DEBAY SLOUGH SITE ASSESSMENT

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1 INTRODUCTION

Natural Systems Design, Inc. (NSD) has prepared this memo to document our analysis of existing conditions within DeBay Slough in Skagit County, Washington. NSD is supporting Skagit County Public Works (SCPW), in partnership with the Washington State Department of Fish and Wildlife (WDFW), to evaluate restoration opportunities to enhance juvenile Chinook rearing and refuge habitat within DeBay Slough, a left bank, off channel slough of the Skagit River (Figure 1). The project area is located just upstream/east of the Nookachamps Creek confluence with the Skagit at approximately river mile (RM) 21.5, east of Burlington. This summary is the first step in the feasibility study and will support future identification of restoration opportunities and development of conceptual designs and an associated Basis of Design report. This memo will ultimately form the basis of that report.

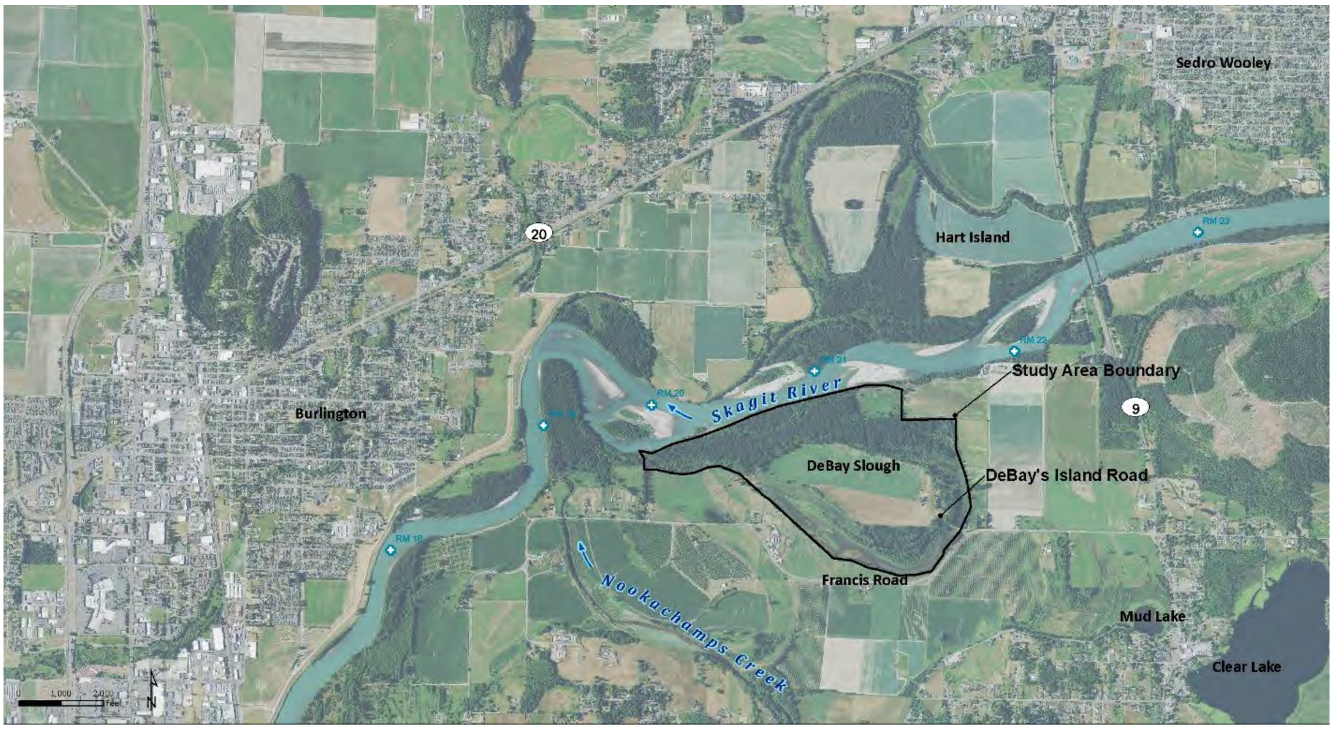

Figure 1. DeBay Slough location and vicinity

Various historical and mapping resources differ in the spelling of the slough and associated roadway. WDFW refers to their reserve as the Johnson/DeBay's Slough Unit; various resources identify the access road as DeBay's Isle or Island Road. We have adopted the nomenclature of DeBay Slough and DeBay's Isle Road herein consistent with the County's parcel database and after consultation with the project Advisory Group.

NSD, SCPW, and WDFW are evaluating the feasibility of habitat and access enhancements at DeBay Slough that consider the slough and its surrounding area's multiple uses (i.e., overwintering tundra and trumpeter swan habitat, waterfowl hunting, birding, natural open space, and agriculture uses). This site assessment evaluates existing conditions relative to the multi-use and multi-species benefits that the site currently provides and will support consideration by SCPW, WDFW, and the project's advisory group of the potential to improve juvenile Chinook rearing and refuge habitat.

2 PROJECT AREA

The DeBay Slough project area encompasses the slough itself, DeBay's Isle Road and culvert which are owned and maintained by Skagit County, an outlet/connector channel to the Skagit River, and the approximately 390-acre Johnson/DeBay's Slough Wildlife Area Unit owned and managed by WDFW (Figure 2).

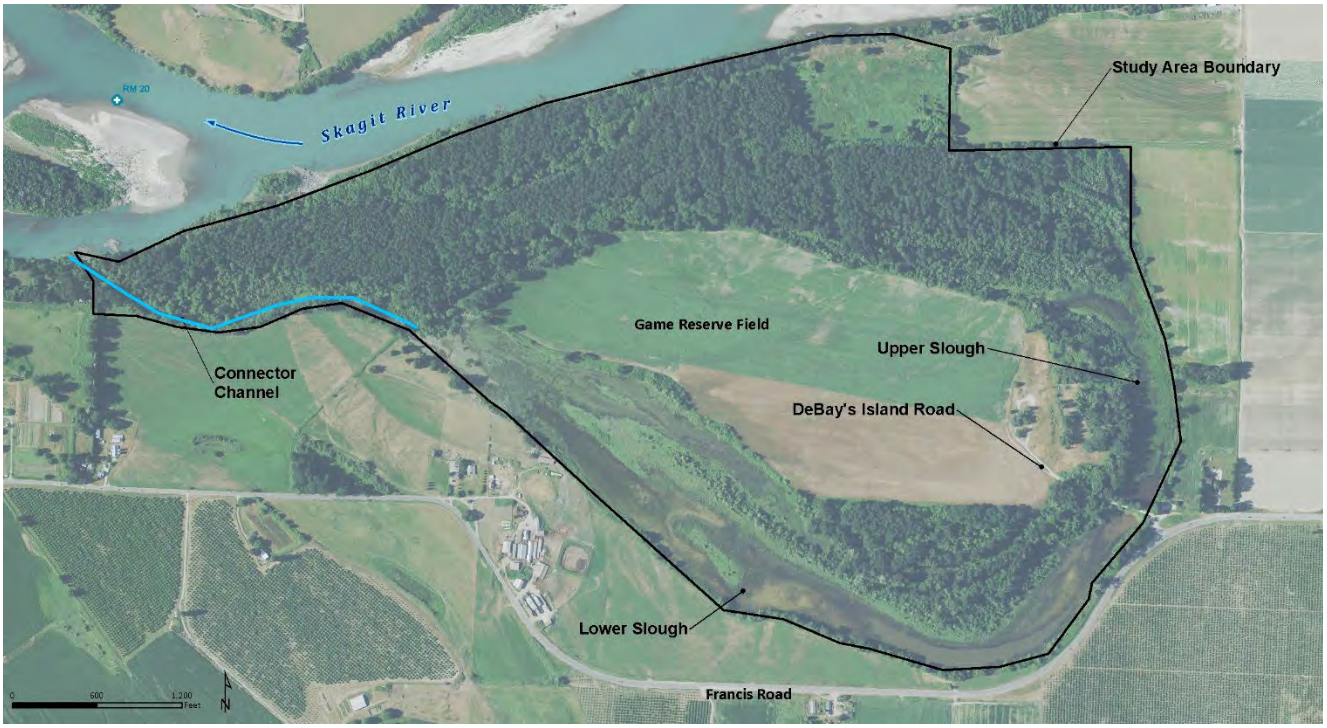

Figure 2. Generalized illustration of DeBay Slough feasibility assessment project area (not intended to represent property ownership or boundaries).

The Johnson/DeBay's Slough Unit was purchased in 1995-1997 to protect a popular swan night roost site and to provide a non-hunted upland reserve for trumpeter and tundra swans where they can feed and rest in the winter. DeBay Slough is named for the DeBay family which owned and farmed the area.

The Johnson/DeBay's Slough Unit is comprised of agricultural fields, riparian forest, and freshwater wetlands. WDFW has primarily managed this area in cooperation with local farmers as a Game Reserve for overwintering trumpeter and tundra swans that migrate to the area from the Arctic to forage and rest. The Reserve also provides limited waterfowl hunting in the portion of DeBay Slough north of DeBay's Isle Road and in the adjacent agricultural field to the east of the upper portion of DeBay Slough. Because the project area includes a diversity of habitats, it also provides birding opportunities including observing the wintering swans and year-round opportunities to observe birds utilizing the slough, wetlands, and riparian forest habitats of the area.

DeBay's Isle Road crosses the slough, providing access to the Game Reserve from Francis Road. The DeBay's Isle Road crossing includes an undersized culvert crossing which limits hydraulic and geomorphic connectivity to the upper portion of the slough.

Private property surrounding the slough is primarily agricultural, with dairy farms along the southern boundary, fields variously cropped in corn to the west, and filbert/hazelnut orchards to the southeast. Public access to the

Game Reserve is limited to the parking and grassy viewing area at the end of DeBay's Isle Road; parking is also available immediately off Francis Road in a small parking lot which provides access to the hunting areas.

2.1.1 Memo Organization

This memo presents the project goals and objectives, followed by a summary of the limiting factors affecting Chinook salmon in the Skagit River. We then present a summary of the site assessment methods and existing conditions analysis for each of the following elements of the project area:

- Topography and Bathymetric Survey
- Hydrology
- Hydraulics
- Geomorphic Assessment
- Aquatic Habitat Conditions and Use
- Terrestrial and Wetland Habitat Conditions and Use
- Summary
- Next Steps in Feasibility Study

3 PROJECT GOALS AND OBJECTIVES

The goal of this project is to assess the feasibility of making habitat enhancement improvements to the DeBay Slough study area for the benefit of Chinook salmon. The study area supports multiple land uses, a wide diversity of terrestrial, wetland, and aquatic habitats, and an important Game Reserve for overwintering swans. Given these considerations, WDFW and SCPW seek to understand the variety of habitats and ecological functions of the study area and to use that information to consider if actions to benefit Chinook salmon could feasibly be considered in the study area without detrimental effects to neighboring properties and land use or to the functions and habitats currently present.

The primary elements being considered by WDFW and SCPW in the assessment of habitat enhancement feasibility, as developed in cooperation with the project's Advisory Group, include:

- Hydraulic connectivity between the slough, connector channel, and Skagit River at flows consistent with important seasons of use by juvenile Pacific salmonids, specifically Chinook Salmon, and waterfowl, including overwintering swans
- Geomorphic context, with an emphasis on trends in river channel migration and stability of DeBay Slough as a landform
- Extent and nature of existing riparian and wetland vegetation and habitat functions they provide to both juvenile salmonids and aquatic-associated wildlife and birds
- Water quality in the slough, including temperature and dissolved oxygen conditions relative to salmonid rearing habitat needs
- Use of the slough by juvenile salmonids as rearing and high flow refuge habitat.
- Use of the slough by other native and non-native fish, aquatic-associated mammals, amphibians, and reptiles
- Use of the slough and surrounding areas by waterfowl, raptors, and migratory and resident birds
- Human use of the Game Reserve for birding and hunting

- Human residential and agricultural use of the areas surrounding the slough

The technical approach to characterizing existing conditions relied on a combination of desktop and field data collection of topographic, hydrologic, hydraulic, geomorphic, and fish and wildlife habitat information to understand the ecological attributes of the study area. This information, coupled with the consideration of the habitat needs of Skagit River Chinook salmon, will form the basis of the feasibility assessment.

4 SKAGIT RIVER CHINOOK LIMITING FACTORS

The Skagit River Chinook Recovery Plan (SRSC and WDFW, 2005) sets forth a framework for evaluating restoration and protection actions for the recovery of Chinook and details specific actions supportive of recovery based on the life history needs and habitat limiting factors for Chinook in the Skagit River basin. NSD reviewed the Recovery Plan to identify specific uses and limiting factors relevant to DeBay Slough and the habitats present within the study area and to consider restorative actions which would specifically address the life history needs and habitat limiting factors for Chinook in the Skagit River basin.

Anadromous forms of ten salmonid species exist within the Skagit Basin. These include six Chinook stocks (spring, summer, and fall); pink salmon; coho salmon; chum salmon; sockeye salmon; summer and winter run steelhead; sea run and resident cutthroat trout; and Dolly Varden and bull trout (SRSC and WDFW, 2005). Chinook, steelhead, and bull trout are each federally listed threatened species protected by the Endangered Species Act.

Lower Skagit fall Chinook spawn in the Skagit River mainstem and its tributaries downstream of the Sauk River, mainly between Sedro Woolley and the Sauk River. They spawn primarily in October, which is generally later than the Upper Skagit summer Chinook (SRSC and WDFW, 2005). DeBay Slough does not provide spawning habitat but may be accessible to juvenile Chinook (as well as other salmonids). Specifically, the slough may provide off-channel, early summer rearing habitat for ocean-type parr migrants, which rear in freshwater for a few months prior to outmigrating to the delta in late May or June. Stream-type yearlings are a Skagit River Chinook life history type in which the juveniles rear in freshwater for over a year, eventually migrating to the estuary from late March through May. These juveniles may use DeBay Slough for winter rearing/high flow refuge and potentially also for early season summer rearing habitat.

Degraded riparian zones and high water temperatures are specific factors that limit or restrict habitat use by Chinook in the portion of the watershed that includes DeBay Slough. Degraded riparian zones lacking in large conifers alter the natural large wood recruitment cycle and the related formation of complex riverine floodplain and wetland habitats that support juvenile Chinook rearing.

Fish passage and access barriers to habitat across life history stages is another factor that negatively affects Chinook in the basin. Access issues include altered hydrologic connections, maintenance of connections to off channel and side channel habitats including open water and wetland areas, as well as access to areas fed by cold hyporheic zone water and with complex foraging and refuge habitat formed by large wood and an interspersion of edge habitats formed by streamside and wetland vegetation.

It has been estimated that approximately 37% of the floodplain in the spawning range of Lower Skagit fall Chinook is disconnected from natural river processes, limiting the formation and accessibility of off channel habitat for juvenile rearing (SRSC and WDFW, 2005). Restoration of freshwater rearing habitats is thus specifically recommended to increase the number of parr migrants which survive to outmigrate through the delta and nearshore environments. The recommended strategy for floodplain restoration generally focuses on reconnecting isolated floodplain areas and restoring mainstem edge habitat. This includes restoration of a diversity of habitats for low velocity flood refuge habitat in off channel and back water areas, such as DeBay

Slough, so that 0+ age juveniles are not displaced downstream into the delta and nearshore, resulting in lower survival, and can instead utilize the freshwater, off channel areas to rear and increase in size (SRSC and WDFW, 2005).

Similarly, floodplain restoration actions that restore the movement of water, wood, and sediment across the floodplain not only support the maintenance and creation of Chinook spawning and rearing habitats, but also increase the base level of productivity through increasing riparian, wetland, and floodplain vegetation primary productivity. In so doing, detritus retention and benthic foodchain productivity is also increased, which directly support juvenile prey resources in off channel and side channel habitats. This feasibility study includes consideration of access to and habitat quality within juvenile rearing habitats, as well as restorative actions that support riparian, wetland, and floodplain vegetation community diversity and extent.

5 SITE ASSESSMENT AND EXISTING CONDITIONS ANALYSIS

NSD collected and synthesized existing information to develop an understanding of the DeBay Slough site and surrounding area. NSD compiled and reviewed relevant background information for the site including aerial photography, mainstem channel occupancy, the lidar digital elevation model (DEM), current and historical land use practices, and previous reports including the Skagit Chinook Recovery Plan (SRSC and WDFW, 2005). NSD also reviewed existing water quality (WQ) and hydrologic data collected by SCPW to compare with existing water quality standards for juvenile Chinook rearing habitat.

NSD conducted field assessments in early 2022 to collect data necessary for the 2D hydraulic modeling and geomorphic assessments, to qualitatively assess fish and wildlife habitat conditions and use, and to support the eventual development of potential habitat restoration actions.

5.1 Topographic and Bathymetric Survey

NSD collected topographic and bathymetric survey data to characterize existing topographic conditions within the slough, the Skagit River mainstem, and the connector channel between DeBay Slough and the Skagit River. Survey data were collected to supplement the existing 2016 lidar coverage at the site, to account for recent channel migration in the Skagit River, and to capture bathymetric data for wetted areas in the slough and mainstem channel.

5.1.1 Methods

The mainstem Skagit River was surveyed using single beam sonar and real time kinematic (RTK) GPS survey by jet boat on February 16, 2022 and using of single beam sonar and RTK from small kayaks and ground-based RTK survey on February 23, 2022. The mainstem Skagit survey spanned from upstream of the SR 9 bridge (RM 23.5) to just downstream of the confluence with Nookachamps Creek (RM 20). DeBay Slough and the connector channel to the Skagit mainstem were surveyed using single beam sonar and ground based RTK on March 10-11, 2022.

Survey data were collected at cross sections chosen for the development of the hydraulic model, with thalweg points and water surface and water’s edge data collected to enable interpolation between cross sections and aid in hydraulic model calibration. Survey data were reviewed for quality assurance and quality control and then imported to a HEC-RAS 2D environment for surface development. Development of the existing surfaces representing the mainstem Skagit River, DeBay Slough, and connector channel bathymetry was performed using the terrain development tools included in HEC-RAS Version 6.2. Terrain development consisted of establishing surveyed cross sections, channel thalweg and banklines from the collected survey data. Terrain interpolation between the surveyed cross sections was performed utilizing the established thalweg and banklines to shape the channel terrain within the limits of the survey.

5.1.2 Results

The bathymetric surfaces representing the mainstem Skagit, DeBay Slough, and connector channel were combined and then composited with existing 2017 North Puget lidar (collected in March 2016, hereafter referred to as '2016 lidar') data obtained from the Washington State Department of Natural Resources lidar Portal. This final composite surface represents the existing conditions at the project site and will serve as the basis for project basemaps and hydraulic model development. All data and the resulting surface are in US survey feet relative to the NAD83/2011 Washington State Plane North (4601) coordinate system and NAVD88 (Geoid 12B) vertical datums, respectively. The final composite surface and limits of survey are shown in Figure 3.

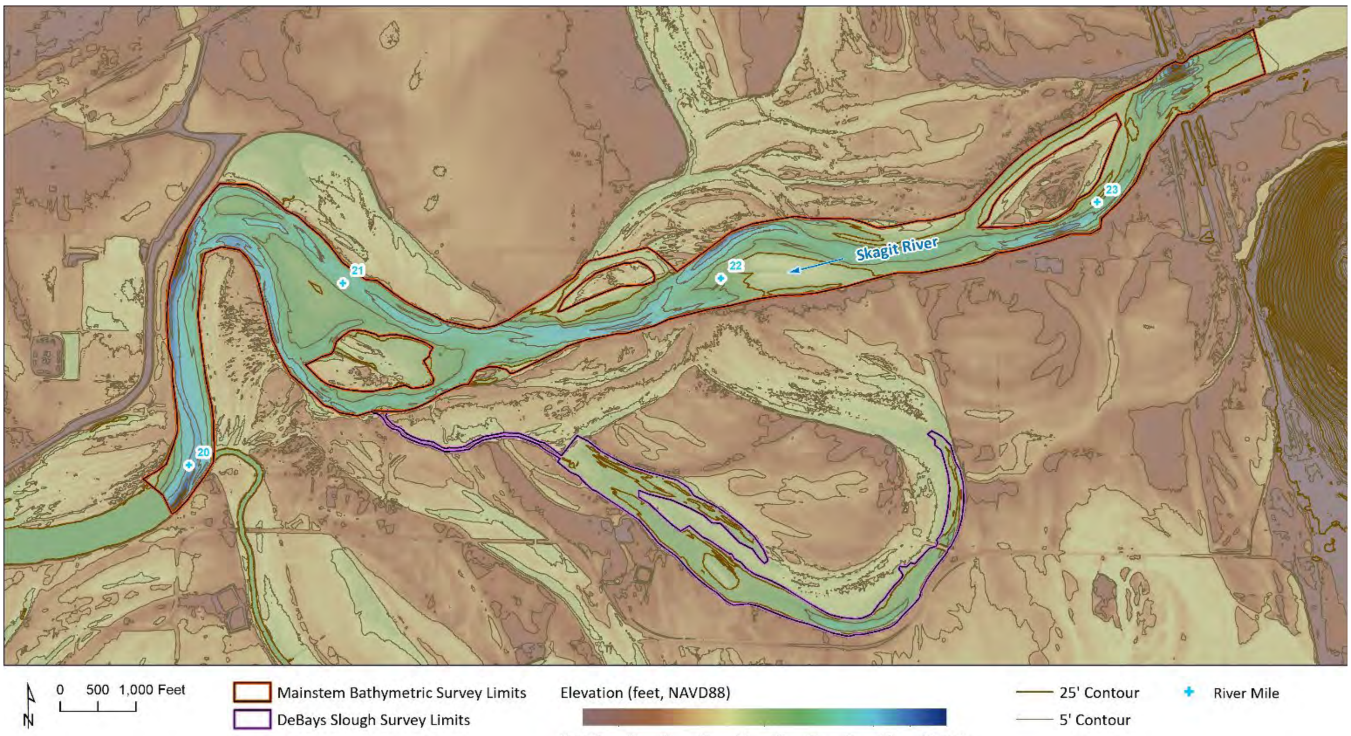

Figure 3. Existing conditions surface based on 2016 lidar augmented with Feb-March 2022 survey.

5.2 Hydrology

5.2.1 Methods

NSD compiled and analyzed hydrologic data collected downstream of the site at the US Geological Survey (USGS) gage for the Skagit River near Mount Vernon (#12200500) and stage data collected by the USGS at the State Route (SR) 9 bridge upstream of the site (#12199000). NSD also reviewed water level data collected by SCPW at sites within DeBay Slough to understand how changes in Skagit River stage (as measured at SR 9 gage) influence water levels and habitat connectivity in the slough.

Daily average flow measurements for the USGS gage on the Skagit River at Mount Vernon were compiled for the period from 1962 to 2022 to assess seasonal flow patterns, identify summer baseflow conditions, and to quantify flow conditions during important life history stages for salmonids. Exceedance probabilities for daily flows represent the number of days or the probability (as a percent likelihood) that a given flow is exceeded. Exceedance probabilities were calculated for the water year (October 1 – September 30) and by month.

Annual peak flow measurements for the USGS gage at Mount Vernon were compiled for the period of record from 1906 to present, which includes 82 approved peak flow measurements. The approved preliminary estimate for peak discharge for the November 16, 2021, flood event was also included in the peak flow analysis to estimate recurrence intervals for the historic record, and to inform hydraulic model boundary conditions. Recurrence interval flows were estimated following USGS Bulletin 17B methods, as modified by Mastin et al., 2016.

Water level logger data collection by SCPW began in late June of 2020 and continued through February 2021, at which point several data loggers were vandalized, missing, or damaged by flooding. SCPW re-deployed level loggers in late winter 2022 in slightly different locations in hopes of collecting another full year of data. However, elevated water conditions in June and July 2022 prevented data download in time for inclusion in this memo. Data collected since redeployment will be summarized during later stages of the feasibility assessment.

All locally collected level logger data were corrected to account for atmospheric pressure from a nearby barologger or using local weather station data (e.g., Washington State University weather station at Sakuma, approximately 2 miles from DeBay Slough). Compensating for atmospheric pressure allows water levels (measured as water pressure) to be converted to water depths based on water density as a function of water temperature, which is measured at each data logger. Water surface elevation (WSE) for each data point is derived from adding recorded water depths to surveyed sensor elevations, measured as offsets from surveyed tops of level logger well caps.

Surveyed WSE points from the February and March 2022 topographic and bathymetric surveys were used to develop an interpolated map of WSE contours between the Skagit River and the slough water surface during the late winter period. To account for the different in flow conditions between the two survey date collection periods, an adjustment of +1.45 feet was made to raise the Skagit River WSE data collected on February 23 (13,500 cfs) to better represent the higher flow conditions of the March 11 (18,100 cfs) survey date. This adjustment in WSE was developed using the average daily stage data from the Mount Vernon and SR9 gages. Stage height at the Mt Vernon USGS gage was 1.85 ft higher on March 11, 2022, and 1.05 ft higher at the SR9 USGS stage gage as compared to river stages on February 23, and the average of these two values, 1.45 feet, was used to adjust the February 23 WSE data. Select WSE returns from 2016 lidar data were also compiled to develop an interpolated WSE surface during the lidar data collection on March 29, 2016 (15,200 cfs) for comparison with recently collected survey data.

5.2.2 Results

Streamflow Patterns

Streamflow patterns in the Skagit River follow a bimodal annual cycle, with the water year beginning with low flows, rising to a first peak driven by fall and winter rainstorms, falling in the late winter as snowpack accumulates in the upper watershed, and then peaking with snowmelt in the early summer months before receding in the late summer and early fall (Figure 4). 49 percent of mean total annual precipitation in the lower Skagit (32.7 inches/year at Mount Vernon) occurs from November through February (USACE 2013). The contributing basin above Mount Vernon receives an average of 92 inches/year, 75 percent of which falls from October – March.

Exceedance probabilities for daily flows aggregated by month show a similar pattern, with a fall peak driven by rainfall and a summer peak driven by snowmelt (Figure 5). Exceedance probabilities for daily flows throughout the entire water year can provide a good indication of baseflow (e.g., 10% exceedance) conditions that are met or exceeded for much of the water year (Figure 6).

Dam operations at the Skagit and Baker hydroelectric facilities capture spring snowmelt runoff and release water when natural inflows are low during the late summer, fall, and mid-winter (SWC, 2011). Hydroelectric operations reduce spring runoff and increase flows during what would naturally be low-flow seasons. Due to the regulated flow regimes in the upper watershed, flow variability in the lower and middle Skagit is driven largely by natural flow regimes in major tributaries to the Skagit below the dams, including the Sauk and Suiattle basins and the Cascade River, which have substantially higher mean annual precipitation than the lower Skagit watershed.

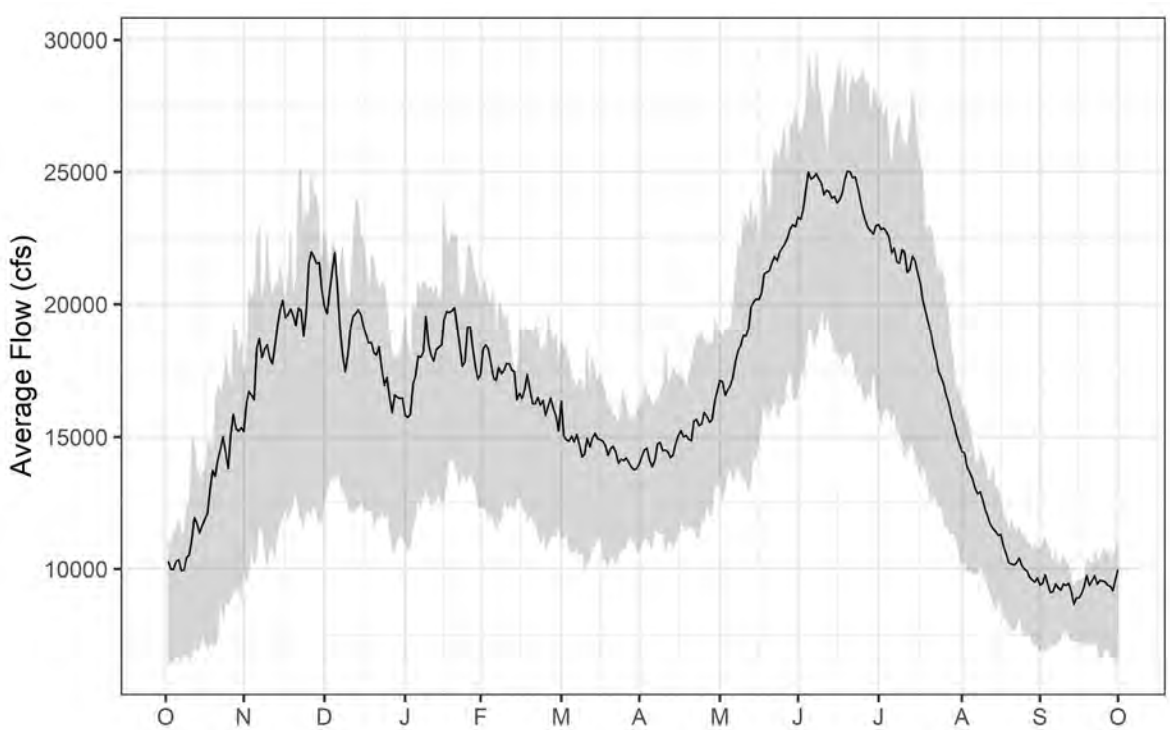

Figure 4. Average daily streamflow for the Skagit River at USGS #12200500 near Mount Vernon. Black line is the mean and gray banded area represents the 25 - 75th percentile range.

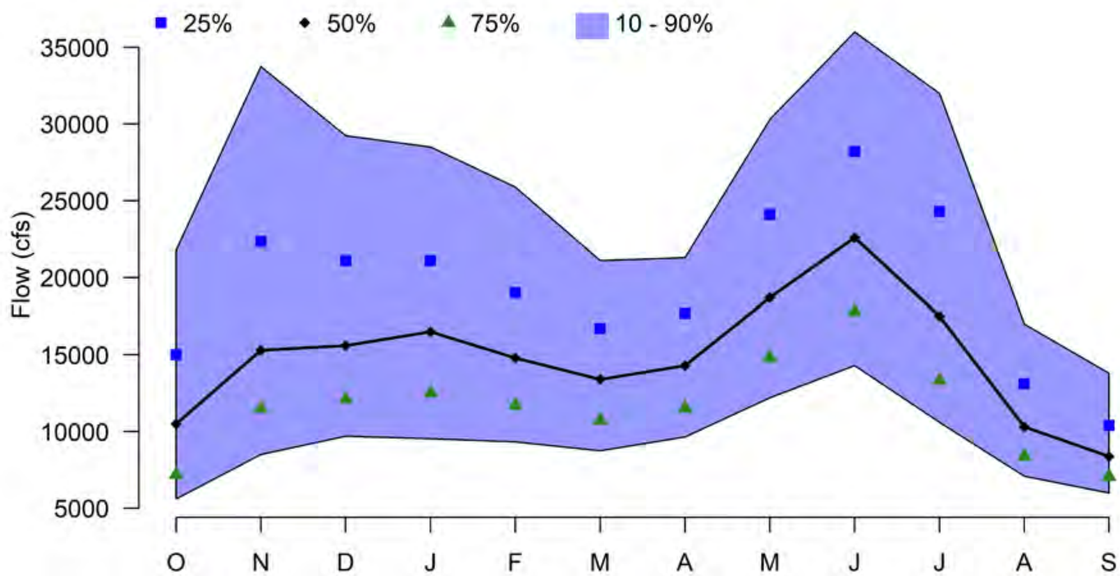

Figure 5. Exceedance probabilities for daily flow aggregated by month at the Skagit River at USGS #12200500 near Mount Vernon. Black line is the median, blue squares are the 25th %, green triangles are the 75th %, and the blue banded area represents the 10 - 90th percentile range. For example, daily streamflow in June exceeded ~35,000 cfs in only 10% of the records, but exceeds ~22,000 cfs in more than 50% of records.

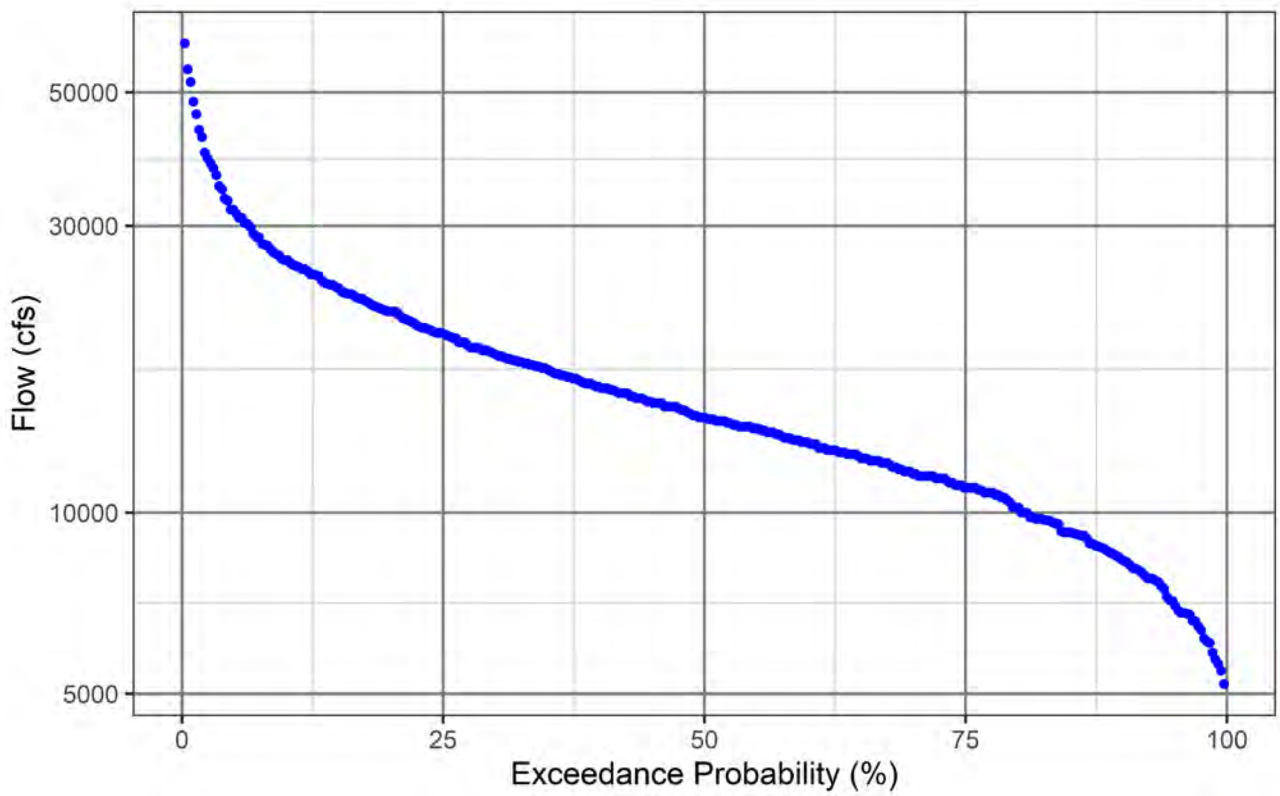

Figure 6. Exceedance probabilities for daily average flows at USGS Gage #12200500 for the Skagit River near Mount Vernon. Values indicate the percentage of days a given flow has been exceeded. Note the log scale for y-axis.

Peak Flows

Annual flood peak records indicate the flood of record occurred in November of 1990, with an observed peak of 152,000 cfs at the Mount Vernon USGS gage site (#12200500, Figure 7). The 1990 flood peak is estimated as roughly a 100-year recurrence flood event (e.g., 1% chance of exceedance; Figure 8). Flood frequency estimates are shown with and without the November 2021 flood event in Table 1, since the USGS has not completed data collection and approval for water year 2022 data (October 1, 2021, through September 30, 2022). Review of peak flow estimates with and without the November 2021 flood event indicate that this most recent flood peak skewed lower probability (larger flood) estimates upward by several thousand cubic feet per second (cfs). Note that flood flows at Mount Vernon are affected by regulation in the upper watershed at the Ross, Diablo, and Baker River dams. The US Army Corps of Engineers (USACE) conducted a peak flow analysis in 2013 to estimate regulated and unregulated peak flows, which differ from Bulletin 17B estimates for the Mount Vernon USGS gage.

Future Flow Regime

Dam operations at Baker Lake and Ross and Diablo Lakes in the upper Skagit attenuate flood peaks, and previous flood frequency analyses suggest that these dams reduce estimated 100 year peak flows in the Skagit by up to 24 percent (USACE, 2003; NHC, 2013), with 14 percent reductions in the estimated 100 year peak flow at Mount Vernon (USACE, 2013). Due in part to flow regulation by the dams, data from Mantua et al. (2010) indicate that the lower Skagit River will likely experience little change in peak flow magnitude under future climate scenarios, however spring and summer snowmelt runoff is expected to decline, and the summer low flow period is projected to increase in duration by the end of the century. Coupled with warming air temperatures, lower summer flows may increase thermal stress for cold water fish (e.g., Chinook, steelhead, bull trout) in the basin (SWC, 2011).

Table 1. Peak flow recurrence estimates for USGS Gage #12200500 for the Skagit River near Mount Vernon. The USGS has not yet included the November 2021 flood event in the approved period of record, since data for water year 2022 is incomplete. USACE 2013 estimates based on regulated peaks affected by dam operations in the upper watershed.

Annual Exceedance Probability	Return Interval (yrs)	Without November 2021 Estimated Discharge (cfs)	With November 2021 Estimated Discharge (cfs)	USACE 2013 Regulated Estimate (cfs)
0.99	1.01	29,290	29,240	-
0.5	2	68,910	69,410	76,900
0.2	5	92,860	93,840	92,900
0.1	10	108,300	109,600	119,000
0.04	25	127,300	129,100	149,800
0.02	50	141,200	143,400	167,600
0.01	100	154,900	157,400	206,500
0.002	500	186,600	189,900	282,600

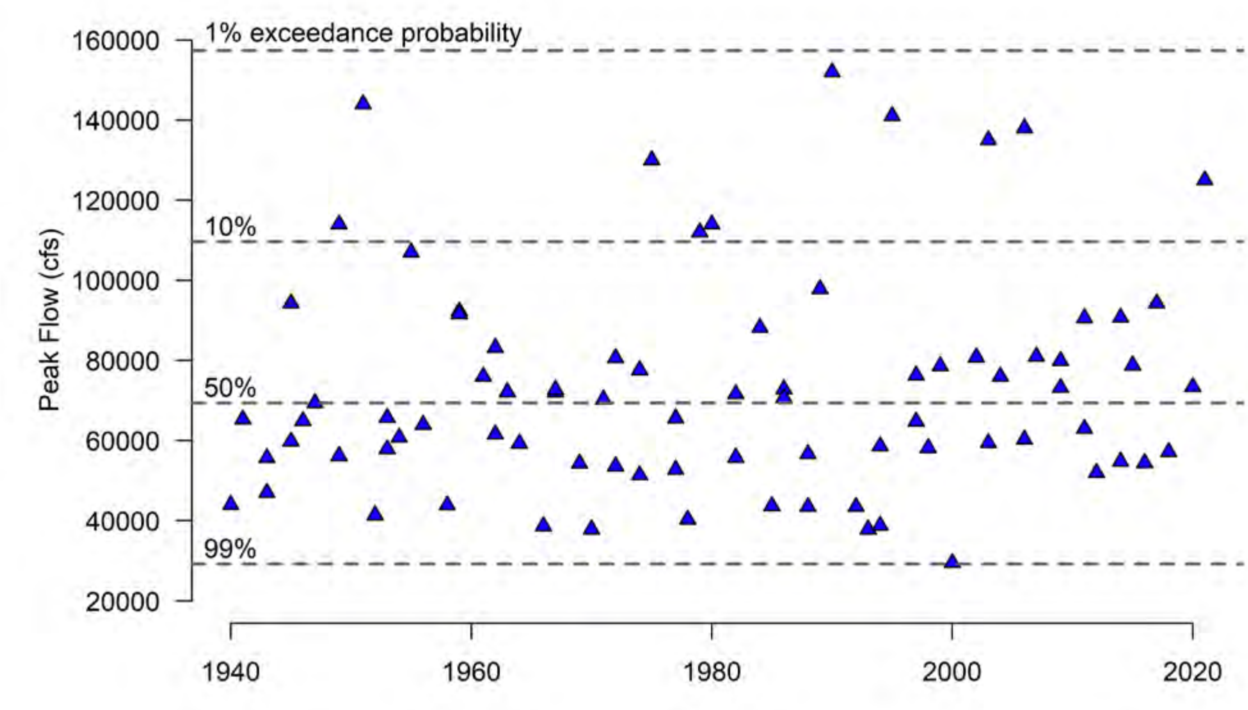

Figure 7. Historical flood peaks for the Skagit River at USGS Gage #12200500 near Mount Vernon. Dashed lines show estimated recurrence floods based on Bulletin 17B Log-Pearson III analysis.

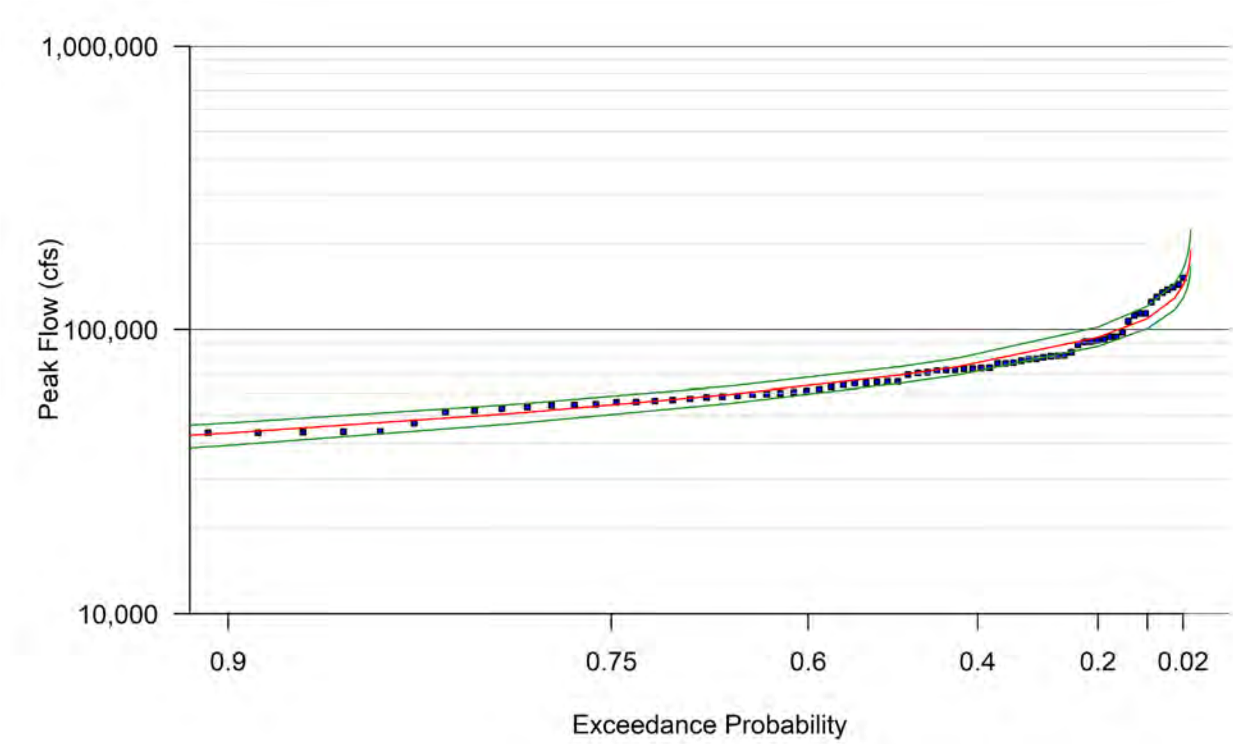

Figure 8. **Log-Pearson III fit for estimating flood recurrence intervals (red line) from historical peaks (blue squares). Green lines show 95% confidence range for peak flow estimates. Data from USGS Gage #12200500 for the Skagit River near Mount Vernon.**

Surface Water Gradients

Water level logger locations for data collected by SCPW are shown in Figure 9, and WSE extracted from the level loggers are shown in Figure 10. Level logger data show a strong linkage between DeBay Slough and the Skagit River (as measured at SR9 USGS gage), with flow peaks in the Skagit generally resulting in increased stage within the slough (Sites 3-5) and the outlet connector channel (Site 2). For periods of data overlap, the water surface at Site 5 on the northern side of the DeBay's Isle Road culvert is perched higher than Site 4 on the southern side of the culvert, which is roughly 0.1 ft higher than the west/downstream end of the slough at Site 3. This pattern of a perched water surface along the northern side of the Slough is consistent with surveyed WSE points (Figure 11). Note that surveyed WSE points occurred during two different flow conditions and were adjusted for the observed difference in stage (see methods above). Comparison of surveyed WSE with the 2016 lidar WSE (Figure 12) shows a similar pattern in surface water gradients within the reach and confirm findings from the adjusted survey WSE. Limited data are available for the connector channel at Site 2, however WSE at Site 2 appears to draw down more rapidly than the slough areas (Sites 3-5) following the spring freshet in June – July 2020 and following fall and winter flood peaks in 2020 – 2021 (Figure 10).

Interpolated contours for surveyed WSE suggest that the northern end of the Slough may be gaining groundwater from the Skagit below the SR9 bridge crossing and losing flow in the western edge via the connector channel and groundwater to a lower base level in the Skagit to the west of the Slough (Figure 11). Overall, the WSE gradient follows a down-valley pattern that is largely consistent with the channel alignment of the Skagit River.

Groundwater monitoring to the northeast, south, and west of DeBay Slough would help resolve local groundwater gradients that govern whether the Slough is gaining or losing flow relative to the Skagit River. Both surveyed and lidar WSE data suggest some gaining at the northeastern end of the slough, however these interpretations are based on limited surface water observations and water surface lidar returns. In general, the agreement between surveyed WSE (Figure 11) and lidar WSE (Figure 12) suggests a gaining groundwater connection at the eastern end of the slough and a losing connection at the west end of the slough.

Figure 9. SCPW water level logger sites for 2020-2022.

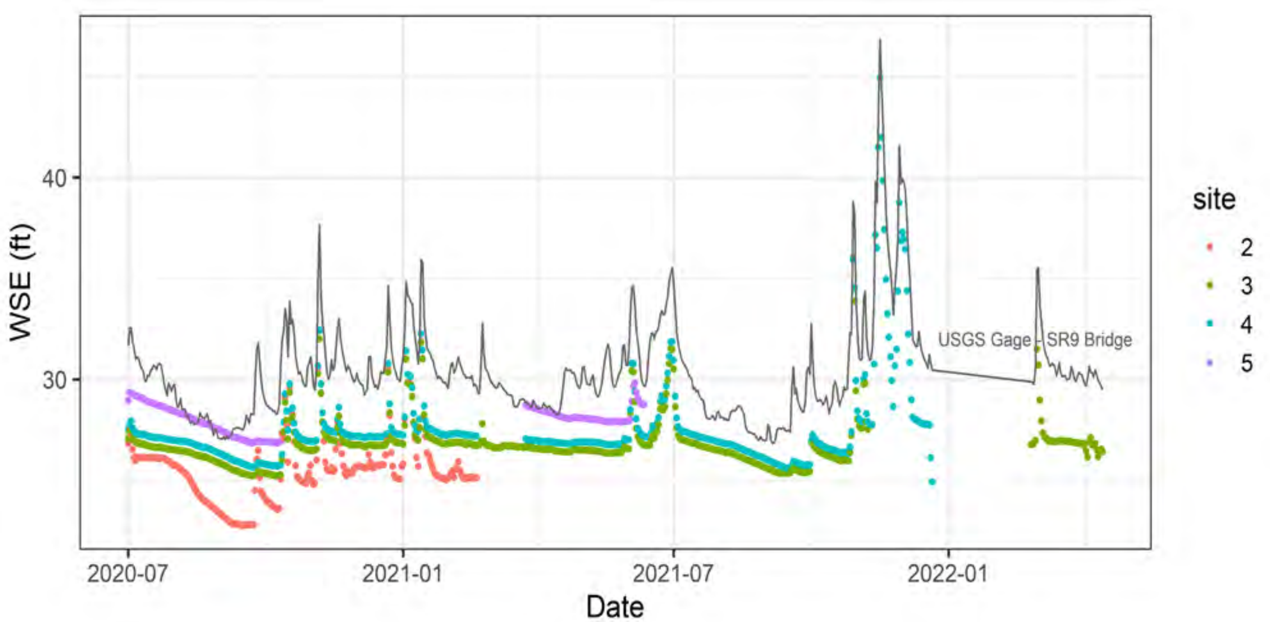

Figure 10. Level logger water surface elevations for SCPW sites 2-5 (colored points) and the USGS stage gage at the SR9 bridge (black line).

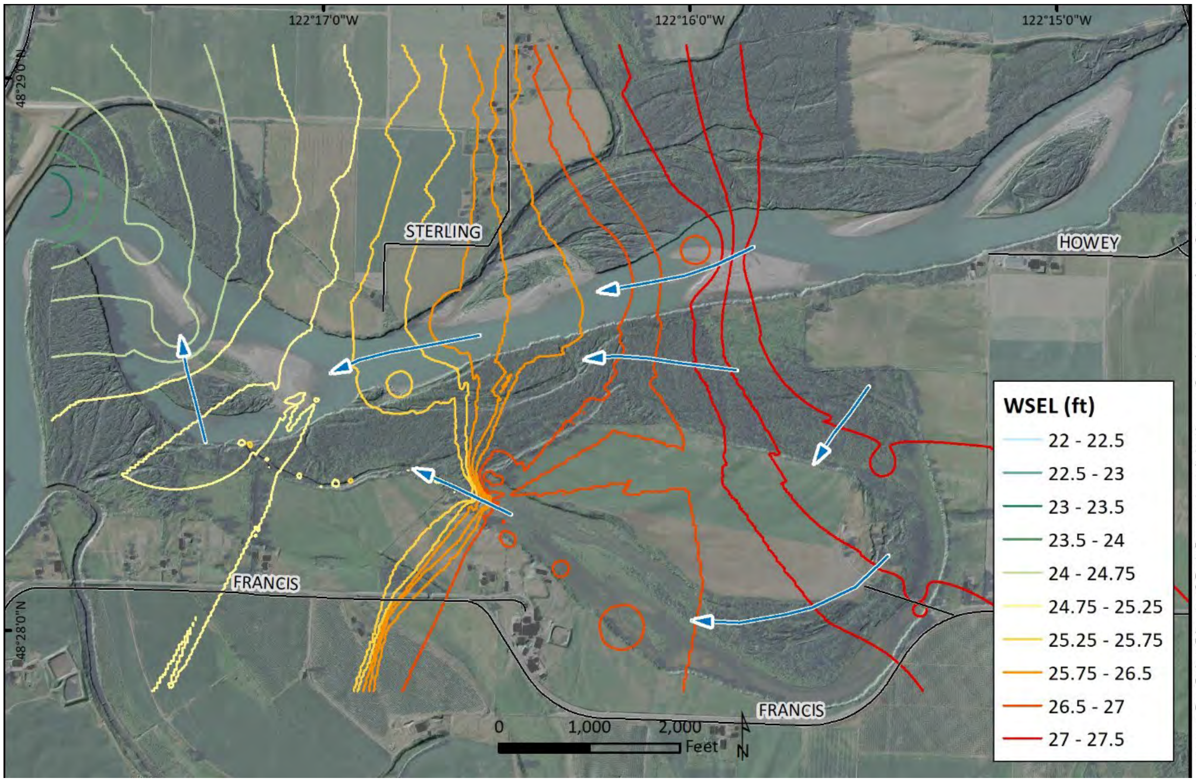

Figure 11. Interpolated contour map of surveyed water surface elevations for DeBay Slough and the Skagit River for March 11, 2022. Mainstem Skagit River survey data for February 23, 2022, were adjusted to account for vertical difference in discharge/stage. Note that contours are based on surveyed WSE only and do not include SCPW levelogger data.

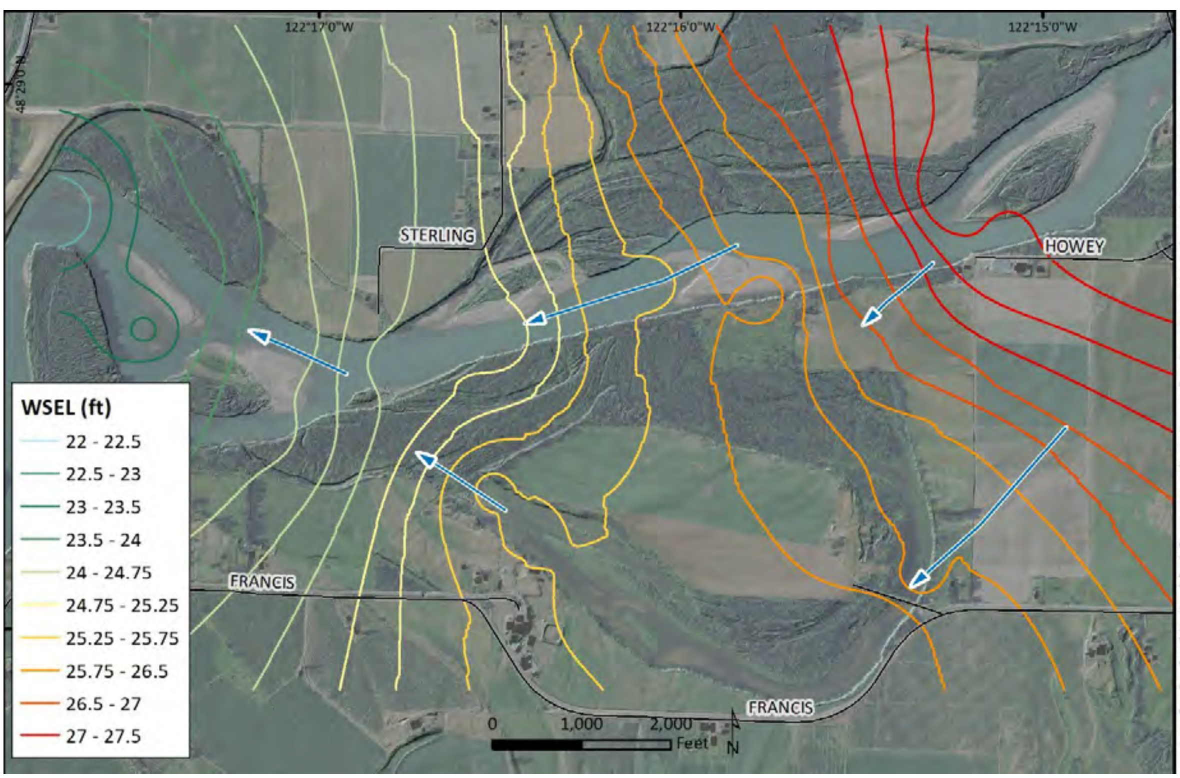

Figure 12. Interpolated contour map of water surface elevations extracted from March 29, 2016 lidar data.

5.3 Hydraulics

5.3.1 Methods

Model Domain

To evaluate hydraulic conditions within DeBay Slough, the Skagit River mainstem and the adjacent floodplain areas, NSD developed a two-dimensional model of the project reach within the U.S. Army Corps of Engineers (USACE) modeling platform, Hydrologic Engineering Center-River Analysis System (HEC-RAS), Version 6.2. The hydraulic model domain spanned from just upstream of the State Route 9 bridge on the Skagit River mainstem down through the confluence with Nookachamps Creek and includes the adjacent DeBay Slough, Hart Slough and surrounding Skagit Valley floodplain. NSD derived the underlying terrain for the model from the composite surface consisting of bathymetric survey data collected by NSD in February and March of 2022 and 2016 lidar data obtained through the DNR lidar portal.

The model mesh utilized varying cell sizes to fully capture terrain details and flow pathways. Cell sizes ranged from 10 feet in the connector channel to 40 feet within the Skagit mainstem and 200 feet in the surrounding Skagit Valley (Figure 13). Model inflow was set at the SR 9 bridge and model outflow was set at the limits of the bathymetric survey data collection just downstream from the confluence with Nookachamps Creek. Model outflow was set to a normal depth condition with a slope of 0.0016 ft/ft as derived from the approximate water surface slope at this location in the 2016 lidar data. Additional model inflows were included in the upper (north of DeBay's Isle Rd) and lower (south of DeBay's Isle Road) portions of DeBay Slough to account for groundwater inflows into the slough. For the peak flow modeling runs, an additional inflow was added for the combined East Fork and West Fork Nookachamps Creek near the Swan Road Bridge crossing, located approximately 4,600 feet southwest of DeBay Slough.

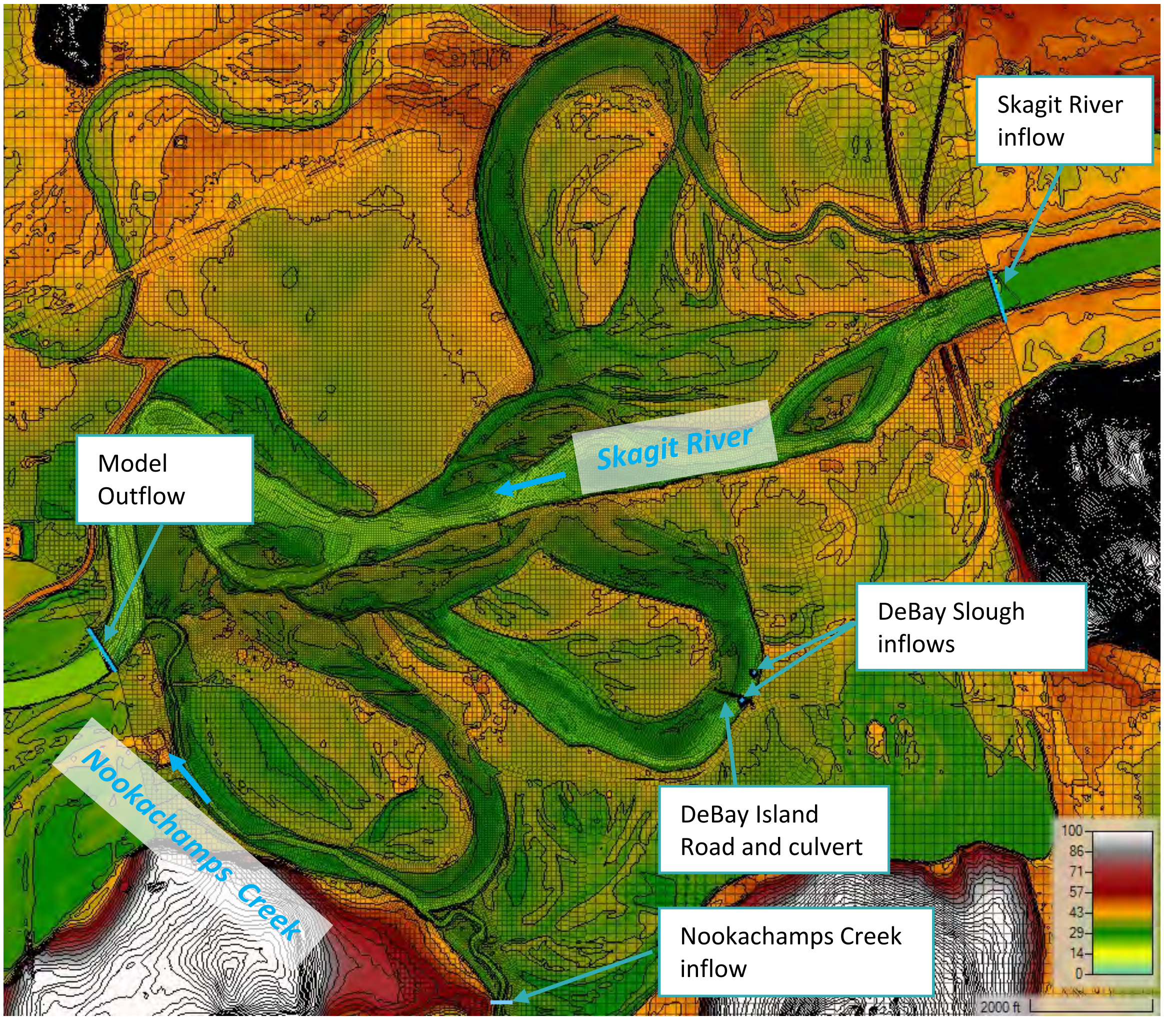

Figure 13. HEC-RAS 2D Model Domain

Model Elements and Roughness

Within the model domain described above, additional model elements were added to the mesh to represent the existing culvert at DeBay's Isle Road and assign Manning's Roughness values based upon land classification to characterize the hydraulic roughness exerted by the varying land types (e.g., main channel, cultivated crops, scrub-scrub, etc.) found in the model domain. The existing culvert crossing at DeBay's Isle Road was included in the model domain as a 2D area connection. The location of the culvert was approximated as it could not be located during the topographic survey; culvert geometry data was obtained from the WDFW barrier assessment (WDFW, 2019). No other drainage structures were included in the model mesh.

To aid in assigning roughness values for the model domain, National Land Cover Data (NLCD) from 2019 was obtained from the Multi-Resolution Land Characteristics Consortium and used to review and assign initial land cover classification data for the model domain (MRLC Consortium, 2022). The NLCD was compared with the 2021 NAIP aerial imagery for the project reach and land classification assignments were revised and simplified within the limits of the hydraulic model domain to add in assigning Manning's Roughness values. The resulting Manning's N values and land classification are shown in Figure 14 and Table 2 below.

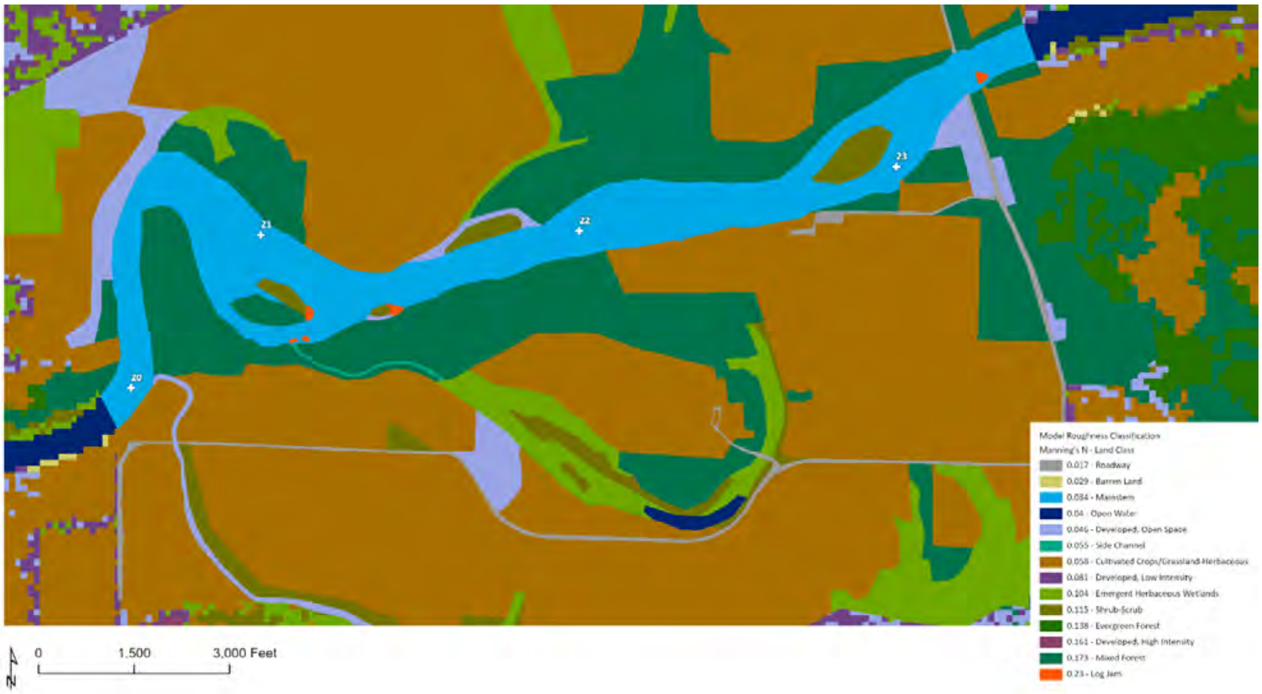

Figure 14. Manning's Roughness values and Land Classification in Model Domain.

Initial Manning's N values were assigned based upon typical value ranges for the various land classifications as outlined in the HEC-RAS 2D User's Manual (USACE, 2021). Roughness values were then further refined based upon the model calibration discussed below and in Appendix A-1.

Table 2. Manning's Roughness Values for HEC-RAS Model

LAND CLASSIFICATION	MANNING'S N VALUE
Roadway	0.017
Barren Land	0.029
Mainstem	0.034
Open Water	0.040
Developed, Open Space	0.046
Side Channel	0.046
Cultivated Crops/Grassland-Herbaceous	0.058
Developed, Low Intensity	0.081
Developed, Medium Intensity	0.104
Emergent Herbaceous Wetlands	0.104
Shrub-Scrub	0.115
Evergreen Forest	0.138
Developed, High Intensity	0.161
Mixed Forest	0.173
Log Jam	0.230

Design Flows

NSD assessed five flow events ranging from a typical summer low flow condition to the November 16, 2021, flood event which was an approximate 25-year event in this area of the Skagit Basin. Table 3 presents the five model runs which includes their inflow values, approximate stage at both the USGS at Mount Vernon and USGS near Sedro Woolley (SR 9 bridge), and approximate DeBay Slough water surface elevation where available.

Table 3. Hydraulic Model Simulation Runs and Input Parameters

DESIGN FLOW		USGS GAGE STAGE (FT[1])		DEBAY SLOUGH (FT, NAVD88)	INFLOW DISCHARGES (CFS)			
Total Flow (cfs)	**Habitat Condition**	**12200500 at Mount Vernon**	**12199000 near Sedro Woolley**	**Lower Slough Stage**	**Mainstem Skagit River**	**DeBay Slough Upper**	**DeBay Slough Lower**	**Combined Nookachamps Creek**
8,000	Typical Aug-Oct Low Flow	11.5	19.9	25.8	8,000	1	-	-
15,000	Typical winter flow during swan use period	14.6	22.1	26.8	15,000	4	-	-
22,000	Typical winter high flow (25% exceedance) for Nov-Jan	17.1	23.6	27.5	22,000	22	-	-
82,000	Typical flooding	30	38	unk[2]	78,934	10[3]	10[3]	3,066
133,000	November 16, 2021, Event	37	42.6	unk[2]	133,000	10[3]	10[3]	4,720

1. USGS gage stages referenced to gage datum. Elevation in feet, NAVD88 at gage locations is gage stage + 3.82 feet.
2. DeBay Slough water surface elevation data were not available for the larger flood events. At these events, floodplain flows are driven by the overbank flow in the Skagit River and less sensitive to antecedent groundwater conditions in the slough.
3. For these two flood events, inflow discharges in upper and lower DeBay Slough are only included to aid in model warmup and do not impact model results for these larger discharges.

Large flood events, such as the 50- and 100-year floods were not assessed in this habitat improvement feasibility study, as floods of this magnitude are less relevant for consideration of habitat improvements in the slough and connector channel. Such events cover very large portions of the Skagit Valley and are best represented by larger scale hydraulic models such as the CWMS developed by the USACE.

Model Calibration

As detailed in Appendix A-1, NSD performed a model calibration process to validate the model's ability to replace hydraulic conditions observed both during the lower habitat flow model runs and the two larger flood model runs. The model calibration process focused primarily on refining the Manning's roughness values used to represent hydraulic roughness within the main channel of the Skagit River, the connector channel, DeBay Slough, and its surrounding floodplain areas. Additional parameters adjusted during the calibration process also included the estimated groundwater inflows into DeBay Slough during lower discharges and the assumed percentage of blockage in the existing culvert under DeBay's Isle Road. The model calibration process and supported analyses are included in Appendix A-1 Hydraulic Model Calibration and are summarized below.

Model calibration of the mainstem Skagit River focused on lower flows and utilized water surface elevation data collected by NSD during the mainstem bathymetric survey on February 23, 2022, and during the DeBay Slough and connector channel survey on March 11, 2022. The low flow model was able to replicate the observed hydraulic conditions in the Skagit River mainstem, DeBay Slough, and connector channel within 0.5 feet as compared to the available observed data. Average difference between the observed Skagit River WSE and the modeled WSE for the same discharge was +0.03 ft, a very close match. Furthermore, the inundated areas of the Skagit River mainstem matched very well with observed edge of water topographic survey points collected by NSD, indicated that the topo-bathymetric surface developed for the Skagit River mainstem is representative of Spring 2022 conditions in the Skagit River. Within DeBay Slough the model over-predicted WSEs slightly with an average difference between the modeled and observed water surface elevations of +0.23 feet. Within the connector channel the model underpredicted WSEs with an average difference of -0.39 feet. All three of the key project areas for the lower, habitat flow runs (Skagit mainstem, DeBay Slough, and connector channel) all calibrated with less than 0.5 feet of absolute difference between the modeled and observed WSEs, indicating good agreement with the observed data and that the model sufficiently represents existing conditions for these flows.

For the high flow model runs, model calibration was done for the run representing the November 16, 2021, flood event in the Skagit Basin and focused on adjusting floodplain roughness values as well as evaluating available flood hydrograph data. Available data used for the high flow calibration included high water marks (HWMs) collected by NHC for Skagit County and summarized in the Post-November 2021 Flood High Water Mark Inventory Skagit River Downstream of Rockport (NHC, 2022) and the US Army Corps Water Management System (CWMS) combined 1D/2D HEC-RAS model that was recently recalibrated to the November 16, 2021, flood event (USACE, 2022). The high flow model run was also able to replicate the observed conditions during the November 16, 2021, flood event within the project vicinity. Available HWMs at DeBay's Isle Road, the SR 9 bridge and the intersection of Frances Road and SR 9 showed that the modeled WSE averaged 0.3 feet less than the observed HMWs. Outside of the project area, but within the model domain, there was greater variation in the modeled versus observed data, and in general, the hydraulic model tended to underpredict WSE compared to the available observed data.

5.3.2 Results

NSD used the calibrated hydraulic model to understand the existing patterns of water movement, depth, elevation, and velocity in the slough and connector channel. Particular focus was applied to the times of year when juvenile salmonids may use the slough for winter refuge and early summer rearing habitat and when swans and other waterfowl use the slough and surrounding area for overwintering and night roosting habitat. Higher flow model runs were performed to better understand overbank and floodplain flows and how they interact with DeBay Slough, the existing crossing at DeBay's Isle Road and the surrounding agricultural lands and residences. The existing conditions hydraulic model results were also considered relative to the culvert through DeBay's Isle Road and its effects on water surface elevation, water quality, and fish and wildlife habitat conditions in the portions of the slough bisected by the roadway. Model output showing computed depth, velocity and water surface elevation at each flow event are included in Appendix A-2 Hydraulic Model Output Maps.

Habitat Flow Results

Three of the five modeled flow events focused on representing key habitat conditions and timing of juvenile salmonid and wintering swans and other waterfowl use of DeBay Slough and the adjacent Skagit River mainstem. These three events included the 8,000, 15,000 and 22,000 cfs discharges which represent the typical low flow conditions during August to October, the typical flow condition during winter months when wintering swans and other waterfowl usage of the slough is at its peak, and a typical winter high flow condition, respectively.

Hydraulic conditions for each of the three modelled habitat flows represent a time period and flow condition where flow within the mainstem Skagit River is contained to the active channel and is connected to DeBay Slough through a varying degree of backwater through the connector channel. During these time periods, no overbank flow from the Skagit River is entering the slough and water present within the slough is a combination of groundwater and backwatering from the mainstem Skagit. The model results indicate typical depths and velocities within the Skagit River range from 6 to 14 feet in depth and 2 to 5 feet per second (fps) during the low flow conditions, to 10 to 18 feet in depth and 3 to 6 fps during the winter high flow. Within DeBay Slough, model velocities are essentially zero at all habitat flows and depths range from 9 to 10 feet deep in the deepest areas of the lower slough. The zero flow velocity within the slough indicates that for the majority of the year, the model shows the slough as a quiescent feature with little to no surface velocity.

To evaluate the effect of backwatering and geomorphic features on water surface elevations within the slough, a longitudinal profile was developed from the Skagit River, through the connector channel and the lower and upper portion of DeBay Slough, including DeBay's Isle Road as shown in Figure 15. At the lowest flow condition (8,000 cfs), which represents an average flow for August through October, the WSE of the Skagit River at the outlet of the connector channel is below the bottom on the connector channel indicating there is no backwatering of the connector channel and DeBay Slough from the Skagit River. Any water present within the slough during this low flow condition is a result of groundwater.

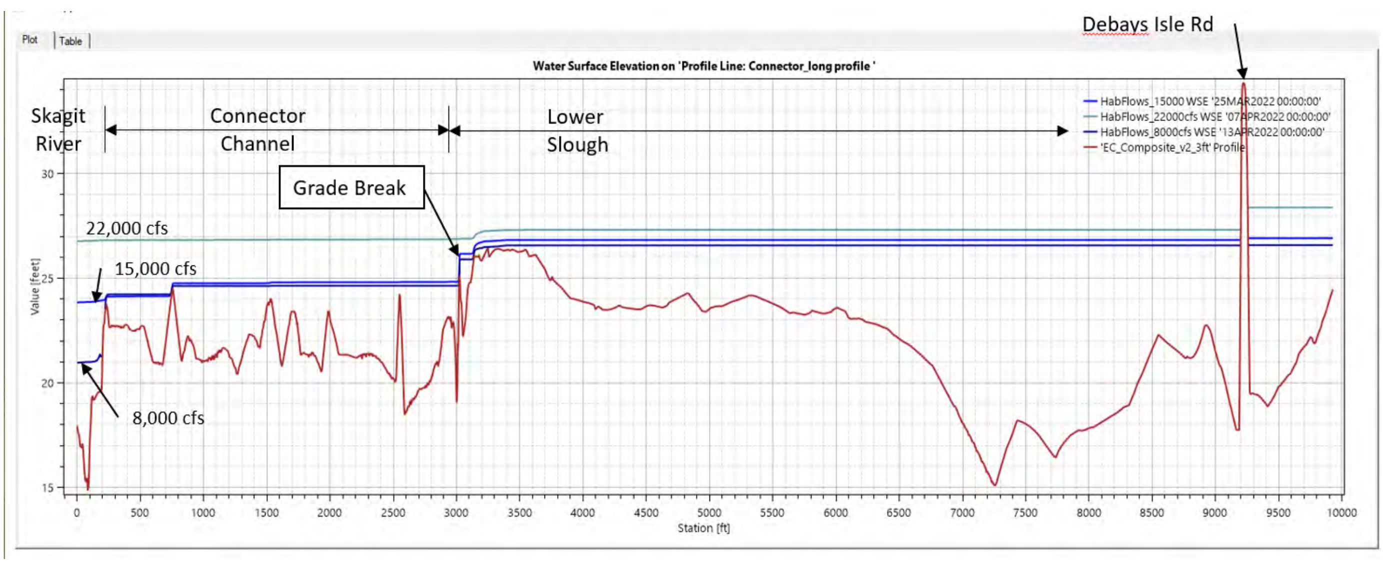

Figure 15. Longitudinal Profile of Water Surface Elevations in Debay Slough from the Skagit River up to DeBay's Isle Road for flows in the Skagit River ranging from 8,000 to 22,000 cfs.

At the typical winter flow condition (15,000 cfs), the water surface at the outlet of the connector channel is approximately even with the water surface in the lower portion of the connector channel. However, as you approach the outlet of DeBay Slough, a grade break consisting of a clay sill functions to hold water surface elevations in the lower slough at an approximately 2-foot higher elevation than within the connector channel. During the typical winter flow, groundwater inflow into the slough is also a main contributor to the stage elevation of the slough and water surface in the slough and connector channel are dependent on antecedent hydraulic conditions as well as stage within the Skagit River.

At the typical winter high flow event (22,000 cfs), the Skagit River backwaters the entire lower slough through the connector channel up through the grade break feature and functions to control water surface elevation and depths within the slough. At this flow event, the impacts of the undersized culvert at DeBay's Isle Road are seen as there is an approximate 0.5-foot water surface difference between the downstream (lower) and upstream (upper) portion of the slough indicating that the culvert is a hydraulic constriction between the upper and lower portions of the slough. This stage difference between the two sections of DeBay Slough is also seen in the difference between Sites 5 and 4 shown in Figure 10 and is further evidence that the existing structure at DeBay's Isle Road creates an impediment to flow between the two areas.

Peak Flow Results

Peak flow modeling for the DeBay Slough area consisted of two model events, one representing a more frequent flood condition where the Skagit River is overtopping the left bank and actively inundating DeBay Slough and the surrounding farmlands and the November 16, 2021, event which was an approximate 25-year flood event and results in widespread flooding throughout the area.

To assess hydraulic conditions in the project reach during typical overbank flood conditions, a discharge event of 82,000 cfs in the Skagit mainstem was selected which corresponds roughly to a gage stage of 30 feet at the USGS at Mount Vernon gage (Table 3). This represents just below a 5-year flood event on the Skagit River in this reach. To represent overbank flooding conditions in the Nookachamps Creek that contribute to flooding in the surrounding floodplain, a 5-year event (3,070 cfs) was applied to the inflow location for Nookachamps Creek. During this event, flow from the Skagit River overtops both banks downstream of the SR 9 bridge and floods through the adjacent farmlands, included over DeBay's Isle Road and Francis Road.

Modeled flow depths in the Skagit River, DeBay Slough and the surrounding floodplain and agricultural lands are shown in Figure 16. Depths within DeBay Slough range from 12 to 25 feet deep and within the lower floodplain areas depths range from 6 to 10 feet. The agricultural field in the middle of the site is nearly fully inundated with depths of up to 6 feet.

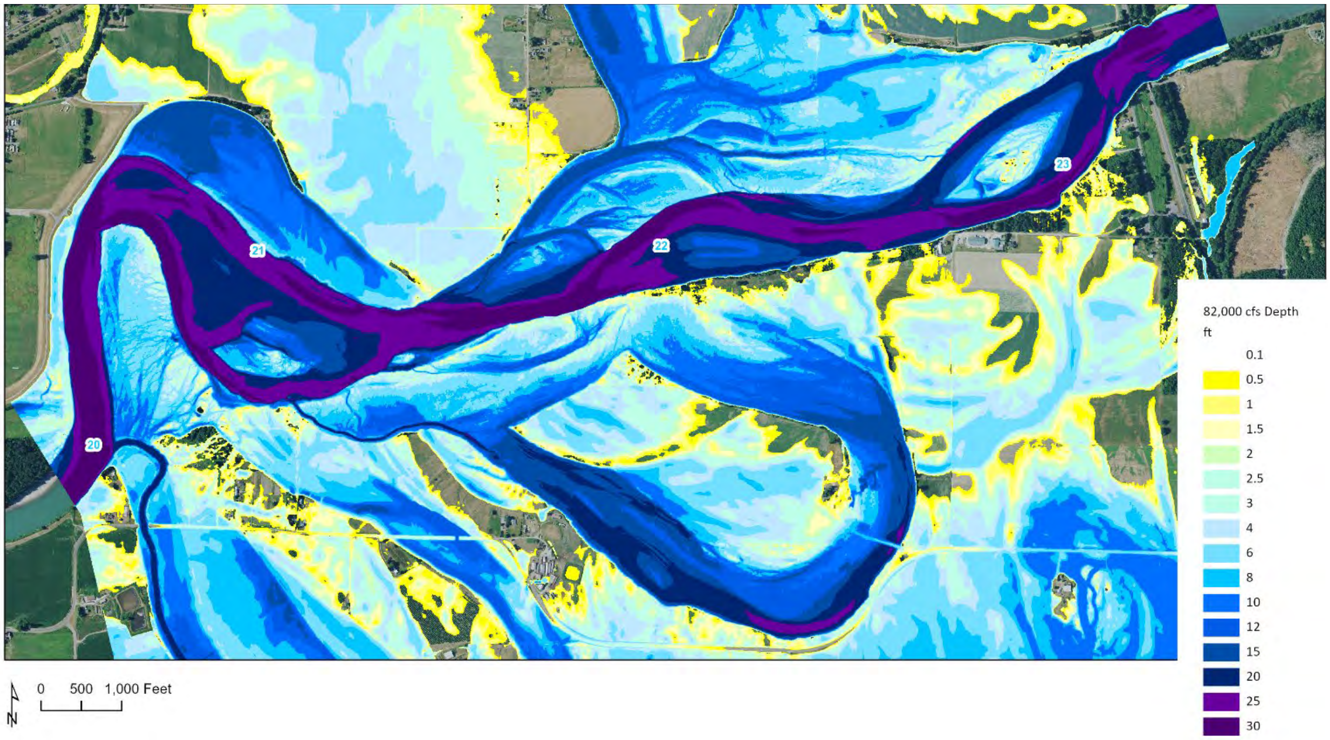

Figure 16. Existing Conditions Flow Depths at 82,000 cfs (approximately 30-foot stage at Mount Vernon USGS gage)

Figure 17 illustrates the resulting flow velocities during this event in the mainstem Skagit River and surrounding DeBay Slough area. Modeled velocities during this flow range from 3 to 10 feet per second (fps) in the main channel whereas in the surrounding floodplain and adjacent farmlands, velocities are lower and in the less than 1.5 fps range. The blue arrows shown in Figure 17 depict some of the prevailing flow pathways indicated in the areas of higher velocities. Of note, is an area along the left bank of the Skagit due north of upper DeBay Slough, where a lower section of the bank allows for more concentrated flows and routes these flows into upper DeBay Slough and down toward DeBay's Isle Road. This flow path both continues to the lower slough and also overtops the eastern bank and flows onto Francis Road and into the surrounding floodplain. Further downstream, flow from the Skagit River overtops the left bank and floods through the riparian forest and into the lower adjacent floodplain area in the vicinity of RM 22. This overbank flow continues in a southern westerly direction, flowing across the connector channel and ultimately turns south, overtops Francis Road and combines with overbank flow from Nookachamps Creek.

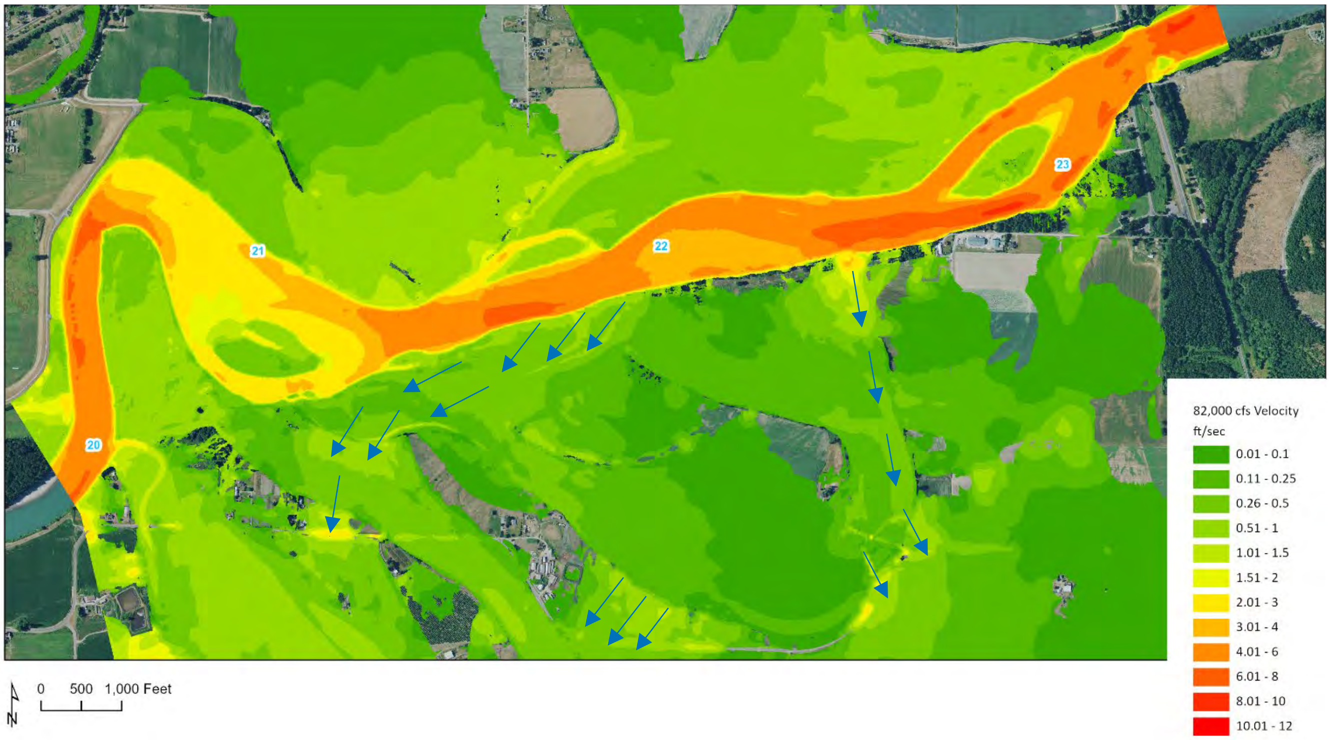

Figure 17. Existing Conditions Velocities at 30-foot Stage at USGS Mount Vernon (82,000 cfs)

Modeled flood conditions during the November 16, 2021, event show widespread inundation through the Skagit Valley with floodplain depths ranging from 3 to 10 feet and inundations extending to the south into the Nookachamps floodplain. Figure 18 displays the predicted depths during this flood event and shows that within DeBay Slough, the deepest portions of the slough were approximately 30 feet deep and floodwater overtopped DeBay's Isle Road by approximately 10 feet. During this larger event, modelled flow pathways for the overbank floodwaters are less defined than in the 30-foot stage event (82,000 cfs) shown in Figure 17, as during this larger event the entire floodplain is inundated, and the modelled flow generally moves in the down-valley direction with velocities ranging less than 1.5 fps.

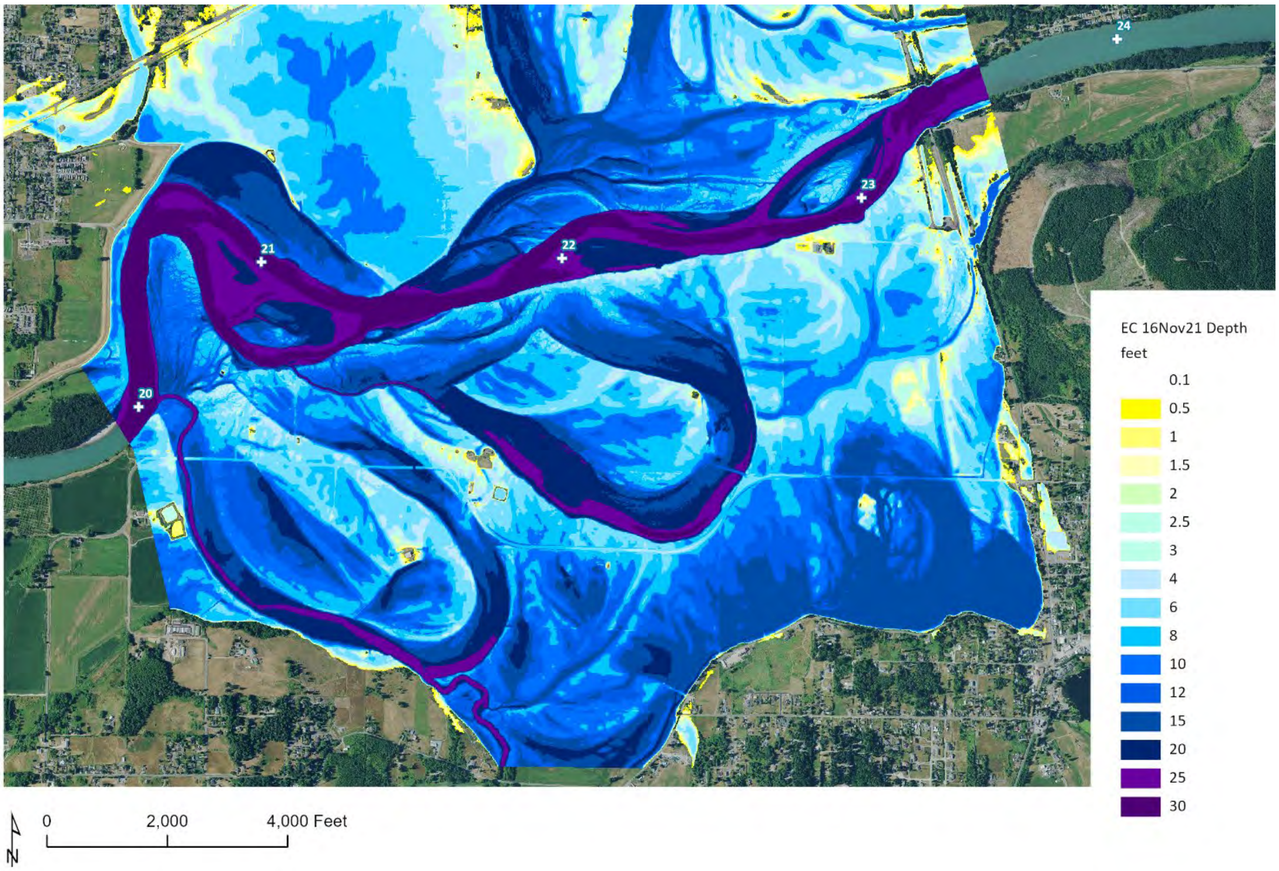

Figure 18. Modeled Depths during the November 15, 2021, Flood Event

5.4 Geomorphic Assessment

5.4.1 Methods

NSD conducted a field and desktop-based geomorphic assessment to evaluate the geomorphic landforms and features of the project area, the channel migration history of the project reach, the stability of the slough and connector channel, the future trajectory of channel changes within the slough and main-stem river corridor, and large wood distribution within the connector channel.

NSD geomorphologist Scott Katz conducted a field assessment on March 10, 2022, to evaluate site conditions. During the site assessment, NSD collected observations and photographs related to geomorphic landforms, sediment characteristics, large wood distribution, and riparian conditions using ESRI's Field Maps software. NSD utilized a relative elevation model (REM) from the National Park Service using 2016 lidar to supplement observations from the site assessment and to evaluate geomorphic landforms of the project area (NPS, in publication). A REM is a geospatial model that projects a plane of the low flow water surface across the landscape in order to estimate what the elevation of the ground is *relative* to the river and is used to identify riverine landforms such as sloughs, side channels, and gravel bars. Cooler colors (blues-greens) show areas of the landscape that are closer in elevation to the river and warmer colors (tans-browns) show areas that are higher in elevation.

NSD completed a channel migration assessment using historical aerial images and maps to evaluate past changes in the slough, connector channel, and Skagit River channel within the vicinity of the project area. NSD georeferenced a historical map showing a survey by the General Land Office (GLO) from 1872; this map represents the earliest known mapping of the Skagit River and its floodplain. To analyze channel changes between 1872 and the present, we then downloaded historical aerial images of the project area from the USGS Earth Explorer online database for 1941, 1951, 1968, 1981, 2006, 2015, and 2021. Polygons of the low flow channel of the Skagit River, the connector channel, and the slough were digitized from the imagery for the geomorphic analysis.

5.4.2 Results

Geomorphic Landforms and Features

DeBay Slough is within the Skagit River floodplain and is surrounded by other floodplain landforms such as relict channel features, through-fill roads, closed depressions, and broad swales (Figure 19). As discussed in the channel migration assessment below, DeBay Slough was likely formed after an avulsion cut off the mainstem Skagit River, forming an oxbow that is now referred to as DeBay Slough. Research by the County into deed records indicates this event occurred in the 1920's. An oxbow feature is seen on the REM where the dimensions of the slough are similar to the Skagit River and by the tortuous angle of the slough that likely contributed to the cut off. Historical accounts of channel changes at DeBay Slough (formerly referred to as Stirling Bend) and Hart Slough were documented in the Hart Slough Enhancement Feasibility Investigation (Inter-fluve, 2003) and describe rapid straightening of the Skagit River in this reach in 1911 and 1923. In 1911, during a large flood event, the Corps of Engineers blasted a cutoff channel through what is now Hart Slough to reduce channel migration and bank erosion northward into agricultural lands. During large floods in 1921, 1923 and 1924, the new downstream meander was cut off, establishing DeBay Slough as an off-channel feature. The net result of this straightening caused a dramatic increase in channel slope in the reach and a consequent lowering of the streambed by approximately 3 feet (Inter-fluve, 2003).

Modern flood overflow pathways between the river and the slough are also evident on the REM and indicate that flood flows both travel around the slough in a clockwise fashion, as well as flowing through the floodplain forest towards the connector channel – a process that is confirmed by the hydraulic model results described above and in Appendix A-2. The connector channel is also evident on the REM and is surrounded by two elevations of floodplain terraces – one of lower elevations along the right bank and one at higher elevations along the left bank.

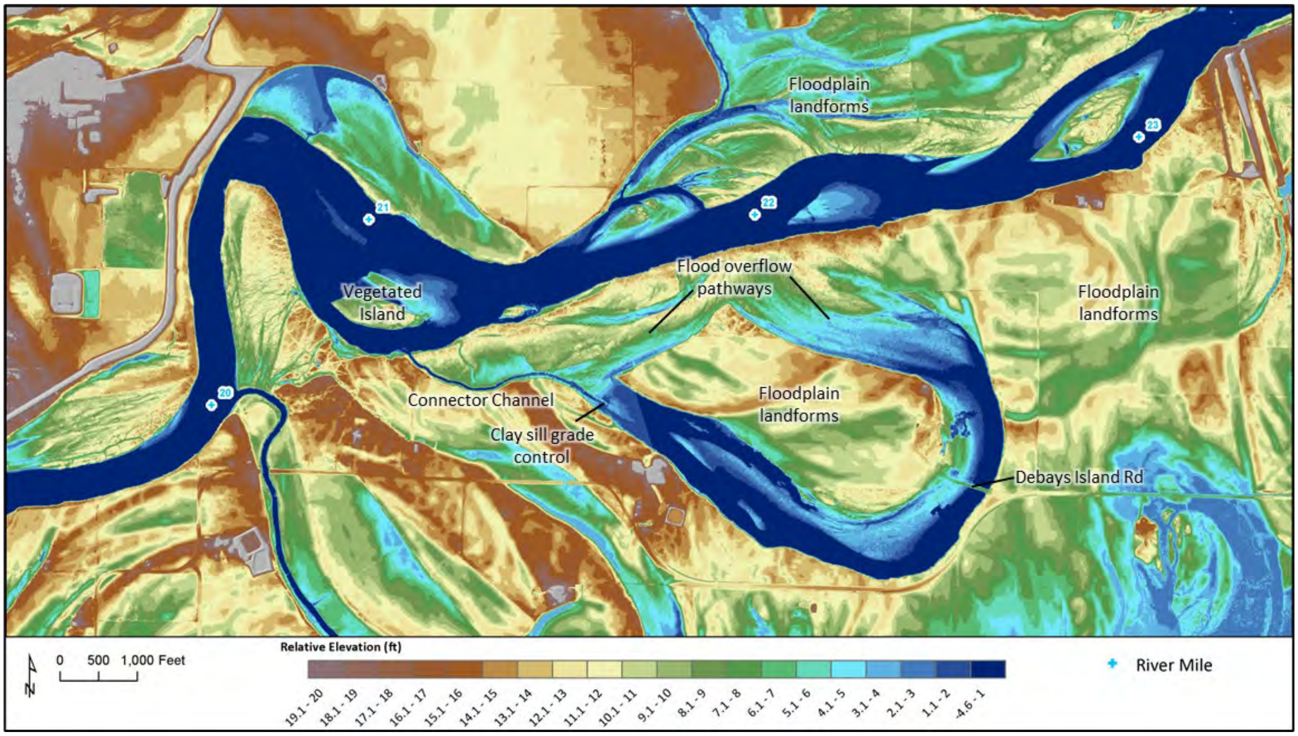

Figure 19. Relative Elevation Model (REM) of the project area. The REM was developed using 2016 lidar (NPS, in publication).

During the field assessment, NSD identified a clay sill at the upstream end of the connector channel which appears to be holding grade (noted as grade control in hydraulic section above) and contributing to the maintenance of water levels in the slough (Figure 20). The sill is comprised of erosion resistant clays and silts and has been in relatively the same location across the historical aerial image record (Figure 21).

The sill is maintaining a drop in grade between the slough and the connector channel, which may cause the sill to migrate upstream in the future if flow through the slough increases. However, given the slow rate of change in the configuration of the slough and low rates of migration of the sill during the past 50+ years, rapid migration of the sill is not expected.

Figure 20. Clay sill holding grade at the downstream end of the slough. The sill appears to be resistant to erosion and is likely contributing to the maintenance of water levels within the slough. The sill forms the upstream end of the connector channel. Photo taken on March 10, 2022, looking upstream.

Channel Migration Assessment

DeBay Slough appears to be a former Skagit River mainstem channel that converted into an oxbow after a meander bend cut off; deed research by County surveyors indicates the cut off occurred in the 1920's. The cut off is evident comparing the 1872 GLO map to the1941 aerial photo (Figure 21). Historical narrative provided in the Hart Slough Feasibility study suggested that these changes occurred in 1911 and 1924 during large flood events and subsequent blasting performed by the USACE (Inter-fluve, 2003). As shown in the comparison between the GLO map and the 1941 aerial image, DeBay Slough is within a southeasterly migrating meander bend of the Skagit that was mapped during the 1872 survey. The meander bend likely migrated ~1,500 feet between the original mapping effort and 1941 before cutting off and forming the modern day slough.

As shown in the 1941 imagery, active river channel migration was likely common during this period as evidenced by the broad gravel bars, braided channels, and migration patterns of the meander bend directly downstream from the slough. However, channel migration rates slowed following the 1968 image, with the planform of the mainstem Skagit River remaining relatively stable between 1968 and the present. Lack of migration is indicated by the overlapping of the low flow channels during this period, with only minor widening of the active river channel corridor. Furthermore, the river also did not migrate substantially towards the slough during that period of minimal channel migration. Given the recent patterns of channel migration, and in consideration of the continued influence of the upstream dams, low channel migration rates are expected to continue within the reach.

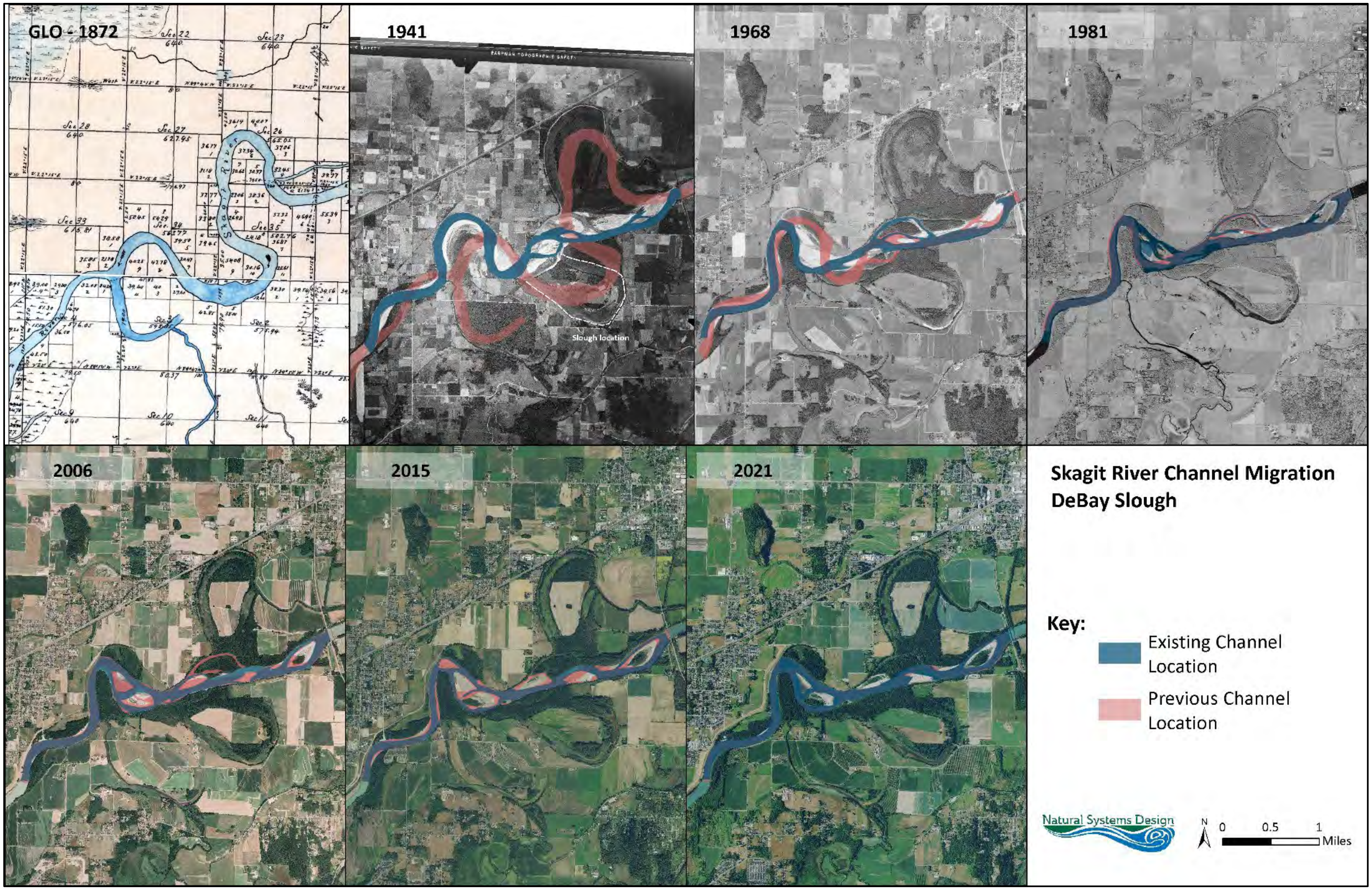

Figure 21. Historical Skagit River channel migration patterns within the project area. The 1872 map was obtained from the General Land Office within the U.S. Bureau of Land Management. The 1941, 1968, 1981, 2006, 2015, and 2021 images were obtained from the USGS Earth Explorer website.

The slough has remained relatively stable since the initial cutoff stabilized between 1872-1941 (Figure 22). In 1941, forest had already begun growing within the cutoff path, DeBay's Isle Road had already been constructed, and land had been cleared within the landform occupying the terrace north of the slough. However, the slough had a better connection to the main stem river at the downstream end during this time as the connector channel had yet to be formed and forest had not encroached on the open water pathway.

By 1968, changes within the slough had slowed and the planform looked very similar to how it does today. The forests of the terrace north of the slough had been fully cleared and the connector channel was in the same location it is today. Between 1968 and 2021, only minor changes to the vegetation patterns, including small expansions of the forest, are evident in the aerial imagery. The slough is predicted to remain relatively stable into the future given the minimal geomorphic changes that have occurred over the past 50+ years.

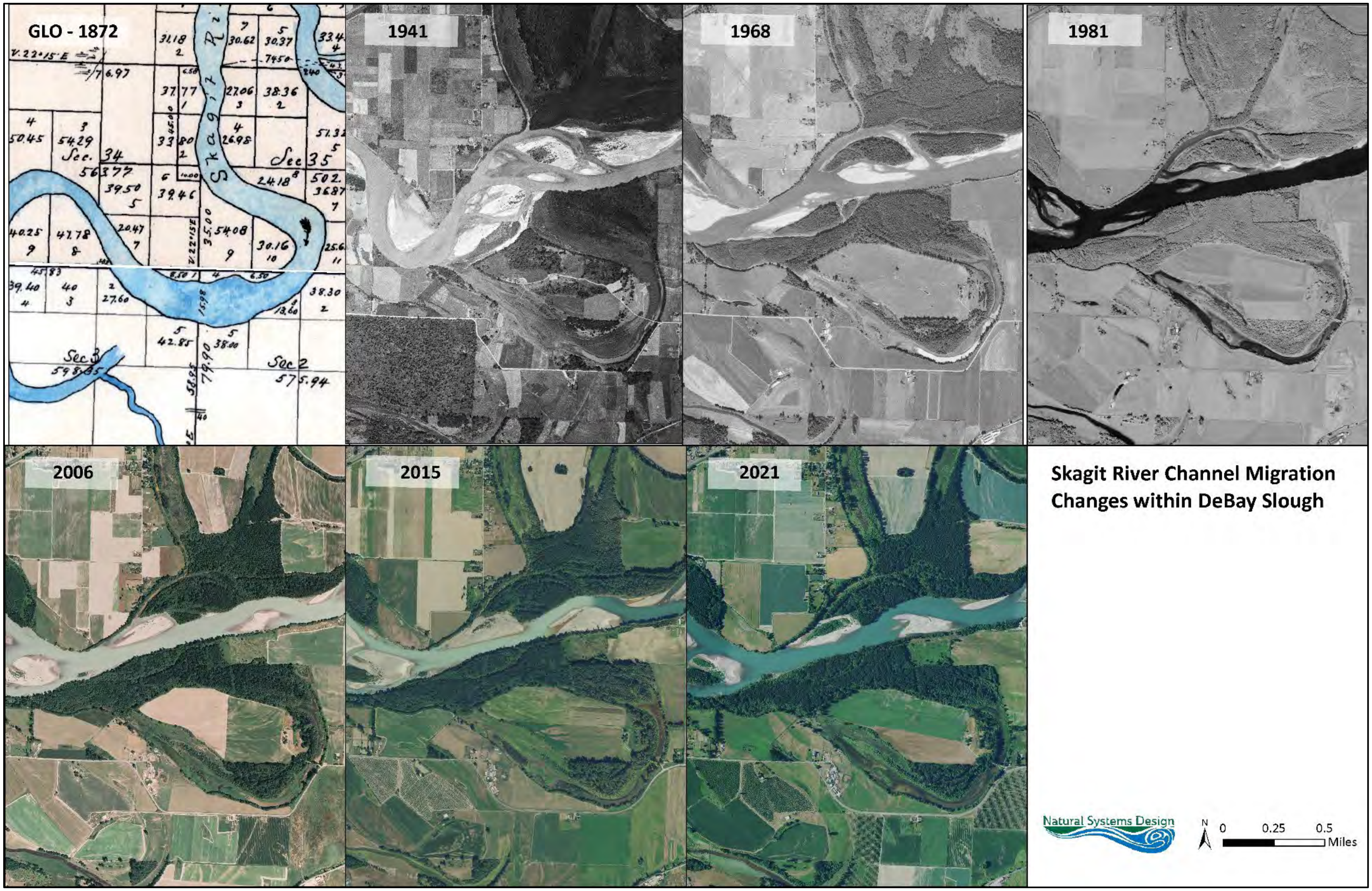

Figure 22. Historical changes within DeBay Slough. The 1872 map was obtained from the General Land Office within the US. Bureau of Land Management. The 1941, 1968, 1981, 2006, 2015, and 2021 images were obtained from the USGS Earth Explorer website.

Connector Channel

Although the slough itself has remained relatively similar since the 1941 aerial image, the connector channel formed later as the forest grew within the slough outlet. In 1941, the slough outlet was open to the river. However, between 1941-1951, forest began growing on gravel bars – narrowing the outlet channel. By the 1951 aerial (Figure 23), a narrow outlet channel is evident between the primary waters of the slough and the Skagit River's active channel corridor. Following 1951, the connector channel developed along the left bank of a former main-stem channel that is evident in 1951 aerial imagery (Figure 23). The location of the channel has remained static with the left bank line (which is adjacent to farmland) since 1951 and appears to be stable. Forest has recruited on the 1951 gravel bar between the left bank of the connector channel and the mainstem river, which has likely acted to further stabilize the channel. Additionally, flows are mediated by the clay sill at the upstream end which may moderate discharge into the connector channel and potentially lower channel migration rates.

Figure 23. 1951 aerial imagery of the project area compared to the 2021 location of the connector channel. The connector channel appears to have formed along the left bank of a former Skagit River main-stem channel and has remained relatively stable since its formation after 1951.

Large wood within the Connector Channel

NSD observed minimal amounts of large wood within the connector channel during the site assessment. The large wood consisted primarily of small, bank attached pieces of red alder with a few small accumulations (Figure 24). The lack of wood within the channel is likely due to the low rates of channel migration within the connector channel which could recruit additional large wood to the system. One exception to the low amounts of large wood is at the connector channel's outlet to the Skagit River where a large log jam was present at the time of the site assessment in early March 2022 (Figure 25). The log jam at the outlet appears to have rafted into the connector channel during the November 2021 flood as evidenced by the position of the logs which have been wedged in an upstream direction. This log jam is likely stable within the connector channel due to the presence of several key pieces (>18-24" DBH) and a large stump, although it is susceptible to being disrupted by a large flood where the Skagit river could re-mobilize the wood.

Figure 24. Typical example of large wood within the connector channel. The majority of the minimal amounts of wood within the channel consist of small, bank attached pieces of red alder or small accumulations. Photo taken on March 10, 2022, looking upstream.

Figure 25. Log jam at the outlet of the connector channel. The log jam appears to have formed from wood rafted down the Skagit River during the November 2021 flood. Photo taken March 10, 2022, looking upstream.

5.5 Aquatic Habitat Conditions and Use

5.5.1 Methods

NSD assessed aquatic habitat conditions using a combination of remote sensing data, water level and temperature data collected by SCPW, NSD's hydraulic modeling results, and field based observations. Field observations were collected during NSD's site visits for topographic survey data collection on March 10-11, 2022.

5.5.2 Results

Aquatic Habitat Conditions and Species Use

DeBay Slough contains two primary aquatic habitats - the slough and the connector channel flowing between the slough and the mainstem Skagit River. The connector channel and the slough both provide juvenile salmonid rearing habitat, with different functions. Neither the slough nor the connector channel provides suitable salmonid spawning habitat as the substrate is predominately fine sediment rather than cobbles and gravels.

The connector channel is a steep sided uniform channel with a flat bed and low gradient. Due to the low gradient, the channel has slow water velocities throughout it (see Appendix A.2 for velocities during modeled flows). The channel connects to the mainstem Skagit River, providing flow refugia compared to the higher velocities in the adjacent Skagit mainstem (Figure 26). The proximity to mainstem means the channel is likely intermittently used by juvenile Chinook, Steelhead/rainbow, and coho salmon. At the junction of the channel with the mainstem river a log jam has formed and provides cover habitat for juveniles. In contrast, throughout most of the channel fish cover is low with open areas comprising a majority of the channel area. Fish cover where present includes undercut banks, aquatic vegetation, and small, bank attached pieces of red alder with a few small that appear to be locally recruited. The bed and banks throughout the connector channel are comprised sand and silt which is likely deposited during floods from the Skagit River.

Figure 26. Connector channel junction where the channel meets the Skagit River (left) and connector channel with the log jam near the mainstem junction in the background. Photos taken March 9, 2022.

The slough is a much wider open water habitat with essentially no water velocity except during flood events. The off channel nature of the slough, coupled with its submerged aquatic vegetation and fringe of emergent wetland plants and fringe of overhanging trees and shrubs (Figure 27), make it likely more suitable for coho salmon rather than steelhead/rainbow trout or Chinook salmon. The collection of more fish use data is needed to verify species, timing, and extent of current salmonid use. During June 2022, the Skagit River Systems Cooperative conducted fish sampling in the slough. Skagit County provided a short video clip taken in the lower slough and found juvenile salmonids that appear to be coho.

Due to summer temperature limitations, discussed in the water quality section below, juvenile Chinook use of the slough is most likely to occur from fall through late spring (i.e., June) as the young salmon seek off channel rearing habitat before outmigrating in ~June down river through the estuary. The majority of the slough's water surface is not shaded, contributing to high summer water temperatures. Aquatic vegetation, primarily yellow pond lily (*Nuphar polysepalum*) grows in patches throughout the slough and provides considerable cover for juvenile fish. Emergent wetland species, described in more detail below, as well as overhanging brush, and small, and large pieces of wood are also present (Figure 27) and provide some cover but are generally low in abundance.

Figure 27. DeBay Slough example of open water habitat looking upstream toward road crossing. Photo taken June 8, 2022.

The chief habitat limitations for use of the slough by juvenile salmonids are summer water quality conditions, non-native warm water predators, and habitat connectivity. Predation may be an issue due the presence of bass and other warm water fish species (anecdotal from discussions with landowners) and invasive bull frogs. Predation, water quality, and a lack of cover habitat may particularly be an issue if any juveniles rearing early in the season remain in the slough during late summer periods when the slough can become disconnected from the connector channel and river.

Water Quality

In considering the potential of DeBay Slough to provide off channel rearing habitat for juvenile salmonids, particularly Chinook salmon, NSD reviewed an initial set of water quality data collected by SCPWs with HOBO gages installed prior to the start of this study at four locations within the project site (Figure 9). The gages recorded summer and winter water levels and temperature data generally from late June 2020 to mid-February 2021 when the gages failed/were vandalized (Figure 28). The gages are each located at the edge of the slough and reflect water temperature recorded within an average depth of water at the sensor of approximately 1.3 to 2.6 feet over the course of the June to February data set. SCPW re-deployed level loggers in late winter 2022 in slightly different locations in hopes of collecting another full year of data. However, elevated water conditions in June and July 2022 prevented data download in time for inclusion in this memo. The full suite of 2022 data will be summarized during later stages of the feasibility assessment as part of the conceptual basis of design report.

DeBay Slough has a state designated use as 'salmonid rearing and spawning' and thus a temperature threshold of 17 degrees Celsius to support salmonid rearing and spawning (WAC section 173-201A-020). Temperatures over 17 degrees Celsius create water quality conditions inconsistent with rearing use by salmonids. Temperatures approaching 21 degrees can be lethal (State of Salmon in Watersheds, 2020).

NSD also reviewed the Washington State Department of Ecology's (Ecology) Water Quality Atlas of Washington State to determine if DeBay Slough or the adjacent portion of the Skagit River are mapped as 'impaired' meaning conditions exceed state water quality criteria (Ecology, 2022).Neither DeBay Slough nor the adjacent portion of the Skagit River are mapped as having impaired water quality conditions (Ecology, 2022), but DeBay Slough is upstream of a portion of the Skagit River which is mapped as having impaired levels of dissolved oxygen and elevated temperature (but not 303d-listed/Category 5 level). Nookachamps Creek, just downstream of DeBay Slough, is 303d listed for impaired dissolved oxygen conditions. Salmonid-supportive water quality is thus an important consideration in assessing the feasibility of habitat improvements at DeBay Slough given the proximity of other off channel and mainstem areas with elevated temperatures which may not be conducive to rearing. Note, although Skagit County completed water quality sampling no data was submitted to Ecology.

The gages recorded water temperatures exceeding the 17 degrees Celsius threshold during the summer (Figure 28), with the shallowing water at sites 2 and 3 (Figure 10) at the downstream end of the slough reaching lethal temperatures from early August through early September. Site 3 along the edge of the slough experienced spikes in temperatures above 17 degrees and periods of lethal temperatures into the beginning of October. Sites 2 and 3 recorded water temperatures in a portion of the slough with generally shallower water (Figure 19) and with little riparian zone to provide shading of the water surface. It should be noted that site 3, near the downstream end of the slough, may have gone dry or the data logger was pulled from the water. Temperatures at site 3 ranged to +30 degrees Celsius (86 degrees Fahrenheit), more typical of air temperature than the highest water temperature recorded nearby at site 2 near the head of the connector channel.

Water temperatures at the gages just upstream and downstream of the DeBay's Isle Road culvert generally remained below the lethal threshold during this same summer period (Figure 28). Water temperature at site 4 downstream of the culvert remained just above the 17 degrees 'rearing and spawning' threshold throughout July and August. This location is shaded by the adjacent riparian forest to both the west and east, in contrast to site 5 in the more impounded portion of the slough upstream of the culvert.

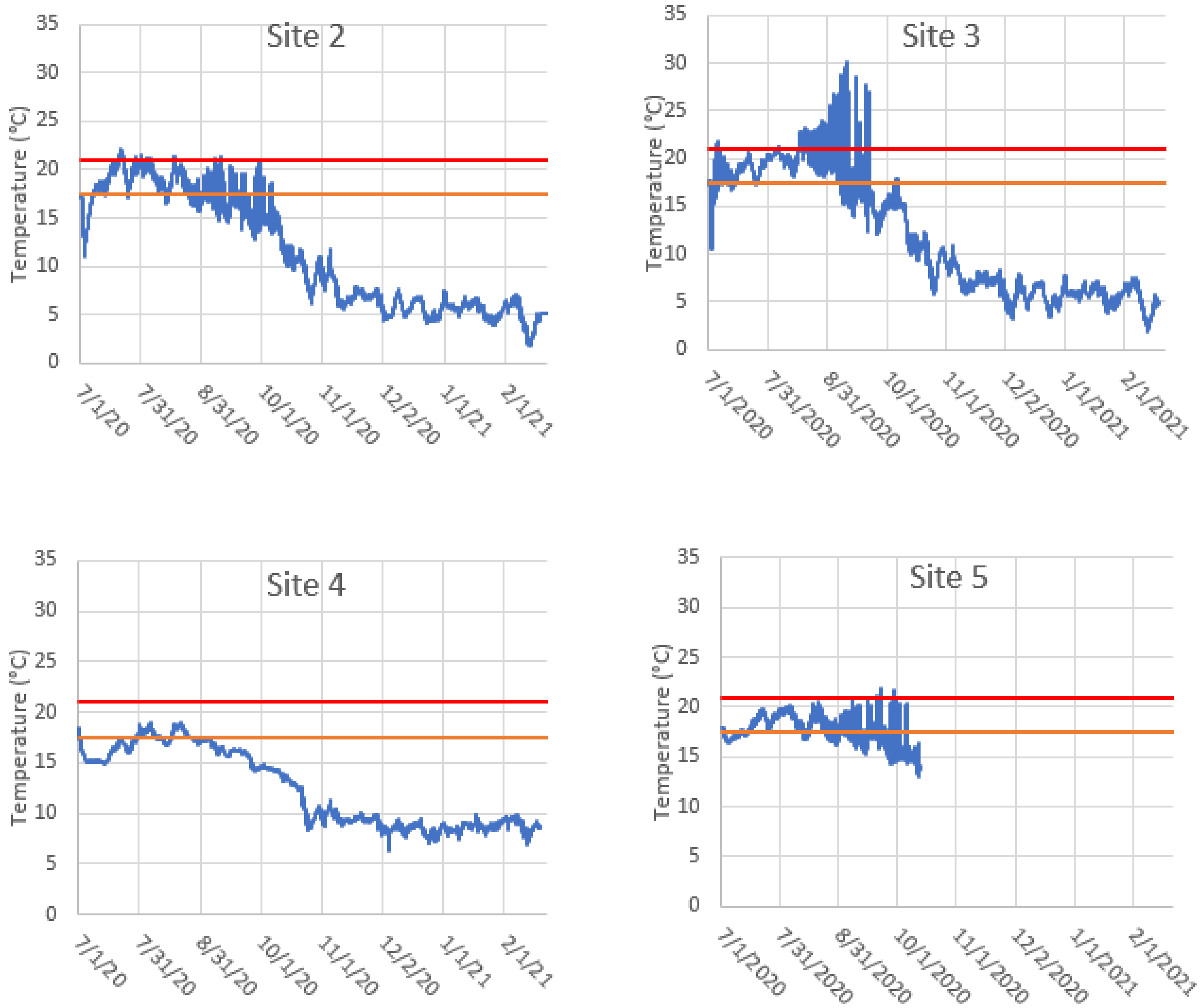

Figure 28. Skagit County Public Works HOBO gage water temperature data recorded at four locations within the DeBay Slough site. Sites 2 and 3 are at the downstream end of the lower slough. Sites 4 and 5 are downstream and upstream of the DeBay's Isle Road culvert, respectively. Orange line indicates temperature threshold for salmonid rearing and migration habitat. Red line indicates lethal temperature threshold for juvenile salmonids.

In addition to elevated temperatures in summer months, nutrient inputs and dissolved oxygen are also concerns. Empirical data on water quality aside from temperature are not currently available but observations on adjacent land use and nutrient loading provide anecdotal evidence to suggest other water quality impairments (e.g., biological oxygen demand (BOD) and decrease dissolved oxygen) may be present.

Aquatic Habitat Considerations

Ingress for aquatic species from the mainstem Skagit to the slough is provided during higher water when the river backwaters the connector channel. Winter rearing conditions in the connector channel and slough are suboptimal, with limited areas of small wood accumulations and edge habitat which provide lower velocity winter refuge habitat compared to the mainstem river channel. The sill at the western end of the slough where the connector channel begins forms a hydraulic drop as water levels decline seasonally, which likely creates a migration barrier for smaller fishes entering the slough from the channel as summer conditions develop.

Egress for aquatic species out of the slough may occur when the river and slough are connected via flow in the connector channel. While more aquatic complexity and edge habitat is created during the spring and summer through annual growth and expansion of submerged aquatic and emergent wetland vegetation, summer rearing habitat conditions may not be conducive to juvenile salmonids. Aerial photo evidence indicates that the connection between the slough and connector channel may go dry in summer (Figure 29). This creates the potential for juveniles that fail to leave the slough as seasonal temperatures increase and water levels decline to be subject to elevated water temperatures, presumably declining levels of dissolved oxygen, and an elevated duration of predation from fish and amphibians adapted to tolerate warmer water conditions.

Figure 29. Western end of DeBay Slough and the connector channel on 8/29/2020 showing no surface water connection between the slough and channel.

Aquatic habitat conditions upstream of the DeBay's Isle Road culvert are similar to those downstream, but with a greater portion of the slough supporting submerged aquatic and emergent wetland vegetation through the growing season and into late summer (Figure 30). The area of open water north of the culvert is confined by late summer to the deepest area immediately upstream of the culvert (Figure 31).

Figure 30. **Slough upstream of culvert, view north. Photo taken September 5, 2021.**

Figure 31. **Slough upstream of DeBay's Isle road culvert, view south toward culvert (background left of center). Photo taken June 8, 2022.**

5.6 Terrestrial and Wetland Habitat Conditions and Use

5.6.1 Methods

NSD conducted a field and desktop-based assessment of terrestrial habitats to evaluate the vegetation communities and wildlife habitat conditions and functions of the project area and to support the development of criteria for evaluating potential restoration actions and alternatives. Our focus was on both habitats and use by wintering waterfowl, including tundra and trumpeter swans associated with the project area's designation as a swan reserve, and habitats and use by resident and migratory birds and aquatic-associated mammals (e.g., beavers and river otter). While not a focus of our assessment, any observed use by reptiles and amphibians was also noted. We also performed a general wetland reconnaissance to determine the extent to which project area supports wetland habitats.

All field surveys were conducted on days were predicted weather conditions were forecast to be conducive to auditory detection of birds (i.e., not during periods of forecasted rain, fog, sleet, snow, or wind). Surveys were conducted with approximately 7 to 10 days between each survey to account for differing bird detection rates by species, breeding season, and time of day. Prior to the surveys, NSD reviewed winter species detections documented in the publicly accessible Ebird database to derive a list of potential species based on previously documented detections. NSD collected observations and photographs of habitats and species use using ESRI's Field Maps software and utilized the REM previously developed from the National Park Service using 2016 lidar to support the wetland reconnaissance.

NSD wetland and wildlife biologists Bob Keller and Torrey Luiting conducted winter surveys of the course of two days (January 26 and February 17, 2022) during the period of time when swans were present in the Darrington and Mount Vernon area along the Skagit River and its floodplain and farmlands. NSD conducted the January survey from mid-afternoon through sunset to observe habitat use by the swans and to document their flight into and use of the slough's open water habitats for night roosting. NSD conducted the February survey from pre-dawn through early afternoon to observe a portion of overnight habitat use. The nature and extent of use by other migratory and resident waterfowl and any other birds and wildlife detected during the surveys was recorded.

NSD wetland and wildlife biologists Bob Keller and Torrey Luiting also conducted two spring site assessments (May 17 and June 8, 2022), focused on waterfowl and wildlife/passerine/neotropical migrant use in the slough and riparian forests and wetlands during spring conditions. During the spring surveys, we conducted six, approximately 20 minute point-counts from locations with good visibility of key habitat areas. During these point-counts, all species seen and heard were recorded.

Concurrent with the spring surveys, we also mapped vegetation communities and considered the potential for low-lying portions of the riparian forest to be jurisdictional wetland (i.e., to meet the indicators required by the U.S. Corps of Engineers for hydric soil, hydrophytic vegetation, and near-surface hydrology to be considered a regulated wetland under the Clean Water Act; Environmental Laboratory, 2010). The wetland reconnaissance was not intended to be comprehensive, but rather was completed to more completely characterize the nature of the habitats and suite of functions provided by the slough and its riparian forest areas, including areas upstream of the DeBay's Isle Road culvert.

5.6.2 Results

The project area is a mix of numerous interspersed habitat types, ranging from open water and emergent wetland to mature cottonwood and alder dominated forests. Habitats include dense native understories below towering trees, dense and tangled willow-dominated wetlands, dense thickets of blackberry along riparian and forest edges, and also open areas: open agricultural fields that undergo seasonal mechanical alteration and changes in vegetation cover, an open grass and forb meadow a portion of which is undergoing active restoration with trees and shrubs, and an area of relatively open understory beneath a young red alder-dominated forest.

From a wildlife habitat perspective, the project area consists of both relatively undisturbed areas and areas that are highly disturbed during portions of the year. In terms of human disturbance, it is likely, for example, that parts of the riparian forest see no physical human presence during most years with the largest human disturbance being noise from hunting during the winter hunt season. Conversely, human presence is common in both parking areas and along DeBay's Isle Road, which see almost daily activity, as well as in areas open to public access (e.g., around the inner parking lot with views of wintering swans and waterfowl in the field).

Terrestrial and wetland habitats within the project area are heavily influenced by the Skagit River with its ongoing hyporheic influence and less frequent but formative flood events. Terrestrial and wetland habitats occur on a landscape marked with the sinuous flow paths created by a history of surface flood events. The lowest relative elevations are occupied by the slough. Elevations just above these are wetlands which occur as emergent species-dominated benches transitioning to forested wetlands, and ultimately to low elevation riparian forests.

The slough area, with its lower relative elevation, experiences the most frequent seasonal riverine influence in the form of changes in the extent of open water and the seasonal expansion and contraction of emergent and aquatic vegetation during high water and lower water seasons (Figure 32 and Figure 33). For approximately three-quarters of the year, the slough is predominantly inundated, with much of the lower elevation emergent benches submerged and aquatic plants either dormant or because of the time of year, not yet a dominant habitat component (Figure 32).

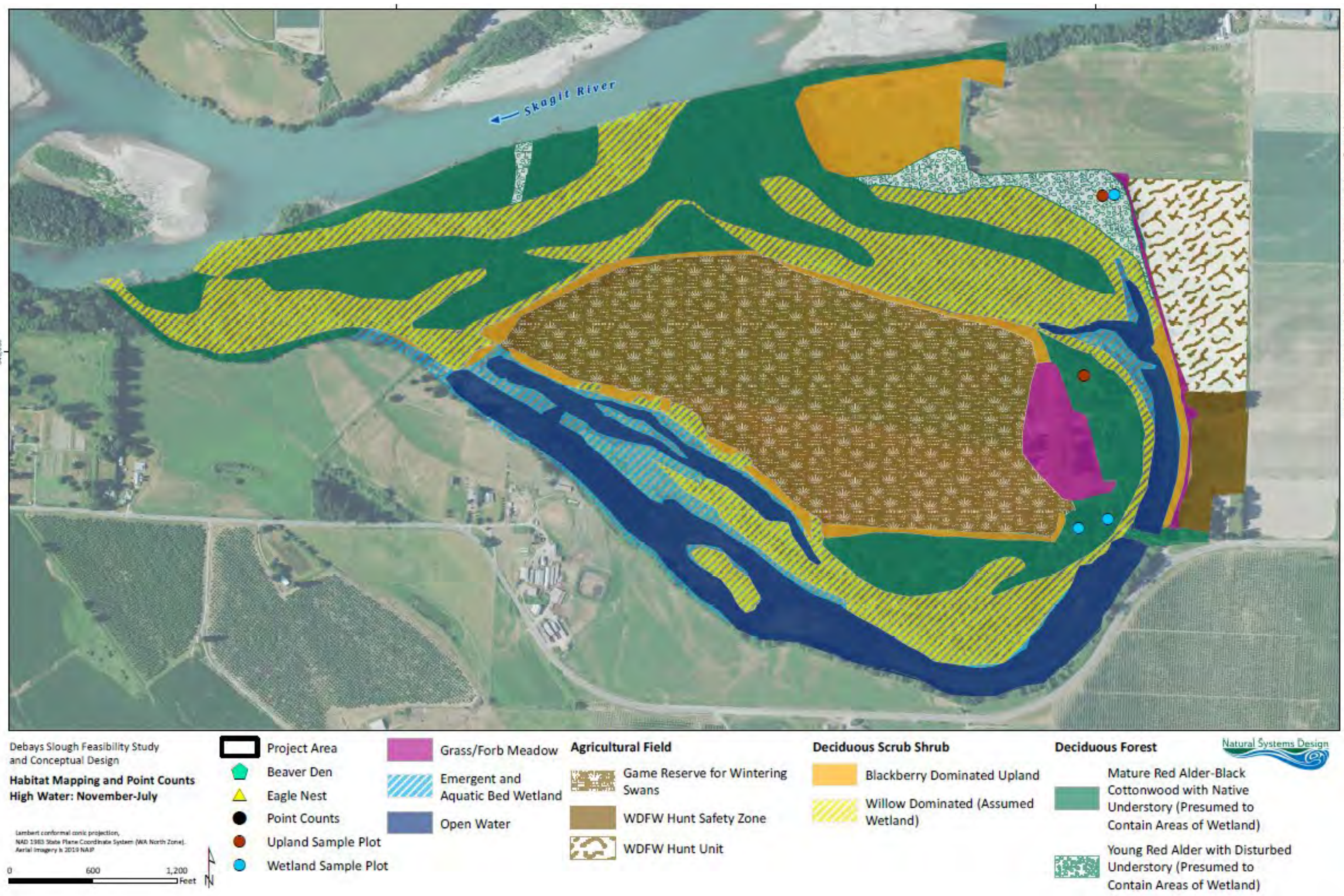

Figure 32. Mapped habitat types based on vegetation during high water periods of the year, November – July.

In contrast, from August into mid-fall, when Skagit River flows are lower, the water surface within the slough lowers and the wetted area is reduced (Figure 33). This allows the seasonal growth and expansion of native emergent species (e.g., common cattail, hardstem bulrush), as well as invasive reed canarygrass (*Phalaris arundinacea*) to expand along the slough's edges. Aquatic vegetation (e.g., yellow pond lily) reaches its annual peak during this time, with approximately 61.4 acres of the slough supporting emergent and aquatic bed vegetation compared to approximately 16.8 acres during higher water periods of the year.

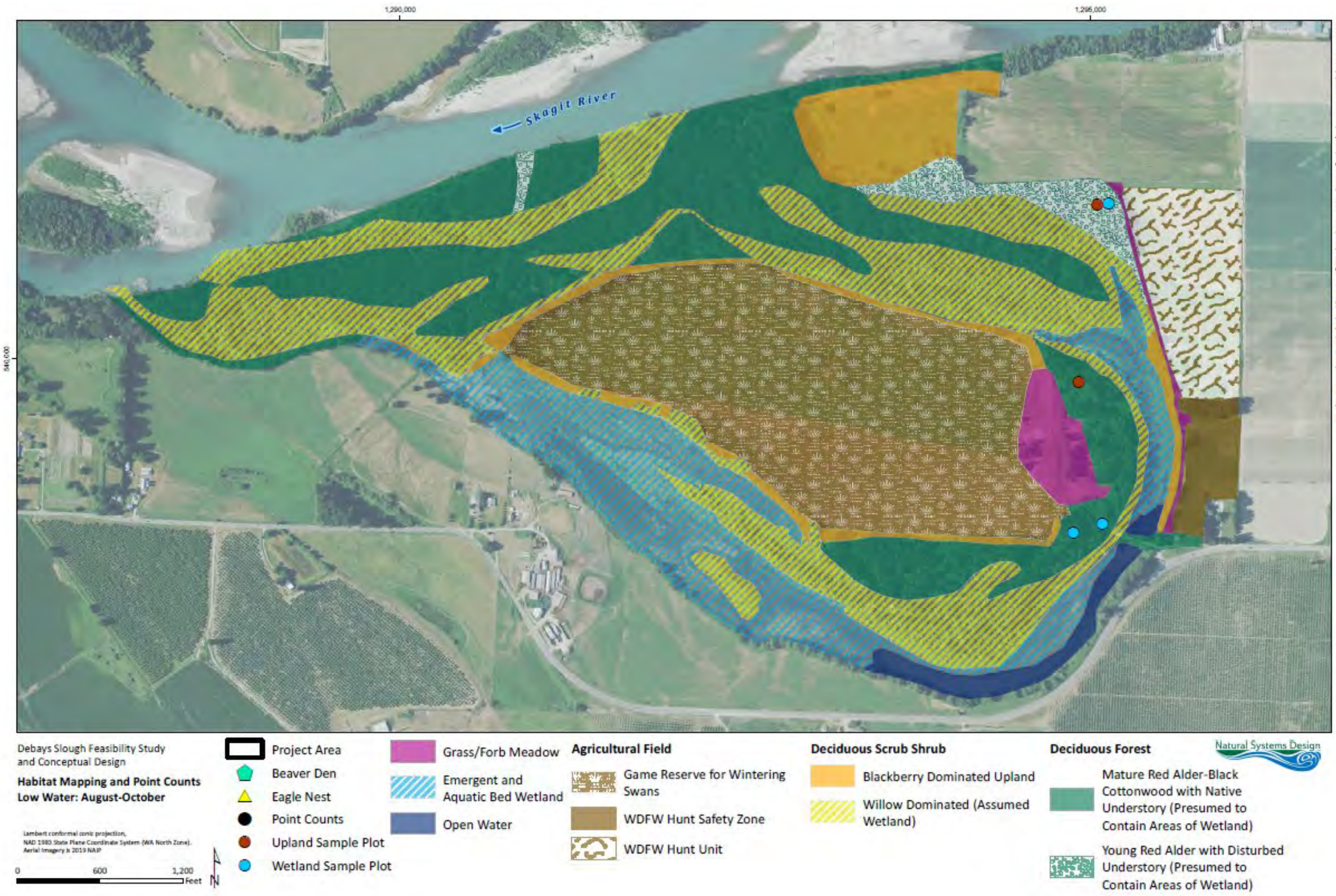

Figure 33. Mapped habitat types based on vegetation during low water periods of the year, August – October.

Habitat attributes present within the project area include:

- Diversity of food sources from the diversity of terrestrial and aquatic plant and animal life
- Edge habitat which provides wildlife the ability to locate food while maintaining cover from predators
- Abrupt changes in vegetation height (e.g., forested stands adjacent to open fields and depressional slough which provides wind protection, thermal traps, and viewing and hunting perches)
- Cover from predators and heat provided by forest and shrub canopy, thicket habitat, and tall stature emergent plants
- Open areas for hunting (predation) and thermal gain (e.g., for soaring)
- Low level of development in surrounding landscape (e.g., Skagit River corridor, farm and timber lands, nearby natural areas) which reduces disturbance
- Periodic flooding as a hydrologic disturbance regime (i.e., wet-dry cycle) which increases rates of decomposition, nutrient and energy cycling, and movement of materials
- Wetlands and year-round water and soil moisture resources which support invertebrates, reptiles, and amphibians
- Uneven-aged forested stands and structural diversity within the forests

- Generations of wildlife use which allows for site fidelity by species

Vegetation Communities

Deciduous Forest

Deciduous riparian forest occupies over a hundred acres of the project area along the Skagit River and south and eastward to the edge of agricultural lands. This community also occurs in a 'hook' shape around the eastern and southeastern edge of the Game Reserve agricultural field, forming a buffer between the field and the middle and upper reaches of the slough. The forest within the 'hook' provides a dramatic structural height difference from the adjacent flat surfaces of the farmed fields and slough. This height differences provides habitat for perching raptors (bald eagles were the most prevalent raptor observed during the site assessment field work), and functions as a windbreak and heat sink for both the field and the slough.

Black cottonwood (*Populus balsamifera*) and red alder (*Alnus rubra*) are the dominant tree species in the mature to semi-mature deciduous forest along the river and along the inner edges of the slough. Widely scattered native western red cedar (*Thuja plicata*) and Sitka spruce (*Picea sitchensis*) trees are also present. Black cottonwood forms the core of the forested areas with red alder dominating in smaller patches. The two species combine to co-dominate most of the 'hook' area, which, because of its high frequency of red alder, has a lower average tree diameter than the forest area to the north of the cropped field. Site wide, most cottonwood trees observed exceed 20-inches dbh, with some exceeding 30-inches. Our informal survey of snag presence noted a fairly high density, with a spacing of approximately every 100 feet. Downed and decaying wood, beaver activity, and an interspersion of upland riparian forest and forested wetland depressions in the forest were also observed (Figure 33).

In this this habitat type, the canopy provides seasonal shade to support a dense, mostly native shrub community. Shrub species within this forest include red elderberry (*Sambucus racemosa*), salmonberry (*Rubus spectabilis*), red-twig dogwood (*Cornus sericea*), snowberry (*Symphoricarpos albus*), and Nootka rose (*Rosa nutkana*) (Figure 34).

Two areas along the northern and northeastern edge of the study area are early successional deciduous forest; they occupy approximately 11 acres of the project area and are dominated by young, even-aged red alder trees (i.e., approximately 20 years old) with almost no other tree species present. This forest type has a simplified understory of sword fern (*Polystichum munitum*) and invasive Himalayan blackberry (*Rubus bifrons/armeniacus*) in drier areas, and invasive reed canary grass (*Phalaris arundinacea*) in lower, wetter areas.

Forested Wetlands

Both deciduous riparian forest and early successional deciduous forest support areas of forested wetland where soil saturation is prolonged enough to create hydric soil conditions for which wetland associated (i.e., hydrophytic) plant species are adapted. NSD documented deciduous forested wetlands in areas with lower relative elevations and greater hyporheic connectivity to the Skagit River (Figure 33), including along both sides of DeBay's Isle Road. These areas share similar plant communities with the surrounding riparian forest, but with a higher prevalence of species adapted to soil saturation for prolonged portions of the year such as red-twig dogwood (*Cornus sericea*), salmonberry (*Rubus spectabilis*), and slough sedge (*Carex obnupta*). Soils in these low-lying areas were typically fine sandy loams with evidence of the redoximorphic features forms by prolonged soil saturation coupled with periods of groundwater fluctuation. Appendix B presents the Corps wetland determination data forms completed by NSD during the field reconnaissance. Sample plot locations are indicated as wetland or upland on Figure 32 and Figure 33.

As described further below, mature black cottonwood-red alder riparian forest supports a greater diversity of animal species than the early-successional red alder forest area. Of all the habitat types surveyed, the mature deciduous forest supported the highest number of bird species. Observed species that rely on forested habitat include western wood-peewee, warbling vireo, downy and pileated woodpeckers, and Swainson's thrush. Notably an active bald eagle nest is located within the deciduous forest adjacent to the slough (Figure 35).

Figure 34. Deciduous forest vegetation community and density of largely native understory; Game Reserve Agricultural field is in the foreground. Photo taken June 8, 2022.

Figure 35. Nest and pair of nesting bald eagles in mature deciduous riparian forest. Photo taken May 17, 2022.

Deciduous Scrub-shrub

Deciduous scrub-shrub habitat of two distinct types is present in the project area:

- invasive Himalayan blackberry-dominated upland that occurs along the boundary between forest and agricultural fields, and where high banks border the slough; approximately 31 acres
- willow-dominated scrub-shrub wetland that borders the slough and also occurs in low elevation depressions within mature deciduous forest, approximately 107 acres

Prominently occupying the many of the edges within the project area are relatively narrow bands of dense scrub-shrub dominated by Himalayan blackberry. This habitat type almost surrounds the Game Reserve agricultural field forming a dense thicket between the farmed field and the mature cottonwood-alder forest (Figure 36). It also occurs in several locations along the slough edge, extending from the top of high banks down to water's edge or to the emergent plant community if the slope gradient allows for an emergent community along the water's edge. This community is extensive along the south and east edges of the slough where riparian forest is absent, very narrow, or sparse. Where it occurs as a riparian edge, the landward uplands are mowed or farmed, thus maintaining the blackberry in a narrow band.

As a densely growing and aggressive invasive species, Himalayan blackberry limits tree and shrub seed germination and growth. Along the east edge of the upper slough mature cottonwood and alder are senescing – losing branches and falling into the slough. In several years, remaining trees will likely also fall and be replaced by expanding blackberry if left unchecked. This will result in loss of shade to the slough, as well as nesting and perching habitat. Himalayan blackberry does provide food and cover for several common bird species such as spotted towhee, dark-eyed junco, white-crowned sparrow, and song sparrow, as well as cover habitat for small mammals and reptiles (e.g., riparian-associated garter snakes).

Figure 36. Himalayan blackberry-dominated deciduous scrub shrub habitat adjacent to agricultural field and the lower slough. Photo take May 17, 2022.

NSD used aerial imagery to map, but did not field verify, a large area dominated by Himalayan blackberry in the north-central part of the management area adjacent to private farmland to the east (Figure 33). From aerial imagery, it appears this area was previously farmed (e.g., grazed or cultivated), but is no longer in agricultural use. In time, the forest to the west and south may expand into the area, with red alder likely to compete successfully with the blackberry, following the same trajectory that is occurring in the early successional, young alder forest described above.

Scrub-shrub Wetland

The willow-dominated wetland habitat consists primarily of Pacific willow (*Salix lasiandra*) with an understory variously dominated in some areas by reed canarygrass. This habitat type is extensive – approximately 107 acres and occupies much of the lower slough edge including a prominent peninsula and an island in the lower slough, as well as the edges of upper slough occupying the elevation between open water/emergent wetland and the mature deciduous forest (Figure 37).

Figure 37. Scrub-shrub community of willows fringing upper slough, with emergent and aquatic bed wetland adjacent, as well as deciduous riparian forest adjacent in background. Photo taken May 17, 2022.

This plant community could be seen extending from the slough into the mature deciduous forest north and west of the Game Reserve agricultural field (Figure 33). Its presence within the mature deciduous forest provides structural diversity due to the reduction in canopy height that offers a modified edge effect within the core of the cottonwood-dominated forest. The relatively open structure of this community provides habitat within the otherwise closed canopy forest for bird species accustomed to brushy and open woodlands such as willow flycatchers and yellow warblers, both observed during the field assessment site visits.

Emergent and Aquatic Bed Wetland

An emergent and aquatic bed wetland forms most of the vegetated community in and immediately surrounding the slough. In places, the emergent-dominated sub-community, described here, exists in narrow bands between the willow-dominated wetlands and open water, but wider stretches of this community exist in some areas including often shallowly submerged islands within the lower slough and along the lower slough's northern shoreline along the major forested bend. The emergent plant community occurs on low gradient areas within and adjacent to seasonally inundated areas (Figure 37). Dominant emergent species in this zone include reed canary grass and hard-stemmed bulrush (*Schoenoplectus acutus)* (Figure 38). Aquatic species occupy areas inundated for a longer duration than the emergent species-dominated sub-areas.

Because the slough's hydroperiod is so heavily influenced by Skagit River flows, the slough maintains vast areas that are shallowly inundated into late July and early August. Shallow water and warmer temperatures support large areas of predominately native aquatic plants, primarily Rocky Mountain/yellow pond lily (*Nuphar lutea, spp. polysepala*), cattail (*Typha spp*.) and an undifferentiated *Potamogeton* (pondweed) species (Figure 39).

A variety of wading and diving birds use the emergent-aquatic bed marsh habitat and open water habitats, as well as aquatic associated mammals such as river otter and beaver. Although no beaver dams were observed in the project area during the field work, an active den is located on an emergent bench along the northern edge of the lower slough (Figure 33) and adjacent property owners documented a beaver dam near/at the clay sill location (Figure 20). Recently harvested willow cuttings, active slide areas, and adult beaver were observed multiple times during our field assessment site visits, as were river otter foraging in the lower slough.

Figure 38. Emergent and aquatic bed vegetation communities in the lower slough. Photo taken May 17, 2022.

Figure 39. Aquatic Bed habitat with water lily and *Potamogeton* spp. in the upper slough. Photo taken May 17, 2022.

Open Water

Open water occupies the lowest relative elevations within DeBay Slough. The open water zone varies in extent substantially within any given year (Figure 32 and Figure 33). For approximately three-quarters of the typical year, open water occupies most of the slough (approximately 56 acres), providing habitat for a wide variety of waterfowl seeking forage or prey over submerged aquatic plant beds. It is during the early part of this full inundation period, when aquatic vegetation is dormant or just sprouting and water temperatures are cool, that waterfowl species, including trumpeter and tundra swans, mallards, and American widgeon, descend onto the slough to roost at night (Figure 45).

During the spring, as water temperatures warm and day lengths increase, aquatic vegetation (primarily pond lily and a *Potamogeton* species) begin to rapidly grow, reaching the surface by mid-spring. During the late summer and early fall months, when mainstem Skagit River levels drop, the open water zone within the slough shrinks, and the marsh and aquatic bed areas expand to approximately 61 acres (Figure 41). During this portion of the year, the open water zone where aquatic vegetation is not observed from aerial imagery, occupies approximately 9 acres of the slough.

Observations of open water wildlife use include:

- Overnight (pre-dusk to after dawn) roosting habitat for trumpeter and tundra swans, mallard, American wigeon, and Canada goose
    - Swans begin to return to their southwestern Alaska breeding grounds in late-March and have typically left DeBay Slough by mid-April. Swans begin to return to the site in late-October.
    - Hunting, feeding, and/or resting habitat for birds including belted kingfisher, ring-billed ducks, double-crested cormorants, buffleheads, pied-billed grebes, Northern pintail, and wood ducks.
    - Avian use of the open water habitat area appears to decline sharply by mid-spring.

Figure 40. Waterfowl use of open water in lower slough, February 17, 2020. Species include Trumpeter Swan, Tundra Swan, Mallard, and American Wigeon.

Figure 41. Open water habitat south of DeBay's Isle Road culvert, with fringe of aquatic bed/emergent wetland, deciduous scrub shrub wetland, and deciduous forest. Photo taken May 17, 2022.

Grass/Forb Meadow

An approximately 10-acre grass/forb meadow dominates the area adjacent to the Game Reserve parking area (Figure 38). This habitat type is characterized by open, un-mowed to infrequently mowed grass and forb species without tree cover but punctuated by sparsely occurring taller shrubs. A portion of this area has recently been planted with native tree and shrub species that are currently less than 5-feet in height. The meadow borders a stand of mature red alder – black cottonwood deciduous forest, the Game Reserve agricultural field, and the Game Reserve parking lot.

Structures within the parking lot such as fence posts and rails, trees, and decaying wood fence material are used by wildlife and were included within the grass/forb meadow habitat observations, since several species were seen moving freely between the meadow and the parking area structures. The meadow was observed to provide food, cover, and perching habitat. Observed wildlife use included multiple bird species and black-tailed deer (Figure 42). Several bird species including Hammond's flycatcher (likely through-migrating), killdeer, and barn swallow were seen only in this habitat type, and this is the habitat preferred by common yellow throat, although this species was also observed at forested edges.

Figure 42. Black-tailed Deer and Common Yellowthroat in the grass/forb meadow area on June 8, 2022.

Agricultural

Agricultural areas include the approximately 108-acre Game Reserve, the 23-acre WDFW Hunt Unit, and the 8-acre WDFW Hunt Safety Zone. All are managed by WDFW as part of the Skagit Wildlife Unit in coordination with a farmer under contract. The fields are managed to produce annual crops such as corn and barley, as well as winter forage for waterfowl, including tundra and trumpeter swans.

Although annual variations may occur, the typical management cycle includes spring seeding, summer grow-out, early-fall harvest, and late-winter/early-spring tillage and prep for spring planting. Standing crops or crop stubble are present for the majority of the year, typically from late-May or June when seeds are sown (Figure 43), through the following April when tillage of the stubble occurs prior to replanting.

Figure 43. Game Reserve agricultural field, June 8, 2022, planted in rows of corn.

Planting zone boundaries and habitat conditions within a field can vary by year. Similarly, different management practices may exist between the Game Reserve and the Hunt Unit resulting in differences in winter swan and waterfowl habitat qualities at any given time. For example, it appeared that the Game Reserve agricultural field was tilled and seeded with a cover crop during the fall of 2021, but success of that crop may have been reduced by the November flood event. While no cover crop was present, unharvested corn was left standing in the eastern portion of the Game Reserve agricultural field (Figure 44) through at least late February 2022 while the hunt unit field retained crop residue and stubble (Figure 45).

Figure 44. Game Reserve agricultural field, eastern edge of unharvested corn adjacent to deciduous riparian forest. Photo taken February 16, 2022.

Figure 45. Example of crop stubble left to overwinter in the Hunt Safety Zone. Photo taken February 16, 2022.

Agricultural fields were observed to provide roosting, foraging, and hunting habitat for various bird species, travel, sunning, and perching habitat for coyote, and sunning habitat for garter snakes. During both winter observation visits, more than 400 mallards were observed using the Game Reserve agricultural field as a night foraging and roosting site (Figure 46). Observed mallard use occurred from the western to the eastern end of the field. Mallard arrival began 45 minutes prior to sunset and lasted for approximately 25 minutes.

Figure 46. Mallards foraging and resting in the Game Reserve field. Photo taken February 17, 2022.

Wildlife Use Summary

Key observations of winter wildlife use include:

- The number and species diversity of waterfowl were greater during the winter observation period than during the spring
- Most waterfowl species confined their habitat use to the open water and aquatic bed habitats.
  - Large numbers of swans (250 – 300+), mallards (300+), and American wigeon (200+) were observed using the open water slough (primarily the lower slough) for night roosting (Figure 40 and Figure 47).
  - Mallards in large numbers (300-400 observed) used the Game Reserve agricultural field as night foraging and roosting habitat (Figure 46).
- Overall number of birds observed was higher in winter owing to swan, mallard, and American wigeon use.
- 30 different bird species were observed during the winter field effort (Table 4)
- Resident songbirds, starlings, and a variety of other resident bird species (e.g., raptors, crows, great blue herons) were present using the forested, scrub-shrub, and emergent/aquatic bed wetland habitats throughout the study area.
- Up to 12 bald eagles were observed in trees surrounding the Game Reserve agricultural field
- A bald eagle nest was observed in the deciduous forest adjacent to the lower slough.

- Beaver and coyote presence (beaver den, beaver slides, coyote tracks and scat) were also observed during the winter observation period. An adult beaver was observed in the upper slough north of DeBay's Isle Road.

Figure 47. Trumpeter swans approaching the slough on February 17, 2022. The vast majority of swan night roosting activity occurred on the lower slough during field observations.

Table 4. Winter wildlife observations, high counts, and habitats used.

Species	High Count	date	Habitat[1]
Canada Goose	12	Feb. 17	AF, OW, E/AqB
Trumpeter/Tundra Swan	300+	Feb. 17	OW, E/AqB
American Wigeon	1000+	Feb. 17	OW, E/AqB
Mallard	1000+	Feb. 17	OW, E/AqB, AF
Northern Pintail	15	Feb. 17	OW, E/AqB
Ring-necked Duck	4	Feb. 17	OW, E/AqB
Bufflehead	10	Feb. 17	OW, E/AqB
Hooded Merganser	3	Jan. 26/Feb. 17	OW, E/AqB
Pied-billed Grebe	3	Feb. 17	OW, E/AqB
Mourning Dove	1	Jan. 26	DSS
American Coot	10	Jan. 26	OW, E/AqB
gull sp.	40	Jan. 26	Fly-over

Species	High Count	date	Habitat[1]
Double-crested Cormorant	5	Jan. 26/Feb. 17	OW
Great Blue Heron	2	Jan. 26/Feb. 17	DF, OW, E/AqB
Northern Harrier	2	Jan. 26	AF
Bald Eagle	12	Feb. 17	DF
Red-tailed Hawk	3	Jan. 26	AG, DF
Belted Kingfisher	2	Jan. 26	DSS, OW
Downy Woodpecker	1	Jan. 26	DF
American Kestrel	1	Jan. 26	DSS
American Crow	20	Jan. 26	DF
Common Raven	2	Feb. 17	Fly-over
Black-capped Chickadee	1	Jan. 26	DF
European Starling	~200	Jan. 26	DF
Dark-eyed Junco	50+	Jan. 26	DSS, AF
White-crowned Sparrow	5	Jan. 26	DF, DSS, AF
Golden-crowned Sparrow	15	Jan. 26	G/FM, DSS, AF
Song Sparrow	7	Feb. 16	DF, DSS
Spotted Towhee	8	Jan. 26	G/FM, DSS, AF
Red-winged Blackbird	4	Feb. 16	E/AqB, DSS
American Beaver	den, signs	Jan. 26/Feb. 17	E/AqB, DSS, DF
Coyote	tracks	Feb. 16	AG, DSS, DF

1. DF = Deciduous Forest. DSS = Deciduous Scrub Shrub. E/AqB = Emergent/Aquatic Bed. G/FM = Grass/Forb Meadow. AG = Agricultural Field. OW = Open Water

Key observations of spring wildlife use include:

- A wide variety of neotropical migrant bird species (20 species) were observed in forested, scrub-shrub, and meadow habitats during the spring observation visits.
- Overall avian species diversity was higher during the spring than winter, with 49 bird species observed (Table 5).
- Waterfowl numbers and species diversity decreased dramatically from winter to spring.
- 80 mallards were observed using the Game Reserve agricultural field during the morning of our May visit. It is speculated that these individuals were night roosting in the field.
- Beaver presence was noted (beaver den, beaver slides, chewed willows).
- A coyote perch was observed on both spring observation visits consisting of an approximately 200 square foot compacted area within the Game Reserve agricultural field. The perch was located along the northern edge of the field, adjacent to the Himalayan blackberry thicket. Plenty of scat and numerous footprint trails emanated and converged in this area. Coyotes have formed a low passageway through the thicket for access into the deciduous forest.
- A river otter was observed on the lower slough, south of DeBay's Isle Road.

- The bald eagle nest continued to be occupied with adults perched in nearby trees and delivering food to the nest.
- Bald eagle presence was lower in spring than in winter, with fewer individuals observed.
- A garter snake, possibly the same individual, was observed on both spring site visits sunning along the blackberry/Game Reserve agricultural field edge.
- A western toad (dead) was found on the edge of DeBay's Isle Road.
- Both Townsend's warbler and Hammond's flycatcher were observed during the May 17, 2022, site visit. The presence of these species may reflect use of the project area as a migration stopover as these species rely on coniferous forest habitats not present on site.

Table 5. Spring wildlife observations, high counts, and habitats used.

SPECIES	HIGH COUNT	DATE	HABITAT[1]
Canada Goose	10	5/17	AF, OW, E/AqB
Wood Duck	2	5/17	OW, E/AqB
Mallard	80	5/17	AF
Hooded Merganser	2	5/17	OW, E/AqB
Mourning Dove	2	5/17	DSS
Anna's Hummingbird	4	5/17	DF, DSS
Rufous Hummingbird	1	6/8	DSS
Killdeer	2	5/17	G/FM
Double-crested Cormorant	2	5/17	OW
Great Blue Heron	2	5/17	DF, E/ABW
Bald Eagle	5	6/8	DF
Red-tailed Hawk	1	5/17	AF, DF
Belted Kingfisher	1	5/17	DSS, OW
Downy Woodpecker	3	5/17	DF
Pileated Woodpecker	1	5/17	DF
Northern Flicker	3	5/17	DF
Western Wood-Pewee	3	6/8	DF
Willow Flycatcher	3	6/8	DF, DSS
Hammond's Flycatcher	1	5/17	G/FM
Pacific-slope Flycatcher	1	5/17, 6/8	DF
Warbling Vireo	2	5/17, 6/8	DF
American Crow	6	5/17	DF
Common Raven	2	5/17, 6/8	Fly-over
Black-capped Chickadee	4	5/17	DF
Tree Swallow	20	5/17	G/FM, DF
Barn Swallow	3	5/17	G/FM
Brown Creeper	1	5/17, 6/8	DF
Bewick's Wren	3	5/17	DF
European Starling	5	5/17	DF
Swainson's Thrush	7	6/8	DF
American Robin	25	5/17	DF, DSS, G/FM
Cedar Waxwing	10	6/8	DF, DSS

SPECIES	HIGH COUNT	DATE	HABITAT[1]
House Finch	2	5/17	DSS, G/FM
Pine Siskin	1	6/8	G/FM
American Goldfinch	10	5/17	DF, DSS
White-crowned Sparrow	5	5/17	DF, G/FM, DSS
Savannah Sparrow	2	5/17	G/FM, DSS
Song Sparrow	10	5/17	DF, DSS
Spotted Towhee	5	5/17	DSS, DF, G/FM
Red-winged Blackbird	15	5/17	DSS. E/AqB
Brown-headed Cowbird	2	5/17	DFD, DSS
Bullock's Oriole	2	6/8	DSS
MacGillivray's Warbler	2	5/17	DSS
Common Yellowthroat	5	6/8	G/FM, DF
Yellow Warbler	6	6/8	DF, DSS
Yellow-rumped Warbler	20	5/17	DF, DSS
Townsend's Warbler	1	5/17	G/FM
Wilson's Warbler	1	5/17	DF
Black-headed Grosbeak	6	5/17	DF, DSS, G/FM
American Beaver	Den and signs	5/17, 6/8	E/AqB, DSS, DF
Coyote	Tracks and scat	5/17, 6/8	AG, DSS, DF
Garter Snake sp.	1	5/17, 6/8	AG, DSS
River Otter	1	5/17	OW
Western Toad	1 (dead)	5/17	DF

[1.] DF = Deciduous Forest. DSS = Deciduous Scrub Shrub. E/AqB = Emergent/Aquatic Bed. G/FM = Grass/Forb Meadow. AG = Agricultural Field. OW = Open Water

6 SUMMARY

The DeBay Slough project area is an ecologically complex area, characterized by the following conditions summarized and organized by the primary elements being considered in the feasibility assessment.

6.1 Hydraulic Connectivity during Typical Seasons of Use by Fish and Wildlife

1. Water level logger data show a strong linkage between DeBay Slough and the Skagit River (as measured at SR9 USGS gage), with flow peaks in the Skagit generally resulting in increased stage within the slough and the outlet connector channel.
2. Water surface on the northern side of the DeBay's Isle Road culvert is perched higher than on the southern side of the culvert, which is roughly 0.1 ft higher than the west/downstream end of the slough.
3. WSE at the connector channel appears to draw down more rapidly than the slough areas following the spring freshet (June – July 2020 data) and following fall and winter flood peaks in 2020 – 2021.
4. Both surveyed and lidar WSE data suggest a gaining groundwater connection at the eastern end of the slough and a losing connection at the west end of the slough.
5. Velocities in DeBay Slough are essentially zero at all modeled habitat flows and depths range from 9 to 10 feet deep in the deepest areas of the lower slough.
6. At the lowest flow condition (8,000 cfs), which represents an average flow for August through October, the WSE of the Skagit River at the outlet of the connector channel is below the bottom on the connector channel indicating there is no backwatering of the connector channel and DeBay Slough from the Skagit River.
7. Any water present within the slough during this low flow condition is a result of groundwater.
8. At the typical winter flow condition (15,000 cfs), the water surface at the outlet of the connector channel is approximately even with the water surface in the lower portion of the connector channel.
9. A grade break consisting of a clay sill near the outlet of the lower slough functions to hold water surface elevations at an approximately 2-foot higher elevation than within the connector channel.
10. At the typical winter high flow event (22,000 cfs), the Skagit River backwaters the entire lower slough through the connector channel up through the grade break feature and functions to control water surface elevation and depths within the slough creating an approximate 0.5-foot water surface difference between the downstream (lower) and upstream (upper) portion of the slough.
11. The DeBay's Isle Road culvert is a hydraulic constriction between the upper and lower portions of the slough.
12. A low area along the left bank of the Skagit due north of upper DeBay Slough allows for more concentrated overbank flows and routes these flows into the slough and down toward DeBay's Isle Road.

6.2 Geomorphic Context - Channel Migration and Landform Stability

1. DeBay Slough is within a southeasterly migrating meander bend of the Skagit that was mapped in 1872. The meander bend likely migrated ~1,500 feet between 1872 and 1941 before cutting off and forming the modern day slough.
2. Low channel migration rates are expected to continue within the reach.

3. Flood overflow pathways between the river and the slough indicate flood flows both travel around the slough in a clockwise fashion, as well as flow through the floodplain forest towards the connector channel – a process that is confirmed by the hydraulic model results.
4. The connector channel is surrounded by two elevations of floodplain terraces – one of lower elevations along the right bank and one at higher elevations along the left bank.
5. There is a clay sill at the upstream end of the connector channel which appears to be holding grade and contributing to the maintenance of water levels in the slough.
    a. The sill is comprised of erosion resistant clays and silts and has been in relatively the same location across the historical aerial image record.
    b. The sill is maintaining a drop in grade between the slough and the connector channel.
6. The location of the connector channel has remained static since 1951 and appears to be stable.
    a. Flows are mediated by the clay sill at the upstream end which may moderate discharge into the connector channel and potentially lower channel migration rates.
7. Minimal amounts of large wood are present within the connector channel, other than a log jam near its outlet with the Skagit River.

6.3 Riparian and Wetland Habitat Functions

1. Winter rearing conditions in the connector channel and slough are suboptimal, with some limited areas of small wood accumulations and edge habitat present to provide lower velocity refuge habitat.
2. Aquatic complexity and edge habitat is created during the spring and summer through annual growth and expansion of submerged aquatic and emergent wetland vegetation.
3. Emergent wetland species, as well as overhanging brush, and small, and large pieces of wood are present and provide some cover but are generally low in abundance.

6.4 Water Quality Conditions and Salmonid Habitat Considerations

1. Limited temperature data currently suggests the slough may be conducive to juvenile rearing in spring through outmigration in ~June, but further data is needed and will be collected over late 2022 and 2023.
2. Predation, water quality, and a lack of cover habitat may be an issue if any juveniles rearing early in the season remain in the slough during late summer periods when the slough can become disconnected from the connector channel and river.
3. DeBay Slough may provide off-channel, early summer rearing habitat for ocean-type juvenile Chinook (parr migrants), which rear in freshwater for a few months prior to out-migrating to the delta in late May or June.
4. Stream-type Chinook yearlings may use DeBay Slough for winter rearing/high flow refuge and potentially also for early season summer rearing habitat before they migrate to the Skagit River estuary from late March through May.
5. Salmonids, believed to be Coho, were documented in the slough in June 2022.
6. Additional fish use data is needed; additional data collection is anticipated in late 2022 through mid-2023.

6.5 Other Fish and Wildlife Use

1. Predation may be an issue due the presence of bass and other warm water fish species (anecdotal from discussions with landowners) and invasive bull frogs.

2. River otter, beaver (including an active den), coyote, western toad, and garter snakes were recorded utilizing the slough and adjacent riparian areas.
3. The project area provides a wide range of structural diversity, as well as a diversity of food, shelter, and breeding habitats.
4. Use of the slough and surrounding areas by waterfowl, raptors, and migratory and resident birds.
5. Waterfowl, including swans, mallards, and widgeon are more prevalent in winter than in spring. 30 different bird species were observed during the winter field effort.
    a. The site appears to be used as a migration stopover for species such as Townsend's warbler and Hammond's flycatcher which inhabit coniferous forests not present on the site.
6. Most waterfowl species confined their habitat use to the open water and aquatic bed habitats.
7. A wide variety of neotropical migrant bird species (20 species) were observed in forested, scrub-shrub, and meadow habitats during the spring. 49 different species were observed during the spring field effort.
8. An active bald eagle nest is present in the riparian forest along the lower slough.

7 NEXT STEPS IN FEASIBILITY STUDY

This site assessment memo will ultimately form the existing conditions sections of the conceptual Basis of Design report. A summary of existing conditions was shared with the Advisory Group at the August 15, 2022, Advisory Group meeting. The Advisory Group and this site assessment effort identified data gaps in the form of fish use data and additional water surface elevation monitoring data.

The County is pursuing additional funds to support efforts to collect additional water surface elevation data and temperature in the slough, the connector channel, and at the confluence of the Skagit River in late 2022 and through mid-2023 to inform the understanding of hydraulic connectivity and water quality conditions. The County is also pursuing collection of fish use data in late 2022 through mid-2023 to determine the nature, extent, and seasonal timing of use by salmonids and activity by warm-water predators. These data will be incorporated into the next phase of the feasibility study – the development of screening and evaluation criteria and restoration actions.

The design team, in collaboration with SCPW, WDFW, and the Advisory Group will use the information detailed in this report and the forthcoming water surface elevation, water quality, and fish use data during the development of screening and evaluation criteria. Human use of the Game Reserve for birding and hunting and the use of the areas surrounding the slough will also be incorporated into the development of these criteria.

A series of potential habitat enhancement actions will then be developed based on the set of specific screening and evaluation criteria. The criteria will then be used to consider and prioritize potential actions. Actions that meet the goals, screening, and evaluation criteria will then be expanded into conceptual design alternatives in collaboration with SCPW, WDFW, and the Advisory Group.

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Appendix A-1

Hydraulic Model Calibration

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APPENDIX A-1. EXISTING CONDITIONS HYDRAULIC MODEL CALIBRATION

1. Mainstem Skagit River Calibration

NSD calibrated the DeBay Slough hydraulic model to two separate flow events to validate the hydraulic model's ability to replicate existing hydraulic conditions at a wide range of discharges in the mainstem Skagit River. Initial model calibration was done using edge of water data and water surface elevations collected during the mainstem bathymetric survey on February 23, 2022, and Debay Slough and connector channel water surface elevations collected on March 11, 2022. The inflow condition on the mainstem Skagit River was set to a discharge of 13,200 cfs based on the average daily flow at the USGS Mount Vernon gage on February 23, 2022. An additional observation point was created at the SR9 bridge and utilized the average daily stage from the USGS gage (USGS 12199000). To achieve model calibration, Manning's N values for the main channel and side channels within the Skagit River were adjusted to achieve a best-fit with the measured water surface elevations in the mainstem Skagit River. The final main channel and side channel Mannings N values determined through this process are 0.034 and 0.046, respectively.

The computed water surface elevations (WSE) from the model were compared to the observed WSE at each of the observation locations and the difference between the two (computed minus observed) was calculated to validate the model's ability to replicate observed conditions. Figure A-1 below shows the spatial distribution of the observed WSE points and the resulting difference between the computed and observed WSE. Of note is how closely the edge of the modeled water surface (shown as the white and yellow depth bands) matches the observed conditions both in terms of actual elevations locations on gravel bars and banks. The observed WSE points were collected as edge of water survey points via ground-based RTK survey and therefore the good agreement between the computed water surface extent and the actual edge of water is an indicator that the underlying model terrain and the existing conditions results are representative of conditions in the Skagit River as of February 2022.

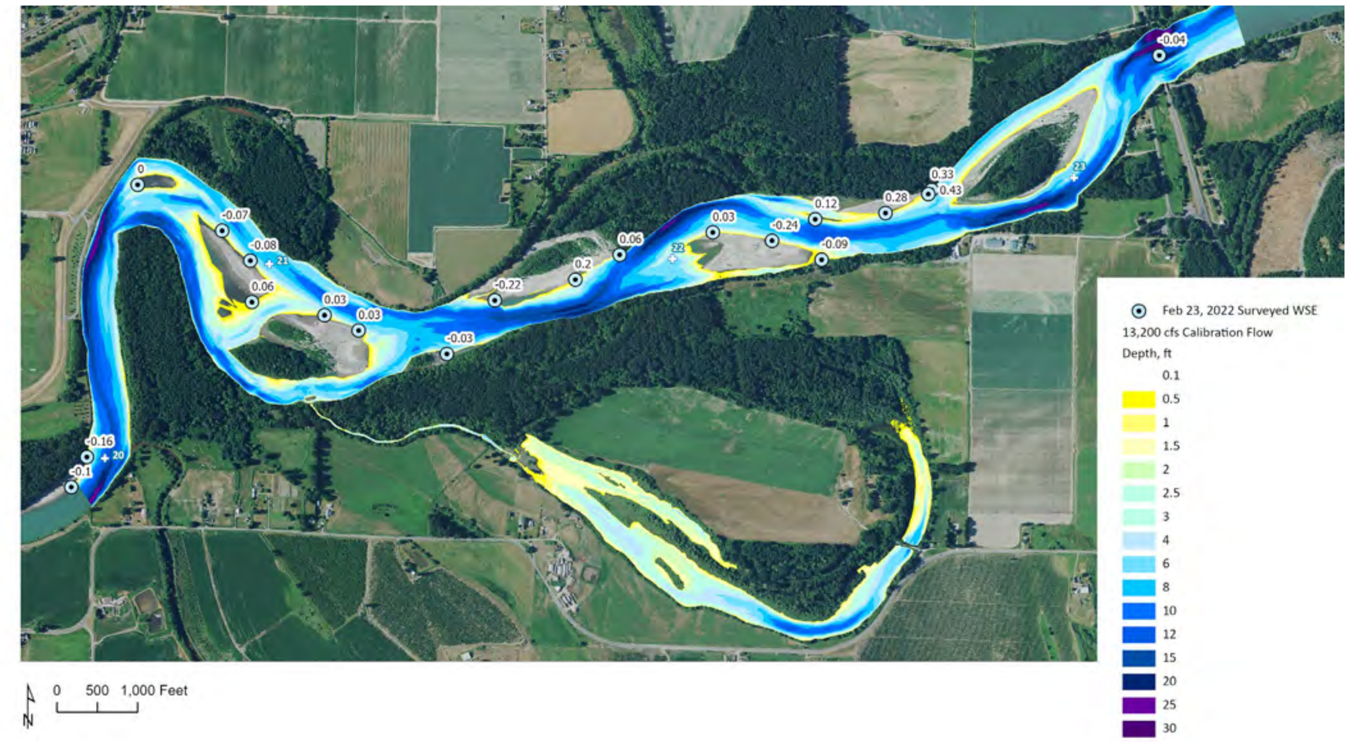

Figure A-1 Mainstem Skagit River Model Calibration. Observed edge of water shots collected by NSD on February 23, 2022, are shown and the difference between the computed and surveyed WSE is shown.

Figure A-2 shows the comparison of modeled and observed WSE in graphical format at each of the 18 surveyed edge of water points and the SR 9 USGS gage. The straight, 45-degree line represents an exact match between the computed WSE and the modeled WSE. The hydraulic model agreed very well to the observed conditions, as indicated by the proximity of the observation points to the points to the 45-degree line shown in Figure A-2. The average difference between the modeled and observed water surface elevation is 0.03 ft.

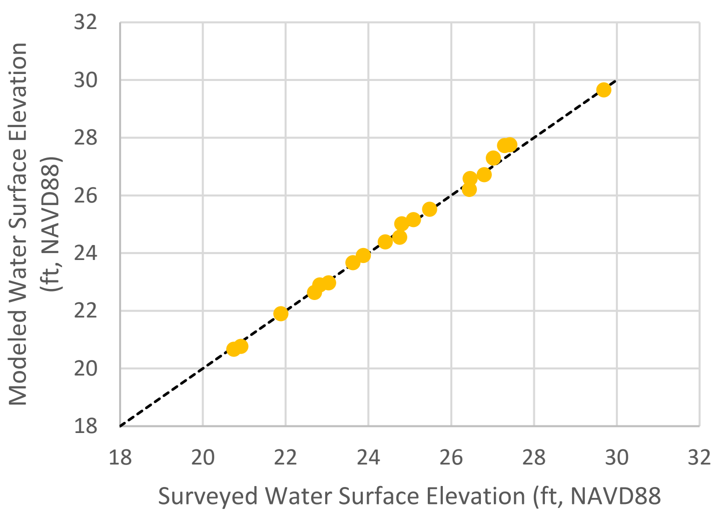

Figure A-2 Mainstem Skagit Modeled WSE vs. Observed WSE

2. DeBay Slough Inflow Discharges Calibration

To represent the water present within DeBay Slough, two inflow locations were set, one in the upper slough north of DeBay's Island Road and one in the lower slough south of the roadway. These point inflows were set to a constant discharge and the modeled water surface elevations within the slough and connector channel were compared to those observed during the slough and connector channel bathymetric and topographic survey conducted on March 10-11, 2022. During this inflow calibration process, the percent of blockage in the existing DeBay's Island Road culvert was modified to best represent the observed stage difference between the upper and lower sloughs as seen in the March 2022 survey data collection and in water level data collected by Skagit County. The resulting process led to a selection of the slough inflow values and connector channel roughness and an assumed blockage of 25% (0.5-foot) in the culvert. Figure A-3 illustrates the resulting modeled versus observed water surface elevations in the slough and connector channel. The resulting modeled water surface elevations in the DeBay Slough have good agreement with the observed data with the average difference between the model and the observed water surface elevations being -0.19 feet. The model tends to underpredict the water surface elevations in the slough near the outlet to the Skagit River mainstem, but otherwise agrees well with the observed data.

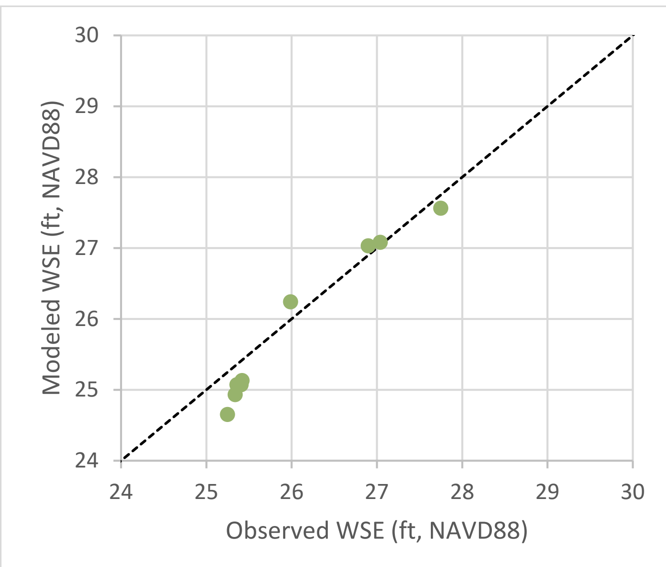

Figure A-3. Modeled vs Observed Water Surface Elevations in DeBay Slough and Connector Channel

3. November 16, 2021 Flood Event and Floodplain Roughness Calibration

NSD also calibrated the DeBay Slough hydraulic model to the November 16, 2021, flood event in the Skagit watershed which caused dramatic flooding throughout the Skagit basin including within the DeBay Slough area. The purpose of this model calibration was to refine floodplain roughness values so that the hydraulic model was capable of accurately representing the hydraulic conditions at the project site during large flood events. To calibrate to the observed conditions during the November 16, 2021, event two data sources were used: high water marks (HWMs) collected by NHC for Skagit County and summarized in the Post-November 2021 Flood High Water Mark (HWM) Inventory Skagit River Downstream of Rockport (NHC 2022) and a copy of the US Army Corps Water Management System (CWMS) combined 1D/2D HEC-RAS model that was recently recalibrated to the November 16, 2021, flood event (U.S. Army Corps of Engineers 2022).

1. November 16, 2021, Inflow Hydrographs

For this high flow model, NSD added an additional inflow representing the combined East Fork and West Fork Nookachamps Creek to the model domain to represent inflows from this drainage area during the flood event. As there is not a current USGS gage in the basin and the existing Ecology gage on the East Fork Nookachamps Creek has a limited period of record, NSD obtained approximate peak flow data for the combined Nookachamps Creek from the USGS StreamStats web application which utilizes a regression-based approach to determine peak flows based up on drainage area and average annual precipitation (USGS 2022).

For the Skagit River inflow, NSD developed an unsteady hydrograph from both the USGS at Mount Vernon gage records and as computed by the calibrated CWMS model run at the approximate location of the SR 9 bridge. Figure A-4 illustrates the two resulting hydrographs. The two hydrographs match fairly closely, however the computed maximum discharge in the CWMS model of 133,000 cfs exceeds the approved peak discharge at the USGS Mount Vernon gage of 127,000 cfs.

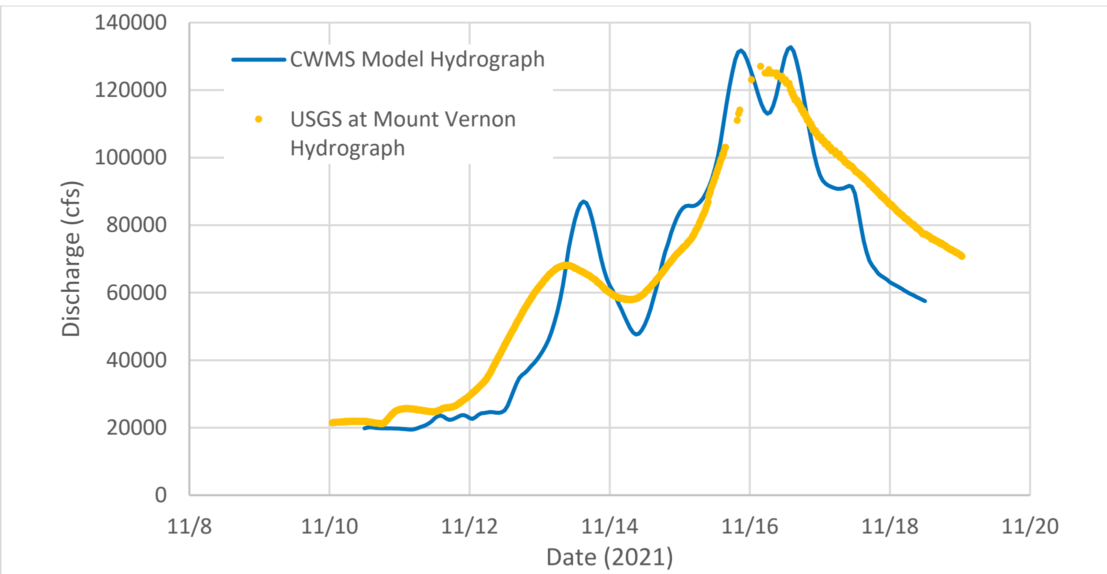

Figure A-4. November 10-19, 2021, Hydrographs

Both hydrographs shown in Figure A-4 were run in the 2D HEC-RAS model and the maximum computed water surface elevation was compared to the observed HWMs collected by NHC, as illustrated in Figure A-5. In general, both inflow hydrographs tended to underestimate the observed HWMs, with the CWMS inflow hydrograph resulting in computed WSE that more closely matched the observed data as compared to the inflow hydrograph from the USGS at Mount Vernon gage data.

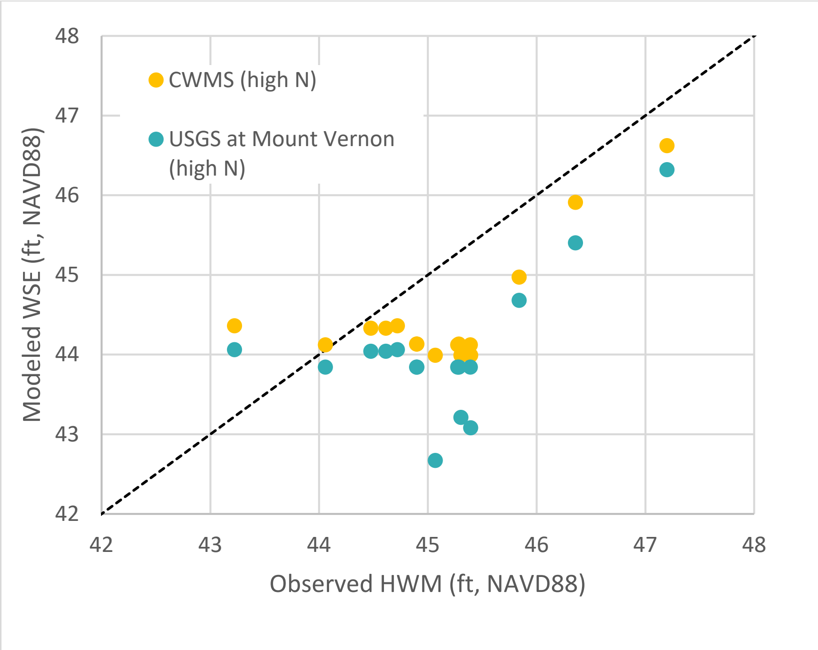

Figure A-5. Observed versus Modeled Water Surface Elevations for November 16, 2021 Event

As the CWMS inflow hydrograph resulted in a maximum WSE that more closely matched the observed HWMs, it was selected as the inflow hydrograph for the model run representing the November 16, 2021, flood conditions at DeBay Slough and the surrounding floodplain area. Figure A-6 shows the computed WSE for the final calibrated model run for the November 16, 2021, event along with the observed HWMs and the difference between the two at each observed location. In general, the model output tended underestimate the observed HMWs, with the difference between computed and observed values ranging from -0.2 to -1.4 feet. However, within the vicinity of DeBay Slough, Francis Road and the SR 9 bridge, the model more closely matches the observed HMWs with values ranging from -0.2 to -0.5 feet compared to the observed HWMs.

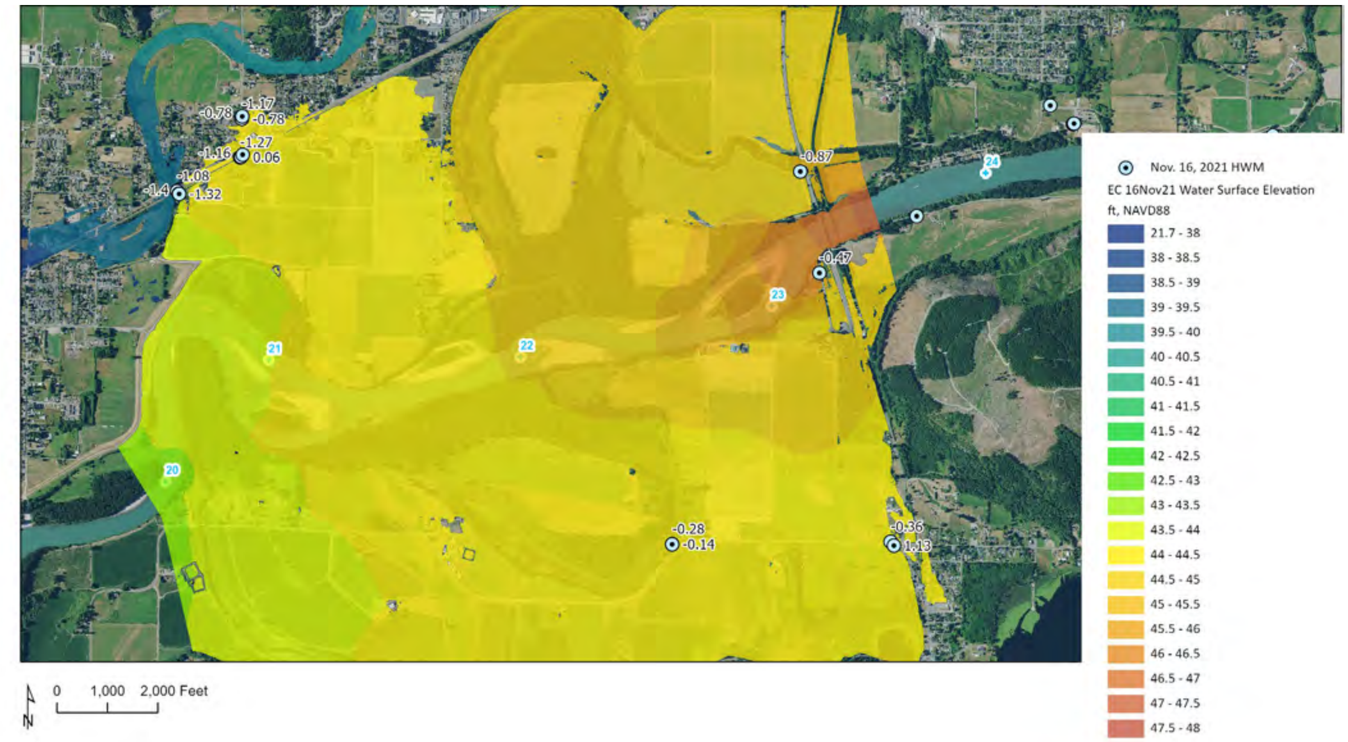

Figure A-6. November 16, 2021, Flood Event and Observed High Water Marks (HWM). Numeric values at each of the HWMs locations is the difference between the computed and observed WSE.

This calibration process resulted in two model set-ups that were suitable for representing both lower flows where flow is largely contained to within the Skagit River and DeBay Slough, and larger flood events where flooding occurs through the floodplain area between the Skagit River and Nookachamps Creek, including DeBay Slough, Francis Road, and adjacent farmland and residences.

Appendix A-2

Existing Conditions Hydraulic Model Output Maps

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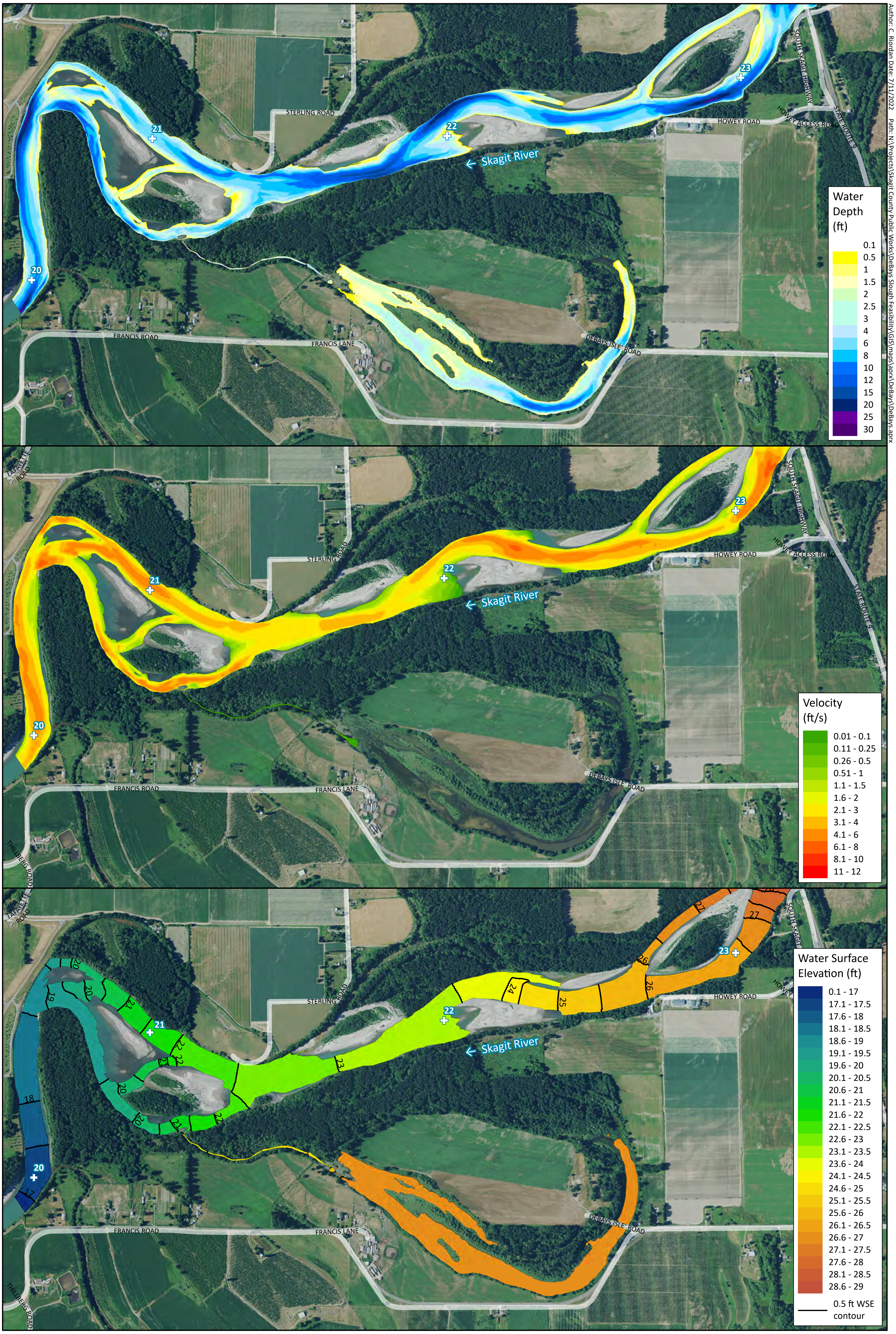

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Debay Slough Feasibility Study

Existing Conditions Hydraulics - USGS at Mount Vernon Stage: 11.5 ft (8,000 cfs)

Projection: NAD 1983 State Plane (WA North Zone). Topographic data source: 2017 LIDAR DEM and 2022 topographic survey by Natural Systems Design. Hydraulic modeling performed using HEC-RAS 2D. Approximate gage stage at Mount Vernon USGS gage (USGS 12200500) based upon daily flow records

0 1,000 2,000 Feet

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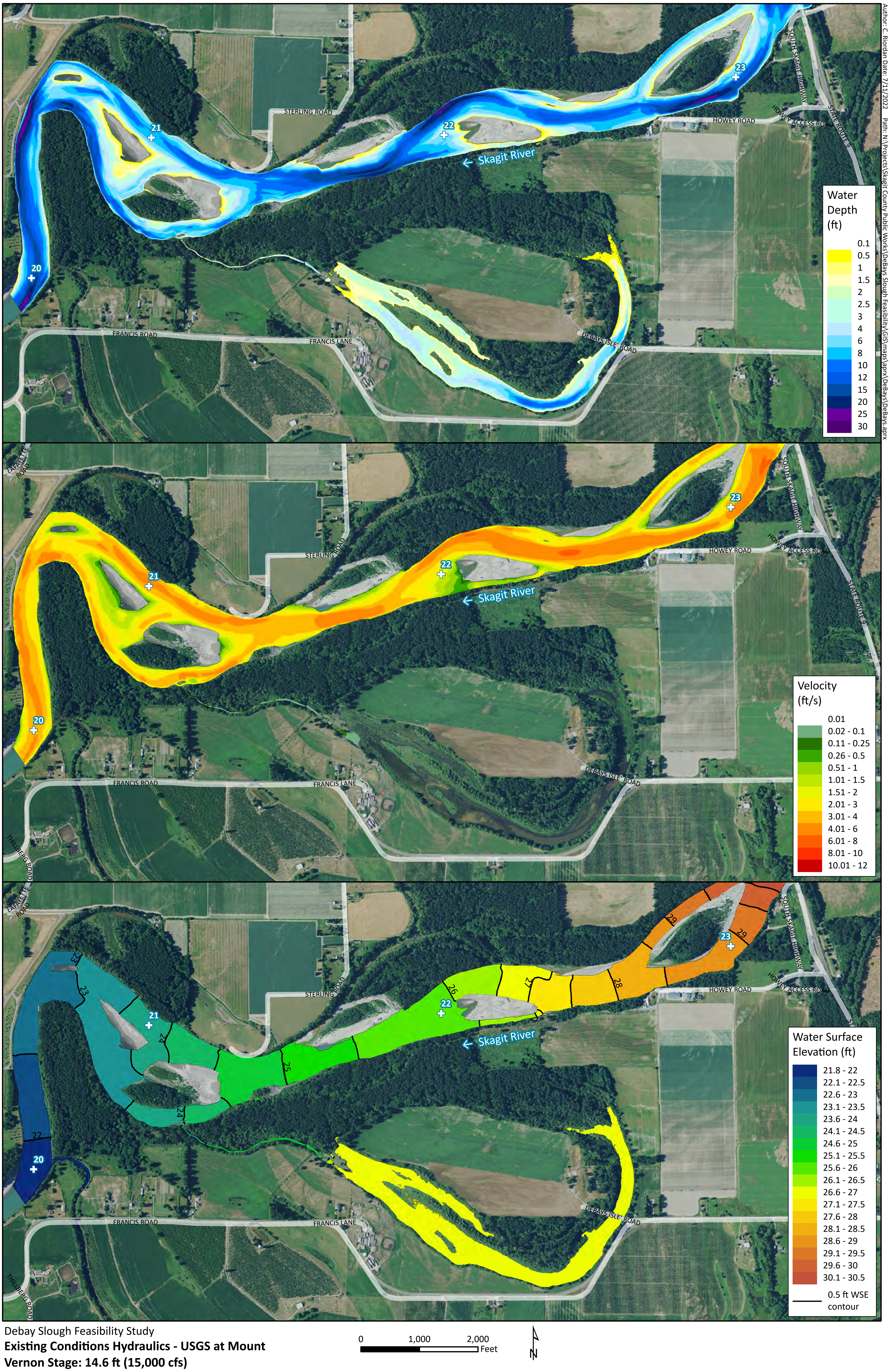

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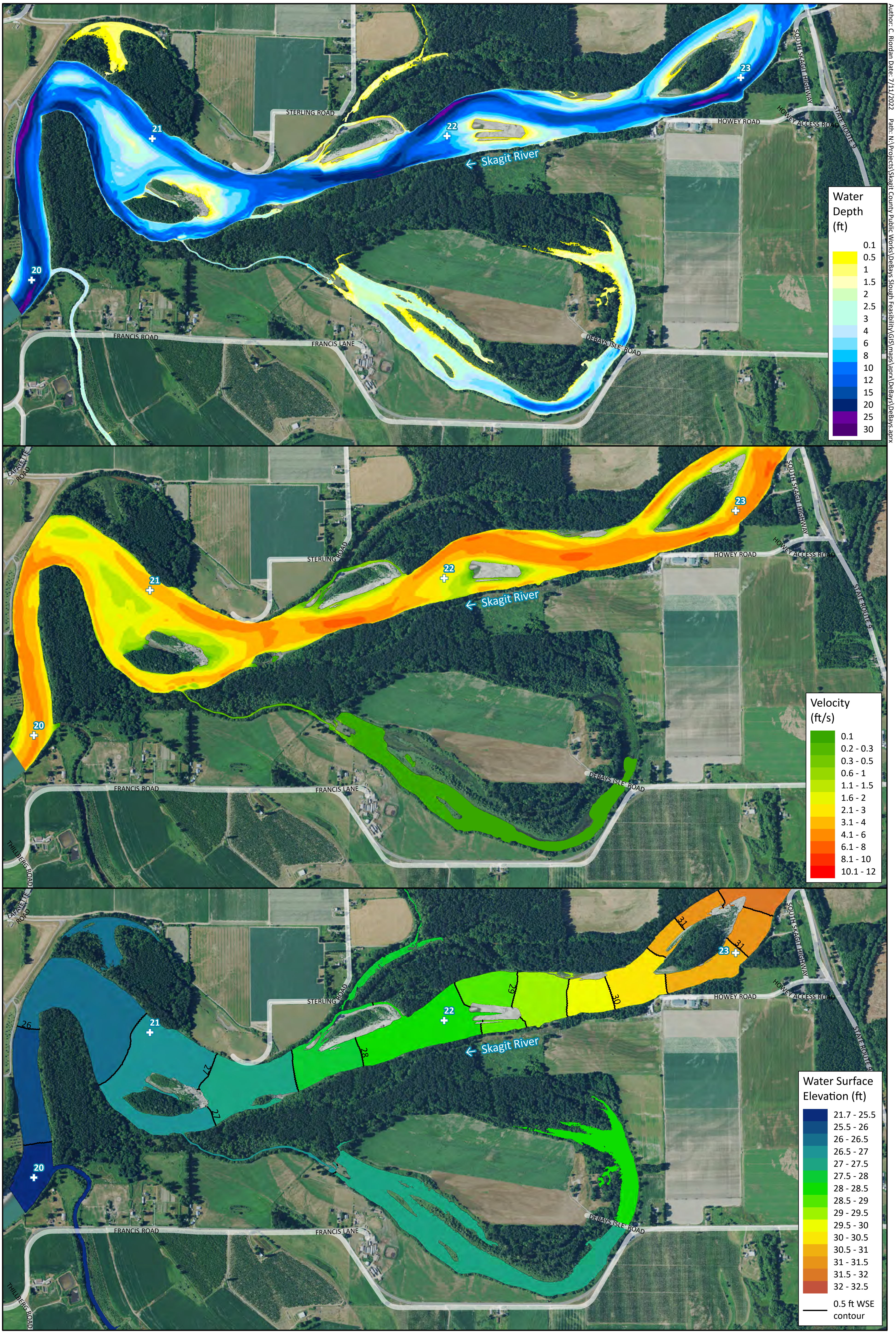
Debay Slough Feasibility Study

Existing Conditions Hydraulics - USGS at Mount Vernon Stage: 14.6 ft (15,000 cfs)

Projection: NAD 1983 State Plane (WA North Zone). Topographic data source: 2017 LIDAR DEM and 2022 topographic survey by Natural Systems Design. Hydraulic modeling performed using HEC-RAS 2D. Approximate gage stage at Mount Vernon USGS gage (USGS 12200500) based upon daily flow records

Natural Systems Design



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Debay Slough Feasibility Study

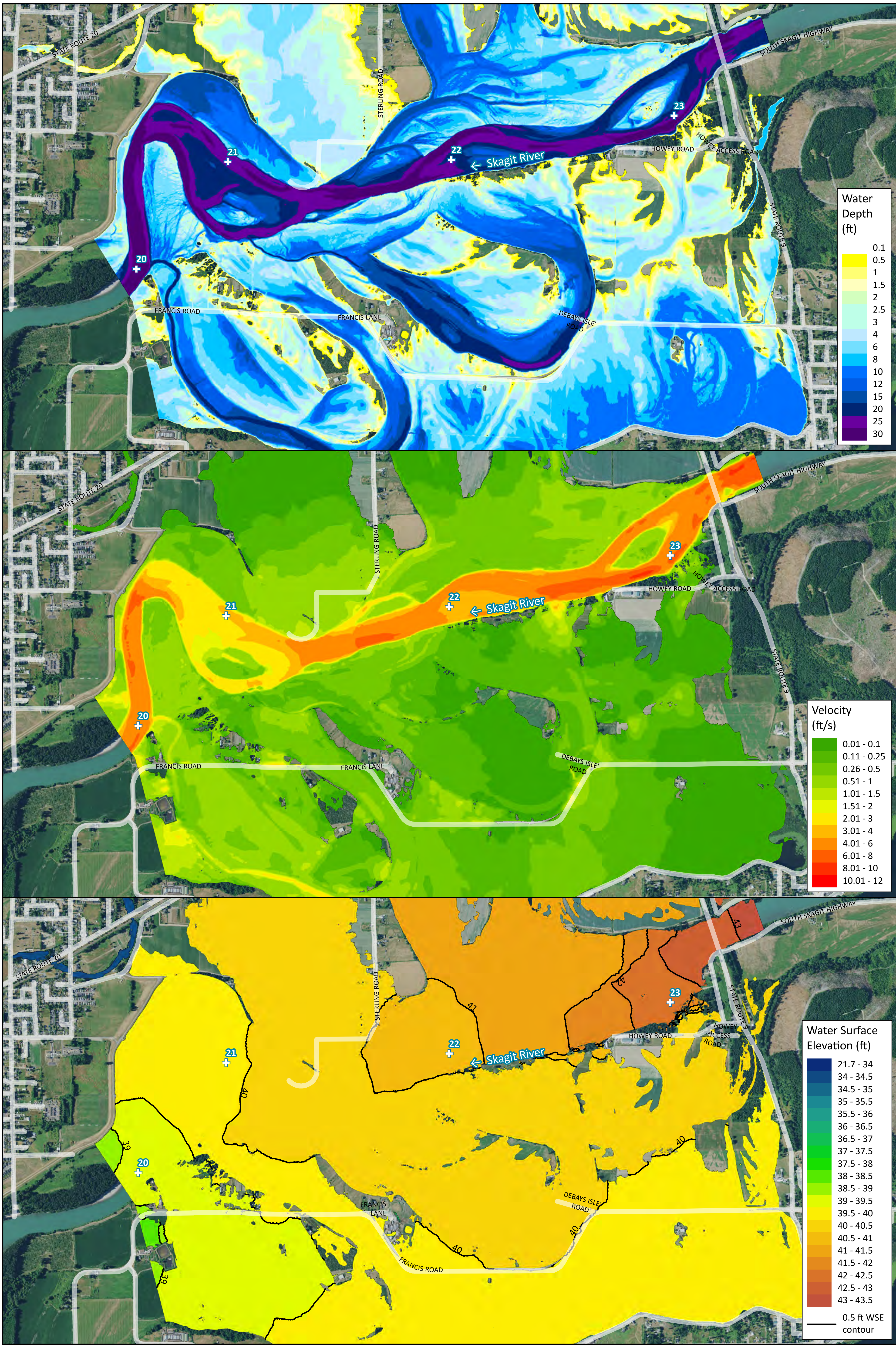
Existing Conditions Hydraulics - USGS at Mount Vernon Stage: 17.1 ft (22,000 cfs)

Projection: NAD 1983 State Plane (WA North Zone). Topographic data source: 2017 LIDAR DEM and 2022 topographic survey by Natural Systems Design. Hydraulic modeling performed using HEC-RAS 2D. Approximate gage stage at Mount Vernon USGS gage (USGS 12200500) based upon daily flow records

0 1,000 2,000 Feet

N

Natural Systems Design

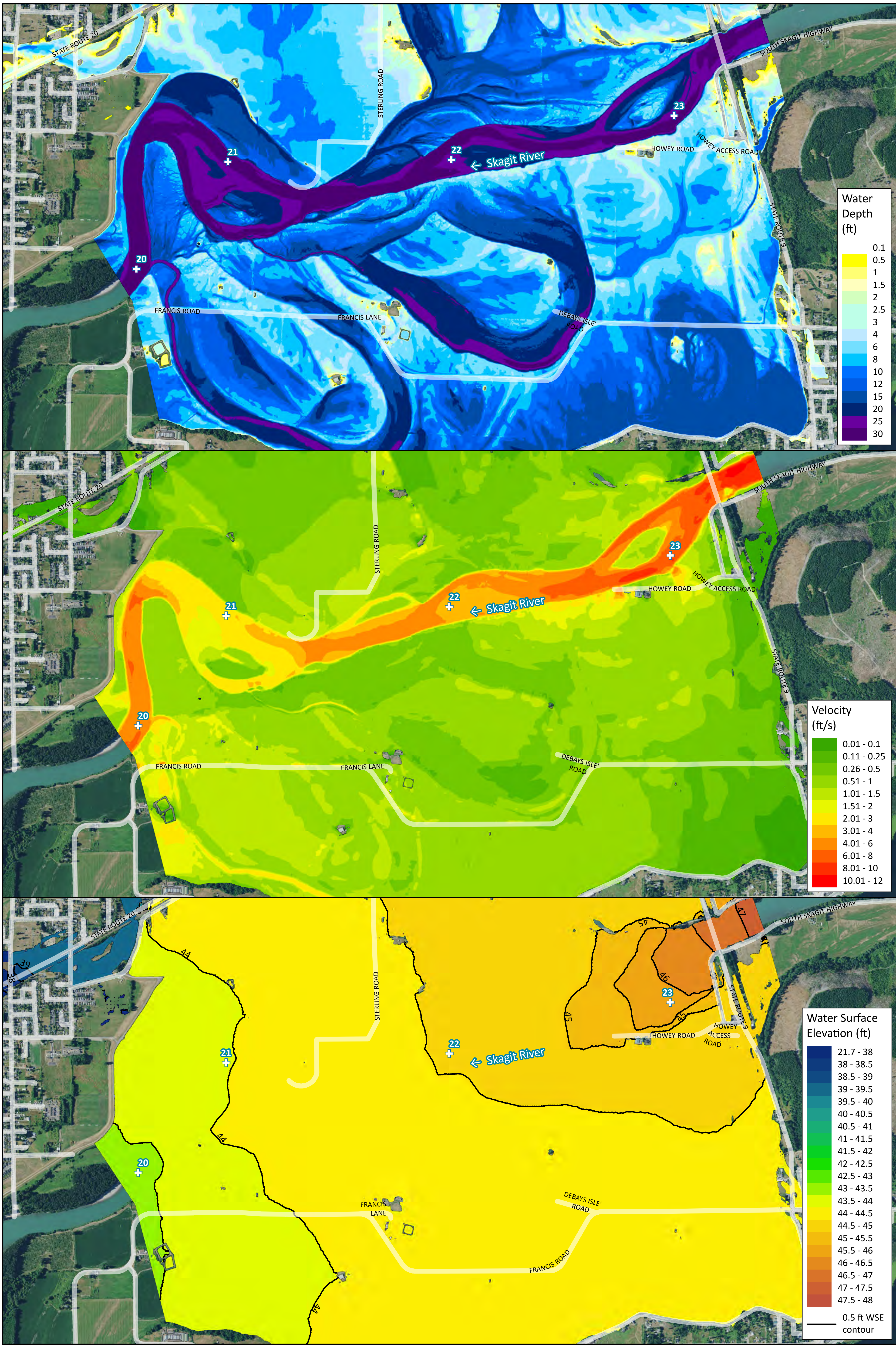


Debay Slough Feasibility Study

Existing Conditions Hydraulics - USGS at Mount Vernon Stage: 30 ft (82,000 cfs)

Projection: NAD 1983 State Plane (WA North Zone). Topographic data source: 2017 LIDAR DEM and 2022 topographic survey by Natural Systems Design. Hydraulic modeling performed using HEC-RAS 2D. Approximate gage stage at Mount Vernon USGS gage (USGS 12200500) based upon daily flow records

Natural Systems Design



Debay Slough Feasibility Study

Existing Conditions Hydraulics - USGS at Mount Vernon Stage: 37 ft (133,000 cfs) 11/16/21 Event

0 1,000 2,000 Feet

N

Projection: NAD 1983 State Plane (WA North Zone). Topographic data source: 2017 LIDAR DEM and 2022 topographic survey by Natural Systems Design. Hydraulic modeling performed using HEC-RAS 2D. Approximate gage stage at Mount Vernon USGS gage (USGS 12200500) based upon daily flow records

Natural Systems Design

Appendix B

U.S. Army Corps of Engineers Wetland Determination Data Forms

Natural Systems Design

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WETLAND DETERMINATION DATA FORM – Western Mountains, Valleys and Coast Region

Project/Site: DeBay Slough Site Assessment City/County: Skagit Sampling Date: 6/8/2022
Applicant/Owner: Skagit County Public Works/Washington Department of Fish and Wildlife State: WA Sampling Point: SP#1
Investigator(s): T. Luiting, B. Keller Section, Township, Range: S02, T34N, R04E
Landform (hillslope, terrace, etc.): Riverine Floodplain Local relief (concave, convex, none): concave Slope (%): 0
Subregion (LRR): Northwest Forests and Coast (LRR A) Lat: 48.470748 Long: -122.257262 Datum: NAD83
Soil Map Unit Name: Sumas Silt Loam NWI Classification: None
Are climatic / hydrologic conditions on the site typical for this time of year? Yes X No ___ (If no, explain in Remarks)
Are Vegetation No , Soil No , or Hydrology No significantly disturbed? Are "Normal Circumstances" Present? Yes X No ___
Are Vegetation No , Soil No , or Hydrology No naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X No ___	**Is the Sampled Area within a Wetland?**	**Yes** ___ **No** X
Hydric Soil Present?	Yes ___ No X		
Wetland Hydrology Present?	Yes ___ No X		

Sample point is located in a riparian forest east of Swan Reserve agricultural field.

VEGETATION

	Absolute % Cover	Dominant Species?	Indicator Status?
Tree Stratum (Plot size: 30' radius)			
1. *Alnus rubra*	10	Yes	FAC
2.			
3.			
4.			
5 = 50% tree cover Total Cover:	10		
2 = 20% tree cover			
Shrub Stratum (Plot size: 10' radius)			
1. *Rosa nutkana*	25	Yes	FAC
2. *Rubus armeniacus*	10	Yes	FAC
3. *Cornus alba*	10	Yes	FACW
4.			
5.			
22.5 = 50% shrub cover Total Cover:	45		
Herb Stratum (5' rad plot) *9 = 20% shrub cover*			
1. *Schedonorus arundinaceus*	80	Yes	FAC
2. *Ranunculus repens*	10	No	FAC
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
45 = 50% herb cover **Total Cover:**	90		
18 = 20% herb cover			
Woody Vine Stratum			
1. *None*			
Total Cover:	0		

% Bare Ground in Herb Stratum 10 % Cover of Biotic Crust 0

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC:	**5**	(A)
Total Number of Dominant Species Across All Strata:	**5**	(B)
Percent of Dominant Species That Are OBL, FACW, or FAC:	**100%**	(A/B)

Prevalence Index Worksheet:

Total % Cover of:		Multiply by:
OBL species		x1 =
FACW species		x2 =
FAC species		x3 =
FACU species		x4 =
UPL species		x5 =
Column Totals:	(A)	(B)

Prevalence Index = B/A = ___

Hydrophytic Vegetation Indicators:

- ___ 1 - Rapid Test for Hydrophytic Vegetation
- **X** 2 - Dominance Test is >50%
- ___ 3 - Prevalence Index is ≤3.0[1]
- ___ 4 - Morphological Adaptation[1] (Provide supporting data in Remarks or on a separate sheet)
- ___ 5 - Wetland Non-Vascular Plants[1]
- ___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? **Yes** X **No** ___

SOIL

Sampling Point: SP#1

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth	Matrix		Redox Features					
(inches)	Color (moist)	%	Color (moist)	%	Type[1]	Loc[2]	Texture	Remarks
0-14	10Y 3/1	100					FSL	Fine Sandy Loam
14-16+	10YR 3/1	100					CS	Coarse Sand

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

___ Histosol (A1)
___ Histic Epipedon (A2)
___ Black Histic (A3)
___ Hydrogen Sulfide (A4)
___ Depleted Below Dark Surface (A11)
___ Thick Dark Surface (A12)
___ Sandy Muck Mineral (S1)
___ Sandy gleyed Matrix (S4)
___ Sandy Redox (S5)
___ Stripped Matrix (S6)
___ Loamy Mucky Mineral (F1) (**except MLRA 1**)
___ Loamy Gleyed Matrix (F2)
___ Depleted Matrix (F3)
___ Redox Dark Surface (F6)
___ Depleted Dark Surface (F7)
___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

___ 2 cm Muck (A10)
___ Red Parent Material (TF2)
___ Other (Explain in Remarks)
___ Very Shallow Dark Surface (TF12)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if present):

Type: None
Depth (inches): N/A

Hydric Soil Present? **Yes** ___ **No** X

Remarks: no redox present; no soil moisture present

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (any one indicator is sufficient)

___ Surface Water (A1)
___ High Water Table (A2)
___ Saturation (A3)
___ Water Marks (B1)
___ Sediment Deposits (B2)
___ Drift Deposits (B3)
___ Algal Mat or Crust (B4)
___ Iron Deposits (B5)
___ Surface Soil Cracks (B6)
___ Inundation Visible on Aerial Imagery (B7)
___ Sparsely Vegetated Concave Surface (B8)
___ Water-Stained Leaves (B9) (**except MLRA 1, 2, 4A and 4B**)
___ Salt Crust (B11)
___ Aquatic Invertebrates (B13)
___ Hydrogen Sulfide Odor (C1)
___ Oxidized Rhizospheres along Living Roots (C3)
___ Presence of Reduced Iron (C4)
___ Recent Iron Reduction in Plowed Soils (C6)
___ Stunted or Stressed Plants (D1) (**LRR A**)
___ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

___ Water-Stained Leaves (B9) (**MLRA 1, 2, 4A and 4B**)
___ Drainage Patterns (B10)
___ Dry-Season Water Table (C2)
___ Saturation Visible on Aerial Imagery (C9)
___ Geomorphic Position (D2)
___ Shallow Aquitard (D3)
___ FAC-Neutral Test (D5)
___ Raised Ant Mounds (D6) (**LRR A**)
___ Frost-Heave Hummocks (D7)

Field Observations:

Surface Water Present?	Yes ___	No	X	Depth (inches):	None
Water table Present?	Yes ___	No	X	Depth (inches):	None
Saturation Present? (includes capillary fringe)	Yes ___	No	X	Depth (inches):	None

Wetland Hydrology Present? **Yes** ___ **No** X

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks: No saturation, no free standing water, no flow paths or debris or other indicators.

WETLAND DETERMINATION DATA FORM – Western Mountains, Valleys and Coast Region

Project/Site: DeBay Slough Site Assessment City/County: Skagit Sampling Date: 6/8/2022
Applicant/Owner: Skagit County Public Works/Washington Department of Fish and Wildlife State: WA Sampling Point: SP#2
Investigator(s): T. Luiting, B. Keller Section, Township, Range: S02, T34N, R04E
Landform (hillslope, terrace, etc.): Riverine Floodplain Local relief (concave, convex, none): concave Slope (%): 0
Subregion (LRR): Northwest Forests and Coast (LRR A) Lat: 48.468087 Long: -122.256675 Datum: NAD83
Soil Map Unit Name: Sumas Silt Loam NWI Classification: Freshwater Emergent Wetland
Are climatic / hydrologic conditions on the site typical for this time of year? Yes X No ____ (If no, explain in Remarks)
Are Vegetation No , Soil No , or Hydrology No significantly disturbed? Are "Normal Circumstances" Present? Yes X No ____
Are Vegetation No , Soil No , or Hydrology No naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X No ____	**Is the Sampled Area within a Wetland?**	**Yes X No ____**
Hydric Soil Present?	Yes X No ____		
Wetland Hydrology Present?	Yes X No ____		

Sample point is located SW of wildlife point count 1 in riparian forest. West of the culvert and north of DeBay Slough.

VEGETATION

Tree Stratum (Plot size: 30' radius)	Absolute % Cover	Dominant Species?	Indicator Status?
1. *Alnus rubra*	10	Yes	FAC
2. *Populus balsamifera*	10	Yes	FAC
3.			
4.			
10 = 50% tree cover Total Cover:	20		
4 = 20% tree cover			
Shrub Stratum (Plot size: 10' radius)			
1. *Cornus alba*	70	Yes	FACW
2. *Rosa nutkana*	10	No	FAC
3.			
4.			
5.			
40 = 50% shrub cover Total Cover:	80		
Herb Stratum (5' rad plot) *16 = 20% shrub cover*			
1. *Moss*	20	N/A	N/A
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
10 = 50% herb cover **Total Cover:**	20		
4 = 20% herb cover			
Woody Vine Stratum			
1. *None*			
Total Cover:	0		
% Bare Ground in Herb Stratum 80	% Cover of Biotic Crust 0		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC:	**3**	(A)
Total Number of Dominant Species Across All Strata:	**3**	(B)
Percent of Dominant Species That Are OBL, FACW, or FAC:	**100%**	(A/B)

Prevalence Index Worksheet:

Total % Cover of:		Multiply by:
OBL species		x1 =
FACW species		x2 =
FAC species		x3 =
FACU species		x4 =
UPL species		x5 =
Column Totals:	(A)	(B)

Prevalence Index = B/A =

Hydrophytic Vegetation Indicators:

- ____ 1 - Rapid Test for Hydrophytic Vegetation
- **X** 2 - Dominance Test is >50%
- ____ 3 - Prevalence Index is ≤3.0[1]
- ____ 4 - Morphological Adaptation[1] (Provide supporting data in Remarks or on a separate sheet)
- ____ 5 - Wetland Non-Vascular Plants[1]
- ____ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? **Yes** X **No** ____

Moss 20% cover and 80% bare ground.

SOIL

Sampling Point: SP#2

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-16	10YR 4/2	98	7.5YR 4/6	2	CS	M	LFS	Loamy Fine Sand

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

___ Histosol (A1)
___ Histic Epipedon (A2)
___ Black Histic (A3)
___ Hydrogen Sulfide (A4)
___ Depleted Below Dark Surface (A11)
___ Thick Dark Surface (A12)
___ Sandy Muck Mineral (S1)
___ Sandy gleyed Matrix (S4)
___ Sandy Redox (S5)
___ Stripped Matrix (S6)
___ Loamy Mucky Mineral (F1) (**except MLRA 1**)
___ Loamy Gleyed Matrix (F2)
___ Depleted Matrix (F3)
X Redox Dark Surface (F6)
___ Depleted Dark Surface (F7)
___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

___ 2 cm Muck (A10)
___ Red Parent Material (TF2)
___ Other (Explain in Remarks)
___ Very Shallow Dark Surface (TF12)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if present):

Type: None
Depth (inches): N/A

Hydric Soil Present? **Yes** X **No** ___

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (any one indicator is sufficient)

___ Surface Water (A1)
___ High Water Table (A2)
___ Saturation (A3)
___ Water Marks (B1)
x Sediment Deposits (B2)
___ Drift Deposits (B3)
___ Algal Mat or Crust (B4)
___ Iron Deposits (B5)
___ Surface Soil Cracks (B6)
___ Inundation Visible on Aerial Imagery (B7)
___ Sparsely Vegetated Concave Surface (B8)
x Water-Stained Leaves (B9) (**except MLRA 1, 2, 4A and 4B**)
___ Salt Crust (B11)
___ Aquatic Invertebrates (B13)
___ Hydrogen Sulfide Odor (C1)
___ Oxidized Rhizospheres along Living Roots (C3)
___ Presence of Reduced Iron (C4)
___ Recent Iron Reduction in Plowed Soils (C6)
___ Stunted or Stressed Plants (D1) (**LRR A**)
___ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

___ Water-Stained Leaves (B9) (**MLRA 1, 2, 4A and 4B**)
___ Drainage Patterns (B10)
x Dry-Season Water Table (C2)
___ Saturation Visible on Aerial Imagery (C9)
X Geomorphic Position (D2)
___ Shallow Aquitard (D3)
X FAC-Neutral Test (D5)
___ Raised Ant Mounds (D6) (**LRR A**)
___ Frost-Heave Hummocks (D7)

Field Observations:

Surface Water Present?	Yes ___	No X	Depth (inches):	None
Water table Present?	Yes X	No ___	Depth (inches):	16"
Saturation Present? (includes capillary fringe)	Yes X	No ___	Depth (inches):	16"

Wetland Hydrology Present? **Yes** X **No** ___

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks: Evidence of ponding in sediment deposits and water stained leaves; nearly saturated at 16"; soils cool and moist with depth

WETLAND DETERMINATION DATA FORM – Western Mountains, Valleys and Coast Region

Project/Site: DeBay Slough Site Assessment City/County: Skagit Sampling Date: 6/8/2022
Applicant/Owner: Skagit County Public Works/Washington Department of Fish and Wildlife State: WA Sampling Point: SP#3
Investigator(s): T. Luiting, B. Keller Section, Township, Range: S02, T34N, R04E
Landform (hillslope, terrace, etc.): Riverine Floodplain Local relief (concave, convex, none): concave Slope (%): 0
Subregion (LRR): Northwest Forests and Coast (LRR A) Lat: 48.468741 Long: -122.256139 Datum: NAD83
Soil Map Unit Name: Sumas Silt Loam NWI Classification: Freshwater Emergent Wetland
Are climatic / hydrologic conditions on the site typical for this time of year? Yes X No ___ (If no, explain in Remarks)
Are Vegetation No, Soil No, or Hydrology No significantly disturbed? Are "Normal Circumstances" Present? Yes X No ___
Are Vegetation No, Soil No, or Hydrology No naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X No ___	**Is the Sampled Area within a Wetland?**	**Yes** X **No** ___
Hydric Soil Present?	Yes ___ No X		
Wetland Hydrology Present?	Yes ___ No X		

Sample point # 3 is located in the floodplain forest east of the culvert and north of DeBay Slough.

VEGETATION

Tree Stratum (Plot size: 30' radius)	Absolute % Cover	Dominant Species?	Indicator Status?
1. *Populus balsamifera*	20	Yes	FAC
2. *Alnus rubra*	10	Yes	FAC
3.			
4.			
15 = 50% tree cover Total Cover:	30		
6 = 20% tree cover			
Shrub Stratum (Plot size: 10' radius)			
1. *Rubus spectabilis*	25	Yes	FAC
2. *Symphoricarpos albus*	10	No	FACU
3. *Cornus alba*	10	No	FACW
4. *Lonicera involucrata*	10	No	FAC
5.			
27.5 = 50% shrub cover Total Cover:	55		
Herb Stratum (5' rad plot) *11 = 20% shrub cover*			
1. *Carex obnupta*	25	Yes	OBL
2. *Moss*	25	N/A	N/A
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
25 = 50% herb cover **Total Cover:**	50		
10 = 20% herb cover			
Woody Vine Stratum			
1. *None*			
Total Cover:	0		
% Bare Ground in Herb Stratum 50 % Cover of Biotic Crust 0			

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC:	**4**	(A)
Total Number of Dominant Species Across All Strata:	**4**	(B)
Percent of Dominant Species That Are OBL, FACW, or FAC:	**100%**	(A/B)

Prevalence Index Worksheet:

Total % Cover of:		Multiply by:
OBL species		x1 =
FACW species		x2 =
FAC species		x3 =
FACU species		x4 =
UPL species		x5 =
Column Totals:	(A)	(B)

Prevalence Index = B/A = ___

Hydrophytic Vegetation Indicators:

- ___ 1 - Rapid Test for Hydrophytic Vegetation
- X 2 - Dominance Test is >50%
- ___ 3 - Prevalence Index is ≤3.0[1]
- ___ 4 - Morphological Adaptation[1] (Provide supporting data in Remarks or on a separate sheet)
- ___ 5 - Wetland Non-Vascular Plants[1]
- ___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? **Yes** X **No** ___

Moss covers 25% of the stratum leaving 50% bare ground.

SOIL

Sampling Point: SP#3

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox Features %	Type[1]	Loc[2]	Texture	Remarks
0-16	10YR 4/2	98	7.5YR 5/6	2	C	M	FSL	Fine Sandy Loam

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Muck Mineral (S1)
- ___ Sandy gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Loamy Mucky Mineral (F1) (**except MLRA 1**)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- X Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

- ___ 2 cm Muck (A10)
- ___ Red Parent Material (TF2)
- ___ Other (Explain in Remarks)
- ___ Very Shallow Dark Surface (TF12)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if present):

Type: None

Depth (inches): N/A

Hydric Soil Present? **Yes** X **No** ___

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (any one indicator is sufficient)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ___ Saturation (A3)
- ___ Water Marks (B1)
- x Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Surface Soil Cracks (B6)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Water-Stained Leaves (B9) (**except MLRA 1, 2, 4A and 4B**)
- ___ Salt Crust (B11)
- ___ Aquatic Invertebrates (B13)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Oxidized Rhizospheres along Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Plowed Soils (C6)
- ___ Stunted or Stressed Plants (D1) (**LRR A**)
- ___ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

- ___ Water-Stained Leaves (B9) (**MLRA 1, 2, 4A and 4B**)
- X Drainage Patterns (B10)
- ___ Dry-Season Water Table (C2)
- ___ Saturation Visible on Aerial Imagery (C9)
- X Geomorphic Position (D2)
- ___ Shallow Aquitard (D3)
- X FAC-Neutral Test (D5)
- ___ Raised Ant Mounds (D6) (**LRR A**)
- ___ Frost-Heave Hummocks (D7)

Field Observations:

	Yes	No	Depth (inches)
Surface Water Present?	___	X	None
Water table Present?	___	X	None
Saturation Present? (includes capillary fringe)	___	X	None

Wetland Hydrology Present? **Yes** X **No** ___

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks: No free water or saturation. Evidence of ponding.

WETLAND DETERMINATION DATA FORM – Western Mountains, Valleys and Coast Region

Project/Site: DeBay Slough Site Assessment | City/County: Skagit | Sampling Date: 6/8/2022

Applicant/Owner: Skagit County Public Works/Washington Department of Fish and Wildlife | State: WA | Sampling Point: SP#4

Investigator(s): T. Luiting, B. Keller | Section, Township, Range: S35 T35N, R04E

Landform (hillslope, terrace, etc.): Riverine Floodplain | Local relief (concave, convex, none): concave | Slope (%): 0

Subregion (LRR): Northwest Forests and Coast (LRR A) | Lat: 48.474389 | Long: -122.25719 | Datum: NAD83

Soil Map Unit Name: Sedrowoolley silt loam | NWI Classification: None

Are climatic / hydrologic conditions on the site typical for this time of year? Yes X No ___ (If no, explain in Remarks)

Are Vegetation No , Soil No , or Hydrology No significantly disturbed? Are "Normal Circumstances" Present? Yes X No ___

Are Vegetation No , Soil No , or Hydrology No naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X	No ___
Hydric Soil Present?	Yes X	No ___
Wetland Hydrology Present?	Yes X	No ___

Is the Sampled Area within a Wetland? **Yes** X **No** ___

Sample point is located in a depressional wetland at the NE portion of the site.

VEGETATION

	Absolute % Cover	Dominant Species?	Indicator Status?
Tree Stratum (Plot size: 30' radius)			
1. *Alnus rubra*	10	Yes	FAC
2. *Salix lasiandra*	10	Yes	FACW
3. *Populus balsamifera*	10	Yes	FAC
4.			
15 = 50% tree cover / *6 = 20% tree cover* — Total Cover:	30		
Shrub Stratum (Plot size: 10' radius)			
1. *Rubus armeniacus*	10	Yes	FAC
2.			
3.			
4.			
5.			
5 = 50% shrub cover / *2 = 20% shrub cover* — Total Cover:	10		
Herb Stratum (5' rad plot)			
1. *Phalaris arundinacea*	20	Yes	FACW
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
10 = 50% herb cover / *4 = 20% herb cover* — **Total Cover:**	20		
Woody Vine Stratum			
1. *None*			
Total Cover:	0		

% Bare Ground in Herb Stratum 80 % Cover of Biotic Crust 0

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC:	**5**	(A)
Total Number of Dominant Species Across All Strata:	**5**	(B)
Percent of Dominant Species That Are OBL, FACW, or FAC:	**100%**	(A/B)

Prevalence Index Worksheet:

Total % Cover of:		Multiply by:
OBL species		x1 =
FACW species		x2 =
FAC species		x3 =
FACU species		x4 =
UPL species		x5 =
Column Totals:	(A)	(B)

Prevalence Index = B/A =

Hydrophytic Vegetation Indicators:

	1 - Rapid Test for Hydrophytic Vegetation
X	2 - Dominance Test is >50%
	3 - Prevalence Index is ≤3.0[1]
	4 - Morphological Adaptation[1] (Provide supporting data in Remarks or on a separate sheet)
	5 - Wetland Non-Vascular Plants[1]
	Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? **Yes** X **No** ___

Slough sedge (Carex obnupta) present outside the sample plot throughout the center of the wetland

SOIL

Sampling Point: SP#4

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-6	10YR 3/1	100					SiL	Silty Loam
6-16+	10YR 5/1	50	10YR 4/6	20	C	M	FS Loam	Fine Sandy Loam
	10YR 4/2	30						mixed matrix

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

___ Histosol (A1)
___ Histic Epipedon (A2)
___ Black Histic (A3)
___ Hydrogen Sulfide (A4)
___ Depleted Below Dark Surface (A11)
___ Thick Dark Surface (A12)
___ Sandy Muck Mineral (S1)
___ Sandy gleyed Matrix (S4)
___ Sandy Redox (S5)
___ Stripped Matrix (S6)
___ Loamy Mucky Mineral (F1) (**except MLRA 1**)
___ Loamy Gleyed Matrix (F2)
___ Depleted Matrix (F3)
X Redox Dark Surface (F6)
___ Depleted Dark Surface (F7)
___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

___ 2 cm Muck (A10)
___ Red Parent Material (TF2)
___ Other (Explain in Remarks)
___ Very Shallow Dark Surface (TF12)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if present):

Type: None
Depth (inches): N/A

Hydric Soil Present? **Yes** X **No** ___

Remarks: soil profile cool and moist with depth

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (any one indicator is sufficient)

___ Surface Water (A1)
___ High Water Table (A2)
___ Saturation (A3)
___ Water Marks (B1)
X Sediment Deposits (B2)
___ Drift Deposits (B3)
___ Algal Mat or Crust (B4)
___ Iron Deposits (B5)
___ Surface Soil Cracks (B6)
___ Inundation Visible on Aerial Imagery (B7)
___ Sparsely Vegetated Concave Surface (B8)
___ Water-Stained Leaves (B9) (**except MLRA 1, 2, 4A and 4B**)
___ Salt Crust (B11)
___ Aquatic Invertebrates (B13)
___ Hydrogen Sulfide Odor (C1)
___ Oxidized Rhizospheres along Living Roots (C3)
___ Presence of Reduced Iron (C4)
___ Recent Iron Reduction in Plowed Soils (C6)
___ Stunted or Stressed Plants (D1) (**LRR A**)
___ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

___ Water-Stained Leaves (B9) (**MLRA 1, 2, 4A and 4B**)
X Drainage Patterns (B10)
___ Dry-Season Water Table (C2)
___ Saturation Visible on Aerial Imagery (C9)
X Geomorphic Position (D2)
___ Shallow Aquitard (D3)
X FAC-Neutral Test (D5)
___ Raised Ant Mounds (D6) (**LRR A**)
___ Frost-Heave Hummocks (D7)

Field Observations:

Surface Water Present?	Yes ___	No	X	Depth (inches):	None
Water table Present?	Yes ___	No	X	Depth (inches):	None
Saturation Present? (includes capillary fringe)	Yes ___	No	X	Depth (inches):	None

Wetland Hydrology Present? **Yes** X **No** ___

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks: No saturation, evidence of surface ponding but no free water or ponding at time of investigation.

WETLAND DETERMINATION DATA FORM – Western Mountains, Valleys and Coast Region

Project/Site: DeBay Slough Site Assessment City/County: Skagit Sampling Date: 6/8/2022
Applicant/Owner: Skagit County Public Works/Washington Department of Fish and Wildlife State: WA Sampling Point: SP#5
Investigator(s): T. Luiting, B. Keller Section, Township, Range: S35 T35N, R04E
Landform (hillslope, terrace, etc.): Riverine Floodplain Local relief (concave, convex, none): concave Slope (%): 0
Subregion (LRR): Northwest Forests and Coast (LRR A) Lat: 48.474531 Long: -122.257555 Datum: NAD83
Soil Map Unit Name: Sedrowoolley silt loam NWI Classification: None
Are climatic / hydrologic conditions on the site typical for this time of year? Yes X No ____ (If no, explain in Remarks)
Are Vegetation No , Soil No , or Hydrology No significantly disturbed? Are "Normal Circumstances" Present? Yes X No ____
Are Vegetation No , Soil No , or Hydrology No naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present? Yes X No ____	**Is the Sampled Area within a Wetland?**	**Yes** ____ **No** X
Hydric Soil Present? Yes ____ No X		
Wetland Hydrology Present? Yes ____ No X		

Sample point is located in a young alder, black berry forest in the northeast corner of the site.

VEGETATION

	Absolute % Cover	Dominant Species?	Indicator Status?
Tree Stratum (Plot size: 30' radius)			
1. *Alnus rubra*	90	Yes	FAC
2.			
3.			
4.			
45 = 50% tree cover Total Cover:	90		
18 = 20% tree cover			
Shrub Stratum (Plot size: 10' radius)			
1. *Rubus armeniacus*	90	Yes	FAC
2.			
3.			
4.			
5.			
45 = 50% shrub cover Total Cover:	90		
Herb Stratum (5' rad plot) *18 = 20% shrub cover*			
1. *Phalaris arundinacea*	10	Yes	FACW
2. *Equisetum arvense*	5	Yes	FAC
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
7.5 = 50% herb cover **Total Cover:**	15		
3 = 20% herb cover			
Woody Vine Stratum			
1. *None*			
Total Cover:	0		
% Bare Ground in Herb Stratum 85 % Cover of Biotic Crust 0			

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: **4** (A)

Total Number of Dominant Species Across All Strata: **4** (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: **100%** (A/B)

Prevalence Index Worksheet:

Total % Cover of:		Multiply by:
OBL species		x1 =
FACW species		x2 =
FAC species		x3 =
FACU species		x4 =
UPL species		x5 =
Column Totals:	(A)	(B)

Prevalence Index = B/A = ____

Hydrophytic Vegetation Indicators:

- ____ 1 - Rapid Test for Hydrophytic Vegetation
- **X** 2 - Dominance Test is >50%
- ____ 3 - Prevalence Index is ≤3.0[1]
- ____ 4 - Morphological Adaptation[1] (Provide supporting data in Remarks or on a separate sheet)
- ____ 5 - Wetland Non-Vascular Plants[1]
- ____ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? **Yes** X **No** ____

SOIL

Sampling Point: SP#5

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth	Matrix		Redox Features					
(inches)	Color (moist)	%	Color (moist)	%	Type[1]	Loc[2]	Texture	Remarks
0-16	10YR 4/2	100					FSL	Fine Sandy Loam

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

___ Histosol (A1)
___ Histic Epipedon (A2)
___ Black Histic (A3)
___ Hydrogen Sulfide (A4)
___ Depleted Below Dark Surface (A11)
___ Thick Dark Surface (A12)
___ Sandy Muck Mineral (S1)
___ Sandy gleyed Matrix (S4)
___ Sandy Redox (S5)
___ Stripped Matrix (S6)
___ Loamy Mucky Mineral (F1) (**except MLRA 1**)
___ Loamy Gleyed Matrix (F2)
___ Depleted Matrix (F3)
___ Redox Dark Surface (F6)
___ Depleted Dark Surface (F7)
___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

___ 2 cm Muck (A10)
___ Red Parent Material (TF2)
___ Other (Explain in Remarks)
___ Very Shallow Dark Surface (TF12)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if present):

Type: None
Depth (inches): N/A

Hydric Soil Present? **Yes** ___ **No** X

Remarks: no redox; dry soils

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (any one indicator is sufficient)

___ Surface Water (A1)
___ High Water Table (A2)
___ Saturation (A3)
___ Water Marks (B1)
___ Sediment Deposits (B2)
___ Drift Deposits (B3)
___ Algal Mat or Crust (B4)
___ Iron Deposits (B5)
___ Surface Soil Cracks (B6)
___ Inundation Visible on Aerial Imagery (B7)
___ Sparsely Vegetated Concave Surface (B8)
___ Water-Stained Leaves (B9) (**except MLRA 1, 2, 4A and 4B**)
___ Salt Crust (B11)
___ Aquatic Invertebrates (B13)
___ Hydrogen Sulfide Odor (C1)
___ Oxidized Rhizospheres along Living Roots (C3)
___ Presence of Reduced Iron (C4)
___ Recent Iron Reduction in Plowed Soils (C6)
___ Stunted or Stressed Plants (D1) (**LRR A**)
___ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

___ Water-Stained Leaves (B9) (**MLRA 1, 2, 4A and 4B**)
___ Drainage Patterns (B10)
___ Dry-Season Water Table (C2)
___ Saturation Visible on Aerial Imagery (C9)
___ Geomorphic Position (D2)
___ Shallow Aquitard (D3)
___ FAC-Neutral Test (D5)
___ Raised Ant Mounds (D6) (**LRR A**)
___ Frost-Heave Hummocks (D7)

Field Observations:

Surface Water Present?	Yes	___	No	X	Depth (inches):	None
Water table Present?	Yes	___	No	X	Depth (inches):	None
Saturation Present? (includes capillary fringe)	Yes	___	No	X	Depth (inches):	None

Wetland Hydrology Present? **Yes** ___ **No** X

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks: No saturation, no free standing water, no flow paths or debris or other indicators.