

Chapter I

Overview

Introduction

GENESIS OF THIS PROJECT

The Wiley Slough Restoration Project is a collaborative project between the Washington Department of Fish and Wildlife (WDFW), the Skagit Watershed Council, the Skagit River System Cooperative, Seattle City Light, the US Fish & Wildlife Service, and others. This project was proposed and funded for preliminary construction design by the Washington State Salmon Recovery Funding Board in early spring of 2003. The intent of this collaboration is to develop a detailed set of construction recommendations and actions that will restore historic tidal and riverine processes on a publicly owned parcel of land located on Fir Island, near the town of Conway, Washington (**Figure 1.0**). The goal of said restoration is to benefit the diversity of fish and wildlife species that rely on estuaries, including salmon and a wide variety of migratory birds.

The directive of this design project is to rehabilitate natural processes within the confines of publicly owned land located at the historic Wiley Slough distributary channel of the South Fork of the Skagit River delta. Project objectives include the need for self-sustaining estuarine habitat for the benefit of indigenous fish, wildlife and vegetation communities common to the Puget Sound fiord ecosystem. To this end, our design approach focuses on restoring important physical processes (tidal and riverine flooding). The project is designed in a way that protects interests of adjacent land owners, the agricultural community, and WDFW obligations while promoting wildlife oriented recreational activities consistent with the restoration objectives.

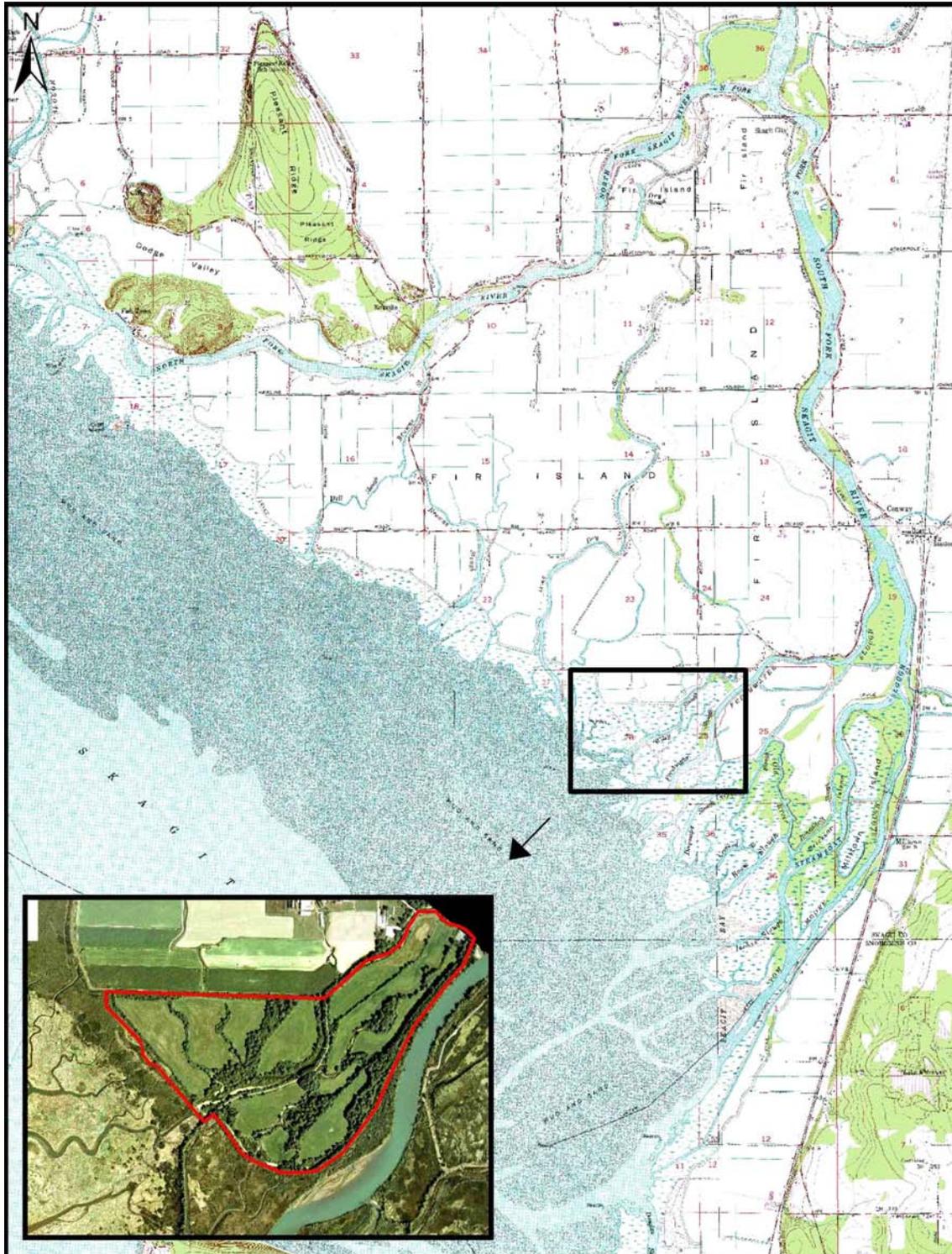


Figure 1.0 Wiley Slough Project Location

Project Background

OVERVIEW

Archival research demonstrates that estuarine habitat in Puget Sound has declined dramatically since Euro-American settlement (Bortleson et al. 1980, Collins and Montgomery 2001). In the Skagit delta approximately 60% of tidal emergent habitat has been lost and 94% of tidal scrub shrub habitat has been lost (Hood, unpublished data). These areas provide critical habitat for a wide variety of fish and wildlife, including shorebirds, ducks, geese, swans, raptors, river otters, beaver, harbor seals, and many fish, most notably juvenile salmonids. Of the salmonids, chinook are the most dependent on estuarine rearing habitat and Puget Sound Chinook are listed as threatened by the Endangered Species Act (64 Federal Register 14308, March 24 1999).

As recently as 1956 the levee system was expanded to isolate the Wiley Slough project area from the key processes of riverine and tidal flooding, thereby altering hydrology, sediment transport and storage, detritus accumulation, vegetative growth and use by aquatic species. This isolation occurred after transfer of the property from the US Fish and Wildlife Service to The State Department of Game (John Garrett, WDFW, Wildlife Area Manager, pers. comm). The loss of riverine and tidal flooding crucially affected the formation and maintenance of a variety of estuarine habitat conditions. For example, construction of the Wiley Slough levee has resulted in direct loss of about 16 acres of tidal channel habitat and approximately 160 acres of intertidal marsh habitat. However, there have been additional off-site impacts as a result of dike construction: 20 acres of intertidal channel habitat have been lost seaward of the dikes due to sediment deposition resulting from loss of tidal prism landward of the dikes (Hood 2004). Additionally, the lower reach of Freshwater Slough has lost sinuosity and associated channel habitat diversity, probably due to loss of floodplain area via dike construction, which caused greater confinement of flood flows within Freshwater Slough (Hood 2004). These off-site impacts from dike construction indicate that off-site areas will also likely respond to any habitat restoration efforts that include significant dike removal.

Historical data indicate the project area is located in a transition zone between forested riverine tidal and estuarine emergent habitats (Collins & Sheikh, 2002). However, vegetation has been significantly altered from historical conditions through conversion from tidal marsh to agriculture. Having been diked, drained and converted to agriculture, with cereal grains planted annually much of the natural forest, shrub, and herbaceous vegetation have been eliminated. Secondary forested areas exist along dikes and small berms adjacent to vestigial tidal channels.

All native anadromous fish and most native resident fish that likely historically used the project site are currently excluded, as are other estuarine organisms dependent on tidal channel habitat. Presently, the site is extensively managed for put-and-take pheasant hunting and waterfowl (e.g., cereal grain is produced and seasonally flooded to attract and feed wintering waterfowl), but is also used by extensively by passerines.

Off-site (seaward of the dikes) impacts to fish and wildlife have occurred as a result of the loss of 20 acres of tidal channel habitat in lower Wiley Slough and the loss of channel sinuosity and associated habitat diversity in lower Freshwater Slough. Fish and wildlife taxa likely to have been directly

affected by loss of off-site habitat include salmon, bull trout, cutthroat trout, sturgeon (in pool habitat), shorebirds (feeding on sandbars), waterfowl (in channel habitat on low tides), and harbor seals.

SITE HISTORY

An 1897 map from the US Engineers Office labels the present-day Wiley Slough as “Freshwater Slough-West Branch”. At this time the slough was connected to Freshwater Slough near the current location of the boat ramp. The slough also extended northward across Fir Island and connected with Dry Slough. An 1889 US Coast and Geodetic Survey map is very similar ([Figure 1.1](#)). Thus, in the late 19th Century, Wiley Slough was a distributary of the Skagit River with connections to both the North and South Forks of the Skagit river.

The project site was acquired by the Washington Game Department from the US Fish and Wildlife Service (USFWS) in 1959 as part of a land exchange. The USFWS traded for lands that are now the Columbia White-tailed Deer Refuge, while the Game Department acquired most of the intertidal marshes in the Skagit delta (John Garrett, WDFW, Wildlife Area Manager, pers. comm.). The management directive for these lands was that they were to be used for the benefit of waterfowl. This directive was not specific in requiring the land to be managed actively (through such actions as diking, draining and planting), or passively (e.g. as natural tidal marsh). However, early land managers chose to convert this site for active management of cereal grains to attract and hold waterfowl for increased hunting opportunities.

To actively manage the area for production of cereal grains the site had to first be drained and converted to tillable soil. As with most of Fir Island this conversion required the construction of a levee to protect the site from tidal influence. This conversion appears to have started with the construction of a central “training dike” along Wiley Slough proper. This feature was built between 1937 and 1956 as aerial photographs from 1937 do not show the training dike present ([Figure 1.2](#)). This spur dike was primarily intended to improve agricultural drainage for existing farmlands to the North, and may have been necessary to address drainage infrastructure requirements prior to the extension of the levee system to include the Wiley Slough site. Finally the photo record and local anecdotal evidence place construction of the existing levee system in 1962. At this time tide gates were installed, and the land was cleared and planted with cereal grain crops for waterfowl and pheasant management (John Garrett, WDFW, Wildlife Area Manager, pers. comm.).

Levee construction resulted in the enclosure and isolation from tidal influence of 160 acres of tidal marsh and 16.3 acres of tidal channel, and elimination of channel usage by juvenile salmon. Inside the dikes, the smaller tidal channels were filled in entirely, plowed over, and assimilated into agricultural fields. The larger tidal channels, including Wiley Slough, have accumulated sediments from farmland erosion and become narrower and shallower than they were historically. Tidal channels seaward of the dikes were also impacted by dike construction. Net channel loss outside the Wiley Slough dikes has amounted to 20.5 acres since dike construction ([Fig. 1.3](#)). This is due to sediment accumulation in the tidal channels, which lost flushing volume as a result of upstream diking (Hood 2004). Sediment cores indicate that channels that were as much as 6 ft deep prior to dike construction have been completely filled in by sediment accumulation since 1962.

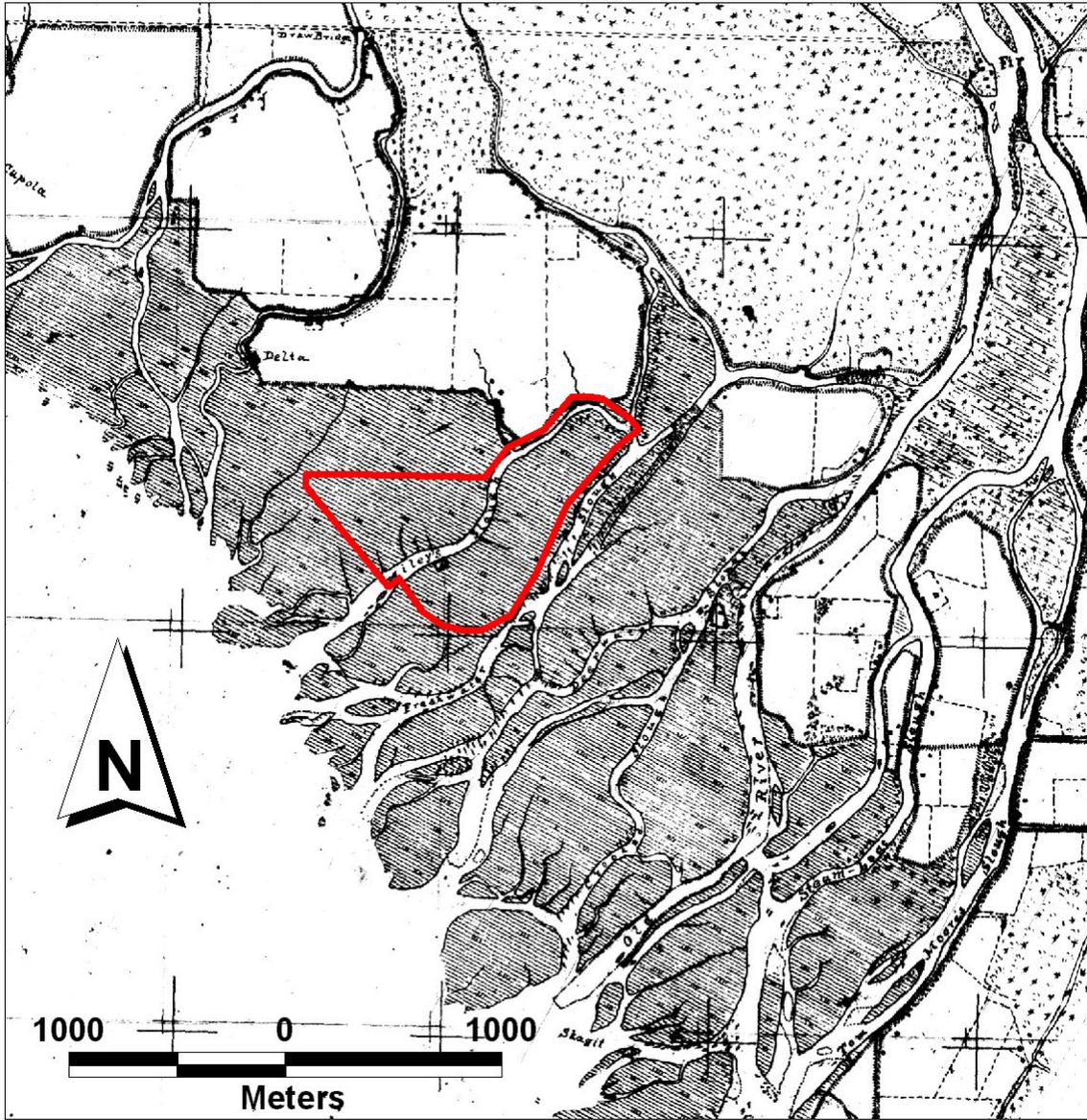


Figure 1.1: Detail of 1889 US Coast and Geodetic Survey map. The Wiley Slough project area is shown outlined in red. Dark hatched areas were tidal marsh in 1889. Light areas were farmland and stippled areas were forested.



Figure 1.2 Wiley Slough Circa 1937

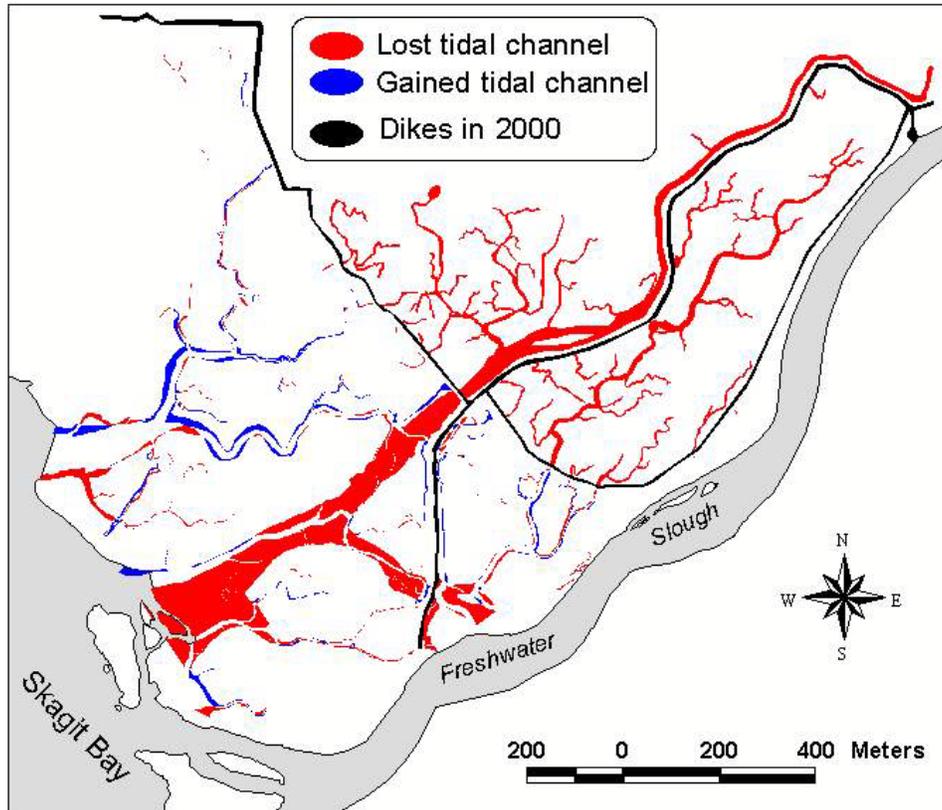


Figure 1.3 Change in tidal channel planform from 1956 (prior to dike construction) to 2000. Lost tidal channel area (red) resulted from either sediment accumulation due to lost tidal flushing (channels exterior to the dikes) or to loss of tidal connection and/or filling from agricultural activity (landward of dikes). Some channel area was eroded (blue) in a few areas seaward of the dikes.

PROJECT HISTORY

Recent efforts to restore this property to estuarine influence are firmly linked to the development and implementation of the Skagit Watershed Council and the publication of its Watershed Restoration Strategy and Application (SWC, 1998; 2000). These documents clearly identified the need and purpose of recovering isolated habitats in identified locations. One such location was the Wiley Slough site subject to this report. While identified as being ranked rather low in the SWC Application document, subsequent investigations by the Skagit System Cooperative, with support from the Bureau of Indian Affairs and Coastal Salmon Recovery Funds, yielded significant findings that argued for further review and emphasis.

As early as 2001, discussions between WDFW and Skagit River System Cooperative (SRSC) personnel led to initial evaluations of the Wiley Slough property. After considerable deliberation and review, WDFW staff were given executive approval from the Agency Director to pursue funding for the design of the Wiley Slough Restoration Project. Subsequent to this approval, the Washington Department of Fish and Wildlife worked closely with the Skagit Watershed Council (SWC) and SRSC to develop a restoration design proposal for review and funding by the Washington State

Salmon Recovery Funding Board (SRFB). Funding for this project was approved at the May 16, 2002 meeting of the SRFB.

PROJECT STAKEHOLDERS

The unique nature of the project area has attracted numerous user groups over the years. The logical outgrowth from this rich history is a diverse array of stakeholders. We have summarized the core stakeholder interests, representative organizations, and designated contacts in **Table 1.0** below;

Stakeholder Group	Organization(s)	Contact
Washington State	WDFW	Bob Everitt Brian Williams Bob Warinner
Tribes	Skagit River System Cooperative	Larry Wasserman
Federal Government	USFWS USACOE NOAA Fisheries NRCS	Curtis Tanner Scott Pozarycki Kurt Fresh Kathy Kilcoyne
Agriculture	Dike and Drainage District #22 Western Washington Ag Association	Curtis Wylie Curtis Johnson
Local Government	Skagit County	
Adjacent Landowners	The Wylie Family The Nelson Family	Dalles Wylie
Conservation Groups	Skagit Watershed Council Ducks Unlimited The Nature Conservancy Skagit Fisheries Enhancement Group	Shirley Solomon Andy Reasoner Bob Carey Allison Studley
Bird Watchers	Skagit Audubon Seattle Audubon	
Utilities	Seattle City Light	Ed Conner
Hunting Groups	Washington Waterfowler Association	Dave Engle Art Kendall

Table 1.0 Project Stakeholders

Goals & Objectives

PRIMARY GOAL

The foremost goal of the Wiley Slough restoration project is to restore natural processes, conditions, functions, and biological responses to the project area (approximately 175 acres), specifically, by removing dikes to restore riverine and tidal flooding to the project area. Restoration of natural estuarine process will result in the restoration of estuarine habitat for a wide variety of fish, wildlife, and other organisms. This is the ultimate goal of the restoration project. Taxa of particular management interest are ESA-threatened Chinook salmon, other salmonids, and wintering waterfowl.

Process-based restoration will provide maximal benefits to a wide variety of estuarine fish and wildlife while incurring little long-term maintenance or costs.

PRIMARY OBJECTIVES

Specific project objectives for the restored area have been identified by the Design Team as follows;

1. Restore tidal and riverine flooding (natural process) to the marsh surface to allow unrestricted movement of water, sediments, nutrients, detritus and organisms across the marsh surface (natural function).
2. Restore channel habitat for juvenile salmonids inside and outside the dikes in the project area as defined by levee alignments similar to the 1956 footprint (natural condition).
3. Restoration of native marsh vegetation (natural condition/biological response) to the site to support detrital food chains (natural function/process) for juvenile salmonids (biological response) as well as provide food plants for wintering waterfowl (biological response).

All three of these objectives will significantly contribute to improvements in the quantity and quality of estuarine habitat on site and near the site (e.g., downstream portions of Wiley Slough sedimented in due to loss of upstream tidal prism) for a wide variety of native fish and wildlife, including juvenile salmonids and waterfowl.

SECONDARY OBJECTIVES

While the primary goals and objectives are concerned with habitat restoration to benefit critical estuarine fish and wildlife, additional objectives related to human use can be compatible with the primary goals and objectives of the project, such as:

1. Provide waterfowl hunting opportunities.
2. Maintain or improve the existing boat ramp facility and parking.
3. Facilitate public access to the site for watchable wildlife opportunities.
4. Provide for agricultural drainage and flood protection.
5. Retain the Skagit Wildlife Management Area headquarters in its current location.

These goals are secondary to the primary, habitat-related goals.

Chapter II

Baseline Condition

This chapter provides a summary of pre-project site condition. Much of this information has been collected throughout the process of developing this design report and therefore should be a reasonably accurate reflection of present day condition.

Due to some limitation in resource availability and time this baseline accounting is not an exhaustive reflection of all biotic elements associated with the site. Rather, this account focuses on key biotic elements that are known to affect design consideration and/or are known to have high social value. Recognizing that additional data will continue to be useful in refining project details, Design Team members will continue to collect information on biotic parameters up to, and throughout, project construction.

Site Characterization

Ownership & land Use

The project area is currently owned by the State of Washington, Department of Fish & Wildlife and is managed as a public hunting and wildlife viewing area. WDFW took title to this property in stages, starting in 1951 with an acquisition from Gavett and Hall. This initial acquisition excluded oil, gas, and mineral rights in addition to a dike easement along what is now the Northern boundary of the project site. This 30' dike right of way was first established in the early 1900's. State ownership of the remainder of the project area was established in 1959 with a subsequent acquisition from the US Fish and Wildlife Service through a land exchange agreement. The levees currently in place around the perimeter of the property have no official record of right of way or easements associated with them, nor were any records identified as to its actual date of construction (Kai Iris, WDFW-Personal Communication, 2004). However, review of available aerial photos from flights taken in 1956 and 1965 clearly indicate that construction occurred at some point within the period of 1956-1965.

Hunting activity on site is primarily walk-in opportunities for waterfowl and pheasant. During the off season the area is used more extensively by bird watchers, hikers and local area residents. In support of these activities the area is extensively farmed in an effort to attract and hold wildlife to increase both hunting and viewing opportunities. Farming activities are typically executed by local operators working under contract with the WDFW. Infrastructure on the site currently includes two parking lots, a day use shelter with seating for approximately 50 people, two separate toilet

facilities, a boat ramp, game bird holding pens, a portable office trailer, a home reserved for the area manager, and an outbuilding that is used for a storage and workshop facility.

In October 2003, a vehicle counter was installed at the entrance to the project site. The installation of this unit coincided with the opening of the 2003 waterfowl season. The counter operates by tallying each passage of a vehicle over its location, differentiating between vehicle types based on the length between the front and rear axles of the vehicle (13 distinct types are differentiated by the unit). To summarize the data here we report the results into four basic groupings: Bikes (2 wheeled vehicles), Cars and trailers, 2 Axle longs (4 & 6 wheeled large trucks) and Other (buses, heavy hauling rigs and construction vehicles).

Theoretically, each vehicle that uses the site is counted twice; once for entering and a second time while leaving. However, due to a levee road located adjacent to the boat ramp (access to a limited number of private cabins) and possible equipment miscounts, this is not always the case. Additionally, there was a total of 10 days (2003) and 52 days (2004) of data lost due to equipment failure. Nov 2004, had the worst problems, with only 9 days of useable data.

The results indicate vehicular access to the site is highest in the late summer and fall seasons, dominated with the heavier personal vehicles (heavy duty and dual wheeled style trucks) (Figure 2.1). This can be attributed to regional hunting openings, Pheasant (Sept 18-24, 2004 *limited*, Sept 25th - Nov 30, 2004) and Migratory Water Fowl (Oct 16-20, 2004 and Oct 23, 2004 -Jan 30, 2005). The highest single day use recorded was 129 vehicles on a Sunday, Nov 16th, 2003. Weekends are clearly the time of highest use during these hunting seasons (Figure 2.4).

After Fall, use of the Wylie Slough area shows a steady decline throughout winter (Figure 2.1) to a minimum of use over spring and early summer. The type of use post-hunting season is dramatically demonstrated in Figure 2.2. After hunting season, the use of the 2 Axle longer vehicles drops quickly, whereas the use of Cars and trailers remains less prone to the extremes of the other vehicle type.

Figure 2.1. Wylie Slough: Overall Vehicle Usage.

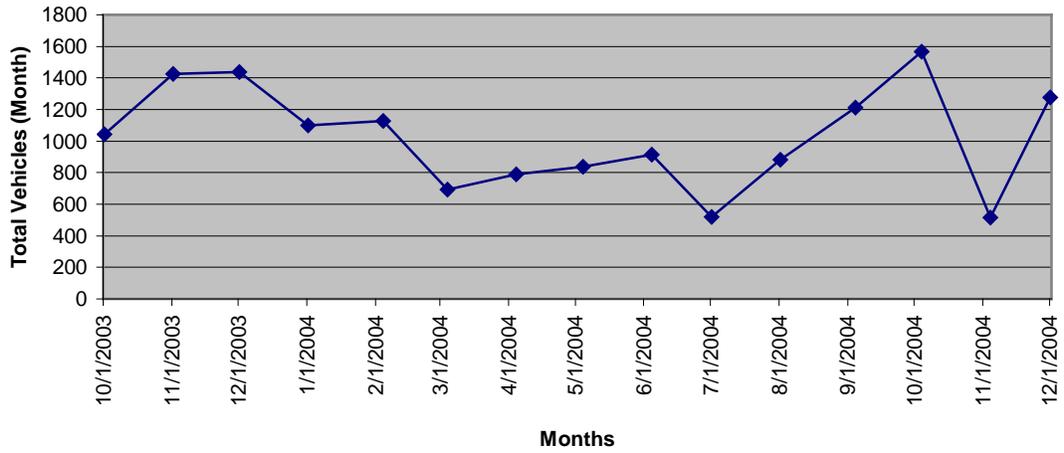


Figure 2.2 Wylie Slough: Usage by vehicle type.

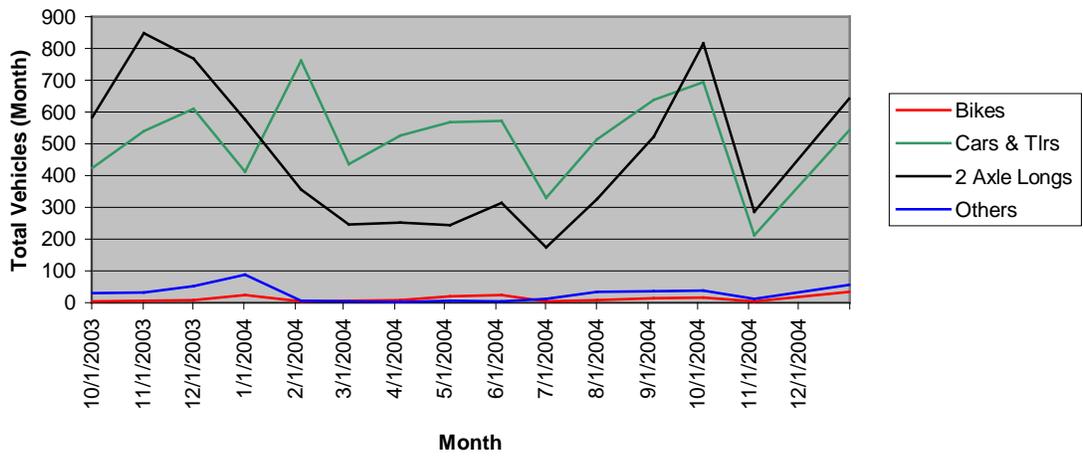


Figure. 2.3. Wylie Slough Seasonal Usage (Fall 2003-Fall 2004)

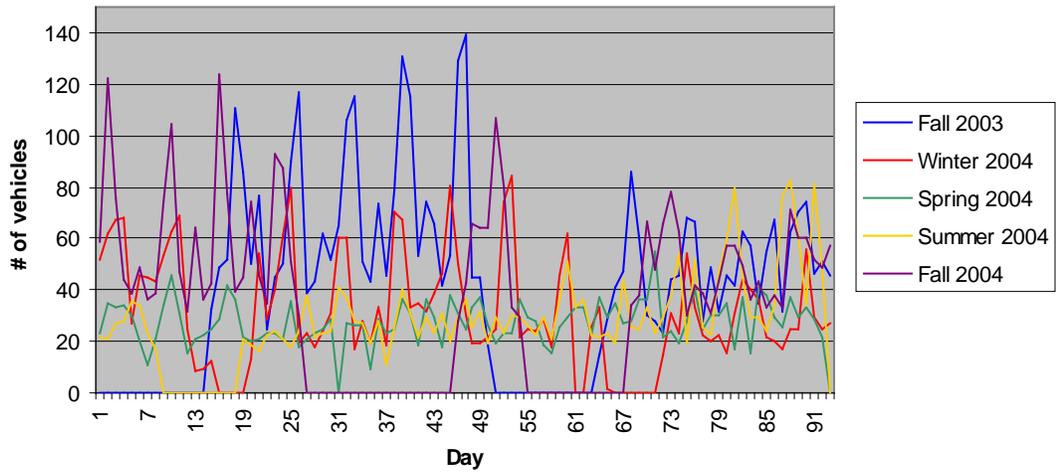


Figure. 2.4. Wylie Slough: Vehicle Usage Fall 2003

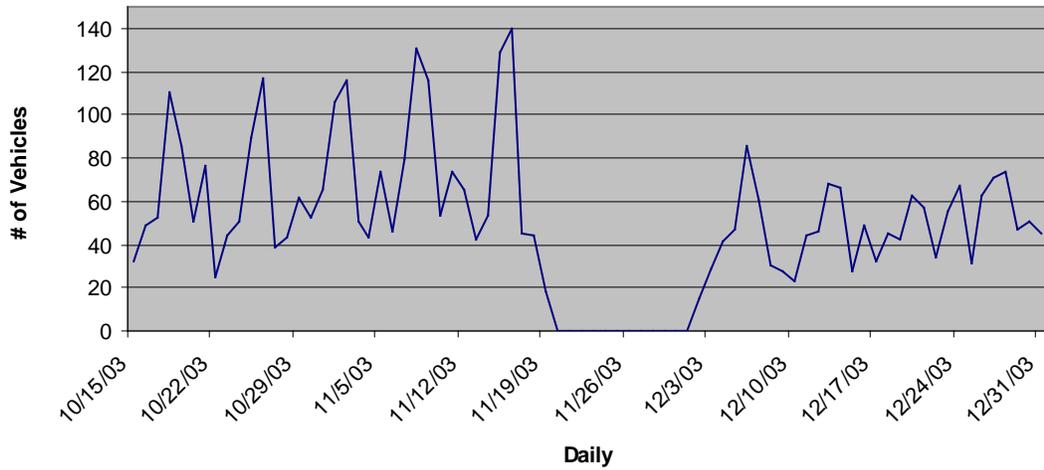


Figure 2.5. Wylie Slough: Vehicle Usage Winter 2004

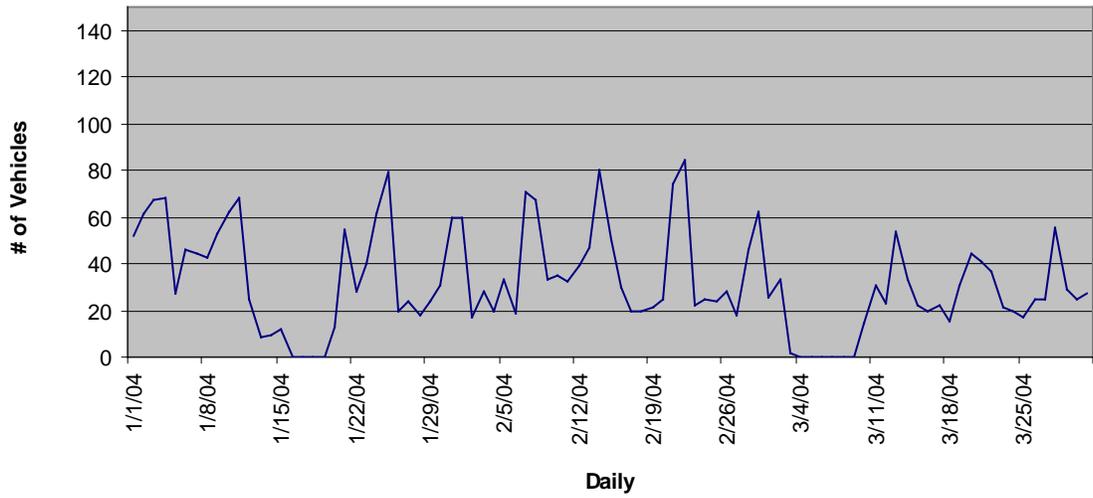


Figure 2.6. Wylie Slough: Vehicle Usage Spring 2004

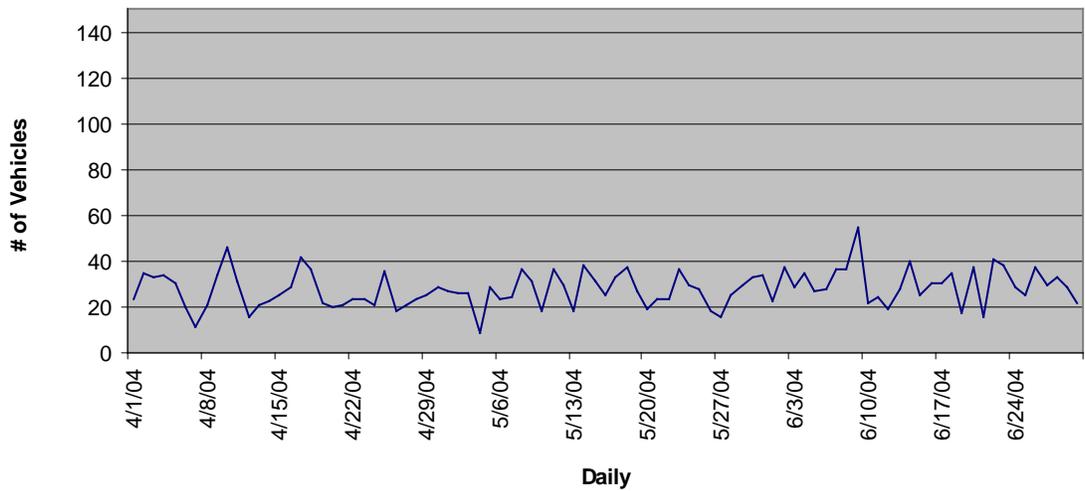
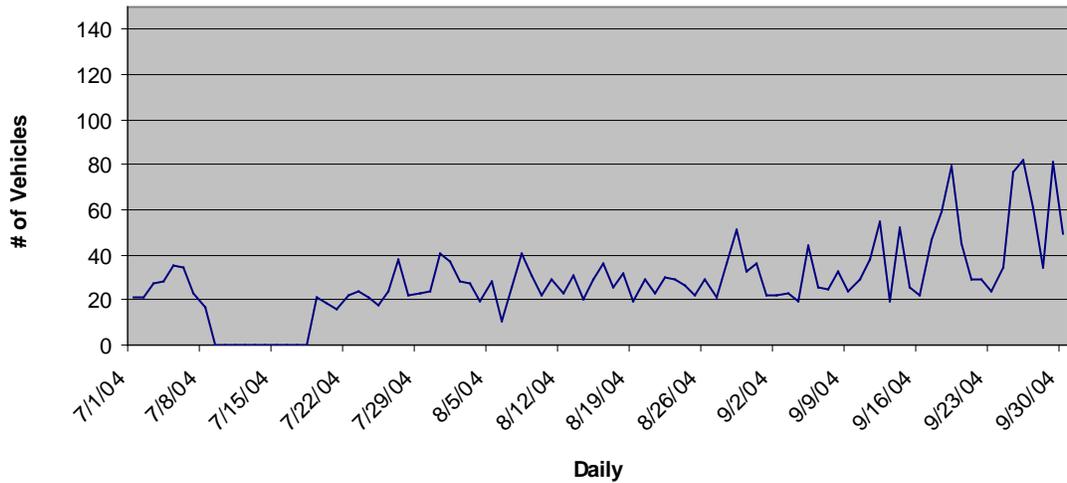


Fig. 2.7. Wiley Slough: Vehicle Usage Summer 2004



Topography

Methods

Detailed topographic data using LIDAR technology were collected by Spenser B. Gross under contract with SRSC for Fir Island in April of 2002. Data acquisition occurred at 7,500' AMT using an AeroScan System at 15,000 pulses per second with an average post spacing of 13 feet, +/- 8 inch vertical accuracy and +/- 12 inch horizontal accuracy during low tide conditions. This data was then processed using ground control points within the project area for LIDAR pre-processing validation and accuracy assessment. Data were processed by Spenser B. Gross for all positional corrections and removal of noise. Individual flight lines were trimmed and mosaiced into a seamless database. Data were post-processed to create a bare earth Digital Elevation Model (DEM).

All elevation data reported in this document are presented in the NGVD 29 Datum (National Geodetic Vertical Datum). To better understand the local relationship between the NGVD 29 datum and MHHW (Mean Higher High Water) we have included [Table 1.1](#) below to aid the reader.

Table 2.1 - Fir Island Tide Elevations

Tide Elevation	Tide Datum	
	MLLW (ft)	NGVD29 (ft)
Highest Estimated Tide	15.0	8.9
Highest Observed Tide	13.4	7.3

Mean Higher High Water (MHHW)	11.7	5.5
Mean High Water (MHW)	10.8	4.6
Mean Tide Level (MTL)	6.8	0.7
NGVD Zero Datum	6.1	0
Mean Low Water (MLW)	2.8	-3.3
Mean Lower Low Water (MLLW)	0	-6.1
Lowest Observed Tide	-2.0	-8.2

Source: U.S. Navy Pier, Crescent Harbor, Washington, Tide Gauge 9447952

Results

Topographic relief at the site is largely attributable to man-made dikes and ditches which criss-cross the area. The dikes in the area have a crest elevation that varies from approximately 7 to nearly 11 feet (NGVD 29 Datum). The exterior dikes (those dikes bordering the Freshwater Slough and tidal marsh land) all have a crest elevation of generally 9.5 feet. LIDAR data collected in spring of 2002 with resolution at +/- 8 inch indicate that ground elevations landward of the dikes are on average about 3 feet lower than that of adjacent land exterior to the dikes (Spencer B. Gross, 2002, SRSC, 2003) [Figure 2.8](#) is a graphic representation of this data using ArcGIS software. Researchers generally attribute this elevational effect to subsidence of drained and farmed agricultural land, marsh aggradation, or both. Ground elevations for the proposed restoration site are generally comparable to lower marsh elevations, which are vegetated primarily by sedge (*Carex lyngbyei*) (Extensive work has been completed in developing a vegetation/elevation relationship for marsh areas in the Skagit delta region which will be discussed in following sections) This lower emergent marsh elevation tends to range from -1 to +4 ft NGVD29. In comparison, mean higher high tides reach +5.3 ft and mean high tides reach +4.4 ft. Most higher areas are along the margins of historical tidal channels, where low natural levees, formed by tidal sediment deposition processes, still remain. Lower areas are found in basins between the historical tidal channels, and historically served as “tidal headwaters” for these channels.

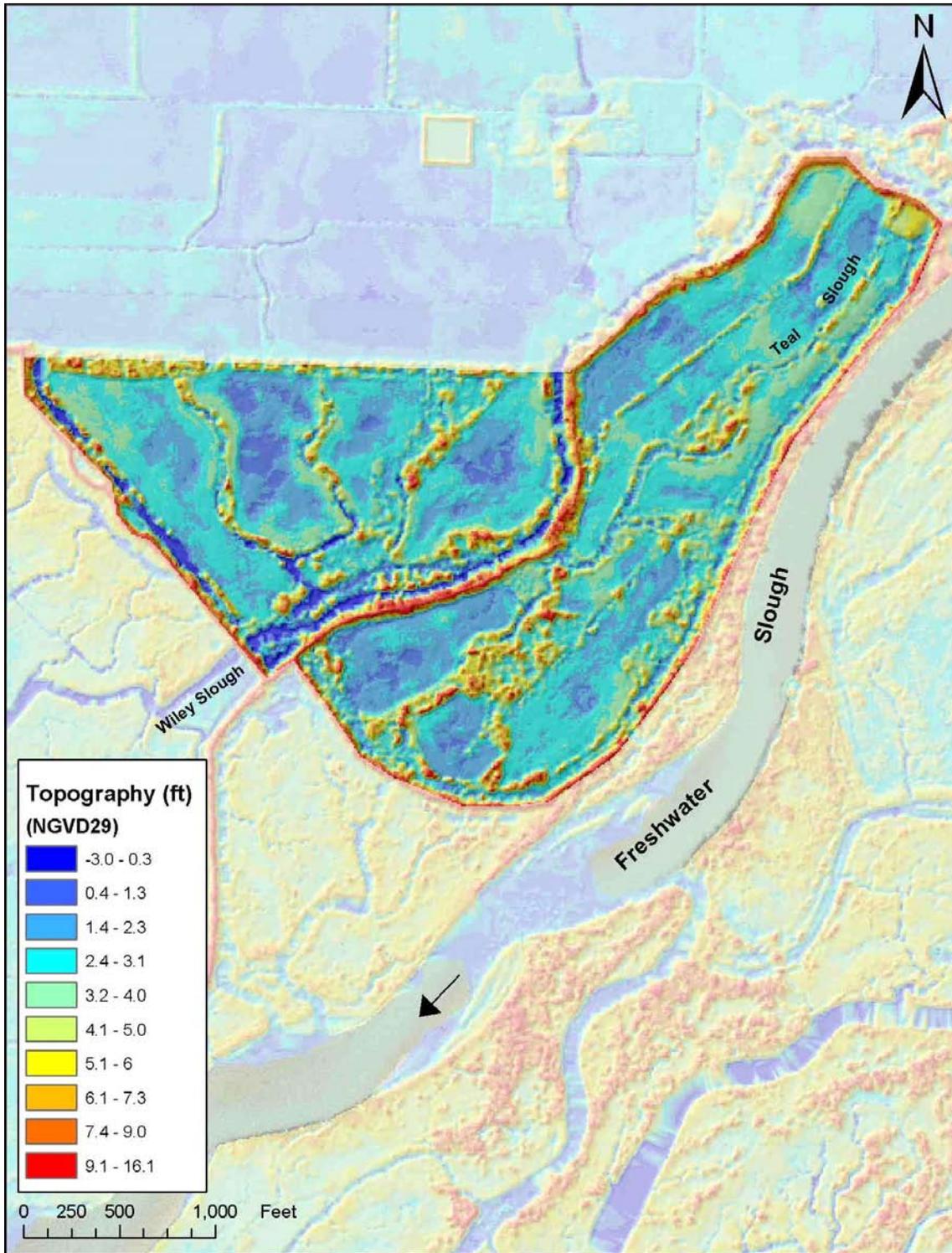


Figure 2.8 LIDAR imagery of the Wiley Slough project site. Ground elevations landward of the dikes are on average about 3 feet lower than that of adjacent land exterior to the dikes. Site elevations are comparable to lower marsh elevations, which are vegetated primarily by sedge (*Carex lyngbye*).

Hydrology

The Design Team hired Jeffery Blank and Kevin Coulton of HDR, Inc to provide their expertise as hydrologists to the project. Tasked with developing a working model of the project site, the consultants produced a hydraulic model to predict the outcomes of prescribed restoration actions. The following discussion provides detailed background about how the hydraulic conditions at the site were evaluated.

Hydraulic Setting

The project site is located in the southern portion of the Skagit River Delta along the northern bank of Freshwater Slough (**Figure 1.1**). The site is dominated by tidal processes and experiences a mean diurnal tide of approximately 11.0 feet. In the vicinity of the project site and throughout the tidal fringe of the Skagit River Delta, extensive inter-tidal mudflats and tidal marshes are present.

The project site originally had an extensive and complex network of tidal slough channels, which are visible on historical aerial photographs (**Figure 1.2**), (also see detailed discussion under site history). To a lesser extent, relic channels remain today and can be seen in recent aerial photos and topographic surveys of the site (**Figure 1.3**). The site has been disconnected from tidal exchange with Freshwater Slough and Skagit Bay for approximately 45 years (since the dikes were constructed sometime between 1956 and 1965). This has precluded the accumulation of suspended sediments delivered from the neighboring tidal mudflats and Freshwater Slough, and has limited the accumulation of fine sediments and organic materials associated with tidal marsh vegetation.

Tidal Characteristics.

Tidal characteristics vary in accordance to a number of variables such as flow and the earth's proximity to the moon, among others. In absence of having a lengthy historic record of actual tide signals specific to this site the design team developed representative tide signals for three specific tidal "windows". These are; 1) A daily diurnal tide cycle representative of at least four seasons, 2) a typical monthly spring/neap tide cycle, and 3) a synthesized extreme tide signal for the 10-year extremal tidal event. The method by which each of these representative tide signals was derived is as follows;

Representative Diurnal Tide Cycle. The representative tide cycle specific to the site was developed through a combined analysis of the tidal datum statistics at Polnell Point (COE gauge #104, near Crescent Harbor <http://www.nwd.wc.usace.army.mil/nws/hh/tides/wi/wi104.htm>), and a statistical analysis of actual water level measurements collected at Wiley Slough by SRSC between April and December of 2004 (Table 2.1). Figure 2.2 shows the locations of the on and off site tide gauge monitoring stations. For the Polnell Point gauge, published datum conversions from MLLW to NGVD29 (feet) were made. For the data collected at Wiley Slough by SRSC scientists, calibrations were applied to account for the installation elevation of the water level

recorder and the effect of barometric pressure on the tide elevation readings. A 5-min tide signal was then synthesized from a combination of the two tidal datums through a cosine interpolation between neighboring high and low water periods. [Figure 2.10](#) illustrates the final representative diurnal tide cycle for the project site.



Figure 2.9 Locations of tide gauges use for representative tidal cycles.

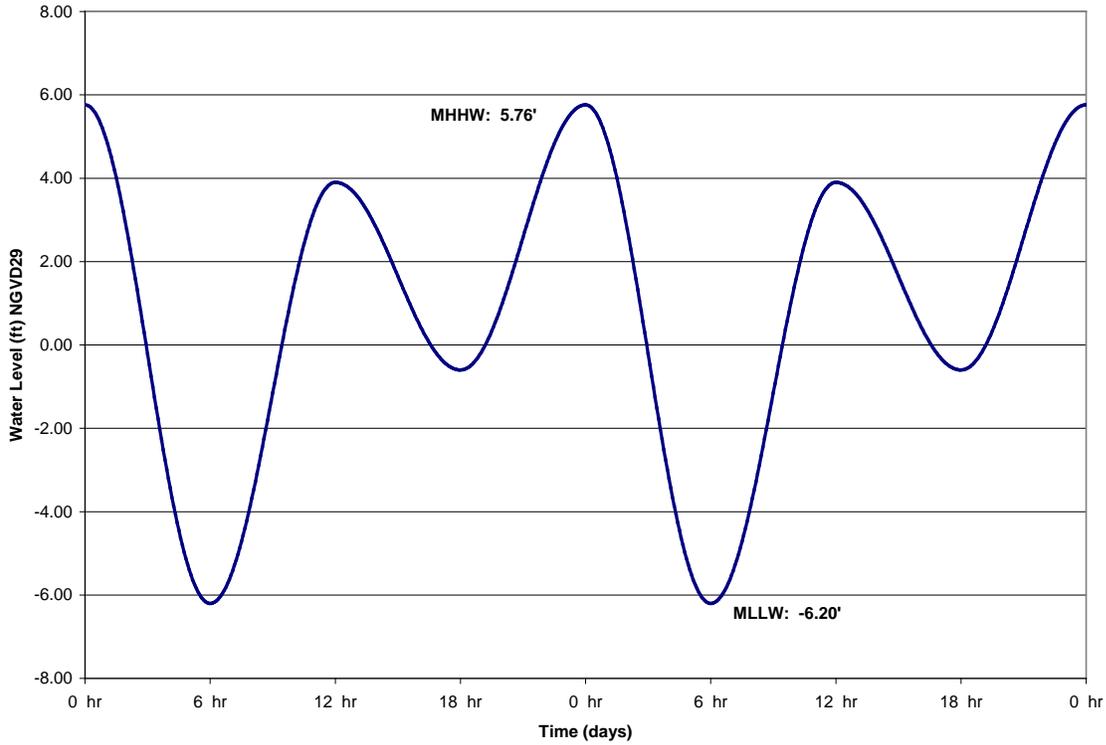


Figure 2.10 Representative Diurnal Tide Cycle @ Wiley Slough Tidegate

Table 2.2 Summary of Tidal Datums at Wiley Slough

Tidal Datum	Polnell Point, WA (COE# 104)	SSC Measurements	Combined Tidal Datums
	NGVD29 (ft)	NGVD29 (ft)	NGVD29 (ft)
MHHW	5.50	5.76	5.76
MHW	4.60	4.83	4.83
MTL	0.60	n/a ¹	0.60
MLW	-3.40	n/a ¹	-3.40
MLLW	-6.20	n/a ¹	-6.20

Note 1: Tidal datums below MHW were not calculated from the water level data collected at Wiley Slough by SRSC because the gauges are located on marsh plain areas that are higher in elevation than the MTL tidal datum.

Spring-Neap Tide Cycle. A representative spring and neap tide cycle was developed so more extreme tide elevations, which are averaged out of the published tidal datums, could be included in the analysis. Spring tides have higher high tides and lower low tides whereas neap tides have lower high tides and higher low tides. In order to model this yearly cycle, a predicted tide signal was generated from the software Tides & Currents (Nobeltec, 2004) for Crescent Harbor (the nearest available gauge) and adjusted to the local NGVD29 datum again using published NGS benchmark conversions. [Figure 2.11](#) illustrates the final predicted spring-neap tide signal for the project site.

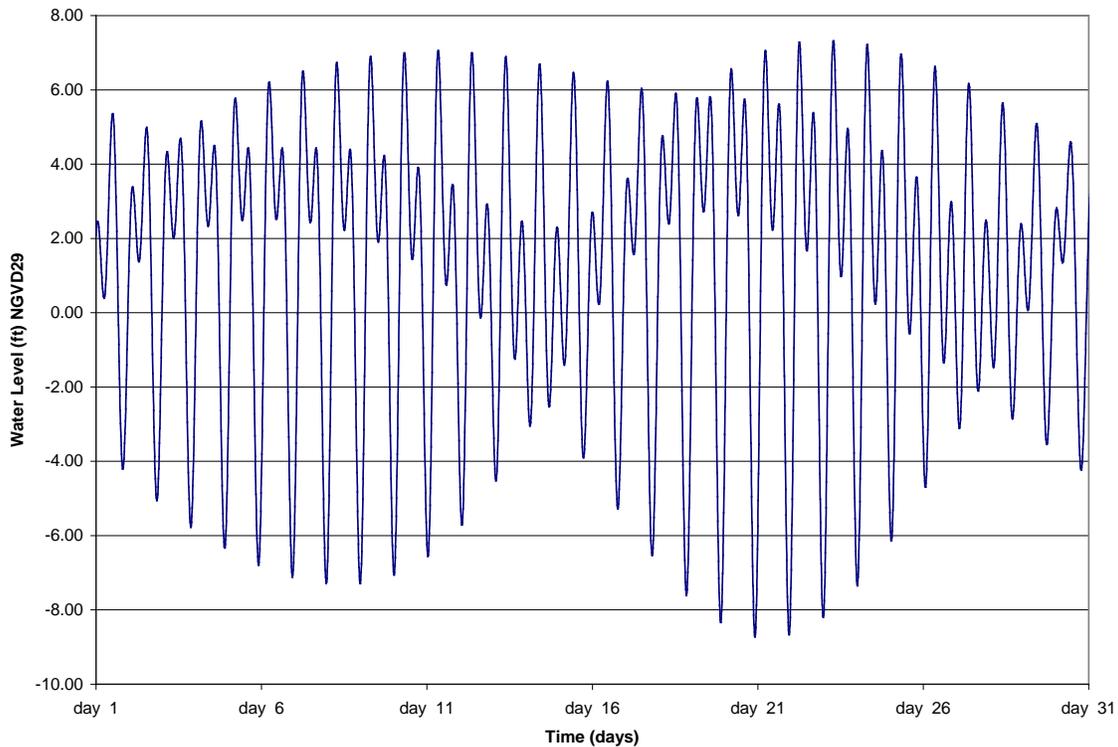


Figure 2.11 Predicted Spring-Neap Tide Cycle for Wiley Slough

Extremal Tide Event. According to the FEMA Flood Insurance Study for Skagit County, Washington (FEMA, 1989), flood elevations at Wiley Slough are not significantly influenced by river discharge, but rather are more predominantly impacted by extreme tidal stillwater elevations of Skagit Bay. Through a stage-frequency analysis, the FEMA study estimated the 10-year stillwater elevation of Skagit Bay in the vicinity of the project site as 7.8 feet (NGVD29). A synthetic tide signal was developed for the project site using this 10-year stillwater elevation by modifying the representative diurnal tide signal discussed previously. [Figure 2.12](#) illustrates the 10-year tide signal developed for Wiley Slough.

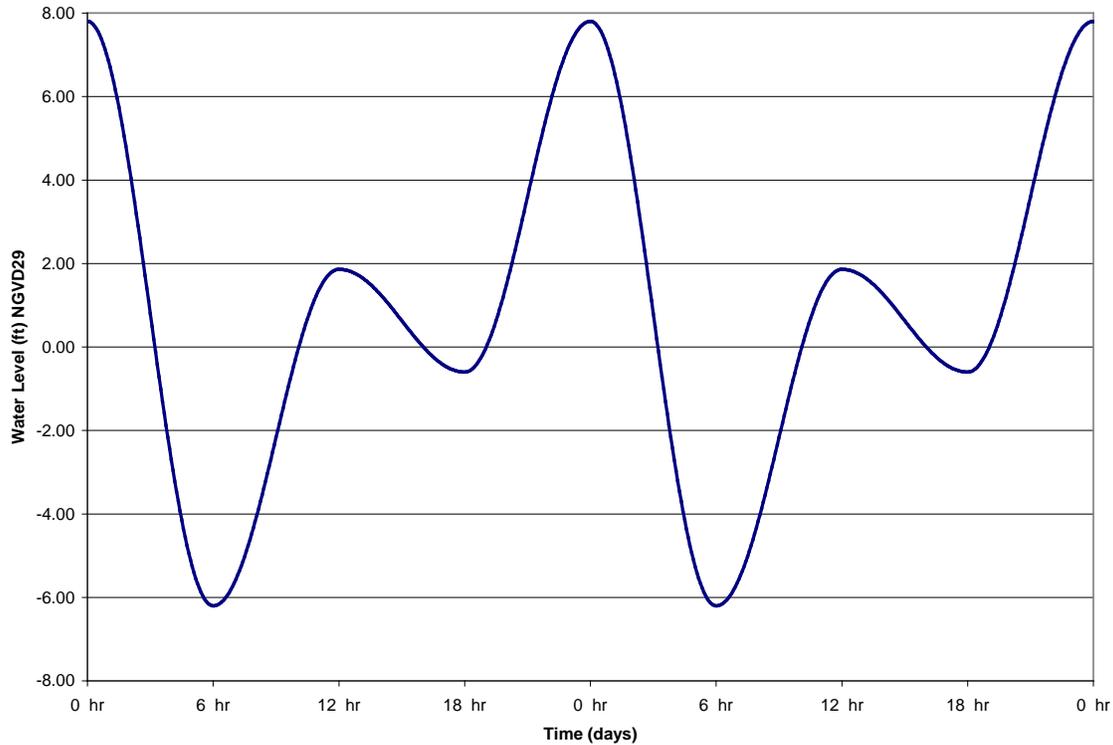


Figure 2.12 Synthetic 10-yr Flood Tide Cycle for Wiley Slough

Freshwater Slough Streamflow Characteristics. Streamflow data specific to the Wiley Slough vicinity was not available for this study. Therefore, discharge estimates for Freshwater Slough were derived by translating the discharge estimates from the nearest USGS gauge (Mount Vernon, WA # 12200500) to the project site. This was accomplished using a two-stage process. First, the Army Corps of Engineer’s UNET model of the Skagit River was used to approximate the average flow split between the North and South Forks of the Skagit River. Based on the model results, an average of 45% of the Skagit River flows down the South Fork. From this point, a second method, based on a top-width (or channel area) ratio was used to further split the flow at the divergence of Freshwater Slough from the South Fork Skagit River and at the Freshwater/Deepwater Slough flow split. To accomplish this, the width of each channel was measured from the corresponding USGS Quad map and a flow split percentage was developed based on the ratio between the two top widths. A top width comparison was assumed adequate because if a parabolic cross-section with the same depth is assumed for each channel at the divergence, then the conveyance areas would be directly proportional to the top width and the same flow split percentage would be valid. By combining the results of the two methods described above, streamflows in Freshwater Slough at the project site were estimated as 12% of the flow measured at the USGS gauge at Mount Vernon. This percentage was assumed to be valid for the range of flows considered in this investigation.

Based on this result, a set of primary design discharges was developed. The mean annual discharge for Freshwater Slough (2,050 cfs) as well as peak monthly summer and winter flows (1,150 and 3,050 cfs respectively) represents a typical daily flow condition. The 1- and 10-yr discharges (3,850 and 13,000 cfs) represent more extreme flooding conditions. Since the levees

within Fir Island are understood to contain flows up to approximately the 10-year flood, streamflow events larger than this were not considered. These five flows were selected because they provide a broad range of hydraulic and erosive conditions that the project site might be subject to and can guide decisions as to where hydraulic restrictions or sedimentation problems may result. [Table 2.3](#) summarizes the Freshwater Slough streamflow boundary conditions used in the present study.

Table 2.3 Summary of Freshwater Slough Streamflow Estimates

Stream Flow	Skagit River @ Mount Vernon (cfs)	Freshwater Slough at Project Site (cfs)
Mean Annual	16,610	2,053
Low Monthly (Sept)	9,369	1,158
High Monthly (Jun)	24,750	3,059
1-yr flood	32,200	3,864
10-yr flood	106,000	13,103

Groundwater Conditions

Groundwater was encountered in each of the geotechnical borings completed along the proposed dike alignment. The groundwater was encountered underlying the upper layer of soft silt, approximately 5 to 7.5 feet below ground surface (bgs). Assuming the groundwater encountered in the geo-technical borings represented the regional groundwater elevation, ground water wells were installed to a depth of 5-7.5 feet at three representative locations represented in [Figure 2.13](#). Solinsit™ pressure transducers were installed in each of the well locations and monitored for seasonal differences. Groundwater should be expected to fluctuate as a function of season, precipitation, water level in the slough, and other factors. Data collected through the period May to December 2004 was used to develop representative daily and seasonal groundwater signals for the project site. [Figures 2.14 and 2.15](#) show these representative signals.



Figure 2.13 Groundwater Well Locations

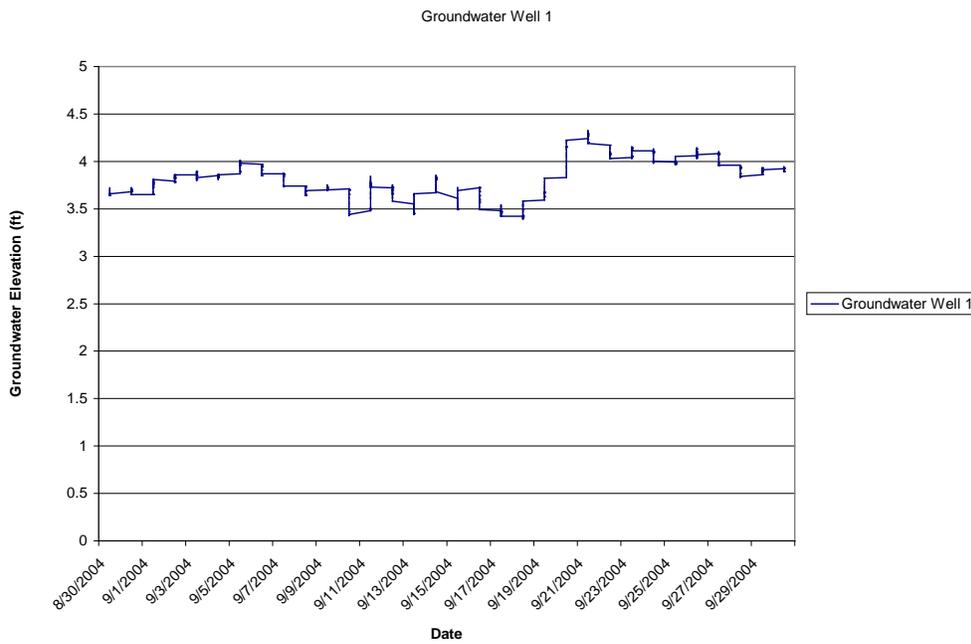


Figure 2.14 Representative Seasonal Groundwater Signal (Autumn)

Soils

Natural Resource Conservation Service soil survey maps list the entire project site located behind the levee system as Tacoma silt loam, Drained (NRCS, 1972). The NRCS survey is shown in Figure 2.9 below.

Subsurface Conditions

Soil Conditions – Proposed Dike Alignment. Subsurface conditions are fairly consistent in each of the three borings completed by project subcontractors along the proposed dike alignment (Figure 2.7). The surficial soils consisted of a sod zone approximately 1 to 1.5 feet thick. A soft layer of gray silt with occasional organic matter was encountered underlying the sod. The soft silt was 3 to 6 feet thick transitioning to a thin layer of silty sand. Loose sand with a varying fines content (that portion passing the No. 200 U.S. sieve based on weight) was encountered underlying the silty sand and extended to the full depth explored. The fines content of the sand was typically less than 6 percent (Geo-Engineers, 2004).

Soil Conditions – Existing Dike. Material encountered in explorations performed by subcontractors within the existing dike alignment (Figure 2.7, TP1-3) consisted primarily of relatively “clean” (low fines content) sand likely obtained from the project vicinity during the original construction of the dike. A surficial layer of crushed rock was encountered 6 to 18 inches thick. This layer was likely placed to provide a hard roadbed for maintenance vehicles. Underlying the crushed rock, silty sand with 20 to 30 percent fines was encountered in test pits TP-1 and TP-2 to a depth of 2.5 and 5 feet below the top of dike elevation, respectively. Cleaner sand with 6 percent fines or less was encountered underlying the silty sand in test pits TP-1 and TP-2 and underlying the crushed rock in test pit TP-3. The sand extended to a depth ranging from 5.5 to 7.5 feet below the top of dike. Medium stiff silt was encountered underlying the sand in all of the test pits and extended to the full depth explored (Geo-Engineers, 2004).

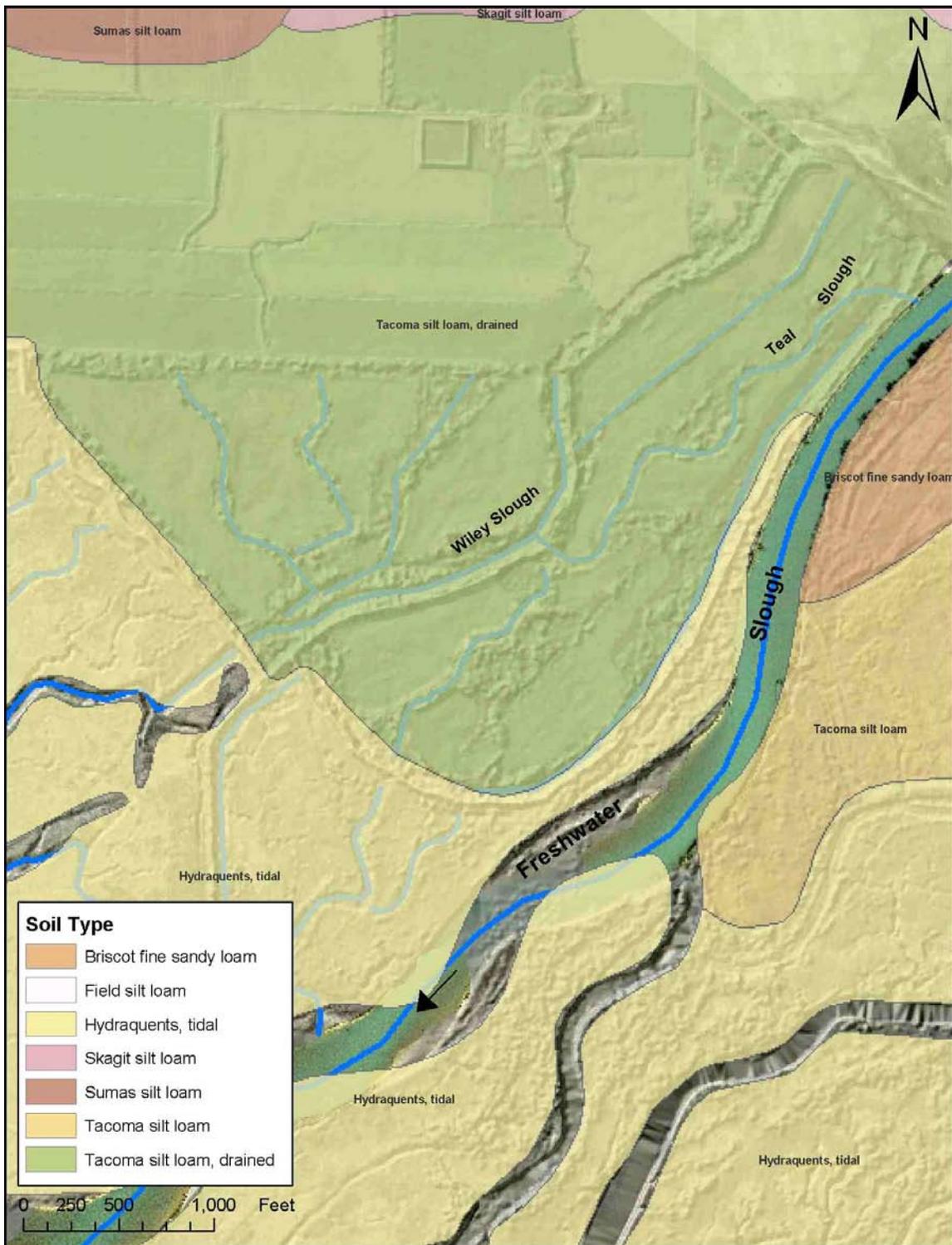


Figure 2.16 NRCS Surficial Soil Classifications of Site

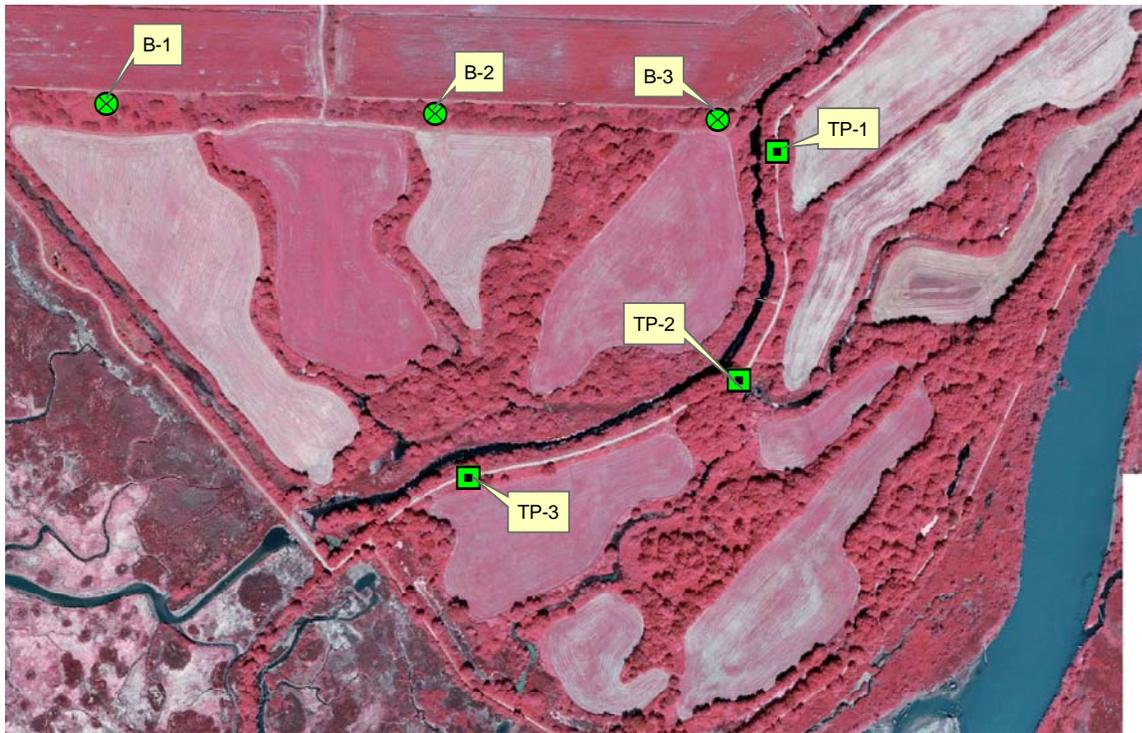


Figure 2.17 Boring and test pit locations

GEOLOGY

Review of the U.S. Geologic (USGS) map for the project area, "Surficial Geologic Map of the Port Townsend 30- by 60-Minute Quadrangle, Puget Sound Region, Washington" by Pessl, Dethier, Booth, and Minard (1989) shows soil deposits in the site area mapped as Holocene alluvium sands, modified land (dikes), or marsh deposits. The Holocene alluvium sands were placed by the Skagit River since the last period of glaciation. The alluvium material is quite thick and can vary significantly from coarse sands to silt and clay. The marsh deposits consist of silt, sand, or clay with variable amounts of decaying organic matter. Marsh deposits are typically identified west of the dikes.

Vegetation

Native Species

Vegetation in the area consists of grasses, shrubs, a variety of deciduous trees, and a scattering of a few conifers. Some areas have been used for agricultural purposes and therefore the vegetation is minimal in those locations. The proposed new dike location is located on the margin of private land and heavily vegetated with brush and small trees.

Invasive Species

A number of invasive species exist on the site, several of which are listed as noxious weeds by the State of Washington Weed Control Board. The weed control board ranks invasive species into three categories based on threat. Weeds are listed as being class A, B or C. Species that have been identified on site or within the general vicinity of the project area are as follows;

Class A Weeds: Non-native species with a limited distribution in Washington. Preventing new infestations and eradicating existing infestations is the highest priority. Eradication is required by law.

<u>Common name</u>	<u>Scientific name</u>
cordgrass, salt meadow	<i>Spartina patens</i>
hogweed, giant	<i>Heracleum mantegazzianum</i>

Class B Weeds: Non-native species presently limited to portions of the state. Species are designated for control in regions where they are not yet widespread. Preventing new infestations in these areas is a high priority. In regions where a Class B species is already abundant, control is decided at the local level, with containment as the primary goal.

<u>Common name</u>	<u>Scientific name</u>
broom, Scotch	<i>Cytisus scoparius</i>
cordgrass, common	<i>Spartina anglica</i>
cordgrass, smooth	<i>Spartina alterniflora</i>
daisy, oxeye	<i>Leucanthemum vulgare</i>
knotweed, giant	<i>Polygonum sachalinense</i>
knotweed, Himalayan	<i>Polygonum polystachyum</i>
knotweed, Japanese	<i>Polygonum cuspidatum</i>
loosestrife, purple	<i>Lythrum salicaria</i>
loosestrife, wand	<i>Lythrum virgatum</i>
ragwort, tansy	<i>Senecio jacobaea</i>

CLASS C WEEDS: Non-native weeds found in Washington. Many of these species are widespread in the state. Long-term programs of suppression and control are a County option, depending upon local threats and the feasibility of control in local areas.

<u>Common name</u>	<u>Scientific name</u>
babysbreath	<i>Gypsophila paniculata</i>
canarygrass, reed	<i>Phalaris arundinacea</i>
groundsel, common	<i>Senecio vulgaris</i>
ivy, English*	*4 cultivars only <i>Hedera hibernica</i> 'Hibernica' <i>Hedera helix</i> 'Baltica' <i>Hedera helix</i> 'Pittsburgh' <i>Hedera helix</i> 'Star'
Knotweed, bohemian	<i>Polygonum Bohemicum</i>
old man's beard	<i>Clematis vitalba</i>
poison hemlock	<i>Conium maculatum</i>

reed, common non-native genotypes	<i>Phragmites australis</i>
St. Johnswort, common	<i>Hypericum perforatum</i>
tansy, common	<i>Tanacetum vulgare</i>
thistle, bull	<i>Cirsium vulgare</i>
thistle, Canada	<i>Cirsium arvense</i>

Fisheries

Fish catch data collected between 1995 through 2004 was compiled by SRSC biologists to evaluate juvenile Chinook salmon use in the vicinity of Wiley Slough and upstream and downstream of the tide gate at the lower end of Wiley Slough (Figure 2.18). Blind channel and distributary slough habitat were sampled using an 80 ft long by 6 ft deep 1/8 inch knotless nylon mesh beach seine.

Catches were grouped by sample years based on differences in outmigrating wild Chinook salmon population size and sampling effort in order to analyze data. Data from years 1995, 1997, 1998, and 2002 were pooled because outmigrant smolt population size ranged from 2.2 to 5.5 million. During these years, sampling was broader, and occurred from March through August for most sites. In 2004 the outmigrant population was notably smaller, with less than one million wild Chinook salmon. During 2004 sampling only occurred in April and May.

Results

Our data indicate that juvenile Chinook, coho, and chum utilize the Wiley Slough area (Figure 2.19). Salmonids are almost completely absent above the Wiley Slough tidegate, while juvenile salmon were found just downstream of the tidegate and in adjacent sloughs (Figures 2.20-2.25). Species richness below the tidegate and in the vicinity around Wiley Slough is approximately 10 to 12 species, including salmonids, smelt, sculpin, flatfish, and others (Figure 2.26). Upstream of the tidegate in Wiley Slough we found only stickleback and one chinook and one coho.

Juvenile Chinook salmon abundance in the Teal Slough marsh may be higher than at the mouth of Wiley Slough below the tidegate even though these sites are immediately adjacent (Figure 2.23 and 2.24). For the period 1995-2002, wild Chinook salmon densities in May were 28 times higher in Teal Slough than lower Wiley Slough. While these results are limited in statistical power due to small sample sizes, the results may indicate that the spur dike between Teal Slough marsh and lower Wiley Slough is interfering with connectivity between the two areas and thus lowering juvenile Chinook salmon use of Wiley Slough below the tidegate.

In the following figures (2.20 -2.25) catch densities are labeled above error bars. Densities reported in graphs are the average catch, normalized to fish per hectare based on the area seined, by month for all years noted. Zero indicates a catch with no chinook. Blank indicates no sample. Error bars are one standard deviation. No error bar indicates only one sample in that month for the year/s noted.

Wiley Slough Monitoring for Fish Use

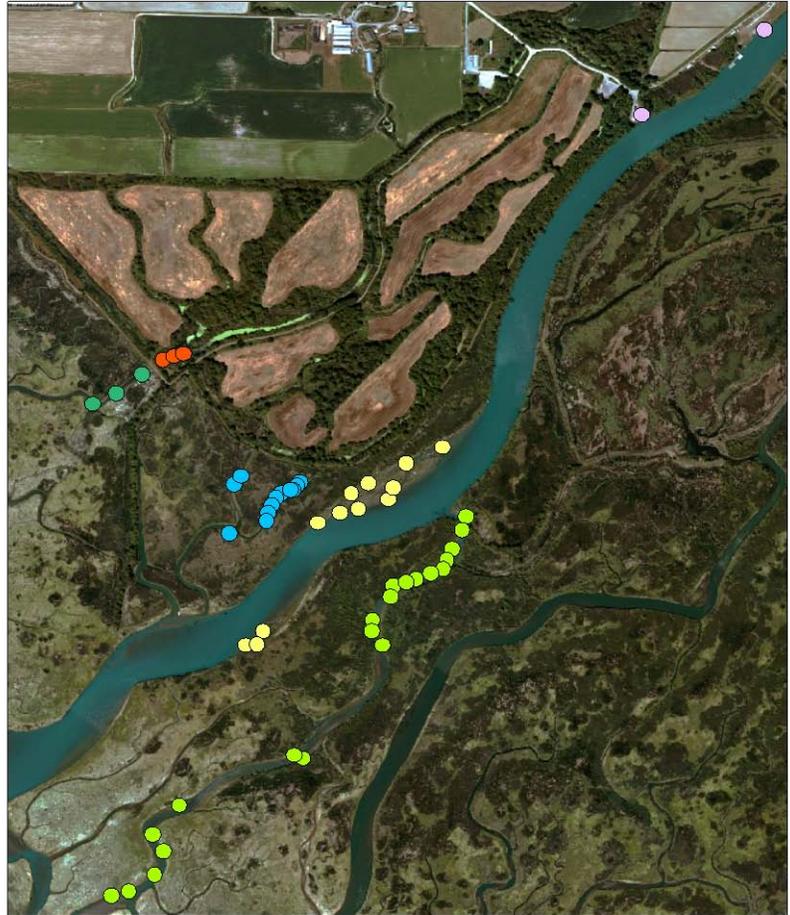
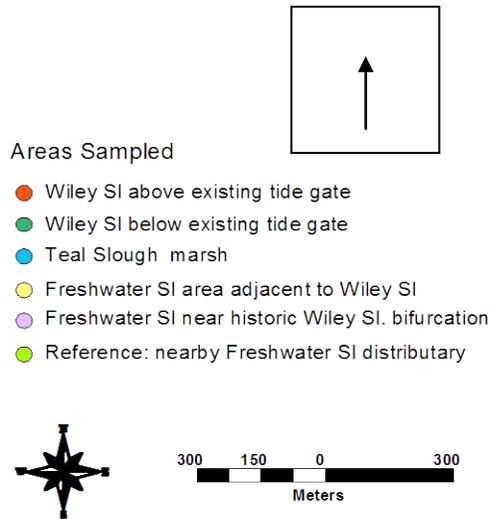


Figure 2.18: Wiley Slough vicinity sampling sites. Each dot represents an individual seining location. We sampled above and below the tide gate at the lower end of Wiley Slough. We also collected samples in Freshwater Slough: 1) near the historic bifurcation of Wiley Slough; 2) in the mainstem Freshwater Slough; 3) in Teal Slough marsh, an area of blind channels on the river side of the a spur dike; and 4) in an unconfined distributary of Freshwater Slough that may serve as a reference condition for Wiley Slough, having a similar size and relative position in the delta.

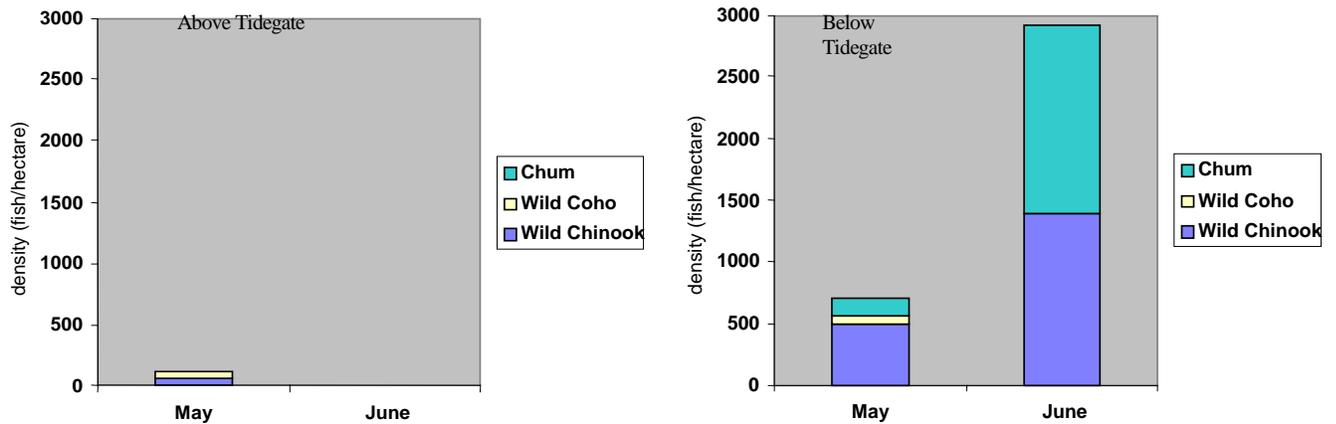


Figure 2.19: Salmonids found above and below the Wiley Slough tidegate, as average fish density, 1995 and 2004. Wild chinook, wild coho, and chum currently make use of Wiley Slough. Salmonid density above the tidegate is close to zero compared to density below the tidegate.

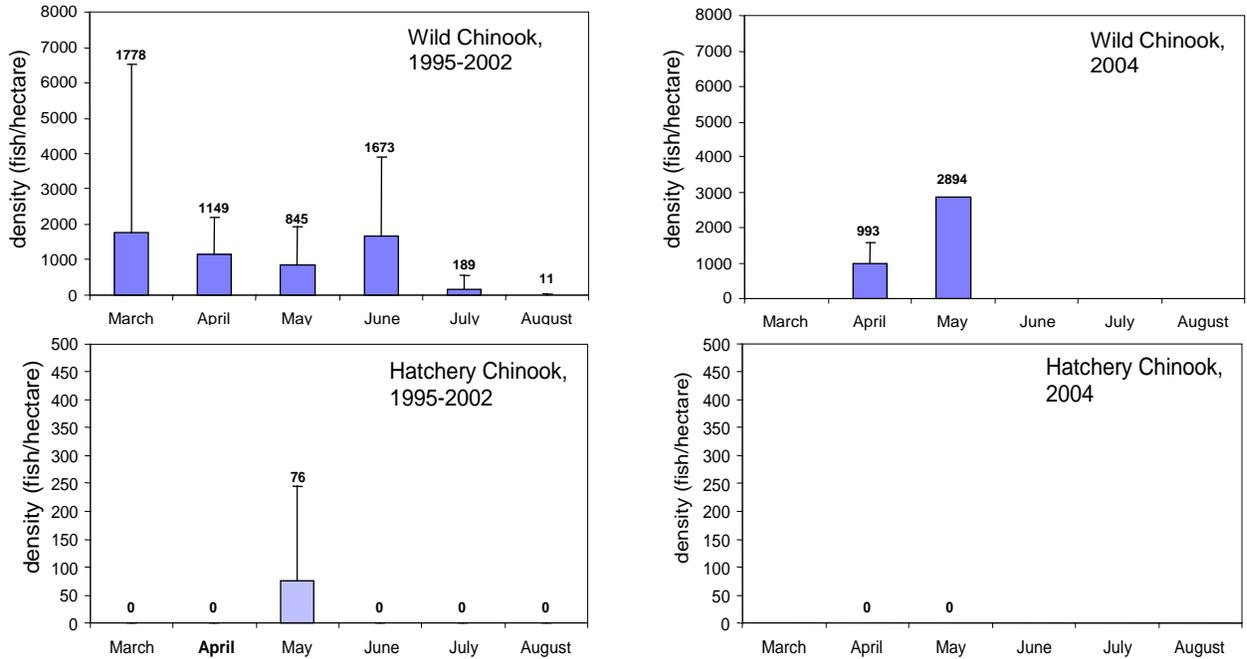


Figure 2.20: Chinook catch in Freshwater Slough main channel adjacent to Wiley Slough. Though the 2004 outmigrant population was low compared to populations for 1995-2002, wild Chinook salmon densities in Freshwater Slough were similar. Hatchery Chinook salmon were almost absent in the main channel of Freshwater Slough. Note the different scales for wild and hatchery fish.

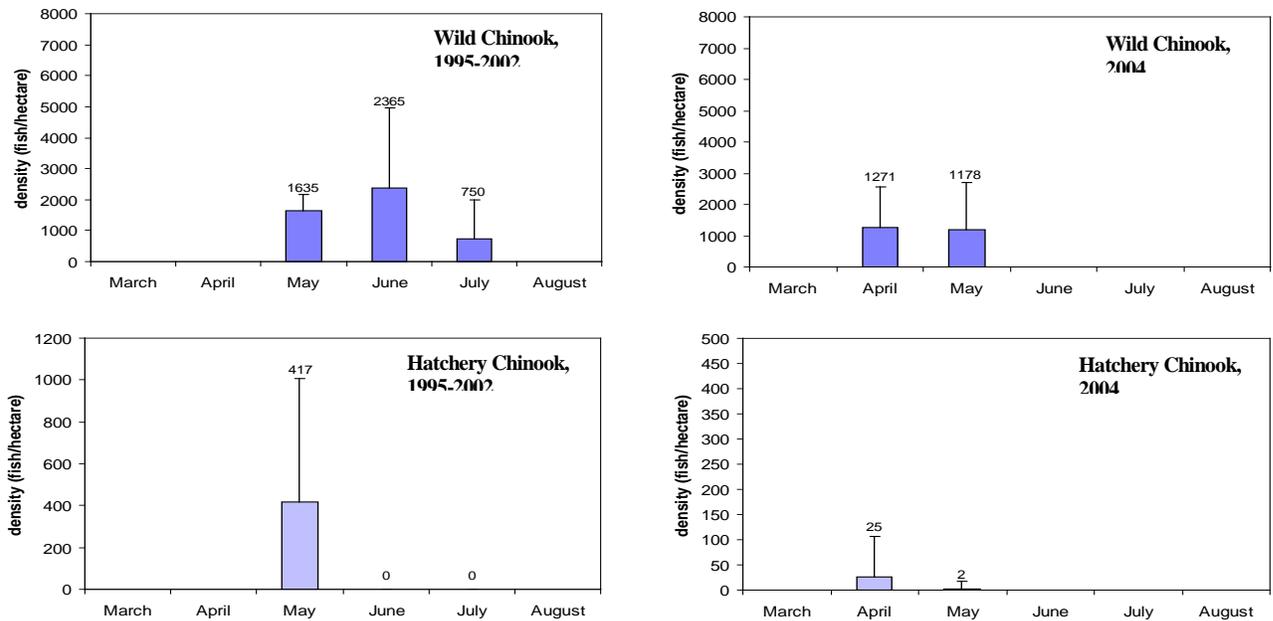


Figure 2.21: Chinook catch in a Freshwater Slough distributary channel comparable in size and location to Wiley Slough. Data from this site may be a good predictor of Chinook salmon use in a reconnected Wiley Slough, as this distributary is of similar size and similar habitat relative channel order and salinity. Again, samples show that despite different outmigrant populations, wild Chinook Salmon densities are typically higher than 1,000 fish per hectare in April through June. **Note the different scales for**

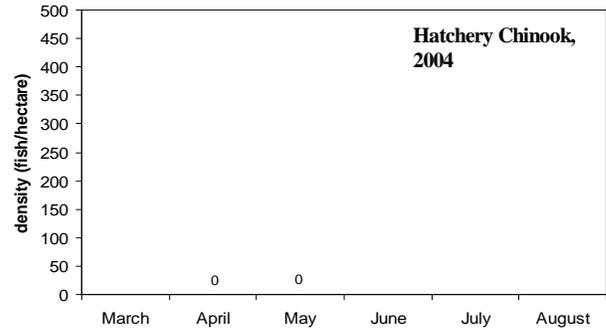
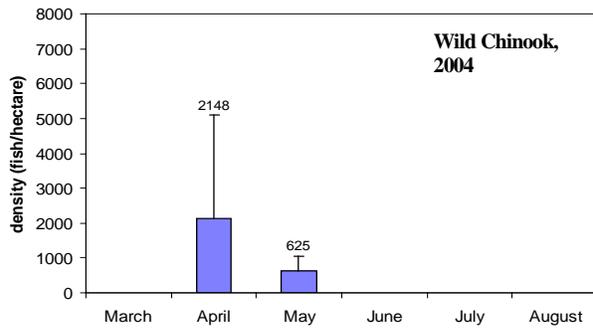


Figure 2.22: Chinook catch in Freshwater Slough near the historic bifurcation of Wiley Slough. Wild Chinook salmon are present in Freshwater Slough main channel at the point where a reconnected Wiley Slough could branch off. These fish would be one source for populating Wiley Slough if reconnected.

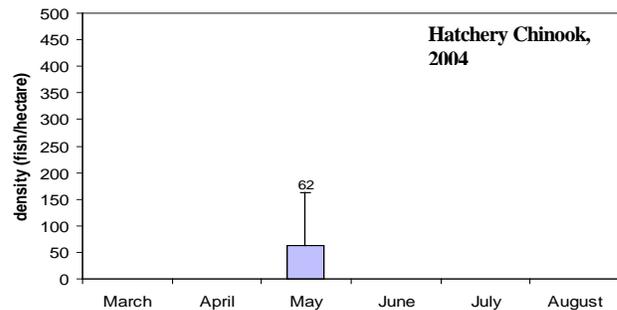
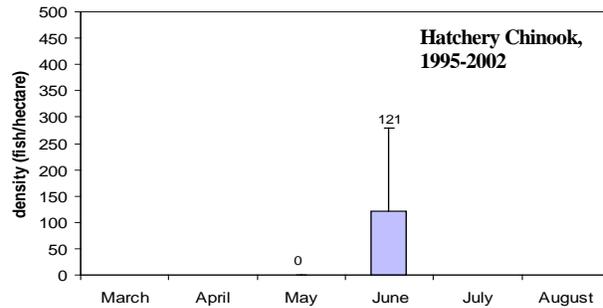
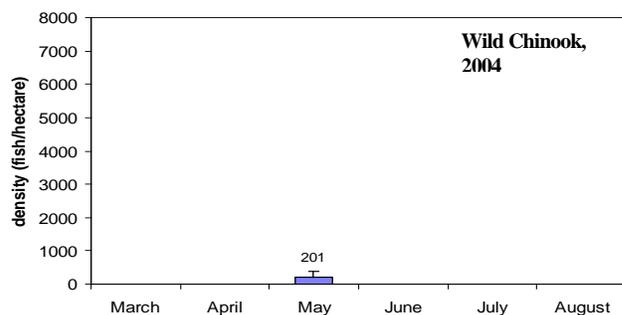
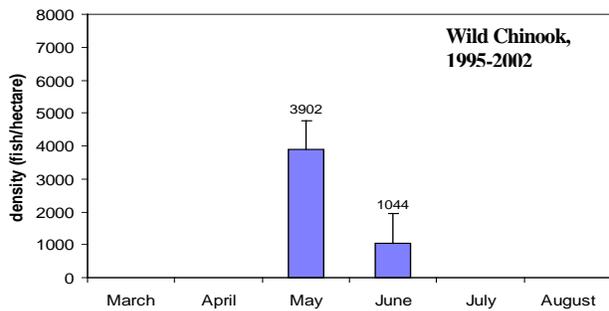


Figure 2.23: Chinook catch in Teal Slough marsh. Juvenile Chinook salmon abundance in the Teal Slough marsh may be higher than at the mouth of Wiley Slough below the tidegate even though these sites are immediately adjacent.

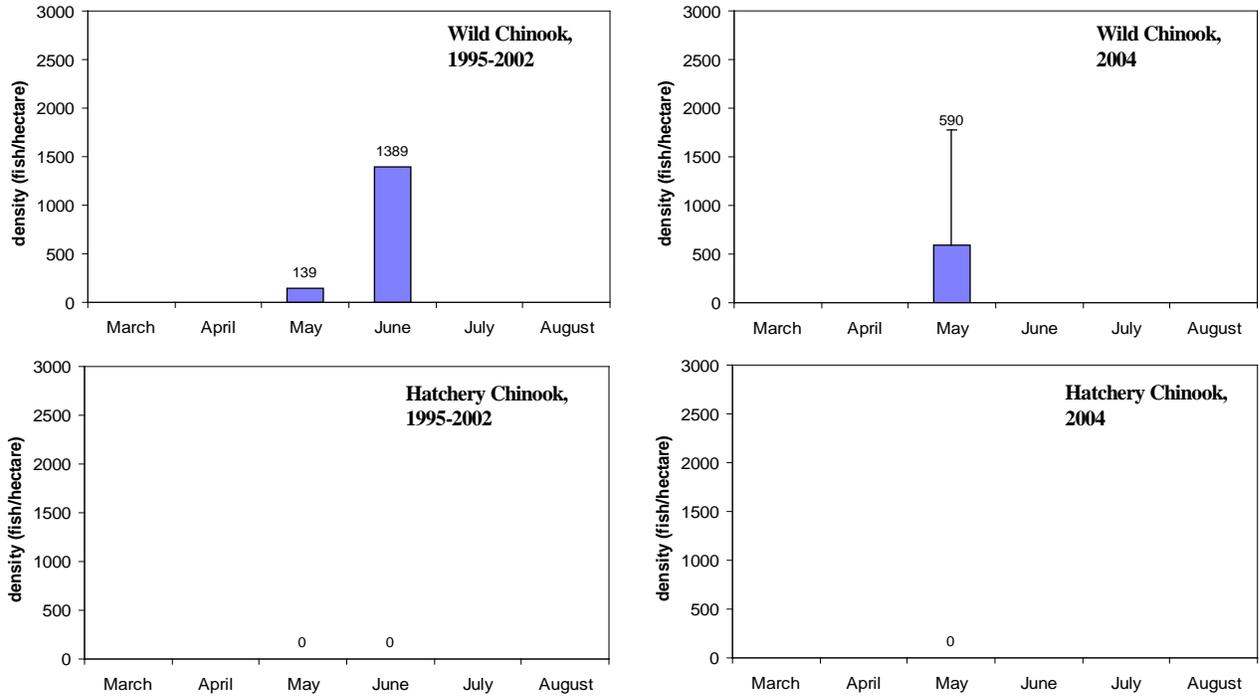


Figure 2.24: Chinook catch in Wiley Slough below the tidegate. Chinook are utilizing Wiley Slough below the tidegate, however, fish densities are lower than south of the spur dike that separates Wiley Slough from Freshwater Slough.

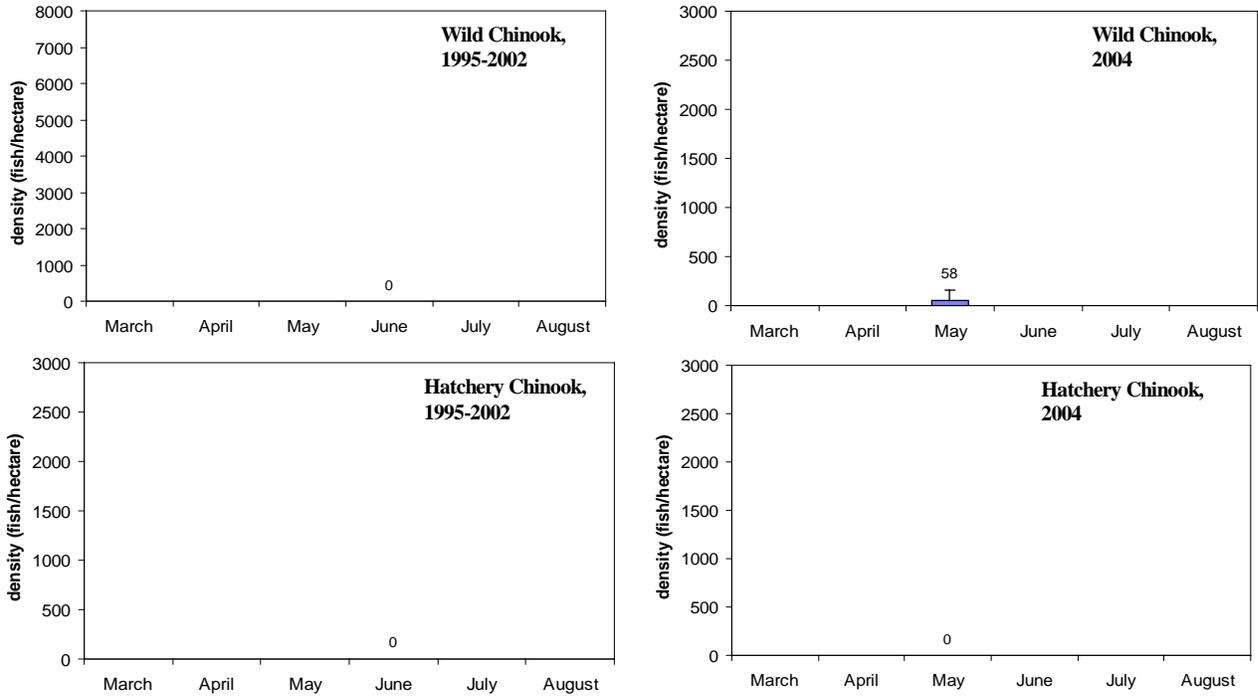


Figure 2.25: Chinook catch in Wiley Slough above the tidegate. Juvenile Chinook salmon were almost completely absent above the tidegate on Wiley Slough..

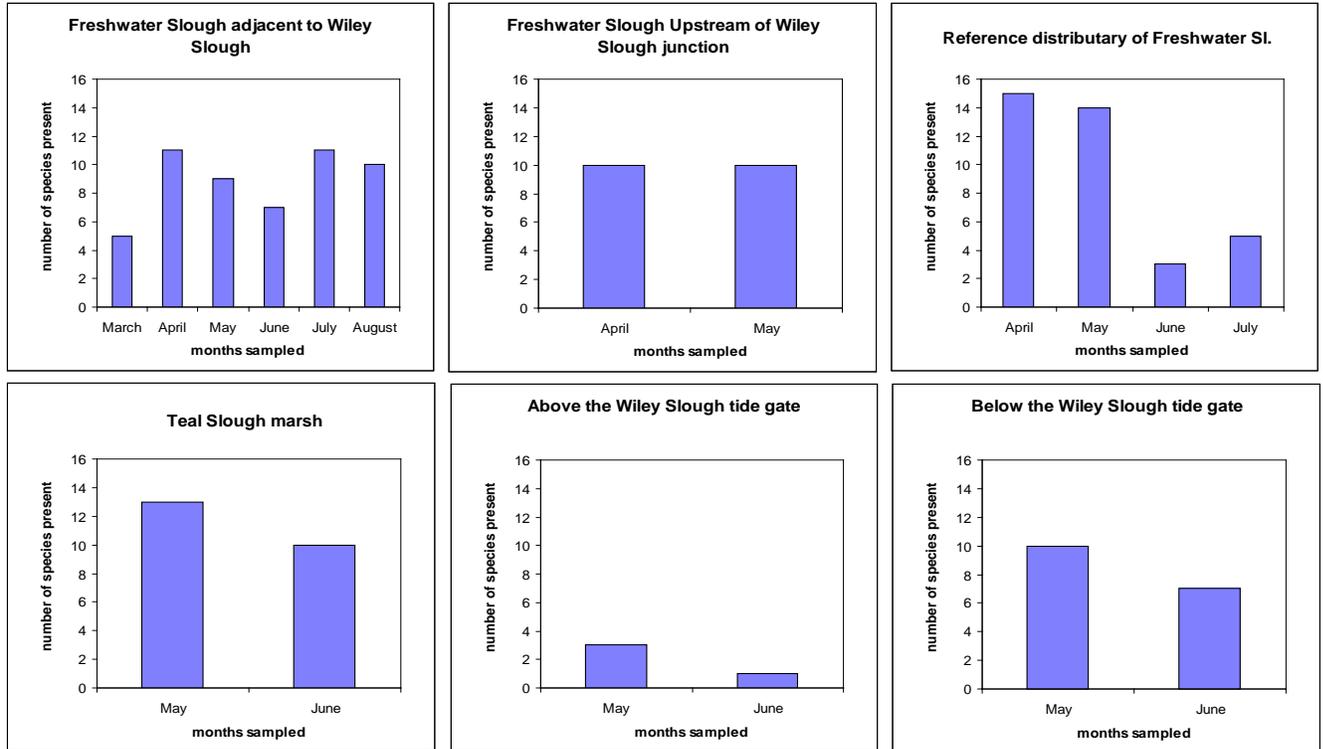


Figure 2.26: Average species richness by month. Species richness above the Wiley Slough tidegate is low compared to all other sites. We found only stickleback plus one juvenile Chinook and one coho salmon. Conversely, species richness in the area below the tidegate and in the vicinity of Wiley Slough is typically about 10 species.

Wildlife Habitat

The Wiley Slough area is primarily managed for waterfowl (i.e., dabbling ducks) and upland game species (i.e., pheasants) by the WDFW. It is also a favored birdwatching area. Thus, this discussion focuses on avian species. Other wildlife species including mammals, amphibians, and reptiles were not examined as a part of this design report.

Much of the information provided here is based on waterbird surveys of the Wiley Slough area that were conducted as part of a larger study examining habitat use by waterbirds in estuarine and agricultural habitats in the Greater Skagit-Stillaguamish River Delta (Slater 2004). This project was conducted from February – May in 2003-2004, from the end of the hunting season through spring migration in each year. The Wiley Slough area was censused during both a high and low tide in each of four sampling periods.

In general, low and irregular waterbird use was observed in the Wiley Slough area. Waterbirds were more abundant in adjacent emergent marsh habitats. Vegetation in the Wiley Slough area is mostly agricultural, consisting of grain crops planted to attract waterfowl, with some deciduous woodlands along dike margins. The most numerous taxa were dabbling ducks, including the four most abundant species in the area: mallard (*Anas platyrhynchos*), green-winged teal (*Anas crecca*), northern pintail (*Anas acuta*), and american wigeon (*Anas americana*). However, ducks

were only observed when standing water was present on the fields, and this varied considerably between years. For example, in 2003 a total of sixteen ducks were observed over the 8 censuses, all of which were mallards. In 2004, when heavy rains in late winter and spring kept many fields flooded into late March, over 600 ducks were counted, and all four species were present. Aside from killdeer (*Charadrius vociferous*), an upland specialist, no wintering or migratory shorebirds were detected, and no goose or swan species were observed using the area. However, in other surveys on the wildlife area, large flocks of dunlin and western sandpipers have been observed in the spring when there is standing water in the fields (R. Canniff, J Garrett, Pers. comm)

Waterbird surveys were not conducted at night or during the hunting season when grains from agricultural fields were available. Dabbling duck use of the Wiley Slough area is likely greater during winter nights because they can access agricultural foods without being hunted. Foods may also be accessed more easily at this time because the area is usually intentionally flooded. The field surveys show that waterbird abundance on agricultural fields was strongly correlated with standing water. However, information on waterfowl use of natural estuarine habitats during winter nights is also lacking, so it is unclear whether waterfowl preferentially select agricultural habitats, or if they utilize agricultural areas in proportion to the total habitat (i.e., estuarine and agricultural) available.

WDFW reports indicate the Wiley slough area is heavily used by waterfowl species in the fall and winter especially during evening hours. Agency sources stress the need for plentiful high energy carbohydrates to supplement the diet of depleted migratory flocks (L. Leshner, J. Garrett, A. Kendall, Pers. Comm.). An exhaustive literature search of research supporting this management strategy was not conducted as a part of this project but sources indicate that studies on feeding habits and energetics is currently being conducted by Ducks Unlimited in the Skagit and Fraser River deltas (A. Kendall, Memo to WSDT May 5, 2005.)

The riparian habitat on the Wiley slough area is important for wintering passerine birds. Many bird watchers are drawn to the site because of the variety of birds that can be seen in this area and there are often species that are out of their normal range.

Infrastructure

The project site is used extensively by recreational interest groups. Interest groups include those involved with hunting (Waterfowl and Upland Bird), bird watching, running, trail walking and boating access. To accommodate these public uses the site has two separate parking lots. The eastern lot is approximately 100 X 150 and capable of handling 30 to 35 passenger vehicles if trailers are not present. The Western lot is approximately 100 X 100 and capable of handling a 25-30 vehicles. Each lot has bathroom facilities. The Western lot is generally more developed, having an ~ 2,200 square foot covered shelter area used for exhibits and presentations, a phone and reader board for site postings. The Eastern lot services a semi-developed boat launch. Both locations have access points to the levee system that serves as a loop trail.

In addition to these features, a 10 acre portion of the site serves as the “headquarters” facility for the Skagit Wildlife Recreation Area. Within this area, that is off limits to the general public, there is a portable trailer used for office space by the area manager, additional parking for 8-10 work vehicles, tractors and implements, the residence of the Area Manager, an ~ 2,700 square foot out building used as a shop, garage, and general storage facility, and net pens used to hold upland game birds prior to release. These amenities are shown in [Figure 2.27](#).

These respective features are described in greater detail in Chapter 3 “Design Elements”



Figure 2.27 Headquarters Infrastructure (Western Portion)

Drainage

As discussed earlier, agricultural drainage with respect to this project is considered a significant design element. Therefore, the design team made a particular effort to describe the agricultural drainage system that relies on the historic Wiley channel in as much detail as possible.

The primary elements of the drainage system are an intricate network of ditches that collect and convey water to either a pump station or tide gate that then discharge effluent water to associated water bodies such as the river or bay. In the case of Wiley Slough an extensive ditch network

covering over 1/3 of Fir Island conveys waters to the relic channel of historic Wiley Slough. This effluent is then discharged via a series of 6 tide gates into the neighboring bay front during low tides. This system is also fitted with a pump station that serves as backup during periods when the system is overloaded. Elements of the existing drainage network are described in detail below.

Drainage network

Watershed boundaries for the drainage area delivering to Wiley Slough were delineated based on available topographic information generated from a 2002 LIDAR flight over the project area, and discussions with local residents and drainage district managers. From this information, and using GIS software, a flow accumulation model was generated by project hydrologists. This model estimated that as much as one third of the runoff from interior areas of Fir Island drain south to Wiley Slough and through the project site. Accordingly, an interior runoff boundary condition was required to evaluate what impact this drainage would have on the relocated tide gate structure. Given the flat topography in the agricultural areas surrounding the project site, design water elevations were determined to be the appropriate boundary condition instead of a runoff discharge. This assumption was made because if a significant flood-causing runoff event were to occur on Fir Island, levee demolition would be the likely solution to alleviate interior flooding and this would limit the maximum interior flood elevations. Consequently, a set of three design water elevations, representing ponding behind the proposed Wiley Slough tide gate structure were developed (Table 2.4):

Table 2.4 Summary of Freshwater Slough Stream flow Estimates

Inland Drainage Scenario	Water Level, feet (NGVD29)
Flood	1.0' (full culvert)
Partial Flow	-1.5' (partially-full culvert)
No Flow	-4.0' (culvert invert)

Note: Assuming a 5' circular tide gate.

1. The “flood” condition represents the worst interior runoff scenario and was used to evaluate the culvert capacity.
2. The “partial flow” condition represents a more typical runoff scenario.
3. The “no-flow” condition represents typical dry conditions where little or no runoff passes through the tide gates. This scenario was used to evaluate sedimentation in Wiley Slough immediately downstream of the tide gates because it produces the lowest channel velocities.

To check these design assumptions, a simple drainage basin rainfall-runoff model was developed to estimate peak runoff rates and volumes at the relocated tide gate structure. The SCS unit

hydrograph method was employed using an approximate delineation of the portion of Fir Island draining to Wiley Slough using available USGS contour maps. During a small flood event (2-yr), peak discharges were predicted to be 85 cfs. During more extreme rainfall events (10-yr), the estimated peak discharge increased to 175 cfs. Given the full flowing capacity of the culverts is 310 cfs (see below, Section IV.4), which would produce a higher head than the 175 cfs estimated by the rainfall runoff model, the interior drainage assumptions listed above in [Table 2.4](#) appear to be somewhat conservative yet appropriate.

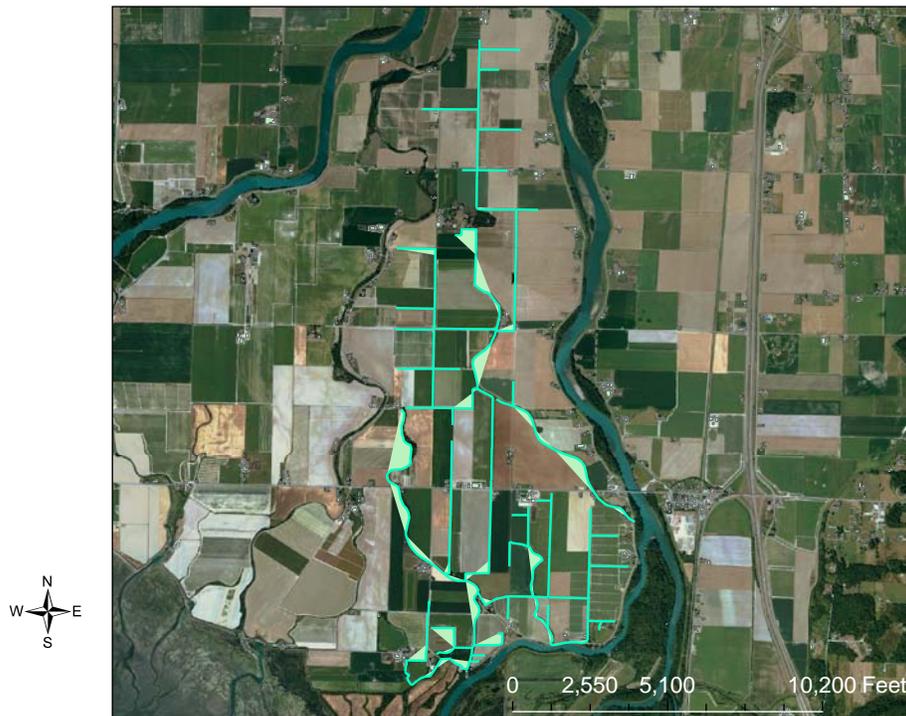


Figure 2.28. Wiley Slough Drainage Network

Historic Wiley Slough

Because of its central role in the conveyance and capacity of the entire drainage network Wiley Slough was examined in greater detail than the drainage system as a whole. To estimate channel plan form and capacity, a field survey was conducted by the Skagit Fisheries Enhancement Group.

Methods Slough elevations were surveyed on August 16 and 17, 2004, using a Topcon level on a tripod, a metric stadia rod, metric measuring tape, and a canoe. The Topcon was set up near the top end of Wiley Slough and referenced according to the existing benchmark along the dike. The benchmark has a red hub with the #34.76. As the survey progressed down the slough, the Topcon was moved at several turning points that were marked with stakes tied with orange ribbon. A backsight and foresight

was recorded at each turning point prior to moving the tripod and Topcon. A surveyor in a canoe took measurements of the main slough channel at 25-meter intervals for the entire length of the slough (1,670 meters). Horizontal distance was measured with a 200-meter fiberglass measuring tape. Elevations were taken mid channel to the top of the mud and then to the bottom of the channel (bottom of the mud). Water depth was also recorded. The water depth represents the depth of water from the surface to the top of mud. Longitudinal data is presented in Figure 2.29.

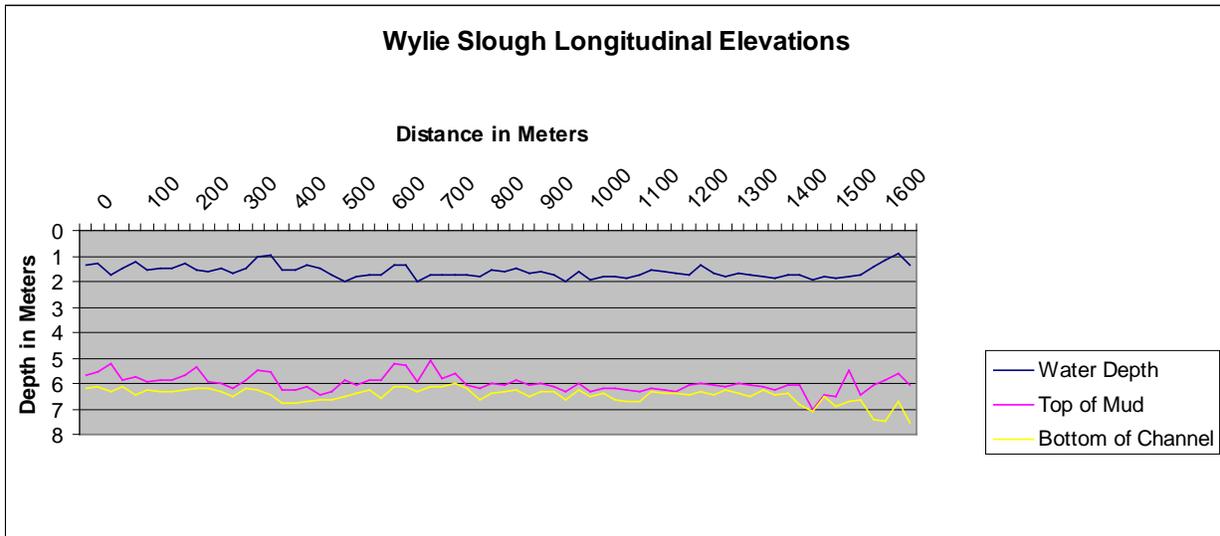


Figure 2.29 Longitudinal Profile of Historic Wylie Slough Channel inside the Levee

Pump Station

The pump station facility on the Wylie Drainage system is comprised of a single 70hp pump motor drawing from a 24-inch intake. This station is located at the historic inlet to the Wylie slough complex which is near the present day boat ramp.

Tide gates

The current tide gates, which are located in Wylie Slough along the western levee consist of four 52-inch culverts and two 48-inch culverts. Assuming full pipe flow, the total capacity of the combined culverts is approximately 250 cfs. The daily conveyance volume through this structure during a typical diurnal tide cycle (with a MHHW elevation of 5.76-feet, NGVD), assuming a fixed upstream water surface of 2.5 feet (NGVD29), is roughly 155 ac-ft over a 24-hour period.

Performance

Methods: Drainage performance is described here as two essential elements, capacity and conveyance. Capacity estimates were derived by delineating the watershed being drained by the Wylie Slough corridor and identifying the various waterways that delivered water to the tidegates at the Wylie outlet. Once the various waterways were identified each was given a nominal ranking based on its connectivity to other ditches within the network. For example, if a ditch was a blind

ditch with no other ditches entering it was given a rank of “1”. If two blind ditches flowed together into one ditch this waterway was given a ranking of “2”. When two number “2” ditches connected the subsequent waterway was given a ranking of “3”. Only when two waterways of the same type intersected was the next nominal order assigned to the subsequent waterway.

For each of these nominal categories a field survey was conducted on a representative waterway to estimate channel planform for that particular class of waterway. Volume estimates were then generated from these estimates by applying them to the length within each class as measured from GIS data layers. The total volume estimates for each class are shown in Table 2.5.

To estimate conveyance, flow measurements were taken from a total of eleven culverts after specific rain events. These measurements took place from June 2004 through October 2004. The first group of culverts is a set of three at the WDFW compound parking lot. The second group of culverts is also a set of three pipes under the entrance road to the compound and boat launch. The seventh pipe is located under Mann Road. The next two pipes are under Wylie Road. The tenth culvert (a box culvert) is under Fir Island Road, and the last culvert lies under Polson Road. [Table 2.5](#) provides information on the size and location of each culvert. Data collection locations are shown on [Figure 2.30: Flow Monitoring Stations](#). The flows were captured during low tide events by inserting a Swoffer flow meter at the downstream end of the culvert in approximately half the depth of the water. The water depth in the culvert was then recorded. (This was not recorded during the first month of data collection). All velocities were recorded in meters per second. Velocity data is contained [Table 2.6](#).



Figure 2.30 Flow sampling stations.

Table 2.5 Wiley Slough Flow Data Locations.

Crossing ID	Culvert Dimensions	Type	Location
1	1 x 9.8	cmp	compound P1 west
2	1 x 9.8	cmp	compound P2 middle
3	1 x 9.8	cmp	compound P3 east
4	1.5 x 17.7	bcp	reserve entrance P1 south
5	1.5 x 17.7	bcp	reserve entrance P2 middle
6	1.5 x 17.7	bcp	reserve entrance P3 north
7	2.5 x 15.3	cmp	Mann Rd
8	1.5 x 11	crp	Wylie Rd south
9	1.5 x 11	crp	Wylie Rd north
10	2.5 x 13	cbox	Fir Island Rd
11	1.5 x 16.8	crp	Polson Rd

cmp – corrugated metal pipe

crp - concrete round pipe

bcp - black corrugated pipe

cbox - concrete box

Chapter III

Design Considerations & Criteria

The project was evaluated in relation to distinct design elements that are related to the primary and secondary objectives listed in Chapter II. The distinct design elements are as follows:

- Levee Setback & Deconstruction
- Tide gate Relocation
- Agricultural Drainage
- Channel Reconnections & Borrow Pit Management
- Headquarters Infrastructure, Which Includes:
 - Boat Ramp
 - Trails
 - Parking facilities
 - Roadways

Each of these design elements was evaluated using an alternate footprint that first maximized the projects primary objects, while attempting to reconcile secondary objectives.

Levee Setback & Deconstruction

Design Development

Element Goal

Restore natural tidal and riverine flooding to the site (Objective 1); maximize sheet flow as well as channelized flow to encourage redevelopment of small tidal channels (Objective 2) and sheet flow exchange of nutrients, fish, and other material (Objective 1).

Constraints

[1] Need to protect adjacent farmland from flooding; [2] need to build project cost effectively.

Criteria

[1] Remove dikes that have greatest potential to interfere with tidal and riverine flooding, tidal channel development, and movement of water, fish, nutrients and other suspended materials; [2] Leave dikes least likely to interfere with riverine and tidal hydraulics.

Proposed Actions

1. Remove all exterior dikes except
 - Dike section along upper Wiley Slough between proposed new tide gate location and boat ramp—may be reinforced if necessary. Not restoring this uppermost portion of Wiley Slough will avoid various impacts to adjacent land owners, e.g., [1] avoid having to obtain an easement from the adjacent landowner to build a dike on the landward side of Wiley Slough; [2] maintain storage capacity in Wiley Slough for waters draining from farmlands; [3] keep an existing pump house in its present location; and [4] avoid impacts to the WDFW Skagit Wildlife Management Area headquarters.
 - Freshwater Slough dike section at river bend. This section of dike is on a depositional (low energy) bend of the river, so river influence on this dike will likely be minimal over the next 5-6 decades.
 - The spur dike, which will only be breached at the sites of 4 historic channels based on 1937 photos. The spur dike does not prevent daily tidal flooding of the marsh, though it may be affecting sediment transport from Freshwater slough to marshes on the north side of the dike. The breaches will allow some riverine influence to extend north of the spur dike.
2. Remove the interior dikes which border the lower portion of Wiley Slough. This allows Wiley Slough to resize and meander after riverine discharge and tidal prism are restored to the channel. It also allows tributary sloughs to reconnect to Wiley Slough and develop into a drainage network.
3. Construct new dike along north property line adjacent to Wiley Farm to protect farmland from tidal flooding and facilitate public access to the restored marsh. And reinforce the existing levee system in those places that will be remaining.

Uncertainties

Three significant uncertainties exist. The first focuses on what is referred to as the central, or “spur” dike. Before the outer levee was constructed and the levee system moved bay

ward in the later 1950's, this spur dike was erected to facilitate drainage throughout the Wiley Slough corridor. Aerial photos suggest that much of this central dike was constructed of material borrowed from dredging Wiley Slough itself and from the adjacent marsh. Representatives from the local Drainage District have communicated to the project team the importance of this "spur" dike to the drainage system even in modern times (Dike District #22 Commissioners meeting February 2004). District Commissioners clearly articulated the role the spur dike played was in allowing the tidegates to operate during flood events. If this was in fact true the restoration design would need to address this in some manner. Therefore, elements of our data collection and modeling efforts have focused on this key question.

The second most significant uncertainty focuses on the suitability of material within the current levee system for use in the construction of the new levee section along the Northern boundary of the property. A few geotechnical explorations were conducted in an effort to address this particular question.

A third question is related to the stability of the Freshwater Slough meander bend where a portion of the retained dike is located. Historical photos indicate that from 1937 to 1956 this meander bend eroded immediately upstream of the dike segment proposed for retention at the rate of up to 1.26 m/yr. From 1956 to 2000 the erosion rate was up to 0.52 m/yr. The retained dike segment is currently about 75 m from the Freshwater Slough channel. Given historical rates of meander bend erosion, the river could conceivably reach the dike segment in 60 to 140 years, although future erosion rates could differ from historic ones. An additional uncertainty is whether the costs of completely removing the spur dike or the retained Freshwater Slough meander bend would be significant. If not, then their complete removal could be feasible.

Summary Statistics

(approximate measurements)

Keep	3,750ft	[1,143 m]
Remove	8,515ft	[2,595 m]
Reinforce	2,570ft	[780 m]
Construct	2,840ft	[865 m]

Element Evaluation

Geotechnical Field Explorations

Subsurface conditions along the Northern boundary of the site were explored by completing three borings and three test pits on March 8 and 9, 2004. The borings were completed using a track mounted M-55 drill rig and the test pits were completed using a rubber tire backhoe both subcontracted to GeoEngineers, Inc. The approximate locations of the explorations are shown in the previous Chapter (Figure 2.10).

The explorations were continuously monitored by an engineering geologist from GeoEngineers, Inc. who examined and classified the soils encountered, obtained representative soil samples, observed groundwater conditions and prepared a detailed log of each exploration. Soils encountered were classified visually in general accordance with ASTM D-2488-90, which is described in the explanation of exploration log symbols shown in [Appendix A: Geotechnical Exploration Logs](#).

The exploration logs are based on interpretation by the field engineer and specific laboratory data from various types of soils encountered. These logs also indicate the depths at which these soils or their characteristics change, although the change might actually be gradual. If the change occurred between samples in the boring, it was interpreted.

Geotechnical Laboratory Results

Representative laboratory testing was completed on selected samples from the explorations. The testing consisted of moisture content tests and percent fines determinations analyses. The results of the laboratory testing are summarized within the boring logs. These logs are included in Appendix A.

Surface Hydrology

Hydraulic analysis of the Wiley Slough project consisted of developing a robust set of hydraulic models that characterize the fluvial and tidal dynamics within the existing and proposed system. The modeling tools were set up in a flexible arrangement such that an evaluation of the likely short- and long-term equilibrium conditions at the site could be considered. With these modeling tools, predictions of flow velocities, water surface elevations and associated estimates of sediment transport and deposition can then be made throughout the project area. Note that sediment transport modeling was not conducted as a part of this analysis; rather sedimentation and depositional characteristics were estimated from the hydraulic parameters provided by the hydraulic models. The following sections describe the development of the models used in the study.

Topographic and Bathymetric Data

Existing topographic and bathymetric data were collected and reviewed to provide input to the hydraulic model setup and site evaluation. Project data were compiled into a spatial database within a GIS (Geographic Information System) by thematic type. This included site aerial photographs, topography and bathymetry for existing and proposed conditions, river discharges, tidal water levels, hydraulic roughness, etc. The marsh plain and tidal slough channel bathymetry data (all in the NGVD29 vertical datum) used in the existing conditions analysis were developed from three sources: 1) bathymetric survey cross-sections of the project site collected by SRSC, 2) an Army Corps of Engineers hydraulic UNET model of the Skagit River Delta, and 3) topographic data for the marsh plain area, originally collected using LiDAR, and provided by SRSC as a 10-foot resolution GIS grid. These three data sets were combined, using the GIS software, to form a single topographic and bathymetric representation of Freshwater Slough, the existing tidal channels and the marsh plain for the entire project site ([See Figure 2.1](#)).

Model Selection

In order to evaluate the complex hydraulic interactions associated with the proposed restoration, a set of two hydraulic models were developed. First, a one-dimensional MIKE-11 model was developed to efficiently simulate the hydraulic response of the project system to a wide variety of stream flow and tidal conditions. Results from the MIKE-11 model were used to estimate slough channel sedimentation, the hydraulic performance of the relocated tide gate structure and hydraulic responses related to the short- and long-term equilibrium conditions of the marsh plain. Secondly, a two-dimensional analysis was performed using a set of two numerical modeling tools; the Surface water Modeling System (SMS) and the River2D software package. The two-dimensional River2D model was developed to evaluate and optimize the hydraulic design of specific project elements such as the boat ramp configuration and sedimentation issues associated with the proposed Freshwater and Teal Slough connection.

1. MIKE-11. A one-dimensional, MIKE 11, hydrodynamic model was constructed to simulate the hydraulic response of the proposed project actions upon the reintroduction of full tidal flushing. Both existing and predicted future conditions (short- and long-term) were analyzed using a number of streamflow and tidal conditions as boundaries. The MIKE-11 model network schematic (Figure 3.1) was developed for the project site using existing and historic aerial photos and the composite topographic/bathymetric data layer. The network was developed to mimic the expected flow paths through the restored slough channels and across the marsh plain. A total of sixteen channels, interlinked by 45 branch connections, and characterized by 134 cross sections, were constructed to describe the slough channels and marsh plain system. Additionally, each channel was made up of a number of cross-sections developed from SRSC survey data and extended using the composite topography/bathymetry layer for the marsh plain area. Figure 3.1 shows the location and extent of the network and cross-sections used in the model, superimposed atop the channel network and a recent aerial photograph.
2. Surface Water Modeling System (SMS) and River2D. SMS is a comprehensive multi-dimensional hydraulic modeling environment that supports pre- and post-processing of 2-D finite element surface water models. For this project, SMS was used to create the finite element mesh and assign physical characteristics, including roughness and bathymetric elevation, to each grid cell. The resulting computational mesh was then exported from SMS into the River2D program using Excel. River2D (Scheffler and Blackburn, 2002) is a finite element two-dimensional model that calculates depth-averaged channel and floodplain hydraulics. River2D was selected as the numerical model for this project because of its ability to accurately and efficiently simulate the spatial interactions of fluctuating water levels between the river, the floodplain and the proposed slough channels. Results from the analysis were used to refine the size, location and alignment of several key project elements to maximize hydraulic performance and minimize sedimentation potential.

Model Boundary Conditions

Boundary conditions for both models were limited to; 1) tidal conditions in Skagit Bay, 2) streamflow in Freshwater Slough above the project site, and 3) runoff from Fir Island, each of which are described in detail under [Chapter 2.0 Baseline Conditions](#).

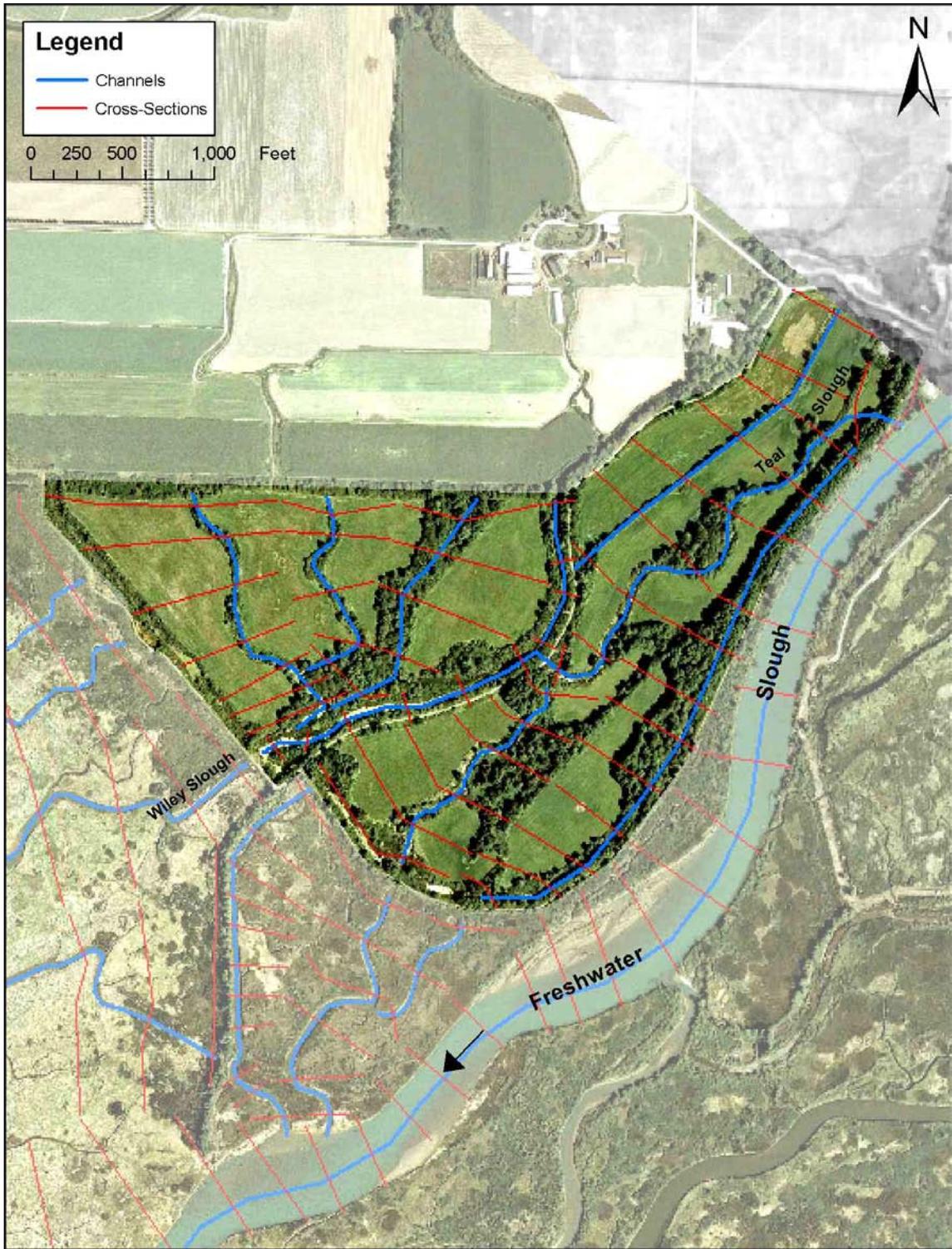


Figure 3.1: Locations of cross-sectional data used to refine model

Existing Conditions Model

An existing condition MIKE-11 model was developed for the project site between the existing levee system and Freshwater Slough to the south and Skagit Bay to the east. Dynamic results from the model show how the current marsh plain west of the existing levee drains and fills with the tides. Without modifications to the existing levee system or tide gate structure, a typical daily tide cycle will not enter the project site. During more significant streamflow events in Freshwater Slough, the constriction created by the spur dike and the high marsh plain elevations on the opposite bank of Freshwater Slough causes upstream water levels to rise higher than the background tides on the west side of the dike. This tendency is illustrated in Figures 3.2 and 3.3. Figure 3.2 shows the actual measured water level difference on either side of the spur dike during a 27,500 cfs (approx. 1-yr) flow in the Skagit River at Mount Vernon and Figure 3.3 illustrates the same trend using predictions from the existing conditions MIKE-11 model for a constant 10-yr flood flow.

Model Verification

A calibration/verification of the MIKE-11 model was performed using water level measurements collected by SRSC at the existing tide gate structure on Wiley Slough, the east side of the spur dike and the Boat Ramp on Freshwater Slough.

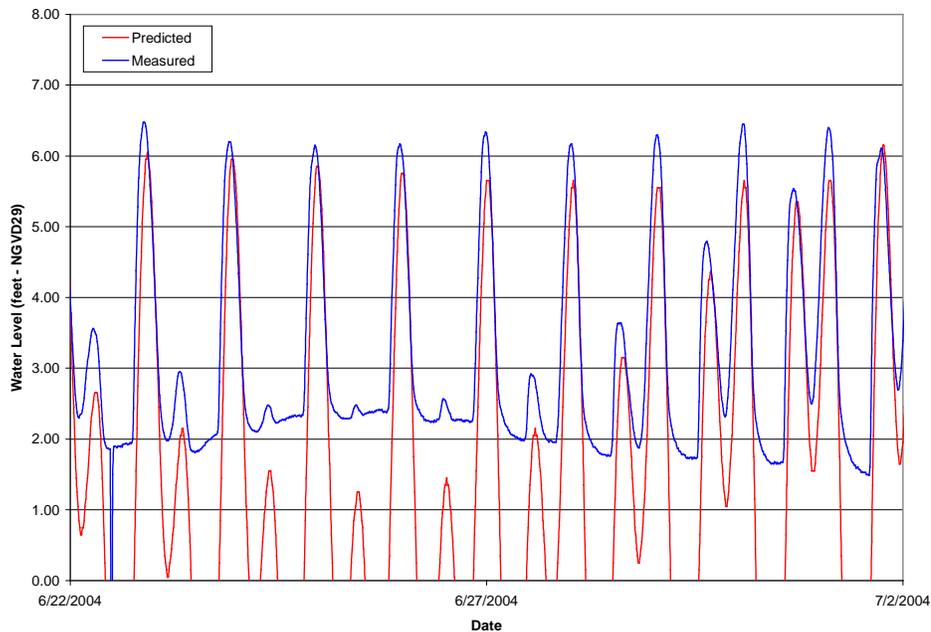


Figure 3.2: Measured water levels at Freshwater Slough side of the spur dike. 1 year flow regime.

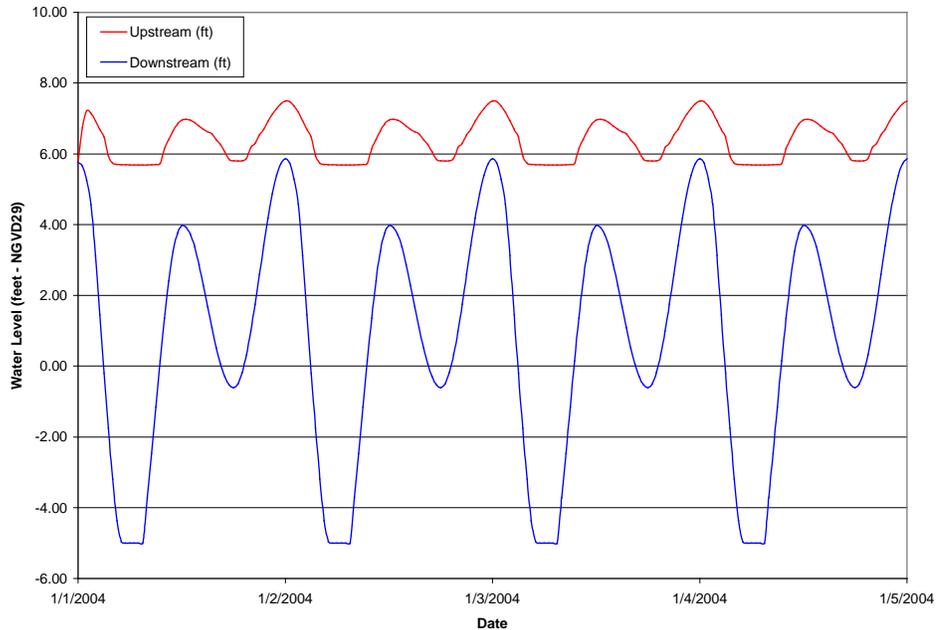


Figure 3.3: Modeled effect of spur dike during a 10 year flood event.

Proposed Conditions Model

A proposed conditions model was developed for the project site assuming both a predicted short- and long-term mature condition for the marsh plain geometry. The objective of this set of model runs was to evaluate the performance of several project components (the slough channel connections, the Wiley Slough backwater area, ponds, the proposed relocated tide gate structure, a breaching scenario and the impact of the spur dike) for the likely short- and long-term site topographic characteristics under a wide variety of tidal and fluvial boundary conditions.

Within tidal marsh systems the succession of slough channel and marsh plain morphology is driven by sediment and hydraulic processes. Such landform-sculpting geophysical process are known to result in fractal landforms (Mandelbrot 1983, Ouchi and Matsushita 1992, Rodriguez-Iturbe and Rinaldo 1997). As the accumulation of fine sediments and organic materials express themselves as specific geomorphic patterns, marsh islands will develop and trend toward a mature condition. Our understanding of fractal geometry allows allometric analysis of tidal channel network geometry (Hood 2002a, b, 2004).

Geophysical processes that give rise to fractal geometry are themselves dynamic in that landscape changes can reshape these processes so that the system remains in flux and tidal marsh succession altered in some way. Some examples of landscape changes in the Skagit include altered sediment inputs and routing as a result of upriver landuse management (e.g., logging, road construction, levee construction, and blockage of cross-island distributaries) to which the marsh system is still adjusting (e.g., accelerated progradation in the North and South Fork marshes, erosion of the bayfront marshes).

Additionally, restoration actions like re-opening Deepwater Slough are also altering

system processes by rerouting water and sediment. And finally, we have experienced about 20cm of sea level rise over the past century and will likely experience an additional 60-100cm of sea level rise in the next century (IPCC 2001).

A theoretical model of morphological succession of tidal marshes in the Puget Sound has been explored by some (Simmenstad, et. al.1996, 2000; Hood, In Review), yet has been largely absent from long term geomorphic or vegetation monitoring strategies (PSNERP, 2003, Hinton, *In Progress*). In the Skagit, long term monitoring strategies have been recently implemented (Hood, 2004 Deepwater Report), Milltown (SRSC, *In progress*), Wiley (SRSC, *In Progress*), Smokehouse (SITC, *In Progress*), but have not been reported or expanded to models of long term geomorphic and vegetative succession for this region.

In the absence of data specific to marsh evolution in the Skagit, HDR hydrologists used existing site topography and conceived improvements (levee removal, channel excavation, etc) to first evaluate hydraulic changes to the site under present day hydrographs. This condition approximates the maximum tidal prism in the project area and consequently results in the highest slough channel velocities. Over time, however, the existing marsh plain and slough channels will continue to evolve and complexity will increase as sediment deposits in the areas restored to the ebb and flood of the tide, causing the marsh surface to rise and tidal prism volume to decrease. Figure XX illustrates this process. Based on the topographic maps of the existing marsh plain, which indicates several feet of subsidence, it is likely that this increase in tidal prism will cause higher levels of short-term erosion, and consequently, channel enlargement at the breach locations should be expected. As a means to control the location and extent of channel enlargement and the overall tidal channel development, low elevation berms created from excess cut material may be considered as a construction element to nudge the restored marsh plain into certain or historic dendritic drainage patterns.

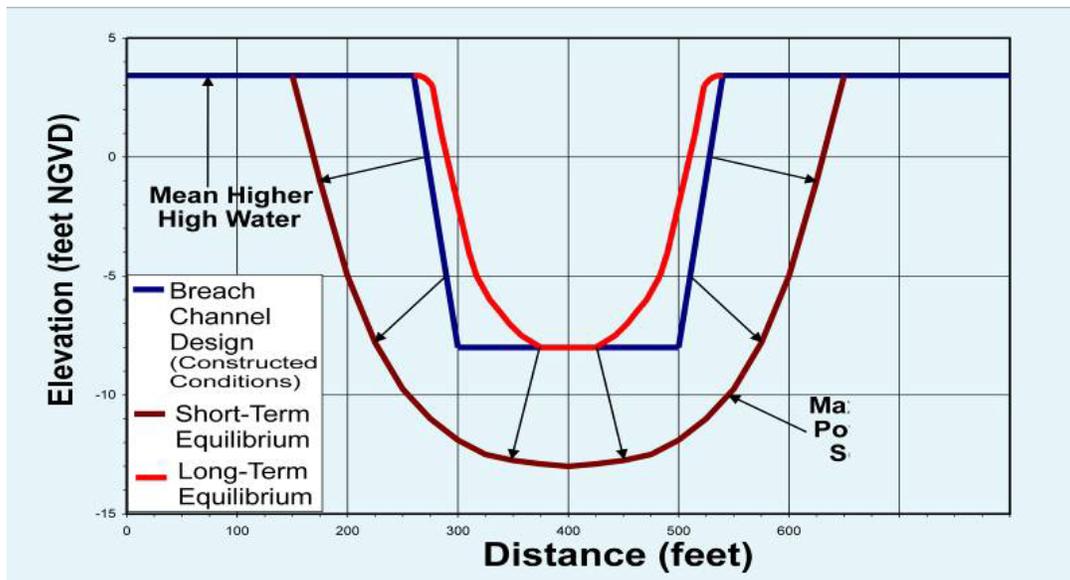


Figure 3.4: Channel evolution schematic.

The Design Team evaluated the conceptual design based on these assumptions. Understanding however, that potential site development will over time find an equilibrium that closely follows the predicted allometric relationships found in reference areas in the South Fork region of the Skagit (Hood, 2000, 2004). This consequently will result in the maximum development of Slough channels commensurate with sustained equilibrium. For example, as the marsh surface rises with sediment accumulation, the tidal prism volume will likely decrease. This would lead to channels slowly decreasing in planform dimensions until an equilibrium was established near the regression line shown in Figure 3.5.

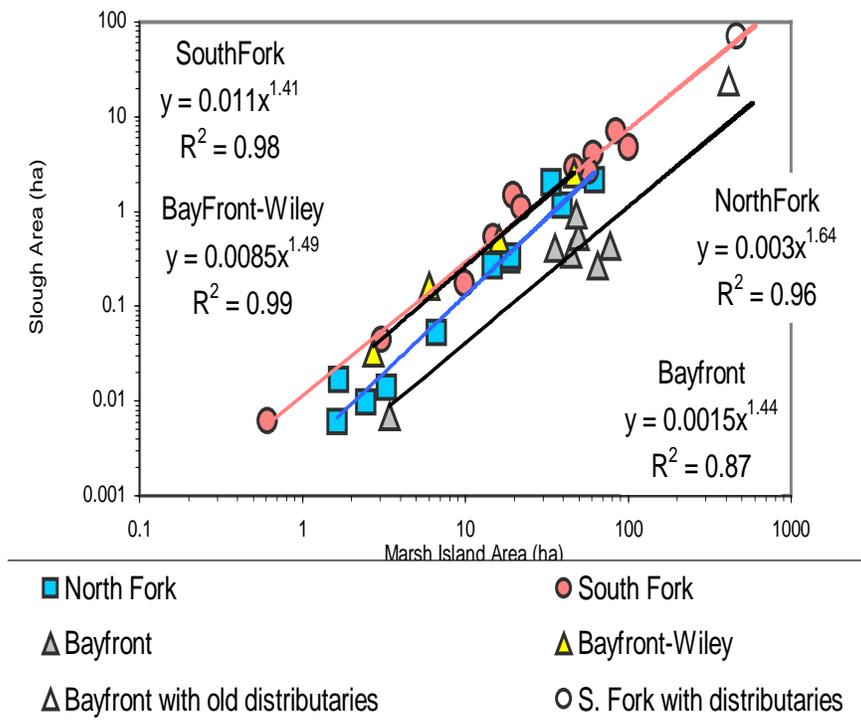


Figure 3.5: Channel equilibrium as predicted by reference marsh regression. Allometric comparisons of tidal marsh islands and the blind tidal channels draining the islands, for the South Fork marsh (stable reference site), the North Fork marsh (prograding delta), and the Bayfront marsh (adjacent to dikes). A distinction is made between two areas of the Bayfront marsh: marsh islands in the vicinity of Wiley Slough (diked between 1956 and 1965) and the rest of the Bayfront (diked circa 1890) (Hood, 2004).

This said, it was still necessary to make predictions concerning the rate of evolution as the marsh plain trended toward the equilibrium described in Hood, 2004. In the absence of site specific data regarding sediment rates and velocities HDR hydrologists utilized a

simplified equilibrium condition estimated and modeled by adjusting the existing cross-sectional data collected by SRSC and The Bureau of Reclamation in 2003, such that the overbank, or marsh plain, elevations match that of adjacent marsh plains not affected by dikes. This was accomplished by assuming the project site would eventually rise to an equilibrium elevation equivalent to the average marsh elevation (4.6-feet NGVD29) from the Deepwater Slough area directly across from the project site. Although this method does not adjust the subtidal slough channel geometry itself, it does dramatically alter the tidal prism and consequently provides a reasonable, yet simple, method for predicting long-term channel velocities and sedimentation potential ([HDR, Appendix A](#)).

Tidegate Relocation

Design Development

Element Goal

Restore fish access (Objective 2) and tidal flooding to the site by removing/relocating tide gates (Objective 1).

Constraints

[1] Adjacent and upstream farmland requires protection from flooding.

[2] Establishing fish passage upstream of the project area will cause concern for private landowners adjacent to Wiley Slough.

Criteria

Remove all site tide gates/culverts restricting flow to the project site. However, project must protect adjacent farmland from flooding and provide drainage at key times of the year (*e.g.* March-June). Conveyance at the gate must remain the same, if not better, than existing conditions.

Evaluated Actions

- Remove multi-tide-gate system at downstream end of Wiley Slough
- Remove tide gate at intersection of Teal and Wiley Sloughs
- Remove any other tide gates and culverts within the project area
- Install a new tide gate at the upstream end of Wiley Slough near the east end of the new north dike.
- The upper end of Wiley Slough will be retained in the existing agricultural drainage system to provide drainage storage for upstream properties. The location and nature of the new tide gate will depend on the calculated drainage storage needs of the upstream properties.

Uncertainties

Storage volumes are not precisely known, so additional construction of detention facilities may be required as supplemental storage. Passage at the newly constructed gates may be required by Federal Law.

Element Evaluation

To estimate the amount of storage capacity being lost to relocation of the tidegates the cross sectional data collected through the Bureau of Reclamation survey was used to make the following estimate. This information was also coupled with data collected by the SFEG on the longitudinal profile of lower Wiley Slough (Figure 3.6). Together these data sets provide a reasonable estimate of agricultural drainage capacity being lost from the current condition.

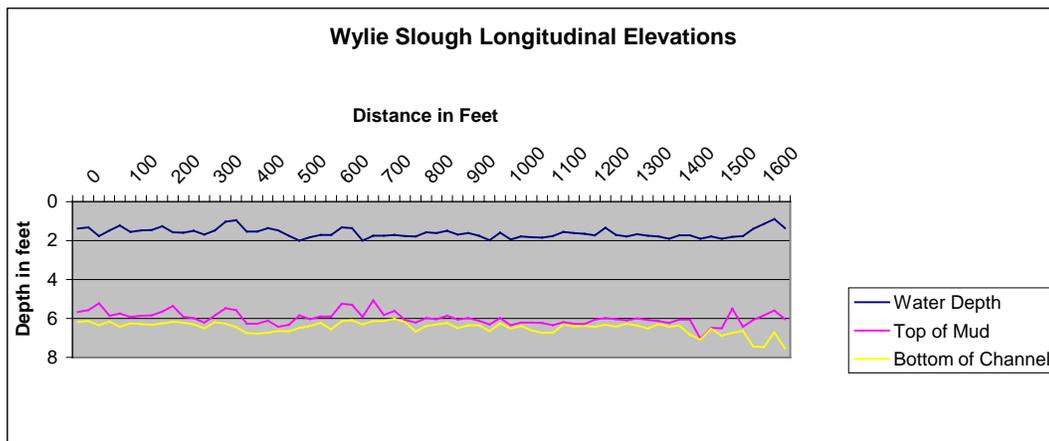


Figure 3.6 Longitudinal data collected by SFEG of Field conditions in Wiley Slough

Estimated Reduction in Agricultural drainage Storage Capacity in the Historic Wiley Channel from project actions (At High Flow)

Average Channel Bankfull width equals	35	feet
Average Channel Bottom width equals	25	feet
Average Depth of Water (High Flow)	5	feet
Trapezoidal area feet	150	square
Length of Channel affected	2540	feet
Estimated Channel Reduction in Storage Capacity	381,000 Or 8.75	cu ft Ac- ft

Conveyance

The present tide gate array was thoroughly evaluated for current condition. Data collected included; existing pipe dimensions, levee height and slope, hydraulic condition above and below the structure, habitat values above and below, fish presence above and below, mean water level, and channel boundary conditions.

Using existing pipe dimensions and tidegate criteria conveyance at the existing pipe is estimated to be less than 250 cfs. ([HDR, Appendix A](#))

Agricultural Drainage

Development

Element Goal

To maintain or improve drainage for agricultural lands on the Eastern half of Fir Island.

Constraints

Limited flow records for the agricultural drainage system. In system constraints are also present such as poorly designed culverts or restrictions in the system that reduces system efficiencies. Long term constraints include prohibition of dredging in estuarine waters.

Criteria

Key elements of the drainage system are flow conveyance and capacity within the system. Capacity is influenced by groundwater interactions and seasonal fluctuations.

Actions Evaluated

- Tidegate relocation
- Tidegate redesign
- Sediment transport below tidegate structure

Summary Statistics

- Estimate of channel capacity lost due to tidegate relocation is approximately 7.2 acre feet.
- Conveyance of existing structure estimated at 155 acre feet over a typical diurnal tidal cycle.

Uncertainties

The two most significant uncertainties are related to the loss of storage capacity and the conveyance of water during flood flow conditions. The design team was uncertain as to the most viable means to replace lost storage capacity. The conveyance of water during flood flows was uncertain due to the question of the spur dike and its role in protecting the tide gate during higher flows.

Evaluation

Hydraulic Performance for Agricultural Drainage

The current tide gates, which are located along the western levee of Wiley Slough, consist of four 52-inch culverts and two 48-inch culverts. Assuming full pipe flow, the total capacity of the combined culverts is approximately 250 cfs. The proposed new design would consist of five 60" culverts, which have a full-flow capacity of approximately 310 cfs. Comparing the performance of the two culvert configurations HDR hydrologists compared the daily conveyance volume through both structures during a typical diurnal tide cycle (with a MHHW elevation of 5.76-feet, NGVD).

Assuming a fixed upstream water surface of 2.5 feet (NGVD29, based on site survey by SRSC, 2003), the total volume of flow passing through the existing culvert configuration is roughly 155 ac-ft over a 24-hour period. Under proposed conditions, this volume is increased to 192 ac-ft, almost a 25% increase. Considering the 7 ac-ft reduction in in-channel storage associated with the levee setback and relocated tide gate structure, the increased culvert size will help to offset that lost storage volume.

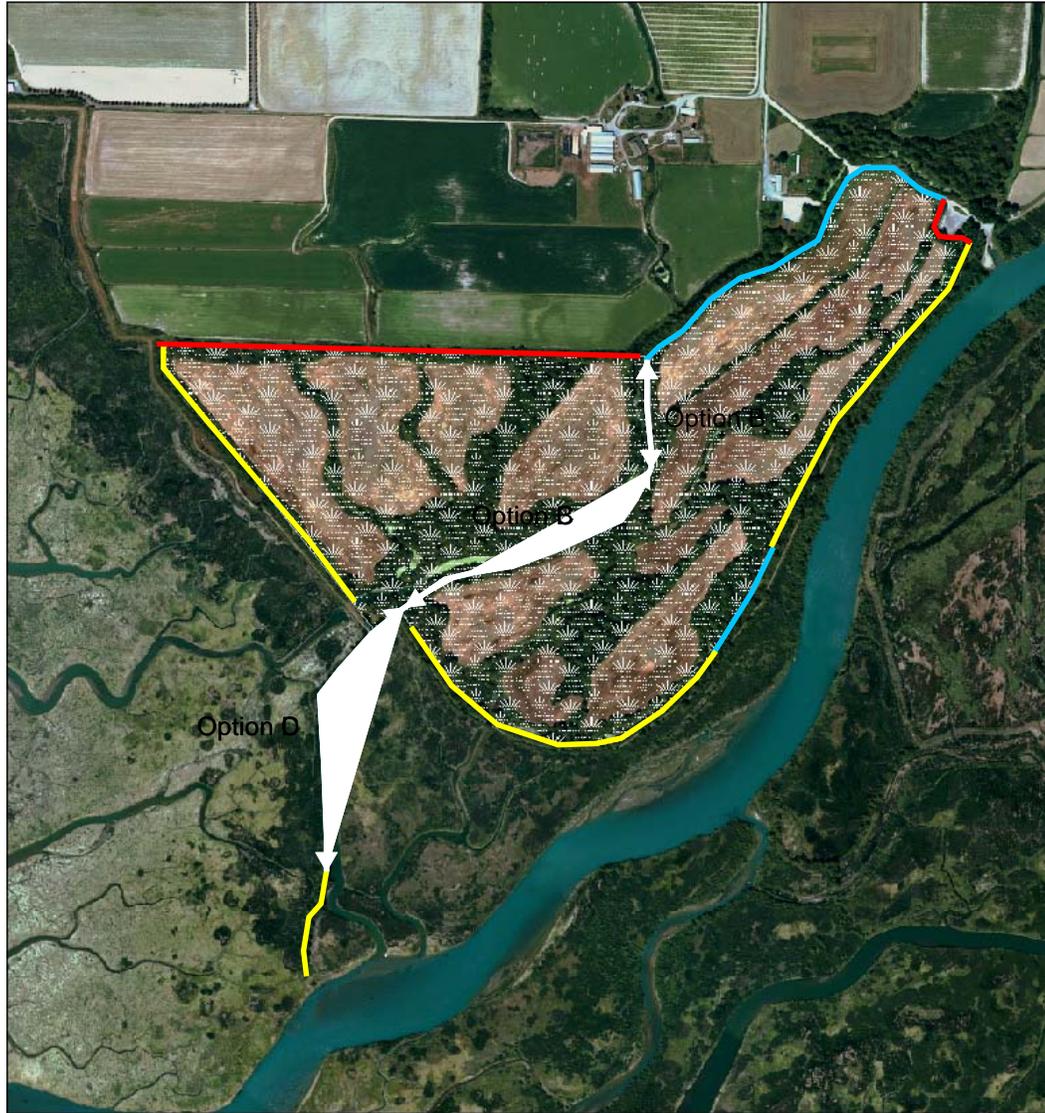
Conveyance at Flood Flows

Evaluation of water level and drainage impacts for various spur dike configurations. A key design element and project objective was to not increase flood hazards to adjacent private properties. Based on several conversations with Dike District Commissioners it was evident that local farmers felt strongly that the existing spur dike protected the tide gates from elevated water levels in Freshwater Slough during flood flows. This protection was essential to allowing drainage of farm fields at low tides even in large flood events. The proposed relocation of the tide gate structure farther inland and essentially upstream

along Freshwater Slough, potentially made the difference between the tide and river water elevations even greater.

To address this issue, a set of four different spur dike configurations were developed by SRSC, in addition to existing conditions, and analyzed using the MIKE-11 model. The five alternatives include 1) a scenario with complete spur dike removal (Option A), 2) a scenario with a small portion of the spur dike retained (~ 1000 feet/Option B), 3) a scenario that retains a moderate length of spur dike extending from the new levee to the present day tide gates (~2500 feet/Option C), 4) a scenario that retains the entire spur dike with the exception of a 500 foot section at the distal end (Option D), and 5) a scenario that retains all of the spur dike. [Figure 3.7](#) graphically illustrates these alternatives.

Wiley Slough



-  Remove dike
-  Build dike
-  Leave dike
-  Restored marsh

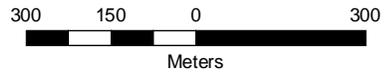


Figure 3.7 Spur dike removal options

Each scenario was compared to a baseline scenario consisting of the existing conditions and using the average diurnal tides and mean annual stream flow as boundary conditions. Each scenario resulted in roughly the same water levels throughout the project site. As larger stream flow events were modeled in Freshwater Slough, however, the results began to differ between alternatives. For example, during a 1-yr flood event, the long spur dike alternative (Option D) fully protects the proposed tide gate structure from high river levels as shown in [Figure 3.8](#). The remaining alternatives do not provide the same level of protection. During more extreme events (the combined 10-yr tides and stream flow), model results for the long spur dike alternative again suggest that the tide gates would remain adequately sheltered from high water levels, consequently maintaining low tide elevations at the relocated tide gate structure and therefore maintaining the ability of the structure to convey interior runoff.

[Table 3.1](#) lists the maximum difference in water elevations between the background tides (MHHW) and the water level at the proposed relocated tide gates. Due to the limited extent of the current modeling analysis, it is difficult to evaluate the impact of the spur dike at more extreme stream flows. That said, once water levels in Freshwater Slough exceed the elevation of the marsh plain to the southeast, the overall conveyance along Freshwater Slough would be substantially increased and the effect of the spur dike would likely be lessened.

Table 3.1 Water Level Difference at High Tide for various Spur Dike Configurations

Scenario ¹	Mean	High	1-yr Flow	10-yr Flow
	Annual Flow	Monthly Flow		
	(feet)	(feet)	(feet)	(feet)
Existing Conditions	< 0.1	< 0.1	<0.1	0.1
Option A	< 0.1	0.3	2.3	7.2
Option B	< 0.1	0.3	0.2	5.5
Option C	<0.1	<0.1	<0.1	0.4
Option D	< 0.1	< 0.1	<0.1	0.1

Note 1: Synthetic diurnal tides were assumed as the tidal boundary conditions for all scenarios

Based on the results above, it can be concluded that the effectiveness of the relocated tide gates to maintain drainage of the inland areas would rely on the longer spur dike alternative to effectively shelter the proposed tide gate structure and maintain positive drainage of the inland areas. As a means to verify this conclusion, water levels measurements collected by SRSC on both sides of the existing spur dike were compared during a higher than normal stream flow event (June 22nd – 30th, 2004, 26,500 cfs.

Roughly a 1-yr event). Figure 3.8 depicts the differences between the predicted water levels and the measured water levels on the upstream side of the existing spur dike.

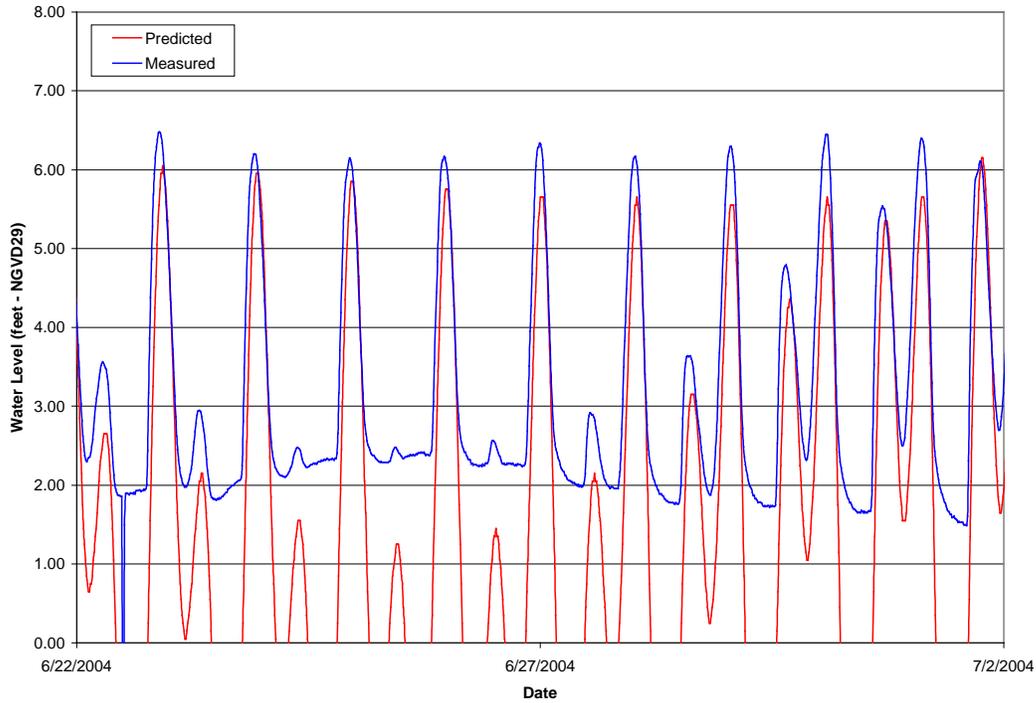


Figure 3.8 Measured Effect of the Spur Dike during a one year event.

To verify these findings in a higher event, SRSC visited the site again on January 20th, 2005, to measure differences during a flood event that measured 69,000 cfs at its peak at the USGS Mount Vernon gauge. At high tide when the river was still rising (64,300 cfs) there was a recorded difference of 12cm (4.72 inches) between the water levels east of the spur dike and those at the Wiley Slough tidegate. At the low tide a reading was taken that demonstrated a 1.2 meter (47.24 inch) difference between the two water levels (Parr, *In progress*). Visual inspection also confirmed the tidegates were draining at these flows. Therefore, this evidence again corroborates the synthetic modeling conducted by HDR.

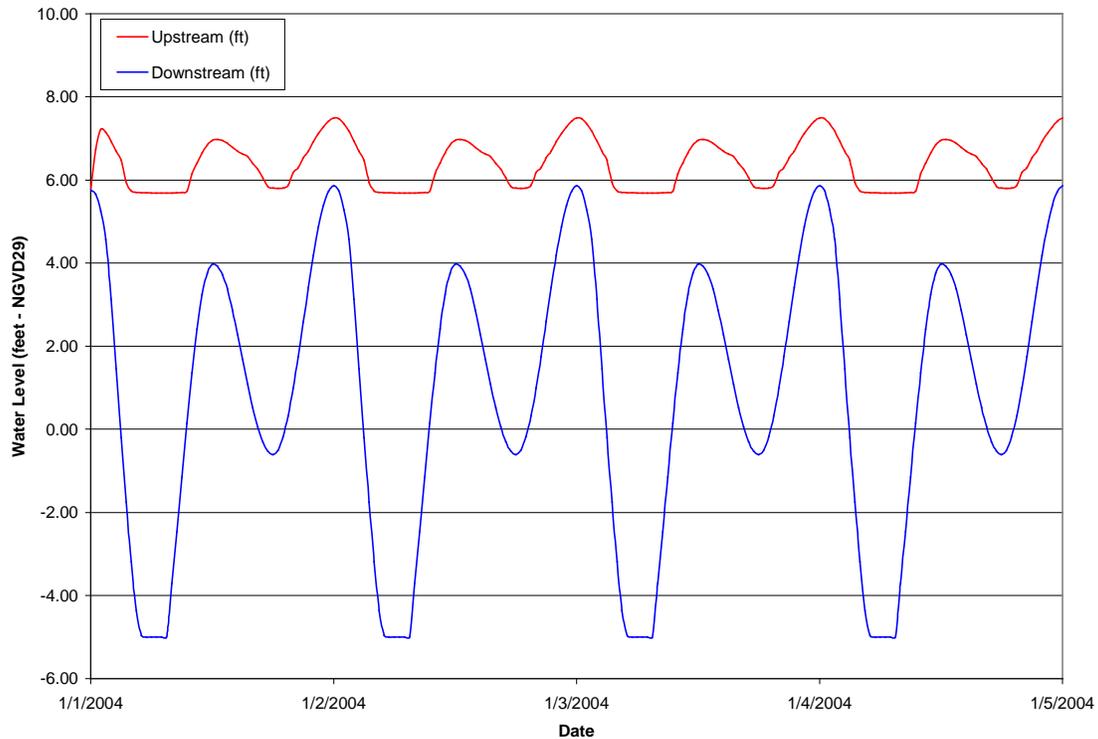


Figure 3.9 Modeled Affect of Spur Dike during a 10-yr Flood Event

Sediment potential at the new tidegate

A sedimentation evaluation was performed to estimate whether or not the backwater area of Wiley Slough would be susceptible to sediment deposition that could adversely impact the carrying capacity of Wiley Slough and potentially exacerbate flooding upstream of the proposed tide gates. Note that sediment transport modeling was not conducted as a part of this analysis; rather sedimentation and depositional characteristics were estimated from the hydraulic parameters provided by the hydraulic models.

In order to assess the sedimentation potential within the project site it was necessary to define the localized soil characteristics. Based on the NRCS soils survey of Skagit County (Figure 2.9) the predominant soil type for the project site and surrounding tide marsh areas is a Tacoma Silt Loam. Silt loams are primarily made up of small-grain silts with a small percentage of fine sands. Based on typical parameters for a silt loam material, a mean particle size of 0.1 mm was assumed for the project site.

In addition to soil characteristics, hydraulic parameters such as channel velocity and bed shear stresses are required to assess sedimentation potential. For this analysis, the average

channel velocity parameter was extracted from the MIKE-11 model for a series of different flow and tidal scenarios. These velocities are summarized in [Table 3.2](#).

Table 3.2 Average Channel Velocity for Backwater Area of Wiley Slough

Scenario		Peak Velocity (ft/s)	Sedimentation Condition
Short-Term Condition	No Culvert Flow	0.06	Depositional
	Partial Culvert Flow	1.0	Erosive/Transportive
	Full Culvert Flow	2.3	Erosive
Long-Term Condition	No Culvert Flow	0.04	Depositional
	Partial Culvert Flow	0.9	Erosive/Transportive
	Full Culvert Flow	2.1	Erosive

Because sediment movement is primarily driven by channel bottom velocities, which are not explicitly calculated in the MIKE-11 model, the Hjulstrom diagram method was used, which provides a relationship between mean sediment size and average channel velocity. The Hjulstrom method provides a graphical approach to evaluate sedimentation potential by defining three regimes; erosive, transportive and depositional ([Figure 3.10](#)). Although this method is relatively simple and graphically-based, it is founded on actual field measurements for a wide variety of sediment sizes. Furthermore, given that more complex cohesive transport equations would at best provide a wide range of sediment deposition and erosions predictions, and that that level of analysis was very much beyond the scope of this project, the above method should serve as a reasonable site-scale assessment of sedimentation potential within Wiley Slough.

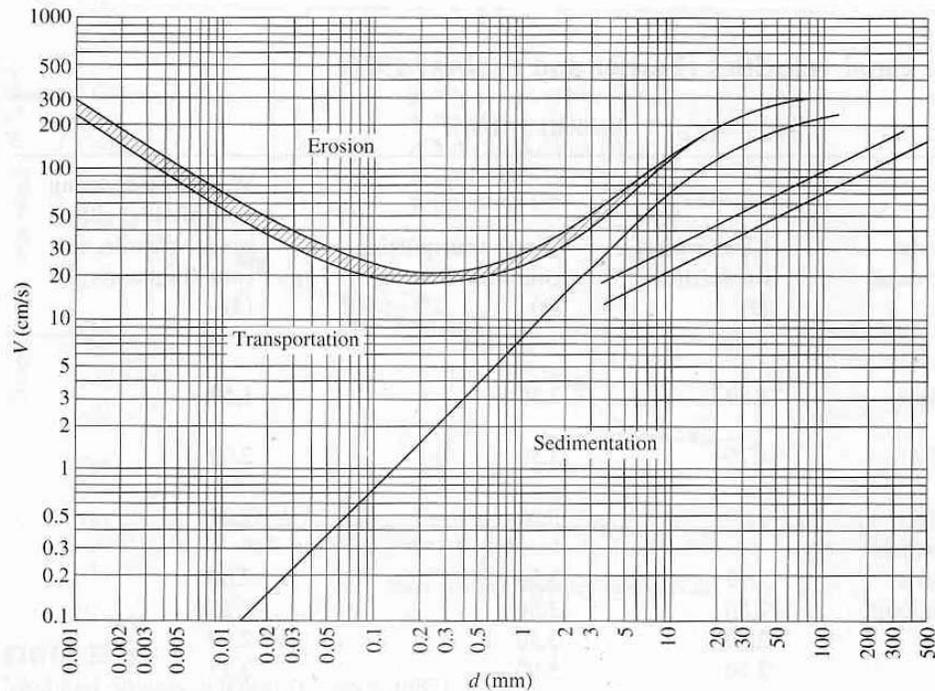


Figure 3.10 Hjulstrom Diagram.

Results during an average diurnal tide with no runoff passing through the relocated tide gate structure presents the lowest channel velocities and represents the worst case scenario for sedimentation. For the short- and long-term marsh plain conditions, the maximum average channel velocities in this backwater area of Wiley Slough are approximately 0.06 and 0.04 ft/s respectively (Figures 3.11 and 3.12). If the larger water level variations of the spring-neap tide condition are considered, the peak velocities increase by less than 10%. If a more typical condition is assumed whereby the tide gates are partially flowing, the maximum velocities in the backwater channel increase significantly to 1.0 and 0.9 ft/s respectively. In an extreme case of inland flooding where the tide gates are assumed to be flowing full, the peak velocities increase to 2.3 and 2.1 ft/s. Therefore, for the “no flow” case, the Hjulstrom diagram suggests that the channel would be depositional. However, if flow is passing through the tide gates, the velocities increase substantially and therefore indicate that the channel conditions would be more conducive to sediment transport, or erosion.

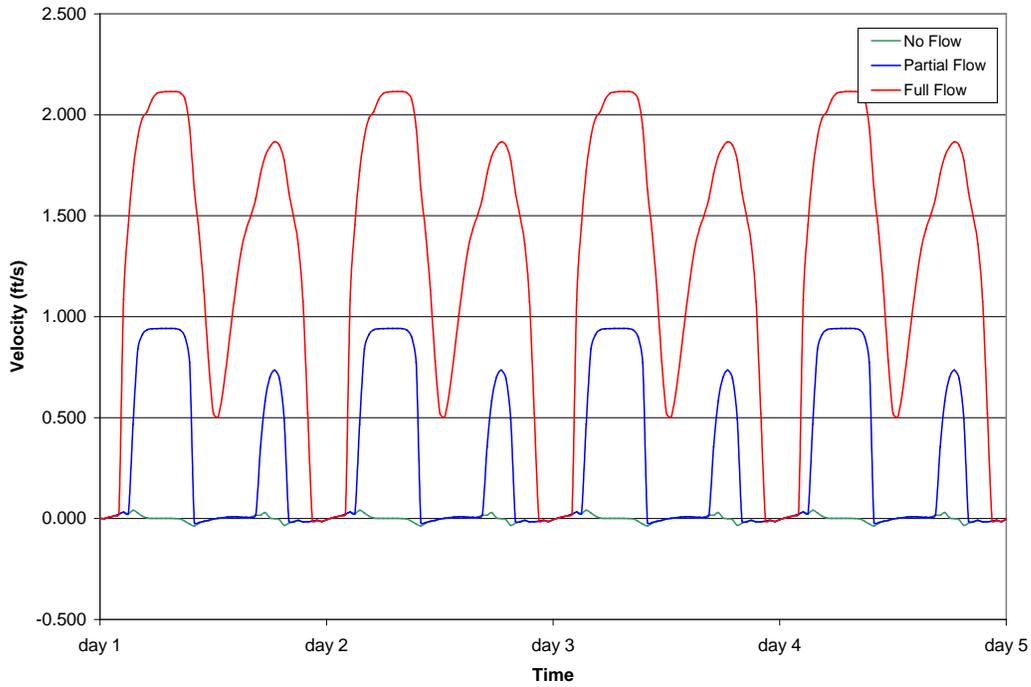


Figure 3.11 Estimated Velocity in Backwater area of Wiley Slough during Long-Term Geomorphic Conditions.

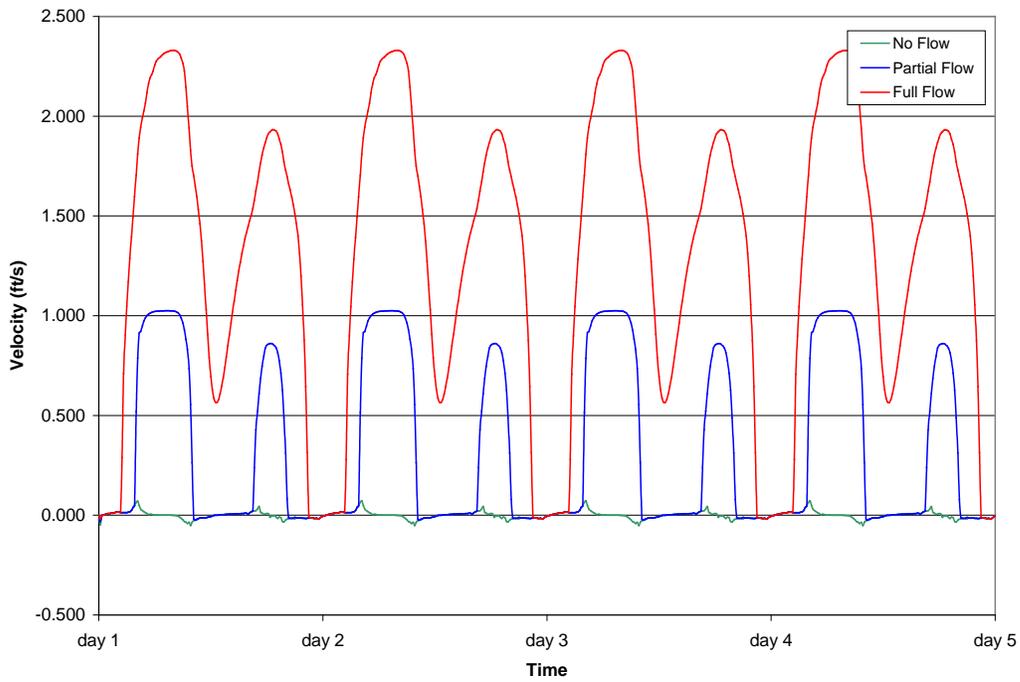


Figure 3.12 Estimated Velocity in Backwater area of Wiley Slough during Short-Term Geomorphic Conditions.

Sediment Potential with Additional Tidal Prism

Results from the initial analysis led the Design Team to question the sustainability of the channel below the tidegate outlet. To address this concern several design alternatives were explored that would increase the volume of water being conveyed by the main channel. The most significant of these being the addition of an impoundment on the bay side of the new levee that would provide additional tidal prism to the channel. This element was conceptually attractive given the desire by some committee members to explore design features that would offset public access components being compromised or altered by the proposed plan. The proposed impoundment offered both additional tidal prism and hunting opportunity in what became known as the “scalloped waterfowl pond” alternative through the design process.

The scalloped pond alternative was evaluated by project hydrologists in relationship to its potential to provide additional erosional energy to the Wiley channel downstream if the proposed tide gates and its long term prospect for sustainability. From a hydraulic standpoint, the inclusion of a scalloped waterfowl pond adjacent to the backwater portion of Wiley Slough was modeled at a size that would provide an increase in tidal prism of approximately 7 acre-feet. Thus, during a typical diurnal tide cycle, more water would pass through the bay side channel of Wiley Slough as it filled and drained the scalloped area. Theoretically, this volumetric addition of water would cause an increase in the average velocity within the channel during the ebb tide, thereby reducing the likelihood of sediment deposition. Additionally, if the connection point between the pond and the channel was close enough to the proposed tide gate structure, increased velocities would be expected along the entire length of the channel and the development of a sediment plug at the culvert outlet would be reduced.

Based on an assumed invert elevation of -0.5 feet (NGVD29) and a surface area of 2.75 acres for the scalloped waterfowl pond and no flow through the tide gates, the enlarged tidal prism would produce increased flow velocities in the backwater channel of as much as 470%. For comparison purposes, the peak flood and ebb tide velocities for the “no flow” conditions without the scalloped waterfowl pond are 0.05 and 0.07 ft/s respectively. For the short-term marsh plain conditions with the scalloped pond, these velocities are increased to 0.47 and 0.41 ft/s respectively (Figure 3.13).

For the long-term marsh plain conditions, it was more difficult to estimate channel velocities because as the marsh plain evolves and rises, the lateral extent and volumetric contribution of the scalloped waterfowl ponds to the tidal prism may be reduced or eliminated, as it could fill with sediment. The committee felt a complex and costly

sediment model could inform this evaluation but lacked sufficient merit for inclusion in this report. Therefore, for purposes of this analysis we assumed the scalloped waterfowl ponds would be maintained in our anticipated long-term marsh plain condition. However, this assumption is considered highly speculative and varies considerably with the inclusion or exclusion of the spur dike feature. If the spur dike remains in place it is plausible for the ponded areas to have a longer term presence on the landscape. Under these assumptions the average velocities during the flood and ebb tides were estimated to be 0.34 and 0.32 ft/s respectively. In both cases, the added tidal prism provides sufficient tidal flushing to increase the velocities to a point where, based on the Hjulstrom Diagram, deposition is less likely and transport would be the dominant regime, with mild erosion of sediments being possible.

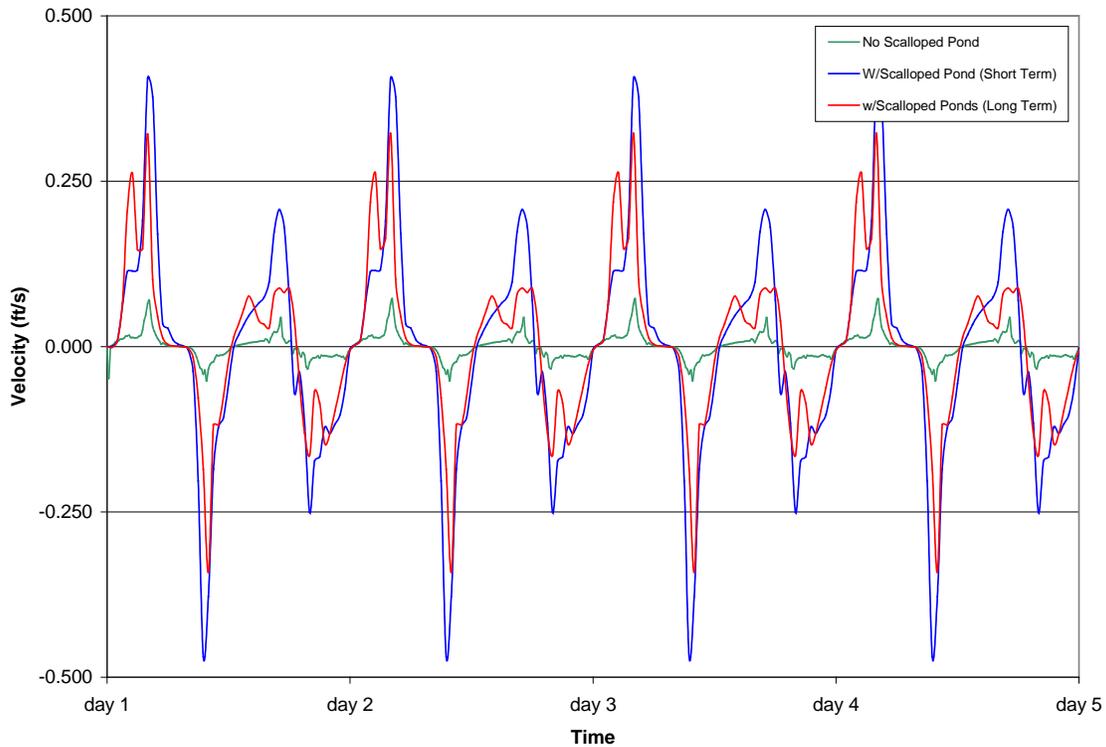


Figure 3.13 Estimated Channel Velocities in Backwater Area of Wiley Slough with and without the proposed Scalloped Waterfowl Pond

Channel Reconnections & Borrow Pit Management

Design Development

Element Goals

Facilitate redevelopment of historical drainage network (objective 2) by

[1] filling borrow ditches that would otherwise interrupt surface drainage, and [2] excavating short channel segments to rejoin disconnected channels, [3] establish a distributary channel by connecting Teal Slough to Freshwater Slough and Wiley Slough

Constraints

Funding limitations require cost-effective actions without compromising restoration objectives.

Criteria

1. Fill ditches that cross current or historic drainage networks and that would therefore disrupt natural drainage (this may have the additional benefit of reducing dike spoil transportation costs),
2. Leave unfilled ditches that run parallel to current or historic drainages where this does not compromise restoration objectives,
3. Excavate to rejoin disconnected channels.

Actions Evaluated

1. Connect Wiley Slough to Freshwater Slough via the historic Teal Slough channel. Excavation will be required to widen the channel in a few places and connect it to Freshwater Slough.
2. Use dike material to fill in most of the interior borrow ditches, except along Freshwater slough – this borrow ditch will be connected to Freshwater slough at its downstream end to become a side channel.
3. Short stretches of borrow ditch will be retained at the northwest corner and the southern tip of the site in order to reconnect internal drainage to existing tidal channels outside of the current dikes.
4. Ignore exterior borrow ditches, because they have been incorporated into the natural tidal drainage network during the last ~45 years.
5. Excavate channel thalwegs to reconnect Wiley Slough, upper Teal Slough, Lower Teal Slough, and three unnamed smaller tidal channels to their original drainage networks. This will occur in conjunction with tide gate removal.

Summary Statistics

Measurements are based on GIS estimates using ERSI ARC map software release 9.0.

- Excavate ~2,200ft [670 m] ~1.40 acres [0.57 ha]
- Fill ~3,470ft [1060 m] ~2.25 acres [0.90 ha]

Uncertainties

Our primary uncertainty is related to the question of the spur dike remaining in place or being removed. Initial design has the spur dike being removed thereby allowing for a distributary connection between the historic Teal Slough and Wiley Slough downstream of the new tidegates.

We are also uncertain as to the temporal scale for redevelopment of historic channels. Will the process occur quickly (within 5 years) or slowly (5-30 years)?

Element Evaluation

Distributary Slough Connection

In an effort to achieve some improvement in the dispersal of juvenile fish throughout the project site project hydrologists modeled the hydraulic performance of a proposed distributary slough channel connection, specifically at the split between Freshwater Slough and Teal Slough. Two distributary alternatives were evaluated.

The Option A examined the creation of a distributary channel between Freshwater Slough and Wiley using the historic footprint of Teal Slough as the channel corridor with a linkage being excavated between the two across the footprint of the central spur dike. In this option Wiley Slough would then be reconnected to both the daily tidal exchange from Skagit Bay and river flow from Freshwater Slough. This connection would also divert a portion of flow from Freshwater Slough west across the project site, thereby allowing migratory fish the ability to disperse more readily to the marsh islands to the West.

Under this scenario, the size of the excavated channel would initially dictate how much water from Freshwater Slough can pass through the project site. We would expect that over time, the erosive nature of the diverted flows would likely continue to adjust and shape the size of the flow split until an equilibrium condition is achieved. Rather than engineering this local connection in great detail we instead used a simplistic, yet suitable method for estimating the cross-sectional geometry. Our reference condition was the estimated planform of the historical Wiley Slough distributary channel. Based on the 1938 aerial photograph, the top width of the Wiley Slough connection point is approximately 45 feet. A second dimension needed to approximate the cross-sectional

area is the invert elevation, which was assumed to have the same invert elevation as the neighboring Freshwater Slough (approx. -3.5 feet, NGVD29). If a parabolic cross-section is assumed, then the channel area below 4.6' NGVD29 (the average elevation of the surrounding marsh plain) would be approximately 250 sq-ft.

In addition to the channel cross-section area, it is equally important to establish the location and orientation for the flow split in a way that takes advantage of the localized velocity distribution of Freshwater Slough. In order to establish this configuration, results from the River-2D model were utilized. Figure 3.14 illustrates a typical velocity distribution in Freshwater Slough during an ebb tide. It is apparent that due to the meandering nature of the channel, the peak channel velocities in the reach of Freshwater Slough adjacent to the project site are located along the outside of the meander bend. This characteristic lends itself to locating and orienting the proposed channel connection point in a streamline configuration that can more readily accept diverted flows. Moreover, an additional advantage of locating the connection point on the outside of a meander bend is related to sedimentation and maintaining a sustainable opening.

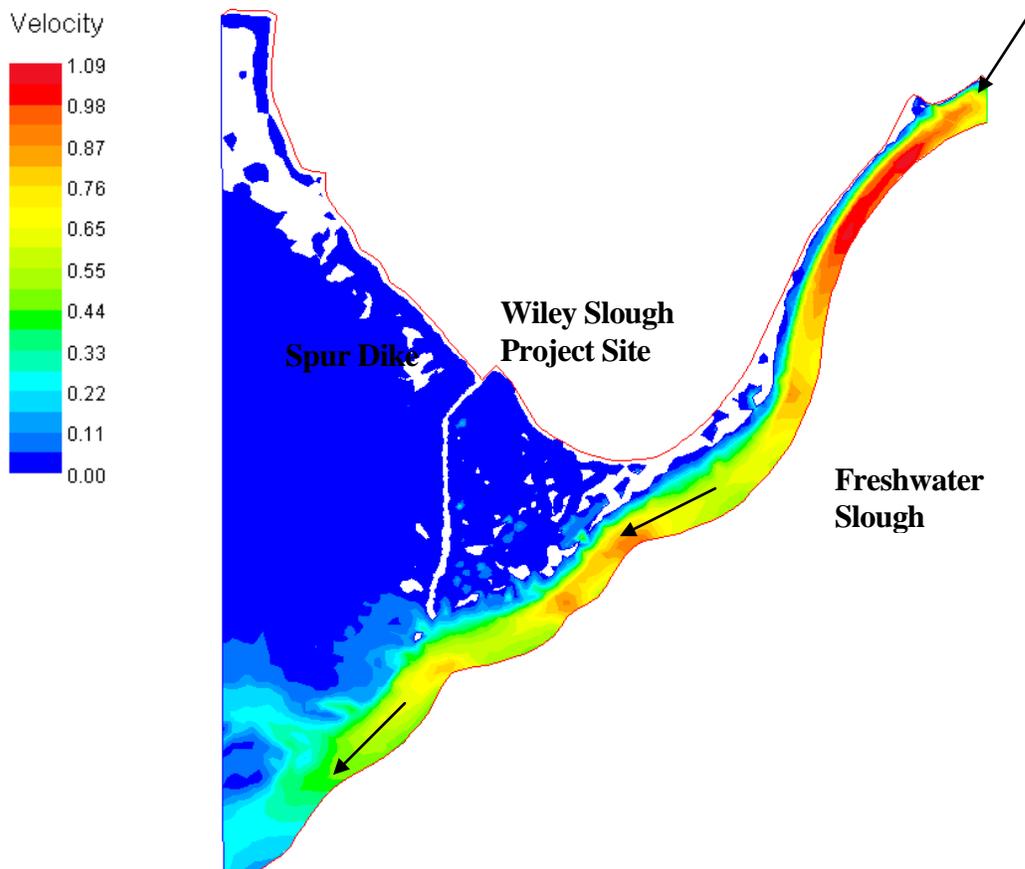


Figure 3.14 Typical Velocity Distribution in Freshwater Slough during an Average ebb Tide.

A second option for the distributary connection was examined that would avoid bisecting the interior spur dike, thereby, allowing for the potential retention of this feature. Option B explored the routing of the Teal Slough distributary down the entire length of historic Teal Slough, thus delivering fish just to the East of the existing spur dike (Figure 3.15). This alternative was less desirable due to its limited effect on the distribution of migratory fish.

A third Option was developed that explored the abandonment of active efforts to establish a distributary corridor across the site in favor of the historic blind channel network that it once was. This more passive approach to restoration was generally considered favorable due to the reduced costs and uncertainties with limited excavation providing connectivity throughout the former channel. In addition adjoining channel networks to the west of the spur dike could be incorporated for improved dispersal with minor excavation through the distal end of the spur dike.

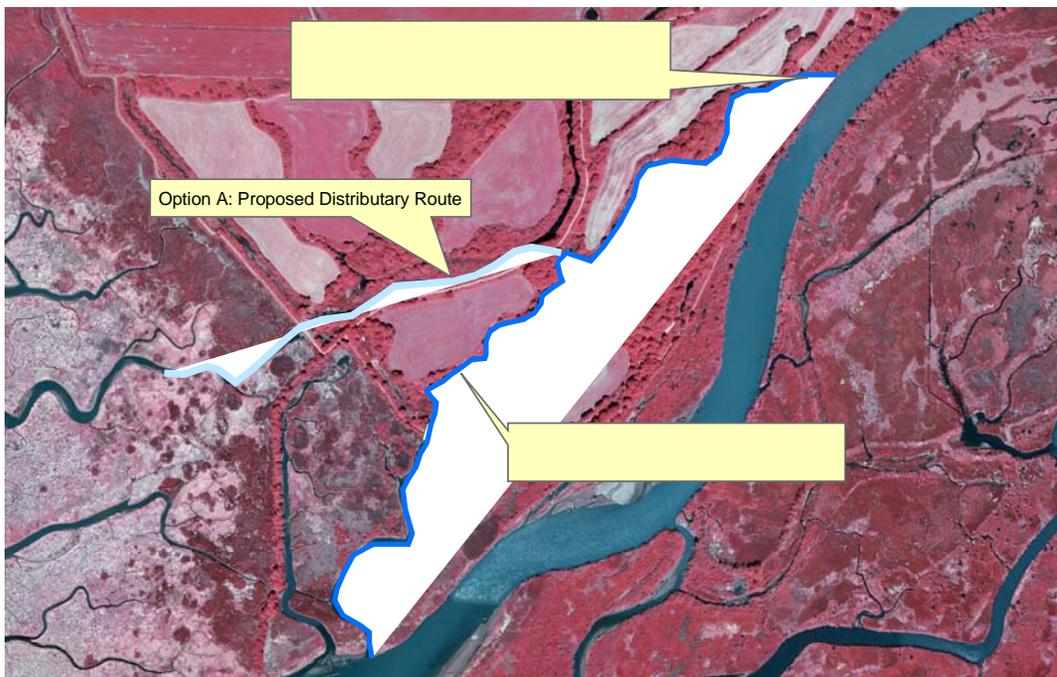


Figure 3.15 Teal Slough Excavations Evaluated

Borrow Ditches

An estimated 3,470 feet [1060 m] of existing borrow ditches are proposed to be filled to top of bank grade. The specific ditches identified for filling were those that ran perpendicular to existing or historic channel networks. (Figure 3.16)



Figure 3.16: Borrow Ditch Management Actions

Localized Channel Excavations

Because of altered site hydrology many of the historic channels inside of the levee system have atrophied, or have anthropogenic alterations to specific locations within their drainage networks. The Design Team worked to identify each of the specific drainage networks within the project site (Figure 3.17) and specific blockages that require some level of excavation.

Headquarters Infrastructure-Boat Ramp

Design Development

Element Goals

Improve the existing Wiley Slough boat ramp that currently requires regular dredging and has limited space for maneuvering vehicles and trailers (Objective 5).

Constraints

1. Location of boat ramp and parking area should not interfere with restoration nor affect adjacent land owners,
2. Design should ensure that maintenance requirements are minimal,
3. Design should consider safety issues, particularly exposure to river current during boat launching.

Criteria

1. Boat launch and parking area should be located in the close vicinity of their current locations to maximize use of existing infrastructure (e.g., access road) and minimize cost,
2. Boat launch should be located on channel bank, rather than set back from the bank as in the existing condition, to minimize sediment accumulation in the boat launch area and associated maintenance dredging,
3. Existing parking capacity should be maintained.

Actions Evaluated

1. Redesign the existing boat ramp into the reconnection of Wiley and Freshwater Slough. Design so that ramp is less of a sediment trap and requires less dredging maintenance. Precise location of ramp is to be determined; it should probably be located upstream of the Wiley-Freshwater junction.
2. Design better turn-around launching options and a better link to the parking area. Elevate the parking area with materials from the dismantled dikes to the height of the current access road which is located on top of a dike which will be retained. This would raise the parking lot out of the tidal flood zone and allow better connection to the boat launch turn-around area.

Uncertainties

Public access needs have not yet been clearly defined by the Department of Fish & Wildlife. Some discussion of relocating boathouse facilities has also led to a variety of design options.

Element Evaluation

Boat Ramp Area

As part of the overall project, improvements to the existing boat ramp area were evaluated in an effort to reduce the need for dredging. Currently, the boat ramp embayment is blocked to a large extent by sediments that have settled out from Freshwater Slough. To address this issue, a focused River2D model was developed for the area immediately surrounding the boat ramp inlet to evaluate and test different design configurations that might be less conducive to sedimentation.

Under existing conditions, the velocity in the embayment is essentially zero. There is a very low energy recirculation pattern near the channel entrance, however throughout the area, the hydraulic environment is fully depositional. In an attempt to reduce the potential for sedimentation, several alternative configurations were tested using the River2D model. The alternatives included streamlining the entrance and exit of the embayment, reducing

the elevation of the parking lot area to the west of the boat ramp and realigning the embayment in a more upstream (or downstream) facing orientation (Figure 3.19 A-D), however none of the configurations produced a significant change to the hydraulic environment and thus all would leave the boat ramp area susceptible to sedimentation and required continual dredging and maintenance.

In an attempt to provide a less depositional condition in the embayment, a potential design was tested whereby the Teal Slough connection would be integrated into the boat ramp area. The scenario produced higher velocities throughout the embayment and therefore was less likely to experience sedimentation; however the increased currents may not be desirable from a boating safety standpoint. Additionally, the level of uncertainty with respect to the ultimate cross-sectional geometry at the Teal/Freshwater Slough connection, and the likelihood of channel enlargement or planform change may preclude this alternative as a reasonable and viable option.

Two other configurations to the boat ramp area were also considered. First, as stated in the SRSC *Concept Plan*, the boat ramp area could be relocated on the channel bank, rather than set back in the existing embayment. This would eliminate the sedimentation concerns altogether, however safety measures would need to be considered given the direct exposure to river currents. The second alternative considered for the boat ramp area included the installation of an instream structure immediately upstream of the embayment entrance (Figure 3.19 E). In a similar way as a beach jetty or groin, the idea behind this design element is that a portion of the transported sediments would be captured behind the structure, thus reducing the likelihood of sedimentation in the embayment. Considering the overall habitat enhancement goals of the project, the instream structure would likely need to be constructed as an engineered log jam or some other bioengineered structure, however other structures like rock groins or piles could be considered.

In addition to the instream structure and the inlet and channel realignment options discussed above, changes in the tidal prism volume of the boat ramp area were evaluated to determine if a sustainable solution could be designed to maintain an adequate opening for recreational boat traffic given the site and tidal characteristics. The evaluation approach involved a comparison of potential diurnal tidal prism volumes to anticipated slough channel geometry and surface area. It is understood that relationships between tidal prism and slough channel geometry are not available for tide marshes in the project vicinity, nor for the north Puget Sound region. Therefore, established tidal prism relationships from the San Francisco Bay area were considered for general application to this project (Coats, et al, 1995).

Graphical plots of tidal prism versus marsh area (acres) and slough channel depth (feet, below MHHW) were referenced (Figure 3.18). The diurnal tidal range for the individual marshes in the database was compared to the tidal range at the project site. The California marsh tide ranges are between 4.3 and 8.4 feet while the tide range in the Wiley Slough vicinity is about 12 feet. This is due to the fact that the project site is located at higher latitude than the California marshes. Data for the marsh with the largest tidal range (Newark Slough at 8.4 feet) was selected as the most representative marsh for the comparison; the Newark Slough data essentially represents the upper limit of an envelope

curve enclosing the two data sets shown in Figure 23. Since the dataset used in this analysis is associated with a tidal range 30-percent less than the actual range at the project site, it is likely that channel geometry for the project site will be larger than estimated using these plots.

Channel geometry was estimated through two approaches. First, the available land area for the potential expansion of the boat ramp area, 1.5 to 2 acres, was used together with the upper envelope curves to estimate a sustainable depth below MHHW of about 4 feet. In other words, for a natural, non-dredged boat ramp area with a surface area of 2 acres, a channel connecting to Freshwater Slough is anticipated to be sustainable at an invert elevation of approximately 1.76-feet, NGVD. A desired design criterion specified by SRSC would be to allow a boat with a 2-foot draft to enter and exit the boat ramp area at MLLW; this would require a channel invert of -8.2-feet, NGVD, which is clearly not achieved using this first approach. A second approach considered the same available 2-acre surface area for an expanded boat ramp area, but assumed the area would be dredged down to MLLW with 3:1 side slopes. This estimated 19 acre-foot volume was used to enter Figure 23 and resulted in an estimated channel depth 9.5-feet below MHHW, or to elevation -3.74-feet, NGVD. This invert elevation is also higher than the -8.2-feet, NGVD invert elevation desired to allow boats to enter and leave the boat ramp area at MLLW.

Based on the findings from the above evaluations, it is concluded that an enlarged boat ramp area, both in surface area and dredged volume below MHHW, will not provide enough tidal prism volume to naturally sustain a connecting channel to Freshwater Slough deep enough to accommodate boat traffic at a MLLW tide elevation. .

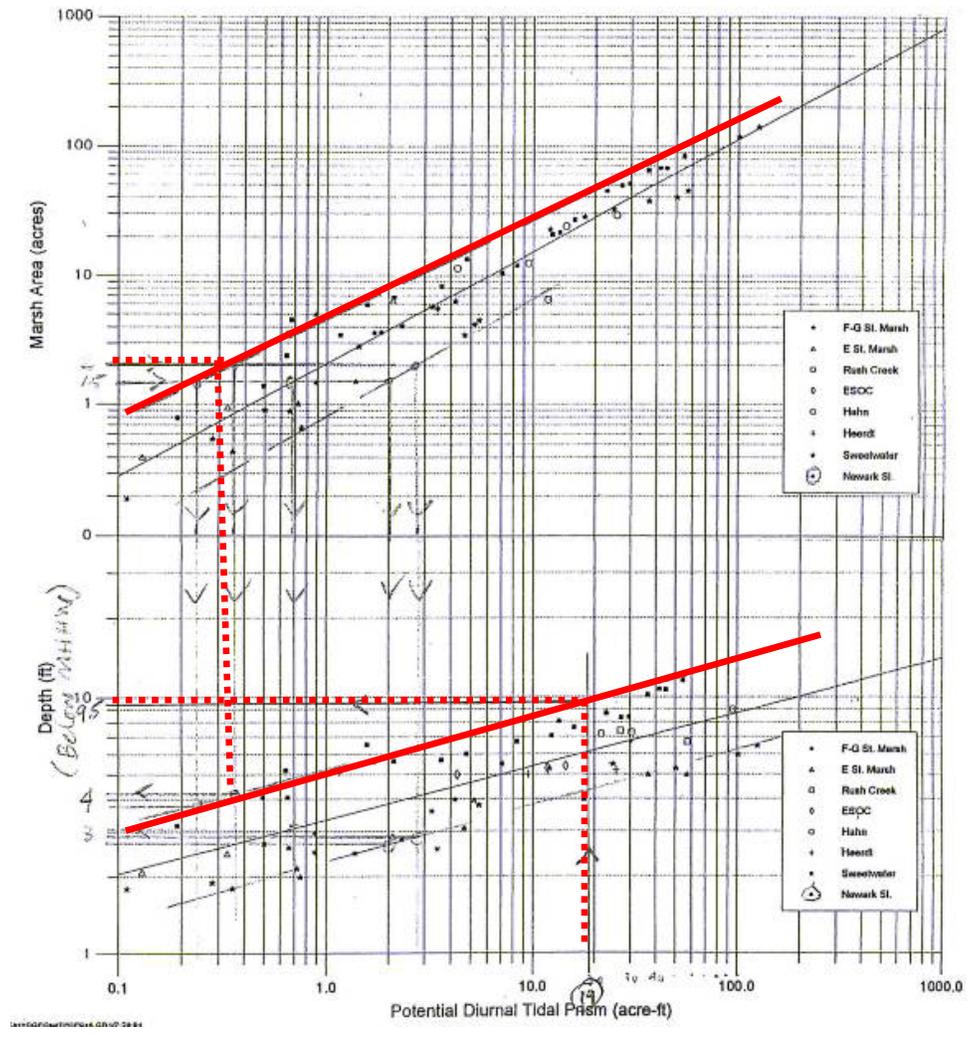


Figure 3.18 Tidal Prism and Area/Depth Relationship

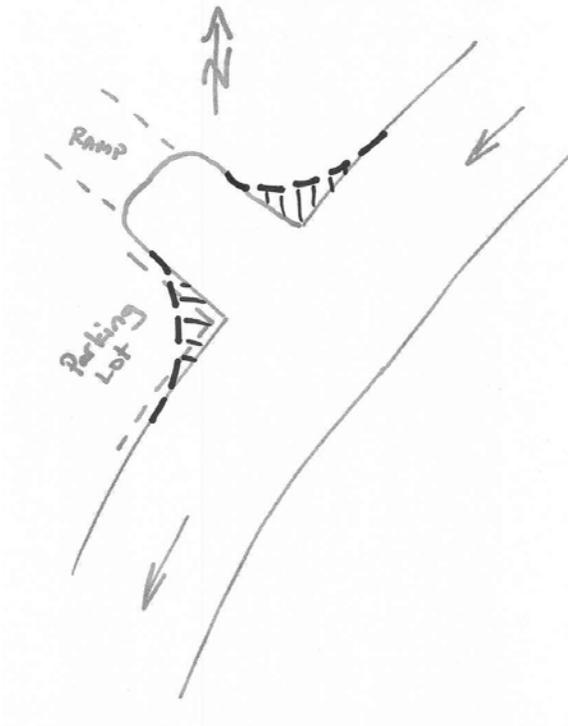


Figure A . Streamline Ramp Entrance

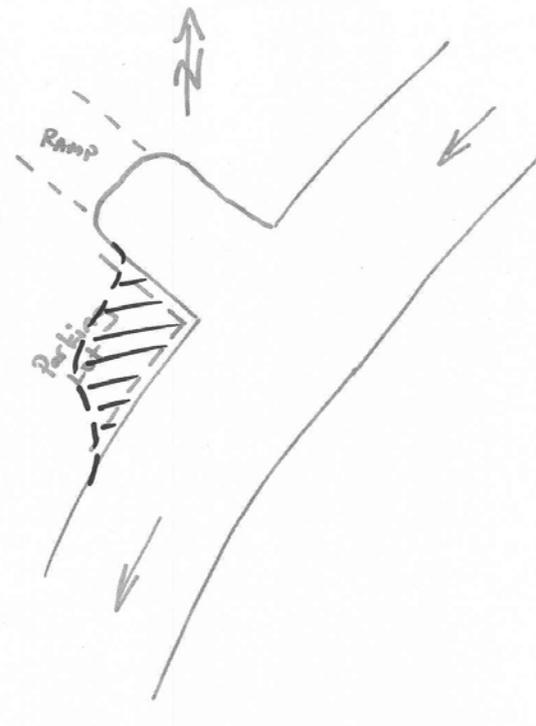
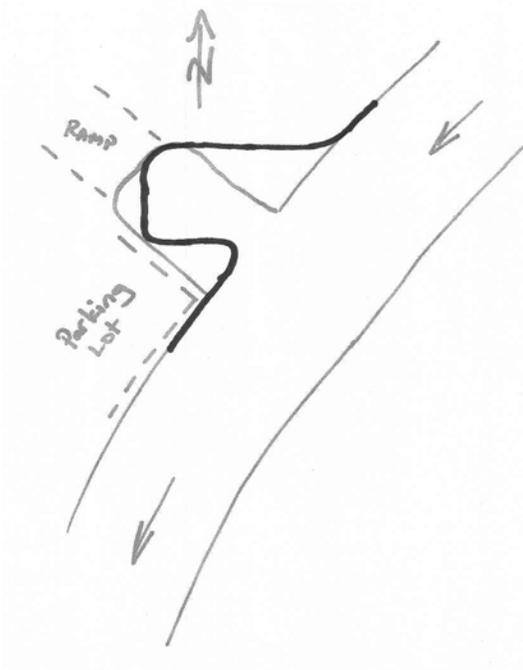


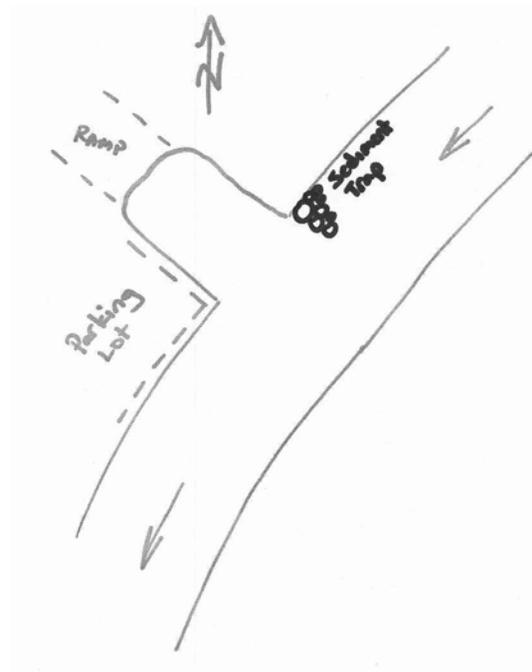
Figure B. Re-grade Spoils Deposition Area



C. Westerly Orientation



D. Northerly Orientation



E. Rock Barb or Weir

Figure 3.19. Evaluated Boat Ramp Configurations

Headquarters Infrastructure-Public Trail Access

Design Development

Element Goals

Provide public access to the Wiley Slough site and adjacent marshes for recreational uses without interfering with restoration (Objective 6).

Constraints

1. Avoid impairment of natural eco-physical processes on the site, e.g., tidal and riverine flooding,
2. Minimize cost of construction and maintenance of trail system,

3. Maximize the safety of trail users.

Criteria

1. Route constructed trails efficiently to minimize cost,
2. Avoid crossing Wiley Slough to minimize cost—a bridge would have to be at least 20m (65ft) wide and would be vulnerable to damage during floods,
3. Avoid exposure to wave energy or likely high energy food routes,
4. Include scenic vistas and exposure to diverse habitats along the route,
5. Provide a looped walking route.

Actions Evaluated

In order to meet project objectives public trail access to the restoration area will need to be constructed and elevated in a manner that does not impede the natural tidal and flood hydrology. The following actions were explored;

- 1) *Boardwalks*: Boardwalk trail systems have been used extensively in many natural settings with minimal disturbance to natural functions. Numerous routes are possible throughout the project area. One such route was explored in some detail by the Design Team (Figure 3.20) near the northern property boundary of the site. This route could be located in on 11 acres of WDFW property that will not be restored to tidal hydrology, but where there is currently no access. The trail could be ~2,250 ft (~685 m) long and wind through forest, along former slough channels, through some freshwater marsh, and along the boundary separating farmed field and forest. This would provide birder watchers and passerines with a variety of habitats (though not necessarily native ones). The trail would connect to retained dikes and form a loop.
- 2) *Levee Trails*: Trails associated with the existing levee system are well established within the project area. The loss of this trail system has been clearly articulated as an area of considerable concern for the greater public. In its existing configuration the trail system provides ~10,400 feet of loop access and ~4,000 feet of one way access. Giving a total of 14,400 feet of trail system. The new levee alignment would provide 2,900 feet of one way access in addition to ~7,050 feet of one way access remaining on the retained spur dike and roadways.
- 3) *Access Easements*: Local landowners and Dike District officials were approached by Design Team members in an effort to explore the potential of securing additional public access opportunities across private land holdings and /or dike district levees. In most all cases these individuals believed there would be merit to exploring these options. The Design Team strongly recommends this discussion with local landowners should be explored by agency personnel.
- 4) *Hunting Access*: Boot access for hunting opportunities is another highly prized public use for the Wiley Slough area. Under the proposed project design this access will be significantly reduced if not altogether eliminated. The elements discussed were related to upland bird hunting, boot access for waterfowl hunting, changes in migratory bird use, and permanent blinds. One feature was developed for evaluation-scalloped ponds.



Figure 3.20: Potential Northern Boundary Trail Route

Uncertainties

1. Maintenance costs of the board walk,
2. Capital requirements for boardwalks
3. ADA requirements
4. The degree to which a boardwalk might interfere with the movement of large woody debris.
5. Sustainability of scallop ponds

Evaluation

Recognizing the unique nature of the Wiley Slough area and its present utilization by a variety of user groups, the Technical Team discussed numerous conceptual visions to

maintain the ambiance and variety of opportunities for public access to the site. Conceptual visions offered and discussed, but not evaluated, include the following;

1. This site allows the public an opportunity to experience and enjoy an estuarine environment. Restoration of the site has the potential to build upon existing viewing and recreational opportunities that are estuarine in nature. Therefore, this project can provide opportunities for increased awareness, understanding, appreciation, and stewardship of estuarine environments. This can be accomplished in part by providing quality access and information to visitors.
2. The loop trail provided by the current levee system is a valued feature for many different users. Access provided by this loop provides a uniquely serene walking experience, as well as abundant opportunity for viewing wildlife. Much of this ambiance is attributed to the well developed canopy of vegetation established along the levee system. The proposed design does not allow for maintaining the loop trail in its current configuration. However, the merits of several loop trail proposals were discussed in detail. The Technical Team determined at least one or more of these alignments are viable for further exploration and recommend further analysis and design through a subsequent study conducted by professionals who can offer more in depth consideration of these alternatives.

Headquarters Infrastructure-Parking Facilities

Design Development

Element Goals

- To improve access to and from the boat ramp facility.
- To improve turn around for boat launching
- To provide more capacity for vehicle/trailer combinations
- To better accommodate buses
- To elevate parking area from tidal inundation

Constraints

- Roadway alignment
- Orientation and positioning of boat ramp
- Extent and proximity of mature vegetation

Criteria

- Number of vehicles accommodated

- Number of vehicle trailer combinations
- Potential Boat Ramp Improvements
- Minimize disturbance to Headquarters area

Actions Evaluated

- West lot expansion & elevation

Uncertainties

- Funding
- WDFW Departmental Objectives
- Location of Moorage Facilities
- Other amenities

Headquarters Infrastructure-Roadway Improvements

Design Development

Element Goals

- Meet near term construction objectives while providing for long term public access needs
- Facilitate drainage objectives

Constraints

- Minimize disturbance to Headquarters Area
- Maximize pre-existing routes

Criteria

Actions Evaluated

- Designated Haul Routes

Uncertainties

Chapter IV

Recommended Actions

In this Chapter the Design Team reports its conclusions regarding detailed actions related to each of the separate design elements. The recommendations are summarized in [Figure 4.1](#) below, and discussed in each of the following sections:

- Levee Setback & Deconstruction
- Tidegate Relocation
- Agricultural Drainage
- Channel Reconnections & Borrow Pit Management
- Headquarters Infrastructure
 - Boat Ramp
 - Public Access
 - Parking Areas
 - Roadways

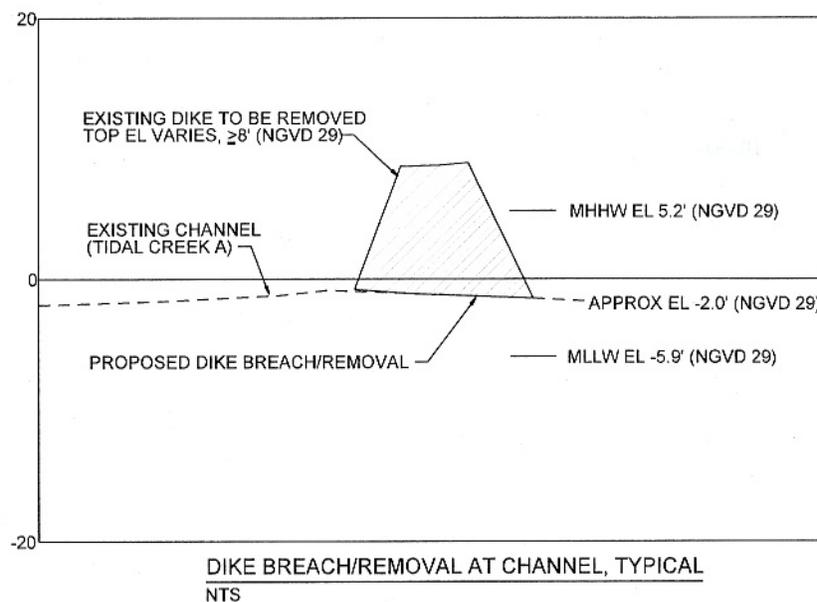


Figure 4.1. Summary of proposed actions (This picture is a placeholder for final)

Wiley Slough Design Report

5/31/05

Draft 3.0: Final

Levee Setback & Deconstruction

General Considerations

GeoEngineers Inc. of Bellingham, WA. and Leonard, Boudinout & Skodje (LBS) of Mount Vernon, WA. were contracted to provide analysis of design details related to the construction of the proposed levee and tidegate locations. The following discussion is a summary of conclusions and recommendations provided in their report to the Technical Committee dated November 18, 2004. This report is included as [Appendix B](#) to this document.

New Levee Construction

New levee construction will follow an alignment that is a true east-west line located at the Northern Boundary of the property owned by the State of Washington. This alignment approximates the historic footprint of the levee system prior to relocation in the late 1950's. The exact location of this proposed footprint is not included in this report. However, this report strongly recommends the footprint be established in such a way as to minimize impact to existing vegetation and avoid ancillary encumbrances with relic levee easements. These two objectives can be met with a levee alignment that closely approximates the location depicted in [Figure 4.2](#). Recognizing that a site specific survey will need to be completed once the Department of Fish & Wildlife makes a final determination as to the merits and recommendations of this report and finalizes the relationship of the proposed levee footprint to the existing site boundary.

At the physical crossing with Wiley Slough (and thereby the new tidegate location), the dike will bend to the south approximately 45 degrees in order to cross perpendicular to the slough and minimize the amount of earthwork that would be required. A design crest elevation of approximately 9.5 feet (NGVD 29 Datum) was targeted to be consistent with the existing local levee system. Specific construction detail for the levee crossing and tide gate structure can be found in [Appendix B](#).

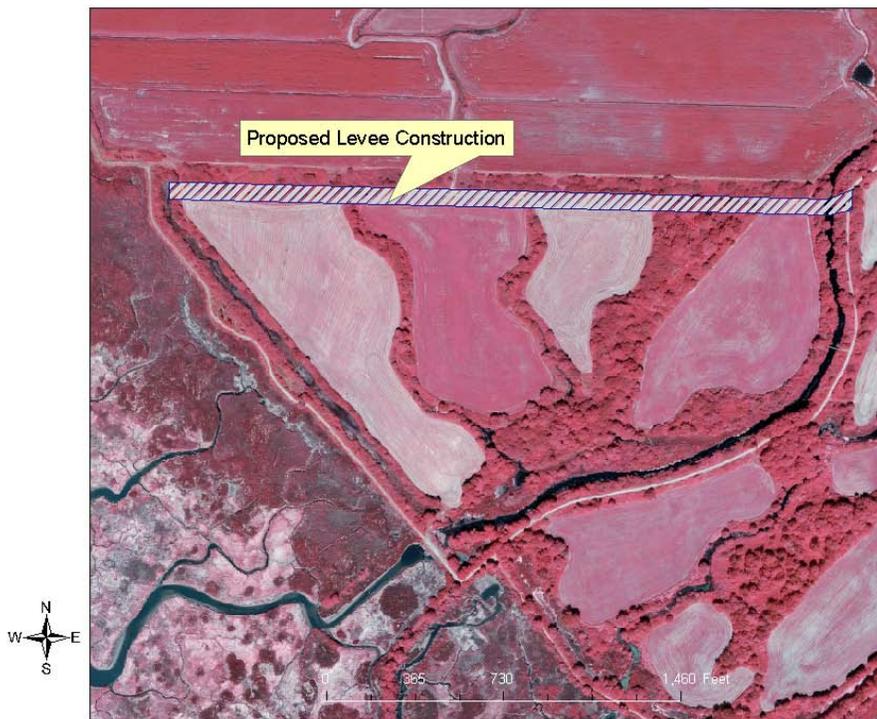


Figure 4.2 Proposed Levee Footprint

Top Crest Width

A levee crest width of 20 feet wide at the location of the new tidegates will be used as the design criterion, however, this top crest width will be reduced to 12 feet throughout the remaining length. Cross sectional detail of the proposed levee construction is depicted in [Figure 4.3](#) below. The purpose of the larger crest width at the gate locations is to provide for a crane for installation and/or service (Bob Boudinou, pers. comm.). The designs for the dike and slough crossing are shown in the plans prepared by LBS and included as Sheet C-2 in Appendix C of this report.

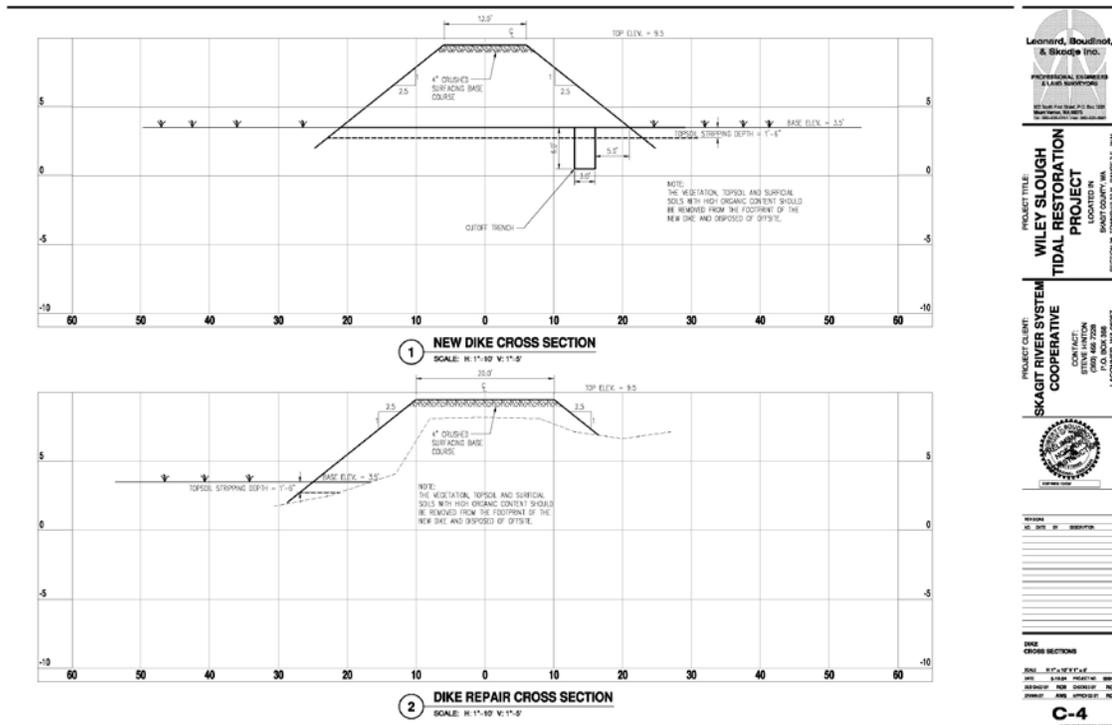


Figure 4.3 Proposed Levee Cross Sectional Detail

Design Elevation

The design elevation of 9.5 feet (NGVD 29) was chosen to match the crest elevation of the existing exterior levees. However the interior (spur) dike elevation at the location of the proposed tide gates is at approximately Elevation 7 feet. Therefore additional earthwork will also be required on the interior dikes to raise the crest elevation to a similar elevation as the exterior levees. This is consistent with the Design Teams proposed action to reinforcing the existing levee system in those locations that are being left in place (Chapter 3)

Slope Stability

The dike should be constructed with slopes of 2.5H:1V (horizontal:vertical) on both sides of the dike due to the possibility of water being present on either side of the dike. The assumed saturation level used by GeoEngineers was approximately 5 feet (NGVD29). Their analysis also indicated this design met factors of safety against slope failure in static, dynamic, steady-state and rapid drawdown conditions are in accordance with the “Dam Safety Guidelines” produced by the Washington State Department of Ecology dated July 1993.

Settlement

The Geo-Engineers Analysis offers the following conclusions regarding settlement;

- Placement of the embankment material will result in consolidation of the underlying silt soils and elastic compression of the loose sandy soils.
- Estimates of settlement along the proposed dike alignment are on the order of 5 to 10 inches, depending on the silt properties, thickness and sequence as well as the height of embankment material needed along the alignment.
- Based on analysis of laboratory data, estimates on the time required for 90 percent of the settlement to occur to be on the order of two to three weeks. However, it is likely that the majority of the settlement will occur during placement of the embankment material.
- Additional settlement may occur within the embankment material considering the type of soil material and the difficulty in maintaining proper moisture contents. Settlement of the embankment material is difficult to quantify due to the variability in moisture content and compaction techniques.
- Up to ½ inch of settlement may occur along the embankment. This would result in a crest width less than the design width. Some extra embankment material can be used as necessary to create a slope no steeper than 2H:1V for the upper few feet of the dike to achieve the 12 foot crest width.

Seepage

Failure due to seepage can occur through two mechanisms: seepage through the embankment and seepage through the foundation soils. Due to the low permeability of the recommended dike material and the assumed short duration of high water against the embankment (diurnal tide and flood conditions only), it is the opinion of GeoEngineers that seepage through berm material is unlikely.

The foundation materials underlying the proposed dike consist of soft silt with organic matter overlying sand with silt. Project engineers report that the layer of soft silt will serve as an adequate barrier against seepage beneath the dike from a stability standpoint, providing that there is continuity between the cutoff trench and the main portion of the dike. The material placed and compacted for the cutoff trench is an additional protection against seepage and piping, although it will not serve as a complete barrier because sand extends to a greater depth than economically feasible to cutoff. The cutoff material placed in accordance with the compaction recommendations provided in this report will have a permeability significantly lower than that of the layer of soft silt.

Seismic Design

The site is located within the Puget Sound region, which is seismically active, so project designs must incorporate the risk of earthquakes. The levee embankment itself will be seismically stable during a design earthquake. However, the foundation soils under the proposed alignment, as well as the soils underlying the majority of the dikes in Skagit County, are highly susceptible to liquefaction during a seismic event. Liquefaction refers to a condition where vibration or shaking of the ground, usually from earthquake forces, results in development of excess pore pressures in saturated soils and subsequent loss of strength in the deposit of soil so affected. In general, soils susceptible to liquefaction include loose to medium dense "clean" to silty sands below the water table.

A liquefaction analysis was not performed for the soils along the proposed alignment because the liquefiable condition is so pervasive throughout the Skagit Valley. This site, as are most within the Skagit Valley, is underlain by sands with a high liquefaction potential. Liquefaction-related phenomena include settlement, flow failure, and lateral spreading. Flow failure can occur in soil that is underlain by a liquefiable layer and has a free face, such as near the edge of a fill or embankment. Lateral spreading can occur on gently sloping or level ground and will also move towards a free face such as a river bank or shoreline. Level ground may oscillate during seismic shaking and may result in large, chaotic movement and excessive vertical settlement and sand boils. The liquefaction hazards applicable to the proposed levee alignment include both lateral spread towards the slough and sudden, vertical settlement, which are typical of most dikes in the Skagit Valley.

Foundation Preparation

The vegetation, topsoil and surficial soils with high organic content will be removed from the footprint of the new levee and disposed off-site. At the selected boring locations, the thickness of the topsoil ranged from 12 to 18 inches. Therefore for planning purposes, Geo-Engineers recommended using an average 18-inch stripping depth.

The design team recommends centering the constructed levee footprint along the east-west alignment southerly of the actual property boundary in such a manner as to minimize disturbance to the existing trees and brush. By locating the constructed footprint in this more southerly location a majority of the disturbance can be relegated to the agricultural fields on the site. Every effort should be made to minimize disturbance to mature trees, however some impacts will be unavoidable. All roots encountered during the removal of trees and shrubs will be grubbed to a diameter less than 1-inch.

Much of the upper site soils contain high fines (silt) content such that repeated construction traffic will result in considerable disturbance during wet weather construction. The embankment material will also have a high fines content. To minimize mud and ponding, construction must be completed during the dry summer months to reduce earthwork costs.

The levee footprint will be thoroughly rolled and compacted to seal seepage paths created during the stripping process. The foundation subgrade will be evaluated by thoroughly proof rolling with heavily loaded rubber-tired construction equipment. If soft or otherwise unsuitable areas are revealed during proof rolling or compaction, the soils will be excavated to firm soil and replaced with compacted structural fill, or as otherwise directed by an on-site soils engineer. The sub-grade suitability will be evaluated by the on-site engineer to identify areas of remedial action.

Cutoff Trench Excavation

The construction of a cutoff trench will control piping under the new levee. The design recommendations provided by Geo-Engineers are as follows;

- This cutoff trench should be constructed as an open trench excavated as a single bucket width.
- The trench should have a minimum width of 3 feet, and a depth necessary to encounter groundwater (likely about 5-6 feet). The cutoff trench should not extend below the groundwater elevation.
- Backfilling of the trench should occur as soon as time and space allow because of potential caving. Therefore, the cutoff trench will need to be completed in sections.
- All excavations and other construction activities must be completed in accordance with applicable county, state and federal safety standards.
- The on-site soils can be excavated using conventional earthmoving equipment.
- Regardless of the soil type encountered in the excavation either shoring, trench boxes or sloped sidewalls will be required for excavations deeper than 4 feet in which personnel will work under Washington Industrial Safety and Health Act (WISHA) under Washington State Administrative Code (WAC) 296-155, Part N.
- For planning purposes only, the native silty sand and sandy silt can be considered a "Type C" soil. The WISHA temporary slopes for these conditions are 1.5H:1V.
- Trench excavations can be made as unshored, open cuts because it is not necessary to have personnel working within the trench, and the trenches will be open for only a short time.
- Compaction will be applied with a backhoe-mounted hoe pack or a sheepsfoot roller attached to an excavator arm such that personnel access is not required.
- These guidelines assume that surface loads such as construction equipment and storage loads will be kept a sufficient distance away from the top of the cut so that the stability of the excavation is not affected. It should be expected that unsupported cut slopes will experience some sloughing and raveling if exposed to surface water.
- Dikes, hay bales or other provisions should be installed along the top of the excavation to intercept surface runoff to reduce the potential for sloughing and erosion of cut slopes during inclement weather.

Levee and Cutoff Trench Material

The levee and cutoff trench should be constructed as a homogenous embankment. The material used to construct the levee and the cutoff trench should meet the following specifications:

Sieve Size	Percent Passing
2" square	100
U.S. No. 40 Sieve	70 (minimum)
U.S. No. 200 Sieve	30 (minimum)

Glacial till or glacial marine deposits found in the Mt. Vernon area will typically meet the specification for this material and these soils have a higher erosion resistance than the native alluvial soils. The till is not typically available for sale at local borrow pits although it is removed as an overburden product. Additionally many construction sites excavate the till and waste it. Identifying potential sources may depend on the construction season at the time of the levee construction. A sample of the proposed levee material should be evaluated by laboratory testing and approval prior to earthwork.

Placement and Compaction

The embankment fill should be placed in horizontal lifts and uniformly compacted. The embankment material should be compacted to at least 90 percent of the maximum dry density in accordance with ASTM D-1557, but not greater than about 92 percent so that the embankment is not brittle considering the settlement that will occur. An on-site engineer will need to monitor fill placement and perform in-place density tests to verify that adequate compaction is being achieved.

Compaction may be achieved with either a large vibratory smooth drum roller or a sheepsfoot roller. The recommended tool for cutoff trench compaction is a sheepsfoot roller attached to an excavator. A hoepack could be used; however, vibratory compaction in the trench will likely result in sloughing or caving of the sidewalls. A sheepsfoot roller is typically used for compaction of fine-grained material because of the kneading action provided along with the pressure. The appropriate lift thickness will depend on the material and the compaction equipment being used. Loose lift thicknesses of 6 to 8 inches are typical when using a smooth drum roller and when using a sheepsfoot roller, the lift thickness should not exceed the length of the projections on the roller. Smooth drum rollers will be appropriate for finish grading and to seal the site prior to inclement weather.

The embankment material will contain a high content of fine grained material. As such, the material is sensitive to relatively small changes in moisture content and adequate

compaction becomes more difficult or impossible to achieve as the moisture content increases. Therefore, levee construction must occur during periods of dry weather.

Erosion Protection

South Slope. The south slope of the levee will be protected against wave action by the portions of the exterior levees that will remain in place. Therefore shear forces along the levee will be limited to those generated by flow parallel to the levee during flood stage. Based on hydraulic modeling provided by HDR, we understand that the maximum velocity along the face of the levee will be on the order of 1.6 feet per second. The south slope of the levee should be protected against erosion with a vegetative cover applied as hydroseed at the end of the project. If the vegetation will not have sufficient time to develop prior to the flood season, a temporary erosion control blanket could be placed along the slope based on the appropriate design parameters. We recommend that the erosion control blanket consist of coconut fibers and provide a minimum of 3 years of protection.

North Slope. We understand that the north slope will typically not be suspect to shear forces from water flow or wave action. The only time that the north slope would be exposed to water would be if Fir Island were to flood. Therefore the north slope of the new levee should be protected against erosion using a grass vegetative cover, installed as hydroseed upon completion of the project. Temporary erosion control blankets could be used if the vegetation will not have sufficient time to develop prior to the flood season.

Crest/Roadway. It is our understanding that crest of the levee will serve as a service road. The compaction recommendations previously provided for the embankment material should be adequate for subbase material. We suggest that a woven geotextile be placed directly over the embankment material prior to the placement of the gravel trail section. The geotextile should consist of a woven fabric with a minimum grab tensile strength (ASTM 4632) of 200 pounds (i.e. Mirafi 500X, Amoco 2002 or Layfield LP 200). The gravel road section should be in accordance with levee district or local jurisdictional standards. We suggest 4 inches of crushed surfacing top course per the Washington State Department of Transportation (WSDOT) Standard Specification 9-03.9(3)).

Levee Removal.

Results from the analysis of agricultural drainage (See next section) indicated that the central spur dike needed to remain in place if the drainage system for the Eastern half of Fir Island was to retain its current level of functionality during flood events. Therefore, the Design Team concluded that the spur dike was to be retained with the exception of 500 feet at its distal end. Extensive deliberation was given to this decision since it clearly impacts the expected benefits from the project. The spur dike will continue to interrupt natural processes across the marsh surface, thereby, attenuating our ability to meet the primary goals of the project. To inform this key decision, SRSC scientists reviewed model predictions to evaluate the net impact to the projects expected outcomes.

With removal of the spur dike restoration was predicted to have resulted in an undivided parcel of restored marsh amounting to 65ha (160.6ac). Leaving the spur dike in place results in 1.6ha (4ac) of dike will be retained, dividing the restoration site into two separate parcels, one of 25.9ha (64ac) and one of 37.5ha (92.7ac). Dike retention directly prevents the restoration of 1.6ha of marsh, obstructs river flooding on 25.9ha of the property, interrupts hydrologic continuity across the site during normal tidal flooding, and impedes fish movement across the site. This is predicted to result in a significant reduction in the amount of tidal channel that can be restored to the site. If the training dike were removed an allometric model of tidal channel geometry (Rice et al. 2005) predicts that the undivided marsh would likely develop 2.9ha (7.2ac) of tidal channel amounting to a total channel length of 14.2km (8.8mi). In contrast, the divided marsh will only develop a total of 2.0ha (4.9ac) of tidal channel amounting to a total length of 11.7km (7.3mi). Therefore, dike retention will likely result in the lost opportunity to restore 0.9ha (2.3ac), or 2.5km (1.5mi) of tidal channel on the Wiley Slough site.

Having reached this conclusion the Design Team recommends the complete removal of the levee sections depicted as yellow in [Figure 4.4](#) below. In totality, the length of levee proposed for deconstruction is approximately 6,500 lineal feet. Using cross sectional data developed through the Bureau of Reclamation site survey was calculated the average volume of the identified sections to be 9.7cubic yards/lineal foot. This would yield an approximate volume of 63,050 cubic yards of total material for removal.

The spur dike remaining in place does offer one advantage for the staging of levee construction. Since the Northern lobe can remain isolated by the spur dike during construction of the new levee, it will be possible to sequence construction such that levee deconstruction throughout the Southern lobe can proceed concurrently with construction tasks. 3850 lineal feet of the total identified for removal are located in the Southeastern lobe. This provides 37,345 cubic yards of material that could be made available for levee construction, augmentation, or parking area development.

Unfortunately, test pits excavated in the existing spur dike did not encounter soils that would meet the specification for levee and cutoff trench material. However, we were not able to explore any of the existing levees. Since most levees in Skagit County often consist of layers of varying materials, and nearly all of the material used in the existing levee were native materials borrowed on site, we will assume that some materials will be suitable for use, however, close monitoring and laboratory testing will be required throughout the deconstruction process to confirm suitability. It is likely that some separation of unsuitable and suitable material will be necessary during construction. We recommend that additional explorations be completed in the levees that will be abandoned during construction to identify possible on-site borrow sources. For purposes of costing this report will assume that 90% of the material located in the Southeastern lobe will be suitable for either levee construction, augmentation, or parking area development.



Figure 4.4: Levee Removal

Levee Retention & Augmentation

The Design Team recommends the retention and augmentation of the dikes and levees identified in [Figure 4.5](#). The portions indicated in blue are identified as needing augmentation to raise the surface level to the design elevation of 9.5 feet. This augmentation will need to be conducted in a manner that will allow this levee section to serve as the primary haul route to and from the areas of new levee construction and the eastern most deconstruction activities. A typical cross section of the proposed augmentation is presented in [Figure 4.6](#). We estimate augmentation to be needed on 3000 lineal feet of the existing levee system. This section of levee currently serves as roadway for access to both parking areas, therefore, augmentation will require suitable material for a roadbed capable of handling heavy equipment throughout the project period.

An additional 2500 lineal feet of the present day spur dike will need to be top dressed with material suitable for roadway improvement. This material must be suitable for use as a haul route to and from the deconstruction activities designated for the bay front levees. Our cost estimates assume this material to be crushed rock specified at 1 1/4" minus or screenings where suitable. Sections identified as needing surface material are indicated as green in [Figure 4.5](#)

The sections identified as being retained but not augmented are indicated as a sand color. These sections either serve a function for drainage or, in the case of the section near Freshwater Slough, as being negligible in their effect on area hydrology.



Figure 4.5: Levee Retention

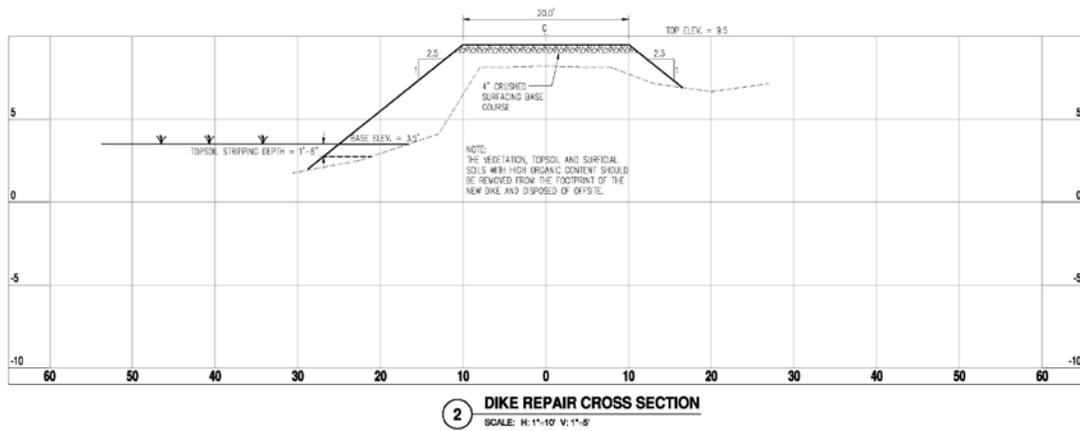


Figure 4.6: Typical Cross Section of Augmented Levee (Place Holder-Formal Drawing will be available for final)

Vegetation management

Native Plant Restoration

Elevation, soil composition and salinity are three key attributes that will affect the specific vegetative communities that will re-colonize the site.

Based from elevational data we believe that following levee removal much of the intertidal portions of the site will eventually reseed via passive seed dispersal from localized seed sources. From extensive field work, SRSC scientists have made predictions of the type of vegetation that will colonize the Wiley Slough area following levee removal. These predictions are based on the observed elevational distribution of vegetation in the oligohaline South Fork tidal reference marshes (Figure 4.7), coupled with LIDAR data on ground elevations for the restoration site (See Figure 2.1.).

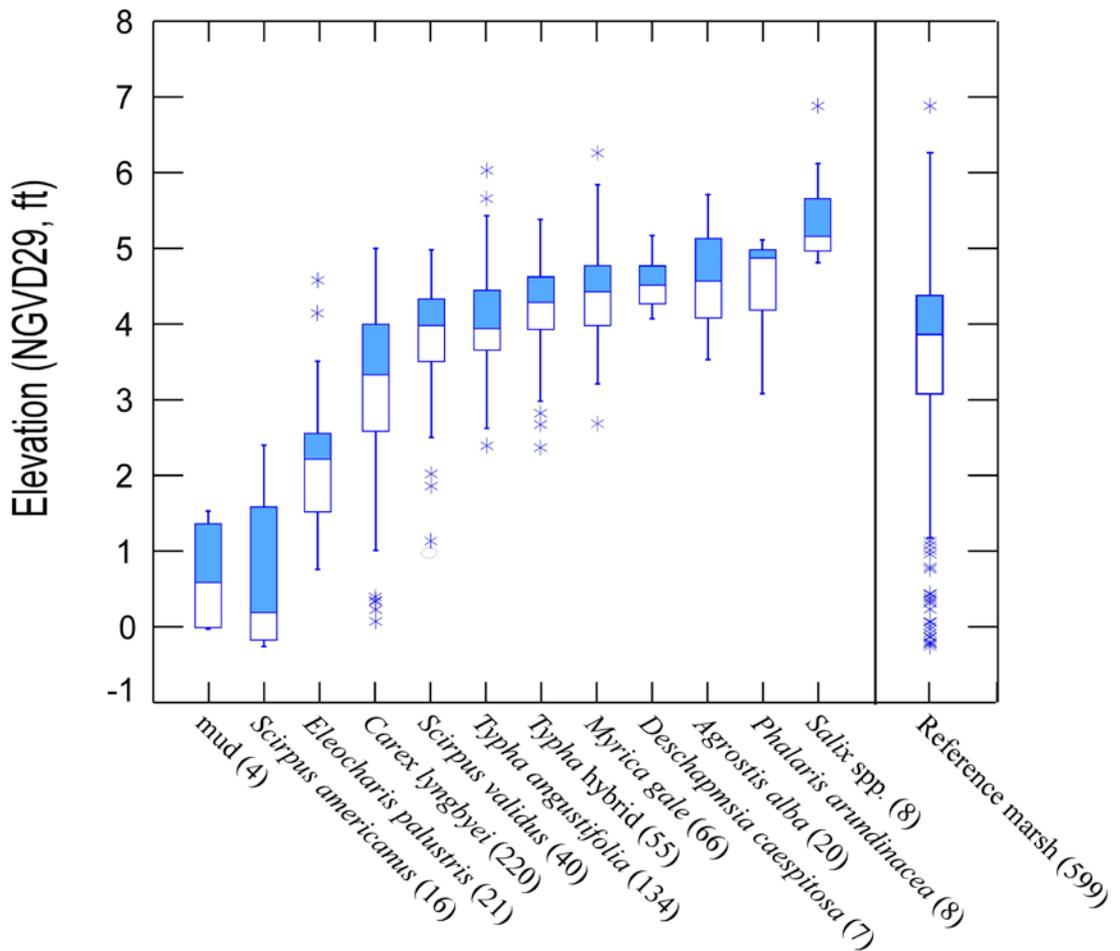
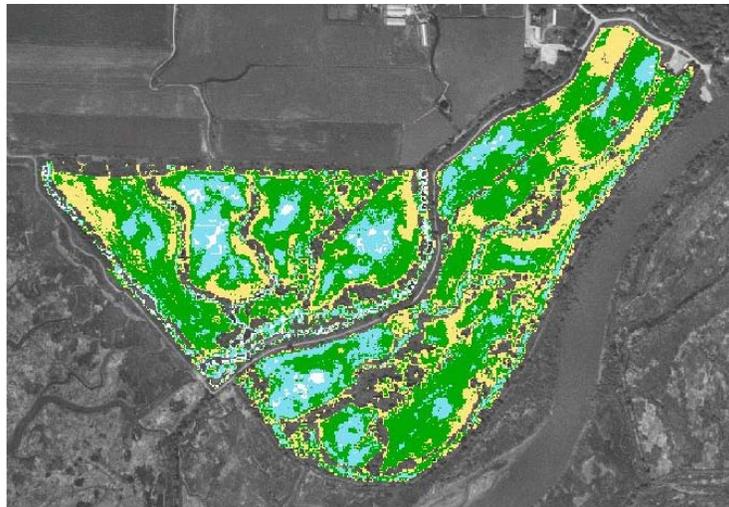


Figure 4.7: Elevation ranges of dominant plant species in the South Fork reference tidal marshes. Numbers in parentheses refer to sample size for each species. Mean high water is 4.63 ft; mean higher high water is 5.51 ft; mean low water is -3.35 ft.

Vegetative changes in response to the Deepwater Slough restoration strongly support the vegetation/elevation relationship derived from this modeling effort in those areas of highly disturbed soils (Hood, 2003). However, in areas that are strongly dominated by invasive species and/or tenacious native colonies equal response has not been recorded. For example, communities of established Narrow leaf cattail have not given way to emergent vegetation in restored areas of Deepwater Slough. However, these communities of cattail have been established for decades given the history of the site. Some research has shown Narrow leaved or lessor cattail (*Typha angustifolia*) can tolerate salinities up to 30 ppt. Common cattail (*Typha latifolia*) does not tolerate salinity greater than 1ppt. There is also evidence of these two species hybridizing in areas throughout the South Fork ecosystem (Hood, pers. Communication).

Monitoring vegetation evolution at the project site following restoration will determine the success of these predictions, it will also be the basis of an adaptive management strategy in which a near term application of passive and active restoration techniques. The details of the suggested monitoring strategy are discussed in the proceeding sections. In summary, the near term strategy would weigh more heavily toward passive management. With active management being directed at areas identified as being more heavily dominated by invasive species, or being at risk from neighboring seed banks of less desirable species such as the lessor cattail.

Based on LIDAR topography of the site and vegetation elevation data collected in reference area along the South Fork we predict colonization by native species of emergent vegetation similar to the pattern depicted in [Figure 4.8](#).



Potential Marsh Vegetation

	Scirpus americanus
	S. americanus - C. lyngbyei - Eleocharis palustris
	Carex lyngbyei
	C. lyngbyei - S. validus

Figure 4.8: Predicted vegetation for the Wiley Slough area, after levee removal. Elevation ranges of vegetation dominating the Sough Fork reference marshes were mapped onto LIDAR data for the Wiley Slough area.

Invasive Species Management

As discussed earlier a number of invasive plant species exist on the site (Chapter Two: Page 28). It is believed that most of the invasive weeds, largely located below MHHW, would not survive the combined effects of flooding and brackish water. Salinities in the region of Wiley slough tend to be in mostly oligohaline due to the strong influences of Freshwater Slough. However, portions of the site that are located away from Freshwater Slough, and somewhat protected from riverine influences could see salinities in the 10 ppt range. The areas that further from the more saline bay side environment may require more active management efforts to control those species that are somewhat salt tolerant..

A species of particular concern is Reed Canarygrass (*Phalaris arundinacea*), a class C weed found throughout the site. Studies have shown reed canarygrass to be generally intolerant of deep inundation (Antieau, 1998), yet “moderately” salt tolerant (Swift, 1997; Hutchinson, 1989; Bernstein, 1964; and Kirkpatrick et al., 1978). These studies have documented tolerance up to 10ppt, however, up to a 50% reduction in yield has been noted starting at 6ppt. A related species, common reed (*Phragmites australis*; a class C weed) can tolerate salinities up to 30ppt (Bart & Hartman, 2002).

Also, cordgrass (*Spartina*, sp.; a class A weed) poses a considerable threat should it begin to colonize the site. Presently, the State Weed Control Board, WDFW, Skagit and Snohomish Counties are actively controlling *Spartina* in the Skagit Bay region through joint efforts. This program is working to prevent the expansion of cordgrass into Skagit Bay marshes from neighboring areas such as Port Susan bay.

Other species that pose some threat and therefore will require active management actions include Purple loosestrife (*Lythrum salicaria*, a class B weed), Japanese Knotweed (*Polygonum cuspidatum*, a class B weed), Scot's broom (*Cytisus scoparius*, class B weed), Canadian and Bull thistle (*Cirsium arvense* & *vulgare* respectively, both Class C weeds), and Blackberry (*Rubus laciniatus* and *Rubus discolor*, neither listed). All of the aforementioned are not tolerant of brackish conditions, but would be likely colonizers of disturbed upland sites (e.g. new levees or parking areas).

Because each of these invasive species can significantly impact the diversity and productivity of the project site for native species we are recommending that some resources are dedicated to the on going control of invasive species within the project area and adjacent marshes.

Tide Gates Relocation

General

The portion of the new levee that crosses Wiley Slough and connects to the existing dike requires additional construction and design considerations due to different foundation conditions and the presence of five 60-inch diameter tide gates passing through the levee. The general geometry, material, and compaction requirements for the levee previously provided have remain unchanged in that portion that crosses the slough. Additional design and construction considerations specific to the section of the levee that crosses the slough are provided below.

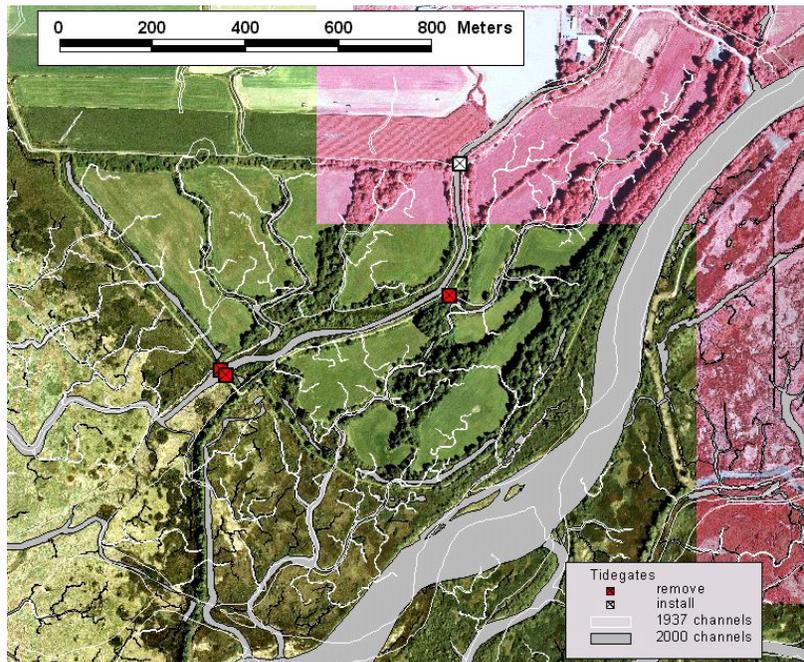


Figure 4.9: Locations of tide gates slated for removal (red) and installation (white). Current (2000, gray) and historic (1937, white outline) tidal channels are shown for reference.

Type & Location

Tide Gates and Pipes

Five 60-inch diameter Hancor Sure-Lok F477 pipes will be used for the tide gates. These pipes consist of corrugated high density polyethylene (HDPE) placed at 9 foot centers. The design invert elevation will be placed at – 4.0 feet NGVD as per the request of Dike & Drainage District #22. The tide gate lid will be constructed from fiberglass/resin composite molded to the end of each pipe.

This new tidegate structure would be located at the intersection between the Wiley Slough channel and the northern most East/West boundary line of the project site. This location is graphically represented in [Figure 4.9](#).

The installation of these pipes into the levee require additional design and construction considerations which are discussed below.

Construction

Dewatering

The construction of the slough crossing must be done in the dry. The ordinary high water elevation in the slough is slightly below Elevation 1 foot NGVD and the base of the slough is at approximately Elevation -5 feet NGVD. Groundwater was encountered in the boring closest to the slough at approximately Elevation -4 feet NGVD. We recommend that the contractor be prepared to dewater the site to approximately Elevation -8 feet during construction to allow for construction of a base-stabilization pad.

Due to the depth of dewatering required, we anticipate that temporary sheet pile walls placed across the slough outside of the construction area will be required. In order to dewater the site to an elevation of -8 feet NGVD, we anticipate that dewatering wells will be required. Sufficient number of wells and pumps should be installed to dewater the levee construction area during the entire time that the levee is under construction. The wells should have a properly designed sand pack to prevent migration of fines and fine sand from the formation. In addition, sumps and pumps may be required to help control additional localized seepage. It may be possible to complete the construction in a staged manner only using localized sumps and pumps if groundwater is low enough. However, if “clean” sand is encountered, it will readily flow in a saturated condition such that this procedure may not provide a stable work environment.

Excavation and Slopes

The geometry of the levee and the installation of the pipes at an invert elevation of -4 foot will require excavation of the existing ground profile. The majority of the excavation will be backfilled as part of the construction of the levee. Therefore temporary slopes in accordance with recommendations below are applicable at those locations. However permanent slopes will be required on the west bank south of the levee and on the east bank north of the levee as shown in Sheet C-1. All temporary cut slopes must comply with WISHA regulations as previously discussed. The contractor performing the work has the primary responsibility for protection of workmen and adjacent improvements. Because the soils at the project site will likely consist of “clean” sand, all excavations extending below groundwater depth must be fully dewatered as discussed previously.

Temporary Cut Slopes.

The soils encountered at the site are classified as Type C soil. Temporary unsupported cut slopes should be inclined no steeper than 1.5H:1V, unless they are cohesive to stand such as Type B soil. This applies to fully dewatered conditions. Flatter slopes may be necessary if seepage is present on the cut face. Temporary cut slopes should encroach no closer than 10 feet laterally from roadways, pavements, structures or other improvements.

If temporary cut slopes experience excessive sloughing or raveling during construction, it may become necessary to modify the cut slopes to maintain safe working conditions and protect adjacent facilities or structures. Slopes experiencing excessive sloughing or raveling can be flattened, re-graded to add intermediate slope benches, or additional dewatering can be provided if the poor slope performance is related to groundwater seepage.

Permanent Cut Slopes.

The cut slopes at the slough crossing that will not be backfilled as part of the levee construction should be cut no steeper than 2.5H:1V, similar to that for the levee. The exposed surface should be protected against erosion using light-loose rip rap as discussed below.

Seepage

The silt unit that underlies the majority of the levee alignment is not anticipated to be encountered at the base of the slough and the construction of a cutoff trench is not feasible due to the water conditions. Therefore our design includes a permanent sheet pile wall beneath the centerline of the levee to control seepage. The piles should consist of straight sheets that are able to resist corrosion from contact with salt water. The piles should extend

85 feet to the west from the top of slope on the east side of the slough as shown in Sheet C-2. The sheet piles should be driven to a tip elevation of -30 feet. Below the pipes the top of the sheet pile should be approximately 1 foot below the invert elevation of the pipes, Elevation -5 feet, and extend up into the levee material. This top of pile elevation should extend 4 feet east and west of the centerlines of the easternmost and westernmost pipes. Beyond the pipe area, the contractor may cut off the top of the sheet pile near the existing ground surface. We recommend that the permanent sheet pile wall be installed prior to the construction of the ground stabilization pad as described below. The levee will settle over the top of the sheet piles during construction.

Sub-grade Stabilization

We did not explore the base of the slough during the exploration program. We anticipate that the soils across the bottom of the slough will consist of soft and saturated sediment. This material will not support construction traffic, nor will it provide an adequate surface for compaction of the levee material. Our design includes removing 2-feet of the soft sediment across the base of the slough and replacement with a 2-foot thick blanket of 2- to 4-inch quarry spalls. The overexcavation of the slough material should extend up the side slopes far enough that firm soils are encountered. The top of the quarry spalls should always remain at least 1 foot below the top of the sheet piles. We recommend that we observe the base excavation during construction to observe the conditions encountered and confirm that this design will provide adequate base support for the levee.

The quarry spall pad is totally wrapped by a geotextile and partially wrapped by an impermeable liner (geomembrane) as shown in sheet C-2. The geomembrane is to prevent water seepage into the quarry spalls layer which could lead to softening of the lower portion of the levee. The geotextile is recommended for two reasons: 1) to limit penetration of the quarry spalls into the underlying subgrade soils and 2) prevent the migration of fines from the overlying levee into the voids in the quarry spalls. The fabric should be placed with a minimum overlap of 18 inches. Because the levee will likely settle overtime, the fabric should not be placed over the permanent sheet pile wall. Instead the geotextile and geomembrane (both underlying and overlying the quarry spalls) should be placed such that a minimum of at least 18 inches of material is placed vertically adjacent to the sheet piles.

The geotextile should consist of a woven fabric suitable for soil stabilization (WSDOT Standard Specification 9-33.2, Table 3) with a grab tensile strength (ASTM D 4632) of 315 pounds (e.g., Amoco 2016 or Mirafi 600X). The geomembrane should consist of a 40-mil EDPM (ethylene propylene diene member) because of its elasticity properties. This product is generally available in 50x50foot rolls and can be field seamed or can be special ordered as one piece and delivered to the site. Specialty contractors can put the two materials together and deliver them to the site.

Buoyancy Forces.

During high tide and low flow in the slough, the buoyancy forces on the pipe will be significant. Therefore, the south ends of the pipes are anchored using a concrete collar that fits around each pipe. The specific design for the headwall is shown in Sheet C-1.

Compaction.

Poor compaction of structural fill around pipes passing through levees has resulted in piping failure. Therefore, it is critical that compaction of the backfill around the pipe and particularly beneath the haunches of the pipe be done correctly. We recommend that the compaction of fill around the pipes be monitored on a full time basis by an on site engineer.

The spacing of the pipes will provide approximately 2.5 feet between each pipe. Compaction will need to be completed by smaller compaction equipment such as a jumping jack. As a result lift thicknesses will need to be thinner (on the order of 4 inches) to achieve adequate compaction.

Bedding.

Bedding materials are included to place the pipes. However, the bedding material is not included within 5 feet of the face of the levee to prevent seepage.

We have included a composite anti-seep collar consisting of two galvanized corrugated metal collars and concrete around each pipe. The two collars will be located 8 and 10 feet downstream (south) of the centerline of the levee as shown in Sheet C-2. The space between the collars should be backfilled with concrete with a compressive strength of at least 3,000 pounds per square inch (psi). The collars should have an outside diameter of at least 10.5 feet and the overlap with the collars on adjacent pipes should be staggered. All of the collars must be in place on all of the pipes prior to placement of the concrete. If an excavation is completed beneath the pipes for installation of the seepage collars, than the entire excavation must be filled with concrete not just the space between the collars.

Settlement.

We expect that the material underlying the levee will consist of loose alluvial deposits or additional soft sediments. These soils will experience settlement due to the weight of the fill embankment. The settlement will occur rapidly as the material is placed, however settlement will result in a sag in the middle of the pipes placed during construction of the levee. This is because the center of the levee will experience more settlement than the edges of the pipe. For this reason, the pipes should be installed with a reverse crown of 4 inches at the proposed centerline of the levee to account for the potential settlement of the levee.

Erosion Protection

Both sides of the levee in the slough channel and the permanent cut slopes will be protected against erosion using 12 inch thick blanket consisting of light-loose rip-rap. The light loose riprap will meet the specifications of Sections 8-15 and 9-13.1(2) of the WSDOT Standard Specifications.

Agricultural Drainage

Drainage Infrastructure: In System Capacity

Analysis of system capacity lost due to the relocation of tide gates yielded an estimate of nearly 7 acre feet. To meet the objectives of the Agricultural drainage design element the Design Team explored way to negate this direct loss of capacity. The following actions are recommended to mitigate this loss;

- ***Improve conveyance***
The up-sizing of the tidegates is estimated to provide 37 acre feet of additional conveyance. This action alone will more than offset the capacity lost. See Conveyance discussion more detail.
- ***Construct a holding pond in the vicinity of the pump station***
The Design Team also recommends the construction of a large ponded area in line with the drainage channel in the wooded area just upstream of the pumping station. The location and configuration of this pond is shown in [Figure 4.10](#). The system capacity being provided by this feature as designed (2.5 acres ~ 3 feet invert elevation) would yield an estimated 7.5 acre feet of storage capacity.



Figure 4.10: Location and configuration of storage pond.

- ***Conduct maintenance dredging from tide gate to Mann Road.***
The design team also recommends that maintenance dredging be conducted throughout the Wiley Slough channel from the Mann Road intersection to the new tidegate location. Based from field surveys there appears to be 1-3 feet of soft sediments in the channel thalweg throughout. In addition, edges appear to have consistently deeper accumulations. If the channel was dredged to its typical 6 foot invert, this action would increase existing capacity by another 3-4 acre feet. However, the Design Team does not consider this to be a long term net gain in capacity for the system. As the system resizes it self to system wide changes, an equilibrium will be reached at which sediment transport will not occur and sediment deposition within the channel will occur in a relationship commensurate with the system hydrology.
- ***Construct additional channel capacity near the Tidegate location.***
Additional storage capacity near the tidegate would be desirable for some sections of the drainage network. This capacity could be realized in locations along the levee alignment and/or in an adjacent farm field were a pond is presently located.

Because of the specific logistic issues and potential for compromising the integrity of the new levee is the ponded area was located too close to the new structure the Design Team does not recommend construction of these features at this time. Increases in conveyance flows will more than offset capacity loses for this reach.

Construction of these features should be at the sole discretion of Dike & Drainage District #22.

Drainage Infrastructure: Conveyance

The Design Team recommends that system conveyance be improved through the following actions:

- ***Upgrade pipe sizing at tidegate***

The current tide gates, which are located in Wiley Slough along the western levee consist of four 52-inch culverts and two 48-inch culverts. Assuming full pipe flow, the total capacity of the combined culverts is approximately 250 cfs. By upsizing the pipes to five 60" culverts, these gates will have a full-flow capacity of approximately 310 cfs. The daily conveyance volume through both structures during an average annual streamflow and a typical diurnal tide cycle (with a MHHW elevation of 5.76-feet, NGVD), assuming a fixed upstream water surface of 0.0 feet (NGVD29), the total volume of flow passing through the existing culvert configuration is roughly 171.3 ac-ft over a 24-hour period. Under proposed conditions, this volume is increased to 196.4 ac-ft, almost a 15% increase, or 25.1 acre feet of additional conveyance.

- ***Bridge system at Mann Road***

Flow information indicates there is a restriction at the Mann road crossing. By resizing this pipe or bridging the channel at this location a significant improvement in system conveyance could be realized. This structure is, however, not located on WDFW land. Being outside the scope of the project site the Design Team recommends Dike and Drainage District #22 and Skagit County consider up-grades at this location.

- ***Re-route access road to Headquarters Parking area.***

In the site's present configuration an access road to both the boat ramp facility and the West parking area enters the site and crosses Wiley Slough. After crossing, the road bisects at the crest of the existing levee crest. The respective road grades then direct traffic flow to the East and West parking lots. The roads traveling to the Western lot must re-cross Wiley Slough. The main access road was recently up-graded in 2004 to improve conveyance as antiqued pipes were beginning to fail under the roadway. However, the road crossing leading to the Western parking area has not been upgraded. This crossing, while adequately conveying flow, could be removed altogether and the parking lot entrance could be relocated along the opposite bank of Wiley Slough with relatively little disturbance to the site. This action would remove a channel constriction, thereby, helping to improve conveyance of surface water through the site.

Drainage Infrastructure: Pump Station

The existing pump station contains a relatively small pump (70 Hp) which is only utilized during extreme circumstances. This facility is regarded as being generally undersized by the District Commissioners, but it is capable of handling most duties without improvement.

Given the relatively small increase in system conveyance and the high cost of electricity to the District, we believe drainage improvements at the pump station yield smaller value for the investment. Therefore, the Design Team does not recommend a pump upgrade at this time.

Channel Reconnections & Borrow Pit Management

Distributary Development

Given the necessity of leaving the “spur” dike in place (see preceding discussion) it became evident that plans to direct the distributary westerly to Wiley Slough (thereby, through the spur dike footprint) would not be possible without significant engineering and expense.

As mentioned previously in Chapter 3, two additional scenarios were discussed and examined. Each one being commensurate with project objectives, but less attractive based on their ability to disperse fish to the Westerly marshes. One in which the distributary would be allowed to run the entire length of the historic Teal Slough, thus delivering fish just to the East of the existing spur dike. The other alternative was to drop the Teal Slough distributary altogether and allow it to become a blind channel network.

Analysis of the distance between Freshwater Slough and where Teal might empty should it be connected as a distributary indicates there is a relatively short movement to the West. Therefore, we believe the objective of dispersing fish more widely is only marginally being accomplished. Given the additional costs and uncertainties associated with constructing a distributary as opposed to the ease of allowing Teal to express itself as a blind channel network the Design Team recommends the blind channel option. Recognizing the value of blind channel networks in relation to distributary networks this option is also attractive in its value from the fish production standpoint. Excavations required to realize this objective and maximize its effectiveness are depicted in [Figure 4.11](#).



Figure 4.11: Teal Slough Excavations

Borrow Ditches

An estimated 3,470 feet [1060 m] of existing borrow ditches are proposed to be filled to top of bank grade. The specific ditches identified for filling were those that ran perpendicular to existing or historic channel networks. These specific ditches are identified in [Figure 4.12](#).

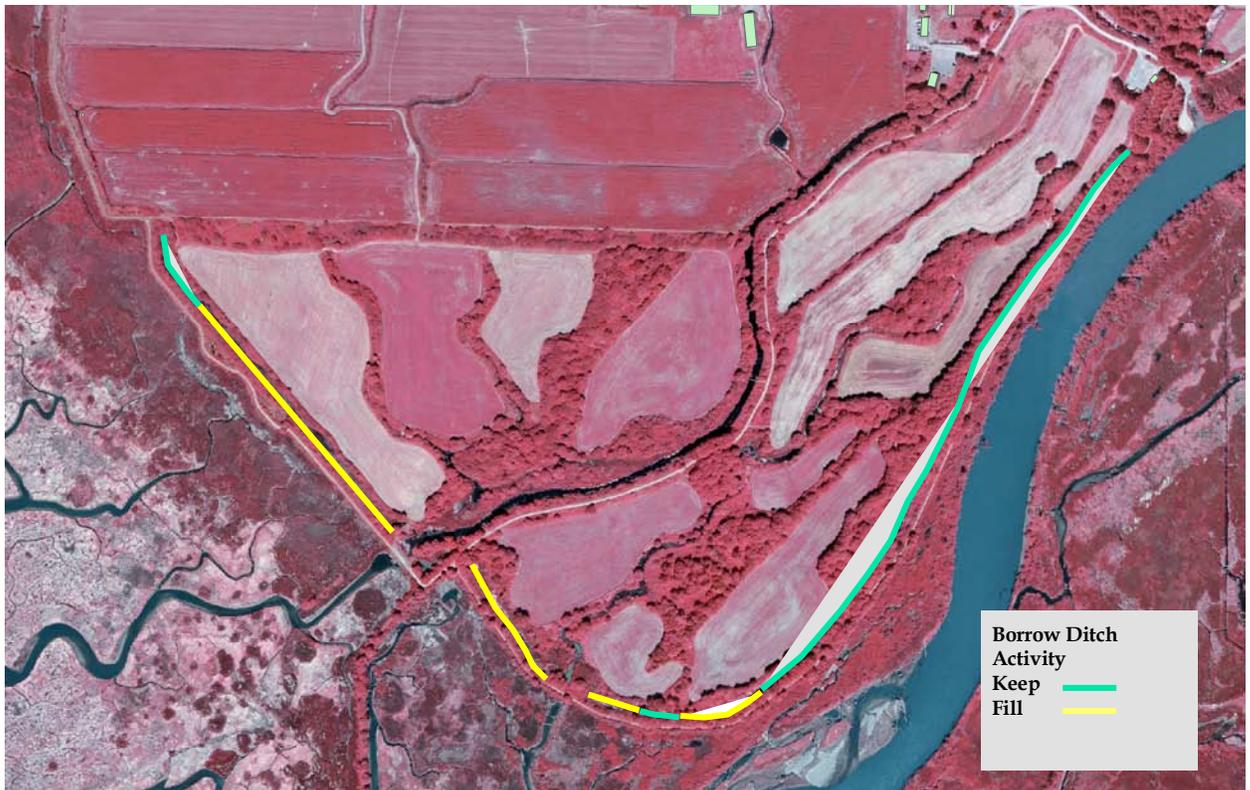


Figure 4.12. Location of ditches to be excavated, filled, and retained. Current (2000) and historical (1937) channels are shown for reference.

Proposed filling would occur first isolating the targeted ditch from other associated water bodies using coffer dam plugs of material from the nearby levee as it is being demolished. Field crews would then use screened trash pumps to dewater the channel channels at a rate of no greater than 500 gals/min. As ditches are being dewatered field crews will be actively working to salvage any stranded fish or wildlife (amphibians, reptiles, etc...) that are unable to readily move to adjoining waters water bodies. Once the ditch has been drained to localize groundwater levels filling will commence. Field crews will continue to pump as the channel is being filled to minimize the volume of water needing displacement. Channels will be overfilled with material 2 feet deep to allow for settlement. Compaction will be accomplished only through the use of excavator bucket as filling proceeds.

Local Channel Excavations

Identified channel excavations are identified in [Figure 4.13](#). These sites are subject to on site evaluation and alteration by the on site project manager. Grubbing and clearing will be kept to an absolute minimum. All excavations will use existing up stream and downstream planforms as templates for the targeted condition. Spoils from these local

sites will be wasted in an off site location, unless the site is proximate to an appropriate near-site need.



Figure 4.13: Proposed local excavations shown in Green

Headquarters Infrastructure-Boat Ramp

Boat Ramp

Because safety issues removed relocation alternatives from analysis all alternatives evaluated that left the ramp *in situ* could not improve the sustainability of the boat ramp condition. The Design Team recommends that the boat ramp be left in its existing location and a long term dredging plan be established through a permitting process with the ACOE. Specific ramp improvements will not be considered as a part of this analysis. Therefore, it is recommended that the existing boat ramp area be maintained through the periodic removal of built-up sediment and/or the installation of localized sediment traps.

Boat Moorage Facility

A Moorage Facility for WDFW equipment is located on leased land to upstream from the boat ramp along Freshwater Slough. The Design Team was asked to evaluate the positive and/or negative effects moving this facility could have on the sustainability of the boat ramp itself.

The proposed configuration was discussed with HDR hydrologists. The configuration was very similar in effect to the rock barb scenario discussed in the evaluation section. Our evaluation indicated that pilings would cause a similar effect as the rock barb, only less so. Pilings could be pinned side by side to form a fence of material like the barb, but this configuration would only rack debris within the moorage area so was dismissed outright. Given the barb was modeled as being ineffective; we assumed the piling configuration would be less effective. Additional model runs demonstrated this assumption to be accurate and further analysis was abandoned.

Therefore the Moorage facility would not be effective at improving the sediment problem at the boat ramp. However, the moorage facility would not exacerbate the condition. The Design Team did not provide a recommendation for or against relocation of this facility.

Headquarters Infrastructure-Public Access

Waterfowl Hunting

Walk- in waterfowl hunting will still be available at the site via the two point destination trails that are part of the site restoration. As natural tidal and riverine hydrology is restored to the site, boat-hunting opportunities at the site will increase. The waterfowl hunting experience will transition from an agriculture field experience to an estuary experience. Though the farmed winter cover crops that have been historically planted at the site to attract waterfowl and hold waterfowl in the area will be displaced by the site restoration, the native vegetation that will colonize the site will provide a valuable forage for waterfowl and will continue to attract waterfowl to the site. WDFW is also looking for suitable sites along Skagit Bay to re-establish the farmed winter cover crops and create additional walk in waterfowl hunting opportunities.

Considerable thought was given to a specific public access feature that involved excavating “scalped ponds” that could be associated with some elements of a public access plan. The design team spent significant time on this issue because it was widely recognized as being potentially un-sustainable in the natural landscape. However,

committee members particularly attuned to the hunting organizations felt this amenity would have particular merit with that interest group. The committee felt it particularly important to weigh any negative effects that these features could have on the restoration of the marsh.

Hydraulic analysis did reinforce the transient nature of these features on the marsh plain. However, there was merit in the ability of these features to add volume to tidal prism being directed toward a specific channel feature. This was seen as generally being positive, albeit transitory, from the perspective of emphasizing channel flushing and accelerating passive channel recovery.

The negative aspect to these features was focused on their effect on the re-establishment of marsh vegetation communities. The elevations and area needed to contribute any significant hydraulic effect to any given channel, or to their utility from a public use perspective, potentially creates large patches of marsh devoid of vegetation. The realized impact from these features hinges on the actual progression of marsh re-colonization by emergent species relative to the progression of sediment accumulation. Because this relationship is not well known the committee felt the scalloped pond idea could be implemented, but on a limited scale.

After considerable discussion the Design Team has recommended that scalloped ponds not be pursued as a final design element. Uncertainty over pond sustainability, additional infrastructure costs, impacts on natural processes and limited benefit provided by these features culminated in the design element being dropped.

Pheasant Hunting

Upland hunting for pheasant will no longer be available at the site. WDFW is looking for a suitable site in Skagit County to re-establish upland pheasant hunting.

Watchable Wildlife

Wildlife watching will still be available from the two point destination trails that will be included as part of the site restoration. The restoration will retain the fringe of existing passerine habitat along the north property boundary, as well as in shrub and forest vegetation remaining along the retained spur dike. There is also the possibility of enhancing passerine habitat on the 11 acres of WDFW property at the north end of the site that will not be part of the site restoration. Passerine habitat enhancement will not be included as part of the site restoration. As natural tidal and riverine hydrology are restored to the site and as the sites transition to estuary habitats, the watchable wildlife will also transition to species native to estuaries.

Trails

The existing loop trail that follows the levee system around the southeastern part of the site will be removed as part of the site restoration. A new point destination trail will be constructed on top of the new dike along the north boundary of the site as part of the site restoration. The existing dike down the center of the site will be retained, and reconstructed as part of the site restoration.

A new loop trail could be constructed on 11 acres of WDFW property at the north end of the site that will not be part of the site restoration. A new loop trail in this location will not be included as part of the site restoration, but would instead be included in a separate construction process. This trail could be located in on 11 acres of WDFW property that will not be restored, but where there is currently no access. The trail could be ~2,250 ft (~685 m) long and wind through forest, along former slough channels, through some freshwater marsh, and along the boundary separating the proposed pond site within the forest. This would provide birder watchers and passerines with a variety of habitats (though not necessarily native ones). The trail would connect to retained dikes and form a loop. (Fig. 4.15)

Elevated board walks and viewing platforms into the restoration site will need to be designed and constructed in a manner that does not impede the natural tidal and flood hydrology. Elevated board walks and viewing platforms will not be included as part of the site restoration, but would instead be included in a separate construction process.



Figure XX. Possible trail configuration. Retained dikes are shown for reference.

Headquarters Infrastructure-Parking Areas

West Parking Lot

The Eastern Parking lot presently holds about 30-35 vehicles if trailers are not present. Its current size is approximately 100 X 150 feet. Because the boat ramp will be remaining in its current location and will still need to have a serviceable parking area the Design Team is recommending the lot be elevated and expanded to a size approximating 150 X 200 with better connectivity between the boat ramp turn around and remaining levee section. [Figure 4.14](#) shows this conceptual design.



Figure 4.14: Generalized Footprint for the West parking area

This configuration would be further refined as a part of the more detailed study regarding public access referenced elsewhere in this report. Conceptually this configuration allows for improved capacity, trailer parking, turn around and drop off, and provides a wasting site for spoils from the project.

Similar to dike construction fill will be placed in horizontal lifts and uniformly compacted. The material will be compacted to at least 90 percent of the maximum dry density in accordance with ASTM D-1557. An on-site engineer will need to monitor fill placement and perform in-place density tests to verify that adequate compaction is being achieved.

Compaction may be achieved with either a large vibratory smooth drum roller or a sheepsfoot roller. The appropriate lift thickness will depend on the material and the compaction equipment being used. Loose lift thicknesses of 6 to 8 inches are typical when using a smooth drum roller and when using a sheepsfoot roller, the lift thickness will not exceed the length of the projections on the roller. Smooth drum rollers will be appropriate for finish grading and to seal the site prior to inclement weather.

The spoil material will likely contain a high content of fine grained material. As such, the material is sensitive to relatively small changes in moisture content and adequate compaction becomes more difficult or impossible to achieve as the moisture content increases. Therefore, construction must occur during periods of dry weather. Specific design details are included in [Appendix C](#).

We recommend that toilet facilities on site be tied into a septic system that allows for adequate on site treatment of waste. We also recommend that facilities be constructed as handicap accessible as per Americans with Disabilities Act guidelines. Specific designs for these facilities will be developed by WDFW as subsequent planning for site access features proceeds during the permitting phase of the project.

East Parking Lot

No improvements are being proposed by the Design Team for this area. The exception being the entrance road way relocation proposed as a means to improve drainage conveyance through the Historic channel. This action is discussed in the more detail in the following section.

Chapter V

Implementation

Sequencing

Public Comment

This design study has undertaken a significant effort to engage the public and specific interest groups in an effort to secure comments and address substantive issues. Upon completion of the final design report the Design Team recommends that the public involvement process continues through two particular vehicles; the Skagit Watershed Council and the Citizens Committee serving the Skagit Wildlife Area. Through these two vehicles it will be possible to continue developing strategies that will address issues related to public access and hunting opportunities.

Agency Concurrence & Permitting

A number of permits will be required to implement this project. The Design Team understands the various types of permits and regulatory approvals will include the following;

- Skagit County Grading Permit
- Joint Aquatic Resources Permit (JARPA)- This permit would cover;
 - Skagit County Shoreline Permit
 - WDFW Hydraulic Project Approval
 - State Environmental Policy Act (SEPA)
 - USACE Section 404 for construction activity in a regulated wetland
 - State Department of Ecology section 401 Water Quality Certification
- USACE Section 10 permit for construction activity in a navigable waterway
- ESA concurrence from NOAA fisheries and USFWS

Acquiring these permits will require some considerable lead time before construction activity can begin. The Design Team recommends work on developing a Biological Assessment for submittal to Federal Regulatory Agencies begins by utilizing elements of this report. Assignments and responsibilities for initiating and delivering this product to permitting agencies rests with the Director of Fish and Wildlife. Adequate detail is present in this report to develop a Biological Assessment (BA) from submission concurrent with funding requests.

The Design Team will assume that funding mechanisms (See following section) will include Federal Agencies. Depending on the Federal funding source the lead agency will vary. However, given the necessity for a section 10 permit we recommend initial consultation begin with the Army

Corps of Engineers and NOAA fisheries upon completion of this report and in preparation of the BA.

Funding

Numerous sources, both public and private, are available for funding a project of these magnitude. However, no single once source will likely fund the entire project. Nor would it be desirable to seek funding from one source. Most funding sources have specific matching requirements, many of which require some element of local contribution. The following is a list of likely funding sources which should be prioritized and pursued concurrent with agency permitting through a agency designated implementation team.

Federal

- **Bureau of Indian Affairs Watershed Restoration Program.**
- **North American Wetlands Conservation Act**
- **NRCS Wetland Reserve Program (WRP)** (<http://www.nrcs.usda.gov/12programs/wr12/>). Mandated by Section 1237 of the Food Security Act of 1985, the WRP is a voluntary program that provides technical and financial assistance to eligible landowners to restore, enhance, and protect wetlands. Landowners have the option of enrolling eligible lands through permanent easements, 30-year easements, or restoration cost-share agreements. The program is offered on a continuous sign-up basis. This program offers landowners an opportunity to establish, at minimal cost, long-term conservation and wildlife habitat enhancement practices and protection.
- **NRC Conservation Partner Initiative**
<http://www.nrcs.usda.gov/programs/cpi>
- **Pacific Salmon Commission Southern Boundary Fund**
- **USFWS: Coastal program** <http://www.fws.gov/cep>
- **USFWS: Partners for Fish and Wildlife Program**
<http://partners.fws.gov/pdfs/05partnersgrants.gov.pdf>
- **U .5. Army Corps of Engineers funding (Sections 1135 and 206 of the Water Resources Development Act)**

Section 206 Water Resources Development Act (WRDA) of 1996. The act provides for aquatic ecosystem restoration and protection if the project will improve the quality of the environment, is in the public interest, and is cost effective. The non-federal share of these projects is 35 percent and the federal share (65 percent) is limited to \$5 million, including studies, plans and specifications, and construction.

Section 1135 of the Water Resources Development Act of 1986. The federal share of each separate project may not exceed \$5 million, including studies, plans and specifications, and construction. A non-federal sponsor is required to provide 25 percent of the cost of the project. Work under this authority provides for modifications in the structures and operations of water resources projects constructed by the Corps of Engineers to improve the quality of the environment. Additionally the Corps may undertake restoration projects at locations where a Corps project has contributed to the degradation. The primary goal of these projects is ecosystem restoration with an emphasis on projects benefiting fish and wildlife. The project must be consistent with the authorized purposes of the project being modified, environmentally acceptable, and complete within itself.

This authority provides for modifying the structure or operation of a Corps project to restore fish and wildlife habitat. The project must result in implementation or change to existing conditions, not in a report or study, and it must be clear that the modification will result in an improvement of the environment, and restoration of resources cannot go beyond pre-project conditions. The project benefits must be associated primarily with restoring historic fish and wildlife resources, and an increase in recreation may be one measure of value.

State

- **Aquatic Lands Enhancement Account (ALEA) Grant.**
- **Salmon Recovery Funding (SRF) Board** (<http://www.iac.wa.gov/srfb>)
- **Puget Sound Nearshore Ecosystem Restoration Program (PSNERP)** (<http://www.cev.washington.edu/lc/PSNERP>)
- **Washington State Department of Ecology Water Quality Funding**

This involves three potential funding programs: Centennial Clean Water Fund, State Revolving Loan Fund, and Section 319 Non-point Source Grants Program. Examples of the type of projects that have been funded in the past include Stream and salmon habitat restoration, and acquiring wetland habitat for preservation.

Private

- **National Fish and Wildlife Foundation, Salmon Sanctuaries Initiative** (<http://www.nfwf.org/>).
- **Priscilla Bullitt Collins Trust Northwest Conservation Fund;** Accepts requests upwards of \$500,000 over 5 year period

Contracting

After agencies have reviewed and any final changes have been incorporated the project will need to be prepared for bid by contractors. This process will require the development of a bid package that addresses the requirements by State contracting standards. The development of bid specifications and contract requirements will be shaped by WDFW policies and involvement. The Design Team recommends the Director assign a team of WDFW engineering personnel familiar with large scale construction projects to the task of bid development as the project moves through the permitting phase.

Estimated Costs

COST ESTIMATE

Planning level Construction Cost Estimate

Project: Wiley Slough restoration
 By: Steve Hinton

Item No.	Stage	Description	Quantity	Unit	Unit price	Amount
	Site prep	Grub & Clear	5	AC	\$3,300.00	\$16,500
		Haulway Preparation	5000	lf	\$3.00	\$15,000
		Localized Grading	10	AC	\$1,700.00	\$17,000
Sub Total						\$48,500
	Build-up	Crushed Surface Rock*Screenings ¹	29820	Tons	\$5.95	\$177,429
		Excavation of Keyway	2840	LF	\$7.00	\$19,880
		Material for Keyway	2750	Tons	\$5.95	\$16,363
		Imported Material for Levee	1420	LF	\$108.00	\$153,360
		Hauling of Import material	38340	Tons	\$4.50	\$172,530
		Material Placement & Compaction	44000	cy	\$3.00	\$132,000
		Additional Material for settlement	3750	tons	\$4.50	\$16,875
		Excavation of identified channels	2400	LF	\$7.00	\$16,800
		New tide gate structure	1	LS	\$100,000.00	\$100,000
Subtotal						\$805,237
	Demolition	Dike Deconstruction	6500	LF	\$29.10	\$189,150
		Fill Borrow Ditch with Dike Material	9,639	CY	\$3.00	\$28,917
		Fill Parking Area with Old Dike material	14,500	CY	\$3.00	\$43,500
		Reinforce existing dike	2650	LF	\$3.33	\$8,825
Subtotal						\$270,392
	Finishing	GeoTextile	7,777	SY	\$1.05	\$8,166
		Hydroseed	70,000	SF	\$0.16	\$11,200
		Demo Existing Tide gates	1	LS	\$10,000.00	\$10,000
		Grade parking area	1.5	AC	\$3,000.00	\$4,500
		Crushed Rock for parking and trails	3,000	Ton	\$5.95	\$17,850
		Hauling for Finish Rock	3,000	Ton	\$4.50	\$13,500
		Remove channel crossing to headquarters	1	LS	\$5,000.00	\$5,000
		Grade and surface new road	500	LF	\$17.50	\$8,750
		Pond Excavation	12,000	CY	\$3.00	\$36,000
		Waste material	25,000	CY	\$3.00	\$75,000
Subtotal						\$189,966
		Dewatering	5%			\$9,498
		Erosion & Sediment Control	10%			\$18,997
		Mobilization	10%			\$18,997
Subtotal						\$1,361,585
		Contingency	30%			\$408,476
Construction Subtotal						\$1,770,061
		State Sales tax	8.50%			\$150,455
Construction w/tax						\$1,920,516
		Construction management/admin	20%			\$384,103
		Permitting	5%			\$96,026
		Additional Engineering	10%			\$192,052
Total Estimated Project Cost (2005)						\$2,592,697
		Wiley Slough Design Report 5/31/05 Draft 3.0:Final	Inflation to 2007	6%		\$124,562
Adjusted Total						\$2,748,259

COST ASSUMPTIONS

Cost Assumptions

1. These cost estimates are in 2005 dollars and do not include financing.
2. This planning level estimate has been prepared for guidance in project evaluation from the information available at the time of preparation and for the assumptions stated. The final costs of the project will depend on actual labor and material costs, actual site conditions, productivity, competitive market conditions, final project scope and schedule, and other variable factors. As a result, the final project costs will vary from those presented above. Because of these factors, funding needs for individual projects must be scrutinized prior to establishing the final project budgets.
3. New levees are assumed to be constructed from 50% imported material
4. Excavation estimates for primary channels have been calculated using GIS and remote sensing data. Area estimates are multiplied by a depth of 3.5 feet to calculate material volumes.
5. Assume that the native material for filling perimeter ditches and hummocks will be obtained from levees being deconstructed.
6. Levee material quantities include 3% extra material for turnouts, maintenance area, ramps, etc.
7. Levees include an extra 2' of material to take into account settlement of the levee material.
8. Assume no native materials used in haul route construction.
9. Haul routes are estimated as being dressed with a 6" layer of 1^{1/4} minus crushed rock or screening material.
10. Final top dressing for levee tops assumed to be assumed to be 3" of 5/8 minus crushed rock to facilitate use as a pedestrian trail .
11. Material and haul estimates are based on delivery from Martin Marietta quarry in South Mt Vernon.
12. Haul rates are based on 15 Ton loads
13. Based on cross sectional work completed by Bureau of Reclamation surveyors the average cross sectional volume of existing bay front levees was estimated to be 9.7 cy/lf.

OPPORTUNITIES TO REDUCE COSTS

The most significant opportunity to reduce costs will be related to disposal of over burden materials. Significant reductions in hauling costs are realized if most, if not all of the overburden is wasted on site. A key variable related to this question is the suitability of materials from the existing levee system for the construction of the new levee. If materials are found to be suitable, then all over burden can be accommodated, and imported material minimized. The following are ways in which waste material will be managed in order to minimize cost;

- During levee demolition unsuitable materials can be placed directly into borrow pits that have been identified for filling to preserve hydraulic continuity. This should reduce hauling expenses significantly.
- Suitable materials can be stockpiled or moved directly into place for new levee construction. Since the interior dike is not being removed we have an opportunity to sequence construction so that the levees along the Southwest lobe can be deconstructed and materials sorted for use in new levee construction.
- Materials of marginal quality can be used as fill for parking lot expansion and elevation.
- In addition to materials needed for levee construction, borrow pits and the parking area additional material will be needed to reinforce the existing levee along Wiley Slough.
- Sources of clean suitable fill material are often generated as part of other construction projects. In many cases developers are seeking locations that can take clean fill. If an area of public land can be identified in the vicinity of South Mt Vernon that can be used to stockpile clean fill the costs of importing material can be reduced to the expense of hauling from the site.
- Local farmers would likely accept loamy soils for field augmentation.
- Tide gate construction should be sequenced at the driest possible time of the year. Low water conditions will minimize problems with construction. The potential to use pumps to irrigate neighboring fields should be explored with local farmers.
- Using local independent contractors for light duty excavation can reduce overhead costs.
- Relocating the Headquarters access road to take advantage of the gated north entrance would allow for West lot access without bridge construction or road development.

UNCERTAINTIES

The most prevalent uncertainty remaining in regard to construction is the suitability of the material within the existing levee system for construction of the new levee.

Uncertainty is also prevalent in the permitting process. As with any large scale project, various jurisdictions will require a variety of conditions based upon potential impacts. The Design Team recommends the Director of WDFW appoint an implementation team that can continue to work toward accounting for, and resolving project related impacts within the regulatory context.

More.....

Monitoring

As recommended by Thom and Wellman (1996), Wiley Slough restoration monitoring will be based on a conceptual model linking ecosystem processes to habitat conditions and functions, and biological responses to those conditions and functions. Additionally, project monitoring will involve baseline and post-restoration monitoring. Baseline monitoring has been conducted on site in preparation for this report since 2001. Largely collected through work conducted by SRSC results to date have been used to describe processes and conditions as they historically existed and currently exist at the Wiley Slough restoration site (e.g., Hood 2004). The contrasts between historical and current conditions have been used to identify an opportunity for habitat restoration and to suggest restoration goals and objectives. Baseline monitoring results have also been used to generate restoration hypotheses, as detailed below. Finally, baseline monitoring results will be contrasted with post-restoration monitoring to evaluate restoration success and test restoration hypotheses.

Levees have isolated the project area from the key processes of riverine and tidal flooding, thereby altering sediment transport and storage processes. These processes are crucial in the formation and maintenance of a number of estuarine habitat conditions. Construction of the Wiley Slough levees, to drain and convert the project site to agricultural use, has resulted in direct loss of 16.3 acres of tidal channel habitat and 160 acres of intertidal marsh habitat. However, there have been additional off-site impacts as a result of levee construction—20 acres of intertidal channel habitat have been lost seaward of the levees due to sediment deposition resulting from loss of tidal prism landward of the levees (Hood 2004). These off-site impacts from levee construction indicate that off-site areas will also likely respond to habitat restoration efforts that include significant levee removal. Thus, monitoring should have a landscape-scale focus, not merely a site-scale focus.

MONITORING OBJECTIVES

Estuarine processes, functions/conditions, and biological responses, should be monitored based on project goals and objectives. Three general monitoring objectives, operating at different scales, will measure the performance of the restoration project relative to project goals and objectives, as recommended by Thom and Wellman (1996):

- To determine whether the restoration actions allow landscape processes to form and maintain habitat conditions and functions supporting natural biota, particularly juvenile Chinook salmon (process level);
- To monitor conditions, functions, and biological responses to provide information by which the project can be adaptively managed (conditions/functions level).
- To learn as much as possible about restoration of lower-river/estuarine ecosystems; to apply this knowledge to future projects, and to share what we learn with all interested parties.

CHANNEL GEOMETRY

Channel geometry responds to tidal and riverine transport of sediments and can therefore be used as an indicator of process restoration. Channel geometry also affects habitat structure and availability for juvenile salmon and other fish and wildlife and is therefore an indicator of habitat quality.

Pre- and post-project monitoring of channel geometry will be accomplished through two parallel methods: [1] remote sensing (historical aerial photographs and modern high-resolution infra-red orthophotos), and [2] on-the-ground surveying. Remote sensing allows quick and accurate measurement of channel planform geometry (x and y data) over large areas, both landward and seaward of the existing Wiley levees. Ground-based surveying supplies information on channel depths (z data) at select channel cross-sections, both landward and seaward of existing Wiley levees. Monitoring of seaward areas is necessary because some levee impacts occurred seaward of the 1962 levees, and tidal channels in these areas will respond to levee removal by increasing in size and complexity. Additionally, reference areas away from levee influences will require monitoring to compare site trajectories with reference area trajectories to distinguish restoration effects from larger-scale system influences (e.g., global climate change effects on sea-level, storm/wind frequency, and river discharge and related sediment transport)

Considerable baseline data exists for channel planform geometry including historical aerial photographs from 1937 and 1941, prior to any levee construction on the project site; from 1956 when a spur levee was present; and from 1965, 1972, 2000 and 2004 when ring levees encircling the project site were also present. This information has already been used to calculate the amount and location of channel habitat lost landward and seaward of the levees, and thus, to define the nature and extent of the restoration and monitoring needed in the Wiley Slough area.

On-the-ground surveying of channel cross-sections to provide information on channel depths prior to levee removal was completed in 2004. Cross-sections were measured in channels landward (~30 sections in 5 channels) and seaward (~22 sections in 6 channels) of existing levees, in areas that are thought likely to be affected by levee removal. Additional information on historical channel depths has been collected by taking sediment cores in channels that have filled with sediment. Further cores may be collected if deemed necessary.

Post-project monitoring will mirror baseline monitoring. Infra-red orthophotos (15-cm pixel resolution or better) of the project site (both landward and seaward of the removed levees) and reference sites should be flown every two years for at least 10 years to follow changes in planform channel geometry. The nearby Deepwater Slough restoration project requires similar monitoring (Hood et al. 2003, Hood 2004b), so monitoring synergies are likely between these two projects and will likely reduce total monitoring costs. An additional synergistic effect of monitoring with orthophotos is that they will also be used to monitor vegetation changes in the Wiley Slough area and vicinity (see below). Post-project monitoring of channel cross-sections will simply require relocation of cross-section coordinates and repetition of the baseline surveys.

PORE WATER SALINITY

The agricultural community in the Skagit delta has voiced concern that estuarine habitat restoration will cause saltwater intrusion into shallow groundwater and impact farmland in the vicinity of restoration sites. To determine whether such concern is warranted we will monitor pore-water salinity on the project site, on agricultural lands adjacent to bayfront levees (on property owned by WDFW), and in reference tidal marshes in the Skagit delta.

Spatially distributed samples of pore-water will be collected from the root-zone of vegetation by digging pits 0.5m (20in) deep and collecting water that seeps into the pit. Sample salinity will be measured using a refractometer. Data will be collected during summer low-flows, which will underestimate the influence of riverine freshwater and maximize the influence of salt-water on pore-water salinity in the Skagit tidal marshes. Most samples will be collected on intermediate tides. However, a subset of sampling sites will be monitored over the course of a tide to determine if tide stage affects measurements and to develop conversion equations for the remaining dataset if tide stage is a significant influence on salinity measurements. Data will be standardized by tide stage, if necessary, and plotted by GIS on digital ortho-photos of the delta. A model will be developed to predict pore-water salinity as a function of distance from river distributaries, blind tidal channels, and Skagit Bay.

Baseline monitoring of pore-water salinity is currently underway in the Skagit delta reference marsh areas, with 136 points having been sampled to date. We anticipate collecting data from several hundred more sampling sites, of which approximately 10 will come from the Wiley Slough restoration site and 10-20 more will come from agricultural sites owned by WDFW. Preliminary results from completed baseline sampling indicates that this density of samples in the Wiley Slough area and other agricultural sites is more than sufficient for characterizing the spatial variation in pore-water salinity within such sites.

VEGETATION

SRSC scientists have made predictions of the type of vegetation that will colonize the Wiley Slough area following levee removal (see proceeding discussion under recommendations). A robust monitoring effort of vegetation evolution in the Wiley Slough project site following restoration will be essential to determining the success of these predictions.

Vegetation will be monitored through two complementary approaches. The first approach relies on interpretation and GIS analysis of biennial infra-red orthophotos, including ground-truthing of the photo-signatures. Orthophotos acquired for vegetation monitoring will also be used for channel monitoring (see above). The second approach will be ground-based sampling using map-grade GPS (<1m accuracy) to map sampling points.

Orthophoto interpretation allows rapid collection of a large amount of information over large areas with minimal effort. It also allows easy observation of spatial distribution of major vegetation types. This is particularly important for this project because area landward of the levees that will be directly restored by levee removal amount to ~175 acres, while areas seaward of the levees that could also be affected by levee removal amount to ~320 acres. This large area (~495 acres) cannot be adequately monitored without infra-red orthophotos. Conversely, quadrat-scale sampling of vegetation over large expanses is labor intensive,

costly, and subject to high variance in some measured parameters (e.g., stem density, cover estimates, biomass estimates).

Ground-based sampling with GPS will be used to characterize marsh vegetation represented by various photo signatures (image color and texture). Data will be collected by GPS in the form of large-scale point-intercept data where points will actually have a diameter of 0.5m and data for each point will consist of a list of all plant species present and estimated coverage of those species with greater than 25% coverage of the point. GPS may also be used to delineate any vegetation patches whose photo signatures are not easily distinguished. Points can be relocated in subsequent years to monitor point-specific changes in vegetation.

FISH

Fish presence/absence, abundance, species diversity, size, growth rates, and diets are all biological variables that respond to habitat conditions that result from restoration of ecosystem processes. All of these response variables will be measured for the Wiley Slough restoration project as an extension of ongoing monitoring of the Deepwater Slough restoration project (Hood et al 2003, Hood 2004b) and baseline/reference site monitoring of the greater Skagit delta. Fish will be sampled with beach seines and fyke nets (depending on channel size) in Wiley Slough, Teal Slough and two smaller un-named sloughs—one on each side of the remaining training dike (SSC 2003). Fish data from the restoration site will be compared to two new reference tidal channels to be established nearby and to other previously established reference sites in the South Fork delta.

WATERBIRDS

While ESA-listed chinook salmon are the principal focus of the Wiley Slough restoration project, waterbirds (ducks, geese, shorebirds, waders) are also of particular management interest due to their recreational importance. Waterbird usage of the restored Wiley Slough site, reference marsh sites, and agricultural lands will be monitored using the same methods as those employed for baseline monitoring (Slater 2004). Monitoring will focus on density estimates and species diversity, but depending on funding, monitoring may include development of activity budgets for waterbirds in the restoration site and in reference sites (e.g., Gray et al. 1996) and detailed observation of feeding activities.

Maintenance

Once the project is completed a number of maintenance activities will be required. Some of the activities are consistent with existing site maintenance, such as those duties associated with drainage infrastructure such as tide gates and the pump station. These activities are currently covered by the Drainage District and are expected to remain the Districts responsibility. If constructed to specification we do not anticipate any additional financial burden to be realized by the district as a result of this project.

Facilities associated with the public access will also need to be addressed. Because final design alternatives have not been selected for recreational access features we are unable to specify maintenance requirements for this infrastructure at this time. We do expect that an operation and maintenance plan will need to be developed by the Department of Fish and Wildlife in conjunction with its decision process in regard to public access.

In regard to restoration actions we do expect some active management of vegetation will be needed to keep invasive species in check.

Proposed Schedule

The proposed schedule for implementation will depend on a number of variables not yet determined at the date of publication. However, assuming approval from the Director Department of Fish & Wildlife by mid 2005 the following schedule could be applicable;

June-December 05'	Submit initial funding requests. Concentrating on permitting, public process, site survey and refining cost estimates. Continue baseline monitoring
April 06''	Complete Biological Assessment and permit applications
December 06'	Complete permitting process.
December 05-June 07'	Secure remaining construction funding
December 06'	Develop bid package
March 07'	Select contractors
July 07'- September 07'	Construct Project. Implement Post Project Monitoring Plan
September 08' –	Complete Public Access amenities.

Appendix C

“Public Outreach”

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WILEY SLOUGH RESTORATION DESIGN PROJECT

OPEN HOUSE

Conway Fire Hall

October 20

anytime between

4:00 p.m. and 9:00 p.m.

Refreshments will be provided

Come and meet members of the Technical Work Team,
hear about the various aspects of the project and discuss
with them your issues and concerns

About the project

The Wiley Slough Restoration project is a collaboration between the Washington Department of Fish and Wildlife, the Skagit Watershed Council, the Skagit River System Cooperative, and several Federal agencies and private interests including Ducks Unlimited and Washington Waterfowl Association. The intent of this partnership is to develop a design for restoring an historic tidal and riverine system, thereby benefiting the diversity of fish and wildlife species that rely on estuaries, including salmon and a wide variety of migratory birds.

Our intention is to rehabilitate natural processes at the Wiley Slough site that will be largely self-sustaining and in turn will support natural fish, wildlife and vegetative communities common to estuarine habitats in Puget Sound. To this end, our design approach focuses on restoring important physical processes (tidal and riverine flooding). The project will be designed in a way that protects interests of adjacent land owners, promotes wildlife oriented recreational activities consistent with the restoration objectives, and considers the perspectives of stakeholders affected by the project.

For more information:

Visit the project website at www.wileyslough.org

Wiley Slough Open House Attendance

1. Amrlein, Seth – National Wildlife Federation
2. Armstrong, Howard – 10352 Wallen Rd, Bow, WA 98232 –
godwits@yahoo.com
3. Aslanian, Gail and Steve – 30015 Cedarvale Road, Arlington, WA 98223
4. Aversa, Tom – 305 NW 75th Street, Seattle, WA 98117
5. Aylor, Jennifer – City of Mt. Vernon P.O. Box 809, Mt. Vernon, WA
98273
6. Barnard, Rebecca – Swinomish Tribe
7. Beatty, Dave – SFEG 1365 Roy Rd., B’Ham, WA 98226
8. Bostwick, Bob – 3449 Timothy Way, Camano Island, WA 98292
9. Bunting, Pat – 3643 Legg Road, Bow, WA 98232
10. Burcham ?, Janet – P.O. Box 6044, Bellingham, WA 98227
11. Burton, Jimmy and Cindy – 293-5832
12. Carey, Bob – TNC - 410 North 4th Street, Mt. Vernon, WA 98273
13. Church, Denny -
14. Corrigan, Tom – P.O. Box 494, La Conner, WA 98257
15. Cunningham, Brenda – SLT - 1220 S. 11th Street, Mt. Vernon, WA
98274
16. Davis, Chris – CommEn Space - 1305 4th #1000, Seattle, WA 98101
17. Doman, Shirley and Scott – 22953 N. Starbird Road, Mt. Vernon, WA
98274
18. Ehlers, ? – 293-7108
19. Ekins, Jeff – Channel Town Press - 466-3315
20. Graham, Oscar – 3643 Legg Road, Bow, WA 98232
21. Grizzel, Jeff – WDNR – NW Region – jeff.grizzel@wadnr.gov
22. Haugen, Mary Margaret Senator – P.O. Box 40482, Olympia, WA
98504 – haugen_ma@leg.wa.gov
23. Heft, Ralph –
24. Hodge, Fred – 16924 Freestad Rd., Arlington, WA 98223
25. Johnson, Rich – WDFW – La Conner
26. Kamb, Wilma – 905 South 3rd, Mt. Vernon, WA, 98273
27. Kilcoyne, Kathy – NRCS –2021 College Way, Suite 214 Mt. Vernon,
WA - kathy.kilcoyne@wa.usda.gov
28. Kleyr, Jeanne – 466-4434
29. Knight, Dick – SFEG -P.O. Box 8, La Conner, WA 98257
30. Kuntz, Anne – 17256 Meadow Lane, Mt. Vernon, WA 98274
31. Kyle, Lori – SCD - lori@skagitcd.org

- 32.Martin, Deborah – 6407 Dow Lane, Anacortes, WA 98221
- 33.Mathews, J.P. - P.O. Box 711, La Conner, WA 98257
- 34.McGowan, Jeff – Skagit County Public Works – 1800 Continental Place,
Mt. Vernon, WA
- 35.McMoran, Don – SCD – 2021 E. College Way, Mt. Vernon, WA
- 36.Miller, Curt – 15816 Polson Road, Mt. Vernon, WA 98273
- 37.Mills, Libby – 10645 Bayview-Edison Rd., Mt. Vernon, WA 98273
Ouzelchick@aol.com
- 38.Nelson, Lyle –
- 39.Nelson, Stan –
- 40.Nolte, Jesse -
- 41.O’Brien-Miller, Colleen – 545 Regency Drive, Oak Harbor, WA 98274
- 42.Olson, David – 18385 Torset Rd., Mt. Vernon, WA 98273
- 43.Orrell, Russ – 588 Shoshone Drive, La Conner, WA 98257
- 44. Penman, Jane – 466-1988**
- 45.Polayes, Joanne – Dept. of Ecology 160th Ave SE, Bellevue, WA 98008
- 46.Riley, Barbara –
- 47.Riley, Ralph – Earthwatch Inst. 407 Main Street, #206, Mt. Vernon WA
98273 –rriley@earthwatch.org
- 48.Robbins, Dee – Earthwatch Inst. 407 Main Street, Suite 206, Mt Vernon,
WA 98273
- 49.Rose, Bob – SPF – P.O. Box 2405, Mt. Vernon, WA 98273
bobr@skagitonians.org
- 50.Scheuch, Brian – P.O. Box 504, La Conner, WA 98257
- 51.Shelby, Mike – WWAA –2017 Continental Pl., #6, Mt. Vernon, WA
98273
- 52.Schmidt, Doyle – 466-5085
- 53.Shreffler, Jim –WWF
- 54.Smith, Dave – 20278 Maupin Road, Mt. Vernon WA 98273
tideflatnw@aol.com
- 55.Stahl, Jon – One/Northwest
- 56.Studley, Alison – SFEG –P.O. Box 2497, Mt. Vernon, WA
astudley@fisheries.org
- 57.Smith, David – 20278 Maupin Road, Mt. Vernon, WA 98273
- 58.Smith, Richard –

59. Swanson, Austin – P.O. Box 454, La Conner, WA 98257466-3585

60. Talman, Linda – 466-3859

61. Thompson, Doug - WDFW, La Conner

62. Vail, Ann and Jim – 500 Colville Way, La Conner, WA 98257

63. Vetter, Mary Jane – dvetter1@juno.com

64. Vogelsang, J.H. – vogeljh@hotmail.com

65. Walker, Edwin -

66. Wiggers, Keith – kwiggers@fidalgo.net

67. Wylie, Dallas – 21954 Wylie Road, Mt Vernon, WA 98273

1. Wiley Slough Walkabout June 9, 2004 Attendance and notes

Bob Carey	TNC
Ed Conner	SCL
Dick Night	SFEG
Deene Alvig	SFEG
Anna Casey	SFEG
Curtis Tanner	USFWS
Greg Hood	SRSC
Bob Warinner	WDFW
Art Kendal	WWA
Ginger Phalen	USFWS
John Roozen	Farmer
Nolan Lee	Farmer
Brad Smith	Farmer
Jeff McGowan	Skagit County
Jennifer Aylor	Wildlands
Fred Partington	
John Okan	Trail User
Martin Tyler	Duck Hunter
Susan Tyler	
Brenda	
Carolyn Avenger	
Kim Byson	Ducks Unlimited
Auni Remain	Trail User
Jim Hamlin	WWA
Scott Sundury	
Amanda	child
Dallas Whyie	Farmer
Paco Rodriguez	USFWS
Rich Carlson	USFWS
Judy	USFWS
Denise Hansted	Neighbor
Josh Hansted	child
Olivia Hansted	child
Alison Studley	SFEG
John Garrett	WDFW
Kurt Wylie	Farmer

Comments/Questions/Statements

John Roozen

- Delta is building itself out & will replace habitat by itself; we should not be telling people that the natural process has been halted.
- How will we ensure ag drainage?
- Thinks that secret meetings are taking place.
- The farmers know how the drainage works.
- Removing the dikes will destroy the drainage on East Fir Island.
- Greg appears very honest and knowledgeable.
- If we had mentioned that we have not actually started the hydraulic analysis, he would not have presumed that secret meetings were taking place.
- We should be careful to explain at the beginning where we are in the process.

Denise Hanstad

- How long will it take for the natural vegetation to re-establish?
- How many salmon has the Deep Water project produced?
- Is it possible to hold meetings (walkabouts) later in the evening in order to accommodate people that work during the day?

Auni Remain

- Why not just breach the dike so the trail can be preserved?
- Primary concern is that removing the dike/trail will eliminate a unique educational opportunity that essentially does not exist elsewhere.
- Is there a way to comment on the project?
- Are the comments read/considered?

Olivia Hamsted

- Will animals be forced from their homes?
- Will this disrupt the ecological balance?

Jim Hamlin

- What precautions/contingencies will be taken to control invasive species after the dike is breached?

Dallas Wylie

- What is going to be done to provide food for waterfowl in the interim between removing the crops and establishing native vegetation?
- The loop trail is the highest priority.
- People feel like they are not being heard.

Martin Tyler

- Why are we doing this here when there seems to be other more appropriate places?

Art Kendall

- What about the people?
- Public access issues must precede bulldozers.
- By the time of the November public meeting, only finishing touches will be left and the search for construction funding will begin.

Kurt Wylie

- During the recent flood Kurt stood on the dike adjacent to the Wiley Slough outlet. While standing there he observed the water level on the riverside of the dike at an elevation approximately 3 feet higher than the water level on the estuary side of the dike.
- Without the dike 1/3 of Fir Island will be flooded.
- The removal of the most central dike will be a deal breaker as far as the dike district is concerned.
- He has spoken to Brian Williams and Steve Hinton regarding this issue but they don't seem to be listening.

2. Suggestions for the next walkabout

- Provide a board to write down comments/questions received during the pre-walk presentation.
- Give out comment cards to allow folks to provide written comments at the walkabout.
- Possibly provide a facilitator to keep presentation/walkabout on track.
- Put a "Mission Statement" on display.
- Start the presentation with a description of where we are in the process currently.
- Start later so that people that work until 5 can attend.

WILEY SLOUGH RESTORATION DESIGN PROJECT FREQUENTLY ASKED QUESTIONS

What's the timeline for the project? What's next?

The design study and final document for the Wiley Slough restoration design project is expected to be completed in January 2005. A public meeting will be held on January 18 at Maple Hall in La Conner to present the design. The decision whether to move forward with construction will then rest with the Director of the Washington Department of Fish and Wildlife. If construction is approved, then funding for the project will be sought in 2005 and likely secured by the end of 2005 or early 2006. After funding is secured then the required permits will be sought during 2006 and, if successful, actual construction would likely begin in 2007 or 2008.

For more information, see Station 5, Project Schedule.

How would public access change in the project area? Would there still be a loop trail?

The current design (see Station 2, Conceptual Design) would eliminate large portions of the existing loop trail. However, there would be considerable dike-top foot access available in the project area, including access to the bayfront using a linear trail as well as a new, smaller loop trail in the northern section of the project. Waterfowl hunting opportunities would still exist on the site, but would be limited to boat hunting during high tides or boot hunting during low tides. Other wildlife oriented recreational opportunities will still be available at the Headquarters/Wiley Slough Area, including birdwatching, hiking, wildlife photography, etc. The boat launch area would remain in the same location with improved parking and the boat ramp maintained with periodic dredging.

For more information, see Station 4, Public Access.

Will WDFW be acquiring lands to replace the hunting and other recreational uses that would be lost if the project happens?

Replacement is not required in order to do the project, but the agency is looking for new opportunities for recreational access throughout Skagit and Snohomish counties. So far the agency has received 2 million dollars in coastal wetlands grants to acquire and restore wetlands and thus provide new recreational opportunities. The agency is also considering leasing access from farmers and partnering with other government agencies and non-governmental organizations in Skagit and Snohomish counties to provide additional recreational opportunities.

For more information, see Station 7, New Opportunities.

How would agricultural drainage/flooding outside the project area be affected by the project?

The design team has delineated the contributing drainage area that empties into Wiley Slough and has run a hydrology model that estimates the volume of water needing to be stored and subsequently conveyed for 2, 5 and 10 year storm events. The final design recommendation will take into account any loss of storage capacity within the drainage

system from tidegate relocation by providing improvements to the system yielding gains in both capacity and conveyance. Preliminary estimates indicate that sufficient passive capacity is available for development. Several design options are available that can make up for any capacity loss from other project features.
For more information, see Station 3, Assessments.

How would salmon benefit from this project?

Restoration of estuarine functions to the Wiley Slough site would provide significant benefits to chinook salmon as well as for chum, coho, pink, sockeye, bulltrout, steelhead and cutthroat. Increased channel habitat both inside (16.3 acres) and outside (20.5 acres) of the existing dikes, recolonization by native marsh species that support detrital food chains, and unrestricted flow of water and nutrients across the marsh surface would be particularly beneficial to juvenile salmonids rearing in the estuary. Estuarine habitat for rearing juvenile salmonids has been identified as a limiting resource for salmon in the Pacific Northwest and in the Skagit Basin in particular.
For more information, see Station 1, Estuary Ecology.

How would the project change bird/waterfowl habitat?

Overall, bird diversity and abundance is expected to increase with the establishment of native tidally-influenced vegetation communities. Several bird taxa will be affected by this project. Waterfowl, especially dabbling duck species, should benefit due to year-round access to marsh foods (i.e., invertebrates, plant material, seeds). Currently, they are limited to seasonally available agricultural foods, which are nutritionally inadequate. Restoration of native marsh habitats will provide nesting habitat for several duck species, and many diving ducks will also use the area as tidal channels are established. In addition, Snow Geese can be expected to graze on emergent marsh vegetation during spring and fall migration.

The passerine community will exhibit a shift from an agricultural and riparian woodland community to one dominated by species associated with tidal marshes and associated scrub forest. It is unclear how passerine diversity will be affected by this restoration project, but there is no evidence that abundance should decrease. Many of the species that use the woodland area, such as Yellow Warblers, Song Sparrows, chickadees, will continue to utilize the scrub shrub habitats. Some forest species, dependent on the mature woodlands inside the dike, will initially disappear and be replaced by marsh associated species such as marsh wrens. Some riparian woodland habitat will not be affected at all, that which is currently already outside the dikes. Some additional wooded areas inside the dikes may also persist in higher areas.

Finally, long-legged waders (e.g., american bittern, rail, heron) and shorebird abundance and diversity will increase substantially. Currently, the entire project area is unavailable to shorebirds, except for Killdeer, an upland specialist. Shorebirds will utilize many of the restored habitats within the project area. Least Sandpipers, Greater and Lesser Yellowlegs, and Dowitchers will utilize the emergent marsh and channel habitat during their spring and fall migrations.

For more information, see Station 1, Estuary Ecology

Please visit www.wileyslough.org for more project information.

ANNOUNCEMENT

COME LEARN MORE ABOUT THE WILEY SLOUGH RESTORATION PROJECT

The Wiley Slough Work Group is hosting
field trips at the proposed restoration site on

April 14

May 12

June 9

July 14

August 11

led by Dr. Greg Hood, the project's Landscape Ecologist
and other members of the Work Group

Meet at 2:00 p.m. at the Shelter
Skagit Wildlife Area off Wylie Road on Fir Island.

ABOUT THE PROJECT

The Wiley Slough Restoration project is a collaboration between the Washington Department of Fish and Wildlife, the Skagit Watershed Council, the Skagit River System Cooperative, and several Federal agencies and private interests including Ducks Unlimited and Washington Waterfowl Association. The intent of this partnership is to develop a design for restoring an historic tidal and riverine system, thereby benefiting the diversity of fish and wildlife species that rely on estuaries, including salmon and a wide variety of migratory birds.

Our intention is to rehabilitate natural processes at the Wiley Slough site that will be largely self-sustaining and in turn will support natural fish, wildlife and vegetative communities common to estuarine habitats in Puget Sound. To this end, our design approach focuses on restoring important physical processes (tidal and riverine flooding). The project will be designed in a way that protects interests of adjacent land owners, promotes wildlife oriented recreational activities consistent with the restoration objectives, and considers the perspectives of stakeholders affected by the project.

For more information:

Visit the project website at www.wileyslough.org

OR

Call Shirley Solomon, Skagit Watershed Council (360) 419-9326

Wiley Slough Restoration Design Project

INFORMATIONAL

OPEN HOUSE

Maple Hall, La Conner

October 23, 2003

4:00 - 7:00 p.m.

<u>Name</u>	<u>Comments</u>
Seth Amrlein	Looks good so far.
Howard Armstrong	I am not opposed to creating more salmon habitat, but am concerned that we will be losing the best passerine habitat in the county. We will gain 10% more estuarine habitat and lose 90% of the passerine habitat. Historically the area behind the dike was estuarine habitat and above that was passerine habitat, but where will the passerine go when the dikes are removed? I know that this is the only place where estuarine habitat can be created and that passerine habitat can be created elsewhere, but I also know that this isn't likely to happen. Who is going to fund creating passerine habitat? I don't think you realize what a fantastic place this is for passerines and people who watch them. I can only support this plan if there is a serious plan to recreate the habitat that is being lost.
Tom Aversa	This Open House was a great idea. It is comforting to see that there is a lot of thought going into this.

	<p>My main concern is for the loss of songbird habitat (migratory primarily). There has been a huge loss of this since the dikes were created. The Wiley Slough area provides one of the BEST, most accessible spots in Puget Sound for birdwatchers. The new dike should include a buffer to the north adjacent to the private agricultural holdings. This will create good passerine habitat that is <u>accessible</u> to birdwatchers. Care should also be taken to provide as <u>much as possible</u> of this upland habitat that will support migratory birds in non-marine alder type forest.</p> <p>At all stages of the process, creation of habitat for NON-GAME species such as songbirds and shorebirds should be of paramount importance.</p> <p>Public access to as much of the area as possible should be a major concern.</p>
Bob Bostwick	<p>You are going to destroy a lot of good duck hunting area. Leave it the way it is now and fix the boat ramp at headquarters.</p>
Denny Church	<p>Replace the land lost for upland bird hunters.</p>
Tom Corrigan	<p>Maintain access for public to view these natural areas. Loop trails are necessary to give some privacy. Need bridges, not boardwalks. Assume that the political future will be better than it is today, it's O.K. to create something that will need new financing in the future.</p>
Brenda Cunningham	<p>Are there alternatives developed? – Wish we could see them! The value of public education and</p>

	<p>providing open space where people can observe and learn about the natural diversity of Skagit Valley has been greatly underrated in this proposal. Building and maintaining a constituency of supporters will require offering them opportunities to appreciate and experience a variety of habitats.</p> <p>This proposal appears to be driven by a concern for a limited number of species in a very diverse ecosystem. Appears to be ESA driven. By considering a compromise that retains some terrestrial habitat and public access as well as ESA listed species, perhaps we can stay ahead of ESA on these other species and foster a new generation of supporters.</p>
<p>Wilma Kamb</p>	<p>I would appreciate if you would keep me current on this project, as I own the farm just north of Wileys’.</p> <p>I wish you would incorporate putting in an emergency canal where Dry Slough used to be – for flood control-something that could be used when the river is high and closed off when not needed.</p>
<p>Scott Doman</p>	<p>I’m encouraged with the approach you are taking however salmon should not be the driving factor – we enjoy the birding opportunities the dikes on the bay front offer, along with habitat for all types of birds – this project is too big a loss of habitat for the few fish it will enhance.</p>

Ralph Heft	It looks like an excellent project. I would like to see more hiking access within the area. It may be possible to mark routes with posts for use at low tide to reach higher ground spots within the project area.
Fred Hodge	Please provide breaching rather than wholesale removal. The objective would be to preserve songbird habitat along the outer margin of existing dikes, while permitting tidal flows throughout low lying areas of this proposed project area. In addition, though it would increase maintenance costs, there should be a network of interconnecting footbridges to permit bird and other wildlife viewing.
Kathy Kilcoyne	Let's get going!
Anne Kuntz	<p>Loss of birdwatching habitat concerns me. WA State Ornithological Society's new bird finding guide due out the first week of November highlights this as a hot spot in Skagit County for migrating passerines. It's a specific habitat the birds and hence the birdwatchers need. It does not suffice to say there is a place over here you can birdwatch in or put viewing areas in a newly flooded estuary to pacify birders. I have encountered birding field trips from around our entire region here birding, not to mention international guests here to bird. Birders put plenty of money into the local economy, but they come for birds in specific habitat.</p> <p>I am also concerned that the walking trails and the ability to make the loop will be gone. There are few trails around where dogs can be off lead. A field to run in is not the same as going on a walk with your owner.</p>

	<p>There are few places I know of with the beauty of this place where families walk, seniors walk, dog lovers walk, birders gather and joggers cyclists and hunters all rub shoulders. It is very much a multiple use area and though the hunters may be the most organized in their opposition; there will be a loss to many more uses.</p>
Lori Kyle	Great venue
Deborah Martin	<p>This is a wonderful and very necessary project. It is well thought out. It will support all needs and concerns. Thank you for this excellent work and perception.</p>
Curt Miller	<p>Several of the presenters made certain assumptions about what was going to occur. Need to be cautious about how the project is presented – just starting, gathering information, will develop and access alternatives, etc. How will future information from the public be gathered and feedback.</p> <p>Greg Hood mentioned that some existing dike material would be used to fill in “old borrow” areas. Rather use this material to create or enhance existing higher ground to create more habitat diversity. Create corridors of common habitat.</p> <p>I heard several people mention possible “compromise” solutions. Rather maximize for fish and then create the best possible habitat for birds and best possible access for public around this fish restoration structure.</p>
Libby Mills	<p>I feel the project must include enhancement of gallery forest/shrub lands for passerines, could include high tide shorebird habitat and should not stop at looking only at salmon enhancement. The value of the existing dikes for education and awareness of wildlife habitat for songbirds cannot be underestimated. I have taken bird classes to the</p>

	<p>dike system and personally studied the songbirds there for years and go there because it is one of the best places in the valley to find these species. The proposed new dike along farmlands has nothing to offer for education/birding access. The loss of habitat for migratory birds in stopovers and nesting habitat is total in a proposal that would take out all the uplands.</p> <p>Let us prepare an alternative proposal and show what habitat for birds we believe could be a compromise.</p> <p>Add ability to keep this valuable songbird/passerine habitat.</p> <p>Add accessibility for education/appreciation/recreation. Maybe we can get a better proposal.</p> <p>Can we make some overlays to your maps and show what we envision?</p>
Jesse Nolte	<p>As a comparison, I would appreciate seeing a more “mitigated” approach that would leave some dikes standing with perhaps controlled flooding. Would such an approach be more or less cost effective? Would it fulfill some or most of the project goals? Would it still allow pheasant and field duck hunting?</p>
Colleen O’Brien Miller	<p>I would like to see a question/answer forum with the sponsors.</p>
Joanne Polayes	<p>This is a great project and a great approach to working with the various affected interests and alleviating their concerns. We need more projects like this!</p>
Brian Scheuch	<p>The people of the state (the owners) are not being considered.</p> <p>This should remain a multi-use recreational area.</p>

	<p>This “fish only” mentality is going to divide the environmental community.</p> <p>The money should be used to acquire environmentally sensitive property – not to remove the people’s recreational property.</p>
Jim Shreffle	<p>Many specific until I asked about specific criteria as to judging success or failure of the project, specifics about hunting access, specifics about separating bird watchers/hunters. Vague promises about possible future monies available to partner with farmers upland to possibly benefit hunters.</p> <p>I am concerned about the loss of hunting opportunities and feel that we are a group who has shown the longest and greatest interest and support of the area. More hard information needs to be provided.</p>
Dave Smith	Very good event – I learned a lot!
Linda Talman	Good Job. Suggestions – maps 1, 2 & 3 correlate as such – see diagram on her comment card.
Ann Godwin Vail	Thanks for the excellent displays. We will keep in touch as you proceed.
James Vail	Blow the dikes, do it today – but I will miss walking my dog on the dikes.
Mary Jane Vetter	<p>Very clear picture of the proposed new dike and are dikes to be removed and opened for wildlife.</p> <p>Interested in the drainage picture, as we are adjacent farm to the Wileys (off Mann Road). We are on Freshwater Slough, which acts as extra drainage for our land; however, it has a tidegate on it now.</p> <p>Would support opening Dry Slough to more H2O and possibility of a fish run again.</p>
Keith Wiggers	I am supportive of restoration of habitat. However, any change is a compromise. Something is gained,

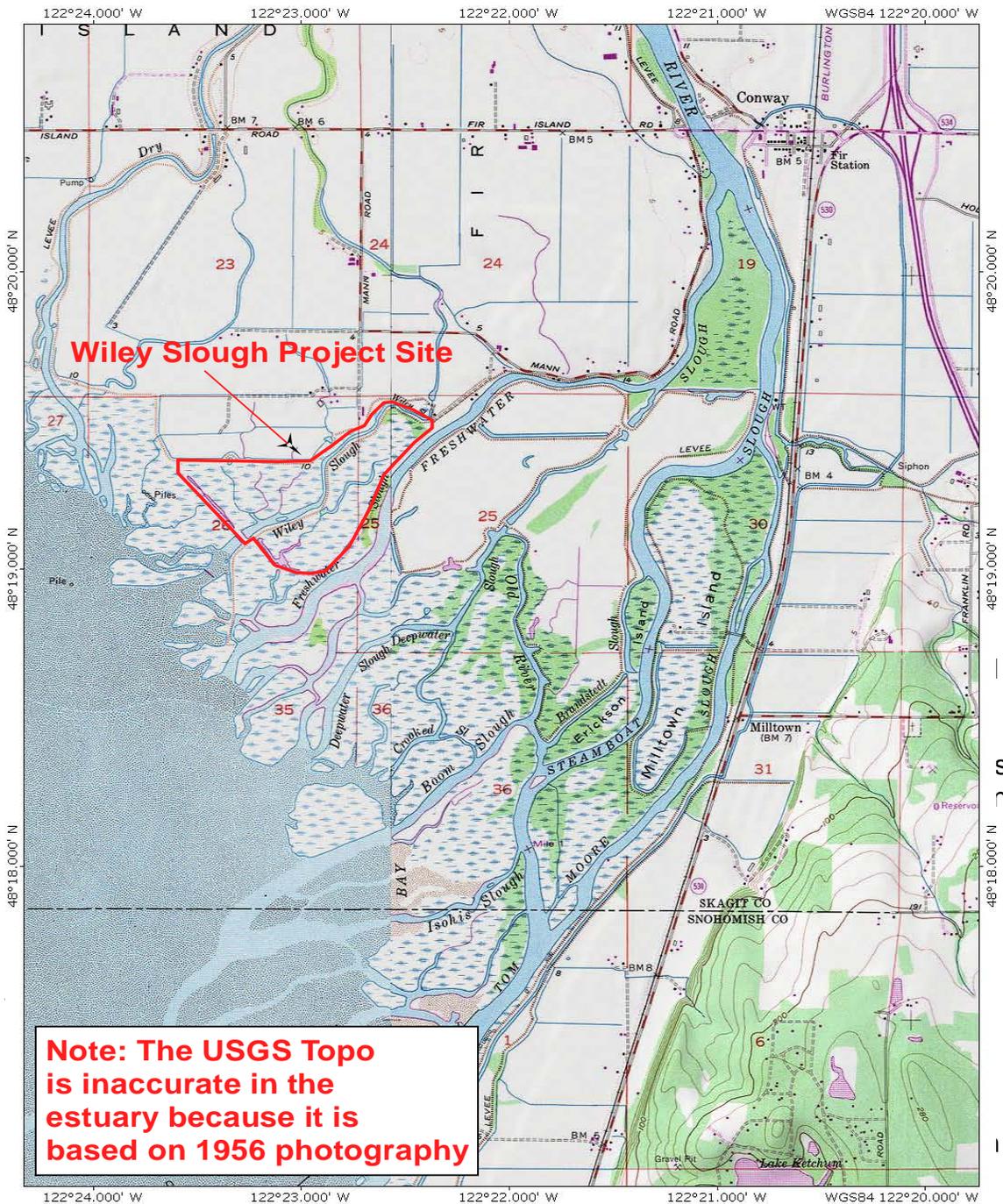
	<p>something is lost. In this particular case the decision is difficult due to the special habitat that will be lost for a large number and variety of species of passerine birds.</p> <p>I would like to see further study and plans that will replace lost habitat.</p>
No Name Given	<p>Please keep or make public access a priority – for walking trails, bird watching, enjoying the out of doors. Bird habitat is important.</p>

Wiley Slough Restoration Design Project: Fact Sheet

October 23, 2003

- Project is co-sponsored by Washington Department of Fish and Wildlife, Skagit Watershed Council, Skagit System Cooperative and Seattle City Light
- Main objective of project is to design a scientifically sound approach to restoring tidal and riverine processes to an area currently isolated by dikes and tidegates. Located in the lower South Fork of the Skagit River on land owned by the Washington Department of Fish and Wildlife, the Wiley Slough study area contains approximately 175 acres of former estuarine marsh and 16.3 acres of historic tidal channel that can be restored to support natural ecosystem functions for fish and wildlife
- The site is currently drained and planted with barley and managed for waterfowl. Historically, the site was estuarine tidal emergent marsh with some estuarine tidal scrub-shrub in the northeastern portion of the site
- The total cost of the project, which will result in a 90% design document, is \$180,000. The Salmon Recovery Funding Board is funding \$145,000 of the work and the remainder is from sponsor match
- The expected completion date for the design report is December 2004
- Several public meetings are planned in order to receive and incorporate public comments
- Organizations represented on the technical design team include the co-sponsors (above), Washington Waterfowl Association, Ducks Unlimited, United States Department of Fish and Wildlife, NOAA Fisheries, and the US Army Corps of Engineers
- Initial focus of design team is to produce a conceptual restoration plan that identifies specific objectives, constraints, proposed actions, and uncertainties. Following technical review and public comment, the conceptual plan will be the basis for developing a 30% design document and then a 90% design document. Public comment will be solicited throughout the process
- Two major goals of the project are that the design 1) provide public access to the site and adjacent marshes for duck hunting, bird watching, and other recreational uses; and 2) include improvements to the existing boat

ramp at the site that currently requires regular dredging and has limited space for vehicles



5. III. PROJECT OBJECTIVES

List the project's objectives. Explain how achieving the objectives will address and help solve the problem identified in II above.

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