CONCEPTUAL RESTORATION ANALYSIS AND PRELIMINARY DESIGN REPORT

Pressentin Park Side Channel to the Skagit River, Marblemount, Washington

Prepared for
Skagit Fisheries Enhancement Group

Prepared by
Herrera Environmental Consultants, Inc.

Note:
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CONCEPTUAL RESTORATION ANALYSIS AND PRELIMINARY DESIGN REPORT

PRESSENTIN PARK SIDE CHANNEL TO THE SKAGIT RIVER, MARBLEMOUNT, WASHINGTON

Prepared for
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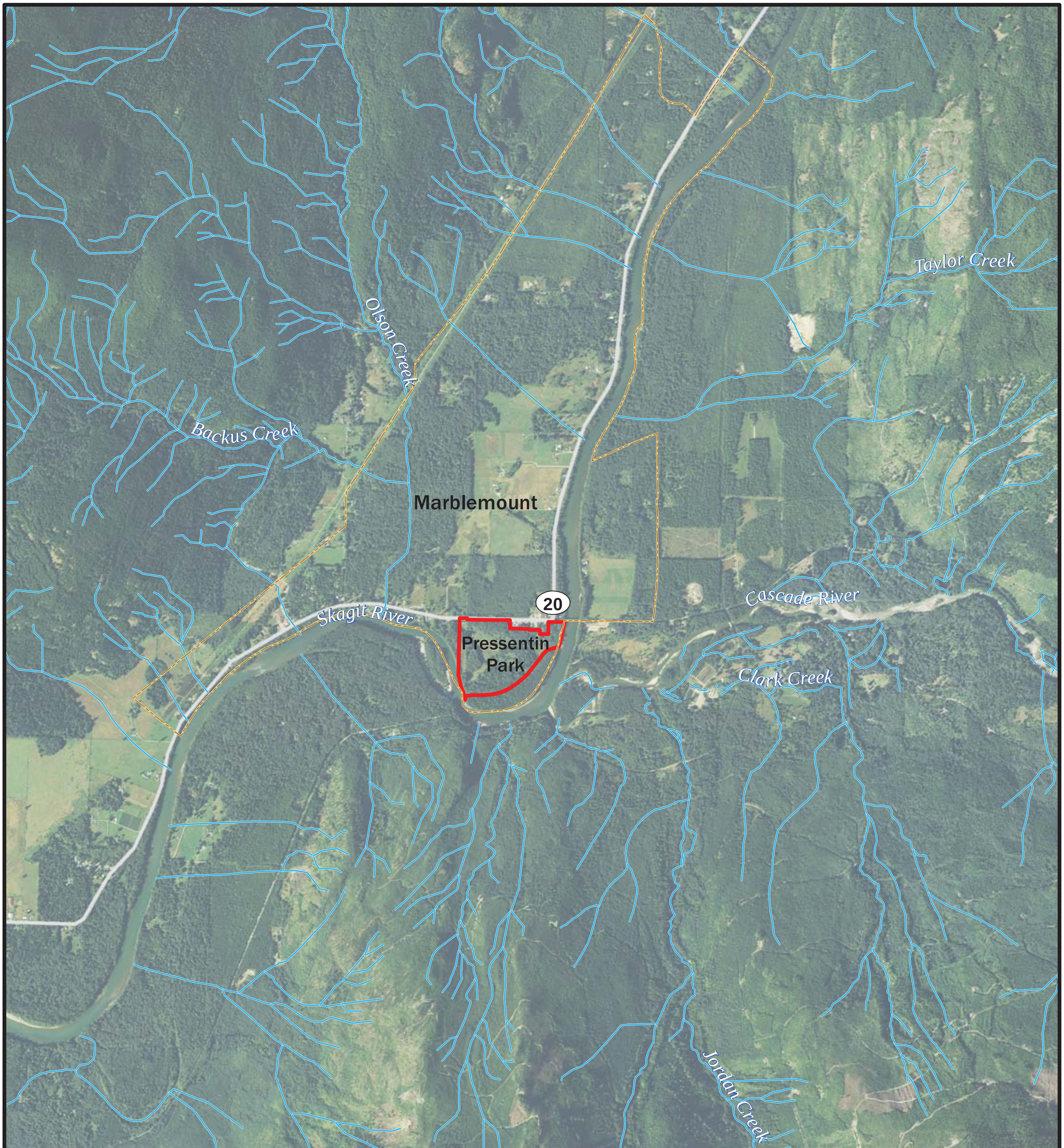
INTRODUCTION

Pressentin Park, located on the Skagit River near the community of Marblemount in Skagit County, contains both existing functional side channel habitat and a historical, remnant side channel currently disconnected from the Skagit River channel. The Skagit River and its tributaries support several salmonid species, including steelhead (*Oncorhynchus mykiss*) and Chinook (*O. tshawytscha*), chum (*O. keta*), pink (*O. gorbuscha*), sockeye (*O. nerka*), and coho (*O. kisutch*) salmon. However, construction of State Route (SR) 20 resulted in floodplain habitat fragmentation and disconnection of parts of the floodplain from the main stem river. In addition, operation of the Skagit Hydroelectric Project significantly altered the flow regime of the Skagit River and has reduced the frequency and magnitude of peak flows during large flood events (Beamer et al. 1999, Graybill et al. 1979). This has severely affected salmonid habitat in the Skagit River by reducing the creation and maintenance of natural off-channel habitat. These combined actions have disconnected and affected the floodplain, prevented seasonal inundation of floodplain areas, and reduced the creation and maintenance of natural off-channel floodplain habitats. Seasonal flooding of the floodplain and associated side channels is a key hydrologic process influencing fluvial ecosystems. In addition, seasonal inundation of the floodplain provides opportunities for juvenile fish to access floodplain and side channel habitats.

Skagit Fisheries Enhancement Group (SFEG) has initiated an effort to develop and analyze alternatives, select a preferred alternative, and prepare preliminary engineering design plans for the Pressentin Park Side Channel Restoration Project (the project) (Figure 1). These efforts are documented in this report. The primary goal of the restoration plan is to increase stable off-channel rearing, refugia, and spawning habitat available to Chinook and other salmon species by re-establishing a second side channel through the park. Besides re-establishment of a side channel, the project objectives include creating pedestrian crossing structures over the side channel to maintain trail connectivity, planting native floodplain vegetation, and controlling invasive plant species.

The restoration plan would be completed in several stages: the conceptual planning stage documented in this report; and future design, permitting, and construction stages. The alternatives analysis described in this document presents the results of the first stage of conceptual project planning completed by Herrera, including characterization of existing project site conditions, definition and evaluation of restoration project alternatives, rationale for selection of a preferred alternative, and conceptual design plans and an engineer's cost estimate for the preferred alternative (see Appendix A).



Legend

- Project area
- Parcel
- Stream or river
- Town limit
- Highway

Figure 1.
Pressentin Park Side Channel Project Vicinity Map.

N

0 1,500 3,000 6,000
Feet

HERRERA

USDA, Aerial (2013)

K:\Projects\Y2014\14-05789-000\Project\Conceptual_Rest_Alt_Analysis\vicinity_map.mxd (3/30/2015)

CHARACTERIZATION OF EXISTING CONDITIONS

This section summarizes key findings from a characterization of existing conditions within the project area, based primarily on a review of historical documents and publicly available remote sensing data, site visits, and input from SFEG.

Review of Historical Information

The project area is on the upper Skagit River in Skagit County's Pressentin Park (Figure 1). The park is a 40-acre historical homestead that was partially donated to the County in 1991, that is largely undeveloped, and that provides open space and hiking trails for local residents. The remaining half of the cost of park acquisition was funded through the Washington State Recreation and Conservation Office's Washington Wildlife Recreation Program. The eastern portion of the park (7.3 acres) was purchased using Recreation and Conservation Office Land and Water Conservation program funds in 2008. That grant requires that park uses conserve and protect habitat and allow public access. Most of Pressentin Park is a stable vegetated meander bar crossed by a perennial side channel (called Marblemount Slough) that runs parallel to and approximately 300 feet landward of the Skagit River, and a remnant of a historical wall-base channel at the toe of the high ground in the northeastern corner of the park (Figure 2). Although site topography suggests that the Skagit River at some point ran along the base of the high ground at the north edge of the park, and that at another point in time it may have occupied the location of Marblemount Slough, neither that side channel nor the channels of the Skagit and Cascade Rivers have moved appreciably over the historical record. Appendix B contains a sequence of maps and aerial photographs, ranging from the 1894 GLO map to a 2013 aerial image from Google Earth showing this channel stability.

Field Reconnaissance, Test Pits, and Groundwater Monitoring

Herrera conducted two field reconnaissance site visits with SFEG staff. The first visit was conducted immediately following the project kick-off meeting on April 28, 2014. Information on geomorphic, hydraulic, and habitat conditions at the project site were collected and discussed during this visit to qualitatively evaluate potential project alternatives discussed during the kickoff meeting. The second site visit was conducted on June 3, 2014, during which Herrera observed the installation of groundwater monitoring gauges within test pits to assess subsurface material properties and groundwater depths at the site. Photos of key features from the site reconnaissance are included in Appendix C.

Field Observations

The field observations most important to characterizing existing site conditions are:

- The existing perennial side channel (Marblemount Slough) is highly functional and provides good quality spawning habitat, primarily for chum salmon, and rearing habitat and flood refugia for juvenile salmonid species.

- The upstream inlet to Marblemount Slough is relatively steep and complex, with large woody debris, variations in channel gradient and bed material, and a mid-channel island.
- There is a sill across the channel composed of fine sediment at the downstream end of Marblemount Slough.
- Existing open field areas within the park provide opportunities for side channel creation. However, the banks of any side channel constructed in those areas should include revegetation design strategies to address potential summer water temperature issues associated with solar irradiance and to minimize juvenile salmonid predation by birds.
- Hyporheic and groundwater connectivity expression was observed at isolated pools within the historical side channel indicating that groundwater was near or at the surface.

Test Pit Observations

Two instruments to monitor water levels were installed in two isolated pools within the historical side channel, and three groundwater monitoring gauges were installed below ground during test pit excavation, between the historical side channel and Marblemount Slough on June 3, 2014 (see Figure 2 for groundwater monitoring and test pit locations).

Test pit observations were made during the excavation of test pits 1, 3, and 4/5. Pits were dug to a depth of approximately 11 feet using a Yanmar ViO45 excavator. Soil properties, soil layer boundaries, and depth to groundwater were recorded, and test pit locations were recorded using a handheld GPS unit. Test pit locations were referenced to LIDAR data and surveyed ground surface elevations at the recorded GPS coordinates to facilitate comparison with existing and proposed side channel locations.

Test pit soil lithology is shown in Figure 3. Test pit observations most important to the existing conditions characterization are:

- Groundwater was encountered at a depth of approximately 8.5 to 9.5 feet below ground surface.
- The soil encountered in test pit 1 is primarily sandy loam and silt loam, underlain by rounded cobble, course gravel, and saturated sand.
- The soil encountered in test pit 3 is primarily gray sand with gravel, silt, sand and cobble underlain by rounded cobble, course gravel, and saturated sand.
- The soil encountered in test pit 4/5 is primarily fine, sandy silt and medium sand, underlain by mottled clay.
- Upgradient test pits (1 and 3) contained more cobble and gravel than downgradient pits (4/5).

Figure 2.
Groundwater Monitoring and Test Pit Locations.

Legend

- Pressentin Park
- Existing maintained trail
- Test pit location and piezometer
- Surface ground water expression gauge
- Parcel

N

0 125 250 500 ft

HERRERA

NAD 1983 HARN
Washington State Plane North FIPS 4601 Feet

ESRI, Aerial (2010); Skagit County, Parcels (2012)

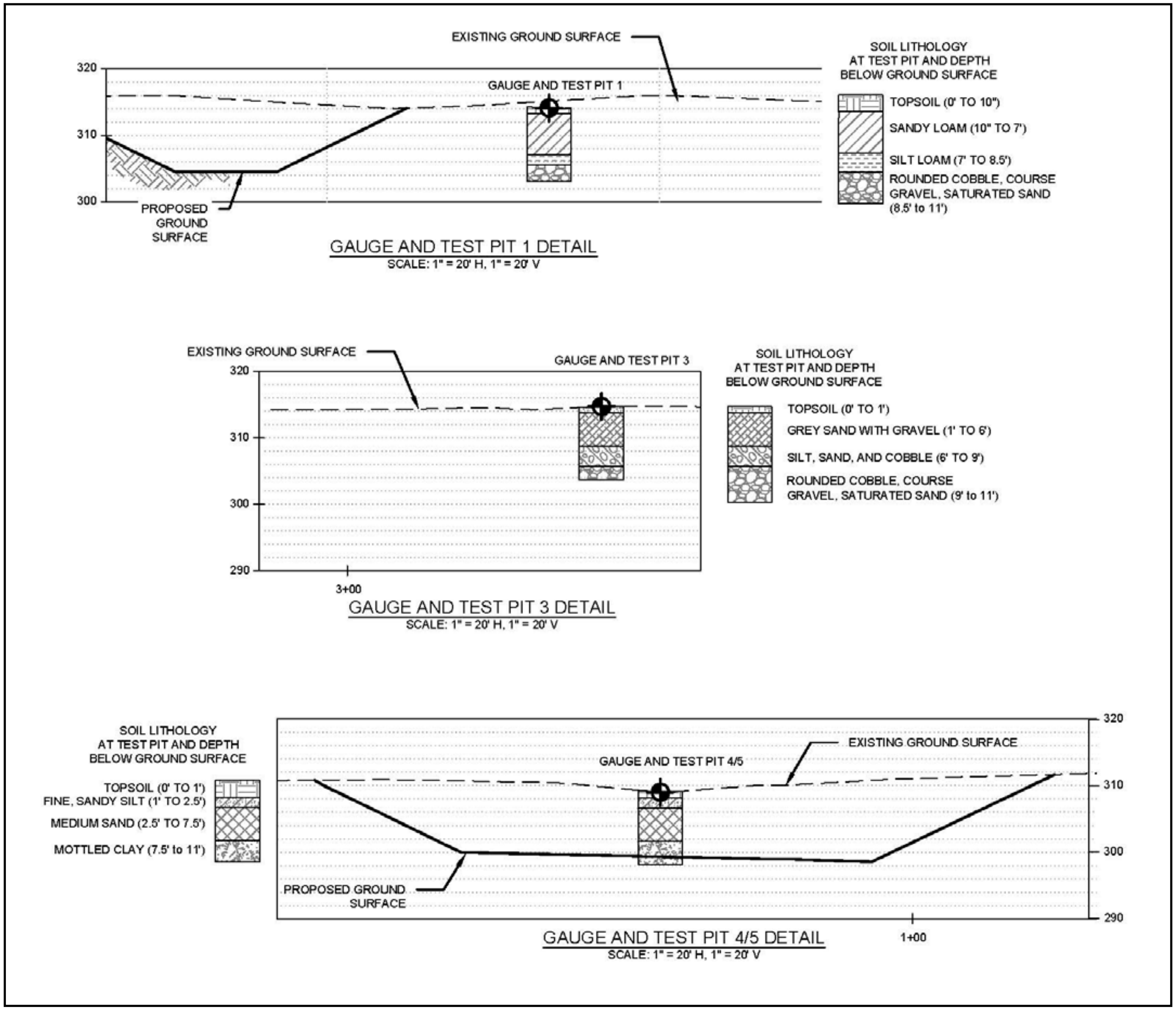


Figure 3. Soil Lithology at Test Pits 1, 3, and 4/5.

- Mottled clay was encountered at a depth of 7.5 feet below ground surface in test pit 4/5.

- Vertical and horizontal variations in test pit lithology are consistent with the side channel being in its existing alignment for a long time, and the natural materials found are consistent with flow energy levels expected through the different portions of a restored side channel.

- Given the presence of spawning-size gravel and cobbles observed within the soil test pits as well as the hyporheic and groundwater connectivity detected on the site (see *Groundwater Monitoring* section), any excavated side channel would likely provide spawning habitat without the need to import spawning substrate to the project site.

- The material most recently deposited in the area is silt and sand, so the proposed side channel need only pass silt and sand. Flow depths and velocities sufficient to move cobble and gravel through the side channel are not required to achieve natural sediment sorting and deposition character.

Groundwater Monitoring

Herrera analyzed groundwater elevation data recorded between June 2014 and June 2015 at five locations in the project area (Figure 2). Measured groundwater elevation data were compared to flow rates and water surface elevations for the same period at the US Geological Survey (USGS) Marblemount streamflow gauge in the Skagit River approximately 0.5 miles upstream of the site. Table 1 shows the groundwater elevation, sensor elevations and groundwater depths recorded at each of the groundwater monitoring gauges/groundwater expression gauges (existing pool surface water).

Table 1. Measured Groundwater Elevations in the Project Area, June 2014 to June 2015.

Test Pit/ Gauge ID	Ground Surface Elevation (feet)	Sensor Elevation (feet)	Groundwater Elevation (feet)		
			Maximum	Average	Minimum
1	313.62	304.18	310.76	305.86	303.93
3	313.15	303.71	308.83	304.32	N/A
4/5	308.74	299.54	308.00	301.32	299.02
7	NA	301.12	309.26	303.48	301.06
8	NA	301.79	310.05	304.89	301.61

N/A – Unable to detect minimum groundwater elevation at groundwater Gauge 3 since the groundwater table went below the depth of the sensor.

Groundwater levels in Gauge 3 reached levels that were not detectable by the sensor since groundwater was below the depth of the sensor between July 20, 2014, and October 21, 2014, and intermittently between February 5, 2015, and June 15, 2015. Had the sensor been placed at a lower elevation, data collected at this location would almost certainly show that groundwater levels in Gauge 3 behave similarly to the other four gauges during these periods (i.e., groundwater level continued to drop over the summer, reaching a minimum elevation in October).

Gauges 3 and 7 were placed at approximately the same longitudinal location along the historical channel alignment, but Gauge 3 was placed between the historical side channel and Marblemount Slough, approximately 300 feet south of the historical side channel. When Gauge 3 recorded groundwater data (June to July 2014 and November 2014 to February 2015), there was a slight difference in the groundwater depths recorded at Gauge 3 and 7, with Gauge 3 being generally lower. Additionally, the difference in groundwater elevations recorded between Gauge 1 and Gauge 4/5 is consistent with groundwater surface elevation differences between the main stem of the Skagit River near the inlet and outlet of the historical side channel. These factors indicate that there is minimal lateral slope in the groundwater surface perpendicular to the historical channel alignment.

Figure 4 displays the groundwater elevations recorded at each of the groundwater monitoring gauges compared to water surface elevations and flow rates recorded over the coincident period at the USGS Marblemount gauge. Regarding the historical channel alignment, groundwater elevations consistently decrease from upstream to downstream over a range of groundwater conditions and flows (i.e., groundwater elevations at Gauge 1 are highest, while groundwater elevations at Gauge 4/5 are lowest). As flows and water surface elevation increase in the Skagit River at Marblemount, groundwater elevations on the site also increase, suggesting that groundwater at the site is hydraulically linked to the level of water in the river rather than responding directly to precipitation on the site or other surface hydrology influences on the site. This correlation indicates that restoring the historical side channel will have little effect on the groundwater table or water levels in Marblemount Slough. It also indicates that a channel excavated to this depth at or below the groundwater level would likely exhibit groundwater upwelling like that seen in Marblemount Slough.

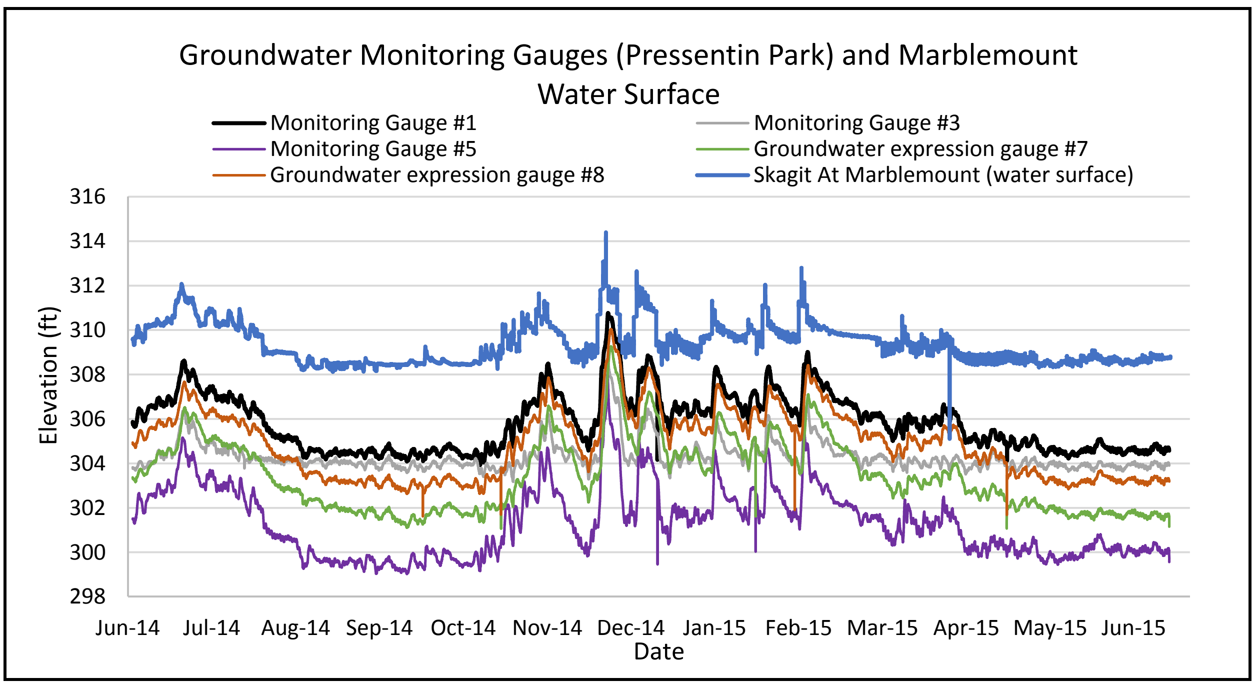


Figure 4. Groundwater Monitoring Gauges and Skagit River Water Surface Elevations.

Hydraulic Analysis

A hydraulic analysis of existing conditions was performed using a two-dimensional hydrodynamic model. A one-dimensional HEC-RAS hydraulic model used for the FEMA Flood Insurance Study (FIS) in the project vicinity was available; however, this model was developed at a coarse scale and did not provide enough resolution to assess important localized hydraulic characteristics around Pressentin Park. Given the Cascade River Road Bridge over the Skagit River is located just upstream of the site, and the confluence of the Skagit and Cascade Rivers is across from Pressentin Park in the immediate project area, a two-dimensional modeling approach was developed to provide a comprehensive understanding of the complex site hydraulics.

The detailed hydraulic model developed for this project provides a good understanding of the hydraulic characteristics and interaction of flow between the Skagit River and the floodplain within the park to assess the effectiveness, sustainability, and performance of project alternatives from both a geomorphic and habitat perspective. The model was not developed to re-establish base flood elevations (BFEs) for flood insurance or other regulatory purposes, but can provide more detailed information consistent with the established BFEs at the appropriate scale necessary to assess the effects of the project alternatives upstream, downstream, and within Pressentin Park.

The following discussion explains the modeling methods, development of the hydraulic model, and discusses results.

Hydraulic Modeling Methods

RiverFlow2D Plus software was used to simulate hydraulic characteristics of the Pressentin Park project site and extended reach of the Skagit River and Cascade River confluence area. RiverFlow2D Plus is a two-dimensional finite volume hydrodynamic modeling program that can route flood flows over complex terrain and provide high resolution of flood hydraulics. It uses a flexible triangular finite element mesh without the stability limitations of older two-dimensional finite element models. A flexible triangular mesh allows the hydraulic modeler to refine the density and resolution of the model to approximate detailed flow fields around key river features in complex river environments.

Unlike other two-dimensional hydraulic models, RiverFlow2D Plus is stable in simulating open channel flows with shallow, broad floodplains, as it automatically deactivates model elements within a specified shallow depth threshold.

Two-dimensional numerical models like RiverFlow2D Plus require input data for boundary conditions, including a geometric computational mesh (i.e., ground surface grid), hydraulic roughness values, and a discharge hydrograph, which together define the computational domain. Boundary conditions and other input data developed for the models of existing conditions and the project alternatives are described below.

Computational Domain and Mesh Development

The upstream limits of the hydraulic model domain are near the Rockport Cascade Road Bridge over the Cascade River and near River Mile (RM) 78.5 of the Skagit River. The model domain extends through the entire Skagit River floodplain to a point downstream of Pressentin Park near RM 76. This relatively large domain is necessary for assessing the hydraulic effects of a proposed side channel on areas upstream and downstream of Pressentin Park. The density of the RiverFlow2D Plus computational mesh was specified with variable element sizes ranging from 60 feet in the floodplain to as small as 3 feet in the main channel, side channel areas, and near the Cascade River Road Bridge. The average element size was approximately 12 feet. The channel and floodplain area was represented with approximately 450,900 elements and 225,825 nodes. The width of the modeled floodplain is primarily bounded by the Skagit River valley wall to the south and SR 20 to the north.

Two primary boundary conditions for a hydraulic model are the geometric representation of the channel and floodplain topography and flow resistance along that topography. A topographic surface was developed by Herrera for the model using a high level of detail in the project area with diminishing detail radiating from the project site. This surface was constructed using the 2006 LIDAR topographic data from the Puget Sound LIDAR consortium, topographic survey data, cross sections from the FEMA FIS hydraulic model, and interpolation of data for locations on the ground among these three data sources. Survey data were collected by Semrau Engineering and Surveying in an area encompassing the existing and proposed side channel areas, high points, and bathymetric cross sections in the Skagit River adjacent to Pressentin Park (Appendix D). Bathymetric cross sections from the FEMA FIS HEC-RAS model (USACE 2011) were used to interpolate bathymetric elevations upstream and downstream of the park. In some areas within the model domain, it was necessary to interpolate the bathymetric surface between the cross sections and between the various data sets. Interpolation was based on site observations and aerial photographs.

Flow resistance at the topographic boundary was estimated using Manning's roughness coefficients ("n" values) (Chow 1959). The dimensionless n-values used included 0.02 for road surfaces, 0.03 for gravel channel and bar areas, 0.04 for grassy and open floodplain areas, 0.1 for the forested floodplain, and 0.12 for local roughness around large woody debris and proposed engineered log structures.

A goal in developing the topographic surface was to enable optimizing the required model output detail and accuracy, balanced by the cost of achieving topographic detail. Data quality in the resultant topographic surface is high in the immediate project area but limited in other areas. The accuracy of the FEMA FIS HEC-RAS model cross sections and the LIDAR data is not a significant limitation for this alternatives analysis.

The 2006 LIDAR appears to have quality issues that were also noted by the Puget Sound Lidar Consortium, but it is the only LIDAR dataset available for the area. Additional topographic data were collected at and around the large bar across the Skagit River from the southwest corner of Pressentin Park. During development of the hydraulic model and evaluation of the alternatives, it was determined this bar, left-bank side channel, and a nearby bedrock outcrop are important features that collectively influence flow distribution from the channel into the floodplain. The current modeling is adequate for feasibility and alternative selection, but additional survey for future design refinements is recommended to be sure that model results are accurate enough for final design and permitting.

Upstream Boundary Conditions

The model was developed with two upstream inflow boundary conditions: one each for the Cascade River and the Skagit River. Both upstream boundary conditions were assumed as a steady state "Type 61" inflow boundary condition. A steady state analysis assumes that the peak discharge is held at a constant rate. This provides a conservative estimate for flow depths and velocities, and minimizes temporal differences and fluctuations that can overcomplicate the comparison of alternatives.

Four inflow conditions were assumed and modeled to support the geomorphic and habitat assessment of alternatives. Two low flows, one moderate flow, and one high flow were selected by the project team to represent frequent flows that would most significantly influence and shape the geomorphic and habitat features of the side channel alternatives. The two low flows selected were 5,000 cubic feet per second (cfs) and 7,600 cfs. The 2-year recurrence flood flow (24,900 cfs in the Skagit River and 7,433 cfs in the Cascade River) was selected as the moderate flow to represent conditions likely to initiate geomorphic changes (scour, bedload movement, and sediment deposition). The model outputs for this flow rate provide information useful for assessing the side channel geometry and sustainability of the side channel inlet. The high flow selected to assess potential upstream and downstream impacts that could affect permitting and implementation of the project was the regulatory (FIS) 100-year flood flow (78,530 cfs in the Skagit River and 21,160 cfs in the Cascade River).

The USGS gauges at the Skagit River near Marblemount (USGS 12182500) and Cascade River (USGS 12182500) were used to derive these four flow rates. The 5,000 cfs flow represents an average low flow in the gauge data that could occur for several weeks to a month, associated with hydroelectric releases from Ross Dam. It is thus highly useful for assessing low-flow side channel connectivity with the main stem river channel. This flow was also useful for model calibration (simulating what has been observed in the project area) since anecdotal information suggests that the existing side channel (Marblemount Slough) is disconnected at the inlet from the main stem river at this flow rate, with flow in the slough driven primarily by hyporheic (groundwater) flows. The 7,600 cfs flow represents an approximate hydropower generation releases from Ross Dam that can be sustained for long periods. The 2-year recurrence flow was estimated by Herrera performing a Log-Pearson Type III analysis on the USGS gauge data. The 100-year recurrence flow was determined from the FEMA FIS HEC-RAS model.

Downstream Boundary Conditions

The downstream model boundary was established near River Mile (RM) 76 of the Skagit River. A "Type 12" normal depth energy grade slope of 0.0014 (0.14 percent) was assumed for the downstream boundary condition as obtained from the FEMA FIS HEC-RAS model. The model was extended far enough downstream so the accuracy of the downstream boundary conditions would have little bearing on the hydraulic results near the project area.

Calibration

Thorough hydraulic model calibration includes a comparison of model results to known and measured conditions, from which model input parameters can be adjusted within reasonable bounds to most accurately replicate the known and measured conditions. The intent of the model prepared for this study was to provide a tool to assess and compare alternatives, not to establish discrete and definitive water surface elevations for a given discharge at a location. Comparing relative differences in hydraulic characteristics between alternatives and assessing changes from existing conditions were the primary objectives of the modeling effort. Evaluating the risk of project impacts on adjacent property is also a key consideration, so it was important that the model produce representative results comparable to the FEMA FIS HEC-RAS model.

Due to hydraulic complexities in any floodplain, it is not possible to exactly reproduce one-dimensional hydraulic model results (FIS HEC_RAS) with a two-dimensional model. The two-dimensional model will provide more detail and local variations that are simply averaged across the floodplain in a one-dimensional approach. A general comparison using professional judgment is required to assess the accuracy of the results and to determine where differences are due to the more accurate and representative detail provided by the two-dimensional analysis approach.

For the 7,600 cfs low flow, a partial calibration was performed for existing conditions. Water surface elevations observed near the Cascade River Road Bridge were compared to the model results, indicating that the model results were within 0.2 feet of observed water levels.

For the 5,000 cfs low flow the model also showed disconnection of the upstream end of Marblemount Slough from the main stem river, which follows observations. The existing conditions model therefore provides a good representation of low-flow conditions for purposes of this project.

Hydraulic Modeling Results

Existing conditions hydraulic model results are shown in Figures 5 through 10. The existing conditions modeling revealed three key findings. First, low-flow connectivity is tenuous for existing Skagit River side channels in the project area. The model indicates that river flow into the upstream end of Marblemount Slough occurs when the river is running at 7,600 cfs, but not when running at 5,000 cfs. Second, the 2-year recurrence flow does not inundate the floodplain at Pressentin Park. This suggests that the Skagit River channel along Pressentin Park is relatively incised, likely due to the upstream bridge, historical removal of large woody debris, and reduced sediment delivery from the Skagit River due to upstream dams. Model results indicate that low-lying areas around Marblemount Slough are inundated during a 2-year flow event, but the majority of the park is not inundated by this flow, which may be considerably lower than the historical 2-year peak flow that shaped the channel and floodplain prior to dam flow regulation upstream of the site. Third, overbank flood events are sensitive to the geometry of the abandoned floodplain terrace at the north end of Pressentin Park. Floodplain flows are constricted and heavily influenced by the abandoned terrace and historical side channel geometry during the 100-year event, and small changes in topography have small but widespread hydraulic effects (0.05-foot elevation change) in the floodplain.

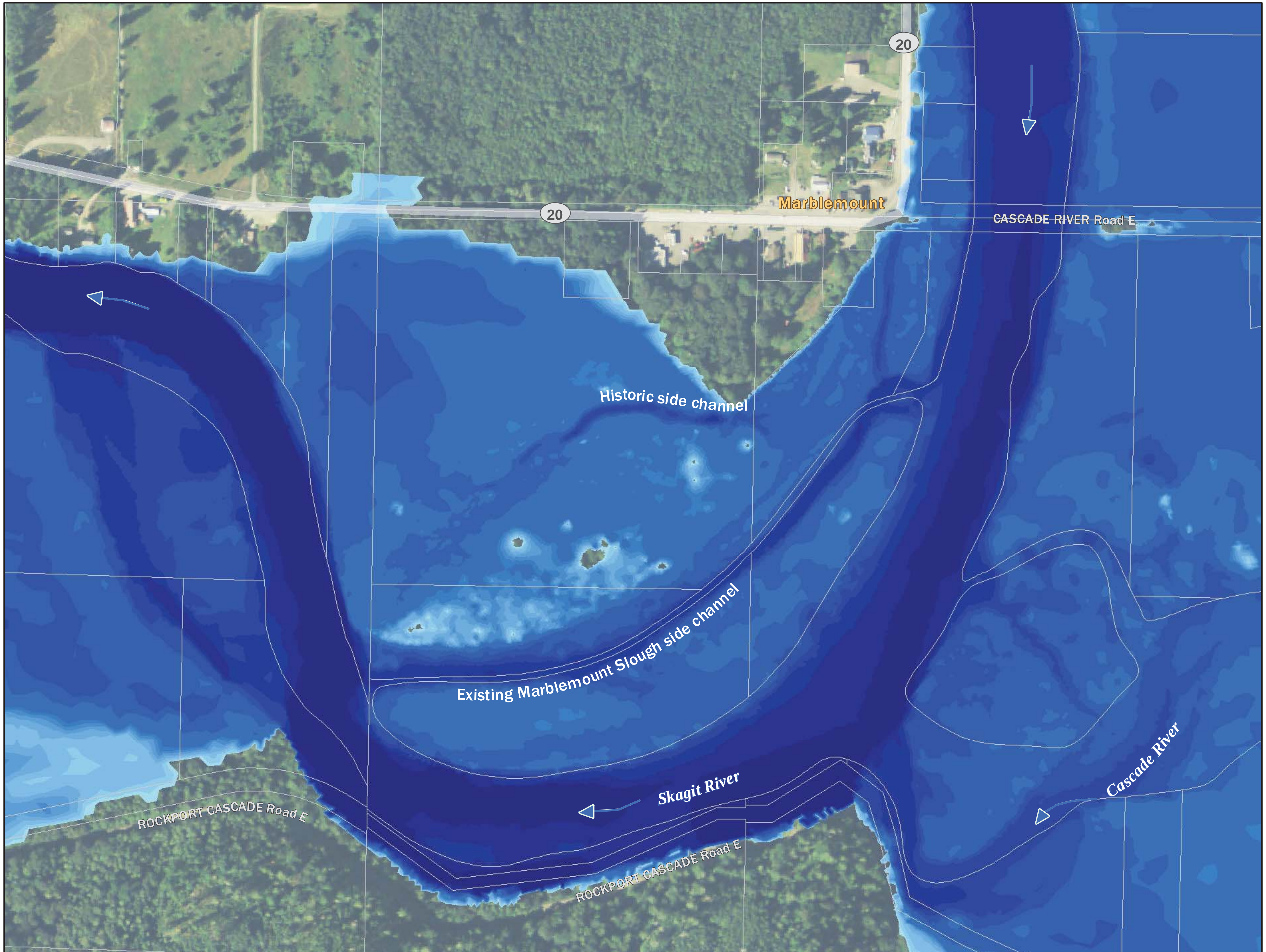


Figure 5.
Existing Conditions Depth,
100-Year Flood.

Legend

- Parcel

Existing Depth (ft)

- 0 to 0.05
- 0.05 to 0.2
- 0.2 to 0.5
- 0.5 to 1
- 1 to 1.5
- 1.5 to 2
- 2 to 2.5
- 2.5 to 3
- 3 to 6
- 6 to 9
- 9 to 12
- 12 to 15
- 15 to 18
- 18 to 21
- > 21

NOTE:
Flood modeling and results shown are approximate and were developed using a project specific River Flow 2D model for the purpose of side channel restoration alternative analysis. Results are not to be used for determining flooding extents or depths (See FEMA Skagit River FIRM maps for regulatory flood conditions).

N

0 175 350 700 ft

HERRERA

NAD 1983 HARN
Washington State Plane North FIPS 4601 Feet

USDA, Aerial (2013); Skagit County, Parcels (2012)

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Figure 6.
Existing Conditions Depth,
2-Year Flood.

Legend

- Parcel

Existing Depth (ft)

- 0 to 0.05
- 0.05 to 0.2
- 0.2 to 0.5
- 0.5 to 1
- 1 to 1.5
- 1.5 to 2
- 2 to 2.5
- 2.5 to 3
- 3 to 6
- 6 to 9
- 9 to 12
- 12 to 15
- 15 to 18
- 18 to 21
- > 21

NOTE:
Flood modeling and results shown are approximate and were developed using a project specific River Flow 2D model for the purpose of side channel restoration alternative analysis. Results are not to be used for determining flooding extents or depths (See FEMA Skagit River FIRM maps for regulatory flood conditions).

N

0 175 350 700 ft

HERRERA

NAD 1983 HARN
Washington State Plane North FIPS 4601 Feet

USDA, Aerial (2013); Skagit County, Parcels (2012)

Figure 7.
Existing Conditions Depth,
7600 cfs Flow.

Legend

- Parcel

Existing Depth (ft)

- 0 to 0.05
- 0.05 to 0.2
- 0.2 to 0.5
- 0.5 to 1
- 1 to 1.5
- 1.5 to 2
- 2 to 2.5
- 2.5 to 3
- 3 to 6
- 6 to 9
- 9 to 12
- 12 to 15
- 15 to 18
- 18 to 21
- > 21

NOTE:
Flood modeling and results shown are approximate and were developed using a project specific River Flow 2D model for the purpose of side channel restoration alternative analysis. Results are not to be used for determining flooding extents or depths (See FEMA Skagit River FIRM maps for regulatory flood conditions).

N

0 175 350 700 ft

HERRERA

NAD 1983 HARN
Washington State Plane North FIPS 4601 Feet

USDA, Aerial (2013); Skagit County, Parcels (2012)

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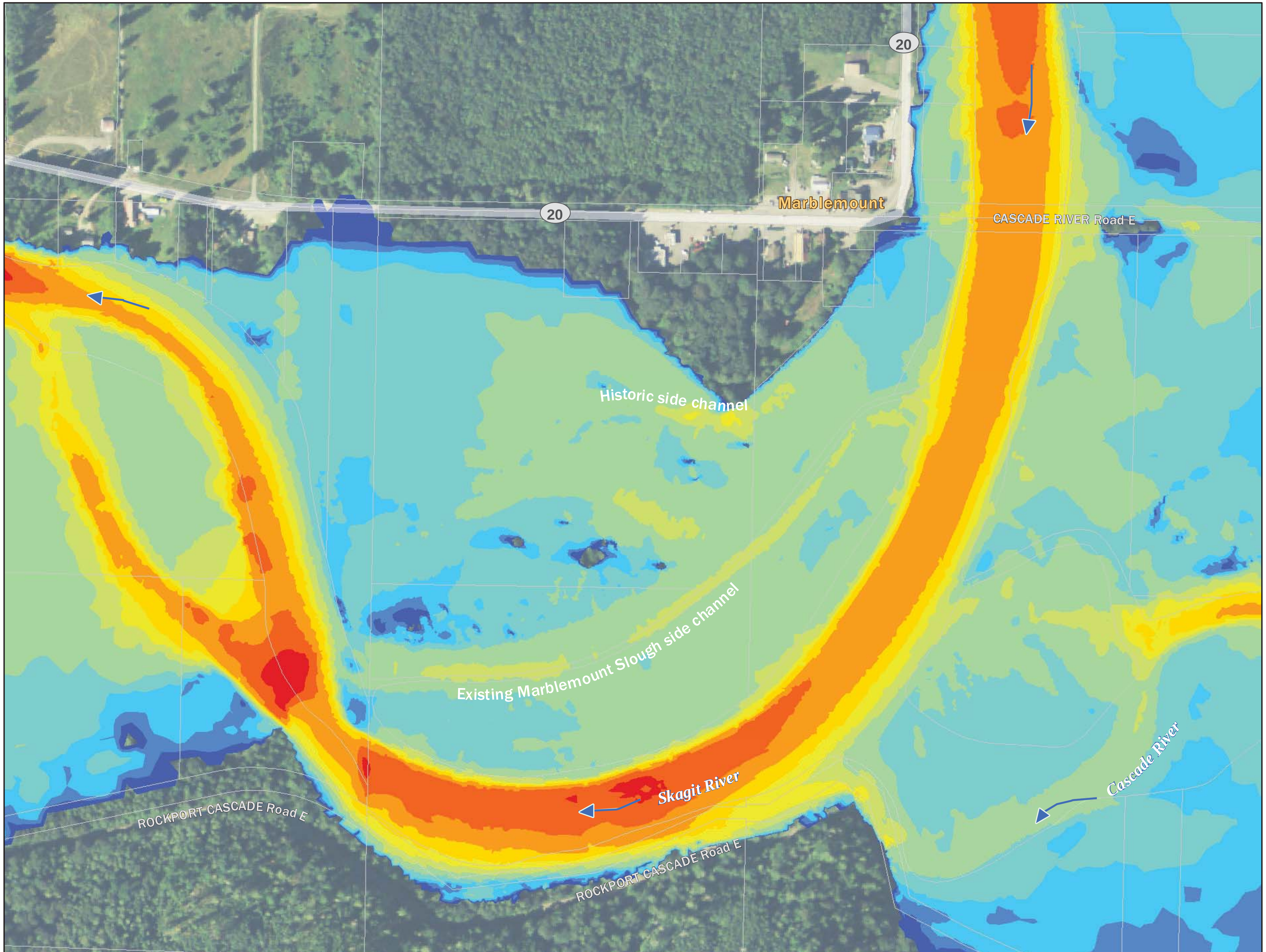
Figure 8.
Existing Conditions Velocity,
100-Year Flood.



Legend

Parcel

Existing velocity (fps)

- 0 to 0.01
- 0.01 to 0.25
- 0.25 to 0.5
- 0.5 to 1
- 1 to 2
- 2 to 4
- 4 to 6
- 6 to 8
- 8 to 10
- 10 to 12
- 12 to 14
- > 14

NOTE:
Flood modeling and results shown are approximate and were developed using a project specific River Flow 2D model for the purpose of side channel restoration alternative analysis. Results are not to be used for determining flooding extents or depths (See FEMA Skagit River FIRM maps for regulatory flood conditions).

N

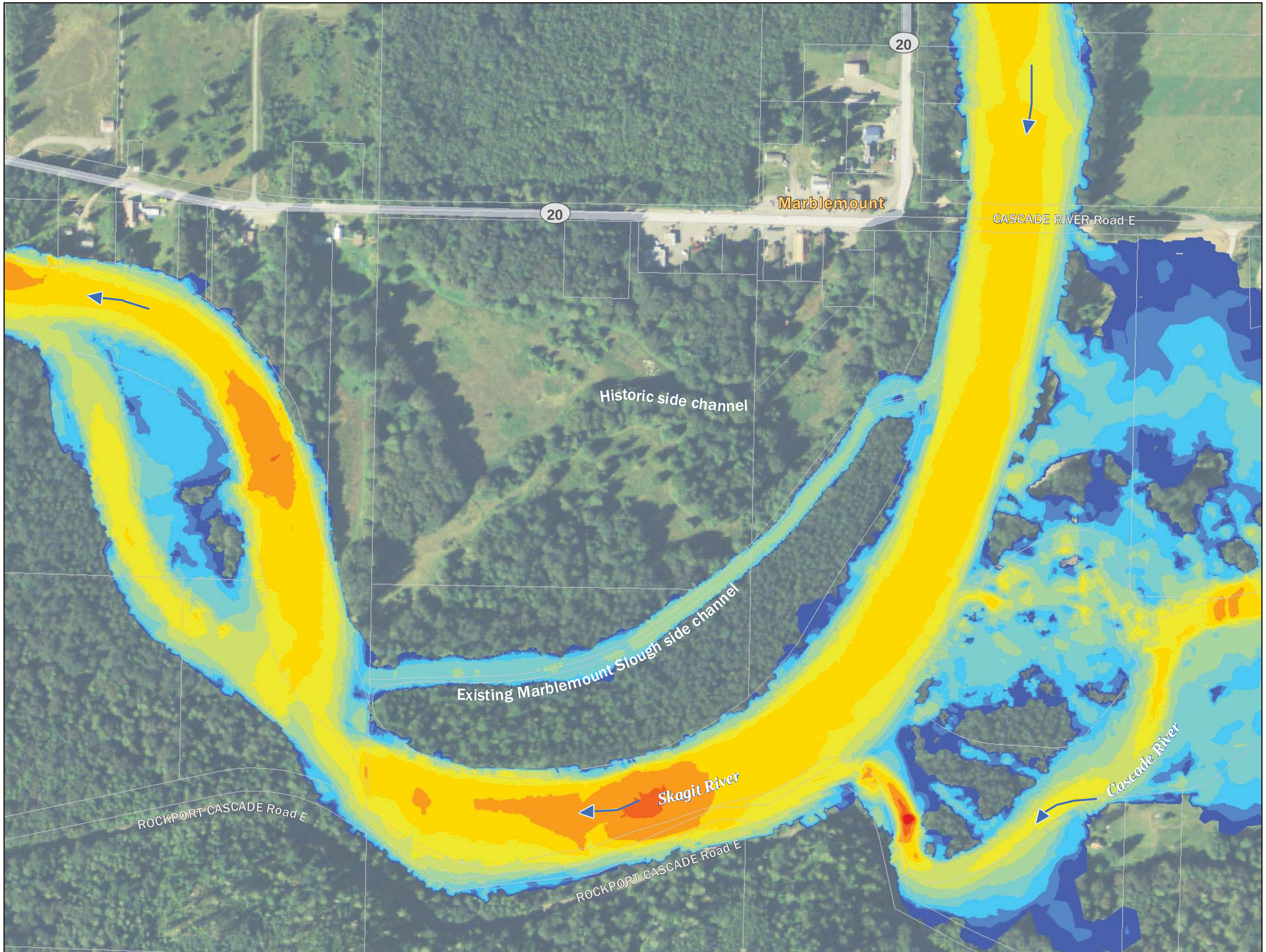
0 175 350 700 ft

HERRERA

NAD 1983 HARN
Washington State Plane North FIPS 4601 Feet

USDA, Aerial (2013); Skagit County, Parcels (2012)

Figure 9.
Existing Conditions Velocity,
2-Year Flood.



Legend

Parcel

Existing velocity (fps)

- 0 to 0.01
- 0.01 to 0.25
- 0.25 to 0.5
- 0.5 to 1
- 1 to 2
- 2 to 4
- 4 to 6
- 6 to 8
- 8 to 10
- 10 to 12
- 12 to 14
- > 14

NOTE:
Flood modeling and results shown are approximate and were developed using a project specific River Flow 2D model for the purpose of side channel restoration alternative analysis. Results are not to be used for determining flooding extents or depths (See FEMA Skagit River FIRM maps for regulatory flood conditions).

N

0 175 350 700 ft

HERRERA

NAD 1983 HARN
Washington State Plane North FIPS 4601 Feet

USDA, Aerial (2013); Skagit County, Parcels (2012)

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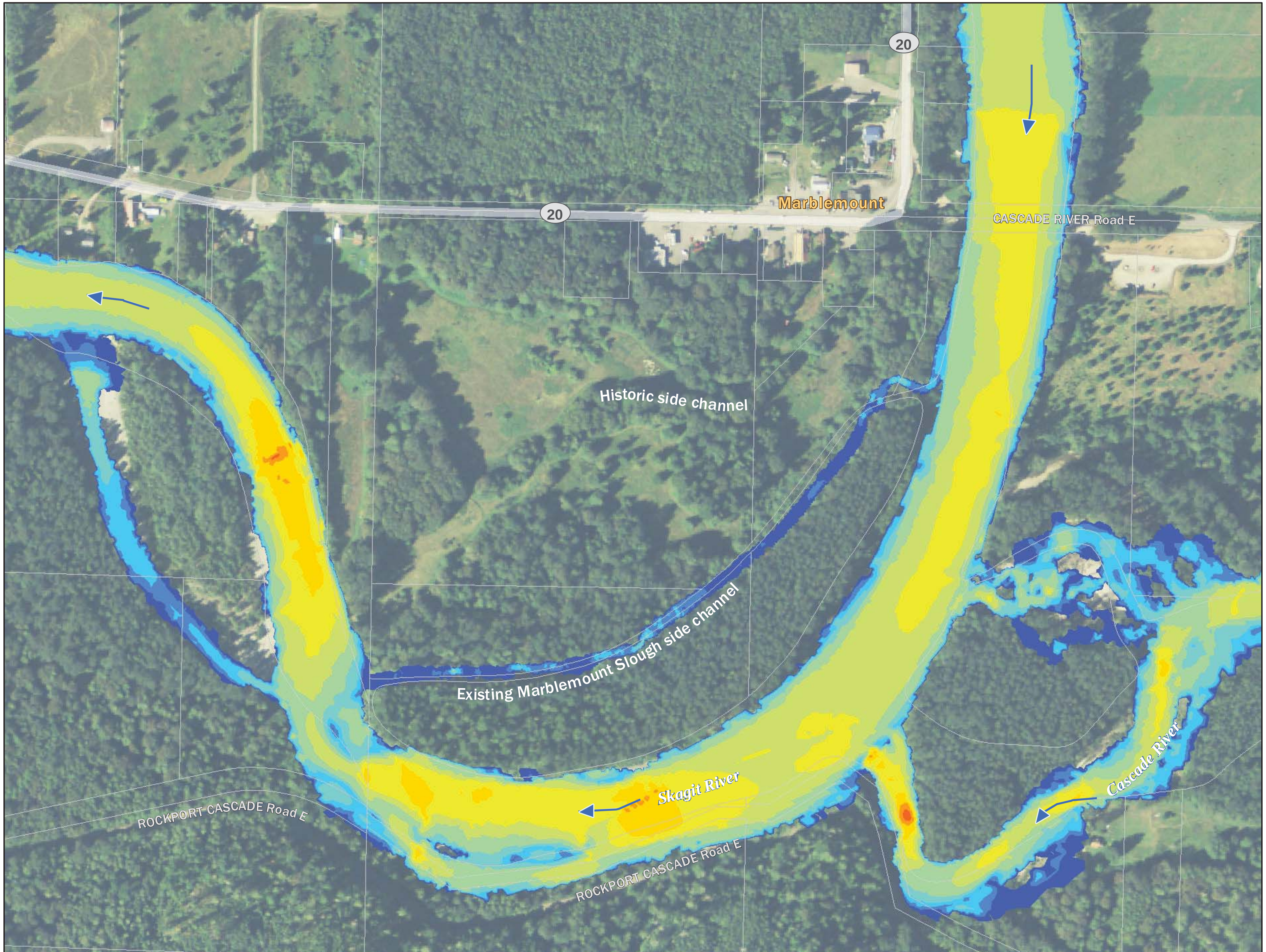
Figure 10.
Existing Conditions Velocity,
7,600 cfs Flow.



Legend

Parcel

Existing velocity (fps)

- 0 to 0.01
- 0.01 to 0.25
- 0.25 to 0.5
- 0.5 to 1
- 1 to 2
- 2 to 4
- 4 to 6
- 6 to 8
- 8 to 10
- 10 to 12
- 12 to 14
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NOTE:
Flood modeling and results shown are approximate and were developed using a project specific River Flow 2D model for the purpose of side channel restoration alternative analysis. Results are not to be used for determining flooding extents or depths (See FEMA Skagit River FIRM maps for regulatory flood conditions).

N

0 175 350 700 ft

HERRERA

NAD 1983 HARN
Washington State Plane North FIPS 4601 Feet

USDA, Aerial (2013); Skagit County, Parcels (2012)

In general, the modeled water surface elevations were within a foot of the 100-year FEMA FIS model BFEs. Modeled water surface elevations were higher in some locations, and lower in other locations, relative to the FEMA FIS BFEs, which is common when comparing one-dimensional and two-dimensional model results. The two-dimensionally modeled water surface elevations were also higher along the outside of the large river bend south of Pressentin Park (which is expected) and along the entire cross section immediately downstream of the site. Due to the recent changes at the bar downstream of the project site (deposition) and bathymetric variability near the large scour hole in this area, these model results suggest that the two-dimensional modeling approach is providing results similar to the one-dimensional FEMA BFEs, but with slightly higher water surface elevations and greater accuracy in replicating natural, existing hydraulic phenomena.

Conducting a sensitivity analysis using various model input flows between the 2-year and 100-year recurrence interval flows would allow the model to better inform floodplain activation flows and timing and will be considered for future design iterations.

Geomorphic Analysis

Three dams in the upper watershed of the Skagit River cut off sediment delivery to the lower reaches including the project area. Although the Cascade River has been delivering large quantities of sediment over the past century, the Skagit River has been starved of sediment due to the construction of the Ross, Diablo, and Gorge dams. The Skagit River has not shifted away from its location against the left valley wall where the Cascade River enters it. This is unusual because where large valley rivers run along tributary fans there is typically a give and take between the large river and the tributary fan, with the river migrating into the toe of the fan during periods in which the tributary produces less sediment, and the fan diverting the river during periods when the tributary is delivering relatively large amounts of sediment (Leeder and Mack 2001).

Were the project area to be as dynamic as the typical interaction between a tributary fan and a large valley river, one might expect that channel migration and sedimentation could lead to avulsion into and/or filling up with sediment of both the existing and proposed side channels. With Pressentin Park, however, those outcomes are unlikely in the foreseeable future. Historical records show that the locations of the Skagit River bend at Pressentin Park and Marblemount Slough have been stable since 1894. These records indicate that, even with regulated flow rates, the Skagit River at Marblemount has sufficient power to transport all of the sediment delivered from the Cascade River and upstream tributaries, as well as the sediment that makes it past the Skagit River dams.

Furthermore, there is a plunging anticline mapped directly under the Pressentin Park bend (Misch 1979), with the Skagit River running parallel to the contact between geologic units as it enters and exits the bend, and with what is likely the weakest rock located at the apex of the bend. While the degree to which local tectonics keep the river fixed in place depends on the (unknown) depth of quaternary fill and the current rate of deformation, with respect to underlying bedrock geology, the river currently occupies the path of least resistance.

Under existing conditions, flow depths and velocities in Marblemount Slough are sufficient to mobilize sand and finer sediment during hydropower generation flows. If the Cascade River were to deliver a large pulse of sediment to its confluence with the Skagit River, it is possible that Marblemount Slough would be filled with sediment, at least initially. However, it is unlikely that the Skagit River itself would avulse through either the existing slough or the proposed side channel because it is constrained in the direction it approaches Pressentin Park by the Cascade River Road Bridge abutments and quite possibly by underlying geology.

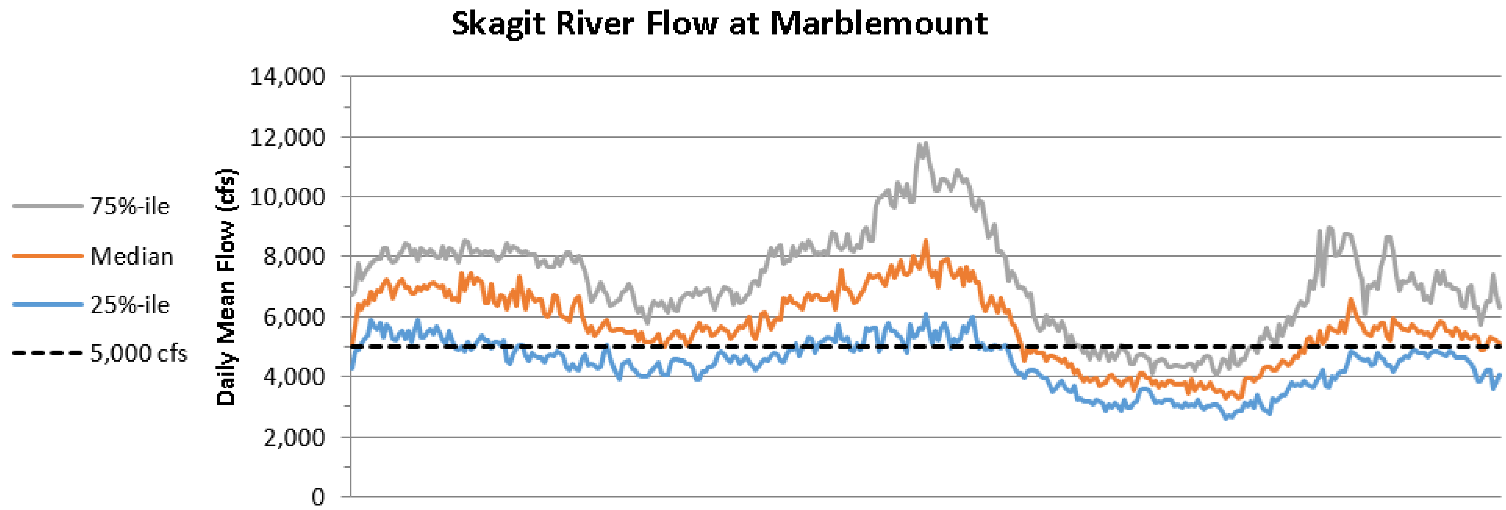
Fish Habitat Conditions

Herrera conducted a remote-sensing desktop data review of publicly available information (aerial photographs, LIDAR, and wetland inventories) to generate a preliminary understanding of existing habitat conditions within the project area. In addition, Herrera staff visited the project site on April 28 and June 3, 2014.

Multiple salmonid species use the Skagit River within the project vicinity during various life stages (Table 2). Of these species, Chinook, coho, and chum salmon spawning has been documented in Marblemount Slough, with chum having a greater number of redds recorded (SFEG 2014). Figure 11 shows adult chum salmon spawning in Marblemount Slough in November 2014. In general, spawning in Marblemount Slough mostly occurs in clusters of redds at two particular locations: one near the channel inlet and the other near the channel outlet (see Figure 12).

Figure 11. Adult Chum Salmon Spawning in Marblemount Slough, November 2014.

Table 2. Fish Species and Life Stages and Flow in the Skagit River.



Month	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Spring Chinook Salmon – *Oncorhynchus tshawytscha*												
Spawning[b]							■	■	■			
Incubation to Rearing/Overwintering[b]	■	■	■	■	■	■	■	■	■	■	■	■
Peak Outmigration[b]			■	■	■	■	■					
Summer Chinook Salmon – *Oncorhynchus tshawytscha*												
Spawning[b, c]								■	■	■		
Incubation to Rearing/Overwintering[b, c]	■	■	■	■	■	■	■	■	■	■	■	■
Outmigration[b, c]	■	■	■	■	■	■	■	■				
Chum Salmon – *Oncorhynchus keta*												
Spawning[b, c]											■	■
Incubation to Rearing/Overwintering[b, c]	■	■	■	■	■						■	■
Outmigration[b, c]			■	■	■							

Table 2 (continued). Fish Species and Life Stages in the Skagit River.

Month	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Summer Steelhead – *Oncorhynchus mykiss*												
Spawning[b]		■	■	■	■	■						
Incubation to Rearing/Overwintering[b]	■	■	■	■	■	■	■	■	■	■	■	■
Peak Outmigration[b]			■	■	■	■	■					
Winter Steelhead – *Oncorhynchus mykiss*												
Spawning[b]	■	■	■	■	■	■						■
Incubation to Rearing/Overwintering[b]	■	■	■	■	■	■	■	■	■	■	■	■
Peak Outmigration[b]			■	■	■	■	■					
Sockeye Salmon – *Oncorhynchus nerka*												
Spawning Run[b]							■	■	■			
Incubation to Rearing/Overwintering[b]	■	■	■	■	■	■	■	■	■	■	■	■
Peak Outmigration[b]			■	■	■	■	■					
Coho Salmon – *Oncorhynchus kisutch*												
Spawning[b]	■									■	■	■
Incubation to Rearing/Overwintering[b]	■	■	■	■	■	■	■	■	■	■	■	■
Peak Outmigration[b]			■	■	■	■	■					
Pink Salmon – *Oncorhynchus gorbuscha*												
Spawning[b, c]									■	■		
Incubation to Rearing/Overwintering[b, c]	■	■	■	■					■	■	■	■
Outmigration[b, c]		■	■	■								
Cutthroat Trout – *Oncorhynchus clarkii*												
Spawning[b]	■	■	■	■	■							■
Incubation to Rearing/Overwintering[b]	■	■	■	■	■	■	■	■	■	■	■	■
Peak Outmigration[b]	■	■	■	■	■	■	■	■	■	■	■	■
Bull Trout – *Salvelinus confluentus*												
Spawning[b]									■	■	■	

Table 2 (continued). Fish Species and Life Stages in the Skagit River.												
Month	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**June**	**July**	**Aug.**	**Sept.**	**Oct.**	**Nov.**	**Dec.**
Incubation to Rearing/Overwintering[b]												
Peak Outmigration[b]												

Data Sources:

[a] Derived from USGS gauge at Marblemount data.

[b] Adapted from FERC (1998) with additional information from Williams et al. (1975), WDF et al. (1993), and WDFW (1998a; 1998b).

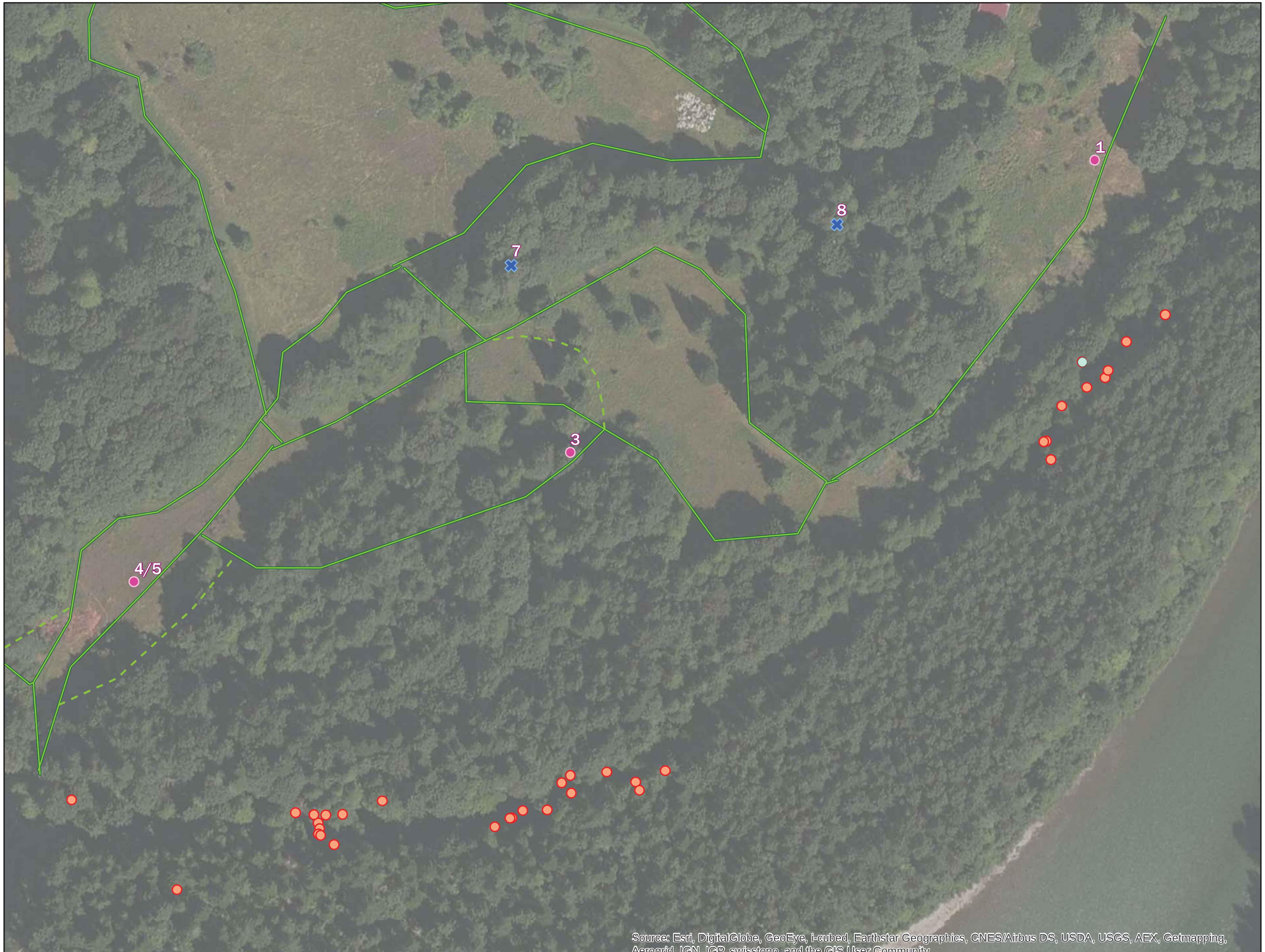
[c] Stober et al. 1992; Meyers et al. 1998; Hard et al. 1996.

No spawning seems to occur within the middle, one-third portion of the slough channel. The upstream spawning cluster is associated with pool habitat, located immediately downstream from a logjam and a riffle. This area where spawning is clustered represents approximately a third of the total Marblemount Slough channel length. The downstream spawning cluster is associated with a riffle and represents approximately a third of the total slough channel length. Given the clustered distribution of the spawning redds, and because they are located downstream of riffles and local increases in hydraulic head caused by wood, it is likely that fish, particularly chum salmon, are responding to upwelling hyporheic flow expressions in selecting the redd locations. Therefore, it is also likely that the effective spawning habitat area may be limited within Marblemount Slough, which means spawning is limited within the entire project area. This may cause redd superimposition, which in turn could cause egg loss, particularly in years with high adult salmon returns.

Flow velocities within Marblemount Slough also appear to influence salmon redd site selection. For example, 2013 and 2014 spawning surveys show redds clustered downstream of locations in Marblemount Slough where modeled flow velocities are between 0.5 and 2 feet per second (fps) when the river is running at 7,600 cfs, and largely absent where velocities are lower than 0.5 fps at 7,600 cfs but above 2 fps during the median annual flood (25,000 cfs). However, redd site selection is also influenced by substrate size and hyporheic flows (upwelling), both of which can be controlled by in-channel large wood distribution. This is because large wood sorts sediment and breaks the channel slope, which results in hydraulic changes (head) that increase hyporheic flows. Figure 13 provides an example of a large wood piece in Marblemount Slough, which provides these functions; a redd cluster occurs downstream of this wood piece. Installation of similar wood pieces in the restored side channel could create similar redd-forming opportunities. The design of any proposed side channel should attempt to reproduce the geomorphic conditions (including longitudinal profile breaks) and wood conditions (including logjams) that favor hyporheic flows, particularly upwelling, and thereby the development of functional spawning habitat.

Consideration was given to the current scientific understanding on juvenile Chinook use of habitat areas where different types and concentrations of woody debris may be present or absent. This included a discussion with Erin Lowery of Seattle City Light, who has led field data collection of juvenile Chinook habitat preferences in the Skagit River (personal communication May 26, 2015). It also included a review of the recent work Erin Lowery and others performed on seasonal distribution and habitat associations of salmonids with extended juvenile freshwater rearing in different precipitation zones of the Skagit River, which included juvenile Chinook salmon (Lowery et al. undated). Woody debris was observed to play a limited role in rearing, with preference appearing to be given to finer substrate and faster moving water generally not associated with pools formed by woody debris. However, design of the proposed side channel should include woody structures (channel roughening, bank roughening) staggered throughout the channel length, primarily for hydraulic and geomorphic complexity that enhance habitat quality and to sort out sediments. These features are necessary to avoid the potential for an over-simplified channel to form following construction due to a lack of in-channel features that distribute and disrupt flow fields and create pool habitats. Additionally, large woody debris will directly provide habitat complexity, which will benefit salmonids (including juvenile Chinook salmon) using the proposed side channel. The extent of large woody debris to place in the proposed side channel is a balance of reducing construction cost as feasible while maintaining the wood density necessary to achieve the desired hydraulic and geomorphic performance. The large woody debris density and placement locations will be refined as part of the final design.

Figure 12.
Marblemount Slough Redd Locations.



Legend

- Chinook redd 2013
- Chum redds 2014
- Test pit location and piezometer
- Surface ground water expression gauge
- Maintained existing trail
- Realigned trail

N

0 75 150 300 ft

HERRERA

NAD 1983 HARN
Washington State Plane North FIPS 4601 Feet

ESRI, Aerial (2010); Skagit County, Parcels (2012)

Produced By: GIS
Project: K:\Projects\Y2014\14-05789-000\Project\Conceptual_Rest_Alt_Analysis\chum_chinook.mxd (3/24/2015)

Historically, the project area was a forested floodplain with multiple layers of vegetation of various species frequency and abundance (Collins and Sheikh 2002). By order of abundance, the tree layer was dominated by western red cedar (*Thuja plicata*), Douglas fir (*Pseudotsuga menziesii*), and Sitka spruce (*Picea sitchensis*), but also included black cottonwood (*Populus trichocarpa*), bigleaf maple (A*cer macrophyllum*), red alder (*Alnus rubra*), and western hemlock (*Tsuga heterophylla*). The shrub layer included Pacific crabapple (*Malus fusca*), willow (*Salix* spp.), vine maple (*Acer circinatum*), and likely other species (Collins and Sheikh 2002).

Land uses have altered the historical vegetation conditions and may have introduced fill within the floodplain where the park is located. Portions of the floodplain in the park lack trees or shrub vegetation. The existing vegetation in these areas is dominated by reed canarygrass (*Phalaris arundinacea*), which is periodically mowed.

Figure 13. Example of Large Wood Piece Within Marblemount Slough.

In addition to past and current land uses, the operation of the Skagit Hydroelectric Project has reduced the frequency and magnitude of peak flows during large flood events (Beamer et al. 1999, Graybill et al. 1979). Theses combined actions have disconnected and affected the floodplain, prevented seasonal inundation of floodplain areas, and reduced the creation and maintenance of natural off-channel floodplain habitats. Seasonal flooding of the floodplain and associated side channels is a key hydrologic process influencing fluvial ecosystems. For example, the flood pulse concept (Junk et al. 1989) establishes that annual high-water pulses are the main force in determining existence, productivity, and interactions of major biota in river–floodplain systems. In addition, seasonal inundation of the floodplain provides opportunities for juvenile fish to access floodplain and side channel habitats.

However, Marblemount Slough is highly functional and provides good quality spawning habitat, primarily for chum salmon, and rearing habitat and flood refugia for several juvenile salmonid species. It provides a good analog that can be used as a reference to determine design criteria for a proposed side channel from the perspectives of physical, hydrologic, hydraulic, and general habitat characteristics. New side channel construction in Pressentin Park would offset some of the current floodplain habitat limitations and could significantly increase the existing side channel area.

Alternatives Development and Analysis

The alternatives analysis for the Pressentin Park Side Channel Restoration Project involved close collaboration with the SFEG to develop conceptual project alternatives and to evaluate associated impacts and the ecological lift that could be achieved. Workshops and site visits were conducted to discuss project objectives, existing conditions, and proposed project alternatives. This process is described in the following sections.

Workshops

Workshop 1

The project kick off meeting (first workshop) was held on April 28, 2014, where alternative assumptions and analysis results, including potential infrastructure risks and lost habitat opportunities, were identified and discussed for a no-action alternative as well as for action alternatives. The discussion of the no-action alternative provided the project team with a common foundation for comparing potential project alternatives. The main objectives of this workshop were to update and refine project objectives, identify potential constraints and opportunities, and discuss and develop potential alternatives for field evaluation following the meeting. This workshop also identified the specific alternative project components to be evaluated and proposed evaluation criteria for the alternatives.

Herrera performed a field evaluation that included geomorphic, hydraulic, and habitat reconnaissance to evaluate qualitatively the potential alternatives discussed during the first workshop. The project team met towards the end of the site visit to discuss preliminary findings, make updates and refinements to the proposed alternatives, and narrow them to three general alternatives (plus the no-action alternative). The alternatives were refined sufficiently to assist with focusing the subsurface, ground water, and survey data collection efforts.

Workshop 2

Herrera developed the hydraulic and geomorphic analyses for the identified project alternatives using the models and information described previously. During the second workshop on June 3, 2014, the project team reviewed the existing conditions hydraulic model results and data gathered in developing the hydraulic models for the proposed alternatives. The evaluation criteria were also refined, as outlined in the following sections. Groundwater monitoring gauges were installed within test pits at the site following this workshop.

Workshop 3

Following the second workshop, geomorphic, hydraulic, and habitat characteristics were evaluated for each of the three action alternatives. The results of this alternatives analysis were presented to the project team during the third workshop on November 10, 2014, enabling the project team to specify a fourth (preferred) alternative, which comprised elements of the others.

Description of Alternatives

Alternatives were developed to address the four priority goals of the project described in the introduction to this report, the physical and ecological constraints of the project site, and the concerns of stakeholders identified during the workshops. A step-wise approach to potential alternatives was captured in the alternatives analysis so the project team could better adapt project implementation to available resources for final design and construction.

Four alternatives were developed: one (Alterative 1) consisting of a simple excavated backwater slough and the remaining three (Alternatives 2 through 4) incorporating a new flow-through side channel intended to be functionally analogous to Marblemount Slough. The inlet of the new flow-through side channel was conceptually designed to be narrow to ensure sediment transport and consistency in width and depth with the existing relict channel to which it connects. The inlet also incorporates a secondary inlet, a configuration that is common in natural perennial side channels (including Marblemount Slough), has worked well on past side channel projects, and increases the likelihood that at least one inlet will be open at any given time. Two of the alternatives (Alternatives 3 and 4) incorporate wider sections downstream of the relict channel to maximize habitat. All of the alternatives incorporate large woody debris placements to create local hydraulic complexity and associated variability in flow depth, velocity, and sediment sorting characteristics. The amount of wood in these structures would be approximately one-fifth of what would be expected in a comparable natural channel (Fox and Bolton 2007); however, this amount is consistent with common restoration practices. The four alternatives are summarized in Table 3 (in terms of linear feet and footprint area of side channel created, excavation volumes, inclusion of engineered logjams [ELJs], trail system length, and number of bridges over the side channel), and graphically depicted in Figures 14 through 17.

Table 3. Configuration of Alternatives.

Alternative		Channel created (LF)	Area Created[a] (acres)	Excavation (CY)	Engineered Logjams	Trail System (LF)	Bridges
1	Backwater slough	1,550	0.79	25,000	None	1,000	None
2	Inlet and outlet connection	2,410	1.43	27,800	8	1,000	3
3	Inlet and outlet connection, wetland benches, blind slough	2,950	2.70	59,000	8	1,000	3
4	Inlet and outlet connection, wetland benches	2,870	2.06	38,000	8	1,000	3

[a] Total wetted area at 7,600 cfs; see Table 6 for area subdivided by flow depth and velocity.

LF = Linear feet.

CY = Cubic yards.

Alternatives Evaluation Methods

Hydraulic Modeling

The hydraulic model developed for the characterization of existing conditions was modified to reflect the project alternative geometries and conditions depicted in Figures 14 through 17. The existing conditions topographic surface was copied and modified for each alternative in one or more of the following ways, depending on the alternative:

- Proposed side channel grading with a variety of configurations
- New backwater channel grading
- Adding flood fence (floodplain roughening) to minimize hydraulic impacts during large flood events
- Adding side channel flow blockages to represent wood habitat structures or ELJs

The Manning's roughness layer in the existing conditions model was also modified for each alternative to represent approximate changes associated with proposed project elements.

The primary method for evaluating the hydraulic effects of the alternatives was the use of model output graphics representing differences between the alternative conditions and existing conditions for water depths and flow velocities. A positive difference means an increase in the depth or velocity, and a negative difference means a decrease compared to existing conditions. This graphic comparison allows for evaluating small or spatially widespread changes that may have geomorphic or habitat significance. The color shades in the graphic model output can also be compared between alternatives to evaluate large or subtle hydraulic differences between alternatives. This approach was used to adjust iteratively components of the alternatives and to refine the alternatives, and then to evaluate, refine, and select the preferred alternative.

Geomorphic Analysis

Geomorphic analysis of the alternatives was based on hydraulic model output, and field and test pit observations. This analysis focused on three factors that could affect the habitat value or sustainability of proposed side channels and Marblemount Slough: avulsion risk, the likelihood of channel sedimentation or erosion across the range of expected flows, and surface and groundwater interactions during low flows in the Skagit River.

Avulsion Risk

As discussed previously in the existing conditions characterization, the risk of avulsion through either Marblemount Slough or any of the proposed alternative side channels is low due to geological and large-scale geomorphic factors. Consequently, further assessment of avulsion mechanisms and likelihoods was not undertaken.

Figure 14.
Alternative 1 Proposed Site Plan.

Legend

- Test pit location and piezometer
- Surface ground water expression gauge
- Bridge
- Existing maintained trail
- Realigned trail
- Pressentin Park
- Parcel
- Contour

Alternative 1 grading
314-ft
294-ft

Note: Existing Shoreline Management Zone shown is approximate and for illustration only. Critical area buffers are not included.

N
0 100 200 400 ft

HERRERA

NAD 1983 HARN
Washington State Plane North FIPS 4601 Feet

ESRI, Aerial (2010); Skagit County, Parcels (2012)

Produced By: GIS
Project: K:\Projects\Y2014\14-05789-000\Project\Conceptual_Rest_Alt_Analysis\alternative_preferred_site_plan.mxd (3/11/2015)

Figure 15.
Alternative 2 Proposed Site Plan.

Legend
- Test pit location and piezometer
- Surface ground water expression gauge
- Bridge
- Existing maintained trail
- Realigned trail
- Pressentin Park
- Parcel
- Contour

Alternative 2 grading
313-ft
295-ft

Note: Existing Shoreline Management Zone shown is approximate and for illustration only. Critical area buffers are not included.

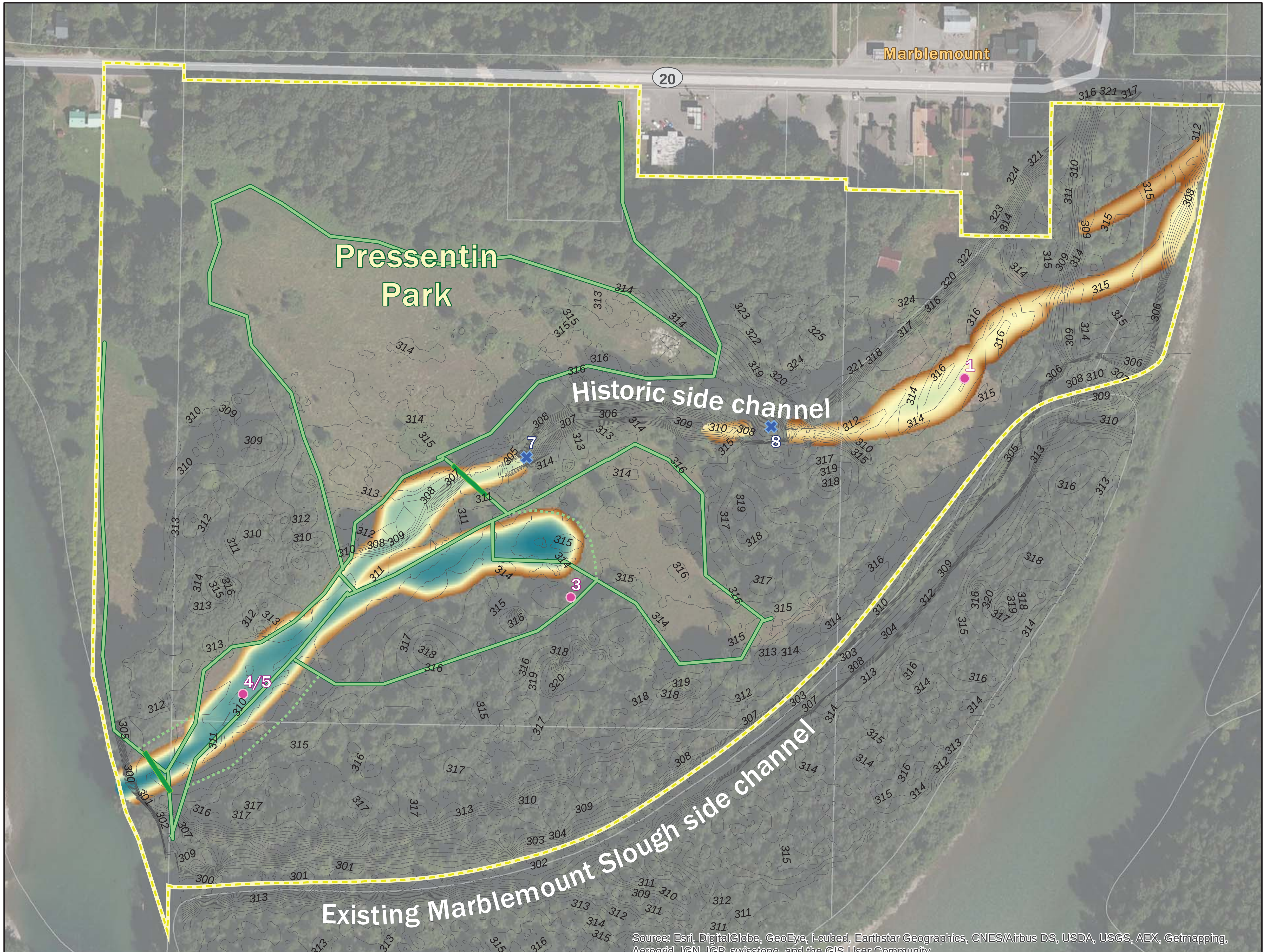
N
0 100 200 400 ft

HERRERA

NAD 1983 HARN
Washington State Plane North FIPS 4601 Feet

ESRI, Aerial (2010); Skagit County, Parcels (2012)

Figure 16.
Alternative 3 Proposed Site Plan.



Legend

- Test pit location and piezometer
- Surface ground water expression gauge
- Bridge
- Existing maintained trail
- Realigned trail
- Pressentin Park
- Parcel
- Contour

Alternative 3 grading
314-ft
294-ft

Note: Existing Shoreline Management Zone shown is approximate and for illustration only. Critical area buffers are not included.

N

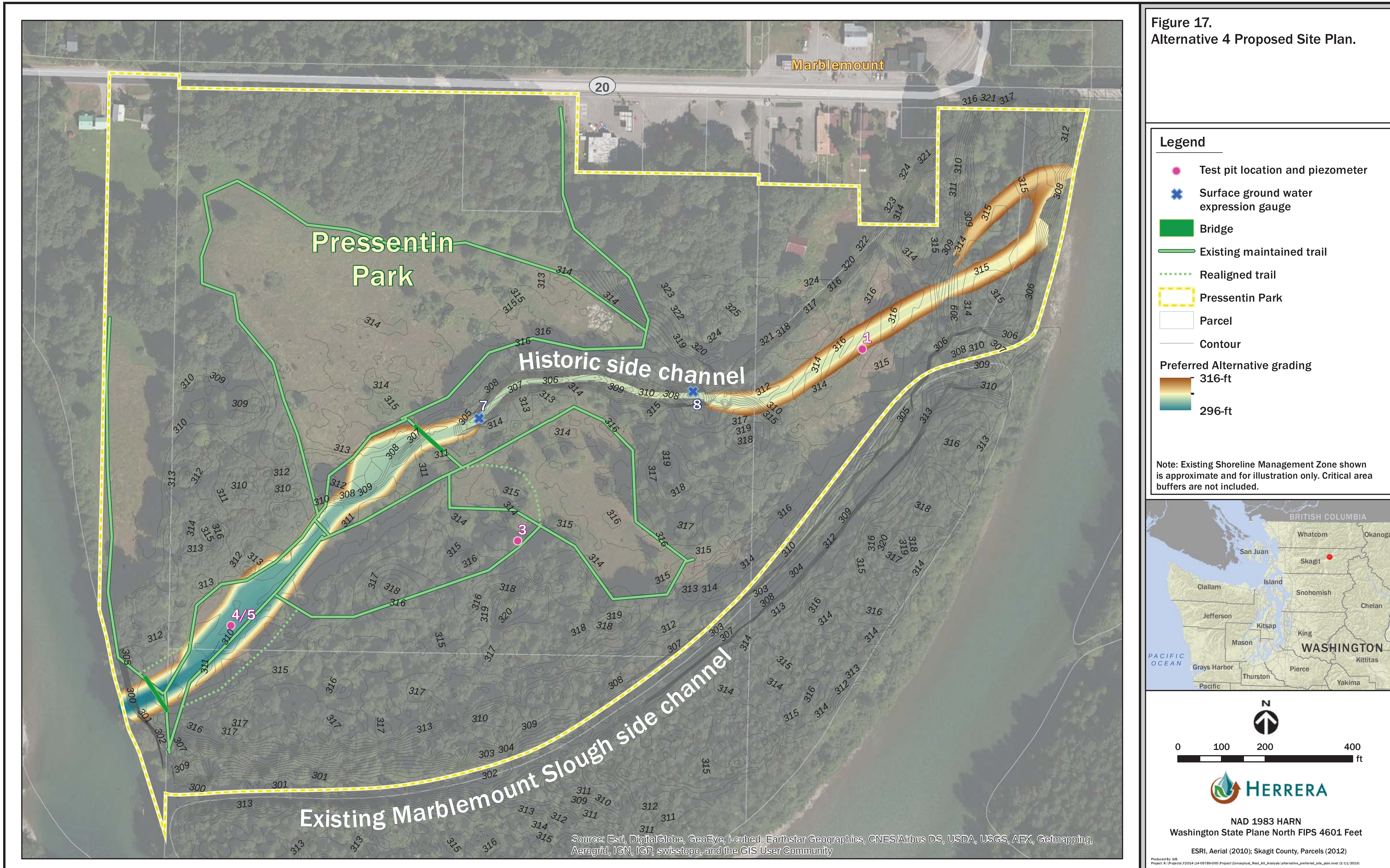
0 100 200 400 ft

HERRERA

NAD 1983 HARN
Washington State Plane North FIPS 4601 Feet

ESRI, Aerial (2010); Skagit County, Parcels (2012)

Figure 17.
Alternative 4 Proposed Site Plan.



Sedimentation and Erosion

The likelihood of sedimentation or erosion is driven by interactions between sediment inputs, channel bed and bank material characteristics, local channel geometry, and hydraulic forces. Sediment mobility thresholds were evaluated using hydraulic model output in conjunction with test pit data to estimate potential sediment flux into and within the project area. Hydraulic model output and the conceptual project plans were used to estimate the approximate magnitude of local scour likely to be associated with channel constrictions, bends, and proposed log structures.

Surface and Groundwater Interactions

Groundwater elevations measured in test pits and with monitoring gauges were interpolated/extrapolated to estimate groundwater levels in the proposed side channel and in Marblemount Slough during Skagit River low flows, and compared with modeled Skagit River water surface elevations to assess the potential impact of the proposed side channel on Marblemount Slough water levels. Given the clear link between Skagit River flows and groundwater levels evident in the groundwater monitoring gauge data and the closer proximity of Marblemount Slough to the river, it was assumed that surface water levels and the direction of groundwater flow in Marblemount Slough is driven primarily by adjacent Skagit River water levels.

Floodplain and Side Channel Habitat Gain and Connectivity Analysis

Using the field-verified remote sensing analysis, survey information, and findings of the geomorphic analysis and hydraulic modeling, Herrera evaluated the potential habitat area gain and the frequency of floodplain and side channel hydrologic connectivity under each alternative.

Potential habitat area gain was calculated for each of the alternatives based on the 2-year recurrence flow and 7,600 cfs low flow. The 2-year flow was selected for this analysis because it represents an adequate recurrence frequency to assess whether juvenile fish rearing in the system for more than a year have opportunity to access and exit side channel and floodplain habitats such as sloughs, ponds, and wetlands. The 7,600 low flow is useful for interpreting areas of inundation, which can be inferred to provide suitable fish habitat.

Analysis of side channel connectivity with the main stem river channel was performed for the 5,000 cfs and 7,600 cfs low flows that can be sustained over a long period, and for a 2-year flood flow (25,000 cfs). These flows were selected by the project team and stakeholders as important for adequately assessing aquatic habitat function and connectivity. Here, side channel connectivity is assumed a proxy for fish access. This is an important assumption, because access opportunity to suitable floodplain and side channel habitats is key for juvenile salmon to realize the ecological functions those habitats provide (Simenstad and Cordell 2000).

In general, the geomorphic characterization of existing conditions and evaluation of geomorphic responses to proposed restoration alternatives provided the physical template for the assessing the habitat potential of the alternatives.

To determine suitability of connected floodplain and side channel habitats, edge habitat criteria (i.e., greater than 0.66 feet deep and less than 1.5 fps flow velocity) were used (Beechie et al. 2005, Beamer et al. 2005). However, the full range of flow velocities describing the relationship between velocity and juvenile Chinook salmon density (Beechie et al. 2005, Beamer et al. 2005) were considered in the analysis. These included edge habitat velocities classified as high (greater than 1.5 fps), medium (0.5 to 1.5 fps), and low (less than 0.5 fps) (Beechie et al. 2005). The goal was to avoid excluding habitat areas known to be generally suitable, but where the modeled range of water depths and flow velocities was outside the edge habitat criteria.

Other important considerations included avoiding fish stranding and the degree to which the new side channel inlet and outlet could be expected to stay open based upon the geomorphic analysis of each alternative.

Alternatives Evaluation General Considerations

The following general considerations underlay the development and evaluation of all alternatives:

- Potential to restore natural hydrogeomorphic processes and functions
- Increase in the area and/or quality of functional habitat, including rearing and spawning habitat for species listed for protection under the Endangered Species Act and riparian/terrestrial habitat for other wildlife
- Potential to promote access (laterally to floodplain habitats) for juvenile fish and passage for adult fish species (upstream to spawning grounds)
- Potential to protect and enhance water quality and aquatic habitat
- Potential to affect cultural resources
- Potential to maintain existing levels of access for recreational uses
- Potential to promote public education
- Potential to reduce/limit/manage hazards and risks to existing infrastructure and adjacent land uses

Alternatives Scoring

Each alternative was scored according to the evaluation criteria and metrics identified below and in the table in Appendix E. Criteria were grouped according to the following four categories with the associated metrics listed below each category:

1. Enhancing processes — expected effectiveness
    - Geomorphic response
    - Sustainability of hydraulic connectivity
    - Hyporheic and hydrologic response

2. Enhancing habitat functions
    - High-flow rearing habitat
    - Low-flow rearing habitat (coho)
    - Low-flow rearing (stream-type Chinook/steelhead)
    - Low-flow rearing habitat
    - Flood refugia
    - Spawning habitat (non-chum species)
    - Spawning habitat (chum species)
3. Risk (high number = low risk)
    - Groundwater alteration
    - Existing side channel alteration
    - Main stem channel capture
    - Risk to property
4. Cost
    - Construction
    - Design

The four alternatives were scored on a scale of 1 to 5 for each of the evaluation metrics listed above, where 1 = negative or no effect, 4 = good, and 5 = excellent. The results of the alternatives analyses and scoring are shown in Appendix E.

Flooding and geomorphic risks to cultural resources was identified as a category requiring a different review process. Given the sensitive nature of historic and archaeological sites, this category will be scored separately by the Upper Skagit Indian Tribe. The scoring information was not yet available to present in this document.

The table in Appendix E provides the basis for how the alternatives were evaluated using the metrics for each criterion. Regardless of the category grouping, each metric was scored from 1 (red color) to 5 (green color) with a 5 being the best score and a 1 being the worst score. The overall score for each alternative was calculated by simply taking the arithmetic mean of all the scores for each metric, using no weighting. The results of the alternative analysis scoring are presented in Table 4, including overall scores and scores for each category. An explanation of the scoring results is provided in Appendix E.

Table 4. Summary of Alternatives Scores.					
Alternative	Enhancing Processes – Expected Effectiveness	Enhancing Habitat Functions	Risk[a]	Cost	Total Score
1	2.33	1.86	4.25	5.00	**2.94**
2	3.67	4.00	3.00	3.00	**3.56**
3	3.67	4.43	2.75	2.00	**3.56**
4	4.00	4.14	2.75	3.00	**3.63**

[a] High Number = Low Risk

Alternatives Evaluation Results

Hydraulic Analysis

Hydraulic model results for Alternatives 1, 2, and 3 are presented in Appendix F. Hydraulic model results for Alternative 4 are shown in Figures 18 through 29. Three key factors were observed for all alternatives:

1. High flow events are sensitive to the abandoned terrace point at the north end of Pressentin Park. More flow conveyance at the terrace point allows more water through the floodplain and redistributes it into the main stem of the Skagit River at the side channel outlet. In turn, the left bank near the large bar island in the river appears to be sensitive to additional flow being redistributed near the terrace constriction point. Therefore, flood fences and ELJs were oriented and adjusted in the model to limit conveyance and redistribution of floodplain and proposed side channel flows to levels consistent with existing conditions.

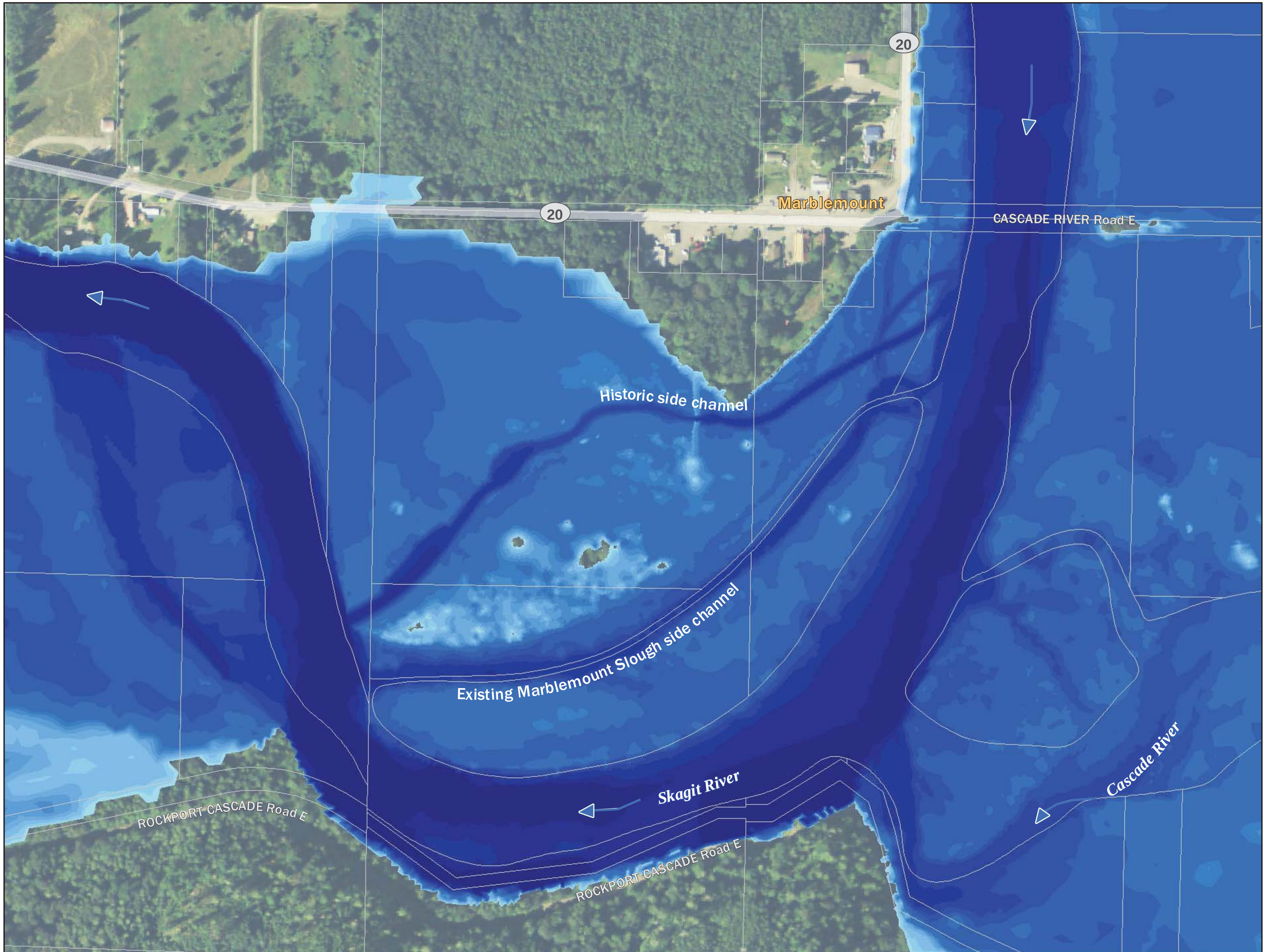
2. Construction of a channel downstream of the terrace point in the relic channel areas lowered high flood flow water surface elevations in the northern part of the park.

3. Areas south of the proposed side channel were much less sensitive to changes to alternative design components than areas near the relic side channel and terrace point.

Alternative 1 – Backwater Slough

Hydraulic model results for this alternative showed a significant redistribution of water surface elevations in the 100-year flood from higher in the floodplain area of Pressentin Park back to the main channel of the Skagit River. Results indicated that construction of the backwater slough acted to generally drain the modeled 100-year floodplain flood flow and water into the slough and route the flow back into the Skagit River main stem at the slough outlet. See Figures 31 through 38 in Appendix F for hydraulic model results.

Figure 18.
Alternative 4
100-Year Flood Depth.



Legend

Parcel

Existing Depth (ft)

- 0 to 0.05
- 0.05 to 0.2
- 0.2 to 0.5
- 0.5 to 1
- 1 to 1.5
- 1.5 to 2
- 2 to 2.5
- 2.5 to 3
- 3 to 6
- 6 to 9
- 9 to 12
- 12 to 15
- 15 to 18
- 18 to 21
- > 21

NOTE:
Flood modeling and results shown are approximate and were developed using a project specific River Flow 2D model for the purpose of side channel restoration alternative analysis. Results are not to be used for determining flooding extents or depths (See FEMA Skagit River FIRM maps for regulatory flood conditions).

N

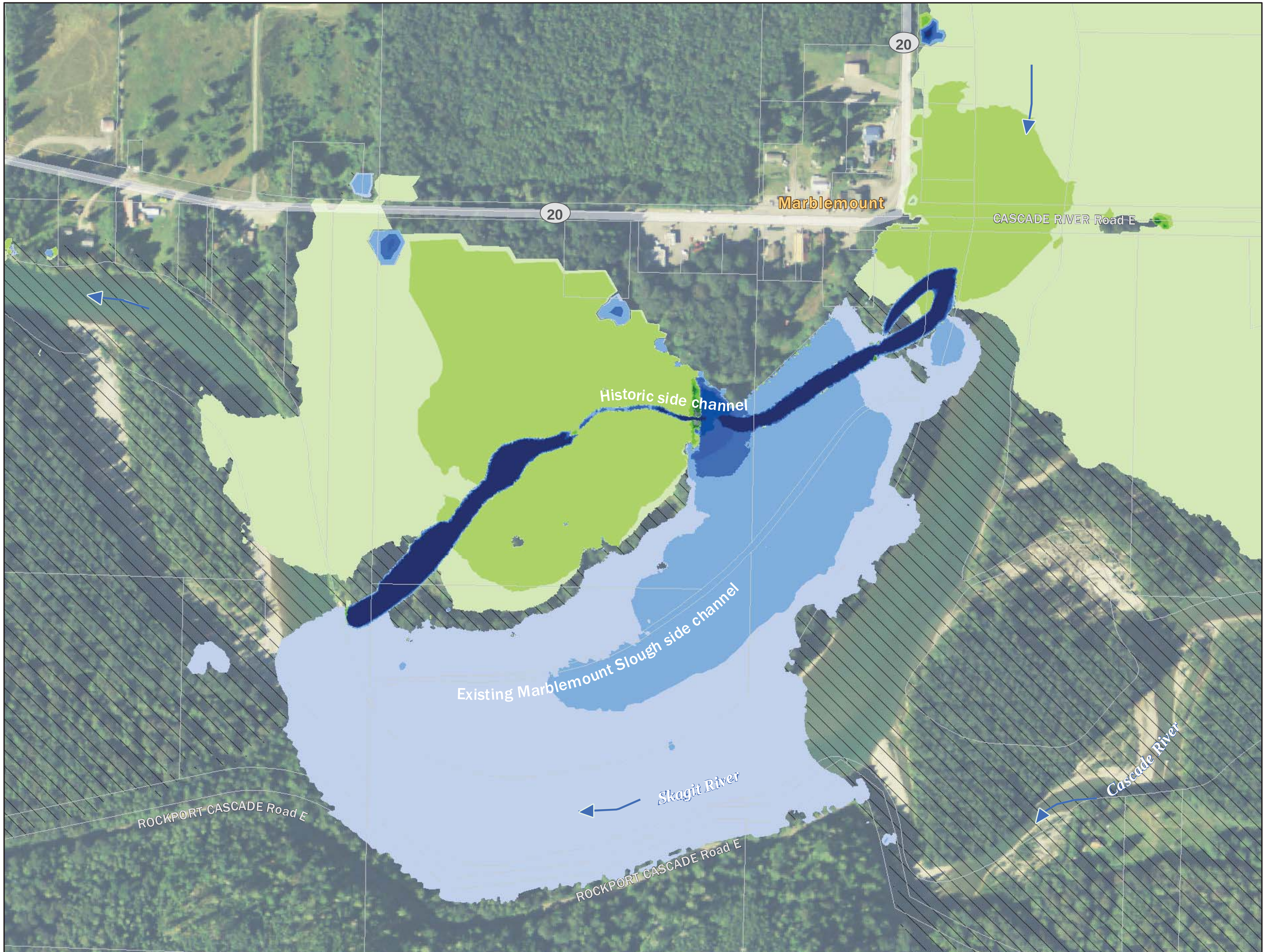
0 175 350 700 ft

HERRERA

NAD 1983 HARN
Washington State Plane North FIPS 4601 Feet

USDA, Aerial (2013); Skagit County, Parcels (2012)

Figure 19.
Alternative 4
100-Year Flood Depth Change.



Legend

Parcel

Depth Difference (ft)

Reduction in flooding depth (ft)
- < -2
- -2 to -1.5
- -1.5 to -1
- -1 to -0.5
- -0.5 to -0.05
- -0.05 to -0.02

-0.02 to 0.02 (no color)

Increase in flooding depth (ft)
- 0.02 to 0.05
- 0.05 to 0.5
- 0.5 to 1
- 1 to 1.5
- 1.5 to 2
- > 2

NOTE:
Flood modeling and results shown are approximate and were developed using a project specific River Flow 2D model for the purpose of side channel restoration alternative analysis. Results are not to be used for determining flooding extents or depths (See FEMA Skagit River FIRM maps for regulatory flood conditions).

N

0 175 350 700 ft

HERRERA

NAD 1983 HARN
Washington State Plane North FIPS 4601 Feet

USDA, Aerial (2013); Skagit County, Parcels (2012)

Figure 20.
Alternative 4
2-Year Flood Depth.

Legend

Parcel

Existing Depth (ft)

- 0 to 0.05
- 0.05 to 0.2
- 0.2 to 0.5
- 0.5 to 1
- 1 to 1.5
- 1.5 to 2
- 2 to 2.5
- 2.5 to 3
- 3 to 6
- 6 to 9
- 9 to 12
- 12 to 15
- 15 to 18
- 18 to 21
- > 21

NOTE:
Flood modeling and results shown are approximate and were developed using a project specific River Flow 2D model for the purpose of side channel restoration alternative analysis. Results are not to be used for determining flooding extents or depths (See FEMA Skagit River FIRM maps for regulatory flood conditions).

N

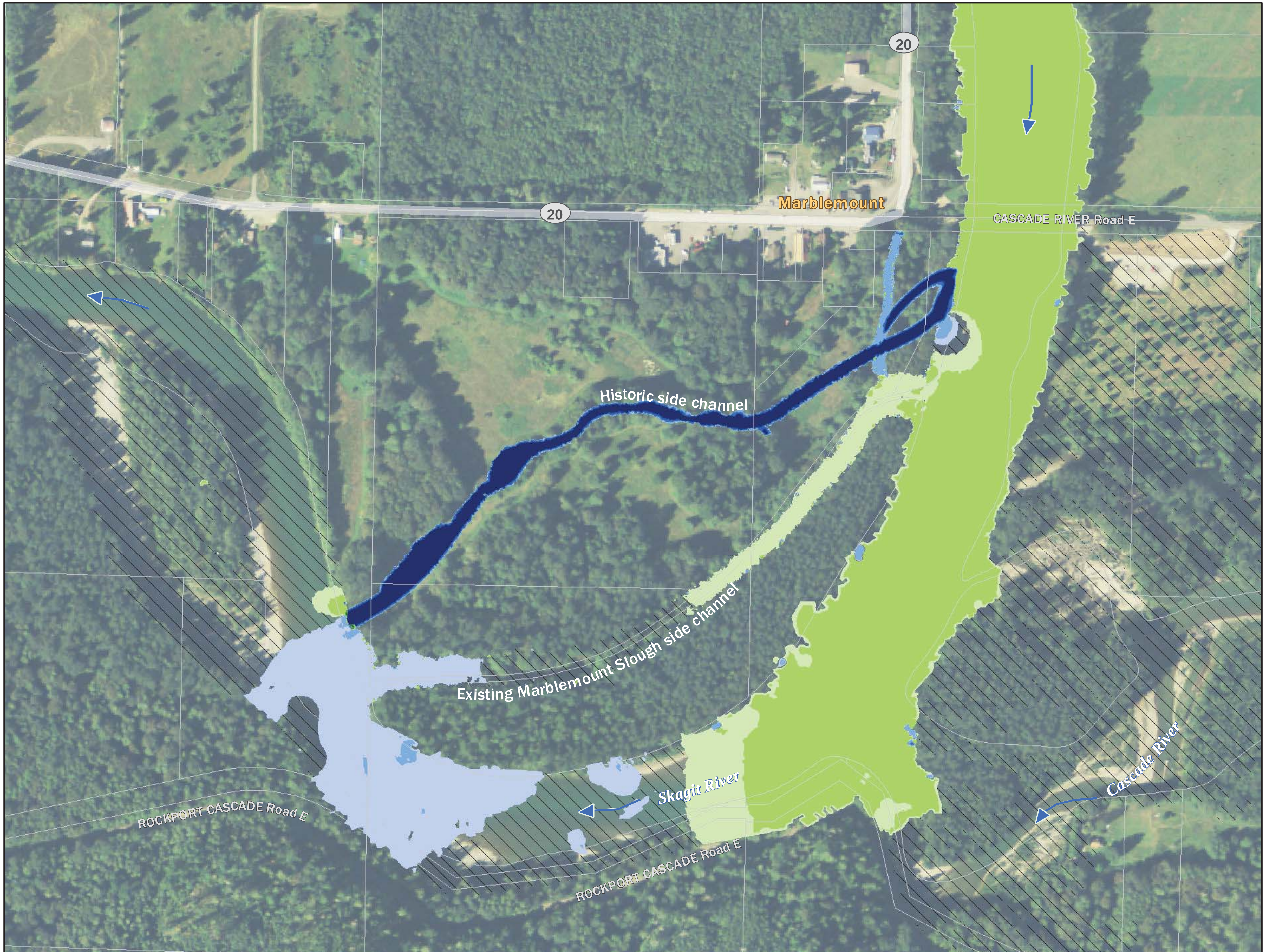
0 175 350 700 ft

HERRERA

NAD 1983 HARN
Washington State Plane North FIPS 4601 Feet

USDA, Aerial (2013); Skagit County, Parcels (2012)

Figure 21.
Alternative 4
2-Year Flood Depth Change.



Legend

Parcel

Depth Difference (ft)

	Color	Range
Reduction in flooding depth (ft)		< -2
		-2 to -1.5
		-1.5 to -1
		-1 to -0.5
		-0.5 to -0.05
		-0.05 to -0.02
		-0.02 to 0.02 (no color)
Increase in flooding depth (ft)		0.02 to 0.05
		0.05 to 0.5
		0.5 to 1
		1 to 1.5
		1.5 to 2
		> 2

NOTE:
Flood modeling and results shown are approximate and were developed using a project specific River Flow 2D model for the purpose of side channel restoration alternative analysis. Results are not to be used for determining flooding extents or depths (See FEMA Skagit River FIRM maps for regulatory flood conditions).

N

0 175 350 700 ft

HERRERA

NAD 1983 HARN
Washington State Plane North FIPS 4601 Feet

USDA, Aerial (2013); Skagit County, Parcels (2012)

Figure 22.
Alternative 4
7600 cfs Depth.

Legend

Parcel

Existing Depth (ft)

- 0 to 0.05
- 0.05 to 0.2
- 0.2 to 0.5
- 0.5 to 1
- 1 to 1.5
- 1.5 to 2
- 2 to 2.5
- 2.5 to 3
- 3 to 6
- 6 to 9
- 9 to 12
- 12 to 15
- 15 to 18
- 18 to 21
- > 21

NOTE:
Flood modeling and results shown are approximate and were developed using a project specific River Flow 2D model for the purpose of side channel restoration alternative analysis. Results are not to be used for determining flooding extents or depths (See FEMA Skagit River FIRM maps for regulatory flood conditions).

N

0 175 350 700 ft

HERRERA

NAD 1983 HARN
Washington State Plane North FIPS 4601 Feet

USDA, Aerial (2013); Skagit County, Parcels (2012)

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Figure 23.
Alternative 4
7600 cfs Depth Change.

Legend

Parcel

Depth Difference (ft)

Reduction in flooding depth (ft)
- < -2
- -2 to -1.5
- -1.5 to -1
- -1 to -0.5
- -0.5 to -0.05
- -0.05 to -0.02

-0.02 to 0.02 (no color)

Increase in flooding depth (ft)
- 0.02 to 0.05
- 0.05 to 0.5
- 0.5 to 1
- 1 to 1.5
- 1.5 to 2
- > 2

NOTE:
Flood modeling and results shown are approximate and were developed using a project specific River Flow 2D model for the purpose of side channel restoration alternative analysis. Results are not to be used for determining flooding extents or depths (See FEMA Skagit River FIRM maps for regulatory flood conditions).

N

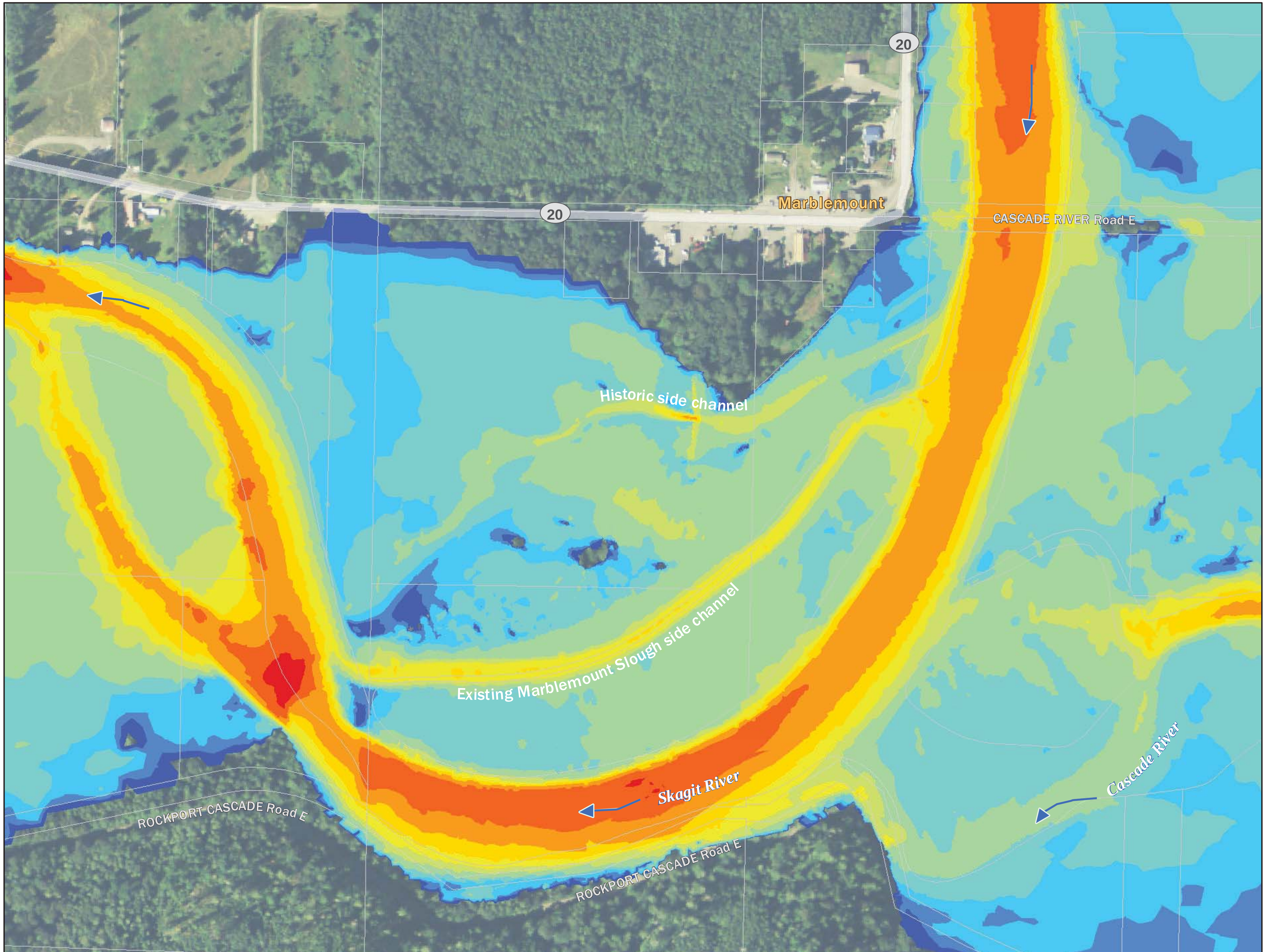
0 175 350 700 ft

HERRERA

NAD 1983 HARN
Washington State Plane North FIPS 4601 Feet

USDA, Aerial (2013); Skagit County, Parcels (2012)

Figure 24.
Alternative 4
100-Year Flood Velocity.



Legend

Parcel

Flood velocity (fps)

- 0 to 0.01
- 0.01 to 0.25
- 0.25 to 0.5
- 0.5 to 1
- 1 to 2
- 2 to 4
- 4 to 6
- 6 to 8
- 8 to 10
- 10 to 12
- 12 to 14
- > 14

NOTE:
Flood modeling and results shown are approximate and were developed using a project specific River Flow 2D model for the purpose of side channel restoration alternative analysis. Results are not to be used for determining flooding extents or depths (See FEMA Skagit River FIRM maps for regulatory flood conditions).

N

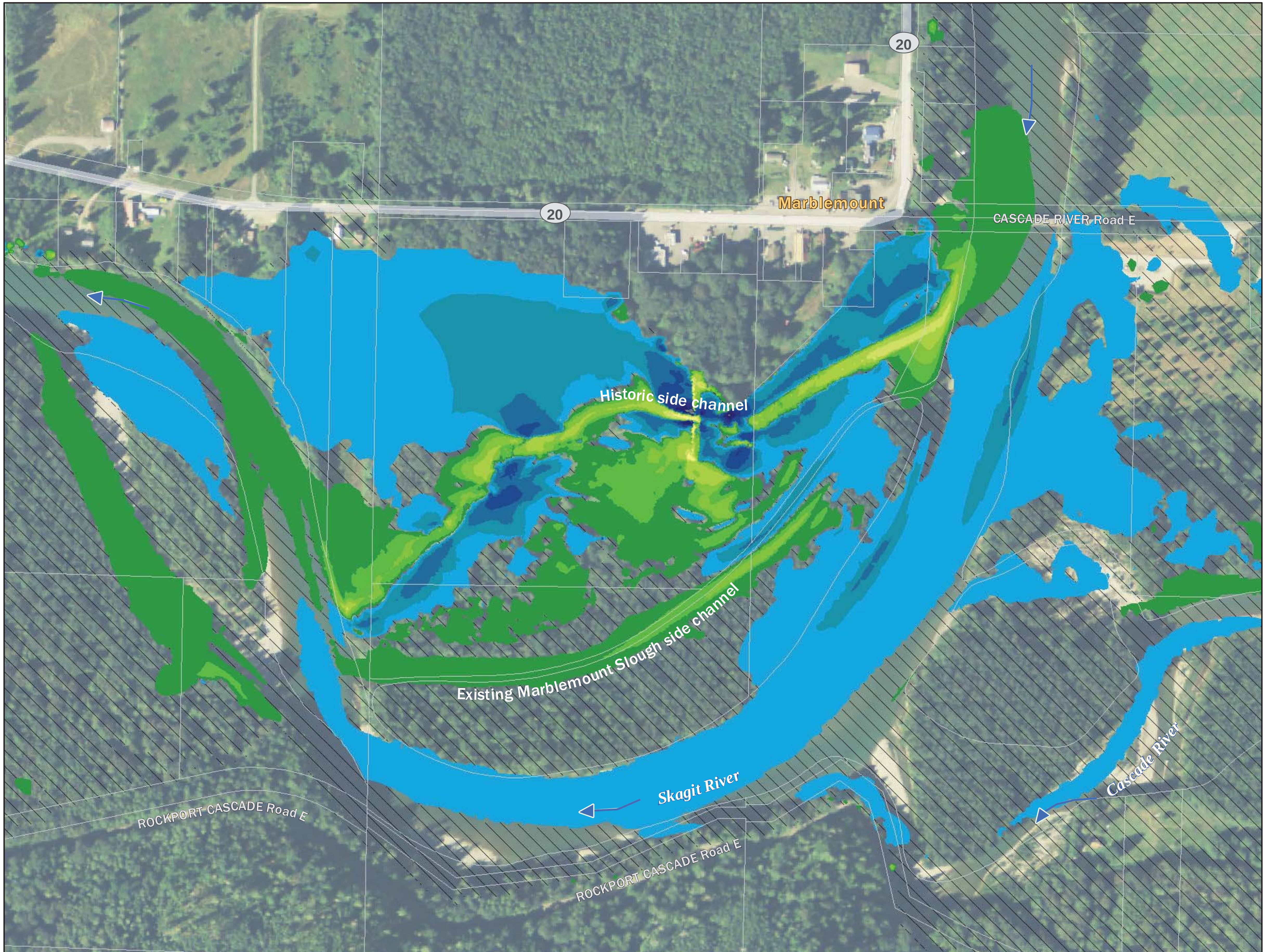
0 175 350 700 ft

HERRERA

NAD 1983 HARN
Washington State Plane North FIPS 4601 Feet

USDA, Aerial (2013); Skagit County, Parcels (2012)

Figure 25.
Alternative 4
100-Year Flood Velocity Change.



Legend

Parcel

Velocity Difference (ft/sec)

Reduction in flood water velocity:
- < -3
- -3 to -2
- -2 to -1
- -1 to -0.5
- -0.5 to -0.25
- -0.25 to -0.05

-0.05 to 0.05 (no color)

Increase in flood water velocity:
- 0.05 to 0.25
- 0.25 to 0.5
- 0.5 to 1
- 1 to 2
- 2 to 3
- > 3

NOTE:
Flood modeling and results shown are approximate and were developed using a project specific River Flow 2D model for the purpose of side channel restoration alternative analysis. Results are not to be used for determining flooding extents or depths (See FEMA Skagit River FIRM maps for regulatory flood conditions).

N

0 175 350 700 ft

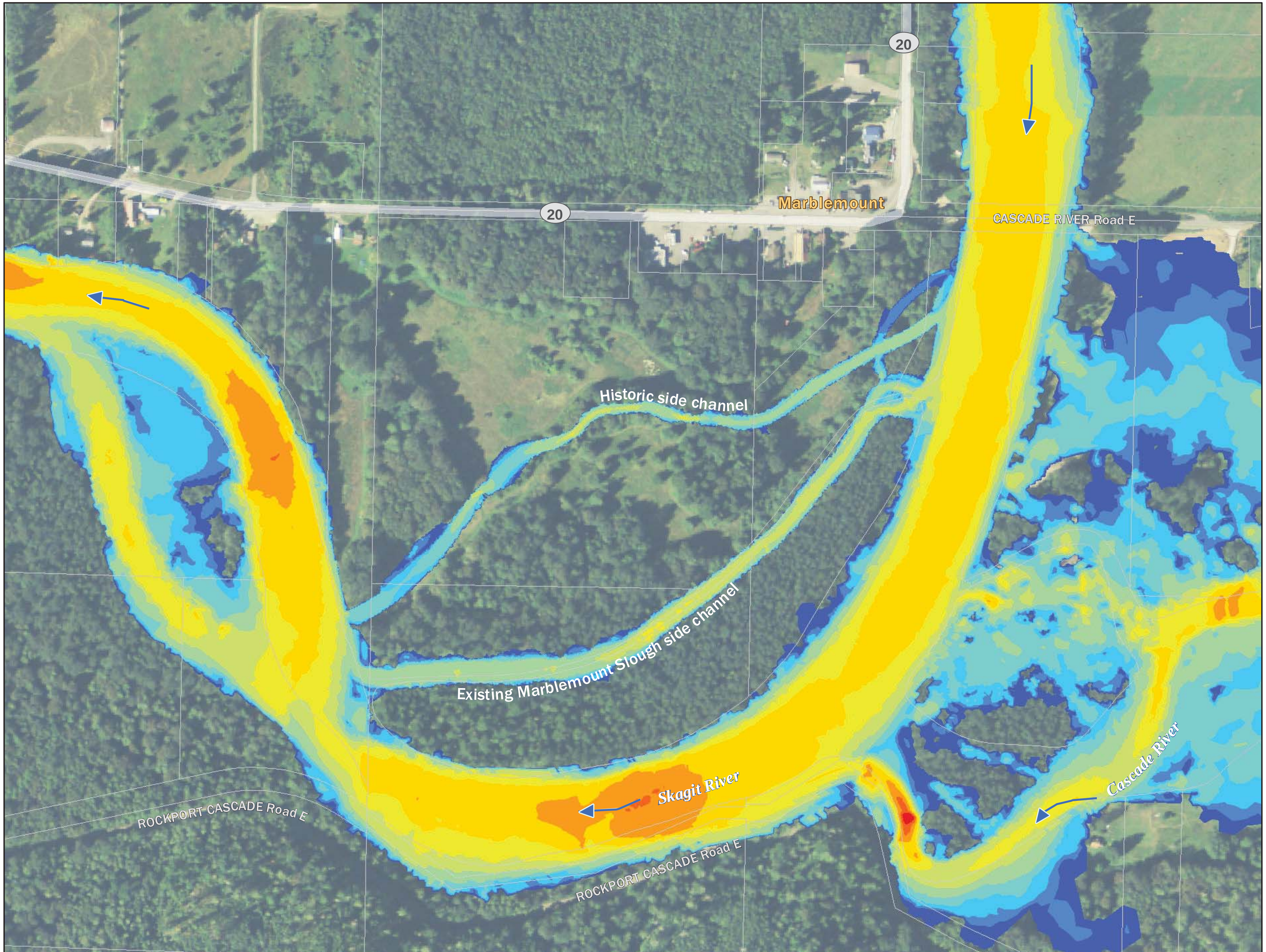
HERRERA

NAD 1983 HARN
Washington State Plane North FIPS 4601 Feet

USDA, Aerial (2013); Skagit County, Parcels (2012)

Produced By: GIS
Project: K:\Projects\Y2014\14-05789-000\Project\Conceptual_Rest_Alt_Analysis\pref_alt_vel_diff.mxd (6/9/2015)

Figure 26.
Alternative 4
2-Year Flood Velocity.



Legend

- Parcel

Flood velocity (fps)

- 0 to 0.01
- 0.01 to 0.25
- 0.25 to 0.5
- 0.5 to 1
- 1 to 2
- 2 to 4
- 4 to 6
- 6 to 8
- 8 to 10
- 10 to 12
- 12 to 14
- > 14

NOTE:
Flood modeling and results shown are approximate and were developed using a project specific River Flow 2D model for the purpose of side channel restoration alternative analysis. Results are not to be used for determining flooding extents or depths (See FEMA Skagit River FIRM maps for regulatory flood conditions).

N

0 175 350 700 ft

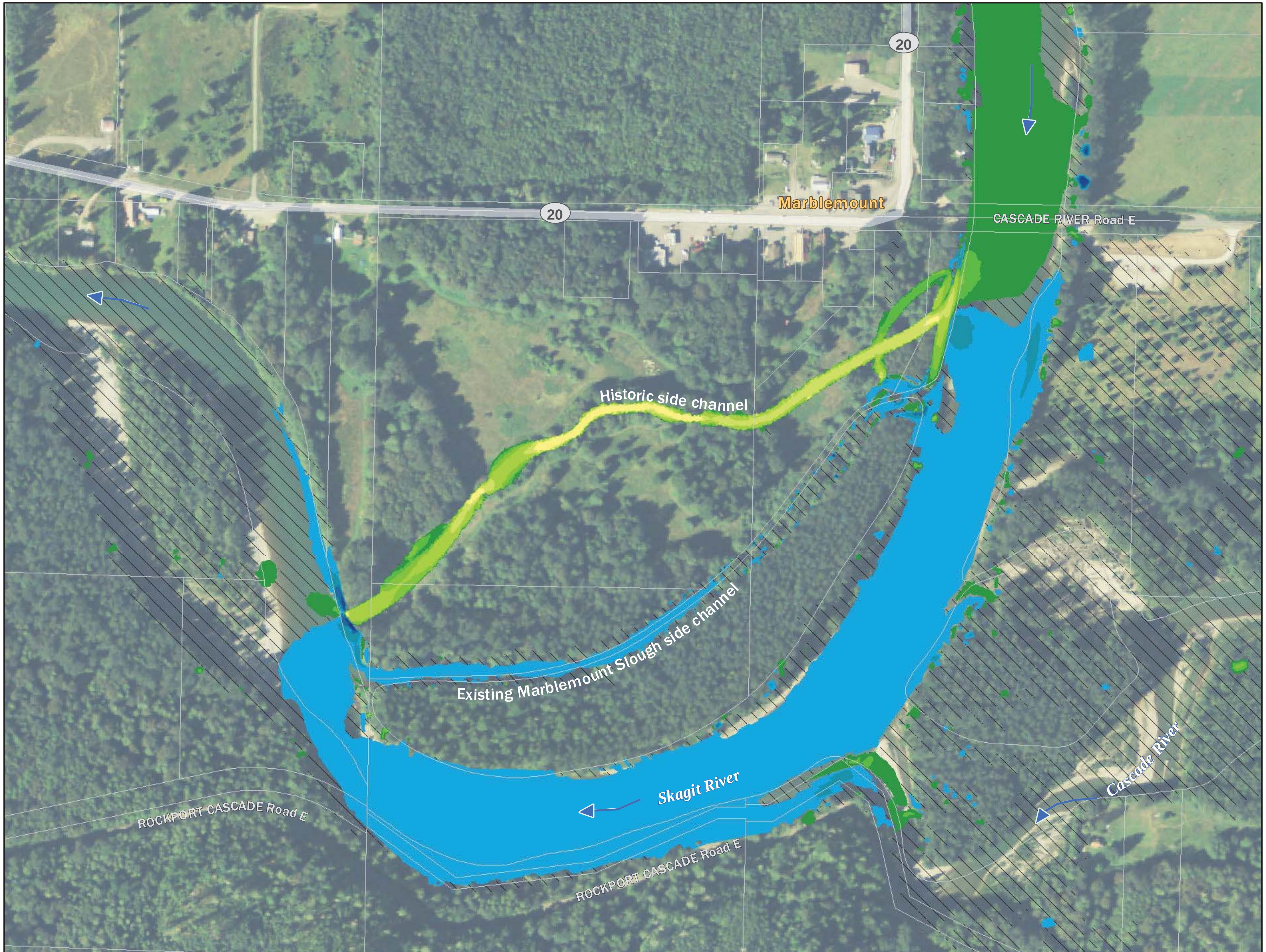
HERRERA

NAD 1983 HARN
Washington State Plane North FIPS 4601 Feet

USDA, Aerial (2013); Skagit County, Parcels (2012)

Produced By: GIS
Project: K:\Projects\Y2014\14-05789-000\Project\Conceptual_Rest_Alt_Analysis\pref_alt_velocity.mxd (6/9/2015)

Figure 27.
Alternative 4
2-Year Flood Velocity Change.



Legend

Parcel

Velocity Difference (ft/sec)

Reduction in flood water velocity		< -3
		-3 to -2
		-2 to -1
		-1 to -0.5
		-0.5 to -0.25
		-0.25 to -0.05
		-0.05 to 0.05 (no color)
Increase in flood water velocity		0.05 to 0.25
		0.25 to 0.5
		0.5 to 1
		1 to 2
		2 to 3
		> 3

NOTE:
Flood modeling and results shown are approximate and were developed using a project specific River Flow 2D model for the purpose of side channel restoration alternative analysis. Results are not to be used for determining flooding extents or depths (See FEMA Skagit River FIRM maps for regulatory flood conditions).

N

0 175 350 700 ft

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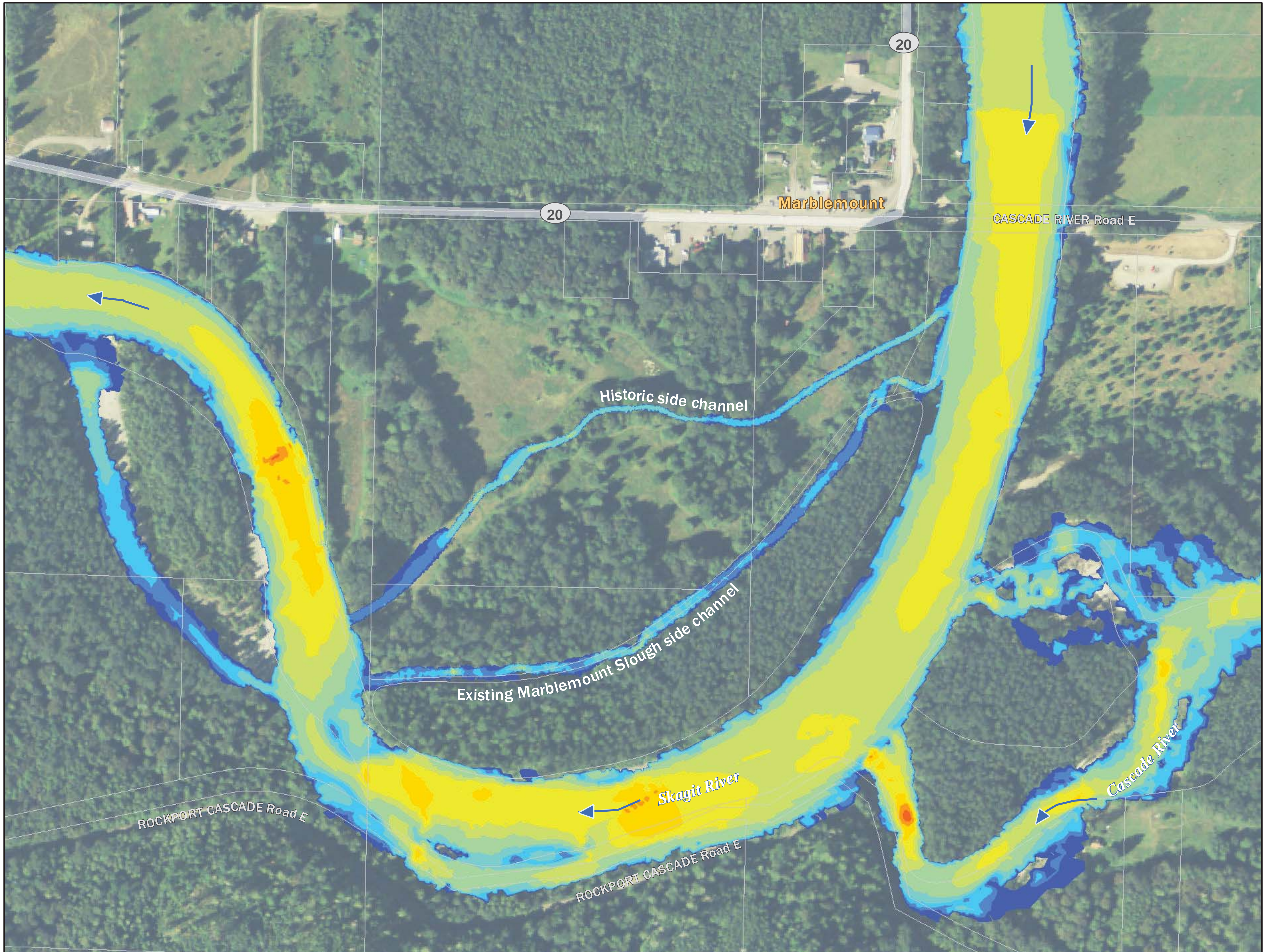
NAD 1983 HARN
Washington State Plane North FIPS 4601 Feet

USDA, Aerial (2013); Skagit County, Parcels (2012)

Produced By: GIS
Project: K:\Projects\Y2014\14-05789-000\Project\Conceptual_Rest_Alt_Analysis\pref_alt_vel_diff.mxd (6/9/2015)

Figure 28.
Alternative 4
7600 cfs Velocity.



Legend

- Parcel

Flood velocity (fps)

- 0 to 0.01
- 0.01 to 0.25
- 0.25 to 0.5
- 0.5 to 1
- 1 to 2
- 2 to 4
- 4 to 6
- 6 to 8
- 8 to 10
- 10 to 12
- 12 to 14
- > 14

NOTE:
Flood modeling and results shown are approximate and were developed using a project specific River Flow 2D model for the purpose of side channel restoration alternative analysis. Results are not to be used for determining flooding extents or depths (See FEMA Skagit River FIRM maps for regulatory flood conditions).

N

0 175 350 700 ft

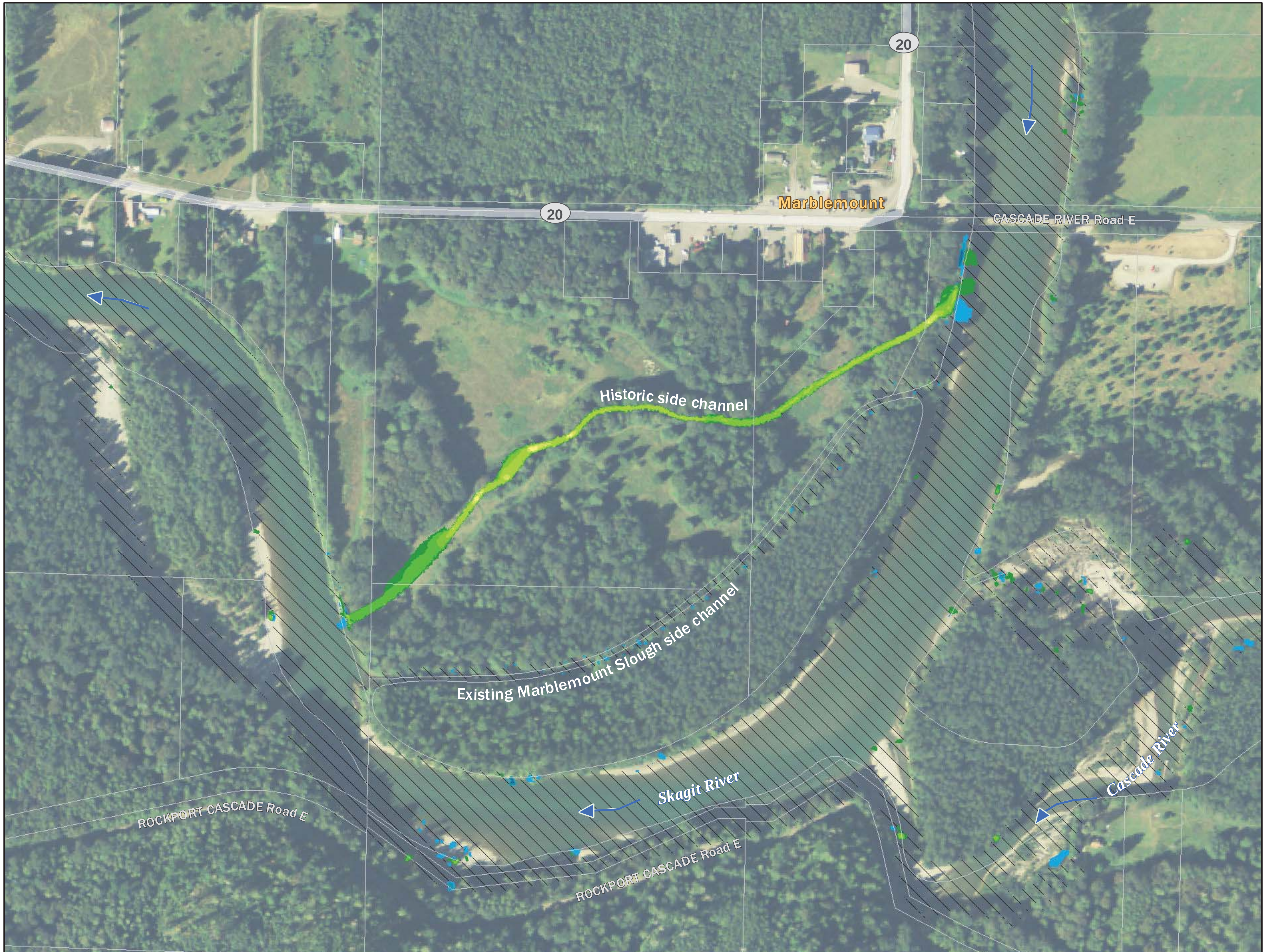
HERRERA

NAD 1983 HARN
Washington State Plane North FIPS 4601 Feet

USDA, Aerial (2013); Skagit County, Parcels (2012)

Produced By: GIS
Project: K:\Projects\Y2014\14-05789-000\Project\Conceptual_Rest_Alt_Analysis\pref_alt_velocity.mxd (6/9/2015)

Figure 29.
Alternative 4
7600 cfs Velocity Change.



Legend

Parcel

Velocity Difference (ft/sec)

Reduction in flood water velocity	< -3	
	-3 to -2	
	-2 to -1	
	-1 to -0.5	
	-0.5 to -0.25	
	-0.25 to -0.05	
	-0.05 to 0.05 (no color)	
Increase in flood water velocity	0.05 to 0.25	
	0.25 to 0.5	
	0.5 to 1	
	1 to 2	
	2 to 3	
	> 3	

NOTE:
Flood modeling and results shown are approximate and were developed using a project specific River Flow 2D model for the purpose of side channel restoration alternative analysis. Results are not to be used for determining flooding extents or depths (See FEMA Skagit River FIRM maps for regulatory flood conditions).

N

0 175 350 700 ft

HERRERA

NAD 1983 HARN
Washington State Plane North FIPS 4601 Feet

USDA, Aerial (2013); Skagit County, Parcels (2012)

Produced By: GIS
Project: K:\Projects\Y2014\14-05789-000\Project\Conceptual_Rest_Alt_Analysis\pref_alt_vel_diff.mxd (6/9/2015)

Alternative 2 – Flow-Through Side Channel

This alternative initially consisted of a complete side channel system with no additional features (flood fence, ELJs etc.). A flood fence and stabilizing ELJs were added through iterative modeling to minimize flood impacts from the project. The model results for the final configuration of this alternative show a decrease in water surface elevations that extends from the side channel entrance upstream through the Cascade River Road Bridge, as well as a decrease in water surface elevations similar to Alternative 1 in the northwest Pressentin Park area. Water surface elevation increases are indicated downstream of the side channel entrances in the Pressentin Park floodplain and in the main Skagit River channel. See Figures 39 through 46 in Appendix F for hydraulic model results.

Alternative 3 – Flow-Through Side Channel with Blind Slough

The model results for this alternative indicate that floodplain inundation would increase in smaller flow events compared to existing conditions and to Alternatives 1 and 2. Alternative 3 could be expected to cause the greatest flood impacts in large flood events, and thus would require more log structures and floodplain roughening to minimize the impacts relative to both Alternative 2 and Alternative 1. See Figures 47 through 54 in Appendix F for hydraulic model results.

Alternative 4 – Flow-Through Side Channel with Wetland Benches

Model results for this alternative indicate that water surface elevation increases during large events would generally be confined to the Pressentin Park area and the main river channel (see Figures 18 through 29). Floodplain inundation is predicted to be greater in smaller flow events compared to existing conditions and Alternative 2. These results indicate this alternative would minimize flood impacts.

Geomorphic Analysis

Geomorphic analysis of the proposed alternatives considered the risk of avulsion through either Marblemount Slough or a proposed side channel, the sustainability and functionality of the proposed side channel, and the effects of the proposed side channel on Marblemount Slough.

Avulsion Risk

As discussed previously in the existing conditions characterization, the risk of the Skagit River avulsing permanently into either Marblemount Slough or any of the proposed alternative side channels is low due to geological and large-scale geomorphic factors. Temporary avulsion might result from the formation of a headcut at the downstream end of a proposed side channel during flood events that then propagates upstream to the new side channel inlet. Since all of the alternatives were designed with a low-gradient outlet and channel slopes consistent with those found in Marblemount Slough, the likelihood of such a headcut forming at the outlet and migrating upstream is negligible. Given the minimal changes to Marblemount Slough flow depths and velocities expected to result from any of the proposed alternatives, the project is unlikely to increase the already low likelihood of an avulsion through Marblemount Slough.

Although opening a proposed side channel could, in theory, affect existing sediment transport capacity if flow or velocity were reduced at the Marblemount Slough inlet, model results indicate negligible change in velocity (< 0.05 feet per second [fps]) or depth (< 0.02 feet) at 7,600 cfs. The 2-year flood velocity at the inlet and around the bend is 8 to 10 fps under existing conditions, and the 100-year flood velocity is 10 to 12 fps. Alternative 4, as an example, reduces flood velocity by between 0.05 and 0.25 fps for both flood events. Depth is reduced by 0.05 to 0.5 feet for the 2-year flood event and increased by 0 to 0.05 feet for the 100-year flood event. These relatively small differences would be unlikely to increase sedimentation, channel migration, or the existing low likelihood of avulsion. Additionally, structures placed at the inlet of the proposed channel will further reduce the likelihood of channel avulsion.

Sustainability and Functionality of the Proposed Side Channel Alternatives

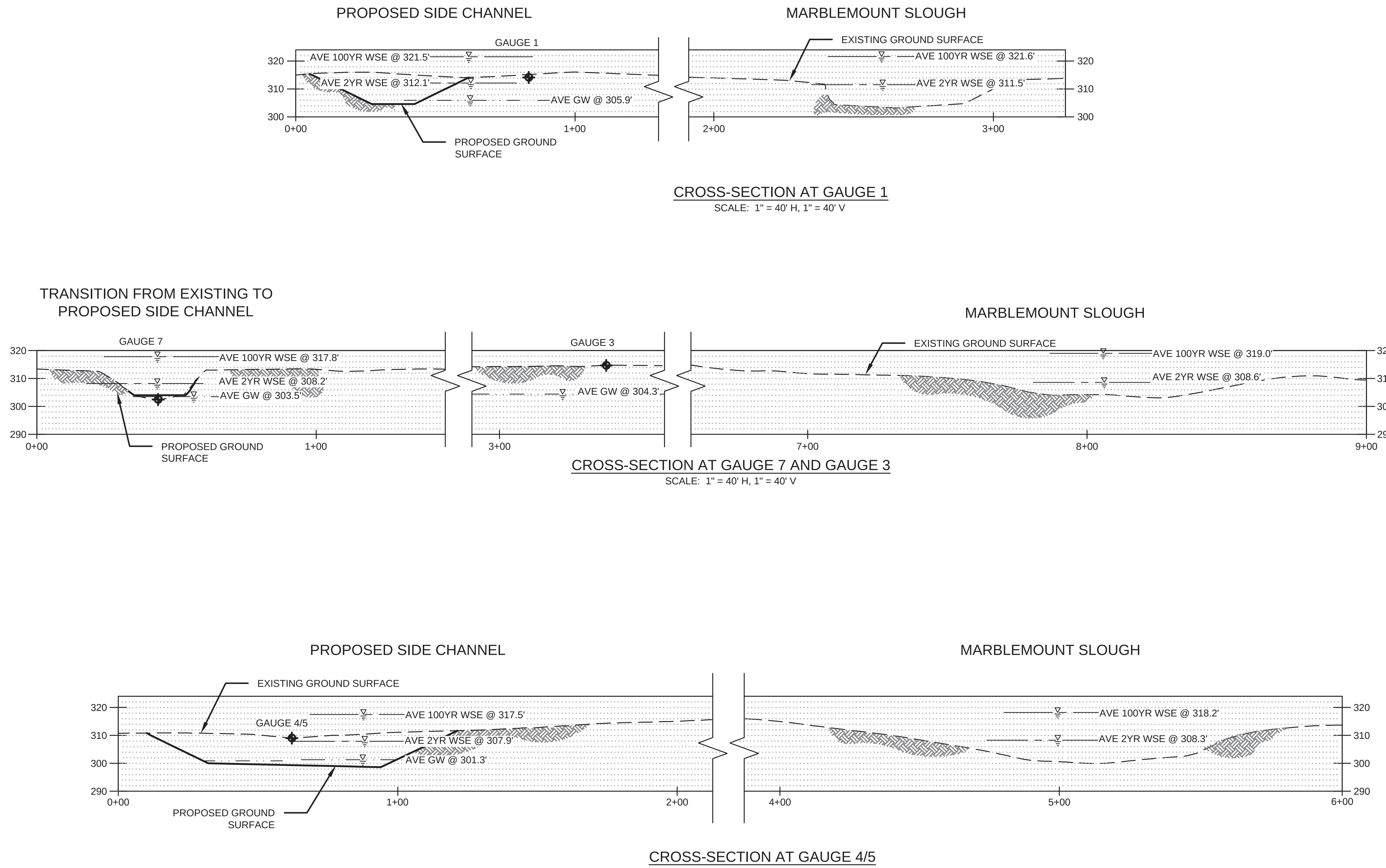
Given the observed long-term stability and functionality of Marblemount Slough, modeled stream flow and groundwater levels for the side channel alternatives were compared with those in Marblemount Slough to assess their likely sustainability and functionality. Cross sections of Alternative 4 and Marblemount Slough are shown with observed groundwater and modeled water surface elevations in Figure 30.

The Marblemount Slough channel and each of the proposed alternatives have bed elevations approximately the same as those at which groundwater was observed during summer low-flows on the Skagit River. Marblemount Slough and the alternative side channels are dry at a flow of 5,000 cfs in the hydraulic model, but a shallow trickle of groundwater has been observed in Marblemount Slough during summer low-flows in the river. The same conditions would probably occur in any of the alternative side channels, especially where constrictions or bank structures promote the formation of scour pools during higher flows.

At a flow of 7,600 cfs (representative of winter to early summer base flows), model results indicate that both Marblemount Slough and the flow-through side channel alternatives (Alternatives 2, 3, and 4) would have water depths between 0.4 and 2.0 feet. At this flow rate, modeled velocities in Marblemount Slough range from 0.1 to 2 fps. Flow velocities in the flow-through side channel for each of Alternatives 2, 3, and 4 are modeled to be between 0.8 and 2 fps, for the most part, with local velocities up to 4 fps at channel constrictions. Depth-velocity sediment mobility thresholds analysis (after Sundborg 1956) indicates that sand-sized particles would be mobile in the faster-velocity areas of Marblemount Slough and along most of the length of the flow-through side channel under either of Alternatives 2, 3, and 4 at a flow of 7,600 cfs. Particles up to the size of fine gravel may be mobilized at 7,600 cfs in higher velocity locations along the flow-through side channel under these alternatives. Both Marblemount Slough and the flow-through side channel under these alternatives could be expected to be gravel-bedded where sand mobility thresholds are equaled or exceeded at a flow of 7,600 cfs.

Because of their generally higher flow velocities, the proposed side channel alternatives would have greater gravel extents and less sandy area, and in places could have coarser gravel than is found in Marblemount Slough. It is possible that the new flow-through side channel inlet may episodically accumulate sediment, but its hydraulic similarity to the perennially-open Marblemount Slough inlet suggests that it is unlikely to silt in permanently. Flow velocities modeled near the outlet of Marblemount Slough and the outlet of all of the proposed side channel alternatives are below the mobility thresholds of very fine sand at 7,600 cfs, so sand particles mobilized from the bed and banks upstream would likely deposit near the outlet. They would form a depositional zone of sediment similar to the fine sediment observed at the Marblemount Slough outlet during field work, and at depth in the test pit closest to the slough outlet and the alternative side channel outlets.

Figure 30.
Preferred Alternative Cross-Sections



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Modeled flow depths and velocities in the proposed flow-through side channel under each of Alternatives 2, 3, and 4 are also comparable to those in Marblemount Slough at the 2-year flood, which suggests that channel-maintaining processes will likewise be comparable. Water depths in Marblemount Slough range from 5 to 9 feet, and would range from 5 to 8 feet in the flow-through side channel alternatives during the 2-year flood flow. Modeled flow velocities in Marblemount Slough range from 1 to 6 fps at the 2-year flow rate. In the flow-through alternatives, they also range from 1 to 6 fps, with about a third of the length having velocities above 3 fps. Particles up to fine gravel size would likely be mobile during the 2-year flow in the faster parts of the flow-through side channel alternatives, and particles up to very coarse sand size would be mobile in Marblemount Slough in this flow, thus maintaining the gravel-bedded character of both channels. Model results indicate that mobility thresholds for sand-sized particles would be exceeded at the outlets of both Marblemount Slough and the flow-through side channel alternatives during the 2-year flood, which should therefore flush out sediment that accumulates during lower flows. This would maintain outlet connections with the Skagit River.

Given their hydraulic and sediment-transport similarity to Marblemount Slough, any of the flow-through side channel alternatives would have similar habitat functions. The habitat functionality of any of the flow-through side channel alternatives would largely depend, however, on local features that a reach-scale hydraulic model is not capable of simulating, such as pools and riffles that form in response to channel constrictions, bends, and large wood placements. Such features in the proposed side channel are likely to be similar to those found in Marblemount Slough. Predicting the likely distribution and estimating the likely dimensions of such features will require design plans with a greater level of detail than were developed for this stage of the project and may require local refinement of the hydraulic model, but should be done in future stages of the project.

Effects of Proposed Side Channel Alternatives on Marblemount Slough

Marblemount Slough would initially be unaffected by any of the proposed alternatives. Hydraulic changes induced by the alternatives might affect it over time, but the hydraulic model results indicate those changes would be very small for all of the analyzed alternatives, and unlikely to have significant effects. Model results for Alternative 1 showed the smallest effect on Marblemount Slough, increasing its modeled water depth by less than 0.001 foot at a flow rate of 7,600 cfs. Model results for Alternatives 2 and 3 showed increased water depths at the outlet of Marblemount Slough of less than 0.01 foot, and decreased water depths at the inlet and midpoint of the slough, also by less than 0.01 foot at a flow of 7,600 cfs. Model results for Alternative 4 show decreased water depths at the inlet to Marblemount Slough by 0.01 feet and at its midpoint by nearly that much, while increasing depth at the outlet by less than 0.001 feet at a flow of 7,600 cfs. These differences fall well within natural variations in flow depths and velocities, are within the range of model uncertainty, and are miniscule in comparison with modeled depths, so even if hydraulic changes occur, they would be unlikely to affect the sustainability or habitat functionality of Marblemount Slough. Additionally, the small differences can be interpreted to mean that changes in water level in the main stem channel would be minimal.

Evaluation of the modeled proportions of flow through the main stem channel, Marblemount Slough, and proposed side channel also provide a perspective on the flow distribution that can be expected. Table 5 presents a summary of these model results, which indicate that a small percentage (2 percent of the 2-year flow and 0.4 percent of the 7,600 cfs low flow) of the main stem flow will be diverted into the proposed side channel during lower flow conditions.

Table 5. Flow through Main Stem, Marblemount Slough, and Proposed Side Channel During 2-year Flow and 7,600 cfs Low Flow.

Reach	Flow	Percentage Main Stem Flow
2-Year Flow		
Main stem channel	23,035 cfs	100%
Marblemount Slough	1,375 cfs	6%
Proposed side channel	490 cfs	2%
7,600 cfs (low flow)		
Main stem channel	7,010 cfs	100%
Marblemount Slough	20 cfs	0.3%
Proposed side channel	30 cfs	0.4%

Floodplain and Side Channel Habitat Gain and Connectivity Analysis

The analysis of habitat gains and side channel connectivity included spawning habitat gains for adult Chinook, sockeye, pink, chum, and coho salmon and steelhead. However, of these species, only Chinook, coho, and chum salmon have been documented to spawn in Marblemount Slough, which was used as reference side channel. Regarding potential use of the proposed side channel for spawning by Chinook salmon, it would most likely be the case in years having significant precipitation during the late summer/early fall (summer Chinook spawns from August through October). The analysis also included rearing habitat and flood refugia gains for juvenile Chinook, coho, and sockeye salmon and steelhead.

It should be noted that the degree to which habitat area would increase for adult spawning or juvenile rearing would depend on the hydrologic conditions in any given year. However, expected habitat gains can be predicted based on modeled conditions. Figure 31 shows rearing habitat areas in the main stem channel, Marblemount Slough, and the proposed side channel at a flow of approximately 7,600 cfs under the preferred alternative, while Table 6 presents the floodplain and side channel habitat gain analysis results for each of the four alternatives. Habitat gains are presented for flow velocity and water depth ranges, based on modeled conditions for the 2-year flood flow and the 7,600 cfs low flow. As can been seen in Table 6, Alternative 4 is expected to minimize high velocity areas unsuitable for juvenile salmonid rearing during both the 2-year flood and the 7,600 cfs flow. Of the total expected 3.9 acres of wetted area during the 2-year flood and 2.1 acres during the 7,600 cfs low flow, 1.9 (48 percent) and 1.4 (67 percent) acres, respectively, meet the edge habitat criteria (greater than 0.66 feet deep and less than 1.5 fps velocity). These results indicate that from the hydrologic and hydraulic perspectives, the proposed side channel would provide suitable rearing habitat for juvenile salmonids. In addition, Alternative 4 includes areas with flow velocities suitable for spawning, similar to those observed within Marblemount Slough.

The degree to which fish may benefit from the proposed side channel habitat is related to three main drivers: 1) hydrological connectivity to the Skagit River main stem, 2) abiotic habitat conditions such as water temperature within the side channel, and 3) the type and availability of food sources supported by the side channel. To benefit from new side channel habitat, fish would need to be able to access it, based on specific temporal life history requirements of the salmonid species known to use this portion of the Skagit River (see Table 2). In this regard, the majority of juvenile fish access to the proposed side channel would be provided at flows greater than 5,000 cfs, which support flow-through hydrologic connectivity based on hydraulic model results (see the section on *Sustainability and Functionality of the Proposed Side Channel Alternatives* for details). Although the majority of juvenile fish access would be provided at flows greater than 5,000 cfs, full access to, and egress from the side channel would be provided year-round through the downstream outlet. Side channel banks and adjacent riparian areas would be planted with native shrub and tree species, which would help to moderate summer water temperature and provide food sources, such as insects.

Table 6. Floodplain and Side Channel Habitat Area Gain by Alternative.

	Alternative 1				Alternative 2				Alternative 3				Alternative 4			
	2–year Flow		7,600 cfs		2–year Flow		7,600 cfs		2–year Flow		7,600 cfs		2–year Flow		7,600 cfs	
Flow Velocity (fps)	**Area (SF)**	**Area (Ac)**	**Area (SF)**	**Area (Ac)**	**Area (SF)**	**Area (Ac)**	**Area (SF)**	**Area (Ac)**	**Area (SF)**	**Area (Ac)**	**Area (SF)**	**Area (Ac)**	**Area (SF)**	**Area (Ac)**	**Area (SF)**	**Area (Ac)**
0 to 0.5	82,632	1.90	29,284	0.67	10,898	0.25	45,511	1.04	73,365	1.68	98,248	2.26	32,972	0.76	30,515	0.70
0.5 to 1.5	2,360	0.05	213	0.00	42,260	0.97	153	0.00	68,360	1.57	235	0.01	48,409	1.11	29,066	0.67
1.5 to 2	40	0.00	24	0.00	17,194	0.39	16	0.00	17,177	0.39	21	0.00	18,146	0.42	7,207	0.17
2 to 4	36	0.00	19	0.00	50,352	1.16	1	0.00	36,882	0.85	32	0.00	49,893	1.15	3,352	0.08
4 to 6	–	–	0	0.00	2,533	0.06	–	–	3,237	0.07	0	0.00	9,514	0.22	596	0.01
6 to 8	–	–	–	–	26	0.00	–	–	171	0.00	–	–	704	0.02	–	–
> 8	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Total Area (greater than 0.66 feet depth)	85,068	1.95	29,541	0.68	123,262	2.83	45,681	1.05	199,190	4.57	98,536	2.26	159,638	3.66	70,736	1.62
Total Area (less than 0.66 feet depth and wet)	5,365	0.12	4,702	0.11	8,927	0.20	16,589	0.38	9,714	0.22	19,218	0.44	9,499	0.22	18,925	0.43
Total Wet Area	**90,433**	**2.08**	**34,243**	**0.79**	**132,189**	**3.03**	**62,270**	**1.43**	**208,904**	**4.80**	**117,754**	**2.70**	**169,137**	**3.88**	**89,661**	**2.06**

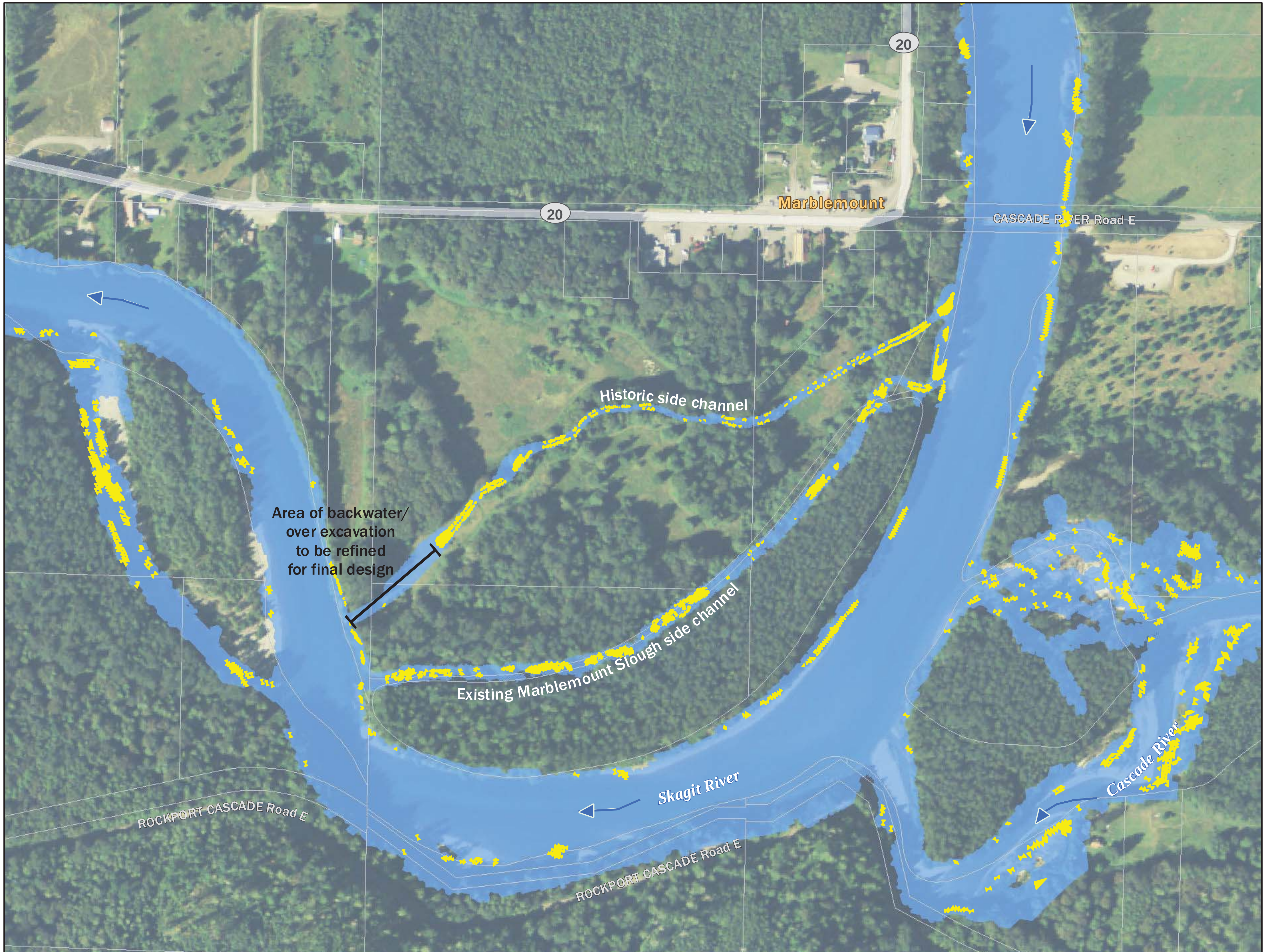
cfs = cubic feet per second

fps = feet per second

SF = square feet

Ac = acres

Figure 31.
Approximate Base Flow Rearing Habitat Areas (Depths between 0.66-1.3 ft and Velocities between 0.5-1.5 fps at 7,600 cfs).



Legend

Areas with 0.5-1.5 fps velocity and 0.66-1.3 ft depth

Parcel

Wetted area

Total Area (in yellow)

Marblemount Slough (0.47 Acres)
Historic Side Channel (0.27 Acres)

N

0 175 350 700 ft

HERRERA

NAD 1983 HARN
Washington State Plane North FIPS 4601 Feet

USDA, Aerial (2013); Skagit County, Parcels (2012)

Although access to, and suitability of, the side channel are important in order for juvenile salmonids to realize the habitat benefits, another important consideration is the side channel inundation frequency and duration since it determines when the full side channel would be available to fish. A monthly flow duration table was created to provide a reference for understanding temporal changes and availability of the created side channel habitat (see Table 7). The table is based on the USGS Marblemount river gauge average daily flows. Using average daily flows does not capture instantaneous or sub-day variations in flow, which in the case of highly regulated/modified flows on rivers, such as the Skagit, can vary by a thousand or more cfs and have multi-hour periods with flows holding steadily above or below the stated averaged values. However, for understanding general flow and hydrologic patterns, and their effect on habitat availability, daily average flows provide valuable insight.

As can be seen in Table 7, with the exception of September, full access to the side channel from the upstream inlet and the downstream outlet, and thereby habitat availability, would be provided 75 percent of the time, as approximate average daily flows would be greater than 5,000 cfs. This rearing and spawning habitat availability is consistent with the life history timing requirements of juvenile Chinook salmon and steelhead, as well as other species (see Table 2). However, the amount of habitat that would be available to juvenile Chinook and steelhead for rearing would be less than what is expected at the 7,600 cfs flow (2.06 acres shown in Table 4) during periods when flow is lower than 7,600 cfs. This is because the available habitat area is proportional to the expected area of inundation, which is reduced during lower flows. This would also be the case from March through May and then August through October, when the probability of exceeding 7,600 cfs is low. It should be noted that:

- The data is averaged.
- The flow in the Skagit River pulses significantly in a day, with long sustained pulses, often 500 to 1,000 cfs or more, which is very different than conditions in nonregulated river systems and over the course of a day may make habitat areas more or less accessible than indicated in the averages shown in the table.

In addition to full flow-through access for juvenile Chinook, steelhead, and other species, access to, and egress from the side channel would be provided at all flows listed in Table 7 through the downstream outlet. So, even in the worst case, when flow conditions may cause a hydrologic disconnection at the upstream inlet of the side channel (see highlighted cells in Table 7), access and egress would always be provided through the downstream outlet. However, the amount of available habitat would be proportionally reduced (for a given flow) from that provided at the 7,600 cfs flow, which is currently the case in Marblemount Slough.

The proposed side channel would provide spawning habitat within the same temporal scale as that provided in Marblemount Slough, and would be consistent with timing requirements for the species known to use this existing side channel (listed in Table 2). Spawning habitat would likely be provided even during some flow conditions when the upstream inlet may be disconnected (for example, 50 percent of the time in August through October). This is because the downstream outlet, which is the way adult fish would enter the side channel, would be accessible year-round. Also, as with Marblemount Slough, hyporheic and groundwater flows are expected in the proposed side channel throughout the year, which are expected to maintain access and egress through the downstream outlet. The hyporheic and groundwater flows will also help provide adequate temperatures and dissolved oxygen levels in isolated pools. Redd locations in the proposed side channel would likely experience a temporal and spatial influence from flow velocities as they do in Marblemount Slough (see related discussion under the *Fish Habitat Conditions* section).

Table 7. Approximate Monthly Flow Duration.

Month	5% Flow Exceedance (cfs)	10% Flow Exceedance (cfs)	25% Flow Exceedance (cfs)	50% Flow Exceedance (cfs)	95% Flow Exceedance (cfs)
January	11,000	9,300	7,800	7,200	5,100
February	8,800	8,200	7,400	6,700	5,600
March	8,100	7,600	6,800	6,100	4,900
April	7,100	6,800	6,000	5,600	4,900
May	9,000	8,400	7,300	6,200	5,000
June	11,200	10,600	8,600	7,500	5,700
July	11,200	10,600	9,000	7,500	5,200
August	6,400	6,100	5,300	4,400	3,200
September	5,500	5,000	4,200	3,800	2,900
October	9,700	8,600	6,000	4,500	3,200
November	13,700	12,200	9,000	7,400	4,400
December	9,600	8,400	6,600	5,600	4,400

Notes:

Exceedance indicates the flow which is exceeded more than x% of the time each month (e.g., flows in January have exceeded 7,200 cfs more than 50% of the time over the period of record).

Highlighted cells indicate conditions where the proposed side channel and Marblemount Slough may be disconnected at the upstream inlet.

Table 7 also shows that there would be flood flow pulses at increasingly lower exceedances. These annual high-water pulses are important for habitat maintenance and are the main force in determining existence, productivity, and interactions of major biota in river–floodplain systems, including side channels (Junk et al. 1989). The side channel would also accommodate the 2-year flood, at which time functional edge habitat would be provided within 3.88 acres (see Table 6).

Selection of Preferred Alternative

Herrera presented the results of the alternatives analysis, including the results of the updated hydraulic modeling, geomorphic analysis, habitat analysis, groundwater monitoring, and soil lithology characterization of the site to SFEG at the third workshop and in a separate meeting with the Skagit County Parks Board. The project team selected Alternative 4, which combines components of Alternative 2 and 3, as the preferred alternative (see design drawings in Appendix G). As Table 4 notes, Alternative 4 scored the highest overall.

The inlet geometry of Alternative 2 was included in the preferred alternative because the hydraulics of the side channel improve if its inlet is narrow, which will help to prevent silting-in of the inlet and reduce flood risk. The outlet geometry of Alternative 3 was included in the preferred alternative because downstream hydraulics are insensitive to outlet geometry, and therefore a wider outlet would provide additional habitat without increasing off-site flood risk or the chance of siltation.

CONCLUSION

Key Findings

- The Skagit and Cascade Rivers and Marblemount Slough have not moved appreciably over the historical record.
- The existing perennial side channel, Marblemount Slough, is highly functional and provides good quality spawning habitat, primarily for chum salmon, and rearing habitat and flood refugia for juvenile salmonid species.
- Existing open field areas within the park provide opportunity for side channel creation. However, the banks of any side channel constructed on those areas should include revegetation strategies to address potential summer water temperature issues associated with solar irradiance and juvenile salmonid predation by birds.
- Given spawning-size gravel and cobbles observed within the soil test pits, any excavated site channel would likely be suitable and sustainable to provide spawning habitat without the need to import spawning substrate to the project site.
- The material most recently deposited in the area is silt and sand, so an excavated channel need only be designed to pass silt and sand; depths and velocities sufficient to move cobble and gravel are not required.
- Groundwater at the site is directly correlated to river flow, rather than directly influenced by rain or surface hydrology.
- Given its hydraulic, substrate, and sediment transport capacity similarities to Marblemount Slough, the preferred alternative is expected to be equally persistent and to have similar habitat functions.

Recommendations for Future Project Phases

As project design proceeds, the following should be considered for improved understanding of project effects and performance, and to inform design of specific features so they function as intended for the long term:

- More detailed topographic survey should be obtained in the downstream half of Marblemount Slough, specifically focused on bathymetry near the outlet.
- Hydraulic modeling should be considered for at least one more moderate flood flow between the 2-year and 100-year flood flow rates to assess floodplain activation and performance of the preferred alternative, and to support more detailed evaluations of erosion and deposition characteristics.
- Quantification of local scour and bed-material differentiation potential for the preferred alternative.

- Although current modeling indicates a reduction in flood flow velocities (risk of erosion) along the abandoned terrace margins, future design conditions should consider additional modeling associated with the existing eroding conditions along the northeast face of the abandoned terrace bank. Placement of native alluvium to address over-steepening and erosion of the bank slope, and construction of a coir blanket and vegetated cap are potential design considerations to be included.

REFERENCES

Beamer, E., A. McBride, C. Greene, R. Henderson, G. Hood, K. Wolf, K. Larsen, C. Rice, and K. Fresh. 2005. Delta and nearshore restoration for the recovery of wild Skagit River Chinook salmon: Linking estuary restoration to wild Chinook salmon populations. Supplemental document to the Skagit Chinook Recovery Plan, Appendix D, 327 p.

Beamer, E., T. Beechie, B. Perkowski, and J. Klochak. 1999. Application of the Skagit Watershed Council Strategy. Skagit Watershed Council, Mount Vernon, Washington.

Beechie, T.J., M. Liermann, E.M. Beamer, and R. Henderson. 2005. A classification of habitat types in a large river and their use by juvenile salmonids. Trans. Am. Fish. Soc. 134(3):717–729.

Chow, V.T. 1959. Open-channel hydraulics. New York, McGraw-Hill, 680 p.

Collins, B.D. and A.J. Sheikh. 2002. Methods used to map the historical riverine landscape and habitats of the Skagit River. Report to the Skagit System Cooperative.

FERC. 1998. Eight hydroelectric projects proposed for the Skagit River basin, Washington. Final environmental impact statement. Federal Energy Regulatory Commission. FERC/EIS-0083-F. Office of Hydropower Licensing, Washington, D.C.

Fox, M. and S. Bolton. 2007. A Regional and Geomorphic Reference for Quantities and Volumes of Instream Wood in Unmanaged Forested Basins of Washington State. North American Journal of Fisheries Management, Volume 27, Issue 1.

Graybill, J.P., R.L. Burgner, J.C. Gislason, P.E. Huffman, K.W. Wyman, R.G. Gibbons, K.W. Kurko, Q.J. Stober, T.W. Fagnan, A.P. Stayman, and D.M. Eggers. 1979. Assessment of reservoir-related effects of the Skagit Project on downstream fishery resources of the Skagit River, Washington. University of Washington, Fisheries Research Institute, Final Report for the City of Seattle Department of Lighting.

Hard, J.J., R.G. Kope, W.S. Grant, F.W. Waknitz, L.T. Parker, and R.S. Waples. 1996. Status review of pink salmon from Washington, Oregon, and California. NOAA Technical Memorandum NMFSNWFSC-25.

Junk, W.J., P.B. Bayley, and R.E. Sparks. 1989. The flood pulse concept in river-floodplain systems. Canadian Special Publication of Fisheries and Aquatic Sciences 106:110–127.

Leeder, M.R. and G.H. Mack. 2001. Lateral erosion (‘toe-cutting’) of alluvial fans by axial rivers: implications for basin analysis and architecture. Journal of the Geological Society: London 158:885–893.

Lowery, E.D., J.N. Thompson, J.P. Shannahan, E. Connor, D. Pflug, B. Donahue, C. Torgersen, and D.A. Beauchamp. Seasonal Distribution and Habitat Associations of Salmonids with Extended Juvenile Freshwater Rearing in Different Precipitation Zones of the Skagit River, Washington.

Meyers, J.M., R.G. Kope, G.J. Bryant, D. Teel, L.J. Lierheimer, T.C. Wainwright, W.S. Grant, F.W. Waknitz, K. Neely, S.T. Lindley, and R.S. Waples. 1998. Status review of Chinook salmon from Washington, Idaho, Oregon, and California. NOAA Technical Memorandum NMFS-NWFSC-35.

Misch, P. 1979. Geologic Map of the Marblemount Quadrangle, Washington. Washington Division of Mines and Geology, Geologic Map GM-23.

Simenstad, C.A. and J.R. Cordell. 2000. Ecological assessment criteria for restoring anadromous salmonid habitat in Pacific Northwest estuaries. Ecological Engineering 15:283-302.

SFEG. 2014. Microsoft Excel spreadsheet with spawning survey data collected since 1968 by the Washington Department of Fish and Wildlife, Skagit Fisheries Enhancement Group, and the Skagit River System Cooperative. Provided by Skagit Fisheries Enhancement Group, Mount Vernon, Washington.

Stober, Q.J., S.C. Crumley, D.E. Fast, E.S. Killebrew, R.M. Woodin, G.E. Engman, and G. Tutmark. 1982. Effects of hydroelectric discharge fluctuations on salmon and steelhead in the Skagit River, Washington. University of Washington, Fisheries Research Institute, Final Report (FRI-UW-8218) for the Period December 1979 to December 1982, Seattle.

Sundborg, Å. 1956. The River Klarälven: a study of fluvial processes. Geografiska annaler, 38 (1956), 2–3.

USACE. 2011. Skagit River Basin, Skagit River Flood Risk Management Study, Draft Report Hydraulic Technical Documentation. US Army Corps of Engineers, March 2011.

WDFW. 1998a. 1998 Washington salmonid stock inventory, bull trout and Dolly Varden appendix. Washington Department of Fish and Wildlife, Olympia, Washington. p 437.

WDFW. 1998b. 1998 Washington State coastal cutthroat stock inventory. Final draft. Washington Department of Fish and Wildlife, Olympia, Washington. 280 p.

WDF, WDW, and WWTIT. 1993. 1992 Washington State salmon and steelhead stock inventory. Washington Department of Fisheries, Washington Department of Wildlife, and Western Washington Treaty Indian Tribes, Olympia, Washington. March 1993.

Williams, R.W., R. Laramie, and J.J. Ames. 1975. A catalog of Washington streams and salmon utilization, Volume 1: Puget Sound. Washington Department of Fisheries. Olympia, Washington.

APPENDIX A

Conceptual Alternative Cost Estimates

Engineering Construction Cost Estimate for Conceptual Design - Alternative 1

Project: **Pressentin Park Side Channel Restoration**
Project #: **14-05789-000**
Client: **Skagit Fisheries Enhancement Group (SFEG)**

Date Modified: 3/12/2015
Spreadsheet by: AS/MB
Checked by: GK
Checked Date: 3/12/2015

Alternative 1

Bid Item #	Spec Section	Item Description	Quantity	Unit	Unit Cost	Price	Total Price	Comments
		Mobilization	**1**	**LS**	**$ 103,626.50**		**$ 103,626.50**	8% of construction subtotal (Div 2 - Div 8 work items)
		Temporary Erosion and Sediment Control	**1**	**LS**	**$ 60,813.68**		**$ 60,813.68**	assumes 5% all other items. Does not include water management
		Traffic Control	**1**	**LS**	**$ 6,500.00**		**$ 6,500.00**	
		Stabilized Construction Entrance	**2**	**EA**	**$ 3,250.00**		**$ 6,500.00**	
		Site Clearing - Clearing and Grubbing and Stripping and Stockpiling of Topsoil	**4.7**	**AC**	**$ 9,100.00**		**$ 42,770.00**	Assumes channel area of 3.7 acres (100ft x 1600ft) and new access road area of 0.3 acres (18ft x 1500ft).
		Common Excavation and Fill Including Haul	**25000**	**CY**	**$ 24.70**		**$ 617,500.00**	Quantity from CAD. Includes control of water, removal, loading, hauling, and disposal, Assumes $6 exc+$4 haul+$7 disposal+$2 per cy for water management. Disposal cost from discussions with Robert Horbeck, owner of Casey's Pit quarry (located 2.3 miles from site).
		Relocated Trail	**1300**	**LF**	**$ 6.50**		**$ 8,450.00**	Assumes mowed grass (simular to existing) trail on south bank of side channel A no longer accessible after construction and requires relocation. Rough distances from CAD.
		Bank Habitat Structure	**8**	**EA**	**$ 5,252.00**		**$ 42,016.00**	Assumes bank habitat structure placed every 100 feet. Specific items included in this bid should include all haul of materials from staging areas, excavation, hauling of excess material, clearing and restoration of laydown areas except as covered in planting bid items.
		Structure Excavation	50	CY	$ 12.00	$ 600.00		$6 to excavate; $2 for backfill and compaction and grading, $4 for water managment.
		Import Logs	4	EA	$ 600.00	$ 2,400.00		
		Installation of 16-24" dia, 40' long w/rootwad	1	EA	$ 260.00	$ 260.00		1 hrs of 2ea exc time at $120/hr plus haul from staging area at 10 minutes at $120/hr
		Installation of 16-24" dia, 30' long w/rootwad	3	EA	$ 260.00	$ 780.00		1 hrs of 2ea exc time at $120/hr plus haul from staging area at 10 minutes at $120/hr
		Bank Roughening Structure	**15**	**EA**	**$ 2,444.00**		**$ 36,660.00**	Assumes mid channel roughening structure placed every 100 feet. Specific items included in this bid should include all haul of materials from staging areas, excavation and structure assembly necessary for a complete system
		Structure Excavation	30	CY	$ 12.00	$ 360.00		$6 to excavate; $2 for backfill and compaction and grading, $4 for water managment. 5 x 4 x 25 (1.5x)
		Import Logs	2	EA	$ 500.00	$ 1,000.00		
		Installation of 12-24" dia, 25' long w/rootwad	1	EA	$ 260.00	$ 260.00		1 hrs of 2ea exc time at $120/hr plus haul from staging area at 10 minutes at $120/hr
		Installation of 12-24" dia, 25' long	1	EA	$ 260.00	$ 260.00		1 hrs of 2ea exc time at $120/hr plus haul from staging area at 10 minutes at $120/hr
		Mid-Channel Roughening Structure	**4**	**EA**	**$ 3,432.00**		**$ 13,728.00**	Assumes mid channel roughening structure placed every 100 feet. Specific items included in this bid should include all haul of materials from staging areas, excavation and structure assembly necessary for a complete system
		Structure Excavation	30	CY	$ 12.00	$ 360.00		$6 to excavate; $2 for backfill and compaction and grading, $4 for water managment.
		Import Logs	3	EA	$ 500.00	$ 1,500.00		
		Installation of 12-24" dia, 25' long w/rootwad	1	EA	$ 260.00	$ 260.00		1 hrs of 2ea exc time at $120/hr plus haul from staging area at 10 minutes at $120/hr
		Installation of 12-24" dia, 25' long	2	EA	$ 260.00	$ 520.00		1 hrs of 2ea exc time at $120/hr plus haul from staging area at 10 minutes at $120/hr
		Water Management	**1**	**LS**	**$ 13,000.00**	**$ 13,000.00**		Outlet sediment control. Silt boom +?
		Hydroseeding	**4**	**AC**	**$ 2,860.00**	**$ 12,298.00**	**$ 12,298.00**	Assumes area that is cleared and grubbed is hydroseeded
		Planting	**7**	**AC**	**$ 15,600.00**	**$109,200.00**	**$ 109,200.00**	
		Bark, Hog Fuel or Wood Chip Mulch	**302**	**CY**	**$ 12.00**		**$ 3,625.00**	Includes temporary access routes (18ft x 1800ft x 0.25ft) and incedental amount for staging area preparation as well as removal as needed
		CSTC	**856**	**TON**	**$ 30.00**		**$ 25,680.00**	6" for 650' of existing trail from SR 20 to staging area. WSDOT unit bid.
		Streambed Gravel	**178**	**CY**	**$ 60.00**		**$ 10,668.00**	Assumes streambed cobble is placed 1ft thick x 6ft wide along half of the stream channel.
		Construction Subtotal					**$ 935,595.00**	
		Subtotal					$ 935,595.00	
		Tax (8.6%)					$ 80,461.17	
		Total (with +30% Contingency and Tax)					**$ 1,020,000.00**	

Engineering Construction Cost Estimate for Conceptual Design - Alternative 2

Project: Pressentin Park Side Channel Restoration
Project #: 14-05789-000
Client: Skagit Fisheries Enhancement Group (SFEG)

Date Modified: 3/12/2015
Spread sheet by: AS/MB
Checked by: GK
Checked Date: 3/12/2015

Alternative 2

Bid Item #	Spec Section	Item Description	Quantity	Unit	Unit Cost	Price	Total Price	Comments
		Mobilization	**1**	**LS**	**$ 205,963.53**		**$ 205,963.53**	8% of construction subtotal (Div 2 - Div 8 work items)
		Temporary Erosion and Sediment Control	**1**	**LS**	**$ 120,870.62**		**$ 120,870.62**	assumes 5% all other items. Does not include water management
		Traffic Control	**1**	**LS**	**$ 6,500.00**		**$ 6,500.00**	
		Stabilized Construction Entrance	**2**	**EA**	**$ 3,250.00**		**$ 6,500.00**	
		Site Clearing - Clearing and Grubbing and Stripping and Stockpiling of Topsoil	**7.4**	**AC**	**$ 9,100.00**		**$ 67,340.00**	Assumes channel area of 6.8 acres (100ft x 2450ft) and new access road area of 0.3 acres (18ft x 3200ft).
		Common Excavation and Fill Including Haul	**27800**	**CY**	**$ 24.70**		**$ 686,660.00**	Quantity from CAD. Includes control of water, removal, loading, hauling, and disposal, Assumes $6 exc+$4 haul+$7 disposal+$2 per cy for water management. Disposal cost from discussions with Robert Horbeck, owner of Casey's Pit quarry (located 2.3 miles from site).
		Relocated Trail	**1400**	**LF**	**$ 6.50**		**$ 9,100.00**	Assumes mowed grass (simular to existing) trail on south bank of side channel A no longer accessible after construction and requires relocation. Rough distances from CAD.
		Furnish and Install Pedestrian Bridges	**2**	**EA**	**$ 58,500.00**		**$ 117,000.00**	Contech ($26k deliv plus abutments).
		Furnish and Install Equipment Bridges	**1**	**EA**	**$ 110,500.00**		**$ 110,500.00**	Contech for 10ft wide $57k deliv + abutments.
		Flood Fence	**1**	**LS**	**$ 77,173.20**		**$ 77,173.20**	
		Import Log: 18-24" DBH, 25-40' long with rootwad	28	EA	$ 800.00	$ 22,400.00		
		Vertical Piles (Import and Install)	46	EA	$ 600.00	$ 27,600.00		Estimated ~30/lf at ~15 ft depth, + pile cost
		Log haul and placement	28	EA	$ 138.00	$ 3,864.00		1 exc. 15 minute delivery r/t, place w/ 2 exc.s needed, 0.2 hour to place (2 Exc+op, laborer 0.2hr @ $150/hr)
		Installation of Racking Logs - 8"-16" DBH, 15'-30' long	50	EA	$ 50.00	$ 2,500.00		
		Installation of Slash	150	CY	$ 20.00	$ 3,000.00		
		Engineered Log Jams - Large Bank Roughening ELJ	**8**	**EA**	**$ 44,814.33**		**$ 358,514.62**	
		Structure Excavation	450	CY	$ 12.00	$ 5,400.00		$10 to excavate; $2 for backfill and compaction and grading. Assumed Excavation of 30 x 10 x 40
		Import Logs	17	EA	$ 600.00	$ 10,200.00		
		Installation of 24" dia, 40' long w/rootwad (R5)	4	EA	$ 260.00	$ 1,040.00		1 hrs of 2ea exc time at $120/hr plus haul from staging area at 10 minutes at $120/hr
		Installation of 18-24" dia, 25' long w/rootwad (R2)	6	EA	$ 260.00	$ 1,560.00		1 hrs of 2ea exc time at $120/hr plus haul from staging area at 10 minutes at $120/hr
		Installation of 16-24" dia, 25' long (L2)	2	EA	$ 260.00	$ 520.00		1 hrs of 2ea exc time at $120/hr plus haul from staging area at 10 minutes at $120/hr
		Installation of vertical logs	5	EA	$ 260.00	$ 1,300.00		
		Installation of Racking Logs - 8"-16" DBH, 15'-30' long	15	EA	$ 50.00	$ 750.00		assumes .5hrs of exc time at $120/hr plus haul from staging area at 10 minutes at $120/hr
		Installation of Slash	50	CY	$ 20.00	$ 1,000.00		assumes .5hrs of exc time at $120/hr plus haul from staging area at 10 minutes at $120/hr
		Installation of Topsoil	5	CY	$ 40.00	$ 200.00		
		Installation of Bark or Wood Chip Mulch	2	CY	$ 30.00	$ 60.00		
		Drilling,lashing and placing deadman rock anchors	12	EA	$ 500.00	$ 6,000.00		
		Ballast Rock	12	TN	$ 36.88	$ 442.56		
		Water Management	1	LS	$ 6,000.00	$ 6,000.00		
		Shoring or Extra Excavation for ELJ Structures	**8**	**EA**	**$ 4,992.00**		**$ 39,936.00**	assumes 40x40x12ft deep exc
		Bank Habitat Structure	**12**	**EA**	**$ 5,252.00**		**$ 63,024.00**	Assumes bank habitat structure placed every 100 feet. Specific items included in this bid should include all haul of materials from staging areas, excavation, hauling of excess material, clearing and restoration of laydown areas except as covered in planting bid items.
		Structure Excavation	50	CY	$ 12.00	$ 600.00		$6 to excavate; $2 for backfill and compaction and grading, $4 for water managment.
		Import Logs	4	EA	$ 600.00	$ 2,400.00		
		16-24" dia, 40' long w/rootwad	1	EA	$ 260.00	$ 260.00		1 hrs of 2ea exc time at $120/hr plus haul from staging area at 10 minutes at $120/hr
		16-24" dia, 30' long w/rootwad	3	EA	$ 260.00	$ 780.00		1 hrs of 2ea exc time at $120/hr plus haul from staging area at 10 minutes at $120/hr
		Bank Roughening Structure	**22**	**EA**	**$ 2,444.00**		**$ 53,768.00**	Assumes mid channel roughening structure placed every 100 feet. Specific items included in this bid should include all haul of materials from staging areas, excavation and structure assembly necessary for a complete system
		Structure Excavation	30	CY	$ 12.00	$ 360.00		$6 to excavate; $2 for backfill and compaction and grading, $4 for water managment. 5 x 4 x 25 (1.5x)
		Import Logs	2	EA	$ 500.00	$ 1,000.00		
		Installation of 12-24" dia, 25' long w/rootwad	1	EA	$ 260.00	$ 260.00		1 hrs of 2ea exc time at $120/hr plus haul from staging area at 10 minutes at $120/hr
		Installation of 12-24" dia, 25' long	1	EA	$ 260.00	$ 260.00		1 hrs of 2ea exc time at $120/hr plus haul from staging area at 10 minutes at $120/hr
		Mid-Channel Roughening Structure	**5**	**EA**	**$ 3,432.00**		**$ 17,160.00**	Assumes mid channel roughening structure placed every 100 feet. Specific items included in this bid should include all haul of materials from staging areas, excavation and structure assembly necessary for a complete system
		Structure Excavation	30	CY	$ 12.00	$ 360.00		$6 to excavate; $2 for backfill and compaction and grading, $4 for water managment.
		Import Logs	3	EA	$ 500.00	$ 1,500.00		
		Installation of 12-24" dia, 25' long w/rootwad	1	EA	$ 260.00	$ 260.00		1 hrs of 2ea exc time at $120/hr plus haul from staging area at 10 minutes at $120/hr
		Installation of 12-24" dia, 25' long	2	EA	$ 260.00	$ 520.00		1 hrs of 2ea exc time at $120/hr plus haul from staging area at 10 minutes at $120/hr
		Hydroseeding	**7**	**AC**	**$ 2,860.00**	**$ 21,164.00**	**$ 21,164.00**	Assumes area that is cleared and grubbed is hydroseeded
		Planting	**10**	**AC**	**$ 15,600.00**	**$156,000.00**	**$ 156,000.00**	
		Bark, Hog Fuel or Wood Chip Mulch	**535**	**CY**	**$ 15.60**		**$ 8,352.50**	Includes temporary access routes (18ft x 3200ft x 0.25ft) and incedental amount for staging area preparation as well as removal as needed
		Slash	**240**	**CY**	**$ 26.00**		**$ 6,240.00**	Apprximately 120 CY per ELJ.
		CSTC	**856**	**TON**	**$ 39.00**		**$ 33,384.00**	6" for 650' of existing trail from SR 20 to staging area. WSDOT unit bid.
		Streambed Gravel	**272**	**CY**	**$ 78.00**		**$ 21,231.60**	Assumes streambed cobble is placed 1ft thick x 6ft wide along half of the stream channel.
		Construction Subtotal					**$ 1,859,547.92**	
		Subtotal					$ 1,859,547.92	
		Tax (8.6%)					$ 159,921.12	
		Total (with +30% Contingency and Tax)					**$ 2,020,000.00**	

Engineering Construction Cost Estimate for Conceptual Design - Alternative 3

Project: Pressentin Park Side Channel Restoration
Project #: 14-05789-000
Client: Skagit Fisheries Enhancement Group (SFEG)

Date Modified: 3/12/2015
Spread sheet by: AS/MB
Checked by: GK
Checked Date: 3/12/2015

Alternative 3

Bid Item #	Spec Section	Item Description	Quantity	Unit	Unit Cost	Price	Total Price	Comments
		Mobilization	**1**	**LS**	**$ 297,939.61**		**$ 297,939.61**	8% of construction subtotal (Div 2 - Div 8 work items)
		Temporary Erosion and Sediment Control	**1**	**LS**	**$ 174,847.19**		**$ 174,847.19**	assumes 5% all other items. Does not include water management
		Traffic Control	**1**	**LS**	**$ 6,500.00**		**$ 6,500.00**	
		Stabilized Construction Entrance	**2**	**EA**	**$ 3,250.00**		**$ 6,500.00**	
		Site Clearing - Clearing and Grubbing and Stripping and Stockpiling of Topsoil	**8.5**	**AC**	**$ 9,100.00**		**$ 77,350.00**	Assumes channel area of 6.8 acres (100ft x 2950ft) and new access road area of 0.3 acres (18ft x 3200ft).
		Common Excavation and Fill Including Haul	**59000**	**CY**	**$ 24.70**		**$ 1,457,300.00**	Quantity from CAD. Includes control of water, removal, loading, hauling, and disposal, Assumes $6 exc+$4 haul+$7 disposal+$2 per cy for water management. Disposal cost from discussions with Robert Horbeck, owner of Casey's Pit quarry (located 2.3 miles from site).
		Relocated Trail	**1400**	**LF**	**$ 6.50**		**$ 9,100.00**	Assumes mowed grass (simular to existing) trail on south bank of side channel A no longer accessible after construction and requires relocation. Rough distances from CAD.
		Furnish and Install Pedestrian Bridges	**2**	**EA**	**$ 58,500.00**		**$ 117,000.00**	Contech ($26k deliv plus abutments).
		Furnish and Install Equipment Bridges	**1**	**EA**	**$ 110,500.00**		**$ 110,500.00**	Contech for 10ft wide $57k deliv + abutments.
		Flood Fence	**1**	**LS**	**$ 77,173.20**		**$ 77,173.20**	
		Import Log: 18-24" DBH, 25-40' long with rootwad	28	EA	$ 800.00	$ 22,400.00		
		Vertical Piles	46	EA	$ 600.00	$ 27,600.00		Estimated ~30/lf at ~15 ft depth, + pile cost
		Log haul and placement	28	EA	$ 138.00	$ 3,864.00		1 exc. 15 minute delivery r/t, place w/ 2 exc.s needed, 0.2 hour to place (2 Exc+op, laborer 0.2hr @ $150/hr)
		Installation of Racking Logs - 8"-16" DBH, 15'-30' long	50	EA	$ 50.00	$ 2,500.00		
		Installation of Slash	150	CY	$ 20.00	$ 3,000.00		
		Engineered Log Jams - Large Bank Roughening ELJ	**8**	**EA**	**$ 44,814.33**		**$ 358,514.62**	
		Structure Excavation	450	CY	$ 12.00	$ 5,400.00		$10 to excavate; $2 for backfill and compaction and grading. Assumed Excavation of 30 x 10 x 40
		Import Logs	17	EA	$ 600.00	$ 10,200.00		
		Installation of 24" dia, 40' long w/rootwad (R5)	4	EA	$ 260.00	$ 1,040.00		1 hrs of 2ea exc time at $120/hr plus haul from staging area at 10 minutes at $120/hr
		Installation of 18-24" dia, 25' long w/rootwad (R2)	6	EA	$ 260.00	$ 1,560.00		1 hrs of 2ea exc time at $120/hr plus haul from staging area at 10 minutes at $120/hr
		Installation of 16-24" dia, 25' long (L2)	2	EA	$ 260.00	$ 520.00		1 hrs of 2ea exc time at $120/hr plus haul from staging area at 10 minutes at $120/hr
		Installation of vertical logs	5	EA	$ 260.00	$ 1,300.00		
		Installation of Racking Logs - 8"-16" DBH, 15'-30' long	15	EA	$ 50.00	$ 750.00		assumes .5hrs of exc time at $120/hr plus haul from staging area at 10 minutes at $120/hr
		Installation of Slash	50	CY	$ 20.00	$ 1,000.00		assumes .5hrs of exc time at $120/hr plus haul from staging area at 10 minutes at $120/hr
		Installation of Topsoil	5	CY	$ 40.00	$ 200.00		
		Installation of Bark or Wood Chip Mulch	2	CY	$ 30.00	$ 60.00		
		Drilling,lashing and placing deadman rock anchors	12	EA	$ 500.00	$ 6,000.00		
		Ballast Rock	12	TN	$ 36.88	$ 442.56		
		Water Management	1	LS	$ 6,000.00	$ 6,000.00		
		Shoring or Extra Excavation for ELJ Structures	**8**	**EA**	**$ 4,992.00**		**$ 39,936.00**	assumes 40x40x12ft deep exc
		Bank Habitat Structure	**18**	**EA**	**$ 5,252.00**		**$ 94,536.00**	Assumes bank habitat structure placed every 100 feet. Specific items included in this bid should include all haul of materials from staging areas, excavation, hauling of excess material, clearing and restoration of laydown areas except as covered in planting bid items.
		Structure Excavation	50	CY	$ 12.00	$ 600.00		$6 to excavate; $2 for backfill and compaction and grading, $4 for water managment.
		Import Logs	4	EA	$ 600.00	$ 2,400.00		
		Installation 16-24" dia, 40' long w/rootwad	1	EA	$ 260.00	$ 260.00		1 hrs of 2ea exc time at $120/hr plus haul from staging area at 10 minutes at $120/hr
		Installation 16-24" dia, 30' long w/rootwad	3	EA	$ 260.00	$ 780.00		1 hrs of 2ea exc time at $120/hr plus haul from staging area at 10 minutes at $120/hr
		Bank Roughening Structure	**25**	**EA**	**$ 2,444.00**		**$ 61,100.00**	Assumes mid channel roughening structure placed every 100 feet. Specific items included in this bid should include all haul of materials from staging areas, excavation and structure assembly necessary for a complete system
		Structure Excavation	30	CY	$ 12.00	$ 360.00		$6 to excavate; $2 for backfill and compaction and grading, $4 for water managment. 5 x 4 x 25 (1.5x)
		Import Logs	2	EA	$ 500.00	$ 1,000.00		
		Installation of 12-24" dia, 25' long w/rootwad	1	EA	$ 260.00	$ 260.00		1 hrs of 2ea exc time at $120/hr plus haul from staging area at 10 minutes at $120/hr
		Installation of 12-24" dia, 25' long	1	EA	$ 260.00	$ 260.00		1 hrs of 2ea exc time at $120/hr plus haul from staging area at 10 minutes at $120/hr
		Mid-Channel Roughening Structure	**6**	**EA**	**$ 3,432.00**		**$ 20,592.00**	Assumes mid channel roughening structure placed every 100 feet. Specific items included in this bid should include all haul of materials from staging areas, excavation and structure assembly necessary for a complete system
		Structure Excavation	30	CY	$ 12.00	$ 360.00		$6 to excavate; $2 for backfill and compaction and grading, $4 for water managment.
		Import Logs	3	EA	$ 500.00	$ 1,500.00		
		Installation of 12-24" dia, 25' long w/rootwad	1	EA	$ 260.00	$ 260.00		1 hrs of 2ea exc time at $120/hr plus haul from staging area at 10 minutes at $120/hr
		Installation of 12-24" dia, 25' long	2	EA	$ 260.00	$ 520.00		1 hrs of 2ea exc time at $120/hr plus haul from staging area at 10 minutes at $120/hr
		Hydroseeding	**9**	**AC**	**$ 2,860.00**	**$ 24,310.00**	**$ 24,310.00**	Assumes area that is cleared and grubbed is hydroseeded
		Planting	**10**	**AC**	**$ 15,600.00**	**$156,000.00**	**$ 156,000.00**	
		Bark, Hog Fuel or Wood Chip Mulch	**535**	**CY**	**$ 15.60**		**$ 8,352.50**	Includes temporary access routes (18ft x 3200ft x 0.25ft) and incedental amount for staging area preparation as well as removal as needed
		CSTC	**856**	**TON**	**$ 39.00**		**$ 33,384.00**	6" for 650' of existing trail from SR 20 to staging area. WSDOT unit bid.
		Slash	**240**	**CY**	**$ 26.00**		**$ 6,240.00**	Apprximately 120 CY per ELJ.
		Streambed Gravel	**328**	**CY**	**$ 78.00**		**$ 25,568.40**	Assumes streambed cobble is placed 1ft thick x 6ft wide along half of the stream channel.
		Construction Subtotal					**$ 2,689,956.72**	
		Subtotal (with +30% Contingency)					$ 2,689,956.72	
		Tax (8.6%)					$ 231,336.28	
		Total (with +30% Contingency and Tax)					**$ 2,930,000.00**	

Engineering Construction Cost Estimate for Conceptual Design - Preferred Alternative

Project: **Pressentin Park Side Channel Restoration**
Project #: **14-05789-000**
Client: **Skagit Fisheries Enhancement Group (SFEG)**

Date Modified: 3/12/2015
Spread sheet by: AS/MB
Checked by: GK
Checked Date: 3/12/2015

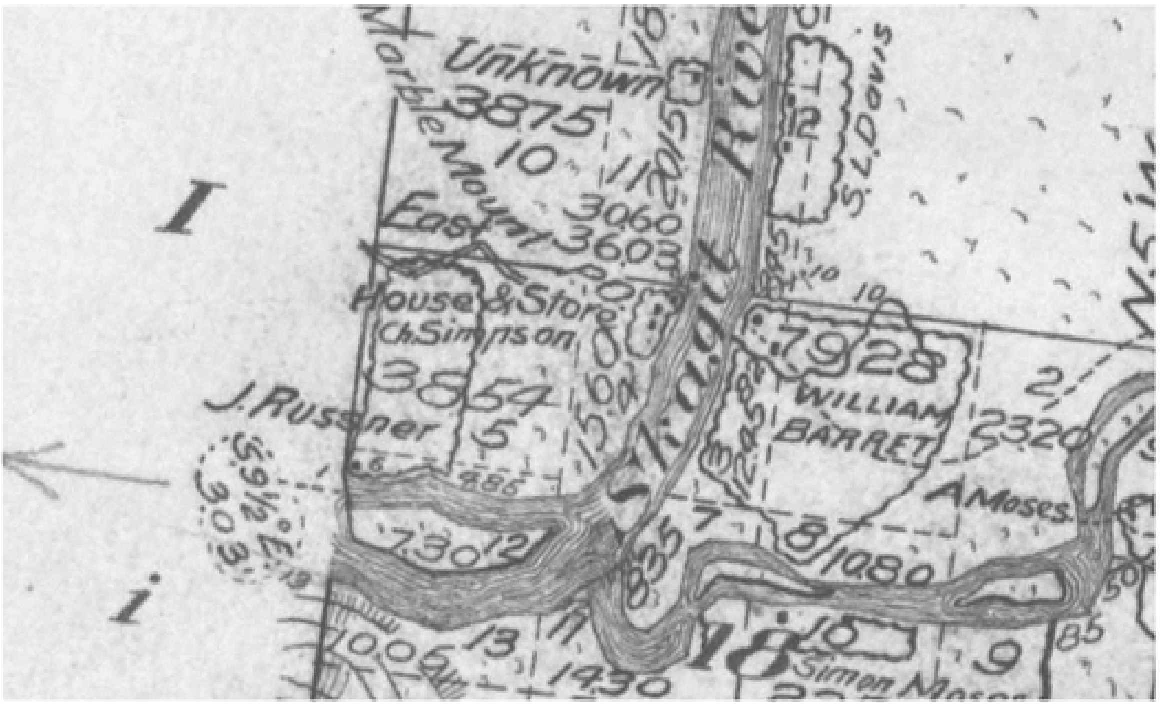
Alternative 4 (Preferred Alternative)

Bid Item #	Spec Section	Item Description	Quantity	Unit	Unit Cost	Price	Total Price	Comments
		Mobilization	**1**	**LS**	**$ 231,232.46**		**$ 231,232.46**	8% of construction subtotal (Div 2 - Div 8 work items)
		Temporary Erosion and Sediment Control	**1**	**LS**	**$ 135,699.80**		**$ 135,699.80**	assumes 5% all other items. Does not include water management
		Traffic Control	**1**	**LS**	**$ 6,500.00**		**$ 6,500.00**	
		Stabilized Construction Entrance	**2**	**EA**	**$ 3,250.00**		**$ 6,500.00**	
		Site Clearing - Clearing and Grubbing and Stripping and Stockpiling of Topsoil	**7.4**	**AC**	**$ 9,100.00**		**$ 67,340.00**	Assumes channel area of 6.8 acres (100ft x 2450ft) and new access road area of 0.3 acres (18ft x 3200ft).
		Common Excavation and Fill Including Haul	**38000**	**CY**	**$ 24.70**		**$ 938,600.00**	Quantity from CAD. Includes control of water, removal, loading, hauling, and disposal, Assumes $6 exc+$4 haul+$7 disposal+$2 per cy for water management. Disposal cost from discussions with Robert Horbeck, owner of Casey's Pit quarry (located 2.3 miles from site).
		Relocated Trail	**1400**	**LF**	**$ 6.50**		**$ 9,100.00**	Assumes mowed grass (simular to existing) trail on south bank of side channel A no longer accessible after construction and requires relocation. Rough distances from CAD.
		Furnish and Install Pedestrian Bridges	**2**	**EA**	**$ 58,500.00**		**$ 117,000.00**	Contech ($26k deliv plus abutments).
		Furnish and Install Equipment Bridges	**1**	**EA**	**$ 110,500.00**		**$ 110,500.00**	Contech for 10ft wide $57k deliv + abutments.
		Flood Fence	**1**	**LS**	**$ 77,173.20**		**$ 77,173.20**	
		Import Log: 18-24" DBH, 25-40' long with rootwad	28	EA	$ 800.00	$ 22,400.00		
		Vertical Piles	46	EA	$ 600.00	$ 27,600.00		Estimated ~30/lf at ~15 ft depth, + pile cost
		Log haul and placement	28	EA	$ 138.00	$ 3,864.00		1 exc. 15 minute delivery r/t, place w/ 2 exc.s needed, 0.2 hour to place (2 Exc+op, laborer 0.2hr @ $150/hr)
		Installation of Racking Logs - 8"-16" DBH, 15'-30' long	50	EA	$ 50.00	$ 2,500.00		
		Installation of Slash	150	CY	$ 20.00	$ 3,000.00		
		Engineered Log Jams - Large Bank Roughening ELJ	**8**	**EA**	**$ 44,814.33**		**$ 358,514.62**	
		Structure Excavation	450	CY	$ 12.00	$ 5,400.00		$10 to excavate; $2 for backfill and compaction and grading. Assumed Excavation of 30 x 10 x 40
		Import Logs	17	EA	$ 600.00	$ 10,200.00		
		Installation of 24" dia, 40' long w/rootwad (R5)	4	EA	$ 260.00	$ 1,040.00		1 hrs of 2ea exc time at $120/hr plus haul from staging area at 10 minutes at $120/hr
		Installation of 18-24" dia, 25' long w/rootwad (R2)	6	EA	$ 260.00	$ 1,560.00		1 hrs of 2ea exc time at $120/hr plus haul from staging area at 10 minutes at $120/hr
		Installation of 16-24" dia, 25' long (L2)	2	EA	$ 260.00	$ 520.00		1 hrs of 2ea exc time at $120/hr plus haul from staging area at 10 minutes at $120/hr
		Installation of vertical logs	5	EA	$ 260.00	$ 1,300.00		
		Installation of Racking Logs - 8"-16" DBH, 15'-30' long	15	EA	$ 50.00	$ 750.00		assumes .5hrs of exc time at $120/hr plus haul from staging area at 10 minutes at $120/hr
		Installation of Slash	50	CY	$ 20.00	$ 1,000.00		assumes .5hrs of exc time at $120/hr plus haul from staging area at 10 minutes at $120/hr
		Installation of Topsoil	5	CY	$ 40.00	$ 200.00		
		Installation of Bark or Wood Chip Mulch	2	CY	$ 30.00	$ 60.00		
		Drilling,lashing and placing deadman rock anchors	12	EA	$ 500.00	$ 6,000.00		
		Ballast Rock	12	TN	$ 36.88	$ 442.56		
		Water Management	1	LS	$ 6,000.00	$ 6,000.00		
		Shoring or Extra Excavation for ELJ Structures	**8**	**EA**	**$ 4,992.00**		**$ 39,936.00**	assumes 40x40x12ft deep exc
		Bank Habitat Structure	**12**	**EA**	**$ 5,252.00**		**$ 63,024.00**	Assumes bank habitat structure placed every 100 feet. Specific items included in this bid should include all haul of materials from staging areas, excavation, hauling of excess material, clearing and restoration of laydown areas except as covered in planting bid items.
		Structure Excavation	50	CY	$ 12.00	$ 600.00		$6 to excavate; $2 for backfill and compaction and grading, $4 for water managment.
		Import Logs	4	EA	$ 600.00	$ 2,400.00		
		16-24" dia, 40' long w/rootwad	1	EA	$ 260.00	$ 260.00		1 hrs of 2ea exc time at $120/hr plus haul from staging area at 10 minutes at $120/hr
		16-24" dia, 30' long w/rootwad	3	EA	$ 260.00	$ 780.00		1 hrs of 2ea exc time at $120/hr plus haul from staging area at 10 minutes at $120/hr
		Bank Roughening Structure	**22**	**EA**	**$ 2,444.00**		**$ 53,768.00**	Assumes mid channel roughening structure placed every 100 feet. Specific items included in this bid should include all haul of materials from staging areas, excavation and structure assembly necessary for a complete system
		Structure Excavation	30	CY	$ 12.00	$ 360.00		$6 to excavate; $2 for backfill and compaction and grading, $4 for water managment. 5 x 4 x 25 (1.5x)
		Import Logs	2	EA	$ 500.00	$ 1,000.00		
		Installation of 12-24" dia, 25' long w/rootwad	1	EA	$ 260.00	$ 260.00		1 hrs of 2ea exc time at $120/hr plus haul from staging area at 10 minutes at $120/hr
		Installation of 12-24" dia, 25' long	1	EA	$ 260.00	$ 260.00		1 hrs of 2ea exc time at $120/hr plus haul from staging area at 10 minutes at $120/hr
		Mid-Channel Roughening Structure	**6**	**EA**	**$ 3,432.00**		**$ 20,592.00**	Assumes mid channel roughening structure placed every 100 feet. Specific items included in this bid should include all haul of materials from staging areas, excavation and structure assembly necessary for a complete system
		Structure Excavation	30	CY	$ 12.00	$ 360.00		$6 to excavate; $2 for backfill and compaction and grading, $4 for water managment.
		Import Logs	3	EA	$ 500.00	$ 1,500.00		
		Installation of 12-24" dia, 25' long w/rootwad	1	EA	$ 260.00	$ 260.00		1 hrs of 2ea exc time at $120/hr plus haul from staging area at 10 minutes at $120/hr
		Installation of 12-24" dia, 25' long	2	EA	$ 260.00	$ 520.00		1 hrs of 2ea exc time at $120/hr plus haul from staging area at 10 minutes at $120/hr
		Hydroseeding	**7**	**AC**	**$ 2,860.00**	**$ 21,164.00**	**$ 21,164.00**	Assumes area that is cleared and grubbed is hydroseeded
		Planting	**10**	**AC**	**$ 15,600.00**	**$ 156,000.00**	**$ 156,000.00**	
		Bark, Hog Fuel or Wood Chip Mulch	**535**	**CY**	**$ 15.60**		**$ 8,352.50**	Includes temporary access routes (18ft x 3200ft x 0.25ft) and incedental amount for staging area preparation as well as removal as needed
		CSTC	**318**	**TON**	**$ 39.00**		**$ 12,393.33**	6" for 650' of existing trail from SR 20 to staging area. WSDOT unit bid.
		Streambed Gravel	**272**	**CY**	**$ 78.00**		**$ 21,231.60**	Assumes streambed cobble is placed 1ft thick x 6ft wide along half of the stream channel.
		Construction Subtotal					**$ 2,087,689.26**	
		Subtotal					$ 2,087,689.26	
		Tax (8.6%)					$ 179,541.28	
		Total					**$ 2,270,000.00**	

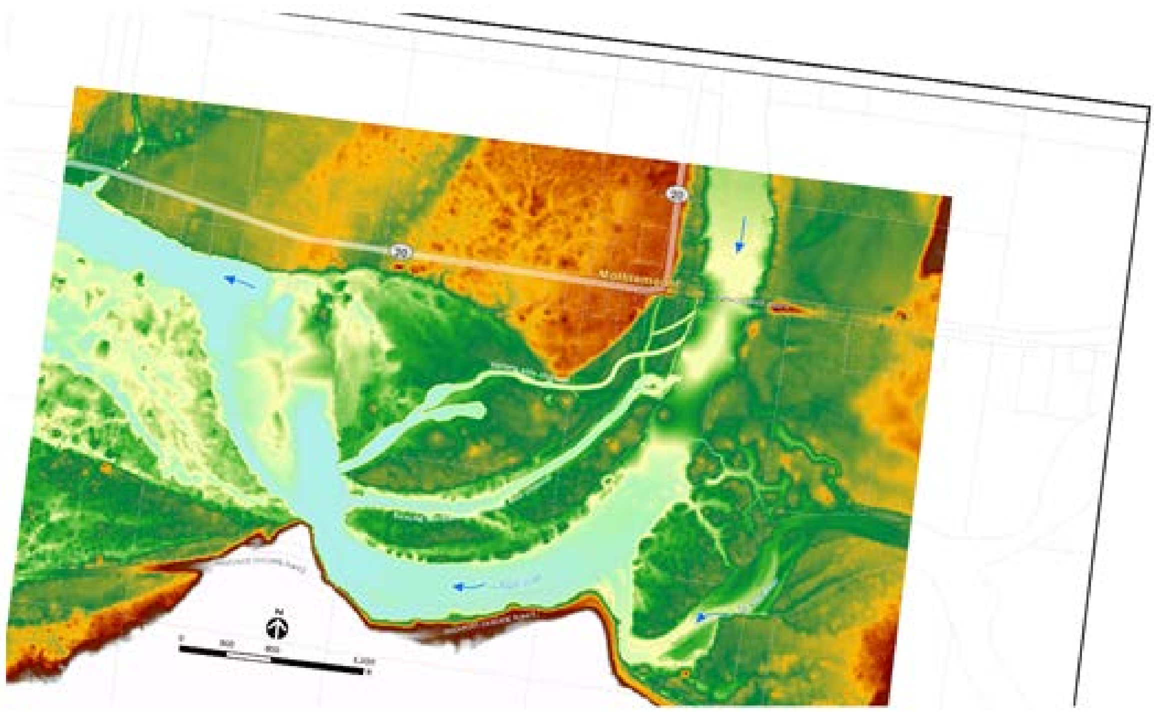
APPENDIX B

Geomorphic Analysis Images

Historical Maps and Aerial Images



1894 GLO Map (NTS)



LIDAR Topography (2006)

1947 (NTS)

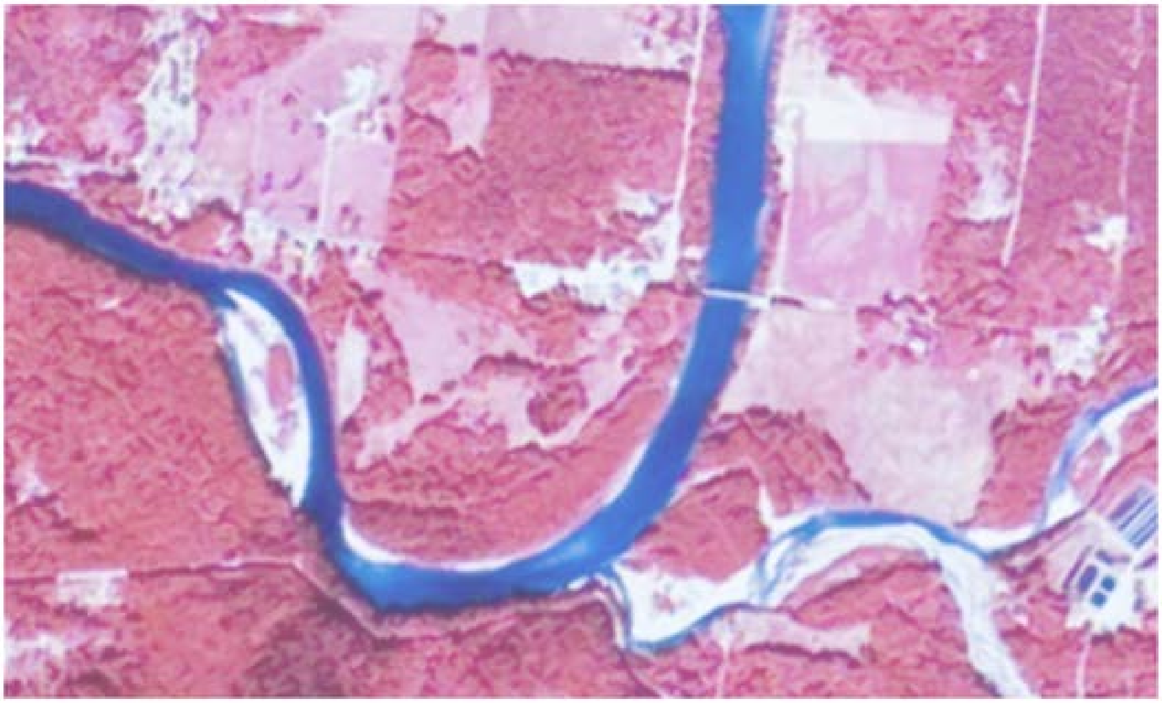
1950 (NTS)

1953 (NTS)

1963 (NTS)

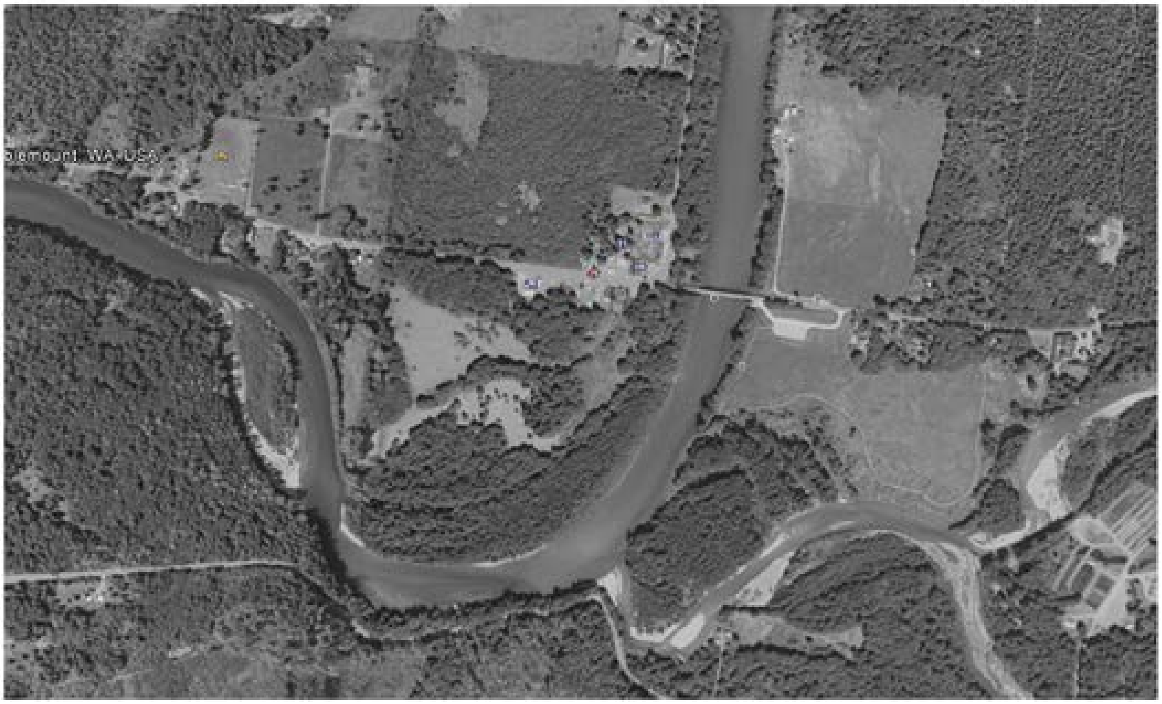
1974 (NTS)

1979 (NTS)



1994 (NTS)

1998 (NTS)



2003 (NTS)

2005 (NTS)

2006 (NTS)

2009 (NTS)

2011 (NTS)

2013 (NTS)

APPENDIX C

Photographic Documentation

Photographic Documentation: Pressentin Park Side Channel to the Skagit River, Marblemount, Washington, June 3, 2014

Photo Number	Photo Description
1	Excavator at Test Pit 1
2	Excavator at Test Pit 3, view 1 (12:44 p.m.)
3	Excavator at Test Pit 3, view 2 (1:54 p.m.)
4	Grassy Meadow with Mowed Path, view 1 (12:44 p.m.)
5	Grassy Meadow with Mowed Path, view 2 (12:45 p.m.)
6	Groundwater Expression in Historical Side-Channel
7	Marblemount Slough Inlet
8	Marblemount Slough LWD
9	Marblemount Slough Near Inlet
10	Marblemount Slough Outlet 1
11	Marblemount Slough Outlet 2
12	Marblemount Slough Outlet 3
13	Marblemount Slough, view 1 (10:45 a.m.)
14	Marblemount Slough, view 2 (10:48 a.m.)
15	Piezometer at Test Pit 1
16	Piezometer at Test Pit 3
17	Test Pit 3 Spoils, view 1 (1:55 p.m.)
18	Test Pit 4

1

2

3


06/03/2014 12:44
4


06/03/2014 12:45
5


06/03/2014 10:04
6


06/03/2014 10:48
7

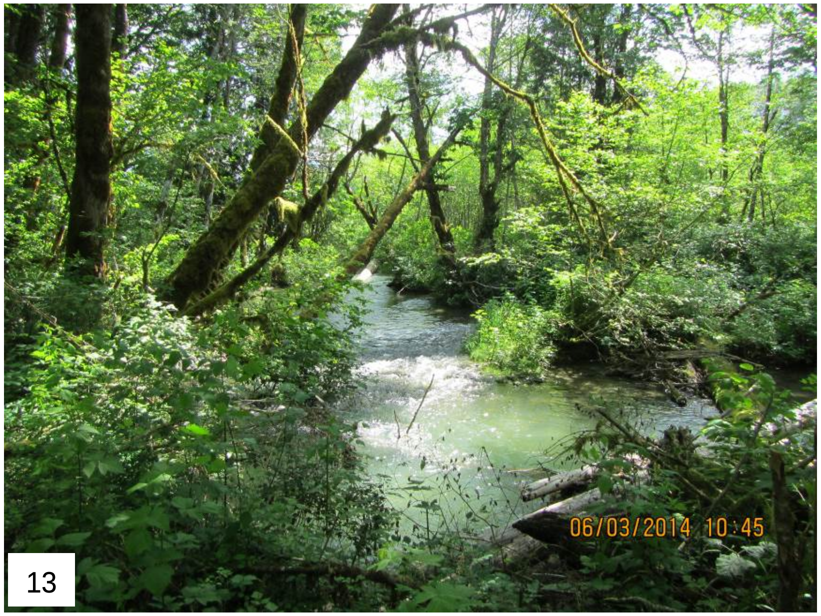
8

9

10

11

12



13

14

15

16

17

18

APPENDIX D

Survey

NOTES:

1. MERIDIAN: NAD 83/11 WASHINGTON STATE PLANE COORDINATES NORTH ZONE.
2. DATUM: NAVD88, FROM W.S.D.O.T. MONUMENT ID: 7148, ELEVATION = 320.95 FEET, AND MONUMENT ID: 7149, ELEVATION = 323.53 FEET.

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SEMRAU ENGINEERING & SURVEYING, PLLC
CIVIL ENGINEERING • LAND SURVEYING • PLANNING
2118 RIVERSIDE DRIVE – SUITE 208
MOUNT VERNON, WA 98273
360-424-9566

JOHN B. SEMRAU
STATE OF WASHINGTON
28626
REGISTERED
PROFESSIONAL LAND SURVEYOR

NO.	DATE	REVISION	BY	REV.

TOPOGRAPHIC SURVEY POINT DATA

SCALES:
HORIZONTAL : 1" = 160'
VERTICAL : N/A

NOTE: IF THIS SHEET IS LESS THAN 22"x 34" THEN SHEET HAS BEEN REDUCED

PRESSENTINE PARK TOPOGRAPHIC SURVEY

SECTION 18, T. 35 N., R. 11 E., W.M.
SKAGIT COUNTY, WASHINGTON

FIELD BOOK/PG.:	LL/1-39
DATE:	10/31/14
DRAWING:	5276AERIAL
JOB NO.:	5276
SHEET:	1 OF 1

APPENDIX E

Alternatives Scoring Matrix

Pressentin Alternatives Matrix (DRAFT)

Score Color Code:

0	1	2	3	4	5
Negative or No Effect			Good		Excellent

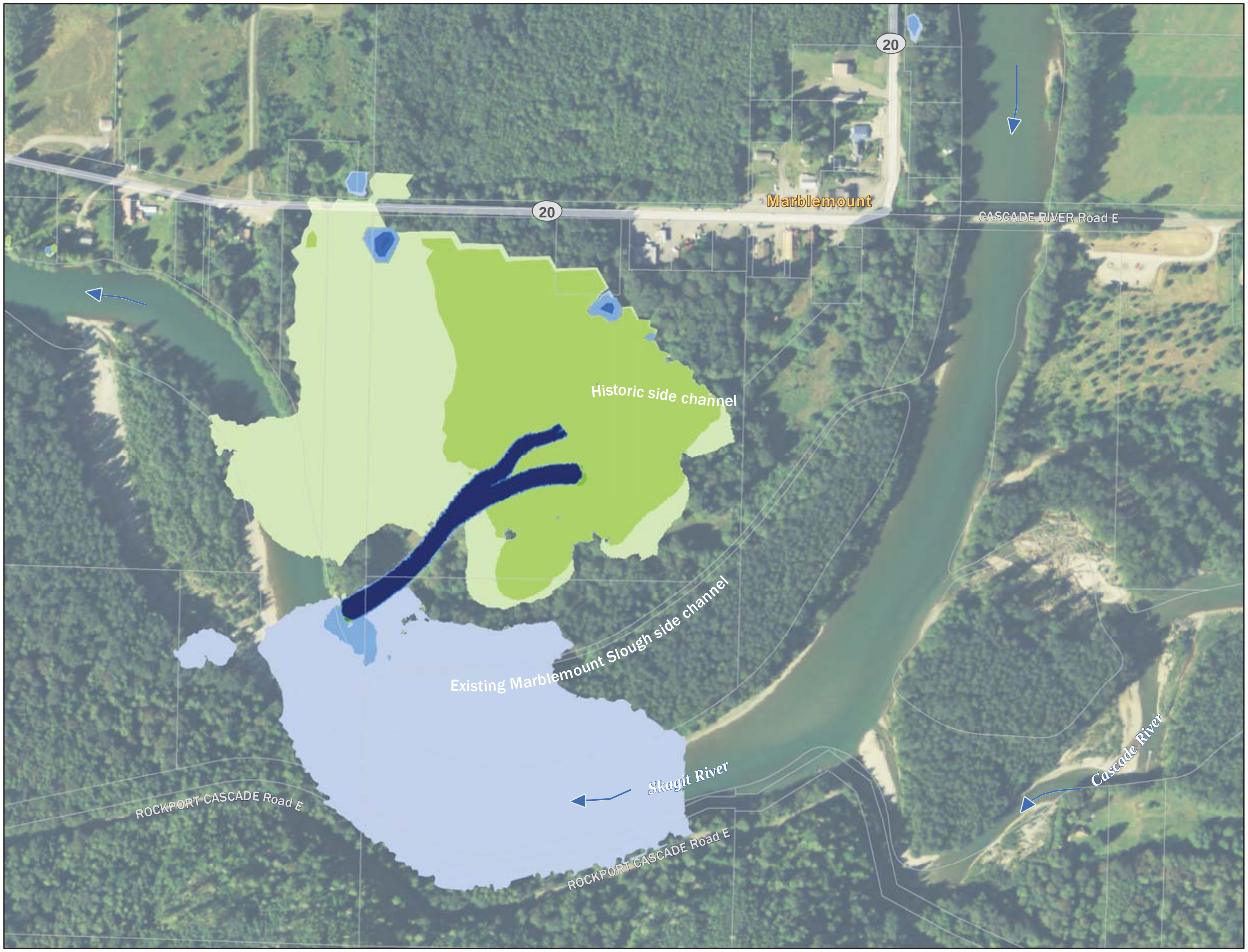
Evaluation Criteria	Geomorphic Response	Sustainability of Hydraulic Connectivity	Hyporheic/hydrologic Response	High Flow Rearing Habitat (Chinook/Coho)	Low Flow Rearing (Coho)	Low Flow Rearing (Stream-Type Chinook/Steelhead)	Low Flow Rearing Habitat	Flood Refugia	Spawning Habitat (Non Chum Species)	Spawning Habitat (Chum)	Groundwater Alteration	Existing Side Channel Alteration	Mainstem Channel Capture	Risk To Property	Construction	Design		Total Score
Alternative	Enhancing Processes – Expected Effectiveness			Enhancing Habitat Functions							Risk (high number = low risk)				Cost			
1 - Backwater Slough	1	4	2	3	2	2	2	3	0	1	3	5	5	4	5	5	Alt 1	2.94
2 - Inlet and Outlet Connection	4	3	4	4	4	4	4	4	4	4	3	3	3	3	3	3	Alt 2	3.56
3 - Inlet and Outlet Connection, Wetland Benches, Blind Sloughs	4	3	4	5	5	4	5	5	3	4	2	3	3	3	2	2	Alt 3	3.56
4 - Inlet and Outlet Connection, Wetland Benches	4	4	4	5	4	4	4	4	4	4	3	3	2	3	3	3	Alt 4	3.63

Alternative	Enhancing Processes – Expected Effectiveness	Enhancing Habitat Functions	Risk (high number = low risk)	Cost
1 - Backwater Slough	Geomorphic Response Low capacity to sort/transport sediment. Moderate susceptibility to fine sediment deposition from Skagit River flows. Hyporheic/Hydrologic Response Little to no potential. to enhance hyporheic flow in constructed channel. Sustainability of Hydraulic Connectivity Little expected sediment source from main stem.	High Flow Rearing Habitat (Chinook/coho) Limited use, likely only for juvenile fish "pushed" into the slough during high flow events. Low Flow Rearing (coho) Limited use due to lack of access. Low Flow Rearing (stream-type Chinook/steelhead) Limited use due to lack of access; could delay outmigration. Low Flow Rearing Habitat Limited use due to lack of access; could delay outmigration; could trap some fish species. Flood Refugia Limited use, likely only for juvenile fish "pushed" into the slough during flooding events. Spawning Habitat (non chum species) Could have limited access; may not provide spawning habitat. Spawning Habitat (chum) Could have limited access; may not provide spawning habitat.	Groundwater Alteration Higher risk because not introducing flows to channel that may elevate water table. Existing Side Channel Alteration Lowest risk because no alteration near inlet. Main Stem Channel Capture Low risk with no inlet being constructed. Risk to Property Very low potential to affect left bank properties downstream of outlet. Very low potential to affect terrace edge stability at parcels P120473, P46185.	Construction Low complexity construction with only one mainstem contact, fewer bridges. Design Low complexity design elements, fewer bridges.
2 - Inlet and Outlet Connection	Geomorphic Response Adequate capacity to sort/transport sediment. Low susceptibility to fine sediment deposition from Skagit River flows. Hydraulic Connectivity High potential to enhance hyporheic flow in constructed channel by introducing flow and using grade controls to keep water levels elevated. Inlet Outlet Hydraulic Connectivity Outlet more susceptible to filling.	High Flow Rearing habitat (Chinook/coho) Access and, so use, will mostly depend on inlet design. Flow through increases access opportunities. Low Flow Rearing (coho) Assumes lack of upstream inlet access. High hyporheic connectivity provides good rearing habitat. Low Flow Rearing (stream-type Chinook/steelhead) Assumes lack of upstream inlet access. High hyporheic connectivity provides good rearing habitat and prevents outmigration delays. Low Flow Rearing Habitat High hyporheic connectivity provides good rearing habitat. Flood Refugia While it may provide some flood refugia, the potential flow-through nature of the channel may limit such function. More likely to function as a side channel during flooding events. Spawning Habitat (non chum species) Good spawning habitat potential. Spawning Habitat (chum) Good potential spawning habitat.	Groundwater Alteration Low risk because introducing flows to channel that may elevate water table. Existing Side Channel Alteration Moderate risk because bank alteration relatively near inlet. Main Stem Channel Capture Inlet being constructed (needs to have ELJs to limit this risk). Risk to Property Low potential to affect left bank properties downstream of outlet. Moderate potential to affect terrace edge stability at parcels 120473, 46185 through potential meandering of inlet channel.	Construction Medium complexity construction with two main stem contact, flow through, multiple bridges. Design Moderate complexity design elements, multiple bridges.
3 - Inlet and Outlet Connection, Wetland Benches, Blind Sloughs	Geomorphic Response Adequate capacity to sort/transport in situ sediment. Low/moderate susceptibility to fine sediment deposition from Skagit River flows. Hydraulic Connectivity High potential to enhance hyporheic flow in constructed channel by introducing flow and using grade controls to keep water levels elevated. Sustainability of Hydraulic Connectivity Similar risk as Alternative 2.	High Flow Rearing Habitat (Chinook/coho) Access, and thus use, will mostly depend on inlet design. Flow through increases access opportunities. Wetland benches provide edge habitat. Low Flow Rearing (coho) Assumes lack of upstream inlet access. High hyporheic connectivity provides good rearing habitat. Slough provides additional rearing habitat. Low Flow Rearing (stream-type Chinook/steelhead) Assumes lack of upstream inlet access. High hyporheic connectivity provides good rearing habitat and prevents outmigration delays. Low Flow Rearing Habitat High hyporheic connectivity provides good rearing habitat. Slough provide additional rearing area. Flood Refugia More likely to function as a side channel during flooding events. However, potential flow-through nature of the channel gets minimized by the wetland benches, which provide edge habitat. Spawning Habitat (non chum species) Good spawning habitat potential. Spawning Habitat (chum) Good potential spawning habitat.	Groundwater Alteration Low risk because introducing flows to channel that may elevate water table Existing Side Channel Alteration Moderate risk because bank alteration relatively near inlet Mainstem Channel Capture inlet being constructed (needs to have ELJs to limit this risk) Risk to Property Low potential to affect left bank properties downstream of outlet Moderate potential to affect terrace edge stability at parcels 120473, 46185 through potential meandering of inlet channel	Construction higher complexity construction with two mainstem contact, sloughs and benches flow through, multiple bridges. Design moderate complexity design elements,, multiple bridges,
4 - Inlet and Outlet Connection, Wetland Benches	Geomorphic Response Adequate capacity to sort/transport in situ sediment Low/moderate susceptibility to fine sediment deposition from Skagit River flows. Hydraulic Connectivity High potential to enhance hyporheic flow in constructed channel by introducing flow and using grade controls to keep water levels elevated. Sustainability of Hydraulic Connectivity Similar risk as Alternative 2.	High Flow Rearing Habitat (Chinook/coho) Access, and thus use, will mostly depend on inlet design. Flow through increases access opportunities. Wetland benches provide edge habitat. Low Flow Rearing (coho) Assumes lack of upstream inlet access. High hyporheic connectivity provides good rearing habitat. Slough provides additional rearing habitat. Low Flow Rearing (stream-type Chinook/steelhead) Assumes lack of upstream inlet access. High hyporheic connectivity provides good rearing habitat and prevents outmigration delays. Low Flow Rearing Habitat High hyporheic connectivity provides good rearing habitat. Slough provide additional rearing area. Flood Refugia More likely to function as a side channel during flooding events. However, potential flow-through nature of the channel gets minimized by the wetland benches, which provide edge habitat. Spawning Habitat (non chum species) Good spawning habitat potential. Spawning Habitat (chum) Good potential spawning habitat.	Groundwater Alteration Low risk because introducing flows to channel that may elevate water table. Existing Side Channel Alteration Moderate risk because bank alteration relatively near inlet. Main Stem Channel Capture Inlet being constructed (needs to have ELJs to limit this risk). Risk to Property Low potential to affect left bank properties downstream of outlet. Moderate potential to affect terrace edge stability at parcels 120473, 46185 through potential meandering of inlet channel.	Construction Higher complexity construction with two main stem contact, sloughs and benches flow through, multiple bridges. Design Moderate complexity design elements, multiple bridges.

APPENDIX F

Hydraulic Modeling Results

Figure 31.
Alternative 1: 100-yr Proposed Depth Difference.



Legend

Parcel

Depth Difference (ft)

Reduction in flooding depth (ft)	< -2	
	-2 to -1.5	
	-1.5 to -1	
	-1 to -0.5	
	-0.5 to -0.05	
	-0.05 to -0.02	
	-0.02 to 0.02 (no color)	
Increase in flooding depth (ft)	0.02 to 0.05	
	0.05 to 0.5	
	0.5 to 1	
	1 to 1.5	
	1.5 to 2	
	> 2	

N

0 175 350 700 ft

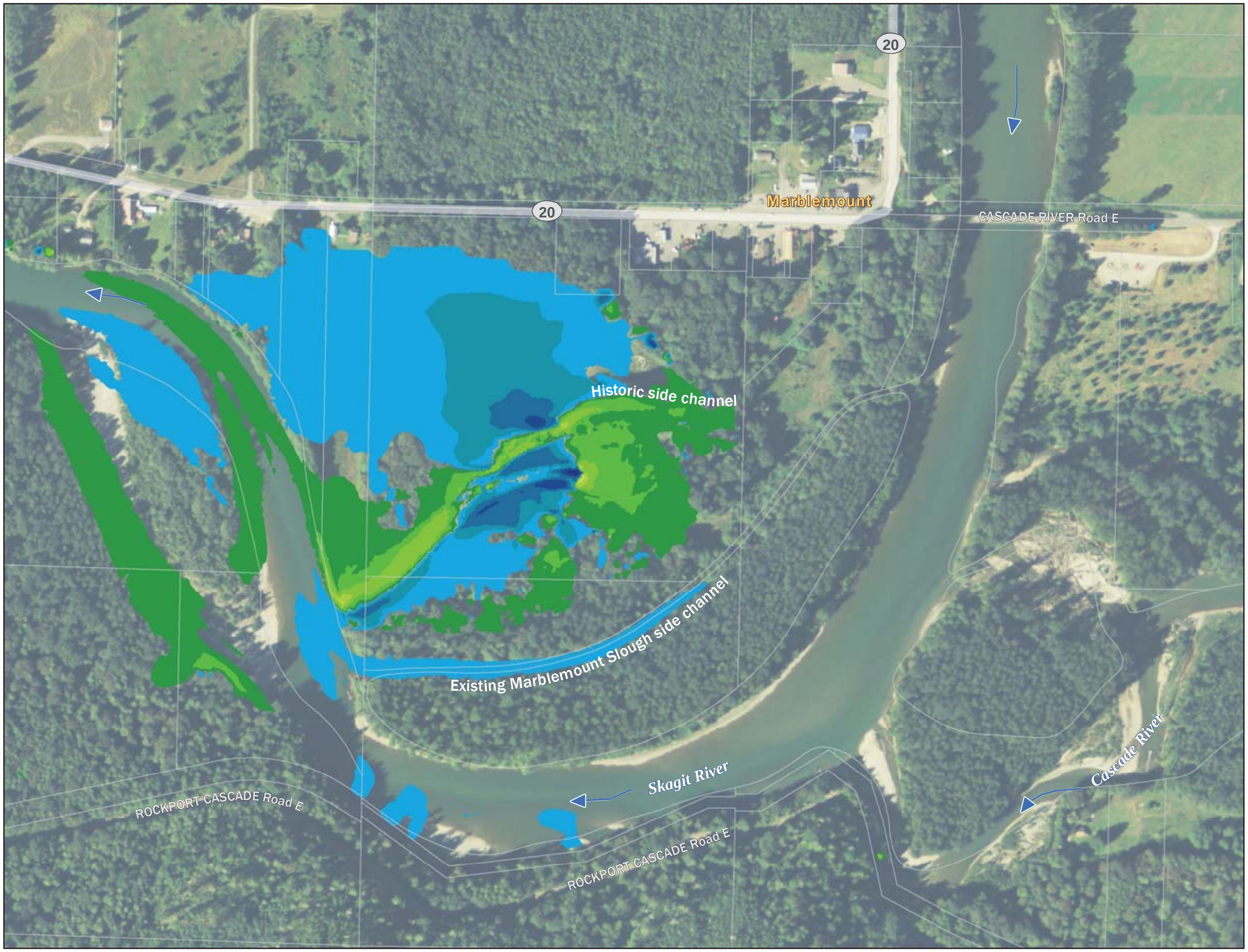
HERRERA

NAD 1983 HARN
Washington State Plane North FIPS 4601 Feet

USDA, Aerial (2013); Skagit County, Parcels (2012)

Project: K:\Projects\Y2014\14-05789-000\Project\Conceptual_Rest_Alt_Analysis\Appendix\alternatives_prop_depth_diff_100yr.mxd (3/12/2015)

Figure 32.
Alternative 1: 100-yr
Velocity Difference.



Legend

Parcel

Velocity Difference (ft/sec)

Reduction in flood water velocity:
- < -3
- -3 to -2
- -2 to -1
- -1 to -0.5
- -0.5 to -0.25
- -0.25 to -0.05

-0.05 to 0.05 (no color)

Increase in flood water velocity:
- 0.05 to 0.25
- 0.25 to 0.5
- 0.5 to 1
- 1 to 2
- 2 to 3
- > 3

N

0 175 350 700 ft

HERRERA

NAD 1983 HARN
Washington State Plane North FIPS 4601 Feet

USDA, Aerial (2013); Skagit County, Parcels (2012)

Figure 33.
Alternative 1: 2-yr
Proposed Depth Difference.

Legend

Parcel

Depth Difference (ft)

Reduction in flooding depth (ft)
- < -2
- -2 to -1.5
- -1.5 to -1
- -1 to -0.5
- -0.5 to -0.05
- -0.05 to -0.02

-0.02 to 0.02 (no color)

Increase in flooding depth (ft)
- 0.02 to 0.05
- 0.05 to 0.5
- 0.5 to 1
- 1 to 1.5
- 1.5 to 2
- > 2

N

0 175 350 700 ft

HERRERA

NAD 1983 HARN
Washington State Plane North FIPS 4601 Feet

USDA, Aerial (2013); Skagit County, Parcels (2012)

Project: K:\Projects\Y2014\14-05789-000\Project\Conceptual_Rest_Alt_Analysis\Appendix\alternatives_prop_depth_diff_002yr.mxd (3/12/2015)

Figure 34.
Alternative 1: 2-yr
Velocity Difference.

Legend

Parcel

Velocity Difference (ft/sec)

Reduction in flood water velocity
- < -3
- -3 to -2
- -2 to -1
- -1 to -0.5
- -0.5 to -0.25
- -0.25 to -0.05

-0.05 to 0.05 (no color)

Increase in flood water velocity
- 0.05 to 0.25
- 0.25 to 0.5
- 0.5 to 1
- 1 to 2
- 2 to 3
- > 3

N

0 175 350 700 ft

HERRERA

NAD 1983 HARN
Washington State Plane North FIPS 4601 Feet

USDA, Aerial (2013); Skagit County, Parcels (2012)

Project: K:\Projects\Y2014\14-05789-000\Project\Conceptual_Rest_Alt_Analysis\Appendix\alternatives_velocity_diff_002yr.mxd (3/12/2015)

Figure 35.
Alternative 1: 7,600 cfs
Proposed Depth Difference.

Legend

Parcel

Depth Difference (ft)

Reduction in flooding depth (ft)
- < -2
- -2 to -1.5
- -1.5 to -1
- -1 to -0.5
- -0.5 to -0.05
- -0.05 to -0.02

-0.02 to 0.02 (no color)

Increase in flooding depth (ft)
- 0.02 to 0.05
- 0.05 to 0.5
- 0.5 to 1
- 1 to 1.5
- 1.5 to 2
- > 2

N

0 175 350 700 ft

HERRERA

NAD 1983 HARN
Washington State Plane North FIPS 4601 Feet

USDA, Aerial (2013); Skagit County, Parcels (2012)

Figure 36.
Alternative 1: 7,600 cfs
Velocity Difference.

Legend

Parcel

Velocity Difference (ft/sec)

Reduction in flood water velocity
- < -3
- -3 to -2
- -2 to -1
- -1 to -0.5
- -0.5 to -0.25
- -0.25 to -0.05

-0.05 to 0.05 (no color)

Increase in flood water velocity
- 0.05 to 0.25
- 0.25 to 0.5
- 0.5 to 1
- 1 to 2
- 2 to 3
- > 3

N

0 175 350 700 ft

HERRERA

NAD 1983 HARN
Washington State Plane North FIPS 4601 Feet

USDA, Aerial (2013); Skagit County, Parcels (2012)

Figure 37.
Alternative 1: 5,000 cfs
Proposed Depth Difference.

Legend

Parcel

Depth Difference (ft)

Reduction in flooding depth (ft)
- < -2
- -2 to -1.5
- -1.5 to -1
- -1 to -0.5
- -0.5 to -0.05
- -0.05 to -0.02

-0.02 to 0.02 (no color)

Increase in flooding depth (ft)
- 0.02 to 0.05
- 0.05 to 0.5
- 0.5 to 1
- 1 to 1.5
- 1.5 to 2
- > 2

N

0 175 350 700 ft

HERRERA

NAD 1983 HARN
Washington State Plane North FIPS 4601 Feet

USDA, Aerial (2013); Skagit County, Parcels (2012)

Figure 38.
Alternative 1: 5,000 cfs
Velocity Difference.

Legend

Parcel

Velocity Difference (ft/sec)

Reduction in flood water velocity
- < -3
- -3 to -2
- -2 to -1
- -1 to -0.5
- -0.5 to -0.25
- -0.25 to -0.05

-0.05 to 0.05 (no color)

Increase in flood water velocity
- 0.05 to 0.25
- 0.25 to 0.5
- 0.5 to 1
- 1 to 2
- 2 to 3
- > 3

N

0 175 350 700 ft

HERRERA

NAD 1983 HARN
Washington State Plane North FIPS 4601 Feet

USDA, Aerial (2013); Skagit County, Parcels (2012)

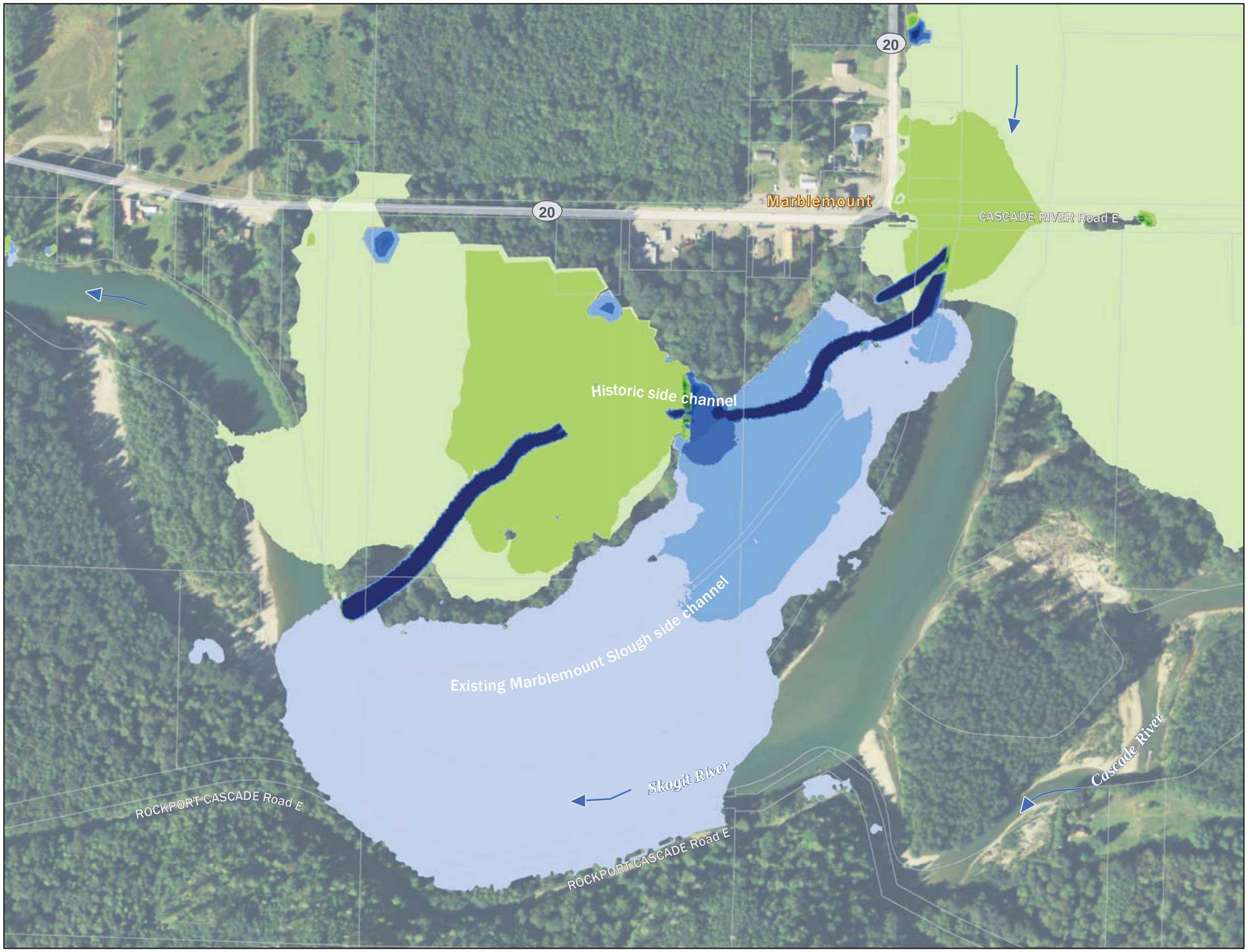


Figure 39.
Alternative 2: 100-yr
Proposed Depth Difference.

Legend

Parcel

Depth Difference (ft)

Reduction in flooding depth (ft)
- < -2
- -2 to -1.5
- -1.5 to -1
- -1 to -0.5
- -0.5 to -0.05
- -0.05 to -0.02

-0.02 to 0.02 (no color)

Increase in flooding depth (ft)
- 0.02 to 0.05
- 0.05 to 0.5
- 0.5 to 1
- 1 to 1.5
- 1.5 to 2
- > 2

N

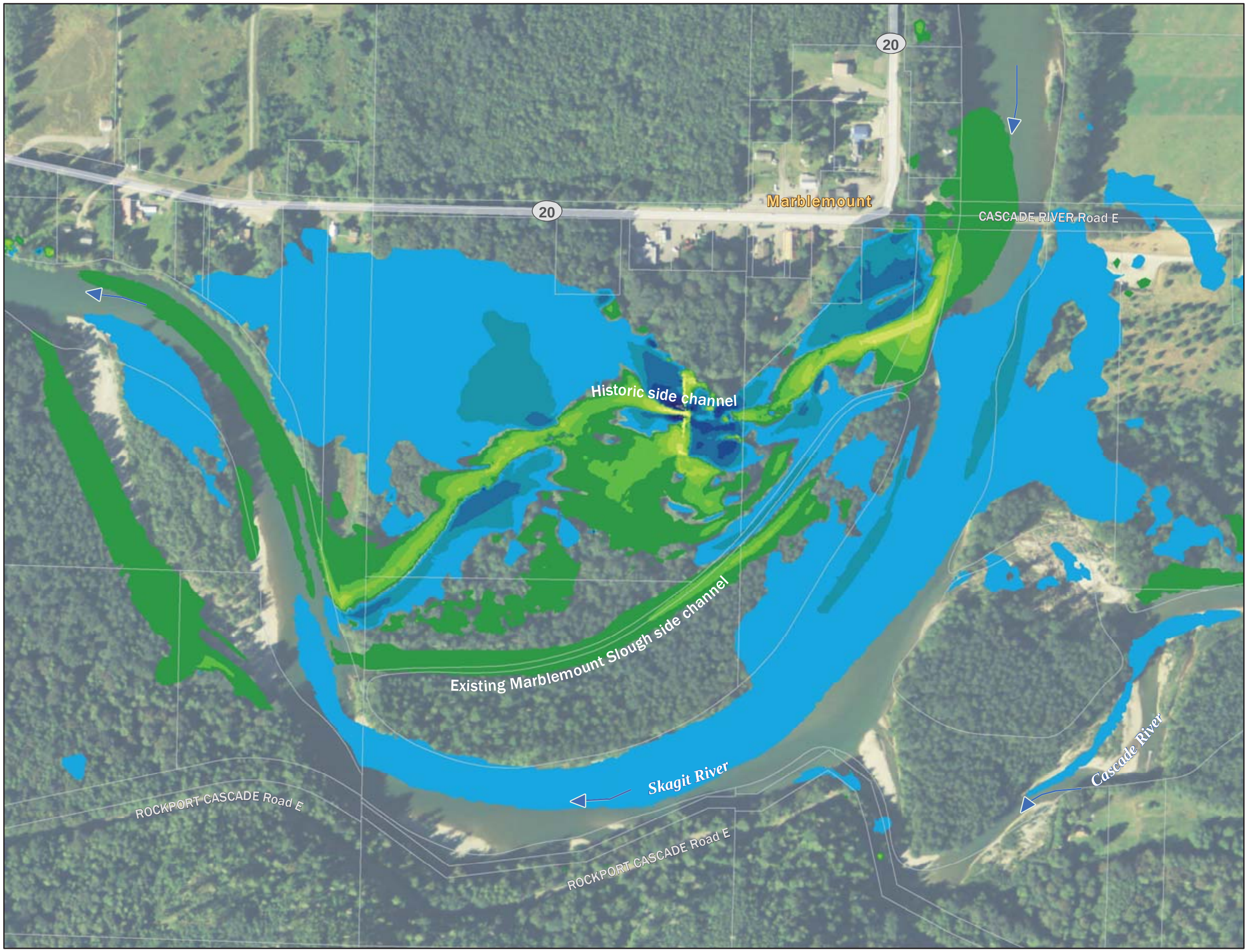
0 175 350 700 ft

HERRERA

NAD 1983 HARN
Washington State Plane North FIPS 4601 Feet

USDA, Aerial (2013); Skagit County, Parcels (2012)

Figure 40.
Alternative 2: 100-yr
Velocity Difference.



Legend

Parcel

Velocity Difference (ft/sec)

Reduction in flood water velocity
- < -3
- -3 to -2
- -2 to -1
- -1 to -0.5
- -0.5 to -0.25
- -0.25 to -0.05

-0.05 to 0.05 (no color)

Increase in flood water velocity
- 0.05 to 0.25
- 0.25 to 0.5
- 0.5 to 1
- 1 to 2
- 2 to 3
- > 3

N

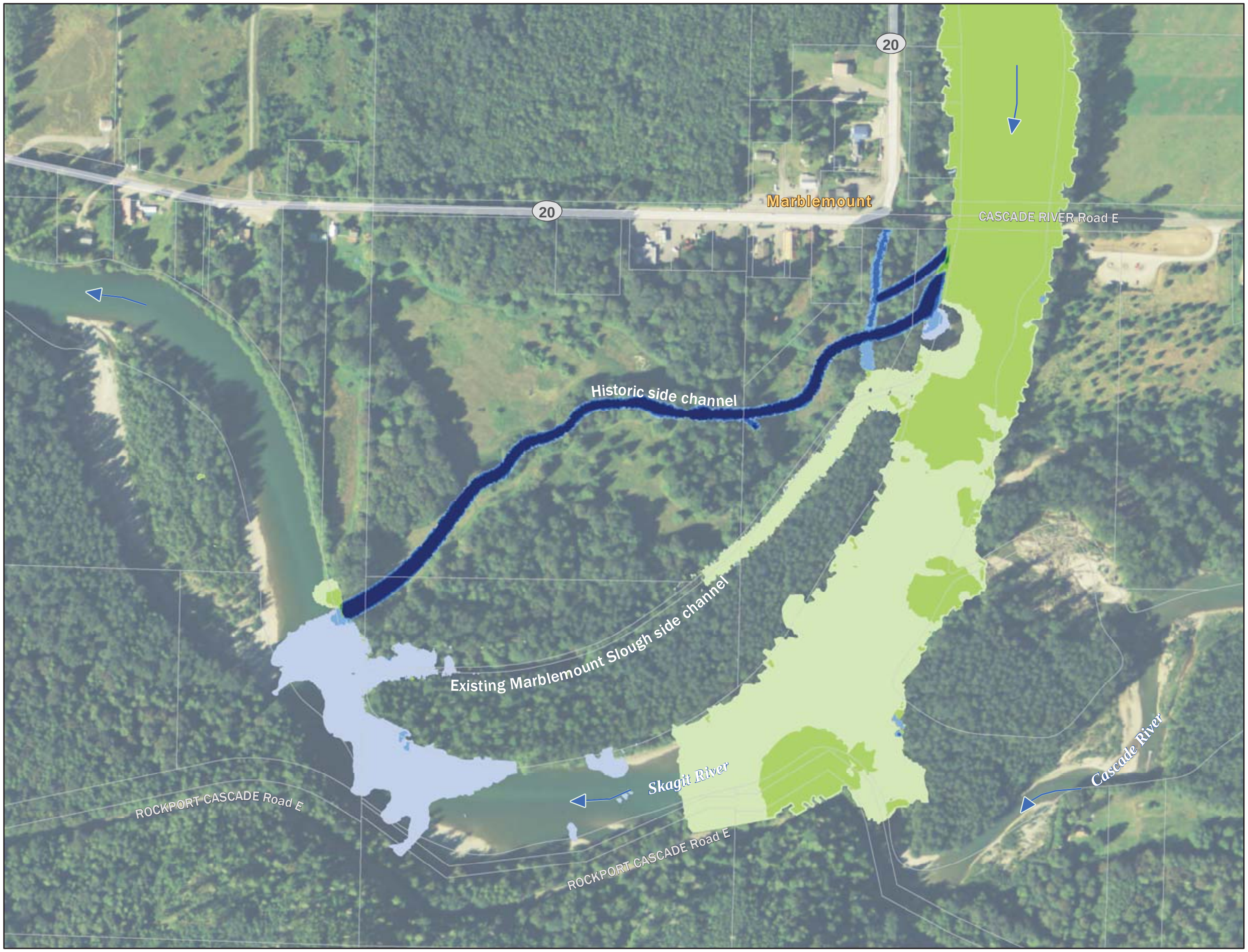
0 175 350 700 ft

HERRERA

NAD 1983 HARN
Washington State Plane North FIPS 4601 Feet

USDA, Aerial (2013); Skagit County, Parcels (2012)

Figure 41.
Alternative 2: 2-yr
Proposed Depth Difference.



Legend

Parcel

Depth Difference (ft)

Reduction in flooding depth (ft)
- < -2
- -2 to -1.5
- -1.5 to -1
- -1 to -0.5
- -0.5 to -0.05
- -0.05 to -0.02

-0.02 to 0.02 (no color)

Increase in flooding depth (ft)
- 0.02 to 0.05
- 0.05 to 0.5
- 0.5 to 1
- 1 to 1.5
- 1.5 to 2
- > 2

N

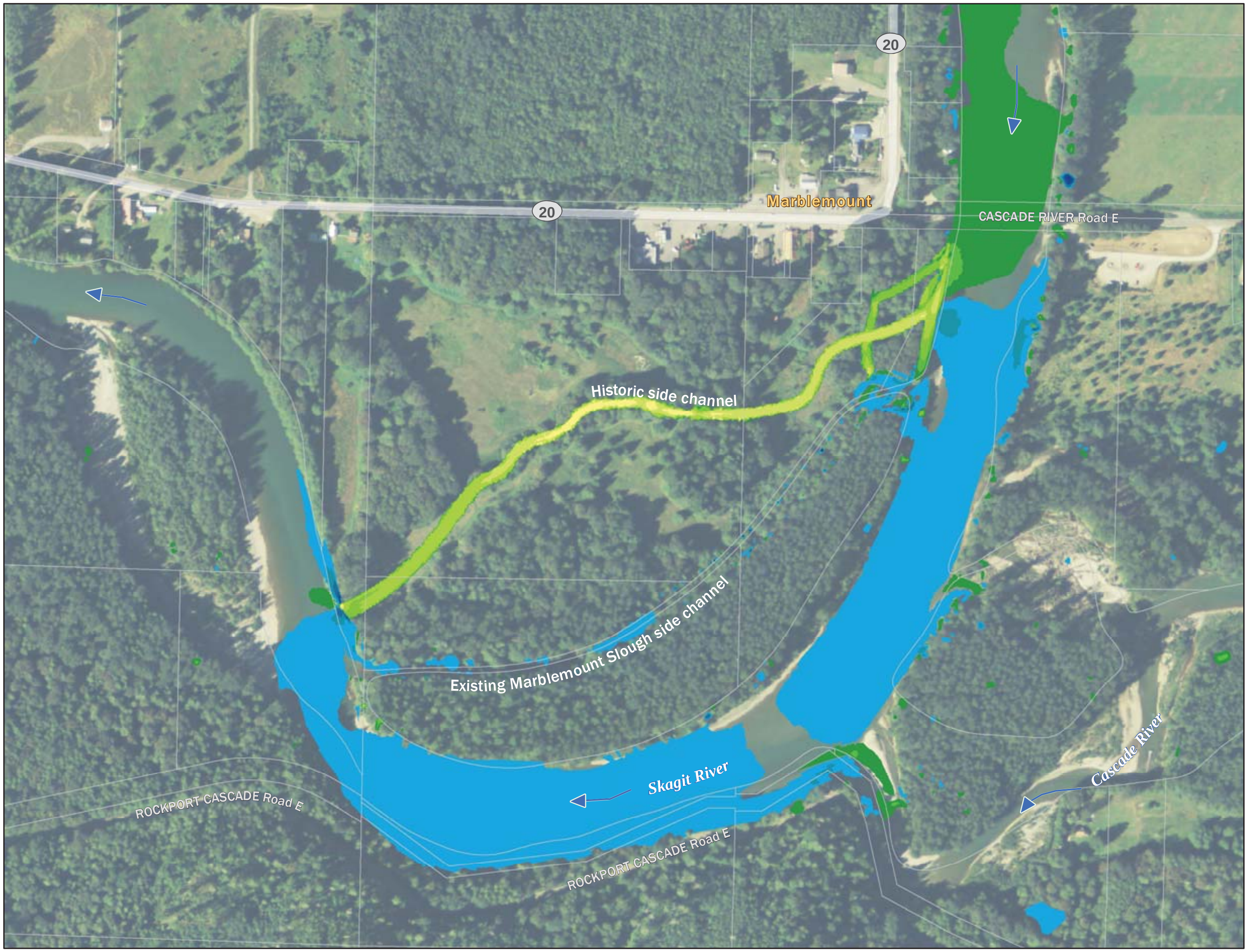
0 175 350 700 ft

HERRERA

NAD 1983 HARN
Washington State Plane North FIPS 4601 Feet

USDA, Aerial (2013); Skagit County, Parcels (2012)

Figure 42.
Alternative 2: 2-yr
Velocity Difference.



Legend

Parcel

Velocity Difference (ft/sec)

Reduction in flood water velocity
- < -3
- -3 to -2
- -2 to -1
- -1 to -0.5
- -0.5 to -0.25
- -0.25 to -0.05

-0.05 to 0.05 (no color)

Increase in flood water velocity
- 0.05 to 0.25
- 0.25 to 0.5
- 0.5 to 1
- 1 to 2
- 2 to 3
- > 3

N

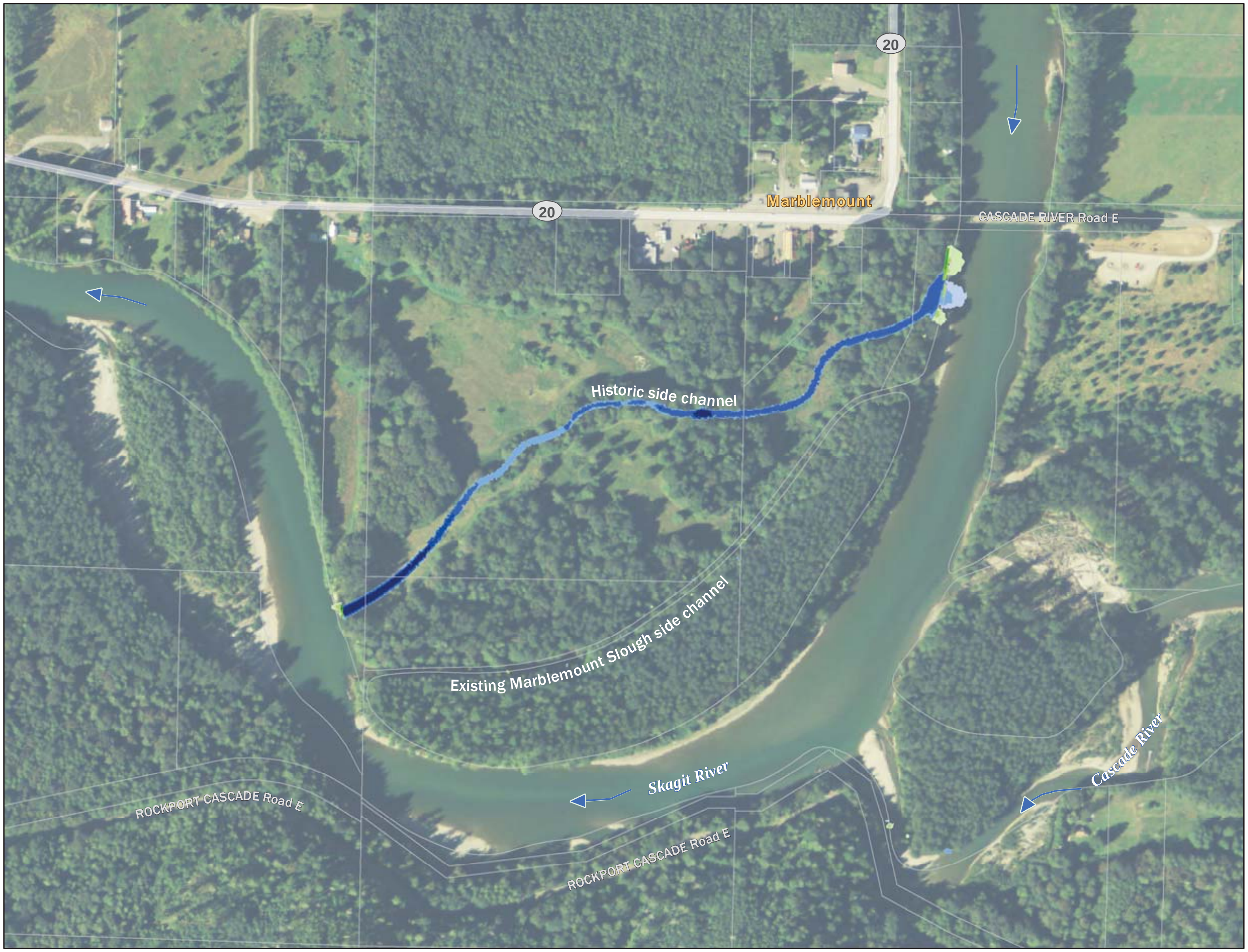
0 175 350 700 ft

HERRERA

NAD 1983 HARN
Washington State Plane North FIPS 4601 Feet

USDA, Aerial (2013); Skagit County, Parcels (2012)

Figure 43.
Alternative 2: 7,600 cfs
Proposed Depth Difference.



Legend

Parcel

Depth Difference (ft)

Reduction in flooding depth (ft)
- < -2
- -2 to -1.5
- -1.5 to -1
- -1 to -0.5
- -0.5 to -0.05
- -0.05 to -0.02

-0.02 to 0.02 (no color)

Increase in flooding depth (ft)
- 0.02 to 0.05
- 0.05 to 0.5
- 0.5 to 1
- 1 to 1.5
- 1.5 to 2
- > 2

N

0 175 350 700 ft

HERRERA

NAD 1983 HARN
Washington State Plane North FIPS 4601 Feet

USDA, Aerial (2013); Skagit County, Parcels (2012)

Figure 44.
Alternative 2: 7,600 cfs
Velocity Difference.

Legend

Parcel

Velocity Difference (ft/sec)

Reduction in flood water velocity
- < -3
- -3 to -2
- -2 to -1
- -1 to -0.5
- -0.5 to -0.25
- -0.25 to -0.05

-0.05 to 0.05 (no color)

Increase in flood water velocity
- 0.05 to 0.25
- 0.25 to 0.5
- 0.5 to 1
- 1 to 2
- 2 to 3
- > 3

N

0 175 350 700 ft

HERRERA

NAD 1983 HARN
Washington State Plane North FIPS 4601 Feet

USDA, Aerial (2013); Skagit County, Parcels (2012)

Project: K:\Projects\Y2014\14-05789-000\Project\Conceptual_Rest_Alt_Analysis\Appendix\alternatives_velocity_diff_7600cfs.mxd (3/12/2015)

Figure 45.
Alternative 2: 5,000 cfs
Proposed Depth Difference.

Legend

Parcel

Depth Difference (ft)

Reduction in flooding depth (ft)
- < -2
- -2 to -1.5
- -1.5 to -1
- -1 to -0.5
- -0.5 to -0.05
- -0.05 to -0.02

-0.02 to 0.02 (no color)

Increase in flooding depth (ft)
- 0.02 to 0.05
- 0.05 to 0.5
- 0.5 to 1
- 1 to 1.5
- 1.5 to 2
- > 2

N

0 175 350 700 ft

HERRERA

NAD 1983 HARN
Washington State Plane North FIPS 4601 Feet

USDA, Aerial (2013); Skagit County, Parcels (2012)

Figure 46.
Alternative 2: 5,000 cfs
Velocity Difference.

Legend

Parcel

Velocity Difference (ft/sec)

Reduction in flood water velocity		< -3
		-3 to -2
		-2 to -1
		-1 to -0.5
		-0.5 to -0.25
		-0.25 to -0.05
		-0.05 to 0.05 (no color)
Increase in flood water velocity		0.05 to 0.25
		0.25 to 0.5
		0.5 to 1
		1 to 2
		2 to 3
		> 3

N

0 175 350 700 ft

HERRERA

NAD 1983 HARN
Washington State Plane North FIPS 4601 Feet

USDA, Aerial (2013); Skagit County, Parcels (2012)

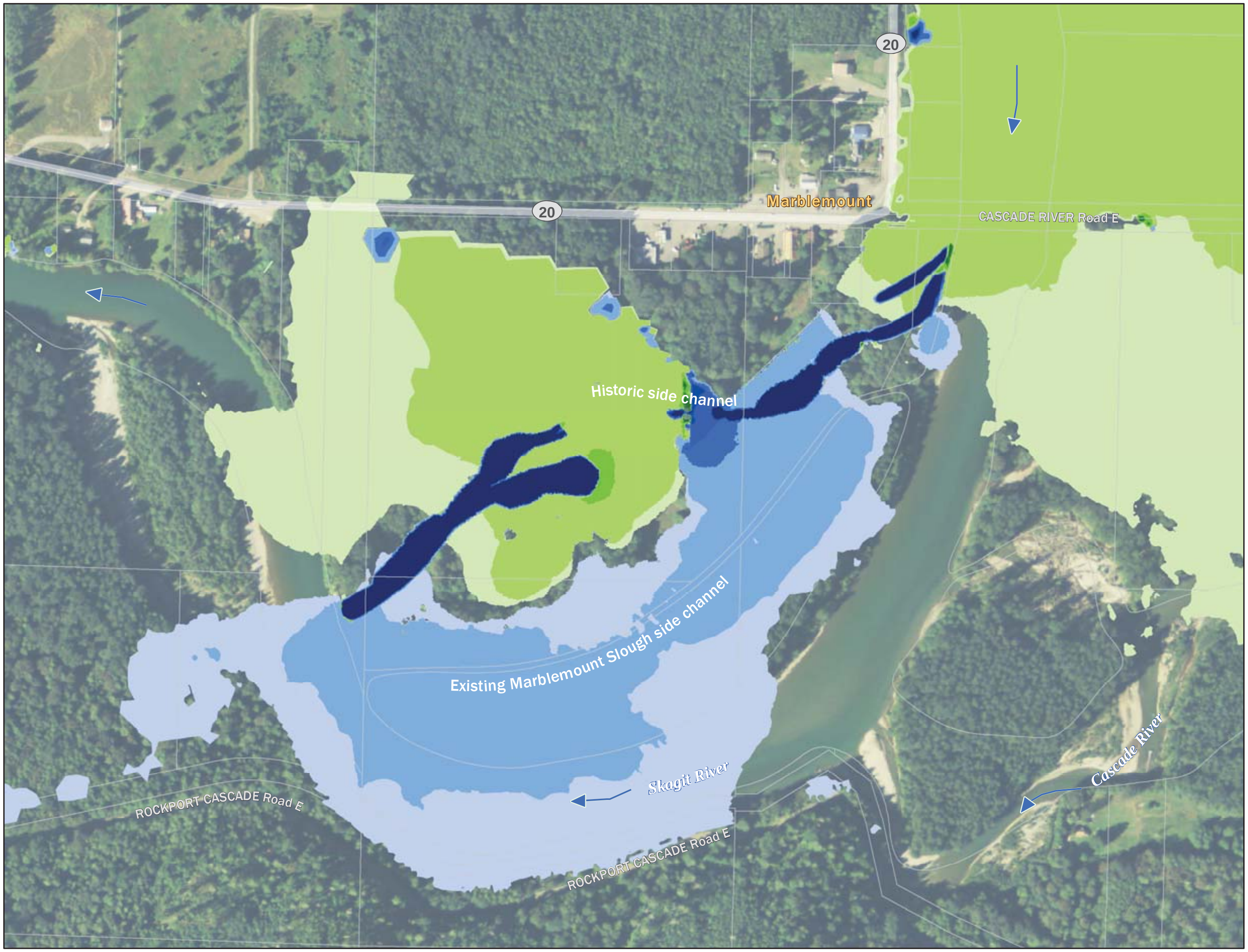


Figure 47.
Alternative 3: 100-yr
Proposed Depth Difference.

Legend

Parcel

Depth Difference (ft)

Reduction in flooding depth (ft)
- < -2
- -2 to -1.5
- -1.5 to -1
- -1 to -0.5
- -0.5 to -0.05
- -0.05 to -0.02

-0.02 to 0.02 (no color)

Increase in flooding depth (ft)
- 0.02 to 0.05
- 0.05 to 0.5
- 0.5 to 1
- 1 to 1.5
- 1.5 to 2
- > 2

N

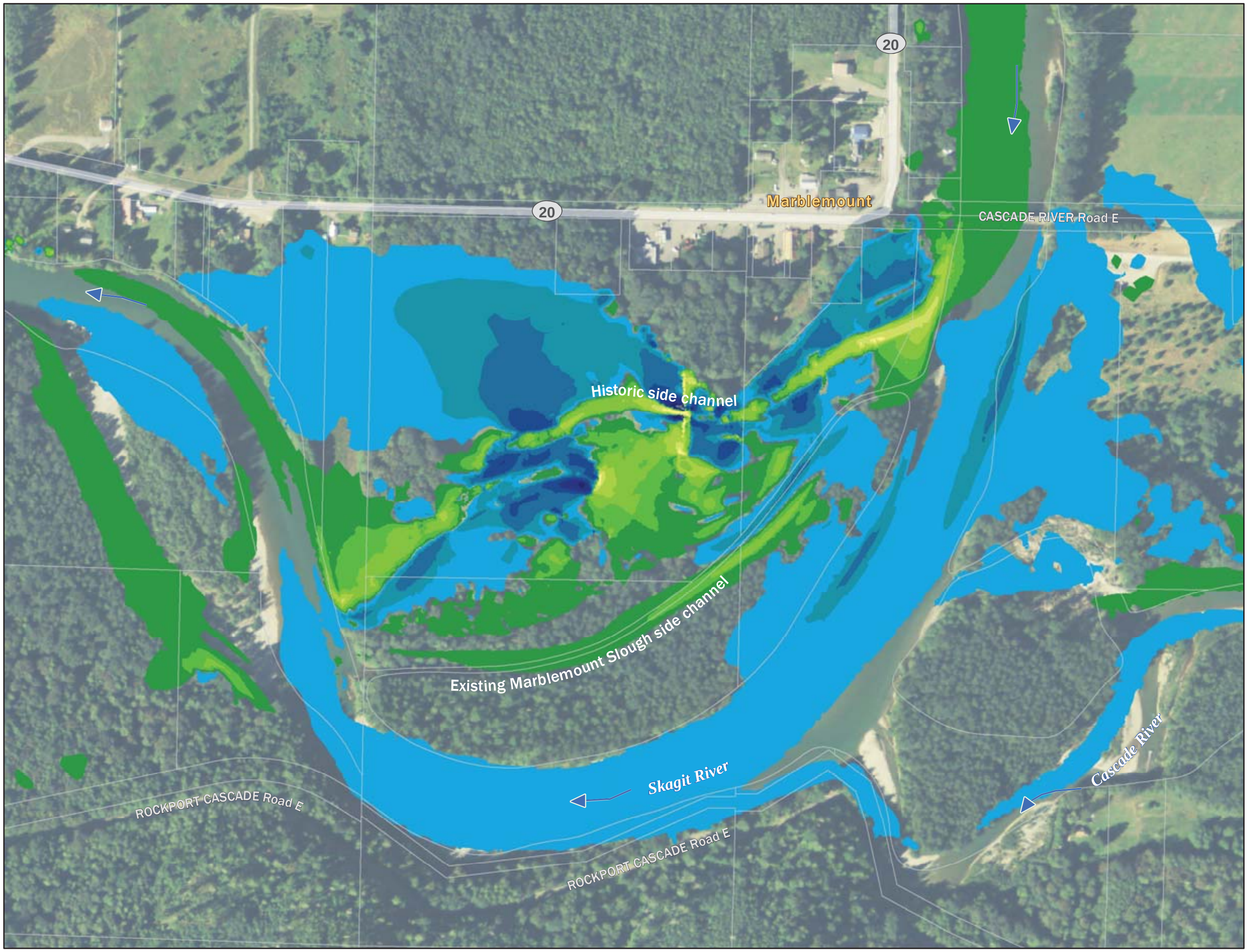
0 175 350 700 ft

HERRERA

NAD 1983 HARN
Washington State Plane North FIPS 4601 Feet

USDA, Aerial (2013); Skagit County, Parcels (2012)

Figure 48.
Alternative 3: 100-yr
Velocity Difference.



Legend

Parcel

Velocity Difference (ft/sec)

Reduction in flood water velocity
- < -3
- -3 to -2
- -2 to -1
- -1 to -0.5
- -0.5 to -0.25
- -0.25 to -0.05

-0.05 to 0.05 (no color)

Increase in flood water velocity
- 0.05 to 0.25
- 0.25 to 0.5
- 0.5 to 1
- 1 to 2
- 2 to 3
- > 3

N

0 175 350 700 ft

HERRERA

NAD 1983 HARN
Washington State Plane North FIPS 4601 Feet

USDA, Aerial (2013); Skagit County, Parcels (2012)

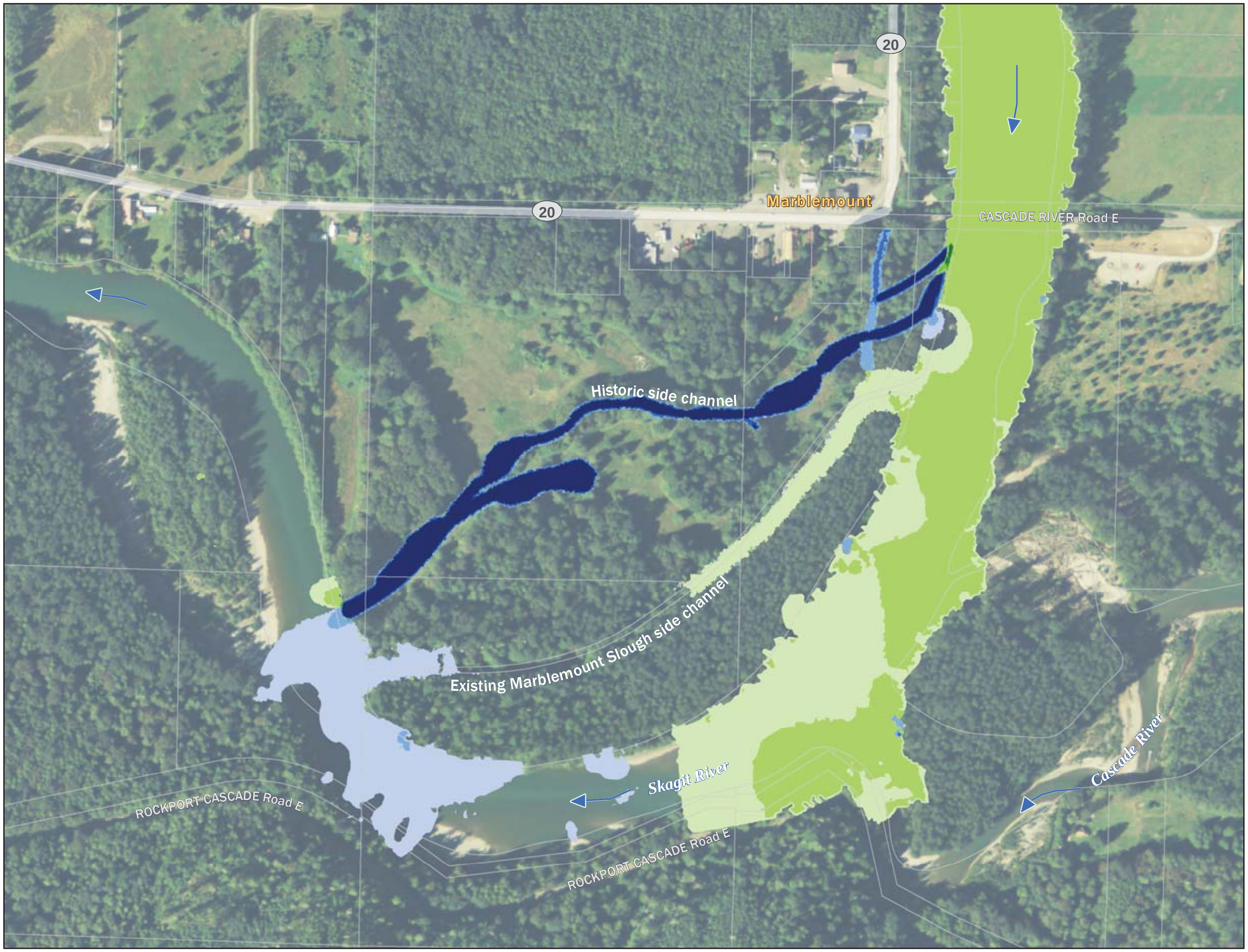
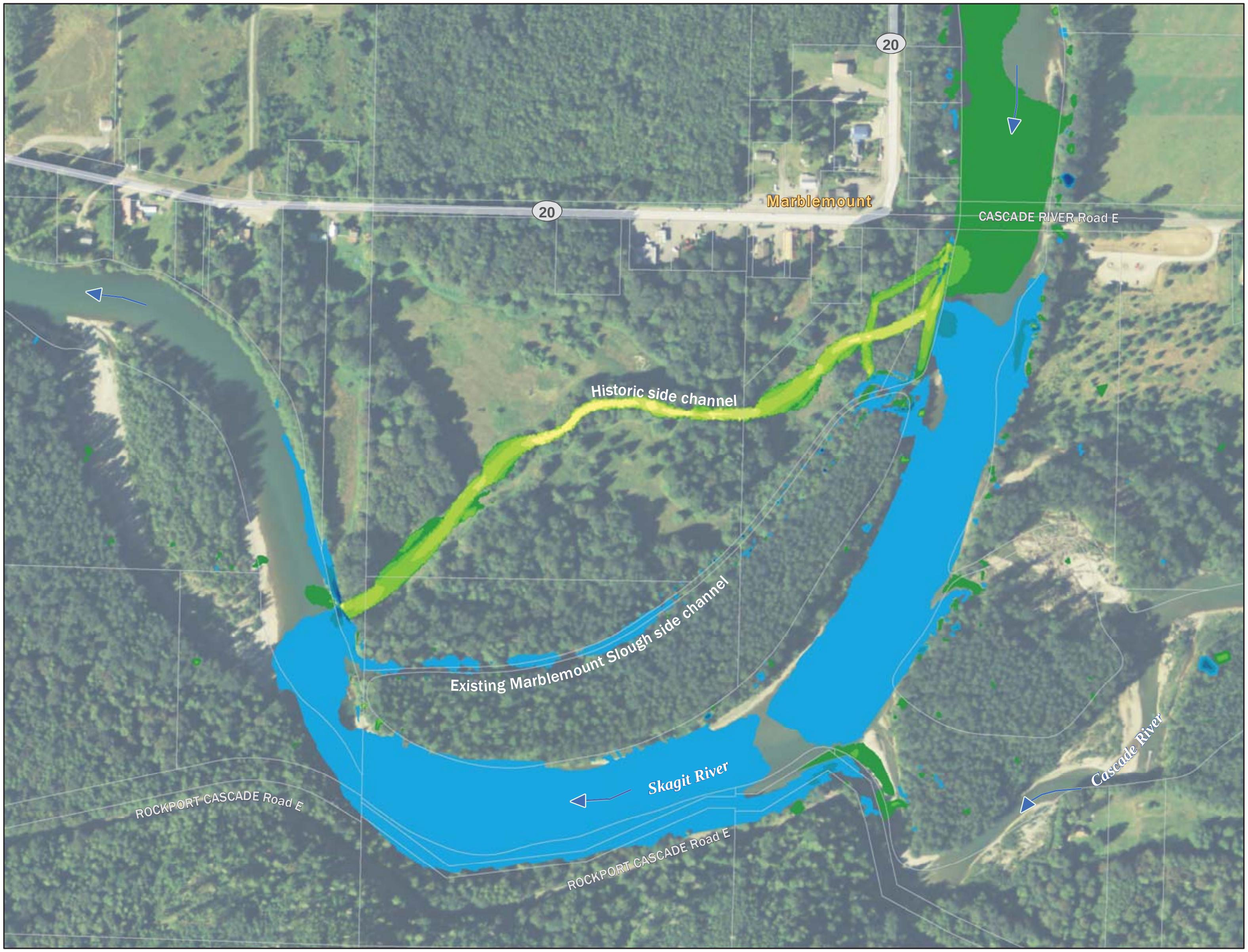


Figure 49.
Alternative 3: 2-yr
Proposed Depth Difference.

Figure 50.
Alternative 3: 2-yr
Velocity Difference.



Legend

Parcel

Velocity Difference (ft/sec)

Reduction in flood water velocity:
- < -3
- -3 to -2
- -2 to -1
- -1 to -0.5
- -0.5 to -0.25
- -0.25 to -0.05

-0.05 to 0.05 (no color)

Increase in flood water velocity:
- 0.05 to 0.25
- 0.25 to 0.5
- 0.5 to 1
- 1 to 2
- 2 to 3
- > 3

N

0 175 350 700 ft

HERRERA

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Washington State Plane North FIPS 4601 Feet

USDA, Aerial (2013); Skagit County, Parcels (2012)

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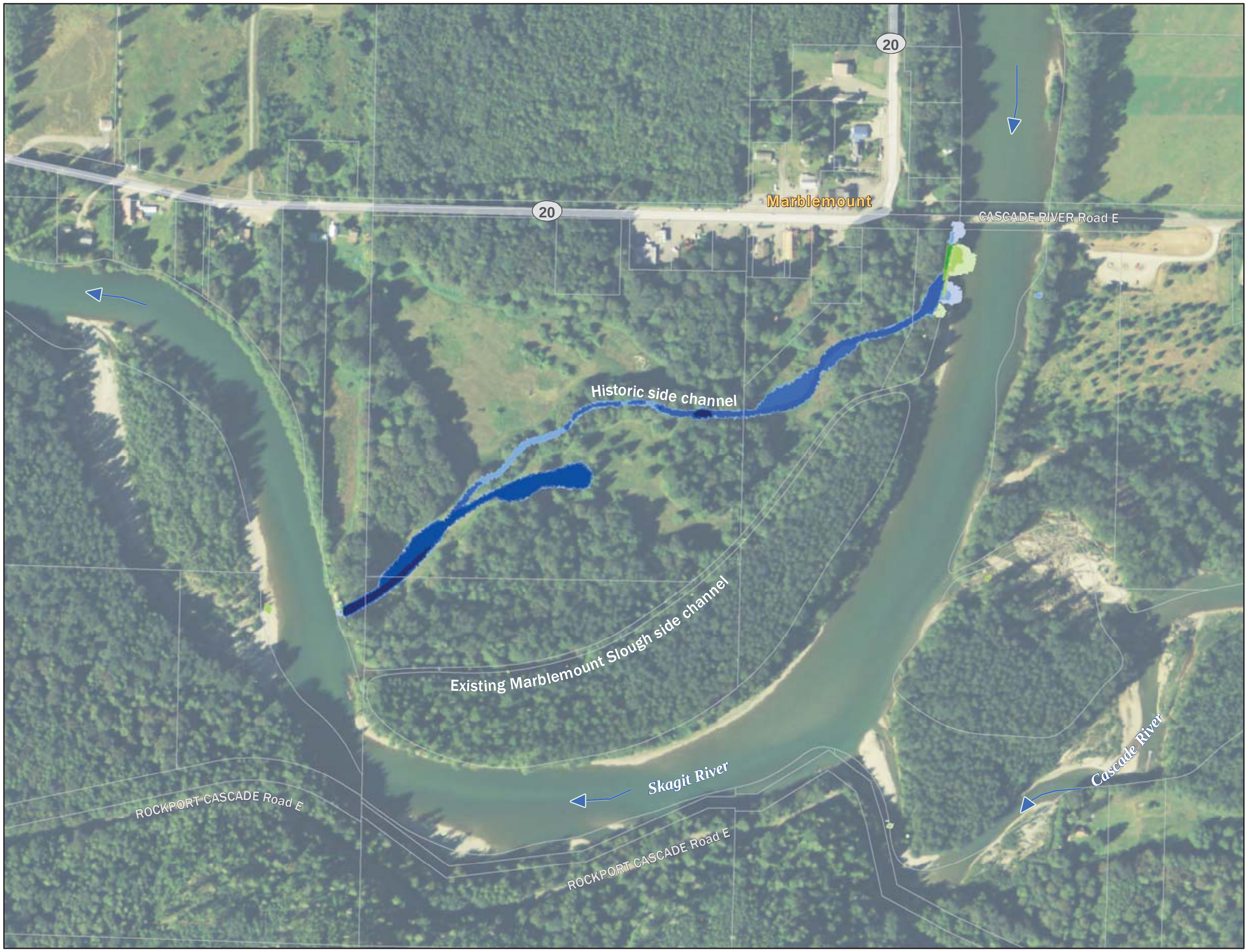


Figure 51.
Alternative 3: 7,600 cfs
Proposed Depth Difference.

Legend

Parcel

Depth Difference (ft)

Reduction in flooding depth (ft)
- < -2
- -2 to -1.5
- -1.5 to -1
- -1 to -0.5
- -0.5 to -0.05
- -0.05 to -0.02

- -0.02 to 0.02 (no color)

Increase in flooding depth (ft)
- 0.02 to 0.05
- 0.05 to 0.5
- 0.5 to 1
- 1 to 1.5
- 1.5 to 2
- > 2

N

0 175 350 700 ft

HERRERA

NAD 1983 HARN
Washington State Plane North FIPS 4601 Feet

USDA, Aerial (2013); Skagit County, Parcels (2012)

Figure 52.
Alternative 3: 7,600 cfs
Velocity Difference.

Legend

Parcel

Velocity Difference (ft/sec)

Reduction in flood water velocity:
- < -3
- -3 to -2
- -2 to -1
- -1 to -0.5
- -0.5 to -0.25
- -0.25 to -0.05

-0.05 to 0.05 (no color)

Increase in flood water velocity:
- 0.05 to 0.25
- 0.25 to 0.5
- 0.5 to 1
- 1 to 2
- 2 to 3
- > 3

N

0 175 350 700 ft

HERRERA

NAD 1983 HARN
Washington State Plane North FIPS 4601 Feet

USDA, Aerial (2013); Skagit County, Parcels (2012)

Figure 53.
Alternative 3: 5,000 cfs
Proposed Depth Difference.

Legend

Parcel

Depth Difference (ft)

Reduction in flooding depth (ft)
- < -2
- -2 to -1.5
- -1.5 to -1
- -1 to -0.5
- -0.5 to -0.05
- -0.05 to -0.02

-0.02 to 0.02 (no color)

Increase in flooding depth (ft)
- 0.02 to 0.05
- 0.05 to 0.5
- 0.5 to 1
- 1 to 1.5
- 1.5 to 2
- > 2

N

0 175 350 700 ft

HERRERA

NAD 1983 HARN
Washington State Plane North FIPS 4601 Feet

USDA, Aerial (2013); Skagit County, Parcels (2012)

Figure 54.
Alternative 3: 5,000 cfs
Velocity Difference.

Legend

Parcel

Velocity Difference (ft/sec)

Reduction in flood water velocity
- < -3
- -3 to -2
- -2 to -1
- -1 to -0.5
- -0.5 to -0.25
- -0.25 to -0.05

-0.05 to 0.05 (no color)

Increase in flood water velocity
- 0.05 to 0.25
- 0.25 to 0.5
- 0.5 to 1
- 1 to 2
- 2 to 3
- > 3

N

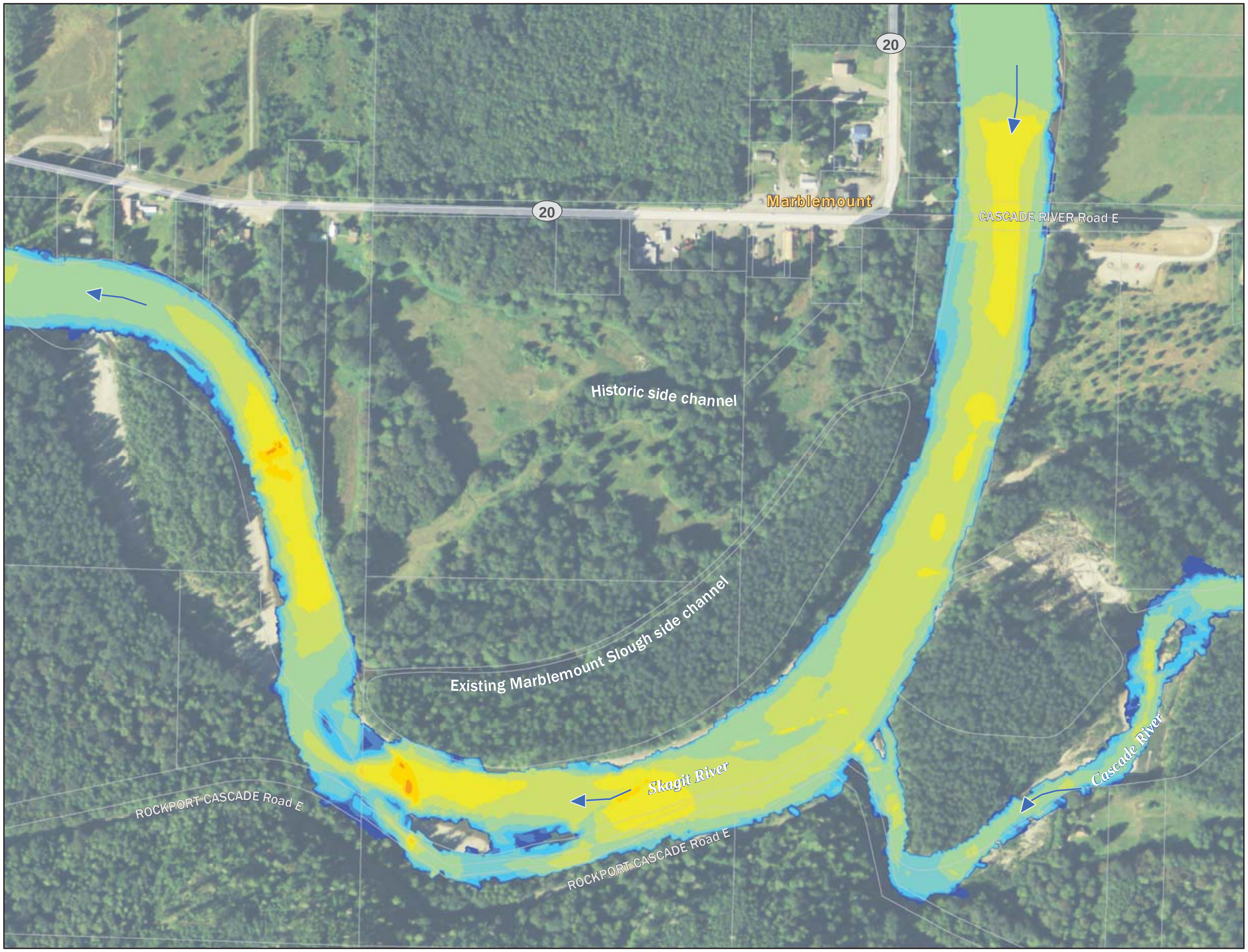
0 175 350 700 ft

HERRERA

NAD 1983 HARN
Washington State Plane North FIPS 4601 Feet

USDA, Aerial (2013); Skagit County, Parcels (2012)

Figure 55.
Existing Conditions Velocity,
5,000 cfs Flow.



Legend

Parcel

Existing velocity (fps)

- 0 to 0.01
- 0.01 to 0.25
- 0.25 to 0.5
- 0.5 to 1
- 1 to 2
- 2 to 4
- 4 to 6
- 6 to 8
- 8 to 10
- 10 to 12
- 12 to 14
- > 14

N

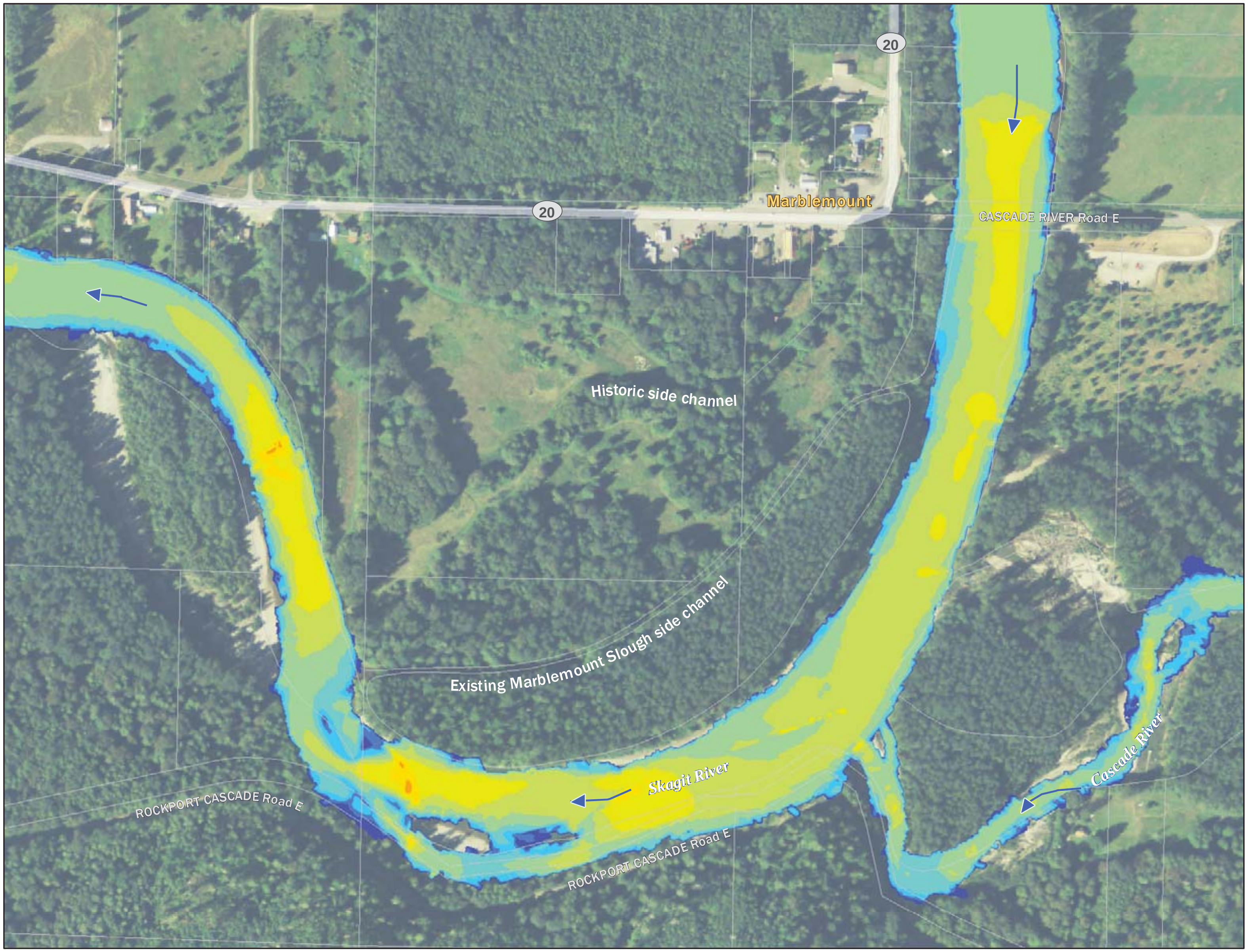
0 175 350 700 ft

HERRERA

NAD 1983 HARN
Washington State Plane North FIPS 4601 Feet

USDA, Aerial (2013); Skagit County, Parcels (2012)

Figure 56.
Existing Conditions Velocity,
5,000 cfs Flow.



Legend

Parcel

Existing velocity (fps)

- 0 to 0.01
- 0.01 to 0.25
- 0.25 to 0.5
- 0.5 to 1
- 1 to 2
- 2 to 4
- 4 to 6
- 6 to 8
- 8 to 10
- 10 to 12
- 12 to 14
- > 14

NOTE:
Flood modeling and results shown are approximate and were developed using a project specific River Flow 2D model for the purpose of side channel restoration alternative analysis. Results are not to be used for determining flooding extents or depths (See FEMA Skagit River FIRM maps for regulatory flood conditions).

N

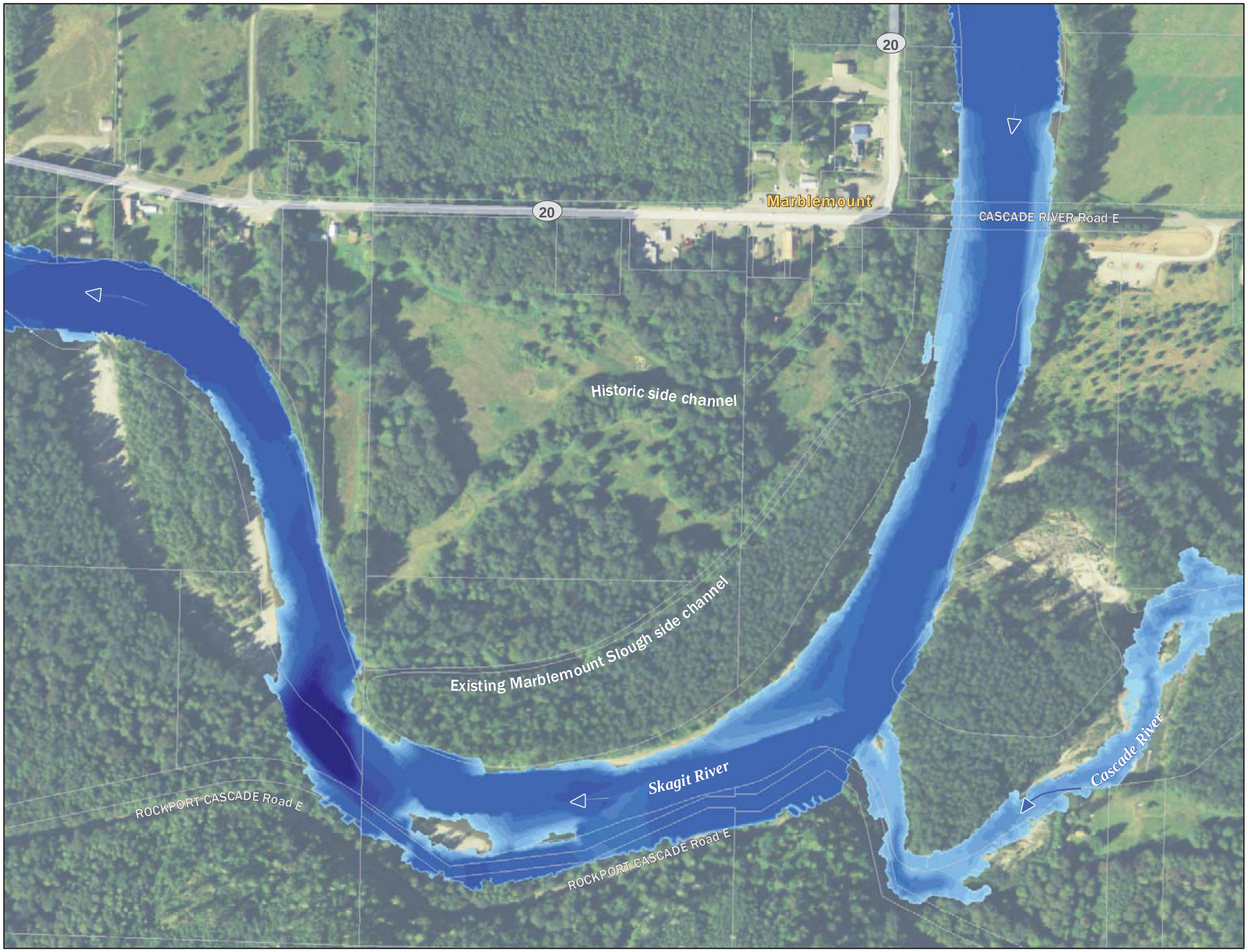
0 175 350 700 ft

HERRERA

NAD 1983 HARN
Washington State Plane North FIPS 4601 Feet

USDA, Aerial (2013); Skagit County, Parcels (2012)

Figure 57.
Existing Conditions Depth,
5,000 cfs Flow.



Legend

Parcel

Existing Depth (ft)

- 0 to 0.05
- 0.05 to 0.2
- 0.2 to 0.5
- 0.5 to 1
- 1 to 1.5
- 1.5 to 2
- 2 to 2.5
- 2.5 to 3
- 3 to 6
- 6 to 9
- 9 to 12
- 12 to 15
- 15 to 18
- 18 to 21
- > 21

NOTE:
Flood modeling and results shown are approximate and were developed using a project specific River Flow 2D model for the purpose of side channel restoration alternative analysis. Results are not to be used for determining flooding extents or depths (See FEMA Skagit River FIRM maps for regulatory flood conditions).

N

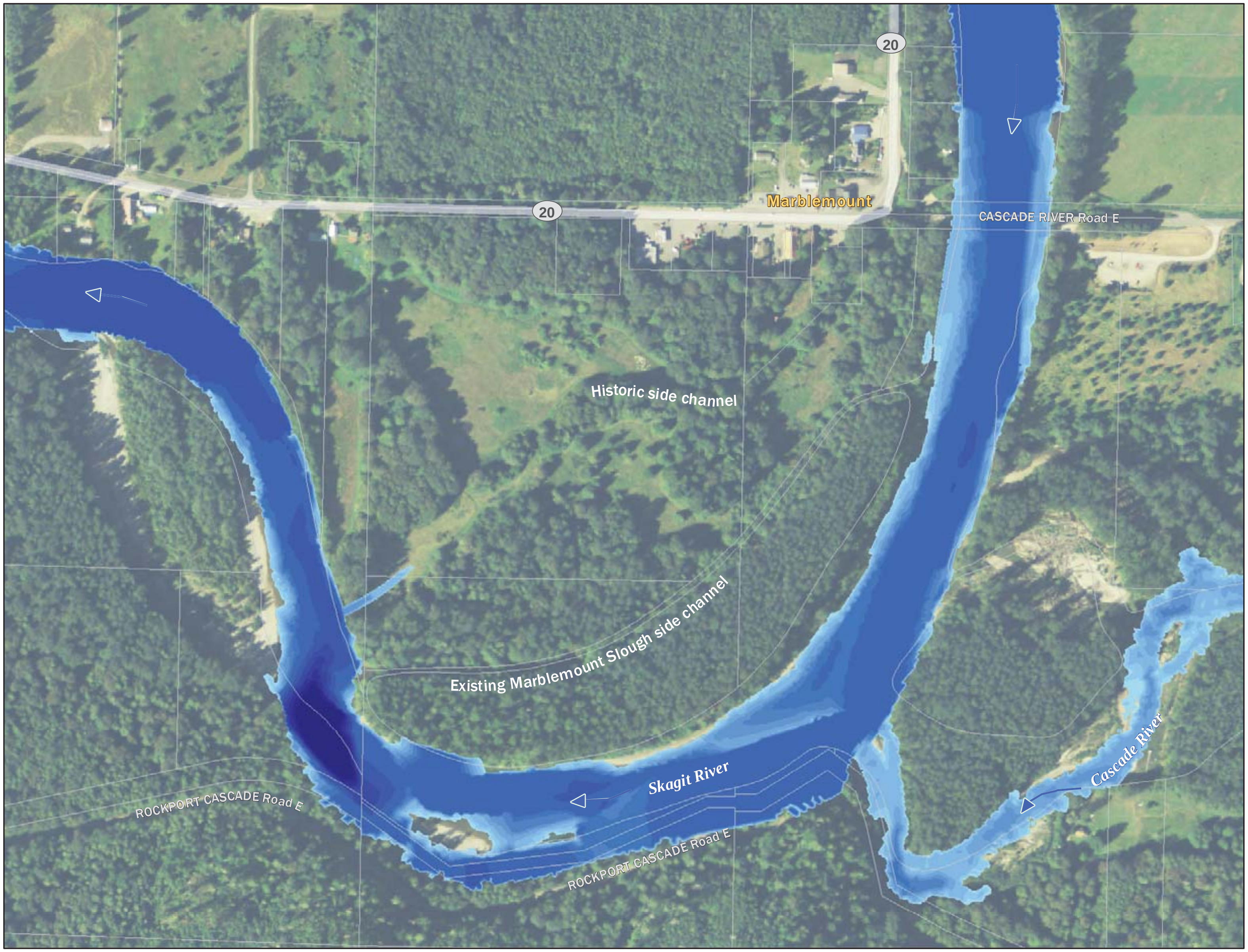
0 175 350 700 ft

HERRERA

NAD 1983 HARN
Washington State Plane North FIPS 4601 Feet

USDA, Aerial (2013); Skagit County, Parcels (2012)

Figure 58.
Alternative 4
5,000 cfs Depth.



Legend

Parcel

Existing Depth (ft)

- 0 to 0.05
- 0.05 to 0.2
- 0.2 to 0.5
- 0.5 to 1
- 1 to 1.5
- 1.5 to 2
- 2 to 2.5
- 2.5 to 3
- 3 to 6
- 6 to 9
- 9 to 12
- 12 to 15
- 15 to 18
- 18 to 21
- > 21

NOTE:
Flood modeling and results shown are approximate and were developed using a project specific River Flow 2D model for the purpose of side channel restoration alternative analysis. Results are not to be used for determining flooding extents or depths (See FEMA Skagit River FIRM maps for regulatory flood conditions).

N

0 175 350 700 ft

HERRERA

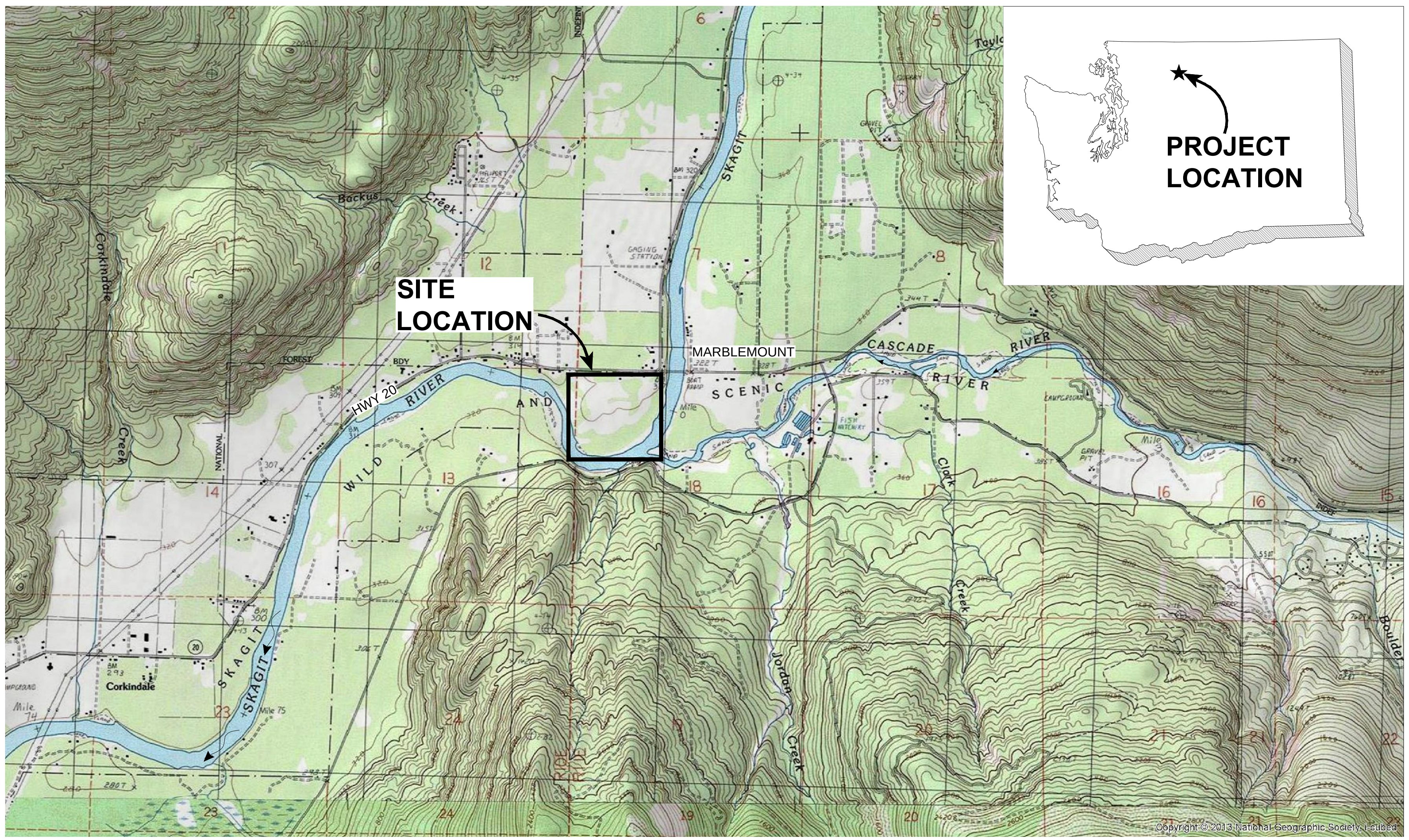
NAD 1983 HARN
Washington State Plane North FIPS 4601 Feet

USDA, Aerial (2013); Skagit County, Parcels (2012)

APPENDIX G

Preferred Alternative Design Drawings

PRESSENTIN PARK
SIDE CHANNEL RESTORATION
SKAGIT COUNTY, WA



VICINITY MAP
SCALE: NTS

Sheet List Table

SHEET NO.	DWG NO.	SHEET DESCRIPTION
1	G-1	VICINITY MAP AND SHEET INDEX
2	G-2	LEGEND AND GENERAL NOTES
3	C-1	EXISTING CONDITIONS
4	C-2	SITE PLAN AND PROPOSED WORK
5	C-3	LOWER GRADING AND SITE PLAN
6	C-4	UPPER GRADING AND SITE PLAN
7	C-5	GRADING DETAILS
8	C-6	INLET PLAN AND DETAILS
9	C-7	OUTLET AND FLOODFENCE PLAN AND DETAILS
10	C-8	ELS DETAILS
11	ESC-1	TESC DETAILS

NOTE AND DETAIL/SECTION REFERENCING

1 / C-3 — DETAIL REFERENCE NUMBER; DRAWING ON WHICH DETAIL IS SHOWN

DETAIL
SCALE: NTS
1 / C-1 — DETAIL REFERENCE NUMBER; DRAWING FROM WHICH DETAIL WAS TAKEN

A / C-4 — SECTION REFERENCE LETTER; DRAWING ON WHICH SECTION IS SHOWN

SECTION
SCALE: NTS
A / C-2 — SECTION REFERENCE LETTER; DRAWING FROM WHICH SECTION WAS TAKEN

"-" INDICATES THAT THE DETAIL/SECTION IS SHOWN ON THE SAME SHEET

"TYP" INDICATES THAT THE DETAIL/SECTION IS UNIFORMLY TYPICAL THROUGHOUT PROJECT EXCEPT WHERE OTHERWISE NOTED

"VAR" SPECIFIES THAT DETAIL/SECTION WAS TAKEN FROM SEVERAL DRAWINGS

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DESIGNED: G. KAYS	DRAWN: E. MARSHALL
DESIGNED: M. BEGGS	DRAWN: -
DESIGNED: -	CHECKED: -
SCALE: AS NOTED	APPROVED: M. EWBANK

PRESSENTIN PARK
SIDE CHANNEL RESTORATION
VICINITY MAP AND SHEET INDEX

DATE: JUNE 2015
PROJECT NO: 14-05789-000
DRAWING NO: G-1
SHEET NO: 1 OF 11

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Plot Date: 6/8/2015 10:03 AM Cad User: Eric Marshall
Plot Style Table: Herrera.ctb Plotter: DWG To PDF.pc3

GENERAL NOTES:

1. MATERIAL STAGING AREAS TO BE LOCATED AS SHOWN ON THE SITE PLAN. MATERIAL SHALL NOT BE STORED OUTSIDE OF IDENTIFIED STAGING AREAS, UNLESS APPROVED BY DISTRICT AND LAND OWNER.
2. CONTRACTOR SHALL LIMIT MACHINERY MOVEMENT TO PROJECT LIMITS DEFINED ON SITE PLAN OR IDENTIFIED AS ACCEPTABLE TO DISTRICT.
3. CLEARING LIMITS FOR TEMPORARY ACCESS ROAD AND PROPOSED STRUCTURES SHALL BE LIMITED TO THE AREA REQUIRED FOR SAFE EQUIPMENT OPERATION. CLEARING LIMITS SHALL BE STAKED BY CONTRACTOR AND APPROVED BY DISTRICT AT LEAST 3 DAYS PRIOR TO CLEARING ACTIVITIES. CLEARING LIMITS SHALL BE STAKED TO MINIMIZE THE AREA OF DISTURBANCE.
4. APPROVED CONSTRUCTION SEQUENCE PLAN SHALL NOT BE ALTERED UNLESS APPROVED BY DISTRICT.
5. FIELD VERIFY WITH DISTRICT ALL ENGINEERED LOGJAM LOCATIONS, LENGTHS, WIDTHS, AND ELEVATIONS PRIOR TO EXCAVATION, ASSEMBLY, AND INSTALLATION OF EACH STRUCTURE.
6. EQUIPMENT USED FOR THIS PROJECT SHALL BE FREE OF EXTERNAL PETROLEUM-BASED PRODUCTS WHILE WORKING NEAR OR ANY SURFACE WATER OR WETLANDS. ACCUMULATION OF SOILS OR DEBRIS SHALL BE REMOVED FROM THE DRIVE MECHANISMS (WHEELS, TRACKS, TIRES, ETC.) AND UNDERCARRIAGE OF EQUIPMENT PRIOR TO ITS WORKING BELOW THE BANKFULL WATER ELEVATION.
7. EQUIPMENT SHALL BE CHECKED DAILY FOR LEAKS, AND ANY NECESSARY REPAIRS SHALL BE COMPLETED PRIOR TO COMMENCING WORK ACTIVITIES.
8. THE CONTRACTOR IS RESPONSIBLE TO ENSURE THAT NO PETROLEUM PRODUCTS, HYDRAULIC FLUID, SEDIMENTS, SEDIMENT-LADEN WATER, CHEMICALS, OR ANY OTHER TOXIC OR DELETERIOUS MATERIALS ARE ALLOWED TO ENTER OR LEACH INTO THE RIVER, GROUNDWATER, OR WETLANDS.
9. IF AT ANY TIME, AS A RESULT OF PROJECT ACTIVITIES, FISH ARE OBSERVED IN DISTRESS, A FISH KILL OCCURS, OR WATER QUALITY PROBLEMS DEVELOP (INCLUDING EQUIPMENT LEAKS OR SPILLS), OPERATIONS SHALL CEASE AND THE DISTRICT SHALL BE NOTIFIED IMMEDIATELY. WASHINGTON DEPARTMENT OF FISH AND WILDLIFE AND WASHINGTON DEPARTMENT OF ECOLOGY SHALL BE CONTACTED IMMEDIATELY BY THE DISTRICT OR BY HIS/HER DESIGNEE. WORK SHALL NOT RESUME UNTIL FURTHER APPROVAL BY DISTRICT REPRESENTATIVE.
10. EROSION CONTROL METHODS SHALL BE USED TO PREVENT SILT-LADEN WATER FROM ENTERING THE RIVER. INITIAL EROSION CONTROL MEASURES ARE SHOWN ON DRAWINGS C-3, AND C-4. CONTRACTOR IS SOLELY RESPONSIBLE FOR SUITABLE BMP'S TO CONTROL SILTATION FROM WORK AREA.
11. ALTERATION OR DISTURBANCE OF THE BANK AND BANK VEGETATION SHALL BE MINIMIZED TO THAT NECESSARY TO CONSTRUCT THE PROJECT. CONTRACTOR SHALL KEEP DISTURBED AREAS WITHIN LIMITS SHOWN ON PLANS.
12. IF HIGH FLOW CONDITIONS THAT MAY CAUSE SILTATION OR EROSION ARE ENCOUNTERED DURING CONSTRUCTION, WORK SHALL STOP UNTIL THE FLOW SUBSIDES.
13. DECKED LOGS SHALL BE ACCESSIBLE FOR INSPECTION.
14. LOG TYPE IDENTIFICATION SHALL BE PAINTED ON ALL LOGS IN A PLACE VISIBLE FOR INSPECTION PRIOR TO PLACEMENT WITH LEAD-FREE, BLAZE-ORANGE SURVEY MARKING PAINT.
15. EXCAVATIONS THAT HAVE POTENTIAL TO IMPACT THE WETTED CHANNEL OF THE SKAGIT RIVER OR SIDE CHANNEL SHALL BE ISOLATED FROM THE ACTIVE CHANNEL. ISOLATION MEANS SHALL CONSIST OF SILT BOOMS, BULK BAGS, BLADDER DAMS OR APPROVED EQUAL AS NECESSARY TO PREVENT IMPACTS TO WATER QUALITY.

SURVEY NOTES:

1. BASIS OF BEARINGS IS THE WASHINGTON STATE PLANE COORDINATE SYSTEM, NORTH ZONE, N.A.D. 83/11.
2. TOPOGRAPHY SHOWN DEVELOPED FROM LIDAR (2006) AND GROUND SURVEY (SEMARU ENGINEERING AND SURVEYING, 2014).
3. VERTICAL DATUM IS NAVD 88. FROM W.S.D.O.T. MONUMENT ID: 7148, ELEVATION = 320.95 FEET, AND MONUMENT ID: 7149, ELEVATION = 323.53 FEET.
4. BASE MAP SURVEY CONTROL FILE TO BE PROVIDED TO CONTRACTOR. CONTRACTOR REQUIRED TO MAINTAIN SURVEY CONTROL. STAKING BY DISTRICT IS DESCRIBED IN PROJECT SPECIFICATION.
5. EXISTING TRAILS, ROADS, BUILDINGS, WETTED CHANNEL EXTENTS, PARCEL LINES, TREES, AND VEGETATION SHOWN ARE APPROXIMATE.

ABBREVIATIONS

APPROX	APPROXIMATE
AVE	AVERAGE
BMP	BEST MANAGEMENT PRACTICE
CSTC	CRUSHED SURFACING TOP COURSE
DIA	DIAMETER
ELJ	ENGINEERED LOG JAM
ELS	ENGINEERED LOG STRUCTURE
FT	FEET
GW	GROUNDWATER
IN	INCHES
MAX	MAXIMUM
MIN	MINIMUM
NTS	NOT TO SCALE
OHW	ORDINARY HIGH WATER
QTY	QUANTITY
TESC	TEMPORARY EROSION AND SEDIMENT CONTROL
TYP	TYPICAL
WSE	WATER SURFACE ELEVATION

LEGEND:

- PARCEL BOUNDARY
- EXISTING TRAIL/PATH
- PARK BOUNDARY
- NORTH CASCADES HIGHWAY
- ACCESS ROAD
- OHWM — ORDINARY HIGH WATER MARK
- 1 — ELJ NUMBER
- BANK ROUGHENING STRUCTURE
- LARGE BANK ROUGHENING STRUCTURE
- FLOODFENCE STRUCTURE
- CHANNEL ROUGHENING STRUCTURES
- TEST PIT/WELL LOCATION
- RIVER FLOW DIRECTION
- WATTLES
- SILT BOOM
- NATIVE GROUND
- SCOUR APRON BOULDERS
- NATIVE BACKFILL
- STAGING AREA

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Plotter: DWG To PDF.pc3
Plot Style Table: Herrera.ctb

No.	REVISION	BY	APP'D	DATE

HERRERA

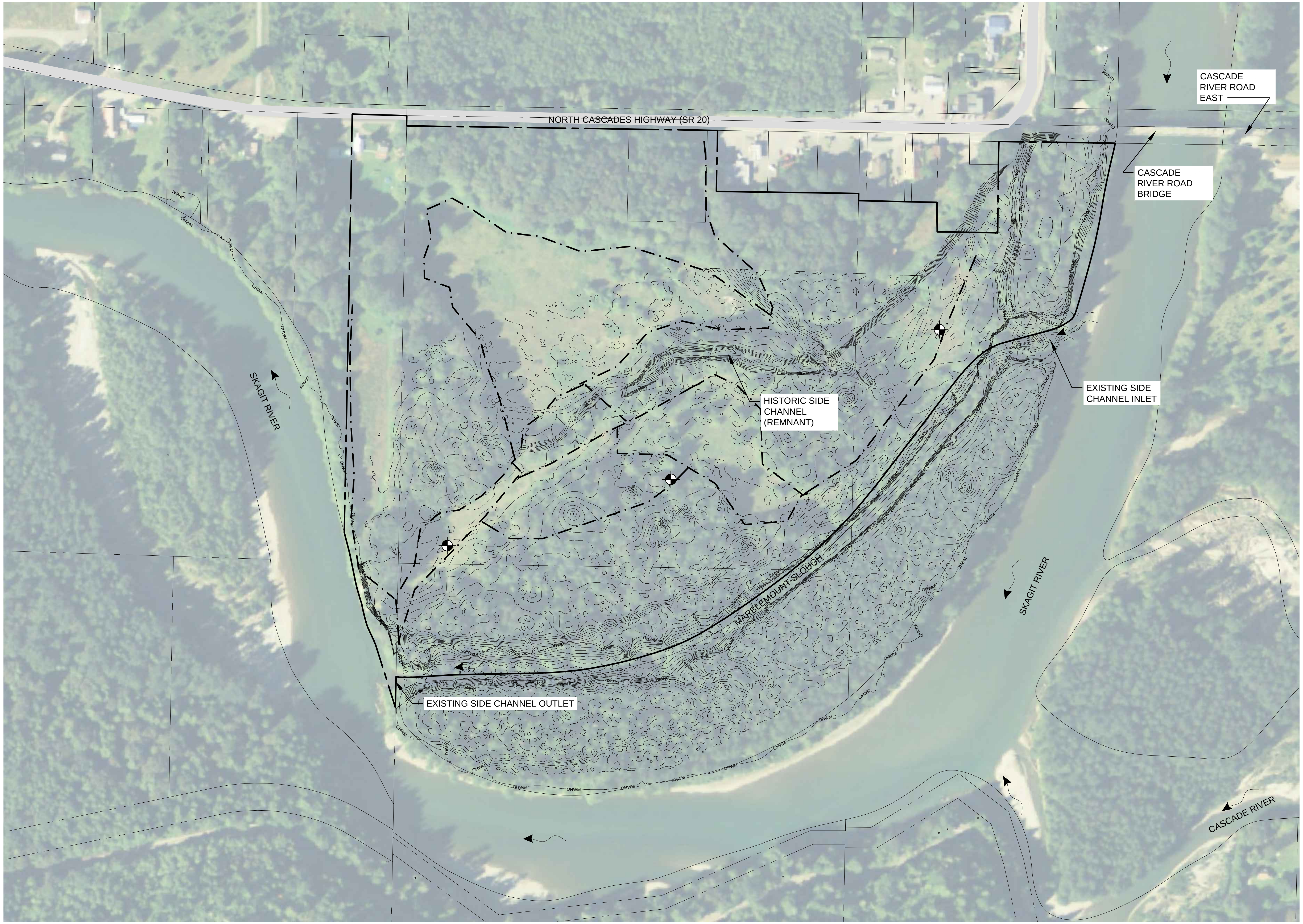
GUS BRIAN KAYS — STATE OF WASHINGTON — 45234 — REGISTERED PROFESSIONAL ENGINEER

DESIGNED: G. KAYS	DRAWN: E. MARSHALL
DESIGNED: M. BEGGS	DRAWN: -
DESIGNED: -	CHECKED: -
SCALE: AS NOTED	APPROVED: M. EWBANK

PRESSENTIN PARK
SIDE CHANNEL RESTORATION

LEGEND AND GENERAL NOTES

DATE: JUNE 2015
PROJECT NO: 14-05789-000
DRAWING NO: G-2
SHEET NO: 2 OF 11



LEGEND:

- PARCEL BOUNDARY
- EXISTING TRAIL/PATH
- PARK BOUNDARY
- NORTH CASCADES HIGHWAY
- TEST PIT/WELL LOCATION
- RIVER FLOW DIRECTION
- OHWM ORDINARY HIGH WATER MARK

NOTES:

1. PARCEL BOUNDARIES PROVIDED BY SKAGIT COUNTY.
2. LAND OWNER AGREEMENTS TO BE COORDINATED BY OWNER.
3. CONSTRUCTION ACCESS VIA NORTH CASCADES HIGHWAY.

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GUS BRIAN HALES, STATE OF WASHINGTON, 25234, REGISTERED PROFESSIONAL ENGINEER

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DESIGNED: M. BEGGS	DRAWN: -
DESIGNED: -	CHECKED: -
SCALE: AS NOTED	APPROVED: M. EWBANK

PRESSENTIN PARK
SIDE CHANNEL RESTORATION

EXISTING CONDITIONS

DATE: JUNE 2015
PROJECT NO: 14-05789-000
DRAWING NO: C-1
SHEET NO: 3 OF 11

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Plotter: DWG To PDF.pc3

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Plot Style Table: Herrera.ctb
Cad User: Eric Marshall
Plotter: DWG To PDF.pc3

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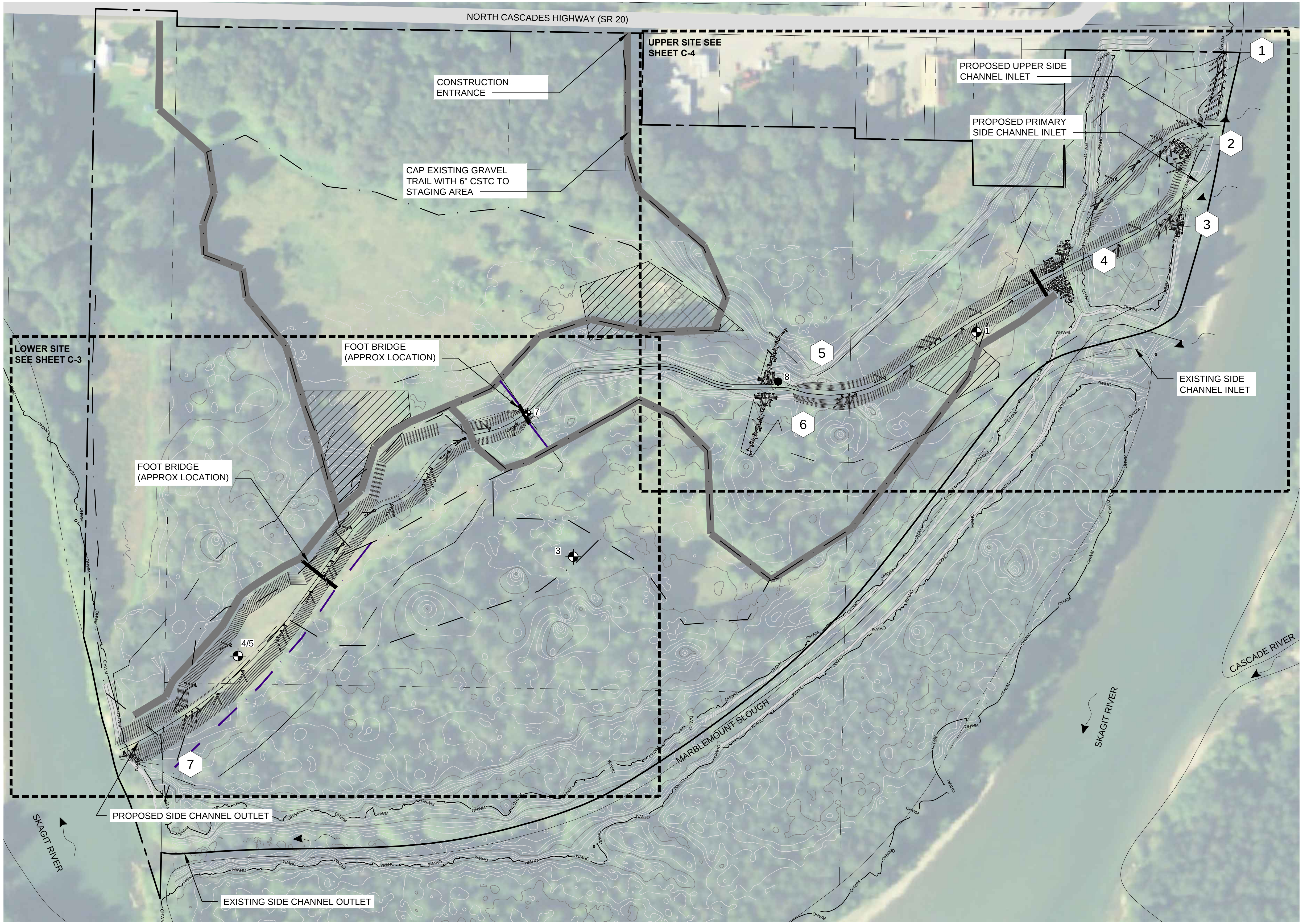

LEGEND:

- PARCEL BOUNDARY
- EXISTING TRAIL/PATH
- PARK BOUNDARY
- ACCESS ROAD
- STAGING AREA
- ELJ NUMBER
- NORTH CASCADES HIGHWAY
- BANK ROUGHENING STRUCTURE
- LARGE BANK ROUGHENING STRUCTURE
- FLOODFENCE STRUCTURE
- CHANNEL ROUGHENING
- TEST PIT/WELL LOCATION
- RIVER FLOW DIRECTION
- ORDINARY HIGH WATER MARK

NOTES:

1. PARCEL BOUNDARIES PROVIDED BY SKAGIT COUNTY.
2. LAND OWNER AGREEMENTS TO BE COORDINATED BY SFEG.
3. CONSTRUCTION ACCESS VIA NORTH CASCADES HIGHWAY.
4. ELJ LOCATIONS AND TYPES SHOWN FOR ILLUSTRATION ONLY. FINAL LOCATIONS AND TYPES SHALL BE PER HYDRAULIC MODELING ANALYSIS AND LAND OWNER AGREEMENTS.
5. CONTRACTOR SHALL SEED ALL DISTURBED AREAS. LAND OWNER SHALL BE RESPONSIBLE FOR ALL SITE PLANTINGS.
6. NOTE ALL DISTURBED AREAS TO BE PLANTED WITH NATIVE SPIECES BY SFEG.
7. EXISTING TRAIL FROM SR 20 TO STAGING AREA TO BE CAPPED WITH 6" CSTC. PROPOSED ACCESS ROADS FROM STAGING AREA TO BE CONSTRUCTED WITH HOG FUEL.. TEMPORARY ACCESS ROADS INCORPORATED INTO EXISTING TRAIL SYSTEM.

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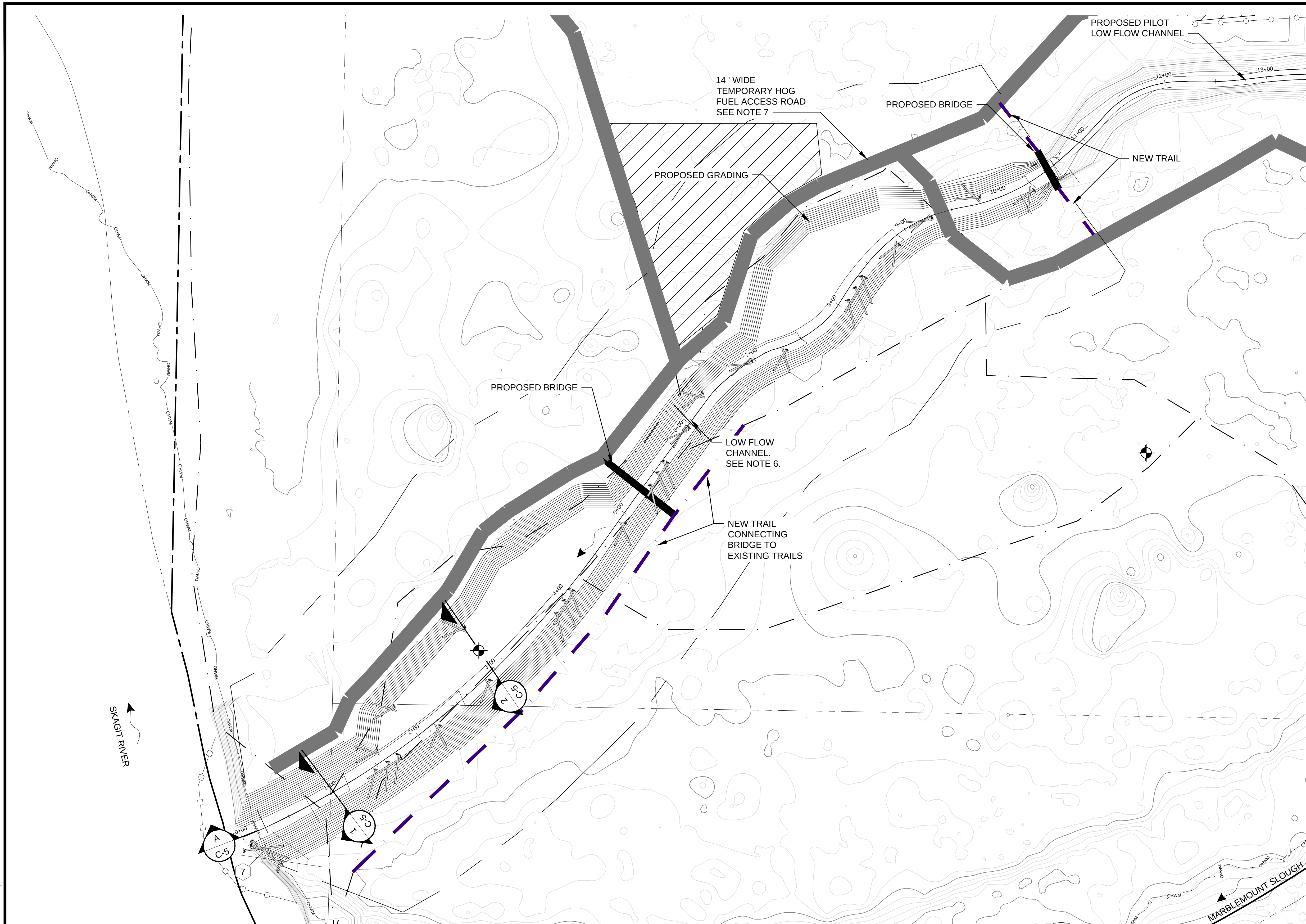
DESIGNED: M. BEGGS	DRAWN: -
DESIGNED: -	CHECKED: -
SCALE: AS NOTED	APPROVED: M. EWBANK

PRESSENTIN PARK
SIDE CHANNEL RESTORATION

SITE PLAN AND PROPOSED WORK

DATE:	JUNE 2015
PROJECT NO:	14-05789-000
DRAWING NO:	C-2
SHEET NO:	4 OF 11



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50 0 50 100
1"=50'

LEGEND:

	PARCEL BOUNDARY
	EXISTING TRAILS/PATHS
	PARK BOUNDARY
	WATTLES
	SILT BOOM
	HOG FUEL ACCESS ROAD
	STAGING AREA
1	ELJ NUMBER
	BANK ROUGHENING STRUCTURE
	LARGE BANK ROUGHENING STRUCTURE
	FLOODFENCE STRUCTURE
	CHANNEL ROUGHENING
	TEST PIT/WELL LOCATION
	RIVER FLOW DIRECTION
OHWM	ORDINARY HIGH WATER MARK

NOTES:

1. PARCEL BOUNDARIES PROVIDED BY SKAGIT COUNTY.
2. LAND OWNER AGREEMENTS TO BE COORDINATED BY OWNER.
3. CONSTRUCTION ACCESS VIA NORTH CASCADES HIGHWAY.
4. ELJ LOCATIONS AND TYPES SHOWN FOR ILLUSTRATION ONLY. FINAL LOCATIONS AND TYPES SHALL BE PER HYDRAULIC MODELING ANALYSIS AND LAND OWNER AGREEMENTS.
5. CONTRACTOR SHALL SEED ALL DISTURBED AREAS. LAND OWNER SHALL BE RESPONSIBLE FOR ALL SITE PLANTINGS.
6. LOW FLOW CHANNEL AND POOL RIFFLE SEQUENCES GRADING NOT SHOWN. CONTRACTOR SHALL GRADE LOW FLOW CHANNEL COMPLEXITY AS DIRECTED BY ENGINEER.
7. ACCESS ROAD INCORPORATED INTO TRAIL NETWORK

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No.	REVISION	BY	APP'D	DATE

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GUS BRIAN MAYS
STATE OF WASHINGTON
25234
REGISTERED PROFESSIONAL ENGINEER

DESIGNED: G. KAYS	DRAWN: E. MARSHALL
DESIGNED: M. BEGGS	DRAWN: -
DESIGNED: -	CHECKED: -
SCALE: AS NOTED	APPROVED: M. EWBANK

PRESSENTIN PARK
SIDE CHANNEL RESTORATION

LOWER GRADING AND SITE PLAN

DATE:	JUNE 2015
PROJECT NO:	14-05789-000
DRAWING NO:	C-3
SHEET NO:	5 OF 11

Path: O:\proj\Y2014\14-05789-000\CAD\Dwgs\C-3.dwg
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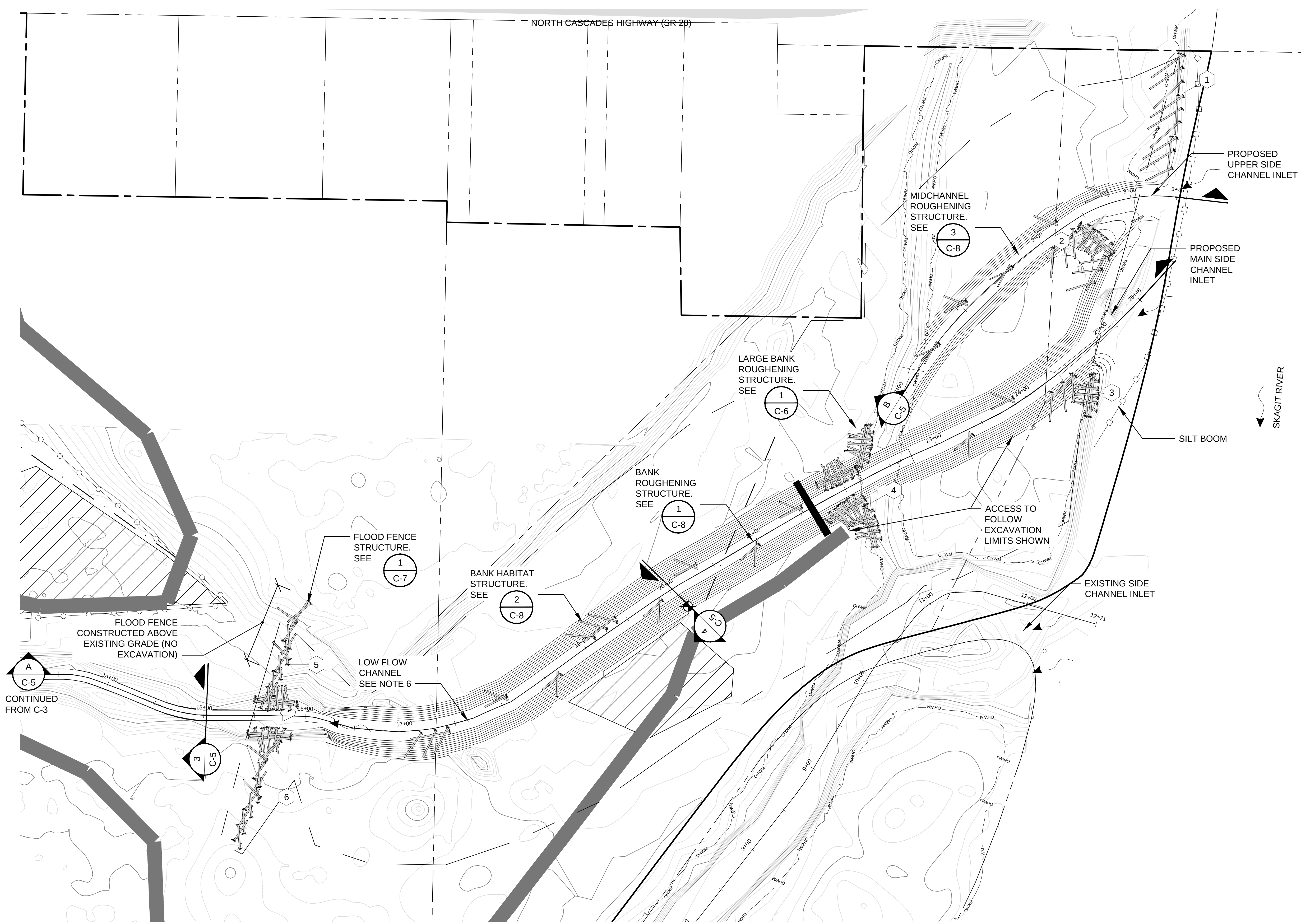

LEGEND:

- PARCEL BOUNDARY
- EXISTING TRAILS/PATHS
- PARK BOUNDARY
- WATTLES
- SILT BOOM
- HOG FUEL ACCESS ROAD
- STAGING AREA
- ELJ NUMBER
- NORTH CASCADES HIGHWAY
- BANK ROUGHENING STRUCTURE
- LARGE BANK ROUGHENING STRUCTURE
- FLOODFENCE STRUCTURE
- CHANNEL ROUGHENING
- TEST PIT/WELL LOCATION
- RIVER FLOW DIRECTION
- OHWM ORDINARY HIGH WATER MARK

NOTES:

1. PARCEL BOUNDARIES PROVIDED BY SKAGIT COUNTY.
2. LAND OWNER AGREEMENTS TO BE COORDINATED BY OWNER.
3. CONSTRUCTION ACCESS VIA NORTH CASCADES HIGHWAY.
4. ELJ LOCATIONS AND TYPES SHOWN FOR ILLUSTRATION ONLY. FINAL LOCATIONS AND TYPES SHALL BE PER HYDRAULIC MODELING ANALYSIS AND LAND OWNER AGREEMENTS.
5. CONTRACTOR SHALL SEED ALL DISTURBED AREAS. LAND OWNER SHALL BE RESPONSIBLE FOR ALL SITE PLANTINGS.
6. LOW FLOW CHANNEL AND POOL RIFFLE SEQUENCES GRADING NOT SHOWN. CONTRACTOR SHALL GRADE LOW FLOW CHANNEL COMPLEXITY AS DIRECTED BY ENGINEER.

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Plot Date: 6/8/2015 10:05 AM
Plot Style Table: Herrera.ctb
Cad User: Eric Marshall
Plotter: DWG To PDF.pc3

No.	REVISION	BY	APP'D	DATE

HERRERA

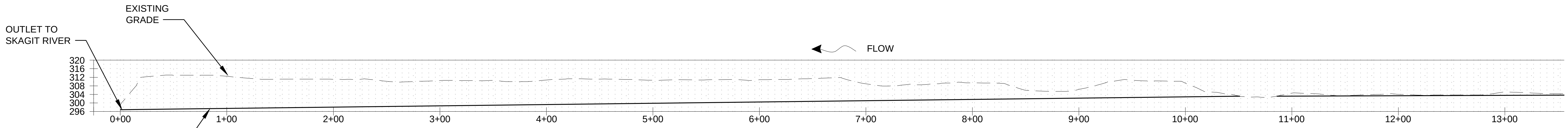
GUS BRIAN NALLS, STATE OF WASHINGTON, 25234, REGISTERED PROFESSIONAL ENGINEER

DESIGNED: G. KAYS	DRAWN: E. MARSHALL
DESIGNED: M. BEGGS	DRAWN: -
DESIGNED: -	CHECKED: -
SCALE: AS NOTED	APPROVED: M. EWBANK

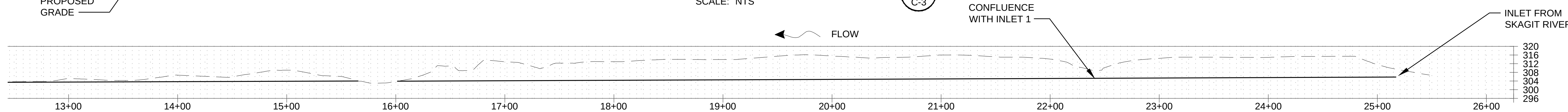
PRESSENTIN PARK
SIDE CHANNEL RESTORATION

UPPER GRADING AND SITE PLAN

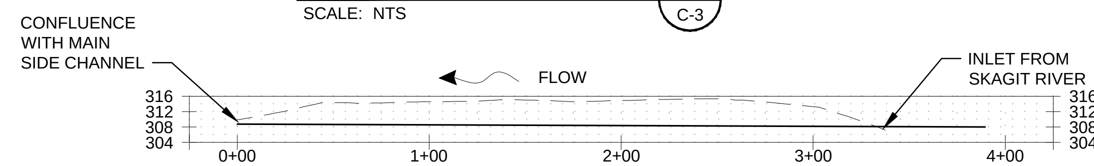
DATE: JUNE 2015
PROJECT NO: 14-05789-000
DRAWING NO: C-4
SHEET NO: 6 OF 11



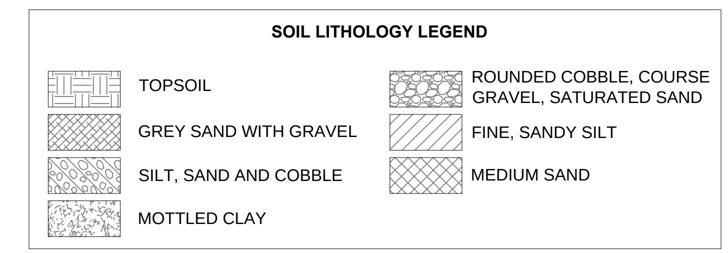
PROFILE - SIDE CHANNEL (A / C-3)
SCALE: NTS



PROFILE - SIDE CHANNEL (A / C-3)
SCALE: NTS



PROFILE - INLET 1 (B / C-3)
SCALE: NTS



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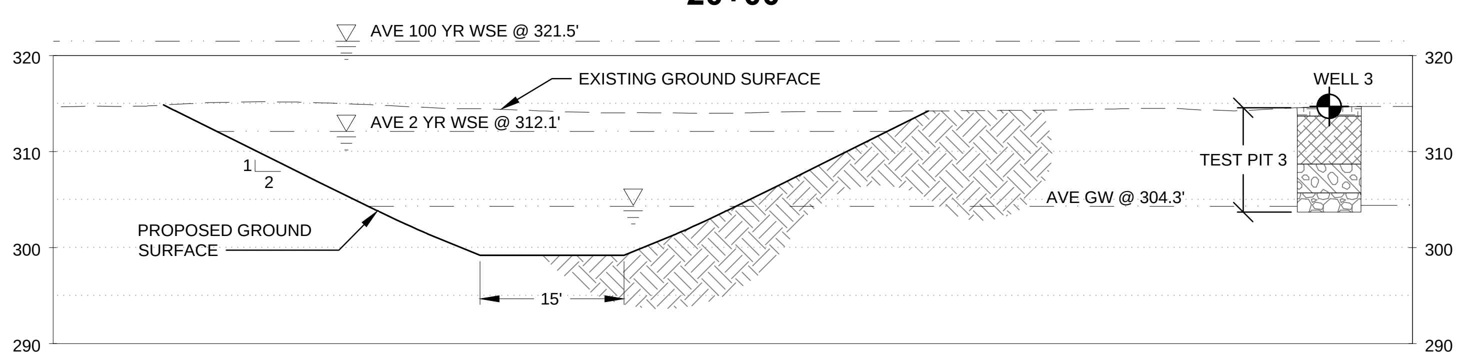
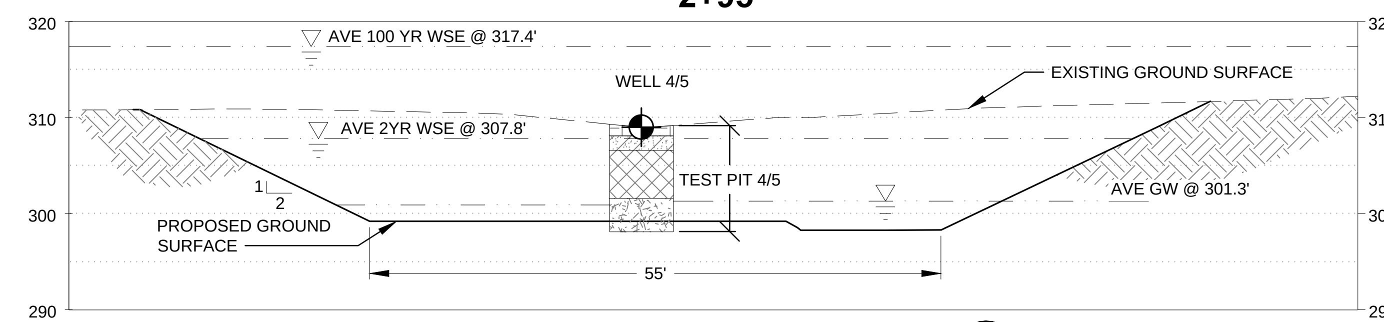


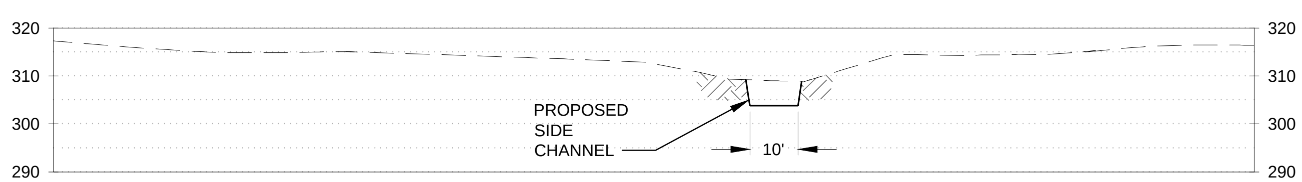
CROSS SECTION (4 / C-4)
SCALE: NTS

2+95



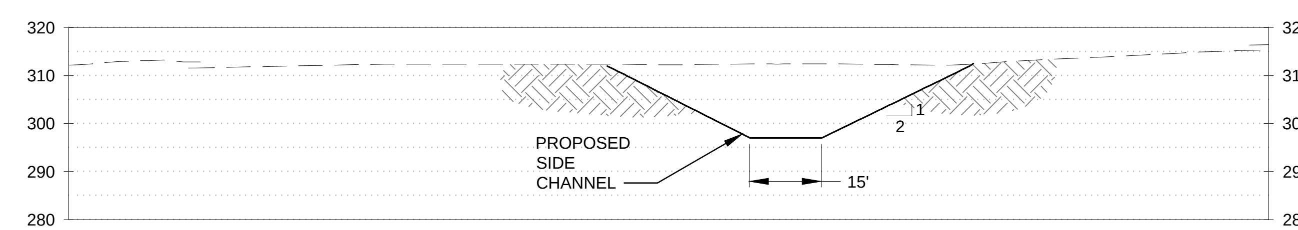
CROSS SECTION (2 / C-3)
SCALE: NTS

15+00



TYPICAL SIDE CHANNEL THALWEG CROSS SECTION (3 / C-4)
SCALE: NTS

1+00

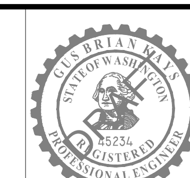


TYPICAL SIDE CHANNEL CROSS SECTION (1 / C-3)
SCALE: NTS

CONCEPT - NOT FOR CONSTRUCTION

No.	REVISION	BY	APP'D	DATE

HERRERA



DESIGNED: G. KAYS	DRAWN: E. MARSHALL		
DESIGNED: M. BEGGS	DRAWN: -		
DESIGNED: -	CHECKED: -		
SCALE: AS NOTED	APPROVED: M. EWBANK		

PRESSENTIN PARK
SIDE CHANNEL RESTORATION

GRADING DETAILS

DATE: JUNE 2015
PROJECT NO: 14-05789-000
DRAWING NO: C-5
SHEET NO: 7 OF 11

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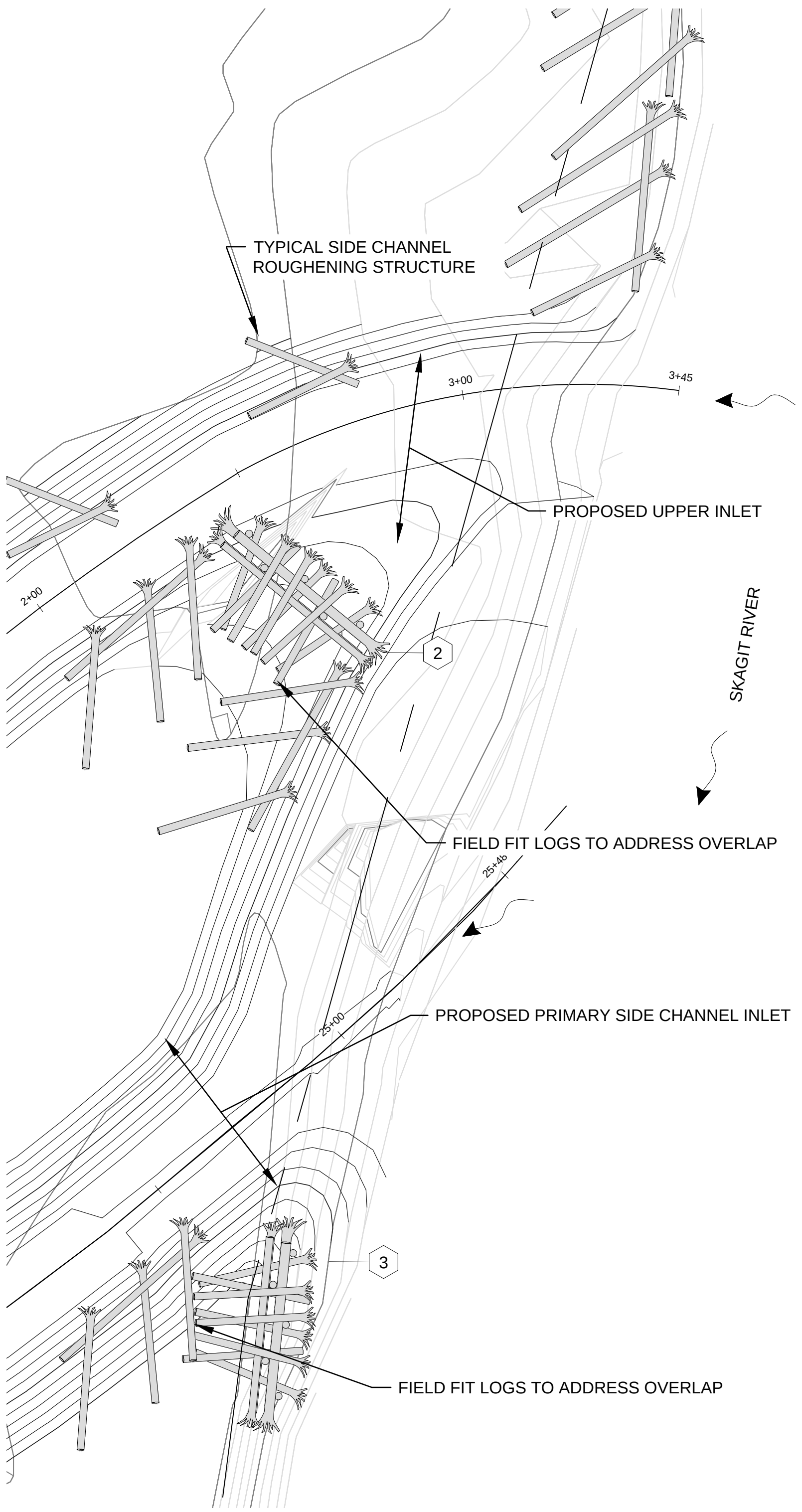
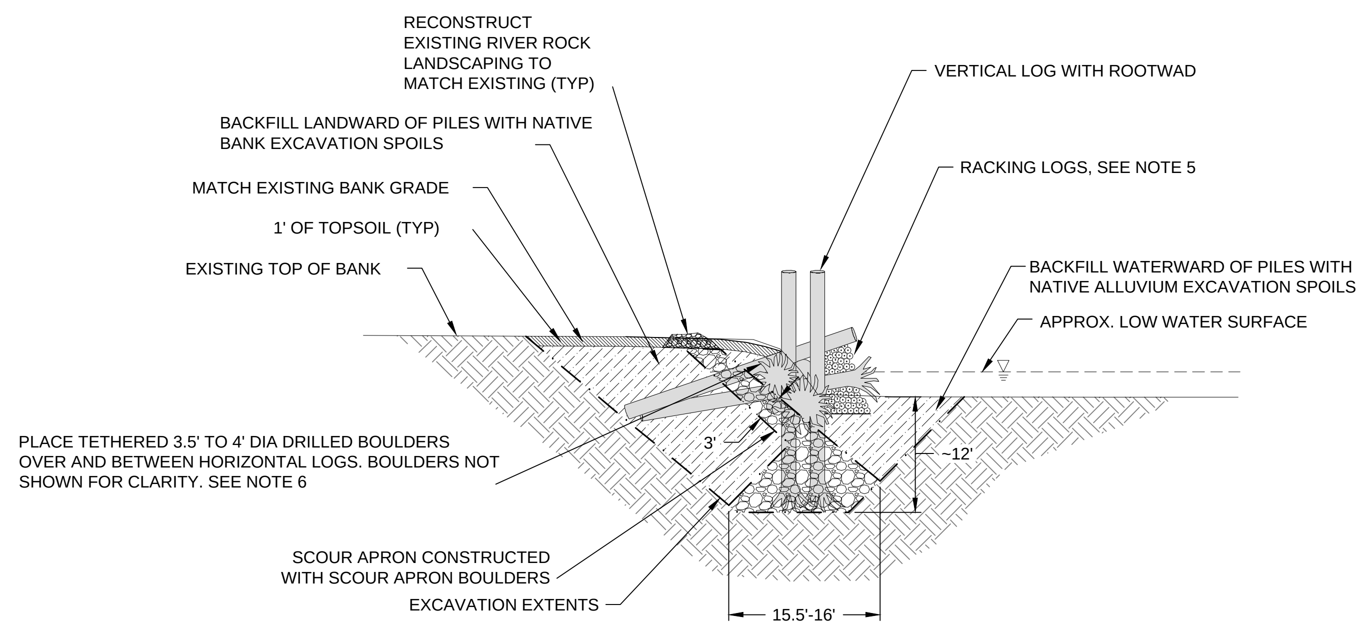
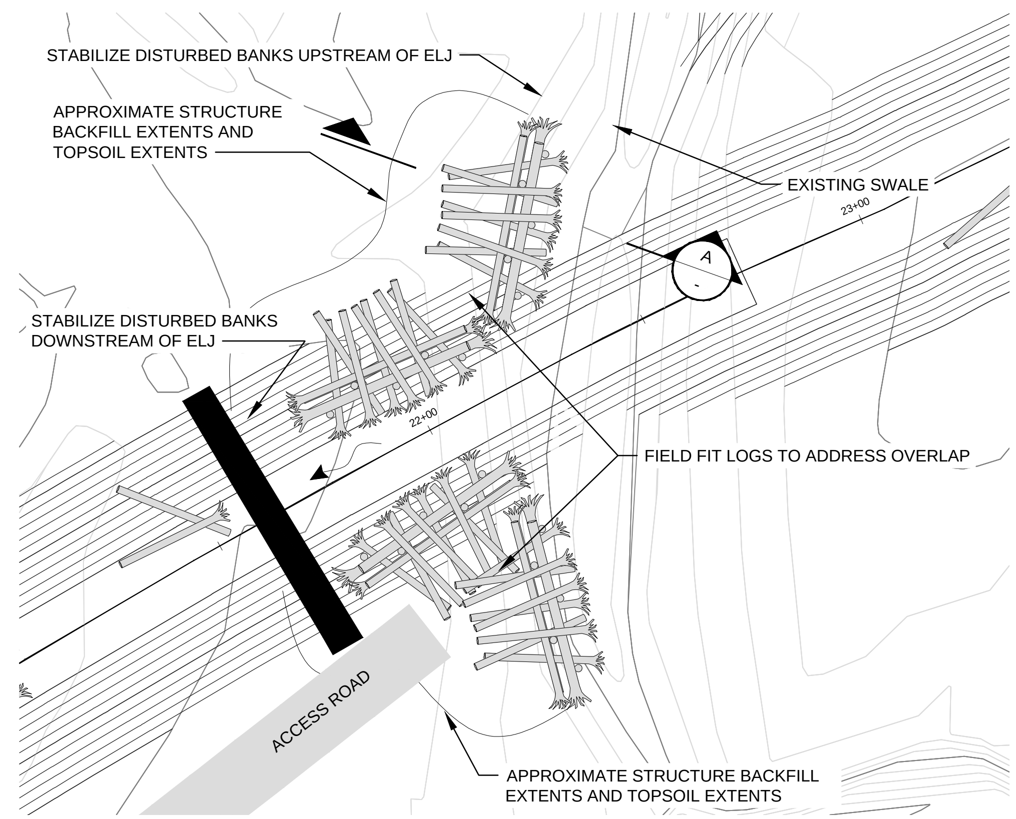
1"=30'



PLAN - INLET DETAILS
SCALE: 1" = 20'
2 / C-4

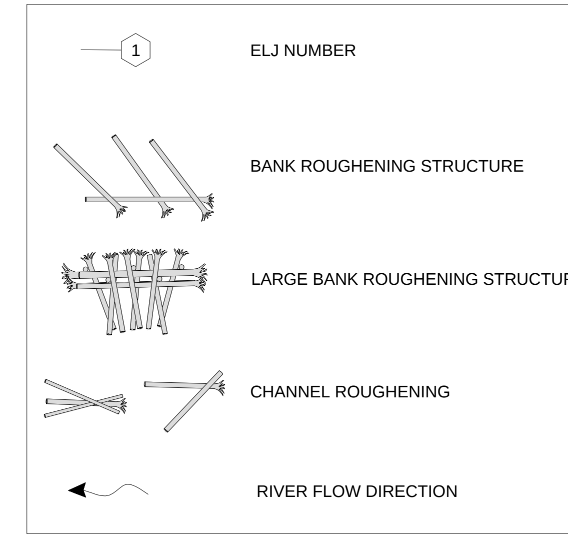


SECTION - LARGE BANK ROUGHENING STRUCTURE
SCALE: 1" = 10'
A / -



PLAN - LARGE BANK ROUGHENING STRUCTURE
SCALE: 1" = 20'
1 / C-4

LEGEND:



GENERAL NOTES:

1. PLANT ELJ BACKFILL WITH TREES AND SHRUBS.
2. RACKING PLACEMENT SHALL BE COORDINATED WITH LOG LAYER PLACEMENT AND SLASH PLACEMENT TO ENSURE RACKING MEMBERS AND SLASH EXTEND THROUGH RACKING MATERIAL.
3. CAP BACKFILL LANDWARD OF PILES WITH 1' OF TOP SOIL TO THE EXTENTS SHOWN ON PLANS.
4. EXCAVATION SPOILS SHALL BE STOCKPILED ADJACENT TO EXCAVATION WHILE MAINTAINING ACCESS TO ALLOW LOG LAYER PLACEMENT
5. RACKING LOGS SHOWN IN THE SECTION SHALL BE INSTALLED WITH APPROXIMATELY 1/3 OF THE LOGS ON THE UPSTREAM FACE OF THE ELJ AND PERPENDICULAR TO THE FLOW, 1/3 PARALLEL TO THE FLOW AND EXTENDING INTO THE CORE OF THE STRUCTURE AND 1/3 PLACED IN RANDOM ORIENTATIONS. PLACEMENT SHALL PRODUCE AN INTERLOCKING/WOVEN EFFECT BETWEEN THE LOG MEMBERS, RACKING, AND SLASH WITH MINIMIZED VOIDS.
6. PLACE TETHERED BOULDERS AS SHOWN ON STRUCTURE LAYERING PLAN.

LOG SCHEDULE - LARGE BANK ROUGHENING STRUCTURE:

LOG TYPE	MINIMUM DIAMETER (IN)	LENGTH (FT)	ROOTWAD	TOTAL QTY PER STRUCTURE
R2	16-24	25	YES	6
L2	16-24	25	NO	2
R5	16-24	40	YES	4
VERT	16-24	25	NO	5

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Plot Date: 6/8/2015 10:06 AM
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Plot Style Table: Herrera.ctb

No.	REVISION	BY	APP'D	DATE

HERRERA

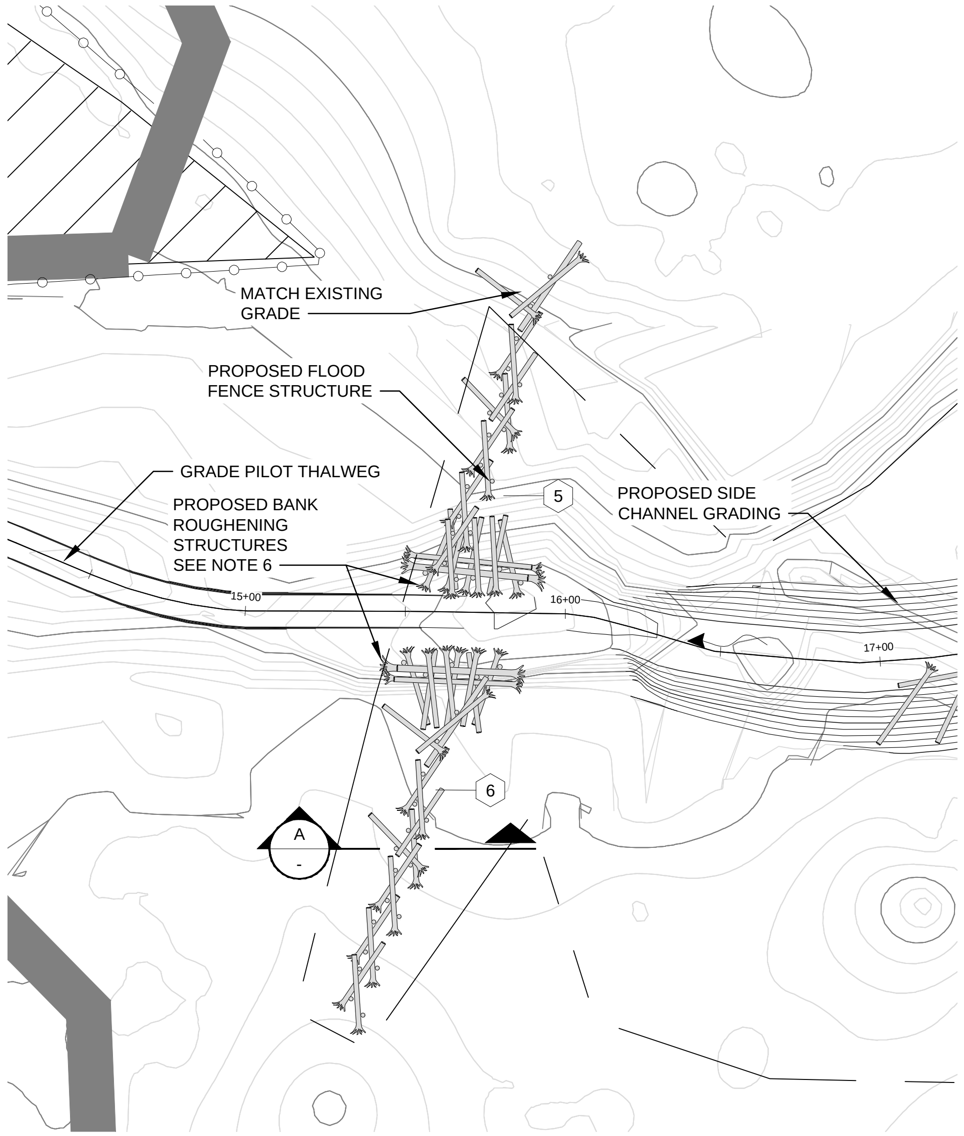
GUS BRIAN HAYS, STATE OF WASHINGTON, 25234, REGISTERED PROFESSIONAL ENGINEER

DESIGNED: G. KAYS	DRAWN: E. MARSHALL
DESIGNED: M. BEGGS	DRAWN: -
DESIGNED: -	CHECKED: -
SCALE: AS NOTED	APPROVED: M. EWBANK

PRESSENTIN PARK
SIDE CHANNEL RESTORATION

INLET PLAN AND DETAILS

DATE: JUNE 2015
PROJECT NO: 14-05789-000
DRAWING NO: C-6
SHEET NO: 8 OF 11



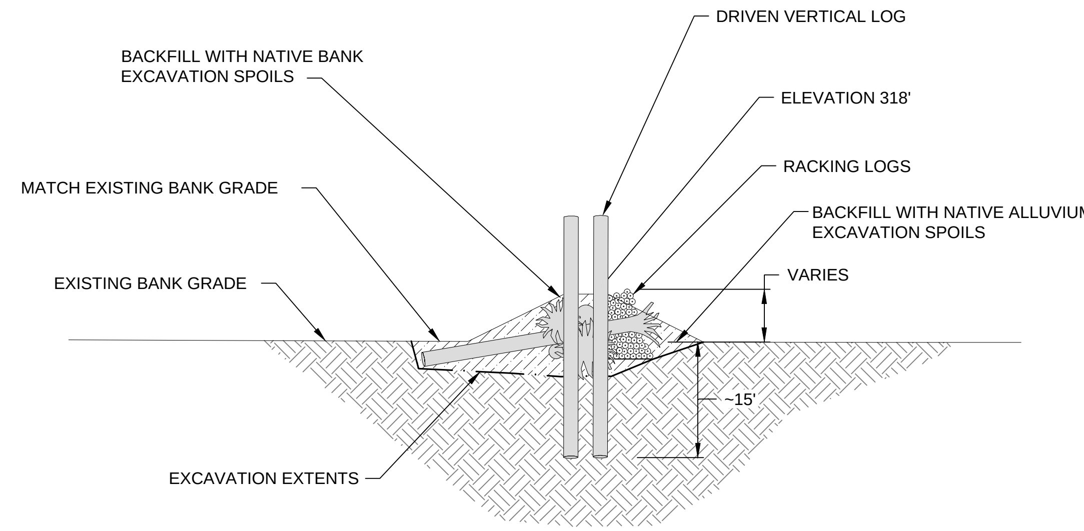
PLAN - FLOOD FENCE STRUCTURE

1
-

SCALE: 1" = 30'

LOG SCHEDULE - FLOOD FENCE STRUCTURE:

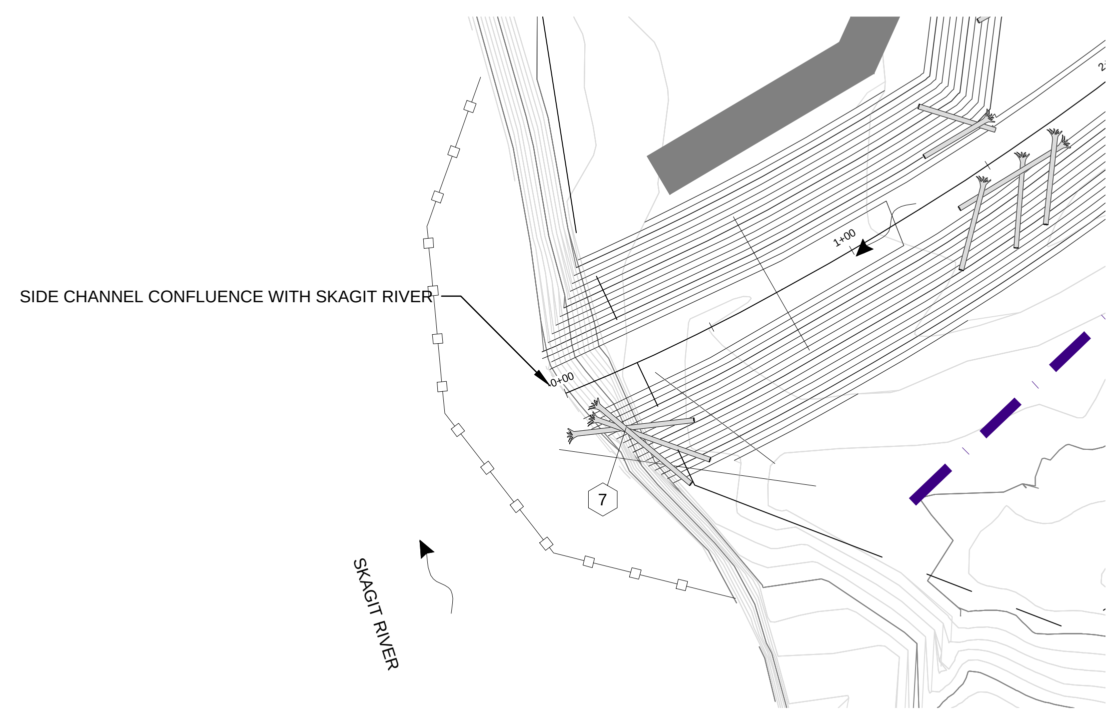
LOG TYPE	MINIMUM DIAMETER (IN)	LENGTH (FT)	ROOTWAD	TOTAL QTY PER STRUCTURE
R2	16-24	25	YES	11
L2	16-24	25	NO	1
R3	16-24	30	YES	1
L4	16-24	35	NO	1
VERT	16-24	25	NO	17



SECTION - FLOOD FENCE STRUCTURE

A
-

SCALE: 1" = 10'



DETAIL - OUTLET STRUCTURE

C
-

SCALE: 1" = 30'

30 0 30 60
1"=30'

LEGEND:

- 1 — ELJ NUMBER
- BANK ROUGHENING STRUCTURE
- LARGE BANK ROUGHENING STRUCTURE
- CHANNEL ROUGHENING
- RIVER FLOW DIRECTION
- SILT BOOM
- HOG FUEL ACCESS ROAD

GENERAL NOTES:

1. PLANT ELJ BACKFILL WITH TREES AND SHRUBS.
2. RACKING PLACEMENT SHALL BE COORDINATED WITH LOG LAYER PLACEMENT AND SLASH PLACEMENT TO ENSURE RACKING MEMBERS AND SLASH EXTEND THROUGH RACKING MATERIAL.
3. CAP BACKFILL LANDWARD OF PILES WITH 1' OF TOP SOIL TO THE EXTENTS SHOWN ON PLANS.
4. EXCAVATION SPOILS SHALL BE STOCKPILED ADJACENT TO EXCAVATION WHILE MAINTAINING ACCESS TO ALLOW LOG LAYER PLACEMENT
5. RACKING LOGS SHOWN IN THE SECTION SHALL BE INSTALLED WITH APPROXIMATELY 1/3 OF THE LOGS ON THE UPSTREAM FACE OF THE ELJ AND PERPENDICULAR TO THE FLOW, 1/3 PARALLEL TO THE FLOW AND EXTENDING INTO THE CORE OF THE STRUCTURE AND 1/3 PLACED IN RANDOM ORIENTATIONS. PLACEMENT SHALL PRODUCE AN INTERLOCKING/WOVEN EFFECT BETWEEN THE LOG MEMBERS, RACKING, AND SLASH WITH MINIMIZED VOIDS.
6. BUILD LARGE BANK ROUGHENING STRUCTURES FIRST, FLOODFENCE STRUCTURE TO BE CONSTRUCTED SO THAT FINAL ELEVATION SHALL BE 318' AT TOP OF LARGE BANK ROUGHENING STRUCTURES.

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Plot Style Table: Herrera.ctb

No.	REVISION	BY	APP'D	DATE

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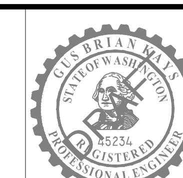

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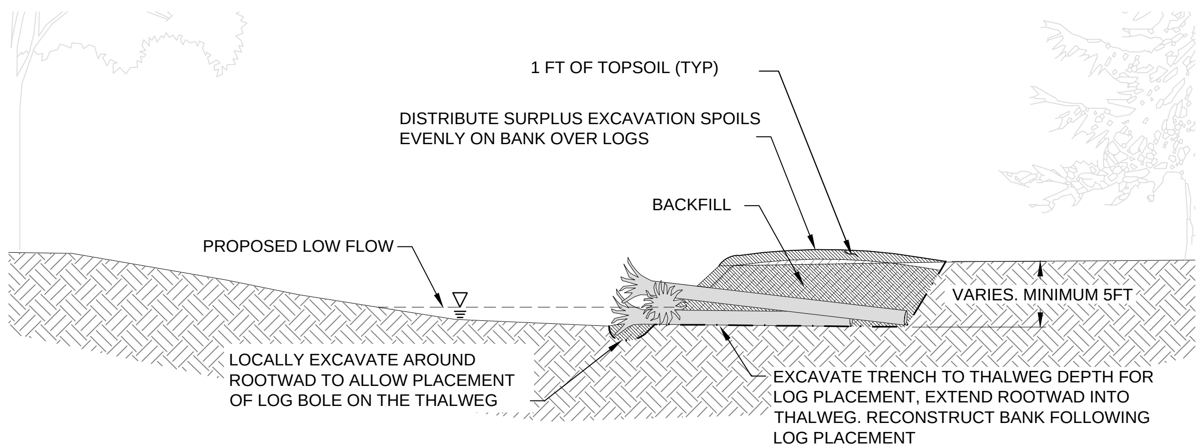
DESIGNED: M. BEGGS	DRAWN: -
DESIGNED: -	CHECKED: -
SCALE: AS NOTED	APPROVED: M. EWBANK

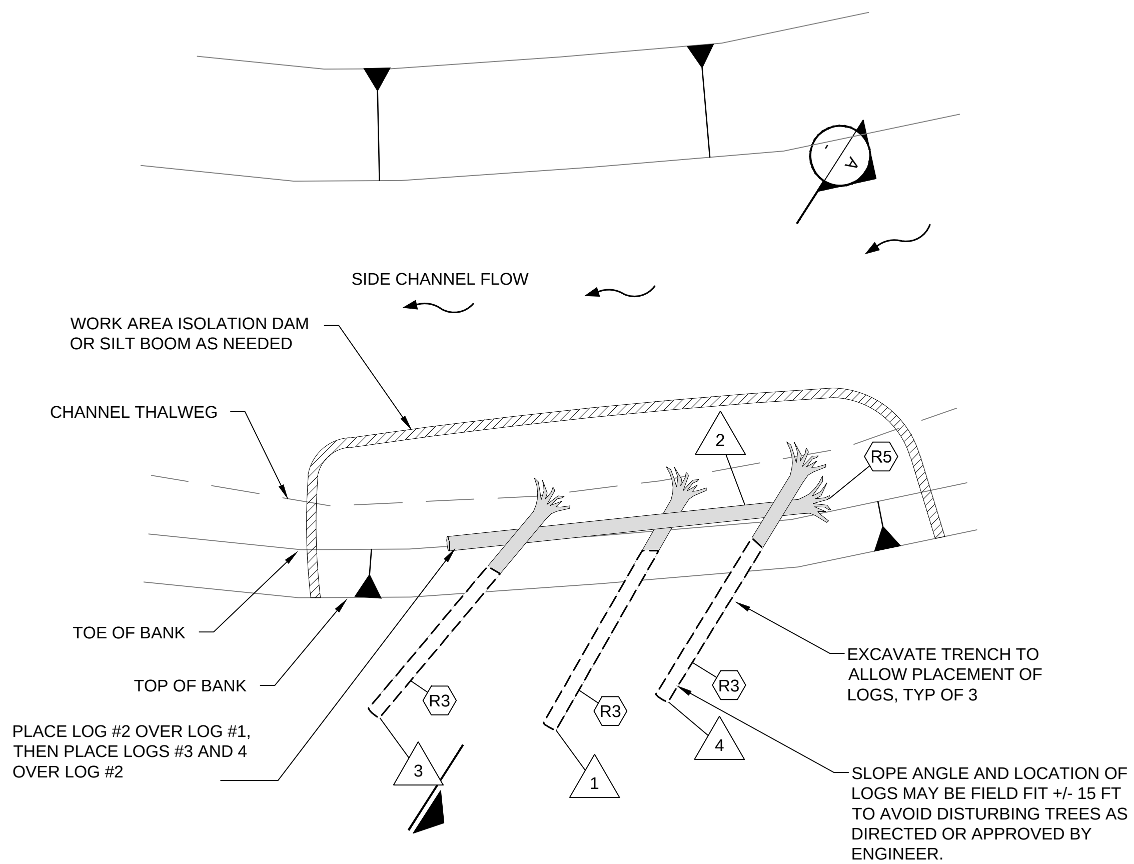
PRESSENTIN PARK
SIDE CHANNEL RESTORATION

OUTLET AND FLOODFENCE PLAN AND DETAILS

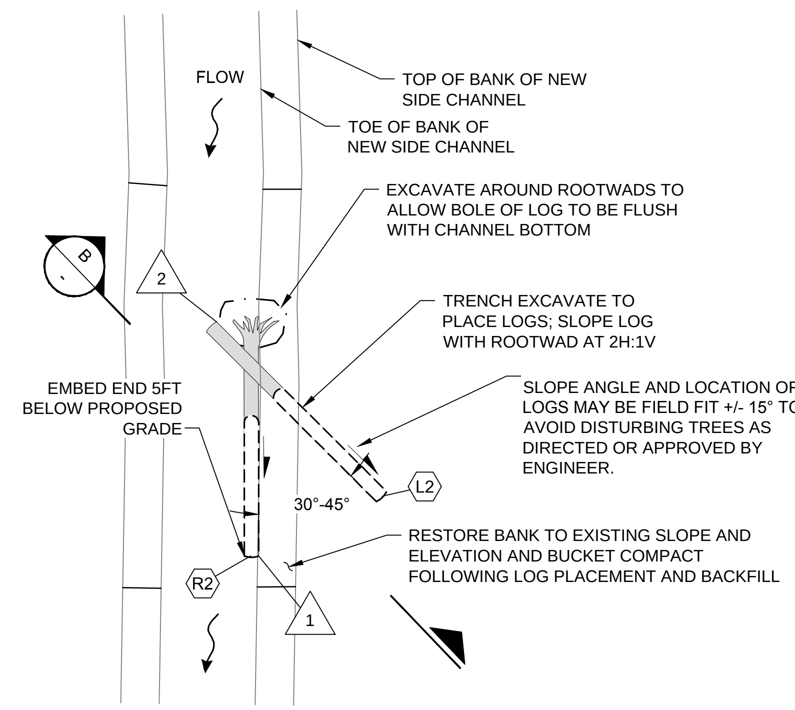
DATE:	JUNE 2015
PROJECT NO:	14-05789-000
DRAWING NO:	C-7
SHEET NO:	9 OF 11



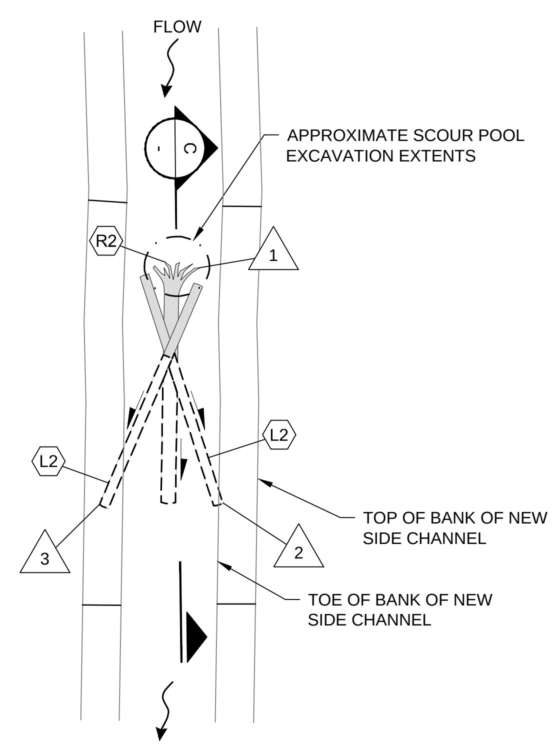
SECTION - BANK HABITAT STRUCTURE (A / -)
SCALE: 1" = 10'



PLAN - BANK HABITAT STRUCTURE (2 / C-3, C-4)
SCALE: 1" = 10'



DETAIL - BANK ROUGHENING STRUCTURE (1 / C-3, C-4)
SCALE: 1" = 10'



DETAIL - MID-CHANNEL ROUGHENING STRUCTURE (3 / C-3, C-4)
SCALE: 1" = 10'

LOG SCHEDULE - BANK ROUGHENING STRUCTURE:

LOG TYPE	MINIMUM DIAMETER (IN)	LENGTH (FT)	ROOTWAD	TOTAL QTY PER STRUCTURE
R2	12-24	25	YES	1
L3	12-24	25	NO	1

LOG SCHEDULE - MID-CHANNEL ROUGHENING STRUCTURE:

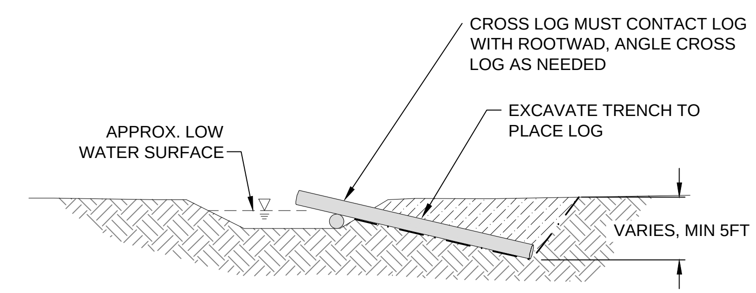
LOG TYPE	MINIMUM DIAMETER (IN)	LENGTH (FT)	ROOTWAD	TOTAL QTY PER STRUCTURE
R2	12-24	25	YES	1
L2	12-24	25	NO	2

LOG SCHEDULE - BANK HABITAT STRUCTURE:

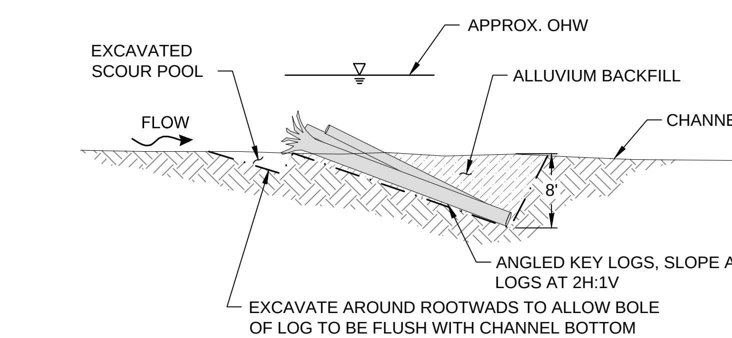
LOG TYPE	MINIMUM DIAMETER (IN)	LENGTH (FT)	ROOTWAD	TOTAL QTY PER STRUCTURE
R5	12-24	40	YES	1
R3	12-24	30	YES	3

LEGEND:

#	ORDER OF LOG PLACEMENT



SECTION - BANK ROUGHENING STRUCTURE (B / -)
SCALE: 1" = 10'



SECTION - MID CHANNEL ROUGHENING STRUCTURE (C / -)
SCALE: 1" = 10'

CONCEPT - NOT FOR CONSTRUCTION

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No.	REVISION	BY	APP'D	DATE

HERRERA

GUS BRIAN MAYS — STATE OF WASHINGTON — 25234 — REGISTERED PROFESSIONAL ENGINEER

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DESIGNED: M. BEGGS	DRAWN: -
DESIGNED: -	CHECKED: -
SCALE: AS NOTED	APPROVED: M. EWBANK

PRESSENTIN PARK
SIDE CHANNEL RESTORATION

ELS DETAILS

DATE:	JUNE 2015
PROJECT NO:	14-05789-000
DRAWING NO:	C-8
SHEET NO:	10 OF 11

Path: O:\proj\Y2014\14-05789-000\CAD\Dwgs\C-8.dwg
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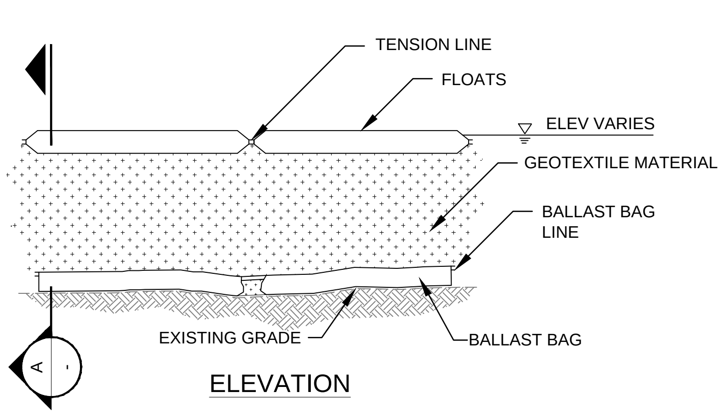
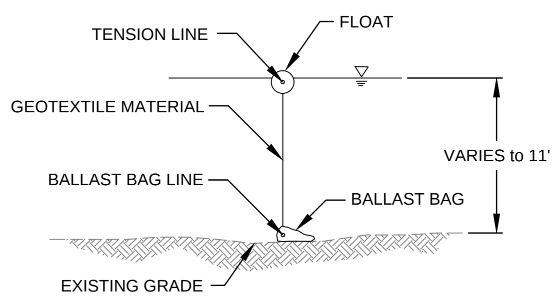


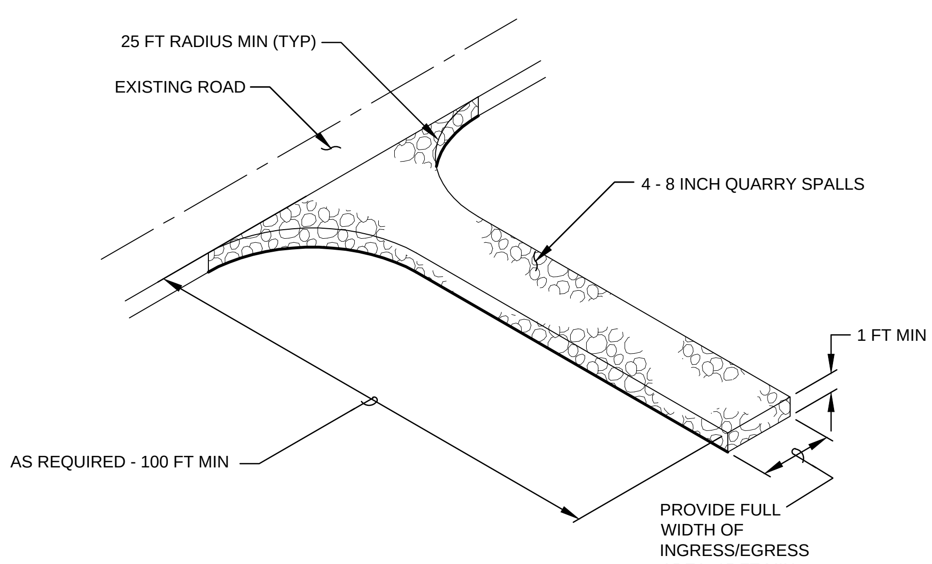
ELEVATION



SECTION A

SILT BOOM

SCALE: NTS

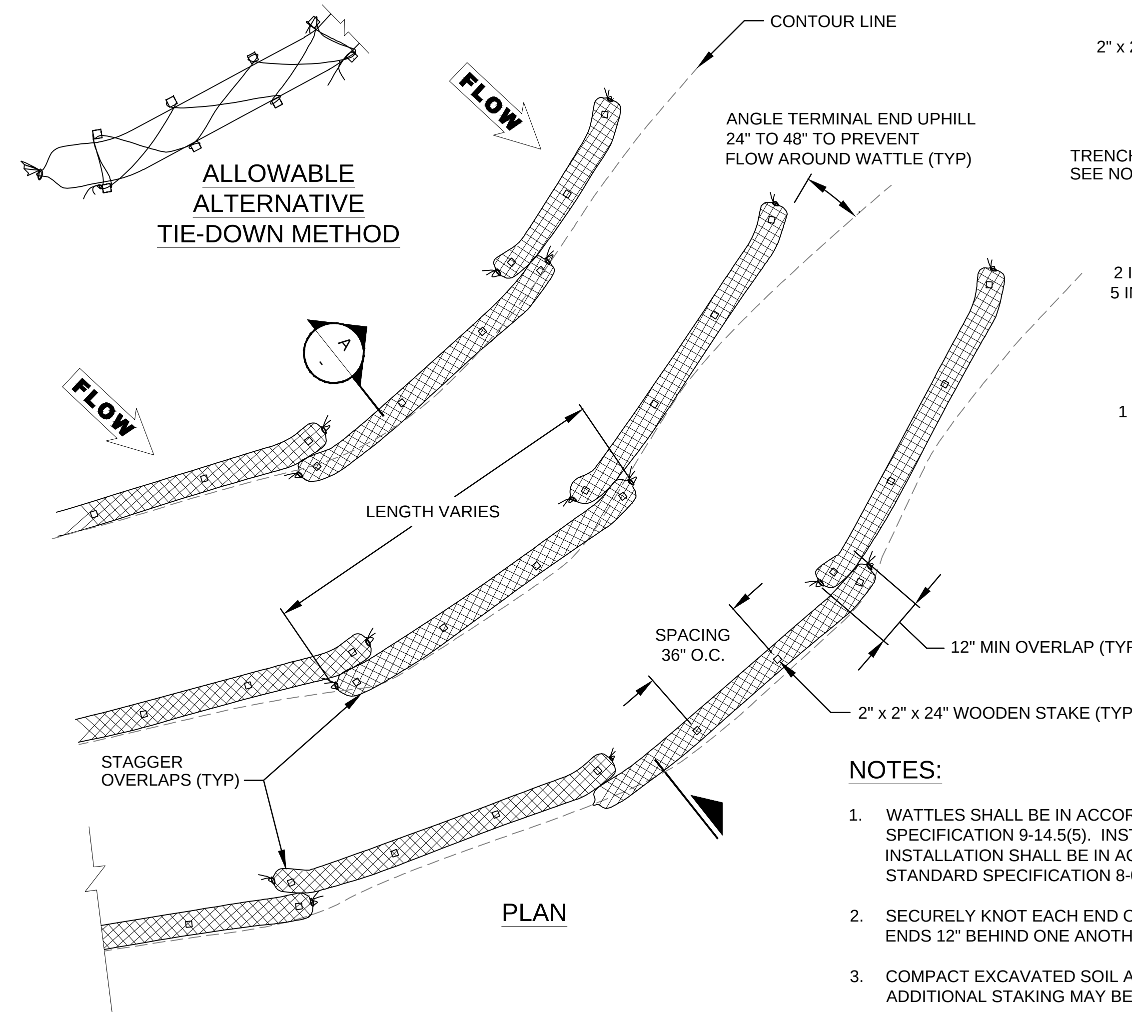


NOTES:

1. PLACE SEPARATION GEOTEXTILE UNDER THE SPALLS TO PREVENT FINE SEDIMENT FROM PUMPING UP INTO THE ROCK PAD. THE GEOTEXTILE SHALL MEET THE STANDARDS IN APPENDIX D OF THE KING COUNTY SURFACE WATER DESIGN MANUAL.
2. ANY QUARRY SPALLS THAT ARE LOOSENED FROM THE PAD AND END UP ON THE EXISTING ROAD SHALL BE REMOVED.

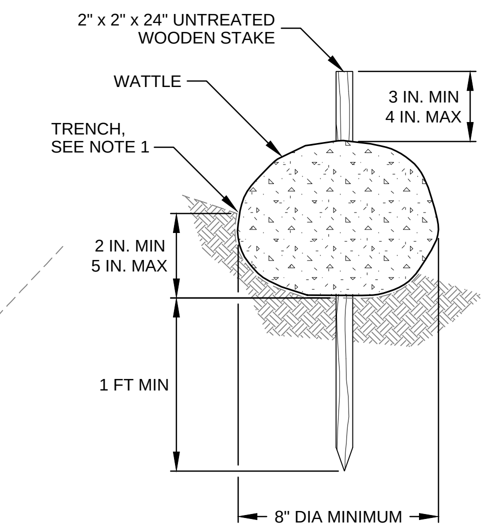
STABILIZED CONSTRUCTION ENTRANCE

SCALE: NTS



ALLOWABLE ALTERNATIVE TIE-DOWN METHOD

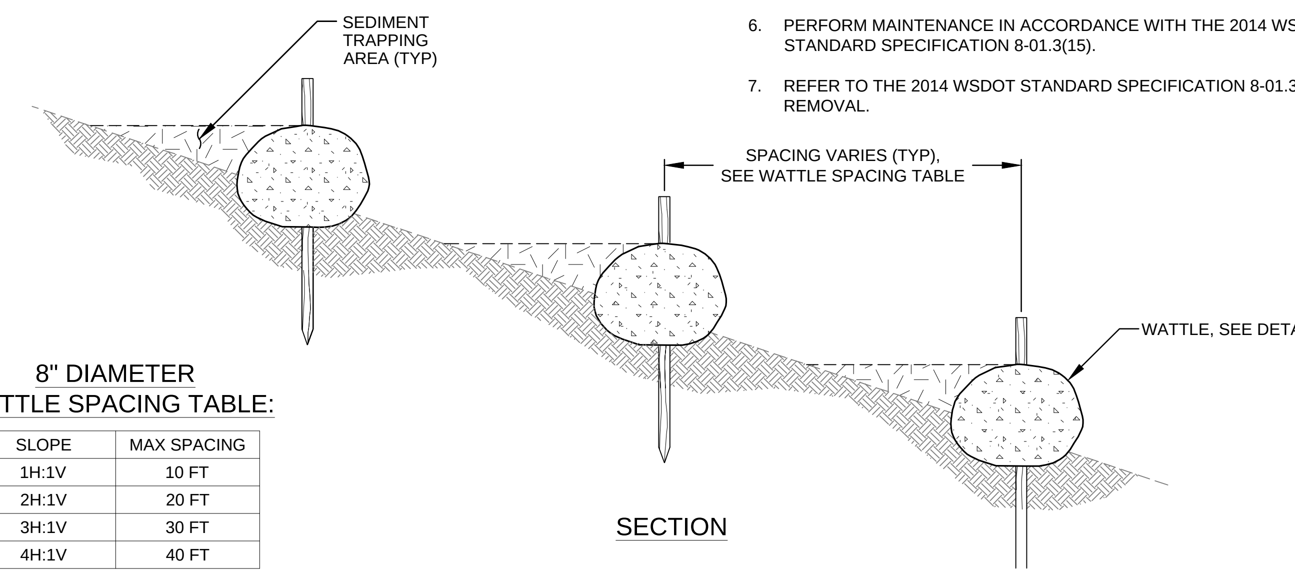
PLAN



DETAIL

NOTES:

1. WATTLES SHALL BE IN ACCORDANCE WITH THE 2014 WSDOT STANDARD SPECIFICATION 9-14.5(5). INSTALL WATTLES ALONG CONTOURS. INSTALLATION SHALL BE IN ACCORDANCE WITH THE 2014 WSDOT STANDARD SPECIFICATION 8-01.3(10).
2. SECURELY KNOT EACH END OF WATTLE. OVERLAP ADJACENT WATTLE ENDS 12" BEHIND ONE ANOTHER AND SECURELY TIE TOGETHER.
3. COMPACT EXCAVATED SOIL AND TRENCHES TO PREVENT UNDERCUTTING. ADDITIONAL STAKING MAY BE NECESSARY TO PREVENT UNDERCUTTING.
4. INSTALL WATTLE PERPENDICULAR TO FLOW ALONG CONTOURS.
5. WATTLES SHALL BE INSPECTED REGULARLY, AND IMMEDIATELY AFTER A RAINFALL PRODUCES RUNOFF, TO ENSURE THEY REMAIN THOROUGHLY ENTRENCHED AND IN CONTACT WITH THE SOIL.
6. PERFORM MAINTENANCE IN ACCORDANCE WITH THE 2014 WSDOT STANDARD SPECIFICATION 8-01.3(15).
7. REFER TO THE 2014 WSDOT STANDARD SPECIFICATION 8-01.3(16) FOR REMOVAL.



SECTION

8" DIAMETER WATTLE SPACING TABLE:

SLOPE	MAX SPACING
1H:1V	10 FT
2H:1V	20 FT
3H:1V	30 FT
4H:1V	40 FT

WATTLE INSTALLATION ON SLOPE

SCALE: NTS

CONCEPT - NOT FOR CONSTRUCTION

ONE INCH

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No.	REVISION	BY	APP'D	DATE

HERRERA

DESIGNED: G. KAYS	DRAWN: E. MARSHALL
DESIGNED: M. BEGGS	DRAWN: -
DESIGNED: -	CHECKED: -
SCALE: AS NOTED	APPROVED: M. EWBANK

PRESSENTIN PARK
SIDE CHANNEL RESTORATION

TESC DETAILS

DATE: JUNE 2015
PROJECT NO: 14-05789-000
DRAWING NO: ESC-1
SHEET NO: 11 OF 11

Path: O:\proj\Y2014\14-05789-000\CAD\Dwgs\ESC-1.dwg
Plot Date: 6/8/2015 10:07 AM
Plot Style Table: Herrera.ctb
Cad User: Eric Marshall
Plotter: DWG To PDF.pc3