

**Appendix IR2020-1.1-A22**

**Tilbury Island Peninsula Enhancement  
Project Design Brief for Habitat Offsetting**

**TILBURY ISLAND PENINSULA ENHANCEMENT PROJECT  
DESIGN BRIEF FOR HABITAT OFFSETTING**

**REPORT**

Prepared for:

**Vancouver Fraser Port Authority**  
Vancouver, British Columbia

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## CREDITS AND ACKNOWLEDGEMENTS

This proposed project was identified by a number of Indigenous groups as an important location for enhancement, was put forward as a Musqueam Indian Band (Musqueam) priority offsetting project for the Roberts Bank Terminal 2 Project, and would be developed in collaboration with Musqueam and other interested Indigenous groups. NHC would also like to acknowledge the contribution of Musqueam, in particular Morgan Guerin who took the time to share his knowledge with our team.

Northwest Hydraulic Consultants Ltd. (NHC) would like to acknowledge the Vancouver Fraser Port Authority's support for this project, including the assistance of Charlene Menezes (Port Authority) and Ravi Chatterji (AECOM). Special acknowledgement to Jemma Scoble for assistance with coordinating the site visits, and Gary Williams, GL Williams & Associates Ltd., for provision of information related to environmental requirements and review.

NHC would also like to acknowledge the Fraser Basin Council for allowing the use of their HECRAS-2D model to assess flow hydraulics at the project site. The results from the model are important for the assessment and design of this offsetting project.

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# 1 INTRODUCTION

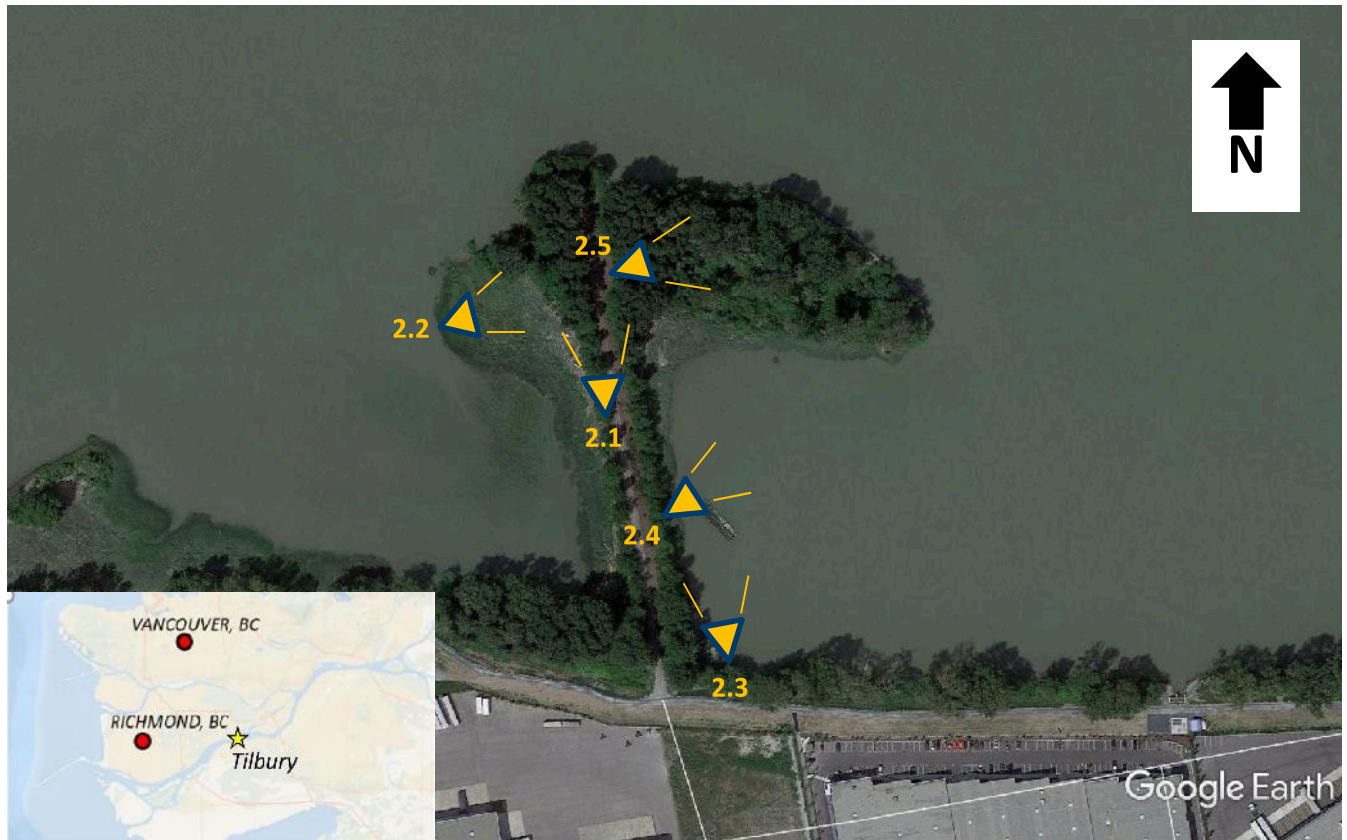
Northwest Hydraulic Consultants Ltd. (NHC) is pleased to present this report to the Vancouver Fraser Port Authority (Port Authority) describing the design basis for the Tilbury Island Peninsula Enhancement Project (Tilbury Project). This proposed offsetting project for the Roberts Bank Terminal 2 Project (RBT2) involves habitat enhancement through the development of brackish tidal marsh habitat on the east side of the Tilbury Island peninsula causeway.

This offsetting initiative related to RBT2, in conjunction with other offsetting initiatives within the broader territory, has been developed to align with the stewardship responsibilities of the Musqueam Indian Band (Musqueam). The proposed project area was identified by the Port Authority as a site for enhancement and supported by a number of Indigenous groups as an important location for habitat enhancement, and was put forward as a Musqueam priority offsetting project to help counterbalance the fish and fish habitat effects of the RBT2 project, as part of a multi-pronged approach to offsetting, which encompasses several different offsetting initiatives, across different project sites.

This report outlines background information on the overall project, provides rationale for the project, details the design criteria, provides preliminary design details and drawings, provides a preliminary estimate of the construction cost, and outlines additional considerations that may need to be addressed prior to construction. As such, this report provides the technical basis for the development of the offsetting works.

## 1.1 Study Area

The Tilbury Project is located in the Tilbury Island area of Delta, BC, in the south arm of the Fraser River, which is an important stopping point for estuarine-rearing juvenile salmon (e.g., Chinook and chum) as they out-migrate from the Fraser River to the marine environment. Musqueam has several named features in and adjacent to the site, which form part of a network of traditional and historical use dating back at least as far as 8,500 years. Past Musqueam elders spoke of a time when this area was all water, before the delta formed. Figure 1.1 shows the location of the Tilbury Project site.



**Figure 1.1 Tilbury Project site (Google Earth image June 2019). Numbers refer to photos showing location and direction of the view.**

## 1.2 Scope of Work & Objectives

The proposed Tilbury Project is being developed as part of the RBT2 offsetting plan. The primary objective of this project is to enhance habitat that will benefit estuarine-rearing Pacific salmon (e.g., Chinook and chum) as well as other fish and wildlife. It is being designed in alignment with the values of Musqueam. The scope of work included four tasks, as follows:

- 1) Site visit – A site inspection was made on 3 July 2020.
- 2) Bathymetric and drone surveys – A site survey was made on 8 July 2020. At the time of the survey the water level was low, exposing the mudflats on either side of the causeway. The survey was conducted using a drone for the exposed wetland and mudflats, while a bathymetric survey from a kayak was used to survey areas below the water. Several transects were also surveyed through the existing marsh vegetation to define the marsh vegetation zones and associated elevation, which are used to establish the constructed marsh elevations and planting prescriptions. Survey results are included in Appendix A.
- 3) Physical assessment – The physical processes governing the development of any potential habitat enhancement project are fairly well known but need to be described with specific reference to the project design and are described herein.

- 4) Preliminary design – This includes concept preparation, design criteria, preliminary plans, specifications, construction cost estimates, construction methodology, and consideration of climate change and sea-level rise resilience. An engineering preliminary design report (this report) shall accompany the technical drawings.

### **1.3 Related Documents**

This report builds upon previous work undertaken for the project site. Key documents are listed below for ease of reference:

- 1) Tilbury Island Peninsula Enhancement Project (Tilbury Project) - Opinion on Site Suitability. Prepared for the Vancouver Fraser Port Authority (Northwest Hydraulic Consultants Ltd, 27 October 2020).

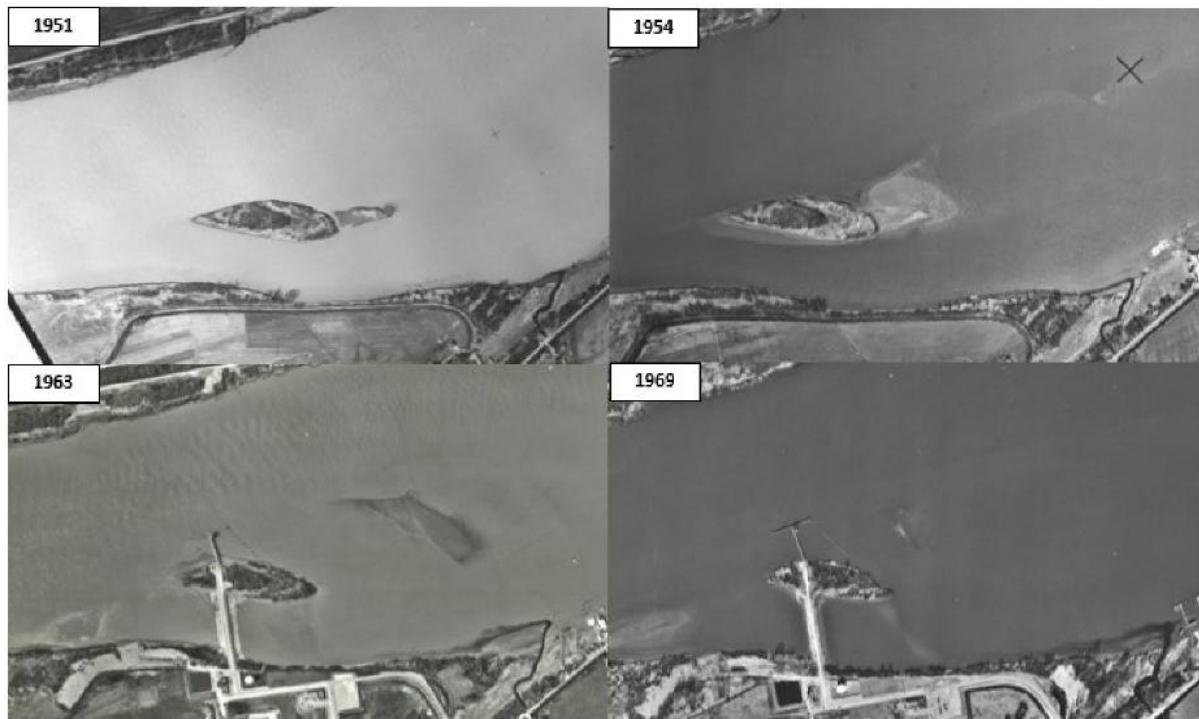
### **1.4 Project Team**

The development of the habitat enhancement concept and preliminary design by NHC was undertaken in collaboration with Gary Williams, R.P.Bio. of G.L. Williams and Associates (GLWA). Ravi Chatterji, R.P.Bio., Senior Aquatic Ecologist with AECOM, provided overall project coordination and management on behalf of the Port Authority, reporting to Charlene Menezes, P.Geo. Team investigations, including onsite field investigations, were arranged with the assistance of Jemma Scoble, Port Authority Indigenous Consultation Support.

## 2 OVERVIEW OF PROJECT

### 2.1 Historical Condition

The peninsula causeway was constructed prior to 1963 based on a review of historical air photos (Figure 2.1), and cut-off flow between the peninsula island and the bank of the Fraser River, and initiated sedimentation on both sides of the causeway; this process is shown beginning to develop in the air photo from 1969 (Figure 2.1). Over time, sediment has deposited within the areas on both sides of the causeway and brackish tidal marsh has established along the perimeter while tidal channels have formed across the mudflats.



**Figure 2.1 Historical aerial photos of the Tilbury Project site. Connecting causeway constructed prior to 1963. Sediment begins to accumulate upstream and downstream of the causeway due to its presence.**

### 2.2 Present Condition

The site is located near Huston Road at the upstream end of Tilbury Island and is accessible by public access along a dyke. A causeway connects the peninsula island to the south bank of the Fraser River as part of its past development as an industrial site. A public park has been established on the causeway and island.

Photos 2.1 to 2.5 show the area and portions of the site investigated, and Photos 2.3 to 2.5 show the areas being proposed for potential habitat enhancement. Key geomorphological processes influencing the site include the morphology of the Fraser River, sediment balance in the river and the mudflat areas, water levels affected by tide, and waves caused by vessel use of the Fraser River.

After discussions with the project team, including Ravi Chatterji and Gary Williams, and with Morgan Guerin of Musqueam, it was determined that the habitat enhancement be developed to the east (upstream) of the peninsula and causeway. This decision was made primarily on the basis of comparing the natural development of the two sites – the west (downstream) mudflat is already showing signs of transitioning into marsh, with marsh vegetation more established within the embayment, compared to a narrower fringing marsh around the edge of the east mudflat. The proposed habitat enhancement also includes deepening the intertidal habitat on the peninsula island (sometimes referred to locally as Duck Island) to create channels to be connected to tidal channels in the proposed marsh area over a larger range of water levels.



**Photo 2.1** View along the causeway north towards the Fraser River (see Figure 1.1 for location and direction of photo).



**Photo 2.2** Western mudflat and wetland area (see Figure 1.1 for location and direction of photo).



**Photo 2.3** Eastern mudflat and wetland area (see Figure 1.1 for location and direction of photo).



**Photo 2.4** Eastern mudflat and wetland area showing existing drainage channel (see Figure 1.1 for location and direction of photo).



**Photo 2.5 Peninsula island wooded area and evidence of periodic flooding (see Figure 1.1 for location and direction of photo).**

## 2.3 Site Suitability

Development along the Fraser River has removed significant off-channel habitat, creating long expanses of shoreline without intertidal marsh or riparian habitat that juvenile salmonids require along the lower Fraser River rearing corridor. The Tilbury Project will provide high quality habitat that numerous migratory and resident fish species will use. Moreover, the Tilbury Project site is at a key estuarine location where out-migrating fish experience increasing salinity. Juvenile salmonids require habitats that support their successful transition from freshwater to saltwater ecosystems.

Construction of the causeway has caused the formation of extensive mudflats from sediment accumulation on both the upstream and downstream sides. Intertidal emergent vegetated marsh has established around the perimeter of the mudflats, which over time will trap additional sediment and will allow the marsh to naturally expand and mature into high quality rearing habitat. This is already demonstrated by the difference between the mudflat characteristics on either side of the causeway.

Presently, the average elevation of the east mudflat is approximately 0.4 m lower than the west mudflat, and it would take several decades for the natural process on the east side to accrete sediment to achieve similar elevation to the west side. For this reason, the development of brackish tidal marsh will focus on the east mudflat area.

By developing habitat enhancements within the east area, such as raised marsh areas, the interventions will increase the rate of the natural processes to result in a more diverse, mature, and productive brackish marsh rearing habitat, and at a faster rate than what would occur naturally.

Other factors that make the east side suitable for environmental enhancements include:

1. Easy access for construction and monitoring.

2. The area is protected from the main channel and is not subject to high currents and is partially sheltered from vessel wake waves.
3. The area is subject to slow, natural sediment accretion and the addition of raised wetland areas would enhance this characteristic.
4. Offers close proximity to potential off-channel areas on the peninsula island.
5. Offers public access for viewing and interpretive signage (e.g., along the causeway), which could include culturally-relevant information.
6. Proximity to other natural and restored salmonid sites that improve the rearing corridor along the lower Fraser River.

Draft concept sketches were previously provided to the Port Authority and form the basis of the preliminary design drawings included in this report (Appendix B). Design criteria and considerations for these enhancements are provided in Section 3. The preliminary design is described in Section 4.

## 3 DESIGN CRITERIA

### 3.1 Vertical Datum

For the purpose of this project, all elevations are referenced to geodetic datum (CVD28GVRD) unless stated otherwise. Note that the following formulas can be used to convert elevations in CVD28GVRD to elevations in Canadian Geodetic datum of 2013 (CGVD2013) or Chart Datum (CD) at the project site:

$$Elev_{CGVD2013} = Elev_{CVD28GVRD} + 0.15$$

$$Elev_{CD} = Elev_{CVD28GVRD} + 1.8$$

### 3.2 Design Working Life

The design working life of an engineered structure is taken as “the specific period for which a structure is to be used for its intended purpose with planned maintenance” [British Standard 6349-1]. This proposed design is intended to have a design working life of approximately 50 years. Note that regular monitoring and maintenance is generally required to meet the working life of any design (particularly directly after installation of natural or nature-based designs); however, the marsh vegetation may function well beyond the design working life due to ability of marshes to adapt and self-repair.

### 3.3 Design Event

The engineering components of habitat enhancement are designed for a 50-year return period event, which is approximately equal to a 1/50-year Annual Exceedance (AEP) probability (i.e. 2.0 % probability) of occurrence in any given year. This design event was chosen as it is a relatively low probability event and will ensure functionality during the likely storm events that can be expected to occur over the design working life. It is not considered necessary that the enhancement works remain fully functional during unlikely and extreme events (e.g. 200- or 500-year return period events that may be considered for assessments pertaining to potential loss of life or livelihood).

### 3.4 Functional Requirements

The proposed Tilbury project meets the functional requirements of offsetting for RTB2 providing high quality habitat for numerous fish species that utilize the Fraser River South Arm (see fish list in Additional Considerations, Section 6). The preliminary design has been developed following consideration of ambient physical and biological processes and incorporation of proven engineering and wetland enhancement measures that have proven successful in the Fraser River estuary (Adams and Williams 2004).

The specific functional requirements of the design include creating:

- intertidal estuarine marsh habitat as part of the Fraser River rearing corridor for juvenile fish rearing (Simenstad 1983; Williams 1989; Levings 2004), particularly for chinook and chum salmon fry (Levings 2016; Simenstad 1983);

- brackish marsh communities using native emergent marsh plants that have high primary productivity to support a detritus-based food web. The estuarine food web includes chironomids and other important invertebrate prey species for juvenile chinook and chum salmon, as well as numerous other fish species utilizing the Fraser River estuary (Northcote et al 1979; Levy and Northcote 1981, 1982; Northcote et al 1979; Levings 2004); and
- refuge habitat for juvenile salmon fry that provides escape from predators and sheltered areas to support the physiological transition from fresh to high salinity waters and increase survival during their oceanic migration life phase (Salo 1991; Healey 1989; Levings 2016).

### 3.5 Environmental Design Considerations

To accomplish the functional requirements, marsh growing medium will be placed over the existing mudflat within rock containment berms that are designed to retain the marsh soils and protect against wave erosion. The resulting marsh benches will be located to retain existing tidal drainage channels. Nursery grown native brackish plant species will be transplanted into the marsh benches to create productive emergent plant communities typical of the lower Fraser River.

#### 3.5.1 Plant species and Elevations

A site reconnaissance was conducted on July 3, 2020 at low tide with representatives from NHC, AECOM, Jemma Scoble Consulting, G.L. Williams and Associates (GLWA), and Musqueam . A follow-up visit was conducted on August 31, 2020 to obtain emergent marsh species elevations using RTK GPS by G. Williams, accompanied by M. Savage, surveyor with Van Bower Construction Services.

The dominant species and elevation ranges observed at the site are shown in Table 3.1. The table lists the proposed marsh planting species and is subject to further Indigenous group input.

**Table 3.1 Proposed Tilbury marsh to be transplanted using nursery grown plugs planted at 0.5 m spacing at the proposed Tilbury site (post-settlement elevations).**

Species		Elevation Range
Common Name	Scientific Name	(m, CVD28GVRD)
Baltic rush	<i>Juncus arcticus</i>	-0.4 - 0.9
Common spikerush	<i>Eleocharis palustris</i>	0.1- 0.29
Jointed rush	<i>Juncus articulatis</i>	0.1 - 0.6
Lyngbye’s sedge	<i>Carex lyngbyei</i>	0.01 - 0.9
Wapato	<i>Sagittaria latifolia</i>	0.14
Softstem bulrush	<i>Schoenoplectus tabernaemontani</i>	0.2 - 0.5
Pointed rush	<i>Juncus oxymers</i>	0.37
Common cattail	<i>Typha latifolia</i>	0.6 -1.5

### 3.5.2 Marsh Bench Configuration

The proposed design maximizes the marsh area and plant diversity but maintains main tidal drainages. Marsh benches will be contained by a rock berm. On the river side (outer marsh), the berm is installed at the existing -0.6 m GD contour has a crest elevation of approximately -0.2 m GD (0.4 m high berm). The berm crest and toe elevations increase along the drainage channels towards the land (0.5 m high berms). Sediments will slope up gently from the berm to blend in with the existing fringe marsh.

Marsh plantings will consist of outer low marsh using Baltic rush planted at 0.5 m spacing over a 3-5 m wide zone along the inside of the berm. Baltic rush is a mat-forming species and was used at the Port Authority's Glenrose Tidal Marsh Project to provide a resilient vegetated band to withstand the effects of boat wake at the downstream tidal marsh site. The species is also not a preferred grazing plant by Canada geese and performed well at this site.

The main marsh bench will be transplanted with Lyngbye's sedge (*Carex lyngbyei*) as the main species, with patches (30-50 plugs each) of softstem bulrush (*Schoenoplectus tabernaemontani*) and other suitable species that colonize lower South Arm marshes. Various other suitable species, including plants that are of interest to Indigenous groups, if available from nurseries, can be added to provide more habitat diversity.

### 3.5.3 Soils

Previous project soil data for compensation and offsetting marshes collected by GLWA as part of post-construction monitoring is shown in Table 3.2. Fraser River marshes that were used as reference sites tend to have loamy sand or sandy loam textured soils, ranging from 75% to 85% sand, as would be expected in the sand reach of the lower river. Exceptions occurred at heavily vegetated marshes that occurred at the South Fraser Perimeter Road Manson Canal (Manson) site, which was dominated by cattail, or upper elevations of the South Fraser Perimeter Road Alex Fraser North Sand Island (Alex Fraser) site, Riverfront Tidal Marsh Legacy (Kerr) site and Glenrose Tidal Marsh (Glenrose) site. At these sites, the thick vegetation reduced water velocities and retained a larger percentage of the suspended materials – typically silt and clay-sized particles. At the Alex Fraser reference marsh, the sample with the highest sand (85%) was taken at the exposed, leading edge that was being colonized by Baltic rush. This site was exposed to waves from passing ships that reworked the substrate and washed out most of the fines.

Imported upland soil, consisting of 44-85% sand, was used in many of the constructed marsh sites. The downstream Glenrose marsh was constructed using dredge spoil from Gunderson Slough, which was silt loam and ranged from 41% sand to as low as 11% sand. The fines, mainly silt, were high (i.e. about 50-75%). Generally, constructed marsh soils tend to be coarser than natural marshes; however, for the Glenrose site, which was constructed using dredged sediments from Gunderson Slough, the constructed marsh had finer soils.

Another important parameter is the amount of organic matter in the soils. Organic matter improves soils fertility, moisture retention, and helps to consolidate sediments. Soils with high sand content are more mobile and are less capable of retaining soil moisture. Generally, constructed marshes tend to

have coarser sediments and lower organic matter than reference marshes, but, over time, transplanted vegetated marshes will cause more sediment accretion and the % fines will increase. The proposed growing medium for this project is silty sand with 5-10% organic matter, with a gentle slope that will allow the marsh bench to drain at low water. The proposed work follows a similar design as the downstream Glenrose marsh, which utilized dredged sediments from the bed of Gunderson Slough within the marsh soils and had a similar organic matter content.

**Table 3.2 Particle size, soil texture, % organic carbon, % organic matter and % loss on ignition data for constructed and reference marshes with design input by GLW constructed in the Fraser River estuary.**

Marsh Site	Organic Carbon (%)	Organic Matter (%)	Loss on Ignition (%)	Particle Size			Soil Texture
				Sand (%)	Silt (%)	Clay (%)	
Alex Fraser (South Arm)	1.8	3.1	3.2	50.6	39.2	10.2	loam
	2.7	4.7	4.6	44.1	42.3	13.6	loam
	2.4	4.2	3.6	44.5	44.5	11.0	loam
Reference (South Arm)	0.8	1.4	1.4	73.7	20.9	5.4	sandy loam
	0.8	1.3	1.3	85.3	11.0	3.7	loamy sand
	5.1	8.8	8.8	13.3	68.4	18.3	silt loam
Manson (Main Arm)	3.0	5.1	4.0	48.2	37.9	13.9	loam
	3.3	5.7	5.5	53.8	35.0	11.2	sandy loam
	2.5	4.3	4.3	53.6	35.3	11.1	sandy loam
Reference (Main Arm)	6.6	11.3	12.5	2.1	71.3	26.6	silt loam
	5.1	8.8	10.9	3.8	72.2	24.0	silt loam
	5.7	9.8	11.3	3.6	69.3	27.1	silt clay loam
Kerr (North Arm)	3.23	5.6	-	66.4	22.0	11.6	sandy loam
	3.35	5.8	-	58.3	28.0	13.7	sandy loam
	2.37	4.1	-	56.8	28.8	14.4	sandy loam
Reference (North Arm)	4.03	6.9	-	33.2	47.2	19.53	loam
	2.31	4.0	-	18.8	60.5	20.8	silt loam
	2.12	3.7	-	9.1	68.0	23.0	silt loam
Glenrose (downstream site) (South Arm)	0.9	1.6	2.7	15.5	74.8	9.7	silt loam
	1.0	1.7	2.9	16.5	73.3	10.2	silt loam
	1.0	1.7	3.4	7.3	80.7	12.0	silt loam
Reference (South Arm)	0.7	1.2	2.3	41.8	53.5	4.7	silt loam
	1.0	1.7	3.6	11.9	76.2	11.9	silt loam
	1.0	1.7	2.8	18.1	72.4	9.5	silt loam

A potential source for marsh growing medium will be dredged material from the Fraser River South Arm navigation channel. The dredged material will require time for settlement prior to transplanting marsh vegetation, anticipated to be one month or more.

## 3.6 Engineering Design Considerations

The proposed brackish tidal marsh habitat will be affected by river flows, water levels and vessel waves. The Fraser Basin Council’s 2-dimensional HECRAS-2D numerical model (NHC, 2019) was used to assess the hydraulic conditions at the site. An analytic study was undertaken for vessel waves. Relevant details on these assessments are included in the following sections.

### 3.6.1 River Flows

The BC Ministry of Forests, Lands and Natural Resource Operation (BCMFLNRO) has estimated the 50-yr river flows, as affected by climate change and sea level rise, for the Fraser River (BCMFLNRO, 2014). Table 3.3 summarizes the Fraser River flows at Hope for a range of return periods and climate change scenarios.

The moderate climate change scenario is characterised by increased wet/cold conditions, while the intense scenario is caused by increased hot/dry conditions (Murdock and Spittlehouse, 2011).

**Table 3.3 Fraser flows at Hope for historic and climate change scenarios.**

Scenario	Maximum Daily Flows (m <sup>3</sup> /s)			
	1:50 AEP	1:100 AEP	1:200 AEP	1:500 AEP
Freshet (historic)	13,400	14,300	15,200	16,500
Freshet (moderate climate change)	15,500	16,700	18,100	19,900
Freshet (intense climate change)	17,100	18,700	20,800	23,900
Winter (historic)	5,120	5,520	5,910	6,420

### 3.6.2 Water Levels

#### Lower Low Water (LLW) and Higher High Water (HHW)

The site is tidally influenced and experiences water level fluctuations of up to 3 m during winter flow conditions and 2 m during moderate freshet conditions. The site is located at river station KM24, which has a Lower Low Water (LLW) of -1.68 m (geodetic datum) and a Higher High Water (HHW) of 2.0 m (geodetic datum)

#### 50-yr Freshet and Winter Levels

BCMFLNRO has simulated the effects of climate change and sea level rise on flood levels along the Fraser River (BCMFLNRO, 2014). Table 3.4 presents the simulated water levels for the 50-year conditions at KM24, for different sea level rise conditions. For the same design events for winter and freshet, the lower Fraser River below Alex Fraser Bridge is dominated by the winter events. It is also

interesting to note that historic winter conditions are higher than freshet conditions with moderate climate change.

**Table 3.4 50-yr water levels (converted to CVD28GVRD) at project site (KM24).**

Scenario	50-yr Water Level (m, CVD28GVRD)				
	0.0m SLR	+0.5m SLR	+1.0m SLR	+1.5m SLR	+2.0m SLR
Freshet (historic)	2.43	2.83	3.25	3.68	4.11
Freshet (moderate climate change)	2.66	3.03	3.41	3.82	4.23
Freshet (intense climate change)	2.84	3.18	3.55	3.93	4.33
Winter (historic)	2.68	3.18	3.64	4.09	4.61

### 2020 Freshet Levels

A peak flow of 11,700 m<sup>3</sup>/s was recorded at Mission on 29 June 2020. The 2D numerical model was used to simulate water levels during the freshet from 15 June to 10 July. Figure 3.1 shows the modelled water levels at three locations. Water levels vary by up to 2.1 m over the largest fluctuations. A minimum level of -0.30 m (CVD28GVRD) occurs a few days before the peak on 30 June 2020 of 1.95 m. Point 1 becomes dry at about level of 0.05 m while the other two points remain wet.

The model simulates a period of 600 hours. Figure 3.2 shows the percentage of this time that areas are underwater. Most of the embayment is wet for the entire period. The typical elevation of the island is approximately 1.6 m and is flooded 50% of the time.

### Typical Winter

A mean winter flow of 1,400 m<sup>3</sup>/s at Mission was combined with the December 2012 tide to establish typical winter water levels at the site. Note that the December 2012 tide was used as it is considered to be representative of tides occurring during a typical winter storm surge condition. Figure 3.3 shows the modelled water levels at three locations for 5 December to 25 December. All of the points become dry over the tidal cycle, with the highest level being 1.65 m elevation.

The model simulates a period of 480 hours. Figure 3.4 shows that the main embayment is wet 50-60% of the time, while the island rarely gets flooded.

### 3.6.3 Flow Patterns and Velocities

The following information is provided to describe the governing physical geomorphological processes at the site and is included to demonstrate that the proposed design is expected to function as intended. Note that a conservative design flow velocity of 0.3 m/s was adopted for the design.

### 2020 Freshet

Figure 3.5 to 3.6 show the flow patterns for 2020 freshet for high and low tide conditions. In both cases the flow is downstream. A large eddy forms in the west (downstream) embayment, and is more directly connected to the main channel, which would tend to pull suspended sediment into the area, compared

to the conditions at the east (upstream) embayment. This can explain why the west mudflat is about 0.5 m higher than the east mudflat.

Velocities across the riverside boundary of the embayment are shown in Figure 3.7 and are approximately 0.2 m/s.

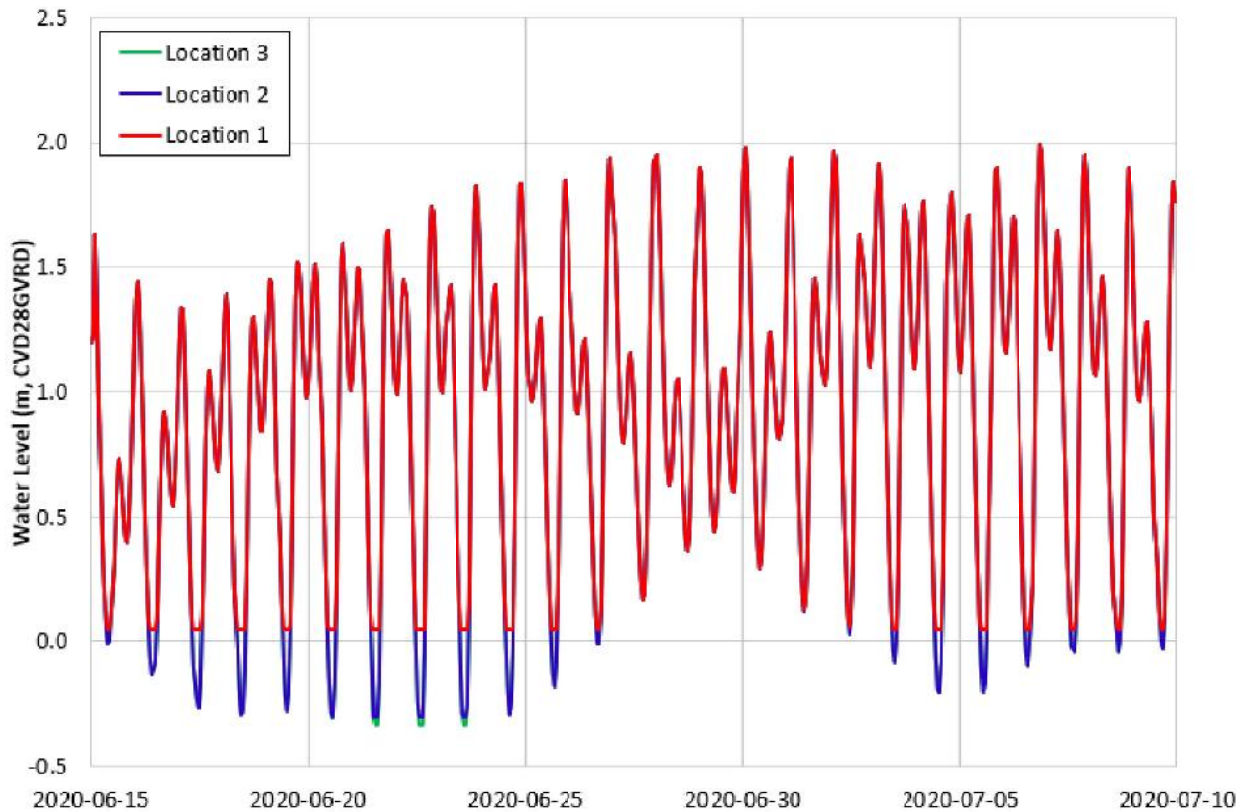
### **Typical Winter**

Figure 3.8 and Figure 3.9 show the flow patterns for a typical winter flow for high and low tide conditions. Flow direction is upstream for the high tide condition and downstream for the low tide conditions. In both cases the west embayment is more directly connected to the main channel, which would tend to pull suspended sediment into the area and can explain why the west mudflat is approximately 0.4 m higher than the east mudflat.

Velocities across the riverside boundary of the embayment are shown in Figure 3.10 and are also approximately 0.2 m/s.



**Water Surface Elevation at Selected Points - 2020 Freshet**



**Figure 3.1 2020 Freshet - Water levels at selected locations, as shown in top panel.**

**Note: The water surface time series for Location 3 overlays Location 2.**

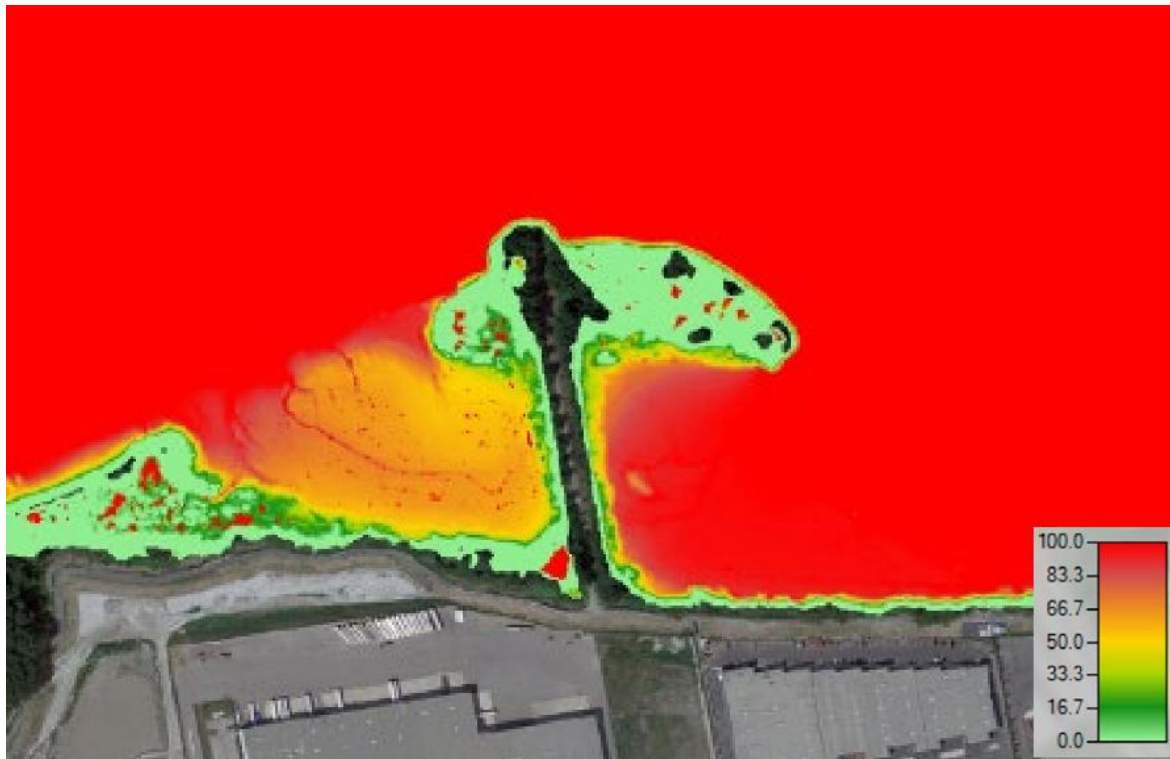


Figure 3.2 2020 Freshet – Percentage of time that areas are underwater (600 hr duration).

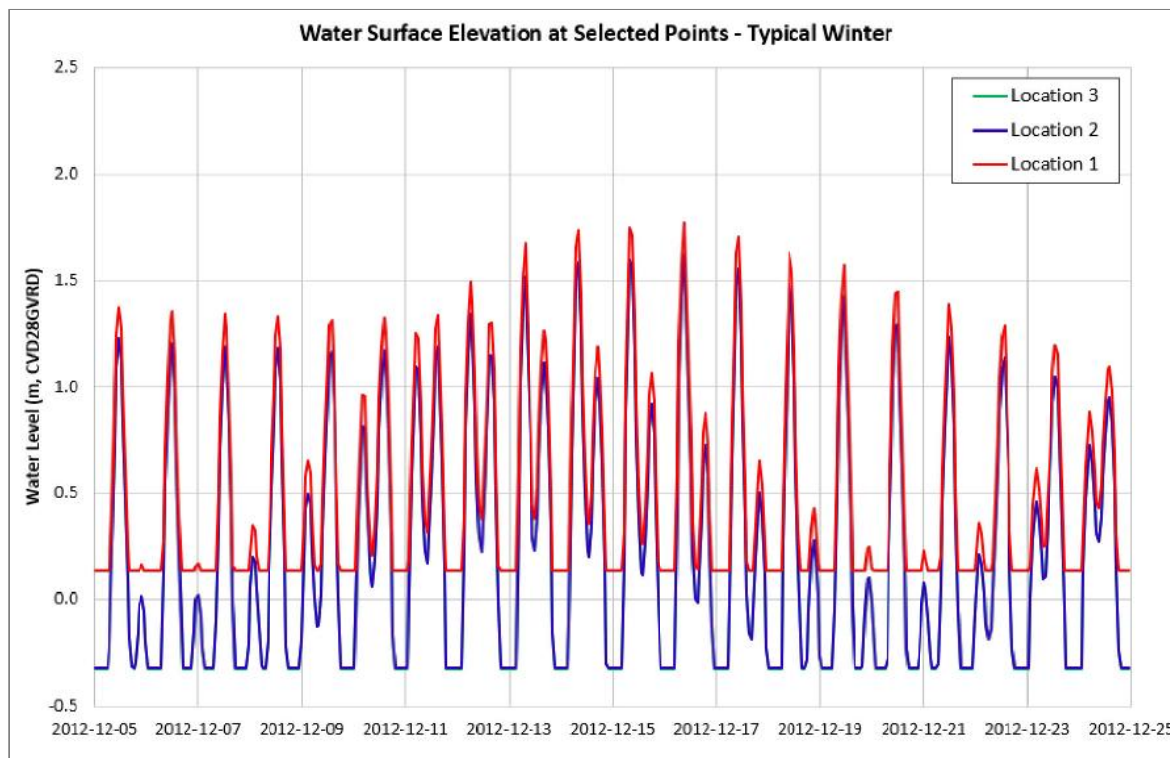


Figure 3.3 Typical Winter - Water levels at selected locations (See top panel of Figure 3.1 for reference locations).

Note: The water surface time series for Location 3 overlays Location 2.

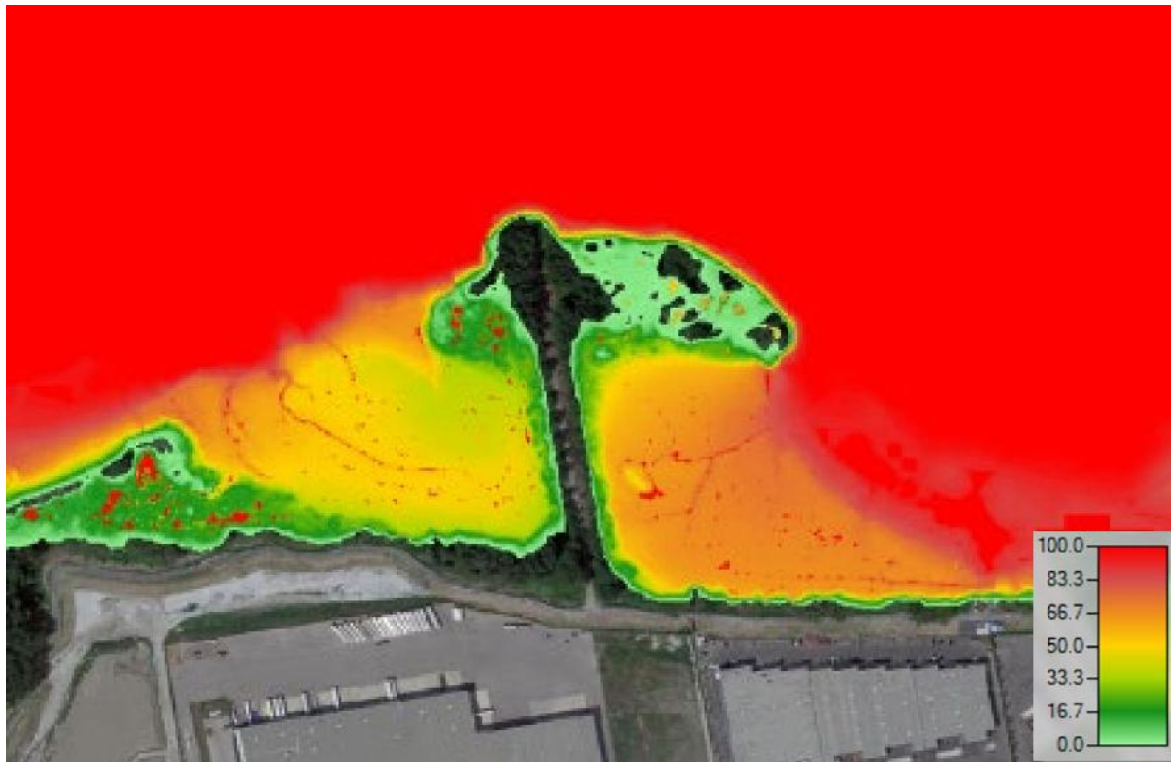


Figure 3.4 Typical Winter - Percentage of time that areas are underwater (480 hr duration).

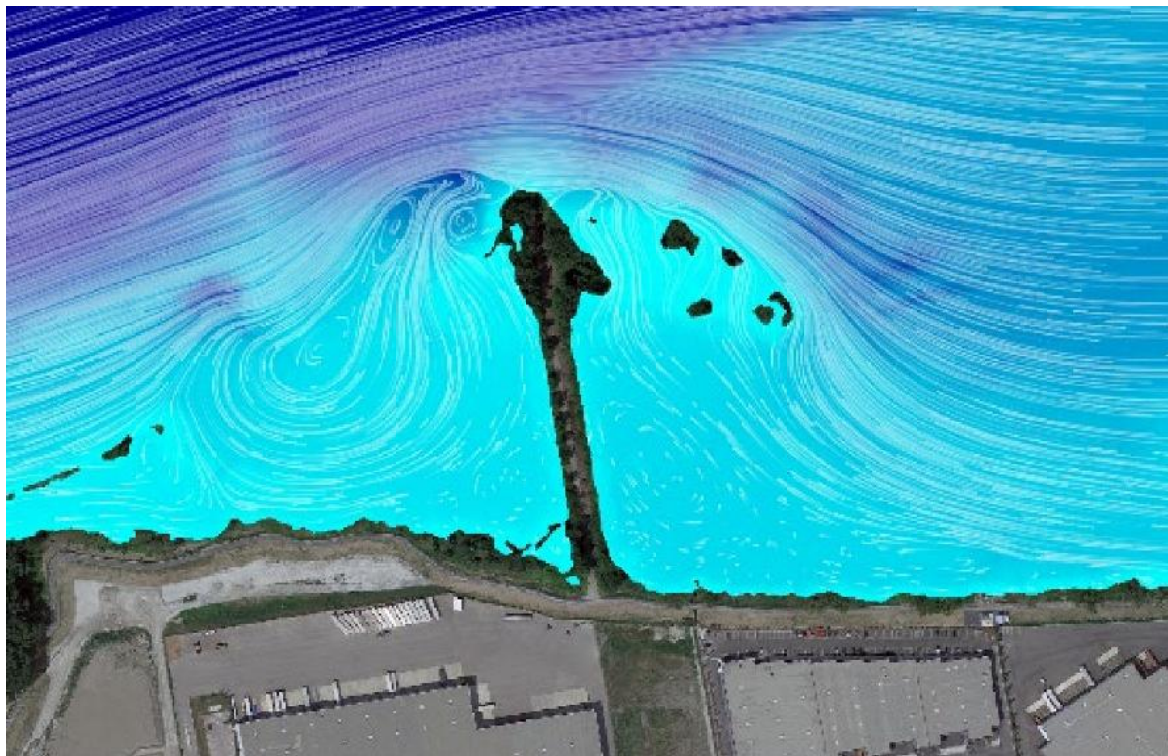
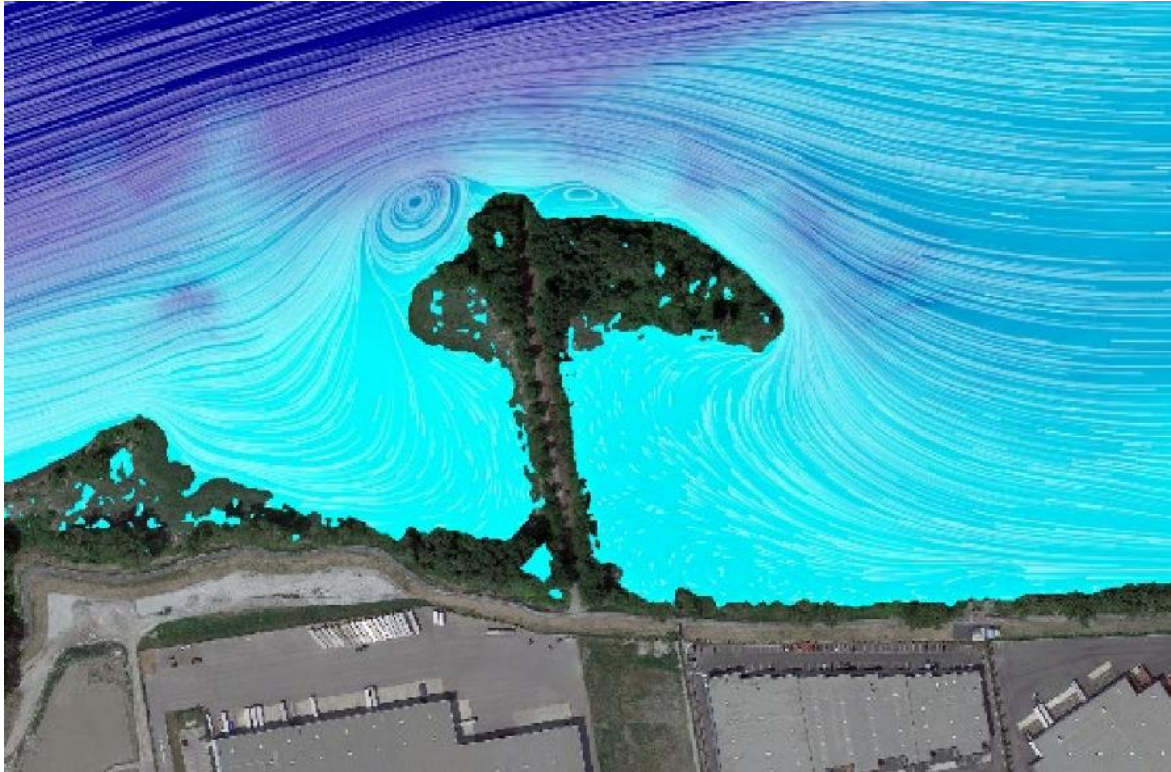
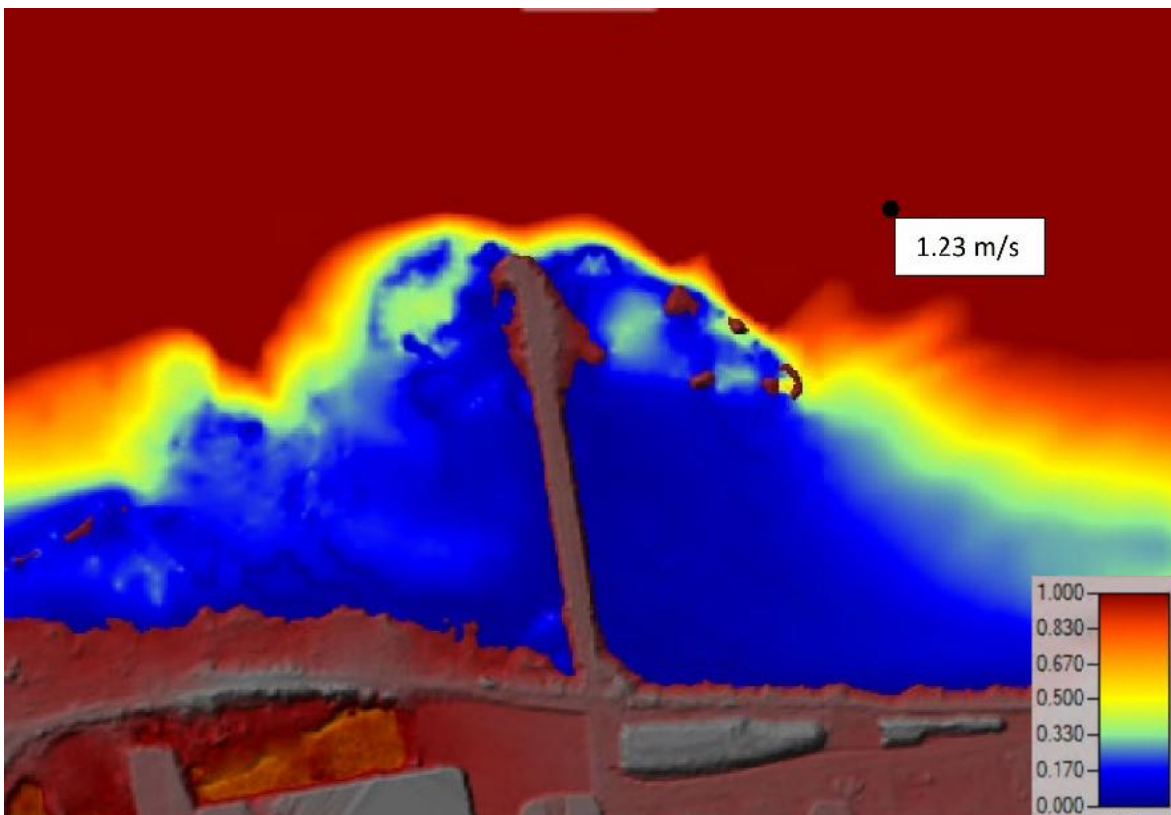


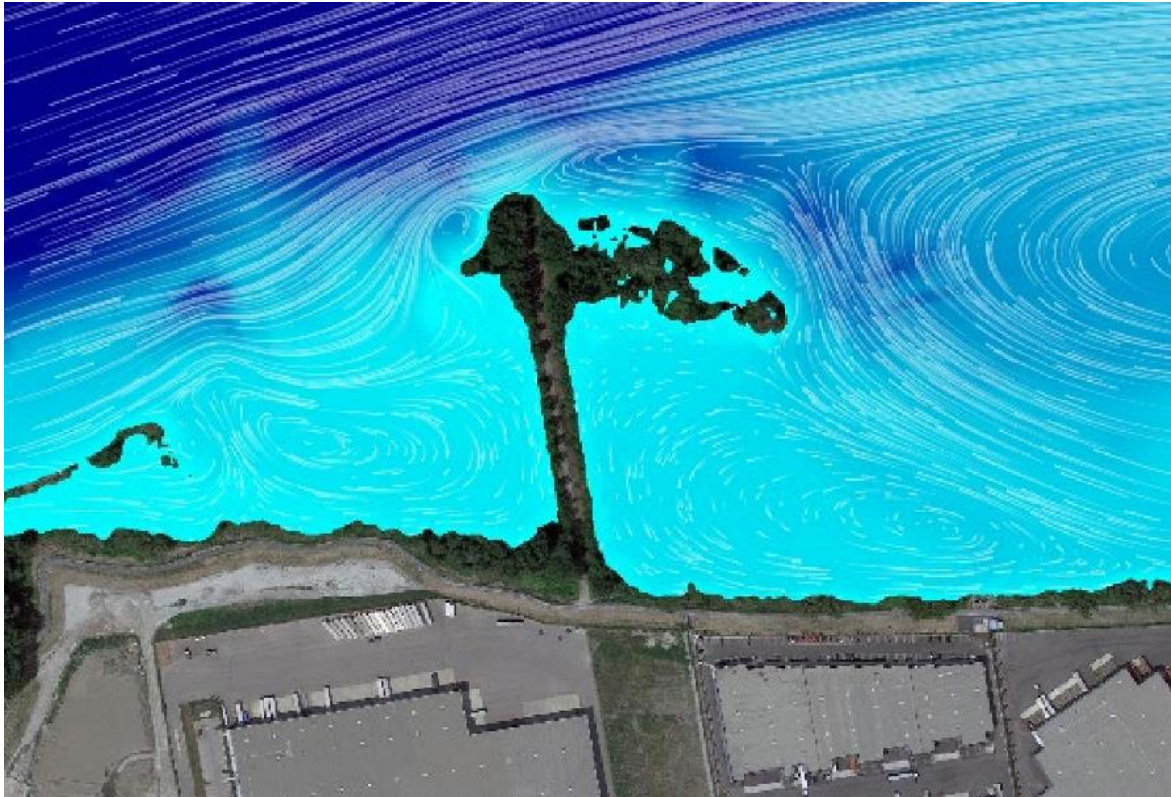
Figure 3.5 2020 Freshet – Streamlines for high tide conditions (main channel flow right to left). Relative depth is shown in shades of blue (background), where dark blue is deeper water.



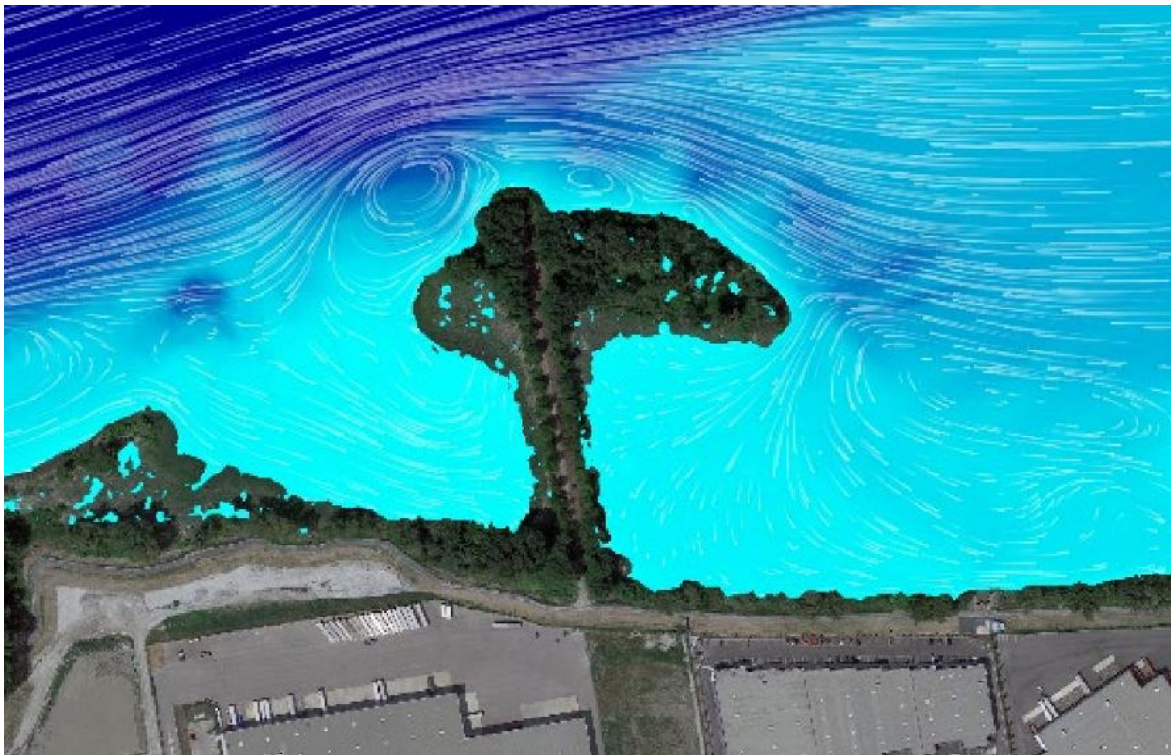
**Figure 3.6** 2020 Freshet – Streamlines for low tide conditions (main channel flow right to left). Relative depth is shown in shades of blue (background), where dark blue is deeper water.



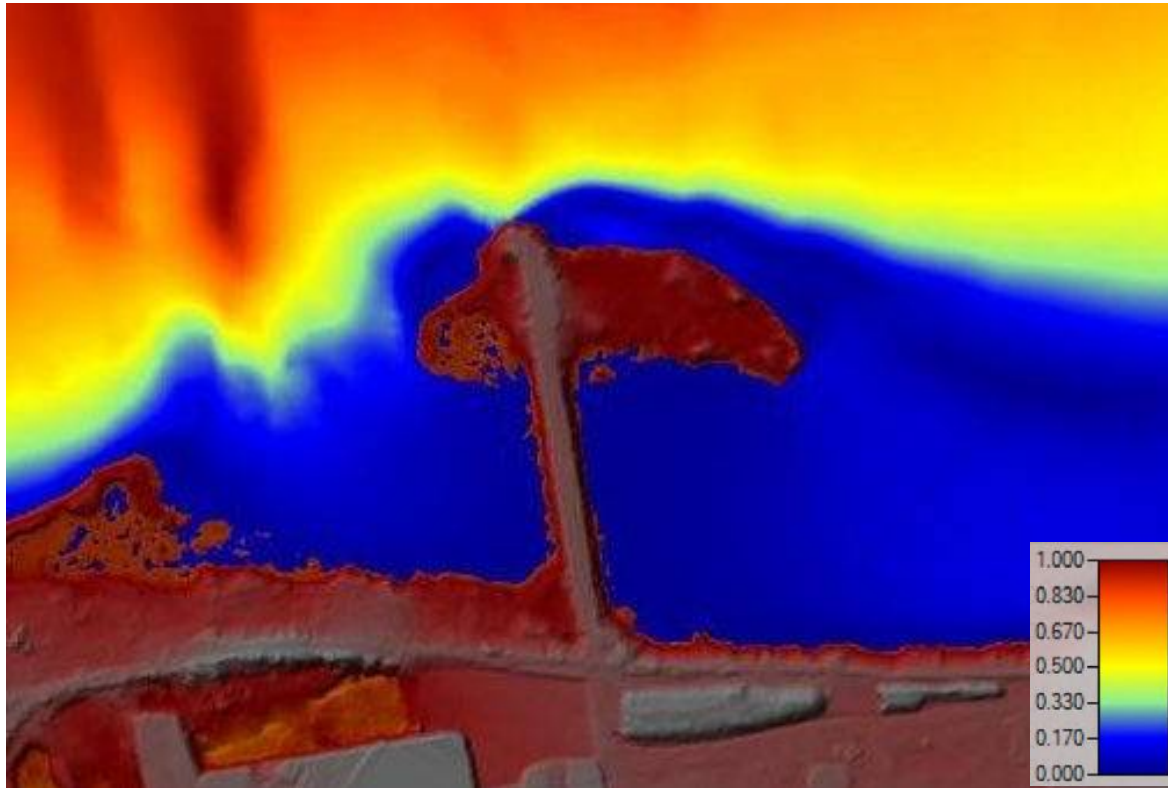
**Figure 3.7** 2020 Freshet – Peak velocities (m/s)



**Figure 3.8** Typical Winter – Streamlines for high tide conditions (main channel flow left to right). Relative depth is shown in shades of blue (background), where dark blue is deeper water.



**Figure 3.9** Typical Winter – Streamlines for low tide conditions (main channel flow right to left). Relative depth is shown in shades of blue (background), where dark blue is deeper water.



**Figure 3.10 Typical winter – Peak velocities (m/s)**

### 3.6.4 Vessel Wake

Vessels passing through the Fraser River South Arm include cargo or carrier (including container) vessels, tugs and patrol boats, passenger vessels, service vessels, and fishing vessels. Of these vessels, tugs are expected to generate the largest vessel wake despite their relatively small size.

Typical service speed for tugs ranges between 7 to 10 knots. The top speed for tugs is assumed to be about 12 knots. For a tug travelling at 12 knots in the center of the channel, where the depth is about 15 m and located 200 m away from the project site, the corresponding vessel wake at the edge of the project area is 0.43 m (Table 3.5 and Table 3.6). For the purpose of design, a conservative vessel wake of 0.5 m with a period of 3.2 seconds was assumed.

**Table 3.5 Changes in vessel wake with respect to distance away from shore.**

Distance from Shore (m)	Vessel Speed (kn)	Vessel Wave Height, H (m)	Wave Period, T (sec)
200	12	0.43	3.2
300	12	0.37	3.2
400	12	0.34	3.2

**Table 3.6 Changes in vessel wake with respect to vessel speed.**

Distance from Shore (m)	Vessel Speed (kn)	Vessel Wave Height, H (m)	Wave Period, T (sec)
200	12	0.43	3.2
200	10	0.21	2.7
200	7	0.05	1.9

### 3.7 Selected Parameters

Based on the above analysis, the following parameters have been selected for the design of the brackish tidal marsh habitat on the east side of the Tilbury Island peninsula causeway.

1. Design Life 50 years
2. Design event 50-yr AEP (annual exceedance probability)
3. Sea level rise (SLR) +0.77 m
4. Design water levels

Condition	Water Level (m, CVD28GVRD)	
	Present Day (0.00 m SLR)	Future (+0.77 m SLR)
Lower Low Water (LLW)	-1.68	n/a
Higher High Water (HHW)	2.00	n/a
50-yr Freshet	2.43	3.04
50-yr Freshet (Moderate Climate Change)	2.66	3.22
50-yr Winter	2.68	3.41*

\*Note that the resultant water level is controlled by the hydraulics of the river channel and so does not correspond directly to ocean levels.

5. Design Vessel Wave  $H_s = 0.5 \text{ m}; T_p = 3.2 \text{ s}$
6. Design Flow Velocity 0.3 m/s
7. Materials

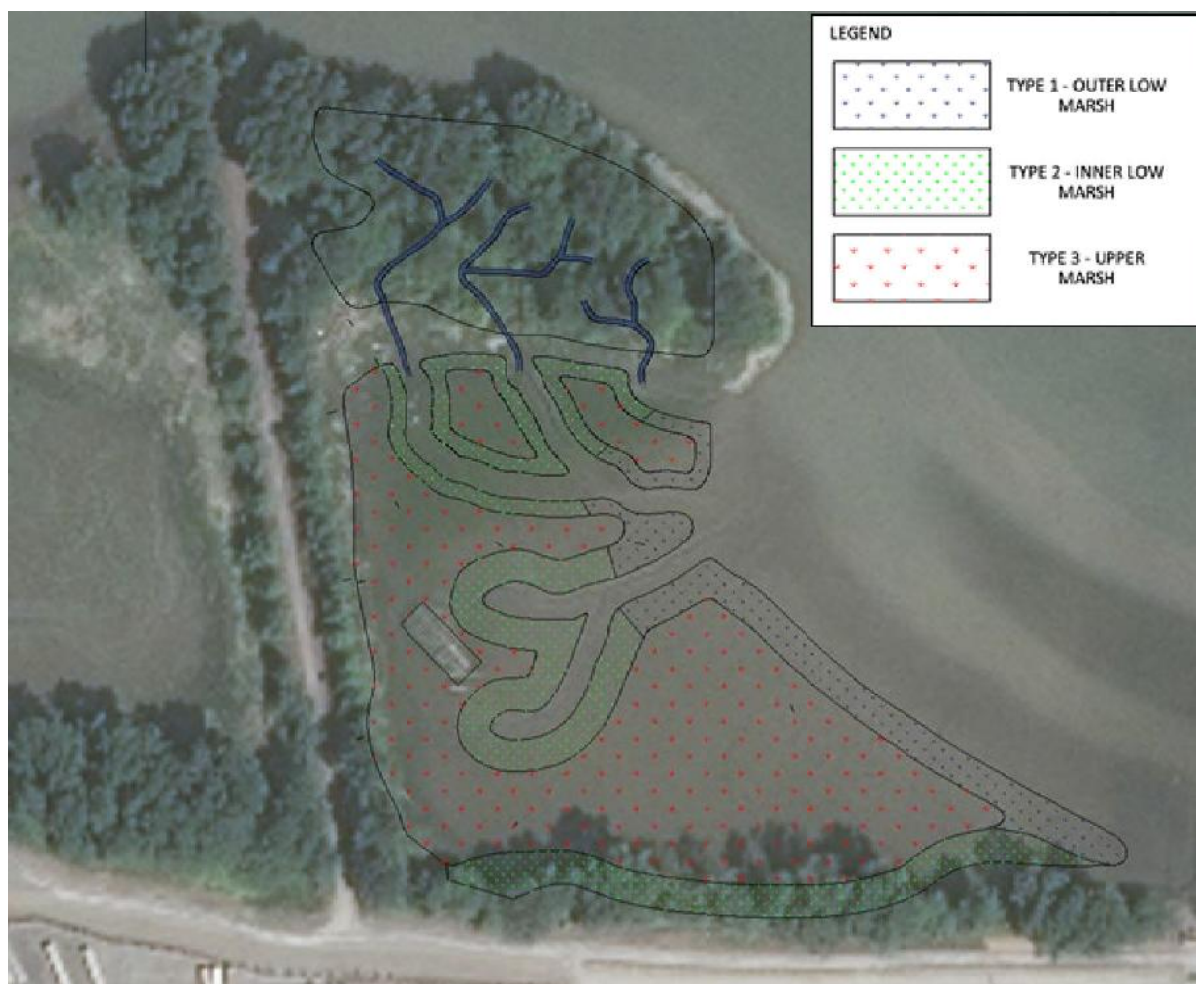
Type	Description	
Class A - Granular Filter Rock	Filter rock with a nominal diameter, $D_n$ , of approximately 100 – 150 mm	
Class B - Riprap	Bulk placed rock with a nominal diameter, $D_n$ , of approximately 250 – 300 mm	
Class C - Marsh Fill	<b>Sieve Size (US Standard)</b>	<b>Gradation (% passing by dry weight)</b>
	2 mm (No. 10)	80 - 100 %
	0.42 mm (No. 40)	45 – 70 %
	0.075 mm (No. 200)	15 – 35 %
	Organic matter	1 – 5 %
	pH	5.5 – 7.0

## 4 PRELIMINARY DESIGN

### 4.1 Layout

#### 4.1.1 Brackish Tidal Marsh

Figure 4.1 shows the plan of the proposed habitat offsetting to develop a brackish tidal marsh habitat on the east side of the Tilbury Island peninsula causeway. The project involves constructing a number of marsh benches with crest elevations between approximately -0.2 to 0.8 m. Sediments will slope up gently to blend in with the existing fringe marsh. The existing tidal channels will be retained to maintain the existing drainage pattern. A channel width of 8 m will be retained, centered on the current channel centerline. An artistic rendering of the marsh is provided in Figure 4.2.



**Figure 4.1 Plan view of the marsh. Refer to Appendix B for the preliminary design drawings.**

A berm will be used around the perimeter of the raised marsh to contain the imported fill. Erosion along the riverside section of the berm is governed by vessel waves and the berm will be constructed of riprap placed on granular filter rock. Along the drainage channels, the berm will consist of only the granular filter rock, since these sections are isolated from vessel waves and are primarily subject to

drainage as the water level rises or recedes. The berms are keyed into the existing marsh substrate to prevent undermining.

A set of preliminary engineering drawings is included in Appendix B.



**Figure 4.2 (Top) Present day conditions at the project site. (Bottom) Artistic rendering of the marsh. Note that the rendering is indicative only.**

#### **4.1.2 Island Channels**

The peninsula island regularly floods and is connected to the east embayment via drainage channels. To improve the link between the two areas, the channels would be excavated to function over a larger range of water levels. The average elevation of the island is 1.7 m. Excavating the channel by up to 1 m to lower the channel bottom elevation to 0.7 m, would significantly increase the duration that the channels are wetted during typical winter and freshet conditions.

The channels would have a bottom width of 1 m and side slopes at 2H:1V. The top width would be up to 5 m wide. Excavated soil could be used to form raised/planted areas near the channel or used as marsh fill (if suitable).

## 4.2 Vegetation

Table 4.1 lists the plants that are proposed to be used to vegetate the marsh. Three mixtures will be used with the planting plan shown in Figure 4.1. Type 1 consists of Baltic rush (*Juncus arcticus*), which will be planted along the riverside marsh edge to provide added protection to plants within the marsh. The table lists the proposed marsh planting species and is subject to further Indigenous Group input.

**Table 4.1 Species mixture and elevation range.**

Type	Species Mixture	Elevation Range (m, CVD28GVRD)
Type 1 Outer Low Marsh	Baltic rush ( <i>Juncus arcticus</i> )	-0.40 – 0.40
Type 2 Inner Low Marsh	Spikerush ( <i>Eleocharis palustris</i> ), jointed rush ( <i>Juncus articulatis</i> )	0.10 – 0.60
Type 3 Upper Marsh	Lyngbye’s sedge ( <i>Carex lyngbyei</i> ), softstem bulrush ( <i>Schoenoplectus tabernaemontani</i> ), common cattail ( <i>Typha latifolia</i> )	0.40 – 0.80

## 4.3 Areas

The approximate footprints of the various project components are summarized in Table 4.2.

**Table 4.2 Approximate project component footprint (areas and lengths).**

Description	Area/length
Marsh (including drainage channels, not including the derelict wooden barge to be retained as a habitat feature)	2.4 ha
Type 1 Outer Low Marsh	0.3 ha
Type 2 Inner Low Marsh	0.5 ha
Type 3 Upper Marsh	1.3 ha
Drainage Channels	0.3 ha
Island	0.7 ha
Island Channel Length (total combined length)	295 m

## 4.4 Construction Method

### 4.4.1 Site Access

The site is accessible from the river via the end of the peninsula. Temporary berthing facilities could be developed to allow delivery of equipment and material. Ground access is also possible via Huston Road

or Berg Road. Ground access will require sections of the dyke to be used, which will require prior consent of the City of Delta.

#### **4.4.2 Construction Access**

It is anticipated that equipment will access the wetland area by constructing ramps from the dyke or connecting road. Water access may provide an additional access route during periods of high tide and low flow. Feasibility of water access will be dependent on the tidal, flow, and weather conditions at the time of construction and contractor equipment availability at the time of construction.

Note that land-based construction has been assumed for the purpose of this report. Details of construction methods and access will be refined further during the ongoing design development process.

#### **4.4.3 Berm Construction**

It is expected that the berm will be constructed by land. Following this method, access to the site would be gained across the mudflats during low tides with limited work windows. It is also expected that the roads/paths would need to be strengthened to prevent vehicles getting stuck. To increase the working window, the contractor may also choose to construct a raised temporary road across the mudflat to allow access over more of the tidal cycle. The vehicle size and loads may be limited. The routes could be optimized so that they would eventually be buried by the marsh fill.

It may be possible to place the berms using water-based equipment (via a barge); however, the daily work window is expected to be very limited given the varying available barge draft (maximum of approximately 2 m).

#### **4.4.4 Marsh Fill**

The proposed marsh fill consists of loamy sand or sandy loam (see Section 3.5.3). Delivery and placement are expected to be undertaken by vehicles using access developed for the berm construction. Alternatively, the area may be filled from water-based equipment by hydraulically pumping fill into containment areas established within the berm system or using a conveyor system from a barge. If pumping wet material, care would need to be taken to manage the water flow from the containment areas. For either method, the top surface of the berm will need to be dressed to form the proper grades, which will likely require ground access.

#### **4.4.5 Vegetation Planting**

The marsh fill material will require time for settlement prior to transplanting marsh vegetation, anticipated to be one month or more. Marsh plantings will consist of outer low marsh using Baltic rush planted at 0.5 m spacing over a 5-10 m wide along the inside of the berm. The main marsh bench will be transplanted with Lyngbye's sedge (*Carex lyngbyei*) as the main species, with patches (30-50 plugs each) of softstem bulrush (*Schoenoplectus tabernaemontani*) and other suitable species that colonize lower South Arm marshes.

## 5 COST ESTIMATE

*Note: This section has been removed (redacted) to protect sensitive information*

## **6 ADDITIONAL CONSIDERATIONS**

### **6.1 Dynamic or ‘Soft’ Techniques**

Dynamic, ‘soft’, or nature-based engineering techniques (such as marsh benches) can have profound benefits to a project in terms of adaptability, aesthetics, and environmental effect; however, they may undergo some reshaping after construction to adjust to incident waves, water levels, and currents. Depending on the coincidence and frequency of storm waves, water levels, and river flows in any given year, the dynamic or ‘soft’ marsh benches will behave slightly differently. The benches are expected to become more stable as planted vegetation establishes. As such, it is generally recommended that an adaptive management approach be taken, and (as with any project) a budget allowance be set-aside for long-term monitoring and maintenance.

### **6.2 Natural Adaptation to Sea Level Rise**

It is typically a requirement that any development projects located within the coastal zone be designed to accommodate future expected sea level rise. However, many habitat enhancement techniques (e.g. vegetation plantings) operate within a narrow range of optimal conditions and must be designed for present-day conditions. The intent of these designs is to allow for natural accumulation of sediment to help keep pace with sea level rise and to allow for sufficient room for vegetation communities to naturally migrate upslope (i.e. avoiding coastal squeeze). This process, in combination with the sloped marsh surface that covers a range of elevations, provides opportunities for adaptation to higher water levels in the future.

### **6.3 Geotechnical Assessment**

The marsh and perimeter berm will be constructed on existing mudflats that deposited relatively recently and rapidly (since approximately the 1960s). These recent deposits may be particularly susceptible to settlement. The design of the marsh references final elevations, which are necessary for the successful growth of the recommended plants. A geotechnical assessment is recommended as part of detailed design to estimate possible settlement and duration since this will affect the amount of material that needs to be placed (to allow for settlement) and the period of time that may be necessary to wait before planting.

### **6.4 Contaminated Soils**

The Tilbury Island project is located in an area subject to considerable historic industrial activity. Although substantial remediation has taken place in recent years, the Port Authority commissioned a Phase 1 Environmental Site Assessment of upland areas within or adjacent to the project site. This assessment was completed in 2020 and identified several areas of potential environmental concern (APECs). The Port Authority is undertaking a review of historical data to further understand the current conditions of these areas. Results from this additional work are expected in winter/spring 2021.

Appropriate management measures will be developed for areas that have the potential to be disturbed during implementation of the proposed works. As part of detailed design beneficial re-use of any excavated material will also be assessed.

## 6.5 Construction Staging and Access

Some aspects of construction access and staging have been outlined in Section 4.4; however, this should be considered further as part of detailed design. In particular, staging and access must consider existing infrastructure (such as dykes, public parks and nearby commercial property) and the preferences of Musqueam.

## 6.6 Construction Scheduling and Phasing

Scheduling and phasing for construction should be considered as part of detailed design. Some initial considerations include the following:

- Work in or near water should generally respect the timing windows for reduced risk set by Fisheries and Oceans Canada (DFO) to avoid harm to fish species. According to the DFO website, for Area 29 (Steveston/Surrey Fraser River estuary from George Massey Tunnel to Mission Bridge), the least risk timing window is June 16 - February 28.
- Work should generally coincide with the tidal work windows and periods of low-flow so that in-water work is avoided as much as possible. To utilize the winter fisheries window, this may require working during the night.
- Prior to planting marsh vegetation, marsh soils should be left for several weeks to months, depending on construction timing and plant growth windows, to allow soils to settle and consolidate prior to transplanting. Marsh elevations should also be measured to confirm that the settled soils are still within the design elevations and additional soil added if necessary.
- Vegetation plugs should be planted in March or April, and as soon as possible after delivery, to avoid plugs drying out. Typically, this means that plugs should be planted within one day of delivery.

## 6.7 Log Accumulation

Log accumulation can occur in both natural and constructed marshes, and has the potential to damage plants. In extreme situations, log accumulations can be excessive and smother marsh vegetation, requiring preventative measures to reduce logs from entering the marsh or implement annual cleanups. However, given the absence of logs at the site, it is not anticipated that log accumulation would negatively impact the Tilbury Island project.

## 6.8 Controlling Geese Grazing

Transplanted marsh consists of species grazed by Canada geese (*Branta canadensis*), which could affect the success of the vegetation establishment. Geese grazing includes cropping above ground growth in the spring as new shoots start to grow as well as seed heads in the summer.

Prior to construction, the potential impact of geese grazing and approaches to control grazing should be considered. To control geese grazing in previous projects, snow fencing has been installed that is supported by wooden posts around the perimeter of the marsh and a rope/caution tape netting tied across the top of the enclosure to prevent geese from flying into the marsh. The enclosures are also susceptible to damage from high winds, floating logs and debris so do require maintenance. Alternative approaches may include allowing geese grazing and only responding if grazing is intense and threatening establishment of the marsh bed.

## **6.9 Control of invasive species**

Many invasive species are widespread within the Fraser River South Arm but one of the most serious is purple loosestrife (*Lythrum salicaria*). This species is now ubiquitous throughout the lower Fraser River and estuary. It is best controlled by manual removal during flowering (i.e. mid to late summer) as part of annual monitoring.

## 7 CLOSURE

The proposed habitat offsetting measures include developing a brackish tidal marsh habitat on the east side of the Tilbury Island peninsula causeway. The proposed project area was identified by a number of Indigenous groups as an important location for habitat enhancement, and was put forward as a Musqueam priority offsetting project to help counterbalance the fish and fish habitat effects of RBT2. The offsetting project is part of Musqueam's multi-pronged approach to offsetting which encompasses many different offsetting initiatives, across different projects.

The primary functional requirements of this project are to improve ecological productivity for estuarine-rearing Pacific salmon, as well as other fish and wildlife species, in alignment with the priorities, preferences, and values of Musqueam. Developing enhanced offsetting habitat within the east embayment, such as the proposed elevated marsh benches, will increase the rate of the natural processes like sediment accretion. In turn, this will result in a more diverse, mature, and productive brackish marsh area, at a faster rate than could occur naturally. A preliminary design has been developed that meets this objective. As such, it is NHC's opinion that the presented design is technically feasible. The following additional work should be undertaken prior to, and as part of, detailed design:

- Develop more detailed construction staging and scheduling plans, including access and staging areas.
- Confirm the degree to which identified areas of potential environmental concern in the surrounding area may influence construction, including material handling and disposal methods.
- Obtain a geotechnical assessment of the amount of settlement that can be expected.

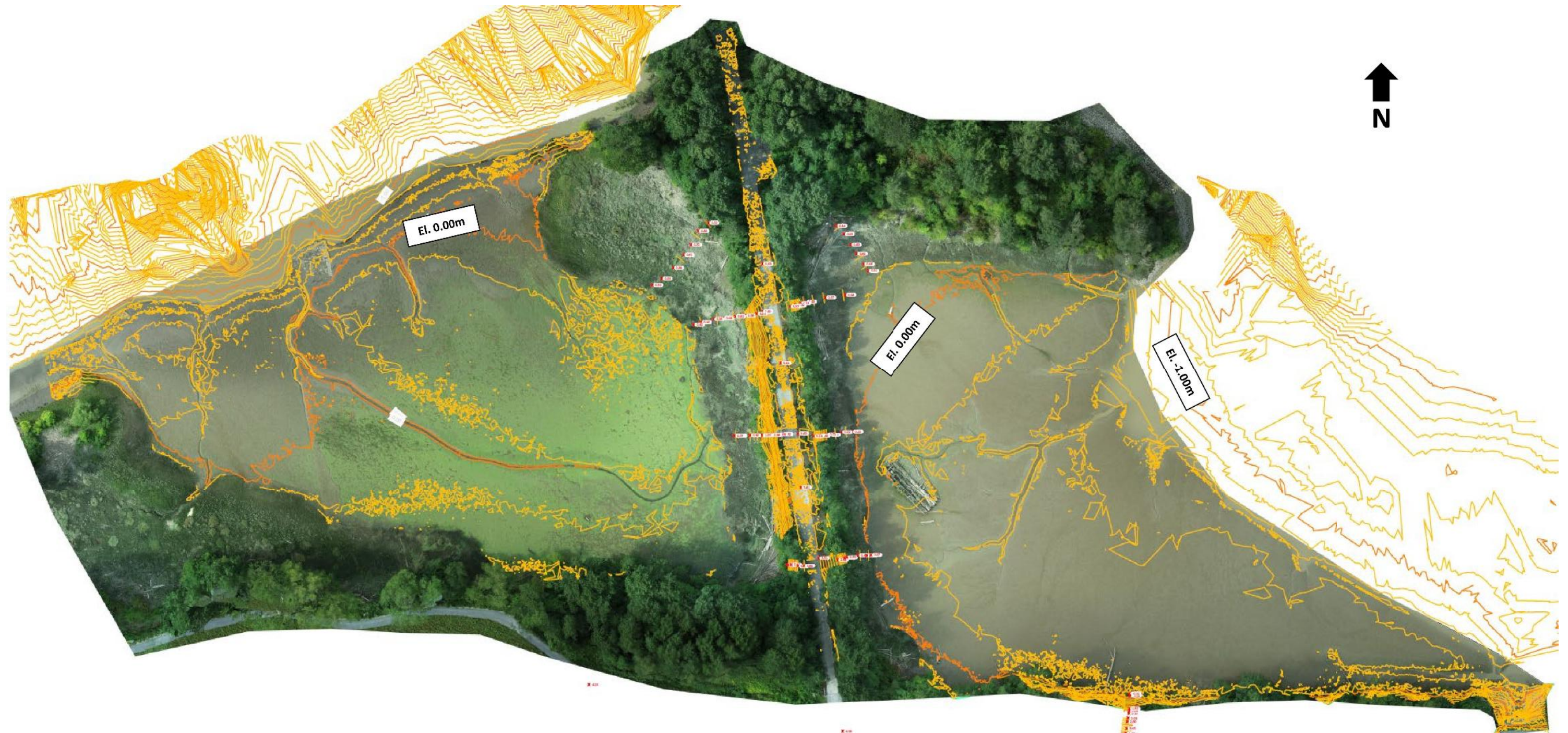
Furthermore, Musqueam should continue to be engaged for further input on the preliminary design, including additional functional requirements, site staging and access constraints, and schedule or phasing considerations.

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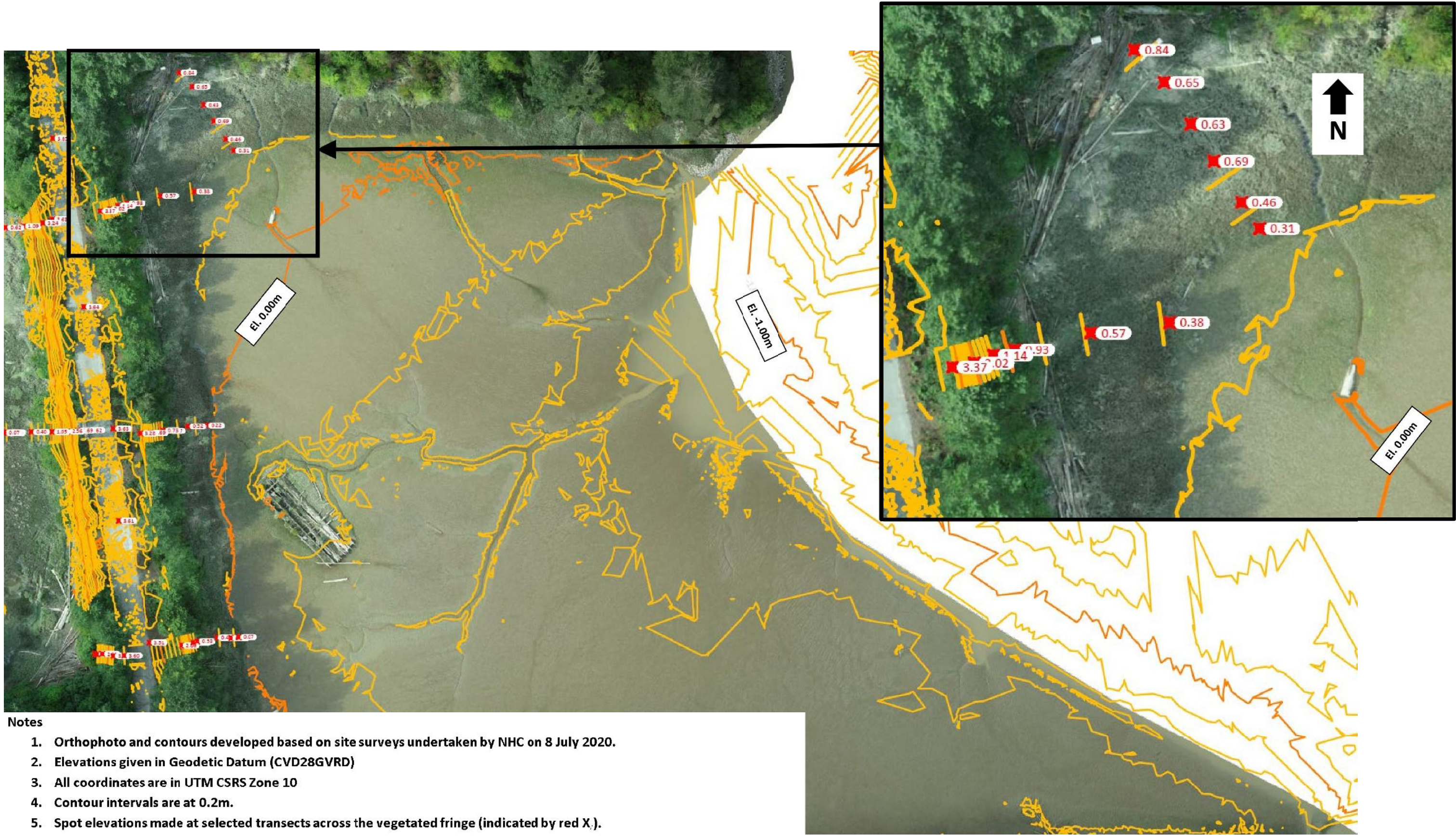
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**Appendix A      Site Surveys**



**Notes**

1. Orthophoto and contours developed based on site surveys undertaken by NHC on 8 July 2020.
2. Elevations given in Geodetic Datum (CVD28GVRD)
3. All coordinates are in UTM CSRS Zone 10
4. Contour intervals are at 0.2m.
5. Spot elevations made at selected transects across the vegetated fringe (indicated by red X; see next page for clearer images).



**Notes**

1. Orthophoto and contours developed based on site surveys undertaken by NHC on 8 July 2020.
2. Elevations given in Geodetic Datum (CVD28GVRD)
3. All coordinates are in UTM CSRS Zone 10
4. Contour intervals are at 0.2m.
5. Spot elevations made at selected transects across the vegetated fringe (indicated by red X).

## **Appendix B      Preliminary Engineering Drawings**

# TILBURY ISLAND PENINSULA ENHANCEMENT PROJECT

## PRELIMINARY DESIGN DRAWINGS

DRAWING INDEX		
SHEET NO.	DESCRIPTION	REVISION
001	COVER SHEET	0
002	GENERAL NOTES	0
101	PLAN VIEW	0
102	PROFILE AND SECTION VIEWS	0



SITE PLAN  
N.T.S.



KEY PLAN  
1:5000

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TILBURY ISLAND PENINSULA ENHANCEMENT PROJECT  
PRELIMINARY DESIGN DRAWINGS  
COVER SHEET

SIZE	DWG.	NO.	SHEET	REV.
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1. GENERAL NOTES

- 1.1. GENERAL
  - 1.1.1. ALL DIMENSIONS ARE IN METERS UNLESS NOTED OTHERWISE.
  - 1.1.2. COORDINATES ARE IN UTM CSRS ZONE 10.
  - 1.1.3. ALL ELEVATIONS ARE TO CVD28GVRD, GEODETIC DATUM IS APPROXIMATELY 1.8m ABOVE CHART DATUM (CD).
  - 1.1.4. ALL ELEVATIONS, DIMENSIONS, AND STATIONING SHALL BE VERIFIED BY THE CONTRACTOR BEFORE CONSTRUCTION BEGINS.
- 1.2. REFERENCES
  - 1.2.1. NHC (2021). TILBURY ISLAND PENINSULA ENHANCEMENT PROJECT. DESIGN BRIEF FOR HABITAT OFFSETTING. DOCUMENT NO. "300044-48 DESIGNREPORT R0".
  - 1.2.2. NHC (2020). ORTHOPHOTO AND CONTOURS FROM NHC SITE SURVEY ON 03 JULY 2020.
- 1.3. DESIGN CRITERIA
  - 1.3.1. DESIGN LIFE: TYP. 50 YEARS
  - 1.3.2. DESIGN EVENT: 1/50 YEAR AEP
  - 1.3.3. DESIGN WATER LEVELS:

CONDITION	WATER LEVEL (M, CVGD28)	
	PRESENT DAY (0.00 M SLR)	FUTURE (0.77 M SLR)
LOW WATER (LW)	-1.68	
HIGH WATER (HW)	2.0	
50-YR FRESHET	2.43	3.04
50-YR FRESHET (MODERATE CLIMATE CHANGE)	2.66	3.22
50-YR WINTER	2.68	3.41

- 1.3.4. DESIGN VESSEL WAVE:  $H_s = 0.5 \text{ m}; T_p = 3.2 \text{ s}$
- 1.3.5. DESIGN FLOW VELOCITY: 0.3 m/s
- 1.4. SCOPE OF WORK
  - 1.4.1. SITE PREPARATION.
  - 1.4.2. SITE SAFETY.
  - 1.4.3. SUPPLY AND PLACEMENT OF REQUIRED MATERIALS.
  - 1.4.4. REMOVAL OF REQUIRED MATERIALS.
  - 1.4.5. MATERIAL DISPOSAL.
  - 1.4.6. SITE CLEAN-UP
- 1.5. SUBMITTALS
  - 1.5.1. DISPOSAL PLAN.
  - 1.5.2. SITE SAFETY PLAN.
  - 1.5.3. TRAFFIC MANAGEMENT PLAN.
  - 1.5.4. SPILL RESPONSE PLAN.
  - 1.5.5. PROJECT SCHEDULE.
  - 1.5.6. SOURCES AND PRODUCT DATA FOR ROCK MATERIALS, SOIL, AND VEGETATION.
  - 1.5.7. WEIGH SLIPS FOR ROCK MATERIALS SOURCED OFF-SITE.

2. MATERIALS

- 2.1. GENERAL
  - 2.1.1. ALL MATERIAL SHALL BE FROM A SOURCE APPROVED BY THE ENGINEERING REPRESENTATIVE AT LEAST 1 WEEK PRIOR TO DELIVERY.
  - 2.1.2. EXCAVATED OR REMOVED MATERIALS SHALL BE REUSED WHERE MATERIAL OF A LIKE COMPOSITION IS REQUIRED FOR THIS WORK, UNDER THE DIRECTION OF THE ENGINEERING REPRESENTATIVE.
- 2.2. ROCK
  - 2.2.1. ROCK MATERIAL SHALL BE DENSE, HARD, DURABLE CHARACTER, FREE OF ORGANIC MATERIAL, IN-FILLED JOINTS, SEAMS OR OTHER DEFECTS, RESISTANT TO BREAKDOWN BY HANDLING, FROST ACTION OR WEATHER, AND NOT SUBJECT TO DETERIORATION IN SEA WATER.
  - 2.2.2. ROCK MATERIAL SHALL BE ROUGH ANGULAR QUARRIED STONE (WITH THE EXCEPTION OF CLASS E ROCK), WITH A UNIT DENSITY NOT LESS THAN 2,600  $\text{Kg/m}^3$ .
  - 2.2.3. ROCK MATERIAL MUST BE ROUGHLY EQUIDIMENSIONAL, WITH THE MAXIMUM DIMENSION NOT MORE THAN 2.5 TIMES THE MINIMUM DIMENSION.
  - 2.2.4. ROCK MATERIAL TYPES ARE PROVIDED BELOW:

TYPE	DESCRIPTION
CLASS A - GRANULAR FILTER ROCK	FILTER ROCK WITH A NOMINAL DIAMETER, $D_n$ , OF APPROXIMATELY 100 - 150 mm
CLASS B - RIPRAP	BULK-PLACED ROCK WITH A NOMINAL DIAMETER, $D_n$ , OF APPROXIMATELY 250 - 300 mm

- 2.3. SAND/GRAVEL FILL
  - 2.3.1. ROCK INCLUDED IN FILL MATERIALS SHALL BE DENSE, HARD, DURABLE CHARACTER, RESISTANT TO BREAKDOWN BY HANDLING, FROST ACTION OR WEATHER, AND NOT SUBJECT TO DETERIORATION IN SEA WATER.
  - 2.3.2. ROCK INCLUDED IN FILL MATERIALS SHALL BE ROUNDED AND SUB-ROUNDED STONE OF FLUVIAL OR GLACIAL ORIGIN.
  - 2.3.3. SAND/GRAVEL FILL MATERIAL TYPES ARE PROVIDED BELOW:

TYPE	DESCRIPTION
CLASS C - MARSH FILL	SANDY LOAM FILL, WITH A MINIMUM OF 5% ORGANIC MATERIAL, SIMILAR IN COMPOSITION TO THE EXISTING MARSH MAKE-UP, MEDIAN DIAMETER, $D_{50}$ , BETWEEN 0.1 - 1.0 mm, pH BETWEEN 5.5 - 7.0.

- 2.3.4. CLASS C MATERIAL SHALL BE GRADED WITHIN THE LIMITS PROVIDED BELOW:

SIEVE SIZE (US STANDARD)	GRADATION (% PASSING BY DRY WEIGHT)
2mm (No. 10)	80 - 100%
0.42 (No. 40)	45 - 70%
0.075 (No. 200)	15 - 35%
ORGANIC MATTER	1 - 5%

2.4. TOPSOIL

- 2.4.1. TOPSOIL SHALL BE SUPPLIED AND INSTALLED ONLY UNDER THE DIRECTION OF THE ENVIRONMENTAL MONITOR TO SUPPORT VEGETATION GROWTH.
- 2.4.2. TOPSOIL SHALL BE FERTILE LOAMY SOIL WITH A MINIMUM OF 2% ORGANIC MATERIAL.
- 2.4.3. SOIL SHALL BE FREE FROM DELETERIOUS MATERIAL, SUCH AS LARGE ROOTS, ROCKS, GARBAGE/DEBRIS, HEAVY CLAYS, NOXIOUS WEEDS, ETC. WHICH MAY ADVERSELY AFFECT ITS SUITABILITY FOR PLANTING NATIVE VEGETATION.

2.5. VEGETATION

- 2.5.1. VEGETATION SHALL BE SUPPLIED AND INSTALLED BY THE CONTRACTOR UNDER THE DIRECTION OF THE PROJECT ENVIRONMENTAL MONITOR.
- 2.5.2. TRANSPORT, HANDLING, AND STORAGE OF VEGETATION SHALL BE AS PER MANUFACTURER INSTRUCTIONS OR THE PROJECT ENVIRONMENTAL MONITOR.
- 2.5.3. PROTECT VEGETATION/PLUGS/SEEDS FROM ADVERSE EFFECTS FROM MOISTURE, SUNLIGHT, ULTRAVIOLET LIGHT, OR WEATHER DURING STORAGE AT THE WORK SITE.
- 2.5.4. VEGETATION SHALL INCLUDE A MIX OF SPECIES BASED ON THE ACHIEVED ELEVATION, AS PROVIDED BELOW:

TYPE	SPECIES MIXTURE	ELEVATION RANGE (m, CGVD28)
TYPE 1 - OUTER LOW MARSH	BALTIC RUSH ( <i>JUNCUS ARCTICUS</i> )	-0.40 - 0.10 m
TYPE 2 - INNER LOW MARSH	SPIKERUSH ( <i>ELEOCHARIS PALUSTRIS</i> ), JOINTED RUSH ( <i>JUNCUS ARTICULATIS</i> )	0.10 - 0.40 m
TYPE 3 - UPPER MARSH	LYNGBYE'S SEDGE ( <i>CAREX LYNGBYEI</i> ), SOFTTAIL BULRUSH ( <i>SCHOENOPLECTUS TABERNAEMONTANI</i> ), COMMON CATTAIL ( <i>TYPHA LATIFOLIA</i> )	0.40 - 0.80 m

3. EXECUTION

- 3.1. PROJECT TIMING
  - 3.1.1. TO BE ESTABLISHED DURING DETAILED DESIGN.
- 3.2. STAGING AREA, SITE ACCESS, & CONSTRUCTION ZONE
  - 3.2.1. TO BE ESTABLISHED DURING DETAILED DESIGN.
- 3.3. SITE PREPARATION
  - 3.3.1. AS MUCH AS POSSIBLE, EXISTING NATIVE VEGETATION SHALL BE PROTECTED. IF VEGETATION IS TO BE DISTURBED, IT SHOULD BE HANDLED SUCH THAT IT CAN BE RE-PLANTED. ALL SUCH VEGETATION HANDLING SHALL BE AS DIRECTED BY THE ENVIRONMENTAL MONITOR.
  - 3.3.2. SALVAGE DRIFT-WOOD THAT IS PRESENT IN THE WORK AREA OR MACHINE ACCESS ROUTES PRIOR TO WORKS.
- 3.4. DISPOSAL
  - 3.4.1. ALL REMOVED MATERIALS, INCLUDING CONTAMINATED MATERIALS, SHALL BE DISPOSED OF OFF-SITE, IN APPROPRIATE DISPOSAL FACILITIES, IN ACCORDANCE WITH LOCAL LAWS AND REGULATIONS.
- 3.5. SITE CLEANUP
  - 3.5.1. ANY DISTURBED ACCESS AND STAGING AREAS SHALL BE RETURNED TO THE SAME CONDITION AS FOUND.
  - 3.5.2. ALL EXCESS MATERIALS AND DEBRIS SHALL BE REMOVED FROM THE PROJECT AREA.
  - 3.5.3. ALL SALVAGED DRIFT-WOOD SHALL BE REINSTATED TO ITS ORIGINAL STATE TO THE SATISFACTION OF THE ENVIRONMENTAL MONITOR.
- 3.6. ENVIRONMENT
  - 3.6.1. ALL ACTIVITIES, INCLUDING THE STORAGE OF MATERIALS, HANDLING OF FUELS AND EQUIPMENT OPERATION SHALL BE CONDUCTED IN ACCORDANCE WITH ENVIRONMENTAL PERMITS.
  - 3.6.2. THE ENVIRONMENTAL MONITOR SHALL HAVE THE AUTHORITY TO IMMEDIATELY STOP WORK, OR DIRECT CHANGES TO ACTIVITY TO PROTECT THE ECOLOGICAL VALUES.
  - 3.6.3. THE CONTRACTOR SHALL WORK IN CO-OPERATION OF THE ON-SITE ENVIRONMENTAL MONITOR. THE ENVIRONMENTAL MONITOR SHALL BE IMMEDIATELY NOTIFIED OF ANY SPILLS, EQUIPMENT FAILURES OR REPAIR WORK THAT OCCURS ON SITE.
  - 3.6.4. WORK SHALL BE LIMITED TO TIMES WHEN ALL ACTIVITIES CAN BE CARRIED OUT IN THE DRY. NO EQUIPMENT SHALL BE OPERATED IN TIDAL WATER, OR WHEN THE WATER IS WITHIN 2 m (HORIZONTALLY) OF ANY ACTIVITY.
  - 3.6.5. IF NECESSARY, THE CONTRACTOR SHALL USE UTILIZE SWAMP PADS (OR SIMILAR) TO PREVENT RUTTING AND/OR COMPACTION OF MATERIALS WITHIN THE INTERTIDAL ZONE.
  - 3.6.6. ALL MACHINERY SHALL BE IN GOOD WORKING CONDITION WITH NO VISIBLE PETROLEUM PRODUCT DISCHARGES.
  - 3.6.7. ALL MACHINERY WORKING IN OR AROUND THE INTERTIDAL AREA SHALL USE ENVIRONMENTALLY SENSITIVE, BIODEGRADABLE, AND INERT HYDRAULIC FLUID.
  - 3.6.8. SPILL KITS SHALL BE MADE AVAILABLE FOR IMMEDIATE USE, AND PERSONNEL SHALL BE AWARE OF THEIR LOCATIONS AND TRAINED IN THEIR USE.
  - 3.6.9. ALL MAINTENANCE AND FUELING SHALL BE COMPLETED ONLY IN THE STAGING AREA. ANY EMERGENCY REPAIRS SHALL, IF POSSIBLE, BE COMPLETED OUTSIDE OF THE FORESHORE. IF NOT POSSIBLE, EVERY EFFORT SHALL BE MADE TO PREVENT AND MINIMIZE ALL ENVIRONMENTAL IMPACTS.
  - 3.6.10. NO MACHINERY SHALL BE LEFT ON THE FORESHORE OUTSIDE OF THE ACTIVE DAILY CONSTRUCTION TIMING.
  - 3.6.11. NO EXCAVATED SLOPES SHALL BE LEFT UNCOVERED OUTSIDE OF THE ACTIVE DAILY CONSTRUCTION TIMING.
  - 3.6.12. ALL WASTE, LITTER, AND OTHER DEBRIS SHALL BE COLLECTED AND DISPOSED OF ON A DAILY BASIS, MAINTAINING A CLEAN, SAFE WORKSITE, THAT IS SAFE FOR THE PUBLIC AND FREE OF GARBAGE.
- 3.7. PUBLIC SAFETY
  - 3.7.1. PUBLIC SAFETY AND CONVENIENCE SHALL BE PRESERVED THROUGHOUT THE PROJECT.
  - 3.7.2. THE WORK AREA IS LOCATED WITHIN A PUBLICLY ACCESSIBLE AREA, IT IS ANTICIPATED THAT THERE MAY BE A PUBLIC PRESENCE AROUND THE CONSTRUCTION SITE.
  - 3.7.3. THE CONTRACTOR SHALL DELINEATE THE ACTIVE WORK AREA AND TAKE ALL MEASURES TO PROTECT THE PUBLIC. THIS MAY INCLUDE SIGNAGE, FENCING, AND SAFETY PERSONNEL ON SITE AS REQUIRED BY BEST MANAGEMENT PRACTICES.

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**TILBURY ISLAND PENINSULA ENHANCEMENT PROJECT**  
**PRELIMINARY DESIGN DRAWINGS**  
**GENERAL NOTES**

Ref. No.	REFERENCE

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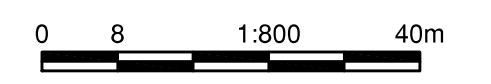
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	TYPE 1 - OUTER LOW MARSH
	TYPE 2 - INNER LOW MARSH
	TYPE 3 - UPPER MARSH

- PROJECT NOTES**
1. THE DERELICT BARGE AT THE WESTERN EDGE OF THE PROJECT SITE WILL BE RETAINED WITH THE MARSH CONSTRUCTED AROUND IT.
  2. THE RIVERSIDE EDGE OF THE OUTER MARSH WILL BE CONSTRUCTED OF SMALL ANGULAR ROCK SUFFICIENTLY SIZED TO RESIST WAVES FROM VESSEL WAKES. THE INSIDE EDGES OF THE MARSH WILL BE CONSTRUCTED USING SMALL ROUNDED MATERIAL.
  3. THE MARSH FRINGE VARIES BETWEEN 5.0 - 10.0 m TO ACCOMMODATE SPACE RESTRICTIONS REQUIRED TO MAINTAIN THE EXISTING DRAINAGE CHANNEL ALIGNMENTS.
  4. MATERIALS AND CONSTRUCTION ACCESS POINTS WILL BE VIA BARGE AT THE NORTH END OF THE SITE ON THE FRASER RIVER, FROM RIVER ROAD VIA THE DYKE, AND FROM WATER AT THE EASTERN EDGE OF THE PROJECT SITE.

DESCRIPTION	AREA
MARSH (INCLUDING DRAINAGE CHANNELS NOT INCLUDING BARGE TO BE RETAINED)	2.4 Ha
TYPE 1 OUTER LOW MARSH	0.3 Ha
TYPE 2 INNER LOW MARSH	0.5 Ha
TYPE 3 UPPER MARSH	1.3 Ha
DRAINAGE CHANNELS	0.3 Ha
ISLAND	0.7 Ha
ISLAND CHANNEL LENGTH	295 m

5444100  
 5444000  
 5443900  
 5443800



499000      499100      499200      499300      499400

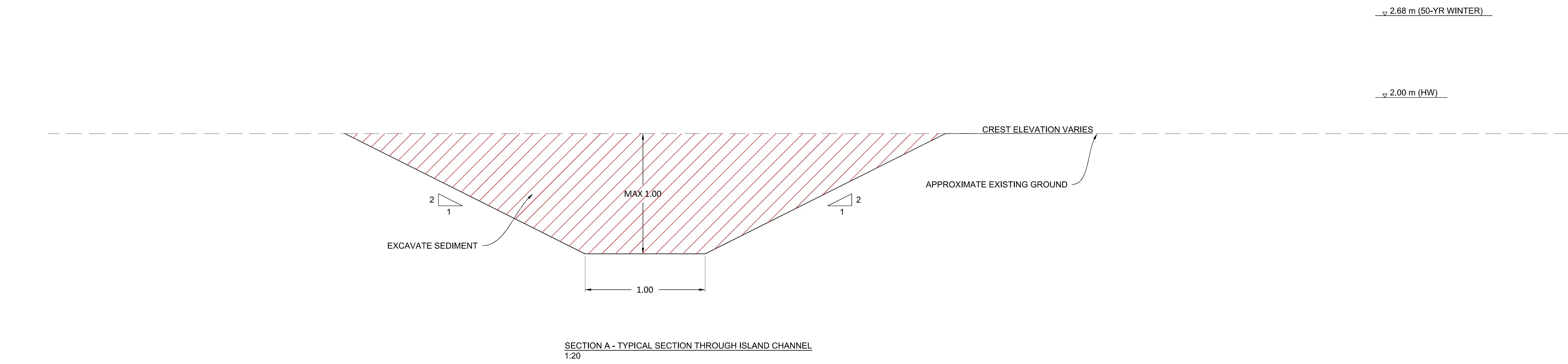
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**TILBURY ISLAND PENINSULA ENHANCEMENT PROJECT  
 PRELIMINARY DESIGN DRAWINGS  
 PLAN VIEW**

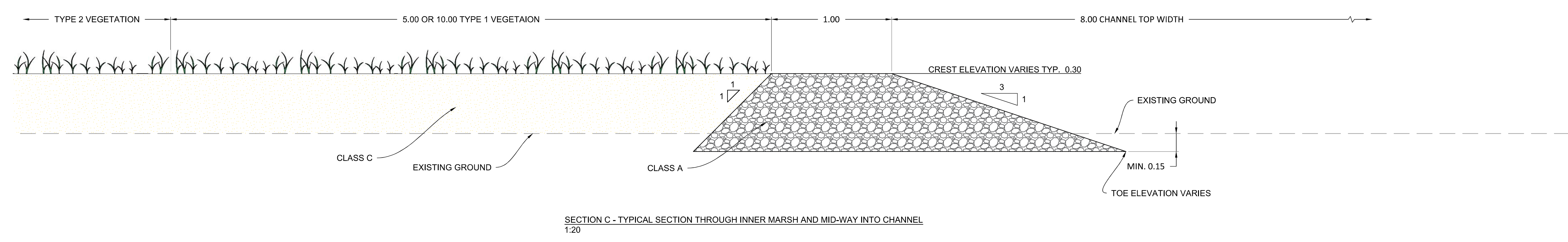
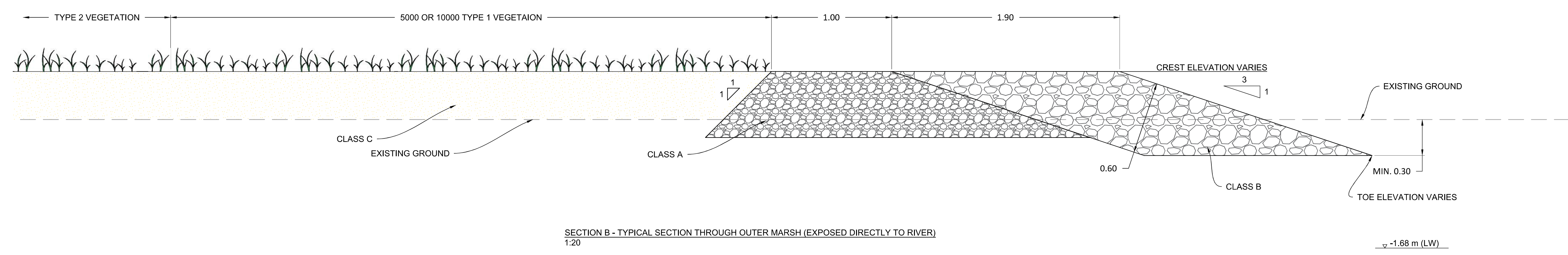
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LEGEND

	EXCAVATION
	CLASS A - GRANULAR FILTER ROCK
	CLASS B - RIPRAP
	CLASS C - MARSH FILL



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**TILBURY ISLAND PENINSULA ENHANCEMENT PROJECT**  
**PRELIMINARY DESIGN DRAWINGS**  
**SECTION VIEWS**

**Appendix IR2020-1.1-A23**  
**Existing Ecological Conditions Report:**  
**Tilbury Island Peninsula Enhancement**  
**Project**

# Existing Ecological Conditions Report: Tilbury Island Peninsula Enhancement Project

Roberts Bank Terminal 2 Project

Vancouver Fraser Port Authority

February 2021

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Revision	Revision date	Details	Authorized	Name	Position

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# 1. Introduction

## 1.1 Background

The Vancouver Fraser Port Authority (port authority) is developing a fish habitat offsetting plan to support an application for *Fisheries Act* Authorization (FAA) for the Roberts Bank Terminal 2 Project (RBT2). The Tilbury Island Peninsula Enhancement Project (Tilbury Project) is one of the fish habitat offsetting projects currently being advanced as part of the RBT2 offsetting plan. The Tilbury Project was identified by a number of Indigenous groups, including Musqueam Indian Band (Musqueam), Tsuu-baa-asatx First Nation and Cowichan Nation Alliance, as an important location for habitat enhancement, and was put forward as a Musqueam priority RBT2 offsetting project.

## 1.2 Project Location and Context

Tilbury Island is located in the South Arm of the Fraser River, in Delta, British Columbia (BC), and is separated from the mainland of Delta by Tilbury Slough. The slough connects with the Fraser River at both upstream and downstream ends. The Tilbury Project is located approximately 20 km upstream of the Fraser River mouth and Strait of Georgia, on Provincial Crown land situated east (upstream) of a peninsula causeway that protrudes north from the upstream end of Tilbury Island (Figure 1). The Tilbury Project area is located to the east of this peninsula causeway (Figure 2). The latitudinal and longitudinal coordinates at the centre of the site are 49.148392°N, -123.012719°W.

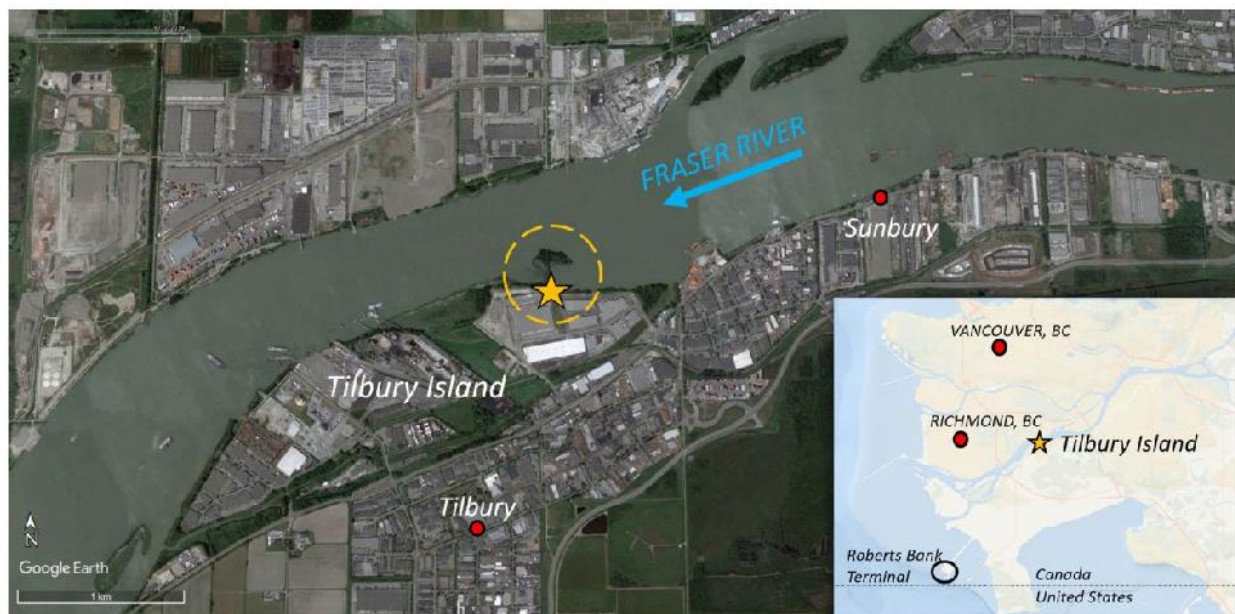


Figure 1: Tilbury Project Location



**Figure 2: Tilbury Project Area**

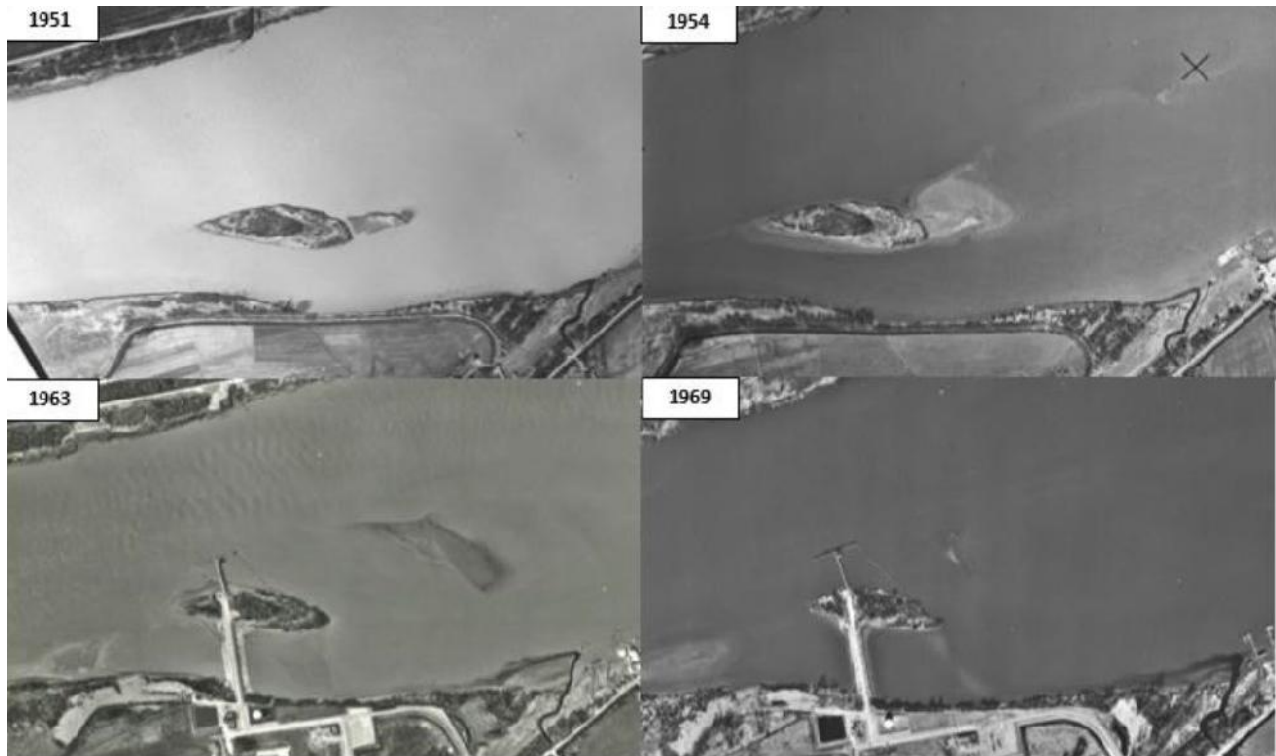
The site is accessible via a gravel road along the dyke (Figure 3) and the paved peninsula causeway (Figure 4), which in turn are accessible via Huston Road on Tilbury Island. The peninsula causeway was constructed between 1954 and 1963 based on a review of aerial imagery (Figure 5; NHC 2021).



Figure 3: West View of Dyke Road to the South of the Tilbury Project Area (Taken July 3, 2020)



**Figure 4: North View Along the Peninsula Causeway to the West of the Tilbury Project Area (Taken July 3, 2020)**



**Figure 5: Historical Aerial Imagery of the Tilbury Project Area (NHC 2021)**

Industry, agriculture and other anthropogenic activity have dominated the foreshore of Tilbury Island for many decades, resulting in the loss of saltmarsh, riparian and back channel habitat. Today, Tilbury Island is a highly developed industrial area, with approximately 80% of the land used for industrial activities, including the existing Lehigh cement plant, the FortisBC Tilbury LNG Plant, Dynacor Coatings Ltd., and several manufacturing and retail businesses, including those in the Tilbury Island Industrial Park. The port authority also operates an annual dredging program in this reach of the Fraser River. Dredging the river maintains the navigation channel and enables the safe passage of marine vessels. The Fraser River Estuary Management Program (FREMP) documented numerous fish habitat offsetting activities (formerly known as “compensation”) having been implemented in the vicinity of the Tilbury Project in the last four decades (Figure 6), including:

- Modalink Vancouver Gateway Distribution Hub Ltd. creation of riparian habitat
- Fraser Richmond Landfill compensation site
- Fraser River Harbour Commission marsh lagoon creation
- C.P. Rail Systems marsh bench with riprap berm
- Kozul Holdings Inc. riparian habitat creation
- Department of Fisheries and Oceans Tilbury Slough Restoration Project
- The City of Delta riparian vegetation replanting in Tilbury Slough
- Linwood Homes Ltd. compensation site



**Figure 6: Historical Compensation Sites in the Vicinity of the Tilbury Project (FREMP n.d.; red polygons denote past compensation sites and the red star represents the Tilbury Project location)**

### 1.3 Project Design

Habitat enhancement is proposed through the development of 2 ha to 4 ha of brackish marsh and off-channel habitat (NHC 2021). The Tilbury Project would focus on enhancing existing lower-value unvegetated intertidal flat into expanded higher-value brackish intertidal marsh habitat (Figure 7) that matches the existing fringing marsh community (Figure 8). This would be achieved through the construction of a containment berm, the placement of fill behind it to create a marsh bench, followed by the planting of that bench with suitable marsh species that reflect the existing marsh community in the area (NHC 2021). The project is expected to benefit a range of fish and wildlife, particularly estuarine-rearing juvenile salmon which use marsh habitats in the Fraser River estuary for anywhere from weeks to months to feed, rear, and take refuge prior to migrating to the marine environment, and are of cultural importance and priority to Indigenous groups.

As identified by Musqueam during a July 2020 collaborative site visit, an opportunity also exists to create off-channel habitat in a low-lying area of the eastern portion of the peninsula island (sometimes referred to as Duck Island (Figure 9). This off-channel habitat is proposed to be integrated into the marsh habitat design.



Figure 7: Proposed Tilbury Project Preliminary Design Layout (Northwest Hydraulic Consultants 2020)



**Figure 8: North View of Existing Fringing Intertidal Marsh Habitat and Unvegetated Intertidal Flat on the Western Edge of the Tilbury Project Area (Taken July 3, 2020; vegetated derelict wooden barge visible)**



**Figure 9: South View of the Periodically Flooded Low-lying Area on the Eastern Side of Duck Island (Taken July 3, 2020; proposed area for off-channel habitat creation)**

## 1.4 Project Rationale

An estimated seventy percent of Fraser River estuary wetlands, marshlands and riparian areas have been diked, drained, or filled for land development purposes (Government of BC, 2006). Given that the Fraser River supports over half of BC's salmon population, making it one of the largest salmon production systems in the world, historic development of the estuary has had a significant impact on the aquatic habitat available to salmon within the province (Henderson and Graham 1998; Northcote and Larkin 1989). In turn, historic development of the estuary has also impacted plant communities, birds, and other wildlife. In this context, the proposed Tilbury Project is considered to provide high-quality habitat for fish and wildlife at an important location within the lower Fraser River and estuary that will complement previous offsetting and enhancement efforts undertaken in the area.

## 1.5 Purpose and Structure of this Report

A range of investigative work and technical studies is being carried out to inform the development of the Tilbury Project. This particular report was prepared to characterize the existing ecological conditions of the project area based on consideration of historical aerial photography and mapping, desktop studies, and field visits. Subsequent sections provide descriptions of existing ecological conditions in respect of vegetation, fish, and wildlife communities, habitats, and species.

## 2. Existing Ecological Conditions

### 2.1 Information Sources

A desktop review of the following existing sources of information was undertaken to summarize existing ecological conditions in the project area:

- Habitat Wizard (Government of BC, 2020a)
- BC Fisheries Inventory Data Queries (Government of BC, 2020b)
- BC CDC Species and Ecosystems Explorer (Government of BC, 2020c)
- City of Delta Online Mapping System – DeltaMap (City of Delta, 2021)
- Fraser River Estuary Management Program Atlas (FREMP n.d.)
- Committee on the Status of Endangered Wildlife in Canada (COSEWIC) Assessment and Status Reports
- Species at Risk Public Registry
- Sensitive Habitat Inventory and Mapping database (SHIM, 2020)
- Published literature on general ecology and population dynamics of relevant species and habitat
- Consultant reports prepared in support of environmental assessments of other development projects in the Fraser River estuary
- Governmental papers and technical reports

In addition to desktop studies, field assessments have been conducted to collect existing ecological information to support the design of the Tilbury Project. These field assessments have focussed on determining the community composition and elevation of existing high-value marsh habitat around the edge of the site, which the Tilbury Project seeks to expand. Specifically, the following two field assessments were conducted:

- A preliminary site visit which was conducted by port authority consultants<sup>1</sup> in collaboration with Musqueam on July 3, 2020
- Bathymetric, drone, and marsh transect surveys which were conducted by port authority consultants on July 8, 2020

### 2.2 Physical Setting

Tilbury Island is located within the Coastal Douglas Fir Moist Maritime (CDFmm) biogeoclimatic subzone (Figure 10; Government of BC 2021). The CDFmm is found along southeastern Vancouver Island and in the southwestern portion of the lower mainland; also included are many islands in the Strait of Georgia. The CDF is limited to elevations below 150 m. Because it lies in the rain shadow of the Olympic and Vancouver Island mountains, it is drier than the surrounding Coastal Western Hemlock Zone, which is found to the north and to the east on Vancouver Island and to the north and to the east on the mainland. The CDF is characterized by warm, dry summers and mild, wet winters (Nuszdorfer et al. 1991).

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<sup>1</sup> Ravi Chatterji (AECOM), Gary Williams (GL Williams and Associates), Jemma Scoble (Jemma Scoble Consulting), and Bruce Walsh and Derek Ray (Northwest Hydraulic Consultants) attended.

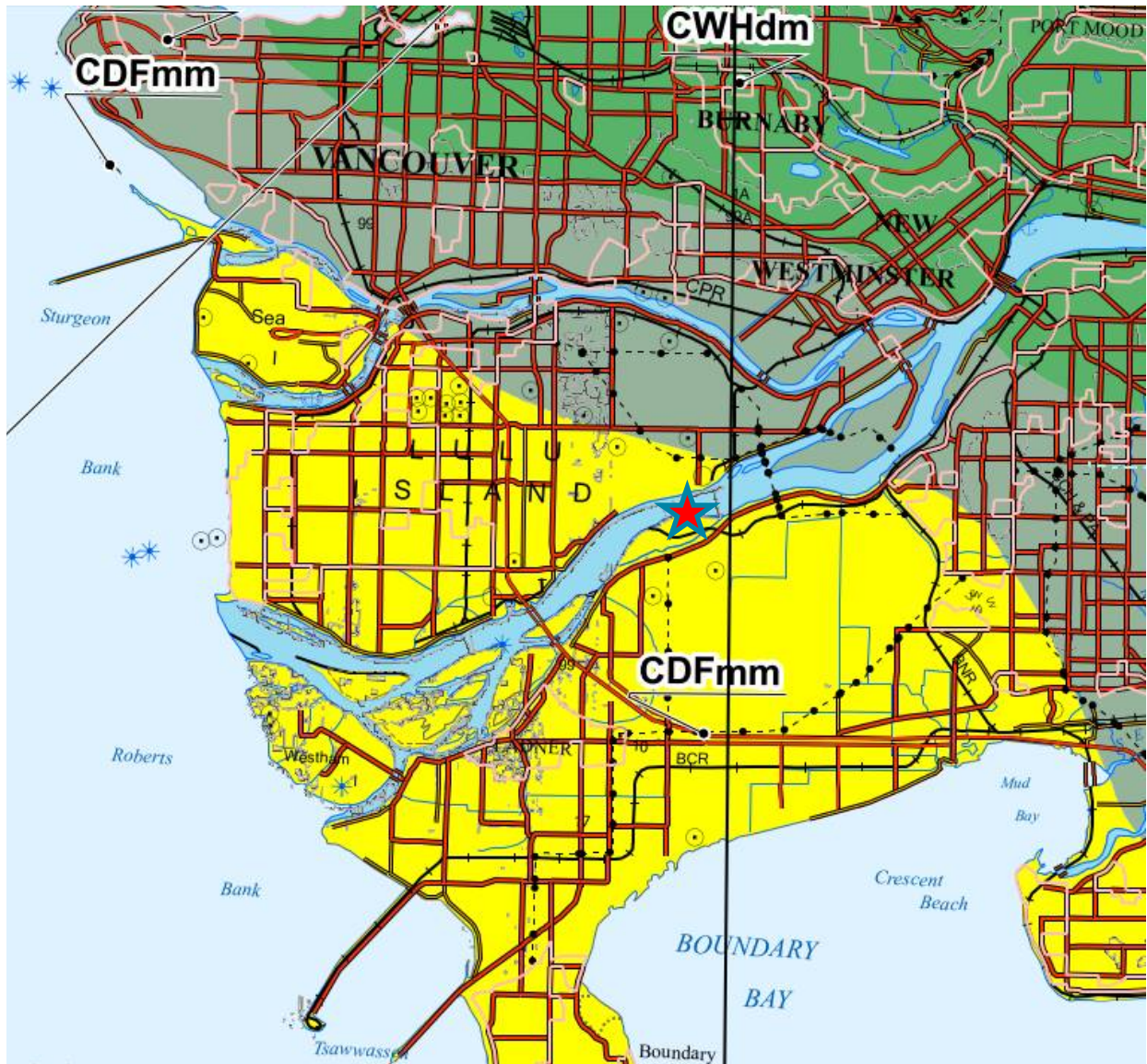
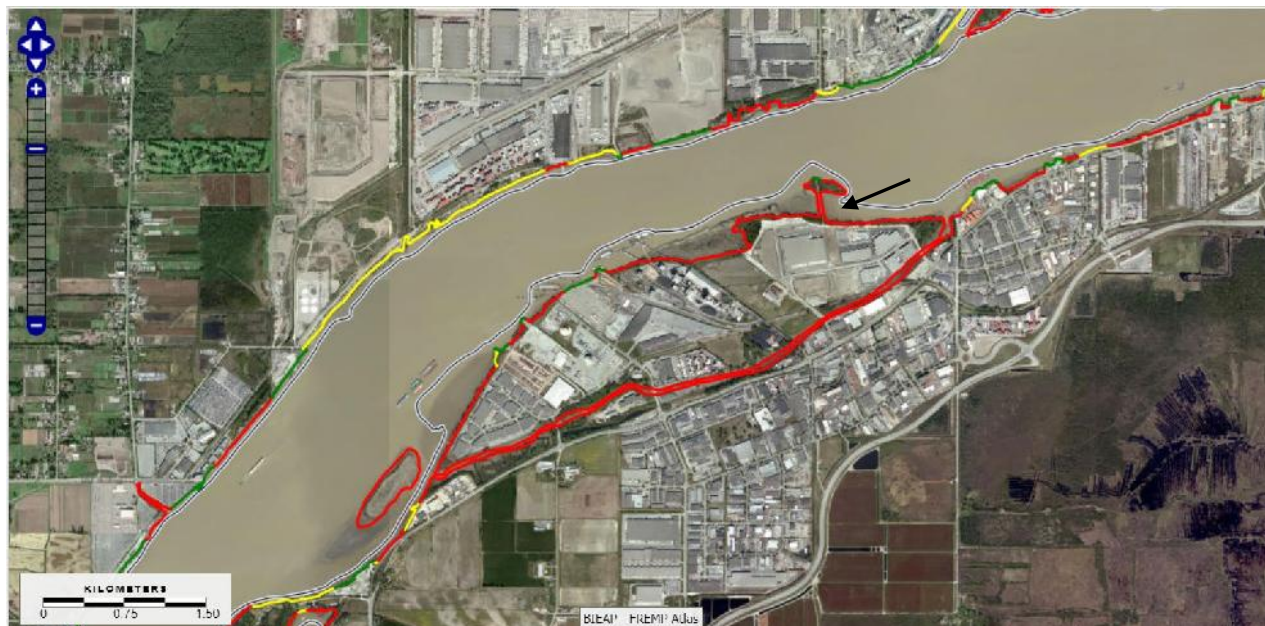


Figure 10: Biogeoclimatic Zones of the Tilbury Project and Surrounding Areas (Government of British Columbia 2021; Tilbury Project location represented by red star)

## 2.3 Habitat Classification

Shoreline habitats of the Fraser River estuary have been classified based on relative value by FREMP, including at and around the Tilbury Project area (Figure 11). Habitat features were assigned a value of high, moderate, or low productivity and this information is made available through the Community Mapping Network (FREMP n.d.). Red-coded shorelines are considered productive and diverse in their current state, contributing to critical fish and wildlife functions. Yellow-coded shorelines are considered to have moderate value and diversity (e.g., due to current conditions or surrounding land use operations). Green-coded shorelines are considered of low productivity (e.g., areas which have been highly modified for industrial or urbanized uses).



**Figure 11: FREMP Habitat Classification at the Tilbury Project and Surrounding Areas (FREMP n.d.; Tilbury Project location represented by black arrow; red, yellow, and green linework denotes high, moderate, and low productivity shoreline habitat, respectively)**

The shoreline around the edge of the eastern embayment is classified as high productivity habitat (FREMP 2016 habitat classification layer), reflecting the existing fringing marsh habitat in that area which the Tilbury Project seeks to expand. The shoreline at the tip of the peninsula to the north is classified as low productivity habitat.

## 2.4 Vegetation Communities

Existing terrestrial vegetation communities in the Tilbury Project area comprises a mix of riparian trees and shrubs along with deciduous or mixed woodland forests further from shore (FREMP n.d.; Figure 12), including the following species:

- Black cottonwood (*Populus trichocarpa*)
- Red alder (*Alnus rubra*)
- Red osier dogwood (*Cornus sericea*)
- Western red cedar (*Thuja plicata*)
- Thimbleberry (*Rubus parviflorus*)

Existing marsh vegetation communities (Figure 12) around the edge of the eastern embayment are dominated by Lyngbye's sedge (*Carex lyngbyei*), Baltic rush (*Juncus balticus*), softstem bulrush (*Schoenoplectus tabernaemontani*), hardstem bulrush (*Schoenoplectus acutus*), common spike rush (*Eleocharis palustris*), and pointed rush (*Juncus oxymeris*). The area proposed for marsh expansion is lower value unvegetated intertidal sand and mud flat.

One rare plant species, Vancouver Island beggarticks (*Bidens amplissima*) has previously been located within the vicinity of the site (Government of BC, 2020a; iMapBC 2021).



Figure 12: FREMP Habitat Inventory at the Tilbury Project and Surrounding Areas (FREMP n.d.; Tilbury Project location represented by red star)

### 2.4.1 Invasive Plant Species

Several invasive species have been detected on Tilbury Island within the vicinity of the Tilbury Project (Government of BC, 2020a), including the following:

- Black locust (*Robinia pseudoacacia*)
- Bull thistle (*Cirsium vulgare*)
- Butterfly bush (*Buddleja davidii*)
- Canada thistle (*Cirsium arvense*)
- Common holly (*Ilex aquifolium*)
- Common ivy (*Hedera helix*)
- Common tansy (*Tanacetum vulgare*)
- Curly dock (*Rumex crispus*)
- Cutleaf blackberry (*Rubus laciniatus*)
- Herb robert (*Geranium robertianum*)
- Himalayan blackberry (*Rubus armeniacus*)
- Knapweed species (*Centaurea spp*)
- Morning glory (*Calystegia sepium*)
- Purple loosestrife (*Lythrum salicaria*)
- Reed canary grass (*Phalaris arundinacea*)
- Sowthistle species (*Sonchus spp*)
- Scotch broom (*Cytisus scoparius*)
- Tansy ragwort (*Senecio jacobaea*)

During the July 3, 2020 site visit, reed canary grass, purple loosestrife, and yellow flag iris (*Iris pseudacorus*) were observed in the Tilbury Project area. In addition, knotweed species (*Fallopia japonica*, *Fallopia x bohemica*, *Fallopia sachalinensis*, and *Polygonum polystachyum/Persicaria wallichii*) and the exotic narrowleaf cattail (*Typha angustifolia*) may potentially be present. The species listed above are considered highly invasive and have the ability to reduce species diversity, displace native plants, and reduce habitat available to native fish, birds and wildlife by forming extensive monocultures.

## 2.4.2 Potential at Risk Plant Communities and Vegetation

The BC Conservation Data Center (CDC) assigns provincial at-risk species, communities, and ecosystems to Red, Blue and Yellow Lists. Red listed species and plant communities are threatened, endangered, extirpated. These species face the risk of extinction if efforts are not made to increase populations. Blue listed species and plant communities are of special concern; they are sensitive to environmental changes and have the potential to be moved to the Red list if conditions persist. By assigning species to Red and Blue lists, the CDC ranks species and ecological communities that are affected by threats such as habitat or resource loss or are facing declining population or restricted distribution.

A number of at-risk plants and plant communities occur within the lower mainland CDFmm subzone and were observed, or have the potential to occur, at in the Tilbury Project area (Table 1 and Table 2). These species and communities are, however, expected to be unaffected by or to benefit from the proposed Tilbury Project (i.e., through the increased availability of suitable habitat).

**Table 1. Provincial at-risk ecological communities within the BC Lower Mainland CDFmm subzone with potential to occur in the Tilbury Project area**

Scientific Name	Common Name	Provincial At-Risk Status	Site Presence	Potential Effects
<i>Alnus rubra</i> / <i>Carex obnupta</i> [ <i>Populus trichocarpa</i> ]	red alder / slough sedge [black cottonwood]	Red	Possible	No effect
<i>Alnus rubra</i> / <i>Lysichiton americanus</i>	red alder / skunk cabbage	Red	Possible	No effect
<i>Alnus rubra</i> / <i>Rubus spectabilis</i> / <i>Equisetum arvense</i>	red alder / salmonberry / common horsetail	Blue	Observed	No effect
<i>Carex lyngbyei</i>	Lyngbye's sedge	Red	Observed	Increase in available habitat
<i>Deschampsia cespitosa</i> ssp. <i>beringensis</i> - <i>Hordeum brachyantherum</i>	tufted hairgrass - meadow barley	Red	Possible	Increase in available habitat
<i>Deschampsia cespitosa</i> ssp. <i>beringensis</i> - <i>Symphotrichum subspicatum</i>	tufted hairgrass - Douglas' aster	Red	Possible	Increase in available habitat
<i>Eleocharis palustris</i>	common spike-rush	Blue	Likely	Increase in available habitat
<i>Populus trichocarpa</i> - <i>Alnus rubra</i> / <i>Rubus spectabilis</i>	black cottonwood - red alder / salmonberry	Blue	Likely	No effect
<i>Ruppia maritima</i>	beaked ditch-grass	Red	Likely	Increase in available habitat
<i>Salix sitchensis</i> - <i>Salix lasiandra</i> var. <i>lasiandra</i> / <i>Lysichiton americanus</i>	Sitka willow - Pacific willow / skunk cabbage	Red	Possible	No effect
<i>Schoenoplectus acutus</i>	hard-stemmed bulrush	Blue	Possible	Increase in available habitat

Scientific Name	Common Name	Provincial At-Risk Status	Site Presence	Potential Effects
<i>Selaginella wallacei</i> / <i>Cladina</i> spp.	Wallace's selaginella / reindeer lichens	Blue	Likely	No effect
<i>Thuja plicata</i> / <i>Oemleria cerasiformis</i>	western redcedar / Indian-plum	Red	Possible	No effect
<i>Thuja plicata</i> - <i>Picea sitchensis</i> / <i>Lysichiton americanus</i>	western redcedar - Sitka spruce / skunk cabbage	Blue	Possible	No effect
<i>Thuja plicata</i> / <i>Polystichum munitum</i> - <i>Lysichiton americanus</i>	western redcedar / sword fern - skunk cabbage	Blue	Possible	No effect
<i>Thuja plicata</i> - <i>Pseudotsuga menziesii</i> / <i>Eurhynchium oregonum</i>	western redcedar - Douglas-fir / Oregon beaked-moss	Red	Possible	No effect
<i>Thuja plicata</i> / <i>Symphoricarpos albus</i>	western redcedar / common snowberry	Red	Likely	No effect
<i>Typha latifolia</i>	common cattail	Blue	Observed	Increase in available habitat

Source: Government of BC, 2020c

**Table 2. Provincial at-risk plant species within the BC Lower Mainland CDFmm subzone with potential to occur in the Tilbury Project area**

Scientific Name	Common Name	Provincial At-Risk Status	COSEWIC Status	SARA Status	Site Presence	Potential Effects
<i>Bidens amplissima</i>	Vancouver Island beggarticks	Blue	Special Concern	Special Concern	Possible	Increase in available habitat
<i>Erigeron philadelphicus</i> var. <i>glaber</i>	salt marsh Philadelphia daisy	Red	Not listed	Not listed	Possible	Increase in available habitat
<i>Lupinus rivularis</i>	streambank lupine	Red	Endangered	Endangered	Possible	Increase in available habitat
<i>Sidalcea hendersonii</i>	Henderson's checker-mallow	Blue	Not listed	Not listed	Possible	Increase in available habitat

Source: Government of BC, 2020c

### 2.4.3 Post Enhancement Conditions

Disturbed and/or enhanced areas will be replanted/planted with suitable native plants. Native plant species used by local Indigenous groups for traditional purposes, as well as listed plant species, will be considered. The port authority will consult with interested Indigenous groups to finalize plant selection.

Three distinct zones of marsh habitat are proposed to be planted as part of the Tilbury Project:

- an outer low marsh habitat planted with Baltic rush
- an inner low marsh habitat comprising:
  - common spike rush, and
  - jointed rush (*Juncus articulatus*)
- and an upper marsh habitat composed of:
  - Lyngbye's sedge

- softstem bulrush, and
- Common cattail (*Typha latifolia*)

## 2.5 Fish and Aquatics

### 2.5.1 Existing Aquatic Conditions

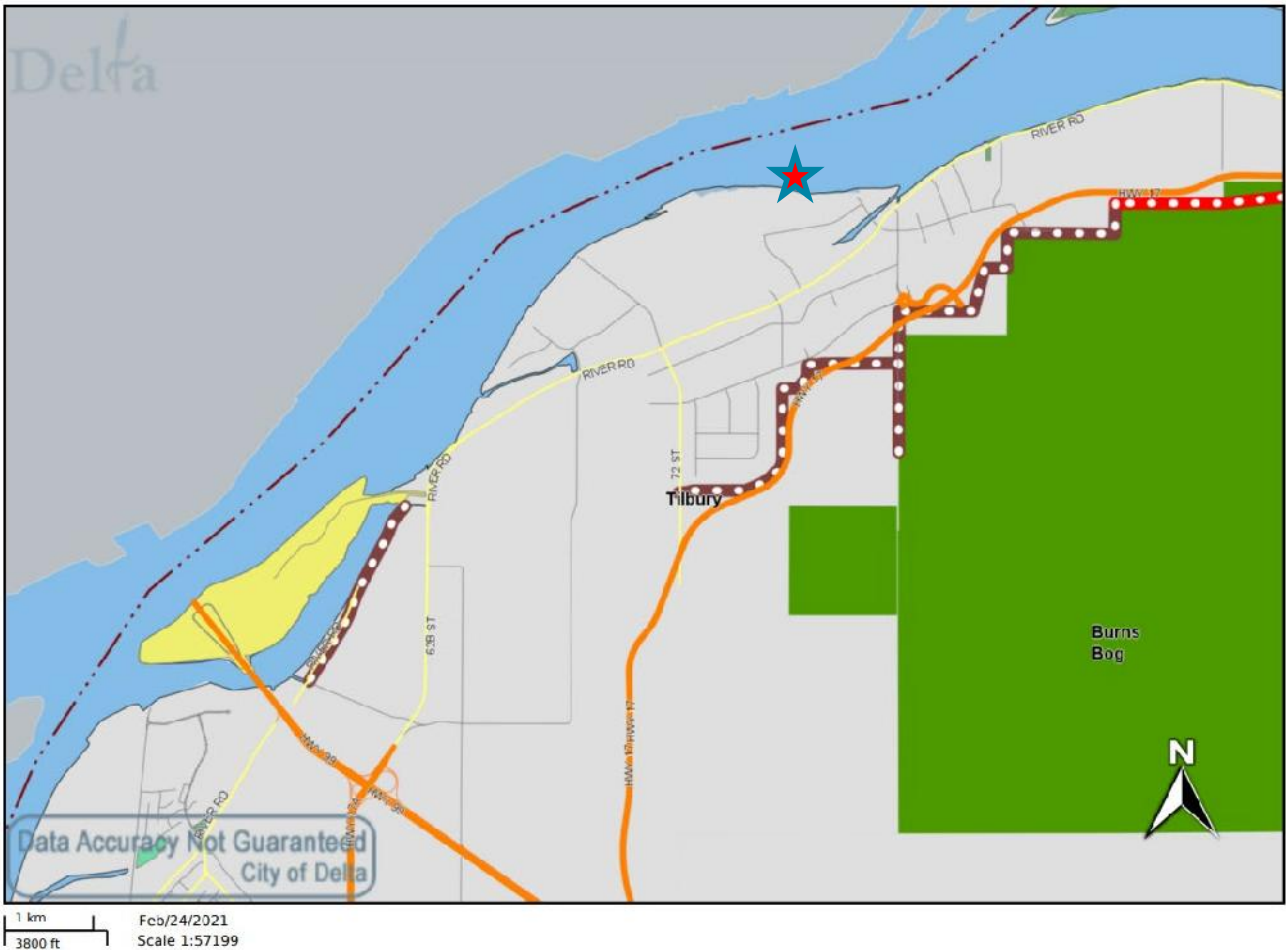
The Fraser River is the longest river in BC, spanning 1350 km from the Rocky Mountains to the Strait of Georgia; the river is also the fifth largest drainage basin in the country, draining the equivalent of a quarter of the province (Lievesley et al. 2016). River discharge follows a snowmelt-driven pattern; flows are stable throughout the winter and increase through the spring season with the highest flows towards the late spring and early summer. The resources provided by the river have sustained Indigenous populations for millennia. The Fraser River continues to be a key navigation network and contributor to the economy through a range of industries. The shorelines of the river in its lower reaches are lined with a variety of operations such as logging, pulp and paper, grain milling, and shipping terminals. In the area of Tilbury Island, the Fraser River is approximately 600-m wide.

The Tilbury Project is located in the South Arm Meso-Tidal channel (FREMP 2006), which extends from the eastern edge of Annacis Island to the western edge of Deas Island, and conveys approximately 80% to 85% of total Fraser River discharge. The freshwater tidal habitat zone, influenced by the Pacific Ocean, extends 90 km upstream to Mission, BC while the lowest most 30 km is regularly inundated by brackish water (Dashtgard et al. 2012). The Tilbury Island Project falls within this 30 km range. Existing aquatic habitat in the Tilbury Project area includes unvegetated intertidal flat with fringing marsh around the edge of the eastern embayment upland of that.

Dissolved oxygen concentrations in this area of the Fraser River have historically ranged from 8.4 mg/L to 13.5 mg/L (Swain 1998). These values are above the Canadian Council of Ministers of the Environment (CCME 2001) minimum requirements for the survival of aquatic life.

It is expected that benthic communities in unvegetated Fraser River intertidal habitats (i.e., soft sediments; Figure 12) surrounding Tilbury Island are dominated by burrowing species with a preference for this type of habitat, such as oligochaete worms (Stronach 1995).

No salmon or special fish streams designated by the City of Delta are proximal to the Tilbury Project nor likely to be affected by its implementation (Figure 13).



**Figure 13: Salmon (Schedule A; red dashed line) and Special Fish (Schedule B; brown dashed line) Streams in the Areas Surrounding the Tilbury Project (City of Delta 2021; Tilbury Project location represented by red star)**

## 2.5.2 Common Fish Species

The fish populations of the lower Fraser River main stem have been well studied by others (iMapBC 2021). Fish species composition, fish habitat availability, fish habitat utilization, and migratory fish run timing are well understood. Despite large changes in the lower Fraser River over recent decades, owing to industrial development and human population growth, the fish species composition is considered to have changed little overall during that time (Richardson et al. 2000). The Fraser River is reported to support between 42 (Richardson et al. 2000) to 70 fish species (iMapBC 2021). Most of these species are native (McPhail and Carveth 1993), and some are considered threatened (e.g., white sturgeon) or of special concern (e.g., eulachon). Many of the fish species using this area of the Fraser River are of cultural, commercial and recreational importance, such as Pacific salmon, trout, char, eulachon, and white sturgeon (MOTI 2016).

The South Arm of the Fraser River provides habitat for a variety of resident and migratory fish species across all life stages, including but not limited to:

- salmonids (Chinook (*Oncorhynchus tshawytscha*), chum (*O. keta*), coho (*O. kisutch*), pink (*O. gorbuscha*), and sockeye (*O. nerka*) salmon, cutthroat trout (*O. clarkia*), rainbow trout/steelhead (*O. mykiss*))
- forage fish (eulachon (*Thaleichthys pacificus*) and surf smelt (*Hypomesus pretiosus*))
- flatfish (e.g., starry flounder (*Platichthys stellatus*))
- white sturgeon (*Acipenser transmontanus*)

- stickleback (*Gasterosteus* spp.)
- prickly sculpin (*Cottus asper*)

A variety of non-native fish species also inhabit the Fraser River system, including common carp (*Cyprinus carpio*), goldfish (*Carassius auratus*), largemouth bass (*Micropterus salmoides*), pumpkinseed sunfish (*Lepomis gibbosus*), brown catfish (*Ameiurus nebulosus*), and black crappie (*Pomoxis nigromaculatus*). The vast majority of the introduced species reside in the lower reaches of the Fraser River (i.e., in the vicinity of Tilbury Island).

Threespine stickleback, goldfish, brassy minnow, and pumpkinseed have been previously captured in Tilbury Island ditches and in Tilbury Slough (iMapBC 2021).

### 2.5.3 Listed Fish Species

Six provincially listed fish species are found within the BC Lower Mainland CDFmm ecological subzone. Five of these species have the potential to occur at or interact with the Tilbury Project. These species are listed in Table 3.

**Table 3. Provincial at-risk fish species within the BC Lower Mainland CDFmm subzone with potential to occur in the Tilbury Project area**

Scientific Name	Common Name	Provincial At-Risk Status	COSEWIC Status	SARA Status	Site Presence Comments	Potential Effects
<i>Acipenser transmontanus</i> pop. 4	White Sturgeon (Lower Fraser River Population)	Red	Threatened	Not listed	Possible	Unlikely to be directly affected (may benefit indirectly from increased prey availability)
<i>Hybognathus hankinsoni</i> - Pacific group	Brassy Minnow - Pacific Group	Blue	Not listed	Not listed	Likely	Increase in available habitat
<i>Oncorhynchus clarkii clarkii</i>	Cutthroat Trout, <i>clarkii</i> subspecies	Blue	Not listed	Not listed	Likely	Increase in available habitat
<i>Salvelinus confluentus</i> pop. 28	Bull Trout - South Coast Population	Blue	Special Concern	Special Concern	Likely	Increase in available habitat
<i>Thaleichthys pacificus</i>	Eulachon	Blue	Threatened	Not listed	Possible	No effect

Source: Government of BC, 2020c

A review of desktop resources has confirmed the presence of white sturgeon within the vicinity (within 1 km) of the project location (iMapBC 2021). The preferred sturgeon spawning habitat of gravel and cobble is not abundant along the Fraser River main stem or in the Tilbury Project area. Most Fraser River sturgeon spawning is reported to occur in fast-flowing areas of the “gravel reach” section (and associated large side channels) between Mission, BC, and Hope, BC (approximately 60 km upstream of the Tilbury Project), with no evidence of spawning in the tidally-influenced main stem (Perrin et al. 2003). Juvenile white sturgeon could potentially use intertidal flat or marsh habitats at the Tilbury Project site as they prefer shallower waters with slow to moderate water velocities and fine substrates for rearing; however, juveniles are less tolerant of the brackish conditions (like those present at the Tilbury Project area) than adults (Parsley and Beckman 1994). As such, white sturgeon present in the vicinity of the Tilbury Project area are considered to be adults feeding over the summer period ((Robichaud et al. 2017a; Robichaud et al. 2017b) and unlikely to be directly affected by the Tilbury Project but may benefit indirectly from increased prey availability (i.e., Pacific salmon) in the wider Fraser River system.

Eulachon are an anadromous species of forage fish in the smelt family with cultural value to Indigenous groups. Additionally, eulachon are a key prey species for a variety of fish, birds, and marine mammals. Spawning stock biomass data indicates that eulachon stocks have been declining since 2004 in the Fraser River system (Plate, 2009). Although the exact reasons for decline are poorly understood, threats to the species exist in both freshwater and marine environments. Eulachon spawning occurs in spring (April/May in the Fraser River; Hay and McCarter

2000; McPhail 2007; DFO 2010/2011), at low water discharge levels prior to spring freshet (Lewis et al. 2002), and upstream of the saltwater wedge which corresponds to the centre of Annacis Island, approximately 6 km upstream of the Tilbury Project. In addition, most eulachon are reported to spawn in areas with clean, coarse sand to small gravel-sized sediments (Plate 2009; Levesque and Therriault 2011), as opposed to the finer sediments currently present at the Tilbury Project site. The location of eulachon spawning is typically not very far upstream of the saltwater wedge; however, in the Fraser River, eulachon spawning has been reported 50 km to 100 km upstream of the saltwater wedge limit (Hay and McCarter 2000), with most eulachon spawning reported to occur between Mission and Chilliwack (McPhail 2007), but also as far upstream as Hope (Moody 2008). Although some eulachon spawning has been documented near the Port Mann Bridge (Plate 2009) and downstream of New Westminster (Hay et al. 2002), based on the factors described above, the potential for successful eulachon spawning to take place in the vicinity of the Tilbury Project is considered to be low.

All other provincially-listed fish species identified in Table 3 may potentially use the Tilbury Project area at some point during their life cycle and are expected to benefit from the habitat enhancement proposed.

## 2.5.4 Post Enhancement Conditions

Although changes to habitat type may affect fish species which use sand and mud flats at high tide, such as starry flounder, the creation of estuarine intertidal marsh habitat is expected to increase the overall fish habitat value in the Tilbury Project area. In particular, the proposed enhancement will provide important rearing habitat for juvenile Pacific salmon, who are reliant on the health of the Fraser River estuary. By providing increased opportunities to juvenile fish, the animals which prey on them will benefit from their increased availability, resulting in increased productivity and complexity across the entire food web.

## 2.6 Wildlife

### 2.6.1 Existing Conditions for Wildlife

The Fraser River estuary remains an important stop over and wintering location for millions of migrating waterfowl and shorebirds. Additionally, the Fraser River estuary provides habitat for resident bird species, mammals, reptiles, and amphibians.

### 2.6.2 Common Wildlife

Common representative mammal species which are found in the CDFmm subzone and are tolerant to the conditions in the Tilbury Project area include:

- Coyote (*Canis latrans*)
- Harbour seal (*Phoca vitulin*)
- Mink (*Neovison vison*)
- Raccoon (*Procyon lotor*)
- River otter (*Lontra canadensis*)
- Townsend's vole (*Microtus townsendii*)

Common representative bird species which are found in the CDFmm subzone and are tolerant to the conditions in the Tilbury Project area include:

- American robin (*Turdus migratorius*)
- American wigeon (*Anas Americana*)
- Barrow's goldeneye (*Bucephala islandica*)
- Brant (*Branta bernicla*)
- Canada goose (*Branta canadensis*)
- Glaucous-winged gull (*Larus glaucescens*)

- Green-winged teal (*Anas carolinensis*)
- Lesser scaup (*Aythya affinis*)
- Mallard (*Anas platyrhynchos*)
- Northwestern crow (*Corvus caurinus*)
- Sharp-shinned hawk (*Accipiter striatus*)

### 2.6.3 Listed Wildlife

No listed wildlife species are known to be present within 1 km of the Tilbury Project (iMapBC 2021). There is potential for several listed species to occur in the Tilbury Project area, as presented in Table 4, Table 5 and Table 6. These species are, however, expected to be unaffected by or to benefit from the proposed Tilbury Project (i.e., through the increased availability of suitable habitat and prey abundance).

**Table 4. Provincial at-risk mammal species within the BC Lower Mainland CDFmm subzone with potential to occur in the Tilbury Project area**

Scientific Name	Common Name	Provincial At-Risk Status	COSEWIC Status	SARA Status	Site Presence Comments	Potential Effects
<i>Corynorhinus townsendii</i>	Townsend's Big-eared Bat	Blue	Not listed	Not listed	Likely	No effect
<i>Mustela frenata altifrontalis</i>	Long-tailed weasel, <i>altifrontalis</i> subspecies	Red	Not listed	Not listed	Likely	No effect

Source: Government of BC, 2020c

**Table 5. Provincial at-risk reptile and amphibian species within the BC Lower Mainland CDFmm subzone with potential to occur in the Tilbury Project area**

Scientific Name	Common Name	Provincial At-Risk Status	COSEWIC Status	SARA Status	Site Presence Comments	Potential Effects
<i>Anaxyrus boreas</i>	Western Toad	Yellow	Special Concern	Special Concern	Possible	Increase in available habitat
<i>Rana aurora</i>	Northern Red-legged frog	Blue	Special Concern	Special Concern	Unlikely	Increase in available habitat

Source: Government of BC, 2020c

**Table 6. Provincial at-risk bird species within the BC Lower Mainland CDFmm subzone with potential to occur in the Tilbury Project area**

Scientific Name	Common Name	Provincial At-Risk Status	COSEWIC Status	SARA Status	Site Presence Comments	Effects of Enhancement
<i>Ardea herodias fannini</i>	Great Blue Heron, <i>fannini</i> subspecies	Blue	Special Concern	Special Concern	Likely	Increase in available habitat
<i>Asio flammeus</i>	Short-eared Owl	Blue	Special Concern	Special Concern	Likely	Increase in prey abundance
<i>Buteo lagopus</i>	Rough-legged Hawk	Blue	Not at Risk	Not Listed	Likely	Increase in prey abundance
<i>Cypseloides niger</i>	Black Swift	Blue	Endangered	Endangered	Likely	Increase in prey abundance
<i>Falco peregrinus anatum</i>	Peregrine Falcon, <i>anatum</i> subspecies	Red	Not at Risk	Special Concern	Likely	Increase in prey abundance
<i>Hirundo rustica</i>	Barn Swallow	Blue	Threatened	Threatened	Likely	Increase in prey abundance

Scientific Name	Common Name	Provincial At-Risk Status	COSEWIC Status	SARA Status	Site Presence Comments	Effects of Enhancement
<i>Progne subis</i>	Purple Martin	Blue	Not Listed	Not Listed	Likely	Increase in prey abundance
<i>Tyto alba</i>	Barn Owl	Red	Threatened	Threatened	Likely	Increase in prey abundance

Source: Government of BC, 2020c

## 2.6.4 Post Enhancement Conditions

The conversion of intertidal flat to brackish marsh habitat will result in a change to habitat used by waterfowl and shorebirds that may currently use the site for resting and foraging. However, increased marsh habitat will provide similar opportunities and provide value to a more diverse range of birds and wildlife that are expected to utilize the enhanced area. No listed wildlife species are expected to be negatively affected by the project. Species that forage for insects or fish, such as the great blue heron or barn swallow may benefit from the project as a result of increased prey abundance.

## 3. Conclusion

The proposed Tilbury Project is expected to provide long-term benefits to a variety of fish (including estuarine-rearing Pacific salmon populations such as Chinook and chum), plant, and wildlife species (e.g., raptors, waterfowl, great blue heron). In particular, the project would restore an important link in the juvenile salmon rearing network in this area of the Fraser River by providing important habitat for estuarine-rearing juvenile salmon seeking refuge and feeding opportunities as they acclimatize to increasing salinities. The expansion of higher-value marsh habitat is also expected to provide additional ecosystem benefits, including but not limited to the following:

- Increased supply of nutrients and detrital material to support food webs in habitats beyond the site
- Increased ecosystem productivity and diversity
- Increased prey availability for terrestrial wildlife, birds and aquatic species
- Opportunities for epiphytic and epifaunal colonization
- Provision of temperature-regulating shade
- Improved water quality through contaminant filtration and oxygen production
- Sediment trapping and accretion
- Reduced erosion through wave and energy-dampening

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**Appendix IR2020-1.1-A24**  
**Semiahmoo Bay – Little Campbell River**  
**Enhancement Project Design Brief for**  
**Habitat Offsetting**

**SEMIAHMOO BAY - LITTLE CAMPBELL RIVER ENHANCEMENT  
PROJECT  
DESIGN BRIEF FOR HABITAT OFFSETTING**

**REPORT**

Prepared for:

**Vancouver Fraser Port Authority**  
Vancouver, British Columbia

Prepared by:

**Northwest Hydraulic Consultants Ltd.**  
North Vancouver, British Columbia

25 February 2021

NHC Ref No. 300044

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## **DISCLAIMER**

This report has been prepared by **Northwest Hydraulic Consultants Ltd.** for the benefit of **the Vancouver Fraser Port Authority (Port Authority)** for specific application to the **Semiahmoo Bay - Little Campbell River Offsetting Project**. The information and data contained herein represent **Northwest Hydraulic Consultants Ltd.** best professional judgment in light of the knowledge and information available to **Northwest Hydraulic Consultants Ltd.** at the time of preparation, and was prepared in accordance with generally accepted engineering practices.

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## CREDITS AND ACKNOWLEDGEMENTS

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# 1 INTRODUCTION

Northwest Hydraulic Consultants Ltd. (NHC) is pleased to present this report to the Vancouver Fraser Port Authority (Port Authority) describing the design basis for the Semiahmoo Bay – Little Campbell River Enhancement Project. This proposed offsetting project for the port authority's Roberts Bank Terminal 2 Project (RBT2) was undertaken in partnership with the Semiahmoo First Nation, who identified the habitat enhancement components to align with identified priorities, including fish species and habitats.

This report outlines background information on the overall project, summarizes the offsetting opportunities, details the design criteria, provides key design details and sketches for each opportunity, provides an estimate of the construction cost for each opportunity, and outlines additional considerations that may need to be addressed prior to construction. As such, this report provides the technical basis for the development of the offsetting opportunities and for which their potential feasibility was determined.

## 1.1 Study Area

The study area is located in Semiahmoo Bay and the Little Campbell River estuary. Semiahmoo Bay is situated south of the Fraser River delta and south of Boundary Bay where the Serpentine and Nicomekl Rivers outlet. Semiahmoo Bay is positioned south of the City of White Rock and just over 1 km north of the Canada-US border. The Little Campbell River flows into the north-eastern region of Semiahmoo Bay at the boundary of the Semiahmoo First Nation Reserve. Figure 1.1 shows the study area and the general extent of habitat offsetting opportunities explored herein.



**Figure 1.1 Study area within Semiahmoo Bay and the Little Campbell River estuary**

## 1.2 Scope of Work & Objectives

The proposed project is being developed as part of the RBT2 offsetting plan. The primary objective of this project is to enhance habitat that will benefit estuarine-rearing Pacific salmon, as well as other fish and wildlife. The project is being designed in alignment with the values, priorities and preferences of the Semiahmoo First Nation in the context of the RBT2 offsetting plan. The scope of work can be divided into two phases and described as follows:

- 1) The first phase of the project involved undertaking a field survey and completing a geomorphic overview assessment. The specific objectives of this phase of work were to understand the governing physical changes and history of human impact that have affected Semiahmoo Bay, the Little Campbell River watershed, and the Little Campbell River estuary. Knowledge shared by Semiahmoo First Nation (in particular Joanne Charles) was heavily incorporated into the resulting geomorphic overview report (Document [2] in Section 1.3).
- 2) The second phase of the project (this report) involved the engineering development of multiple opportunities for habitat offsetting within the study area. The objectives of this work were to develop viable offsetting opportunities, develop a design basis, prepare design sketches and specifications, and develop construction cost-estimates. Information gained during the geomorphic overview assessment phase was leveraged during this phase of work to inform the development of technically feasible preliminary habitat offsetting designs.

This report outlines the design basis for identified habitat offsetting opportunities (see Section 2) in the Semiahmoo Bay and Little Campbell River estuary study area.

## 1.3 Related Documents

Key documents specifically related to this project are listed below for ease of reference, while a complete list of references is provided in Section 8.

- [1] Semiahmoo Bay Site Draft Fact Sheet – Habitat Banking Offsetting Options – Indigenous Group (IG) Suggested Sites. (Vancouver Fraser Port Authority, 2020)
- [2] Semiahmoo Bay and Little Campbell River Coastal Geomorphology Overview Study. Prepared for the Vancouver Fraser Port Authority. (Northwest Hydraulic Consultants Ltd, 2020)
- [3] Preliminary Planting Design Criteria for Vancouver Fraser Port Authority (VFPA), Roberts Bank Terminal 2 Semiahmoo Habitat Offsetting. (GL Williams & Associates Ltd.)
- [4] Semiahmoo Bay – Little Campbell River Enhancement Project Design Concepts. Prepared for the Vancouver Fraser Port Authority. (Northwest Hydraulic Consultants Ltd, 2020)

## 1.4 Project Team

The development of habitat enhancement opportunities and designs by NHC was undertaken in collaboration with Mr. Gary Williams, R.P.Bio. of G.L. Williams and Associates. Dr. Ravi Chatterji, R.P.Bio., Senior Aquatic Ecologist with AECOM, provided overall project coordination and management on behalf of the Port Authority, reporting to Ms. Charlene Menezes, P.Geo. (Port Authority). Team investigations, including onsite field investigations, were arranged with the assistance of Ms. Jemma Scoble, Port Authority Indigenous Consultation Support. Councillor Joanne Charles (Semiahmoo First Nation) provided insight into local flora and fauna, as well as the Indigenous use of the estuarine and foreshore habitat.

## 2 OVERVIEW OF OFFSETTING OPPORTUNITIES

The Semiahmoo people have lived in the Semiahmoo Bay – Campbell River estuary area since time immemorial (NHC, 2020). In the mid-1800s, the area was used by European settlers as a military and border crossing camp. In the 1900s, the Great Northern Railway and the sawmill site was constructed within the estuary. During operation of the sawmill, the channel and tidal flats were regularly dredged. A large pier was constructed in 1921 by the sawmill company on the foreshore west of the river mouth. The mill was closed in 1927 at which time most buildings and infrastructure were removed. The pier burned in the 1950s. Remnant piles, wood structures, and concrete materials are still visible in the estuary and on the foreshore. Changes to the physical character and habitat within the estuary are prominent reminders of the intensive past site usage. Through remediating these legacy conditions, there is great potential to develop effective habitat offsetting opportunities in the area. Some of the habitat offsetting opportunities identified in the Geomorphology Overview Study (NHC, 2020) include the following:

- Adding vegetation along the shoreline to shade forage fish spawning areas
- Improving water quality through enhancing riparian areas upstream
- Controlling water levels in the estuary to optimize fish habitat and minimize flooding potential
- Increasing the size of the outlet of the Little Campbell River through removing or altering the gravel bar
- Increasing sediment supply to the beaches or retaining sediment near the outlet of the Little Campbell River to foster beach development
- Removing derelict wood and piles to restore natural sediment flows, remove a source of potential contamination, and improve the visual quality of the area

After discussions with the project team (including Ravi Chatterji and Gary Williams) and with the support of the Semiahmoo First nation, it was determined that the following enhancement opportunities would be explored and developed to a preliminary design level:

- Opportunity 1.** Large woody debris complexes
- Opportunity 2.** Pile and derelict wood removal
- Opportunity 3.** Inter-island channel and salt marsh
- Opportunity 4.** East salt marsh
- Opportunity 5.** East river bank protection
- Opportunity 6.** Sediment lobe removal
- Opportunity 7.** Western foreshore enhancement
- Opportunity 8.** Eastern foreshore enhancement

Design criteria and considerations for these offsetting opportunities are provided in Section 3. The offsetting opportunities are each described in detail in Section 4. Preliminary design sketches are provided in Appendix A.

### 3 DESIGN CRITERIA

#### 3.1 Vertical Datum

For the purpose of this project, all elevations are referenced to geodetic datum (CVD28GVRD) unless stated otherwise. Note that the following formulas can be used to convert elevations in CVD28GVRD to elevations in Chart Datum (CD) or Canadian Geodetic datum of 2013 (CGVD2013) at the project site:

$$Elev_{CD} = Elev_{CGVD28} + 2.8$$

$$Elev_{CGVD2013} = Elev_{CGVD28} + 0.05$$

#### 3.2 Design Working Life

The design working life of an engineered structure is taken as “the specific period for which a structure is to be used for its intended purpose with planned maintenance” (British Standard 6349-1, 2013) . This study considers designs that generally have a working life of approximately 50 years but there are notable exceptions to this, as described in Table 3.1. Note that, depending on the offsetting design, regular monitoring and maintenance may be required to meet this design working life (e.g. for more dynamic/flexible designs). See Section 4 for more information on the expected design life and associated monitoring/repair requirements associated with each opportunity.

**Table 3.1 Design working life for habitat offsetting opportunities**

Offsetting Opportunity	Design life	Description
Opportunity 1. Large woody debris complexes	20 years	Wood decomposition often necessitates replacement of logs to achieve a design life beyond 20 years
Opportunity 2. Pile and derelict wood removal	N/A	Not applicable
Opportunity 3. Inter-island channel and salt marsh	50+ years	Opportunity may perform well beyond the design working life due to ability of marshes to adapt and self-repair
Opportunity 4. East salt marsh	50+ years	Opportunity may perform well beyond the design working life due to ability of marshes to adapt and self-repair
Opportunity 5. East river bank protection	50 years	-
Opportunity 6. Sediment lobe removal	20 years	Maintenance/excavation is expected in order to achieve a design life longer than 20 years, particularly if Opportunity 7 or 8 is not undertaken
Opportunity 7. Western foreshore enhancement	50 years	-
Opportunity 8. Eastern foreshore enhancement	50 years	-

### 3.3 Design Event

The engineering components of habitat offsetting opportunities are generally designed for a 50-year return period event, which is approximately equal to a 1/50 year Annual Exceedance (AEP) probability (i.e. 2.0 % probability) of occurrence in any given year. This design event was chosen as it is a relatively low probability event and will ensure functionality during the likely storm events over the design working life. It is not considered necessary that the offsetting opportunities remain fully functional during unlikely and extreme events (e.g. 200 or 500-year return period events which may be considered for assessments pertaining to potential loss of life or livelihood).

Note that the combined probability of the design wind event coinciding with a design water level will be slightly lower at the beginning of the design life than at the end because an allowance for sea level rise has been considered (see Section 3.6.1). This sea level rise allowance effectively allows for an additional factor of safety for some of the opportunities (e.g. Opportunity 5, 7, and 8) at the beginning of their design life.

### 3.4 Functional Requirements

The primary functional requirement for design opportunities is to restore or improve ecological function and productivity in the Little Campbell River estuary and Semiahmoo Bay area, in a way that contributes to offsetting the residual effects of the RBT2 project on fish and fish habitat. More specifically, ecological functions that may be restored or improved at the site include the following:

- Increase biodiversity and primary productivity by constructing salt marsh and backshore habitat.
- Improve backshore habitat productivity and diversity by planting suitable grass and herbaceous marine vegetation.
- Supplement the detritus food web through the establishment of marsh and backshore vegetation.
- Create intertidal habitat to produce invertebrates that are important benthic and drift prey items for juvenile salmonids and other fishes.
- Provide suitable sand gravel beach nourishment along the mid to upper beach to improve sand lance and surf smelt spawning habitat, respectively.
- Remove potential sources of contamination (such as derelict piles and wood) into the river and coastal environment.

In addition, the offsetting opportunities are also intended to provide beneficial functions for the Semiahmoo First Nation. It is understood that the following services may serve to benefit the Semiahmoo First Nation:

- Remove remnants of historical industrial activities.
- Restore or improve traditional First Nation fisheries.
- Improve traditional access to Semiahmoo Bay.
- Reduce the risk of flooding and erosion.

Potential habitat offsetting opportunities should also not negatively impact existing habitat or infrastructure in the area, such as outfalls or the Burlington Northern Sante Fe (BNSF) railway track.

### 3.5 Environmental Design Considerations

Environmental design considerations for habitat offsetting opportunities were prepared by Gary Williams, Professional Wetland Scientist, GL Williams & Associates, with input from NHC personnel. These design considerations reflect many of the findings presented in the memo *'Preliminary Planting Design Criteria for Vancouver Fraser Port Authority (VFPA) Roberts Bank Terminal 2 Semiahmoo Habitat Offsetting'* (GL Williams & Associates, 2020). In addition, Joanne Charles (Semiahmoo First Nation) provided an overview of the traditional use of the estuarine and foreshore habitat that, besides hunting, fishing, and gathering harvesting marine invertebrates, includes harvesting of plants for food, medicine, and other personal uses.

#### 3.5.1 Large Woody Debris

The Little Campbell River has been confirmed as having high productive potential based on trout population studies (Rempel et al. 1984). LWD is typically an integral component of the physical processes of coastal BC streams, provides important habitat for salmonids, and supports the following ecological functions in the Little Campbell River main channel:

- Cover and habitat complexity for juvenile salmonids during their instream rearing period and downstream migration;
- Cover and resting areas for adult salmonids migrating upstream to spawn;
- Enhancement of instream complexity in the form of scour pools at the base of the root wads.

Notably, spawning is not expected within this reach of the river because of the elevated salinity levels and fine substrates within the lower, tidally-influenced reach of the Campbell River. Most salmonids spawn well above the salt influence, but chum salmon may spawn just above the influence of marine waters. However, it is unlikely that chum will spawn in the vicinity of the proposed LWD.

Cover provided by overhanging riparian vegetation and instream LWD is expected to be utilized by several salmonid species during the upstream spawning migration. For example, chinook and steelhead enter freshwater streams prior to spawning and utilize cover near spawning areas to avoid disturbance and predation (Meehan and Bjournn, 1991). Cover provides shade and reduces water temperature, and is an important feature that increases the carrying capacity of streams for salmonids (Bjournn and Reiser, 1991). Cover from overhanging vegetation and LWD provides security from predation, allowing fish to occupy portions of streams they might not otherwise use. It has been found that adding more LWD increased coho salmon in streams surrounded by mature-mixed conifer forest than streams lined with red alder.

In terms of habitat complexity, LWD promotes an increase in the number and size (depth and area) of pools, and provides refuge from high water velocities. LWD and overhanging vegetation provides shade and is attractive to rearing juvenile salmonids during feeding. Placement of LWD can increase overwinter survival and smolt output of juvenile coho salmon (Reeves et al., 1991). LWD also plays a key role in the in-channel retention of organic debris affecting the distribution of detritus and invertebrate processors (Murphy et al., 1991). The Little Campbell River riparian zone has reduced overhanging vegetation within

the lower reach and is devoid of instream cover. Management of the riparian zone for LWD is an important focus for improving stream habitat complexity and improving salmonid production and carrying capacity (Reeves et al., 1991).

For the purpose of this project, consideration should be made for the following design features:

- Species type: Western Red Cedar is the recommended species (Anon. 1980).
- Placement: LWD should be placed in a manner that will provide both habitat complexity and cover. Placement that results in impervious surfaces or linear features should be avoided. Arranging the LWD with the root-wad within the stream will promote formation of in-stream pools.
- Cover: LWD should also be placed such that void spaces that provide cover are encouraged.

### 3.5.2 Marsh Substrate

Marsh soils provide an anchoring material for plants to root, fertility for growth, and suitable characteristics that promote stability and drainage under ambient intertidal conditions. At the Semiahmoo Bay and Little Campbell River estuary project site, subsoils exposed by excavation will be compacted and may not have suitable physical or fertility characteristics to be used as a growing medium. Instead, it is recommended that a soil layer be added on top of the excavated material to provide a planting medium. Clean mineral soil, free from rocks, debris, and contamination is required.

Data from previous marsh construction projects in Burrard Inlet (e.g. Williams, 1998), indicate that natural marshes tend to have a higher portion of fines being formed from the natural deposition of silts and clays during tidal or fluvial deposition over a long period of time. However, marshes do develop from sandy sediments if that is the main source material. Low elevation marshes range from loamy sand (i.e. 80-85% sand and 15-20% fines) to silty clay loam (i.e. 15-40% sand and 60-85% fines). Constructed marshes tend to be towards the coarser ranged, sandy loam to loamy sand, ranging from 75-85% sand and 15-25% fines, but soils vary depending on the available source material. Another important component is organic matter, which ranges from 15-25 % or more in natural marshes but is typically from 1-10% in constructed marshes. Organic matter will increase as constructed marshes age and autochthonous material is incorporated into the soils.

In choosing a suitable soil, the following should be considered:

- Use of manufactured soil is not recommended because sawdust and peat moss typically used in its fabrication makes it more buoyant and it may not remain in place when submerged by tides and exposed to waves.
- Suitable soils may include dredged material or imported soil from an upland source, including on-site soil.
- Past projects have included using dredged material for marsh growing medium, particularly dredged material with higher proportion of fines than pre-load material or imported terrestrial soil that meets specifications.

- Since marsh plant roots typically grow in the top 0.1 to 0.2 m of soil, it may be cost effective to use sand as the structural base and add a top layer 0.1-0.2 m thick of silty sand or loamy textured soil with higher organic matter.

### 3.5.3 Marsh Vegetation & Elevations

On September 1, 2020 elevations of emergent marsh at the project site were surveyed by G. Williams (GL Williams & Associates) and M. Savage (Van Bower Construction Services). Emergent salt marsh species were identified and the elevation range was measured to provide site specific data to guide offsetting habitat design (Table 3.2).

**Table 3.2 Salt marsh plant elevations measured in September 2020**

Species		Elevation Range (m, CGVD28)	
Scientific Name	Common Name	Low	High
<b>Edge of marsh</b>			
<i>Spergularia spp.</i>	Sandspurry	0.50	1.27
<i>Sarcocornia pacifica</i>	Pickleweed	0.51	1.51
<b>Marsh Platform</b>			
<i>Carex lyngbyei</i>	Lyngbye’s Sedge	0.99	1.18
<i>Distichlis spicata</i>	Saltgrass	0.86	1.60
<i>Triglochin maritima</i>	Arrowgrass	1.02	1.19
<i>Symphotrichum subspicatum</i>	Douglas’ Aster	1.40	-
<b>Above High Water Line (HHWMT)</b>			
<i>Cakile edentula</i>	Sea Rocket	1.70	-
<i>Leymus mollis</i>	Dunegrass	1.24	1.47
<i>Ambrosia chamissonis</i>	Silver Burweed	2.08	-

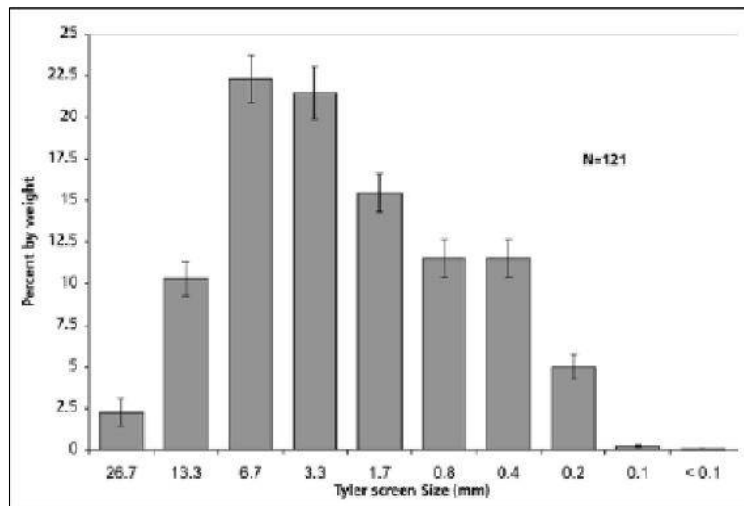
To capture the full tidal range for growth of salt marsh vegetation, and allow for some settlement, marsh habitat designs may include construction of a marsh bench between approximately 0.6 m and 1.8 m CGVD28 (present day HHWLT). The marsh soil surface should be gently sloping to ensure complete drainage at low water (i.e. 1% to 3%). Vegetation may be planted with a 0.5 m spacing. The vegetation planting plan should mimic the vegetation observed in the nearby established marshes (e.g. similar to Table 3.2), with consideration for settlement and space restrictions. Dunegrass or backshore plant species may be planted as described in Section 3.5.5.

In addition, the port authority will continue to engage with Semiahmoo First Nation with regards to the incorporation of traditionally important vegetation.

### 3.5.4 Forage Fish Spawning Substrate

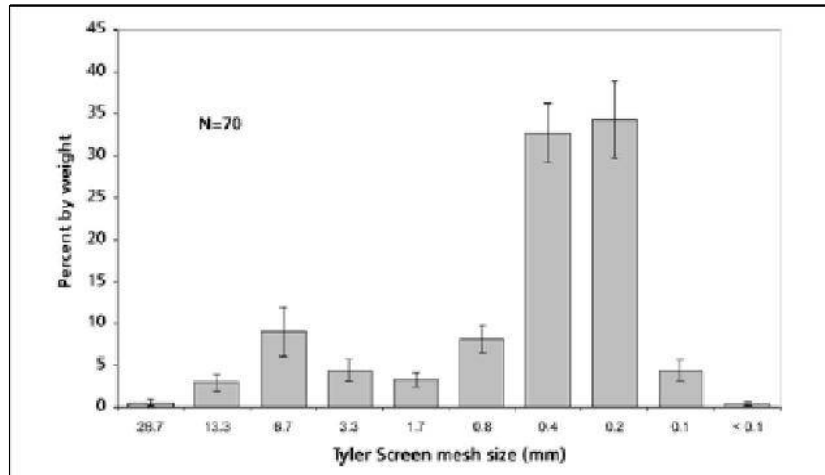
Foreshore beaches with sandy gravel substrate provide important habitat for forage fish species such as sand lance and surf smelt along the Pacific Coast of North America, including British Columbia (Levy 1985; Williams 1989; Pentilla 2007; Therriault et al. 2002; Thuringer). Spawning surveys have recorded surf smelt and sand lance spawning in Boundary Bay (de Graaf 2007; Barrett et al. 2015).

Surf smelt spawn over a mix of sand to pea-sized gravel, 1-7 mm diameter (Figure 3.1) in shallow water in the high intertidal in protected areas and low intertidal in exposed sites (Pentilla, 2007). Spawning occurs in summer or winter. Eggs fall into and adhere to gravel where they incubate until emergence. A mix of beach substrate (e.g. pebbles to sand with little or no fines) allows eggs to settle deeper in the substrate and keeps eggs from desiccating in the direct sun. The thickness of spawning substrate in the upper beach varies with the local wave action and sediment supply regimes, ranging from 1-10 cm, and physical area of spawning habitat can vary from a discontinuous array of small patches to nearly continuous bands several meters wide and several kilometers long (Pentilla, 2007). Seepage areas or shade from backshore trees enhances egg survival by keeping eggs moist (see Section 3.5.5).



**Figure 3.1 Sound surf smelt spawning substrate grain-size spectrum (Pentilla, 2007)**

Sand lance spawning occurs during the fall and winter between November and February. They spawn in sand, which is finer grained material than used by surf smelt, with the bulk of the material ranging between 0.2-0.4 mm in diameter with little or no silt (Figure 3.2) (Pentilla, 2007). Thuringer (2004) reports substrate range between 0.2 -0.5 mm. Spawning occurs within the upper third of the intertidal beach, extending lower than surf smelt but often overlapping. Spawning habitat tends to occur at accretionary shoreforms such as beaches at distal ends of drift cells, e.g. sand spits and cusped forelands (Pentilla, 2007). Forage fish spawning was documented in Boundary Bay (Barrett et al. 2015) and along constructed beaches on the east side of Roberts Bank causeway (summarized in Thuringer, et al. 2014).



**Figure 3.2 Puget Sound sand lance spawning substrate grain-size spectrum (Pentilla, 2007)**

The existing beach to the west of the river mouth is characterized by a moderately sloping and well sorted sand, gravel, and cobble beach face, with moderate deposits of eelgrass and macroalgae wrack (Photo 3.1). Based on grain size analysis conducted by NHC in September 2020 (Table 3.3), sediments on the beach face range in size from approximately 0.1 – 50 mm, with a D<sub>50</sub> of approximately 12 mm. Notably, a strip of finer and more mobile sediment was located along the center of the beach face, amongst the beach wrack, at the time of the measurements.



**Photo 3.1 Moderately sloping and well sorted sand, gravel, and cobble beach face west of the river mouth (looking northwest)**

**Table 3.3 Measured sediment sizes on sediment lobe and foreshore measured by NHC in September 2020**

Sample	Sediment Diameter (mm)		
	D <sub>16</sub>	D <sub>50</sub>	D <sub>84</sub>
<b>Sediment Lobe</b>			
1 - Lobe Crest	0.7	12.7	35.0
2 - Slope Face	0.2	2.4	26.2
<b>Foreshore West of River Mouth</b>			
5 – Upper Beach Face	0.4	16.0	38.8
3 – Central Beach Face	0.3	7.2	18.6
4 – Lower Beach Face	0.2	13.9	46.3

Dominant longshore morphological processes have resulted in the formation of a gravel lobe that extends under the railway bridge on the west side of the river mouth, as described in the ‘*Semiahmoo Bay and Little Campbell River Coastal Geomorphology Overview Study*’ (NHC, 2020). The sediment lobe composition is similar to that present on the foreshore directly west of the river mouth (Table 3.3); however, the material is relatively segregated, with finer material located on the slope and larger material on the crest (Photo 3.2).



**Photo 3.2 View from the top of the sediment lobe (looking south)**

The Little Campbell River outlet and sediment lobe interrupt longshore sediment transport of gravel materials to the east side of the river mouth. The foreshore east of the river mouth is relatively deflated,

with a narrow band of gravel, and fine sediments extending up to the base of the existing riprap slope (Photo 3.3). This section of shoreline currently provides very little existing habitat for forage fish.



**Photo 3.3 Relatively deflated beach profile with fine sediments extending up to the base of the existing riprap slope, on the southeast side of the river mouth (looking southeast)**

De Graff (2007) surveyed beaches west and east of the mouth of the Little Campbell River and identified potential spawning habitat located between elevations of approximately 0.6 to 1.1 m (geodetic datum) on the beach directly to the west of the river mouth and approximately 0.6 - 0.8 m to the east of the mouth. The sediments were found to be largely composed of coarse gravel and would benefit from nourishment with a mixture of smaller gravels and sand.

For the purpose of enhancing or developing new forage fish habitat on the foreshore, the following aspects should be considered:

- The existing mixed gravel beach to the west of the river mouth currently provides some forage fish habitat, but is expected to benefit from expansion and nourishment with a mixture of sand and fine gravel.
- The beach to the east of the river mouth currently provides poor forage fish habitat and would benefit from nourishment with mixed sand, gravel, and cobble material, if control structures were present to promote stabilization and retention.
- Material removed from the existing sediment lobe may be reused to nourish the beaches, but should be supplemented with a mixture of sand and fine gravel.
- Riparian vegetation should be considered to provide shade and provide a buffer between upland activities and the foreshore (See Section 3.5.5).

### 3.5.5 Coastal Riparian Vegetation & Elevations

The backshore west of the river mouth (immediately above the high tide line) is characterized by marine grass and herbaceous vegetation above the high water line, including orache (*Atriplex patula*), silver burweed (*Ambrosia chamissonis*), dunegrass (*Leymus mollis*), sea rocket (*Cakile edentula*) and other herbaceous species. Along the levee on each side of the river mouth, pickleweed (*Sarcocornia pacifica*) saltmarsh vegetation is establishing on the intertidal gravel substrate along the crest and sea lettuce (*Ulva* sp.) is present along the mudflat and lower beach face. Similarly, on the crest of the sediment lobe, vegetation growth includes small amounts of silver burweed and sea rocket. Backshore vegetation east of the river mouth is confined to occasional clumps of orache, sea rocket, and other marine herbaceous species between the armour rock protecting the bank.

If sufficient elevation is achieved, offsetting opportunities on the foreshore may incorporate vegetation similar to the existing. More specifically, a plant mixture for the coastal riparian area above HHWLT may include sea rocket, dunegrass, and silver burweed. See the preliminary design drawings included in Appendix A for a breakdown of proposed vegetation plantings and associated elevations.

## 3.6 Engineering Design Considerations

Engineering design considerations for the proposed habitat offsetting opportunities are included herein. For additional information, please reference the '*Semiahmoo Bay and Little Campbell River Coastal Geomorphology Overview Study*' (NHC, 2020).

### 3.6.1 Ocean Water Levels

Ocean water levels (including tides, storm surge, wind set-up, and expected relative sea level rise) were investigated and reported for the project site as part of the '*Semiahmoo Bay and Little Campbell River Coastal Geomorphology Overview Study*' (NHC, 2020). These values have been used to develop various design water levels for the project site, as provided in Table 3.4. Note that for the purpose of this project, a local relative sea level rise of +0.77 m has been considered at the project site<sup>1</sup>.

Note that water levels within the estuary are considered to be similar to ocean water levels during high tide for both nominal and peak river flow conditions up to 1.9 km upstream of the river outflow (KWL, 2011). The influence of river flows are discussed in Section 3.6.5.

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<sup>1</sup> The total local relative sea level rise is based upon the global SLR allowance of 10 mm/year and 1 mm/year of land subsidence. Over a 50-year period (i.e. a project service life to year 2070), 11 mm/year of local relative sea level rise would increase the sea level 0.77 m above the year 2000 reference water levels.

**Table 3.4 Design water levels (adapted from NHC, 2020)**

Description	Water Level (m, CGVD28)	
	Present Day (0.0 m SLR)	Future (+0.77 m SLR)
Lower Low Water Large Tide (LLWLT)	-2.80	-2.03
Lower Low Water Mean Tide (LLWMT)	-1.70	-0.93
Mean Water Level (MWL)	0.00	0.77
Higher High Water Mean Tide (HHWMT)	1.30	2.07
Higher High Water Large Tide (HHWLT)	1.80	2.57
1/50 AEP Joint Surge and Tide	2.23	3.00

Notes:

1. HHWLT represents the average of the highest high waters, one from each of 19 years of predictions.
2. HHWMT represents the average of all the higher high water levels in the same period.
3. MWL is the average hourly water level and corresponds approximately to CGVD28 or Mean Sea Level (MSL).

### 3.6.2 Wave Climate

The expected incident (deep-water) wave climate offshore of the project site during severe southwesterly (29.7 m/s) and northwesterly (22.8 m/s) storm events is as follows (NHC, 2020):

- Southwesterly:  $H_s = 3.4 \text{ m}$  ;  $T_p = 7.1 \text{ s}$
- Northwesterly:  $H_s = 2.5 \text{ m}$  ;  $T_p = 6.4 \text{ s}$

The nearshore wave climate (waves at the shoreline) will be further influenced by the shape and depth of the foreshore in front of the project site. Most notably, the shallow foreshore, will cause wave shoaling, refraction, and wave breaking, resulting in a smaller and more normally incident waves at the shoreline. As sea levels rise, the dissipative influence of the foreshore is expected to lessen, resulting in larger waves at the shoreline that are capable of driving more sediment transport than historically observed. The nearshore wave heights expected at the project sites for the governing southwesterly storm event accompanied with a 1/50 AEP joint surge and tide conditions are presented in Table 3.5 for present day and future sea level rise conditions.

**Table 3.5 Expected nearshore wave characteristics for a 1/50 AEP joint surge and tide event**

Storm Scenario	Nearshore Wave Characteristics	
	Present Day (0.0 m SLR)	Future (+0.77 m SLR)
Southwesterly	$H_s = 1.4 \text{ m}$ ; $T_p = 7.1 \text{ s}$	$H_s = 1.8 \text{ m}$ ; $T_p = 7.1 \text{ s}$
Northwesterly	$H_s = 1.3 \text{ m}$ ; $T_p = 6.4 \text{ s}$	$H_s = 1.7 \text{ m}$ ; $T_p = 6.4 \text{ s}$

### 3.6.3 Tidal Currents

At the project site, tidal current velocities are not expected to exceed 0.1 m/s (NHC, 2020). Since tidal currents are weak, sediment transport along the foreshore is likely driven by the net effect of stronger wave-driven currents.

### 3.6.4 Wave-Driven Currents and Longshore Transport

As described in the Semiahmoo Bay and Little Campbell River Coastal Geomorphology Overview Study (NHC, 2020), waves that break at an angle to the shoreline are capable of generating significant longshore currents. Although storms from the southeast and southwest drive sediment transport near Semiahmoo spit, they are unlikely to drive significant longshore currents and littoral drift at the project site because wave breaking will occur relatively parallel to the shoreline. However, westerly and northwesterly storms will generate waves that are not normally-incident to the foreshore at the project site, causing waves to break at an angle to the shoreline and driving currents towards the southeast. The combined effects of these wave-driven currents result in a net longshore drift from NW to SE along the White Rock and Semiahmoo First Nation waterfront. The design of habitat offsetting opportunities located near the foreshore (Opportunities 5, 6, 7, and 8) must take into account this dominant geomorphological process.

Notably, the long-term transport of gravel material longshore has led to the development and expansion of the gravel bar or ‘sediment lobe’ at the river mouth. The *Semiahmoo Bay and Little Campbell River Coastal Geomorphology Overview Study* (NHC, 2020) describes the evolution of this geomorphic feature since the 1940s when it first became visible in airphotos. Notably, since 1986 the bar has undergone rapid growth. As such, any efforts to remove sediment without construction of additional control structures (such as that included in Opportunities 7 and 8) and/or regular maintenance cannot be expected to remain effective longer than approximately 20 years (see Section 3.2 - Design Working Life).

### 3.6.5 River Discharge

As part of the Integrated Stormwater Management Plan (ISMP) (KWL, 2011), a hydraulic model was developed and flood discharge was calculated at a variety of locations within the Little Campbell River watershed. Calculated discharges for the entire watershed (e.g. at the river mouth) are presented in Table 3.6 for present and future anticipated land uses. The 50-year return period flood discharge was estimated using a linear approximation based on the modelled 2, 10, and 200-year flood discharge estimated by KWL (2011).

**Table 3.6 Estimated design discharges for the Little Campbell River (adapted from (Kerr Wood Leidal Associates Ltd., 2011)**

Return Period, $T_R$	Discharge ( $m^3/s$ )	
	Present Land Use	Future Land Use
Summer baseflow	0.15	
Winter baseflow	0.46	
2-year	30.5	-
10-year	34.4	-
50-year (*approximated)	43.3	47.2
200-year	77.0	83.9

\*Estimated by NHC using linear approximation.

In addition, in the absence of more detailed analysis<sup>2</sup>, Engineers and Geoscientists of British Columbia (EGBC, formally APEGBC) recommends increasing the design flood condition by 10% to allow for potential changes in temperature and precipitation due to climate change until approximately year 2070 (APEGBC, 2017). With this allowance for climate change related effects, a 50-year return period flood discharge of 52  $m^3/s$  has been considered for this study<sup>3</sup>, corresponding to an approximate average channel velocity of 1.3 m/s within the lower estuary.

<sup>2</sup> Additional detailed analysis on the impacts of climate change on temperature and precipitation would not be expected to result in substantially different design criteria, designs, or estimated costs. As such, detailed analysis of these items is not recommended for this project.

<sup>3</sup> 52  $m^3/s$  is the approximated 50-year discharge associated with future land use changes, with a 10% increase to account for climate change.

## 4 OFFSETTING OPPORTUNITIES

### 4.1 Overview

Figure 4.1 shows the relative location of the eight proposed habitat offsetting opportunities within the Semiahmoo Bay – Little Campbell river estuary. Descriptions and artistic renderings of each opportunity are also provided in the following sub-sections.



**Figure 4.1 Plan view of the eight habitat offsetting opportunities**  
(see Appendix A for a higher-resolution plan view image of the eight opportunities)

### 4.2 Opportunity 1 – Large Woody Debris Complexes

Large Woody Debris (LWD) complexes consist of a matrix of logs with root wads anchored onto the outer edge (right side) of the river channel. The preliminary design includes cedar logs between 5 – 8 m in length, and 0.5 – 0.9 m in diameter, with intact root wads. Logs are snugly attached to several large diameter ballast rocks with cables running through the log. The LWD complexes extend approximately 90 m in length along the river bank, approximately 400 m from the mouth of the river. The design aims to provide cover, habitat complexity, and resting areas for salmonids during rearing and migration. In addition, scour pools tend to form at the base of the root wads, providing additional instream habitat

complexity. Additional habitat offsetting measures may be added during detailed design, including planting native backshore vegetation.

The approximate footprints related to Opportunity 1 are as follows:

- LWD complexes (including logs and ballast): 0.08 ha
- Scour pools: 0.03 ha

Preliminary design sketches (plan and typical sections) are provided in Appendix A. An artistic rendering of Opportunity 1 is provided in Figure 4.2.



**Figure 4.2 (Left) Present day conditions at the project site. (Right) Artistic rendering of Opportunity 1 – Large Woody Debris Complexes. Note that the rendering is indicative only.**

### 4.3 Opportunity 2 – Pile and Derelict Wood Removal

The Little Campbell River estuary currently contains a large quantity of derelict wood and piles, which are remnants of historical industrial activities in the area. This opportunity includes removal of these materials via hand-tools. The precise location and quantity of materials to be removed will be determined in collaboration with Semiahmoo First Nation via an additional site visit during detailed design, but is expected to include at least 270 tonnes of material. It is currently not anticipated that these materials and surrounding sediments are contaminated; however, it is recommended that material testing be completed prior to construction. If materials are contaminated, special considerations would need to be made for their removal and disposal. During construction, special consideration would also be made for wood that currently serves to retain shoreline materials (shoring materials), to ensure that removal does not result in increased shore erosion. In addition, it may be beneficial to retain some piles to provide raptor perches.

The approximate footprint related to Opportunity 2 is as follows:

- Pile and derelict wood removal: 0.35 ha

Preliminary design sketches (plan and typical sections) are provided in Appendix A. An artistic rendering of Opportunity 2 is provided in Figure 4.3.



**Figure 4.3 (Left) Present day conditions at the project site. (Right) Artistic rendering of Opportunity 2 – Pile and Derelict Wood Removal. Note that the rendering is indicative only.**

#### 4.4 Opportunity 3 – Inter-Island Channel & Salt Marsh

The construction of salt marsh and backshore habitat is supported by the Department of Fisheries and Oceans (DFO) national fish habitat policy and is an important management effort for supporting estuarine-rearing Pacific salmon, such as Chinook and chum. As such, Opportunity 3 involves constructing a marsh bench between approximately 0.6 – 1.4 m elevation CGVD28. The existing intertidal substrate will be excavated and side cast to form drainage channels for the marsh. Additional marsh fill will be imported to site and topped with a 0.3 m thick topsoil to provide a proper growing medium for marsh vegetation. The marsh will be planted with one vegetation mix along the marsh edge (containing Pickleweed, Arrowgrass, Saltgrass, Baltic rush, and Seacoast Bulrush) and another mix on the main marsh platform (containing Lyngbye’s sedge, Plantain, Pacific silverweed, Pickleweed, Gumweed, Arrowgrass, and Douglas’ aster). The channel banks will be faced with small rock to help retain marsh soils and provide some protection from erosion.

The approximate footprints related to Opportunity 3 are as follows:

- Vegetated marsh: 0.78 ha
- Drainage channels: 0.09 ha

Preliminary design sketches (plan and typical sections) are provided in Appendix A. An artistic rendering of Opportunity 3 is provided in Figure 4.4.



**Figure 4.4 (Left) Present day conditions at the project site. (Right) Artistic rendering of Opportunity 3 – Inter-Island Channel & Salt Marsh. Note that the rendering is indicative only.**

#### 4.5 Opportunity 4 – East Salt Marsh

Opportunity 4 involves constructing a marsh bench on the lee-side of the railway track between approximately 0.6 – 1.4 m elevation CGVD28. Similarly to the previous opportunity, the existing intertidal substrate will be excavated and side cast to form drainage channels for the marsh. Additional marsh fill and topsoil will be imported to provide a proper growing medium for marsh vegetation, with the same mixture as describe in Section 4.3. The channel banks will be faced with granular material (rock) to help retain marsh soils and provide some protection from erosion. In addition, the channel outlet will include a rock mattress to provide flow control and erosion protection.

The approximate footprints related to Opportunity 4 are as follows:

- Vegetated marsh: 0.74 ha
- Drainage channels: 0.11 ha

Preliminary design sketches (plan and typical sections) are provided in Appendix A. An artistic rendering of Opportunity 4 is provided in Figure 4.5.



**Figure 4.5 (Left) Present day conditions at the project site. (Right) Artistic rendering of Opportunity 4 – East Salt Marsh. Note that the rendering is indicative only.**

#### 4.6 Opportunity 5 – East River Bank Protection

The east bank of the river mouth (beneath the railway abutment) has experienced significant erosion related to the gradual realignment of the river in this location. Construction of erosion protection in this area would have the benefits of preventing further erosion and realignment of the river, helping to protect the railway abutment, and protecting the proposed marsh enhancements to the east (e.g. Opportunity 4 – East Salt Marsh). As such, Opportunity 5 includes regrading the existing slope, placing a rock filter layer, and placing a rock armour layer. On the seaward edge of the protection, the armour layer includes larger and specially-placed armour rock to prevent wave-induced erosion. Notably, detailed design must include careful consideration of design and construction restrictions in the vicinity of the bridge abutments. Additional habitat measures may also be considered during detailed design, such as live staking or plantings.

The approximate footprint related to Opportunity 5 is as follows:

- Bank protection: 0.04 ha

Preliminary design sketches (plan and typical sections) are provided in Appendix A. An artistic rendering of Opportunity 5 is provided in Figure 4.6.



**Figure 4.6 (Left) Present day conditions at the project site. (Right) Artistic rendering of Opportunity 5 – East River Bank Protection. Note that the rendering is indicative only.**

#### 4.7 Opportunity 6 – Sediment Lobe Removal

Dominant longshore morphological processes have resulted in the formation of the gravel lobe on the west side of the river mouth. Excavation of much of the sediment lobe would serve to realign the river mouth, reducing erosion on the east side of the river mouth and reducing the flood risk to the Semiahmoo First Nation’s land. In addition, the sediment lobe composition is similar that present on the foreshore directly west of the river mouth. Excavated material could therefore provide beneficial re-use in enhancing foreshore habitat (see Opportunities 7 and 8). The preliminary design assumes removal of approximately 1,740 m<sup>3</sup> of mixed gravel material; however the precise quantity will depend on the volume of material present at the time of construction. Notably, there is an opportunity to expand the footprint of the excavation to include material seaward of the railway bridge, to facilitate traditional access between the Little Campbell River Estuary and Semiahmoo Bay. In addition, the river bathymetry

was not surveyed prior to preliminary design, and should be confirmed to better define material quantities and scope of work prior to detailed design.

The approximate footprint related to Opportunity 6 is as follows:

- Sediment removal: 0.13 ha

Preliminary design sketches (plan and typical sections) are provided in Appendix A. An artistic rendering of Opportunity 6 is provided in Figure 4.7.



**Figure 4.7 (Left) Present day conditions at the project site. (Right) Artistic rendering of Opportunity 6 – Sediment Lobe Removal. Note that the rendering is indicative only.**

#### 4.8 Opportunity 7 – Western Foreshore Enhancement

The intent of Opportunity 7 is to improve surf smelt and sand lance spawning habitat through the addition of suitable sand-gravel beach nourishment along the mid to upper foreshore. Construction of a rock groyne along the western bank of the tidal channel will help to both stabilize the beach nourishment and prevent further development of the sediment lobe. Material removed from the sediment lobe (Opportunity 6) may be reused as beach nourishment material; however, it is recommended to supplement the material with sand to provide an optimal substrate for surf smelt and sand lance. Notably, Opportunity 6 is expected to result in more material than is required for the current concept design and, as such, there is may be an opportunity to expand the footprint of this opportunity.

The approximate footprints related to Opportunity 7 are currently as follows.

- Beach nourishment: 0.04 ha
- Groyne: 0.01 ha

Preliminary design sketches (plan and typical sections) are provided in Appendix A. An artistic rendering of Opportunity 7 is provided in Figure 4.8.



**Figure 4.8 (Left) Present day conditions at the project site. (Right) Artistic rendering of Opportunity 7 – Western Foreshore Enhancement. Note that the rendering is indicative only.**

#### 4.9 Opportunity 8 – Eastern Foreshore Enhancement

Opportunity 8 also aims to improve forage fish spawning habitat through the addition of a sand-gravel beach nourishment. However, fine material is not expected to be stable on this reach of shoreline without construction of additional control structures to stabilize the material. As such, the design includes a pocket beach complex with rock headland control structures. The headlands are composed of large armour rock on a filter rock mattress. To improve backshore habitat productivity, a mixture of suitable riparian vegetation may be planted, consisting of Sea Rocket, Dunegrass, and Silver Burweed. Material removed from the sediment lobe may be repurposed and supplemented with sand to provide an optimal substrate for surf smelt and sand lance. There may also be an opportunity to expand the footprint of this opportunity (8) to utilize excess material removed from the sediment lobe.

The approximate footprints related to Opportunity 8 are currently as follows:

- Beach nourishment: 0.05 ha
- Headlands: 0.04 ha

Preliminary design sketches (plan and typical sections) are provided in Appendix A. An artistic rendering of Opportunity 8 is provided in Figure 4.9.



**Figure 4.9 (Left) Present day conditions at the project site. (Right) Artistic rendering of Opportunity 8 – Eastern Foreshore Enhancement. Note that the rendering is indicative only.**

## 5 COST-ESTIMATES

*Note: This section has been removed (redacted) to protect sensitive information*

## 6 ADDITIONAL CONSIDERATIONS

### 6.1 Dynamic or ‘Soft’ Techniques

Dynamic or ‘soft’ engineering techniques (such as beach nourishments) can have profound benefits to a project in terms of adaptability, aesthetics, and environmental effect; however, they typically undergo reshaping after construction to accommodate incident waves, water levels, and currents, and establish a new ‘dynamic equilibrium’. Depending on the coincidence and frequency of storm waves, water levels, and river flows in any given year, the dynamic or ‘soft’ designs will behave slightly differently. As such, it is generally recommended that an adaptive management approach be taken, and (as with any project) a budget allowance be set-aside for long-term monitoring and maintenance.

### 6.2 Natural Adaptation to Sea Level Rise

It is typically a requirement that any development projects located within the coastal zone be designed to accommodate future expected sea level rise. However, many habitat enhancement techniques (e.g. vegetation plantings) operate within a narrow range of optimal conditions and must be designed for present-day conditions. Instead, the intent of these designs is to allow for natural accumulation of sediment to help keep pace with sea level rise and to allow for sufficient room for vegetation communities to naturally migrate upslope (i.e. avoiding coastal squeeze).

### 6.3 Contaminated Materials

It is currently not anticipated that materials or sediments within the Little Campbell River estuary are contaminated. However, derelict wood and piles slated for removal, as well as surrounding sediments, should be tested for contamination prior to construction. If materials are contaminated, special considerations would need to be made for their removal and disposal.

### 6.4 Construction Staging and Access

Construction staging and access areas will be further refined during detailed design. In particular, staging and access considerations will include the following items:

- Interaction and coordination between offsetting opportunities and their individual components.
- Permissions and coordination for staging and access through Semiahmoo First Nation land.
- Permissions and coordination with BNSF railway, for working near the railway, under the railway bridge and adjacent to the abutments, and usage of the railway itself for delivery of material and site access.
- Location of other existing infrastructure (such as outfalls).
- Feasibility of material and equipment supply via water.

## 6.5 Construction Scheduling and Phasing

Scheduling and phasing for construction should be considered as part of detailed design. Some initial considerations include the following:

- Work in or near water should generally respect the timing windows for reduced risk set by Fisheries and Oceans Canada (DFO) to avoid harm to fish species. According to the DFO website, work in the foreshore at the project sites (Area 29 – Steveston/Surrey) should generally occur between August 16<sup>th</sup> – February 28<sup>th</sup>. Work in freshwater should generally avoid periods when fish are spawning, no eggs or alevins are present in in-stream gravels, and no juvenile fish are over-wintering in the stream. These periods of lower-risk are specific to the fish species present in the watercourse.
- Work should generally coincide with the tidal work windows and periods of low-flow so that in-water work is avoided as much as possible. To utilize the winter fisheries window, this may require working during the night, which in turn may have implications with respect to disturbance to nearby residents.
- Prior to planting marsh vegetation, marsh soils should be left for several weeks to months, depending on construction timing and plant growth windows to allow soils to settle and consolidate prior to transplanting. Marsh elevations should also be measured to confirm that the settled soils are still within the design elevations and additional soil added if necessary.
- Vegetation plugs should be planted as soon as possible after delivery, to avoid plugs drying out. Typically, this means that plugs should be planted within one day of delivery.

## 6.6 Log Accumulation

Log accumulation can occur in both natural and constructed marshes, and has the potential to damage plants. In extreme situations, log accumulations can be excessive and smother marsh vegetation, requiring preventative measures to reduce logs from entering the marsh or implement annual cleanups. However, it is not anticipated that logs within the Little Campbell River estuary will cause problematic log accumulation in the constructed salt marshes in the area.

## 6.7 Controlling Geese Grazing

Transplanted marsh consists of species grazed by Canada geese (*Branta canadensis*), which could affect the success of the vegetation establishment. Geese grazing includes cropping above ground growth in the spring as new shoots start to grow as well as seed heads in the summer.

Prior to construction, the potential impact of geese grazing and approaches to control grazing should be considered. To control geese grazing in previous projects, snow fencing has been installed that is supported by wooden posts around the perimeter of the marsh and a rope/caution tape netting tied across the top of the enclosure to prevent geese from flying into the marsh. The enclosures are also susceptible to damage from high winds, floating logs and debris so do require maintenance. Alternative approaches may include allowing geese grazing and only responding if grazing is intense and threatening establishment of the marsh bed.

## 7 CLOSURE

There is great potential to develop effective habitat offsetting opportunities within the Semiahmoo Bay and Little Campbell River estuary area through remediating legacy conditions. The primary functional requirement for offsetting opportunities in this area is to restore or improve ecological function and productivity, in a way that contributes to offsetting the residual effects of the RBT2 project on fish and fish habitat. To maximize potential benefits, eight offsetting opportunities were developed to a preliminary design level:

- Opportunity 1.** Large woody debris complexes
- Opportunity 2.** Pile and derelict wood removal
- Opportunity 3.** Inter-island channel and salt marsh
- Opportunity 4.** East salt marsh
- Opportunity 5.** East river bank protection
- Opportunity 6.** Sediment lobe removal
- Opportunity 7.** Western foreshore enhancement
- Opportunity 8.** Eastern foreshore enhancement

All eight offsetting opportunities were developed in consideration of functional, ecological, and engineering design requirements. As such, it is NHC's opinion that all presented offsetting opportunities are technically feasible. Prior to detailed design and construction (which would include consideration for construction access, staging, and phasing), however, the following steps should be taken to fill identified information gaps:

- Confirm if all opportunities are to proceed to detailed design.<sup>4</sup>
- Obtain river bathymetry (depths) near the sediment lobe, the eastern bank of the river mouth, and the river outlet channel.
- Obtain additional elevation points in areas not visible from the previous drone (UAV) survey data, such as heavily vegetated areas or beneath the railway bridge.
- Undertake contamination testing of derelict piles and wood for removal, as well as surrounding sediments.
- Estimate quantity of derelict piles and wood for removal.

The Semiahmoo First Nation should continue to be engaged for further input on the preliminary designs, including additional functional requirements, environmental input, site staging and access restrictions, schedule or phasing considerations, and general preference. In addition, BNSF railway should be approached to discuss the project feasibility and provide additional functional requirements for working near the railway.

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<sup>4</sup> This may include expansion of Opportunity 6 to remove additional gravel materials seaward of the railway bridge to facilitate traditional access to Semiahmoo Bay, and/or expansion of Opportunity 7 or 8 to utilize more of the removed materials.

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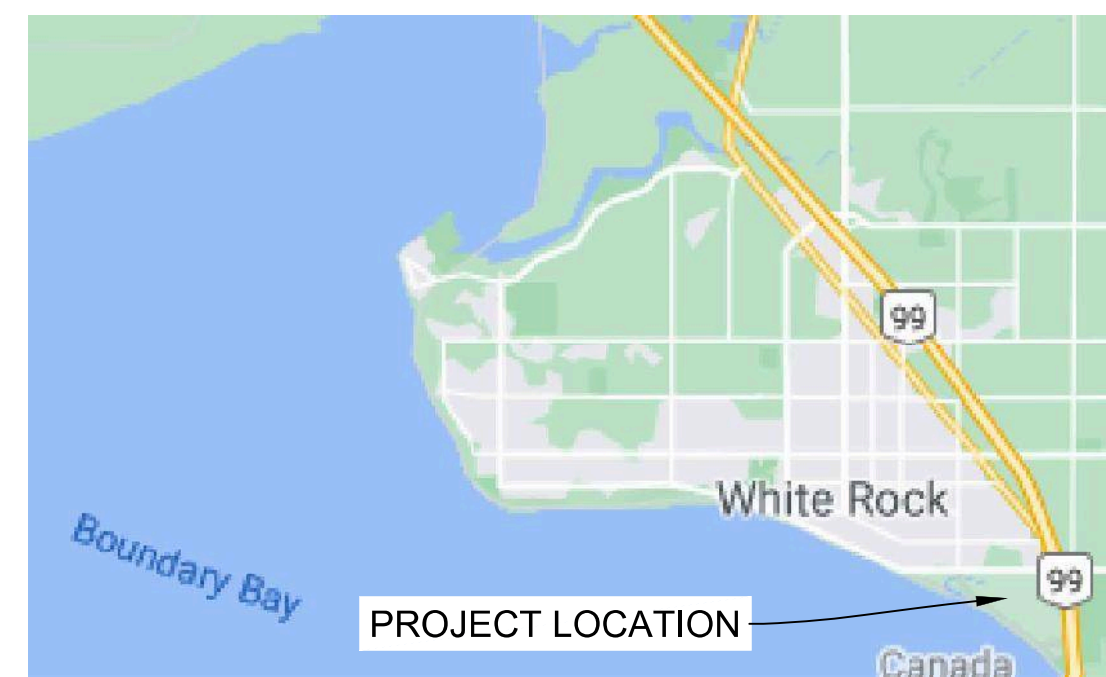
## **Appendix A      Preliminary Design Drawings**

Semiahmoo Bay – Little Campbell River Enhancement Project, Preliminary Design Drawings

# SEMAIAHMOO BAY - LITTLE CAMPBELL RIVER ENHANCEMENT PROJECT

## PRELIMINARY DESIGN DRAWINGS

DRAWING INDEX		
SHEET NO.	DESCRIPTION	REVISION
001	COVER SHEET	0
002	GENERAL NOTES	0
003	GENERAL SITE PLAN	0
101	OPPORTUNITY 1 - LWD COMPLEXES	0
102	OPPORTUNITY 2 - PILE AND DERELICT WOOD REMOVAL	0
103	OPPORTUNITY 3 - INTER-ISLAND CHANNEL & SALT MARSH	0
104	OPPORTUNITY 4 - EAST SALT MARSH	0
105	OPPORTUNITY 5 - EAST RIVER BANK PROTECTION	0
106	OPPORTUNITY 6 - SEDIMENT LOBE REMOVAL	0
107	OPPORTUNITY 7 - WESTERN FORESHORE ENHANCEMENT	0
108	OPPORTUNITY 8 - EASTERN FORESHORE ENHANCEMENT	0



SITE PLAN  
N.T.S.



KEY PLAN  
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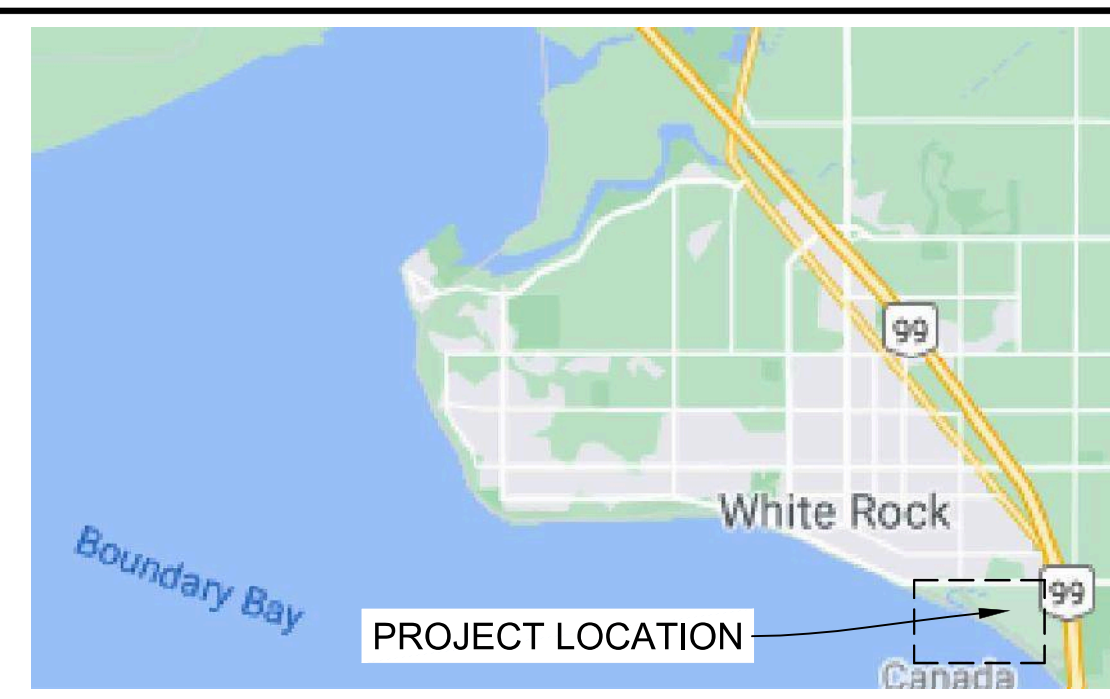
**SEMAIAHMOO BAY - LITTLE CAMPBELL RIVER  
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PRELIMINARY DESIGN DRAWINGS  
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PROJECT NOTES:  
 1. APPROXIMATE FOOTPRINT FOR ALL OPPORTUNITIES: 2.49 ha

- LEGEND**
- OPPORTUNITY 1 - LWD COMPLEXES
  - OPPORTUNITY 2 - FILL AND DERELICT WOOD REMOVAL
  - OPPORTUNITY 3 - INTER-ISLAND CHANNEL & SALT MARSH
  - OPPORTUNITY 4 - EAST SALT MARSH
  - OPPORTUNITY 5 - EAST RIVER BANK PROTECTION
  - OPPORTUNITY 6 - SEDIMENT LOBE REMOVAL
  - OPPORTUNITY 7 - WESTERN FORESHORE ENHANCEMENT
  - OPPORTUNITY 8 - EASTERN FORESHORE ENHANCEMENT

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 ENHANCEMENT PROJECT  
 PRELIMINARY DESIGN DRAWINGS  
 SITE PLAN**

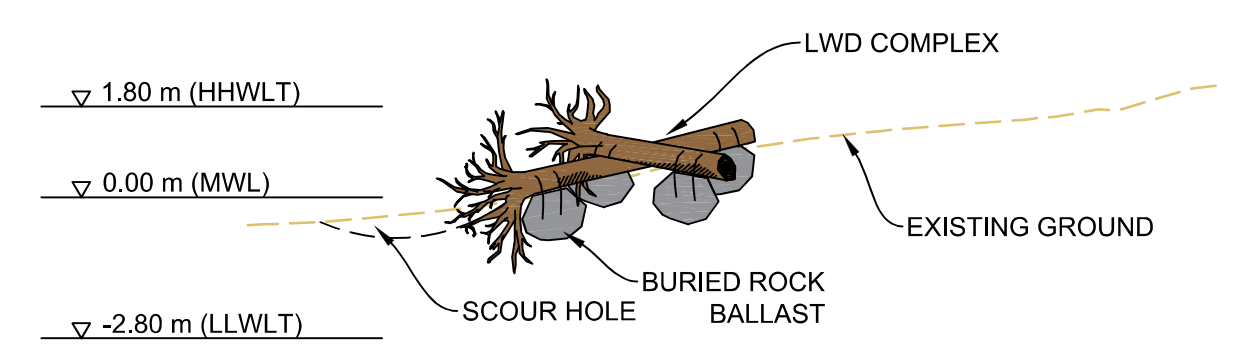
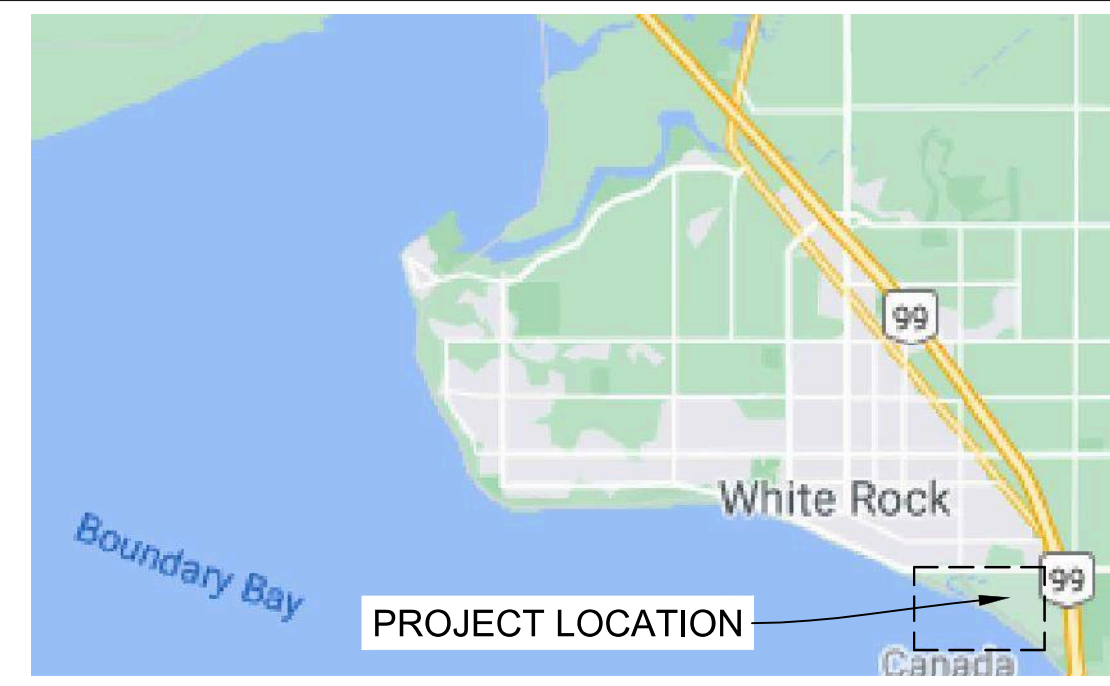
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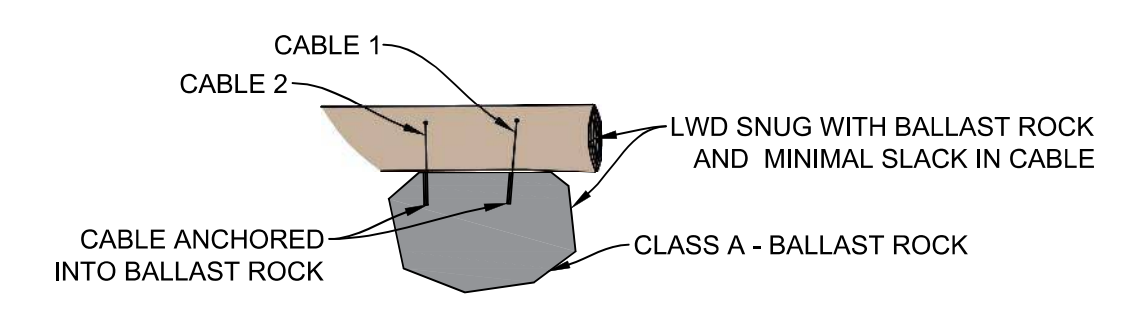
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TYPICAL SECTION - LWD  
1:150



TYPICAL DETAIL - LWD ANCHOR  
1:25

- PROJECT NOTES:
- LWD REFERS TO 'LARGE WOODY DEBRIS'.
  - PLACEMENT AND ARRANGEMENT OF LWD COMPLEXES MAY VARY FROM DRAWINGS AS PER DIRECTION OF ENGINEERING REPRESENTATIVE.
  - ADDITIONAL HABITAT MEASURES MAY BE INCLUDED TO PROVIDE IN-STREAM COVER FOR JUVENILE SALMONIDS AND HABITAT COMPLEXITY.
  - APPROXIMATE PROJECT FOOTPRINT: 0.11 ha

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**SEMAHMOO BAY - LITTLE CAMPBELL RIVER  
ENHANCEMENT PROJECT  
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OPPORTUNITY 1 - LWD COMPLEXES**

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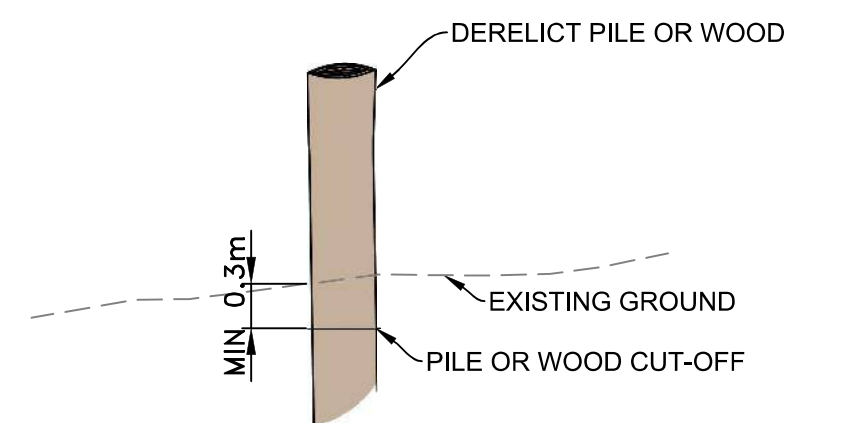
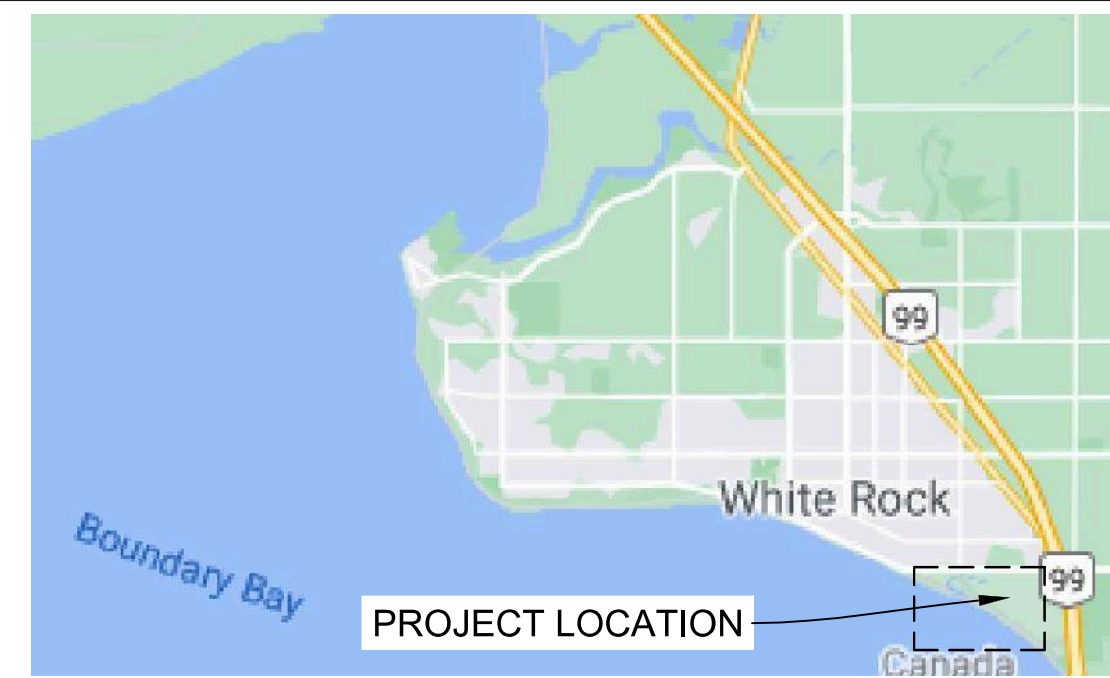
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APPROXIMATE LOCATIONS OF DERELICT PILE AND WOOD REMOVAL (IN YELLOW)



TYPICAL DETAIL - PILE REMOVAL  
1:50

LEGEND:

APPROXIMATE LOCATION OF DERELICT PILE AND WOOD REMOVAL

- PROJECT NOTES:
1. REMOVAL OF PILES AND DERELICT WOOD VIA HAND-TOOLS.
  2. WOOD MAY BE SOURCE OF CONTAMINANTS, REQUIRING SPECIAL HANDLING AND DISPOSAL.
  3. LOCATION OF WOOD FOR REMOVAL IS APPROXIMATE ONLY. PRECISE LOCATION AND QUANTITY TO BE DETERMINED PRIOR TO CONSTRUCTION.
  4. SOME PILES MAY BE RETAINED TO PROVIDE RAPTOR PERCHES AT THE DISCRETION OF THE PROJECT BIOLOGIST.
  5. WOOD CURRENTLY RETAINING SHORELINE MATERIAL SHALL BE REMOVED AT THE DISCRETION OF THE ENGINEERING REPRESENTATIVE.
  6. APPROXIMATE PROJECT AREA (IN YELLOW): 0.35 ha

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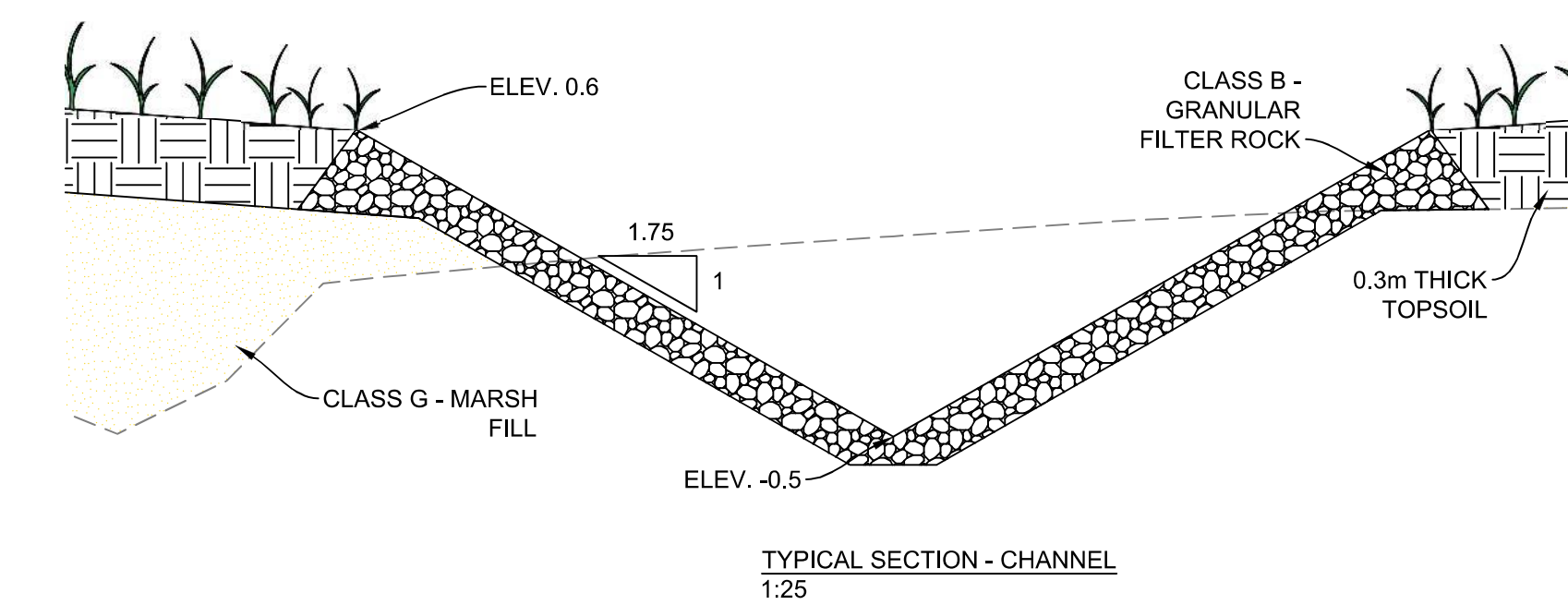
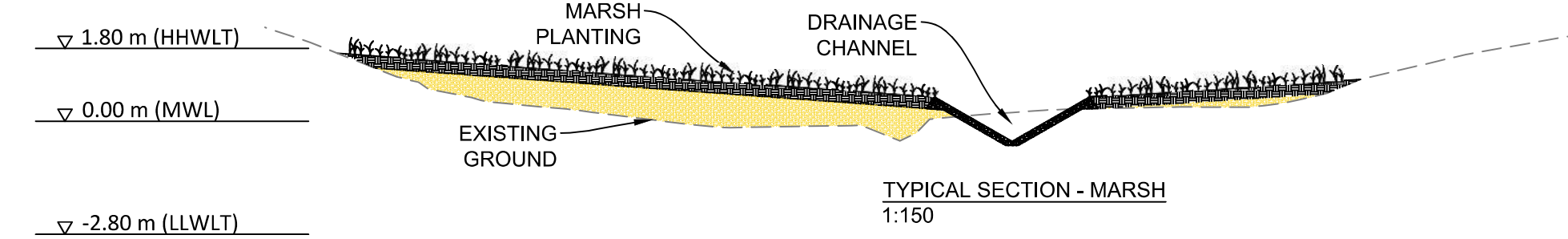
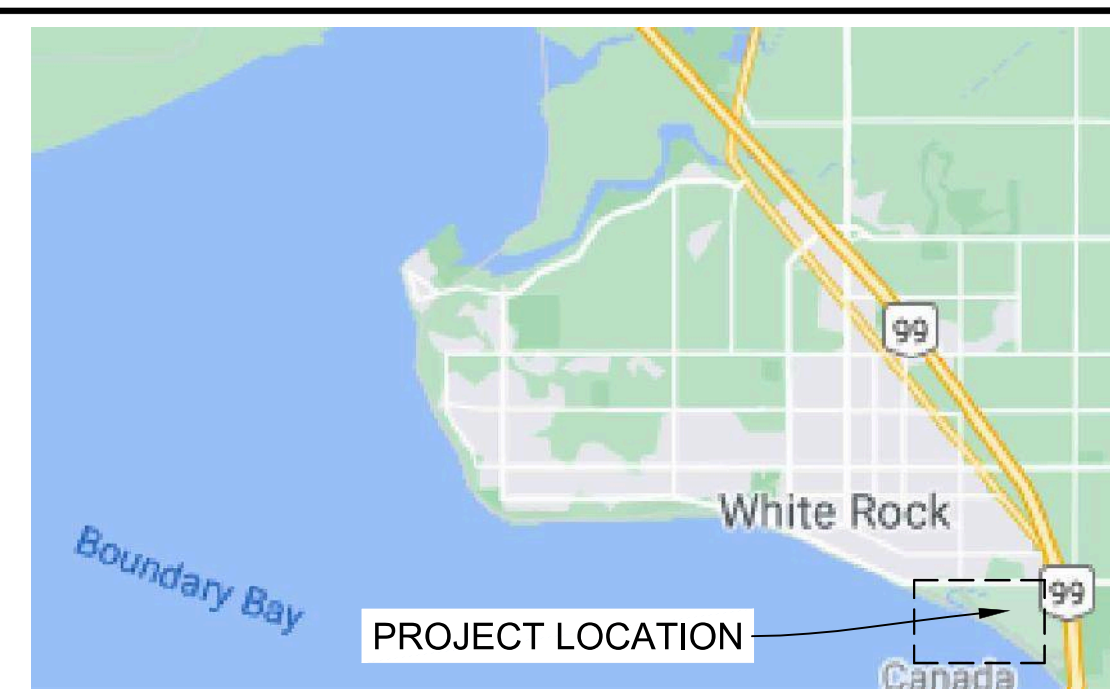
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**SEMAHMOO BAY - LITTLE CAMPBELL RIVER  
ENHANCEMENT PROJECT  
PRELIMINARY DESIGN DRAWINGS  
OPPORTUNITY 2 - PILE AND DERELICT WOOD REMOVAL**

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- LEGEND:**
- TYPE 1 - EDGE OF MARSH
  - TYPE 2 - MARSH PLATFORM
  - TOPSOIL
  - CLASS B - GRANULAR FILTER ROCK
  - CLASS G - MARSH FILL

- PROJECT NOTES:**
- SALT MARSH VEGETATION SHALL INCLUDE A MIX OF SPECIES BASED ON THE ACHIEVED MARSH ELEVATION, AS PER TABLE 4, GENERAL NOTES.
  - TOPSOIL SHALL BE LIGHTLY COMPACTED DURING CONSTRUCTION TO REDUCE SETTLEMENT POST-CONSTRUCTION.
  - APPROXIMATE PROJECT FOOTPRINT (INCLUDING MARSH AND TIDAL CHANNEL): 0.87 ha

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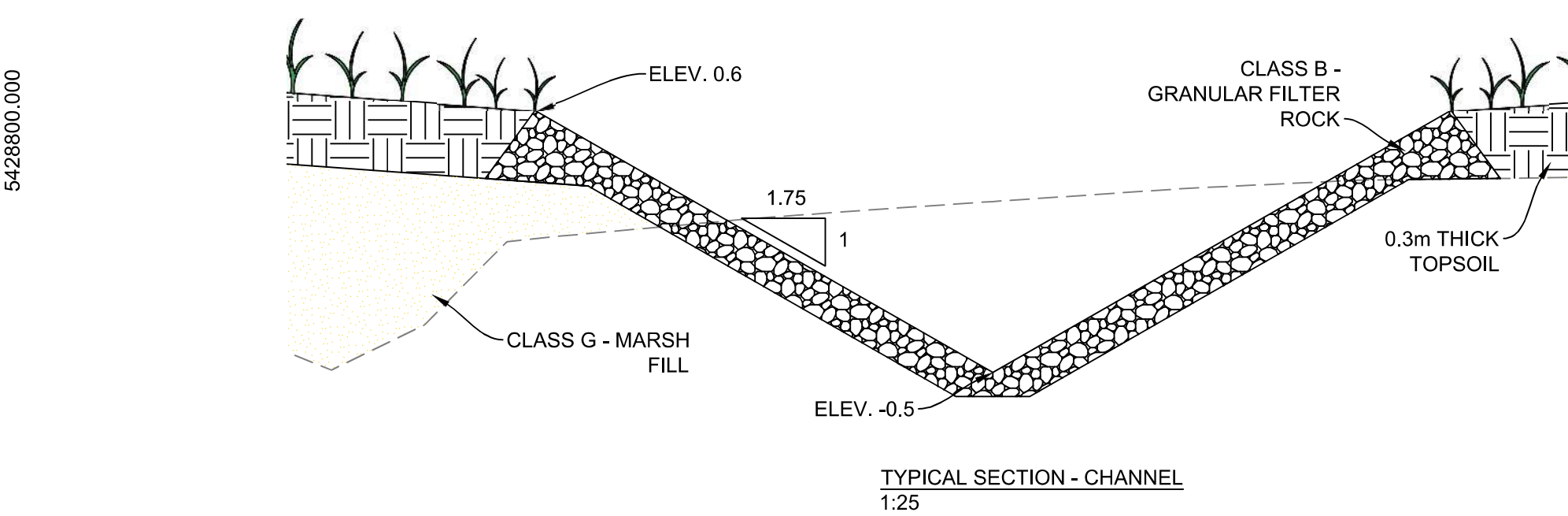
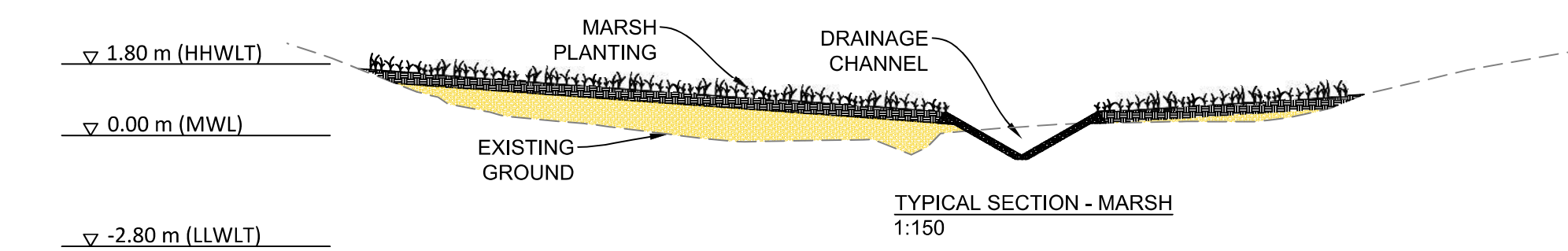
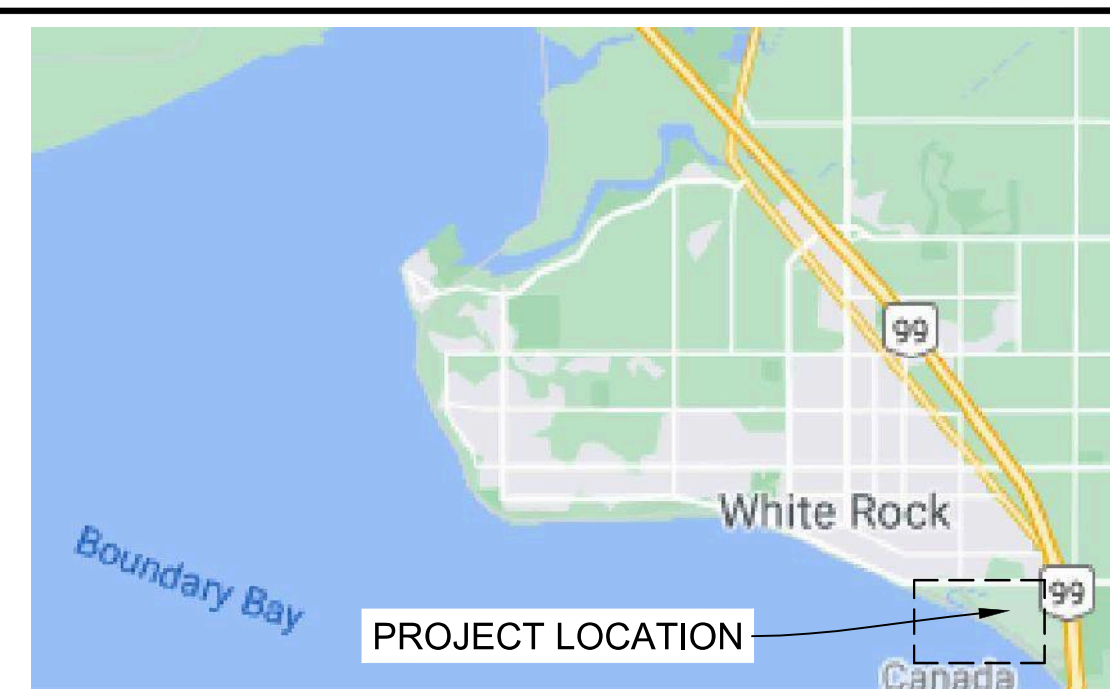
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<b>SEMAHMOO BAY - LITTLE CAMPBELL RIVER ENHANCEMENT PROJECT PRELIMINARY DESIGN DRAWINGS OPPORTUNITY 3 - INTER-ISLAND CHANNEL &amp; SALT MARSH</b>	
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- LEGEND:**
- TYPE 1 - EDGE OF MARSH
  - TYPE 2 - MARSH PLATFORM
  - TOPSOIL
  - CLASS B - GRANULAR FILTER ROCK
  - CLASS C - RIPRAP
  - CLASS G - MARSH FILL

- PROJECT NOTES:**
1. SALT MARSH VEGETATION SHALL INCLUDE A MIX OF SPECIES BASED ON THE ACHIEVED MARSH ELEVATION, AS PER TABLE 4, GENERAL NOTES.
  2. TOPSOIL SHALL BE LIGHTLY COMPACTED DURING CONSTRUCTION TO REDUCE SETTLEMENT POST-CONSTRUCTION.
  3. APPROXIMATE PROJECT FOOTPRINT (INCLUDING MARSH AND TIDAL CHANNEL): 0.85 ha

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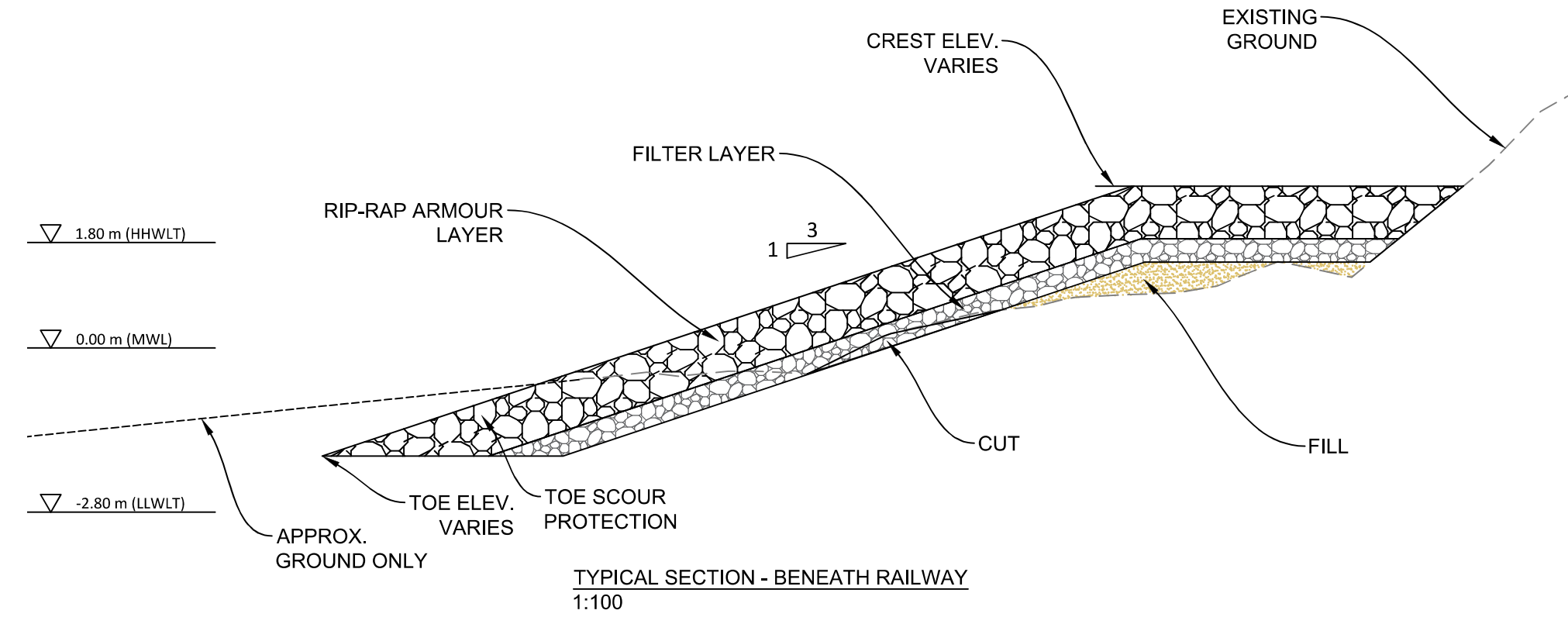
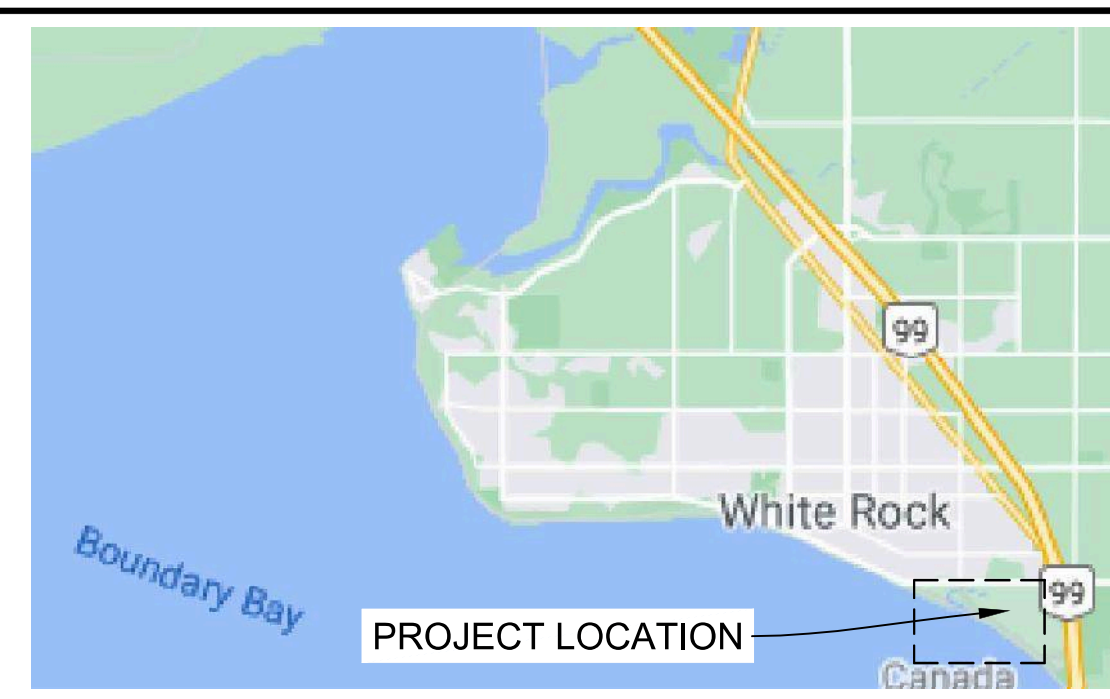
**SEMAHMOO BAY - LITTLE CAMPBELL RIVER  
 ENHANCEMENT PROJECT  
 PRELIMINARY DESIGN DRAWINGS  
 OPPORTUNITY 4 - EAST SALT MARSH**

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- LEGEND:**
- FILL MATERIAL (EITHER RE-USE CUT MATERIAL OR CLASS B - GRANULAR FILTER ROCK)
  - CLASS B - GRANULAR FILTER ROCK
  - CLASS C - RIPRAP
  - CLASS D - ARMOUR ROCK

- PROJECT NOTES:**
1. OPPORTUNITY REQUIRES COORDINATION WITH BNSF RAILWAY.
  2. DETAILED DESIGN MUST INCLUDE CONSIDERATION OF DESIGN AND CONSTRUCTION IN VICINITY OF BRIDGE ABUTMENTS.
  3. ADDITIONAL MEASURES MAY INCLUDE LIVE STAKING OR PLANTINGS FOR SLOPES ON THE NORTHERN SIDE OF THE RAILWAY.
  4. APPROXIMATE PROJECT FOOTPRINT: 0.04 ha

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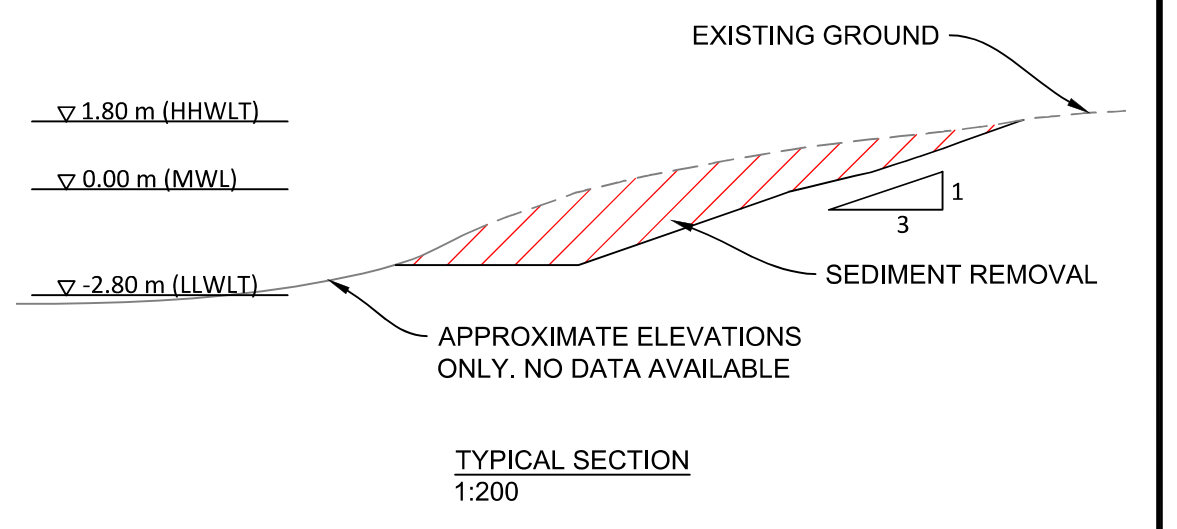
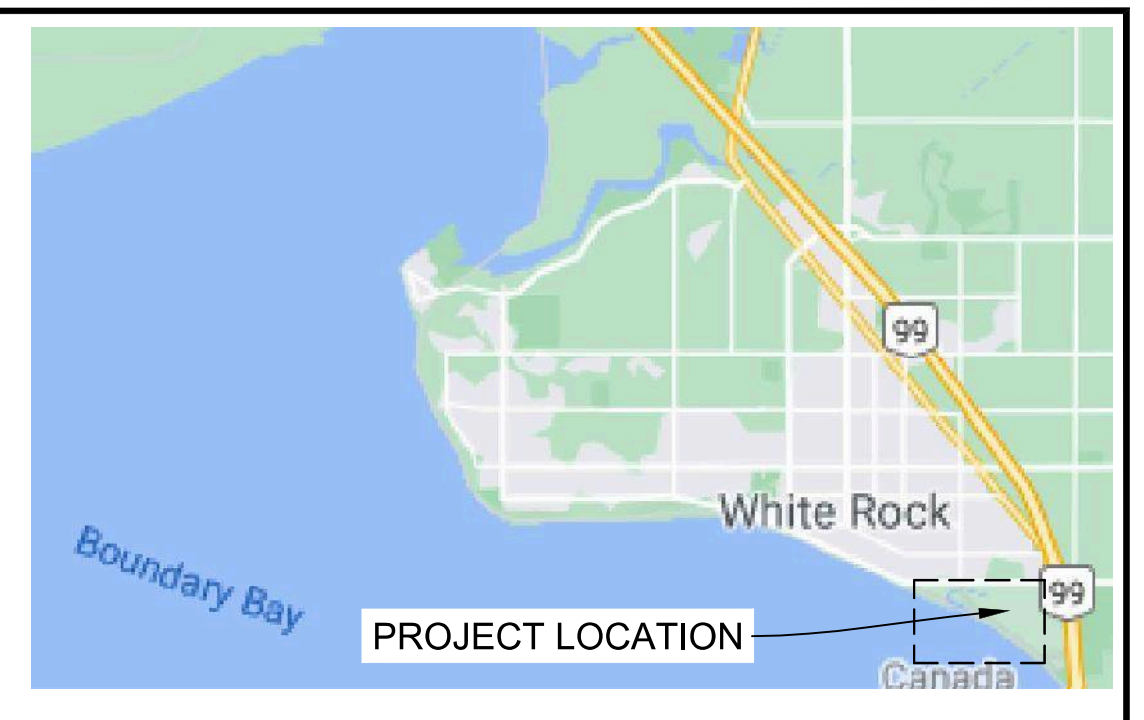
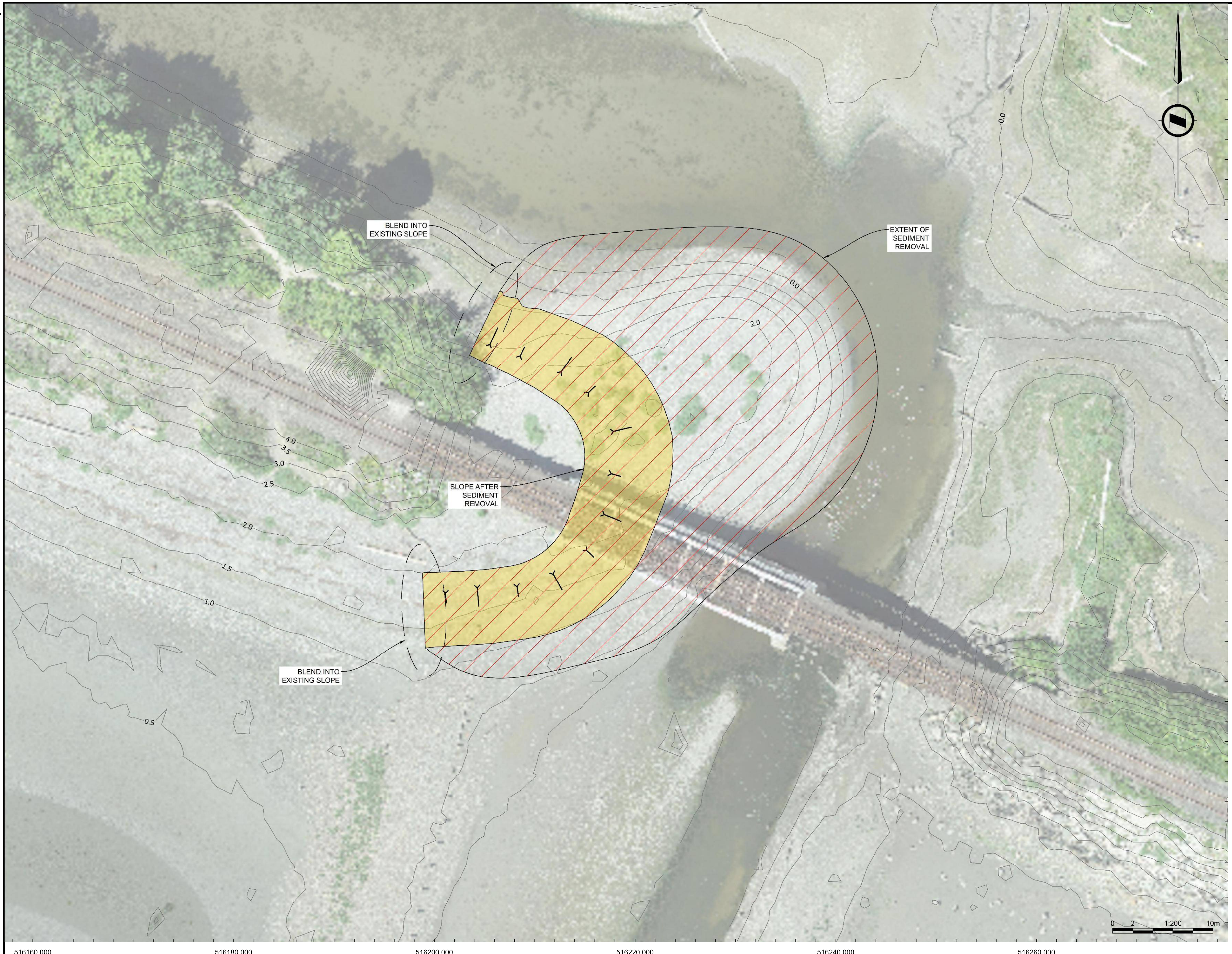
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**SEMAHMOO BAY - LITTLE CAMPBELL RIVER  
 ENHANCEMENT PROJECT  
 PRELIMINARY DESIGN DRAWINGS  
 OPPORTUNITY 5 - EAST RIVER BANK PROTECTION**

SIZE	DWG.	<b>300044-47-105</b>	SHEET	REV
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LEGEND:

	SEDIMENT REMOVAL
	SLOPE AFTER SEDIMENT REMOVAL

- PROJECT NOTES:
1. REMOVED SEDIMENT TO BE SET ASIDE FOR BENEFICIAL REUSE.
  2. OPPORTUNITY REQUIRES COORDINATION WITH BNSF RAILWAY.
  3. APPROXIMATE FOOTPRINT OF REMOVED SEDIMENT: 0.13 ha

516160.000	516180.000	516200.000	516220.000	516240.000	516260.000
5428980.000	5428980.000	5428980.000	5428980.000	5428980.000	5428980.000
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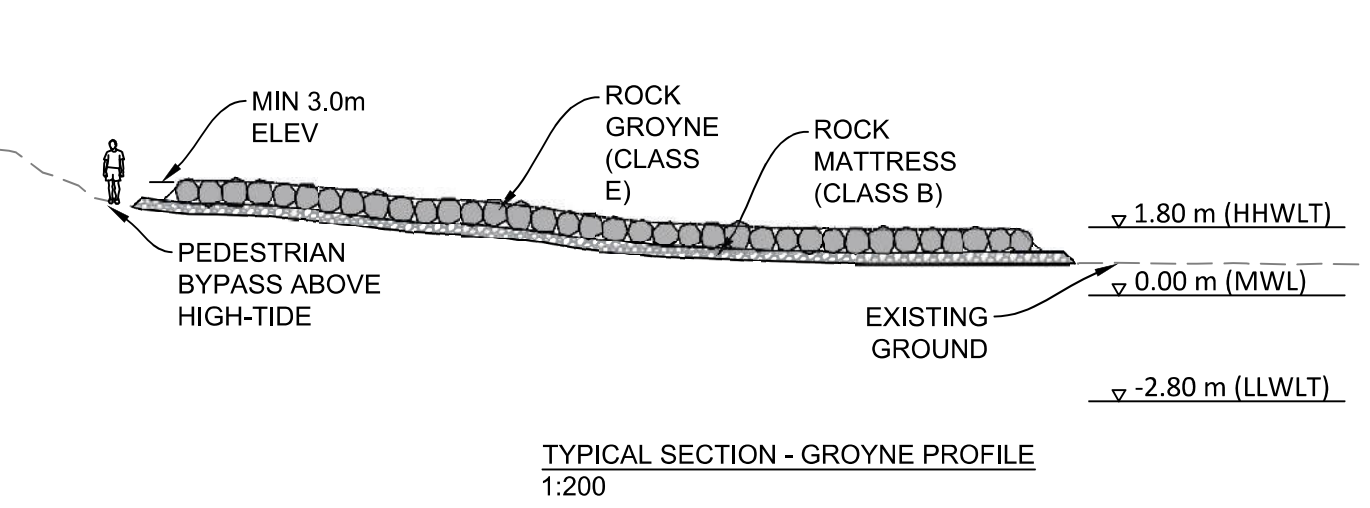
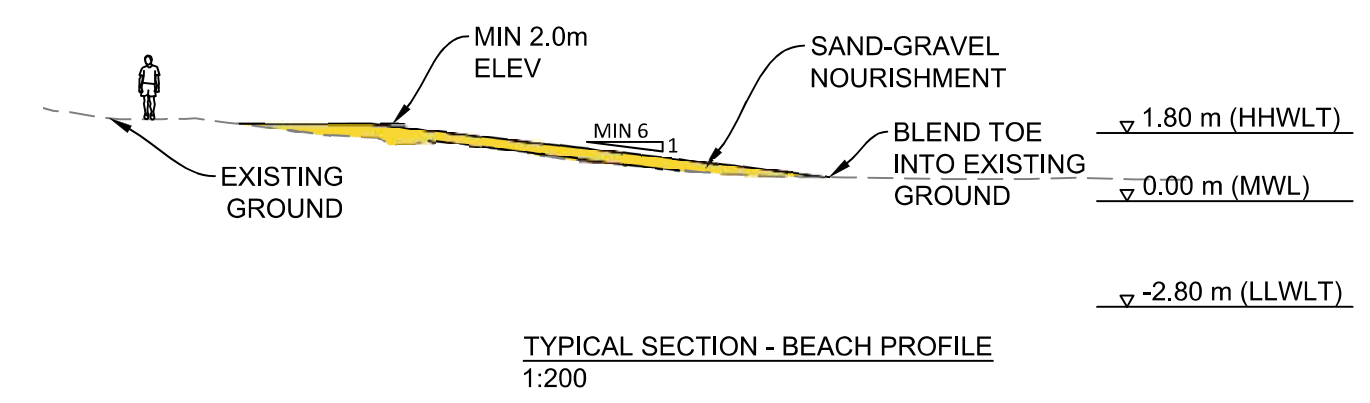
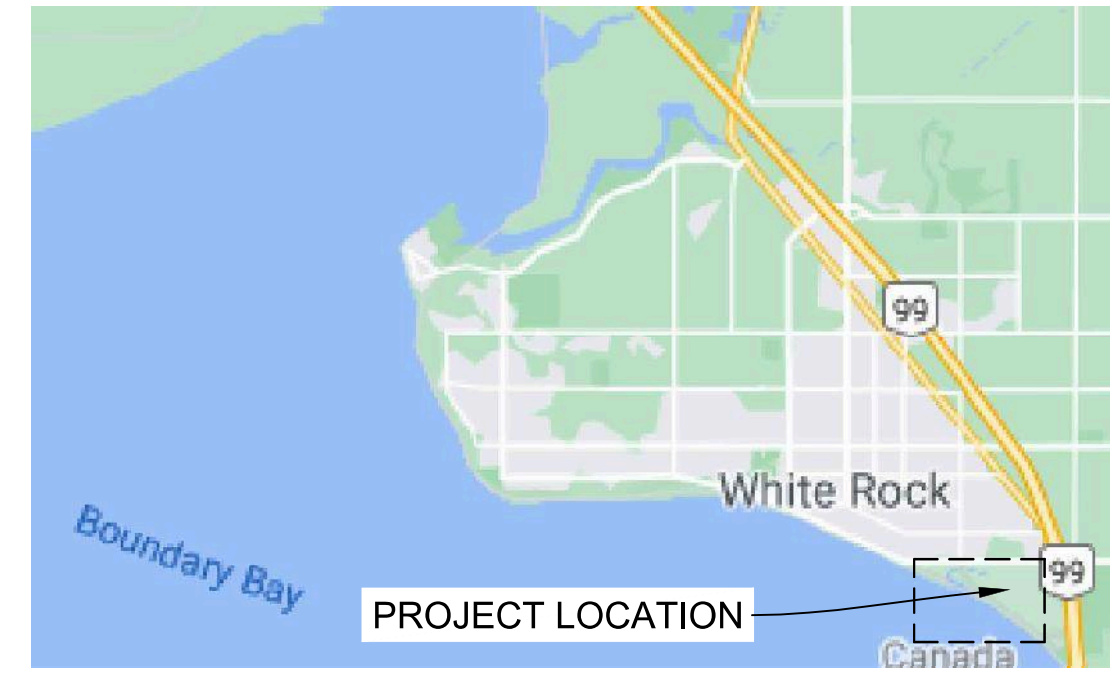
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**SEMAHMOO BAY - LITTLE CAMPBELL RIVER  
 ENHANCEMENT PROJECT  
 PRELIMINARY DESIGN DRAWINGS  
 OPPORTUNITY 6 - SEDIMENT LOBE REMOVAL**

SIZE	DWG.	300044-47-106	SHEET	9 OF 11	REV	0
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- LEGEND:
- CLASS B - GRANULAR FILTER ROCK
  - CLASS E - ROUNDED ROCK BOULDERS
  - CLASS F - BEACH FILL

- PROJECT NOTES:
1. APPROXIMATE FOOTPRINT OF BEACH NOURISHMENT: 0.04 ha
  2. APPROXIMATE FOOTPRINT OF GROYLE: 0.01 ha

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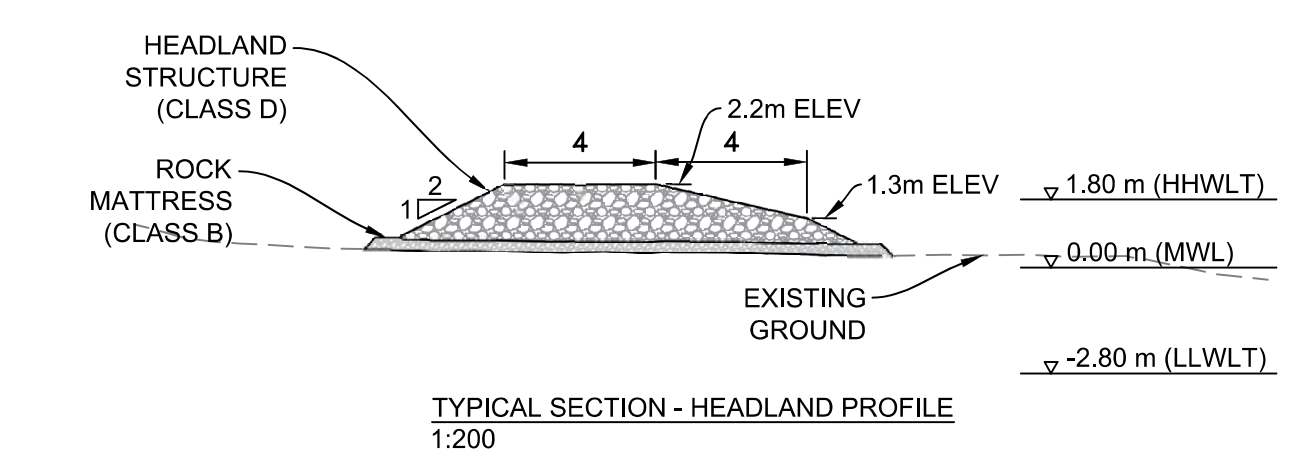
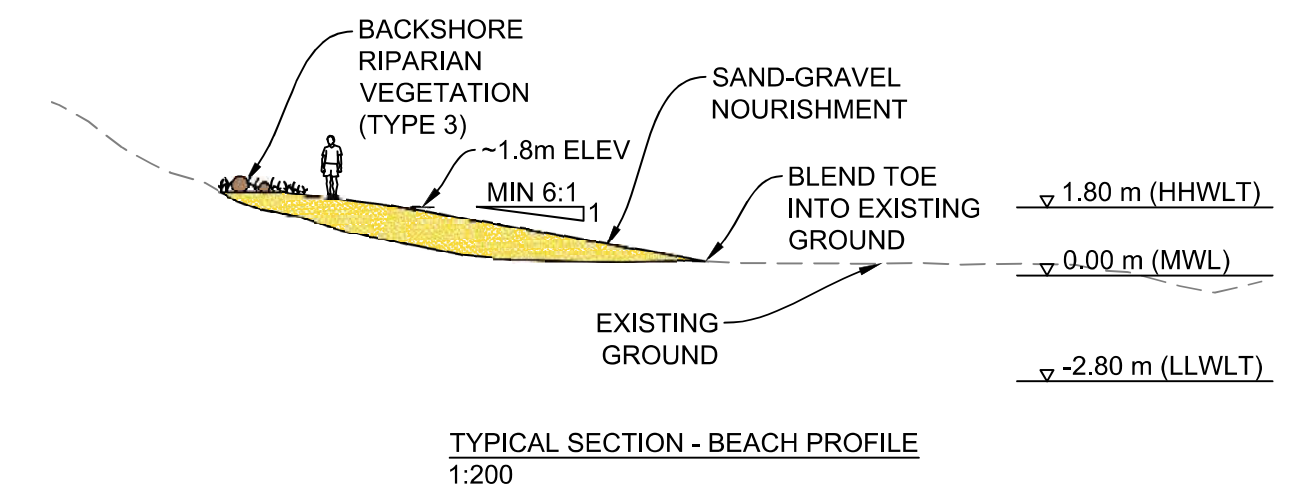
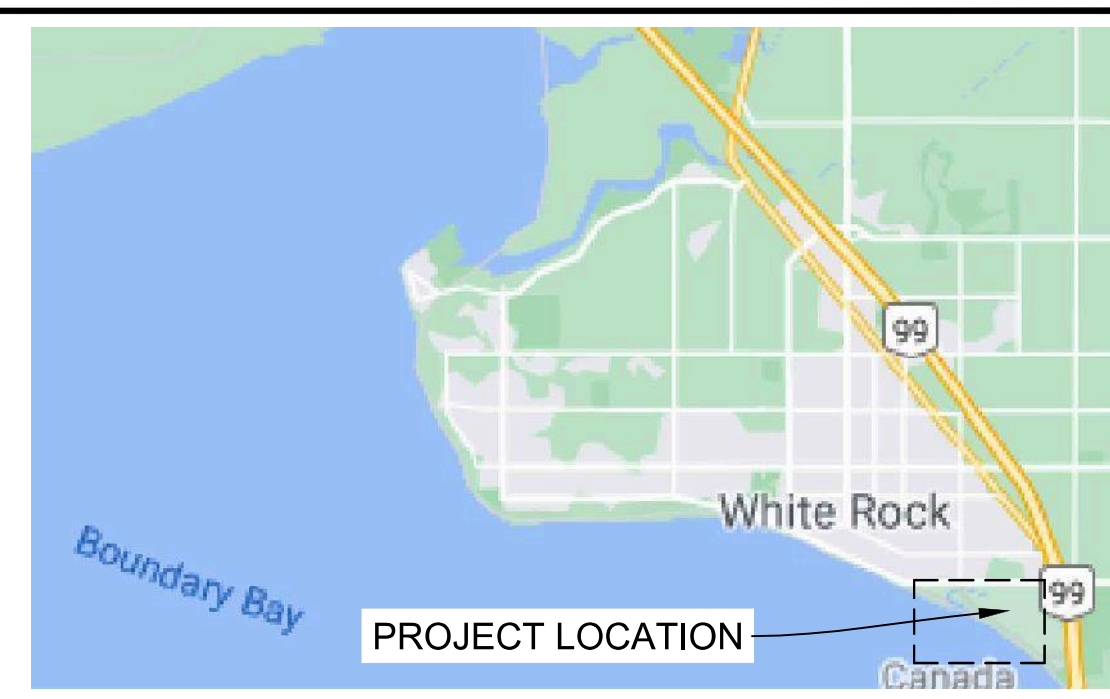
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**SEMAHMOO BAY - LITTLE CAMPBELL RIVER  
ENHANCEMENT PROJECT  
PRELIMINARY DESIGN DRAWINGS  
OPPORTUNITY 7 - WESTERN FORESHORE ENHANCEMENT**

SIZE	DWG.	<b>300044-47-107</b>	SHEET	REV
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- LEGEND:**
- TYPE 3 - BACKSHORE RIPARIAN VEGETATION
  - CLASS B - GRANULAR FILTER ROCK
  - CLASS D - ARMOUR ROCK
  - CLASS F - BEACH FILL

- PROJECT NOTES:**
1. OPPORTUNITY SHOULD BE UNDERTAKEN IN CONJUNCTION WITH THE GROUYNE IN OPPORTUNITY 7.
  2. APPROXIMATE FOOTPRINT OF BEACH NOURISHMENT: 0.05 ha
  3. APPROXIMATE FOOTPRINT OF HEADLANDS: 0.04 ha

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SEMIAHMOO BAY - LITTLE CAMPBELL RIVER  
 ENHANCEMENT PROJECT  
 PRELIMINARY DESIGN DRAWINGS  
 OPPORTUNITY 8 - EASTERN FORESHORE ENHANCEMENT

SIZE	DWG.	300044-47-108	SHEET	11 OF 11	REV	0
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**Appendix IR2020-1.1-A25**  
**Existing Ecological Conditions Report:**  
**Semiahmoo Bay-Little Campbell River**  
**Enhancement Project**

# Existing Ecological Conditions Report: Semiahmoo Bay-Little Campbell River Enhancement Project

Roberts Bank Terminal 2 Project

Vancouver Fraser Port Authority

February 2021

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## Revision History

Revision	Revision date	Details	Authorized	Name	Position

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# 1. Introduction

## 1.1 Background

The Vancouver Fraser Port Authority (port authority) is developing a fish habitat offsetting plan to support an application for *Fisheries Act* Authorization (FAA) for the Roberts Bank Terminal 2 Project (RBT2). The Semiahmoo Bay-Little Campbell River Enhancement Project (Semiahmoo Project) is one of the fish habitat offsetting projects currently being advanced as part of the RBT2 offsetting plan. The Semiahmoo Project was brought forward as a priority RBT2 offsetting project by, and is being advanced in partnership with, Semiahmoo First Nation.

## 1.2 Project Location and Context

The Semiahmoo Project is located in and around the Semiahmoo First Nation Reserve in White Rock, Surrey, B.C.—just over one kilometre north of the Canada-U.S. border (Figure 1). The project area includes the mouth and lower reach of the Little Campbell River, as well as a portion of the Semiahmoo Bay foreshore (Figure 2). Semiahmoo Bay is located south of the City of White Rock and the Little Campbell River flows into the north-eastern region of Semiahmoo Bay. The mouth of the Little Campbell River is located at 49.012857°N, -122.778137°W. With the permission of Semiahmoo First Nation, the Semiahmoo Project area is accessible via Beach Road off Highway 99.

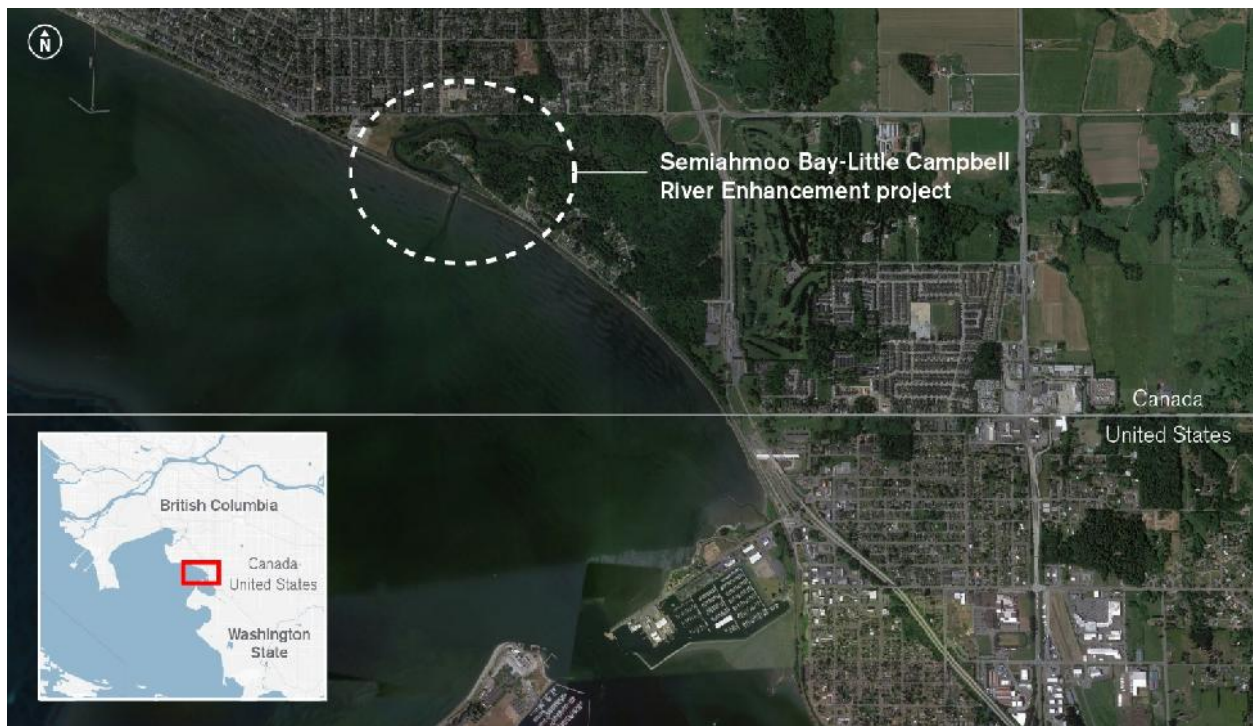


Figure 1: Semiahmoo Project Location



**Figure 2: Semiahmoo Project Area**

Historically, the Little Campbell River estuary served as an important harvesting area for First Nations communities, particularly Semiahmoo First Nation. Traditionally, harvesting included salmonids, marine fish, shellfish and food plants (Williams, 2017).

Industrial activity in the area began in the 1800s and continued into the 1900s with the construction of a camp, railway and a sawmill. The railway that crosses the mouth of the Little Campbell River was built in the early 1900s (Councillor Joanne Charles pers. comm. 2020; NHC 2020) and is now owned and maintained by BNSF Railway. The railway, which runs along the shoreline of Semiahmoo Bay, hardened the coastline and changed sediment transport along the shore (NHC 2020).

The Campbell River Lumber Company sawmill, which is visible in historical imagery from 1940 (Figure 3) but absent from imagery from 1949 (Figure 4), reportedly opened in 1913 and has altered the Little Campbell River estuary through the installation of piles and other wooden structures as well as geomorphological changes caused by maintenance dredging during operation (Councillor Joanne Charles pers. comm. 2020; NHC 2020). Sawmill operations are understood to have continued at the site until the 1920's (Councillor Joanne Charles pers. comm. 2020).



Figure 3: Historical Aerial Imagery of the Semiahmoo Project Area from 1940 (note the sawmill infrastructure in the top left corner; NHC 2020)



Figure 4: Historical Aerial Imagery of the Semiahmoo Project Area from 1949 (note the absence of sawmill infrastructure in the top left corner; NHC 2020)

The Fraser River Estuary Management Program (FREMP) documented one fish habitat offsetting activity (formerly known as “compensation”) having been implemented in the vicinity of the Semiahmoo Project in the last four decades (Figure 5). The offsetting involved the creation of smelt spawning habitat in an area of the Semiahmoo Bay foreshore approximately 2 km northwest of the Semiahmoo Project. The offsetting work was implemented in the early 1990s on behalf of the City of White Rock, to address disturbance resulting from the construction of a promenade along the White Rock foreshore.



**Figure 5: Historical Compensation Site in the Vicinity of the Semiahmoo Project (FREMP n.d.; red polygon denotes past compensation site and the red star represents the Semiahmoo Project location)**

### 1.3 Project Design

Various intertidal habitat enhancement and restoration opportunities (approximately 1 ha to 3 ha in total) are proposed as part of the Semiahmoo Project (Figure 6). These opportunities include the removal of derelict wood structures (e.g., piles) and sediment buildup, and construction of marsh bench tidal channels, large-woody debris complexes, tidal salt marsh habitat, and forage fish spawning habitat. As such, the Semiahmoo Project is expected to benefit a wide variety of plant, fish and wildlife, such as salmonids, forage fish, and migratory and resident birds. The specific offsetting opportunities being proposed are as follows (numbering corresponds to that presented in Figure 6:

1. The installation of large woody debris complexes to provide fish cover (especially for migratory salmon) in an area of low habitat complexity approximately 500 m upstream of the Little Campbell River mouth (Figure 7)
2. The removal of derelict piles and wooden structures from the Little Campbell River estuary – remnants of sawmill operation (not shown on Figure 6 due to larger areal extent; see Figure 8 for an example of remnant piles)
3. Saltmarsh habitat and tidal channel enhancement in the unvegetated intertidal secondary arm of the Little Campbell River immediately upstream of the river mouth (Figure 9)
4. Saltmarsh habitat and tidal channel enhancement in an unvegetated intertidal flat area northeast of the mouth along the railway line (associated with opportunity #5; Figure 10)

5. Armouring the east bank of the river immediately upstream of the railway bridge to address bank erosion (Figure 11)
6. Direct removal of problem sedimentation on the west side of the Little Campbell River mouth which has developed through longshore morphological processes in the absence of sawmill maintenance dredging (NHC 2021) and is adversely affecting fish habitat availability and Indigenous access (Figure 11)
7. Groyne implementation and sandy gravel beach enhancement (using material removed in association with opportunity #6) to increase forage fish spawning opportunities in the western foreshore area (where only small pockets of suitably sized material exists; Figure 12) and the eastern foreshore area (where no suitable forage fish spawning habitat is considered to be present; Figure 13)



Figure 6: Areas Targeted for Habitat Enhancement or Restoration as part of the Semiahmoo Project (NHC 2021)



Figure 7: Northwest View of Area Proposed for Large Woody Debris Complexing as part of the Semiahmoo Project (Taken May 22, 2020)



Figure 8: Northeast View of Remnant Piles Proposed to be Removed as part of the Semiahmoo Project (Taken May 22, 2020)



**Figure 9: Southwest View of Unvegetated Intertidal Secondary Arm of the Little Campbell River Targeted for Salt Marsh Habitat Enhancement as part of the Semiahmoo Project (Taken May 22, 2020)**



**Figure 10: West View of Unvegetated Intertidal Flat Area Northeast of the Little Campbell River Mouth Targeted for Saltmarsh Habitat Enhancement as part of the Semiahmoo Project (Taken May 22, 2020)**



Figure 11: Southwest View of the Little Campbell River Mouth and the East and West Bank Areas Proposed for Armouring and Sediment Removal as part of the Semiahmoo Project (Taken May 22, 2020)



Figure 12: East View of Western Semiahmoo Bay Foreshore Area Targeted for Groyne Implementation and Sandy Gravel Beach Enhancement as part of the Semiahmoo Project (Taken May 22, 2020)



**Figure 13: East View of Eastern Semiahmoo Bay Foreshore Area Targeted for Groyne Implementation and Sandy Gravel Beach Enhancement as part of the Semiahmoo Project (Taken May 22, 2020)**

## 1.4 Project Rationale

The Little Campbell River is considered one of the only natural-state estuaries in the lower mainland without diking or major diversions (Chief Harley Chappell pers. comm. 2020), and one of the most important salmon rivers in the lower mainland relative to its size (Kerr Wood Leidal 2011).

Several opportunities for habitat enhancement exist at the mouth of Little Campbell River. The offsetting opportunities being advanced as part of the Semiahmoo Project, including the expansion of existing intertidal salt marsh and forage fish spawning habitat, are expected to improve the availability of highly productive habitat for both fish and other wildlife. Additionally, removing the derelict piles and other wood structures associated with past sawmill operations, removing sediment build up at the river mouth, and installing new foreshore structures (i.e., groynes) will help to maintain the integrity and quality of this habitat into the future. The Semiahmoo Project is also expected to enhance the use and enjoyment of the area by the Semiahmoo First Nation.

## 1.5 Purpose and Structure of this Report

A range of investigative work and technical studies is being carried out to inform the development of the Semiahmoo Project. This particular report was prepared to characterize the existing ecological conditions of the project area based on consideration of historical aerial photography and mapping, desktop studies, and field visits. Subsequent sections provide descriptions of existing ecological conditions in respect of vegetation, fish, and wildlife communities, habitats, and species.

# 2. Existing Ecological Conditions

## 2.1 Information Sources

As well as being guided by personal communications with Semiahmoo First Nation representatives, a desktop review of the following existing sources of information was undertaken to summarize existing ecological conditions in the project area:

- Habitat Wizard (Government of BC, 2020a)
- BC Fisheries Inventory Data Queries (Government of BC, 2020b)
- BC CDC Species and Ecosystems Explorer (Government of BC, 2020c)
- City of Surrey Mapping Online System – COSMOS (City of Surrey, 2020)
- Fraser River Estuary Management Program Atlas (FREMP n.d.)
- Committee on the Status of Endangered Wildlife in Canada (COSEWIC) Assessment and Status Reports
- Species at Risk Public Registry
- Sensitive Habitat Inventory and Mapping database (SHIM 2020)
- Published literature on general ecology and population dynamics of relevant species and habitat
- Consultant reports prepared in respect of the project area
- Governmental papers and technical reports

In addition to desktop studies, field assessments have been conducted to collect existing ecological information to support the design of the Semiahmoo Project. These field assessments have focussed on determining fish habitat complexity and value, as well as the community composition and elevation of existing high-value marsh habitat, in the project area – both of which the Semiahmoo Project seeks to expand and improve. Specifically, the following two field assessments were conducted:

- On May 22, 2020, a preliminary site visit was conducted by port authority consultants<sup>1</sup> in collaboration with Semiahmoo First Nation, during which Councillor Joanne Charles communicated the nation's preferences for habitat enhancement in the area and described Indigenous use
- On September 1, 2020, elevations of existing marsh habitats within the Semiahmoo Project area were assessed by G. Williams (GL Williams & Associates) and Mike Savage (Van Bower Construction Services)

## 2.2 Physical Setting

The Semiahmoo Project is located within the Coastal Douglas Fir Moist Maritime (CDFmm) biogeoclimatic subzone (Figure 14; Government of BC 2021). The CDFmm subzone is found along southeastern Vancouver Island and in the southwestern portion of the lower mainland; also included are several islands in the Strait of Georgia. The CDFmm subzone is limited to elevations below 150 m. As it lies in the rain shadow of the Olympic and Vancouver Island mountains, it is drier than the surrounding Coastal Western Hemlock (CWH) Zone, which is found to the north and to the east on Vancouver Island and to the north and to the west on the mainland. The CDF is characterized by having warm and dry summers, and mild and wet winters (Nuszdorfer et al. 1991).

The Little Campbell River estuary is located along the northeastern side of Semiahmoo Bay, a coastal body of water which covers an approximately 34 km<sup>2</sup> area (NHC 2012). The Little Campbell River drains an area of approximately 75 km<sup>2</sup> within the Township of Langley, the City of Surrey, the City of White Rock, Blaine (Washington State, USA) and the Semiahmoo First Nation Reserve (Kerr Wood Leidal 2011). The Little Campbell River flows through a mixture of forested, urban, farmland, and marsh areas (NHC 2020) before discharging into the tidal sand flats of Semiahmoo Bay (Figure 15).

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<sup>1</sup> Ravi Chatterji (AECOM), Gary Williams (GL Williams and Associates), Jemma Scoble (Jemma Scoble Consulting), and Derek Ray (Northwest Hydraulic Consultants) attended.

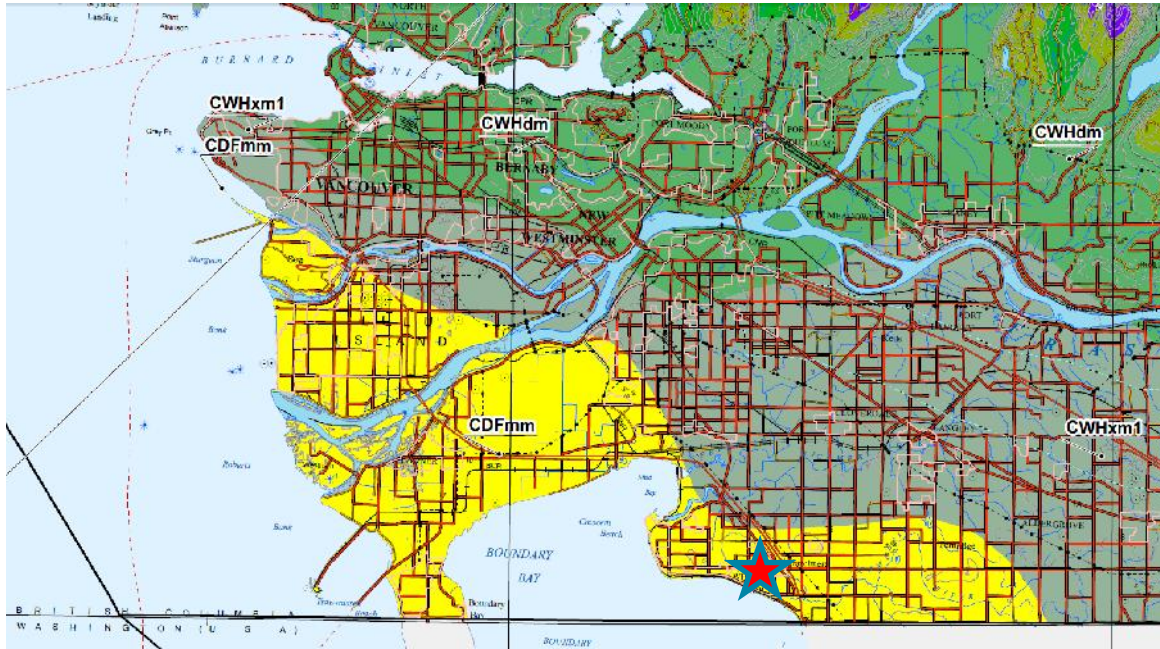


Figure 14: Biogeoclimatic Zones of the Semiahmoo Project and Surrounding Areas (Government of British Columbia 2021; Semiahmoo Project location represented by red star)



Figure 15: The Little Campbell River Discharging into the Tidal Sand Flats of Semiahmoo Bay

## 2.3 Habitat Classification

Shoreline habitats of the Fraser River estuary have been classified based on relative value by FREMP, including at the Semiahmoo Project Area (Figure 16). Habitat features are assigned a value of high, moderate, or low productivity and this information is made available through the Community Mapping Network (FREMP n.d.). Red-coded shorelines are considered productive and diverse in their current state, contributing to critical fish and wildlife functions. Yellow-coded shorelines are considered to have moderate value and diversity (e.g., due to current conditions or surrounding land use operations). Green-coded shorelines are considered of low productivity (e.g., areas which have been highly modified for industrial or urbanized uses).



**Figure 16: FREMP Habitat Classification at the Semiahmoo Project and Surrounding Areas (FREMP n.d.; Semiahmoo Project location represented by red star; red linework denotes high productivity shoreline habitat)**

Despite modifications made for railway, infrastructure, and residential developments, the Semiahmoo Bay shoreline in the vicinity of the Semiahmoo Project has been classified as high productivity habitat (FREMP 2016 habitat classification layer). Studies focussed on forage fish, however, have identified a lack of suitable spawning habitat in this area which is recommended to be addressed by supplying a mixture of smaller gravels (de Graaf 2007). The Little Campbell River itself has not been directly classified under this system.

## 2.4 Vegetation Communities

Existing plant communities in the Semiahmoo Project area include a mix of intertidal salt and freshwater marsh, meadow close to the edge of the river, and riparian shrubs and deciduous tree woodland further upland (FREMP n.d.; Figure 17). A vegetation survey conducted by GL Williams and Associates Ltd. detected the presence of numerous native plants which are characteristic of the CDFmm biogeoclimatic subzone (Williams, 2017), including the following:

- Baltic Rush (*Juncus arcticus*)
- Big leaf maple (*Acer macrophyllum*)
- Black cottonwood (*Populus trichocarpa*)
- Black twinberry (*Lonicera involucrata*)
- Bracken fern (*Pteridium aquilinum*)
- Cattail (*Typha latifolia*)
- Douglas fir (*Pseudotsuga menziesii*)
- Dull-Oregon grape (*Mahonia nervosa*)
- Hardhack (*Spiraea douglasii*)
- Indian Plum (*Oemleria cerasiformis*)
- Lyngbye's sedge (*Carex lyngbyei*)
- Nootka rose (*Rosa nutkana*)
- Ocean spray (*Holodiscus discolor*)
- Pacific crabapple (*Malus fusca*)
- Pacific silverweed (*Potentilla anserina*)
- Pickleweed (*Sarcocornia pacifica*)

- Red alder (*Alnus rubra*)
- Red-osier dogwood (*Cornus sericea*)
- Salmonberry (*Rubus spectabilis*)
- Saltgrass (*Distichlis spicata*)
- Seacoast bulrush (*Bolboschoenus maritimus*)
- Sitka spruce (*Picea sitchensis*)
- Snowberry (*Symphoricarpos albus*)
- Sword fern (*Polystichum munitum*)
- Thimbleberry (*Rubus parviflorus*)
- Western red cedar (*Thuja plicata*)

Existing marsh vegetated habitat (Figure 17) in the Semiahmoo Project area includes the following:

- Salt marsh fringing the existing unvegetated intertidal mud flat on the east bank of the Little Campbell River mouth—dominated by pickleweed and dune grass (*Leymus mollis*)
- Intertidal marsh farther upstream near the secondary Little Campbell River channel—dominated by Baltic rush
- Green filamentous algae in the intertidal area of the mainstem upstream of the river mouth
- Intertidal marsh benches downstream of the 8th Avenue pedestrian bridge—dominated by Lyngbye’s sedge
- A patch of sea lettuce (*Ulva sp.*) on the foreshore west of the Little Campbell River mouth (visible on Figure 6)

The area proposed for marsh expansion is lower-value unvegetated intertidal mud flat (Figure 17).

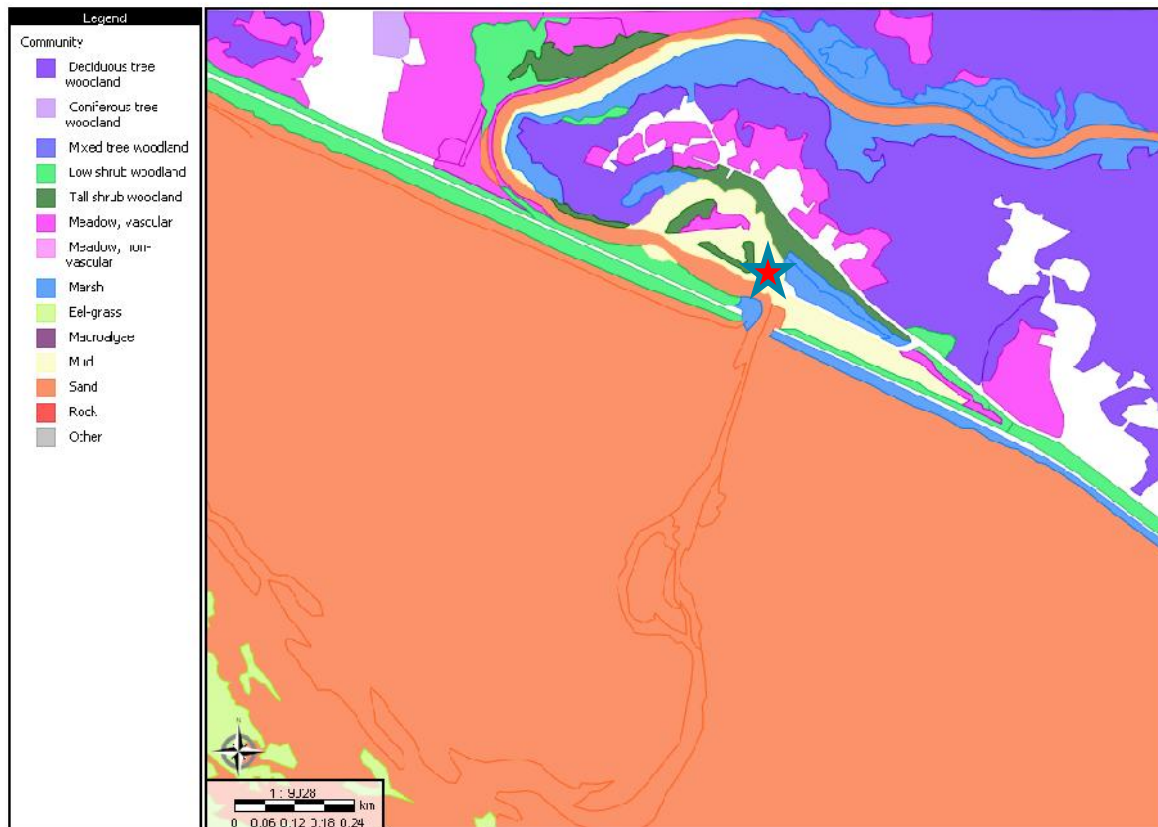


Figure 17: FREMP Habitat Inventory at the Semiahmoo Project and Surrounding Areas (FREMP n.d.; Semiahmoo Project location represented by red star)

## 2.4.1 Invasive Plant Species

The presence of invasive plant species in the vicinity of the project area was determined using provincial databases (Government of BC, 2020a) and based on vegetation surveys conducted by Terry Taylor and Teresa Hitch (Taylor and Hitch, 2005) and GL Williams and Associates Ltd. (Williams, 2017), and includes the following:

- Bull Thistle (*Cirsium vulgare*)
- Common tansy (*Tanacetum vulgare*)
- English holly (*Ilex aquifolium*)
- English ivy (*Hedera helix*)
- Himalayan blackberry (*Rubus armeniacus*)
- Japanese knotweed (*Fallopia japonica*)
- Oxeye daisy (*Leucanthemum vulgare*)
- Scotch broom (*Cytisus scoparius*)
- Spurge-laurel (*Daphne laureola*)
- St John's wort (*Hypericum perforatum*)
- Poison hemlock (*Conium maculatum*)
- Prostate knotweed (*Polygonum aviculare*)
- Reed canary grass (*Phalaris arundinacea*)

## 2.4.2 Potential at Risk Plant Communities and Vegetation

The BC Conservation Data Center (CDC) assigns provincial at-risk species, communities, and ecosystems to Red, Blue and Yellow Lists. Red listed species and plant communities are threatened, endangered, or extirpated. These species face the risk of extinction if efforts are not made to increase populations. Blue listed species and plant communities are of special concern; they are sensitive to environmental changes and have the potential to be moved to the Red list if conditions persist. By assigning species to Red and Blue lists, the CDC ranks species and ecological communities that are affected by threats such as habitat or resource loss or are facing declining population or restricted distribution.

A number of at-risk plants and plant communities occur within the lower mainland CDFmm subzone and were observed, or have the potential to occur, in the Semiahmoo Project area (Table 1 and Table 2). These species and communities are, however, expected to be unaffected by or to benefit from the proposed Semiahmoo Project (i.e., through the increased availability of suitable habitat).

**Table 1. Provincial at-risk ecological communities within the BC Lower Mainland CDFmm subzone with potential to occur in the Semiahmoo Project area**

Scientific Name	Common Name	Provincial At-Risk Status	Site Presence	Potential Effects
<i>Alnus rubra</i> / <i>Rubus spectabilis</i> / <i>Equisetum arvense</i>	red alder / salmonberry / common horsetail	Blue	Likely	No effect
<i>Bolboschoenus maritimus</i> var. <i>paludosus</i>	seacoast bulrush	Red	Observed	Increase in available habitat
<i>Carex lyngbyei</i>	Lyngbye's sedge	Red	Observed	Increase in available habitat

<i>Deschampsia cespitosa</i> ssp. <i>beringensis</i> - <i>Hordeum brachyantherum</i>	tufted hairgrass - meadow barley	Red	Observed	Increase in available habitat
<i>Deschampsia cespitosa</i> ssp. <i>beringensis</i> - <i>Symphotrichum subspicatum</i>	tufted hairgrass - Douglas' aster	Red	Observed	Increase in available habitat
<i>Distichlis spicata</i> - <i>Sarcocornia pacifica</i>	seashore saltgrass - Pacific swampfire	Red	Observed	Increase in available habitat
<i>Juncus arcticus</i> - <i>Plantago macrocarpa</i>	arctic rush - Alaska plantain	Red	Possible	Increase in available habitat
<i>Leymus mollis</i> ssp. <i>mollis</i> - <i>Lathyrus japonicus</i>	dune wildrye - beach pea	Red	Possible	Increase in available habitat
<i>Populus trichocarpa</i> - <i>Alnus rubra</i> / <i>Rubus spectabilis</i>	black cottonwood - red alder / salmonberry	Blue	Observed	No effect
<i>Ruppia maritima</i>	beaked ditch-grass	Red	Possible	Increase in available habitat
<i>Sarcocornia pacifica</i> - <i>Lysimachia maritima</i>	American glasswort - sea-milkwort	Red	Observed	Increase in available habitat
<i>Thuja plicata</i> - <i>Picea sitchensis</i> / <i>Lysichiton americanus</i>	western redcedar - Sitka spruce / skunk cabbage	Blue	Possible	No effect
<i>Thuja plicata</i> / <i>Symphoricarpos albus</i>	western redcedar / common snowberry	Red	Observed	No effect
<i>Typha latifolia</i>	common cattail	Blue	Observed	Increase in available habitat

Source: Government of BC, 2020c

**Table 2. Provincial at-risk plant species within the BC Lower Mainland CDFmm subzone with potential to occur in the Semiahmoo Project area**

Scientific Name	Common Name	Provincial At-Risk Status	COSEWIC Status	SARA Status	Site Presence	Potential Effects
<i>Bidens amplissima</i>	Vancouver Island beggarticks	Blue	Special Concern	Special Concern	Possible	Increase in available habitat
<i>Erigeron philadelphicus</i> var. <i>glaber</i>	salt marsh Philadelphia daisy	Red	Not Listed	Not Listed	Possible	Increase in available habitat
<i>Lupinus rivularis</i>	streambank lupine	Red	Endangered	Endangered	Possible	Increase in available habitat
<i>Sidalcea hendersonii</i>	Henderson's checker-mallow	Blue	Not listed	Not listed	Possible	Increase in available habitat

Source: Government of BC, 2020c

### 2.4.3 Post Enhancement Conditions

Disturbed and/or enhanced areas will be replanted/planted with suitable native plants. Native plant species used by local Indigenous groups for traditional purposes, as well as listed plant species, will be considered. The port authority will consult with Semiahmoo First Nation to finalize plant selection. The proposed marsh planting list includes Lyngbye's sedge, saltgrass, Baltic rush, seacoast bulrush, plantain, Pacific silverweed, pickleweed, gumweed, arrow grass (*Triglochin maritima*), and Douglas' aster.

## 2.5 Fish

### 2.5.1 Existing Aquatic Conditions

Sediment supply to the Little Campbell River is predominantly silts and clays (Kerr Wood Leidal 2011) and that was reflected in the largely fine substrates observed in the Little Campbell River within the Semiahmoo Project area. The Little Campbell River flows at an average monthly rate of 0.9 m<sup>3</sup>/s. Semiahmoo Bay provides protection from wave action as well as prevailing southeasterly to easterly winds.

The Semiahmoo Project area comprises a variety of fish habitat types including a shallow bay, tidal flats, an upper intertidal area, an estuary (including some fringing intertidal marsh habitat), river channels, and vegetated riparian areas; and provides unique opportunities for both fresh and saltwater aquatic species.

Little Campbell River and the surrounding ocean provide important aquatic habitat for a variety of resident and migratory fish species across all life stages, including but not limited to salmonids (Chinook, chum, coho, pink, and sockeye salmon, cutthroat trout, rainbow trout/steelhead), forage fish (e.g., eulachon, surf smelt, herring), flatfish (e.g., starry flounder), rockfish, lingcod, carp, stickleback, and prickly sculpin.

A salmon and trout hatchery is located approximately 8 km upstream of the project location. In a typical year, the hatchery produces 10,000 steelhead (*Oncorhynchus mykiss*), 35,000 Chinook (*Oncorhynchus tshawytscha*), 100,000 coho (*Oncorhynchus kisutch*), and 15,000 cutthroat trout (*Oncorhynchus clarkii*); over 3,500 spawning salmon return up Little Campbell River to the hatchery annually (Semiahmoo Fish and Game Club, 2020). Around 1000-2000 of returning fish are coho salmon, although records suggest that runs once surpassed 10,000 (Warren, 1978).

The City of Surrey classifies watercourses using the following three categories:

- Class A (RED): Inhabited by salmonids year-round or potentially inhabited year-round
- Class A(O) (RED dashed): Inhabited by salmonids primarily during the over-wintering period or potentially inhabited during the over-wintering period with access enhancement
- Class B (YELLOW): Significant food/nutrient value. No fish present.
- Class C (GREEN): Insignificant food/nutrient value. No fish present.

Other than the Little Campbell River itself, which is considered a Class A watercourse, no watercourses in the vicinity of the Semiahmoo Project are designated by the City of Surrey as Class A or Class A(O) (Figure 18).

### 2.5.2 Common Fish Species

Little Campbell River and the surrounding ocean provide habitat for a variety of resident and migratory fish species across all life stages, including but not limited to:

- salmonids (Chinook (*Oncorhynchus tshawytscha*), chum (*O. keta*), coho (*O. kisutch*), and pink (*O. gorbuscha*) salmon, cutthroat trout (*O. clarkii*), and rainbow trout/steelhead (*O. mykiss*)
- forage fish (e.g., surf smelt (*Hypomesus pretiosus*))
- flatfish (e.g., starry flounder (*Platichthys stellatus*))
- rockfish (e.g., pacific rockfish (*Sebastes alutus*))
- lingcod (*Ophiodon elongatus*)
- stickleback (*Gasterosteus spp.*)
- prickly sculpin (*Cottus asper*)

Over 18 fish species have been captured at the Little Campbell River mouth, including the four pacific salmon species mentioned above, cutthroat trout, rainbow trout, and steelhead (Government of BC, 2020a).

### 2.5.3 Invasive Fish Species

The following invasive or introduced fish species have been recorded in the vicinity of the project area (Government of BC, 2020a):

- Atlantic salmon (*Salmo salar*)
- common carp (*Cyprinus carpio*)
- pumpkinseed sunfish (*Lepomis gibbosus*)
- fathead minnow (*Pimephales promelas*)
- brown bullhead (*Ameiurus nebulosus*)

### 2.5.4 Listed Fish Species

Six provincially listed fish species found within the BC Lower Mainland CDFmm ecological subzone have the potential to occur at or interact with the Semiahmoo Project area. These species are listed in Table 3.



Figure 18: City of Surrey Fish Classifications at the Semiahmoo Project and Surrounding Areas (City of Surrey 2020; Semiahmoo Project location represented by red star)

**Table 3. Provincial at-risk fish species within the BC Lower Mainland CDFmm subzone with potential to occur in the Semiahmoo Project area**

Scientific Name	Common Name	Provincial At-Risk Status	COSEWIC Status	SARA Status	Site Presence	Potential Effects
<i>Acipenser transmontanus</i> pop. 4	White Sturgeon (Lower Fraser River Population)	Red	Threatened	Not Listed	Possible	Increase in available habitat
<i>Hybognathus hankinsoni</i> - Pacific group	Brassy Minnow - Pacific Group	Blue	Not Listed	Not Listed	Likely	Increase in available habitat
<i>Oncorhynchus clarkii clarkii</i>	Cutthroat Trout, <i>clarkii</i> subspecies	Blue	Not Listed	Not Listed	Likely	Increase in available habitat
<i>Salvelinus confluentus</i> pop. 28	Bull Trout - South Coast Population	Blue	Special Concern	Special Concern	Possible	Increase in available habitat
<i>Thaleichthys pacificus</i>	Eulachon	Blue	Threatened	Not Listed	Possible	No effect
<i>Catostomus</i> sp. 4	Salish Sucker	Red	Threatened	Threatened	Possible	No effect

Source: Government of BC, 2020c

White sturgeon and bull trout have not been recorded in the vicinity of the Semiahmoo Project (iMapBC 2021). Were they to use the Semiahmoo Project area, they would be expected to benefit from the proposed habitat enhancement.

Eulachon have not been recorded in the vicinity of the Semiahmoo Project (iMapBC 2021). Furthermore, eulachon spawn upstream of the saltwater wedge, and most eulachon are reported to spawn in areas with clean, coarse sand to small gravel-sized sediments (Plate 2009; Levesque and Therriault 2011). Such conditions are not considered to be present within the area of the Semiahmoo Project, nor would these conditions be present after project implementation.

Salish sucker have been observed in the Little Campbell River (Government of BC 2020b) and may, therefore, interact with the Semiahmoo Project area. Their distribution in the Little Campbell River, however, is reportedly further upstream on the other side of Highway 99 (City of Surrey 2020). Furthermore, the species is known to favour headwater reaches with substantial riparian cover that provides cooler water temperatures, with overwintering typically taking place in off-channel habitats like those used by juvenile coho salmon and spawning occurring at riffles with fine gravel bottoms (Wydoski and Whitney 2003). These preferred conditions are not present within the Semiahmoo Project area.

The other provincially-listed fish species identified in Table 3 (i.e., brassy minnow and cutthroat trout) are likely to use the Semiahmoo Project area at some point during their life cycle and are expected to benefit from the habitat enhancement proposed.

## 2.5.5 Post Enhancement Conditions

Although changes from intertidal mud flat to intertidal marsh habitat may affect fish species which use the former at high tide, such as starry flounder, the creation of estuarine intertidal marsh habitat is expected to increase the overall fish habitat value in the Semiahmoo Project area. In particular, the proposed enhancement will provide important habitat for estuarine-rearing juvenile Pacific salmon like Chinook and chum. By providing increased opportunities for juvenile fish, the animals which prey on them will benefit from their increased availability, resulting in increased productivity and complexity across the entire food web.

In addition, the removal of remnant piles and other wood structures and debris would further support fish populations by making additional areas of riverbed available and removing sources of potential contamination. Installing large woody debris complexes upstream of the river mouth would provide increased cover and habitat diversity for migratory fish like Pacific salmon. Removing sediment build up at the river mouth would make additional river channel and riverbed habitat available to fish. Lastly, nourishing the Semiahmoo Bay foreshore either side of the Little

Campbell River mouth (including the synergistic use of the sediment removed from the river mouth) would be expected to increase spawning opportunities for forage fish such as surf smelt in those areas (de Graaf 2007).

## 2.6 Wildlife

### 2.6.1 Existing Conditions for Wildlife

The land surrounding Little Campbell River and the Semiahmoo First Nation reserve has been developed primarily for residential and recreational purposes. Despite this land development the area has remained an important stop over and wintering location for many migrating waterfowl and shorebirds. Additionally, the Little Campbell River provides habitat for resident bird species. Other types of wildlife which may currently use the area include reptiles, amphibians, and terrestrial and marine mammals.

### 2.6.2 Common Wildlife

Common representative mammal species which are found in the CDFmm subzone and are tolerant to the conditions in the Semiahmoo Project area include:

- Coyote (*Canis latrans*)
- Harbour seal (*Phoca vitulina*)
- Mink (*Neovison vison*)
- Raccoon (*Procyon lotor*)
- River otter (*Lontra canadensis*)
- Townsend's vole (*Microtus townsendii*)

Common representative bird species which are found in the CDFmm subzone and are tolerant to the conditions in the Semiahmoo Project area include:

- American robin (*Turdus migratorius*)
- American wigeon (*Anas Americana*)
- Barrow's goldeneye (*Bucephala islandica*)
- Brant (*Branta bernicla*)
- Canada goose (*Branta canadensis*)
- Glaucous-winged gull (*Larus glaucescens*)
- Green-winged teal (*Anas carolinensis*)
- Lesser scaup (*Aythya affinis*)
- Mallard (*Anas platyrhynchos*)
- Northwestern crow (*Corvus caurinus*)
- Sharp-shinned hawk (*Accipiter striatus*)

### 2.6.3 Listed Wildlife

Sightings for barn swallows (*Hirundo rustica*) have been recorded in the Semiahmoo Project area (Government of BC 2020a). In addition, there is potential for several listed species to occur at the site, as presented in Table 4, Table 5, and Table 6. These species are, however, expected to either be largely unaffected by the proposed Semiahmoo Project, or to benefit from increased availability of suitable habitat and prey abundance.

**Table 4. Provincial at-risk mammal species within the BC Lower Mainland CDFmm subzone with potential to occur in the Semiahmoo Project area**

Scientific Name	Common Name	Provincial At-Risk Status	COSEWIC Status	SARA Status	Site Presence	Potential Effects
<i>Corynorhinus townsendii</i>	Townsend's Big-eared Bat	Blue	Not Listed	Not Listed	Likely	No effect
<i>Mustela frenata altifrontalis</i>	Long-tailed weasel, <i>altifrontalis</i> subspecies	Red	Not Listed	Not Listed	Likely	No effect

Source: Government of BC, 2020c

**Table 5. Provincial at-risk reptile and amphibian species within the BC Lower Mainland CDFmm subzone with potential to occur in the Semiahmoo Project area**

Scientific Name	Common Name	Provincial At-Risk Status	COSEWIC Status	SARA Status	Site Presence	Potential Effects
<i>Anaxyrus boreas</i>	Western Toad	Yellow	Special Concern	Special Concern	Possible	Increase in available habitat
<i>Rana aurora</i>	Northern Red-legged frog	Blue	Special Concern	Special Concern	Unlikely	Increase in available habitat

Source: Government of BC, 2020c

**Table 6. Provincial at-risk bird species within the BC Lower Mainland CDFmm subzone with potential to occur in the Semiahmoo Project area**

Scientific Name	Common Name	Provincial At-Risk Status	COSEWIC Status	SARA Status	Site Presence	Potential Effects
<i>Aechmophorus occidentalis</i>	Western Grebe	Red	Special Concern	Special Concern	Likely	Increase in prey abundance
<i>Ammodramus savannarum</i>	Grasshopper Sparrow	Red	Not Listed	Not Listed	Possible	No effect
<i>Ardea herodias fannini</i>	Great Blue Heron, <i>fannini</i> subspecies	Blue	Special Concern	Special Concern	Likely	Increase in available habitat
<i>Butorides virescens</i>	Green Heron	Blue	Not Listed	Not Listed	Possible	Increase in available habitat
<i>Asio flammeus</i>	Short-eared Owl	Blue	Special Concern	Special Concern	Likely	Increase in prey abundance
<i>Branta bernicla</i>	Brant	Blue	Not Listed	Not Listed	Likely	Increase in available habitat
<i>Branta canadensis occidentalis</i>	Canada Goose, <i>occidentalis</i> subspecies	Red	Not Listed	Not Listed	Possible	Increase in available habitat
<i>Buteo lagopus</i>	Rough-legged Hawk	Blue	Not Listed	Not Listed	Likely	Increase in prey abundance
<i>Calidris canutus</i>	Red Knot	Red	Endangered/Threatened	Endangered/Threatened	Possible	Increase in available habitat
<i>Cypseloides niger</i>	Black Swift	Blue	Endangered	Endangered	Likely	Increase in prey abundance
<i>Falco peregrinus anatum</i>	Peregrine Falcon, <i>anatum</i> subspecies	Red	Not at Risk	Special Concern	Likely	Increase in prey abundance

Scientific Name	Common Name	Provincial At-Risk Status	COSEWIC Status	SARA Status	Site Presence	Potential Effects
<i>Hirundo rustica</i>	Barn Swallow	Blue	Threatened	Threatened	Likely	Increase in prey abundance
<i>Melanitta americana</i>	Black Scoter	Blue	Not Listed	Not Listed	Possible	No effect
<i>Melanitta perspicillata</i>	Surf Scoter	Blue	Not Listed	Not Listed	Likely	No effect
<i>Numenius americanus</i>	Long-billed Curlew	Blue	Special Concern	Special Concern	Possible	No effect
<i>Progne subis</i>	Purple Martin	Blue	Not Listed	Not Listed	Likely	Increase in prey abundance
<i>Recurvirostra americana</i>	American Avocet	Blue	Not Listed	Not Listed	Possible	No effect
<i>Synthliboramphus antiquus</i>	Ancient Murrelet	Blue	Not Listed	Not Listed	Possible	Increase in prey abundance
<i>Tringa incana</i>	Wandering Tattler	Blue	Not Listed	Not Listed	Possible	No effect
<i>Tyto alba</i>	Barn Owl	Red	Threatened	Threatened	Likely	Increase in prey abundance

Source: Government of BC, 2020c

## 2.6.4 Post Enhancement Conditions

The conversion of intertidal flat to salt marsh habitat will result in a change to habitat used by waterfowl and shorebirds that may currently use the site for resting and foraging. However, increased marsh habitat will provide similar opportunities and provide value to a more diverse range of birds and wildlife that are expected to utilize the enhanced area. In addition, the removal of remnant piles and other wood structures and debris will make new areas of riverbed and banks available to foraging shorebirds. No listed wildlife species are expected to be negatively affected by the project. Species that forage for insects or fish, such as the great blue heron or barn swallow may benefit from the project as a result of increased prey abundance.

## 3. Conclusion

The proposed Semiahmoo Project is expected to increase the quality, diversity, and sustainability of habitats in the area. As a result, the project will provide long-term benefits to a variety of fish (including estuarine-rearing Pacific salmon populations such as Chinook and chum, and forage fish such as surf smelt), plant, and wildlife species (e.g., raptors, waterfowl, great blue heron).

The expansion of higher-value marsh habitat is also expected to provide additional ecosystem benefits, including but not limited to the following:

- Increased supply of nutrients and detrital material to support food webs in habitats beyond the site
- Increased ecosystem productivity and diversity
- Increased prey availability for terrestrial wildlife, birds and aquatic species
- Opportunities for epiphytic and epifaunal colonization
- Provision of temperature-regulating shade
- Improved water quality through contaminant filtration and oxygen production
- Sediment trapping and accretion
- Reduced erosion through wave and energy-dampening

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**Appendix IR2020-1.1-A26**  
**Finn Slough Enhancement Project Design**  
**Report**



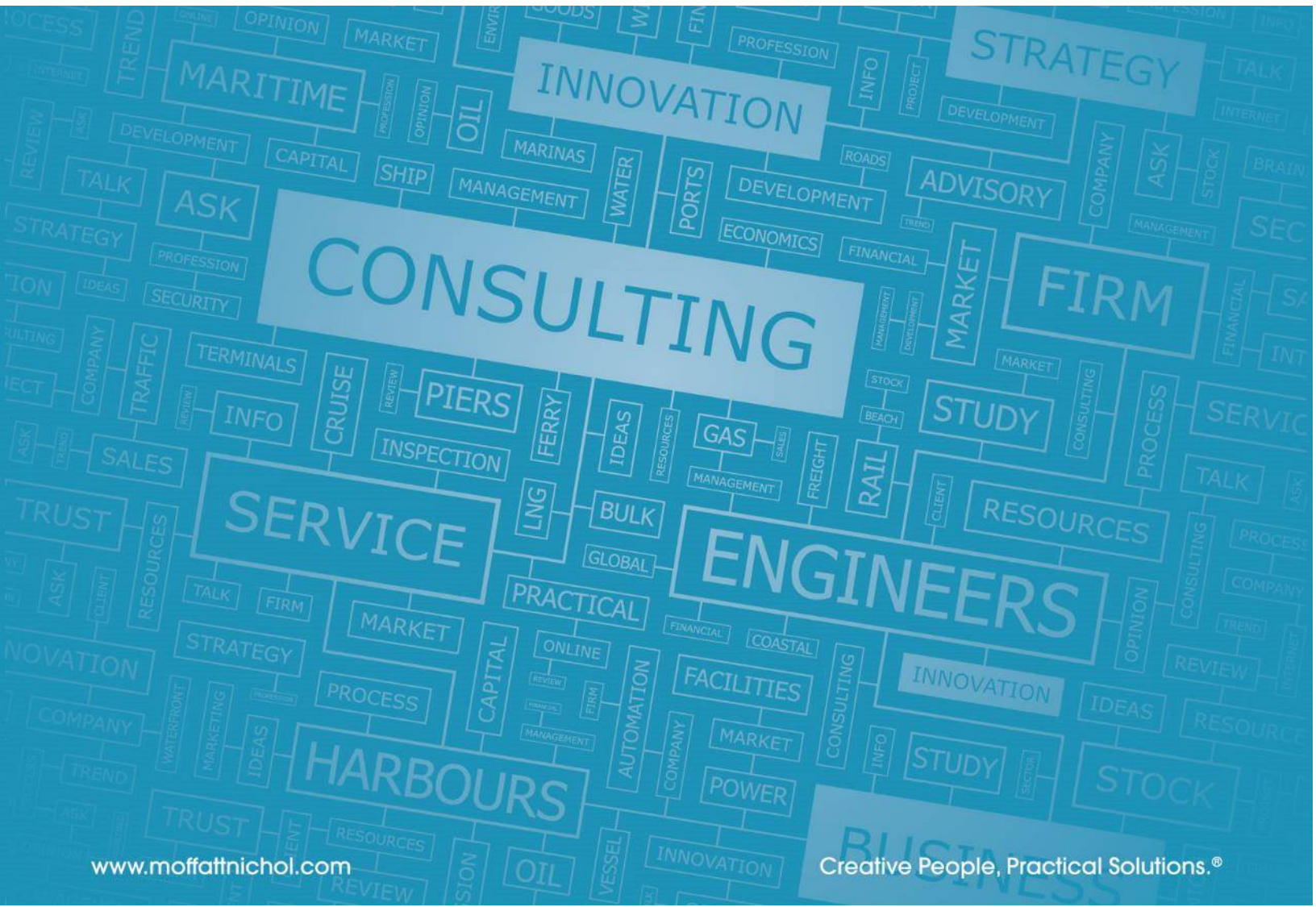
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# Finn Slough Enhancement Project Design Report

PRODUCED FOR



SEPTEMBER 20, 2021



## Document Verification

<b>Client</b>	Vancouver Fraser Port Authority
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C	Preliminary Design incorporating Owner's comments	LW	February 4, 2021	YN/MJ
D	Preliminary Design incorporating Project Team's comments	YN	February 22, 2021	MC
E	Preliminary Design incorporating City of Richmond's comments	YN	September 20, 2021	MJ

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# 1. Introduction

The Vancouver Fraser Port Authority (Port Authority) is proposing to provide habitat enhancement projects to offset impacts resulting from the Roberts Bank Terminal 2 (RBT2) Project. The RBT2 Project is a proposed new marine container terminal on Canada's west coast, led by the Port Authority, that would play a critical role in supporting Canadian trade. The RBT2 Project involves construction of a new three-berth marine container terminal in Delta, British Columbia. The terminal would be located in deep, subtidal waters to minimize environmental effects, and will be funded by the Port Authority and private investment, not tax dollars, see (Port Authority, 2021) for further details.

Typical examples of habitat that potentially could be affected by construction of RBT2 include eelgrass beds, saltwater and brackish tidal marshes, and tidal flats. One of the offsetting projects being considered is the Finn Slough Enhancement Project (Finn Slough Project). This proposed Finn Slough Project was identified by a number of Indigenous groups as an important location for enhancement. It was put forward as a Musqueam Indian Band priority offsetting project for the RBT2 Project and as an opportunity for collaboration. The project is being advanced through a collaborative approach and is further informed by knowledge and input received during consultation with Indigenous groups.

The objective of the proposed Finn Slough Project is to allow for the natural expansion of the existing brackish marsh through log removal and improving fish access and tidal circulation by connecting the existing slough to the Fraser River on the upstream end of Gilmour Island. Seventy percent of the Fraser River estuary wetlands have been diked, drained, and filled to reclaim land for development over the last century (Ministry of Environment, 2006). The construction of tidal marsh habitat provides productive and important habitat for estuarine-rearing Pacific salmon, thereby increasing marine survival and improving the fitness of adult salmon returning to spawning grounds. This in turn can provide benefits to estuarine/marine mammals as well as commercial, recreational, and First Nation fisheries.

Moffatt & Nichol (M&N) has developed a preliminary design for the proposed Finn Slough Project in collaboration with G.L. Williams & Associates Ltd. and AECOM. This report presents the details of the preliminary design, including the assumptions used for the development of the design criteria for the Finn Slough Project.

Following the Introduction presented in Section 1, Section 2 provides a description of the Site Conditions and details the estuarine processes and Fraser River conditions. Section 3 presents a description of the proposed design elements including log removals, channel extension, and implementation of shear booms. The criteria used to develop the design of the Finn Slough Project are discussed in Section 4. In addition to the general project design criteria, the design concepts include a description of the functional, physical, and biological criteria as well as applied engineering standards. Section 5 discusses the construction details for the Finn Slough Project including site conditions and access. The construction methodology is also presented in this section. Section 6 presents the Construction Direct Cost (CDC). Limitations of design and recommendations for next steps are presented in Section 7.

## 2. Site Conditions/Setting

### 2.1. Project Site

The project site is located at Gilmour Island along the Fraser River South Arm at river kilometer 15 – 16, between the cities of Richmond and Delta. Figure 2-1 shows the location of the Finn Slough site along the lower Fraser River.



**FIGURE 2-1: PROJECT LOCATION**

Gilmour Island is an island partially connected to shore on the northeastern end. Finn (Gilmour) Slough refers to the shallow muddy backwater channel between Gilmour Island and Dyke Road. Figure 2-2 shows an overview of Gilmour Island on the Canadian Hydrographic Survey (CHS) Nautical Chart #3490 as well as a Google Earth aerial image. Finn Slough is tidally connected to the Fraser River only on the southwest (downstream) side of the island, despite being depicted on the nautical chart with two connections to the Fraser River on the southwest and northeast ends. The island is surrounded by intertidal habitat.

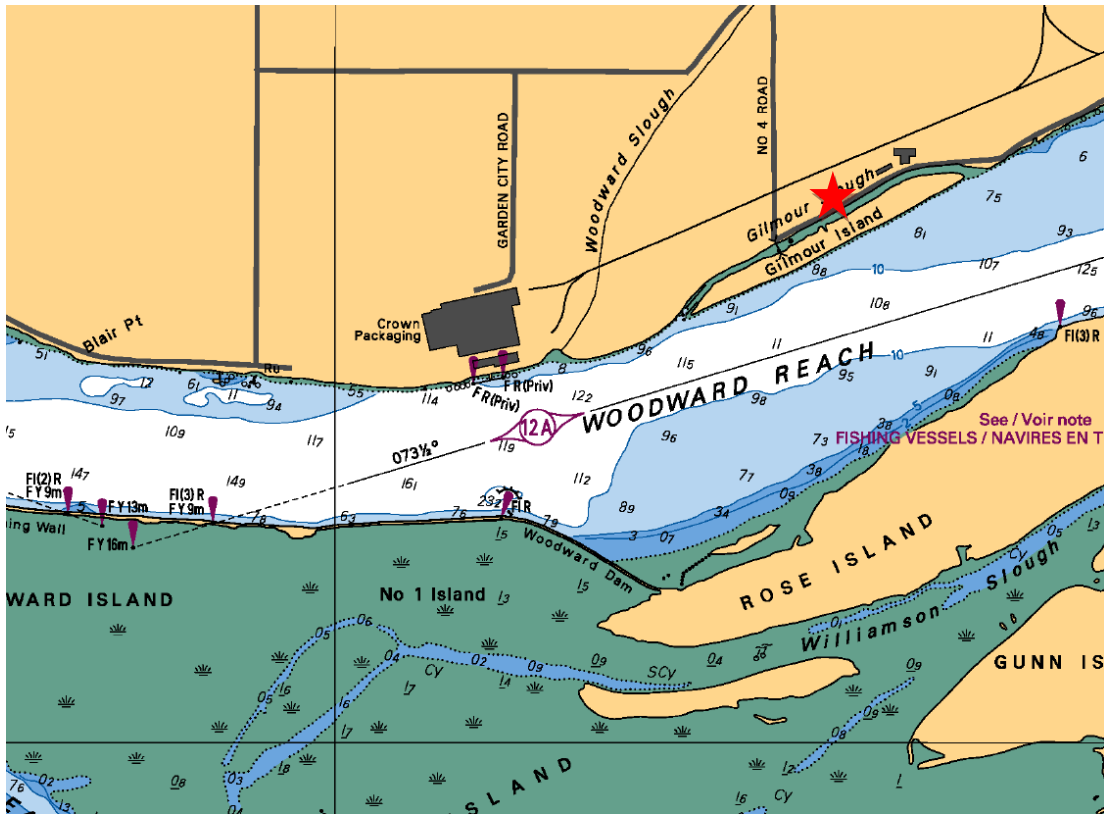


FIGURE 2-2: LOCATION OF GILMOUR ISLAND ON (A) NAUTICAL CHART; (B) GOOGLE EARTH

The Gilmour Island shoreline is exposed to episodic high water events and passing vessel wake resulting in limited shoreline erosion, see Figure 2-3 for September 2020 drone imagery of the project site. Log accumulation along the shoreline can be seen along Gilmour Island, with higher concentration on the south-west end and north-east end of the island (see Figure 2-4 and Figure 2-5). The existing channel can be seen extending from the downstream end of the island and ends close to the northeastern junction at Dyke Street. The island is protected by a stretch of revetment on the southern side, revetment is also seen on the shoreline north of the island. At the channel opening on the north-east end of the island (Figure 2-5), the revetment configuration suggests that the channel was once connected to the Fraser River and was silted up by sediments.

The slough opening on the west and eastern end of the island are shown in photos captured from the river in October 2020, shown in Figure 2-6 and Figure 2-7, respectively. Limited ground survey and site reconnaissance work was conducted as part of a collaborative site visit with Musqueam Indian Band in February 2021. The findings of this work will be incorporated into the future design development of this project.

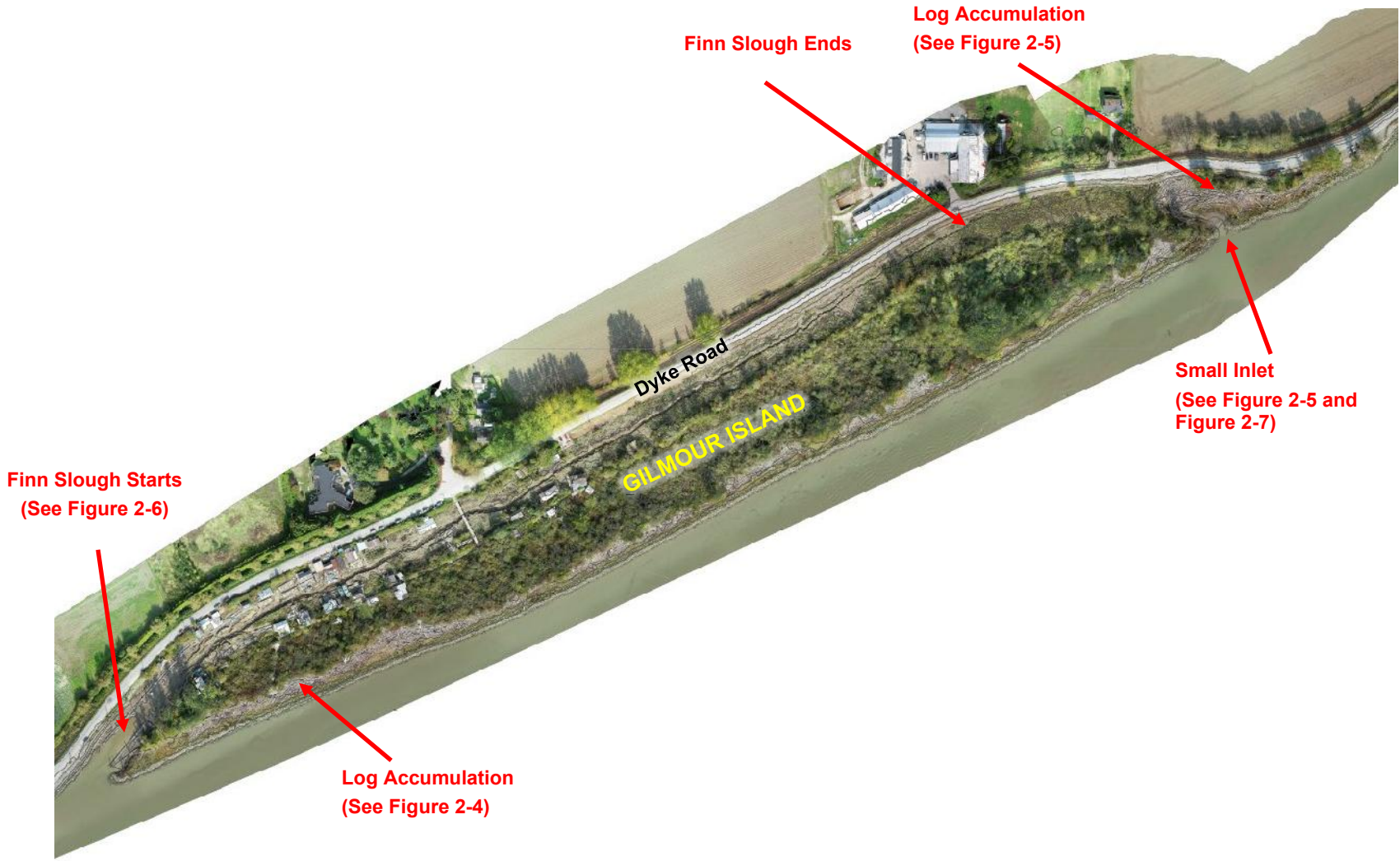


FIGURE 2-3: FINN SLOUGH DRONE SURVEY (SOURCE: VAN BOWER)



**FIGURE 2-4: LOG ACCUMULATION ON SOUTH-WESTERN END OF GILMOUR ISLAND**



FIGURE 2-5: LOG ACCUMULATION AND A SMALL INLET ON NORTH-EASTERN END OF GILGOUR ISLAND

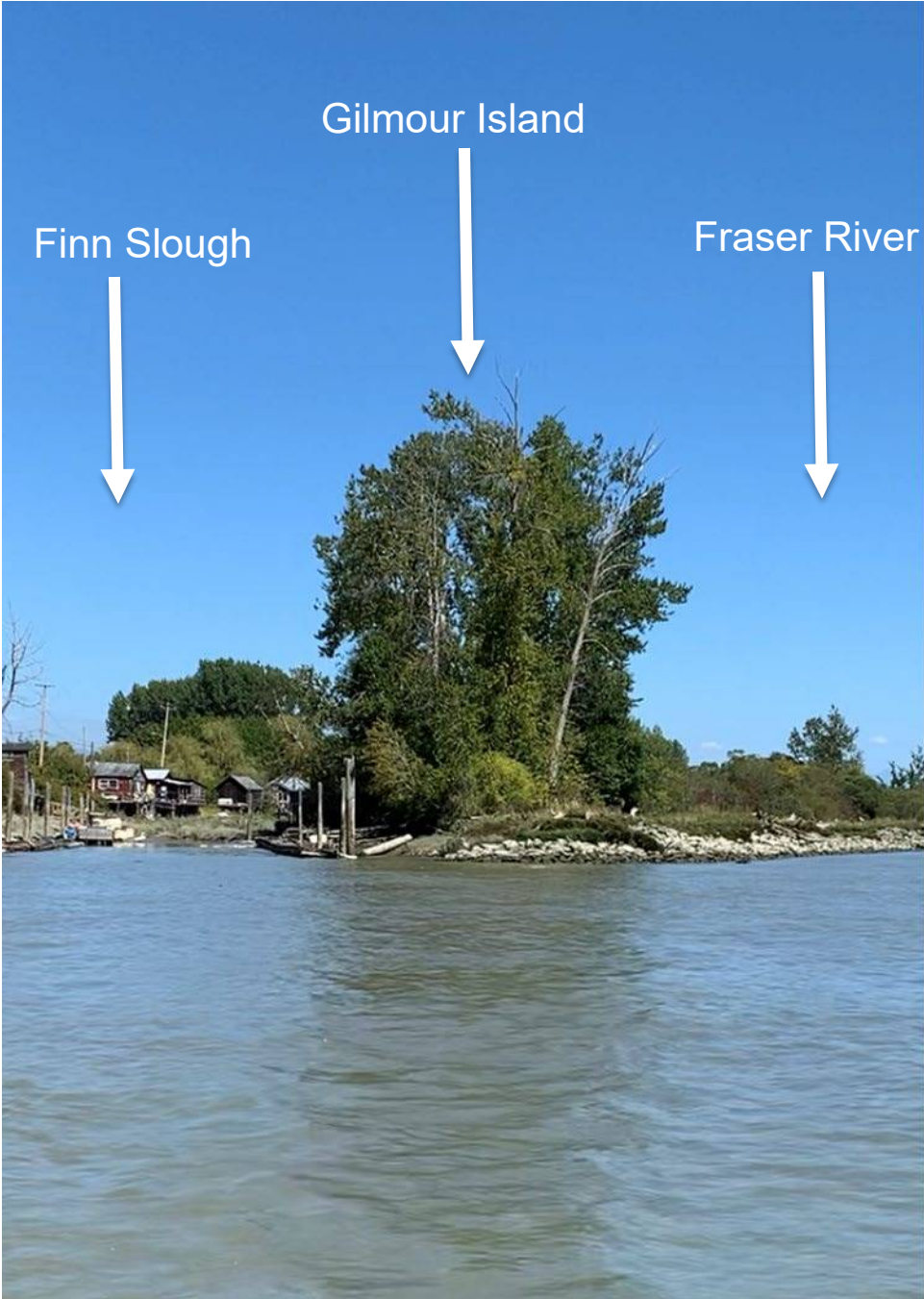


FIGURE 2-6: FINN SLOUGH INLET, LOOKING UPSTREAM (NORTHEAST)



**FIGURE 2-7: SMALL INLET ON NORTH-EASTERN END OF GILMOUR ISLAND, LOOKING NORTH**

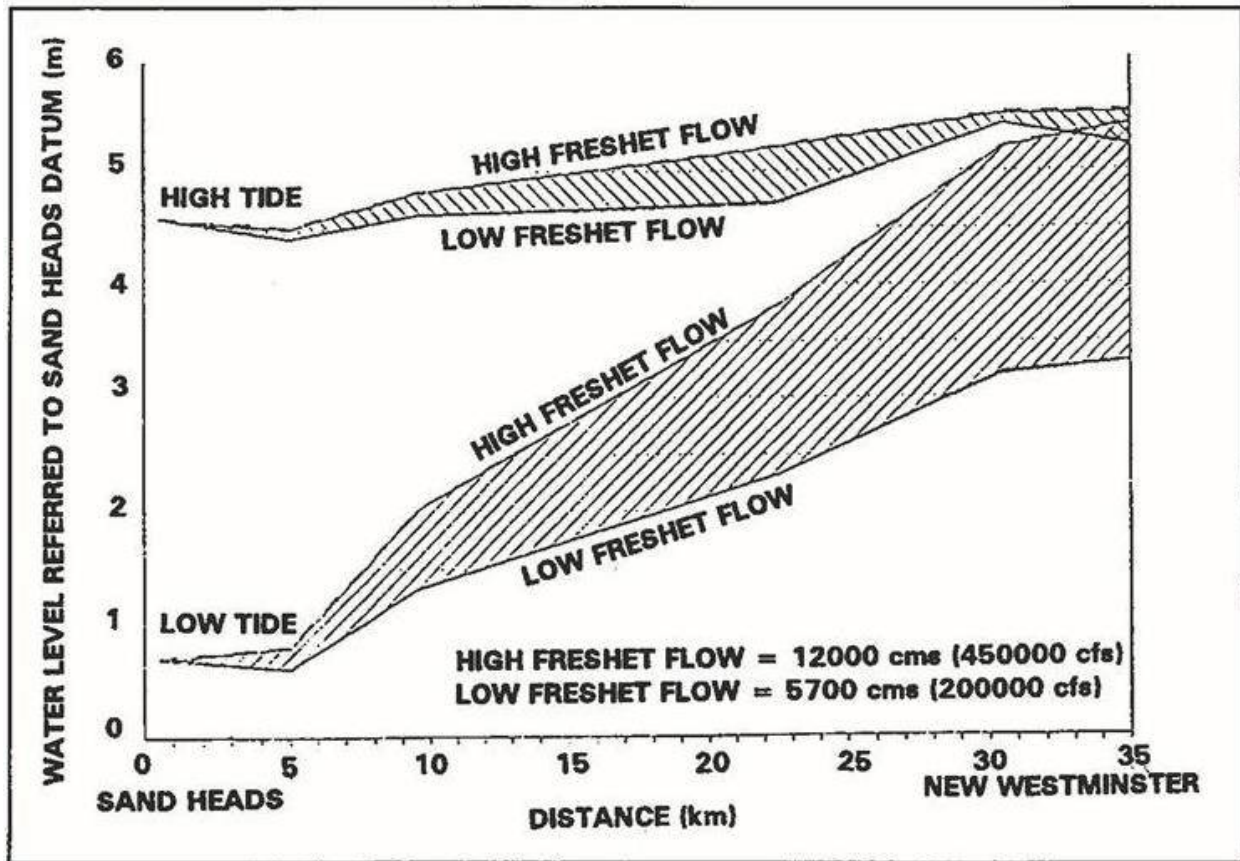
## 2.2. General Setting

The Fraser River is the largest river along the Canadian Pacific Coast and one of the largest rivers on the west coast of North America. With a drainage basin of approximately 217,000 km<sup>2</sup>, the river covers a terrain length of 1,370 km before passing through Metro Vancouver and debouching into the Salish Sea (Thomson, 1981). In general, the river bifurcates into two main distributaries near New Westminster, the North and South Arms. Each arm also has a distributary, the Middle Arm and Canoe Passage associated with the North and South Arms, respectively. A summary of characteristic information on Fraser River is provided in Table 2-1, including information about the mean, high, and low flow rates, distributary flow share, and sediment loads.

**TABLE 2-1: FRASER RIVER CHARACTERISTICS**

Description	Magnitude	Source
Daily Flow at Hope:		See Morrison et al, 2002
Mean flow	2,803 m <sup>3</sup> /s	
Mean peak flow	8,705 m <sup>3</sup> /s	
Mean minimum flow	687 m <sup>3</sup> /s	
Lowest flow, January 8, 1916	340 m <sup>3</sup> /s	
Highest flow, May 31, 1948	15,200 m <sup>3</sup> /s	
Present distributary flow share	85% South Arm 10% North Arm 5% Canoe Passage	NHC-Triton, 2004 Chapter 2.5.1
Total sediment load at Mission	17.3x10 <sup>6</sup> tonnes/year	NHC-Triton, 2004
Granular distribution	35% sand 50% silt 15% clay	Chapter 2.1
*Bed-material load to sea	2.8x10 <sup>6</sup> tonnes/year	NHC-Triton, 2004 Chapter 2.1
Sand delivered through Canoe Passage	50,000 tonnes/year, or 0.83% of total sand load	NHC-Triton, 2004 Chapter 2.5.1
*Bed-material load is defined as medium to coarse sand (0.25 mm to 2 mm). Sand (2 mm ≥ sand ≥ 0.063 mm); silt (0.063 mm ≥ silt ≥ 0.004 mm); clay (≤ 0.004 mm).		

Due to the distributary flow share, the water levels along the South Arm are affected by freshets. Figure 2-8 shows the effects of freshets on water level in the reach starting from Sand Heads, in open water, to New Westminster.



**FIGURE 2-8: EFFECTS OF FRESHETS ON WATER LEVEL IN THE FRASER RIVER ESTUARY, BRITISH COLUMBIA (FERGUSON, 1991)**

The history of changes of the Fraser basin system development is marked by human intervention in confinement of channels by protection works, diking, navigation dredging, and reclamation of delta fringes by dredgeate.

In their dredging management strategy report, BIEAP-FREMP (2006) had delineated the Fraser River South Arm into three units: (1) the Sand Heads open tidal flat area, (2) the South Arm Tidal area, and (3) the South Arm Meso-Tidal area. The Finn Slough site is part of the Fraser River South Arm Tidal area (Figure 2-9).



**FIGURE 2-9: OVERVIEW OF SOUTH ARM TIDAL AREA (BIEAP-FREMP, 2006)**

Due to its commercial and economic importance, the Fraser River and associated system has been studied extensively (e.g., Thomson, 1981; Ferguson, 1991; McLean and Church, 1986; Miller and Barua, 1999; Morrison et al, 2002; Ellis et al, 2004; Williams et al, 2009; and CBA, 2010). The river is an important waterway for access to the port and facilitates the transport of 50 million tonnes of coastal and deep-sea cargo and supports some 650 million young salmon migrating downstream and 10 million spawning salmon. Within the South Arm Tidal segment, salmonid fish utilization is largely limited to upstream adult migration in fall and downstream juvenile salmon migration in spring to mid-summer periods. In addition, the segment also supports other species such as eulachon spawning migration in spring and white sturgeon migrations throughout most of the year (BIEAP-FREMP, 2006).

One important aspect of maintaining the port and navigation fairway that affects the hydro-morphologic setting of the river is annual dredging. Between 1975 and 1990, some 7 million m<sup>3</sup> of sand was dredged annually. Current guidelines limit dredging to 70% of the incoming bed-material load (BIEAP-FREMP, 2006), some 3.5 million m<sup>3</sup> annually.

Several studies and research reports are available on the hydraulics and morphology of the Fraser River Estuary. These studies were mostly sponsored by public agencies such as the Fraser River Estuary Management Program (BIEAP-FREMP), Environment Canada, Canadian Coast Guard, and

Port Authority. Based on 1D Mike 11 modeling, Canadian Coast Guard maintains a website (<https://www2.pac.dfo-mpo.gc.ca/index-eng.html>) named AVADEPTH to forecast water level and currents for navigation along the Fraser River. AVADEPTH forecast reaches of the Fraser River Estuary by km are presented in Figure 2-1.

## 3. Design Criteria

This section describes the criteria that guided the design of the Finn Slough Project. The objectives of the project are to selectively remove accumulated logs to allow for natural marsh expansion, install shear booms to prevent future log accumulation, and extend the channel to improve fish access and tidal circulation. This section includes a description of the functional, physical, and biological design criteria as well as applied engineering standards.

### 3.1. General Design Criteria

#### 3.1.1. Project Datum and Units

The horizontal coordinate system is based on NAD83 UTM Zone 10. The vertical datum is Geodetic Datum (GD). All drawings are presented in SI (metric) units. At Fraser River South Arm km 15-16, the GD is approximately 2.0 m above Chart Datum (CD).

#### 3.1.2. Service Life and Return Period

Standard industry practice is to design shore protection without any factors of safety implicit in the design methods applied. Durable design is achieved by selecting a design condition that is unlikely to be exceeded over the service life of the structure. For permanent structures that are designed to suffer no damage, such as a marine terminal, a 100-year or more return period event is often used. However, for this project, the structures are less critical since the site does not impact the existing flood protection infrastructure (BC MOE, 2007). As such, a return period of 50 years for the extreme event was adopted for the shear boom design.

#### 3.1.3. Codes, Standards and Design Guidelines

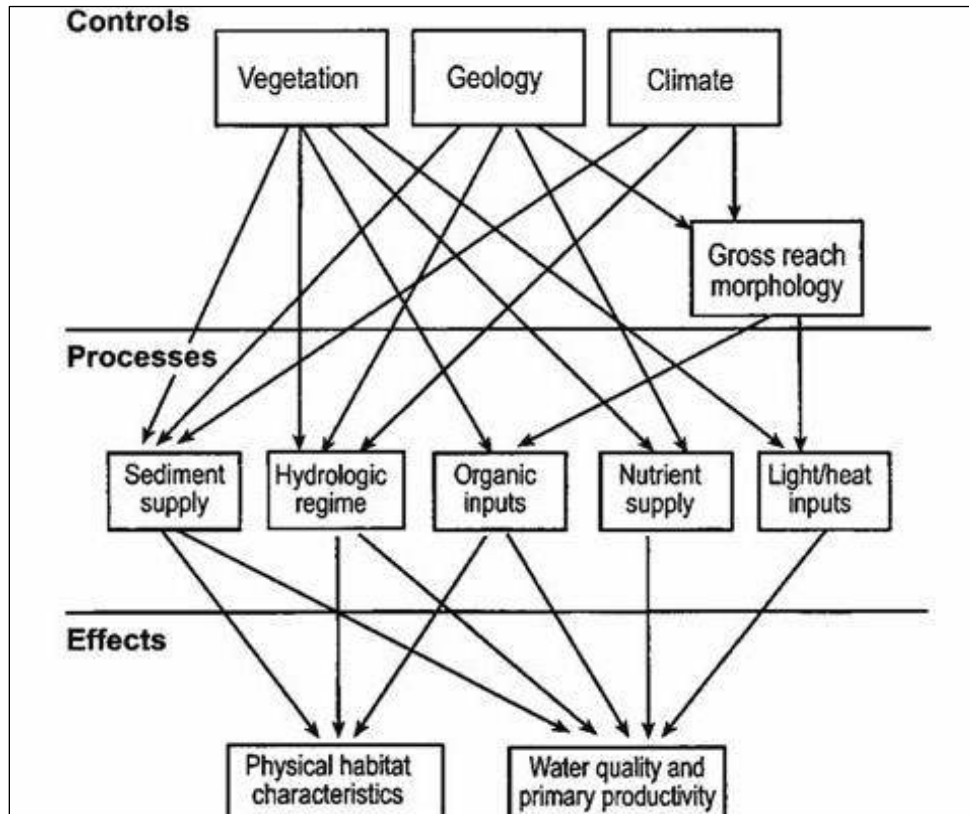
The following guidelines, codes, and standards were used for this project:

- British Columbia Building Code 2018 (BCBC '18); and
- Coastal Engineering Manual (CEM, US Army Corps of Engineers, 2002).

It is noted that the development of the Finn Slough Project does not include structures such as pedestrian bridges, piers, and buildings where public health and safety, fire protection, and structural sufficiency are directly applicable. The proposed habitat enhancement expands the existing natural foreshore environment. The Finn Slough site is restricted from public access. As such, where typical building code design criteria such as environmental (snow, rain, temperature, and seismic) and structural loads do not apply in most cases, appropriate engineering judgment will be used when assessing these requirements.

### 3.1.4. Functional Requirements

Figure 3-1 shows a schematic of processes and controls that define a habitat. Engineering and other interventions must take note of the delicate balance among relevant factors to avoid destruction or significant modification of a habitat.



**FIGURE 3-1: SCHEMATIC OF INTERRELATIONSHIPS AND HABITAT CHARACTERISTICS (RONI ET AL, 2002)**

It is important that identified habitats are preserved and maintained. BIEAP-FREMP (CBA, 2010) had identified four basic guidelines for water-based works in their habitat management strategy policy statement. Relevant highlights of these guidelines are summarized in Table 3-1.

**TABLE 3-1: BIEAP-FREMP HABITAT MANAGEMENT GUIDELINES (CBA, 2010)**

Guideline	Description
1	<p>Preserve habitat features to maintain fish and wildlife functions:</p> <ul style="list-style-type: none"> <li>• fish feeding (marshes),</li> <li>• waterfowl and shorebird nesting,</li> <li>• roosting and feeding (trees and shrubs),</li> <li>• leaf and insect input, and</li> <li>• wildlife feeding and refuge cover.</li> </ul>
2	Design facilities to minimize structure or surface footprints, even for elevated structures such as docks.
3	Preserve intertidal areas, including sand flats, mudflats, and marsh to the degree possible.
4	For mitigation, consider complexing marsh habitat, e.g., using tidal channels, planting, and large woody debris, to improve fish access and utilization.

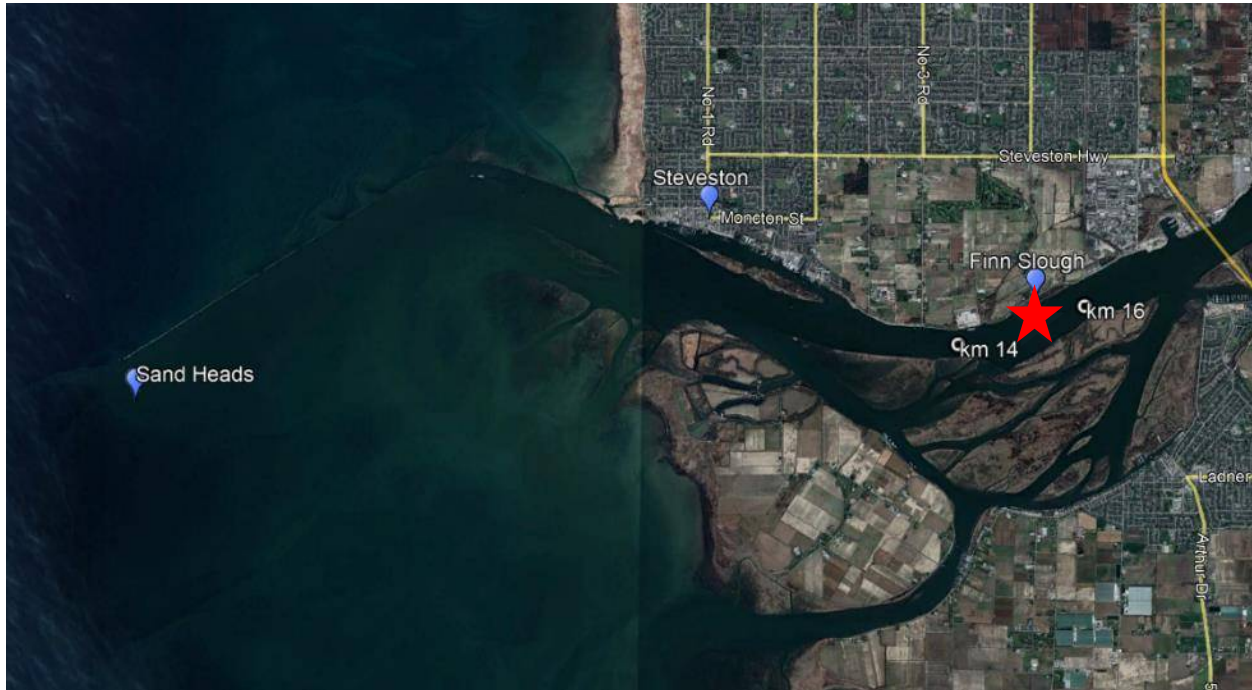
Further to these basic guidelines for marine/estuarine work, the aim is to enhance habitat sites that will be self-sustaining and work within the natural setting of the project location.

## 3.2. Site-Specific Design Criteria

### 3.2.1. Physical Design Criteria

#### 3.2.1.1. Water Levels

Water levels along the Fraser River are influenced by tidal variations in the Salish Sea and river discharge rates. Finn Slough is located at approximately km 15-16 of the Fraser River South Arm. Figure 3-2 shows tide stations with available data in proximity to the project site.



**FIGURE 3-2: TIDE STATIONS IN THE PROXIMITY OF FINN SLOUGH**

The closest tide station with available tidal datums is Sand Heads, with tidal datums listed in Table 3-2. Tide levels at Sand Heads are mostly astronomical.

**TABLE 3-2: SAND HEADS TIDAL DATUM (CHS CHART #3490)**

Tidal Datum	Elevation (m CD)
Higher High Water Large Tide (HHWLT)	+4.9
Higher High Water Mean Tide (HHWMT)	+4.3
Mean Water Level (MWL)	+3.1
Lower Low Water Large Tide (LLWLT)	+1.3
Lower Low Water Mean Tide (LLWMT)	+0.2

Water levels at Finn Slough are more affected by the Fraser River Discharge. CHS provided water level data at a few stations along the Fraser River based on the river discharge; the nearest available data is at Steveston station. Water level variation at Steveston under varying tide elevations at Point Atkinson and different discharge rates at Hope are presented in Table 3-3 (from Canadian Tide and Current Tables 2020). The water levels are referenced to CD.

**TABLE 3-3: WATER LEVELS AT STEVESTON**

Point Atkinson (m CD)	Tidal Heights at Steveston (m CD)			
	Discharge at Hope			
	700 m <sup>3</sup> /s (December – March)	2,800 m <sup>3</sup> /s (April, August – November)	5,700 m <sup>3</sup> /s (May, July)	8,500 m <sup>3</sup> /s (June)
5.0	4.2	4.2	4.3	4.3
4.5	3.7	3.8	3.8	3.8
4.0	3.3	3.3	3.3	3.3
3.5	2.8	2.8	2.9	2.9
3.0	2.3	2.3	2.4	2.4
2.5	1.8	1.8	1.9	2.0
2.0	1.4	1.4	1.5	1.5
1.5	0.9	1.0	1.0	1.1
1.0	0.4	0.6	0.7	0.8
0.5	0.1	0.2	0.4	0.5
0.0	-0.2	0.0	0.2	0.3

Table 3-4 summarizes the recommended design water level relative to local geodetic datum and the approximate river km location. These values are in line with the Port Authority’s Guideline for Shoreline Protection Inspection, Maintenance, Design and Repair Guideline (Port Authority, 2020). The Fraser River datums were obtained from CHS.

**TABLE 3-4: DESIGN WATER LEVELS AT PROJECT SITE AND STEVESTON REFERENCE STATION**

Design Water Level/Datum	Steveston		Finn Slough (km 15 – 16)	
	CD	GD	CD	GD
High Water Level – High Discharge	+4.30	+2.10	+4.30	+2.30
High Water Datum	+4.20	+2.00	+4.00	+2.00
Low Water Datum	0.00	-2.20	-0.04	-1.96
Low Water Level – Low Discharge	-0.20	-2.40	-0.20	-2.40

### 3.2.1.2. Wind Generated Waves

The site is relatively sheltered from any significant wind-generated waves.

### 3.2.1.3. Passing Vessel Wakes

Fraser River shorelines are exposed to the wake of vessel traffic. Typically, waves generated by speeding small crafts or tugs are much higher than wake waves generated by large tankers or bulk carriers. Vessel wake wave heights also decrease away from the vessel hull. The vessel wakes along the project site shoreline were estimated based on a tugboat with a length of 33.3 m, a breadth of 9.5 m, and a draft of 3.5 m using the methodology developed by Sorensen (1997). Anticipated vessel-generated wake height for a sailing distance of 30 m was estimated to be 0.6 m using a desktop analysis.

### 3.2.1.4. Currents

Examination of forecasts of current velocity along Finn Slough, provided by AVADEPTH, suggests that during the mean peak flow on the Fraser River of 8,500 m<sup>3</sup>/s, the maximum depth-averaged ebb-current (flowing at a higher speed than a flood current) is approximately about 1.0 m/s at the Finn Slough site. Figure 3-3 shows a snapshot of a representative peak ebb flow in June 2020.

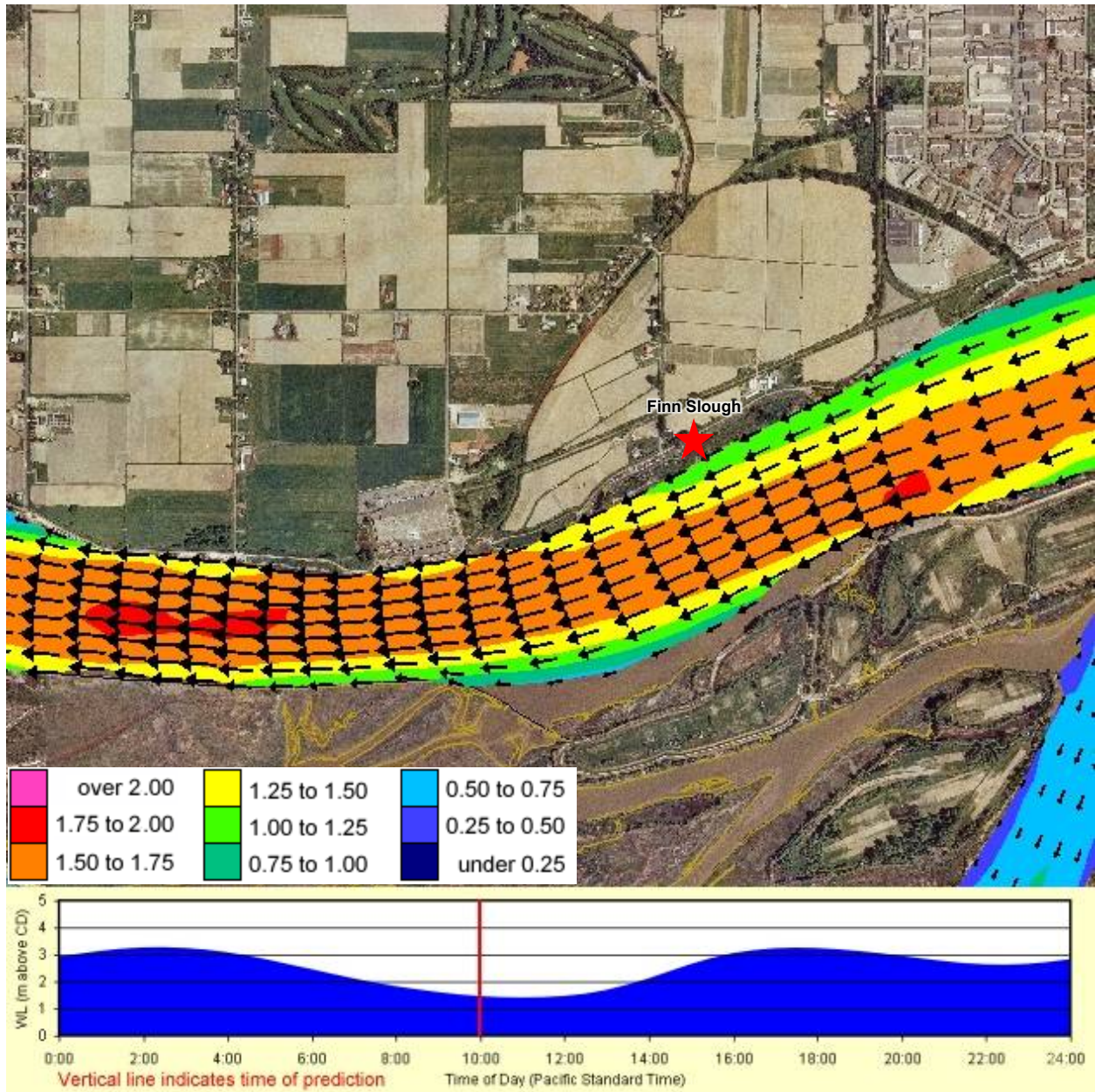


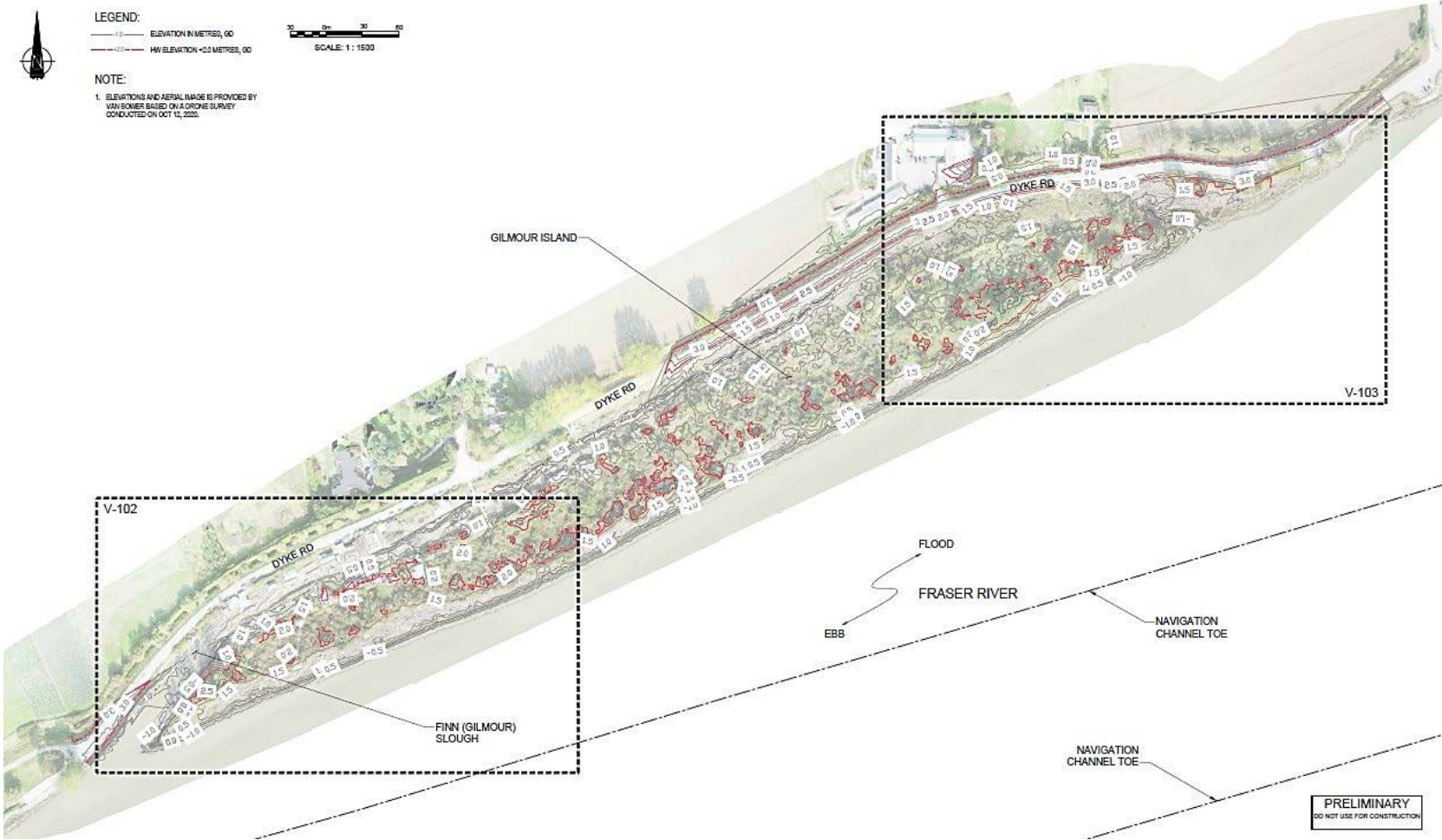
FIGURE 3-3: CURRENT VELOCITY DURING A FRASER RIVER PEAK EBB FLOW EVENT, JUNE 2020  
(SOURCE: AVADEPTH)

## 3.2.2. Biological Design Criteria

### 3.2.2.1. Existing Marsh Conditions

Drone surveys in September 2020 indicated existence of tidal marshes on Gilmour Island. However, based on experience with nearby sites, marsh vegetation would include Lyngbye's sedge (*Carex lyngbyei*), common cattail (*Typha latifolia*), softstem bulrush (*Schoenoplectus tabernamontani*), spikerush (*Eleocharis palustris*), and Baltic rush (*Juncus balticus*).

Based on drone surveys conducted in fall 2020, existing marsh elevation ranges from about 1.0 m GD elevation to about 2.0 m towards the center of Gilmour Island. Figure 3-4 presents an overview of the existing condition with red contour lines at +2.0 m GD.



**FIGURE 3-4: EXISTING SITE PLAN**  
 \* SEE APPENDIX A FOR A FULL-SIZE DRAWING

## 4. Proposed Design

The overall goal for the project is to enhance marsh habitat by allowing the existing marsh to expand naturally upon removal of the accumulated logs and pieces of debris. At this stage, no marsh planting is anticipated at the site. To facilitate the marsh growth process, shear booms will be installed to prevent future log accumulation along the shoreline. Installation of shear booms is expected to not have adverse impacts on the existing navigation channel.

The main design features of the project also include a channel extension to reconnect the eastern end of Finn Slough to the Fraser River. This is expected to improve tidal circulation, fish access, and water quality. Details of the design features are presented in the Project Drawings (Appendix A).

### 4.1. Log Removal

Historical aerial images of the area show that log accumulation at Finn Slough dates back to at least 10 years ago. Figure 4-1 presents images dated April 2009 and July 2018, which show significant log accumulation through the years. Log accumulation prevents vegetative growth on the underlying soil due to deprivation of oxygen and sunlight. By removing accumulated logs and exposing the underlying soil, the existing marsh is expected to expand naturally into those areas. The extent of log removal areas is presented in Figure 4-2 and Figure 4-3. For the project, the total expected log removal area is approximately 0.5 ha.

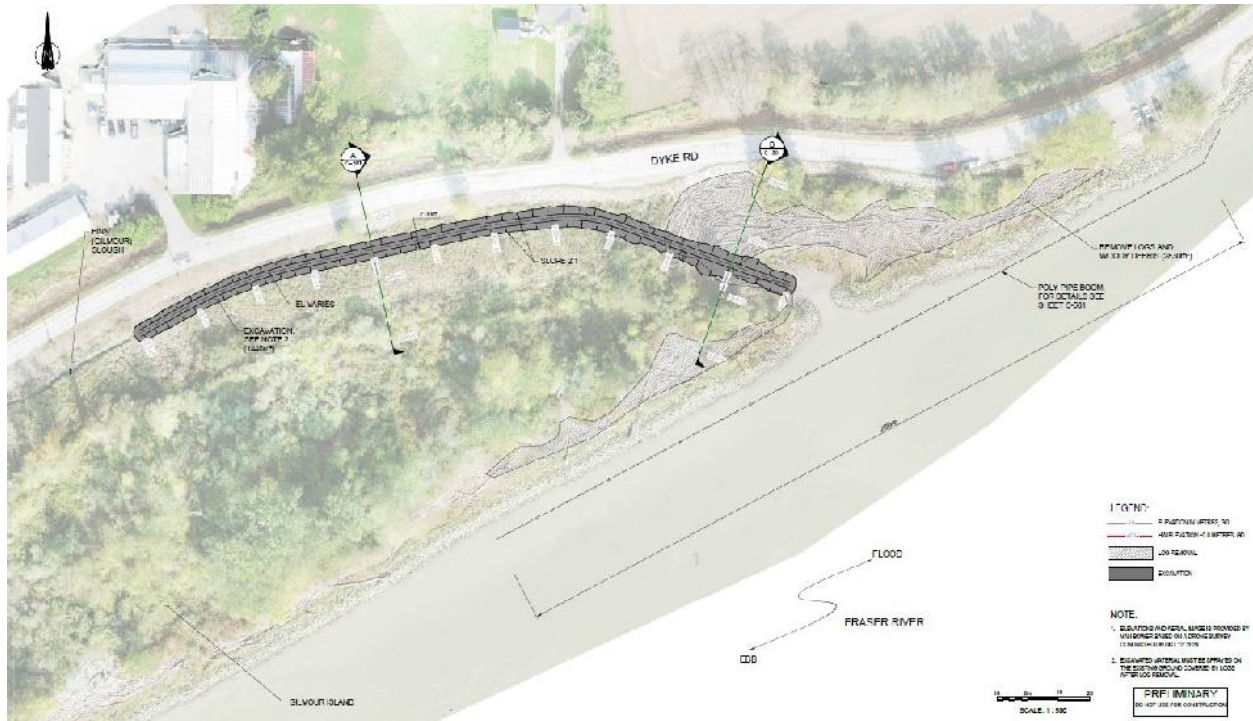


FIGURE 4-1: HISTORICAL LOG ACCUMULATION (SOURCE: GOOGLE EARTH)

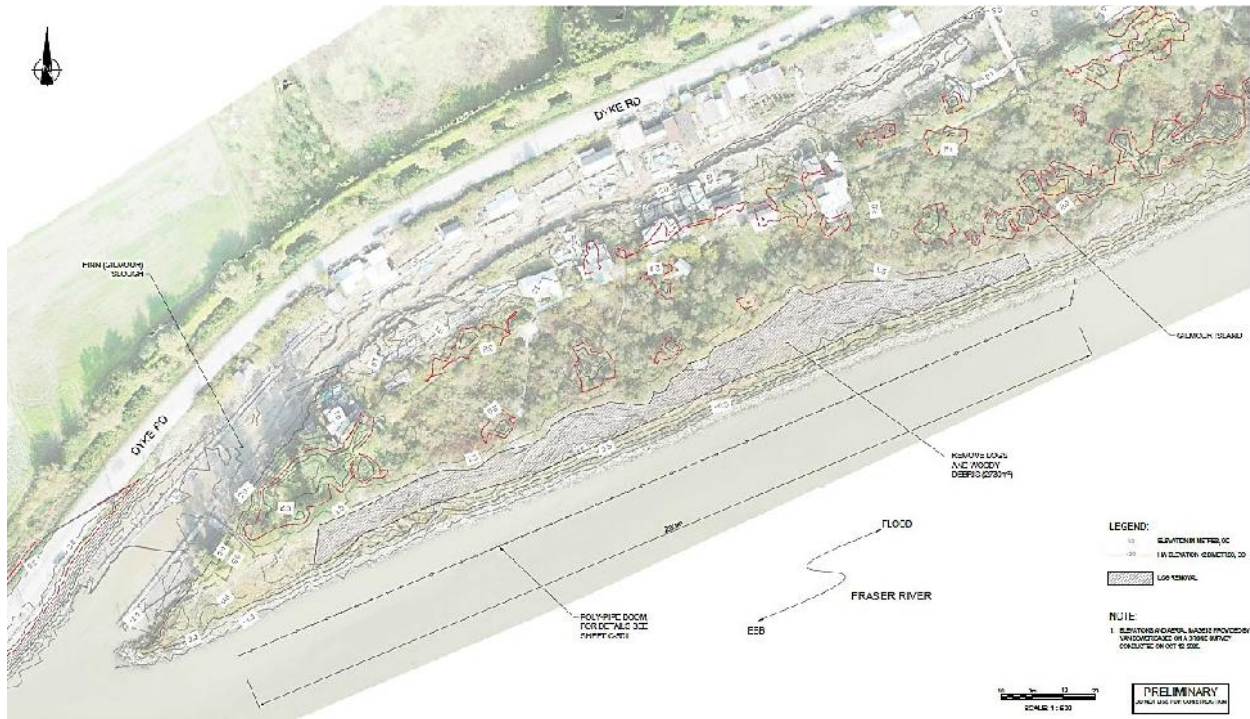
### 4.2. Slough Extension

At the channel opening on the north-east end of the island, the revetment configuration suggests that the channel was once connected to the Fraser River and was silted up by sediments. The proposed design includes an extension of the channel to connect back to the Fraser River at the same location.

Connecting the channel will allow for better tidal circulation and improve fish habitat availability and access in that area and further downstream in the slough. The proposed channel configuration is presented in Figure 4-2. The channel extension will be achieved by excavating a channel down to varying elevation between -1.93 m GD to +0.51 m GD with side slopes of 1V:2H. The channel extension is expected to generate a habitat gain of 0.2 ha.



**FIGURE 4-2: PROPOSED LOG REMOVAL AND CHANNEL EXTENSION (UPSTREAM)**  
\* SEE APPENDIX A FOR A FULL-SIZE DRAWING



**FIGURE 4-3: PROPOSED LOG REMOVAL AND SHEAR BOOM INSTALLATION (DOWNSTREAM)**  
\* SEE APPENDIX A FOR A FULL-SIZE DRAWING

### 4.3. Shear Boom (Debris Deflector)

The content in this section reflects input provided by the City of Richmond during recent engagement.

To reduce and/or prevent future log accumulation, shear booms (also referred to as debris deflectors) are proposed for the site. There are a few types of shear booms that have been used along the Fraser River and in the United States of America (USA), as presented in Figure 4-4. Comparison of these four debris deflector types based on various factors are summarized in Table 4-1.

**Pile Dike (Steveston, BC)**



**Debris Screen (McDonald Park, BC)**



**Log Boom (Riverfront Park, BC)**



**Poly-pipe Boom (Oregon, USA)**



**FIGURE 4-4: SHEAR BOOM TYPES**

**TABLE 4-1: SHEAR BOOM COMPARISON**

Type	Pile Dike	Debris Screen	Log Boom	Poly-pipe Boom
Location	Steveston, BC	McDonald Park, BC	Riverfront Park, BC	Oregon, USA
Effectiveness to Deflect Large Volume of Debris	High	High	Low	High
Robustness (Requiring Less Maintenance)	Medium	High	Low	High
Cost Effectiveness	Low	High	Medium	Low
Adaptive Capacity against Future Sea Level Rise	Medium	Low	High	High
Fish Friendly (Smaller Potential for Adverse Impacts on Fish such as Stranding)	High	Low	High	High
Potential to Reduce Aquatic Habitat Footprint Effects	Low	High	Medium	Medium
Aesthetics / Natural Looking	Medium	Medium	High	Low

Pile dikes and debris screens involve significantly large structures impacting the aquatic habitat and are less adaptive to sea level rise and debris screens could impede fish passage or result in fish stranding; therefore, they are not recommended for the Finn Slough Project. Pile dikes can also impact river flow hydrodynamics and sediment transport. Log booms are less intrusive for the aquatic habitat and aesthetically more pleasing. However, log booms, compared to poly-pipe boom, require more maintenance. Log booms in some sites along the Fraser River such as Kerr Street, Angus Park, and Deering Island have experienced episodic damage and need for maintenance (the chains holding the log booms were damaged and the boom had to be removed from the site). In addition, when a large volume of debris was present, the debris could overtop the boom or move under the boom, allowing debris re-accumulation along the shoreline.

The poly-pipe boom, compared to the log boom, is more robust and requires less maintenance as the stacked-up booms minimize the risk of debris overtopping compared to traditional log booms. A poly-pipe boom structure is expected to be more effective in preventing debris overtopping and consequently likely to avoid/minimize impacts on City of Richmond's dike from floating debris impacts. The poly-pipe boom may also provide cover for juvenile fishes migrating down the river, especially if periphytic algae attaches to the poly-pipe boom, and may even provide a feeding source for some fish species or habitat for invertebrates. Existing industry design guidelines and professional practice do not require seismic design for debris deflectors. During a seismic event, the piles/debris deflector could be undermined due to soil liquefaction. However, given the proposed alignment and distance between the debris deflector and the dike, any potential damage to the dike would be limited and localized, and any effects to dike integrity could be easily addressed after the event.

In terms of adaptability to climate change, the following can be said about the shear boom types.

The pile dikes typically have medium adaptability to sea-level rise resulting from climate change. The constraint is the (vertical) pile elevations. For this type of structure, a sea-level rise allowance can be built into the design by making the vertical piles taller, and with sufficient embedment and capacity to accommodate debris loads associated with future sea-level rise.

The limitation to the debris screen in accommodating sea-level rise is the cap beam elevation of the screen. If sea level rises to a level above the cap beam elevation, debris will be able to float over the screen. It would be possible to add height to the screen later, but it would entail a major upgrade in terms of construction. Vertical supports would have to be bolted onto the main piles to support a screen section above the existing. The age of the structure may be a consideration at that time, and if the timber has sufficient remaining capacity to support the added superstructure. Batter piles<sup>1</sup> may have to be added to withstand the increased debris load that would come from adding to the screen height. Batter piles would be needed if the pile embedment prescribed in the initial design is insufficient in accommodating the increased debris load (higher overturning moment due to debris load acting higher up on the structure). For these reasons, adaptation to future sea-level rise would typically be incorporated at the design stage, i.e., making the screen section taller initially to be ready to

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<sup>1</sup> A batter pile is a pile driven into the ground at an angle to provide resistance to horizontal forces.

accommodate future sea-level rise. For this type of structure, it should, however, be considered if the added screen height presents a visual obstruction.

The log boom is more readily adaptable to future sea-level rise as the design enables the boom to move vertically with the change in water level. If the vertical range of boom movement is fixed, the connections can be moved up in response to sea-level rise as part of periodic inspection and maintenance. The (horizontal) boom section may also be designed with a connection that will enable the boom to rise unconstrained with the water level. The limiting height in terms of sea-level rise adaptation then becomes the cap elevation of the main (vertical) piles. If sea-level was to rise above the cap elevation of the piles, the boom would be lifted up over the top of the piles and could float away. The solution could be to incorporate hold-downs at the cap to prevent this from happening, but the boom would then be submerged and there would be a potential for debris to float over. It is not easy to add height to the vertical piles after installation, so a typical measure to incorporate a sea-level rise allowance would be to add height to the piles as part of the initial design and construction.

The poly-pipe boom is the most adaptable to sea level rise of the shear boom types considered. This type of boom arrangement is designed with a sleeve connection that will allow the (horizontal) boom to move vertically up and down the main (vertical) piles. The limiting elevation is the cap elevation of the vertical piles. If sea level rises above this level, the boom would float up over the piles and could drift away. This can be prevented by incorporation of hold-downs, but the boom would then be submerged and there would be a potential for debris to float over. Because this option utilizes steel piles for the vertical members, it could be possible to weld on additional vertical pipe sections to accommodate future sea level rise. However, a number of factors would need to be considered in this regard, such as cleaning of the piles for welding (issues could be corrosion and loss of section), potential environmental impact of welding above water, potential issues of piles leaning or being off center, and consideration of batter piles to accommodate the increased load. For these reasons, it may be more feasible to consider sea level rise adaption at the design stage and incorporate a sea level rise allowance into the initial design.

Ultimately, selection of the debris deflector type (between the log boom vs. poly-pipe boom) hinges the balance between aesthetics, robustness (maintenance), effectiveness, and upfront cost. At this phase of the project, a poly-pipe boom has been presented in the design drawings. It is recommended that the preferred option for the debris deflector is selected based on input from stakeholders as well as project expectations relating to aesthetics, robustness (maintenance), effectiveness, and upfront cost.

For the current design, the proposed poly-pipe boom will consist of approximately 100 pipe piles with 24-inch (610 mm) diameter, resulting in an in-water footprint of approximately 29 m<sup>2</sup>. The shear boom will be located approximately 100 m away from the toe of the navigation channel with an orientation parallel to the river flow. The footprint is relatively small and is not expected to alter river hydrodynamics or sediment transport.

## 5. Construction

### 5.1. Site Description

The proposed project involves removal of accumulated logs on the island and along the shoreline and the installation of shear booms to prevent future log accumulation, as well as excavation to extend the channel and improve fish access and tidal circulation.

The total habitat enhancement area for the proposed Finn Slough Project is shown in Table 5-1.

**TABLE 5-1: TOTAL HABITAT ENHANCEMENT AREA**

Log Removal	Channel Extension	Total Area
0.5 ha	0.2 ha	0.7 ha

### 5.2. Site Access

It is assumed that site ingress/egress for personnel involved in the demolition, construction, import of materials and equipment for log removal and channel construction, and transportation of materials for off-site disposal will be land-based via No.4 Road leading to Dyke Road.

For shear boom installation, access to the site could be achieved using water-based equipment via the Fraser River.

### 5.3. Construction Methodology

Construction of the project would be undertaken using a combination of heavy land-based equipment (including excavators and dump trucks) as well as water-based equipment.

Log removal on most of the north-eastern area is anticipated to be performed with excavators and loaded to dump trucks for offsite disposal. There is unrestricted access for land-based equipment to the site through No.4 Road and Dyke Road. Excavated logs and debris material will be transported to an appropriate offsite location for disposal. On the western area and portions of the north-eastern area that cannot be accessed from land, log removal is anticipated to be performed using water-based equipment. In this case, log removal will be performed by a crane barge and stored on a flat deck barge for disposal. The logs will be unloaded at a nearby barge ramp and loaded to dump trucks for disposal.

The slough extension work will be completed through land-based access with excavators. Excavated material from the channel will be spread onsite or be reused for regrading the log removal areas to appropriate elevations for marsh growth. For shear boom installation, water-based equipment on barges is anticipated for pile driving. It is expected that the piles for the shear booms will be brought to the site by barge.

## 5.4. Construction Schedule

The proposed Project would involve consideration of any constraints, typical production rates, and material delivery. Specifically, the schedule includes:

### **Fisheries Closures (in-water works):**

- Juvenile salmon (March 1 through July 15)

### **Marine Mammals (in-water works):**

- Temporary works stoppage if specific marine mammals are observed in the area

### **Production Rates**

- Working hours: Monday-Friday, 8am-5pm
- Log removal: 200 m<sup>3</sup>/day
- Excavation/grading: 200 m<sup>3</sup>/day
- Pile driving: 2 piles/day

Based on these assumptions the schedule indicates a construction period of approximately three (3) months. See Appendix B for Schedule Layout.

## 6. Construction Direct Cost (CDC)

This section has been removed.

## 7. Limitations and Recommendations for Next Steps

The proposed project elements presented herein have been developed at a preliminary level of design. Additional analyses and further refinement of design is expected to be performed at the next phases of design, and subject to continued engagement with the City of Richmond. The following considerations should be included for the next phases of design:

- Finn Slough is already connected to Fraser River and water levels along Finn Slough are influenced by Fraser River water levels. Peak water levels and extent of flooding along the Finn Slough is likely to not change resulting from connection of Finn Slough to Fraser River on the north-east end of Gilmour Island. Potential changes on upland flooding and peak water levels at private residences along Finn Slough resulting from construction of project should be investigated to confirm this understanding.
- The proposed Finn Slough extension to reconnect the north-east end of Finn Slough to the Fraser River will allow greater flow conveyance through Finn Slough. The channel extension will be designed to minimize and avoid impacts on upland flooding along Dyke Road resulting from construction of the project.
- Next phases of design must accommodate a buffer between the toe of existing dike and the proposed channel sufficient to allow potential changes to the City of Richmond's dike.
- Vibration monitoring and settlement monitoring during pile driving and construction activities should be implemented to monitor and avoid any damage to the dike.
- Consideration will be given during future design development regarding reducing the risk of recreational users (e.g., kayakers) getting stuck behind the debris deflectors.

## 8. References

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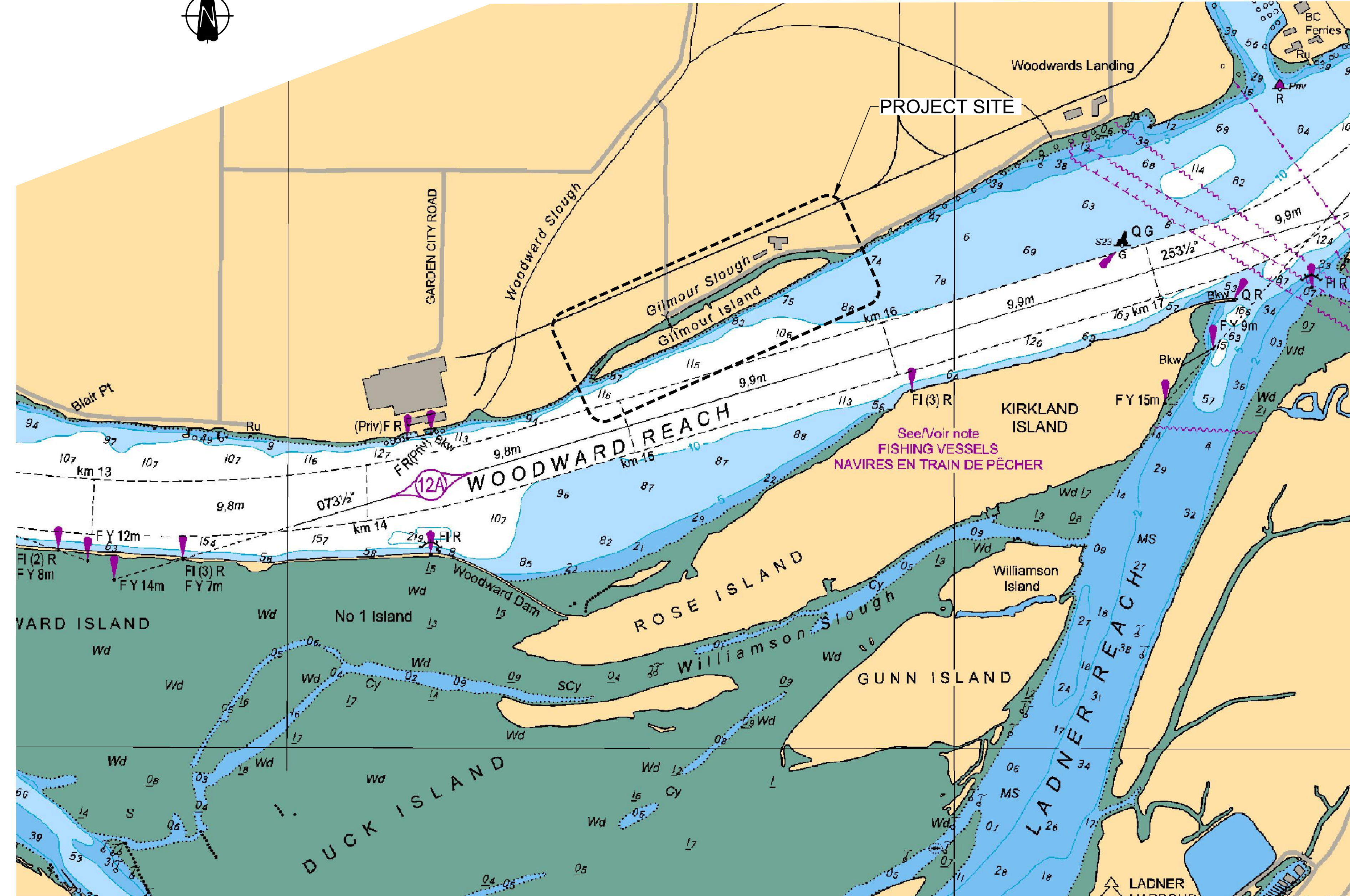
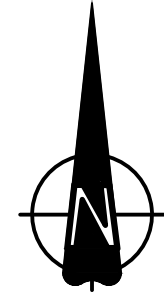
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## Appendix A: Project Drawings

# VANCOUVER FRASER PORT AUTHORITY

## RBT2 OFFSETTING

### FINN SLOUGH ENHANCEMENT PROJECT



VICINITY MAP  
NTS

**DRAWING LIST:**

- G-001 COVER SHEET & DRAWING INDEX
- G-002 GENERAL NOTES
- V-101 EXISTING CONDITIONS - GENERAL SITE PLAN
- V-102 EXISTING CONDITIONS - WEST SITE PLAN
- V-103 EXISTING CONDITIONS - EAST SITE PLAN
- C-101 PROPOSED WEST SITE PLAN
- C-102 PROPOSED EAST SITE PLAN
- C-301 SECTION A
- C-501 POLY-PIPE BOOM DETAILS

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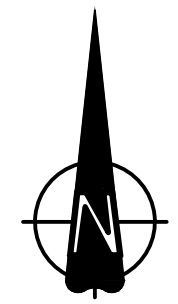


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<b>FINN SLOUGH ENHANCEMENT PROJECT</b>			
<b>COVER SHEET &amp; DRAWING INDEX</b>			
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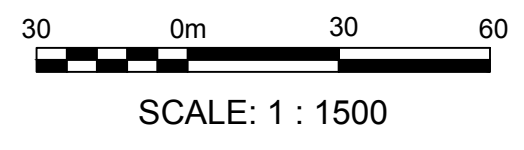


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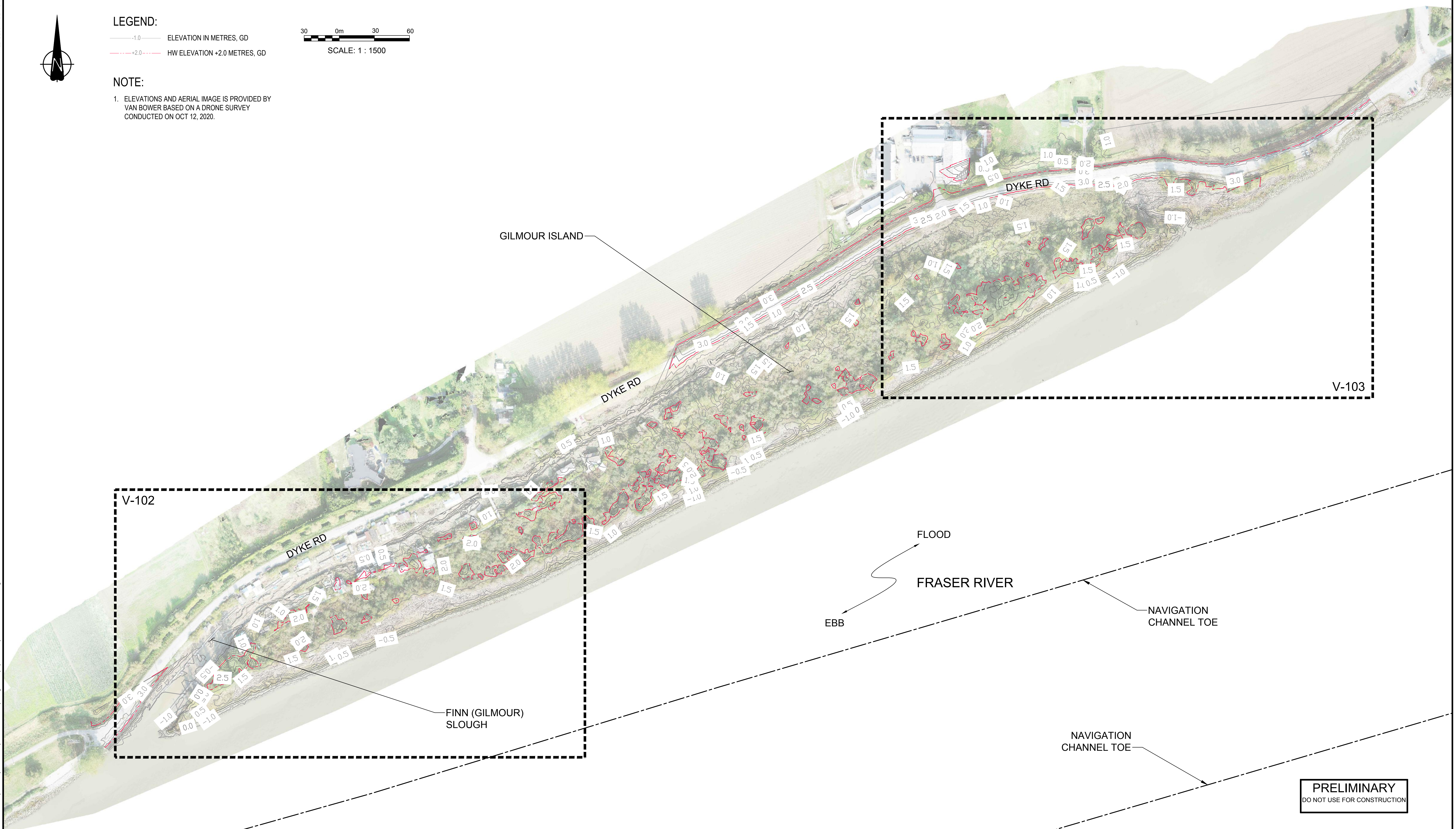
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**NOTE:**

1. ELEVATIONS AND AERIAL IMAGE IS PROVIDED BY VAN BOWER BASED ON A DRONE SURVEY CONDUCTED ON OCT 12, 2020.



Ref.No.	REFERENCE

IN ASSOCIATION WITH:

**moffatt & nichol**

IN ASSOCIATION WITH:

**GL Williams & Associates Ltd.**  
 Shoreline Management Consulting

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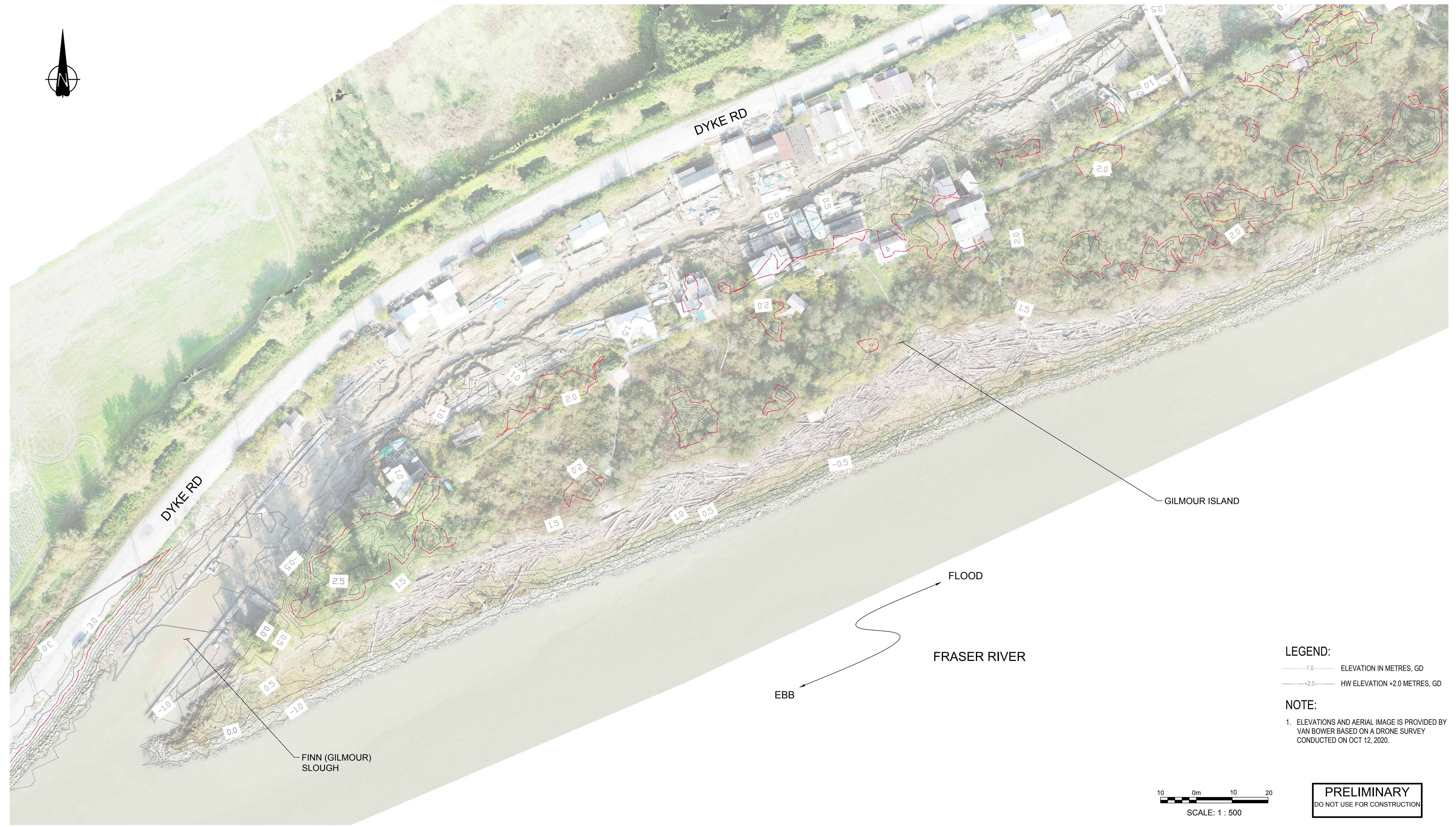
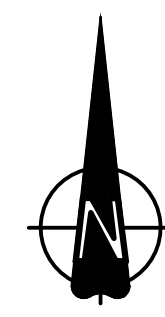
**PORT of vancouver**

VANCOUVER FRASER PORT AUTHORITY  
 ENGINEERING DEPARTMENT

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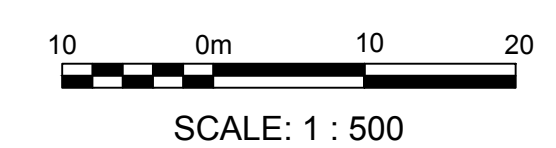
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 EXISTING CONDITIONS - GENERAL SITE PLAN**

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**NOTE:**  
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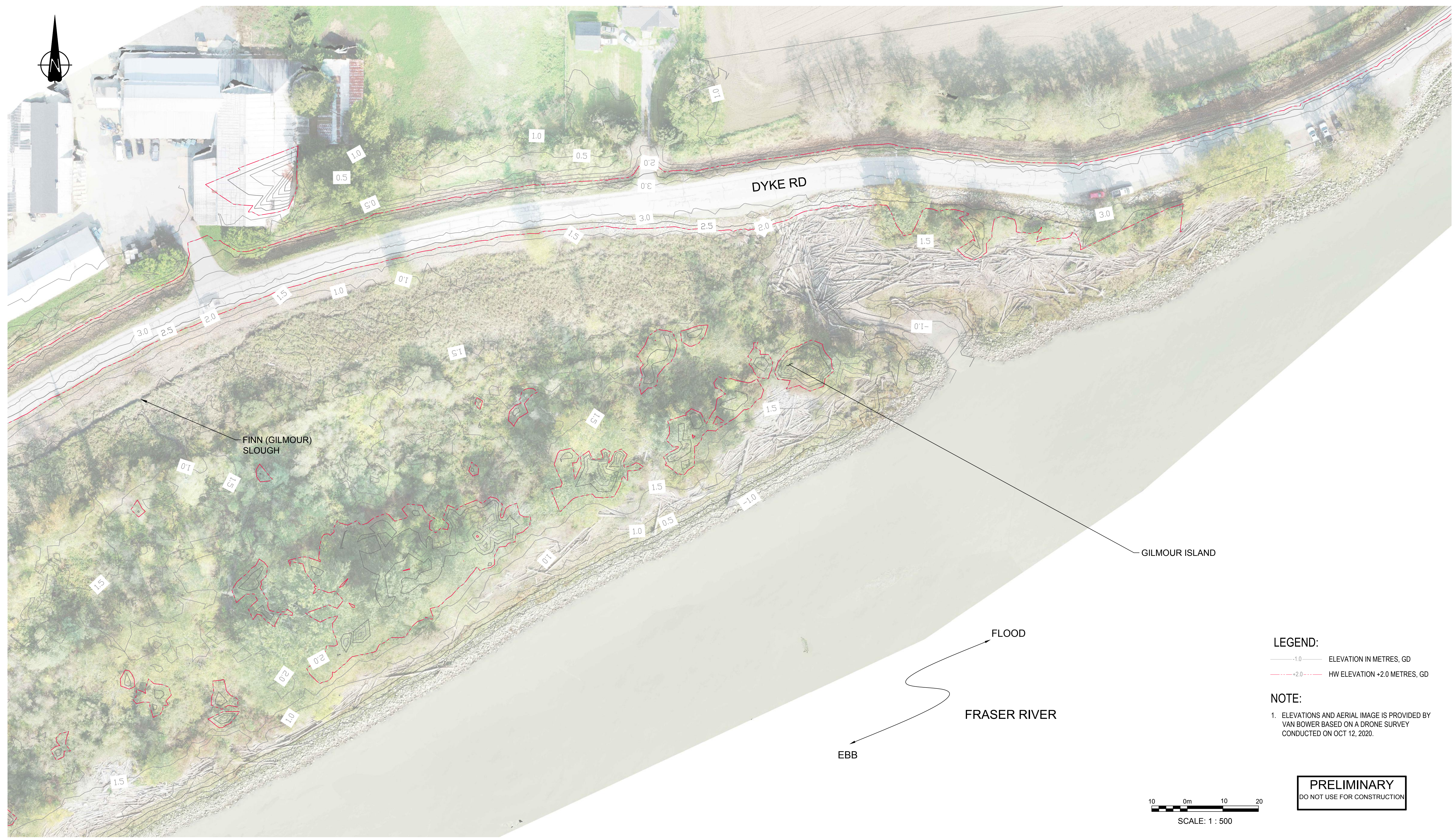
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A	10/30/2020	CONCEPTUAL DESIGN	RG	YN



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SCALE	
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**RBT2 OFFSETTING**  
**FINN SLOUGH ENHANCEMENT PROJECT**  
**EXISTING CONDITIONS - WEST SITE PLAN**

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Ref.No.	REFERENCE

IN ASSOCIATION WITH:

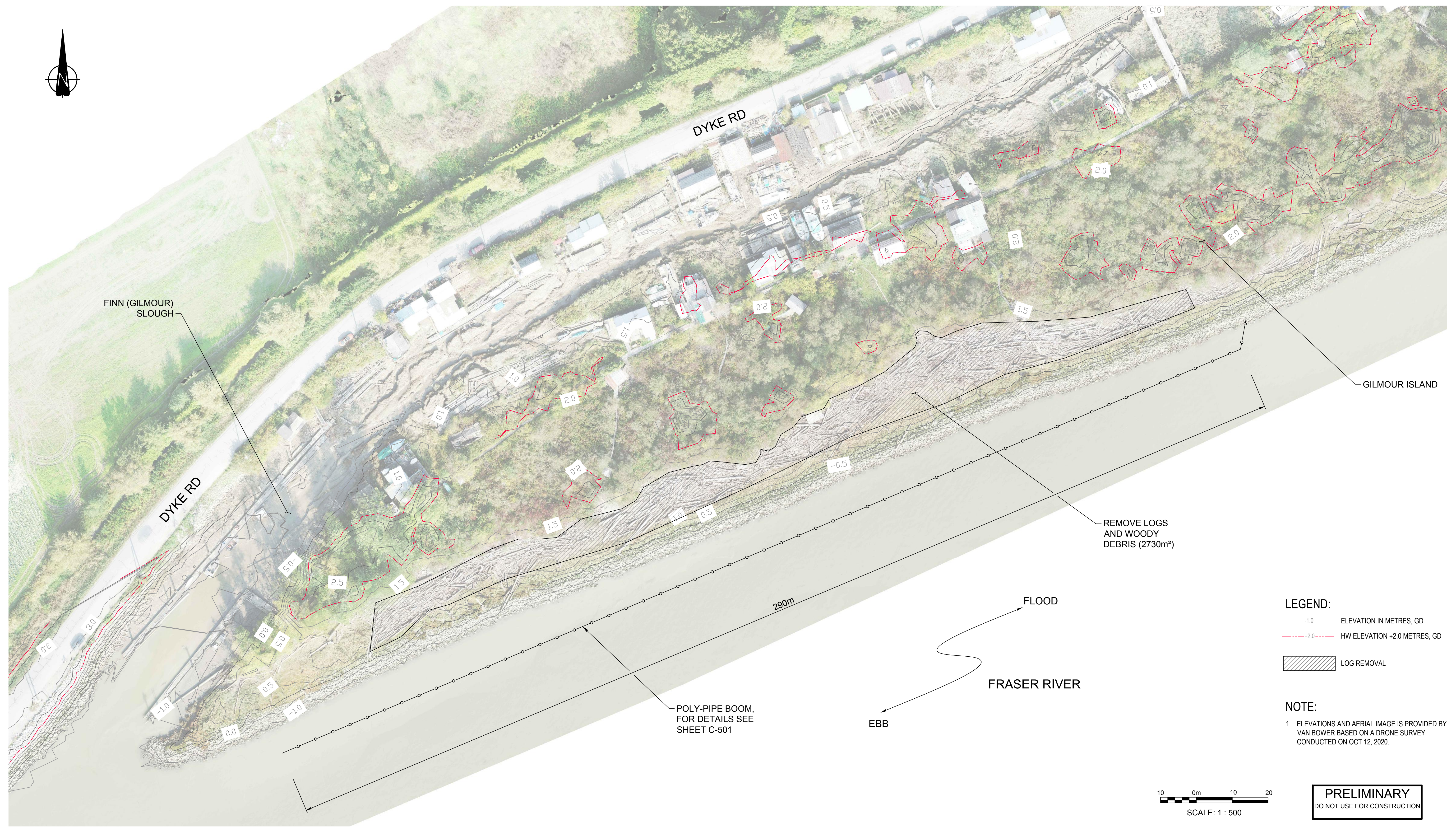
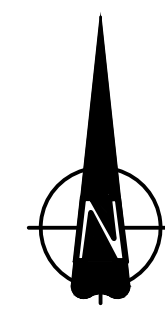
No.	Date	REVISION	Dr'n	Ch'd
B	11/18/2020	PRELIMINARY DESIGN	RG	YN
A	10/30/2020	CONCEPTUAL DESIGN	RG	YN

VANCOUVER FRASER PORT AUTHORITY  
 ENGINEERING DEPARTMENT

DESIGN BY	
DRAWN BY	
APPROVED	
DATE	
SCALE	
PMV SITE	

**RBT2 OFFSETTING**  
**FINN SLOUGH ENHANCEMENT PROJECT**  
**EXISTING CONDITIONS - EAST SITE PLAN**

SIZE: D  
 SHEET: V-103  
 REV: A

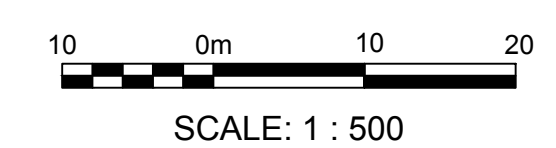


**LEGEND:**

- 1.0 — ELEVATION IN METRES, GD
- +2.0 — HW ELEVATION +2.0 METRES, GD
- [Hatched Box] LOG REMOVAL

**NOTE:**

1. ELEVATIONS AND AERIAL IMAGE IS PROVIDED BY VAN BOWER BASED ON A DRONE SURVEY CONDUCTED ON OCT 12, 2020.



**PRELIMINARY**  
DO NOT USE FOR CONSTRUCTION

Ref.No.	REFERENCE



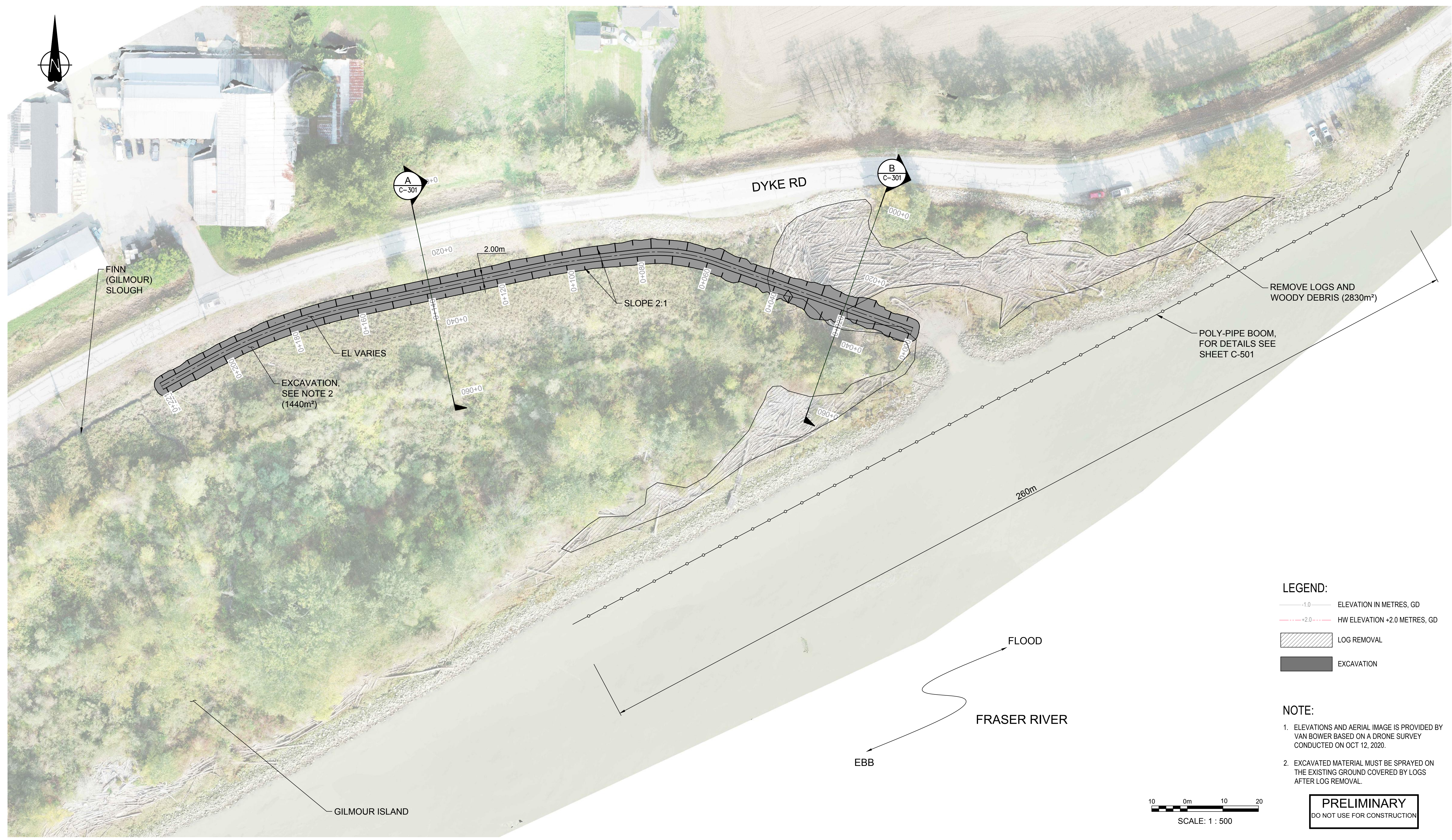
No.	Date	REVISION	Dr'n	Ch'd
B	11/18/2020	PRELIMINARY DESIGN	RG	YN
A	10/30/2020	CONCEPTUAL DESIGN	RG	YN



DESIGN BY	
DRAWN BY	
APPROVED	
DATE	
SCALE	
PMV SITE	

**RBT2 OFFSETTING  
FINN SLOUGH ENHANCEMENT PROJECT  
PROPOSED WEST SITE PLAN**

SIZE	DWG.	C-101	SHEET	REV.
D				A



- LEGEND:**
- 1.0 ELEVATION IN METRES, GD
  - +2.0 HW ELEVATION +2.0 METRES, GD
  - LOG REMOVAL
  - EXCAVATION

- NOTE:**
1. ELEVATIONS AND AERIAL IMAGE IS PROVIDED BY VAN BOWER BASED ON A DRONE SURVEY CONDUCTED ON OCT 12, 2020.
  2. EXCAVATED MATERIAL MUST BE SPRAYED ON THE EXISTING GROUND COVERED BY LOGS AFTER LOG REMOVAL.

**PRELIMINARY**  
 DO NOT USE FOR CONSTRUCTION

Ref.No.	REFERENCE

IN ASSOCIATION WITH:




No.	Date	REVISION	Dr'n	Ch'd
B	11/18/2020	PRELIMINARY DESIGN	RG	YN
A	10/30/2020	CONCEPTUAL DESIGN	RG	YN



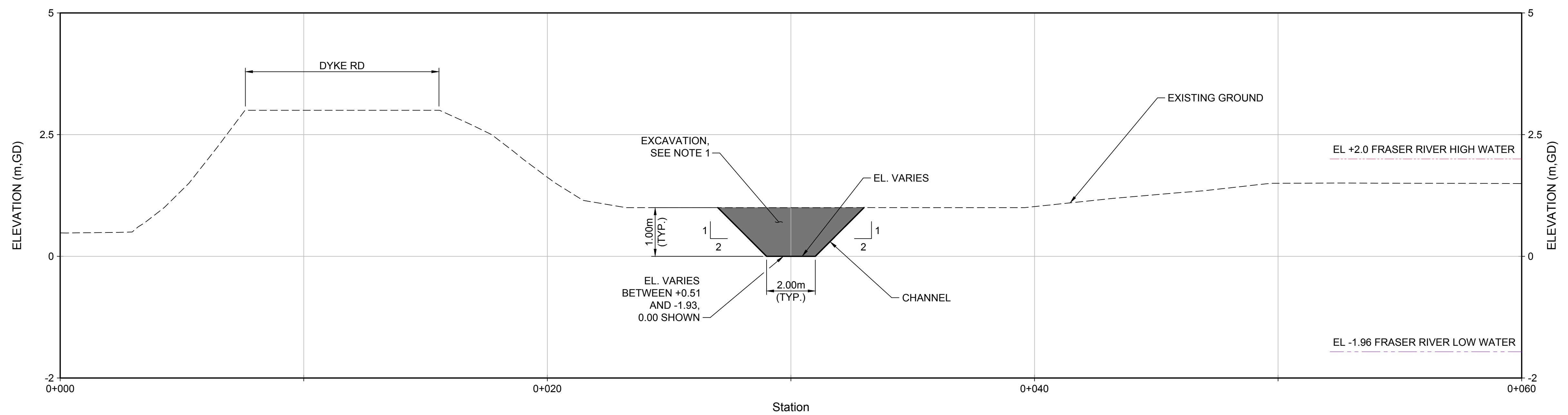
VANCOUVER FRASER PORT AUTHORITY  
 ENGINEERING DEPARTMENT

DESIGN BY	
DRAWN BY	
APPROVED	
DATE	
SCALE	
PMV SITE	

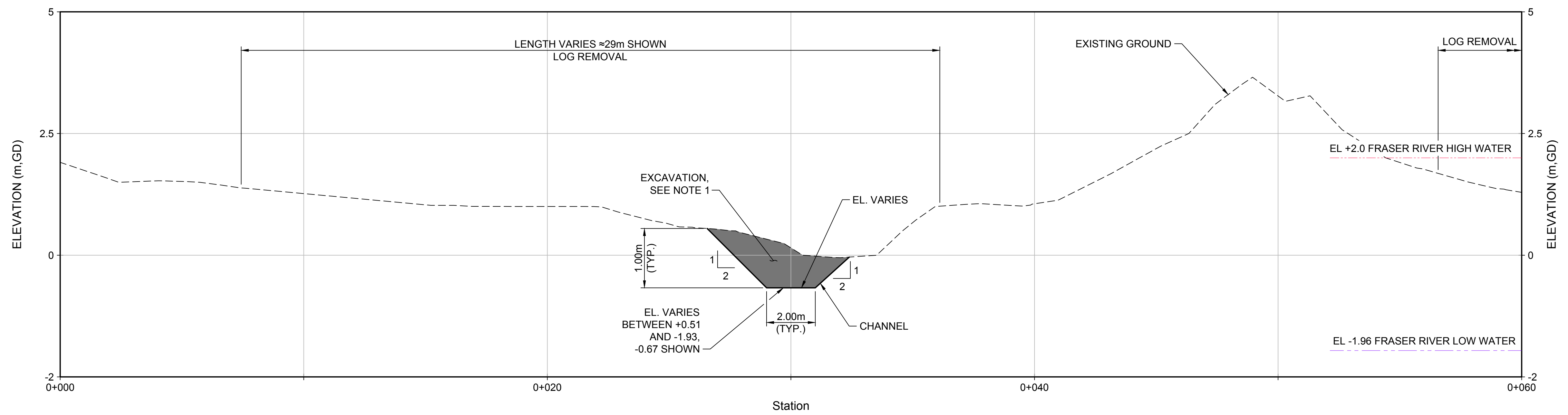
**RBT2 OFFSETTING  
 FINN SLOUGH ENHANCEMENT PROJECT  
 PROPOSED EAST SITE PLAN**

SIZE: D    SHEET: C-102    REV: A

DATE: 2020/12/09 - 11:40am  
 PATH: G:\VAN\9117 - see P drive\CADD\Active\_SheetSet (Mitigation)\FINN\9117-C-301.dwg  
 TITLE BLOCK: DL-TR.dwg



**A** SECTION  
 C-102 SCALE: H= 1:100  
 SCALE: V= 1:50

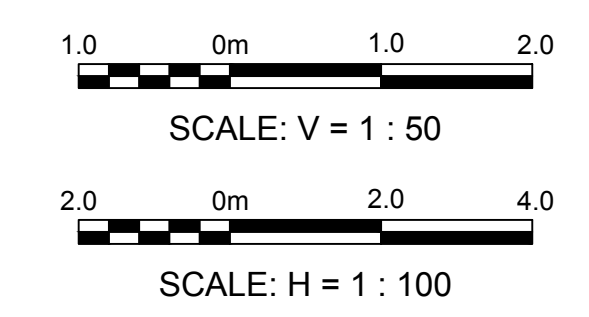


**B** SECTION  
 C-102 SCALE: H= 1:100  
 SCALE: V= 1:50

- LEGEND:**
- EXISTING GROUND
  - HIGH WATER LEVEL
  - LOW WATER LEVEL
  - █ EXCAVATION

**NOTE:**

1. EXCAVATED MATERIAL MUST BE SPRAYED ON THE EXISTING GROUND COVERED BY LOGS AFTER LOG REMOVAL.



**PRELIMINARY**  
DO NOT USE FOR CONSTRUCTION

Ref.No.	REFERENCE

IN ASSOCIATION WITH:

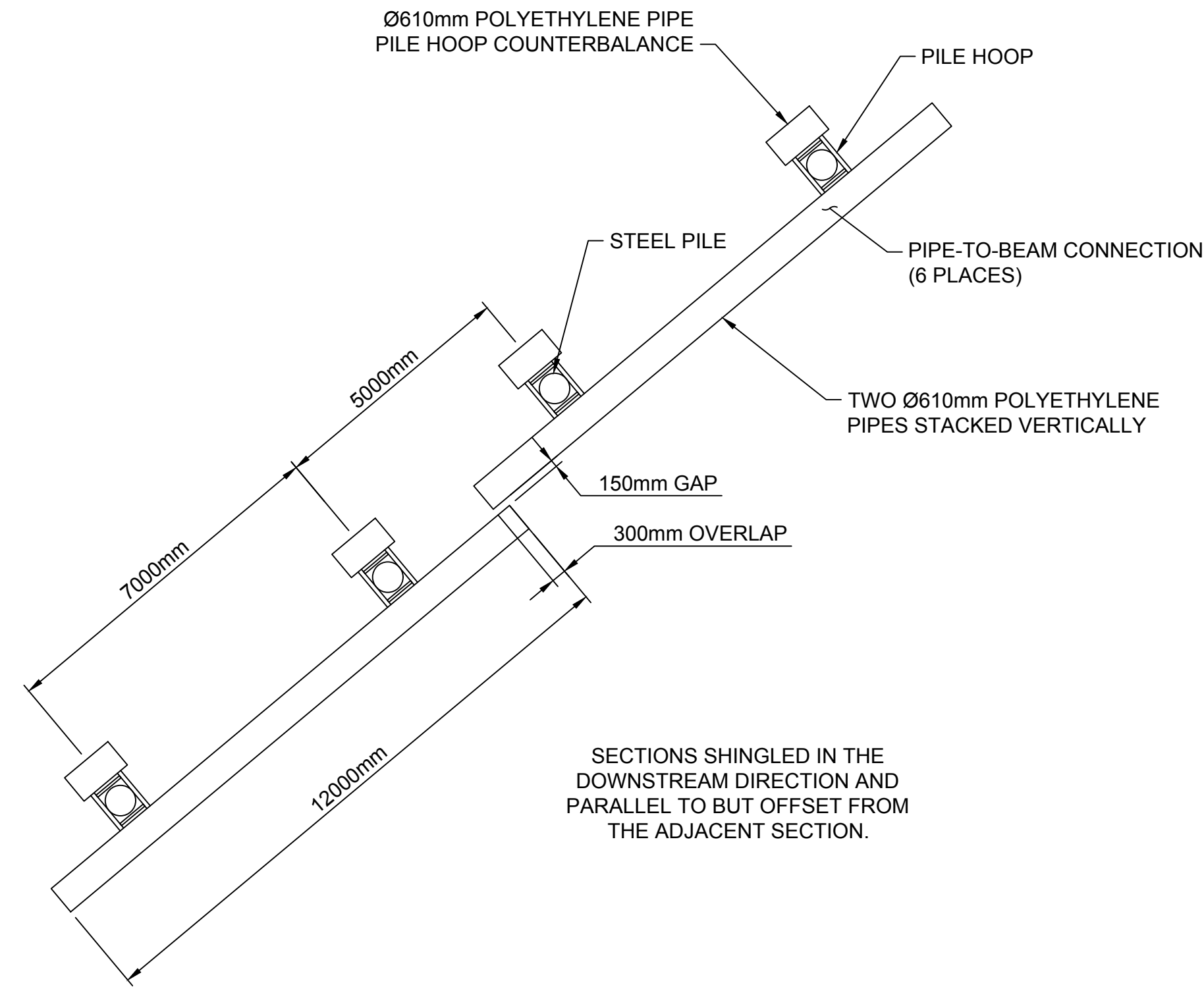
**moffatt & nichol**  
 Shoreline Management Consulting

No.	Date	REVISION	Dr'n	Ch'd
B	11/18/2020	PRELIMINARY DESIGN	RG	YN
A	10/30/2020	CONCEPTUAL DESIGN	RG	YN

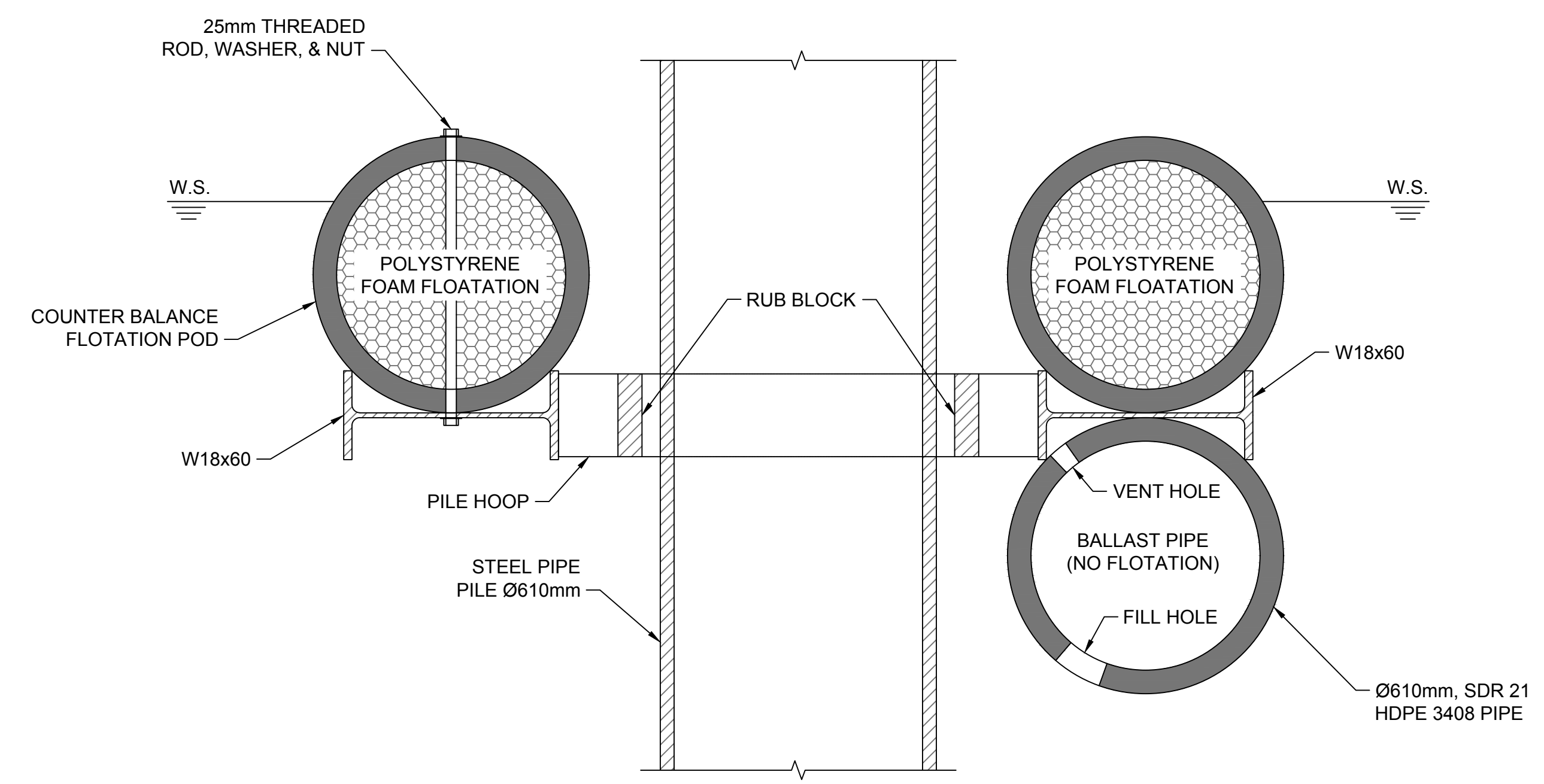
**VANCOUVER FRASER PORT AUTHORITY**  
ENGINEERING DEPARTMENT

DESIGN BY	
DRAWN BY	
APPROVED	
DATE	
SCALE	
PMW SITE	

<b>RBT2 OFFSETTING FINN SLOUGH ENHANCEMENT PROJECT SECTIONS</b>		SIZE	DWG.	<b>C-301</b>	SHEET	REV.
		D				A



**POLY-PIPE BOOM LAYOUT**  
 SCALE: 1:100



**SECTION AT PILE HOOP**  
 SCALE: 1:10

**PRELIMINARY**  
 DO NOT USE FOR CONSTRUCTION



DESIGN BY
DRAWN BY
APPROVED
DATE
SCALE
PMW SITE

**RBT2 OFFSETTING  
 FINN SLOUGH ENHANCEMENT PROJECT  
 POLY-PIPE BOOM DETAILS**

Ref.No.	REFERENCE
---------	-----------

No.	Date	REVISION	Dr'n	Ch'd
B	11/18/2020	PRELIMINARY DESIGN	RG	YN
A	10/30/2020	CONCEPTUAL DESIGN	RG	YN

SIZE	DWG.	C-501	SHEET	REV.
				A

## **Appendix B: Construction Schedule**

ID	Task Name	Duration	Start	Finish	Year 1																																															
					Jan				Feb				Mar				Apr				May				Jun				Jul				Aug				Sep				Oct				Nov				Dec			
					w1	w2	w3	w4	w1	w2	w3	w4	w1	w2	w3	w4	w1	w2	w3	w4	w1	w2	w3	w4	w1	w2	w3	w4	w1	w2	w3	w4	w1	w2	w3	w4	w1	w2	w3	w4	w1	w2	w3	w4	w1	w2	w3	w4	w1	w2	w3	w4
1	<b>Environmental Closures</b>																																																			
	Juvenile Salmon Closure		3/1	8/15																																																
2	<b>General</b>																																																			
	Mobilization	10 days	8/5	8/16																																																
	Construction Access	2 days	8/19	8/20																																																
	Pre-Construction Survey	2 days	8/21	8/22																																																
	Post-Construction Survey	2 days	11/4	11/5																																																
	Demobilization	10 days	11/6	11/9																																																
3	<b>Log Removals</b>																																																			
	Log Removal and Disposal (1,415 sq.m. - land access)	5 days	8/23	8/29																																																
	Log Removal and Disposal (4,145 sq.m. - water access)	14 days	8/23	9/11																																																
4	<b>Slough Extension</b>																																																			
	Excavation	12 days	9/12	9/27																																																
	Spread on Site	12 days	9/12	9/27																																																
5	<b>Shear Boom</b>																																																			
	Shear Boom Installation	50 days	8/23	11/1																																																



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