

Fir Island Farm Restoration

Final Monitoring and Adaptive Management Plan



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Prepared by Washington State Department of Fish and Wildlife

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1.0 INTRODUCTION

Written by Brian Williams, Washington Department of Fish and Wildlife

The Washington Department of Fish and Wildlife (WDFW) will set back 5,800 lineal feet of existing coastal flood dike and associated tidegates to restore the natural tidal prism of Skagit Bay to 131 acres of WDFW's 250 acre Fir Island Farm. Approximately 126 acres of tidal marsh habitat and 5 acres of tidal channel habitat will be restored within the restoration footprint. As a result of the restored tidal prism, an additional 12 acres of tidal channel habitat is expected to be restored in the existing adjacent tidal marsh. The Fir Island Farm Estuary Restoration Project (Project) is expected to provide additional rearing capacity for an estimated 65,000 juvenile Chinook smolts annually. The Project is designed to maintain snow goose management, public access, and agriculture capabilities at the farm. Drainage, flood and salt intrusion protection for the remaining and neighboring farmland will be also maintained.

The Fir Island Farm Monitoring and Adaptive Management Plan (Plan) is designed to address the inherent uncertainty and risks associated with a large scale estuary restoration project. This Plan is designed to assist WDFW with evaluating the effectiveness of the restoration actions relative to the regulatory, agriculture and ecological objectives of the project.

WDFW is both the project proponent and the landowner. This Plan considers both of these roles. As the project proponent, WDFW recognizes the importance of monitoring the ecological effectiveness of the Project. As the landowner, WDFW also recognizes our regulatory responsibility to control invasive species on our lands and our financial liabilities associated with the Project's ability to successfully achieve the agriculture flood, drainage and salt protection objectives. From the perspective of both project proponent and landowner, WDFW has prioritized the monitoring objectives in the following descending order of priority: regulatory requirements, agriculture objectives, ecological objectives. Given that the restored tidal processes at the project site will be so significant and dominant, with the exception of adjustments to the marsh vegetation, there are very few ecological adaptive management actions that are practical or cost effective. Consequently, adaptive management is only recommended for the invasive species regulatory objective, the agriculture objectives and one ecological objective (lesser cattail management).

2.0 RESTORATION PROJECT DESCRIPTION

Written by Brian Williams, Washington Department of Fish and Wildlife

2.1 Project location

The Fir Island Farm Estuary Restoration Project (Project) is located in Skagit County, Washington, and is part of the Greater Skagit Delta landscape (Figure 1). The Project is located on WDFW's 258-acre Fir Island Farm property (Figure 2), which is located on Fir Island between the North Fork and South Fork of the Skagit River. WDFW's Fir Island Farm is bordered by Skagit Bay to the southwest, Brown Slough to the north and west, Fir Island Road to the north, and Dry Slough to the east and southeast.

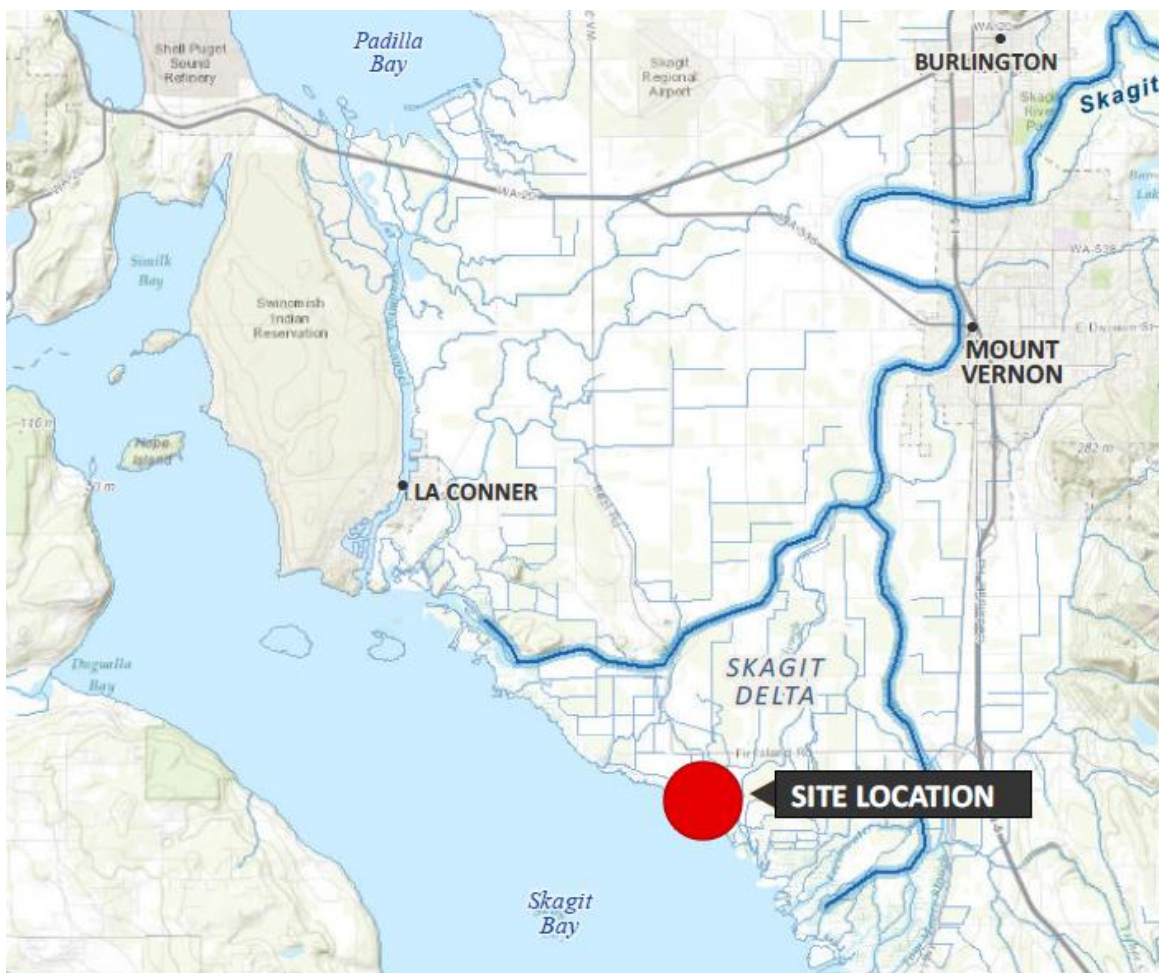


Figure 1. Location of the Fir Island Farm project site within the Skagit River delta.

2.2 Existing Project Site Description

The Project is located entirely on agricultural lands historically reclaimed from intertidal estuarine marsh. Fir Island Farm is currently productive agriculture land managed by WDFW as a snow goose reserve. As such, the farm is leased to a neighboring farm to grow row crops during the spring, summer, and fall and snow goose forage in the winter. The agricultural potential of the farm is maintained

through a system of dikes, drainage watercourses and two tidegates that are managed by Skagit Consolidated Diking District #22 in consultation with WDFW. The existing tidegates on Claude O. Davis Slough and Dry Slough allow for upland interior drainage to Skagit Bay but block upstream fish passage into these historic distributary channels. The historic connection between Claude O. Davis Slough and Dry Slough has been eliminated. The tidegate complex on Brown Slough also provides upland drainage but includes a 4-foot diameter open culvert that allows restricted upstream fish passage from the tidegate complex to the tidegates at Fir Island Road. Watchable wildlife recreation is encouraged at the farm through a driveway access, parking lot and short dike top trail. Hunting is currently not a permitted activity at the farm (Figure 2).



Figure 2. Oblique aerial of WDFW's Fir Island Farm property.

2.3 Project Background

Farming is a significant industry in the Skagit River Delta and on Fir Island. Over the past century, a complex system of dikes and drainage infrastructure has been developed in the Delta for the purpose of creating and maintaining farmland. Approximately 73 percent of tidal wetlands and channels have been lost in the Delta as the result of dike and drainage activities (SRSC & WDFW 2005). The Delta contains some of the highest quality agricultural soils in the world. The continuance of agriculture in the Delta is dependent upon the preservation of flood dikes and an intricate drainage system. Many in the agricultural community view the restoration of farmland to estuarine habitats as a significant threat to farmland drainage and viability. Through consultation with Skagit Consolidated Diking District #22 commissioners and outreach to the local agriculture community, WDFW's Fir Island Farm Estuary

Restoration Project has been designed to maintain flood, drainage and salt protection for the adjacent farmland and the farmland within the No Name Slough watershed on Fir Island.

Scientists consider the Greater Skagit Delta, which includes the Skagit River Delta as well as the smaller Samish River and Stillaguamish River Deltas to the north and south respectively, one of the most important places on the northwest coast for estuarine and nearshore conservation because of its wealth of biodiversity and key role in the life histories of dozens of internationally important, estuarine-dependent species (TNC 2005). The Skagit Delta provides critical rearing habitat for several federally listed fish species, including Puget Sound Chinook salmon, Coastal Puget Sound bull trout and their designated critical habitats. The delta is critical for the survival of shorebirds and waterfowl.

Nearly 65-90 percent of Puget Sound area overwintering shorebirds and more than 90 percent of the waterfowl that overwinter in western Washington rely on the Greater Skagit Delta. The area was recently designated a Site of Regional Importance in the Western Hemisphere Shorebird Reserve Network. Migratory waterfowl, particularly dabbling ducks, depend heavily on the tidal flats, marsh, exposed aquatic beds, and adjacent agricultural land that occur in sheltered bays along the coast.

The Skagit River estuary is a rich nursery that provides the following four main interrelated functions for juvenile salmon: physiological transition from freshwater to saltwater, foraging and growth, predator avoidance, and migratory corridors (Simenstad and others, 1982; Beamer and others, 2005). The significant historic loss of tidal wetlands and channels in the Delta has significantly impacted the estuary rearing habitats for salmonids. The lack of estuary habitat is a limiting factor for Chinook recovery in the Skagit and throughout Puget Sound. The project is consistent with the Skagit Chinook Recovery Plan (SRSC and WDFW 2005), which was adopted by National Marine Fisheries Service (NMFS) as a chapter in the Puget Sound Chinook Recovery Plan (NMFS, 2006). The Skagit Watershed Council (a designated lead entity under Washington State Legislation ESHB 2496 salmon recovery planning act) identified estuary restoration as a Tier 1 priority within its 2010 Strategic Approach and the Project is listed in the Skagit Watershed Council's current Three Year Work Program. Based on an empirical model for estimating the juvenile carrying capacity of habitat used in the Skagit Chinook Recovery Plan (SRSC and WDFW 2005), approximately 2,700 acres of restored estuarine habitat will be needed to achieve the Skagit Delta estuarine juvenile Chinook recovery goal of 1.35 million smolts annually. The project is expected to restore 131 acres of estuarine habitat and provide carrying capacity for 65,000 juvenile Chinook smolts annually.

As a snow goose reserve, Fir Island Farm is a popular waterfowl and bird watching area. There is a public access road, parking lot and dike top trail. As a reserve, hunting is not permitted.

2.4 Project Restoration Design

The restoration design restores the natural tidal prism of Skagit Bay to 131 acres of WDFW's 258 acre Fir Island Farm by setting back approximately 5,800 lineal feet of coastal dike (Figure 3). The design is expected to restore approximately 126 acres of estuarine intertidal emergent marsh and 5 acres of estuarine intertidal channel within the restoration footprint. An additional 12 acres of estuarine intertidal channel is predicted to develop in the existing adjacent intertidal marsh. The design will

maintain drainage and flood protection for the 105 acres of farmland retained at the farm, neighboring farmland and farmland within the No Name Slough watershed on Fir Island through the construction of a new flood dike, new tidegates, drainage storage pond and pump station. The design maintains the existing public access driveway, parking lot and dike top trail. The design allows WDFW to continue managing the entire farm, the retained farmland as well as restored tidal marsh, as a snow goose reserve.

The restoration design includes the following elements:

- Site Access and Haul Routes
- Staging Area
- Dikes
 - New Setback Dike
 - Spur Dike Extension
 - Existing Dike Demolition
- Interior Drainage
 - Storage Pond
 - Tidegates
 - Pump Station
- Marsh Restoration Area
 - High Marsh Fill Grading
 - Pilot Tidal Channels
 - Native Seeding

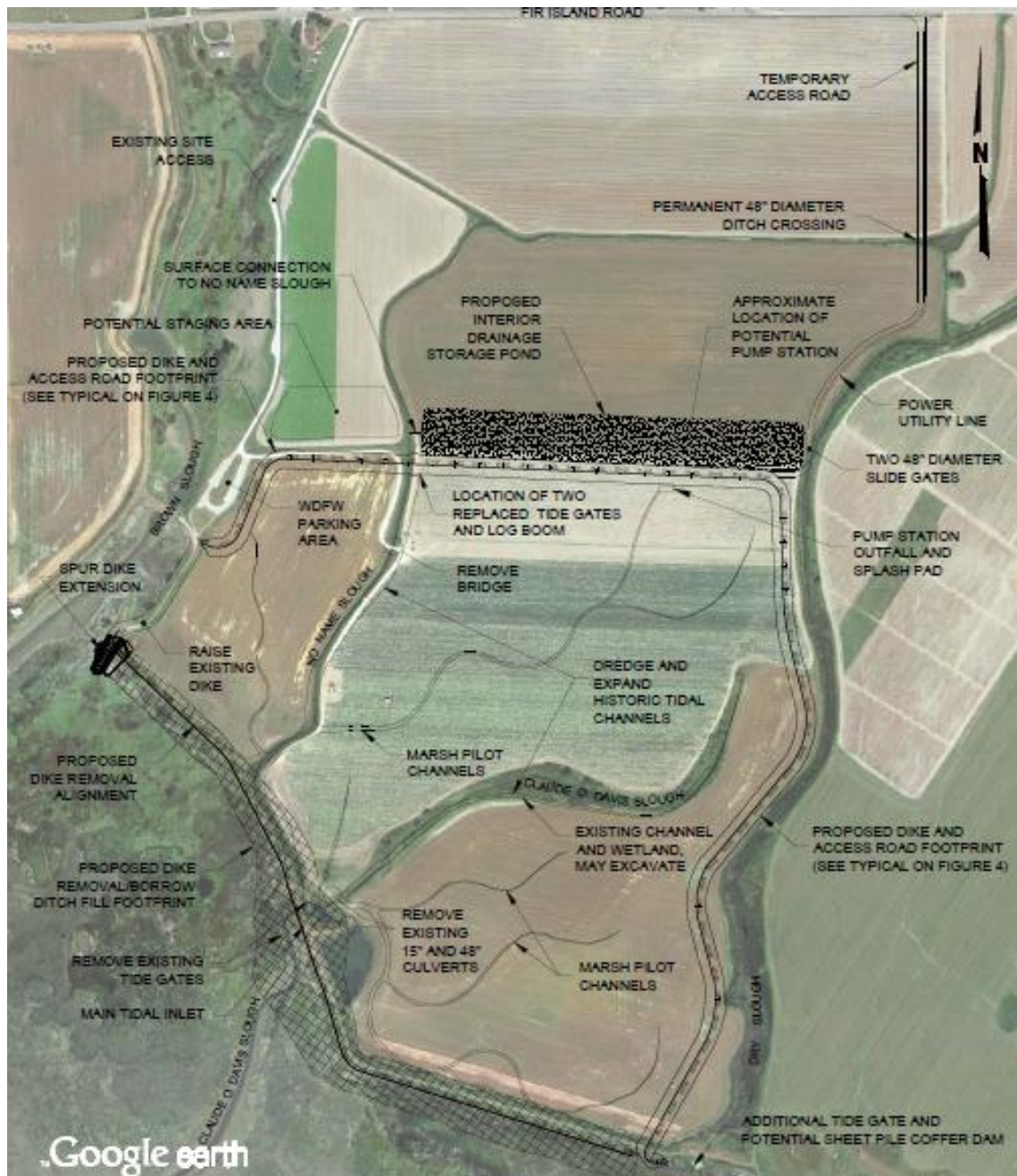


Figure 3. Project activities at the Fir Island Farm restoration site.

A feasibility study to restore estuary habitats at the Project site was completed in December 2011. The final restoration design and permitting will be completed by December 31, 2014.

2.6 Project Restoration Goals and Objectives

The goal of the Project is to restore the natural tidal processes of Skagit Bay to 131 acres of existing farmland at WDFW's Fir Island Farm by setting back 5,800 lineal feet of existing flood dike and the associated tidegates.

The following objectives for the Project were identified during the feasibility study/early design phase of the project (Shannon and Wilson, 2011) and later refined through the final design phases.

- Restore tidal flooding.
- Restore unrestricted movement of water, sediments, nutrients, detritus and organism.
- Restore native tidal marsh habitat.
- Restore tidal channel habitat within the restoration footprint.
- Restore tidal channel habitat in the existing adjacent tidal marsh.
- Restore tidal marsh habitat and tidal channels beneficial to multiple fish and wildlife species.
- Restore estuary rearing habitat for six ESA-listed populations of Chinook salmon.
- Minimize impacts to adjacent private landowners.
- Maintain a public parking area.
- Maintain public recreational uses.
- Maintain/improve the drainage, flood and salt intrusion protection for adjacent landowners.
- Maintain snow geese management capabilities.

2.7 References

- Beamer, Eric, et al. (2005) Delta and nearshore restoration for the recovery of wild Skagit River chinook salmon: linking estuary restoration to wild chinook salmon populations, Appendix D, Skagit Chinook Recovery Plan.
- National Marine Fisheries Service. 2006. Recovery Plan for the Puget Sound Chinook Salmon (*Oncorhynchus tshawytscha*). National Marine Fisheries Service, Northwest Region. Seattle, WA.
- Shannon and Wilson. 2011. Fir Island Snow Goose Reserve Restoration Feasibility Study. Washington Dept., of Fish and Wildlife, Fir Island, Washington.
- Simenstad, C. A.; Fresh, K.; and Salo, E, 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, 6th Biennial International Estuarine Research Conference, Geneden Beach, Oreg., 1981, Proceedings: N. Y., Academic Press, p. 343-363.
- Skagit River System Cooperative (SRSC) and WDFW. 2005. Skagit Chinook Recovery Plan. Available at: <http://www.skagitcoop.org/documents/>
- The Nature Conservancy (TNC) 2005 The Greater Skagit Delta Biodiversity Assessment and Conservation Plan (draft 2005 – The Nature Conservancy)

3.0 MONITORING AND ADAPTIVE MANAGEMENT

Written by Brian Williams, Washington Department of Fish and Wildlife

3.1 Monitoring Defined

The importance of pre-project and post-project monitoring has been advocated repeatedly (Kondolf, 1998; Jungwirth et al., 2002; Downs & Kondolf, 2002). Monitoring documents changes between existing (pre-project) and restored (post-project) conditions at a project site. Though this monitoring design makes it difficult to separate the effects of project restoration actions from natural changes that may be affecting the larger landscape over time (Smith et al. 1993), monitoring control sites requires more resources than are typically available to individual projects.

The development of restoration objectives, hypotheses and monitoring objectives for an estuary restoration project are typically guided by a conceptual model that describes linkages among controlling factors, processes, structures, and functions in tidal wetlands in Puget Sound (Rice et al. 2005; Clancy et al. 2009). The conceptual model shown in Figure 4 describes how the restoration actions at a project site are predicted to affect ecosystem processes, structures, and functions.

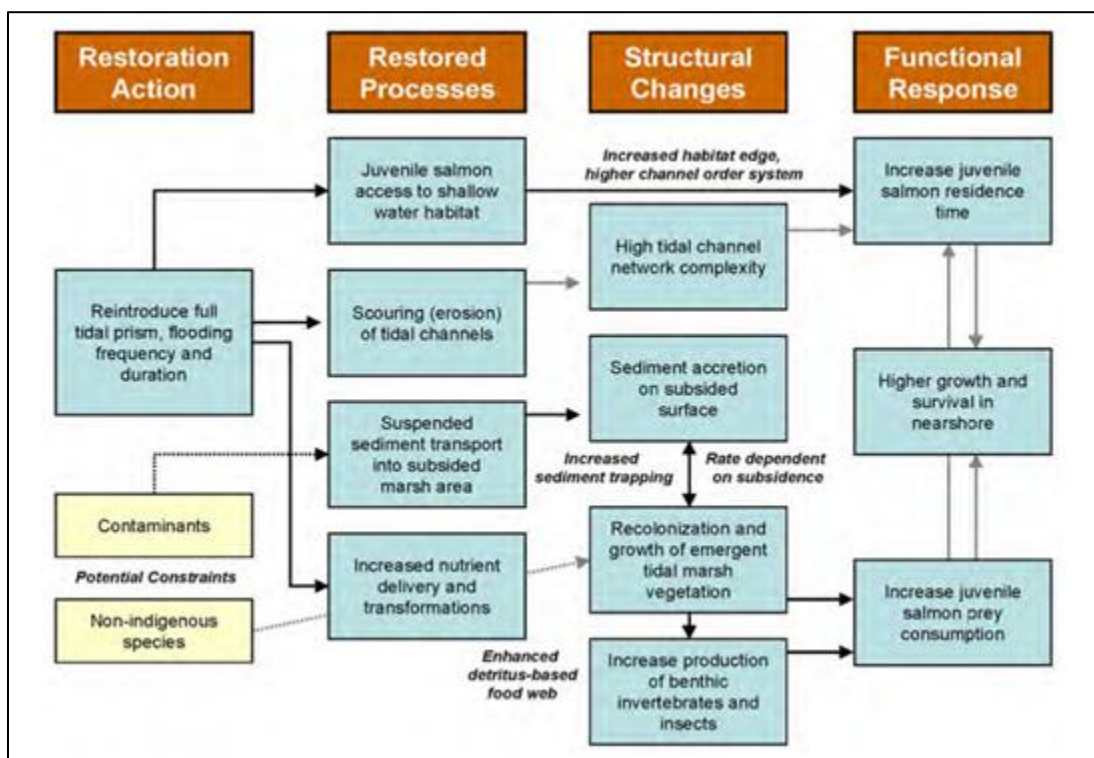


Figure 4: Conceptual model for Berm or Dike Removal or Modification (Clancy et al. 2009).

3.2 Adaptive Management Defined

Post-project monitoring will help determine whether additional actions or adjustments are needed and can provide useful information for future restoration efforts. This process of monitoring and adjustment is known as adaptive management (Figure 5).

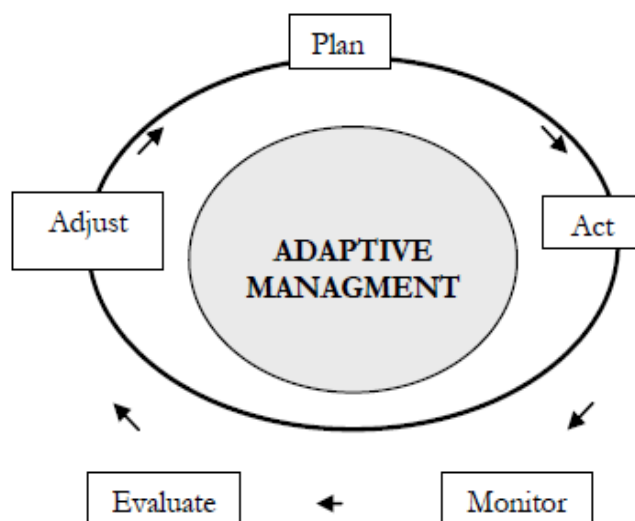


Figure 5. Diagram depicting the adaptive management process (Shreffler, 2007; modified from Thom and Wellman 1996).

Adaptive management has been broadly defined as the process of “learning by doing” and then applying what has been learned to improve the “doing.” It is a process that “relies on an accumulation of credible evidences to support a decision that demands action” (Thom 2000).

Adaptive management is designed to address the inherent uncertainty in ecological restoration projects, and seeks to minimize this uncertainty by learning about the system being managed (Thom and Wellman 1996; Thom 2000; Linkov et al. 2006). Per Thom (2000), adaptive management for a restoration project requires:

- Measuring the existing condition of the system, using selected indicators;
- Assessing progress toward goals and performance criteria; and
- Making a decision on which actions to take.

Adaptive management actions can involve doing nothing, implementing appropriate corrective measures, or altering the project objectives if the original targets are found to be unreasonable in light of the project site realities.

3.3 Monitoring and Adaptive Management Plan Structure

The scope of a Monitoring and Adaptive Management Plan is significantly influenced by its unique location within the landscape. Different locations within the landscape will often have different restoration objectives, restoration treatments, and necessitate different adaptive management and monitoring objectives and strategies. Given the Project location within the farmland landscape of Fir Island in the Skagit River Delta and, in particular, within the No Name Slough watershed of Fir Island, the Fir Island Farm Monitoring and Adaptive Management Plan (Plan) is intentionally structured and prioritized to evaluate not only the ecological objectives of the Project but also the risks and liabilities associated with the agriculture objectives.

WDFW is both the project proponent and the landowner. This Plan considers both of these roles. As the project proponent, WDFW recognizes the importance of monitoring the ecological effectiveness of the Project. As the landowner, WDFW also recognizes our regulatory responsibility to control invasive species and our financial risks and liabilities associated with the failure of the Project to successfully achieve the agriculture flood, drainage and salt protection objectives. From the perspective of both project proponent and landowner, this Plan prioritizes the monitoring objectives for the Project in the following descending order of priority: regulatory requirements, agriculture objectives, ecological objectives. The ecological objectives are prioritized further in light of the fact that grant funding to support adaptive management and monitoring at individual sites is limited.

This Plan is designed to address the inherent uncertainty and risks associated with a large scale estuary restoration project. This Plan builds upon the following adaptive management and monitoring components:

1. A conceptual model of existing conditions and ecological processes affecting the restoration site that has been used to predict the likely outcomes (hypotheses) of individual restoration actions.
2. Clear prioritized monitoring objectives for the restoration project.
3. Performance parameters and thresholds for evaluating outcomes relative to the monitoring objectives.
4. Monitoring the effects of the restoration actions relative to performance parameters and thresholds.
5. Adaptive management actions and a decision framework for implementing these actions.

The restoration objectives for the Project were initially developed during the Feasibility Study phase of the Project and subsequently refined during the design phases. For this Plan, each restoration objective is translated into a monitoring objective or objectives. For each monitoring objective, a hypothesis was developed. For the ecological objectives, the conceptual model illustrated in Figure 4 was used to develop the hypotheses. A performance parameter was developed to evaluate each hypothesis. The hypotheses and performance parameters combined to guide the selection of the monitoring method most suitable to evaluate the hypotheses.

This Plan includes monitoring in the footprint of the Project as well as in the adjacent tidal marsh and farmland. This Plan identifies what, when, where, who and how monitoring data will be collected, how it will be evaluated and how it will be used to implement adaptive management. This Plan includes:

- Monitoring Objectives.
- Monitoring Priorities.
- Adaptive Management Priorities.
- Adaptive Management Decision Framework.
- Individual Chapters for the Monitoring Objectives.

3.4 Project Monitoring Objectives

This Plan is designed to assist WDFW with evaluating the effectiveness of the Project relative to the regulatory, agriculture, and ecological objectives of the project. WDFW identified the following monitoring objectives:

Regulatory

- Tidal Marsh Habitat Restoration – invasive species response at project site.

Agricultural

- Flood Protection – top elevation of new flood dike.
- Flood Protection – dike toe erosion.
- Flood Protection – drift log management.
- Groundwater Level Protection – groundwater elevations landward of dike.
- Groundwater Salinity Protection – groundwater salinity landward of dike.
- Surface Water Salinity Protection – surface water salinity landward of dike.
- Surface Water Drainage Protection – surface water elevations landward of dike.

Ecological

- Tidal Marsh Habitat Restoration – cattail response at the project site.
- Tidal flooding – project area where tidal process is restored.
- Tidal Marsh Habitat Restoration – sediment accretion and erosion.
- Tidal Marsh Habitat Restoration – native vegetation response in restored area.
- Tidal Channel Habitat Restoration – tidal channel extent and change.
- General Habitat Development – qualitative visual assessment in restored area.
- Tidal Flooding – surface water salinity dynamics in restored area.
- Tidal Flooding – tidal amplitude/water level in restored area.
- Tidal Flooding – water temperature dynamics in restored area.
- Fish and Wildlife Species Utilization – fish utilization in restored area.
- Fish and Wildlife Species Utilization – waterfowl and other wildlife use of restored area.

Social

- Recreation – public use.
- Socio Economic Effects – socioeconomic impacts of the restoration.

This Plan includes a separate chapter for each monitoring objective. Each chapter includes the following elements:

- Introduction
- Monitoring Objective
- Hypotheses
- Performance Parameter
- Monitoring Method
- Performance Threshold
- Adaptive Management Action(s)
- Monitoring Schedule

- References

3.5 WDFW'S Monitoring Priorities

As noted above, this Plan considers not only the ecological objectives of the Project but also the risks and liabilities associated with the agriculture flood, drainage and salt protection objectives. As such, WDFW has intentionally prioritized monitoring objectives in the following descending order of priority: regulatory requirements, agriculture objectives, ecological objectives and intends to seek grant funding to implement these monitoring objectives.

Regulatory

- Tidal Marsh Habitat Restoration – invasive species response at project site.

Agriculture

- Flood Protection – top elevation of new flood dike.
- Flood Protection – dike toe erosion.
- Flood Protection – drift log management.
- Groundwater Level Protection – groundwater elevations landward of dike.
- Groundwater Salinity Protection – groundwater salinity landward of dike.
- Surface Water Salinity Protection – surface water salinity landward of dike.
- Surface Water Drainage Protection – surface water levels landward of dike.

Ecological

- Tidal Marsh Habitat Restoration – cattail response at the project site.
- Tidal flooding – project area where tidal process is restored.
- Tidal Marsh Habitat Restoration – sediment accretion and erosion.
- Tidal Marsh Habitat Restoration – native vegetation colonization.
- Tidal Channel Habitat Restoration – tidal channel extent and change.
- General Habitat Development – qualitative visual assessment.
- Fish and Wildlife Species Utilization – fish utilization in restored area.

Baseline data collection for each of these priority monitoring objectives will be completed prior to re-introducing the tidal prism of Skagit Bay to the Project site which is expected to occur in the fall of 2016. Post construction data collection will begin in 2017 and will continue either annually or every other year through 2019 or 2021, depending on the monitoring objective.

In addition to these priority monitoring objectives, WDFW has identified the following “additional” monitoring objectives that will not be implemented by WDFW but, with WDFW permission, can be implemented by a third party.

Ecological

- Tidal Flooding – surface water salinity dynamics in restored area.
- Tidal Flooding – tidal amplitude/water level in restored area.
- Tidal Flooding – water temperature dynamics in restored area.

- Fish and Wildlife Species Utilization –wildlife utilization in restored area.

Social

- Recreation – public use of Fir Island Farm.
- Socio Economic Effects – socio economic impacts of the restoration.

3.6 WDFW's Adaptive Management Priorities

Not all of the monitoring objectives identified in the previous section have associated adaptive management strategies. This Plan considers adaptive management for the following priority monitoring objectives:

Regulatory

- Tidal Marsh Habitat Restoration – invasive species response at project site.

Agricultural

- Flood Protection – top elevation of new flood dike.
- Flood Protection – dike toe erosion.
- Flood Protection – drift log management.
- Groundwater Level Protection – groundwater elevations landward of dike.
- Groundwater Salinity Protection – groundwater salinity landward of dike.
- Surface Water Salinity Protection – surface water salinity landward of dike.
- Surface Water Drainage Protection – surface water levels landward of dike.

Ecological

- Tidal Marsh Habitat Restoration – cattail response at the project site.

Given the significance and dominance of the restored tidal processes at the project, with the *exception of marsh vegetation management (invasive species and lesser cattail)*, there are very few ecological adaptive management actions that are practical and/or cost effective.

This Plan identifies a performance threshold for each of the priority monitoring objectives where adaptive management is considered. Each of the performance thresholds can be objectively assessed through the collection of monitoring data. Tracking the monitoring data for these priority objectives will help to determine which of the priority monitoring objectives are on course to achieve its intended performance threshold and which are not.

3.7 WDFW'S Adaptive Management Decision Framework

WDFW will annually compile and analyze the post construction monitoring data for the Project. WDFW will annually meet with the Commissioners of Skagit County Consolidated Diking District #22 to review and discuss the baseline and post construction monitoring data. If one of the adaptive management priorities noted above is not meeting its performance threshold or is not on a trajectory to meeting its performance threshold, WDFW and Skagit Consolidated Diking District #22 will collaboratively determine which of the following adaptive management alternatives is appropriate. The appropriate

alternative will take into account the analysis of baseline and post construction monitoring data as well as subjective information, project site constraints and cost/benefit considerations.

- Take no action.
- Intervene by implementing an adaptive management action.
- Adjust the project objective.

3.8 References

- Clancy, M., I. Logan, J. Lowe, J. Johannessen, A. MacLennan, F.B. Van Cleve, J. Dillon, B. Lyons, R. Carman, P. Cereghino, B. Barnard, C. Tanner, D. Myers, R. Clark, J. White, C. A. Simenstad, M. Gilmer, and N. Chin. 2009. Management Measures for Protecting the Puget Sound Nearshore. Puget Sound Nearshore Ecosystem Restoration Project Report No. 2009-01. Published by Washington Department of Fish and Wildlife, Olympia, Washington.
- Downs, P. W., and G. M. Kondolf. 2002. Post-project appraisals in adaptive management of river channel restoration. *Environmental Management*. 29:477–496.
- Feist, and P. Roni. 2005. Monitoring rehabilitation in temperate North American estuaries. In P. Roni (ed), *Monitoring Stream and Watershed Restoration*, Chapter 7, p. 167-207, American Fisheries Society, Bethesda, Maryland.
- Jungwirth, M., Muhar, S. and Schmutz, S. 2002. Re-establishing and assessing ecological integrity in riverine landscapes. *Freshwater Biology*. 47:867–87.
- Kondolf, G. M. (1998), Lessons learned from river restoration projects in California. *Aquatic Conservation: Marine and Freshwater Ecosystems*, 8: 39–52.
- Linkov, I., F.K. Satterstrom, G. Kiker, C. Batchelor, T. Bridges, and E. Ferguson. 2006. From comparative risk assessment to multi-criteria decision analysis and adaptive management: Recent developments and applications. *Environment International* 32: 1072-1093.
- Rice, C. A., W. G. Hood, L. M. Tear, C. A. Simenstad, G. D. Williams, L. L. Johnson, B. E.
- Shreffler, D. 2007. Salmon Creek Estuary Restoration Project: Vegetation Monitoring Plan. Prepared for North Olympic Salmon Coalition by Shreffler Environmental.
- Smith, P. E., D. R. Orvos, and J. Cairns. 1993. Impact assessment using the before-after control-impact (BACI) model: concerns and comments. *Canadian Journal of Fisheries and Aquatic Sciences* 50:627-637.
- Thom, R. M. and K. F. Wellman. 1996. Planning aquatic ecosystem restoration monitoring programs. U.S. Army Corps of Engineers, Institute for Water Resources and Waterways Experiment Station. IWR Report 96-R-23, December 1996.
- Thom, R.M. 2000. Adaptive management of coastal ecosystem restoration projects. *Ecological Engineering* 15: 365-372.

4.0 WDFW Monitoring and Adaptive Management Priorities

This section identifies each monitoring objective that is associated with adaptive management actions. For each monitoring objective, each sub-section describes the hypotheses, monitoring method(s), thresholds that trigger adaptive management, and the specific adaptive management actions.

4.1 Priority 1: Regulatory Objective: Invasive Species

Written by David Heimer, Washington Department of Fish and Wildlife

Introduction

Approximately 131 acres of upland will be reconnected to Puget Sound with the removal and setback of a proposed coastal levy (dike). The passive colonization of the former upland with native, salt marsh plants is expected to occur relatively quickly, creating new habitat for fish and wildlife, Hood 2009. In addition to native plants, non-native invasive plants (i.e. weeds) often colonize disturbed and created wetlands. Noxious weeds are those plant species classified by the State Noxious Weed Control Board and placed on the Noxious Weed List. Many of the listed weeds require management by law.

In addition to noxious weeds, there are other plants that may interfere with management objectives at the site and are considered weeds and managed below some threshold. The approach to managing weeds is called integrated pest management (IPM). IPM is a process that uses the most appropriate tool, or set of tools to meet a management objective. In the case of Fir Island Farm, the areas inside and outside of the existing dike will be surveyed two times during the 2014 field season for noxious and other weeds to set a baseline. Known weeds in the general area are summarized in Table 1.

Table 1. Summary of weeds in the Project vicinity

Scientific Name	Common Name	Weed Class
<i>Spartina anglica</i>	Common cordgrass	A
<i>Spartina alterniflora</i>	Smooth cordgrass	A
<i>Typha angustifolia</i>	Narrow-leaf cattail	C
<i>Typha angustifolia</i> x <i>T. latifolia</i>	Hybrid cattail	C
<i>Lythrum salicaria</i>	Purple loosestrife	B
<i>Zostera japonica</i>	Japanese eelgrass	C
<i>Cirsium arvense</i>	Canada thistle	C
<i>Rubus armeniacus</i>	Himalayan blackberry	C
<i>Iris pseudocarus</i>	Yellow flag iris	C
<i>Phalaris arundinacea</i>	Reed canarygrass	C

This monitoring and adaptive management section describes how noxious weeds will be monitored and outlines the structure for determining whether or not adaptive management actions are triggered. New weed problems that occur in the future (but are not listed in this chapter) will be evaluated and managed on a case-by-case basis using the best available science.

Monitoring Objective

The objective for monitoring invasive species is to meet legal requirements for weed control to protect the biological and physical processes of a dynamic, intertidal habitat.

Hypothesis

Invasive plant species will colonize the disturbed areas of the restoration project site.

Performance Parameter

The presence of invasive plant species at the project site.

Monitoring Method

The restored area will be surveyed on foot by the weed control crew by moving through the marsh and recording point data using a GPS device when a noxious weed is found.

Performance Threshold

Adaptive management actions shall be triggered if WDFW determines that the following thresholds in Table 2 have been exceeded.

Table 2. Thresholds for Adaptive Management Actions

Scientific Name	Common Name	Action Threshold
<i>Spartina anglica</i>	Common cordgrass	1 plant
<i>Spartina alterniflora</i>	Smooth cordgrass	1 plant
<i>Typha angustifolia</i>	Narrow-leaf cattail	1 plant
<i>Typha angustifolia</i> x <i>T. latifolia</i>	Hybrid cattail	1 plant
<i>Lythrum salicaria</i>	Purple loosestrife	1 plant
<i>Zostera japonica</i>	Japanese eelgrass	NA
<i>Cirsium arvense</i>	Canada thistle	Skagit WLA
<i>Rubus armeniacus</i>	Himalayan blackberry	Skagit WLA
<i>Iris pseudocarus</i>	Yellow flag iris	1 plant
<i>Phalaris arundinacea</i>	Reed canarygrass	Skagit WLA

Adaptive Management Action(s)

Adaptive management actions for noxious weeds will be conducted as described in Table 3.

Table 3. Adaptive Management Actions for noxious weeds

Scientific Name	Common Name	Adaptive Management Action
<i>Spartina anglica</i>	Common cordgrass	Dig single plants, use herbicide on larger clones
<i>Spartina alterniflora</i>	Smooth cordgrass	Dig single plants, use herbicide on larger clones
<i>Typha angustifolia</i>	Narrow-leaf cattail	Dig single plants, or cut to the mud for small patches, or use herbicide
<i>Typha angustifolia</i>	Hybrid cattail	Dig single plants, or cut to the mud for

<i>x T. latifolia</i>		small patches, or use herbicide
<i>Lythrum salicaria</i>	Purple loosestrife	Dig single plants, use herbicide on small patches
<i>Zostera japonica</i>	Japanese eelgrass	NA
<i>Cirsium arvense</i>	Canada thistle	Treat with appropriate herbicide
<i>Rubus armeniacus</i>	Himalayan blackberry	Mow small patches and/or treat with a selective herbicide
<i>Iris pseudocarus</i>	Yellow flag iris	Treat with an aquatic herbicide
<i>Phalaris arundinacea</i>	Reed canarygrass	Mow large patches and treat both large and small patches with herbicide.

Monitoring Schedule

A pre-project baseline survey will be conducted in the spring/summer and fall of 2015. Post project surveys will occur annually twice a year (spring/summer and fall) beginning 2017 and ending in 2021 or when the priority weed are not found during surveys in three consecutive years.

References

Hood, 2009, Habitat Monitoring Strategy for the Tidal Skagit Delta.

Washington State Noxious Weed Control Board, Printable Noxious Weed Control List,
<http://www.nwcb.wa.gov/printable.htm>

4.2 Priority 2: Agricultural Objective: Flood Protection – Flood Dike Elevation

Written by Loren Brokaw, Washington Department of Fish and Wildlife

Introduction

A coastal levy (dike) is proposed to be constructed as part of this project to protect WDFW and farm property, roads, infrastructure, and rural residential properties from tidal inundation, flooding, storm surge, wind wave overtopping, erosion, and scour of the levee embankment. Results from a hydrodynamic study of the site (Battelle, 2013) were used to provide a recommended dike height elevation of 15 feet NAVD88 (Shannon & Wilson, 2014).

Some degree of dike settlement is expected. Settlement at the analyzed locations is expected to range from about 5 to 7 inches. It is estimated that approximately 90 percent of the settlement will occur during construction as the dike fill is placed, with less than 1 inch occurring between 1 and 20 years following construction. The dike will be designed and overbuilt to account for the predicted degree of settlement, so that the final elevation of the dike is expected to be equal to or greater than the recommended dike height elevation of 15 feet NAVD88 (Shannon & Wilson, 2014).

This monitoring and adaptive management section describes how the elevation of the constructed dike will be monitored and outlines the structure for determining whether or not adaptive management actions are triggered.

Monitoring Objective

The objective for monitoring dike elevation is to assure that the dike is constructed at the design elevation, and maintains an elevation equal to or greater than the recommended dike height elevation of 15 NAVD88 (17.14 MLLW). The intent of systematically monitoring dike height is to identify potential problems in time to install adaptive management measures, before problems present as a flood protection risk.

Hypotheses

The top elevation of the new flood dike will be 15 feet NAVD88 or greater.

Performance Parameter

The top elevation will be measured to determine dike height.

Monitoring Method

Using accepted survey methods and established on-site bench marks, the top elevation of the new dike will be established every 500 feet down the center of the dike and in any additional areas that visually appear to have settled. The stations along the top of the dike where elevations are determined will be marked with permanent monuments and assigned sequential numbers. The station monuments along the top of the dike will also be used as photo points for dike to erosion, drift log accumulation and general habitat development monitoring.

Performance Threshold

Adaptive management action(s) shall be triggered if WDFW in consultation with SCCD#22 determine that any portion of dike falls below the target dike height elevation of 15 feet NAVD88 (17.14 MLLW). A decision to implement adaptive management actions shall be made per the decision framework presented in section 3.3.3 of the Plan.

Adaptive Management Action(s)

Appropriate materials will be imported to the site to augment the top of the flood dike where the dike top elevation is below the target dike height elevation of 15 feet NAVD88 (17.14 MLLW).

Monitoring Schedule

Dike height will be measured no later than 30 days dike construction is completed (2016). This measurement will be used to determine the as-built height of the dike and will represent the baseline condition. The as-built dike height shall be equal to or greater than the design height elevation of 15 feet NAVD88. Subsequent dike height measurements will be made annually for 3 years post-construction (2017-2019).

References

- Battelle, 2013, Hydrodynamic modeling analysis for the Fir Island Farm restoration project in Skagit Bay, Washington: Report prepared by Battelle, Seattle, Washington, PNWD-4398, for Shannon & Wilson, Seattle, Washington, September.
- Shannon & Wilson, Inc., 2014, Fir Island Farm Final Design and Permitting, Draft Coastal Engineering Report, Skagit County Washington: Report prepared by Shannon & Wilson. Inc, Seattle, Wash., 21-1-12318-217, for Washington Department of Fish and Wildlife, Olympia, Wash., January 10, 2014.

4.3 Priority 2: Agricultural Objective: Flood Protection – Flood Dike Toe Erosion

Written by Loren Brokaw, Washington Department of Fish and Wildlife

Introduction

A coastal levy (dike) is proposed to be constructed as part of this project to protect WDFW and farm property, roads, infrastructure, and rural residential properties from tidal inundation, flooding, storm surge, wind wave overtopping, erosion, and scour of the levee embankment. Based on observations and history of the existing dike erosion characteristics, and the hydrodynamic modeling results (Battelle, 2013), the dike will be subject to erosion from wind waves, possible tidal channel development along the levee toe, and impacts from floating large wood debris (Shannon & Wilson, 2014).

To protect against erosion of the dike toe, a series of protection measures are included in the project design, i.e., riprap along the face of the dike, raising the elevation of the marsh bed along the dike toe with imported fill, and colonizing the marsh areas adjacent to the dike toe with native marsh plant species. The riprap will have a minimum average diameter of 2.0 feet, minimum thickness of 2.0-3.0 feet, and minimum toe down depth of 3.0-4.0 feet (Shannon & Wilson, 2014).

This monitoring and adaptive management section describes how erosion of the constructed dike toe will be monitored and outlines the decision framework for determining whether or not adaptive management actions are triggered.

Monitoring Objective

The objective for monitoring dike toe erosion is to assure that erosion does not threaten the dikes ability to provide flood protection to the surrounding area. The intent of systematically monitoring dike toe erosion is to identify potential problems in time to implement adaptive management measures, before the integrity of the dike is sufficiently compromised to create a risk of tidal flooding.

Hypotheses

Erosion of the dike toe threatens the integrity of the dike and its function to provide flood protection to the adjacent farmland.

Performance Parameter

Dike erosion will be assessed through qualitative visual observation and photo documentation.

Monitoring Method

Dike erosion will be assessed through qualitative observation and will be documented with photographs. Permanent photo points will be assigned on the dike top, spaced 500 feet apart. These photo points will coincide with the points used to measure dike elevation, be marked with permanent monuments, and assigned sequential station numbers.

At each photo point, two digital photographs will be taken – each facing opposite directions, parallel to the waterward side of the dike. The camera will be positioned horizontally, approximately 5 feet above the ground. Photos will be saved as electronic files in a photo log, and named by station number,

direction, and date (yyyymmdd). For example, a photo taken at the Fir Island Farm station #1, facing north, on February 15, 2016 would be coded as: FIF01_N_20160215. If toe erosion is detected at the photo point locations, additional photographs of the eroding toe will be taken.

Additionally, any locations visually observed to have experienced unusual rates of erosion will be photographed, regardless of whether or not they occur at a photo point. These locations will be marked in the field and assigned a station name at the discretion of the photographer, and saved in the photo log with a corresponding name so they can be monitored during subsequent monitoring events.

Performance Threshold

Adaptive management actions shall be triggered if WDFW in consultation with SCCD#22 determines that dike toe erosion presents a risk to the integrity of the dike and creates a risk of tidal flooding. A decision to implement adaptive management actions shall be made per the decision framework presented in section 3.3.3 of the Plan.

Adaptive Management Action(s)

Appropriate materials will be imported to the dike toe erosion sites to rebuild and protect the original dike toe.

Monitoring Schedule

The photo documentation will be used to monitor this objective. The baseline photographs will be taken within 30 days after dike construction is completed (2016) to record as-built condition.

Subsequently, dike toe erosion monitoring will occur annually for 3 years post-construction. The timing of the dike toe erosion monitoring will coincide with dike height monitoring. Dike toe erosion monitoring will occur at tides that are at or below 3.0 NAVD88 (5.14 MLLW).

References

- Battelle, 2013, Hydrodynamic modeling analysis for the Fir Island Farm restoration project in Skagit Bay, Washington: Report prepared by Battelle, Seattle, Washington, PNWD-4398, for Shannon & Wilson, Seattle, Washington, September.
- Parametrix, 2010. Fisher Slough Tidal Marsh Restoration Monitoring and Adaptive Management Plan. Prepared by Parametrix, Bellevue, Washington for The Nature Conservancy. September 2010.
- Shannon & Wilson, Inc., 2014, Fir Island Farm Final Design and Permitting, Draft Coastal Engineering Report, Skagit County Washington: Report prepared by Shannon & Wilson, Inc, Seattle, Wash., 21-1-12318-217, for Washington Department of Fish and Wildlife, Olympia, Wash., January 10, 2014.

4.4 Priority 2: Agricultural Objective: Flood Protection - Drift Log Management

Written by Brian Williams, Washington State Department of Fish and Wildlife

Introduction

The Project will restore the natural tidal prism of Skagit Bay to 131 acres of WDFW's 258 acre Fir Island Farm by setting back approximately 5,800 lineal feet of coastal dike. The project site is oriented towards the southwest which is the predominant wind and winter storm direction for Skagit Bay (Battelle, 2013). Consequently, drift log materials from Skagit Bay are expected to recruit to the site and generally accumulate along the toe of the new flood dike. More significant drift log accumulation may occur in the northwest corner of the project site. Drift log recruitment to the site and accumulation in the vicinity of the new tidegates in No Name Slough could negatively impact the operation of the tidegates and/or gravity drainage in No Name Slough (Shannon and Wilson, 2014).

In addition to maintaining the log boom structure that was designed and constructed to protect the new No Name Slough tidegates, drift log accumulations that impact the operation of the tidegates or gravity drainage in No Name Slough will need to be physical removed to another location in the restoration site.

This monitoring and adaptive management section describes how drift log accumulation will be monitored and outlines the structure for determining whether or not adaptive management actions are triggered.

Monitoring Objective

Photographs will be used to monitor drift log accumulation along the toe of the new flood dike and in the vicinity of the new No Name Slough tidegates and will support qualitative visual observations of drift logs that are negatively impacting the operation of the new tidegates and/or gravity drainage in No Name Slough.

Hypotheses

Drift log accumulation in the vicinity of the tidegates can negatively impact the operation of the tidegate and gravity drainage in No Name Slough.

Performance Parameter

Accumulation of drift logs in the vicinity of the new No Name Slough tidegates will be assessed through qualitative visual observations.

Monitoring Method

Drift log accumulation along the toe of the new flood dike and in the vicinity of the new No Name Slough tidegates will be assessed through qualitative observation and will be documented with photographs. Permanent photo points will be assigned along the dike top, spaced 500 feet apart. These photo points will coincide with the points used to measure dike elevation and dike toe erosion, will be marked with permanent monuments, and assigned sequential station numbers.

At each photo point, two digital photographs will be taken – each facing opposite directions, parallel to the waterward side of the dike. The camera will be positioned horizontally, approximately 5 feet above

the ground. Photos will be saved as electronic files in a photo log, and named by station number, direction, and date (yyyymmdd). For example, a photo taken at the Fir Island Farm station #1, facing north, on February 15, 2016 would be coded as: FIF01_N_20160215.

Additionally, any locations visually observed to have experienced unusual drift log accumulations will be photographed, regardless of whether or not they occur at a photo point. These locations will be marked in the field and assigned a station name at the discretion of the photographer, and saved in the photo log with a corresponding name so they can be monitored during subsequent monitoring events.

Performance Threshold

Adaptive management action shall be triggered if WDFW in consultation with SCCD#22 determines that drift log accumulation in the vicinity of the No Name Slough tidegates are impeding the normal operation of the tidegates and/or gravity drainage in the No Name Slough channel. A decision to implement adaptive management actions shall be made per the decision framework presented in section 3.3.3 of the Plan.

Adaptive Management Action(s)

Drift logs that are impeding the normal operation of the new No Name Slough tidegates and/or gravity drainage in the No Name Slough channel and that are within the reach of a long reach excavator operating from the tidegate maintenance access ramps will be physically removed by to another location within the restoration site.

Monitoring Schedule

Photo documentation will be used to monitor this objective. The baseline series of photographs shall be taken within 30 days after dike construction is completed (2016) to record as-built conditions. Subsequent to the baseline photographs, drift log accumulation monitoring will occur annually for 3 years post-construction (2017-2019). The timing of the drift log accumulation monitoring will coincide with dike height and dike toe erosion monitoring. Drift log accumulation monitoring shall occur at tides that are at or below 3.0 NAVD88 (5.14 MLLW).

References

- Battelle, 2013, Hydrodynamic modeling analysis for the Fir Island Farm restoration project in Skagit Bay, Washington: Report prepared by Battelle, Seattle, Washington, PNWD-4398, for Shannon & Wilson, Seattle, Washington, September.
- Shannon and Wilson. 2014. Fir Island Farm Draft 60% Design Report. Washington Dept., of Fish and Wildlife, Fir Island, Washington.

4.5 Priority 2: Agricultural Objection: Groundwater Level Protection

Written by Bob Barnard, Brian Williams and Loren Brokaw, Washington Department of Fish and Wildlife

Introduction

The greater Skagit Delta area, including properties adjacent to the project site, is extensively used for farming. Levees, dikes, tidegates, and drainage ditches were installed in the Skagit Delta beginning in the 1860s to prevent river and tidal flooding and to provide the drainage necessary for agricultural use. In addition to affecting when farmers can access their fields in the spring, groundwater levels are important because crops have tolerance thresholds to root zone inundation (NRCS, 2005).

The Project will alter the existing drainage infrastructure by relocating two tidegate structures, installing a new interior drainage storage pond and a new pump station (Shannon & Wilson, 2014). The new drainage infrastructure is designed to mitigate impacts to groundwater levels caused by the project, in reference to adjacent farming activities (Shannon & Wilson, 2014). However, it is recommended that groundwater levels in the project vicinity be monitored before and after project implementation to detect any unexpected anomalies that may occur as a result of the project.

This monitoring and adaptive management section describes how groundwater levels will be monitored and evaluated. It also outlines the process for determining if and when adaptive management actions will be implemented.

Monitoring Objective

The project is not expected to increase the pre project baseline groundwater levels. The objective of collecting and evaluating the pre project and post project groundwater elevation data is to determine whether the groundwater elevations are responding to the restoration project consistent with pre-project expectations (no affect).

Hypotheses

Post project groundwater levels are within the expected range of variation based on the pre-project baseline groundwater water levels.

Performance Parameter

A baseline correlation between the monthly average groundwater elevation from shallow groundwater wells adjacent to the restoration site and the monthly total rainfall from the Fir Island weather station will be used to evaluate the post project correlation between monthly average groundwater elevation and monthly total rainfall.

Monitoring Method

Groundwater level data is collected from three (3) paired well installations. Groundwater level data will be collected prior to project construction and continue post project construction. Groundwater observation well installations include three pairs of (dual-depth) observation wells on WDFW and adjacent properties (Figure 6). Each well paring is installed with one well in the shallow, estuarine,

slightly clayey SILT/upper farm soil layer, and the second well located in the underlying, slightly silty SAND, alluvial layer. Wells were installed in June of 2013 (Shannon & Wilson, 2014).

Groundwater levels are monitored using 6 Solinst Model 3001 LTC surface water data loggers, which measure pressure (used to calculate water surface elevation), temperature, and conductivity (used with temperature to calculate the salinity of the water) (Shannon & Wilson, 2014). Detailed information on these loggers is available at: <http://solinst.com/products/dataloggers-and-telemetry/3001-levellogger-series/ltc-levellogger-junior/datasheet.php>. One barometric data logger, which measures air pressure and temperature only, is also deployed to collect data which is used to correct the water pressure data for air pressure (Shannon & Wilson, 2014). Each logger is set to record a pressure reading on 15-minute intervals. Data are downloaded from each logger in the field every 3-4 months. For detailed instructions on field data collection, logger download and data handling procedures, see Appendix A).

Rainfall duration and intensity can influence the level of the groundwater on Fir Island and at the project site. The groundwater level data during the months critical to soil preparation for crop production (February 16 – October 31) will be used to establish baseline monthly average ground water elevation. The rainfall data from the Fir Island weather station for this same period of time will be used to establish monthly total rainfall. The baseline monthly average ground water elevation will be correlated with the monthly total rainfall to establish a baseline correlation for each month. The post project correlation between monthly average groundwater level and monthly total rainfall will be compared to the baseline correlation.



Figure 6. Location of groundwater monitoring wells and surface water monitoring sites at the Fir Island Farm restoration site.

Performance Threshold

The performance threshold for this objective is the baseline correlation between monthly average groundwater elevation from shallow groundwater wells adjacent to the restoration site and the monthly total rainfall data from the Fir Island weather station.

Figure 7 below shows an example of the groundwater and precipitation data for the year 2013 – 2014. The figure shows that there is a general association of groundwater elevation with rainfall for any given year. The assumption is that when the data from several years is analyzed, a clearer relationship will be revealed and we can use that to evaluate the post-project performance.

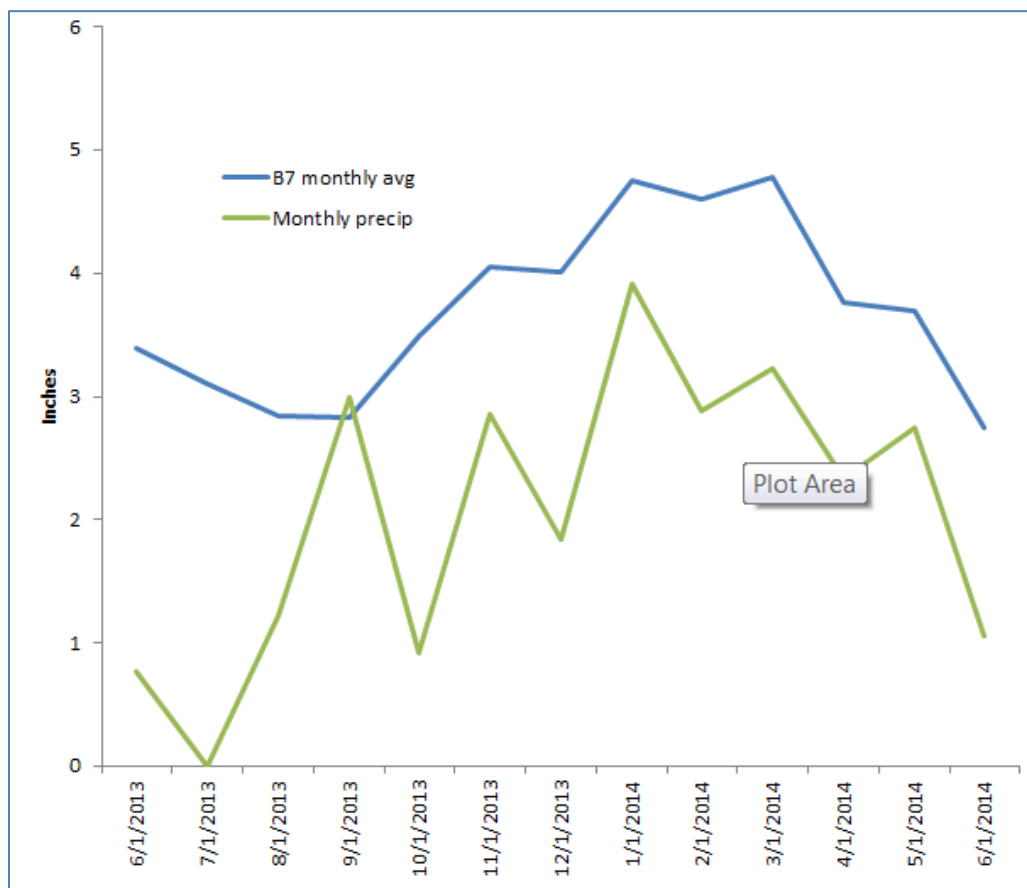


Figure 7. Relationship between precipitation and groundwater elevations

The following chart shows a possible array of precipitation and groundwater elevation for a given month, say April. The three diamonds are three years of pre-project data showing a general correlation of precipitation and groundwater. If a post-project groundwater elevation and precipitation total results in a point such as “a” then we could say that the groundwater is within an expected range for that month (shaded area). On the other hand, if a groundwater elevation-precipitation pair results in a point such as “b” then it would trigger adaptive management actions.

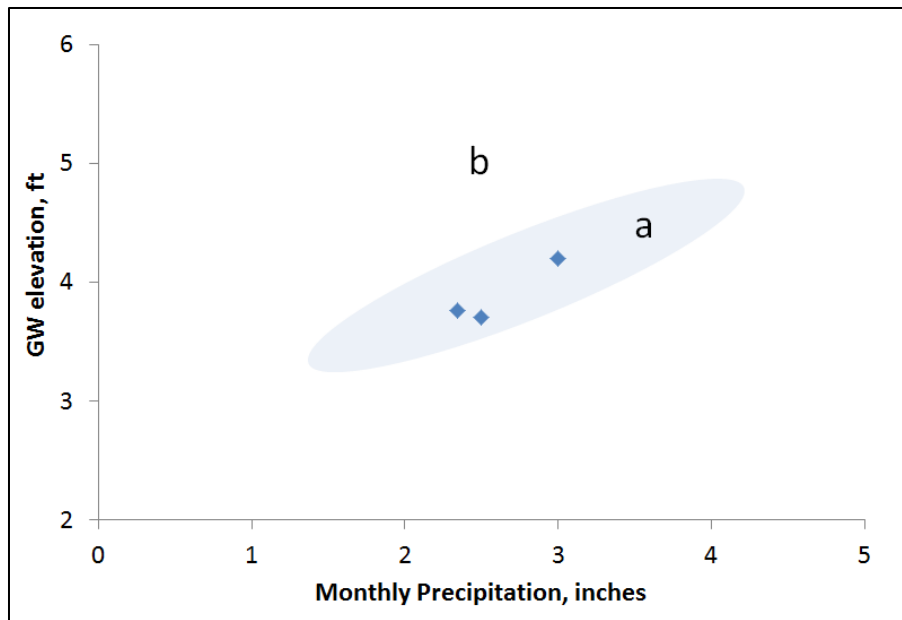


Figure 8. Predicted relationship between monthly precipitation and groundwater elevation

Adaptive Management Action(s)

Step 1: The ground water elevation data will be used to establish pre project and post project correlation between the monthly average groundwater elevation data from shallow groundwater wells adjacent to the restoration site and the monthly total rainfall data from the Fir Island weather station.

Step 2: If the post project groundwater elevation exceeds the expected range of correlation variation, WDFW will further evaluate the post project groundwater elevation data to identify whether the exceedance is related to project related or non-project related influences.

Step 3: If the exceedance is related to project related influences, WDFW and CDD#22 will work together to alleviate the project related influence.

Step 4: If the exceedance is related to non-project influences, CDD#22 can choose to implement actions to alleviate the non-project related influences.

Monitoring Schedule

Baseline data will be collected as described above and compiled annually from June 2013 to August 2016. Post construction data collection will occur as described above and compiled annually from September 2017 through 2019.

References

- Natural Resources Conservation Service (NRCS), 2005, National Engineering Handbook, Part 632 Irrigation Guide, Chapter 8, Project and Farm Water Irrigation Requirements.
- Shannon & Wilson, Inc., 2014, Fir Island Farm Final Design and Permitting, Draft Coastal Engineering Report, Skagit County Washington: Report prepared by Shannon & Wilson. Inc, Seattle, Wash., 21-1-12318-217, for Washington Department of Fish and Wildlife, Olympia, Wash., January 10, 2014.

Shannon & Wilson, Inc., 2014, Fir Island Farm Final Design and Permitting, Draft Interior Drainage Engineering Report, Skagit County Washington: Report prepared by Shannon & Wilson. Inc, Seattle, Wash., 21-1-12318-216, for Washington Department of Fish and Wildlife, Olympia, Wash., February 26, 2014.

4.6 Priority 2: Agricultural Objective: Groundwater Salinity Protection

Written by Brian Williams, Bob Barnard and Loren Brokaw, Washington Department of Fish and Wildlife

Introduction

The greater Skagit Delta, including properties adjacent to the project site, is extensively used for crop farming. Levees, dikes, tidegates, and drainage ditches were installed in the Skagit Delta beginning in the 1860s to expand and improve the agricultural area in the delta. The tidegates and other drainage infrastructure inhibit tidal processes that are not conducive to farming, including salt intrusion into the groundwater table. Groundwater salinity levels are important because crops have salinity tolerance thresholds that, if surpassed, will damage or kill the crop (NRCS, 2005).

The proposed project involves altering infrastructure that inhibits groundwater salt intrusion, including removal and installation of two new tidegate structures, and construction of over 5,000 linear feet of a new setback dike (Shannon & Wilson, 2014). Proposed new infrastructure is designed to maintain or reduce groundwater salinity levels, in reference to adjacent farming activities (Shannon & Wilson, 2014). However, it is recommended that groundwater salinity in the project vicinity be monitored before and after project implementation to detect any anomalies that may occur as a result of the project.

This monitoring and adaptive management section describes how groundwater salinity levels will be monitored and evaluated. It also outlines the process for determining if and when adaptive management actions will be implemented.

Monitoring Objective

The objective for monitoring groundwater salinity is to detect significant changes in post project groundwater salinity as compared to pre-project baseline conditions.

Hypotheses

Post project ground water salinity levels do not exceed pre project groundwater salinity levels.

Performance Parameter

Baseline monthly maximum groundwater salinity data from shallow groundwater wells adjacent to the restoration site will be used to evaluate post project groundwater salinity data.

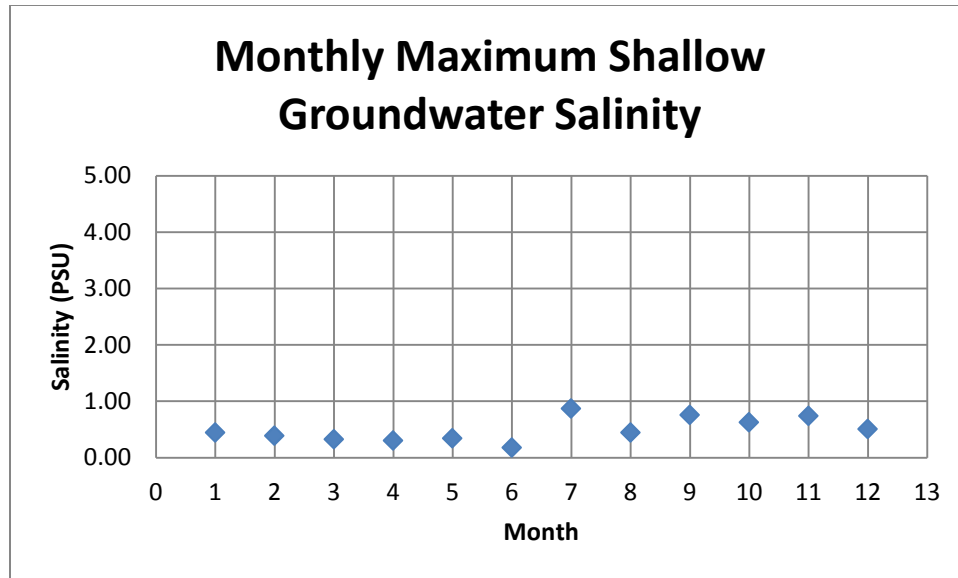


Figure 9. Pre-project monthly maximum salinity data

Monitoring Methods

Groundwater salinity is being monitored prior to project construction, and will remain in place following project construction. Groundwater observation well installations include three pairs of (dual-depth) observation wells on WDFW and adjacent properties (see Figure 6). Each well pairing is installed with one well in the shallow, estuarine, slightly clayey SILT/upper farm soil layer, and the second well located in the underlying, slightly silty sand, alluvial layer. Wells were installed in June of 2013 (Shannon & Wilson, 2014).

Groundwater salinity is monitored using 6 Solinst Model 3001 LTC surface water data loggers, which measure pressure (used to calculate water surface elevation), temperature, and conductivity (used with temperature and pressure data to calculate the salinity of the water) (Shannon & Wilson, 2014).

Detailed information on these loggers is available at: <http://solinst.com/products/dataloggers-and-telemetry/3001-levellogger-series/ltc-levellogger-junior/datasheet.php>. Each logger is set to record a pressure/temperature/conductivity reading on a 15-minute interval. Data is downloaded from each logger in the field every 3 to 4 months. For detailed instructions on data download procedures, see Appendix A).

Salinity at each well location is calculated using conductivity, temperature, and depth readings that are recorded on 15-minute intervals. Salinity is computed and converted to practical salinity units (PSU) using the UNESCO International Equation of State (IES 80) as described in Fofonoff (1985).

The groundwater salinity data will be used to establish baseline relationship between daily average groundwater salinity at shallow and deep wells.

Performance Threshold

The performance threshold for this objective is a change in monthly maximum groundwater salinity in shallow groundwater.

Adaptive Management Action(s)

If the post-project maximum monthly salinity is different than the pre-project maximum monthly salinity, WDFW will further evaluate the post project groundwater salinity data to determine if the ground water salinity during the time period February 16 – May 31 has exceeded 5ppm for 24 hours and if the groundwater level inundated the root zone (24 inches).

The root zone refers to the depth of soil used by the main body of the plant roots to obtain most of the stored moisture and plant food under proper irrigation (NRCS, 2005). Root zone depths for crops typically grown in the project vicinity range from 6 to 18 inches (NRCS, 2005). This adaptive management action threshold uses a critical root zone depth of 24 inches (2 feet) as a conservative estimate. The commercial crops grown in the project area and on Fir Island can tolerate water salinity levels up to 5 ppm without effecting the growth, health and productivity of the crops.

If it is determined that the groundwater salinity exceeded 5ppm and inundated the root zone (24 inches) for 24 hours during the growing season, WDFW will consult with CDD#22 and determine if and when the following adaptive management actions will be implemented.

The following adaptive management actions are proposed:

1. Determine whether farming practices have changed in the watershed that could potentially elevate ground water salinity.

Monitoring Schedule

Baseline data will be collected as described above and compiled annually from June 2013 to August 2016. Post construction data collection will occur as described above and compiled annually from September 2017 through 2019.

References

- Fofonoff, N. P., "Physical Properties of Seawater: A New Salinity Scale and Equation of State of Seawater," Journal of Geophysical Research, Vol 90 No. C2, pp 3332-3342, March 20, 1985.
- Natural Resources Conservation Service (NRCS), 2005, National Engineering Handbook, Part 632 Irrigation Guide, Chapter 13, Quality of Water Supply.
- Shannon & Wilson, Inc., 2014, Fir Island Farm Final Design and Permitting, Draft Coastal Engineering Report, Skagit County Washington: Report prepared by Shannon & Wilson. Inc, Seattle, Wash., 21-1-12318-217, for Washington Department of Fish and Wildlife, Olympia, Wash., January 10, 2014.
- Shannon & Wilson, Inc., 2014, Fir Island Farm Final Design and Permitting, Draft Interior Drainage Engineering Report, Skagit County Washington: Report prepared by Shannon & Wilson. Inc, Seattle, Wash., 21-1-12318-216, for Washington Department of Fish and Wildlife, Olympia, Wash., February 26, 2014.

4.7 Priority 2: Agricultural Objective Surface Water Salinity Protection

Written by Brian Williams, Bob Barnard and Loren Brokaw, Washington Department of Fish and Wildlife

Introduction

The greater Skagit Delta area, including properties adjacent to the project site, is extensively used for crop farming. Levees, dikes, tidegates, and drainage ditches were installed in the Skagit Delta beginning in the 1860s to expand and improve the agricultural area in the delta. The tidegates and other drainage infrastructure inhibit tidal processes that are not conducive to farming, including salt intrusion into the surface water. Surface water salinity is important because crops have salinity tolerance thresholds that, if surpassed, will damage or kill crops (NRCS, 2005).

The proposed project involves altering infrastructure that inhibits groundwater salt intrusion, including removal and installation of two new tidegate structures, and construction of over 5,000 linear feet of a new setback dike (Shannon & Wilson, 2014). Proposed new infrastructure is designed to maintain or reduce surface water salinity levels, in reference to adjacent farming activities (Shannon & Wilson, 2014). However, it is recommended that surface water salinity in the project vicinity be monitored before and after project implementation to detect any anomalies that may occur as a result of the project.

This monitoring and adaptive management section describes how surface water salinity levels will be monitored and evaluated. It also outlines the process for determining if and when adaptive management actions will be implemented.

Monitoring Objective

The objective for monitoring surface water salinity is to detect significant changes in post project surface water salinity from pre-project baseline conditions.

Hypotheses

Post project surface water salinity levels do not exceed pre project surface water salinity levels.

Performance Parameter

The moving 7-day average surface water salinity data from immediately upstream of the tidegates in Brown Slough, Dry Slough and No Name Slough (February 16 – October 15) will be used to surface water salinity.

Monitoring Method

Surface water salinity level data will be collected before and after project construction. Surface water salinity level data will be collected from seven surface water monitoring stations installed on the site (see Figure 6). Four of these sites are located landward of the setback dike location and tidegates and will be the stations used to monitor this parameter. These four sites are labeled SW-BS-3.1-LTC, SW-NNS-2.1-LTC, SW-DS-1.1-LTC, and SW-DS-1.3-LTC. Surface water monitoring stations were installed in June of 2013 (Shannon & Wilson, 2014).

Surface water salinity levels will be monitored using Solinst Model 3001 LTC surface water data loggers, which measure pressure (used to calculate water surface elevation), temperature, and conductivity (Shannon & Wilson, 2014). Detailed information on these loggers is available at: <http://solinst.com/products/dataloggers-and-telemetry/3001-levellogger-series/ltc-levellogger-junior/datasheet.php>. Each logger is set to record a pressure reading on a 15-minute interval. Data are downloaded from each logger in the field every 3-4 months. For detailed instructions on data download procedures, see Appendix A).

Salinity at each monitoring location is calculated using conductivity, temperature, and depth readings that are recorded on 15-minute intervals. Salinity is computed and converted to practical salinity units (PSU) using the UNESCO International Equation of State (IES 80) as described in Fofonoff (1985).

Performance Threshold

Surface water salinity data are variable depending on the location of the data logger. Locations on seaward side of the existing dike (SW-BS_3.0, SW-NNS-2.0, and SW-DS-1.0) generally indicate higher and more variable salinity values. Locations on the landward side of the existing dike show less variability and lower salinity values.

The performance threshold for this adaptive management plan will only evaluate surface water salinity in monitoring locations landward of the new dike (SW-BS-3.1, SW-NNS-2.1, and SW-DS-1.1 and 1.3). In general, the pre-project data indicate a trend of gradually declining salinity levels through the winter, spring, and summer, with a spike in the late fall (mid to late October). The performance threshold for this objective is an increase in the moving 7-day average pre-project salinity as compared to post-project salinity during the months critical to soil preparation for crop production (February 16 – October 15).

Adaptive Management Action(s)

If the post project correlation between the moving 7-day average surface water salinity data during the months critical to soil preparation for crop production (February 16 – October 15) exceeds the pre-project moving 7-day average WDFW will:

Further evaluate the post project surface water salinity data to determine if the surface water salinity during the growing season has exceeded 5ppm for 24 hours and further evaluate the post project surface water level data for the period of time when the surface water salinity exceeded the baseline and 5ppm to determine if the surface water level inundated the root zone (24 inches).

The root zone refers to the depth of soil used by the main body of the plant roots to obtain most of the stored moisture and plant food under proper irrigation (NRCS, 2005). Root zone depths for crops typically grown in the project vicinity range from 6 to 18 inches (NRCS, 2005). This adaptive management action threshold uses a critical root zone depth of 24 inches (2 feet) as a conservative estimate. The commercial crops grown in the project area and on Fir Island can tolerate water salinity levels up to 5 ppm without effecting the growth, health and productivity of the crops.

If it is determined that the groundwater salinity exceeded the baseline moving 7-day average and 5ppm and inundated the root zone (24 inches) for 24 hours during the growing season, WDFW will consult

with CDD#22 and determine if and when the following adaptive management actions will be implemented per the decision framework presented in section 3.3.4 of the Plan.

The following adaptive management actions are proposed:

- Determine whether farming practices have changed in the watershed that could potentially elevate surface water salinity.
- Reduced pumping in No Name Slough to mitigate potential surface water salinity effects.

Monitoring Schedule

Baseline data will be collected as described above and compiled annually from June 2013 to August 2016. Post construction data collection will occur as described above and compiled annually from September 2017 through 2019.

References

- Fofonoff, N. P., "Physical Properties of Seawater: A New Salinity Scale and Equation of State of Seawater," *Journal of Geophysical Research*, Vol 90 No. C2, pp 3332-3342, March 20, 1985.
- Natural Resources Conservation Service (NRCS), 2005, *National Engineering Handbook*, Part 632 Irrigation Guide, Chapter 13, Quality of Water Supply.
- Parametrix, 2010. *Fisher Slough Tidal Marsh Restoration Monitoring and Adaptive Management Plan*. Prepared by Parametrix, Bellevue, Washington for The Nature Conservancy. September 2010.
- Shannon & Wilson, Inc., 2014, *Fir Island Farm Final Design and Permitting, Draft Coastal Engineering Report*, Skagit County Washington: Report prepared by Shannon & Wilson. Inc, Seattle, Wash., 21-1-12318-217, for Washington Department of Fish and Wildlife, Olympia, Wash., January 10, 2014.
- Shannon & Wilson, Inc., 2014, *Fir Island Farm Final Design and Permitting, Draft Interior Drainage Engineering Report*, Skagit County Washington: Report prepared by Shannon & Wilson. Inc, Seattle, Wash., 21-1-12318-216, for Washington Department of Fish and Wildlife, Olympia, Wash., February 26, 2014.

4.8 Priority 2: Agricultural Objective: Surface Water Drainage Protection

Written by Bob Barnard, Brian Williams and Loren Brokaw, Washington Department of Fish and Wildlife

Introduction

The greater Skagit Delta area, including properties adjacent to the project site, is extensively used for farming. Levees, dikes, tidegates, and drainage ditches were installed in the Skagit Delta beginning in the 1860s to prevent river and tidal flooding and to provide the drainage necessary for agricultural use. In addition to affecting when farmers can access their fields in the spring, surface water and groundwater levels are important because crops have tolerance thresholds to root zone inundation (NRCS, 2005).

The Project will change the existing drainage infrastructure in by setting back the existing flood dike, relocating two tidegates in No Name Slough, installing a new tidegate in Dry Slough, installing a new interior drainage storage pond, installing two new floodgates between Dry Slough and the new drainage storage pond, and installing a new pump station (Shannon & Wilson, 2014). The new drainage infrastructure is designed to mitigate impacts to surface water levels caused by the project, in reference to adjacent farming activities (Shannon & Wilson, 2014). However, it is recommended that surface water levels in the project vicinity be monitored before and after project implementation to detect any unexpected anomalies that may occur as a result of the project.

This monitoring and adaptive management section describes how surface water levels will be monitored and evaluated. It also outlines the process for determining if and when adaptive management actions will be implemented. Given that the restoration design intentionally avoids impact to Brown and Dry Sloughs, this monitoring and adaptive management section addresses No Name Slough, Brown Slough, and Dry Slough independently.

NO NAME SLOUGH

Monitoring Objective

The project is not expected to increase the pre project baseline water surface levels immediately upstream of the new No Name Slough tidegate by more than 0.9 feet. The objective of collecting and evaluating the pre project and post project surface water elevation monitoring data is to determine whether the No Name Slough surface water elevations are responding to the restoration project consistent with pre project expectations (0.9 feet above baseline conditions).

Hypotheses

Post project surface water levels to not exceed 0.9 feet above baseline conditions and are within the expected range of variation based on the pre-project baseline surface water levels.

Performance Threshold

The 7-day maximum surface water level measured immediately upstream of the No Name Slough tidegates correlated to the corresponding total 7-day rainfall from the Fir Island weather station.

Monitoring Method

Surface water level data will be collected before and after project construction. Surface water level data for No Name Slough will be collected from two surface water monitoring stations, SW-NNS-2.0-LTC and SW-NNS-2.1-LTC as shown in Figure 6. Site SW-NNS – 2.0 will be relocated TBD following construction. These surface water monitoring stations were installed in June of 2013 (Shannon & Wilson, 2014).

Surface water levels will be monitored using Solinst Model 3001 LTC surface water data loggers, which measure pressure (used to calculate water surface elevation), temperature, and conductivity (Shannon & Wilson, 2014). Detailed information on these loggers is available at:

<http://solinst.com/products/dataloggers-and-telemetry/3001-levellogger-series/ltc-levellogger-junior/datasheet.php>. One barometric data logger, which measures air pressure and temperature only, was also deployed to collect data used to compensate for air pressure readings of the water pressure data loggers (Shannon & Wilson, 2014). Each logger is set to record a pressure reading on a 15-minute interval. Data are downloaded from each logger in the field every 3-4 months. For detailed instructions on data download procedures, see Appendix A).

Surface water levels at each station are calculated using pressure readings that are recorded on 15-minute intervals, which are tied to a permanent vertical datum and compensated with data collected from the barometric data logger. The top of the stand pipe at each monitoring station has been surveyed and tied to local survey control. The offset level between the top of stand pipe and the water surface is measured at the time of download to tie into the local survey control.

Rainfall duration and intensity can influence the level of the surface water on Fir Island and at the project site. Surface water elevation data will be used to establish baseline 7-day maximum for the surface water elevation. The rainfall data from the Fir Island weather station for this same period of time will be used to establish baseline total 7-day rainfall. The baseline 7-day maximum surface water elevation will be correlated with the total 7-day rainfall to establish a baseline. The post project 7-day maximum surface water level will be compared to the baseline range for that same week of the month taking into consideration the weekly rainfall and the tidal sequence. An example of the data discussed is shown in the chart below.

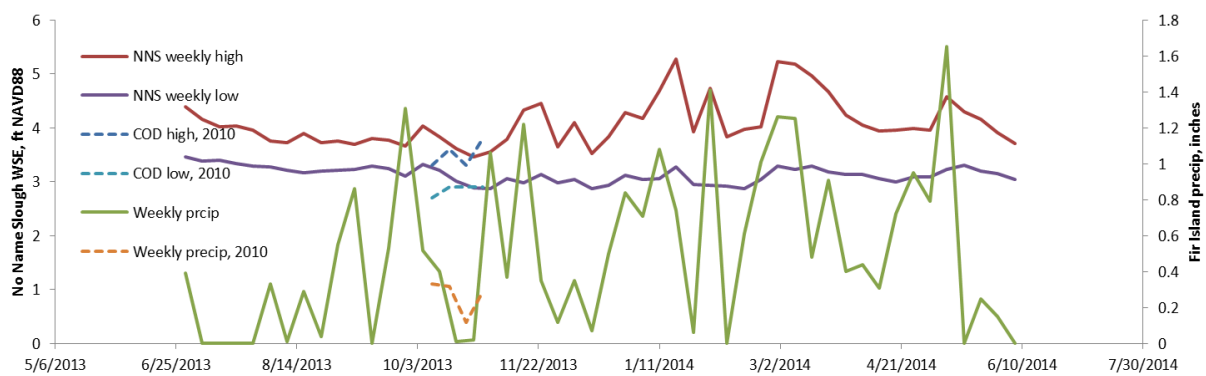


Figure 10.

The chart shows the weekly (Sunday to Saturday) maximum and minimum water surface elevation in No Name Slough (red and blue lines). The weekly precipitation at the WSU Fir Island weather station is shown as a green line. Maximum water surface elevation clearly responds to spikes in rainfall, although the response is not always the same due in part to the tidal sequence (spring vs. neap tide), groundwater elevation, and longer patterns of precipitation. Four weeks of data was also available for October, 2010, although it is hard to see how this fits in as a trend without a longer period of record.

For any given 1 week period, post-project water surface elevation can be compared to pre-project conditions as a function of precipitation.

Performance Threshold

The performance threshold for this objective is the baseline correlation between the 7-day maximum surface water elevation from immediately upstream of the tidegates in Brown Slough, Dry Slough and No Name Slough and the total 7-day rainfall from the Fir Island weather station.

In the chart below the maximum WSE for the first week of October is shown for the years 2010 and 2013 with the corresponding total rainfall for that week. There is, in this case, a positive correlation between rainfall and WSE. We would expect that if there was an increase in rainfall, there would be an increase in maximum WSE, as shown by letter “a” – the implication is that there is range of expected values, roughly represented by the shaded area.

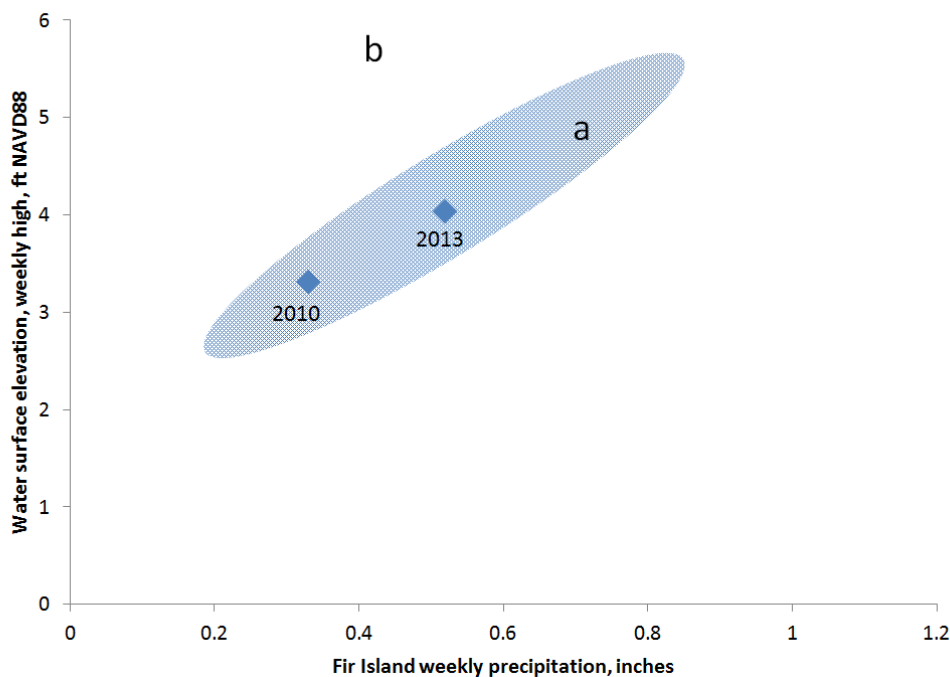


Figure 11

On the other hand, if the WSE is quite a bit higher for a given rainfall, like “b,” then we would suspect either non-project-related factors (tidal sequence, high groundwater, or longer term precipitation totals) or a project-related factor.

Adaptive Management Action(s)

Step 1: The surface water elevation data will be used to establish pre project and post project correlations between the 7-day maximum surface water level and total 7-day average rainfall data from the Fir Island weather station.

Step 2: If the post project surface water elevation data exceed the expected range of correlation variation, WDFW will further evaluate the post project surface water elevation data to identify whether the exceedance is related to project related or non-project related influences.

Step 3: If the exceedance is related to project related influences, WDFW and CDD#22 will work together to alleviate the project related influence.

Step 4: If the exceedance is related to non-project influences, CDD#22 can choose to implement actions to alleviate the non-project related influences.

Monitoring Schedule

Baseline data will be collected as described above and compiled annually from June 2013 to August 2016. Post construction data collection will occur as described above and compiled annually from September 2017 through 2019.

BROWN SLOUGH

Monitoring Objective

The project is not expected to increase the pre project baseline water surface levels in Brown Slough. The objective of collecting and evaluating the pre project and post project surface water elevation monitoring data is to determine whether the Brown Slough surface water elevations are affected by the restoration project.

Hypotheses

Post project surface water levels are within the expected range of variation based on the pre-project baseline surface water levels.

Performance Parameter

The 7-day maximum surface water level measured immediately upstream of the No Name Slough tidegates correlated to the corresponding total 7-day rainfall from the Fir Island weather station.

Monitoring Method

Surface water level data will be collected before and after project construction. Surface water level data for Brown Slough will be collected from two surface water monitoring stations, SW-NNS-2.0-LTC and SW-BS-3.1-LT as shown in Figure 6. Site SW-NNS – 2.0 will be relocated TBD following construction. These surface water monitoring stations were installed in June of 2013 (Shannon & Wilson, 2014).

Surface water levels will be monitored using Solinst Model 3001 LTC surface water data loggers, which measure pressure (used to calculate water surface elevation), temperature, and conductivity (Shannon & Wilson, 2014). Detailed information on these loggers is available at:

<http://solinst.com/products/dataloggers-and-telemetry/3001-levellogger-series/ltc-levellogger-junior/datasheet.php>. One barometric data logger, which measures air pressure and temperature only, was also deployed to collect data used to compensate for air pressure readings of the water pressure data loggers (Shannon & Wilson, 2014). Each logger is set to record a pressure reading on a 15-minute interval. Data are downloaded from each logger in the field every 3-4 months. For detailed instructions on data download procedures, see Appendix A).

Surface water levels at each station are calculated using pressure readings that are recorded on 15-minute intervals, which are tied to a permanent vertical datum and compensated with data collected from the barometric data logger. The top of the stand pipe at each monitoring station has been surveyed and tied to local survey control. The offset level between the top of stand pipe and the water surface is measured at the time of download to tie into the local survey control.

Rainfall duration and intensity can influence the level of the surface water on Fir Island and at the project site. Surface water elevation data will be used to establish baseline 7-day maximum for the surface water elevation. The rainfall data from the Fir Island weather station for this same period of time will be used to establish baseline total 7-day rainfall. The baseline 7-day maximum surface water elevation will be correlated with the total 7-day rainfall to establish a baseline. The post project 7-day maximum surface water level will be compared to the baseline range for that same week of the month taking into consideration the weekly rainfall and the tidal sequence. An example of the data discussed is shown in the chart above in the No Name Slough section.

The chart shows the weekly (Sunday to Saturday) maximum and minimum water surface elevation in No Name Slough (red and blue lines). The weekly precipitation at the WSU Fir Island weather station is shown as a green line. Maximum water surface elevation clearly responds to spikes in rainfall, although the response is not always the same due in part to the tidal sequence (spring vs. neap tide), groundwater elevation, and longer patterns of precipitation. Four weeks of data was also available for October, 2010, although it is hard to see how this fits in as a trend without a longer period of record.

For any given 1 week period, post-project water surface elevation can be compared to pre-project conditions as a function of precipitation.

Performance Threshold

The performance threshold for this objective is the baseline correlation between the 7-day maximum surface water elevation from immediately upstream of the tidegates in Brown Slough, Dry Slough and No Name Slough and the total 7-day rainfall from the Fir Island weather station.

In the chart above in the No Name Slough section, the maximum WSE for the first week of October is shown for the years 2010 and 2013 with the corresponding total rainfall for that week. There is, in this case, a positive correlation between rainfall and WSE. We would expect that if there was an increase in rainfall, there would be an increase in maximum WSE, as shown by letter “a” – the implication is that there is range of expected values, roughly represented by the shaded area.

On the other hand, if the WSE is quite a bit higher for a given rainfall, like “b,” then we would suspect either non-project-related factors (tidal sequence, high groundwater, or longer term precipitation totals) or a project-related factor.

Adaptive Management Action(s)

Step 1: The surface water elevation data will be used to establish pre project and post project correlations between the 7-day maximum surface water level and total 7-day average rainfall data from the Fir Island weather station.

Step 2: If the post project surface water elevation data exceed the expected range of correlation variation, WDFW will further evaluate the post project surface water elevation data to identify whether the exceedance is related to project related or non-project related influences.

Step 3: If the exceedance is related to project related influences, WDFW and CDD#22 will work together to alleviate the project related influence.

Step 4: If the exceedance is related to non-project influences, CDD#22 can choose to implement actions to alleviate the non-project related influences.

Monitoring Schedule

Baseline data will be collected as described above and compiled annually from June 2013 to August 2016. Post construction data collection will occur as described above and compiled annually from September 2017 through 2019.

DRY SLOUGH

Monitoring Objective

The project is not expected to increase the pre project baseline water surface levels immediately upstream of the new Dry Slough tidegate. The objective of collecting and evaluating the pre project and post project surface water elevation monitoring data is to determine whether the Dry Slough surface water elevations are responding to the restoration project consistent with pre project expectations.

Hypotheses

Post project surface water levels are within the expected range of variation based on the pre-project baseline surface water levels.

Performance Parameter

The 7-day maximum surface water level measured immediately upstream of the No Name Slough tidegates correlated to the corresponding total 7-day rainfall from the Fir Island weather station.

Monitoring Method

Surface water level data will be collected before and after project construction. Surface water level data for Dry Slough will be collected from two surface water monitoring stations, SW-DS-1.1-LTC and SW-DS-1.0-LTC as shown in Figure 6. These surface water monitoring stations were installed in June of 2013 (Shannon & Wilson, 2014).

Surface water levels will be monitored using Solinst Model 3001 LTC surface water data loggers, which measure pressure (used to calculate water surface elevation), temperature, and conductivity (Shannon & Wilson, 2014). Detailed information on these loggers is available at: <http://solinst.com/products/dataloggers-and-telemetry/3001-levellogger-series/ltc-levellogger-junior/datasheet.php>. One barometric data logger, which measures air pressure and temperature only, was also deployed to collect data used to compensate for air pressure readings of the water pressure data loggers (Shannon & Wilson, 2014). Each logger is set to record a pressure reading on a 15-minute interval. Data are downloaded from each logger in the field every 3-4 months. For detailed instructions on data download procedures, see Appendix A).

Surface water levels at each station are calculated using pressure readings that are recorded on 15-minute intervals, which are tied to a permanent vertical datum and compensated with data collected from the barometric data logger. The top of the stand pipe at each monitoring station has been surveyed and tied to local survey control. The offset level between the top of stand pipe and the water surface is measured at the time of download to tie into the local survey control.

Rainfall duration and intensity can influence the level of the surface water on Fir Island and at the project site. Surface water elevation data will be used to establish baseline 7-day maximum for the surface water elevation. The rainfall data from the Fir Island weather station for this same period of time will be used to establish baseline total 7-day rainfall. The baseline 7-day maximum surface water elevation will be correlated with the total 7-day rainfall to establish a baseline. The post project 7-day maximum surface water level will be compared to the baseline range for that same week of the month taking into consideration the weekly rainfall and the tidal sequence. An example of the data discussed is shown in the chart below.

The chart above in the No Name Slough section shows the weekly (Sunday to Saturday) maximum and minimum water surface elevation in No Name Slough (red and blue lines). The weekly precipitation at the WSU Fir Island weather station is shown as a green line. Maximum water surface elevation clearly responds to spikes in rainfall, although the response is not always the same due in part to the tidal sequence (spring vs. neap tide), groundwater elevation, and longer patterns of precipitation. Four weeks of data was also available for October, 2010, although it is hard to see how this fits in as a trend without a longer period of record.

For any given 1 week period, post-project water surface elevation can be compared to pre-project conditions as a function of precipitation.

Performance Threshold

The performance threshold for this objective is the baseline correlation between the 7-day maximum surface water elevation from immediately upstream of the tidegates in Brown Slough, Dry Slough and No Name Slough and the total 7-day rainfall from the Fir Island weather station.

In the chart above in the No Name Slough section, the maximum WSE for the first week of October is shown for the years 2010 and 2013 with the corresponding total rainfall for that week. There is, in this case, a positive correlation between rainfall and WSE. We would expect that if there was an increase in

rainfall, there would be an increase in maximum WSE, as shown by letter “a” – the implication is that there is range of expected values, roughly represented by the shaded area

On the other hand, if the WSE is quite a bit higher for a given rainfall, like “b,” then we would suspect either non-project-related factors (tidal sequence, high groundwater, or longer term precipitation totals) or a project-related factor.

Adaptive Management Action(s)

Step 1: The surface water elevation data will be used to establish pre project and post project correlations between the 7-day maximum surface water level and total 7-day average rainfall data from the Fir Island weather station.

Step 2: If the post project surface water elevation data exceed the expected range of correlation variation, WDFW will further evaluate the post project surface water elevation data to identify whether the exceedance is related to project related or non-project related influences.

Step 3: If the exceedance is related to project related influences, WDFW and CDD#22 will work together to alleviate the project related influence.

Step 4: If the exceedance is related to non-project influences, CDD#22 can choose to implement actions to alleviate the non-project related influences.

Monitoring Schedule

Baseline data will be collected as described above and compiled annually from June 2013 to August 2016. Post construction data collection will occur as described above and compiled annually from September 2017 through 2019.

References

- Natural Resources Conservation Service (NRCS), 2005, National Engineering Handbook, Part 632 Irrigation Guide, Chapter 8, Project and Farm Water Irrigation Requirements.
- Shannon & Wilson, Inc., 2014, Fir Island Farm Final Design and Permitting, Draft Coastal Engineering Report, Skagit County Washington: Report prepared by Shannon & Wilson. Inc, Seattle, Wash., 21-1-12318-217, for Washington Department of Fish and Wildlife, Olympia, Wash., January 10, 2014.
- Shannon & Wilson, Inc., 2014, Fir Island Farm Final Design and Permitting, Draft Interior Drainage Engineering Report, Skagit County Washington: Report prepared by Shannon & Wilson. Inc, Seattle, Wash., 21-1-12318-216, for Washington Department of Fish and Wildlife, Olympia, Wash., February 26, 2014.

4.9 Priority 3: Ecological Objectives: Tidal Marsh Habitat Restoration – Cattail Response

Written by David Heimer, Washington Department of Fish and Wildlife

Introduction

Approximately 131 acres of farmland will be reconnected to Skagit Bay with the removal and setback of a proposed coastal levee (dike). The passive colonization of the former upland with native, salt marsh plants is expected to occur relatively quickly, creating new habitat for fish and wildlife, Hood 2009. *Typha latifolia*, native cattail, is a component of freshwater and brackish wetlands and may colonize the site. Distribution of *T. latifolia* is constrained by water depth and salinity. *T. latifolia* colonization at the project site will be managed in order to maintain a diverse plant community. The presence of highly competitive, non-native cattails and hybrids threatens this diversity and those noxious weed species will be removed (see section 4.1.1, Invasive Species). Native cattail response will be monitored by identifying and quantifying *T. latifolia* on the project site to create a baseline. Based on the project's proposed physical parameters (e.g. water depth), a target acreage for *T. latifolia* will be determined and changes in acreage and distribution will be monitored annually. This monitoring and adaptive management section describes how *T. latifolia* will be monitored and outlines the decision structure for determining whether or not adaptive management actions are triggered.

Monitoring Objective

The objective for monitoring native cattail response is to ensure the establishment of a beneficial wetland plant at a level and distribution that increases the habitat value of restoration site.

Hypotheses

Unmanaged colonization of the restoration site by native cattail, *Typha latifolia*, threatens the species diversity of the restored tidal marsh.

Performance Parameter

The acreage of *T. latifolia* will be estimated and the locations recorded annually.

Monitoring Method

The project area will be surveyed by the weed control crew by moving through the marsh on foot and recording *T. latifolia* point data using a GPS device and estimated acreage. Surveys will occur once per year in the summer when cattail species are more easily identified and will occur concurrently with the survey for invasive cattails.

Performance Threshold

Adaptive management actions shall be triggered if WDFW determines that the area of *T. latifolia* exceeds the baseline area by more than 0.5 acres, not including areas such as drainage channel, or inpondments. *T. latifolia* in these areas will be maintained to allow adequate water flow and holding capacity for drainage.

Adaptive Management Action(s)

Adaptive management actions for *T. latifolia* will include a combination of methods to reduce the size and/or distribution of the plant across the project site. Methods can include mowing, crushing, digging and herbicide application. Herbicides are applied during low tide cycles to allow the uptake of the herbicide before the tide returns.

Monitoring Schedule

A preliminary baseline survey for *T. latifolia* will be conducted in the summer of 2016. Post construction monitoring of *T. latifolia* will occur once a year from 2017 to 2021.

References

Hood, G. 2009. Habitat Monitoring Strategy for the Tidal Skagit Delta.

5.0 WDFW MONITORING PRIORITIES

5.1 Monitoring Priority 1: Additional Ecological Objectives: Tidal Flooding

Written by Brian Williams, Washington State Department of Fish and Wildlife

Introduction

The proposed project is expected to restore the natural tidal processes of Skagit Bay to 131 acres of WDFW's 258 acre Fir Island Farm by setting back approximately 5,800 lineal feet of coastal dike as depicted in Figure 7 (Shannon and Wilson, 2014).



Figure 12. Project activities at the Fir Island Farm restoration site.

Monitoring Objective

The tidal flooding monitoring objective will determine the total area (acres) of the project site where tidal processes have been restored.

Hypotheses

Tidal processes will be restored to 131 acres of the restoration site.

Performance Parameter

The area of the project site that is at or below a tidal elevation of 13.0 feet (Mean Lower Low Water = 0.00).

Monitoring Method

Tidal datum references indicate that 13.0 feet (MLLW) is the typical extreme high tide observed at Swinomish and Crescent Harbor. The area of the project site that is at or below a tidal elevation of 13.0 feet (Mean Lower Low Water = 0.00) will be determined through the built site plan for the project site that will be developed in 2016 immediately prior to restoring tidal processes to the site.

Performance Threshold

None

Adaptive Management Actions(s)

None

Monitoring Schedule

A site plan will be developed in 2014 as part of the final restoration design plans for the project will be used to represent baseline pre-restoration conditions. An as-built site plan developed in 2016 immediately prior to restoring tidal processes to the site and will be used to determine the area of the site that is below the tidal elevation of 13.0 feet (MLLW = 0.00).

References

Shannon and Wilson. 2014. Fir Island Farm Draft 60% Design Report. Washington Dept., of Fish and Wildlife, Fir Island, Washington.

5.2 Monitoring Priority 1: Additional Ecological Objectives: Tidal Marsh Habitat Restoration - Sediment

Written by Bob Barnard, Washington Department of Fish and Wildlife

Introduction

The accretion rate and the relative elevation of the marsh surface are of vital importance for its development. Vegetation colonization and density are correlated to elevation relative to the tidal frame (Cornu and Sadro, 2002) and marsh vegetation is the basis of the food chain for the insects and animals that live there (Krone, 1993).

Soil texture and composition are fundamental to plant colonization and growth. When a marsh is restored the soil is a main determinate of success. Allowing the soil to naturally accrete insures that appropriate materials are available to form the substrate for a diverse and robust marsh community.

Tidal channels form a hydraulic and ecological function in the intertidal wetland. They must be sized appropriately for efficient tidal circulation and provide a corridor for the movement of organisms, nutrients and sediment in the marsh. These functions evolve over long periods of time under natural conditions. They begin on the mudflat as shallow depressions that develop into a complex, sinuous dendritic pattern. As the mudflat accretes, vegetation colonizes the surface and creates a more resistant root-soil matrix, setting the channels more firmly in place (Coats, Williams et al. 1995).

A conceptual model is often used as a basis for understanding the relationship between a restoration action and the functional responses expected. Figure 13 illustrates the conceptual model for Management Measure 3, Berm or Dike Removal or Modification, which begins with the reintroduction of tidal inundation (Clancy, Logan et al. 2009). Dike removal restores several processes, primarily the reintroduction of sediment, but also nutrients that feed wetland plants and various marine organisms. These restored processes bring about structural changes; increases in subsided surface elevation and recolonization of plants and animals, create the goods and services that are the goal of this restoration project. Diked wetland typically subside because the soil is drained, organic matter breaks down and the soil is compacted by farming operations. Additional sediment input has also been cut off and the tidal channel network has been largely erased. The accretion of sediment on the subsided surfaces critically tracks the marsh trajectory.

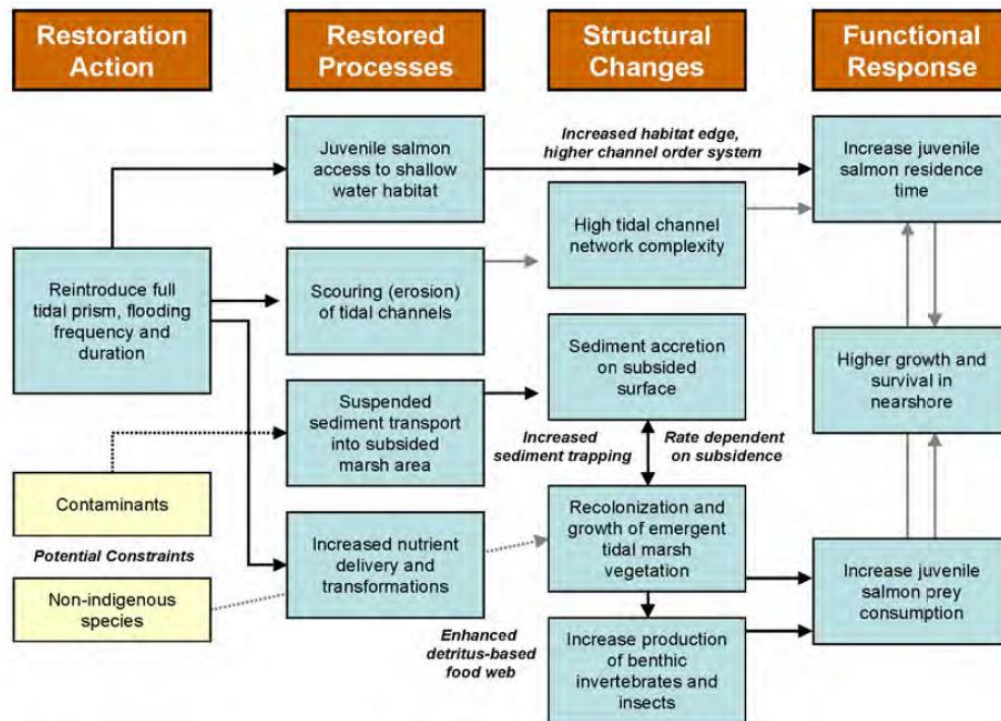


Figure 13: Conceptual model for MM 3 Berm or Dike Removal or Modification (Clancy, Logan et al. 2009).

There are a number of constraints and concerns regarding this restoration strategy, but the principle ones concern the recovery of the formerly diked wetland. The trajectory of the restored site is linked to sea level rise and the rate of accretion which diverges either to mudflat if accretion falls behind SLR, or follows an asymptotic path to high marsh. We do not know which path the marsh at Fir Island Farm will take but can monitor accretion rate and marsh elevation to plot its course.

Monitoring Objective

The purpose of this monitoring program to:

- 1) Establish the rate of accretion in various parts of the restored estuary.
- 2) Monitor the change in marsh surface elevation over time.
- 3) Determine the recovery trajectory toward high salt marsh or mudflat, and the future of the marsh with predicted sea level rise.

Hypotheses

The restored marsh surface elevation will change over time as a result of sediment erosion and deposition.

Performance Parameter

The performance parameter is the rate of sediment accretion and erosion on the site.

Monitoring Method

Two variables are linked in the evolution of the marsh; the sediment accretion rate and subsurface processes. One cannot simply measure the elevation of a marsh surface and know whether changes over time are due to sediment accumulation or erosion, as opposed to subsidence or expansion of the soils beneath it (Cahoon, 2000).

Accretion Rate

In order to measure surface sediment accretion without interference from subsurface processes, a marker horizon is placed near the surface as a reference to measure the change in depth of sediment. From the marker horizon one can determine the accretion rate, which is defined as the change in the vertical distance between the horizon and the sediment surface over a given length of time. For this study, marker horizons are placed around SET tables (see next section) and are 0.25m x 0.25m areas of the substrate that have been covered in a thin layer (1-2mm) of G200 feldspar clay. The white powdered clay is layered onto the existing marsh surface inside 0.25m x 0.25m quadrats, as sediment accretes it covers the clay. This accretion can be measured by freeze-coring within the quadrats and measuring the accreted sediment on top the white layer of clay (see Figure 9). The mean accretion rate is calculated by taking the average of the 3-4 measurements for one time period. The mean annual mean accretion rate is the total accretion divided by the number of years since the horizon was placed.



Figure 14: Free-core sample showing accretion above artificial horizon. (Image from USGS Surface Elevation Table website, Cahoon and Lynch).

rSET Device

The Rod Set Elevation Table (rSET) device can measure differences in surface elevation as they relate to sub surface processes with a high degree of accuracy. Used in combination with marker horizons, the rSet not only documents surface elevation change, but allows one to determine if the elevation change

is the result of subsurface or surface processes. Elevation is defined as the average surface level relative to an established benchmark. Since a natural soil surface can vary many millimeters over very short distances, a large number of measurements must be made. In addition, the soil surface is soft and the measuring device must apply a minimum amount of force on the surface. The Sediment Elevation Table (SET) is designed to determine the marsh surface elevation with a high degree of accuracy. The design and operation of the SET table is extensively covered in this web page:

<http://www.pwrc.usgs.gov/set/>

A typical rSET site is shown on Figure 10, with the rSET mounting base located in the center. Our experience has been that the corner posts must be stout, visible and deeply set – caution, 1/2" PVC pipe is way too small. Other configurations are possible. It is better to have two platform planks and a 3rd to bridge between them. The rSET base is supported by a stainless rod driven into the soil to the point of refusal with a jackhammer or post pounder. The top of the rod is cut off close to the surface and fitted with a receptacle that holds the rSET. Then the base is set in a concrete pedestal with a survey bench mark. The rSET sites are surveyed in to established bench marks to link to a datum.

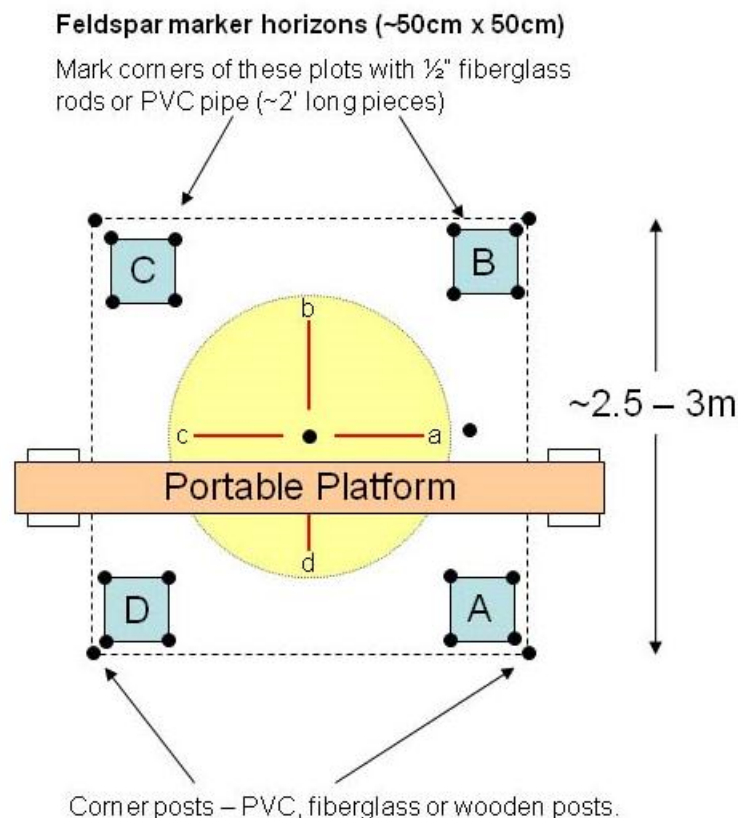


Figure 15: Typical rSET site (image from USGS Surface Elevation Table website, Cahoon and Lynch).

Monitoring data consists of offset distances from the rSET and accretion soil depths from the freeze cores. The offset distances are analyzed for mean and standard deviation and then converted to elevations based on the datum. The accretion depths are averaged and reported as accretion since the

establishment of the artificial horizon. Figure 11 is an example of rSET data from the Salmon Creek estuary (Discovery Bay) restoration project.

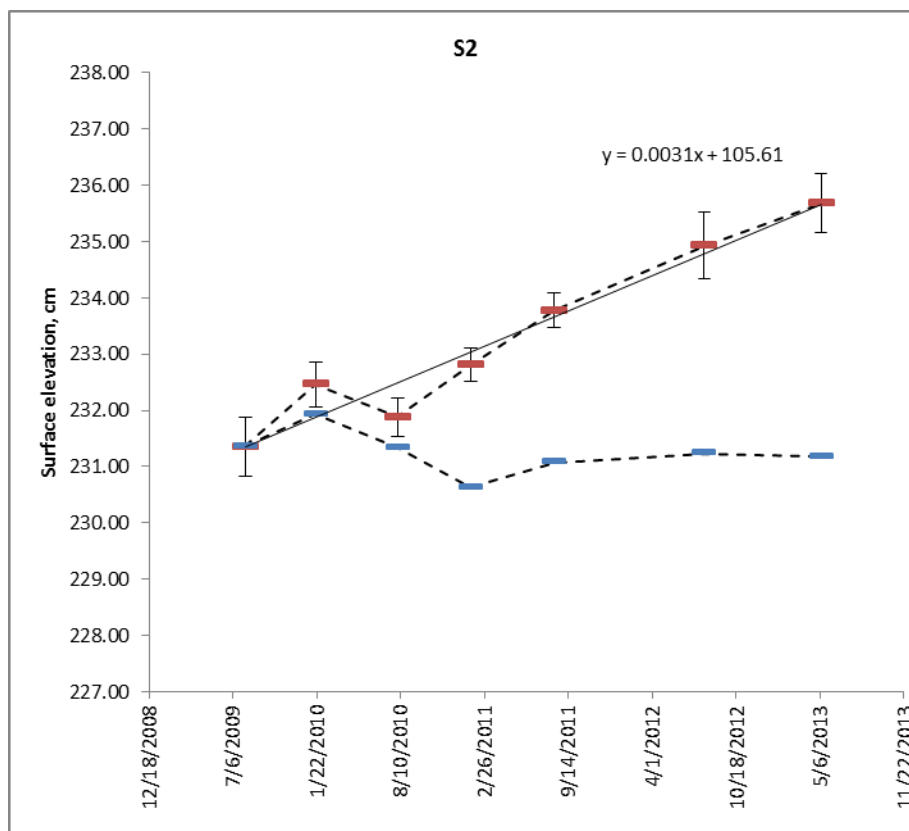


Figure 16: Monitoring results for Salmon Creek estuary as an example of rSET data (Barnard). Red bars are the surface elevation (with one standard deviation whiskers). The black solid line is the linear regression of elevation with the equation. Blue bars are the top surface of the artificial horizon. The difference between the red and blue bars is the depth of accreted material over time.

Three rSET sites will be established as shown in Figure 12. It is important to locate the sites away from areas that may erode, are likely to be tampered with, or are otherwise difficult to maintain. On the other hand, they have to be located correctly to capture prevailing trends in sediment accumulation. Site S1 is in a more quiescent area away from the main tidal channels but not at toe of the setback dike – an area that may be augmented with excavated soil for the dike removal or tidal channel construction. S2 is as close as possible to the main breach and the source of suspended sediment. Both S1 and S2 are at a similar elevation. S3 is located near the old sea dike and at a lower elevation with greater tidal residence time. Waves overtopping the existing exterior marsh surface could disturb this site so some investigations should be made prior to deploying. Establishing and monitoring these sites requires some heavy equipment, and the marsh surface can be quite soft, so access to them cannot be too difficult. S1 and S3 are relatively close to the new dike which will have a road on top. S2 is a long way from the dike and must be approached from the north east because No Name and Claude O Davis Sloughs may be full of water and not wadable.

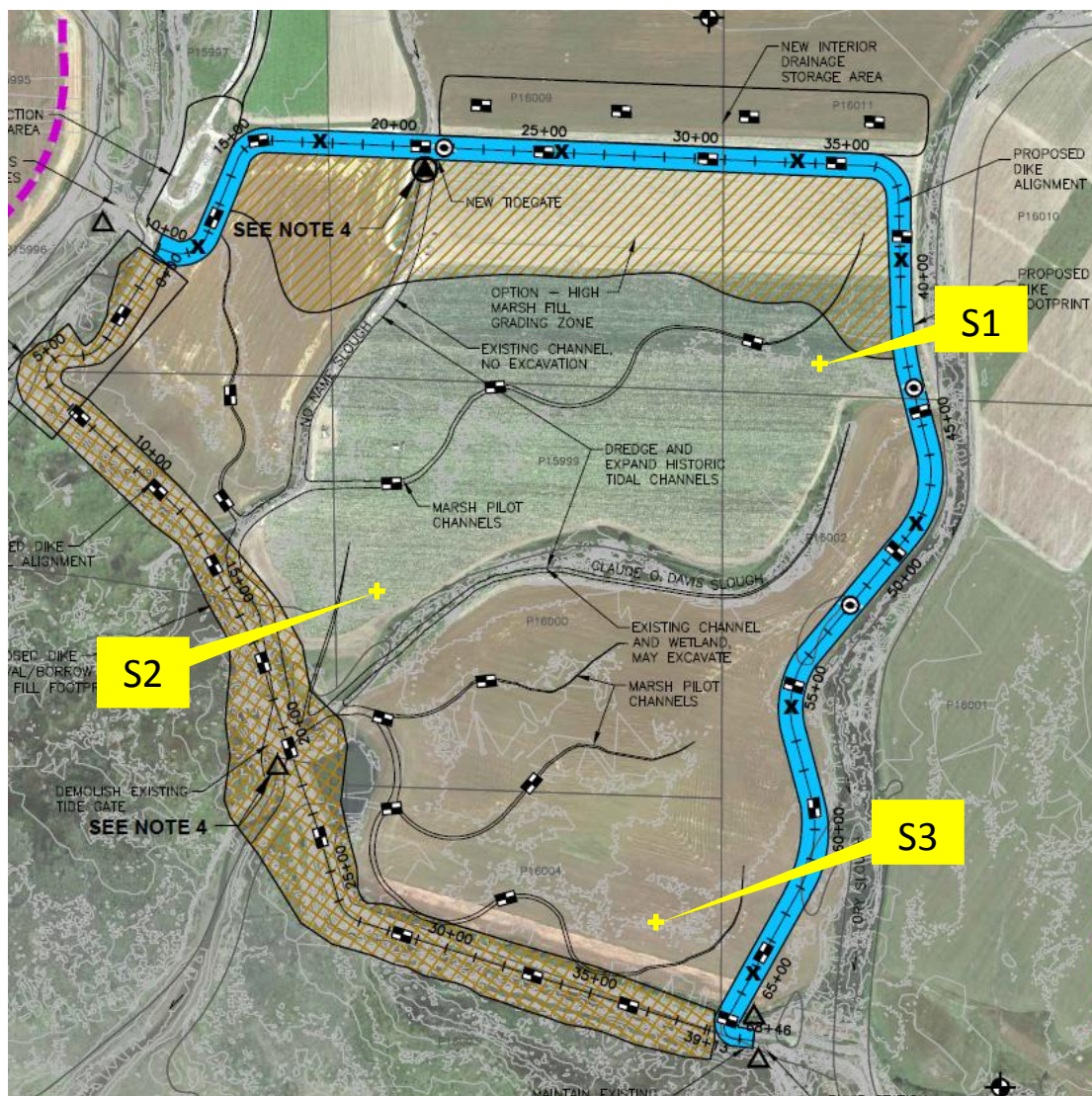


Figure 17: Location of the 3 sediment monitoring site, S1, S2, and S3.

Performance Threshold

None

Adaptive Management Action(s)

None

Monitoring Schedule

These sites should be established as soon after construction as possible to document the transition from dry agricultural field to estuarine wetland. The sites should be monitored at least yearly to establish a smooth curve of accretion and elevation data. The sites should also be visited several times a year to make sure that they have not been tampered with and so that any damage can be repaired. In particular, the corner posts and artificial horizons are easily disturbed.

References

- Cahoon, D. R., J. R. French, T. Spencer, D. Reed, I. Moller (2000). Vertical accretion versus elevation adjustment in UK saltmarshes: an evaluation of alternative methodologies. *Coastal and estuarine environments: sedimentology, geomorphology, and geoarchaeology*. London, Geological Society of London: 223-238.
- Carr, A. P. and M. W. L. Blackley (2006). "Seasonal changes in surface level of a salt marsh creek." *Earth Surface Processes and Landforms* 11(4): 427-439.
- Clancy, M., I. Logan, et al. (2009). Management Measures for Protecting the Puget Sound Nearshore, Report No. 2009-01. Olympia, Washington, Puget Sound Nearshore Estuary Restoration Project.
- Coats, R. N., P. B. Williams, et al. (1995). Design guidelines for tidal channels in coastal wetlands. Conte Madera, CA, Phillip Williams and Associates.
- Cornu, C. E. and S. Sadro (2002). "Physical and functional responses to experimental marsh surface elevation manipulation in Coos Bay's South Slough." *Restoration Ecology* 10(3): 474-486.
- Krone, R. B. (1993). Fundamental principles of tidal wetland restoration *Hydraulic Engineering*, 1993. S. T. Su and F. Wang. San Francisco, CA.
- Mote, P., A. Petersen, et al. (2008). "Sea Level Rise in the Coastal Waters of Washington State." University of Washington Climate Impacts Group and the Washington Department of Ecology, University of Washington, Seattle: 11.
- Paquette, C. H., K. L. Sundberg, et al. (2004). "Changes in Saltmarsh Surface Elevation Due to Variability in Evapotranspiration and Tidal Flooding." *Estuaries* 27(1): pp. 82-89.

5.3 Monitoring Priority 1 Additional Ecological Objectives: Tidal Marsh Fir Island Farms Restoration

Written by W. Gregory Hood, PhD, Skagit River System Cooperative

Introduction

The Washington Department of Fish and Wildlife intends to restore 131 acres of their Fir Island Farm property to tidal inundation to restore tidal marsh habitat to benefit estuarine fish and wildlife, including threatened juvenile Chinook salmon. The proposed restoration site has a similar elevation range as the adjacent reference marsh just seaward of the dikes that will be breached to restored tidal inundation to the project site. Previous experience in restoration projects has shown that natural recruitment of seeds to sites with restored tidal hydrology results in rapid vegetation colonization of the restoration sites (i.e., within three years) especially when natural seed sources are nearby, but providing that site elevations are not too low (Hood, personal observations; see also Cornu & Sadro 2002, Leck 2003, Tuxen et al. 2008, Diggory & Parker 2010, Erfanzadeh et al. 2010, Brand et al. 2012, Hood 2013). The restoration site is adjacent to an approximately 0.3-mile wide band of tidal marsh that will easily supply the necessary seed source (Figure 18). Thus, there is little doubt the site will be naturally colonized by vegetation. Of greater interest is predicting which species will dominate, what will their spatial distribution be on the restoration site, how quickly will they become established, and how will the established vegetation compare to reference marsh conditions. This monitoring proposal describes how these questions can be answered through the use of an empirical predictive vegetation model (PVM) that has been developed by the Skagit River System Cooperative (SRSC). This model has been successfully applied in the Skagit Delta (Hood 2013) and is currently being employed for restoration design and monitoring in the Stillaguamish Delta by SRSC on behalf of the Stillaguamish Natural Resources Department. The PVM will use topography (elevation) and salinity to predict the spatial distribution tidal marsh plant species. Elevation is generally correlated to inundation frequency and duration, disturbance, and often other edaphic factors (Ewing 1983; Bertness and Ellison 1987) that have significant influence on tidal marsh vegetation. Soil pore water salinity is also a strong determinant of species distribution in tidal marshes.

In spite of the high likelihood of successful natural vegetation colonization, costly experimental seeding of common spikerush (*Eleocharis palustris*) and soft-stem bulrush (*Schoenoplectus tabernaemontani*) are also planned for a portion of the restoration site. The goal of this artificial seeding is to minimize weed establishment and kick-start native plant establishment on the restoration site. Thus, this monitoring proposal will also describe how the areas of artificial seeding will be compared to those of natural seed recruitment and to the reference tidal marshes (as represented by the PVM), with the ultimate goal of evaluating the cost/benefit of artificial seeding. The PVM will be essential to evaluate whether the species chosen for artificial seeding were actually appropriate, or whether artificial seeding can pre-empt colonization by seeds tidally transported from adjacent marshes and thereby displace species that might have established in the absence of artificial seeding.

It should be noted that the seeding plan also calls for seeding the entire restoration site with perennial ryegrass (*Lolium perenne*), white clover (*Trifolium repens*), and rough bluegrass (*Poa trivialis*) to

minimize weed establishment and reduce erosion during site grading and channel excavation prior to dike breaching. Because there is no control site, where site grading and excavation occur without this seeding, we cannot test the hypothesis that this treatment will actually reduce weed establishment or erosion. This is in contrast to the proposed seeding of spikerush and soft-stem bulrush, which will occupy only a fraction of the restoration site, allowing the remainder of the site to be a control for the artificial seeding treatment.

Monitoring Objectives

[1] Development and application of a PVM to predict areas of the site that are likely to be vulnerable to invasion by undesirable non-native species. These areas can then be targeted as requiring particular vigilance to detect and remove any invaders. [2] Use of the PVM to serve as a representation of natural reference marsh conditions against which the performance of the restoration site can be compared. Deviations from expectations can be further investigated to determine their cause and to take corrective action if necessary. Conformance to expectations can be used to document restoration success and to communicate this result to the public. [3] Evaluation of the benefit of artificial seeding of spikerush and soft-stem bulrush compared to passive recruitment and colonization of tidal marsh vegetation.

Hypotheses

The hypotheses tested by this monitoring plan are that [1] restoration of natural tidal hydrology will result in rapid (within 3-5 years) natural recruitment of colonizing vegetation to the restoration site, with the corollary [2] that there will be no significant difference (after 3-5 years) in species composition between the treatment (artificial seeding) and control (passive seed recruitment) sites for the experimental seeding plan; [3] species distributions will be constrained only by topography and salinity; and [4] the restoration site will resemble natural reference sites in the spatial distribution of dominant species of marsh vegetation.

Performance Parameter

The performance parameter will be statistically significant differences or similarities in the spatial distributions of dominant tidal marsh vegetation species in the restoration site compared to that predicted by an empirical model versus observed on the restoration site 1, 3, and 5 years following restoration of tidal hydrology, with particular reference to seeding treatment, i.e., artificial seeding of spikerush and soft-stem bulrush versus passive seed recruitment and vegetation colonization (e.g., Hood 2013). A dominant species is defined in this effort as a species that is locally abundant and characteristic of the tidal marsh. Typical examples in the Skagit Delta are *Carex lyngbyei*, *Schoenoplectus pungens*, *S. maritimus*, *S. tabernaemontani*, *Typha angustifolia*, *Eleocharis palustris*, *Agrostis stolonifera*, *Distichlis spicata*, *Myrica gale*, etc., depending on topography and soil salinity. Typically, a dominant species will have a canopy cover of > 20% in a given area.

Methods

Soil pore water salinity has been measured by SRSC at 1500 points throughout the Skagit Delta on a sampling grid with a resolution of 150 m. The marsh seaward of the Fir Island Farm restoration site has soil pore water salinities ranging from 5 to 13 ppt, during average river flow conditions. SRSC has also collected paired data on vegetation and elevation through RTK-GPS surveys (3 cm horizontal and vertical

resolution) throughout the delta. Approximately, 1000 vegetation-elevation data points were collected within the 5 to 13 ppt salinity range in the Skagit Delta, from which vegetation-elevation distributions have been constructed to predict vegetation spatial distributions following restoration of tidal hydrology to the restoration site (Figure 19). These data points are located primarily in the bay fringe tidal marshes adjacent to the Fir Island sea-dike. Additional points are located in portions of the South Fork and North Fork deltas that are in the same salinity zone. Vegetation elevation distributions will be applied to available lidar data to generate spatial probabilities of vegetation presence on the restoration site for native and non-native species typical of the Skagit Delta (e.g., Hood 2013). This PVM will essentially serve as a representation of natural reference site species distributions relative to elevation and salinity, the standard against which the restoration site performance can be measured. For example, by comparing the vegetation that develops in those portions of the site that are artificially seeded with spikerush and soft-stem bulrush to the spatially explicit PVM predictions we can evaluate whether the appropriate species were chosen for the seeding location or if artificial seeding was capable of overwhelming natural seed recruitment and displacing species that might have established otherwise.

The site performance will be monitored through RTK-GPS point samples of vegetation taken on a grid throughout the restoration site, with a grid resolution of 20 m and a sample size of approximately 1,200. Site performance will be evaluated by comparing model predictions to observed vegetation colonization (including non-native species) over time, as previously demonstrated by Hood (2013) elsewhere in the Skagit Delta. Spatial association of observed vegetation distributions with areas of relatively high predicted probability of occurrence (predicted “hotspots”) will be tested on three site types using bootstrap randomization of the empirical data. The first site type will be a reference marsh which was not used to generate the PVM. The role of testing this reference site will be to validate the model. Model development and validation will be a recursive process, terminating when predictions match observations. The second site type will be the portion of the restoration site that was artificially seeded in spikerush and soft-stem bulrush. The third site type will be the passively seeded and colonized portion of the restoration site. Distinct bootstrap tests will be made for each of the dominant species in each of the three site types. The observed quantity of occurrences of the tested species in the three site types will be randomly assigned to locations inside and outside the prediction hotspots. Through 10,000 simulations, the proportion of times that simulated occurrences within the hotspot equal or exceed the empirical data will be used as the p value for the randomization test (e.g., Hood 2013). It should be noted that the PVM has an explicitly spatial aspect, so traditional non-spatial statistical methods are weak tests of the model. For example, goodness of fit tests comparing the probability distributions (relative to elevation and salinity) of a given species between any two site types can be used to gain some insight into patterns, but the spatial association test is more rigorous and is more directly relevant to the question of where a given species is likely to become established in a given restoration site. An even weaker test would be analysis of similarity (ANOSIM), which is often used to compare community composition between restoration and reference sites, but which is completely insensitive to spatial pattern. As an exercise, the traditional statistical analysis will be carried out and compared to the PVM-based statistical analysis to contrast their strengths and weaknesses.

It should be noted that non-native, invasive plant species may be encountered on the restoration site during vegetation monitoring. The locations of these plants will be noted so that adaptive management efforts can be implemented. The PVM will also predict locations vulnerable to invasion by exotic species, and these areas can be targeted for greater scrutiny for invasion.

Monitoring Schedule

Baseline monitoring will take place in summer of 2015 to acquire vegetation/elevation data in reference mesohaline marshes at elevations comparable to the high points on the restoration site. This data will improve the predictive quality of the model at these elevations. By filling this data gap the predictive vegetation model (PVM) will be more robust. The PVM will be parameterized with this and existing data (1000 data points at lower elevations in mesohaline reference marshes). In 2016 the restoration site will be intensively surveyed with RTK-GPS (3-cm horizontal and vertical accuracy) to characterize the topography of the restoration site following site grading and channel excavation. A DEM (digital elevation model) will be constructed in a GIS from this survey data. Following this, a probabilistic predictions of species distributions will be generated for the restoration site using the previously parameterized PVM. Post-restoration vegetation sampling will take place during peak growing season in 2017 and 2018, following restoration of tidal hydraulics to the site. Results will be compared to PVM predictions each year. Ideally, additional monitoring should occur in 2019 and 2021, by which time vegetation colonization should be nearly complete and stabilizing.

Expected Results

Data collected by RTK-GPS from the tidal marsh adjacent to the restoration site, suggests most of the lower elevations of the site will be colonized by sedges typical of low-mesohaline Skagit Delta tidal marshes, i.e., *Schoenoplectus pungens*, *S. maritimus*, *S. tabernaemontani*, and *Carex lyngbyei* (Figure 18). However, modeling is still required for more quantitative predictions and to predict higher elevation vegetation distributions. Higher elevations could potentially be vulnerable to invasion by non-native narrow-leaf cattail, *Typha angustifolia*.

Pre-construction seeding of the site with ryegrass, clover, and bluegrass is unlikely to affect colonization by salt marsh vegetation. The seeded species are intolerant of tidal inundation and salinity. The portions of the site that will be artificially seeded with spikerush and soft-stem bulrush (the experiment) could have two possible outcomes: [1] the artificial seeding could fail because the experimental site is inappropriate for these species and thus the site will be colonized by other marsh species through passive seed recruitment, in which case the vegetation on the experimental portion of the restoration site will resemble that predicted by the PVM, as will the vegetation on the control site which will only be subject to passive seed recruitment; or [2] the artificial seeding could be successful and overwhelm the natural seed recruitment process so that the vegetation on the experimental site will differ from the PVM predictions, while the vegetation in the control site will resemble the PVM.

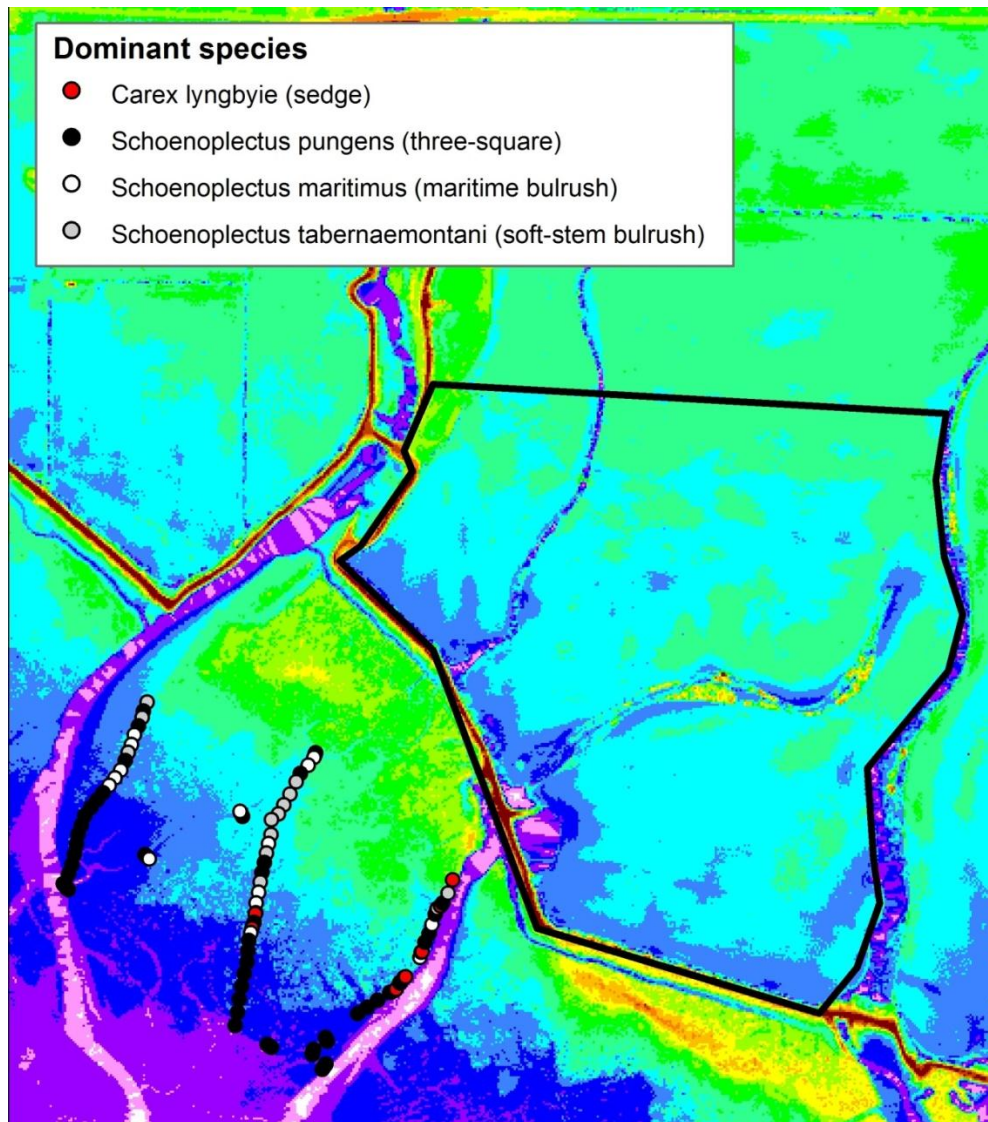


Figure 18. Outline of Fir Island Farm restoration site (black polygon) overlain on lidar-based elevation model. Adjacent, undiked, tidal marsh is located in the bottom-left portion of this image, from the lower right corner to the midpoint of the left edge of the figure. Cooler colors are lower in elevation; warmer colors are higher in elevation. The unvegetated tidal sand flat is approximated by the purple elevation zone; the lower limit of marsh vegetation is approximated by the blue-purple boundary. Colored points are RTK-GPS point samples of elevation and vegetation in the tidal marsh adjacent to the restoration site, and are color-coded to show the dominant species.

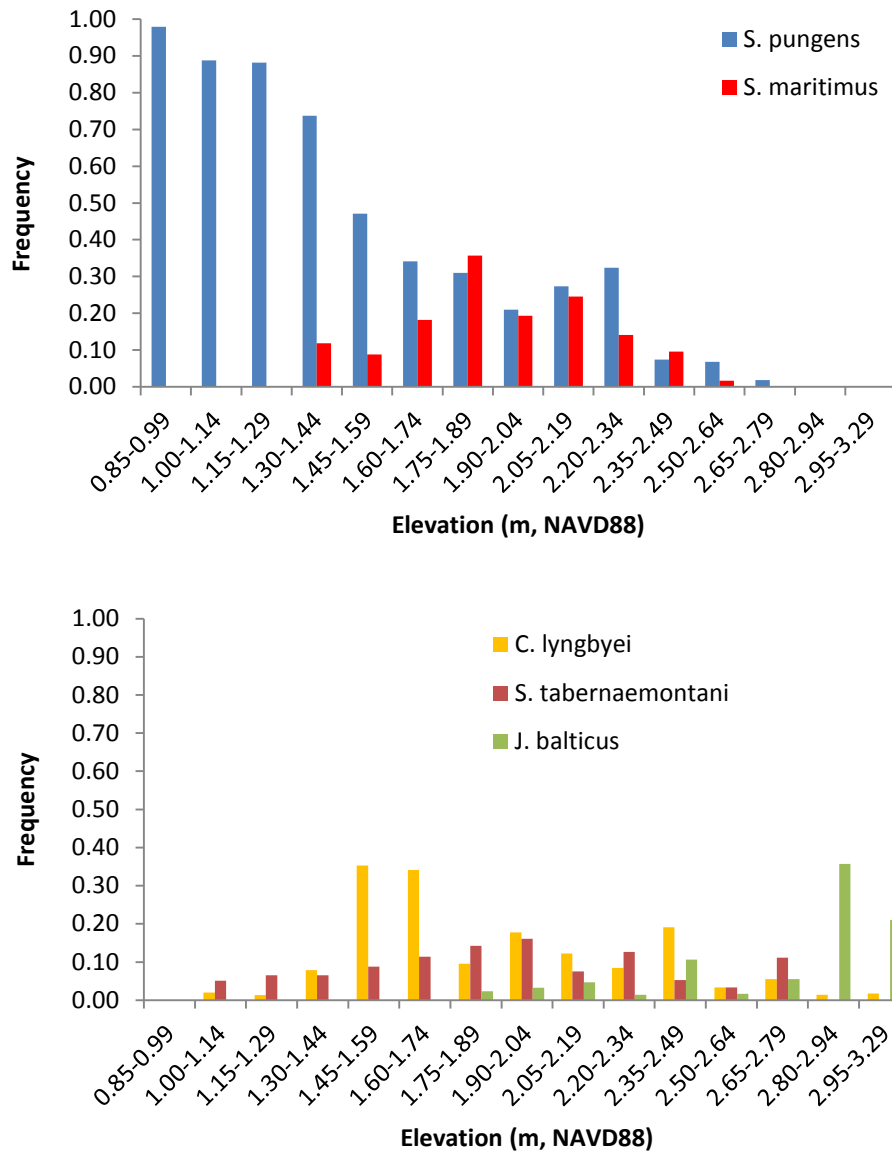


Figure 19. Elevation distribution of five of the most common native plant species found in the 5-13 ppt pore water salinity zone in the Skagit Delta.

References

- Bertness MD, AM Ellison. 1987. Determinants of pattern in a New England salt marsh plant community. *Ecological Monographs* 57:129–147.
- Brand LA, LM Smith, JY Takekawa, ND Athearn, K Taylor, GG Shellenbarger DH Schoellhamer, R Spenst. 2012. Trajectory of early tidal marsh restoration: Elevation, sedimentation and colonization of breached salt ponds in the northern San Francisco Bay. *Ecological Engineering* 42:19-29.
- Cornu CE, S Sadro. 2002. Responses to experimental marsh surface elevation manipulation in Coos Bay's South Slough. *Restoration Ecology* 10:474-486.

- Diggory ZE, VT Parker. 2010. Seed supply and revegetation dynamics at restored tidal marshes, Napa River, California. *Restoration Ecology* 19:121-130.
- Erfanzadeh R, A Garbutt, J Petillon, J-P Maelfait, M Hoffman. 2010. Factors affecting the success of early salt-marsh colonizers: Seed availability rather than site suitability and dispersal traits. *Plant Ecology* 206:335-347.
- Ewing K. 1983. Environmental controls in Pacific Northwest intertidal marsh plant communities. *Canadian Journal of Botany* 61:1105–1116.
- Hood WG. 2013. Applying and testing a predictive vegetation model to management of the invasive cattail, *Typha angustifolia*, in an oligohaline tidal marsh reveals priority effects caused by non-stationarity. *Wetlands Ecology and Management* 21:229-242.
- Leck MA. 2003. Seed-bank and vegetation development in a created tidal freshwater wetland on the Delaware River, Trenton, New Jersey, USA. *Wetlands* 23:310-343.
- Tuxen KA, LM Schile, M Kelly, SW Siegel. 2008. Vegetation colonization in a restoring tidal marsh: A remote sensing approach. *Restoration Ecology* 16:313-323.

5.4 Monitoring Priority 1: Additional Ecological Objectives: Tidal Channel Habitat Restoration

Written by Robert Warinner, Washington State Department of Fish and Wildlife

Introduction

A specific objective of the Fir Island Farms habitat restoration project is the re-establishment of tidal channels known to be a preferred habitat of rearing juvenile Chinook salmon and other species (Beamer & Larsen 2004). Of all delta habitats, juvenile Chinook have been found to be most abundant in blind tidal channels (appendix DII Beamer & Henderson 2004). As of 2000, 94.6% of blind tidal channel habitat from Camano Island to Padilla Bay has been lost from direct and indirect impacts (Beamer 2005). Direct loss has occurred inside (landward) of the dikes by eliminating and isolating the habitat, while less obvious indirect loss of habitat has occurred outside the dikes due to an altering of the tidal prism that erodes the marsh and maintains channel geomorphology.

In the Fir Island Farms Feasibility Study, predictions of the amount of restored tidal channel habitat produced by the restoration were made using an allometric model (Hood 2007). This information in turn was used to predict the specific smolt production output of the project. In order to confirm the predictions and determine the effectiveness of the habitat restoration, WDFW along with its project partners will monitor the marsh channels on the project site before and after the restoration.

Monitoring Objectives

Monitor the length, area, and thalweg profile of marsh channels to determine the effect of the restoration project.

Monitor the trajectory of channel geomorphology to determine the long term habitat value of restored tidal marsh.

Hypotheses

Tidal channels will be restored at the project site and in the existing adjacent tidal marsh.

Performance Parameter

Tidal channel area, extent and change over time.

Monitoring Method

Channel geomorphology on the site, inside and outside of the dikes, will be monitored remotely with the use of orthophotos and with onsite survey of channel cross sections. Georeferenced orthophotos with a 4 inch pixel resolution taken in 2013 and 2015 will be examined to determine baseline preconstruction channel length and area. Post project channel length and area will be determined with the examination of orthophotos to be taken in 2017, 2019, and 2021. A Geographical Information System (GIS) layer will be developed for each of the photo examinations. The GIS layer will be composed of polygons with a minimum width of 2 feet digitized at a minimum scale of 1:300. Channels outside of the project area will be digitized to the mean lower low water (MLLW) line.

Prior to construction in the spring of 2015, channel cross sections and thalweg profiles will be taken water ward (outside) and landward (inside) of the dike in each of Browns Slough, Claude O Davis Slough, and Dry Slough (Figure 15 [from: *figure C3 Technical Memorandum 1.1.1*]). Channel cross sections and thalweg profiles will be taken at a maximum interval of 20 channel widths.

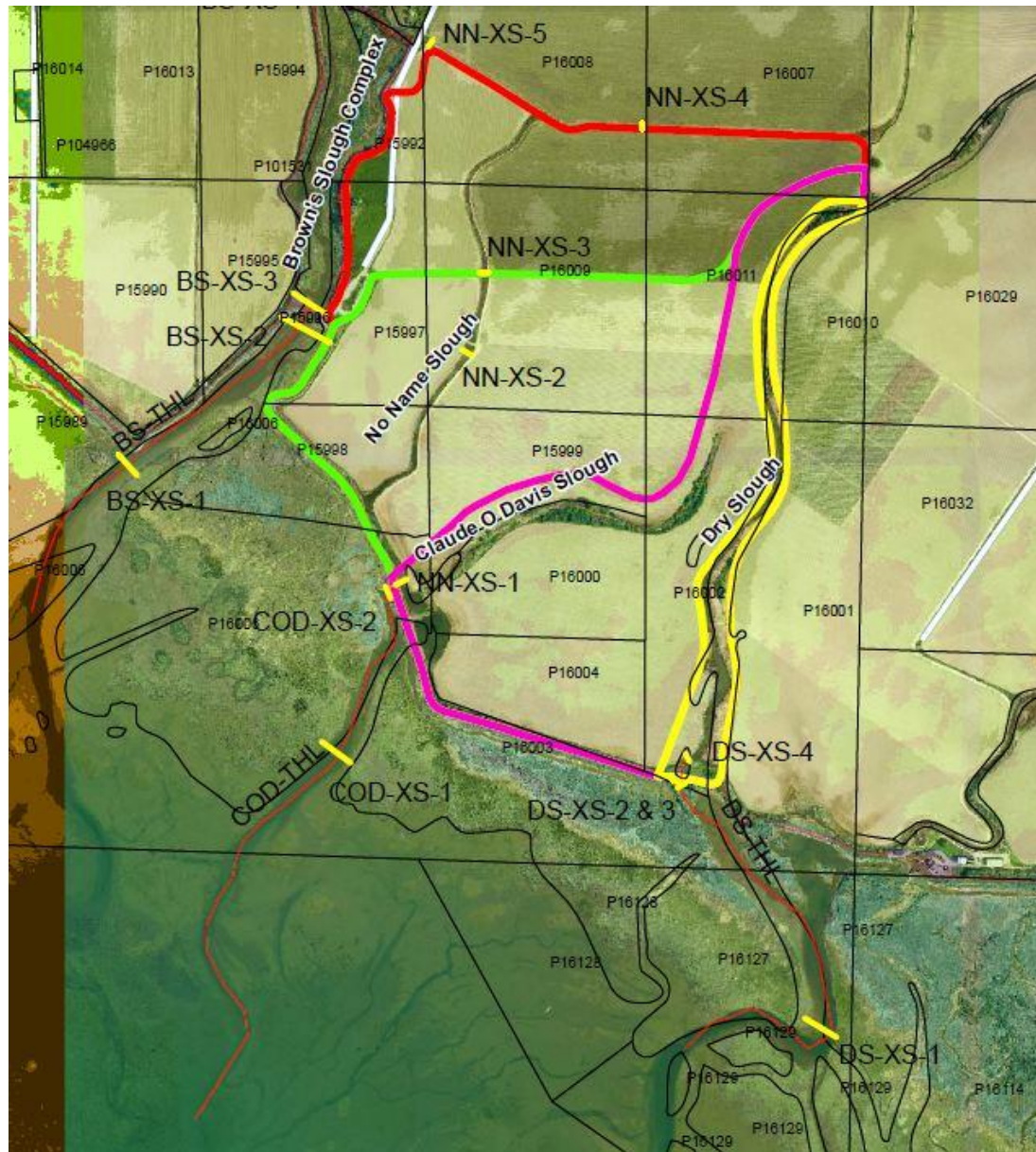


Figure 20: Baseline thalweg profile and cross section locations.

Immediately after construction channel cross sections and thalweg profiles will be taken in No Name Slough and in the pilot channels excavated during construction (Figure 20). Channel cross sections and thalweg profiles will be taken at a maximum interval of 20 channel widths. Post construction channel cross sections and thalweg profiles will be taken at the same sites in 2017, 2019, and 2021. Channel

cross sections and thalweg profiles will be taken at a maximum interval of 20 channel widths. A GIS layer with survey sites and cross sectional information will be developed for each of the surveys.

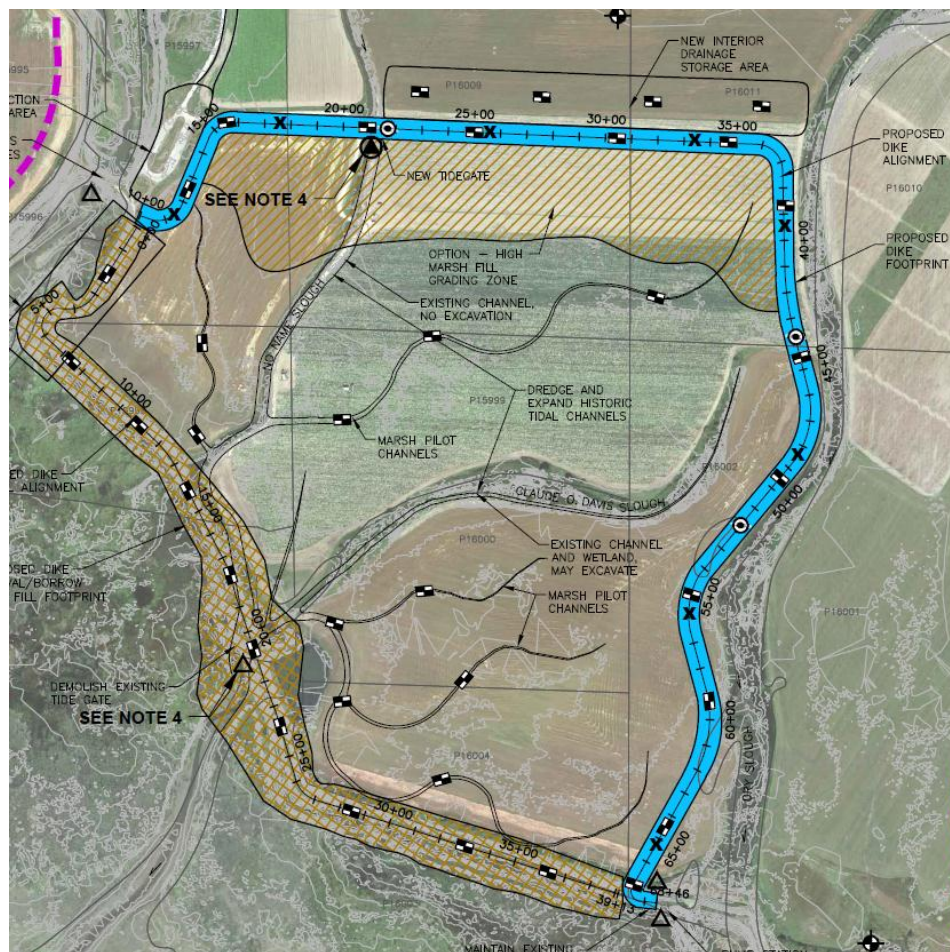


Figure 21: Existing and proposed marsh channels.

The cross section survey will be conducted with the use of a Total Station or similar surveying instrument referencing a known permanent landmark. GIS layers developed from the examination of orthophotos will be compared to the onsite channel examinations each year to ensure accuracy of the channel area digitization. Comparisons of each successive remote monitoring survey and onsite monitoring survey will be conducted to determine the temporal trajectory of channel geomorphology. Monitoring data of the channel geomorphology of the previously isolated area as well as the area in the un-isolated marsh will be compared to predictive models of channel formation such as presented in Hood (2007) to help identify if and when equilibration is attained.

Channel equilibrium is a long term landscape process; in order to accurately determine the effect of marsh restoration it may be necessary to monitor the site longer than the monitoring period proposed here (Hood 2007). Several more years or possibly even decades of monitoring may be necessary.

Performance Threshold

None

Adaptive Management Action(s)

None

Monitoring Schedule

Baseline channel data will be collected in 2013 and 2015. Post project construction channel data will be collected in 2017, 2019 and 2021.

References

- Beamer, E., et al. (2005) Delta and nearshore restoration for the recovery of wild Skagit River chinook salmon: linking estuary restoration to wild chinook salmon populations, Appendix D, Skagit Chinook Recovery Plan.
- Beamer, E. and K. Larsen (2004). The importance of Skagit delta habitat on the growth of wild ocean-type chinook in Skagit Bay: implications for delta restoration, Skagit River System Cooperative, La Conner, WA
- Hood, W. G. (2007), Scaling tidal channel geometry with marsh island area: A tool for habitat restoration, linked to channel formation process, Water Resources. Res., 43, W03409, doi:10.1029/2006WR005083.

5.5 Monitoring Priority 1: Additional Ecological Objectives: General Habitat Development

Written by Brian Williams, Washington State Department of Fish and Wildlife

Introduction

The Project will restore the natural tidal prism of Skagit Bay to 131 acres of WDFW's 258 acre Fir Island Farm by setting back approximately 5,800 lineal feet of coastal dike. The Project is expected to restore approximately 126 acres of estuarine intertidal emergent marsh and 5 acres of estuarine intertidal channel (Shannon and Wilson, 2014). Photos will be taken of the restoration site from photo points established along the top of the new flood dike to demonstrate the temporal changes occurring at the restoration site.

Monitoring Objective

The objective for using photographs to monitor the restoration site is to characterize the changes that occur over time at the restoration site.

Hypotheses

Restoring the natural tidal processes to the site will change the physical character of the site over time.

Performance Parameter

Qualitative visual assessment in the restored area.

Monitoring Method

A single photograph will be taken into the restoration site at each of the permanent and sequentially numbered stations established every 500 feet along the top of the new flood dike to monitor the top elevation of the new flood dike. The photographs will be taken perpendicular to the new flood dike during a minus tide cycle in the first two weeks of July.

Performance Threshold

None

Adaptive Management Action(s)

None

Monitoring Schedule

Baseline photographs will be taken in 2016 prior to restoring tidal processes to the site. Post restoration photographs will be taken every other year during years 2017, 2019, and 2021.

References

Shannon and Wilson. 2014. Fir Island Farm Draft 60% Design Report. Washington Dept. of Fish and Wildlife, Fir Island, Washington.

5.6 Monitoring Priority 1: Additional Ecological Objectives: Fish and Wildlife Utilization – Fish Utilization in Restored Area

Written by Eric Beamer, Skagit River System Cooperative

Introduction

Delta habitats within the Skagit River Basin and other Salish Sea river estuaries have been identified as priority habitat for restoration for the benefit of juvenile Chinook salmon and other listed species by numerous regional planning processes (SRSC and WDFW 2005, the Puget Sound Chinook Recovery Plan, and the Puget Sound Nearshore Ecosystem Restoration Program, among others). Thus, significant public investment has been made in restoration actions within the Skagit River estuary, including planned restoration through dike setback design at Fir Island Farms in late summer of 2016. In response to the restoration at Fir Island Farms, we propose to monitor fish use of the restored areas during the juvenile Chinook salmon outmigration seasons for two seasons before restoration occurs (2015 and 2016) and two five seasons after restoration has been completed (2017 through 2021). However, funding and products for this proposal has only been estimated for the first three years (2015 through 2017).

Monitoring Objectives

The fish monitoring design for Fir Island Farms would be BACI (i.e., before & after restoration) stratified random design with references. We propose to use beach seine methods after Beamer et al. (2014) for the full juvenile Chinook outmigration period (February through August) in order to compare results at Fir Island Farms with long term monitoring (reference) sites in the Skagit delta (Greene and Beamer 2006; Greene and Beamer 2012). Monitoring questions addressed in the report are:

- 1) What fish species are present within the restored area?
- 2) How does juvenile Chinook salmon density and size vary by year, season, habitat type, and spatially within the restored area?
- 3) How does seasonal juvenile Chinook salmon density in the restored area compare to reference sites throughout the Skagit River estuary?
- 4) What is the carrying capacity of the restored area for juvenile Chinook salmon rearing?

Hypotheses/Expected Results

Fish assemblage:

- For the before restoration period, we expect an estuarine fish species assemblage consistent with other Skagit estuarine reference sites is present downstream of the tidegate but will not be present upstream of the tidegate.
- For the after restoration period, we expect estuarine fish species (consistent with other Skagit estuarine reference sites) to be present within the restored area after restoration and to be similar to the assemblage downstream of the old tidegate site.

Juvenile Chinook salmon

- For the before restoration period, we expect a higher density of juvenile Chinook salmon downstream of the tidegate than upstream.
- For the after restoration period, we expect similar densities of juvenile Chinook salmon between the two areas (downstream of the old tidegate site, within the restored area).
- For the after restoration period, we expect seasonal patterns, densities, and fish size of juvenile Chinook salmon to be consistent with other Skagit estuarine reference sites.

Local Environment

- For the before restoration period, we expect different local environment results (water temperature, salinity, and dissolved oxygen) in wetted fish habitats (channels/impoundments) downstream of the tidegate than upstream.
- For the after restoration period, we expect similar local environment (water temperature, salinity, and dissolved oxygen) in wetted fish habitats (channels/impoundments) downstream of the tidegate than upstream.

Performance Parameter

- Fish data (catch by species, size of individual fish by species) in spreadsheets by year
- Environmental data (temperature, salinity, dissolved oxygen) representing the areas where fish sampling occurs in spreadsheets by year
- Annual technical memo for each year summarizing fish species and selected environmental variables (water temperature, salinity, and dissolved oxygen) inside and outside of the project area.
- Comprehensive report for the first three years of monitoring testing the listed hypotheses. This report will be provided to DFW and NOAA.

Methods

Site Selection, Timing, and Frequency: For the before restoration time period (2015 and 2016), three beach seine sites will be established outside (downstream) of the tidegate located on No Name Slough and three beach seine sites will be established inside (upstream) of the tidegate (Figure 1). These six sites will be established as index (repeatedly sampled) sites and also sampled in years after restoration has occurred. For the after restoration period (2017 through 2021), one index site and three randomly selected sites will be sampled by beach seine in each of the four restored blind channel complexes (west branch of No Name Slough, east branch of No Name Slough, Claude Davis Slough, and south branch of Claude Davis Slough) (Figure 2). The exact locations will be determined after restoration has occurred and we can observe the tidal channels and/or impoundments that form. Beach seining will likely be done during early stages of the flood tide. We select this tidal stage because 1) the water is mostly confined to channel areas during this time and 2) we avoid high water velocities occurring on ebbing tides which makes seining difficult. The exact tidal stage of seining will be determined after selecting the sites and observing their tidal conditions. Sampling will occur once per month in February and August and twice per month March through July, giving a total of 12 sampling days each year. A total of 6 beach seine sets will be made for each of the 12 sampling events for the before restoration years (2015 &

2016). A total of 22 beach seine sets will be made for each of the 12 sampling events for the after restoration years (2017 through 2021).

Field Methods: We use a small net beach seine method to sample sites. Small net beach seine methodology uses an 80-ft (24.4 m) by 6-ft (1.8 m) by 1/8-inch (0.3 cm) mesh knotless nylon net. The net is set in “round haul” fashion by fixing one end of the net on the beach, while the other end is deployed by setting the net “upstream” against the water current, if present, and then returning to the shoreline in a half circle. Both ends of the net are then retrieved, yielding a catch. Average beach seine set area was 96 square meters. For each set, we identify and count fish by species. All the fish are returned alive to the water, with the exception of hatchery-origin salmon with coded-wire tags embedded in their snouts. These fish are sacrificed in order to read the tags. We do not report or discuss coded wire tag results in this report. We also recorded the time and date of each set, the percent of set area (the area that the net covers compared to setting in a perfect half circle), and measure selected environmental conditions (salinity, temperature, dissolved oxygen (DO), velocity, depth, substrate class, and vegetation class) that are present within the seined area at the time of seining. Water temperature, salinity, and DO are measured using a YSI Professional Plus Model meter. Depth is measured with a stadia rod. Surface water velocity is measured using a Swoffer Model 2100 flow meter. Four velocity measurements are taken across the area seined after the set is made and these values are converted to meters per second and the average value of these readings is reported for each site/date combination. Substrate and vegetation at each site are recorded according to criteria described in SSC (2003).

Analytical approach: From fish and environmental data, we summarize all results into different variables based on their type (e.g., spatial, temporal, environmental, and fish) and how it is used in statistical tests. For statistical tests, variables are categorized as dependent, factor, or covariate:

- A dependent variable is what you want to examine in a statistical test (i.e., response). Dependent variables are continuous and numeric.
- A factor is one or more categorical variables (grouping variables) that split the dataset into two or more groups. Factors are hypothesized to affect the dependent variable.
- A covariate is a quantitative independent variable that adds variability to the dependent variable.

Our general analytical approach uses ANOVA to test for mixed effects (factor and covariate) on selected dependent variables. Pairwise testing (such as Scheffé) would be used for comparison between groups.

Monitoring Schedule

The monitoring schedule by task/product is shown in Table 1. Years 2018 through 2021 are not shown in Table 1 but will follow the same format as years shown in Table 1 with respect to tasks, products, and product deadlines for year. It will be determined later what level of product (comprehensive analysis or summary of results) is needed for years 2018, 2019, and 2020. It is assumed a comprehensive analysis of all years of data after the five year post restoration monitoring is completed.

Table 1. Monitoring schedule by task/product for the first three years of monitoring.

Monitoring Period	Year	Task	Product	Product deadline
Before Restoration	2015	Field sampling, February through August	Log of dates when sampling occurs	Aug 31, 2015
		Data entry and QA/QC	Spreadsheets of fish and environmental data collected	Sep 30, 2015
		Summary of results	Technical memo	Oct 31, 2015
	2016	Field sampling, February through August	Log of dates when sampling occurs	Aug 31, 2016
		Data entry and QA/QC	Spreadsheets of fish and environmental data collected	Sept 30, 2016
		Summary of results	Technical memo	Oct 31, 2016
After Restoration	2017	Field sampling, February through August	Log of dates when sampling occurs	Aug 31, 2017
		Data entry and QA/QC	Spreadsheets of fish and environmental data collected	Sep 30, 2017
		Comprehensive analysis	Draft technical report	Dec 15, 2017
			Final technical report	Jan 31, 2018

References

- Beamer, E., R. Henderson, C. Ruff, and K. Wolf. 2014. Juvenile Chinook salmon utilization of habitat associated with the Fisher Slough Restoration Project, 2009 - 2013. Report prepared for The Nature Conservancy, Washington. Available at www.skagitcoop.org.
- Greene, CM, and E. Beamer. 2006. Monitoring of population responses by Skagit River Chinook salmon to estuary restoration. Appendix E in the Skagit Chinook Recovery Plan. Skagit River System Cooperative, LaConner, WA. Available at www.skagitcoop.org.

Greene, CM, and E. Beamer. 2012. Monitoring Population Responses to Estuary Restoration. Skagit River Chinook Salmon: Intensively Monitored Watershed Project Annual Report, 2011. Skagit River System Cooperative, LaConner, WA. Available at www.skagitcoop.org.

Skagit River System Cooperative and Washington Department of Fish and Wildlife. 2005. Skagit Chinook Recovery Plan. Skagit River System Cooperative, La Conner, WA. Available at www.skagitcoop.org/.

Skagit System Cooperative. 2003. Estuarine fish sampling methods. Skagit River System Cooperative, LaConner, WA. Available at www.skagitcoop.org/.

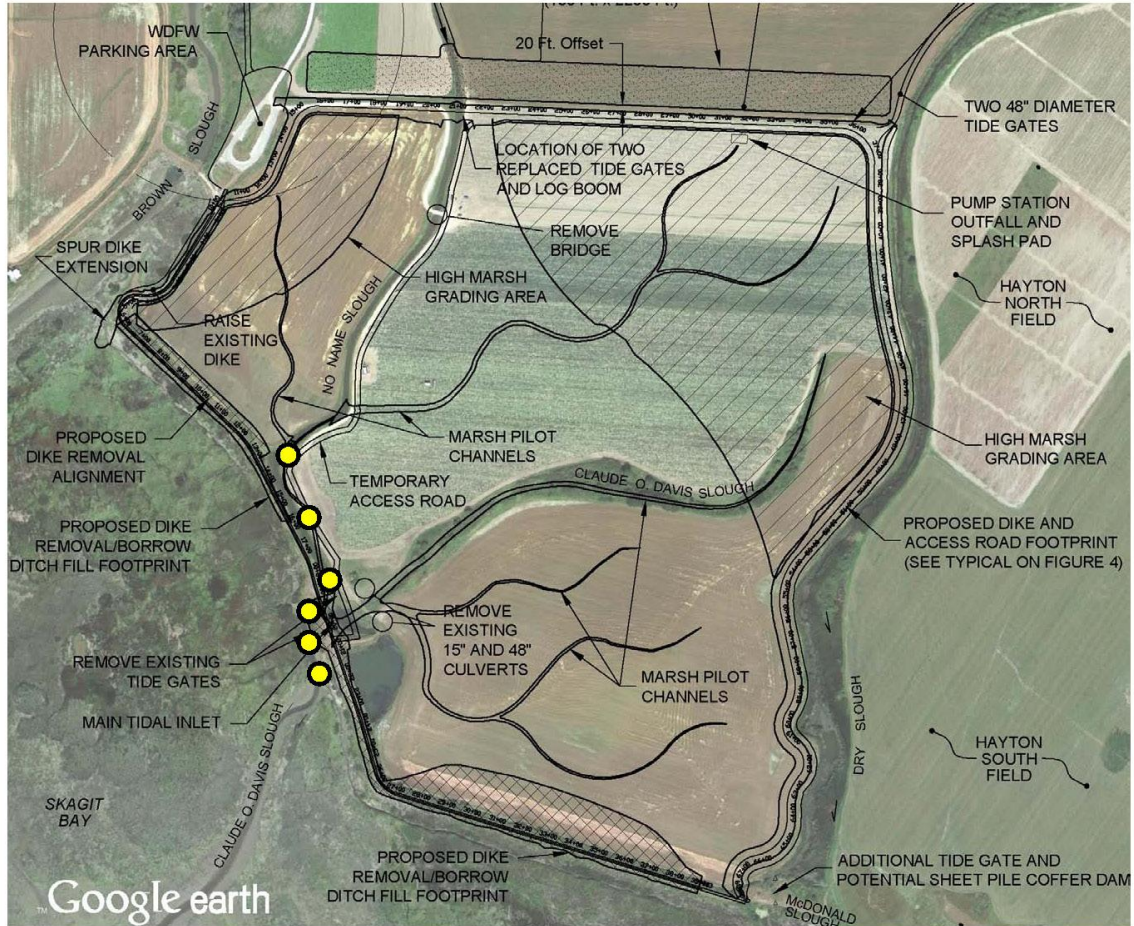


Figure 1. Approximate location of 6 beach seine sites (3 outside of the dike; 3 inside of the dike) before dike setback restoration occurs in late summer of 2016. Beach seine sites are shown as yellow circles.

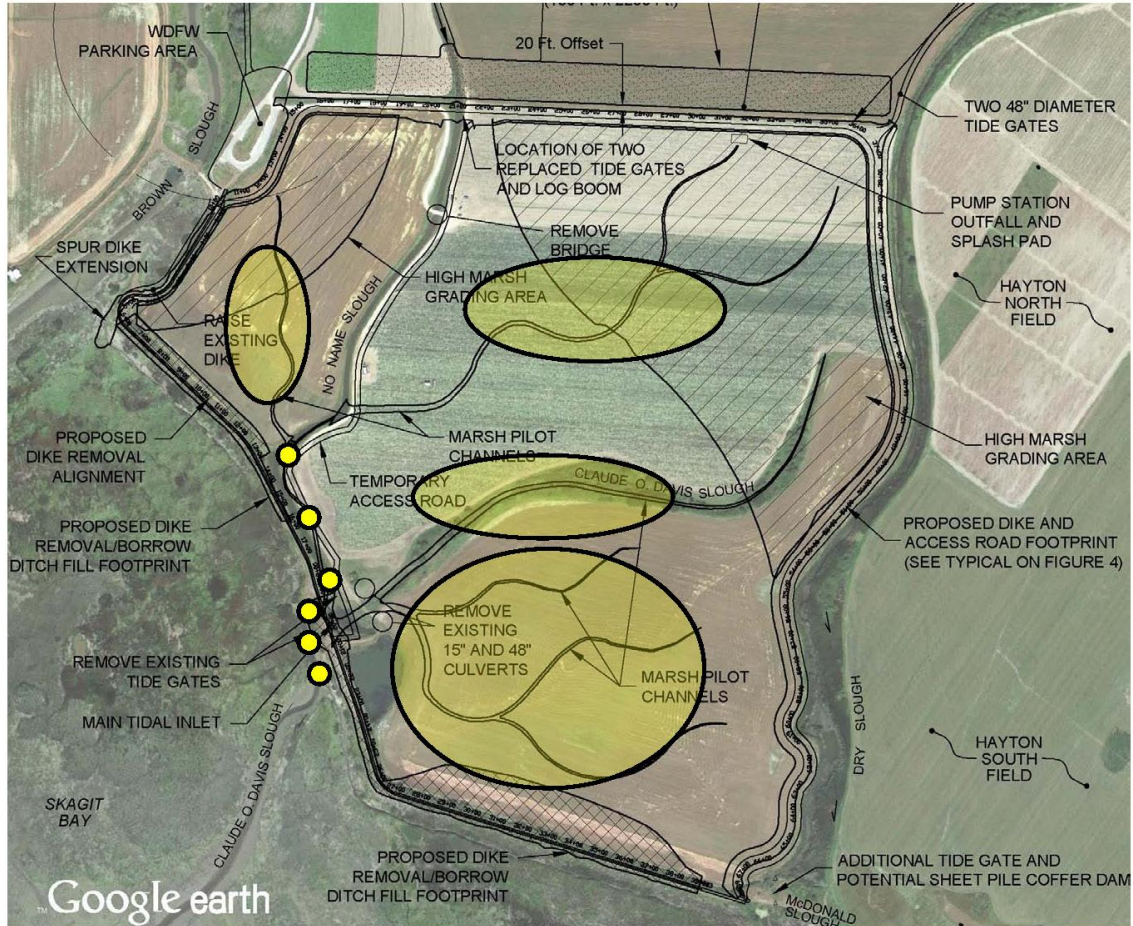


Figure 2. Approximate location of beach seine sites after dike setback restoration occurs. Sites include a repeat of the 6 before restoration project sites. New beach or open water seine sites will occur in four tidal channel/impoundment complexes: 1) west branch of No Name Slough, 2) east branch of No Name Slough, 3) Claude Davis Slough, and 4) south branch of Claude Davis Slough.

5.7 Monitoring Priority 2: Additional Project Objectives

The following monitoring objectives provide valuable feedback. WDFW will not implement these monitoring objectives but will invite interested third parties to implement these monitoring activities. The monitoring objective and methodology will be determined by the party interested in conducting the monitoring.

- Tidal Flooding – Surface Water Salinity Dynamics
- Tidal Flooding - Tidal Amplitude
- Tidal Flooding – Water Temperature Dynamics
- Fish and Wildlife Species – Fish Utilization
- Fish and Wildlife Species – Waterfowl and Wildlife Utilization
- Recreation – Public Use
- Socio Economic – Socio Economic Effect

6.0 MONITORING STAFF EXPERTISE

WDFW staff and/or contracted individuals with the appropriate expertise and experience authored each of the monitoring objective chapters in the Plan. Optimally, each chapter author will implement the described data collection and analysis. In those instances where the chapter author is unable to implement the described data collection and analysis, an individual with commensurate expertise and experience will be engaged.

7.0 MONITORING REPORTS AND SCHEDULE

The baseline monitoring data collected from 2013 through 2016 will be compiled and presented in a baseline data compilation report completed December 2016. The post project monitoring data collected from 2017 through 2021 will be compiled and presented in a post project data compilation report and completed annually in December.

8.0 MONITORING AND ADAPTIVE MANAGEMENT BUDGET AND FUNDING SOURCES

The budget estimates for the Fir Island Farm Monitoring and Adaptive Management Plan (Plan) are presented in Table 5. The total estimated cost to implement the Plan is \$367,424. PSAR and NOAA construction grant funding (secured) will fund implementation through 2017. ESRP learning project grant funding (unsecured) will support implementation of the Plan from 2018 through 2021.

Table 5. Proposed Monitoring Budget

Monitoring Category	Monitoring Objective	Performance Parameter	Method	Monitoring Party	Post Project Monitoring Period	Estimated Cost	Funding Source
Ecological Objective	Tidal Marsh Restoration	Cattail response	Ground survey 1x/yr	WDFW	5 years	\$76,000	PSAR ESRP
	Tidal Marsh Restoration	Invasive plant response	Ground survey 2x/yr	WDFW	5 years		
Agricultural Objectives	Flood Protection	Top elevation of new flood dike	Survey top elevation of dike	WDFW	3 years	\$10,000	NOAA ESRP
		Dike toe erosion	Photo monitoring	WDFW	3 years		
		Drift Log Management	Photo monitoring	WDFW	3 years		
	Groundwater Level Protection	Groundwater elevations	Groundwater level loggers	WDFW	3 years	\$56,850	
	Groundwater Salinity Protection	Groundwater salinity conc.	Groundwater salinity loggers	WDFW	3 years		
	Surface Water Salinity Protection	Surface water salinity conc.	Surface water salinity loggers	WDFW	3 years		
	Surface Water Drainage Protection	Surface water elevations	Surface water level loggers	WDFW	3 years		

Table 5. Proposed Monitoring Budget (continued)

Monitoring Category	Monitoring Objective	Performance Parameter	Method	Monitoring Party	Post Project Monitoring Period	Estimated Cost	Funding Source
Ecological Objectives	Tidal Flooding	Area of restored tidal processes	Project area below +13 (MLLW = 0.00)	Construction Contractor	--	Construction Budget	NOAA ESRP
	Tidal Marsh Habitat Restoration	Sediment accretion and erosion	Sediment pins, horizon markers/SETs	WDFW	5 years	\$13,050	
		Native vegetation response	Survey transects	SRSC	5 years	\$82,620	PSAR ESRP
	Tidal Channel Habitat Restoration	Tidal channel area, extent and change	Channel cross sections, longitudinal profiles	WDFW	5 years	\$20,500	NOAA ESRP
			Aerial imagery	WDFW	5 years		
	Fish Utilization	Fish species and individual size	Beach seines	SRSC	5 years	\$90,225	
	General Habitat Development	Qualitative visual assessment	Photo monitoring	WDFW	5 years	\$82,620	
TOTAL COST							\$349,245

APPENDIX A

Level Logger Download Procedures

- Field
 - Minimum equipment needed: Solinst Level Logger with cables, keys to locks, tape measure, water level indicator, field book, appropriate PPE. Bolt cutters and waders may be needed as well depending on the time of year and condition of the equipment. Bringing a laptop loaded with the Solinst software as well as a dock can be a good backup to the Level Logger.
 - Use the tape measure, WLI, or staff gage to measure the water surface elevation at the data logger on a 15-minute interval. Measure from the designated reference mark to the water surface level. Reference mark is the top of plastic cap for stations SW-BS-3.1-LT, SW-NNS-2.1-LTC, SW-DS-1.1-LTC, and SW-DS-1.3-LTC. Reference mark is the top of the opened metal well monument (at the hinge of the metal cap) for stations GW-B-04-13-LTC, GW-B-05-13-LTC, GW-B-06-13-LTC, GW-07-13-LTC, GW-B-08-13-LTC, and GW-B-09-13-LTC. The staff gage reading is the only measurement that needs to be recorded for stations SW-BS-3.0-LT, SW-NNS-2.0-LTC, and SW-DS-1.0-LTC. Note the logger number, WSE, date and time in the field book.
 - After the 15-minute interval has passed (i.e. at 11:16), remove the cap and connect to the direct read cable (or, for data loggers using a string deployment, remove the data logger itself). Follow the prompts on the level logger screen to connect to, and then download the data from the logger.
 - Optional: After the data has been downloaded, verify that the data file is stored on the level logger by going back to the main menu and viewing data files. The most recent file is the highest numbered one.
 - Restart the data logger using the level logger prompts. This will erase the data from the logger. Use the future start time to set the logger to collect on 15 minute intervals, starting at the next 15-minute interval (i.e. 11:30)
 - For string installations, make sure that the data logger is placed back in position before it records the next interval (i.e. place back in the well no later than 11:29).
 - Measure and record the WSE at the next interval.
- Office
 - Transfer field notes to the data logger worksheet (for Fir Island, here: "[I:\WIP\21-1\12318 Fir Island\216 GW-INT DRAINAGE\DATALOGGERS\Logger Record.xlsx](#)"). This will calculate reference elevations based on the field measurements.
 - Connect the level logger to a computer equipped with the Solinst level logger software. Turn the level logger on, select “connect to pc” and then use the software to connect to the level logger
 - Download the appropriate files from the level logger to the computer. Store the files in a folder labeled “raw data”

- Open the data compensation tab. Perform the barometric compensation for all files at once
- Do a reference elevation compensation for each file individually using the reference elevation and time at the start of the monitoring period (be sure to click the “add” button after you enter the data). Check the value at the end of the time period against the recorded data; it should match within +/- 0.1 feet (at the most). If not, look for errors in measurement or possible malfunctioning of the logger itself. Calculate the salinity (if applicable) at this step as well, converting to PSU (practical salinity units). Compensated files will be stored in the raw data file.
- Export the compensated data to a csv file in a folder labeled “processed data”
- Graph the data by combining with previous data in the folder “graphed data” to evaluate long-term trends. Note any discrepancies or shifts in the dat