

NOBLE CREEK TIDELANDS RESTORATION PROJECT EXISTING CONDITIONS, ALTERNATIVES, AND 30% BASIS OF DESIGN REPORT



prepared for
Coos Soil and Water Conservation District



**Coos Soil and Water
Conservation District**

prepared by



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1.0 INTRODUCTION AND NEED FOR PROJECT

The Noble Creek Tidelands Project, a multi-benefit collaborative effort led by Coos Soil and Water Conservation District (CSWCD) and Oregon Department of Fish and Wildlife (ODFW), aims to provide salmon habitat and community benefits in the unincorporated community of Green Acres, Oregon (**Figure 1**). Isthmus Slough, the largest tidal inlet of Coos Bay, ends at the confluence with Noble Creek.

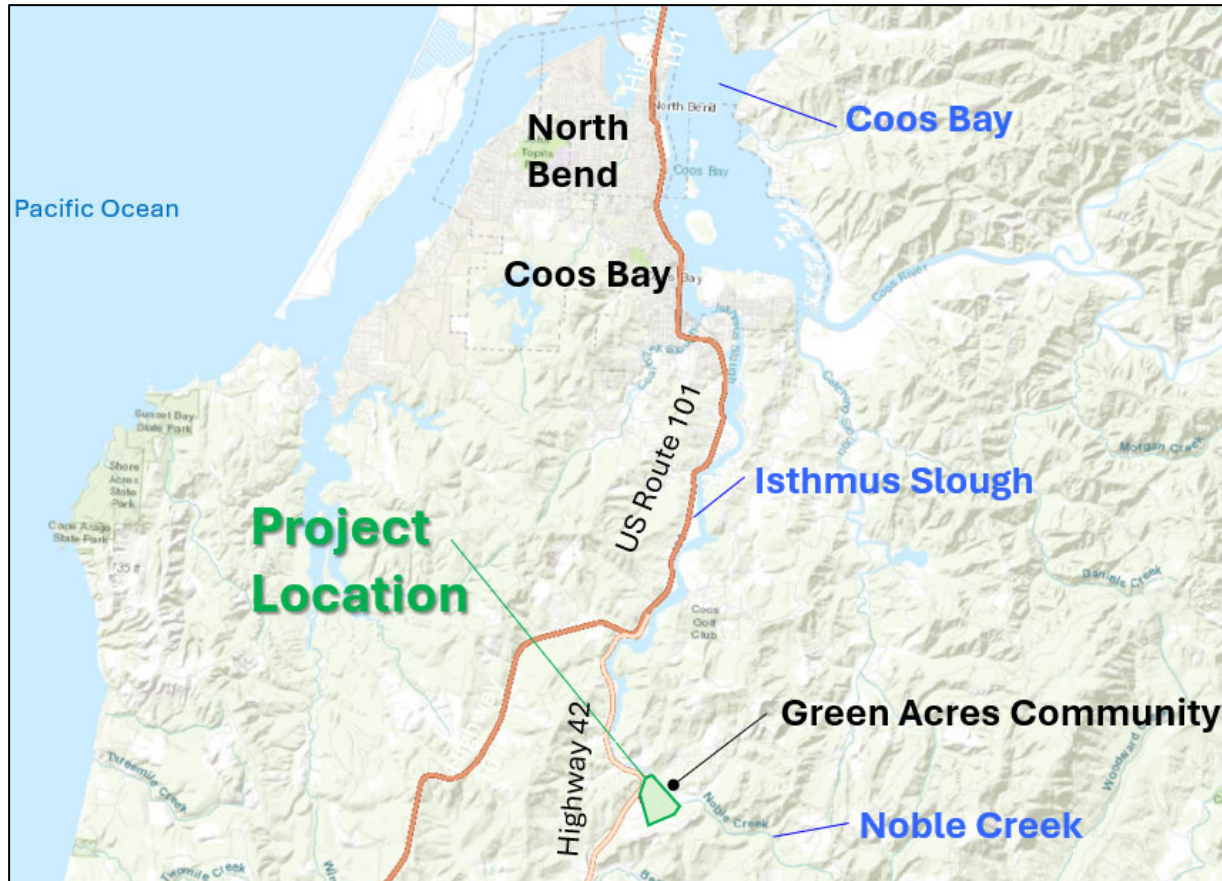


Figure 1. Location of Project Site South of Coos Bay

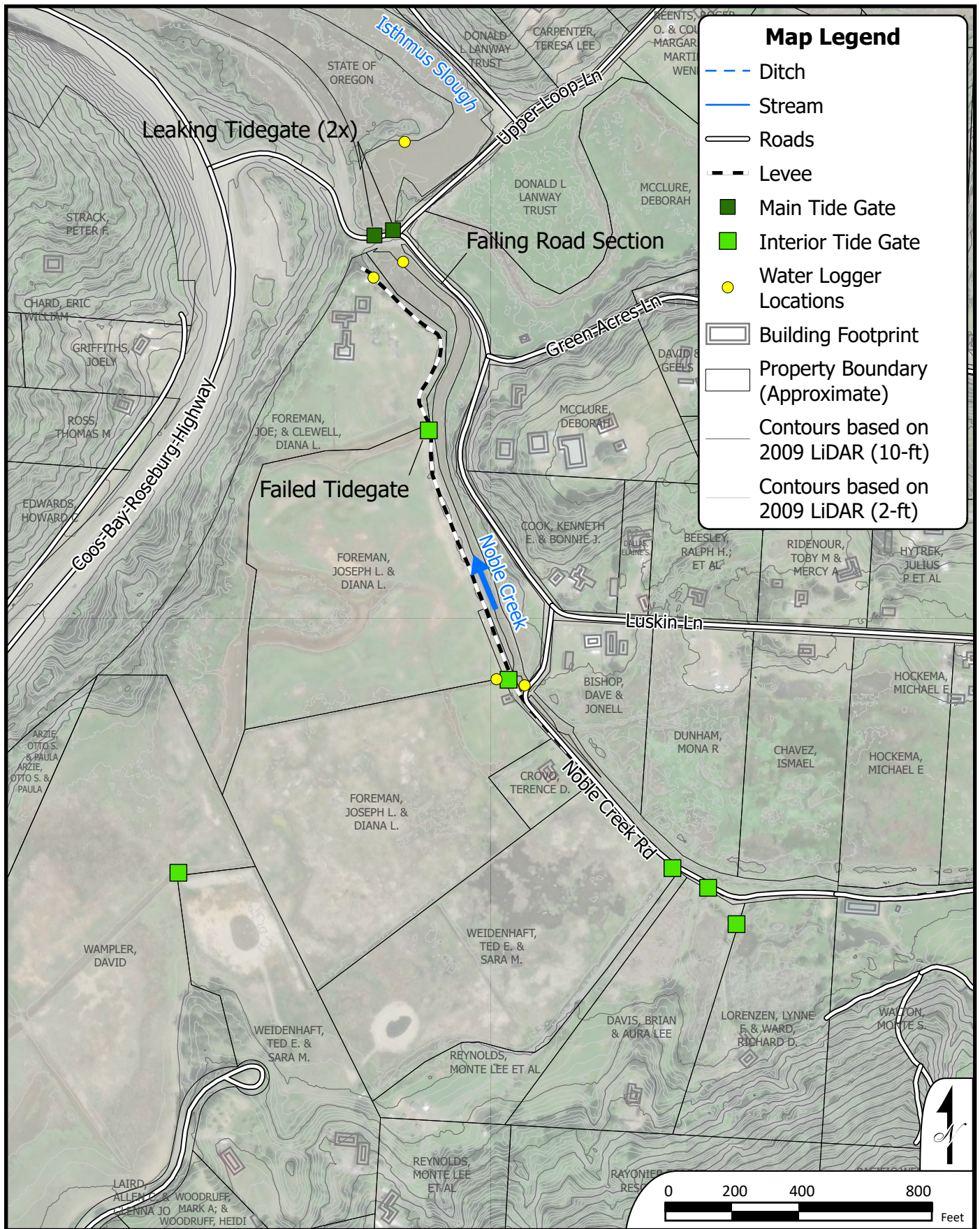
Two aging wooden culverts with leaking tide gates separate Isthmus Slough from Noble Creek, and partially reduce flooding of a low tidal flood basin (**Figure 2**). The two culverts and tide gates are directly under Green Acres Lane, a county road that is the only entrance and exit to the Green Acres community. The roadway prism of Green Acres Lane is eroding around the failing tide gates and in at least one other location along Noble Creek. Both the Green Acres community members and the Coos County Roadmaster recognize that the Green Acres Lane crossing must be repaired or replaced to prevent a future failure that could result in an unplanned loss of access to the community.

In addition to being a local community hazard, the failing tide gates at the crossing over Noble Creek also prevent salmon from accessing the large, lowland tidal floodplain at the entrance to the Green Acres community (**Figure 2**), referred to as the Noble Creek Tidelands. Loss of access to floodplain tidal wetlands is a primary factor inhibiting salmon recovery in the Coos Bay watershed. One of the primary

restoration objectives in the Coos Basin Coho Partnership’s Strategic Action Plan (CBCP, 2022) is to “reconnect tidal wetland and slough habitats (permanent and seasonal) in estuary and lower mainstems”. By 2045, the CBCP aims to restore 93.4 acres of disconnected fresh and salt marsh to tidal reconnection; restoring fish access to and enhancing a large part of the approximately 100-acre Noble Creek Tidelands would represent a significant step towards meeting this.

CSWCD and ODFW recognized the opportunity to develop a project that would simultaneously address the infrastructure concerns and provide significant habitat uplift. Since 2020, CSWCD worked to secure funding for the Noble Creek Tidelands project and oversaw the early phases of the work. The work to date on this project included community outreach, bathymetric and topographic survey, development and calibration of a complex hydraulic model, geotechnical and structural engineering, alternatives analysis, selection of a preferred alternative, and development of conceptual level (30%) design drawings. This report summarizes the findings of the work done to date, the alternatives considered, and the basis for the conceptual-level designs.

The 30% design drawings are provided as **Appendix A** of this report.



Existing Conditions Map

**Nobble Creek
Tidelands Restoration
Project**



**FIGURE
2**

2.0 EXISTING CONDITIONS

2.1 PROJECT SITE OVERVIEW

2.1.1 Green Acres Lane Crossing

The crux of the project area is the crossing of Green Acres Lane (GAL) over Noble Creek (**Figure 3**). The GAL crossing marks the upstream (southernmost) extent of Isthmus Slough. Noble Creek is connected to Isthmus Slough through two aging culverts under GAL.

Both culverts have tide gates on the northern (downstream) side of GAL, which are meant to reduce tidal inflows from the north while allowing Noble Creek flow to exit southward towards Isthmus Slough (**Figure 3**). The eastern culvert is a 3-foot X 9-foot wooden box culvert with a wooden tide gate attached by chains from the top; and the western culvert is a 6-foot diameter round metal culvert with a wooden top-hinged tide gate (**Figure 4**). Leakage through both tide gates results in a dampened tidal signal on the Noble Creek side of the GAL crossing. The leaking tide gates, combined with a deteriorated levee along the west side of Noble Creek, together prevent most flooding at Diana Foreman's house, which is built on the former tidal floodplain surface at 3 to 4 feet above sea level (NAVD 88). The current tide gates and levee are unreliable and could fail in a future high flow and/or tidal event, putting this house at an imminent risk of flooding.

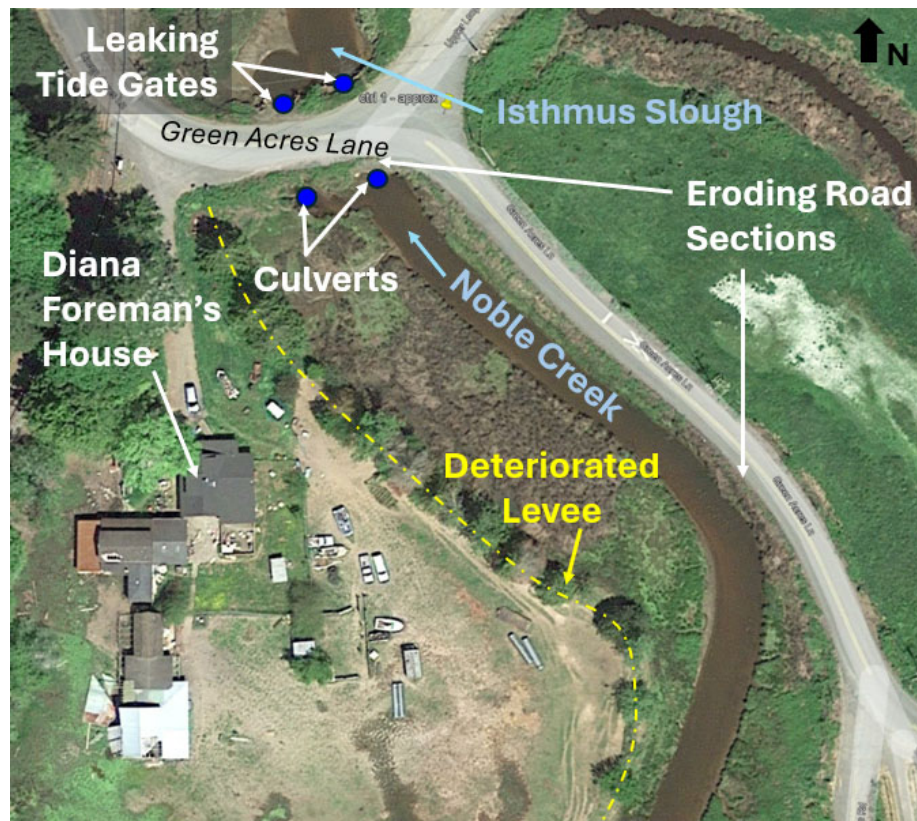


Figure 3. Annotated Air Photo of Green Acres Lane Crossing Over Noble Creek

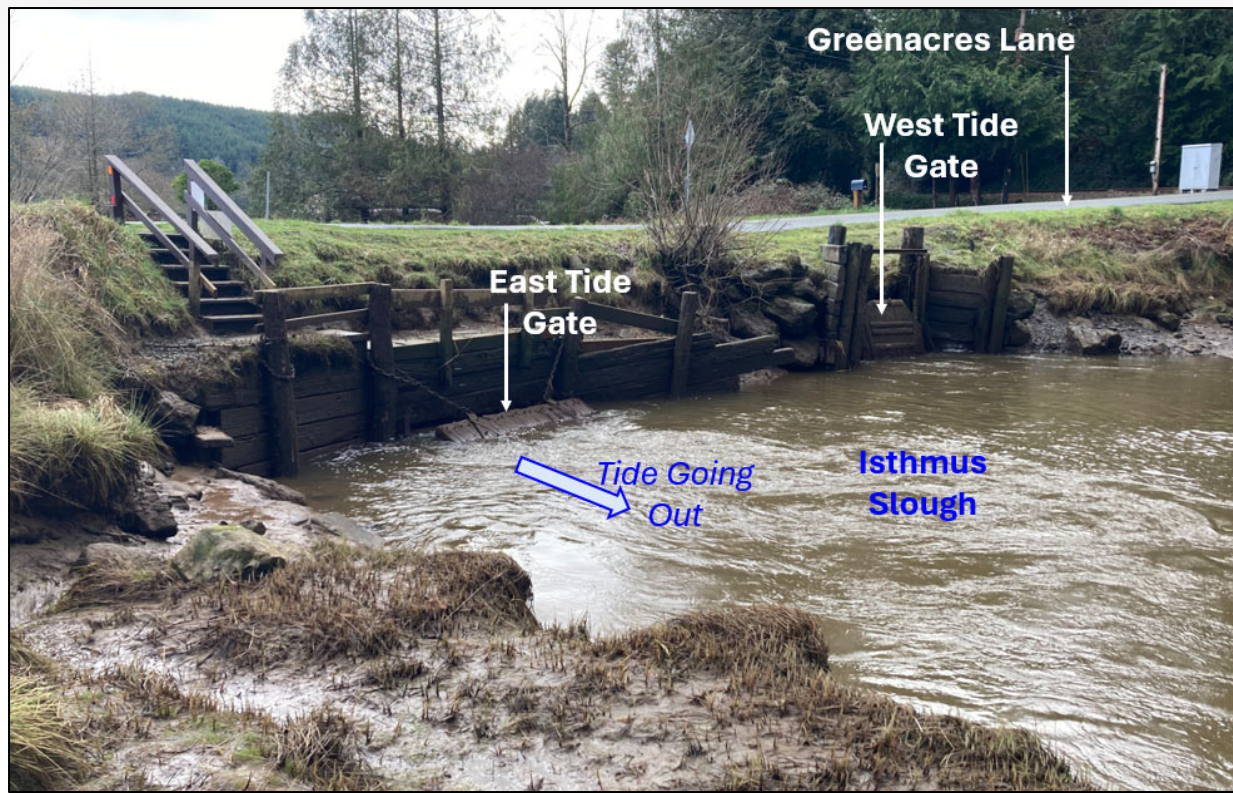


Figure 4. Photo Looking Upstream (South) at Greenacres Lane Crossing

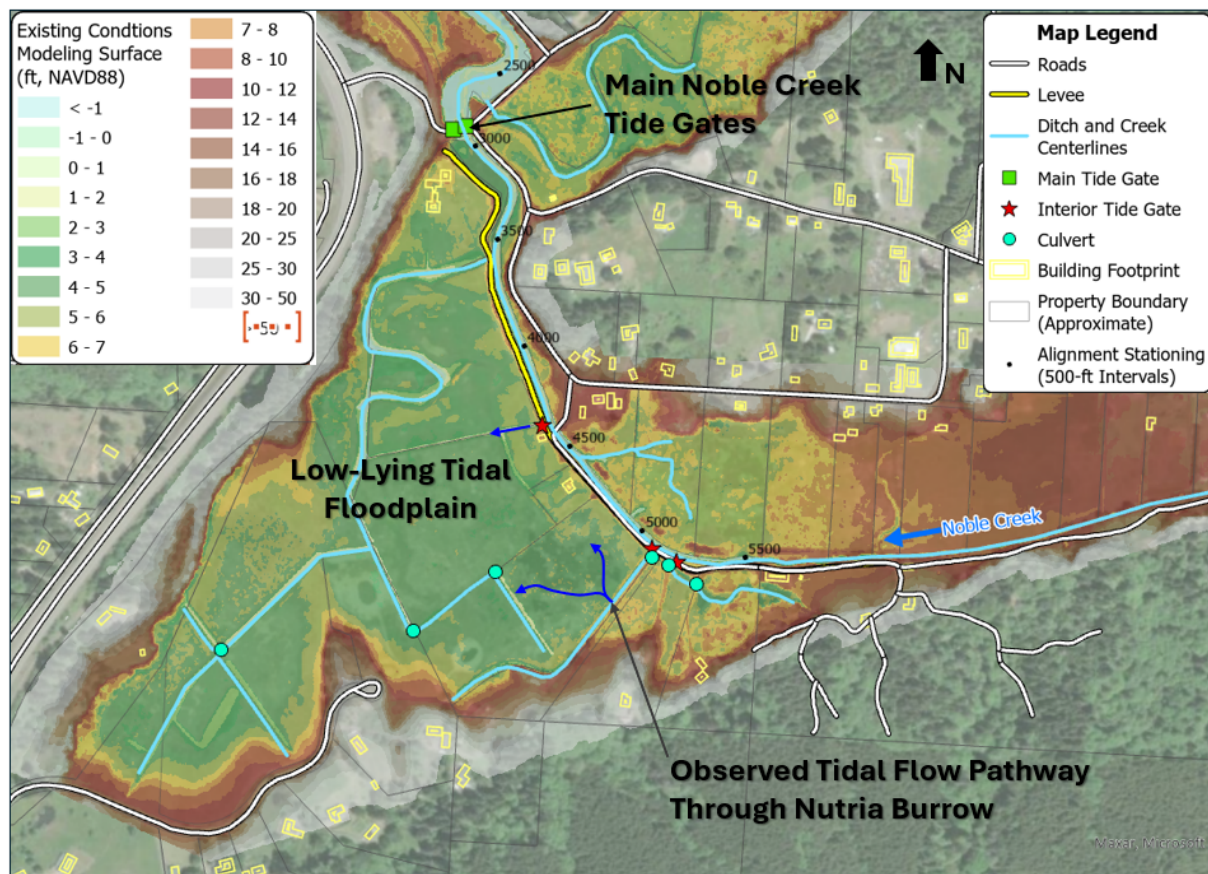
2.1.2 Interior Tidal Flood Basin

Behind (upstream of) the main Noble Creek tide gates is a broad, low-lying interior tidal floodplain occupying a geological structural basin in the coastal mountains. Approximately 100-acres of land behind the tide gates is below 5 feet elevation, and much of the interior flood basin lies at elevations between 3 and 4 feet above sea level. (**Figure 5**). Although the tidal signal is dampened by the tide gates at GAL, much of the lowland is still subject to some tidal flooding because of leakage through the tide gates and inflows from Noble Creek.

At present, tidal flows enter the floodplain through leaking interior tide-gated culverts, ditches, and deteriorated levee sections. A nutria burrow underneath a low berm is a primary pathway for tidal flows entering the floodplain and ditch network (see blue arrows in **Figure 5**). Tidal inflows move slowly up the ditch and channel network. Some flow pathways are so long that water in distal floodplain areas continues to rise hours after the peak high tide in the mainstem of Noble Creek.

In recent decades, as infrastructure has deteriorated, flooding has increased. Residents report that the amount and frequency of flooding in the fields has been increasing over the past several decades due to deterioration of flood protection (tide gate leakage, deterioration of berms and levees), land subsidence, and sea level rise. Presently, large portions of the tidal basin are flooded much of the year, and portions of the tidelands have gradually been taken out of agricultural production. In the absence of any actions, these factors will continue to increase flooding in these fields.

Upgrading the tide gates and crossing at Green Acres Lane will cause major changes to the timing and extent of inundation on the floodplain. Assuming fish passage is allowed, this offers a significant opportunity to create and enhance critical tidal habitats for salmonids in the interior tidal flood basin. Some of the landowners have indicated they are willing to allow habitat restoration activities, such as filling ditches, excavating tidal channels, and installing large wood structures.



folding and faulting of the Earth's crust, creating ridges and depressional basins, one of which contains the Noble Creek Tidelands. Since the beginning of the tectonic compression, these structural low zones have gradually filled in with riverine and tidal sediment. Presently, the faults and synclines delineate much of the extensive network of sloughs and tidal floodplains in the Coos Bay region.

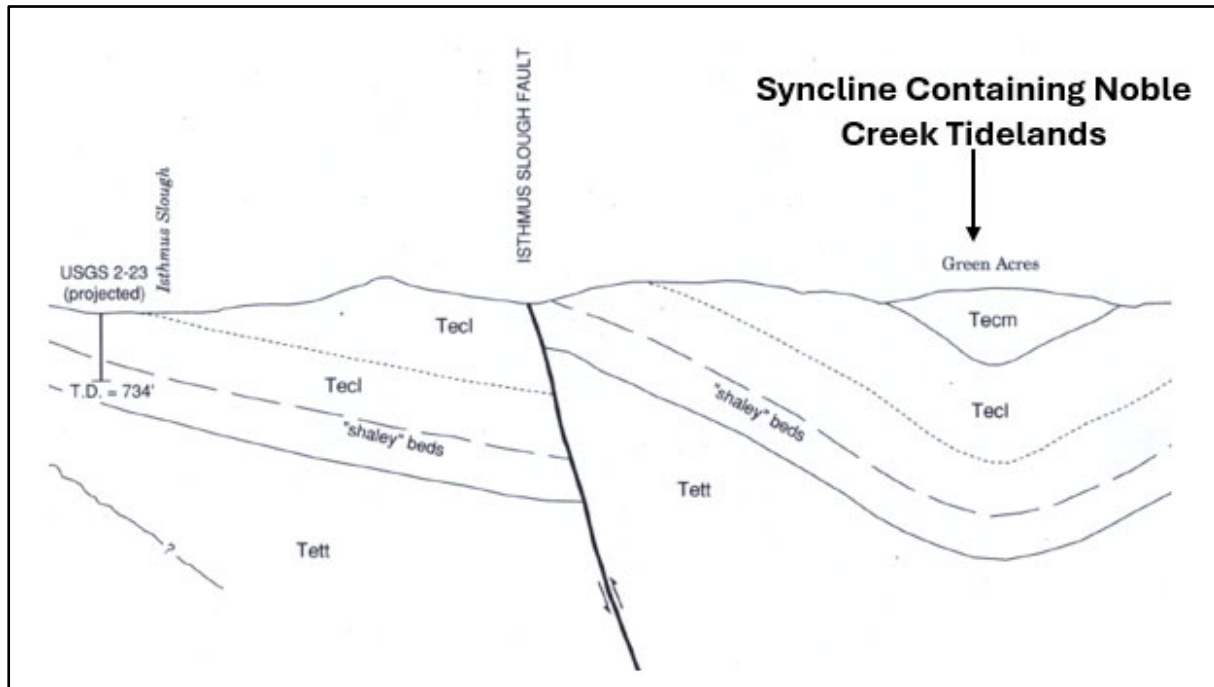


Figure 7. Part of Geologic Cross Section of Area Near Noble Creek and Green Acres (from Black and Madin, 1995) Just North of Project Area. Location of Cross Section is Shown in Figure 6.

In the vicinity of the project area, the sedimentary bedrock underlying the highlands is the Coaledo Formation, consisting of thick beds of mud deposited in a tidal setting in late Eocene time (38-45 Million Years Old), and later folded and faulted due to tectonic movements along the western edge of North America.

2.3 GEOTECHNICAL INVESTIGATION

The project will include constructing or repairing roads, culverts, bridges, and flood-control levees in poorly consolidated, water-saturated sediments in an earthquake prone setting. A geotechnical investigation was performed by Pali Consulting in May 2023 to document subsurface conditions to support the proposed design solutions. The investigation consisted of geotechnical borings at five locations, to a maximum depth of 66.5 feet below ground surface, followed by sampling and laboratory analyses. Two borings were completed in the vicinity of the existing tide gated culverts at Green Acres Lane, and two borings were completed on the levee on either side of the proposed interior tide gate with MTR (**Figure 8**). The Geotechnical Report documenting the full results of the investigation is provided in **Appendix B**. The results of the investigation are summarized briefly below.

2.3.1 Green Acres Lane Crossing

At Green Acres Lane (Borings B1 and B2), the subsurface soils are comprised of soft silts and sands to 30-40 feet below ground surface, overlying a siltstone bedrock. This is presumably the middle member Coaledo Formation (Tecm in Figure 7).

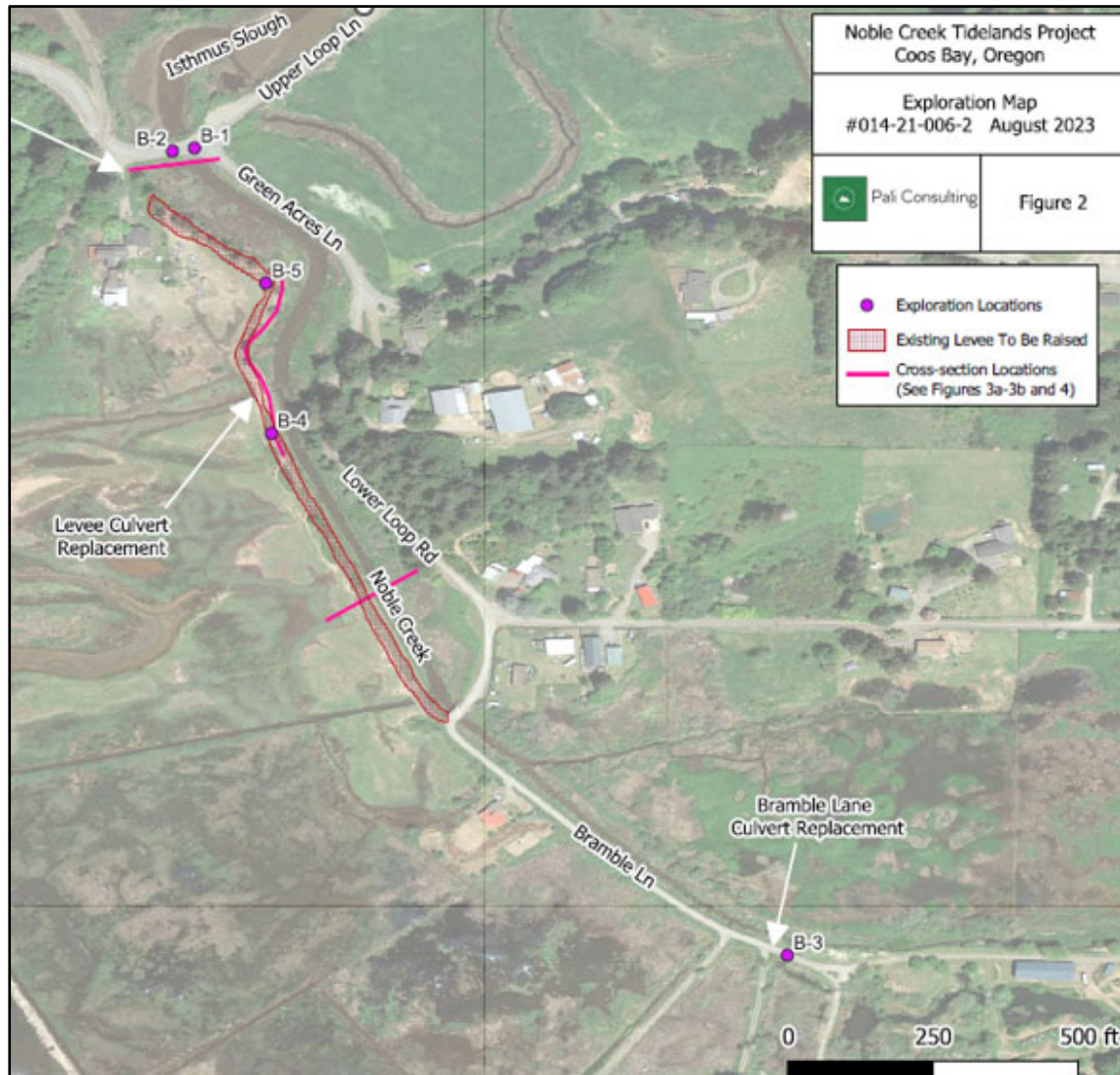


Figure 8. Locations of Geotechnical Borings in the Project Area by Pali Consulting (2023).

The initial concept designs for this project assumed that a cast-in-place culvert with a “fish-friendly” tide gate would be the preferred solution for replacing the existing culverts. The geotechnical investigation (**Appendix B**) showed that the saturated soils at the crossing were not strong enough to support a spread footing culvert, and that this approach would also require pile supported foundations. This finding led to changes in the design approach, as explained in the Alternatives Analysis Section (see Section 4.2.4).

2.3.2 Noble Creek Levee

The borings along the levee (Borings B-3, B-4, and B-5) showed similar subsurface conditions as the borings at Green Acres Lane, except the siltstone bedrock was only encountered at one of the borings. However, because the proposed culvert at these locations will be comprised of plastic pipe, rather than a cast-in-place concrete structure or bridge, there is less concern about the strength of the soils to support the culvert. The main question evaluated by the borings along the levee (especially B-4 and B-5) is what effect that potentially upgrading the levee will have on the underlying soils. The results of this analysis suggested that increasing the height of the existing levee will reduce the stability of the levees as a result of near term and long term settlement. The amount of settlement will be determined by the height and width of the proposed fill, and designs for the levee repair must account for this potential.

2.4 EXISTING CONDITIONS HYDROLOGY

The hydrology of the project area includes two features: (1) the hydrology tied to tides in Coos Bay and translated up Isthmus Slough to the project site, and (2) flows in Noble Creek controlled by rainfall and runoff in the Noble Creek watershed.

Tidal Hydrology

Water level data for the project area were needed to help develop alternative concepts, calibrate and validate the hydraulic model, and test the hydraulic performance of potential project scenarios. Coos Soil and Water Conservation District (CSWCD) installed one barometric pressure sensor and six water level sensors in the streams, sloughs, and ditches in the project area (**Figure 9**). These were maintained from December, 2021 through April, 2023. This period of record includes multiple king tide events, Noble Creek floods, and two data sets for each season of the year.

The data show that tidal fluctuations in Isthmus Slough just outside the main Noble Creek tide gates (**Figure 9A**, blue line) range from 10 feet at high tides and 0 feet at low tides, and can exceed 11 feet elevation during king tides. Just inside the main Noble Creek tide gates (orange line), the tidal fluctuations are muted by the leaking tide gates, rarely exceeding 8 feet elevation, and high tides typically around 6 feet. The interior ditches (**Figure 9B**, purple and red lines) are muted tidal systems, in which high tides are typically closer to about 4 to 5 feet elevation. Upstream of the project area (**Figure 9B**, blue line), water levels reflect flows in Noble Creek and there is a small tidal signal observable during lower stream flow periods.

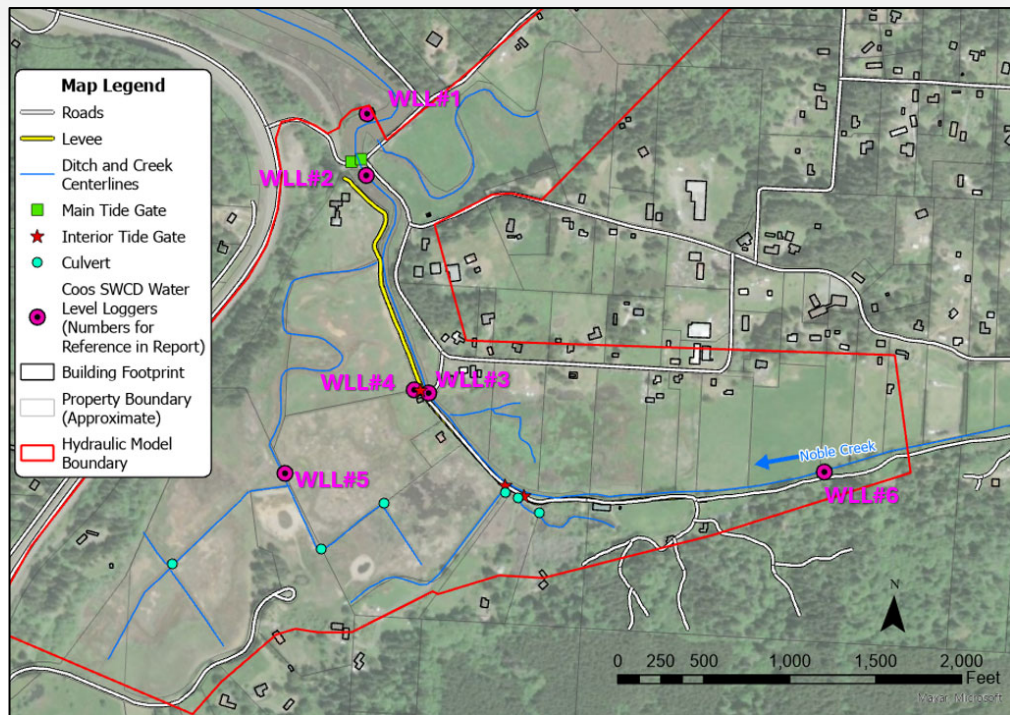


Figure 9. Locations of Water Level Loggers in the Project Area Installed and Maintained by CSWCD.

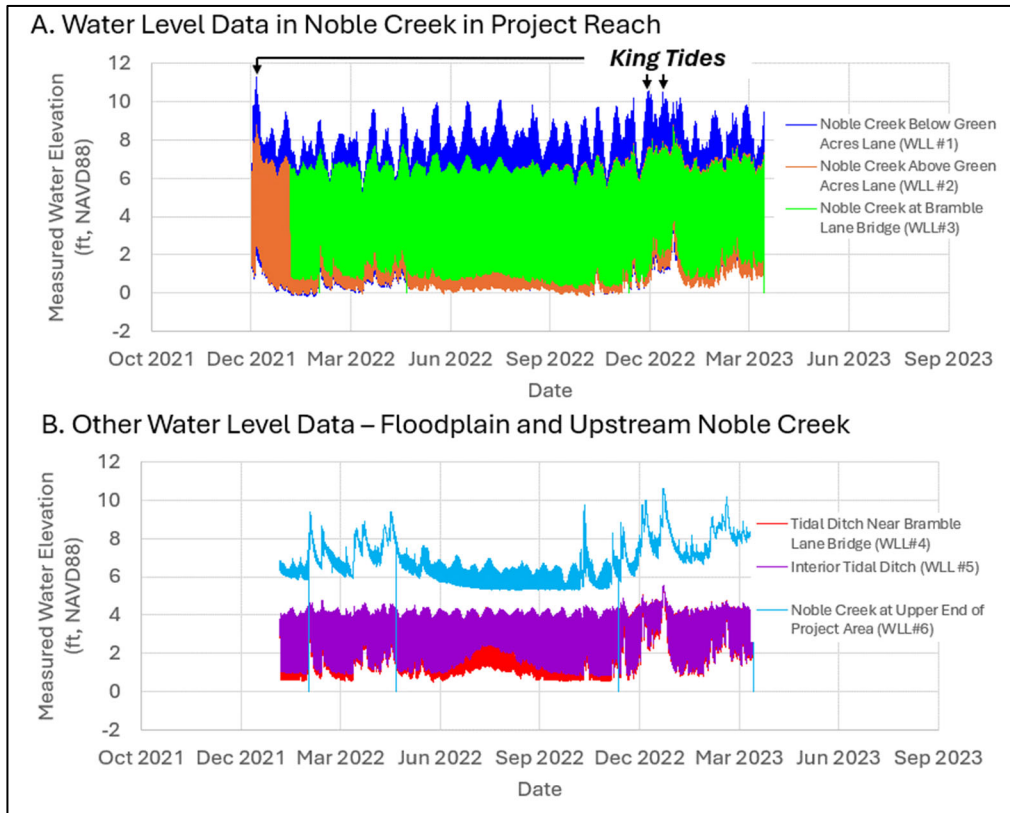


Figure 10. Water Level Data Summary.

Noble Creek Hydrology

Noble Creek drains a 5 mi² watershed in the coastal mountains east of the project area. Flow in Noble Creek is usually small, remaining below about 4 cfs about half the time, and remains below 60 cfs more than 90% of the time. More significant flows occur following large rainstorm events. Based on the calculations of USGS StreamStats' program, discharge in Noble Creek approaches 300 cfs once every 2 years on average, and reaches 1,000 cfs about once per century (**Table 1**).

The peak flow estimates based on StreamStats are significantly higher than the values computed using an alternative method based on a flood frequency analysis using nearby stream gage data. The Oregon Water Resources Department operates a "near real time" stream gage on Johnson Creek near Bandon, OR, a watershed with a similar drainage area and precipitation as Noble Creek. The flood frequency analysis suggest that the estimate of the 2-year and 100-year recurrence interval flows in Noble Creek using this data are about 130 cfs and 610 cfs, respectively, compared with 300 and 1,000 cfs using StreamStats. Because the purpose of the analysis is to evaluate the potential for flooding, using the StreamStats values is more conservative than using the estimates based on the nearby OWRD gage. Therefore, for the subsequent analysis the values from StreamStats shown in **Table 1** are used to simulate flooding in Noble Creek.

Table 1. Noble Creek at Green Acres Lane Watershed Statistics (from USGS StreamStats) and Comparison with Johnson Creek at Bandon (Peak Flow Statistics based on Flood Frequency Analysis)

Statistic	Value from StreamStats	Values Computed from Johnson Creek in Bandon OWRD Gage	Units
Basin Statistics:			
Drainage Area	5.2	4.6	mi ²
Minimum Elevation	0.6		ft.
Mean Basin Slope	12.9	4.29	degrees
Mean Annual Precipitation	63.3	63.2	in.
Peak Flow Statistics:			
2-Year Recurrence Interval Peak Flow	294	130	cfs
10-Year Recurrence Interval Peak Flow	581	300	cfs
100-Year Recurrence Interval Peak Flow	1,000	610	cfs
Low Flow Statistics:			
Flow that is Exceeded 95 Percent of the Time	0.03		cfs
Flow that is Exceeded 50 Percent of the Time	4.4		cfs
Flow that is Exceeded 10 Percent of the Time	42		cfs
Flow that is Exceeded 5 Percent of the Time	55		cfs

3.0 EXISTING CONDITIONS HYDRAULICS

Understanding the complex hydraulics in the Noble Creek Tidelands area and predicting the effects of different management scenarios will be critical to achieving the project's objectives. The hydraulics of this site are impacted by flows in Noble Creek, tidal fluctuations in Isthmus Slough, two leaking tide gates at the Green Acres Lane crossing, three interior leaking tide gated culverts, an artificial ditch network, and an important flow pathway through a nutria burrow in an existing levee. This section covers the development and calibration of the Existing Conditions model. The findings of the Proposed Conditions modeling are covered in Section 6 of the report.

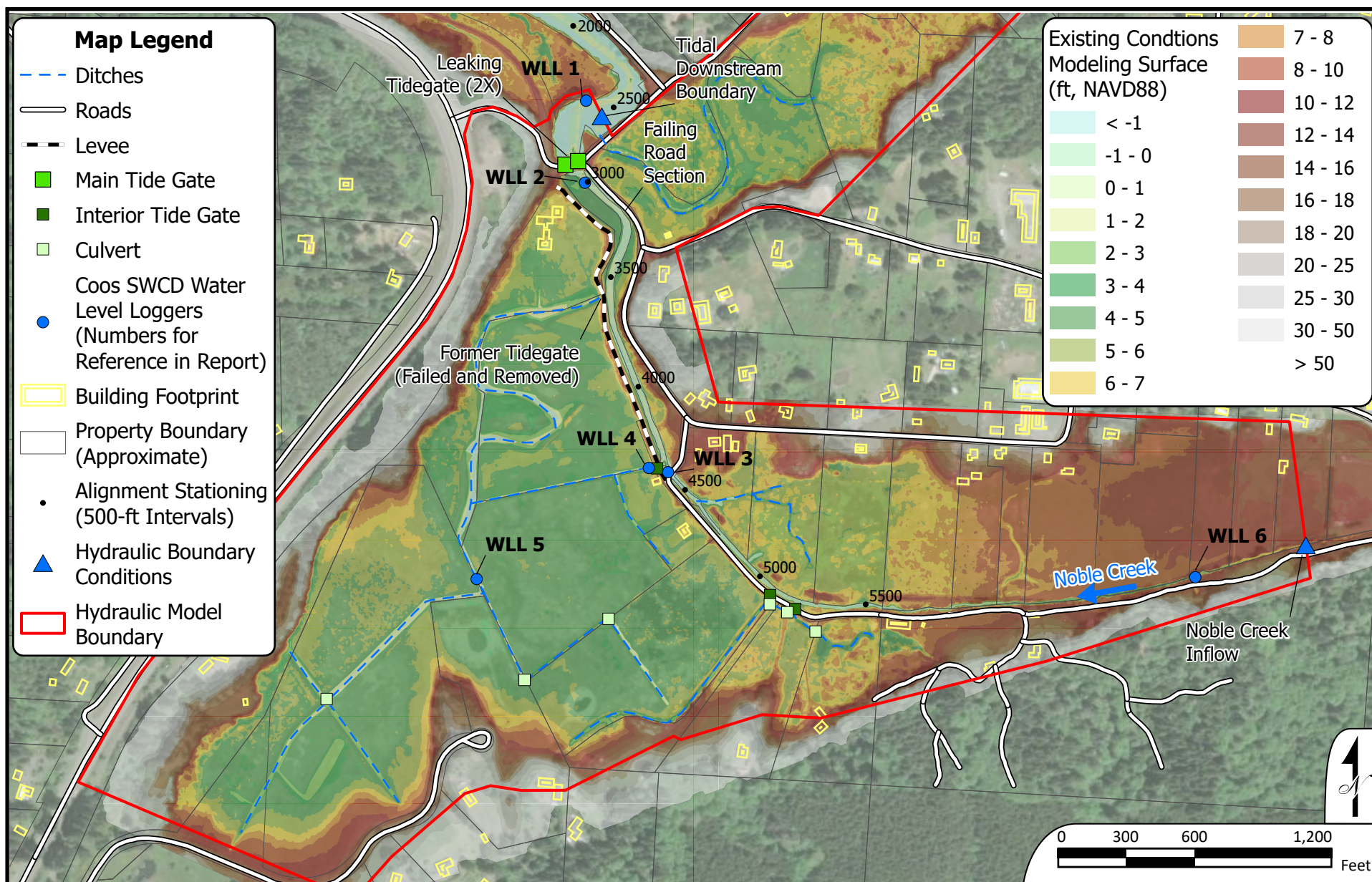
3.1 MODEL DEVELOPMENT

3.1.1 Data Sources and Model Set Up

Topographic and Bathymetric Data. Figure 11 shows the model extent and layout, along with the locations of modeled hydraulic structures, boundary conditions, and calibration points. The best available LiDAR data, collected in 2009, was used for topographic information for most of the interior floodplain and upland areas. Bathymetric data (river bed topography) in Isthmus Slough, Noble Creek, and parts of the interior ditch and channel network were collected in 2022 by Solmar Hydro Inc., using single beam sonar from a remotely operated hydrographic survey vessel. In addition, Waterways collected extensive ground based topographic survey data on the main road, culverts, tide gates, levees, ditches, houses, above ground utilities, and throughout the floodplain using RTK GPS and laser total station. Figure 12 shows the extent of the ground survey data. The LiDAR, bathymetric, and ground survey data were merged to create a single continuous topographic surface for modeling.

Leaking Tide Gates. One complexity with modeling this system is that the hydraulic conditions inside the Noble Creek Tidelands are presently driven by several leaking tide gates, especially the main Noble Creek tide gates at Green Acres Lane. The leaking tide gates transfer a "muted" tidal signal across the culverts. This leakage is a primary control on water levels on the interior of the project area, but the tidegate leakage rates are not known, and are difficult to measure directly. For the purposes of the Existing Conditions model, the leakage was modeled using a modification in the HEC-RAS model in which we included a secondary "dummy" culvert in the model at the location of each leaking tide gate. The dummy culvert allows flow in one direction only (inflow) when the water level in Isthmus Slough is higher than in Noble Creek on the inside of the tide gates. The flow rate representing the leakage was estimated through a calibration process, using water level data from the both sides of the leaking tide gates to estimate the diameter of the dummy culvert that best reproduced water level fluctuations at the interior water level sensor. Paired water level data were available at the main Green Acres Lane tide gates and at an interior tide gated culvert just at Bramble Lane Bridge over Noble Creek, near river station 4400 (WLL 3 and WLL 4 in Figure 11).

Hydraulic Roughness. The initial hydraulic roughness values in the model are based on a roughness map (Figure 13) created manually by digitizing roughness areas using aerial images, topographic information and field photos. These were adjusted during the calibration process.



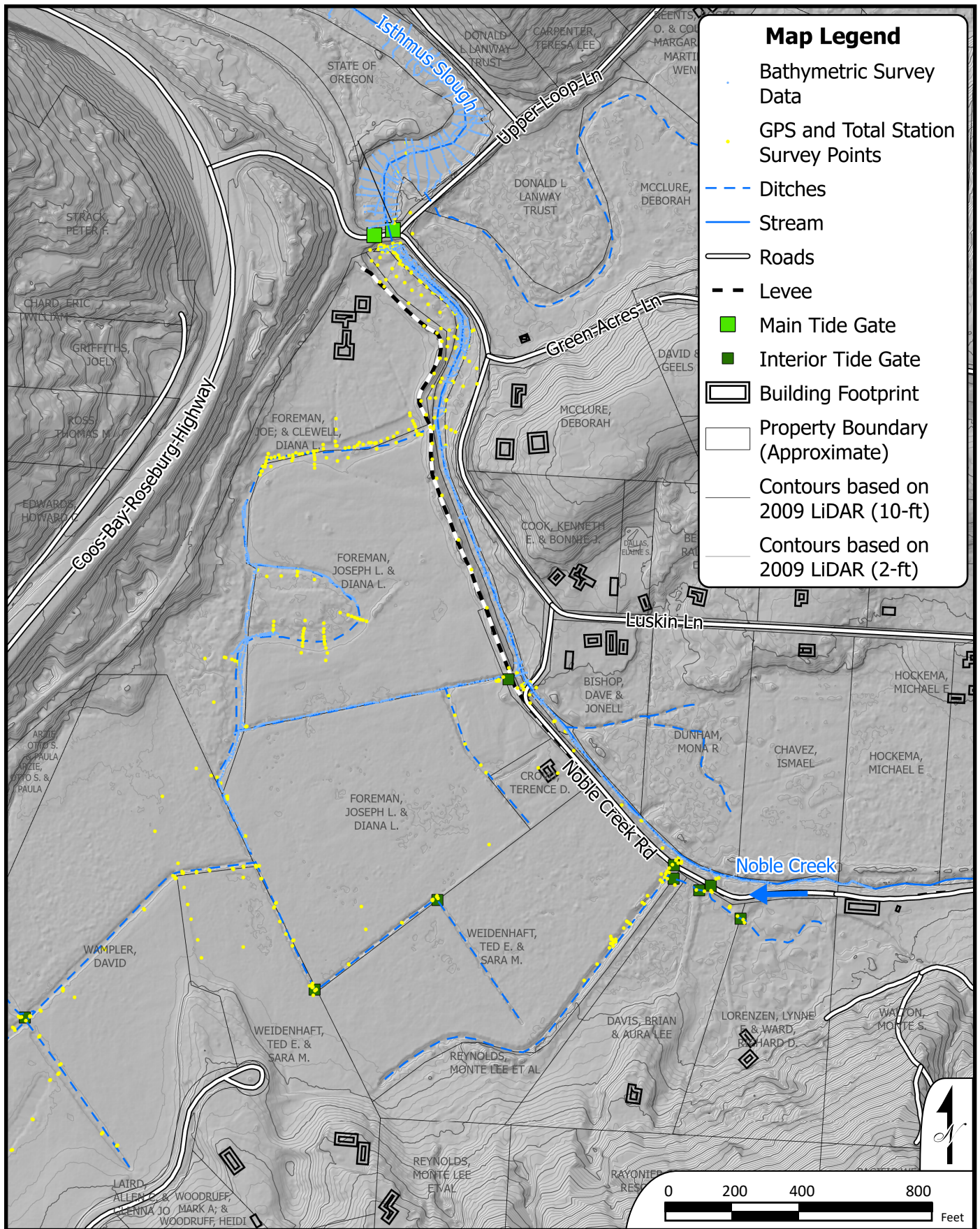
FIGURE

11

Noble Creek Tidal Hydraulics Model Overview

Noble Creek
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Project

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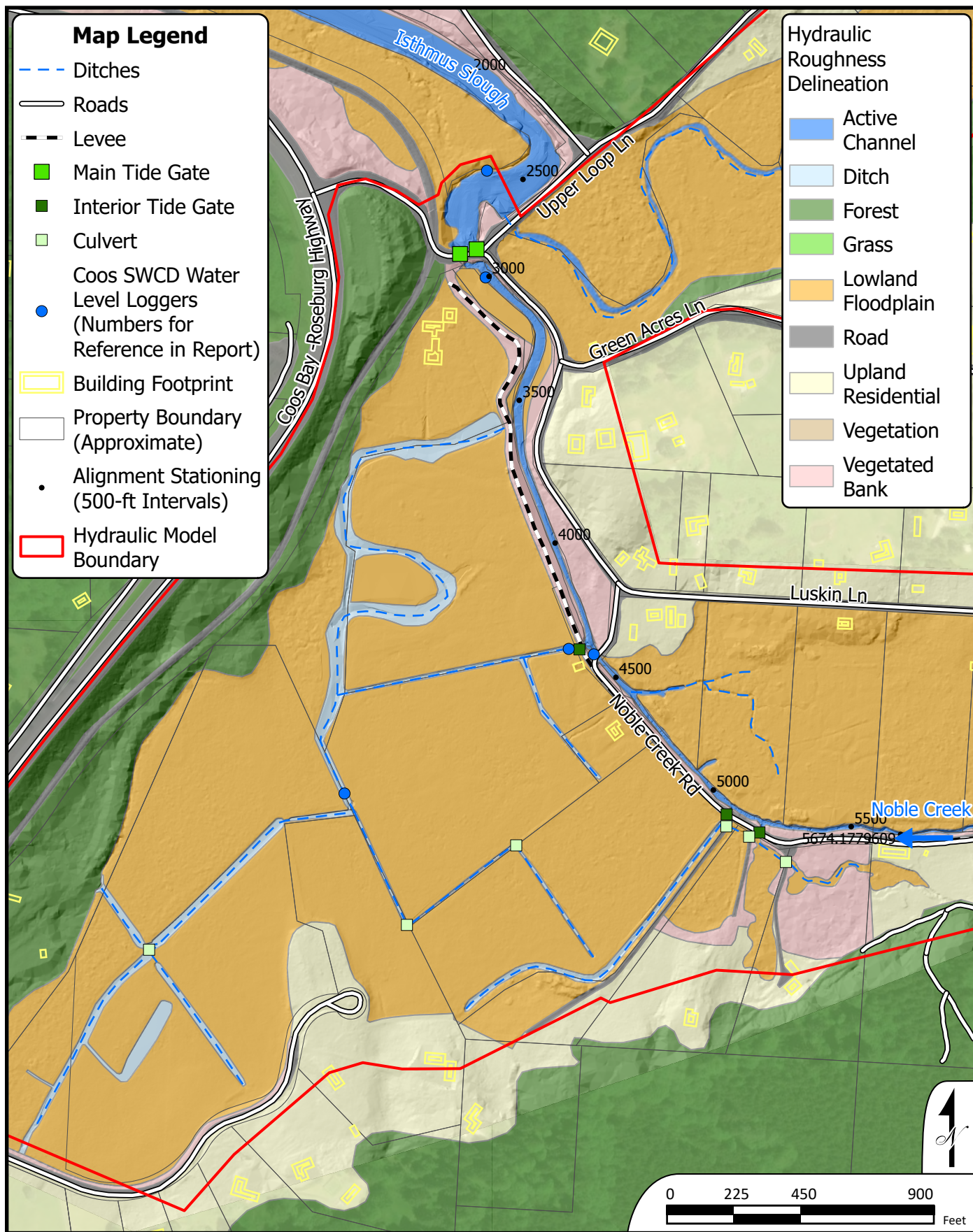


Ground Based Survey Data to Support Model

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**FIGURE
12**



Surface Roughness Regions for Noble Creek Hydraulic Model

Noble Creek
Tidelands Restoration
Project

3.1.2 Model Calibration and Validation

Model calibration consists of trying to improve the performance of a model by comparing the modeled predictions with measured field data and adjusting parameters in the model to better match the field data. In this model, calibration was used to estimate leakage across the leaking tide gates (discussed above), and to adjust roughness parameters in the channel, ditches and floodplain.

The selected calibration period was April 19-21, 2022. This coincided with the dates of the ground survey when Waterways staff also measured water levels at several locations at different points in the tidal cycle (**Figure 14** and **Table 2**).

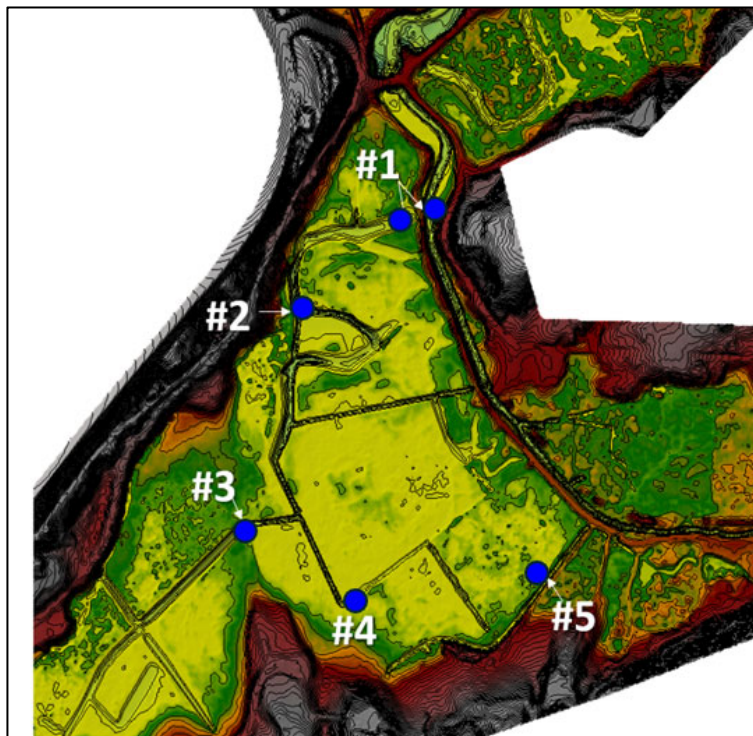


Figure 14. Locations of RTK-GPS Water Level Measurements in April 2022. Data are in Table 2.

The calibration process included 54 iterations of the model for the April 19-21, 2022 calibration period. Between model runs, roughness values and tide gate leakage values were adjusted and results were compared with field data. The calibration results are summarized in **Figure 15** and **Table 2**. **Figure 15** shows a time series of measured and modeled water levels for the final calibration run (Run 54), along with several early calibration runs to illustrate the effect calibration process on the model predictions. **Table 2** compares the surveyed water levels and modeled water levels at the corresponding times, based on the final model calibration run.

Figure 15 compares modeled and measured water levels for the April 19-21 calibration period, at each of the 6 water level loggers (logger locations are shown in **Figure 11**). The graphs show the model predictions for two of the 54 calibration runs: Run 1, the initial, uncalibrated model; and Run 54, which

was the final, calibrated model. Showing the initial and final calibration runs provides a good idea of the impact of the calibration.

Water Level Logger 1 (WLL #1), at Isthmus Slough (upper left graph) just outside the main tide gates, is the downstream model boundary condition; at that location, the modeled and measured water levels are the same. At WLL #2 and WLL #3, on the mainstem of Noble Creek behind the tide gate, the model calibrated well by the final calibration run. Using the “dummy culverts” and roughness adjustments, it was also possible to calibrate the model for interior ditches behind leaking tide gates (WLL #4 and #5) during the calibration period. The water levels at the upstream boundary (WLL #6, bottom right graph) are based on the flows measured at a nearby stream gage, Johnson Creek near Bandon, OR (ORWD Gage 14327122). Flows were adjusted slightly based on the difference in drainage area; however, little adjustment was needed because both basins are approximately 4.5 mi².

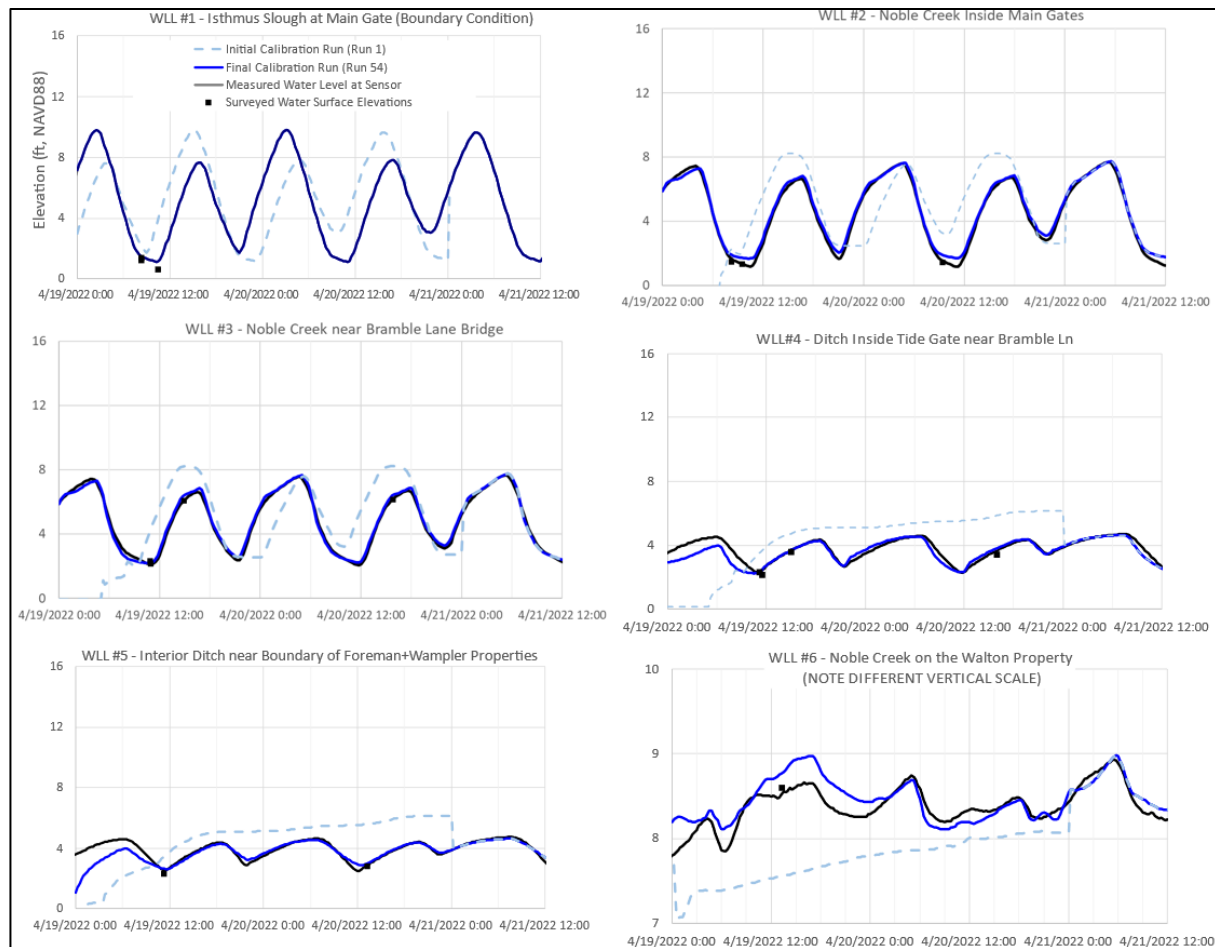


Figure 15. Final Calibration Results and Comparison with Initial Model Run

Table 2 compares instantaneous water surface elevation measurements with the model prediction at the same time and place. This comparison suggests that the instantaneous model error is typically between 0.2 and 0.6 feet, and can be as much as 1 foot. However, this discrepancy in instantaneous model predictions and surveyed elevations overestimates the limitations of the model, which calibrated well to the measured data. Most of the instantaneous error is related to the model's timing of the movement tidal signal through the system, rather than the maximum tidal elevation. The model's ability to predict maximum tidal inundation at a given location is more important than the timing, and based on **Figure 15**, the model matches the measured data well through the calibration period.

It is important to note that the model errors shown in **Table 2** and **Figure 15** are for the calibration period only. Predictions for non-calibration period, or for hypothetical events outside of the data collection window, will probably have larger errors.

Table 2. Selected Water Elevation Measurements with RTK GPS During April 19-21, 2022 Calibration Period

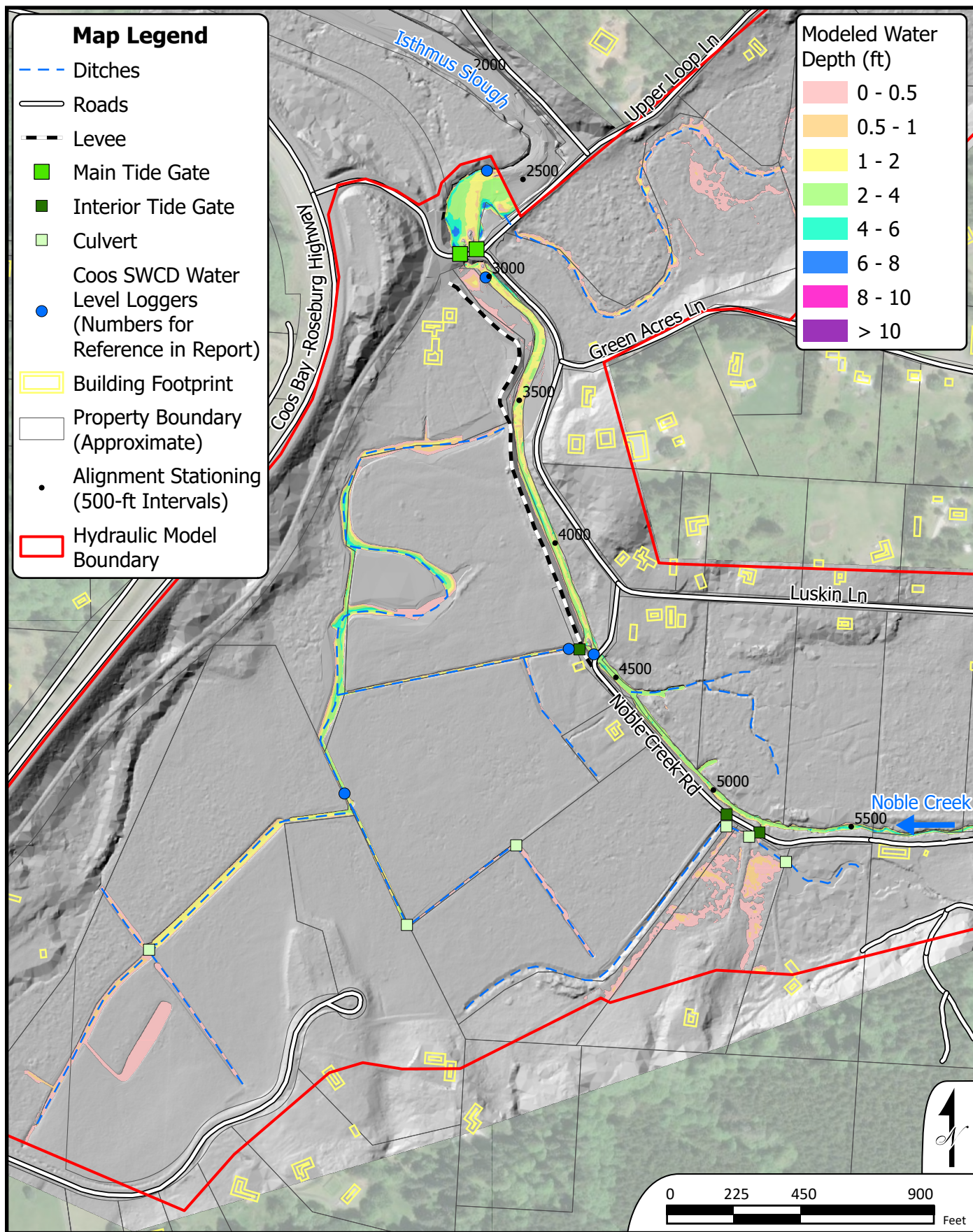
Location and Measurement Description	Date	Time	Measured Water Surface Elev. (ft, NAVD88)	Modeled Water Surface Elev. (ft, NAVD88)	Difference (Modeled minus Measured) (ft)
<i>Calibration Run #54</i>					
By Failed Tide Gate (#1)					
<i>High Tide:</i>					
2013 Inside Failed TG	04/19/22	3:45 PM	3.50	3.84	0.34
2012 Outside Failed TG (Noble Ck)	04/19/22	3:45 PM	6.21	6.61	0.41
<i>Near Low Tide:</i>					
3067 Inside Failed TG	04/20/22	10:18 AM	3.50	3.77	0.27
3068 Outside Failed TG (Noble Ck)	04/20/22	10:20 AM	1.70	2.03	0.33
North End Big Meander (#2)					
4034 North End of Big Meander	04/20/22	1:30 PM	2.25	3.23	0.98
Bend in Ditch (#3)					
4120 Bend in Ditch	04/20/22	2:56 PM	3.10	3.60	0.50
90 Degree Bend in Ditch (#4)					
4064 90 Degree Bend	04/20/22	2:28 PM	2.91	3.47	0.56
4065 90 Degree Bend	04/20/22	2:30 PM	3.06	3.47	0.41
Levee (#5)					
5031 Breach in Levee	04/21/22	9:39 AM	5.21	4.60	-0.61
5032 Breach in Levee	04/21/22	9:40 AM	5.02	4.60	-0.42

3.2 EXISTING CONDITIONS MODEL RESULTS

The calibrated model was used to simulate a variety of scenarios to better understand the site's hydraulic function. This section discusses the findings of the Existing Conditions modeling; modeling of several Proposed Conditions model is discussed under the Alternatives Analysis. The existing conditions model was run using the measured water level at WLL #1 as the downstream boundary condition. Flows into the model from Noble Creek were estimated using flow data from nearby stream gage at Johnson Creek (ORWD Gage 14327122) as discussed above. The model simulated the water levels and velocities throughout the project area over time. Some of the results are summarized in **Figure 16, 17, and 18**, which show the predicted inundation patterns at a typical summer low tide, a typical winter high tide, and during a king tide event.

The following bullet points summarize Waterways' interpretations of the Existing Conditions model results:

- During low tides in the summer (**Figure 16**), one to four feet of water remain in the mainstem of Noble Creek and in the large, curved abandoned channel in the center of the Foreman's property.
- Less than 1 foot of water remains in the ditches and ponded areas in the floodplain at low tides (**Figure 16**).
- During typical high tides (**Figure 17**), enough water gets into the ditches because of leakage through tide gates to fill ditches and cause minor flooding of fields. At high tide, the water depths in the center of the ditches and abandoned channel are 2 to 6 feet.
 - There is also a hole in a levee on the east side of the basin where nutria have burrowed under a levee on the east side of the basin, allowing water to enter the floodplain. This is included in the model as a small culvert, which probably underestimates the impact of the burrow.
- In a king tide, model shows more inundation across floodplain (**Figure 18**), but presumably much less flooding than if there were no tide gates in place.

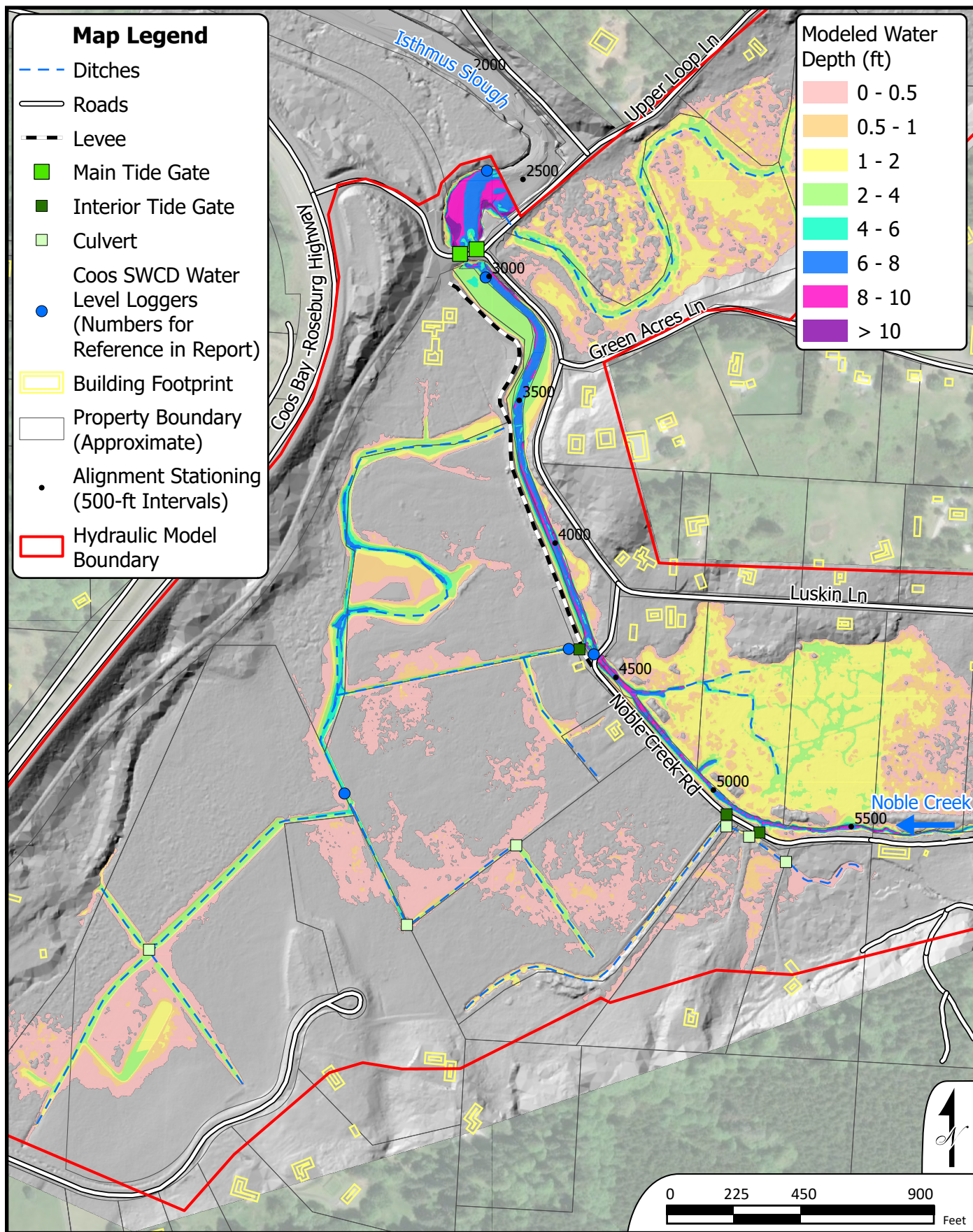


Existing Conditions Model Depth
Typical Low Tide
May 15, 2022 7:30 AM

Noble Creek
Tidelands Restoration
Project

WATERWAYS
 CONSULTING, INC.
 Santa Cruz, CA | watways.com | Portland, OR

FIGURE
16

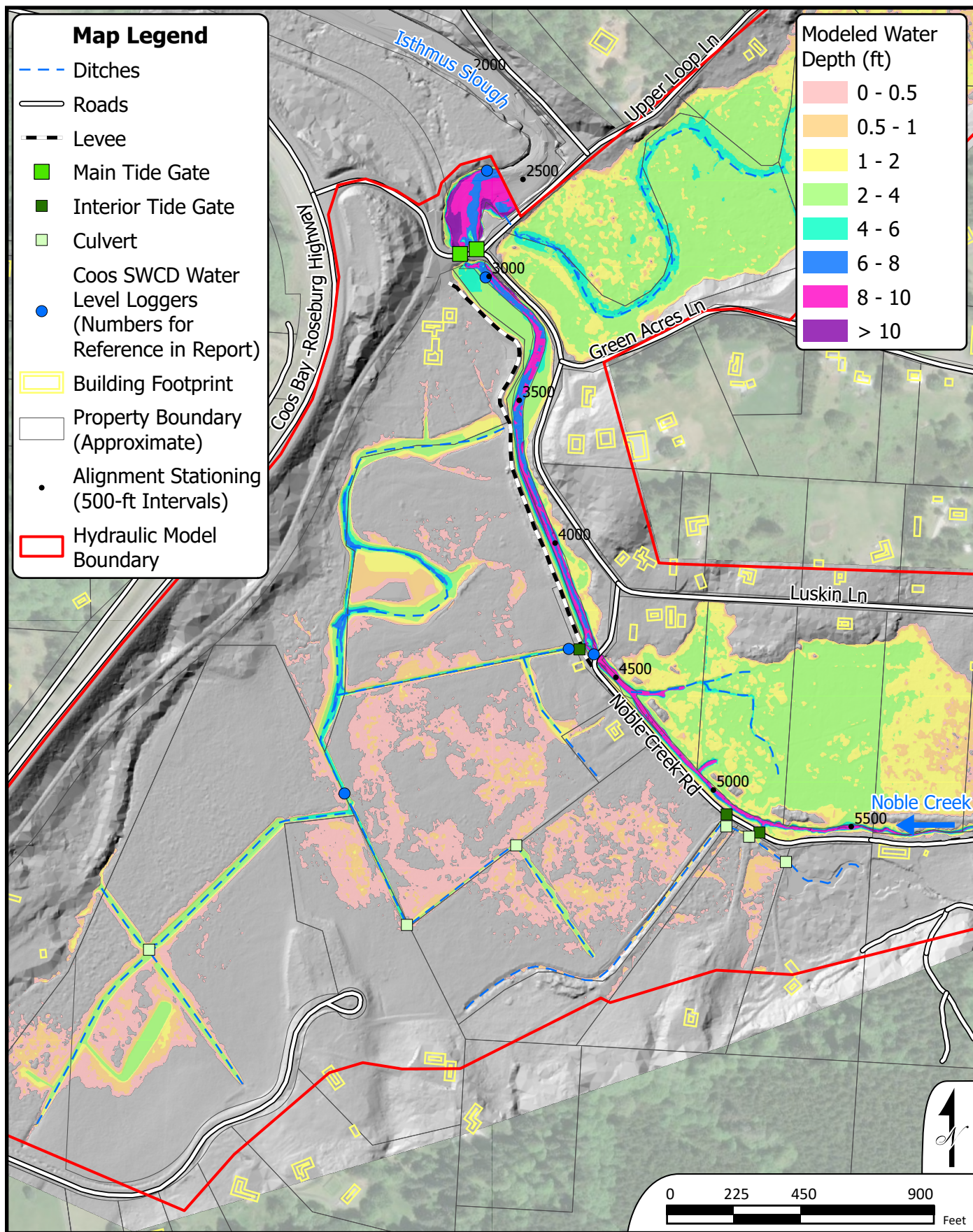


**Existing Conditions Model Depth
Typical High Tide
May 16, 2022 3:00 AM**

**Noble Creek
Tidelands Restoration
Project**

WATERWAYS
CONSULTING, INC.
Santa Cruz, CA | watways.com | Portland, OR

**FIGURE
17**



Existing Conditions Model Depth
King Tide
January 3, 2022 1:15 PM

Noble Creek
Tidelands Restoration
Project

 **WATERWAYS**
 CONSULTING, INC.
 Santa Cruz, CA | watways.com | Portland, OR

FIGURE
18

4.0 ALTERNATIVES ANALYSIS

4.1 OPPORTUNITIES AND CONSTRAINTS

The Noble Creek Tidelands Restoration Project is a multi-objective effort that aims to accomplish multiple infrastructure, public safety, and habitat goals. The main opportunities and constraints for the project are summarized below.

Project Opportunities

- Work with Coos County to improve crossing to ensure reliable access to Green Acres community
- Replace existing deteriorated and leaking tide gates with “fish-friendly” tide gates to restore fish access to large area of critical tidal habitat.
- Upgrade interior levees where appropriate to provide better flood protection.
- Excavate new tidal channels, fill ditches, and add wood and other complexity elements to improve the quality of newly accessible tidal habitat.

Project Constraints

- Vehicle access to the Green Acres community must be maintained without interruption.
- Project must ensure the same or a higher level of protection from tidal inundation for residences in floodplain.
- Landowners must approve of the location and frequency of increased tidal inundation as a result of the project.
- All new tide gates must meet fish passage criteria as laid out by Oregon Department of Fish and Wildlife guidelines.

The alternatives analysis was subdivided into two parts: (1) Consideration of alternatives at Green Acres Lane, and (2) Consideration of alternatives for the interior tidal floodplain. Each of these two parts of the project offer separate, but dependent, options. For the purposes of this project, it was important to first clarify what the preferred alternative would be at the Green Acres Lane crossing. Once that was defined, it was possible to compare various options for improving the newly accessible habitat.

CSWCD organized a community meeting in December 2022 at which the design team presented the alternatives. The Alternatives Analysis presentation from the community meeting is provided in **Appendix C**, and the key points are summarized below.

4.2 ALTERNATIVES AT GREEN ACRES LANE

The crux of the project is the improvements to the crossing of Green Acres Lane (GAL) over Noble Creek. At this crossing Noble Creek enters Isthmus Slough through two aging and deteriorated wooden

culverts with leaking wooden tide gates. Just upstream from the GAL crossing is a failing section of road on river right along Noble Creek, which is slated to be upgraded by Coos County (**Figure 19**).

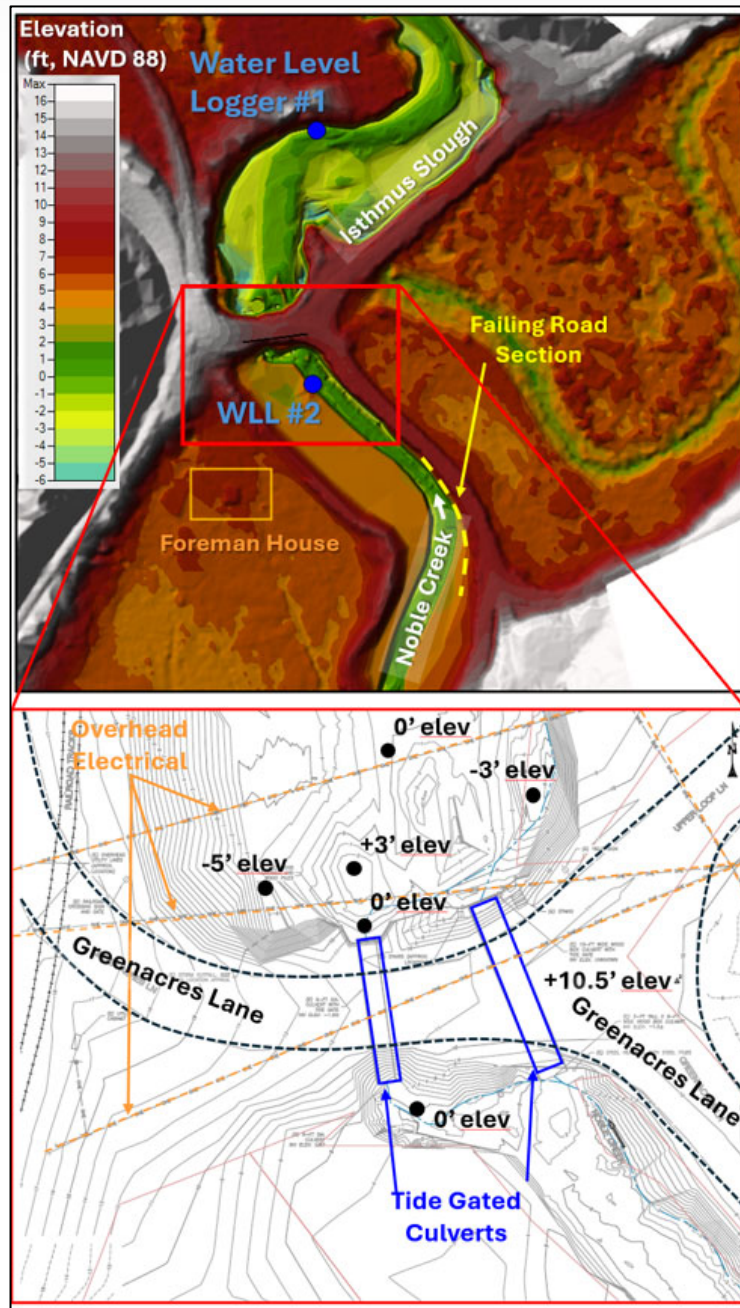


Figure 19. Existing Conditions Near the Green Acres Lane Crossing

The design team looked at three alternative options for upgrading the crossing (**Figure 20**): (A) Replace the GAL crossing and culverts with a new bridge; (B) Replace the GAL crossing with new, upgraded, tide gated culverts; and (C) Replacing the crossing with two separate structures: a bridge or culvert

road crossing for traffic, and a separate structure containing tide gates, which would be used to control the water levels.

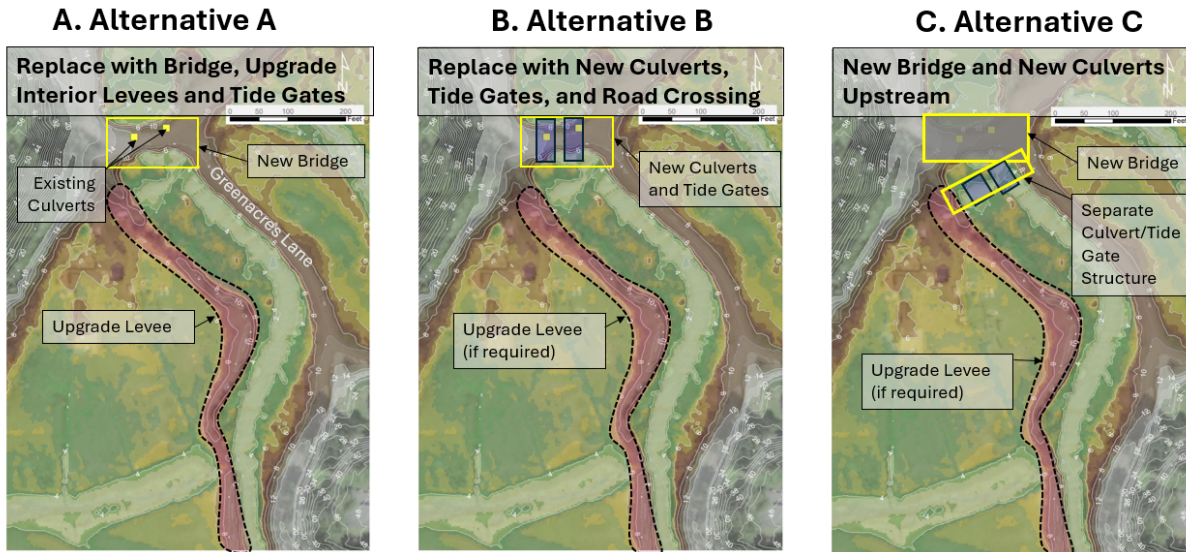


Figure 20. Alternatives for Near the Green Acres Lane Crossing

4.2.1 Alternative A - Bridge Only Option

Alternative A (a.k.a. Bridge Only Option) is the option for Green Acres Lane that assumes the existing tide gated culverts would be replaced with a single span bridge to provide fish passage at all stages. This would be coupled with increasing the heights of the interior levees and installing interior tide gates to protect against tidal flooding on adjacent properties (**Figure 20A**). This would be the simplest solution for the Green Acres Lane crossing but may not provide enough flood protection.

To evaluate the impact of replacing the culverts with a bridge, we modeled tidal flooding under existing and proposed conditions for measured a king tide event (January 3, 2022). In this version of the model, the tide gates were removed and replaced by a bridge, and the interior levee elevations were *not* raised to compensate for this. **Figure 21** shows the extent and depth of modeled inundation for existing conditions and this “Bridge Only” option. The model shows much more widespread flooding in a king tide event with the tide gates replaced by a bridge. Without any tide gates, in a king tide the water surface elevations would exceed levee elevations along almost the entire length of the southern levee and overtop the road. This implies that the entire southern levee along Noble Creek, which is about 2,700 feet long, would need to be raised by as much as several feet to provide the same level of protection to the adjacent pastures, houses, and other infrastructure. Extensive rebuilding of the levee would require soil import because of the poor quality of on-site soils for levee construction (see above, Section 2.3, and geotechnical report, **Appendix B**). In addition, this Alternative also would increase the extent of flooding for landowners to the north of Noble Creek, so additional flood protection may also need to be provided on the north side of the creek.

Given the findings from the hydraulic modeling and the levee soil properties discussed in the geotechnical investigation (Section 2.3 and **Appendix B**), this Alternative was considered infeasible and was discarded as a design solution.

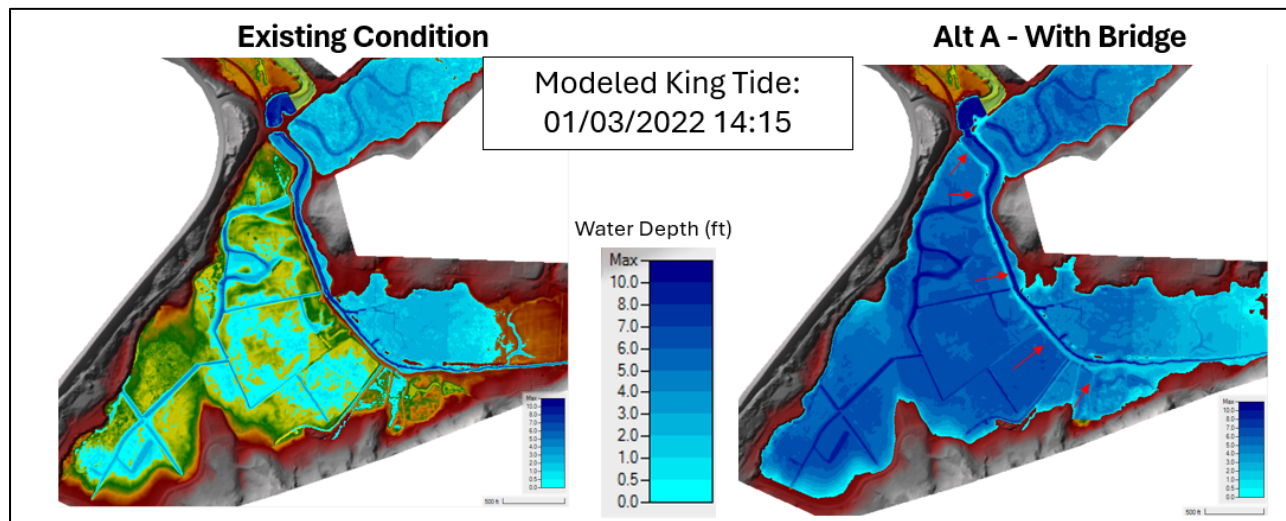


Figure 21. Comparison of Modeled Inundation King Tide Under Existing Condition and Alternative A. Red arrows in right panel indicate primary areas where levee would be overtopped.

4.2.2 Alternative B - New Crossing, Tide Gate and Culverts

Alternative B would replace the existing tide gated culverts at GAL with new culverts, tide gates, and muted tidal regulators (**Figure 20B**). Interior levees may need to be upgraded based on the water management plan, but they would not need to be fully constructed along their entire length as in Alternative A.

Based on initial modeling which showed that at least two 8-foot diameter culverts would be required to meet the fish passage requirements for the tide gates at this location, it was assumed that the culverts would be concrete culverts cast in place on a spread foundation. To maintain vehicular access to the Green Acres community throughout the construction process, two options would be possible: (1) build a temporary crossing either upstream or downstream of the current crossing, then remove and rebuild the crossing and tide gated culverts and remove the temporary crossing, or (2) build the new permanent crossing in a different location from the current crossing, and then remove the current GAL crossing and culverts after the new crossing is completed. Of these two, option 1 would be more likely because the current location is the most suitable long term crossing location due to the configuration of the roads, utilities, private properties and existing wetlands (see **Figure 19**).

In this scenario, long term maintenance responsibilities could be unclear. Coos County would maintain the road and crossing. However, the county does not want to be responsible for maintaining the

tidegate infrastructure, and this task may need to be taken on by project sponsors, landowners, or a community drainage district. If the road and tide gates are integrated into the same structure, maintenance responsibility under some scenarios could become complicated.

4.2.3 Alternative C - Separate Bridge and Tide Gate Structures

In this alternative, the crossing would be replaced by a bridge, and a separate tide gate and culvert structure would be built separate from the bridge (**Figure 20C**). In this scenario the ownership and maintenance responsibilities would be more clearly defined compared with Alternative B. There would be some constructability advantages with this option, which would be constructed over two summers. In year one, the separate tide gate structure could be constructed without interrupting traffic flow to the neighborhood. In the second construction season, traffic could be temporarily diverted over the tide gate structure while the new bridge was being built, and traffic could be re-directed over the bridge before the winter.

While Alternative C provides some advantages over Alternative B in terms of constructability and maintenance responsibility, it comes with a much higher cost because two separate permanent structures would need to be built. It was determined by the design team, in consultation with the community and Coos County roadmaster, that the benefits of Alternative C did not justify the added costs.

4.2.4 Selection of a Preferred Alternative for Green Acres Lane Crossing

Coos SWCD organized and hosted a community meeting at the Noble Creek Fish Hatchery on December 14, 2022 to discuss the project, to hear feedback regarding the community's preferences, and begin the process of selecting a preferred alternative. At the community meeting, CSWCD and ODFW provided an introduction to the project to the community. Waterways reviewed the alternatives discussed above and presented some initial modeling results, and CSWCD facilitated a community discussion about the project. The presentation materials outlining the alternatives are provided as **Appendix C**.

In general, the community members were supportive of a project to improve the reliability of the Green Acres Lane crossing while improving and expanding salmonid habitat. There were concerns expressed about the costs to community members of maintaining tide gates, as well as vehicle access to the community during construction. Following the meeting, CSWCD followed up with community members, landowners, and with the Coos County roadmaster. Waterways further developed the alternatives and the hydraulic analyses. Following this process, the design team (CSWCD, ODFW, and Waterways) selected Alternative B as the most effective and efficient option. Following the full geotechnical investigation in May 2023, however, it became clear that the culverts on a spread foundation would not be possible due to unstable soils, and that very deep piles would be required to anchor any bridge or culvert (**Appendix B**). This led to replacing the preferred alternative (Alternative B) with a variation on this Alternative B. In short, there will be a bridge crossing with deep piles, plus a separate tide gate structure immediately adjacent to the bridge. The tide gates will be attached to a

sheet pile wall, without the need for heavy concrete culverts. The selected option is shown in the design drawings (**Appendix A**, Sheet C4) described in more detail in the Basis of Design (Section 5.1).

4.3 ALTERNATIVES FOR INTERIOR OF PROJECT AREA (BEHIND MAIN TIDE GATE)

Once it was determined that the current Green Acres Lane crossing would be replaced with a new tide gated crossing at about the same location (Alternative B), it was possible to begin to evaluate alternatives for enhancements to the interior of the project area. Three alternatives for the interior project area were considered:

- No interior improvements
- Upgrade interior tide gates
- Upgrade interior tide gates with channel and floodplain restoration

4.3.1 Alternative A - No Interior Improvements

Alternative A for the interior project area is the “No Action” alternative. In this scenario, the project would focus on replacing the crossing and tide gates at the Green Acres Lane crossing and necessary levee upgrades, with no improvements or upgrades to interior tide gates, ditches, or channels for fisheries benefit.

Advantages of Alternative A. This option would improve the reliability of neighborhood access in the Green Acres community while also improving fish passage and allowing salmonids to access tidal habitat. This Alternative would be the simplest and cheapest option and allow the design and construction process to focus on the road crossing and a single work area. This option would also leave open the possibility for doing interior habitat enhancements and upgrading interior tide gates as part of potential future projects.

Disadvantages of Alternative A. The main disadvantage of this approach is that it would not maximize the habitat enhancement opportunities of the site. The Noble Creek Tidelands consist of nearly 100 acres of potentially tidally inundated channels and floodplains that are mostly disconnected from natural tidal processes due to levees, berms, ditches, and tide gates. While improving passage at the main GAL tide gates will allow fish to access the main stem of Noble Creek and part of the floodplain, the fisheries benefit from this approach may be limited. Although it is possible that future projects will continue to enhance the site, it is not certain that will happen. In addition, potential funders of the project are primarily interested in habitat benefits. Without more interior habitat improvements, it may be difficult to fund the project.

Therefore, Alternative A was discarded in favor of other options that will provide more habitat benefit.

4.3.2 Alternative B - Interior Tide Gates Only

In Alternative B, the Noble Creek crossing at Green Acres Lane would be upgraded as described in above, and interior (upstream of the GAL crossing) culverts and tide gates would also be improved to provide more fish access and better flood protection (**Figure 22**) For the initial evaluation, it was assumed that three interior culverts would be installed, removed, or upgraded:

- (1) A new culvert would be installed in the levee on river left, several hundred feet upstream of GAL crossing (**Figure 23A**). This new culvert would be at the same location where a culvert washed out in May of 2020. Depending on the water management plan at the main GAL tide gates that stakeholders agree on, this interior culvert may or may not need a tide gate. If a tide gate is required, it would probably be equipped with a muted tidal regulator (MTR) that would allow fish passage into the Tidelands. This site would be a primary access point for fish into the floodplain and tidal channel network.
- (2) A culvert and tide gate on river left just downstream of the Bramble Lane Bridge over Noble Creek would be removed (**Figure 23A**). This is currently a leaking tide gated culvert that allows part of the existing ditch network to drain into Noble Creek. This feature will not be needed if the other culverts are upgraded, especially if the ditches are filled. The culvert would be removed and the levee section would be reconstructed.
- (3) An interior culvert and wooden tide gate in the upstream part of the project area would be replaced (**Figure 23B**). Leakage through this culvert currently allows some tidal exchange; however, the tidal signal is muted and fish passage is limited to non-existent. The upgraded culvert and tide gate would be designed to allow more tidal exchange and fish passage into the southeastern part of the Noble Creek Tidelands.

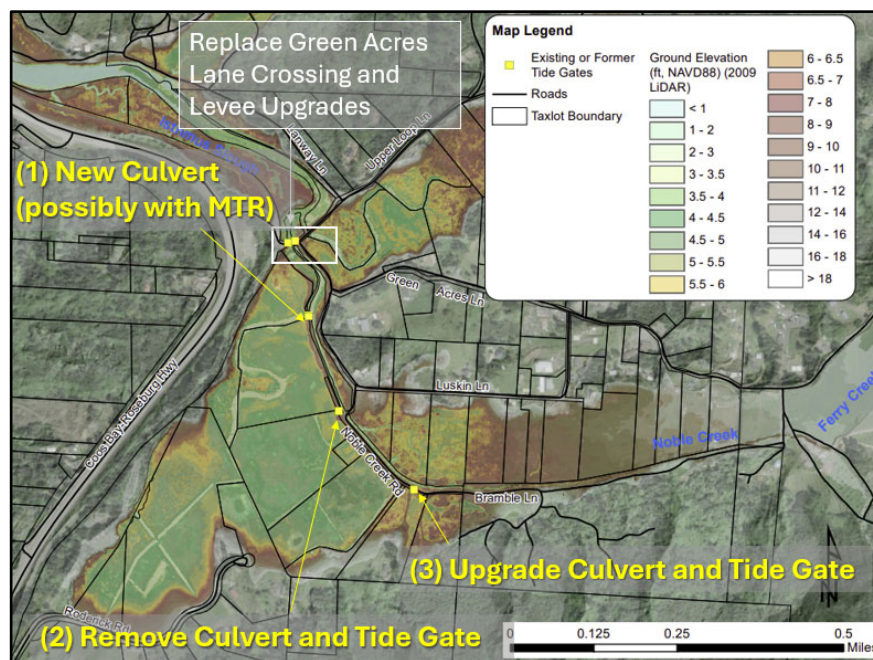


Figure 22. Alternative B for the Interior Project Area – Upgrade Interior Culverts and Tide Gates.

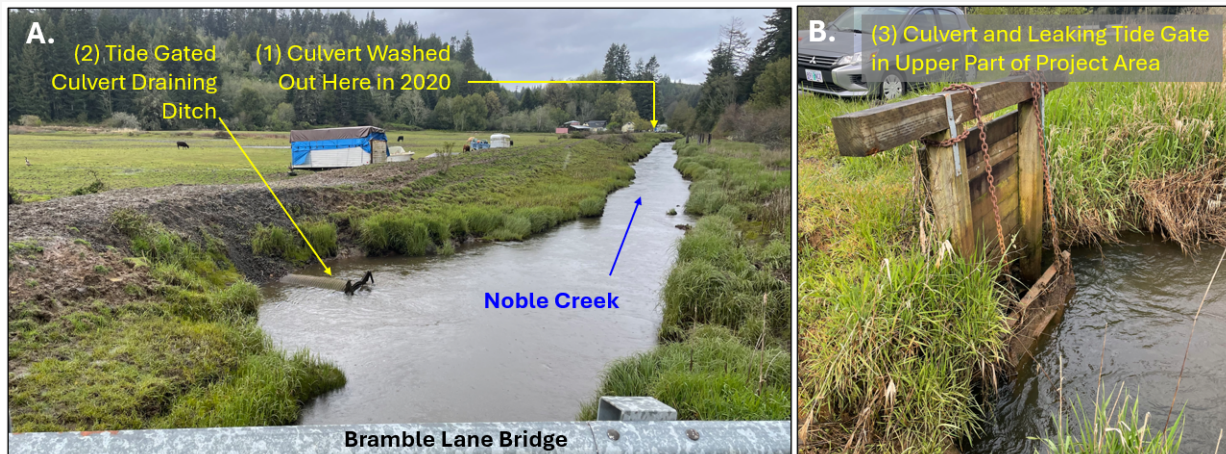


Figure 23. Photos of Current Locations Where Interior Culvert and Tide Gate Improvements are Proposed. (A) View Looking Downstream at Leveed Section of Noble Creek from Bramble Lane Bridge. (B) Photo of Tide Gate and Leaking Culvert in the Upper Part of Project Area

Advantages of Alternative B. Compared with Alternative A, this option would significantly improve fish access and tidal exchange in much of the 80-acre low elevation floodplain southwest of Noble Creek. This option would also upgrade failing and leaking culverts and tide gates on private properties with modern, engineered drainage systems compatible with current land uses. Upgrading the interior culverts and tide gates will also allow for more control and the ability to “fine tune” the water management plan and make adaptive changes to the WMP over time.

Disadvantages of Alternative B. This option would increase the complexity of the project compared with Alternative A, with work occurring in multiple private properties and land use types. The cost of design and construction of the project will increase compared to Alternative A. This option, while improving tidal exchange and fish access, does not improve the quality of the habitat behind the tide tide gates.

4.3.3 Alternative C - Interior Tide Gates with Restoration

Alternative C would be a comprehensive project that combines upgrading the main tide gates, the Noble Creek levee, the interior tide gates, and also adding earthwork and large wood supplementation to restore the tidal channel network southwest of Noble Creek. The earthwork would consist of filling ditches and excavating a more sinuous and complex tidal channel network that would provide more and higher quality habitat than the ditches would provide. The habitat quality in these channels would be further enhanced by placing hundreds of trees and root wads in the channels and floodplain to provide more shade, cover, and edge habitat (**Figure 24**).

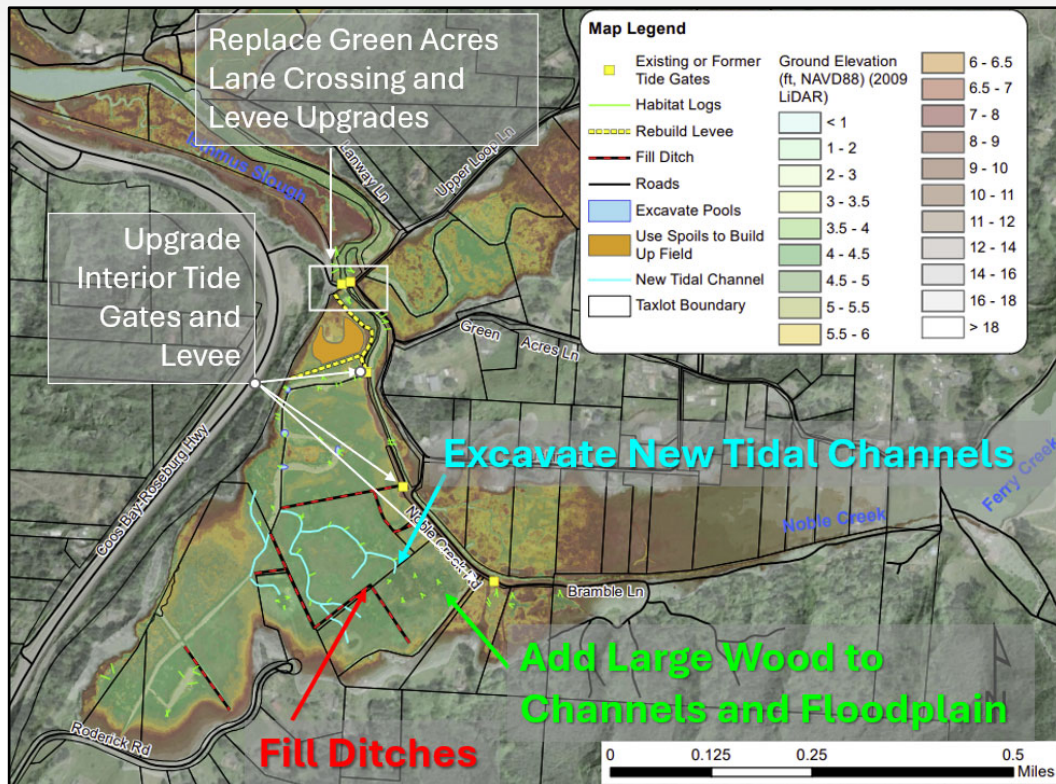


Figure 24. Alternative C for Interior Project Area- Tidal Channel and Floodplain Restoration

Advantages of Alternative C. Compared with Alternatives A and B, this option would improve the amount and quality of fish habitat in the 80-acre low elevation floodplain southwest of Noble Creek (no channel grading or other work is proposed on the 20-acre tidal lowland north and east of Noble Creek).

Disadvantages of Alternative B. This option would increase the complexity of the project compared with Alternatives A and B, with work occurring in even more private properties. The significant amount of grading and large wood proposed will increase the cost of the project substantially. Extensive disturbance of wetland soils will be required. Equipment operation could be difficult in the mucky areas. Permitting studies and cultural resources evaluations may be more complicated and more costly due to the larger disturbance area.

costs.

4.3.4 Selection of a Preferred Alternative for Interior of Project Area

The project team determined that the project would have be more impactful, and have a better chance of being funded, by maximizing the habitat benefits of the site. Based on this, the full restoration alternative (Alternative C) for the interior project area was the selected alternative.

5.0 BASIS OF DESIGN

Once the Alternatives Analysis was completed and a preferred alternative had been selected, further design work included additional survey, modeling, geotechnical and structural engineering. The following sections describe the basis of design for the Drawings presented in **Appendix A**.

5.1 GREEN ACRES LANE CROSSING

The recommended Green Acres Lane crossing and Noble Creek tide gate replacement consists of two separate structures, a bridge and a tide gate wall. As described in previous sections, the geotechnical analyses showed that the subsurface soil strength is poor, so the proposed bridge and tide gate structure are separately supported on piles extending to the underlying bedrock (**Figure 25**).

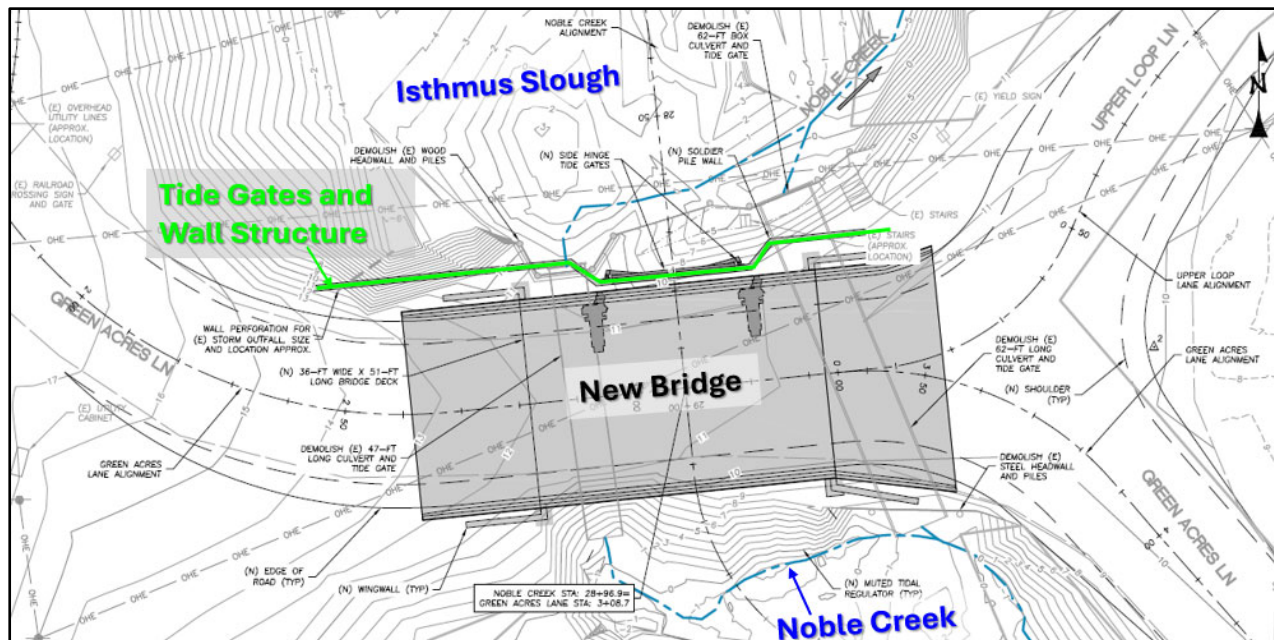


Figure 25. Proposed New Crossing and Tide Gate Structure at Green Acres Lane (Appendix A, Sheet C4)

The proposed bridge design at Green Acres Lane consists of 51-foot-long prestressed concrete bridge girders supported on pilings embedded in siltstone bedrock as shown in the structural drawings by McGee Engineering (**Appendix A**). The total curb-to-curb width of the bridge is 32 feet including 12-foot driving lanes with 4-foot shoulders on either side to meet current road design standards. The vertical and horizontal alignment of Green Acres Lane will not be changed as part of this design. The design team identified that under proposed conditions, the horizontal turning radius on Green Acres Lane to the east of the new bridge would not meet standard design recommendations for this location. Waterways understands that the County is planning on relocating this portion of Green Acres Lane further east independent of this project, so the proposed design assumes that this deficiency will be addressed by the County's realignment of the road on the east side of the bridge.

The separate tide gate wall structure would be built at the same time, and designed specifically to act as a floodwall and support two aluminum side hinged tide gates. The wall will consist of a reinforced concrete wall casted over sheet piling embedded into the substrate to the elevation of the siltstone. This wall would support two 10-foot-wide by 8-foot-tall tide aluminum gates with opening invert elevations of -0.5 feet. This is approximately 0.3' below the lowest measured tide (-0.2 ft NAVD88) at this location from the field data collection period of record discussed above. The muted tidal regulators (MTRs) for the gates would be located under the bridge and attached to either the bridge girders or pile caps for support.

For the purposes of modeling the MTRs, it was assumed that the gates will be set to close when water reaches an elevation of 6.5 feet. These model scenarios will be modified once the project team and affected landowners come to consensus on Water Management Plan that includes seasonal target closure heights (see Section 7.0).

5.2 INTERIOR CULVERTS AND TIDE GATES

The selected alternative includes: (1) installing one new interior culvert through the Noble Creek levee, (2) removing an existing culvert in the Noble Creek levee, and (3) upgrading one culvert and tide gate under Bramble Lane (**Figure 22** and **Figure 23**). The interior culverts have the following design criteria:

- **Culvert through Noble Creek levee (Appendix A, Sheet C6):** This culvert will be a 7-foot diameter HPDE culvert. For the 30% designs, it is assumed the culvert would be equipped with a side hinge tide gate and a muted tidal regulator to allow for control over the seasonal extents of floodplain inundation allowable as determined by the water management plan. However, the need for a tide gate and muted tidal regulator is not yet certain, and this decision will be based on modeling results, landowner requirements, and the final water management plan.
- **Culvert removal near Bramble Lane Bridge:** A tide gated culvert of unknown diameter on river left just downstream of Bramble Lane Bridge will be removed or abandoned in-place, because the associated ditches draining to this culvert will be filled and all flow will be directed to the Noble Creek Levee Culvert described above.
- **Culvert through Noble Creek levee (Appendix A, Sheet C8):** An existing 30-inch diameter culvert and tide gate on Bramble Lane to the east of the Bramble Lane bridge will be replaced with a 4-foot diameter culvert with side hinged tide gate and an auxiliary door (i.e. pet door) that provides additional flow through the gate when the gate is closed.

5.3 LEVEE REPAIR

The existing levee in the vicinity of the Foreman property is deteriorating thereby exposing the residence on the property to flooding risk. This risk will continue to increase as the levee and tide gate infrastructure continue to deteriorate. The low point elevation of this levee is approximately 8.9 feet. The geotechnical analysis indicates that increasing the height of these levees could further weaken the underlying soils. Given these constraints, Waterways recommends that levee repair should be limited

to widening existing levees to more stable side slopes, but not to increase elevations over existing conditions. This should also be considered when establishing the water management plan.

5.4 FLOODPLAIN HABITAT ENHANCEMENT ELEMENTS

Floodplain habitat enhancement will include excavation of new sinuous channels that better mimic natural tidal channels, and using the excavated material to fill sections of existing straight ditches. Tidal pools will be excavated in historic channel meanders to provide off-channel rearing habitat.

Logs with root wads will be installed throughout the channel network and ponds to provide additional shade, cover, and habitat complexity.

6.0 IMPACTS OF PROJECT ON FLOODING

We modeled the proposed post-project conditions to better understand how replacing the tide gates at Green Acres Lane and reconnecting the tidal basin behind it would impact flow and inundation patterns in the Noble Creek Tidelands. In the Proposed Conditions model, the leaking tide gates at Green Acres Lane are replaced by two parallel culverts with the same size and configuration as shown in the 30% Designs (Appendix A, Sheet C4). Because HEC-RAS software does not include any routines for operating the tide gates as Muted Tidal Regulators, some additional code was written to simulate the operations of an MTR on each of the two culverts. In the model, the MTR was set to an elevation of 6.5 feet – which means that the gate closes when the water level reaches 6.5 feet elevation and is forced open when the water level is below that height. Using this feature, the model was run using measured water levels from Isthmus Slough.

The model was run for the following scenarios to understand the range of potential conditions:

- Typical dry season tidal cycle (May 10-12, 2022)
- Typical winter tidal cycle (January 16-21, 2022)
- King tide cycle (January 2-5, 2022)
- Typical winter tidal cycle in which Noble Creek is flooding (2-, 10-, and 100-year floods)

Appendix D contains a set of side-by-side map figures comparing the maximum water depths and inundation patterns for each of these scenarios, and the implications of these results are discussed in this section.

Important Note: The results presented here reflect a simulated project that does not include any interior flood control measures such as interior tide gates or levee upgrades. As a result, the model results may show more flooding than what is acceptable to landowners. These results are meant to inform a discussion between CSWCD, ODFW, landowners and the County about the amount, locations, and timing of flooding that is acceptable. Once stakeholders clarify the answer to this question, additional measures to reduce flooding may be incorporated into later stages of the designs.

6.1 PROPOSED CONDITIONS MODEL SET UP

To develop the Proposed Conditions model, we made the following modifications to the Existing Conditions Model to reflect features of the proposed designs:

- Added two new 8-foot x 10-foot tide gates equipped with Muted Tidal Regulators (MTR) at the Green Acres Lane crossing, with an assumed MTR setting of 6.5 feet (NAVD 88)
- Added a new 7-foot diameter interior culvert without a tide gate under the Noble Creek levee on river left on the Foreman property.
- Added a new 4-foot diameter interior culvert without a tide gate under Bramble Lane at the upstream end of the project area.
- Existing ditches were filled and new channels excavated as depicted in the Design Drawings (Appendix A, Sheet C9)

Modeling Muted Tidal Regulator. A primary focus for the model was to understanding flows and inundation patterns after replacing the existing failing tide gates with two new tide gates equipped with Muted Tidal Regulators (MTR). The MTRs are equipped with a float and activator arm to fully open to allow fish passage at lower tides and shut when water reaches a set elevation to prevent flooding. Modeling an MTR in HEC-RAS required developing additional code outside of the pre-programmed default settings. In this application, MTRs were simulated using Storage Area (SA)/2D flow connection in combination with a rules-based gate condition. The HEC-RAS default tide gate settings allows simple tide gates to be modeled with flap gates that block flow from either the upstream or downstream direction. To simulate an MTR, which is a tide gate that shuts at a specified water elevation, the gate needs to open and close across multiple tidal cycles based on the float valve elevation. To accomplish this a SA/2D connection was created at Green Acres Lane to connect the exterior (Isthmus Slough) to the interior (Noble Creek). A tide gate with appropriate dimensions and invert elevations was added to the SA/2D connection. After defining the gate, a ‘rules’-based boundary condition allowed for code to be written that determines when the gate would be open and shut. For the purpose of the model, the float valve was located on the Isthmus Slough side of the gate. The primary variable determining whether the gate was open or closed in the model was the tidal elevation in Isthmus slough (note: in the actual design calls for the float and activator to be on the Noble Creek side of the tide gate).

For the current set of runs, the MTR was set at elevation 6.5-feet (NAVD88). Therefore, in these runs the MTR remained closed during high tide periods above elevation 6.5-feet, then opened on the receding tide when the tidal elevation fell below 6.5-feet. A secondary condition was written into the code specifying that if the water surface elevation on the Noble Creek side is greater than the tidal elevation in Isthmus Slough, due to flows in Noble Creek, the MTR remains open to allow water to drain. If water levels on the Noble Creek side are higher than the Isthmus Slough side, this will push the gate open to allow water to drain towards Isthmus Slough. If this condition was not added to the model, water could accumulate behind the Noble Creek tide gates when a flood flow coincides with high tides.

6.2 PROPOSED CONDITIONS MODEL RESULTS

6.2.1 Summer Low and High Flows

Low Tides. Figure 26 compares the Existing Conditions and Proposed Conditions model results for a low tide scenario. During low tides, the water depths and inundation extents are similar periods, with relatively little change because of the project at low tide. Generally, at low tides there will be one to several feet of water in the main channel, ditches, and floodplain channels, regardless of the project. There will be slightly more areas of inundation under Proposed Conditions, but this is mostly because of standing water in the floodplain left over from the previous high tide.

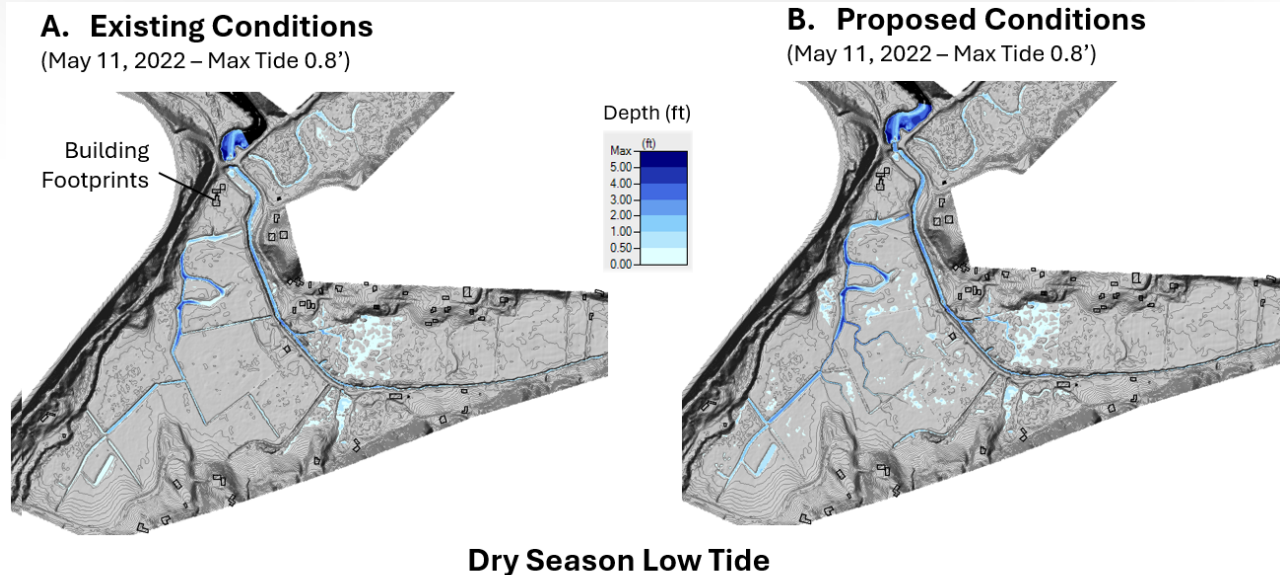


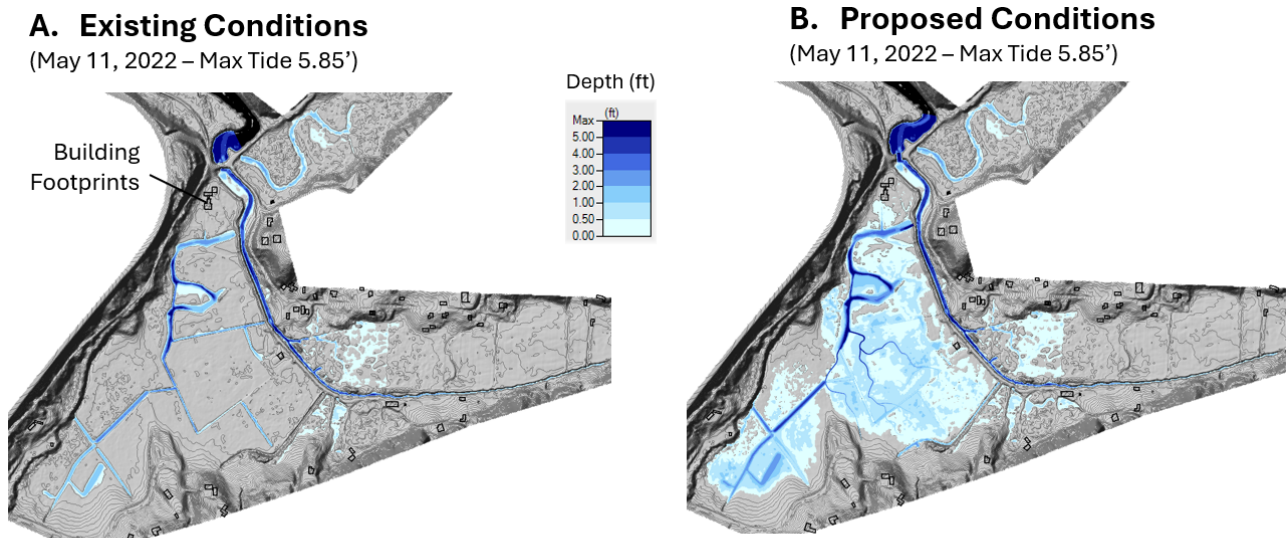
Figure 26. Modeled Water Depths During a Typical (+0.8') Dry Season Low Tide

Dry Season High Tides. Each day, there are typically two high tides with different amplitudes. To understand how flooding on these fields would be impacted during the dry (grazing) season, model results are presented below for both “lower high” and “higher high” tides during the dry season.

During a “lower high” tide of 5.85 feet elevation (**Figure 27**), there would be a significantly more inundation under proposed conditions. By design, the project would allow more water into the floodplain and open up more of the Noble Creek Tidelands for fish rearing. During a lower high tide, much of the floodplain west and south of Noble Creek would have 0.5 to 2 feet of water. The newly excavated tidal channels would have as much as 6 feet of water, providing substantial off-channel tidal rearing habitat for salmonids. Most of this water would enter the floodplain through the 7-foot culvert under the Noble Creek Levee on the Foreman property, where inflows would exceed 100 cfs during incoming tides. During a lower high tide in the dry season, there would also be slightly more inundation in the tidal wetland to the north of Noble Creek across from Bramble Lane, as a result of the increased flow entering Noble Creek through the main GAL tide gates.

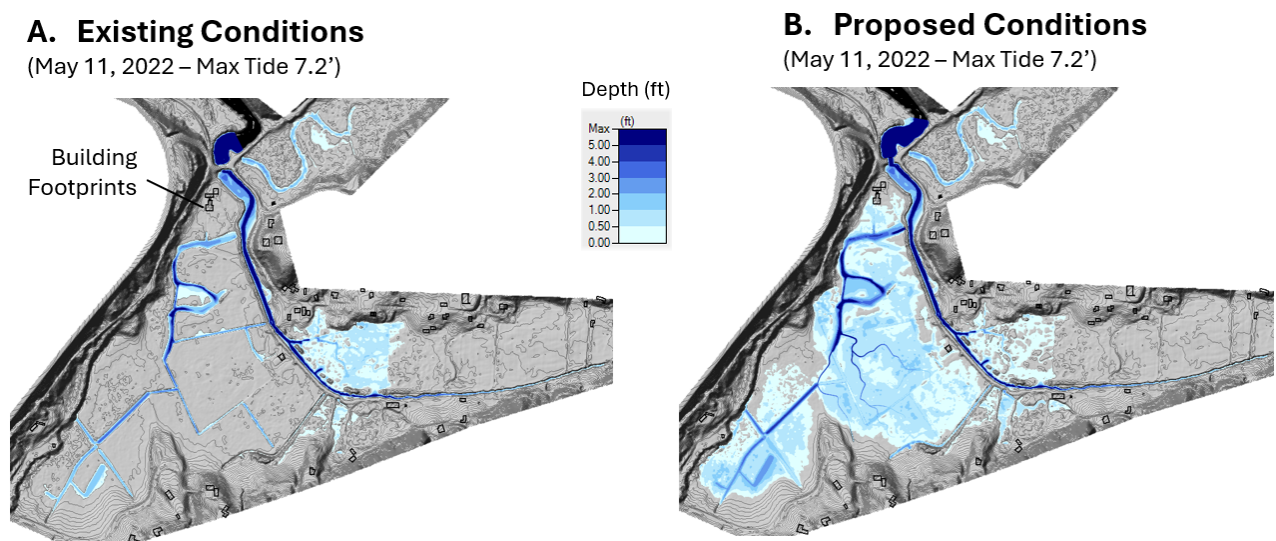
The modeled inundation patterns during a “higher high” tide of about 7.2 feet elevation (**Figure 28**) resembles the pattern during the lower high tide. Although the maximum tide is almost 1.5 feet higher, there is only an incremental increase in the amount of flooding. During the dry season higher high tide, the model shows the high tide water approaching, but not reaching, the Foreman house near the main Noble Creek tide gate. If the house and the adjacent field need additional protection, this could be provided by building a low berm along the north side of the channel conveying water into the floodplain.

Counterintuitively, the model shows reduced flooding in the zone to the tidal area north and east of Noble Creek under this scenario compared with existing conditions (**Figure 28**). The reduction in inundation in that portion of the project area is because so much of the flow that enters through the GAL tide gates would flow into the floodplain south of Noble Creek, leaving less water in the channel to enter that wetland.



Dry Season Lower High Tide

Figure 27. Modeled Water Depths During a Typical Dry Season Lower High Tide (5.85')



Dry Season Higher High Tide

Figure 28. Modeled Water Depths During a Typical Dry Season Higher High Tide (7.2')

6.2.2 Winter High Tides and King Tides

Typical Winter High Tide. Figure 29 shows the maximum inundation in a typical winter high tide of about 8.8 feet elevation. Under existing conditions, there is a distinct difference between the extent of flooding in the winter high tide (8.8 feet) compared with high tide in the dry season (7.2 feet): in the 8.8-foot tide, the relict channel and ditch network overtops and spreads out onto the floodplain, whereas in the 7.2-foot high tide, water remains mostly confined to channels and ditches (Figures 28B and 29B). Under proposed conditions, however, the extent of inundation for the two high tides is nearly identical (Figures 28B and 29B). The reason for this discrepancy is that under proposed conditions, water is more freely exchanged with the floodplain and water will flood nearly all the land below the high tide level in Noble Creek, which is limited by the MTR. Under existing conditions, the extent of flooding is controlled more by the amount of water that flows through the leaking tide gates, because the tide recedes long before the floodplain fills with water. The amount of leakage depends on head differences between inside and outside the main and interior tide gates, which is greater during a higher tide cycle.

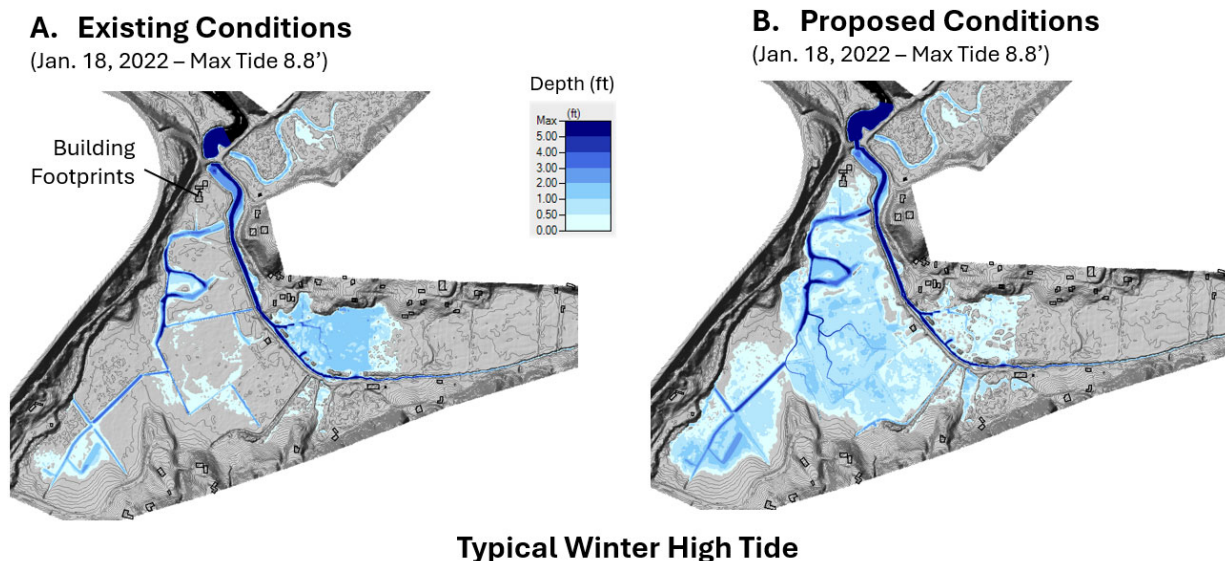


Figure 29. Existing and Proposed Conditions for a Typical Winter High Tide Scenario

King Tide. Figure 30 shows the extent of flooding during a king tide, as measured on January 3, 2022 in Isthmus Slough. The extent of modeled flooding under existing and proposed conditions is very similar, and both show flooding at the Foreman house. However, the mode of flooding is different: under existing conditions, according to the model, water would overtop the road to the north of Noble Creek in a king tide, which would allow floods to overtop the Noble Creek levee and enter the large floodplain south of Noble Creek. In contrast, under proposed conditions enough water would flow through the new culvert that the levee would not overtop.

It is not clear whether the Existing Conditions model is correct in predicting that the road would overtop and flooding occur in very high tides. This may be accurate, or it may be due to a model error in predicting water elevations at king tides. A small error in the predicted water elevation could cause

the model to show widespread flooding, even if it does not actually occur. It would be helpful to know from locals whether the road overtopped during the 2022 king tide event, and if there was as extensive flooding as shown in **Figure 30A**.

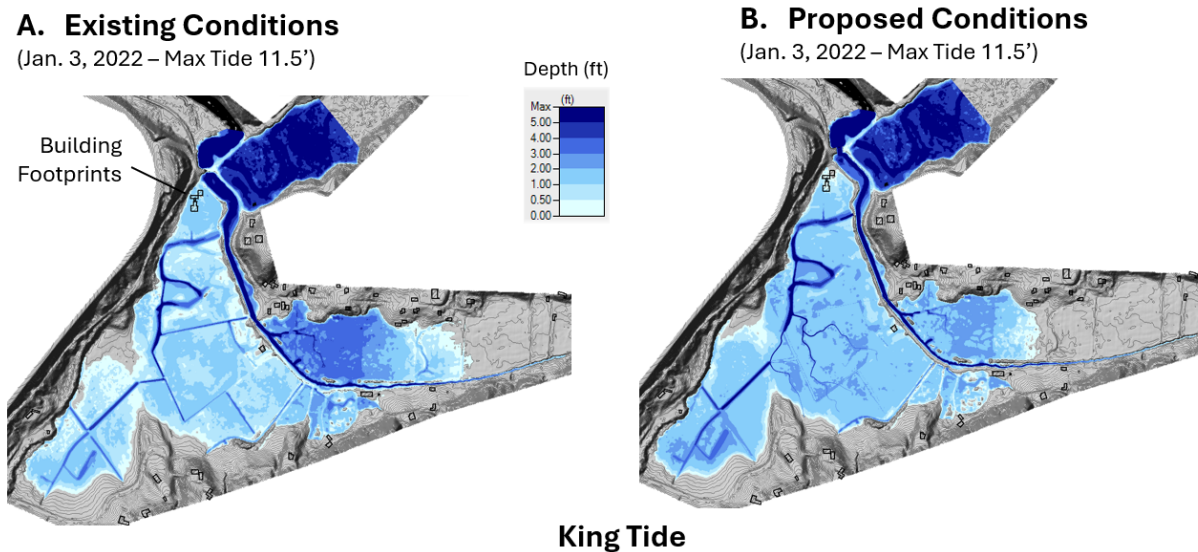


Figure 30. Existing and Proposed Conditions for a King Tide Scenario

6.2.3 Flooding in Noble Creek Coinciding with a Winter High Tide

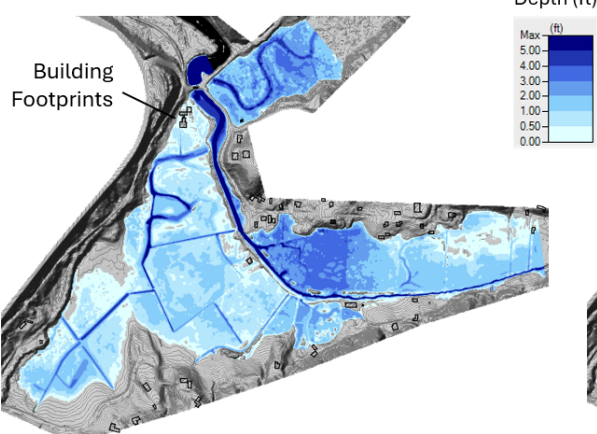
A final set of model runs simulated how flooding in Noble Creek would affect inundation throughout the project area. For these model runs we assumed that the flood peak in Noble Creek coincided with the winter high tide (8.8 feet). This is considered conservative, because if the flood peak and high tide coincide this would increase the amount of flooding, since Noble Creek flows would not be able to exit the GAL tide gates. This flooding scenario is also conservative because of the flows used for Noble Creek. Two methods were used to develop the 2-year, 10-year, and 100-year floods: (1) the USGS program StreamStats, which uses basin characteristics and regional regressions to estimate peak flows, and (2) data from a stream gage on a nearby creek with a similar drainage area and topography (Johnson Creek in Bandon, operated by Oregon Department of Water Resources). Flows estimated using StreamStats were almost twice as much flow as those estimated using the ODWR gage. Therefore, it is likely that the flows used for this analysis overestimate the amount of water in Noble Creek.

Figures 31, 32, and 33 show the predicted inundation maps for the 2-year, 10-year, and 100-year floods in Noble Creek. Based on the model, the inundation extent for existing and proposed conditions would be similar; however, water depths would be generally deeper in the flooded areas under proposed conditions. Under existing conditions most of the flow entering the tidelands would be over

the road and levee; under proposed conditions, the levees would not overtop as much but instead, flow would enter the floodplain through the 7-foot culvert under the Noble Creek levee.

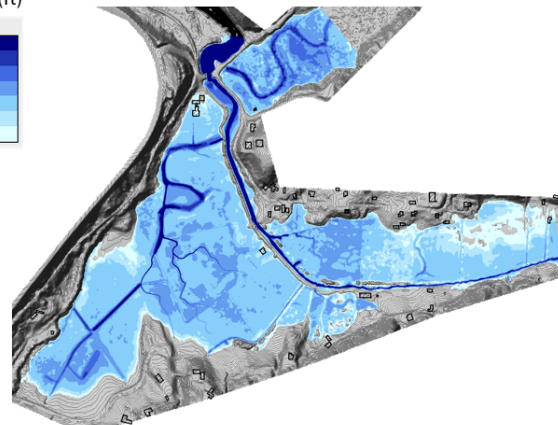
A. Existing Conditions

(Jan. 18, 2022 – Max Tide 8.8')



B. Proposed Conditions

(Jan. 18, 2022 – Max Tide 8.8')



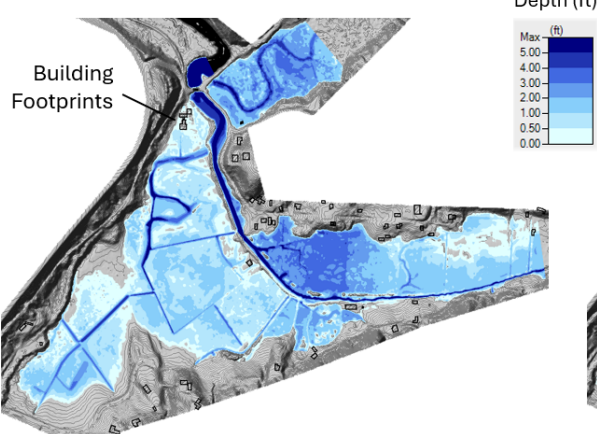
Typical Winter High Tide With 2-Year Flood* in Noble Creek

*Peak Flow in Noble Creek 294 cfs, based on StreamStats (which is 2X estimate based on nearby gage)

Figure 31. Existing and Proposed Conditions for a 2-Year Flood in Noble Creek Coinciding with a Typical Winter High Tide

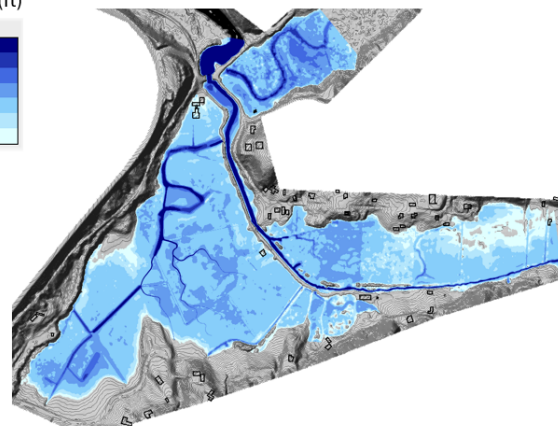
A. Existing Conditions

(Jan. 18, 2022 – Max Tide 8.8')



B. Proposed Conditions

(Jan. 18, 2022 – Max Tide 8.8')



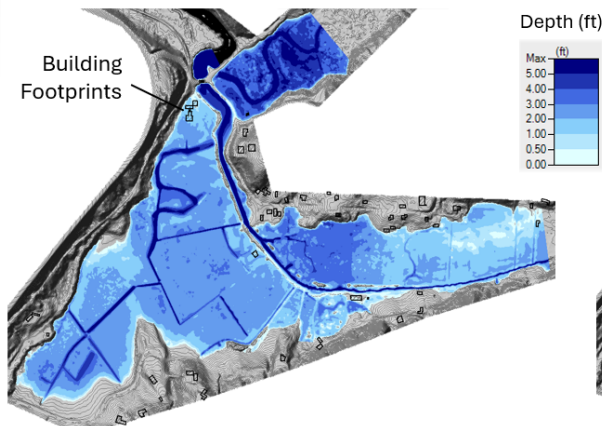
Typical Winter High Tide With 2-Year Flood* in Noble Creek

*Peak Flow in Noble Creek 294 cfs, based on StreamStats (which is 2X estimate based on nearby gage)

Figure 32. Existing and Proposed Conditions for a 10-Year Flood in Noble Creek Coinciding with a Typical Winter High Tide

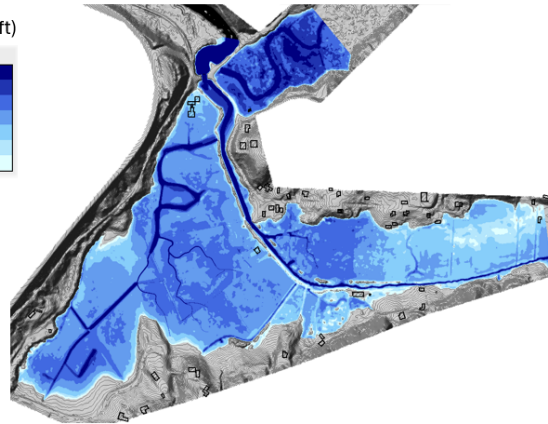
A. Existing Conditions

(Jan. 18, 2022 – Max Tide 8.8')



B. Proposed Conditions

(Jan. 18, 2022 – Max Tide 8.8')



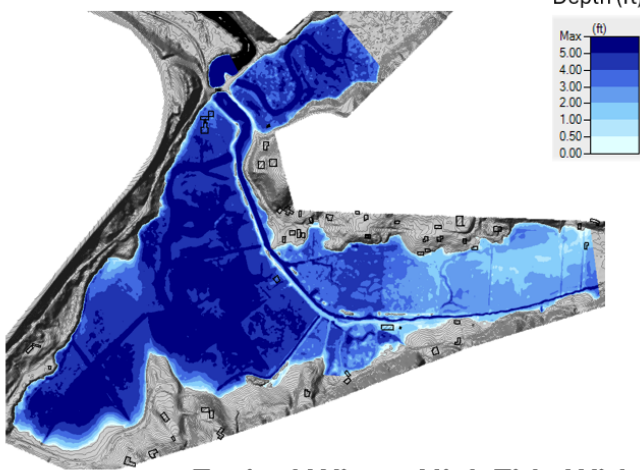
Typical Winter High Tide With 10-Year Flood* in Noble Creek

*Peak Flow in Noble Creek 580 cfs, based on StreamStats (appears high based on nearby gage)

Figure 33. Existing and Proposed Conditions for a 10-Year Flood in Noble Creek Coinciding with a Typical Winter High Tide

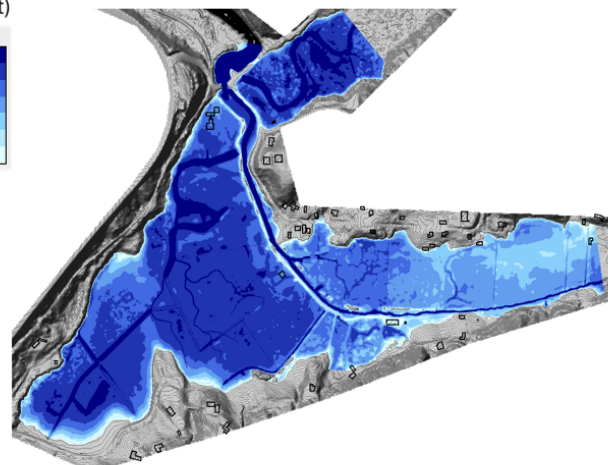
A. Existing Conditions

(Jan. 18, 2022 – Max Tide 8.8')



B. Proposed Conditions

(Jan. 18, 2022 – Max Tide 8.8')



Typical Winter High Tide With 100-Year Flood* in Noble Creek

*Peak Flow in Noble Creek 1,000 cfs, based on StreamStats (appears high based on nearby gage)

Figure 34. Existing and Proposed Conditions for a 100-Year Flood in Noble Creek Coinciding with a Typical Winter High Tide

6.3 PRELIMINARY FISH PASSAGE ANALYSIS

Because the project will involve installing at least one new tide gate at the Green Acres Lane crossing, the project will need to meet Oregon Department of Fish and Wildlife (ODFW) requirements for fish passage at new tide gates. Current tide gate replacement fish passage criteria in Oregon (OAR 635-412-0035) require new tide gates to meet the following criteria:

- A. Be a minimum of 4 feet wide unless the natural channel conditions are less than 4 feet wide;
- B. Consist of an aluminum tide gate door or other equivalent light weight material;
- C. Be a side hinged door configuration;
- D. Meet the requirements of OAR 635-412-0035(2) or 635-412-0035(3)(b) within the design streamflow range and for an average of at least 51 percent of tidal cycles, excluding periods when the channel is not passable under natural conditions;
 - i. Design streamflow range shall include tidal exchange, freshwater stream discharge and water storage volumes draining to the tide gate;
 - ii. Design streamflow range should consider sub-surface flows if appropriate at the project location;
- E. Design invert elevation of tide gate and associated structure to be placed at 1 foot below Mean Lower Low Water elevation or as otherwise appropriate for the site to prevent perched low flow fish passage conditions and allow proper tide gate function;
- F. Consider the use of pet doors, mitigators, self-managed and self-regulating tide gate devices to maximize fish passage, time of tide gate door openness, water exchange, and tidal inundation if the tide gate is associated with high priority restoration habitat; and
- G. Submit a water management plan for projects implementing self-managed or self-regulating devices.

The designs in **Appendix A** meet requirements A, B, C, E, and F, and any revised design drawings will also meet those requirements. A water management plan (criteria G) will be developed by CSWCD and ODFW based on a later (60%) version of the design.

The designs must also meet criterion D, which requires the tide gates remain open and water velocities below 2 feet per second for 51% of the time on average. At the present (30%) level of design, there are still some significant uncertainties related to fish passage. For one, it is not certain whether interior tide gates will be included in the project. In addition, some of the details of the main tide gates at Green Acres Lane may still change from the 30% plans. Therefore, a more thorough analysis of fish passage permitting will be prepared based on the 60% designs.

To ensure that the next phase of designs will not have to be drastically modified to meet ODFW guidelines, a simple informal preliminary analysis was done based on the current designs to confirm that the project is on track to provide necessary fish passage requirements. In this analysis, the model with the MTR operation code was run for the period January 22 through February 10, 2022 – a period that included a relatively large tidal amplitude ranging from more than 9.8 feet to a minimum of -0.1

feet. During this period, with an MTR gate setting of 6.5 feet, the tide gate would remain open for 83.5 percent of the model duration. Water velocities going through the tide gate opening in the sheet pile wall were estimated by dividing the modeled discharge through the opening by the cross-sectional area of flow. The modeling showed that velocities will sometimes exceed the 2 foot per second criteria, especially when the gate first opens. The maximum velocity for the model period was 2.9 feet per second. However, with a tide gate setting of 6.5 ft/s, the project will still be fish passable (i.e., gates open and velocity less than 2 feet per second) about 60 percent of the time. There is a chance that much lower MTR settings than this could make it more difficult to meet the requirements.

Based on this analysis, the next phase of design and the development of the water management plan should be done in conjunction with more modeling to ensure the fish passage criteria will be met.

7.0 ISSUES TO BE RESOLVED/NEXT STEPS

The next step in the process will be to advance the designs presented here to a 60% level of design, suitable for seeking permits and construction funding for the project. However, before that level of design it will be necessary to work with landowners, stakeholders, and permitting agencies to finalize some of the design parameters, so they meet the requirements of all parties. Based on the current project status, Waterways recommends CSWCD focus on the following next steps before advancing to the 60% designs:

- **Determine Landowner Requirements for Flood Protection.** Clearly define which locations need to be protected from flooding, which areas can flood, and at what frequency. Use the Proposed Conditions model results in **Appendix D** to determine the extent and timing of flooding in the interior of the Noble Creek Tidelands that is acceptable to landowners.
- **Decide on Interior Flooding Measures.** Depending on the extent of acceptable flooding, determine which interior flood control measures should be included in the next phase of the designs. The following measures can be used to control flooding the flooding shown in **Appendix D**.
 - a) Include an MTR on the larger 7-foot interior culvert in the Noble Creek levee on the Foreman's property (as shown in the 30% Design Drawings).
 - b) Include tide gate with an auxiliary door (pet door) on the 4-foot interior culvert along Bramble Lane (as shown in the 30% Design Drawings).
 - c) Build berms or flood walls around specific fields or structures.
 - d) Reduce the MTR setting at the main tide gates at Green Acres Lane.
 - e) Reduce the MTR setting at the interior tide gate.
- **Agree on a Water Management Plan.** Once the interior flood protection measures are determined, the project leaders (CSWCD and ODFW) will work with landowners and designers to develop a Water Management Plan (WMP) for both the main tide gates and interior tide gates.
- **Expand the Channel Network and Tidal Pond Excavation.** The excavated channel network shown in the 30% Design Drawings (Appendix A) does not generate enough material to fill the ditches.

Expanding the channel network beyond what is shown in the drawings, and adding more tidal “bulbs,” would create more fish rearing habitat while also generating more spoils material needed for other parts of the project.

- **Add More and More Complex Wood Structures.** More wood structures could be added to the current version of the designs to increase uplift without significantly increasing the cost of the project.
- **Decide on a Revegetation Plan.** The current Design Drawings do not include any revegetation aside from standard erosion control seeding. Once the water management plan is determined, the Project Team should assess what types of native plants are expected to survive based on the new hydrologic regime. This may include revegetation with herbaceous plugs and/or woody plant stock. Any revegetation plans should be approved by a revegetation professional familiar with native plants of the area.
- **Fencing and Livestock Crossings.** The current Design Drawings do not include any fencing or livestock crossings for the proposed channels. The project leaders (CSWCD and ODFW) will work with landowners to determine the extent of fencing and locations of livestock culverts prior to 60% design.
- **Initial Consultations with Wetland and Permitting Experts.** Waterways recommends doing some early consultations with wetland and permitting subconsultants, prior to developing the 60% plans, to solicit recommendations for the design that will minimize negative impacts and avoid potential permitting hurdles.

APPENDIX A

30% DESIGN DRAWINGS

APPENDIX B

GEOTECHNICAL REPORT FOR THE NOBLE CREEK TIDELANDS PROJECT

APPENDIX C

ALTERNATIVES PRESENTATION TO STAKEHOLDERS AND LANDOWNERS

APPENDIX D

SUMMARY OF EXISTING AND PROPOSED CONDITIONS MODELING RESULTS