Appendix IR2020-1.1-A11

T2 Habitat Offsetting Engineering Support – Updated Hydrodynamic Model of Roberts Bank

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MEMORANDUM

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	Mr. Rowland Atkins, Golder Associates
	Mr. Michael Cho and Mr. Harold Westerman, Moffatt & Nichol
From:	**Christopher Devick, Moffatt & Nichol**
Date:	**March 16, 2012**
Subject:	**T2 Habitat Offsetting Engineering Support - Updated Hydrodynamic Model of Roberts Bank**
M&N Job No.:	**7627-22**

This memorandum serves to document the Hydrodynamic (HD) Model used to simulate the potential changes to tidal currents on Roberts Bank related to the proposed eelgrass beds. The project site is located on Roberts Bank approximately 2.2 kilometers offshore of Tsawwassen, British Columbia, Canada. The eelgrass beds are proposed along the east side of the Roberts Bank Causeway as shown in Figure 1, as a part of the T2 Habitat Offsetting Project.

An existing HD model of Roberts Bank was developed for the Vancouver Port Authority, now Port Metro Vancouver, Deltaport Berth 3 project. This model was updated to reflect the proposed changes on Roberts Bank related to the Eelgrass beds. Details regarding the initial development, calibration, and validation of the HD model can be found in the Report for Wind, Wave, and Current Analysis[1].

Model Updates

The HD model was initially reviewed to determine if it accurately represented the existing condition of the project site. Model bathymetry was compared to available Canadian Hydrographic Service (CHS) Chart 3492 Roberts Bank (July 1, 2005). The primary objective was to confirm that that the tidal channel running parallel to the Roberts Bank Causeway was accurately described in the model. This channel plays an important role in the tidal propagation over the mudflats in the vicinity, acting as one of the two primary drainage pathways. Within the resolution of the model, no changes were deemed necessary to the model's existing condition bathymetry.

[1] Moffatt and Nichol. 2005. Report for Wind, Wave, and Current Analysis. Prepared for Vancouver Port Authority August 10, 2005.

For the proposed condition, the HD model was revised based on the Habitat Banking Site 31 Tsawwassen Ferry Causeway 75% submittal plans dated February 17, 2012 and discussions with Cynthia Durance of Precision Identification. The area and bed elevation of the two eelgrass beds are shown graphically in Figure 1 and provided in Table 1. It was decided that the north and south sites would have different final grade elevations due to the donor eel grass available.

Table 1: Eelgrass Bed Area and Final Grade Elevation

Bed Location	Area (m^2)	Final Grade Elevation (m, CD)
North Site	14,550	-1.0
South Site	26,290	-2.25

Simulation Results

Velocities near the proposed eelgrass beds were determined based on a tidal variation between Higher High Water Large Tide and Lower Low Water Large Tide, 4.5m and 0.1m Chart Datum respectively. Table 2 provides the peak and average velocities between proposed and existing conditions. The four points shown in Table 2 represent the velocity along edge of the proposed eelgrass beds within the tidal channel. Two dimensional vector fields of peak currents are shown in Figure 3. The plots show velocity direction and magnitude for post-project conditions. A time series comparing existing and post-project current speeds is provided in Figure 4.

Table 2: Peak and Average Current Velocities for Existing and Proposed Conditions

	Peak Velocity (m/s)					Average Velocity (m/s)				
Case	Overall	1	2	3	4	Overall	1	2	3	4
Existing	0.28	0.33	0.30	0.26	0.23	0.12	0.12	0.12	0.12	0.10
Proposed	0.28	0.33	0.30	0.25	0.26	0.12	0.12	0.13	0.12	0.12

Table 2 shows that peak and average currents are essentially the same for the south site and deviate very slightly for the north site compared to existing conditions. Figure 4 shows that this increase in the vicinity of the north site is fairly consistent at each peak current during the tidal period modeled. The greatest change in peak velocity is approximately 0.04 m/s. This should be expected as the change in the north site creates a larger constriction compared to the south site.

Summary

The existing HD model for Roberts Bank developed for the Deltaport Berth 3 project was modified to describe the proposed eelgrass bed project. These modifications included confirming that the model appropriately described the existing tidal channel which runs parallel to the Roberts Bank Causeway and updating existing bathymetry to reflect the proposed eelgrass beds.

The results show that the construction of the eel grass beds will result in a very slight change in peak and average currents within the channel in the vicinity of the north site and no change for the south site. This is due to the greater constriction which the north site creates with its higher bed elevation. In general the maximum peak current, which is in the vicinity of the south site, remains at approximately 0.33m/s with the proposed project.

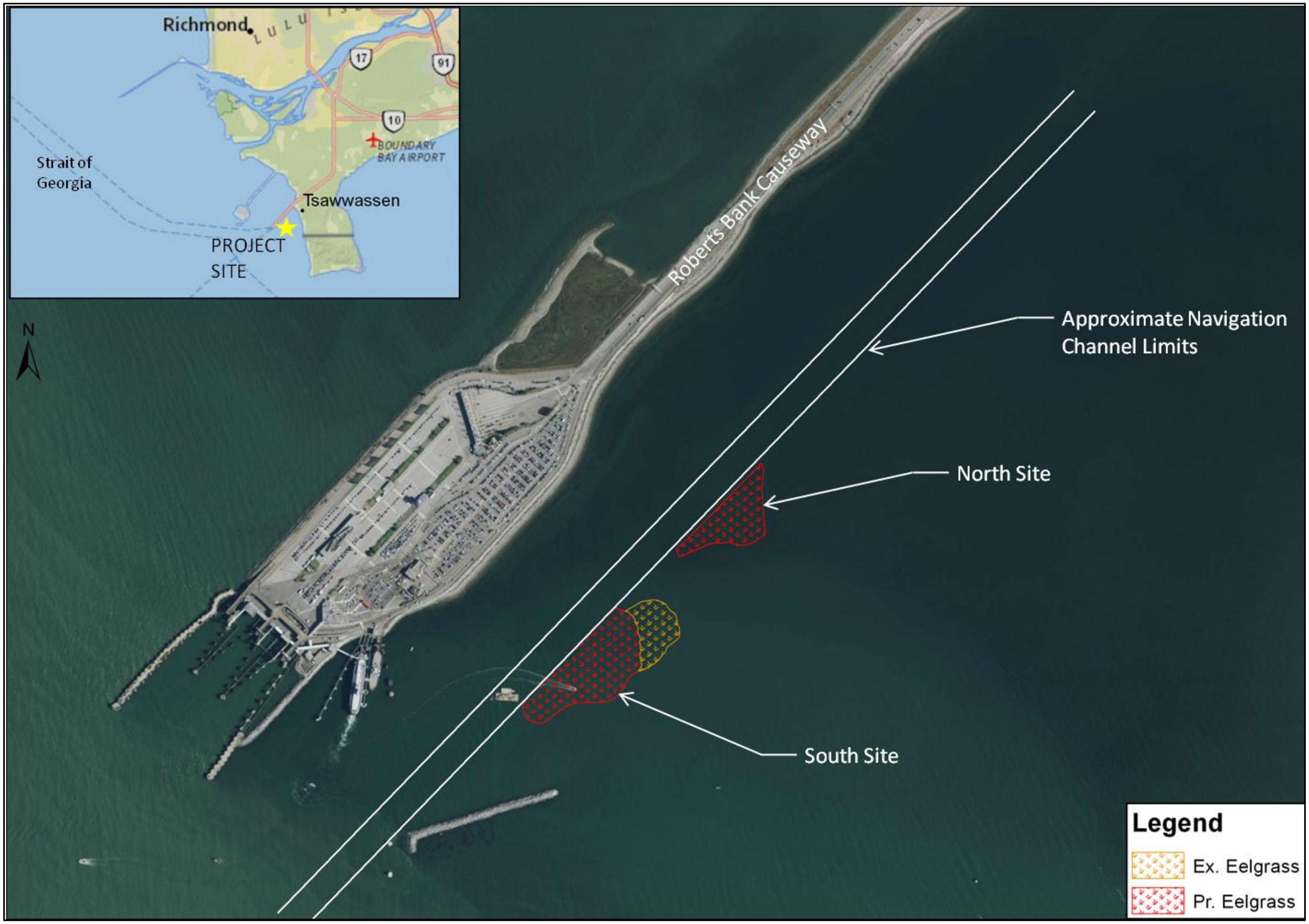

Figure 1: Proposed Eelgrass Bed Layout

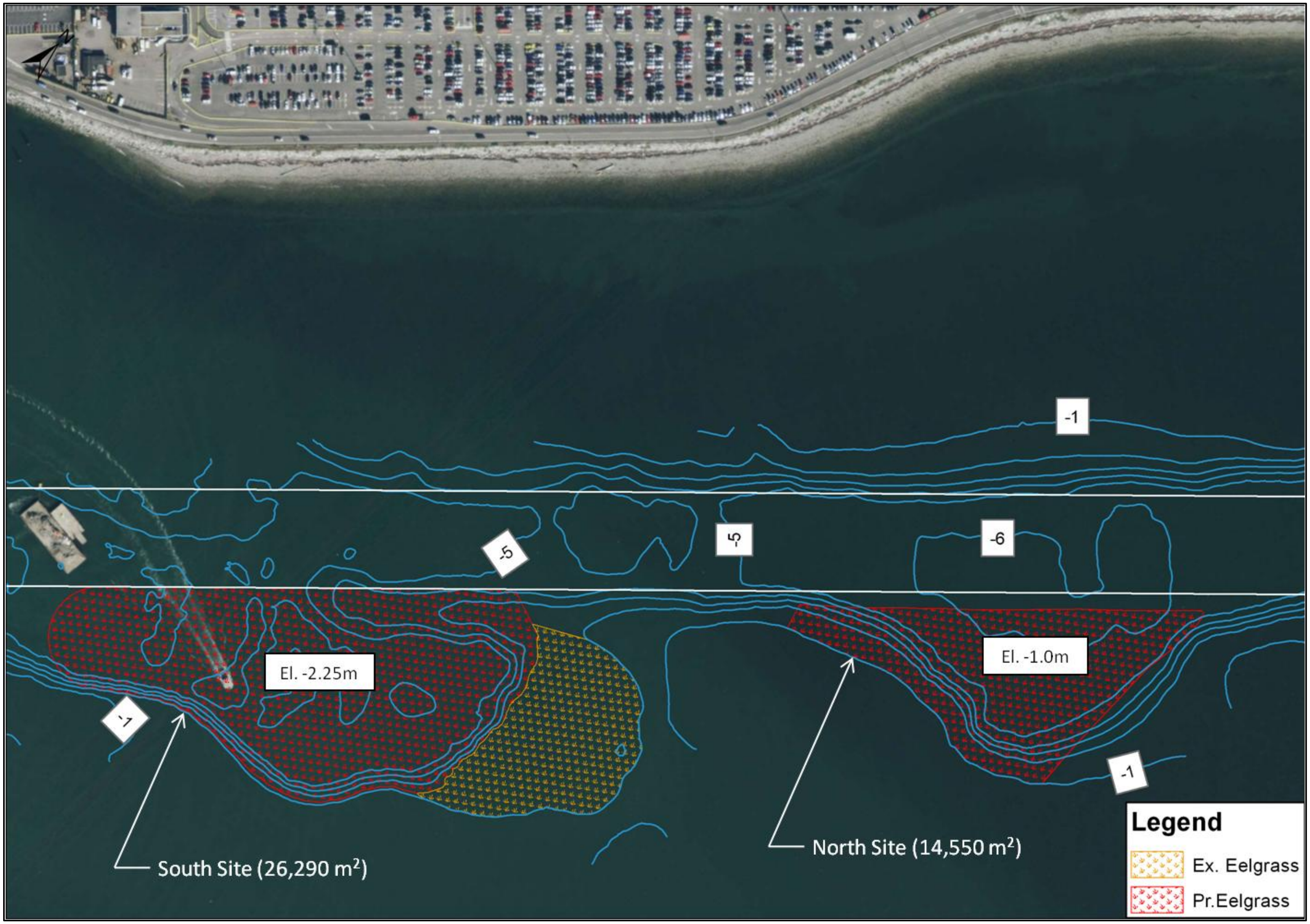

Figure 2: Eelgrass Bed Area and Elevation (Elevations In Chart Datum)

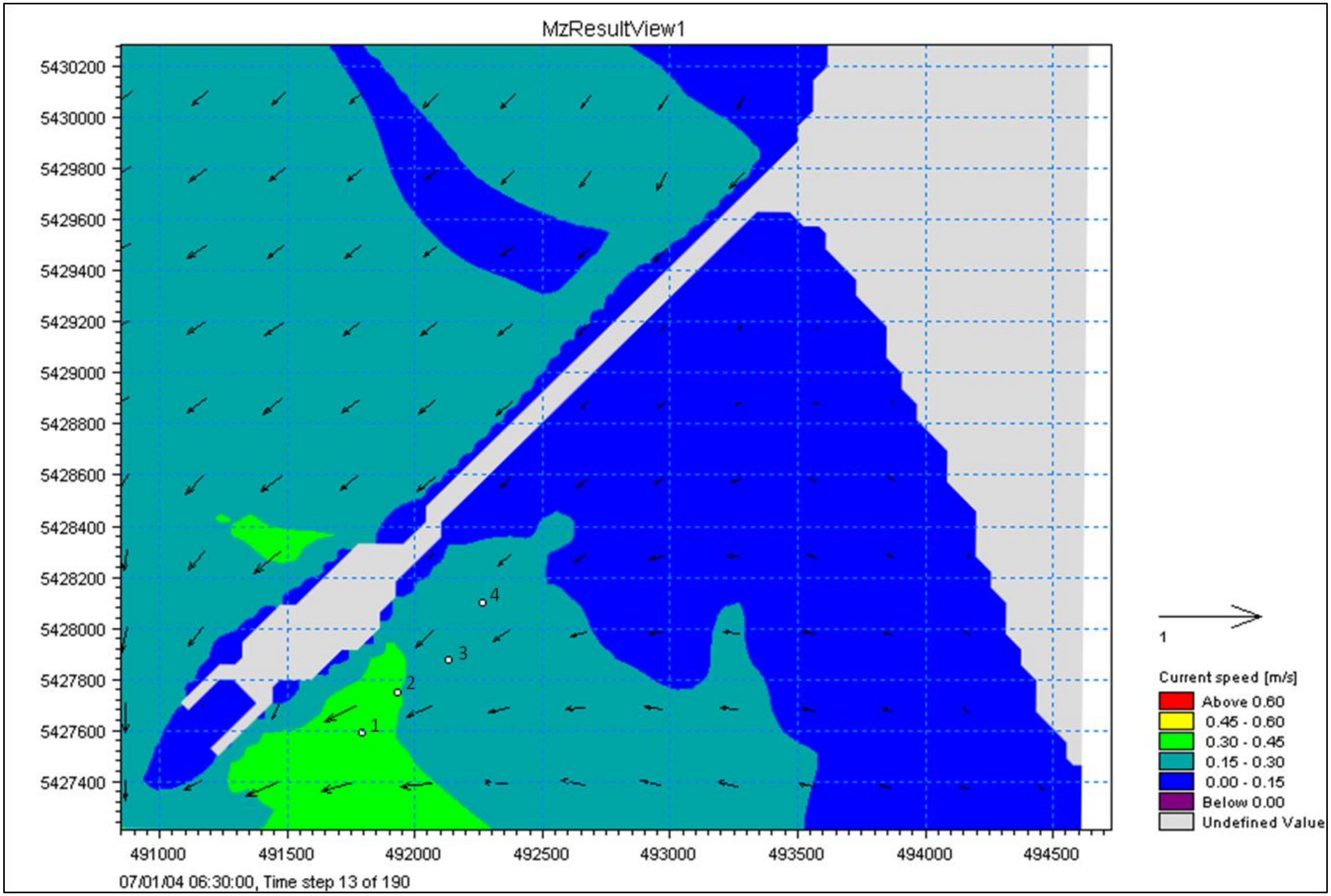

Figure 3: Post-project Peak Current Speeds (m/s)

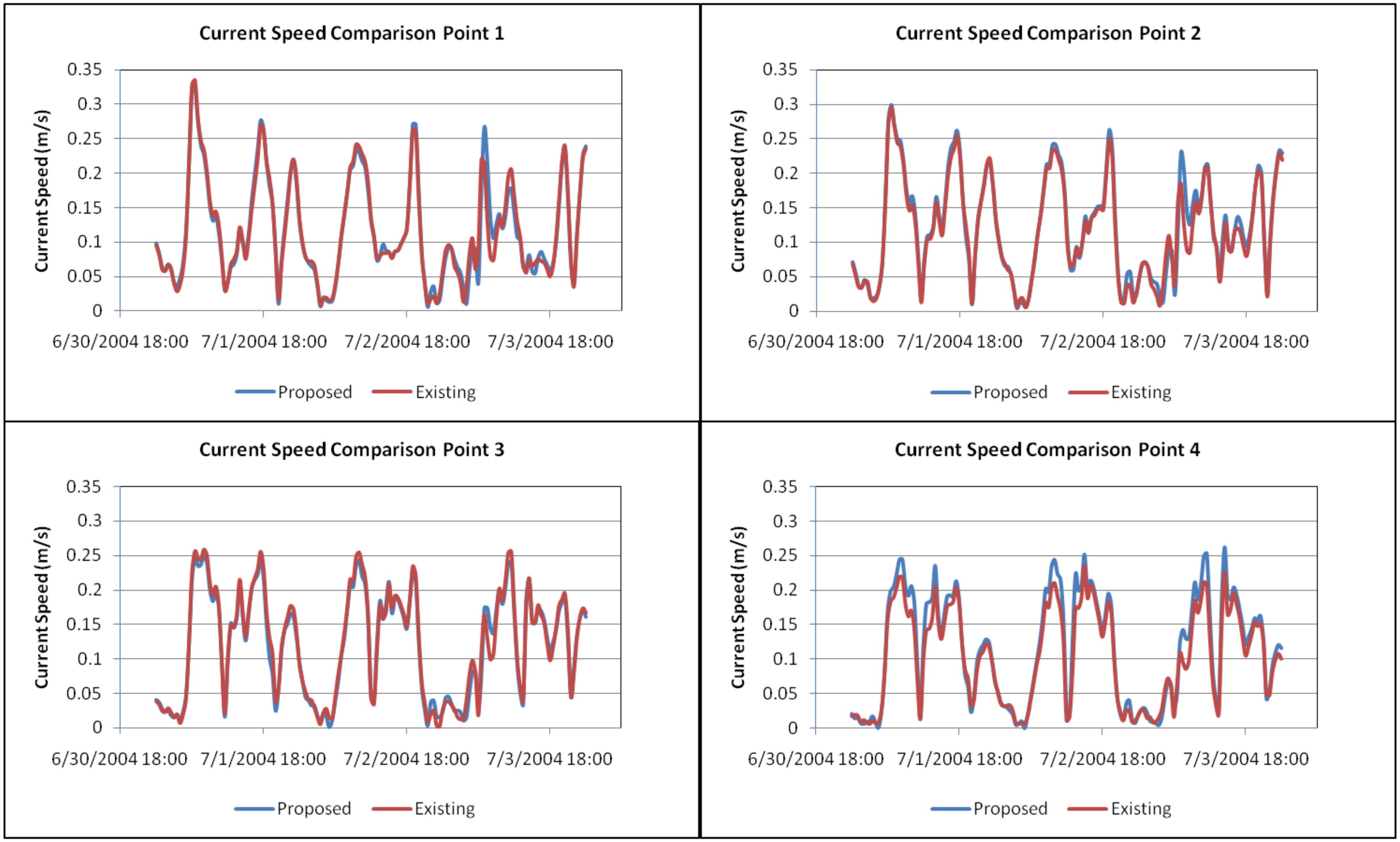

Figure 4: Comparison of Existing and Post-project Current Speeds (m/s)

Appendix IR2020-1.1-A12

Tsawwassen Eelgrass Project Design Report

moffatt & nichol

Tsawwassen Eelgrass Project
Design Report

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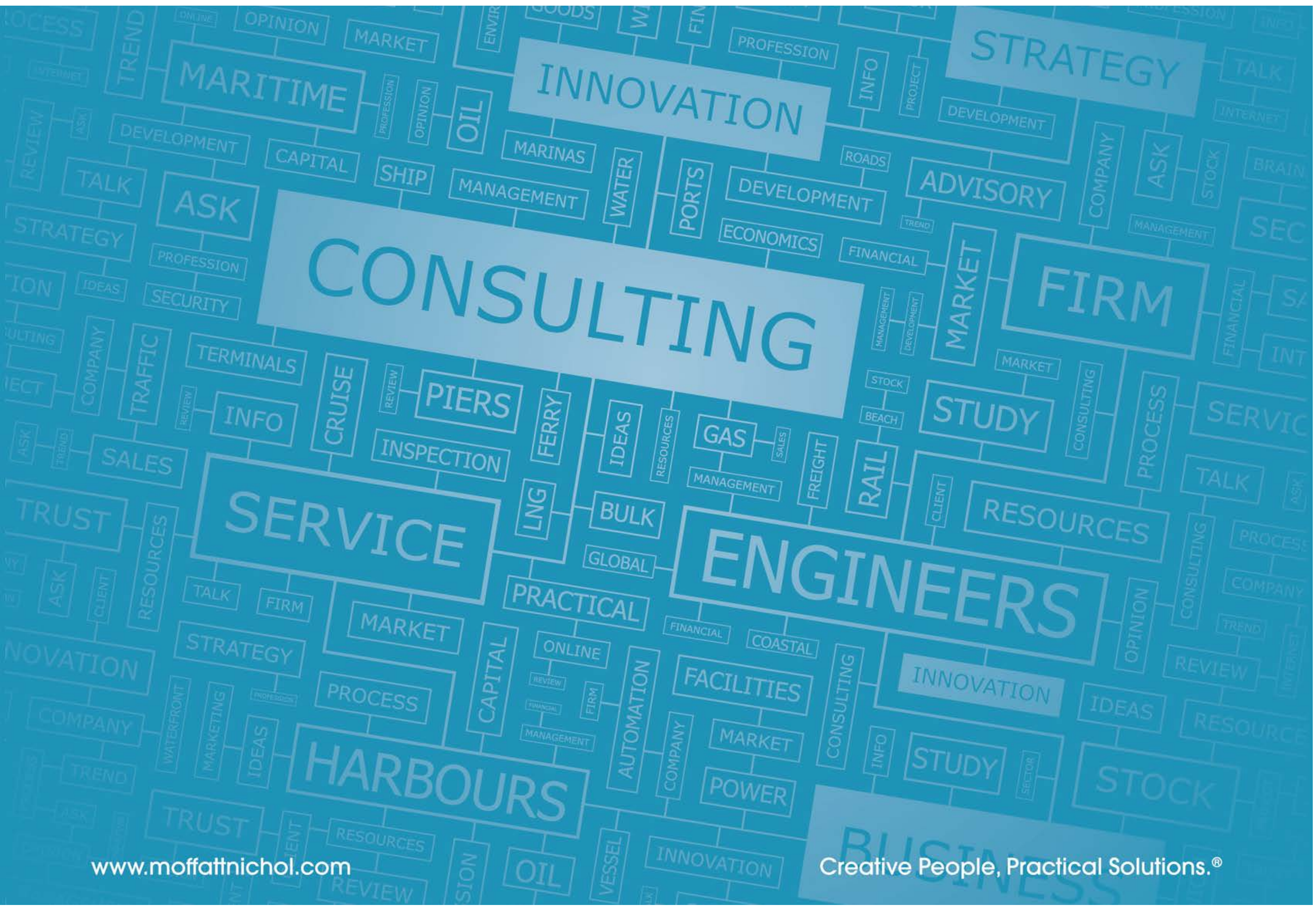
OCTOBER 6, 2020



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1. Introduction

The Vancouver Fraser Port Authority (VFPA) is proposing to provide habitat restoration projects to offset impacts from construction of the Roberts Bank Terminal 2 (RBT2) project. Typical examples of habitat that could be affected by port development include eelgrass beds, saltwater, brackish, freshwater and tidal marshes, and tidal flats. One of the projects under investigation includes the Tsawwassen Eelgrass Project (TEP).

TEP consists of two subtidal sites located south of the Tsawwassen Ferry Terminal near Delta, British Columbia. In general, the Project involves converting lower-value subtidal areas into higher value eelgrass habitat through the construction of rock containment berms followed by placement of sand fill material and transplanting of eelgrass.

This report provides the criteria that have been considered in developing the design for the Project. A discussion of the existing site conditions is provided in Section 2. By characterizing the existing site conditions the design concept was developed.

Subsequently, the criteria used to develop the design of the site are discussed in Section 3. The Project design criteria also include a description of the functional, physical and biological criteria as well as the applied engineering standards.

The construction details and schedule for the Project are discussed in Section 4 including: rock containment berms, sand fill, material quantities, eelgrass transplanting, site access, and construction methodology. Details on construction direct cost are provided in Section 5.

2. Site Description

The Project consists of constructing two eelgrass beds located adjacent to the existing recreational boat channel as the blue linear feature parallel to the BC Ferries causeway in Delta (Figure 2-1). To the south and east of the Project lie surrounding existing eelgrass beds. Near Tsawwassen, eelgrass thrives at elevations close to the low water level, ranging from -2.5 to -1.0 m Chart Datum (CD) requiring adequate light exposure. Previous planting performed in 2008 immediately adjacent to the proposed project has been thriving, serving as assurance that the area will support this habitat.

The two sites comprising the Project currently consist of subtidal depressions within the recreational boating channel located south of the Ferry Causeway. In their present state with elevations primarily in the range of -5.0 m to -6.0 m chart datum (CD), these depressions are too deep to be colonized by eelgrass.

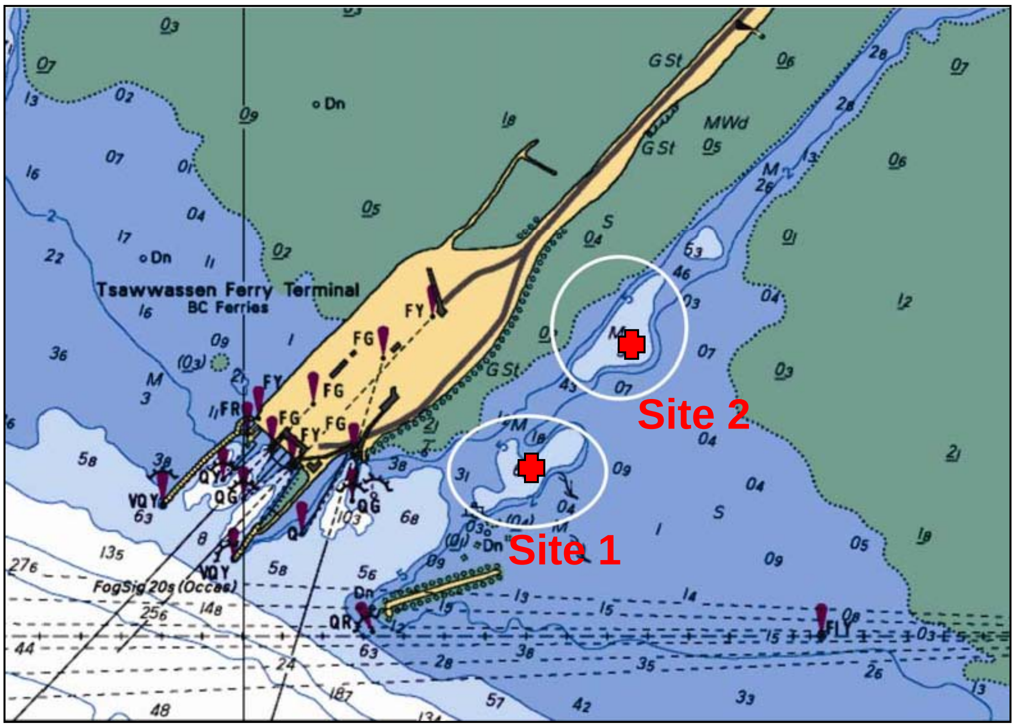

FIGURE 2-1: TSAWWASSEN FERRY CAUSEWAY S. CHANNEL LOCATION (SOURCE: CHS 3492)

The Project involves creation of subtidal eelgrass beds by placing sand fill between constructed containment berms and existing slopes. The containment berms are comprised of quarry run rock and quarry screenings orientated along the north-western slope of the proposed eelgrass beds, adjacent to the existing recreational boat channel. The containment berms will serve to reduce erosion along the outer edge of the eelgrass beds and serve to contain sand fill added into the existing depressions. The eastern edges of the sand fill will be blended to match the elevations of the adjacent existing eelgrass beds.

The recreational boat channel adjacent to the Project is used by local boaters to access the boat ramp that is located approximately mid-way along the Tsawwassen Ferry Causeway. The channel is currently unmarked and the surrounding mudflats are very shallow. An approximately 60 m wide channel is preserved for boating access; the Project infilling occurs outside of the existing channel. Navigation markers have been incorporated as part of this project to delineate the edge of the Project for boater safety and for preservation of the eelgrass beds.

A photo at low tide of the successful 2008 eelgrass development located adjacent to the Project site is shown in Figure 2-2.

FIGURE 2-2: NEARBY EXISTING EELGRASS BEDS AT NORTH EAST END OF TSAWWASSEN CAUSEWAY LOOKING SOUTH WEST

3. Design Criteria

This section describes the criteria that guided the design of the Project. This section includes a description of the functional, physical and biological design criteria as well as the applied engineering standards.

3.1. General Design Criteria

3.1.1. Project Datum and Units

The project horizontal coordinate system is NAD83 UTM Zone 10. The vertical datum is Canadian Hydrographic Service (CHS) Chart Datum (CD). All drawings are presented in SI (metric) units.

3.1.2. Service Life and Return Period

A return period of 25 years for the extreme current event will be used in the design.

3.1.3. Codes, Standards and Design Guidelines

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

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

3.1.4. Functional Requirements

The purpose of the Project is to create vegetated subtidal habitat by partially infilling the existing depressions and transplanting native eelgrass (*Zostera marina*). The vegetated subtidal habitat provides numerous ecological benefits including high quality fish and wildlife habitat that supports a number of ecological functions (i.e. feeding, rearing, spawning, refuge, oxygen production, carbon sequestration, etc.) and increasing the overall habitat productivity and diversity of the site. This project is similar to the previously planted 2008 eelgrass beds at adjacent areas in the channel for the Vancouver Island Transmission Reinforcement Project (VITR) (Jacques Whitford-Axys 2007).

3.2. Site Specific Design Criteria

3.2.1. Physical Design Criteria

3.2.1.1. Property Boundaries

The Tsawwassen water lot bisects a portion of one of the fill areas. For illustrative purposes an alternative layout has been prepared to address this constraint if the site must remain outside of that boundary. Both the original full layout and the alternative layout avoiding the Tsawwassen water lot are shown on Figure 3-1.

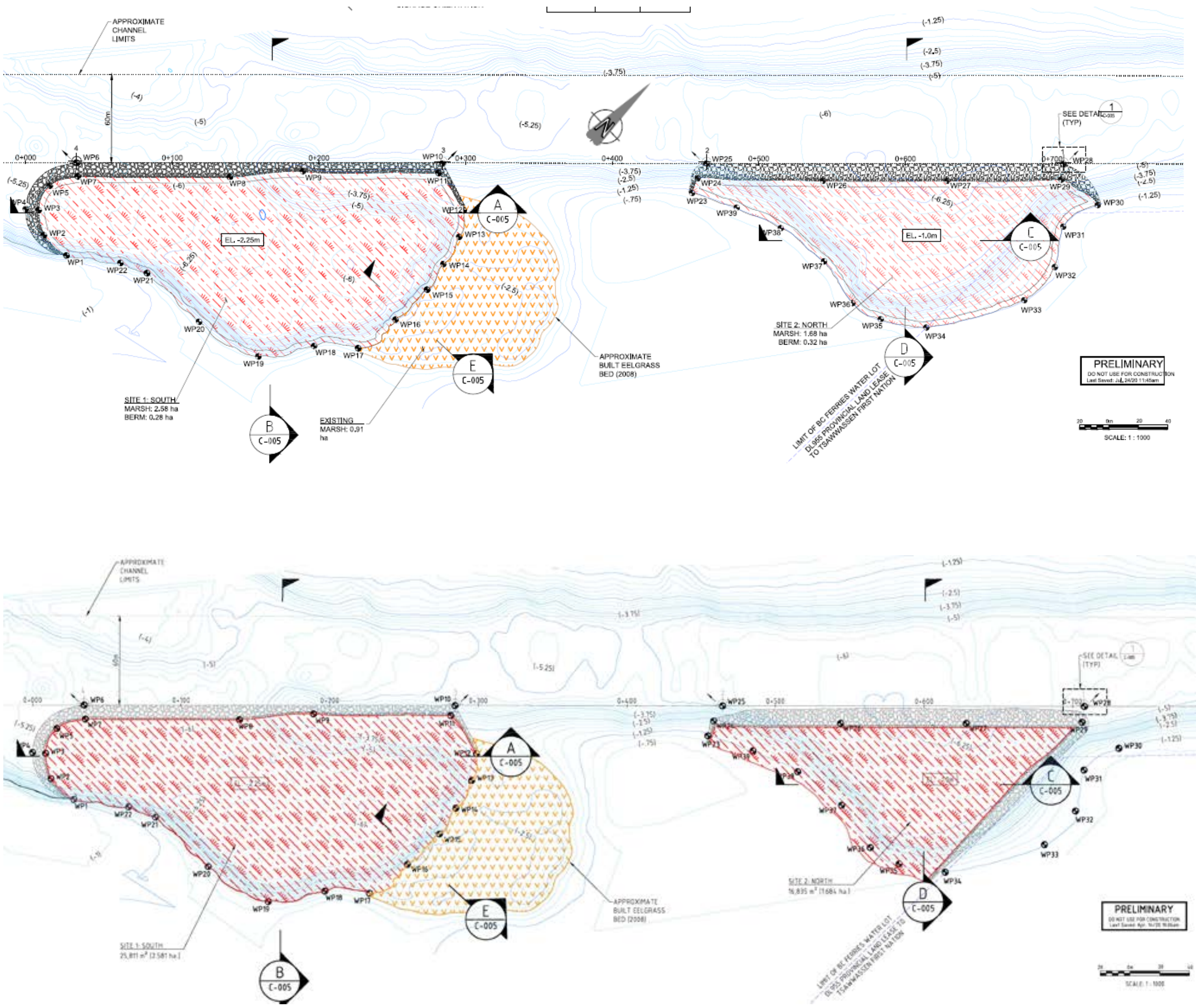

FIGURE 3-1: ORIGINAL LAYOUT (TOP) AND ALTERNATIVE LAYOUT (BOTTOM)

3.2.1.2. Tidal Datums

Tidal datums at the site are similar to those at Tsawwassen (Canadian Hydrographic Service Chart Number 3492) which are listed in Table 3-1.

TABLE 3-1: TSAWWASSEN WATER LEVEL ELEVATIONS

Water Level	Elevation Chart Datum (m)
Higher High Water, Large Tide (HHWLT)	+4.8
Higher High Water, Mean Tide (HHWMT)	+4.1

Water Level	Elevation Chart Datum (m)
Mean Water Level (MWL)	+3.0
Lower Low Water, Mean Tide (LLWMT)	+1.2
Lower Low Water, Large Tide (LLWLT)	+0.1

Source: CHS Chart 3492

3.2.1.3. Waves

For the design of the sub-tidal eelgrass beds at the Tsawwassen site a wave condition analysis is not required as localized currents govern the design. The site is located in a depth limited breaking wave environment which limit the waves height propagation, and therefore, the effects. The boat wake in this area is limited to small craft due to the very shallow and narrow channel condition.

3.2.1.4. Currents

M&N developed a MIKE 21 model of the Tsawwassen and Deltaport region that was used to determine existing peak currents within the Tsawwassen Ferry Causeway south channel (M&N 2012). The simulation was determined using a tidal variation between higher high water and lower low water. The channel acts as a main drainage channel for the surrounding mudflats. During normal tidal exchanges, current velocities within the channel average 0.12 m/s with a peak of 0.33 m/s. Peak currents at the proposed Project locations range from, 0.23 to 0.33 m/s.

A detailed hydrodynamic analysis was undertaken to evaluate the potential change to the tidal hydrodynamics of the inlet resulting from construction of the proposed eelgrass beds (M&N 2012). Table 3-2 provides the peak and average velocities between proposed and existing conditions. The four points shown in the table represent the velocity along the edge of the proposed eelgrass beds within the tidal channel (point 1 is located at the southwestern extent, point 4 at the northeastern extent, see Figure 3-2 for locations).

Analysis shows that the construction of the eelgrass beds will have small (< 0.02 m/s) impact to the tidal currents in the existing channel. Post-project peak current speeds are shown graphically in Figure 3-2.

Further details are provided in M&N’s memorandum Updated Hydrodynamic Model of Roberts Bank, dated March 16, 2012, in Appendix A.

TABLE 3-2: PEAK AND AVERAGE CURRENT VELOCITIES FOR EXISTING AND PROPOSED CONDITIONS

	Peak Velocity (m/s)					Average Velocity (m/s)				
Case	Overall	1	2	3	4	Overall	1	2	3	4
Existing	0.28	0.33	0.30	0.26	0.23	0.12	0.12	0.12	0.12	0.10
Proposed	0.28	0.33	0.30	0.26	0.23	0.12	0.12	0.13	0.12	0.12

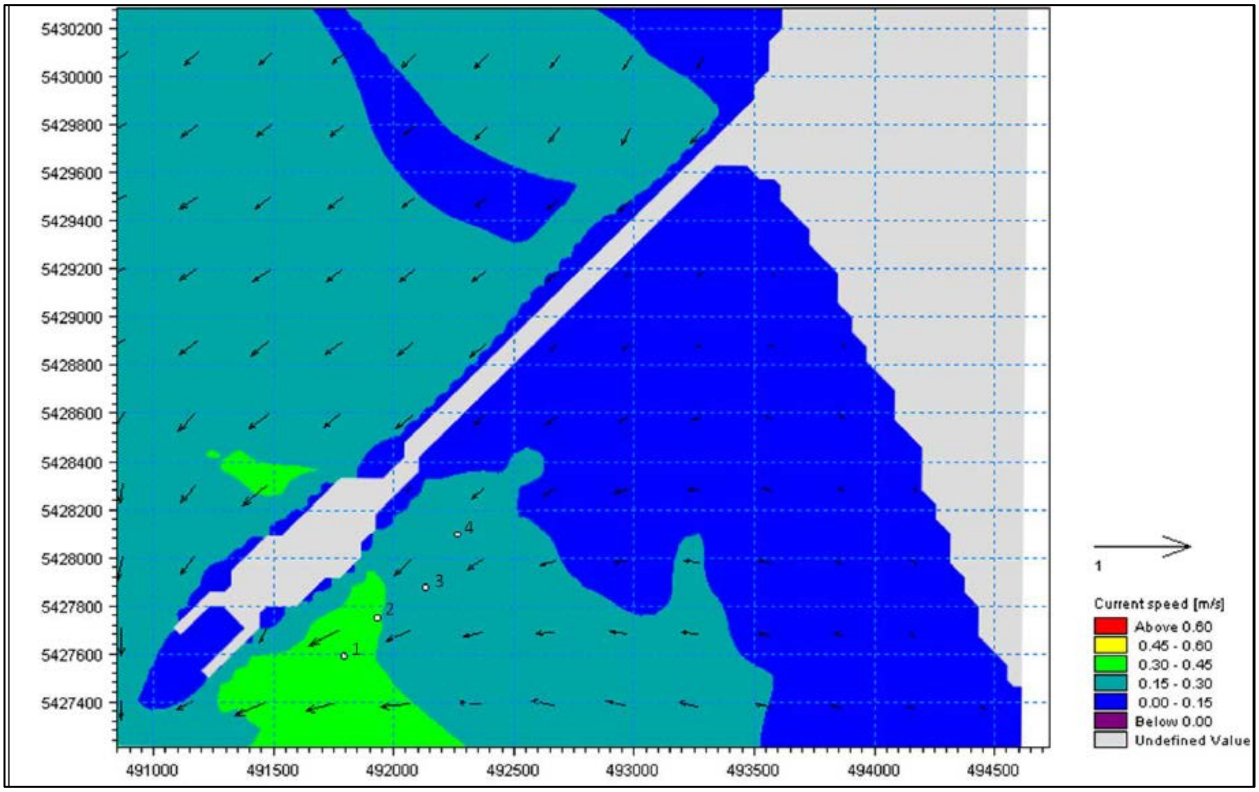

FIGURE 3-2: TSAWWASSEN – POST-PROJECT PEAK CURRENT

3.2.1.5. Geotechnical Conditions

Dive surveys conducted in 2007 adjacent to the current Project site indicate the depressions consists primarily of fine sand and clay, with the occasional cobble and shells (Jacques Whitford-Axys, 2007). It is assumed that these same geotechnical conditions apply to the Project site.

Hemmera Envirochem Inc.'s 2015 ecological conditions report (Hemmera, 2015) included an appended biophysical survey of the Project site by Precision Identification (Precision Identification, 2013). The survey described the south site (site 1) as having sediments ranging from sand to sandy silt. Adjacent to the VITR project the survey found an area of sand with some coarse gravel and pebbles. No Sunken logs were observed. At the north site (site 2) the sediment ranged from sand to sandy silt. No sunken logs were observed.

Appendix B contains a desktop geotechnical assessment completed by Golder Associates Ltd (Golder) in August 2017. The report presents the anticipated geotechnical conditions and preliminary comments on geotechnical considerations for design and construction. The report concludes that the depressions that are to be filled-in have effectively been 'preloaded', therefore placement of fill to similar elevations that previously existed will have only nominal settlement up to 50 mm over the course of six months following the end of construction. A secondary long-term consolidation over the design life of the project is expected to be between 50 and 300 mm with the preloaded behaviour at the lower end of the range. Golder notes that information regarding the history of dredging at the site is anecdotal and detailed information is not available. To offset the anticipated settlement and consolidation, the eelgrass bed elevations have been raised (in comparison with the previous July 14th, 2017 design submission) by 200 mm at both Site 1 and Site 2.

Golder recommends that fill placement should consider placement in stages no thicker than about 1 m to 2 m and should consider commencing fill activities within the deepest areas of project site to allow for most of the settlement to occur during construction. The waiting period will be determined on the basis of construction monitoring activities.

All available geotechnical information has been considered in the development of the material quantities for this project presented in Section 4.1.

3.2.2. Biological Design Criteria

3.2.2.1. Background and Rationale

From the VFPA website[1]:

> The proposed sites were selected for eelgrass restoration because of their current relatively low habitat values. Consistent with the broader understanding of eelgrass habitats in the Pacific Northwest, local studies suggest that fish communities within eelgrass habitats are more diverse and abundant than fish communities within areas devoid of eelgrass.
>
> Eelgrass provides:
>
> - important habitat for fish and wildlife including juvenile salmon, Pacific herring, Dungeness crab, migrating Brant geese, bivalves, shrimp, and sea stars
> - refuge and nurseries for juvenile fish and invertebrates
> - support for a number of other critical ecological functions including nutrient cycling, protection of shorelines from storms, export of organic matter, and carbon storage

The existing ecological conditions for the Project site have been characterized by Hemmera Envirochem Inc. (Hemmera, 2015) and confirm the low habitat values of the existing site.

Also, given the success of the adjacent 2008 eelgrass project, we expect similar parameters such as salinity, light exposure, water quality, etc. would lead to the successful TEP.

3.2.2.2. Eelgrass Bed Elevation

Two depressions have been identified along the channel adjacent to the ferry causeway for creating suitable sites for constructing eelgrass habitat. The depressions would be filled with Fraser River Sand

[1] http://www.portvancouver.com/development-and-permits/development/tsawwassen-eelgrass-project/ accessed Jul 28, 2020

(fine sand with little silt). The south depression would be filled to match the adjacent transplanted eelgrass bed, while the north depression would be filled to match the adjacent donor stock material.

3.2.2.3. Eelgrass Planting

The Project specifications for planting have been written to follow the methods developed by Precision Identification (Durance 2007). In general, the eelgrass plant material will be harvested from adjacent beds and transplanted into the site by a crew of SCUBA divers. Transplanting will be completed at 1.0 m spacing with either six (6) or eight (8) shoots per cluster as specified on the Project Drawings (Appendix C). The planting will be completed between May and September during two consecutive years.

As part of the Project team Cynthia Durance of Precision Identification will be involved with the eelgrass harvesting and transplanting operation as she has completed or directed most of the eelgrass transplanting projects in BC. Ms. Durance designed and supervised the transplant of 2.09 hectares of eelgrass adjacent to the project sites in 2008 for the VITR project.

4. Construction Details[2]

4.1. Construction Features

The containment berms will be comprised of quarry run rock and quarry screenings at the gradations specified on the Project drawings (included in Appendix C). The quarry run will be placed with a slope of 2 horizontal: 1 vertical adjacent to the existing recreational boating channel. The crest of the containment berms will be 1 m wide at elevations shown in the design drawings. The quarry screenings will be placed along the inside slope (sand fill side) of the containment berms.

The purpose of the quarry screenings is to provide a filtering layer between the rock containment berm and the sand fill (e.g. similar to filter fabric used on upland work where hydraulics can influence the movement of material from a filled condition through a more porous structure – like a shoreline revetment). The quarry screenings can work to fulfill the filter requirements – essentially to prevent the sand fill from leaching out through the quarry run.

The total estimated quantity of quarry run and quarry screenings required for the Project are presented in the Project drawings (Appendix C), respectively. The rock quantities have been increased by a factor of 10% to account for shore term settlement & consolidation, gradation of rock material, anticipated placement methods, anticipated out of template losses, and the proximately to the existing boating channel.

M&N reviewed the sediment grain size information contained in the Source Sediment Characterization Report by Hemmera Envirochem Inc. (Hemmera, 2015b). Based on the provided information it is expected that very fine sand will comprise the project sand fill material (samples FR1-1 to FR30-1 Hemmera, 2015b). M&N calculated that the expected settling velocities for this very fine sand to be on the order of 2.5 mm/s, i.e. very slow.

Given the water depths at the two fill sites and the tide range, sediment dropped down through the water column could take up to 30 minutes to settle out. M&N have assumed that sediment that has fallen below the crest elevation of the final fill as "settled" since it will have a limited possibility of escaping the placement area (bowl) once below the rim.

However, considering the tidal flow velocities in the area of 0.12 m/s on average, and up to 0.33 m/s there is a risk of sediment to disperse outside of the fill areas. It's therefore highly important that the contractor discharge the material as close to the bottom as practical, and e.g. use a diffuser mouthpiece to minimize turbulent dispersal. (Based on information provided by FRPD, we have assumed this methodology will be followed). Giving consideration to these factors, M&N has included a 10% increase factor above in-place neat line volume of fill needed for the subtidal eelgrass beds to account for losses during placement.

[2] Based on the original full layout

In addition, to minimize losses the contractor should:

- avoid dumping the fill material from above water or at the water line, and around high tide as this will increase the potential for substantial drift of sediment plumes;
- avoid placement during times of high wave action in the area as this will work to agitate sediment and keep the material in suspension for longer;
- alternatively, deploy turbidity measures (e.g. silt curtain around the perimeter of the fill areas) in order to contain as much as practical the sediment during placement.

In addition, M&N have considered the project requirement that measurement for sand fill will be calculated from the measured load in the contractor's hopper barge. To account for the water content of the load M&N has recommended that the hopper measurement volume should include an increase of 20% above the final, in-place neat line volume of fill needed for the subtidal eelgrass beds. The Fraser River sand fill material is expected to be transported directly from the annual maintenance dredging and will be mostly made up of sands (not finer silts and clays) and since the final placement of the material is subtidal it is expected that the water content should not be a significant factor (i.e. require an increase of greater than 20%).

The total estimated quantity of final includes an increase by a factor of 10% above neat line values to account for losses during placement plus an increase of 20% above neat line values to account for measurement in the hopper. Losses due to settlement and consolidation have been addressed through raising the design elevation. The estimated material quantities for the Tsawwassen Eelgrass Project are shown on the Project drawings. The total proposed habitat area are detailed in Table 4-1 below. The total eelgrass area presented includes TFN water lot area.

TABLE 4-1: TOTAL HABITAT AREA

EEELGRASS AREA	ROCK BERM AREA	TOTAL AREA
4.3 ha	0.6 ha	4.9 ha

4.2. Site Access

Site access (marine based equipment) is generally from the existing boating channel. It can be heavily used by recreational boaters to access the boat ramp on the ferry causeway. The contractor shall provide adequate marine traffic signage, markers, and other means to adequately separate and secure the site from the recreational boat traffic. The contractor will be instructed to not stockpile material within the existing boating channel or perform work that causes interference with the boating traffic within the existing boating channel.

4.3. Construction Methodology

Sand fill are required to construct the eelgrass beds, with the deepest locations requiring up to 6 m of fill. It is envisioned that the containment berm will be constructed first to reduce turbidity and contain the sand during placement.

It is understood based on discussions between VFPA and a local marine contractor that the Project will most likely be constructed by hydraulically placing the sand fill using a cutter suction dredge acting as a diffuser (Figure 4-1). The cutter suction dredge would be connected via pipeline to a hopper barge (Figure 4-2). The use of the cutter suction dredge as a diffuser will reduce the velocity of the sand particles exiting the pipeline which will serve to reduce turbidity. In addition, the use of the diffuser will allow for improved placement accuracy and control for the required sand fill lifts. To achieve final design grades the contractor may, however, be required to execute underwater grading of the sand fill to meet project tolerances. This could be achieved using an underwater grading beam pulled by a self-propelled barge, for example. This methodology has been implemented at both the Port of Portland and the Port of Seattle.

Two options exist for where to moor the hopper barge. The hopper barge could moor north of the Tsawwassen ferry terminal due to the space restrictions around the Project site. The pipeline would be placed on the seafloor and run a distance up to approximately 600 m before surfacing at the diffuser. This option would require coordination with BC Ferries as the pipeline would run underneath the ferry vessels leaving the Tsawwassen ferry terminal. The second option includes stationing the hopper barge south of the Tsawwassen ferry terminal at or below the US border along the 10 m contour. Discussions between BC Ferries and the contractor will also be required for this option to determine any required offset that is required from the ferry terminal.

Additional equipment at the Project site during earthworks construction is expected to include a spud barge with a crane and one to two material scows for construction of the containment berms. During eelgrass transplanting, a single materials barge is expected to serve as a working platform with the support of numerous smaller workboats.

The general area south of the Tsawwassen Ferry Causeway is exposed to high south-easterly winds and severe waves. Construction, and subsequent eelgrass transplanting, is therefore best suited to avoid the typical late fall and early winter storms (November and December) although high wind events, which slow down marine construction, can occur any time of the year. The contractor will also need to work around the tide cycle as the surrounding mudflats and access channel are relatively shallow.

As detailed in the project specifications, the contractor must execute all onsite activities ensuring minimal impact on the existing sensitive eelgrass beds. Under no circumstance will barges or other vessels be allowed to ground on the existing eelgrass beds or otherwise disturb the existing eelgrass beds (disturbance as a result of propeller wash), except within the footprint of the sand fill with the use of spuds. The contractor will be required to abide by all applicable environmental requirements, laws and regulations. All onsite activities will be coordinated with the Authority's Representative to ensure minimal impact on the existing sensitive shoreline environment.

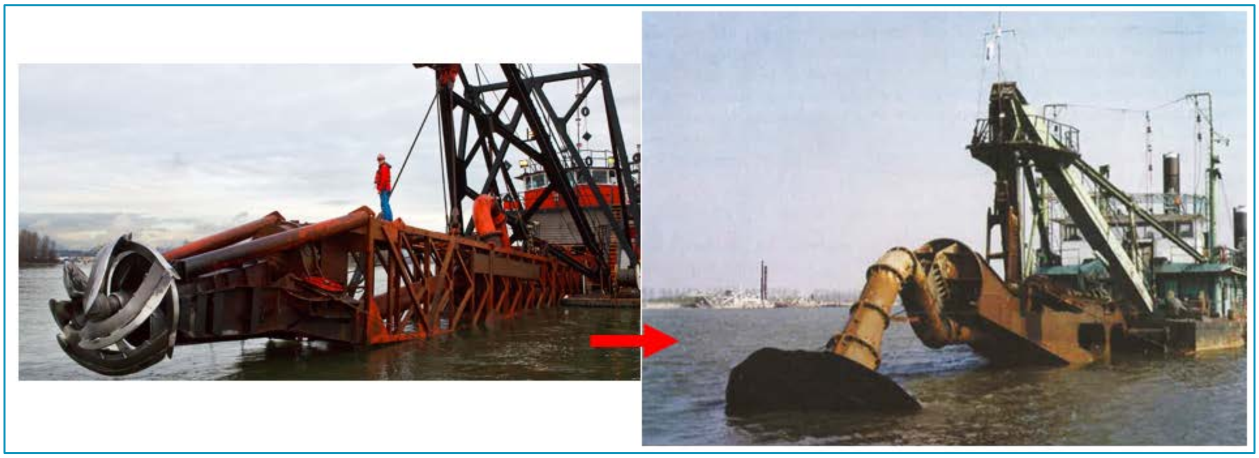

FIGURE 4-1: FRPD COLUMBIA CUTTER SUCTION DREDGE (LEFT) AND PROPOSED DIFFUSER MODIFICATION (SOURCE: FRPD)

FIGURE 4-2: FRPD 309 TRAILING SUCTION HOPPER DREDGE (SOURCE: FRPD)

4.4. Construction Schedule

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

Fisheries Closures:

- Juvenile Salmon-applies to water column above elevation -5m (March 1 through August 15)
- Crab-applies to seabed below -5.0m (October 15 through March 30) (Not applicable to this project)

Marine Mammals:

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

Source/Equipment

- Fraser River Maintenance dredging operates from June 15 through February 28. Actual dates depend on freshet conditions and degree of shoaling in critical areas.
- The rates of offloading will consider the FRPD dredge 309 if the material is supplied through the Fraser River maintenance.
- Rock and some fill materials are assumed to be delivered by barge and spread on-site using land based equipment mobilized via barge/crane.

Production Rates

- Working hours M-F, 6am-5pm
- Dredge pumpout 2500 m^3/day. (Light loaded to allow closer approach to shore).
- Rock placement 400 m^3/day
- Planting (Not covered in this document).

Based on these assumptions the schedule indicates a construction period of approximately seven (7) months, excluding planting. See Appendix D for schedule layout.

5. Construction Direct Cost[3]

5.1. Cost Considerations

The cost estimate includes supply and installation of the containment berm; eelgrass bench (sand), environmental protection measures and mobilization/demobilization. An allowance is included for possible environmental protections measures that may be required by the approving agencies, such as, preparing an environmental protection plan, installing and maintaining turbidity booms. Direct costs are based on anticipated equipment, labor and materials. The cost estimate excludes marsh planting; indirect costs for the owner's project management, construction administration and third-party consulting fees; and all applicable taxes.

- The costs are limited to the civil construction elements such as rock, mobilization, buoys, etc.
- Planting costs (sourcing and installation) are excluded from these estimates.
- The overall 2020 RBT2 CDC opinion of probable cost unit rates were used where applicable. Where the RBT2 CDC unit prices were not available, previous estimates were escalated to 2020.
- Contingency varies by status of design. The project carries a 20% contingency.

For further background on 2020 CDC RBT2 cost estimate methods, limitations and uncertainties refer to Moffatt & Nichol Memorandum RBT2 CDC Summary and Cost Drivers Memo, Rev.A – DRAFT. dated February 28, 2020.

5.2. Limitations

In providing opinions of estimate, it is recognized that the OE has no control over the costs of labour, equipment or materials, over the Contractor's methods of determining prices, or of the bidding climate. Opinions of estimate prepared by the OE are based on reasonable professional judgement and experience and do not constitute a warranty, expressed or implied, that the Contractor's bids or the negotiated price of the Work, or the actual cost of the Work, will not vary from the Client's budget or from any opinion of estimate prepared by the OE.

TABLE 5-1: CONSTRUCTION DIRECT COST

Note – This section is removed.

[3] Based on the original full layout which includes TFN water lot

References

BIEAP-FREMP, 2006. Environmental Management Strategy for Dredging in the Fraser River Estuary. Burrard Inlet Environmental Action Program (BIEAP) and Fraser River Estuary Management Program (FREMP).

BC Ministry of Environment (BC MOE), Lower Mainland Region Dyke Mapping. 2007.

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CHS (Canadian Hydrographic Services), 2005. Charts #3492

Durance, C. 2007 (Abstract). Eelgrass restoration and compensation in British Columbia, Session 7C Eelgrass Restoration in Salish Sea, 2007 Georgia Basin Puget Sound Research Conference, March 26-29, 2007, Vancouver, BC.

Hemmera Environchem Inc. 2015. Existing Ecological Conditions Proposed Tsawwassen Eelgrass Enhancement Project

Hemmera Environchem Inc. 2015b. Tsawwassen Eelgrass Enhancement Project Source Sediment Characterization

Jacques Whitford-Axys. 2007. Vancouver Island Transmission Reinforcement Project; Application for Navigable Waters Act Authorization for Habitat Compensation Works on Roberts Bank, Tsawwassen, BC.

Jacques Whitford-Axys. 2007. Vancouver Island Transmission Reinforcement Project; Fish Habitat Compensation Plan, Tsawwassen, BC.

Moffatt & Nichol. 2012. Memorandum on Updated Hydrodynamic Model of Roberts Bank, prepared for Hemmera Environchem Inc. Reference Job No. 7627-22. Dated March 16, 2012.

Precision Identification. 2013. Assessment of Potential Eelgrass Transplant Sites, prepared for Port Metro Vancouver. Tsawwassen, Delta. April 2013.

Appendix A:
M&N Hydrodynamic Model Memorandum

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MEMORANDUM

To:	**Mr. Benjamin Wheeler, Hemmera**
Cc.	**Ms. Eriko Arai, Hemmera**
	Mr. Gary Williams, GL Williams and Associates
	Mr. Rowland Atkins, Golder Associates
	Mr. Michael Cho and Mr. Harold Westerman, Moffatt & Nichol
From:	**Christopher Devick, Moffatt & Nichol**
Date:	**March 16, 2012**
Subject:	**T2 Habitat Offsetting Engineering Support - Updated Hydrodynamic Model of Roberts Bank**
M&N Job No.:	**7627-22**

This memorandum serves to document the Hydrodynamic (HD) Model used to simulate the potential changes to tidal currents on Roberts Bank related to the proposed eelgrass beds. The project site is located on Roberts Bank approximately 2.2 kilometers offshore of Tsawwassen, British Columbia, Canada. The eelgrass beds are proposed along the east side of the Roberts Bank Causeway as shown in Figure 1, as a part of the T2 Habitat Offsetting Project.

An existing HD model of Roberts Bank was developed for the Vancouver Port Authority, now Port Metro Vancouver, Deltaport Berth 3 project. This model was updated to reflect the proposed changes on Roberts Bank related to the Eelgrass beds. Details regarding the initial development, calibration, and validation of the HD model can be found in the Report for Wind, Wave, and Current Analysis[1].

Model Updates

The HD model was initially reviewed to determine if it accurately represented the existing condition of the project site. Model bathymetry was compared to available Canadian Hydrographic Service (CHS) Chart 3492 Roberts Bank (July 1, 2005). The primary objective was to confirm that that the tidal channel running parallel to the Roberts Bank Causeway was accurately described in the model. This channel plays an important role in the tidal propagation over the mudflats in the vicinity, acting as one of the two primary drainage pathways. Within the resolution of the model, no changes were deemed necessary to the model's existing condition bathymetry.

[1] Moffatt and Nichol. 2005. Report for Wind, Wave, and Current Analysis. Prepared for Vancouver Port Authority August 10, 2005.

For the proposed condition, the HD model was revised based on the Habitat Banking Site 31 Tsawwassen Ferry Causeway 75% submittal plans dated February 17, 2012 and discussions with Cynthia Durance of Precision Identification. The area and bed elevation of the two eelgrass beds are shown graphically in Figure 1 and provided in Table 1. It was decided that the north and south sites would have different final grade elevations due to the donor eel grass available.

Table 1: Eelgrass Bed Area and Final Grade Elevation

Bed Location	Area (m^2)	Final Grade Elevation (m, CD)
North Site	14,550	-1.0
South Site	26,290	-2.25

Simulation Results

Velocities near the proposed eelgrass beds were determined based on a tidal variation between Higher High Water Large Tide and Lower Low Water Large Tide, 4.5m and 0.1m Chart Datum respectively. Table 2 provides the peak and average velocities between proposed and existing conditions. The four points shown in Table 2 represent the velocity along edge of the proposed eelgrass beds within the tidal channel. Two dimensional vector fields of peak currents are shown in Figure 3. The plots show velocity direction and magnitude for post-project conditions. A time series comparing existing and post-project current speeds is provided in Figure 4.

Table 2: Peak and Average Current Velocities for Existing and Proposed Conditions

	Peak Velocity (m/s)					Average Velocity (m/s)				
Case	Overall	1	2	3	4	Overall	1	2	3	4
Existing	0.28	0.33	0.30	0.26	0.23	0.12	0.12	0.12	0.12	0.10
Proposed	0.28	0.33	0.30	0.25	0.26	0.12	0.12	0.13	0.12	0.12

Table 2 shows that peak and average currents are essentially the same for the south site and deviate very slightly for the north site compared to existing conditions. Figure 4 shows that this increase in the vicinity of the north site is fairly consistent at each peak current during the tidal period modeled. The greatest change in peak velocity is approximately 0.04 m/s. This should be expected as the change in the north site creates a larger constriction compared to the south site.

Summary

The existing HD model for Roberts Bank developed for the Deltaport Berth 3 project was modified to describe the proposed eelgrass bed project. These modifications included confirming that the model appropriately described the existing tidal channel which runs parallel to the Roberts Bank Causeway and updating existing bathymetry to reflect the proposed eelgrass beds.

The results show that the construction of the eel grass beds will result in a very slight change in peak and average currents within the channel in the vicinity of the north site and no change for the south site. This is due to the greater constriction which the north site creates with its higher bed elevation. In general the maximum peak current, which is in the vicinity of the south site, remains at approximately 0.33m/s with the proposed project.

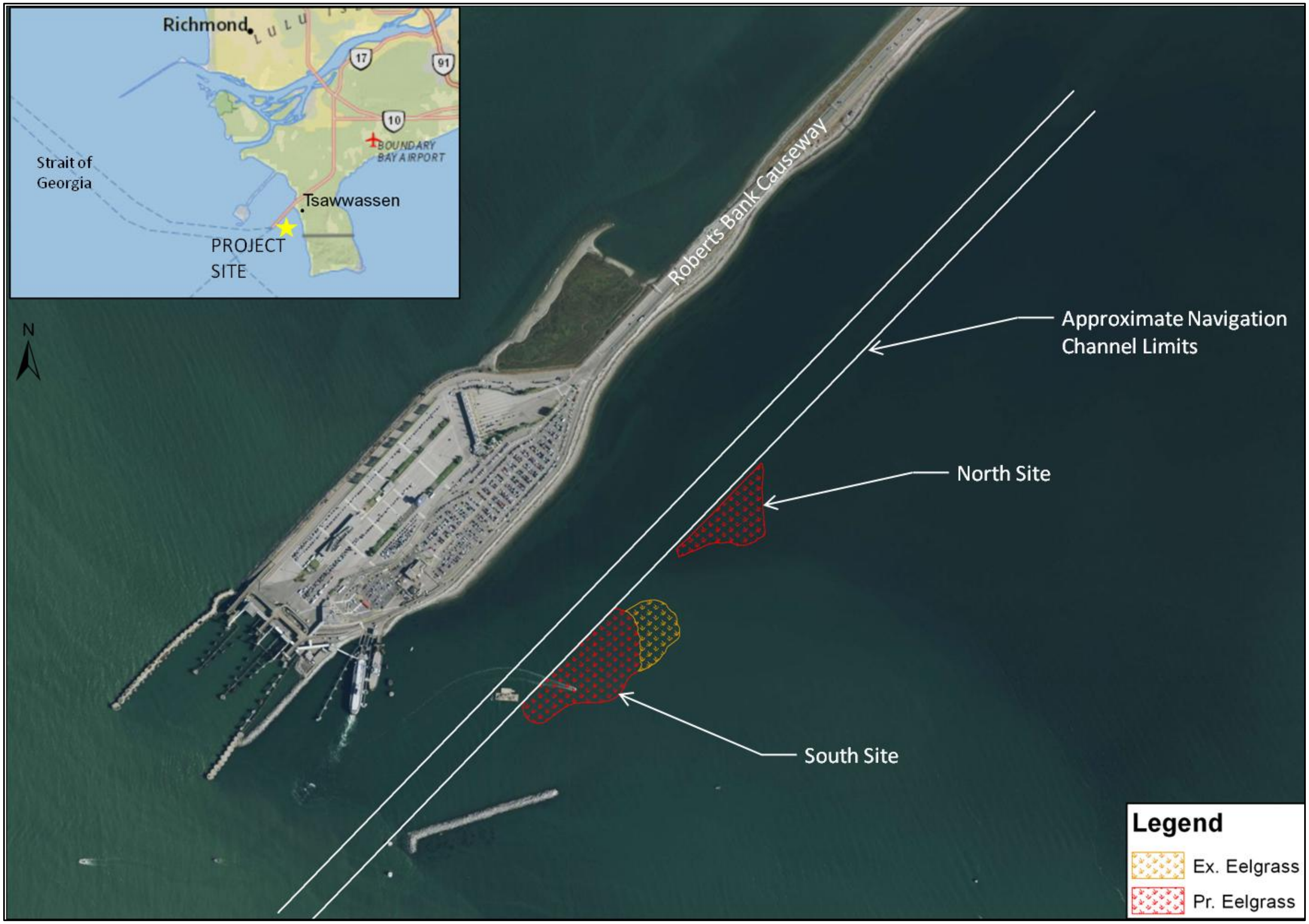

Figure 1: Proposed Eelgrass Bed Layout

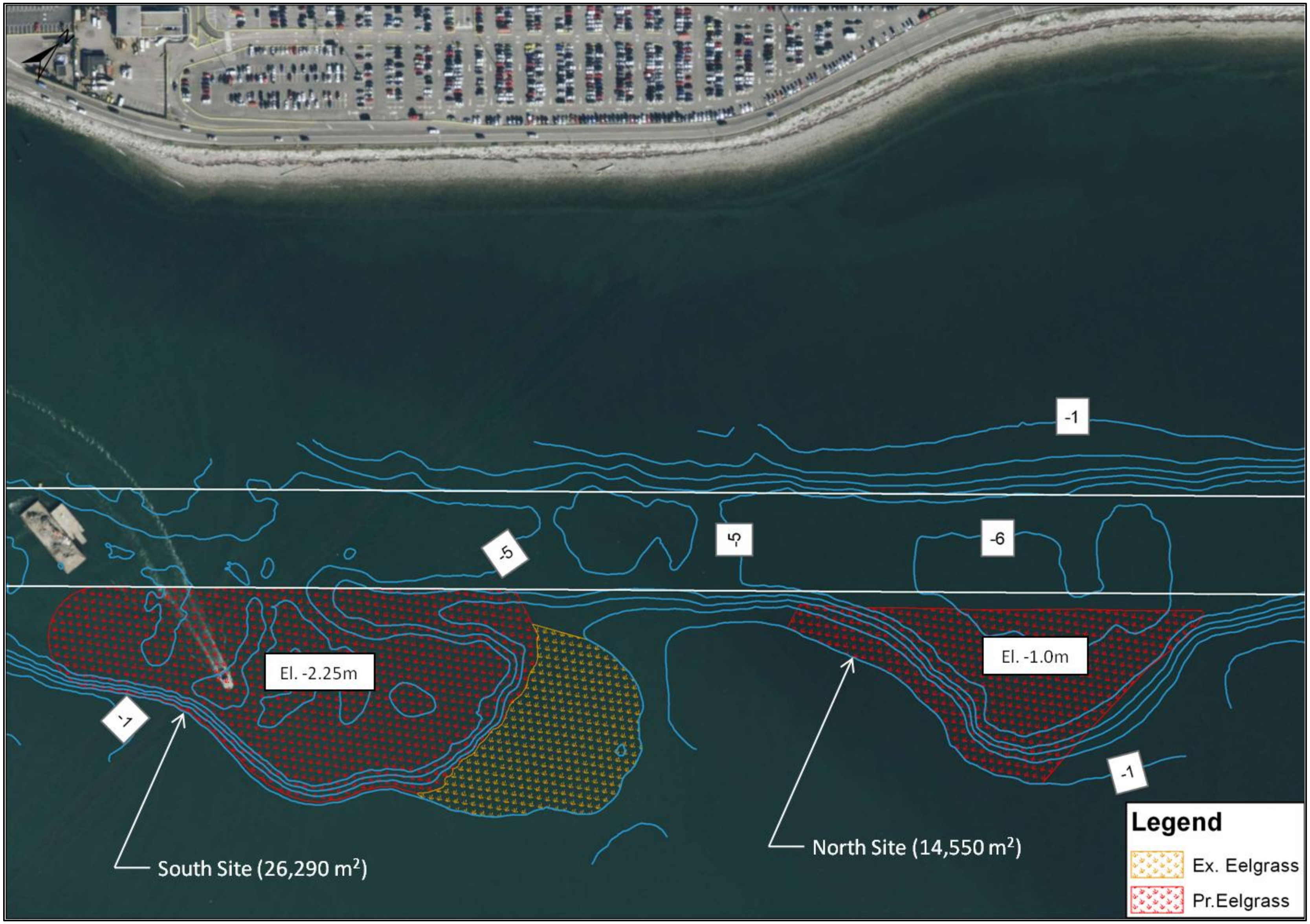

Figure 2: Eelgrass Bed Area and Elevation (Elevations In Chart Datum)

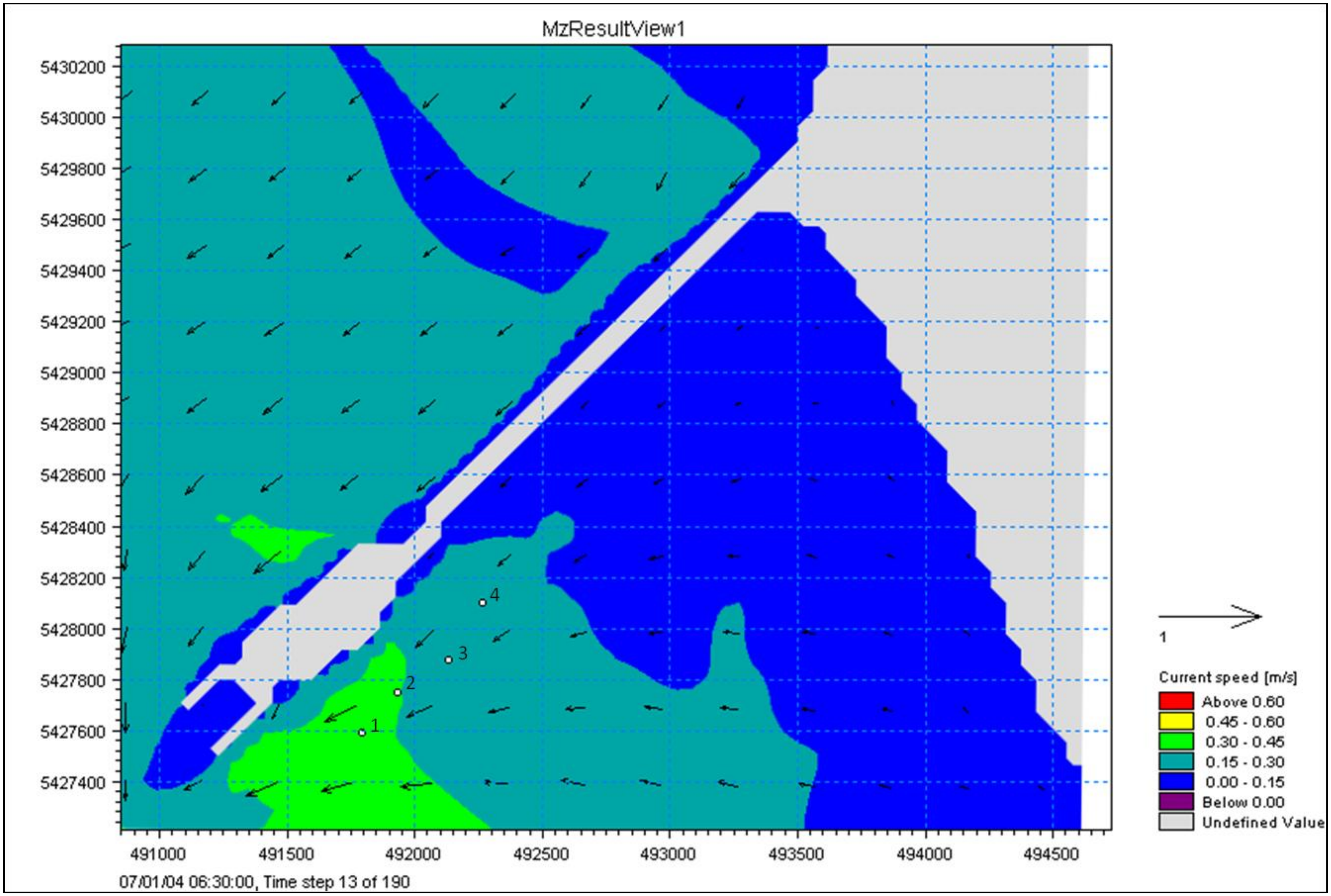

Figure 3: Post-project Peak Current Speeds (m/s)

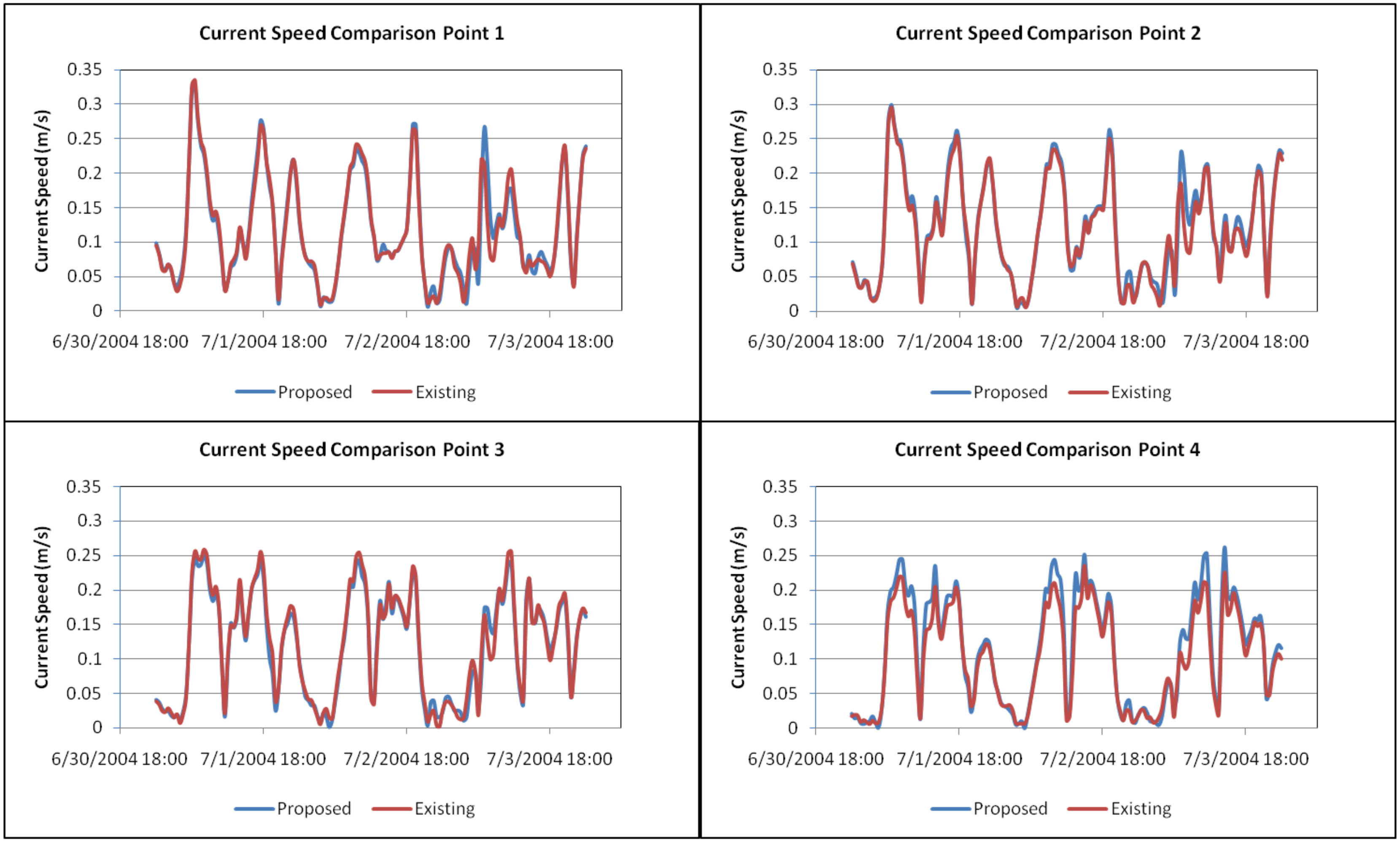

Figure 4: Comparison of Existing and Post-project Current Speeds (m/s)

Appendix B:
Geotechnical Report

21 August 2017

GEOTECHNICAL ASSESSMENT

Habitat Enhancement: Tsawwassen Eelgrass Project, Tsawwassen, BC

Submitted to:
Moffatt & Nichol
Suite 301 0 777 West Broadway
Vancouver, BC
V5Z 4J7

Attention: Mr. Mike Tranmer

REPORT

Report Number: 1784137-001-R-Rev0

Distribution:

1 e-Copy - Moffatt and Nichol
1 e-Copy - Golder Associates Ltd.

Golder Associates

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FIGURES

APPENDICES

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has carried out a geotechnical assessment for the proposed habitat enhancement sites located at Tsawwassen, BC. The assessment was requested by Moffatt and Nichol (MN) on behalf of Vancouver Fraser Port Authority (VFPA). The development of the habitat enhancement sites involves fill placement as required to achieve a ground surface elevation suitable for the support of eelgrass habitat.

The geotechnical assessment was carried out on the basis of a desktop geotechnical study and did not include site specific drilling investigations, soil sampling or laboratory testing. This report presents the anticipated geotechnical conditions and preliminary comments on geotechnical considerations for design and construction of the habitat enhancement site. All elevations discussed within this report are referenced to Chart Datum.

The work on this report has been carried out in accordance with Golder proposal dated 29 June 2017. The work has been completed in accordance with the terms and conditions outlined in the Reciprocal Master Service Agreement for consulting services between MN and Golder dated 11 March 2011.

The scope of this report is limited to the provision of geotechnical engineering services only and does not include any allowance for the testing or assessment of potential soil and/or groundwater contamination at the site, nor for archaeological, geophysical, biological or bio-environmental services for the project.

This report should be read in conjunction with the “Important Information and Limitations of this Report” which is included following the text of this report. The reader’s attention is specifically drawn to this information, as it is essential that it is followed for the proper use and interpretation of this report.

2.0 SITE AND DEVELOPMENT DESCRIPTION

The Tsawwassen Eelgrass Sites are located immediately adjacent to the Tsawwassen Ferry Terminal Causeway, and recreational boating channel, as shown on Figure 1. There are two proposed sites, both of which are local depressions in the seabed. Details of the Sites are summarized in Table 1. The seabed surrounding the depressions is generally at about EL-1 m.

Table 1: Details of Proposed Sites

Site	Current Elevation (m)	Final Elevation (m)	Fill Thickness (m)	Area (ha)
1	-6	-2.25	3.8	2.58
2	-6	-1.40	5.6	1.68

It has been reported to Golder anecdotally from two different sources (ref: sources from MN) that the depressions were created during the construction of the Tsawwassen Ferry Causeway which started in 1959.

The proposed development involves filling the depressions with Fraser River Sand. On the free face, the Fraser River Sand will be constrained by a containment structure constructed of quarry run rock with particle size distribution generally ranging from 75 mm and 5 mm. The containment slope is proposed at 2 horizontal in 1 vertical. The quarry run rock will be separated from the Fraser River Sand with a 0.6 m wide filter comprising quarry screenings with particle size distribution generally ranging from 0.075 to 4.75 mm. The design of the slope revetment (i.e., the containment structure and filter) has been carried out by others.

3.0 BACKGROUND STUDY

3.1 Regional Geological Maps

Surficial geology information published by the Geological Survey of Canada (ref: Map 1486A dated 1979 Scale 1:50,000) indicates that the area is underlain by the following sequence of deposits:

- Marine Shore Sediments comprising of sand to sandy loam up to 2 m thick; overlying
- Fraser River Sediments comprising interbedded fine sand to clayey silt, between 10 and 185 m thick; overlying
- Up to approximately 400 m thickness of competent glacial and pre-glacial soils; overlying
- Bedrock.

3.2 Adjacent Habitat Construction

A similar habitat enhancement platform was constructed immediately adjacent the proposed location of Site 1 in 2008. It would be expected the performance of Site 1 (and most likely Site 2) would be very similar to this previous project in terms of settlements and requirements for staging of fill placement. Records of this development in terms of ground response to backfilling (as opposed to environmental conditions) were not available. It is understood the project was constructed successfully.

3.3 Review of Geotechnical Information

A review of geotechnical information in the vicinity of the Site was carried out as summarized below. The approximate locations of the previous investigations are shown in Figure 1.

Golder 2009-2011

Golder previously carried out a geotechnical investigation approximately 4 km northwest of the Site. The investigation included a total of four test pits, four auger holes, one seismic cone penetration test and one cone penetration test. Standpipe piezometers were installed in selected augerholes. In addition, a test fill embankment was constructed and monitored over six months. The test fill included the installation and monitoring of 20 settlement gauges and comprised two zones as follows:

- A lower fill embankment constructed to approximately 1.5 to 2 m above original site grade, measuring approximately 200 by 100 m in plan.
- A higher (upper) fill embankment constructed to approximately 4.5 to 5 m above original site grade, measuring 50 by 50 m.

Golder 2010-2012

Golder carried out a number of field investigation programs during 2010, 2011 and 2012 as part of the proposed Terminal 2 project and the Deltaport Terminal Road and Rail Improvement Project (DTRRIP). The results show between 60 to 80 m of interbeded sand and silt underlain by a clay deposit estimated to be 20 to 60 m in thickness, underlain by glacial till.

- In 2010, two deep SCPTs paired with sonic drill sampling were pushed to collect subsurface data as input to the assessment of seismic stability of the Roberts Bank delta-front slope.
- During 2011, two field investigation programs involving static and seismic cone penetration tests were carried out. The first investigation involved pushing 9 static CPTs to depths varying from 30 to 40 m below existing ground surface. The CPTs from this investigation are identified as the "600" series. A second field investigation was carried out involving pushing 8 static CPTs and a single seismic CPT to depths varying from 50 and 60 m below existing ground surface. The CPT soundings from this investigation are identified as the "700" series.
- During 2012, a site investigation was carried out. The investigation involved pushing five CPTs and a single seismic CPT to depths varying from 60 to 100 m.

4.0 SUBSURFACE CONDITIONS

A summary of inferred stratigraphic units based on the previous drilling investigation work at nearby sites is presented herein. The summary is not intended to represent a site-specific, detailed or comprehensive description of the subsurface conditions. Given the data is not site specific, but instead the closest available information, significant variation should be anticipated. The generalized subsurface conditions at the nearby sites comprised:

- Interlayered Silt, Sand and Silty Sand strata approximately 40 to 80 m thick; underlain by
- Silty clay to clay sequence extending to depths of approximately 100 m.

5.0 GEOTECHNICAL CONSIDERATIONS

The following briefly summarizes significant geotechnical design and construction considerations for the proposed habitat compensation structures:

- The subgrade soils comprise of an extensive sequence of deltaic and estuarine deposits that are inferred to extend to depths in the order of 100 m below ground surface. These soils include weak and moderately compressible, near-surface silt to clayey silt deposits, extensive loose to compact sand deposits and an interlayered sequence of silt, sand and clayey silt soils.
- Development will require the placement of permanent grade fills of up to about 5.6 m at Site 2 and 3.8 m at Site 1. The placement of this fill may cause consolidation of the underlying fine-grained subgrade soils depending on whether the Sites have been pre-loaded or not.
- Sequencing should consider specifying limitations on the thickness of fill placed in any single lift; each lift placement should be separated from the next by a waiting period to allow strength gain and dissipation of pore water pressures in the underlying deposits and mitigate the potential for ground failures.

- There may be difficulties in controlling the nature of the fill placement due to constraints associated with dredging and submerged fill placement.
- The low-plastic silt and extensive loose sand deposits are susceptible to soil liquefaction during intermediate to strong seismic (earthquake) levels of shaking, which will result in loss of soil strength. We understand, however, that the design of the proposed habitat development will not consider the effects of seismic loading.

5.1 Settlement Assessment

Site 1 and Site 2 are notable depressions, anecdotally reported to have been formed by dredging operations within the recreational channel to which they adjoin. Detailed information regarding the extent of anecdotal dredging is not available, but would indicate the previous elevation of the site (prior to dredging) was at, or higher than the proposed elevation of the habitat enhancement structures.

If this anecdotal information is accurate, the Sites have effectively been "preloaded", meaning that the placement of fill to elevations that existed prior to dredging will have less impact and only nominal settlement would be expected to occur as follows:

- A nominal allowance of 50 mm is considered reasonable.
- This would be expected to occur within 6 months following the end of construction.

Should the anecdotal evidence be inaccurate, either in full or in part, then the site would be expected to behave in a non-preloaded manner (or perhaps partially preloaded). As described in Section 3.3, a test fill embankment was constructed at a project 4 km from this Site. If behaving in a non-preloaded manner, the response of Sites 1 and 2 could be expected to be similar to that of the test embankment:

- 1.5 to 2 m fill thickness: approximately 50 to 150 mm over the first 6 month period with an additional 25 mm over the following 18 month period.
- 4.5 to 5 m fill thickness: approximately 60 to 250 mm over the same 6 month period with an additional 25 mm over the following 18 month period.

Both preloaded and non-preloaded response would also be expected to exhibit secondary consolidation of about 50 to 300 mm that could occur over the design life of the habitat embankment (assumed at 25 years). The preloaded behaviour at the lower end and the non-preloaded at the upper end. The design of the final grades suitable for supporting the eelgrass habitat should consider the above settlement estimates.

5.2 Staged Fill and Placement Sequencing

For initial planning purposes, we have assumed that the habitat compensation structure will be constructed in a staged loading sequence to allow sequential strength gain of the underlying compressible soils. Stage loading produces sequential gains of strength in the soft soils and mitigate the risk of ground failures. A waiting period between lifts should be observed to allow dissipation of excess pore pressures induced by the fill, and to avoid overstressing the underlying highly compressible fine-grained soils. The waiting period should be determined on site on the basis of construction monitoring activities; an allowance of two weeks should be included for planning purposes.

Staging of fill placement should consider placement in stages no thicker than about 1 to 2 m. Placement of fill in an uncontrolled manner (without staging) may result in failure of the underlying soils resulting in lateral movements at and beyond the toe of the fill affecting construction.

The planning of the construction should consider fill placement within the deepest part of the habitat banking first. This will allow the majority of the settlement to occur during construction and final grading operations to accommodate settlement can be carried out prior to the Contractor demobilizing from site.

5.3 Construction Monitoring

It is recommended that a geotechnical engineer be contracted to review the stability of the side slopes and make periodic inspections during placement of the fill. The geotechnical engineer should also determine appropriate waiting periods between staged lifts during construction. The Contractor should include a program of monitoring elevations with time with sufficient accuracy in order to assist the engineer in decision making regarding appropriate waiting periods, and to confirm the observed behaviour is consistent with the anticipated behaviour. This type of monitoring is especially important given the engineering recommendations are based on available information as opposed to site specific data. Golder can provide input into the construction specifications and/or tendering package for this work if requested.

6.0 CLOSURE

We trust that the information presented in this report is sufficient for your immediate requirements. Should you have any questions or require further information, please feel free to contact us.

GOLDER ASSOCIATES LTD.

PROFESSIONAL ENGINEER PROVINCE OF BRITISH COLUMBIA J. L. PERRETT # 34265

21 AUGUST 2017

JoAnne Perrett, PEng
Associate, Senior Geotechnical Engineer

Roberto Olivera
Geotechnical Engineer

RO/JP/syd/lmk

\\golder.gds\gal\burnaby\final\2017\3 proj\1784137 tsawwassen eelgrass habitat\1784137-001-r-rev0\1784137-001-r-rev0-tsawwassen eelgrass-21aug_17.docx

LEGEND

- SH10- SERIES SH/CPT LOCATION (2010)
- CPT11-600 SERIES DRILLED CPT LOCATION (2011)
- CPT11-800 SERIES DRILLED CPT LOCATION (2011)
- CPT12- SERIES DRILLED CPT LOCATION (2012)
- TSAWWASSEN HABITAT ENHANCEMENT SITE

NOTE

1. ALL TEST HOLE LOCATIONS ARE APPROXIMATE, OBTAINED BY HAND HELD GPS COORDINATES.

REFERENCES

1. SOURCE DRAWING INFORMATION SUPPLIED BY CLIENT FROM PORT OF VANCOUVER "HABITAT ENHANCEMENT PROGRAM TSAWWASSEN EELGRASS PROJECT SITE 1 AND 2 GRADING PLAN", DRAWING NO. 34-348-EN-6023.dwg-Rev A, DATED FEB 17/12.
2. IMAGE OBTAINED FROM GOOGLE EARTH PRO, USED UNDER LICENCE. IMAGE DATA 17-08-2016, USED UNDER LICENSE. GOOGLE EARTH IMAGE IS NOT TO SCALE.

CLIENT

moffatt & nichol

CONSULTANT

Golder Associates

YYYY-MM-DD	2017-08-18
DESIGNED	JP
PREPARED	AF
REVIEWED	JP
APPROVED	RO

PROJECT

GEOTECHNICAL ASSESSMENT HABITAT ENHANCEMENT: TSAWWASSEN EELGRASS PROJECT, TSAWWASSEN, BC

TITLE

KEY PLAN AND PREVIOUS INVESTIGATION LOCATIONS

PROJECT NO.	Phase	REV.	FIGURE
1784137	1000	0	01

25 mm

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D

Path: \\golder.gds\gal\Burnaby\CAD-GIS\Client\Moffatt-Nichol\Tsawwassen\99_PROJECTS\1784137\02_PRODUCTION\1000\ | File Name: 1784137-1000-01.dwg

APPENDIX A

Important Information and Limitations of this Report

IMPORTANT INFORMATION AND LIMITATIONS OF THIS REPORT

Standard of Care: Golder Associates Ltd. (Golder) has prepared this report in a manner consistent with that level of care and skill ordinarily exercised by members of the engineering and science professions currently practising under similar conditions in the jurisdiction in which the services are provided, subject to the time limits and physical constraints applicable to this report. No other warranty, expressed or implied is made.

Basis and Use of the Report: This report has been prepared for the specific site, design objective, development and purpose described to Golder by the Client. The factual data, interpretations and recommendations pertain to a specific project as described in this report and are not applicable to any other project or site location. Any change of site conditions, purpose, development plans or if the project is not initiated within eighteen months of the date of the report may alter the validity of the report. Golder cannot be responsible for use of this report, or portions thereof, unless Golder is requested to review and, if necessary, revise the report.

The information, recommendations and opinions expressed in this report are for the sole benefit of the Client. No other party may use or rely on this report or any portion thereof without Golder’s express written consent. If the report was prepared to be included for a specific permit application process, then upon the reasonable request of the client, Golder may authorize in writing the use of this report by the regulatory agency as an Approved User for the specific and identified purpose of the applicable permit review process. Any other use of this report by others is prohibited and is without responsibility to Golder. The report, all plans, data, drawings and other documents as well as all electronic media prepared by Golder are considered its professional work product and shall remain the copyright property of Golder, who authorizes only the Client and Approved Users to make copies of the report, but only in such quantities as are reasonably necessary for the use of the report by those parties. The Client and Approved Users may not give, lend, sell, or otherwise make available the report or any portion thereof to any other party without the express written permission of Golder. The Client acknowledges that electronic media is susceptible to unauthorized modification, deterioration and incompatibility and therefore the Client cannot rely upon the electronic media versions of Golder’s report or other work products.

The report is of a summary nature and is not intended to stand alone without reference to the instructions given to Golder by the Client, communications between Golder and the Client, and to any other reports prepared by Golder for the Client relative to the specific site described in the report. In order to properly understand the suggestions, recommendations and opinions expressed in this report, reference must be made to the whole of the report. Golder cannot be responsible for use of portions of the report without reference to the entire report.

Unless otherwise stated, the suggestions, recommendations and opinions given in this report are intended only for the guidance of the Client in the design of the specific project. The extent and detail of investigations, including the number of test holes, necessary to determine all of the relevant conditions which may affect construction costs would normally be greater than has been carried out for design purposes. Contractors bidding on, or undertaking the work, should rely on their own investigations, as well as their own interpretations of the factual data presented in the report, as to how subsurface conditions may affect their work, including but not limited to proposed construction techniques, schedule, safety and equipment capabilities.

Soil, Rock and Groundwater Conditions: Classification and identification of soils, rocks, and geologic units have been based on commonly accepted methods employed in the practice of geotechnical engineering and related disciplines. Classification and identification of the type and condition of these materials or units involves judgment, and boundaries between different soil, rock or geologic types or units may be transitional rather than abrupt. Accordingly, Golder does not warrant or guarantee the exactness of the descriptions.

Special risks occur whenever engineering or related disciplines are applied to identify subsurface conditions and even a comprehensive investigation, sampling and testing program may fail to detect all or certain subsurface conditions. The environmental, geologic, geotechnical, geochemical and hydrogeologic conditions that Golder interprets to exist between and beyond sampling points may differ from those that actually exist. In addition to soil variability, fill of variable physical and chemical composition can be present over portions of the site or on adjacent properties. **The professional services retained for this project include only the geotechnical aspects of the subsurface conditions at the site, unless otherwise specifically stated and identified in the report.** The presence or implication(s) of possible surface and/or subsurface contamination resulting from previous activities or uses of the site and/or resulting from the introduction onto the site of materials from off-site sources are outside the terms of reference for this project and have not been investigated or addressed.

Soil and groundwater conditions shown in the factual data and described in the report are the observed conditions at the time of their determination or measurement. Unless otherwise noted, those conditions form the basis of the recommendations in the report. Groundwater conditions may vary between and beyond reported locations and can be affected by annual, seasonal and meteorological conditions. The condition of the soil, rock and groundwater may be significantly altered by construction activities (traffic, excavation, groundwater level lowering, pile driving, blasting, *etc.*) on the site or on adjacent sites. Excavation may expose the soils to changes due to wetting, drying or frost. Unless otherwise indicated the soil must be protected from these changes during construction.

Sample Disposal: Golder will dispose of all uncontaminated soil and/or rock samples 90 days following issue of this report or, upon written request of the Client, will store uncontaminated samples and materials at the Client's expense. In the event that actual contaminated soils, fills or groundwater are encountered or are inferred to be present, all contaminated samples shall remain the property and responsibility of the Client for proper disposal.

Follow-Up and Construction Services: All details of the design were not known at the time of submission of Golder's report. Golder should be retained to review the final design, project plans and documents prior to construction, to confirm that they are consistent with the intent of Golder's report.

During construction, Golder should be retained to perform sufficient and timely observations of encountered conditions to confirm and document that the subsurface conditions do not materially differ from those interpreted conditions considered in the preparation of Golder's report and to confirm and document that construction activities do not adversely affect the suggestions, recommendations and opinions contained in Golder's report. Adequate field review, observation and testing during construction are necessary for Golder to be able to provide letters of assurance, in accordance with the requirements of many regulatory authorities. In cases where this recommendation is not followed, Golder's responsibility is limited to interpreting accurately the information encountered at the borehole locations, at the time of their initial determination or measurement during the preparation of the Report.

Changed Conditions and Drainage: Where conditions encountered at the site differ significantly from those anticipated in this report, either due to natural variability of subsurface conditions or construction activities, it is a condition of this report that Golder be notified of any changes and be provided with an opportunity to review or revise the recommendations within this report. Recognition of changed soil and rock conditions requires experience and it is recommended that Golder be employed to visit the site with sufficient frequency to detect if conditions have changed significantly.

Drainage of subsurface water is commonly required either for temporary or permanent installations for the project. Improper design or construction of drainage or dewatering can have serious consequences. Golder takes no responsibility for the effects of drainage unless specifically involved in the detailed design and construction monitoring of the system.

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Suite 200 - 2920 Virtual Way
Vancouver, BC, V5M 0C4
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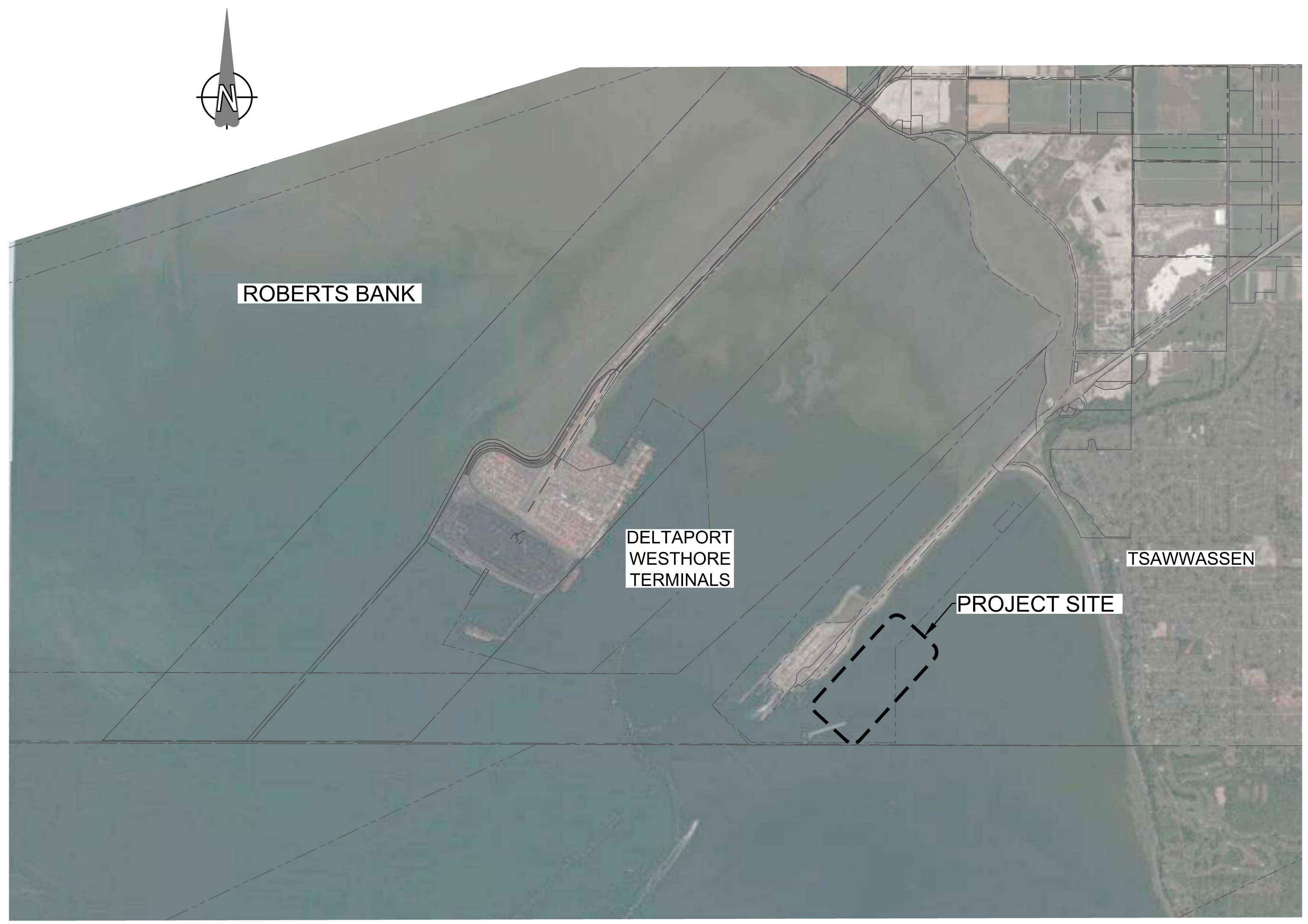
Appendix C:
Project Drawings

VANCOUVER FRASER PORT AUTHORITY

RBT2 OFFSETTING

TSAWWASSEN EELGRASS PROJECT



VICINITY MAP
NTS

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1	CHS CHART 3490

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		REVISION IN PROGRESS		

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VANCOUVER FRASER PORT AUTHORITY
ENGINEERING DEPARTMENT

DESIGN BY
DRAWN BY
APPROVED
DATE
SCALE
PMV SITE

RBT2 OFFSETTING
TSAWWASSEN EELGRASS PROJECT
TITLE SHEET & LOCATION

SIZE	DWG.	SHEET	REV.
D	G-001		

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DRAWING LIST:

G-001	TITLE SHEET & LOCATION
G-002	DRAWING INDEX
G-003	NOTES & SEQUENCE
G-004	SITE AND ACCESS MAP
C-001	SURVEY CONTROL
C-002	PHOTOS - EXISTING CONDITIONS
C-003	SITE PLAN
C-004	GRADING PLAN
C-005	FILL/EXCAVATION SECTIONS SHEET
PL-XXX	PLANTING PLANS, AMENDMENTS ETC BY OTHERS (5-10 SHEETS)

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PMV SITE

RBT2 OFFSETTING
TSAWWASSEN EELGRASS PROJECT
DRAWING INDEX

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1.0GENERAL NOTES

1.1 SCOPE OF WORK: THE WORK GENERALLY INCLUDES CREATING HIGH QUALITY FISH AND WILDLIFE HABITAT THROUGH THE INFILL OF EXISTING SEABED DEPRESSIONS TO A SUBTIDAL ELEVATION THAT WILL SUPPORT EELGRASS. THE WORK ALSO INCLUDES A ROCK CONTAINMENT BERM; TRANSPLANTING EELGRASS WILL OCCUR UNDER SEPARATE CONTRACT.

1.2 THE CONTRACTOR SHALL VERIFY THE DRAWINGS AGAINST THE PROJECT SITE AND NOTIFY THE AUTHORITY'S REPRESENTATIVE IN WRITING OF ANY DISCREPANCIES IN DIMENSIONS OR SITE CONDITIONS. THE CONTRACTOR SHALL NOT BEGIN CONSTRUCTION IN ANY SUCH AFFECTED AREA UNTIL THE DISCREPANCY HAS BEEN RESOLVED BY THE AUTHORITY'S REPRESENTATIVE.

1.3 ALL DIMENSIONS ARE GIVEN IN MILLIMETERS UNLESS NOTED OTHERWISE.
ELEVATIONS AND CONTOURS ARE GIVEN IN METRES AND DECIMALS THEREOF.
SCALE INDICATED ON DRAWING IS APPROPRIATE TO SCALE AT FULL SIZE (D) 22" X 34"

1.4 NOTES AND DETAILS ON THE DRAWINGS SHALL TAKE PRECEDENCE OVER THESE GENERAL NOTES. REFER TO RELATED SPECIFICATIONS IN THE SPECIAL PROVISIONS FOR ADDITIONAL PROJECT REQUIREMENTS.

2.0 SURVEY, WATER LEVELS AND DATUM

2.1. ALL ELEVATIONS ARE REFERENCED TO TIDE AND CHART DATUM. HYDROGRAPHIC SURVEY WAS COMPLETED IN DECEMBER 2014; THE RESULTS WILL BE MADE AVAILABLE TO THE CONTRACTOR FOR REFERENCE.

2.2 PROPERTY LINES WERE PROVIDED BY VANCOUVER FRASER PORT AUTHORITY (VFPA).

2.3 COORDINATES ARE UTM (NAD 83) ZONE 10 MAPPING PLANE COORDINATES.

2.4 SURVEY REFERENCE BENCHMARK (BM 77C010) IS LOCATED ALONG THE TSAWWASSEN FERRY CAUSEWAY (NEAR THE BOAT RAMP).

(2004) VALUES FOR BM 77C010 ARE: EL 6.371m CD (3.499m GEODETIC),
N 5429,259.61m, E 491,478.72m

2.5 TIDAL PARAMETERS (REFERENCE: CANADIAN HYDROGRAPHIC SERVICES) FOR TSAWWASSEN ARE AS FOLLOWS:

TIDAL PARAMETER	ELEVATION (CD)
HIGHER HIGH WATER LARGE TIDE (HHWLT)	4.8m
HIGHER HIGH WATER MEAN TIDE (HHWMT)	4.1m
MEAN WATER LEVEL (MWL)	3.0m
LOWER LOW WATER MEAN TIDE (LLWMT)	1.2m
LOWER LOW WATER LARGE TIDE (LLWLT)	0.1m

3.0 AGGREGATE MATERIAL (QUARRY SCREENING, QUARRY RUN, SAND)

3.1 QUARRY RUN SHALL BE IMPORTED CLEAN, ROUGH ANGULAR QUARRIED STONE OF A DENSE, HARD, DURABLE CHARACTER, FREE OF ORGANIC MATERIAL, IN-FILLED JOINTS, SEAMS, OR OTHER DEFECTS, RESISTANT TO BREAKDOWN BY HANDLING OR WEATHERING OR EXPOSED TO SEA WATER THAT MEETS THE TEST REQUIREMENTS PROVIDED IN THE SPECIAL PROVISIONS, UNLESS NOTED OTHERWISE.

3.2 QUARRY RUN SHALL MEET THE FOLLOWING GRADATION:

SIEVE SIZE (mm)	GRADATION LIMITS % PASSING BY DRY WEIGHT
150	100
75	0 - 40
5	0 - 5

3.3 QUARRY SCREENING SHALL BE NATURALLY OCCURRING, NON-MANUFACTURED CLEAN GRANULAR MATERIAL FREE OF ORGANIC MATTER, VEGETATION AND OTHER DELETERIOUS MATERIAL.

3.4 QUARRY SCREENINGS SHALL MEET THE FOLLOWING GRADATION:

SIEVE SIZE (mm)	GRADATION LIMITS % PASSING BY DRY WEIGHT
9.5	100
4.75	70 - 85
2.36	40 - 50
1.18	25 - 35
0.60	15 - 25
0.30	10 - 20
0.15	5 - 15
0.075	5 - 10

3.5 SAND (FRASER RIVER SAND) SHALL BE NATURALLY OCCURRING, NON-MANUFACTURED GRANULAR MATERIAL AND MEET THE FOLLOWING GRADATION:

SIEVE SIZE (mm)	GRADATION LIMITS % PASSING BY DRY WEIGHT
19	100
4.76	80 - 100
0.60	20 - 100
0.42	10 - 100
0.25	0 - 100
0.12	0 - 95
0.074	0 - 50

3.6 THE CONTRACTOR SHALL PROVIDE AGGREGATE SUPPLIER'S TEST RESULTS THAT THE AGGREGATE MATERIALS SUPPLIED CONFORMS TO THE REFERENCED SPECIAL PROVISIONS / GRADATIONS.

PRELIMINARY
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VANCOUVER FRASER PORT AUTHORITY
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APPROVED
DATE
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RBT2 OFFSETTING
TSAWWASSEN EELGRASS PROJECT
NOTES & SEQUENCE

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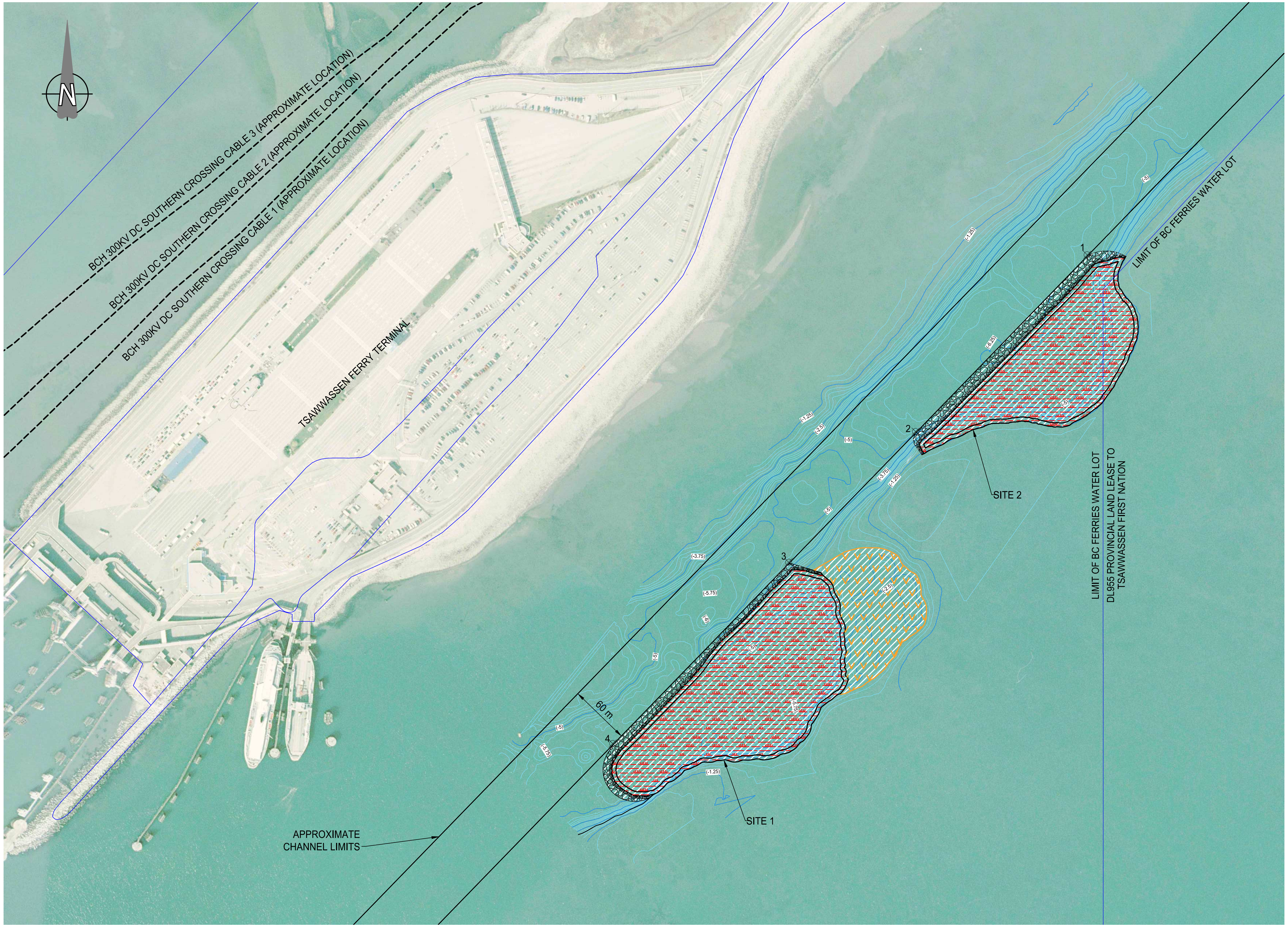

LEGEND:

- CONTAINMENT BERM
- PROPOSED EELGRASS BEDS (PLANTING BY OTHERS)
- EXISTING EELGRASS BED (2008)
- CROWN FEDERAL PROPERTY LINES
- (XX) EXISTING BATHY
- NAVIGATION MARKER

NOTES:

1. BATHYMETRIC CONTOURS ARE SHOWN AT A 0.25m INTERVAL.

QUANTITIES:

EELGRASS	4.3 ha
BERM (RIPRAP)	0.6 ha
EXISTING EELGRASS	0.9 ha

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40 0m 40 80
SCALE: 1 : 2000

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RBT2 OFFSETTING
TSAWWASSEN EELGRASS PROJECT
SITE PLAN

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TSAWWASSEN FERRY TERMINAL

SITE AREA			
	TOTAL	BC FERRIES WATER LOT	TFN WATER LOT
SITE 1	2.86 ha	2.86 ha	0
SITE 2	2.00 ha	1.72 ha	0.28 ha
TOTAL	4.86 ha	4.58 ha	0.28 ha

VOLUME QUANTITIES			
MATERIAL	SITE 1	SITE 2	TOTAL
SAND INFILL	73,650 m^3	42,600 m^3	116,250 m^3
QUARRY RUN	6,555 m^3	11,060 m^3	17,615 m^3
QUARRY SCREENING	1,015 m^3	1,315 m^3	2,330 m^3

LEGEND:

PROPOSED EELGRASS BEDS (PLANTING BY OTHERS)

EXISTING BUILT EELGRASS BED (2008)

CONTAINMENT BERM

CROWN FEDERAL PROPERTY LINES

(XX) EXISTING BATHY

NAVIGATION MARKERS (1-4)

SIGNAGE ORIENTATION

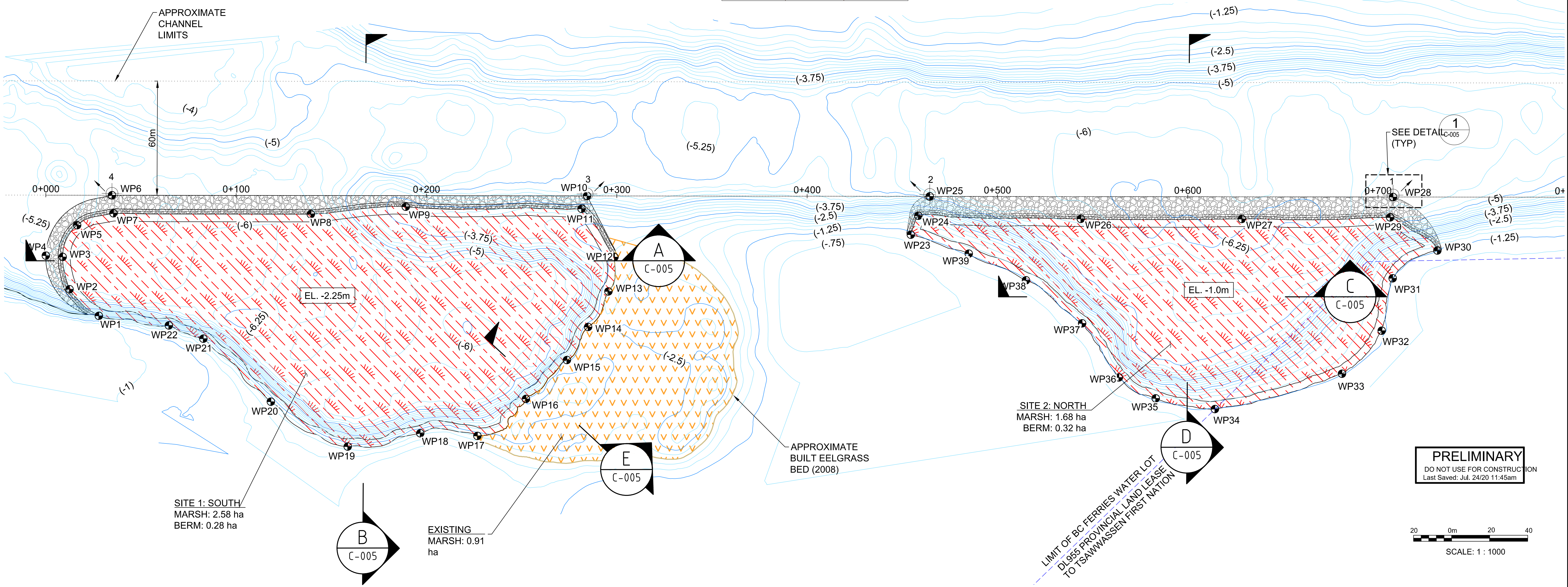
WORK POINTS - SITE 1		
POINT NO.	NORTHING	EASTING
WP1	5428019.145	490914.525
WP2	5428017.788	490893.784
WP3	5428027.018	490879.060
WP4	5428021.154	490872.416
WP5	5428044.076	490872.381
WP6	5428068.196	490873.813
WP7	5428062.157	490881.182
WP8	5428136.310	490953.643
WP9	5428174.884	490985.518
WP10	5428247.297	491047.687
WP11	5428240.518	491050.543
WP12	5428235.287	491080.807
WP13	5428220.435	491091.565
WP14	5428199.791	491097.550
WP15	5428179.706	491102.294

WORK POINTS - SITE 1		
POINT NO.	NORTHING	EASTING
WP16	5428150.020	491101.979
WP17	5428118.195	491098.208
WP18	5428097.569	491076.310
WP19	5428065.335	491054.842
WP20	5428052.708	491009.813
WP21	5428050.249	490961.319
WP22	5428042.062	490943.730

NAVIGATION MARKERS		
POINT NO.	NORTHING	EASTING
1	5428551.858	491341.966
2	5428377.187	491172.393
3	5428247.993	491046.970
4	5428068.892	490873.096

WORK POINTS - SITE 2		
POINT NO.	NORTHING	EASTING
WP23	5428355.344	491180.672
WP24	5428365.084	491176.239
WP25	5428376.490	491173.110
WP26	5428425.305	491236.835
WP27	5428486.046	491295.701
WP28	5428551.161	491342.684
WP29	5428542.600	491349.329
WP30	5428548.320	491379.075
WP31	5428521.285	491373.225
WP32	5428498.002	491388.995
WP33	5428467.272	491390.720
WP34	5428406.409	491357.617
WP35	5428387.970	491331.957
WP36	5428381.715	491310.600

WORK POINTS - SITE 2		
POINT NO.	NORTHING	EASTING
WP37	5428387.609	491276.734
WP38	5428382.136	491239.965
WP39	5428370.267	491208.986



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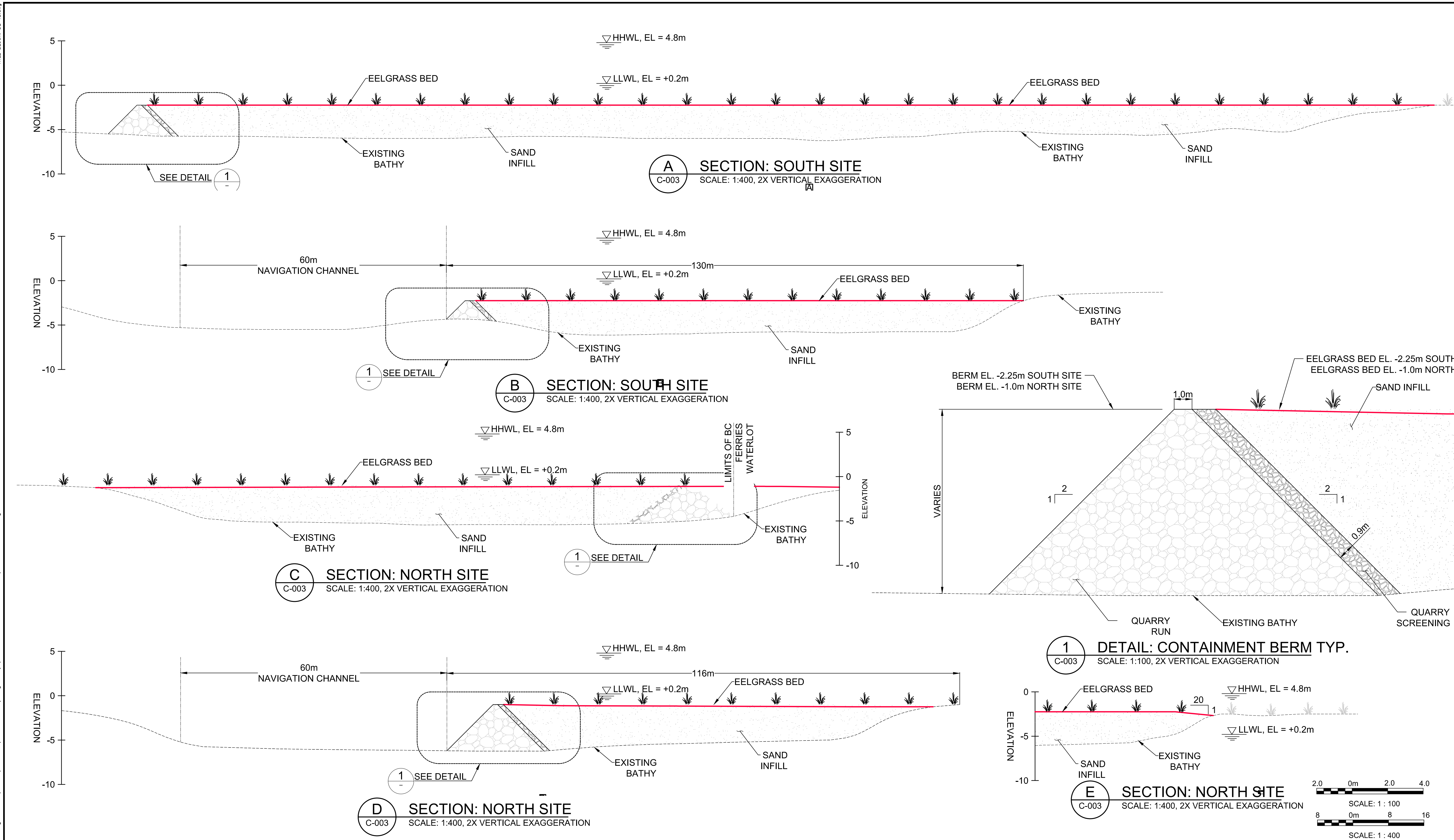
RBT2 OFFSETTING
TSAWWASSEN EELGRASS PROJECT
GRADING PLAN

SIZE	DWG.	SHEET	REV.
D	C-004		



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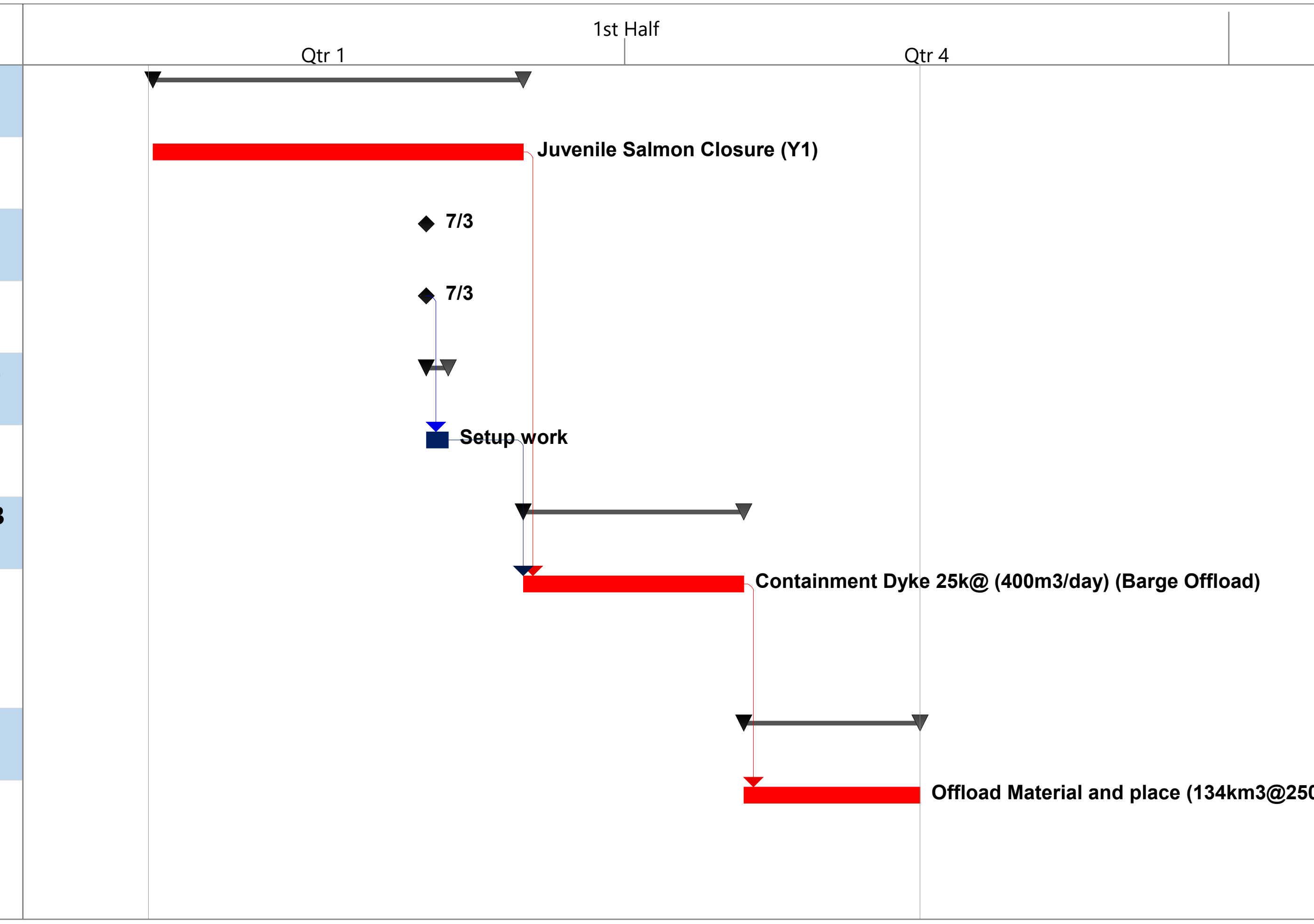
RBT2 OFFSETTING
TSAWWASSEN EELGRASS PROJECT
SECTIONS SHEET

SIZE	DWG.	SHEET	REV.
D	C-005		

Appendix D:
Construction Schedule

ID	Task Name	Duration	Predecessors	Start	Finish
1	**Environmental Closures**	**168 days**		**Wed 3/1/23**	**Tue 8/15/23**
2	Juvenile Salmon Closure (Y1)	168 days		Wed 3/1/23	Tue 8/15/23
3	**Milestones and Target Dates**	**0 days**		**Mon 7/3/23**	**Mon 7/3/23**
4	Start of Construction	0 days		Mon 7/3/23	Mon 7/3/23
5	**Setup**	**10 days**		**Mon 7/3/23**	**Wed 7/12/23**
6	Setup work	10 days	4	Mon 7/3/23	Wed 7/12/23
7	**Eelgrass Dyking (25kM3)**	**100 days**		**Wed 8/16/23**	**Thu 11/23/23**
8	Containment Dyke 25k@ (400m3/day) (Barge Offload)	100 days	2,6	Wed 8/16/23	Thu 11/23/23
9	**Fill Eelgrass Areas (134 kM3)**	**80 days**		**Fri 11/24/23**	**Sun 2/11/24**
10	Offload Material and place (134km3@2500m3/day)	80 days	8	Fri 11/24/23	Sun 2/11/24



Project: 2020.06.18 Tsawwassen Eelg
Date: Fri 6/19/20

Task	Inactive Task	Manual Summary Rollup	External Milestone	Manual Progress
Split	Inactive Milestone	Manual Summary	Deadline	
Milestone	Inactive Summary	Start-only	Critical	
Summary	Manual Task	Finish-only	Critical Split	
Project Summary	Duration-only	External Tasks	Progress	

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Appendix IR2020-1.1-A13

Existing Ecological Conditions – Proposed Tsawwassen Eelgrass Enhancement Project

Existing Ecological Conditions
Proposed Tsawwassen Eelgrass Enhancement Project

Prepared for:
Port Metro Vancouver – Habitat Enhancement Program
100 The Pointe, 999 Canada Place
Vancouver, BC V6C 3T4

Prepared by:
Hemmera Envirochem Inc.
18th Floor, 4730 Kingsway
Burnaby, BC V5H 0C6

File: 302-035.04
May 2015

HEMMERA | 20 YEARS 1994 – 2014

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1.0 INTRODUCTION

The proposed Tsawwassen Eelgrass Project (the Project) near Tsawwassen, in the Corporation of Delta, B.C., is a proposed project under Port Metro Vancouver's (PMV's) Habitat Enhancement Program (HEP). Project planning is being undertaken in accordance with the "Working Agreement Concerning Procedures for Development and Operation of the Port Metro Vancouver Habitat Bank" (2012) between Fisheries and Oceans Canada (DFO) and PMV.

The objectives of this assessment were to document the existing ecological features and potential species use of the proposed Project located southeast of BC Ferries Tsawwassen Terminal causeway. General ecosystem conditions and occurrences of species of management concern will inform project design and construction mitigation at the site.

1.1 RATIONALE

As part of HEP, PMV is applying a landscape approach to identify potential sites where the productivity of habitat can be increased, existing habitat can be enhanced, or degraded habitat can be restored to benefit fish and wildlife species that utilize the Fraser River estuary and Burrard Inlet.

The proposed Project is located within the "Fraser Estuary, Boundary Bay, Burrard Inlet, Fraser and North Arms" Geographic Service Area (GSA). Site selection was based on factors including need, habitat productivity, site location, feasibility and cost, sustainability, ownership and tenure, and consideration towards First Nations and communities.

Creation of eelgrass habitat will improve the overall productivity of Roberts Bank, near Tsawwassen, and increase high-quality habitat availability for juvenile salmonids, forage fish species, Dungeness crab (*Metacarcinus magister*), birds and wildlife that utilize Roberts Bank.

Information considered during preparation of this report included:

- Desktop review and background research;
- Field reconnaissance information (Precision Identification 2013 (draft) **- Appendix A**); and
- Site 3 Field Reconnaissance information (Hemmera 2015 - **Appendix B**).

2.0 PROJECT LOCATION

The proposed Tsawwassen Eelgrass Project is located in close proximity to the International Boundary between Canada and the United States, near the Corporation of Delta, BC (**Figure 1**). The proposed enhancement sites are located on the southern portion of Roberts Bank, adjacent to the southeast side of the BC Ferries Causeway and a 60 m wide recreational boating channel, near Tsawwassen, BC (**Figure 2**).

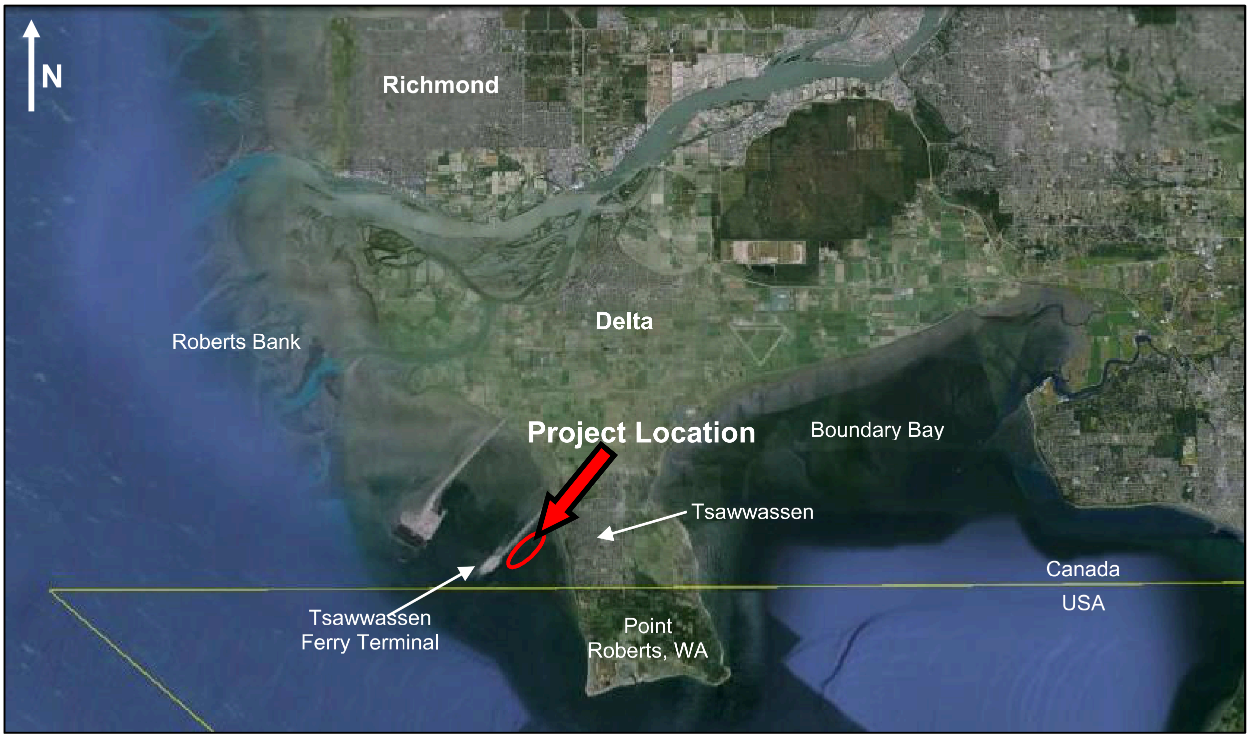

Figure 1 Tsawwassen Eelgrass Project – Regional Setting (Google Earth Maps)

Figure 2 Tsawwassen Eelgrass Project – Site Location (DeltaMap Imagery 2014)

3.0 PROPOSED HABITAT ENHANCEMENT

3.1 SITE HISTORY

The area southeast of the Tsawwassen Ferry Terminal causeway was originally part of the contiguous Roberts Bank tidal flat. This area was bisected in 1960 with completion of the Tsawwassen Ferry Terminal causeway (**Figure 2**). During construction, a dredged borrow channel was created southeast of the causeway, and is evident in subsequent historic aerial photos (Precision Identification 2006). The channel remains open due to ongoing use by recreational boaters and natural physical processes, such as scouring from tidal currents (BCTC 2007).

Prior to anthropogenic modifications (BC Ferries causeway and Roberts Bank causeway (completed 1970), eelgrass beds on Roberts Bank were patchy, possibly due to high flow velocities and high turbidity, and encompassed approximately 386 ha (Triton 1996). Between 1960 and 1996, eelgrass beds expanded seaward and landward and increased in density, changing from a patchy to continuous distribution (Triton Environmental 1996). In addition, changes in drainage patterns on the intertidal flats are evident in the development of two new dendritic channels, flowing east from the inshore section of the dredge borrow channel (Triton Environmental 1996).

Aerial photography, and data from the Fraser River Estuary Management Program (FREMP) and Precision Identification, indicates that from 1981 to 2005 the expansion of intertidal eelgrass continued corresponding with similar increases observed throughout Roberts Bank (Precision Identification 2006). Eelgrass expansion has been attributed to physical changes that have increased the area available for colonization by eelgrass, including deflection of the Fraser River plume (improving water clarity) and increased sedimentation due to reduced flow regimes (resulting in seabed elevation increases).

Eelgrass habitat was previously created in close proximity to the proposed Project. In 2008, British Columbia Transmission Corporation (BCTC) constructed two eelgrass beds totalling 2.09 ha as fish habitat compensation for the Vancouver Island Transmission Reinforcement (VITR) project (**Figure 3**). Post-construction monitoring results from 2010 demonstrated that bed density had increased three-fold from the original transplant density (Golder Associates Ltd. 2011).

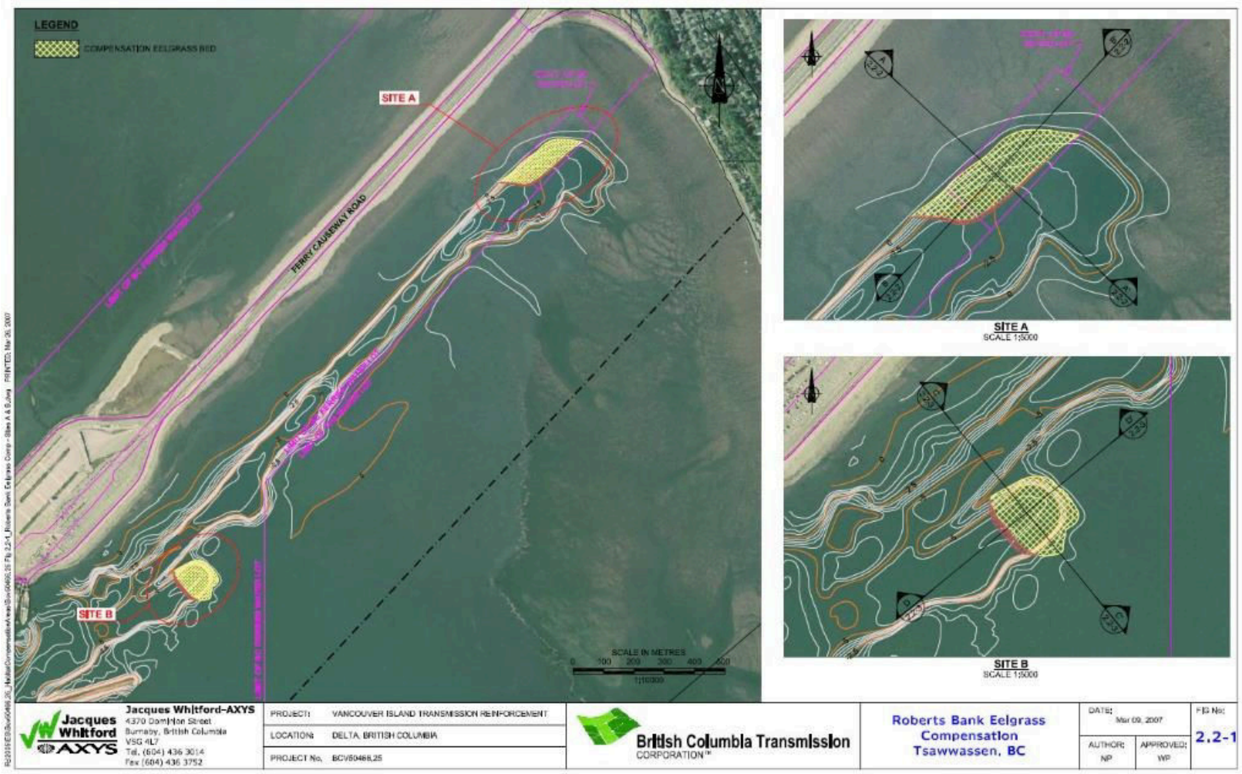

Figure 3 BCTC Eelgrass Compensation Sites near the Proposed Tsawwassen Eelgrass Enhancement Sites

3.2 PROPOSED WORKS

The Project proposes to create three subtidal eelgrass beds southeast of the Tsawwassen ferry terminal causeway. Approximately 4.8 ha of habitat enhancement could be undertaken at three sites (**Figure 4**). Sites 1, 2 and 3 would encompass 2.63 ha, 1.73 ha, and 0.46 ha respectively.

The proposed Project will raise the seabed elevation at three subtidal depressions (approximately -4.0 m to -6.0 m CD) formed by historic dredging activities, to elevations suitable for the establishment and persistence of native eelgrass (*Zostera marina*; approximately -2.25 m CD to -1.0 m CD). Perimeter berms will be created along the western edge (adjacent to the deep channel) of each proposed site to reduce erosion along the outer edges of the eelgrass beds and to contain fill added to the depressions. The eastern edges of the proposed eelgrass enhancement sites will be blended (e.g. elevations will match) with the adjacent eelgrass beds, with reasonably even and uniform substrate surfaces. After a substrate settlement period, the raised seabed will be transplanted using plants from a nearby suitable donor site.

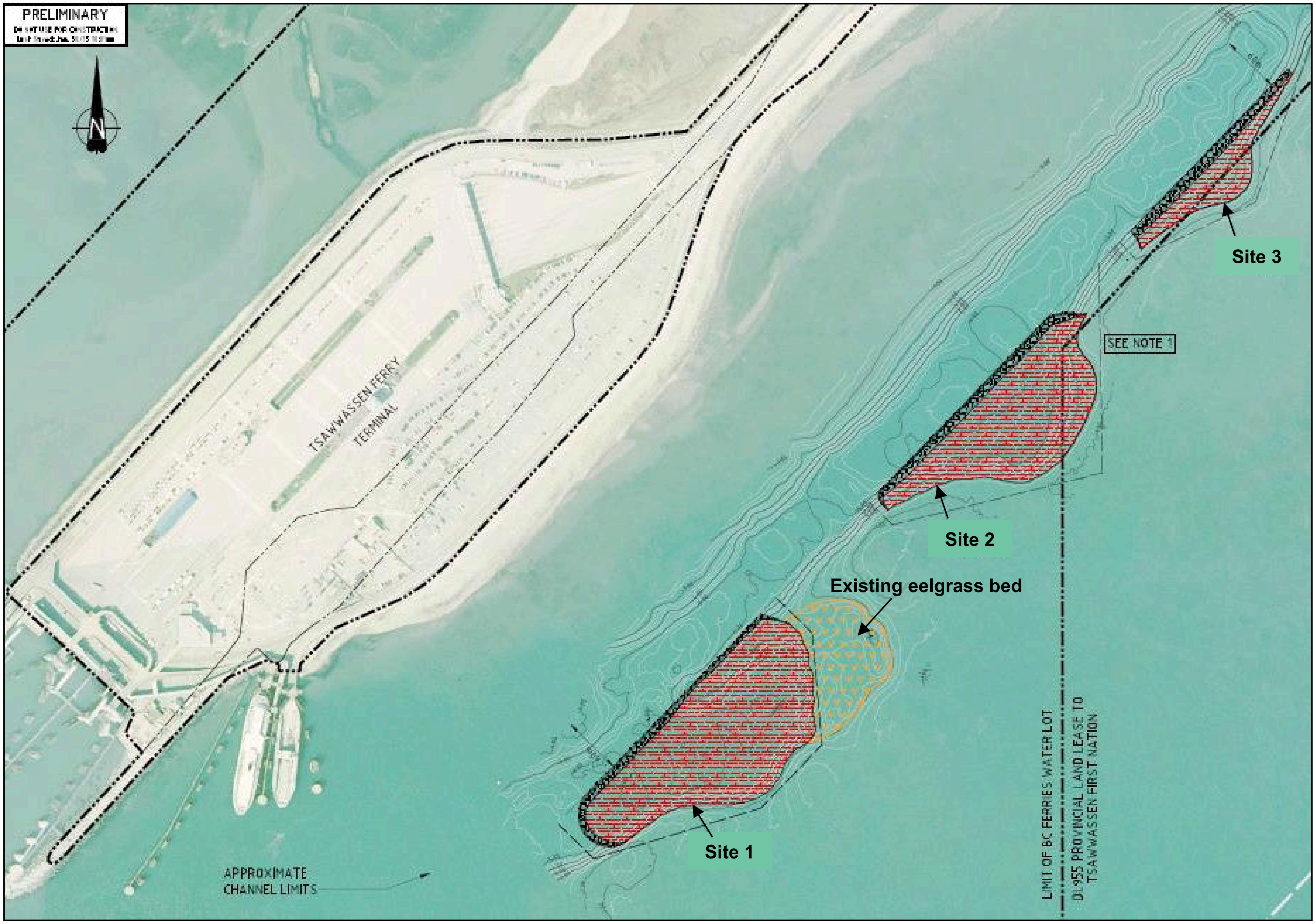

Figure 4 Proposed Tsawwassen Eelgrass Project sites (Moffatt & Nichol 2015)

4.0 BIOPHYSICAL CONDITIONS

Information related to the biophysical conditions of the proposed Project was obtained from the following sources:

- Online Sensitive Habitat Inventory and Mapping (SHIM 2013);
- Online Fraser River Estuary Management Program (FREMP) and Burrard Inlet Environmental Action Program (BIEAP) Habitat Atlas (FREMP 2013);
- Online Fisheries Information Summary System (FISS 2013);
- Online E-Fauna B.C. database (Klinkenberg 2013);
- Online B.C. Species and Ecosystems Explorer (B.C. Ministry of Environment 2013);
- Online iMap database (iMap 2013); and
- Field studies and site visits conducted by Precision Identification (2013; **Appendix A**) and Hemmera (2015, **Appendix B**).

4.1 GENERAL SITE DESCRIPTION

The proposed Project falls within the Fraser Lowland Ecosection (FRL) of the Lower Mainland Ecoregion (http://www.env.gov.bc.ca/ecology/ecoregions/humidtemp.html). The FRL consists of the Fraser delta, estuary, lowlands, and associated uplands and was formed primarily by deposition from the Fraser River. The Coastal Douglas-fir Moist Maritime (CDFmm) biogeoclimatic subzone occupies upland and terrestrial areas near the proposed Project (**Figure 5**; SHIM 2013, Government of B.C. 2012). The CDFmm subzone is limited to the south coast of British Columbia, including only a narrow strip of the Lower Mainland (Nuszdorfer et al. 1991).

The proposed Project is adjacent to the Roberts Bank Wildlife Management Area (WMA), an 8,770 ha area that is protected under Section 4 of the B.C. *Wildlife Act* (BC FLNRO 2015, **Figure 6**). This WMA was designated in 2011 for the conservation of critical, internationally significant habitat for waterfowl, shorebird, and raptor populations, as well for as the preservation of important fish habitats (BC FLNRO 2015).

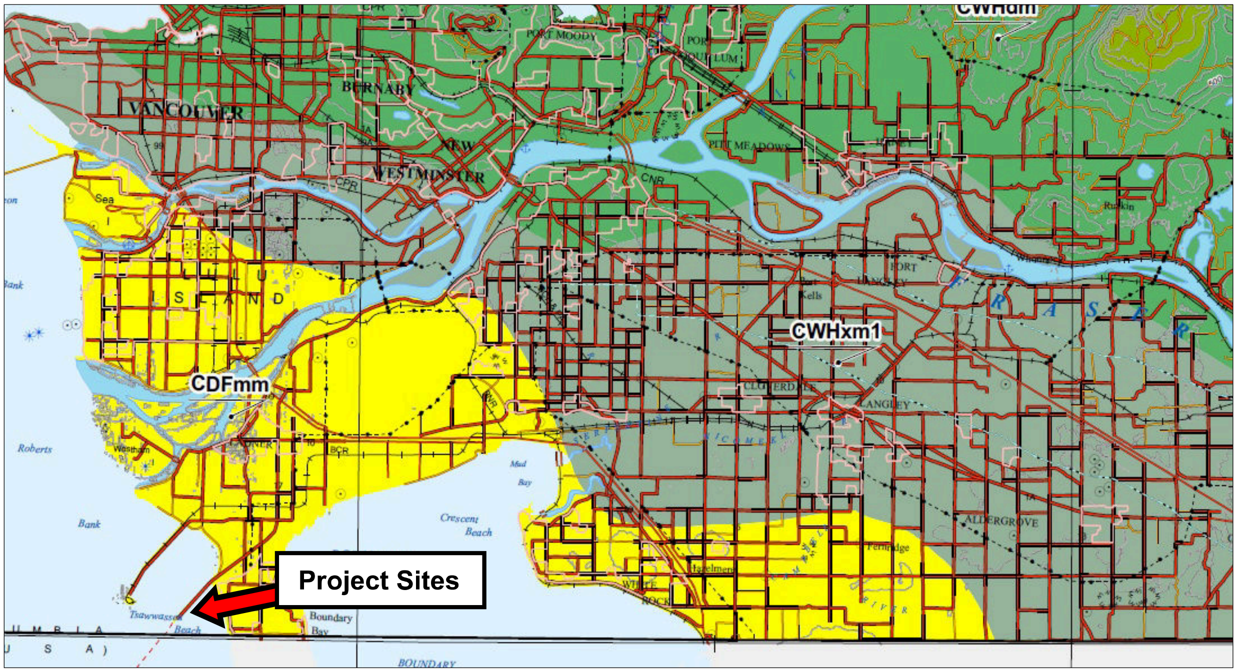

Figure 5 Biogeoclimatic Subzones of Metro Vancouver with Project Location (Government of B.C. 2012)

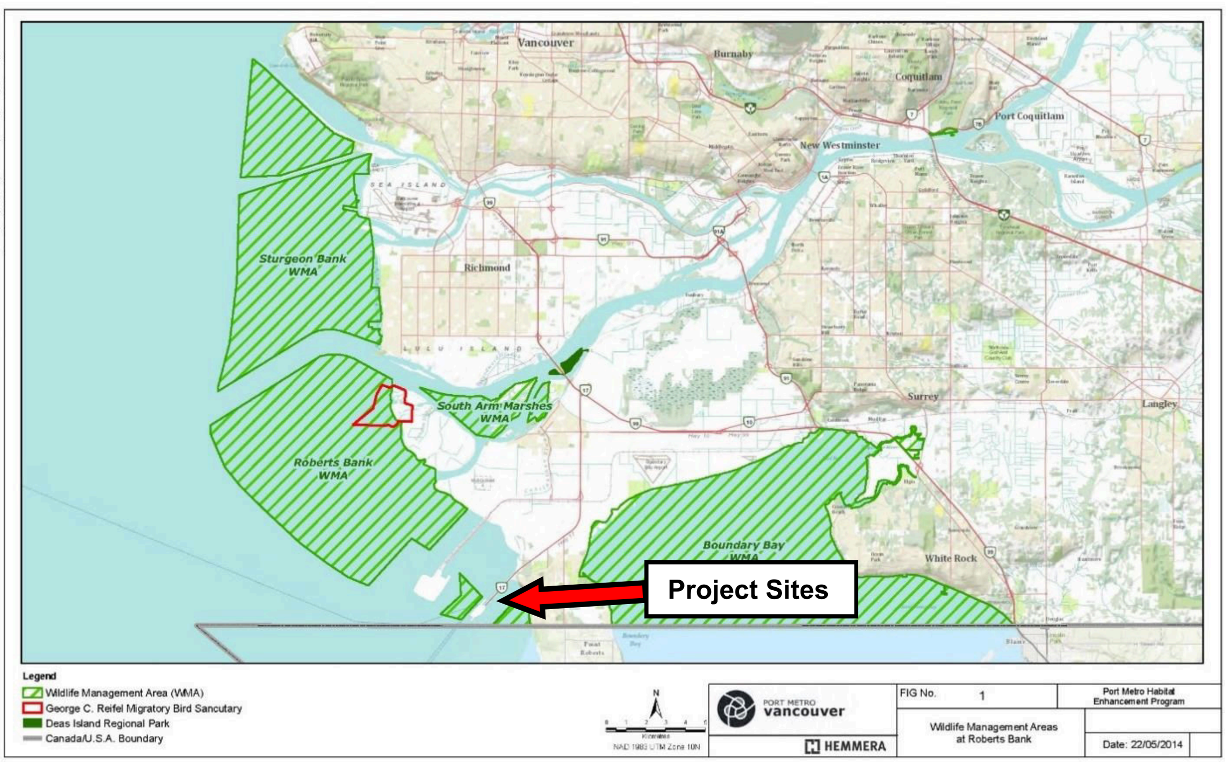

Figure 6 Roberts Bank Wildlife Management Area in Relation to the Proposed Project

4.2 HABITAT CLASSIFICATION

FREMP classifies shorelines within the Fraser River estuary on the basis of the relative values of their habitat features (FREMP 2002). The classification system was created from an inventory of habitat types in the estuary, including features such as mudflats, marshes, and riparian habitats. Although FREMP no longer exists, the coding still provides useful guidance on the condition and relative value of the existing shoreline habitats. FREMP (2002) habitat classifications include:

- Red (High Productivity): includes productive and diverse habitat features that support critical fish and wildlife functions on-site or as part of a more regional context and/or areas where habitat compensation has been previously constructed to offset habitat losses.
- Yellow (Moderate Productivity): habitats include habitat features that are of moderate value in structure or diversity due to existing conditions (e.g., surrounding land uses or productivity) and support moderate fish and wildlife functions.
- Green (Low Productivity): habitats include areas where habitat features and functions are limited due to existing conditions (e.g., developed for port or other urbanized uses).

The shoreline close to the proposed Project (along the Tsawwassen Ferry Terminal causeway) is coded Red, indicating that this is a highly productive habitat (**Figure 7**). As FREMP did not inclulde subtidal habitat classifications, the Project is not classified. The proposed enhancement will not affect the FREMP coding for the nearby shoreline and will ultimately enhance local productivity.

Figure 7 FREMP Habitat Classification nearby the Project, Delta, BC

4.3 Field Assessment Methods

4.3.1 Sites 1 and 2

In 2013 Precision Identification conducted a biophysical survey via SCUBA of site 1 and 2 of the proposed Project. A meandering survey of each site recorded flora, fauna, and sediment information. One diver operated a high definition digital video camera and collected sample footage of the benthos and habitat variations. A second diver with a digital still camera observed fish, benthic organisms, and fish habitat. A vessel tender approximated the positions of the divers within the area surveyed using a GPS unit. The diver's notes and information from the video were used to rank the relative abundance of each species (**Appendix A: Precision Identification Report, Section 2.1.1**).

4.3.2 Site 3

A biophysical survey of Site 3 was conducted by Hemmera in early 2015 (**Appendix B: Tsawwassen Site 3 Eelgrass Field Reconnaissance Report**). SCUBA surveys were conducted along two, 60 m transects and extended from within Site 3 to adjacent eelgrass beds to characterise conditions within and adjacent to the proposed enhancement site. Survey methods consisted of sampling a 1.0 m^2 quadrat every five metres for:

- Eelgrass presence, density, morphological features;
- Substrate conditions; and,
- The presence of other marine life.

One sediment sample was taken along each transect and analysed for sediment grain size (**Appendix B, Section 3.0**).

4.4 Existing Conditions

4.4.1 Site 1 Observations

The subtidal depression at Site 1 ranges from approximately -5.0 m to -6.0 m chart datum (CD). A dive survey indicated that the biophysical attributes at Site 1 are relatively homogenous (**Appendix A**). Sediments consisted of a range from sand to sandy silt. Near the northeastern edge of the basin, adjacent to the fill area for the BCTC compensation site from 2008, an area of sand with coarse gravel and pebbles was noted (**Appendix A: Section 2.1.2.1**).

Drift macroalgae and eelgrass (*Zostera marina*) detritus were noted. The only vegetation observed at the site was a thin layer of microalgae (diatoms) covering surface sediments.

Several species of marine invertebrates were observed including: white-spotted dendronotid (*Dendronotus albopunctatus*), opalescent nudibranch (*Hermissenda crassicornis*), unidentified tube worms, burrowing brittle star (*Amphiodia sp.*), *Mysiid* shrimp and orange sea pen (*Ptilosarcus gurnyeii*) (southwest corner of the site). There was also an abundance of mounded burrow openings typical of the bay ghost shrimp (*Neotrypea californiensis*). A full list of the species observed, including a summary of their relative abundance, is provided in **Appendix A: Section 2.1.2.1**, **Table 2**.

During the dive survey a few small sculpin (unknown species) were observed, while no wildlife species were observed. For a discussion of common and listed fish species with the potential to occur at this site please refer to **Section 4.4.4**. For a discussion of common and listed wildlife species with potential to occur at or near the proposed Project, see **Section 4.4.5**.

4.4.2 Site 2 Observations

The subtidal basin at Site 2 ranged from approximately -5.0 m to -6.0 m CD. This site was characterized similarly to Site 1, with biophysical attributes being fairly homogenous. Sediments observed ranged from sand to sandy silt. Accumulations of drift macroalgae and eelgrass detritus were observed. A thin layer of diatoms covering sediment was the only vegetation present at the site.

Several species of marine invertebrates were observed at lower abundances (rare to few), while the same commonly or abundantly encountered species as Site 1 were also noted. For a full list of species observed refer to **Appendix A: Section 2.1.2.1**, **Table 3**.

No fish or wildlife species were observed at Site 2 during dive surveys. For a discussion of common and listed fish species with the potential to occur at this site please refer to **Section 4.4.4**. For a discussion of common and listed wildlife species with potential to occur at or near the proposed Project, see **Section 4.4.5**.

The observations from the Site 1 and Site 2 dive surveys indicate that these sites consist primarily of unproductive subtidal habitat that does not appear to provide any significant fisheries habitat value (**Appendix A**).

4.4.3 Site 3 Observations

The existing base of Site 3 ranges from approximately -4.0 m to -6.0 m CD. Biophysical attributes were noted as being relatively homogenous. Sediments were mainly silty substrate (observed to be below -4.0 m CD). Moving east up the slope, sediments were composed primarily of sand and silt, becoming progressively sandier as the transect approached 0 m CD (**Appendix B: Section 4.0**). Lab data from analysis of the two sediment samples is presented in **Table A**.

Table A Summary of Site 3 Sediment Sample Particle Size Analysis

Sample ID[1]	Transect	Sample Location	Distance (m)	Depth (m CD)	Sediment Classification		
					Clay (%)	Sand (%)	Silt (%)
3 B	1	In proposed enhancement area	10	-2.0	5.3	95	<2
3 A	2	Adjacent to proposed enhancement area	0	-4.2	9.3	74	17

Notes: [1]Refer to Appendix B: Figure 2 for sediment sample locations

Aside from native eelgrass detritus (**Photo 1**), which was widely distributed over the bottom of the dredge basin, no vegetation was noted during dive surveys. A large sandflat populated with native eelgrass is located southeast of the site at elevations between -1.4 m to 0.0 m CD (**Photo 2**). A continuous bed of eelgrass was present beginning at approximately -1.4 m CD depths.

A single juvenile common sunstar (*Crossaster papposus*) was observed at Site 3. Site 3 dive survey transects extended from within Site 3 into adjacent eelgrass beds, in order to characterize conditions within and adjacent to the proposed site (**Appendix B: Section 3.0**). Marine life common to the adjacent eelgrass bed included: Dungeness crab (*Metacarcinus magister*), green anemone (*Pharamachus sp.*), eelgrass limpet (*Lottia alveus*), hooded nudibranch (*Melibe leonina*) and a high abundance of bivalve shells **(Appendix B: Section 4.0**).

A smoothhead sculpin (*Artedius lateralis*) was observed in the eelgrass bed adjacent to Site 3, while no wildlife species were observed. For a discussion of common and listed fish species with the potential to occur at this site please refer to **Section 4.4.4**. For a discussion of common and listed wildlife species with potential to occur at or near the proposed Project, see **Section 4.4.5**.

Similar to Sites 1 and 2, the depression at Site 3 appears to be both limiting eelgrass expansion and acting as a sink for detritus, lowering its overall productivity and not providing significant fisheries habitat value. The adjacent eelgrass bed is very productive and provides significant habitat values for fisheries species. The biophysical characteristics of the neighboring eelgrass bed indicate the viability of eelgrass enhancement opportunities if suitable elevations, slope and sediment type can be established at Site 3 (**Appendix B: Section 5.0**)

Photo 1 Dense Eelgrass Detritus Along Transect 1 in Proposed Site 3

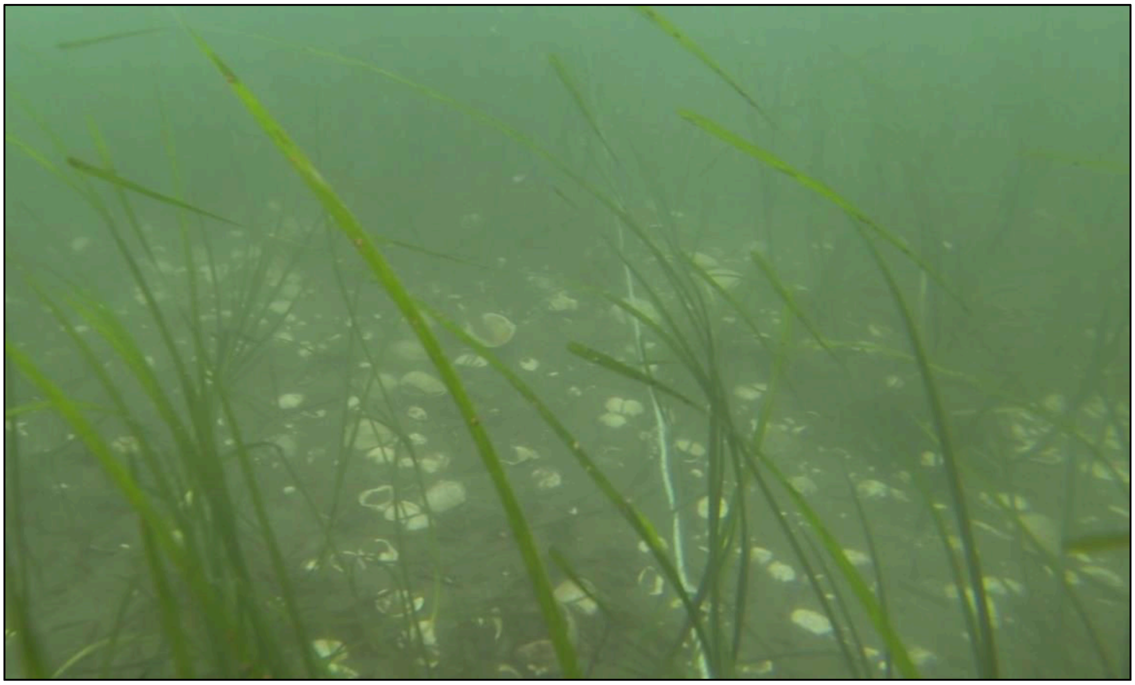

Photo 2 Eelgrass with Shells on Sandy Bottom Substrate Adjacent to Proposed Site 3

4.4.4 Potential Fish and Invertebrate Species Use

The South Arm of the Fraser River is an important fish migration route including ecologically and economically important salmonids. For example, the valuable juvenile Harrison-run Chinook salmon (*Oncorhynchus tshawytshca*) rear in the lower Fraser River (DFO 1999). Coho (*O. kisutch*), chum (*O. keta*), pink (*O. gorbuscha*), and sockeye salmon (*O. nerka*), cutthroat trout (*O. clarkii*), Dolly Varden char (*Salvelinus malma miyabei*) and steelhead trout (*O. mykiss*) all occur in the Fraser River (SHIM 2012).

The proposed Project is also accessible to freshwater-tolerant marine fish species from the Strait of Georgia. An inventory of the fish species present at Roberts Bank indicates the area is used by a wide range of species, including flatfish, rockfish, lingcod (*Ophiodon elongatus*), spiny dogfish (*Squalus acanthias*), gobies, sculpins, perch, and forage fish such as Pacific herring (*Clupea pallasii*) and Pacific sandlance (*Ammodytes hexapterus*) (Precision Identification 2007). The most common fish species in sand/mudflat habitats are flatfish (English sole (*Parophrys vetulus*); Pacific sanddab (*Citharichthys sordidus*), rock sole (*Lepidopsetta petraborealis*), starry flounder (*Platichthys stellatus*)) and Pacific sandlance (Archipelago 2013).

While very few fish species were observed during dive surveys, species that prefer sand and mudflat habitats, such as starry flounder and Pacific sandlance, likely utilize the proposed Project area.

Several listed marine and freshwater fish species occur regionally within Metro Vancouver (BC Ministry of Environment 2013; **Table B**). The potential of these species to occur at or near the proposed Project and the effect the proposed works will have on these species is provided in **Table B**.

Several commercially important species are known to occur or are likely to occur in and around the proposed project sites: Dungeness crab, slender crab (*Metacarcinus gracilis*), Manila, littleneck and butter clam, and cockle (BCTC 2006, **Appendix A**). Scallops (Pectinidae) and geoducks (*Panopea generosa*) are harvestable species that have the potential to occur at or nearby the proposed Project, but were not observed during field surveys. All three sites fall within DFO Fisheries Management Area 29-7 which is subject to a complete harvest ban on shellfish for any reason as well as a ban on crab-fishing adjacent to the Tsawwassen Ferry Terminal (DFO 2015). The Project Sites consists primarily of low productivity subtidal habitat that does not appear to provide significant fisheries habitat value (**Appendix A 2013**).

Table B Listed Fish Species with the Potential to Occur Near the Project Sites (BC Ministry of Environment 2013)

Scientific Name	English Name	Provincial Listing[1]	SARA[2]	COSEWIC[3]	Comments	Potential to Occur Post-Enhancement
Acipenser medirostris	green sturgeon	Red	1-SC (2006)	SC (1987)	Habitat preferences are poorly understood, but it is unlikely these fish would use the Project Site as they are primarily observed in marine waters off the BC coast.	Unlikely to be affected by habitat enhancement.
Acipenser transmontanus	white sturgeon - Lower Fraser River population	Red	Not listed	T (2012)	Have been observed near the proposed Project Site and juveniles, which prefer shallow water depths, could potentially use the mudflat or marsh habitats at the Project Site. Known to occur in the South Arm of the Fraser River (iMap 2013)	Unlikely to be affected by habitat enhancement.
Oncorhynchus clarkii clarkii	cutthroat trout, *clarkii* subspecies	Blue	Not listed	Not listed	May forage in eelgrass or along habitat edges near the Project Site.	Additional eelgrass would provide habitat for prey species.
Oncorhynchus kisutch	Coho salmon	Blue	Not listed	Not listed	Juveniles may rear in eelgrass habitats adjacent to the project sites. May forage in eelgrass or along habitat edges near the Project Site.	Additional eelgrass would provide rearing habitat and habitat for prey species.

Notes: [1] Red = Endangered or Threatened, Blue = Special Concern
[2] Schedule 1 = federal species at risk
[3] E = Endangered, T = Threatened, SC = Special Concern

4.4.5 Potential Wildlife Species

While no wildlife species were noted at the proposed Project during dive surveys, the Fraser River estuary is recognized as a key stop-over and wintering area for millions of migratory waterfowl and shorebirds (BC FLNRO 2015, Butler and Campbell 1987, WHSRN 2005) and numerous resident species. It is likely that some of these species utilize the proposed Project area and, more broadly, Roberts Bank. Species representative of the CDFmm zone within estuaries, shallow bays, intertidal and sub-tidal marine ecosystems that have the potential to use the proposed Project area are listed in **Table C** (adapted from Table 11 of Nuszdorfer et al. 1991).

Table C Common Wildlife Species within Estuaries, Shallow Bays, Intertidal and Sub-tidal Marine Ecosystems with the Potential to Use the Project (Nuszdorfer et al. 1991)

Taxa	Representative Wildlife Species Most Likely to Occur
Mammals	River Otter (*Lontra canadensis*), Stellar Sea Lion (*Eumetopias jubatus*), Harbour Seal (*Phoca vitulina*), Harbour Porpoise (*Phocoena phocoena*)
Birds	Red-throated Loon (*Gavia stellate*), Yellow-billed Loon (*Gavia adamsii*), Trumpeter Swan (*Cygnus buccinators*), Canada Goose (*Branta canadensis*), Brant (*Branta bernicla*), Barrow's Goldeneye (*Bucephala islandica*), Black Scoter (*Melanitta americana*), Surf Scoter (*Melanitta perspicillata*), White-winged Scoter (*Melanitta deglandi*), Mallard (*Anas platyrhynchos*), Northern Shoveller (*Anas clypeata*), American Wigeon (*Anas americana*), Lesser Scaup (*Aythya affinis*), Green-winged Teal (*Anas carolinensis*), Pigeon Guillemot (*Cepphus Columba*), Glaucous-winged Gull (*Larus glaucescens*), California Gull (*Larus californicus*), Northwestern Crow (*Corvus caurinus*), Bald Eagle (*Haliaeetus leucocephalus*), Great Blue Heron (*Ardea herodias*)

In addition to the species listed in Table C, bird species identified by VITR (BCTC 2007) as common in the Tsawwassen area include:

- **Loons**: Red-throated loons (year round; most abundance in May), common loons (*Gavia immer*; winter), Pacific loons (*Gavia pacifica*; winter), western grebes (*Aechmophorus occidentalis*; late summer and early fall), horned grebes (*Podiceps auritus*; October to April), and pied-billed grebes (*Podilymbus podiceps*; winter).
- **Cormorants**: Double-crested cormorants (*Phalacrocorax auritus*; colonies near Deltaport; most abundant October to May), Brandt's cormorant (*Phalacrocorax penicillatus*; winter) and pelagic cormorants (*Phalacrocorax pelagicus*; colony near Deltaport).
- **Waders**: Great blue heron (four known colonies in the vicinity of the Sites – Point Roberts, south of the Tsawwassen Ferry Terminal, Nicomekl River and Serpentine Slough – currently they only occur in the vicinity of the Sites around Roberts Bank and the Tsawwassen terminal).
- **Geese and Swans**: Trumpeter swans (October to March, prefer intertidal areas), tundra swans (*Cygnus columbianus*; common to uncommon, winter), lesser snow geese (*Chen caerulescens*; fall to winter on outer banks), brant geese (*Branta bernicla*; spring stopover; some overwintering; peak mid-March to early May; sandy beaches and eelgrass beds), greater white-fronted geese (*Anser albifrons*; transient, spring and fall), and Canada geese (*Branta canadensis*; common).

- **Dabbling Ducks**: Twelve species of dabbling duck occur near Tsawwassen. The majority are comprised of: American wigeon, northern pintail (*Anas acuta*) and mallard. Others include green-winged teal, northern shoveller, cinnamon teal (*Anas cyanoptera*), and gadwall (*Anas strepera*). The ducks feed at or near the water's surface on invertebrates, seeds and other plant material. They are most abundant from September to December, and would likely use the area surrounding the Sites at low tide.
- **Diving Ducks**: Harlequin ducks (*Histrionicus histrionicus*), white-winged scoters, common goldeneye (*Bucephala clangula*), greater scaup (*Aythya marila*), common merganser, Barrow's goldeneye, lesser scaup, canvasback (*Aythya valisineria*), and ruddy duck (*Oxyura jamaicensis*). Diving ducks usually loaf and feed along rocky shorelines. They dive to access aquatic plants, fish, shellfish and other molluscs. They are present between October and May. Surf scoter and bufflehead are the most common ducks in the Tsawwassen area.
- **Gulls and Terns**: Glaucous-winged gull, mew gull (*Larus canus*), ring-billed gull (*Larus delawarensis*), herring gull (*Larus argentatus*), Bonaparte's gull (*Chroicocephalus philadelphia*) and Caspian tern (*Hydroprogne caspia*) are present at and around the Sites. Gulls are most abundant between June and October.
- **Alcids**: Year-round off the coast of BC. Common murres (*Uria aalge*) and marbled murrelets (*Brachyramphus marmoratus*) have been observed off Roberts Bank, but their important wintering habitat is the Strait of Georgia. The pigeon guillemot is common in the region. None of these species are likely to use the Sites.
- **Shorebirds**: Numerous species of shorebird migrate through the Fraser River Estuary, foraging on sand/mudflats and in the rocky intertidal zone. While shorebirds extensively use Roberts Bank and Boundary Bay, the proposed Project and surrounding eelgrass beds would not be accessible to shorebirds due to depth.

Due to the subtidal nature of the site, marine mammals have the potential to use the proposed Project area. Harbour seals (*Phoca vitulina*) are abundant in the Strait of Georgia and are resident year round, while California and Stellar sea lions (*Zalophus californianus and Eumetopias jubatus*) arrive in the fall and depart in the spring (Keple 2002). All three species may utilize the area. Harbour porpoises are present year-round in the Strait of Georgia, usually in shallow inshore waters, and have been observed in the Fraser River and in shallow water (<100m) near the Tsawwassen Ferry Terminal (BCTC 2006).

Southern resident killer whale (*Orcinus orca*) (SRKW) are listed in Schedule 1 of the Species at Risk Act (SARA) and are considered endangered. SRKW are at risk because of their population size, low reproductive rate and anthropogenic threats such as environmental contamination, reductions in prey availability and physical/acoustic disturbances.

During summer and fall, SRKW are primarily found in the trans-boundary waters of Haro Strait, Boundary Pass, the Strait of Juan de Fuca, and southern portions of the Strait of Georgia. This area is designated as 'critical habitat' based on consistent and prolonged seasonal occupancy. During summer and fall, the principal prey of SRKW appears to be chinook and chum salmon (*Oncorhynchus tshawytscha* and *O. keta*). At present, use of the proposed Project sites by SRKW would be low as depths are shallow and preferred prey species are not common in the small habitat patches. Habitats such as eelgrass beds, which support forage fish rearing and spawning, and rearing by juvenile salmonids, could in turn benefit the preferred prey of SRKW.

The subtidal nature of the proposed Project sites precludes site use by listed terrestrial wildlife species that commonly occur in the CDFmm. **Table D** indicates listed wildlife species that have been identified as potentially occurring at or near the proposed Project. None of the listed species are dependent on the proposed Project or expected to be adversely affected by the project and a net overall benefit is expected for some of the species.

Table D Listed Wildlife Species with a Potential to Occur at the Project Site (BC Ministry of Environment 2013)

Scientific Name	English Name	Provincial Listing[1]	SARA Schedule[2]	COSEWIC[3]	Potential to Occur Comments[4]
Birds					
Ardea herodias fannini	Great Blue Heron, *fannini* subspecies	Blue	1-SC (Feb 2010)	SC (Mar 2008)	Species forage for fish near Project Sites; roost nearby at Reifel Bird Sanctuary; nearest nesting colony is ~10km away at Point Roberts
Phalacrocorax auritus	Double-crested Cormorant	Blue	Not listed	NAR (May 1978)	May forage for fish at site; between fishing it often spends time perched on man-made structures over or near water
Phalacrocorax pelagicus pelagicus	Pelagic cormorant	Red	Not listed	Not listed	Kelp beds (foraging) and rocky cliffs (nesting, roosting); Marine intertidal and subtidal; sheltered waters. Foraging opportunities at and near the project sites.
Phalacrocorax penicillatus	Brandt's cormorant	Red	Not listed	Not listed	Kelp beds (foraging) and rocky cliffs (nesting, roosting); Marine intertidal and subtidal; sheltered waters. Foraging opportunities at and near the project sites.
Hydroprogne caspia	Caspian Tern	Blue	Not listed	NAR (May 1999)	May forage at Project Site
Brachyramphus marmoratus	Marbled Murrelet	Blue	1-T (Jun 2003)	T (May 2012)	May forage for fish at Project Site
Falco peregrinus anatum	Peregrine Falcon, *anatum* subspecies	Red	1-SC (Jun 2012)	SC (Apr 2007)	May forage for birds over Project Site
Hirundo rustica	Barn Swallow	Blue	Not listed	T (May 2011)	May forage for flying insects over Project Site; nest under man made coverings close to a source of mud which is used to construct their nests
Progne subis	Purple Martin	Blue	Not listed	Not listed	May be found foraging flying insects over Project Site
Melanitta perspicillata	Surf Scoter	Blue	Not listed	Not listed	Forage near and at project sites.
Uria lomvia	Thick-billed Mure	Red	Not listed	Not listed	Forage near and at project sites.
Aechmophorus occidentalis	Western Grebe	Red	SC (May 2014)	Not listed	Forage near and at project sites.
Gavia adamsii	Yellow-billed Loon	Blue	NAR (May 1997)	Not listed	Forage near and at project sites.

Scientific Name	English Name	Provincial Listing[1]	SARA Schedule[2]	COSEWIC[3]	Potential to Occur Comments[4]
Branta bernicla	Brant goose	Blue	Not listed	Not listed	Season use of Roberts Bank. Forage on eelgrass and will likely used the project sites upon completion of enhancement.
Mammals					
Eschrichtius robustus	Grey whale	Blue	1-SC (2005)	SC (2004)	Migratory. Feed in benthic habitats in Strait of Georgia during spring migration.
Phocoena phocoena	Harbour porpoise	Blue	1-SC (2005)	SC (2003)	Preys on forage fish in bays and estuaries.
Megaptera novaeangliae	Humpback whale	Blue	1-T (2005)	SC (2011)	Migratory. Feed on forage fish and crustaceans in Strait of Georgia during spring migration.
Orcinus orca pop. 5	Killer whale (Northeast Pacific southern resident population)	Red	1-E (2003)	E (2008)	Project occurs in SRKW critical habitat. SRKW are observed near Roberts Bank seasonally.
Eumetopias jubatus	Steller sea lion	Blue	1-SC (2005)	SC (2013)	The only *SARA*-listed pinniped species that occurs in the Fraser River estuary. Steller sea lions prefer to haul-out on secluded rocky islands and rocky ledges. May forage at the Project sites

Notes
1 Red = Endangered or Threatened, Blue = Special Concern
2 Schedule 1 = federal species at risk
3 T = Threatened, SC = Special Concern, NAR = Not at Risk
4 Species information was taken from The Birds of North American Online 2013 and E-Fauna BC 2013

4.5 Post-Enhancement Conditions

Following the proposed enhancement works at sites 1, 2, and 3 the unvegetated subtidal habitats, which now function as sinks for large volumes of eelgrass detritus, will be converted to approximately 4.8 ha of productive eelgrass habitat. The previous success of the eelgrass transplants constructed for the VITR Project in close proximity to Site 1 and 3, and the existing extensive eelgrass meadows surrounding Site 3 suggest that, given careful sediment placement and adequate engineering considerations to prevent erosion these Sites are ideal for eelgrass habitat enhancement.

Establishment of eelgrass habitat will increase the primary productivity of the Sites. This contribution to the estuarine detritus-based food web will result in increased production of forage and prey items for fish and wildlife species.

Alteration of the existing habitat at the three sites would significantly enhance the fisheries value of the sites by improving habitat complexity and productivity, allowing for rapid colonization by fish and invertebrate species from adjacent eelgrass beds. The proposed works will also increase the availability of critical habitat for commercially, culturally and ecologically important species including out-migrating juvenile salmon (*Oncorhynchus* spp.), Pacific herring (*Clupea harengus*) and Dungeness crab. For example, eelgrass provides an excellent spawning medium for Pacific herring that attach their eggs to submergent vegetation.

The improved fisheries habitat value and increased productivity associated with construction of eelgrass beds at the proposed Project Site will have a positive effect on habitat values for many fish eating bird species, such as double-crested cormorant and loons, and particularly for eelgrass-associated species such as Brant geese. Other common bird species will not be negatively affected by eelgrass enhancement.

The Project sites occur within SRKW Critical Habitat, although habitat utilization at the proposed Project sites would be low. Use of the Project Site by SRKW will not be negatively affected by proposed enhancement works and increased habitat productivity for forage fish species will potentially benefit SRKW prey species.

5.0 CONCLUSION

The proposed Project will create high-value eelgrass habitat that will provide long-term benefits for fish and invertebrates that depend upon eelgrass beds for nursery/rearing habitat, along with other fish and wildlife species such as waterfowl and diving birds.

Expansion of the eelgrass habitat will contribute to the following ecological functions:

- Increasing primary productivity;
- Supplementing the detritus based food web;
- Creating intertidal habitat for benthic and drift invertebrates that are important prey items for juvenile salmonids and other fishes;
- Providing intertidal and subtidal vegetation cover and refuge for juvenile salmonids and rockfish species, as they utilize shoreline habitats prior to out-migrating;
- Increasing the habitat diversity of the area by converting relatively bare subtidal habitat into eelgrass habitat; and
- Creating habitat for waterfowl feeding, nesting, loafing, and refuge

We sincerely appreciate the opportunity to have assisted you with this project and if there are any questions, please do not hesitate to contact the undersigned.

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7.0 STATEMENT OF LIMITATIONS

This report was prepared by Hemmera Envirochem Inc. ("Hemmera"), based on fieldwork and/or research conducted by Hemmera, for the sole benefit and exclusive use of Port Metro Vancouver. The material in it reflects Hemmera's best judgment in light of the information available to it at the time of preparing this Report. Any use that a third party makes of this Report, or any reliance on or decision made based on it, is the responsibility of such third parties. Hemmera accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions taken based on this Report.

Hemmera has performed the work as described above and made the findings and conclusions set out in this Report in a manner consistent with the level of care and skill normally exercised by members of the environmental science profession practicing under similar conditions at the time the work was performed.

This Report represents a reasonable review of the information available to Hemmera within the established Scope, work schedule and budgetary constraints. The conclusions and recommendations contained in this Report are based upon applicable legislation existing at the time the Report was drafted. Any changes in the legislation may alter the conclusions and/or recommendations contained in the Report. Regulatory implications discussed in this Report were based on the applicable legislation existing at the time this Report was written.

In preparing this Report, Hemmera has relied in good faith on information provided by others as noted in this Report and has assumed that the information provided by those individuals is both factual and accurate. Hemmera accepts no responsibility for any deficiency, misstatement or inaccuracy in this Report resulting from the information provided by those individuals.

The liability of Hemmera to Port Metro Vancouver shall be limited to injury or loss caused by the negligent acts of Hemmera. The total aggregate liability of Hemmera related to this agreement shall not exceed the lesser of the actual damages incurred, or the total fee of Hemmera for services rendered on this project.

APPENDIX A

Precision Identification Report

Port Metro Vancouver

Habitat Enhancement Program

Assessment of Potential Eelgrass Transplant Sites

Tsawwassen, Delta

April 2013

Revised April 2015

Prepared for: Port Metro Vancouver
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COVER PHOTOGRAPHS (TOP TO BOTTOM): BARE SEDIMENT PRIOR TO EELGRASS TRANSPLANT, RECENTLY PLANTED EELGRASS, EELGRASS AND ASSOCIATED FAUNA IN TRANSPLANTED EELGRASS HABITAT.

1.0 INTRODUCTION

Port Metro Vancouver is considering constructing eelgrass (*Zostera marina*) habitat as part of their habitat enhancement program. Two areas have been identified in Tsawwassen as potential sites that could, following physical modifications, support eelgrass and greatly enhance the local fisheries habitat value.

Biophysical surveys of each site were conducted to determine their current fisheries habitat value. A summary of the results from these surveys is provided in the following report.

2.0 Site Assessments

The locations of the potential eelgrass enhancement sites in Tsawwassen are shown in Figure 1.

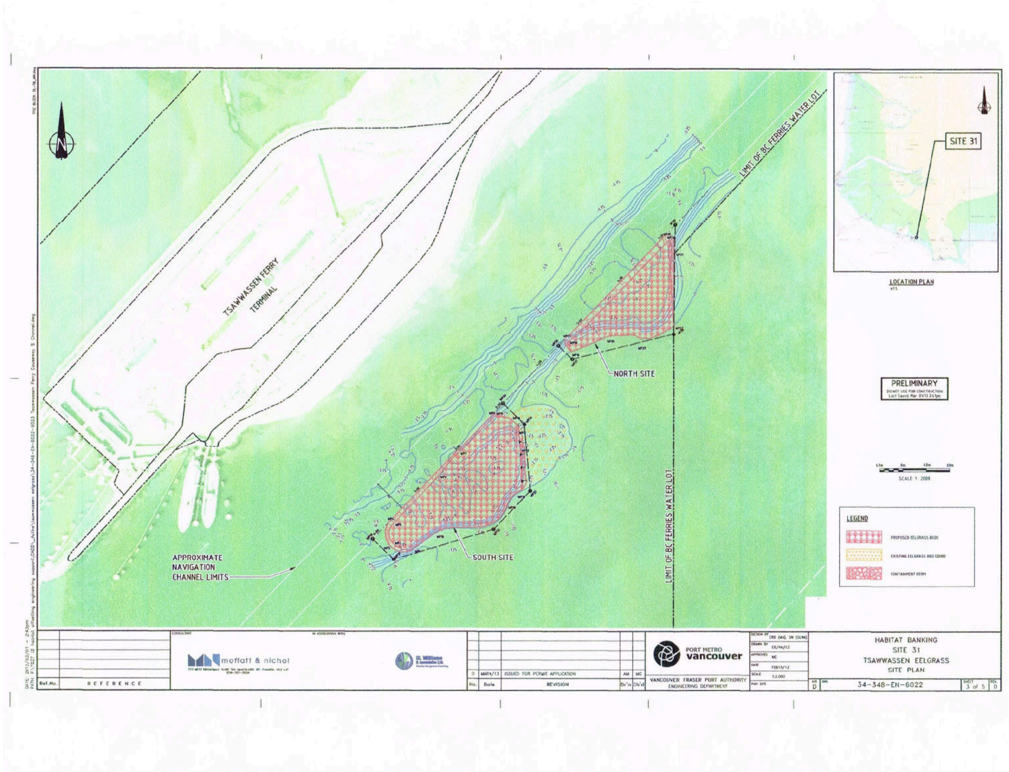

Figure 1. The sites at Tsawwassen that could be modified to support eelgrass.

2.1.1 Methods

A GPS and depth sounder were used to locate the sites. The SCUBA team conducted a meandering survey of each site recording flora, fauna, and sediment information. One diver operated a high definition digital video camera and collected sample footage of the benthos and habitat variations. A second diver with a digital still camera looked for fish, benthic organisms, and fish habitat. Divers were equipped with float lines to the surface. Float lines to the surface were 15 m long and allowed a tender vessel to follow the divers and collect GPS determined positions of the divers within the area surveyed. The boat operator collecting GPS positions attempted to compensate for slackness in the line, wind, and currents driving the diver's surface marker float away from the actual position of the diver.

A figure showing the path that the divers followed is provided in Appendix 1.

The video imagery was reviewed following the survey to search for any additional details or species that were not noted during the dive. The diver’s notes and information from the video were used to rank the relative abundance of each species (Table 1).

The diver's depth gauge measurements minus the estimated height of the tide at the time during the survey matched the bathymetry.

Table 1. Relative abundance scale.

Abundance	Definition
rare	observed only one or two times
few	observed three to seven times
common	observed eight to twenty times
abundant	observed more than twenty times

2.1.2 Results

The sites were surveyed on April 12, 2013.

2.1.2.1 South Site

The biophysical attributes of the South Site were fairly homogenous. The sediment within the proposed enhancement areas ranged from sand to sandy silt. An area of sand with some coarse gravel and pebbles was encountered at a point along the edge of the area filled to create a platform for eelgrass in 2008. This area appears to be subject to high currents that may be removing sand and fine sediments (1 to 10 cm depth) placed in the created eelgrass platform.

Sunken logs were not observed during the dives.

A dense bed of sea pens was encountered near the southwest corner of the site. A few small sculpins were observed. There was an abundance of burrowing brittle stars (cf. *Amphiodia* sp.) and mounded burrow openings typical of the bay ghost shrimp (*Neotrypea californiensis*).

Drift macroalgae and eelgrass detritus were noted however microalgae (diatoms) appeared to be the only plants that had established on the site.

A list of species observed and their relative abundance is provided in Table 2.

Table 2. Species observed at the South Site in Tsawwassen.

Genus	Species	Common Name	Relative abundance
COELENTERATES			
Halacampa	*decemtentaculata*	dwarf sand-dwelling anemone	rare
Metridium	*farcimen*	plumose anemone	few
Peachia	*quinquecapitata*	jelly-dwelling anemone	rare
Ptilosarcus	*gurneyi*	sea pen	abundant
MOLLUSCA			
Calliostoma	*sp.*	topsnail	few
Ceratostoma	*foliatum*	leafy hornmouth	rare
Evalea	*tenuisculpta*	Odostome snail	few
Clinocardium	*nuttallii*	Nuttall's cockle	rare
Tresus	*capax*	fat gaper clam	rare
Humalaria	*kennerleyi*	Kennerly's venus clam shell	few
Macoma	*nasuta*	bent-nose macoma shell	few
Saxidomus	*giganteus*	butter clam shell	few
Armina	*californica*	striped nudibranch	few
Dendronotus	*albopunctatus*	white-spotted dendronotid	abundant
Melibe	*leonina*	hooded nudibranch	few
Hermissenda	*crassicornis*	opalescent nudibranch	abundant
ANNELIDA			
Pista	*sp.*	spaghetti worm	few
Myxicola	*sp.*	funnel shaped polycheate	rare
sand worm tubes	-	unidentified tube worms	abundant
parchment worm tubes	-	unidentified tube worms	common
ARTHROPODA			
Mysiidacea	-	*Mysiid shrimp*	common
Balanus	*sp.*	barnacles on shells	common
Metacarcinus	*magister*	Dungeness crab	few
Pagurus	*ochotensis*	Alaskan hermit	few
ECHINODERMS			
Dermasterias	*imbricata*	leather star	few
Luidia	*foliolata*	sand star	few
Pisaster	*brevispinus*	pink star	few
Pycnopodia	*helianthoides*	sunflower star	few
Amphiodia	*sp.*	cf. burrowning brittle star	abundant

Photographs and video documenting the habitat at the South Site have been downloaded and are available upon request. A selection of the photographs taken at the South Site is provided below.

Photograph 1. A ten-tentacled burrowing anemone surrounded by a film of diatoms.

Photograph 2. A leather star roving the surface.

Photograph 3. Nuttall's cockle surrounded by tube worms.

2.1.2.2 North Site

The biophysical attributes of the North Site were also fairly homogenous. The sediment ranged from sand to sandy silt and was covered in most areas by a layer of diatoms. Logs were not observed during the dives. There was an abundance of mounded burrow openings typical of the bay ghost shrimp (*Neotrypea californiensis*).

Drift macroalgae and eelgrass were noted. A list of species observed and their relative abundance is provided in Table 3.

Table 3. Species observed at the North Site in Tsawwassen.

Genus	Species	Common Name	Relative abundance
COELENTERATES			
Halacampa	*decemtentaculata*	dwarf sand-dwelling anemone	rare
Metridium	*farcimen*	plumose anemone	few
Peachia	*quinquecapitata*	jelly-dwelling anemone	rare
Ptilosarcus	*gurneyi*	sea pen	common
MOLLUSCA			
Humalaria	*kennerleyi*	Kennerly's venus clam shell	few
Macoma	*nasuta*	bent-nose macoma shell	few
Saxidomus	*giganteus*	butter clam shell	few
Armina	*californica*	striped nudibranch	few
Dendronotus	*albopunctatus*	white-spotted dendronotid	abundant
Melibe	*leonina*	hooded nudibranch	few
Hermissenda	*crassicornis*	opalescent nudibranch	abundant
ANNELIDA			
Spiochaetopterus	*costarum*	jointed three-section tubeworm	common
sand worm tubes	-	unidentified tube worms	abundant
parchment worm tubes	-	unidentified tube worms	common
ARTHROPODA			
Mysiidacea	-	Mysiid shrimp	common
Balanus	*sp.*	barnacles on shells	common
Metacarcinus	*magister*	Dungeness crab	few
Pagurus	*ochotensis*	Alaskan hermit	few
ECHINODERMS			
Dermasterias	*imbricata*	leather star	few
Luidia	*foliolata*	sand star	few
Pisaster	*brevispinus*	pink star	few
Pycnopodia	*helianthoides*	sunflower star	few
Amphiodia	*sp.*	cf. burrowning brittle star	abundant

Photographs and video documenting the habitat at the North Site have been downloaded and are available upon request. A selection of the photographs taken at the North Site is provided below.

Photograph 4. An opalescent nudibranch and diatom mat.

Photograph 5. A partially buried sand star.

Photograph 6. A striped nudibranch and sea pen.

2.1.3 Discussion

The biophysical habitat at the sites in Tsawwassen appeared relatively unchanged since the 2006 survey. The 2006 survey was conducted in December, at that time the sites contained large amounts of eelgrass detritus and a few submerged logs. The April 2013 survey observed minimal detritus and no logs. The reduced amount of detritus is likely due to the fact that the previous survey was conducted at a time when the eelgrass shoots on the tidal flats had recently shed many leaves; this typically happens in the fall. The majority of the detritus is carried away by currents and tides during the winter.

Sunken logs rolling through the transplant area adjacent to the South Site was an issue at the time that the VITR transplant was being conducted (spring/summer 2008). The divers did not see any logs during the 2013 survey, however as the visibility was minimal, the divers could only see clearly for a distance of approximately 0.5 metres. It is possible that logs were in fact present.

There was an abundance of burrowing brittle stars (cf. *Amphiodia* sp.) and mounded burrow openings typical of the bay ghost shrimp (*Neotrypea californiensis*). A total of two live fat gaper clams (*Tresus capax*) and two Nuttall's cockle (*Clinocardium nutallii*) were seen during the dive surveys (North & South sites combined). Orange sea pens (*Ptilosarcus gurneyi*) were noted at both sites, the highest density was located near the western end of the South site.

3.0 CONCLUSION

The Tsawwassen sites did not appear to provide any significant fisheries habitat value.

The fisheries habitat values at both sites could be significantly enhanced by the alteration of existing habitat to allow for the development of eelgrass habitat.

Appendix 1 Tsawwassen Sites

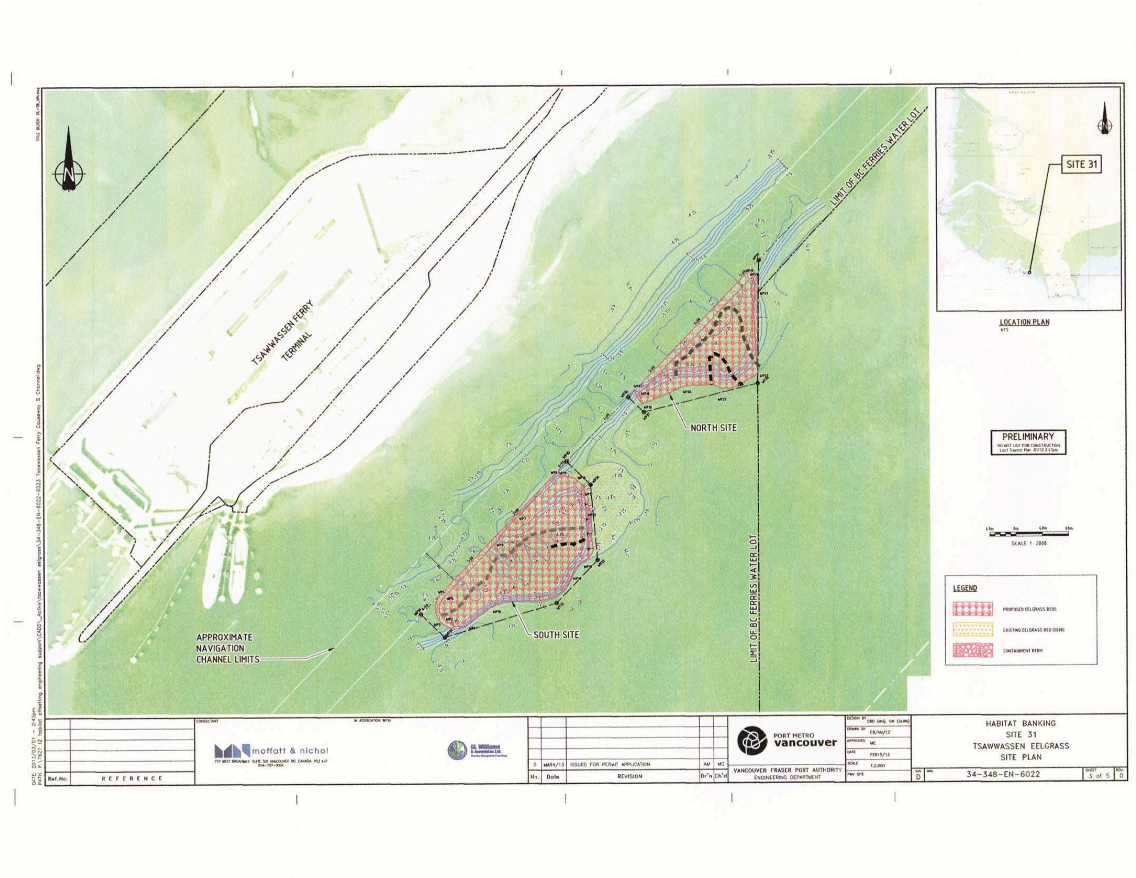

Figure 1-1. The paths followed by the divers are represented by dashed lines. The graphic representation is based on the GPS waypoints and by comparing recorded diver depths with the chart.

APPENDIX B

Tsawwassen Site 3 Eelgrass Field Reconnaissance Report

Tsawwassen Site 3 Eelgrass Field Reconnaissance
Port Metro Vancouver Habitat Enhancement Program

Prepared for:
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Prepared by:
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File: 302-035.04
February 2015

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February 4, 2015
File: 302-035.04

Port Metro Vancouver
100 The Pointe – 999 Canada Place
Vancouver, BC V6C 3T4

Attn: Gord Ruffo and Charlotte Olson

Dear Mr. Gord Ruffo and Ms. Charlotte Olson,

Re: Habitat Enhancement Program (HEP): Report on Tsawwassen Eelgrass Site 3 Field Reconnaissance for the Purposes of Habitat Enhancement

We have appreciated the opportunity to work with you on this project and trust that this report meets all your requirements. Please feel free to contact the undersigned by phone or email regarding any questions or further information that you may require.

Regards,
Hemmera Envirochem Inc.

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1.0 INTRODUCTION

Native eelgrass (*Zostera marina*) provides important habitat for many valuable fish and wildlife species including Dungeness crab (*Metacarcinus magister),* juvenile salmonids (*Oncorhynchus* species) and Brant geese (*Branta bernicla*). Transplanting native eelgrass for habitat enhancement has a proven history of success in British Columbia (Precision 2002). Port Metro Vancouver's (PMV's) Habitat Enhancement Program (HEP), in consultation with BC Ferry Corporation (BCFC) and eelgrass specialist Cynthia Durance (Precision Identification), have identified several opportunities for eelgrass enhancement south of the BCFC Tsawwassen Terminal and causeway. Sites 1 and 2, southeast of the ferry terminal, were investigated with conceptual project designs completed in 2012 and 2013, respectively (Precision 2013), however Site 3 (**Figure 1**) had not previously been surveyed or advanced to the design phase. The boundaries of the BCFC waterlot (BLOCK F, PLAN BCP5645 025-701-118 OWNED: BC TRANSPORTATION FINANCIAL AUTHORITY LEASED TO BC FERRRIES) and Tsawwassen First Nations (TFN) waterlot (DL955 PROVINCIAL LAND LEASE TO TSAWWASSEN FIRST NATION) are indicated on **Figure 1**. Sites 2 and 3 lie primarily within the BCFC waterlot but extend into the TFN waterlot as well. Site 1 exists exclusively within the BCFC waterlot. The assessment findings are expected to support detailed design and to confirm the suitability of the site for eelgrass transplant.

Detailed bathymetry was collected to confirm the suitability of Sites 1 and 2 in 2012 and a reconnaissance visit was conducted in April 2013 using SCUBA to assess baseline habitat and biotic conditions. Detailed bathymetry was collected at Site 3 in December 2014 to determine the potential of this enhancement opportunity. December 2014 bathymetric surveys also re-confirmed depth contours at Sites 1 and 2, which had previously been surveyed in 2012 (**Figure 2**). A one-day field program was conducted on January 7, 2015 using SCUBA to collect baseline habitat and biotic conditions data comparable to that collected for Sites 1 and 2.

A large-scale eelgrass habitat transplant was successfully completed southeast of the BCFC Tsawwassen Terminal and causeway by the British Columbia Transmission Corporation as part of habitat compensation for the Vancouver Island Transmission Reinforcement Project (VITR) (Golder 2011). Proposed habitat creation projects at Sites 1, 2 and 3 would be similar to the VITR project and involve placement of fill to raise the elevation of the seafloor from approximately -5.0 m CD to between -2.0 m to -1.0 m CD. After the site is filled, the sediment will be allowed to settle and transplanted with eelgrass from suitable nearby donor sites. Eelgrass habitat enhancement at all three sites is estimated to result in the creation of approximately 4.8 ha of eelgrass (26,300 m^2 at Site 1; 17,300 m^2 at Site 2 and 4,600 m^2 at Site 3), to be confirmed with further design work.

Figure 1 Tsawwassen eelgrass transplant candidate Sites 1, 2 and 3 and existing eelgrass transplant areas

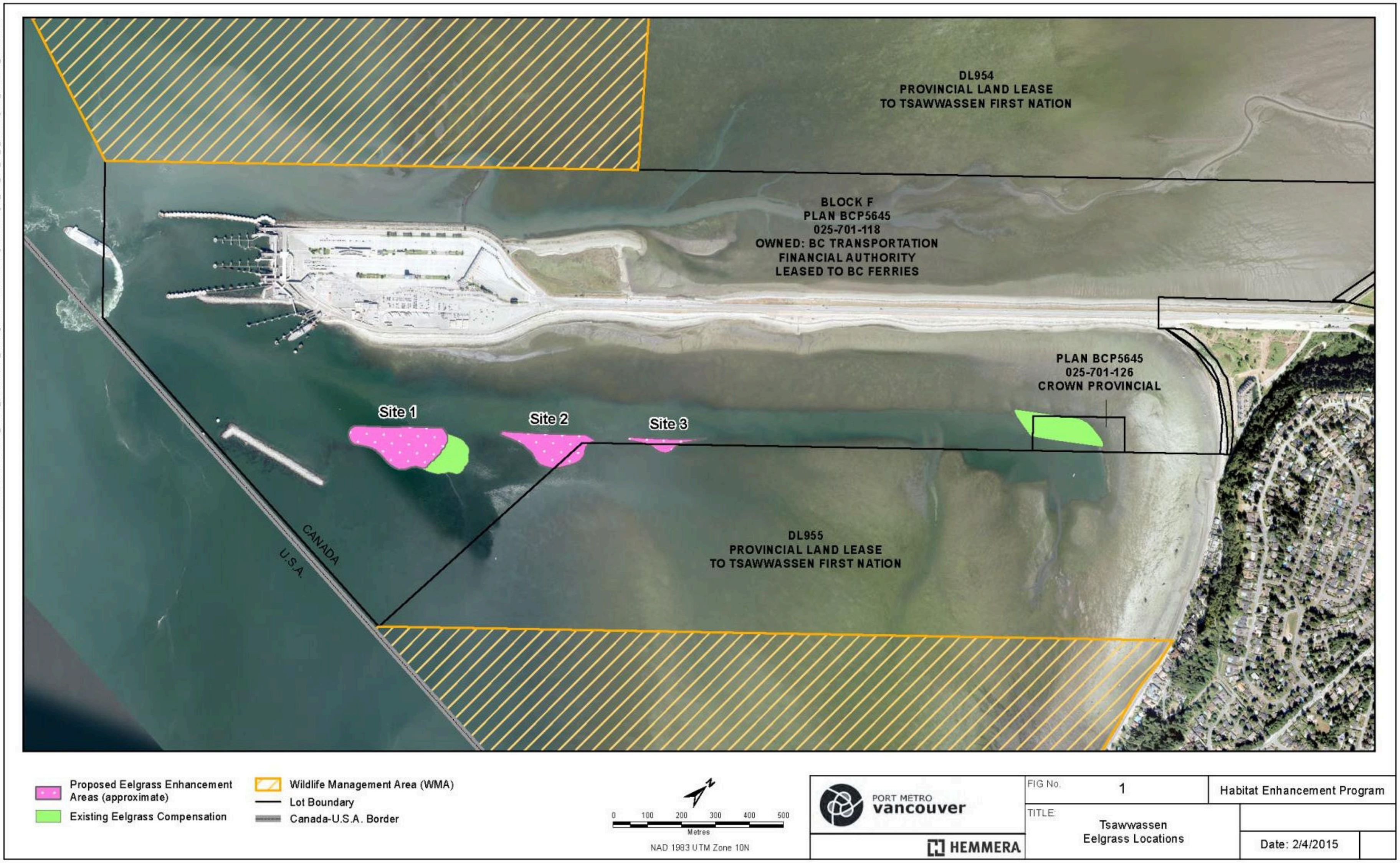
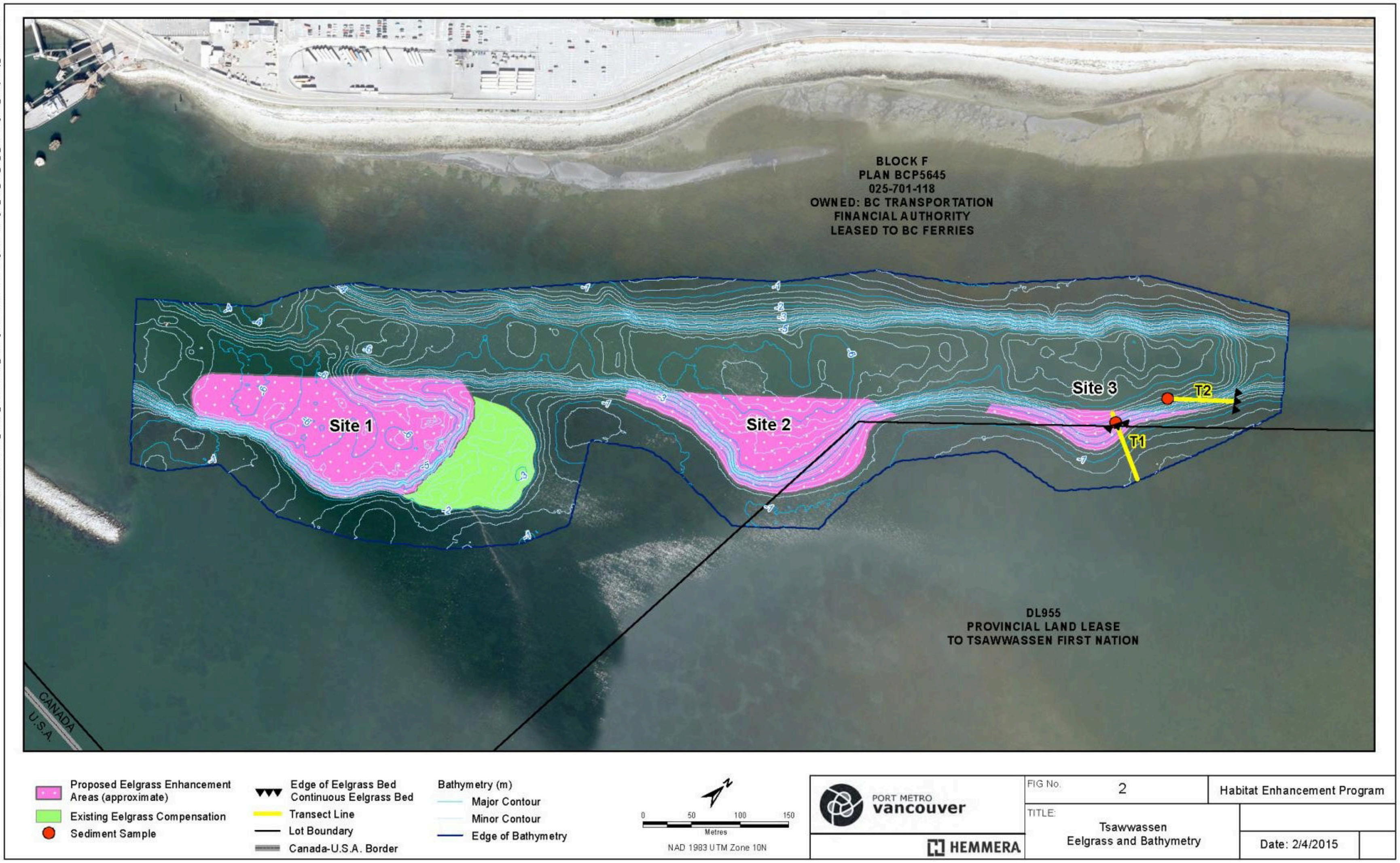


Figure 2 Tsawwassen eelgrass transplant candidate sites 1, 2 and 3 with December 2014 bathymetry overlay and January 7th 2015 dive transects



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2.0 OBJECTIVES

The primary objective of Site 3 reconnaissance field program was to:

1. Determine the viability of Site 3 as a potential eelgrass transplant recipient location;
2. Conduct a baseline assessment of the Site 3 habitat including species presence and substrate types;
3. Verify the potential area available for eelgrass transplanting, including area within the TFN waterlot; and
4. Evaluate the viability of the adjacent eelgrass bed as a donor site.

3.0 METHODS

The reconnaissance of Site 3 was conducted using SCUBA and followed a transect-based sampling design similar to the work performed by Precision Identification at Sites 1 and 2 in 2013 (Precision 2013). Transects were delineated during desktop review of the 2014 bathymetry and a polygon overlay of the proposed Site 3; transects were positioned to capture the elevation difference and transition between existing eelgrass beds near Site 3 and to characterize the following conditions:

a. baseline biological and physical conditions at Site 3, including any existing eelgrass
b. depths and sediment quality conditions at Site 3 for appropriateness of eelgrass habitat enhancement

Two predetermined transects were completed on January 7th 2015 (**Figure 2**) with each located in the field using a Garmin GPS (+/- 4 m) and established using sinking transect lines set in advance of the dives. SCUBA surveys were conducted along each 60 m transect and extended from within Site 3 to adjacent eelgrass beds to characterise conditions within and adjacent to the proposed enhancement site. Survey methods consisted of sampling a 1.0 m^2 quadrat (**Photo 1**) every five metres for eelgrass presence, density, morphological features, substrate conditions, and the presence of other marine life. One sediment sample was taken along each transect, within Site 3, and sent to Maxxam Analytics for sediment grain size analysis.

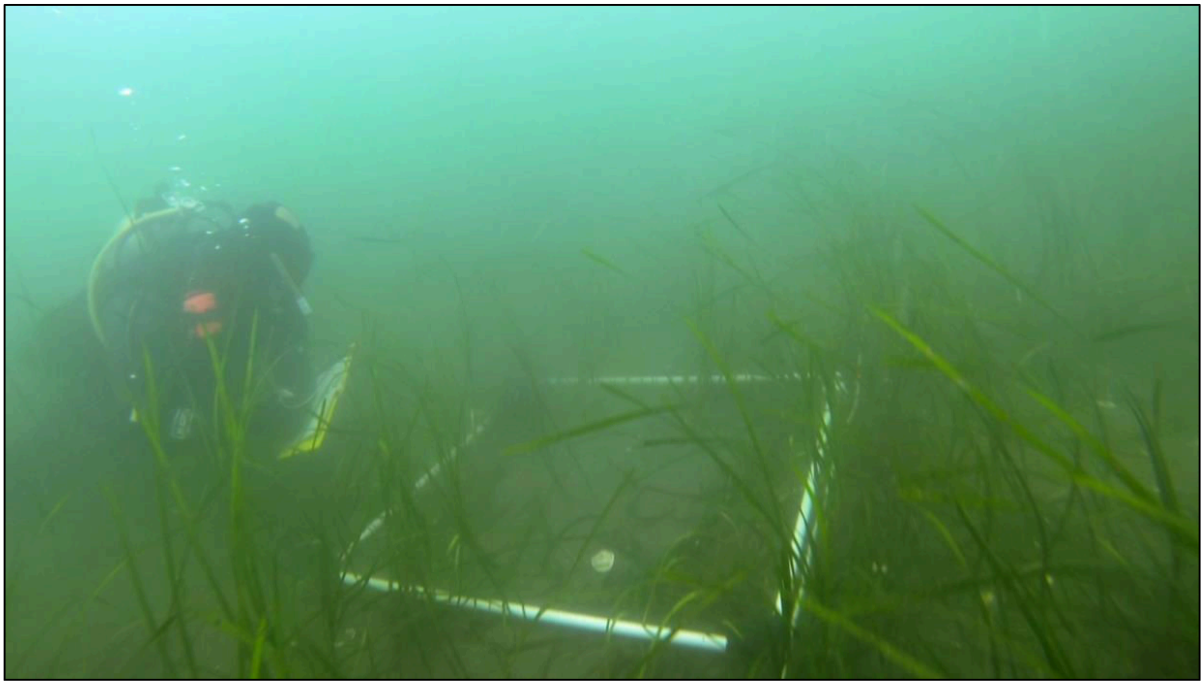

Photo 1 Quadrat (1.0 m2) used to sample eelgrass and substrate conditions January 7th, 2015.

4.0 RESULTS

Detailed diver observations are presented in **Appendix A: Table 1** and are summarized in **Table 1** below. Lab data from analysis of the two sediment samples is presented in **Appendix B** and are summarized in **Table 2** below.

Table 1 Summary of Diver Observations

Date	Transect	Distance (m)	Depth (m CD)	Continuous eelgrass start (depth)	Substrate
Jan. 7 2015	1	60	-3.8 m to 0 m	-1.4 m CD to 0 m CD	95% silt (deep) to 95% sand (shallow)
Jan. 7 2015	2	65	-4.2 m to -1.4 m	-1.4 m CD	90% silt (deep) to 50% sand (shallow)

Table 2 Summary of sediment sample particle size analysis

Sediment Sample	Date	Transect	Distance (m)	Depth (m CD)	Clay (%)	Sand (%)	Silt (%)
Tsawwassen Site 3 B	**Jan. 7 2015**	1	10	-2.0	5.3	95	<2
Tsawwassen Site 3 A	**Jan. 7 2015**	2	0	-4.2	9.3	74	17

4.1 TRANSECT 1

Transect 1 was positioned approximately perpendicular to the ferry causeway, beginning in Site 3 at -3.8 m CD, and ending outside Site 3 at 0 m CD. The edge of the continuous eelgrass bed was identified at 15 m along the transect and at 1.4 m below CD. Continuous eelgrass was observed throughout the remainder of the transect (15 m to 60 m). Sediment sample B was taken on a mainly sand slope at 10 m along Transect 1.

The surface substrate between 0 m and 10 m on the transect was observed to be predominantly silt (95% silt, 5% sand), and *Z. marina* detritus (piles ~0.3 m deep) were widely distributed over the surface (quadrats at 0 m and 5 m along the transect were completely covered with eelgrass debris) (**Photo 2**). A single juvenile sun star (*Crossaster papposus*) was observed in this area.

Photo 2 Dense eelgrass detritus along Transect 1, Jan. 07 2015, dive 1.

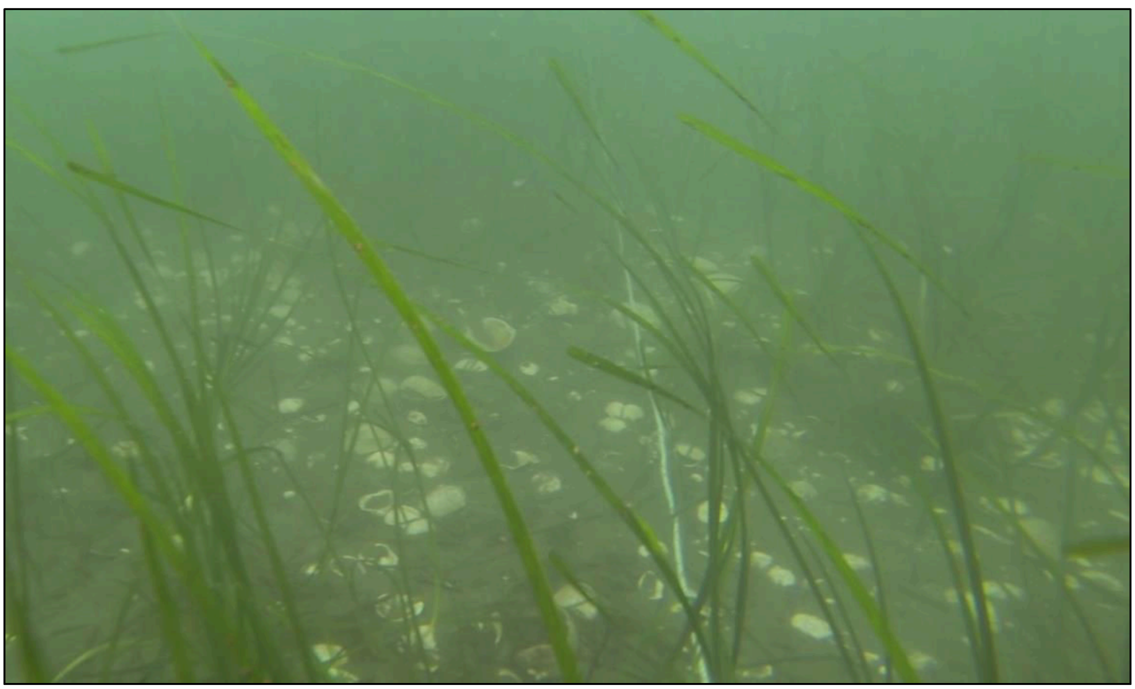

Photo 3 Eelgrass with shells on sandy bottom substrate along Transect 1, Jan. 07 2015, dive 1.

Within the eelgrass bed (from 15 m to the end of the transect) the surface substrate was predominantly sand (30% silt, 70% sand) and became progressively sandier (95% sand at 60 m) as the transect approached 0 m CD (**Photo 3**). Average density was 19.7 shoots/m^2, leaf blade width was constant at 7 mm, while average blade length averaged 1.0 m. Eelgrass covered an average of 26% of the bottom surface area, and shells (including *Macoma spp*., corrugated clams (*Humilaria kennerleyi*), and cockle shells (*Clinocardium nuttalli*)) covered an average of 5% of bottom surface area (**Photo 3**). In the last quadrat sampled 20% of the bottom substrate surface was covered in a diatom mat.

After the transect was complete, a reconnaissance of the sediment northeast of the transect was conducted to observe a greater portion of the proposed footprint. The deeper sediments appear to be a continuous silty-sand with a dark hypoxic layer deeper underneath (**Photo 4**). A few Dungeness crab were observed.

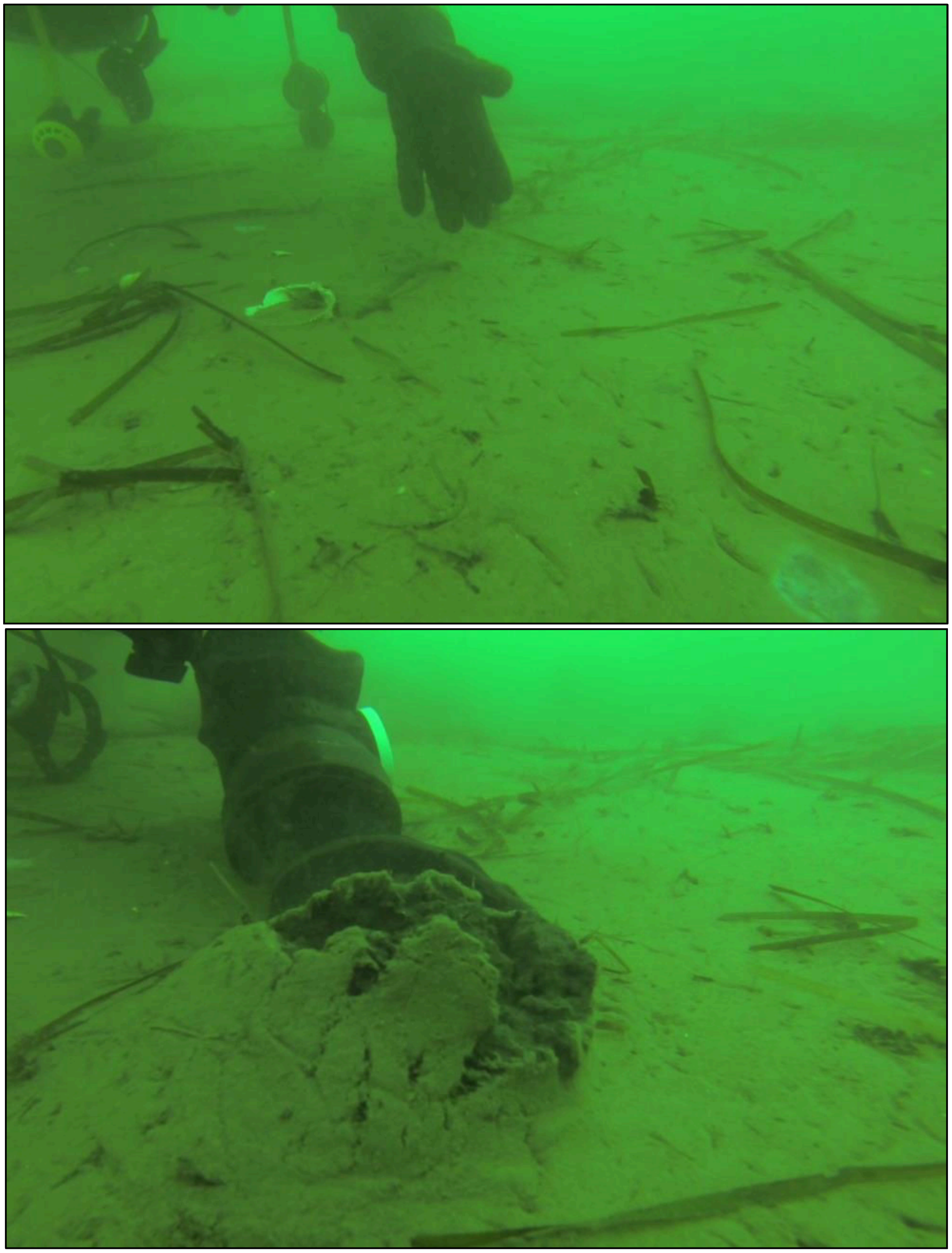

Photo 4 Sediment with dark hypoxic layer underneath, Transect 1, Jan. 07 2015, dive 1.

Species observed between 15 m and 60 m of Transect 1 included unidentified infauna, a green anemone (unknown species), eelgrass limpets (*Lottia alveus*) on eelgrass blades (**Photo 5**), a smoothhead sculpin (*Artedius lateralis*) (**Photo 6**), hooded nudibranchs (*Melibe leonina*) (**Photo 5**), and an adult Dungeness crab (**Photo 7**).

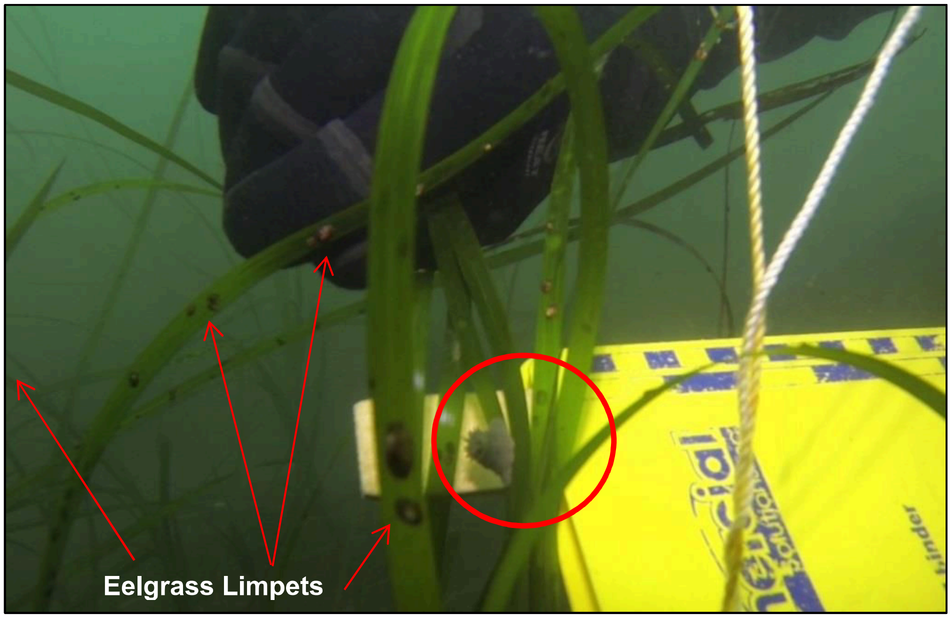

Photo 5 **Eelgrass limpets and anemone on eelgrass blades, Transect 1, Jan. 07 2015, dive 1.**

Photo 6 **Sculpin in eelgrass bed along Transect 1, Jan. 07 2015, dive 1.**

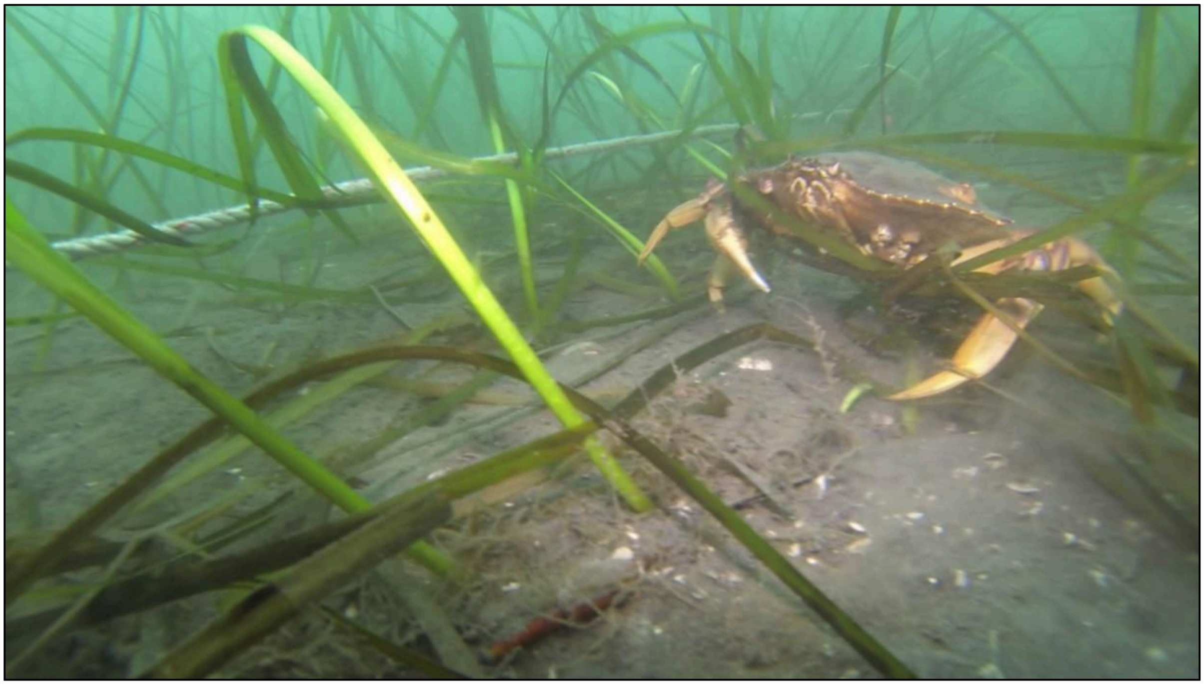

Photo 7 Adult Dungeness crab in eelgrass bed along Transect 1, Jan. 07 2015, dive 1.

4.2 TRANSECT 2

Transect 2 was positioned approximately parallel to the ferry causeway, with sampling beginning in Site 3 at 4.1 m below CD and ending outside Site 3 at 1.5 m below CD. The edge of the continuous eelgrass bed was encountered at 65 m along the transect and at 1.4m below CD, although sparse eelgrass was noted at 60 m and at 1.9 m below CD. Between 30 m and 60 m the transect ran along a slope. Sediment sample A was taken at 0 m along Transect 2. Video was recorded from shallow to deep in the opposite direction to sampling.

From 0 m to 20m along the transect, the proportion of silt in the substrate was estimated between 90 and 95% silt (**Photo 8**); silt content decreased with decreasing depth along the transect and the transition from the depression to the slope. On average 65% of the surface area was covered in eelgrass detritus from 0 m to 20 m, but detritus completely covered the sediment surface in some quadrats (**Photo 9**). The bottom surface substrate was observed to be almost equally silt and sand, with an average estimate of 45% silt and 55% sand, from the beginning of the slope at 30 m to the end of the transect (**Photo 10** and **Photo 11**). Eelgrass detritus covered an average of 13% of the surface of quadrats sampled from 30 m to 65 m.

Shells (*Macoma spp.* and *Clinocardium* sp.) were observed at three points along the transect, but were not widespread, making up less than 5% of the surface area. No other species were observed along this transect.

Photo 8 Silty substrate with eelgrass detritus, Transect 2, Jan. 07 2015, dive 2.

Photo 9 Dense eelgrass detritus, Transect 2, Jan. 07 2015, dive 2.

Photo 10 Silty-Sand substrate on slope of project site, Transect 2, Jan. 07 2015, dive 2.

Photo 11 Edge of continuous eelgrass bed, Transect 2, Jan. 07 2015, dive 2.

5.0 DISCUSSION AND RECOMMENDATIONS

The reconnaissance survey confirmed Site 3 as a potential eelgrass habitat enhancement opportunity. The depression left at site 3 appears to be both limiting eelgrass expansion and acting as sink for detritus, lowering its overall productivity. A continuous eelgrass bed spread into the depression to a depth of approximately 1.4 m below CD on both transects. The eelgrass growth was likely limited by the steep slope, which is not a preferred habitat as the roots become exposed making the plant susceptible to damage. The presence of the eelgrass bed immediately adjacent to the proposed project footprint indicates the viability of eelgrass enhancement opportunities if suitable bottom elevations and slopes can be established. In the deeper areas of Site 3, surface substrates were predominantly fine, hypoxic silt and organics due to the accumulation and breakdown of detritus which may be limiting primary production due to shading and leading to a hypoxic sediment environment. Softer substrates in deeper areas may be subject to settling after infilling. Site 3 was confirmed to be mainly unvegetated. Eelgrass detritus was common. There was little evidence of macrofauna, valued invertebrates or fish species on the surface of the substrate or in the water column.

The previous success of the eelgrass transplants constructed for the VITR Project in close proximity to Site 3, and the existing extensive eelgrass meadows surrounding Site 3 suggest that, given careful sediment placement up to at approximately -1.4 m CD and adequate engineering considerations to prevent erosion, Site 3 is an ideal site for eelgrass habitat enhancement. The reconnaissance survey confirmed that there is eelgrass enhancement opportunity within BCFC waterlot and extending southeast into the TFN waterlot. Currents in the area are of a relatively low velocity and would facilitate material placement, eelgrass harvesting and transplanting operations. Abundant eelgrass for donor stock exists in close proximity to Site 3, directly southeast of the site within the TFN waterlot. The survey results suggest that the steep slopes and depth are likely the main barriers preventing colonization.

6.0 CLOSURE

We sincerely appreciate the opportunity to have assisted you with this project and if there are any questions, please do not hesitate to contact the undersigned by phone or email.

Report prepared by:
Hemmera Envirochem Inc.

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Senior Marine Biologist
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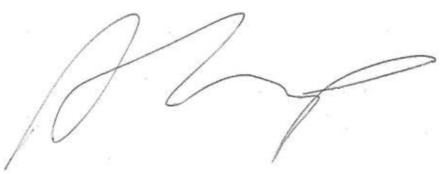
Report senior-reviewed by:
Hemmera Envirochem Inc.



Scott Northrup, R.P.Bio., P.Biol.
Project Director
250.619.2807
snorthrup@hemmera.com

7.0 REFERENCES CITED

Golder Associates (Golder). 2011. Annual Summary report No. 4, Vancouver Island Transmission Reinforcement (VITR) Project. Submitted to BC Environmental Assessment Office, by Golder Associates. Report N° 09-1422-5013. Accessed at: http://a100.gov.bc.ca/appsdata/epic/documents/p250/1309475718503_702dfa3e2b078ac9c5efefd7dd0ee71a8e1ead5102602c9e0beb9343e310b395.pdf.

Precision Identification (Precision). 2002. A review of and assessment of eelgrass transplant projects in British Columbia. Prepared for: Fisheries and Oceans Canada, Nanaimo, BC. Pages 59.

Precision Identification (Precision). 2013. Habitat Banking Program; Assessment of Potential Eelgrass Transplant Sites Tsawwassen and Maplewood. Prepared for Port Metro Vancouver by Precision Identification and Seacology.

8.0 STATEMENT OF LIMITATIONS

This report was prepared by Hemmera Envirochem Inc. ("Hemmera"), based on fieldwork conducted by Hemmera, for the sole benefit and exclusive use of Port Metro Vancouver. The material in it reflects Hemmera's best judgment in light of the information available to it at the time of preparing this Report. Any use that a third party makes of this Report, or any reliance on or decision made based on it, is the responsibility of such third parties. Hemmera accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions taken based on this Report.

Hemmera has performed the work as described above and made the findings and conclusions set out in this Report in a manner consistent with the level of care and skill normally exercised by members of the environmental science profession practicing under similar conditions at the time the work was performed.

This Report represents a reasonable review of the information available to Hemmera within the established Scope, work schedule and budgetary constraints. It is possible that the levels of contamination or hazardous materials may vary across the Site, and hence currently unrecognised contamination or potentially hazardous materials may exist at the Site. No warranty, expressed or implied, is given concerning the presence or level of contamination on the Site, except as specifically noted in this Report. The conclusions and recommendations contained in this Report are based upon applicable legislation existing at the time the Report was drafted. Any changes in the legislation may alter the conclusions and/or recommendations contained in the Report. Regulatory implications discussed in this Report were based on the applicable legislation existing at the time this Report was written.

In preparing this Report, Hemmera has relied in good faith on information provided by others as noted in this Report, and has assumed that the information provided by those individuals is both factual and accurate. Hemmera accepts no responsibility for any deficiency, misstatement or inaccuracy in this Report resulting from the information provided by those individuals.

The liability of Hemmera to Port Metro Vancouver shall be limited to injury or loss caused by the negligent acts of Hemmera. The total aggregate liability of Hemmera related to this agreement shall not exceed the lesser of the actual damages incurred, or the total fee of Hemmera for services rendered on this project.

APPENDIX A
Field Survey Data

Table 1 SCUBA survey transect observations, Jan. 7th 2015

Dive Number/ Quadrat	Time (PDT)	Distance (m)/ tape mark	Gauge Depth (ft)	Tide Height (ft)	Eelgrass Shoot Density/ 1.0 m^2	Eelgrass Blade Width (mm)	Eelgrass Blade Length (m)	Substrate		Observations
								Silt (%)	Sand (%)	
1.1	12:04	0	23	10.5				95	5	100% deep *Z. marina* detritus pile (~0.3 m); 1 sun star *Crossaster papposus* (juvenile)
1.2		5	21					95	5	100% deep *Z. marina* detritus pile (~0.3 m)
1.3		10	17					30	70	15% deep *Z. marina* detritus; **sediment sample 1**
1.4		15/35	15		6	7		30	70	10% deep *Z. marina* detritus; edge of eelgrass bed, continuous (-1.4 m CD)
1.5		20/40	14		21	7	0.9	20	80	*Z. marina* 20%, 60% *Z. marina* detritus, shell 4% (saltwater clam (*Macoma spp*) and corrugated clam (*Humilaria kennerleyi*))
1.6		25/45	13		25	7	1	20	80	*Z. marina* 20%, 60% *Z. marina* detritus, shells 1%, ~50 eelgrass limpet (*Lottia alveus*) on blades, 1 green anemone (sp. unknown)
1.7		30	13		17	7	1.1	20	80	*Z. marina* 20%, *Clinocardium nuttallii* (cockle) shells, low infauna (3),
1.8		35	12		18	7		20	80	*Z. marina* 20%, 60% *Z. marina* detritus, shell 1%, >75 *Lottia alveus* (eelgrass limpets) on blades
1.9		40	11		23	7	0.75-1.0	10	90	Shells 5% (cockle, *Macoma*), *Z. marina* detritus 25%;
1.10		45	11		27	7	>1.0	10	90	*Z. marina* detritus 25%; shells 10% (cockle (*Clinocardium nuttallii*), *Macoma spp.*), 1 hooded nudibranch (*Melibe leonina*), >100 *Lottia alveus* (eelgrass limpet) on blades
1.11		50	11		19	7		10	90	*Z. marina* 20%, shells 15% (*Clinocardium nuttallii* (cockle), *Macoma spp.*), *Z. marina* detritus 10%; 3 *Z. marina* root exposed
1.12		55	11		25	7	0.75-1.0	5	95	*Z. marina* 35%, 1 unidentified sculpin (Cottidae), 1 Dungeness crab (adult) (*Metacarcinus magister*)
1.13	13:07	60	10	10.1	16	7	~0.75	5	95	*Z. marina* detritus 10%; shells 10% (cockle (*Clinocardium nuttallii*), *Macoma spp.*), 1 hooded nudibranch (*Melibe leonina*), 20% diatoms <50 eelgrass limpet (*Lottia alveus*) on blades

Dive Number/ Quadrat	Time (PDT)	Distance (m)/ tape mark	Gauge Depth (ft)	Tide Height (ft)	Eelgrass Shoot Density/ 1.0 m^2	Eelgrass Blade Width (mm)	Eelgrass Blade Length (m)	Substrate		Observations
								Silt (%)	Sand (%)	
2.1	14:10	0	24	10.2				90	10	Shells 5%, *Z. marina* detritus - **sediment sample 2 (far end)**
2.2		5	24					90	10	100% *Z. marina* detritus
2.3		10	22					95	5	100% *Z. marina* detritus
2.4		15	23					95	5	50% *Z. marina* detritus
2.5		20	22					95	5	90% *Z. marina* detritus
2.6		25	22					70	30	50% *Z. marina* detritus, shells 2% cockle (*Clinocardium nuttallii*)/*Macoma spp.*
2.7		30	21					50	50	*Z. marina* detritus 25%, slope
2.8		35	21					50	50	*Z. marina* detritus 25%, slope
2.9		40	21					50	50	*Z. marina* detritus 25%, slope
2.1		45	21					50	50	*Z. marina* detritus 25%, slope
2.11		50	20					40	60	*Z. marina* detritus , slope
2.12		55	18					40	60	*Z. marina* detritus , shell 1% cockle (*Clinocardium nuttallii*), slope
2.13		60	17					30	70	*Z. marina* starts, slope (-1.7 m CD)
2.14	14:35	65	15	10.5	13	5	0.75	50	50	*Z. marina* sparse, continuous bed (-1.4 m CD)

APPENDIX B

Sediment Sample Lab Data

Your P.O. #: OP 51952 000
Site Location: SE OF TSAWWASSEN FERRY CAUSEWAY
Your C.O.C. #: 150109DIVESED

Attention:Charlotte Olson

VANCOUVER FRASER PORT AUTHORITY
Port Metro Vancouver
100 The Pointe
999 Canada Place
Vancouver, BC
CANADA V6C3T4

Report Date: 2015/01/15
Report #: R1787967
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B501929
Received: 2015/01/09, 15:55

Sample Matrix: Sediment
Samples Received: 2

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Texture by Hydrometer (Sand, Silt, Clay)	2	N/A	2015/01/15	BBY6SOP-00051	Carter 2nd ed 55.3

* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.

Encryption Key

Maxxam
15 Jan 2015 11:07:53 -08:00

Please direct all questions regarding this Certificate of Analysis to your Project Manager.
Amandeep Nagra, Account Specialist
Email: ANagra@maxxam.ca
Phone# (604)639-2602
==
This report has been generated and distributed using a secure automated process.
Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Maxxam Job #: B501929
Report Date: 2015/01/15

VANCOUVER FRASER PORT AUTHORITY
Site Location: SE OF TSAWWASSEN FERRY CAUSEWAY
Your P.O. #: OP 51952 000
Sampler Initials: TA

RESULTS OF CHEMICAL ANALYSES OF SEDIMENT

Maxxam ID		LM3729	LM3730		
Sampling Date		2015/01/07	2015/01/07		
COC Number		150109DIVESED	150109DIVESED		
	Units	**TSW EELGRASS ST3 A**	**TSW EELGRASS ST3 B**	**RDL**	**QC Batch**
Physical Properties					
% sand by hydrometer	%	74	95	2.0	7777527
% silt by hydrometer	%	17	<2.0	2.0	7777527
Clay Content	%	9.3	5.3	2.0	7777527
RDL = Reportable Detection Limit					

Maxxam Analytics International Corporation o/a Maxxam Analytics Burnaby: 4606 Canada Way V5G 1K5 Telephone(604) 734-7276 Fax(604) 731-2386

Maxxam Job #: B501929
Report Date: 2015/01/15

VANCOUVER FRASER PORT AUTHORITY
Site Location: SE OF TSAWWASSEN FERRY CAUSEWAY
Your P.O. #: OP 51952 000
Sampler Initials: TA

GENERAL COMMENTS

Results relate only to the items tested.

Maxxam Analytics International Corporation o/a Maxxam Analytics Burnaby: 4606 Canada Way V5G 1K5 Telephone(604) 734-7276 Fax(604) 731-2386

Maxxam Job #: B501929
Report Date: 2015/01/15

QUALITY ASSURANCE REPORT

VANCOUVER FRASER PORT AUTHORITY
Site Location: SE OF TSAWWASSEN FERRY CAUSEWAY
Your P.O. #: OP 51952 000
Sampler Initials: TA

			RPD		QC Standard	
QC Batch	Parameter	Date	Value (%)	QC Limits	% Recovery	QC Limits
7777527	% sand by hydrometer	2015/01/15	0.11	35	99	90 - 110
7777527	% silt by hydrometer	2015/01/15	NC	35	89	68 - 132
7777527	Clay Content	2015/01/15	NC	35	115	60 - 140

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

QC Standard: A sample of known concentration prepared by an external agency under stringent conditions. Used as an independent check of method accuracy.

NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (one or both samples < 5x RDL).

Maxxam Analytics International Corporation o/a Maxxam Analytics Burnaby: 4606 Canada Way V5G 1K5 Telephone(604) 734-7276 Fax(604) 731-2386

Maxxam Job #: B501929
Report Date: 2015/01/15

VANCOUVER FRASER PORT AUTHORITY
Site Location: SE OF TSAWWASSEN FERRY CAUSEWAY
Your P.O. #: OP 51952 000
Sampler Initials: TA

VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

Andy Lu, Data Validation Coordinator

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Maxxam Analytics International Corporation o/a Maxxam Analytics Burnaby: 4606 Canada Way V5G 1K5 Telephone(604) 734-7276 Fax(604) 731-2386

Maxxam
A Bureau Veritas Group Company

Burnaby: 4606 Canada Way, Burnaby, BC V5G 1K5. Toll Free (800) 665-8566

CHAIN OF CUSTODY RECORD

BBY FCD-00077/05

COC #: 150109 DIVE SED

Page 1 of 1

Invoice Information		Report Information (if differs from invoice)		Project Information (where applicable)		Turnaround Time (TAT) Required
Company Name:	Port Metro Vancouver	Company Name:	PMV Charlotte Olson	Quotation #:	/	☐ Regular TAT 5 days (Most analyses)
Contact Name:	send elecronic copy of invoice to Accounts.Payable@portmetrovancouver.com	Contact Name:	charlotte.olson@portmetrovancouver.com	P.O. #/ AFE#:	OP 51952 000	PLEASE PROVIDE ADVANCE NOTICE FOR RUSH PROJECTS
Address:		Address:	604 349 4411	Project #:		Rush TAT (Surcharges will be applied)
	cc:Percy.Hui@portmetrovancouver.com and Michelle Duffy at michelle.duffy@worleyparsons.com. A		~~tabata~~	Site Location:	SE of tsawwassen ferry causeway	☐ Same Day ☐ 2 Days
Phone:		Phone:	labdata@hemmera.com	Site #:		☐ 1 Day ☒ 3 Days
Email:	follow-up hard copy is not necessary	Email:	tabercrombie@hemmera.com	Sampled By:	Tim Abercrombie and Jamie Slogan	Date Required:

Regulatory Criteria

☐ BC CSR Soil ☐ BC CSR Water
☐ CCME (Specify) ☐ Other (Specify)
☐ Drinking Water ☐ BC Water Quality

Special Instructions

Analysis: % sand, %silt, % clay, no flocculation

note: empty spare bottles also in cooler

Analysis Requested

Analysis columns with nothing marked for either sample: BTEX/VPH ☐ MTBE ☐ VOC/VPH ☐; EPH ☐ TEH ☐; PAH ☐ LEPH/HEPH ☐; CCME-PHC BTEX/F1 ☐ F2-F4 ☐; Dissolved Metals Filtered? ☐ Preserved? ☐; Dissolved Mercury Filtered? ☐ Preserved? ☐; Total Metals Field Preserved? ☐; Total Mercury Field Preserved? ☐; Chloride ☐ Fluoride ☐ Sulphate ☐; TSS ☐ TDS ☐ BOD ☐ COD ☐; pH ☐ Conductivity ☐ Alkalinity ☐; Nitrite ☐ Nitrate ☐ Ammonia ☐

Rush Confirmation #:

LABORATORY USE ONLY

CUSTODY SEAL Y / (N)		COOLER TEMPERATURES
Present	Intact	10, 11, 10

COOLING MEDIA PRESENT Y / N

SAMPLES MUST BE KEPT COOL (< 10 °C) FROM TIME OF SAMPLING UNTIL DELIVERY TO MAXXAM

#	Sample Identification	Lab Identification	Date Sampled (YYYY/MM/DD)	Time Sampled (HH:MM)	Matrix	Particle Size Distribution	# OF CONTAINERS SUBMITTED	HOLD - DO NOT ANALYZE	COMMENTS
1	TSW Eelgrass ST3 A	LM3729	1/7/2015		SED	X	1		
2	TSW Eelgrass ST3 B	LM3730	1/7/2015		SED	X	1		
3									
4									
5									
6									
7									
8									
9									
10									

B501929

RELINQUISHED BY: (Signature/Print)	DATE: (YYYY/MM/DD)	TIME: (HH:MM)	RECEIVED BY: (Signature/Print)	DATE: (YYYY/MM/DD)	TIME: (HH:MM)	MAXXAM JOB #
			SARANISIR TAKHAR	2015/01/09	15:55	B501929

Appendix IR2020-1.1-A14

Tsawwassen Eelgrass Project Existing Ecological Conditions Update Assessment

Hemmera
An Ausenco Company

MEMORANDUM

Date:	February 25, 2021
To:	Ravi Chatterji (AECOM), on behalf of Vancouver Fraser Port Authority
From:	Joe Walker, Lori Leach
File:	102738-10
Re:	Tsawwassen Eelgrass Project Existing Ecological Conditions Update Assessment

1.0 INTRODUCTION

The proposed Tsawwassen Eelgrass Project[1] (TEP; the Project), near Tsawwassen, in the City of Delta, British Columbia (B.C.), is a project proposed for inclusion in the Roberts Bank Terminal 2 (RBT2) Offsetting Plan, as part of the *Fisheries Act* Authorization application. As part of the proposed RBT2 Offsetting Plan, the port authority is currently advancing a number of potential habitat offsetting projects. Potential sites where productivity can be restored or enhanced are being assessed to determine their viability. The Project is an opportunity to create two subtidal eelgrass beds totalling approximately 4.0 hectares (ha) by raising the elevation at two subtidal depressions to the appropriate elevation for establishment and persistence of native eelgrass (*Zostera marina*) at those locations. The depressions are understood to be remnant features from historic dredging activities.

The Project proposes to create two subtidal eelgrass beds in order to enhance fish habitat values at Roberts Bank. Originally proposed as potential sites for the Vancouver Fraser Port Authority's Habitat Enhancement Program, an initial biophysical survey was undertaken by Precision Identification in 2013. The Project has since been proposed as Project-specific offsetting habitat for the proposed RBT2 Project, in accordance with the requirements of the *Fisheries Act*. Hemmera was retained by the port authority to conduct a confirmatory dive assessment of the two proposed TEP sites 1 and 2, located immediately southeast of the BC Ferries causeway in Tsawwassen, BC. (**Figure 1**). Given the location, the port authority is seeking to advance this offsetting project collaboratively with TFN, acknowledging that the preferred design will not overlap with TFN's water lot, and with particular focus on aligning design and construction considerations with TFN's preferences and use.

2.0 METHODS

The scope of the assessment was to update and ground truth the existing conditions reported in the previous biophysical survey conducted at the site by Precision Identification in 2013. Hemmera conducted surveys of at Sites 1 and 2 on July 24, 2020 using a three-person WorkSafeBC certified Commercial SCUBA team. The roaming-diver surveys, which were exclusively confined to the BC Ferries water lot (Block F Plan BCP5645 025-701-118), recorded substrate, flora, and fauna information supported by high-definition video and still photos.

---

1 The port authority is in the process of changing the name of this project. The new name will be included in the final IR2020-1.1 RBT2 Fish and Fish Habitat Potential Offsetting Projects report in response to the minister of environment and climate change Canada.

3.0 EXISTING SITE CONDITIONS

3.1 Site 1

The elevation of the subtidal depression at Site 1 ranges from approximately -4.2 m chart datum (CD) to -5.7 m CD. The bathymetry slopes gradually to the deepest area, which is towards the middle of the depression. The substrate is homogenous and consists predominantly of sand and silty sand. No gravel or coarse substrates were observed during the 2020 site survey.

Occasional drift macroalgae, eelgrass, and rockweed (*Fucus distichus*) were observed throughout Site 1, although never in high densities (Photo 1). Consistent with observations made in 2013, the depressions appear to be acting as sinks for drift detritus which is likely deposited into the areas of lower elevation by prevailing currents, wind, and waves and negatively impacting fish habitat value. Additionally, occasional diatomaceous mats were observed colonizing the substrate (Photo 2). The diatoms were sparse when present and did not represent a significant feature of the substrate.

Several marine invertebrates were observed. Most notably, a large number of orange sea pens (*Ptilosarcus gurneyi*) have colonized the deeper sections of the Site. The sea pens were abundant throughout the southern area of the site and common in the northern, shallower slopes. While sea pens were observed during the 2013 survey, the abundance and extent of the bed appears to have increased in the intervening years. Sea pens are motile and their distribution can often be patchy and highly episodic, although the underlying factors precipitating these factors are unknown (Hemmera Envirochem (Hemmera) and Archipelago Marine Research Ltd. 2014). In several locations, the density of sea pens exceeded 5 / m^2 (Photo 3), although the average density for the Site was < 1 / m^2. Often, striped nudibranchs (*Armina californica*) were observed throughout the orange sea pen beds (Photo 4). Adult Dungeness crabs (*Metacarcinus magister*) were commonly observed on the surface (Photo 5) of the substrate and buried within it, and several commercial-grade crab pots had been laid within Sites 1 and 2 at the time of the survey. The crabs did not appear to be associated with the sea pens. A single six-rayed sea star was observed at Site 1 (Photo 6). Holes in the substrate were observed throughout the Site, with an average abundance of 9 holes / m^2 (Photo 7). While no organisms were directly observed in or associated with the holes, many members of the infaunal community (within the substrate) create holes and mounds including bivalves, worms, polychaetes, and shrimp. The holes ranged from several millimetres to several centimetres in diameter.

Abundant starry flounder (*Platichthys stellatus*) were observed throughout the Site, often identified only by the sudden movement and remnant cloud of sediment as they were flushed away from the divers. Occasional northern ronquil (*Ronquilus jordani*) and a single tubesnout (*Aulorhynchus flavidus*) were observed in low (i.e. < 10) numbers at Site 1 (Photo 8).

3.2 Site 2

The elevation of the subtidal depression at Site 2 ranges from - 6.0 m CD to - 6.4 m CD. The bathymetry is generally flat throughout the western half of the Site. The substrate is homogenous and consists of sandy silt, with a higher proportion of fines than was observed at Site 1. No gravel or coarse substrates were observed during the 2020 site survey.

Drift macroalgae, eelgrass, and rockweed were more common at Site 2 than at Site 1 (Photo 9), although large accumulations were not observed. Diatoms were not observed during the survey.

Orange sea pens were largely absent from Site 2. Only one sea pen and no nudibranchs were observed. Dungeness crabs were common throughout Site 2, in approximately similar abundance to Site 1, and crab traps were laid throughout the site. The holes in the substrate were more abundant (average 12 holes / m^2) and larger than those found in Site 1 with the majority of holes being several centimeters in diameter, indicating a different species assemblage making up the infaunal community, likely due to the higher silt content in the sediment (Photo 10).

A juvenile big skate (*Raja binoculata*) was observed at Site 2 (Photo 11), and was the only finfish observed at the site potentially due to reduced visibility compared to Site 1. Occasional clouds of sediment were observed indicating that fish or mobile invertebrates had disturbed the sediment.

3.3 Fish Habitat

Sites 1 and 2 provide habitat typical of sandy and silty substrate in the shallow subtidal zone. While Roberts Bank is used by a wide variety of fish, the most common in these habitats are flatfish (predominantly starry flounder). The Sites do not provide preferred habitat for rockfish, lingcod, or rearing Pacific salmon, although all may transit through the area.

Much of the habitat value that currently exists at Sites 1 and 2 is for invertebrate species including commercially important Dungeness crab and bivalve species. The Project Sites provide predominantly lower-productivity subtidal habitat value that is ubiquitous to the area and does not appear to provide significant habitat value.

4.0 SUMMARY

4.1 Site 1

Overall, the habitat provides the same function as was observed by Precision Identification (2013). Sediment quality remains predominantly sand and sandy silt. The coarse gravel and pebbles observed in the northeastern edge of the depression during the survey undertaken in 2013 were not observed in 2020, however due to poor visibility conditions at the time of the 2020 site assessment, it is possible that the divers did not assess that specific location. The species assemblage observed in 2020 was similar to that observed during the 2013 survey, and remains typical of the existing subtidal soft sediment habitat type within shallow coastal waters. Flatfish, crabs, and bivalves dominated in both surveys (2013 and 2020) and the large sea pen bed has increased in size and colonization of Site 1. Sea pens were observed to be concentrated to the southwest corner of Site 1 during the previous survey. The survey undertaken in 2020 observed a dense population of sea pens throughout the Site, including in the southwest corner, indicating that the bed has either moved or grown.

4.2 Site 2

Similar to Site 1, the habitat conditions at Site 2 have remained relatively stable since 2013. Substrates observed during the 2020 survey appeared to consist predominantly of silt with a small proportion of sand, whereas sand appeared to be the dominant substrate observed during the previous survey. Overall abundance of the benthic community at Site 2 remained lower than was observed at Site 1, which is consistent with observations of the previous surveys.

4.3 Fish Habitat

The proposed eelgrass transplant sites continue to presently provide lower-value subtidal fish habitat, typical of the substrate and depth. Site 2 provided habitat of lower quality than was observed at Site 1. The proposed TEP therefore presents an opportunity to increase habitat complexity and enhance existing conditions at these locations; and provide higher-value subtidal fish habitat that will benefit estuarine-rearing juvenile salmon (e.g., Chinook and chum), Dungeness crab, Pacific herring, and a range of other fish and wildlife. The species that were observed currently utilizing the habitat in Sites 1 and 2 are not expected to be displaced by the habitat enhancement. In many cases, the habitat will become preferred for a number of species as eelgrass beds provide high-quality habitat for the recruitment of juveniles and foraging opportunities for adult crabs and bivalves.

5.0 REFERENCES

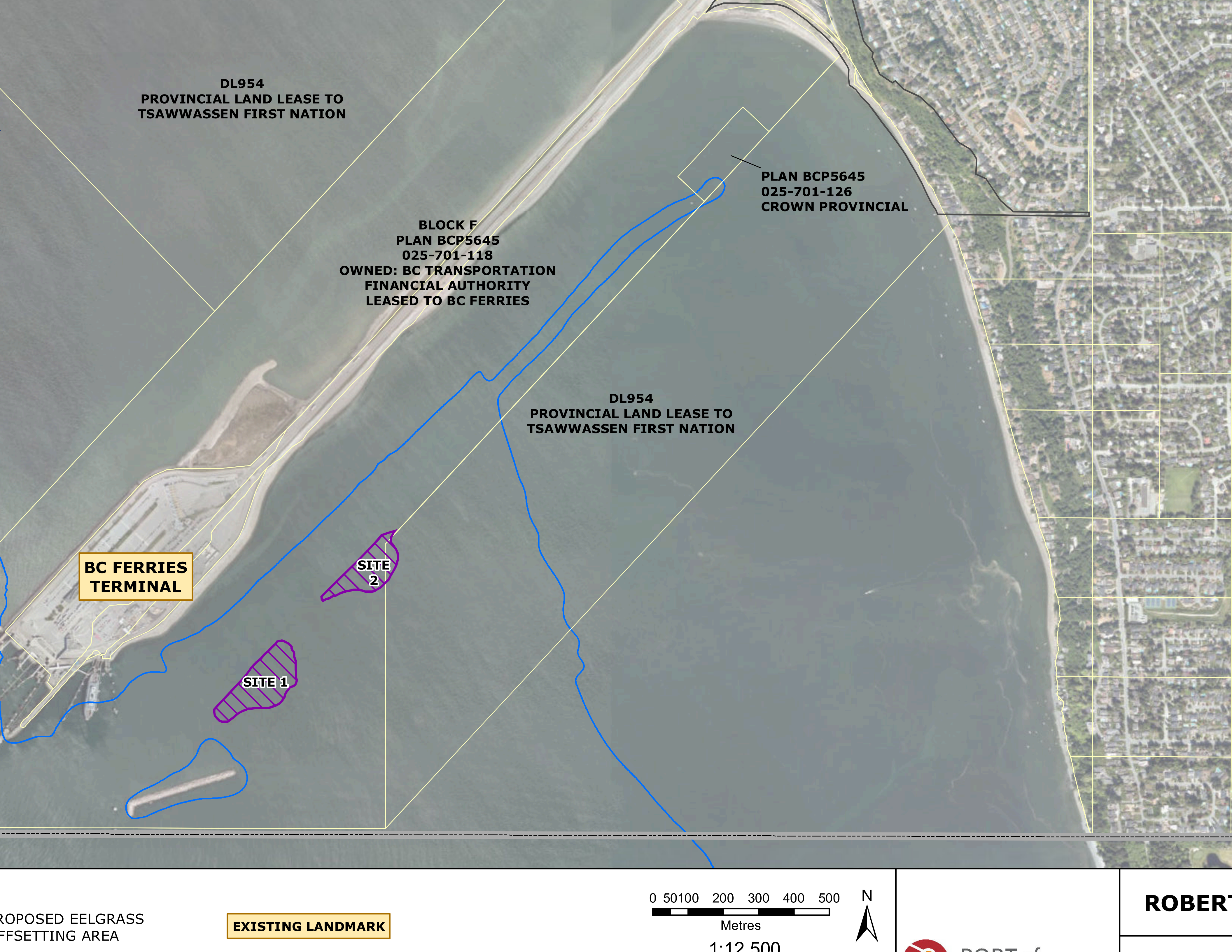
Hemmera Envirochem (Hemmera) and Archipelago Marine Research Ltd. 2014. ROBERTS BANK TERMINAL 2 TECHNICAL DATA REPORT: Marine Invertebrates Orange Sea Pens (Ptilosarcus gurneyi).

Precision Identification Biological Consultants. 2013. Port Metro Vancouver habitat enhancement program assessment of potential eelgrass transplant sites, Tsawwassen, Delta. Port Metro Vancouver (PMV).

6.0 DISCLAIMER

This report has been prepared by Hemmera, based on fieldwork conducted by Hemmera, for use by the Vancouver Fraser Port Authority. In performing this work, Hemmera has relied in good faith on information provided by others, and has assumed that the information provided by those individuals is both complete and accurate. This work was performed to current industry standard practice for similar environmental work, within the relevant jurisdiction and same locale. The findings presented herein should be considered within the context of the scope of work and project terms of reference; further, the findings are time sensitive and represent current conditions at the time the report was produced. The conclusions and recommendations contained in this Report are based upon the applicable guidelines, regulations, and legislation existing at the time the report was produced; any changes in the regulatory regime may alter the conclusions and/or recommendations.

FIGURE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APPENDIX A
Photographs

Photo 1 Detritus algae observed at Site 1. Photo taken July 24, 2020.

Photo 2 Occasional diatomaceous mats colonizing soft substrate at Site 1. Photo taken July 24, 2020.

Photo 3 Orange sea pens (*Ptilosarcus gurneyi*) colonizing the soft substrate at Site 1. Photo taken July 24, 2020

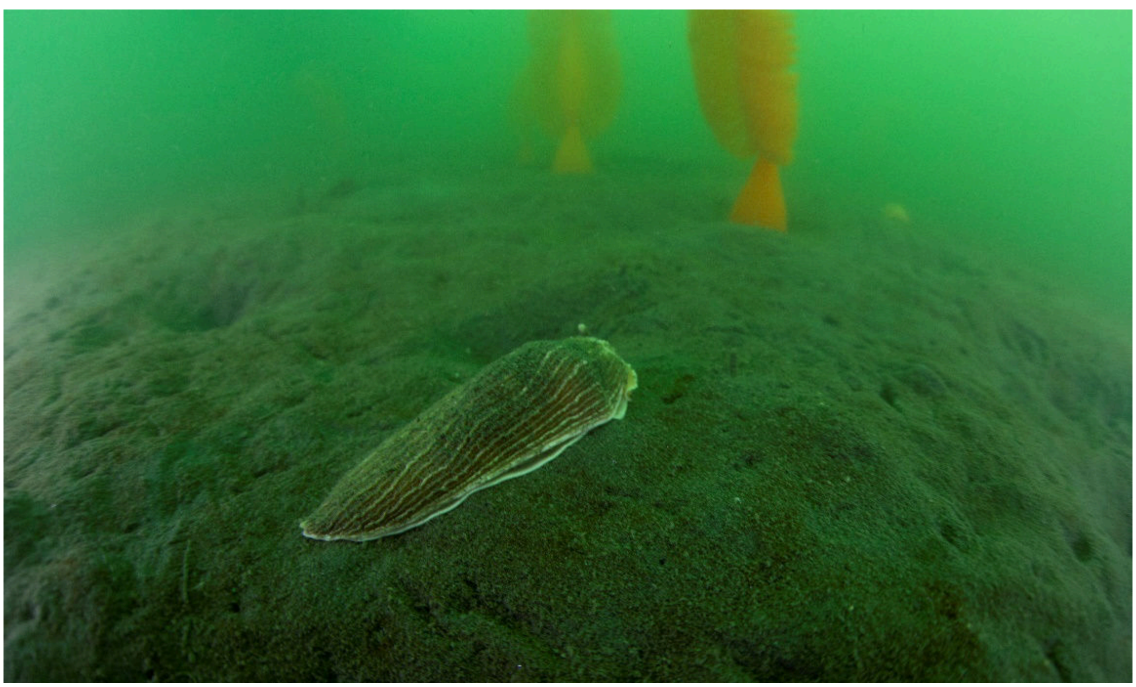

Photo 4 Striped nudibranchs (*Armina californica*) observed in the orange sea pens beds at Site 1. Photo taken July 24, 2020.

Photo 5 Adult Dungeness crab (*Metacarcinus magister*) observed in the orange sea pen beds at Site 1. Photo taken July 24, 2020.

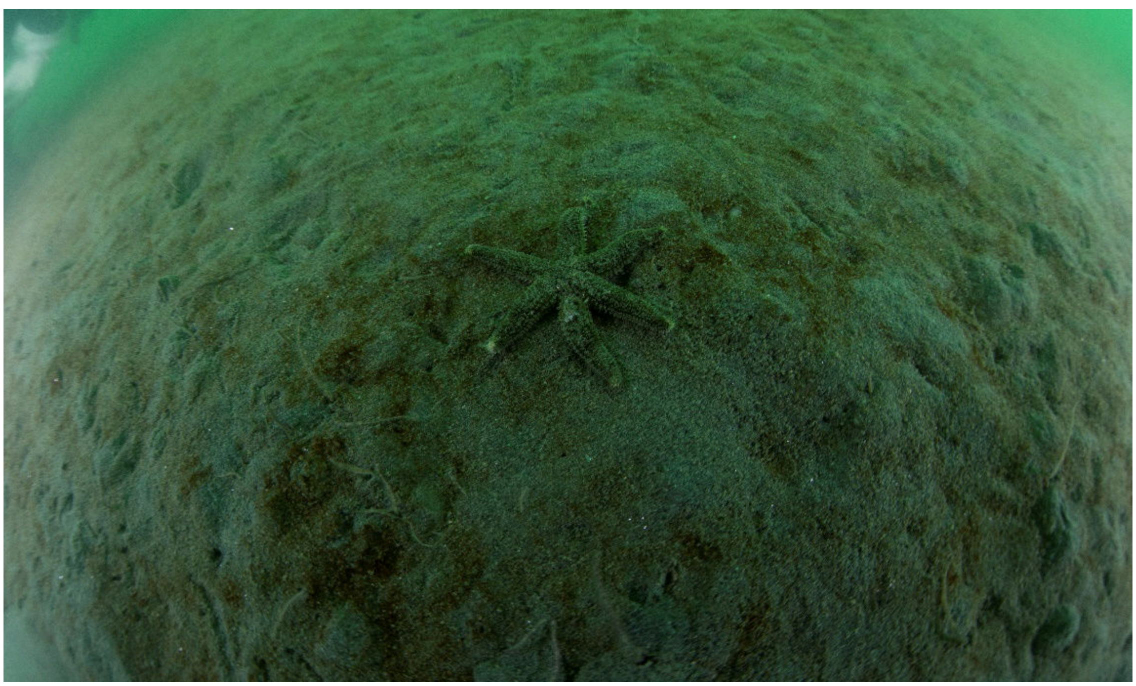

Photo 6 Unknown 6-rayed sea star observed on soft substrate at Site 1. Photo taken July 24, 2020.

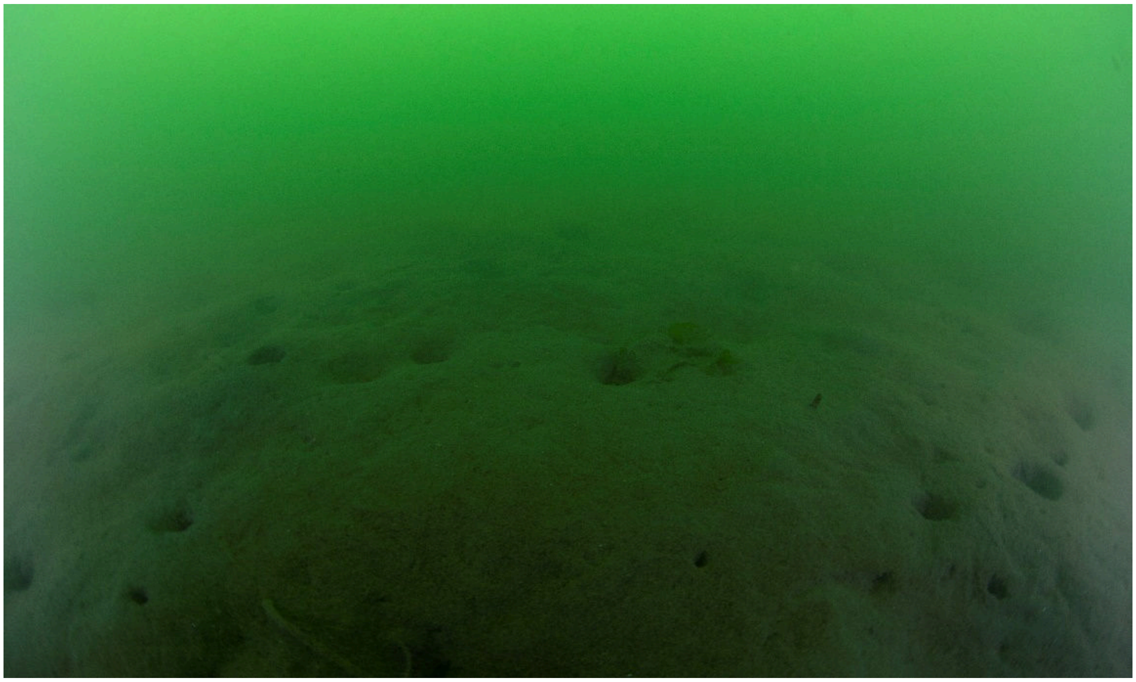

Photo 7 Typical condition of the substrate at Site 1 with abundant holes in the substrate representing the infaunal community. Photo taken July 24, 2020.

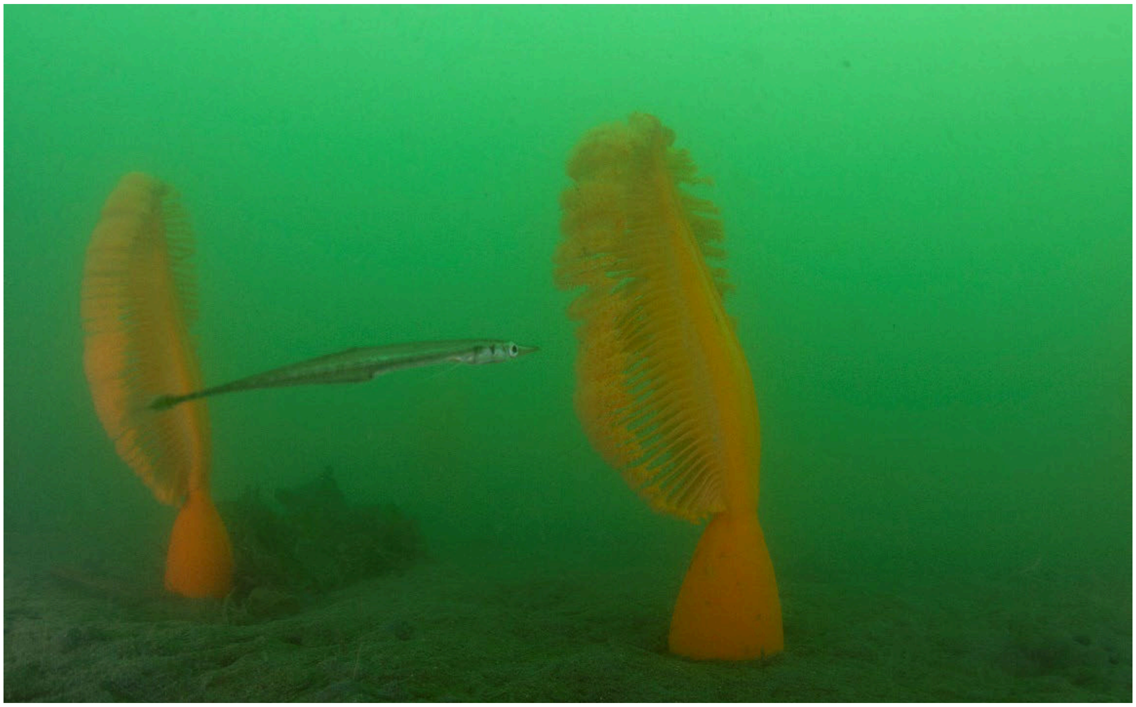

Photo 8 Tubesnout (*Aulorhynchus flavidus*) observed at Site 1. Photo taken July 24, 2021.

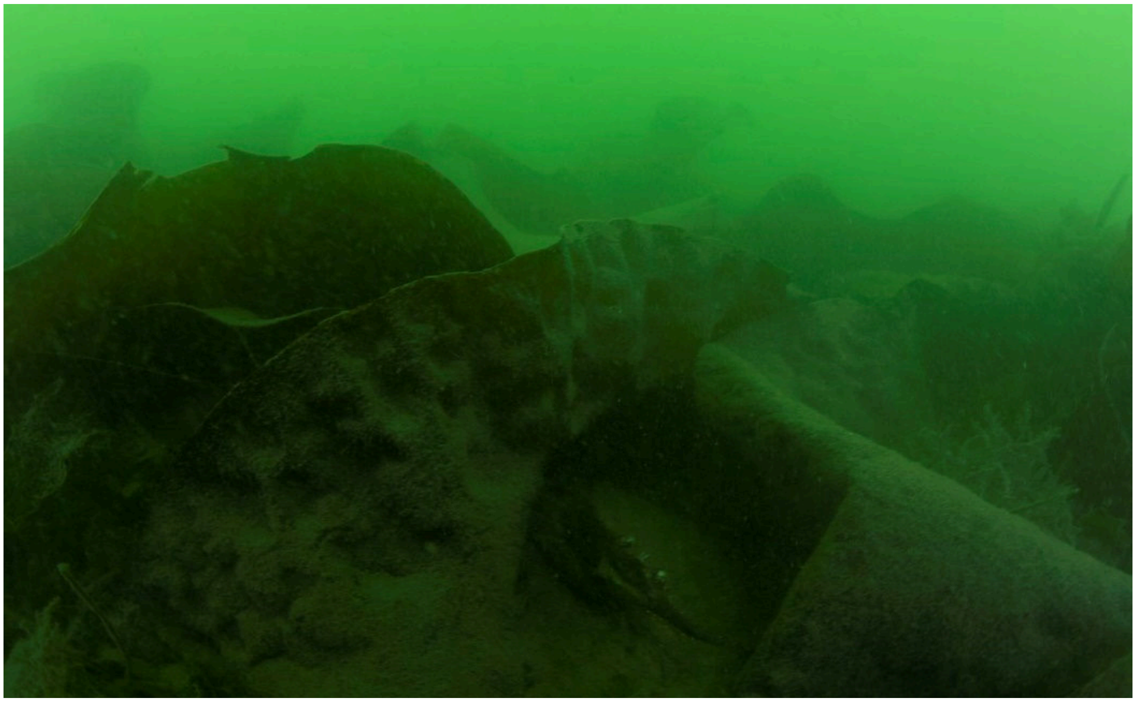

Photo 9 Detritus algae observed at Site 2. Photo taken July 24, 2020.

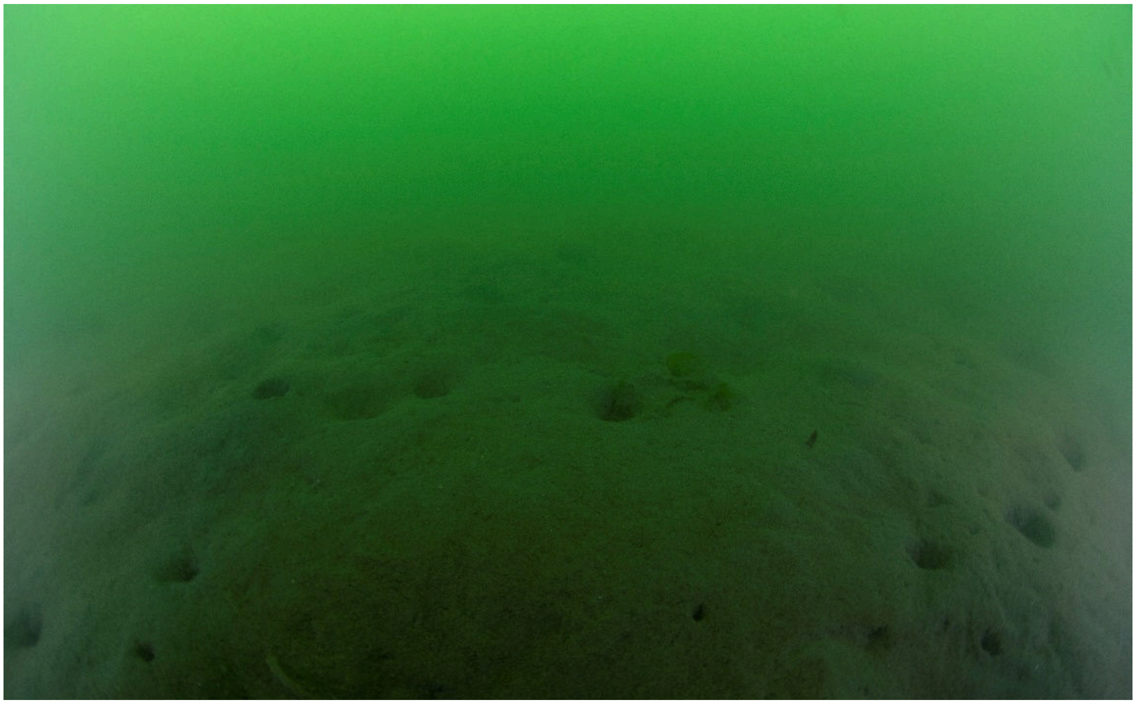

Photo 10 Larger and more abundant holes in substrate, typical of condition at Site 2. Photo taken July 24, 2020.

Photo 11 Juvenile big skate (*Raja binoculata*) observed at Site 2. Photo taken July 24, 2020.

Appendix IR2020-1.1-A15

Geotechnical Assessment – Habitat Enhancement: Tsawwassen Eelgrass Project, Tsawwassen, BC

21 August 2017

REPORT

GEOTECHNICAL ASSESSMENT

Habitat Enhancement: Tsawwassen Eelgrass Project, Tsawwassen, BC

Submitted to:
Moffatt & Nichol
Suite 301 0 777 West Broadway
Vancouver, BC
V5Z 4J7

Attention: Mr. Mike Tranmer

Report Number: 1784137-001-R-Rev0

Distribution:

1 e-Copy - Moffatt and Nichol
1 e-Copy - Golder Associates Ltd.

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FIGURES

APPENDICES

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has carried out a geotechnical assessment for the proposed habitat enhancement sites located at Tsawwassen, BC. The assessment was requested by Moffatt and Nichol (MN) on behalf of Vancouver Fraser Port Authority (VFPA). The development of the habitat enhancement sites involves fill placement as required to achieve a ground surface elevation suitable for the support of eelgrass habitat.

The geotechnical assessment was carried out on the basis of a desktop geotechnical study and did not include site specific drilling investigations, soil sampling or laboratory testing. This report presents the anticipated geotechnical conditions and preliminary comments on geotechnical considerations for design and construction of the habitat enhancement site. All elevations discussed within this report are referenced to Chart Datum.

The work on this report has been carried out in accordance with Golder proposal dated 29 June 2017. The work has been completed in accordance with the terms and conditions outlined in the Reciprocal Master Service Agreement for consulting services between MN and Golder dated 11 March 2011.

The scope of this report is limited to the provision of geotechnical engineering services only and does not include any allowance for the testing or assessment of potential soil and/or groundwater contamination at the site, nor for archaeological, geophysical, biological or bio-environmental services for the project.

This report should be read in conjunction with the “Important Information and Limitations of this Report” which is included following the text of this report. The reader’s attention is specifically drawn to this information, as it is essential that it is followed for the proper use and interpretation of this report.

2.0 SITE AND DEVELOPMENT DESCRIPTION

The Tsawwassen Eelgrass Sites are located immediately adjacent to the Tsawwassen Ferry Terminal Causeway, and recreational boating channel, as shown on Figure 1. There are two proposed sites, both of which are local depressions in the seabed. Details of the Sites are summarized in Table 1. The seabed surrounding the depressions is generally at about EL-1 m.

Table 1: Details of Proposed Sites

Site	Current Elevation (m)	Final Elevation (m)	Fill Thickness (m)	Area (ha)
1	-6	-2.25	3.8	2.58
2	-6	-1.40	5.6	1.68

It has been reported to Golder anecdotally from two different sources (ref: sources from MN) that the depressions were created during the construction of the Tsawwassen Ferry Causeway which started in 1959.

The proposed development involves filling the depressions with Fraser River Sand. On the free face, the Fraser River Sand will be constrained by a containment structure constructed of quarry run rock with particle size distribution generally ranging from 75 mm and 5 mm. The containment slope is proposed at 2 horizontal in 1 vertical. The quarry run rock will be separated from the Fraser River Sand with a 0.6 m wide filter comprising quarry screenings with particle size distribution generally ranging from 0.075 to 4.75 mm. The design of the slope revetment (i.e., the containment structure and filter) has been carried out by others.

3.0 BACKGROUND STUDY

3.1 Regional Geological Maps

Surficial geology information published by the Geological Survey of Canada (ref: Map 1486A dated 1979 Scale 1:50,000) indicates that the area is underlain by the following sequence of deposits:

- Marine Shore Sediments comprising of sand to sandy loam up to 2 m thick; overlying
- Fraser River Sediments comprising interbedded fine sand to clayey silt, between 10 and 185 m thick; overlying
- Up to approximately 400 m thickness of competent glacial and pre-glacial soils; overlying
- Bedrock.

3.2 Adjacent Habitat Construction

A similar habitat enhancement platform was constructed immediately adjacent the proposed location of Site 1 in 2008. It would be expected the performance of Site 1 (and most likely Site 2) would be very similar to this previous project in terms of settlements and requirements for staging of fill placement. Records of this development in terms of ground response to backfilling (as opposed to environmental conditions) were not available. It is understood the project was constructed successfully.

3.3 Review of Geotechnical Information

A review of geotechnical information in the vicinity of the Site was carried out as summarized below. The approximate locations of the previous investigations are shown in Figure 1.

Golder 2009-2011

Golder previously carried out a geotechnical investigation approximately 4 km northwest of the Site. The investigation included a total of four test pits, four auger holes, one seismic cone penetration test and one cone penetration test. Standpipe piezometers were installed in selected augerholes. In addition, a test fill embankment was constructed and monitored over six months. The test fill included the installation and monitoring of 20 settlement gauges and comprised two zones as follows:

- A lower fill embankment constructed to approximately 1.5 to 2 m above original site grade, measuring approximately 200 by 100 m in plan.
- A higher (upper) fill embankment constructed to approximately 4.5 to 5 m above original site grade, measuring 50 by 50 m.

Golder 2010-2012

Golder carried out a number of field investigation programs during 2010, 2011 and 2012 as part of the proposed Terminal 2 project and the Deltaport Terminal Road and Rail Improvement Project (DTRRIP). The results show between 60 to 80 m of interbeded sand and silt underlain by a clay deposit estimated to be 20 to 60 m in thickness, underlain by glacial till.

- In 2010, two deep SCPTs paired with sonic drill sampling were pushed to collect subsurface data as input to the assessment of seismic stability of the Roberts Bank delta-front slope.
- During 2011, two field investigation programs involving static and seismic cone penetration tests were carried out. The first investigation involved pushing 9 static CPTs to depths varying from 30 to 40 m below existing ground surface. The CPTs from this investigation are identified as the "600" series. A second field investigation was carried out involving pushing 8 static CPTs and a single seismic CPT to depths varying from 50 and 60 m below existing ground surface. The CPT soundings from this investigation are identified as the "700" series.
- During 2012, a site investigation was carried out. The investigation involved pushing five CPTs and a single seismic CPT to depths varying from 60 to 100 m.

4.0 SUBSURFACE CONDITIONS

A summary of inferred stratigraphic units based on the previous drilling investigation work at nearby sites is presented herein. The summary is not intended to represent a site-specific, detailed or comprehensive description of the subsurface conditions. Given the data is not site specific, but instead the closest available information, significant variation should be anticipated. The generalized subsurface conditions at the nearby sites comprised:

- Interlayered Silt, Sand and Silty Sand strata approximately 40 to 80 m thick; underlain by
- Silty clay to clay sequence extending to depths of approximately 100 m.

5.0 GEOTECHNICAL CONSIDERATIONS

The following briefly summarizes significant geotechnical design and construction considerations for the proposed habitat compensation structures:

- The subgrade soils comprise of an extensive sequence of deltaic and estuarine deposits that are inferred to extend to depths in the order of 100 m below ground surface. These soils include weak and moderately compressible, near-surface silt to clayey silt deposits, extensive loose to compact sand deposits and an interlayered sequence of silt, sand and clayey silt soils.
- Development will require the placement of permanent grade fills of up to about 5.6 m at Site 2 and 3.8 m at Site 1. The placement of this fill may cause consolidation of the underlying fine-grained subgrade soils depending on whether the Sites have been pre-loaded or not.
- Sequencing should consider specifying limitations on the thickness of fill placed in any single lift; each lift placement should be separated from the next by a waiting period to allow strength gain and dissipation of pore water pressures in the underlying deposits and mitigate the potential for ground failures.

- There may be difficulties in controlling the nature of the fill placement due to constraints associated with dredging and submerged fill placement.
- The low-plastic silt and extensive loose sand deposits are susceptible to soil liquefaction during intermediate to strong seismic (earthquake) levels of shaking, which will result in loss of soil strength. We understand, however, that the design of the proposed habitat development will not consider the effects of seismic loading.

5.1 Settlement Assessment

Site 1 and Site 2 are notable depressions, anecdotally reported to have been formed by dredging operations within the recreational channel to which they adjoin. Detailed information regarding the extent of anecdotal dredging is not available, but would indicate the previous elevation of the site (prior to dredging) was at, or higher than the proposed elevation of the habitat enhancement structures.

If this anecdotal information is accurate, the Sites have effectively been "preloaded", meaning that the placement of fill to elevations that existed prior to dredging will have less impact and only nominal settlement would be expected to occur as follows:

- A nominal allowance of 50 mm is considered reasonable.
- This would be expected to occur within 6 months following the end of construction.

Should the anecdotal evidence be inaccurate, either in full or in part, then the site would be expected to behave in a non-preloaded manner (or perhaps partially preloaded). As described in Section 3.3, a test fill embankment was constructed at a project 4 km from this Site. If behaving in a non-preloaded manner, the response of Sites 1 and 2 could be expected to be similar to that of the test embankment:

- 1.5 to 2 m fill thickness: approximately 50 to 150 mm over the first 6 month period with an additional 25 mm over the following 18 month period.
- 4.5 to 5 m fill thickness: approximately 60 to 250 mm over the same 6 month period with an additional 25 mm over the following 18 month period.

Both preloaded and non-preloaded response would also be expected to exhibit secondary consolidation of about 50 to 300 mm that could occur over the design life of the habitat embankment (assumed at 25 years). The preloaded behaviour at the lower end and the non-preloaded at the upper end. The design of the final grades suitable for supporting the eelgrass habitat should consider the above settlement estimates.

5.2 Staged Fill and Placement Sequencing

For initial planning purposes, we have assumed that the habitat compensation structure will be constructed in a staged loading sequence to allow sequential strength gain of the underlying compressible soils. Stage loading produces sequential gains of strength in the soft soils and mitigate the risk of ground failures. A waiting period between lifts should be observed to allow dissipation of excess pore pressures induced by the fill, and to avoid overstressing the underlying highly compressible fine-grained soils. The waiting period should be determined on site on the basis of construction monitoring activities; an allowance of two weeks should be included for planning purposes.

Staging of fill placement should consider placement in stages no thicker than about 1 to 2 m. Placement of fill in an uncontrolled manner (without staging) may result in failure of the underlying soils resulting in lateral movements at and beyond the toe of the fill affecting construction.

The planning of the construction should consider fill placement within the deepest part of the habitat banking first. This will allow the majority of the settlement to occur during construction and final grading operations to accommodate settlement can be carried out prior to the Contractor demobilizing from site.

5.3 Construction Monitoring

It is recommended that a geotechnical engineer be contracted to review the stability of the side slopes and make periodic inspections during placement of the fill. The geotechnical engineer should also determine appropriate waiting periods between staged lifts during construction. The Contractor should include a program of monitoring elevations with time with sufficient accuracy in order to assist the engineer in decision making regarding appropriate waiting periods, and to confirm the observed behaviour is consistent with the anticipated behaviour. This type of monitoring is especially important given the engineering recommendations are based on available information as opposed to site specific data. Golder can provide input into the construction specifications and/or tendering package for this work if requested.

6.0 CLOSURE

We trust that the information presented in this report is sufficient for your immediate requirements. Should you have any questions or require further information, please feel free to contact us.

GOLDER ASSOCIATES LTD.

PROFESSIONAL ENGINEER PROVINCE OF BRITISH COLUMBIA J. PERRETT # 34265

21 AUGUST 2017

JoAnne Perrett, PEng
Associate, Senior Geotechnical Engineer

Roberto Olivera
Geotechnical Engineer

RO/JP/syd/lmk

\\golder.gds\gal\burnaby\final\2017\3 proj\1784137 tsawwassen eelgrass habitat\1784137-001-r-rev0\1784137-001-r-rev0-tsawwassen eelgrass-21aug_17.docx

LEGEND

- SH10- SERIES SH/CPT LOCATION (2010)
- CPT11-600 SERIES DRILLED CPT LOCATION (2011)
- CPT11-800 SERIES DRILLED CPT LOCATION (2011)
- CPT12- SERIES DRILLED CPT LOCATION (2012)
- TSAWWASSEN HABITAT ENHANCEMENT SITE

NOTE

1. ALL TEST HOLE LOCATIONS ARE APPROXIMATE, OBTAINED BY HAND HELD GPS COORDINATES.

REFERENCES

1. SOURCE DRAWING INFORMATION SUPPLIED BY CLIENT FROM PORT OF VANCOUVER "HABITAT ENHANCEMENT PROGRAM TSAWWASSEN EELGRASS PROJECT SITE 1 AND 2 GRADING PLAN", DRAWING NO. 34-348-EN-6023.dwg-Rev A, DATED FEB 17/12.
2. IMAGE OBTAINED FROM GOOGLE EARTH PRO, USED UNDER LICENCE. IMAGE DATA 17-08-2016, USED UNDER LICENSE. GOOGLE EARTH IMAGE IS NOT TO SCALE.

CLIENT

moffatt & nichol

777 WEST BROADWAY, SUITE 301 VANCOUVER, BC, CANADA, V5Z 4J7 604-707-9004

CONSULTANT

Golder Associates

YYYY-MM-DD	2017-08-18
DESIGNED	JP
PREPARED	AF
REVIEWED	JP
APPROVED	RO

PROJECT

GEOTECHNICAL ASSESSMENT HABITAT ENHANCEMENT: TSAWWASSEN EELGRASS PROJECT, TSAWWASSEN, BC

TITLE

KEY PLAN AND PREVIOUS INVESTIGATION LOCATIONS

PROJECT NO.	Phase	REV.	FIGURE
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APPENDIX A

Important Information and Limitations of this Report

IMPORTANT INFORMATION AND LIMITATIONS OF THIS REPORT

Standard of Care: Golder Associates Ltd. (Golder) has prepared this report in a manner consistent with that level of care and skill ordinarily exercised by members of the engineering and science professions currently practising under similar conditions in the jurisdiction in which the services are provided, subject to the time limits and physical constraints applicable to this report. No other warranty, expressed or implied is made.

Basis and Use of the Report: This report has been prepared for the specific site, design objective, development and purpose described to Golder by the Client. The factual data, interpretations and recommendations pertain to a specific project as described in this report and are not applicable to any other project or site location. Any change of site conditions, purpose, development plans or if the project is not initiated within eighteen months of the date of the report may alter the validity of the report. Golder cannot be responsible for use of this report, or portions thereof, unless Golder is requested to review and, if necessary, revise the report.

The information, recommendations and opinions expressed in this report are for the sole benefit of the Client. No other party may use or rely on this report or any portion thereof without Golder’s express written consent. If the report was prepared to be included for a specific permit application process, then upon the reasonable request of the client, Golder may authorize in writing the use of this report by the regulatory agency as an Approved User for the specific and identified purpose of the applicable permit review process. Any other use of this report by others is prohibited and is without responsibility to Golder. The report, all plans, data, drawings and other documents as well as all electronic media prepared by Golder are considered its professional work product and shall remain the copyright property of Golder, who authorizes only the Client and Approved Users to make copies of the report, but only in such quantities as are reasonably necessary for the use of the report by those parties. The Client and Approved Users may not give, lend, sell, or otherwise make available the report or any portion thereof to any other party without the express written permission of Golder. The Client acknowledges that electronic media is susceptible to unauthorized modification, deterioration and incompatibility and therefore the Client cannot rely upon the electronic media versions of Golder’s report or other work products.

The report is of a summary nature and is not intended to stand alone without reference to the instructions given to Golder by the Client, communications between Golder and the Client, and to any other reports prepared by Golder for the Client relative to the specific site described in the report. In order to properly understand the suggestions, recommendations and opinions expressed in this report, reference must be made to the whole of the report. Golder cannot be responsible for use of portions of the report without reference to the entire report.

Unless otherwise stated, the suggestions, recommendations and opinions given in this report are intended only for the guidance of the Client in the design of the specific project. The extent and detail of investigations, including the number of test holes, necessary to determine all of the relevant conditions which may affect construction costs would normally be greater than has been carried out for design purposes. Contractors bidding on, or undertaking the work, should rely on their own investigations, as well as their own interpretations of the factual data presented in the report, as to how subsurface conditions may affect their work, including but not limited to proposed construction techniques, schedule, safety and equipment capabilities.

Soil, Rock and Groundwater Conditions: Classification and identification of soils, rocks, and geologic units have been based on commonly accepted methods employed in the practice of geotechnical engineering and related disciplines. Classification and identification of the type and condition of these materials or units involves judgment, and boundaries between different soil, rock or geologic types or units may be transitional rather than abrupt. Accordingly, Golder does not warrant or guarantee the exactness of the descriptions.

Special risks occur whenever engineering or related disciplines are applied to identify subsurface conditions and even a comprehensive investigation, sampling and testing program may fail to detect all or certain subsurface conditions. The environmental, geologic, geotechnical, geochemical and hydrogeologic conditions that Golder interprets to exist between and beyond sampling points may differ from those that actually exist. In addition to soil variability, fill of variable physical and chemical composition can be present over portions of the site or on adjacent properties. **The professional services retained for this project include only the geotechnical aspects of the subsurface conditions at the site, unless otherwise specifically stated and identified in the report.** The presence or implication(s) of possible surface and/or subsurface contamination resulting from previous activities or uses of the site and/or resulting from the introduction onto the site of materials from off-site sources are outside the terms of reference for this project and have not been investigated or addressed.

Soil and groundwater conditions shown in the factual data and described in the report are the observed conditions at the time of their determination or measurement. Unless otherwise noted, those conditions form the basis of the recommendations in the report. Groundwater conditions may vary between and beyond reported locations and can be affected by annual, seasonal and meteorological conditions. The condition of the soil, rock and groundwater may be significantly altered by construction activities (traffic, excavation, groundwater level lowering, pile driving, blasting, *etc.*) on the site or on adjacent sites. Excavation may expose the soils to changes due to wetting, drying or frost. Unless otherwise indicated the soil must be protected from these changes during construction.

Sample Disposal: Golder will dispose of all uncontaminated soil and/or rock samples 90 days following issue of this report or, upon written request of the Client, will store uncontaminated samples and materials at the Client’s expense. In the event that actual contaminated soils, fills or groundwater are encountered or are inferred to be present, all contaminated samples shall remain the property and responsibility of the Client for proper disposal.

Follow-Up and Construction Services: All details of the design were not known at the time of submission of Golder’s report. Golder should be retained to review the final design, project plans and documents prior to construction, to confirm that they are consistent with the intent of Golder’s report.

During construction, Golder should be retained to perform sufficient and timely observations of encountered conditions to confirm and document that the subsurface conditions do not materially differ from those interpreted conditions considered in the preparation of Golder’s report and to confirm and document that construction activities do not adversely affect the suggestions, recommendations and opinions contained in Golder’s report. Adequate field review, observation and testing during construction are necessary for Golder to be able to provide letters of assurance, in accordance with the requirements of many regulatory authorities. In cases where this recommendation is not followed, Golder’s responsibility is limited to interpreting accurately the information encountered at the borehole locations, at the time of their initial determination or measurement during the preparation of the Report.

Changed Conditions and Drainage: Where conditions encountered at the site differ significantly from those anticipated in this report, either due to natural variability of subsurface conditions or construction activities, it is a condition of this report that Golder be notified of any changes and be provided with an opportunity to review or revise the recommendations within this report. Recognition of changed soil and rock conditions requires experience and it is recommended that Golder be employed to visit the site with sufficient frequency to detect if conditions have changed significantly.

Drainage of subsurface water is commonly required either for temporary or permanent installations for the project. Improper design or construction of drainage or dewatering can have serious consequences. Golder takes no responsibility for the effects of drainage unless specifically involved in the detailed design and construction monitoring of the system.

As a global, employee-owned organisation with over 50 years of experience, Golder Associates is driven by our purpose to engineer earth's development while preserving earth's integrity. We deliver solutions that help our clients achieve their sustainable development goals by providing a wide range of independent consulting, design and construction services in our specialist areas of earth, environment and energy.

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Appendix IR2020-1.1-A16

Land Tenure Application & Management Plan – Westham Island / Canoe Pass Tidal Marsh Habitat Banking Project

PORT METRO
vancouver

January 23, 2014

Front Counter BC
Ministry of Forests, Lands &
Natural Resource Operations
#200 – 10428 153rd Street
Surrey, BC
V3R 1E1

Dear Sirs:

Re: Westham Island/Canoe Pass Tidal Marsh Habitat Banking Project
Application for Lease of Submerged Land Fronting DL 93, Trim Road
Westham Island, Delta

This application concerns a 7.17 hectare waterlot parcel along the southeast corner of Westham Island in the Fraser River, as shown and legally described on Sketch Plan No. S2014-025 dated January 16, 2014. The application for a 60 year lease over Provincial Crown Land is being made in support the proposed Westham Island/Canoe Pass Tidal Marsh Habitat Banking Project.

The Project is a part of Port Metro Vancouver's (PMV) Habitat Banking Program, which involves creating and improving fish and wildlife habitat in advance of development projects to ensure potential impacts to existing habitat can be offset. This is a pro-active measure intended to provide a balance between the overall health of the environment and any future development projects that may be required for PMV operations.

The Project will enlarge an existing, low quality intertidal island and create a high quality intertidal brackish marsh. It will include construction of a containment berm, followed by placement of fill material to the appropriate elevations for establishment of intertidal marsh vegetation. The creation of a marsh bench and subsequent planting of marsh vegetation at the site will result in the establishment of approximately 4.0 hectares of prime habitat for juvenile fish rearing and waterfowl feeding and roosting.

In support of the Application, please find attached:

- Completed Crown Land Tenure application form
- Cheque in the amount of $525
- Site Plan showing the proposed habitat area outlined in yellow
- Report entitled "Management Plan - Habitat Banking Program Westham Island/Canoe Pass Tidal Marsh Project". This report provides an overview and description of the Project as outlined in the Industrial-General Application Requirements List.
- Letter of Support from Tsawwassen First Nation

.../2

The proposed Project fronts one upland parcel, Remainder DL 93, owned by the Nature Trust of BC. PMV has been in discussion with the Nature Trust and will obtain consent to interfere with riparian rights, now that the Project footprint has been confirmed. A copy of the consent letter will be provided as soon as possible. Since we anticipate being able to obtain consent within the next two weeks, we respectfully request that FrontCounter BC commence the referral process prior to its receipt, as time is of the essence in obtaining a lease over this property in order to meet the Fisheries' window for construction in June/July 2014.

The Project Description/Development Plan that describes the scientific, environmental and ecological aspects of the Project will be submitted under separate cover; anticipated date is January 30th. The original report dated July 2013 and submitted to the BC Environmental Assessment Office on July 29, 2013 is being updated as a result of the change in the Project footprint. The EAO provided an exemption from obtaining an environmental assessment certificate on October 23, 2013. PMV has also engaged in ongoing consultation with First Nations, various agencies and interested parties. A description of those engagements will be included in the Updated Project Description/Development Plan.

As indicated above, since time is of the essence in obtaining this tenure, any effort to expedite the application is greatly appreciated. If PMV can facilitate that process in any way, please contact us.

Should you have any questions regarding the Application or the Westham Island/Canoe Pass Tidal Marsh Project, please do not hesitate to me at 604-665-9573, or Gord Ruffo, Project Manager, Habitat Banking Program at 604-665-9018 (Cell 604-202-8022).

Thank you for your cooperation in reviewing this Application.

Yours truly,

PORT METRO VANCOUVER

Catherine Thomas
Senior Property Administrator, Real Estate

cc. Gord Ruffo, P.Eng.
Project Manager, Habitat Banking Program

Encls.

PORT METRO vancouver

Westham Island / Canoe Pass Tidal Marsh Habitat Banking Project

Land Tenure Application – January 20, 2014

Application Check List:

- ☐ Application Form
- ☐ Cheque
- ☐ Site Plan
- ☐ Report entitled "Habitat Banking Program Westham Island / Canoe Pass Tidal Marsh Project Management Plan"
- ☐ Letter of Support from Tsawwassen First Nation

BRITISH COLUMBIA

Applying for a Crown Land Tenure

All applications must include completed application form, general location map, local detail map, appropriate fees and attachments as indicated below.

INFORMATION REGARDING APPLYING FOR CROWN LAND AVAILABLE AT
www.for.gov.bc.ca/Land_Tenures/crown_land_application_information/general_information_for_applications.html

PART 1. NAME(S) AND MAILING ADDRESS

Applicant Name:
FULL LEGAL NAME of Individual(s), Company or Society, Ministry or Government Agency Your File: DEL306-102450
Vancouver Fraser Port Authority

Contact Name for Company or Ministry Applicants:
Catherine Thomas,
Senior Property Administrator, Real Estate

Applicant Mailing Address:
100 The Pointe
999 Canada Place
Vancouver, BC postal code V6C 3T4

Applicant Contact Numbers: Phone: 604-665-9573
Daytime Phone: ______________ Fax: 1-866-212-1686
Applicant Email Address: catherine.thomas@portmetrovancouver.com

Are you an Agent submitting this application on behalf of your client?
☐ Yes ☒ No
Letter of Agency attached ☐ Yes ☒ No

Agent Name & Mailing Address:
N/A
____
______________ postal code ______

Agent Contact Numbers:
Phone: __________ Fax: __________

Agent Email Address:

Is the Applicant or the Applicant's Spouse a Provincial Government Employee
☐ Yes ☒ No
(FOR OFFICE USE ONLY. To address application processing for Provincial Government Employees go to the Land Procedure: Allocation Procedures - Applications)

For applications made by more than one individual: ☐ Joint Tenants or ☐ Tenants in Common
For your information: Joint Tenants: on the death of one tenant the interest passes to surviving tenant.
Tenants in Common: on the death of one tenant the interest passes to the beneficiaries of the estate.

BC Inc. #, BC Registration # or Society #: N/A Federal Entity | **GST Registration #:** 10816 7669 RT

Age: 19 or over ☐ Yes ☐ No N/A | **Canadian Citizen or Permanent Resident** ☐ Yes ☐ No N/A

Do you hold another Crown land tenure? ☒ Yes ☐ No If yes, provide File Number: 008 595 and 0166029

Period of Projected Use: Requesting 60 year lease term
☐ Two years or less ☐ Two to five years ☐ Five to ten years ☐ Ten to thirty years ☒ More than thirty years

Application Type: ☐ new application ☒ replacement application – file number Project 110048/117005
☐ investigative permit application ☐ amendment application – file number ______________

Proposed Use/Tenure Type: (e.g. powerline right of way, gravel quarry licence): Habitat Site - creation of intertidal bench and preservation of habitat

FOR OFFICE USE ONLY		
(date/time received)	**File Number:**	**Project Number:**
	Disposition ID:	**Client Number:**

PART 2. PURPOSE, LOCATION, AREA

PLEASE SELECT APPROPRIATE PROPOSED LAND USE

Proposed Land Use Program Area	New Application Fees (including GST)	Program Specific Requirements Website
☐ Aggregates & Quarry	$1,050.00	for.gov.bc.ca/Land_Tenures/tenure_programs/programs/aggregates/index.html
☐ Agriculture – Intensive	$ 262.50	for.gov.bc.ca/Land_Tenures/tenure_programs/programs/agriculturein/index.html
☐ Agriculture - Extensive	$ 262.50	for.gov.bc.ca/Land_Tenures/tenure_programs/programs/agricultureex/index.html
☐ Airport – private	*$50 per hour process time	Contact FrontCounter BC
☐ Alpine Skiing	Type 1 (minor) $1,050.00 Type 2 (major) contact FrontCounter BC	resort_development/how_process_works/tenure_permits/allocation_by_proposal.htm
☐ Aquaculture – Fin fish	$5,171.25	for.gov.bc.ca/Land_Tenures/tenure_programs/programs/aquaculture/index.html
☐ Aquaculture – Shellfish	$1,260.00	for.gov.bc.ca/Land_Tenures/tenure_programs/programs/aquaculture/index.html
Clean Energy - ☐ Waterpower ☐ Wind Power ☐ Ocean Energy	Investigative licence...$525.00 OR Investigative Permit ...$525.00 Wind Meteorological tower ....$525.00 Project $3,465.00	http://www.env.gov.bc.ca/wsd/water_rights/waterpower/index.html http://www.for.gov.bc.ca/land_tenures/tenure_programs/programs/windpower/index.html http://www.for.gov.bc.ca/land_tenures/tenure_programs/programs/oceanenergy/index.html
☐ Commercial - General	$ 262.50	for.gov.bc.ca/Land_Tenures/tenure_programs/programs/generalcommercial/index.html
☐ Commercial - Film	$525.00	for.gov.bc.ca/Land_Tenures/tenure_programs/programs/film/index.html
☐ Adventure Tourism	Non-Motorized $262.50 Motorized $3,465.00	for.gov.bc.ca/Land_Tenures/tenure_programs/programs/adventure_tourism/index.html
☐ Communication Site	$1,050.00	for.gov.bc.ca/Land_Tenures/tenure_programs/programs/communicationsites/index.html
☐ Community/ Institutional	$ 262.50	for.gov.bc.ca/Land_Tenures/tenure_programs/programs/community/index.html
☐ Federal Reserves	$3,465.00	Federal Government Only – Contact FrontCounter BC
☐ Ferry Terminals	*$50 per hour process time	
☒ General Industrial	$ 525.00	for.gov.bc.ca/Land_Tenures/tenure_programs/programs/generalindustrial/index.html
☐ Golf Course	$3,465.00	for.gov.bc.ca/Land_Tenures/tenure_programs/programs/golfcourses/index.html
☐ Grazing	$ 262.50	for.gov.bc.ca/hra/Legislation/grazing.htm
☐ Head Lease	$50 per hour process time	Contact FrontCounter BC
☐ Log Handling	$1,050.00	for.gov.bc.ca/Land_Tenures/tenure_programs/programs/loghandling/index.html
☐ Marina	$ 525.00	for.gov.bc.ca/Land_Tenures/tenure_programs/programs/marinas/index.html
☐ Mining	$ 525.00	for.gov.bc.ca/Land_Tenures/tenure_programs/programs/mining/index.html
☐ Oil and Gas	$ 525.00	for.gov.bc.ca/Land_Tenures/tenure_programs/programs/oil_gas/index.html
☐ Private Moorage	$ 262.50	for.gov.bc.ca/Land_Tenures/tenure_programs/programs/privatemoorage/index.html
☐ Provincial Reserves	For Provincial Government Ministries Only	
☐ Utilities (Linear Use)	Less than 25 Km $1,050.00 More than 25 Km *$50 per hour Access to single lot $262.50	for.gov.bc.ca/Land_Tenures/tenure_programs/programs/utilities/index.html
☐ Residential	$ 262.50	for.gov.bc.ca/Land_Tenures/tenure_programs/programs/residential/index.html
☐ Roadways – Public	$ 262.50	for.gov.bc.ca/Land_Tenures/tenure_programs/programs/roadways/index.html
☐ Roadways – Industrial	$1,050.00	for.gov.bc.ca/Land_Tenures/tenure_programs/programs/roadways/index.html

Note: **Investigative Permits** (available for all program areas): **$525.00** (including GST)
Replacement Application Fees: 50% of above fee or $210.00 (including GST), as a minimum.
Amendment Fees: Contact FrontCounter BC

* To be paid at a later date

PART 2 (continued)

General Location of Crown land (i.e. distance from nearest community, Indian Reserve or significant geographic location such as a lake or mountain; location on a named road; etc.):

Westham Island, Delta, BC

Please provide a shape file if available.

Area in Hectares: 7.17 **OR** length (km/m): ________ width (km/m): ________

PART 3. LEGAL DESCRIPTION OR BOUNDARY DESCRIPTION

If surveyed, give legal description: as provided by the local Land Title Office (e.g., Lot 1 of Section 31, Township 12 W6M Kamloops Division of Yale District Plan 18411). A legal description is found in the Certificate of Title (CofT). A copy of the CofT must be attached to the application. A copy of your Registered Survey Plan, if available. will confirm the dimensions of the place of use.

not applicable

If unsurveyed: enter description of unsurveyed Crown land and description of boundaries.

see attached

Instructions to Describe Unsurveyed Crown Land

• The point of commencement, for unsurveyed parcels, should be described in terms of an existing survey post (e.g., 18 metres west of the S.E. corner of the parcel) or a readily identifiable geographic feature (e.g., a prominent point of land or intersection
of two roads) to enable accurate location of the parcel.

• Boundary lines of the area must be, as much as possible, astronomically true north, south, east and west so that a rectangular lot is formed.

• Where the topographic features of the area do not allow for rectangular boundary lines running true north, south, east and west, then boundaries will be permitted in other directions as long as they do not interfere with the orderly survey of other surrounding land.

• The side lines of small parcels fronting on lakes, rivers, tidal waters and on certain surveyed highways shall, where possible, be parallel to each other and perpendicular to the general trend of the features on which the small parcel fronts.

• The sidelines for unsurveyed foreshore shall, as a general rule, be laid out at right angles to the general trend of the shore. This may be varied to suit special conditions, but encroachment on the foreshore fronting adjoining lands shall be avoided. The outside or waterward boundary shall be a straight line or series of straight lines joining the outer ends of the side boundaries. On narrow bodies of water the outside boundary shall not normally extend beyond the near edge of the navigable channel.

1 hectare = 2.471 acres
1 metre = 3.281 feet
100 metres x 100 metres = 10,000 square metres or 1 hectare

PART 4. APPLICATION CERTIFICATION

All applications must be complete. Incomplete applications will be returned to applicant.
Please refer to the specific program requirements (e.g., Aggregates, Commercial, Residential) for information that must be submitted with this application.

All of the following **must** be attached to or enclosed with this application form:

☒ **Fees** (in the amount indicated in Part 2) to **Minister of Finance** (cheque or credit card authorization form attached or pay in person with debit card or cash)

☒ **General Location Map(s)** at a scale of 1:50,000 to 1:250,000 indicating general location of the area under application and the location of access roads, watercourses and other major landmarks.

☒ **Detailed Site Map(s)** outlining in detail the area under application, showing the exact perimeter boundaries of the application area including the dimensions (in metre) and area (ha), including watercourses, district lots etc.

☒ **Program Specific Requirements** (i.e. communication site, agriculture, industrial, aquaculture). Program specific requirements can be confirmed at http://www.for.gov.bc.ca/Land_Tenures/crown_land_application_information/program_areas.html

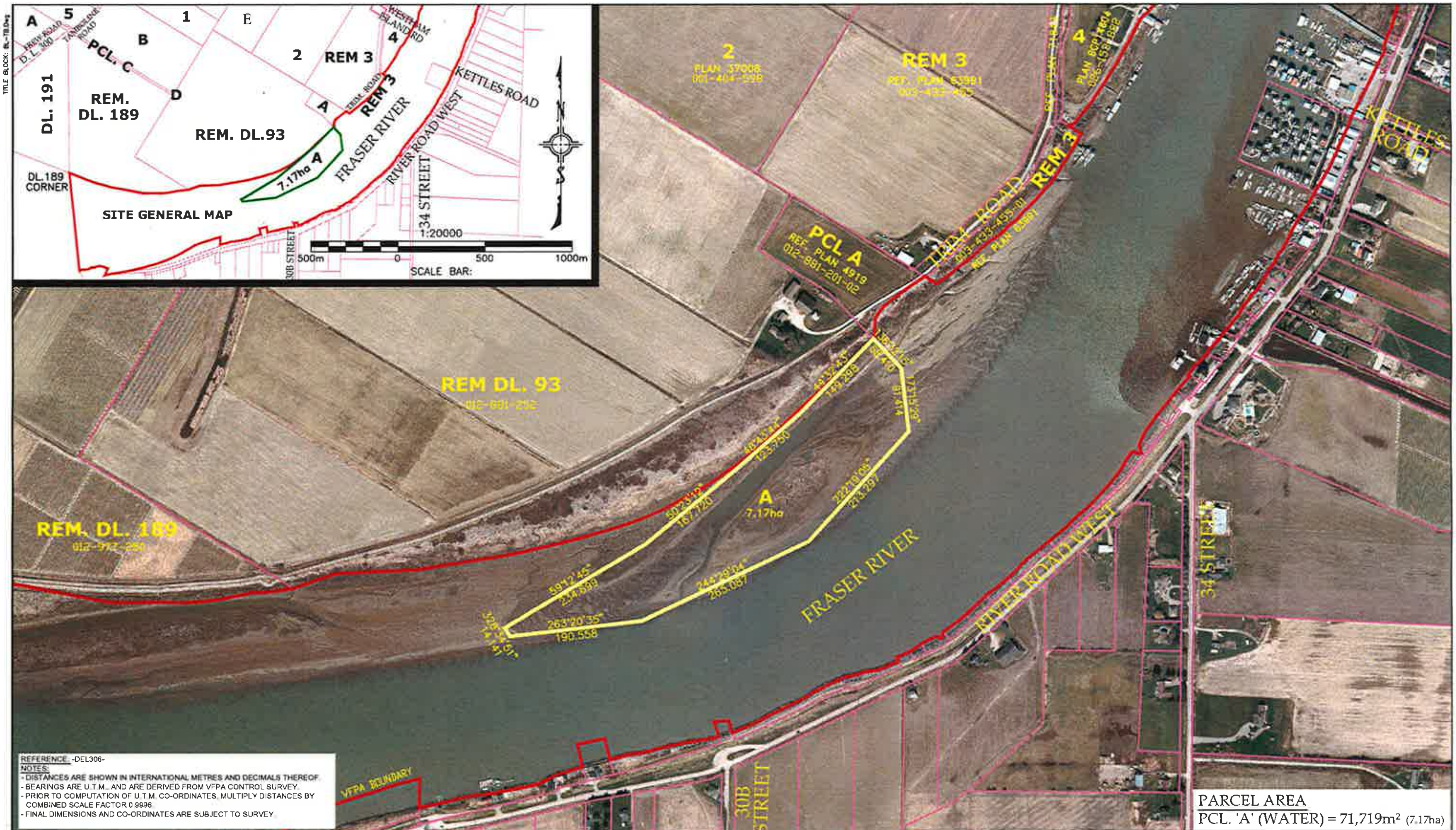
PLEASE NOTE: Additional items may be required (e.g. Advertising, Security Deposit, Proof Of Insurance, Letter Of Consent) Please consult Program Policies or contact FrontCounter BC for further information. Some items may have additional associated costs or require additional processing time.

Applicant or Agent signature(s): CATHERINE THOMAS	**Date:** Jan 20, 2014

PLEASE RETAIN A COPY OF THIS APPLICATION FOR YOUR RECORDS
- APPLICATIONS ARE NOT TRANSFERABLE -

NOTE: The information you provide will be subject to the Freedom of Information and Protection of Privacy Act. If you have any questions regarding the treatment of your personal information, please contact the Manager, Privacy, Information Access and Records Management.

The submission of this form does not in any manner convey any rights to use or occupy Crown land.



REFERENCE -DEL306-
NOTES:
- DISTANCES ARE SHOWN IN INTERNATIONAL METRES AND DECIMALS THEREOF.
- BEARINGS ARE U.T.M. AND ARE DERIVED FROM VFPA CONTROL SURVEY.
- PRIOR TO COMPUTATION OF U.T.M. CO-ORDINATES, MULTIPLY DISTANCES BY COMBINED SCALE FACTOR 0.9996.
- FINAL DIMENSIONS AND CO-ORDINATES ARE SUBJECT TO SURVEY.

PARCEL AREA
PCL. 'A' (WATER) = 71,719m² (7.17ha)

CERTIFIED CORRECT
on the 16th day of January 2014

DARCY KEITH LESUEUR
Engineering Survey Technician

Ref.No.	REFERENCE	No.	Date	REVISION	Dr'n	Ch'd

PORT METRO vancouver
PORT METRO VANCOUVER
ENGINEERING DEPARTMENT

DESIGN BY
DRAWN BY DKL
APPROVED
DATE 16-JANUARY-2014
SCALE 1:5000
VPA SITE DEL306

PORT METRO VANCOUVER
PROPOSED LEASE AREA FRONTING DISTRICT LOT 93 GROUP 2 EXCEPT FIRSTLY: PARCEL A (REF. PLAN 4919) SECONDLY: PARCEL D (STATUTORY RIGHT OF WAY PLAN 20004) N. W. D.
Corporation of Delta

SIZE B | DWG. LEASE PLAN No. 2014-025 | SHEET 1 of 1 | REV.

TITLE BLOCK: BL-TB.Dwg

VANCOUVER FRASER PORT AUTHORITY
100 The Pointe, 999 Canada Place
Vancouver, B.C. V6C 3T4 **604-665-9000**

N° 00156786

VENDOR#: **138039** NAME: **Minister of Finance** CHEQUE TOTAL: **525.00** CHEQUE DATE: **14/01/17** Page 1 of 1

REFERENCE NUMBER	INVOICE DATE	REMARK	GROSS AMOUNT	NET AMOUNT PAID
RFP140116	14/01/16	FLNRO-Westham Island Lease		525.00
FOR PAYMENT INQUIRIES PLEASE CALL ACCOUNTS PAYABLE			**TOTAL**	525.00

VANCOUVER FRASER PORT AUTHORITY
100 The Pointe
999 Canada Place
Vancouver, BC V6C 3T4

ADMINISTRATION PORTUAIRE VANCOUVER-FRASER
100 The Pointe
999 Canada Place
Vancouver, C,-B. V6C 3T4

THE ROYAL BANK OF CANADA
Hastings & Granville Branch
685 West Hastings St
Vancouver, BC V6B 1N9

00156786

DATE 2 0 1 4 0 1 1 7
Y Y Y Y M M D D

PAY FIVE HUNDRED TWENTY FIVE AND 00/100 DOLLARS **$** *******525.00

TO THE ORDER OF **Minister of Finance**
c/o FrontCounter BC

⑈00156786⑈ ⑆06550⑉003⑆ 127⑉192⑉3⑈

VANCOUVER FRASER PORT AUTHORITY
100 The Pointe, 999 Canada Place
Vancouver, B.C. V6C 3T4 **604-665-9000**

N° 00156786

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VANCOUVER FRASER PORT AUTHORITY
100 The Pointe
999 Canada Place
Vancouver, BC V6C 3T4

ADMINISTRATION PORTUAIRE VANCOUVER-FRASER
100 The Pointe
999 Canada Place
Vancouver, C,-B. V6C 3T4

THE ROYAL BANK OF CANADA
Hastings & Granville Branch
685 West Hastings St
Vancouver, BC V6B 1N9

00156786

DATE 2 0 1 4 0 1 1 7
Y Y Y Y M M D D

PAY FIVE HUNDRED TWENTY FIVE AND 00/100 DOLLARS **$** *******525.00

TO THE ORDER OF **Minister of Finance**
c/o FrontCounter BC

⑈00156786⑈ ⑆06550⑉003⑆ 127⑉192⑉3⑈

TSAWWASSEN FIRST NATION
sc̓əwaθən məsteyəxʷ

June 27, 2013

Jemma Scoble
Habitat Banking Program
PORT METRO VANCOUVER
100 The Pointe, 999 Canada Place
Vancouver, BC Canada V6C 3T4

Dear Ms. Scoble,

Tsawwassen First Nation is fully supportive of Port Metro Vancouver undertaking rehabilitation efforts related to the Westham Island Canoe Pass Tidal Marsh.

Tsawwassen First Nation is concerned over the potential impacts of development within our traditional territory, and believe that these habitat compensation measures are an important step to mitigate the impacts of developments.

This project involves the conversion of the existing unvegetated intertidal to more productive brackish marsh, which would improve the habitat productivity of the site. Canoe Passage requires maintenance dredging of the navigation channel, and dredged material could be used in the construction of the marsh habitat.

The creation of this brackish marsh (e.g. bulrush and sedge) would provide fish and wildlife habitat. The site is at a prime estuarine location to provide high quality habitat for juvenile fish rearing and waterfowl feeding and roosting.

This project will be an important contributor to the protection and enhancement of TFN's over-stressed traditional territory.

Sincerely,

Chief Bryce Williams
Tsawwassen First Nation

Administration Office: 1926 Tsawwassen Drive, Tsawwassen, British Columbia V4M 4G2
Tel: (604) 943-2112 • Fax: (604) 943-9226 Website: tsawwassenfirstnation.com

PORT METRO
vancouver

Habitat Banking Program

Westham Island / Canoe Pass Tidal Marsh Habitat Banking Project

Management Plan

Submitted to Ministry of Forests, Lands and Natural Resource Operations

Contact: Gord Ruffo, P.Eng. Project Manager
Habitat Banking Program 604-665-9018
Gord.Ruffo@portmetrovancouver.com

Catherine Thomas
Senior Property Administrator 604-665-9573
Catherine.thomas@portmetrovancouver.com

Date: January 24, 2014

Canada

Habitat Banking Program

Westham Island / Canoe Pass Tidal Marsh
Habitat Banking Project

Management Plan

Submitted to Ministry of Forests, Lands and Natural Resource Operations

Signed: ______________________ Date: January 24, 2014

Gord Ruffo, P. Eng.
Project Manager
Habitat Banking Program

Section A - Project Overview

I. Project and Purpose

Port Metro Vancouver's Habitat Banking Program involves creating and restoring fish and wildlife habitat in advance of PMV's development projects, to ensure potential impacts to existing habitat can be offset. This is a proactive measure intended to provide a balance between the overall health of the environment and any future development projects that may be required for port operations.

The proposed Westham Island / Canoe Pass Tidal Marsh Project is being undertaken in accordance with a working agreement with Fisheries and Oceans Canada that acknowledges the mutual benefits of a Habitat Bank to Port Metro Vancouver and Fisheries and Oceans Canada (DFO), while also providing guidelines for the establishment of Habitat Banking sites.

The Project would enlarge an existing intertidal island and create intertidal brackish marsh, resulting in the establishment of approximately 4.0 hectares of new marsh habitat.

II. Location, Size and Main Features

The proposed Westham Island / Canoe Pass Tidal Marsh Project site is located near the south side of Westham Island in Delta, in Canoe Pass, in the south arm of the Fraser River.

Construction would include a rock containment berm, placement of fill material and installation of marsh vegetation (e.g. bulrush and sedge). A marsh drainage channel would be constructed along the northwest end of the marsh. Pilings located in the northeast corner of the site would be removed and permanent navigation signage installed along the outer berm.

Project benefits include the establishment of high quality intertidal marsh habitat at a prime Fraser River estuarine location, with a wide range of anticipated environmental benefits including enhanced fish and wildlife habitats.

III. Access Plans

Primary construction activities are to be carried out utilizing marine access. Delivery of equipment and materials for tidal marsh construction would be facilitated using barge transportation via the adjacent channel (Canoe Pass).

Vehicular access to the project site via Trim Road would be limited to the activities of construction crew transportation and the delivery of light materials, not to exceed the designated road weight restriction (5,000kg). With the consent of the adjacent upland property owner (The Nature Trust of British Columbia), four pathways providing foot access from Trim Road to the project site would be required for the duration of construction activities. These pathways would be restored upon completion of the work.

IV. Construction Schedule

Construction is anticipated to take place over a period of approximately two months, between July 16th and September 30th, 2014.

Section B - Project Description

I. Background

Product/service being offered

The Project would result in the establishment of approximately 4.0 hectares of new intertidal brackish marsh habitat.

Intertidal marshes have high primary productivity, making them one of the most productive habitats on earth. They also provide a wide range of important ecological roles within estuarine and marine foreshore areas, including a variety of critical fish and wildlife habitat functions and support to coastal physical processes. Within the Fraser River estuary, more than 70% of the original tidally influenced habitats (including brackish marshes) have been lost over the past 100 to 150 years due to dyking, filling and other human development activities.

Brackish marshes not only provide broad ecological values, but are also extremely productive to a wide range of fish species including Pacific salmon. As a result, conservation or enhancement of this habitat type is a high priority for DFO. Following the guidance of the PMV/DFO working agreement, along with project-specific consultation with DFO, the proposed intertidal brackish marsh has been prioritized for construction by the PMV Habitat Banking Program.

Once the intertidal brackish marsh has been constructed, it can be banked by PMV as "habitat credits". There are advantages to creating habitat ahead of a development project, as it allows habitat to properly mature and become functional, allowing for the success of that habitat to be verified prior to being used by both PMV and regulators.

Potential markets

The intertidal brackish marsh habitat to be created by this project would be banked by PMV as "habitat credits". Once "banked", PMV will be responsible for monitoring and any required maintenance of the habitat so it is available to offset any habitat impacts that may apply to future PMV development projects. Before any "habitat credits" can be applied to future projects, further discussion with DFO is required to ensure that these credits are appropriate for specific impacts that are being offset.

Although the PMV Habitat Bank will be primarily used for PMV development projects, the PMV/DFO working agreement also provides for the potential future sale of "habitat credits" to others. Any PMV tenants and others with an interest in advancing projects that require habitat offsetting will be able to make an application to purchase "habitat credits" from the habitat bank.

II. Location & Development Requirements/Impacts

General description of location

The proposed Westham Island / Canoe Pass Tidal Marsh Project site is located on the north side of Canoe Pass within the Fraser River, near the southeast shore of Westham Island in Delta (see Figure 1). It is located approximately 500 m to the southwest (downstream) of the Canoe Pass and Wes-Del float home communities and the Westham Island Bridge.

Figure 1 – Site Location

Project Justification

The PMV Habitat Banking Program has identified locations within the Fraser River estuary and Burrard Inlet where productive capacity can be increased (e.g., conversion of unproductive sites to productive fish and wildlife habitat), existing habitat can be enhanced to increase its productivity, or degraded habitat can be restored to benefit fish and wildlife species. The Westham Island / Canoe Pass Tidal Marsh Project falls best within the category of habitat enhancement.

This Project is located within the Habitat Banking Program's "Fraser Estuary, Boundary Bay, Burrard Inlet, Fraser and North Arms" Geographic Service Area (GSA). With consideration towards the ecological value of intertidal marsh and the extensive history of impact by human development, the program is placing a priority on intertidal marsh enhancement in this GSA wherever a potential exists for a substantial and meaningful improvement in habitat productivity. Final site selection for this particular Project was based on various factors, including: need, habitat productivity, site location, feasibility and cost, sustainable habitat creation, ownership and tenure, and consideration towards First Nations and communities.

Converting the existing unvegetated intertidal flats (primarily sandflats) into more productive brackish marsh would improve the productivity at the site of a prime estuarine location for juvenile salmon rearing and wildlife use.

New facilities/infrastructure

The proposed project involves the creation of intertidal brackish marsh on existing unvegetated intertidal flats, on the edge of Canoe Pass within the Fraser River.

This would be achieved through the construction of a rock containment berm, placement of fill material and a marsh drainage channel along the northwest end of the proposed marsh. Pilings located in the northeast corner of the site would be removed and permanent navigation signage installed along the outer berm.

Following the physical construction of the marsh, marsh vegetation (e.g. bulrush and sedge) would then be planted.

Existing and proposed roads/road use by season

Primary construction activities are to be carried out utilizing marine access.

Road use requirements related to the project are limited to the existing Trim Road, with no implementation of additional new or temporary roads required. Usage of Trim Road will be limited to the activities of construction crew transportation and the delivery of light materials, not to exceed the designated road weight restriction (5,000kg). Use of Trim Road for these purposes will be required for the duration of project construction, scheduled from July 16th to September 30th, and only with the prior consent of The Nature Trust of British Columbia (within whose property the road is situated).

General land-use on adjacent parcels

Land-use within nearby parcels on the adjacent Westham Island is predominantly agriculture, with a secondary focus on wildlife (primarily waterfowl) management and conservation. These agricultural lands are located on the landward (north) side of a private dyke. The directly adjacent upland parcel is owned by the Nature Trust of BC and is managed and farmed on their behalf by Ducks Unlimited.

Across Canoe Pass, similar land-use (agriculture) applies. Approximately 500 m to the northeast (upstream) is the Wes-Del Marina and the adjacent Westham Island Bridge.

Any other significant development impacts

Within the general setting of the proposed project, no significant development plans or pre-existing impacts are known to apply. Given the pastoral setting of the surrounding agricultural lands, most of which are afforded some protection by the Agricultural Land Commission, it also appears unlikely that any imminent development impacts would apply.

Furthermore, it is noted that the project will itself result in the enhancement of the existing site providing long-term benefits towards a wide variety of fish and wildlife species.

III. Utilities

Utility (power, electrical, telecommunications) requirements and sources

As this is a Habitat Banking project, the scope of proposed project activities will not require the utilization of existing or temporary power, electrical or telecommunications infrastructure.

Water supply

The scope of proposed project activities will not require the utilization of existing water infrastructure.

Sewage disposal

The requirement for sewage disposal services is limited to the construction period and achieved through the use of a portable toilet, which would be professionally maintained.

Section C - Additional Information

I. Environmental

Preserving the environment is a core value at PMV. Our programs work to minimize impacts of PMV operations as well as enhance the surrounding environment. We are committed to operating in a responsible manner to safeguard the environment and the health and safety of our employees, customers and the public.

As the first North American port to employ a dedicated team of specialists to address issues concerning the environment, PMV shares this vital responsibility with Transportation Canada, Environment Canada, DFO, Metro Vancouver, and with the support of other local organizations.

The PMV Habitat Banking Program is only advancing projects at sites where existing habitat can be enhanced to increase its productivity, or where degraded habitat can be restored to benefit fish and wildlife species.

a. Land Impacts

The project would involve the creation of intertidal brackish marsh on existing un-vegetated intertidal flats, with construction equipment accessing the site by barge. As this work would be undertaken within intertidal areas, below the highwater mark of the river, no land impacts (e.g. land surface disturbance, clearing or logging, building construction) are anticipated.

With respect to potential impacts on archaeological value, especially within adjacent foreshore areas on or near the edge of the highwater mark, the actual risk of impacts is considered to be low. Further assessment by an archaeologist was required to refine archaeological potential, and subsequently indicated that no specific concerns were present.

Potential effects relating to aquatic areas (i.e., water or land covered by water) are described below in relation to Aquatic Impacts (c.)

b. Atmospheric Impacts

Any potentially adverse atmospheric impacts would only apply throughout the project construction period. Construction is scheduled to be carried out from July 16th to September 30th. Project activities with the potential for negative atmospheric impacts are limited to the use of barges and some heavy equipment (e.g., clam-shell excavator and wide-track machinery). Any potential short-term adverse impacts on air quality would be appropriately mitigated through the use of properly maintained equipment and the application of anti-idling provisions.

The constructed marsh could be expected to provide long-term atmospheric benefits, through the absorption of carbon dioxide from the atmosphere (i.e. carbon sequestration), which helps reduce the greenhouse gases responsible for climate change.

c. Aquatic Impacts

The Project would provide an overall net benefit to an instream area below the highwater mark of the Fraser River, resulting in the enhancement of associated fish and wildlife values. Throughout both the planning and implementation planning of the proposed Project, specific attention was given to ensure that the potential adverse impacts of other aquatic values had also been considered.

In order to ensure that the proposed project would not adversely affect aquatic areas, including river flow/function, a multi-disciplinary design team has been involved in project design. This has included the involvement and expert advice of appropriately qualified engineers, a wetland ecologist, and a coastal geomorphologist.

Works within aquatic areas would entail the placement of a rock containment berm with the use of a clam-shell excavator on a barge, followed by the placement of fill material and construction of a marsh drainage channel along the northwest end of the proposed marsh. Pilings located in the northeast corner of the site would also be removed using appropriate equipment. Any potential adverse effects would be avoided or minimized with application of standard Best Management Practices (BMP), which are required by DFO for projects of this type.

With consideration towards other aquatic impacts, the need to address navigation is also recognized and addressed through the installation of permanent navigation signage at key locations along the edge of the containment berm.

d. Fish & Wildlife Habitat

The PMV Habitat Banking Program is focused on creating and improving fish and wildlife habitat many years in advance of Port development, to ensure potential impacts to existing habitat can be offset.

The proposed Westham Island / Canoe Pass Tidal Marsh Project would result in the creation of a substantial area of intertidal brackish marsh which would provide a prime biophysical resource for the local ecosystem and to fish and wildlife.

With the anticipated utilization of silt and sands from existing dredging programs as fill material for the marsh, the Project would create an opportunity to keep Fraser River sediment within the river system. This helps maintain the "sediment balance" within the Fraser River, while also reducing the amount of dredged material that may have otherwise been destined for ocean disposal.

The proposed project applies the DFO Best Management Practice (BMP) to minimize the risk of impacts to downstream migrating juvenile salmonids, and as such is scheduled to be carried out within the window of least risk (July 16th to February 28th)

See supplemental "Habitat Banking Program: Westham Island/Canoe Pass Tidal Marsh Project - Project Description – January 2014" for detailed project information.

II. Socio-Community

PMV is committed to leading the growth of Canada's Pacific Gateway, in a manner that enhances the well-being of Canadians. PMV focuses on long-term economic, social and environmental performance so that future generations will enjoy the benefits of trade, improved quality of life, and a healthy, vibrant ecosystem. We lead by example and collaborate with our partners to promote development that improves the Port's economic, environmental, and social performance over the long term.

PMV has been constructing and maintaining habitat banks since 1991. The PMV Habitat Banking Program has and continues to consult with regulators, First Nations and adjacent communities to ensure that socio-community considerations are an integral component of planning and implementing individual projects. This project is being delivered in a manner consistent with Port Metro Vancouver's value of sustainability: thinking long term, considering social, environmental and financial matters.

a. Land Use

Based upon a review of Corporation of Delta zoning, the immediate upland sites on Westham Island are zoned as agricultural land. Further upstream on Westham Island, other zoning applies (light industrial). On the south, or mainland, side of Canoe Pass there is an area of "Floating Home Residential" coinciding with a float home community.

As a result, general land-use within nearby parcels on Westham Island is agriculture (cash crops). These agricultural lands are located on the landward (north) side of a private dyke. Nature Trust of British Columbia, a non-profit, non-advocacy, land conservation organization, is the owner of the adjacent, upland parcel of land. The objectives of the proposed Project are in line with the mandate of Nature Trust of British Columbia. On the southern side of Canoe Pass, similar land-use (agriculture) applies. Just upstream of the Project, next to the Westham Island Bridge, is an in-river residential area associated with the Canoe Pass and Wes-Del float home communities.

Although Canoe Pass is not a notable navigation channel given its relatively shallow draft, it is used by locals (including the residents in the float home communities). It is also of noted importance to First Nation fisheries. Recreational use is limited primarily to boating, as the upland areas (including the dyke) are all on private land. There is a private dock located approximately 400 metres upstream of the proposed intertidal brackish habitat. An engineering assessment of this project has determined that there should not be any adverse effects to this dock.

The Project is not expected to have any impacts on land, or water use (including navigation or fishing), associated with Canoe Pass and adjacent upland areas on Westham Island or the mainland. Through the efforts of a multi-disciplinary design team, with expert advice from appropriately qualified professionals, the project design has been developed in such a way that no significant adverse impacts are anticipated on either the river or adjacent upland areas.

b. Socio-Community Conditions

PMV is committed to sustainable operations and development, mindful of economic, social and environmental impacts.

Given the instream location of the proposed Project within Canoe Pass and the adjacent pastoral setting, community services and infrastructure would not be impacted by this project. Adjacent land-uses are primarily agricultural. Upstream of the site and on the opposite side of Canoe pass are two float home communities.

The proposed Project is not expected to have any impacts on land and the design has been developed in such a way that water use (including navigation or fishing) would not be adversely affected.

c. Public Health

There are no potential project-related risks to public health. No waste materials will be generated by the Project and there is no risk of site contamination, as only clean and environmentally-safe materials will be used in the construction.

d. First Nations

Port Metro Vancouver is consulting with regulators, First Nations and adjacent communities, as appropriate, to determine current uses for proposed habitat sites, including the Westham Island / Canoe Pass Tidal Marsh Project.

The Westham Island / Canoe Pass Project would result in the transformation of an unproductive, un-vegetated intertidal habitat into a highly productive intertidal marsh bench that has the potential to increase fish and wildlife presence in the area. These proposed activities are in line with the priorities of local First Nations and environmental groups.

Port Metro Vancouver has structured and implemented a First Nations consultation process with the objective of ensuring effective two-way communication and information sharing with First Nations. This will allow for potential Project related benefits to be maximized, potential adverse effects to be minimized and any legal obligations to First Nations to be fully met. Consultation with First Nations is ongoing and includes meetings, site visits, emails and phone calls, and the provision of Project-related materials.

Through consultation, First Nations have requested that traditional plants be incorporated into the design of the Project. Further input from First Nations will be used to help select the species of plants that will be included in the final planting plan. Port Metro Vancouver continues to consult with First Nations to ensure the incorporation of traditional knowledge into the Project design and input into plant selection.

Additionally, First Nations have expressed an interest in the Project as populations of fish species that are important for traditional purposes have been diminishing. The Project will benefit salmon, eulachon and other fish species through the creation of high quality fish habitat.

See supplemental "Habitat Banking Program: Westham Island/Canoe Pass Tidal Marsh Project - Project Description – January 2014" for First Nation consultation record.

Appendix IR2020-1.1-A17

Preliminary Field Reconnaissance of the Proposed Cane Pass/Westham Island Habitat Banking Development

Stantec Consulting Ltd.
4370 Dominion Street, 5th Floor
Burnaby, BC V5G 4L7
Tel: (604) 436-3014
Fax: (604) 436-3752

Via Email: Gord.Ruffo@portmetrovancouver.com

April 22, 2013
File: 123210259

Attention: **Gord Ruffo**

Dear Gord:

Reference: **Draft - Preliminary Field Reconnaissance of the Proposed Canoe Pass/Westham Island Habitat Banking Development**

On April 3rd, 2013, Chris Burk, an archaeologist with Stantec Consulting Ltd. conducted a Preliminary Field Reconnaissance (PFR) of the proposed habitat banking development of Canoe Pass/Westham Island. The purpose of the PFR was to assess the archaeological potential of the proposed development area through a pedestrian survey of the project area.

No archaeological sites were identified during the PFR and no areas within the development area were considered to have the potential for buried archaeological materials. Accordingly, no further archaeological investigations are recommended for the proposed development and it is recommended that the development proceed without any need for archaeological permits.

This recommendation applies solely to physical archaeological evidence of past human activity and in no way attempts to encompass any heritage concerns of the various First Nations people with asserted traditional territories in the study area.

Although a thorough attempt was made to locate and record all archaeological and other cultural heritage features located within the specified survey area boundaries, the possibility exists that not all cultural materials were identified. If any currently unidentified archaeological or cultural heritage materials are encountered during development activities, any work that threatens those materials should stop and the Archaeology Branch of the Ministry of Forests, Lands, and Natural Resource Operations should be contacted at (250) 953-3334. This agency will then provide direction as to an appropriate course of action to take regarding management of the materials.

It is recommended that construction personnel be given the *Chance Find Protocol* included in Appendix A of the *Archaeological Overview Assessment Port Metro Vancouver Habitat Banking Program – Potential Projects 2013* in case of the unlikely event that archaeological materials are found during construction of the habitat area. Historic and prehistoric materials older than AD 1846 are protected by legislation and if discovered, all work in the vicinity of the finds should stop and the Archaeology Branch be notified. Such materials may consist of historic refuse or structural remains and/or prehistoric materials consisting of fire modified rocks (FMR), shell midden, chipped stone or ground stone tools or tool fragments, and/or debitage (debris from the manufacturing of stone tools).

If you have any questions please let us know.

Reference: Draft - Preliminary Field Reconnaissance of the Proposed Canoe Pass/Westham Island Habitat Banking Development

Respectfully,

STANTEC CONSULTING LTD.

Reviewed by:

Rob Commisso
Technical Unit Lead—Archaeology

Chris Burk, RPCA
Project Manager - Archaeology

Appendix IR2020-1.1-A18

Salinity Impacts for the Westham Island/Canoe Passage Tidal Marsh Project

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MEMORANDUM

To: Vancouver Fraser Port Authority

From: Cheng-Feng Tsai, Alan Alcorn, Michael Cho, Moffatt & Nichol

Date: June 9, 2020

Subject: Salinity Impacts for the Westham Island/Canoe Passage Tidal Marsh Project

The farmers on the adjacent land along the Canoe Passage have indicated their concerns regarding the salinity impacts to the water, as a result of the proposed Westham Island/Canoe Passage Tidal Marsh Project. The passage has always been the primary freshwater source to the farmland.

The recent modelling work[1] by Moffatt & Nichol confirms that the project is located where the freshwater from the Fraser River mixes with the saltwater from the Strait of Georgia. The most dominant controlling factor for salinity mixing is the Fraser river discharge, e.g. Figure 1 indicates that the Canoe Passage is fresh irrespective of tide stage when the Fraser discharge is medium or higher (such as freshet). When the Fraser discharge is low, the secondary factor of the oscillating tides increases its contribution to the mixing process. As shown in Figure 2, the salinity at the passage transitions from fresh to brackish when the tide stage is high. In addition, the passage does not exhibit a notable stratification as the nearby Fraser River South Arm (e.g. surface layer vs. bottom layer). In general, M&N's modelling results are consistent with the measurements and modelling results from the Northwest Hydraulic Consultants[2].

From the salinity mixing perspective, only the change of the volume of freshwater or saltwater input (e.g. flow path alteration) or a significant reduction of the cross-sectional area in the flow conveyance (e.g. blockage) may alter the salinity level in the Canoe Passage. The overall reduction of the cross-sectional area due to the project is estimated less than 4 to 5%. Since the project is located at the shallower part of the channel, even less flow area will be impacted (e.g. lower impacts when the water level is high). Given the proposed tidal marsh project does not change the volume of freshwater or saltwater input and does not significantly reduce the cross-sectional area, the project is not expected to alter the salinity level in the Canoe Passage.

One of the farm inlets is very close to the tie-in to east end of the project area. Because the project does not connect the berm to the bank, so there will always be a channel that can feed this inlet. In addition, smaller channels will be created within the habitat so there will not be any stagnation impacts from either the farm weir intake or outlet. Finally, with a fresh environment in the Canoe Passage being a prominent condition for all except during the high

[1] Moffatt & Nichol, 2020. Supplemental Hydrodynamic and Salinity Analysis by Incorporating Phase 2 Breaching into the South Arm Jetty Tidal Marsh Project. Memorandum. May 28, 2020.
[2] Northwest Hydraulic Consultants, 2014. Coastal Geomorphology Study, Proposed Roberts Bank Terminal 2 Technical Report. Final Report. March 2014.

tide, low Fraser flow condition, the intakes will not experience saltier condition as a result of the project.

It should be noted that this memorandum only takes into account the current states of the hydrological regime, any potential climate change-induced alterations of freshwater (e.g. changes in precipitation patterns) or saltwater characteristics (e.g. sea level rise or storminess) are not considered.

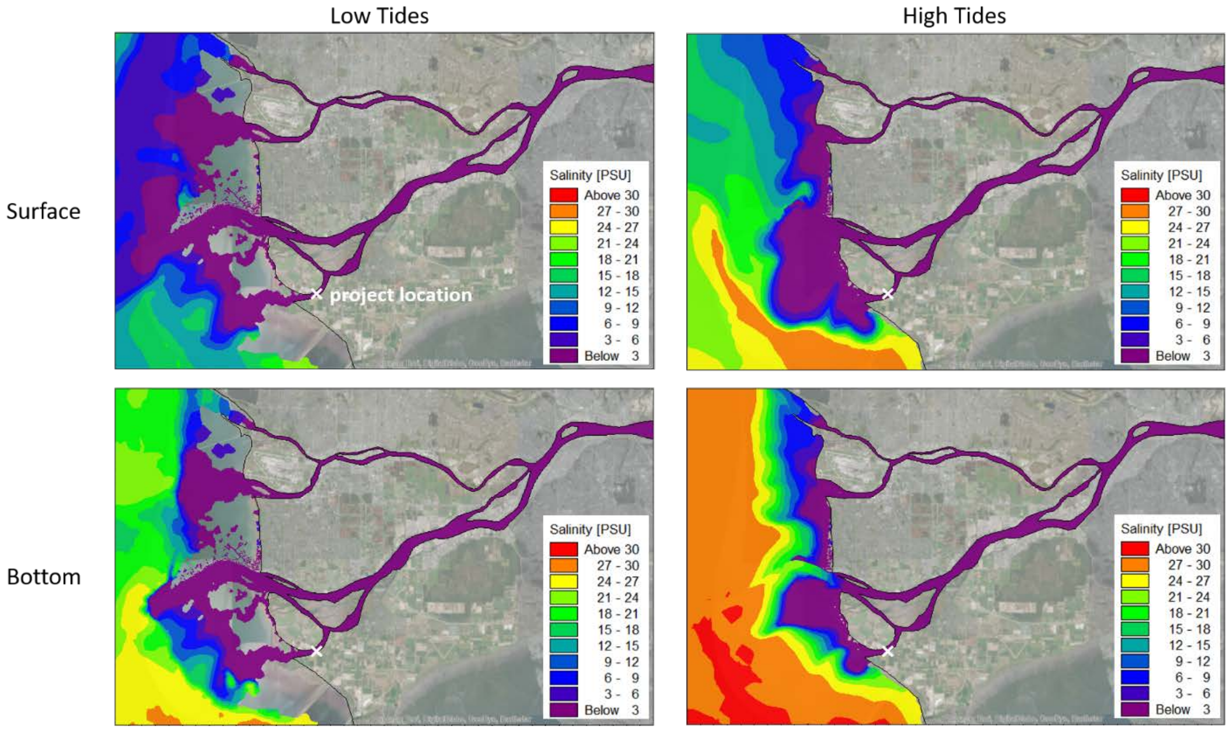

Figure 1: Salinity Distribution for Medium Fraser Flow (5,500 m^3/s), at Surface (Top Panel) and Bottom (Bottom Panel) Layer during Low (Left Panel) and High (Right Panel) Tide Stage

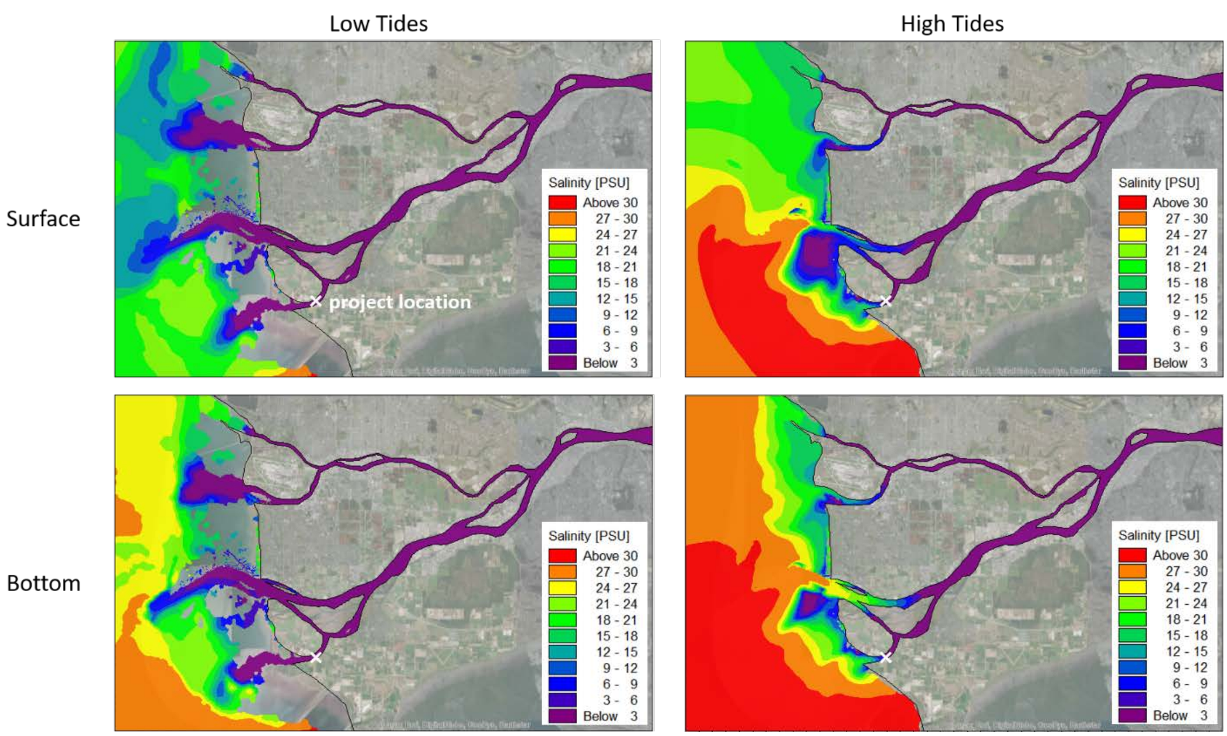

Figure 2: Salinity Distribution for Low Fraser flow (2,000 m^3/s), at Surface (Top Panel) and Bottom (Bottom Panel) Layer during Low (Left Panel) and High (Right Panel) Tide Stage

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Appendix IR2020-1.1-A19

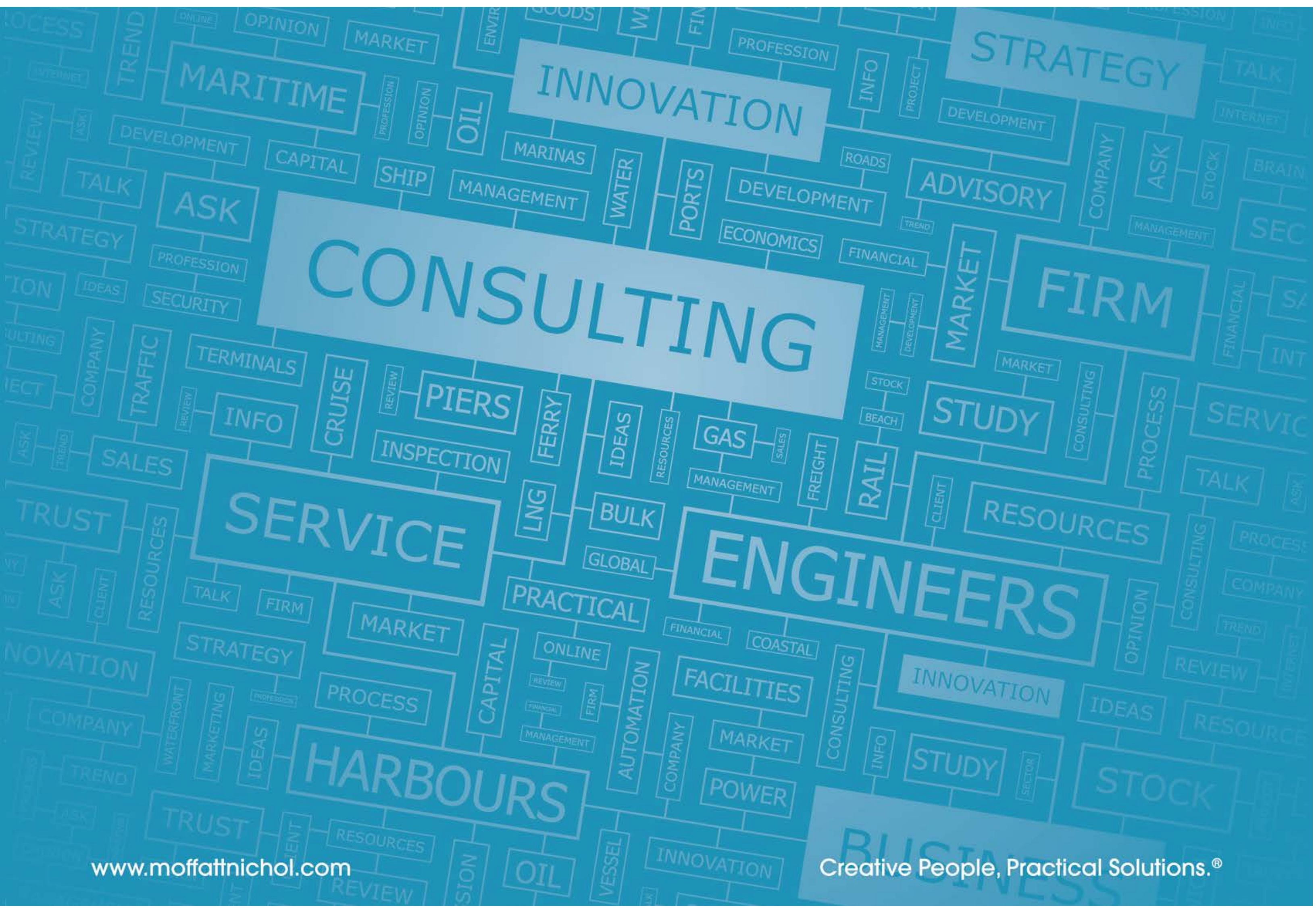
Westham Island Canoe Pass Tidal Marsh Project Design Report

Westham Island Canoe Pass Tidal Marsh Project Design Report

PRODUCED FOR

PORT of vancouver

OCTOBER 6, 2020



Document Verification

Client	Vancouver Fraser Port Authority
Project name	Westham Island Canoe Pass Tidal Marsh
Document title	Design Report
Date	October 6, 2020
Project number	9117

Revision	Description	Issued by	Date	Checked
	Draft Report	MT	December 13, 2013	MC
B	Issued for Review	AA/LW	July 30, 2020	YN/MC
C	Issued for Review	LW	October 6, 2020	MC

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This study is qualified in its entirety by, and should be considered in light of, these limitations, conditions and considerations.

1. Introduction

The Vancouver Fraser Port Authority (VFPA) is proposing to provide habitat restoration projects to offset impacts from construction of the Roberts Bank Terminal 2 (RBT2) project. Typical examples of habitat that could be affected by port development include eelgrass beds, saltwater, brackish, freshwater and tidal marshes, and tidal flats. One of the projects under investigation includes the Westham Island Canoe Pass (WICP). The WICP site will be defined by a new containment berm; the existing sand bars will be in-filled with sand and the marsh area will be vegetated

Current agricultural water supply is obtained from the South Arm in proximity to the proposed project. An assessment has been provided and is included in Appendix E. The conclusion of this assessment is that the project will have no material impact on the quality or quantity of irrigation water.

This report provides justification for the development of the criteria that have been considered in the design for the WICP project. The System Characterization and Site Conditions are discussed in Section 2 and detail the coastal processes and conditions of the Fraser River.

The criteria used to develop the design of the WICP project are discussed in Section 3. In addition to the general project design criteria, the design concepts include a description of the functional, physical and biological criteria as well as the applied engineering standards.

The construction details for the WICP project are discussed in Section 4. Following a general site description, the features of the project are presented, including: the containment berm, the marsh bench, site conditions and access. Construction methodology and schedule are also presented in this section. Following the construction details, Section 5 includes information on construction costs.

2. System Characterization and Site Conditions

2.1. Background

The Fraser River is the largest river along the Canadian Pacific Coast. Figure 2-1 shows the location of the Westham site in the lower Fraser River. The river crosses the urban area of Metro Vancouver and debouches into the Salish Sea connected to the Pacific Ocean through the Strait of Juan de Fuca.

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 (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^3 of sand was dredged annually. Current guidelines limit dredging to 70% of the incoming bed-material load (BIEAP-FREM, 2006), some 3.5 million m^3 annually.

Based on distinct physical and biological processes, Williams et al (2009) have identified five habitat types in the Roberts Bank delta fringe system. These are: (1) sand flat habitat, (2) mudflat habitat, (3) eelgrass habitat, (4) tidal marsh habitat and (5) backshore habitat. A similar t classification has been proposed by CBA (2010). For the purpose of habitat enhancement/offsetting, these concepts are applied and modified to capture main geomorphic units and features of the site.

The objective of the proposed Westham Island/Canoe Pass Tidal Marsh Project is to create productive intertidal brackish marsh salmon rearing habitat which will also benefit other fish species and wildlife utilizing the Fraser River estuary. The lower Fraser River estuary has experienced a loss of approximately 70% of its wetlands through diking and shoreline modifications over the last century. The construction of tidal marsh habitat is supported by the Department of Fisheries and Oceans Canada (DFO) and is one of the main enhancement/offsetting project efforts implemented to support Pacific salmon. Providing productive rearing habitat can increase marine survival and improve fitness of adult salmon returning to spawning grounds, provide benefits to marine mammals as well as commercial, recreational and First Nation fisheries.

Specific ecological functions that can be enhanced or improved at the Westham site include:

Increasing primary productivity by constructing tidal marsh;

- Supplementing the detritus food web through the establishment of marsh vegetation;
- Creating intertidal habitat for the production of invertebrates (e.g. chironomids, amphipods, etc.) that are important benthic, epibenthic, and drift prey items for juvenile salmonids and other fishes; and
- Providing intertidal vegetation cover and refuge for juvenile salmonids during yearly downstream migration and utilization of shallow shoreline habitats in the lower Fraser River

rearing corridor prior to out-migrating to their marine life phase in the Salish Sea and the Pacific Ocean.

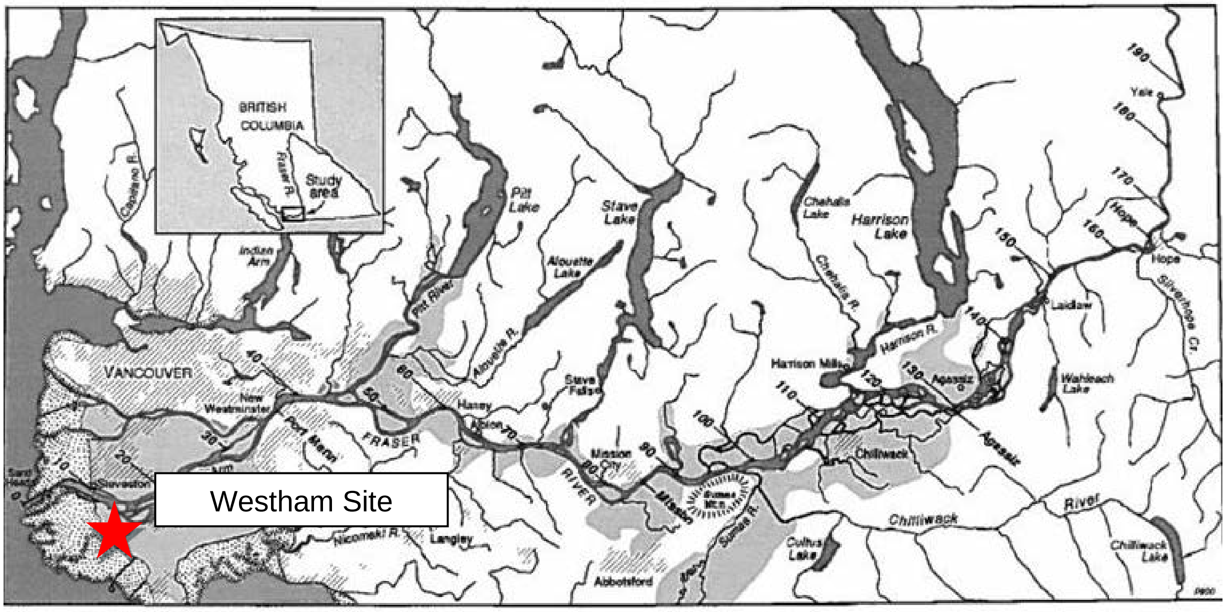

FIGURE 2-1: LOWER FRASER RIVER SYSTEM SHOWING THE WESTHAM SITE[1] (MODIFIED AFTER ELLIS ET AL, 2004)

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 Burrard Inlet Environmental Action Program and Fraser River Estuary Management Program (BIEAP-FREMP), Environment Canada, Canadian Coast Guard and Port Metro Vancouver (PMV). Based on 1D Mike 11 modeling, Canadian Coast Guard maintains a website (http://www2.pac.dfo-mpo.gc.ca/index.aspx) codenamed AVADEPTH to forecast water level and currents for navigation along the Fraser River. Figure 2-2 shows AVADEPTH forecast reaches of the Fraser River Estuary.

[1] ★ represents the Westham site on all figures

FIGURE 2-2: AVADEPTH MODEL FORECAST SNAPSHOT

As Figure 2-2 shows, the forecast system includes only the main arm of the Fraser River excluding Fraser River North Arm and Canoe Passage.

2.2. General Setting

The proposed project site is located in the Fraser River Estuary in Canoe Passage – a minor distributary of the Fraser River outer delta. Figure 2-3 gives a general impression of the physiography of the delta. Section 2.3 describes hydraulic, sedimentology and morphologic characteristics of the site. A brief review of the general physical setting of the Fraser River system is presented in this section.

FIGURE 2-3: FRASER RIVER DELTA FRINGE PHYSIOGRAPHY (AFTER WILLIAMS ET AL, 2009)

The Fraser River is one of the largest rivers in the Pacific west coast of North America. With a drainage basin of approximately 217,000 km^2, the river covers a terrain length of 1,370 km before 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 the 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: Mean flow	2,803 m^3/s	See Morrison et al, 2002

Description	Magnitude	Source
Mean peak flow Mean minimum flow Lowest flow, January 8, 1916 Highest flow, May 31, 1948	8,705 m^3/s 687 m^3/s 340 m^3/s 15,200 m^3/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 Granular distribution	17.3×10^6 tonnes/year 35% sand 50% silt 15% clay	NHC-Triton, 2004 Chapter 2.1
*Bed-material load to sea	2.8×10^6 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 the freshets. Figure 2-4 shows the effects of freshets on water level in the reach starting from Sand Heads, in open water, to New Westminster. The figure shows that mean water level rises by more than 1 m from Sand Heads to New Westminster during freshets.

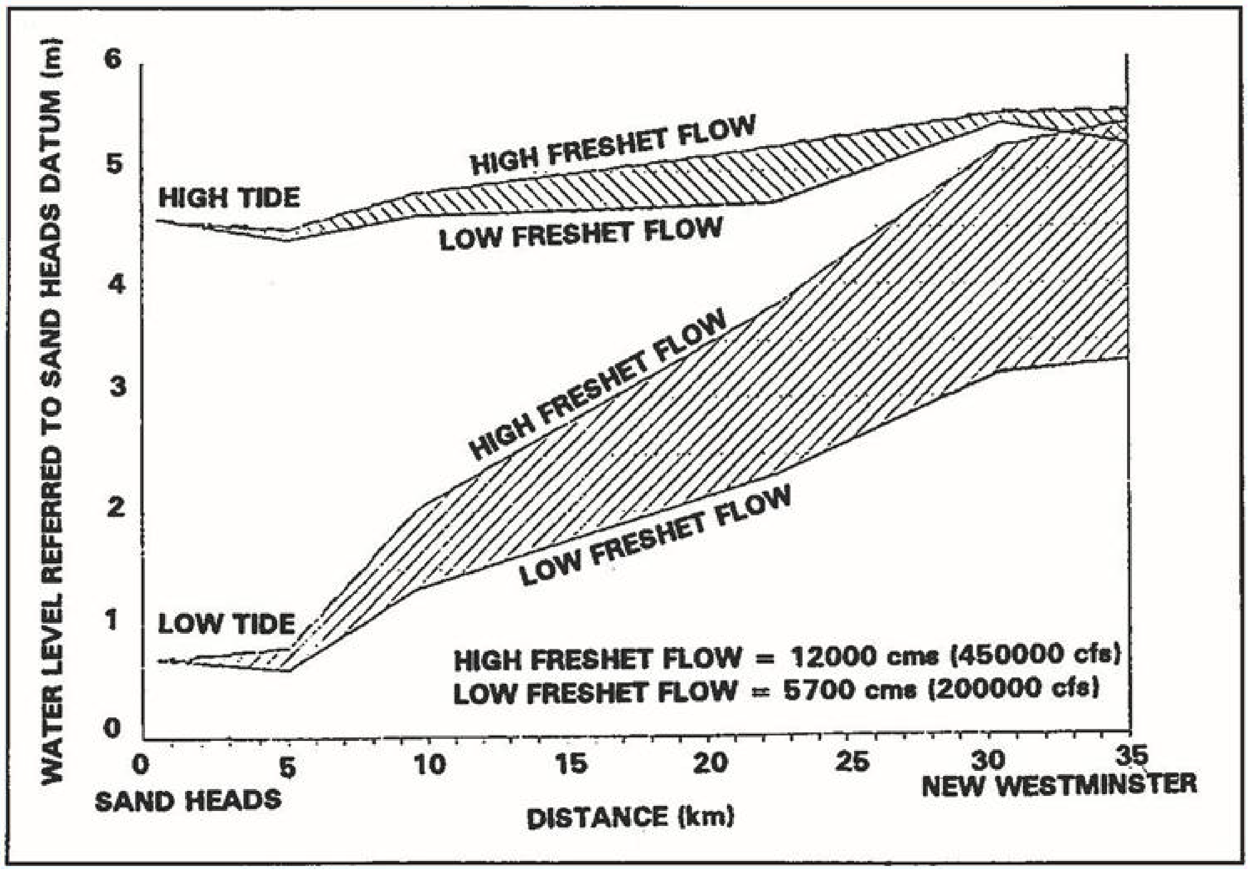

FIGURE 2-4: EFFECTS OF FRESHETS ON WATER LEVEL IN THE FRASER RIVER ESTUARY, BRITISH COLUMBIA (AFTER FERGUSON, 1991)

History of changes of 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-FRMEP (2006) has 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 Westham site is part of the Fraser River South Arm Tidal.

2.3. Project Site

The Westham Island/Canoe Pass Tidal Marsh site is located on the Canoe Passage, the southern-most distributary of the Fraser River. The existing site is characterized as a series of sandbars that are prominent at lower water levels but become partially submerged at higher water levels. Trends in changes of flows, sediment load, offtake and delta-fringe morphology suggest that the channel is gradually losing its flushing capacity. The process is being accelerated by continuous navigation dredging of Steveston Cut and Woodwards Reach.

Figure 2-5 shows location of the site along the Canoe Passage on a portion of the Canadian Hydrographic Survey (CHS) hydrographic chart #3492. Apart from some small outer bend and constriction scour holes deeper than 5 m, most of the channel is shallower than 5 m. A submerged sill to a height of 2 m above chart datum occupies the offtake.

FIGURE 2-5: CANOE PASSAGE ROBERTS BANK SYSTEM ACCORDING TO CHS CHART #3492

As shown in Figure 2-6, the offtake area is also located within the limits of freshet salt-wedge intrusion zone. A salt-wedge is a distinct vertical stratification system with the dense salt water forming an intrusion wedge at the channel bottom. River borne sediments encounter diminishing transport capacity in the wedge intrusion area and accumulate.

FIGURE 2-6: CANOE PASSAGE OFFTAKE AREA AND SALT-INTRUSION LIMITS DURING FRESHETS (BIEAP-FREMP, 2006)

A series of orthophotos from 1966, 1979, 1984 and 2002 compiled by NHC-Triton (2004) show a narrowing of Canoe Passage main channel over time and bar development on Roberts Bank. This implies decreasing hydraulic capacity of Canoe Passage over the years.

Some photographic snapshots captured during low water on August 19, 2020 are shown in Figure 2-7 through Figure 2-10. They indicate present morphological features and conditions of the Westham site, which are summarized in Table 2-2.

FIGURE 2-7: EXISTING DRAINAGE CHANNELS AT THE WESTHAM SITE.

FIGURE 2-8: WESTHAM SITE LOOKING SOUTH FROM FORESHORE

FIGURE 2-9: SEAWARD EDGE OF EXISTING TIDAL MARSH AT WESTHAM SITE

FIGURE 2-10: NEW MARSH GROWTH ON MARSH ISLAND – LOOKING WEST

The main hydro-morphologic features of the site are summarized in Table 2-2.

TABLE 2-2: MAIN HYDRO-MORPHOLOGIC CHARACTERISTICS OF THE WESTHAM SITE

FEATURE	DESCRIPTION
Planform	• A meandering channel system from distributary offtake in the Fraser River to Roberts Bank. • A fixed revetted outer bank opposite to the project site. • Point-bar deposits on the inner bank typical of a meandering channel. Point bars are shore-attached crescent-shaped depositions on the inner bank of a meander. • Embankments on both banks with drainage outlets/sluices. • Lower intertidal point-bars are overlain by ripple to dune-scale bedforms and eroded benches. The continuity of the point-bar deposit is broken by channels. The orientation of bedforms indicates the effects of ebb-tidal current at certain phases of the falling tide. • Upper tidal marsh on the inner bank side.
Cross-section	• Main channel on the left outer bank. • Lower intertidal sand/mud banks/bars with surface marks of ripple to dune-scale bedforms. • Upper tidal marsh areas to the inner bank. • River bank and embankment on both sides.
Hydro-morphology	• Overall, the site represents a net sediment depositional deltaic regime. • The portion of Fraser River discharge in Canoe Passage has reduced which has led to a narrowing of the river thalweg and increase in bank flats. • The surface bed-material of the intertidal area appears highly erodible silty-clayey fine sand.

3. Design Criteria

This section describes the criteria that guided the design of the Westham site. The objective of the Westham Island/Canoe Pass Tidal Marsh Project is to expand an existing tidal marsh by installing a riprap containment berm, infilling with clean fill and transplanting intertidal brackish marsh vegetation. This section includes a description of the functional, physical and biological design criteria as well as the applied engineering standards.

3.1. General Design Criteria

3.1.1. Project Datum and Units

Horizontal coordinate system is based on NAD83 UTM Zone 10. The vertical datum is Geodetic Datum. All drawings are presented in SI (metric) units.

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 containment structures for the habitat features 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 will be used in the 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 Westham site does not include marine structures such as pedestrian bridges, piers, and buildings where public health and safety, fire protection, and structural sufficiency are directly applicable. The proposed habitat development enhances or expands the existing natural foreshore environment. The Westham site is not a public gathering space and 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.

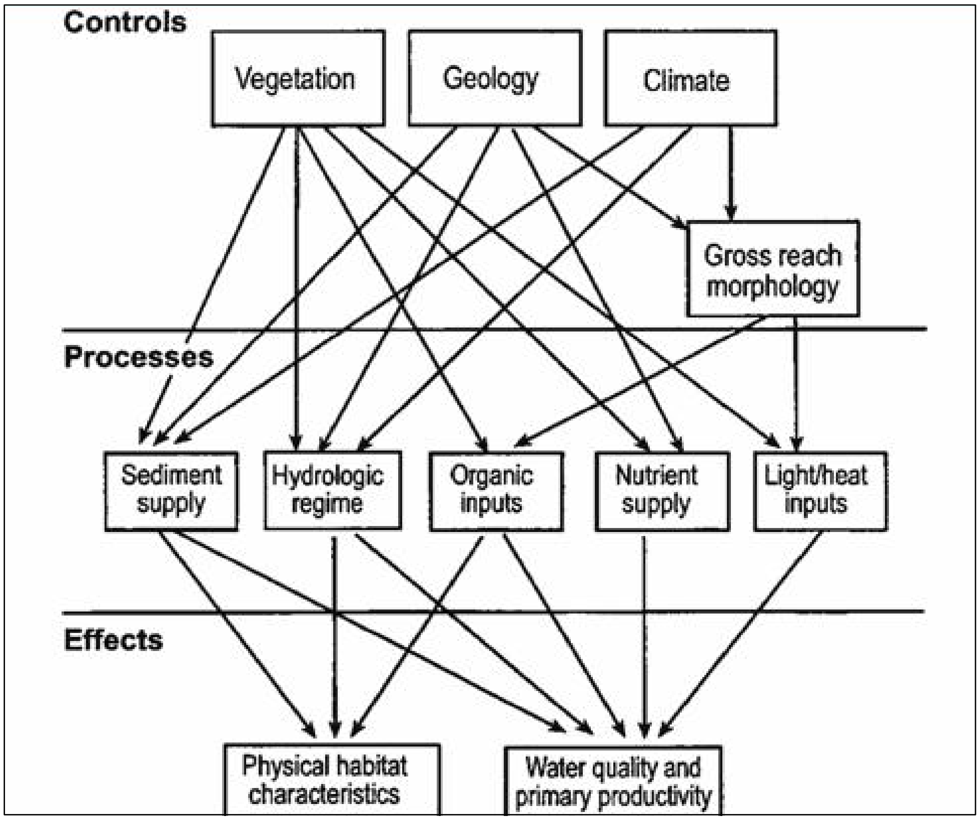

FIGURE 3-1: SCHEMATIC OF INTERRELATIONSHIPS AND HABITAT CHARACTERISTICS (RONI ET AL, 2002)

It is important that identified habitats are preserved and maintained. BIEAP-FREMP (CBA, 2010) has identified four basic guidelines for marine 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	Preserve habitat features to maintain fish and wildlife functions: • fish feeding (marshes), • waterfowl and shorebird nesting, • roosting and feeding (trees and shrubs), • leaf and insect input, and • wildlife feeding and refuge cover.
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. tidal channels, planting, large woody debris to improve fish access and utilization.

Further to these basic guidelines for marine work, the aim is to create 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. Tidal Datums

Tidal datums at the site are shown in Table 3-2. Geodetic Datum is 2.2 m above Chart Datum at this site

TABLE 3-2: TSAWWASSEN TIDAL DATUMS

Datum	Chart Datum (m)	Geodetic Datum (m)
HHWLT	+4.0	+1.8
HHWMT	+3.4	+1.2
MWL	+2.2	0.0
LLWMT	+0.4	-1.8
LLWLT	-0.7	-2.9

Source: CHS

3.2.1.2. Waves

Wave conditions at the Westham site are represented by vessel generated waves as the site is relatively immune from any significant wind generated waves. Vessel wakes from slow moving vessels can generate erosive waves for unprotected shoreline. The vessel wake prediction for the site is based on a tugboat with a length of 33.3 m, a breadth of 9.5 m and a draft of 3.5 m.

- Anticipated Vessel Generated Wave Height: 0.6 m
- Design Wave Height: 1.0 m

3.2.1.3. Currents

Examination of AVADEPTH forecasts suggests that during the mean peak flow on the Fraser River of 8,705 m^3/s, the maximum depth-averaged ebb-current is likely about 0.5 m/s at the Westham site. As a conservative measure, at the Westham site, the design current will be set at 1.0 m/s.

3.2.1.4. Geotechnical Conditions

A preliminary geotechnical assessment was carried out by Golder Associates Ltd. on the basis of a desktop geotechnical study and limited site reconnaissance (Appendix A). Upon review of available geotechnical information nearby to the project site and upon review of data from surficial geology maps, it is inferred that conditions at the site may comprise 2 to 4 m of clayey silt overlying loose to compact sand to depths of about 40 m, overlying compressible marine deposits to depths in the order of 100 m. While specific information pertinent to consolidation characteristics of the silt and marine deposits is not available, past experience in surrounding areas suggests that settlement of about 50 to 200 mm could be expected to occur during the construction period (assuming 4 month duration) with secondary consolidation following construction in the order of 25 to 100 mm over life of the project.

To effectively manage settlement during the construction phase, fill placement within the deepest portions of the site could be completed first. This will facilitate much of the settlement to occur during construction and allow for final grading operations to be carried out prior to the Contractor's departure from the site. The requirement to stage fill placement will be a function of whether there are surficial soft clays and silts over the site. In the absence of information on the presence of such deposits, staging may be considered.

3.2.2. Biological Design Criteria

3.2.2.1. Existing Marsh Conditions

Site surveys in the spring and summer of 2012 indicated tidal marshes exist along the Westham Island dike and on an island located in Canoe Passage at the downstream end of the site. The main species colonizing the shoreline marsh was Lyngbye's sedge (*Carex lyngbyei*). Above the sedge zone is a narrow band of common cattail (*Typha latifolia*) and hardstem bulrush (*Schoenoplectus acutus*) that exists along a depression at the base of the dike. Small patches of softstem bulrush (*Schoenoplectus tabernaemontani*) and hardstem bulrush occur within the sedge. At the lower edge of the sedge, common spikerush (*Eleocharis palustris*) and threesquare bulrush (*Schoenoplectus pungens*) grow just above the unvegetated mudflat elevation. Threesquare bulrush grows in brackish marshes with elevated salinity of approx. 1-15 ppt and illustrates that the salt wedge effects are evident in Canoe Passage. The island at the downstream end of the site is much higher in elevation and supports a more diverse plant community including common cattail, rushes, grasses and other species.

Based on topographical surveys conducted in early April 2013, sedge extended from about 1.0 m (Geodetic) elevation near the dike to about -0.8 m at the lower elevation adjacent to the mudflat

3.2.2.2. Soils

Marsh soils provide an anchoring material for plants to root, fertility for growth, and suitable characteristics that promote stability and drainage under intertidal conditions. Marsh soil typically will depend on the supply source and could involve dredged material or imported soil from an upland source. Clean mineral soil free from rocks, debris, and contamination are preferable. Use of manufactured soil is not recommended as sawdust and peat moss typically used in its fabrication make it more buoyant and it may not remain in place when exposed to river currents and waves.

Data from previous marsh construction projects indicate that natural marshes tend to have a higher proportion of fines than constructed marshes. Marsh vegetation traps naturally deposited silts and clays during yearly freshets over a long period of time. However, marshes can be established on sandy sediments if that is the main source material. Low elevation marshes range from loamy sand (i.e. 85% sand and 15% fines), to sandy loam (i.e. 75% sand and 25% fines), to silt loam (i.e. 15% sand and

85% fines). Constructed marshes tend to be sandy loam, ranging from 50-75% sand, but soils vary depending on the available source material. Another important component is organic matter, which ranges from 1-10% in natural marshes.

Observations of the existing unvegetated sandflat indicate that the sandy sediments (in excess of 95% sand) are mobile under the existing hydraulic conditions, while the sediments with a higher component of fines (i.e. 60-70% sand) are more stable. The marsh substrate is only 9% sand and 91% fines. However, dense marsh vegetation will encourage sediment deposition and will result in a higher percentage of fines.

3.2.2.3. Marsh Plants

The proposed plant species list is presented in Table 3-3. Nursery grown plant material, typically plugs, will be transplanted at approximately 0.5 m centre to centre spacing (i.e. 4 plugs per m^2). For larger donor material, such as common cattail or softstem bulrush, larger containers are typically used to promote underground tuber production and plant spacing will be wider at approximately 0.75 m centre to centre. Transplanting should occur from March to mid-June. Marsh soils should be left for several weeks to months, depending on construction timing and plant growth window to allow soils to settle and consolidate prior to transplanting.

TABLE 3-3: PROPOSED MARSH PLANT SPECIES FOR THE WESTHAM ISLAND/CANOE PASS TIDAL MARSH PROJECT

Scientific Name	Common Name
Carex lyngbyei	Lyngbye's sedge
Eleocharis palustris	Common Spikerush
Schoenoplectus tabernaemontani	Softstem bulrush
Schoenoplectus pungens	Threesquare bulrush

Transport of the donor marsh plants to the transplant site should not damage existing marsh habitat. For example, driving a truck to Trim Road and off-loading at the dike, will require packing trays containing the plugs across the existing sedge marsh. Due to the large number of plugs required, foot traffic will damage marsh vegetation and compact sediments. To reduce impacts from the transplanting operation, plywood should be laid over existing vegetation in foot traffic areas to avoid permanently damaging the marsh.

Alternately, a herring skiff or vessel equipped with a bow ramp, could be used so that plant material and planting crew could be transported to the site by water and avoid impacts to the existing marsh habitat. A suitable staging point would be the boat launch ramp at Wellington Point Park along River Road in Delta. This alternative also has the advantage of bringing material closer to the transplanting site, which will maximize planting efficiency.

4. Construction Details

4.1. Site Descriptions

The proposed project involves the construction of a containment berm and infilling with sand to establish a marsh bench. The containment berm will circle the southern end of an existing marsh and extend northwards delineating a new outline for additional marsh area. The toe of the containment berm will be placed at the low water level while the crest of the berm will be above the mean water level to match the elevation of the existing marsh. The area within the containment berm will be filled with sand to the same elevation as the crest of the containment berm. The maximum width of the marsh is approximately 130 meters. The overall length of the existing marsh coupled with the new extended marsh area is approximately 670 meters.

4.2. Construction Features

4.2.1. Rock Berm

The proposed work involves construction of a containment berm to an approximate elevation of just below mean water level. The containment berm will be a typical riprap berm cross section. The containment berm quantities are based on the rock berm design profile as detailed on the Project Drawings (Appendix B). The containment berm consists of an underlayer of crushed granular sub-base, an underlayer of filter stone and a layer of riprap stone on top. The crest of the containment berm is approximately 1.6 meters wide.

A toe trench will be excavated at the offshore edge of the rock berm to prevent scour of the containment berm toe. The existing material excavated for the toe trench will be sidecast onto the existing low-lying marsh area for use as fill.

4.2.2. Marsh Bench Quantities

The containment berm will serve to enclose a marsh bench composed of sand extending from the back edge of the containment berm to the existing shoreline.. The marsh bench will be constructed through infilling the existing drainage channel and lower lying areas with sand fill to raise the existing substrate to the same elevation as the existing marsh plateau. The marsh bench will facilitate native plant growth providing enhanced habitat for the area.

The marsh platform fill quantity is based on the area and fill depths within the containment berm alignment as shown on the site plan and typical sections on the drawings. The drainage channel near the existing shoreline will require a majority of the fill, with the thickness of fill tapering off as the marsh platform approaches the existing marsh plateau and containment berm limits. The fill will be required to bring the existing substrate up to the required marsh elevation. The geotechnical assessment provided by Golder Associates indicated that settlement in the order of 50 to 200 mm could be expected to occur during the construction period with secondary consolidation of 50 to 200 mm anticipated over the design life of habitat site. To account for the anticipated consolidation of the existing substrate during construction, the furnished and placed quantity of sand fill was increased by

15%. To account for placement losses during construction, the sand fill quantities were increased an additional 10%. To account for dredging losses for sand supply to be pumped in place from Wellington Point, the sand fill quantities were increased by an additional 25%.

The proposed total habitat area for the Westham site is shown in Table 4-1 below.

TABLE 4-1: TOTAL HABITAT AREA

Marsh Area	Rock Berm	Total Area
4.0 ha	0.3 ha	4.3 ha

4.3. Site Access

To access the site with marine equipment, the contractor will need to pass through the Westham Island Bridge. The swing span has a vertical clearance of 1.6 meters when closed and will open only for vessels that cannot pass under the bridge. The width between the fenders is approximately 15 meters which limits the size of barge that can pass through the open swing span. The passage through the swing span needs to be timed with the appropriate tidal and current conditions.

Land-based equipment can be transported across the bridge on trucks. The project site, located on private land, can be accessed from the end of Trim Road. Entry through the gate at the end of Trim Road will be needed for the land based equipment to gain access to the project site. Vehicle load limits of 50 tonnes on the bridge and 5,000 kg on Trim Road will have to be followed.

4.4. Construction Methodology

Due to the width restrictions at the Westham Island Bridge, the largest barges that can pass through the swing span are limited to 12.2-13.7 m in width. Barges of this size vary in length from 24.4-36.6 m in length and 2.1-3 m in depth. Barges of this size have a limited carrying capability with the typical capacity no greater than 1,500 tonnes.

The existing piles at the north end of the site will need to be removed with a vibratory extractor or cut off at the mudline. The removal method will depend on the pile type (timber or steel) and condition. The debris along the shoreline will also need to be removed from the site prior to placement of fill.

Construction of the containment berm and excavation of the containment berm toe trench can be performed using either a barge mounted excavator or a derrick barge. Excavators or cranes of the size required to construct the containment berm can be placed on smaller size barges or on sectional barges and towed through the swing span. Examples of barge mounted excavators and derrick barges are included in Appendix C.

Barges will be limited to 1,500 tonne or less of rock. The rock will be placed with a barge mounted excavator or by a derrick barge with a small clamshell bucket. Due to the limited depths in the project area, the rock will need to be placed at the higher tide levels so the barges can maintain maneuverability along the containment dike alignment. The barges can be allowed to sit on the bottom at lower tides, however it is not ideal and the working area is smaller due to the limited reach of the excavator or crane. The rock prism can also be shaped using a small excavator working from the existing ground at lower tides.

The sand infill material is assumed to be sourced from Wellington Point located 1.5 km upstream, although other sources may be used. It can be hydraulically transported to the site using a pipeline over the containment berm. Given the low draft at Wellington Point a hydraulic suction dredge can be used. Depending on the characteristics of the dredged material some level of grading by land-based, low-ground contact pressure equipment can be expected, especially to achieve the desired grading.

One potential issue with locally dredged material may be the turbidity of the discharge, given the size of the site and the large volume of water and material flowing from the pipeline (35,000-40,000 gpm slurry with 8-20% fines). The fines could wash over the containment berm during fill placement. To mitigate against this a turbidity boom can be placed around the site to help knock down some of the turbidity from hydraulic placement; however turbidity booms can be difficult to anchor.

4.5. Potential Hydraulic Effects

The layout of proposed stone berms lying on the channel bed generally follows the planform lay of channels and bars and is neither retarder, nor accelerator, nor diverter type. Therefore, it is not expected to modify local flow behavior to any relevance. Hydraulic effects are initiated by formation of vortices, its strength scales with local flow velocities; for structures lying on the channel-bottom, the local flow velocities are very low. Transported downstream, the turbulence and vortices usually disperse and lose intensity. Only structures with large discontinuity could initiate large vortices; the possibility of such effect caused by the proposed structure is marginal, if any.

Similar arguments apply for riprap habitat structures on the bank. Aligned with the existing bank, the riprap structures are not expected to have functions other than fixing the bank and enhancing the habitat.

As discussed above, hydraulic effects are initiated by shedding of eddies by the structure - the strength of which scales with local flow velocities. Once formed, the eddies are usually transported downstream by local flow velocities and in the process, they usually disperse and lose strength. In addition, eddy sizes usually vary from millimeter size Kolmogorov scale to the maximum of local water depth (Yalin, 1992; see also Barua and Rahman, 1998 for turbulent flow structure). With water depths in the order of 10 m and channel widths in the order of 350 m at the Westham site, there is no possibility that eddies, if formed, are transported cross-stream to affect the opposite bank.

Extending the Westham tidal marsh further downstream (west) and providing stable marsh habitat is difficult due to the hydrodynamics of the system in that area. Presently the containment structure for the fill is located to provide an offset distance from the river thalweg (centerline of deepest portion of the river) position at the time of design. The reasoning for this positioning being the thalweg will vary in location over time due to variation in flow conditions, therefore a buffer is included to prevent the containment structure from potential undermining by possible variation in thalweg position.

Moving further downstream (west) of the Westham site the position of the river thalweg is much closer to the existing marsh area, limiting the potential for including an offset between the thalweg and a containment structure for new fill material. Additionally, downstream of the Westham site there are visual indicators that the area is likely much more dynamic in terms of sediment transport, fluvial processes, tidal processes (flow reversal) as indicated by the larger lateral channels, larger sand waves and sand ripples compared to the presently designed upstream portion. This increase in energy is expected when approaching the offshore marine boundary conditions. For these reasons, adding additional marsh area downstream was not included in the design.

Current agricultural water supply is obtained from the South Arm in proximity to the proposed project. An assessment has been provided and is included in Appendix E. The conclusion is that the project will have no material impact on the quality or quantity of irrigation water.

4.6. Construction Schedule

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

Fisheries Closures:

- Juvenile Salmon-applies to water column above elevation -5m (March 1 through August 15)
- Crab-applies to seabed below -5.0m (October 15 through March 30) (Not applicable to this project)

Marine Mammals:

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

Source/Equipment

- Fraser River Maintenance dredging operates from June 15 through February 28. Actual dates depend on freshet conditions and degree of shoaling in critical areas.
- The rates of offloading will consider the FRPD dredge 309 if the material is supplied through the Fraser River maintenance.
- Rock and some fill materials are assumed to be delivered by barge and spread on-site using land based equipment mobilized via barge/crane.

Production Rates

- Working hours M-F, 6am-5pm
- Dredge pumpout 2500 m^3/day. (Light loaded to allow closer approach to shore).
- Rock demolition/removal 500 m^3/day
- Rock placement 400 m^3/day
- On-site excavation/grading 1000 m^3/day

- Planting (Not covered in this document).

Based on these assumptions the schedule indicates a construction period of approximately four (4) months. See Appendix D for schedule layout

5. Construction Direct Cost

5.1. Cost Considerations

The cost estimate includes supply and installation of the containment berm; marsh bench (sand); environmental protection measures; and mobilization/demobilization. An allowance is included for possible environmental protections measures that may be required by the approving agencies, such as, preparing an environmental protection plan, installing and maintaining turbidity booms. Direct costs are based on anticipated equipment, labor and materials.; indirect costs for the owner's project management, construction administration and third-party consulting fees; and all applicable taxes.

- The costs are limited to the civil construction elements such as rock, mobilization, buoys, etc. excluding planting.
- The overall 2020 RBT2 CDC opinion of probable cost unit rates were used where applicable. Where the 2020 RBT2 CDC unit rates were not available, previous estimates were escalated to 2020.
- Contingency varies by status of design. The projects carries a 20% contingency.

For further background on 2020 CDC RBT2 cost estimate methods, limitations and uncertainties refer to Moffatt & Nichol Memorandum RBT2 CDC Summary and Cost Drivers Memo, Rev.A – DRAFT. dated February 28, 2020.

5.2. Limitations

In providing opinions of estimate, it is recognized that the Owner's Engineer (OE) has no control over the costs of labour, equipment or materials, over the Contractor's methods of determining prices, or of the bidding climate. Opinions of estimate prepared by the OE are based on reasonable professional judgement and experience and do not constitute a warranty, expressed or implied, that the Contractor's bids or the negotiated price of the Work, or the actual cost of the Work, will not vary from the Client's budget or from any opinion of estimate prepared by the OE

TABLE 5-1: CONSTRUCTION DIRECT COST

Note – This section is removed.

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Appendix A:
Geotechnical Assessment

December 13, 2013

GEOTECHNICAL ASSESSMENT

Phase 1 Habitat Compensation: Westham Island, Delta, BC

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REPORT

Report Number: 1314470047-003-R-Rev0

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Golder Associates

Table of Contents

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) carried out a geotechnical assessment of the Phase 1 proposed habitat compensation site to be built at Westham Island, Delta, BC. The assessment was requested by Moffatt and Nichol (MN) on behalf of Port of Metro Vancouver (PMV). The development of the habitat compensation site involves site grading, fill placement and excavation as required to achieve a ground surface elevation suitable for the support of habitat.

The geotechnical assessment was carried out on the basis of a desktop geotechnical study and limited site reconnaissance. This report presents the anticipated geotechnical conditions and preliminary comments on geotechnical considerations for design and construction of the habitat compensation site. All elevations discussed within this report are referenced to Geodetic Datum.

The assessment of the Westham Island site is being carried out as part of a larger habitat compensation project which includes additional Phase 1 and Phase 2 sites at various locations. The reports for other sites have been issued under separate cover, grouped by Phase and geographic location.

The work on this assignment has been carried out in accordance with the Golder proposal dated November 02, 2012. The work has been completed in accordance with the terms and conditions outlined in the reciprocal master agreement for consulting services between MN and Golder dated March 11, 2011.

The scope of this report is limited to geotechnical aspects of the proposed site development under static conditions (specifically excludes seismic response and design considerations), and does not include any provision for environmental services such as the investigation, testing or assessment of the potential presence or impact of soil or groundwater contamination at the site, archeological or biological considerations or other hydrogeological services including but not limited to sediment transportation, erosion and/or scouring potential of the proposed developments.

This report should be read in conjunction with the ***"Important Information and Limitations of This Report"*** that follows this text. The reader's attention is specifically drawn to this information as it is essential for the proper use and interpretation of this report.

2.0 SITE CONDITIONS AND PROPOSED DEVELOPMENT

2.1 Site Location and Description

The site is located on the south-east perimeter of Westham Island in Canoe Pass, approximately 0.5 km downstream of the Westham Island Bridge, as shown on Figure 1. The existing site is characterized as a series of sandbars that are prominent at lower water levels but become partially submerged at higher water levels.

The Site is offset from the dyke surrounding the perimeter of Westham Island as follows:

- About 32 m offset at the south-east end; increasing to:
- Greater than 100 m offset at the south end.

2.2 Proposed Habitat Compensation

Site geometry and proposed development details are based on plans and sections provided to Golder by MN (ref: MN Drawings 6047 to 6051, included within Appendix B of the MN submission to PMV dated December 13, 2013). The MN drawings indicate the proposed habitat compensation involves the construction of a containment berm and infilling with sand/silt to establish a permanent marsh platform as follows:

- The arc-shaped containment berm will encompass the southern end of an existing marsh and over adjacent banks for construction of additional marsh area.
- The overall length of the existing marsh coupled with the new extended marsh area will be approximately 670 m, with a maximum width of approximately 100 m and area of approximately 40,000 m^2.
- The design elevation of the top of the marsh is at about 0.3 m. This will require fill placement of, on average, approximately 1 m thick and up to approximately 3.3 m thick in the existing “drainage channel” located at the northern edge of the marsh.
- The containment berm will comprise a 1.6 m wide crest and 2H:1V slope armoured with a 0.46 m thick layer of riprap protection (32 kg riprap stone) underlain with a 0.22 m thick layer of filter stone.

3.0 SITE RECONNAISSANCE

A Golder representative attended a site viewing by boat of the Westham Island project site, on March 11, 2013, with representatives from MN and PMV and other consultants for the project. Site photographs were taken during the viewing.

4.0 REVIEW OF AVAILABLE INFORMATION

4.1 Regional Surficial Geology

Surficial geology information published by the Geological Survey of Canada (ref: Map 1486A dated 1979) indicates that the area is underlain by the following sequence of deposits:

- **Fraser River Sediments** comprising of:
  - Overbank silty to silt clay loam normally less than 2 m thick; overlying
  - Deltaic and distributary channel fill of interbedded fine to medium sand about 15 m thick; overlying
  - Estuarine interbedded fine sand to clayey silt, between 10 m to 185 m thick; overlying
- Up to approximately 400 m thickness of competent glacial and pre-glacial soils; overlying
- Bedrock.

4.2 Previous Geotechnical Investigations

A review of available geotechnical reports in the vicinity of the Sites was carried out as summarized below.

Golder 1980 and 2000

Golder previously carried out two separate geotechnical investigations on the north east side of Westham Island approximately 2.5 m from the Site. The purpose of the investigations was to determine the soil conditions at the respective sites and to provide geotechnical recommendations for the design and construction of proposed flood boxes. In the 1980 investigation, one augerhole was put down to a depth of approximately 19 m below ground surface with standard penetration tests carried out during drilling to assess the relative densities of the soils at the site. In the 2000 investigation, two augerholes and two dynamic cone penetration tests were put down to depths of 6 m below the existing ground surface.

Golder 2009-2011

Golder previously carried out a geotechnical investigation approximately 3.5 km southeast of the Site. The investigation included a total of four test pits, four auger holes, one seismic cone penetration test and one cone penetration test. Standpipe piezometers were installed in selected augerholes. In addition, a test fill embankment was constructed and monitored over six months at site. The test fill included the installation and monitoring of 20 settlement gauges and comprised two zones as follows:

- A lower fill embankment constructed to approximately 1.5 m to 2 m above original site grade, measuring approximately 200 m by 100 m in plan; and
- A higher (upper) fill embankment constructed to approximately 4.5 m to 5 m above original site grade, measuring 50 m by 50 m.

Golder 2010-2011

Golder carried out a number of field investigation programs during 2010 and 2011 as part of the Terminal 2 and DTRRIP projects. These included a number of CPTs and sampling holes using mud rotary and sonic drilling techniques located along Deltaport Way some 2 km southeast of the project site. The results show between 60 to 80 m of interbeded sand and silt underlain by a clay deposit estimated to be 20 to 60 m in thickness, underlain by glacial till.

4.3 Aerial Photographs

A review of available historical air photographs from 1963 to 2013 indicated the following:

- There appears to be little to no development at the site. The site appears to have comprised a marsh bench since the earliest available aerial photograph and this appears not to have been disturbed throughout recent history;

- Use of the immediately adjacent upslope land appears to have been limited to agriculture since 1963 (the first available historical aerial photograph);
- The perimeter dyke to Westham Island may have been present in 1963; and
- Any changes to the configuration of the sand flats are most likely due to accretion or erosion within the littoral zone.

5.0 SUBSURFACE CONDITIONS

A summary of inferred stratigraphic units based on the references presented in 4.2 is presented herein. The summary is not intended to represent a site-specific, detailed or comprehensive description of the subsurface conditions. Given the considerable distance of the closest available information, significant variation should be anticipated. The generalized subsurface conditions at the nearby sites comprised:

- Fill up to about 1.7 m thick at the dyke flood box sites;
- Sandy to clayey silt up to approximately 3.0 m thick; overlying
- Sand and silty sand strata approximately 40 m to 80 m thick; inferred to be underlain by
- Silty clay to clay sequence extending to depths of approximately 100 m.

5.1 Silt

Silt layers, varying from clayey silt to silt with some sand, were encountered beneath surficial fill at our previous investigations and extended to depths of approximately 2 - 5 m below ground surface. The unit generally comprised soft clayey silt transitioning to loose to compact silt with depth.

CPT Tip resistance values measured in this layer were typically about 4 bars and generally less than 10 bars, indicating that the consistency of this deposit is generally loose or soft. CPT friction ratio values were generally in the order of 1.5 to 3.5 percent, indicating a primarily fine-grained, cohesive soil unit.

5.2 Interlayered Sand and Silty Sand

The loose to compact silt strata are underlain by fine to medium sand containing some silt. The upper boundary of this layer was encountered in our previous investigations at depths ranging from about 2.5 m to 9.0 m below ground surface. The stratum generally consists of an upper, more uniform sand deposit extending to 12 to 17 metres below ground surface, overlying interlayered deposits of sand and silty sand. All of Golder's augerholes and CPTs put down during our previous investigations were terminated within this sequence (greater than 39.7 m below ground surface in our 2009 investigation) and it is anticipated that this sequence extends to approximately 50 m or more below ground surface.

CPT tip resistance values measured within this layer were observed to vary significantly within this sequence, varying from approximately 50 to greater than 200 bars, indicating a loose to compact relative density.

5.3 Marine Deposits

An extensive sequence of compressible marine deposits comprising silty clay to clay with occasional interlayers and interbeds of sand, sandy silt strata is inferred to underlie the silt and sand sequences described above. Published surficial geology information and deep borehole data obtained at adjoining sites indicates that this sequence extends to depths in the order of 100 m below ground surface, and is underlain by competent Pleistocene deposits including glacial till soils.

6.0 GEOTECHNICAL CONSIDERATIONS

The following briefly summarizes significant geotechnical design and construction considerations for the proposed habitat compensation structures:

- The subgrade soils comprise of an extensive sequence of deltaic and estuarine deposits that are inferred to extend to depths in the order of 100 m below ground surface. These soils include weak and moderately compressible, near-surface silt to clayey silt deposits, extensive loose to compact sand deposits and an interlayered sequence of silt, sand and clayey silt soils;
- Development will require the placement of permanent grade fills to an elevation of about 0.3 m, requiring about 1 m of fill over a broad area but up to approximately 3.3 m to fill in the existing drainage channel. The placement of this fill will cause consolidation of the underlying fine-grained subgrade soils;
- Sequencing should consider specifying limitations on the thickness of fill placed in any single lift; each lift placement should be separated from the next by a waiting period to allow strength gain and dissipation of pore water pressures in the underlying deposits;
- There may be difficulties in controlling the nature of the fill placement due to constraints associated with dredging and submerged fill placement; and
- The low-plastic silt and extensive loose sand deposits are susceptible to soil liquefaction during intermediate to strong seismic (earthquake) levels of shaking, which will result in loss of soil strength.

6.1 Settlement Assessment

As described in Section 4.2.4, a test fill embankment was constructed at a project 3.5 km from this Site. Settlement measured at gauges installed within a fill embankment indicated the following order of magnitude of settlement:

- 1.5 to 2 m fill thickness: approximately 50 to 150 mm over the first 6 month period with an additional 25 mm over the following 18 month period; and
- 4.5 to 5 m fill thickness: approximately 60 to 250 mm over the same 6 month period with an additional 25 mm over the following 18 month period.

Settlement in the order of 50 to 200 mm could be expected to occur during the construction period with secondary consolidation of about 50 mm to 300 mm could occur over the design life of the habitat embankment (assumed at 25 years).

6.2 Staged Fill and Placement Sequencing

For initial planning purposes, we have assumed that the habitat compensation structure will be constructed in a staged loading sequence to allow sequential strength gain of the underlying compressible soils. Stage loading produces sequential gains of strength in the soft soils. A waiting period between lifts should be observed to allow dissipation of excess pore pressures induced by the fill, and to avoid overstressing the underlying highly compressible fine-grained soils.

Staging of fill placement should consider placement in stages no thicker than about 0.5 m. Placement of fill in an uncontrolled manner (without staging) may result in failure of the underlying soils resulting in lateral movements at and beyond the toe of the fill affecting construction.

The planning of the construction should consider fill placement within the deepest part of the habitat banking first. This will allow the majority of the settlement to occur during construction and final grading operations to accommodate settlement can be carried out prior to the Contractor demobilizing from site.

6.3 Construction

Golder understands that consideration is being given to hydraulic placement of dredged material at Westham Island. Hydraulic dredging method entails excavating material from a submerged borrow area and pumping a slurry of suspended sediments and water through a pipeline to the fill site. The slurry is typically about 70-80% water, so the discharged material will tend to run, resulting in a mild residual beach slope.

The side slope achievable in berm construction is mainly a factor of grain size and sediment density, but the compaction of material, dredging and placement method, and currents during placement also determine the final slope. Based on the cross sections provided; it appears the work will comprise placement of only veneer of fill at the sloping section. Consideration should be given to constructing the rip rap berm first prior to fill placement at the side slopes. This will make it easier to maintain the design grades and minimize material losses from various littoral processes.

6.4 Suitability of Dredge Materials as Reclamation Fill

Generally, dredged and placed sand with less than 10% to 15% of fines is considered suitable as engineering fill. Sand meeting this criterion is a better reclamation material for the following reasons:

- It’s easier to handle;
- Drainage is good and consolidation occurs quickly;

- The reclaimed land has a higher bearing capacity;
- The long-term settlements occurring within the reclaimed soils are small.

Dredged and placed sand with fines content greater than 15% could still be usable, but longer consolidation/settling times could be expected. It is anticipated that in-situ silty sands and sandy silts will lose some amount of fines during the dredging and reclamation processes followed for site development by the dredging contractor.

The amount of fines existing within the seabed deposits will be altered during the dredging and reclamation processes as the soil particles segregate during transportation and deposition into the reclamation cells. Determining the actual amount of fines that would remain in place within the reclamation area following dredging, pumping and placement of the dredgeate depends on how the reclamation work is staged and carried out and contractor's methodology, all of which are unknown at the time of preparation of this report.

6.5 Impact on Adjacent Dyke

The proposed fill thickness appears relatively small in the area where the habitat bank encroaches closest to (within 32 m of) the existing dyke. Significant fill thickness (in the drainage channel) is in an area offset some 70 m away from the existing dyke. Considering the balance between fill thickness and offset from the dyke, the proposed construction is not anticipated to impact the existing Westham Island Dyke. The assumptions on fill thickness should be verified with cross-sections cut at the eastern end of the habitat site.

7.0 CLOSURE

We trust that the information presented in this report is sufficient for your immediate requirements. Should you have any questions or require further information, please feel free to contact us.

Yours truly,

GOLDER ASSOCIATES LTD.

ORIGINAL SIGNED

Kieran McNally, EIT
Junior Geotechnical Engineer

ORIGINAL SIGNED

Jo-Anne Perrett, P.Eng.
Associate, Senior Geotechnical Engineer

KMN/JIP

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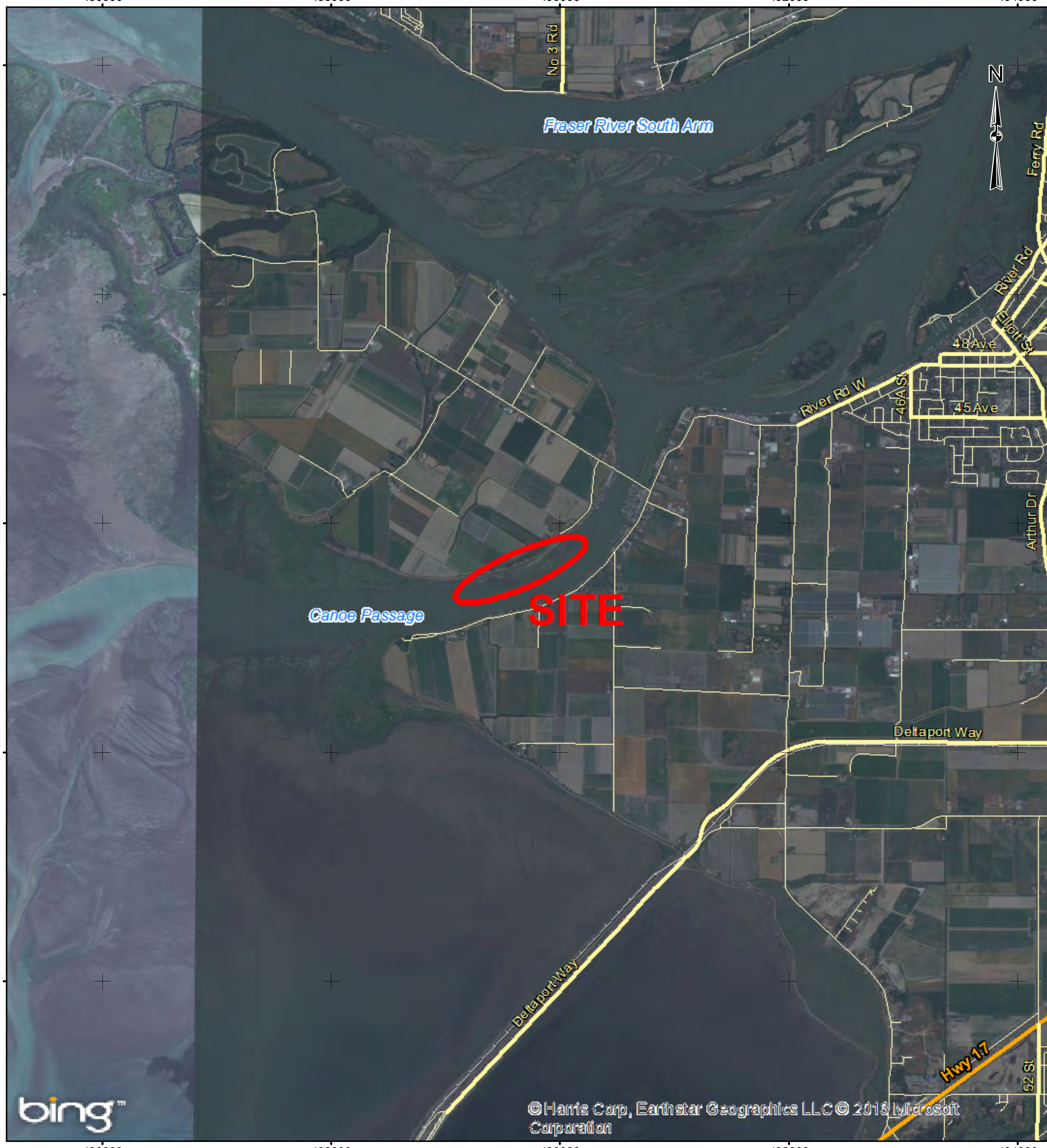

N:\Bur-Graphics\Projects\2013\1447\13-1447-0047\GIS\Mapping\MXD\General\Figure-1_Key_PlanC.mxd

LEGEND

- PROPOSED SITE (APPROXIMATE LOCATION)
- EXPRESSWAY
- MAJOR ROAD
- LOCAL ROAD
- RAILROAD

1 0 1

SCALE 1:50,000 KILOMETRES

REFERENCE

TRANSPORTATION FEATURES OBTAINED FROM THE PROVINCE OF BRITISH COLUMBIA.
IMAGERY OBTAINED FROM BING MAPS FOR ARCGIS PUBLISHED BY MICROSOFT CORPORATION, REDMOND, WA, APRIL 2013.
INSET DATA OBTAINED FROM E.S.R.I.
DATUM: NAD83 PROJECTION: UTM ZONE 10

PROJECT

MOFFATT & NICHOL
HABITAT COMPENSATION
WESTHAM ISLAND

TITLE

KEY PLAN

Golder Associates

PROJECT		13-1447-0047	FILE No.	
DESIGN	KMN	18 Apr. 2013	SCALE AS SHOWN	REV. 0
GIS	DSC	19 Apr. 2013	**FIGURE: 1**	
CHECK				
REVIEW				

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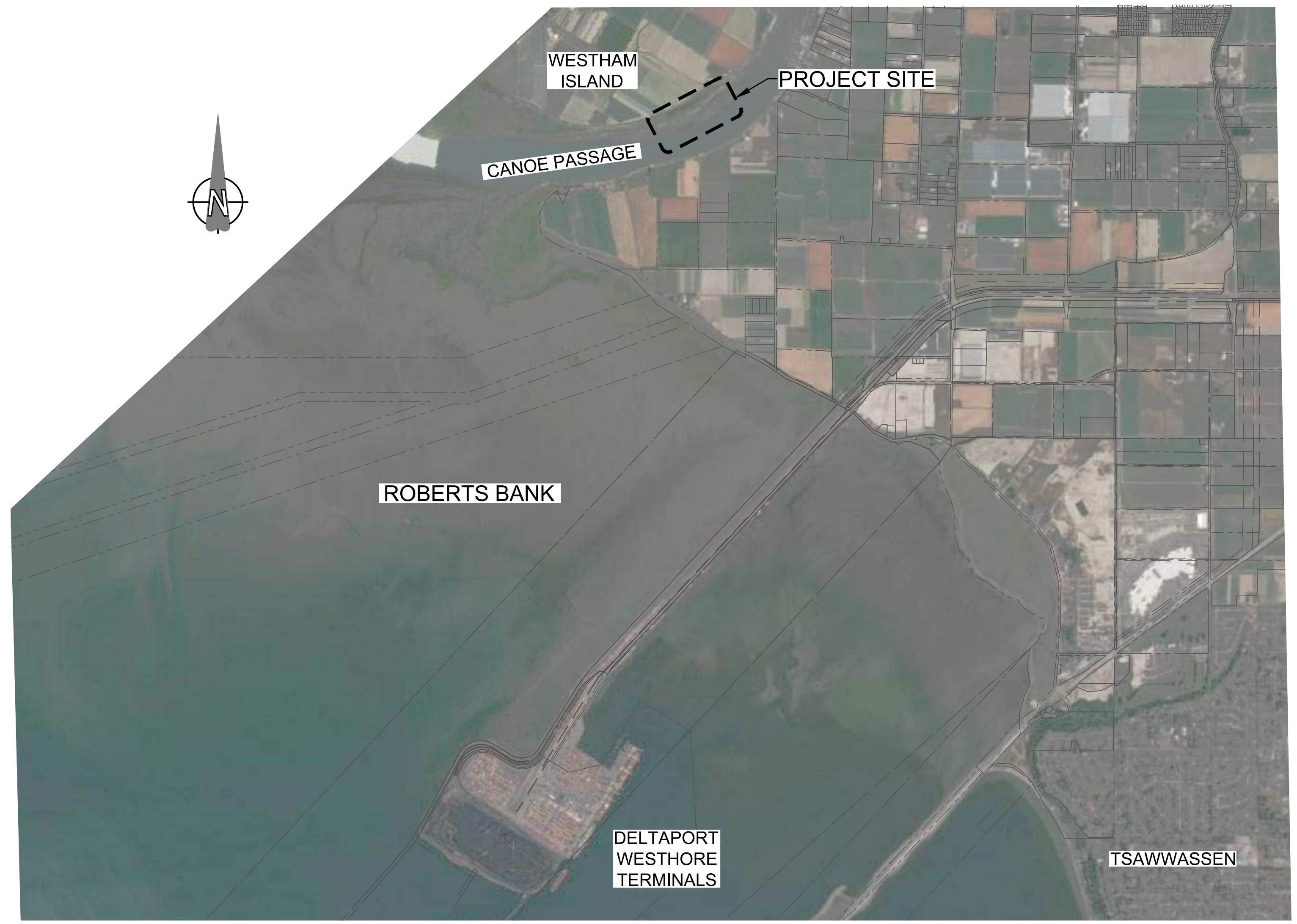
Golder Associates

Appendix B:
Project Drawings

VANCOUVER FRASER PORT AUTHORITY

RBT2 OFFSETTING

WESTHAM ISLAND CANOE PASS



VICINITY MAP
NTS

PRELIMINARY
DO NOT USE FOR CONSTRUCTION

Ref.No.	REFERENCE
1	CHS CHART 3490

moffatt & nichol

IN ASSOCIATION WITH:

GL Williams & Associates Ltd. Shoreline Management Consulting

No.	Date	REVISION	Dr'n	Ch'd
		REVISION IN PROGRESS		

PORT of vancouver
VANCOUVER FRASER PORT AUTHORITY
ENGINEERING DEPARTMENT

DESIGN BY
DRAWN BY
APPROVED
DATE
SCALE
PMV SITE

RBT2 OFFSETTING
WESTHAM ISLAND CANOE PASS
TITLE SHEET & LOCATION

SIZE D | DWG. G-001 | SHEET | REV.

DRAWING LIST:

PRELIMINARY
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		REVISION IN PROGRESS		

PORT of vancouver

VANCOUVER FRASER PORT AUTHORITY
ENGINEERING DEPARTMENT

DESIGN BY
DRAWN BY
APPROVED
DATE
SCALE
PMV SITE

RBT2 OFFSETTING
WESTHAM ISLAND CANOE PASS
DRAWING INDEX

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1.0 GENERAL NOTES

1.1 ALL DIMENSIONS ARE GIVEN IN MILLIMETERS UNLESS NOTED OTHERWISE. ELEVATIONS AND CONTOURS ARE GIVEN IN METRES AND DECIMALS THEREOF. SCALE INDICATED ON DRAWING IS APPROPRIATE TO SCALE AT FULL SIZE (D) 22" X 34"

1.2 SUPPLY AND INSTALLATION OF PLANTS BY OTHERS.

1.3 AERIAL PHOTOS PROVIDED BY PMV, 2013.

2.0 SURVEY, WATER LEVEL AND DATUM

2.1 ALL ELEVATIONS ARE TO GEODETIC DATUM.
CHART DATUM = (GEODETIC DATUM) + (2.2 METERS)
(REFERENCE: CHS CHART#3490, STEVESTON STATION)

UPLAND TOPOGRAPHIC SURVEY DATA (2009) PROVIDED BY MCELHANNEY, AND UNDERWATER HYDROGRAPHIC SURVEY DATA (2012) WAS PROVIDED BY ATEK HYDROGRAPHIC SURVEYS LTD.

2.2 COORDINATES ARE UTM (NAD 83) ZONE 10 MAPPING PLANE COORDINATES.

2.3 SURVEY REFERENCE MONUMENT MON 6901

X = 490336.877 Y = 5436561.963 Z = 1.753 (GEODETIC)

2.3 TIDAL PARAMETERS FOR THE SITE ARE AS FOLLOWS:

TIDAL PARAMETER	ELEVATION (GEODETIC)
HIGHER HIGH WATER LARGE TIDE (HHWLT)	1.8m
HIGHER HIGH WATER MEAN TIDE (HHWMT)	1.2m
MEAN WATER LEVEL (MWL)	0.0m
LOWER LOW WATER MEAN TIDE (LLWMT)	-1.8m
LOWER LOW WATER LARGE TIDE (LLWLT)	-2.9m

3.0 SITE PREPARATION

3.1 SEE SPECIAL PROVISIONS.

4.0 AGGREGATE MATERIAL (RIPRAP, FILTERSTONE, SAND)

4.1 RIPRAP AND FILTER STONE SHALL BE IMPORTED CLEAN, ROUGH ANGULAR QUARRIED STONE OF A DENSE, HARD, DURABLE CHARACTER, FREE OF ORGANIC MATERIAL, IN-FILLED JOINTS, SEAMS, OR OTHER DEFECTS, RESISTANT TO BREAKDOWN BY HANDLING OR WEATHERING OR EXPOSED TO SEA WATER THAT MEETS THE TEST REQUIREMENTS PROVIDED IN THE SPECIFICATIONS, UNLESS NOTED OTHERWISE.

4.2 SAND SHALL BE NATURALLY OCCURRING, NON-MANUFACTURED CLEAN GRANULAR MATERIAL FREE OF ORGANIC MATTER, VEGETATION, AND OTHER DELTERIOUS MATERIALS. SAND SHALL BE DREDGED MATERIAL SUPPLIED BY OTHERS, REFER TO SPECIFICATIONS FOR DETAILS.

4.3 RIPRAP (CLASS 32 kg) SHALL MEET THE FOLLOWING GRADATION:

	% SMALLER (BY WEIGHT) THAN			
MASS (Kg)	TARGET	LOWER LIMIT	UPPER LIMIT	APPROX. AVE. DIMENSION ± (mm)
128	100	95	100	365
96	85	75	95	330
32	50	40	65	230
11	15	5	30	160
4	5	0	5	115

4.4 FILTER STONE (D50 = 3 kg) SHALL MEET THE FOLLOWING GRADATION:

	% SMALLER (BY WEIGHT) THAN			
MASS (Kg)	TARGET	LOWER LIMIT	UPPER LIMIT	APPROX. AVE. DIMENSION ± (mm)
13	100	95	100	170
10	85	70	95	155
3	50	40	65	105
1	15	5	25	74
0.4	5	0	5	53

4.5 CRUSHED GRANULAR SUB-BASE (75 mm) SHALL MEET THE FOLLOWING GRADATION:

SIEVE SIZE (mm)	GRADATION LIMITS % PASSING BY DRY WEIGHT
75	100
38	60 - 100
19	35 - 80
9.5	26 - 60
4.75	20 - 40
2.36	15 - 30
1.18	10 - 20
0.6	5 - 15
0.3	3 - 10
0.075	0.5

4.6 THE CONTRACTOR SHALL PROVIDE AGGREGATE SUPPLIER'S TEST RESULTS THAT THE AGGREGATE MATERIALS SUPPLIED CONFORMS TO THE REFERENCED SPECIFICATIONS / GRADATIONS.

CROSS-REFERENCE LEGEND

A
XXXX

SECTION OR DETAIL IDENTIFICATION, SEE NOTE

REFERENCE SHEET ON WHICH SECTION OR DETAIL IS SHOWN

NOTE: LETTER INDICATES SECTION; NUMBER INDICATES DETAIL. WHERE THERE IS NO REFERENCE SHEET INDICATED, IT MEANS THE DETAIL OR SECTION IS TAKEN AND SHOWN ON THE SAME SHEET.

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Ref.No.	REFERENCE

moffatt & nichol

IN ASSOCIATION WITH:

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		REVISION IN PROGRESS		

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APPROVED
DATE
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PMV SITE

RBT2 OFFSETTING
WESTHAM ISLAND CANOE PASS
NOTES & SEQUENCE

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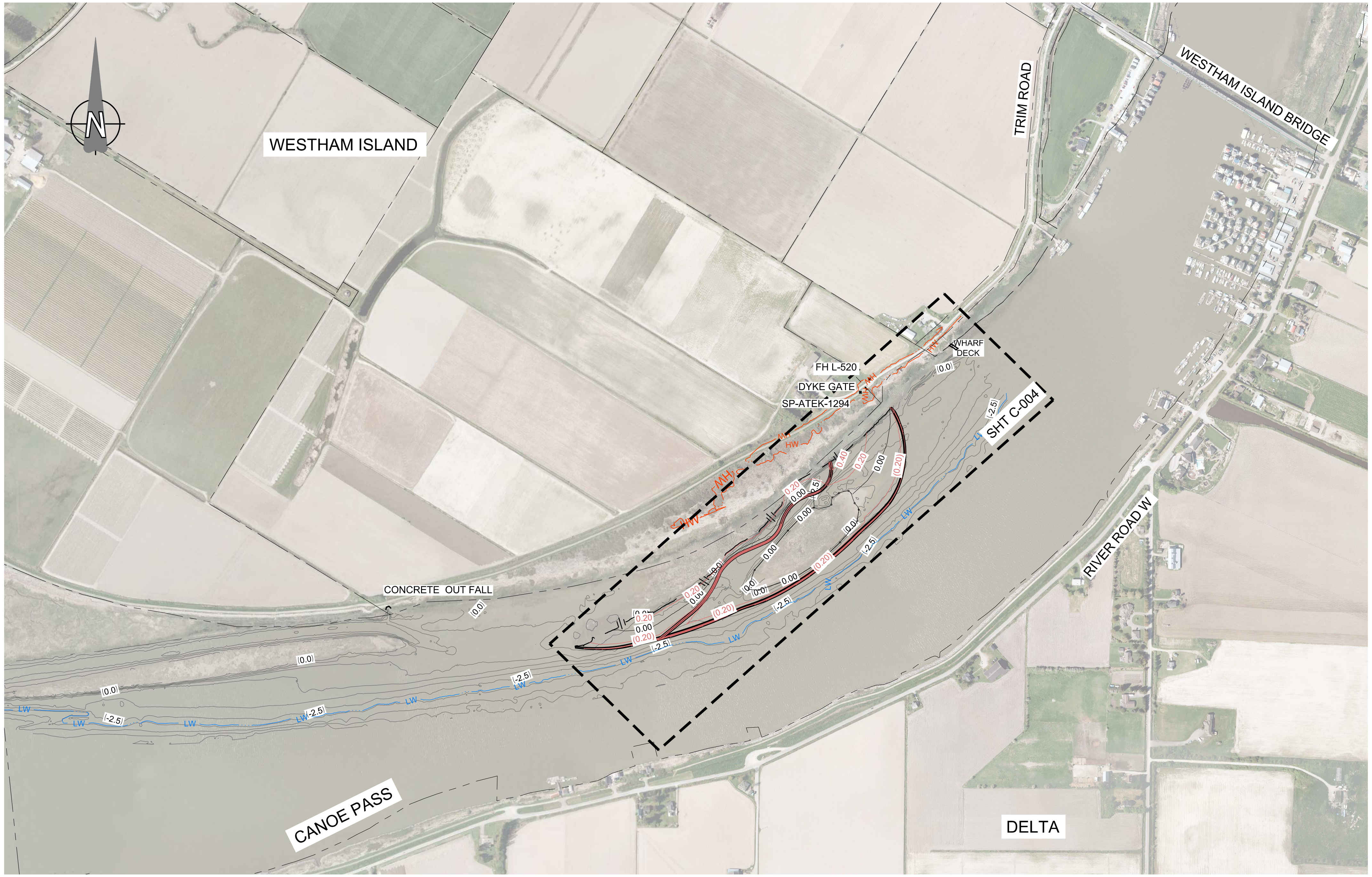

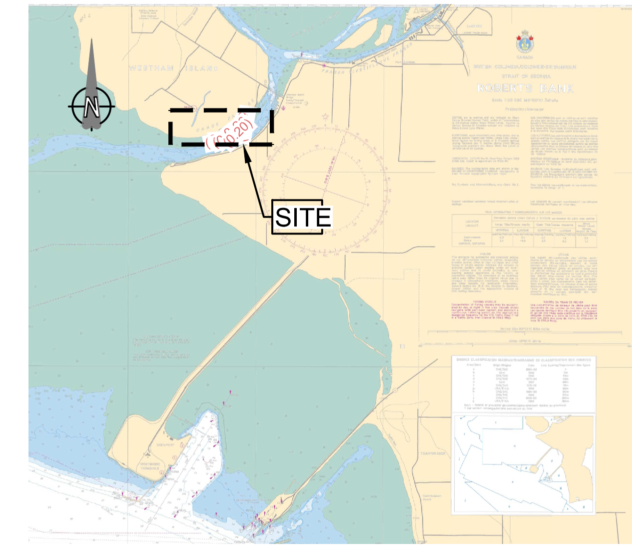

LOCATION PLAN:
NTS (REF. CHS #3492)

NOTES:

1. EXISTING GROUND BATHYMETRY (CANOE PASS) ARE TAKEN FROM PWGSC/CANADIAN COAST GUARD PUBLISHED SURVEYS (CANOE PASS - BRIDGE TO BRUNSWICK PT. - JAN. 2010)
2. EXISTING GROUND BATHYMETRY (MARSH AREA) AND TOPO FEATURES ARE TAKEN FROM ATEK HYDROGRAPHIC SURVEYS LTD. (2012)
3. ALL ELEVATIONS ARE TO GEODETIC DATUM.
CHART DATUM = (GEODETIC DATUM) + (2.2 METERS)
4. TIDAL PARAMETERS FOR THE SITE ARE AS FOLLOWS:

TIDAL PARAMETER	ELEVATION (GEODETIC)
HIGHER HIGH WATER LARGE TIDE (HHWLT)	1.8m
HIGHER HIGH WATER MEAN TIDE (HHWMT)	1.2m
MEAN WATER LEVEL (MWL)	0.0m
LOWER LOW WATER MEAN TIDE (LLWMT)	-1.8m
LOWER LOW WATER LARGE TIDE (LLWLT)	-2.9m

LEGEND:

PROPERTY LINE
HEADLEASE BOUNDARY
(XX) EXISTING CONTOUR
HW HIGHER HIGH WATER LARGE TIDE (HHWLT)
LW LOWER LOW WATER LARGE TIDE (LLWLT)

80m 0 80m 160m
SCALE: 1:4000

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DATE
SCALE
PMV SITE

RBT2 OFFSETTING
WESTHAM ISLAND CANOE PASS
LOCATION PLAN

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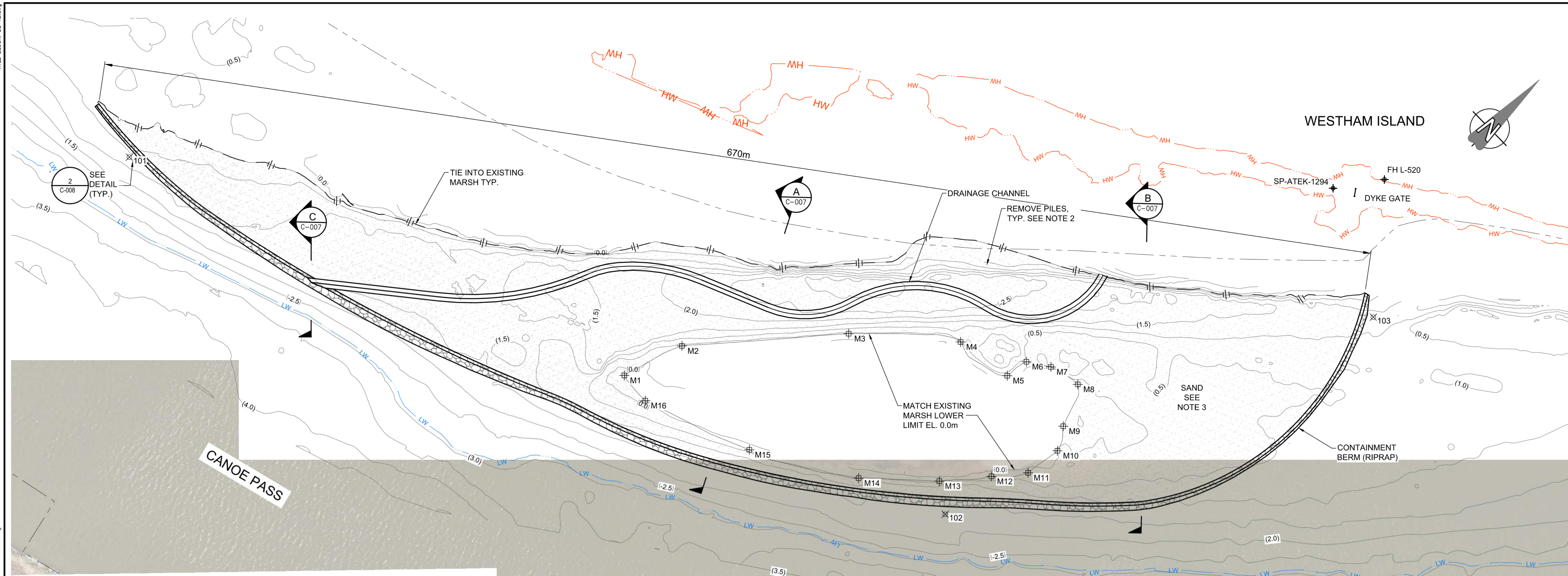

EXISTING MARSH LOWER LIMIT AS SHOWN:

WORK POINTS		
POINT NO.	NORTHING	EASTING
M1	5435563.48	489795.83
M2	5435595.74	489805.83
M3	5435662.47	489862.12
M4	5435701.27	489906.07
M5	5435706.39	489935.72
M6	5435718.65	489937.50
M7	5435725.93	489948.39
M8	5435729.57	489964.66
M9	5435708.88	489975.03
M10	5435697.76	489982.06
M11	5435678.78	489979.55
M12	5435663.79	489967.51
M13	5435642.58	489950.29
M14	5435613.50	489919.66
M15	5435583.00	489869.22
M16	5435562.05	489812.88

EXISTING MARSH LOWER LIMIT AREA 1.3ha

NAVIGATION MARKERS		
POINT NO.	NORTHING	EASTING
101	5435458.18	489533.67
102	5435632.65	489964.78
103	5435864.49	490047.49

QUANTITIES:

MARSH	4.0 HA
BERM (RIPRAP)	0.3 HA

LEGEND:

- HEADLEASE BOUNDARY
- (XX) EXISTING CONTOUR
- HW HIGHER HIGH WATER LARGE TIDE (HHWLT)
- LW LOWER LOW WATER LARGE TIDE (LLWLT)
- MARSH EDGE NAVIGATION MARKER
- WORK POINT
- SAND
- CONTAINMENT BERM (RIPRAP)

NOTES

1. SEE GENERAL NOTES ON SHT G-003.
2. ALL VISIBLE PILES WITHIN FOOTPRINT OF MARSH SHALL BE REMOVED.
3. SAND AREA EXCLUDES EXISTING MARSH AREA.

NOT FOR CONSTRUCTION

20m 0m 20m 40m
SCALE: 1 : 1000

Ref.No. REFERENCE

moffatt & nichol

IN ASSOCIATION WITH:

GL Williams & Associates Ltd. Shoreline Management Consulting

REVISION IN PROGRESS

No.	Date	REVISION	Dr'n	Ch'd

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ENGINEERING DEPARTMENT

DESIGN BY
DRAWN BY
APPROVED
DATE
SCALE
PMV SITE

RBT2 OFFSETTING
WESTHAM ISLAND CANOE PASS
SITE PLAN

SIZE D DWG. C-004 SHEET REV.

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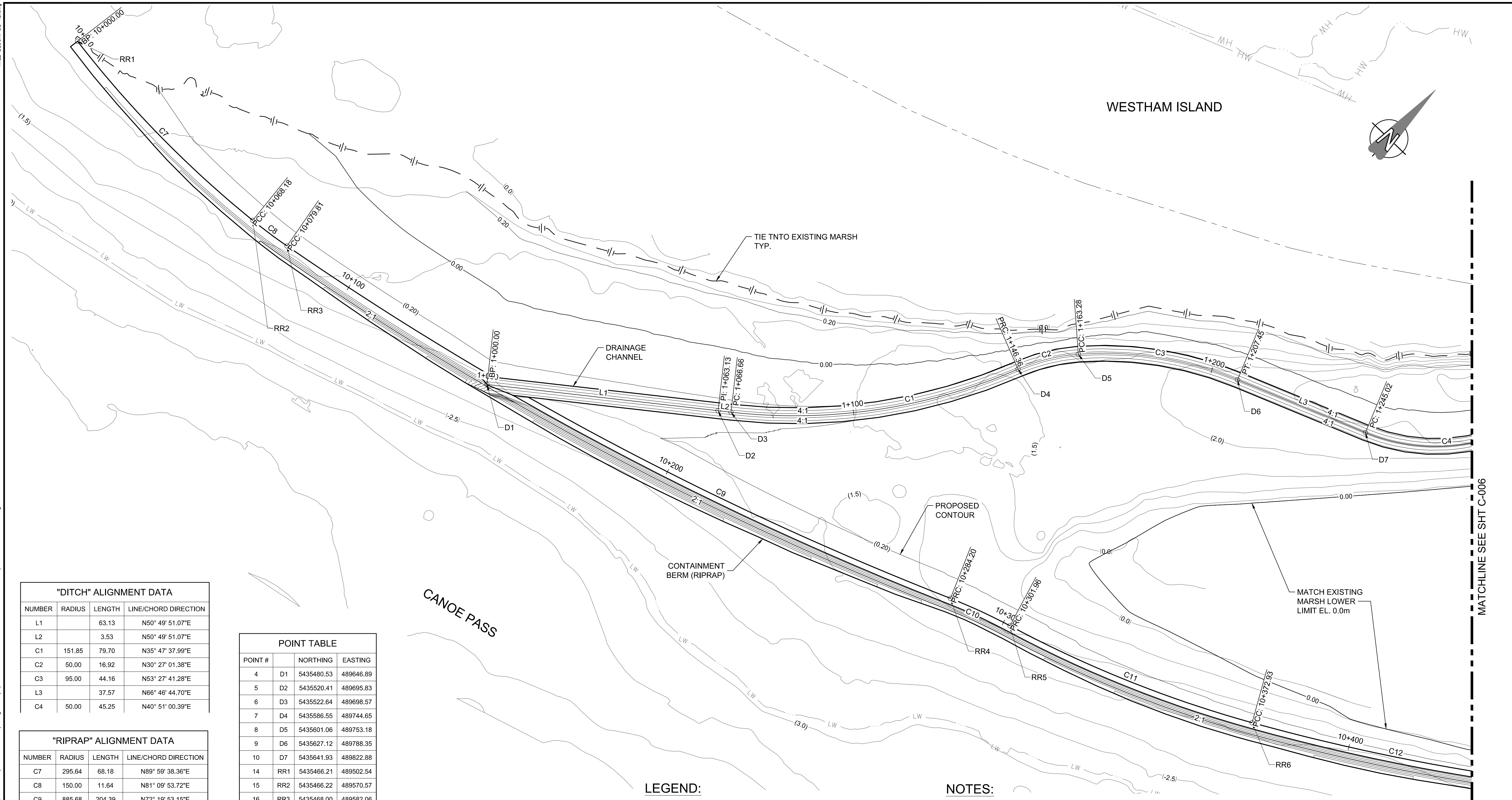

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C2	50.00	16.92	N30° 27' 01.38"E
C3	95.00	44.16	N53° 27' 41.28"E
L3		37.57	N66° 46' 44.70"E
C4	50.00	45.25	N40° 51' 00.39"E

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C10	150.00	17.76	N69° 06' 47.08"E
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7	D4	5435586.55	489744.65
8	D5	5435601.06	489753.18
9	D6	5435627.12	489788.35
10	D7	5435641.93	489822.88
14	RR1	5435466.21	489502.54
15	RR2	5435466.22	489570.57
16	RR3	5435468.00	489582.06
17	RR4	5435529.90	489776.38
18	RR5	5435536.23	489792.96
19	RR6	5435564.85	489857.74

LEGEND:

- HEADLEASE BOUNDARY
- HW — HIGHER HIGH WATER LARGE TIDE (HHWLT)
- LW — LOWER LOW WATER LARGE TIDE (LLWLT)
- (XX) — EXISTING CONTOUR
- PROPOSED CONTOUR

NOTES:

1. SEE GENERAL NOTES SHT G-002.
2. COORDINATE AND REVIEW THE SURVEY LAYOUT WITH THE OWNER'S REPRESENTATIVE PRIOR TO CONSTRUCTION. FINAL DIMENSIONS AND LAYOUT ARE SUBJECT TO SURVEY REVIEW.

NOT FOR CONSTRUCTION

10m 0m 10m 20m

SCALE: 1 : 500

Ref.No.	REFERENCE

moffatt & nichol

IN ASSOCIATION WITH:

GL Williams & Associates Ltd.
Shoreline Management Consulting

REVISION IN PROGRESS

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PMV SITE

RBT2 OFFSETTING
WESTHAM ISLAND CANOE PASS
GRADING PLAN SHEET 1 OF 2

SIZE D | DWG. C-005 | SHEET | REV.

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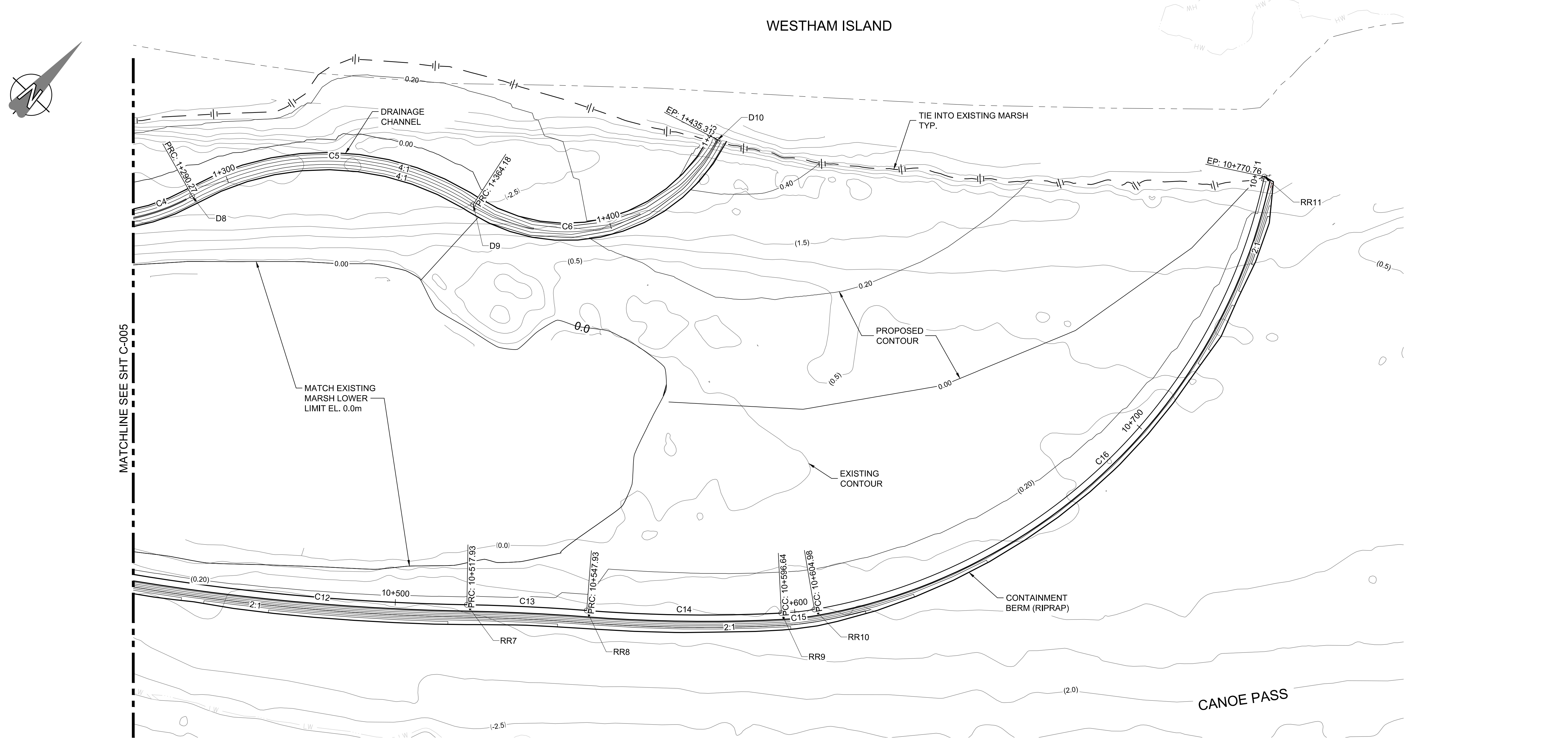

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NUMBER	RADIUS	LENGTH	LINE/CHORD DIRECTION
C12	574.00	145.00	N52° 34' 59.83"E
C13	500.00	30.00	N47° 03' 55.16"E
C14	380.00	48.71	N45° 06' 42.08"E
C15	70.00	8.34	N38° 01' 38.96"E
C16	138.98	165.78	N0° 26' 32.91"E

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21	RR8	5435673.15	489994.56
22	RR9	5435707.51	490029.05
23	RR10	5435714.07	490034.18
24	RR11	5435870.19	490035.38

10m 0m 10m 20m
SCALE: 1 : 500

NOT FOR CONSTRUCTION

LEGEND:

HEADLEASE BOUNDARY
HW — HIGHER HIGH WATER LARGE TIDE (HHWLT)
LW — LOWER LOW WATER LARGE TIDE (LLWLT)
PROPOSED CONTOUR
(XX) — EXISTING CONTOUR

NOTES:

1. SEE GENERAL NOTES ON SHT C-003.
2. COORDINATE AND REVIEW THE SURVEY LAYOUT WITH THE OWNER'S REPRESENTATIVE PRIOR TO CONSTRUCTION. FINAL DIMENSIONS AND LAYOUT ARE SUBJECT TO SURVEY REVIEW.

Ref.No.	REFERENCE

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RBT2 OFFSETTING
WESTHAM ISLAND CANOE PASS
GRADING PLAN SHEET 2 OF 2

SIZE D | DWG. C–006 | SHEET | REV.

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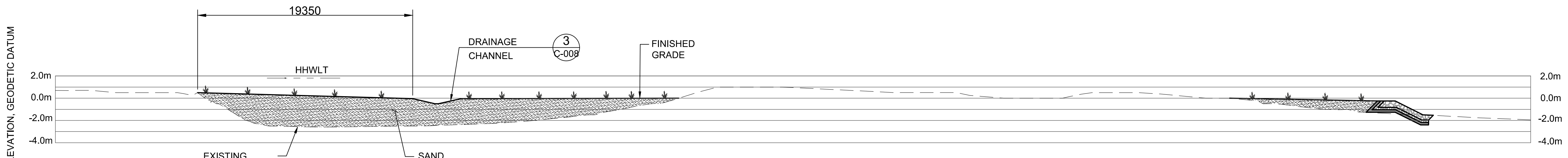

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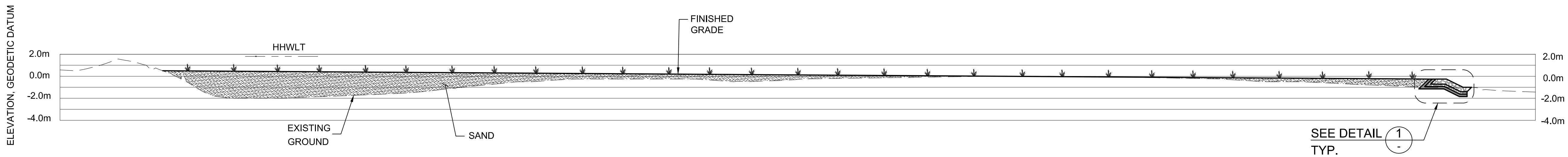

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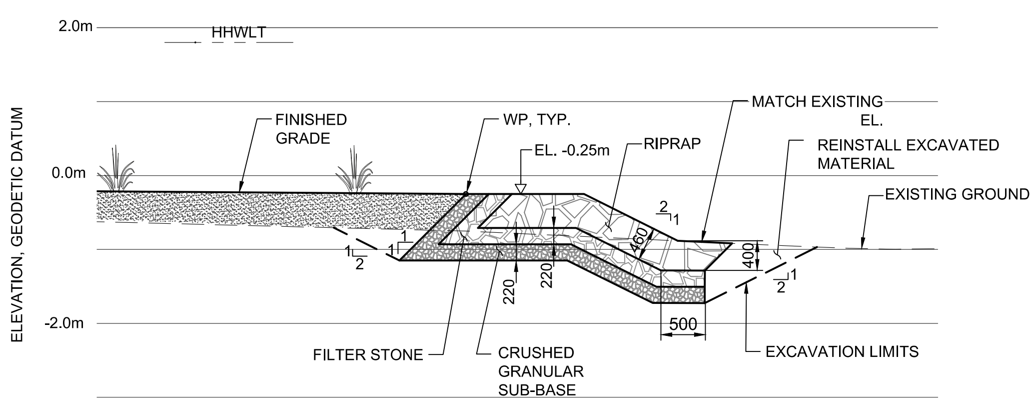

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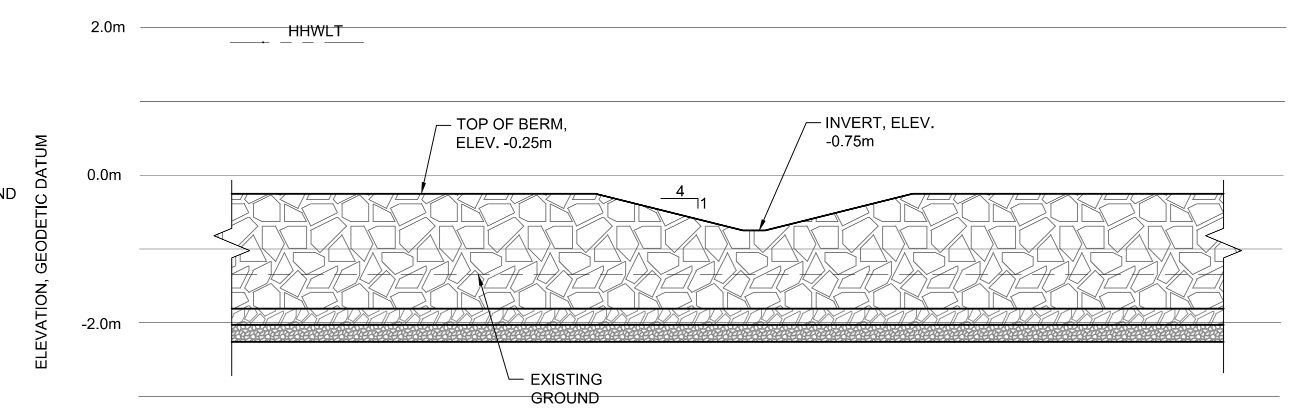

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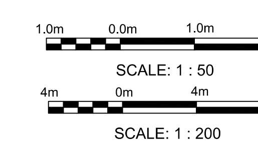

LEGEND:

- SAND
- RIPRAP
- FILTER STONE
- CRUSHED GRANULAR SUB BASE

NOTES:

1. SEE GENERAL NOTES G-003

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RBT2 OFFSETTING
WESTHAM ISLAND CANOE PASS
SECTIONS SHEET 1 OF 3

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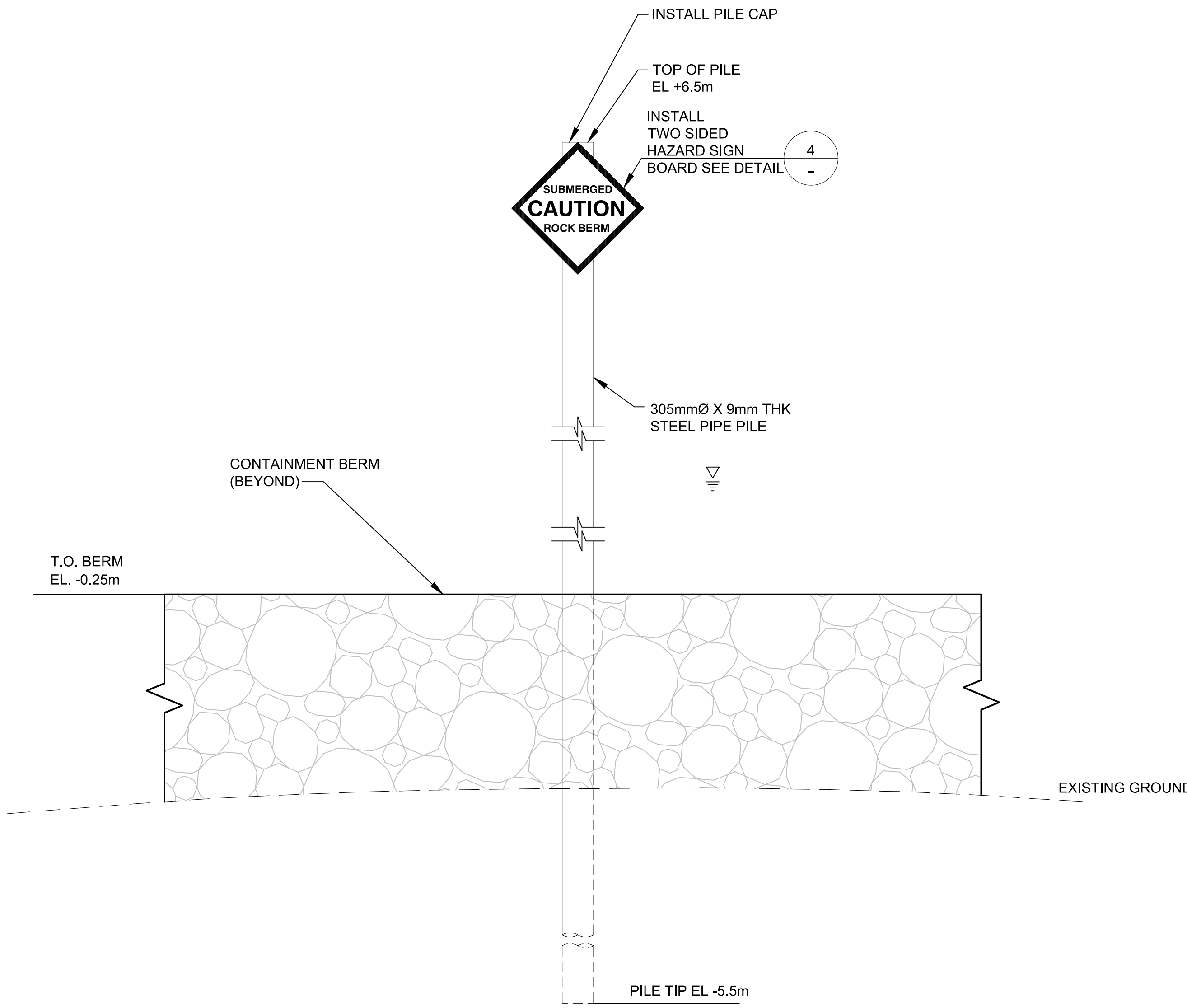

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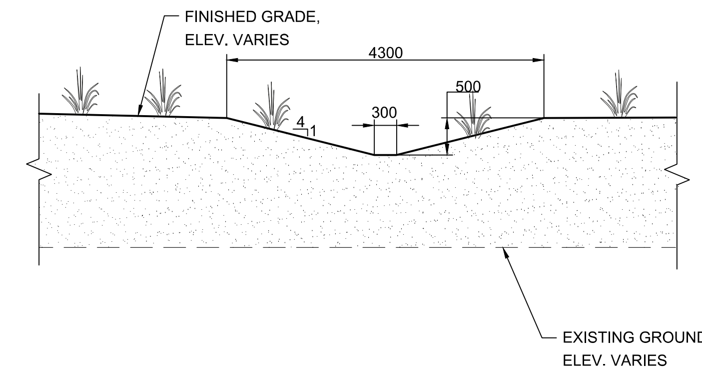

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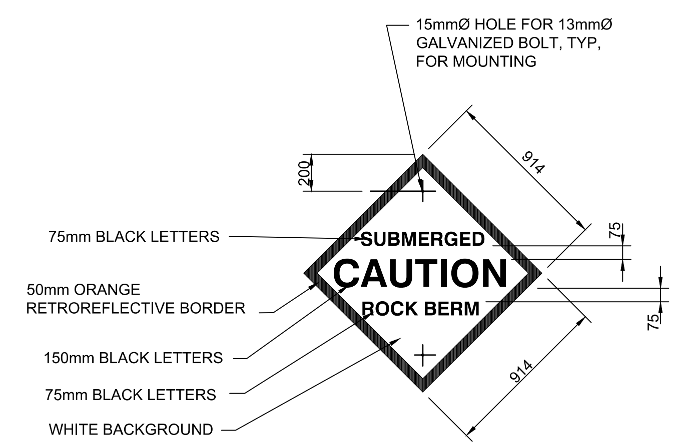

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LEGEND

SAND

RIPRAP

NOTES

1. SEE GENERAL NOTES ON SHEET G-003.

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		REVISION IN PROGRESS		

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RBT2 OFFSETTING
WESTHAM ISLAND CANOE PASS
SECTIONS SHEET 2 OF 3

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Appendix C:
Construction Equipment Figures

8 CY Hydraulic Excavator on Sectional Barges

Derrick Barge - 91’ x 40’ x 6’-11”

Hydraulic Excavator mounted on FlexiFloat Sectional Barges

Derrck Barge - 105' x 40' x 7'-6"

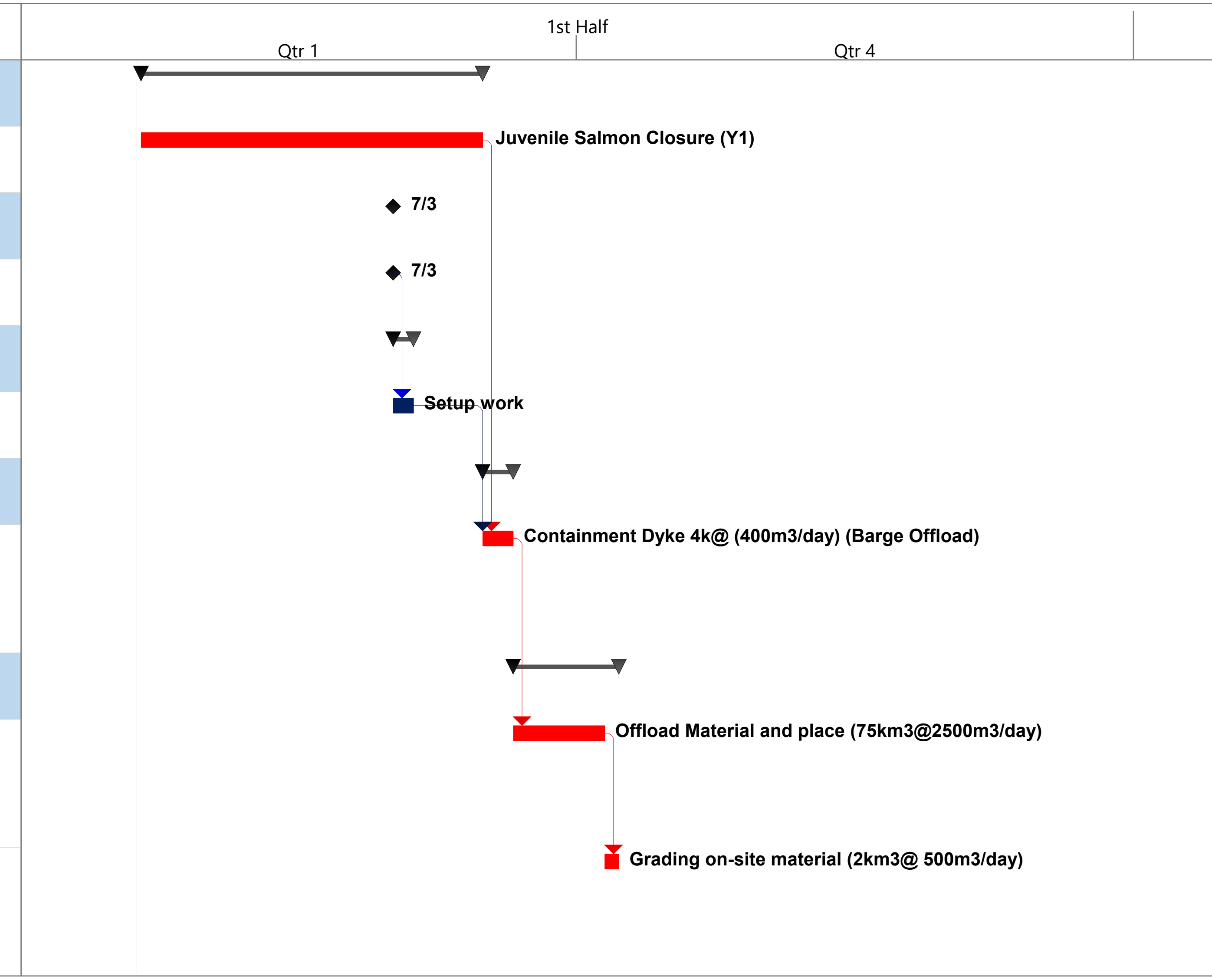
50-Ton Hookload Capacity Crane on FlexiFloat Sectional Barges

Beach fill placement at Texas City, TX (approx. 15-20% silt content)

Beach fill placement at Texas City, TX (approx. 15-20% silt content)

Appendix D:
Construction Schedule

ID	Task Name	Duration	Predecessors	Start	Finish
1	**Environmental Closures**	**168 days**		**Wed 3/1/23**	**Tue 8/15/23**
2	Juvenile Salmon Closure (Y1)	168 days		Wed 3/1/23	Tue 8/15/23
3	**Milestones and Target Dates**	**0 days**		**Mon 7/3/23**	**Mon 7/3/23**
4	Start of Construction	0 days		Mon 7/3/23	Mon 7/3/23
5	**Demolition, Setup**	**10 days**		**Mon 7/3/23**	**Wed 7/12/23**
6	Setup work	10 days	4	Mon 7/3/23	Wed 7/12/23
7	**Marsh Dyking (4kM3)**	**15 days**		**Wed 8/16/23**	**Wed 8/30/23**
8	Containment Dyke 4k@ (400m3/day) (Barge Offload)	15 days	6,2	Wed 8/16/23	Wed 8/30/23
9	**Fill Marsh Areas (75 kM3)**	**52 days**		**Thu 8/31/23**	**Sat 10/21/23**
10	Offload Material and place (75km3@2500m3/day)	45 days	8	Thu 8/31/23	Sat 10/14/23
11	Grading on-site material (2km3@ 500m3/day)	7 days	10	Sun 10/15/23	Sat 10/21/23



Project: 2020.06.18 Westham/Canoe P
Date: Fri 6/19/20

Task	Inactive Task	Manual Summary Rollup	External Milestone	Manual Progress
Split	Inactive Milestone	Manual Summary	Deadline	
Milestone	Inactive Summary	Start-only	Critical	
Summary	Manual Task	Finish-only	Critical Split	
Project Summary	Duration-only	External Tasks	Progress	

Appendix E:
Memorandum Addressing Agricultural Water Supply Impacts

moffatt & nichol

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MEMORANDUM

To: Vancouver Fraser Port Authority

From: Cheng-Feng Tsai, Alan Alcorn, Michael Cho, Moffatt & Nichol

Date: June 9, 2020

Subject: Salinity Impacts for the Westham Island/Canoe Passage Tidal Marsh Project

The farmers on the adjacent land along the Canoe Passage have indicated their concerns regarding the salinity impacts to the water, as a result of the proposed Westham Island/Canoe Passage Tidal Marsh Project. The passage has always been the primary freshwater source to the farmland.

The recent modelling work[1] by Moffatt & Nichol confirms that the project is located where the freshwater from the Fraser River mixes with the saltwater from the Strait of Georgia. The most dominant controlling factor for salinity mixing is the Fraser river discharge, e.g. Figure 1 indicates that the Canoe Passage is fresh irrespective of tide stage when the Fraser discharge is medium or higher (such as freshet). When the Fraser discharge is low, the secondary factor of the oscillating tides increases its contribution to the mixing process. As shown in Figure 2, the salinity at the passage transitions from fresh to brackish when the tide stage is high. In addition, the passage does not exhibit a notable stratification as the nearby Fraser River South Arm (e.g. surface layer vs. bottom layer). In general, M&N's modelling results are consistent with the measurements and modelling results from the Northwest Hydraulic Consultants[2].

From the salinity mixing perspective, only the change of the volume of freshwater or saltwater input (e.g. flow path alteration) or a significant reduction of the cross-sectional area in the flow conveyance (e.g. blockage) may alter the salinity level in the Canoe Passage. The overall reduction of the cross-sectional area due to the project is estimated less than 4 to 5%. Since the project is located at the shallower part of the channel, even less flow area will be impacted (e.g. lower impacts when the water level is high). Given the proposed tidal marsh project does not change the volume of freshwater or saltwater input and does not significantly reduce the cross-sectional area, the project is not expected to alter the salinity level in the Canoe Passage.

One of the farm inlets is very close to the tie-in to east end of the project area. Because the project does not connect the berm to the bank, so there will always be a channel that can feed this inlet. In addition, smaller channels will be created within the habitat so there will not be any stagnation impacts from either the farm weir intake or outlet. Finally, with a fresh environment in the Canoe Passage being a prominent condition for all except during the high

[1] Moffatt & Nichol, 2020. Supplemental Hydrodynamic and Salinity Analysis by Incorporating Phase 2 Breaching into the South Arm Jetty Tidal Marsh Project. Memorandum. May 28, 2020.
[2] Northwest Hydraulic Consultants, 2014. Coastal Geomorphology Study, Proposed Roberts Bank Terminal 2 Technical Report. Final Report. March 2014.

tide, low Fraser flow condition, the intakes will not experience saltier condition as a result of the project.

It should be noted that this memorandum only takes into account the current states of the hydrological regime, any potential climate change-induced alterations of freshwater (e.g. changes in precipitation patterns) or saltwater characteristics (e.g. sea level rise or storminess) are not considered.

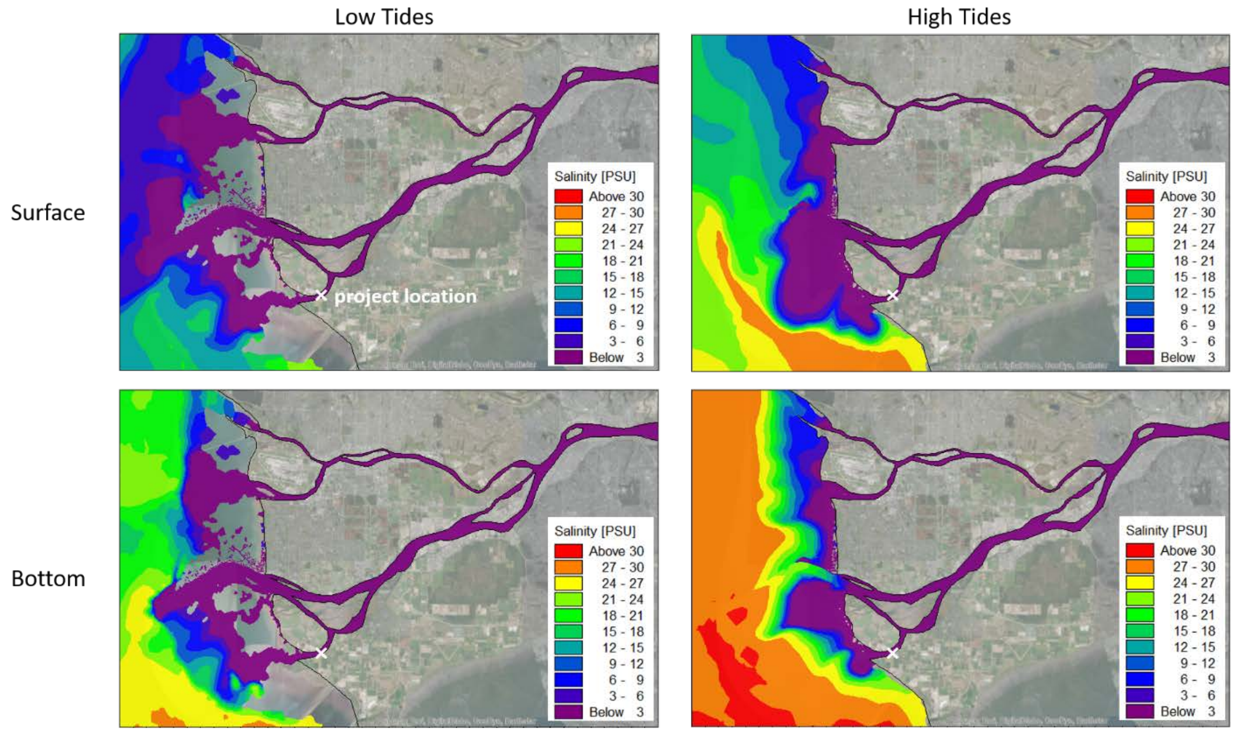

Figure 1: Salinity Distribution for Medium Fraser Flow (5,500 m^3/s), at Surface (Top Panel) and Bottom (Bottom Panel) Layer during Low (Left Panel) and High (Right Panel) Tide Stage

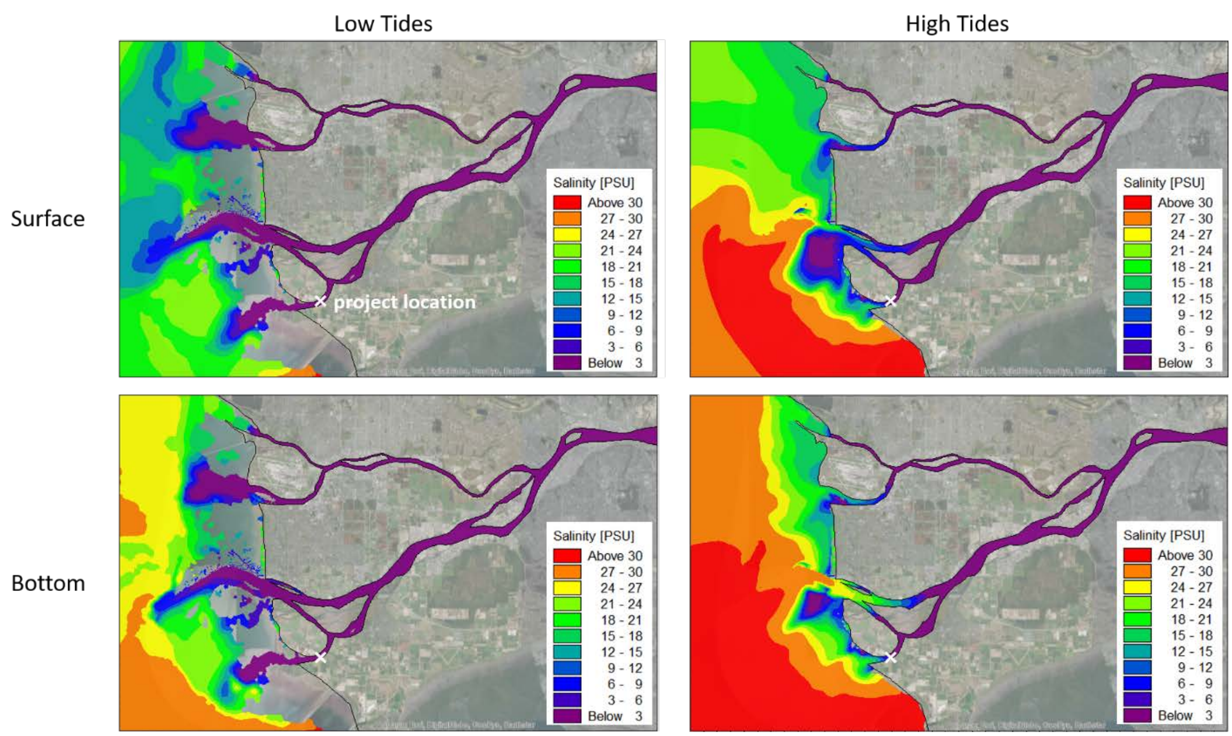

Figure 2: Salinity Distribution for Low Fraser flow (2,000 m^3/s), at Surface (Top Panel) and Bottom (Bottom Panel) Layer during Low (Left Panel) and High (Right Panel) Tide Stage

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Appendix IR2020-1.1-A20

Ecological Conditions at Proposed Westham Island Tidal Marsh Project

ECOLOGICAL CONDITIONS AT PROPOSED WESTHAM ISLAND TIDAL MARSH PROJECT

Prepared for:
Port Metro Vancouver
100 The Pointe, 999 Canada Place
Vancouver, BC V6C 3T4

Prepared by:
Hemmera
250 – 1380 Burrard Street
Vancouver, BC V6Z 2H3

File: 302-035.04
March 2014

HEMMERA

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1.0 INTRODUCTION

The proposed Westham Island Tidal Marsh Creation Project (the Project) in the Corporation of Delta, B.C., is being considered as a potential project under PMV's Habitat Enhancement Program. Project planning is being undertaken in accordance with the "Working Agreement Concerning Procedures for Development and Operation of the Port Metro Vancouver Habitat Bank" (September 19, 2012) between Fisheries and Oceans Canada (DFO) and PMV.

1.1 RATIONALE

As part of the Habitat Enhancement Program, PMV is applying a landscape approach to identify locations where productive capacity of fish habitats can be increased (e.g., by conversion of unproductive upland to productive fish and wildlife habitat); existing habitat can be enhanced to increase its productivity, or degraded habitat can be restored to benefit fish and wildlife species utilizing the lower Fraser River estuary.

This project is located within the Habitat Enhancement Program's "Fraser Estuary, Boundary Bay, Burrard Inlet, Fraser and North Arms" Geographic Service Area (GSA). More than 70% of the original estuarine marsh habitat in this GSA has been impacted by diking and shoreline development over the last century. Marsh restoration in this GSA is considered a very high priority for PMV's Habitat Enhancement Program, wherever a substantial and meaningful improvement in habitat productivity can be provided. The final site selection for this Project was based on factors including need, habitat productivity, site location, feasibility and cost, sustainable habitat creation, ownership and tenure, and consideration towards First Nations and communities.

Conversion of an unvegetated intertidal flat to brackish marsh at the Project site will increase the productivity of Canoe Passage and provide high-quality habitat at a prime estuarine location for juvenile salmonids, other fish species, birds and wildlife utilizing the Fraser River estuary.

The primary sources of information considered during preparation of this report included:

- A review of current and historical aerial photographs.
- Field reconnaissance information collected in 2012 (Pers. Comm.GL Williams 2012)
- Desktop study and background research.

2.0 PROJECT LOCATION

The Project site is located in Canoe Passage in the Corporation of Delta (**Figure 1**), in the intertidal zone on the south-east shore of Westham Island less than 1 km downstream of the Wes-Del Marina (**Figure 2**).

Figure 1 Westham Island Tidal Marsh Project Site – Regional Setting (Google Inc. 2013)

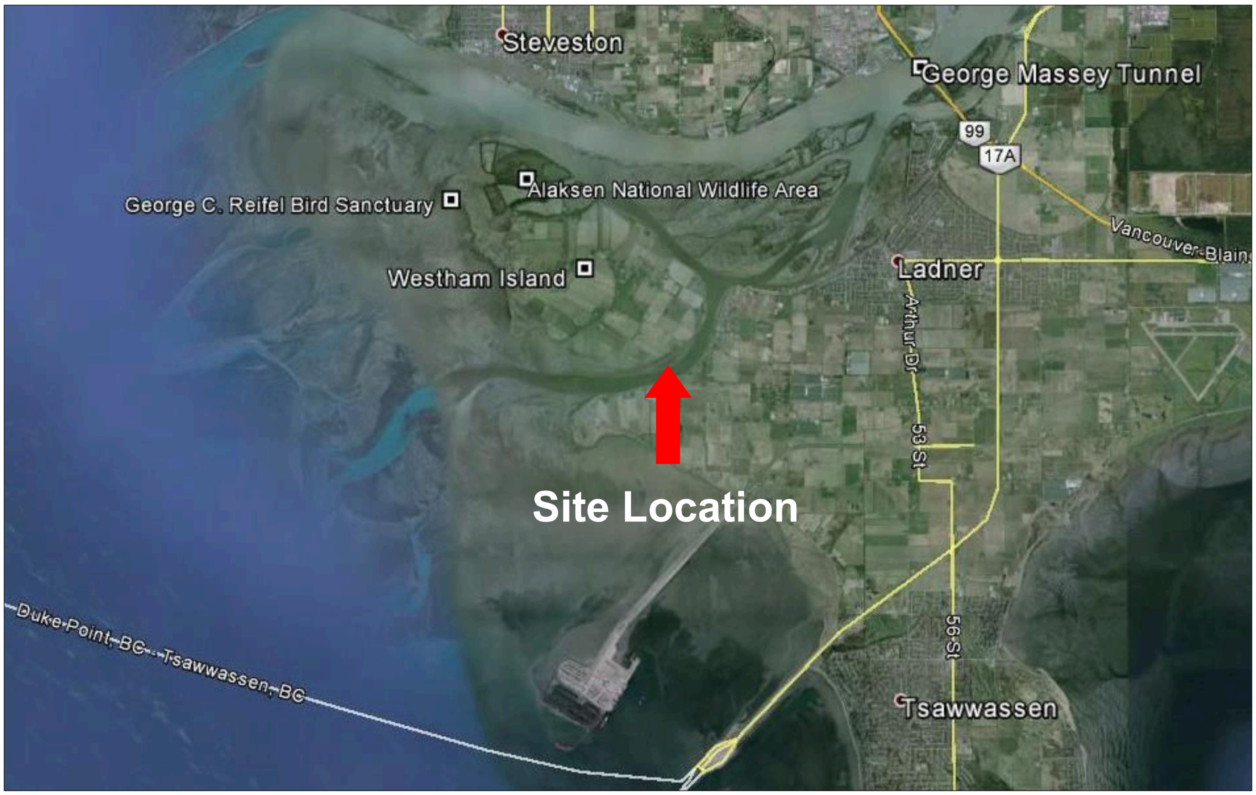


Figure 2 Westham Island Tidal Marsh – Site Location (Google Inc. 2009)

3.0 PROPOSED PROJECT

3.1 SITE HISTORY

Westham Island was settled by farmers and fishermen in the early 1870's (Corporation of Delta 2013a) shortly after settlers Thomas and William Ladner in 1868 began to cultivate land in what is now part of Ladner town centre (Delta Farmland & Wildlife Trust 2011). The island was used as agricultural lands, as a barge-loading site for horses sent to logging camps along the lower coast of BC (Delta Farmland & Wildlife Trust 2011), and was also the site of several canneries, including the ABC Cannery (est. 1988) (Strukoff 2013). Prior to the flourishing of Steveston's cannery industry, the 14 canneries surrounding Ladner formed the most important cannery centre in the region (Destination BC Corporation 2013).

By the late 1800's Ladner, and surrounding areas, was a centre of agriculture and related industries (Delta Farmland & Wildlife Trust 2011). In order to protect Ladner's industry, many dikes had been built along the Fraser River by the turn of the century. Nearby river islands either had minimal protection or were left to flood naturally. Many of these river islands were used as fishing camp sites supplying the local salmon canneries. Ewen Slough on Westham Island was the site of one of these fishing camps (British Columbia Waterfowl Society 2012).

The construction of the Westham Island Bridge in 1910 created a key transportation route for the canneries and farms on the Island; prior to its construction a small ferry connected island residents to the mainland (Strukoff 2013). To this day, Westham Island is an important agricultural component in the Fraser Delta (Google Inc. 2009).

The Project Site is adjacent to a 90.8 ha property that was acquired by the Nature Trust of British Columbia in 1995-1997. Most of the Nature Trust property sits on the landward side of the dike. Managed by Ducks Unlimited, the property provides feeding and overwintering habitat for waterfowl through its conservation of agricultural land (The Nature Trust of British Columbia 2012). Also located on Westham Island, the 300 ha George C. Reifel Migratory Bird Sanctuary is located about 4 km northwest of the Project Site. The Reifel Sanctuary was established in the 1960s to preserve the area's importance as a migration stop-over and a wintering area for large numbers of migratory birds.

The Project Site is located within a net sediment depositional zone on the inner bend of Canoe Passage (Moffatt & Nichol 2014). A review of existing aerial photographs (1996, 1979, 1984 and 2002) shows both a lengthening and narrowing of Canoe Passage over time (NHC-Triton 2004). This narrowing of Canoe Passage has resulted in a decrease in its hydraulic capacity. In 2004 Canoe Passage was estimated to be conveying 5% of the Fraser River's flow, compared to 14% in the 1980's (Moffatt & Nichol 2014).

The Project area is currently used by First Nations for fishing, hunting and harvesting of traditional plants. The Tsawwassen, Musqueam and Hwlitsum First Nations have indicated that Canoe Pass was once an important area for eulachon, sturgeon and other finfish but that siltation, creased vessel traffic and other factors have adversely affected fish and wildlife habitat. The Project area falls within the Tsawwassen First Nations migratory bird, wildlife and fishing areas that is currently accessed by members exercising treaty rights. Musqueam Indian Band currently uses Canoe Pass for salmon fishing and duck hunting. Members of Hwlitsum First Nation currently fish, hunt and harvest traditional plants in the Project area.

3.2 PROPOSED WORKS

Proposed fish habitat enhancement works in Canoe Passage involve the creation of productive intertidal brackish marsh on an area that is currently occupied by un-vegetated intertidal mud/sand flat. The creation of an intertidal brackish marsh on the site will be accomplished through the construction of a perimeter rock berm, followed by placement of clean fill material to specified elevations, and planting of marsh vegetation.

Unvegetated areas extend approximately 2.3 km along the Westham Island shoreline, with a total estimated area at low tide of approximately 11 to 12 ha. The design of this project consists of the construction of a low-elevation containment berm that will follow the existing channel and sandbar, creating an outline of an area that can be filled to create marsh (**Figure 3**). The maximum width of this created marsh will be approximately 100 m, and it will extend approximately 670 m downstream of the end of Trim Road (**Figure 4**). The total resulting tidal wetland habitat will be approximately 4.0 ha. The project is not expected to negatively affect river flow, sedimentation or erosion within Canoe Passage (GL Williams & Associates Ltd. 2012).

Figure 3 Proposed Habitat Enhancement Design for the Westham Island Tidal Marsh Project BC NTS (Moffatt & Nichol 2014)

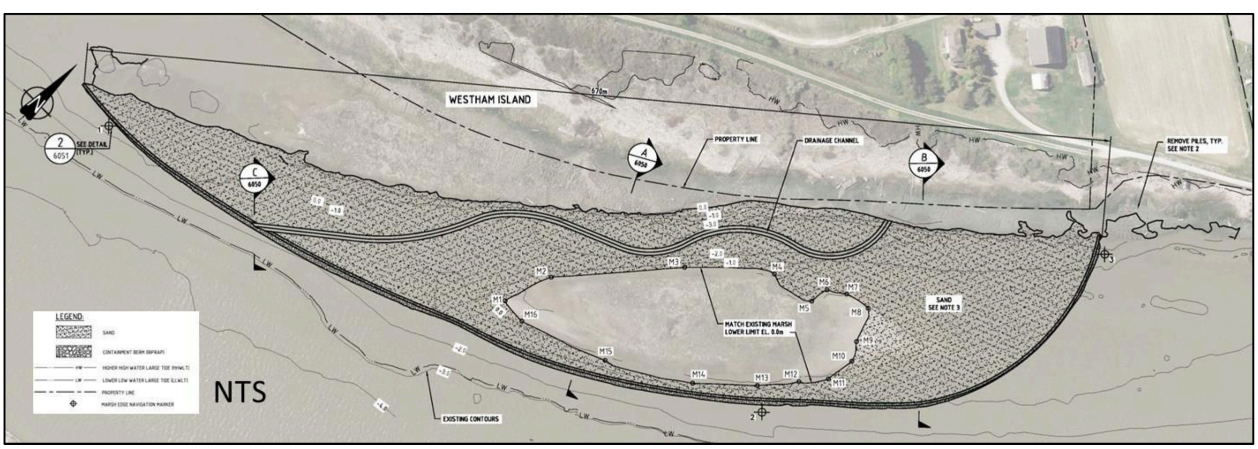


Figure 4 A) Existing Site Conditions, B) Rendering of Proposed Post-Enhancement Conditions

4.0 BIOPHYSICAL CONDITIONS

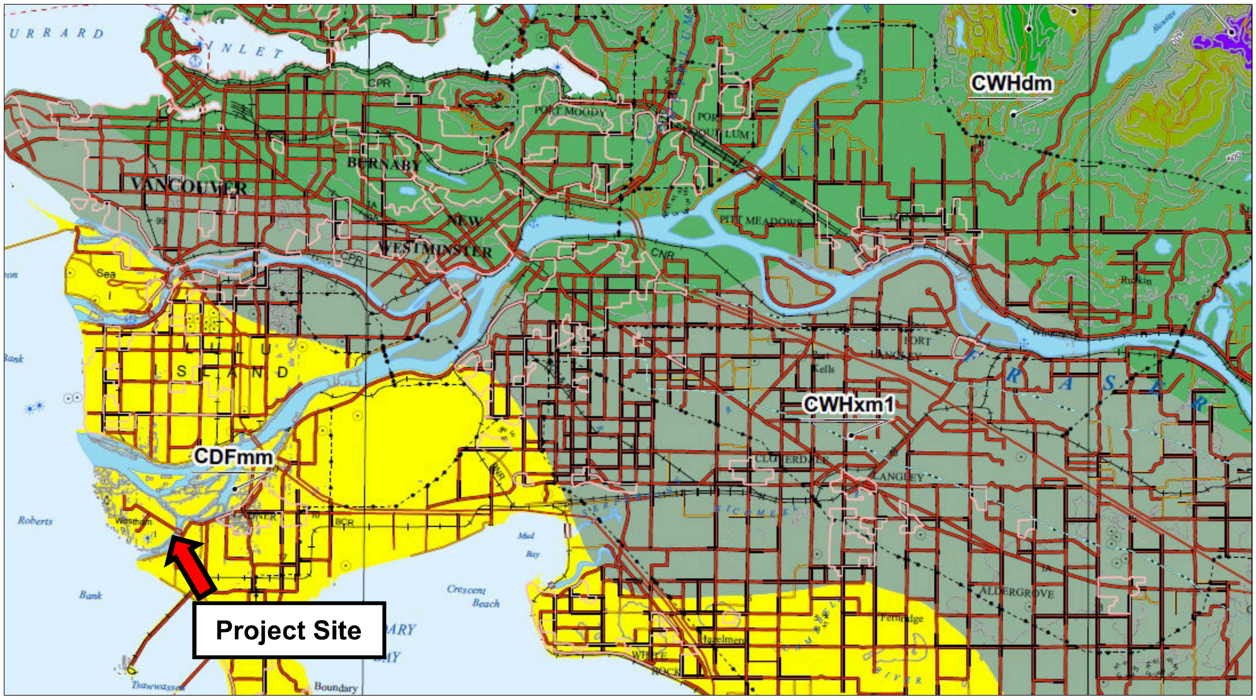
Information related to the biophysical conditions of the Project Site was obtained from the following sources:

- Online Sensitive Habitat Inventory and Mapping database (SHIM 2013).
- Online Fraser River Estuary Management Program and Burrard Inlet Environmental Action Program Habitat Atlas (FREMP 2013).
- Online BC Species and Ecosystems Explorer database (BC Ministry of Environment 2013).
- Online E-fauna BC database (Klinkenberg 2013).
- Online iMap BC database (iMap BC 2013).
- Online Deltamap database (Corporation of Delta 2013).
- Aerial photographs (W. Jans/PMV 2013).
- Delta Watersheds Fish and Amphibian Distributions map (Corporation of Delta 2003).
- Westham Island memo: GL Williams & Associates Ltd to Hemmera (GL Williams & Associates Ltd. 2012).

4.1 GENERAL SITE DESCRIPTION

The Project Site occurs within the Coastal Douglas-fir Moist Maritime (CDFmm) biogeoclimatic subzone (SHIM 2013; **Figure 5**). The CDFmm subzone is limited to the south coast of British Columbia, and includes several Strait of Georgia islands, a small portion of southeastern Vancouver Island, and a narrow strip of the Lower Mainland. The CDFmm occurs at elevations of less than 150 m above sea level and typically has warm, dry summers and mild, wet winters (Nuszdorfer et al. 1991). The mean annual temperature in the CDFmm is 9.2 to 10.5°C and the mean annual precipitation ranges from 647 to 1263 mm (Nuszdorfer et al. 1991).

Figure 5 Biogeoclimatic Subzones of Metro Vancouver (Government of British Columbia 2012)



4.2 Physical Characteristics

4.2.1 Existing Conditions

The Project Site currently consists of an unvegetated intertidal point bar, ranging in width from 120 to 230 m, with substrates characterized by sand and mud (**Photo 1**). At low tide, the sand flat drains via several small surface channels. Adjacent to the Project Site, several larger drainage channels transect the existing marsh (**Photo 2**).

Photo 1 Upstream View of the Proposed Enhancement Area

Photo 2 Tidal Channel within the Existing Marsh Adjacent to Project Site

4.3 HABITAT

4.3.1 Habitat Classification

FREMP classifies shorelines within the Fraser River estuary on the basis of the relative values of their habitat features (FREMP 2002). The classification system was created from an inventory of habitat types in the estuary, including features such as mudflats, marshes, and riparian habitats. FREMP (2002) habitat classifications include:

- Red (High Productivity): includes productive and diverse habitat features that support critical fish and wildlife functions on-site or as part of a more regional context and/or areas where habitat compensation has been previously constructed to offset habitat losses.
- Yellow (Moderate Productivity): habitats include habitat features that are of moderate value in structure or diversity due to existing conditions (e.g., surrounding land uses or productivity) and support moderate fish and wildlife functions.
- Green (Low Productivity): habitats include areas where habitat features and functions are limited due to existing conditions (e.g., developed for port or other urbanized uses).

The Project Site is currently coded Red, indicating that this is a highly productive habitat (**Figure 6**). This classification is likely due to the existing narrow strip of marsh adjacent to the Project Site. The Project Site itself is not classified by FREMP. However, since the Project Site mainly consists of mudflat, which is low in productivity, it would likely be classified as Yellow. The proposed enhancement is intended to increase the producitivity of habitats along the shoreline, and will therefore not affect the FREMP coding for the area.

Figure 6 FREMP Habitat Classification at and Near Westham Island, Fraser River, Delta, BC (FREMP 2013)

4.3.2 Fish and Wildlife Habitats

4.3.2.1 Existing Habitats

Intertidal Marsh and Mudflats

The Project Site is largely unvegetated intertidal sand/mudflat habitat (GL Williams & Associates Ltd. 2012). Intertidal brackish marsh is present along the toe of the dike and in patches on the sand/mudflat (GL Williams & Associates Ltd. 2012) (**Photo 3**). The dominant marsh vegetation species is Lyngby's sedge (*Carex lyngbyei*). Softstem bulrush (*Schoenoplectus tabernaemontani*), threesquare bulrush (*Schoenoplectus pungens*), and spike rush (*Eleocharis palustris*) are also present (GL Williams & Associates Ltd. 2012). The upper intertidal marsh contains invasive purple loosestrife (*Lythrum salicaria*) (GL Williams & Associates Ltd. 2012).

Photo 3 Existing Brackish Marsh with Spike Rush and Lyngby's Sedge

4.3.2.2 Post-Enhancement Conditions

Existing intertidal marsh habitat at The Project Site will not be negatively affected by proposed enhancements works. Existing tidal marshes along the dike and on the sandflat will connect with the enhanced marsh post construction. Four native marsh species will be transplanted to the enhanced area (**Table A**).

Local First Nations have used local plants, including cattail, for traditional purposes. Proposed marsh transplant species will potentially include traditional and medicinal plants. Final plant selection will be determined in consultation between PMV staff and interested First Nations groups.

Table A Proposed Marsh Transplant Species for Westham Island

Scientific Name	Common name
Carex lyngbyei	Lyngby's sedge
Eleocharis palustris	spikerush
Schoenoplectus tabernaemontani	softstem bulrush
Schoenoplectus pungens	threesquare bulrush

4.3.3 Listed Plant Communities

Provincial at-risk species and ecosystems are assigned by the B.C. Conservation Data Centre to either the Red or Blue lists. Red-listed species or ecosystems are considered Threatened, Endangered or Extirpated. Blue-listed species or ecosystems are considered to be of Special Concern, i.e., sensitive to activities which could lead to them becoming extinct or extirpated. The rankings highlight species and ecological communities that have particular threats, declining population trends, or restricted distributions that indicate that they require special attention.

4.3.3.1 Existing Conditions

A number of listed estuarine and wetland ecosystems occur in the CDFmm subzone (**Table A1**, **Appendix A**). **Table B** indicates only those species from **Table A1** that have been identified as having a potential of occurring at the site, based upon their known geographic distributions and habitat associations (BC Ministry of Environment 2013).

Table B Listed Wetland Ecosystems with the Potential to Occur at the Project Site (BC Ministry of Environment 2013)

Scientific Name	English Name	Provincial Listing[1]	Potential to Occur[2]	Effects of Enhancement
Carex lyngbyei Herbaceous Vegetation	Lyngbye's sedge herbaceous vegetation	Red	May occur at the site; this ecosystem is classified as an Estuary Marsh	**Benefit: possible creation of habitat**
Deschampsia cespitosa ssp. *Beringensis - Hordeum brachyantherum*	tufted hairgrass - meadow barley	Red	May occur at the site; this ecosystem is classified as an Estuary Meadow	**Benefit: possible creation of habitat**
Deschampsia cespitosa ssp. beringensis - Symphyotrichum subspicatum	tufted hairgrass - Douglas's aster	Red	May occur at the site; this ecosystem is classified as an Estuary Meadow	**Benefit: possible creation of habitat**
Distichlis spicata var. spicata Herbaceous Vegetation	seashore saltgrass Herbaceous Vegetation	Red	May occur at the site; this ecosystem is classified as an Estuary Meadow	**Benefit: possible creation of habitat**
Juncus arcticus - Plantago macrocarpa	arctic rush - Alaska plantain	Red	May occur at the site; this ecosystem is classified as an Estuary Meadow	**Benefit: possible creation of habitat**
Ruppia maritima Herbaceous Vegetation	beaked ditch-grass Herbaceous Vegetation	Red	May occur at the site; this ecosystem is classified as an Estuary Meadow	**Benefit: possible creation of habitat**
Sarcocornia pacifica - Glaux maritima	American glasswort - sea-milkwort	Red	May occur at the site; this ecosystem is classified as an Estuary Marsh	**Benefit: possible creation of habitat**

Notes: [1] Red = includes any ecological community that is Extirpated, Endangered, or Threatened in BC,
Blue = includes any ecological community considered to be of Special Concern (formerly Vulnerable) in BC
[2] Ecosystem information cited from B.C. Conservation Data Centre (2013)

Nineteen listed wetland vegetation species occur in the CDFmm subzone (BC Ministry of Environment 2013; **Table A2 Appendix A**). **Table C** lists only the species from **Table A2** that have the potential of occurring at the Project site or that will likely be affected by the proposed enhancement works. Three of these species have been recorded near the Project site (iMap BC 2013) (**Table C**). A detailed vegetation inventory was not undertaken at the site, however, a series of site visits were conducted to describe existing plant species, plant communities, and fish and wildlife habitats at the site. The blue-listed Henderson's checker-mallow (*Sidalcea hendersoni*) was identified in the brackish marsh, adjacent to the dike on Westham Island (GL Williams & Associates Ltd. 2012).

Table C Listed Plant Species with Potential to Occur at the Project Site (BC Ministry of Environment 2013)

Scientific Name	Common Name	Provincial Listing[1]	SARA[2]	COSEWIC[3]	Potential to Occur[4]	Effects of Enhancement
Anagallis minima	Chaffweed	Blue			May occur at the site; this species utilizes wet river banks and salt marshes in the lowland zone.	Benefit: creation of additional habitat
Bidens amplissima	Vancouver Island beggarticks	Blue	1-SC (2003)	SC (2001)	May occur at the site; this species utilizes estuary environments such as intertidal mudflats and salt marshes. Known to occur on nearby Reifel Island (iMap BC 2013).	Benefit: creation of additional habitat
Caltha palustris var. *radicans*	Yellow marsh-marigold	Blue			May occur at the site; this species utilizes wet habitats such as brackish marshes.	Benefit: creation of additional habitat
Carex scoparia	Pointed broom sedge	Blue			May occur at the site; this species utilizes brackish tidal marshes.	Benefit: creation of additional habitat
Elatine rubella	Three-flowered waterwort	Blue			May occur at the site; this species utilizes estuarine tidal marsh environments.	Benefit: creation of additional habitat
Eleocharis parvula	Small spike-rush	Blue			May occur at the site; this species utilizes intertidal brackish wetlands.	Benefit: creation of additional habitat
Eleocharis rostellata	Beaked spike-rush	Blue			May occur at the site; this species may utilize salt marshes.	Benefit: creation of additional habitat
Glyceria leptostachya	Slender-spiked mannagrass	Blue			May occur at the site; this species may utilize brackish tidal marshes.	Benefit: creation of additional habitat
Lilaea scilloides	Flowering quillwort	Blue			May occur at the site; this species utilizes intertidal mudflats and marshes. Known to occur on nearby Reifel Island and north side of Westham Island (iMap BC 2013).	Benefit: creation of additional habitat
Sidalcea hendersonii	Henderson's checker-mallow	Blue			May occur at the site; this species utilizes wet coastal areas including mudflats and high marshes. Known to occur on nearby Duck Island, Woodward Island and Ladner marsh (iMap BC 2013).Recorded adjacent to proposed enhancement site (GL Williams & Associates Ltd. 2012).	Benefit: creation of additional habitat

Notes:
1 Red = endangered or threatened, Blue = special concern
2 Schedule 1 = federal species at risk
3 E = Endangered, SC = Special Concern
4 Species Information from BC Conservation Data Centre (2013) and E-Flora BC (2013)

4.3.3.2 Post-Enhancement Conditions

Proposed enhancement works will result in the addition of approximately 4.02 ha of brackish tidal marsh habitat. Marsh creation may create physical conditions that are suitable for some of the listed species presented in **Table C**, particularly those that are tolerant of brackish tidal conditions. None of the listed species are included in the list of potential transplant species for the project. Therefore, their occurrence in the enhanced area would be the result of natural dispersal or vegetative growth from nearby occurrences.

Henderson's checker-mallow was observed adjacent to the proposed enhancement site and it occurs in wet meadows, estuaries and tidal wetlands. Flowering quillwort (*Lilaea scilloides*) is an annual herb that occurs as an understory species in the tidal marshes of the lower Fraser estuary. Both of these species have the potential to occur in the enhanced area once physical works are complete and vegetation becomes established. Post-construction monitoring focussed on the identification of plants species will confirm the presence of these species.

4.4 FISH

4.4.1 Common Fish Species

4.4.1.1 Existing Conditions

The south arm of the Fraser River is an important migratory, rearing and spawning area for fishes, including ecologically and economically important salmonids. For example, the valuable Harrison-run chinook salmon (*Oncorhynchus tshawytshca*) rear in the lower Fraser River (DFO 1999). Coho salmon (*O. kisutch*), cutthroat trout (*O. clarkii*), chum salmon (*O. keta*), pink salmon (*O. gorbuscha*), sockeye salmon (*O. nerka*), Dolly Varden char (*Salvelinus malma*) and steelhead trout (*O. mykiss*) all occur in the Fraser River (SHIM 2013).

The Project Site would be accessible, via Canoe Passage, to freshwater tolerant marine fish species that occur in the Strait of Georgia. An inventory at nearby Roberts Bank shows the area is used by a wide range of fishes, including: flatfish, salmonids, rockfish, lingcod (*Ophiodon elongatus*), spiny dogfish (*Squalus acanthius*), gobbies, sculpins, perch, and forage fish such as Pacific herring (*Clupea pallasii*) and Pacific sandlance (*Ammodytes hexapterus*) (Precision Identification Consultants 2007). The most common fish species found in sand/mudflat habitats were flatfish such as English sole (*Parophrys vetulus*), Pacific sanddab (*Citharichthys sordidus*), rock sole (*Lepidopsetta petraborealis*), starry flounder (*Platichthys stellatus*) (Pers. Comm. Pam Thuringer 2013). These sand/mudflat species have potential to occur at the Project Site, particularly starry flounder, which is freshwater-tolerant, and Pacific sandlance, a burrowing forage fish that is an important prey item for a number of locally valued species (Taylor and Perrin 2005).

The Project Site is within the Corporation of Delta's FA-1 watershed and near to the FA-2 watershed (**Figure 7**). Several agricultural ditches and three sloughs (London, Ewen and Tamboline) occur north of the site. Delta sloughs are generally highly impacted by channelization and riparian removal and suffer from low water quality, likely due to agricultural inputs that influence water temperature and primary productivity (Fraser River Action Plan 1999). The natural flow regime of the Delta sloughs has been modified and most act as storm drainage channels with pump houses or flap gates that cut off direct connection to the Fraser River. Flood control structures prevent access by anadromous fishes, except during periods of high flow (Fraser River Action Plan 1999). The west arm of London Slough runs into the Reifel Bird Sanctuary, where it is protected from development (British Columbia Waterfowl Society 2012). Neither London nor Tamboline slough are known support salmonids year-round. Juvenile salmonids are known to access portions of these areas during high flows, such as in the summer when the areas are flooded for agriculture (Fraser River Action Plan 1999). The following fish species have been observed in Watershed FA-1: brassy minnow (*Hydognathus hankinsoni*), redside shiner (*Richardsonius balteatus*), carp (*Cyprinus carpio*), brown catfish (*Ameiurus nebulosus*), and threespine stickleback (*Gasterosteus aculeatus*) (Corporation of Delta 2008; **Figure 8**).

First Nations have harvested fish from the Fraser Estuary since their colonization of the area. First Nations currently exercise the Aboriginal Right to Fish in Canoe Pass and have indicated that Canoe Pass is an important area for salmon and was previously important for eulachon.

Figure 7 Watersheds and Waterbodies Near the Project Site (Corporation of Delta 2003)

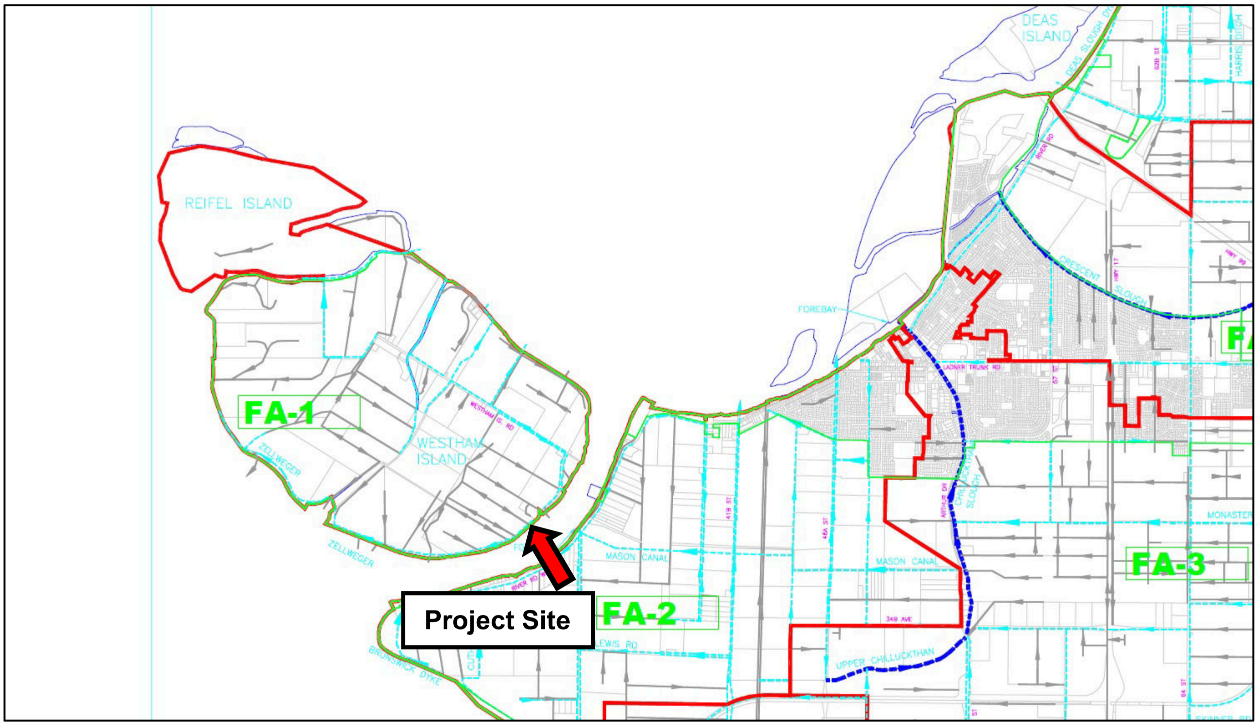
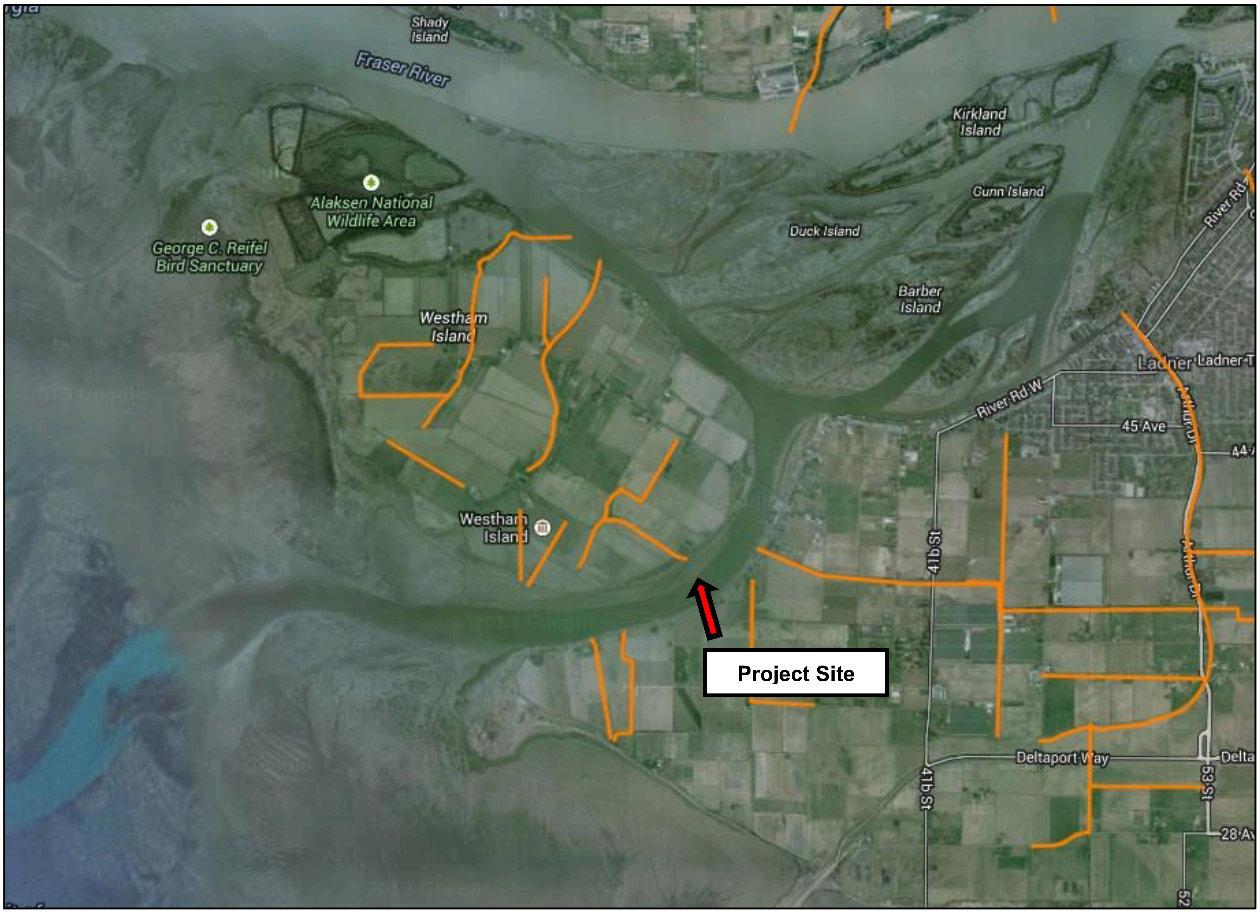


Figure 8 Watercourse Classification Close to the Project Site. Orange Streams are Endangered (FREMP 2013).



4.4.1.2 Post-Enhancement Conditions

Establishment of brackish tidal marsh habitat will increase the productivity of fish and wildlife habitat in Canoe Passage and provide important rearing habitat for juvenile Pacific salmon, particularly chum and chinook salmon. The benefits of increased productivity will also extend to other fish species.

The enhanced productivity of the proposed project will contribute to the estuarine detritus-based food web and result in increased production of important forage and prey items in adjacent unvegetated flats. The restoration of tidal marshes, which have been subject to up to 70% losses due to human development, is a desirable management outcome for the lower Fraser River estuary.

4.4.2 Listed Fish Species

4.4.2.1 Existing Conditions

Three listed marine and freshwater fish species occur in the CDF biogeoclimatic zone within Metro Vancouver (BC Ministry of Environment 2013; **Table D**). The potential of these species to occur at or near the Project Site and the effect the proposed works will have on these species is given in **Table D**.

Table D Listed Fish Species with the Potential to Occur Near the Project Site (BC Ministry of Environment 2013)

Scientific Name	English Name	Provincial Listing[1]	SARA[2]	COSEWIC[3]	Comments	Effects Enhancement
Acipenser medirostris	Green sturgeon	Red	1-SC (2006)	SC (1987)	Habitat preferences are poorly understood. Green sturgeons have only been observed in marine waters off the BC coast.	n/a
Acipenser transmontanus (Lower Fraser River population)	White sturgeon	Red	Not listed	T (2012)	Have been observed near Project Site and juveniles, which prefer shallow water depths, could potentially use the mudflat or marsh habitats at the Project Site. Known to occur in the south arm of the Fraser River (iMap BC 2013).	Unlikely to be affected by creation of marsh habitat.
Oncorhynchus clarkii clarkii	Cutthroat trout, *clarkii* subspecies	Blue	Not listed	Not listed	May use marsh habitat and habitat edges near the project site.	Additional marsh and marsh edge may provide foraging and cover opportunities during periods of high tide.

Notes: 1 Red = endangered or threatened, Blue = special concern
2 Schedule 1 = federal species at risk
3 E = Endangered, T = Threatened, SC = Special Concern

4.4.2.2 Post-Enhancement Conditions

The project site is proposed for an accreting mud/sand bar on the inside bend of Canoe Passage. The Project will essentially accelerate the rate of deposition, with the goal of creating a tidal brackish marsh along the bar. The replacement of tidal sand/mudflat with tidal marsh will result in the loss of habitat that may be utilized by some fish species, particularly at high tide (e.g., flatfish such as starry flounder (*Platichthys stellatus*)). The proposed enhancements will create more complex, productive habitat with high value to juvenile salmonids rearing in the lower Fraser River estuary.

4.5 WILDLIFE

4.5.1 Common Wildlife

4.5.1.1 Existing Conditions

Species representative of the CDFmm subzone that occur in estuaries, shallow bays, intertidal and sub-tidal marine ecosystems are listed in **Table E** (Nuszdorfer et al. 1991).

Table E Common Wildlife Species with Potential to Occur at the Project Site (from Nuszdorfer et al. 1991)

Taxa	Species
Mammals	raccoon (*Procyon lotor)* mink (*Neovison vison)* river otter (*Lontra canadensis*) harbour seal (*Phoca vitulina*) American beaver (*Castor canadensis*) coyote (*Canis latrans*) muskrat (*Ondatra zibethicus*)
Birds	Pacific loon (*Gavia pacifica*) horned grebe (*Podiceps auritus*) Canada goose (*Branta canadensis*) snow goose (*Chen caerulescens*) Barrow's goldeneye (*Bucephala islandica*) bufflehead (*B. albeola*) mallard (*Anas platyrhynchos*) American wigeon (*A. americana*) green-winged teal (*A. carolinensis*) glaucous-winged gull (*Larus glaucescens*) northwestern crow (*Corvus caurinus*) Pacific dunlin (*Calidris alpina*)

The Fraser River Estuary, including Westham Island, is globally recognized as a key migratory stop-over and wintering area for millions of waterfowl and shorebirds (Butler and Campbell 1987; WHSRN 2005). The area is also home to countless resident bird species. A list of bird species that have been observed at the Reifel Migratory Bird Sanctuary is presented in **Appendix A** (**Table A3**). American beaver (*Castor canadensis*), coyote (*Canis latrans*) and muskrat (*Ondatra zibethicus*) all occur on Westham Island (BC Ministry of Environment 2003). Reptiles and amphibians including common garter snake (*Thamnophis sirtalis*) and the northern Pacific treefrog (*Pseudacris regilla*) have all been observed in the area (Delta Corporation 2003; iMap BC 2013).

In addition to native species found at Westham Island, non-native species recorded near the site include green frog (*Lithobates clamintans*), American bullfrog (*Lithobates catesbeiana*), and red-eared slider turtle (*Trachemys scripta*) (Delta Corporation 2003; iMap BC 2013).

During reconnaissance of the Project Site, a flock of Canada geese (*Branta canadensis*) were observed loafing on the tidal flats as well as a pair of mute swans (*Cygnus olor*) with seven cygnets swimming and feeding near shore (GL Williams & Associates Ltd. 2012; **Photo 4**).

Photo 4 Canada Geese Loafing at Proposed Enhancement site

4.5.1.2 Post-Enhancement Conditions

The intertidal sand/mud flat at the Project Site will be converted to intertidal brackish marsh. Converting this habitat to intertidal marsh will result in the loss of some intertidal flats habitat that is currently used as a loafing site for waterfowl (e.g., Canada geese and mute swans) and as a potential foraging area for shorebirds, although use of the less-productive sand flat is likely limited compared to more highly utilized mudflats in the outer estuary. Tidal flats at and immediately downstream of the Project Site are extensive, and include Roberts Bank, Sturgeon Bank and Boundary Bay. The benefits of the intertidal marsh will extend to a wide range of birds and wildlife that utilize the lower Fraser River (Moffatt & Nichol 2014). For example, productive marsh habitat provides foraging and protective roosting grounds for waterfowl such as the American widgeon (*Anas americana*).

4.5.2 Listed Wildlife

4.5.2.1 Existing Conditions

Thirty-two wildlife species occur in the CDFmm biogeoclimatic subzone within Metro Vancouver Regional District (**Table A4 Appendix A**). **Table F** indicates only those species from **Table A4** that have been identified as having a potential of occurring at the site.

Table F Listed Wildlife Species with a Potential to Occur at the Westham Island Site (BC Ministry of Environment 2013)

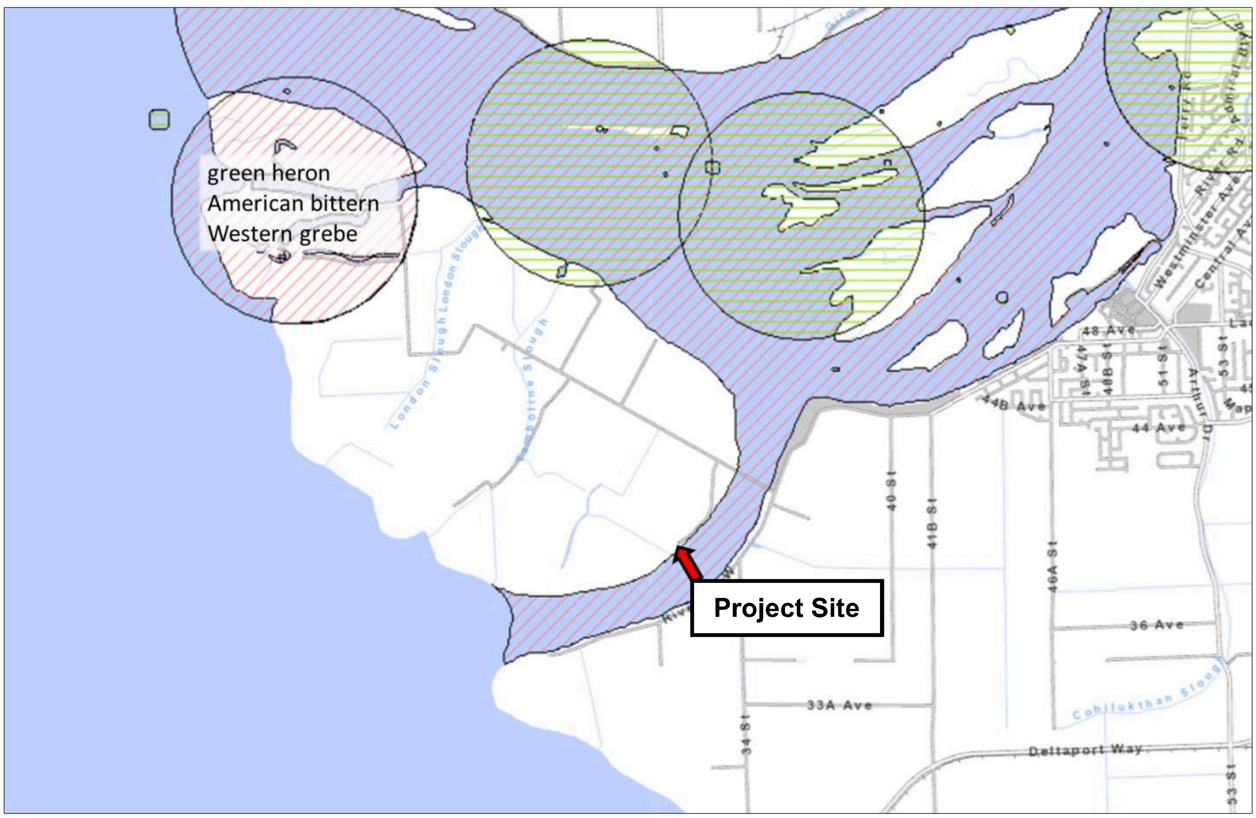
Scientific Name	English Name	Provincial Listing[1]	SARA Schedule[2]	COSEWIC[3]	Potential to Occur Comments[4]	Effects of Enhancement
Birds						
Ardea herodias fannini	Great blue heron, *fannini* subspecies	Blue	1-SC (Feb 2010)	SC (Mar 2008)	Forages for fish near and/or at the site; roosts nearby at Reifel Bird Sanctuary; nearest nesting colony is ~10km away at Point Roberts.	Benefit: possible increase in prey abundance
Botaurus lentiginosus	American bittern	Blue	Not listed	Not listed	Not likely found at the site currently; this species is tied to wetlands with tall emergent vegetation (e.g., cattails) year-round.	Benefit: creation of habitat
Butorides virescens	Green heron	Blue	Not listed	Not listed	May forage for fish at the site, although it is unlikely.	Benefit: possible increase in prey abundance
Nycticorax nycticorax	Black-crowned night-heron	Red	Not listed	Not listed	Not likely found at the site currently; this species may forage for fish in marshes.	Benefit: creation of foraging habitat
Phalacrocorax auritus	Double-crested Cormorant	Blue	Not listed	NAR (May 1978)	May forage for fish at site during high tide; between fishing it often spends time perched on man-made structures over or near water.	Benefit: possible increase in prey abundance
Buteo lagopus	Rough-legged hawk	Blue	Not listed	NAR (May 1995)	Not Likely found at this site currently; this species may forage for rodents over marshes.	Benefit: creation of foraging habitat
Hydroprogne caspia	Caspian tern	Blue	Not listed	NAR (May 1999)	May forage for fish at the site during high tide.	Benefit: possible increase in prey abundance
Tyto alba	Barn owl	Blue	1-SC (Jun 2003)	T (Nov 2010)	Not likely found at the site currently; may forage for rodents over marsh habitat.	Benefit: creation of foraging habitat
Asio flammeus	Short-eared owl	Blue	1-SC (Jul 2012)	SC (Mar 2008)	Not likely found at the site currently; this species is an open grassland and marshland specialist.	Benefit: creation of habitat
Falco peregrinus anatum	Peregrine falcon, *anatum* subspecies	Red	1-SC (Jun 2012)	SC (Apr 2007)	May forage for birds over the site.	No effect
Hirundo rustica	Barn swallow	Blue	Not listed	T (May 2011)	May forage for flying insects over the site; nest under man made coverings close to a source of mud which is used to construct their nests.	Benefit: possible increase in prey abundance

Scientific Name	English Name	Provincial Listing[1]	SARA Schedule[2]	COSEWIC[3]	Potential to Occur Comments[4]	Effects of Enhancement
Mammals						
Myotis keenii	Keen's myotis	Blue	3 (Mar 2005)	DD (Nov 2003)	May be found foraging insects over the site.	Benefit: possible increase in prey abundance
Myotis lucifugus	Little brown myotis	Yellow	Not listed	E (Nov 2012)	May be found foraging insects over the site.	Benefit: possible increase in prey abundance
Mustela frenata altifrontalis	Long-tailed weasel, *altifrontalis* subspecies	Red	Not listed	Not listed	Not likely found at site; open habitats near marshes and riparian areas; can tolerate close proximity to humans.	Benefit: creation of habitat

Notes:
1 Red = endangered or threatened, Blue = special concern, Yellow = not at risk
2 Schedule 1 = federal species at risk, Schedule 3 = Species under consideration for Schedule 1
3 E = Endangered, T = Threatened, SC = Special Concern, NAR = Not at Risk, C = Candidate for upcoming assessment
4 Species information was taken from The Birds of North American Online 2013 and E-Fauna BC 2013

American bittern (*Botaurus lentiginosus*) and green heron (*Butorides virescens*), listed in **Table F**, have been recorded at nearby Reifel Migratory Bird Sanctuary (Raffan 2013). The provincially red listed western grebe (*Aechmophorus occidentalis*) has been sighted at Westham Island (iMap BC 2013; **Figure 9**), however it is not one of the species listed by the BC Species and Ecosystem Explorer within the Metro Vancouver CDF zone (BC Ministry of Environment 2013; **Table F**). Another species not listed on the BC Species and Ecosystem Explorer within the Metro Vancouver CDFmm subzone, the Steller sea lion (*Eumetopias jubatus*) is the only listed pinniped species that have been seen within the Fraser River Estuary. When not in the water, Steller sea lions prefer to haul-out on secluded rocky islands and rocky ledges, so it is unlikely that they occur at the proposed Project Site (COSEWIC 2003). The painted turtle (*Chrysemys picta*) is a red listed species with recorded sighting(s) near the site (BC Ministry of Environment 2003).

Figure 9 Known Occurrences of Listed Wildlife Species near Westham Island Site, BC (iMap BC 2013)



4.5.2.2 Post-Enhancement Conditions

Listed wildlife species occurrences and use of the Westham Island area will not likely be negatively affected by proposed tidal marsh enhancement projects. Listed species are not likely to occupy the study area for critical life history functions. Species that forage for insects may benefit from additional insect production resulting from increased marsh area and productivity. Fish eating species, such as great blue heron and double-crested cormorant may benefit during spring salmon rearing.

5.0 CONCLUSION

DFO's Fisheries Protection Program has supported the enhancement of intertidal marsh habitat to create higher value fish habitat in the Fraser River Estuary. As one of the primary management efforts conducted to support Pacific Salmon, this activity creates or improves productive rearing habitat. It has also been show to increase marine survival and improve fitness of returning adult salmon, in turn, providing benefits to marine mammals as well as First Nations commercial and recreational fisheries. Construction of productive intertidal brackish marsh will also benefit other fish species, birds, and wildlife utilizing the lower Fraser River.

Construction of intertidal marsh habitat at the Project Site aims to restore or improve the following specific ecological functions:

- Increasing primary productivity.
- Supplementing the detritus food web.
- Creating intertidal habitat for the benthic and drift invertebrates (e.g., chironomids, amphipods) that are important prey items for juvenile salmonids and other fishes.
- Providing intertidal vegetation cover and refuge for juvenile salmonids as they utilize shoreline habitats in the lower Fraser River rearing corridor prior to out-migrating to the Strait of Georgia and the Pacific Ocean (Moffatt & Nichol 2014).
- Providing shoreline protection from storm waves (wave dampening), promoting sediment accretion and reducing erosion.
- Increasing prey availability for avian species.

We sincerely appreciate the opportunity to have assisted you with this project and if there are any questions, please do not hesitate to contact the undersigned by phone at 604.669.0424.

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APPENDIX A

Coastal Douglas-Fir Moist Maritime Biogeoclimatic Subzone – Common and Listed Species and Ecosystems

Table A1 At-risk Wetland Ecosystems within the Metro Vancouver CDFmm Subzone (BC Ministry of Environment 2013)

Scientific Name	English Name	Provincial Listing[1]	Potential to Occur Comment[2]
Alnus rubra / Carex obnupta [*Populus trichocarpa*]	red alder / slough sedge [black cottonwood]	Red	Not likely to occur at the site; this ecosystem is classified as a Wetland Swamp
Alnus rubra / Lysichiton americanus	red alder / skunk cabbage	Red	Not likely to occur at the site; this ecosystem is classified as a Wetland Swamp
Carex lasiocarpa - Rhynchospora alba	slender sedge - white beak-rush	Red	Not likely to occur at the site; this ecosystem is classified as a Wetland Fen
Carex lyngbyei Herbaceous Vegetation	Lyngbye's sedge herbaceous vegetation	Red	May occur at the site; this ecosystem is classified as an Estuary Marsh
Deschampsia cespitosa ssp. *Beringensis - Hordeum brachyantherum*	tufted hairgrass - meadow barley	Red	May occur at or near the site; this ecosystem is classified as an Estuary Meadow
Deschampsia cespitosa ssp. beringensis - Symphyotrichum subspicatum	tufted hairgrass - Douglas' aster	Red	May occur at or near the site; this ecosystem is classified as an Estuary Meadow
Distichlis spicata var. spicata Herbaceous Vegetation	seashore saltgrass Herbaceous Vegetation	Red	May occur at the site; this ecosystem is classified as an Estuary Meadow
Dulichium arundinaceum Herbaceous Vegetation	three-way sedge Herbaceous Vegetation	Red	Not likely found at the site; this ecosystem is classified as an Wetland Marsh
Eleocharis palustris Herbaceous Vegetation	common spike-rush Herbaceous Vegetation	Blue	Not likely to occur at the site; this ecosystem is classified as a Wetland Marsh
Juncus arcticus - Plantago macrocarpa	arctic rush - Alaska plantain	Red	May occur at or near the site; this ecosystem is classified as an Estuary Meadow
Menyanthes trifoliata - Carex lasiocarpa	buckbean - slender sedge	Blue	Not likely to occur at the site; this ecosystem is classified as a Wetland Fen
Myrica gale / Carex sitchensis	sweet gale / Sitka sedge	Red	Not likely to occur at the site; this ecosystem is classified as a Wetland Bog
Pinus contorta / Sphagnum spp.	lodgepole pine / peat-mosses CDFmm	Red	Not likely to occur at the site; this ecosystem is classified as a Wetland Bog

Scientific Name	English Name	Provincial Listing[1]	Potential to Occur Comment[2]
Ruppia maritima Herbaceous Vegetation	beaked ditch-grass Herbaceous Vegetation	Red	May occur at or near the site; this ecosystem is classified as an Estuary Meadow
Rhododendron groenlandicum / Kalmia microphylla / Sphagnum spp.	Labrador tea / western bog-laurel / peat-mosses	Blue	Not likely to occur at the site; this ecosystem is classified as a Wetland Bog
Salix sitchensis - Salix lasiandra var. *lasiandra / Lysichiton americanus*	Sitka willow - Pacific willow / skunk cabbage	Red	Not likely to occur at the site; this ecosystem is classified as a Wetland Swamp
Sarcocornia pacifica - Glaux maritima	American glasswort - sea-milkwort	Red	May occur at the site; this ecosystem is classified as an Estuary Marsh
Schoenoplectus acutus Deep Marsh	hard-stemmed bulrush Deep Marsh	Blue	Not likely to occur at the site; this ecosystem is classified as a Wetland Swamp
Typha latifolia Marsh	common cattail Marsh	Blue	Not likely to occur at the site; this ecosystem is classified as a Wetland Marsh

Notes:
1 Red = endangered or threatened, Blue = special concern
2 Ecosystem information cited from BC Conservation Data Centre (2013)

Table A2 At-risk Plant Species within the Metro Vancouver CDFmm Subzone (BC Ministry of Environment 2013)

Scientific Name	Common Name	Provincial Listing[1]	SARA[2]	COSEWIC[3]	Potential to Occur Comments[4]
Alopecurus carolinianus	Carolina meadow-foxtail	Red	--	--	Not likely to occur at the site; this species does not generally occur in intertidal estuary environments.
Anagallis minima	Chaffweed	Blue	--	--	**May occur at the site; this species utilizes wet river banks and salt marshes in the lowland zone.**
Bidens amplissima	Vancouver Island beggarticks	Blue	1-SC (2003)	SC (2001)	**May occur at the site; this species utilizes estuary environments such as intertidal mudflats and salt marshes.**
Callitriche heterophylla var. *heterophylla*	Two-edged water-starwort	Blue	--	--	Not likely to occur at the site; this is an aquatic species typically found in lakes or pond.
Caltha palustris var. *radicans*	Yellow marsh-marigold	Blue	--	--	**May occur at the site; this species utilizes wet habitats such as brackish marshes.**
Carex interrupta	Green-fruited sedge	Red	--	--	Not likely to occur at the site; this species does not generally occur in intertidal estuary environments.
Carex scoparia	Pointed broom sedge	Blue	--	--	**May occur at the site; this species utilizes brackish tidal marshes.**
Claytonia washingtoniana	Washington springbeauty	Red	--	--	Not likely to occur at the site; this species does not occur in intertidal estuary environments.
Cuscuta campestris	Field dodder	Blue	--	--	Not likely to occur at the site; this species does not occur in intertidal estuary environments.
Elatine rubella	Three-flowered waterwort	Blue	--	--	**May occur at the site; this species utilizes estuarine tidal marsh environments.**
Eleocharis parvula	Small spike-rush	Blue	--	--	**May occur at the site; this species utilizes intertidal brackish wetlands.**
Eleocharis rostellata	Beaked spike-rush	Blue	--	--	**May occur at the site; this species may utilize salt marshes.**
Erigeron philadelphicus var. *glaber*	Salt marsh Philadelphia fleabane	Red	--	--	Not likely to occur at the site; this species occurs in moist mesic grassland, shrubland and open forests.
Eutrochium maculatum var. *bruneri*	Joe-pye weed	Red	--	--	Not likely to occur at the site; this species primarily occurs in swamps, pond margins and forest openings.

Scientific Name	Common Name	Provincial Listing[1]	SARA[2]	COSEWIC[3]	Potential to Occur Comments[4]
Glyceria leptostachya	Slender-spiked mannagrass	Blue	--	--	**May occur at the site; this species may utilize brackish tidal marshes.**
Helenium autumnale var. *grandiflorum*	Mountain sneezeweed	Blue	--	--	Not likely to occur at the site; this species utilizes mesic streambanks, meadows and forest openings.
Isoetes nuttallii	Nuttall's quillwort	Blue	--	--	Not likely to occur at the site; this species does not generally occur in intertidal estuary environments.
Juncus oxymeris	Pointed rush	Blue	--	--	Not likely to occur at the site; this species does not generally occur in intertidal estuary environments.
Lilaea scilloides	Flowering quillwort	Blue	--	--	**May occur at the site; this species utilizes intertidal mudflats and marshes.**
Lupinus rivularis	Streambank lupine	Red	1-E (2005)	E (2002)	Not likely to occur at the site; this species primarily occurs in wet/moist meadows and riverbanks.
Myriophyllum ussuriense	Ussurian water-milfoil	Blue	--	--	Not likely to occur at the site; this species does not generally occur in intertidal estuary environments.
Navarretia intertexta	Needle-leaved navarretia	Red	--	--	Not likely to occur at the site; this species does not generally occur in intertidal estuary environments.
Pleuropogon refractus	Nodding semaphoregrass	Blue	--	--	Not likely to occur at the site; this species does not generally occur in intertidal estuary environments.
Rubus nivalis	Snow bramble	Blue	--	--	Not likely to occur at the site; this species does not occur in intertidal estuary environments.
Rupertia physodes	California-tea	Blue	--	--	Not likely to occur at the site; this species does not occur in intertidal estuary environments.
Sidalcea hendersonii	Henderson's checker-mallow	Blue	--	--	**May occur at the site; this species utilizes wet coastal areas including mudflats and high marshes.**

Table A3 Bird Species Observed at the George C. Reifel Migratory Bird Sanctuary from 1963 to 2013 (Raffan 2013)

Red-throated Loon Pacific Loon Common Loon Pied-billed Grebe Horned Grebe Red-necked Grebe Eared Grebe Western Grebe Double-crested Cormorant Brandt's Cormorant Pelagic Cormorant American Bittern American White Pelican* Brown Pelican* Great Blue Heron Great Egret* Cattle Egret* Green Heron Black-crowned Night-Heron Trumpeter Swan Tundra Swan Mute Swan Greater White-fronted Goose Lesser Snow Goose Ross' Goose Emperor Goose* Brant Canada Goose Cackling Goose Wood Duck Mandarin Duck* Green-winged Teal Eurasian Green-winged Teal* Mallard American Black Duck* Northern Pintail Blue-Winged Teal Cinnamon Teal Northern Shoveler Gadwall Eurasian Wigeon American Wigeon Canvasback	Peregrine Falcon Gyrfalcon Prairie Falcon* Ring-necked Pheasant California Quail* Virginia Rail Sora American Coot Sandhill Crane Black-Bellied Plover American Golden Plover Semipalmated Plover Killdeer Black Oystercatcher* Black-necked Stilt* Red-necked Stint* American Avocet Greater Yellowlegs Lesser Yellowlegs Willet Spotted Redshank* Solitary Sandpiper Wood Sandpiper* Spotted Sandpiper Upland Sandpiper* Whimbrel Long-billed Curlew Hudsonian Godwit Bar-tailed Godwit Marbled Godwit Ruddy Turnstone Black Turnstone Rock Sandpiper* Red Knot Sanderling Semipalmated Sandpiper Western Sandpiper Temminck's Stint* Least Sandpiper Baird's Sandpiper Pectoral Sandpiper Sharp-tailed Sandpiper Dunlin Stilt Sandpiper	Barn Owl Western Screech Owl* Great Horned Owl Snowy Owl Boreal Owl* Barred Owl Long-eared Owl Short-eared Owl Northern Saw-whet Owl Common Nighthawk Black Swift Vaux's Swift Anna's Hummingbird Calliope Hummingbird* Rufous Hummingbird Belted Kingfisher Lewis's Woodpecker* Red-naped Sapsucker* Red-breasted Sapsucker Downy Woodpecker Hairy Woodpecker Three-toed Woodpecker* Northern Flicker Pileated Woodpecker Olive-sided Flycatcher Western Wood-Pewee Willow Flycatcher Hammond's Flycatcher Pacific-slope Flycatcher Ash-throated Flycatcher* Dusky Flycatcher* Eastern Phoebe Say's Phoebe Western Kingbird Eastern Kingbird Tropical Kingbird* Blue-gray Gnatcatcher* Horned Lark Purple Martin Tree Swallow Violet-green Swallow Northern Rough-winged Swallow Bank Swallow Cliff Swallow Barn Swallow Steller's Jay Blue Jay*	Bohemian Waxwing Cedar Waxwing Northern Shrike European Starling Crested Myna* Cassin's Vireo Hutton's Vireo Warbling Vireo Philadelphia Vireo* Red-eyed Vireo Orange-crowned Warbler Nashville Warbler Tennessee Warbler* Magnolia Warbler* Yellow Warbler Chestnut-sided Warbler* Yellow-rumped Warbler Black-throated Gray Warbler Townsend's Warbler Hermit Warbler* Black-throated Green Warbler* Palm Warbler* Black-and-white Warbler American Redstart* Northern Waterthrush MacGillivray's Warbler Common Yellowthroat Wilson's Warbler Prothonotory Warbler* Yellow-breasted Chat* Western Tanager Black-headed Grosbeak Evening Grosbeak Pine Grosbeak Spotted Towhee Green-tailed Towhee* American Tree Sparrow Chipping Sparrow Clay-coloured Sparrow* Vesper Sparrow* Savannah Sparrow Fox Sparrow Song Sparrow Lincoln's Sparrow Swamp Sparrow White-throated Sparrow Golden-crowned Sparrow White-crowned Sparrow

Redhead Ring-necked Duck Tufted Duck* Greater Scaup Lesser Scaup Long-tailed Duck Black Scoter Surf Scoter White-winged Scoter Common Goldeneye Barrow's Goldeneye* Bufflehead Smew* Hooded Merganser Common Merganser Red-breasted Merganser Ruddy Duck Turkey Vulture Osprey Black-shouldered Kite* Bald Eagle Northern Harrier Sharp-shinned Hawk Cooper's Hawk Northern Goshawk Red-tailed Hawk Rough-legged Hawk Golden Eagle* American Kestrel American Pipit	Buff-breasted Sandpiper* Ruff* Short-billed Dowitcher Long-billed Dowitcher Common Snipe Wilson's Phalarope Red-necked Phalarope Red Phalarope* Parasitic Jaeger Franklin's Gull Heermann's Gull* Bonaparte's Gull Mew Gull Ring-Billed Gull California Gull Herring Gull Thayer's Gull Western Gull* Glaucous-winged Gull Glaucous Gull Caspian Tern Common Tern Black Tern* Marbled Murrelet Common Murre* Eurasian Collared Dove Rock Pigeon Band-tailed Pigeon	Black-billed Magpie* Northwestern Crow Common Raven Black-capped Chickadee Mountain Chickadee Chestnut-backed Chickadee Bushtit Red-breasted Nuthatch Brown Creeper Bewick's Wren House Wren Pacific Wren Marsh Wren Golden-crowned Kinglet Ruby-crowned Kinglet Mountain Bluebird* Townsend's Solitaire Veery* Swainson's Thrush Hermit Thrush American Robin Varied Thrush Grey Catbird* American Dipper* Northern Mockingbird*	Harris' Sparrow* Dark-eyed Junco Lapland Longspur* Snow Bunting* Bobolink* Red-winged Blackbird Western Meadowlark Yellow-headed Blackbird Rusty Blackbird* Brewer's Blackbird Common Grackle* Brown-headed Cowbird Bullock's Oriole Brambling* Purple Finch House Finch Cassin's Finch* Red Crossbill Common Redpoll Pine Siskin American Goldfinch House Sparrow Merlin Mourning Dove

*species observed but rare, or uncommon

Table A4 Species-at-risk within the Metro Vancouver CDFmm Subzone (BC Ministry of Environment 2013)

Scientific Name	English Name	Provincial Listing[1]	SARA Schedule[2]	COSEWIC[3]	Potential to Occur Comments[4]
Birds					
Dendragapus fuliginosus	Sooty grouse	Blue	Not listed	Not listed	Site is not within species range
Ardea herodias fannini	Great blue heron, *fannini* subspecies	Blue	1-SC (Feb 2010)	SC (Mar 2008)	Species forage for fish near and/or at the site; roost nearby at Reifel Bird Sanctuary; nearest nesting colony is ~10km away at Point Roberts
Botaurus lentiginosus	American bittern	Blue	Not listed	Not listed	Not likely found at the site currently; this species is tied to wetlands with tall emergent vegetation (e.g. cattails) year-round
Butorides virescens	Green heron	Blue	Not listed	Not listed	May forage fish at the site, although it is unlikely
Nycticorax nycticorax	Black-crowned night-heron	Red	Not listed	Not listed	Not likely found at the site currently; this species may forage for fish in marshes
Phalacrocorax auritus	Double-crested cormorant	Blue	Not listed	NAR (May 1978)	May forage for fish at site during high tide; between fishing it often spends time perched on man-made structures over or near water
Accipiter gentilis laingi	Northern goshawk, *laingi* subspecies	Red	1-T (Jun 2003)	T (Apr 2013)	Not likely found at this site; this species prefers mature forests and old growth
Buteo lagopus	Rough-legged hawk	Blue	Not listed	NAR (May 1995)	Not Likely found at this site currently; this species may forage for rodents over marshes
Hydroprogne caspia	Caspian tern	Blue	Not listed	NAR (May 1999)	May forage for fish at the site during high tide
Brachyramphus marmoratus	Marbled murrelet	Blue	1-T (Jun 2003)	T (May 2012)	May forage for fish at the site during high tide
Patagioenas fasciata	Band-tailed pigeon	Blue	1-SC (Feb 2011)	SC (Nov 2008)	Not likely found at the site; this species typically breeds and feeds in open areas within forests or in suburban gardens and parks
Tyto alba	Barn owl	Blue	1-SC (Jun 2003)	T (Nov 2010)	Not likely found at the site currently; may forage for rodents over marsh habitat
Asio flammeus	Short-eared owl	Blue	1-SC (Jul 2012)	SC (Mar 2008)	Not likely found at the site currently; this species is an open grassland and marshland specialist

Scientific Name	English Name	Provincial Listing[1]	SARA Schedule[2]	COSEWIC[3]	Potential to Occur Comments[4]
Megascops kennicottii kennicottii	Western screech-owl, *kennicottii* subspecies	Blue	1-SC (Jan 2005)	T (May 2012)	Not likely found at this site; this species is primarily associated with riparian or low elevation forests
Chordeiles minor	Common nighthawk	Yellow	1-T (Feb 2010)	T (Apr 2007)	Not likely to utilize the site
Cypseloides niger	Black swift	Yellow	Not listed	C (Jul 2011)	Not likely to utilize the site
Falco peregrinus anatum	Peregrine falcon, *anatum* subspecies	Red	1-SC (Jun 2012)	SC (Apr 2007)	May forage for birds over the site
Contopus cooperi	Olive-sided flycatcher	Blue	1-T (Feb 2010)	T (Nov 2007)	Not likely found at the site; this species forages and breeds in forest openings
Hirundo rustica	Barn swallow	Blue	Not listed	T (May 2011)	May forage for flying insects over the site; nest under man made coverings close to a source of mud which is used to construct their nests
Progne subis	Purple martin	Blue	Not listed	Not listed	Not likely to occur (foraging)
Mammals					
Aplodontia rufa	Mountain beaver	No Status	1-SC (Jun 2003)	SC (May 2012)	Site not within species range
Myodes gapperi occidentalis	Southern red-backed vole, *occidentalis* subspecies	Red	Not listed	Not listed	Not likely found at the site; this species is generally associated with mature forest cover with high levels of structural diversity and large woody debris
Lepus americanus washingtonii	Snowshoe hare, *washingtonii* subspecies	Red	Not listed	Not listed	Not likely found at the site; habitat generally includes non-fragmented adequately sized riparian woodlands
Sorex rohweri	Olympic shrew	Red	Not listed	Not listed	Not likely found at the site; this species is associated with dry riparian habitat around streams and wetlands with high levels of structural diversity and deep organic soil layers
Sorex trowbridgii	Trowbridge's shrew	Blue	Not listed	Not listed	Not likely found at the site; this species prefer upland areas away from water
Corynorhinus townsendii	Townsend's big-eared bat	Blue	Not listed	Not listed	Not likely found at the site; this species forages over forests, grasslands, shrub thickets and riparian areas with limited human disturbances

Scientific Name	English Name	Provincial Listing[1]	SARA Schedule[2]	COSEWIC[3]	Potential to Occur Comments[4]
Myotis keenii	Keen's myotis	Blue	3 (Mar 2005)	DD (Nov 2003)	May be found foraging insects over the site
Myotis lucifugus	Little brown myotis	Yellow	Not listed	E (Nov 2012)	May be found foraging insects over the site
Mustela frenata altifrontalis	Long-tailed weasel, *altifrontalis* subspecies	Red	Not listed	Not listed	Not likely found at the site currently; this species may be found in open habitats often near marshes and riparian areas and can tolerate close proximity to humans
Amphibians					
Anaxyrus boreas	Western toad	Blue	1-SC (Jan 2005)	SC (2012)	Site not within species range
Rana aurora	Northern red-legged frog	Blue	1-SC (Jan 2005)	SC (Nov 2004)	Not likely found at the site; this species is associated with structurally complex wetlands with slow moving waters relatively free of urban and agricultural runoff
Reptiles and turtles					
Chrysemys picta pop. 1	Painted turtle - Pacific coast population	Red	1-E (Dec 2007)	E (Apr 2006)	Not likely found at the site; this species is associated with slow-moving, permanent water bodies

Appendix IR2020-1.1-A21

Geotechnical Assessment – Phase 1 Habitat Compensation: Westham Island, Delta, BC

REPORT

December 13, 2013

GEOTECHNICAL ASSESSMENT

Phase 1 Habitat Compensation: Westham Island, Delta, BC

Submitted to:
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Suite 301, 777 West Broadway
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Report Number: 1314470047-003-R-Rev0

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Golder Associates

Table of Contents

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) carried out a geotechnical assessment of the Phase 1 proposed habitat compensation site to be built at Westham Island, Delta, BC. The assessment was requested by Moffatt and Nichol (MN) on behalf of Port of Metro Vancouver (PMV). The development of the habitat compensation site involves site grading, fill placement and excavation as required to achieve a ground surface elevation suitable for the support of habitat.

The geotechnical assessment was carried out on the basis of a desktop geotechnical study and limited site reconnaissance. This report presents the anticipated geotechnical conditions and preliminary comments on geotechnical considerations for design and construction of the habitat compensation site. All elevations discussed within this report are referenced to Geodetic Datum.

The assessment of the Westham Island site is being carried out as part of a larger habitat compensation project which includes additional Phase 1 and Phase 2 sites at various locations. The reports for other sites have been issued under separate cover, grouped by Phase and geographic location.

The work on this assignment has been carried out in accordance with the Golder proposal dated November 02, 2012. The work has been completed in accordance with the terms and conditions outlined in the reciprocal master agreement for consulting services between MN and Golder dated March 11, 2011.

The scope of this report is limited to geotechnical aspects of the proposed site development under static conditions (specifically excludes seismic response and design considerations), and does not include any provision for environmental services such as the investigation, testing or assessment of the potential presence or impact of soil or groundwater contamination at the site, archeological or biological considerations or other hydrogeological services including but not limited to sediment transportation, erosion and/or scouring potential of the proposed developments.

This report should be read in conjunction with the ***"Important Information and Limitations of This Report"*** that follows this text. The reader's attention is specifically drawn to this information as it is essential for the proper use and interpretation of this report.

2.0 SITE CONDITIONS AND PROPOSED DEVELOPMENT

2.1 Site Location and Description

The site is located on the south-east perimeter of Westham Island in Canoe Pass, approximately 0.5 km downstream of the Westham Island Bridge, as shown on Figure 1. The existing site is characterized as a series of sandbars that are prominent at lower water levels but become partially submerged at higher water levels.

The Site is offset from the dyke surrounding the perimeter of Westham Island as follows:

- About 32 m offset at the south-east end; increasing to:
- Greater than 100 m offset at the south end.

2.2 Proposed Habitat Compensation

Site geometry and proposed development details are based on plans and sections provided to Golder by MN (ref: MN Drawings 6047 to 6051, included within Appendix B of the MN submission to PMV dated December 13, 2013). The MN drawings indicate the proposed habitat compensation involves the construction of a containment berm and infilling with sand/silt to establish a permanent marsh platform as follows:

- The arc-shaped containment berm will encompass the southern end of an existing marsh and over adjacent banks for construction of additional marsh area.
- The overall length of the existing marsh coupled with the new extended marsh area will be approximately 670 m, with a maximum width of approximately 100 m and area of approximately 40,000 m^2.
- The design elevation of the top of the marsh is at about 0.3 m. This will require fill placement of, on average, approximately 1 m thick and up to approximately 3.3 m thick in the existing “drainage channel” located at the northern edge of the marsh.
- The containment berm will comprise a 1.6 m wide crest and 2H:1V slope armoured with a 0.46 m thick layer of riprap protection (32 kg riprap stone) underlain with a 0.22 m thick layer of filter stone.

3.0 SITE RECONNAISSANCE

A Golder representative attended a site viewing by boat of the Westham Island project site, on March 11, 2013, with representatives from MN and PMV and other consultants for the project. Site photographs were taken during the viewing.

4.0 REVIEW OF AVAILABLE INFORMATION

4.1 Regional Surficial Geology

Surficial geology information published by the Geological Survey of Canada (ref: Map 1486A dated 1979) indicates that the area is underlain by the following sequence of deposits:

- **Fraser River Sediments** comprising of:
  - Overbank silty to silt clay loam normally less than 2 m thick; overlying
  - Deltaic and distributary channel fill of interbedded fine to medium sand about 15 m thick; overlying
  - Estuarine interbedded fine sand to clayey silt, between 10 m to 185 m thick; overlying
- Up to approximately 400 m thickness of competent glacial and pre-glacial soils; overlying
- Bedrock.

4.2 Previous Geotechnical Investigations

A review of available geotechnical reports in the vicinity of the Sites was carried out as summarized below.

Golder 1980 and 2000

Golder previously carried out two separate geotechnical investigations on the north east side of Westham Island approximately 2.5 m from the Site. The purpose of the investigations was to determine the soil conditions at the respective sites and to provide geotechnical recommendations for the design and construction of proposed flood boxes. In the 1980 investigation, one augerhole was put down to a depth of approximately 19 m below ground surface with standard penetration tests carried out during drilling to assess the relative densities of the soils at the site. In the 2000 investigation, two augerholes and two dynamic cone penetration tests were put down to depths of 6 m below the existing ground surface.

Golder 2009-2011

Golder previously carried out a geotechnical investigation approximately 3.5 km southeast of the Site. The investigation included a total of four test pits, four auger holes, one seismic cone penetration test and one cone penetration test. Standpipe piezometers were installed in selected augerholes. In addition, a test fill embankment was constructed and monitored over six months at site. The test fill included the installation and monitoring of 20 settlement gauges and comprised two zones as follows:

- A lower fill embankment constructed to approximately 1.5 m to 2 m above original site grade, measuring approximately 200 m by 100 m in plan; and
- A higher (upper) fill embankment constructed to approximately 4.5 m to 5 m above original site grade, measuring 50 m by 50 m.

Golder 2010-2011

Golder carried out a number of field investigation programs during 2010 and 2011 as part of the Terminal 2 and DTRRIP projects. These included a number of CPTs and sampling holes using mud rotary and sonic drilling techniques located along Deltaport Way some 2 km southeast of the project site. The results show between 60 to 80 m of interbeded sand and silt underlain by a clay deposit estimated to be 20 to 60 m in thickness, underlain by glacial till.

4.3 Aerial Photographs

A review of available historical air photographs from 1963 to 2013 indicated the following:

- There appears to be little to no development at the site. The site appears to have comprised a marsh bench since the earliest available aerial photograph and this appears not to have been disturbed throughout recent history;

- Use of the immediately adjacent upslope land appears to have been limited to agriculture since 1963 (the first available historical aerial photograph);
- The perimeter dyke to Westham Island may have been present in 1963; and
- Any changes to the configuration of the sand flats are most likely due to accretion or erosion within the littoral zone.

5.0 SUBSURFACE CONDITIONS

A summary of inferred stratigraphic units based on the references presented in 4.2 is presented herein. The summary is not intended to represent a site-specific, detailed or comprehensive description of the subsurface conditions. Given the considerable distance of the closest available information, significant variation should be anticipated. The generalized subsurface conditions at the nearby sites comprised:

- Fill up to about 1.7 m thick at the dyke flood box sites;
- Sandy to clayey silt up to approximately 3.0 m thick; overlying
- Sand and silty sand strata approximately 40 m to 80 m thick; inferred to be underlain by
- Silty clay to clay sequence extending to depths of approximately 100 m.

5.1 Silt

Silt layers, varying from clayey silt to silt with some sand, were encountered beneath surficial fill at our previous investigations and extended to depths of approximately 2 - 5 m below ground surface. The unit generally comprised soft clayey silt transitioning to loose to compact silt with depth.

CPT Tip resistance values measured in this layer were typically about 4 bars and generally less than 10 bars, indicating that the consistency of this deposit is generally loose or soft. CPT friction ratio values were generally in the order of 1.5 to 3.5 percent, indicating a primarily fine-grained, cohesive soil unit.

5.2 Interlayered Sand and Silty Sand

The loose to compact silt strata are underlain by fine to medium sand containing some silt. The upper boundary of this layer was encountered in our previous investigations at depths ranging from about 2.5 m to 9.0 m below ground surface. The stratum generally consists of an upper, more uniform sand deposit extending to 12 to 17 metres below ground surface, overlying interlayered deposits of sand and silty sand. All of Golder's augerholes and CPTs put down during our previous investigations were terminated within this sequence (greater than 39.7 m below ground surface in our 2009 investigation) and it is anticipated that this sequence extends to approximately 50 m or more below ground surface.

CPT tip resistance values measured within this layer were observed to vary significantly within this sequence, varying from approximately 50 to greater than 200 bars, indicating a loose to compact relative density.

5.3 Marine Deposits

An extensive sequence of compressible marine deposits comprising silty clay to clay with occasional interlayers and interbeds of sand, sandy silt strata is inferred to underlie the silt and sand sequences described above. Published surficial geology information and deep borehole data obtained at adjoining sites indicates that this sequence extends to depths in the order of 100 m below ground surface, and is underlain by competent Pleistocene deposits including glacial till soils.

6.0 GEOTECHNICAL CONSIDERATIONS

The following briefly summarizes significant geotechnical design and construction considerations for the proposed habitat compensation structures:

- The subgrade soils comprise of an extensive sequence of deltaic and estuarine deposits that are inferred to extend to depths in the order of 100 m below ground surface. These soils include weak and moderately compressible, near-surface silt to clayey silt deposits, extensive loose to compact sand deposits and an interlayered sequence of silt, sand and clayey silt soils;
- Development will require the placement of permanent grade fills to an elevation of about 0.3 m, requiring about 1 m of fill over a broad area but up to approximately 3.3 m to fill in the existing drainage channel. The placement of this fill will cause consolidation of the underlying fine-grained subgrade soils;
- Sequencing should consider specifying limitations on the thickness of fill placed in any single lift; each lift placement should be separated from the next by a waiting period to allow strength gain and dissipation of pore water pressures in the underlying deposits;
- There may be difficulties in controlling the nature of the fill placement due to constraints associated with dredging and submerged fill placement; and
- The low-plastic silt and extensive loose sand deposits are susceptible to soil liquefaction during intermediate to strong seismic (earthquake) levels of shaking, which will result in loss of soil strength.

6.1 Settlement Assessment

As described in Section 4.2.4, a test fill embankment was constructed at a project 3.5 km from this Site. Settlement measured at gauges installed within a fill embankment indicated the following order of magnitude of settlement:

- 1.5 to 2 m fill thickness: approximately 50 to 150 mm over the first 6 month period with an additional 25 mm over the following 18 month period; and
- 4.5 to 5 m fill thickness: approximately 60 to 250 mm over the same 6 month period with an additional 25 mm over the following 18 month period.

Settlement in the order of 50 to 200 mm could be expected to occur during the construction period with secondary consolidation of about 50 mm to 300 mm could occur over the design life of the habitat embankment (assumed at 25 years).

6.2 Staged Fill and Placement Sequencing

For initial planning purposes, we have assumed that the habitat compensation structure will be constructed in a staged loading sequence to allow sequential strength gain of the underlying compressible soils. Stage loading produces sequential gains of strength in the soft soils. A waiting period between lifts should be observed to allow dissipation of excess pore pressures induced by the fill, and to avoid overstressing the underlying highly compressible fine-grained soils.

Staging of fill placement should consider placement in stages no thicker than about 0.5 m. Placement of fill in an uncontrolled manner (without staging) may result in failure of the underlying soils resulting in lateral movements at and beyond the toe of the fill affecting construction.

The planning of the construction should consider fill placement within the deepest part of the habitat banking first. This will allow the majority of the settlement to occur during construction and final grading operations to accommodate settlement can be carried out prior to the Contractor demobilizing from site.

6.3 Construction

Golder understands that consideration is being given to hydraulic placement of dredged material at Westham Island. Hydraulic dredging method entails excavating material from a submerged borrow area and pumping a slurry of suspended sediments and water through a pipeline to the fill site. The slurry is typically about 70-80% water, so the discharged material will tend to run, resulting in a mild residual beach slope.

The side slope achievable in berm construction is mainly a factor of grain size and sediment density, but the compaction of material, dredging and placement method, and currents during placement also determine the final slope. Based on the cross sections provided; it appears the work will comprise placement of only veneer of fill at the sloping section. Consideration should be given to constructing the rip rap berm first prior to fill placement at the side slopes. This will make it easier to maintain the design grades and minimize material losses from various littoral processes.

6.4 Suitability of Dredge Materials as Reclamation Fill

Generally, dredged and placed sand with less than 10% to 15% of fines is considered suitable as engineering fill. Sand meeting this criterion is a better reclamation material for the following reasons:

- It's easier to handle;
- Drainage is good and consolidation occurs quickly;

- The reclaimed land has a higher bearing capacity;
- The long-term settlements occurring within the reclaimed soils are small.

Dredged and placed sand with fines content greater than 15% could still be usable, but longer consolidation/settling times could be expected. It is anticipated that in-situ silty sands and sandy silts will lose some amount of fines during the dredging and reclamation processes followed for site development by the dredging contractor.

The amount of fines existing within the seabed deposits will be altered during the dredging and reclamation processes as the soil particles segregate during transportation and deposition into the reclamation cells. Determining the actual amount of fines that would remain in place within the reclamation area following dredging, pumping and placement of the dredgeate depends on how the reclamation work is staged and carried out and contractor's methodology, all of which are unknown at the time of preparation of this report.

6.5 Impact on Adjacent Dyke

The proposed fill thickness appears relatively small in the area where the habitat bank encroaches closest to (within 32 m of) the existing dyke. Significant fill thickness (in the drainage channel) is in an area offset some 70 m away from the existing dyke. Considering the balance between fill thickness and offset from the dyke, the proposed construction is not anticipated to impact the existing Westham Island Dyke. The assumptions on fill thickness should be verified with cross-sections cut at the eastern end of the habitat site.

7.0 CLOSURE

We trust that the information presented in this report is sufficient for your immediate requirements. Should you have any questions or require further information, please feel free to contact us.

Yours truly,

GOLDER ASSOCIATES LTD.

ORIGINAL SIGNED

ORIGINAL SIGNED

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KMN/JIP

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LEGEND

- PROPOSED SITE (APPROXIMATE LOCATION)
- EXPRESSWAY
- MAJOR ROAD
- LOCAL ROAD
- RAILROAD

1 0 1

SCALE 1:50,000 KILOMETRES

PROJECT

MOFFATT & NICHOL
HABITAT COMPENSATION
WESTHAM ISLAND

TITLE

KEY PLAN

REFERENCE

TRANSPORTATION FEATURES OBTAINED FROM THE PROVINCE OF BRITISH COLUMBIA.
IMAGERY OBTAINED FROM BING MAPS FOR ARCGIS PUBLISHED BY MICROSOFT CORPORATION, REDMOND, WA, APRIL 2013.
INSET DATA OBTAINED FROM E.S.R.I.
DATUM: NAD83 PROJECTION: UTM ZONE 10

Golder Associates

PROJECT		13-1447-0047	FILE No.	
DESIGN	KMN	18 Apr. 2013	SCALE AS SHOWN	REV. 0
GIS	DSC	19 Apr. 2013		
CHECK			**FIGURE: 1**	
REVIEW				

N:\Bur-Graphics\Projects\2013\1447\13-1447-0047\GIS\Mapping\MXD\General\Figure-1_Key_PlanC.mxd

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