GEOMORPHIC EVALUATION - DRAFT MEMORANDUM

To: Rod Lundberg, Cascade Environmental Group

From: John Dvorsky, Waterways Consulting, Inc.

Date: November 6, 2015

Re: Dahl Beach Mitigation Project

Introduction/Project Objectives

Cascade Environmental Group (CEG) is leading the planning, engineering, and permitting effort to restore two areas of hardened stream bank along the Clackamas and Willamette Rivers to a more natural bank profile. Both restoration areas are on City property, which consists of the Parking Lot Area located within Dahl Beach Park and the Bulkhead Removal Area located in Meldrum Bar Park (Figure 1). The effort is being funded by the Port of Portland (Port) to mitigate for bank hardening conducted by the Port on the Willamette River within Port property. To support the design effort, CEG has asked Waterways Consulting, Inc. (Waterways) to evaluate geomorphic conditions within and around the vicinity of the proposed projects. The primary objective of the geomorphic evaluation is to identify historic geomorphic and sediment transport processes, geomorphic dynamics of the modern river, and expected future trends after restoration construction.

The project areas are located adjacent to the confluence of the Clackamas and Willamette Rivers, and extend from the north bank of the Clackamas River, downstream and along the east bank of the Willamette River (Figure 2). The Parking Lot Area is located along the north bank of the lower Clackamas River and the proposed restoration actions focus on removing a portion of the lower parking lot and restoring a more natural beach profile. The Bulkhead Removal Area is located downstream on the Willamette River and the proposed restoration actions focus on removing a failed bulkhead consisting of reinforced sheet pile. This report summarizes the outcome of the geomorphic evaluation and includes a discussion of how geomorphic conditions and trends should be considered during the engineering design phase.

Project Location

Meldrum Bar and Dahl Beach Park (Park) are owned and managed by the City of Gladstone and encompasses riverside property on the north side of the confluence of the Clackamas and Willamette Rivers. The Park includes several parking areas, sandy beaches, trails, golf course and a Natural Area. The Park is heavily used for fishing, due to its location at the confluence of the Clackamas and Willamette Rivers. Several publicly accessible, developed boat access ramps occur nearby including the Clackamette Park Boat Ramp to the south, and the Meldrum Bar Boat Ramp to the north. Highway 99E Bridge crosses the Clackamas River just to the east of the project area and the Highway 205 Bridge crosses the Willamette River to the south of the project area. The project areas occur in a dynamic river environment that has experienced significant changes in the past century.

Geomorphic History

Historically, the confluence of the Clackamas and Willamette Rivers was a dynamic environment largely controlled by the sediment transport regime of the Clackamas River. Cobble, gravel, and sand delivery from the Clackamas River created a large depositional feature and braided channel morphology where the higher gradient Clackamas River transitioned to the lower gradient and tidally influenced Willamette River (Photo 1). The disparities in the gradients of these two large river systems resulted in formation of a tributary alluvial fan at the mouth of the Clackamas River as coarse bed material emanating from the higher energy Clackamas River deposited in the lower energy confluence environment. Coarse bed load deposition at the mouth had a significant influence on the bed elevations and morphology of the Willamette River for thousands of feet upstream and downstream of the confluence. Goat Island is a remnant of this feature and in fact many maps still refer to this portion of the Willamette River as the Clackamas Rapids. The bed of the Willamette River, adjacent to the Clackamas River, was on the order of 10 -20 feet higher in elevation than the present day bed elevation. The reach at that time was most likely not influenced by tidal process and prior to the 1930's, navigation past this portion of the Willamette River would have been difficult.

Photo 1: The photo on the left shows the Clackamas and Willamette confluence in the 1920's and pre-dates significant mining activity at the mouth (photo on the right). Mining activity limited the influence of the Clackamas River on the overall Willamette-Clackamas confluence by inhibiting bed load transport (photo on the right is from 1938).

Over the past century, changes to both the Clackamas and Willamette River watersheds (i.e. – dam construction, modified hydrology, levee construction and bank revetments) along with local impacts associated with gravel mining and dredging of the Willamette to improve navigation, has resulted in major changes at the confluence. Regional-scale changes to the form and function of the Willamette, Clackamas, and even Columbia Rivers has reduced channel complexity and narrowed and deepened the river along these mainstem river systems, often driven by the desire to improve navigation, provide flood control, and encourage development of floodplain and terrace areas.

Dam construction in the Clackamas River watershed has severely reduced the sediment supply to the lower river. Much of the remaining sediment currently delivered to the lower river is supplied from tributaries downstream of the large dams and bank erosion along the mainstem. These factors have contributed to significant changes in the project area whereby the lower portion of the Clackamas River,

from the confluence with the Willamette River to the Highway 99E Bridge over the Clackamas, functions more as a backwater of the Willamette River during most flow conditions.

Within the restoration area reaches, deepening of the Willamette River channel to improve navigation, and reductions in bed load supply from the Clackamas River has resulted in channel degradation that has simplified the geometry of the Willamette River. Historically, the Willamette River was much shallower and wider with extensive gravel bars along the margin of the low flow channel that were scoured annually and free of vegetation. Mid-channel bars, that were historically unvegetated because they were frequently in contact with scouring flow events, converted to vegetated islands with higher resistance to flow, causing further incision of the channel. Beginning around 1970, managed flows on the Columbia River led to lower overall water surfaces on the Willamette River. The overall results of these management activities has been a deeper thalweg, wider low flow channel, steeper banks, and less cross-sectional complexity.

To visualize the changes that have occurred over the past 80+ years at the confluence of the Clackamas and Willamette Rivers, aerial photos dating back to the 1930's were acquired and georeferenced. The results, shown in Figures 3 and 4, show a clear reduction in the form and function of the river and stabilization of sand and gravel depositional features through establishment of riparian vegetation. As reference, the locations of the two project areas are overlain on the series of aerial photos along with approximate location of the bank line from the 2012 condition. The bank line was determined to be the edge of vegetation.

Existing Conditions

An evaluation of existing geomorphic conditions within and adjacent to the project area was conducted. The approach included a field-based reconnaissance-level assessment followed by a focused evaluation using topographic data and hydraulic modeling outputs to understand and interpret geomorphic observations. The more detailed evaluation focused primarily on understanding geomorphic conditions that directly relate to the elements of the engineering design for the two restoration areas. The primary concerns that arose during discussions with stakeholders during the early stages of the project included the following:

- How would the proposed plan to remove a portion of the parking lot along the lower Clackamas affect the overall trend of erosion that has been observed over the past several decades?
- It appears that gravel bars are beginning to form on the lower Clackamas downstream of the Highway 99E Bridge. If that trend continues how will the project be affected?
- Will the proposed parking lot and bulkhead removals affect the presence of and access to sandy beaches that occur along the northern shoreline of the Clackamas and eastern shoreline of the Willamette?
- Where is the inclusion of log structures appropriate as habitat elements?

These concerns and questions were addressed through the following evaluations:

- Reconnaissance-level geomorphic evaluation of the project area to understand sediment dynamics, existing and future erosion risks, and substrate conditions,
- An evaluation of hydraulic conditions from upstream of the 99E Bridge to the confluence with the Willamette using a 1-dimensional hydraulic model developed by WEST Consultants, and

- An evaluation of existing bank angles on the Willamette River upstream and downstream of the bulkhead project site as reference conditions for regrading of the bank at the bulkhead.

Reconnaissance Assessment

The reconnaissance-level geomorphic assessment consisted of field-based observations of site conditions extending from the inlet of Clackamette Cove at the upstream end to approximately 500 feet downstream of the bulkhead project site. A graphic summary of the findings of the assessment are presented in Figure 5. Segments of the riverbed dominated by scour or deposition are noted along with bank segments that are either erosion-dominated, armored with coarse bed substrate, or experience slack water conditions during high flow events. Figure 6 presents a series of photos taken of the project area, the locations of which are noted on Figure 5.

The following key observations were made during the assessment:

- Much of the coarse bed load being delivered to the lower Clackamas River is being deposited upstream of the Highway 99E Bridge at the mouth of Clackamette Cove. There appears to be several reasons for this: the constricting effect of the Bridge which causes a slight backwater upstream; and expansion of the flow at the entrance to Clackamette Cove which reduces shear and encourages deposition of bed load. There is a potential that the material deposited in this reach will eventually mobilize downstream as the bed aggrades and the profile steepens.
- Efforts to protect the 99E Bridge abutments from scour through placement of riprap has encouraged bed scour through the Bridge. There is currently a deep hole under the Bridge that may require future maintenance.
- Bar formation downstream of the Bridge in the vicinity of the Clackamette Boat Ramp appears to be material scoured from the streambed under the 99E Bridge rather than material delivered from upstream. Because this deposition is favored on the inner bend on the Gladstone side of the Clackamas, higher velocities and erosive forces are likely to be directed at the boat ramp on the Oregon City side.
- The sandy beach erosion on the Gladstone side of the Clackamas River appears to be associated with wave action from boats.
- Slackwater effects on the Gladstone side of the Clackamas and downstream of the bulkhead on the Willamette River have created sandy beaches.
- Coarsening of the bank material along the Willamette River due to erosive forces during high flow events have led to a cobble-dominated armored bank condition.

Hydraulic Modeling Results

A 1-dimensional hydraulic model of the lower Clackamas River from Clackamette Cove to approximately 400 feet from the confluence with the Willamette River was provided for our use by WEST Consultants[1]. The model was set up to generate hydraulic output for the 10-year, 50-year, 100-year and 500-year

[1] Additional modeling may eventually be available for the portion of the Willamette River within the project area but it was not available at the time this report was prepared.

events under both a free flowing (normal depth boundary condition) and backwater condition from the Willamette. To evaluate the accuracy of observations made during the reconnaissance-level assessment, the model was run for both the free-flowing and backwatered condition at the 10-year event. The locations of the modeled cross-sections and modeling results for key hydraulic variables are presented in Figure 7. Key hydraulic variables that are presented include velocity and shear stress. Velocity represents the rate of flow of the water at the modeled discharge and shear stress represents a measure of work being conducted on the bed of the channel. Because this is a 1-dimensional model the numbers presented represent averages along the cross-section.

The results largely confirm the findings of the reconnaissance-level assessment. From upstream to downstream there is a dip in shear stress at the entrance to Clackamette Cove (Station 2050), followed by an increase just downstream as water flows over the steepened riffle created by bedload deposition at the Cove. At the Bridge (Station 1391) the shear stress spikes and then declines in the downstream direction as the cross-section widens out and velocities decline within the backwater of the Willamette River.

Reference Bank Angles

In general, bank slopes along the Willamette River, within and adjacent to the project area, are relatively steep with surface conditions dominated by coarse material, such as cobble. As discussed above, this condition is due to the historic lowering of the bed of the Willamette River to enhance navigation and the successive encroachment of land use into the floodplain and terraces areas. Although the prevailing bank conditions are steep and localized erosion does occur, in general, the banks have eroded to a stable angle that represents an equilibrium condition.

To understand what bank angles occur within this reach of the Willamette River we utilized LiDAR-generated topography and in-channel bathymetric surveys compiled from a variety of sources to measure bank angles. The analysis consisted of equally spaced cross-section along approximately 2,000 feet of the Willamette River extending from the mouth of the Clackamas and downstream along the east bank. At each cross-section bank angles were measured from the toe of the slope to the top of bank upstream, downstream, and within the project area. A total of seven locations were assessed with the following results:

- Average bank angle: 2.5:1 or 39% slope
- Maximum bank angle: 1.4:1 or 69% slope
- Minimum bank angle: 4:1 or 25% slope
- Standard deviation: 15% slope; 1.8:1 to 4.1:1

Design Implications

An engineering design that focuses on conversion of an armored, modified bank to a more natural bank condition needs to consider a variety of factors in the design approach including the presence of existing infrastructure, geotechnical stability recommendations, the desire to integrate habitat elements, and the overall geomorphic context and expected future trends. Furthermore, the design needs to consider societal interests and the desire to maintain existing landscape features, where feasible. Achieving a finalized design approach is often based on the need to balance these sometimes disparate interests within the context of limiting risks of failure.

From a purely geomorphic perspective there is always the understanding that rivers, especially at confluences of major systems such as the Clackamas and Willamette, are dynamic by nature with processes that are the result of the integration of processes occurring at the reach and watershed scale. We can predict trends based on past and current trends but there will always be unknowns that can change the overall dynamics. For example, a decision could be made in the future to deepen the Willamette River channel for navigation which could ultimately affect bank stability through the reach.

With that said, we have the following comments on the 30% engineering design with the goal of addressing the questions laid out in the Existing Conditions discussion:

- ***Erosion Trends:*** The proposed modifications to the Parking Lot and Bulkhead areas are not expected to increase the potential for erosion at the project areas. Currently, the presence of the bulkhead and associated sheet pile structure likely exacerbates erosion in the vicinity because of the turbulence created by the structure at high flows. Removal of the bulkhead and contouring of the site to match upstream and downstream conditions will reduce the risk of catastrophic bank failure at and adjacent to the bulkhead. Long-term, following removal of the bulkhead, we would expect the bank condition at the bulkhead site to look very similar to conditions immediately upstream and downstream, which are characterized by a relatively steep, armored slope consisting of cobble and gravel. Removing the bulkhead will result in removal of an unnatural discontinuity.
- ***Bar Development along the Lower Clackamas:*** The noted bar development appears to be the result of bed scour at the 99E Bridge. In this case it is difficult to assess what the future trend might be given the unknowns associated with any necessary maintenance activities at the Bridge and any dredging of the channel proposed at the mouth of Clackamette Cove. If no maintenance is conducted it is likely that the gravel bars will grow slowly but the impact is likely to be additional bank erosion along the Oregon City side of the River.
- ***Presence of Sandy Beaches:*** The proposed partial parking lot removal is not expected to impact the hydraulic dynamics at the sandy beach located just downstream of the Parking Lot Area. That feature was present even before the parking lot was constructed and the alcove and beach would be expected to persist into the future. That feature is a result of an eddy current that develops where flow from the Clackamas River interacts with flow from the Willamette River. Conversely, we do expect that the sandy beach downstream of the bulkhead will not persist once the bulkhead is removed and the bank is recontoured. Sand only accumulates in that location because it is in the "shadow" of the sheet pile structure. It will likely require a 5-year event or greater to mobilize the sand and expose the underlying cobble.
- ***Log Structures:*** It is our recommendation that log structures only be integrated into the parking lot removal portion of the project. The flow dynamics and importance of the confluence area as fish habitat drives this recommendation. It is an area where there would likely be some natural recruitment of large wood. That is not the case for the bulkhead site where flow vectors are parallel in the downstream direction and natural recruitment would be highly unlikely do the lack of a natural eddy.

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FIGURES

FIGURE 1

Regional Location Map showing Project Area

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FIGURE 2

Project area and points of interest

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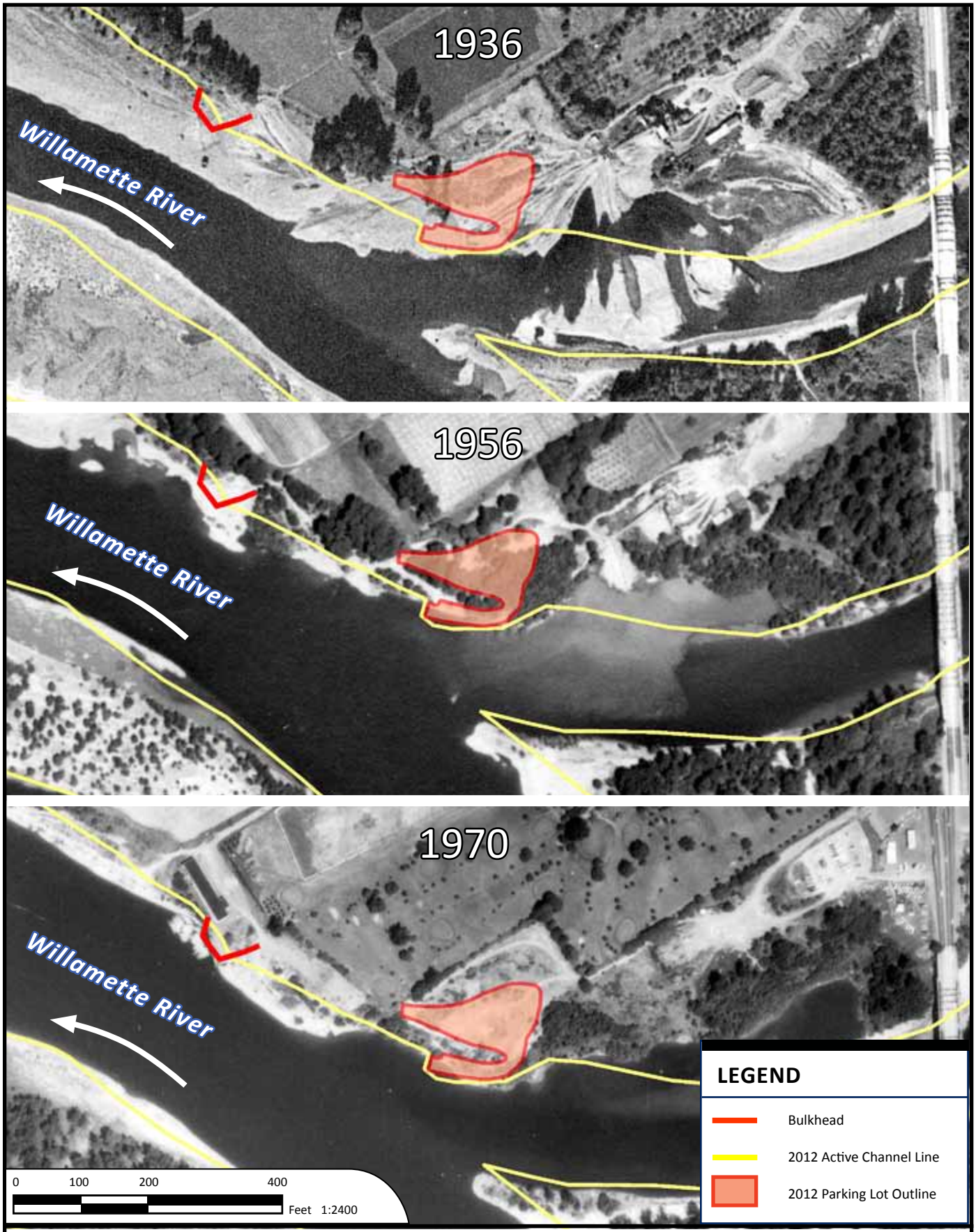

Historic Photos with
2012 Parking Lot, Bulkhead,
and Channel Bank Line

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FIGURE
3

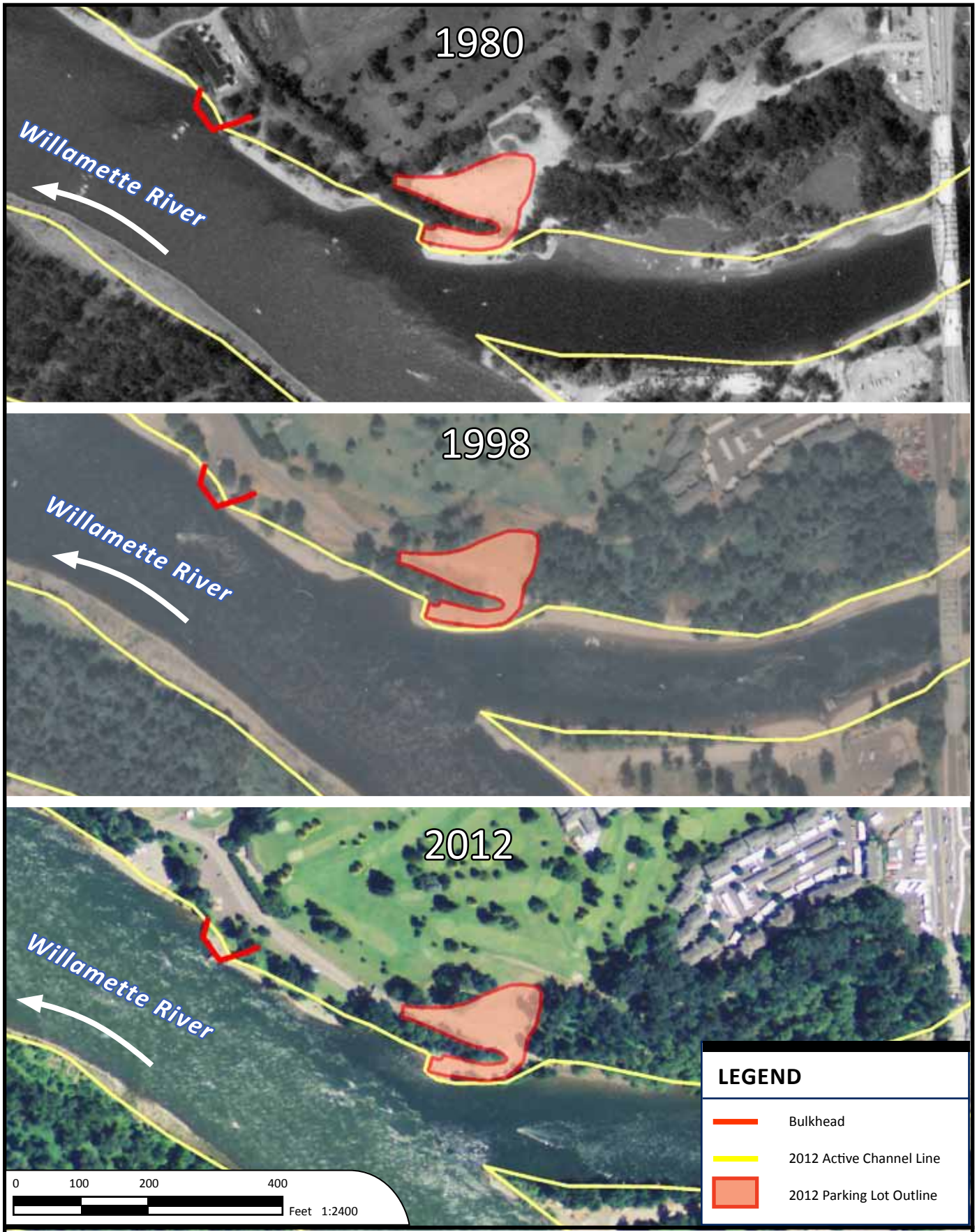

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FIGURE
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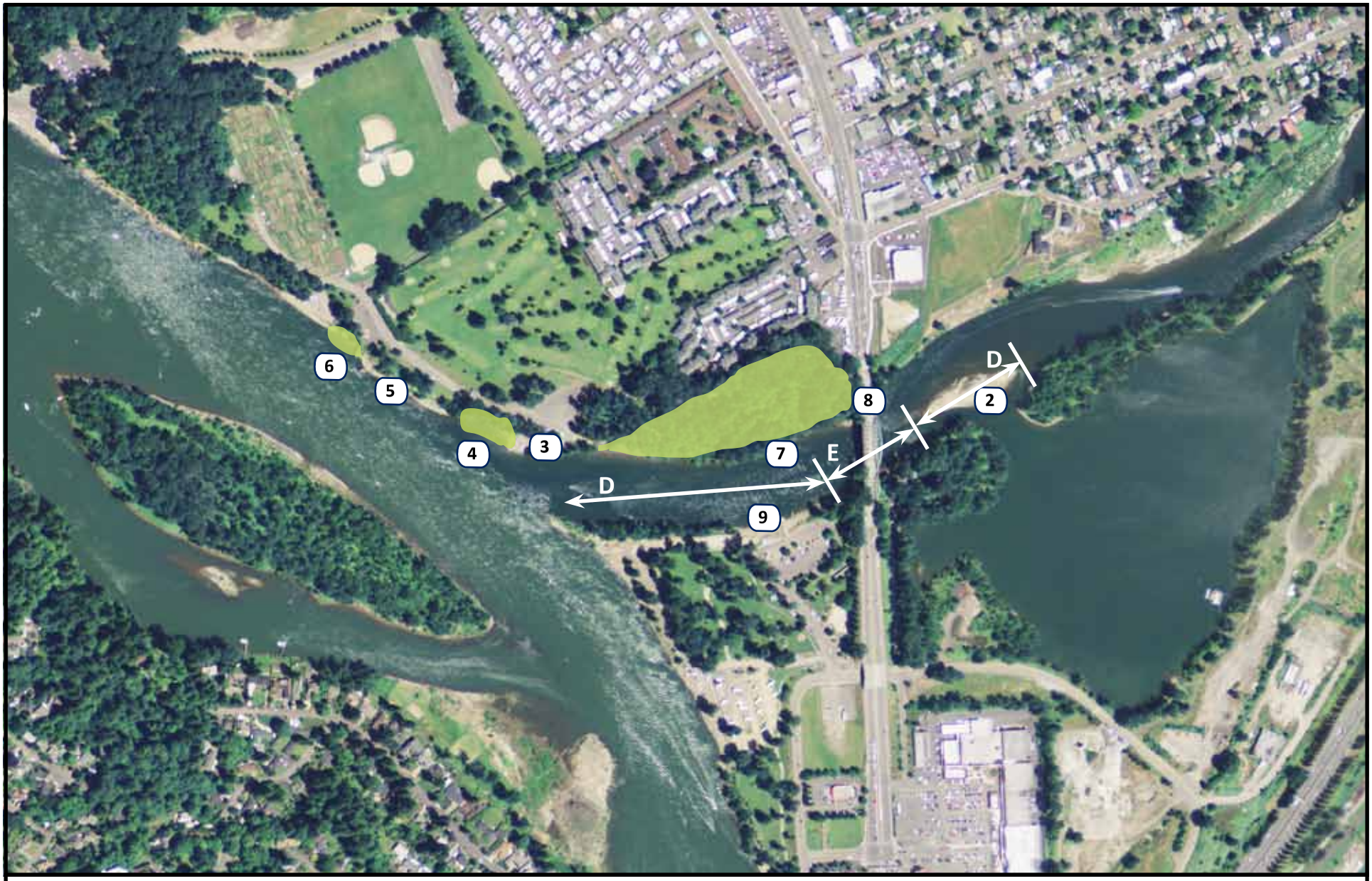

FIGURE 5

Results of reconnaissance-level geomorphic assessment showing locations of erosion, scour, and areas that experience slackwater conditions during high flow events. Numbers correspond with photos shown in Figure 6. D = Depositional reach; S = Scour/Erosional reach; Polygons represent slackwater areas.

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Site 2: Bar at Clackamette Cove; Site 3: Inundated parking lot during 2-year event; Site 4: Alcove/Beach downstream of parking lot; Site 5: Armored bank upstream of bulkhead; Site 6: Slackwater/beach at bulkhead; Site 7: Beach erosion from boat wake; Site 8: Scour pool under 99E Bridge; Site 9: Bar formation near Boat Ramp.

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FIGURE
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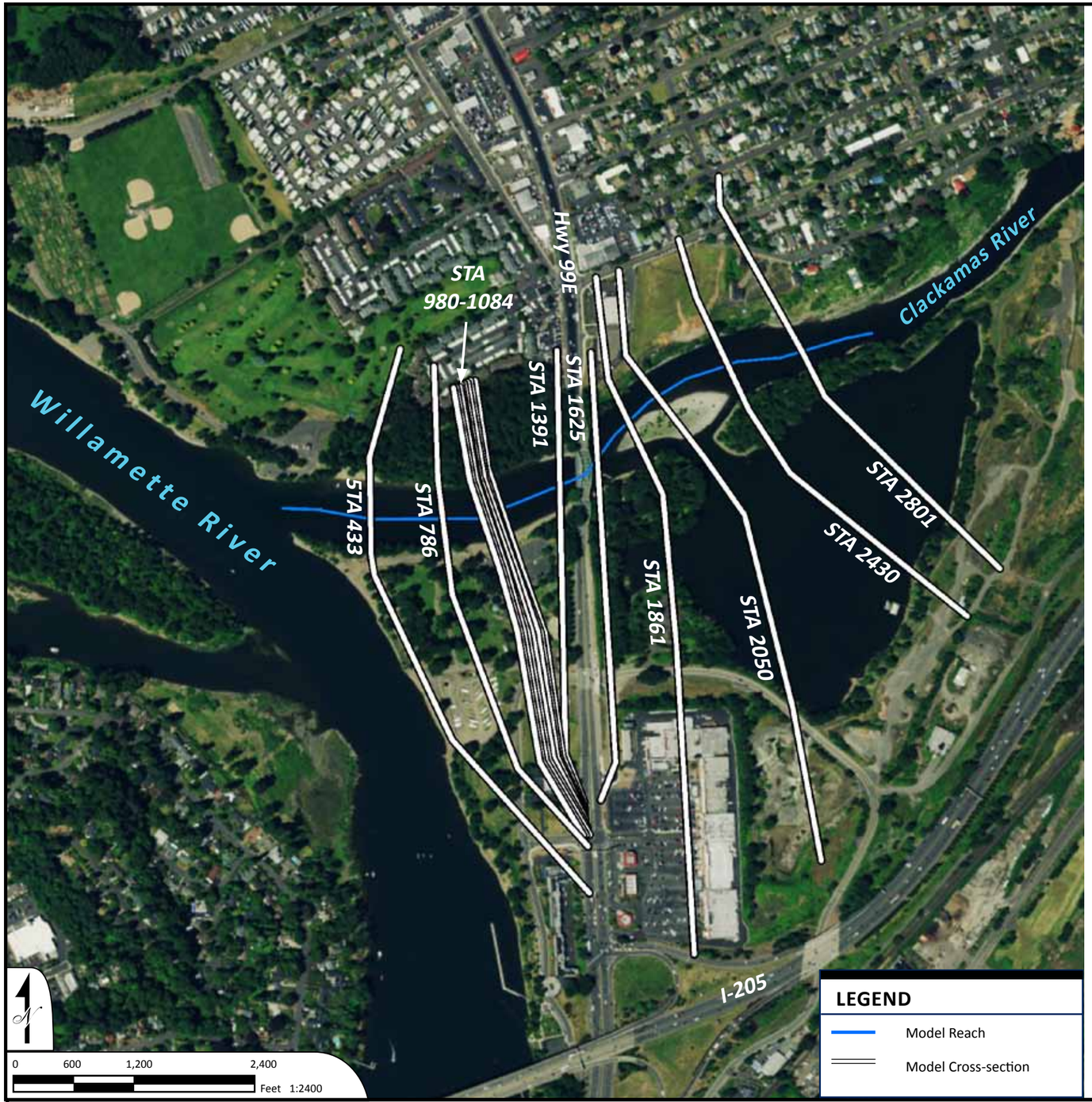

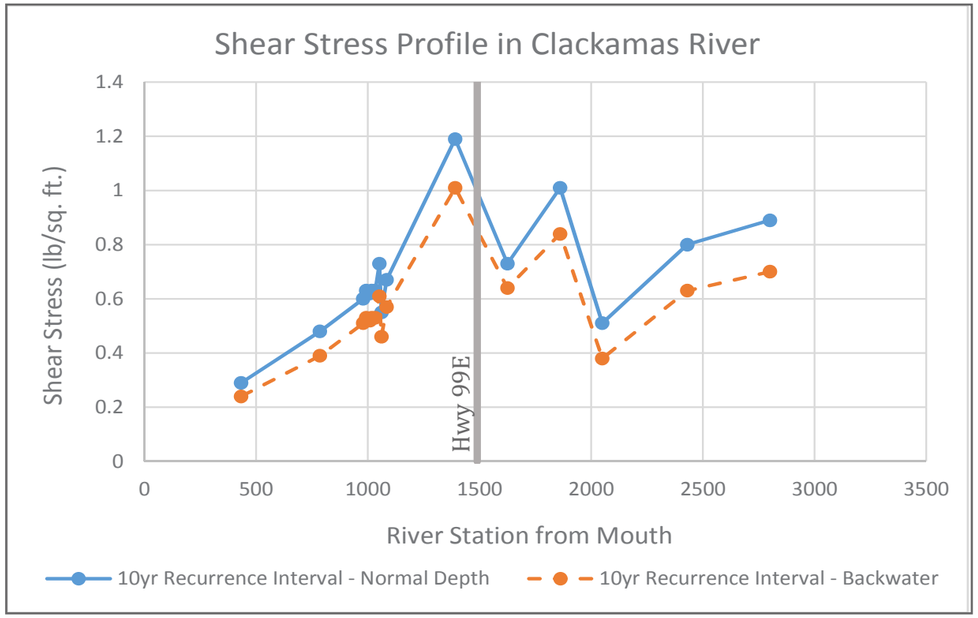

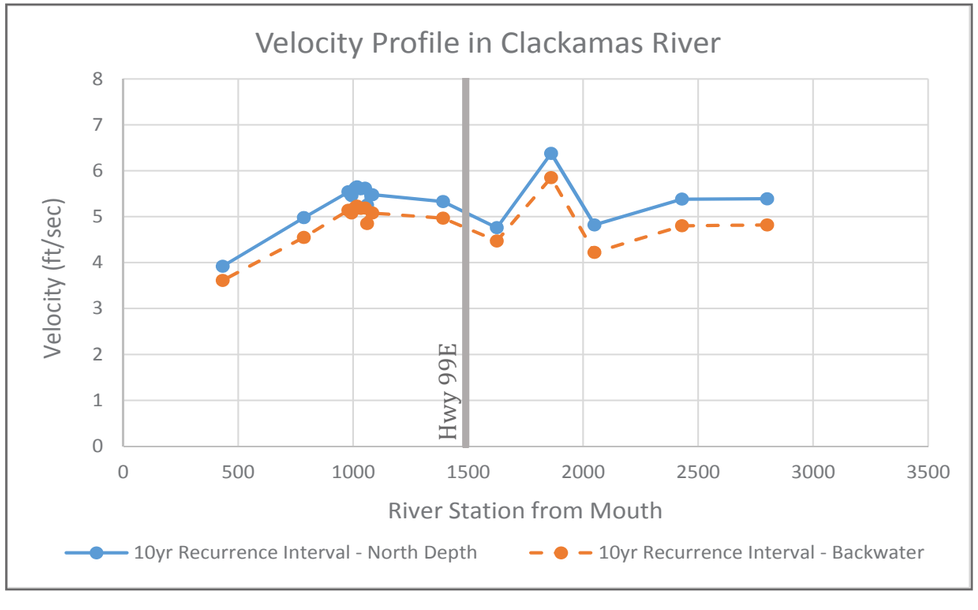

Locations of HEC-RAS model cross-sections and hydraulic output for the lower Clackamas River. The model was provided by WEST Consultants.

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FIGURE 7