

NHC Ref. No. 3004562

8 July 2019

Wolf Water Resources

1001 SE Water Ave, Suite 180
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97214

Attention: **Curtis Loeb, MS, PE**
Restoration Engineer

Via email: cloeb@wolfwaterresources.com

Re: **Kilchis River Estuary Porter Tract Restoration – Detailed Design
Hydrodynamic Model Results**

Dear Mr. Loeb:

This letter report provides the methodology and results for the hydrodynamic modeling completed by Northwest Hydraulic Consultants Ltd. (NHC) for Wolf Water Resources Inc. (W²r) regarding the detailed design of the Kilchis River Estuary Porter Tract Restoration Project (the Project).

1 INTRODUCTION

Wolf Water Resources Inc. is working strategically with the Nature Conservancy to restore fish habitat in the Kilchis River Estuary. Hydrodynamic modeling and analyses were conducted by NHC for W²r to examine the potential hydraulic impacts of the proposed detailed design restoration measures (**Figure 1**). This work is a continuation of the hydraulic model that was previously completed for the conceptual design. The detailed design measures include:

1. Expanding the connector channel to about 35' wide at all locations;
2. Filling all the linear ditches;
3. Excavating Channels shown in the detailed design drawings and removing the water control structures on them;
4. Removing the pretty small berm areas to El. 9 ft along Stasek and berm area along Hathaway Slough to the north; and

- Placing low mounds to 18" to 30" above existing grade;

This report presents the modeling methodology, analyses and results for the scope of work.

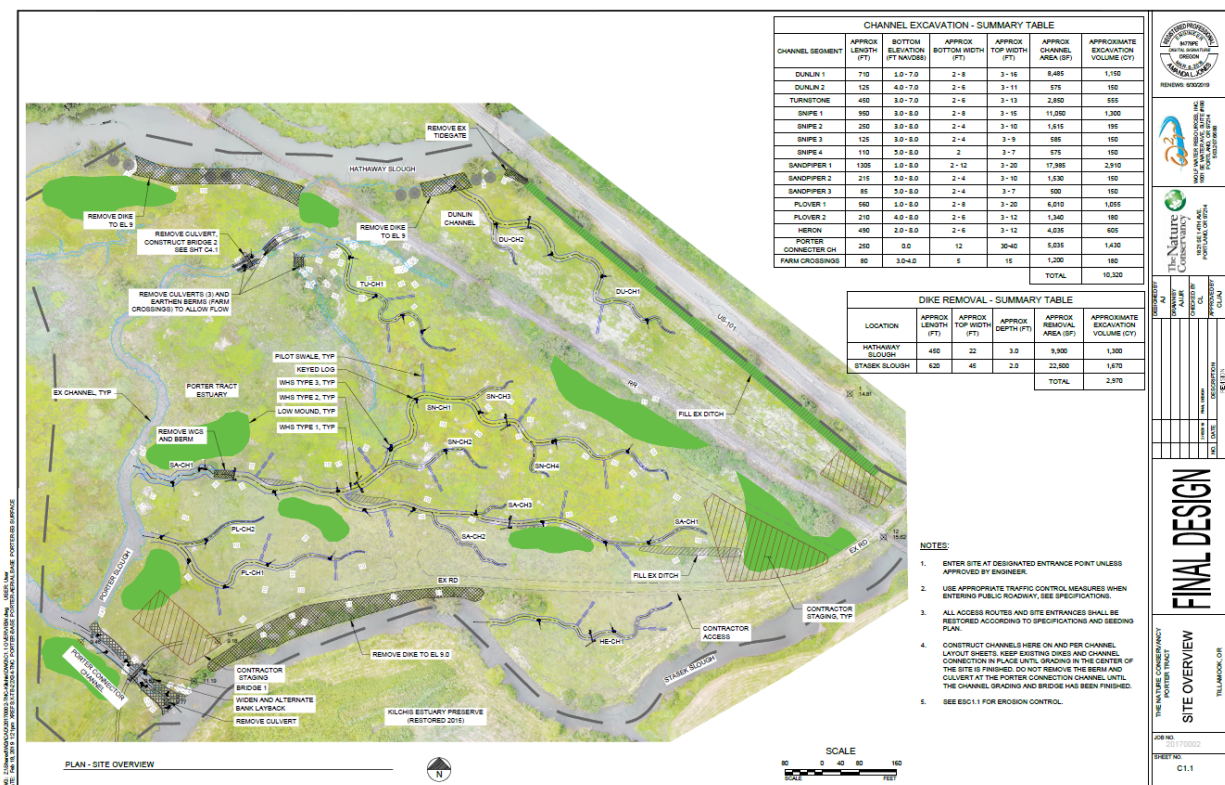


Figure 1. Site overview of detailed design restoration measures – provided by W²r on May 6, 2019

2 MODEL METHODOLOGY

2.1 Hydrodynamic Model Verification

A previously-calibrated Delft3D model of Kilchis River estuary was provided to NHC by W²r for the conceptual design phase of the project. This model was verified by NHC and W²r for the earlier phase with of the model verification findings provided in Attachment I. The current model is wholly suitable for the purposes of this study.

2.2 Model Geometry

The following updates to the model geometry were made for the proposed Porter Tract Restoration scheme:

- Removed berms along the north side of Hathaway Slough and Stasek Slough;

2. Widened the connector channel and removed the culvert;
3. Linear ditches were not visible given the model resolution, therefore no changes were made to the geometry in these locations;
4. Fill areas were added to the model geometry where indicated by W²r by increasing the elevation of the existing ground by 24”;
5. Removed water control structures as indicated by matching the surrounding stream bed elevations; and,
6. Additional channels TU-CH, DU-CH, SA-CH, SN-CH, PL-CH, and HE-CH were added to the model geometry based on the alignment and depths provided by W²r.

Figure 4 and **Figure 5** show the existing topography and the proposed geometry. **Figure 6** shows the bed elevation changes between the existing and proposed model geometries.

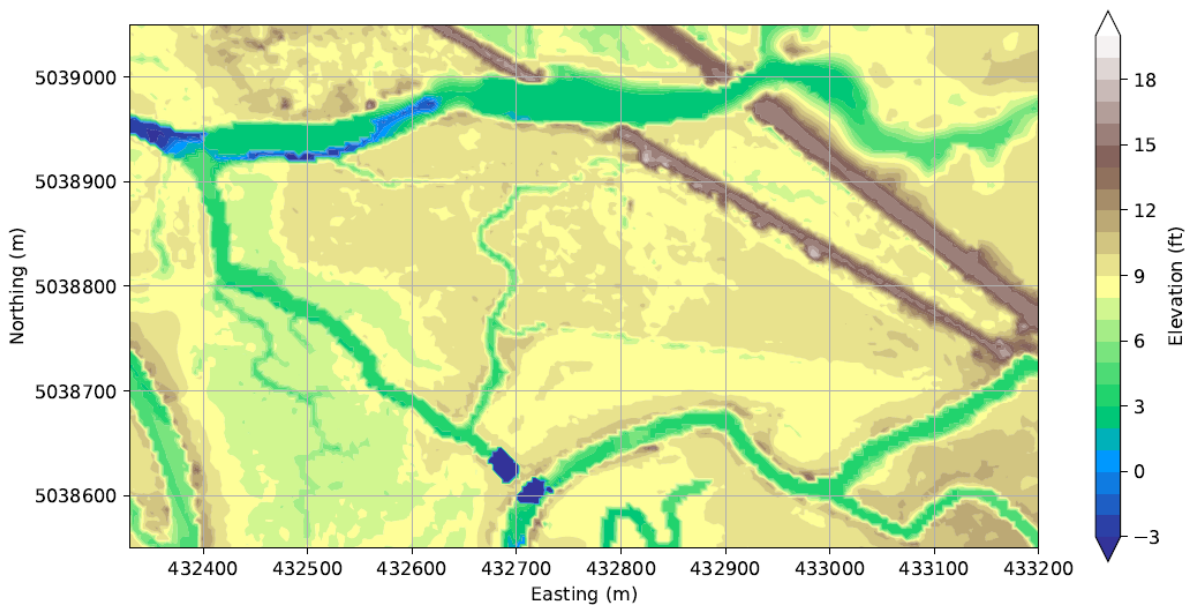


Figure 2. Existing topography.

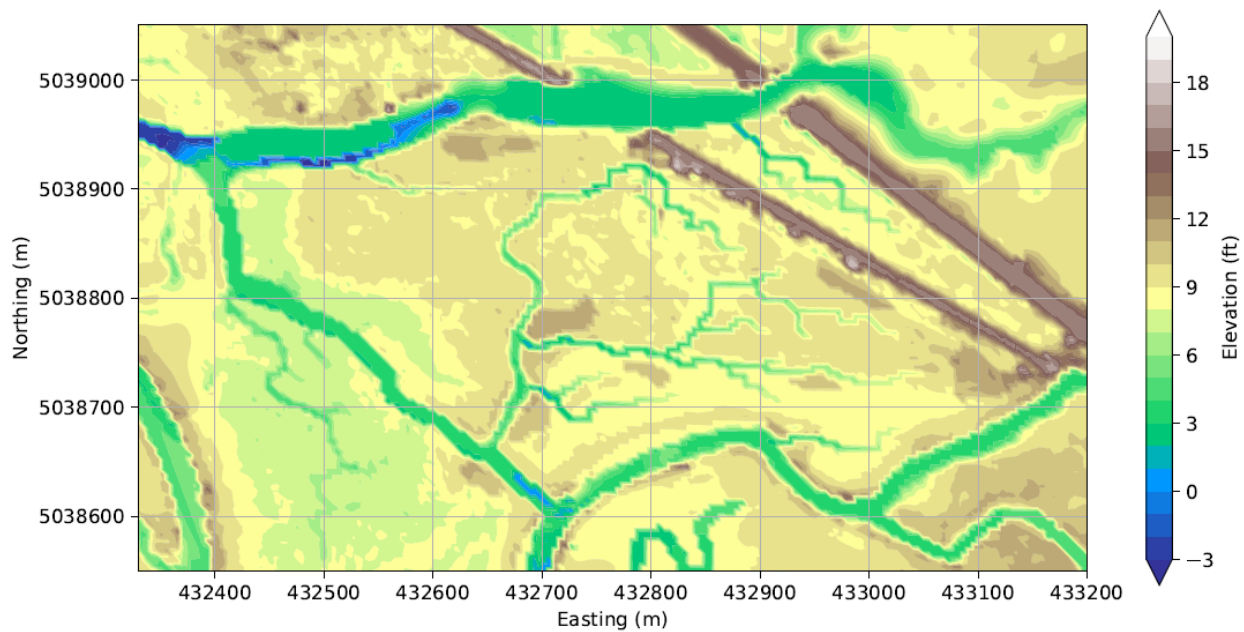


Figure 3. Topography with proposed restoration measures.

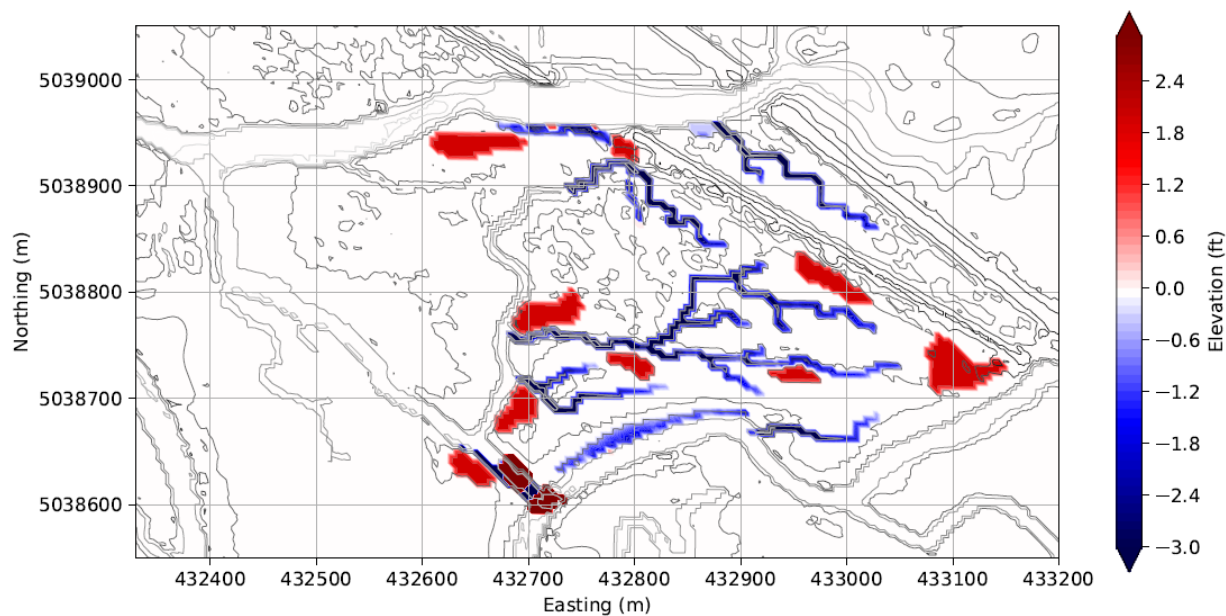


Figure 4. Differences between existing topography and proposed topography.

2.3 Simulation Period

The hydrodynamic model simulations were conducted using the December 2015 and the January 2017 periods to simulate the peak flow and the typical conditions, respectively. Boundary conditions for the two simulations are shown in **Figure 7** and **Figure 8**. Model results are provided in the following section.

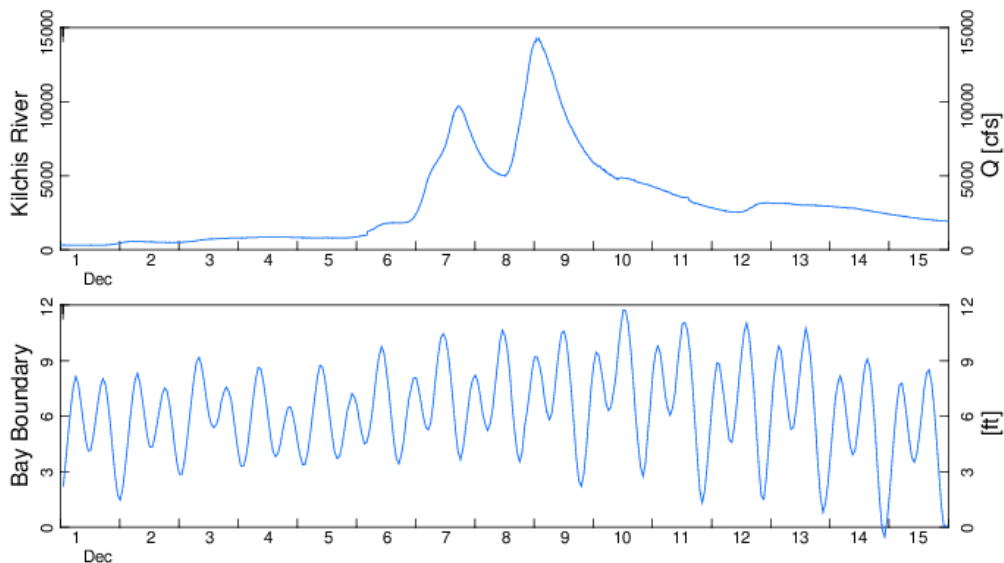


Figure 5. December 2015 model boundary conditions.

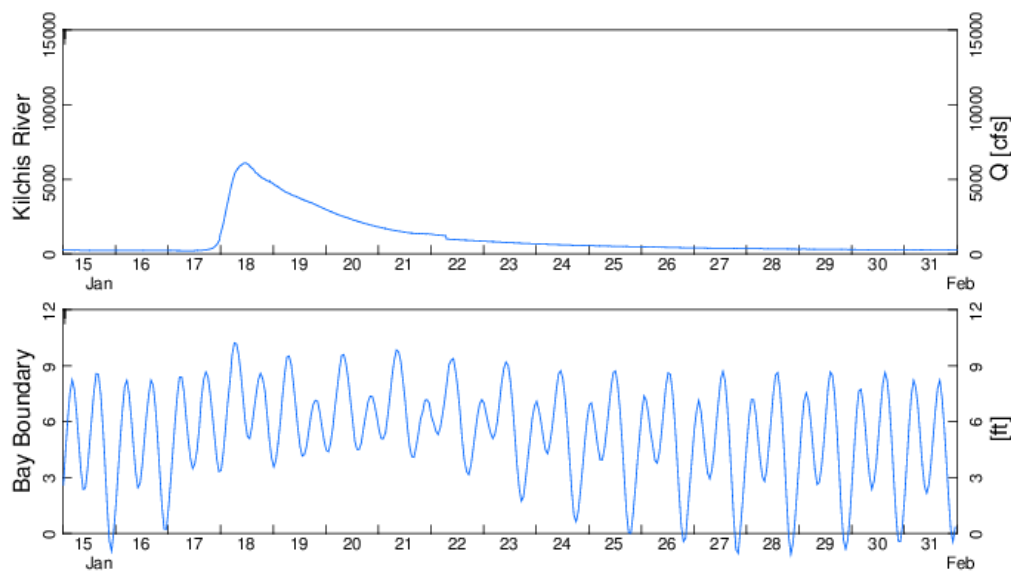


Figure 6. January 2017 model boundary conditions.

3 MODEL RESULTS

The inundation extents for the existing and proposed models are shown in **Figure 9** and **Figure 10** for the December 2015 peak flow scenario. The water level differences are shown in **Figure 11**. The change in water level resulting from the Porter Tract Restoration at Stasek Slough is shown in **Figure 12**; water levels are reduced during normal flow conditions, but there are no changes to the water level during peak flow.

The change in water levels at Hathaway Slough are shown in **Figure 13**; there is a slight increase in water levels during normal flow conditions, and again, no change during peak flows. The slight increase in water levels at Hathaway Slough are a result of increased flow through the Porter Connector Channel during ebb tide. The water levels during the ebb tide on December 6, 2015 at 18:00 are shown in **Figure 14** and **Figure 15** for the existing and proposed models, respectively. The water level differences are shown in **Figure 16**.

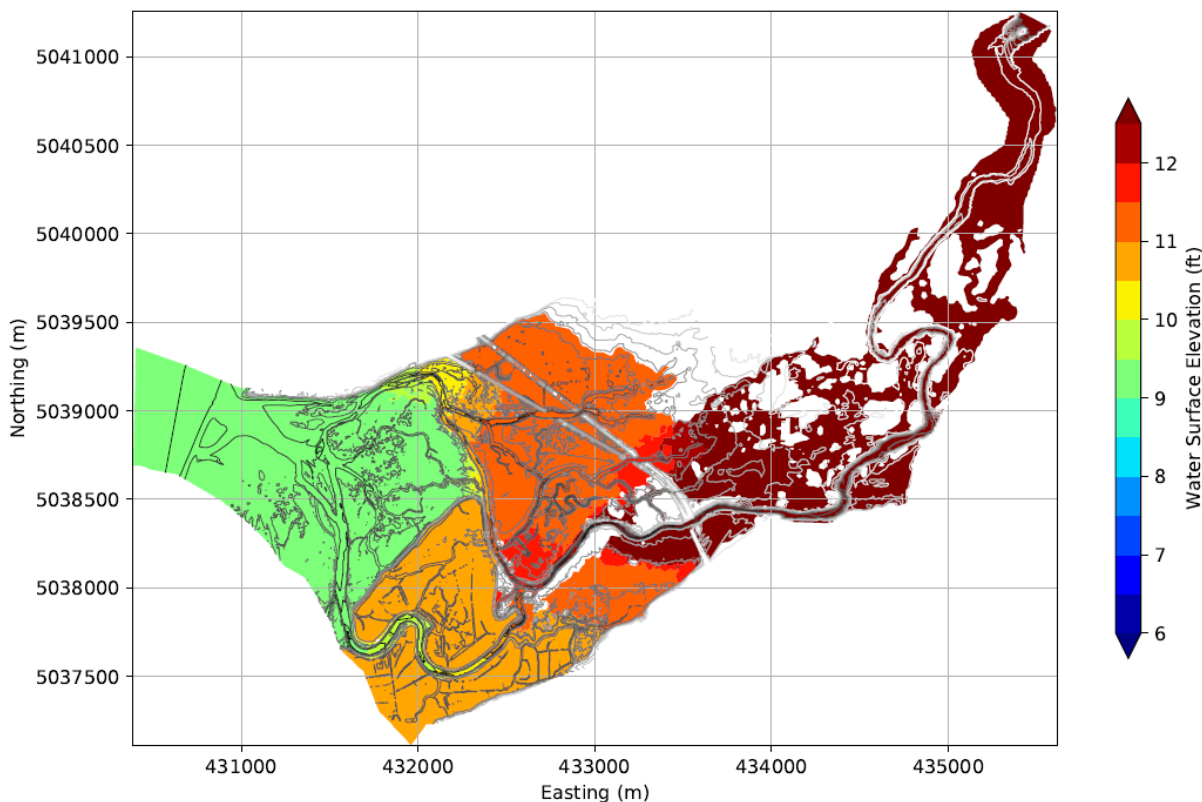


Figure 7. Water surface elevation on December 9th, 2015 01:00 – Existing conditions

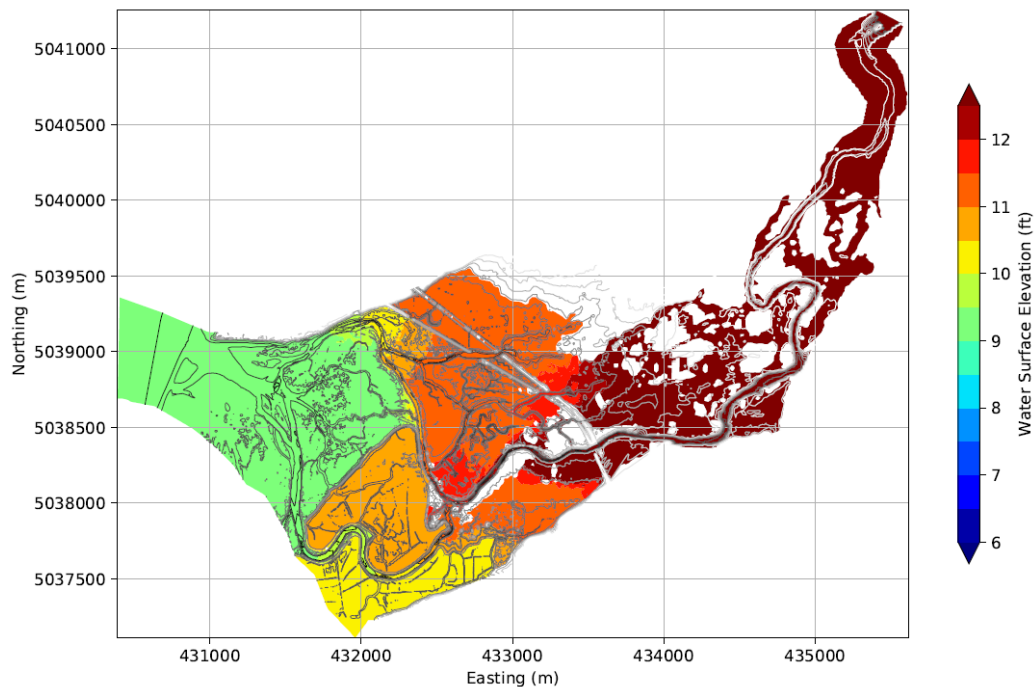


Figure 8. Water surface elevation on December 9th, 2015 01:00 – with proposed restoration measures

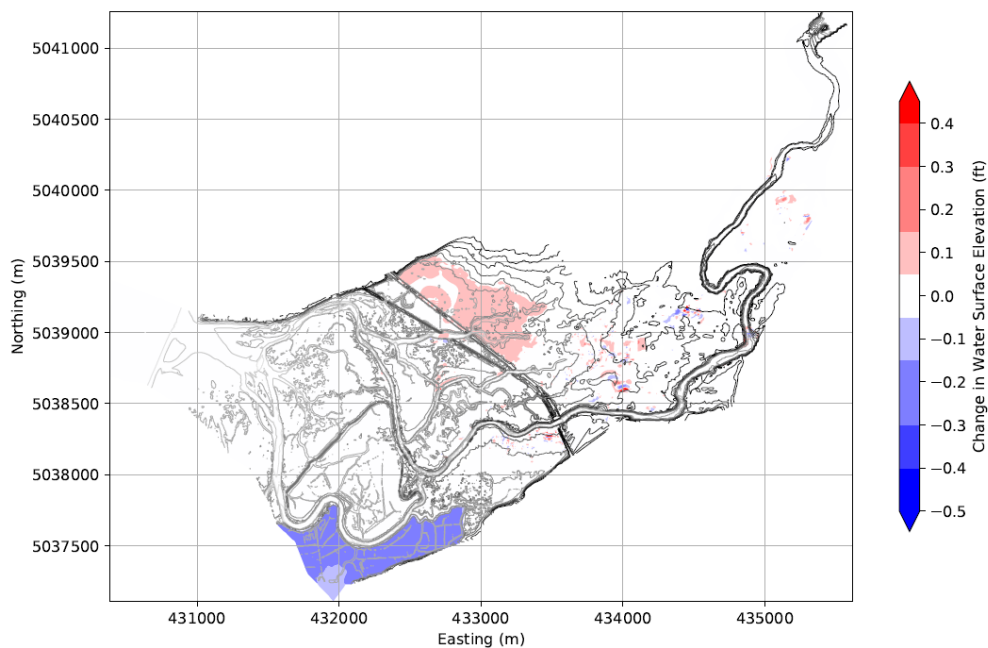


Figure 9. Differences in water surface elevation on December 9th, 2015 01:00

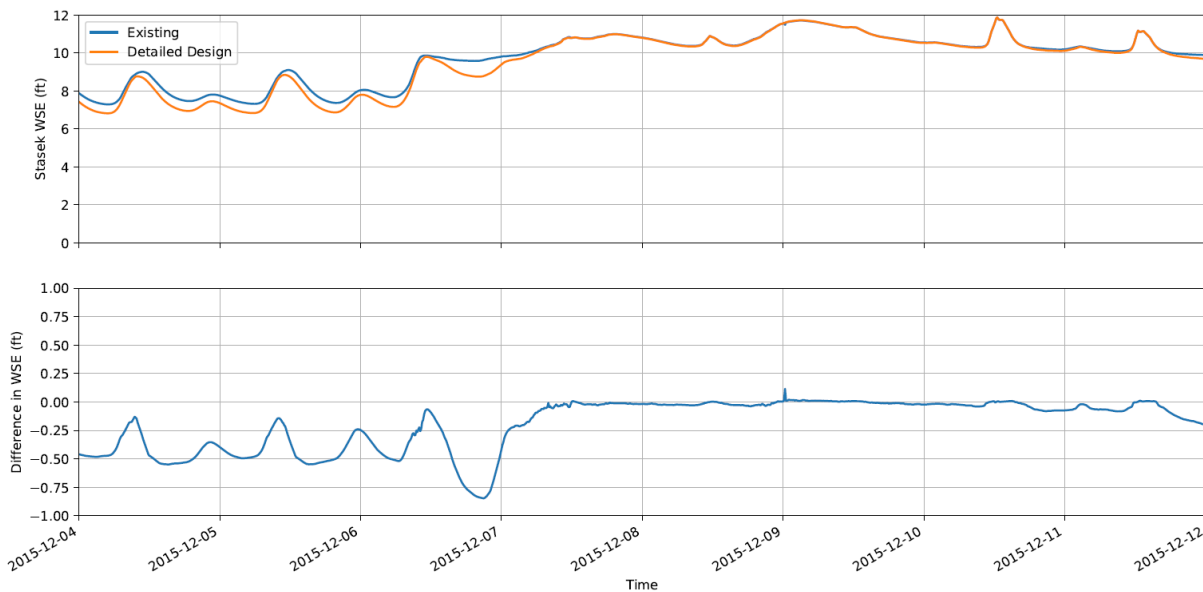


Figure 10. Change in water level at Stasek Slough – 2015 December simulation

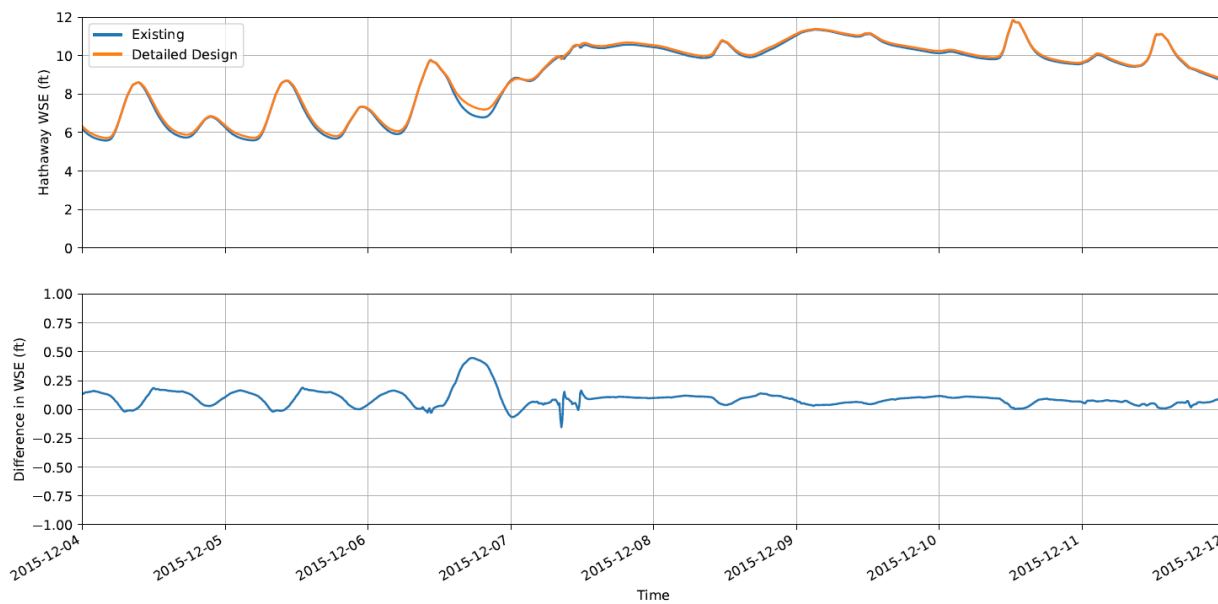


Figure 11. Change in water level at Hathaway Slough – 2015 December simulation

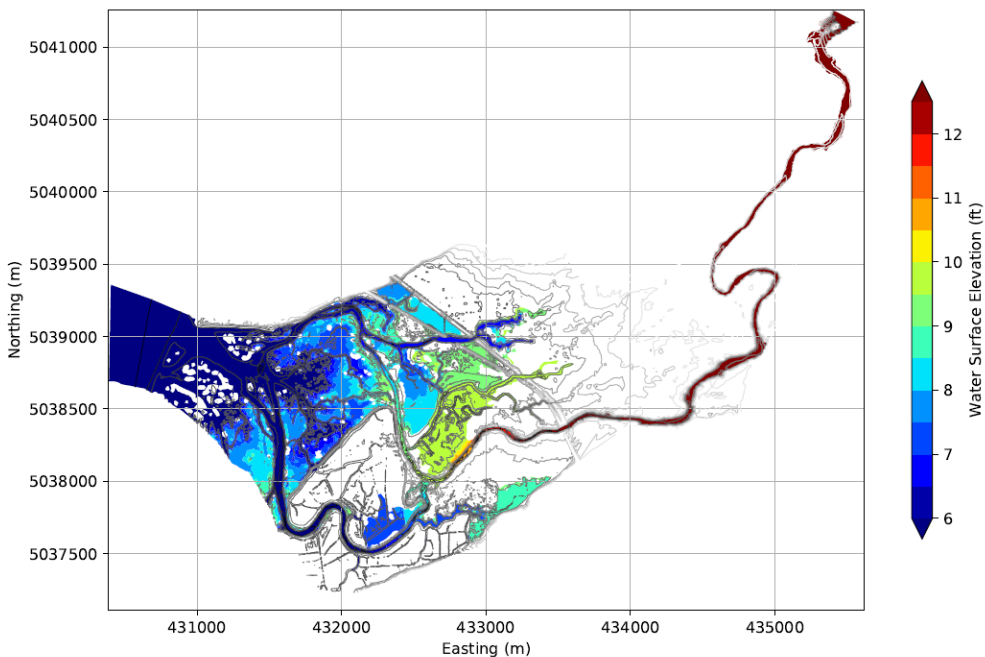


Figure 12. Water surface elevation on December 6th, 2015 18:00 – Existing conditions

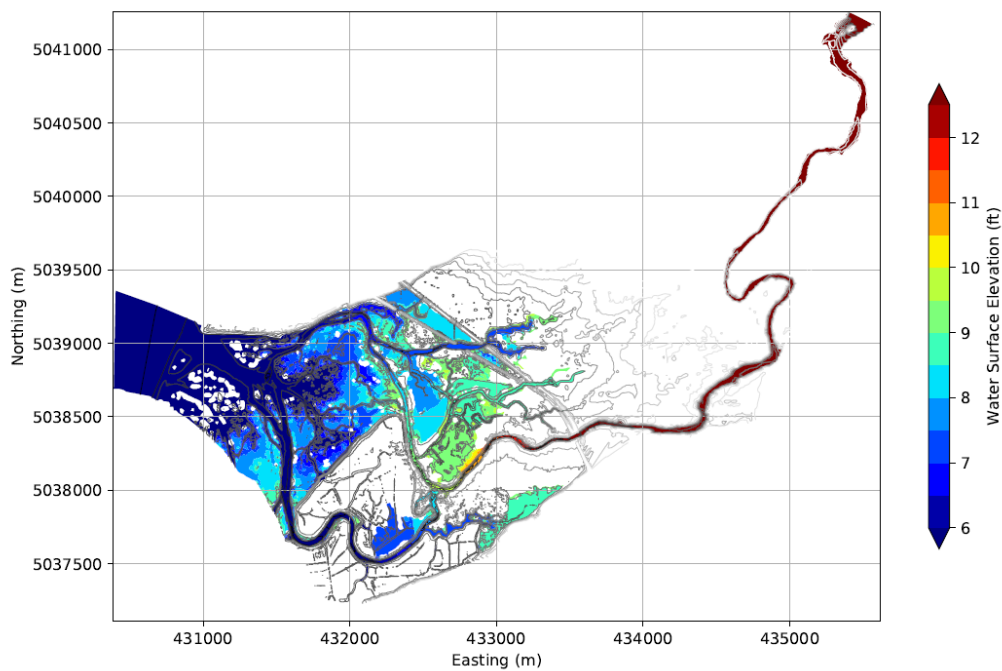


Figure 13. Water surface elevation on December 9th, 2015 18:00 – with proposed restoration measures

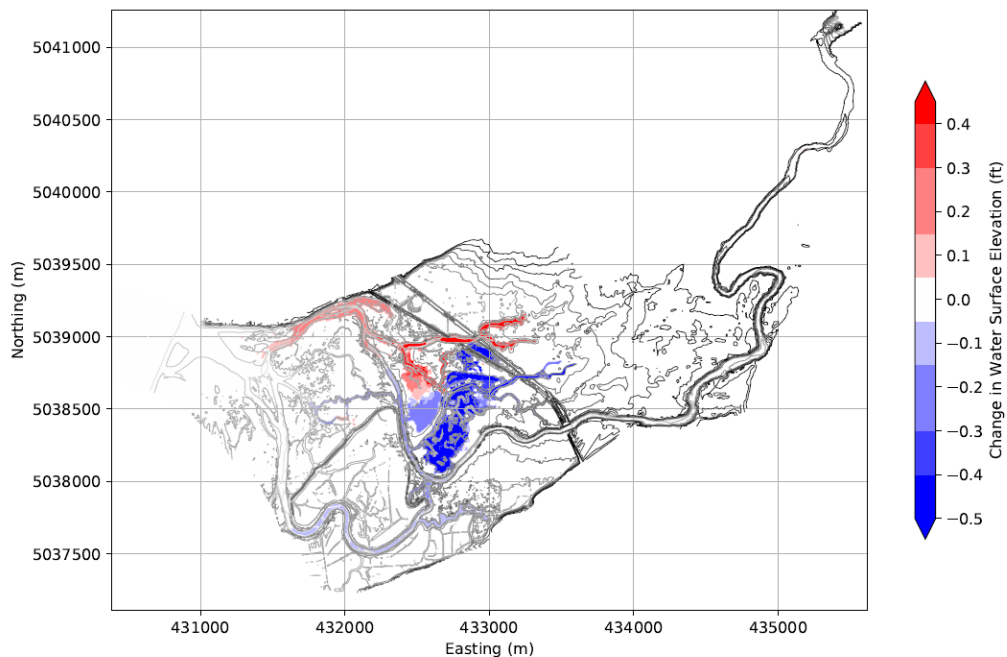


Figure 14. Differences in water surface elevation on December 6th, 2015 18:00

Time-series of water levels at selected monitoring locations (**Figure 14, Table 1**) for each simulations are provided in the EXCEL file attached with this report.

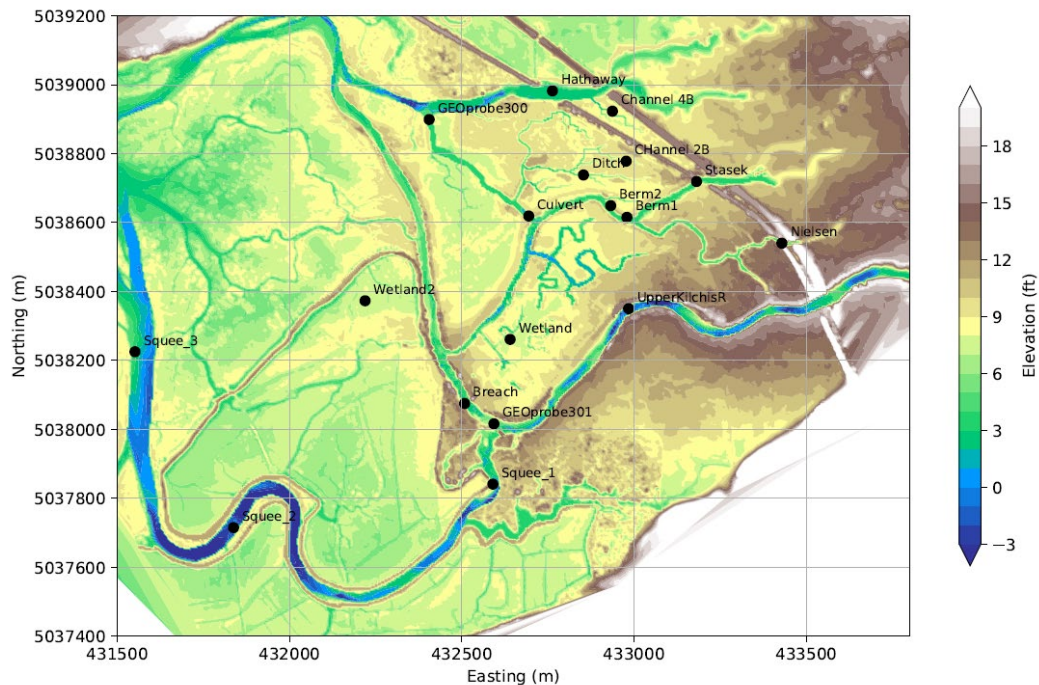


Figure 15. Monitoring station locations

Table 1. Monitoring station coordinates (UTM)

Monitoring Station	Northing (m)	Easting (m)
UpperKilchisR	5038350	432984
Squee_1	5037841	432590
Squee_2	5037715	431837
Squee_3	5038225	431551
GEOprobe300	5038899	432405
GEOprobe301	5038016	432593
Hathaway	5038982	432763
Stasek	5038719	433181
Nielsen	5038540	433429
Breach	5038075	432508
Wetland	5038261	432640
Wetland2	5038373	432219
Channel 2B	5038778	432977
Channel 4B	5038923	432937
Culvert	5038619	432694
Ditch	5038738	432853
Berm1	5038615	432979
Berm2	5038649	432932

4 SUMMARY

Delft3D hydrodynamic modeling simulations were conducted to evaluate the potential hydraulic impacts of proposed restoration measures for the detailed design phase of the project. Modelling inputs files from a previously calibrated model were provided by W²r. No additional work was conducted to verify model's ability to reproduce the December 2015 flood and the January 2017 events, which were used for the hydraulic impact assessment. The results conclude:

1. Overall, the changes in water surface elevations expected with the Project are minor (± 0.1 m) for the peak flow scenario (December 2015) and for the typical conditions scenario (January 2017);
2. Water levels resulting from the Project at Stasek Slough are reduced during normal flow conditions and unchanged during the peak flow event for both the January 2017 and December 2015 model events; and
3. Water levels at Hathaway Slough are slightly increased during normal flow conditions, and unchanged during peak flows for both the January 2017 and December 2015 model events.

5 CLOSURE

We hope this work and report meets your current needs. If you have any questions or would like to further discuss these findings, please contact Edwin Wang at our North Vancouver office at (604) 980-6011 or by email (ewang@nhcweb.com).

Sincerely,

Northwest Hydraulic Consultants Ltd.

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Enc.

Attachment I - Kilchis River Estuary Porter Tract Restoration Hydrodynamic Model Results – Conceptual Design

DISCLAIMER

This document has been prepared by **Northwest Hydraulic Consultants Ltd.** for the benefit of **Wolf Water Resources** for specific application to the **Kilchis River Estuary**. The information and data contained herein represent **Northwest Hydraulic Consultants Ltd.** best professional judgment in light of the knowledge and information available to **Northwest Hydraulic Consultants Ltd.** at the time of preparation, and was prepared in accordance with generally accepted engineering practices.

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