House Bill 1418 Report:
Tidegates and Intertidal Salmon Habitat in the Skagit Basin

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With Contributing Chapters by

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Acknowledgements

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Executive Summary

This is an estuarine habitat enhancement report developed as a product of Engrossed Second Substitute House Bill (ESSHB) 1418. ESSHB 1418 states that if a limiting factors analysis has been conducted for a specific geographical area and shows insufficient intertidal salmon habitat, then a plan may be developed that addresses the intertidal habitat goals contained in the limiting factors analysis. The limiting factors analysis for the Skagit Basin identified constraints within the Skagit estuary for Skagit River chinook salmon (Smith 2003). As directed by ESSHB 1418, a task force was formed, which through a planning process directed the following document for restoration of estuarine habitat for Skagit chinook salmon.

A primary consideration of the ESSHB 1418 report is the protection of agricultural lands. A recent estimate of total economic output plus value added impacts for Skagit County agriculture is $500 million annually (Andrews and Stuart 2003). Within the county, the Skagit Valley produces vegetable seed, berries, potatoes, row crop vegetables, bulbs and flowers, and contributes nearly $200 million annually to the local economy (American Farmland Trust 1999). The value of Skagit County's agriculture extends beyond the direct economic benefits. From every dollar of revenue generated, there is a $.51 cost in services. This compares to residential development that costs $1.25 in services for every $1.00 of generated revenue (American Farmland Trust 1999). There are currently about 93,000 acres of actively farmed land in Skagit County (Andrews and Stuart 2003). There is increasing pressure to develop Skagit agricultural land for residential and urban uses. However, once land is urbanized, habitat value for fish and wildlife decrease, as well as salmon habitat restoration opportunities.

The purpose of this report is to identify and prioritize intertidal salmon habitat enhancement sites within the context of science-based salmon recovery and protection of agricultural land. Because the limiting factors analysis indicates that estuarine habitat is limiting for wild Skagit chinook salmon, the document focuses on habitat specific to these stocks and life-history stages (fry migrants, tidal delta fry, and parr). Nearshore habitat has not been identified as limiting at this time, and is not included in this report. Therefore intertidal habitat used by older chinook juveniles is not included.

Within the Skagit Basin, all three types of estuarine habitats (riverine tidal, scrub-shrub estuarine-forested transition, and emergent marsh) have been greatly reduced with loses of 66-84%. Channels that allow salmon to access these habitats have also been greatly reduced. These include distributary (open) channels, which are important to maintain natural processes such as water, nutrient, and sediment transport in addition to providing habitat and migration paths to various habitat zones, and blind channels formed by tidal action. Blind channels have been shown to contain large numbers of juvenile chinook salmon in the Skagit Basin.

Much of the historic estuarine habitat of the Skagit Delta is currently diked, farmed, and developed. The dikes and associated tidegates prevent flooding and facilitate drainage necessary for agriculture and other uses. Tidegates are one-way check valves embedded in the dikes, and provide three major functions: 1) tidegates prevent saltwater intrusion, which is necessary because salt kills crops and water in drainage systems may be used for irrigation and therefore must be salt free (Soil Conservation Service 1960); 2) tidegates maximize drainage potential thereby keeping the water table low to reduce soil saturation and increase the length of the growing season by allowing an earlier start in the spring; and 3) tidegates create a reservoir between tides in which water can be collected for dispersal during the next low tide.

As part of this estuarine restoration report, a complete inventory of tidegates, floodgates (gates that function in predominately freshwater areas), and pump stations was developed and mapped. In WRIA 3, 100 different sites have one or more tidegates, 21 sites have pump stations, and 3 sites have manual gates. Sites associated with tidegates were further assessed if they met the following criteria: 1) sites must be located within the 13-foot tidal range; 2) sites were further assessed if located south of the Swinomish Channel rock jetty due to Skagit chinook accessibility issues; and 3) sites should be located on historic sloughs to maximize restoration potential.

Assessment of the sites included quantifying the potential channel habitat and vegetative communities both interior and exterior to dikes. Sites were evaluated as public lands only and as public lands plus neighboring private lands in areas where a minimum of 100 acres interior to dikes was not met by only public lands. The site assessment assumed full restoration within the site boundaries, while noting that restoration could extend outside those boundaries to increase benefits to chinook. Other information provided by the assessment includes land ownership, infrastructure, LIDAR elevations, juvenile salmon use, and current and historic habitat and land use.

After the assessments were completed, the sites were prioritized by combining rankings based upon land ownership and level of infrastructure with prioritization based upon benefit to chinook salmon. Highest rankings were assigned to public lands sites and areas containing lower levels of infrastructure. The assessment sites were also prioritized based upon benefits to chinook salmon, and were also ranked based upon the quantity of potential channel habitat expected at each site and weighed by geographic location and habitat accessibility to juvenile salmon. The rankings for land ownership/infrastructure and benefit to chinook salmon were illustrated in a scatterplot to facilitate prioritization decisions.

The prioritization process led to the following recommendations by the ESSHB 1418 Task Force. All three tiers of potential projects could provide significant benefits for chinook salmon, however the prioritization process used for this report resulted in these three tiers based on the relative pros and cons of the specific assessment sites that included information on benefits to salmon as well as factors such as infrastructure, private ownership, etc. Tier 1 areas for future estuarine restoration include Wiley Slough, Leque Island, Milltown Island, and Deepwater Slough. Tier 2 areas include the Dry/Brown Slough area, the sites near La Conner, and Dodge Slough. Tier 3 sites are those near Rawlins Road, the South Fork pole yard, and Halls Slough.

There are two major issues that would greatly impact this prioritization scheme. One is the Swinomish Channel rock jetty, which poses a migration barrier (physical and chemical) that limits most Skagit River chinook juveniles from using estuarine habitat north of Skagit Bay. If this access issue were addressed, distribution of Skagit chinook could expand to more fully use habitat north of the rock jetty. The Task Force highly recommends addressing the rock jetty access problem. The second major issue is the creation of a new distributary channel from the Skagit River to Skagit Bay. If such a channel were constructed, estuarine lands in the central Fir Island area would have an increased benefit for Skagit chinook because access would be improved. In addition, increased ecological function would also be restored. However, concern exists regarding private property, agricultural land conversion, and drainage impacts to District 22.

Non-natal estuaries that border Skagit Bay are additional potential restoration sites for Skagit chinook salmon. Dugualla Bay has been documented as a pocket estuary that is used by Skagit chinook. It also lies within the high priority area designated by the 1418 Task Force. However, Dugualla Bay was not included in the assessment due to possible negative impacts to NAS Whidbey as presented by the Island County Commissioners (see letter in Appendix 3).

The 1418 Task Force has concluded this process by providing this estuarine report to the Skagit Watershed Council. The document has provided several key pieces of information. These include a complete tidegate inventory, a detailed assessment of potential sites, a prioritization scheme that includes both land ownership and salmon benefit rankings, and recommendations for continued work that were supported by the broad membership of the Task Force. The Task Force has also sent letters of support for two projects. One letter supports the public lands component of the Wiley Slough project, while the other supports work to address the chinook access issues with the Swinomish Channel rock jetty.

There is still additional work that is greatly needed to progress with estuarine habitat restoration. Many of these needs have been stated in ESSHB 1418, and this report accomplished most of the ESSHB requirements such as:

- Reviewed intertidal salmon habitat studies.
- Described the role of intertidal fish habitat for various life stages of salmon.
- Characterized current estuarine habitat conditions in WRIA 3.
- Mapped assessment areas to illustrate historic habitat, current conditions, zoning (including commercial agricultural lands), infrastructure, and potential habitat.
- Analyzed the impacts of saltwater intrusion on agricultural land.
- Discussed the role of tidegates in drainage systems.
- Explained the effect of saturated soil on crop production.
- Conducted an extensive inventory of tidegates and pump stations.
- Developed a strategy to prioritize lands (public and private) for salmon enhancement.
- Produced a prioritized list of intertidal salmon enhancement projects.

However, some of the ESSHB requirements were not completed because either the funding level for this project was insufficient or specific information to complete the task was unavailable. Many of these data needs are typically addressed in detailed feasibility studies with assessments that cost much more than the available funds for this project. The unmet requirements include:

- Identify salmon habitat goals. This is a complex modeling task that must involve staff from additional agencies and the tribes. While there has been progress towards developing goals specific to Skagit estuarine habitat, such goals have not been finalized as of the completion of this document.
- Quantify the intertidal habitat currently accessible to fish. This is a directive that is more complex than it seems, and does not provide information that is as useful as other products that we developed in this process. Tidegates allow partial access to often times altered habitat that might not be suitable for salmon. Rather than quantify partially accessible areas that might not be currently suitable, we quantified current, historic, and potential habitat based upon full restoration at individual sites. We also restricted the quantification to the high priority area south of the Swinomish Channel rock jetty due to limited funds.
- Assess the economic impacts to existing land uses for tidegate alterations. This task would require hiring a consultant, and insufficient funding existed for this task. It could be part of future feasibility studies.
- Provide specific descriptions of how a property could be enhanced for salmon habitat. There was local resistance to assessing a specific property, especially privately owned properties. Specificity should occur at a later stage such as during a feasibility study on lands that have local support for restoration. If private lands are involved, then there must first be a willing seller before specific restoration options are detailed.
- Describe the costs to enhance properties for salmon restoration. This would also be a task completed in a later stage (feasibility study). Costs depend greatly upon the scope of the project and the geographic boundaries. These are unknown until defined by the project proponents and presence of willing sellers.
- Include the maintenance history of tidegates. Such data are not available.
- Provide information on the short and long-term impacts that restored areas would have on the viability of adjacent agricultural lands. The Task Force was unable to carry this out due to a lack of funding and time.

Introduction

House Bill 1418

Engrossed Second Substitute House Bill 1418 states that if a limiting factors analysis has been conducted for a specific geographical area and shows insufficient intertidal salmon habitat, then a plan may be developed that addresses the intertidal habitat goals contained in the limiting factors analysis. The limiting factors analysis for the Skagit Basin was completed in June 2003, identifying constraints within the Skagit estuary for Skagit River chinook salmon (Smith 2003). This led to the formation of a task force, which through a planning process directed the following report for restoration of estuarine habitat for Skagit chinook salmon.

ESSHB1418 required the Fish and Wildlife Commission and Skagit County to jointly appoint a Task Force comprising of the following representatives (the specific names of people filling those roles are in parenthesis):

One representative from the Fish and Wildlife Commission (Will Roehl)
Two representatives from the agricultural industry (Curtis Johnson, John Roozen)
Two representatives of environmental interest organizations (Alison Studley, Bob Carey)
One representative of a diking and drainage district (Lyle Wesen)
One representative of the Lead Entity of the county (Shirley Solomon)
One representative or each county in the geographic area (Ken Dahlstead, Skagit and Phil Bakke, Island, no representation provide by Snohomish County)
One representative from the Office of the Governor (Ron Shultz)

In addition, representatives of the Environmental Protection Agency, NRCS, USFWS, NOAA Fisheries, and the local tribes were invited to participate. Those who attended on a regular basis are:

Micheal Rylko, Environmental Protection Agency
Frank Easter, Natural Resource Conservation Service

A 1418 technical team formulated many of the report's components. Attendees included:

Josh Greenberg, Skagit County
Tom Karsh, Skagit County
Ed Manary, Conservation Commission
Jeff McGowen, Skagit County
Ben Perkowski, Skagit Watershed Council
Michael Rylko, Environmental Protection Agency
Carol Smith, Conservation Commission
Alison Studley, Skagit Regional Fisheries Enhancement Group
Bob Warinner, WDFW
Brian Williams, WDFW

The restoration report focuses on estuarine areas used by Skagit chinook that are associated with tidegates. Although intertidal habitat includes estuarine and nearshore habitat, salmon habitat limitations were only demonstrated for estuarine habitat in the limiting factors analysis (Smith 2003). Insufficient information existed about nearshore habitat conditions. The document focuses on Skagit chinook salmon because estuarine habitat was identified as limiting for Skagit chinook, but not for other species or for chinook from other drainages within WRIA 3 (Smith 2003). In addition to tidegate areas, other areas were included, where recommended, but the report does not include all possible areas of estuarine restoration. The document includes the following chapters.

- 1418 Report Goal
- Salmon Use of Intertidal Habitat
- The Role of Tidegates in Drainage Systems
- Tidegate Inventory for Water Resource Inventory Area (WRIA) 3
- Salmon Habitat Assessment of Project Areas for Skagit Chinook
- Estuarine Restoration Strategies
- Analysis of the Restoration Potential of Former Tidelands in the Skagit Delta
- 1418 Assessment Site Prioritization
- Findings
- Intertidal Salmon Habitat Funding
- Unresolved Issues
- Corrections
- Literature Cited

1418 Report Goal

The purpose of this report is to identify and prioritize intertidal salmon habitat enhancement sites within the context of science-based salmon recovery and protection of agricultural land.

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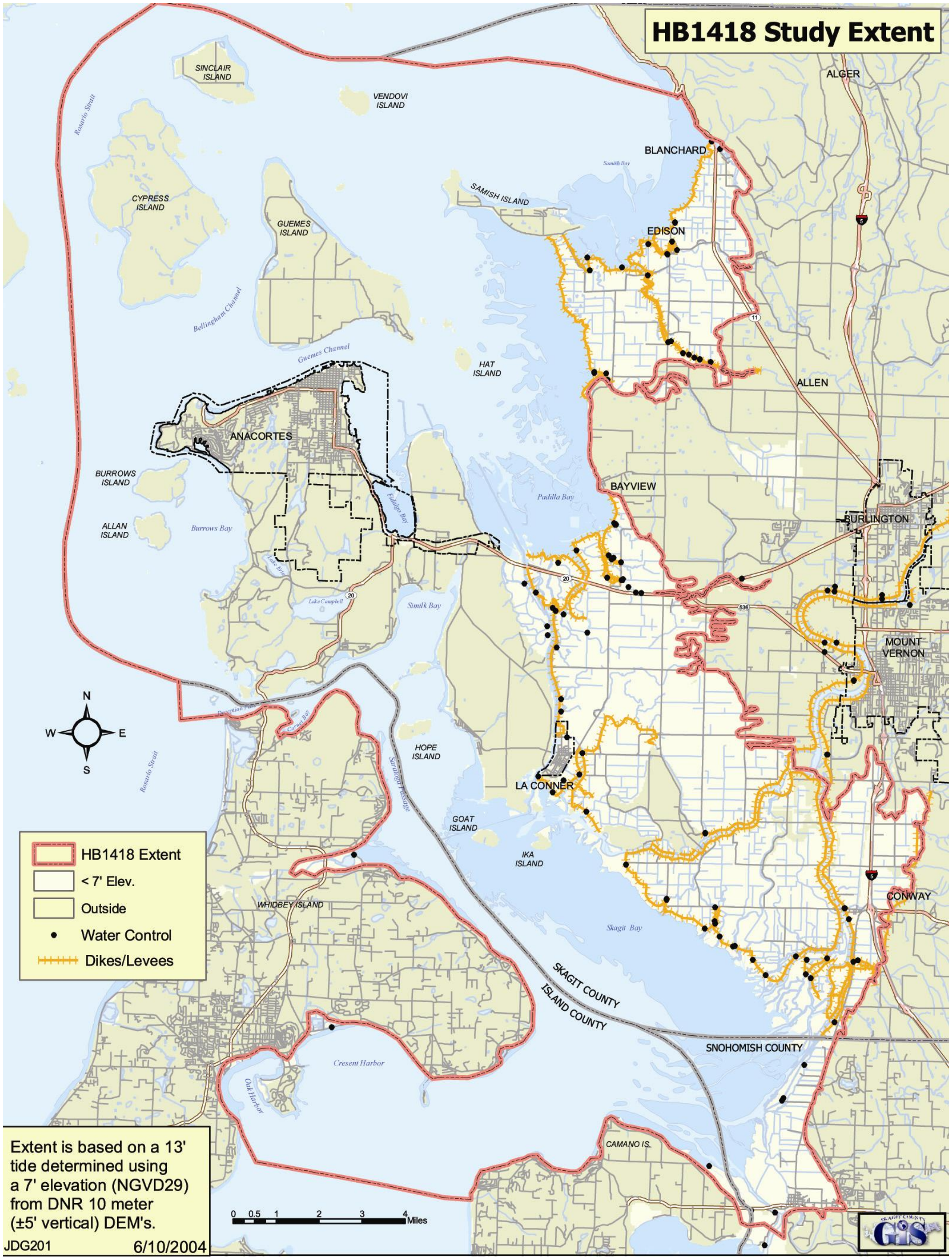
The Role of Intertidal Fish Habitat For Various Life History Stages of Salmon

Estuary vs. Nearshore Habitat
Engrossed Second Substitute House Bill (ESSHB) 1418 refers to intertidal habitat, which is defined as the area from the lowest low tide to the highest high tide, and ranges from –4.5 to +13' near La Conner (ACOE 2000). Intertidal habitat can either be estuarine delta habitat or nearshore habitat. These two types of intertidal habitat have dissimilar characteristics and are used differently by salmon. Because of this, they are separated in this report. The entire project area is shown in Figure 1.

In this project, estuarine (delta) habitat refers to a body of water adjacent to freshwater systems where saltwater mixes with freshwater. The estuary deltas included in this project are those in WRIA 3, such as the Samish, east Padilla, Swinomish Channel, North and South Fork Skagit, central Skagit and Douglas Slough deltas, as well as estuaries along the northeast coast of Whidbey Island (Dugualla Bay), northern shore of Camano Island (WRIA 6), and the estuary associated with Colony Creek in WRIA 1. For this project, we defined the upper extent of estuarine habitat to the maximum high tide for the project area, which is a 13-foot tide (ACOE 2000) (Figure 1). Tides higher than that are very rare in this area. The upstream extent of the project area within the Skagit River was defined at the confluence of the North and South Forks. Due to the evidence that the loss of estuarine habitat is limiting for wild Skagit chinook salmon, the focus of intertidal habitat for this project should be within the estuarine delta areas (see review in Smith 2003). This will maintain consistency with the language in ESSHB 1418 that defines the criteria for the analysis.

The nearshore environment is distant from major freshwater sources, and serves as the interface between marine and terrestrial habitats. It extends from the outer limit of the photic zone (the well-lit subsurface area of water where plants can photosynthesize) to coastal landforms such as bluffs, sand spits, and coastal wetlands, including the riparian zone on or adjacent to any of these areas. There is an estimated 229 miles of nearshore shoreline in Skagit County (Berry et al. 2001). The nearshore reaches in this report include all shorelines that are not immediately adjacent to a freshwater drainage including Samish Bay, Padilla Bay, north Fidalgo Island, south and west Fidalgo Island, northeast Whidbey Island, and all other islands within WRIA 3 (Sinclair, Vendovi, Cypress, Guemes, Burrows, and Allen Islands) (Figure 1). The northeast shoreline of Whidbey Island and the northern coast of Camano Island are not in WRIA 3, but are included because of their proximity to the Skagit River delta and importance for Skagit Chinook (Figure 1). In the limiting factors analysis, known information was summarized about nearshore conditions. Though much is unknown about the nearshore processes specific to this area, nearshore conditions were not identified as a major constraint at this time.

Figure 1. The 1418 project area is bordered by red, and includes the 13-foot tidal range.



The Role of Estuaries for Salmon Habitat
Estuaries serve many important functions such as providing habitat for smoltification, migration, rearing, and refuge (Simenstad et al. 1982). For anadromous fish species, estuaries provide a critical mixing zone of fresh and salt water where juvenile and adult life stages can physiologically transition between freshwater and saltwater habitats. If the habitats necessary for successful rearing and predator refuge are not available within this mixing zone, the survival of these fish is jeopardized.

Estuaries also contribute to habitat complexity and ecological processes, such as detritus (material formed by decaying plants) cycling (Williams and Thom 2000; Aitkin 1998). The detritus-based food webs begin with primary productivity, the rate, which plants, convert sunlight to organic matter (Simenstad 2001). As plant material grows and decays, it eventually supplies detritus to the food web. The coating of microorganisms that forms on the detritus, as well as the detritus itself, provides a major source of food supply for small invertebrates. Many juvenile salmonids and forage fish feed on these invertebrates. Estuarine detritus also serves as the primary base for the nearshore marine food web.

Certain prey items appear to be selectively chosen over others depending on the salmonid life history stage. For example, juvenile chum salmon feed on a certain type of copepod that lives on the microflora and microfauna associated with decaying eelgrass (Simenstad and Salo 1982), while prey items for small chinook juveniles includes midges, crab larvae, flies, water fleas and other insects and crustaceans (Healey 1991). Estuary habitats also produce prey species important to juvenile salmonids and forage fish species that are in turn, prey of adult salmonids. In order to support the diverse prey needs of the different salmon species and life history stages in the estuary, an assortment of habitat types in an estuary need to be available and hydrologically accessible. The intertidal, shallow sub-tidal, blind channel, and distributary channel habitats in the estuary provide juvenile salmonids with access corridors to estuary habitats producing preferred prey species (Shreffler and Thom 1993). In addition, the interaction of tides and channel habitats provides a delivery system that transports preferred prey species from estuary habitats that are not accessible by juvenile salmonids. Declines in available prey have been shown to result in small juvenile salmonids migrating more quickly to other areas in search of prey (Simenstad et al. 1980). The expenditure of extra energy for this migration is thought to slow growth, leading to an increased risk of predation.

The estuarine channels also serve as migration corridors for juvenile salmonids, while deeper water distributary channels provide migration corridors for adults (Shreffler and Thom 1993). Distributary channels provide critical migration and movement routes between habitats.

Estuarine Use by Juvenile Salmon
Of the five species of Pacific salmon, three have considerable use of the estuarine areas: chinook, chum, and pink salmon. Chinook salmon are the most dependent on estuarine habitat (see full discussion in next section), chum salmon the second most dependent and pink salmon the third (see review in Groot and Margolis 1991). Some estuarine use by coho and sockeye salmon occurs, but it is usually brief, and not nearly to the extent as that found for wild chinook, chum, and pink salmon.

The variation of estuarine habitat use relates to other life history stages, particularly to the length of freshwater rearing, a stage that happens after fry (salmon juvenile stage between yolk sac and parr/fingerling stages) leave their gravel nests. In general, salmon that have a longer freshwater rearing time have a shorter estuarine rearing period. The extent of freshwater rearing varies considerably from species to species and in some cases, within species. Chum and pink salmon fry migrate quickly to the estuary compared to coho, sockeye, and most chinook salmon. As pink salmon approach the lower rivers and estuaries, they form schools as a method of predator avoidance (Heard 1991). They travel quickly through the Skagit tidal delta (Beamer 2003) to the shallow waters along shorelines, often mingled with chum salmon juveniles. The estuarine residence time for chum salmon in the Skagit estuary is about one week (Beamer 2003), but in other systems, estuarine use can extend up to three weeks (Healy 1982). After a period of growth, pink and chum salmon juveniles move from the shallow nearshore waters to deeper offshore waters to begin their marine residence.

The two species of salmon that use the estuary the least are coho and sockeye salmon. Coho salmon remain in freshwater for a full year after emergence from the nests, and generally spend little time in estuarine habitat. Most sockeye salmon rear in lakes after emergence, migrating quickly through the estuary after spending a year in freshwater. However, a small number of coho and sockeye have been known to spend little time in freshwater with more extended use of estuarine habitat compared to their freshwater-reared cohorts.

Chinook Salmon and Extent of Estuary Use

The use of estuarine habitat by chinook salmon varies according to a number of factors. In the Skagit Basin, there are two major life history types of chinook salmon: ocean type and stream type. Stream type chinook (yearlings), such as some spring chinook, reside in the freshwater environment for at least a year prior to their saltwater migration, and use the estuary for a brief period of time. In other basins, the larger spring type chinook juveniles occupy the deeper waters along the delta front (Healey 1980, 1982; Levy and Northcote 1981).

Ocean type chinook, on the other hand, head for saltwater shortly after leaving the gravel nests, but not all chinook leave their nests at the same time, which results in the use of the estuary over many months. In the Skagit River, chinook fry have been found as early as January and continue to be found throughout March (data from D. Seiler, WDFW, personal communication). The extended timing of fry sightings is related to the different spawn timings found between the six stocks of chinook salmon in the Skagit Basin (spring, summer, and fall runs).

Following emergence of fry from nests, ocean type chinook fry can potentially move through a variety of life history trajectories or pathways (Wissmar and Simenstad 1998). Life history diversity represents different strategies or approaches to how fish occupy and use habitats as a way to cope with the environmental variability that they experience (Healy 1991; Healey and Prince 1995). Life history diversity allows the species and populations to persist. In the Skagit, four main chinook life history trajectories or pathways have been identified that vary in their use of estuarine habitats (E. Beamer, personal communication). First, *fry migrants* migrate soon after emergence directly to the estuary with little or no rearing in freshwater. In the Skagit area, Beamer et al. (2003) found that many of these early fry migrants appear to move into small, non-natal estuaries where they rear. Second, *tidal delta fry* are those that also migrate directly to the estuary soon after emergence but remain and rear for extended periods in natal delta habitats. Third, *parr migrants* rear for up to 6 months in freshwater streams before leaving freshwater to migrate to estuarine habitats. Fourth, *yearlings* rear for approximately one year in freshwater before migrating to sea.

In the Skagit Basin, the most dominant form of ocean type chinook (tidal delta fry) use the tidal delta for an average of 35 days of rearing from February through July, reaching about 70mm in fork length before migrating to Skagit Bay (Beamer et al. 2002a). Small numbers of ocean type chinook (fry migrants) migrate quickly through the estuary to rear directly in Skagit Bay as fry migrants (40 mm fork length), while others (parr migrants) rear a couple months in the river as parr (young fingerling salmon with dark bands), and upon reaching about 70 mm fork length, migrate through the estuary to Skagit Bay (Beamer et al. 2002a).

Hatchery reared chinook salmon use the estuarine and nearshore habitats to a lesser extent than do wild chinook (Rice et al. 2003), and appear to use different areas of estuarine habitat compared to wild chinook. This is likely related to the prolonged freshwater rearing that occurs for most hatchery chinook stocks, allowing those fish to reach a larger size and older age prior to estuarine exposure. This could result in fish that prefer a different type of habitat and have increased salinity tolerance. For example, in the Salmon River (Oregon), hatchery chinook favored the larger mainstem channels, while naturally produced chinook juveniles reared in the small channels within the emergent marsh habitat (Cornwell et al. 2001).

The average residence time for ocean-type chinook in the Skagit estuary is 35 days. In basins other than the Skagit, estuarine residence of chinook can extend longer. For example, estuarine residence can last as long as 60 days in Nanaimo (Healy 1980) and 52 to 64 days in the Sacramento-San Joaquin basin (Kjelson et al. 1982). In the British Columbia streams, chinook tend to disperse along the marsh edges during high tide, remaining in tidal channels during low tide (Healy 1980, 1982; Levy and Northcote 1981, 1982; Levings 1982). Chinook appear to be very dependent on the tidal channels, as they are the last salmonid to leave this type of habitat, and their preference appears to be for larger low bank tidal channels that have sub-tidal refugia (Levy and Northcote 1981,1982). This type of habitat allows them to come in contact with the vegetation types that support the insect and crustacean prey items preferred at this stage for rapid growth, and provides protection from some predators. In the Skagit Basin, up to 7,800 chinook juveniles have been found per acre of blind channels (Beamer et al. 2002b).

Estuarine Habitat Classification

Estuarine habitat can be divided into three major types based upon vegetation. The outer edge (distal to freshwater) is emergent marsh habitat, characterized by sedges and grasses. Upstream of this zone is an area of transition habitat between the emergent vegetation and the upstream-forested zone. The vegetation in the transition area consists of scrub-shrub or small trees and bushes. The upper extent of estuarine habitat is the forested riverine tidal zone, which supports trees. The functions of each of these zones and how they relate to salmon rearing are not well understood. However, in the Skagit, chinook juveniles grow fastest in the emergent marsh habitat with growth rates averaging 1.68 mm/day, compared to a rate of 0.53 mm/day in the transitional (scrub-shrub) and forested zones (Beamer et al. 2002a). Tidal marsh habitat is also very productive, producing an average annual standing crop of five tons of vegetation per hectare, supporting a vast array of insects and crustaceans that serve as prey for juvenile salmon (Kistritz 1996).

In addition to the vegetative types of estuarine habitat, it is vital to have channels within each of these habitat zones to allow for fish access, sediment transport, water transport and flushing, and other ecosystem functions. There are two major types of channels, blind (closed at one end) and open or distributary channels, which branch from a mainstem and extend to the estuary. Blind channels are formed by tidal action, and are more commonly found in the emergent marsh habitat zone, which is exposed to greater tidal action. Distributary channels carry water and sediment to maintain and create new habitat and to allow for additional migratory pathways for salmon between freshwater and saltwater. Both types of channels are discussed in greater detail below.

Current vs. Historic Conditions: the Quantity and Characterization of Intertidal Fish Habitat in the Skagit Estuary

The following is provided for an improved perspective of various types of estuarine habitat, and to increase our understanding of how ocean type chinook depend upon that habitat for juvenile rearing. That information provides increased opportunities to restore or recreate lost estuarine habitats.

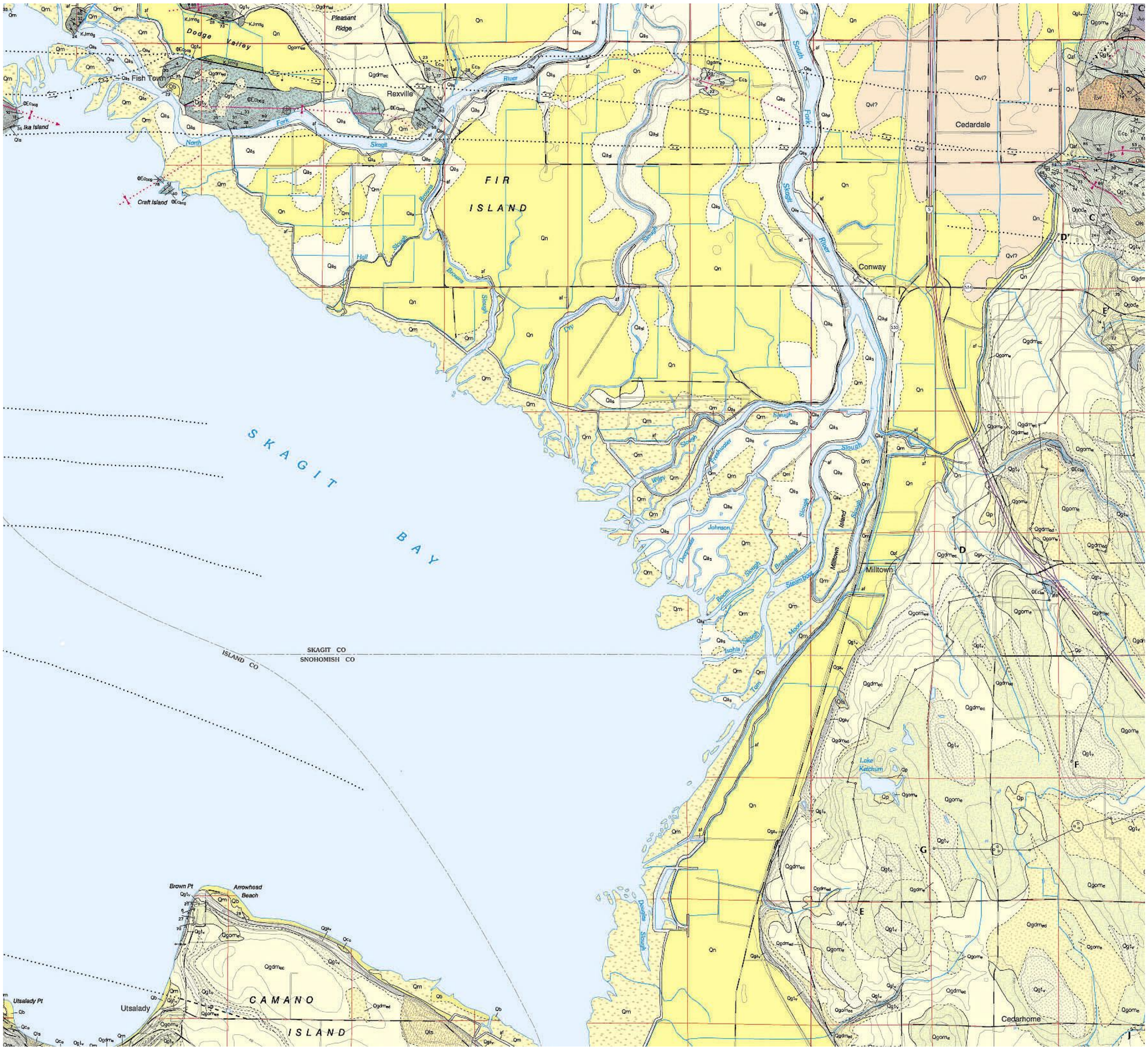
In this report, the historic condition of the Skagit estuary refers to the time immediately prior to development by Euro-American settlers in the mid-1800s. This time period was chosen because early records and recent estimates of habitat conditions are available that describe conditions at this time for the Skagit estuary. However it should be noted that the Skagit River and delta position have changed many times prior to this. For example, about 5,000 years ago, the Skagit River delta was located near what is now the City of Mount Vernon (Dragovich et al. 2002). During the late Holocene epoch (the last 11,000 years), the delta grew considerably, filling with sediments from the Skagit River and volcanic and lahar deposits (Figure 2, Dragovich et al. 2002).

The estuarine delta before large-scale human caused development best describes properly functioning estuarine fish habitat. In the Skagit River delta, distributary channels were historically numerous, and wetland complexes covered more than half of the Skagit River delta resulting in a large amount of land in contact with saltwater (Figures 3 and 4) (Bortleson et al. 1980; Collins and Montgomery 2001). Prior to human impacts, blind tidal habitat comprised an estimated 8250 hectares (ha), while riverine tidal wetlands covered about 4200 ha in the Skagit and Samish deltas for a total of 12,450 ha (Collins and Montgomery 2001).

By the end of the 19th century, dikes had isolated most of the Skagit wetlands and by the mid 20th century, numerous distributary channels had been closed off (Collins and Montgomery

2001). Many channels were converted to ditches that drain farmlands and are no longer accessible to salmonids at their upper ends, and more than 100 miles of drainage ditches exist in the Skagit delta (Phinney and Williams 1975). In addition, much of the land isolated by dikes has been ditched, dredged, or filled, resulting in a considerable loss and conversion of wetland habitat.

Figure 2. Geologic map of the Skagit River delta (Dragovich et al. 2002). Legend is shown below Figure 2, next page.



Geologic Units

QUATERNARY SEDIMENTARY AND VOLCANIC DEPOSITS

Holocene Nonglacial Deposits

- af — Fill
- Qb — Beach deposits (Holocene)
- Qn — Nearshore deposits (Holocene)
- Qm — Marsh deposits (Holocene)
- Qa_s — Skagit River alluvium, undivided (Holocene)
- Qa_{sl} — Sand levees (Holocene)—Overbank sand deposits of the Skagit River
- Qp — Peat (Holocene)
- Qaf — Alluvial fan deposits (Holocene to latest Pleistocene)
- Qls — Landslide deposits, undivided (Holocene to latest Pleistocene)
- Qvl — Lahar runout deposits (Holocene)

Pleistocene Glacial and Nonglacial Deposits

- $Qgdm_e$ — Everson glaciomarine drift, undivided (Pleistocene)
- $Qgdm_{ec}$ — Everson fine-grained glaciomarine sediment (Pleistocene)
- $Qgdm_{ed}$ — Everson glaciomarine diamicton (Pleistocene)
- Qgo_e — Everson terrestrial to marine recessional outwash (Pleistocene)
- $Qgod_e$ — Everson deltaic outwash complex (Pleistocene)
- $Qgom_e$ — Everson glaciomarine drift, undivided (Pleistocene)
- $Qgom_{ee}$ — Everson emergence (beach) deposits (Pleistocene)
- Qgt_v — Vashon till (Pleistocene)
- Qga_v — Vashon advance outwash (Pleistocene)
- Qgl_v — Transitional silt and clay deposits (Pleistocene)
- Qc_o — Olympia nonglacial deposits (Pleistocene)

TERTIARY SEDIMENTARY AND VOLCANIC ROCKS

- $ΦEc_{bs}$ — Rocks of Bulson Creek, upper lithofacies (Oligocene to Eocene)
- $ΦEc_{bcg}$ — Rocks of Bulson Creek, lower conglomeratic lithofacies (Oligocene to Eocene)
- Evr — Andesitic to rhyolitic volcanic rocks (Eocene)
- Ec_b — Chuckanut Formation, Bellingham Bay Member (Eocene)

MESOZOIC LOW-GRADE METAMORPHIC ROCKS OF THE DARRINGTON–DEVILS MOUNTAIN FAULT ZONE

- $KJms_g$ — Goat Island terrane metasedimentary rocks (Cretaceous to Jurassic)

MESOZOIC LOW-GRADE METAMORPHIC ROCKS OF THE NORTHWEST CASCADES SYSTEM

- Jmv_h — Helena–Haystack mélange greenstone (Jurassic)
- Ju_h — Helena–Haystack mélange ultramafite (Jurassic)
- Ju_{hl} — Helena–Haystack mélange silica-carbonate rocks (Jurassic)
- $Jhmc_h$ — Helena–Haystack mélange metasedimentary rocks, chert-bearing (Jurassic)

Geologic Symbols

- Contact—Dashed where inferred
- Fault—Dashed where inferred; dotted where concealed
- Strike-slip fault—Arrows show relative horizontal movement; dotted where concealed
- Thrust fault—Sawteeth on upper plate; dotted where concealed
- Oblique-slip fault—Arrows show relative horizontal movement, dashed where inferred; dotted where concealed, bar and ball on downthrown side; queried where presence or character uncertain
- Syncline—Showing direction of plunge; dotted where concealed
- Anticline—Dotted where concealed
- Overturned anticline—Dashed where approximately located; dotted where concealed

Strike and dip of Quaternary bedding

- inclined (glacial deposits only); 'f'adjacent to symbol indicates foreset bedding
- orientation of overturned, glacial ice shear-induced fold axes in thinly bedded advance outwash

Strike and dip of Tertiary bedding

- horizontal
- inclined; 'f' adjacent to symbol indicates foreset bedding
- vertical
- overturned

Strike and dip of syn- to late-metamorphic cleavage (may be combined with other symbols)

- inclined
- vertical

Strike and dip of fracture cleavage

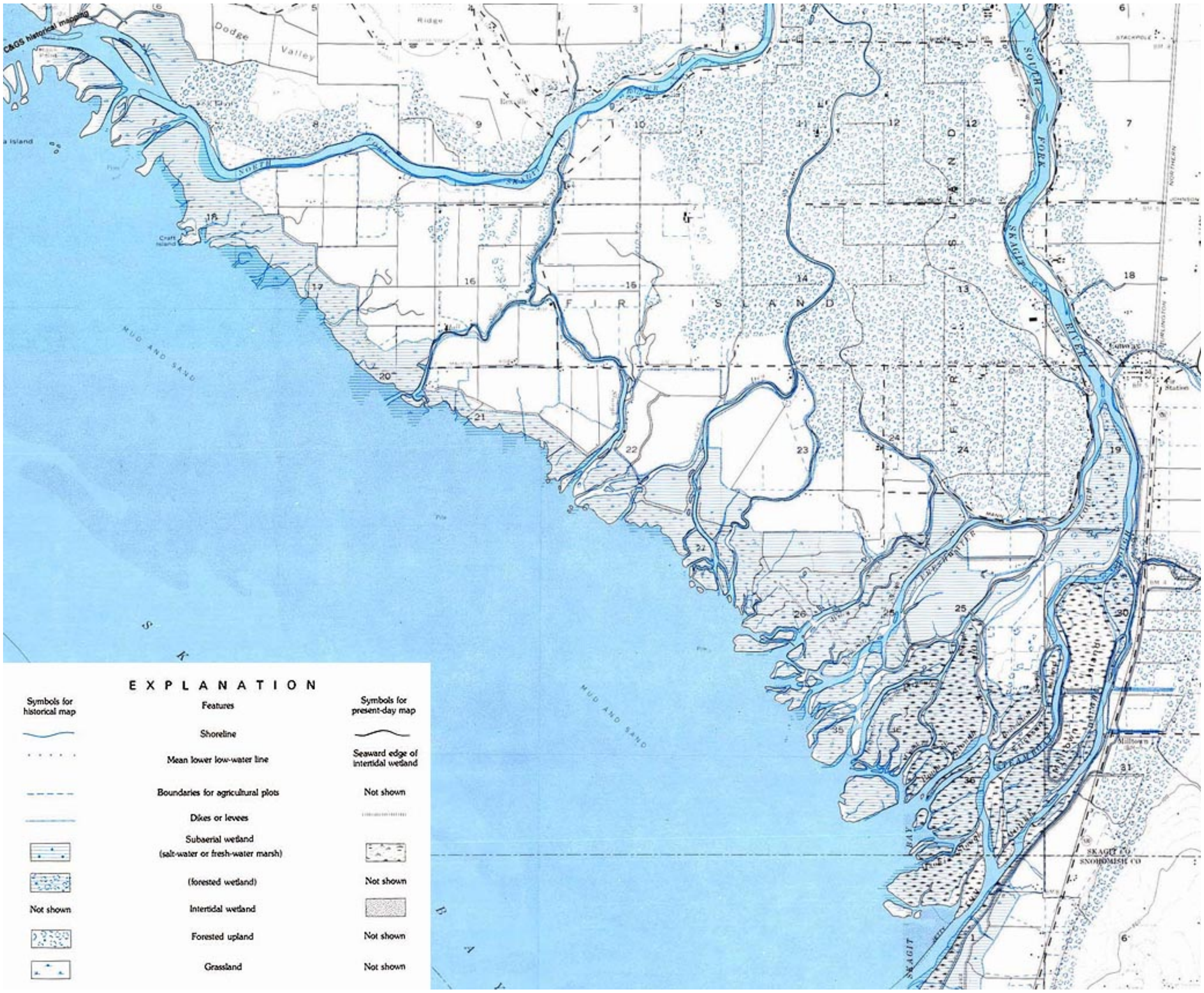
- inclined
- vertical

Lineation; arrow indicates direction of plunge

- inclined

Composite well shown on cross section using information from two or more water well boring logs

Figure 3. Changes in the Skagit Delta Channels and Wetlands (Bortleson et al. 1980).



Recent estimates indicate that total estuarine/riverine tidal habitat now covers 2556 ha with 1015 ha of estuarine emergent marsh, 1000 ha emergent/forested transition, and 541 ha of forested riverine/tidal zone (Hayman et al. 1996). Channel area is estimated at 581 ha of mainstem channel, 87 ha subsidiary channels, 24 ha large blind channels, and a maximum of 94 ha small blind channels (Hayman et al. 1996).

A 72% loss of total estuarine delta habitat has been estimated for the Skagit Basin from the mouth to Sedro Woolley (Figures 5 and 6) (Beamer et al. 2002b). The highest percentage loss is forested riverine tidal habitat, which has been reduced by about 84% (Figures 5 and 6). Estuarine-forested transition habitat (scrub-shrub) and estuarine emergent marsh habitat have also shown dramatic losses of 66% and 68%, respectively (Beamer et al. 2002a). In a separate analysis, distributary slough habitat has an estimated loss of 75% (review in Beechie et al. 2001). Currently, there is a fringe of marsh habitat seaward of the dikes in the north

Skagit delta and an area of marsh along the South Fork Skagit River mouth (Figure 3) (Bortleson et al. 1980).

Figure 4. Historic estuarine habitat and channels in WRIA 3 (from Brian Collins, in prep. and in Yates 2001).

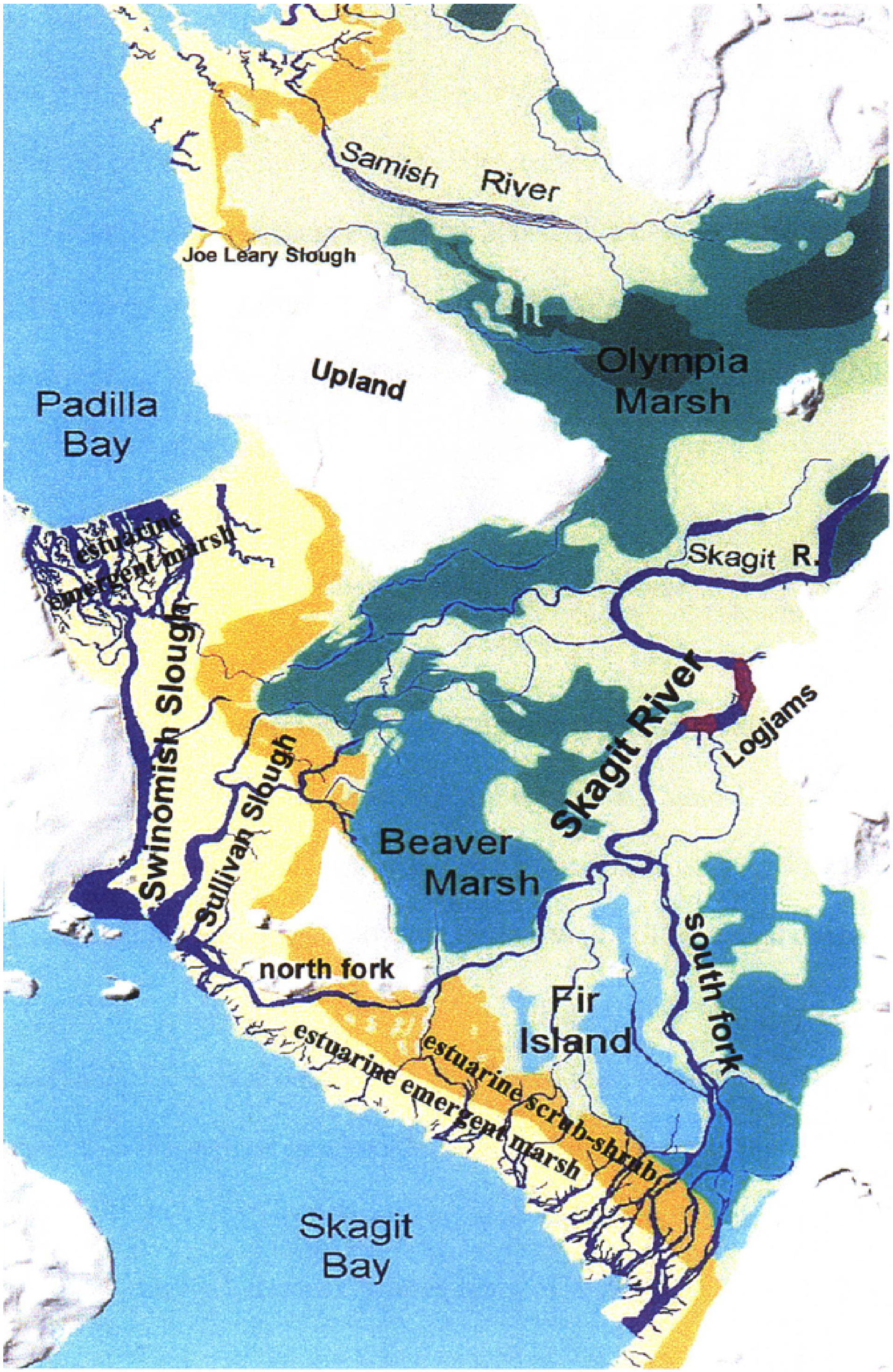


Figure 5. Historic (left) compared to current (right) estuarine habitat in WRIA 3 (from Beamer et al. 2002b and Brian Collins in prep.).

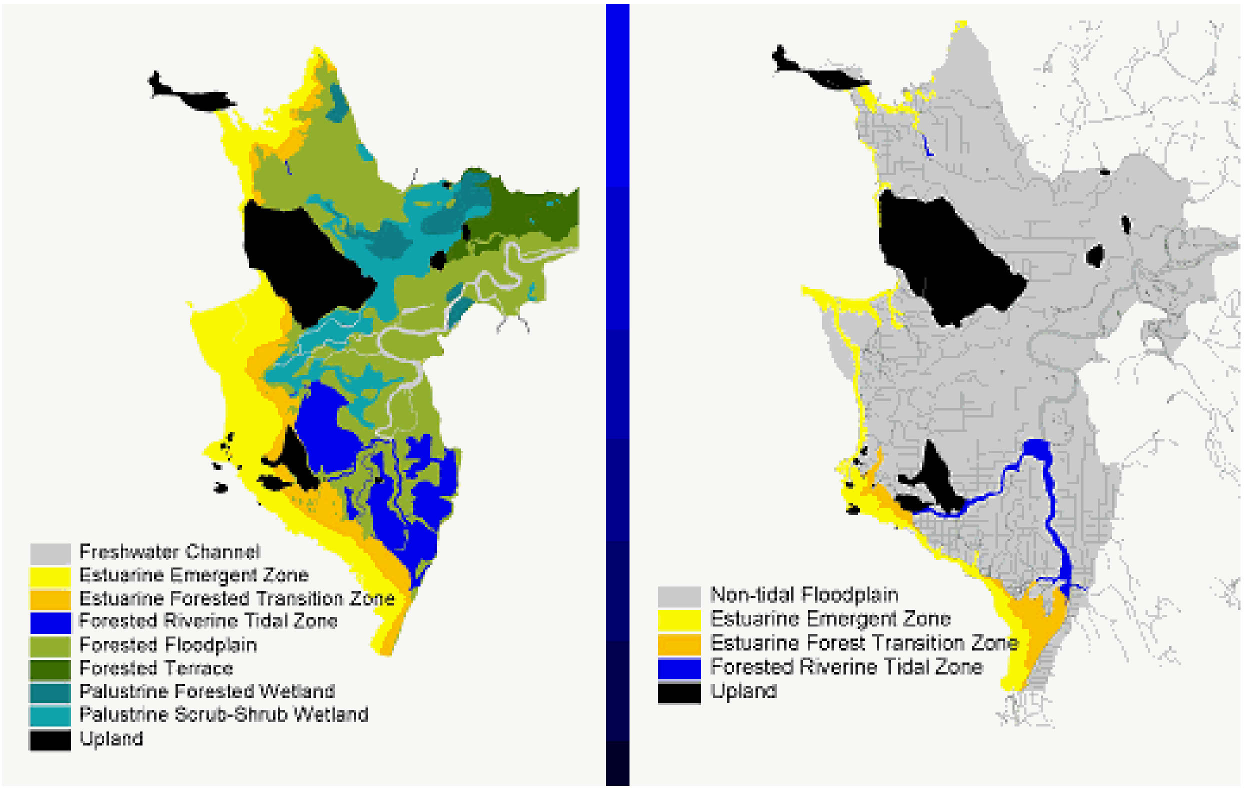
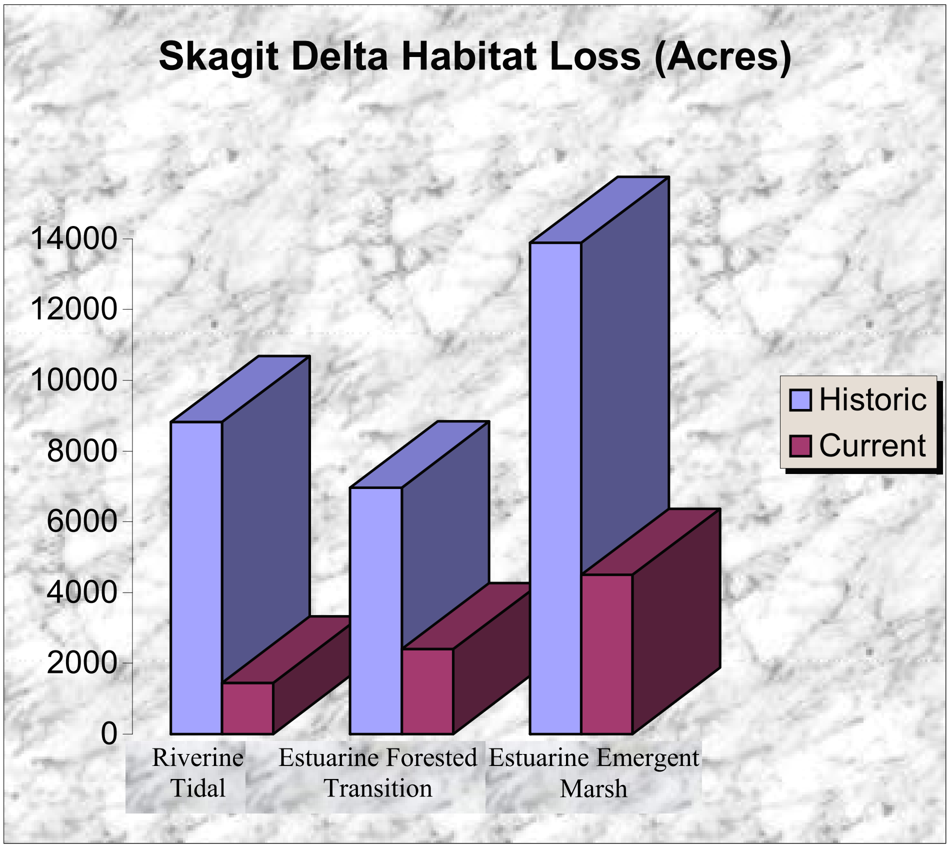


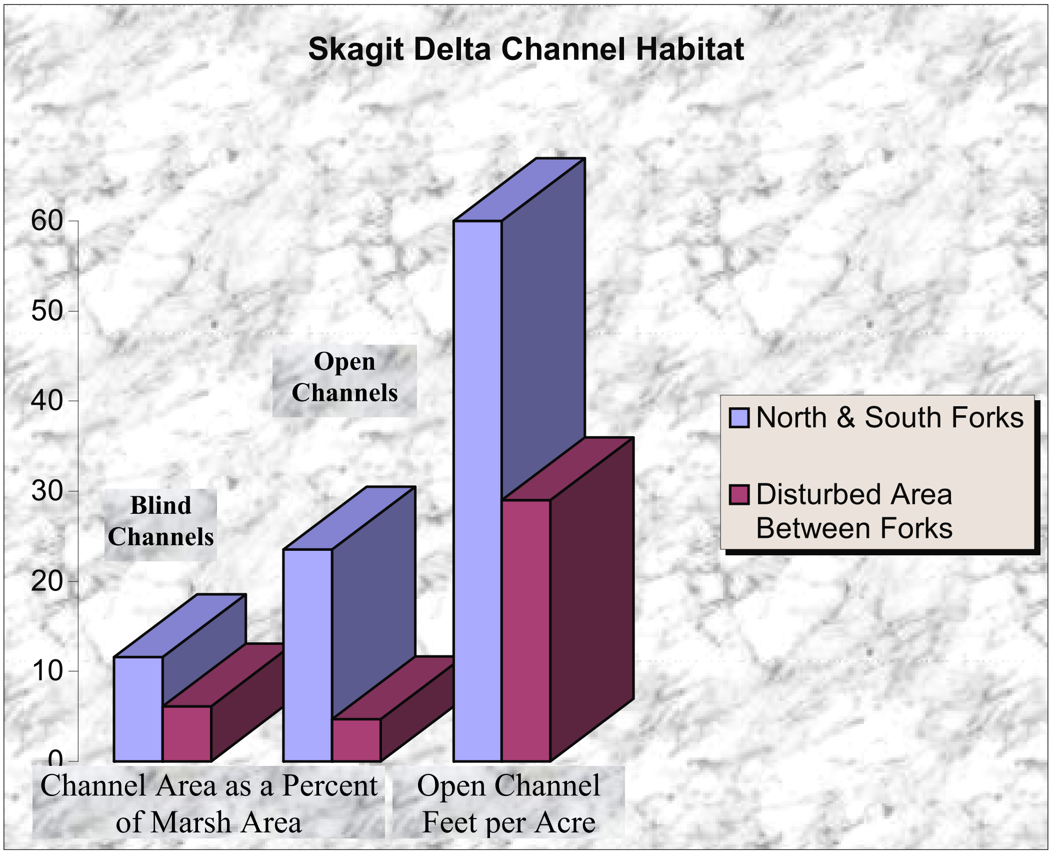
Figure 6. Loss of habitat in the Skagit Delta (data from Beamer et al. 2002a)



Evidence of Constraints to Chinook Salmon

The reduction in estuarine habitat has great impact to chinook salmon. Historically, this habitat included an extensive network of blind and open channels. These types of channels are essential to juvenile chinook salmon, and up to 7,800 chinook per acre of blind channel have been recorded in the Skagit estuary (Beamer et al. 2002b). Currently, the North and South Fork Skagit Rivers still have numerous blind channels, while the area between the Forks has been greatly altered and has an average of 6% blind channel habitat per marsh area compared to nearly 12% in the North and South Fork areas (Figure 7). The disturbed area (between the Forks) also has much less open channel area; about 1/5 the area and ½ the length compared to the North and South Fork Skagit (Figure 7) (Beamer et al. 2002b).

Figure 7. Changes in the Skagit Delta Channel Habitat (data from Beamer et al. 2002a)



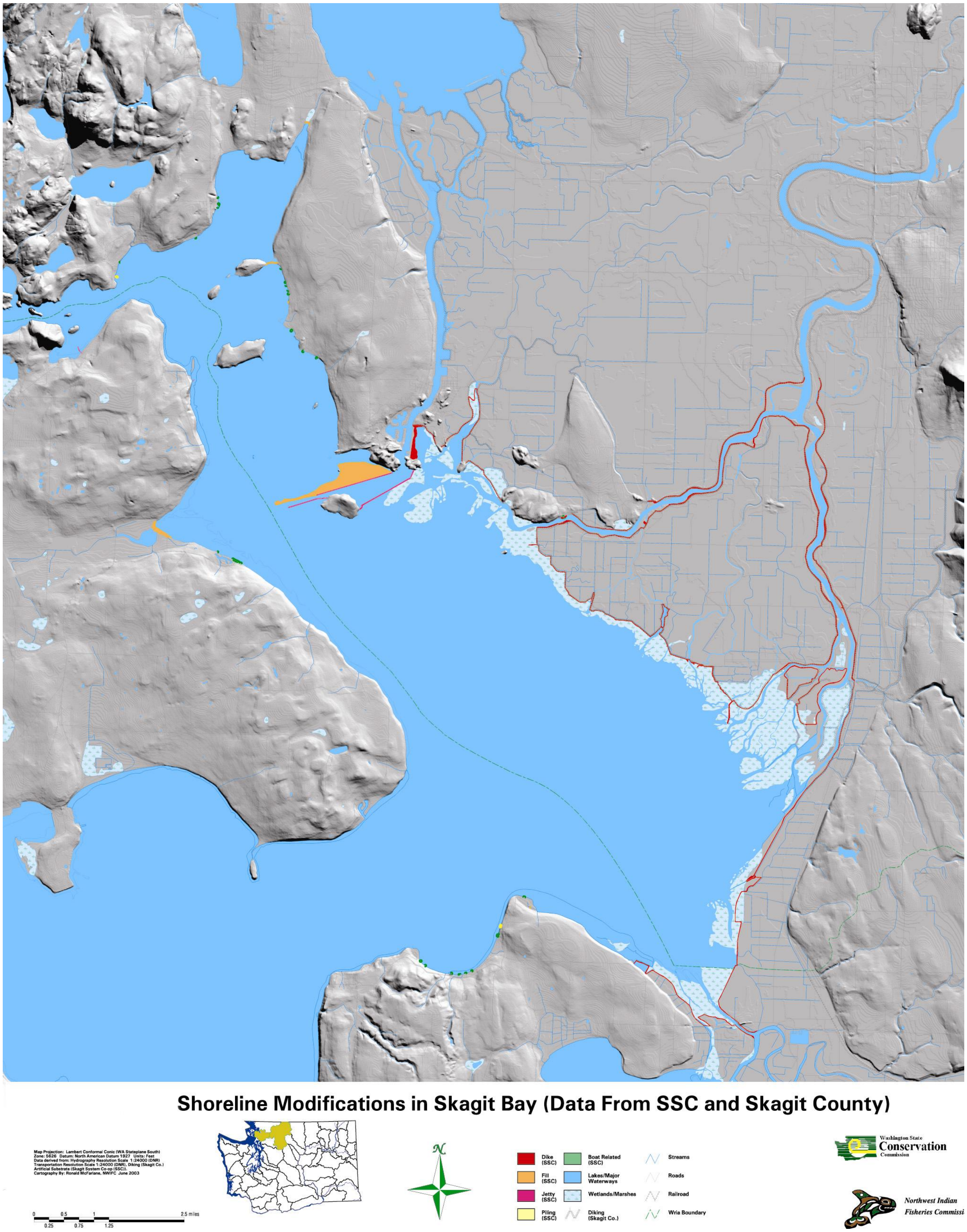
Beamer et al. (2002b) strongly suggest that the carrying capacity of the Skagit estuarine habitat is exceeded (constrained) for chinook juveniles that rear in the delta (tidal delta fry and parr migrants), even with current depressed populations. They have found that when the smolt population increases, the percentage of chinook juveniles that migrate quickly from the estuary increases and the fish that remain to rear in the estuary delta are smaller (shorter fork length). Survival to adult is much lower for non-estuary rearing chinook (Reimers 1973; Levings et al. 1989), indicating that the loss of Skagit estuarine habitat is likely a serious impact to the overall abundance of Skagit chinook. Seining has indicated that juveniles that do not rear in Skagit delta (fry migrants) appear to be primarily using nearby non-natal estuaries (such as Similk Bay along Fidalgo Island and Dugualla Bay off of Whidbey Island) and nearshore areas secondarily (Beamer et al. 2002b). Skagit Bay areas with known substantial juvenile chinook use include Pull and Be Damned Flats, Snee-Oosh Beach, Hoypus Point, North Fork Flats, Strawberry Point, and Lone Tree Point. This suggests that these non-natal (pocket) estuaries may be important sites to consider for restoration alternatives.

Dikes are one of the major causes of estuarine habitat loss in the Skagit delta. An estimated 62% of the mainstem channel edge has been diked within 60 meters of the channel edge, bank hardened, or both (Beamer et al. 2000). This estimate includes the mainstem channels from the mouth to Sedro Woolley. When the Skagit delta (from the confluence of the Forks to Skagit Bay) is examined, nearly all of the channel length is diked (Figure 8). The few areas that are not diked have a naturally elevated topography that acts as a natural dike (Figure 8). Extensive diking is also located along the lower 5.5 miles of Carpenter Creek (Figure 8). As discussed above, the dikes have resulted in the isolation of large quantities of productive salmonid habitat. In addition, other habitat alterations behind the dikes, such as draining, ditching, and filling, have further degraded historic salmonid habitat. If this isolated habitat is to be reconnected, additional restoration actions will be necessary in many of these once productive areas to improve the habitat quality.

The Fir Island dikes have not only limited and isolated estuarine habitat, but have reduced the large distributary channels that transitioned across all types of estuarine habitat (forested riverine tidal, transitional scrub-shrub, and emergent marsh) (Philip Williams & Associates et al. 2003). These served several important functions, including access to emergent marsh habitat along the mid-delta front and maintenance and creation of estuarine habitat through sediment and water transport. Currently, the central Skagit delta (Fir Island) is losing habitat that would be maintained and created by sediment carried by cross-island distributary channels, while the North and South Fork deltas prograde as they carry the entire Skagit Basin sediment load (Philip Williams & Associates et al. 2003). In addition, access to existing estuarine habitat in the central Skagit estuarine delta (Brown Slough and Dry Slough vicinity) is hindered because the historic cross-island distributary channels have been cut-off since the 1950s (Collins and Montgomery 2001).

Another major constraint for chinook salmon is the lack of access to estuarine areas north of Skagit Bay. The jetty near the south end of Swinomish Channel was constructed in 1937 and reconstructed in 1973 to minimize sediment deposition near the channel and therefore dredging activity (Yates 2001). However, this and other changes to the channel have resulted in higher salinity levels that discourage the use of the channel by most chinook salmon. The estimated percent of chinook that pass through Swinomish Channel is only 5.5% (Yates 2001). The migration of pink salmon was also examined, and they did not appear to be greatly impacted. Pink salmon juveniles have a greater tolerance for higher salinity than do chinook salmon (Heard 1991; Healy 1991). Historically, chinook salmon had access to the numerous salt marshes that once existed near the north end of Swinomish Channel.

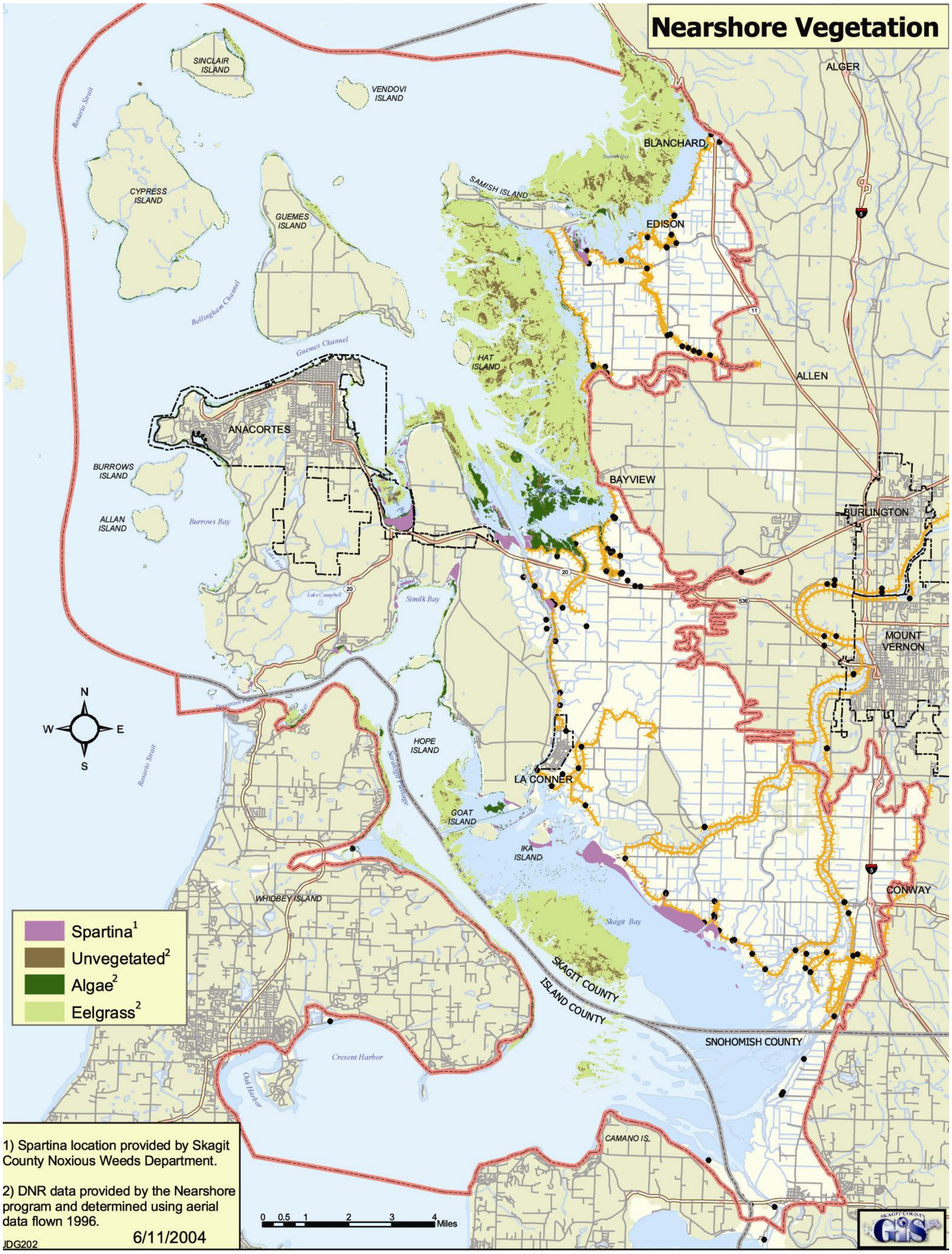
Figure 8. Shoreline modifications (dikes, etc.) along eastern Skagit Bay outlined in red.



The Quality and Characterization of the East Skagit Bay Shoreline and Waters
Skagit Bay is one of the most important rearing areas for salmonids because of its proximity to the Skagit River. Yet, dikes have extensively modified its shoreline. Nearly all of the eastern Skagit Bay shoreline from the southern end of the Swinomish Channel to West Pass is diked (Figure 8). In addition, north Camano Island near West Pass is diked. Historically, the Stillaguamish River used to flow through West Pass into Skagit Bay until diking occurred around 1906 (Collins and Montgomery 2001). And while this primarily impacts the Stillaguamish River, the change is significant for freshwater, nutrient, and sediment inputs to Skagit Bay. The impacted Fir Island area was also historically very productive delta habitat, and is now isolated from contact with saltwater by dikes (Collins and Montgomery 2001).

Spartina has also been documented in Skagit Bay (Berry et al. 2001; Noffke and Beamer 2001). *Spartina* grows on mudflats and traps sediment from the water column, causing increased elevation of the mudflat. The change in elevation and vegetation can alter the animal assemblages that live in the mud and the loss of open mudflats can reduce foraging habitat for fish. The impact of *Spartina* on salmon production is unknown, but the extent of *Spartina* coverage within the project area is as follows. Skagit County applied for a permit to treat 30 acres within Skagit County, and Snohomish County applied for a permit to treat 65 acres in south Skagit Bay, north Port Susan, and other unnamed Snohomish County shorelines in 2002 (DOE 2002). Sites in or near Skagit Bay that have had past infestations are near Hall and Browns Sloughs and Kiket Island. The northern Camano Island shoreline has documented *Spartina* invasion, especially near Davis Slough, West Pass, Livingston Bay, and Triangle Cove (Wilkosz 2000). *Spartina* has decreased by 42% from 1997 to 1999 in Skagit County, but has increased in south Skagit Bay in Snohomish County (PSWQAT 2000). Figure 9 shows where *Spartina* has been found within Skagit County, but the location and extent of infestation changes with time.

Figure 9. Known *Spartina* sitings in WRIA 3.



Estuarine Habitat Quality and Characterization in Douglas Slough and the Central Skagit Sloughs

Several sloughs drain into east Skagit Bay including Sullivan, Hall, Browns, Dry, Freshwater, Deepwater, Steamboat, Tom Moore, and Douglas Sloughs. As discussed in the Skagit delta section, dikes have isolated and transformed much of the historic salmonid distribution with a considerable loss of blind and open channels (Figure 4).

In addition to the loss of connectivity caused by dikes, water quality conditions were rated as poor for many of these sloughs (Smith 2003). Warm water temperatures and low dissolved oxygen levels have been recorded in Hall, Browns, Dry, and Wylie Sloughs, particularly in the summer months (Entranco 1993). High pH readings (9.2 to 9.4) have been documented in Browns Slough with higher pH samples towards the bay (Beamer and LaRock 1998). Low and high pH readings have also been measured in all of these sloughs (Entranco 1993). In 1992, the pH ranged from 5.9 to 8.7, and extreme fluctuations suggest high nutrient loading. Phosphorus and nitrogen levels were also high in each of these sloughs (Entranco 1993). The causes for the water quality problems are thought to be low flows, non-point pollution, loss of riparian vegetation, loss of wetland habitat, and absence of flushing and circulation due to hydromodifications. Restoration activities that increase tidal flushing should also help address some of the water quality and vegetation impacts.

Estuarine Habitat Quality and Characterization along Northeast Whidbey Island and North Camano Island

The western Skagit Bay shoreline (northeast Whidbey Island) is in a relatively natural condition, and most of the land is classified as rural with park zoning along the northern tip of Whidbey Island (see Map 6 in Wilkosz 2000). No dikes have been documented, although two small jetties, a few boat-related sites, and a large fill (dike) at the head of Dugualla Bay have been noted (data from the Skagit System Coop. 2002). There are four known tidegates within this area, Dugualla Creek (Wilkosz 2000), Crescent Harbor, north Camano Island at Gerdes Road, and north Camano Island east of West Pass (Island County unpublished data 2003). The Dugualla estuary is an important pocket estuary potentially serving as a non-natal estuarine site for Skagit chinook.

Chinook Estuarine Habitat North of Skagit Bay

Additional estuarine habitat could be available north of Skagit Bay, especially associated with the Samish River and the sloughs draining into Padilla Bay. However, high levels of salinity greatly impede the migration of juvenile chinook through the Swinomish Channel to this habitat (Yates 2001).

If access were restored north of the Swinomish Channel jetty, other factors need to be considered. The general conditions of the streams and sloughs draining into Padilla and Samish Bays are poor with water quality problems, diking and bank hardening, and other habitat impacts (Smith 2003). Some of these problems can be overcome by restoring natural processes, such as increasing tidal flushing through dike removal or set-backs. Historically, greater quantities of freshwater from the Skagit River flowed into Padilla Bay at times (Belle W. Baruch Institute 2002), and the Swinomish Channel was a shifting, braided channel rich with emergent marsh habitat at its northern end (Figure 3). The decreases in freshwater input to Padilla Bay have likely increased its salinity to its current level of 28 ppt (Belle W. Baruch Institute 2002), contributing to the rich eelgrass beds. However because chinook salmon fry seek lower salinity habitat (<10 ppt) during the early estuarine life history stage (Levy and Northcote 1982; Levings et al. 1986; Clarke et al. 1989; Beamer et al. 2000), the salinity changes in Padilla Bay, might not provide the type of habitat needed for the early estuarine life history stage. While additional estuarine habitat is important north of the jetty, estuarine habitat that is more closely associated with the Skagit River is likely preferable to habitat that requires more extensive migration that increases the risk of mortality.

Conclusions

- Limited estuarine delta habitat has been shown to be constraining for Skagit chinook. Nearshore habitat has not been identified as limiting at this time, as much is still unknown regarding nearshore conditions and how they directly relate to salmon production from the Skagit River. Because ESSHB 1418 addresses intertidal habitat that constrains salmon, restoration activity in this area should be focused on estuarine (where freshwater mixes with saltwater) habitat rather than nearshore.

- Within the Skagit Basin, all three types of estuarine habitats (riverine tidal, scrub-shrub estuarine-forested transition, and emergent marsh) have been greatly reduced with loses of 66-84%. Restoration activities that increase these types of habitat and/or access to these habitats should be encouraged.

- Distributary (open) channels are important to maintain natural processes such as water, nutrient, and sediment transport in addition to providing habitat and migration paths to various habitat zones. Distributary channels have been greatly reduced in the Skagit delta.

- Blind channels are formed by tidal action and have been shown to contain large numbers of juvenile chinook salmon in the Skagit Basin. Actions that increase tidal interactions with historic estuarine habitat will aid in the formation of blind channel habitat.

- The rock jetty near the south entrance to the Swinomish Channel poses a migration barrier (physical and chemical) that limits most Skagit River chinook juveniles from using estuarine habitat north of Skagit Bay. For this reason, restoration activities intended for Skagit chinook salmon should be currently focused along the shorelines lying south of the Swinomish Channel rock jetty, +including the northeast shore of Whidbey Island and north Camano Island. Future actions to eliminate this barrier are greatly needed.

- Non-natal estuaries that border Skagit Bay are additional potential restoration sites for Skagit chinook salmon. Dugualla Bay is an example of such a site.

The Role of Tidegates in Drainage Systems

Prepared by The Western Washington Agricultural Association May, 2004

The Economic Value of Agriculture in Skagit County

A recent estimate of total economic output and value added impacts for Skagit County agriculture is $500 million annually based upon traditional analysis (Andrews and Stuart 2003). Within the county, the Skagit Valley produces vegetable seed, berries, potatoes, row crop vegetables, bulbs and flowers, and contributes nearly $200 million to the local economy annually (American Farmland Trust 1999). The value of Skagit County's agriculture extends beyond the direct economic benefits. From every dollar of revenue generated, there is a $.51 cost in services. This compares to residential development that costs $1.25 in services for every $1.00 of generated revenue (American Farmland Trust 1999). There are currently about 93,000 acres of actively farmed land in Skagit County (Andrews and Stuart 2003). There is increasing pressure to develop Skagit Agricultural land for residential and urban uses. However, once land is urbanized, habitat value for fish and wildlife decrease, as well as salmon habitat restoration opportunities.

In the Skagit Basin, agriculture land was created when dikes were constructed in the mid- to late 1800's. When dikes were built, the land could not be used for crops for about 2-3 years due to salinity effects (Riggs 1999). The early crops consisted of oats and barley that are relatively salt tolerant. Many of the crops currently grown in the Skagit Valley are 2-3 times more salinity sensitive (Riggs 1999).

The Importance of On-Farm Drainage in Skagit County

When the first dikes were constructed in Skagit County in the late 1800s, early settlers realized the absolute necessity to provide both surface and subsurface drainage in order to grow crops. Lands in the lower valley were cleared, diked, drained, leached, and farmed in that order. Early drainage technology was simple and consisted of open drainage ditches on-farm with larger drainage district ditches that led to tidegate outlets. It was common to take advantage of the swales, sloughs, and old channels to route drainage water.

As time progressed, technology replaced the horse with the tractor, and some tidegates with pumps or better gates and drainage improved the ability of the land to support a larger variety of crops. Throughout the 1950s, 60s, and 70s, new drainage technology and active agronomic research made Skagit County a world leader in the production of several vegetable seed crops, flower bulbs, as well as other crops.

By the late 1970s, Skagit farmers were actively installing thousands of feet of subsurface patterned drainage systems rather than the old random systems in low spots in the fields. All of these new systems required an adequate outlet provided by a drainage district. These new subsurface systems were to support a wide array of crops that require better drainage throughout the year not just in the spring and summer. It was also in the late 1970s when farmers began to notice more surface ponding of water in their fields. Subsurface drainage systems were not functioning as designed, and no one was planting winter cover crops like they had in the past.

Studies completed by WSU and SCS in the late 1970s have elucidated several key relationships to crop production and drainage that are still valid today.

- There is a causal relationship between soil permeability, soil infiltration, tillage practices, crop rotations, and drainage.

- On-farm drainage and crop production are totally dependent on timely removal of drainage water provided by drainage district infrastructure.

- Without adequate drainage outlets provided to each farm by drainage districts, anoxic conditions would prohibit crop production (saturated soil conditions).

- The highest annual risk of crop failure is drainage related.

As the early settlers discovered over 100 years ago, the Skagit delta soils require drainage to be farmed. The future of agriculture in Skagit County relates to farmers being able to farm with acceptable risks. On-farm drainage supported by a well maintained drainage district infrastructure is the foundation for the future.

Tidegate Function
The dikes and associated tidegates prevented flooding and facilitated drainage necessary for agricultural use. These dikes or levees were constructed with the use of shovels and slip-scrapers along the South and North forks of the Skagit River and its main stem as well as along the eastern edge of Skagit Bay. Embedded in the dikes are tidegates (the outlet valves of the drainage infrastructure), which serve these vital functions:

1. Keep saltwater out of the maintained ditches (prevent saltwater intrusion). This is necessary for two reasons, a) salt kills plants (crops) and b) water in drainage systems may be used for irrigation and therefore must be salt free (Soil Conservation Service 1960);
2. Maximize drainage potential thereby keeping the water table low to reduce soil saturation and increase the length of the growing season by allowing an earlier start in the spring; and
3. Create a reservoir between tides in which water can be collected for dispersal during the next low tide.

A tidegate consists of a flap mounted on the end of a pipe (culvert) that is incorporated into a dike (Figure 10). When the water level outside the dike (tide water) is higher than the water level inside the dike (drainage water), the outside water pressure closes the flap (tidegate) preventing saltwater intrusion into the land enclosed by the dike system. The flap opens when the tidewater recedes to a level lower that the drainage system water, which allows the drainage water to flush into the saltwater. A tidegate can only be closed by tidewater pushing against it. It is a one-way check valve that keeps salt water out of the drainage infrastructure and, as such, is the most critical component of sub-tidal drainage system.

Controlled drainage has been used historically to reduce subsidence in drained organic soils (Stevens, 1955). With drainage, the surface of an organic soil shrinks and the ground level lowers, due to both the removal of water and the oxidation of the organic matter. The removal of water is purely a physical phenomenon. Undrained organic soil has high water content, typically 80 to 90% (Fuchsman, 1986) and the removal of water, either by drainage or evapotranspiration from the surface, will reduce the volume of the soil itself. The gradual oxidation of an organic soil is, however, a more complicated process involving both chemical and biological processes. The transition from waterlogged and anaerobic conditions to aerated conditions within the soil introduces a completely new set of chemical processes that result in a vastly increased rate of decomposition of the organic matter. It has been observed that the rate of subsidence is related to the lowering of the water table by drainage (Millette and Broughton 1992).

Figure 10. Conventional tidegate located in Skagit County.

A typical conventional tidegate fulfills the three vital functions listed above, all of which are necessary for economically viable agriculture.

Recently, an alternative device called a “Self Regulating Tidegate” has been proposed. This device allows a two-way flow to periodically inundate farmland inside the dike with saltwater. This would actually negate the three vital functions provided by a conventional tidegate. Any alternative device must be scientifically tested and proven to provide the three vital functions of a tidegate in order to be considered by drainage and irrigation district commissioners for use in a drainage system.

Several "Self Regulating Tidegates" exist in Washington State, and one is located in Skagit County. It was installed in Edison Slough around 1999, and has been blamed by local farmer Larry Jensen for a rising watertable and saltwater intrusion into his nearby farmland (Curtis Johnson, personal communication, 2005).

Saltwater Intrusion

The first vital function of a tidegate is to keep saltwater out of the drainage infrastructure. Crop yields are negatively impacted by salinity, and different plant species have varying tolerances to salt levels. The most common response of plants to salt is stunted growth, and increased salinity has resulted in decreased fruit and tuber production (Maas and Grattan 1999). Emerging seedlings are most sensitive to salt with greater salt tolerance occurring as plants grow older. The root zones are the most responsive plant structure to salinity effects because that is where most of the water is taken up (Rhoades 1999). Salt stress is worsened by water deficits, so plants have a greater salt tolerance in cool humid weather. The method for determining impacts of salinity on crops has been based on yield and reduction in crop quality that are directly related to the economics of crop production (Maas and Grattan 1999).

Most of the salinity research has focused on three salts: sodium, chloride and boron. Sodium affects the physical condition of soil by decreasing the soil permeability to water and air. Although it can have beneficial effects when below the plant's salt tolerance threshold, it can quickly accumulate to toxic levels above the threshold, particularly for woody plants (Maas and Gattan 1999). Chloride is non-toxic, but contributes to osmotic stress. Boron is a nutrient that is commonly added to the annual fertilizer program because naturally occurring concentration in the Skagit soils is deficient. These are just three of many salts, which, in excess, damage crops. To discuss them all is beyond the scope of this paper but the literature is replete with information and examples (see Van Schilfgaarde 1974; Skaggs and Van Schilfgaarde 1999).

Supplemental irrigation in the Skagit Valley is used during the summer months when high moisture stress occurs on critically important crops. Drainage districts have, in recent years, reorganized as drainage and irrigation districts to allow for management of the water table in adjacent fields and to allow the use of the fresh water in the ditches for irrigation. For this reason water in the drainage/irrigation infrastructure must be salt free.

Drainage and Soil Saturation

The second vital function of tidegates is to reduce the risk of soil saturation by providing a drain for excess rain and ground water so that excess water is not trapped by the dike. The diked delta soils are predominately the Skagit-Sumas-Field series that are very deep, poorly and moderately drained and are level or nearly level (Soil Conservation Service 1981). The elevation of the farmland ranges from below sea level to slightly above high tide (see Skagit County GIS inundation map). Dikes, tidegates, pump stations and open ditches are the primary means of keeping farmland drained. During the months of November through

March, there is excess rainfall and the surface water is removed by this drainage system (Anderson et.al 2000). The water table in these soils during the rainy season typically ranges from 6 inches to 2 feet below the surface (Soil Conservation Service 1981). The effectiveness of tile drainage is limited because of the low water permeability through the soil and difficulty of installing drainage systems with adequate grade to flow properly (see Dr. Anderson's basic background information sheet, Appendix 1 at end of this chapter). Inadequate drainage results in saturated soils that exclude air from the soil pores and limit biological activity in soil (Evans and Fausey 1999). Both plant roots and microbes in the soil require oxygen. In well-aerated soils, the oxygen content is similar to air at around 20%. Waterlogged soils can have oxygen levels as low as <2%. The effects on crops include decreased seed germination; decreased root function, growth and development; decreased shoot development and growth; and decreased crop yield and quality (Evans and Fausey1999). As the duration of soil saturation increases, the crop yield generally decreases. Due to marine climate in the region, many crops can be successfully grown without supplemental irrigation. The typical soils retain much of the necessary moisture and because of a relatively high water table even during the summer months considerable moisture is moved up into the crop root zone through capillary action for utilization. Evapotranspiration from the growing crops depletes water from the surface of the soil resulting in increased salinity concentration. The salinity is removed during the winter rainy period when excess accumulated water in the field is removed through the drainage system. For these reasons, both irrigation and corresponding drainage are necessary for most types of agriculture.

Reservoir Function of Tidegates

The third vital function of tidegates is to provide an empty reservoir between high tides so that a lower free water surface exists in the systems' watercourses providing a hydraulic gradient to drain water from the soil even when the tidegate is closed (Darcy 1856, Hooghoudt 1940) (see Appendix 2 at end of this chapter). At low tide this stored drainage water is rapidly eliminated when the tidegate opens. As more and more uplands are developed with the attendant increase in impervious surfaces, the capacity of the reservoir needs to be increased. If the reservoir capacity is inadequate or becomes inadequate, expensive, high maintainance pumping systems become necessary. The gravity alternative is obviously a better option and is just another reason for maintaining the integrity of drainage infrastructure.

Appendix 1 for Drainage Chapter

Basic Background Information for the Evaluation of Drainage Under Flood Plain and Delta Soil in the Skagit County*

By Dr. Wilbur C. Anderson, Horticulturalist

Skagit Series – Skagit Silt Loam – Field – Tacoma soil types
  Accounts for about 44,000 acres in Skagit County

Climate**
  Average rainfall is about 32" annually (range of 24-45" depending on location)
  2/3 of rainfall occurs during the months of October through March
  Average air temp = 51^{o}F

Characteristics of the Topography
  Farmland is in the Skagit river flood plain and delta
  Soils are recent alluvium and volcanic ash
Land is well suited for cropland, but requires specially designed drainage system and adequate pumping system to control water table
Farmland is protected by dikes
Field elevation is 0-50'
Characteristic slope in the field is 0-1% (general elevation variation in a normal field is about 3')
Fields are subject to ponding during winter months
Hazard to water erosion is slight

Characteristics of the soil
Very deep, poorly drained soils
Permeability of Skagit series soils are moderate (0.6-2.0 inches/hour)
Effective rooting depth is restricted due to high water table during the winter months
Water table is 6-24" November – March and is 36-60" during summer months
Available water capacity is high (0.19-0.21 in/in)

Effects of excess rainfall beyond the soil's capability of serving as a reservoir
Rainfall is accommodated by the following factors
Soil serves as a reservoir until it is fully saturated
Evapotranspiration – reduced 25% in the winter months due to slow plant growth and high humidity
Drainage through the soil profile – slow because the water table is high and movement is primarily lateral
Surface runoff – rate depends on an exit with some fall
An excess of 1 inch of rainfall beyond the soil reservoir capacity is 27.154 gallons per acre or in a 40-acre field an accumulation of about 1 million gallons of water
If there is a swale in the middle of the field that accumulated this water, it would require 5 acres with water averaging 8" deep

Appendix 2 for Drainage Chapter

Darcy's Law

1. A law describing the rate of flow of water through porous media. (Named for Henry Darcy of Paris, who formulated it in 1856 from extensive work on the flow of water through sand filter beds.) As formulated by Darcy the law is:

   $Q = kS (H + e) / e$

   Where
   Q is the volume of water passed in unit time,
   S is the area of the bed,
   e is the thickness of the bed,
   H is the height of the water on top of the bed, and
   "k is a coefficient depending on the nature of the sand" and
   for cases where the pressure "under the filter is equal to
   the weight of the atmosphere."

2. Generalization for three dimensions: The rate of viscous flow of water in isotropic porous media is proportional to, and in the direction of, the hydraulic gradient.
3. Generalization for other fluids: The rate of viscous flow of homogeneous fluids through isotropic porous media proportional to, and in the direction of, the driving force.

Inventory of Tidegates in the Skagit Basin

As part of the 1418 project, all known tidegates within WRIA 3 (Samish and lower Skagit Basins) were included in the following inventory. It should be noted that the 1418 project had more narrow geographic limits than the bounds for the inventory, and that the inventory is complete for all gate structures in WRIA 3 no matter if they are within the 1418 study area or not. The data were updated as late as December 2004, and represent a complete inventory of tidegates, floodgates, and pump station as known at that time. The database is maintained through Skagit County GIS.

In WRIA 3, 100 different sites have one or more tidegates or floodgates, 21 sites have pump stations, and 3 sites have open tubes (note that there is no number 48, which is why these numbers add up to 124 not 125). Generally, floodgates are gate structures located in freshwater, while tidegates are located in brackish or saltwater. However, there are no strict definitions for these categories, and it is possible that a site labeled with a floodgate might be located in brackish water or within an area subjected to tidal influence. The 1418 Task Force defined our study area as within the 13-foot tidal range, and any gate structure within that range was considered for further assessment. The structures are listed in Table 1 and also shown in the following map (Figure 11). Detailed maps of tidegate locations can be found in Appendix 1, which is in a separate file on this CD and website (http://www.scc.wa.gov/programs/tidegates/1418_documents.html).

Table 1. Tidegate, floodgate, and pump station inventory in WRIA 3. Information for each structure is in two sections and should be matched using the ID #.

ID #	DISTRICT	NAME	TYPE	TUBES DESCRIPTION
1	DRIR 19	DOWNEY DAM	OPEN TUBE	7-48" OPEN TUBES (NOT IN SERVICE)
2	DRIR 15	SULLIVAN SLOUGH	PUMP STATION	3-36" TUBES & GATES
3	DRIR 15	SULLIVAN SL BY-PASS	TIDEGATE	4-6' TIDEGATES
4	PRIVATE	SWANSON SLOUGH	TIDEGATE	1-36" TIDEGATE
5	DRIR 15	WHITE SLOUGH	TIDEGATE	1-36" TIDEGATE
6	DRIR 22	DODGE SLOUGH	PUMP STATION	2-20" PUMPS/ 2-24" PUMPS
7	DKDR 22	RAWLINS ROAD	TIDEGATE	1-48" TIDEGATE
8	DKDR 22	HALL SLOUGH	PUMP STATION	1-12" PUMP/15" TUBE W/GATE
9	DKDR 22	HALL SLOUGH	TIDEGATE	1-36" TIDEGATE
10	DKDR 22	GENE KING/SKAGIT BAY	TIDEGATE	1-30" TIDEGATE
11	DKDR 22	GENE KING/BROWN SL	TIDEGATE	1-36" TIDEGATE
12	DKDR 22	BROWN SL/SKAGIT BAY	TIDEGATE	2-48" TIDEGATES/1-48" MANUAL SCREW GATE
13	DKDR 22	BROWN SL/FIR ISLAND RD	TIDEGATE	1-48" TIDEGATE
14	DKDR 22	DAVIS SLOUGH	TIDEGATE	2-48" TIDEGATES
15	DKDR 22	DRY SLOUGH	TIDEGATE	2-48" TIDEGATES
16	DKDR 22	WILEY SLOUGH	TIDEGATE	1-36" TIDEGATE
17	DKDR 22	WILEY SLOUGH	TIDEGATE	6-48" TIDEGATES
18	DKDR 22	WILEY SLOUGH PUMP	PUMP STATION	1-18" PUMP TO SKAGIT RIVER
19	SUB FLOOD	MCELROY SLOUGH	TIDEGATE	1-48" TIDEGATE
20	TRIBE	RESERVATION, FORNSBY SL	TIDEGATE	1-24" TIDEGATE
21	TRIBE	RESERVATION M	TIDEGATE	1-24" TIDEGATE
22	TRIBE	RESERVATION N	TIDEGATE	2-36" TIDEGATES
23	0	UPRIVER	FLOOD GATE	TUBE WITH FLAP GATE
24	0	UPRIVER	FLOOD GATE	MANUAL FLOOD GATE
25	DRIR 16	SOUTH EDISON	TIDEGATE	3-36" TIDEGATE
26	DK 3	FISHER SLOUGH/SKAGIT R	FLOOD GATE	3 10'X15' FLOOD GATES
27	0	UPRIVER	FLOOD GATE	TUBE WITH FLAP
28	0	UPRIVER	FLOOD GATE	TUBE WITH FLAP
29	SUB FLOOD	MCELROY SLOUGH	TIDEGATE	2-60" X 60" TIDEGATES W/ 2-60" GATES
30	COUNTY	EDISON SLOUGH	TIDEGATE	1-9'X4' BOX W/ 2 GATES, 2-6'X4' BOX W/ 2 GATES, 1-48" SRT
31	DRIR 18	NORTH EDISON	TIDEGATE	1-48" TIDEGATE/1-42" TIDEGATE
32	DRIR 18	KNUTZEN FARM	PUMP STATION	1-20" PUMP (40 HP)/20" TUBE
33	DRIR 18	KNUTZEN FARM	TIDEGATE	1-48" TIDEGATE
34	DRIR 16	SOUTH EDISON	PUMP STATION	1-25 HP W/15" TUBE & GATE/1-60 HP W/22" TUBE & GATE
35	DRIR 16	HENRY FARM/EDISON SL	TIDEGATE	4-48" TIDEGATES
36	DKDRIR 5	SHROEDER PLACE	TIDEGATE	1-48" TIDEGATE
37	DKDRIR 5	ALICE BAY	TIDEGATE	4-48" FIBERGLASS
38	DKDRIR 5	SAMISH R WEST OF BRIDGE	FLOOD GATE	4-48" FLOOD GATES
39	DKDRIR 5	ALICE BAY	TUBE	1-18" FIBERGLASS TUBE FROM ALICE BAY PUMP
40	DKDRIR 5	JOE LEARY SL N. SIDE	TIDEGATE	1-36" TIDEGATE
41	DKDRIR 5	JOE LEARY SLOUGH	PUMP STATION	1-16" PUMP
42	DKDRIR 5	JOE LEARY/D'ARCY ROAD	TIDEGATE	1-12" TIDEGATE
43	DRIR 14	JOE LEARY SLOUGH	TIDEGATE	12-48" TIDEGATES

44	DKDRIR 12	NO NAME SLOUGH	PUMP STATION	1-24" TUBE & GATE (50 HP)/1-18" TUBE & GATE (25 HP)
45	DKDRIR 12	TIDEGATE NEAR NO NAME SL	TIDEGATE	1-36"X48 " ALUMINUM TIDEGATE (24"X18") (50 YDS. NORTH)
46	DRIR 19	BOAT BASIN TIDEGATE	TIDEGATE	1-36" TIDEGATE
47	DK 3	LOG YARD DRAINAGE	PUMP STATION	1-SMALL PUMP LOG YARD TO SKAGIT RIVER
49	DK 1	DUNBAR RD	PUMP STATION	1-PUMP SUBMERGED
50	DK 1	DUNBAR RD	FLOOD GATE	1-8" PIPE ASSOCIATED WITH CID49
51	PRIVATE	HIGGINS SL/MICKEY JENSEN	PUMP STATION	1-PRIVATE PUMP STATION
52	DRIR 19	HIGGINS SL/MICKEY JENSEN	FLOOD GATE	1-24" PIPE DRAIN INTO HIGGINS SLOUGH
53	DRIR 19	HIGGINS SL/SWINOMISH CH	TIDEGATE	1-48" BYPASS TIDEGATE
54	DRIR 19	C. KNUTSEN/SWINOMISH CH	TIDEGATE	1-24" TIDEGATE
55	DRIR 19	INDIAN SL/SCALEHOUSE	FLOOD GATE	2-30" FLAP GATES
56	DRIR 19	INDIAN SL UNDER HWY 20	FLOOD GATE	2-36" FLAP GATES
57	DK 12	GAGES SLOUGH/SKAGIT R	FLOOD GATE	1-28" FLAP GATE (ORIGINAL DISCHARGE LOCATION)
58	DK 12	GAGES SLOUGH/SKAGIT R	PUMP STATION	2-30" (150 HP) PUMPS
59	DRIR 19	INDIAN SL/DAHLSTEDT FARM SW	FLOOD GATE	1-24" TIDEGATE & MANUAL SCREW GATE
60	DRIR 19	INDIAN SLOUGH DAM	TIDEGATE	7-48" TIDEGATES
61	DRIR 19	INDIAN SLOUGH	PUMP STATION	2-24" TUBES & GATES
62	DRIR 19	HIGGINS SL/MICKEY JENSEN	PUMP STATION	1-PUMP (PRIVATE)
63	DKDR 25	SAMISH R/LOOP W THOMAS RD	FLOOD GATE	1-12" FLOOD GATE
64	DKDR 25	SAMISH R/LOOP E THOMAS RD	OPEN TUBE	1- 6" CAPPED
65	DKDR25	EGBERT/SC DITCH/E THOMAS RD	FLOOD GATE	1-2' FLOOD GATE
66	DKDR 25	SAMISH RVR/NELSON-LOOP	FLOOD GATE	1-2' FLOOD GATE
67	DKDR 25	SAMISH RIVERLOOP FARM	FLOOD GATE	1-2' FLOOD GATE
68	DKDR 25	SAMISH RIVER/N SIDE/LOOP	FLOOD GATE	1-18" FLOOD GATE
69	DKDR 25	SAMISH RIVER/NELSON	FLOOD GATE	1-18" FLOOD GATE
70	DKDR 25	SAMISH RIVER/HAMPEL	FLOOD GATE	1-12" FLOOD GATE
71	DKDR 25	SAMISH R/JURGENSEN/NELSON	FLOOD GATE	1-18" FLOOD GATE
72	DKDR 25	SAMISH RIVER/PICKETT	RETURN FLOOD GATE	1-4' FLOOD GATE
73	DKDR 25	SAMISH RIVER/NELSON	FLOOD GATE	1-18" FLOOD GATE
74	DKDR 25	FARM TO MRKT/S C DITCH/E SIDE	FLOOD GATE	1-3' FLOOD GATE
75	DKDR 25	SAMISH RIVER/N SIDE	FLOOD GATE	1-12" FLOOD GATE
76	DRIR 19	HIGGINS SL/SWINOMISH CH	TIDEGATE	5-60" TIDEGATES
77	DKDRIR 12	TELEGRAPH SLOUGH/BALL PL	TIDEGATE	2-36" TIDEGATES
78	DRIR 19	INDIAN SLOUGH/JONES 3	FLOOD GATE	1-30" FLOOD GATE
79	DRIR 19	INDIAN SL @ BEN WELTON	TIDEGATE	2-30" TIDEGATES
80	DKDRIR 12	LITTLE INDIAN SL/SISSON W	TIDEGATE	1-24" TIDEGATE
81	DKDRIR 12	LITTLE INDIAN SL/SISSON E	TIDEGATE	1-24" TIDEGATE
82	DRIR 19	LITTLE INDIAN SLOUGH	TIDEGATE	2-48" TIDEGATES
83	DK 12	GAGES SLOUGH	PUMP GATE	2-30" COPOLYMER FLEX VALVES
84	SUB FLOOD	SKAGIT RIVER	PUMP STATION	1-PUMP STATION URBAN DRAINAGE
85	SUB FLOOD	SKAGIT RIVER	FLOOD GATE	1-18" DIA ASSOC WITH PUMP STATION
86	SUB FLOOD	BRITT SLOUGH	FLOOD GATE	1-ASSOC WITH PUMP STATION
87	SUB FLOOD	BRITT SLOUGH	FLOOD GATE	1-FLOOD GATE ON BRITT SLOUGH
88	SUB FLOOD	BRITT SLOUGH	PUMP STATION	1-PUMP STATION
89	DRIR 15	REXVILLE	PUMP STATION	1-18" PUMP/1-24" PUMP
90	DRIR 15	REXVILLE	FLOOD GATE	1-24" TUBE & GATE/1- 30" TUBE & GATE
91	DRIR 17	KAYTON'S SL (CONWAY)	PUMP STATION	3-24" TUBES & GATES
92	DRIR 17	KAYTON'S SL (CONWAY)	FLOOD GATE	1-36" MANUAL SCREW FLOOD GATE

93	DK 12	VIRGIL NELSON FARM	PUMP STATION	1-18 " PUMP & COPOLYMER FLEX VALVE
94	DRIR 17	SKAGIT RIVER/RIVERBEND	FLOOD GATE	1-24" FLOOD GATE AT SKAGIT RIVER
95	DKDRIR 12	NO NAME SLOUGH	TIDEGATE	1-48" TIDEGATE (100 YDS. NORTH)
96	DKDRIR 20		FLOOD GATE	1-DRAIN DIST 20 FLOOD GATE
97	DK 12	WHITMARSH RD/SKAGIT R (PORT)	PUMP STATION	3-75 HP PUMPS
98	DK 12	WHITMARSH RD/SKAGIT R (PORT)	FLOOD GATE	1-30" TUBE & COPOLYMER FLEX VALVE
99	DKDRIR 5	ALICE BAY	PUMP STATION	1-16" TUBE & GATE
100	DK 3	FISHER SLOUGH	RETURN FLOOD GATE	6-5'X6' FLOOD GATES
101	DK 12	LITTLE INDIAN SL/ERICKSON	TIDEGATE	1-24" TIDEGATE
102	DRIR 19	INDIAN SLOUGH	FLOOD GATE	1-FLOOD GATE ON INDIAN SLOUGH
103	DKDRIR 12	NO NAME SLOUGH	TIDEGATE	2-30" X 48" TIDEGATES (2 @ PUMP HOUSE)
104	PRIVATE	AXEL JENSON FARM	TIDEGATE	1-12" TIDEGATE
105	PRIVATE	AXEL JENSON FARM	TIDEGATE	1-18" TIDEGATE
106	PRIVATE	HEDLIN (HOMEPLACE)	TIDEGATE	1-18" TIDEGATE
107	PRIVATE	SAM CRAM (CHAMBERS)	TIDEGATE	1-18" TIDEGATE
108	DKDR22	MCDONALD SLOUGH	TIDEGATE	
109	WDFW	981876	TIDEGATE	1-30" Screw Gate attached
110	WDFW	981923	TIDEGATE	1-24" Screw Gate no longer being used(shut)
111	WDFW	981874	TIDEGATE	1-36" Combo Tidegate
112	WDFW	981875	TIDEGATE	1-36" Combo Tidegate
113	DKDR 25	SAM. R/EGBERT/E OF THOMAS RD	RETURN FLOOD GATE	1-4' FLOOD GATE
114	DKDR25	SAMISH RVR/S SIDE/JENSEN	FLOOD GATE	1-12" FLOOD GATE
115	DKDR25	SAMISH R/FARM TO MARKET RD	RETURN FLOOD GATE	1-4' FLOOD GATE
116	DKDR25	SAMISH RVR/NELSON	FLOOD GATE	1-12" FLOOD GATE
117	DKDR25	SAMISH RVR/JENSON	FLOOD GATE	1-8" FLOOD GATE
118	DKDR25	SAMISH R/LOOP/E OF THOMAS RD	FLOOD GATE	1-18" FLOOD GATE
119	DKDR25	SAMISH R/LOOP/E OF THOMAS RD	FLOOD GATE	1-12" FLOOD GATE
120	DKDR25	SAMISH R/LOOP/E OF THOMAS RD	FLOOD GATE	1-12" FLOOD GATE
121	DKDR25	SAMISH RVR/ SSIDE/OMDAL LN	RETURN FLOOD GATE	1-4' FLOOD GATE W/ 700' OF 4' PIPE
122	DKDR25	SAMISH RVR/CHUCKANUT HWY	RETURN FLOOD GATE	1-3' FLOOD GATE
123	DKDR25	SAMISH R/S SIDE/LAUTENBACH	FLOOD GATE	1-3' FLOOD GATE
124	DKDR25	SAMISH R/S SIDE/E OF RAILROAD	FLOOD GATE	1-3' FLOOD GATE
125	DKDR 25	SAMISH RIVER/HAMPEL	RETURN FLOOD GATE	1-4' FLOOD GATE

ID#	PIPE MATERIAL	LID MATERIAL	MAINTENANCE	LATITUDE	LONGITUDE
1	CONCRETE	NONE		48.43296414000	-122.48072795600
2	STEEL	STEEL		48.39223632570	-122.48196163100
3	CORR	ALUMINUM		48.39749604770	-122.48992629900
4	PLASTIC	FIBERGLASS	REPAIRED 2003	48.40622717060	-122.49321222100
5	PLASTIC	ALUMINUM	REPAIRED 2002	48.41030177350	-122.49343660600
6	FIBERGLASS	FIBERGLASS	PUMPS/1950/1992	48.37253720870	-122.47940255500
7	PLASTIC	ALUMINUM	1988/NEEDS REPAIR	48.35498594680	-122.45876909300
8	PLASTIC	STEEL		48.34377321810	-122.43764746200
9	CORR	ALUMINUM	SILTED IN	48.34347112350	-122.43778023900
10	PLASTIC	FIBERGLASS		48.33399022170	-122.41801808800
11	STEEL	ALUMINUM	NEEDS REPLACEMENT	48.33649964300	-122.41317737100
12	STEEL	ALUMINUM		48.33566748550	-122.41288124800
13	CORR	FIBERGLASS		48.34122482900	-122.41295398900
14	CORR	FIBERGLASS		48.33140288080	-122.41059845500
15	GALV/PLASTIC	FIBERGLASS	1-MOVED 1961/REPAIRED 2002	48.32817005110	-122.40355093100
16	PLASTIC	PLASTIC		48.32370026310	-122.39344728500
17	CORR/PLASTIC	STEEL/ALUM.	NEEDS REPAIR	48.31860821370	-122.38683961800
18	STEEL	STEEL		48.32522486840	-122.37172966100
19	CORR	FIBERGLASS	NEW GATE IN 1998	48.59959688160	-122.42279627700
20	CORR	CAST IRON	LID BROKEN	48.43181200700	-122.50081222700
21	CORR	STEEL		48.43492652350	-122.50111288900
22	CORR	ALUMINUM		48.44899889190	-122.51316442300
23				48.51839288380	-122.19603495600
24				48.52332206910	-121.99707112100
25	FIBERGLASS	FIBERGLASS	REPAIRED 1982	48.56110014900	-122.44414089200
26	STEEL	WOOD		48.32384756740	-122.34263031400
27				48.51551510770	-122.11672998900
28				48.52423554480	-122.05423328100
29	CORR	FIBERGLASS	IMPROVED 1990'S	48.59708617410	-122.41854899100
30	CONCRETE/FIBER	FIBERGLASS	SRT & IMPROVE 2000	48.56261152610	-122.43926159300
31	PVC	FIBERGLASS	REPAIRED 1994/1998	48.56557694600	-122.44203467000
32	FIBERGLASS	FIBERGLASS	NEW PUMP 2003	48.57183522900	-122.44062429000
33	FIBERGLASS	FIBERGLASS	REPAIRED 1992	48.57197105010	-122.44063588300
34	FIBERGLASS	FIBERGLASS		48.56127376030	-122.44423723300
35	PLASTIC	FIBERGLASS	REPAIRED 1999	48.56446936930	-122.45393132000
36	FIBERGLASS	FIBERGLASS		48.55637602250	-122.46709630800
37	CORR/FIBERGLASS	FIBERGLASS	1983 FIBERGLASS ENDS	48.55958674540	-122.48492363800
38	PLASTIC	FIBERGLASS		48.55402933960	-122.45389809100
39	FIBERGLASS	FIBERGLASS		48.55513595030	-122.48347530600
40	STEEL PIPE	GALV STEEL	NEEDS REPAIR	48.52071272140	-122.48016205100
41				48.52090236640	-122.48012073000
42	CORR	FIBERGLASS		48.52047270600	-122.47391732200
43	CORR/PLASTIC	FIBERGLASS	UPGRADED 1970'S & 1980'S	48.51836322220	-122.47306477000
44	CORR	FIBERGLASS		48.46957176890	-122.46743759500

45	CORR	FIBERGLASS		48.46993212940	-122.46789932900
46	CORR	CASTIRON	NEEDS NEW TUBE	48.42773700330	-122.49615030300
47				48.33819307800	-122.34512137100
49				48.42816778980	-122.36011158700
50				48.43124708200	-122.36026622300
51				48.43895870620	-122.49298646600
52				48.43899820270	-122.49294479700
53	CORR	ALUMINUM	REPAIRED 1989	48.44114128710	-122.49850968000
54	CORR	ALUMINUM		48.44620992960	-122.50736681700
55				48.44687034010	-122.45659264600
56				48.44674240680	-122.45381336200
57	CONCRETE	CAST IRON		48.44878148500	-122.35926339600
58			UPGRADED IN 1998	48.45029478970	-122.35565390700
59				48.45092798090	-122.46386109300
60	CONCRETE	ALUMINUM		48.45088439270	-122.46353779200
61	CORR	FIBERGLASS		48.45097355370	-122.46375902800
62				48.45224198730	-122.40297121600
63	CORR/STEEL	STEEL		48.52207219530	-122.41328207300
64	CORR/PLASTIC	CAPPED		48.52098258540	-122.40983198600
65	CORR/STEEL	STEEL		48.52091413860	-122.40966139000
66	CORR/STEEL	STEEL		48.52274799690	-122.41552090800
67	CORR/STEEL	STEEL		48.52290804050	-122.41552899900
68	CORR/STEEL	STEEL		48.52522228740	-122.42100182600
69	CORR/STEEL	STEEL		48.52647661710	-122.42928977700
70	CORR/STEEL	STEEL		48.52592257470	-122.42657201700
71	CORR/STEEL	STEEL		48.52613264270	-122.42658093300
72	CORR/STEEL	STEEL		48.52790765810	-122.43527035500
73	CORR/STEEL	STEEL		48.52751014780	-122.43210303000
74	CORR/STEEL	STEEL		48.53161041200	-122.44278933600
75	CORR/STEEL	STEEL		48.53188017490	-122.44145322600
76	CORR/FIBERGLASS	FIBERGLASS		48.44005798670	-122.49700294700
77	CONCRETE	ALUMINUM	SILTED IN	48.46056832990	-122.48722430000
78	CORR/ALUM	ALUMINUM		48.44858226940	-122.46042215600
79	PLASTIC	ALUMINUM	REPAIRED 1999	48.45160864460	-122.47135156600
80	PLASTIC	ALUMINUM	REPAIRED IN 2004	48.45844201310	-122.46818839700
81	PLASTIC	ALUMINUM	REPAIRED IN 2004	48.45919351220	-122.47064902000
82	CORR/FIBERGLASS	FIBERGLASS		48.45698621130	-122.46436329600
83	PLASTIC	RUBBER	UPGRADED IN 1998	48.44854344230	-122.35576778800
84				48.41878350070	-122.34518840800
85				48.41854051100	-122.34516165300
86				48.39348757490	-122.35795207000
87				48.39358584650	-122.35787634900
88				48.39349890760	-122.35766030300
89				48.36625818240	-122.41881629600
90	CORR	STEEL	NEEDS REPAIR	48.36606893070	-122.41881640900
91	CORR	STEEL		48.34183944960	-122.34734451400
92	CORR	CAST IRON		48.34172339930	-122.34760720500
93	PLASTIC	RUBBER	REPAIRED 1999	48.45641776410	-122.49636274700

94	CORR	ALUMINUM	REPAIRED 1990	48.43141340820	-122.35420442300
95	PLASTIC	ALUMINUM	REPAIRED 2003	48.47011331490	-122.46824199200
96				48.44454425640	-122.31745165500
97				48.44774458790	-122.33155622400
98	PLASTIC	RUBBER	NEW	48.44632342800	-122.33151463200
99	FIBERGLASS	FIBERGLASS		48.55526090820	-122.48332666000
100	CONCRETE	ALUMINUM		48.32429498510	-122.34038522200
101	FIBERGLASS	FIBERGLASS	REPAIRED IN 1985	48.45781599310	-122.46933323400
102				48.45120561890	-122.46331465600
103	WOOD	FIBER/ALUM.		48.46961178110	-122.46773893300
104	CORR	CAST IRON		48.37895818720	-122.49652090600
105	PLASTIC	FIBERGLASS		48.38419785250	-122.50415140800
106	PLASTIC	ALUMINUM	REPAIRED 1980'S	48.38293709190	-122.49124200500
107	PLASTIC	ALUMINUM	REPAIRED 2003	48.38505724320	-122.48331827300
108				48.32831248580	-122.40253090800
109				48.32417908950	-122.36614738400
110	CORR			48.32478228490	-122.35594579900
111	CORR			48.31922887520	-122.36637898900
112	CORR			48.31798693230	-122.36387180200
113	CORR/STEEL	ALUMINUM		48.52097700010	-122.40966140200
114	CORR/STEEL	STEEL		48.52499056390	-122.42098206800
115	CORR/STEEL	ALUMINUM		48.53156249890	-122.44273923500
116	CORR/STEEL	STEEL		48.52908226860	-122.43647603100
117	CORR/STEEL	STEEL		48.52409064950	-122.41856311700
118	CORR/STEEL	STEEL		48.52136065370	-122.40728440700
119	CORR/STEEL	STEEL		48.52186798430	-122.40299459200
120	CORR/STEEL	STEEL		48.52244188570	-122.39888303500
121	CORR/STEEL	ALUMINUM		48.51936380660	-122.38747535300
122	CORR/STEEL	ALUMINUM		48.51674936580	-122.37722268900
123	CORR/PLASTIC	ALUMINUM		48.51876284070	-122.37301671800
124	CORR/STEEL	STEEL		48.52054158250	-122.35369543100
125	CORR/STEEL	ALUMINUM		48.52592257470	-122.42657201700

Figure 11. Tidegates, floodgates, and pump stations in WRIA 3 with a focus on those in the 1418 study area as outlined in red.

Salmon Habitat Assessment of Project Areas for 1418

This is an outline of the protocol that was used to define specific areas for further assessment as potential projects under HB 1418. Following this protocol is a list of the types of information that was provided, where possible, for each of the project areas and options. The defined areas are for assessment purposes only. They provide a consistent approach to compare areas for prioritization in this report. All of Fir Island is potential estuarine habitat, but the current social and political realities greatly limit the quantity of land that can be restored to salmonid habitat. Because of this, the areas described below should be considered a minimal amount of habitat that would provide an ecological function. These conceptual areas will need further refinement and study for further project development. One future assessment needed is a study on the sustainability of habitat for each of the high priority sites. Sustainability is defined as equal or better habitat conditions in 100 years without maintenance.

In prior discussions, the 1418 Technical Team concluded that the study area south of the Swinomish Channel rock jetty is currently more accessible to Skagit River juvenile chinook and therefore has a higher restoration value than the area north of the Swinomish Channel rock jetty. The 1418 process includes all potential salmon estuarine habitat in the 13-foot tidal range throughout the entire 1418 study area (Figure 1), but assessment areas were only created south of the Swinomish Channel rock jetty at this time and within the 13-foot tidal range. Tidegates that are not located on historic sloughs were thought to have little to no restoration potential for salmon habitat and were not included for further analysis even if they are located south of the rock jetty. These include tidegates bordering Skagit Bay in north Snohomish County and one known tidegate on north Camano Island.

Two project areas require additional explanation.

- Site 105 is a tidegate near Sullivan Slough that appears to be north of the Swinomish Channel rock jetty. It remains on the assessment list because it is thought that drainage from this slough can go in either direction, and its potential drainage into Sullivan Slough would be important for hydrologic function. Another important reason is that with restoration efforts, the area has the possibility to serve as potential passage to Swinomish Channel. Also, efforts were made to include a large enough size of Sullivan Slough to assess for adequate restoration potential.
- Site 6 is a pump station near Sullivan Slough, and it remains on the list because of its restoration potential. It also adds to the size of overall potential areas of Sullivan Slough needed for ecological function.

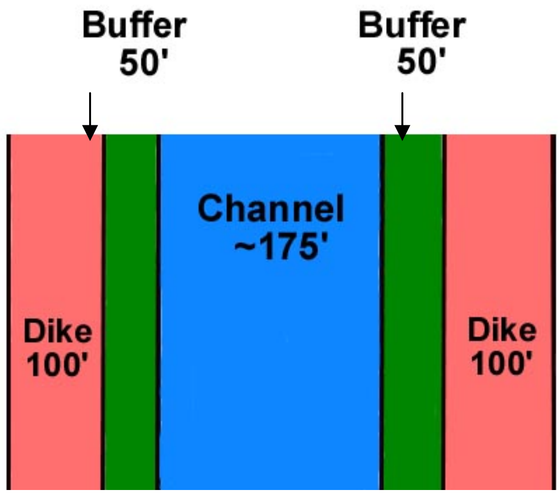
The assessment occurred in a stepped fashion to allow for a variety of options within a given area. The stepped approach also provides a perspective of habitat gain that can be realized with larger land parcels. All sites were located south of the Swinomish Channel, within the 13-foot tidal range, and associated with historic sloughs as discussed above.

Step 1:
All public lands landward of existing dikes and tidegate structures were assessed according to the parameters described in Step 4. In addition, the public lands seaward of the dike and tidegate structure at the end of Rawlins Road were assessed.

Step 2:
Assessment areas were defined to initially include approximately 100 acres of land landward of dikes regardless of land ownership. This quantity was determined to provide a minimal ecological function and a greater possibility of sustainability (Philip Williams & Associates et al. 2003). The assessment areas were defined as a circle with the center of the circle located at the mouth of all historic channels. In most cases, the circle includes 100 acres landward of dikes and 100 acres seaward of dikes. Because dikes have been shown to decrease channel habitat seaward as well as landward (Hood 2004), land on both sides of the dike were included in the circle for assessment.

Step 3:
In addition to the land within the assessment circles, corridors that include some historic or created distributary channels between Skagit Bay and the North Fork Skagit River were considered. The recommendation in the Philip Williams & Associates et al. (2003) report was for a distributary channel with a minimum width of 475'. This includes an approximate channel width of 175' (the average width of historical distributary channels in Fir Island) plus 150' on each side of the historic channel (Figure 12). The 150' width on each side of the historic channel includes 100' of dike structure and 50' of habitat buffer. The 50' buffer is a minimum width that is expected to provide habitat connectivity, fish access, water and sediment transport, an adequate water quality buffer, and flood protection for neighboring lands. Because the historic channels do not follow the current lowest elevations on Fir Island, it may be better to construct a mid-island distributary channel corridor between Skagit Bay and the North Fork Skagit River following current low elevations.

Figure 12. Width components of a hypothetical Fir Island distributary channel.



Step 4:

For each priority site and option, the following information is provided where such information is available. More specific information such as costs, specific actions, and possible impacts to agricultural lands, etc. will be necessary in the future, consistent with the requirements of Engrossed Substitute House Bill 1418. Potential habitat is defined as habitat that can be expected with full restoration within that site. The assessment of these sites is presented in the chapter: Analysis of the Restoration Potential of Former Tidelands in the Skagit Delta. Additional maps that support the assessment can be found in Appendix 2. This appendix is in a separate file on the CD or website (http://www.scc.wa.gov/programs/tidegates/1418_documents.html).

- Site map.
- Site area and description.
- General restoration options.
- Site ownership, public versus private, and type of public ownership.
- Infrastructure- includes culverts, roads, buildings, and utilities where such information exists.
- Drainage infrastructure- dikes, tidegates, pump stations, etc. (see Role of Tidegates in Drainage Systems chapter).
- Land use with note of agricultural lands of significant long-term importance.
- Site topography/elevation.
- Vegetative communities: potential or historic versus current percentages of emergent marsh, scrub/shrub, and riverine tidal.
- Channels interior to existing dikes length/area/type of channel (blind/open): potential versus current.
- Channel habitat exterior to existing dikes: length/width/area/type of channel (blind/open): potential versus current.
- Juvenile salmon access to site: full, partial, none.
- Chinook life history stage that would use the site (tidal delta fry, fry migrants).

Estuary Restoration Strategies

Due to time and cost constraints under the 1418 process, all of the following assessments examined full restoration potential at each site. However, for each of the assessment sites, a variety of estuary restoration goals and strategies could be identified and implemented. The restoration goals for a given site will determine the restoration strategies. The restoration goals could range from very limited channel restoration to more extensive channel restoration in combination with emergent tidal, scrub/shrub tidal and/or riverine tidal forest habitats, and actions can range from a single flow control tidegate to complete dike removal. It is assumed that each proposed estuary restoration project will necessitate a site specific feasibility and design analysis, and the various restoration options will be examined at that time for a specific site. It is also assumed that for an estuary restoration project to be successful, the restoration strategy must maintain flood protection, drainage and salt intrusion protection for the adjacent farmlands.

Minimum Restoration:

Goal:
Restore limited tidal inundation to only the historic channels (natural processes).
Restore and maintain blind channel habitat through natural process.
Restore estuary vegetation community within the existing the blind channels.
Provide fish access to the blind channels.

Strategy:
Restrict tidal inundation (maximum water elevation) into blind channels through a Self Regulating Tidegate or Screw Gate Tidegate (i.e. Brown Slough).

Moderate Restoration:

Goal:
Restore tidal inundation (riverine inundation where possible) to historic channels and adjacent public land (natural processes).
Restore and maintain blind channel habitat through natural processes.
Restore and maintain distributary channel habitat through natural processes.
Restore and maintain estuary vegetation community throughout the tidally inundated area through natural processes.
Provide fish access to the blind and distributary channels.

Strategy:
Re-introduce tidal and/or riverine inundation across the restoration site.
Relocate existing tidegates to more landward location.
Relocate flood dikes to more landward location.

Intensive Restoration:

Goal:
Restore tidal inundation (riverine inundation where possible) to historic channels, adjacent public land, and adjacent private land (natural process).
Restore and maintain blind channel habitat through natural processes.
Restore and maintain distributary channel habitat through natural processes.
Restore and maintain estuary vegetation community throughout the inundated area through natural processes.

Provide fish access to the blind and distributary channels.

Strategy: Re-introduce tidal and/or riverine processes across the restoration site.
Relocate existing tidegates to more landward location.
Relocate flood dikes to more landward location.
Re-introduce tidal and/or riverine processes across the restoration site.

Analysis of the Restoration Potential of Former Tidelands in the Skagit Delta

Produced at the request of the 1418 Task Force by W. G. Hood, PhD, Skagit River System Cooperative PO Box 368 La Conner, WA 98257 5 October 2004.

Introduction

Engrossed Second Substitute House Bill 1418 states that if a limiting factors analysis has been conducted for a specific geographical area and shows insufficient intertidal salmon habitat, then a plan may be developed that addresses the intertidal habitat goals contained in the limiting factors analysis. The limiting factors analysis for the Skagit Basin was completed in June 2003, identifying constraints within the Skagit estuary for Skagit River chinook salmon (Smith 2003). This led to the formation of a task force (Appendix A at end of this chapter), whose purpose was to direct a plan for restoration of estuarine habitat for Skagit chinook salmon.

The goal of the Skagit estuary restoration plan being developed under the guidance of the 1418 Task Force (hereafter, "the 1418 Plan") is to identify intertidal salmon habitat restoration sites to meet the goals of salmon recovery while protecting agricultural land. The Task Force agreed to first prioritize sites located along Skagit Bay south of Swinomish Channel lying within the 13-foot high tide zone because these sites would more likely directly benefit wild Skagit chinook. It is the intent of the 1418 plan that among these sites, restoration on public land will be the highest priority. Inter-tidal salmon restoration sites lying on private land will be identified with the understanding that activity on private land will be voluntary and will not adversely impact adjacent agricultural land.

In support of the Skagit estuary habitat restoration plan and in accord with HB1418, the following analysis was conducted in an effort to present the potential for restoration for various sites selected by the 1418 Task Force throughout the Skagit estuary. The analysis includes predictions of the potential quantity of tidal channels and the potential estuarine vegetation that could be restored to select restoration sites. These two factors were chosen because they reflect habitat quantity and quality for juvenile chinook salmon.

This assessment of restoration potential assumes process-based restoration. That is, it assumes that the physical process that structures the landscape and habitat will be restored as much as possible to the restoration sites. These physical process include riverine and tidal flooding, sediment transport (including erosion and deposition), transport of large woody debris, nutrient dispersal and transformation, etc. (Beamer et al. 2004). A variety of biological and ecological processes are dependent on physical processes, among them, community succession, primary productivity, secondary productivity, nutrient cycling, biodiversity maintenance, etc. Critical system properties that rely on natural process restoration include resilience to disturbance (both natural and anthropogenic disturbance) and sustainability (Holling 1973, Wu and Loucks 1995, Landres et al. 1999, Folke et al. 2002).

Methods

Site Selection

The Skagit estuary restoration plan focuses on historically estuarine areas formerly used by Skagit chinook that are currently blocked by dikes and tidegates. All of Fir Island is potential estuarine habitat, but current social, economic and political realities limit the quantity of land that can be restored to salmonid habitat. Consequently, the areas described below can be viewed as a compromise between practical considerations and fundamental ecological needs of chinook salmon for habitat restoration. The 1418 Task Force selected each of these sites for consideration based on member input. It's worth noting that each of these conceptual areas will need further refinement and study for actual project development.

Based on discussions with Task Force representatives we understand site selection followed the following general guidelines:

1) The study area south of the Swinomish Channel rock jetty is currently more accessible to Skagit River juvenile chinook and therefore has a higher restoration value than the area north of the Swinomish Channel rock jetty.
2) The 1418 process includes all potential salmon estuarine habitat in the 13' tidal range throughout the entire 1418 study area, but assessment areas will only be created south of the Swinomish Channel rock jetty at this time.
3) Tidegates that are not located on historic sloughs were thought to have little to no restoration potential for salmon habitat and were not included for further analysis even if they are located south of the rock jetty. These include tidegates bordering Skagit Bay in north Snohomish County and one known tidegate on north Camano Island.
4) The 1418 Technical Team decided, in accordance with HB1418, that all public lands landward of existing dikes and tidegate structures will be assessed, and that the public lands seaward of the dike and tidegate structure at the end of Rawlins Road will be assessed.
5) Additionally, the 1418 Technical Team decided to include areas of approximately 100 acres landward of dikes and blocking tidegates regardless of land ownership. This quantity was determined to provide a minimal ecological function and a greater possibility of sustainability (Philip Williams & Associates et al. 2003).
6) The assessment areas were defined by the 1418 Technical Team as a circle with the center of the circle located at the mouth of all historic channels. In most cases, each circle included 100 acres landward of dikes and 100 acres seaward of dikes. Because dikes have been shown to decrease channel habitat seaward as well as landward (Hood 2004), land on both sides of the dike were included in the circle for assessment.

Historical Vegetation

Historical (ca. 1860) vegetation has been reconstructed from archival records for the Skagit, Stillaguamish and Snohomish deltas (Collins 2000, Collins and Montgomery 2001). A GIS layer of historical vegetation types (estuarine emergent, estuarine scrub shrub, riverine-tidal scrub shrub, riverine-tidal forested, and forested floodplain) was provided by Brian Collins, while a shape file that outlined the study areas was provided by the 1418 Technical Team. Both GIS layers were superimposed (using ArcView GIS 3.2a) and areas of overlap were selected for calculation of on-site historical habitat area.

Current Vegetation

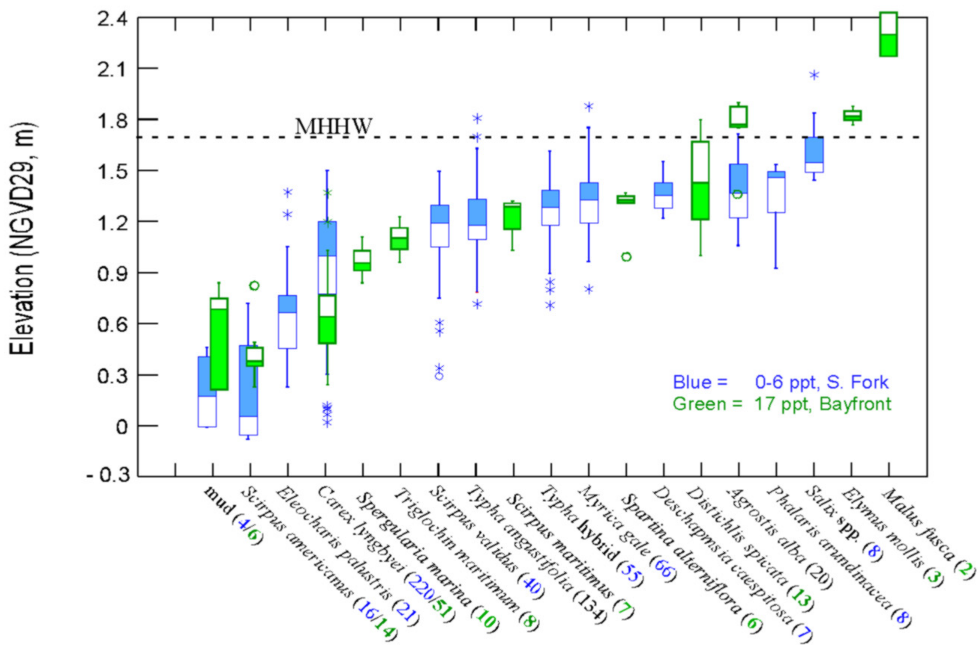
Current site vegetation was assessed by interpretation of digital orthophotos flown in the summer of 2000. Color infra-red (CIR) orthophotos with 15-cm pixel resolution were used where available (most sites in the South Fork area, some sites or portions of sites in the North Fork area). True-color orthophotos with 45-cm pixel resolution were used when CIR photo coverage was not available. Both sets of photos have been extensively ground-truthed to relate photo signatures (colors and textures) to vegetation types (estuarine emergent, estuarine scrub shrub, riverine-tidal scrub shrub, riverine-tidal forested).

Potential Vegetation

Potential vegetation was predicted from a simple model that relates tidal marsh vegetation to marsh elevation. Elevation and salinity are the two most important physical factors affecting tidal vegetation distribution (Ewing 1982, Snow and Vince 1984, Pennings and Callaway 1992, Zedler et al. 1999). A predictive model was developed for the Skagit delta marshes by simultaneously collecting elevation and vegetation data at 600 points in the tidal marshes of the South Fork Skagit River. Elevation data was collected using real-time kinetic (RTK) global positioning system (GPS) surveying (2 cm vertical and horizontal accuracy). Extensive sampling of soil salinity in the Skagit tidal marshes (>200 data points) indicates that soil salinities in the South Fork and North Fork tidal marshes range from 0 to 6 parts per thousand (ppt) (freshwater is < 0.5 ppt, seawater is approximately 32 ppt). However, soil salinities in the bayfront tidal marshes (between the North and South Forks) are approximately 17 ppt (range = 14 to 20 ppt). Thus, to account for the likely effects of salinity on the elevation ranges of tidal vegetation, an additional 125 vegetation-elevation data points were sampled in the bayfront tidal marsh in the vicinity of Rawlins Road (Figure 13). While data were collected for individual species, the results were aggregated by vegetation type (i.e., estuarine emergent, estuarine scrub-shrub, riverine-tidal scrub-shrub). The most significant effect of increased salinity on vegetation elevation ranges was to increase the elevation of the lower limit of vegetation by about 1 foot and to increase the lower limit of scrub-shrub vegetation by about 3 feet.

The resulting vegetation-elevation relationships were linked to LIDAR data collected in March of 2002 (LIDAR is topographic data acquired by airplane-mounted laser-based instrumentation) of Fir Island and Leque Island (Gross 2002). LIDAR elevations were compared to 600 vegetation-elevation data points collected by RTK-GPS and corrected for vegetation cover (laser penetration of vegetation was incomplete, depending on vegetation type). Agricultural areas did not need correction because no significant vegetation covered these areas at the time that LIDAR was collected (prior to the growing season). Corrected LIDAR elevations were recoded to vegetation type according to vegetation elevation ranges and potential vegetation was mapped in a GIS. LIDAR elevations were accurate to approximately 15 cm.

Figure 13. Elevation ranges of dominant vegetation in the South Fork Skagit River tidal marshes (blue) and bayfront marshes near Rawlins Road (green). Sample size for each species is indicated in parentheses. MHHW = mean higher high water.



Current Tidal Channel Condition

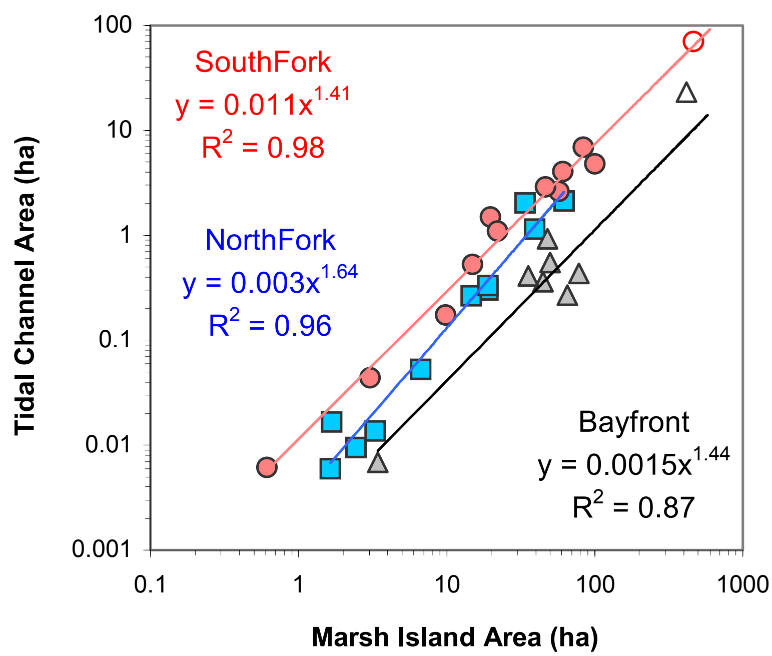
Current tidal channel condition was evaluated from digital orthophotos in a GIS. Color infra-red (CIR) orthophotos with 15-cm pixel resolution were used where available (most sites in the South Fork area, some sites or portions of sites in the North Fork area). True-color orthophotos with 45-cm pixel resolution were used when CIR photo coverage was not available. Channels as small as 0.5 m width are visible in the photos.

Potential Restored Tidal Channels

The potential for restoring tidal channels was evaluated through two means. Where possible (Wiley Slough and Dodge Valley), historical photos showing study areas prior to diking and conversion to farm land were rectified in a GIS. Historical tidal channels were digitized and quantified using GIS.

Areas diked prior to the development of aerial photography had to be evaluated through geomorphic modeling. The model is based on fractal theory as applied to landforms (Ouchi and Matsushita 1992, Rodriguez-Iturbe and Rinaldo 1997, Hood 2002). Data collected in the Skagit delta (Hood, in prep.) show that tidal channel network planform geometry scales with the size of the marsh islands that are drained by the tidal channel networks (Figure 14). There is a very high correlation ($R^2 > 0.95$) between marsh area and tidal channel surface area for the North and South Fork tidal marshes.

Figure 14. Scaling of tidal channel surface area with marsh island area.



The model reveals several important patterns. First, tidal channel density varies by location. Density is highest in the South Fork tidal marshes and lowest in the bayfront tidal marshes. In fact channel density is 7 times higher in the South Fork tidal marshes as in the bayfront marshes. North Fork channel density is more than twice as high as bayfront channel density. The low density of tidal channels in the bayfront area is consistent with the observation of historical impacts to tidal channels seaward of dikes, caused by conversion of marsh lands to diked and drained uplands (Hood 2004). The lower channel density in the North Fork marshes compared to the South Fork marshes is probably related to the high rates of sediment accretion and channel filling in the North Fork area (Hood, in review). Perhaps the most important pattern revealed in the data is that as marsh islands increase in size, the total area of tidal channels that drain an island increases even more rapidly (the exponents of the fitted power functions are > 1), i.e., one large island supports more channel area than two or more smaller islands of equal total size. The data indicate that it is more efficient and effective to restore one large area than several smaller areas of equivalent total area.

Results

Milltown Island

Milltown Island is bounded by two large distributaries of the South Fork Skagit River, Steamboat and Tom Moore Sloughs, and it is owned entirely by WDFW. The current Milltown Island site was historically a mosaic of several islands separated by distributary channels. However the Skagit Navigation Project of 1911 resulted in diking and dredging that cut off many distributary and tidal channels. Even non-diked channels were lost due to siltation, particularly near the northeast end of Milltown Island (Sheldon 1996). Dredge spoils now act as large levees in some areas of the island (USACE 1999).

From 1890 to the 1940s, the island was farmed, but from the 1940s to the present time, the island has become mostly fallow (Hinton 2004). It was acquired by the Department of Game through a land exchange with the federal government, and is currently managed as public open space (Warinner 2004 draft). Milltown Island was farmed to support wildlife, but flooding in the early 1990s resulted in several dike breaches that prevented successful agriculture (USACE 1999). Breaches in the western end of the island currently allow for limited tidal influence, and project funding has been obtained by the Skagit River System Cooperative to further restore estuarine habitat.

The site is owned by WDFW and consists of a total of 212 acres, of which 175 acres are behind historical dikes. The remaining 37 acres are located in the northeast corner of the island and are not entirely enclosed by dikes, but they are partially isolated from the river by a spur dike composed of dredge spoils. Approximately 96 acres at the south end of the island have never been diked off. Site topography is shown in the LIDAR image of Figure 15.

The historical vegetation of the site consisted entirely of tidal scrub-shrub vegetation (Figure 16). The current site vegetation is about 76% tidal emergent vegetation (cattails and reed canarygrass) and 24% riverine tidal forest. Site restoration would likely result in 75% tidal scrub-shrub vegetation, 19% riverine tidal forest vegetation, and 6% emergent tidal vegetation.

Tidal channel density in undiked reference tidal marshes in the South Fork Skagit delta indicate that marsh area of 212 acres (the amount of area directly influenced by Milltown Island dikes) should support approximately 19 tidal channels amounting to a total of 14.8 acres and approximately 12.2 miles length. Instead, only 5 tidal channels amounting to 5.3 acres and 2.9 miles length are observed in the portion of Milltown Island behind dikes (Figure 17), far less than predicted by the model. In comparison, the southern portion of Milltown Island, which was never farmed or diked and consists of 96 acres of tidal shrub wetlands, is predicted to support 11 tidal channels amounting 4.8 acres total. In fact, 10 tidal channels totaling 3.9 acres are observed, which is in good agreement with model predictions. The contrast between predicted and observed tidal channel geometry for the diked versus undiked portions of Milltown Island suggests that there is potential for significant restoration of tidal channels to the diked portion of Milltown Island. The limited amount of existing dike breaches probably constrains tidal channel development. More extensive dike removal may allow greater tidal channel development.

Channel density in the southern, undiked portion of Milltown Island is very similar to that of undiked reference tidal marshes elsewhere in the South Fork Skagit delta. Consequently, it is unlikely that dike removal will have significant effects on channel development outside of the dikes. The benefits of dike removal would accrue primarily to areas within the dikes.

Juvenile salmon (40-110mm fork length) currently have access to the site. Restoration actions on this site could result in additional tidal channel habitat (following a period of channel network development) and higher quality tidal marsh vegetation. Restoration actions assume by this analysis include removal of at least 6,000 feet of dike.

Figure 15. Topography from LIDAR imagery (left) of Milltown Island. Potential vegetation, assuming elevation control (right).

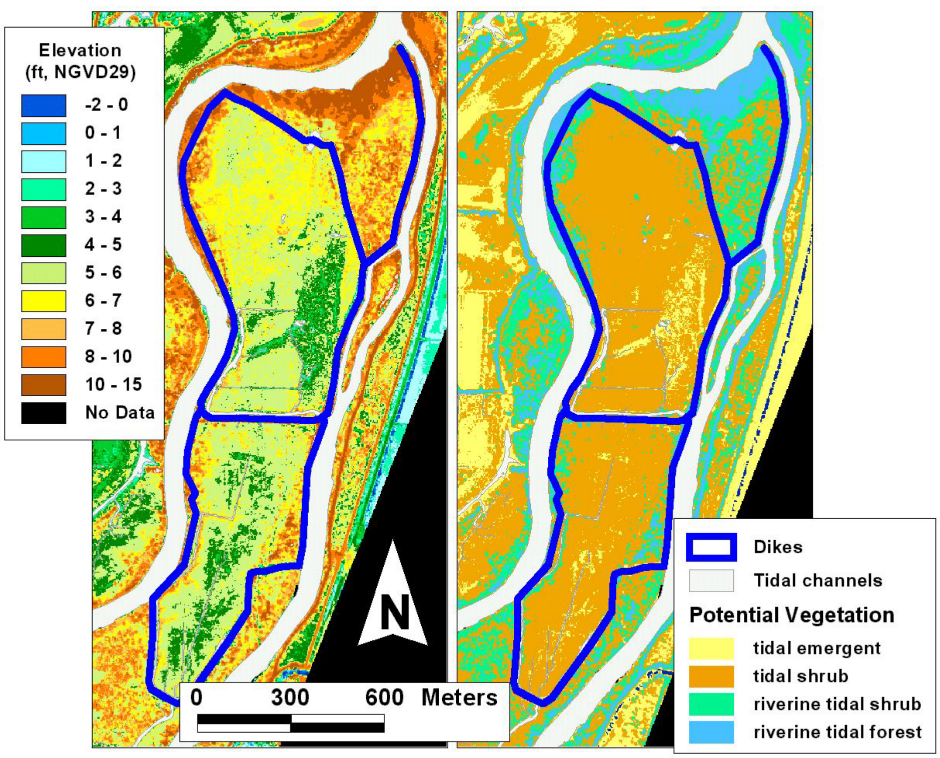


Figure 16. Historical (left) and current (right) vegetation types in the Milltown Island site. Estuarine vegetation is tidally influenced. Red lines bound the study site and depict dike locations.

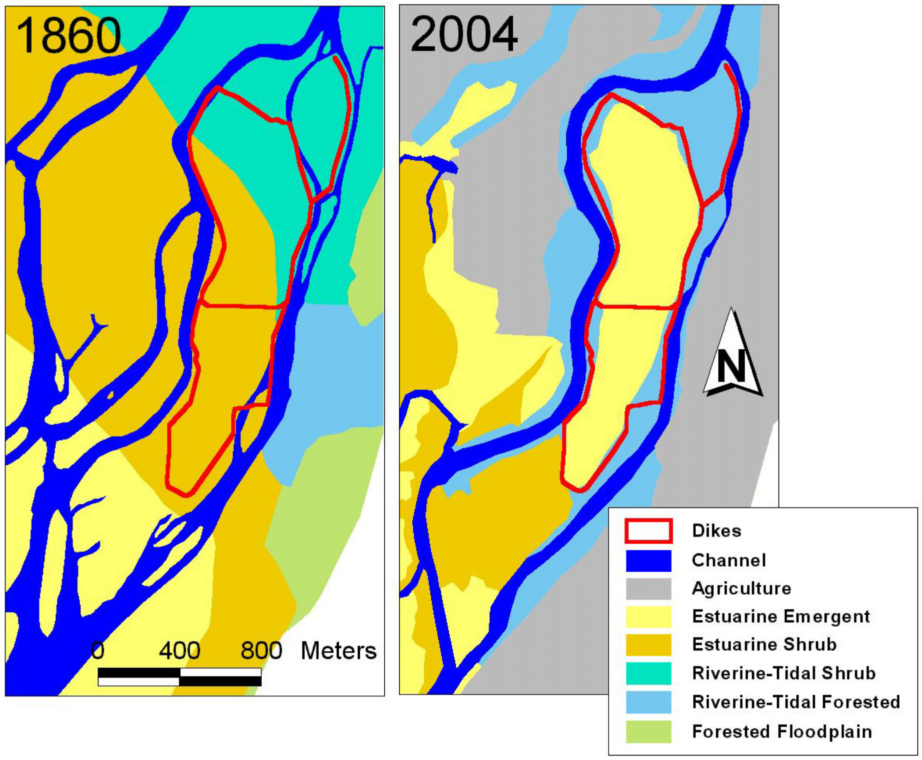
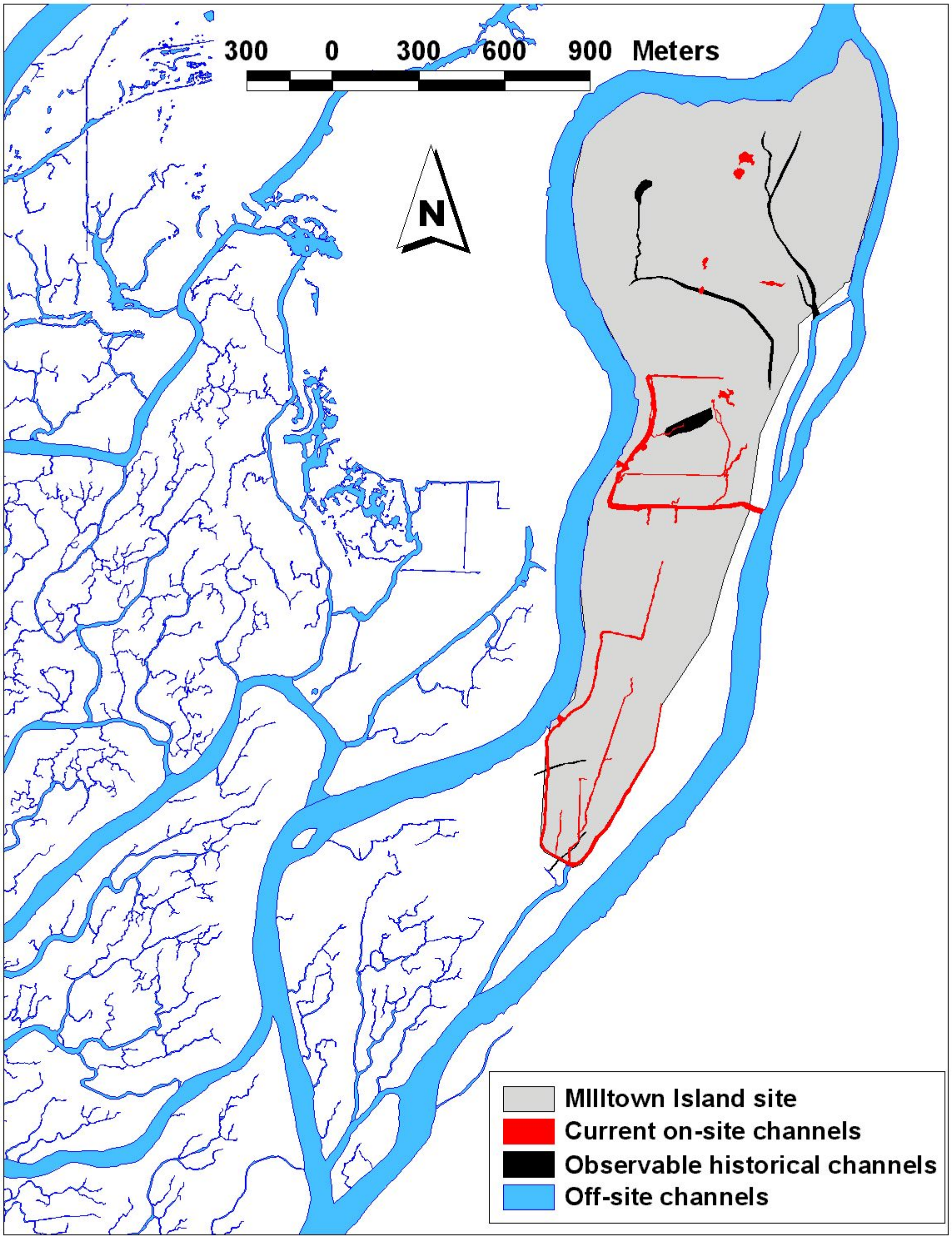


Figure 17. Current on-site channels (red), including borrow ditches on Milltown Island. Historical channels (black; observed from maps or historical photos) often coincide with current channel remnants or topographic swales visible in LIDAR imagery (compare to Figure 15). Most of the site was already diked by 1889, so detailed reconstruction of historical channels is not possible.



Deepwater Slough

The Deepwater Slough assessment site is also known as "the Farmed Island". It is located west of the Milltown site and east of the Wiley Slough area. The site is bisected by Deepwater Slough, with Freshwater Slough on the northeast side and Steamboat Slough to the southwest. In records dating back to 1908, flows through Deepwater Slough were apparently greater than those in Freshwater Slough, and a greater complexity of channels and islands existed in this area than is found today (Sheldon 1996). The Skagit River Navigation Project in 1911 significantly altered the Deepwater Slough area by focusing the flow to fewer channels through dredging and dike construction (USACE 1999). Many sub-channels were closed and estuarine habitat became isolated and converted to other uses.

In the early 1900s, the Farmed Island was lightly settled and farmed, and the dikes were low. Additional diking occurred later, and was maintained by the Army Corps of Engineers until the 1950s (USACE 1999). The project was deauthorized in 1978. In the late 1940s, the Washington Department of Game purchased the property as part of the Skagit Wildlife Area. During this time the upper half of Deepwater Slough, the principal distributary of the South Fork Skagit River, was isolated from the river by two dams (one at each end of the isolated reach). The acquired fields have ever since been planted with grain crops to support waterfowl hunting. Poorly drained areas have lain fallow and become dominated by cattail and reed canarygrass.

In 2000, a habitat restoration project re-established part of the island's historic estuary by removing the dams on Deepwater Slough and 14,000 feet of dikes to restore tidal and riverine hydrology to about 200 acres of the site (USACE 2004a). As a result, tidal and riverine flow was re-established through the historic Deepwater Slough distributary channel, and the project has resulted in the development of new tidal channel networks in the restored tidal marshes (Hinton 2004). Only part of the island was restored at that time due to pressure from waterfowl hunters. Dikes still protect part of the island, which continues to be actively farmed with waterfowl attracting grain crops.

The potential restoration site is owned by WDFW amounts to 273 acres total (104 ac in west lobe, 169 ac in east lobe). Site topography is shown in Figure 18.

Historically, the Deepwater Slough site consisted entirely of tidally influenced shrub habitat, probably dominated by sweetgale (*Myrica gale*) and willows (*Salix* spp.). Currently, the site is mostly (89%) in non-commercial agriculture (for waterfowl management) with areas fringing internal drainage channels supporting non-tidal wetland vegetation (non-tidal emergent, 3%; non-tidal scrub-shrub 3%; non-tidal forest, 5%). Potential vegetation would be tidally influenced, if dikes were breached or removed. Because there has been 2-4 feet of land subsidence over about half of the site, tidal shrub habitat could be restored to only 37% of the site, tidal forested habitat (mostly spruce [*Picea sitchensis*]) to nearly 6% of the site, while the rest would be tidal emergent vegetation, most likely a patchy mix of waterfowl foods such as spikerush (*Eleocharis palustris*), sedge (*Carex lyngbyei*), and bulrush (*Scirpus validus*), as well as cattails (*Typha angustifolia* and *T. latifolia*) (Figure 19).

The site currently is drained by very wide borrow ditches (whose excavated material was used to build dikes), other narrower ditches (which may in some cases be the straightened remains of historical tidal channels), and medium to large remnant tidal channels. These channels amount to 16.0 acres in surface area and 6.5 miles in length. Most of the historical tidal channels have been plowed over, filled in, re-aligned, or otherwise obscured by agricultural activities.

Restoration of tidal influence to the site through dike breaching or removal could restore a more complicated drainage network, amounting to 12.2 acres in surface area and 10 miles in length (Figure 20). Wide borrow ditches would narrow over time (filling in with river- and tide-borne sediments) while smaller dendritic tidal channels would be carved into the restored marsh surface. Total channel area could decrease, but total channel length would increase. Certainly, access by fish to channel habitat would be greatly improved and habitat quality would increase as the dendritic channel network grew.

Areas adjacent to the Deepwater Slough site have been recently (summer of 2000) returned to tidal influence through dike removal. Channel development is still occurring in these areas, with new small tidal channels becoming established throughout. Many large water bodies in the previously restored areas are not channelized but consist instead of large ponds, which were excavated historically to provide material for dike construction and repairs. Over time (decades) these ponded areas are likely to fill in with tidal sediments and become marshes drained by tidal channels.

Restoration of the Deepwater Slough area could affect adjacent, previously restored areas by contributing tidal prism (tidally driven flushing volumes which provide erosive energy to a site) to the adjacent areas. Quantitative prediction of these effects is problematic, but qualitative predictions include increased rates of channel development in the previously restored area, and increased numbers and sizes of tidal channels in the adjacent areas.

Juvenile salmon (40-110mm fork length) access to site is currently obstructed by tidegates. Restoration would at a minimum provide site access to juvenile salmon. Restoration actions assumed by this analysis include removal of at least 15,000 feet of dike.

Figure 18. Topography from LIDAR imagery (left) of the Deepwater Slough site. Potential vegetation, assuming elevation control (right).

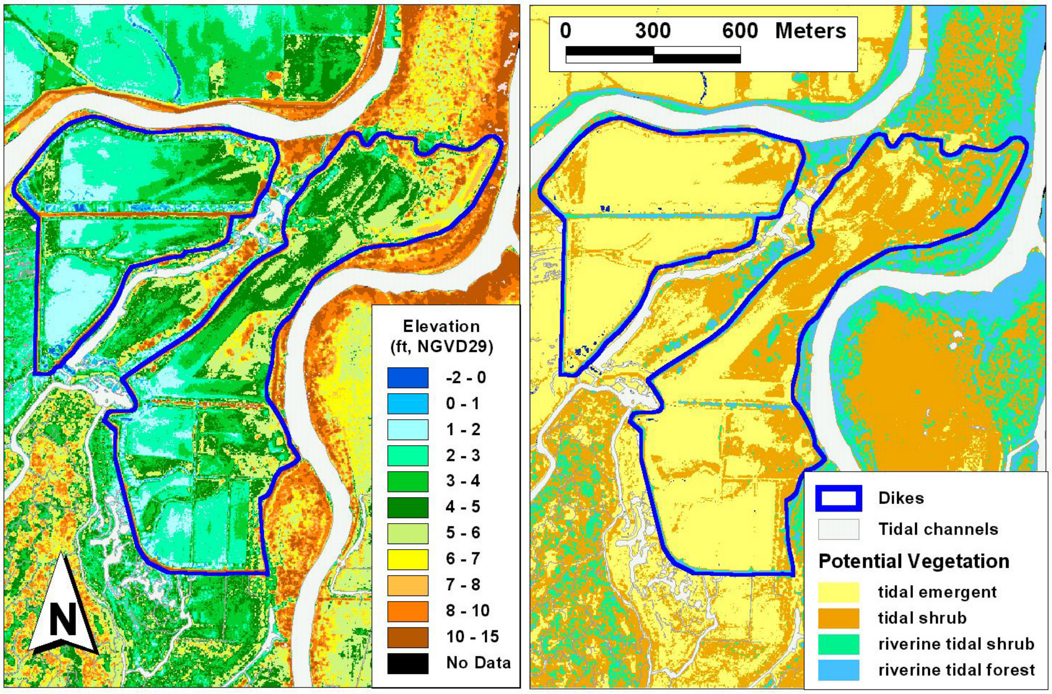


Figure 19. Historical (left) and current (right) vegetation types at the Deepwater Slough site. Estuarine vegetation is tidally influenced. Palustrine areas are non-tidal wetlands. Red lines bound the study site and depict dike locations.

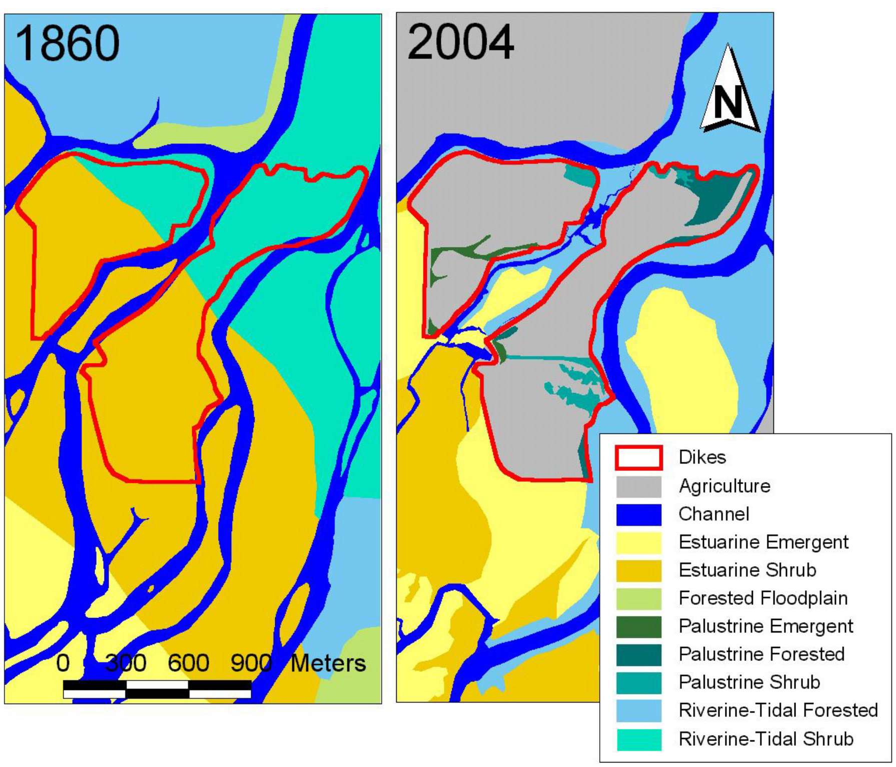
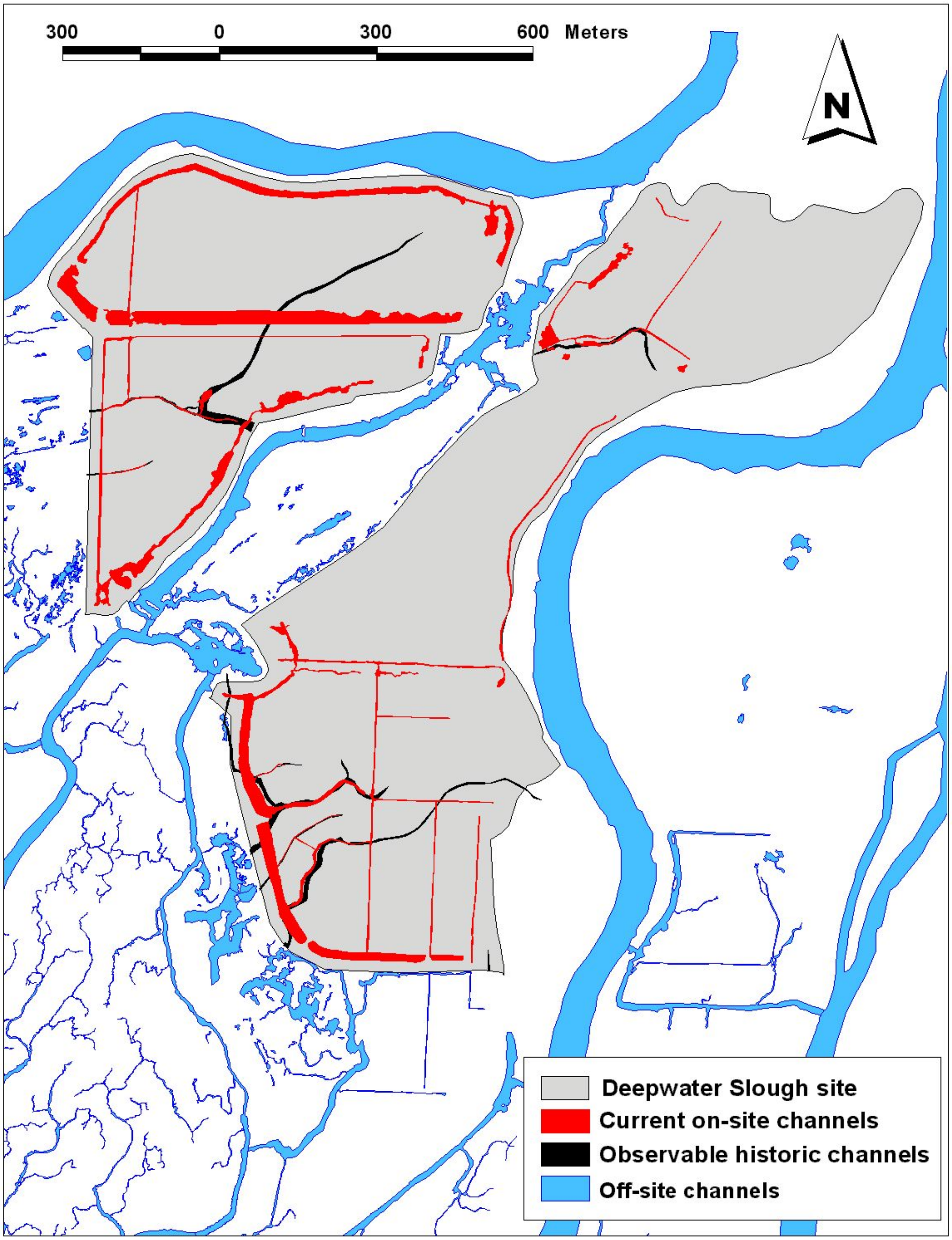


Figure 20. Current on-site channels (red), including borrow ditches at the Deepwater Slough site. Historical channels (black; observed from maps or historical photos) often coincide with current channel remnants or topographic swales visible in LIDAR imagery (compare to Figure 18). Most of the site was already diked by 1889, so detailed reconstruction of historical channels is not possible.



Wiley Slough

Wiley Slough is located across the Freshwater Slough Channel from Deepwater Slough and about a mile southeast of the Snow Goose Preserve. The portion of Wiley Slough owned by the Department of Fish and Wildlife was purchased in the 1940s to provide waterfowl hunting opportunity. This downstream portion was diked in 1962 to facilitate crop development for waterfowl (C. Wylie, personal communication), leading to a loss of 175 acres of estuarine habitat (Hood 2004). Until 1962, lower Wiley Slough was intertidal marsh habitat consisting of a mixture of emergent marsh and scrub/shrub communities surrounding an estimated 16.5 acres of tidal channel. Diking and agricultural development on WDFW lands resulted in filling 10.6 acres of tidal channel and converting an additional 5.7 acres to ditches (Hood 2004).

The upstream section of Wiley Slough was historically a high flow distributary channel off of Dry Slough that was disconnected in the course of agricultural settlement of Fir Island (C. Wylie, personal communication). Historically, Wiley Slough was also connected to Freshwater Slough and an 1889 map of Fir Island calls Wiley Slough the "West Fork of Freshwater Slough" (US Coast & Geodetic Survey 1889). This connection was severed between 1929-1940 (Collins 1998).

Currently an estuary restoration design is being developed for the WDFW portion of Wiley Slough. The restoration will likely include the removal of dikes to reconnect Wiley Slough to Freshwater Slough and Skagit Bay.

The study site consists of 190 acres in public ownership and 69 acres in private ownership. Two study circles are examined together at this site, because they are linked by intervening public lands. Site topography is represented by LIDAR data in Figure 21.

Historical vegetation was about half (52%) tidal emergent vegetation and half (48%) tidal scrub-shrub vegetation (Figure 22). Current vegetation is primarily agriculture (78%), followed by non-tidal forest (20%) and non-tidal emergent vegetation (2%). Potential vegetation after restoration of tidal influence would likely be mostly tidal emergent (82%), followed by tidal scrub-shrub (16%) and riverine tidal forest (2%).

Current channels landward of dikes in the study area total 12.4 acres in surface area and 4.1 miles in length. Of this total, 1.8 ac and 0.3 miles are on private land with the remainder on public land. Historical photos indicate that restoration has the potential to restore tidal channels amounting to a total of 22.4 acres and 10.4 miles, of which 3.0 acres and 2.4 miles would be on private land. Should this study area be restored, the bulk of the increase in channel area and length would be from the development of small- to medium-width tributaries to existing remnants of large trunk channels (Figure 23).

Channels exterior to dikes in the study area amount to 29.3 acres and 12.1 miles. Historical photos indicate the restoration would increase tidal prism to these channels and result in the further development of an additional 23.7 acres of tidal channel. Channel length is unlikely to increase significantly outside of the dikes, should they be removed.

Figure 21. Topography from LIDAR imagery (left) of Wiley Slough. Potential vegetation, assuming elevation control (right). Study site is outlined by heavy red line. Thin black line outlines public land. Two study sites were examined together because public land connected both areas.

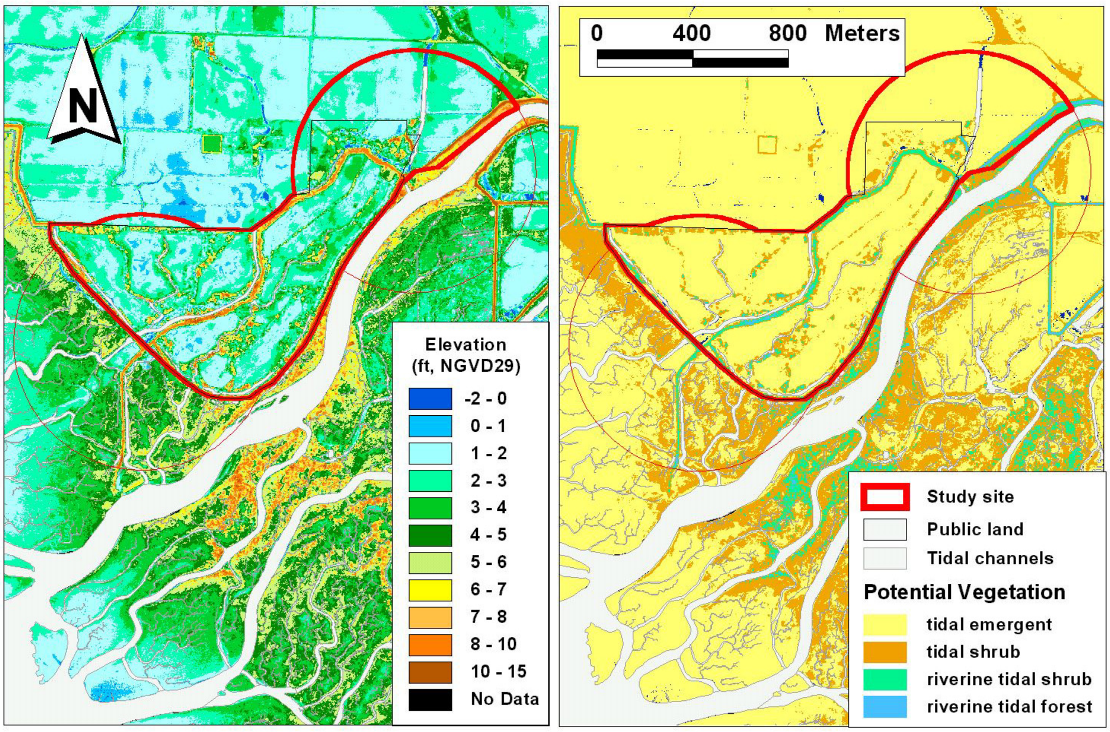


Figure 22. Historical (left) and current (right) vegetation types at Wiley Slough. Estuarine vegetation is tidally influenced. Palustrine areas are non-tidal wetlands. Heavy red lines bound the study site.

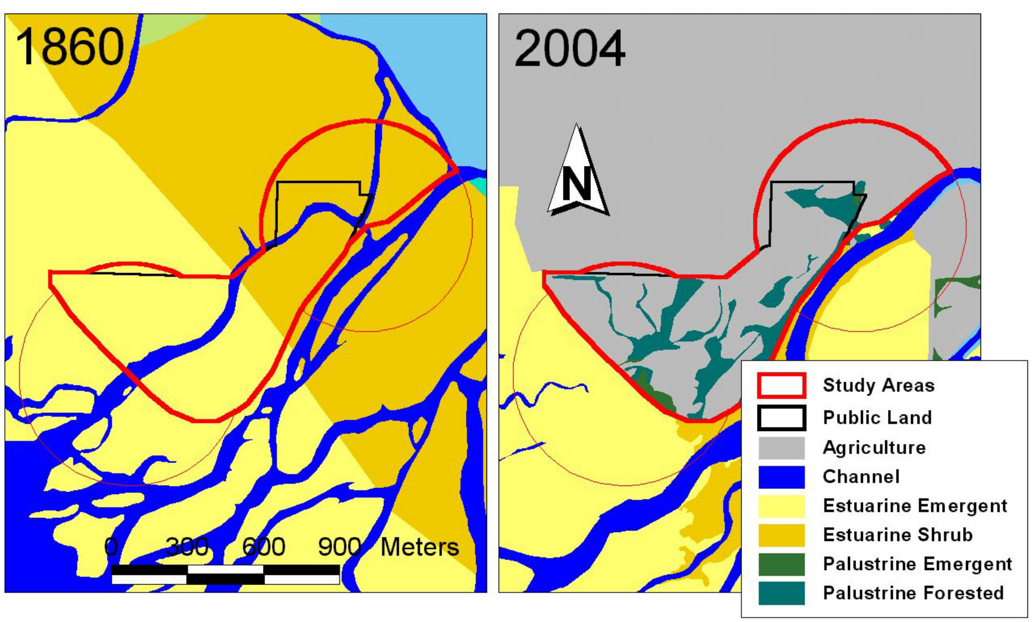
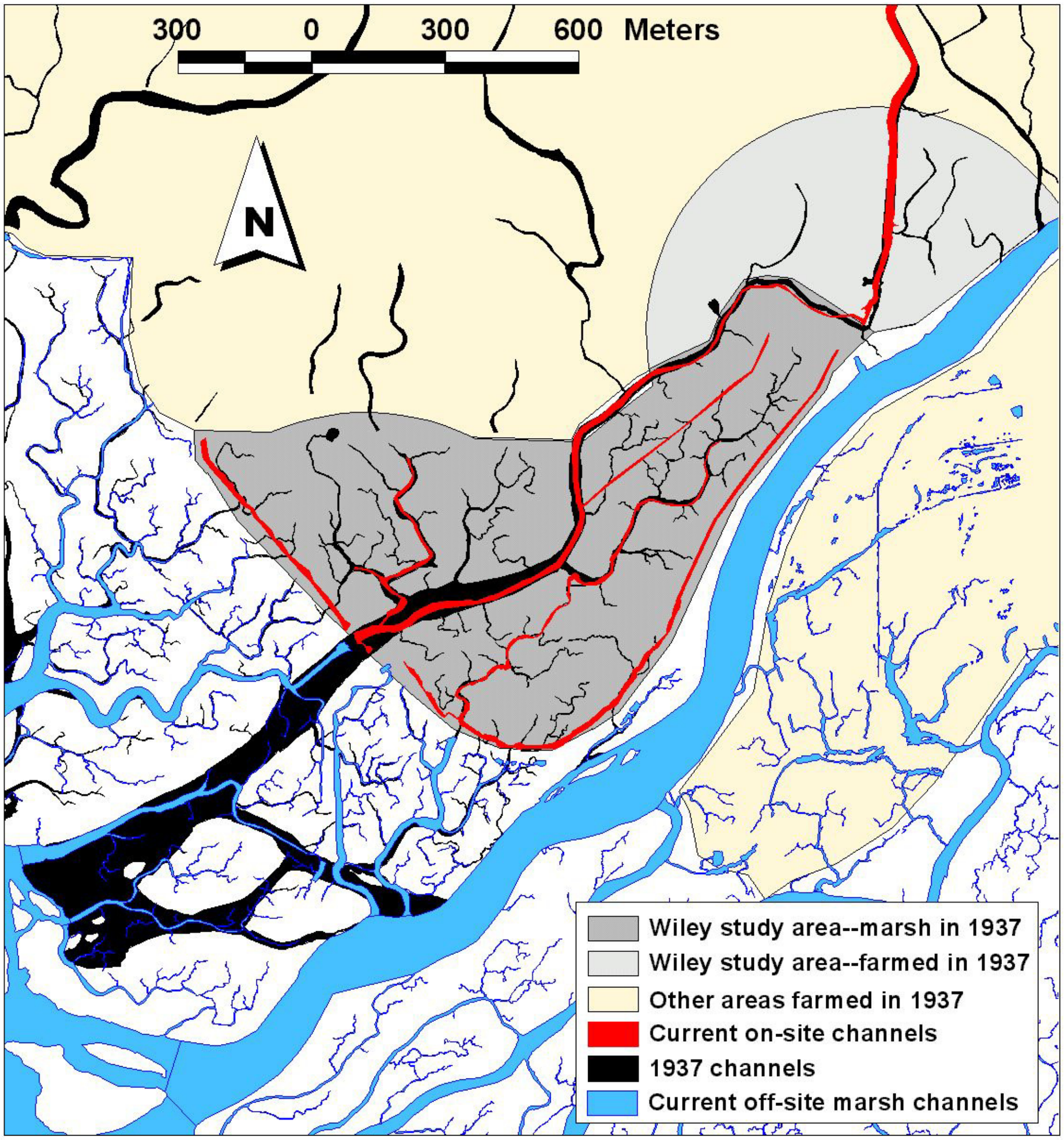


Figure 23. Current on-site channels (red), including borrow ditches at Wiley Slough. Historical channels (black; observed from 1937 photos) often coincide with current channel remnants. The northeastern portion of the site was diked by 1889. The remainder was not diked until the early 1960s, so detailed reconstruction of historical channels on much of the site is possible through reference to historical (1937 and 1956) photos.



Rather, channel width, particularly for the downstream portion of Wiley Slough, will increase and thereby increase channel surface area.

Juvenile salmon (40-110mm fork length) access to site is currently obstructed by tidegates. Restoration would at a minimum provide site access to juvenile salmon. Restoration actions assumed by this analysis include removal of 10,000 ft of dike, construction of nearly 3,000 ft of dike, and relocation of tidegates.

Brown's/Dry Slough

Historically, Dry Slough was a distributary channel of the Skagit River during higher flows (sometimes referred to as Deer Slough or the Middle Fork Skagit River) that provided an additional connection between the North Fork Skagit River and Skagit Bay (Moen 2002; Tetra Tech 2002). Its terminus was described as having "many tentacles" (Moen 2002). The Hayton family had land on a small island within the historic slough. Steamboats used to come up Dry Slough at least as far as the Hayton's property around the turn of the century to collect hay and oats that were grown by the Haytons (Moen 2002). Diking and further agricultural conversion resulted in the loss of this major distributary channel and associated intertidal habitat. The upper end of Dry Slough was disconnected between 1952-1956 (C. Wylie, personal communication), during which time McDonald Slough was also disconnected from Dry Slough (Collins 1998). Additional downstream channels were disconnected from 1889-1907 and from 1968-1991. McDonald Slough lost a downstream distributary channel between 1940 and 1956. Dry Slough currently has two tidegates and numerous road crossings. It is now a freshwater wetland (Tetra Tech 2002).

Brown's Slough is joined to Hall Slough, and together, they formed a major distributary channel from the North Fork Skagit River to Skagit Bay, branching off from each other midway to the bay (Collins 1998). The upper end was closed off by dikes between 1940 and 1956, and further disconnections downstream occurred from 1940 to 1991 (Collins 1998). Both Dry and Brown's Slough are discussed together due to their downstream proximity and similar land ownership and management policies.

The WDFW acquired part of the area in the late 1980s to early 1990s. Currently, the area consists of a public lands portion owned by WDFW called the Snow Goose Preserve along with the private lands owned by the Hayton family. The entire area is farmed. WDFW allows the Hayton family to farm WDFW lands in the spring and summer as long as they plant a cover crop for waterfowl habitat in the fall. No hunting is allowed on the site, as it is a reserve for wintering snow geese.

The study area amounts to 260 acres in public ownership, 52 acres in private ownership west of Brown's Slough, and an additional 125 acres in private ownership east of Dry Slough. Four study circles were consolidated at this site due to extensive overlap. Site topography is represented by LIDAR in Figure 24.

Historical vegetation on the public portion of the site consisted of 58% tidal emergent vegetation and 42% tidal scrub-shrub vegetation (Figure 25). Current vegetation is almost completely agriculture (97%) with some emergent non-tidal vegetation in drainage ditches and vestigial channels (3%). Restoration of tidal flooding to the site would result in mostly tidal emergent vegetation (96%) and some tidal scrub-shrub vegetation (4%).

Vegetation communities on private lands were historically almost entirely tidal emergent vegetation (99%) with the remainder tidal scrub-shrub. Current vegetation is primarily agriculture (97%) with the remainder non-tidal emergent associated with drainage ditches and vestigial channels. Restoration would result in 99% coverage by tidal emergent vegetation and 1% tidal scrub-shrub vegetation.

With both public and private lands considered jointly, historical vegetation was 75% tidal emergent and 25% tidal scrub-shrub. Current vegetation is 97% agriculture and 3% non-tidal emergent. Potential restored habitat would be 97% tidal emergent and 3% tidal scrub-shrub. The potential for restoring tidal shrub wetlands is less than the historical abundance due to land subsidence of about 2-3 feet landward of the dikes.

Currently, channels landward of the dikes in the study area include 2.5 acres (0.35 miles) of a former distributary channel on private land (Figure 26). This channel is isolated from the North Fork Skagit River and not currently functioning as a distributary. Former blind tidal channels on amount to 4.4 acres and 2.3 miles on public land, and 3.1 acres and 1.8 miles on private land. Restoration of tidal flooding to the study site could result in the redevelopment of 22.1 acres and 18.2 miles of blind tidal channel on private lands and 20.0 acres and 16.5 miles of blind tidal channel on public lands.

Tidal channels exterior to dikes in the study area amount to 31.2 acres and 8.5 miles of blind tidal channels. This includes former distributaries, which are now blocked and functioning as blind channels. Aerial photos from 1937 show 6.0 acres and 6.3 miles of blind channel and 33.3 acres and 3.6 miles of distributary channel. It should be noted that the 1937 aerial photo was in black and white and had considerably lower resolution than the 2000 color aerial photo. Modeling indicates the possibility of sustaining 41.4 acres, 8.5 miles of blind tidal channel, without restoration of distributary connections to the North Fork Skagit River.

Juvenile salmon (40-110mm fork length) access to site is currently obstructed by tidegates. Restoration actions assumed in this analysis included removal of approximately 12,800 ft of dike, construction of 14,500 ft of dike, relocation of tidegates, and no reconnection of Dry Slough or Brown’s Slough to the North Fork Skagit River.

Figure 24. Topography from LIDAR imagery (left) of Browns/Dry Slough. Potential vegetation, assuming elevation control (right). Study site is outlined by heavy red line. Thin black line outlines public land. Several study areas were grouped together due to extensive overlap.

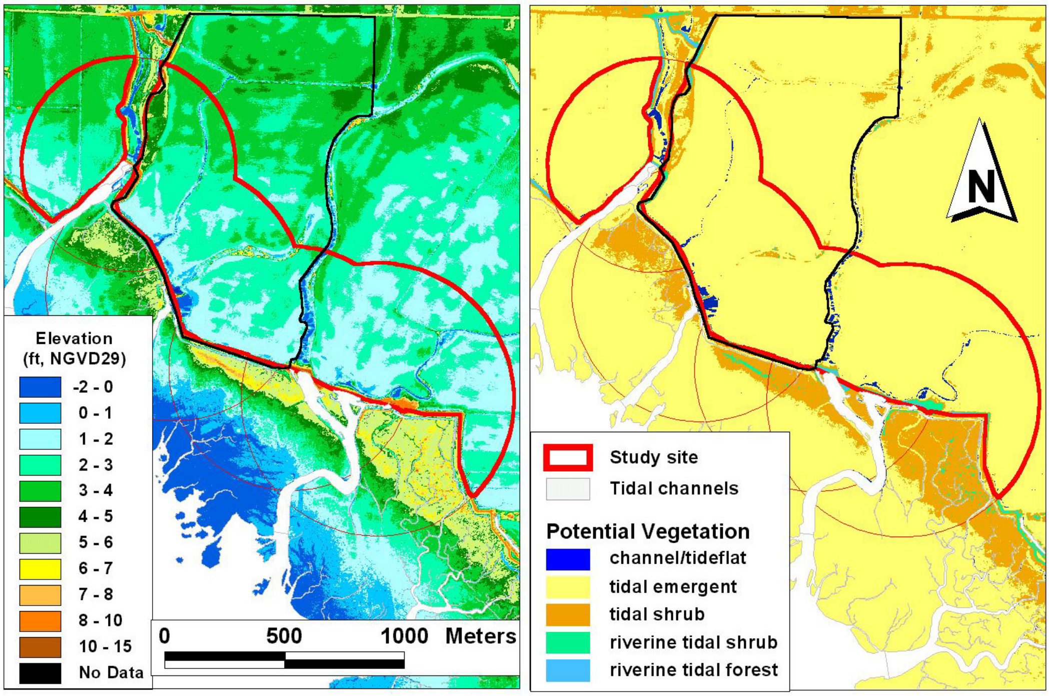


Figure 25. Historical (left) and current (right) vegetation types in the Browns/Dry Slough area. Estuarine vegetation is tidally influenced. Palustrine areas are non-tidal wetlands.

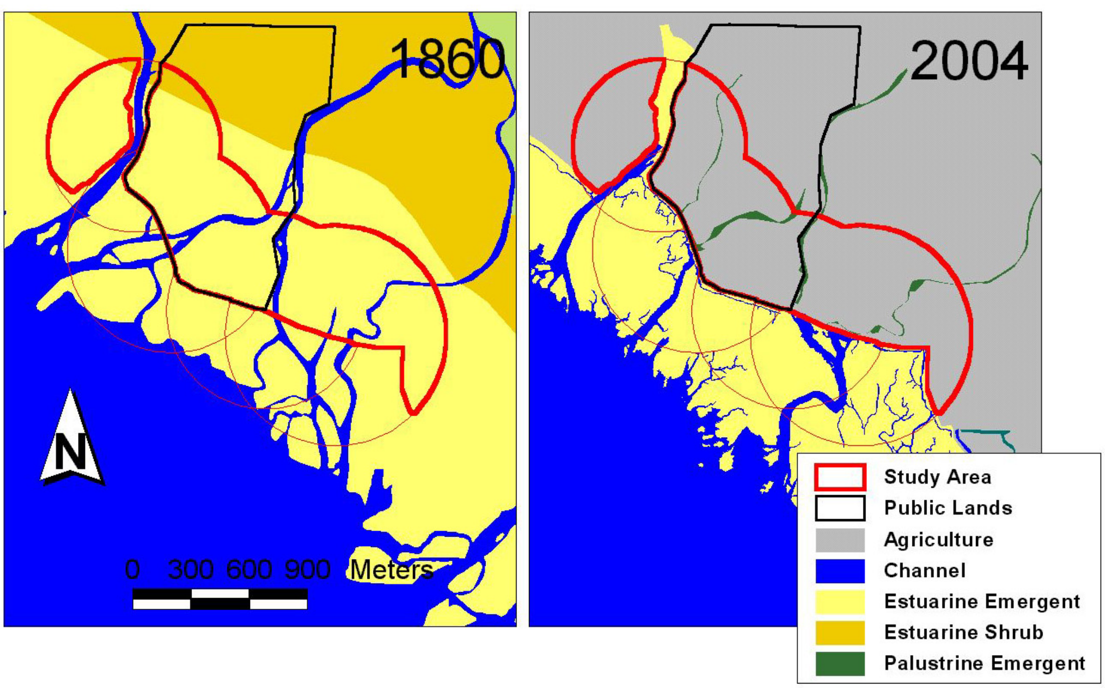
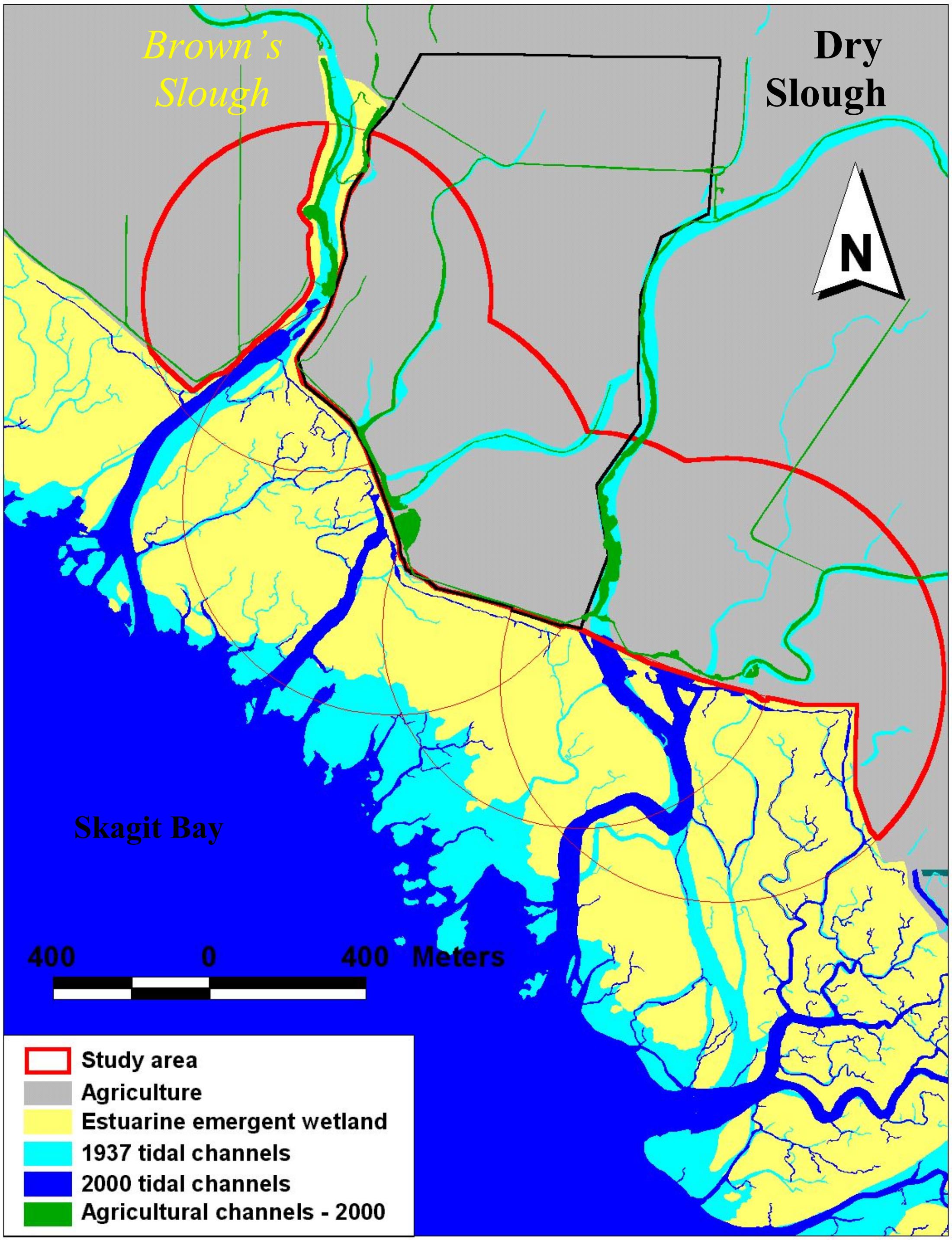


Figure 26. Channels interior (green) and exterior (dark blue [2000] and light blue [1937]) to the dikes in the Browns/Dry Slough area. Light blue areas outside the dikes have since filled in with sediment and are currently emergent tidal marsh. Light blue areas inside the dikes have also filled in and become agricultural fields. Note that the 1937 aerial photo was in black and white and had considerably lower resolution than the 2000 color aerial photo. Consequently, 1937 channel abundance is likely underestimated. NB: During 1937 Brown's and Dry Slough were connected to the North Fork Skagit River.



Hall Slough

Hall Slough is joined to Brown's Slough, and together they were a major distributary channel from the North Fork Skagit River to Skagit Bay, branching off from each other about midway to the bay (Collins 1998). The upper end was closed off by dikes between 1940 and1956, and further disconnection from the bay downstream occurred from 1940 to 1991 (Collins 1998). Levees constrain the limited existing salt marsh habitat downstream of Maupin Road, and a tidegate prevents salmonid access beyond the road. The tidegate doesn't work, and much of the drainage goes through Brown's Slough (C. Wylie, personal communication). Upstream of Maupin Road, the slough is now a ditch that drains farmland and has no riparian vegetation (Tetra Tech 2002). A small levee spur off of the main levee is thought to be unnecessary (Tetra Tech 2002).

The study site amounts to 100 acres in private ownership. Site topography/elevation is represented by LIDAR in Figure 27.

Historical vegetation on the site was entirely tidal emergent marsh (Figure 28), while current vegetation is almost entirely agriculture (99%) with some non-tidal emergent (1%) in drainage ditches and vestigial tidal channels. Restoration of tidal flooding to the site could result in 90% coverage by tidal emergent vegetation and 10% tidal scrub-shrub vegetation.

Channels landward of dikes on the site (Figure 29) include 0.4 acres or 0.27 miles of a former distributary, which is not currently connected to the North Fork Skagit River. There are also 0.9 acres or 0.74 miles of drainage ditches or vestigial blind tidal channels. Restoration of tidal inundation could result in the redevelopment of 5.1 acres or 4.2 miles of blind tidal channel, without reconnection of the former distributary to the Skagit River. Channels seaward of dikes currently amount to 3.0 acres or 0.8 miles of blind tidal channel. Photos from 1937 show 1.0 acre, 0.44 miles of blind channel and 5.9 acres, 0.7 miles of distributary channel. Note that the 1937 aerial photo was in black and white and had considerably lower resolution than the 2000 color aerial photo. Thus, the historical photo probably underestimates the true amount of tidal channel. Modeling indicates the possibility of sustaining 5.3 acres or 1.5 miles of blind tidal channel seaward of the dikes (without restoration of distributary connection to the North Fork Skagit River) due to increased tidal prism of this area.

Juvenile salmon (40-110mm fork length) access to site is currently obstructed by tidegates. Restoration actions assumed in this analysis include removal of approximately 4,400 ft of dike, construction of 10,000 ft of dike, relocation of tidegates, and no reconnection of Hall's Slough to the North Fork Skagit River.

Figure 27. Topography from LIDAR imagery (left) of Hall Slough. Potential vegetation, assuming elevation control (right). Areas classified as riverine shrub and forest are actually dikes.

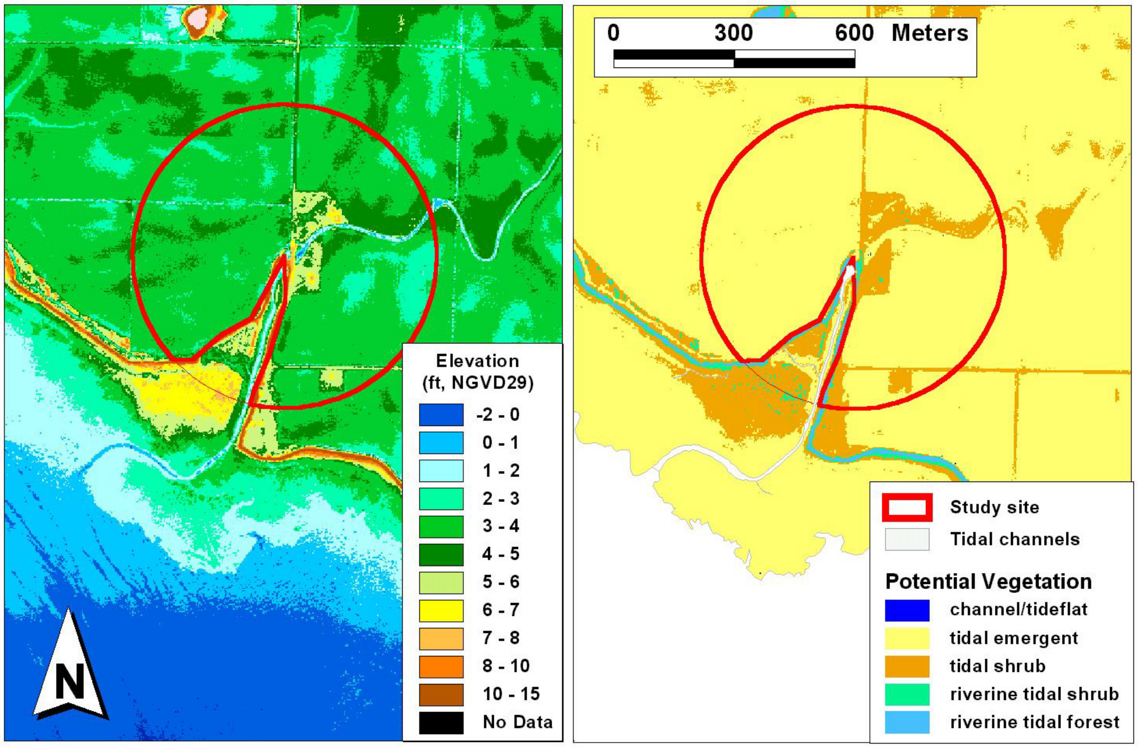


Figure 28. Historical (left) and current (right) vegetation types of Hall Slough. Estuarine vegetation is tidally influenced. Palustrine areas are non-tidal wetlands.

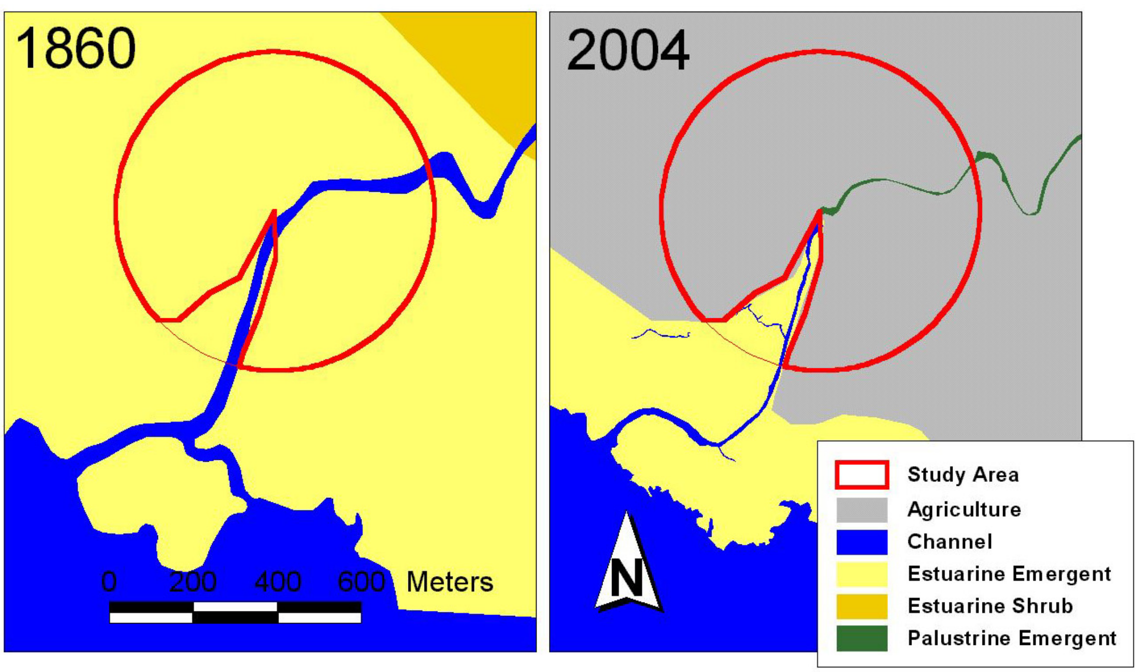
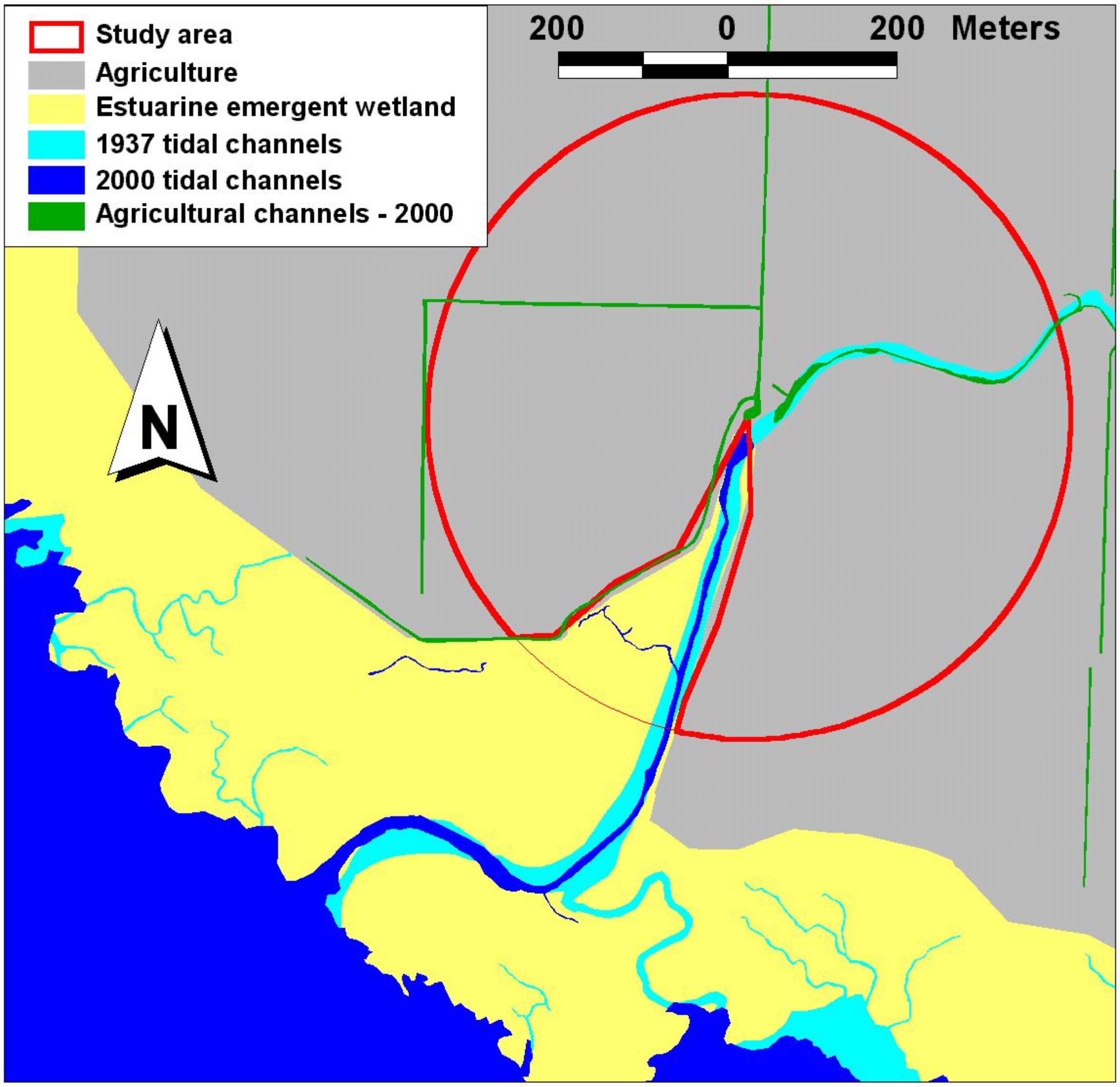


Figure 29. Channels interior (green) and exterior (dark blue [2000] and light blue [1937]) to the dikes in the Hall Slough area. Note that the 1937 aerial photo was in black and white and had considerably lower resolution than the 2000 color aerial photo. Consequently, 1937 channel abundance is likely underestimated. NB: Hall's Slough during 1937 was connected to the North Fork Skagit River.



Rawlins Road

The Rawlins Road assessment area includes public land (WDFW) outside of the dike, and could be expanded to include up to 100 acres of private land inside the dike. In the early 1900s, the land outside of the dike was farmed and another dike used to be located where intertidal habitat is now found (C. Wylie, personal communication). Much of the land outside of the dike contains functioning blind tidal channels. A proposal has been submitted to the Salmon Recovery Funds Board to study the feasibility of augmenting channel habitat by constructing a short distributary channel outside the dike. The privately owned land is currently farmed, and the landowner is not currently interested in selling.

The tidegate at this site does not provide much drainage as most of the drainage goes through Brown's Slough (C. Wylie, personal communication). Near the tidegate there is a wing dike built from spoils about 15 years ago. Removal of this dike has been proposed to allow additional tidal action.

The study site amounts to 114 acres in private ownership. Site topography is represented by LIDAR in Figure 30. Historical vegetation was entirely tidal emergent marsh. Current vegetation is entirely agriculture. Restoration of tidal inundation would result in complete coverage of the site by tidal emergent vegetation (Figure 31).

Currently, no historical channels remain inside the dikes, only rectilinear agricultural drainage. This area was diked prior to the 1889 map, so there is no historical record of tidal channels on this site. However, modeling indicates the possibility of sustaining 4.1 acres or 0.8 miles of blind tidal channel should the study area landward of the dikes be restored.

Tidal channels seaward of the dikes currently amount to 3.2 acres or 2.7 miles. Modeling predicts that 3.7 acres of blind tidal channel should be present outside the dikes. This is comparable to the 3.2 acres that are observed.

Juvenile salmon (40-110mm fork length) access to site (landward of dikes) is currently obstructed by tidegates. Restoration actions assumed in this analysis included removal of approximately 5,600 ft of dike, construction of 4,000 ft of dike, and relocation of tidegates.

Figure 30. LIDAR topography (left) of the Rawlins Road site. Potential vegetation, assuming elevation control (right). Some areas classified as riverine shrub and forest are actually dikes.

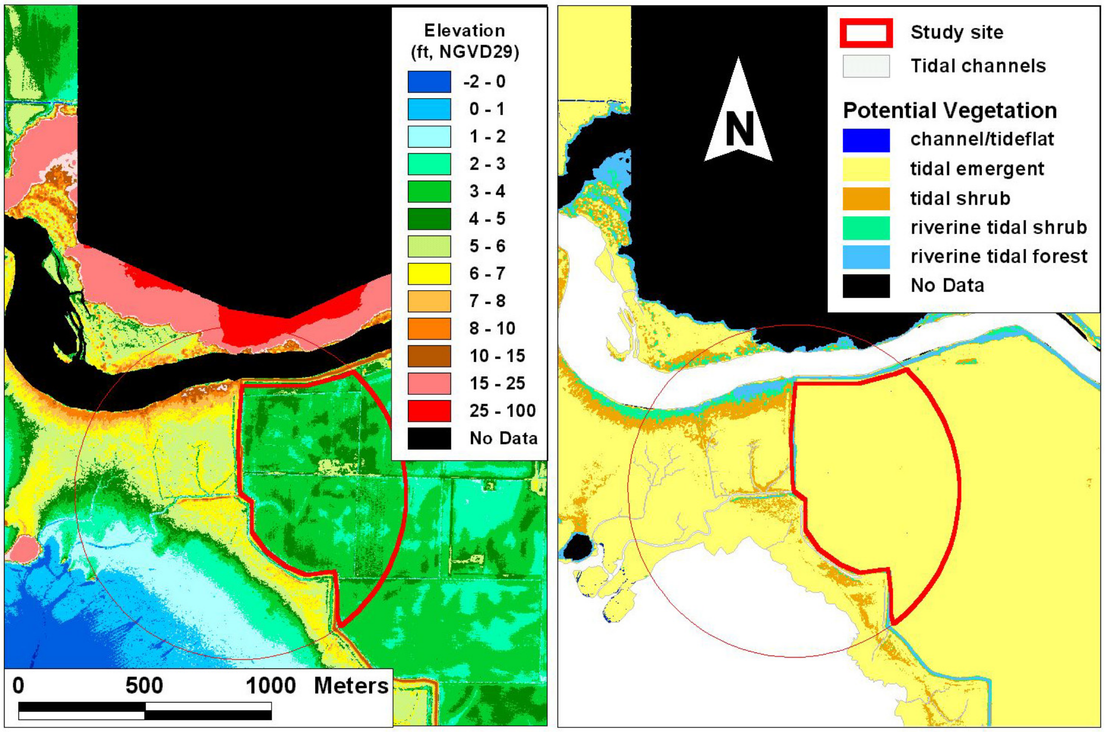
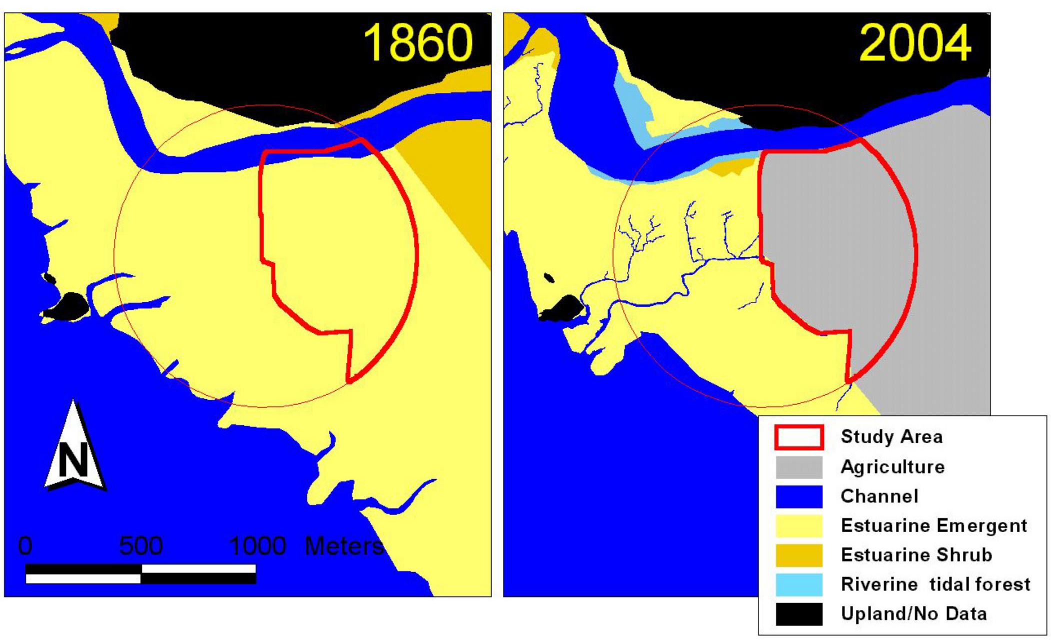


Figure 31. Historical (left) and current (right) vegetation types in the Rawlins Road site. Estuarine vegetation is tidally influenced.



Dodge Valley

Dodge Slough drains an approximately 2200-acre watershed located south and east of Sullivan Slough. It is a small slough with a dike and pump station near its mouth (Curtis Johnson, personal communication). Historically, the slough was considerably larger, but diking and drainage of marshes in the study area significantly reduced the tidal prism and flushing power of the slough and this led to sediment accumulation in channel remnants seaward of the dikes (Hood 2004). Marsh conversion in the study area occurred in two phases, approximately 100 acres in the late 1930s to early 1940s and another 100 acres in the late 1950s to early 1960s As sediments have built-up outside of the dike, pumping has become the only way to drain the agricultural land behind the dike (Curtis Johnson, personal communication). The first pump was installed in 1951. Most of the flow through Dodge Slough is currently from agricultural drainage with a lesser amount believed to come from Pleasant Ridge (Curtis Johnson, personal communication).

The study site amounts to 110 acres in private ownership. Site topography is represented by LIDAR in Figure 32. Historical vegetation was almost entirely tidal emergent (99%) with some tidal scrub-shrub (1%), while current vegetation is almost entirely agriculture (98%) with some non-tidal emergent (2%) in drainage channels (Figure 33). Restoration of tidal inundation could result in mostly tidal emergent vegetation (98%) with some tidal scrub-shrub (2%).

Currently, 2.6 acres or 1.0 miles of ditches or vestigial tidal channels exist landward of dikes on the study site (Figure 34). Restoration of tidal inundation could result in the redevelopment of 5.8 acres or 4.8 miles blind tidal channels. Seaward of the dikes there are currently 1.3 acres or 0.8 miles of blind tidal channel. Photos from 1937 show 3.4 acres or 0.7 miles of blind tidal channel seaward of the dikes. Modeling indicates the possibility of sustaining 1.9 acres, 1.6 miles of blind tidal channel. This amount is less than historical because the study site is half the size of the amount of marsh present in this area in 1937 (later diked by 1965).

Juvenile salmon (40-110mm fork length) site access (landward of dikes) is currently obstructed by tidegates. Restoration actions assumed: removal of approximately 3,400 ft of dike, construction of 6,000 ft of dike, and relocation of tidegates.

Figure 32. LIDAR topography (left) of the Dodge Slough site. Potential vegetation (right).

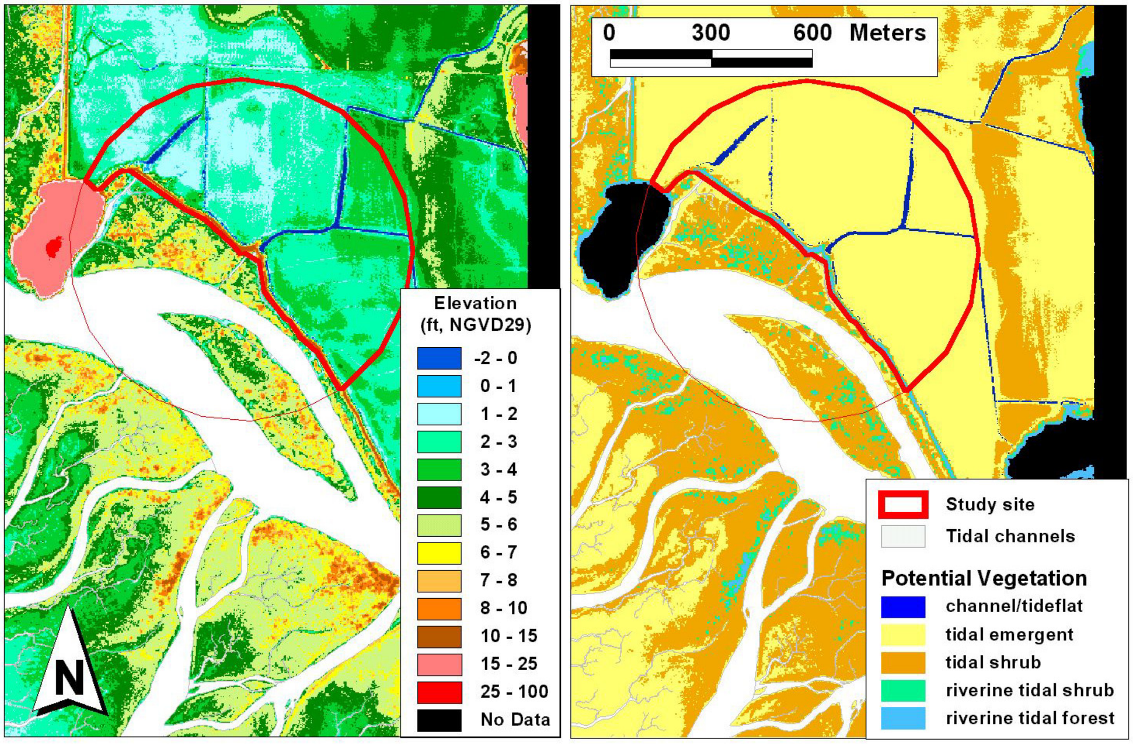


Figure 33. Historical (left) and current (right) vegetation types of the Dodge Slough site. Estuarine vegetation is tidally influenced. Palustrine areas are non-tidal wetlands.

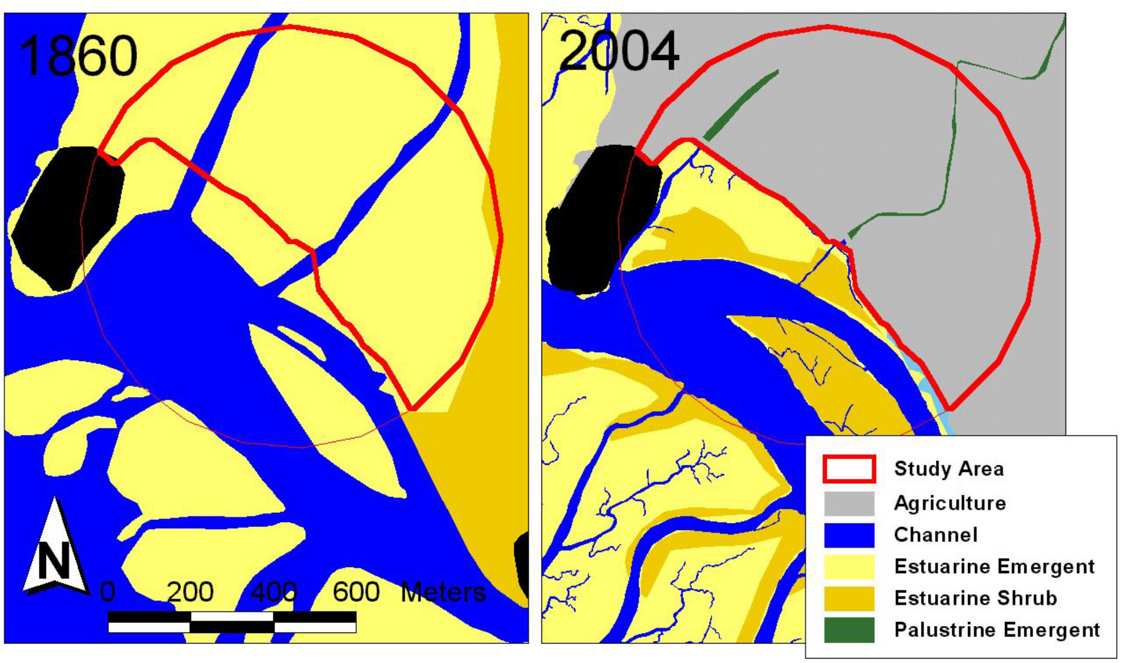
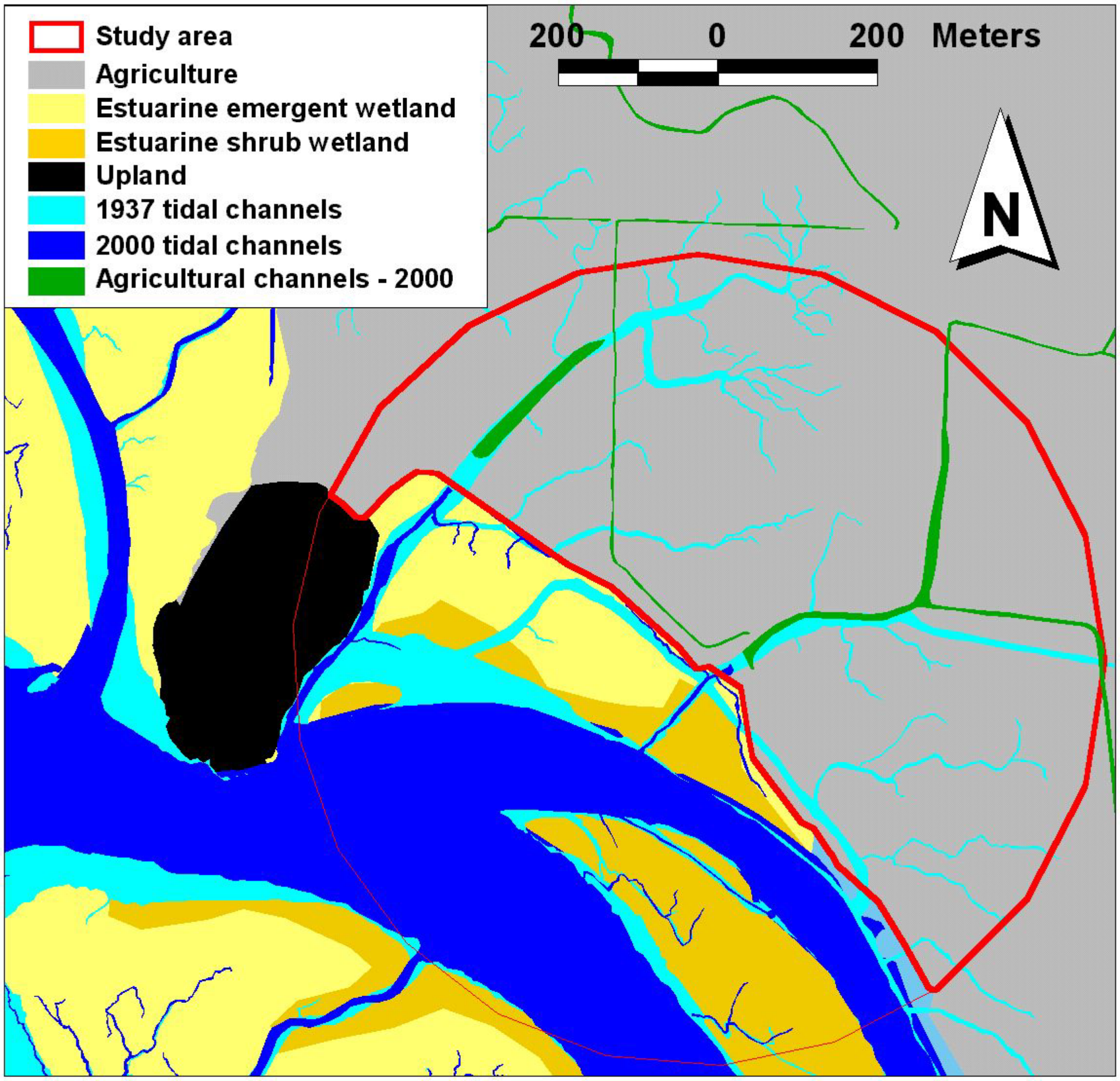


Figure 34. Channels interior (green) and exterior (dark blue [2000] and light blue [1937]) to the dikes in the Dodge Slough area. Light blue areas have filled in with sediments since 1937 and been transformed to marsh (outside the dikes) or agricultural land (inside the dikes). Note that the 1937 aerial photo was in black and white and had considerably lower resolution than the 2000 color aerial photo. Consequently, 1937 channel abundance is likely underestimated.



Sullivan Slough

Historically, Sullivan Slough was a large tidal channel with numerous branches, two of which remain. It was described in 1885 as the largest river on Puget Sound during high tide (in Collins 1998). Levees were first constructed along both sides of Sullivan Slough prior to 1918, and paddle wheelers traveled up the slough at high tide to a grainery located on the northern levee (John Roozen, personal communication). Around 1918, the slough was dammed at Chilberg Road and there is no longer any tidal exchange or fish access to areas upstream of the dam.

In addition to the dam, several other important historic activities have altered Sullivan Slough. Construction of the Swinomish Channel jetty is thought to have resulted in increased sedimentation near the mouth of Sullivan Slough (Tetra Tech 2002), and this sediment accumulation has necessitated the use of pumps to aid agricultural drainage (John Roozen, personal communication). It is also likely that damming Sullivan Slough has contributed to sediment accumulation in the remaining seaward portions of the channel by eliminating significant tidal prism and tidal flushing (Hood 2004). A bypass was constructed in the mid-1930s to connect Sullivan Slough to the Swinomish Channel to allow some gravity-driven drainage (John Roozen, personal communication).

The site amounts to 186 acres in private ownership and 9 acres in Tribal ownership for a total of 195 acres. Four study area circles were consolidated into one area due to extensive overlap between circles. Additionally, some areas within the circles consisted of low hills, i.e., upland areas incapable of supporting intertidal wetlands. These hills were removed from area calculations and any other further consideration. Site topography is shown in LIDAR in Figure 35.

Historical vegetation was 56% tidal emergent and 44% tidal scrub-shrub, all on what are today private lands. Current Tribal lands were subtidal or unvegetated intertidal flats (Figure 36). Currently site vegetation is 95% agriculture, 4.5% urban (fill and gravel road, on Tribal land), and 0.5% non-tidal emergent in drainage channels. Restoration of tidal inundation could result in 90% tidal emergent vegetation and 3 % tidal scrub-shrub vegetation with the remaining 7% depending on the amount of fill removal.

Current channels landward of dikes amount to 1.3 acres or 0.8 miles. Tidal inundation could lead to the development of 8.2 acres or 6.8 miles of blind tidal channels. Tidal channels seaward of dikes currently amount to 19.2 acres or 8.2 miles. The question of how much tidal channel historically existed seaward of current dikes is not particularly meaningful for the Sullivan Slough study site, for two reasons. [1] There have been extensive historical changes in Dunlap Bay, which has filled in with sediment and transformed from a small shallow bay to a marsh. The cause of this change was the construction of a causeway from La Conner to McGlinn Island. [2]. There have been extensive historical changes in Sullivan Slough, which has filled in with sediment due to being isolated from its basin by dikes, with consequent loss of tidal prism. Furthermore, prior to river levee construction, Sullivan Slough was also a flood over-flow channel. Loss of riverine flood flows also contributed to channel filling. Marsh restoration in the Sullivan Slough area would not address either the cause of Sullivan Slough infilling or of Dunlap Bay infilling and thus it would have little effect on channel development in these seaward areas. In addition, current tidal channel abundance outside of the dikes is very high, such that the allometric model of tidal channel geometry does not predict significant additional channel development outside of the dikes in the case of site restoration. On-site channel development will be far more significant.

Figure 35. LIDAR topography (left) of Sullivan Slough/La Conner area. Potential vegetation (right). The study site is outlined by heavy red line, tribal land in the study area by a black line.

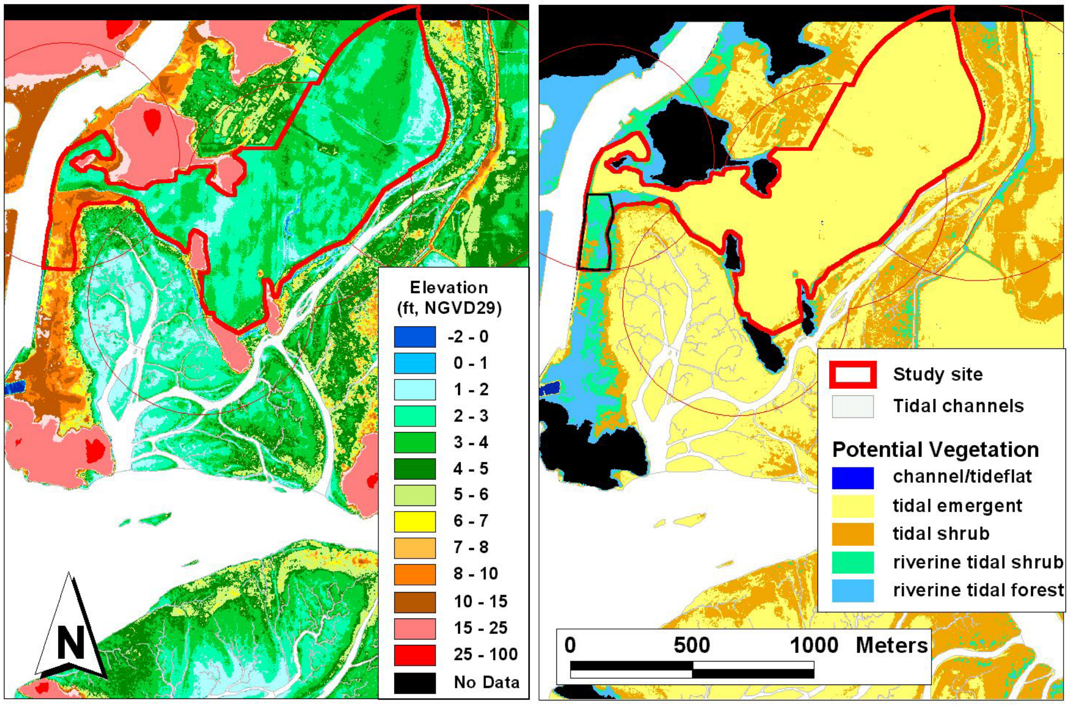
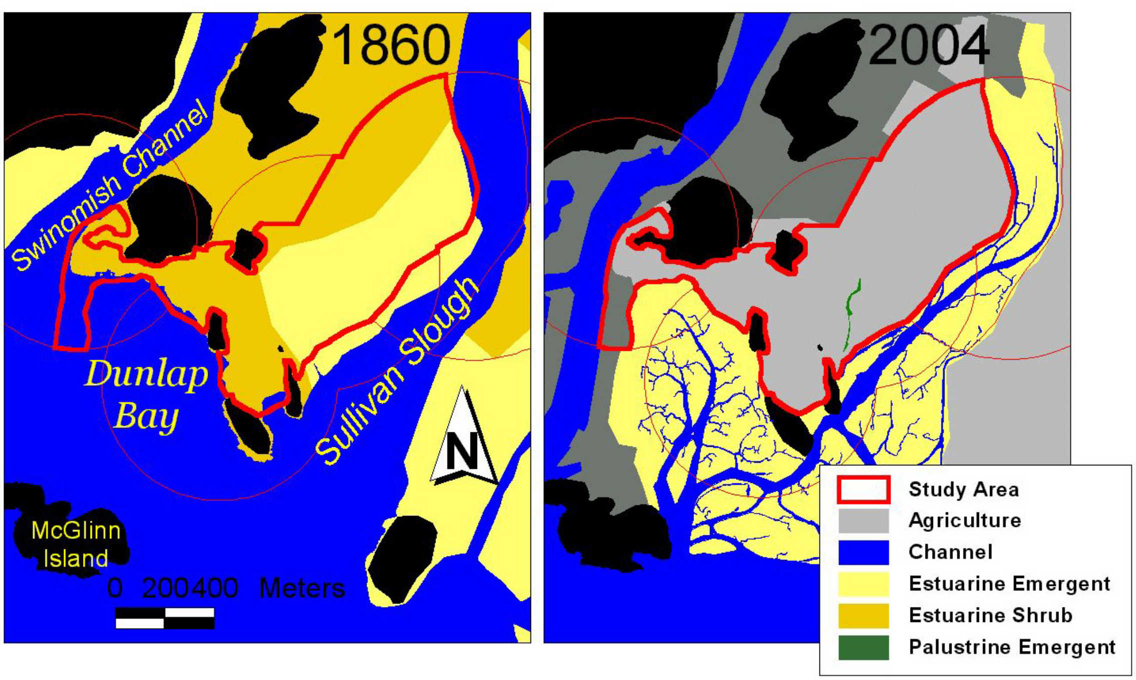


Figure 36. Historical (left) and current (right) vegetation in the La Conner area. Estuarine vegetation is tidally influenced. Palustrine areas are non-tidal wetlands. Note extensive filling of Dunlap Bay and Sullivan Slough from 1860 to 2004, due to causeway and jetty construction (Dunlap Bay) and dike/levee construction eliminating tidal prism and flood flows (Sullivan Slough).



Juvenile salmon (40-110mm fork length) site access (landward of dikes) is currently obstructed by tidegates. Assumed restoration actions included removal of approximately 7,800 ft of dike, construction of 5,100 ft of dike, and relocation of tidegates.

Leque Island

Leque Island is located between Stanwood and Camano Island. If restored it would likely provide important estuarine rearing habitat for both Stillaguamish and Skagit salmonids. Prior to 1870, Leque Island consisted of about 475 acres of salt marsh (Collins 1997). By 1886, diking reduced the salt marsh habitat to 214 acres, and by 1968, only 85 original acres of habitat existed along with 220 new acres formed by accretion.

The island is owned by WDFW, and consists of two management units (Warinner 2004 draft). The Leque Island portion is managed for waterfowl hunting opportunity through the planting of waterfowl-attracting crops such as barley. The Swan Reserve is also managed with grain planting to attract waterfowl, but hunting is not allowed in this area. A project has been recently proposed to remove dikes on the Leque Island management portion, and to reconnect the sloughs associated with the Stillaguamish River.

The study site includes 105 acres in private ownership and 303 acres in public. Three study circles and adjacent public lands were grouped together. High density urban infrastructure and bridge footings were avoided in the following analysis. Site topography is represented by LIDAR in Figure 37.

Historical vegetation was entirely tidal emergent, while current vegetation is entirely agriculture or fallow fields (Figure 38). Restoration of tidal inundation would return the site to 100% tidal emergent vegetation. Current channels landward of dikes amount to 2.6 acres or 1.6 miles of vestigial blind tidal channels and 7.6 acres or 5.0 miles of agricultural drainage channels, of which 2.1 acres or 1.7 miles are on private land. Modeling indicates that restoration of tidal inundation could sustain 29.4 acres or 12 miles of blind tidal channel, of which 4.4 acres or 3 miles are on private land. Blind tidal channels seaward of dikes currently amount to 4.3 acres or 4.2 miles. Modeling indicates that 5.1 acres or 4.4 miles of blind tidal channel could be expected outside the dikes due to increased tidal prism following site restoration.

Juvenile salmon (40-110mm fork length) site access (landward of dikes) is currently obstructed by tidegates. Restoration actions assumed: removal of approximately 25,000 ft of dike, construction of 12,000 ft of dike, and relocation of tidegates.

Figure 37. Topography from LIDAR imagery (left) at the Leque Island site. Potential vegetation, assuming elevation control (right).

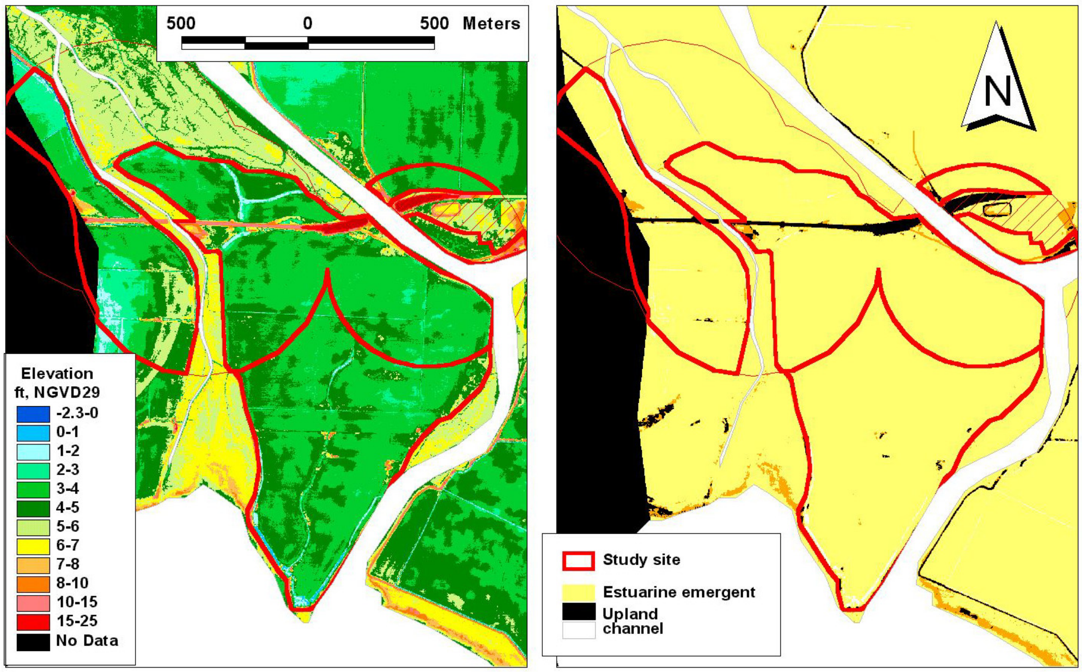
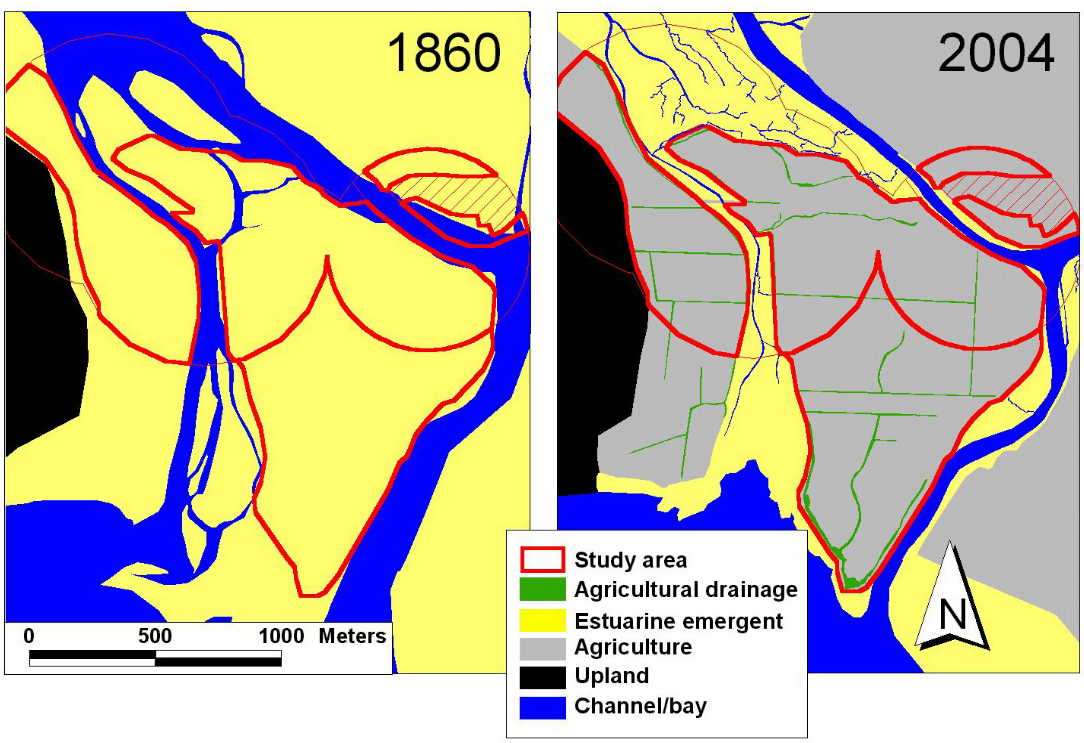


Figure 38. Historical (left) and current (right) vegetation types in the Leque Island site. Estuarine vegetation is tidally influenced. Hatched areas were not considered for restoration.



South Fork Skagit Logyard

This area includes a small piece of public land surrounded by private ownership. It was once a wetland complex but has been diked (Collins 1998). Part of the area is currently owned by the Port of Skagit County and is used as a pole yard. Private ownership within study area includes 36 acres west of Pioneer Highway and 20 acres east of the highway. Another 50 acres, occupied by roads, homes, stores, etc. (i.e., the town of Conway), were considered infeasible for restoration. Bridge footings were also considered a constraint. Public lands include 3.2 acres owned by the Washington State Department of Transportation and 27 acres owned by the Port of Skagit County. Site topography is represented by LIDAR in Figure 39.

Historically, this site consisted entirely of tidal emergent vegetation (Figure 40). Currently the area is 42% agriculture and 58% urban/industrial. LIDAR data is available for only a portion of the site, so precise estimates of potential vegetation are not possible. However, the available LIDAR coverage for on-site and similar nearby areas suggests that restoration could result in a 70:30 mix of tidal shrub and riverine tidal shrub near the river, and a 60:40 mix of tidal shrub and tidal emergent vegetation away from the river on the other side of Pioneer Highway.

Currently a there is tributary channel on private land that amounts to 1 acre or 0.2 miles, within the study area. The former tributary is not currently connected to the South Fork Skagit River. The tributary could be moved south of Conway to reconnect it to the Skagit River at the South Pole Yard via a culvert under the railroad and Pioneer Highway. This would also allow potential for greater restoration further eastwards. This channel realignment could restore 1.6 acres, 0.33 miles of tributary channel within the restoration site. Modeling suggests an additional 0.8 acres or 0.4 miles of blind tidal channel could be restored to the site of which approximately half would be on private land and half on public land. The only channel seaward of the dikes, currently or historically, is the Skagit River South Fork.

Juvenile salmon (40-110mm fork length) site access (landward of dikes) is currently obstructed by tidegates. Restoration actions assumed: removal of approximately 2,240 ft of dike, construction of 8,000 ft of dike, placement of a group of culverts under the railroad and Pioneer Highway and excavation of a channel.

Figure 39. LIDAR topography (left) of the South Fork poleyard. Potential vegetation, assuming elevation control (right). Hatched areas in the heavy semi-circle were not considered feasible for restoration due to the high density of urban infrastructure.

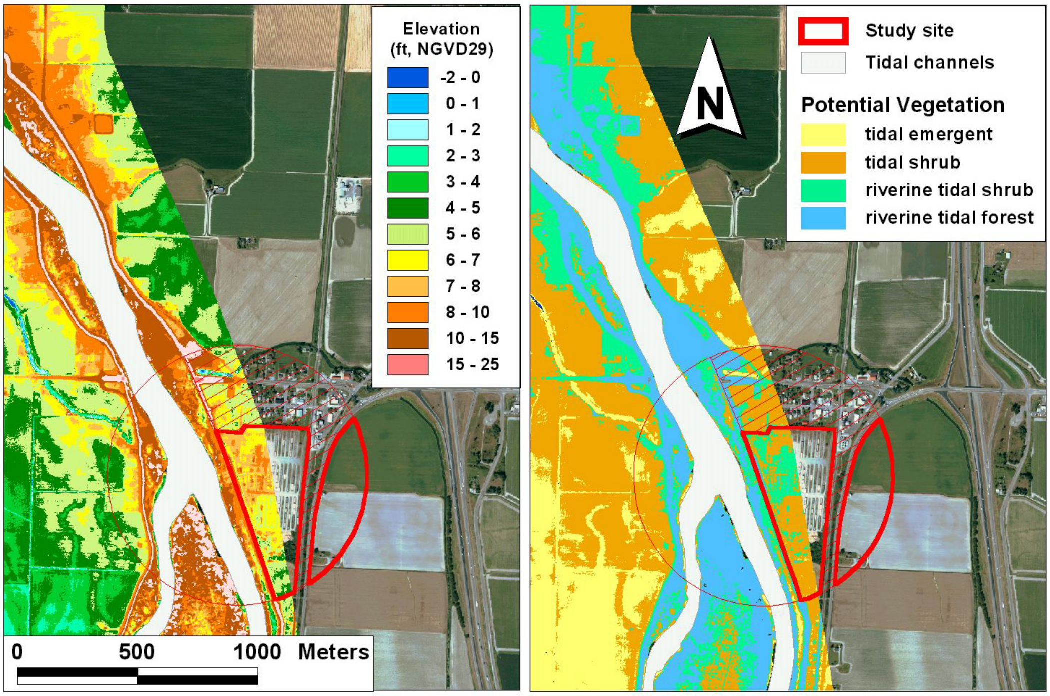
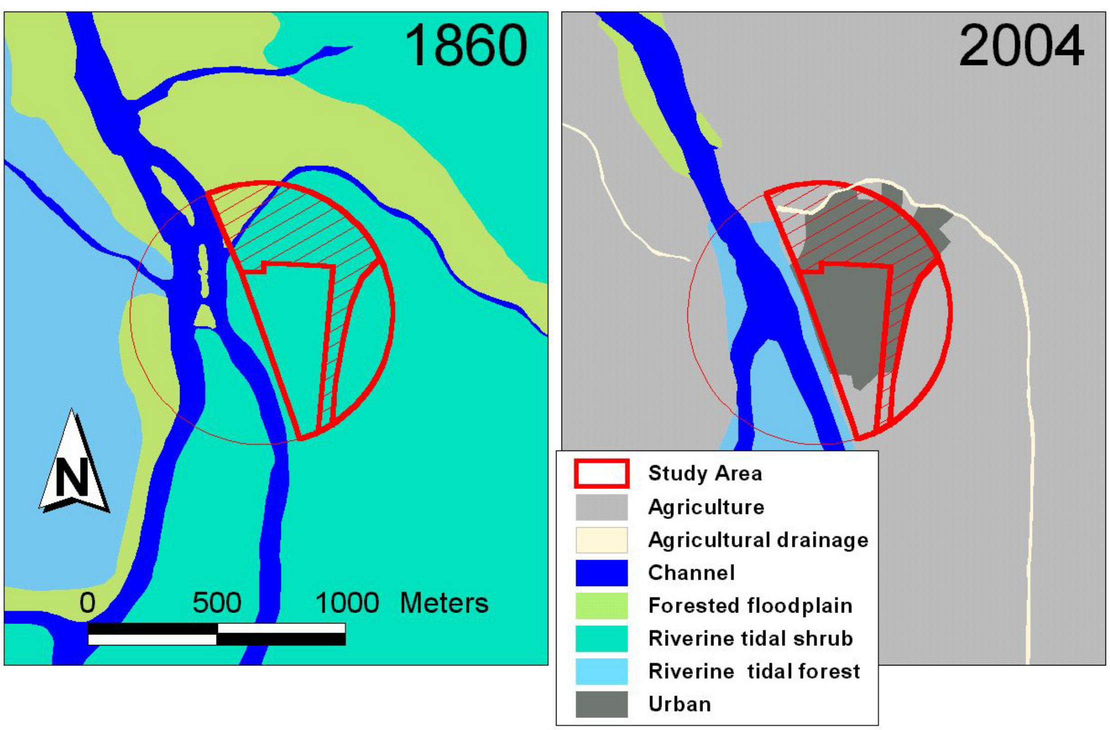


Figure 40. Historical (left) and current (right) vegetation types in the South Fork poleyard.



Discussion

Distributary Restoration

The preceding analysis of possible restoration sites has considered each site independently, in relative isolation from the rest of the landscape. However, the Brown's/Dry Slough site and the Hall Slough site would have significantly greater habitat value if they were also connected to the North Fork Skagit River by the restoration of the historical distributary channels of Hall Slough, Brown's Slough or Dry Slough. Another alternative, to avoid existing infrastructure along these channels, would be to construct an entirely new distributary connection from the North Fork to the restored bayfront marshes across portions of Fir Island that have little infrastructure.

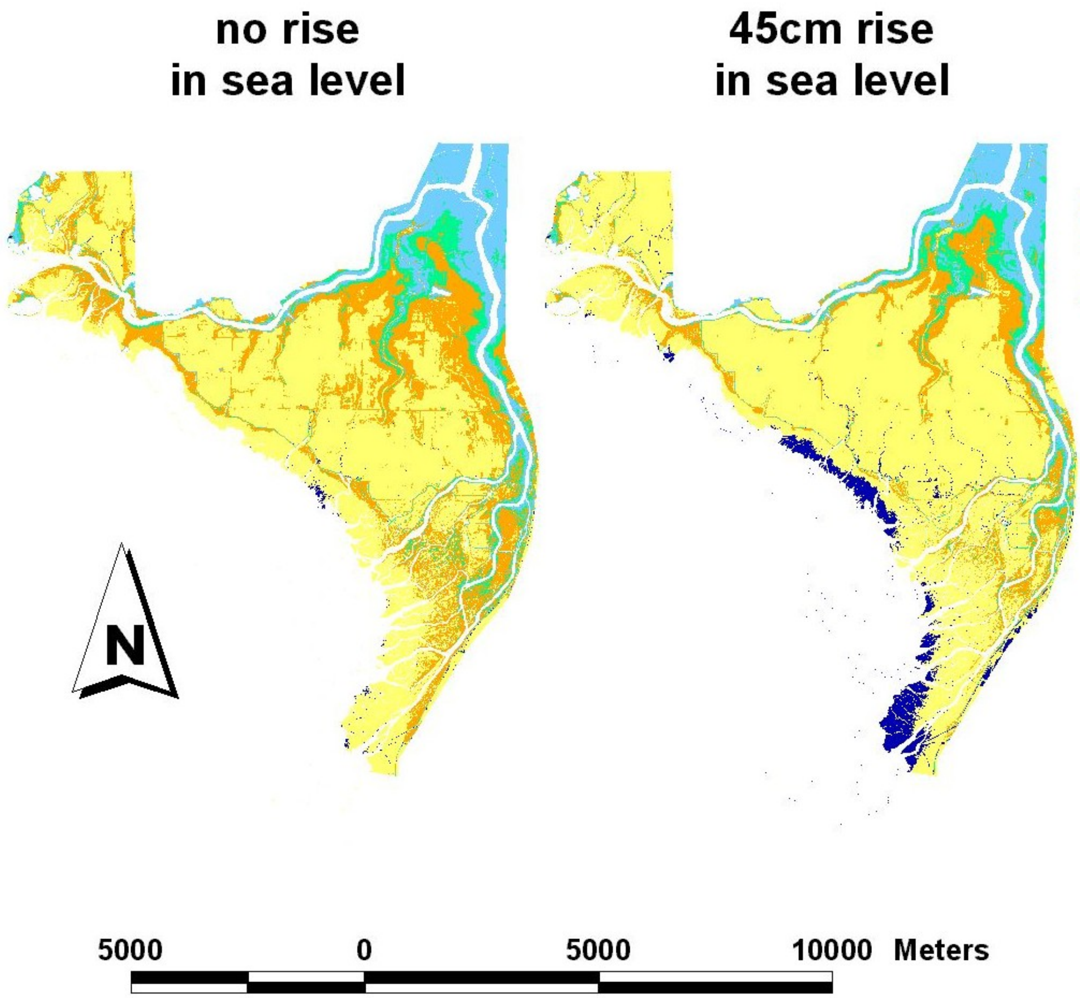
Distributary channel restoration would provide significant delivery of juvenile salmon to the otherwise relatively isolated bayfront marshes. Long-term sampling for juvenile salmon throughout the Skagit tidal marshes has shown that juvenile salmon densities in the bayfront marshes are approximately 1/6 those in marshes connected directly to the South Fork or North Fork of the Skagit River (Beamer et al. 2001). Restoration of the Brown's/Dry Slough or Hall Slough sites without distributary restoration would result in additional but underutilized marsh habitat due to their relative isolation from outmigrating juvenile salmon. In addition to effectively delivering juvenile salmon to the bayfront restoration sites, restored distributaries could themselves also provide additional habitat, depending on the width of the distributary corridor, i.e., the amount of adjacent marsh habitat bordering the distributary channel.

Global Climate Change and Sea Level Rise

The preceding analysis has also assumed static sea level. However, there is a scientific consensus that global climate change will cause sea level to rise. Predictions of the amount of sea-level rise vary greatly and are increasingly imprecise the further they are projected into the future. However, when US EPA estimates for global sea level rise (Titus and Narayanan 1995) are applied to the Puget Sound (Canning 2001) there is at least a 50% chance that sea level will rise by 45 cm (1.5 ft) by 2100. According to other estimates of global sea level rise (IPCC 1995), sea level has a 50% chance of rising by 67 cm (2 ft). Assuming the more conservative estimate nevertheless results in a projection of significant change in marsh vegetation in the Skagit tidal marshes, including a net conversion of approximately 580 acres of tidal marsh to unvegetated sandflats by 2100, i.e., net loss of marsh habitat (Figure 41). Additionally, there is a projected 50% loss in tidal shrub and tidal forest habitats during the next century, primarily through conversion to tidal emergent vegetation. Tidal shrub and tidal forest are both particularly rare habitat types in the Puget Sound.

The predicted effects of sea level rise on Skagit marsh vegetation, presented here, are tentative because they do not include the possible ameliorative effects of sedimentation during this time, although these depend on a high rate of sedimentation and rapid vegetation response. However, this tentative prediction also does not include the likely exacerbating effects of sea level rise on vegetation stress through increased salinity in the marshes, or of increased tidal inundation duration from the decreased tidal asymmetry that might result from sea level rise. These uncertainties indicate that the Skagit estuarine ecosystem is at risk within the relatively near future (i.e., the lifetimes of our children). Habitat restoration can compensate for some of this risk. The more the system is restored the more it can physically and ecologically respond to disturbance, climate change, and other threats to its ecological integrity and sustainability.

Figure 41. Potential native vegetation communities on Fir Island. Dark blue = sandflat, yellow = tidal emergent, orange = tidal scrub-shrub, green = riverine tidal scrub-shrub, light blue = riverine tidal forest (Hood, unpublished).



Literature Cited

Beamer, E., T. J. Beechie, B. Perkowski, J. Klochak. 2004. Restoration of habitat-forming processes: an applied restoration strategy for the Skagit River, Washington. *J. Am Water Resources Assoc.* In Press

Beamer, E., S. Hinton, and W. G. Hood. 2001. Estimation of Fish Benefits for the Brown's-Hall Slough Restoration Feasibility Study Located in the Skagit River Delta. Report prepared for The Skagit Watershed Council, Mt. Vernon, Washington.

Canning, D. J. 2001. Climate variability, climate change, and sea-level rise in Puget Sound: possibilities for the future. Proceedings, Puget Sound Research 2001 Conference, February 12-14, Bellevue, Washington.

Collins, B. D. 1998. Preliminary Assessment of Historic Conditions of the Skagit River in the Fir Island Area: Implications for Salmonid Habitat Restoration. Report prepared for the Skagit System Cooperative, LaConner, Washington.

Collins, B. D. 2000. Mid-19th century stream channels and wetlands interpreted from archival sources for three north Puget Sound estuaries. Report prepared for the Skagit System Cooperative, LaConner, Washington.

Collins, B. D. and D. R. Montgomery. 2001. Importance of Archival and Process Studies to Characterizing Pre-Settlement Riverine Geomorphic Processes and Habitat in the Puget Lowland. pp. 227-243 *IN*: Geomorphic Processes and Riverine Habitat. J.M. Dorara, D. R. Montgomery, B. Palczak and F. Fitzpatrick (eds.). Am. Geophys. Union. Washington, DC.

Ewing, K. 1982. Environmental controls in Pacific Northwest intertidal marsh plant communities. *Can. J. Bot.* 61:1105-16.

Folke, C., S. Carpenter, T. Elmqvist, L. Gunderson, C. S. Holling, B. Walker, J. Bengtsson, F. Berkes, J. Colding, K Danell, M. Falkenmark, L. Gordon, G. Kasperson, N. Kautsky, A. Kinzig, S. Levin, K. Mäler, F. Moberg, L. Ohlsson, P. Olsson, E. Ostrom, W. Reid, J. Rockström, J. Savenije, U. Svedin. 2002. Resilience and Sustainable Development: Building Adaptive Capacity in a World of Transformation. The Environmental Advisory Council to the Swedish Government. Ministry of the Environment, Stockholm, Sweden.

Gross, Spenser B. Fir Island LIDAR Mapping Project. Contractual Flight Report to Skagit System Cooperative, LaConner WA. 2002

Hinton, S. 2004. Milltown Island estuarine habitat restoration proposal to the Salmon Recovery Funding Board. Skagit River System Cooperative, La Conner, Washington through the Skagit Watershed Council.

Holling, C. S. 1973. Resilience and stability of ecological systems. *Annual Review of Ecology and Systematics* 4: 1-23.

Hood, W. G. 2004. Indirect environmental effects of dikes on estuarine tidal channels: thinking outside of the dike for habitat restoration and monitoring. *Estuaries* 27:273-82.

Hood, W. G. 2002. Application of landscape allometry to restoration of tidal channels. *Restoration Ecology* 10:213-222.

Intergovernmental Panel on Climate Change. 1995. The Second Assessment Report of the Intergovernmental Panel on Climate Change, UNEP and WMO. Cambridge University Press, Cambridge, England.

Landres, P, P. Morgan, and F.J. Swanson. 1999. Overview of the use of natural variability concepts in managing ecological systems. *Ecological Applications* 9: 1179-1188.

Moen, M. J. 2002. Fir Community in territorial days. http://www.stumpranchonline.com /skagitjournal/WestCounty/MV-SW/Pre-1900/Fir02-Moen.html.

Ouchi, S. and Matsushita, M. 1992. Measurement of self-affinity on surfaces as a trial application of fractal geometry to landform analysis. *Geomorph.* 5: 115-30.

Pennings, S. C. and R. M. Callaway. 1992. Salt marsh plant zonation: the relative importance of competition and physical factors. *Ecology* 73:681-690.

Phillip Williams & Associates, Ltd., S. R. Hinton, W. G. Hood. 2004. An Assessment of Potential Habitat Restoration Pathways for Fir Island, Washington. Prepared for The Skagit Watershed Council, Mount Vernon, Washington.

Rodriguez-Iturbe, I. and Rinaldo, A. 1997. Fractal River Basins: Chance and Self-Organization. Cambridge University, Cambridge.

Sheldon, D. 1996. Deepwater Slough restoration feasibility analysis. Prepared for the Skagit System Cooperative, La Conner, Washington.

Smith, C. 2003. Salmonid habitat limiting factors in WRIAs 3 and 4, the Skagit Basin. Washington State Conservation Commission, Lacey, Washington.

Snow, A. and S. Vince. 1984. Plant zonation in an Alaskan salt marsh. II. An experimental study of the role of edaphic conditions. *J. Ecology* 72:669-684.

Tetra Tech. 2002. Skagit River flood control project: environmental restoration and mitigation planning. Evaluation area studies. Prepared for the U.S. Army Corps of Engineers, Seattle District. 59 pp.

Titus, J. G. and V. K. Narayanan. 1995. The Probability of Sea Level Rise. EPA 230-R-95-008. US Environmental Protection Agency, Office of Policy, Planning, and Evaluation. Washington, DC, USA.

USACE. 1999. Ecosystem restoration report and environmental assessment. Skagit River, Skagit County, Washington. Seattle District.

USACE. 2004. http://www.nws.usace.army.mil/PublicMenu/Menu.cfm?Sitename=waterres&pagename=skagitsamish.

Warinner, R. 2004 draft. Untitled draft white paper, subject: WDFW owned lands within the Skagit estuary. WDFW, La Conner, WA.

Wu, J. and O. L. Loucks. 1995. From balance of nature to hierarchical patch dynamics: a paradigm shift in ecology. *The Quarterly Review of Biology* 70: 439-466.

Wylie, Curt. 2004. Personal communication. Private citizen and adjacent property owner, Conway, Washington.

Zedler, J., J. C. Callaway, J. S. Desmond, G. Vivian-Smith, G. D. Williams, G. Sullivan, A. E. Brewster, B. K. Bradshaw. 1999. California salt-marsh vegetation: an improved model of spatial pattern. *Ecosystems* 2:19-35.

Appendix A. HB1418 Task Force.

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1418 Assessment Site Prioritization

The 1418 Task Force prioritized assessment sites based upon land ownership, level of infrastructure, and benefit to chinook salmon. The prioritization is based strictly on the boundaries of the designated assessment site areas, which are linked to tidegate locations and limited by the circles drawn for the purpose of this coarse analysis. Actual projects (after further analysis) will likely be different than these boundaries, and could have significantly more or less benefits depending on the project scope. These are coarse and conceptual assessments, and are not a substitute for a full feasibility analysis. The sites were first scored based upon land ownership and infrastructure, then separately ranked by benefit to chinook salmon. Lastly, a combined scatter plot was developed using all criteria. These methods are discussed in greater detail below. To assist this process, Skagit County GIS produced a series of maps that detail infrastructure, zoning, historical channels, historical aerial photos, current aerial photos, and LIDAR where available. These are located in Appendix 2, which are in a separate file on this or website (http://www.scc.wa.gov/programs/tidegates/1418_documents.html).

Prioritization Based upon Land Ownership and Infrastructure:
The sites were sorted by a total score that incorporates land ownership with the level of infrastructure currently present on the assessment site. For land ownership, solely public lands not bounded by private lands are the first priority with a score of 1. Second priority areas are public lands with neighboring private lands. Mixed public/private land ownership results in a third priority, followed lastly by private lands with a score of 4.

Within each of these groups, the sites were secondarily sorted based upon the extent of infrastructure, including flood protection structures and drainage systems on adjacent private lands. Sites with a low level of infrastructure were given a score of 1 for a higher priority. Infrastructure in this category includes tidegates or pump stations, a public building, or a bridge or road that is not significantly used by the public. Sites were deemed as having moderate (score of 2) infrastructure if they had three or fewer residences plus any of the structures in the low category. Sites with multiple residences, roads or bridges of significant public use, or railroads were classified as having high levels of infrastructure and would be prioritized lower with a score of 3. A detailed list of the sites and their known infrastructure is listed below in Table 2, followed by the prioritization results in Table 3. Not all types of infrastructure were evaluated due to a lack of data. In addition, the scores for both ownership and infrastructure were combined, and these results are shown in Table 3.

Table 2. Levels of Known Infrastructure on 1418 Assessment Sites. 1= low level of infrastructure (higher priority). 2= moderate level. 3= high level.

Site Name	Known Infrastructure	Extent of Infrastructure
Milltown	None	1
Deepwater	Farm access bridge	1
Wiley public only lands	Dike/tidegate complex	1
South Fork pole yard public only lands	1 public building	1
Leque public lands only	1 highway bridge that will not be disturbed. 1 public-owned residence.	1
Rawlins Road public only lands	1 tidegate and manmade drainage complex	1
Dry/Brown public only lands	Multiple tidegates and a parking area	1
Dodge Valley	1 residence and a pump station	2
Rawlins Road public/private	1 residence and a dead-end road	2
Wiley public/private	Multiple public-owned cabins	2
Dry/Brown public/private	1 residence. Can restore around home.	2
Leque public/private	2 residences	2
La Conner	3 residences, some road	2
Cross Island Connector	Several road crossings. Neighboring agricultural drainage.	2
South Fork Pole Yard public/private	Pioneer Highway, railroad, multiple buildings	3
Halls Slough	Multiple residences, 1 major road.	3

Table 3. Priorities Based On Ownership and Infrastructure. The lower the score, the higher the priority, such that 1= high priority.

Project Site	Ownership Type	Priority Score based upon Ownership	Infrastructure Priority Score	Total Priority Score (Ownership + Infrastructure)
Milltown Island	Public	1	1	2
Deepwater Slough	Public	1	1	2
South Pole Site public lands only	Public with Adjacent Private Land	2	1	3
Leque Island public lands only	Public with Adjacent Private Land Public	2	1	3
Wylie Slough public lands only	Public with Adjacent Private Land Public	2	1	3
Rawlins Road public lands only	Public with Adjacent Private Land Public	2	1	3
Dry/Brown Slough public lands only	Public with Adjacent Private Land Public	2	1	3
Wylie Slough entire site	Public/Private	3	2	5
Rawlins Road entire site	Public/Private	3	2	5
Dry/Brown Slough entire site	Public/Private	3	2	5
Leque Island entire site	Public/Private	3	2	5
Cross Island connector	Public/Private	3	2	5
South Fork pole yard entire site	Public/Private	3	3	6
Dodge Valley	Private	4	2	6
La Conner	Private	4	2	6
Halls Slough	Private	4	3	7

Prioritization Based upon Benefit to Chinook Salmon:

The assessment sites were prioritized based upon benefits to chinook salmon using data from the SRSC assessment (Hood 2004; see previous chapter). Brian Williams (WDFW) summarized these data (Table 4), and Table 5 and Figure 42 show the ranking of these sites. The sites are ranked based upon two criteria: 1) current habitat area of the North Fork versus the South Fork, and 2) habitat accessibility to juvenile salmon. It should be noted that these sites do not include all potentially available habitat because circles were drawn around tidegates to include 100 acres interior to dikes. It is also assumed that complete restoration would occur at these sites.

The South Fork marshes currently occupy about 3500 acres, the North Fork marshes to about 1100 acres, and the central marshes about 880 acres. This results in more habitat currently existing near the South Fork and implies that marsh habitat is more limited in the North Fork, assuming that both of these areas have equal accessibility for chinook salmon juveniles. Projected habitat gains were weighted by the relative amount of habitat so that areas near the North Fork are multiplied by a factor of 3.2 (3500/1100).

For accessibility, the North and South Fork marshes are equally accessible to chinook juveniles, but chinook density data demonstrate that densities in the central Fir-Island areas are 1/6 the densities associated with the North or South Forks (Beamer et al. 2001). Because of this, central island sites were divided by 6. Central Island sites include the area from Dry Slough through Rawlins Road. The Rawlins Road site was included in the central island grouping because there is a topographical ridge that runs from Craft Island to NE of the North Fork bend and Rawlins Road lies south of this ridge. If the Rawlins Road site is included in the North Fork grouping, its weighted total area will change to 14.72 for the public/private site and 1.6 for the public only site.

Habitat diversity can also be applied as a secondary sort between project sites that have similar scores. This is based upon three vegetation communities. A score of 3 is assigned to sites that will support all three vegetative communities, 2 is assigned to sites that will support 2 types of communities, and a score of 1 to sites that will support 1 type of vegetation community.

Table 6 sorts the sites based upon the presence of a cross-island distributary channel. Because cross-island distributaries would arise from the North Fork, they would benefit mostly North Fork juvenile chinook, thereby making the central marshes an extension of the North Fork marshes. North Fork chinook would redistribute between the North Fork marshes and the central island marshes. This changes the weighting factor to 1.8 (3500/1980), where North Fork and central sites are multiplied by 1.8 to reflect more limited marsh habitat compared to the South Fork. Cross-island distributaries greatly increase the value of the existing and potential future habitat in the central marshes (Figure 43).

Table 4. Summary Data for Benefit to Salmon Data (compiled by Brian Williams, WDFW, and based upon data by Greg Hood, SRSC).

Assessment Site	Habitat Type	Net Gain Totals Public/Private Lands	Net Gain Public Land	Net Gain Private Land
Milltown Island	interior channel	9.5 acres	9.5 acres	0 acres
		9.3 miles	9.3 miles	0 miles
	exterior channel	0 acres	0 acres	0 acres
		0 miles	0 miles	0 miles
	emergent tidal	-148.4 acres	-148.4 acres	0 acres
	scrub/shrub tidal	159.0 acres	159.0 acres	0 acres
	riverine tidal forest	-10.6 acres	-10.6 acres	0 acres
Deepwater Slough	interior channel	12.2 acres	12.2 acres	0 acres
		10 miles	10 miles	0 miles
	exterior channel	0 acres	0 acres	0 acres
		0 miles	0 miles	0 miles
	emergent tidal	157.0 acres	157.0 acres	0 acres
	scrub/shrub tidal	100.5 acres	100.5 acres	0 acres
	riverine tidal forest	15.8 acres	15.8 acres	0 acres
Wiley Slough	interior channel	22.4 acres	19.4 acres	3 acres
		10.4 miles	8 miles	2.4 miles
	exterior channel	23.7 acres	23.7 acres	0 acres
		0 miles	0 miles	0 miles
	emergent tidal	212.4 acres	155.8 acres	56.6 acres
	scrub/shrub tidal	42.5 acres	31.2 acres	11.32 acres
	riverine tidal forest	4.1 acres	3.0 acres	1.1 acres

Assessment Site	Habitat Type	Net Gain Assessment Site Totals Public and Private Lands	Net Gain Public Land	Net Gain Private Land
Dry Slough	Interior channel	42.1 acres	20 acres	22.1 acres
		34.7 miles	16.5 miles	18.2 miles
	Exterior channel	10.2 acres	7.1 acres	3.1 acres
		4.9 miles	3.4 miles	1.5 miles
	emergent tidal	424.9 acres	250.6 acres	174.3 acres
	scrub/shrub tidal	12.1 acres	9.4 acres	2.7 acres
	Riverine tidal forest	0 acres	0 acres	0 acres
Hall Slough	interior channel	5.1 acres	0 acres	5.1 acres
		4.2 miles	0 miles	4.2 miles
	exterior channel	2.3 acres	2.3 acres	0 acres
		.7 miles	.7 miles	0 miles
	emergent tidal	89.6 acres	0 acres	89.6 acres
	scrub/shrub tidal	10.4 acres	0 acres	10.4 acres
	riverine tidal forest	0 acres	0 acres	0 acres
Rawlins Road	interior channel	4.1 acres	0 acres	4.1 acres
		.8 miles	0 miles	.8 miles
	exterior channel	.5 acres	.5 acres	0 acres
		0 miles	0 miles	0 miles
	emergent tidal	114.0 acres	0 acres	114.0 acres
	scrub/shrub tidal	0 acres	0 acres	0 acres
	riverine tidal forest	0 acres	0 acres	0 acres

Assessment Site	Habitat Type	Net Gain Assessment Site Totals Public and Private Lands	Net Gain Public Land	Net Gain Private Land
Dodge Valley	interior channel	5.8 acres	0 acres	5.8 acres
		4.8 miles	0 miles	4.8 miles
	exterior channel	.6 acres	.3 acres	.3 acres
		.8 miles	.4 miles	.4 miles
	emergent tidal	108.1 acres	0 acres	108.1 acres
	scrub/shrub tidal	1.9 acres	0 acres	1.9 acres
	riverine tidal forest	0 acres	0 acres	0 acres
La Conner	interior channel	8.2 acres	0 acres	8.2 acres
		6.8 miles	0 miles	6.8 miles
	exterior channel	0 acres	0 acres	0 acres
		0 miles	0 miles	0 miles
	emergent tidal	175.5 acres	0 acres	175.5 acres
	scrub/shrub tidal	6.2 acres	0 acres	6.2 acres
	riverine tidal forest	13.1 acres	0 acres	13.1 acres
Leque Island	interior channel	29.4 acres	25 acres	4.4 acres
		12 miles	9 miles	3 miles
	exterior channel	.8 acres	.8 acres	0 acres
		.2 miles	.2 miles	0 acres
	emergent tidal	408 acres	303 acres	105 acres
	scrub/shrub tidal	0 acres	0 acres	0 acres
	riverine tidal forest	0 acres	0 acres	0 acres

Assessment Site	Habitat Type	Net Gain Assessment Site Totals Public and Private Lands	Net Gain Public Land	Net Gain Private Land
South Pole Yard	interior channel	2.4 acres	1.2 acres	1.2 acres
		.73 miles	.37 miles	.37 miles
	exterior channel	0 acres	0 acres	0 acres
		0 miles	0 miles	0 miles
	emergent tidal	8.0 acres	~4.0 acres	~4.0 acres
	scrub/shrub tidal	42.0 acres	~21acres	~21.0 acres
	riverine tidal forest	0 acres	0 acres	0 acres
Totals	**interior channel**	**141.2 acres**	**93.5 acres**	**47.7 acres**
		93.7 miles	**58.2 miles`**	**35.5 miles**
	exterior channel	**38.1 acres**	**34.7 acres**	**3.4 acres**
		6.6 miles	**4.7 miles**	**1.9 miles**
	emergent tidal	**1562.7 acres**	**731.6 acres**	**831.1 acres**
	scrub/shrub tidal	**374.6 acres**	**300.1 acres**	**74.5 acres**
	riverine tidal forest	**61.8 acres**	**47.6 acres**	**14.2 acres**
	CHANNEL TOTAL (acres)	**179.3 acres**	**128.2 acres**	**51.1 acres**
	VEGETATION TOTAL (acres)	**1999.1 acres**	**1079.3 acres**	**919.8 acres**
	CHANNEL/ VEGETATION TOTAL (acres)	**2178.4 acres**	**1207.5 acres**	**970.9 acres**

Notes:

1. Channel habitat interior to dikes

a. Using the potential or historic channel area and length data for channel net gain.

b. Assume that the existing interior channels, manmade or historic, are isolated by the existing dikes and tidegates.

c. Many of the existing manmade channels interior to the dikes would be filled under a probable restoration scenario.

d. Assume that the historic channels interior to the dikes and tidegates would be restored through re-introduction of tidal and/or riverine hydrology.

2. Channel habitat exterior to dikes

a. Using potential channel data (area and length) minus existing channel data (area and length) for channel net gain.

3. Vegetation Community

a. Using total acres interior to dikes multiplied by potential % for each vegetation community type (emergent tidal, scrub/shrub tidal, riverine tidal forest).

b. Assumes that all the existing vegetation communities interior to the dikes are isolated from natural processes by the exiting dikes and tidegates.

Table 5. Priorities Based upon Benefit to Salmon.

These are ranked based upon weighted channel area where the North Fork marsh areas are multiplied by a factor of 3.2 to reflect current limited habitat and central marsh areas are divided by 6 based upon lower chinook densities found in central marsh areas (Beamer et al. 2001). Specific channel areas are not available for the Swinomish Channel and cross-island connector. These are not ranked, but are included in the table because of their significant benefit to chinook and because if implemented, these projects will greatly change habitat rankings. See Table 6 for an example.

Rank	Project Site	Location	Habitat Diversity (# of vegetative communities)	Weighted Total Area
	Swinomish Channel Rock jetty			
	Cross Fir-Island Connector			
1	Wiley public/private	SF	3	46.1
2	Wiley public only	SF	3	43.1
3	Leque public/private	SF	1	30.2
4	La Conner	NF	3	26.2
5	Leque public only	SF	1	25.8
6	Dodge	NF	2	20.5
7	Deepwater public only	SF	3	12.2
8	Milltown public only	SF	1	9.5
9	Dry public/private	C	2	8.7
10	Dry public only	C	2	4.5
11	SF Pole Yard public/private	SF	2	2.4
12	Halls	C	2	1.2
13	SF Pole Yard public only	SF	2	1.2
14	Rawlins Rd. public/private	C	1	0.8
15	Rawlins Rd. public only	C	1	0.1

Table 6. Priorities based upon benefit to chinook salmon with a cross-island connector.

Sites associated with the North Fork or central island are multiplied by a factor of 1.8.

Ranking	Site Name	Weighted Total Channel Area
1	Dry public/private	94.1
2	Dry public only	48.8
3	Wiley public/private	46.1
4	Wiley public only	43.1
5	Leque public/private	30.2
6	Leque public only	25.8
7	La Conner	14.8
8	Halls	13.3
9	Deepwater public only	12.2
10	Dodge	11.5
11	Milltown public only	9.5
12	Rawlins Rd. public/private	8.3
13	South Fork Pole Yard	2.4
14	South Fork Pole Yard public only	1.2
15	Rawlins Road public only	0.9

Figure 42. This scatterplot illustrates the site rankings based upon all selected criteria (land ownership, infrastructure, and benefit to chinook salmon).

Projects higher on the graph have a greater benefit to chinook salmon, while projects to the right have a greater ranking based upon land ownership and infrastructure. The best projects that fulfill all criteria are located in the upper right of the graph, while those with the lowest rankings for all criteria are in the lower left of the graph. Graph developed by Dr. Josh Greenberg, Skagit County GIS.

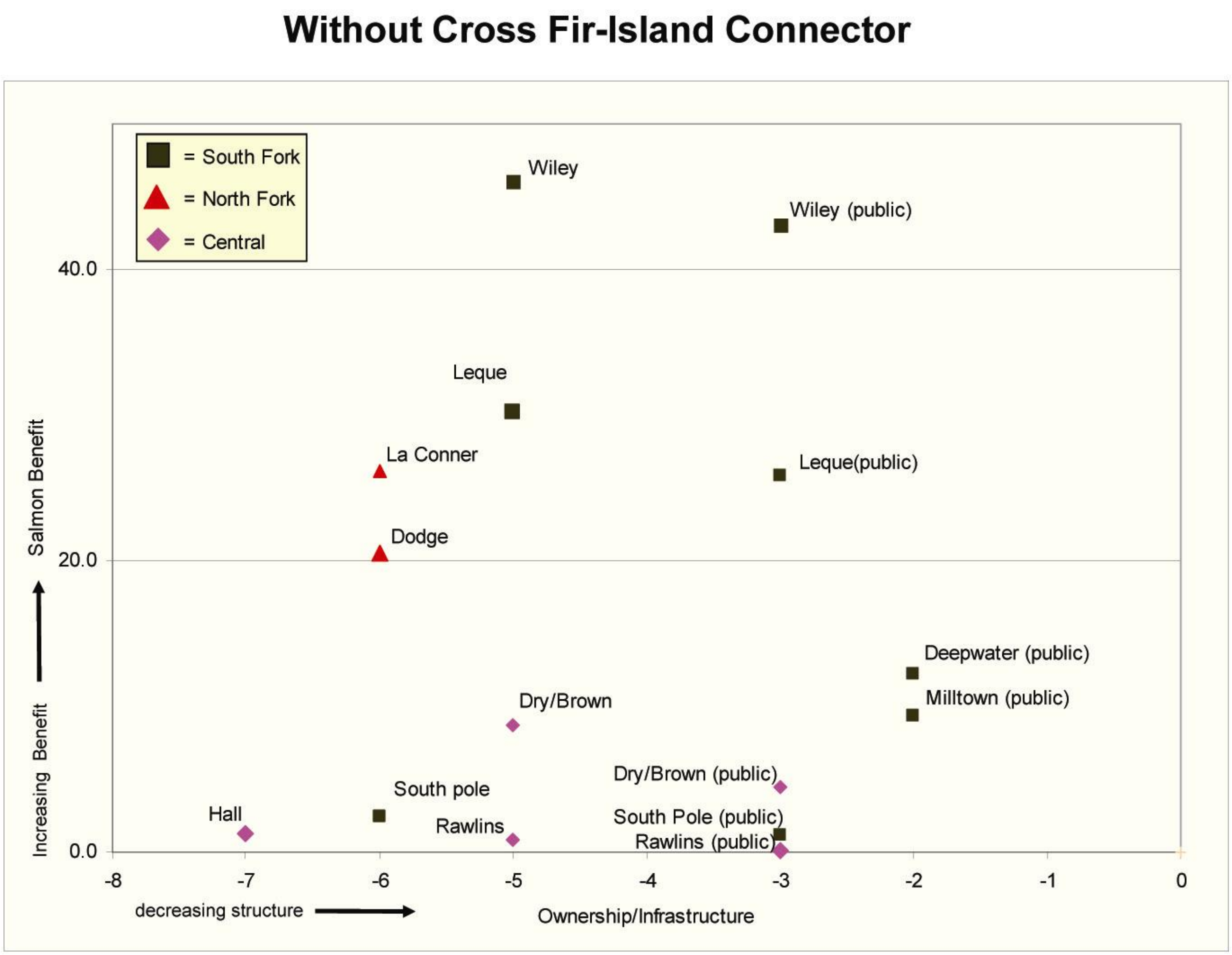
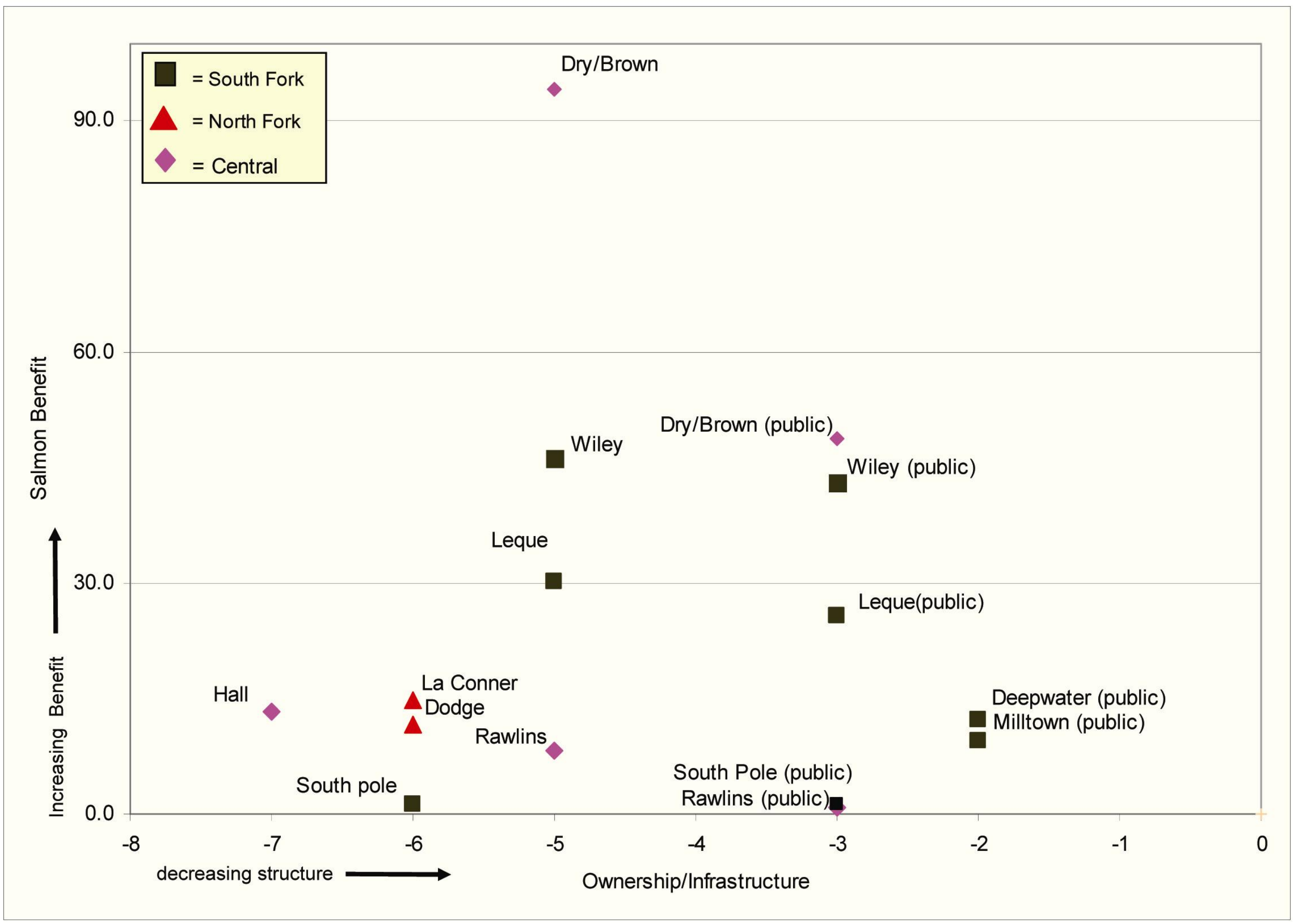


Figure 43. A scatterplot to illustrate the site rankings based upon all selected criteria (land ownership, infrastructure, and benefit to chinook salmon).

Projects higher on the graph have a greater benefit to chinook salmon, while projects to the right have a greater ranking based upon land ownership and infrastructure. The best projects that fulfill all criteria are located in the upper right of the graph, while those with the lowest rankings for all criteria are in the lower left of the graph. This version of the plot shows the changed prioritization if a cross-island distributary channel were constructed. Graph developed by Dr. Josh Greenberg, Skagit County GIS.

With Cross Fir-Island Connector



Findings

The Skagit Basin historically produced the greatest abundance and diversity of wild chinook salmon in Puget Sound. It is recognized by the Limiting Factors Analysis (Smith 2003) that estuarine habitat is one of the limitations to wild Skagit chinook production, especially in years with greater juvenile abundance. Because of this, any estuarine restoration project that benefits wild Skagit chinook salmon will be valuable to the recovery of Puget Sound chinook. Also, the ranking of the projects below are relative to each other. Each one of them can contribute to the recovery of Skagit chinook, and are considered a high priority in the larger picture.

This report is predicated on three basic assumptions: 1) Habitat restoration is voluntary and will require the concurrence and active participation of the landowner; 2) To develop an actual project at any one of the assessment locations in this document a site-specific feasibility and design analysis is necessary; and 3) The integrity of the agricultural drainage infrastructure must be maintained or improved.

Based upon the work of the 1418 Task Force, estuarine projects were ranked by benefit to chinook salmon in combination with land ownership and infrastructure. This results in the following ranked recommendations.

Tier 1 Projects:

1) **Wiley Slough.** Based upon benefit to chinook salmon, both the Wiley private/public and the Wiley Slough public-only sites are the top ranked projects based upon acreage of channel habitat. A design study is underway for the public lands component of Wiley Slough. The 1418 Task Force endorses the Wiley Slough Restoration Design Study as well as its effort to address adjacent drainage issues.

2) **Leque Island.** The assessment sites chosen for Leque Island include a public lands only component and another site that adds private land to the public component. Both projects rated high for benefit to chinook (Table 5), and have low levels of infrastructure (Table 3). The 1418 Task Force views these projects as having a high future restoration potential.

3) **Milltown Island**. Milltown Island ranked in the middle range for benefit to chinook salmon (Table 5) with low levels of infrastructure and no private lands (Table 3), resulting in an overall high priority for restoration. Even though Milltown Island has a lower benefit to chinook, it is ranked higher than Deepwater Slough because Milltown Island has less infrastructure. The Salmon Recovery Funding Board has approved funding for this project. The 1418 Task Force supports these efforts.

4) **Deepwater Slough.** Deepwater Slough has a medium level benefit to chinook (Table 5) salmon coupled with a low level of infrastructure and no private lands component (Table 3). This results in an overall high prioritization. The 1418 Task Force recommends restoration of Deepwater Slough, but it is recognized that issues

regarding competing public access issues and ACOE dike maintenance requirements must be addressed.

Tier 2 Projects:

5) **Dry/Brown Slough.** This area is located in the central Fir-Island area. One assessment site includes only public lands, and the other encompasses nearby private lands. The public/private combination site has a medium benefit to chinook salmon, while the public-lands only site has a lower benefit to chinook value (Table 5). Both have relatively low levels of infrastructure (Table 3). A high quantity of blind channel habitat is expected at this site upon full restoration, and if a cross-island distributary channel is formed to allow improved access to these channels, the benefit to chinook salmon would increase to make this the top individual site for benefit to chinook (Table 6). The private property issue requires that restoration for the private/public combination site must be on a voluntary basis only, and that impacts to neighboring agricultural lands must be fully addressed. At this time, this area has a middle level of priority.

6) **La Conner area and Dodge Slough.** These two areas rated higher than Deepwater Slough and Milltown Island for benefit to chinook salmon (Table 5), but have higher levels of infrastructure and no public lands component (Table 3), resulting in an overall medium priority level. Any restoration actions on private land would need to occur on a voluntary basis between a willing buyer and willing seller. Future actions would need to address any impacts on neighboring agricultural lands.

Tier 3 Projects:

7) **Rawlins Road.** Two different assessment sites were evaluated near Rawlins Road. One includes only public lands, which were located outside the dikes. The other is a combination of private and public lands. The Rawlins Road public lands site has a relatively low benefit to chinook value, but the private/public combination site has a higher value (Table 5). If access issues are addressed at the private/public site, the benefit to chinook would increase to a level similar to Dodge Slough and La Conner. A feasibility study to assess potential restoration alternatives in the Rawlins Road area and beyond has been funded.

8) **South Fork Pole Yard.** The South Fork pole yard site has low benefits to chinook salmon (Table 5) and while a low benefit is better than no benefit, the two assessment areas (public and public/private) near the pole yard should be further investigated after efforts to restore higher priority sites have been completed. In addition, high levels of infrastructure increase the difficulty for restoration at the South Fork pole yard (Table 3).

9) **Halls Slough.** This area has only private landownership and has a high level of infrastructure (Table 3) coupled with a low benefit to chinook salmon (Table 5), resulting in a low overall priority for restoration. Construction of a cross-island

distributary channel would improve the benefit to chinook salmon, but the high level of infrastructure will remain as a difficult issue to overcome.

Other recommendations include baseline monitoring of projects prior to implementation as well as ongoing monitoring after project completion to assess the impact and benefits to neighboring agricultural lands and salmon habitat. Such monitoring shall include assessment of factors that affect saltwater intrusion, drainage capacity, or irrigation (See chapter titled: The Role of Tidegates in Drainage Systems). Continued efforts are encouraged for collaboration between salmon restoration proponents and private landowners. Another recommendation is that WDFW accelerate their search for new opportunities for public use.

Several additional potential projects were not ranked due to a lack of analysis, and time did not permit discussion of all potential projects. However, further work is recommended for the following projects.

- **The Swinomish Channel Rock jetty.** If chinook juvenile access issues are addressed, a significant amount of habitat becomes available to chinook, and the prioritization of individual sites should be changed to include those north of the Swinomish Channel. The Skagit River System Cooperative in cooperation with the U.S.G.S. has received funding by the Salmon Recovery Funding Board (SRFB) to study alternatives to address access issues through the Swinomish Channel due to the rock jetty. This is a high priority issue that precludes access of estuarine habitat north of the Swinomish Channel to most Skagit chinook juveniles. The 1418 Task Force endorses this project to improve access conditions for juvenile chinook salmon, and has written a letter of support for this project.
- **A cross Fir-Island connector.** The 1418 Task Force recognizes that a cross-Fir Island connector would change the ranking of the above recommendations. A connector would improve juvenile chinook access to the central island sites and create additional habitat function. However, private property and agriculture protection issues exist, and because of these issues and the lack of a detailed analysis, no recommendation can be made at this time.
- **Intertidal Salmon Habitat Enhancement Opportunities Lying Outside of Dikes.** Some 1418 Task Force members believe there is considerable opportunity to improve intertidal habitat in areas that lie outside of Fir Island dikes, particularly on Department of Fish and Wildlife property. Many other members of the 1418 task force believe that very little, if any opportunity exists to create additional intertidal channels outside of the existing dikes on Fir Island. In part due to these divergent views, a feasibility study that includes Rawlins Road and other sites was submitted for funding through the Skagit Watershed Council to assess potential projects, while providing additional benefit to chinook salmon. The 1418 Task Force supports the proposed feasibility study, which has been funded by the SRFB.
- **Fisher Slough**. Dikes isolate potential estuarine habitat near Fisher Slough, a tributary to the South Fork Skagit River. A feasibility study proposal to restore this site has been funded. This site was not included in the 1418 assessment sites, but would fulfill the criteria for a potential high priority area for benefit to chinook

salmon because of its location adjacent to the South Fork Skagit River. The 1418 Task Force supports the proposed feasibility study. However, insufficient detail exists at this time regarding the specific actions of this project to determine the level of benefit and how that level would place this project relative to the sites that were assessed.

- **Numerical Chinook Recovery Goals.** The goals of this plan were limited due to a lack of numerical recovery goals for Skagit chinook salmon estuarine habitat. Numerical salmon recovery goals specific to the Skagit basin and linkage to habitat types (especially estuarine habitat) are greatly needed.

Intertidal Salmon Habitat Funding

The alteration of the Skagit delta has occurred over a great number of years using funds from a variety of sources, private, local, state and federal. The following is categorized list of potential sources that could be used to fund salmon intertidal enhancement projects in the Skagit delta. Sources for this information are listed below the table.

Table 7. Potential Funding Sources for Skagit Estuarine Projects.

Grant	Description	Sponsor
Federal Government Funding		
Puget Sound Near Shore Project	This is a joint project between the State of Washington & The Army Corps of Engineers (ACOE) to restore nearshore areas in Puget Sound. Funding would be appropriated by the United States Congress.	
National Fish & Wildlife Foundation	Established by Congress approximately 20 years ago. The foundation is very interested in Skagit Bay. Non-profit organizations, local, state or federal government agencies are eligible to apply for funds for community-based projects that improve and restore native salmon habitat, remove barriers to fish passage, or for the acquisition of land/ conservation easements on private lands where the habitat is critical to salmon species. Proposals should focus on building local partnerships to implement on-the-ground restoration projects. Throughout the year they also provides many types of challenge grants to assist priority fish, wildlife, and plant conservation programs.	National Fish and Wildlife Foundation 1120 Connecticut Avenue, NW, #900 Washington, DC 20036 Kathleen Pickering 202-857-0166 www.nfwf.org Local Office in Portland, Oregon 502-417-8700 extension 21
Direct Federal Appropriation	Funding of this nature is procured by working through the state's Congressional delegation once a specific project has been identified.	

U.S. Fish and Wildlife Service	The U.S. Fish and Wildlife Service has a Small Grants Program offering funds for wetlands projects under $50,000. The North American Wetlands Conservation Act requires that these funds, as well as the dollar-for-dollar non-Federal matching funds, be used only for wetlands acquisition, creation, enhancement, and/or restoration. For details visit northamerican.fws.gov/NAWCA/grants.htm USFWS offers grants for wetlands restoration and acquisition from the National Coastal Wetlands Conservation Grant program. For more information about the National Coastal Wetlands Conservation Grants program write to the National Coastal Wetlands Conservation Grant Program, Division of Habitat Conservation, U.S. Fish and Wildlife Service, 4401 North Fairfax Drive, Room 400, Arlington, Virginia 22203; or visit the program's Internet site at www.fws.gov/cep/cwgcover.html.	U.S. Fish and Wildlife Service 510 Desmond Drive SE, Suite 102 Lacey, WA 98503 www.r1.fws.gov/
U.S. Environmental Protection Agency	Many different types of grants are available. Some include: www.epa.gov/enviroed/grants.html Five Star Restoration Challenge Grants EPA Grants Webpage www.epa.gov/ogd/competition/open_awards.htm EPA Resources for Non profit Organizations www.epa.gov/epahome/nonprof.htm	U.S. Environmental Protection Agency Region 10, 1200 Sixth Avenue Seattle, WA 98101
NOAA Fisheries Community Based Restoration Program	Projects must result directly in on-the-ground habitat restoration, clearly demonstrate significant benefits to marine, estuarine or anadromous fisheries resources, especially sportfish, and must involve community participation through an educational or volunteer component tied to the restoration activities. Funding requests fall within $5,000 to $25,000 and matching funds greatly enhance the merit of the application.	American Sportfishing Association and NOAA F/HC3 1315 East-West Highway Silver Spring, MD 20910 chris.doley@noaa.gov

American Heritage Rivers	American Heritage Rivers / Services www.epa.gov/rivers/services/ This webpage, a link from the American Heritage Rivers EPA webpage, has substantial funding and educational resources for anyone involved in rivers-related environmental work.	
State Level Funding		
Coastal Zone Management (CZM) Grant	Applications located within the 15 coastal counties are eligible. There is a 50% local match.	Department of Ecology PO Box 47600 Olympia, WA 98504 (360) 407-7254 bhue461@ecy.wa.gov
Aquatic Weeds Financial Assistance Program	Provides funding for technical assistance, public education and grants to help control aquatic weeds. Grant projects must address prevention and/or control of freshwater, invasive, non-native aquatic plants.	Washington State Department of Ecology Aquatic Weeds Financial Assistance Program Post Office Box 47600 Olympia, Washington 98504-7600 jrus461@ecy.wa.gov www.ecy.wa.gov/programs/wq/plants/grants/index.html
Washington Sea Grant Program	In the past, funding has been available for research in marine biotechnology, marine products, estuarine studies and nearshore habitat, fisheries and living resources, environmental and resource policy and technology in support of marine resources.	University of Washington Office of Marine Environmental and Resource Programs 3716 Brooklyn Ave NE Seattle, WA 98105 (206) 543-6600 seagrant@u.washington.edu
Washington Wildlife Recreation Program (WWRP)	The WWRP provides funds for the acquisition and development of recreation and conservation lands. WWRP funds are administered by account and category. The Habitat Conservation Account includes critical habitat, natural areas, and urban wildlife categories.	Interagency Committee for Outdoor Recreation 1111 Washington St SE PO Box 40917 Olympia, WA 98504 (360) 902-3000 info@iac.wa.gov

Salmon Habitat Recovery Grant	Established in the late 1990s, the Salmon Recovery Board receives both state and federal dollars. Annually, the Board funds salmon enhancement projects forwarded by lead entities across the state. The Board has already funded numerous projects in the Skagit watershed and will undoubtedly fund more in the future. Applications available at http://www.iac.wa.gov/srfb/grants.asp	Salmon Recovery Funding Board 1111 Washington St SE PO Box 40917 Olympia, WA 98504 (360) 902-2636 Salmon@iac.wa.gov
Aquatic Lands Enhancement Account (ALEA	This account is primarily funded by revenues from the lease of state lands and geoduck revenues. Originally handled by the Department of Natural Resources (DNR), the program is now administered by the Interagency for Outdoor Recreation (IAC). Funding from this source would be requested by a state agency and used on public lands.	
Volunteer and Cooperative Projects Program	The Washington Department of Fish and Wildlife (WDFW) accepts grant applications from individuals and volunteer groups conducting local projects to benefit fish and wildlife. Grants have ranged from $300 to $75,000 in past years to help volunteers pay for materials necessary for projects approved by the agency. Funding cannot be used for wages or benefits. Examples of past projects include habitat restoration, improving access to fish and wildlife areas for disabled people, fish and wildlife research, public education and fish-rearing projects that can benefit the public.	Washington Department of Fish and Wildlife Volunteer and Cooperative Projects Program 600 Capitol Way North Olympia, WA 98501-1091 360-902-2806. wdfw.wa.gov/volunter/volunteer_funding.htm
Local Funding		
Real Estate Excise Tax	CONSERVATION AREAS:RCW 82.46.070 authorizes counties and cities to levy up to 1.0 percent, and can be used only for the acquisition and maintenance of conservation areas. This tax was authorized in 1990 by the legislature, and to-date, has only been implemented by San Juan County.	

<table>
<tr><td>Retail Sales Tax</td><td colspan="2">PUBLIC Facilities: RCW 82 14.370 authorizes rural counties to impose a local sales/use tax of up to 0.08 percent. Eligible counties are those with an average population density of less than 100 residents per square mile. Currently, 31 counties qualify under this definition. The tax receipts may only be used for financing of public facilities. The public facility must be listed as an item in the officially adopted county overall economic development plan, or the economic development section of the county's comprehensive plan. This is not an additional tax for consumers, and it does not change the overall retail sales/use tax rate. Rather, the receipts are credited against the state 6.5 percent tax, and therefore the burden is shifted to the state general fund. Once a county qualifies and the tax has been levied, it may continue for up to 25 years.</td></tr>
<tr><td>Conservation Futures</td><td colspan="2">RCW 84.34.230 authorizes a regular property tax levy of 0.0625 percent for purposes of acquiring conservation futures as well as other rights and interests consistent with RCW 84.34.210 and RCW 84.34.220 (Acquisition of Open Space, Land or Rights). This regular property tax levy is not subject to levy rate lids. Skagit County uses this to acquire development rights on farmland.</td></tr>
<tr><td>Special Levy</td><td colspan="2">Most taxing districts may request additional property taxes from voters of a district pursuant to RCW 84.52. A special voter-approved property tax levy for purposes of tidegates, land acquisition, and other public infrastructure can be deemed needed for intertidal habitat. This proposal is presented in terms of a total dollar amount, and the levy rate is determined by the assessed value of the district. Special levies must be used for bond retirement of capital facilities. Bond levies pay the annual principle and interest required for the term of the bonds. Special levies must be approved by a 60 percent majority of the votes cast. There is no limit on the dollar amount of special levies.</td></tr>
<tr><td colspan="3">Funds from Utilities</td></tr>
<tr><td>Puget Sound Energy</td><td>Gives small grants to organizations within its service territory for environmental, fish and wildlife improvements, conservation, and environmental education projects.</td><td>Puget Sound Energy
P.O. Box 97034
Bellevue, WA 98009-9734
425-462-3779
www.pse.com/community/giving/corporategiving.html</td></tr>
</table>

Seattle City Light	Early Action ESA program. Funds projects and research to recover ESA listed salmonid species.	
Private Funding		
The Brainerd Foundation	The foundation has three environmental programs: Endangered Ecosystems, Toxics and Communities, and Communications and Capacity Building. The foundation's fields of interest are natural resource conservation and protection.	The Brainerd Foundation 1601 Second Ave., Suite 610 Seattle, WA 98101-1541 206.448.0676, info@brainerd.org www.Brainerd.org
The Bullitt Foundation	Gives grants to a variety of environmental projects in the Pacific Northwest. These include projects that leads to the protection and preservation of mountains, forests, rivers, wetlands, coastal areas, soils, and fish and wildlife.	The Bullitt Foundation 1212 Minor Avenue Seattle, WA 98101-2825 Emory Bundy, Program Director 206-343-0807, info@Bullitt.org www.bullitt.org
The Compton Foundation	Grants are awarded for public education, fish habitat, and public policy in natural resource management, with a focus on watershed protection and long-term habitat and ecosystem preservation and restoration. Grants are awarded to incorporated 501(c)(3) organizations only.	The Compton Foundation 545 Middlefield Road, Suite 178 Menlo Park, CA 94025 650-328-0101 www.comptonfoundation.org/

The Conservation Alliance	The alliance is a group of 65 outdoor businesses whose collective contributions support grassroots citizen-action groups and their efforts to protect wild and natural areas. Provides small and large grants to groups working nationally to protect rivers and public land. Possible source for hands-on projects. Call to request application materials.	The Conservation Alliance c/o Recreational Equipment, Inc. 6750 S 228th Street Kent, WA 98032 David Jayo 253-395-5928, djayo@rei.com www.conservationalliance.com/index.m
FishAmerica Foundation	This organization supports small projects designed to enhance fish populations such as habitat enhancement and water quality improvement projects. Applications should be made approximately one year in advance of anticipated need for funding.	FishAmerica Foundation 225 Reinekers Lane, Suite 420 Alexandria, VA 22314 703-519-9691, info@asafishing.org www.asafishing.org/content/conservation/fishamerica/faf_grant.cfm
Harder Foundation	This is a small foundation. It funds environmental action projects in support of habitat protection, especially prime habitat areas facing immediate threats on public lands. It also funds river protection work. A very small portion of the Harder Foundation's grants involve acquisition of natural areas, especially when they are of regional biological significance. Forty percent of their grants in aggregate are made to grantees in the states of Washington and Oregon.	Harder Foundation 401 Broadway Tacoma, WA 98402 Del Langbauer, President 253-593-2121, HARDERFNDN@aol.com
Northwest Fund for the Environment	This group gives grants for environmental purposes, including grants for stewardship programs, action plans, strategic litigation, and capacity building for conservation organizations. It also gives grants for protection of wildlife habitats, water quality, sustainable forestry, and shoreline and wetland environments.	Northwest Fund for the Environment 1904 3rd Ave. Suite 615 Seattle, WA 98101 Fund Administrator 206- 386-7220, staff@nwfund.org www.nwfund.org/

Russell Family Foundation	The foundation is committed to improving protection of the environment in western Washington, with an emphasis on the waters of Puget Sound and awards grants in each of three areas of activity: Puget Sound, Environmental Education and Green Business. Projects must address water quality of Puget Sound; improve public understanding of water quality issues, stewardship and sustainable practices; and increase use of environmentally sustainable services and products.	Russell Family Foundation P.O. Box 2567 Gig Harbor, WA 98335 1-888-252-4331, info@trff.org www.trff.org/home.asp
William C. Kenney Watershed Protection	Focuses on protection of remaining wild rivers of the west. Primarily funds groups based in the community in which they work, with operating budgets less than $500,000, and that are "pragmatic, innovative and produce measurable results." Projects must be place-based campaigns focused on a specific western river or river system or policy development campaigns working on regional or national policies and laws.	William C. Kenney Watershed Protection Foundation 3030 Bridgeway, Suite 204 Sausalito, CA 94965 415-332-1363, grants@kenneyfdn.org www.kenneyfdn.org/

Information Sources:

Stephanie Kaknes, Snohomish County SWM
http://www.co.snohomish.wa.us/publicwk/swm/salmon/grants.htm

King County Funding Sources
for Watershed Stewardship Projects
http://dnr.metrokc.gov/wlr/PI/Fundsrcs.htm#anchor149508

Ed Manary, Conservation Commission
Lacey, Washington

Unresolved Issues

1) **Dugualla Bay.** Despite Dugualla Bay being a documented pocket estuary that is used by Skagit chinook salmon, the 1418 Task Force did not include it in the assessment. Dugualla Bay was not included in the assessment due to possible negative impacts to NAS Whidbey as presented by the Island County Commissioners (see letter in Appendix 3).

Corrections

1) There is mention of the Wiley Slough habitat restoration design study on page 71. This study is ongoing. For up-to-date information please contact the Skagit Watershed Council at skagitws@nwlink.com or 360-419-9326, Brian Williams, Department of Fish and Wildlife at (360) 466-4345 ext. 250 or the Wiley Project website at www.wileyslough.org

2) The description of the feasibility study for the Rawlins Road area in the first paragraph on page 81 should read:

A proposal has been funded by the Salmon Recovery Funding Board to study the feasibility of alternatives for restoring estuary habitat in the western section of Fir Island that extends generally from the Browns/Hall Slough complex on Fir Island westward into public lands administered by the Washington Department of Fish and Wildlife that are outside the bayfront dikes on Fir Island.

Literature Cited

ACOE. 2000. Tide datums. http://www.nwd-wc.usace.army.mil/nws/hh/tides/wi/wi108.htm

Aitkin, J.K., 1998. The importance of estuarine habitats to anadromous salmonids of the Pacific Northwest: A literature review. U.S. Fish and Wildlife Service, Aquatic Resources Division, in cooperation with the U.S. Fish and Wildlife Service, Puget Sound Program.

American Farmland Trust. 1999. Cost of community services Skagit County, Washington. American Farmland Trust, Puyallup, Washington. 36 pp.

Anderson, Wilbur, Shiou Kuo, Douglas Bulthuis. 2000. Benefits of fall-planted cover crops in the Puget Sound row crop production system. Cooperative Extension, Washington State University. EB1900.

Andrews, A. and D. Stuart. 2003. Economic impacts of agriculture in Skagit County, WA. American Farmland Trust, Puyallup, Washington. 31 pp.

Beamer, E. M. and R.G. LaRock. 1998. Fish use and water quality associated with a levee crossing the tidally influenced portion of Browns Slough, Skagit River Estuary, Washington. Skagit System Cooperative, La Conner, Washington. Prepared for: Skagit County Diking District No. 22. 47 pp.

Beamer, E. M., J.C. Satori, and K.A. Larson. 2000. Skagit chinook life history study: progress report number 3. Non-Flow Coordination Committee (FERC Project 553), Skagit System Cooperative, La Conner, Washington.

Beamer, E.R., T. Beechie, B. Perkowski, and J. Klochak. 2001. Application of the Skagit Watershed Council's Strategy. River basin analysis of the Skagit and Samish Basins: Tools for salmon habitat restoration and protection. Skagit Watershed Council. Mount Vernon, Washington. 86 pp.

Beamer, E. R. Henderson, and K. Larsen. 2002a. Moving towards a more complete understanding of Skagit chinook production. Presentation made May 15, 2002 for the Salmon Habitat Modeling in the Puget Sound Basin workshop (Ray Hilborn, Mary Ruckleshaus, and Jeff Richey, instructors). University of Washington. Seattle, Washington.

Beamer, E., R. Henderson, and K. Larsen. 2002b. Evidence of an estuarine habitat constraint on the production of wild Skagit chinook. Presentation at Western Division AFS Meeting in Spokane April 29-May1, 2002. Skagit System Cooperative. La Conner, Washington.

Beamer, E. R. 2003. Chinook salmon use of the Skagit estuary. Presented at: Where the River Meets the Sound: A Salmon's Perspective. SIRC Seminar, Silvana, Washington. Summary can be found at: http://www.co.snohomish.wa.us/publicwk/swm/salmon/stillyplan/workshops/estuary013003.htm

Beechie, T.J., B.D. Collins, and G.R. Pess. 2001. Holocene and recent geomorphic processes, land use, and salmonid habitat in two North Puget Sound River Basins. *In:* Geomorphic Processes and Riverine Habitat (Dorava, J.M., D.R. Montgomery, B.B. Palcsak, F.A. Fitzpatrick, eds.). Water Science and Application Volume 4, pp.37-54.

Belle W. Baruch Institute for Marine and Coastal Sciences. 2002. Padilla Bay. http://inlet.geol.sc.edu/PDB/index.html

Berry, H.D., J.R. Harper, T.F. Mumford, Jr., B.E. Bookheim, A.T. Sewell, and L.J. Tamayo. 2001. The Washington State Shore Zone Inventory User's Manual. Nearshore Habitat Program, Washington State Department of Natural Resources. Olympia, Washington.

Bortleson, G.C., M.J. Chrzastowski, and A.K. Helgerson. 1980. Historical changes of shoreline and wetland at eleven major deltas in the Puget Sound Region, Washington. U.S. Dept. of the Interior, Geological Survey.

Clarke, W.C., J.E. Shelbourn, T. Ogasawara, and T. Hirano. 1989. Effect of initial daylength on growth, seawater adaptability, and plasma growth hormone levels in underyearling coho, chinook, and chum salmon. Aquaculture, 82: 51-62.

Collins, B.D. and D.R. Montgomery. 2001. Importance of archival and process studies to characterizing pre-settlement riverine geomorphic processes and habitat in the Puget lowland. *In*: Geomorphic Processes and Riverine Habitat (Dorava, J.M., D.R. Montgomery, B.B. Palcsak, and F.A. Fitzpatrick, eds.). Water Science and Application Volume 4, pp. 227-243.

Cornwell, T.J., D.L. Bottom, and K.K. Jones. 2001. Rearing of juvenile salmon in recovering wetlands of the Salmon River estuary. Oregon Dept. of Fish and Wildlife, Information Reports 2001-2005, Portland, Oregon. 42 pp.

Cutler, J. 2001. Salmon habitat limiting factors anadromous and resident salmonid distribution water resource inventory areas 3 and 4 Skagit and Samish Watersheds. Washington State Conservation Commission. Olympia, Washington.

Department of Ecology (DOE). 2002. Aquatic noxious weed control NPDES general permit. Washington Department of Ecology. Olympia, Washington. http://www.ecy.gov/programs/final.pesticides/noxious/spartina_coverages.html.

Dragovich, J.D., L.A. Gilbertson, D.K. Norman, G. Anderson, G.T. Petro. 2002. Geologic Map of the Utsalady and Conway 7.5-minute Quadrangles, Skagit, Snohomish, and Island Counties, Washington. Department of Natural Resources Division of Geology and Earth Resources, Olympia, Washington.

Entranco. 1993. Lower Skagit River Basin water quality study. Final report November 1993. For: Skagit County Dept. of Planning and Community Development and Washington Dept. of Ecology. Bellevue, Washington. 75 pp.

Evans, R.O. and N.R. Fausey. 1999. Effects of inadequate drainage on crop growth and yield. In: R.W. Skaggs and J. Van Schilfgaarde (eds.) Agricultural Drainage. Number 38 in the series Agronomy. Published by the American Society of Agronomy, Inc., Crop Science Society of America, Inc., and Soil Science Society of America, Inc. Madison, Wisconsin.

Gilliam, J.W., J.L. Baker, and K.R. Reddy. 1999. Water quality effects of drainage in humid regions. In: R.W. Skaggs and J. Van Schilfgaarde (eds.) Agricultural Drainage. Number 38 in the series Agronomy. Published by the American Society of Agronomy, Inc., Crop Science Society of America, Inc., and Soil Science Society of America, Inc. Madison, Wisconsin.

Groot C. and L. Margolis (editors). 1991. Pacific salmon life histories. UBC Press Vancouver, British Columbia.

Hayman, R., E. Beamer, R. McClure. 1996. FY 1995 Skagit River chinook research. Skagit System Cooperative chinook restoration research progress report #1, NWIFC Contract #3311 for FY 1995. Skagit System Cooperative, La Conner, Washington.

Healy, M.C. 1980. Utilization of the Nanaimo River estuary by juvenile chinook salmon, *Oncorhynchus tshawytscha*. Fish. Bull. 77:653-668.

Healy, M.C. 1982. Juvenile Pacific salmon in estuaries: the life support system, pp. 315-341. In: V.S. Kennedy (editor) Estuarine Comparisons. Academic Press, New York, New York.

Healy, M.C. 1991. Life history of chinook salmon (*Oncorhynchus tshawytscha*). In: Groot C. and L. Margolis (editors). Pacific Salmon Life Histories. UBC Press Vancouver, British Columbia. pp. 311-394.

Healy, M.C. and A. Prince. 1995. Scales of variation in life history tactics of Pacific salmon and the conservation of phenotype and genotype. In: J.L. Nielsen (ed.). Evolution and the Aquatic Ecosystem: Defining Unique Units in Population Conservation. American Fisheries Society Symposium 17:176-184.

Heard, W.R. 1991. Life history of pink salmon (*Oncorhynchus gorbuscha*). In: Groot C. and L. Margolis (editors). Pacific Salmon Life Histories. UBC Press Vancouver, British Columbia. pp. 119-230.

Hoffman, G.J. and D.S. Durnford. 1999. Drainage design for salinity control. In: R.W. Skaggs and J. Van Schilfgaarde (eds.) Agricultural Drainage. Number 38 in the series Agronomy. Published by the American Society of Agronomy, Inc., Crop Science Society of America, Inc., and Soil Science Society of America, Inc. Madison, Wisconsin.

Hood, W. G. 2004. Indirect environmental effects of dikes on estuarine tidal channels: thinking outside of the dike for habitat restoration and monitoring. Estuaries Vol. 27 No. 2. pp. 273-282.

Kistritz R. 1996. Why wetlands #3? Because they provide fish habitat. British Columbia Wetlands Society Newsletter 96-01. Delta, British Columbia.

Kjelson, M.A., P.F. Raquel, and F.W. Fisher. 1982. Life history of fall-run juvenile chinook salmon, *Oncorhynchus tshawytscha*, in the Sacramento-San Joaquin estuary, California. Pp. 393-411. In: V.S. Kennedy (editor), Estuarine Comparisons. Academic Press, New York, New York.

Levings, C.D. 1982. Short term use of a low tide refuge in a sandflat by juvenile chinook, *Oncorhynchus tshawytscha*, Fraser River estuary. Can. Tech. Rep. Fish, Aquat. Sci. 1111:33.

Levings, C.D., C.D. McAllister, and B.D. Chang. 1986. Differential use of the Campbell River estuary, BC, by wild and hatchery-reared juvenile chinook salmon (*Oncorhynchus tshawytscha*). Can. J. Fish, Aquat. Sci. 43: 1386-1397.

Levings, C.D., C.D. McAllister, J.S. Macdonald, T.J. Brown, M.S. Kotyk, and B.A. Kask. 1989. Chinook salmon (*Oncorhynchus tshawytscha*) and estuarine habitat: a transfer experiment can help evaluate estuary dependency. Pp. 116-122 *In:* Proceedings of the National Workshop on Effects of Habitat Alteration on Salmonid Stocks (C.D.Levings, L.B.Holtby, and M.A.Henderson, eds.). Can. Spec. Publ. Fish. Aquat. Sci. 105.

Levy, D.A. and T.G. Northcote. 1981. The distribution and abundance of juvenile salmon in marsh habitats of the Fraser River estuary. Westwater Res. Cent. Univ. British Columbia Tech. Report. 25:117.

Levy, D.A. and T. G. Northcote. 1982. Juvenile salmon residency in a marsh area of the Fraser River estuary. Can. J. Fish. Aquat. Sci. 39:270-276.

Lunetta, R.S., B.L. Cosentino, D.R. Montgomery, E.M. Beamer, and T.J. Beechie. 1997. GIS-Based evaluation of salmon habitat in the Pacific Northwest. Photogrammetric Engineering & Remote Sensing. Vol. 63, No. 10, pp.1219-1229.

Maas, E.V. and S.R. Grattan. 1999. Crop yields as affected by salinity. In: R.W. Skaggs and J. Van Schilfgaarde (eds.) Agricultural Drainage. Number 38 in the series Agronomy. Published by the American Society of Agronomy, Inc., Crop Science Society of America, Inc., and Soil Science Society of America, Inc. Madison, Wisconsin.

Nouffke, A. and E.R. Beamer. 2001. Skagit Bay nearshore habitat characterization. Skagit System Cooperative, Report to Seattle City Light, Seattle, Washington.

Philip Williams & Associates, Ltd., S.R. Hinton, and G. Hood. 2003. An assessment of potential habitat restoration pathways for Fir Island, WA. Prepared for the Skagit Watershed Council. Mount Vernon, Washington. 64 pp.

Phinney, D. and Williams. 1975. A catalog of Washington streams and salmon utilization. Vol. 1 Puget Sound. Washington Department of Fisheries. Olympia, Washington.

Pickett, P. 1997. Lower Skagit River Total Maximum Daily Load Water Quality Study. Washington Department of Ecology. Olympia, Washington. Publication 97-326A.

Puget Sound Water Quality Action Team. 2000. Puget Sound's Health 2000. Olympia, Washington.

Reimers, P.E. 1973. The length of residence of juvenile chinook salmon in the Sixes River, Oregon. Fish Commission of Oregon Research Reports 4(2) 1-43.

Rhodes. 1999. Use of saline drainage water for irrigation. In: R.W. Skaggs and J. Van Schilfgaarde (eds.) Agricultural Drainage. Number 38 in the series Agronomy. Published by the American Society of Agronomy, Inc., Crop Science Society of America, Inc., and Soil Science Society of America, Inc. Madison, Wisconsin.

Rice, C., E. Beamer, D. Lomax, R. Henderson, G. Pess. 2003. Distribution and abundance of hatchery and wild juvenile chinook salmon in nearshore waters of Skagit Bay, Puget Sound, Washington. Presented in Salmon Habitat and Population Studies for the Puget Sound Action Team.

Riggs, S. 1999. Skagit topics: 19th century diking in lower delta. Skagit County Historical Museum video tape, Mount Vernon, Washington.

Robinson, M. and D.W. Rycroft. 1999. The impact of drainage on streamflow. In: R.W. Skaggs and J. Van Schilfgaarde (eds.) Agricultural Drainage. Number 38 in the series Agronomy. Published by the American Society of Agronomy, Inc., Crop

Science Society of America, Inc., and Soil Science Society of America, Inc. Madison, Wisconsin.

Simenstad, C.A. 2001. The relationship of estuarine primary and secondary productivity to salmonid production: bottleneck or window of opportunity? NOAA-NMFS-NWFSC Publication TM-29: Estuarine and Ocean Survival of Northeastern Pacific Salmon.

Shreffler, D.K. and R. Thom. 1993. Restoration of urban estuaries: new approaches for site location and design. Prepared for Washington Dept. of Natural Resources. Olympia, Washington. 107 pp.

Simenstad, C.A., W.J. Kinney, S.S. Parker, E.O. Salo, J.R. Cordell, and H. Buechner. 1980. Prey community structure and trophic ecology of outmigrating juvenile chum and pink salmon in Hood Canal, Washington: a synthesis of three years' studies, 1977-1979. Fisheries Research Institute, University of Washington. Seattle, Washington.

Simenstad, C.A. and E.O. Salo. 1982. Foraging success as a determinant of estuarine and near-shore carrying capacity of juvenile chum salmon (*Oncorhynchus keta*) in Hood Canal, Washington. Pages 21-37 *in:* Proceedings of the North Pacific Aquaculture Symposium (B.R. Meltreff and .A. Neve, editors). Alaska Sea Grant Rep. 82-2.

Simenstad, C.A., K.L. Fresh, and E.O. Salo. 1982. The role of Puget Sound and Washington coastal estuaries in the life history of Pacific salmon: An unappreciated function. *In* Kennedy, V.S. (ed.), Estuarine comparisons, p. 343-364. Academic Press, New York.

Smith, C. 2003. Salmonid habitat limiting factors in WRIAs 3 and 4 the Skagit Basin. Washington State Conservation Commission, Lacey, Washington.

Soil Conservation Service. 1960. Soil Survey Skagit County Washington. United States Department of Agriculture, Soil Conservation Service. In cooperation with Washington Agricultural Experiment Station.

Soil Conservation Service. 1981. Soil Survey of Skagit County, Washington. United States Department of Agriculture, Soil Conservation Service. In cooperation with Washington State Department of Natural Resources and Washington State University, Agricultural Research Center.

Van Schilfgaarde, J. (ed.). 1974. Drainage for Agriculture. Number 17 in the series Agronomy. Published by the American Society of Agronomy, Inc., Crop Science Society of America, Inc., and Soil Science Society of America, Inc. Madison, Wisconsin.

Wilkosz, M. 2000. Salmon and steelhead habitat limiting factors in Island County. Washington Conservation Commission Olympia, Washington.

Williams, G.D., and Thom, R., 2000. White Paper: Development of Guidelines for Aquatic Habitat Protection and Restoration – Marine and Estuarine Shoreline Modification Issues (Review Draft). Prepared for the Washington State Department of Transportation, the Washington Department of Fish and Wildlife, and the Washington Department of Ecology. Olympia, Washington.

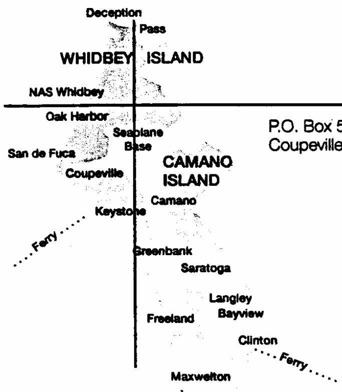
Wissmar, R.C. and C.A. Simenstad. 1998. Variability of estuarine and riverine ecosystem productivity for supporting Pacific salmon. Chapter 6. Pages 253-301 *in* G.R. McMurray and R.J. Bailey (eds.), Change in Pacific Northwest Coastal Ecosystems. Proceedings of the Pacific Northwest Coastal Ecosystems Regional Study Workshop, August 13-14, 1996, Troutdale, Oregon. NOAA Coastal Ocean Program, Decision Analysis Series No. 11. NOAA Coastal Ocean Office, Silver Spring, MD. 342 pp.

Yates, S. 2001. Effects of Swinomish Channel jetty and causeway on outmigrating chinook salmon (*Oncorhynchus tshawytscha*) from the Skagit River Washington. Master of Science Thesis, Western Washington University, Bellingham, Washington. 65 pp.

Appendices 1 and 2

See separate files on this CD or website (http://www.scc.wa.gov/programs/tidegates/1418_documents.html).

Appendix 3
Letter from Island County regarding Dugualla Bay restoration.



Island County Board of Commissioners

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May 5, 2004

Ron Shultz
Chairman, HB 1418 Task Force Committee
Policy Division, Office of Financial Management
P. O. Box 43113
Olympia, WA 98504-3113

RE: Island County Commissioner Staff Session 4-21-04
HB 1418 Task Force Committee
Dugualla Bay Dike

Dear Chairman Shultz:

We would like to begin by thanking you, Mr. Roehl and Mr. Manary for attending our Staff Session and discussing the Task Force issues relating to the Dugualla Bay Dike.

As stated on April 21st, the Board of Island County Commissioners strongly objects to an assessment being performed in relationship with the Dugualla Bay Dike. Island County has raised numerous issues that in our opinion preclude this area from being a viable area for intertidal salmon habitat enhancement. Modification or breaching of the Dike would cause severe impacts to adjacent property owners and the citizens of Island County and the State of Washington.

Below is a summary of issues raised substantiating our position:

- Substantial flooding of productive farm lands
- Strong opposition from landowners
- Flooding of Dike Road
- Probable flooding of the State Highway (Certainly there would be a need to armor the highway.)
- Cause the Navy to replace their drainage system.

- Even with new drainage flooding it will be more difficult to prevent flooding of the Navy runway.

- Most of all creating more upland critical areas will increase the number of birds in the area which will significantly endanger the lives of our Navy Pilots due to "bird strikes".

- If the assessment is done on the schedule outlined it will be done in the worst possible timeframe due to the BRAC Commission timeline. Other communities would likely use this assessment as a tool to convince BRAC that Naval Air Station Whidbey Island is not a good long term base due to the encroachment described above.

- Protecting Navy interests is a top priority of the Board of Island County Commissioners and a requirement of recent legislation signed by the Governor. If Naval Air Station Whidbey Island were to close it would result in over ten thousand lost jobs at NAS Whidbey along with an untold number of jobs in the local community, resulting in a loss of at least 434.6 million dollars in direct military funds to Island County. Forty-seven percent of all personal earnings in Island County can be attributed to military payroll.

For the reasons briefly listed above the Board of Island County Commissioners adamantly opposes Task Force authorization of an assessment and would ask that the Dugualla Bay Dike not be included in an assessment. Both local governments and the United States Navy are aware of the severe impacts that would take place in the event the Dike is breached or modified in a manner to allow salt water to back up behind the Dike. They have been working in good faith with the appropriate agencies to study Crescent Harbor and Maylor's Marsh as alternative sites for salmon habitat restoration.

Again we thank you for your time and consideration on this. If we can be of any assistance please feel free to contact us or Phil Bakke our Planning and Community Development Director.

BOARD OF COUNTY COMMISSIONERS OF
ISLAND COUNTY, WASHINGTON

William J. Byrd, Chairman

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WJB:ph:em

cc: Honorable Governor Locke
Honorable Mary Margaret Haugen, Senator
Honorable Barry Sehlin, Representative
Honorable Barbara Bailey, Representative
Honorable Mayor Cohen
Phil Bakke, Director, Planning & Community Development
Bill Oakes, Director, Public Works Department