
0.5790	52	52	100	Pass
0.5883	46	46	100	Pass
0.5976	44	44	100	Pass
0.6068	40	40	100	Pass
0.6161	39	39	100	Pass
0.6254	38	38	100	Pass
0.6347	37	37	100	Pass
0.6440	32	32	100	Pass
0.6533	30	30	100	Pass
0.6626	27	27	100	Pass
0.6719	26	26	100	Pass
0.6812	24	24	100	Pass
0.6905	24	24	100	Pass
0.6998	22	22	100	Pass
0.7091	20	20	100	Pass
0.7183	20	20	100	Pass
0.7276	18	18	100	Pass
0.7369	15	15	100	Pass
0.7462	12	12	100	Pass
0.7555	12	12	100	Pass
0.7648	11	11	100	Pass
0.7741	10	10	100	Pass
0.7834	10	10	100	Pass
0.7927	10	10	100	Pass
0.8020	9	9	100	Pass
0.8113	9	9	100	Pass
0.8206	8	8	100	Pass
0.8298	8	8	100	Pass
0.8391	7	7	100	Pass
0.8484	7	7	100	Pass

0.8577	7	7	100	Pass
0.8670	7	7	100	Pass
0.8763	7	7	100	Pass
0.8856	7	7	100	Pass
0.8949	6	6	100	Pass
0.9042	5	5	100	Pass
0.9135	5	5	100	Pass
0.9228	5	5	100	Pass
0.9321	4	4	100	Pass
0.9413	4	4	100	Pass
0.9506	4	4	100	Pass
0.9599	3	3	100	Pass
0.9692	3	3	100	Pass
0.9785	3	3	100	Pass
0.9878	3	3	100	Pass
0.9971	3	3	100	Pass
1.0064	3	3	100	Pass
1.0157	3	3	100	Pass
1.0250	3	3	100	Pass
1.0343	3	3	100	Pass
1.0436	3	3	100	Pass
1.0528	3	3	100	Pass
1.0621	3	3	100	Pass
1.0714	3	3	100	Pass
1.0807	3	3	100	Pass
1.0900	3	3	100	Pass
1.0993	3	3	100	Pass
1.1086	3	3	100	Pass
1.1179	3	3	100	Pass
1.1272	3	3	100	Pass
1.1365	3	3	100	Pass
1.1458	3	3	100	Pass

Water Quality BMP Flow and Volume for POC #2
On-line facility volume: 0 **acre-feet**
On-line facility target flow: 0 **cfs.**
Adjusted for 15 min: 0 **cfs.**
Off-line facility target flow: 0 **cfs.**
Adjusted for 15 min: 0 **cfs.**

LID Report

LID Technique	Used for Treatment?	Total Volume Needs Treatment (ac-ft)	Volume Through Facility (ac-ft)	Infiltration Volume (ac-ft.)	Cumulative Volume Infiltration Credit	Percent Volume Infiltrated	Water Quality	Percent Water Quality Treated	Comment
Total Volume Infiltrated		0.00	0.00	0.00		0.00	0.00	0%	No Treat. Credit

Compliance with LID Standard 8
Duration Analysis Result = Passed

Stream Protection Duration

Predeveloped Landuse Totals for POC #3
Total Pervious Area:102.06
Total Impervious Area:14.65

Mitigated Landuse Totals for POC #3
Total Pervious Area:102.06
Total Impervious Area:14.65

Flow Frequency Return Periods for Predeveloped. POC #3

Return Period	Flow(cfs)
2 year	5.073626
5 year	7.314316
10 year	9.034932
25 year	11.49654
50 year	13.550907
100 year	15.804546

Flow Frequency Return Periods for Mitigated. POC #3

Return Period	Flow(cfs)
2 year	5.073626
5 year	7.314316
10 year	9.034932
25 year	11.49654
50 year	13.550907
100 year	15.804546

Stream Protection Duration
Annual Peaks for Predeveloped and Mitigated. POC #3

Year	Predeveloped	Mitigated
1949	7.796	7.796
1950	3.901	3.901
1951	6.953	6.953
1952	7.051	7.051
1953	7.977	7.977
1954	3.706	3.706
1955	3.473	3.473
1956	2.655	2.655
1957	7.922	7.922
1958	3.540	3.540
1959	3.568	3.568
1960	5.576	5.576
1961	3.383	3.383
1962	5.776	5.776
1963	3.788	3.788
1964	4.273	4.273
1965	10.738	10.738
1966	4.566	4.566
1967	8.231	8.231
1968	6.655	6.655
1969	3.511	3.511

1970	8.167	8.167
1971	5.429	5.429
1972	3.257	3.257
1973	5.527	5.527
1974	4.356	4.356
1975	12.908	12.908
1976	10.026	10.026
1977	4.211	4.211
1978	7.406	7.406
1979	4.626	4.626
1980	5.532	5.532
1981	4.656	4.656
1982	4.971	4.971
1983	4.435	4.435
1984	4.779	4.779
1985	5.814	5.814
1986	3.484	3.484
1987	3.410	3.410
1988	8.369	8.369
1989	5.162	5.162
1990	5.032	5.032
1991	6.782	6.782
1992	5.246	5.246
1993	2.739	2.739
1994	3.465	3.465
1995	3.065	3.065
1996	6.998	6.998
1997	15.481	15.481
1998	4.937	4.937
1999	2.502	2.502
2000	6.930	6.930
2001	4.542	4.542
2002	3.337	3.337
2003	4.199	4.199
2004	16.560	16.560
2005	5.580	5.580
2006	6.029	6.029
2007	4.972	4.972
2008	4.876	4.876
2009	5.727	5.727

Stream Protection Duration
Ranked Annual Peaks for Predeveloped and Mitigated. POC #3

Rank	**Predeveloped**	**Mitigated**
1	16.5601	16.5601
2	15.4813	15.4813
3	12.9084	12.9084
4	10.7377	10.7377
5	10.0261	10.0261
6	8.3691	8.3691
7	8.2306	8.2306
8	8.1667	8.1667
9	7.9769	7.9769
10	7.9218	7.9218
11	7.7963	7.7963
12	7.4064	7.4064

13	7.0507	7.0507
14	6.9979	6.9979
15	6.9526	6.9526
16	6.9304	6.9304
17	6.7822	6.7822
18	6.6547	6.6547
19	6.0292	6.0292
20	5.8143	5.8143
21	5.7758	5.7758
22	5.7270	5.7270
23	5.5796	5.5796
24	5.5758	5.5758
25	5.5318	5.5318
26	5.5269	5.5269
27	5.4286	5.4286
28	5.2464	5.2464
29	5.1623	5.1623
30	5.0316	5.0316
31	4.9722	4.9722
32	4.9706	4.9706
33	4.9370	4.9370
34	4.8763	4.8763
35	4.7790	4.7790
36	4.6558	4.6558
37	4.6258	4.6258
38	4.5655	4.5655
39	4.5424	4.5424
40	4.4349	4.4349
41	4.3563	4.3563
42	4.2734	4.2734
43	4.2108	4.2108
44	4.1993	4.1993
45	3.9008	3.9008
46	3.7876	3.7876
47	3.7061	3.7061
48	3.5678	3.5678
49	3.5402	3.5402
50	3.5112	3.5112
51	3.4839	3.4839
52	3.4734	3.4734
53	3.4649	3.4649
54	3.4096	3.4096
55	3.3830	3.3830
56	3.3374	3.3374
57	3.2574	3.2574
58	3.0648	3.0648
59	2.7393	2.7393
60	2.6551	2.6551
61	2.5021	2.5021

Stream Protection Duration
POC #3
The Facility PASSED

The Facility PASSED.

Flow(cfs)	Predev	Mit	Percentage	Pass/Fail
2.5368	1184	1184	100	Pass
2.6481	1009	1009	100	Pass
2.7593	866	866	100	Pass
2.8706	764	764	100	Pass
2.9818	664	664	100	Pass
3.0931	573	573	100	Pass
3.2043	501	501	100	Pass
3.3156	448	448	100	Pass
3.4268	392	392	100	Pass
3.5381	345	345	100	Pass
3.6493	301	301	100	Pass
3.7606	274	274	100	Pass
3.8719	247	247	100	Pass
3.9831	223	223	100	Pass
4.0944	204	204	100	Pass
4.2056	187	187	100	Pass
4.3169	174	174	100	Pass
4.4281	166	166	100	Pass
4.5394	153	153	100	Pass
4.6506	136	136	100	Pass
4.7619	131	131	100	Pass
4.8731	118	118	100	Pass
4.9844	106	106	100	Pass
5.0956	102	102	100	Pass
5.2069	97	97	100	Pass
5.3181	90	90	100	Pass
5.4294	85	85	100	Pass
5.5407	80	80	100	Pass
5.6519	74	74	100	Pass
5.7632	71	71	100	Pass
5.8744	66	66	100	Pass
5.9857	63	63	100	Pass
6.0969	58	58	100	Pass
6.2082	56	56	100	Pass
6.3194	52	52	100	Pass
6.4307	51	51	100	Pass
6.5419	50	50	100	Pass
6.6532	49	49	100	Pass
6.7644	46	46	100	Pass
6.8757	42	42	100	Pass
6.9870	40	40	100	Pass
7.0982	35	35	100	Pass
7.2095	35	35	100	Pass
7.3207	35	35	100	Pass
7.4320	33	33	100	Pass
7.5432	29	29	100	Pass
7.6545	29	29	100	Pass
7.7657	28	28	100	Pass
7.8770	23	23	100	Pass
7.9882	20	20	100	Pass
8.0995	20	20	100	Pass
8.2107	19	19	100	Pass
8.3220	18	18	100	Pass
8.4332	17	17	100	Pass
8.5445	17	17	100	Pass
8.6558	17	17	100	Pass

8.7670	16	16	100	Pass
8.8783	15	15	100	Pass
8.9895	15	15	100	Pass
9.1008	14	14	100	Pass
9.2120	14	14	100	Pass
9.3233	14	14	100	Pass
9.4345	13	13	100	Pass
9.5458	12	12	100	Pass
9.6570	12	12	100	Pass
9.7683	11	11	100	Pass
9.8795	10	10	100	Pass
9.9908	9	9	100	Pass
10.1020	8	8	100	Pass
10.2133	8	8	100	Pass
10.3246	6	6	100	Pass
10.4358	6	6	100	Pass
10.5471	5	5	100	Pass
10.6583	5	5	100	Pass
10.7696	4	4	100	Pass
10.8808	4	4	100	Pass
10.9921	4	4	100	Pass
11.1033	4	4	100	Pass
11.2146	4	4	100	Pass
11.3258	4	4	100	Pass
11.4371	4	4	100	Pass
11.5483	4	4	100	Pass
11.6596	4	4	100	Pass
11.7709	4	4	100	Pass
11.8821	4	4	100	Pass
11.9934	4	4	100	Pass
12.1046	4	4	100	Pass
12.2159	4	4	100	Pass
12.3271	4	4	100	Pass
12.4384	4	4	100	Pass
12.5496	4	4	100	Pass
12.6609	4	4	100	Pass
12.7721	4	4	100	Pass
12.8834	4	4	100	Pass
12.9946	3	3	100	Pass
13.1059	3	3	100	Pass
13.2171	3	3	100	Pass
13.3284	3	3	100	Pass
13.4397	3	3	100	Pass
13.5509	3	3	100	Pass

Water Quality BMP Flow and Volume for POC #3
On-line facility volume: 0 **acre-feet**
On-line facility target flow: 0 **cfs.**
Adjusted for 15 min: 0 **cfs.**
Off-line facility target flow: 0 **cfs.**
Adjusted for 15 min: 0 **cfs.**

LID Report

LID Technique	Used for Treatment?	Total Volume Needs Treatment (ac-ft)	Volume Through Facility (ac-ft)	Infiltration Volume (ac-ft.)	Cumulative Volume Infiltration Credit	Percent Volume Infiltrated	Water Quality	Percent Water Quality Treated	Comment
Total Volume Infiltrated		0.00	0.00	0.00		0.00	0.00	0%	No Treat. Credit

Compliance with LID Standard 8
Duration Analysis Result = Passed

Perlnd and Implnd Changes

No changes have been made.

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Appendix F
Transportation Evaluation Memorandum (KPFF)

Similk Beach Restoration

Transportation Study

April 2022

kpff
Consulting
Engineers

Similk Beach Restoration Transportation Study

April 2022

Prepared for:

Blue Coast Engineering
119 N Commercial Street
Suite 1110
Bellingham, WA 98225

Prepared by:

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Appendices

1. Purpose

A team of consultants led by Blue Coast Engineering, including KPFF, has been retained by the Skagit River System Cooperative (SRSC) to provide analysis and design for the Similk Beach Restoration Project. The purpose of the project is to re-establish hydraulic connectivity between Similk Bay and the historic saltwater marsh that existed north of the present-day road.

Similk Bay is located on the south facing shoreline of Fidalgo Island between the east and west land masses that make up the island and Similk Beach is located along the north shore of that bay. When Satterlee Road (and an adjacent berm) was constructed along the shoreline, the hydraulic connectivity between the bay and a historic saltwater marsh was cut off. Today, drainage accumulates in the low-lying area between the landmasses in a channel that extends north from Satterlee Road through the former marsh land. A lift station on the north side of the road pumps the water across the road and discharges to the beach on the opposite side of the barrier berm. An earlier study was performed to determine the feasibility of restoring the hydraulic connection between the bay and the areas to the north to restore that marsh or to create a barrier lagoon environment. This study focuses on the roadway and infrastructure improvements required to implement that restoration plan.

The purpose of this study is to document the design requirements for a roadway and bridge to accommodate a new channel opening to provide that restorative function.

Figure 1-1: Project Location

2. Existing Conditions

Similk Bay is located on the south facing shoreline of Fidalgo Island between the east and west land masses that make up the island and Similk Beach is located along the north shore of that bay. Drainage accumulates in the low-lying area between the landmasses in a channel that extends north from Satterlee Road through the former marsh land which is owned by the Swinomish Tribe. A lift station discharges drainage to the beach.

Satterlee Road is owned by Skagit County and parcels adjacent to the project are primarily owned by the Swinomish Tribe. Near the very east and west extents of the roadway improvements there are privately-owned parcels, and the design strives to minimize impacts to these properties. The extents of work are expected to largely remain in the right of way except for grading required to tie into existing driveways.

3. Technical Data and Design Assumptions

3.1 CODES AND REFERENCES

The following manuals and standards provide applicable guidance for the design and construction if the proposed bridge and roadway:

- Skagit County Road Standards (2000)
- WSDOT Design Manual (2021)
- WSDOT Bridge Design Manual (2020)
- AASHTO Policy on Geometric Design of Highways and Streets (2018)
- AASHTO LRFD Bridge Design Specifications, 9th Edition AASHTO Guide (2020)
- Flood Insurance Study, Federal Emergency Management Agency (FEMA)
- Department of Ecology Stormwater Management Manual for Western Washington (as amended 2019)

3.2 ROADWAY DESIGN STANDARDS

Roadway Classifications

Satterlee Road has a current functional classification of Urban Local Access Road. Traffic counts were collected by Skagit County on April 5 and 6, 2022 and found to have a total daily counts of 498 and 641 vehicles per day respectively. Satterlee Road is not, however, located in a defined urban area. Discussions with County staff suggest a more appropriate classification would be Rural Major and Minor Collector. Subsequent phases of design will work toward reclassifying this roadway through FHWA and for the purposes of this study a rural roadway section without sidewalk, curb and gutter has been assumed. The conceptual design is based on Skagit County Standard Plan B-6, a Rural Major and Minor Collector Roadway with an ADT greater than 400.

Stormwater Management

Implementation of these projects must be done in conformance with Skagit County's stormwater code and the Department of Ecology Stormwater Management Manual for Western Washington (SMMWW). This study has not developed specific concepts to address this; however, it can be a significant cost associated with the construction of a roadway. Outlined here are the minimum requirements that would apply to reconstruction of Satterlee Road. This project would be considered a transportation redevelopment project. It is assumed that most of the existing pavement will be removed down to the base course prior to reconstructing the road and as such, the applicable requirements will apply to all new and replaced hard surfaces. Of the nine minimum requirements, all are applicable to this project, however the project would be exempt from Minimum Requirement No. 7 – Flow Control, due to its proximity to Puget Sound. Of the remaining 8, providing treatment for runoff will be the requirement that will have the most significant cost and space considerations in final design.

Utilities

There exist three utilities within and along Satterlee Road today: overhead power, gas and water.

The overhead power runs along the south, or outside of Satterlee Road as it comes down the hill from the west. The widened roadway will necessitate the relocation of the power line to be beyond the clear zone. The powerline is owned by Puget Sound Energy (PSE) and located in an easement and therefore the project proponent will need to compensate for a new easement and the cost of relocation. Outreach to PSE has not occurred at this time but an underground relocation may be considered in final design.

The 6-inch asbestos concrete water main is owned by Skagit County Public Utility District (PUD). The gas line is owned by Cascade Natural Gas and the size is unknown at this time. The conceptual design assumes that the utilities, which are located in the right of way currently, will be attached to the underside of the bridge structure in their final configuration. Temporary systems to maintain service during excavation of the channel and construction of the bridge will need to be addressed in coordination with the utility providers. The cost of the temporary and permanent installations of water and gas are presumed to be borne by the utility provider as these two are under franchise in the County right of way.

3.3 PRELIMINARY DESIGN ASSUMPTIONS

Hydraulic Parameters

• Minimum Channel Width	80 feet (Preliminary Hydraulic Study)
• Minimum Clear Span Between Bridge Abutments	100 feet
• Bottom of Channel	Elev. 4.0, NAVD88 (Preliminary Hydraulic Study)
• 100-Year Still-Water-Level	Elev. 11.8, NAVD88 (FEMA)
• Minimum Vertical Clearance	3 feet between bridge low chord and 100-Year Still-Water-Level (WDFW)

Geotechnical Parameters

At the time of this report, geotechnical data has not been collected. For the purposes of developing costs for the options listed below, this report assumes driven piles will be necessary to support a structure over the new channel. The number, size, and location of piles is based on previous similar project experience and is subject to change after in-depth geotechnical information becomes available.

3.4 CONSTRUCTABILITY CONSIDERATIONS

The project is located on Fidalgo Island in Skagit County, Washington. While it is technically classified as an urban area, it is rural in nature. Access to and from the project site can be made from either direction on Satterlee Road, although from the west is more probable given the proximity to State Route (SR) 20.

Access During Construction

Satterlee Road provides an east/west access for the communities on either side of the island but is not a major thoroughfare and does not provide access to any parks or major destinations. Satterlee Road is the sole detour route for closures for SR 20 on Fidalgo Island. Construction will likely require a full road closure. Residents can access from either side, using SR 20, however it would be a lengthy detour of nearly three miles.

Construction Access to Project Site

Access to and from the project site can be made from either direction on Satterlee Road although from the west will likely be the primary access given the proximity to SR 20. Delivery of the steel piling and precast concrete girders will require extended length trucks (over 100-ft). Expected truck routes for girder and pile delivery off of SR 20 westbound (WB) from Burlington to the project site are expected to follow either:

- SR 20 WB – Thompson Road to Summit Park Road to Satterlee Road, or
- SR 20 WB (toward Whidbey Island) – Gibralter Road to Satterlee Road.

The roadway appears to have adequate width and trucks delivering bridge girders are capable of accessing the site.

Construction Staging Area

The existing 22-foot roadway can provide sufficient staging area during construction. However, a full road closure would be required, which may be an issue as Satterlee Road is part of the only detour for SR 20. This option would need to be evaluated in subsequent design phases for feasibility. Alternatively, an adjacent parcel could be used as a staging area if an easement from the Swinomish Tribe can be obtained.

4. Bridge and Roadway Improvements

It is proposed to remove the existing culvert and pumped discharge and replace with an 80-foot channel out to the bay. A new precast concrete bridge with a clear span of 100-feet is proposed to carry the roadway over the new channel. The bridge elevation is established to provide the necessary clearance from the design high water elevation established as the FEMA 100-year flood elevation of 11.8 feet (NAVD88).

The bridge superstructure will consist of precast prestressed concrete deck bulb tee girders with HMA/asphalt surfacing. The girders will be supported on concrete abutments on steel pipe piles. The final number and size/depth of the piles will be determined after geotechnical data is collected.

The roadway alignment for the concept design follows the existing alignment which is not centered within the existing right of way. The existing road has 22-feet of total lane width with 2-foot gravel shoulders. A Rural Major Collector in this environment should have a design speed of 40 mph, however Satterlee Road is currently posted for 25 mph. The existing roadway geometrics are not deficient for the reduce design speed.

The design proposes to modify the vertical alignment of the roadway to raise the road above the highest astronomical tide elevation of 10.8 feet (NAVD88) and provide 3-feet of clearance from the 100-year FEMA flood elevation in the new channel. Wing walls will be needed to contain additional fill required to raise the roadway and maintain the new channel limits.

To achieve a profile that met these criteria and reduced impacts to residential driveways, certain assumptions were made:

- The roadway will continue to be posted for a 25 mph speed limit
- The final design will incorporate grade breaks with a 1% maximum algebraic difference

Alternatively, the horizontal alignment can be revised in subsequent design. Aligning Satterlee Road along the existing right of way centerline would move the road to the north providing additional clearance from adjacent properties which will improve the grading for driveway connections.

4.3 EXAMPLE PHOTOS

Illabot Creek Bridge, completed by KPFF for Skagit County in 2018, uses precast, prestressed wide flange deck girders (WF39DG), cast-in-place concrete abutments, and wing walls. The span length is approximately 105 feet. Wing walls extend back at a 45-degree angle from the abutments. The structure is similar to that proposed for the Similk Bridge. See Figure 5-1 below.

Figure 5-1: Illabot Creek Bridge

Another bridge with a similar structure to the proposed options is Davis Slough Bridge, a project completed by KPFF for Skagit County in 2014. This bridge uses precast, prestressed concrete deck bulb tee (W35DG) girders and cast-in-place concrete abutments and wing walls. The span length is approximately 60 feet. The wing walls on this bridge extend back at a 90-degree angle from the abutment. See Figure 6-1 below.

Figure 6-1: Davis Slough Bridge

5. Cost Estimate

A preliminary cost estimate has been prepared that includes estimated costs for roadway, bridge, and mobilization. Costs associated with construction of the channel and utilities are not included. Taking into consideration elements that that will need to be resolved in subsequent design, a contingency of 30% has been included.

Table 7-1: Simılk Beach Cost Overview

Item	Cost
Bridge	$2,590,000
Roadway	$960,000
Mobilization and Design Contingencies	$1,412,000
Grand Total	***$4,944,000***

Notes:

1. Cost in 2022 dollars.
2. Cost does not include sales tax, engineering, construction administration, or permitting.
3. Costs for foundations are based on previous projects.
4. Costs do not include construction of the channels (e.g., channel excavation, slope protection, erosion control, channel armoring, etc.) or tide gate structure for the respective options.
5. Costs do not include Right of Way Acquisition or mitigation for impacts.

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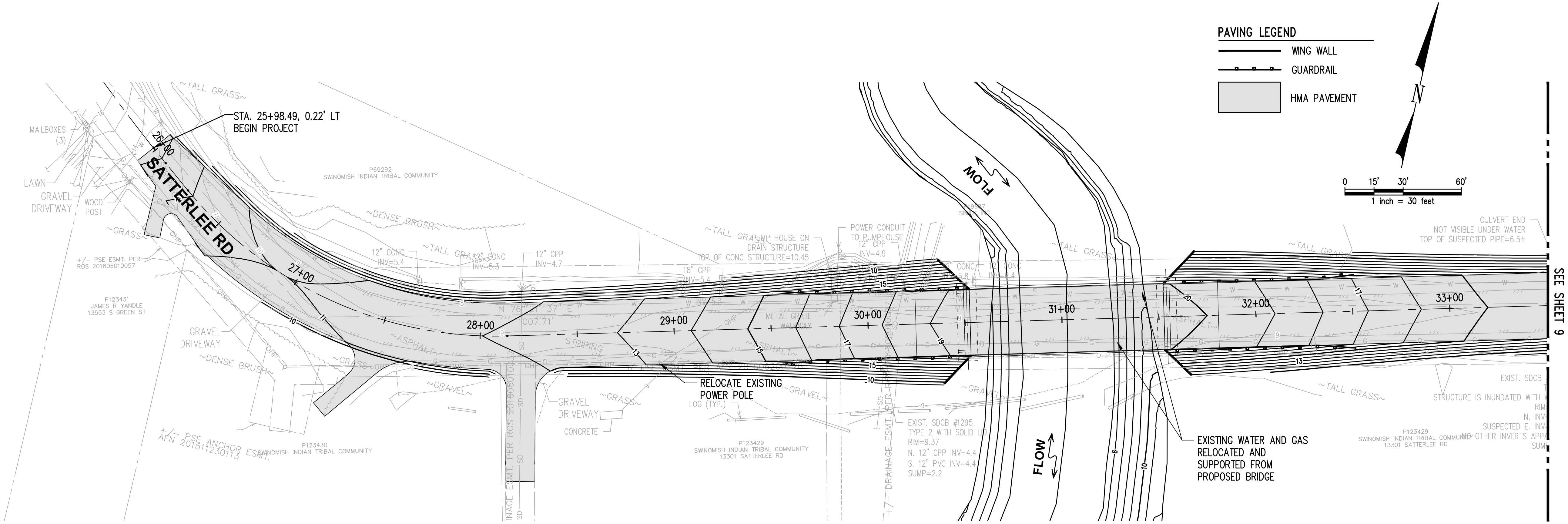
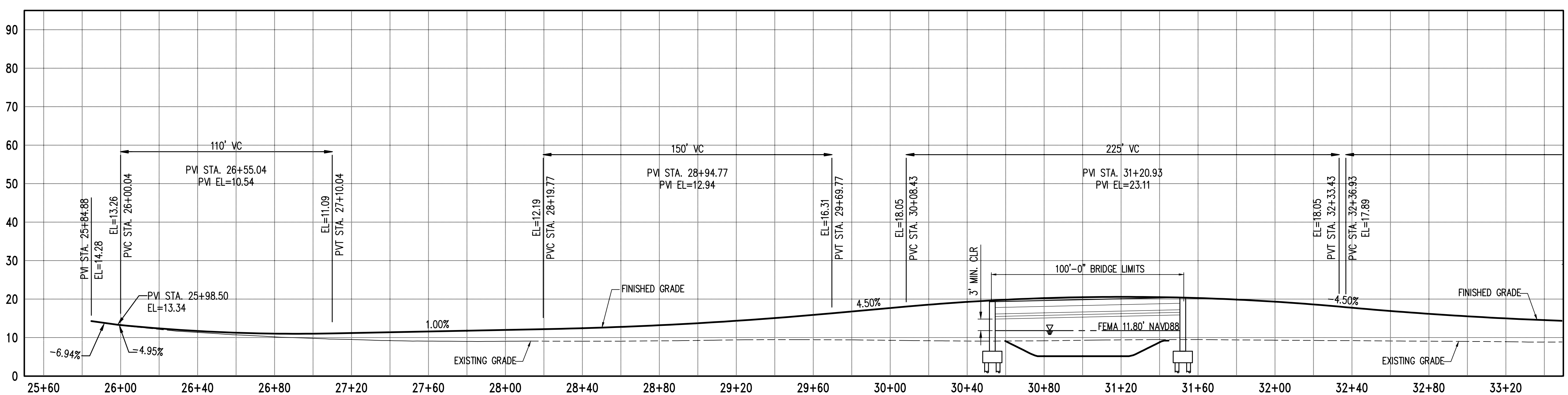
Appendix A

Plan and Profile Drawings





CONCEPTUAL DESIGN

REVISIONS

NO.	REVISIONS	DATE

ENGINEER OF RECORD

DESIGN ENGINEER

kpff

1601 5th Avenue, Suite 1600
Seattle, WA 98101
206.622.5822
www.kpff.com

PROJECT NO.: ES24100-2
FED. AID NO.: N/A
DESIGNED BY:
DRAWN BY:
CHECKED BY:
APPROVED BY:

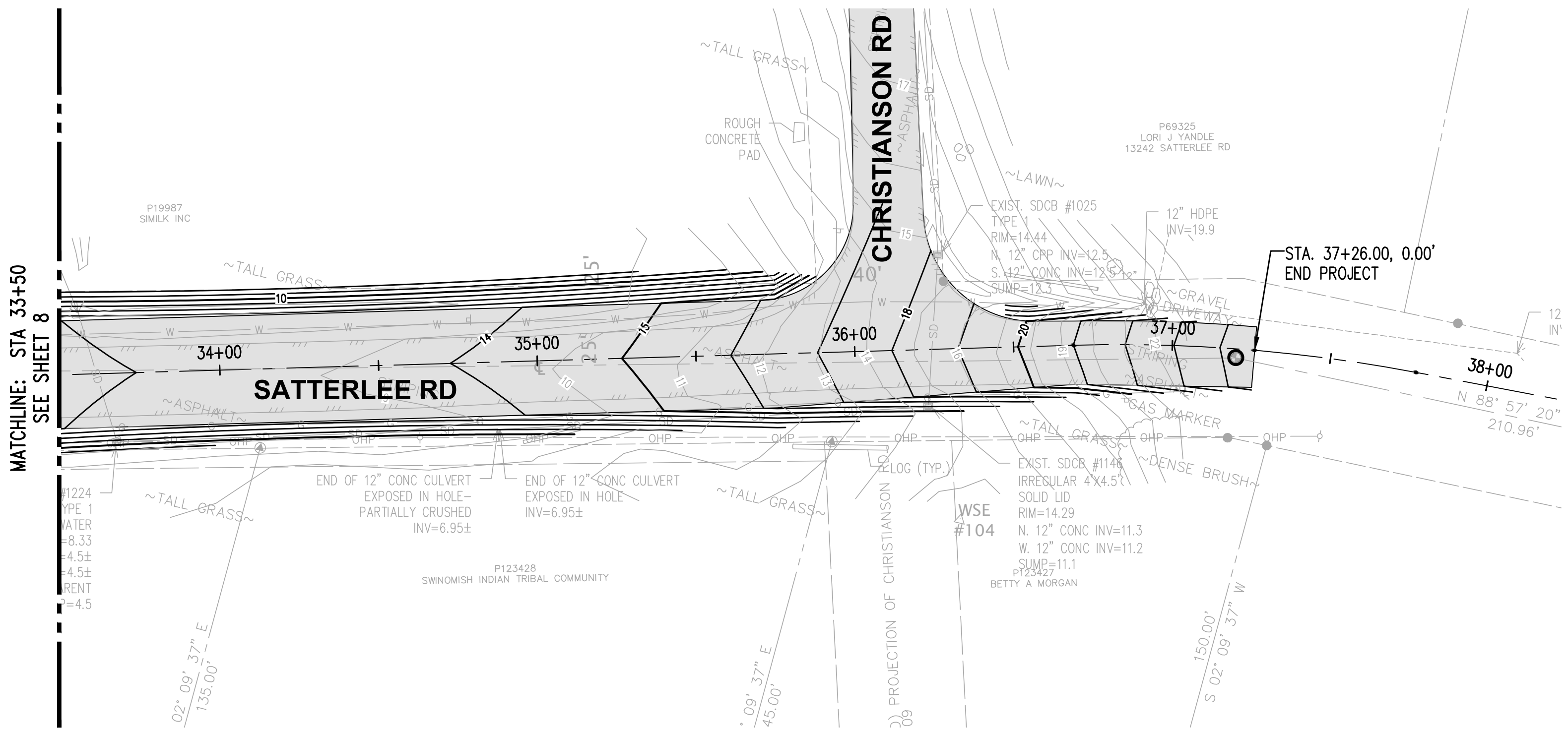
PROJECT LOCATED NEAR:
SATTERLEE ROAD

SIMILK TIDAL MARSH RESTORATION PROJECT

ROADWAY PLAN AND PROFILE

1 INCH SCALE BAR
ADJUST SCALE ACCORDINGLY

SHEET
8 OF 12



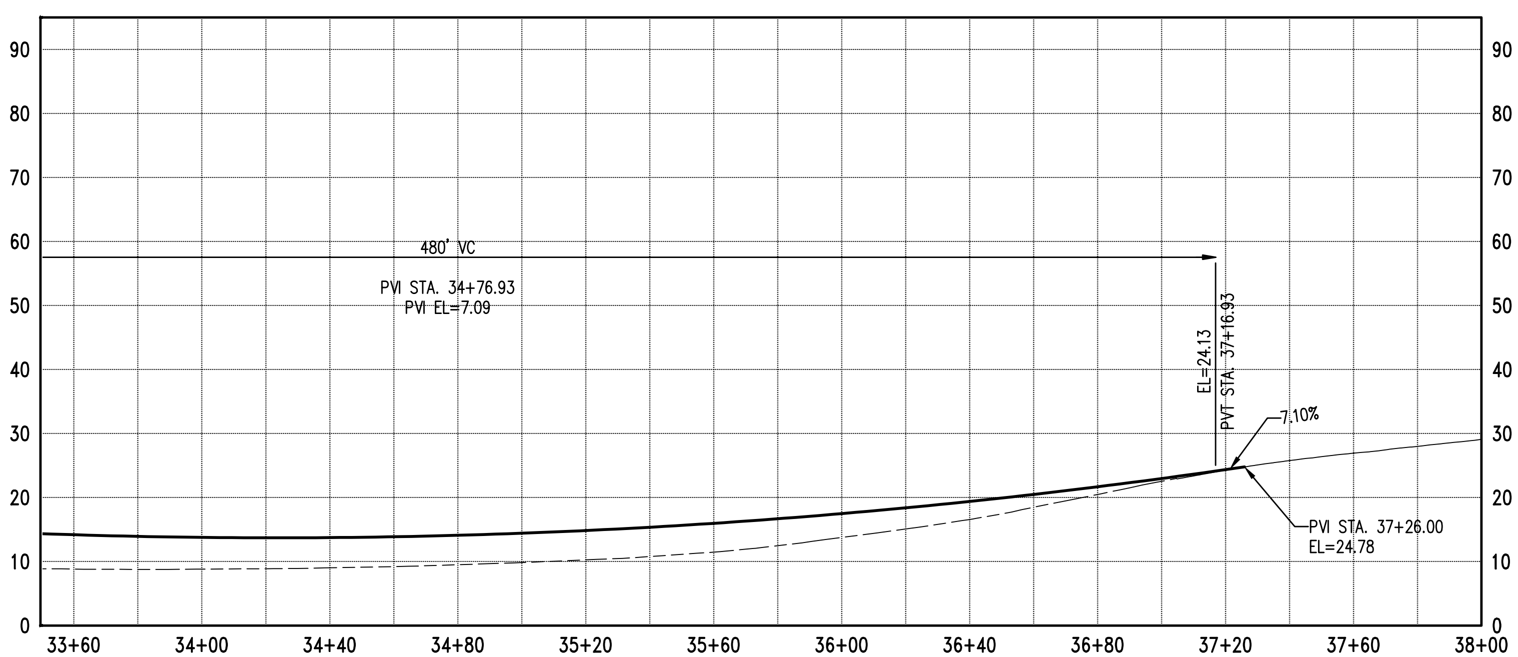
PAVING LEGEND

GUARDRAIL

HMA PAVEMENT

N

0 15' 30' 60'
1 inch = 30 feet



CONCEPTUAL DESIGN

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APPROVED BY:
PROJECT LOCATED NEAR:
SATTERLEE ROAD

SIMILK TIDAL MARSH
RESTORATION PROJECT

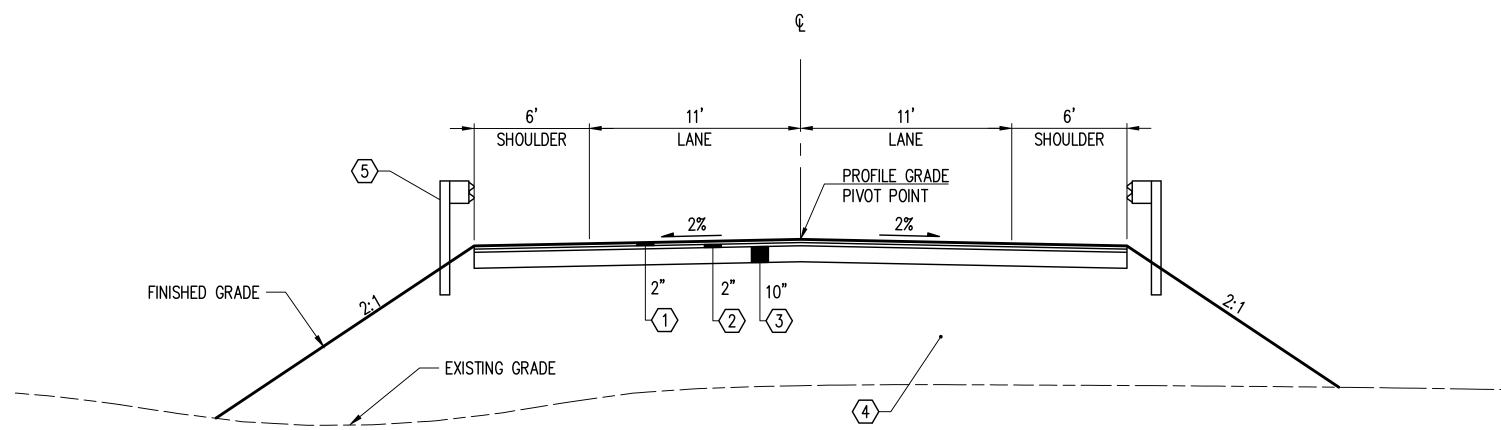
ROADWAY PLAN AND PROFILE

1 INCH SCALE BAR
ADJUST SCALE ACCORDINGLY

SHEET
9 OF 12

CONSTRUCTION NOTES:

1. HMA CL 1/2 IN PG 58H-22
2. CRUSHED SURFACING TOP COURSE
3. CRUSHED SURFACING BASE COURSE
4. GRAVEL BORROW INCL. HAUL
5. TYPE 31 BEAM GUARDRAIL



TYPICAL ROADWAY SECTION

CONCEPTUAL DESIGN

NO.	REVISIONS	DATE

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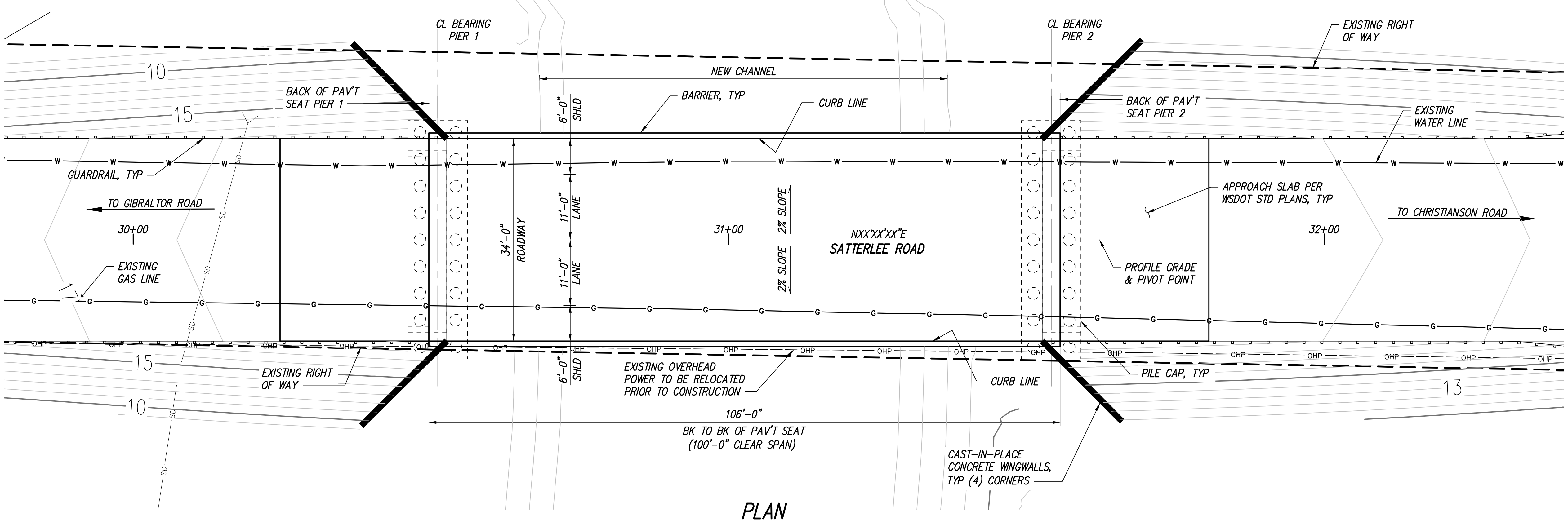
APPROVED BY:
PROJECT LOCATED NEAR:
SATTERLEE ROAD

SIMILK TIDAL MARSH RESTORATION PROJECT

TYPICAL ROADWAY SECTION

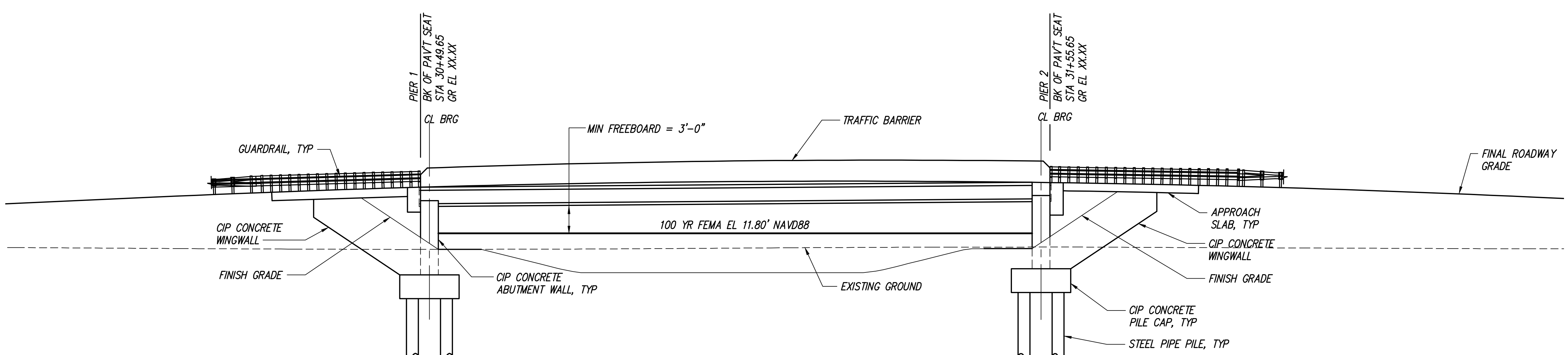
1 INCH SCALE BAR
ADJUST SCALE ACCORDINGLY

SHEET
10 OF 12



PLAN

0 10 20 30
SCALE IN FEET



ELEVATION

0 10 20 30
SCALE IN FEET

PRECAST PRESTRESSED CONCRETE
WF39DG WIDE FLANGE DECK GIRDERS
LOADING: HL-93

CONCEPTUAL DESIGN

NO.	REVISIONS	DATE

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PROJECT LOCATED NEAR:
SATTERLEE ROAD

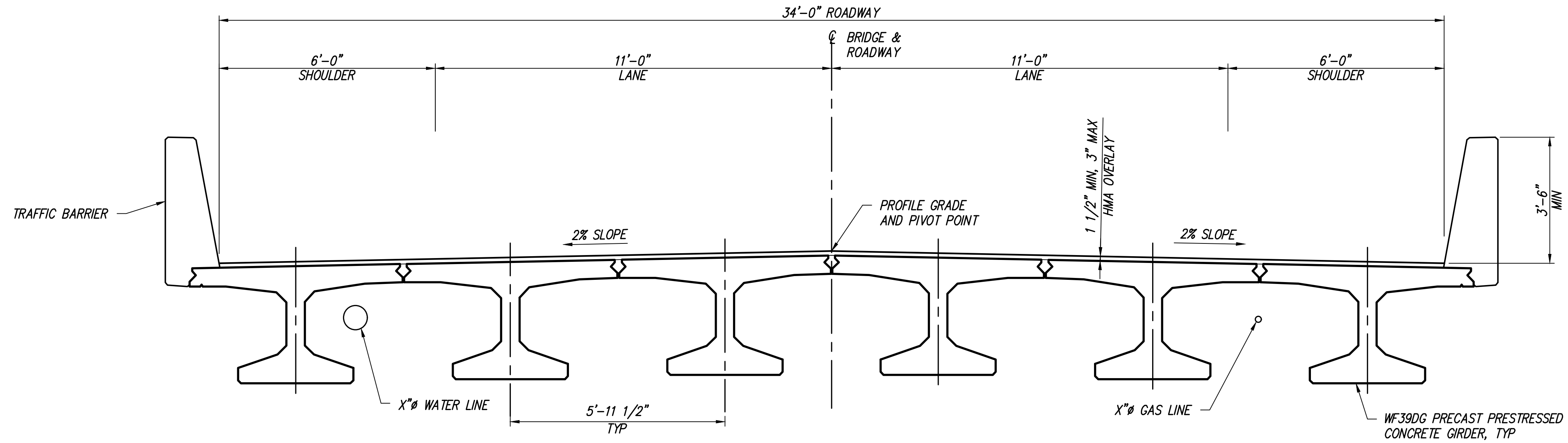
SIMILK TIDAL MARSH RESTORATION PROJECT

PLAN AND ELEVATION

1 INCH SCALE BAR
ADJUST SCALE ACCORDINGLY

SHEET
11 OF 12

TAUNIEP – April 6, 2022 – 3:03 PM – V:\2100269 (SIMILK BRIDGE)\02_DESIGN (V2019)\SB_S01.DWG



TYPICAL SECTION

LOOKING AHEAD ON STATION

CONCEPTUAL DESIGN

NO.	REVISIONS	DATE

ENGINEER OF RECORD

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DESIGNED BY: AS
DRAWN BY: TP
CHECKED BY:
APPROVED BY:

PROJECT LOCATED NEAR:
SATTERLEE ROAD

SIMILK TIDAL MARSH RESTORATION PROJECT

TYPICAL SECTION

1 INCH SCALE BAR
ADJUST SCALE ACCORDINGLY

SHEET
12 OF 12

TAUNIEP - April 6, 2022 - 3:03 PM - V:\2100269 (SIMILK BRIDGE)\02_DESIGN (V2019)\SB_S02.DWG

Appendix B

Traffic Data

MetroCount Traffic Executive
SCOG Report

CustomList-88 -- English (ENU)

Datasets:

Site:	**[145000050] Satterlee Rd W of Christianson Rd <25 mph>**
Attribute:	County
Direction:	8 - East bound A>B, West bound B>A. **Lane:** 0
Survey Duration:	0:00 Tuesday, April 5, 2022 => 15:10 Friday, April 8, 2022,
Zone:	
File:	145000050 0 2022-04-08 1511.EC0 (Plus)
Identifier:	Q232BNE6 MC56-L4 [MC55] (c)Microcom 19Sep03
Algorithm:	Factory default axle (v5.06)
Data type:	Axle sensors - Paired (Class/Speed/Count)

Profile:

Filter time:	**0:00 Tuesday, April 5, 2022 => 0:00 Thursday, April 7, 2022 (2)**
Included classes:	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13
Speed range:	6 - 99 mph.
Direction:	North, East, South, West (bound), P = East, Lane = 0-16
Separation:	Headway > 0 sec, Span 0 - 328.084 ft
Name:	Default Profile
Scheme:	Vehicle classification (Scheme F3)
Units:	Non metric (ft, mi, ft/s, mph, lb, ton)

Column Legend:

0 [Time]	24-hour time (0000 - 2359)
1 [Total]	Number in time step (AB)
2 [Total]	Number in time step (BA)
3 [Total]	Number in time step
4 [Cls]	Class totals

* Tuesday, April 5, 2022

Time <--	Total AB	Total BA	Total	Cls 1	Cls 2	Cls 3	Cls 4	Cls 5	Cls 6	Cls 7	Cls 8	Cls 9	Cls 10	Cls 11	Cls 12	Cls 13
0000	1	1	2	0	2	0	0	0	0	0	0	0	0	0	0	0
0100	2	1	3	0	2	1	0	0	0	0	0	0	0	0	0	0
0200	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0
0300	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0
0400	1	2	3	0	2	1	0	0	0	0	0	0	0	0	0	0
0500	2	0	2	0	2	0	0	0	0	0	0	0	0	0	0	0
0600	6	2	8	0	6	1	0	1	0	0	0	0	0	0	0	0
0700	14	8	22	0	16	4	0	2	0	0	0	0	0	0	0	0
0800	19	15	34	0	20	10	1	2	0	0	0	1	0	0	0	0
0900	12	12	24	0	14	7	0	3	0	0	0	0	0	0	0	0
1000	21	11	32	0	22	8	0	2	0	0	0	0	0	0	0	0
1100	12	17	29	0	24	5	0	0	0	0	0	0	0	0	0	0
1200	15	14	29	0	25	3	0	0	1	0	0	0	0	0	0	0
1300	20	18	38	0	29	7	0	2	0	0	0	0	0	0	0	0
1400	25	17	42	0	25	12	0	5	0	0	0	0	0	0	0	0
1500	15	23	38	0	23	12	0	3	0	0	0	0	0	0	0	0
1600	19	44	63	0	50	10	0	2	1	0	0	0	0	0	0	0
1700	20	36	56	0	43	9	0	4	0	0	0	0	0	0	0	0
1800	8	20	28	0	18	8	0	2	0	0	0	0	0	0	0	0
1900	10	10	20	0	18	2	0	0	0	0	0	0	0	0	0	0
2000	7	6	13	1	6	6	0	0	0	0	0	0	0	0	0	0
2100	2	5	7	1	5	1	0	0	0	0	0	0	0	0	0	0
2200	2	1	3	0	3	0	0	0	0	0	0	0	0	0	0	0
2300	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
00-00	**235**	**263**	**498**	**2**	**357**	**107**	**1**	**28**	**2**	**0**	**0**	**1**	**0**	**0**	**0**	**0**

Peak step 16:00 (63) **AM Peak step** 8:00 (34) **PM Peak step** 16:00 (63)

Vehicles = 498
Posted speed limit = 25 mph, Exceeding = 425 (85.34%), Mean Exceeding = 31.52 mph
Maximum = 49.3 mph, **Minimum** = 11.9 mph, **Mean** = 30.0 mph
85% Speed = 34.78 mph, **95% Speed** = 38.36 mph, **Median** = 30.20 mph
10 mph Pace = 25 - 35, **Number in Pace** = 358 (71.89%)
Variance = 29.95, **Standard Deviation** = 5.47 mph

* Wednesday, April 6, 2022

Time <--	Total AB	Total BA	Total	Cls 1	Cls 2	Cls 3	Cls 4	Cls 5	Cls 6	Cls 7	Cls 8	Cls 9	Cls 10	Cls 11	Cls 12	Cls 13
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0100	2	2	4	0	4	0	0	0	0	0	0	0	0	0	0	0
0200	2	0	2	0	1	1	0	0	0	0	0	0	0	0	0	0
0300	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0
0400	0	3	3	0	3	0	0	0	0	0	0	0	0	0	0	0
0500	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0
0600	7	5	12	1	7	3	0	1	0	0	0	0	0	0	0	0
0700	10	9	19	0	15	3	0	1	0	0	0	0	0	0	0	0
0800	14	12	26	2	14	10	0	0	0	0	0	0	0	0	0	0
0900	18	15	33	0	25	7	0	0	0	0	0	1	0	0	0	0
1000	21	11	32	0	21	9	0	2	0	0	0	0	0	0	0	0
1100	34	17	51	3	33	11	0	4	0	0	0	0	0	0	0	0
1200	21	26	47	0	25	18	0	2	0	0	0	2	0	0	0	0
1300	27	30	57	4	35	14	0	3	1	0	0	0	0	0	0	0
1400	31	34	65	6	38	16	0	4	0	0	0	1	0	0	0	0
1500	24	22	46	3	32	9	0	2	0	0	0	0	0	0	0	0
1600	27	44	71	3	52	14	0	1	1	0	0	0	0	0	0	0
1700	28	46	74	2	47	21	0	4	0	0	0	0	0	0	0	0
1800	12	19	31	2	19	7	0	3	0	0	0	0	0	0	0	0
1900	7	20	27	0	15	11	0	1	0	0	0	0	0	0	0	0
2000	6	7	13	0	11	2	0	0	0	0	0	0	0	0	0	0
2100	3	9	12	0	9	3	0	0	0	0	0	0	0	0	0	0
2200	1	4	5	0	4	1	0	0	0	0	0	0	0	0	0	0
2300	2	6	8	0	4	4	0	0	0	0	0	0	0	0	0	0
00-00	**298**	**343**	**641**	**26**	**417**	**164**	**0**	**28**	**2**	**0**	**0**	**4**	**0**	**0**	**0**	**0**

Peak step 17:00 (74) **AM Peak step** 11:00 (51) **PM Peak step** 17:00 (74)

Vehicles = 641
Posted speed limit = 25 mph, Exceeding = 496 (77.38%), Mean Exceeding = 31.06 mph
Maximum = 57.0 mph, **Minimum** = 8.5 mph, **Mean** = 28.4 mph
85% Speed = 34.34 mph, **95% Speed** = 37.23 mph, **Median** = 28.97 mph
10 mph Pace = 25 - 35, **Number in Pace** = 426 (66.46%)
Variance = 40.66, **Standard Deviation** = 6.38 mph

*** Virtual Day (2)**

Time <--	Total AB	Total BA	Total	Cls 1	Cls 2	Cls 3	Cls 4	Cls 5	Cls 6	Cls 7	Cls 8	Cls 9	Cls 10	Cls 11	Cls 12	Cls 13
0000	1	1	2	0	2	0	0	0	0	0	0	0	0	0	0	0
0100	2	2	4	0	3	1	0	0	0	0	0	0	0	0	0	0
0200	2	0	2	0	1	1	0	0	0	0	0	0	0	0	0	0
0300	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0
0400	1	3	3	0	3	1	0	0	0	0	0	0	0	0	0	0
0500	2	0	2	0	2	0	0	0	0	0	0	0	0	0	0	0
0600	7	4	10	1	7	2	0	1	0	0	0	0	0	0	0	0
0700	12	9	21	0	16	4	0	2	0	0	0	0	0	0	0	0
0800	17	14	30	1	17	10	1	1	0	0	0	1	0	0	0	0
0900	15	14	29	0	20	7	0	2	0	0	0	1	0	0	0	0
1000	21	11	32	0	22	9	0	2	0	0	0	0	0	0	0	0
1100	23	17	40	2	29	8	0	2	0	0	0	0	0	0	0	0
1200	18	20	38	0	25	11	0	1	1	0	0	1	0	0	0	0
1300	24	24	48	2	32	11	0	3	1	0	0	0	0	0	0	0
1400	28	26	54	3	32	14	0	5	0	0	0	1	0	0	0	0
1500	20	23	42	2	28	11	0	3	0	0	0	0	0	0	0	0
1600	23	44	67	2	51	12	0	2	1	0	0	0	0	0	0	0
1700	24	41	65	1	45	15	0	4	0	0	0	0	0	0	0	0
1800	10	20	30	1	19	8	0	3	0	0	0	0	0	0	0	0
1900	9	15	24	0	17	7	0	1	0	0	0	0	0	0	0	0
2000	7	7	13	1	9	4	0	0	0	0	0	0	0	0	0	0
2100	3	7	10	1	7	2	0	0	0	0	0	0	0	0	0	0
2200	2	3	4	0	4	1	0	0	0	0	0	0	0	0	0	0
2300	1	3	4	0	2	2	0	0	0	0	0	0	0	0	0	0
00-00	**267**	**303**	**570**	**14**	**387**	**136**	**1**	**28**	**2**	**0**	**0**	**3**	**0**	**0**	**0**	**0**

Vehicles = 1139
Posted speed limit = 25 mph, Exceeding = 921 (80.86%), Mean Exceeding = 31.27 mph
Maximum = 57.0 mph, **Minimum** = 8.5 mph, **Mean** = 29.1 mph
85% Speed = 34.45 mph, **95% Speed** = 37.80 mph, **Median** = 29.53 mph
10 mph Pace = 25 - 35, **Number in Pace** = 781 (68.57%)
Variance = 36.52, **Standard Deviation** = 6.04 mph

In profile: Vehicles = 1139 / 1924 (59.20%)

Appendix C

Concept Desgin Cost Estimate

Skagit River System Cooperative
Similk Beach Restoration
4/12/2022

Engineer's Estimate of Probable Cost

Estimated % Complete:

	ITEM	UNIT	UNIT PRICE	QTY	COST
	PREPARATION				
1	CLEARING AND GRUBBING	LS	$ 5,000	1.0	$5,000
2	REMOVAL OF STRUCTURES AND OBSTRUCTIONS	LS	$ 30,000	1	$30,000
	GRADING				
3	ROADWAY EXCAVATION INCL. HAUL	CY	$ 55	10	$550
4	GRAVEL BORROW INCL. HAUL	CY	$ 30	8,529	$255,870
	STRUCTURE				
5	BRIDGE SUPERSTRUCTURE	LS	$ 1,170,000	1	$1,170,000
6	BRIDGE SUBSTRUCTURE	LS	$ 1,420,000	1	$1,420,000
	SURFACING				
7	CRUSHED SURFACING BASE COURSE	TN	$ 55	2,310	$127,050
	HOT MIX ASPHALT				
9	HMA CL. 3/8 IN. PG 58H-22	TON	$ 125	1,023	$127,875
	EROSION CONTROL AND ROADSIDE PLANTING				
10	EROSION CONTROL AND WATER POLLUTION PREVENTION	LS	$ 176,579	1	$176,579
	TRAFFIC				
11	PROFILED PLASTIC LINE	LF	$ 3	1,220	$3,660
12	PROJECT TEMPORARY TRAFFIC CONTROL	LS	$ 25,000	1	$25,000
13	BEAM GUARDRAIL TYPE 31 INCL. TRANSITION SECTIONS AND TERMINALS	LS	$ 55,000	1	$55,000
	OTHER ITEMS				
14	ROADWAY SURVEYING	LS	$ 25,000	1	$25,000
15	STRUCTURE SURVEYING	LS	$ 10,000	1	$10,000
16	UTILITY RELOCATION	LS	$ 100,000	1	$100,000

Subtotal =		**$3,531,584**
WSST	0.0%	$0
Mobilization =	10.0%	$353,158
Design Contingency =	30%	$1,059,475
Total Estimated Construction Cost =		**$4,944,218**

Assumptions
(1) Cost in 2022 year dollars.
(2) Cost does not include Sales Tax (RCW 82.04.050(10)), Engineering, Construction Management, Construction Administration, or costs associated with permitting.
(3) Cost does not include Right of Way Acquisition or Mitigation for wetland, stream, or buffer impacts
(4) Costs do not include construction of the channels (e.g., channel excavation, slope protection, erosion control, channel armoring, etc.) or tide gate structure for the respective options
(5) Costs do not include Right of Way Acquistion or mitigation for impacts

Appendix G
Golf Course Water Quality Evaluation
(Available Upon Request)

Copies of the Golf Course Water Elevation Memorandum may be requested from the Swinomish Indian Tribal Community.

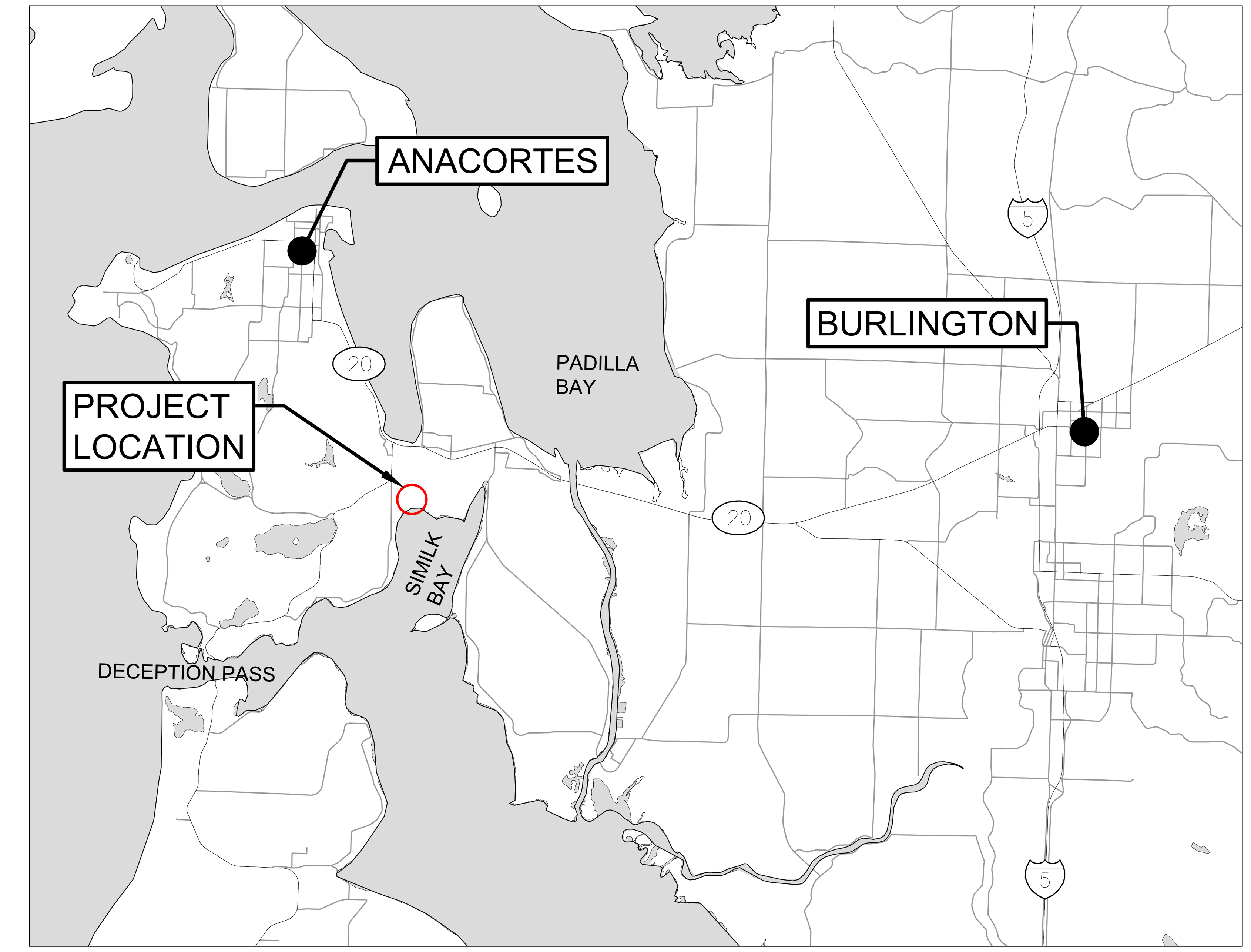
Appendix H
Preliminary Design Drawings

PRELIMINARY (60%) DESIGN

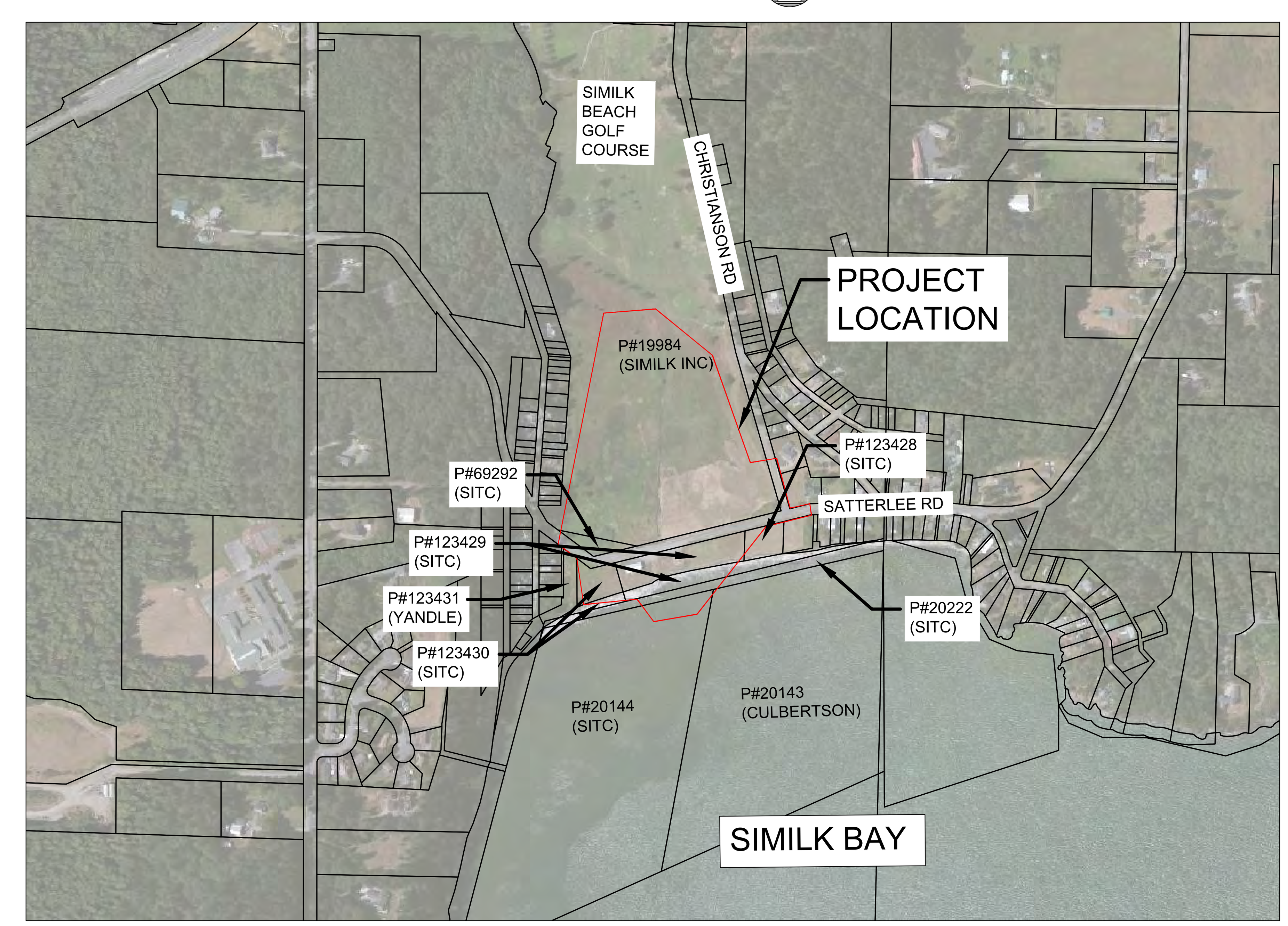
SIMILK TIDAL MARSH RESTORATION

SHEET INDEX	
SHEET NUMBER	SHEET TITLE
TIDAL MARSH RESTORATION (PRELIMINARY, 60%, DESIGN)	
G-01	COVER SHEET
G-02	GENERAL & CONSTRUCTION NOTES
C-01	EXISTING CONDITIONS PLAN (1 OF 2)
C-02	EXISTING CONDITIONS PLAN (2 OF 2)
C-03	ACCESS, STAGING, & TESC PLAN
C-04	TESC DETAIL
C-05	CHANNEL DESIGN PLAN VIEW
C-06	CHANNEL DESIGN SECTIONS
C-07	CHANNEL DESIGN DETAIL
TRANSPORTATION IMPROVEMENTS (CONCEPTUAL DESIGN)	
C-08	ROADWAY PLAN & PROFILE (1 OF 3)
C-09	ROADWAY PLAN & PROFILE (2 OF 3)
C-10	ROADWAY PLAN & PROFILE (3 OF 3)
C-11	PLAN & ELEVATION (ROADWAY BRIDGE)
C-12	TYPICAL SECTION (ROADWAY BRIDGE)

VICINITY MAP



SITE MAP



BLUE COAST ENGINEERING

DRAFT NOT FOR CONSTRUCTION

KATHRYN KETTERIDGE, STATE OF WASHINGTON, 52805, REGISTERED PROFESSIONAL ENGINEER

REVISIONS			
REV:	DESCRIPTION:	BY:	DATE:

DESIGNED: KK
DRAWN: GC
CHECKED: XX
DATE: 04/06/22
SCALE: AS NOTED

SIMILK TIDAL MARSH RESTORATION PRELIMINARY DESIGN

COVER SHEET

SHEET NO: G-01

GENERAL CONSTRUCTION NOTES

1. CONTRACTOR SHALL FURNISH ALL MATERIALS, EQUIPMENT, AND LABOR NECESSARY TO COMPLETE ALL WORK AS INDICATED ON THE DRAWINGS AND IN THE SPECIFICATIONS.
2. CONTRACTOR SHALL NOT DEVIATE FROM THE DRAWINGS AND SPECIFICATIONS WITHOUT RECIEVEING PRIOR WRITTEN APPROVAL FROM THE OWNER'S REPRESENTATIVE.
3. DISCREPANCIES BETWEEN THE DRAWINGS AND THE SPECIFICATIONS SHALL BE BROUGHT TO THE ATTENTION OF THE OWNERS REPRESENTATIVE PRIOR TO PROCEEDING WITH THE WORK.
4. THE CONTRACTOR SHALL RECEIVE, IN WRITING, AUTHORIZATION TO PROCEED BEFORE STARTING WORK ON ANY ITEM NOT CLEARLY DEFINED OR IDENTIFIED BY THE CONTRACT DOCUMENTS.
5. THE CONTRACTOR SHALL PLACE AND INSTALL ALL EQUIPMENT AND MATERIALS IN ACCORDANCE WITH MANUFACTURER'S RECOMMENDATIONS UNLESS SPECIFICALLY INDICATED OTHERWISE BY THE OWNER'S REPRESENTATIVE OR WHERE LOCAL CODE OR REGULATIONS TAKE PRECEDENCE.
6. CONTRACTOR SHALL ASSUME SOLE AND COMPLETE RESPONSIBILITY FOR JOB SITE CONDITIONS DURING THE COURSE OF CONSTRUCTION OF THIS PROJECT INCLUDING SAFETY OF ALL PERSONS AND PROPERTY. THIS REQUIREMENT SHALL APPLY CONTINUOUSLY AND NOT BE LIMITED TO NORMAL WORKING HOURS.
7. THE CONTRACTOR SHALL BE SOLELY RESPONSIBLE FOR ALL CONSTRUCTION MEANS, METHODS, TECHNIQUES, SEQUENCES, AND PROCEDURES AND FOR COORDINATING ALL PORTIONS OF THE WORK TO MEET THE CONTRACTOR'S CONSTRUCTION SCHEDULE AS REQUIRED BY THE SPECIFICATIONS.
8. CONTRACTOR SHALL KEEP JOB SITE AREA CLEAN AND HAZARD-FREE. CONTRACTOR SHALL DISPOSE OF ALL DIRT, DEBRIS, AND RUBBISH FOR DURATION OF THE WORK. UPON COMPLETION OF WORK, CONTRACTOR SHALL REMOVE ALL MATERIAL AND EQUIPMENT NOT SPECIFIED AS REMAINING ON THE PROPERTY.
9. NOTES AND DETAILS ON THE DRAWINGS SHALL TAKE PRECEDENCE OVER GENERAL NOTES HEREON AND OVER THE SPECIFICATIONS WHERE A CONFLICT EXISTS.
10. DIMENSION CALLOUTS SHALL TAKE PRECEDENCE OVER SCALES SHOWN ON THE CONTRACT PLANS.

PERMIT & REGULARTORY REQUIREMENTS

1. THE CONTRACTOR SHALL BE RESPONSIBLE FOR SATISFYING ALL APPLICABLE PERMIT REQUIREMENTS AND FOLLOWING ALL APPLICABLE ORDINANCES.
2. THE PERMITS SHALL BE FURNISHED BY THE OWNER TO THE CONTRACTOR PRIOR TO COMMENCEMENT OF CONSTRUCTION.
3. THE CONTRACTOR SHALL REVIEW ALL PERMIT REQUIREMENTS AND NOTIFY THE OWNER OR OWNER'S REPRESENTATIVE OF ANY DISCREPANCIES BETWEEN THE DRAWINGS, SPECIFICATIONS, AND PERMIT REQUIREMENTS OR REGULATIONS.
4. ALL WORK SHALL SATISFY CONDITIONS AND REQUIREMENTS OF LOCAL, STATE, AND FEDERAL PERMITS, AS APPLICABLE. IN CASES WHERE CONDITIONS AND/OR REQUIREMENTS VARY FROM PERMIT TO PERMIT, THE MOST STRINGENT CONDITION AND/OR REQUIREMENT OR ORDINANCE GOVERNS THE PROJECT.

WORK RESTRICTIONS

1. ALL WORK SHALL BE CONDUCTED WITHIN THE LIMITS OF WORK AS SHOWN ON THE DRAWINGS INCLUDING CONTRACTOR OPERATION OF VEHICLES AND MACHINERY EXCEPT FOR ACCESS TO THE SITE THROUGH THE CONSTRUCTION ACCESS CORRIDOR OR OFF-SITE STAGING AND STOCKPILING ACTIVITIES PER THE SPECIFICATIONS.
2. ALL WORK SHALL BE COMPLETED IN THE DRY, NO IN-WATER WORK SHALL BE CONDUCTED AS PART OF THIS WORK.
3. WORK AT OR BELOW THE OHWM ELEVATION SHALL BE COMPLETED ONLY BETWEEN AUGUST 1 AND FEBRUARY 10.
4. CONTRACTOR SHALL NOT EXCAVATE OR DISTURB EXISTING SITE SEDIMENTS, MATERIALS, OR VEGETATION OUTSIDE OF THE HORIZONTAL AND VERTICAL EXTENTS INDICATED ON THE DRAWINGS.
5. THE AREAS WITHIN OR OUTSIDE OF THE WORK AREA LIMITS DISTURBED BY THE CONTRACTOR SHALL BE RESTORED TO PRE-CONSTRUCTION CONDITIONS AT NO ADDITIONAL COST TO THE OWNER.

ABBREVIATIONS

CY = CUBIC YARD
EL = ELEVATION
FT = FEET
HCA= HABITAT CRITICAL AREA
MIN = MINIMUM
BMP = BEST MANAGEMENT PRACTICES
OHWM = ORDINARY HIGH WATER MARK
TESC = TEMPORARY EROSION AND SEDIMENT CONTROL

SURVEY CONTROL

EXISTING CONDITIONS TOPOGRAPHY IS BASED ON THE 2020 USGS PUGET SOUND CONED TOPOBATHY DEM AND WILSON ENGINEERING APRIL 2021 TOPOGRAPHIC SURVEY (21050SV00_NAD83-11_NAVD88_v2019.DWG).

HORIZONTAL DATUM: WASHINGTON COORDINATE SYSTEM, NORTH ZONE, US SURVEY FEET, NAD83

VERTICAL DATUM : NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88), US SURVEY FEET

TIDAL ELEVATIONS (FEET NAVD88):

HIGHEST ASTRONOMICAL TIDE/ HIGH TIDE LINE (HTL):	+10.5
MEAN HIGHER HIGH WATER (MHHW):	+8.9
MEAN HIGH WATER (MHW):	+8.0
MEAN TIDE LEVEL (MTL):	+4.5
MEAN LOW WATER (MLW):	+1.0
MEAN LOWER LOW WATER (MLLW):	-1.6

DATA SOURCE: NOAA VDATUM ONLINE TOOL
HTL DETERMINED BY BLUE COAST ENGINEERING AS AVERAGE PREDICTED HIGH TIDE OVER 10 YR PERIOD FROM 2021 TO 2030 AT NOAA TURNER BAY STATION.

ON-SITE SURVEY CONTROL TABLE

POINT NAME	NORTHING	EASTING	ELEVATION (NAVD88)
100	532888.22	1,217,228.76	22.74
101	533192.51	1,218,181.94	21.77
102	534,652.94	1,217,830.32	28.78
103	532,802.36	1,217,848.22	11.60
104	532,906.67	1,218,295.98	17.89

UTILITY NOTES

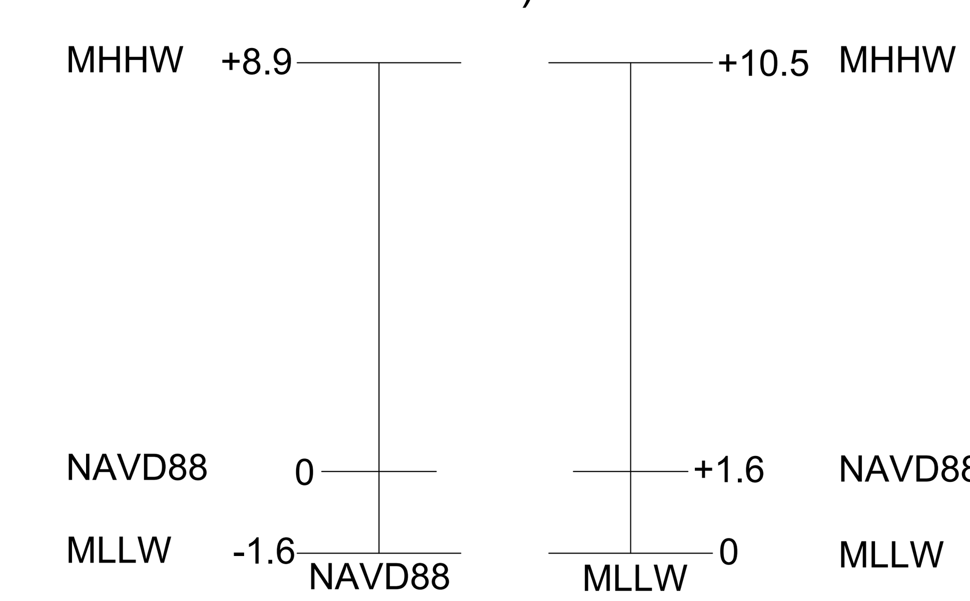
1. CONTRACTOR SHALL CONDUCT A COMPREHENSIVE SUBSURFACE AND ABOVE-GROUND UTILITY LOCATE WITHIN THE WORK AREA LIMITS AND SHALL BE RESPONSIBLE FOR PROTECTING IN PLACE ALL EXISTING UTILITIES THAT ARE NOT TO BE REPLACED AS PART OF THE WORK.
2. DAMAGE OF KNOWN OR UNKNOWN UTILITIES BY THE CONTRACTOR SHALL BE REPAIRED OR REPLACED AT NO ADDITIONAL COST TO THE OWNER.

MATERIAL QUANTITIES

THE MATERIAL QUANTITIES SUMMARIZED BELOW ARE PROVIDED FOR CONTRACTOR'S INFORMATION AND PLANNING PURPOSES ONLY AND DO NOT REPRESENT PAYMENT QUANTITIES. CONTRACTOR IS RESPONSIBLE FOR VERIFYING QUANTITIES. THE OWNER ASSUMES NO LIABILITY FOR THE VALIDITY OF THESE ESTIMATED QUANTITIES OF MATERIALS.

ESTIMATED QUANTITIES	
TIDAL MARSH RESTORATION	
DESCRIPTION	IN SITU QUANTITY
EXCAVATE SOIL & PLACE ON SITE	5,800 CY
EXCAVATE SOIL & DISPOSE OF OFF SITE	1,000 CY
IMPORT & PLACE LARGE WOOD	T.B.D.
REMOVE DEBRIS & DISPOSE OF OFF SITE	T.B.D.
IMPORT & PLACE FISH MIX MATERIAL IN CHANNEL OPENING	400 CY

DATUM CONVERSION NOTE:
1. TO CONVERT ELEVATIONS FROM NAVD88 TO MEAN LOWER LOW WATER (MLLW): ADD 1.6 FT TO ELEVATIONS IN NAVD88. (SOURCE: NOAA VDATUM)



BLUE COAST ENGINEERING

DRAFT NOT FOR CONSTRUCTION

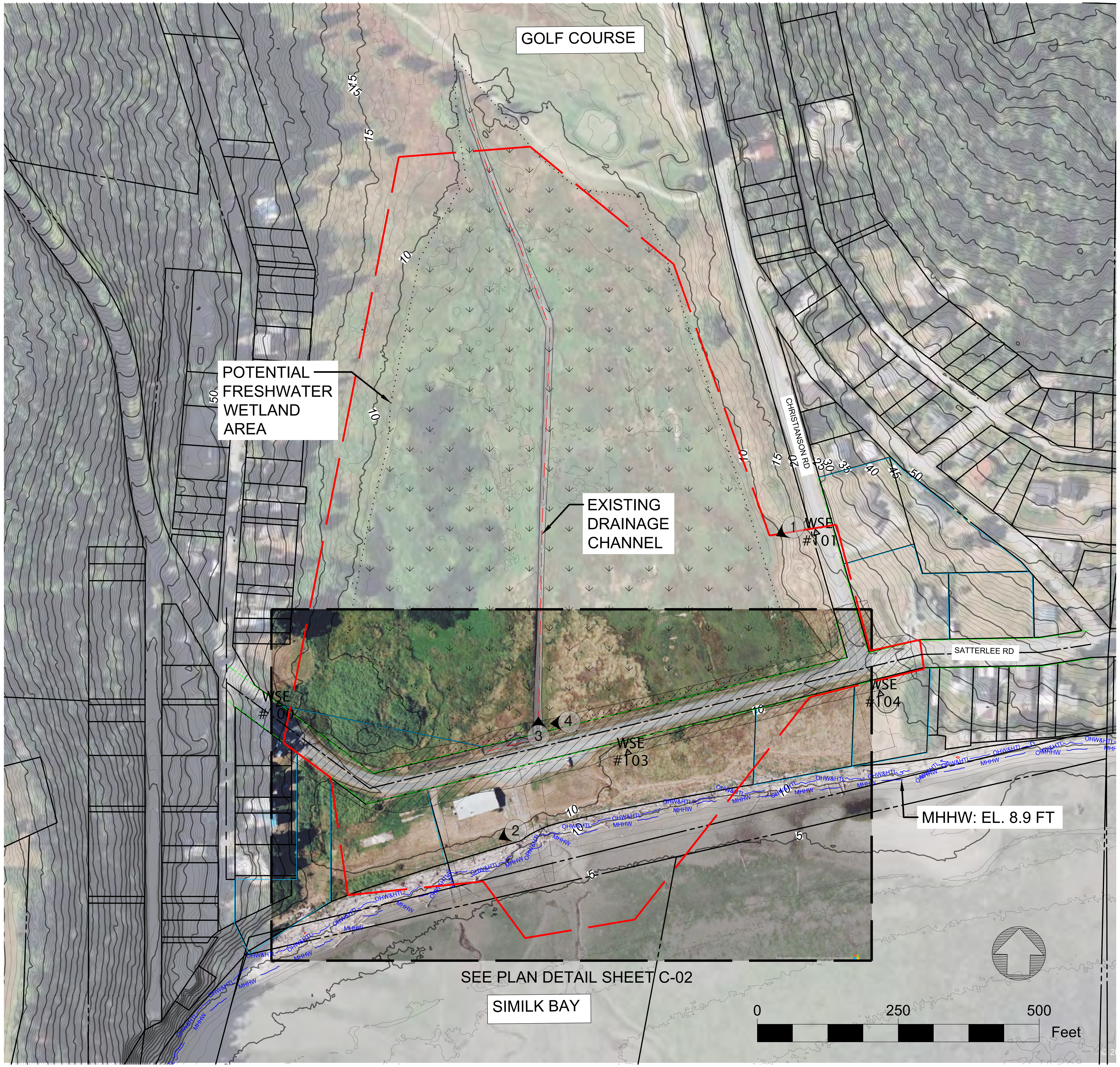
REV:	DESCRIPTION:	BY:	DATE:

REVISIONS

DESIGNED: KK
DRAWN: GC
CHECKED: XX
DATE: 04/06/22
SCALE: AS NOTED

SIMILK TIDAL MARSH RESTORATION
PRELIMINARY DESIGN
GENERAL & CONSTRUCTION NOTES

SHEET NO: G-02

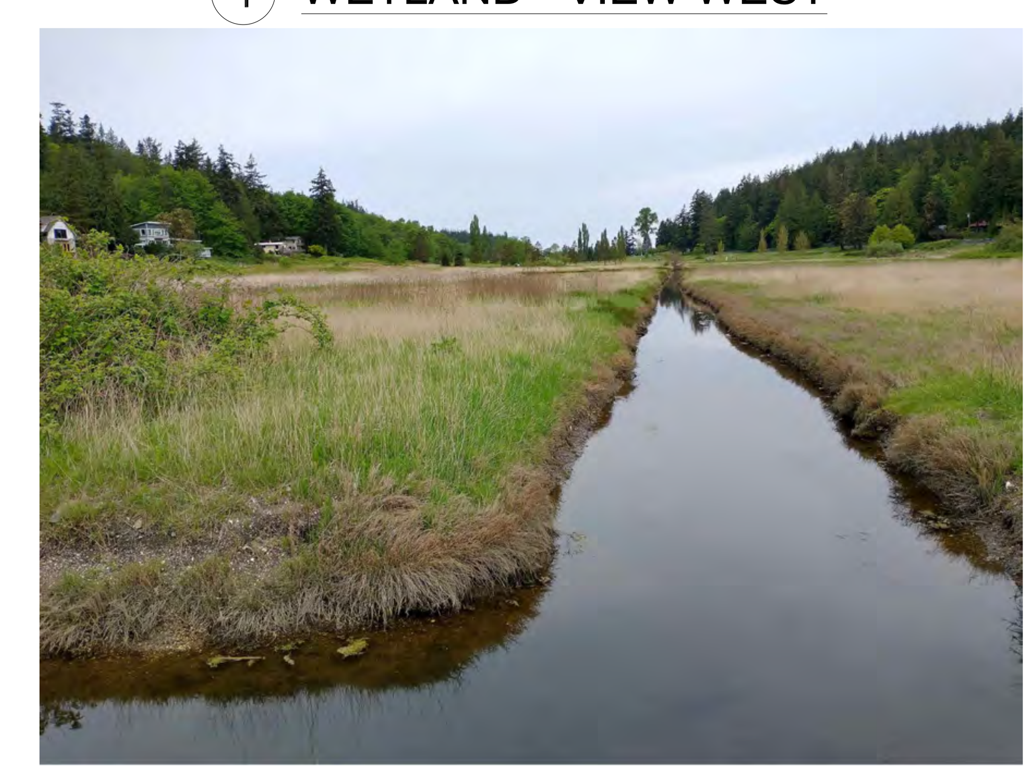


LEGEND

- = HIGH TIDE LINE, 10.5 FT NAVD88 / OHWM
- = MHHW TIDAL DATUM, 8.9 FT NAVD88
- = POTENTIAL FRESHWATER WETLAND AREA (PENDING WETLAND DELINEATION)
- = LIMITS OF TOPOGRAPHIC SURVEY
- = RIGHT-OF-WAY
- = RIGHT-OF-WAY CENTERLINE
- = PROPERTY BOUNDARY (COUNTY GIS)
- = PROPERTY BOUNDARY (SURVEY)
- = EASEMENT
- = EXISTING DRAIN CHANNEL (APPROX)
- = WORK AREA LIMITS
- = CONTROL POINT
- = GROUND PHOTO CALLOUT

1 WETLAND - VIEW WEST

2 NEARSHORE - VIEW WEST



3 CHANNEL - VIEW NORTH

4 PUMPHOUSE - VIEW WEST

SURVEY NOTES:

1. EXISTING CONDITIONS TOPOGRAPHY OUTSIDE THE ROADWAY BASED ON 2020 USGS CONED TOPOBATHY DATABASE.
2. TOPOGRAPHY & SITE SURVEY WITHIN THE ROADWAY RIGHT-OF-WAY, INCLUDING UTILITIES, BASED ON SURVEY CONDUCTED BY WILSON ENGINEERING IN APRIL 2021.
3. OHWM DELINEATED ON-SITE BY BLUE COAST ENGINEERING
4. HTL DETERMINED BY BLUE COAST ENGINEERING AS AVERAGE PREDICTED HIGH TIDE OVER TEN YR PERIOD FROM 2021 TO 2030 AT NOAA TURNER BAY STATION.
5. GROUND PHOTO CALLOUT LOCATIONS & VIEW DIRECTIONS ARE APPROXIMATE & FOR CONTRACTOR REFERENCE ONLY.

BLUE COAST ENGINEERING

DRAFT NOT FOR CONSTRUCTION

KATHRYN KETTERIDGE · STATE OF WASHINGTON · REGISTERED PROFESSIONAL ENGINEER

REVISIONS

REV:	DESCRIPTION:	BY:	DATE:

DESIGNED: KK
DRAWN: GC
CHECKED: XX
DATE: 04/06/22
SCALE: AS NOTED

SIMILK TIDAL MARSH RESTORATION
PRELIMINARY DESIGN
EXISTING CONDITIONS

SHEET NO: C-01

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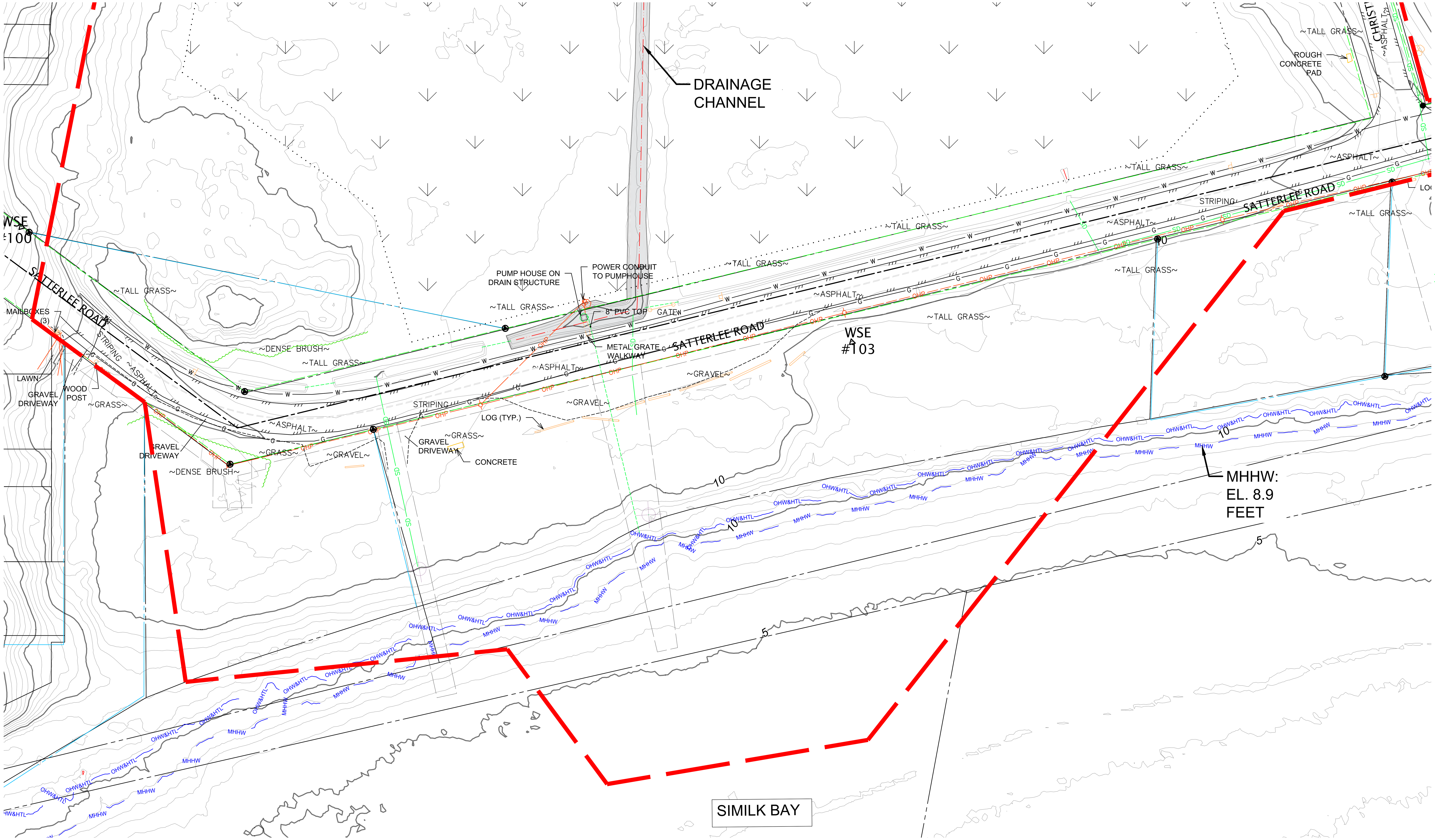

LEGEND

- = HIGH TIDE LINE, 10.5 FT NAVD88 / OHWM
- = MHHW TIDAL DATUM, 8.9 FT NAVD88
- = POTENTIAL FRESHWATER WETLAND AREA (PENDING WETLAND DELINEATION)
- = RIGHT-OF-WAY
- = RIGHT-OF-WAY CENTERLINE
- = PROPERTY BOUNDARY COUNTY GIS
- = PROPERTY BOUNDARY (SURVEY)
- = EASEMENT
- = EXISTING DRAIN CHANNEL (APPROX)
- = EXISTING GRAVEL EDGE
- = EXISTING ASPHALT EDGE
- = EXISTING CONCRETE EDGE
- = EXISTING BUILDING
- = EXISTING GAS LINE
- = EXISTING STORM DRAIN
- = EXISTING WATER LINE
- = EXISTING CULVERT
- = EXISTING BURIED POWER LINE
- = EXISTING AERIAL POWER LINE
- = EXISTING TREE OR SHRUB LINE
- = EXISTING ROAD STRIPING
- = WORK AREA LIMITS
- = FOUND IRON PIPE IN CASE
- = FOUND PROPERTY CORNER
- = FOUND ALUMINUM DISK
- = CONTROL POINT
- = EXISTING POWER METER
- = EXISTING UTILITY POLE
- = EXISTING WATER VALVE
- = EXISTING SIGN
- = EXISTING MAIL BOX
- = EXISTING GATE POST
- = EXISTING BOULDER
- = EXISTING STORM DRAIN CATCH BASIN TYPE 1
- = EXISTING STORM DRAIN CATCH BASIN TYPE 2
- = EXISTING 2" (ETC) CONIFEROUS TREE
- = EXISTING 2" (ETC) DECIDUOUS TREE

0 100 200 Feet

SURVEY NOTES:

1. EXISTING CONDITIONS TOPOGRAPHY OUTSIDE THE ROADWAY BASED ON 2020 USGS CONED TOPOBATHY DATABASE.
2. TOPOGRAPHY & SITE SURVEY WITHIN THE ROADWAY RIGHT-OF-WAY, INCLUDING UTILITIES, BASED ON SURVEY CONDUCTED BY WILSON ENGINEERING IN APRIL 2021.
3. OHWM DELINEATED ON-SITE BY BLUE COAST ENGINEERING
4. HTL DETERMINED BY BLUE COAST ENGINEERING AS AVERAGE PREDICTED HIGH TIDE OVER TEN YR PERIOD FROM 2021 TO 2030 AT NOAA TURNER BAY STATION.
5. GROUND PHOTO CALLOUT LOCATIONS & VIEW DIRECTIONS ARE APPROXIMATE & FOR CONTRACTOR REFERENCE ONLY.

BLUE COAST ENGINEERING

DRAFT NOT FOR CONSTRUCTION

KATHRYN KETTERIDGE STATE OF WASHINGTON 52803 REGISTERED PROFESSIONAL ENGINEER

REVISIONS			
REV:	DESCRIPTION:	BY:	DATE:

DESIGNED: KK
DRAWN: GC
CHECKED: XX
DATE: 04/06/22
SCALE: AS NOTED

SIMILK TIDAL MARSH RESTORATION PRELIMINARY DESIGN

EXISTING CONDITIONS

SHEET NO: C-02

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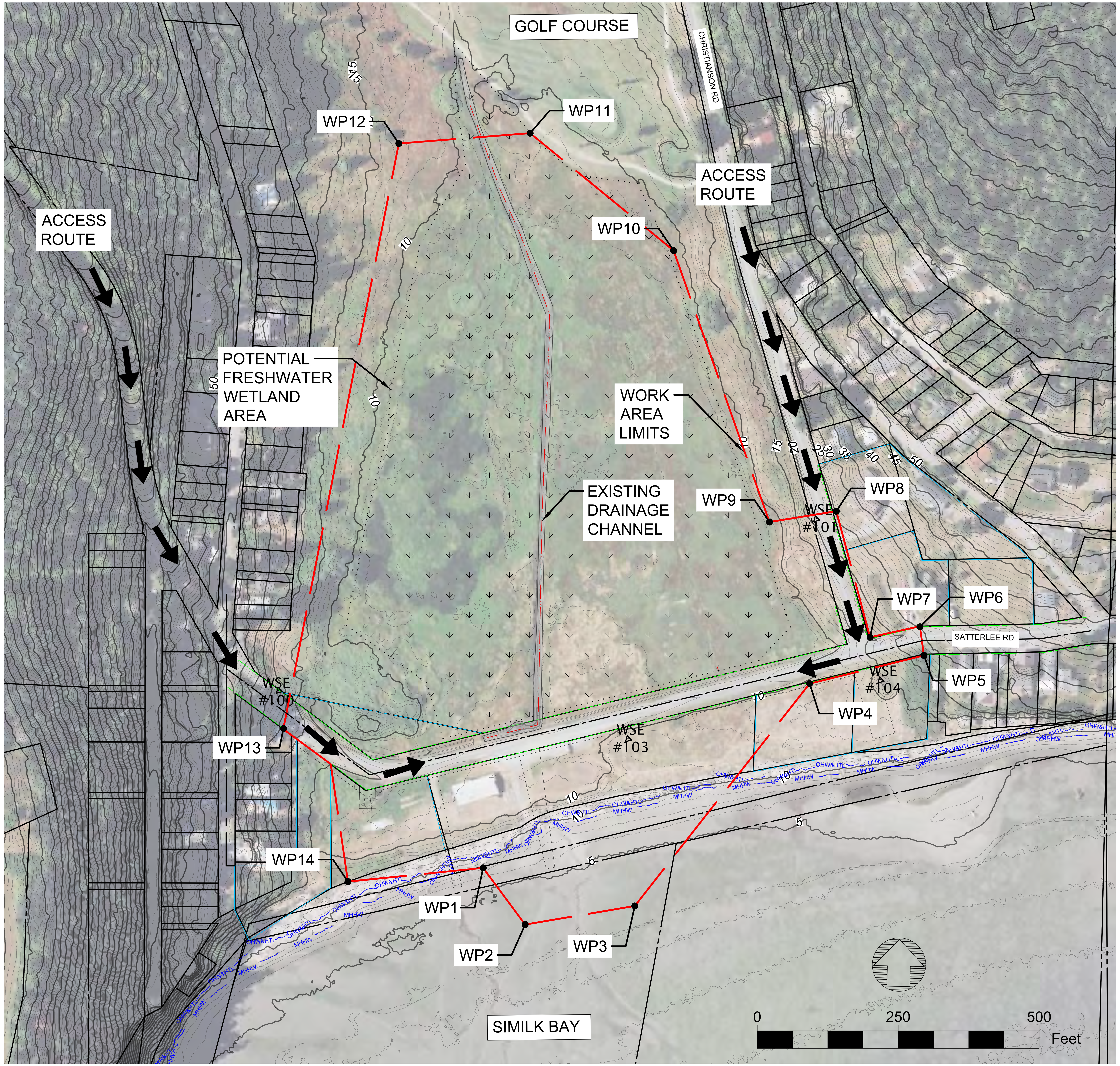


LEGEND

OHW&HTL	= HIGH TIDE LINE, 10.5 FT NAVD88 / OHWM
MHHW	= MHHW TIDAL DATUM, 8.9 FT NAVD88
	= RIGHT–OF–WAY
	= RIGHT–OF–WAY CENTERLINE
	= PROPERTY BOUNDARY (COUNTY GIS)
	= PROPERTY BOUNDARY (SURVEY)
	= EASEMENT
	= EXISTING DRAIN CHANNEL (APPROX)
	= POTENTIAL FRESHWATER WETLAND AREA (PENDING WETLAND DELINEATION)
	= WORK AREA LIMITS
△	= CONTROL POINT

TESC NOTES:

1. DIVERT STREAM UPSTREAM OF MARKED LOCATION THROUGH TEMPORARY BYPASS PIPE TO SIMILK BAY. INSTALL TEMPORARY FISH BLOCK NETS PRIOR TO COFFERDAM/BYPASS PIPE INSTALLATION. INSTALL ENERGY DISSIPATION PAD AT DOWNSTREAM BYPASS TO REDUCE SCOUR ON BEACH.
2. CONTRACTOR WILL VERIFY POTENTIAL STAGING AREAS ARE ADEQUATE.
3. CONTRACTOR MAY NOT CONDUCT WORK IN AREAS THAT ARE INUNDATED BY TIDAL WATERS, INCLUDING AREAS INUNDATED REPEATEDLY BY WAVES OR WAVE RUN-UP.
4. CONTRACTOR SHALL SUBMIT AS PART OF CONSTRUCTION WORK PLAN THE TEMPORARY EROSION AND SEDIMENTATION CONTROL (TESC) PLAN AND STREAM BYPASS PLAN WHICH MEETS REQUIREMENTS SHOWN HERE. TESC MEASURES INCLUDE BMPS SUCH AS BUT NOT LIMITED TO THE FOLLOWING: SILT FENCING, VEHICLE TRACK OUT PROTECTION, ABSORBANT WATTLES, STOCKPILE COVERS. SEE SHEET C-04 FOR DETAILS.

ACCESS & STAGING NOTES:

1. CONSTRUCTION ACCESS TO THE SITE WILL BE FROM UPLAND ALONG CHRISTENSON ROAD FROM THE EAST AN SATTERLEE ROAD FROM THE WEST. NO BARGE OR WATERSIDE ACCESS FOR CONSTRUCTION WILL BE ALLOWED.
2. STAGING MAY OCCUR ANYWHERE WITHIN THE WORK AREAS LIMITS AS ALLOWED BY LOCAL, STATE AND FEDERAL PERMITS. SPECIFIC STAGING AREAS WILL BE DETERMINED AT LATER PHASES OF DESIGN BASED ON SEQUENCING FOR CONSTRUCTION BETWEEN ROADWAY IMPROVEMENTS AND RESTORATION ACTIVITIES.
3. SATTERLEE ROAD CLOSURES WILL LIKELY BE REQUIRED DURING CONSTRUCTION AND MUST BE MINIMIZED TO THE EXTENT POSSIBLE.

BLUE COAST ENGINEERING

DRAFT NOT FOR CONSTRUCTION

KATHRYN KETTERIDGE STATE OF WASHINGTON 52003 REGISTERED PROFESSIONAL ENGINEER

REVISIONS

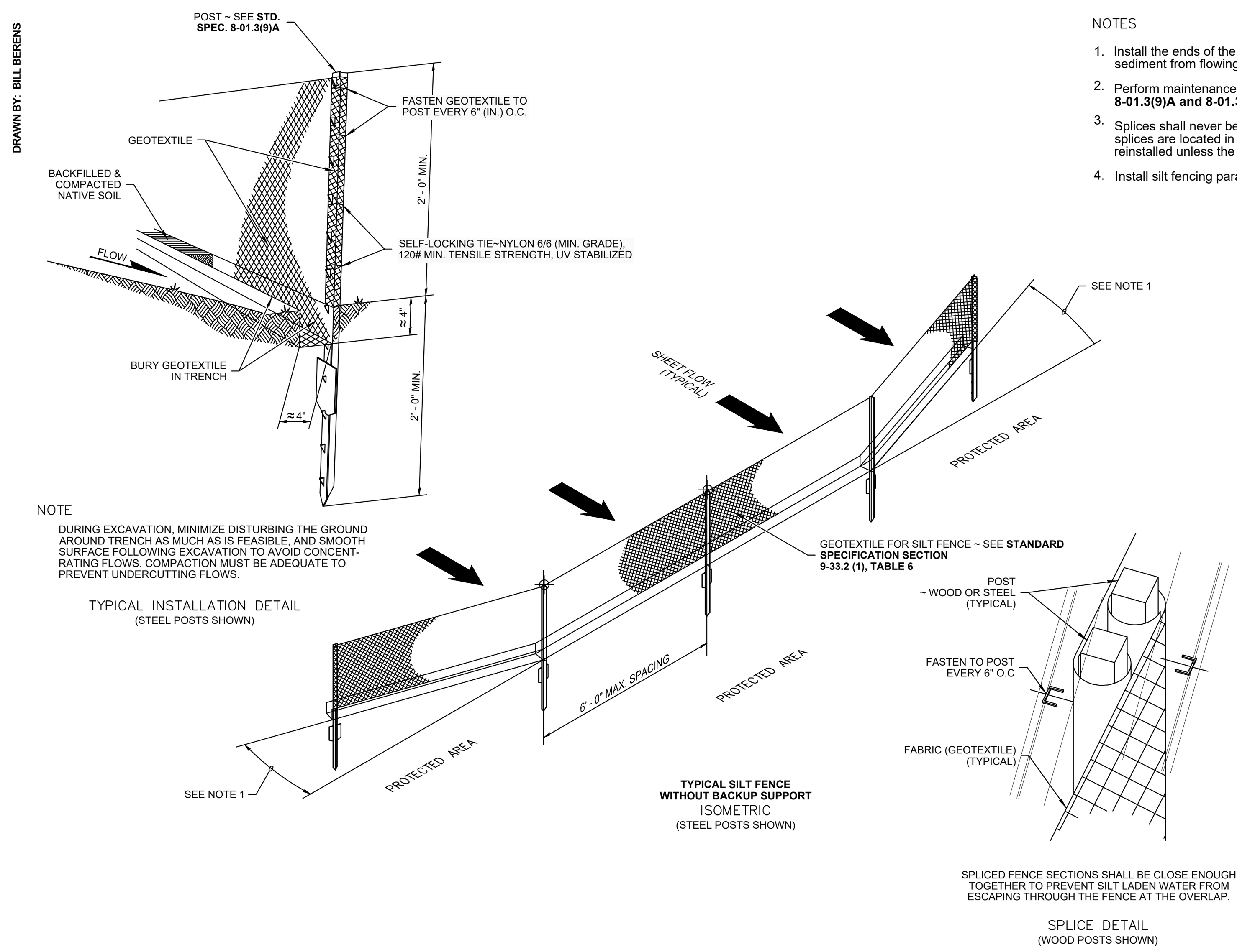
REV:	DESCRIPTION:	BY:	DATE:

DESIGNED: KK
DRAWN: GC
CHECKED: XX
DATE: 04/06/22
SCALE: AS NOTED

SIMILK TIDAL MARSH RESTORATION PRELIMINARY DESIGN

ACCESS, STAGING, & TESC PLAN

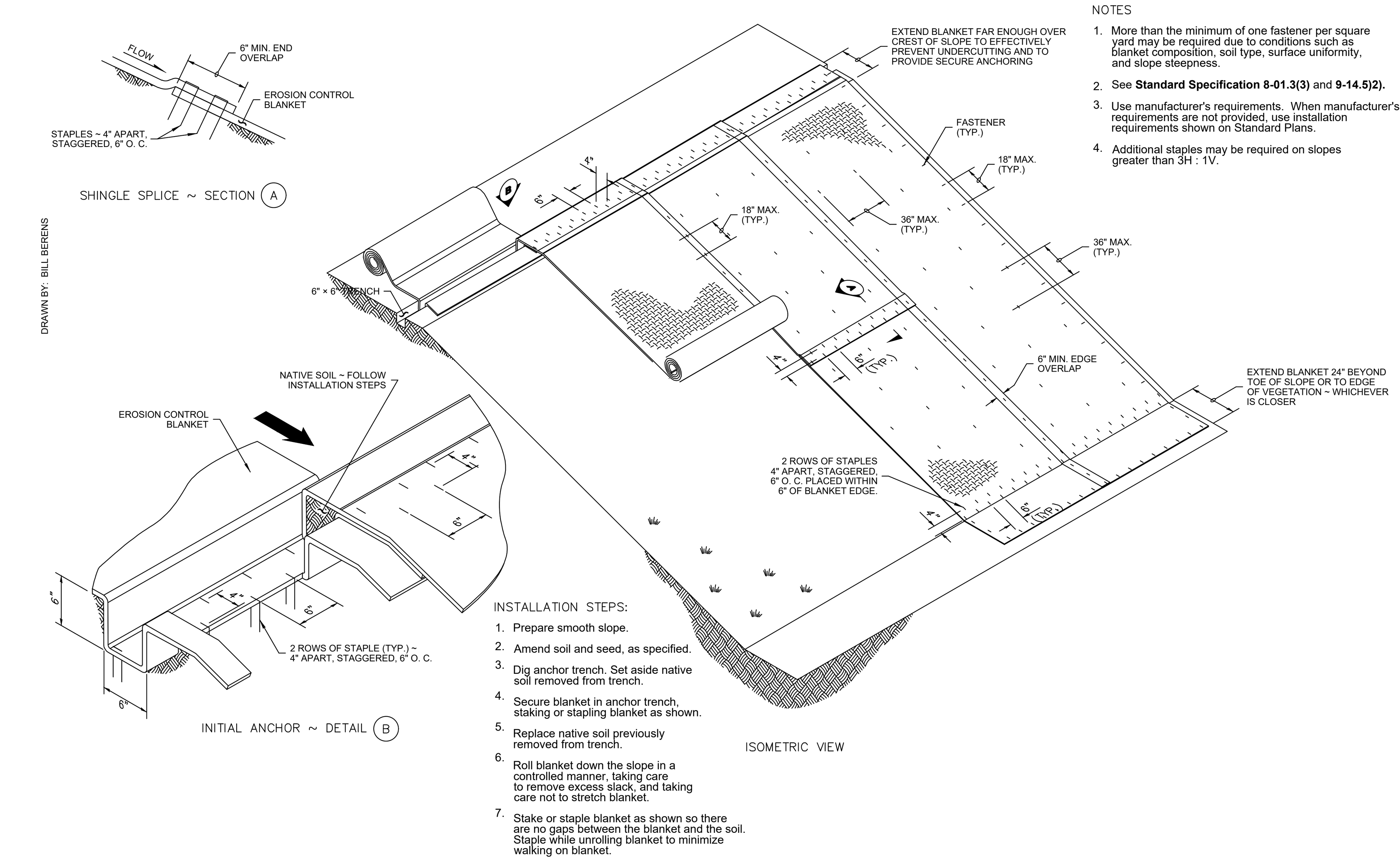
SHEET NO: C-03



NOTES

1. Install the ends of the silt fence to point slightly upslope to prevent sediment from flowing around the ends of the fence.
2. Perform maintenance in accordance with **Standard Specifications 8-01.3(9)A and 8-01.3(15)**.
3. Splices shall never be placed in low spots or sump locations. If splices are located in low or sump areas, the fence may need to be reinstalled unless the Project Engineer approves the installation.
4. Install silt fencing parallel to mapped contour lines.

A C-03 DETAIL: SILT FENCE (TYPICAL DETAIL, WSDOT)



INSTALLATION STEPS:

1. Prepare smooth slope.
2. Amend soil and seed, as specified.
3. Dig anchor trench. Set aside native soil removed from trench.
4. Secure blanket in anchor trench, staking or stapling blanket as shown.
5. Replace native soil previously removed from trench.
6. Roll blanket down the slope in a controlled manner, taking care to remove excess slack, and taking care not to stretch blanket.
7. Stake or staple blanket as shown so there are no gaps between the blanket and the soil. Staple while unrolling blanket to minimize walking on blanket.

NOTES

1. More than the minimum of one fastener per square yard may be required due to conditions such as blanket composition, soil type, surface uniformity, and slope steepness.
2. See **Standard Specification 8-01.3(3)** and **9-14.5)2).**
3. Use manufacturer's requirements. When manufacturer's requirements are not provided, use installation requirements shown on Standard Plans.
4. Additional staples may be required on slopes greater than 3H : 1V.

A C-03 DETAIL: SLOPE EROSION CONTROL (TYPICAL DETAIL, WSDOT)

BLUE COAST ENGINEERING

DRAFT NOT FOR CONSTRUCTION

KATHRYN KETTERIDGE STATE OF WASHINGTON 52805 REGISTERED PROFESSIONAL ENGINEER

REVISIONS			
REV:	DESCRIPTION:	BY:	DATE:

DESIGNED: KK
DRAWN: GC
CHECKED: XX
DATE: 04/06/22
SCALE: AS NOTED

SIMILK TIDAL MARSH RESTORATION PRELIMINARY DESIGN

TESC DETAILS

SHEET NO: C-04

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TIDAL MARSH RESTORATION NOTES:

1. EXCAVATION OF ~6,800 CY OF MATERIAL TO CREATE THE RESTORED TIDAL CHANNELS.
2. LARGE WOOD (LW) WILL BE PLACED WITHIN THE PRIMARY TIDAL CHANNEL AT DIRECTION OF ENGINEER. (AMOUNT OF LW TO BE PLACED T.B.D.)
3. EXCAVATED MATERIAL FROM CHANNEL CREATION WILL BE PLACED IN FIVE DISCRETE AREAS WITHIN THE RESTORED TIDAL MARSH TO PROVIDE VARIABILITY IN ELEVATION WITHIN THE MARSH TO SUPPORT VARIATION IN VEGETATION WITH THE RESTORED MARSH.
4. TYPICAL EXCAVATED MATERIAL PLACEMENT AREA(S) WILL BE 100 FEET X 100 FEET IN HORIZONTAL DIMENSION AND THICKNESS OF PLACEMENT WILL BE 3 FEET (~1,100 CY)
5. EXISTING DRAINAGE CHANNEL WILL BE BACKFILLED.

SHELLFISH ACCESS AREA IMPROVEMENT NOTES:

1. THE SHELLFISH ACCESS AREA WILL PROVIDE CONTINUED ACCESS FOR THE SWINOMISH INDIAN TRIBAL COMMUNITY (SITC) TO THE SHELLFISH BEDS THAT ARE LOCATED IN THE LOWER INTERTIDAL BEACH AREA JUST SOUTH OF THE PROJECT SITE. THE SHELLFISH ACCESS AREA IS CURRENTLY USED FOR THIS PURPOSE. THE TOTAL AREA USED FOR ACCESS HAS BEEN REDUCED TO SUPPORT RESTORATION AT THE PROJECT SITE.
2. THE SHELLFISH ACCESS AREA WILL ALSO ACT AS FLOOD PROTECTION TO ADJACENT PROPERTIES TO THE WEST OF THE AREA FROM TIDAL INUNDATION FOLLOWING RESTORATION OF THE PROJECT SITE.
3. APPROPRIATE IMPORT FILL WILL BE PLACED WITHIN THE DESIGNATED SHELLFISH ACCESS AREA TO A MAXIMUM THICKNESS (COMPACTED) OF 4 FEET. THE FINAL ELEVATION OF THE AREA WILL VARY FROM 12 TO 10.5 FEET NAVD88 SLOPING TO THE EAST FOR DRAINAGE. THE MAXIMUM ELEVATION OF THE SHELLFISH ACCESS AREA MATCHES THE ELEVATION OF THE ADJACENT BEACH BERM (~12 FEET NAVD88).
4. THE SHELLFISH ACCESS AREA HAS BEEN PRELIMINARILY SIZED TO ACCOMMODATE REQUIREMENTS OF THE SITC TO ACCESS AND MAINTAIN THE SHELLFISH BEDS.
5. A CATCH BASIN STRUCTURE WILL BE INSTALLED TO THE WEST OF THE SHELLFISH ACCESS AREA ON SITC PROPERTY TO PROVIDE DRAINAGE DURING RAINFALL EVENTS OF LOW LYING (~10 TO 12 FEET NAVD88) PROPERTY TO THE WEST OF THE SHELLFISH ACCESS AREA. THE CATCH BASIN STRUCTURE WILL HAVE A RIM ELEVATION OF ~10.0 FEET NAVD88 AND AN INVERT OUTLET ELEVATION OF ~8.5 FEET NAVD88. FINAL ELEVATIONS WILL BE DEVELOPED DURING 90% DESIGN FOR THE PROJECT.
6. A CONVEYANCE PIPE WILL BE INSTALLED TO DRAIN WATER FROM THE CATCH BASIN STRUCTURE, THROUGH THE SHELLFISH ACCESS AREA AND INTO THE RESTORED TIDAL MARSH AS SHOWN ON THE DRAWINGS. THE INVERT ELEVATION FOR THE CONVEYANCE (AT THE CATCH BASIN STRUCTURE) WILL BE ~8.5 FEET NAVD88 AND THE OUTLET FOR THE CONVEYANCE WILL BE ~7.5 FEET NAVD88 (AT THE RESTORED TIDAL SIDE CHANNEL). FINAL ELEVATIONS WILL BE DEVELOPED DURING 90% DESIGN FOR THE PROJECT. A TIDE FLAP MAY NEED TO BE INSTALLED WITHIN THE CONVEYANCE STRUCTURE, WHICH WILL ALSO BE DETERMINED DURING 90% DESIGN FOR THE PROJECT.

BLUE COAST ENGINEERING

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KATHRYN KETTERIDGE STATE OF WASHINGTON 52865 REGISTERED PROFESSIONAL ENGINEER

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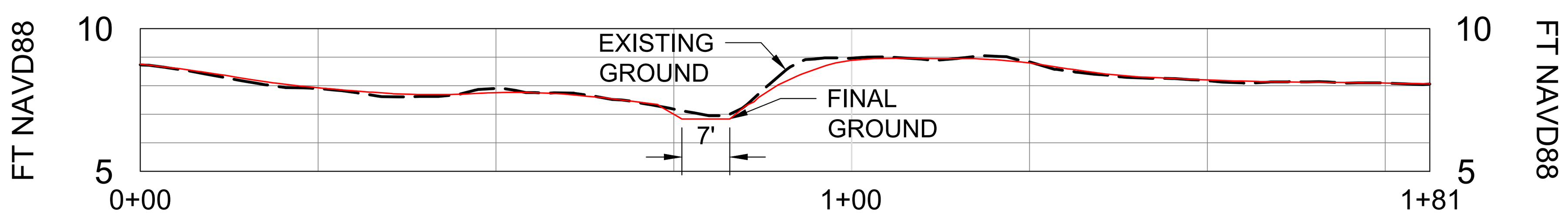
DESIGNED: KK
DRAWN: GC
CHECKED: XX
DATE: 04/06/22
SCALE: AS NOTED

SIMILK TIDAL MARSH RESTORATION PRELIMINARY DESIGN

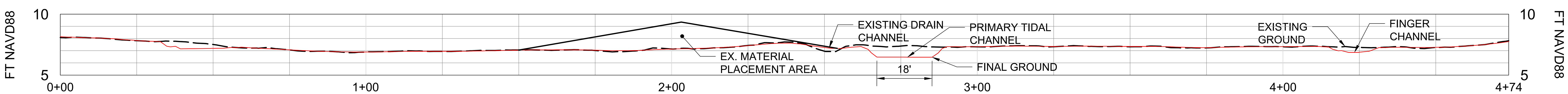
CHANNEL DESIGN PLAN VIEW

SHEET NO: C-05

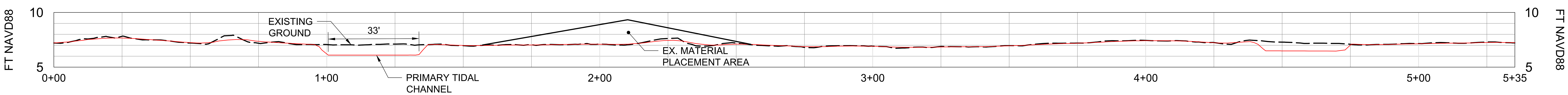
- C05 PRIMARY TIDAL CHANNEL
Scale: 1:50H, 4:1V



A C05 SECTION A
Scale: 1:20H, 4:1V



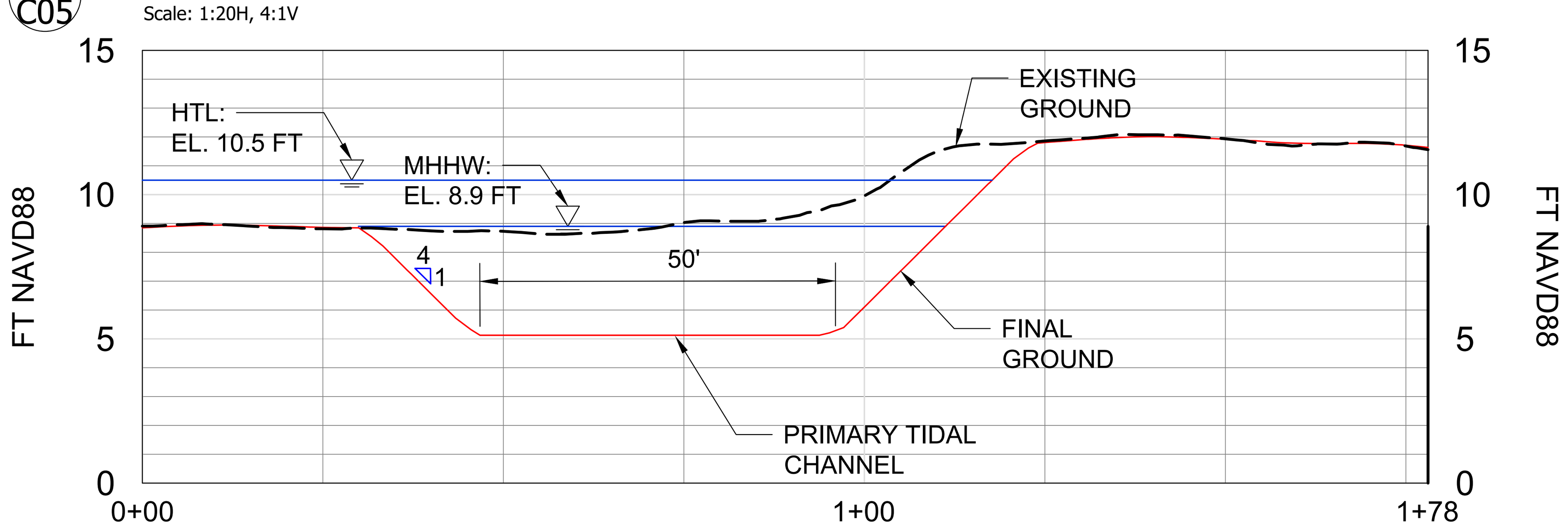
B C05 SECTION B
Scale: 1:20H, 4:1V

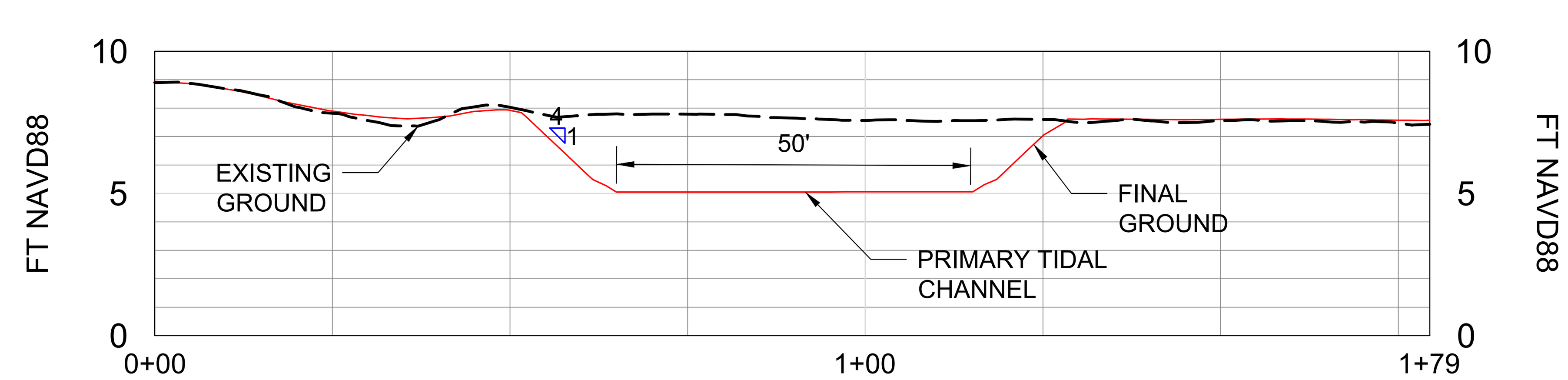


C C05 SECTION C
Scale: 1:20H, 4:1V

D C05 SECTION D
Scale: 1:20H, 4:1V

E C05 SECTION E
Scale: 1:20H, 4:1V





F C05 SECTION F
Scale: 1:20H, 4:1V

G C05 SECTION G
Scale: 1:20H, 4:1V

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DATE: 04/06/22
SCALE: AS NOTED

SIMILK TIDAL MARSH RESTORATION PRELIMINARY DESIGN

CHANNEL DESIGN SECTIONS

SHEET NO: C-06

PLACEHOLDER FOR FINAL DESIGN

BLUE COAST ENGINEERING

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REVISIONS			
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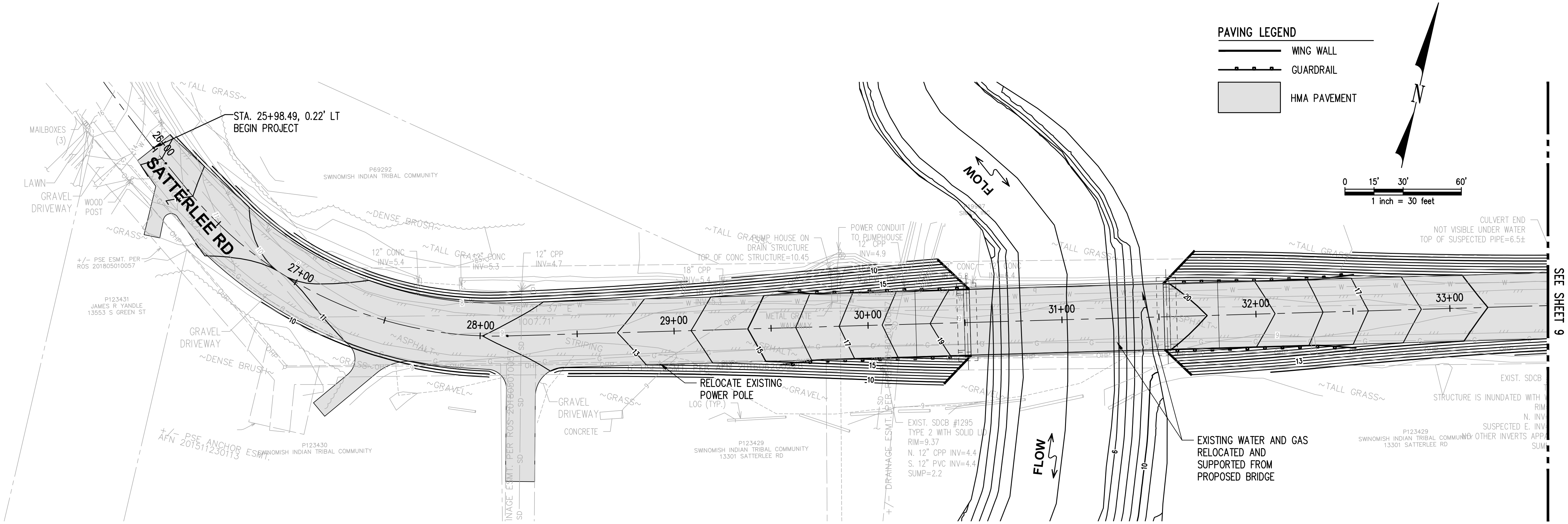
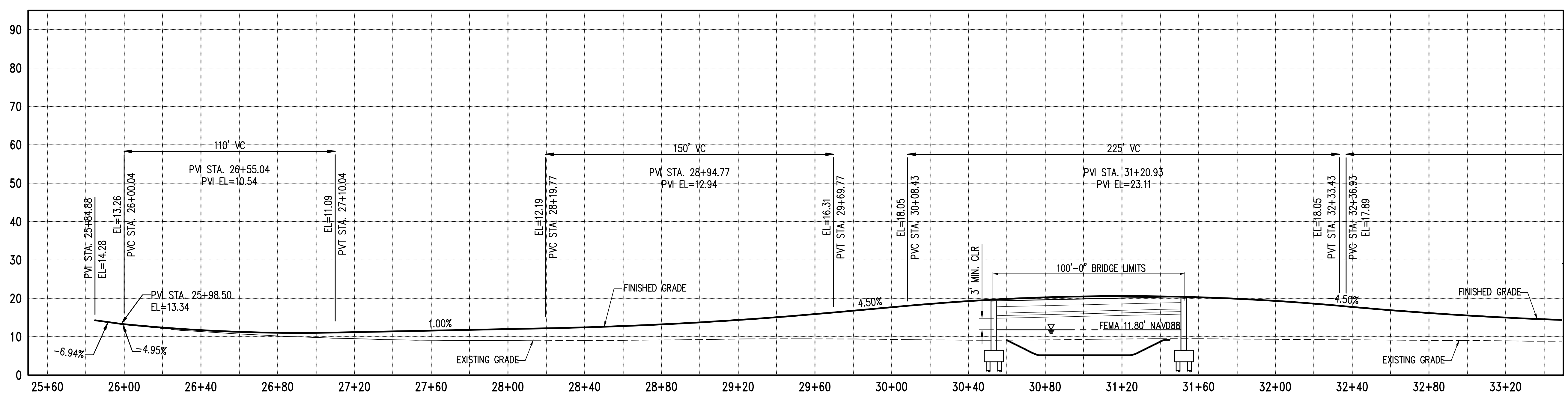
DESIGNED: KK
DRAWN: GC
CHECKED: XX
DATE: 04/06/22
SCALE: AS NOTED

SIMILK TIDAL MARSH RESTORATION
PRELIMINARY DESIGN

CHANNEL DESIGN DETAIL

SHEET NO: C-07





CONCEPTUAL DESIGN

NO.	REVISIONS	DATE

DESIGN ENGINEER

kpff

1601 5th Avenue, Suite 1600
Seattle, WA 98101
206.622.5822
www.kpff.com

ENGINEER OF RECORD

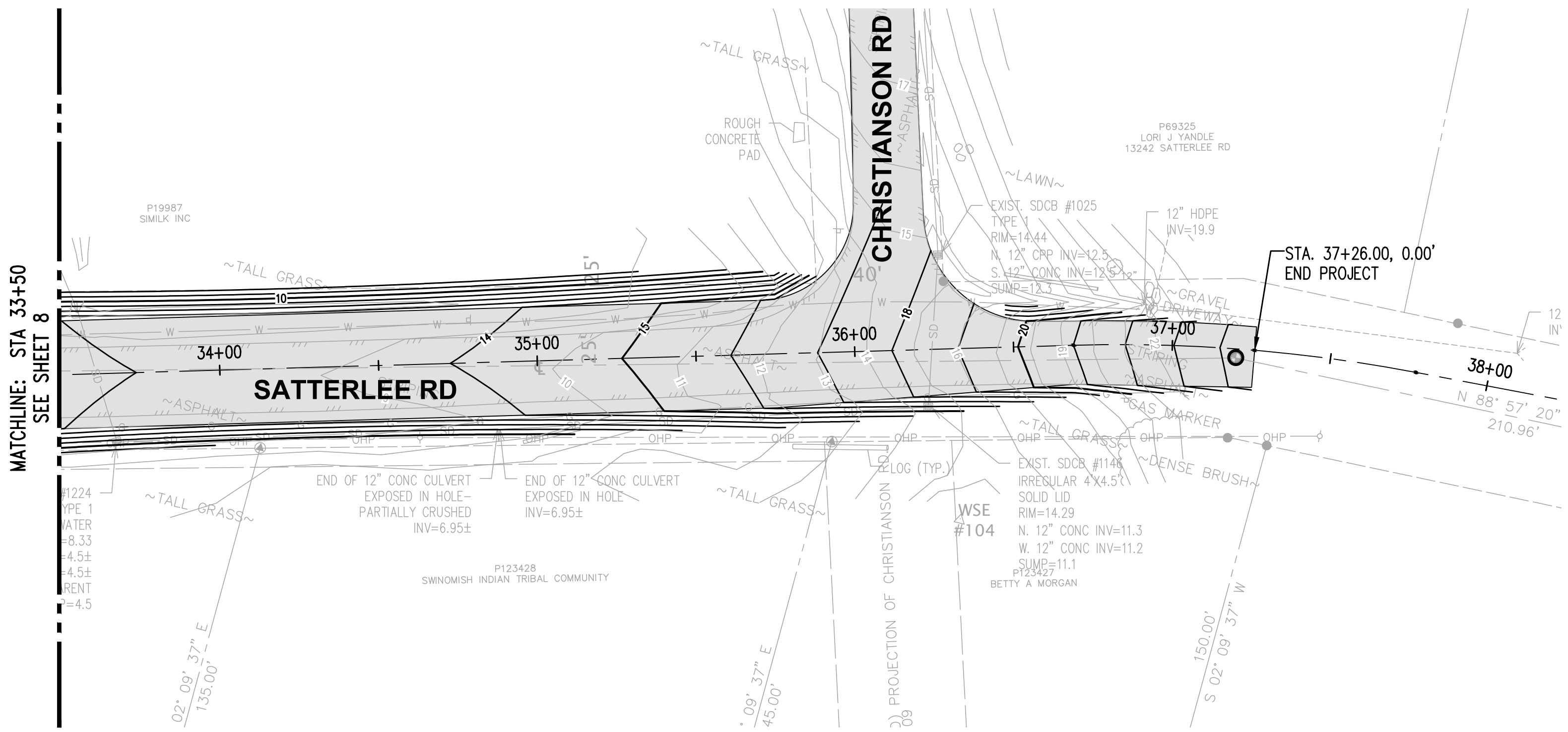
PROJECT NO.: ES24100-2
FED. AID NO.: N/A
DESIGNED BY:
DRAWN BY:
CHECKED BY:
APPROVED BY:
PROJECT LOCATED NEAR:
SATTERLEE ROAD

SIMILK TIDAL MARSH RESTORATION PROJECT

ROADWAY PLAN AND PROFILE

1 INCH SCALE BAR
ADJUST SCALE ACCORDINGLY

SHEET
8 OF 12



PAVING LEGEND

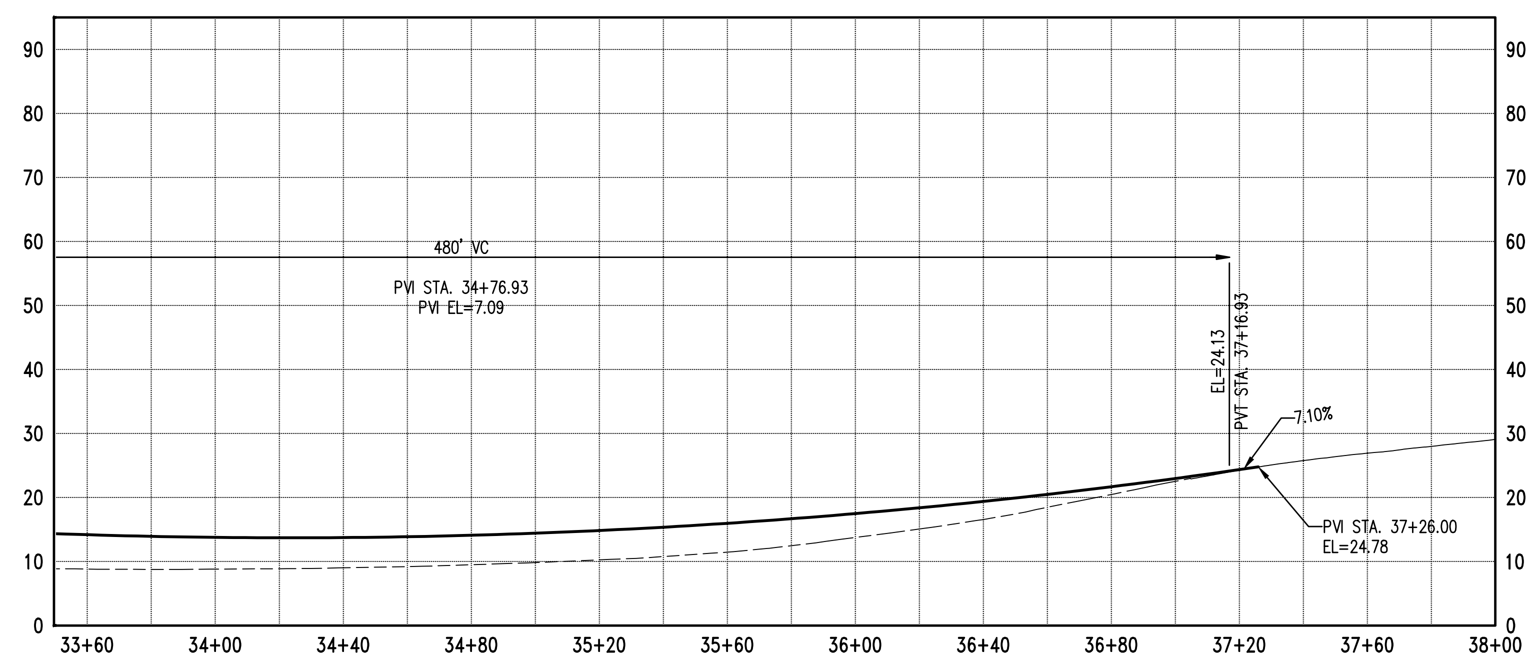
GUARDRAIL

HMA PAVEMENT

N

0 15' 30' 60'

1 inch = 30 feet



CONCEPTUAL DESIGN

ENGINEER OF RECORD

DESIGN ENGINEER

kpff

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NO.	REVISIONS	DATE

PROJECT NO.: ES24100-2
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CHECKED BY:
APPROVED BY:

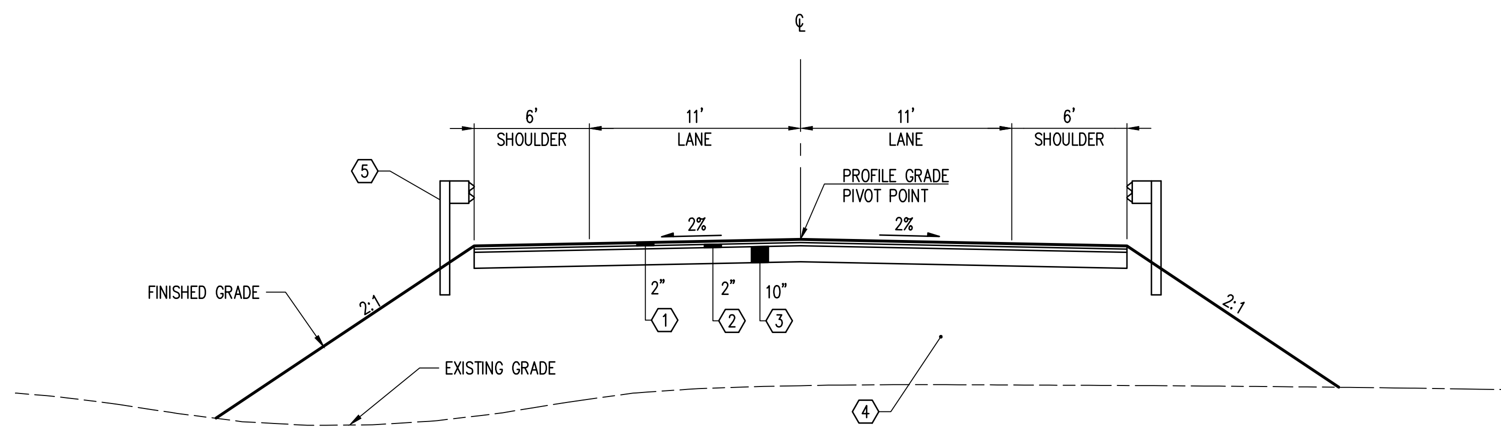
PROJECT LOCATED NEAR:
SATTERLEE ROAD

SIMILK TIDAL MARSH RESTORATION PROJECT

ROADWAY PLAN AND PROFILE

1 INCH SCALE BAR
ADJUST SCALE ACCORDINGLY

SHEET
9 OF 12



TYPICAL ROADWAY SECTION

CONSTRUCTION NOTES:

1. HMA CL 1/2 IN PG 58H-22
2. CRUSHED SURFACING TOP COURSE
3. CRUSHED SURFACING BASE COURSE
4. GRAVEL BORROW INCL. HAUL
5. TYPE 31 BEAM GUARDRAIL

CONCEPTUAL DESIGN

NO.	REVISIONS	DATE

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DESIGNED BY:
DRAWN BY:
CHECKED BY:
APPROVED BY:

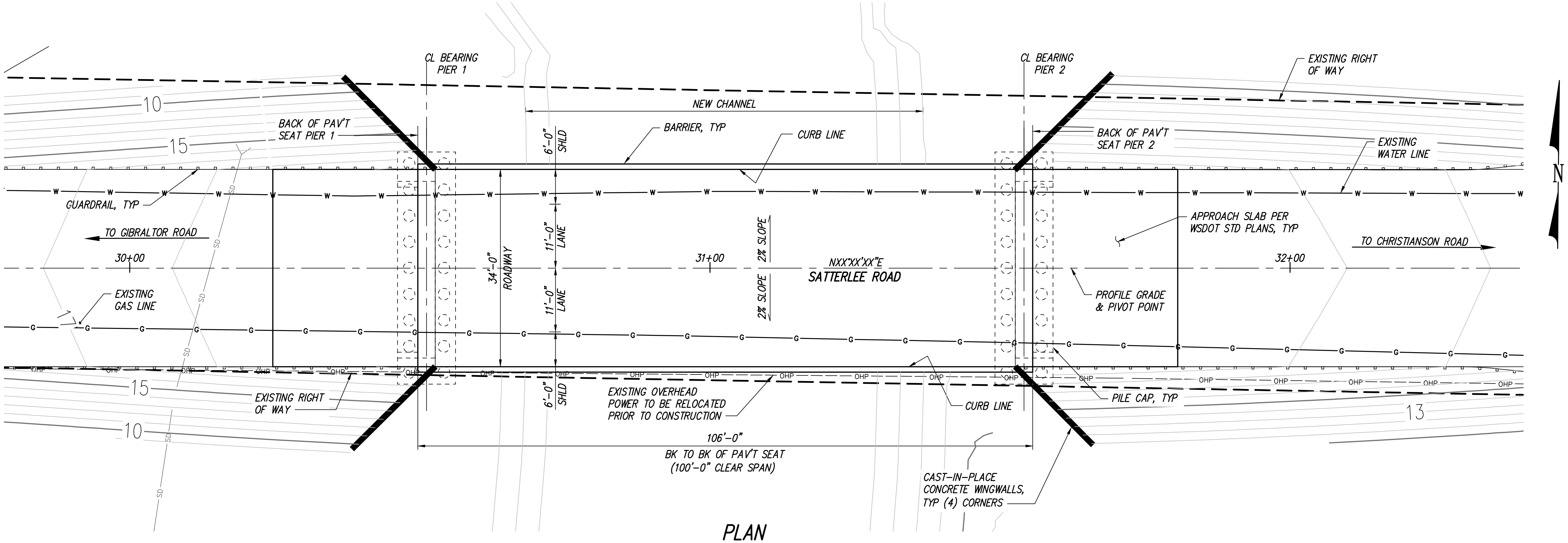
PROJECT LOCATED NEAR:
SATTERLEE ROAD

SIMILK TIDAL MARSH
RESTORATION PROJECT

TYPICAL ROADWAY SECTION

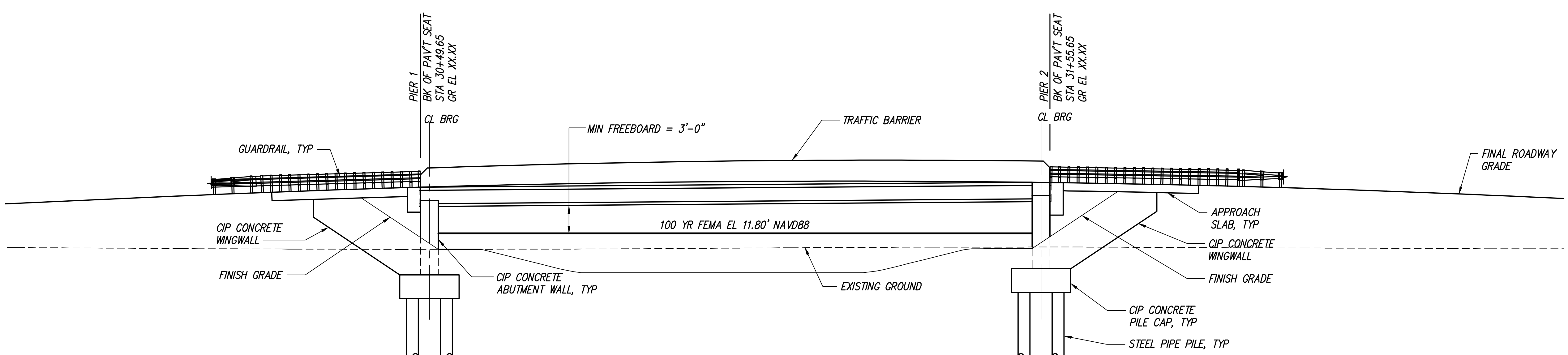
1 INCH SCALE BAR
ADJUST SCALE ACCORDINGLY

SHEET
10 OF 12



PLAN

0 10 20 30
SCALE IN FEET



ELEVATION

0 10 20 30
SCALE IN FEET

PRECAST PRESTRESSED CONCRETE
WF39DG WIDE FLANGE DECK GIRDERS
LOADING: HL-93

CONCEPTUAL DESIGN

NO.	REVISIONS	DATE

ENGINEER OF RECORD

DESIGN ENGINEER
kpff
1601 5th Avenue, Suite 1600
Seattle, WA 98101
206.622.5822
www.kpff.com

PROJECT NO.: ES24100-2
FED. AID NO.: N/A
DESIGNED BY: AS
DRAWN BY: TP
CHECKED BY:
APPROVED BY:
PROJECT LOCATED NEAR:
SATTERLEE ROAD

SIMILK TIDAL MARSH RESTORATION PROJECT

PLAN AND ELEVATION

1 INCH SCALE BAR
ADJUST SCALE ACCORDINGLY

SHEET
11 OF 12

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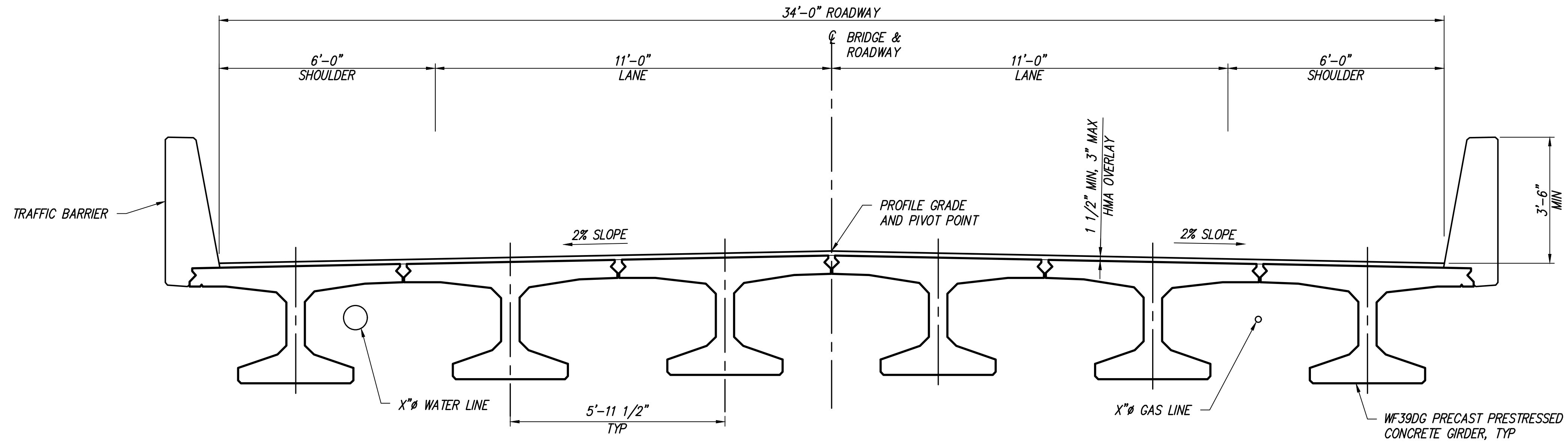

TYPICAL SECTION

LOOKING AHEAD ON STATION

CONCEPTUAL DESIGN

NO.	REVISIONS	DATE

ENGINEER OF RECORD

DESIGN ENGINEER

kpff

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Seattle, WA 98101
206.622.5822
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PROJECT NO.: ES24100-2
FED. AID NO.: N/A
DESIGNED BY: AS
DRAWN BY: TP
CHECKED BY:
APPROVED BY:

PROJECT LOCATED NEAR:
SATTERLEE ROAD

SIMILK TIDAL MARSH
RESTORATION PROJECT

TYPICAL SECTION

1 INCH SCALE BAR
ADJUST SCALE ACCORDINGLY

SHEET
12 OF **12**

TAUNIEP – April 6, 2022 – 3:03 PM – V:\2100269 (SIMILK BRIDGE)\02_DESIGN (V2019)\SB_S02.DWG