IR2020-2.2 Avoidance and Mitigation Measures for Project Construction – Juvenile Salmon

Background

In his letter of August 24, 2020, the minister of environment and climate change (the minister) requested the Vancouver Fraser Port Authority (the port authority) provide additional information regarding operational measures and design options that could avoid or reduce habitat loss and potential disruption of juvenile salmon migration.

After the public hearing, the port authority committed to the following design-related mitigation measures applicable to avoiding or reducing effects to juvenile salmon from habitat loss:[1]

- Designing the project within the footprint defined in the project construction update,[2] which includes the following:
    - Placement of the marine terminal in predominantly subtidal waters, thereby reducing direct footprint effects on intertidal habitats, such as intertidal marsh and eelgrass, that provide food and refuge opportunities to migrating juvenile salmon[3]
    - Optimized footprint of the tug basin to promote drainage during tidal exchanges in order to maintain good water quality in this localized area of the inter-causeway area and reduce potential effects on rearing juvenile salmon
- Designing the project such that the causeway widening has a reduced footprint,[4] to reduce overlap with eelgrass habitat in the lower intertidal zone and marsh habitat in the upper intertidal zone important for juvenile salmon rearing
- Designing and constructing the project to reduce the effects of channel formation during dyke construction,[5] to reduce temporary disturbance to intertidal zone habitat important for juvenile salmon rearing

The port authority proposed mitigation of effects to juvenile salmon from a potential disruption to juvenile salmon migration through the following measures:

- Reducing excess artificial lighting during project operation[6] as outlined in the Light Management Plan[7] to reduce disruption to juvenile salmon migration that could potentially result from project-related changes in

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[1] CIAR Document #2001 From the Vancouver Fraser Port Authority to the Review Panel re: Updated Project Commitments. https://iaac-aeic.gc.ca/050/documents/p80054/130776E.pdf
[2] CIAR Document #1210 From the Vancouver Fraser Port Authority to the Review Panel re: Project Construction Update. https://iaac-aeic.gc.ca/050/documents/p80054/122934E.pdf; CIAR Document #2001, commitment #3
[3] The location and configuration of the marine terminal in subtidal waters is predicted to create a wave shadow effect immediately north of the terminal where physical conditions are predicted to become conducive to increases in prey (macrofauna) and rearing habitat (native eelgrass) for juvenile salmon.
[4] CIAR Document #2001, commitment #4
[5] CIAR Document #2001, commitment #5
[6] Other sub-plans that will be implemented as part of the Operation Environmental Management Plan (described in CIAR Document #2001) that are applicable to the marine environment and hence will benefit juvenile salmon include Light Management Plan, Water Quality Management Plan, Environmental Training Plan, Waste and Hazardous Materials Management Plan, and Spill Preparedness and Response Plan (commitment #16).
[7] CIAR Document #2001, commitment #24

the light environment and changes in habitat availability (through placement of the proposed marine terminal in deeper waters). The port authority has committed to implementing a follow-up program (FUP) element to monitor the effectiveness of lighting mitigation measures[8]

- Creating onsite offsetting habitats[9] in the form of native eelgrass transplants and reconstructed tidal marsh, which will increase food supply and refuge for juvenile salmon and enhance their productivity

With the above mitigation, including offsetting, changes in juvenile salmon productivity from potential project-related disruption to migration and light-related effects were determined in the environmental impact statement (EIS) as negligible.

The port authority has proposed a FUP element for juvenile salmon to verify assessment predictions by evaluating potential changes in density and distribution of juvenile salmon.[10] Monitoring studies to support the juvenile salmon FUP element commenced in 2020 and will be ongoing prior to and following project construction.

The port authority acknowledges that Indigenous groups and regulators have continued to express concerns with respect to potential effects of the project on juvenile salmon migration. Since the public hearing, the port authority has undertaken additional work to further avoid, reduce, or offset potential project-related effects to juvenile salmon, including the following:

- Identifying and evaluating the potential for additional footprint reductions for the marine terminal and widened causeway to reduce project-related effects to productive juvenile salmon habitat in the intertidal zone (in addition to the previous commitments to locate the marine terminal in predominantly subtidal waters and optimize the widened causeway footprint, as reflected in reference concept design[11]). These reductions are summarized **IR2020-2.1**.
- Expanding the offsetting program. The port authority is currently advancing up to 86 hectares (ha) of conventional offsetting habitat, including marsh and eelgrass, for the project. All potential offsetting measures being considered to offset project-related effects to juvenile salmon are described in **IR2020-1.1**.
- Identifying and evaluating additional operational mitigation measures, including design changes such as a breach and habitat complexing, that could reduce effects to juvenile salmon productivity from potential disruption to migration during project operation. These potential measures will be the subject of ongoing consultation with Indigenous groups and engagement with appropriate regulatory agencies and stakeholders (including the Province of British Columbia, BC Rail, and terminal operators). The potential for each measure to mitigate the potential harm to juvenile salmon is discussed in the response below.
- Adding measures to reduce operational underwater noise as presented in **IR2020-3** and described in the response below.
- Reviewing and explaining how residual effects of the project on fish, including juvenile salmon, and fish habitat, will be fully offset by the measures proposed. The net gain in juvenile salmon productivity, considering avoidance, reduction, and offsetting mitigation measures is presented in **IR2020-1.2**.

The response below provides the information requested by the minister regarding juvenile salmon operational and design mitigation. The work done to develop this information was guided by information provided to the port authority in consultation with Indigenous groups and engagement with regulators. In addition to providing descriptions of measures, implications for juvenile salmon productivity are described.

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[8] CIAR Document #2001, commitment #81, C20
[9] CIAR Document #2001, commitment #41.
[10] CIAR Document #2001, commitment #81, C9
[11] Described in the CIAR Document #181 and updates provided in CIAR Document #1210.

Response

Minister's request: Provide any additional operational mitigations (e.g. lighting or noise) or terminal and causeway design options (e.g. breaches) that could avoid or mitigate habitat loss and potential disruption of juvenile salmon migration that would be caused by the proposed Project.

In response to the minister's request, the port authority has evaluated additional operational mitigation measures and terminal and causeway design changes to determine whether there are feasible measures that would further mitigate both i) project-related habitat loss and ii) potential disruption of juvenile salmon migration. Project footprint optimizations to reduce potential juvenile salmon habitat loss, along with associated predicted benefits to juvenile salmon productivity, are described in **IR2020-2.1**. Habitat offsetting measures to further offset juvenile salmon habitat loss and their associated predicted benefits to juvenile salmon productivity are described in **IR2020-1.1** and **IR2020-1.2**, respectively.

The response provided below describes additional design and operational measures to reduce the potential disruption of juvenile salmon migration from the project. The response is provided in two sections:

- The first section describes marine terminal and widened causeway design changes that could reduce potential project-related disruption to juvenile salmon migration. The changes include the installation of a breach and complexing of the west marine terminal perimeter with refuge habitat specific to juvenile salmon.
- The second section describes additional mitigation measures that could be implemented during project operation to reduce the potential for effects to juvenile salmon migration from lighting and underwater noise.

Each section provides a description of how the measures could reduce project-related effects on juvenile salmon.

Consultation with Indigenous groups on design changes and operational mitigation measures outlined in **IR2020-2.2** was undertaken in a phased approach with sharing of response approach, early concepts, and then draft response review. Input from Indigenous groups has been received and is reflected in this response (the full consultation process is described in **IR2020-6**).

Potential project design changes to reduce the potential for disruption of juvenile salmon migration

In addition to further optimizing the project footprint to reduce juvenile salmon habitat loss as described in **IR2020-2.1**, the port authority considered the following potential design changes, as requested by the minister:

- A breach located at the east end of the proposed Roberts Bank Terminal 2 (RBT2) marine terminal or along the Roberts Bank causeway, installed through both existing and proposed RBT2 widened areas
- Juvenile salmon refuge habitat on the west side of the marine terminal perimeter

The evaluation of each potential project design change is described below.

The potential project-related disruption of juvenile salmon migration

To better understand the effectiveness of potential measures to reduce the project's potential to disrupt juvenile salmon migration and to provide context to understand how the additional design changes could mitigate any potential disruption, information on the distribution of juvenile salmon at Roberts Bank, including factors that influence this distribution, is provided here (previously detailed in the EIS).

As described in the port authority's closing remarks following the public hearing,[12] placement of the marine terminal in deeper waters has the potential to disrupt juvenile salmon migration by increasing the shoreline distance that juvenile salmon would have to swim from the intertidal flats north of the Roberts Bank causeway to access rearing habitats in the inter-causeway area. Before mitigation, disruption to migration was predicted (qualitatively) to result in a minor effect (i.e., 6% to 30%) on juvenile salmon productivity (see also response to IR5-18[13]). The assessment reported in the EIS accounts for empirical and literature information indicating that juvenile salmon movements in the estuary are influenced by environmental factors (such as tidal exchange, salinity, water temperature), as well as behavioural factors (such as the motivation of a juvenile salmon to access quality habitats, seek food or refuge).[14] Aided by the tides, juvenile salmon access productive habitats in the intertidal zone when the flats are inundated during flood tides. When the tidal flats are dry during ebb tides, juvenile salmon use turbid subtidal waters (influenced by the Fraser River plume) to seek refuge from visual predators.

Since the public hearing, additional analysis has been undertaken using modelling technology that was not available at the time of EIS submission. This has enabled the port authority to quantify potential effects on juvenile salmon productivity from a potential disruption to migration (**Appendix IR2020-2.2-E**). This quantitative analysis confirms that the effect (without taking mitigation into account) would be minor. Project-related disruption of juvenile Chinook salmon migration could reduce their use of the inter-causeway area by disrupting migration of those juvenile salmon individuals that would have reached the inter-causeway area without the project in place. The effect predicted by modelling is equivalent to a disruption of approximately 7% to 14% of the inter-causeway area proportion of juvenile Chinook salmon abundance that would have reached the inter-causeway area without the project in place, or approximately 2 to 4 kilograms per year (35 to 70 juvenile salmon per day[15]). However, this disruption and apparent effect is unlikely to result in a loss of Chinook salmon productivity because those individuals diverted from the inter-causeway area will either remain north of the causeway, where they will benefit from the increased productivity in new offset habitats and increases with the project in native eelgrass and intertidal marsh forecasted by the ecosystem model, and/or they will migrate and successfully rear in offshore and other nearshore habitats in the estuary. Juvenile salmon diverted offshore will occupy the same offshore habitats and experience the same offshore predation risk as do all juvenile Chinook salmon when they migrate offshore currently.

As demonstrated in the EIS, onsite offsetting habitat development, in the form of native eelgrass transplants and intertidal marsh, would offset a minor reduction on juvenile salmon productivity from potential project-related disruption to migration. Furthermore, the location and configuration of the marine terminal in subtidal waters will create a wave shadow immediately north of the terminal leading to physical conditions becoming conducive to increases in prey (macrofauna) and rearing habitat (native eelgrass) for juvenile salmon.

The EIS concluded that with mitigation, including offsetting, the effect on juvenile salmon productivity from potential project-related disruption to migration would be negligible. The port authority also indicated that it would continue to refine the conceptual offsetting plan by focusing on priority species, such as Chinook salmon, and priority habitats.[16]

In addition, since the public hearing, and in recognition of the continued concerns of Indigenous groups and regulators with respect to potential effects of the project on juvenile salmon, the port authority has increased the

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[12] CIAR Document #2045 From the Vancouver Fraser Port Authority to the Review Panel re: Closing Remarks. https://iaac-aeic.gc.ca/050/evaluations/document/132548

[13] CIAR Document #934 From the Vancouver Fraser Port Authority to the Review Panel re: Compilation of the Review Panel's Information Requests and the Vancouver Fraser Port Authority's Responses (Note: Updated February 15, 2019). https://iaac-aeic.gc.ca/050/evaluations/document/128131

[14] For more information on environmental and behavioural factors influencing movements of juvenile salmon in the estuary, including Roberts Bank, refer to the response to IR5-18 in CIAR Document #934.

[15] Calculation is based on an average body weight of 1.85 grams, measured during field surveys undertaken for the project in spring and summer 2020, and a 30-day period to account for a full-moon cycle that influences the tides at Roberts Bank and thus movements of rearing juvenile salmon.

[16] CIAR Document #2001, commitment #41

amount of offsetting proposed, focusing on priority species, such as Chinook salmon, and priority habitats, such as marsh and eelgrass. As demonstrated in **IR2021-1.2**, the project after mitigation (including offsetting and the additional mitigation measures described in this response) will result in a net gain in juvenile salmon productivity (and not a negligible change as assessed in the EIS).

Potential marine terminal and causeway breach locations

In response to the minister's request, the port authority evaluated the feasibility of including a breach (i.e., fish passage) to allow juvenile salmon to move between the north side of the project and the inter-causeway area.

Feedback from Indigenous groups has indicated high interest in a breach to benefit fish. In particular, Tsawwassen First Nation identified a causeway breach as a priority in addressing its concerns. As an example, Tsawwassen First Nation provided the following input:

> *"The benefits of a causeway breach would be two-fold, much less time for juvenile salmon to navigate around the causeway and reduced distance between preferred nearshore habitats such as eelgrass and salt marshes (see comment above re importance of connectivity). Predation effects may still be a concern but [could] be mitigated). TFN sees a causeway breach as an important mitigating measure and encourages the VFPA to work collaboratively with TFN to explore all means to make it happen."*

The port authority received similar feedback from other Indigenous groups. Fisheries and Oceans Canada (DFO) also advised that a causeway breach may have an additional benefit with the enhancement of fisheries habitat in the intercauseway area.

Through a multi-disciplinary design and evaluation process,[17] breach concepts at four locations, one along the east side of the proposed marine terminal and three separate locations through the causeway (**Figure IR2020-2.2-1**), have been evaluated. Through this process, the port authority also identified differences among the breach locations that may affect the productivity of juvenile salmon, other fish species, and fish habitat. These differences are discussed below.

A terminal breach will reduce the shoreline distance between the intertidal flats (north of the causeway) and the inter-causeway area, directly mitigating the direct effect of the project. A causeway breach could offset the direct effect by providing an alternative, more direct, migration pathway to the inter-causeway area. In addition, as well as offsetting the direct effect a breach in the causeway could also be considered an enhancement measure, improving fish passage due to existing infrastructure. A breach at either the causeway or marine terminal location would provide for fish movement and therefore mitigate the potential for juvenile Chinook salmon migration disruption. At this time, the port authority can confirm that subject only to permitting, a terminal breach is technically and economically feasible.

Under a conventional mitigation hierarchy—first avoid, then reduce, then offset—the terminal breach is preferable. However, the port authority acknowledges that Tsawwassen First Nation and others have expressed a preference for a causeway breach. The port authority does not own the causeway. Consequently, if as a matter of public policy the minister prefers offsetting with a causeway breach to direct mitigation with a terminal breach, additional effort and engagement will be required to determine whether a causeway breach is economically and technically feasible.

As explained in more detail below, a breach of the causeway is feasible based on engineering design and constructability evaluations. However, in contrast to a terminal breach, the port authority does not own the

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[17] In the multi-disciplinary design process, aspects related to road and rail crossing structure designs for each breach location and location constraints were led by Stantec on the Owner's Engineer Team, conceptual channel design and hydraulic aspects were led by Northwest Hydraulic Consultants, and environmental objectives and requirements were led by Hemmera.

causeway and other parties use the causeway. The interests of those parties will have to be addressed and their agreement to a causeway breach obtained.

If the minister wishes to pursue a causeway breach, investigations will have to be completed and a final decision made by the minister on which location to construct a breach before an FAA application is submitted by the port authority to DFO. The port authority at present anticipates that this will be approximately six months after a decision on the project by the minister. Due to the nature of, and existing space constraints within which operations currently occur, a causeway breach must be constructed prior to final infrastructure installation on the widened causeway to ensure construction staging plans would be technically and economically feasible.

Given the minister’s request, the port authority expects that the minister will consider requiring a breach at either the terminal or causeway as a condition of approval. Accordingly, and given the interest expressed in a causeway breach, the port authority has continued to investigate feasibility and consult with Indigenous groups and DFO to advance the conceptual design. The port authority has also conducted early engagement with the Province of British Columbia and DFO about causeway breach permitting requirements and constructability, which would have to be addressed if the minister wishes to pursue a causeway breach.

To summarize,

- RBT2 has the potential to disrupt juvenile salmon migration by increasing the shoreline distance that juvenile salmon would have to swim from the intertidal flats north of the Roberts Bank causeway to the inter-causeway area
- The port authority proposes a terminal breach as a technically and economically feasible mitigation measure that would directly reduce the potential to disrupt migration resulting from the placement of the terminal
- Tsawwassen First Nation and Indigenous groups have expressed their preference for a causeway breach
- The technical and economic feasibility of a causeway breach has not yet been determined. While some technical questions have been answered, and the ability to facilitate movement of fish has been identified, uncertainty remains, among other matters, the agreement of third parties will be required.
- Minor adverse effects to fish and fish habitat were determined at all three causeway breach locations due to formation of tidal channels; tidal channels (and related effects) are not anticipated from a marine terminal breach. A potential risk of an adverse interaction between tidal channels at the two shoreward causeway breach locations and biofilm habitat and western sandpiper foraging were identified; similar effects were not identified from the most seaward causeway breach and from a marine terminal breach; if the existing causeway is to be breached, there may be a public benefit to doing so during construction of the RBT2 Project—the total cost and disruption of retrofitting a breach later will likely be greater. However, that benefit will be lost if a decision is not made in a timely manner.

Despite the uncertainty, the minister may wish to consider whether the public interest favours offsetting the potential to disrupt migration by establishing a causeway breach over directly reducing the potential with a terminal breach. The minister can provide that opportunity by imposing a condition that requires the port authority to continue to investigate a causeway breach, to report to the minister, and then to construct a breach in accordance with the minister’s determination on the terms shown below.

Proposed condition

The port authority proposes new conditions as follows:

1. The Proponent shall, to the extent that it can do so acting expeditiously and in good faith, investigate the technical and economic feasibility of a causeway breach, and provide a feasibility report to the Minister describing whether and under what conditions a causeway breach would be technically and economically feasible.
    a) In preparing the report, pursuant to condition 1, the following factors must be addressed in the investigation of the technical feasibility:

i. The constructability of a causeway breach;
ii. The potential for activity required to construct a causeway breach and the presence of the breach to disrupt the operations of all parties who use the causeway;
iii. The legal rights of parties who use the causeway, including the extent to which their consent will be required to incorporate a breach into the causeway; and
iv. The extent to which third parties with rights which may be impacted agree to the incorporation of a breach, and any conditions or qualifications to their agreement.

b) In preparing the report pursuant to condition 1, the following must be addressed in the investigation of the economic feasibility:

i. The cost to construct a terminal breach;
ii. The cost to maintain a terminal breach;
iii. The cost to construct a causeway breach;
iv. The cost to maintain a causeway breach;
v. Any cost or loss that may be suffered by, and any compensation that may have to be paid to, the owners and users of the causeway as a result of i) construction, ii) maintenance, and iii) the presence of a causeway breach.

c) The Proponent shall provide a draft of the feasibility report required by condition 1 to Indigenous groups, Fisheries and Oceans Canada, Environment and Climate Change Canada, and tenants at Roberts Bank and provide each with at least 60 days to comment.

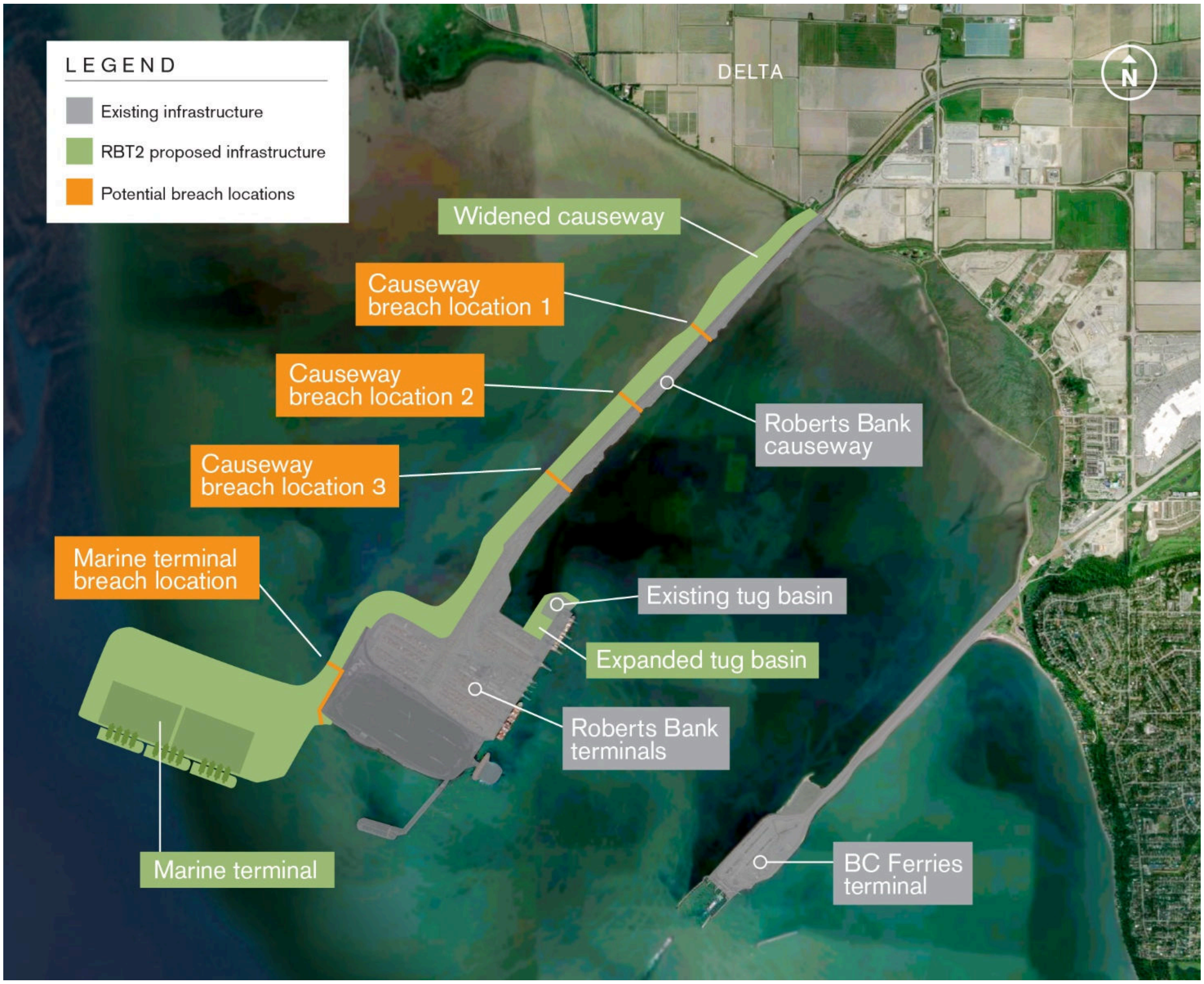
i. A description of the feedback received during the consultation required in condition 1c must be included in or provided with the final feasibility report prepared pursuant to condition 1.

d) The final feasibility report must be delivered to the Agency within 6 months from issuance of the Minister's decision statement.

e) The Proponent shall incorporate a breach in either:

i. the terminal; or
ii. the causeway if, by the latter of a date 6 months after a decision statement is issued or a date identified in the feasibility report, the Minister directs the port authority to do so in accordance with the feasibility report.

Figure IR2020-2.2-1: Potential breach locations evaluated for reducing potential disruption of juvenile salmon migration



Evaluation of potential breach locations

Evaluations of the potential breach locations are presented in subsequent sections by first describing which breach location and crossing structure types are feasible, based on evaluations from an engineering design and constructability perspective, and second by describing how a breach would reduce the potential disruption of juvenile salmon migration and the potential effects to juvenile salmon productivity. The implications of a breach to predation on juvenile salmon and potential adverse effects on fish habitat are then described. Lastly, potential constraints for causeway breach locations (e.g., factors outside of the care and control of the port authority) are identified.

Any of the four breach locations, each with illuminated culvert crossing structures, would allow juvenile Chinook salmon to move to and from the inter-causeway area. The marine terminal breach location would maintain the existing migration corridor for juvenile salmon (along the west side of the existing Roberts Bank terminals), while any of the three causeway breach locations would provide direct access from the north side of the causeway to the inter-causeway area.

Not all juvenile salmon occupying habitats along the proposed widened causeway and marine terminal are expected to use a breach. As described above, juvenile salmon migrate in all directions as they leave the Fraser River, influenced by environmental and behavioural factors. Juvenile salmon presently use productive habitats that are widespread across Roberts Bank, including north and south of the project. With RBT2, juvenile salmon are expected to rear on both sides of the causeway, but with a breach, there would be greater opportunity for movement into the inter-causeway area.

Physical habitat changes potentially resulting from a breach are limited to less than approximately 10 m from breach entrances, except for tidal channel development (which hold the potential to affect fish, fish habitat, and bird habitat) that would likely result from any of the causeway breach locations. All four potential breach locations pose an equal risk of juvenile Chinook salmon predation (by fish and/or birds); additional effort to identify predator exclusion measures to reduce predation of juvenile Chinook salmon is advisable.

Engineering evaluation

At the proposed marine terminal, the only technically feasible location for a breach is at the east end, given design and operational requirements for proposed infrastructure that, in turn, dictate the configuration of the marine terminal (see **IR2020-2.1** for more information). Along the Roberts Bank causeway, three locations were identified for evaluation of a causeway breach.[18] Structures to allow for the crossing of road and rail infrastructure would be required for any breach. The engineering evaluation is based on the assumption that construction of any breach and associated crossing structures would occur during the construction of RBT2.[19]

Both bridge and culvert crossing structures were considered at road and rail crossings for each of the four breach locations. **Table IR2020-2.2-1** summarizes the conceptual design specifications by breach location. For information on crossing structure design constraints and technical assessment criteria, as well as plan view and cross-section drawings, refer to **Appendix IR2020-2.2-A** for the marine terminal breach location and **Appendix IR2020-2.2-B** for the causeway breach locations.

For the marine terminal breach, road and rail crossings would be required across the structural segment of the breach (at the north end of the channel), while the remainder of the alignment (open channel segment, at the south end of the channel) could consist of an open channel with sloped sides, running parallel to the perimeter of Westshore Terminals. For the causeway breach locations, which intersect the existing and proposed widened causeway completely, crossing structures would be required along the entire length of the breach. At each of the six causeway breach entrance locations (one entrance at each end of the breach), and for the open channel segment of the marine terminal breach location, channel sides were assumed to incorporate sloped riprap to maintain consistency with the sloped riprap around port infrastructure (i.e., causeway and Westshore Terminals). Maintaining continuity of the shoreline with any of the breach locations would help to moderate changes in water velocity and facilitate use by juvenile salmon.

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[18] The causeway breach locations shown in **Figure IR2020-2.2-1** do not necessarily represent an ultimate installation location, should one of these options be pursued further. They are, however, representative of the range of conditions along the causeway where a breach could be located.
[19] Construction of a causeway breach outside of the RBT2 construction period may or may not be feasible, but would not be undertaken as part of the project. If it is feasible at all, constructing a causeway breach during project construction provides the federal government with an opportunity to reduce the total cost. At the very least, the cost and risk of breaching the RBT2 widened causeway with new rail and road infrastructure would be avoided.

During the early stages of concept development, a preliminary hydraulic analysis for various channel geometries[20] was conducted. An effective channel width of approximately 10 m was considered to provide suitable cross-sectional area to accommodate passage by juvenile salmon (further information provided below). Based on available topographic information, the bottom of the channel was set at the natural bed elevation of the adjacent tidal flats or seabed at either end of the channel to maximize the time the channel was wetted between tidal cycles (wetted duration), while minimizing both erosive forces on the seabed during tidal exchanges and stranding of marine organisms in standing water within the breach during low tidal conditions.

It was also determined during the early stages of concept development that either natural light penetration through an open crossing structure (bridge) or artificial lighting within a closed crossing structure (culvert) would be required to promote juvenile salmon passage through a breach. Based on this lighting requirement, concept designs for road and rail bridges included an open deck to allow for natural light penetration to the channel below, while the culvert design incorporated roof-mounted light fixtures to artificially illuminate the water column during daytime.

Based on the consideration of bridge and culvert crossing structures at each of the four locations (eight alternatives in total), four are feasible from an engineering design and construction standpoint (**Table IR2020-2.2-1**). Only culvert structures are technically feasible. A bridge structure is not technically feasible (from an engineering design standpoint) at any of the breach locations, as there is insufficient elevation to satisfy freeboard[21] design criteria. Refer to **Appendices IR2020-2.2-A** and **IR2020-2.2-B** for the engineering evaluations of the marine terminal and causeway breach locations, respectively.

[20] Six channel geometries, having various widths and invert (bottom) elevations, were initially assessed as part of a preliminary sensitivity analysis on a straight marine terminal channel alignment to determine the range of hydraulic conditions that could be expected to occur in response to tidal exchange. The hydraulic analysis demonstrated that maximum flow velocities were generally quite low (less than 0.6 m/s) at the channel midpoint, and the maximum velocity was relatively insensitive to overall channel width. Channel bottom elevations were found to have a secondary effect by virtue of limiting or extending the duration of flow for higher and lower elevations, respectively. These preliminary results were used to inform the breach conceptual designs described herein.

[21] Freeboard is defined as the clearance above the design high water level (including future sea level rise) to the underside of the bridge span.

Table IR2020-2.2-1: Summary for concept design specifications at evaluated breach locations

Breach Location	Breach length (m)	Type of Crossing Structure	Channel bottom elevation[a] (m CD)	Conceptual channel geometry and overall width[b] (m)	Channel effective width[c] (m)	Engineering evaluation conclusion[d]
Marine terminal	60 m structural segment 300 m open channel	culvert in structural segment	1.3 m	structural segment rectangular, 14.9 m wide (Appendix IR2020-2.2-A, Figure 3) open channel segment with sloped sides (Appendix IR2020-2.2-A, Figure 4)	12.8 m for culvert 15.0 m at top 2.75 m at bottom	Feasible, based on engineering design
		bridge in structural segment	1.3 m	structural segment with sloped sides (Appendix IR2020-2.2-A, Figures 7 and 8) open channel segment with sloped sides (Appendix IR2020-2.2-A, Figure 4)	15.0 m at top 2.75 m at bottom	Not feasible, due to insufficient freeboard
Causeway location 1	170 m	culvert	3.7 m to 3.4 m	rectangular shape, 12.1 m wide (Appendix IR2020-2.2-B, Figure 3)	10.0 m	Feasible, based on engineering design
		bridge	*Concept not advanced due to limitation of low causeway elevation*			Not feasible, due to insufficient freeboard
Causeway location 2	220 m	culvert	3.1 m to 3.6 m	rectangular shape, 12.1 m wide (similar in concept to Location 1)	10.0 m	Feasible, based on engineering design
		bridge	*Concept not advanced due to limitation of low causeway elevation*			Not feasible, due to insufficient freeboard
Causeway location 3	220 m	culvert	2.8 m to 3.0 m	rectangular shape, 12.1 m wide (Appendix IR2020-2.2-B, Figure 4)	10.0 m	Feasible, based on engineering design
		bridge		rectangular shape, 13.3 m wide (Appendix IR2020-2.2-B, Figure 2)	11.0 m	Not feasible, due to insufficient freeboard

Notes:

a. Channel bottom (invert) elevation in metres chart datum (m CD); ranges presented from north end to south end of the breach.
b. Overall width is the distance (in metres) between the outer limits of a culvert or bridge structure; for a channel with sloped sides, dimensions provided in channel effective width column. For each breach concept design, the overall width reflects the maximum breach width possible while maintaining at least 10 m clearance distance from rail turnouts required for operational safety reasons.
c. Channel effective width is the width (in metres) of a culvert or bridge structure that will convey flow.
d. Feasible means technical feasibility based solely on engineering design evaluations (details provided in **Appendices IR2020-2.2-A** and **IR2020-2.2-B).** Bridge structure concepts are not technically feasible based on engineering design evaluations, due to insufficient elevation at the breach location to satisfy freeboard design criteria. Freeboard is defined as the clearance above the design high water level (including future sea level rise) to the underside of the bridge span.

Effectiveness of mitigation of juvenile salmon migration disruption

A breach at any of the four locations would effectively reduce the potential for disruption of juvenile salmon migration from RBT2. Historical and recent sampling of juvenile salmon at Roberts Bank demonstrates that they are present in the area of each of the breach locations along the shoreline of the existing Westshore Terminals and the existing causeway. In addition, breaches through embankments are a common enhancement technique for salmon in estuaries that have been proven effective (review by Gerwing et al. 2020). Accordingly, juvenile salmon would encounter and would pass through any of the breaches directly, reducing the potential migration disruption by the project.

Based on a review of historical and recent literature and empirical data on behaviour, habitat use, and migration of juvenile salmon in estuaries, several key environmental factors considered in the environmental effects descriptions below have been evaluated. These key factors are water depth, water velocity, channel width, channel side slope, salinity, and light. Other factors such as predation may influence the effectiveness of the breach and have also been considered. To support the evaluation of the breach locations, hydraulic and geomorphic analyses were undertaken, and these are detailed in **Appendices IR2020-2.2-C** and **IR2020-2.2-D**.

Water depth: Based on hydraulic analyses, a breach at any of the four locations would have adequate depth to allow free and unimpeded movement of juvenile salmon. The duration that a breach would have a minimum water depth of 0.5 m increases with distance of the breach location from shore, ranging from 9% at causeway location 1 to 86% at the marine terminal breach location (causeway location 3 is wetted 37% of the time). The minimum depth criterion was set at 0.5 m to accommodate juvenile Chinook salmon, which avoid movement into tidal channels when depths are shallower than 0.4 m (e.g., Hering et al. 2010). Empirical juvenile salmon data collected for the project in 2020 demonstrated greater density along the causeway at locations farther from shore.

Water velocity: A breach at any of the four locations will allow juvenile salmon to migrate with the current following the rising and falling tides, as they do in natural tidal channels (Hering et al. 2010). Juvenile salmon predominantly move with tidal currents (Hering et al. 2010), migrating into shallower habitats (marshes and tidal channels) with the flood tide and emigrating with the ebb tide to occupy low tide refuge areas (Levy and Northcote 1982, Weinstein and Kreeger 2000, Hering et al. 2010). Peak salmon movement in tidal channels occurs during mid- to late flood tides, and late ebb tides (Hering et al. 2010). When rearing in shallow nearshore habitats, juvenile Chinook and chum salmon in estuaries occupy habitats with low to moderate velocities from 0.2 m/s to 0.5 m/s (Bottom et al. 2005, Rempel et al. 2012, Pellett et al. 2013).

Based on hydraulic analysis, typical water velocities within any of the breach channels are predicted to be similar and less than 0.3 m/s (within the range cited above). Breach channels at all potential locations provide water velocity conditions conducive to juvenile salmon use. Peak water velocities, which would be sustained over a short duration (several hours), are predicted to range from 0.5 m/s at the marine terminal location to 1.4 m/s at causeway location 2.

Water velocities modelled within the breach are not anticipated to negatively influence juvenile salmon movement and use of any of the four potential breach locations during the percentage of time the breaches will have adequate depth. Juvenile salmon are anticipated to move through any of the four potential breach locations with the predominant flow direction when there is adequate water depth to do so (i.e., 0.5 m, for assessment purposes). Therefore, any of the four potential breach locations could be used by migrating juvenile salmon 100% of the time when water depth is sufficient.

Migrating juvenile salmon regularly experience eddies and turbulent flow in natural conditions (e.g., tidal channels) and such potential eddies in a breach are not anticipated to affect juvenile salmon use of any of the four breach locations. The formation of large eddies or other macroturbulence features within the channel at any of the causeway breach locations is not expected to be significant as the channels are straight (linear) and bounded by the smooth concrete of the culvert sidewalls. For the proposed marine terminal breach channel, effort was made to smooth the transitions within the channel bends, as represented in the numerical model, to reduce the formation of eddies. The conclusions reached on water velocities will not be materially different for the breach geometry assessed through numerical modelling versus that presented in the conceptual level design. Further evaluation of water velocities and potential eddy formation will be undertaken once a preferred breach location has been identified.

Channel width: Juvenile Chinook and chum salmon commonly use tidal channels in marshes (Levy and Northcote 1981, Healey 1991, Chalifour et al. 2019) and tidal channels measuring between 5 m and 25 m in width are common in the estuary between the main arm of the Fraser River and the BC Ferries causeway.

The marine terminal and causeway breaches are of similar width to tidal channels found in the estuary. The marine terminal breach culvert concept has an effective channel width of 12.8 m and an open channel that varies in width from 15 m at the top of the channel to 2.75 m at the bottom of the channel. The causeway locations have effective channel widths of 10 m. Juvenile migrating salmon are anticipated to use any of the four potential breach locations.

The width of each individual culvert is sufficient for juvenile Chinook salmon to pass (there is evidence of them using channels—natural or otherwise—of similar width at Roberts Bank and elsewhere).The port authority is not aware of the existence of similarly-sized marine fish passage culverts, but notes a similar fish access upgrade has recently been implemented in a long, relatively narrow training berm in the Squamish River estuary specifically to improve juvenile Chinook salmon survival. Similar engineered culverts or naturalized channels allow salmonid access to tributaries along the lower Fraser River (e.g., lower reaches of Nelson Creek, Brunette River, Coquitlam B.C.). In freshwater environments, channels to facilitate salmonid movement and use are common, proven mitigation measures and include fishways (e.g., Hell's Gate East Main Bank, Fraser River, B.C. – 130 m in length), bypass channels (e.g., Millstone River Fish Bypass Channel, Nanaimo B.C. – 850 m in length), and rearing/spawning channels (e.g., McNab Creek groundwater channels, Howe Sound B.C. – 1,000 m in length).

Channel side slope: At any of the breach locations, the riprap slopes along the perimeter of the project and existing infrastructure will continue to the entrances of the breach to maintain continuity with that habitat type. In the Fraser River and Columbia River estuaries, juvenile Chinook salmon prefer tidal channels with low banks and many subtidal refugia (Levings 1982, Healey 1991). For the marine terminal location, as stated previously, the conceptual design for the open channel segment has rocky sloped sides instead of vertical sheet pile walls on either side to maintain continuity with the rocky slope around Westshore Terminals, thereby promoting use of the breach by migrating juvenile salmon.

Salinity: A breach is predicted to induce a very small change in salinity (between 1 and 2 practical salinity units (psu)) over a relatively small area in waters adjacent to the breach entrances. The very small salinity change is because of the predicted low flow rates[22] that pass through the breach compared to the high flow rate during tidal exchanges at Roberts Bank. Therefore, all four breach locations will result in salinity conditions similar to what juvenile salmon currently experience.

There is an existing difference in salinity on either side of the causeway and a causeway breach will not change this regime. However, the influence a breach has on salinity is slightly higher in the inter-causeway area than on the area north of the causeway because of the strongly asymmetrical flows that predominantly discharge from north to south (**Appendix IR2020-2.2-C**). Salinity differences at all causeway breach locations, for the freshet period, may be up to 2 psu over a maximum area of approximately 20 m by 30 m near the north entrance, and a similar magnitude of salinity decrease over an area of approximately 40 m by 50 m near the south entrance. The magnitude of difference is similar during the non-freshet period, but the extent is smaller (approximately 10 m by 10 m), due to less freshwater being present at this time. Juvenile salmon that would pass through a breach at any of the causeway locations would encounter different salinity levels within the breach and upon exiting the breach but within the range of conditions found within the estuary. Changes in salinity from the marine terminal breach would be insignificant because the differences in salinity on either side of the marine terminal breach are small and flow exchange induced by the breach would be extremely small.

[22] Maximum flow rate (discharge) through the breaches ranges from 2.6 m^3/s to 6.3 m^3/s, a small fraction of maximum flow rates around the northwest corner of the proposed RBT2 terminal (700 m^3/s) and into the inter-causeway area (1,600 m^3/s) (**Appendices IR2020-2.2-C** and **IR2020-2.2-D**).

Light: The culvert concepts for the breaches integrate roof-mounted light fixtures with light level sensors to illuminate the water column during the daytime. Therefore, all four breach locations will provide light conditions conducive to juvenile salmon use. Low light levels within covered structures (e.g., culvert) can contribute to increased avoidance behaviour and deviation away from shaded areas during the daytime, leading to delay in juvenile salmon migration. At night, illuminated structures may cause juvenile salmon to congregate, thereby increasing the risk of predation, and therefore lights would be turned off at night (for review of the literature on lighting effects on juvenile salmon migration, see responses to IR5-18 and IR5-25 in CIAR Document #934).

Potential for fish stranding: It is unlikely that juvenile Chinook salmon could be stranded in the breach channel. Juvenile salmon predominantly move with prevailing water flows and tidal currents, migrating into shallower habitats (including tidal channels) with the flood tide and receding to deeper water with the ebb tide to occupy low tide refuge areas (including offshore). Hence, as the channel drains juvenile salmon would exit the breach with this flow. Breach channel drainage will be considered during subsequent design phases, incorporating site-specific factors at the preferred breach location, such as the seabed elevation at each entrance and channel slope, to mitigate the potential for fish stranding in the channel as well as in the shallow basins that are expected to form at the entrances.

Potential breach blockage: Without mitigation, there is some potential that debris within the breach could adversely affect the ability of the breach to allow migrating juvenile salmon to pass. Flow in the breaches is anticipated to be bi-directional, hence this may minimize the potential for breach blockage. Standard measures (e.g., grates or coarse screens at entrances) could potentially mitigate this potential risk.

Predation

Migration of juvenile salmon through any of the four breach locations has the potential to result in increased risk of juvenile salmon predation. The level of predation risk is expected to be similar for all locations, given the mobility and opportunistic behaviour of the common predators of juvenile salmon. Given the greater depth at the marine terminal breach location, predatory pressure may be exerted by predators such as seals, while coastal birds may prey upon migrating juvenile salmon, especially in the low and high intertidal zone, such as at the shallower (north) entrance of the marine terminal breach location and at all three causeway breach locations. Predation risk may increase in areas where tidal flows are concentrated (e.g., at the entrance of a breach). For example, seals aggregate and prey on salmon at constrictions in tidal channels (e.g., Zamon 2001, Hastie et al. 2016).

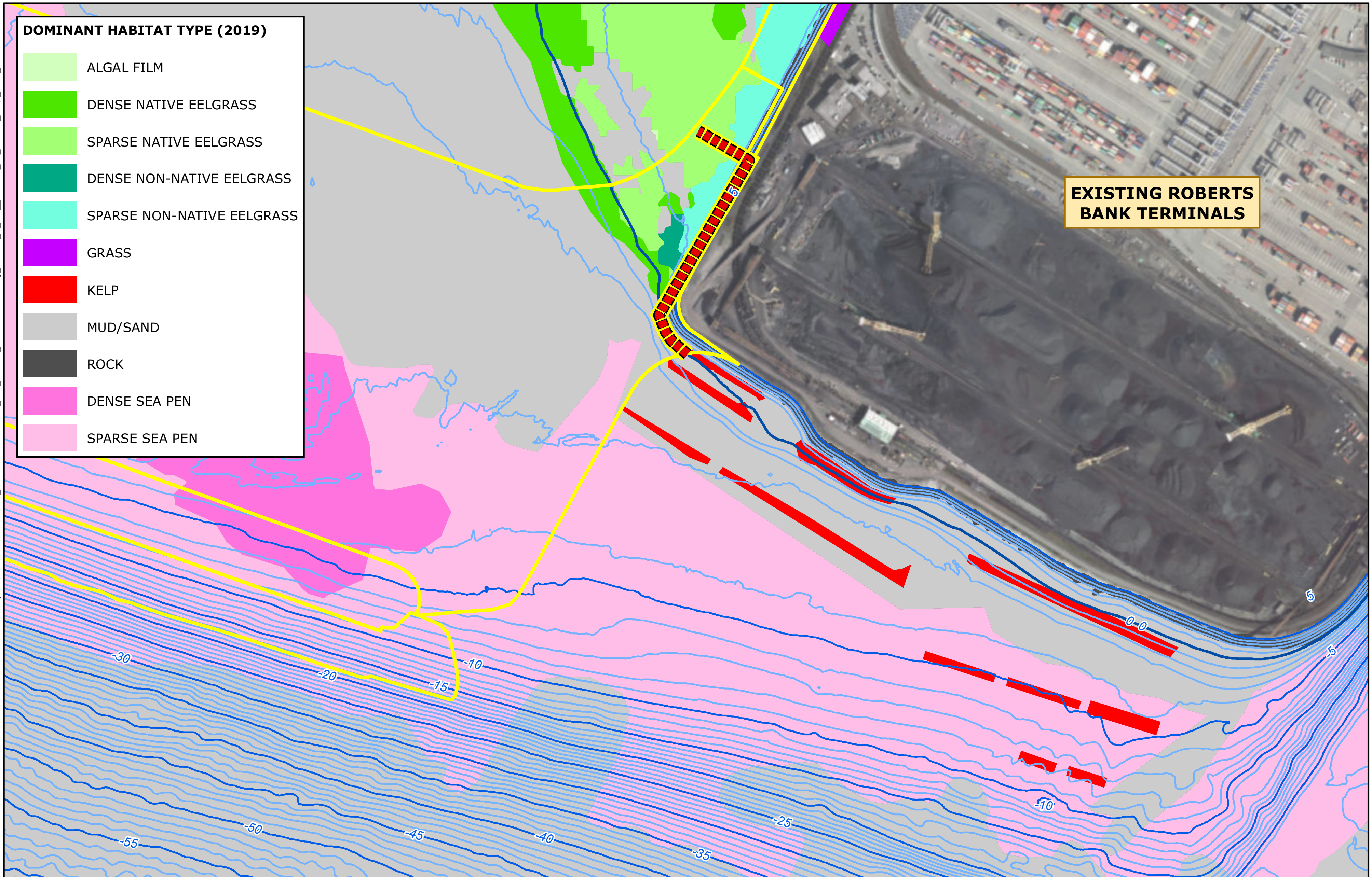
The seaward (south) entrance of the marine terminal breach location is adjacent to the existing subtidal rock reefs seaward of Westshore Terminals. In response to comments by Tsawwassen First Nation and other Indigenous groups, the port authority undertook additional investigation of this area and identified the presence of canopy-forming macroalgal (including kelp) species on the existing subtidal rocky reefs in this area (see **Figure IR2020-2.2-2**). Based on literature, kelp canopy at the water surface provides effective refuge against predation of juvenile Chinook salmon (Shaffer et al. 2020), as juvenile Chinook salmon remain at or near the water surface and do not typically inhabit deeper subtidal waters where reef fish species associated with subtidal rock reefs may exert predation pressure on juvenile salmon. Hence, at the south entrance of the marine terminal breach location, existing kelp canopy (**Figure IR2020-2.2-2**) is expected to provide refuge habitat to those juvenile salmon that may migrate through the marine terminal breach location. Additional mitigation measures are described below that could be considered for exclusion of mammalian and avian predators, including at the landward (north) and will be evaluated further at the preferred breach location.

Fish rearing facilities for enhancement and aquaculture purposes commonly use fences and overhead screens to exclude mammalian and avian predators (e.g., Big Qualicum rearing channels, Capilano hatchery). Where required, electric or noise deterrents can be added to discourage entry. In the approach to the channel, predators can be discouraged from congregating by employing one or more of the following:

- Contouring and surfacing of the shoreline with materials that provide predation refugia and limit predator access
- Use of garlands (e.g., foil tape, such as that used in the blueberry farming industry) to deter birds; this may be effective for deterring great blue herons from locating near the breaches

- Use of netting (e.g., such as that used in orchards) to exclude birds; large mesh netting will effectively exclude great blue herons (while not trapping smaller birds)
- Use of noise or light generating devices to deter bird access
- Use of fences and bar screen at the channel entrance to exclude mammalian predators and debris
- Use of netting in the approach waters to exclude seals, as is used by the aquaculture industry (e.g., reviewed by Thompson et al. 2020)

Such measures will be evaluated during subsequent design phases of the preferred breach location and incorporated in the breach design, as required.



Legend

BOUNDARY OF PROJECT AREA

RBT2 CONCEPTUAL BREACH LOCATION

EXISTING LANDMARK

BATHYMETRY (m CD)

0 m (CHART DATUM)

5 m INTERVAL (CHART DATUM)

1 m INTERVAL (CHART DATUM)

0 50 100

Metres

1:8,000

NAD 1983 UTM Zone 10N

N

PORT of vancouver

ROBERTS BANK TERMINAL 2

POTENTIAL MARINE TERMINAL BREACH LOCATION AND EXISTING (2019) KELP HABITAT

DATE: **22/09/2021**

FIG No. **IR2020-2.2-2**

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

Path: S:\Geomatics\Projects\102738\10\Ministers_Information\Salmon_and_Breach_Locations\mxd\Fig_IR2020_2_2-2__102738_10_Breach_Kelp_8x11_210922.mxd

Potential alteration of fish habitat

Although breaches at any of the four locations would reduce disruption to migration, each location has the potential to adversely affect fish habitat to some degree. This is described below for the marine terminal location first and the three causeway locations subsequently. In summary, effects to fish habitat from the marine terminal breach are localized (within 10 m of the breach). Due to inherent uncertainty associated with tidal channel formation from causeway breach construction, it is not possible to accurately predict the extent to which such channels may affect fish and fish habitat (tidal channels from a marine terminal breach location are not anticipated).

<u>Marine terminal breach location</u>: Based on results of hydraulic analyses for the marine terminal breach location (**Appendix IR2020-2.2-D**), water flow through the breach is predicted to mobilize sediment up to approximately 2 mm in diameter and smaller within the breach and on the seabed at each entrance at various times.[23] Seabed scour is predicted to be localized[24] and can be managed with the use of scour protection. Changes to the seabed from localized scour and placement of scour protection would result in a localized alteration to fish habitat but would not limit the effectiveness of mitigation in facilitating juvenile salmon migration.

Tidal channels are not expected to form at the marine terminal breach location. The necessary conditions for tidal channel development to occur are a) that water drains across the soft sediments of the tidal flats while exposed at low tide, and b) that the area is relatively protected from waves and ocean currents that would otherwise redistribute sediments of the tidal flats and prevent channel formation. The south (seaward) entrance is located in subtidal waters and because the sediments are always submerged, there is no potential for tidal channel formation. The north (landward) entrance is located in the intertidal area of the tidal flats adjacent to the existing terminal; as such, it is exposed to large waves that would redistribute sediments and preclude a channel from forming. Based on hydraulic analyses for the marine terminal breach location, localized seabed scour is predicted at each entrance to the marine terminal breach as a result of water flow through the breach. Seabed scour can be managed with the use of a scour blanket at each entrance.

The port authority is not anticipating any direct or indirect effects from the marine terminal breach on the onsite offsetting proposed for the north side of the terminal. As indicated earlier, tidal channel formation at the marine terminal breach is not anticipated, and salinity changes from a breach has been determined to be subtle and within 20m to 50 m of the breach entrance (and therefore unlikely to interact with most of the onsite habitat). Interactions between the marine terminal breach and proposed offsetting are anticipated for juvenile salmon, given both are being considered expressly to benefit the migration and growth of juvenile salmon (respectively). The marine terminal breach location being near offsetting habitat will provide a more direct route for fish to move to open waters during low tides. If selected as the preferred breach location, as part of a subsequent design phase, the marine terminal breach would be designed with a sloping channel invert elevation to ensure that water fully drains from the channel. Given juvenile Chinook salmon move with prevailing water flows, a sloped channel design would avoid risk of their stranding in the breach as all the water will drain from the breach.

<u>Causeway breach locations</u>: A breach through the causeway would facilitate direct migration to the inter-causeway area. However, there is high probability that a causeway breach would initiate the development of tidal channels, thereby altering existing fish habitat. With the inherent uncertainty in predicting the extent of tidal channel formation, all three causeway breach locations are likely to result in similar tidal channel formation.

Tidal channel development is predicted to initiate from each end of the breach due to flow acceleration at the breach entrance and latent discharge from the breach after the tide has receded. Regardless of the location of a causeway breach, there is a high probability that a tidal channel would extend outwards from the breach across

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[23] Sediments are likely to become mobile at velocities exceeding approximately 0.1 m/s, or shear stresses exceeding approximately 0.15 Pa (**Appendix IR2020-2.2-C**).
[24] Seabed scour is predicted to be confined to locations within 10 m of the toe of riprap slopes at the north breach entrance, and within the extents of the toe of riprap slope at the south breach entrance (see Figure 3-11 in **Appendix IR2020-2.2-C**).

the tidal flats within the apron zone adjacent to the existing causeway (outlined in **Appendix IR2020-2.2-C**, Figure 4-7). There is a moderate probability that a tidal channel would extend beyond this apron zone. If a new tidal channel was to interact with one of the existing systems of tidal channels within the inter-causeway area (see Appendix 1 of **Appendix IR2020-2.2-C** for information on existing tidal channel systems), tidal channel forming processes would be accelerated and result in a greater extent of the tidal flat being affected. This risk of interaction with an existing tidal channel is higher at causeway location 1, due to the proximity to an existing drainage channel network at the south entrance.

Based on past examples of tidal channels at Roberts Bank (see Appendix 1 of **Appendix IR2020-2.2-C**), tidal channel formation from a causeway breach is expected to alter fish habitat due to sediment erosion within the tidal channel and sediment deposition at lower elevations, leading to changes in distribution and productivity of fish habitat. Fish habitat[25] along the north shoreline of the causeway is characterized by sparse low marsh eastward, transitioning to non-native eelgrass westward. Along the south shoreline of the causeway, fish habitat is predominantly non-native and native eelgrass. Encroachment of a tidal channel into a native eelgrass bed could result in patchy distribution and potentially loss of vegetation. Currents could also tear leaves and erode the substrate exposing the rhizomes (roots) (e.g., Archipelago et al. 2009, Hemmera et al. 2010). Within areas of deposition, eelgrass could be buried under soft sediment (e.g., Archipelago et al. 2009, Hemmera et al. 2010).

Modification of vegetative habitats to exposed substrate could also affect fish and invertebrate productivity. For example, decreases in abundance and species richness of invertebrate fish-food organisms could occur due to an increase in exposed bare substrates and fragmentation of vegetative habitats (e.g., Archipelago et al. 2009). Within tidal channels, localized increases in the abundance of species associated with bare substrates, such as flatfish, could also occur. Juvenile salmon species composition and abundance are not expected to be affected by tidal channel formation (e.g., Archipelago et al. 2009). Tidal channels are used by juvenile salmon as refuge habitat during low tides (e.g., Levings 1982), as well as to access high intertidal marsh habitats during flood tides (e.g., Hering et al. 2010).

With the inherent uncertainty in predicting the extent of tidal channel formation from a causeway breach, the potential extent of effects to biofilm habitat and intertidal habitat supporting the avian community are uncertain. Additionally, associated changes would likely benefit some species and be detrimental to the habitat for others. For example, the formation of tidal channels may benefit piscivorous bird species such as great blue heron through the entrapment of fish within channels during a receding tide, but detrimental to herbivorous species that feed on eelgrass, such as brant and some waterfowl. Regarding potential effects to biofilm, an important habitat for migrating shorebirds, causeway location 3 is not expected to adversely affect biofilm due to its location (greater than a kilometre from the upper intertidal zone that supports dense biofilm), and the expected direction of tidal channel formation to be perpendicular to the causeway.

Once formation processes are initiated, mitigating tidal channel development may not be possible. Past efforts to mitigate channel development have demonstrated that installation of scour protection (armouring) material or berms is not successful due to the highly dynamic nature of the environment and the fact that the sediments of the tidal flats are very easily erodible (refer to **Appendix IR2020-2.2-C**, Section 4.1 for more information). Installation of armour material on the seabed would change the physical characteristics of the substrate and fish habitat. Input from Indigenous groups indicates that use of shells may be effective in managing tidal channel development and the port authority will work with Indigenous groups to investigate use of shells for this purpose.

In response to comments from DFO, the port authority concluded that effects to fish and fish habitat from a potential causeway breach would be considered minor. The term ‘minor’ used here is consistent with the definition provided in the EIS and represents a change of 6% to 30% (for definition see EIS Volume 3 and response to IR-7.31.15-07 (CIAR Document #314[26])). Minor changes are anticipated to habitats such as sparse low marsh, non-

[25] Refer to Figures 1 and 2 in **Appendix IR2020-2.1-A** for fish habitats present along the north and south sides of the Roberts Bank causeway.
[26] CIAR Document #314 From Port Metro Vancouver to the Canadian Environmental Assessment Agency re: Completeness Review - Responses to Additional Information Requirements (See reference document # 271) for the Environmental Impact Statement. https://iaac-aeic.gc.ca/050/documents/p80054/103668E.pdf

native and native eelgrass that characterize the apron along the north and south sides of the Roberts Bank causeway as well as fish, invertebrate, and bird communities associated with these habitats. Due to uncertainty associated with tidal channel formation, including the extent of a tidal channel extending across the tidal flats and the likelihood of encountering an existing channel system (which could result in larger tidal channel formation, as outlined above), the magnitude of the potential effect is characterized as low to moderate (i.e., resulting in a measurable change within or outside the range of natural variability of the affected flora and fauna but would not affect population integrity).

Potential breach constraints

There are several potential constraints relating to implementation of a causeway breach that are outside of the care and control of the port authority.

1. Land tenure. The existing causeway is owned by the Province of British Columbia. Implementation of a potential causeway breach is therefore subject to cooperation with the Province of British Columbia.
2. Permitting. Two potential permitting requirements have been identified. First, there may be permitting requirements associated with constructing a causeway breach on lands owned by the Province of British Columbia. Second, at all three causeway locations, a breach may directly or indirectly alter existing compensation habitat along the south side of the causeway. That habitat, called the Deltaport Third Berth (DP3) East Causeway Habitat Compensation Project, was established under a FAA. Additional permits may be required.
3. Terminal operations and impacts to existing infrastructure. Input from Westshore Terminals, Global Container Terminals, B.C. Ministry of Transportation and Infrastructure, and BC Rail would be required to refine the specific location for a breach, evaluate potential operational impacts on existing rail, road, and terminal operations during breach construction, and determine appropriate mitigation measures to reduce operational impacts.

In response to DFO comments on potential breach constraints, the port authority notes the following:

- The timeline for securing access to causeway lands is dependent on discussions with the Province of British Columbia and hence an exact timeline is not available. The port authority received feedback from Indigenous groups. DFO noted that a causeway breach may have an additional benefit with the enhancement of fisheries habitat in the inter-causeway area and based on this input the port authority has proposed a draft condition in this response to complete additional causeway breach feasibility studies within six months following ministerial decision on the project (see above for the scope of a causeway breach feasibility report that would be developed during this time).
- Further discussions with the Province of British Columbia, DFO, existing terminal operators at Roberts Bank, and BC Rail will be required about i) causeway breach permitting requirements, ii) constructability and overall feasibility, iii) to identify and address the legal interests of third parties (which would have to be addressed if the minister wishes to pursue a causeway breach), and iv) responsibility for long-term maintenance of culverts and lighting.
- The breach itself will result in the creation of new fish and fish habitat and would promote use of the DP3 East Causeway Offsetting Habitat. The marine terminal breach location will not affect DP3 East Causeway Offsetting Habitat because there is no physical interaction between the two. It is not presently possible to determine if a causeway breach may affect the DP3 East Causeway Offsetting Habitat given the location of a causeway breach has not been identified. Once the preferred breach location has been identified, the port authority will work with Indigenous groups and DFO to determine the direct and indirect effects of a breach. However, direct or indirect effects are likely to be minor on the compensation sites given the relatively small footprint of the culverted options, localized indirect effects and overall benefits to juvenile salmon that direct access would provide.

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West terminal juvenile salmon refuge habitat

With a breach at any one of the four locations identified, the potential for minor project-related disruption of juvenile Chinook salmon migration will be mitigated effectively and additional mitigation for juvenile Chinook salmon migration disruption is not warranted. In addition, the port authority is currently evaluating the technical and economic feasibility of an additional juvenile salmon migration mitigation measure that could provide refuge habitat during migration to and from the intertidal zone during tidal exchanges, as discussed below.

Onsite offsetting habitat enhancement is being proposed on the north side of the marine terminal (see **IR2020-1.1**) to increase juvenile salmon productivity. On the west side of the marine terminal, the port authority has undertaken a preliminary review of potential habitat complexing opportunities that would allow for the continuation of intermittent refuge habitat from the north side of the terminal for juvenile salmon that swim around the west side of the terminal.

At a concept level, it may be technically feasible to complex some portions of the terminal's west side without compromising the structural integrity of the marine terminal. Habitat complexing could be achieved, for example, by facilitating establishment of kelp, which is known to provide effective juvenile Chinook salmon habitat (Shaffer et al. 2020). Environmental conditions (e.g., current velocities, wave height) with the project along the west perimeter slope of the proposed marine terminal (see EIS Appendix 9.5-A) are predicted to be similar to conditions that prevail along the west perimeter of the Westshore Terminals which have facilitated the establishment of marine macroalgal communities (including kelp species) (see technical data report MVB-1 in CIAR Document #388[27]).

Operational mitigation

The port authority has considered additional measures to further reduce project-related effects to juvenile salmon during project operation related to project infrastructure lighting, underwater noise generated by container vessels and support tugs, and maintenance dredging. Potential measures to reduce potential disruption to juvenile salmon migration and the effectiveness of each are described below.

Light-related mitigation

The port authority proposes to update the Light Management Plan, with the objective of reducing light trespass into the marine environment from project infrastructure lighting without compromising the lighting required for effective, safe operation on the terminal and causeway.

As outlined above in the background section, changes in the light environment could contribute to the project-related disruption of juvenile salmon migration. The mitigation stated in commitment #24 is comprehensive, and includes adequate specificity based on the current conceptual level of project design. The port authority proposes to update the described mitigation, nevertheless, in view of the importance placed by Indigenous groups and others on reducing effects to the marine environment, including migrating juvenile salmon. The current mitigation commitment and proposed updates (presented in bold text) are provided in **Table IR2020-2.2-2**.

[27] CIAR Document #388 From Port Metro Vancouver to the Canadian Environmental Assessment Agency re: Completeness Review - Responses to Additional Information Requirements Follow-Up (See Reference Document # 345) including 22 Technical Data Reports. https://iaac-aeic.gc.ca/050/evaluations/document/115188

Table IR2020-2.2-2: Light Management Plan mitigation[28]

Reducing the number of light installations, controlling light levels **and reducing light intensity**, avoiding the use of decorative lighting, and limiting light use to only that required for safety, operations, or regulatory requirements, including those designated by Transport Canada
Orienting lights downward and away from residential and marine **environment** areas
Controlling light levels and limit light use to areas where activities are occurring
Using fixtures that emit light at specific wavelengths, if appropriate **for marine species (i.e., fish and birds) of interest**
Avoiding the use of solid burning or slow pulsing warning lights unless required for safety, operation, or regulatory purposes
Using down-shielded lighting fixtures (or equivalent technology) to minimize light trespass**, including in the marine environment**
Using dredge lighting shields to minimize light spilling outside the basic working footprint of the dredge. **If maintenance dredging of the tug basin is required during operation, conduct dredging, below –5 m CD, outside of the juvenile salmon fisheries-sensitive window (i.e., outside of the time period between March 1 and August 15)**
Avoiding, or restricting the time of operation of, exterior lights such as spotlights and floodlights that function to highlight the exterior features of buildings, including on humid, foggy, or rainy nights
In relation to any on-terminal navigational lighting requirements, using the minimum amount of obstruction avoidance lighting on tall structures. This includes use of only strobe lights at night, at the minimum intensity and minimum number of flashes per minute (longest duration between flashes) allowable by Transport Canada
Ensuring that nighttime terminal lighting does not exceed 100 lux or greater on the adjacent seabed, within 50 m of the terminal

The port authority will update the Light Trespass and Sky Glow Effects Predictions and Mitigation Effectiveness FUP[29] element to expand monitoring in the marine environment to verify effectiveness of project infrastructure lighting mitigation. In the updates, the port authority proposes the following:

- Evaluate existing light conditions in the marine environment (including in areas where project components are proposed) from natural light and artificial light from existing infrastructure, focusing on the spring-summer period when salmon are present at Roberts Bank
- Monitor potential changes to light levels in the marine environment during operation from existing conditions to determine if and where additional technically and economically feasible measures could be implemented to reduce light trespass in the marine environment. The objective is to get as close as possible to a no-net increase in light in the marine environment, while still satisfying safety, operation, and regulatory requirements

In conclusion, the additional measures above would further reduce potential changes in light in the marine environment that could disrupt juvenile salmon migration.

Underwater noise mitigation

The port authority has been working since the public hearing to identify mitigation measures to further reduce the potential for acoustic effects to southern resident killer whales from underwater noise from project operation (described in **IR2020-3**). Juvenile salmon are hearing generalists and are not known to be sensitive to continuous noise that will be generated during project operation (as explained in the EIS[30]). Nevertheless, further reduction to

[28] CIAR Document #2001, updated commitment #24
[29] CIAR Document #2001, commitment #81, FUP element: Light Trespass and Sky Glow Effects Predictions and Mitigation Effectiveness (Table C20).
[30] CIAR Document #181 Roberts Bank Terminal 2 Project - Environmental Impact Statement, Volume 3: Biophysical Effects Assessments, Section 13.0. h https://iaac-aeic.gc.ca/050/evaluations/document/114311

underwater noise levels in the marine environment near the proposed terminal, as described here, will be generally beneficial to all marine species, including juvenile salmon. The measures to reduce underwater noise during project operation[31] that could benefit juvenile salmon at Roberts Bank are the following:

- Evaluating the potential effectiveness of technologies to reduce underwater noise associated with tug activities (e.g., electric tugs) and implementing once feasible
- Providing shore power connection for container vessels equipped to plug into land-based electric power while berthed at the RBT2 terminal

With the proposed operational mitigation stated above for southern resident killer whales and below for maintenance dredging, the effects on salmon from underwater noise during project operation will be reduced and therefore will continue to be negligible (as determined in the EIS).

Maintenance dredging mitigation

Maintenance dredging of the expanded tug basin is not anticipated to be required during project operation, based on current observed sedimentation patterns at the existing tug basin, and other depositional areas (i.e., with lower seabed elevation) in the inter-causeway area. Nevertheless, if maintenance dredging below 5 m CD is required, it can be conducted outside of the juvenile salmon fisheries-sensitive window (i.e., outside of the time period between March 1 and August 15).

In conclusion, conducting maintenance dredging outside of the juvenile salmon fisheries-sensitive window will avoid interaction with, and potential adverse effects from, associated increases in light and underwater noise, to juvenile salmon that rear in the inter-causeway area in spring and summer (Riddell et al. 2018, Scott et al. 2019). By late summer, juvenile salmon have transitioned to marine waters of the Strait of Georgia away from the estuary (Riddell et al. 2018).

Conclusion

The minister requested the port authority provide any additional operational mitigation measures or terminal and causeway design options that could avoid or mitigate habitat loss and the potential for the project to disrupt juvenile salmon migration. In this response, the port authority provides the additional information requested. This includes reduction of juvenile salmon habitat loss from further reductions to the project footprint (as described in **IR2020-2.1**); mitigation for migrating juvenile salmon, including breaching the marine terminal or causeway and evaluating juvenile salmon refuge habitat on the marine terminal (as described above); as well as operational measures to reduce the amount of light and underwater noise from project operation to further reduce effects to juvenile salmon.

With the addition of offsetting habitat designed specifically for juvenile salmon (as described in **IR2020-1.1**), and the design changes and operational mitigation measures described above, the project is forecasted to result in a net gain in juvenile salmon productivity (as detailed in **IR2020-1.2**).

[31] Measures to reduce underwater noise, and in turn effects to fish, during in-water project construction activities will also be implemented by the port authority (in accordance with the Underwater Noise Management Plan of the project's Construction Environmental Management Plan; commitment #37, CIAR Document #2001), including adherence to fisheries-sensitive windows to the extent possible, use of a vibratory hammer predominantly for pile installation and use of an impact hammer to only drive piles to the final penetration depth, use of sound attenuation measures during impact piling, and implementation of underwater noise monitoring with adaptive work procedures in case of exceedances of fish injury thresholds.

Appendices

Appendix IR2020-2.2-A Stantec Memo: RBT2 Causeway Breach Technical Evaluation

Appendix IR2020-2.2-B Stantec Memo: RBT2 Marine Terminal Breach Technical Evaluation

Appendix IR2020-2.2-C Northwest Hydraulic Consultants Report: RBT2 – Roberts Bank Causeway Breach Hydraulic and Geomorphic Assessments

Appendix IR2020-2.2-D Northwest Hydraulic Consultants Report: RBT2 – Marine Terminal Breach Hydraulic Assessment

Appendix IR2020-2.2-E Hemmera Memo: RBT2 – Quantification of Productivity Losses from Potential Project-related Disruption to Juvenile Salmon Migration

References

Archipelago, GL Williams, and Precision Identification. 2009. Deltaport Third Berth Habitat Compensation Monitoring: Sandbar Stabilization Pre-construction Baseline Study. Prepared for Port Metro Vancouver, Prepared by Archipelago Marine Research Ltd., GL Williams and Associates Ltd., and Precision Identification Biological Consultants, Victoria, B.C.

Bottom, D. L., C. A. Simenstad, J. Burke, A. M. Baptista, D. A. Jay, K. K. Jones, E. Casillas, and M. H. Schiewe. 2005. Salmon at River's End: The Role of the Estuary in the Decline and Recovery of Columbia River Salmon. United States Department of Commerce, NOAA Technical Memorandum NMFS-NWFSC-68. Available at https://pdxscholar.library.pdx.edu/cgi/viewcontent.cgi?article=1023&context=cengin_fac. Accessed March 2021.

Chalifour, L., D. C. Scott, M. MacDuffee, J. C. Iacarella, T. G. Martin, and J. K. Baum. 2019. Habitat Use by Juvenile Salmon, Other Migratory Fish, and Resident Fish Species Underscores the Importance of Estuarine Habitat Mosaics. Marine Ecology Progress Series 625:145–162.

Gerwing, T. G., M. M. Davies, J. Clemens, A.-M. Flores, H. M. Thomson, K. R. Nelson, K. Kushneryk, E. K. Brouard-John, B. Harvey, and E. Plate. 2020. Do You Want to Breach an Embankment? Synthesis of the Literature and Practical Considerations for Breaching of Tidally Influenced Causeways and Dikes. Estuarine, Coastal and Shelf Science 245:107024.

Hastie, G. D., D. J. F. Russell, S. Benjamins, S. Moss, B. Wilson, and D. Thompson. 2016. Dynamic Habitat Corridors for Marine Predators; Intensive Use of a Coastal Channel by Harbour Seals is Modulated by Tidal Currents. Behavioural Ecology and Sociobiology 70:2161–2174.

Healey, M. C. 1991. Life History of Chinook Salmon (*Oncorhynchus tshawytscha*). Pages 311–394. In C. Groot, and L. Margolis, Editors, Pacific Salmon Life Histories. UBC Press.

Hemmera, NHC, and Precision Identification. 2010. Deltaport Third Berth Adaptive Management Strategy 2010 Annual Report. Prepared for Vancouver Fraser Port Authority, Prepared by Hemmera Envirochem Inc., Northwest Hydraulic Consultants, and Precision Identification Biological Consultants, Burnaby, B.C.

Hering, D. K., D. L. Bottom, E. F. Prentice, K. K. Jones, and I. A. Fleming. 2010. Tidal Movements and Residency of Sub-yearling Chinook Salmon (*Oncorhynchus tshawytscha*) in an Oregon Salt Marsh Channel. Canadian Journal of Fisheries and Aquatic Sciences 67:524–533.

Levings, C. D. 1982. Short Term Use of a Low Tide Refuge in a Sandflat by Juvenile Chinook (*Oncorhynchus tshawytscha*), Fraser River Estuary. Canadian Technical Report of Fisheries and Aquatic Sciences No. 1111. Available at https://waves-vagues.dfo-mpo.gc.ca/Library/31537.pdf. Accessed March 2021.

Levy, D. A., and T. G. Northcote. 1982. Juvenile Salmon Residency in a Marsh Area of the Fraser River Estuary. Canadian Journal of Fisheries and Aquatic Sciences 39(2):270–276.

Pellett, K., J. Craig, and C. Wightman. 2013. Preliminary Investigation of Habitat Preferences and Abundance of Juvenile Chinook Salmon in the Lower Cowichan River Floodplain (Spring, 2013), with Reference to Habitat Compensation Options. BC Conservation Foundation, Lantzville, B.C. Available at https://marinesurvivalproject.com/wp-content/uploads/Cowichan-River-Juveniles_FINAL-DRAFT-Oct-8-2013.pdf. Accessed February 2021.

Rempel, L. L., K. Healey, and F. J. A. Lewis. 2012. Lower Fraser River Juvenile Fish Habitat Suitability Criteria. Canadian Technical Report of Fisheries and Aquatic Sciences 2991. Available at https://waves-vagues.dfo-mpo.gc.ca/Library/346413.pdf. Accessed February 2021.

Riddell, B., R. D. Brodeur, A. V. Bugaev, P. Moran, J. M. Murphy, J. A. Orsi, M. Trudel, L. A. Weitkamp, B. K. Wells, and A. C. Wertheimer. 2018. Ocean Ecology of Chinook Salmon. Pages 555–696, in R. J. Beamish, Editor. Ocean Ecology of Pacific Salmon and Trout. The American Fisheries Society, Bethesda, MD.

Scott, D. C., L. Chalifour, M. MacDuffee, J. K. Baum, and S. G. Hinch. 2019. Variation in Out-migration Timing and Estuary Reliance of “Ocean-type” Chinook Salmon in the Fraser River Estuary, B.C. North Pacific Anadromous Fish Commission Technical Report 15. Available at https://npafc.org/wp-content/uploads/technical-reports/Tech-Report-15-DOI/Technical-Report-15.pdf. Accessed March 2021.

Shaffer, J. A., S. H. Munsch, and J. R. Cordell. 2020. Kelp Forest Zooplankton, Forage Fishes, and Juvenile Salmonids of the Northeast Pacific Nearshore. Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science 12:4–20.

Thompson, D., A. J. Coram, R. N. Harris, and C. E. Sparling. 2020. Review of Non-lethal Seal Control Options to Limit Seal Predation on Salmonids in Rivers and Fish Farms. Scottish Marine and Freshwater Science Vol 12 No 6. Available at https://data.marine.gov.scot/sites/default/files//Scottish%20Marine%20and%20Freshwater%20Science%20%28SMFS%29%20Vol%2012%20No%206%20-%20Review%20of%20non-lethal%20seal%20control%20options%20to%20limit%20seal%20predation%20on%20salmonids%20in%20rivers%20and%20at%20finfish%20farms.pdf. Accessed July 2021.

Weinstein, M. P., and D. A. Kreeger. 2000. Concepts and Controversies in Tidal Marsh Ecology. Springer, New York.

Zamon, J. E. 2001. Seal Predation on Salmon and Forage Fish Schools as a Function of Tidal Currents in the San Juan Islands, Washington, USA. Fisheries Oceanography 10(4):353–366.