Existing Ecological Conditions
Proposed Tsawwassen Eelgrass Enhancement Project

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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**).

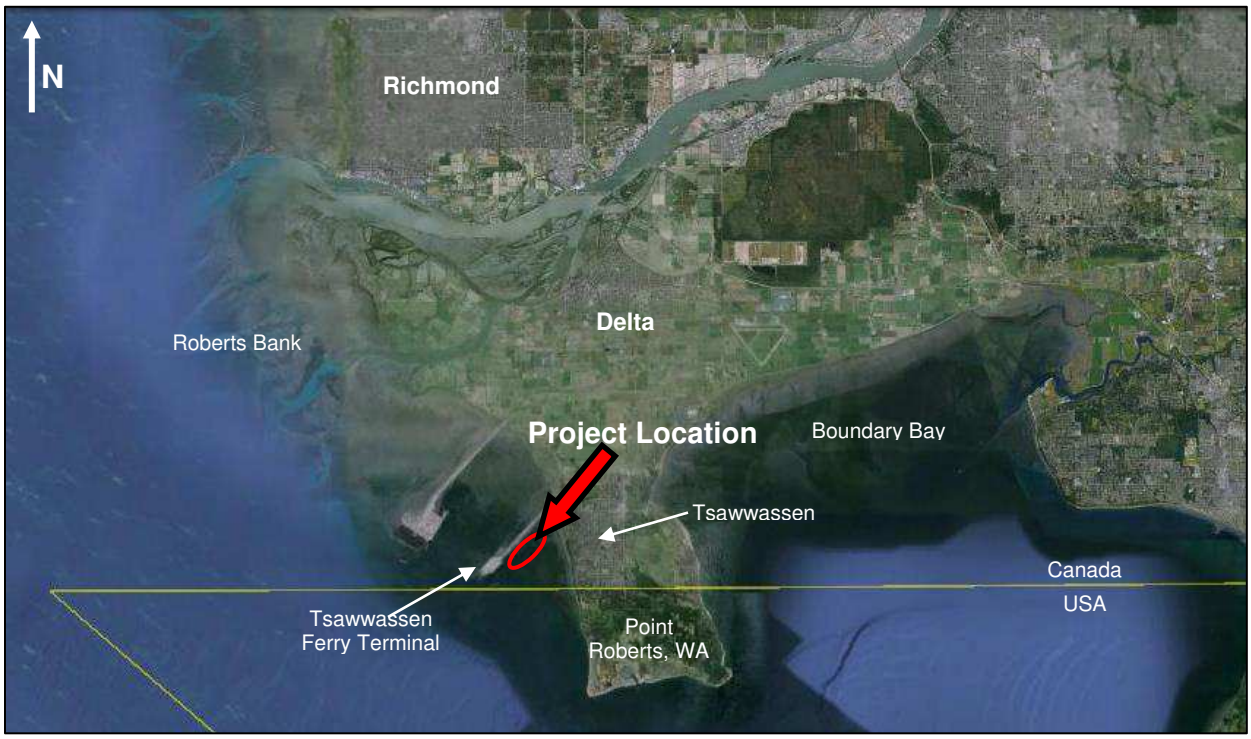


Figure 1 Tsawwassen Eelgrass Project – Regional Setting (Google Earth Maps)

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).

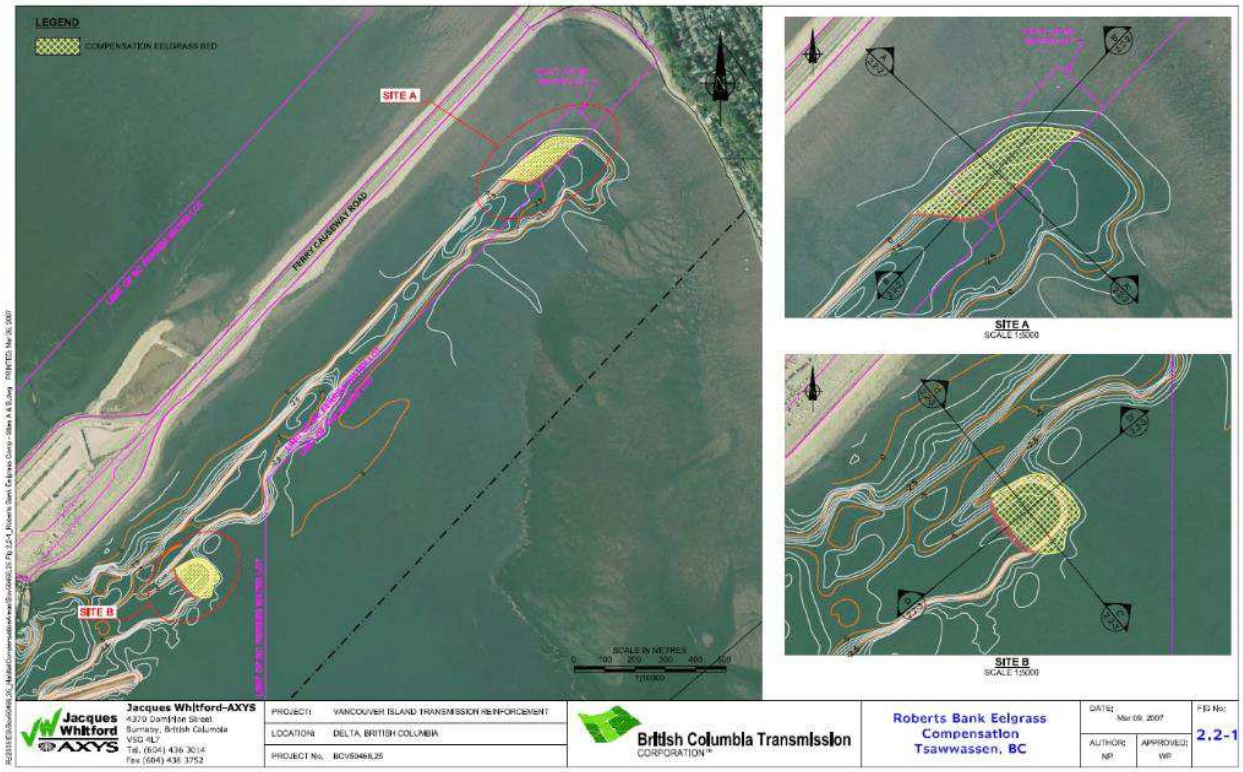


Figure 3 BCTC Eelgrass Compensation Sites near the Proposed Tsawwassen Eelgrass Enhancement Sites

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.

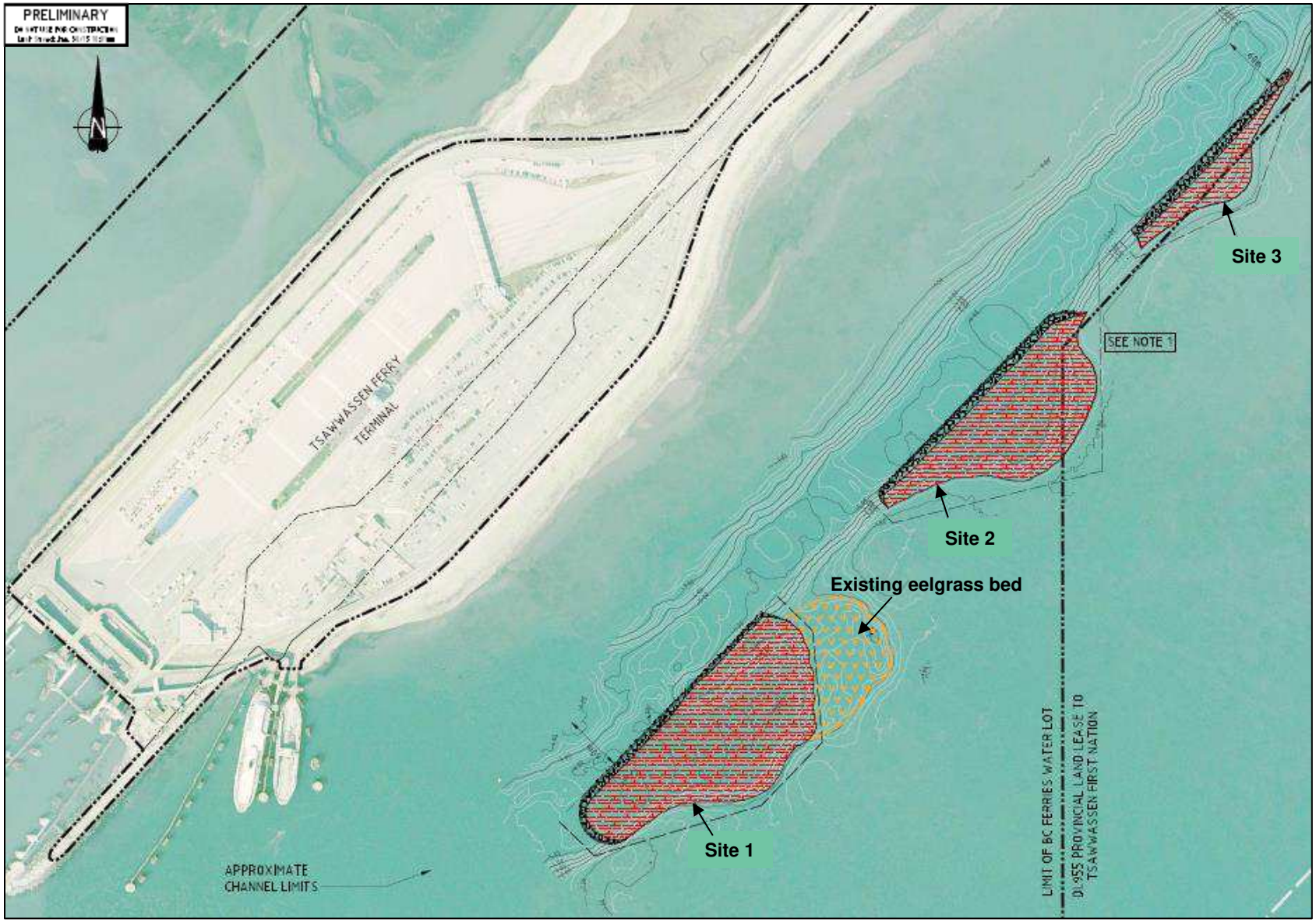


Figure 4 Proposed Tsawwassen Eelgrass Project sites (Moffatt & Nichol 2015)

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).

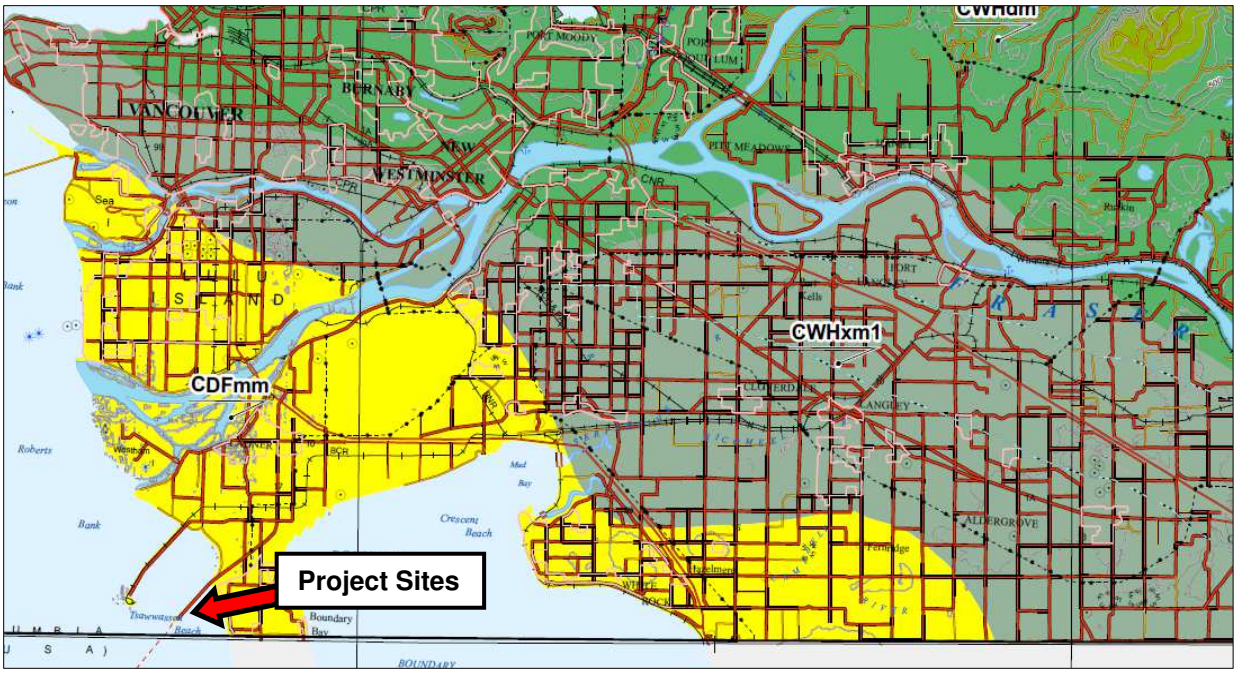


Figure 5 Biogeoclimatic Subzones of Metro Vancouver with Project Location (Government of B.C. 2012)

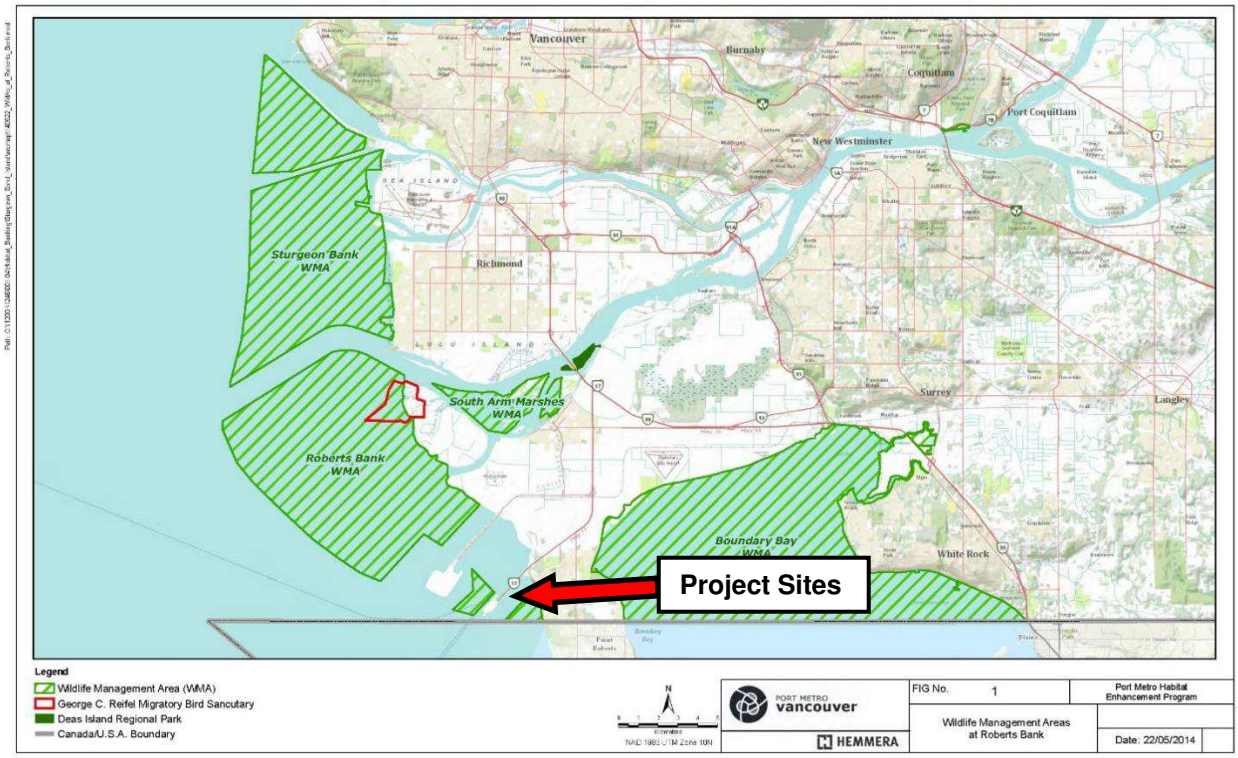


Figure 6 Roberts Bank Wildlife Management Area in Relation to the Proposed Project

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

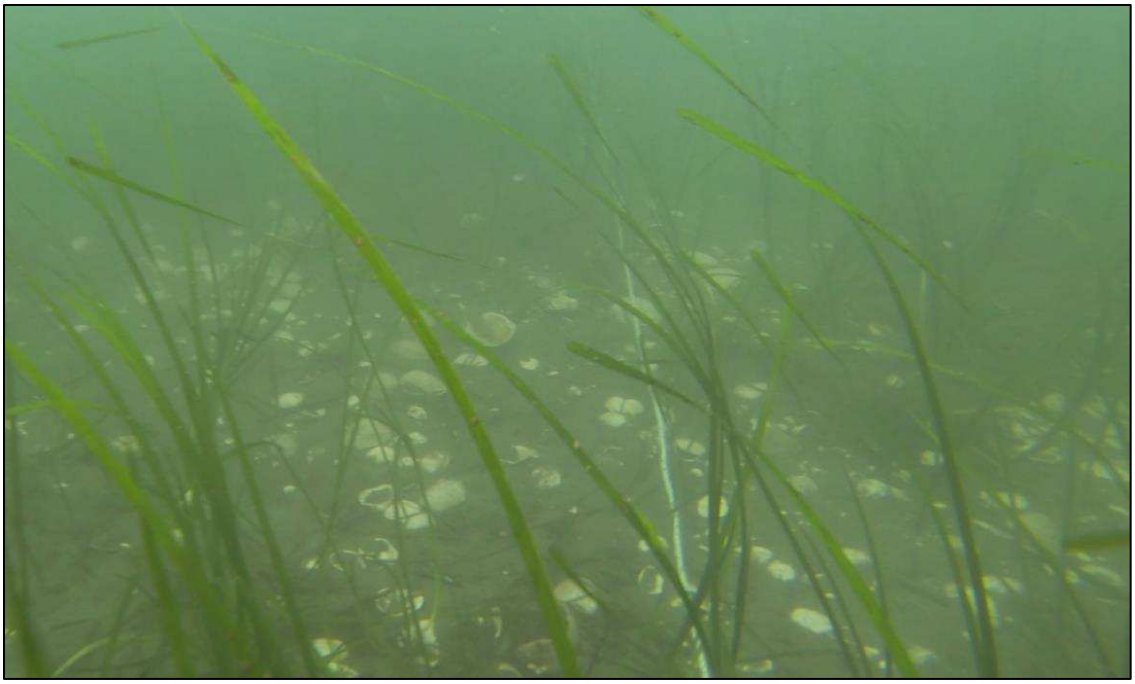


Photo 2 Eelgrass with Shells on Sandy Bottom Substrate Adjacent to Proposed Site 3

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:

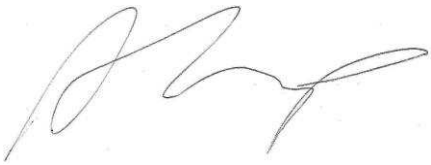
- Increasing primary productivity;
- Supplementing the detritus based food web;
- Creating intertidal habitat for benthic and drift invertebrates that are important prey items for juvenile salmonids and other fishes;
- Providing intertidal and subtidal vegetation cover and refuge for juvenile salmonids 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.

Report prepared by:
Hemmera Envirochem Inc.

Mikaela Davis, M.Sc.
Project Biologist

Report peer reviewed by:
Hemmera Envirochem Inc.



Scott Northrup, R.P.Bio., P.Biol., EP
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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

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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.

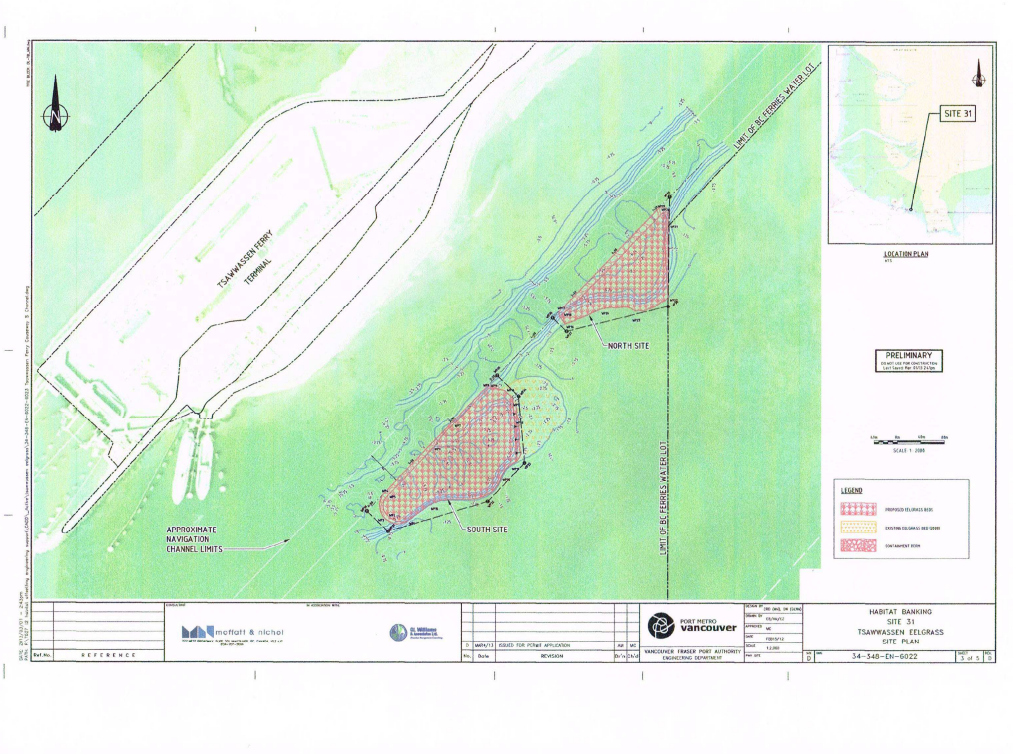

FIGURE 1. THE SITES AT TSAWWASSEN THAT COULD BE MODIFIED TO SUPPORT EELGRASS.

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

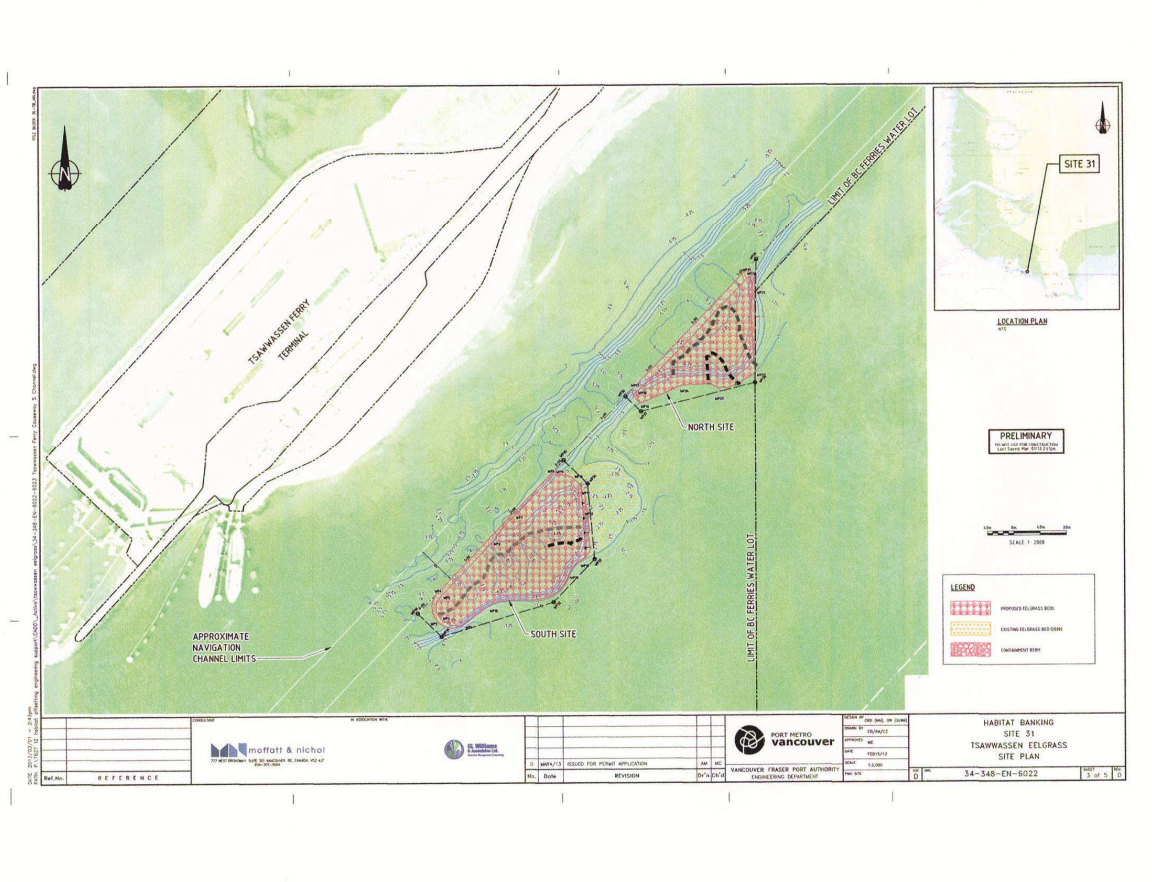

Figure 1-1. The paths followed by the divers are represented by dashed lines. The graphic representation is based on the GPS waypoints and by comparing recorded diver depths with the chart.

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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Vancouver, BC V6C 3T4

Prepared by:
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File: 302-035.04
February 2015

HEMMERA | 20 YEARS 1994 – 2014

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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

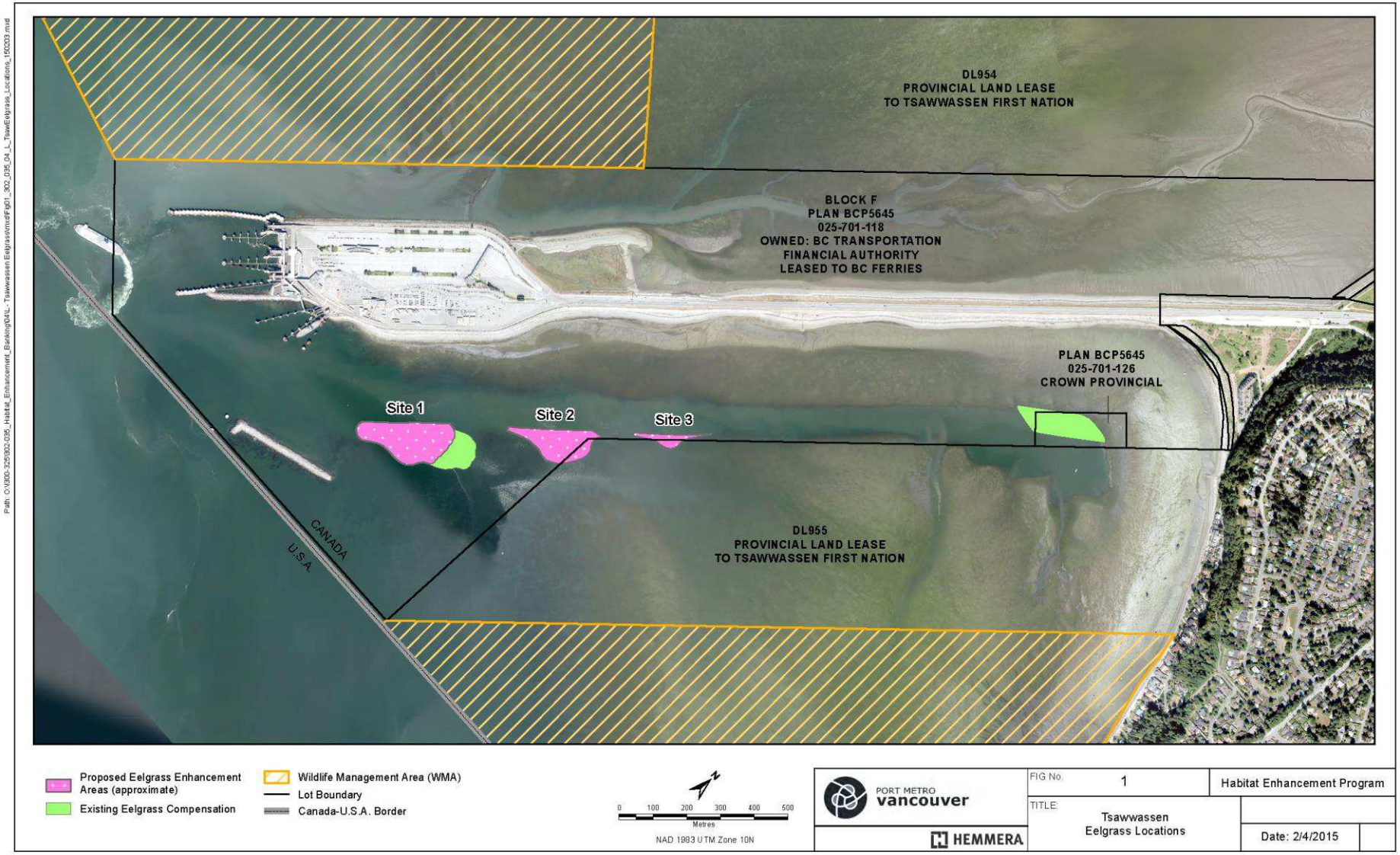
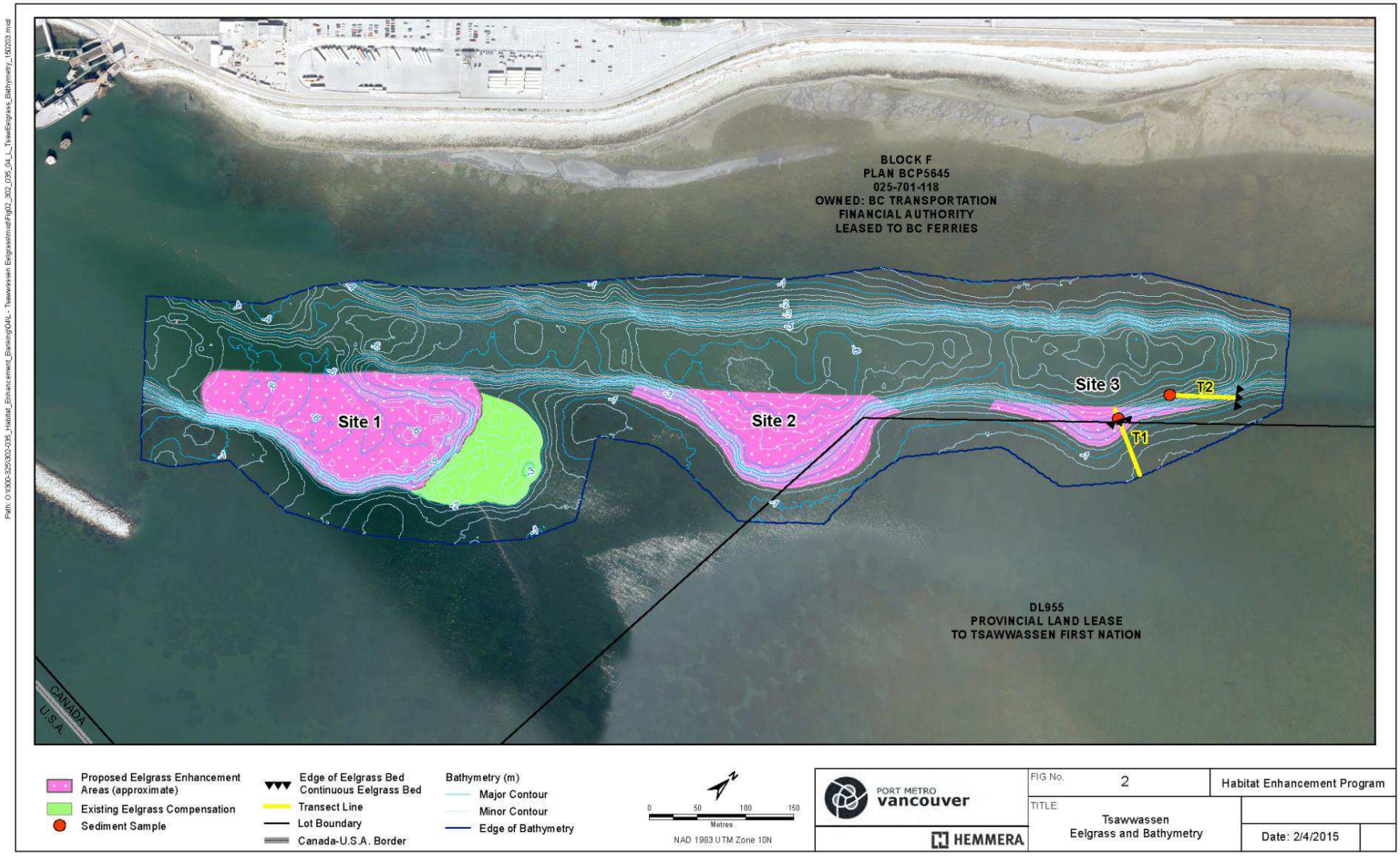


Figure 2 Tsawwassen eelgrass transplant candidate sites 1, 2 and 3 with December 2014 bathymetry overlay and January 7th 2015 dive transects



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.

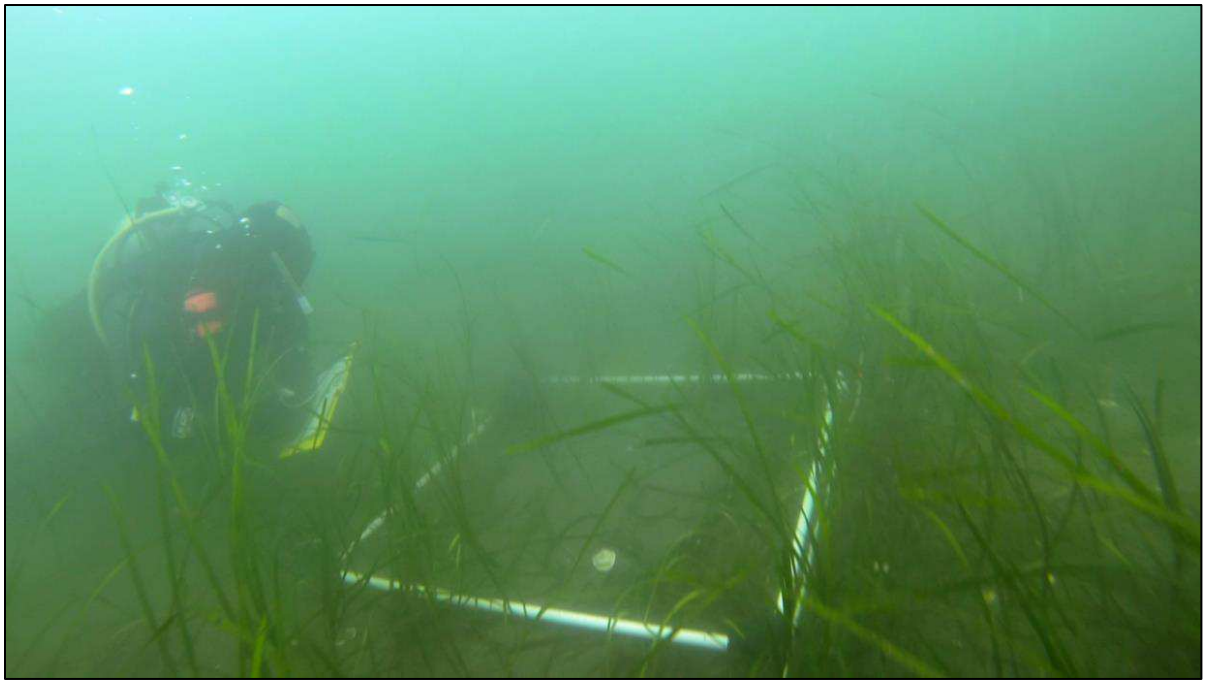


Photo 1 Quadrat (1.0 m2) used to sample eelgrass and substrate conditions January 7th, 2015.

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.

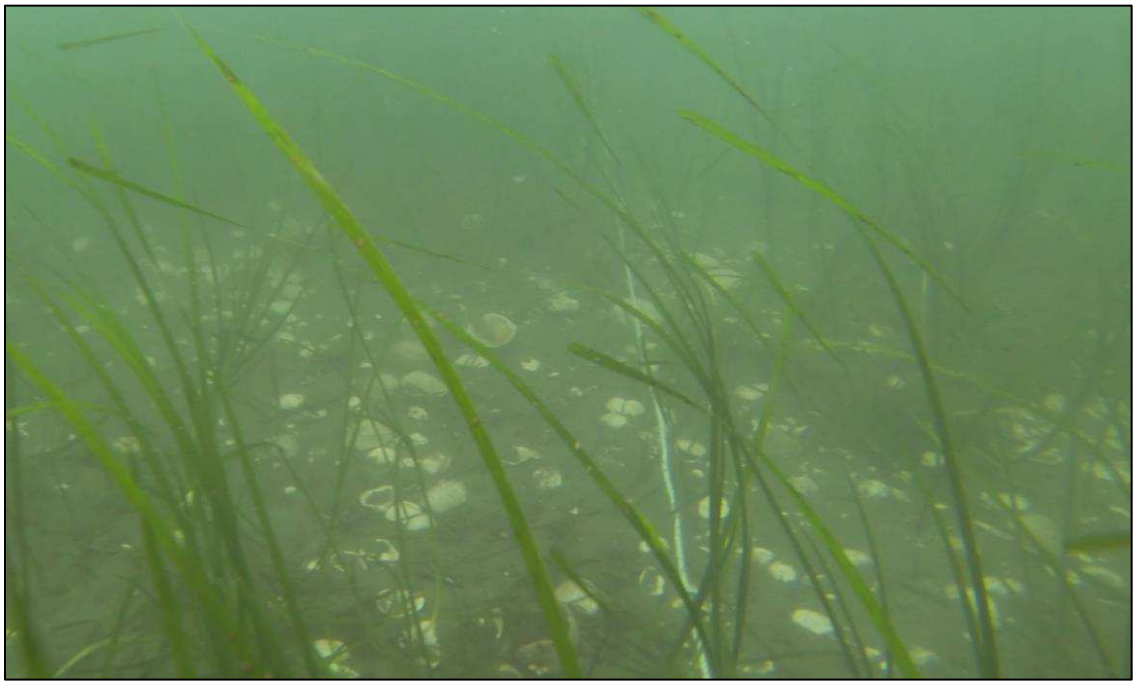


Photo 3 Eelgrass with shells on sandy bottom substrate along Transect 1, Jan. 07 2015, dive 1.

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.

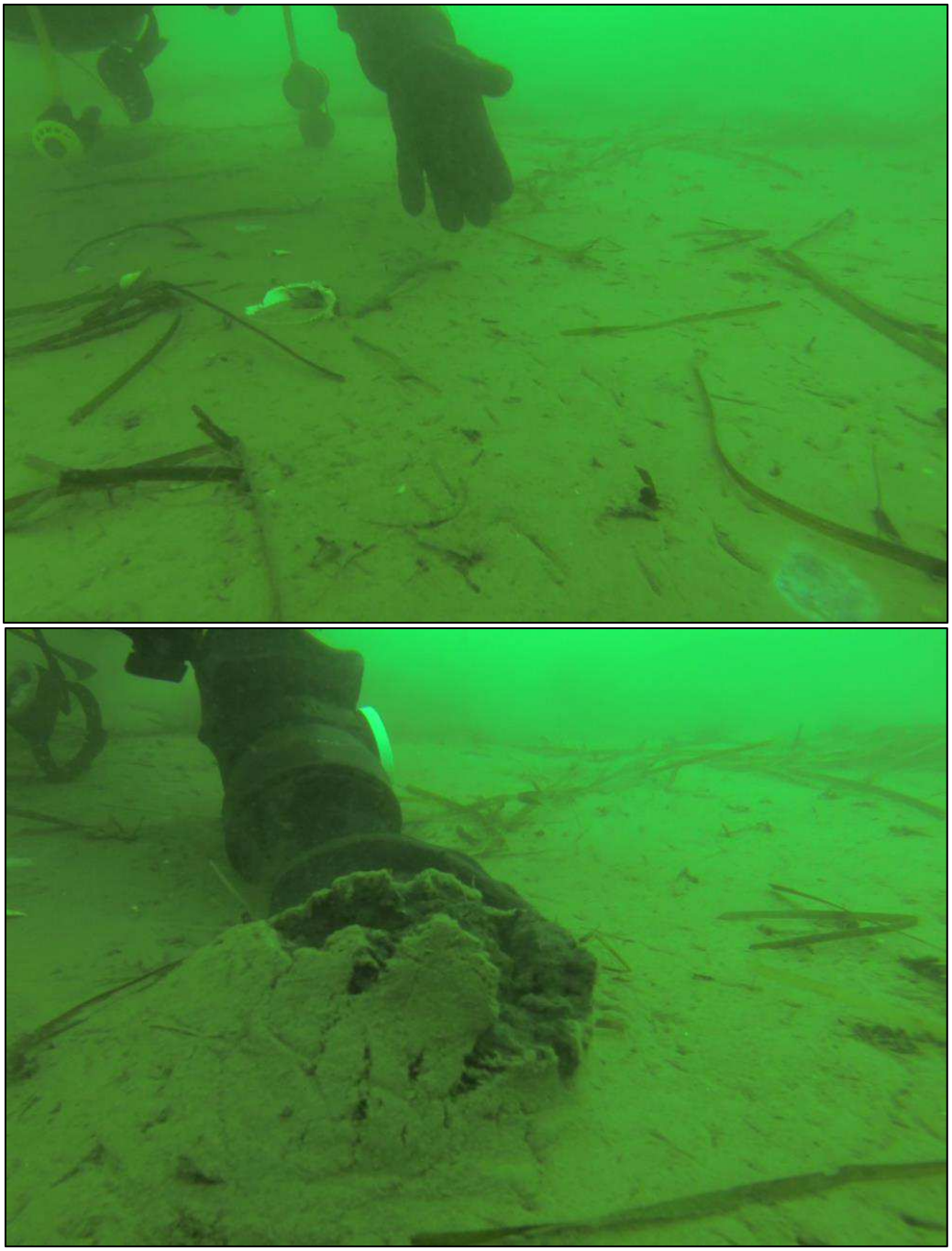


Photo 4 Sediment with dark hypoxic layer underneath, Transect 1, Jan. 07 2015, dive 1.

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**).

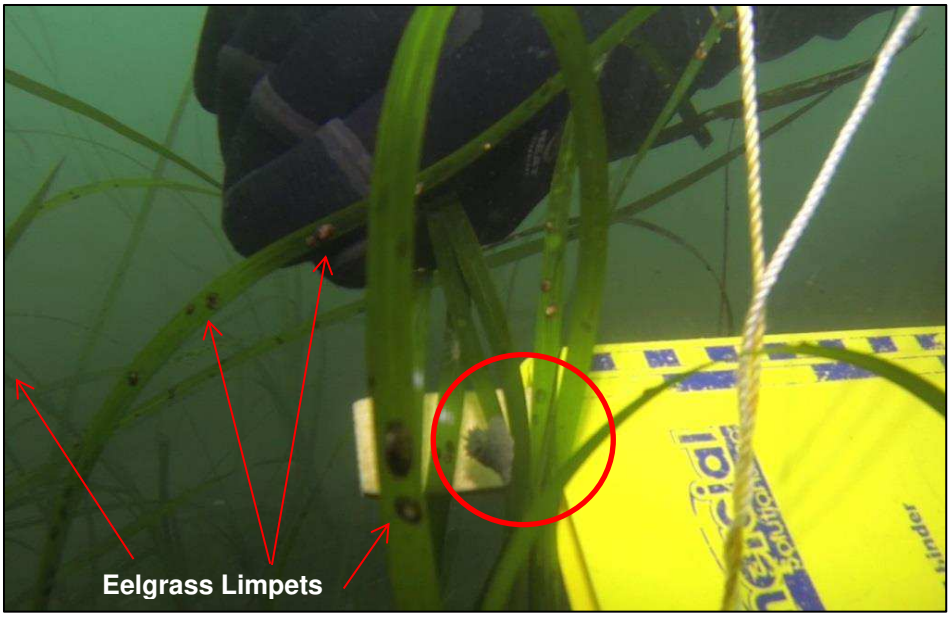


Photo 5 Eelgrass limpets and anemone on eelgrass blades, Transect 1, Jan. 07 2015, dive 1.

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

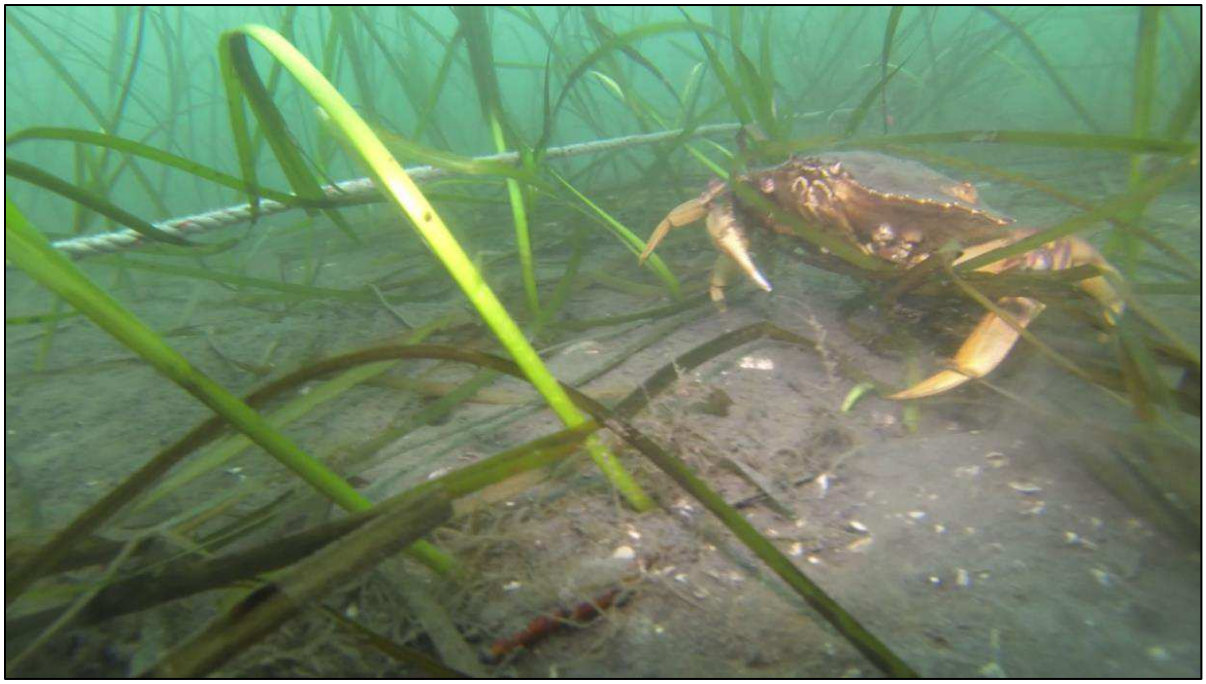


Photo 7 Adult Dungeness crab in eelgrass bed along Transect 1, Jan. 07 2015, dive 1.

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.

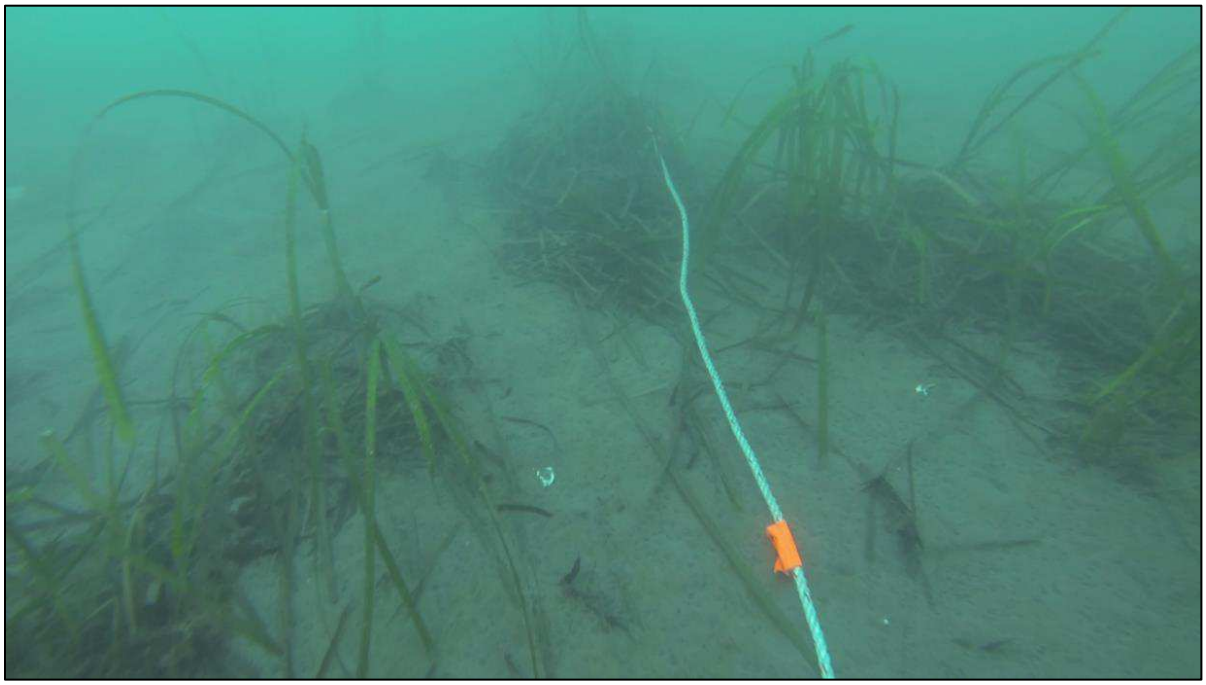


Photo 11 Edge of continuous eelgrass bed, Transect 2, Jan. 07 2015, dive 2.

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.

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7.0 REFERENCES CITED

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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

Maxxam
A Bureau Veritas Group Company

Success Through Science®

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 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

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
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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.

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

CHAIN OF CUSTODY RECORD

COC #: 150109 DIVESED

BBY FCD-00077/05
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 #:	1	☐ 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 4111	Project #:		Rush TAT (Surcharges will be applied)
Phone:	cc:Percy.Hui@portmetrovancouver.com and Michelle Duffy at michelle.duffy@worleyparsons.com. A follow-up hard copy is not necessary	Phone:	~~labdata~~ labdata@hemmera.com	Site Location:	SE of tsawwassen ferry causeway	☐ Same Day ☐ 2 Days ☐ 1 Day ☒ 3 Days
Email:		Email:	tabercrombie@hemmera.com	Site #:		Date Required:
				Sampled By:	Tim Abercrombie and Jamie Slogan	Rush Confirmation #:

Regulatory Criteria		Special Instructions
☐ BC CSR Soil	☐ BC CSR Water	Analysis: % sand, %silt, % clay, no flocculation
☐ CCME (Specify)	☐ Other (Specify)	*note: empty spare bottles also in cooler*
☐ Drinking Water	☐ BC Water Quality	

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

Analysis Requested

	Sample Identification	Lab Identification	Date Sampled (YYYY/MM/DD)	Time Sampled (HH:MM)	Matrix	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 ☐	Particle Size Distribution				# OF CONTAINERS SUBMITTED	HOLD - DO NOT ANALYZE	COMMENTS
1	TSW Eelgrass ST3 A	LM 3729	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

LABORATORY USE ONLY

CUSTODY SEAL Y / N		COOLER TEMPERATURES
Present	Intact	
		10.11.10

COOLING MEDIA PRESENT Y / N

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