PORT of vancouver | Vancouver Fraser Port Authority

IR2020-4 Biofilm and Effects to Migratory Birds

Background

In his letter of August 24, 2020,[1] the minister of environment and climate change (the minister) requested the Vancouver Fraser Port Authority (the port authority) provide additional information regarding avoidance and other mitigation measures, including technically feasible project design options, to avoid or reduce effects to fish and fish habitat. In the following responses, the port authority has provided additional information regarding the feasibility of on-site design changes, from an engineering design and constructability standpoint, as well as other considerations:

- **IR2020-2.1** – describes potential on-site design optimizations that could reduce the project's proposed reference concept design footprint[2] by up to approximately 14.4 hectares (ha)
- **IR2020-2.2** – describes potential breach locations at the east end of the marine terminal and at three potential locations along the causeway

For considerations related to feasibility for these design changes, please consult the applicable response.

The minister also requested that, in respect of any technically feasible on-site design changes, the port authority undertake a geomorphological assessment. This response includes the requested assessments, including predictions for salinity and coastal processes, assuming the inclusion of these design changes. This response also summarizes the implications for biofilm and migratory birds of these design changes, including results of the geomorphic assessment.

Response

Minister's request: If alternate on-site design options are being considered for the Caisson–Pile and Deck Wharf, the Caisson–Flow Passage Channel, or other components of the Project in consideration of fish and fish habitat mitigation measures referenced above, undertake a geomorphological assessment of each of the technically feasible on-site design alternatives.

Port authority response:

The port authority has undertaken the requested geomorphological assessment to predict changes from technically feasible (from an engineering design and constructability standpoint) on-site design changes to four key physical parameters: salinity, tidal flows (tidal currents), waves (expressed in terms of wave height), and erosion and deposition (i.e., morphodynamic evolution of the seabed). These assessments include modelling for two scenarios:

- Scenario 1 – potential project footprint reduction of 14.4 ha (maximum potential reduction chosen for modelling purposes), consisting of reduction of the marine terminal footprint by 10.3 ha and the widened causeway by 4.1 ha (as described in **IR2020-2.1**)

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[1] CIAR Document #2067 From the Minister of Environment and Climate Change to the Vancouver Fraser Port Authority re: Information Request. https://iaac-aeic.gc.ca/050/documents/p80054/135827E.pdf

[2] Described in CIAR Document #181 Roberts Bank Terminal 2 Project – Environmental Impact Statement, Volume 1, Section 4 (Project Description) (https://www.ceaa-acee.gc.ca/050/documents/p80054/101388E.pdf) and updates provided in CIAR Document #1210 Project Construction Update (https://www.ceaa-acee.gc.ca/050/documents/p80054/122934E.pdf).

- Scenario 2 – potential project footprint reduction (**IR2020-2.1**) in Scenario 1, plus causeway breach location 3 (as described in **IR2020-2.2**)

For Scenario 1, modelling was conducted to predict changes to all four physical parameters. For Scenario 2, only modelling of salinity was undertaken, as the modelling results from Scenario 1 for the other three parameters are applicable to Scenario 2. The incorporation of a breach in the causeway (Scenario 2) is unlikely (based on known coastal processes) to induce appreciable changes to seabed morphology through erosion and sedimentation, or changes in waves or tidal flow. As described later in this response, morphological changes on the tidal flats (i.e., formation of tidal channels at causeway breach entrances), and scour at the marine terminal breach entrances, are not represented in the numerical model results described in this response, but are described using empirical and geomorphic assessment approaches in **IR2020-2.2**.

A third scenario, Scenario 3, which consists of a potential project footprint reduction of 14.4 ha (**IR2020-2.1**), plus a marine terminal breach (**IR2020-2.2**), was also assessed, but not modelled directly. The assessment for Scenario 3 is based on the results of modelling for Scenarios 1 and 2 that are representative of the anticipated changes to waves, currents, and the seabed, and assessed changes in salinity based on known coastal processes. The rationale for this approach is described in more detail below.

The outcomes of geomorphological assessment per the minister's specific requirements for the four physical parameters, as set out in his letter of August 24, 2020, are described below, assuming the hypothetical incorporation of each scenario in the proposed reference concept design.

Assessment approach

Minister's specific requirement:

The geomorphological assessments shall:

- **model the change in salinity over Roberts Banks. Modelling shall be conducted using the same approach as was used in the Environmental Impact Statement;**

Port authority response:

Numerical modelling to assess the potential changes that the project might have on the physical processes at Roberts Bank was previously undertaken using the TELEMAC-MASCARET (Telemac) numerical modelling system. The numerical modelling approach is outlined in the environmental impact statement (EIS), Section 9.5.5 Coastal Geomorphology, Methods, and a detailed description is documented in EIS Appendix 9.5-A and in related information supplements and requests.[3] As requested by the minister, the same approach has been used to model changes to four physical parameters, with the following required modifications:

- Changes to the model mesh and model boundaries to represent the extent of the reduced project footprint (Scenario 1 only)
- Refinements to the model mesh to support the calculation of flow through the causeway breach (Scenario 2 only)

These modifications were incorporated in the Telemac model to specifically represent the reduced project footprint and the causeway breach. These required changes to the model are known to have a potential effect on how the model calculates some of the physical parameters, in particular salinity, as compared to the model setup that was used for the EIS. This known effect was taken into consideration during the validation of model results

[3] CIAR Document #547 From the VFPA to the Review Panel re: Answers to preliminary technical questions submitted during the completeness phase from Fisheries and Oceans Canada, Natural Resources Canada, and Environment and Climate Change Canada, concerning the ecosystem modelling to support the Roberts Bank Terminal 2 Project environmental review (https://iaac-aeic.gc.ca/050/documents/p80054/115571E.pdf); and CIAR Document #934 VFPA Response to Information Request Package 2 (https://iaac-aeic.gc.ca/050/evaluations/document/128131).

and the presentation of predictions (when comparing results from the EIS model with those from the updated model).

Statistical summaries of predicted salinity changes

Minister's specific requirement:

The geomorphological assessments shall:

- **show statistical summaries of predicted salinity changes, including mean, median, minimum, maximum, standard deviation, 90th percentile, 95 Upper Confidence Limits for Means for the range of current salinity concentrations, and the predicted changes with the alternate project designs. These summaries shall be predicted under both freshet and non-freshet conditions;**
- **present results as in Table IR-02-3 and related figures, and using the spatial extent shown in Figures 9.7-3, 9.7-4, 9.7-9 and 9.7-10 in Section 9.7 of the Environmental Impact Statement;**

Port authority response:

Table IR2020-4-1 summarizes the statistical expressions of salinity that have been requested. This summary is similar to that which was provided in the response to IR2-02,[4] and is provided here for clarity.

Table IR2020-4-1: Summary of statistical expressions of model salinity output

Statistic	Explanation
Mean	The average of all values, calculated by summing all values and dividing by the number of values
Median	When all values are ranked, the median value lies in the middle of the population such that 50% of the values are greater and 50% of the values are smaller. The median value is the same as the 50th percentile value.
Minimum	The lowest value in the dataset
Maximum	The highest value in the dataset
Standard deviation (STD)	The square root of the variance of the values in the dataset. This statistic describes how much the values vary from the central mean. Two assumptions are made: 1) each value in the dataset is independent of the others (which is not true in the case of salinity values), and 2) the population fits a normal distribution (which is an untested assumption). In areas where salinity is more variable (e.g., the upper intertidal) the STD will be larger relative to areas that are less variable (e.g., Strait of Georgia).
50th percentile	See explanation for median value above. 50th percentile is provided for comparison purposes, since IR2-02 and EIS Section 9.7 utilized 50th percentile values in describing potential changes in the future with the project.
90th percentile	When all values are ranked, the 90th percentile value describes the value for which 10% of salinity values are greater and 90% are smaller.
95 upper confidence limits for means (95% upper CI)	This is a statistical expression of the confidence with which the mean is estimated for a sample of the population. This statistic is not applicable to the salinity data output from the TELEMAC-3D model because means are derived from the entire population of salinity values.

[4] The previous salinity-related information request response relevant to this response is IR2-02 (CIAR Document #934) and the table reference in this information request should have been IR2-02-3, not IR-02-3.

Table IR2020-4-2 provides a summary of model runs and the corresponding figure numbers where the results are presented. For the purposes of responding to this part of the minister's request, results from modelling of Scenario 1 are presented, as the changes to salinity associated with the causeway breach (Scenario 2) are too small to be visible at the requested scale. Therefore, **Figure IR2020-4-1** to **Figure IR2020-4-4** reflect the expected salinity changes in the future with the project for Scenario 1, which are essentially indistinguishable from the expected salinity changes in the future with the project for Scenarios 2 and 3. As discussed below, **Figures IR2020-4-15** and **IR2020-4-16** provide a comparison of the change in salinity for freshet and non-freshet periods, respectively, that was previously predicted for the EIS reference concept design to that predicted for Scenario 1.

In the figures provided below, a statistical representation of the dataset[5] is made for each node (point value) in the area of interest to collapse the various values of salinity (numbering in the hundreds to thousands depending on the length of time that is modelled) to a single number at each node, and the results are plotted spatially. The values between nodes are interpolated to create a continuous map of predicted values. The theoretical maximum range in the values is from zero practical salinity units (psu) (i.e., freshwater) to 32, which is the maximum salinity experienced at Roberts Bank.[6] The statistical expressions for the freshet period (May to July) are based on the 2012 year and reflect an above average freshet year, while the non-freshet period (October to December) reflects a typical low flow period below the average freshet year.

Table IR2020-4-2: Summary of model runs for which statistics are presented

<table>
<tr><th rowspan="2">Statistic</th><th colspan="2">Freshet period</th><th colspan="2">Non-freshet period</th><th colspan="2">Existing conditions minus future conditions</th></tr>
<tr><th>Existing conditions</th><th>Future conditions</th><th>Existing conditions</th><th>Future conditions</th><th>Freshet period</th><th>Non-freshet period</th></tr>
<tr><td>Mean</td><td rowspan="8">Provided in IR2-02 (Figure IR2-02-5)</td><td rowspan="8">Figure IR2020-4-1</td><td rowspan="8">Provided in IR2-02 (Figure IR2-02-7)</td><td rowspan="8">Figure IR2020-4-2</td><td rowspan="8">Figure IR2020-4-3</td><td rowspan="8">Figure IR2020-4-4</td></tr>
<tr><td>Median</td></tr>
<tr><td>Minimum</td></tr>
<tr><td>Maximum</td></tr>
<tr><td>Standard Deviation (STD)</td></tr>
<tr><td>50th Percentile</td></tr>
<tr><td>90th Percentile</td></tr>
<tr><td>95 Upper Confidence Limits for Means (95% Upper CI)</td></tr>
</table>

[5] The entire dataset is analyzed, so in statistical terms, the sample and the population are the same.
[6] For reference, the maximum salinity measured near the mouth of Juan de Fuca Strait in June and September 2012 was 34.

Figure IR2020-4-1: Various statistical expressions of salinity during the freshet period under future conditions with reduced project footprint (Scenario 1)

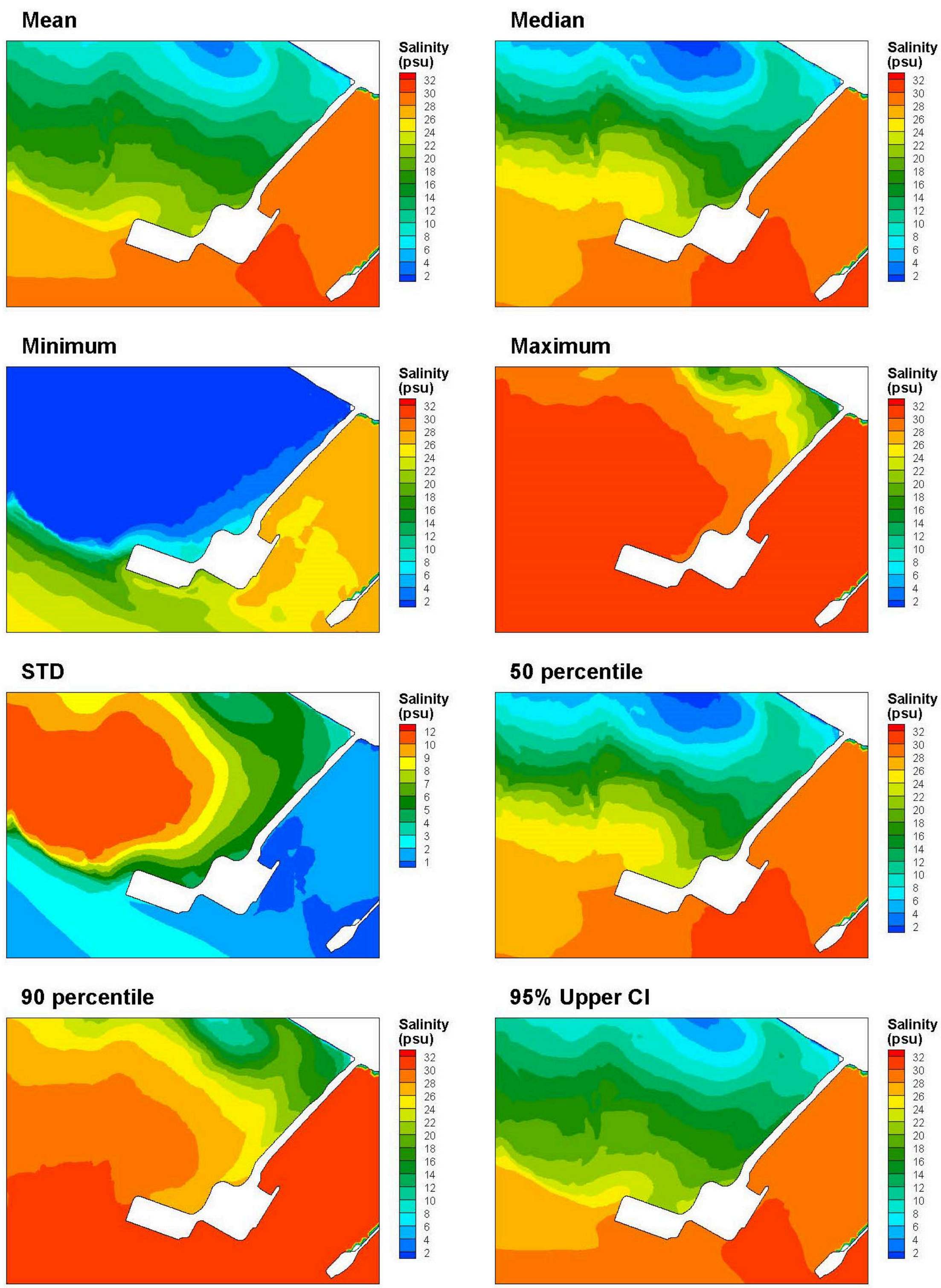


Figure IR2020-4-2: Various statistical expressions of salinity during the non-freshet period under future conditions with reduced project footprint (Scenario 1)

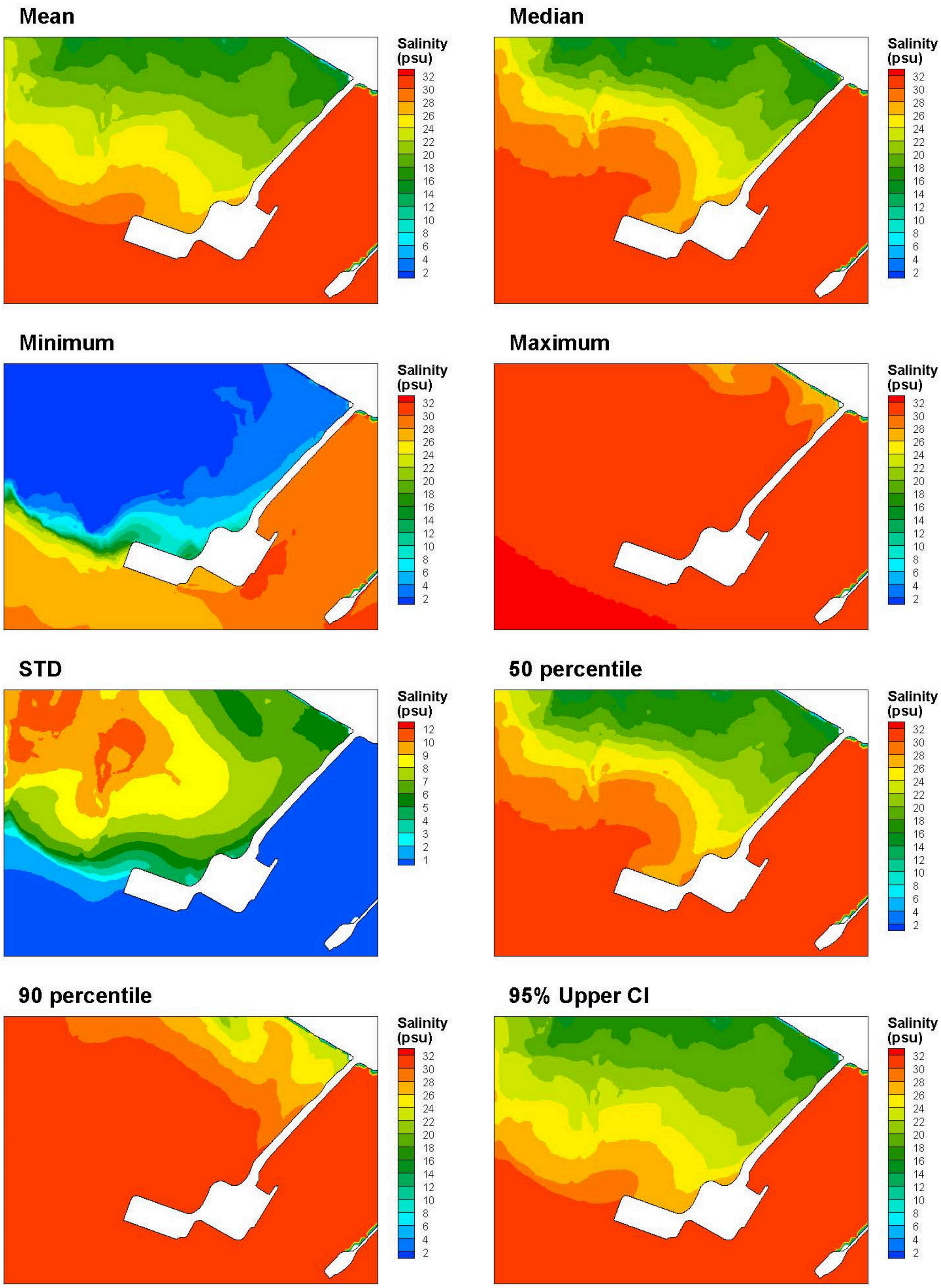


Figure IR2020-4-3: Various statistical expressions of salinity during the freshet period, shown as difference (delta) between existing conditions and future conditions with reduced project footprint (Scenario 1)

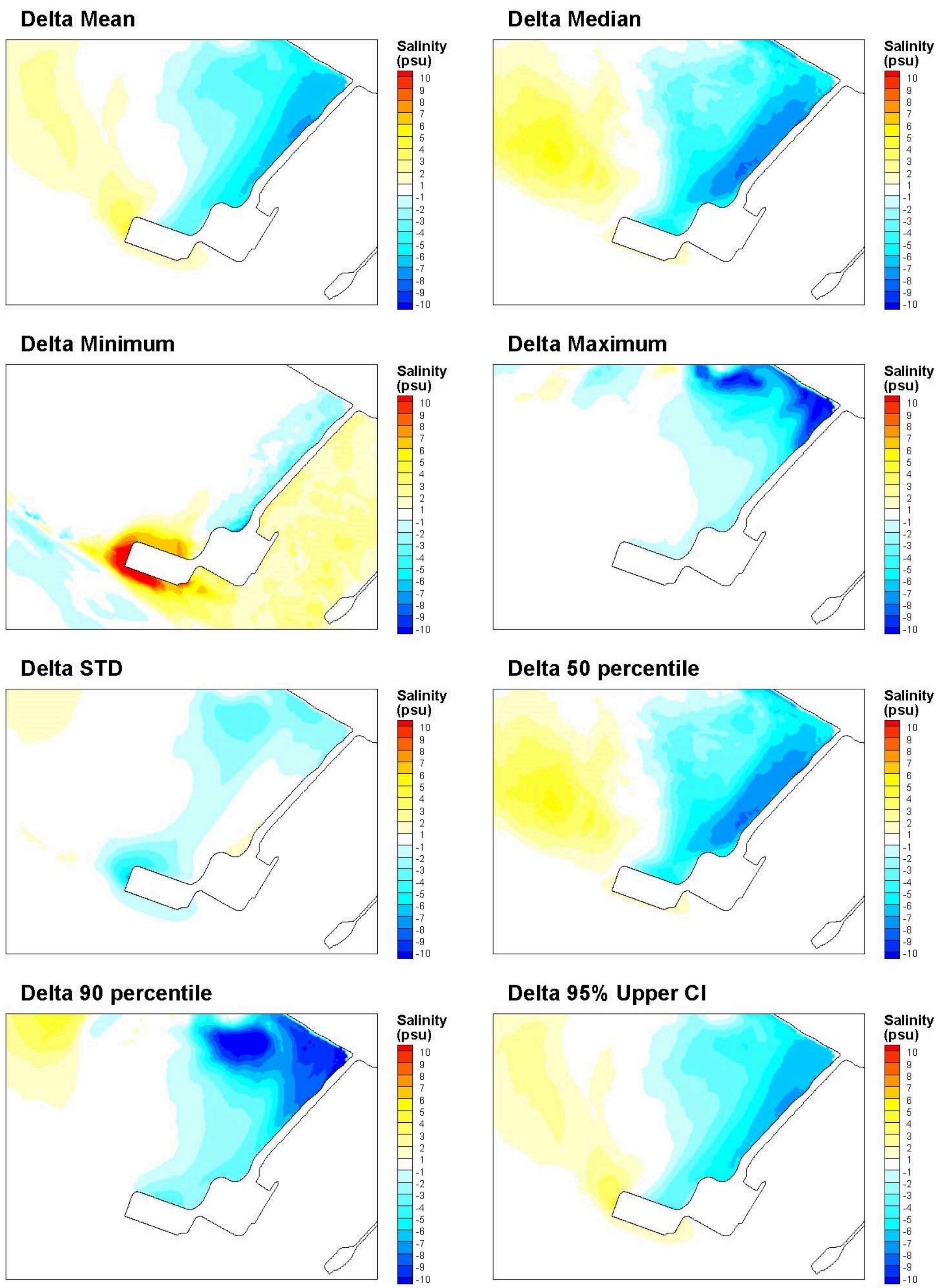
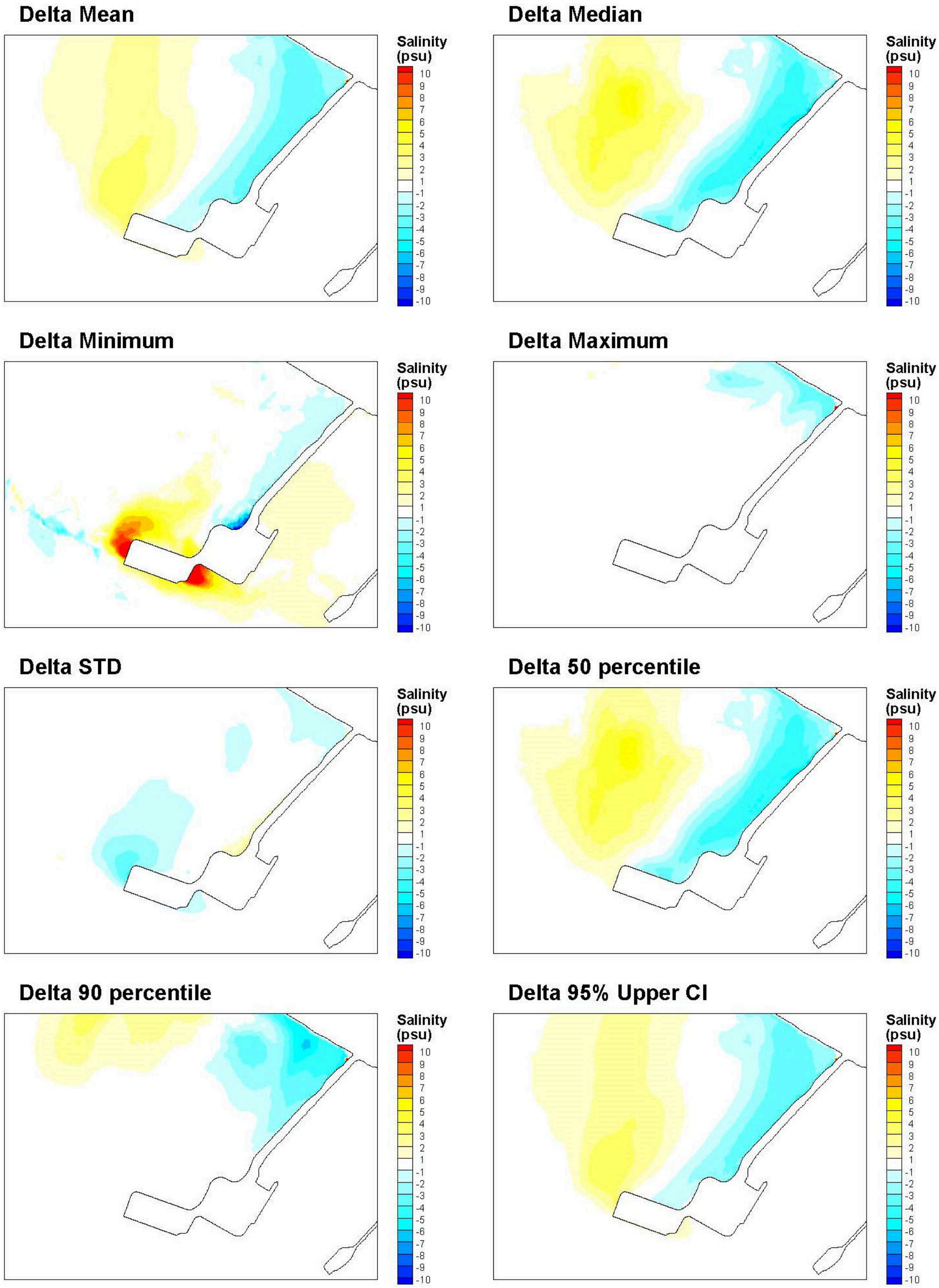


Figure IR2020-4-4: Various statistical expressions of salinity during the non-freshet period, shown as difference (delta) between existing conditions and future conditions with reduced project footprint (Scenario 1)



Predicted salinity from on-site project design changes

Minister's specific requirement:

The geomorphological assessments shall:

- **characterize the magnitude, geographic extent, duration and frequency of any change in the salinity regime;**

Port authority response:

The salinity regime at Roberts Bank varies spatially and temporally based on proximity to the Fraser River and in response to daily, seasonal, and inter-annual changes in tides and freshwater inputs (as shown above in **Figure IR2020-4-1** to **Figure IR2020-4-2** and described in EIS Section 9.7). The change that the reduced project footprint is expected to have on salinity, as compared to the change previously predicted for the EIS reference concept design, is very subtle (see discussion below regarding **Figures IR2020-4-15** and **IR2020-4-16**).

With respect to the magnitude, geographic extent, duration, and frequency of change in the salinity regime, **Figure IR2020-4-5** and **Figure IR2020-4-6** show the 50^{th} percentile salinity for the reduced project footprint (Scenario 1) during the freshet and non-freshet periods, respectively. **Figure IR2020-4-7** and **Figure IR2020-4-8** show the difference between the 50^{th} percentile salinity for existing conditions (EIS Appendix 9.5-A Figure 74 and Figure 76) and Scenario 1 (**Figure IR2020-4-5** and **Figure IR2020-4-6**) during the freshet and non-freshet periods, respectively. These difference results are essentially indistinguishable from those presented in EIS Appendix 9.5-A Figure 78 for the freshet period, indicating that the 14.4 ha footprint reduction would not measurably change salinity. A comparison to a previously submitted figure describing changes with the EIS reference concept design during the non-freshet period is not available in the EIS.[7]

The changes to the salinity regime for freshet and non-freshet periods that are expected to occur as a result of the addition of a causeway breach in Scenario 2 are shown in **Figures IR2020-4-9** and **IR2020-4-10**. As shown in **Figure IR2020-4-11** and **Figure IR2020-4-13**, the difference between Scenario 1 and Scenario 2 is not visible at the requested figure scale. A larger figure scale is shown in **Figure IR2020-4-12** and **Figure IR2020-4-14** to illustrate the small spatial extent over which the change to salinity induced by flow exchange across the causeway occurs during the freshet and non-freshet periods, respectively. For the freshet period (**Figure IR2020-4-12**) the difference is an increase of between 1 and 2 psu over an 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 winter period (**Figure IR2020-4-14**), but the extent is smaller (approximately 10 m by 10 m), and only detectable near the north entrance. The smaller effect during the non-freshet period is due to the fact that there is less freshwater present in the system and so the difference in salinity on either side of the causeway is smaller.

As noted above, the marine terminal breach (Scenario 3) was not modelled directly. Given the very small change in salinity related to the Scenario 2 causeway breach, the marine terminal breach would be expected to have an insignificant influence on salinity. This conclusion is based in part on comparing the salinity regime of the inter-

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[7] During development of this information request response, a review of relevant non-freshet salinity figures presented in IR2-02 and EIS Appendix 9.5-A was undertaken. In both of these documents, figures showing future conditions with the EIS reference concept design were erroneously generated from interim model results rather than final production run results, resulting in a reported salinity difference of approximately 1–2 psu in localized areas, as compared to the final production run results. The correct values of predicted project-related salinity change in the non-freshet period show a smaller reduction in salinity in the zone adjacent to the causeway and in the upper intertidal area (see **Figure IR2020-4-16**). These errors in figures apply only to the non-freshet period and do not materially impact any results or related analysis of project effects on valued components. The comparisons of modelling for Scenario 1 to the EIS reference concept design presented in this response are to the final production run results.

causeway area, which is essentially fully saline, to that on the north side of the causeway, which is influenced by freshwater from the Fraser River. Also of note is the extremely small flow exchange induced by either of the breach locations (see response to **IR2020-2.2**). Compared to the salinity difference between the seaward and shoreward sides of the marine terminal, which is only 5–6 psu during the freshet period and 1–2 psu during the non-freshet period, the change induced by the terminal breach would be insignificant.

Regarding duration and frequency, the salinity at any location at Roberts Bank is highly variable through time; however, there is a general spatial pattern that emerges on average: fresher conditions in close proximity to the outlet of Canoe Passage and higher salinity conditions at more distal locations. The spatial distribution of freshwater mixing across Roberts Bank is difficult to map over various time scales. During the port authority's oral presentation to the Roberts Bank Terminal 2 (RBT2) review panel at the public hearing on western sandpiper and biofilm on May 27, 2019, the port authority presented a video that more effectively shows the distribution of salinity in response to rising and falling tides at Roberts Bank during a neap and spring tide cycle of the western sandpiper's northward migration period. Existing conditions (without the project) are shown in the left panel of the video, which is available via the Canadian Impact Assessment Registry.[8] As illustrated in the video (right panel showing future conditions with the project) and described in EIS Section 9.7, the marine terminal is expected to change the direction of tidal currents over the tidal flats in the vicinity of the terminal, primarily because tidal exchange that presently flows directly on and off shore will need to flow around the proposed structure. This video is representative of conditions for both the project reference concept design, which is described in the EIS, and the scenario incorporating a project footprint reduction. This is because the directional effect is largely a function of the length of the terminal, which is not changing with the project footprint reduction design change (see below for further information). Over much of this area, the change to salinity is subtle and the difference is relatively small compared to the large daily, seasonal, and inter-annual variations that occur because of changes to the volume of freshwater discharging from the Fraser River and tidal variability.

[8] CIAR Document #1778 Vancouver Fraser Port Authority oral presentation: Coastal birds - Western sandpiper and biofilm, May 27, 2019, at Slide 16. Video link: https://youtu.be/phpi0gKk3fw.

Figure IR2020-4-5: 50th percentile salinities associated with the freshet period under future conditions with reduced project footprint (Scenario 1)

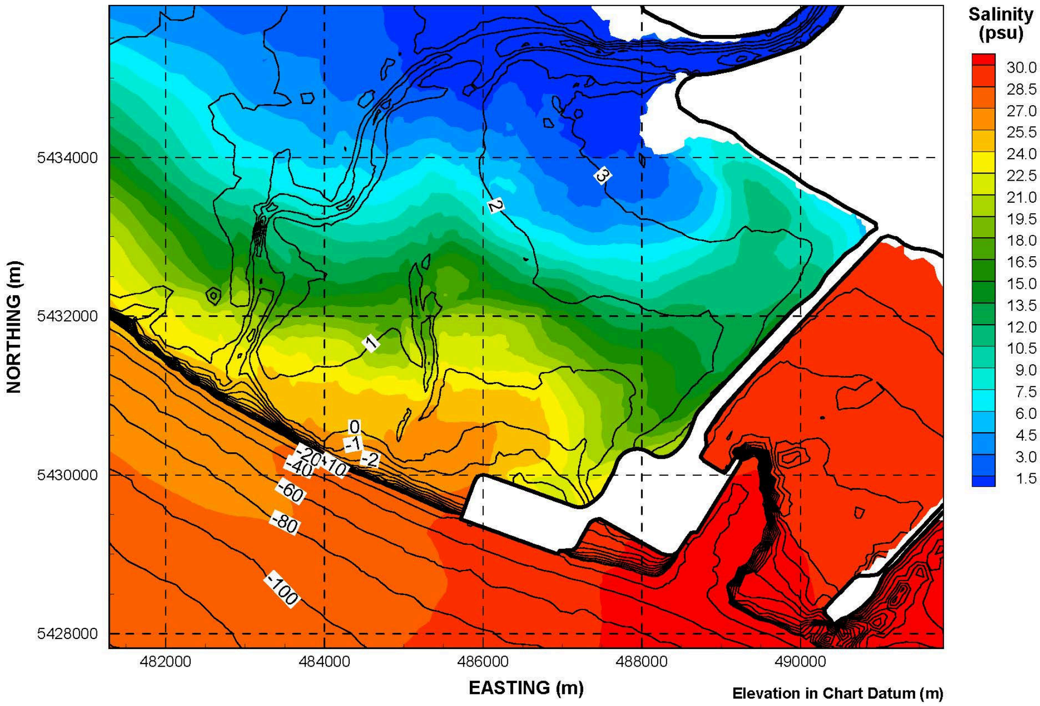


Figure IR2020-4-6: 50th percentile salinities associated with the non-freshet period under future conditions with reduced project footprint (Scenario 1)

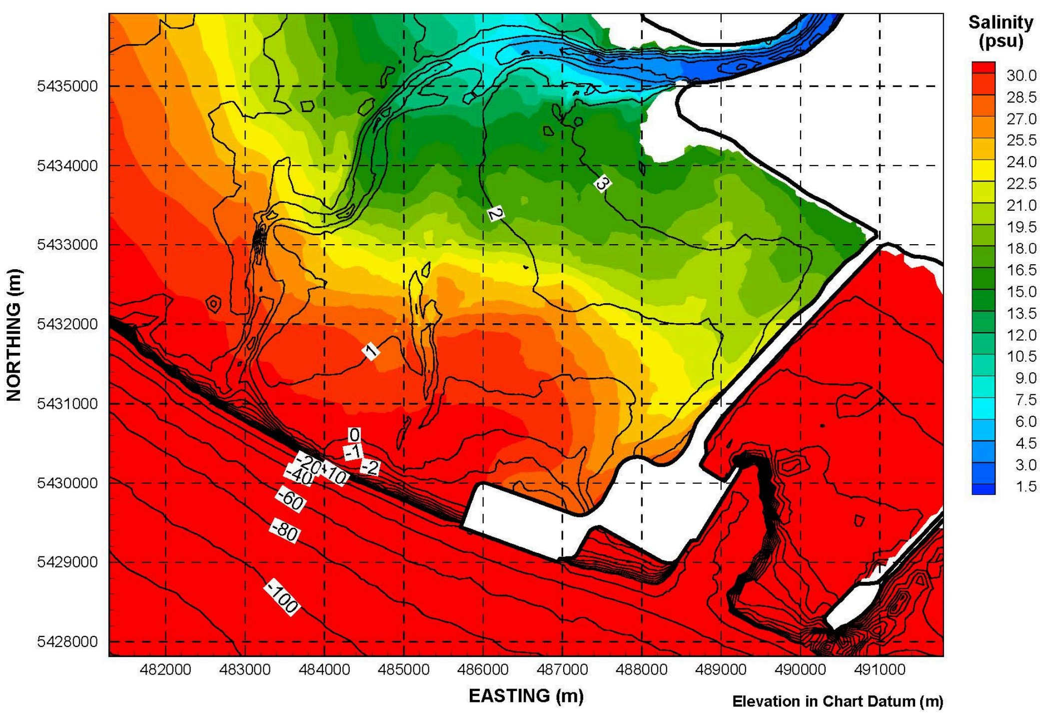
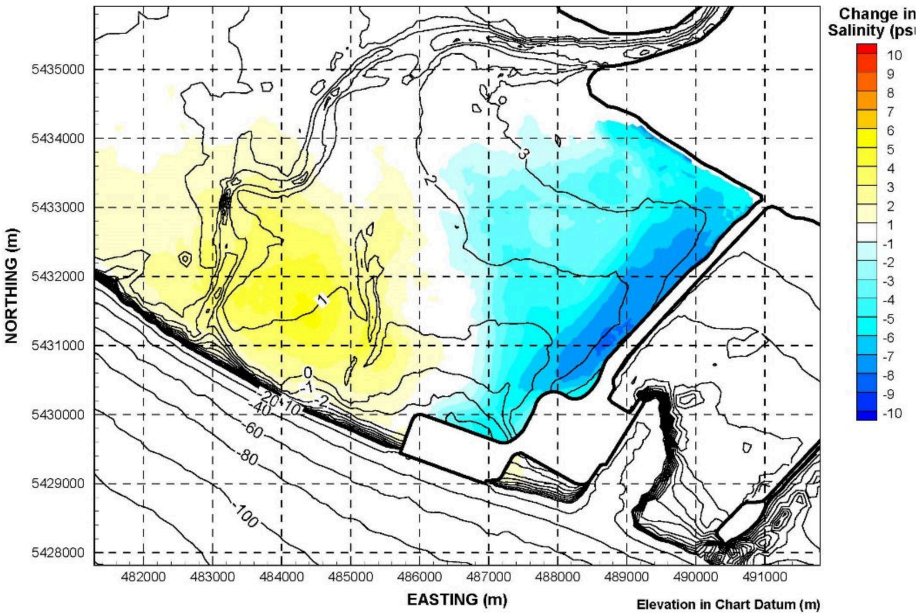
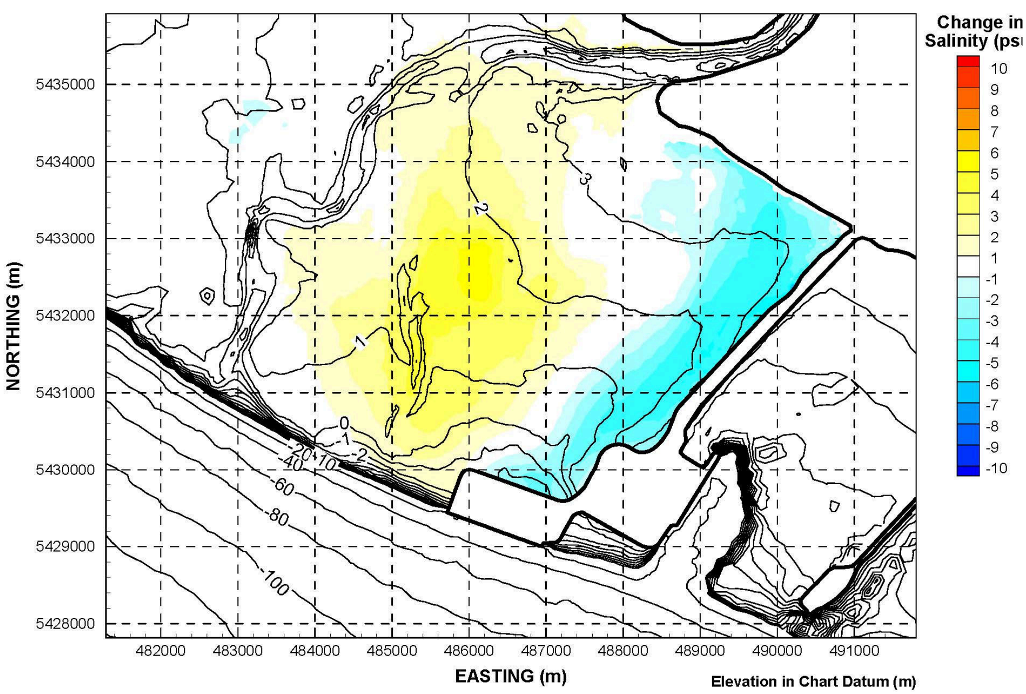


Figure IR2020-4-7: Predicted change* in 50th percentile salinities associated with the freshet period comparing existing conditions predictions (per the EIS) and Scenario 1 predictions



* Calculated based on difference between EIS Appendix 9.5-A Figure 74 (existing conditions for freshet period) and **Figure IR2020-4-5.** The comparable figure for predicted changes comparing existing conditions and the footprint of the EIS reference concept design is EIS Appendix 9.5-A Figure 78.

Figure IR2020-4-8: Predicted change* in 50th percentile salinities associated with the non-freshet period comparing existing conditions predictions (per the EIS) and Scenario 1 predictions



* Calculated based on difference between EIS Appendix 9.5-A Figure 76 (existing conditions for non-freshet period) and **Figure IR2020-4-6.** A comparable figure from the EIS is not available (see footnote 7 above).

Figure IR2020-4-9: 50th percentile salinities associated with the freshet period under future conditions with reduced project footprint and causeway breach (Scenario 2)

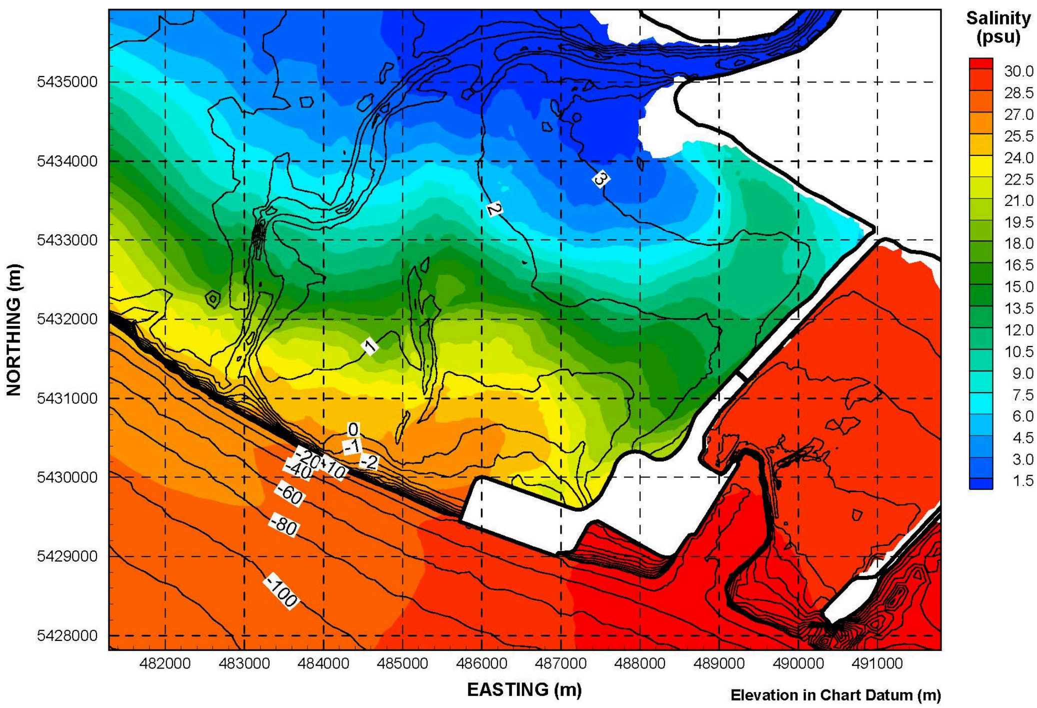


Figure IR2020-4-10: 50th percentile salinities associated with the non-freshet period under future conditions with reduced project footprint and causeway breach (Scenario 2)

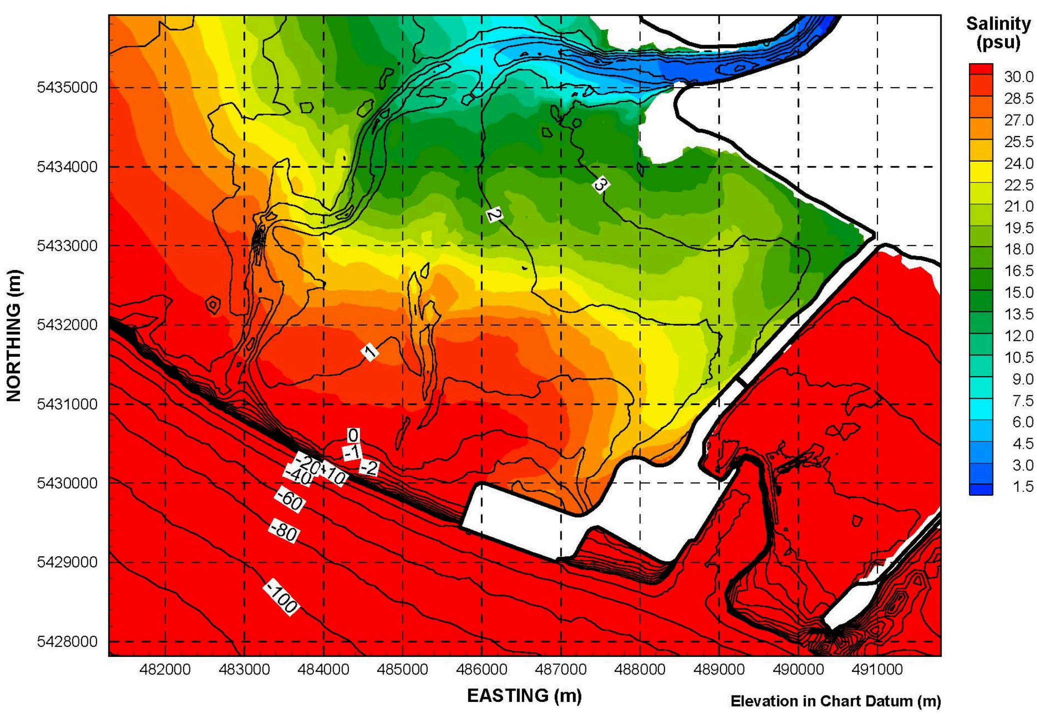
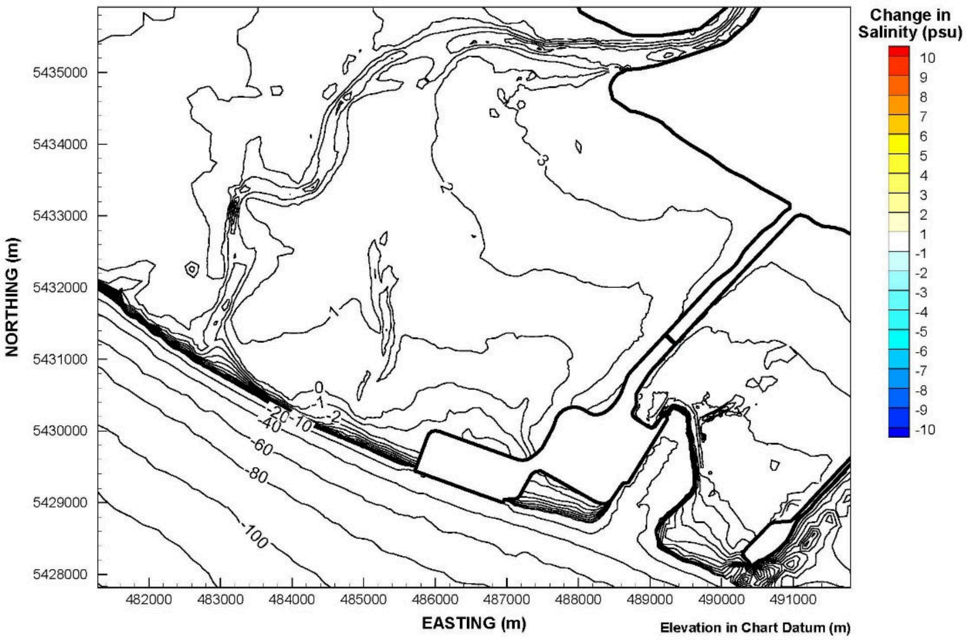


Figure IR2020-4-11: Predicted change* in 50th percentile salinities associated with the freshet period comparing Scenario 1 with Scenario 2 at requested spatial scale



* Calculated based on difference between **Figure IR2020-4-5** and **Figure IR2020-4-9**

Figure IR2020-4-12: Predicted change* in 50th percentile salinities associated with the freshet period comparing Scenario 1 with Scenario 2, at larger spatial scale at causeway breach location 3

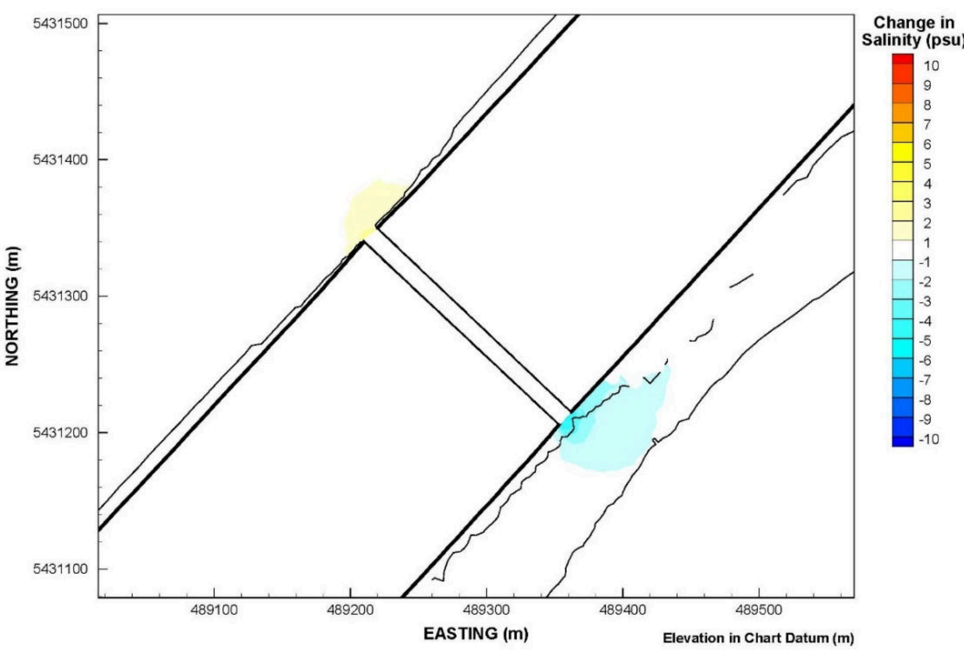
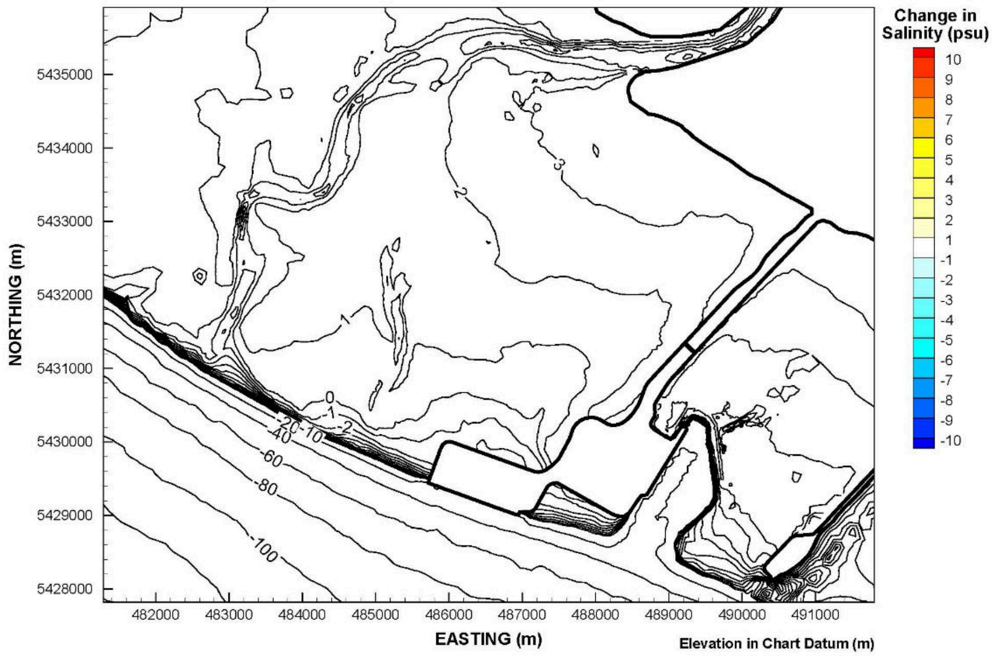
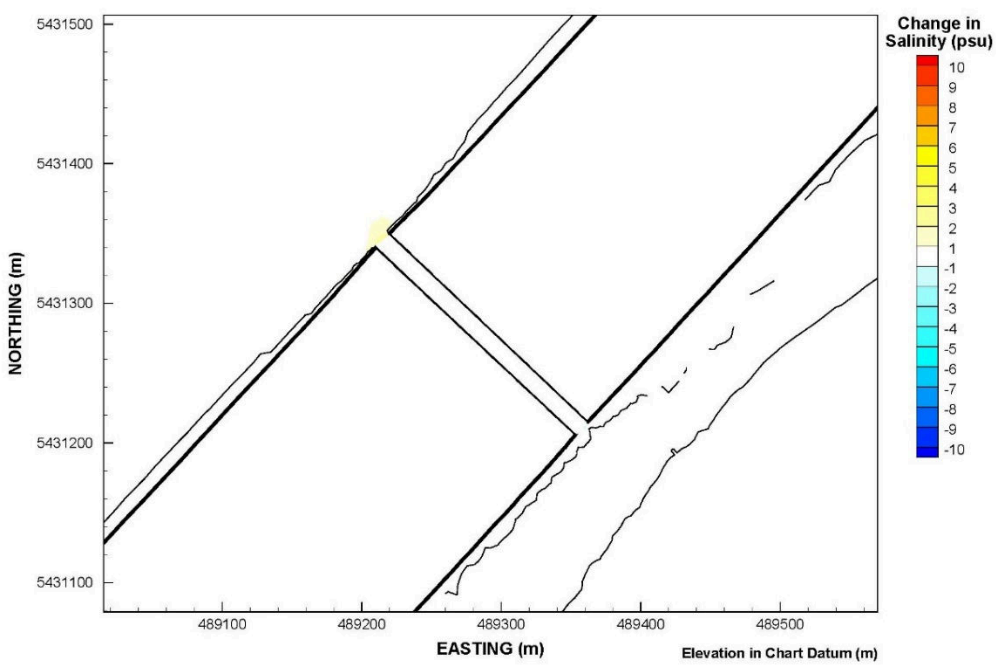


Figure IR2020-4-13: Predicted change* in 50th percentile salinities associated with the non-freshet period comparing Scenario 1 with Scenario 2 at requested spatial scale



* Calculated based on difference between **Figure IR2020-4-6** and **Figure IR2020-4-10**

Figure IR2020-4-14: Predicted change in 50th percentile salinities associated with the non-freshet period comparing Scenario 1 with Scenario 2, at larger spatial scale at causeway breach location 3



Minister's specific requirement:

The geomorphological assessments shall:

- **describe the relative difference in measured change in the salinity regime (as described in the bullets above) to the current design option and the other design alternatives under consideration;**

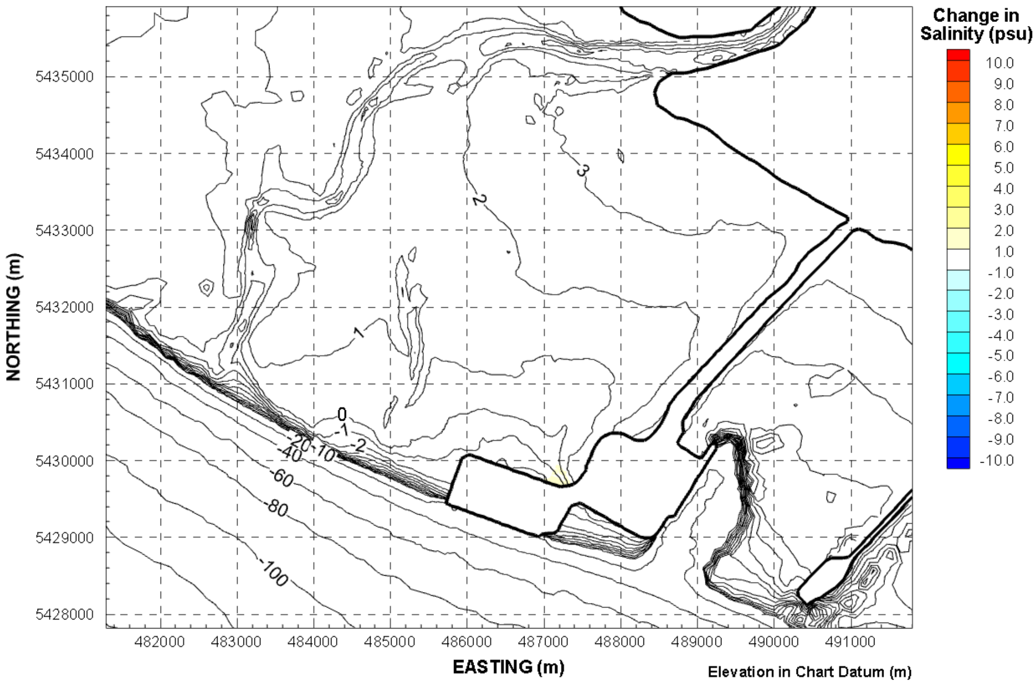
Port authority response:

To clarify, this part of the response to the minister's request is based on model-predicted changes, not measured changes, as the current project reference concept design, which is described in the EIS, and the design changes presented in Scenarios 1 to 3 are future potential design changes.

As demonstrated above, the relative differences in predicted salinity changes between Scenarios 1, 2, and 3 are extremely small to non-existent, due to the relatively insignificant amount of flow that is exchanged across either of the potential breach locations (causeway or marine terminal) compared to the overall volume of water exchanging over the tidal flats. Similarly, despite the reduction in the project footprint by 14.4 ha, the modelled change to salinity during the freshet and non-freshet periods compared to the existing conditions is essentially the same as that predicted for the EIS reference concept design (as shown in the EIS and reiterated in IR2-02 for the freshet period)**.** The comparisons shown in both **Figure IR2020-4-15** and **Figure IR2020-4-16** are between the predicted changes for the project reference concept design and Scenario 1 configuration for the freshet period and non-freshet periods, respectively.

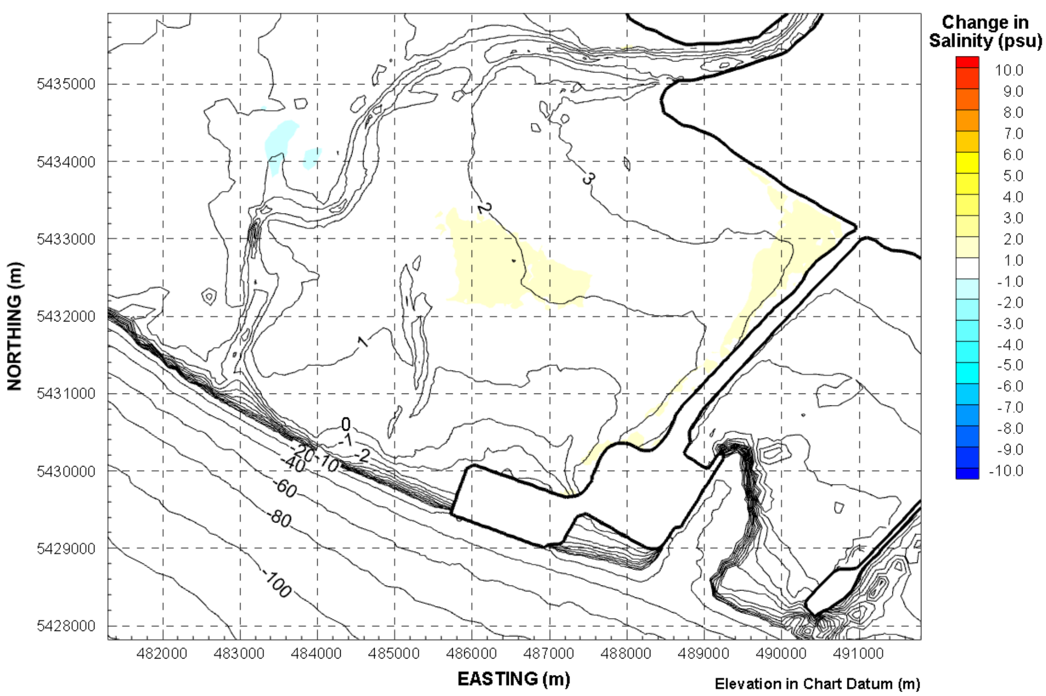
These results are expected. The anticipated change to salinity at Roberts Bank is primarily related to the change in direction of tidal currents induced by the project, which is largely a function of the length of the proposed terminal. The marine terminal footprint reduction that is being considered (approximately up to 10.3 ha along the north side of the marine terminal) will reduce the terminal width (by approximately 67 m) but not the overall length of the terminal. As a result, the footprint reduction would not appreciably change the magnitude or direction of tidal currents, as compared to the project reference concept design that was evaluated for the EIS.

Figure IR2020-4-15: Predicted change* in 50th percentile salinities associated with the freshet period comparing the EIS project reference concept design predictions with Scenario 1 predictions



* Calculated based on difference between EIS Appendix 9.5-A Figure 75 (future conditions, project reference concept design) and **Figure IR2020-4-5**

Figure IR2020-4-16: Predicted change* in 50th percentile salinities associated with the non-freshet period comparing the EIS project reference concept design predictions with Scenario 1 predictions



* Calculated based on difference between the results from the model run for future conditions, project reference concept design and **Figure IR2020-4-6.**

Minister's specific requirement:

The geomorphological assessments shall:

- **characterize the magnitude, geographic extent, frequency and reversibility of any change in other coastal processes, including erosion and deposition, wave height and tidal flow.**

Port authority response:

As described above, numerical modelling of currents, waves, and changes to the seabed (erosion and deposition) was undertaken for Scenario 1. The modelling results for Scenario 1 are also representative for Scenarios 2 and 3 because the additional influence of a causeway or marine terminal breach on these processes would be negligible, as explained further below. Modelling results for each parameter (currents, waves, and morphodynamics) are presented in the sub-sections below. In each case, the results are shown for the freshet and non-freshet periods, and comparisons are provided to the existing conditions (as documented in EIS Section 9.5, Appendix 9.5-A) for both freshet and non-freshet conditions.

A causeway or marine terminal breach is not expected to influence waves or currents over the adjacent areas of seabed. Waves would be attenuated (reduced) as they pass through the breach channel because of bed friction and interactions with culverts in the channel (or channel bends, as in the marine terminal breach), which would physically block the waves. Expected flow exchange through any of the breach locations is extremely small compared to the volume of water that is exchanged over the tidal flats in response to tides in the Strait of Georgia (see **IR2020-2.2**). As discussed in EIS Section 9.5, morphodynamic changes to the seabed that are calculated in the model are primarily driven by currents, and currents are not expected to be influenced by any of the breach locations. For these reasons, Scenario 1 model results for currents, waves, and morphodynamics are also representative of conditions for Scenarios 2 and 3. Based on the modelling results presented in the figures below that show both magnitude and geographic extent of current velocities (**Figure IR2020-4-17** and **Figure IR2020-4-18**) and waves (**Figure IR2020-4-21** and **Figure IR2020-4-22**), the expected changes to current velocities (**Figure IR2020-4-19** and **Figure IR2020-4-20**) and wave heights (**Figure IR2020-4-23** and **Figure IR2020-4-24**) are essentially the same as predicted in the EIS. This is expected given that the overall length of the marine terminal (east-west direction) is unchanged with the modelled footprint reduction (described further in **IR2020-2.1**, which indicates that a reduction in terminal length is not technically feasible, but a reduction in terminal width is). As noted above, the length of the terminal is also the primary factor for driving change in the direction of currents, and is also the most important factor with respect to interactions with waves. The reduction in overall width by up to 67 m of the marine terminal makes essentially no difference to currents, and would have only a very minor influence on waves coming from the northwest.

The frequency at which these changes occur is related to the frequency at which the physical processes occur. Currents are driven by the semi-diurnal tidal cycle, and the magnitude of change is directly related to the magnitude of the current speed; therefore, change from existing conditions would not be measurable during slack tide when currents are very small, and largest during the highest current speeds that occur during spring tide cycles. The changes are not reversible as they are caused by the interaction between the physical processes and the project infrastructure.

Based on the numerical model results, the only predicted appreciable difference that the reduced project footprint has on the physical parameters, as compared to the changes that were predicted to be induced by the footprint of the EIS reference concept design, is that the depth of scour and sediment deposition in the immediate vicinity of the terminal's rounded northwest corner are both slightly reduced[9] (**Figure IR2020-4-25** to **Figure IR2020-4-27**). This relatively minor change is most likely due to the north perimeter of the marine terminal (and northwest corner) being shifted seaward by approximately 67 m (i.e., shift to deeper water would reduce seabed erosional forces resulting from flow being diverted around the terminal during tidal exchanges). Neither tidal channel

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[9] The area of scour in the immediate vicinity of the terminal's rounded northwest corner, assuming a marine terminal footprint reduction of 10.3 ha, is estimated to be approximately 5 ha, as compared to 5.5 ha that was reported in EIS Section 9.5 based on the project reference concept design footprint.

development nor entrance scour are represented in the numerical model results described in this response. Nevertheless, further information on seabed scour resulting from the breach locations is described in the response to **IR2020-2.2**, including the following predictions and assessment approaches:

- It is anticipated that a tidal channel will form at both breach entrances for any of the causeway breach locations, based on a geomorphic assessment. It is not possible to accurately represent the processes that initiate and form tidal channels in the numerical model used in this geomorphological assessment (or another model, as discussed in **Appendix IR2020-2.2-C**).
- Scour of the seabed is predicted at each marine terminal breach entrance, based on an empirical analysis of changes in local shear stress and currents (**Appendix IR2020-2.2-D**). Due to the entrances being located in subtidal waters, tidal channel formation processes would not be induced.

Current velocity predictions

Figure IR2020-4-17: 50th percentile current velocities associated with the freshet period under future conditions with reduced project footprint (Scenario 1)

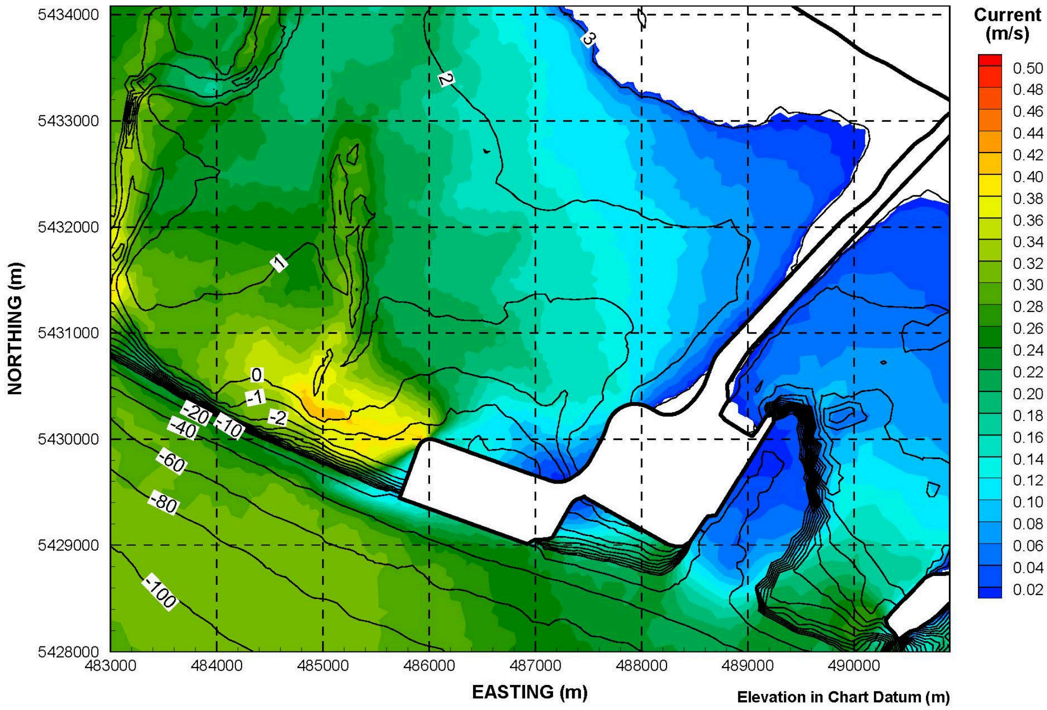


Figure IR2020-4-18: 50th percentile current velocities associated with the non-freshet period under future conditions with reduced project footprint (Scenario 1)

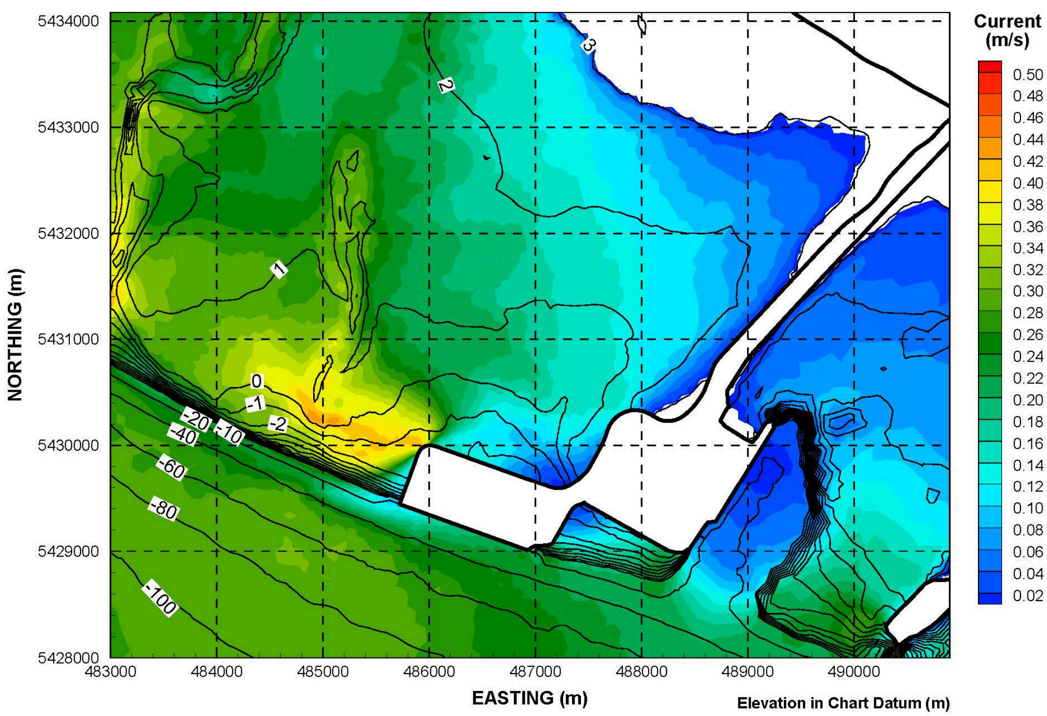
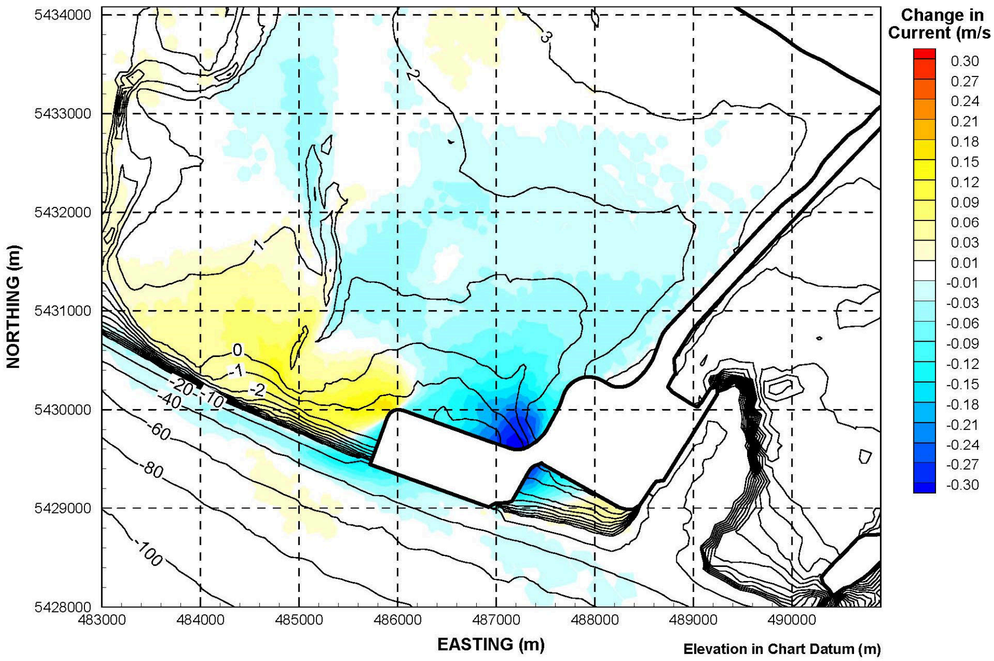
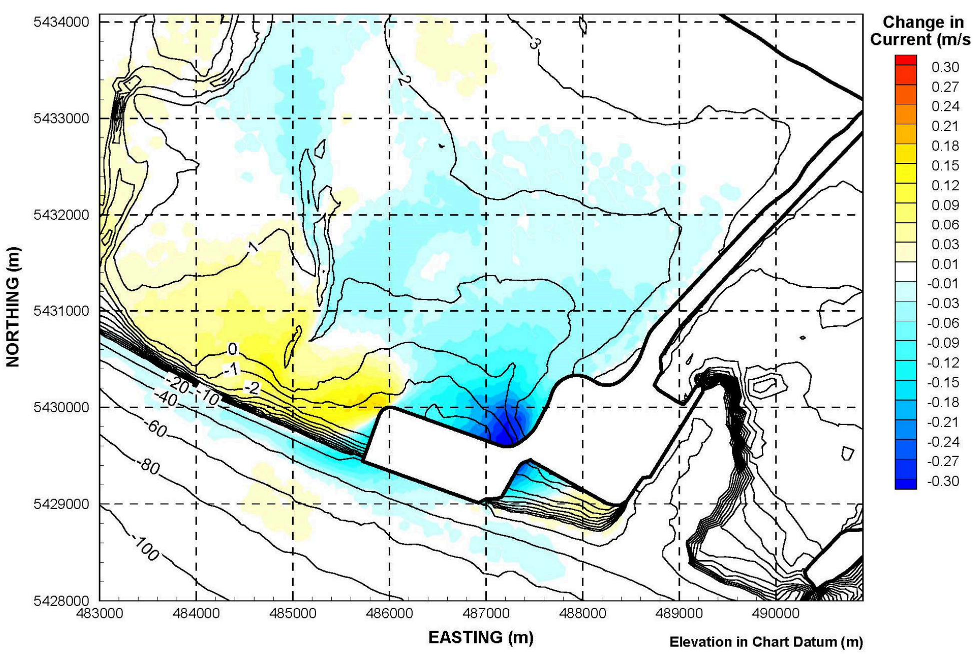


Figure IR2020-4-19: Predicted change* in 50th percentile current velocities associated with the freshet period comparing existing conditions predictions (per the EIS) and Scenario 1 predictions



* Calculated based on difference between EIS Appendix 9.5-A Figure 61 (existing conditions) and **Figure IR2020-4-17.** The comparable figure for predicted changes comparing existing conditions and the footprint of the EIS reference concept design is EIS Appendix 9.5-A Figure 65.

Figure IR2020-4-20: Predicted change* in 50th percentile current velocities associated with the non-freshet period comparing existing conditions predictions (per the EIS) and Scenario 1 predictions



* Calculated based on difference between EIS Appendix 9.5-A Figure 63 (existing conditions) and **Figure IR2020-4-18.** The comparable figure for predicted changes comparing existing conditions and the footprint of the EIS reference concept design is EIS Appendix 9.5-A Figure 66.

Wave height predictions

Figure IR2020-4-21: 50th percentile wave heights associated with the freshet period under future conditions with reduced project footprint (Scenario 1)

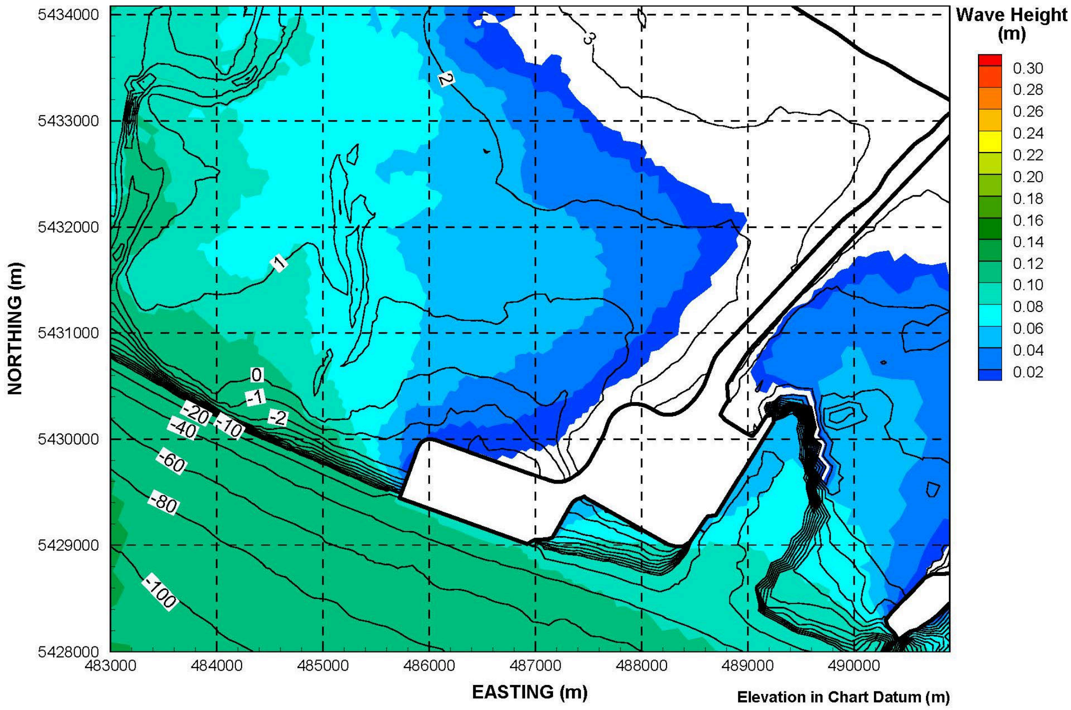


Figure IR2020-4-22: 50th percentile wave heights associated with the non-freshet period under future conditions with reduced project footprint (Scenario 1)

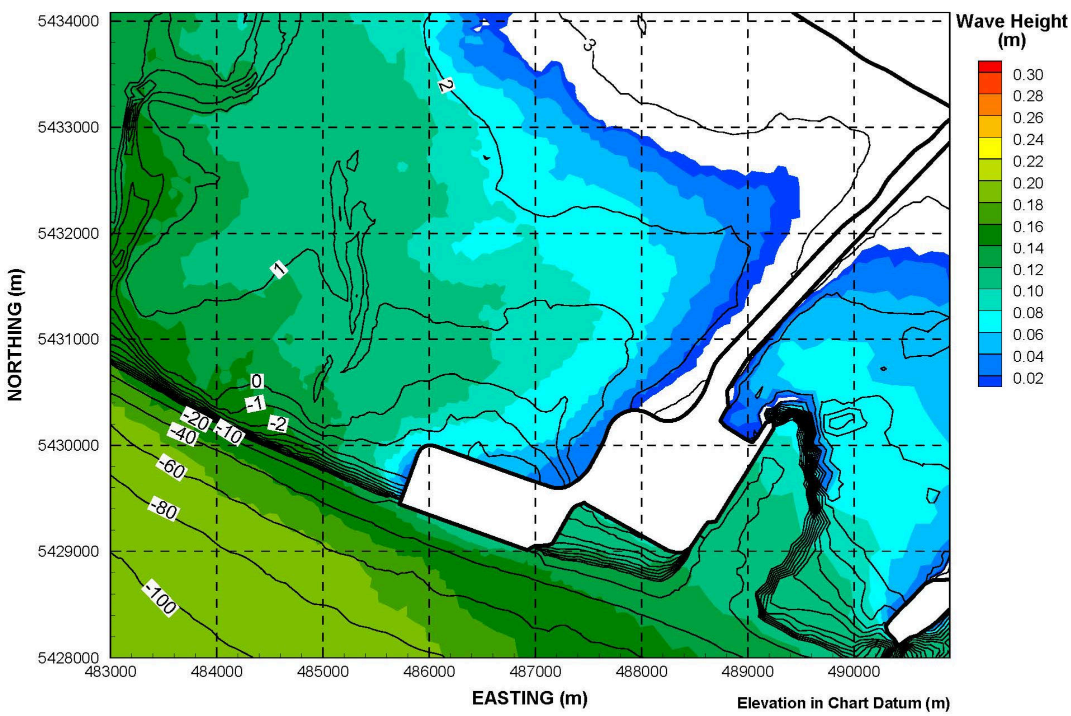
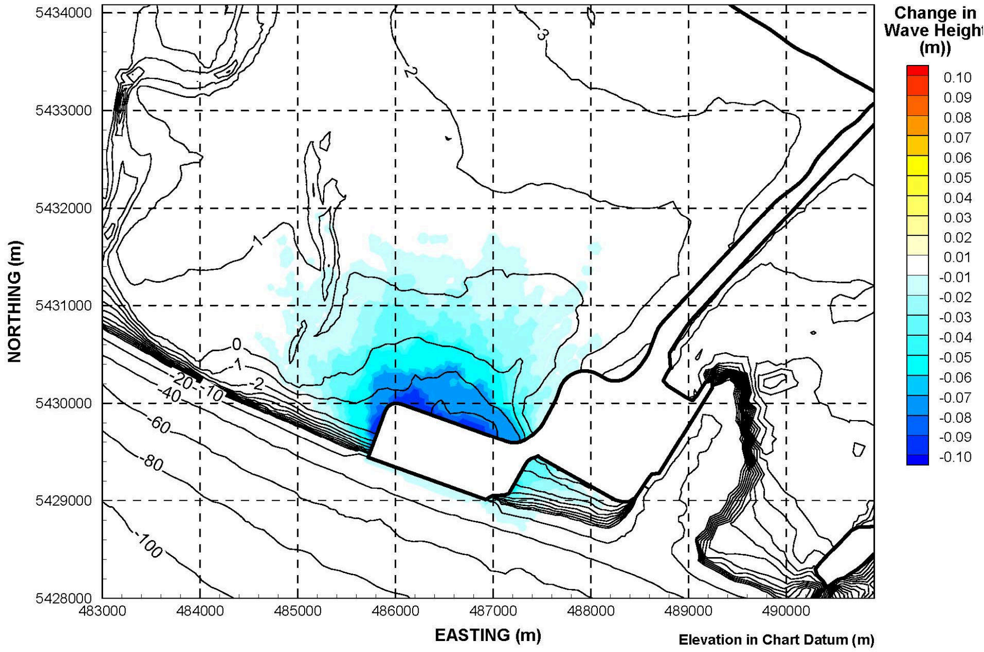
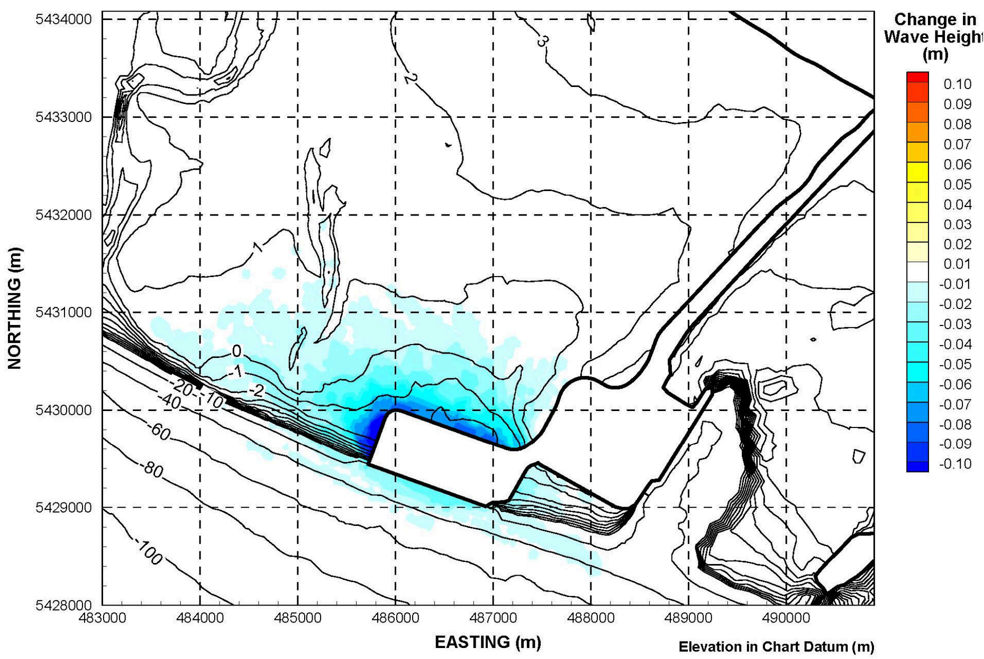


Figure IR2020-4-23: Predicted change* in 50th percentile wave heights associated with the freshet period comparing existing conditions predictions (per the EIS) and Scenario 1 predictions



* Calculated based on difference between EIS Appendix 9.5-A Figure 89 (existing conditions) and **Figure IR2020-4-20**. The comparable figure for predicted changes comparing existing conditions and the footprint of the EIS reference concept design is EIS Appendix 9.5-A Figure 93.

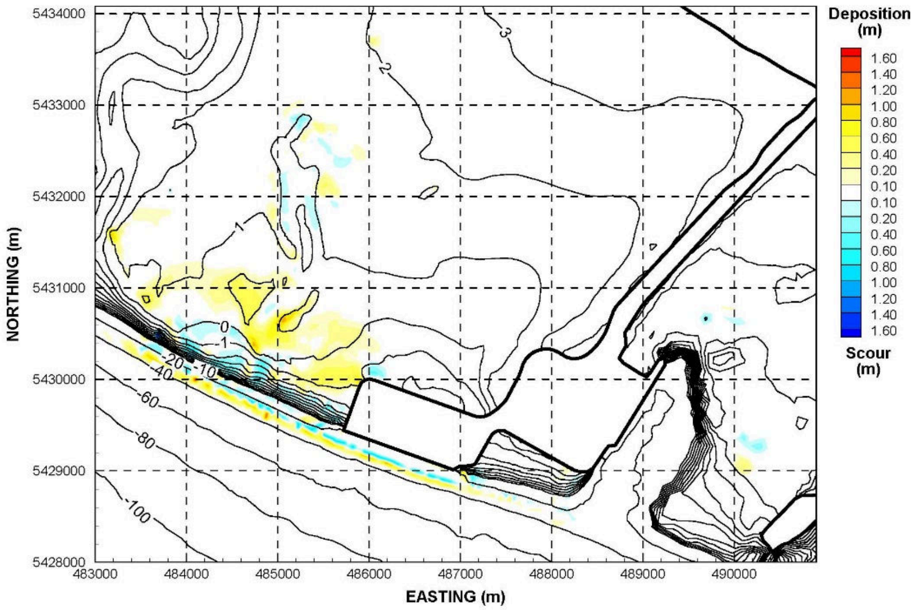
Figure IR2020-4-24: Predicted change* in 50th percentile wave heights associated with the non-freshet period comparing existing conditions predictions (per the EIS) and Scenario 1 predictions



* Calculated based on difference between EIS Appendix 9.5-A Figure 91 (existing conditions) and **Figure IR2020-4-21.** The comparable figure for predicted changes comparing existing conditions and the footprint of the EIS reference concept design is EIS Appendix 9.5-A Figure 94.

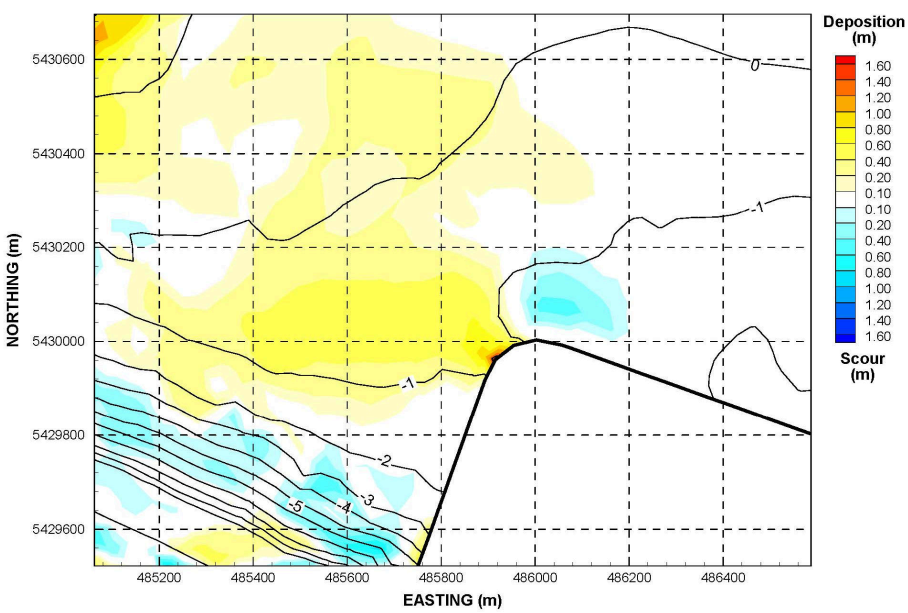
Morphodynamic evolution (seabed change) predictions

Figure IR2020-4-25: Morphodynamic evolution from tidal currents after 1,440 simulated days – Scenario 1 predictions



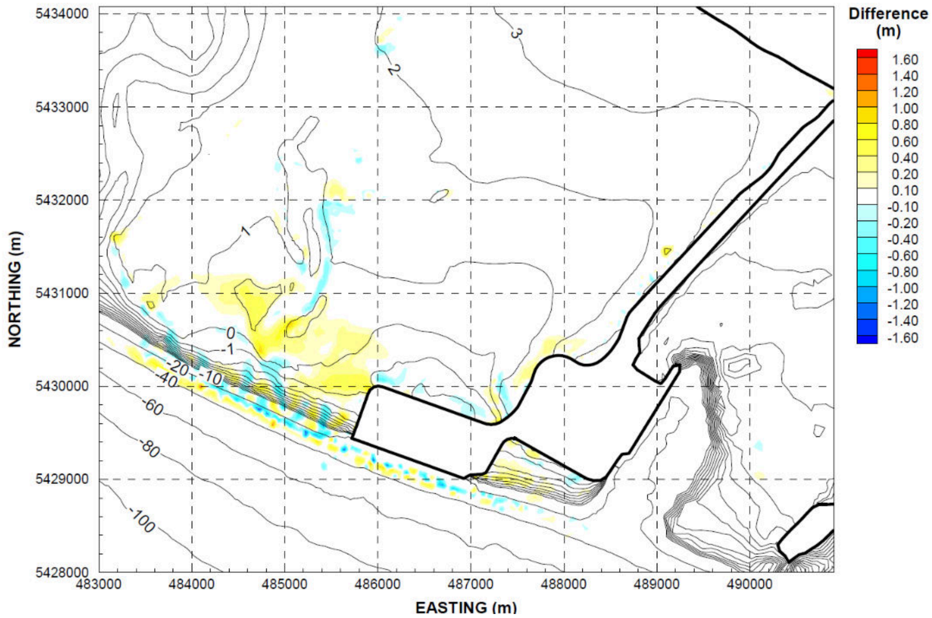
* The comparable figure for predicted seabed evolution associated with the footprint of the EIS reference concept design is EIS Appendix 9.5-A Figure 103.

Figure IR2020-4-26: Morphodynamic evolution from tidal currents after 1,440 simulated days – detailed view of Figure IR2020-4-24 predictions at marine terminal northwest corner



* The comparable figure for predicted seabed evolution associated with the footprint of the EIS reference concept design is EIS Appendix 9.5-A Figure 104.

Figure IR2020-4-27: Morphodynamic evolution from tidal currents after 1,440 simulated days – difference between expected conditions predictions[10] (per the EIS) and Scenario 1 predictions



* Calculated based on difference between EIS Appendix 9.5-A Figure 106 and **Figure IR2020-4-25**. The comparable figure for predicted changes comparing expected conditions and the footprint of the EIS reference concept design is EIS Appendix 9.5-A Figure 107.

Minister's specific requirement:

The Proponent shall provide all raw data used in each of the geomorphological assessments.

Port authority response:

The geomorphological assessments incorporated raw data on tides, Fraser River flows, salinity, and wind. Based on clarification from the Impact Assessment Agency of Canada with regard to the port authority providing all raw data, the port authority confirms the data used in the geomorphological assessments is publicly available (unless stated) from the following sources:

- Tides – Tidal levels at the open boundaries (Ballenas Island and Port Renfrew) were obtained using the WebTide Tidal Prediction model (Fisheries and Oceans 2005) based on Foreman (2000). The program uses eight tidal constituents, including M2, S2, N2, K2, K1, O1, P1, and Q1.[11]
- Fraser River flows – Inflows to the Fraser River at New Westminster were computed using a hydraulic model of the lower Fraser River that uses the MIKE11 one-dimensional hydrodynamic software developed by the Danish Hydraulic Institute. Northwest Hydraulic Consultants (NHC) developed the Fraser River MIKE11 model for the Fraser Basin Council in 2006 (NHC 2006) and updated it for the B.C. Ministry of Environment two years later (NHC 2008).

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[10] Expected conditions refers to the future evolution of the seabed that would occur under the prevailing existing conditions (future condition without RBT2).

[11] M2=principal lunar, S2=principal solar, N2=larger lunar elliptic, K2=luni-solar, K1=luni-solar diurnal, O1=principal lunar diurnal, P1=principal solar diurnal, Q1=larger lunar elliptic.

- Salinity – The initial salinity field and salinity profiles along the open boundaries were estimated based on April, June, and September 2012 water properties data collected by Fisheries and Oceans Canada.[12] A salinity value of zero is prescribed for the Fraser River inflow.
- Wind – To account for wind stress acting at the water surface, hourly wind data were obtained from five Meteorological Service of Canada (MSC) stations (Nanaimo Airport, Pam Rocks, Race Rocks, Sand Heads, and Victoria), Environment Canada's Halibut Bank wave buoy, and four National Oceanic and Atmospheric Administration (NOAA) stations (Cherry Point, Port Townsend, Smith Island, and West Point) and prescribed to the TELEMAC-3D Strait of Georgia model.

All of the above information is publicly available (and spatially referenced) except for the Fraser River MIKE11 model results. The MIKE11 model is the intellectual property of the Fraser Basin Council and so these results cannot be transmitted to a third party. NHC obtained permission to use it to calculate the boundary conditions for the Telemac model.

Outcomes regarding biofilm and effects to migratory birds

The information presented above was requested by the minister in the context of biofilm and effects to migratory birds. With the predictions of very subtle to no change in geomorphological conditions (including salinity) resulting from the reduced project footprint reduction and potential breach locations, compared to the EIS project reference concept design, the conclusions of the EIS effects assessments for biofilm and migratory shorebirds (notably western sandpiper, *Calidris mauri*) remain unchanged. The EIS conclusion that salinity changes resulting from the project will not adversely affect biofilm and migratory shorebirds is supported by evidence showing that biofilm at Roberts Bank thrives and is abundant under variable salinity conditions.[13] This is consistent with the RBT2 review panel conclusion that "the project would not have an adverse effect on biofilm productivity".[14] Studies documenting shorebird foraging distribution in the local assessment area provide clear and consistent evidence that western sandpiper feed intensively on biofilm across the salinity gradient.[15]

Furthermore, the anticipated changes in salinity with the project in place (i.e., either with the reference concept design footprint or with the 14.4 ha project footprint reduction) will be small compared to natural variation currently experienced across almost every part of Roberts Bank due to tidal fluctuations and highly variable freshwater inputs from the adjacent Fraser River.

The footprint reduction at the shoreward end of the causeway will reduce direct impacts to biofilm by approximately 0.6 ha. The predictions of physical changes to the seabed (i.e., scour at the marine terminal breach entrances) would have a minimal effect on overall biofilm abundance within the local assessment area and is not anticipated to affect western sandpiper foraging. The anticipated development of tidal channels (from erosional processes) beyond the entrances of causeway breach location 3 are also predicted to not affect biofilm or western sandpiper foraging (see **IR2020-2.2** for more information).

Additional contextual information provided in **Appendix IR2020-4-A** will assist the minister to better understand the relationship between the predicted project-related changes to salinity and the potential environmental effects of the project on biofilm and migratory birds.

The port authority will continue to work with Indigenous groups, regulators, and others to i) incorporate feedback to inform the selection and advancement of the technically feasible project design changes described in this

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[12] http://www.pac.dfo-mpo.gc.ca/science/oceans/
[13] CIAR Document #934 VFPA response to IR8-04, at Appendix IR8-04-A; CIAR Document #1215 Biofilm Dynamics during 2017 Northward Migration (https://iaac-aeic.gc.ca/050/documents/p80054/123348E.pdf); CIAR Document #1385 Biofilm Dynamics during 2018 Northward Migration (https://iaac-aeic.gc.ca/050/documents/p80054/126516E.pdf).
[14] CIAR Document #2062 Report of the Review Panel, Vancouver Fraser Port Authority Roberts Bank Terminal 2 Project (page 1) https://www.ceaa-acee.gc.ca/050/documents/p80054/134506E.pdf
[15] CIAR Document #388 VFPA response to AIR #10, at Appendix AIR10-C, TDR CB-1 (https://iaac-aeic.gc.ca/050/evaluations/document/115188).

response, and ii) implement three follow-up program elements related to verifying effect predictions with the project in place for salinity, geomorphic features and sediment erosion and deposition, and western sandpiper prey (including biofilm).[16]

Appendices

Appendix IR2020-4-A Effects to Biofilm and Migratory Birds

References

Fisheries and Oceans Canada. 2005. WebTide Tidal Prediction Model. [online] Available at http: //www.mar.dfo-mpo.gc.ca/science/ocean/coastal_hydrodynamics/WebTide/webtide.html.

Foreman, M. G. G., Crawford, W. R., Cherniawsky, J. Y., Henry, R. F., and Tarbotton, M. R. 2000. A high-resolution assimilating tidal model for the northeast Pacific Ocean. Journal of Geophysical Research, 105(28), 629–652.

Northwest Hydraulic Consultants (NHC). 2006. Lower Fraser River Hydraulic Model Final Report. Prepared by Northwest Hydraulic Consultants and Triton Consultants for Fraser Basin Council.

NHC. 2008. Fraser River Hydraulic Model Update (Final Report). Report prepared for the BC Ministry of Environment by Northwest Hydraulic Consultants Ltd. 227 pp.

[16] CIAR Document #2001 Updated Project Commitments, at Appendix C, at Table C15: Salinity Model Evaluation and Associated Effects Predictions, Table C2: Coastal Geomorphic Process Evaluation and Associated Effects Predictions, and Table C14: Western Sandpiper Prey Effects Prediction (https://iaac-aeic.gc.ca/050/documents/p80054/130776E.pdf).