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PNWD-4262

# Lower Columbia River and Estuary Restoration Reference Site Study

## 2010 Final Report and Site Summaries

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May 2011

Prepared for:
Lower Columbia River Estuary Partnership
Portland, Oregon

Lower Columbia River Estuary Partnership

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## Abstract

This report summarizes data collected from 2007 - 2010 from 43 wetland sites in the lower Columbia River and estuary (LCRE) considered to represent "reference" or relatively undisturbed conditions. The purpose of this study was to provide data from a suite of reference wetlands that would serve as a baseline of wetland conditions, reduce uncertainties regarding the factors controlling these wetlands, provide data to inform restoration design, and enable the evaluation of restoration action effectiveness monitoring. Methods are provided for all data collection efforts and data analysis. The results are detailed in individual Site Summaries, where data on all monitored metrics are provided in tables and graphs. Preliminary conclusions and are set forth as are recommendations for further analysis and management applications of this dataset.

## Preface

The Reference Site Study (RSS) presented in this report is part of the research, monitoring, and evaluation (RME) effort developed by the Action Agencies (Bonneville Power Administration [BPA], U.S. Army Corps of Engineers [USACE], and U.S. Bureau of Reclamation) in response to obligations under the Endangered Species Act as a result of operation of the Federal Columbia River Power System. Battelle conducted the multi-year study under contract with the Lower Columbia River Estuary Partnership (LCREP) with funding provided by BPA. This report represents the final year of data collection and reporting under this phase of the project.

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## Acknowledgements

Foremost, we wish to thank the Lower Columbia River Estuary Partnership for recognizing the importance of this research and facilitating it since 2007. Specifically, we thank Scott McEwen, who was instrumental in initiating the project and who provided many helpful ideas in the formative stages. We also appreciate the efforts of Jason Karnezis, whose previous work gathering potential reference site information was the starting point for site selection. Evan Haas and Catherine Corbett provided patient support and helped ensure the project remained funded and on schedule. We are grateful to the sponsoring agency, Bonneville Power Association, for providing the funds to carry out the project. We thank the property owners - Columbia Land Trust, The Nature Conservancy, and the Garvin family, for allowing access and providing information about their beautiful properties. The following agencies were also instrumental in providing access to and information about several sites throughout the estuary: Scappoose Bay Watershed Council, Oregon State Parks, Oregon Department of Fish and Wildlife, National Park Service, and US Fish and Wildlife Service. Finally, we could not have completed this project without the people who helped conduct the field work, at times putting in very long hours and enduring arduous conditions. We are very grateful for the hard work and great attitudes of Amanda Bryson, Jimmie Cotton, Dana Field, Julia Ledbetter, Lori Lilly, Keith Marco, Micah Russell, Jina Sagar, Ian Sinks, and Kathryn Sobocinski.

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# 1.0 Introduction

This report summarizes data collected by Battelle[1] and collaborators from 2007 - 2010 to evaluate reference sites for baseline characterization and action effectiveness monitoring in the lower Columbia River and estuary (LCRE). Funding was provided by Bonneville Power Administration (BPA) to the Lower Columbia River Estuary Partnership (EP), which subcontracted with Battelle. This annual report provides the methods and results from all years of research, highlighting data summaries for each of the 43 sites evaluated as part of this study.

## 1.1 Purpose of Study

The purpose of this study was to provide data from a suite of reference wetlands that would serve as a baseline of wetland conditions, reduce uncertainties regarding the factors controlling these wetlands, provide data to inform restoration design, and enable the evaluation of restoration action effectiveness monitoring. The data from this study can be used to quantify the ecological conditions necessary for development of wetland plant communities and tidal channel networks, which is critical to designing and evaluating the effectiveness of restoration projects (Kentula et al. 1992; Steyer et al. 2003; Thayer et al. 2005). This critical information was previously lacking for the LCRE. The data developed on these sites provides baseline characterization to address uncertainties regarding the elevation, soil, and inundation ranges required by native tidal wetland vegetation. Additionally, information on hydrology, natural morphology of tidal channel networks, and occurrence of invasive species was collected to guide restoration actions in the future. Ultimately, this network of reference sites is intended to provide resource managers a means for statistically analyzing and comparing projects along temporal restoration trajectories. Results from this study will enable restoration effectiveness to be assessed at the site scale and at the estuary-wide scale through the coordinated, inter-agency habitat protection/restoration program described in the Research, Monitoring, and Evaluation plan for the LCRE (Johnson et al. 2008).

## 1.2 Ecological Indicators Monitored

Our understanding of the relationship between ecosystem structure and ecosystem function in the LCRE derives from numerous studies. Briefly, vegetation composition and species cover provide an indication of the production of organic matter (i.e., macrodetritus) that eventually comprises an important component of the aquatic food web. Vegetation, and the detritus it produces, is the base of the food web for many species in the LCRE (Maier and Simenstad 2009). This component of the food web is thought to have decreased relative to historical levels in the Columbia River (Sherwood et al., 1990), making the restoration of marsh macrodetritus production and export to the main stem river a critical result of restoration efforts. The vegetation structure also provides habitat for many fish and wildlife species, including juvenile salmon (Bottom et al. 2005), and contributes to overall biodiversity of the ecosystem. Assessment of channel cross sections and channel networks provides

[1] Battelle operates the Pacific Northwest National Laboratory (PNNL) for the Department of Energy (DOE). The Marine Sciences Laboratory is a part of PNNL. The work described in this report was conducted through a contract with Battelle as part of PNNL's agreement with DOE to allow work to be conducted for other organizations.

information on the potential for fish access (*i.e.*, opportunity *sensu* Simenstad and Cordell 2000) as well as the pathway for export of prey, organic matter, and nutrients.

This study used standard monitoring protocols (Roegner et al. 2009) to assess the structure, condition, and forcing factors of a suite of brackish and tidal freshwater wetland habitats. The monitored parameters include vegetation composition and percent cover, water surface elevation, elevation, channel morphology, substrate characteristics, and accretion rates. These parameters represent important structural components and are indicators of critical habitat functions. In addition, elevation, hydrology, and substrate are the primary factors that control wetland vegetation composition and productivity (Gilman 1993) and sediment accretion is important for maintaining wetland elevation (Elliot 2004). Thus, baseline information on sediment accretion rates is important for predicting the evolution of a restoration site; however, rates can vary substantially between natural and restored systems initially (Diefenderfer et al. 2009), indicating a need to monitor changes over time. Information on channel morphology supports development of the relationship between cross-sectional dimensions and marsh size, which aids in understanding the channel dimensions characteristic of self-maintaining restored marshes (Diefenderfer et al. 2008).

## 1.3 Collaboration with Other Studies

This project has benefited from coordination and collaboration with other studies and monitoring efforts. We have coordinated at many levels with the Cumulative Ecosystem Response of Restoration (CE) project, a multi-organizational study comprised of Pacific Northwest National Laboratory (PNNL), NOAA Fisheries, Columbia River Estuary Study Task Force (CREST), and University of Washington Columbia Basin Research and funded by the US Army Corps of Engineers (USACE) through the Columbia River Fish Mitigation Program. During 2007, we developed the methodologies for sampling vegetation and elevation in forested wetlands on the CE project. In 2008-2009, the CE project monitored four natural dike-breach sites that were breached between 13 and 50 years ago, providing a means to place these sites on a restoration trajectory. Finally, some of the reference sites used for a paired comparison to restoration areas under the CE study were also evaluated for this study in 2009. We also coordinated with the Estuary Partnership's Ecosystem Monitoring project (EM; funded by BPA) in 2008-2010 to share methodology development and habitat data from previously studied sites. Lastly, we coordinated with CREST on the collection of data from Cooperage Slough located along the Young's River.

Out of the forty-three sites included in our study, many are being monitored through the collaborations described above. In these cases, additional information was gathered as appropriate to ensure the data were adequate for comparison to restoration sites and complete under the study design reported herein. This includes for example, the possible addition of water level sensors, channel cross sections, sediment samples, sedimentation stakes, additional vegetation data, and/or analysis of channel metrics.

# 2.0 Methods

## 2.1 Study Area

The study area is located on the northwest coast of the United States (Figure 1). This region extends 235 km from the river mouth to Bonneville dam, the first hydrologic dam on the river. The extent of saltwater intrusion is approximately 20-40 km depending on seasonal flows (Chawla et al. 2008), while tidal influence extends to Bonneville dam. Therefore, most of the sites in the study area are tidal freshwater wetlands, with some brackish wetlands located in the lower part of the estuary. In an inventory of the Columbia River, Christy and Putera (1993) described the "freshwater tidelands" ecosystem as being "of low relief, typically flooded or sub-irrigated at high tide, and permeated by conspicuous, dendritic and meandering tidal streams and sloughs. Cut banks, when present, show mucky soils with high organic content."


**Figure 1.** The study area comprises the historical floodplain below Bonneville Lock and Dam of the lower Columbia River and estuary.

Kunze (1994) further characterized tidal freshwater wetlands in the LCRE as comprising four wetland types: the "coastal surge plain wetlands, surge plain wetlands, overflow plain wetlands, and Columbia River Gorge wetlands." Typical surge plain wetlands are flooded during incoming tides and drain during low tides, and the water is fresh (<0.5 ppt salt). Coastal surge plain wetlands are tidal freshwater wetlands that occur along the Columbia River and its tributaries up to Cathlamet, Washington (rkm 64). The surge plain continues, with slightly different communities, from Cathlamet to Longview, Washington (rkm 105). Overflow plain wetlands occur from Longview to Skamania, Washington (rkm 225) and exhibit limited tidal influence; water level is affected more by river flows. The floodplain in this region lacks prominent tidal channels, but contains sloughs, side channels, backwater areas, ponds, and islands. Columbia River Gorge wetlands occur between Skamania and the Bonneville dam and are hydrologically dominated by high river flows. Substrates are typically coarse sand and gravel. Throughout the study area, substantial variation in water levels occur depending on river flows and tidesBecause wetland vegetation growth and distribution are tightly determined by prevailing water levels, understanding the magnitude and dynamics of water level in the LCRE is critical to explaining variation in shallow-water vegetation assemblages.

## 2.2 Site Selection

At the outset of the study in 2007, numerous resources were employed to compile a list of potential reference sites in the LCRE. These included literature review and interviews with local experts, as well as evaluation of other data sources such as the National Wetlands Inventory, landcover maps, aerial photos, and LiDAR data. In addition, site visits and information from other studies were used to compile the most comprehensive list possible. Borde et al. (2008c) provides a table and maps with descriptive information and the location of 120 potential sites. Of these sites, 43 sites were selected to be part of this study based on available research funding. The selection criteria were habitat type, location, hydrogeomorphic setting, access, proximity to known restoration efforts and access, as described in Borde et al. (2008b).

Information gathered in this study helps to illuminate our understanding of the trajectory of restoration sites progressing from a state of early development, through successional stages, to a stable and resilient state more like undisturbed reference sites (Figure 2). Likewise, three categories of sites are included in this study, as follows:

- Historical habitat – sites including several specific habitat types such as brackish marshes, tidal freshwater marshes, tidal freshwater shrub/scrub, tidal freshwater forested swamps (dominated by Sitka spruce), and riparian woodlands (dominated by Oregon ash and Pacific willow). These sites provide the stable endpoint on the trajectory for restoration sites.

- Previously breached habitats – these sites are previously diked areas that were breached either by natural forces or by intentional restoration actions. The sites have begun their progression back to a pre-diked state and therefore provide data points along the restoration trajectory.

- Created sites – these island sites were created from disposal of dredged material. The age of these sites can be estimated and the structure and function evaluated to predict the potential restoration trajectories for these types of habitats.

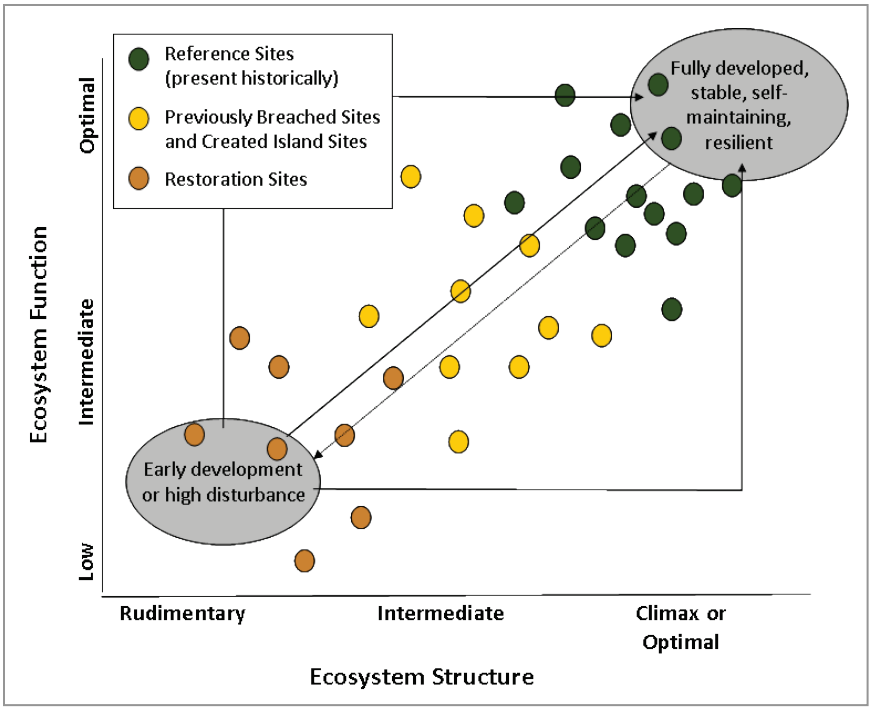



**Figure 2. Matrix showing restoration trajectories and hypothetical location of reference sites (Thom et al., 2011 as adapted from Thom 1997).**

The reference sites are distributed throughout the Estuary and intended to represent habitats in each of the eight hydrogeomorphic reaches defined by the Columbia River Estuary Ecosystem Classification System (Leary et al., 2005) (Table 1). Sites were selected to represent different settings in each reach, for example, islands, the mainland, tributaries, sloughs, and alongside channels (Figure 3).

**Table 1. Distribution of sites in hydrogeomorphic reaches of the LCRE.**

| Reach | Total number of potential sites identified in 2007 | Number of sites included in this study (2007-2010) |
|---|---|---|
| A | 15 | 7 |
| B | 32 | 9 |
| C | 21 | 10 |
| D | 6 | 2 |
| E | 7 | 4 |
| F | 13 | 4 |
| G | 15 | 4 |
| H | 11 | 3 |

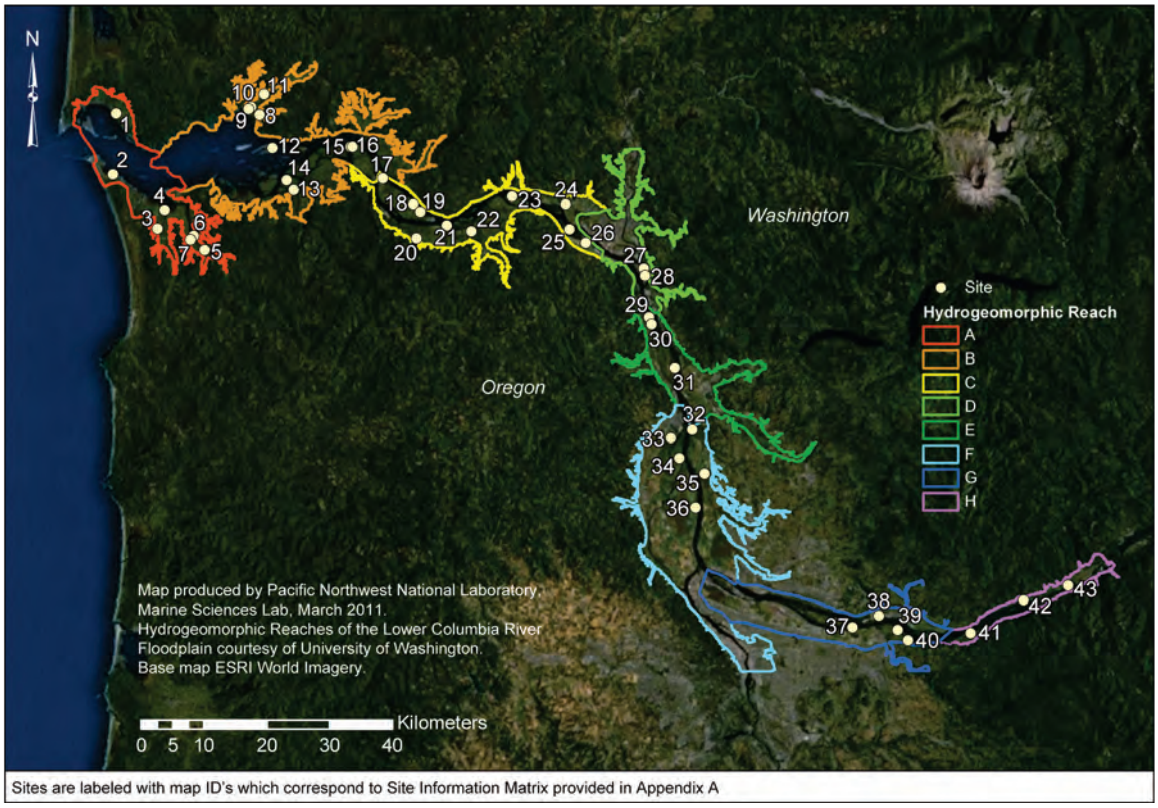



**Figure 3. Location of study sites and hydrogeomorphic reaches in the study area. The site numbers correspond to the Map ID in Table 2 and in the Site Monitoring Matrix in Appendix A.**

## 2.3 Study Sites

Forty-three sites, sampled from 2007 to 2010, are discussed in this report (Table 2). Each site was given a code, which will be used throughout the rest of the report. In general, the first two letters of the code represent the site initials and the last letter designates the type of site. For example, CCR represents the Coal Creek Riparian site. The type designations are as follows:

S Swamp (a forested evergreen tree dominated wetland)

Shrub (shrub dominated wetland)

R Riparian (a forested deciduous tree dominated wetland)

M Historical marsh (an herbaceous, emergent wetland present on historical maps from the 1880s[2])

B Previously diked marsh (breached accidentally or for restoration more than 10 years ago)

C Created marsh (from dredged material placement).

[2] Historical maps for the Columbia River are available online at: http://historicalcharts.noaa.gov/ and were recently georeferenced and digitized (Burke 2010).

The forested wetlands surveyed in this study were present historically. According to Franklin and Dyrness (1988), "tideland spruce" border tidal flats and channels throughout the Pacific Northwest coast, including the Columbia River to rkm 64. Tideland spruce were historically abundant below Puget Island (rkm 61), however, the area of these swamps was reduced by 77% between 1870 and 1980 (Thomas 1983). Deciduous dominated forested wetlands have likely been reduced on the mainland due to diking and development, however a gain in these wetlands is likely to have occurred on the created islands in the River. Shrub dominated wetlands represent a successional stage between emergent wetlands and forested wetlands. These wetland types were not distinguished in the historical estimates of wetland cover and were likely included in the forested wetland category. Like the deciduous dominated wetlands, these areas are not common and are present primarily in remnant un-diked areas and on islands.

The term historical marshes is used to describe tidal wetlands with emergent marsh vegetation that were found in locations present on historical maps of the estuary from the 1880's and that have never been diked. Emergent marshes occurred historically throughout the surge plain of the Columbia River estuary. Thomas (1983) estimated the historical extent of tidal marshes from the mouth to just past Puget Island (rkm 77) to be 6,500 ha. By 1980, nearly half of this coverage was lost.

The term created marshes refers to wetland areas that were not present historically, based on evaluation of the earliest maps from the late 1800's. For example, Figure 4 shows the location of the shoreline of Sandy Island on the 1877 map compared to the present day (2005) shoreline. Today, the island is larger and includes two emergent marsh areas that were not present historically. The increase in area is likely due to the installation of pile dikes and placement of dredge material (Trask & Associates, unpublished data).

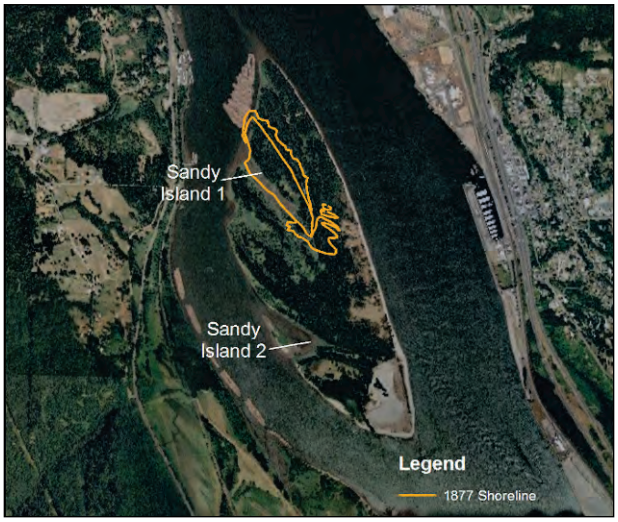



**Figure 4. Aerial image with historical shoreline (1877) overlayed in orange**

Created sites are being included in the current study to provide a point along the ecological and temporal trajectory (Figure 2) for comparison to historical emergent wetlands to provide a means of evaluating habitat creation sites.

The previously breached marshes were studied in coordination with the Cumulative Effects of Restoration project (CE) as a means of placing these "restored" sites in context with other restoration projects. For this study, they also provide context for comparison along an ecological and temporal trajectory toward reference conditions (Figure 2). Dikes were built throughout the Columbia River estuary (CRE) floodplain starting in the 1890s with approximately 99,000 acres diked by 1948 (Christy and Putera 1993). Some dikes have been breached naturally because of flooding and storm damage, while a few have been purposefully breached for restoration. Many accidental breaches are repaired, however, a few have remained open to tidal flow and provide an opportunity to observe change in conditions over time. Assuming that the time of breaching can be approximated, then the estimated time since "restoration" can be determined and the site compared to other non-diked systems.The previously breached sites are all emergent marshes located in the lower part of the estuary.

Most of the sites are tidal freshwater wetlands, however, a few sites in Reach A are brackish.. A full list of the sites, the monitoring metrics, and schedule are provided in Appendix A. Data summaries for each site are provided in Appendix B.

**Table 2. Characteristics of 43 sites monitored between 2007-2010[3].**

| Site Name | Site Code | Wetland Type | Wetland History | River kilometer (rkm) | Reach | Map ID | Monitoring Year |
|---|---|---|---|---|---|---|---|
| Chinook | CHM | marsh | historical | 12 | A | 1 | 2009 |
| Trestle Bay | TBB | marsh | breach | 12 | A | 2 | 2008 |
| Fort Clatsop | FCB | marsh | breach | 19 | A | 3 | 2008 |
| Lewis and Clark River mouth | LCM | marsh | historical | 20 | A | 4 | 2009 |
| Cooperage Slough | CSM | marsh | historical | 23 | A | 5 | 2007 |
| Grant Island | GIM | marsh | historical | 23 | A | 6 | 2009 |
| Haven Island | HIB | marsh | breach | 23 | A | 7 | 2009 |
| Crooked Creek | CCS | swamp | historical | 37 | B | 8 | 2008 |
| Secret River | SRM | marsh | historical | 37 | B | 9 | 2008 |
| Secret River | SRS | swamp | historical | 37 | B | 10 | 2008 |
| Seal Slough | SSS | swamp | historical | 37 | B | 11 | 2009 |
| Miller Sands | MSC | marsh | created | 39 | B | 12 | 2009 |
| Karlson Island | KIS | swamp | historical | 40 | B | 13 | 2008 |
| Karlson Island | KIB | marsh | breach | 41 | B | 14 | 2008 |
| Welch Island | WIM | marsh | historical | 53 | B | 15 | 2008 |
| Welch Island | WIS | shrub | historical | 53 | B | 16 | 2009 |
| Ryan Island | RIM | marsh | historical | 61 | C | 17 | 2009 |
| Jackson Island | JIC | marsh | created | 71 | C | 18 | 2010 |
| Whites Island | WHC | marsh | created | 72 | C | 19 | 2010 |
| Westport Slough | WSS | shrub | historical | 73 | C | 20 | 2010 |
| Wallace Island | WAC | marsh | created | 77 | C | 21 | 2010 |
| Clatskanie River | CRM | marsh | historical | 80 | C | 22 | 2009 |
| Gull Island | GUC | marsh | created | 89 | C | 23 | 2009 |
| Coal Creek Slough | CCR | riparian | historical | 98 | C | 24 | 2009 |
| Lord Island 2 | LI2 | marsh | created | 100 | C | 25 | 2009 |
| Dibblee Slough | DSC | marsh | created | 104 | C | 26 | 2005,10 |
| Cottonwood Island 1 | CI1 | marsh | created | 113 | D | 27 | 2010 |
| Cottonwood Island 2 | CI2 | marsh | created | 114 | D | 28 | 2010 |
| Sandy Island 1 | SI1 | marsh | created | 121 | E | 29 | 2007 |
| Sandy Island 2 | SI2 | marsh | created | 123 | E | 30 | 2007 |
| Goat Island | GIC | marsh | created | 131 | E | 31 | 2009 |
| Gee Creek | GCR | riparian | historical | 141 | E | 32 | 2010 |
| Scappoose Bay | SBM | marsh | historical | 143 | F | 33 | 2010 |
| Cunningham Lake | CLM | marsh | historical | 145 | F | 34 | 2010 |
| Campbell Slough | CS1 | marsh | historical | 149 | F | 35 | 2010 |
| Sauvie Slough (Willow Bar) | SSC | marsh | created | 154 | F | 36 | 2005,10 |
| McGuire Island | MIC | marsh | created | 190 | G | 37 | 2006 |
| Washougal River mouth | WRM | marsh | historical | 195 | G | 38 | 2010 |
| Old Sandy River mouth | OSM | marsh | historical | 198 | G | 39 | 2007 |
| Chattham Island | CIC | marsh | created | 201 | G | 40 | 2006 |
| Sand Island (Rooster Rock) | SIM | marsh | historical | 211 | H | 41 | 2008 |
| Franz Lake | FLM | marsh | historical | 221 | H | 42 | 2009 |
| Pierce Island | PIM | marsh | historical | 228 | H | 43 | 2008 |

[3] Two sites (26 - Dibblee Slough and 36 - Sauvie Slough) were originally monitored in 2005 as part of the EM study. Additional metrics were monitored in 2010 to conform to the design of the present study.

## 2.4 Sampling Metrics

All sampling occurred in the summer between the end of June and mid August to capture the vegetation during peak biomass and during low daytime tides to facilitate in-channel work. In general, data collection was conducted as outlined in the Protocols for Monitoring Habitat Restoration Projects in the Lower Columbia River and Estuary ("Protocols;" Roegner et al., 2009). Specific methods are discussed below.

### 2.4.1 Sediment Characterization

Sediment cores were collected at each site in the channel and from the marsh/swamp plain. These samples were analyzed for grain size and total organic carbon (TOC) content by Columbia Analytical Services, Kelso, Washington. Sediment cores from sites monitored under the Ecosystem Monitoring program are included in this report.

### 2.4.2 Accretion Rate

Sedimentation stakes used in this study and described in the Protocols, are simply PVC stakes separated by one meter where the distance from the plane at the top of the stakes to the sediment surface is measured as accurately as possible every 10 cm along the one meter distance. The stakes are deployed during the summer and measured one year later to evaluate the change in surface elevation over the year. Stakes were placed at 40 reference sites; however, environmental issues in the field beyond our control precluded the use of eight sets.

**Figure 5. Measuring sediment accretion using PVC stakes.**

### 2.4.3 Vegetation Assemblage

Vegetation was sampled in all habitat types. Necessarily, different methods were used at emergent marsh sites, shrub wetland sites, and forested wetland sites.

Emergent marsh vegetation species composition and percent cover were assessed according to the Protocols using a systematic, random sampling design. Transects were established at equal intervals along an established 'baseline' with a random start point. Sample plots were also spaced equally on each transect with a randomly selected starting point. At each sample plot, percent cover by species was estimated in a 1-$m^2$ quadrat using 5% increments. In addition, descriptive information about the site was collected in field notes where possible to complement the vegetation monitoring. Vegetation mapping of broad plant communities was conducted at some sites, where feasible, using a handheld GPS unit (GeoXT, Trimble, Sunnyvale, California).

For forested and shrub wetland sites, a systematic sampling design from a random start, similar to that for emergent marshes, was used to establish transects. The length of the tidal channel to be sampled was determined and a random number was generated as the start point for placement of

the first transect. Remaining transects were located parallel to the first and systematically spaced. Transects crossed the channel, encompassing the riparian area on both sides (50 m) and submerged aquatic vegetation within the channels, which were sampled at low tide. Along each transect, tree, shrub, and herb plots were systematically placed as follows:

Trees: 10-m diameter circular plots with 15-m spacing between plot centers starting 10 m from the bank of the channel.

Shrubs: 1-m by 10-m belts within the tree plot at a random subset of the tree plots, or placed at regular intervals from a random start along the transects for the shrub-only sites.

Herbs: 1-$m^2$ plots from a random start at 10 m intervals on each transect (similar to the method for herbaceous cover in emergent marshes), including the channel.

Species cover was determined using the following techniques:

Trees: A 10-m tape was placed perpendicular to the transect tape to delineate the 10-m diameter tree plot with "crosshairs." All trees in the plot were identified to species and diameter at breast height (dbh) measured with a dbh tape.

Shrubs: A 10-m tape was placed perpendicular to the transect tape to delineate a 1-m by 10-m "belt" across the tree plot. All shrubs that were rooted within the belt were identified to species and the number of stems were counted by size class. Percent cover of the shrub layer was estimated for each 1 x 10 m plot by visually estimating the cover in 5% increments for each half of the plot (1 x 5 m).

Herbs: The percent cover of the herbaceous layer was estimated in 1-$m^2$ plots as described for emergent marsh sampling above.

In 2008, an assessment of existing reference site datasets throughout the estuary was conducted to determine the appropriate sample size for different types of vegetation communities (Diefenderfer et al. 2006; Borde et al. 2008a; John Skalski[4], personal communication 6/20/2008). The following sample sizes (i.e., number of replicate samples) were determined based on this assessment:

| | | |
|---|---|---|
| Emergent marshes: | Herbs | 20-30 |
| Forested wetlands: | Trees | 30 |
| | Shrubs | 6 |
| | Herbs | 42 |

The sample size necessary to adequately represent the site corresponds to the diversity of the plant communities (Tiner 1999), which can vary greatly in freshwater marsh ecosystems. Therefore, final determination of sample size in the marshes was made on site. In general, the sample size exceeded the numbers recommended above to ensure adequate sampling was accomplished. In particular, the number of shrub plots was increased to at least nine to ensure representation of a greater proportion of biodiversity.

[4] John Skalski, PhD, Professor of Biological Statistics, University of Washington

### 2.4.4 Elevation

At each site, a benchmark was used to reference all survey data. An established local benchmark was used if one could be located and a Trimble real-time kinematic global positioning system (RTK) base receiver was set up over the benchmark and the coordinates were entered into the system. If an existing benchmark was not available, then a temporary benchmark was established. In this case, a Trimble base receiver was set up at or near the site and GPS data were logged over a 4 – 6 hour period. The data were then sent to an automated Online Positioning User Service (OPUS) provided by National Geodetic Survey (NGS). The OPUS data provides a Root Mean Squared (RMS) value for each set of static data collected by the base receiver. The RMS is the circular positional error around a point. RMS is an indicator of the random error associated with each surveyed point. Elevation data collected with the roving collection unit was corrected using the post-processed base receiver data. Data collected from the RTK were processed using Trimble Geomatics Office (TGO) software. Each survey was imported and reviewed. Points collected that have a high RMS value were flagged by the processing software and were manually removed from the survey, after which the survey was exported in a GIS shapefile format. The surveys were visually checked within TGO and GIS software for validity.

Sources of error from these RTK methods include: 1) Low satellite coverage, 2) OPUS processing errors, and 3) multipath errors. Error estimates associated with the RTK data have been made and on average equate to approximately ± 4 cm. Further analysis of our data is underway to evaluate spatial and temporal variation in the elevation data.

In some cases, data were collected using the auto-level method. These data were entered into a spreadsheet and corrected using the RTK reference point elevations exported from TGO. All elevation surveys are referenced to the North American Vertical Datum of 1988 (NAVD88).

**Figure 6. RTK base receiver set up near a study site to collect static data for the temporary benchmark used at the study site.**

Elevation data were collected for the following locations:

1) a temporary benchmark (if created)
2) reference points (if necessary for auto-level use)
3) vegetation sample locations
4) longitudinal vegetation and elevation surveys
5) water level sensors
6) sediment accretion stakes
7) channel cross-sections.

Surveys were completed using only the RTK at most marsh sites where overhead vegetation did not block satellite acquisition, while a combination of RTK and auto-level methods were needed at swamp sites where large trees and shrubs frequently block satellites. If tree cover did not permit RTK use then a temporary reference point was established with the RTK rover in a nearby location where more satellite signals were available. The auto-level was set up in a location with line-of-sight to both the reference point and the area(s) to be surveyed. Two methods were used to determine elevation of vegetation species; in marshes, vegetation plots were surveyed, and in swamps, individual species were surveyed along a subset of transects. Efforts were made to measure individual species in multiple locations to capture their upper and lower ranges and to ensure elevations of all species in the sample area were captured.

### 2.4.5 Channel Morphology

Channel cross sections were measured to characterize the primary tidal channel at each site. If possible, five channel cross-sections from the mouth of a main marsh channel to the upper extent were surveyed; intermediate cross-section surveys were conducted above the confluence of major secondary channels or equidistant along the channel if appropriate, as recommended by the Oregon Coastal Hydrogeomorphic (HGM) Assessment Method (Adamus 2005).

Elevations were measured with an RTK at each point or feature of a channel cross-section. Alternatively, the RTK rover was used to determine the elevation of the end post(s) of the cross section and an auto-level and stadia rod were used to measure elevations relative to the end posts.

**Figure 7. Surveying a channel cross section at a swamp site using auto level and stadia rod.**

### 2.4.6 Hydrology

We used *in situ* water level loggers (HOBO U20 Water Level Logger, Onset Computer Corporation, Bourne, Massachusetts) to measure water level and temperature at the monitoring sites. The accuracy of these sensors is estimated to be approximately 2 cm. The sensors were deployed during the summer months and were retrieved one year later. At the time of deployment and retrieval, the distance from the sensor to the top of the post and the water level above the sensor were measured for elevation correction and calibration. The top of the post was surveyed as described in the Elevation section above to convert the relative water levels to elevations relative to NAVD88.

**Figure 8. Water level sensor deployed in channel at marsh site.**

Thirty-nine water level loggers were deployed at the study sites; however, four either failed or were displaced during the deployment period. When a sensor was located within one kilometer of a study site, data from the nearby sensor was used for inundation calculations. This occurred when only one sensor was deployed in a region or when one of the proximal sensors failed.

## 2.5 GIS Analysis

River kilometer (rkm) was established for each site using a river mile GIS data layer from USGS as the starting point. The river mile attributes for the points were converted to kilometers and then a channel midline was created by connecting the points. Next, a route tool was used to create a point at every kilometer along the midline. Rkm was established for each site based on proximity to point from the next GIS layer. If the point was off not in the Columbia River, i.e. up a tributary, the center point of the confluence of the Columbia and the tributary was used for the proximity comparison.

Distance from main channel was determined for each site based on the following criteria:

1. Sites sharing a boundary with either the Columbia River or a bay (e.g. Grays Bay) were considered to have a distance of 0 km from the main channel.

2. Sites on a side channel of the River (e.g., channel between an island and the mainland) were also considered to have a distance of 0 km from the main channel.

If neither of the above criteria were satisfied then distance from the main channel was determined by creating a line feature in GIS from the closest sampling area within the site to the water body considered the main-channel (as defined above).

Channel length, distances between channel cross sections, and site area were delineated using GIS software (ArcGIS 9.3, ESRI, Redlands, CA).The channel metrics were delineated using the 2005 LIDAR and 2009 National Agricultural Image Program (NAIP) imagery to define the location and extent of the primary tidal channel at each site. Channel distances were calculated using a route definition tool.

The site areas were also defined using the 2005 LIDAR to delineate topographic/hydrologic boundaries and the 2005 and 2009 NAIP imagery to define vegetation boundaries. A “site” was defined as the area surrounding the primary tidal channel where the monitoring was conducted. In

many cases, the area of emergent wetland may have extended beyond these boundaries; however, this definition provided a consistent delineation between sites.

Site study area is an attribute characterizing the specific area at each site that was monitored. At forested sites this was calculated as the area directly surrounding the vegetation sampling transects. At sites which included GPS mapping as part of the monitoring the area of the polygons created from that effort was used to calculated the site study area.

Data from the GPS mapping effort were downloaded and post-processed using Trimble's Pathfinder Office software. The files created were moved into a GIS and polygons were created from the lines and points collected in the field. Vegetation community attributes were created by associating field determined attributes with the polygons. The resulting polygons were used as a base layer in site maps created for each site.

## 2.6 Data Analysis

### 2.6.1 Sediment Accretion Rate

The 11 measurements collected at the accretion stakes are averaged. The average of measurements collected in the second year of collection is subtracted from the average of measurements collected in the first year. A positive value indicates accretion occurred at the site while a negative value indicates erosion.

### 2.6.2 Vegetation

Average percent cover was calculated for each herbaceous species identified at a site along with bare ground and litter/wrack. At forested sites, stem density was also calculated for all tree and shrub species. Basal area was calculated for tree species. Species were identified as either native or non-native using sources such as the USDA plant database. Species richness was separated into native and non-native species and a count of each type was provided for each site.

### 2.6.3 Elevation

In marsh systems, elevation data for each vegetation plot was applied to the plant species sampled in the plot. The average, minimum, and maximum elevation was calculated for each species. In the swamp systems, average elevations for each species were calculated. Cross section data and water level data were corrected to real (not relative) elevations. To make information more comparable between sites and relative all elevation data were converted to Columbia River Datum (CRD) or Mean Lower Low Water (MLLW). The CRD is a fixed low water which we applied to our sites using the CRD/MLLW conversion information from tidal benchmark data provided by NOAA. The data was used to create a GIS data layer. This layer was overlayed on the rkm data and conversion values were interpolated between known values to create a conversion factor for each rkm. This conversion factor could then be applied to all elevation data collected at a site by looking up the conversion factor by the rkm established for the site.

Vegetation community elevation boundaries were determined at some sites by collecting elevation data as part of a longitudinal transect across the site and perpendicular to the elevation gradient. At each boundary between vegetation communities an elevation point was collected and

relevant species noted. This data was later overlayed on the vegetation mapping data and compared to the vegetation plot data to determine the overall elevation boundaries of the vegetation communities at each site.

### 2.6.4 Channel Morphology

Channel width and area were calculated by first determining the top of bank and thalweg for each cross section. This was based on field notes and evaluation of the data. The top of bank was then used to determine the width of the channel, which was used as the upper plane to calculate the area of the cross section and the depth of the channel. Channel slope is calculated from the difference between the upper and lower channel thalweg elevations divided by the distance along the channel between the two cross sections.

### 2.6.5 Hydrology

Inundation times were calculated for the wetland surface and channels. In the channels, the calculation included the time that the water level was greater than 15 cm in the channel and greater than the elevation of top of the bank at each cross section. These attributes were selected as those important for fish access to the channel and the wetland edge. Similarly, inundation of the wetland surface was calculated for the time the water level was greater than the average and range of elevations at the site. In forested wetlands, the average elevations for the herbaceous, shrub, and tree layers were evaluated separately. The inundation periods were calculated for one year of deployment and for the growing season. The growing season was based on the Natural Resource Conservation Service (NRCS) wetland determination (WETS) table for Clark County, WA (NRCS 2002), which provides the average length of the growing season based on 30 years of climate data. The most conservative estimate of season length was used, based on the dates when the temperature is above 32° Fahrenheit for 15 out of the 30 years, and was 22 April through 12 October. The frequency of inundation during the growing season was also limited to daylight hours (between 0900 and 1700) in order to better evaluate the effect of inundation on plants

We developed a graph that combines hydrology data with vegetation community elevation boundaries (see above elevation section). Inundation time was calculated at each site for every 10 centimeters between 0 m and 4.5m. These values were then plotted against elevation. The vegetation community boundaries were added to this graph showing the relationship between inundation and the vegetation communities at each site.

Sum exceedance value (SEV) is a metric that combines magnitude and duration of inundation at a site into a single value that represents the cumulative inundation over time. For this analysis, the period had to be exactly the same length to allow comparison between sites, therefore, the 1-year and growing season periods were necessarily decreased by removing the dates between June 22 and August 19. The dates removed reflect a gap in water level data at some sites when sensor was removed before an entire year of data was collected. Following work conducted in the US and in Europe (Gowing et al., 2002; Simon et al., 2007; Araya et al., 2010) we calculated the SEV using the following equation:

$$SEV = \sum_{i=1}^{n} (d_{elev})$$

where $n$ is the number of days present in the growing season, $d_{elev}$ is the daily average water level elevation above the average marsh elevation. The SEV was calculated for each site relative to average vegetation elevation and a standard elevation value. The average elevation at each site was calculated by averaging the elevations taken at each vegetation plot within the sampling area. The standard elevation value was created by averaging all site average elevations. The SEV unit is meters of water per year or per growing season.

# 3.0 Results

The research results described below augment the existing descriptions (Christy and Putera 1993, Kunze 1994, Christy 2004, Christy and Brophy 2007) of brackish and tidal freshwater wetland ecology for the LCRE by providing quantitative measures of both plant community composition and ecological processes (e.g., hydrological patterns and sediment accretion/erosion rates) suitable for use as restoration objectives. Additionally, the results provide ranges of the variability in channel area, and elevations of plant species relative to inundation levels, in order to inform restoration project design. Taken together, the data on community composition, species cover, elevation, inundation, channel cross section morphology, and sediment accretion rate provide descriptors of "model" habitats that can be used a targets for shallow water habitat restoration projects.

Tidal wetland communities in the LCRE can be divided into four broad hydrologic categories following the classification of Kunze (1994) and as described in the Study Area section of this report (Section 2.1). Within these broad hydrologic categories, habitat types are each comprised of differing community compositions and dominant vegetation species depending on the factors controlling their distribution (e.g., hydrology, elevation, substrate, seed sources,, etc.). These habitat types are organized here following Cowardin et al. (1979), which are further divided by vegetation type and/or historical information, as follows:

- Estuarine Forested Wetlands
  - Evergreen (Swamps)
  - Deciduous (Riparian)
- Estuarine Shrub Wetlands
- Estuarine Emergent Wetlands (Marshes)
  - Historical
  - Created
  - Previously Diked

## 3.1 Site Summaries

To encourage and facilitate access to data from specific reference sites by restoration managers, data are presented as "Reference Site Summaries" (Appendix B). This section is meant to be a guide to the data presented in the Summaries and follows the same order as that within the Summaries, as follows: Site Description, Elevation, Vegetation, Inundation, Sediment, and Channels.

### 3.1.1 General Information

The Summaries are a succinct reference providing ranges of structural metrics measured at relatively undisturbed wetland reference sites in the lower Columbia River and estuary (LCRE). They are presented in order by river kilometer (rkm) from the mouth to Bonneville dam (rkm 235). The following terms are used in the Summaries and are defined here for clarity:

Site – refers to the whole area defined by the site boundary indicated on the site maps.

Study Area – refers to monitored areas at each site, including vegetation sampling and mapping, cross sections, depth sensor, photo points and sediment accretion stakes. At some locations, where the channel length was extensive, the cross sections extend outside the primary study area.

Monitoring Locations – points located throughout the study area. These points are indicated on the site maps.

### 3.1.2 Site Description

Within the Summaries, this section provides general physical and spatial information about the following characteristics of each site.

**Hydrogeomorphic reach** classification is a GIS classification of the lower Columbia River and estuary developed by the University of Washington. As the name implies, this classification is based on hydrologic and geomorphic differences in the LCRE and is lettered A (at the mouth) through H below Bonneville Dam.

**Coordinates** are provided for each site in the Universal Transverse Mercator (UTM) projection relative to the North American Datum of 1983 (NAD83) in meters. This projection is preferred because it eliminates differences between the states and is easy to use in field work.

**Distance from Columbia River mouth** is the distance in kilometers along the Columbia River. This value does not include the distance off the main channel, such as up a tributary or slough.

**Distance from main channel** of the Columbia River is the distance from the site, along the water to the main channel of the river; the main channel definition includes bays and side channels.

**Type** refers to the wetland classification. Type is determined based on vegetation community and history of the site. Categories are:

- Swamp – forested wetlands in the coastal zone of the River (to approximately rkm 75) dominated by conifers, especially Sitka spruce (*Picea sitchensis*)
- Riparian Wetland – forested wetlands along the fluvial dominated portion of the LCRE dominated by deciduous trees such as cottonwood (*Populus balsamifera*) and Oregon ash (*Fraxinus latifolia*)
- Shrub Wetland – shrub dominated wetlands with few trees
- Marsh – emergent wetlands that were present on historical maps from the 1880s
- Created Marsh – marshes that were not present on the historical maps from the 1880s and are primarily created from the placement of dredge material over the past 100 yrs
- Previously Breached Marsh – marshes that have formerly been diked, but the dike was breached either by natural causes or by restoration actions

**Total site area** is the area within the Site Boundary represented in orange on the site overview map.

**Study area** encompasses the area that is covered by the vegetation mapping, if conducted at the site, or is the area that includes all the monitoring locations.

**Total channel length** is the length of the primary channel running through the site (if there is one) and is depicted by a blue line on the site overview map.

**Channel surveyed** is the length of the channel from to mouth of the channel to the upper-most surveyed cross section and is depicted by a yellow line on the site overview map.

**Channel slope (**or gradient) is calculated from the difference between the upper and lower channel thalweg elevations divided by the distance along the channel between the two cross sections.

The **site map** includes the vegetation community map (if mapping was done at the site), the monitoring locations, a site overview map, and a river/estuary map showing the location of the site on the River (Figure 9).

**Site information** is provided, including a brief disturbance history as well as information on ownership and general physical features.

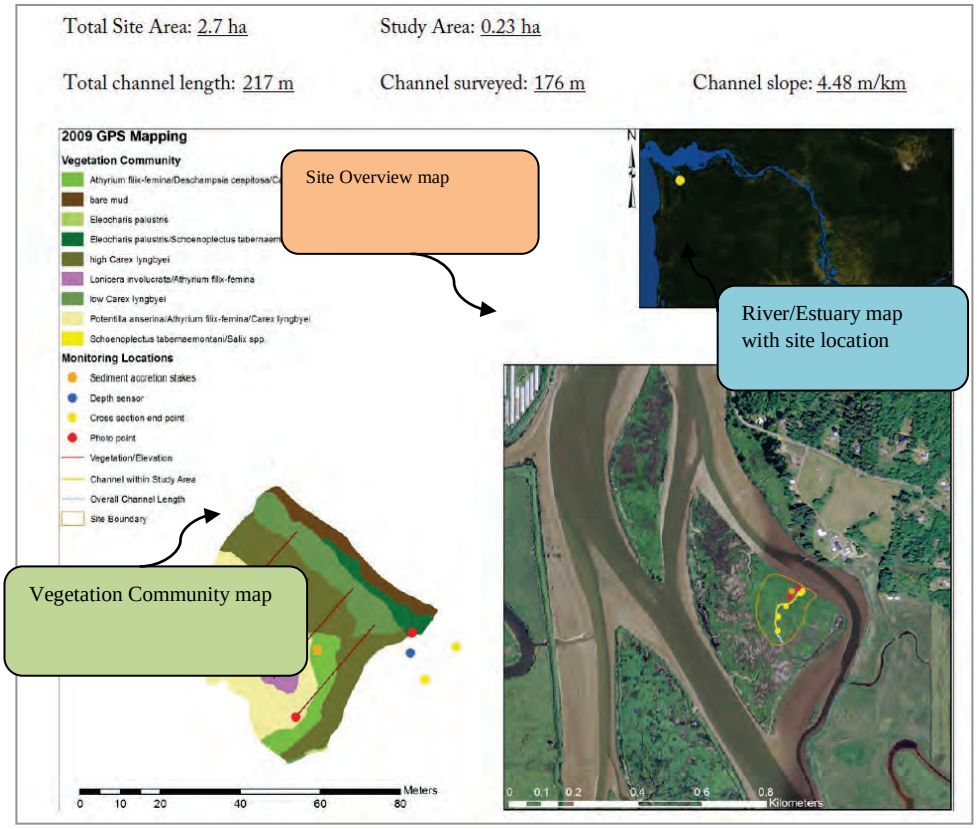



**Figure 9. Example of the maps provided in the Site Summaries.**

### 3.1.3 Elevation

Elevation, for most of the sites, is listed in meters relative to Columbia River Datum (CRD). At tributary sites, the CRD is not applicable, so the elevations at these sites are provided in meters relative to the North American Vertical Datum 1988 (NAVD88). Main stem sites below rkm 35 have no CRD conversion, therefore elevations were converted Mean Lower Low Water (MLLW).

Elevations for the lowest and highest wetland areas found at the site are provided in both NAVD88 and CRD/MLLW, where applicable. Elevation ranges are also shown for each sampled vegetation species on the graph in the vegetation section (Figure 10)

### 3.1.4 Vegetation

Native and non-native species counts and cover data are summarized in this section. The graph provides the average percent cover for all of the species found within the vegetation sampling area and their average elevation (elevation range shown as the error bars on the graph) (Figure 10). For shrub and tree sites, information on density is also included. Species codes were used, which are the first two letters of the genus and first two of the species. A species list that defines the codes is provided in Appendix C.

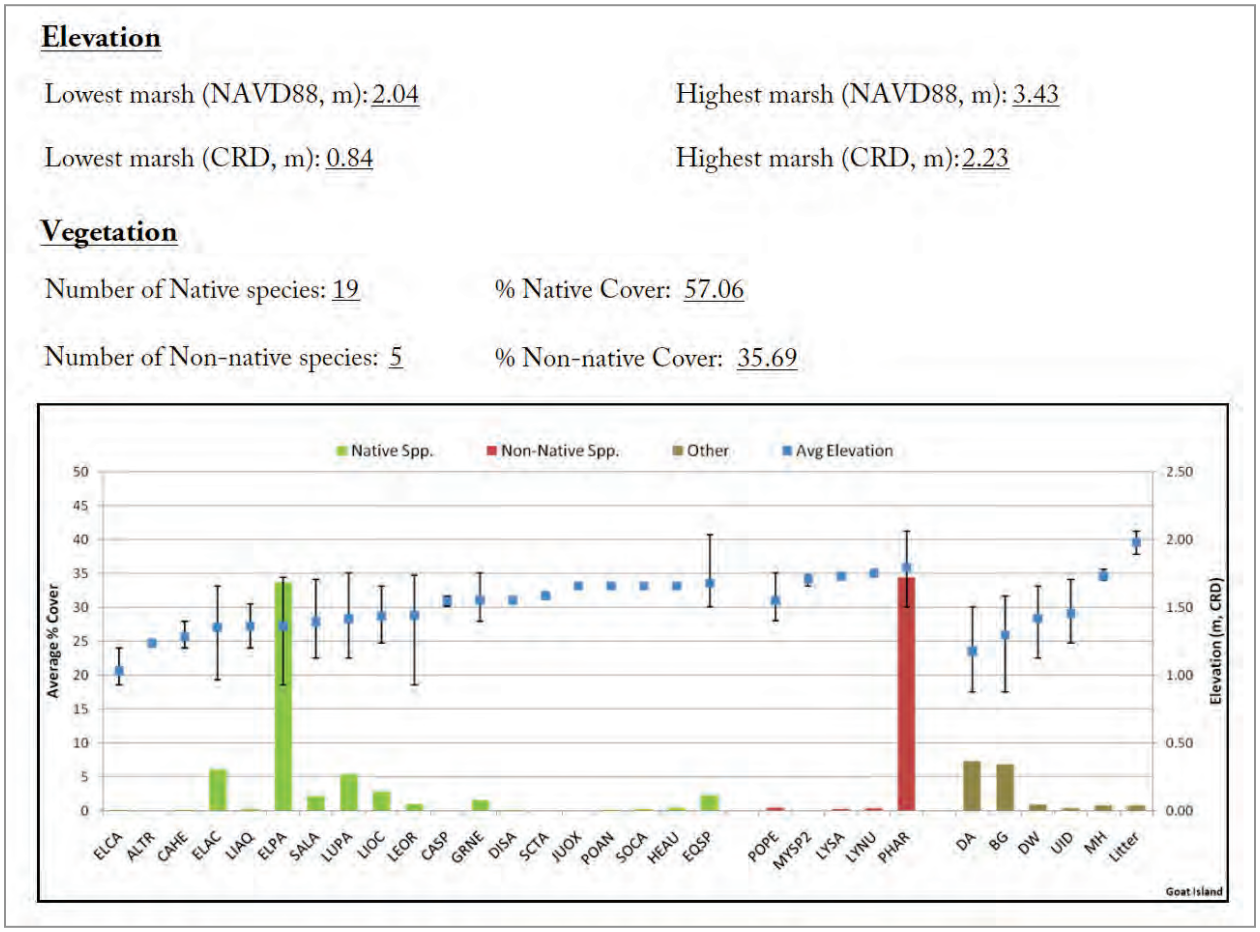



**Figure 10. Example of summarized vegetation and elevation data from the Site Summaries.**

### 3.1.5 Inundation

This section includes the results of hydrologic data analysis as related to elevation and vegetation at the sites where we deployed water level sensors (Figure 11). As part of this analysis, we calculated inundation in two ways:

1. The Sum Exceedance Value (SEV)

2. Percent of time inundated

**Sum Exceedance Value (SEV)** encompasses magnitude and timing of inundation and provides a means to evaluate differences in water regimes on vegetation communities. The SEV is calculated during a time period defined as a Modified Growing Season, which has been developed to be a standard period of time so that calculations at all the sites are comparable. It is based on the growing season for wetlands in Clark County, Washington, with two summer months removed due to differences in sensor deployment and retrieval dates.

The SEVs are calculated at the following relevant elevations for each site:

- The "Standard" (**Std**) elevation is the average elevation of all 43 sites and is used for comparing the SEVs throughout the estuary.
- The **Average elev** is the average elevation of the vegetation sampling area for the broad vegetation community at the site (e.g., marsh, herb, shrub, and tree).

The hydrograph shows the water level data collected at the site over a 1-year period (or less if a year was not available). The red line across the graph represents the average site elevation.

The inundation graph shows **Percent Time Inundated** over the range of elevations found at the site regardless of vegetation. Colored dots with droplines mark the elevation boundaries of major vegetation communities found at the site. Vegetation communities are listed by species code in a color matching the color of the dots. Tree communities only have a lower boundary because they often extend beyond the range of the graph and the study area.

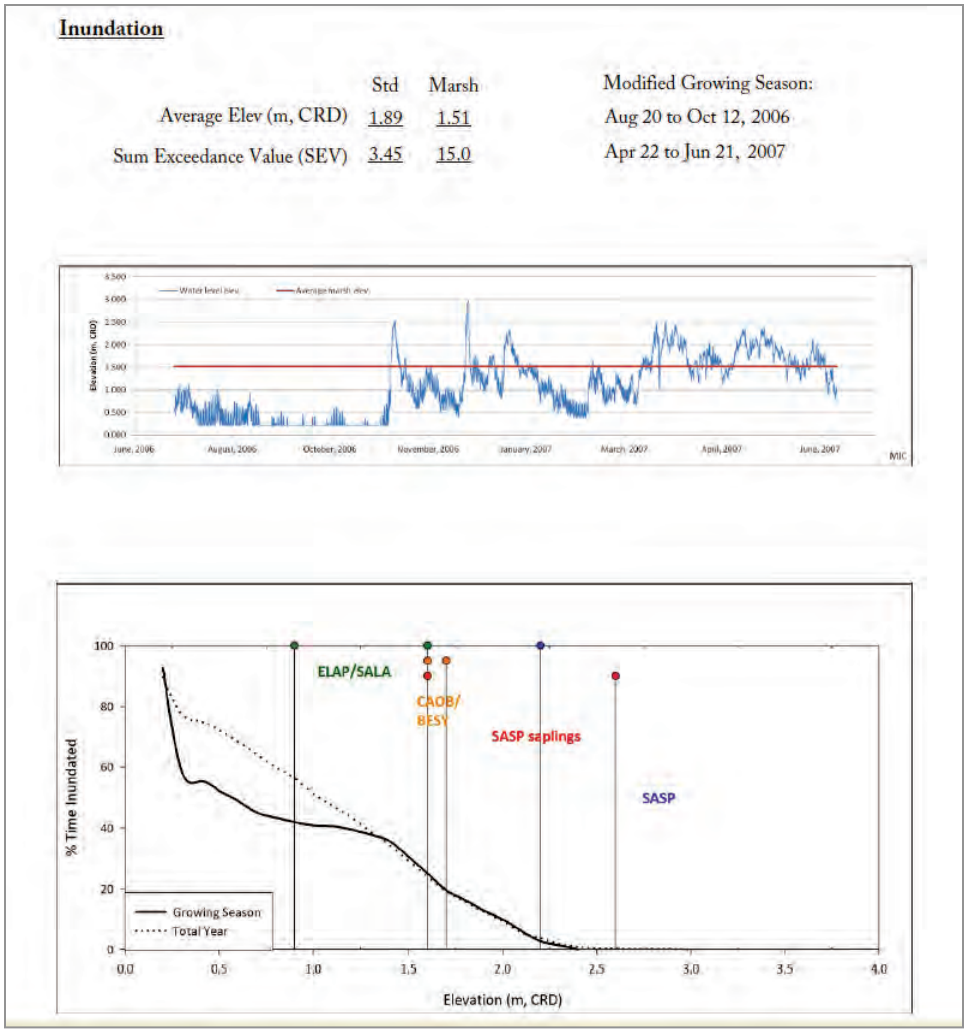



**Figure 11. Example of the inundation analysis from the Site Summaries.**

### 3.1.6 Sediment

**Sediment accretion rate** and elevation values of the sediment stakes are provided if stakes were deployed. Percent **total organic carbon (TOC)** and a grain size chart are included if sediment samples were taken at the site (Figure 12).

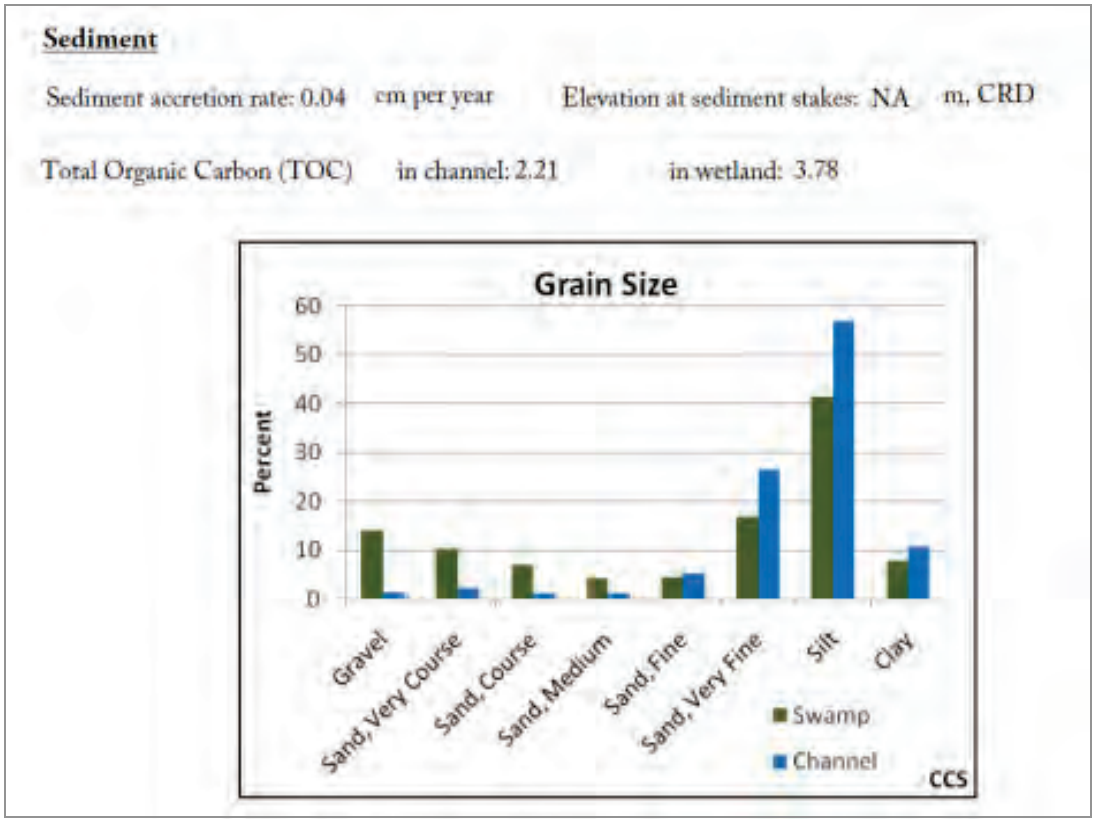



**Figure 12. Example of sediment elevation and composition data from the Site Summaries.**

### 3.1.7 Channels

Physical channel metrics for the site are given where channel data was collected (Figure 13). Channel inundation information was calculated if a depth sensor was present at or near the site and the site included a channel. **Bank elevation** and **thalweg elevation** were determined based on channel cross section data and were usually the top of the cut bank and the deepest point in the channel, respectively. **Time WL > thalweg** was calculated as the percent of time the water level was greater than the thalweg elevation +15cm; an indication of the opportunity for fish access. Likewise, the **time WL > bank** was calculated as the percent of time the water level was greater than the bank elevation as an indicator of the time would have access to the marsh edge. Both inundation times were calculated during the entire deployment period (**year**) and for the **growing season**. Future calculations should be made for a period of time representative of the peak juvenile salmon out-migration period to provide a better indication potential access time. The cross section graph is a 3D depiction of the elevations along transects perpendicular to the channel and distance up the wetland channel (Figure 13).

**Channels**

| | | Physical Metrics | | | | | | Inundation | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Year | | Growing Season | |
| | Cross Section | Bank Elevation (m) | Thalweg Elevation (m) | Channel Depth (m) | Cross Section Area ($m^2$) | Channel Width (m) | Width: Depth Ratio | Time WL > Thalweg (%) | Time WL > Bank (%) | Time WL > Thalweg (%) | Time WL > Bank (%) |
| CCS | 1 (mouth) | 2.16 | -0.58 | 2.74 | 31.4 | 18.0 | 6.6 | 100 | 18 | 100 | 10 |
| | 2 | 2.47 | 0.20 | 2.27 | 23.8 | 16.6 | 7.3 | 89 | 8 | 84 | 3 |
| | 3 | 3.20 | 0.76 | 2.44 | 29.5 | 19.3 | 7.9 | 69 | 0 | 64 | 0 |

**Cross Sections**

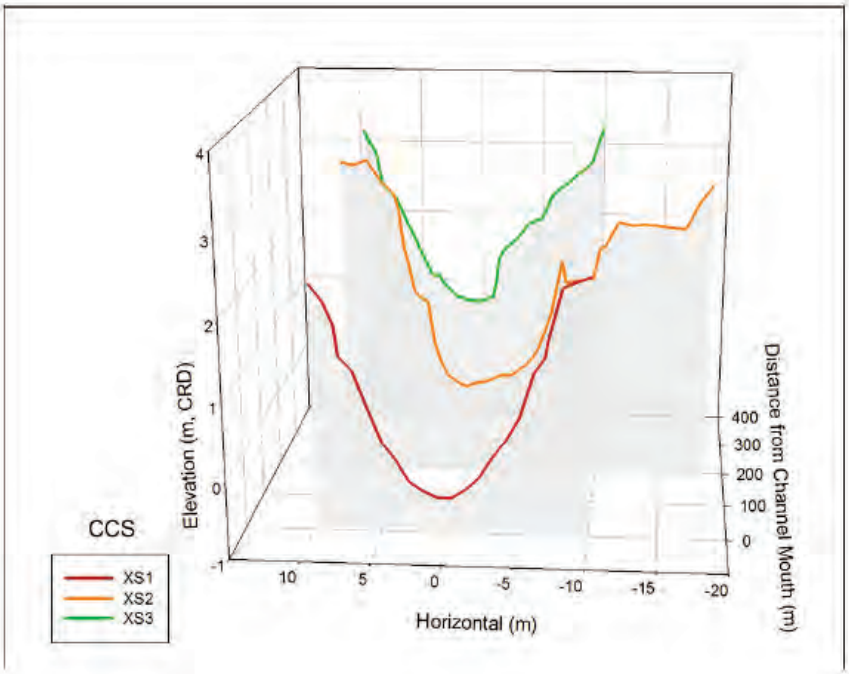



**Figure 13. Example of the primary tidal channel metrics and calculation from the Site Summaries.**

Results are summarized broadly in the following sections, while specific data for each site are provided in the Site Summaries at the end of this report.

## 3.2 Sediment

Sediment samples were taken to characterize the substrate at each site and to provide a means of comparing restoration to reference conditions. Total organic carbon and grain size were sampled at each site from the primary channel and from within the vegetated wetland area (marsh or riparian zone).

### 3.2.1 Sediment Accretion Rate

The change in sediment surface elevation was primarily positive (accretion) at the 32 study sites where the rate was measured. Eleven sites had accretion rates between 0 and 0.5 cm per year and 15 between 0.5 and 2.8 cm per year. Six sites had negative or erosion rates between 0 and -1.5 cm per year.

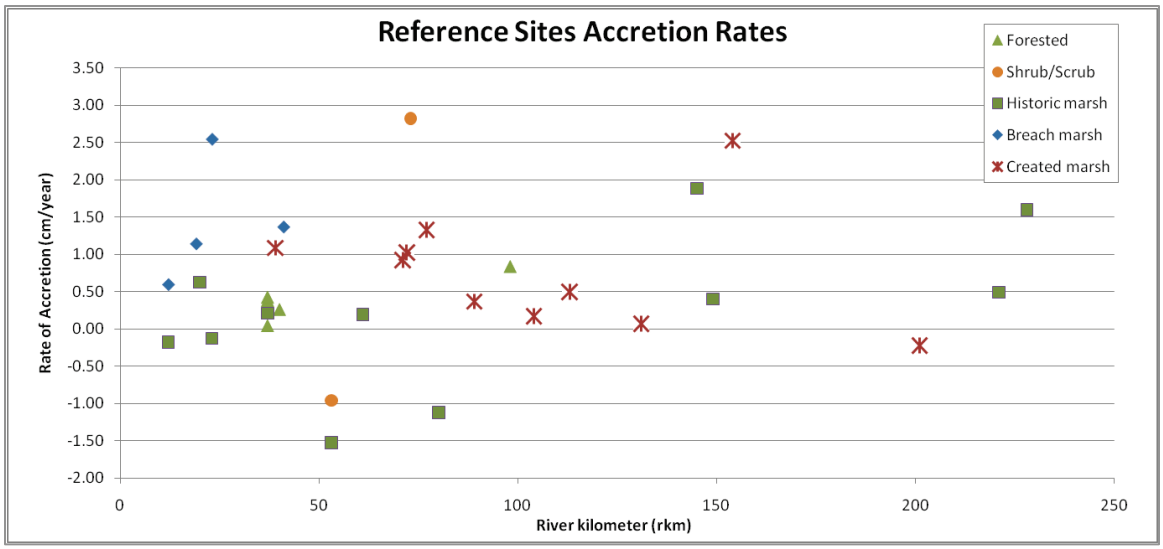
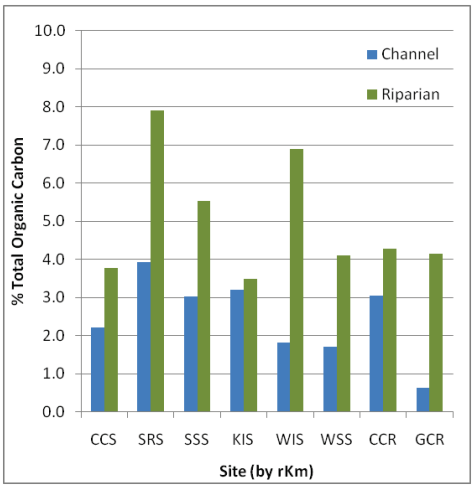



**Figure 14. Sediment accretion rates for 32 reference sites monitored between 2007 and 2010. Accretion rates are shown relative to the sites position along the Columbia River (river kilometer [rkm] from the mouth).**

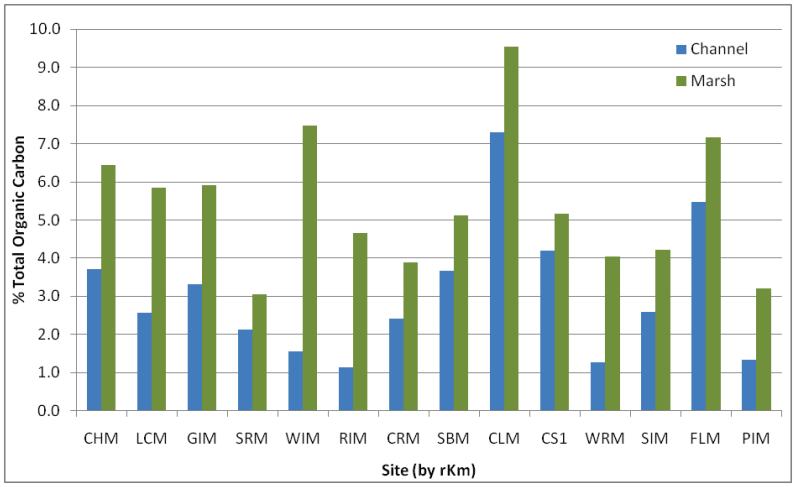
### 3.2.2 Total Organic Carbon

All of the sites sampled were below the range at which they would be considered organic (<12% TOC; Mitsch and Gosselink (2000). The historical marsh and forested sites consistently had TOC in the vegetated areas (riparian or marsh) that were greater than three percent, with most samples (14 of 22) greater than four percent. In contrast, the samples from the vegetated areas of the created sites were all below four percent (Figure 15). The previously diked sites were most similar to the historical sites in TOC content. The TOC in the channels was more highly variable, perhaps related to the amount of submerged aquatic vegetation present in these locations.

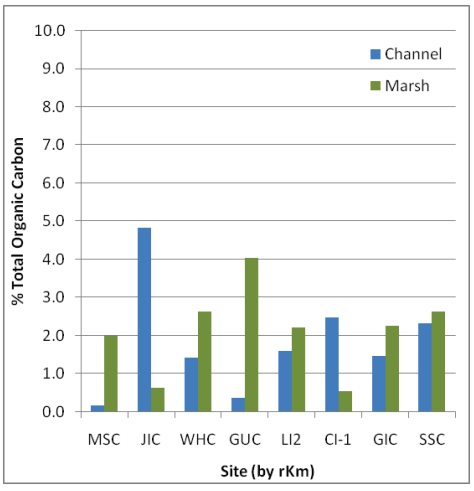
(a)




(b)




(c)




(d)

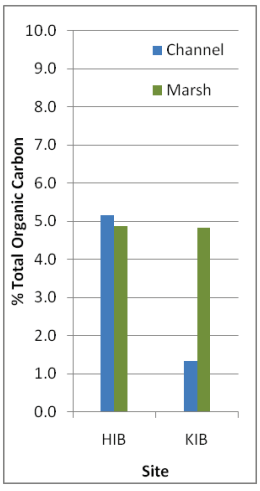
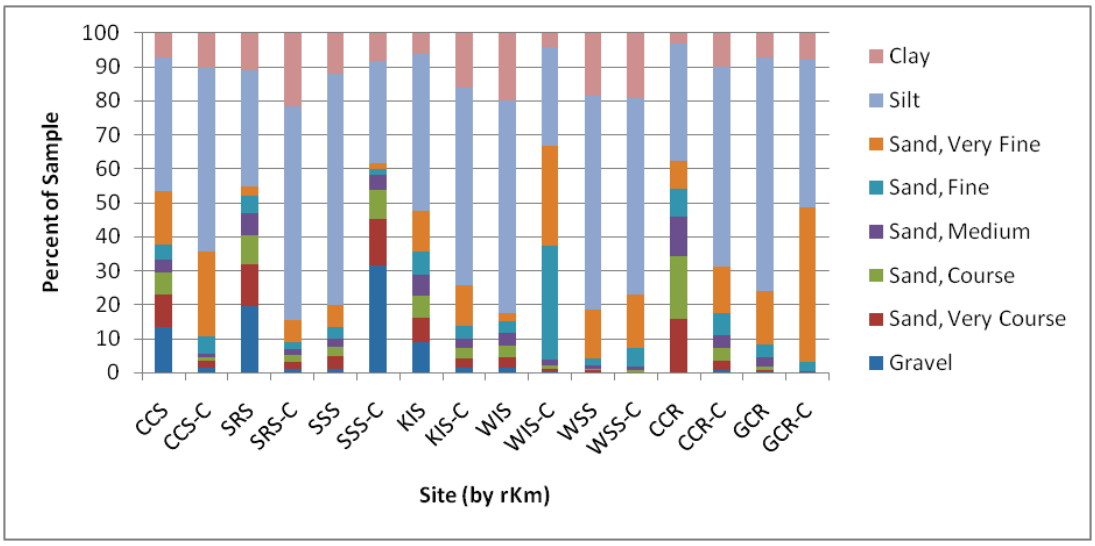



**Figure 15. Total organic carbon in sediment cores taken from (a) historical forested and shrub sites (b) historical marshes (c) created marshes, and (d) previously diked sites.**

### 3.2.3 Grain Size

All sites have predominantly silty sediment. Four of the six samples from forested sites were comprised of sandy sediments (>50 percent sand and/or gravel), the other forested and shrub sites had 15 to 20 percent sand and/or gravel in their riparian samples (Figure 16). The historical marsh sites had more sand in all samples above rkm 190, except at Franz Lake (FLM) a backwater slough (Figure 17), while the samples from the created sites had a greater sand content from sites above approximately rkm 89.

(b)




(a)

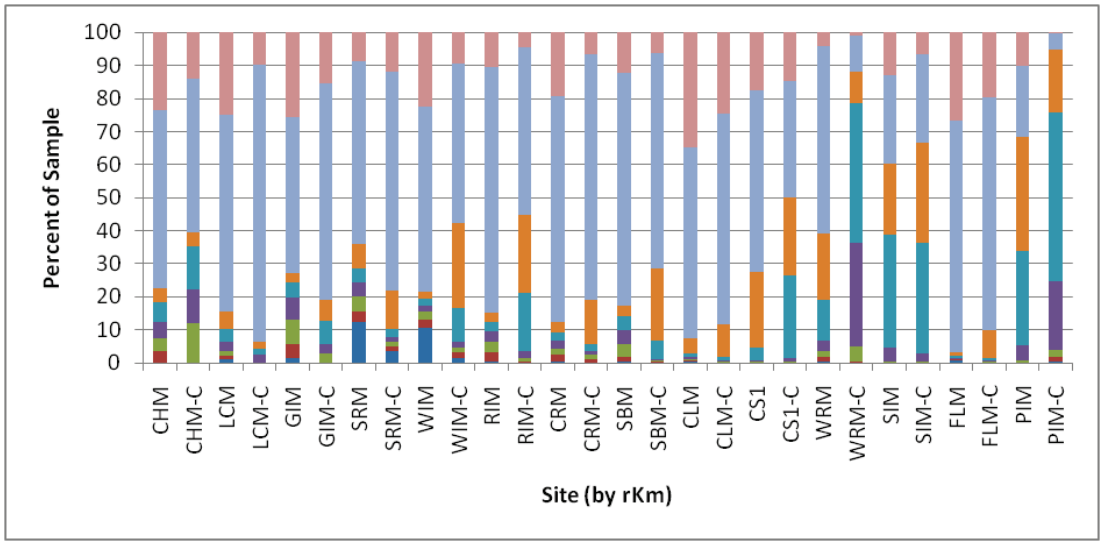



**Figure 16. Grain size in sediment cores taken from (a) historical forested and shrub sites and (b) historical marsh sites.**

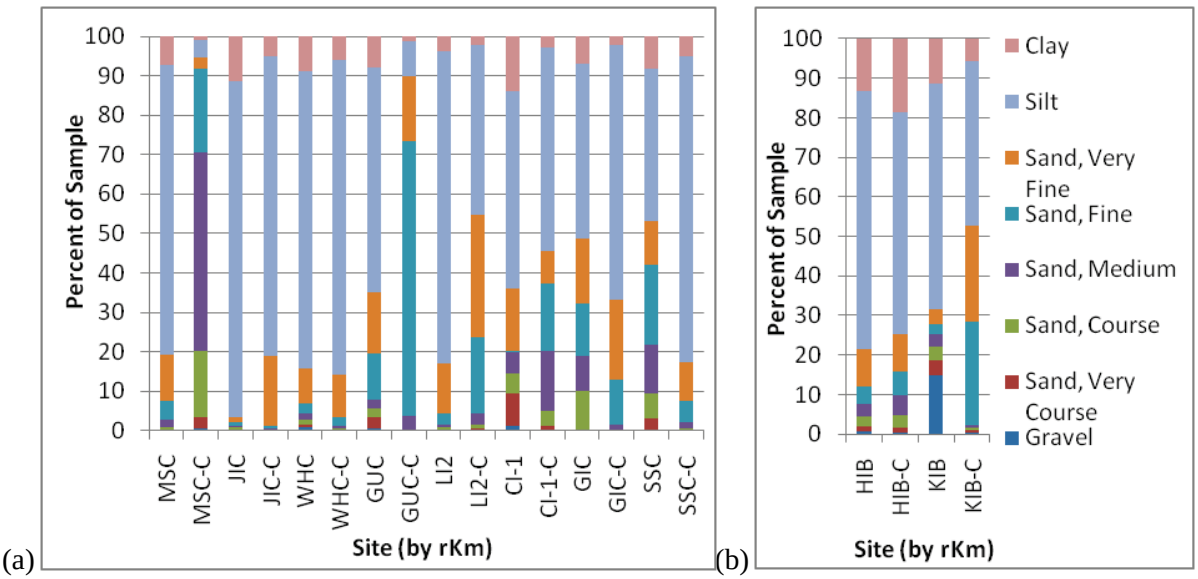



**Figure 17. Grain size in sediment cores taken from (a) created and (b) previously diked marsh sites.**

## 3.3 Vegetation

Vegetation data is provided for each community type present at each site. Species were identified to genus and species whenever possible, with nomenclature following the PLANTS database of the USDA Natural Resources Conservation Service (http://plants.usda.gov). Four letter codes are used for species names, representing the first two letters of the genus and the first two letters of the species name. Plant lists for all the sites with the code, scientific name, common name, wetland indicator, and native status are located in Appendix B.

The number of species found at each site and the percent of non-native species are shown in Table 3. Forested and shrub wetlands had the highest number of species and the lowest percent cover of non-native species. In emergent marshes, non-native species cover was higher in the middle reaches of the River (rkm 53 to 154) and lower at the mouth and above rkm 154.

**Table 3. Total number of species and number of non-native species found at the study sites.**

| Site Name | Site Code | Rkm | Total Number of Species | Number of Non-native Species | % Non-native Species | % Non-native Cover * |
|---|---|---|---|---|---|---|
| **Forested and Shrub Sites** | | | | | | |
| Crooked Creek swamp | CCS | 37 | 49 | 7 | 14 | 7 |
| Secret River swamp | SRS | 37 | 41 | 3 | 7 | 4 |
| Seal Slough | SSS | 37 | 50 | 5 | 10 | 7 |
| Karlson Is. swamp | KIS | 40 | 45 | 5 | 11 | 1 |
| Welch Island | WIS | 53 | 61 | 12 | 20 | 13 |
| Westport Slough | WSS | 73 | 32 | 1 | 3 | 7 |
| Coal Creek Slough | CCR | 98 | 30 | 2 | 7 | 14 |
| Gee Creek | GCR | 141 | 28 | 5 | 18 | 16 |

| Site Name | Site Code | Rkm | Total Number of Species | Number of Non-native Species | % Non-native Species | % Non-native Cover * |
|---|---|---|---|---|---|---|
| **Historical Marsh Sites** | | | | | | |
| Chinook River Low Marsh | CHM-L | 12 | 12 | 1 | 8 | 0 |
| Chinook River High Marsh | CHM-H | 12 | 12 | 1 | 8 | 0 |
| Lewis and Clark River mouth | LCM | 20 | 21 | 7 | 33 | 25 |
| Grant Island | GIM | 23 | 25 | 5 | 20 | 4 |
| Cooperage Slough | CSM | 23 | 17 | 2 | 12 | 2 |
| Secret River high marsh | SRM-H | 37 | 26 | 8 | 31 | 17 |
| Secret River low marsh | SRM-L | 37 | 17 | 3 | 18 | 9 |
| Welch Is. marsh | WIM | 53 | 29 | 8 | 28 | 61 |
| Ryan Island | RIM | 61 | 41 | 13 | 32 | 54 |
| Clatskanie River | CRM | 80 | 30 | 11 | 37 | 77 |
| Scappoose Bay | SBM | 143 | 14 | 3 | 21 | 49 |
| Cunningham Lake | CLM | 145 | 19 | 5 | 26 | 59 |
| Campbell Slough | CS1 | 149 | 25 | 9 | 36 | 44 |
| Washougal River mouth | WRM | 195 | 20 | 1 | 5 | 67 |
| Old Sandy River mouth | OSM | 198 | 38 | 13 | 34 | 11 |
| Sand Is. marsh | SIM | 211 | 13 | 5 | 38 | 9 |
| Franz Lake marsh | FLM | 221 | 17 | 2 | 12 | 28 |
| Pierce Is. marsh | PIM | 228 | 20 | 9 | 45 | 18 |
| **Created Marsh Sites** | | | | | | |
| Miller Sands | MSC | 39 | 13 | 6 | 46 | 41 |
| Jackson Island | JIC | 71 | 33 | 6 | 18 | 23 |
| Whites Island | WHC | 72 | 36 | 11 | 31 | 65 |
| Wallace Island | WAC | 77 | 30 | 8 | 27 | 68 |
| Gull Island | GUC | 89 | 30 | 7 | 23 | 53 |
| Lord Island 2 | LI2 | 100 | 17 | 4 | 24 | 24 |
| Dibblee Slough | DSC | 104 | 20 | 5 | 25 | 43 |
| Cottonwood Island 1 | CI1 | 113 | 33 | 8 | 24 | 40 |
| Cottonwood Island 2 | CI2 | 114 | 25 | 6 | 24 | 32 |
| Sandy Island 1 | SI1 | 121 | 19 | 6 | 32 | 16 |
| Sandy Island 2 | SI2 | 123 | 20 | 8 | 40 | 48 |
| Goat Island | GIC | 131 | 24 | 5 | 21 | 36 |
| Sauvie Slough (Willow Bar) | SSC | 154 | 11 | 3 | 27 | 43 |
| McGuire Island | MIC | 190 | 21 | 5 | 24 | 6 |
| Chattham Island | CIC | 201 | 20 | 6 | 30 | 6 |
| **Previously Diked Marsh Sites** | | | | | | |
| Trestle Bay | TBB | 12 | 14 | 4 | 29 | 2 |
| Fort Clatsop | FCB | 19 | 24 | 5 | 21 | 29 |
| Haven Island | HIB | 23 | 20 | 7 | 35 | 16 |
| Karlson Island | KIB | 41 | 28 | 8 | 29 | 48 |

* At forested and shrub wetland sites, the non-native cover values are only for herbaceous species. At emergent marsh sites, the cover calculation includes the occasional shrub or tree.

## 3.4 Channels

Wetland channel morphology and elevation were surveyed at most study sites, with greater than 60 percent of the primary channel length surveyed at 75 percent of the sites (Table 4). At Secret River (SR) and Welch Island (WI) the primary channel graded from the historical marsh into the forested or shrub portion and is presented as a single site. Overall, average channel depth was smaller at the created sites than the other types of sites.

**Table 4. Channel length, slope, and average depth for all study sites.**

| Site Code | Reach | Rkm | Full Channel Length (km) | Surveyed Channel Length (km) | Proportion of Channel Surveyed | Slope (m/km) | Average Channel Depth (m) |
|---|---|---|---|---|---|---|---|
| SR | B | 37 | 1.97 | 1.44 | 0.73 | 0.59 | 1.95 |
| WI | B | 53 | 1.10 | 0.85 | 0.77 | 0.60 | 1.72 |
| **Forested and Shrub Sites** | | | | | | | |
| CCS | B | 37 | 0.43 | 0.38 | 0.88 | 3.56 | 1.68 |
| SSS | B | 37 | 0.45 | 0.42 | 0.94 | 3.13 | 1.65 |
| KIS | B | 40 | 0.57 | 0.41 | 0.72 | 3.51 | 2.25 |
| WSS | C | 73 | 0.84 | 0.56 | 0.67 | 7.16 | 4.51 |
| CCR | C | 98 | 2.88 | 1.74 | 0.60 | 1.03 | 5.09 |
| GCR | E | 141 | 3.19 | 0.83 | 0.26 | 0.47 | 2.53 |
| **Historical Marsh Sites** | | | | | | | |
| CHM | A | 12 | 0.97 | 0.66 | 0.69 | 1.37 | 0.75 |
| LCM | A | 20 | 0.34 | 0.15 | 0.45 | -0.35 | 1.26 |
| CSM | A | 23 | 1.08 | 0.19 | 0.18 | 0.67 | 2.27 |
| GIM | A | 23 | 0.22 | 0.18 | 0.81 | 4.48 | 1.06 |
| WIM | B | 53 | 1.10 | 0.71 | 0.65 | 0.60 | 1.82 |
| RIM | C | 61 | 0.73 | 0.61 | 0.83 | 1.34 | 1.39 |
| CRM | C | 80 | 0.61 | 0.36 | 0.60 | 1.40 | 0.98 |
| SBM | F | 143 | 0.97 | 0.73 | 0.75 | -0.07 | 0.98 |
| CLM | F | 145 | 7.09 | na | na | na | 0.44 |
| CS1 | F | 149 | 4.39 | 1.55 | 0.35 | -0.11 | 1.30 |
| OSM | G | 198 | 1.53 | 0.01 | 0.01 | na | 0.93 |
| SIM | H | 211 | 0.16 | 0.16 | 1.00 | 1.00 | 0.49 |
| FLM | H | 221 | 1.97 | 1.27 | 0.64 | 0.64 | 1.38 |
| PIM | H | 228 | 0.17 | 0.17 | 1.00 | 1.00 | 0.83 |
| **Created Marsh Sites** | | | | | | | |
| MSC | B | 39 | 0.31 | 0.24 | 0.78 | 2.10 | 0.29 |
| JIC | C | 71 | 0.72 | 0.67 | 0.93 | 1.12 | 0.63 |
| WHC | C | 72 | 0.32 | 0.23 | 0.71 | 1.24 | 1.02 |
| WAC | C | 77 | 0.55 | 0.55 | 1.00 | 0.75 | 0.89 |
| GUC | C | 89 | 0.43 | 0.26 | 0.61 | 3.66 | 0.57 |
| LI2 | C | 100 | 0.91 | 0.48 | 0.53 | -0.05 | 0.66 |
| CI1 | D | 113 | 0.96 | 0.93 | 0.96 | 2.10 | 0.68 |
| CI2 | D | 114 | 0.34 | 0.29 | 0.85 | -0.28 | 0.40 |
| SI1 | E | 121 | 0.55 | 0.55 | 1.00 | 0.29 | 0.59 |
| SI2 | E | 123 | 0.44 | 0.29 | 0.66 | 0.66 | 0.31 |
| GIC | E | 131 | 1.33 | 0.33 | 0.25 | -0.44 | 2.29 |
| **Previously Diked Marsh Sites** | | | | | | | |
| TBB | A | 12 | 1.88 | 1.29 | 0.69 | 0.08 | 1.70 |
| FCB | A | 19 | 0.41 | 0.34 | 0.83 | 2.76 | 1.85 |
| HIB | A | 23 | 0.33 | 0.21 | 0.62 | 9.39 | 2.52 |
| KIB | B | 41 | 1.05 | 0.86 | 0.82 | 3.13 | 2.55 |

# 4.0 Discussion and Recommendations

In this report, we summarize fundamental data on representative reference wetlands from the LCRE. This work represents a major step in characterizing reference wetland conditions in the Lower Columbia River Estuary. Taken together, these data provide the most comprehensive 'baseline' assessment of shallow vegetated habitats so far compiled for the LCRE against which one can assess long term changes in the system.

Water level is complex in the LCRE, affected by tides and river flow, which have variable influences along a continuum between the mouth and Bonneville Dam (Jay et al. 2011). We suspect that inundation timing and patterns have an strong influence on vegetation communities based on an analysis of 5-years of data from 2 sites in this study area (Campbell Slough and Cunningham Lake; Borde et al., 2011) and the data from the present study. Further analyses are required to better define the effect of the major controlling factors on vegetation community structure. Additionally, predictive models could be developed to assist with design criteria and for predicting the consequences of changes in water level.

Linking the ecological implications of wetland channel metrics to the accessibility potential by juvenile salmonids is of particular interest to resource managers in the Columbia River estuary. Opportunity is tightly coupled with hyrdrogeomorphic properties of wetland channels, which can be evaluated through a coupling of channel morphology and *in situ* water level data. Due to the dynamic nature of water fluctuation within the estuary (as related to tidal, seasonal, and anthropogenic manipulation of flow regimes), the opportunity for salmonids to access these channels varies greatly spatially and temporally. Channel inundation frequencies determine the opportunity for fish to access tidal wetland channels. Preliminary data from the water level sensors indicates that access to the channel mouths was feasible much of the time; however, the amount of time accessible decreased farther up the channel. In addition, access to the marsh edge was much less frequent. These data are a means of quantifying fish access on a site by site basis and further analysis could allow a quantitative comparison of this metric between different habitat types and between restoration and reference areas.

As a whole, the data from this study provide practical information required to inform multiple aspects of restoration science. The information can be used to improve restoration planning, design, and monitoring as follows:

- Controlling factors data such as elevation, hydrology, and accretion rates provide a basis to understand conditions necessary for restoration success.

- Vegetation assemblage structure for undisturbed shallow water wetland habitats provides a target for restoration project design and a means to evaluate wetland development through time.

- Data on the location and elevation of invasive plant species can be used to implement restoration programs to avoid colonization by non-native species.

- Natural channel morphology provides engineering design criteria for restoration sites.
- Information on naturally breached sites and older created island sites is applicable to evaluate temporal trajectories and develop realistic performance criteria.
- Communities on created islands can be used to develop functional design criteria for future creation efforts.
- Predictions can be made regarding the consequences of flow regulation and the effects of climate change (including altered hydrology, salinity and sea level) on the vegetated communities of these habitats.

The metrics monitored in this study can be directly compared to metrics monitored at restoration sites to determine restoration action effectiveness. For example, vegetation assemblages and cover can be compared between restoration and multiple reference sites using a similarity index (Bray and Curtis 1957; Czekanowski 1909) and other statistical methods. In addition, channel morphological features such as area, depth, length, and the ratios between them can be compared to those formed at a restoration site to determine whether the structure is approaching the target condition. Data on elevation, accretion rates, and hydrology can be used to explain the vegetation and channel morphology resulting from restoration actions, by providing ranges of those metrics that occur in relatively undisturbed, reference conditions.

Overall, the data collected as part of this study provide practical information on wetland elevation, inundation, channel morphology, and other factors along with the type of vegetation community that occurs naturally under various conditions. The results of this study, describe the 'climax' reference communities along the entire estuary that will help inform the vision for restoration projects in the system.

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# Appendix A

# Monitoring Site Matrix

Reference Site Study
Monitoring Schedule

| | | | | | | | | Metrics | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Vegetation | | Elevation | Channels | Hydrology (water level sensor) | | | | TOC/Grain Size | Sediment Accretion Stakes | | |
| Site | Site Code | Primary Classification | Secondary Classification | Reach | rKm | Map ID | Monitoring Year | Cover | Mapping | | Cross sections (#)** | Ownership | Deployment Date | Retrieval Date | Survey Status | | Project | Deployment Date | Retrieval Date |
| Chinook | CHM | marsh | | A | 12 | 1 | 2009 | RS | RS | RS | RS | RS | 2008 | 2009 | Y | RS | RS | 2008 | 2009 |
| Trestle Bay | TBB | marsh | breach | A | 12 | 2 | 2008 | CE | -- | CE | RS/CE | RS | 2008 | 2009 | Y | -- | RS | 2008 | 2009 |
| Fort Clatsop | FCB | marsh | breach | A | 19 | 3 | 2008 | CE | -- | CE | RS/CE | RS | 2008 | 2009 | Y | -- | RS | 2008 | 2009 |
| Lewis and Clark River mouth | LCM | marsh | | A | 20 | 4 | 2009 | CE | RS | CE | RS/CE | CE | 2007 | 2009 | Y | RS | CE | 2005 | 2009 |
| Cooperage Slough | CSM | marsh | | A | 23 | 5 | 2007 | CREST | -- | RS | RS/CREST | CREST | 2007 | 2008? | Y | -- | RS/CREST | 2007 | 2008? |
| Grant Island | GIM | marsh | | A | 23 | 6 | 2009 | RS | RS | RS | RS (?) | RS | 2009 | 2010 | Y | RS | RS | 2009 | 2010 |
| Haven Island | HIB | marsh | breach | A | 23 | 7 | 2009 | RS/CE | RS | RS/CE | RS/CE (?) | RS | 2009 | 2010 | Y | RS | RS | 2009 | 2010 |
| Crooked Creek | CCS | swamp | | B | 37 | 8 | 2007 | RS/CE | -- | RS/CE | RS/CE (3) | RS | 2007 | 2008 | Y | RS | RS | 2008 | 2009 |
| Secret River | SRM | marsh | | B | 37 | 9 | 2008 | RS | -- | RS | RS (2) | RS | 2007 | 2008 | Y | RS | RS | 2008 | 2009 |
| Secret River | SRS | swamp | | B | 37 | 10 | 2008 | RS | -- | RS | RS (4) | RS | 2007 | 2008 | Y | RS | RS | 2008 | 2009 |
| Seal Slough | SSS | swamp | | B | 37 | 11 | 2009 | CE | -- | CE | RS/CE | CE | 2005 | 2009 | Y | RS | CE | 2006 | 2009 |
| Miller Sands | MSC | marsh | created | B | 39 | 12 | 2009 | CE | RS | CE | RS/CE | RS | 2009 | 2010 | Y | RS | RS | 2009 | 2010 |
| Karlson Island | KIS | swamp | | B | 40 | 13 | 2008 | RS | -- | RS | RS | RS | 2007 | 2008 | Y | RS | RS | 2008 | 2009 |
| Karlson Island | KIB | marsh | breach | B | 41 | 14 | 2008 | CE | -- | CE | RS/CE | RS | 2007 | 2008 | Y | RS | RS | 2008 | 2009 |
| Welch Island | WIM | marsh | | B | 53 | 15 | 2008 | RS | -- | RS | RS | RS | 2008 | 2009 | Y | RS | RS | 2008 | 2009 |
| Welch Island | WIS | shrub/scrub | | B | 53 | 16 | 2009 | RS | -- | RS | RS | RS | 2009 | 2010 | Y | RS | RS | 2009 | 2010 |
| Ryan Island | RIM | marsh | | C | 61 | 17 | 2009 | HM | HM | HM | RS | HM | 2009 | 2010 | Y | HM | RS | 2009 | 2010 |
| Bradwood Slough | BSM | marsh | | C | 62 | -- | 2010 | -- | -- | HM | -- | HM | 2009 | 2010 | Y | -- | RS | 2009 | 2010 |
| Jackson Island | JIC | marsh | created | C | 71 | 18 | 2010 | HM | HM | HM | HM | HM | 2009 | 2010 | Y | HM | RS | 2009 | 2010 |
| Whites Island | WHC | marsh | created | C | 72 | 19 | 2009 | HM | HM | HM | RS | HM | 2009 | 2010 | Y | HM | RS | 2008 | 2009 |
| Westport Slough | WSS | shrub/scrub | | C | 73 | 20 | 2010 | RS | RS | RS | RS | RS | 2009 | 2010 | Y | RS | RS | 2009 | 2010 |
| Wallace Island | WAC | marsh | created | C | 77 | 21 | 2010 | HM | HM | HM | HM | HM | 2009 | 2010 | Y | HM | RS | 2009 | 2010 |
| Clatskanie River | CRM | marsh | | C | 80 | 22 | 2009 | RS | RS | RS | RS | RS | 2008 | 2009 | Y | RS | RS | 2008 | 2009 |
| Gull Island | GUC | marsh | created | C | 89 | 23 | 2009 | CE | RS | CE | RS/CE | CE | 2008 | 2009 | Y | RS | CE | 2008 | 2009 |
| Coal Creek Slough | CCR | riparian wetland | | C | 98 | 24 | 2009 | RS | -- | RS | RS (?) | RS | 2008 | 2009 | Y | RS | RS | 2008 | 2009 |
| Lord Island 2 | LI2 | marsh | created | C | 100 | 25 | 2009 | HM | HM | HM | RS | HM | 2008 | 2009 | Y | HM | -- | -- | -- |
| Dibblee Slough | DSC | marsh | created | C | 104 | 26 | 2005 | HM | HM | HM | -- | RS | 2009 | 2010 | Y | RS | RS | 2009 | 2010 |
| Cottonwood Island 1 | CI1 | marsh | created | D | 113 | 27 | 2005/10 | HM | HM | RS | RS | RS | 2009 | 2010 | Y | RS | RS | 2009 | 2010 |
| Cottonwood Island 2 | CI2 | marsh | created | D | 114 | 28 | 2005/10 | HM | HM | RS | RS | -- | -- | -- | -- | -- | -- | -- | -- |
| Sandy Island 1 | SI1 | marsh | created | E | 121 | 29 | 2007 | HM | HM | HM | HM | RS | 2009 | 2010 | Y | RS | RS | 2009 | 2010 |
| Sandy Island 2 | SI2 | marsh | created | E | 123 | 30 | 2007 | HM | HM | HM | HM | -- | -- | -- | -- | -- | -- | -- | -- |
| Goat Island | GIC | marsh | created | E | 131 | 31 | 2009 | CE | RS | CE | RS/CE (?) | RS | 2008 | 2009 | Y | RS | RS | 2008 | 2009 |
| Gee Creek | GCR | riparian wetland | | E | 141 | 32 | 2010 | RS | RS | RS | RS | RS | 2009 | 2010 | Y | RS | RS | 2009 | 2010 |
| Scappoose Bay | SBM | marsh | | F | 143 | 33 | 2010 | HM | HM | HM | RS | RS | 2009 | 2010 | Y | RS | RS | 2009 | 2010 |
| Cunningham Lake* | CLM | marsh | | F | 145 | 34 | 2009 | HM | HM | HM | RS (2) | HM | 2009 | 2010 | Y | RS | RS | 2009 | 2010 |
| Campbell Slough* | CS1 | marsh | | F | 149 | 35 | 2010 | HM | HM | HM | HM | HM | 2009 | 2010 | Y | -- | RS | 2009 | 2010 |
| Sauvie Cove | SSC | marsh | created | F | 154 | 36 | 2005 | HM | HM | HM | RS | RS | 2009 | 2010 | Y | RS | RS | 2009 | 2010 |
| McGuire Island | MIC | marsh | created | G | 190 | 37 | 2006 | HM | HM | HM | -- | HM | 2006 | 2007 | Y | RS | RS | 2008 | 2009 |
| Washougal River mouth | WRM | marsh | | G | 195 | 38 | 2010 | RS | RS | RS | RS | RS | 2009 | 2010 | Y | RS | RS | 2009 | 2010 |
| Old Sandy River mouth | OSM | marsh | | G | 198 | 39 | 2007 | TFM | TFM | TFM | TFM (1) | TFM | 2007 | 2008 | Y | -- | -- | -- | -- |
| Chatham Island | CIC | marsh | created | G | 201 | 40 | 2006/7 | HM/TFM | HM/TFM | HM/TFM | -- | TFM | 2007 | 2008 | Y | RS | RS | 2008 | 2009 |
| Sand Island (Rooster Rock) | SIM | marsh | | H | 211 | 41 | 2008 | HM | HM | HM | HM (8) | HM | 2008 | 2009 | Y | HM | RS | 2008 | 2009 |
| Franz Lake | FLM | marsh | | H | 221 | 42 | 2008 | HM | HM | HM | HM (4) | HM | 2008 | 2009 | Y | HM | RS | 2008 | 2009 |
| Pierce Island | PIM | marsh | | H | 228 | 43 | 2008 | HM | HM | HM | HM | HM | 2008 | 2009 | Y | HM | RS | 2008 | 2009 |

* Ongoing monitoring site for Ecosystem Monitoring project since 2005
** Number of x-sections = 5 unless otherwise noted

Legend
Monitored in 2007
Monitored in 2008
Monitored in 2009
Monitored in 2010

CE = Cumulative Effects of Restoration, funded by USACE, PNNL project manager: Gary Johnson
CREST = Columbia River Estuary Study Taskforce
HM = Habitat Monitoring (part of EP Ecosystem Monitoring Program), funded by BPA, PNNL project manager: Amy Borde
RS = Reference Site Study (part of EP Restoration Program), funded by BPA, PNNL project manager: Amy Borde
TFM = Tidal Freshwater Monitoring Program, funded by BPA, PNNL project manager: Gary Johnson

# Appendix B

# Site Summaries

## Site Description

Hydrogeomorphic Reach: A

Coordinates (UTM, NAD83 meters):

Northing: 5127618 Easting: 425468

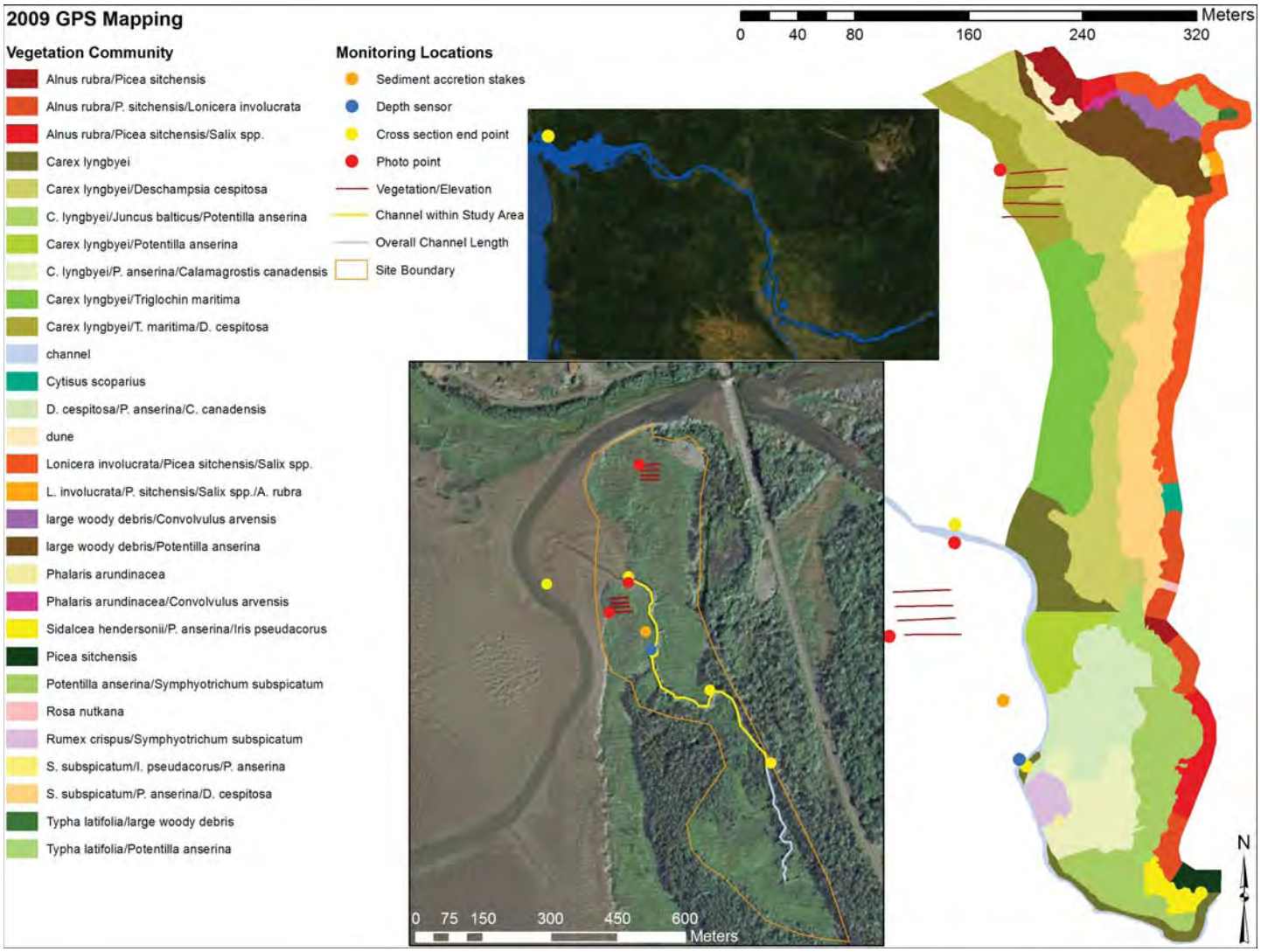
Distance from Columbia River mouth: 12 rkm

Distance from main channel: 0 meters

Type: Marsh

Total Site Area: 23.7 ha Study Area: 3.78 ha

Total channel length: 965 m Channel surveyed: 664 m Channel slope: 1.37 m/km



## Site Information

Chinook River marsh is located at the mouth of the Chinook River on Baker Bay and is in private ownership. The marsh is bisected by a deep tidal channel, which extends up to a Sitka spruce dominated forested wetland. The site was present on the maps from the 1880's and is one of the last remaining historic brackish marshes in the estuary.

## Elevation

Lowest marsh (NAVD88, m): 1.23

Highest marsh (NAVD88, m): 3.07

Lowest marsh (MLLW, m): 1.46

Highest marsh (MLLW, m): 3.30

## Vegetation

Number of Native species (low marsh): 11

% Native Cover (low marsh): 113.3

Number of Non-native species (low marsh): 1

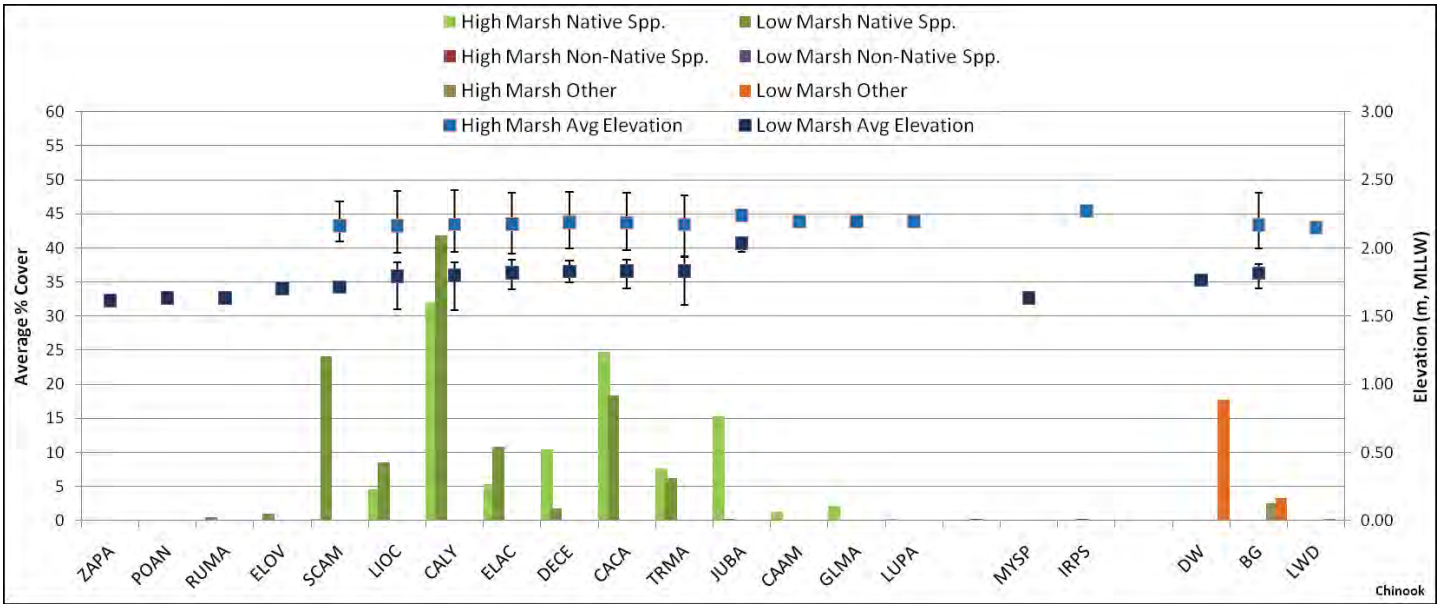
% Non-native Cover (low marsh): 0.25

Number of Native species (high marsh): 11

% Native Cover (high marsh): 104.5

Number of Non-native species (high marsh): 1

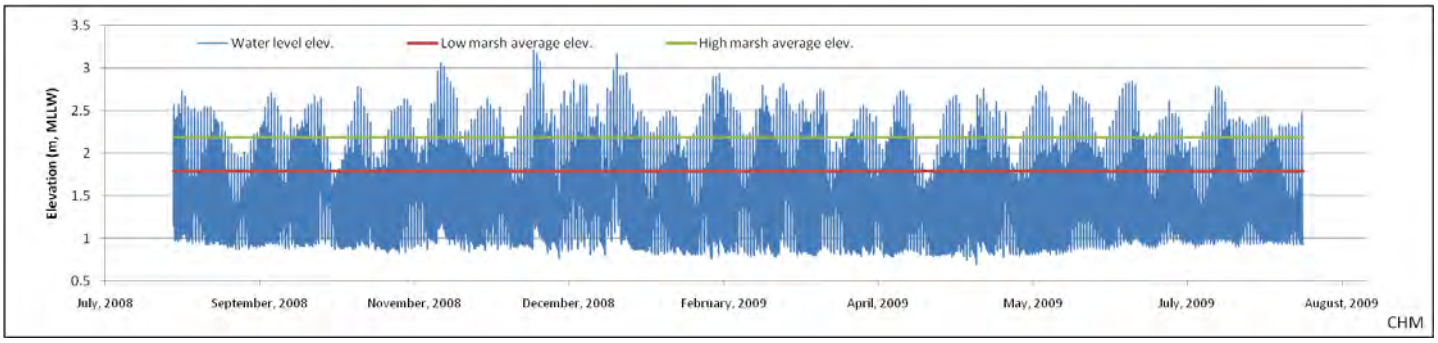
% Non-native Cover (high marsh): 0.25

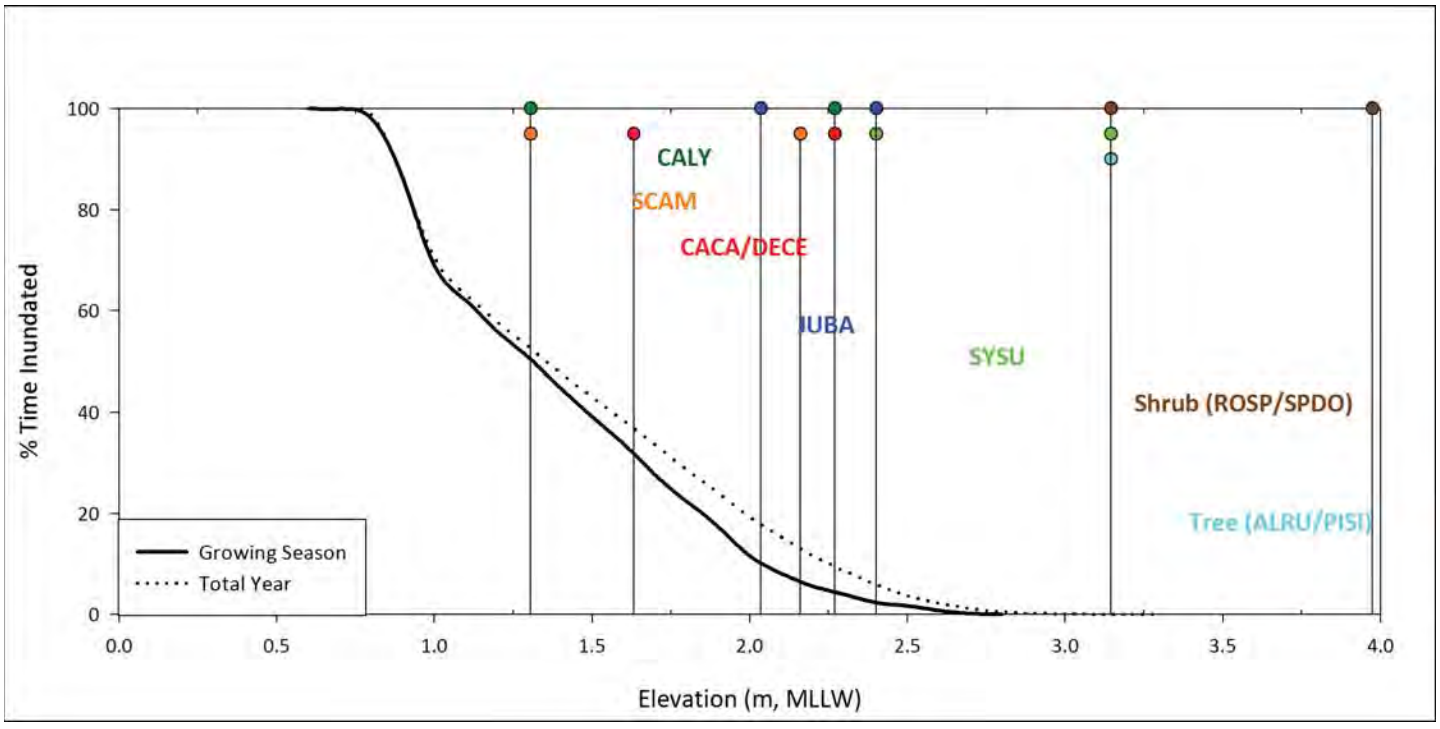


## Inundation

| | Std | Low Marsh | High Marsh |
|---|---|---|---|
| Average Elev (m, MLLW) | 1.89 | 1.95 | 2.34 |
| Sum Exceedance Value (SEV) | 13.25 | 11.3 | 2.82 |

Modified Growing Season:
Aug 20 to Oct 12, 2008
Apr 22 to Jun 21, 2009

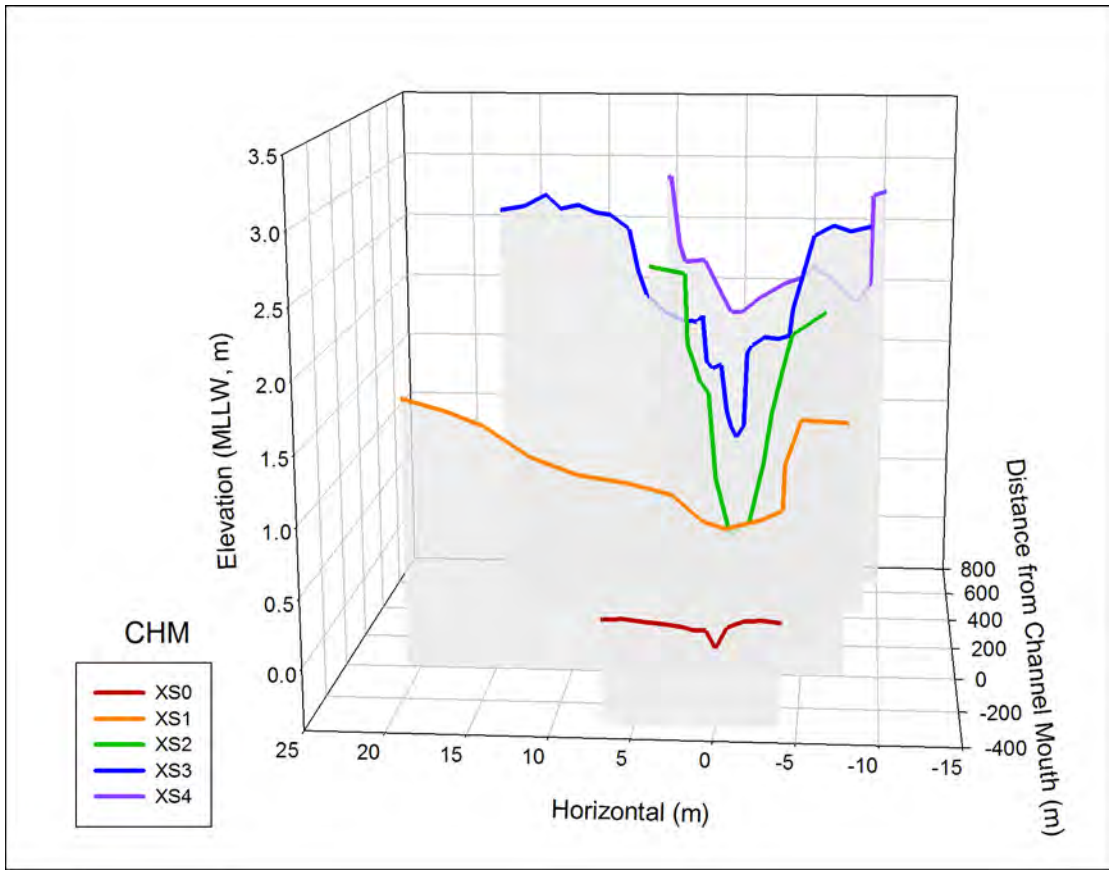


## Channels

| | Physical Metrics | | | | | | | Inundation | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Year | | Growing Season | |
| | Cross Section | Bank Elevation (m) | Thalweg Elevation (m) | Channel Depth (m) | Cross Section Area ($m^2$) | Channel Width (m) | Width: Depth Ratio | Time WL > Thalweg (%) | Time WL > Bank (%) | Time WL > Thalweg (%) | Time WL > Bank (%) |
| CHM | 0 | 0.26 | 0.11 | 0.15 | 0.1 | 2.5 | 16.8 | 100 | 100 | 100 | 100 |
| | 1 | 1.03 | 0.65 | 0.38 | 2.5 | 13.4 | 34.9 | 99 | 68 | 99 | 66 |
| | 2 | 1.94 | 0.40 | 1.54 | 5.9 | 6.9 | 4.5 | 100 | 22 | 100 | 15 |
| | 3 | 1.92 | 0.96 | 0.96 | 2.5 | 6.1 | 6.4 | 62 | 23 | 61 | 16 |
| | 4 | 1.93 | 1.81 | 0.12 | 2.4 | 2.7 | 22.3 | 21 | 23 | 14 | 16 |

### Cross Sections



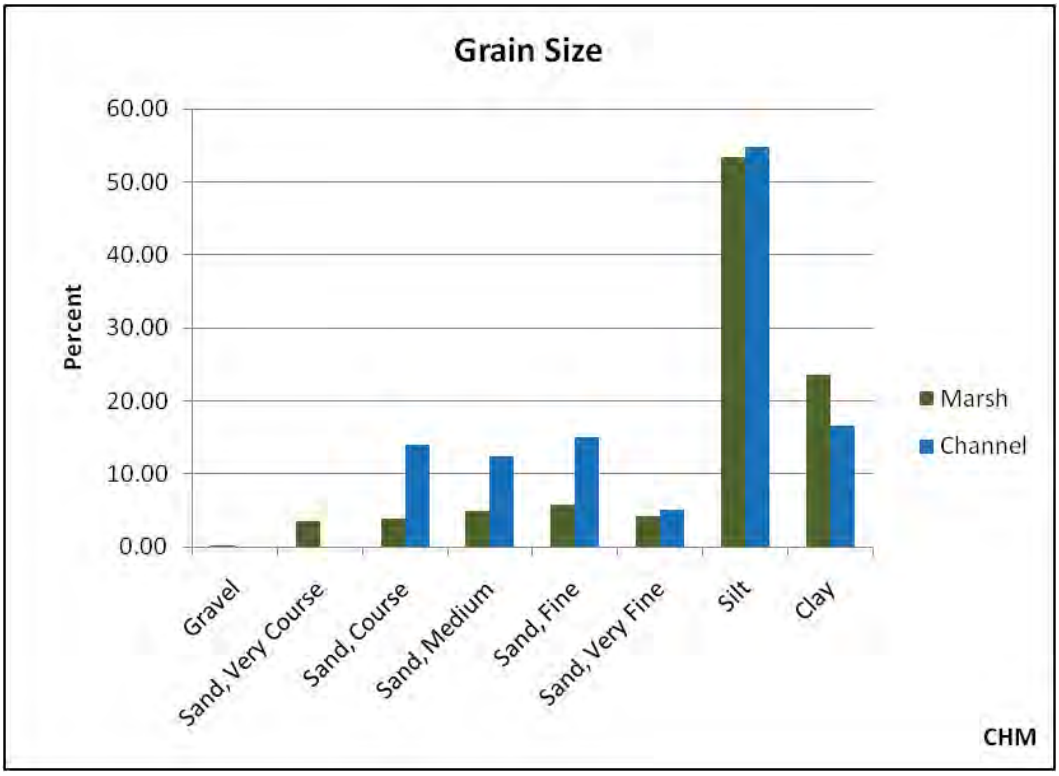
## Sediment

Sediment accretion rate: -0.18 cm per year

Elevation at sediment stakes: 2.50 m, MLLW

Total Organic Carbon (TOC) in channel: 3.71

in wetland: 6.43



## Site Description

Hydrogeomorphic Reach: A

Coordinates (UTM, NAD83 meters):

Northing: 5117721 Easting: 424791

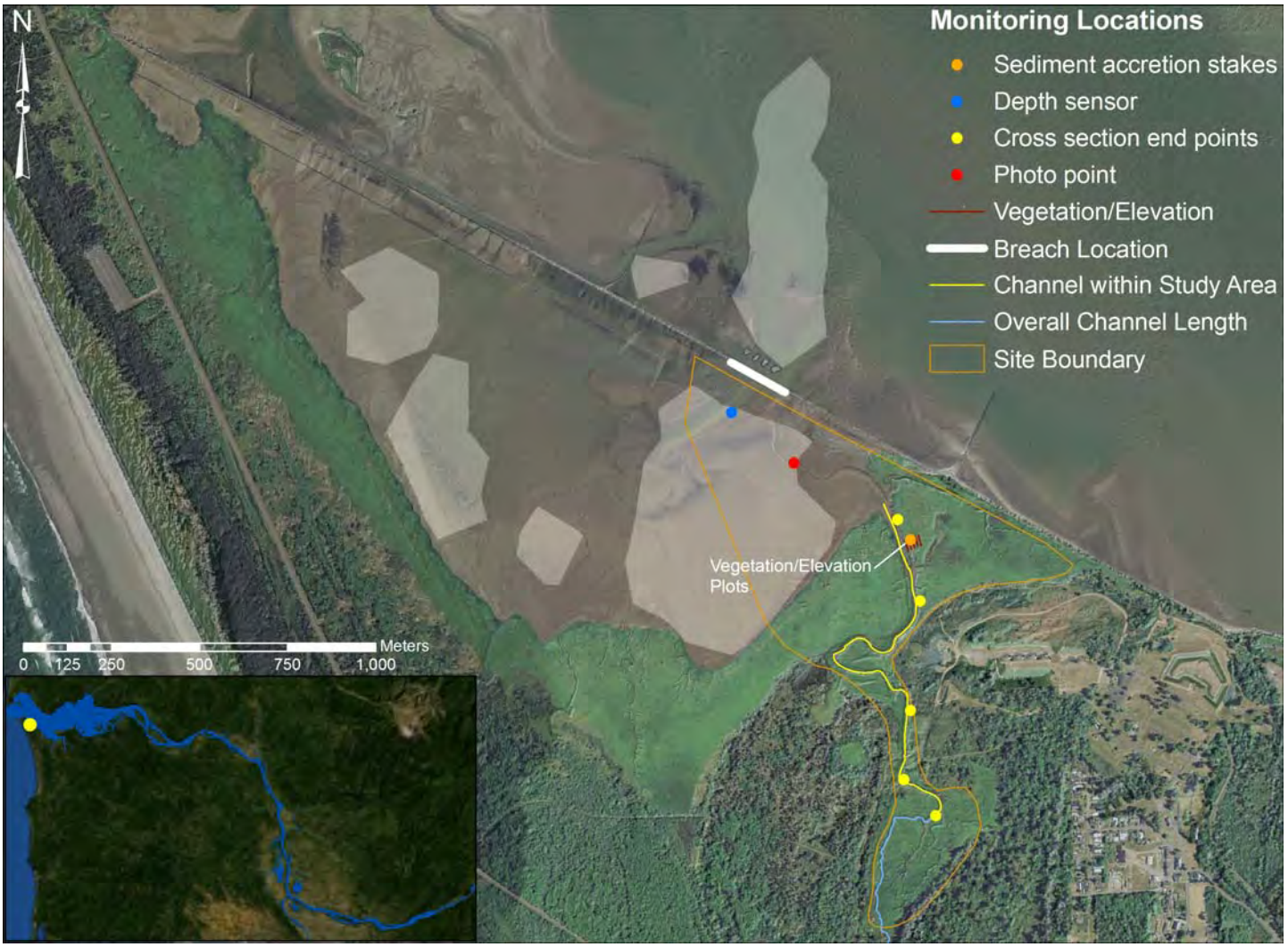
Distance from Columbia River mouth: 12 rkm

Distance from main channel: 1086 meters

Type: Old Breach

Total Site Area: 57.4 ha Study Area: 2.06 ha

Total channel length: 1880 m Channel surveyed: 1343 m Channel slope: 0.08 m/km



## Site Information

Trestle Bay is a brackish bay comprised of shallow subtidal and intertidal mudflats and intertidal marsh. The bay is part of the Fort Stevens State Park and was originally formed by the construction of the South Jetty in the late 1800's. A trestle was built as part of the jetty construction reducing connectivity to the Columbia River. The trestle was breached in 1995 to regain at least partial connectivity. The sample site was located in the marsh on the south side of the Bay.

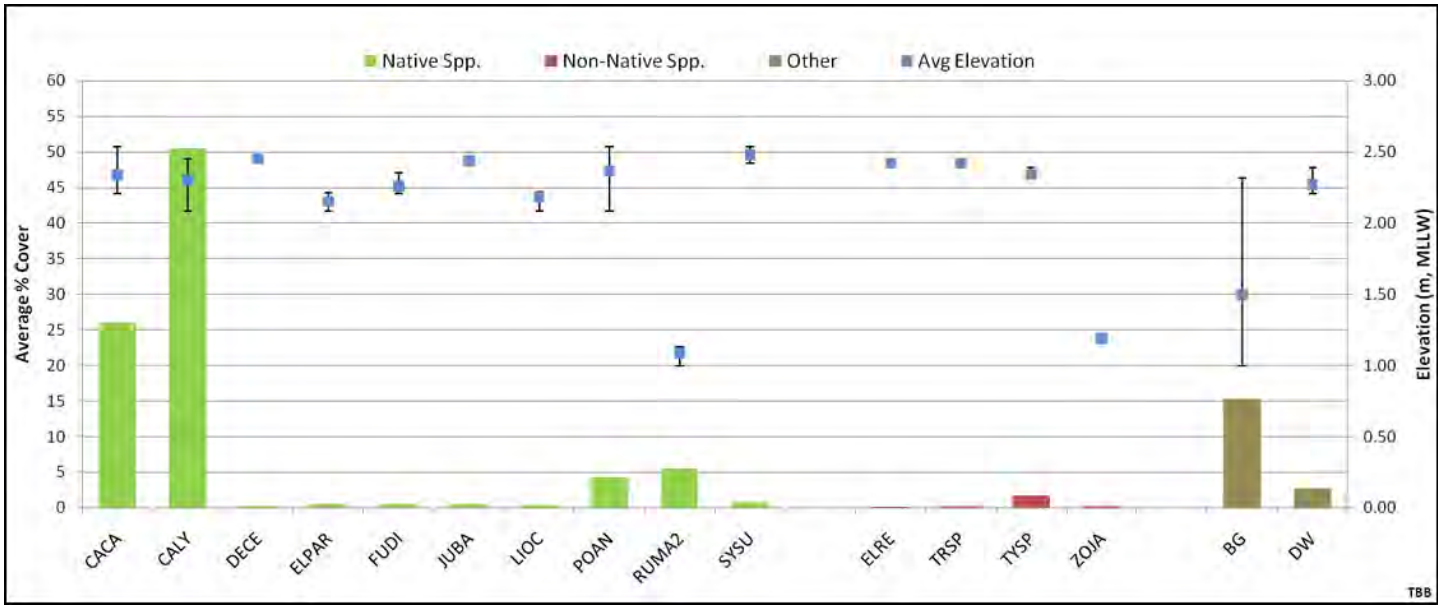
## Elevation

| | NAVD88, m | | MLLW, m | |
|---|---|---|---|---|
| | Lowest | Highest | Lowest | Highest |
| Marsh | 1.86 | 2.82 | 2.09 | 3.06 |
| CALY | 1.86 | 2.22 | 2.09 | 2.45 |
| POAN | 1.86 | 2.54 | 2.09 | 2.77 |
| CACA | 1.98 | 2.82 | 2.21 | 3.06 |
| TYSP | 2.03 | 2.45 | 2.26 | 2.68 |
| LEMO | 2.41 | 2.82 | 2.64 | 3.06 |

## Vegetation

Number of Native species: 10 % Native Cover: 89.35

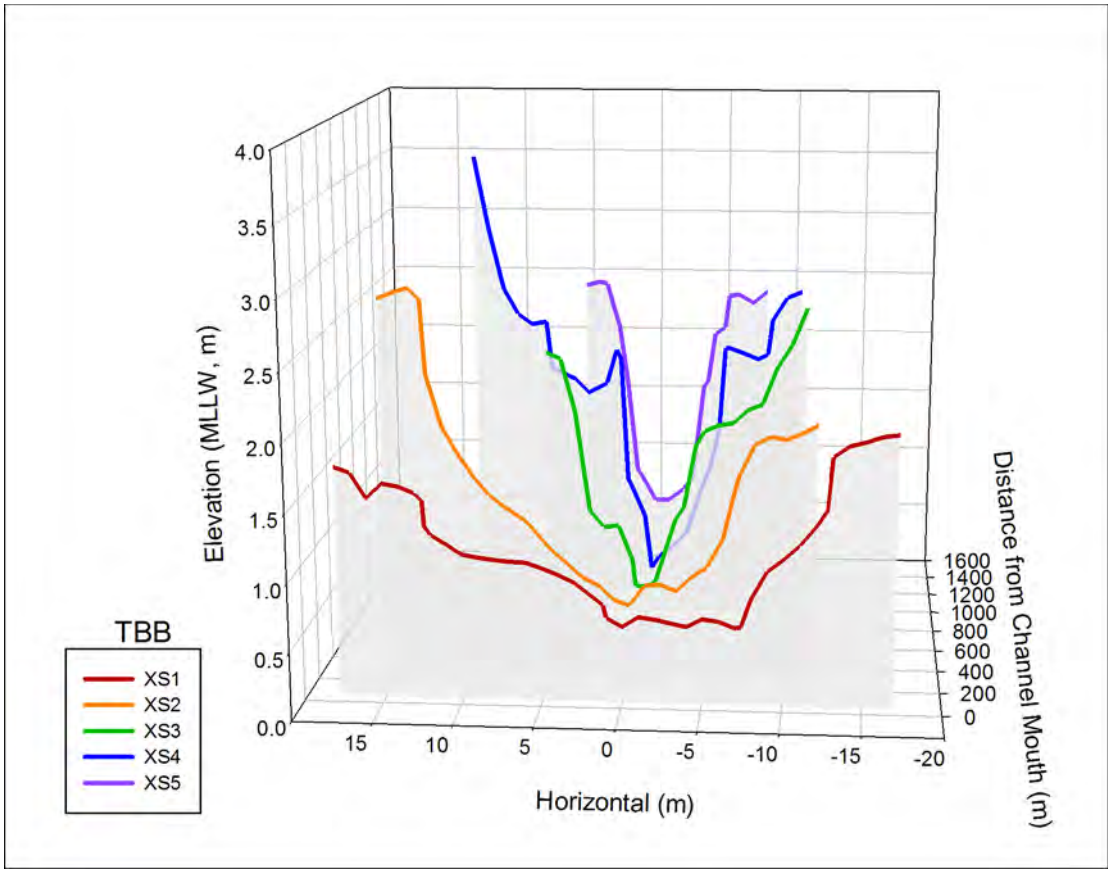
Number of Non-native species: 4 % Non-native Cover: 2.30



## Channels

| | Physical Metrics | | | | | | |
|---|---|---|---|---|---|---|---|
| | Cross Section | Bank Elevation (m) | Thalweg Elevation (m) | Channel Depth (m) | Cross Section Area ($m^2$) | Channel Width (m) | Width: Depth Ratio |
| TBB | 1 | 1.70 | 0.56 | 1.14 | 21.2 | 30.9 | 27.2 |
| | 2 | 1.92 | 0.54 | 1.38 | 18.2 | 24.2 | 17.5 |
| | 3 | 2.09 | 0.19 | 1.90 | 15.0 | 16.5 | 8.7 |
| | 4 | 2.51 | 0.19 | 2.31 | 19.1 | 21.0 | 9.1 |
| | 5 | 2.44 | 0.67 | 1.77 | 9.9 | 11.4 | 6.4 |

### Cross Sections




## Sediment

Sediment accretion rate: 0.59 cm per year Elevation at sediment stakes: 2.22 m, MLLW

## Site Description

Hydrogeomorphic Reach: A

Coordinates (UTM, NAD83 meters):

Northing: 5109079 Easting: 432043

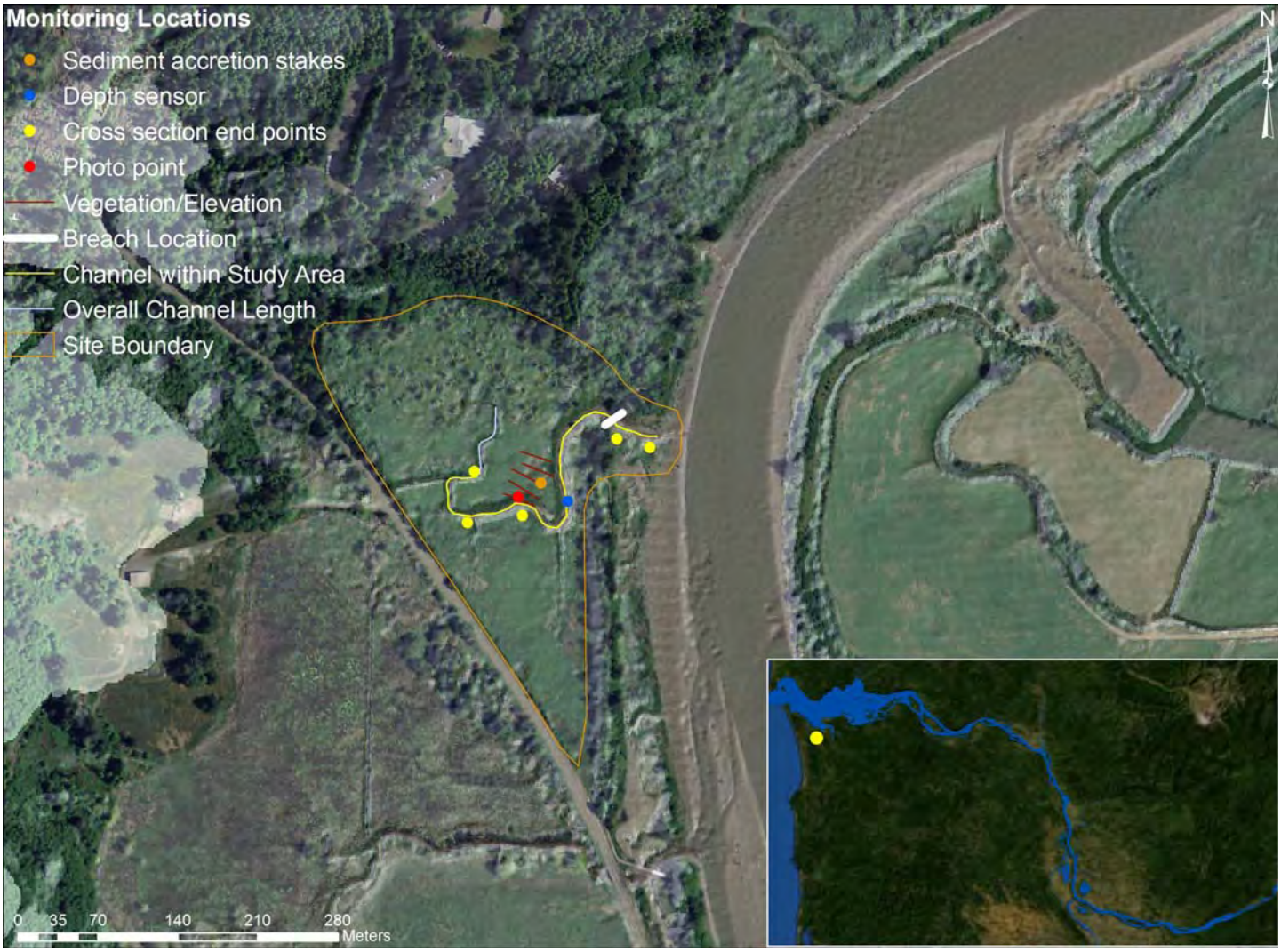
Distance from Columbia River mouth: 19 rkm

Distance from main channel: 3505 meters

Type: Natural Breach

Total Site Area: 6.2 ha Study Area: 2.23 ha

Total channel length: 408 m Channel surveyed: 339 m Channel slope: 2.76 m/km



## Site Information

The Fort Clatsop site is located approximately 3.5 rkm from the mouth of the Lewis and Clark River, a tributary to Young's Bay. The site is part of the Fort Clatsop unit of Lewis and Clark National Historical Park and is owned by the National Park Service. This site was diked around the turn of the century and was breached by floods and storms in 1959, approximately 50 years ago. The site is predominantly emergent marsh with small areas of shrub/scrub and a few Sitka spruce trees (*Picea sitchensis*).

## Elevation

Lowest marsh (NAVD88, m): 0.91

Highest marsh (NAVD88, m): 2.78

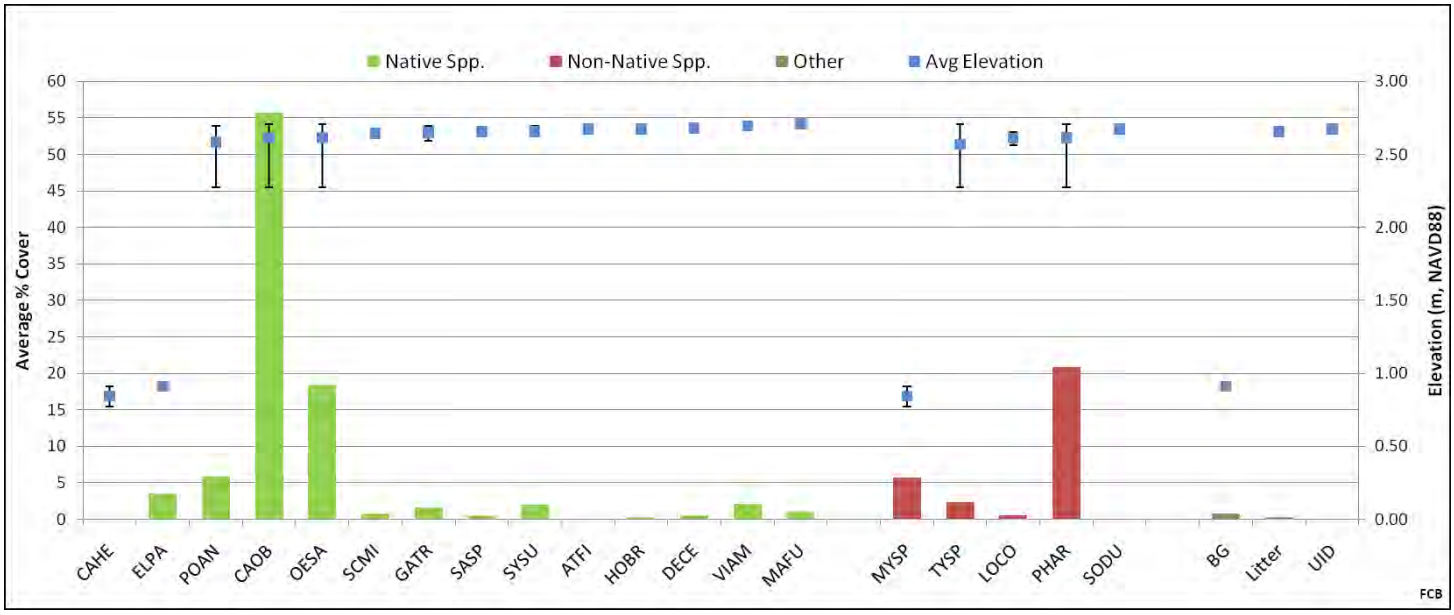
## Vegetation

Number of Native species: 19

% Native Cover: 92.40

Number of Non-native species: 5

% Non-native Cover: 29.40




## Sediment

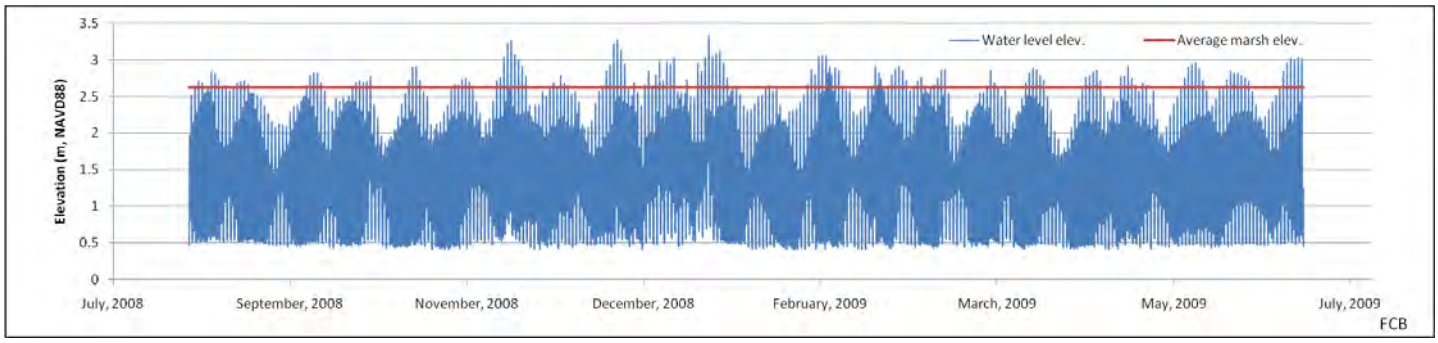
Sediment accretion rate: 1.14 cm per year

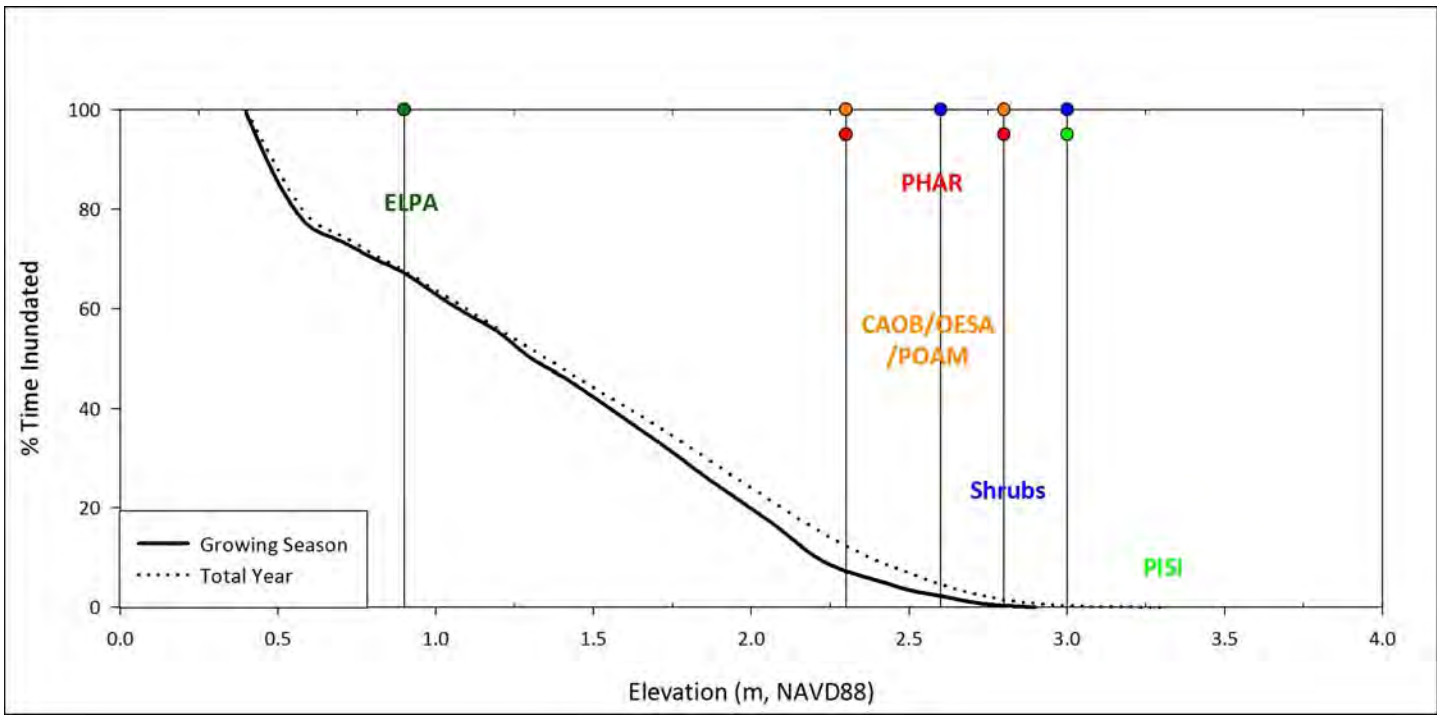
Elevation at sediment stakes: 2.61 m, NAVD88

## Inundation

| | Std | Marsh |
|---|---|---|
| Average Elev (m, NAVD88) | 1.89 | 2.62 |
| Sum Exceedance Value (SEV) | 11.6 | 0.38 |

Modified Growing Season:
Aug 20 to Oct 12, 2008
Apr 22 to Jun 21, 2009

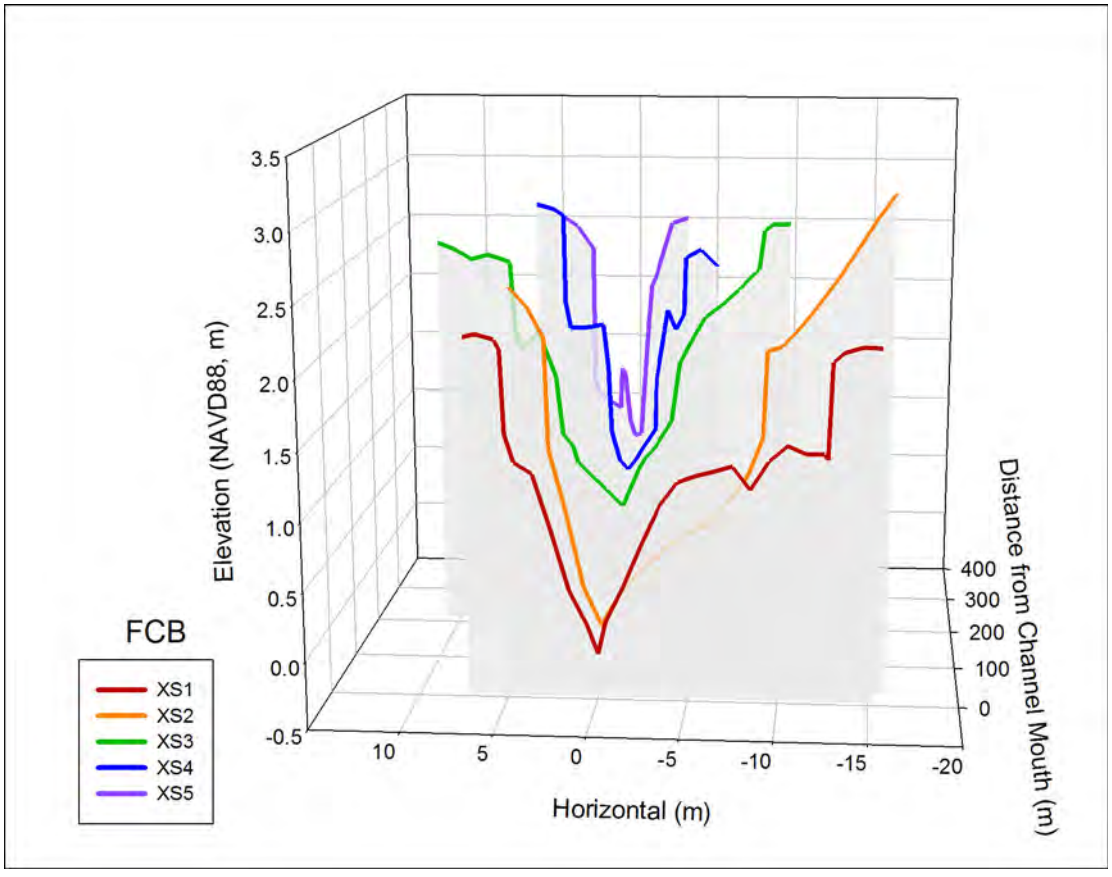


## Channels

| | Physical Metrics | | | | | | | Inundation | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Year | | Growing Season | |
| | Cross Section | Bank Elevation (m) | Thalweg Elevation (m) | Channel Depth (m) | Cross Section Area ($m^2$) | Channel Width (m) | Width: Depth Ratio | Time WL > Thalweg (%) | Time WL > Bank (%) | Time WL > Thalweg (%) | Time WL > Bank (%) |
| FCB | 1 (mouth) | 2.11 | -0.17 | 2.28 | 21.4 | 19.9 | 8.7 | 100 | 20 | 99 | 15 |
| | 2 | 2.03 | -0.03 | 2.06 | 16.9 | 12.3 | 6.0 | 100 | 23 | 99 | 19 |
| | 3 | 2.37 | 0.44 | 1.94 | 15.0 | 14.9 | 7.7 | 100 | 10 | 99 | 6 |
| | 4 | 2.35 | 0.62 | 1.73 | 7.1 | 7.5 | 4.3 | 100 | 11 | 99 | 6 |
| | 5 | 2.02 | 0.76 | 1.26 | 3.3 | 3.7 | 2.9 | 100 | 23 | 99 | 19 |

## Cross Sections



## Site Description

Hydrogeomorphic Reach: A

Coordinates (UTM, NAD83 meters):

Northing: 5112166 Easting: 433118

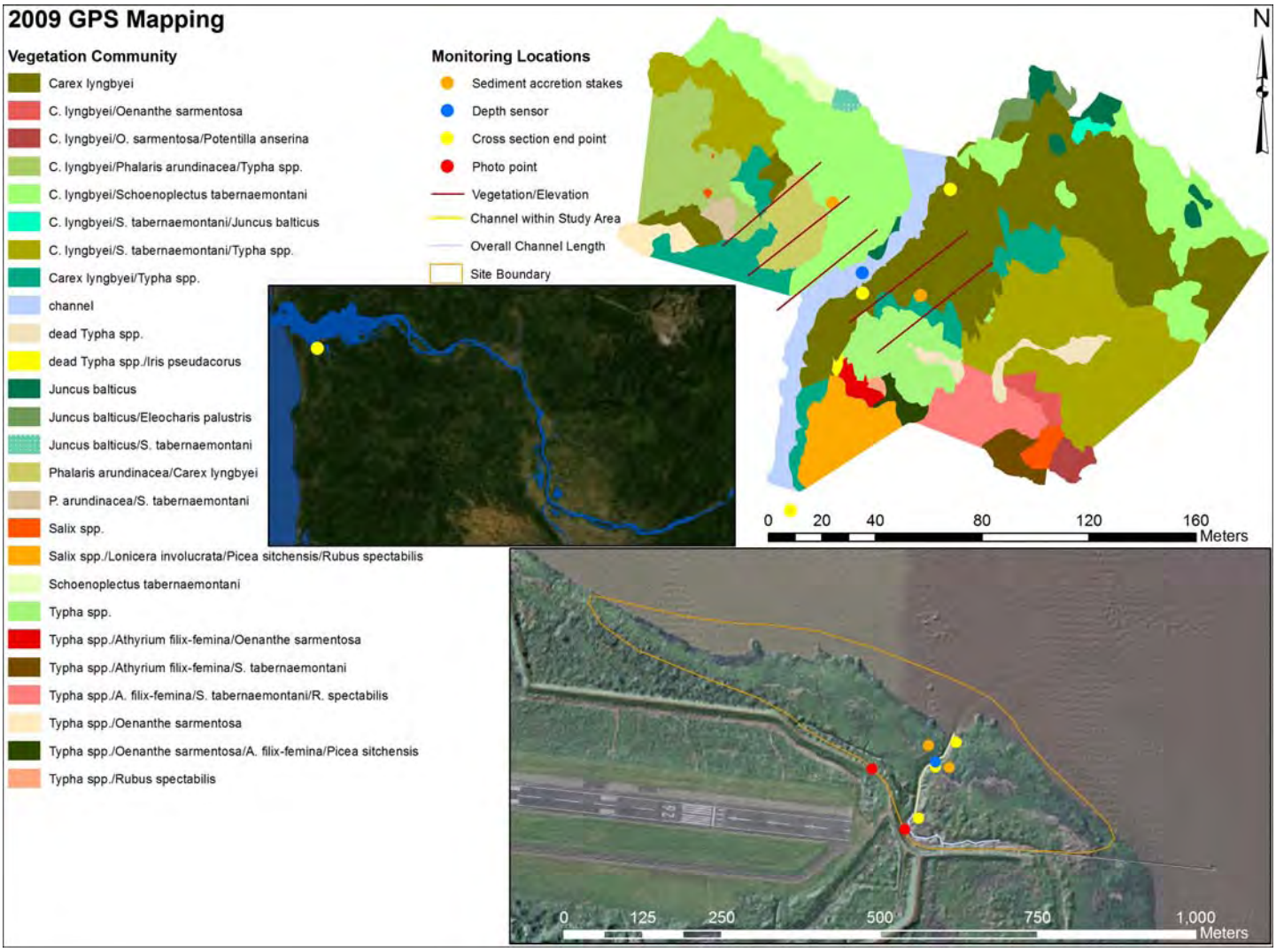
Distance from Columbia River mouth: 20 rkm

Distance from main channel: 0 meters

Type: Marsh

Total Site Area: 12.4 ha Study Area: 2.13 ha

Total channel length: 339 m Channel surveyed: 153 m Channel slope: -0.35 m/km



## Site Information

The marsh, located near the mouth of the Lewis and Clark River on Youngs Bay, grades up from an emergent wetland to a dike protecting the Astoria Municipal Airport. The monitoring site is owned by the Port of Astoria. The site was recently used as a reference for tide gate replacement on Vera Slough — along the dike to the west.

## Elevation

Lowest marsh (NAVD88, m): 0.96

Highest marsh (NAVD88, m): 2.80

Lowest marsh (MLLW, m): 1.00

Highest marsh (MLLW, m): 2.84

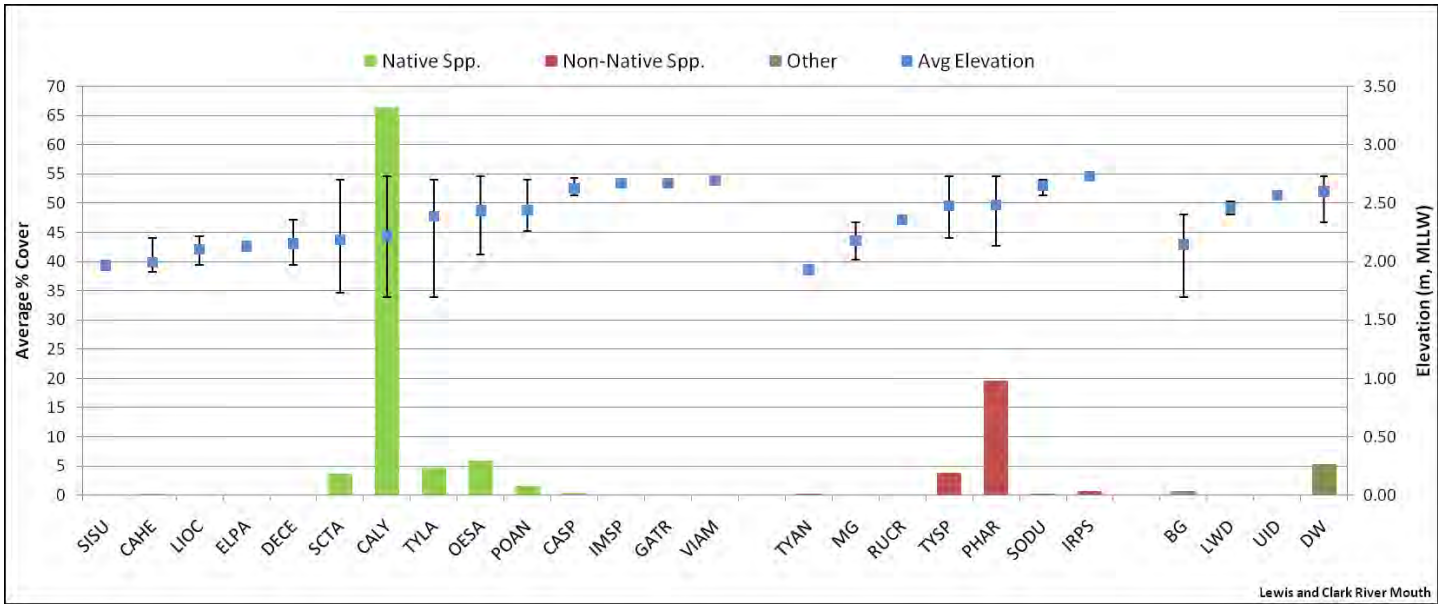
## Vegetation

Number of Native species: 14

% Native Cover: 83.39

Number of Non-native species: 7

% Non-native Cover: 24.80



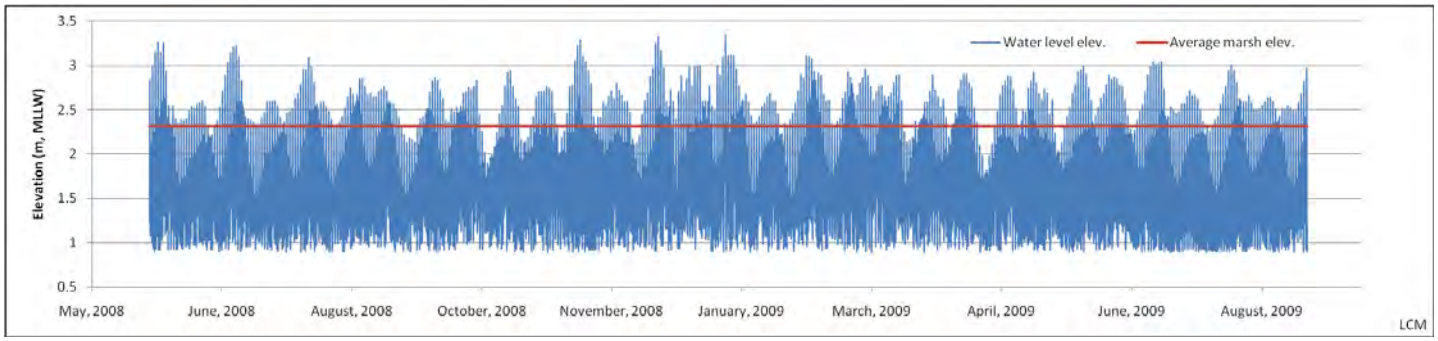

## Inundation

| | Std | Marsh |
|---|---|---|
| Average Elev (m, MLLW) | 1.89 | 2.32 |
| Sum Exceedance Value (SEV) | 19.6 | 4.81 |

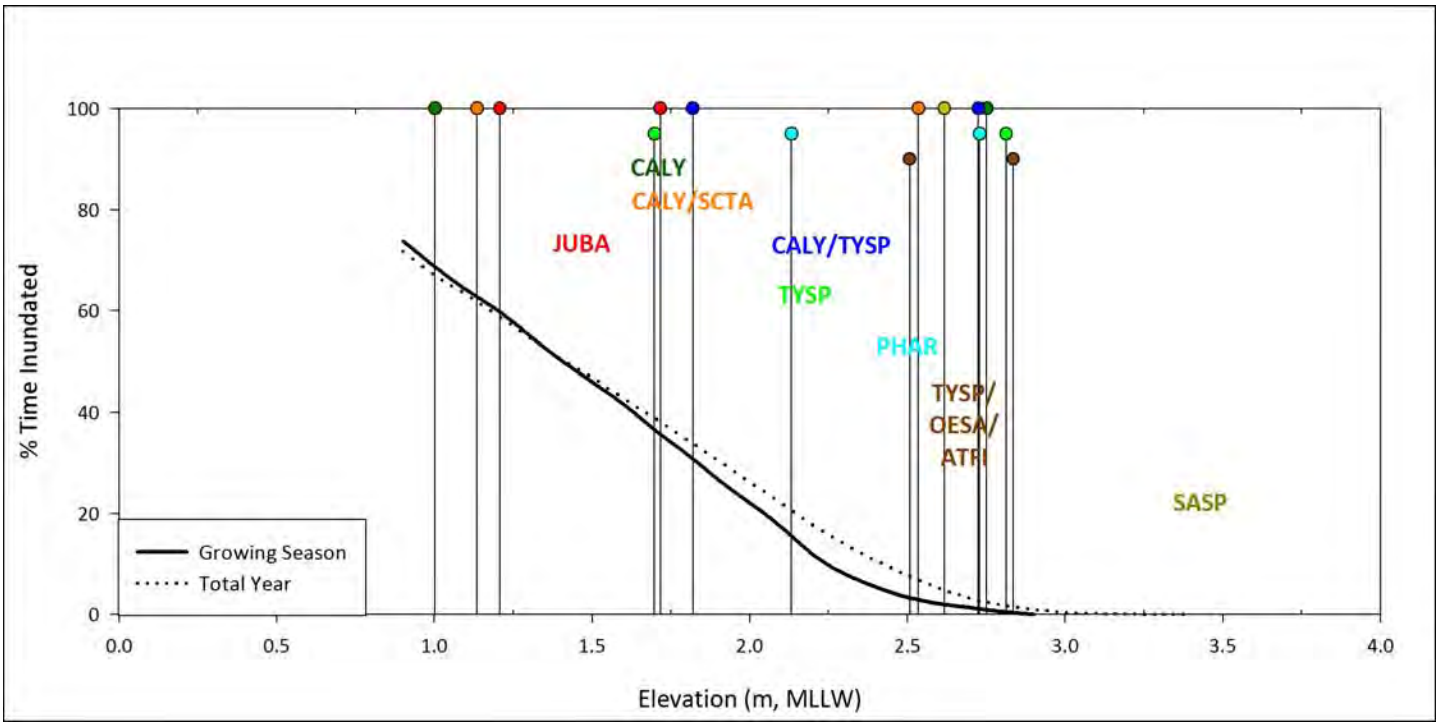
Modified Growing Season:

Aug 20 to Oct 12, 2008

Apr 22 to Jun 21, 2009



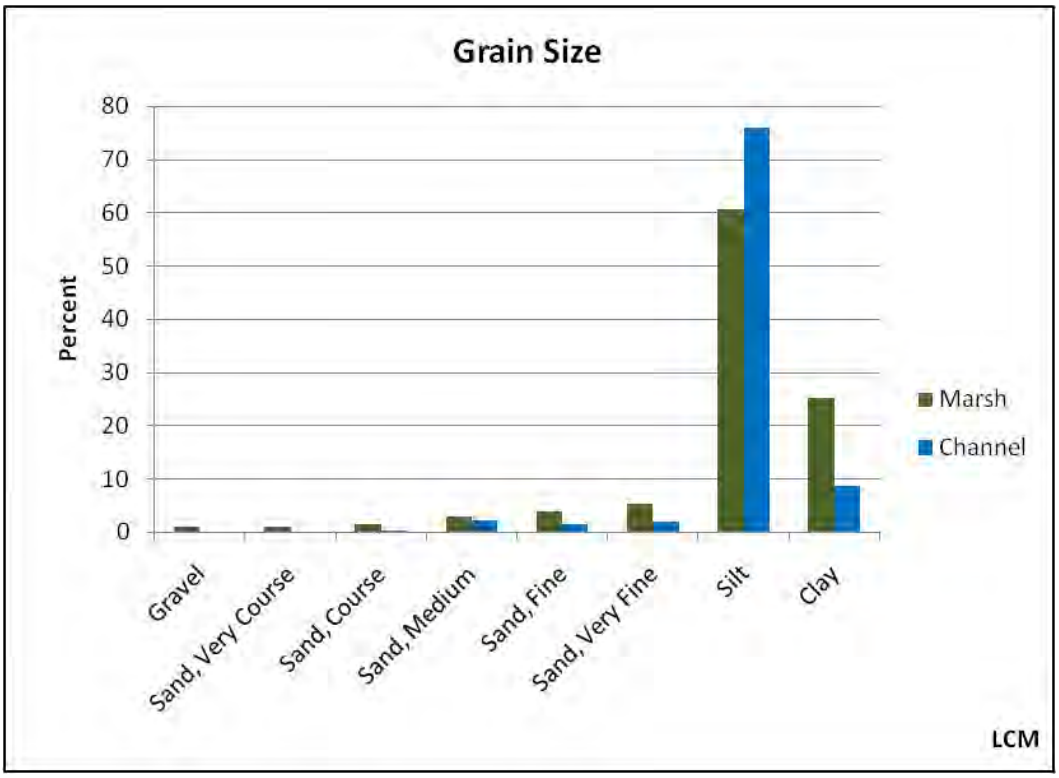
## Inundation (cont.)




## Sediment

Sediment accretion rate: 0.63 cm per year Elevation at sediment stakes: 2.19 m, MLLW

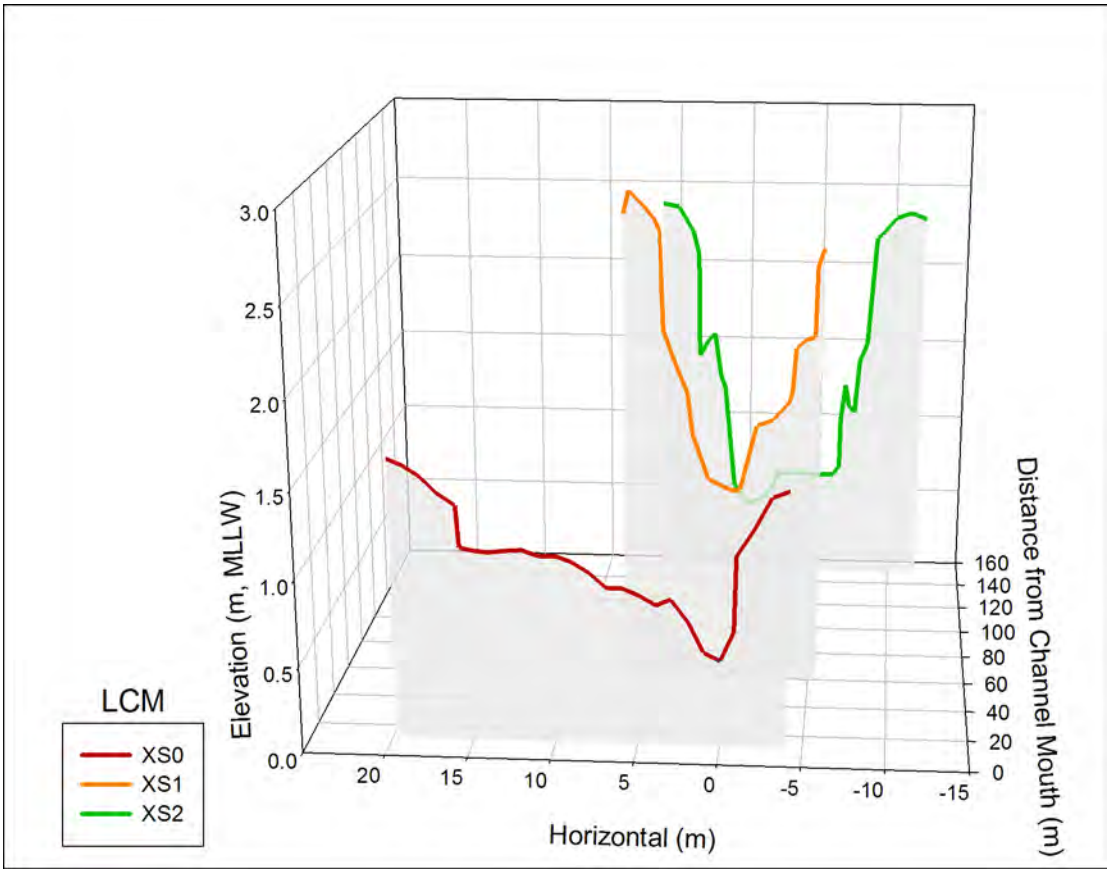
Total Organic Carbon (TOC) in channel: 2.57 in wetland: 5.84



## Channels

| | | Physical Metrics | | | | | | Inundation | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Year | | Growing Season | |
| | Cross Section | Bank Elevation (m) | Thalweg Elevation (m) | Channel Depth (m) | Cross Section Area ($m^2$) | Channel Width (m) | Width: Depth Ratio | Time WL > Thalweg (%) | Time WL > Bank (%) | Time WL > Thalweg (%) | Time WL > Bank (%) |
| LCM | 0 | 1.36 | 0.50 | 0.85 | 7.4 | 18.3 | 21.5 | | | | |
| | 1 | 2.45 | 1.15 | 1.31 | 8.5 | 9.7 | 7.4 | 55 | 9 | 55 | 4 |
| | 2 | 2.08 | 0.45 | 1.63 | 14.6 | 12.2 | 7.5 | | 23 | | 18 |

### Cross Sections



## Site Description

Hydrogeomorphic Reach: A

Coordinates (UTM, NAD83 meters):

Northing: 5105472 Easting: 439587

Distance from Columbia River mouth: 23 rkm

Distance from main channel: 10282 meters

Type: Marsh

Total Site Area: 20.8 ha Study Area: 0.70 ha

Total channel length: 1080 m Channel surveyed: 192 m Channel slope: 0.67 m/km

## Site Information

Cooperage Slough is located 10 rkm up the Young's River, a tributary to Young's Bay. The site is a mainland slough that grades from high marsh to forested swamp.

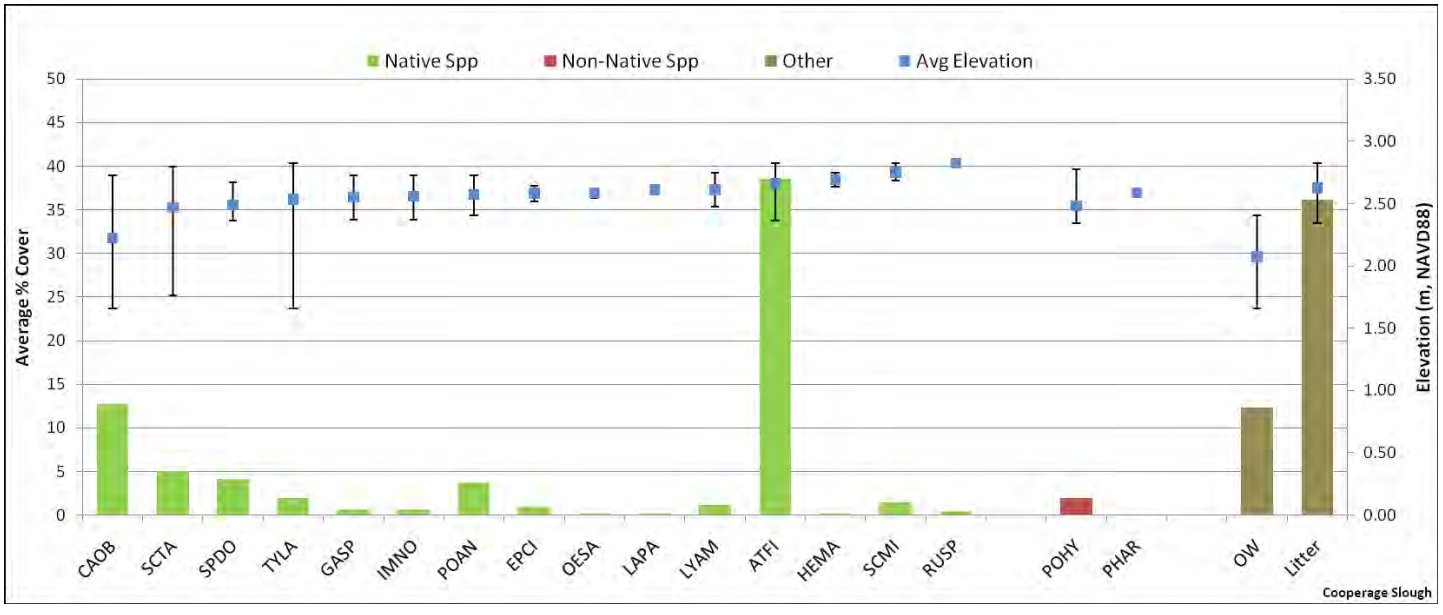
## Elevation

| | NAVD88, m | |
|---|---|---|
| | Lowest | Highest |
| Marsh | 1.66 | 2.80 |
| CAOB/SCTA | 1.66 | 2.80 |
| ATFI/SPDO | 2.36 | 2.67 |

## Vegetation

Number of Native species: 15 % Native Cover: 71.85

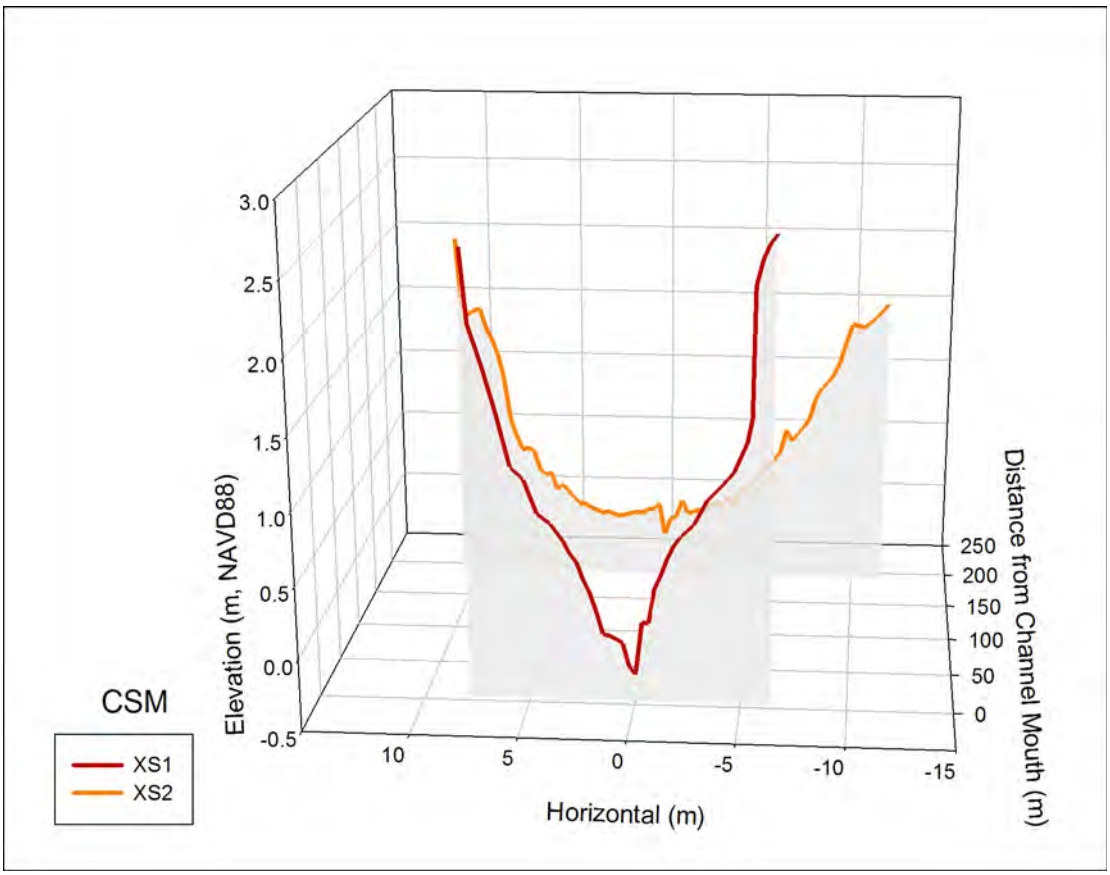
Number of Non-native species: 2 % Non-native Cover: 1.97



## Channels

| | Physical Metrics | | | | | | |
|---|---|---|---|---|---|---|---|
| | Cross Section | Bank Elevation (m) | Thalweg Elevation (m) | Channel Depth (m) | Cross Section Area ($m^2$) | Channel Width (m) | Width: Depth Ratio |
| CSM | 1 (mouth) | 2.57 | -0.31 | 2.88 | 24.3 | 13.9 | 4.8 |
| | 2 | 1.47 | -0.18 | 1.65 | 21.7 | 19.4 | 11.7 |

### Cross Sections



## Site Description

Hydrogeomorphic Reach: A

Coordinates (UTM, NAD83 meters):

Northing: 5108026 Easting: 437796

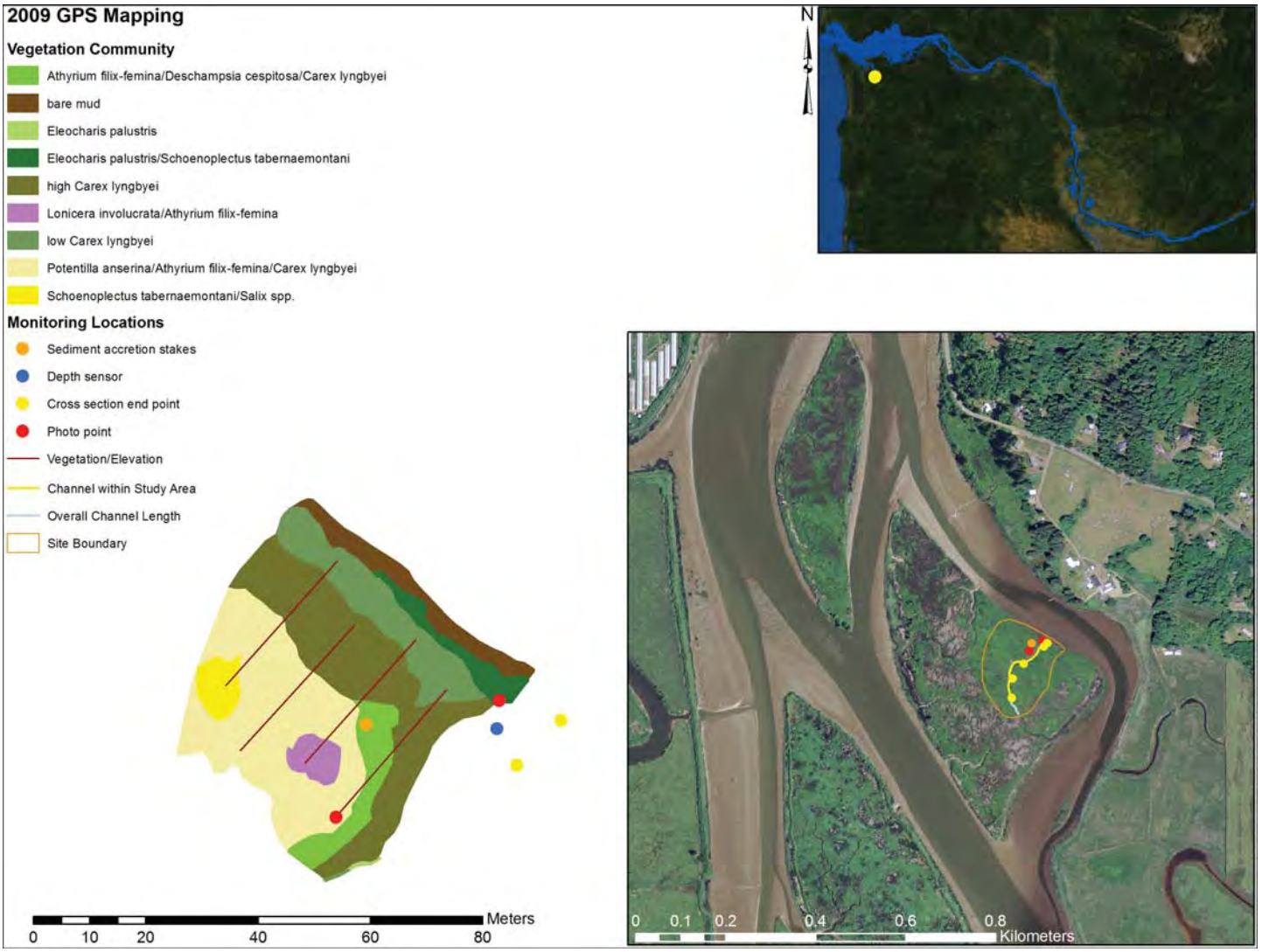
Distance from Columbia River mouth: 23 rkm

Distance from main channel: 6905 meters

Type: Marsh

Total Site Area: 2.7 ha Study Area: 0.23 ha

Total channel length: 217 m Channel surveyed: 176 m Channel slope: 4.48 m/km



## Site Information

Grant Island is positioned approximately 6 miles up the Youngs River, a tributary to the Columbia River, and is primarily covered by emergent marsh and dendritic tidal channels. The island is beyond the extent of historic mapping efforts so condition relative to then is unknown, however we know the site has never been diked and has no sign of recent disturbance. Grant Island is currently owned by Clatsop County.

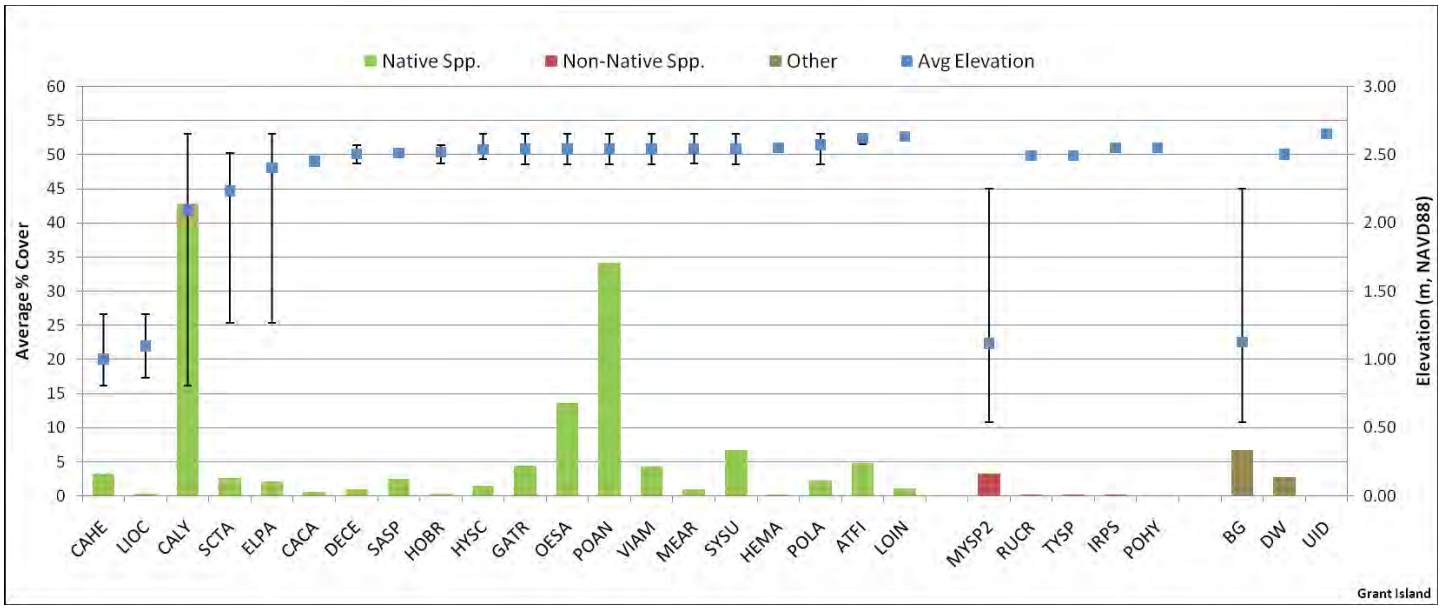
## Elevation

Lowest marsh (NAVD88, m): 0.81 Highest marsh (NAVD88, m): 2.65

## Vegetation

Number of Native species: 20 % Native Cover: 129.83

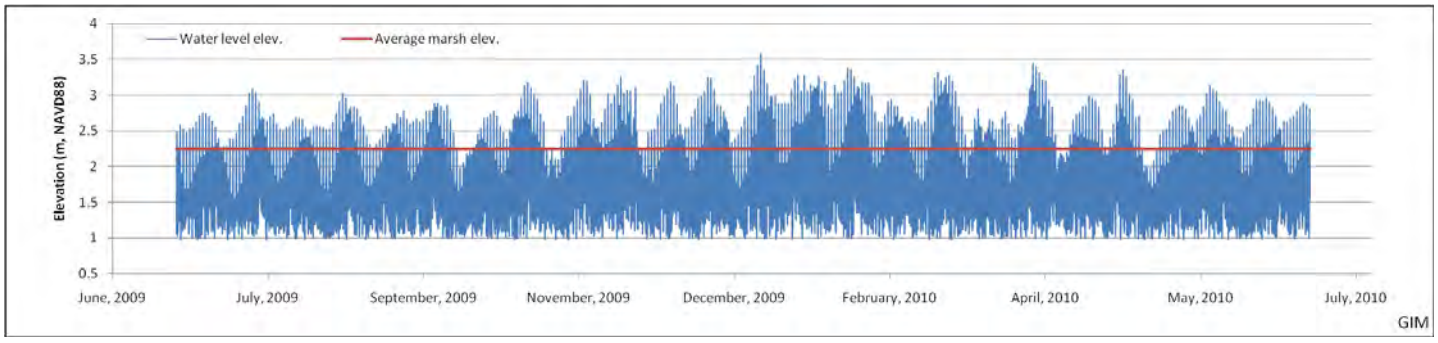
Number of Non-native species: 5 % Non-native Cover: 4.22



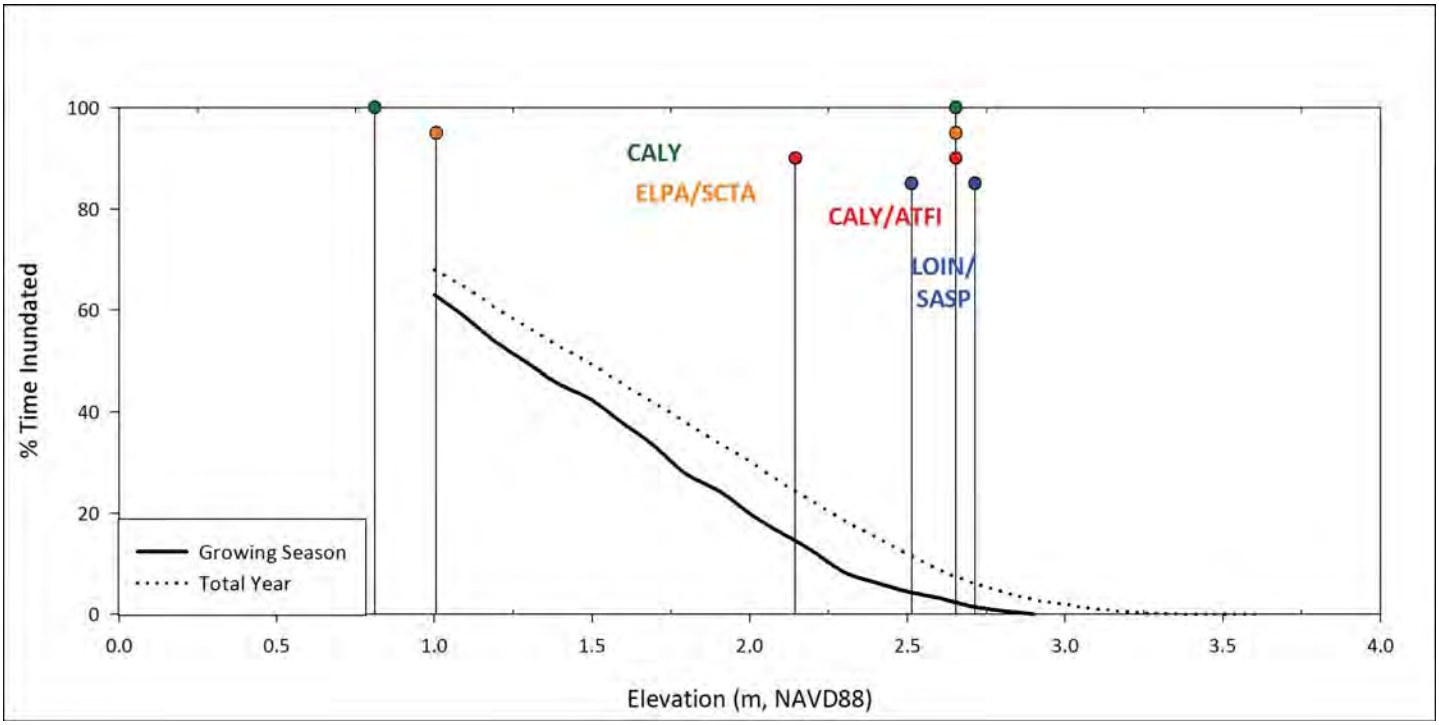

## Inundation

| | Std | Marsh |
|---|---|---|
| Average Elev (m, NAVD88) | 1.89 | 2.25 |
| Sum Exceedance Value (SEV) | 24.1 | 8.81 |

Modified Growing Season:
Aug 20 to Oct 12, 2009
Apr 22 to Jun 21, 2010



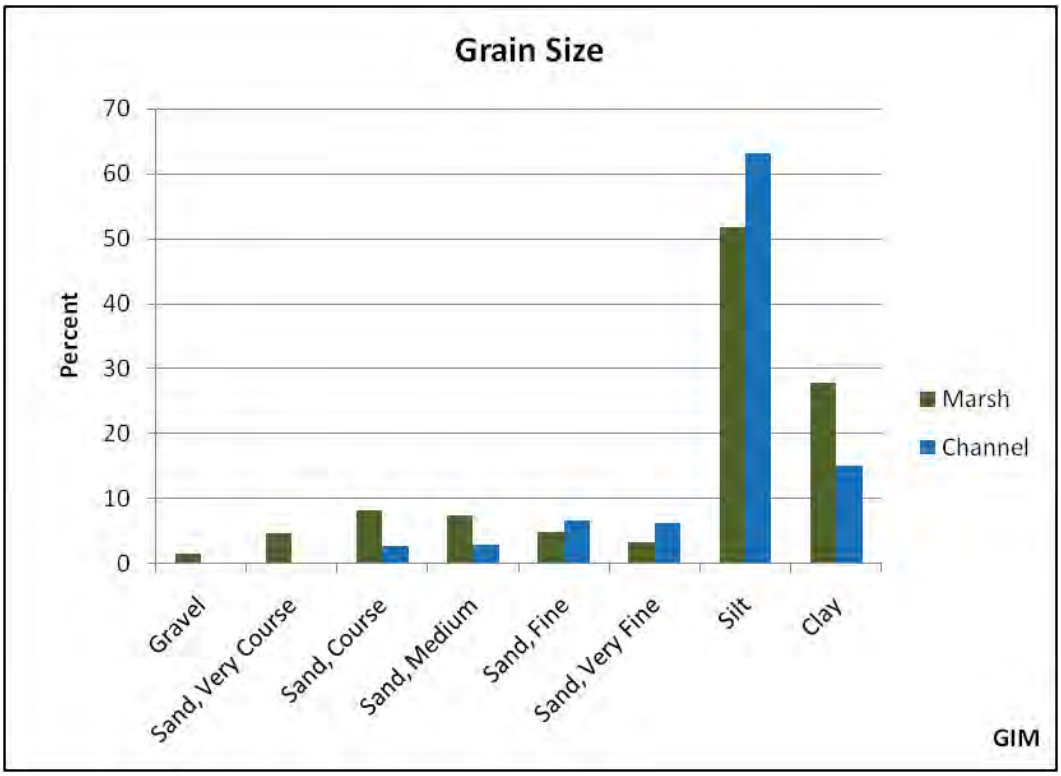
## Inundation (cont.)




## Sediment

Sediment accretion rate: -0.13 cm per year Elevation at sediment stakes: 2.69 m, NAVD88

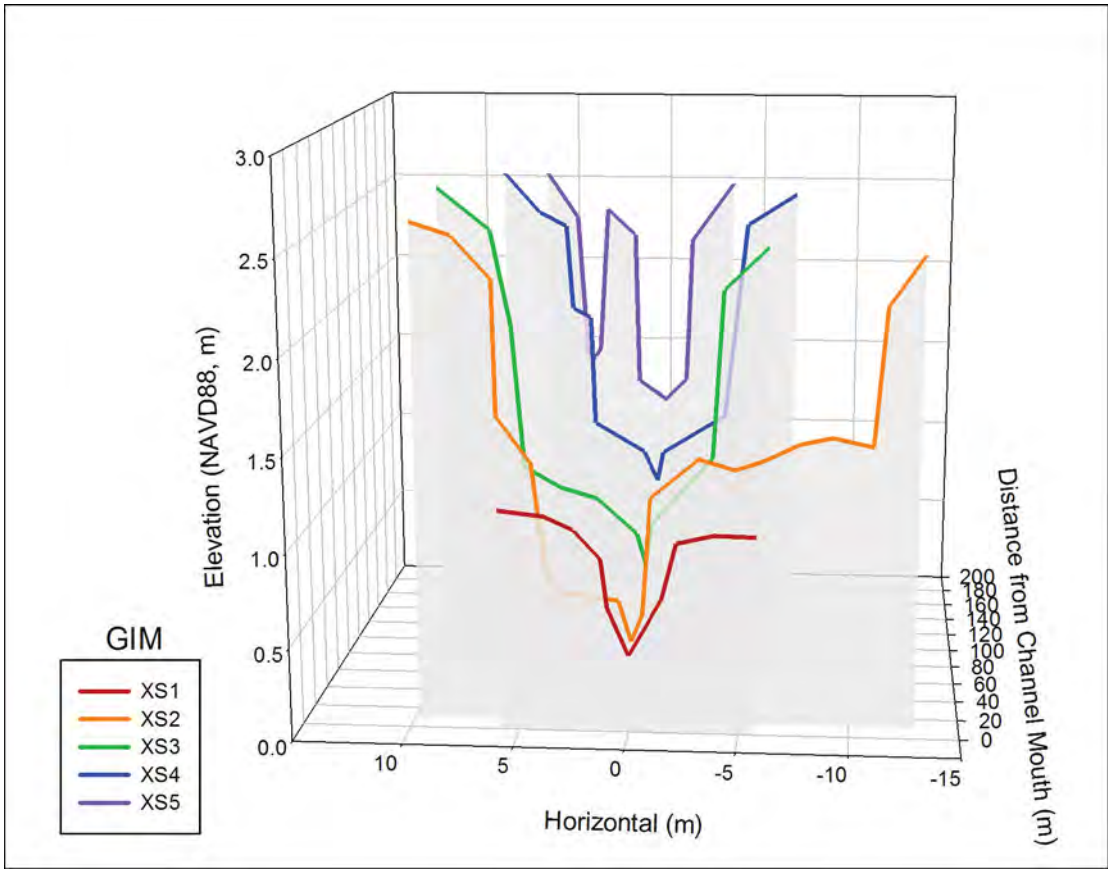
Total Organic Carbon (TOC) in channel: 3.32 in wetland: 5.92



## Channels

| | | Physical Metrics | | | | | | Inundation | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Year | | Growing Season | |
| | Cross Section | Bank Elevation (m) | Thalweg Elevation (m) | Channel Depth (m) | Cross Section Area ($m^2$) | Channel Width (m) | Width: Depth Ratio | Time WL > Thalweg (%) | Time WL > Bank (%) | Time WL > Thalweg (%) | Time WL > Bank (%) |
| GIM | 1 | 0.93 | 0.41 | 0.51 | 1.0 | 3.2 | 6.3 | 83 | 71 | 80 | 67 |
| | 2 | 1.21 | 0.44 | 0.77 | 2.6 | 5.2 | 6.8 | 82 | 61 | 79 | 55 |
| | 3 | 2.14 | 0.61 | 1.53 | 11.3 | 10.6 | 6.9 | 77 | 26 | 73 | 16 |
| | 4 | 2.34 | 0.86 | 1.49 | 9.6 | 9.2 | 6.2 | 69 | 18 | 64 | 8 |
| | 5 | 2.17 | 1.20 | 0.97 | 2.5 | 3.0 | 3.1 | 56 | 25 | 49 | 15 |

## Cross Sections



## Site Description

Hydrogeomorphic Reach: A

Coordinates (UTM, NAD83 meters):

Northing: 5107537 Easting: 437414

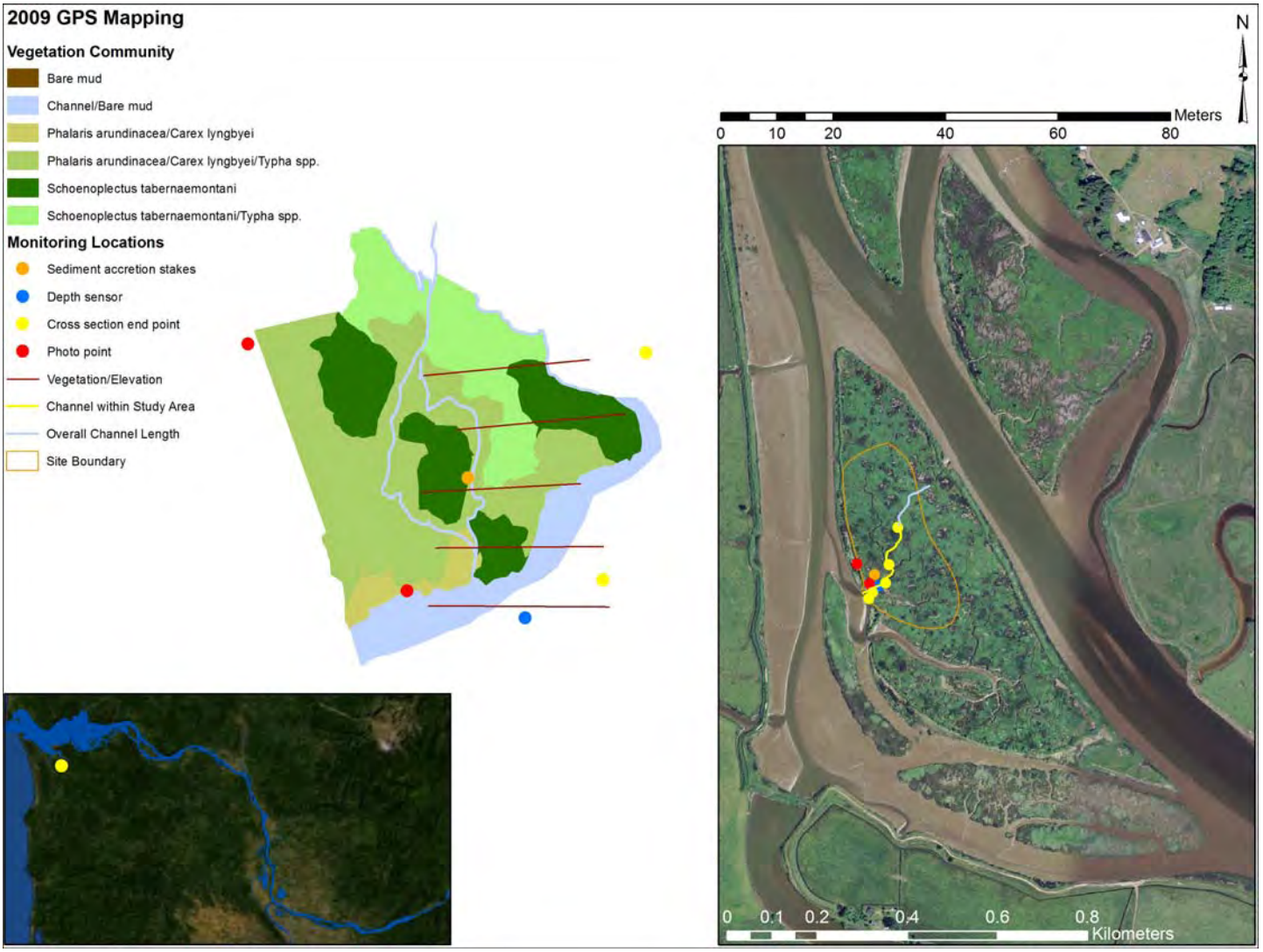
Distance from Columbia River mouth: 23 rkm

Distance from main channel: 7557 meters

Type: Natural Breach

Total Site Area: 6.8 ha Study Area: 0.29 ha

Total channel length: 334 m Channel surveyed: 207 m Channel slope: 9.39 m/km



## Site Information

Haven Island is a formerly diked island recently breached and located approximately 7 miles up the Youngs River, a tributary to the Columbia River. The monitoring site was on the western side of the island near one of the 2 dike failures that occured around 1999. In 2010, Columbia Land Trust, owner of the island, breached the dike in 5 places on the eastern side of the island as part of an ongoing restoration project.

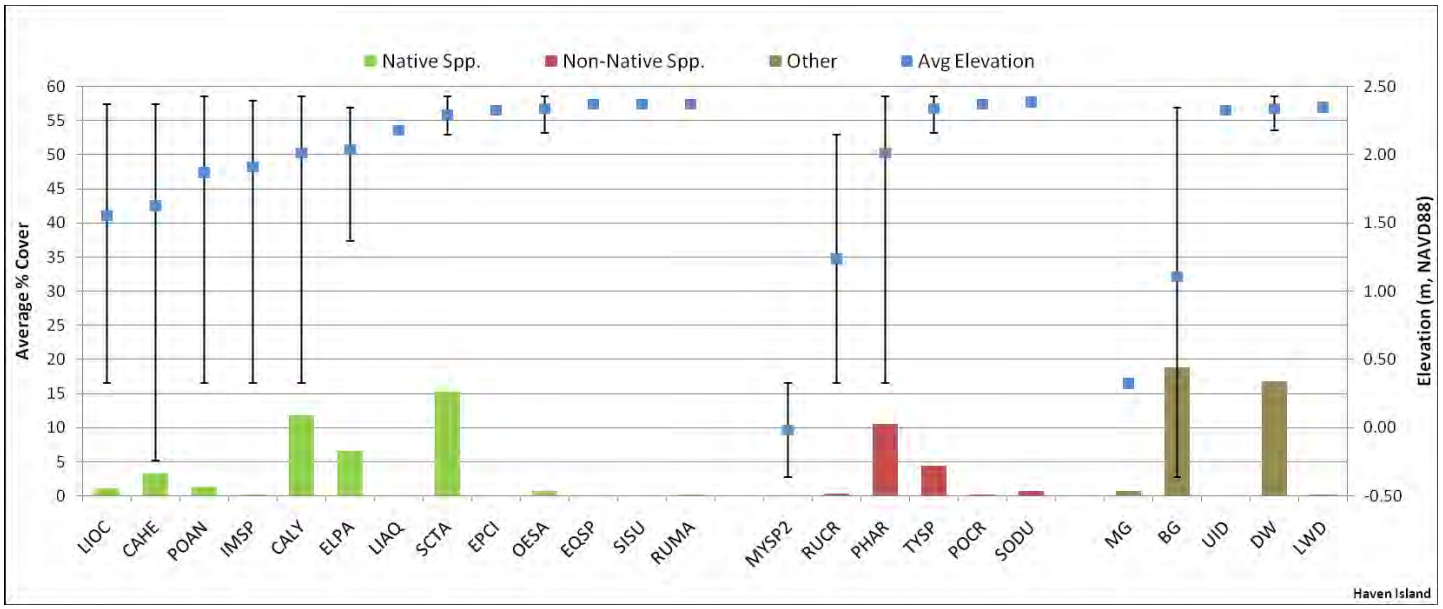
## Elevation

Lowest marsh (NAVD88, m): 0.30 Highest marsh (NAVD88, m): 2.46

## Vegetation

Number of Native species: 13 % Native Cover: 40.85

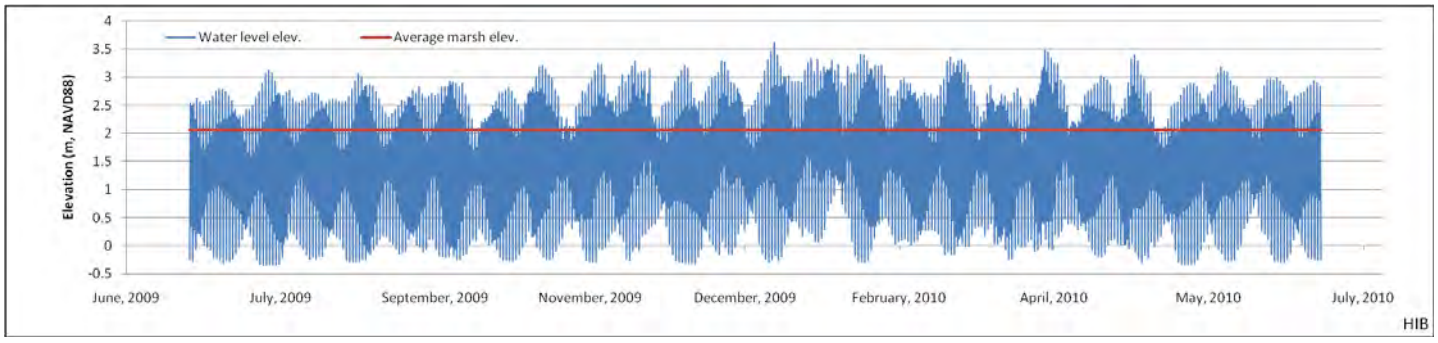
Number of Non-native species: 7 % Non-native Cover: 16.30



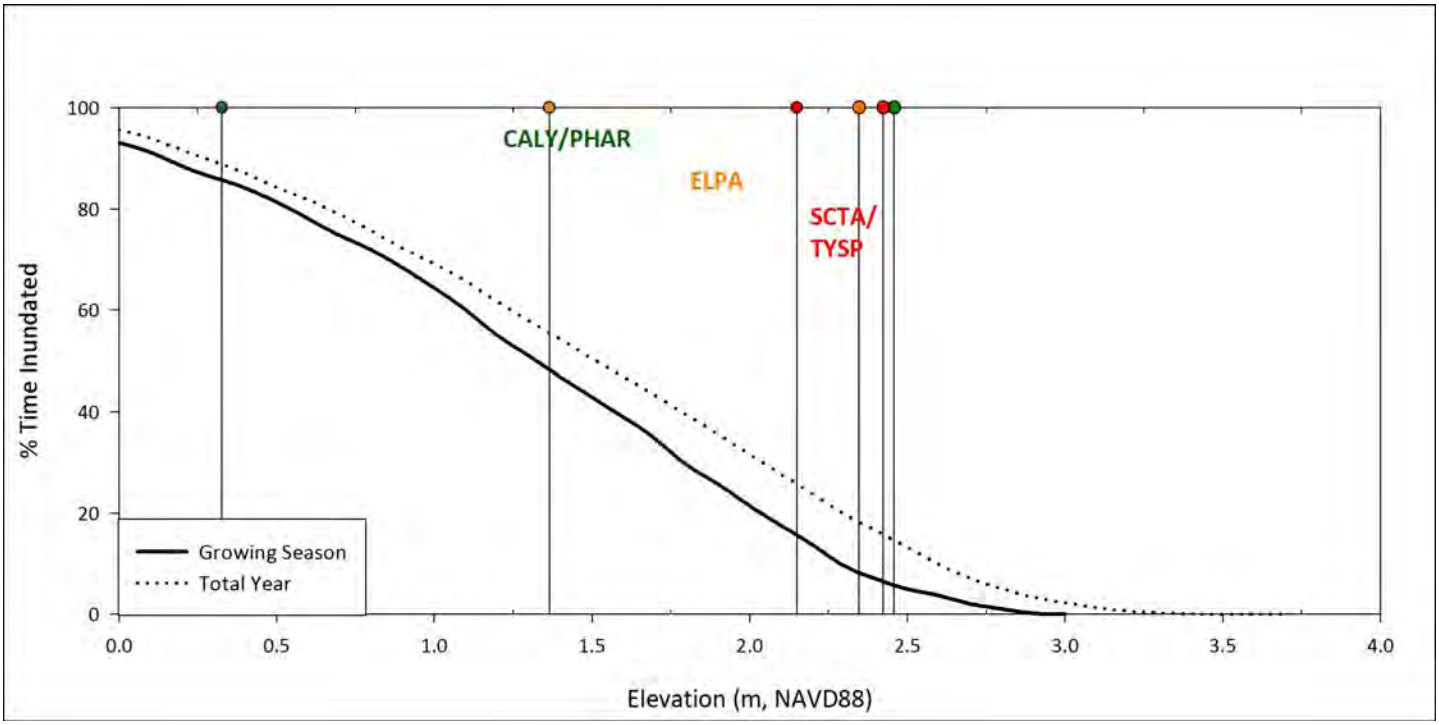

## Inundation

| | Std | Marsh |
|---|---|---|
| Average Elev (m, NAVD88) | 1.89 | 2.07 |
| Sum Exceedance Value (SEV) | 17.1 | 11.1 |

Modified Growing Season:
Aug 20 to Oct 12, 2009
Apr 22 to Jun 21, 2010



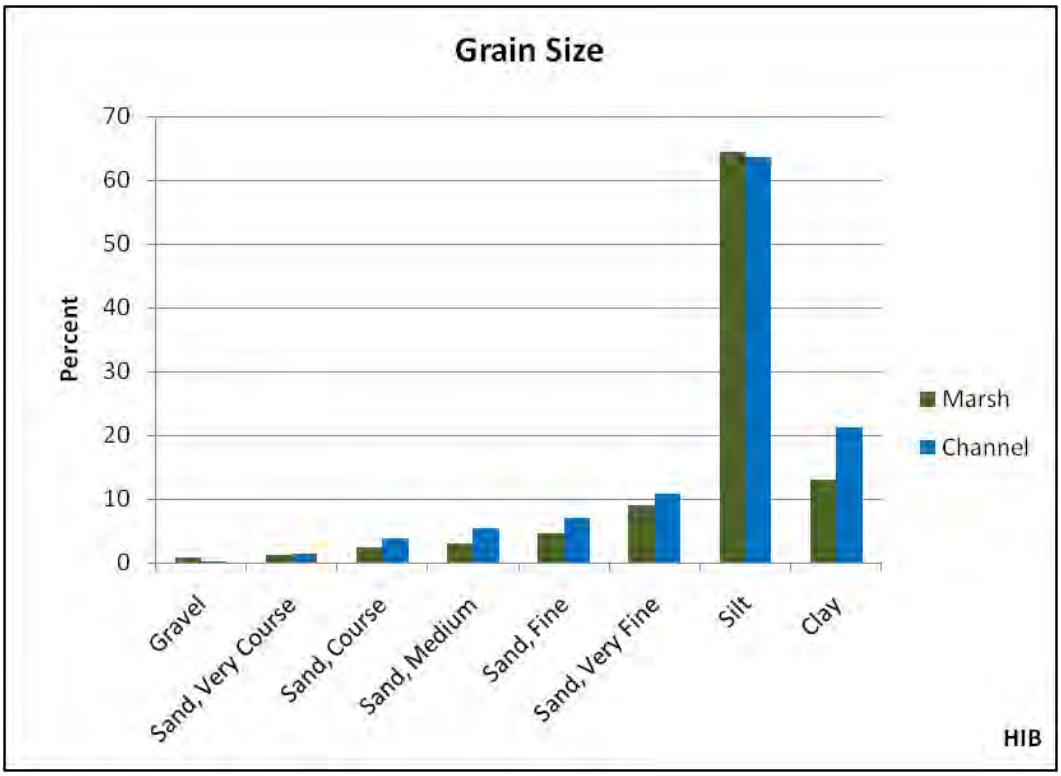
## Inundation (cont.)




## Sediment

Sediment accretion rate: 2.55 cm per year Elevation at sediment stakes: 2.41 m, NAVD88

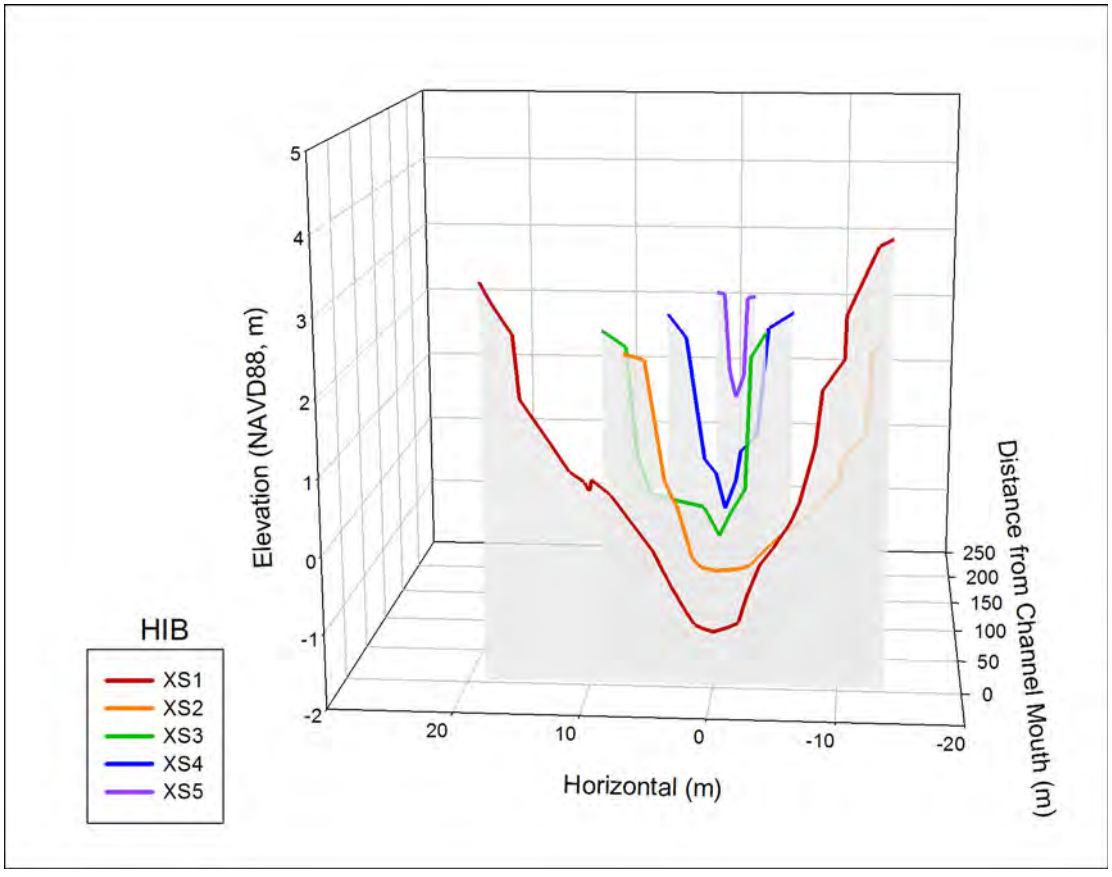
Total Organic Carbon (TOC) in channel: 5.16 in wetland: 4.88



## Channels

| | Physical Metrics | | | | | | | Inundation | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Year | | Growing Season | |
| | Cross Section | Bank Elevation (m) | Thalweg Elevation (m) | Channel Depth (m) | Cross Section Area ($m^2$) | Channel Width (m) | Width: Depth Ratio | Time WL > Thalweg (%) | Time WL > Bank (%) | Time WL > Thalweg (%) | Time WL > Bank (%) |
| HIB | 1 | 2.31 | -1.29 | 3.59 | 54.5 | 26.0 | 7.3 | 100 | 20 | 100 | 9 |
| | 2 | 2.18 | -0.58 | 2.76 | 36.3 | 18.1 | 6.5 | 100 | 24 | 100 | 14 |
| | 3 | 2.06 | -0.35 | 2.41 | 18.6 | 10.2 | 4.2 | 98 | 29 | 96 | 19 |
| | 4 | 2.05 | -0.33 | 2.38 | 10.1 | 6.9 | 2.9 | 98 | 30 | 96 | 19 |
| | 5 | 2.14 | 0.66 | 1.48 | 2.1 | 2.1 | 1.4 | 75 | 26 | 72 | 16 |

## Cross Sections



## Site Description

Hydrogeomorphic Reach: B

Coordinates (UTM, NAD83 meters):

Northing: 5126799 Easting: 448119

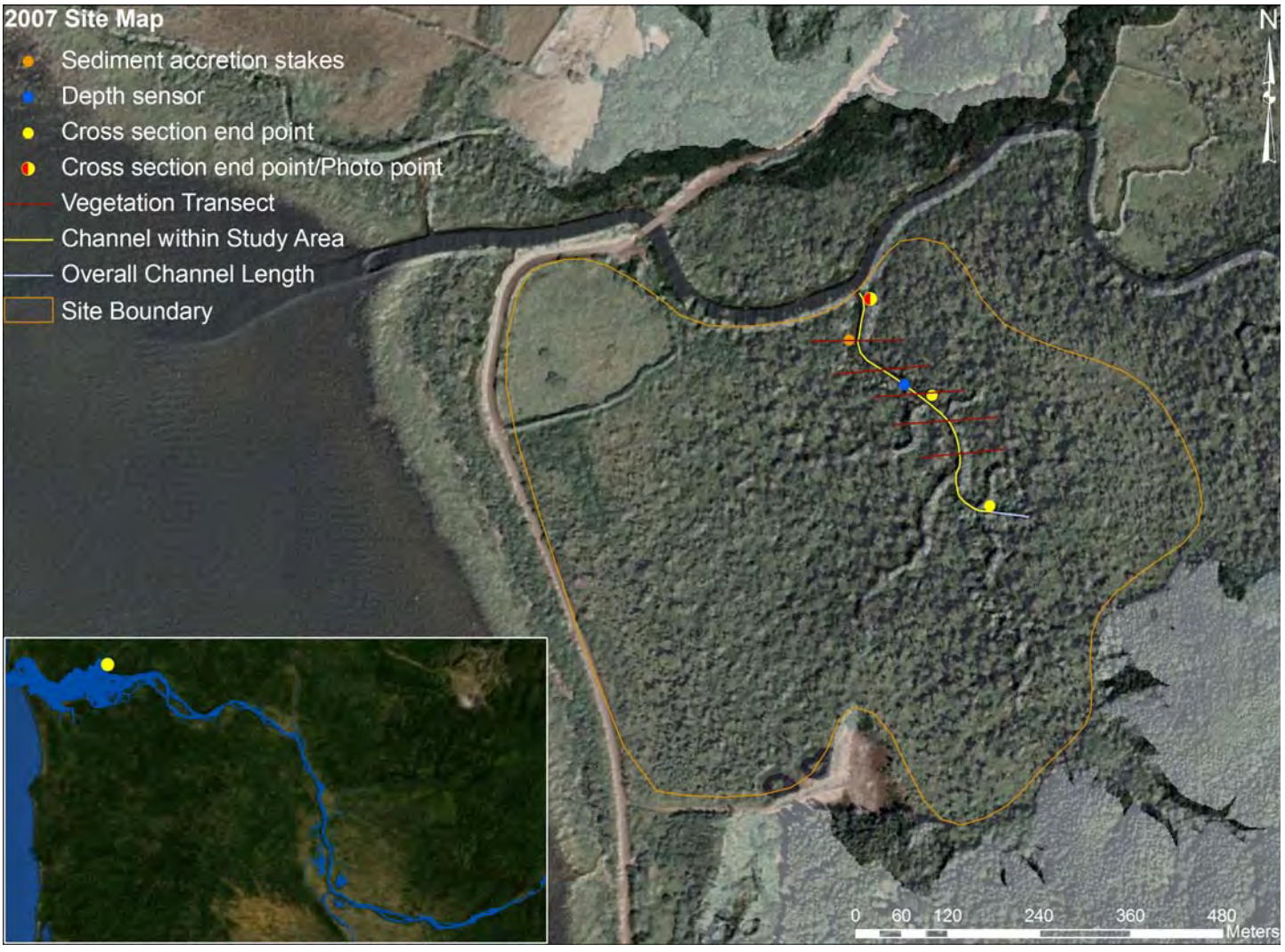
Distance from Columbia River mouth: 37 rkm

Distance from main channel: 667 meters

Type: Swamp

Total Site Area: 47.5 ha Study Area: 3.74 ha

Total channel length: 427 m Channel surveyed: 376 m Channel slope: 3.56 m/km



## Site Information

Crooked Creek, located in Washington, is a tributary to Grays Bay. The site at Crooked Creek spans both sides of a small channel that inputs near the mouth of Crooked Creek. The site is a forested wetland swamp dominated by Sitka spruce (P. sitchensis) and is owned by the Columbia Land Trust.

## Elevation

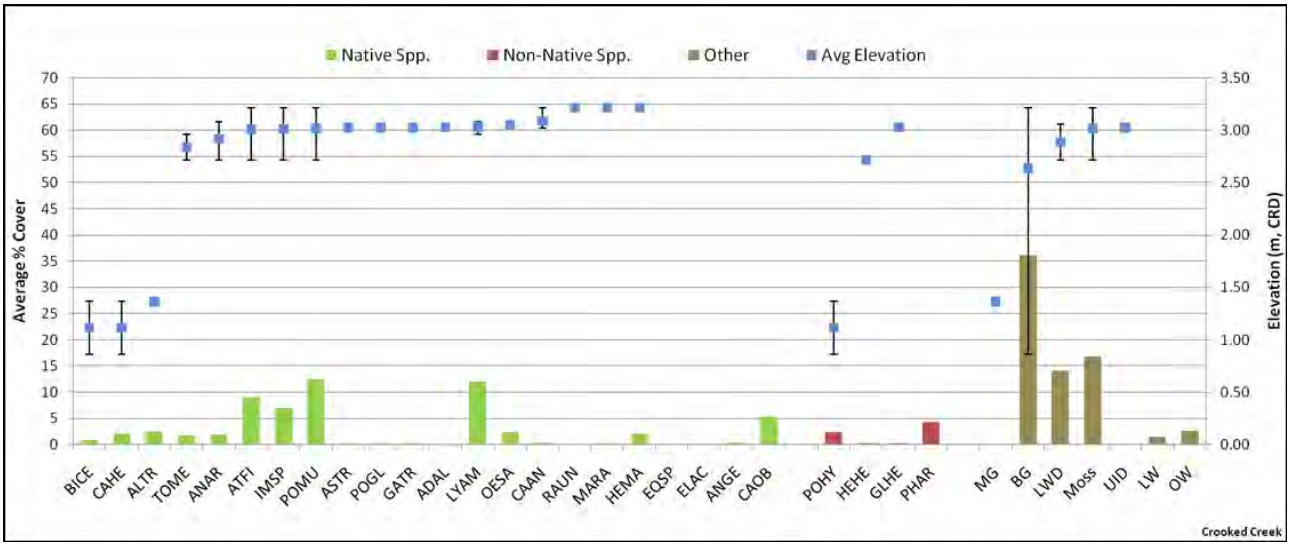
| | Herb | | Shrub | | Tree | |
|---|---|---|---|---|---|---|
| | Lowest | Highest | Lowest | Highest | Lowest | Highest |
| CRD, m | 0.86 | 3.21 | 2.88 | 3.42 | 3.06 | 5.03 |
| NAVD88, m | 0.98 | 3.33 | 3.00 | 3.54 | 3.18 | 5.15 |

## Vegetation

| | Herb | Shrub | Tree |
|---|---|---|---|
| Number of Native species | 22 | 13 | 7 |
| Number of Non-native species | 5 | 2 | 0 |

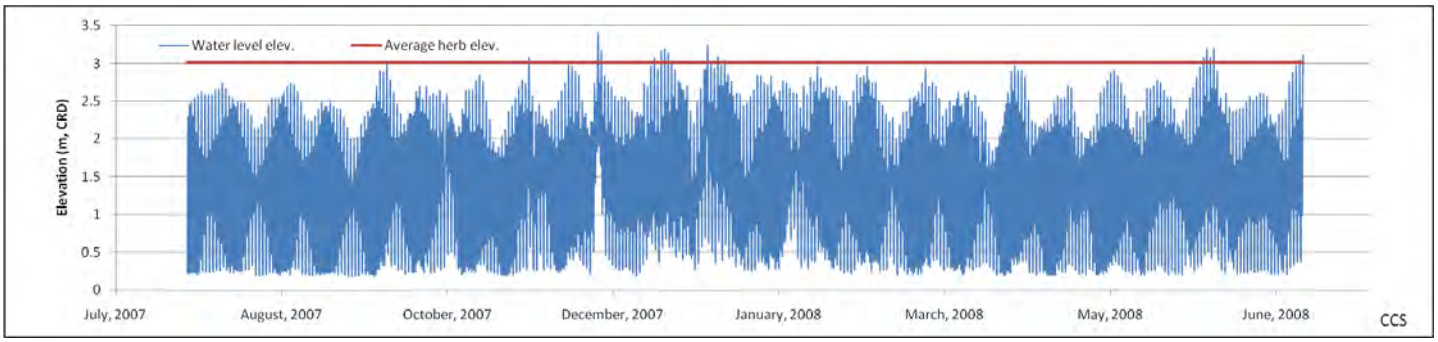
| Species | Density Stems/ha | Relative Frequency % | Relative Density % | Relative Dominance % | Elevation (m, CRD) Min | Max |
|---|---|---|---|---|---|---|
| Crooked Creek | | | | | | |
| ALRU | 153 | 36.2 | 48.6 | 37.0 | 3.23 | 3.77 |
| CRDO | 13 | 2.1 | 4.1 | 0.1 | nd | nd |
| PISI | 76 | 23.4 | 24.3 | 45.7 | 3.23 | 5.03 |
| PREM | 8 | 2.1 | 2.7 | 0.1 | nd | nd |
| RHPU | 21 | 8.5 | 6.8 | 0.3 | 3.22 | 3.92 |
| THPL | 30 | 10.6 | 9.5 | 16.1 | 3.06 | 3.06 |
| TSHE | 13 | 6.4 | 4.1 | 0.7 | 3.78 | 3.78 |
| no trees | na | 10.6 | na | na | na | na |

| Species | Density (stems/ha) | Relative Density (%) |
|---|---|---|
| ACCI | 2333 | 4.3 |
| AMAL | 167 | 0.3 |
| COSE | 167 | 0.3 |
| GASH | 2833 | 5.2 |
| OECE | 7000 | 12.9 |
| RIDI | 333 | 0.6 |
| RUAR | 1167 | 2.2 |
| RULA | 167 | 0.3 |
| RUPA | 3333 | 6.2 |
| RUSP | 27000 | 49.8 |
| RUUR | 7000 | 12.9 |
| SARA | 167 | 0.3 |
| SASP | 167 | 0.3 |
| SYAL | 167 | 0.3 |
| VAPA | 2167 | 4.0 |



## Inundation

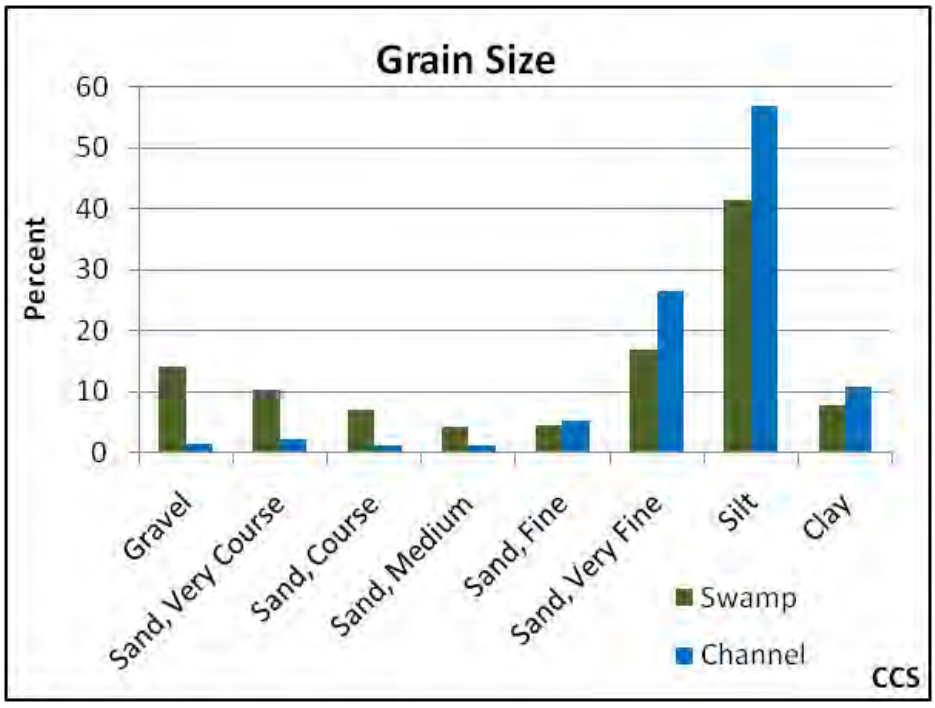
| | Std | Herb | Shrub | Tree | Modified Growing Season: |
|---|---|---|---|---|---|
| Average Elev (m, CRD) | 1.89 | 3.02 | 3.47 | 3.66 | Aug 20 to Oct 12, 2008 |
| Sum Exceedance Value (SEV) | 11.2 | 0.03 | 0.00 | 0.00 | Apr 22 to Jun 21, 2009 |




## Sediment

Sediment accretion rate: 0.04 cm per year Elevation at sediment stakes: NA m, CRD

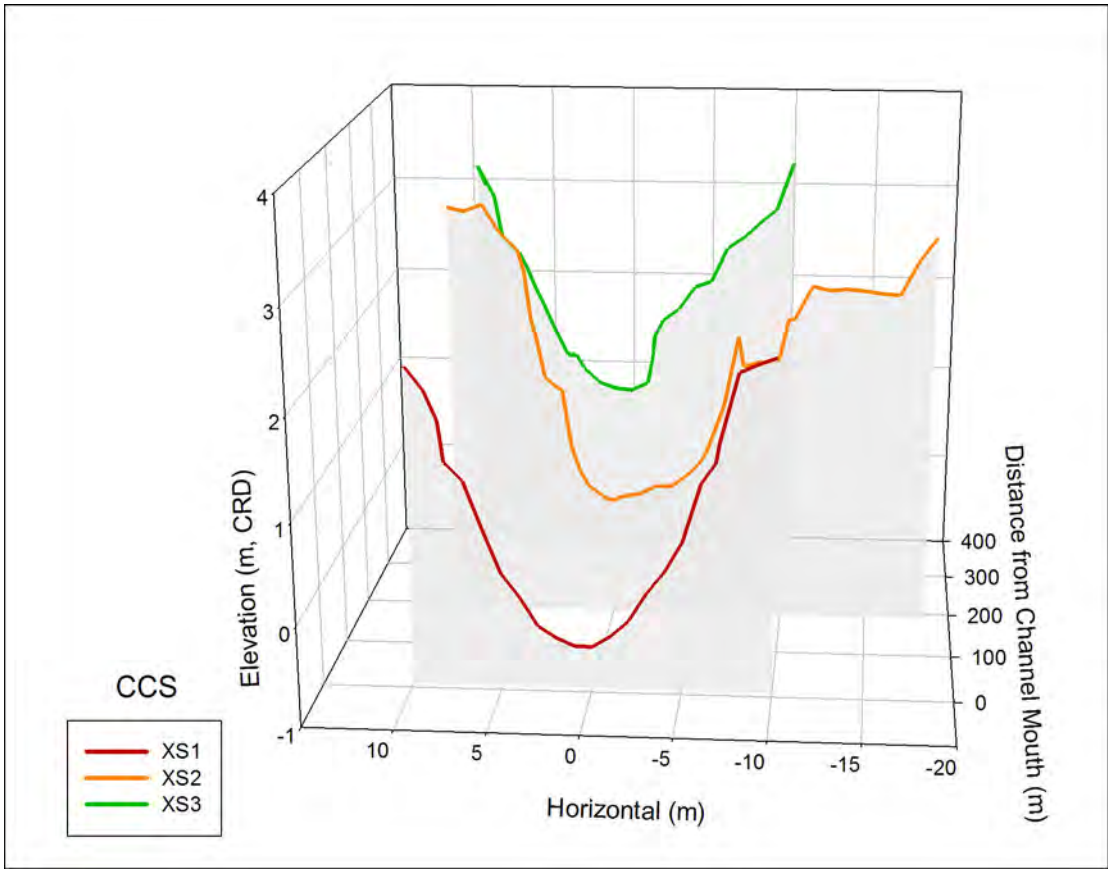
Total Organic Carbon (TOC) in channel: 2.21 in wetland: 3.78



## Channels

| | | Physical Metrics | | | | | | Inundation | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Year | | Growing Season | |
| | Cross Section | Bank Elevation (m) | Thalweg Elevation (m) | Channel Depth (m) | Cross Section Area ($m^2$) | Channel Width (m) | Width: Depth Ratio | Time WL > Thalweg (%) | Time WL > Bank (%) | Time WL > Thalweg (%) | Time WL > Bank (%) |
| CCS | 1 (mouth) | 2.16 | -0.58 | 2.74 | 31.4 | 18.0 | 6.6 | 100 | 18 | 100 | 10 |
| | 2 | 2.47 | 0.20 | 2.27 | 23.8 | 16.6 | 7.3 | 89 | 8 | 84 | 3 |
| | 3 | 3.20 | 0.76 | 2.44 | 29.5 | 19.3 | 7.9 | 69 | 0 | 64 | 0 |

## Cross Sections



## Site Description

Hydrogeomorphic Reach: B

Coordinates (UTM, NAD83 meters):

Northing: 5130446 Easting: 449056

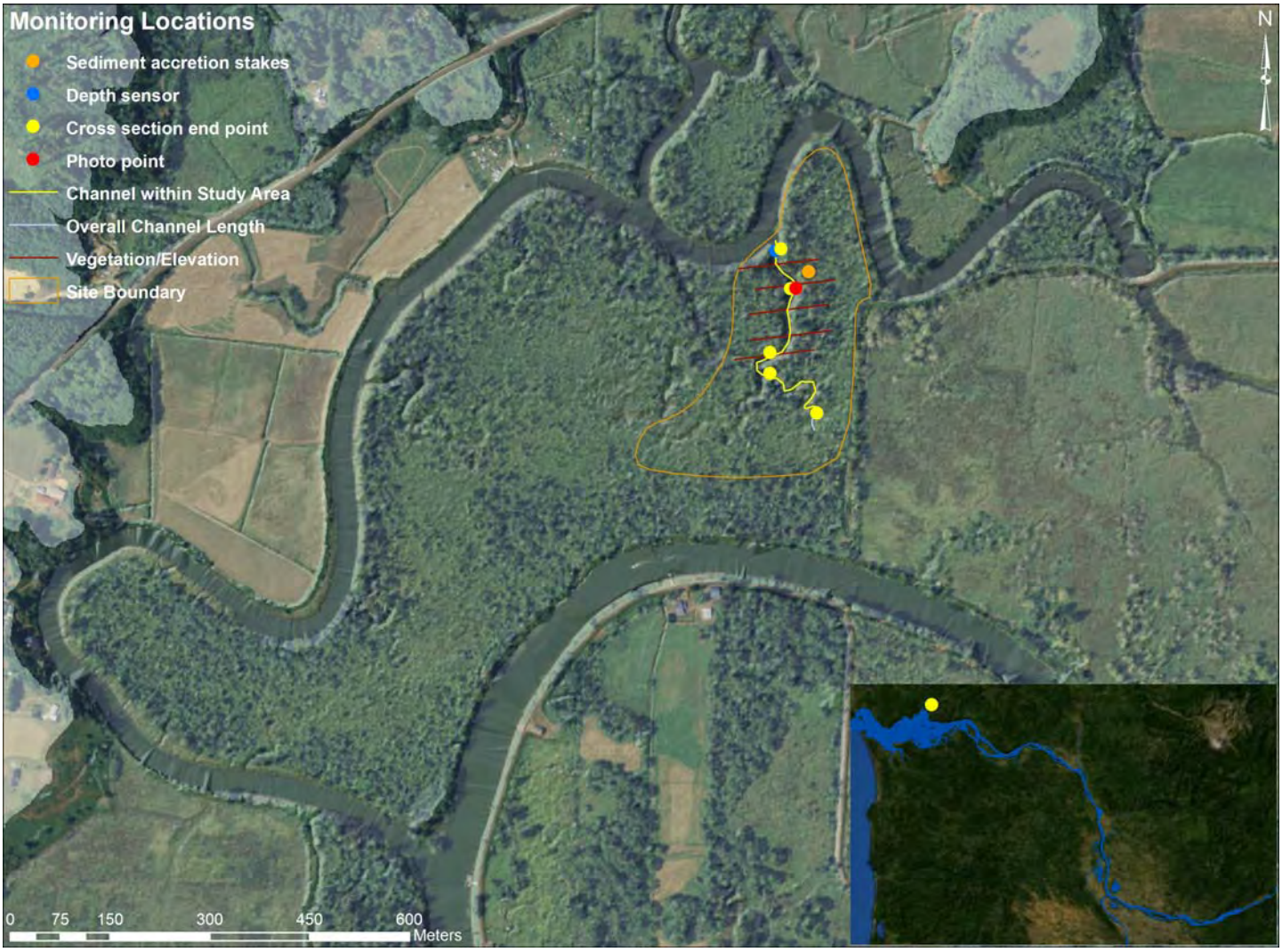
Distance from Columbia River mouth: 37 rkm

Distance from main channel: 6498 meters

Type: Swamp

Total Site Area: 9.1 ha Study Area: 2.12 ha

Total channel length: 447 m Channel surveyed: 422 m Channel slope: 3.13 m/km



## Site Information

Seal Slough is a tributary to the Grays River, and is located approximately 7.3 km from the mouth of the Grays River. The Seal Slough site spans both sides of a small channel that inputs into Seal Slough. The site is a forested wetland swamp dominated by Sitka spruce (P. sitchensis) and is owned by the Columbia Land Trust. This site was recently used as reference for a culvert replacement project nearby at Kandoll Farm.

## Elevation

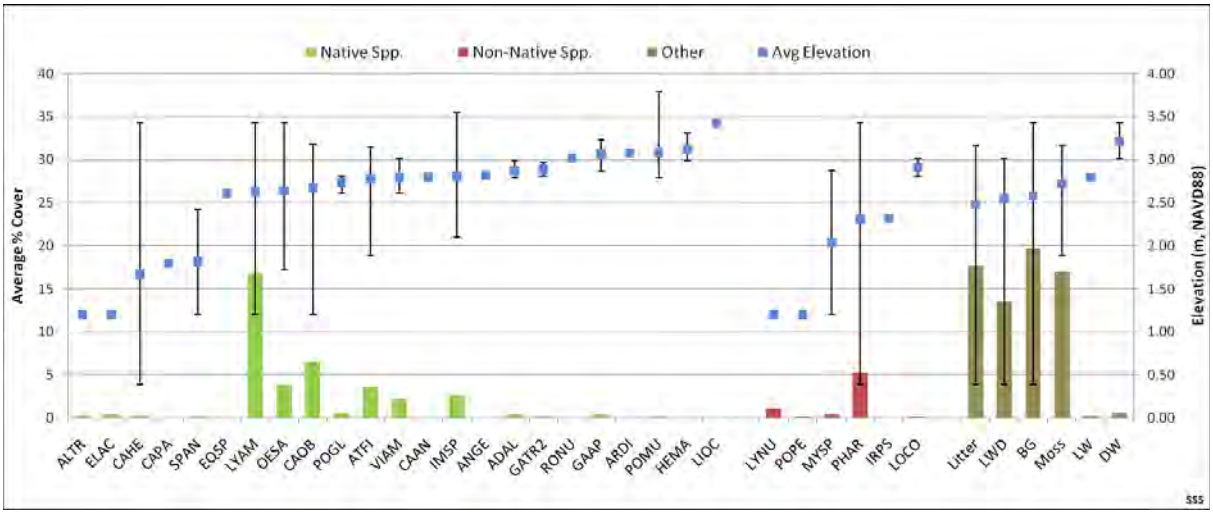
| | Herb | | Shrub | | Tree | |
|---|---|---|---|---|---|---|
| | Lowest | Highest | Lowest | Highest | Lowest | Highest |
| NAVD88, m | 0.39 | 3.79 | 2.59 | 4.03 | 2.10 | 3.70 |

## Vegetation

| | Herb | Shrub | Tree |
|---|---|---|---|
| Number of Native species | 23 | 15 | 7 |
| Number of Non-native species | 5 | 0 | 0 |

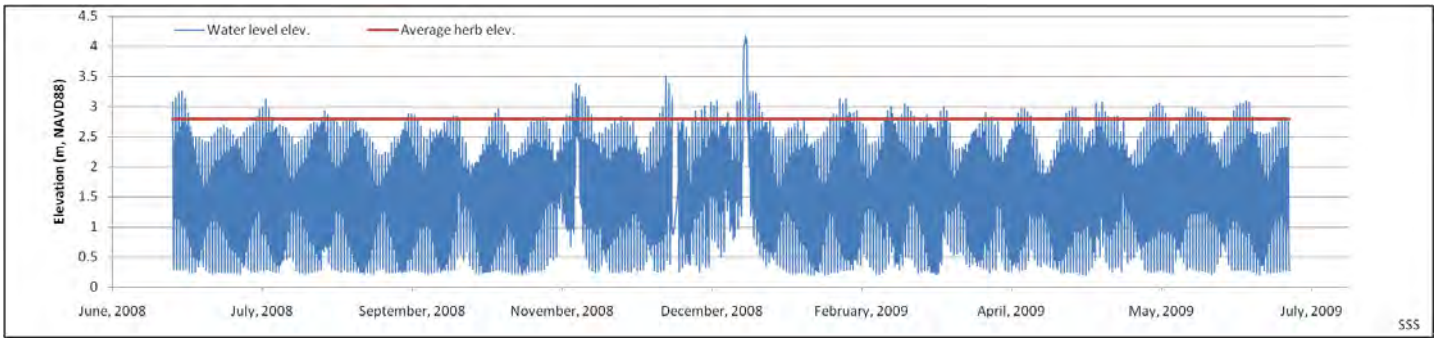
| Species | Density Stems/ha | Relative Frequency % | Relative Density % | Relative Dominance % | Elevation (m, CRD) Min | Max |
|---|---|---|---|---|---|---|
| Seal Slough | | | | | | |
| ALRU | 14 | 10.9 | 9.8 | 10.7 | 2.39 | 3.07 |
| FRLA | 10 | 10.9 | 7.0 | 11.0 | 2.39 | 3.65 |
| MAFU | 55 | 23.4 | 38.5 | 0.9 | 2.10 | 3.31 |
| PISI | 32 | 20.3 | 22.4 | 57.3 | 2.67 | 4.09 |
| RHPU | 18 | 15.6 | 12.6 | 1.3 | 2.48 | 3.67 |
| THPL | 10 | 10.9 | 7.0 | 16.9 | 2.10 | 3.77 |
| TSHE | 4 | 3.1 | 2.8 | 2.0 | 2.10 | 3.76 |
| no trees | na | 4.7 | na | na | na | na |

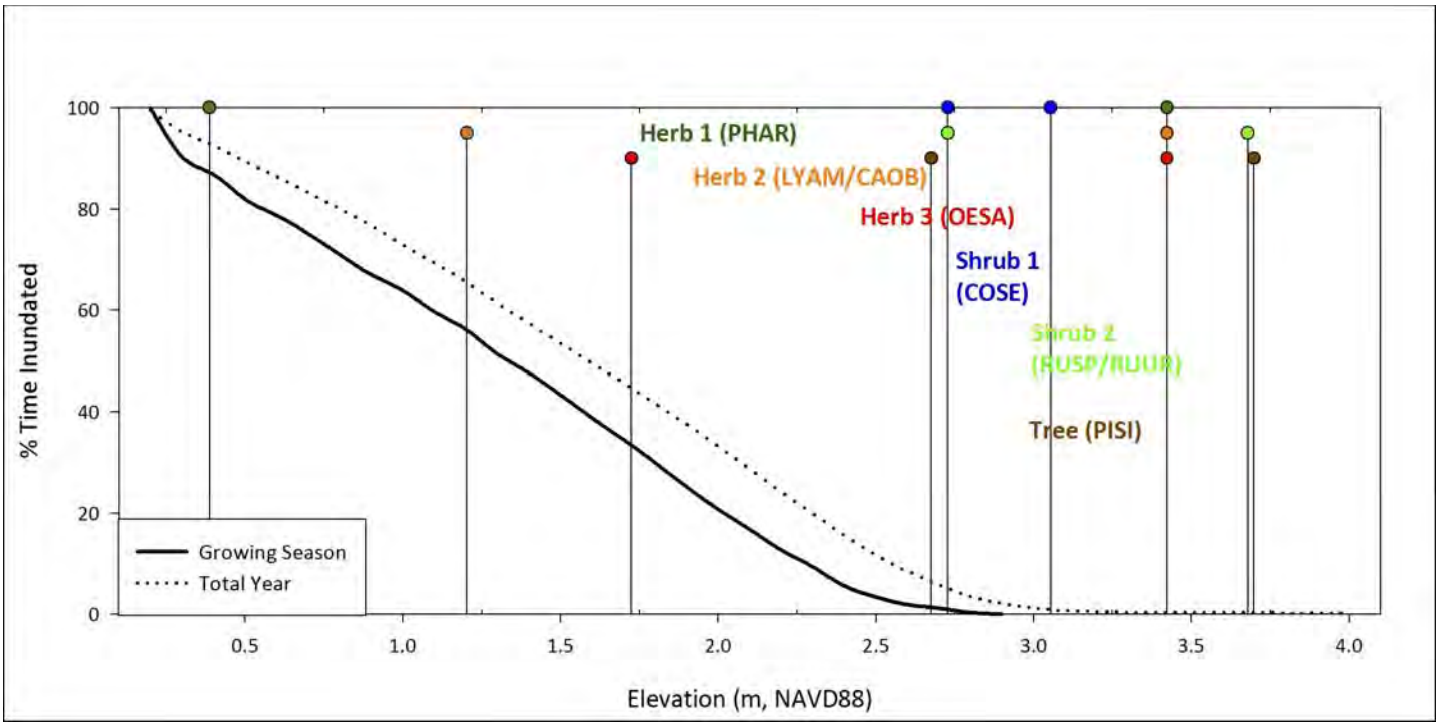
| Species | Density (stems/ha) | Relative Density (%) |
|---|---|---|
| ACCI | 200 | 0.3 |
| AMAL | 2200 | 3.4 |
| COSE | 6200 | 9.7 |
| GASH | 11500 | 17.9 |
| LOIN | 3700 | 5.8 |
| OECE | 100 | 0.2 |
| PHCA | 5600 | 8.7 |
| RIDI | 1500 | 2.3 |
| RILA | 1000 | 1.6 |
| RONU | 2400 | 3.7 |
| RUPA | 8300 | 12.9 |
| RUUR | 6900 | 10.8 |
| RUSP | 11600 | 18.1 |
| SPDO | 2100 | 3.3 |
| VAPA | 600 | 0.9 |
| UID | 200 | 0.3 |



## Inundation

| | Std | Herb | Shrub | Tree | Modified Growing Season: |
|---|---|---|---|---|---|
| Average Elev (m, NAVD88) | 1.89 | 2.80 | 3.12 | 3.55 | Aug 20 to Oct 12, 2008 |
| Sum Exceedance Value (SEV) | 18.9 | 0.30 | 0.00 | 0.00 | Apr 22 to Jun 21, 2009 |




## Sediment

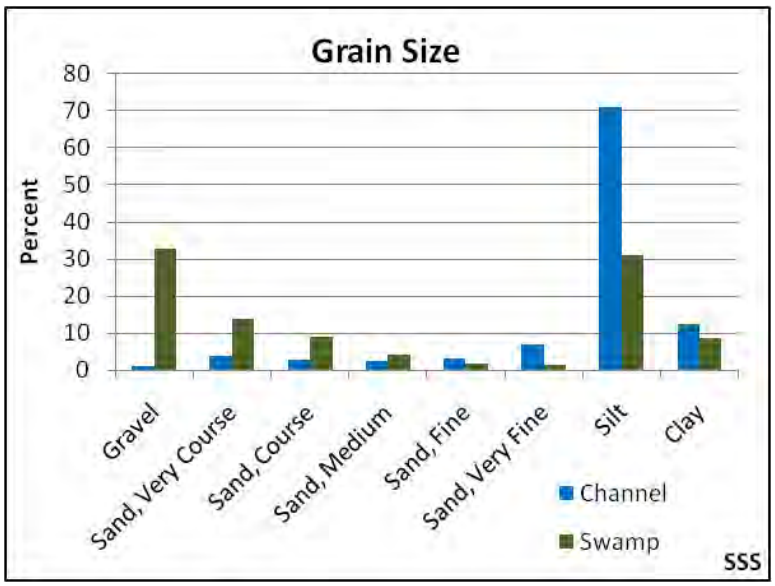
Sediment accretion rate: 0.38 cm per year

Elevation at sediment stakes: 2.68 m, NAVD88

Total Organic Carbon (TOC)

in channel: 3.02

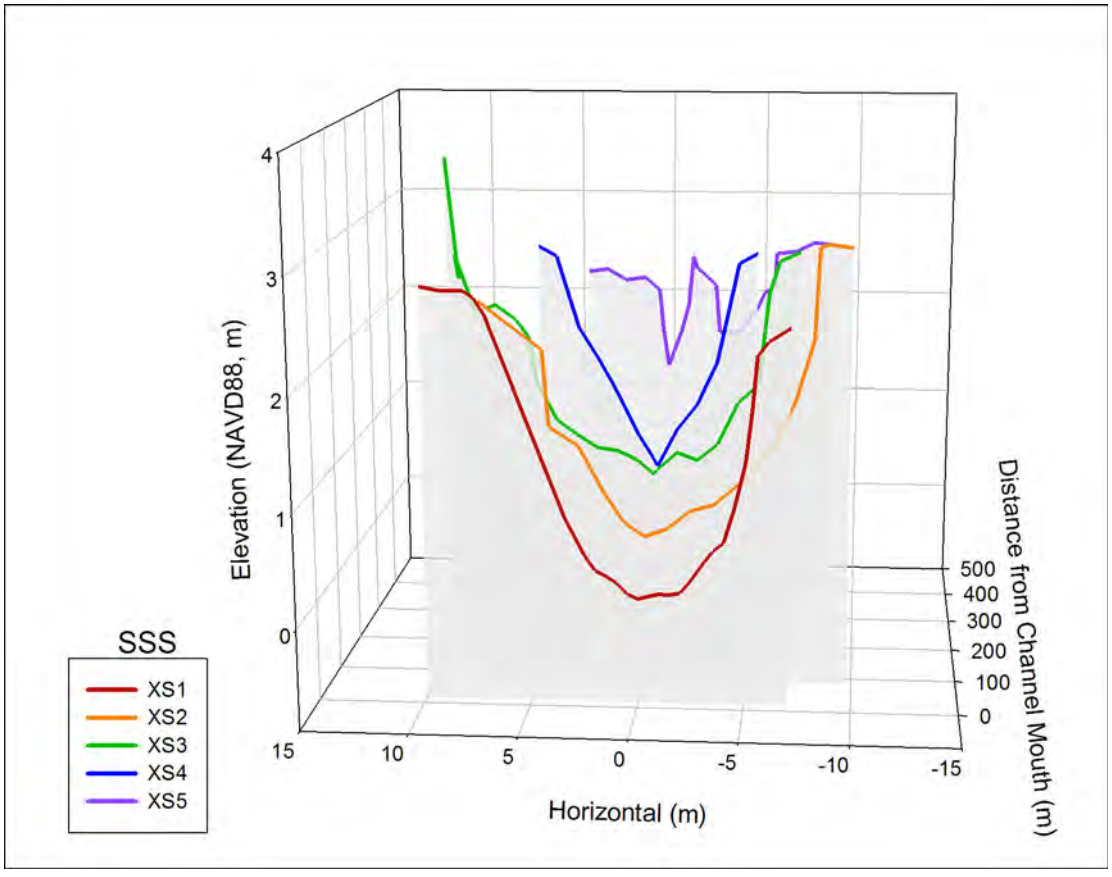
in wetland: 5.54



## Channels

| | | Physical Metrics | | | | | | Inundation | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Year | | Growing Season | |
| | Cross Section | Bank Elevation (m) | Thalweg Elevation (m) | Channel Depth (m) | Cross Section Area ($m^2$) | Channel Width (m) | Width: Depth Ratio | Time WL > Thalweg (%) | Time WL > Bank (%) | Time WL > Thalweg (%) | Time WL > Bank (%) |
| SSS | 1 | 2.20 | 0.05 | 2.16 | 17.9 | 11.8 | 5.5 | 99 | 24 | 100 | 13 |
| | 2 | 2.10 | 0.43 | 1.68 | 14.4 | 12.7 | 7.6 | 87 | 29 | 80 | 17 |
| | 3 | 2.45 | 0.74 | 1.71 | 16.2 | 14.9 | 8.7 | 77 | 14 | 68 | 5 |
| | 4 | 2.63 | 0.69 | 1.94 | 10.3 | 9.1 | 4.7 | 79 | 8 | 69 | 2 |
| | 5 | 2.12 | 1.36 | 0.76 | 1.5 | 5.7 | 7.5 | 53 | 28 | 42 | 16 |

### Cross Sections



## Site Description

Hydrogeomorphic Reach: B

Coordinates (UTM, NAD83 meters):

Northing: 5128446 Easting: 446754

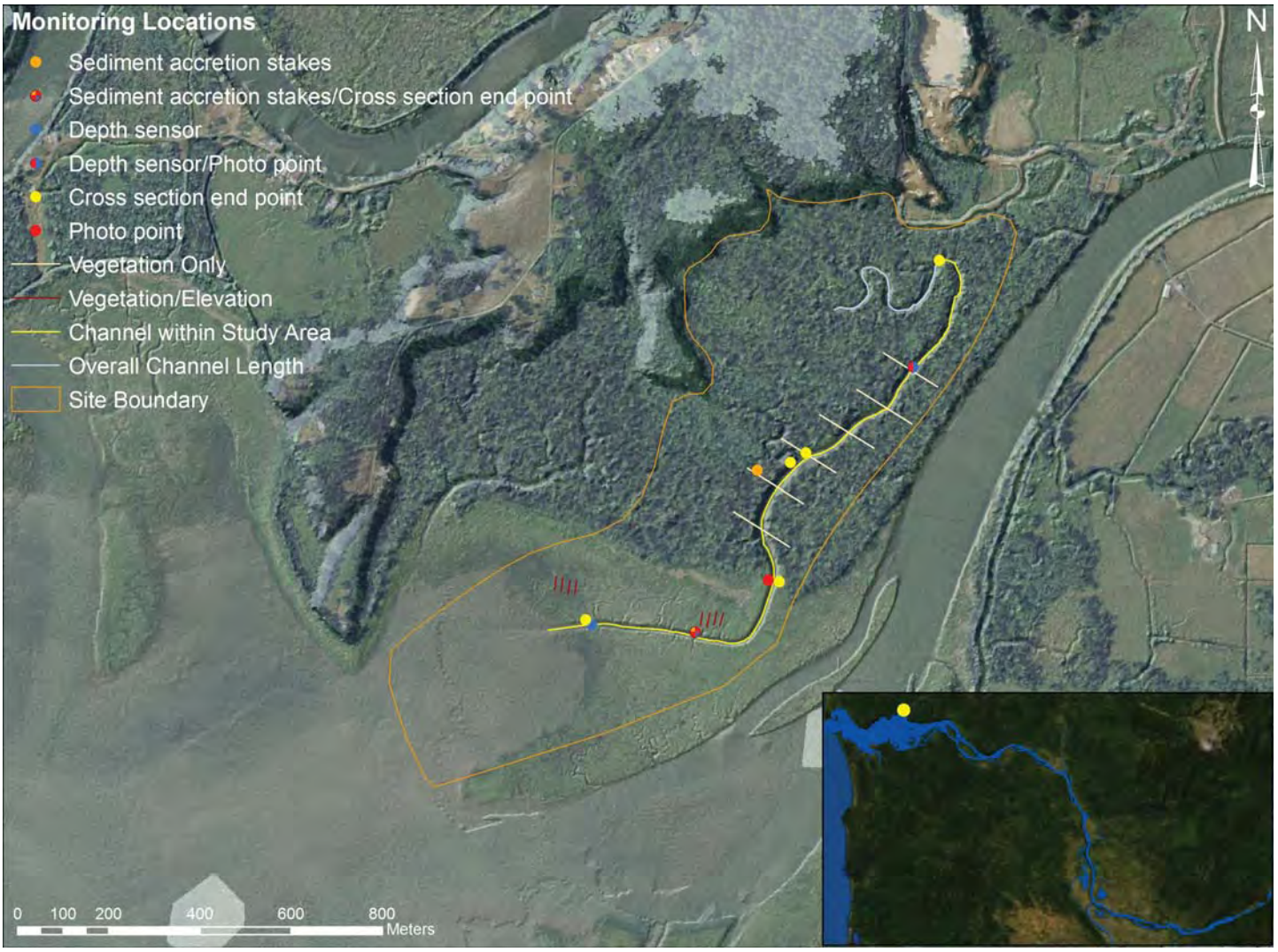
Distance from Columbia River mouth: 37 rkm

Distance from main channel: 0 meters

Type: Marsh and Swamp

Total Site Area: 23.7 ha Study Area: 16.7 ha

Total channel length: 1974 m Channel surveyed: 1523 m Channel slope: 0.59 m/km



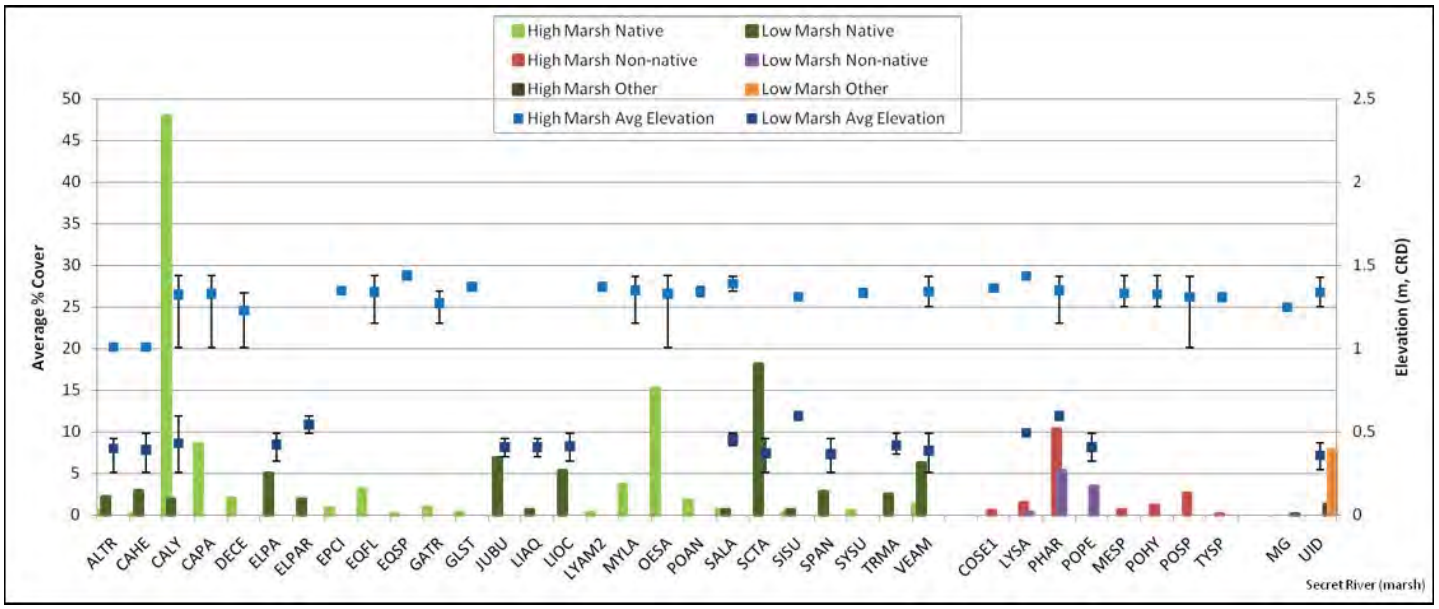
## Site Information

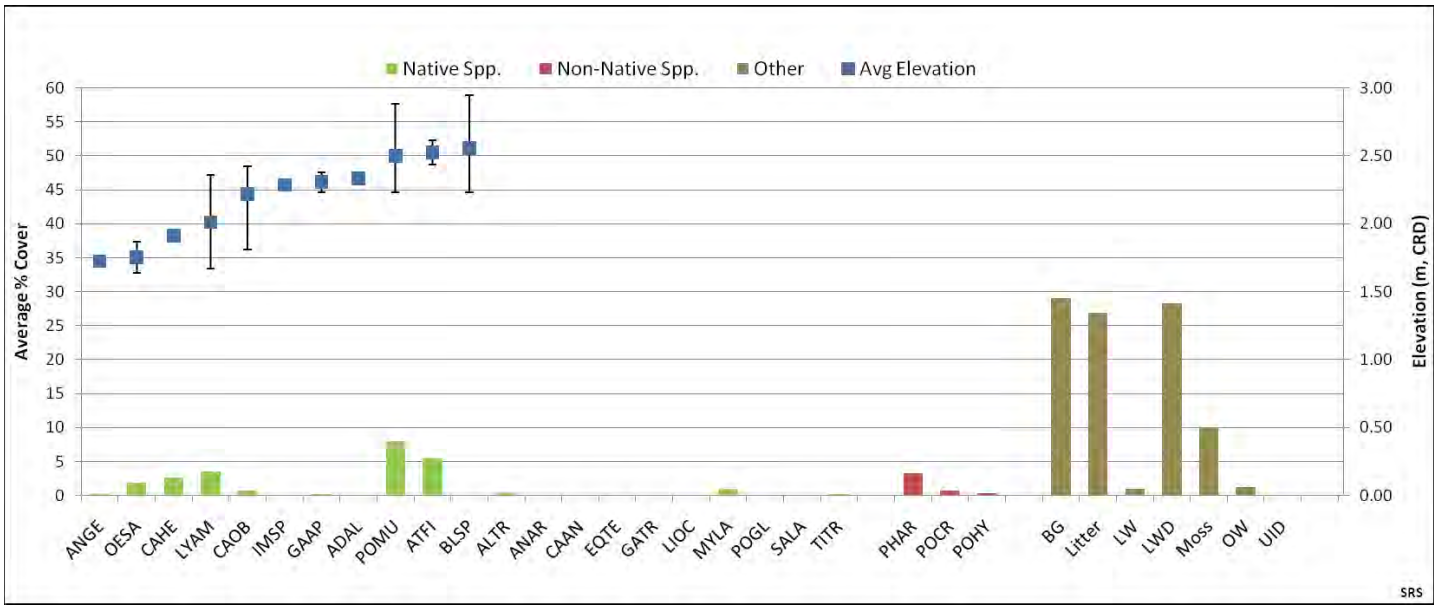
Secret River is a small tributary to Grays Bay on the Washington mainland. The Secret River site is owned by the Columbia Land Trust. The marsh site is comprised of high marsh and low marsh communities and grades up to a forested wetland (swamp). The swamp site spans both sides of the Secret River channel and is dominated by Sitka spruce (P. sitchensis).

## Elevation

| | Marsh | | Herb | | Shrub | | Tree | |
|---|---|---|---|---|---|---|---|---|
| | Lowest | Highest | Lowest | Highest | Lowest | Highest | Lowest | Highest |
| CRD, m | 0.16 | 2.12 | 1.64 | 2.94 | 1.90 | 3.50 | 2.03 | 3.23 |
| NAVD88, m | 0.27 | 2.24 | 1.79 | 3.06 | 2.02 | 3.61 | 2.15 | 3.35 |

## Vegetation



## Vegetation (cont.)

| | Low Marsh | High Marsh | Herb | Shrub | Tree |
|---|---|---|---|---|---|
| Num. of Native species | 14 | 18 | 21 | 10 | 7 |
| % Cover Native species | 57.94 | 88.41 | 24.90 | NA | NA |
| Num. of Non-native species | 3 | 8 | 3 | 0 | 0 |
| % Cover Non-native species | 9.06 | 16.94 | 4.35 | NA | NA |

| Species | Density Stems/ha | Relative Frequency % | Relative Density % | Relative Dominance % | Elevation (m, CRD) Min | Max |
|---|---|---|---|---|---|---|
| | | | Secret River | | | |
| ALRU | 130 | 24.0 | 17.4 | 17.8 | 2.91 | 2.91 |
| FRLA | 8 | 2.0 | 1.1 | 0.4 | 2.03 | 2.10 |
| MAFU | 326 | 19.0 | 43.6 | 0.8 | 2.37 | 2.79 |
| PISI | 103 | 25.0 | 13.8 | 61.7 | 2.39 | 3.23 |
| RHPU | 48 | 7.0 | 6.4 | 0.1 | 2.80 | 2.80 |
| THPL | 114 | 18.0 | 15.2 | 18.0 | nd | nd |
| TSHE | 19 | 5.0 | 2.5 | 1.1 | 2.96 | 2.96 |
| no trees | na | 0.0 | na | na | na | na |

| Species | Density (Stems/ha) | Relative Density (%) |
|---|---|---|
| | Secret River | |
| ACCI | 1808 | 5.0 |
| COSE | 2333 | 6.5 |
| GASH | 13333 | 37.1 |
| LOIN | 333 | 0.9 |
| OECE | 667 | 1.9 |
| ROSP | 167 | 0.5 |
| RUPA | 6333 | 17.6 |
| RUSP | 6833 | 19.0 |
| RUUR | 3500 | 9.7 |
| VAPA | 667 | 1.9 |

## Sediment

### Marsh

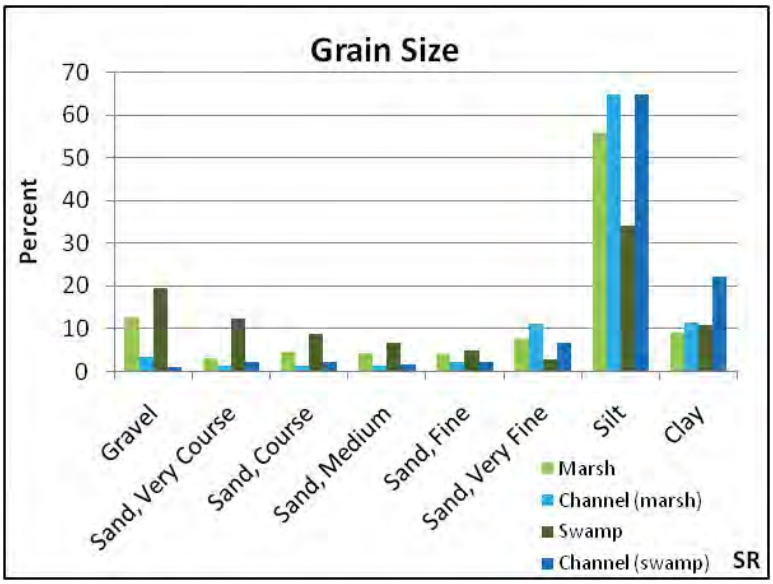
Sediment accretion rate: 0.21 cm per year

Elevation at sediment stakes: 1.43 m, CRD

### Swamp

Sediment accretion rate: 0.43 cm per year

Elevation at sediment stakes: NA m, CRD




### Total Organic Carbon (TOC)

### Marsh

in channel: 2.12

in wetland: 3.06

### Swamp

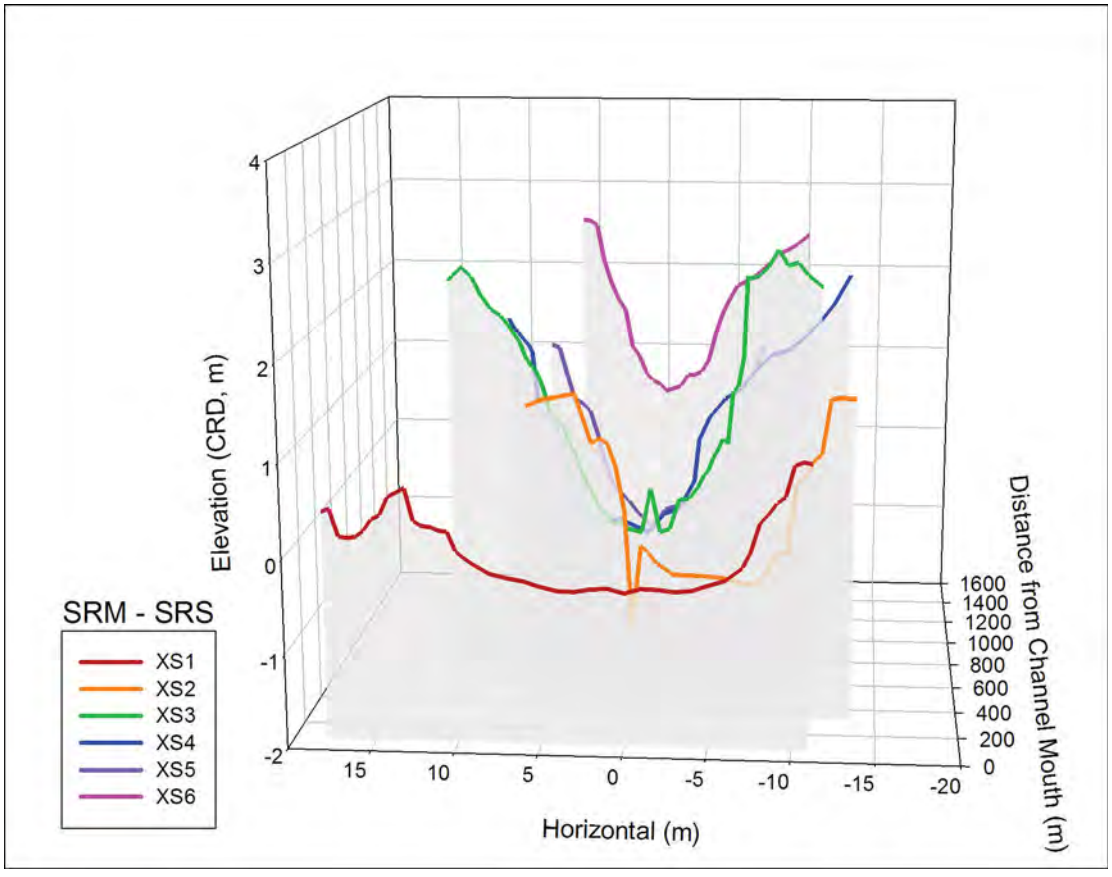
in channel: 3.92

in swamp: 7.91

## Channels

| | | Physical Metrics | | | | | | Inundation | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Year | | Growing Season | |
| | Cross Section | Bank Elevation (m) | Thalweg Elevation (m) | Channel Depth (m) | Cross Section Area ($m^2$) | Channel Width (m) | Width: Depth Ratio | Time WL > Thalweg (%) | Time WL > Bank (%) | Time WL > Thalweg (%) | Time WL > Bank (%) |
| SR | 1 | 0.69 | -0.37 | 1.06 | 18.4 | 22.5 | 21.3 | 99 | 53 | 99 | 46 |
| | 2 | 1.47 | -1.02 | 2.49 | 22.5 | 16.0 | 6.4 | 100 | 21 | 100 | 13 |
| | 3 | 1.78 | -0.28 | 2.07 | 19.1 | 14.1 | 6.8 | 93 | 9 | 90 | 4 |
| | 4 | 1.48 | -0.59 | 2.07 | 20.0 | 15.9 | 7.7 | 100 | 30 | 100 | 20 |
| | 5 | 1.52 | -0.54 | 2.06 | 18.1 | 14.0 | 6.8 | 100 | 28 | 100 | 19 |
| | 6 | 2.41 | 0.48 | 1.94 | 14.9 | 14.9 | 7.7 | 65 | 1 | 56 | 0 |

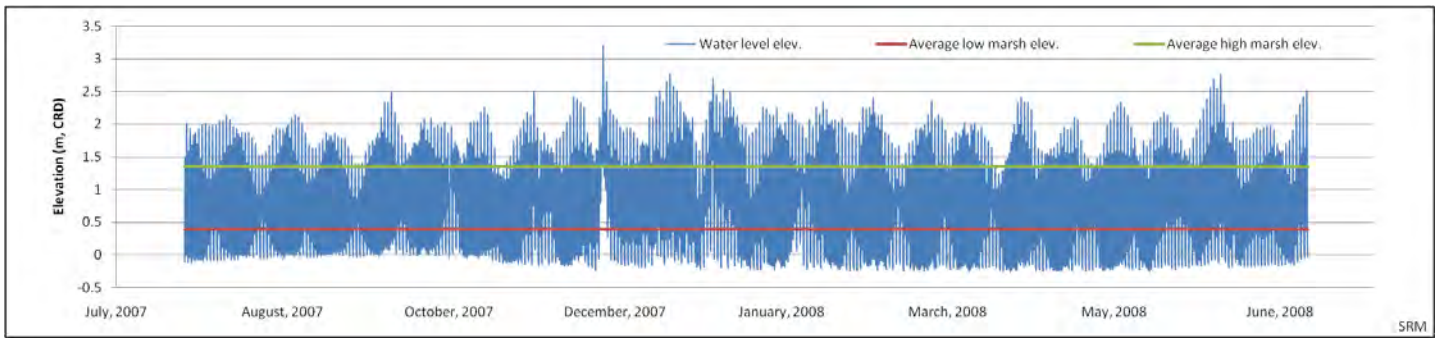
### Cross Sections

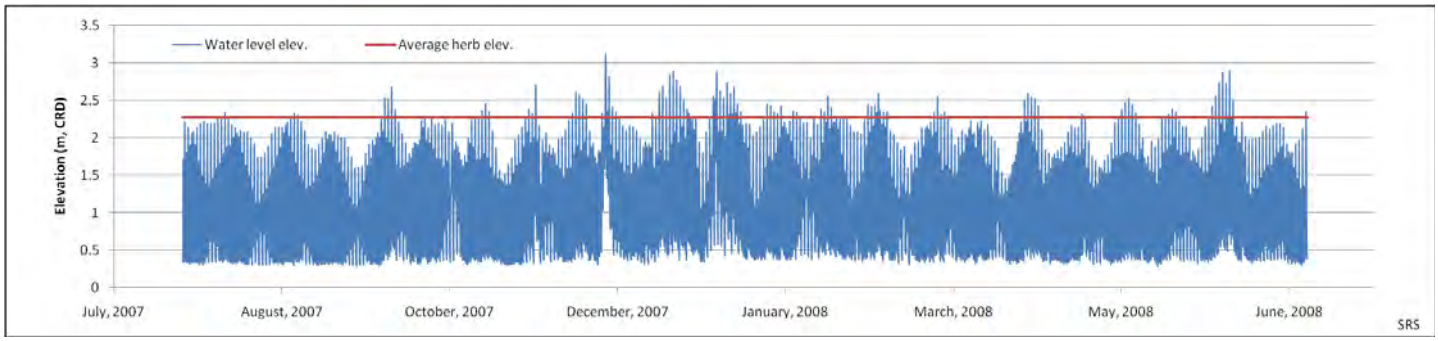


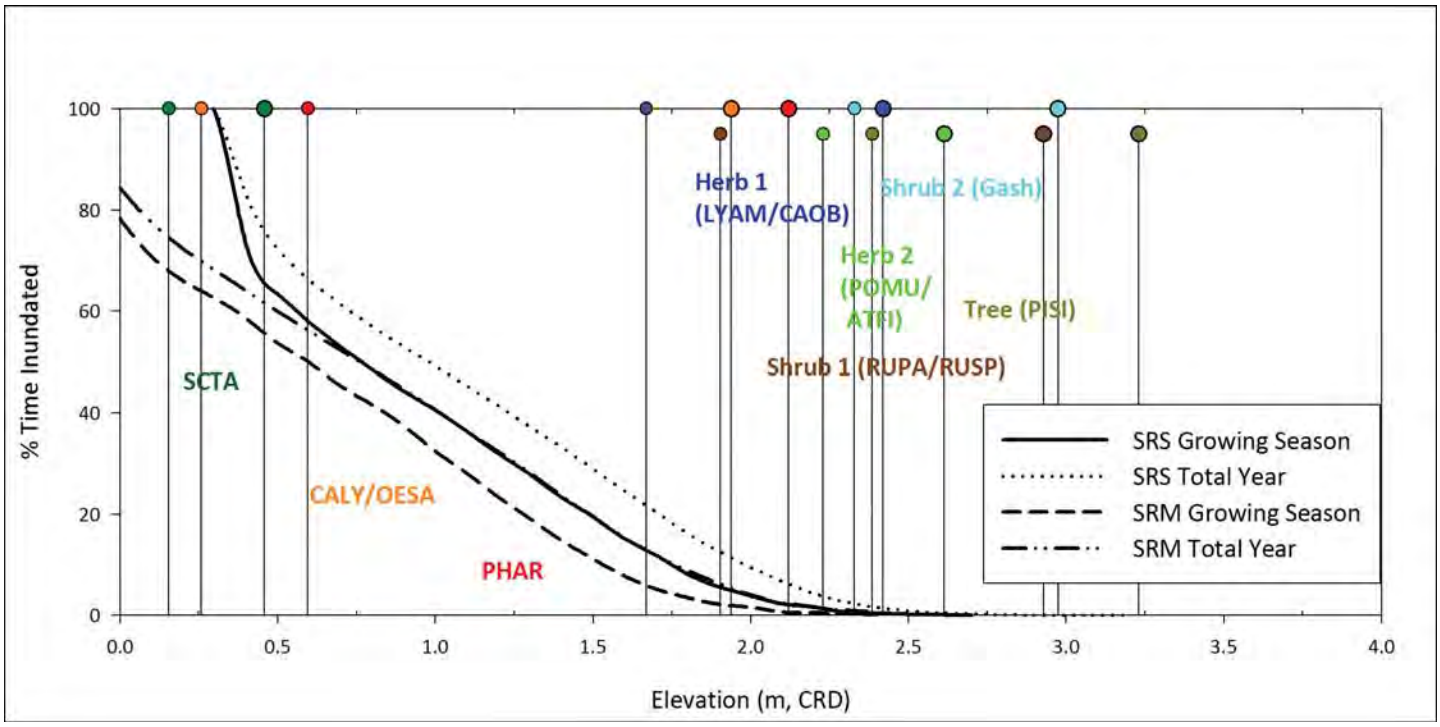
## Inundation

| | Marsh Std | Low Marsh | High Marsh | Swamp Std | Herb | Shrub | Tree |
|---|---|---|---|---|---|---|---|
| Average Elev (m, CRD) | 1.89 | 0.39 | 1.35 | 1.89 | 2.27 | 2.49 | 2.69 |
| Sum Exceedance Value (SEV) | 1.08 | 56.6 | 8.99 | 2.88 | 0.54 | 0.12 | 0.03 |

Modified Growing Season: Aug 20 to Oct 12, 2007 Apr 22 to Jun 21, 2008



## Site Description

Hydrogeomorphic Reach: B

Coordinates (UTM, NAD83 meters):

Northing: 5121994 Easting: 450095

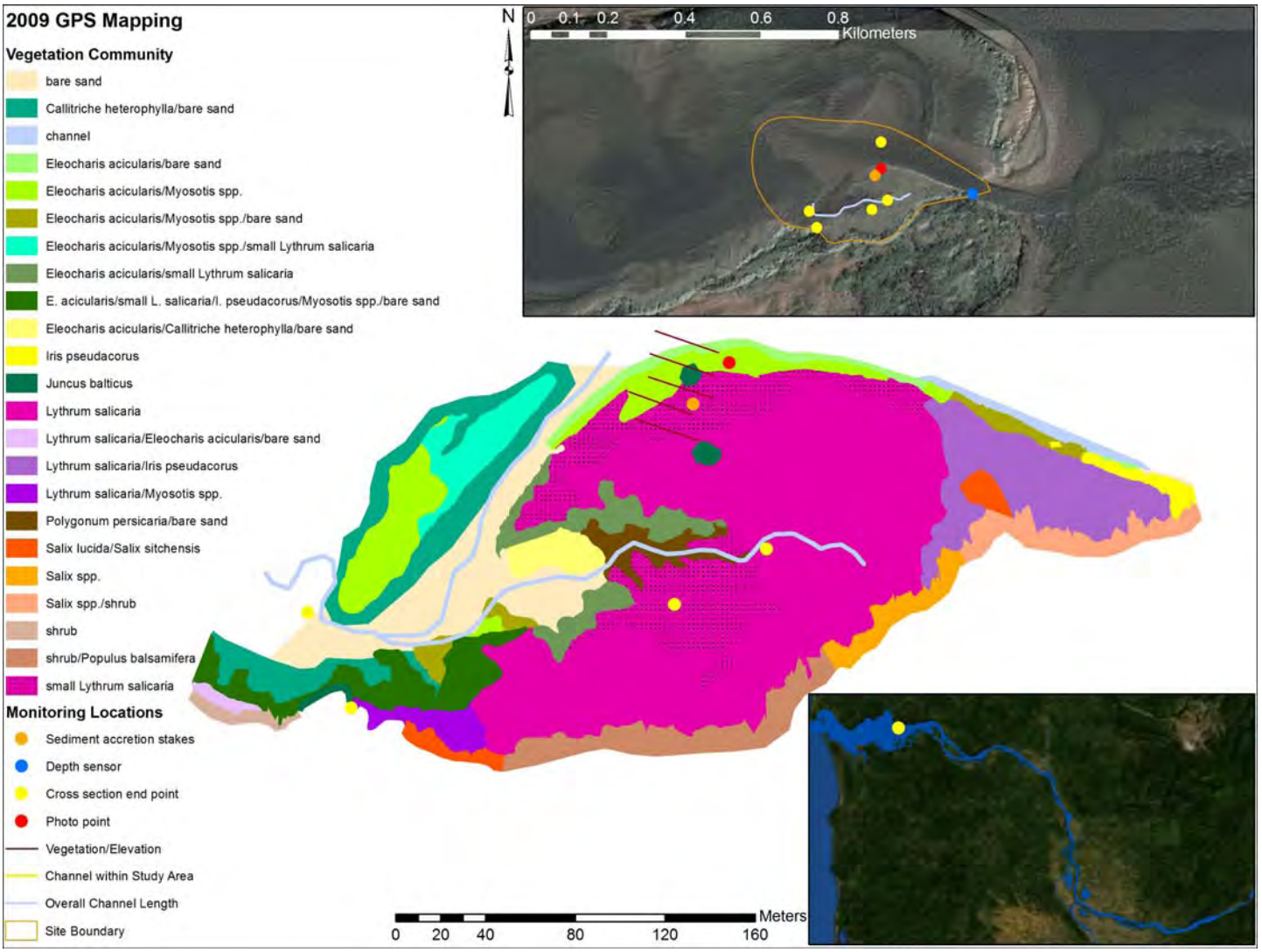
Distance from Columbia River mouth: 39 rkm

Distance from main channel: 649 meters

Type: Created

Total Site Area: 13.6 ha Study Area: 3.03 ha

Total channel length: 305 m Channel surveyed: 238 m Channel slope: 2.10 m/km



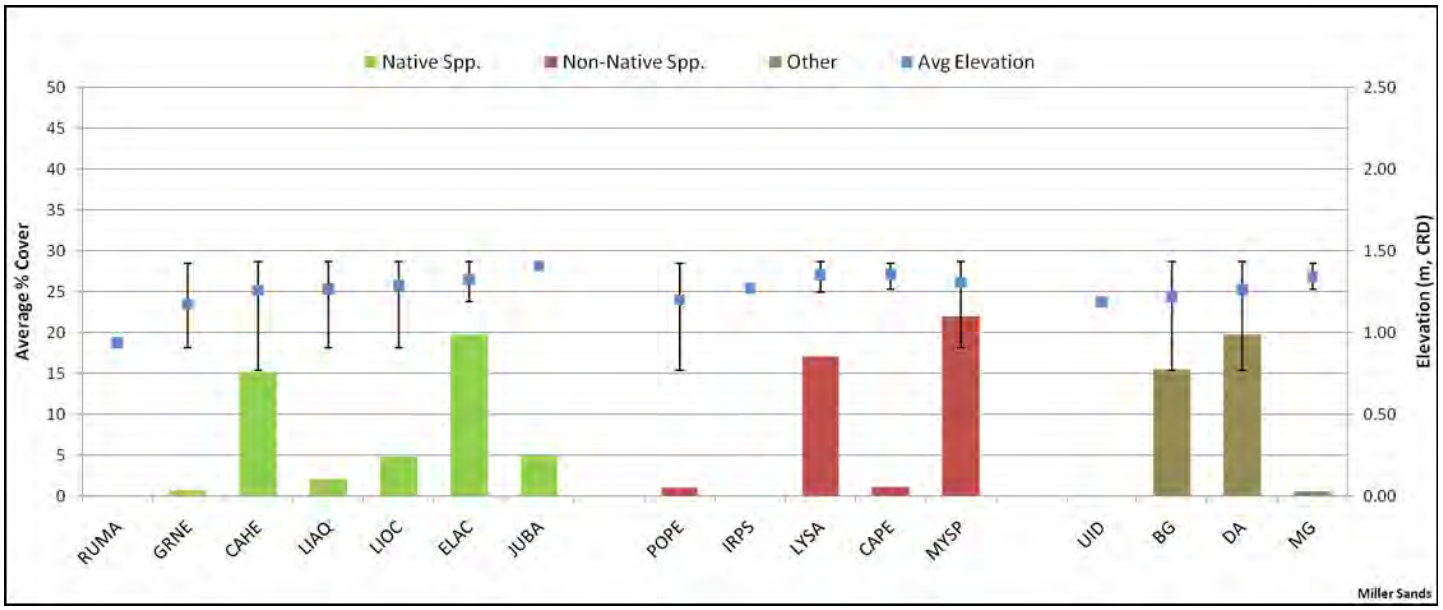
## Site Information

Miller Sands is an island complex created from dredge material. Large shallows surround the island and a large shallow inlet leads to the center of the island. In 1978, the US Army Corps of Engineers Waterway Experiment Station funded a restoration project on the north side of the island complex to prevent the island from erosion and to create habitat for salmon and other wildlife. The monitoring site is a depressional area in the sheltered center of the island complex.

## Vegetation

Number of Native species: 7 % Native Cover: 47.80

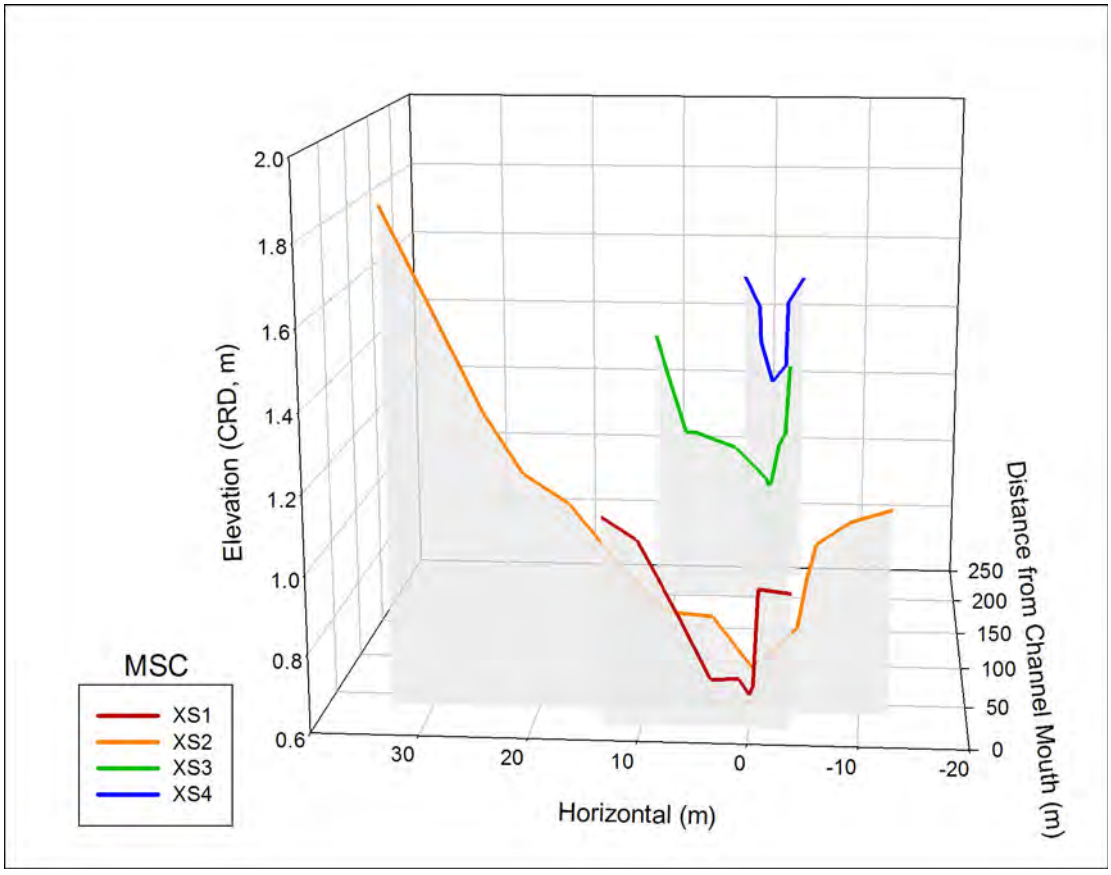
Number of Non-native species: 6 % Non-native Cover: 41.20



## Channels

| | Physical Metrics | | | | | | |
|---|---|---|---|---|---|---|---|
| | Cross Section | Bank Elevation (m) | Thalweg Elevation (m) | Channel Depth (m) | Cross Section Area ($m^2$) | Channel Width (m) | Width: Depth Ratio |
| MSC | 1 (mouth) | 0.95 | 0.69 | 0.27 | 1.4 | 8.7 | 32.4 |
| | 2 | 1.04 | 0.72 | 0.32 | 3.5 | 20.2 | 63.4 |
| | 3 | 1.28 | 0.93 | 0.35 | 2.8 | 13.3 | 38.1 |
| | 4 | 1.41 | 1.19 | 0.22 | 0.5 | 3.1 | 13.8 |

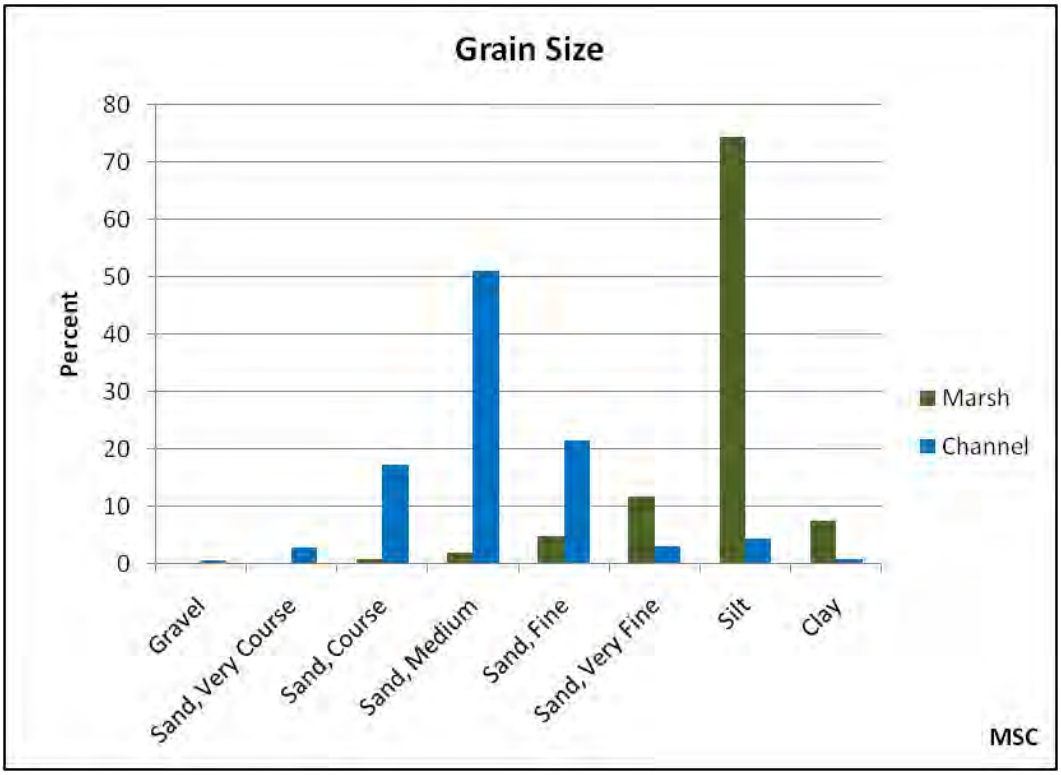
### Cross Sections



## Sediment

Sediment accretion rate: 1.09 cm per year Elevation at sediment stakes: 1.37 m, CRD

Total Organic Carbon (TOC) in channel: 0.17 in wetland: 1.98




## Elevation

| | NAVD88, m | | CRD, m | |
|---|---|---|---|---|
| | Lowest | Highest | Lowest | Highest |
| Marsh | 0.92 | 2.07 | 0.77 | 1.92 |
| CAHE | 0.92 | 1.58 | 0.77 | 1.43 |
| ELAC | 1.06 | 1.80 | 0.91 | 1.65 |
| MYSP | 1.06 | 1.85 | 0.91 | 1.70 |
| LYSA | 1.23 | 2.07 | 1.08 | 1.92 |
| IRPS | 1.28 | 2.01 | 1.13 | 1.86 |
| COSE/SASP | 2.00 | NA | 1.85 | NA |
| POBA/SARA | 2.31 | NA | 2.16 | NA |

## Site Description

Hydrogeomorphic Reach: B

Coordinates (UTM, NAD83 meters):

Northing: 5115377 Easting: 453882

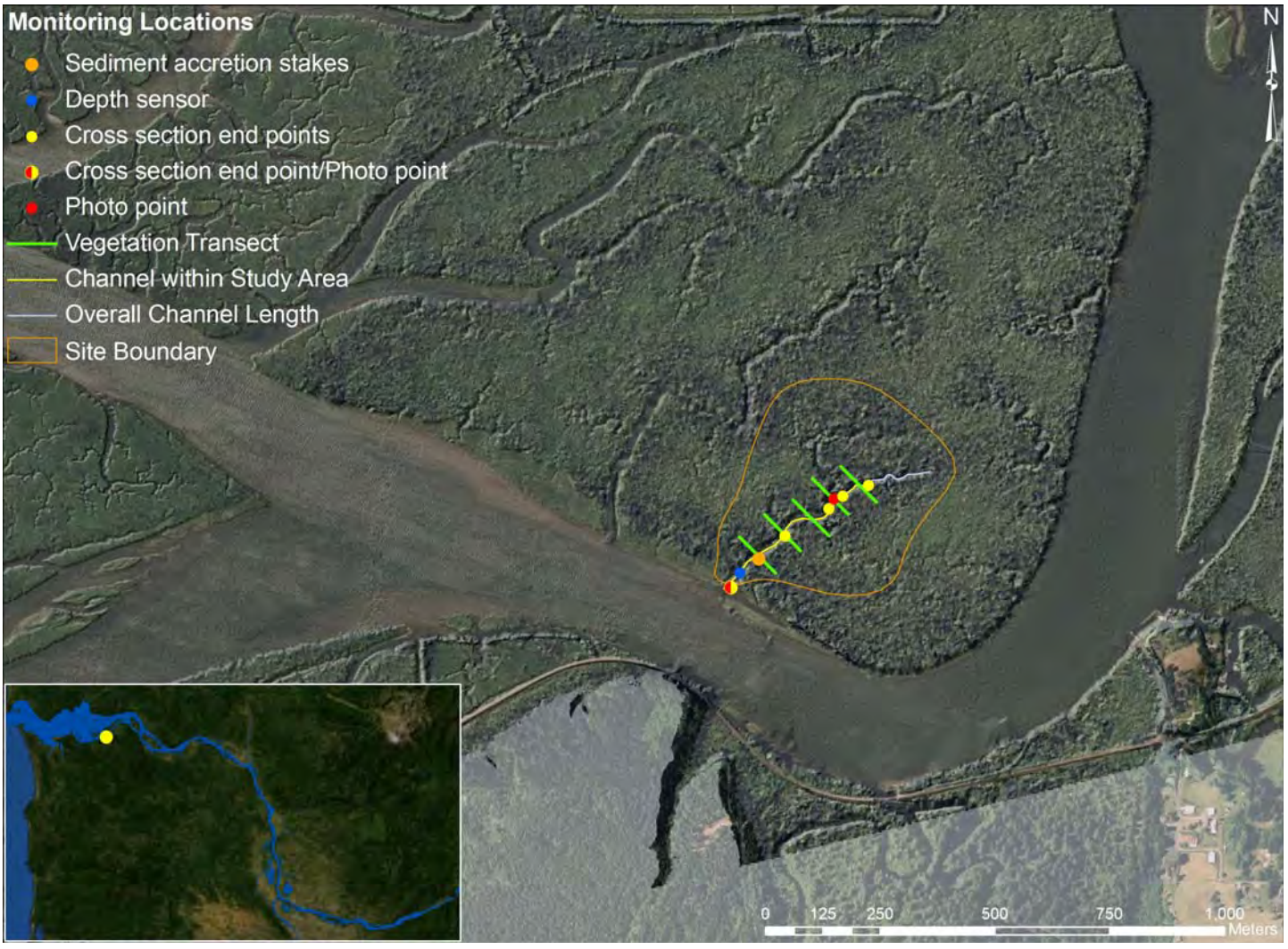
Distance from Columbia River mouth: 40 rkm

Distance from main channel: 0 meters

Type: Swamp

Total Site Area: 17.5 ha Study Area: 6.87 ha

Total channel length: 572 m Channel surveyed: 421 m Channel slope: 3.51 m/km



## Site Information

Karlson Island is part of the complex of islands that make up the Lewis and Clark National Wildlife Refuge in Cathlamet Bay, Oregon. The island includes natural marsh, a diked area that has been breached, and a forested wetland swamp dominated by P. sitchensis. The sampling area was located on both sides of a tidal channel in the forested wetland.

## Elevation

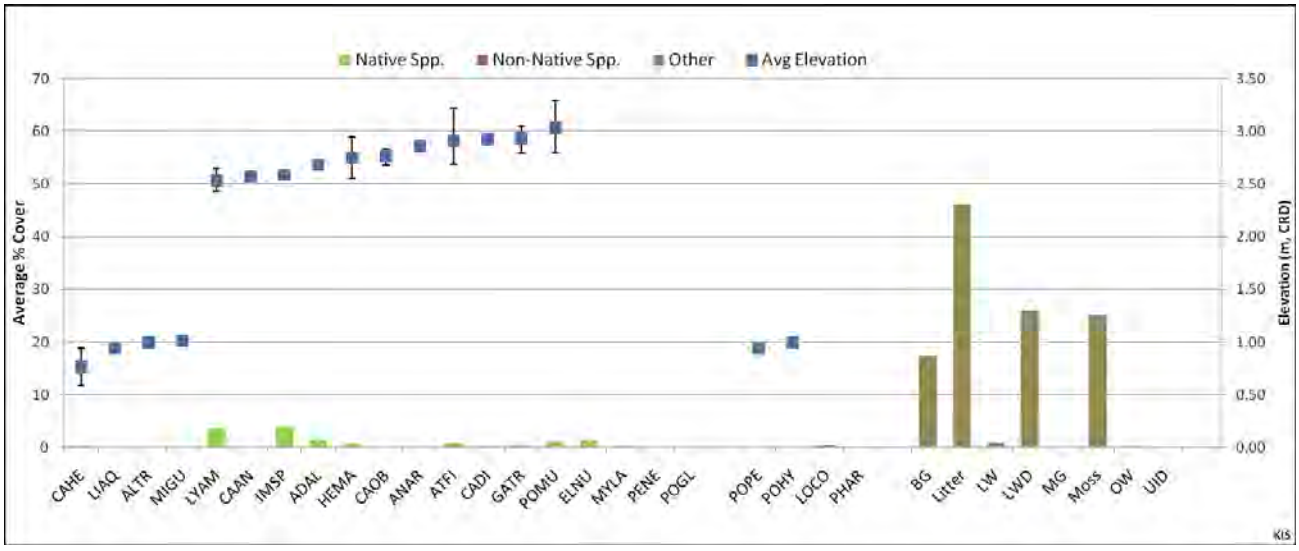
| | Herb | | Shrub | | Tree | |
|---|---|---|---|---|---|---|
| | Lowest | Highest | Lowest | Highest | Lowest | Highest |
| CRD, m | 0.59 | 3.29 | 2.25 | 3.32 | 2.23 | 4.67 |
| NAVD88, m | 0.74 | 3.44 | 2.40 | 3.48 | 2.39 | 4.82 |

## Vegetation

| | Herb | Shrub | Tree |
|---|---|---|---|
| Number of Native species | 19 | 14 | 7 |
| Number of Non-native species | 5 | 0 | 0 |

| Species | Density Stems/ha | Relative Frequency % | Relative Density % | Relative Dominance % | Elevation (m, CRD) Min | Max |
|---|---|---|---|---|---|---|
| Karlson Island | | | | | | |
| ALRU | 110 | 16.5 | 14.3 | 6.3 | 2.58 | 2.58 |
| MAFU | 195 | 13.9 | 25.3 | 0.6 | nd | nd |
| PISI | 182 | 27.8 | 23.6 | 78.1 | 2.23 | 4.67 |
| PREM | 34 | 7.6 | 4.4 | 0.2 | 2.29 | 2.64 |
| RHPU | 153 | 12.7 | 19.8 | 0.6 | 3.07 | 3.07 |
| THPL | 85 | 16.5 | 11.0 | 13.7 | 2.43 | 3.12 |
| TSHE | 13 | 3.8 | 1.6 | 0.4 | nd | nd |
| no trees | na | 1.3 | na | na | na | na |

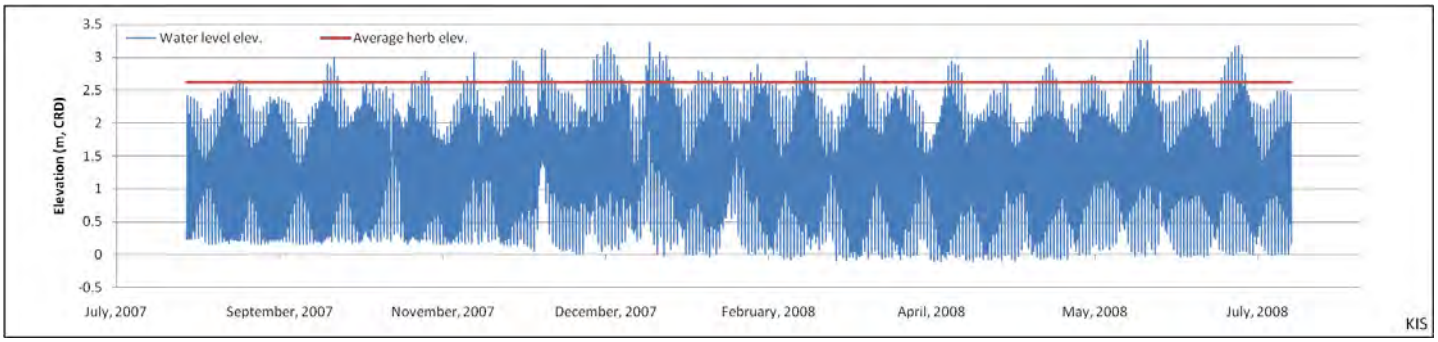
| Species | Density (stems/ha) | Relative Density (%) |
|---|---|---|
| AMAL | 6300 | 8.1 |
| COSE | 10100 | 12.9 |
| GASH | 18200 | 23.3 |
| LOIN | 900 | 1.2 |
| OECE | 1800 | 2.3 |
| RIDI | 100 | 0.1 |
| RILA | 400 | 0.5 |
| ROSP | 7000 | 9.0 |
| RUPA | 2800 | 3.6 |
| RUSP | 11600 | 14.9 |
| RUUR | 13600 | 17.4 |
| SALU | 2200 | 2.8 |
| SASP | 1300 | 1.7 |
| SYAL | 1800 | 2.3 |

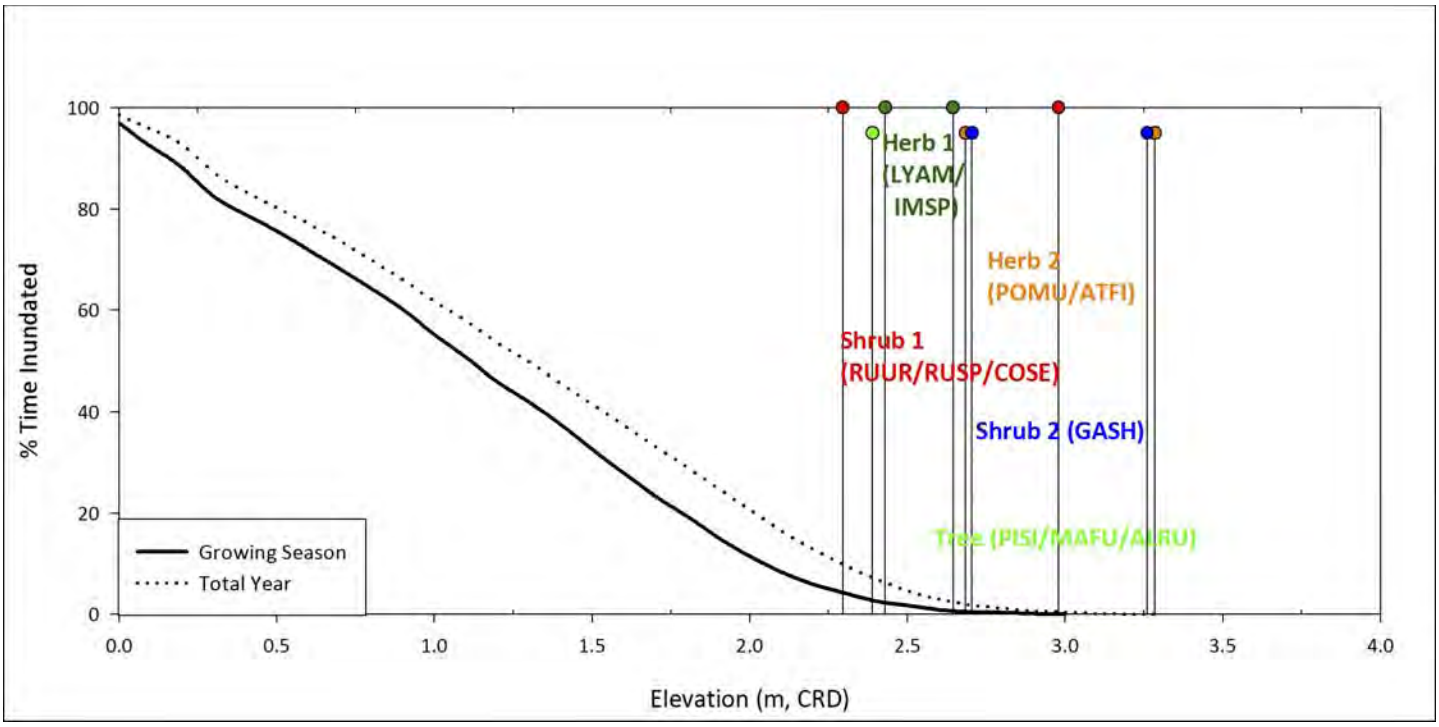


## Inundation

| | Std | Herb | Shrub | Tree |
|---|---|---|---|---|
| Average Elev (m, CRD) | 1.89 | 2.63 | 2.71 | 3.00 |
| Sum Exceedance Value (SEV) | 9.01 | 0.40 | 0.26 | 0.04 |

Modified Growing Season:
Aug 20 to Oct 12, 2007
Apr 22 to Jun 21, 2008




## Sediment

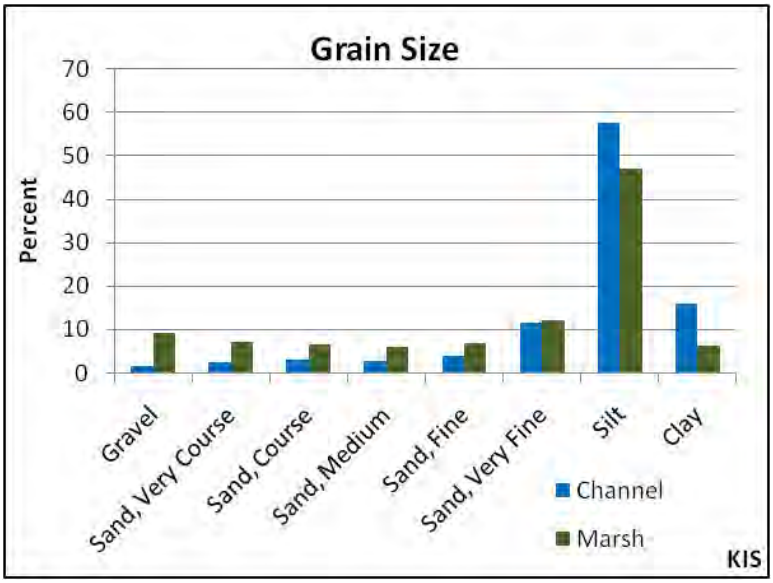
Sediment accretion rate: 0.26 cm per year

Elevation at sediment stakes: NA m, CRD

Total Organic Carbon (TOC)

in channel: 3.21

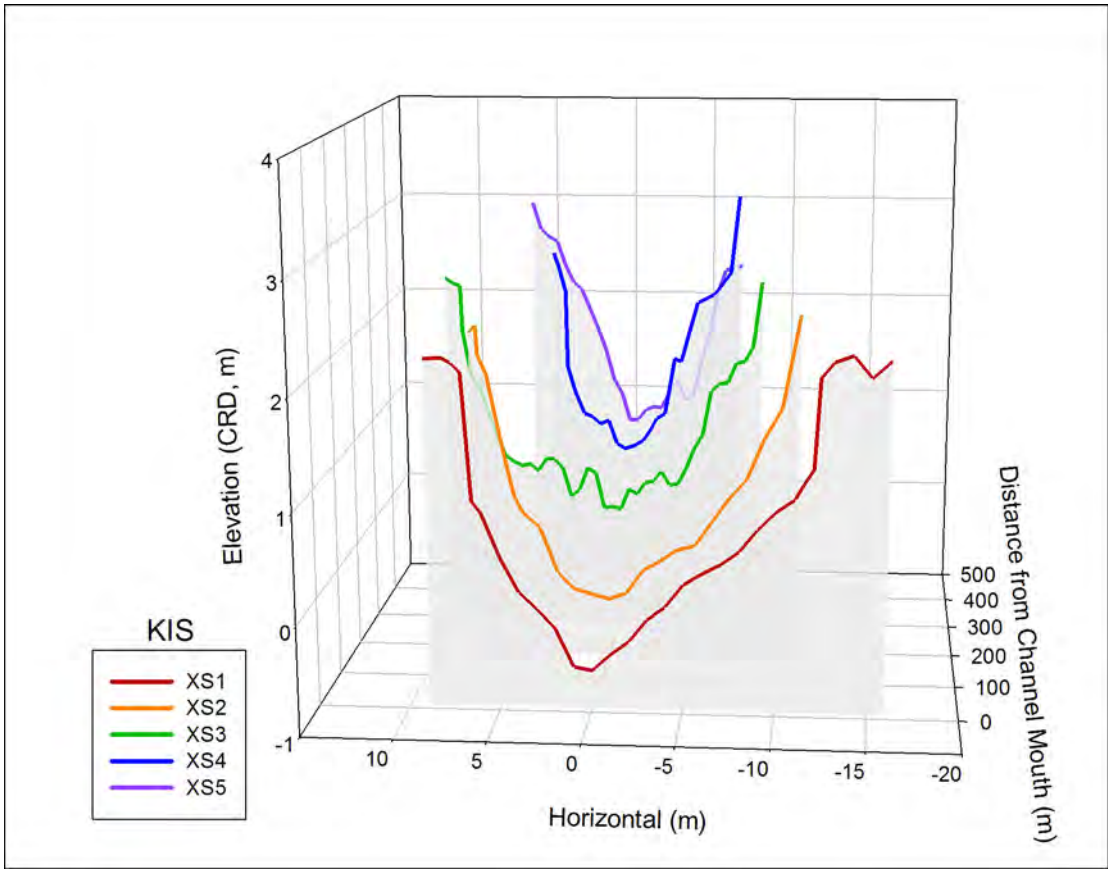
in wetland: 3.48



## Channels

| | | Physical Metrics | | | | | | Inundation | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Year | | Growing Season | |
| | Cross Section | Bank Elevation (m) | Thalweg Elevation (m) | Channel Depth (m) | Cross Section Area ($m^2$) | Channel Width (m) | Width: Depth Ratio | Time WL > Thalweg (%) | Time WL > Bank (%) | Time WL > Thalweg (%) | Time WL > Bank (%) |
| KIS | 1 (mouth) | 2.18 | -0.65 | 2.83 | 38.0 | 21.0 | 7.4 | 100 | 14 | 100 | 7 |
| | 2 | 2.18 | -0.44 | 2.62 | 33.6 | 18.4 | 7.0 | 100 | 14 | 100 | 6 |
| | 3 | 2.36 | 0.12 | 2.24 | 28.8 | 18.5 | 8.2 | 88 | 8 | 84 | 3 |
| | 4 | 2.46 | 0.63 | 1.84 | 12.0 | 10.5 | 5.7 | 71 | 5 | 65 | 2 |
| | 5 | 2.36 | 0.79 | 1.57 | 9.5 | 9.9 | 6.3 | 64 | 8 | 58 | 3 |

### Cross Sections



## Site Description

Hydrogeomorphic Reach: B

Coordinates (UTM, NAD83 meters):

Northing: 5116913 Easting: 452813

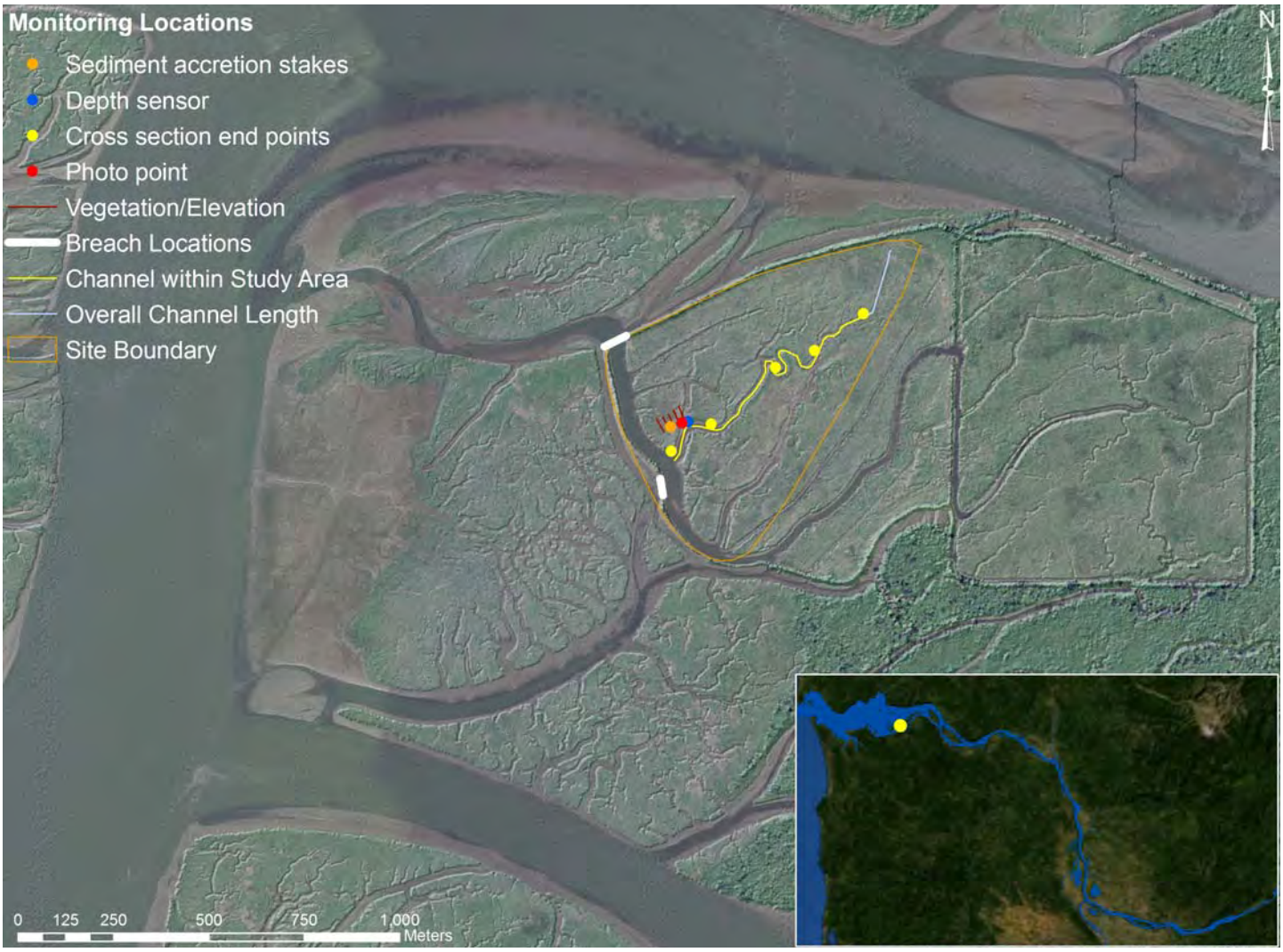
Distance from Columbia River mouth: 41 rkm

Distance from main channel: 1662 meters

Type: Natural Breach

Total Site Area: 38.3 ha Study Area: 1.87 ha

Total channel length: 1053 m Channel surveyed: 860 m Channel slope: 3.13 m/km



## Site Information

Karlson Island, located in Cathlamet Bay, Oregon, is part of the complex of islands that make up the Lewis and Clark National Wildlife Refuge. The island includes natural marsh, a diked area that has been breached, and a forested wetland swamp. The sampling site was located along a tidal channel within the dike-breach portion of the island. The dike was built in the early 1900's and is estimated to have been breached sometime in the 1960's or 1970's, thereby reconnected to tidal flows for 30-40 years.

## Elevation

Lowest marsh (NAVD88, m): 1.31

Highest marsh (NAVD88, m): 2.22

Lowest marsh (CRD, m): 1.13

Highest marsh (CRD, m): 2.04

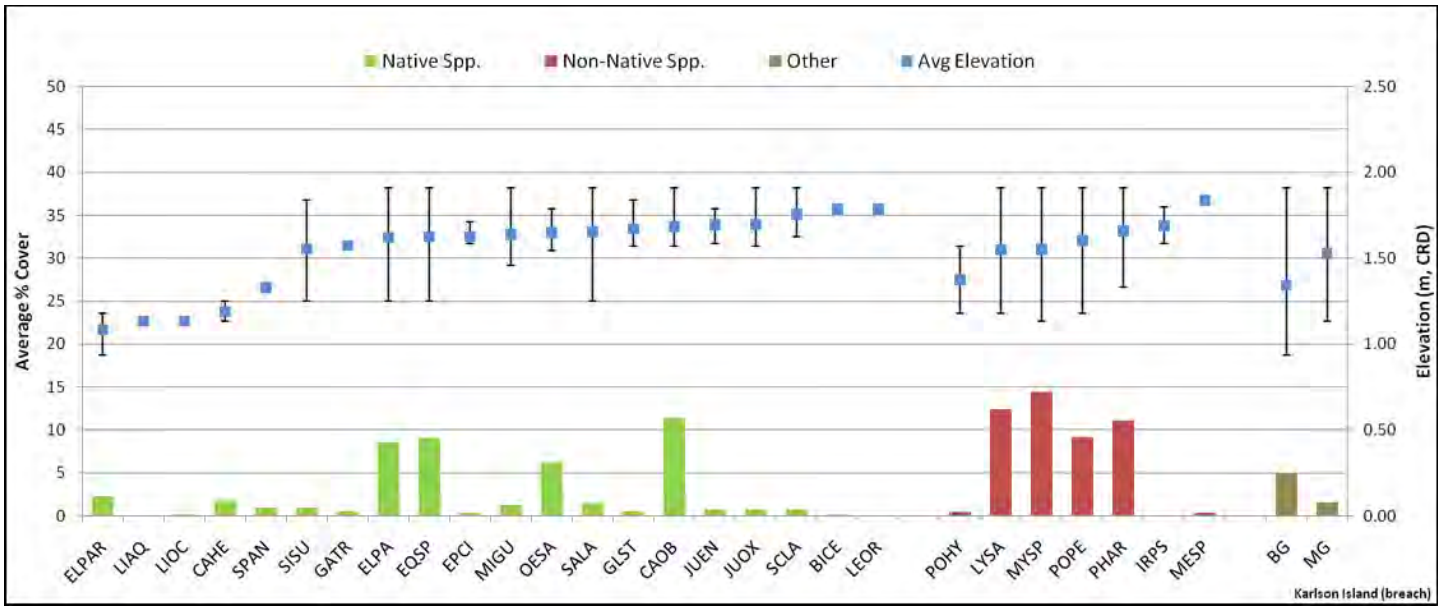
## Vegetation

Number of Native species: 20

% Native Cover: 48.40

Number of Non-native species: 8

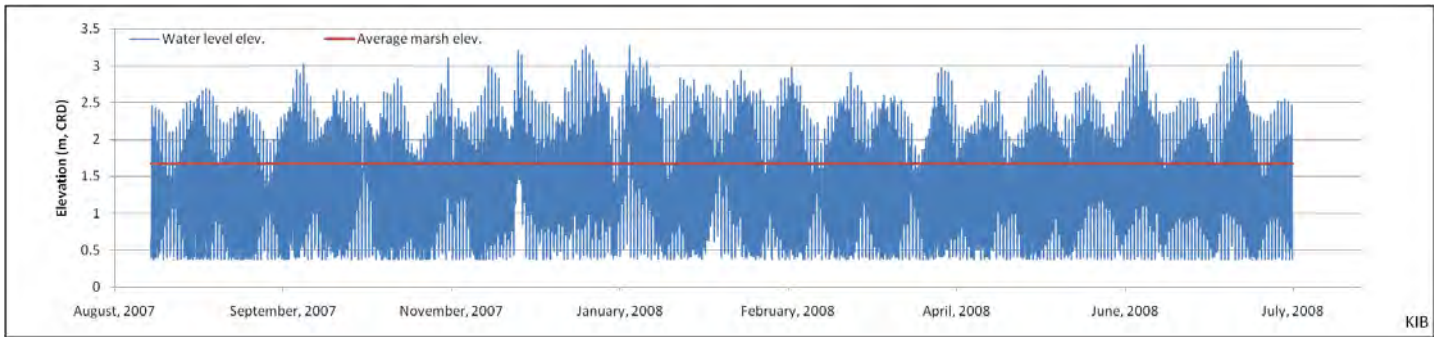
% Non-native Cover: 48.04



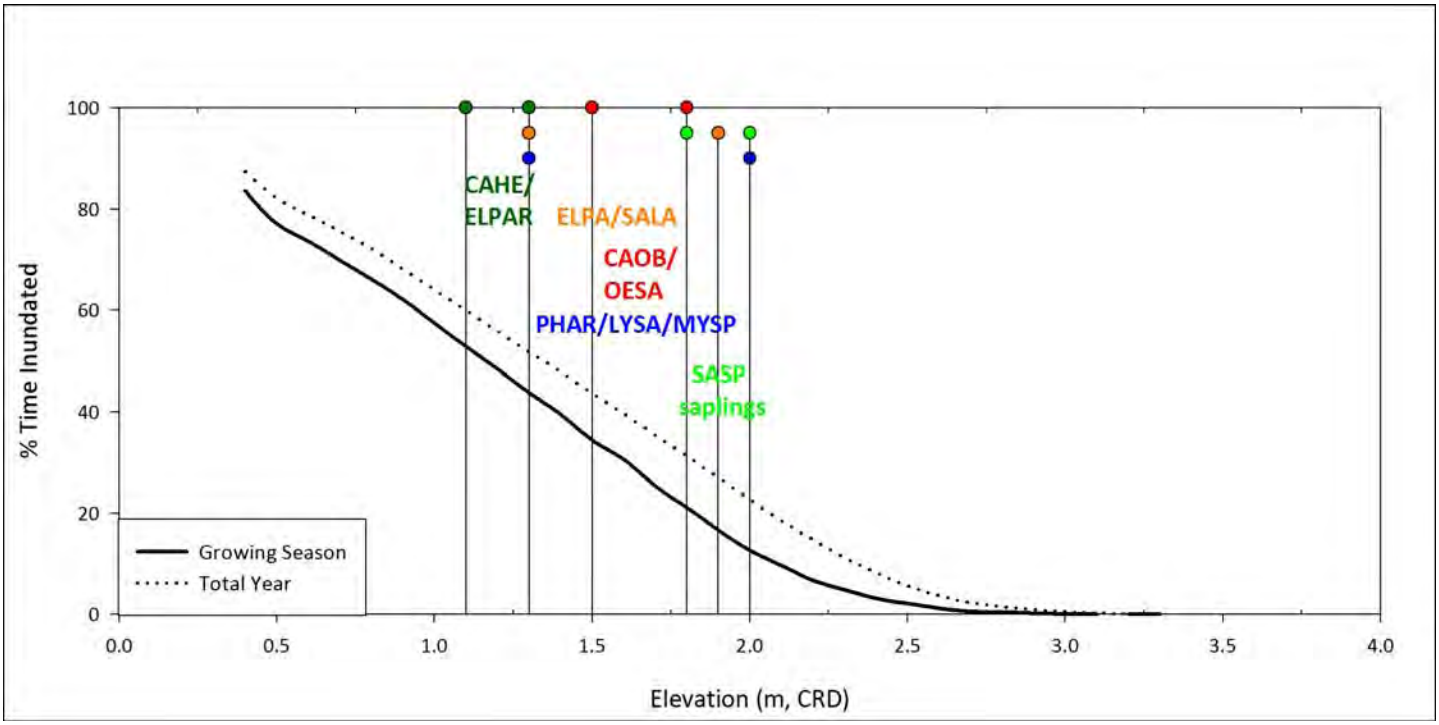

## Inundation

| | Std | Marsh |
|---|---|---|
| Average Elev (m, CRD) | 1.89 | 1.67 |
| Sum Exceedance Value (SEV) | 10.9 | 18.9 |

Modified Growing Season:
Aug 20 to Oct 12, 2007
Apr 22 to Jun 21, 2008



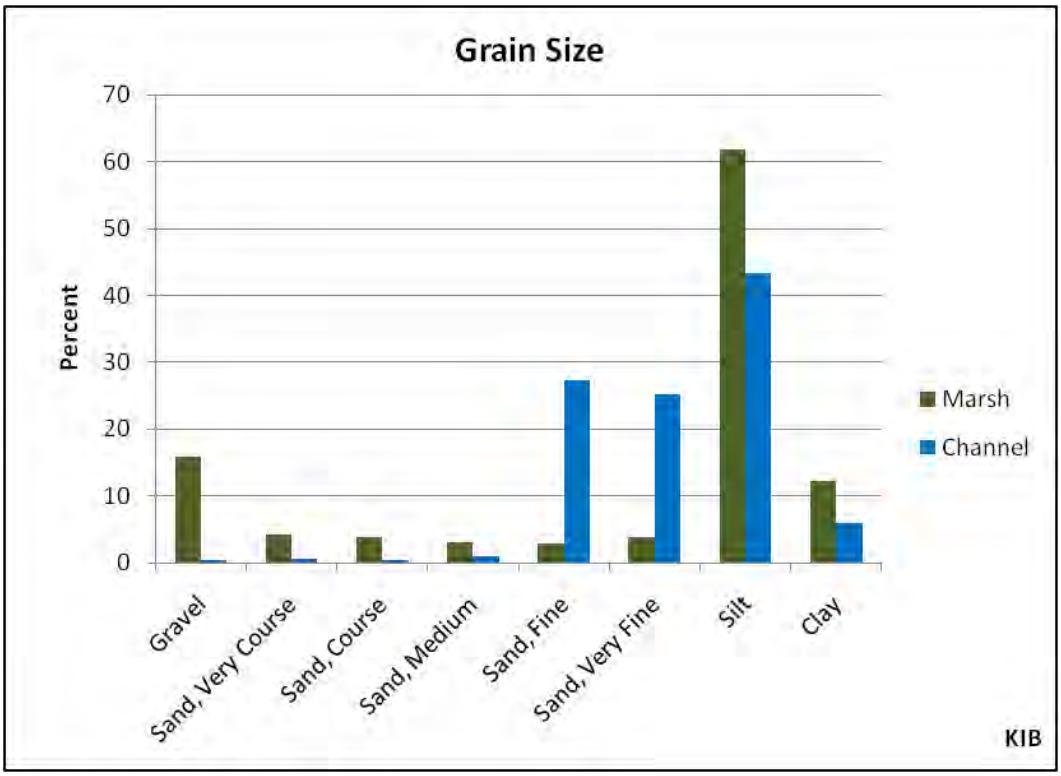
## Inundation (cont.)




## Sediment

Sediment accretion rate: 1.37 cm per year Elevation at sediment stakes: 1.61 m, CRD

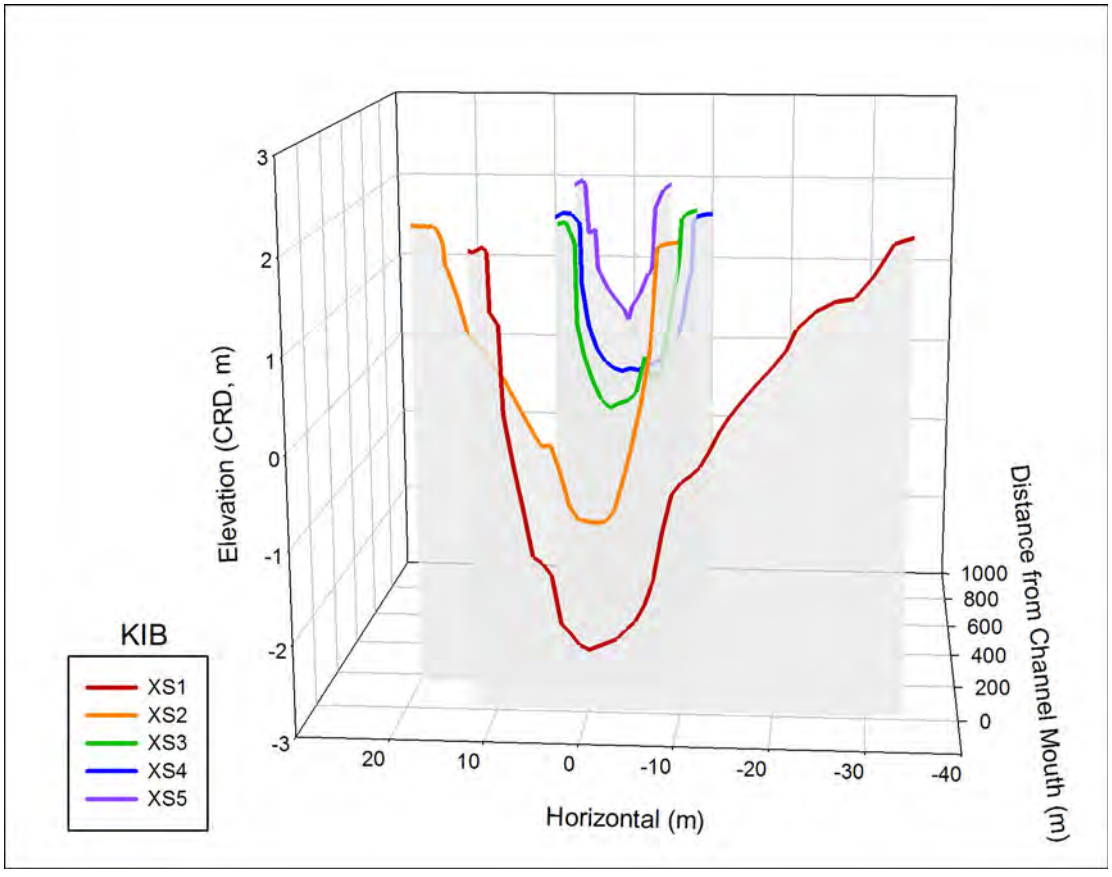
Total Organic Carbon (TOC) in channel: 1.34 in wetland: 4.84



## Channels

| | | Physical Metrics | | | | | | Inundation | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Year | | Growing Season | |
| | Cross Section | Bank Elevation (m) | Thalweg Elevation (m) | Channel Depth (m) | Cross Section Area ($m^2$) | Channel Width (m) | Width: Depth Ratio | Time WL > Thalweg (%) | Time WL > Bank (%) | Time WL > Thalweg (%) | Time WL > Bank (%) |
| KIB | 1 (mouth) | 1.91 | -2.33 | 4.24 | 91.3 | 41.7 | 9.8 | 95 | 27 | 96 | 16 |
| | 2 | 1.86 | -1.16 | 3.02 | 44.1 | 23.5 | 7.8 | 95 | 29 | 96 | 19 |
| | 3 | 1.87 | -0.24 | 2.11 | 20.3 | 13.3 | 6.3 | 95 | 28 | 96 | 18 |
| | 4 | 1.65 | -0.10 | 1.75 | 19.9 | 13.7 | 7.8 | 95 | 38 | 96 | 28 |
| | 5 | 1.98 | 0.36 | 1.62 | 10.0 | 10.3 | 6.3 | 82 | 24 | 77 | 14 |

### Cross Sections



## Site Description

Hydrogeomorphic Reach: B

Coordinates (UTM, NAD83 meters):

Northing: 5122272 Easting: 462926

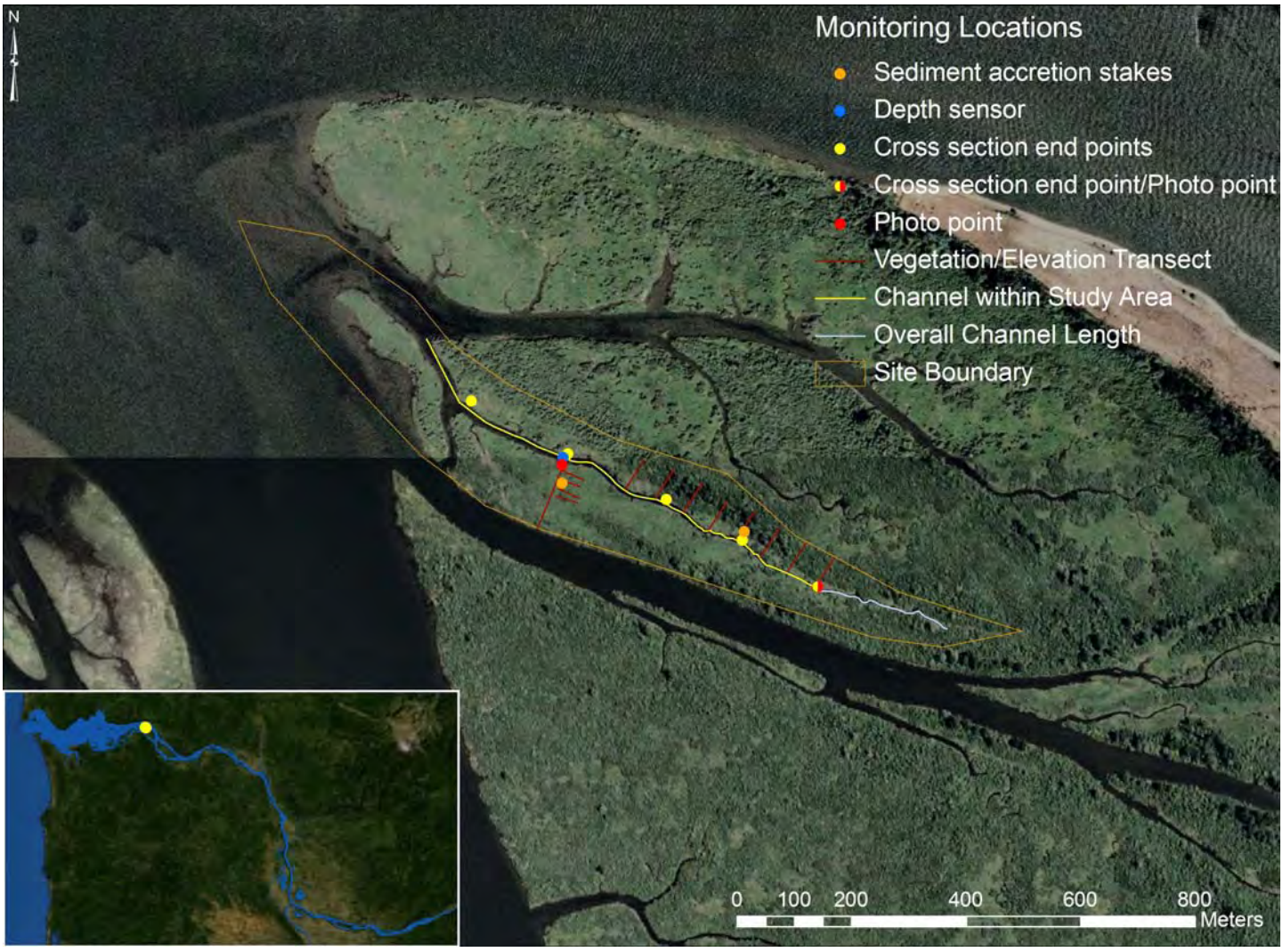
Distance from Columbia River mouth: 53 rkm

Distance from main channel: 664 meters

Type: Marsh and Shrub/Scrub

Total Site Area: 22.6 ha Study Area: 4.67 ha

Total channel length: 1098 m Channel surveyed: 850 m Channel slope: 0.60 m/km



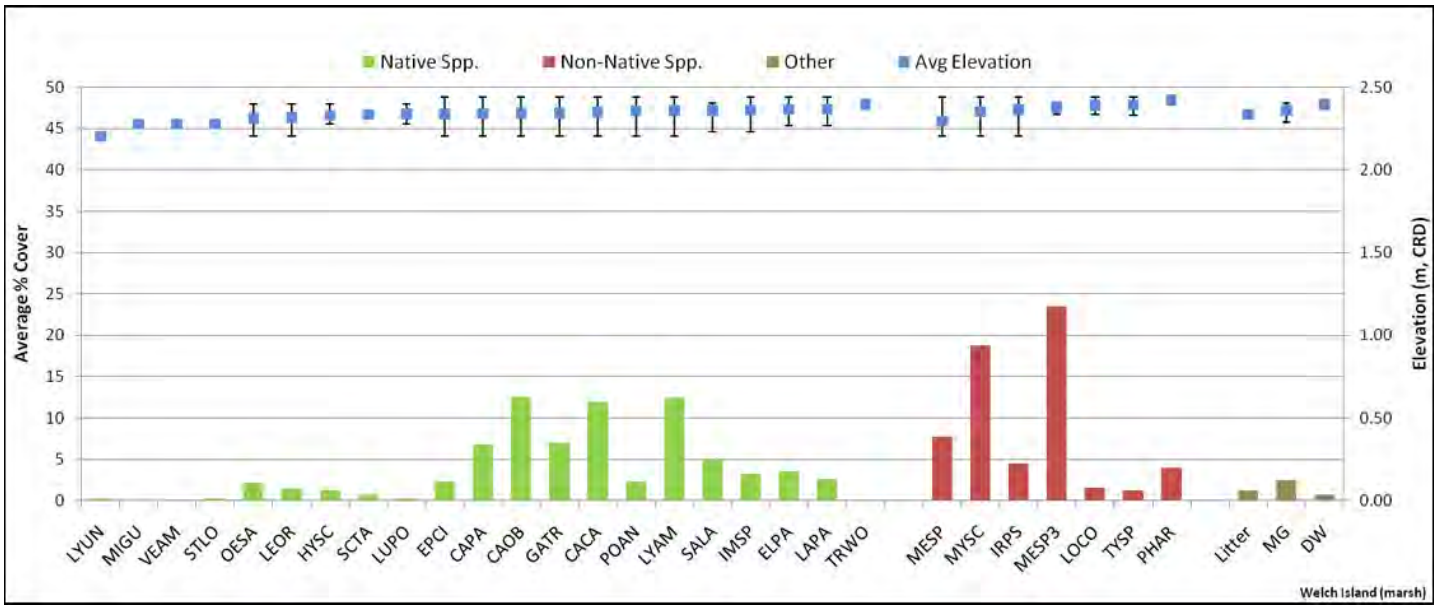
## Site Information

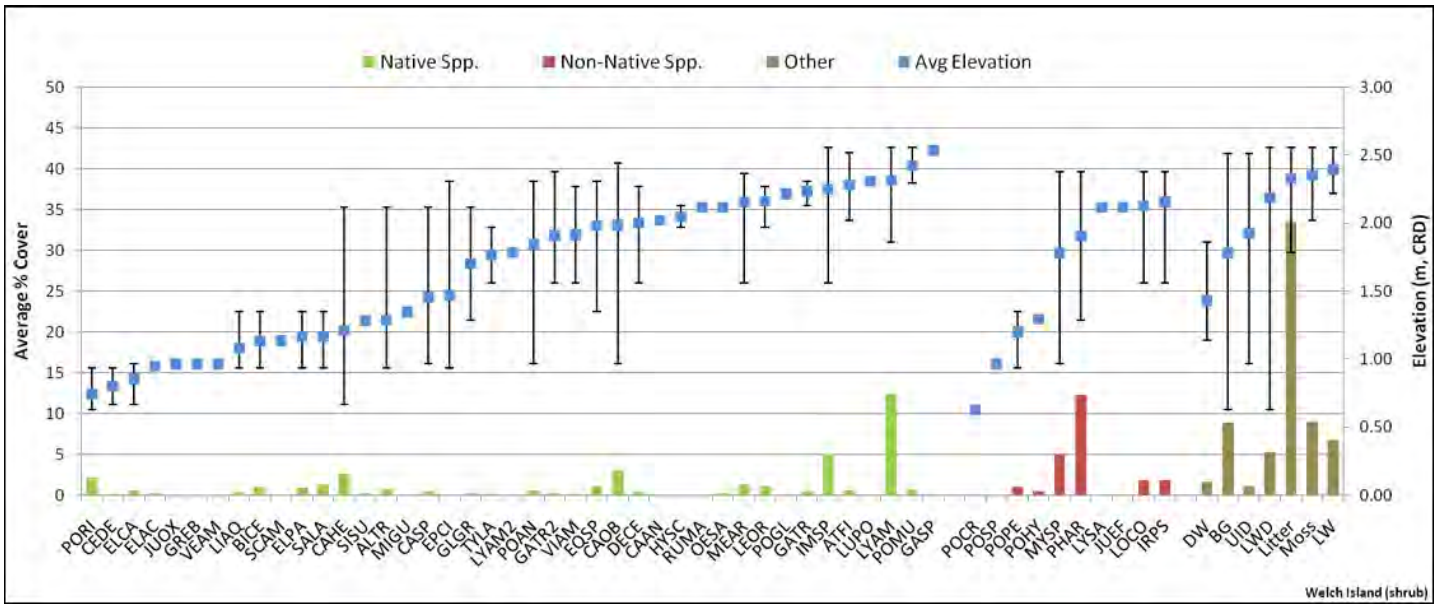
Welch Island is part of the Lewis and Clark National Wildlife Refuge. The island is comprised of shrub/scrub dominated wetlands and emergent marsh. The latter was the location of the sample site in 2008 and the shrub/scrub area the target site for sampling in 2009.

## Elevation

| | Marsh | | Herb | | Shrub | |
|---|---|---|---|---|---|---|
| | Lowest | Highest | Lowest | Highest | Lowest | Highest |
| CRD, m | 0.67 | 2.55 | 1.56 | 2.55 | 1.84 | 2.94 |
| NAVD88, m | 0.85 | 2.73 | 1.74 | 2.73 | 2.02 | 3.12 |

## Vegetation



## Vegetation (cont.)

| | Number | % Cover |
|---|---|---|
| Native Marsh species | 21 | 76.35 |
| Non-native Marsh species | 8 | 61.4 |
| Native Herb species | 41 | 40.6 |
| Non-native Herb species | 10 | 22.8 |
| Native Shrub species | 8 | 109.8 |
| Non-native Shrub species | 2 | 3.1 |

| Species | Density (stems/ha) | Cover (%) |
|---|---|---|
| COSE | 6625 | 48.1 |
| CRDO | 313 | 1.4 |
| LOIN | 188 | 1.3 |
| PHCA | 563 | 7.0 |
| ROPI | 875 | 4.5 |
| RUAR | 1813 | 3.0 |
| RUUR | 7438 | 1.9 |
| SASI | 3688 | 28.7 |
| SYAL | 938 | 0.0 |

## Sediment

Marsh

Sediment accretion rate: -1.53 cm per year

Elevation at sediment stakes: 2.20 m, CRD

Shrub

Sediment accretion rate: -0.96 cm per year

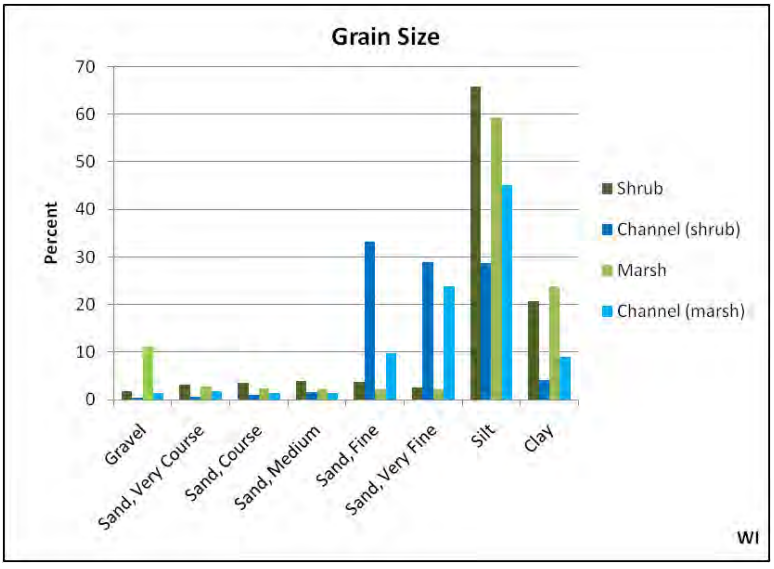
Elevation at sediment stakes: 2.15 m, CRD

Total Organic Carbon (TOC)

in channel: 1.55

in wetland: 7.47

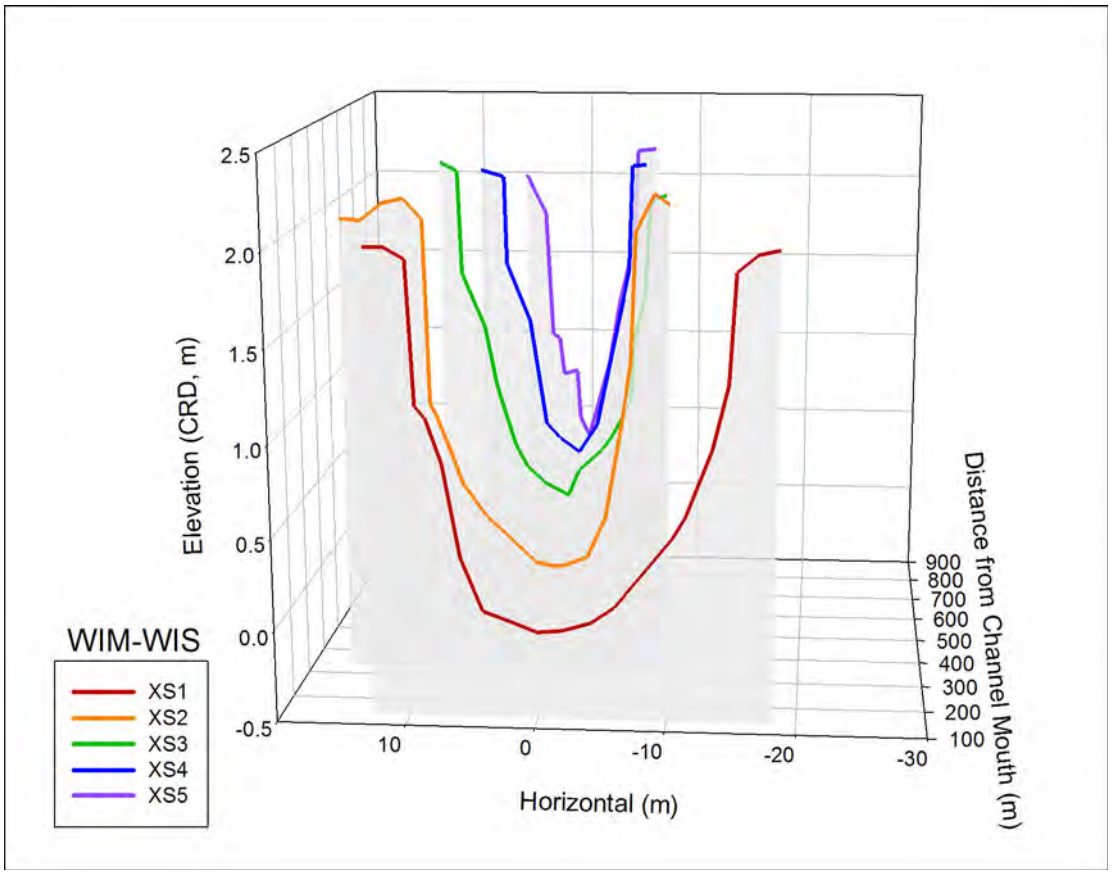
in shrub/scrub: 6.89



## Channels

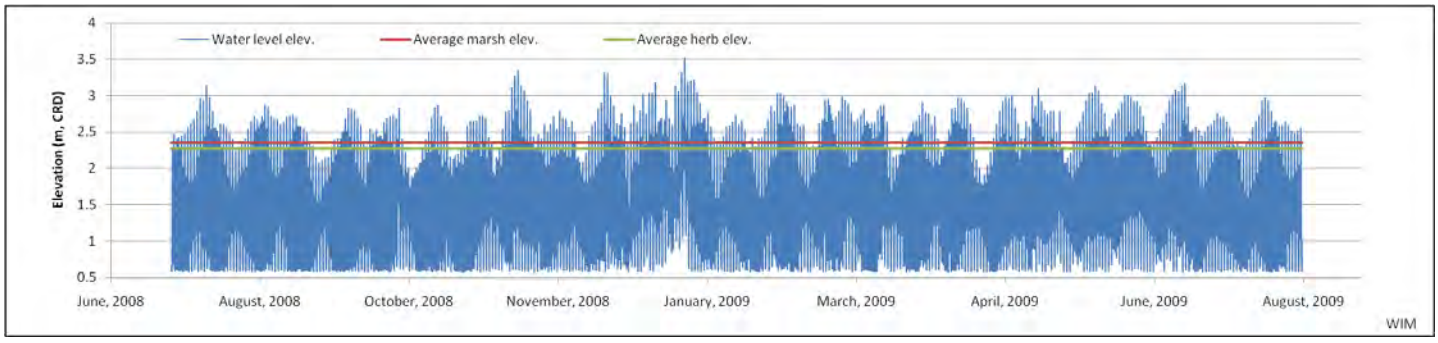
| | | Physical Metrics | | | | | | Inundation | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Year | | Growing Season | |
| | Cross Section | Bank Elevation (m) | Thalweg Elevation (m) | Channel Depth (m) | Cross Section Area ($m^2$) | Channel Width (m) | Width: Depth Ratio | Time WL > Thalweg (%) | Time WL > Bank (%) | Time WL > Thalweg (%) | Time WL > Bank (%) |
| WI | 1 | 1.90 | -0.03 | 1.93 | 37.1 | 24.8 | 12.9 | 97 | 32 | 96 | 21 |
| | 2 | 1.98 | 0.10 | 1.87 | 25.7 | 17.0 | 9.1 | 97 | 29 | 96 | 18 |
| | 3 | 2.00 | 0.30 | 1.70 | 19.5 | 16.1 | 9.5 | 97 | 28 | 96 | 18 |
| | 4 | 2.08 | 0.41 | 1.67 | 13.3 | 11.3 | 6.7 | 97 | 25 | 96 | 14 |
| | 5 | 1.78 | 0.36 | 1.41 | 7.1 | 8.2 | 5.8 | 97 | 38 | 96 | 27 |

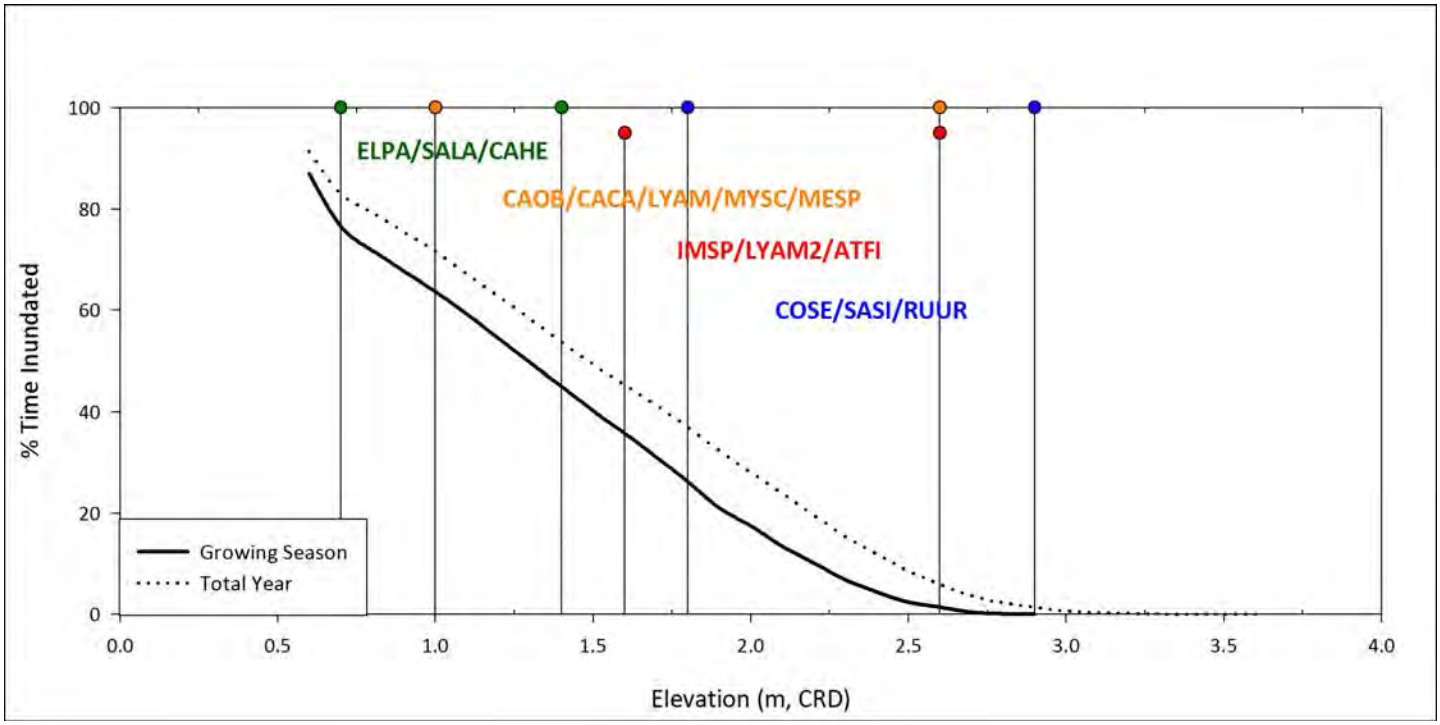
### Cross Sections



## Inundation

| | Std | Marsh | Herb | Shrub | Modified Growing Season: |
|---|---|---|---|---|---|
| Average Elev (m, CRD) | 1.89 | 2.35 | 2.27 | 2.40 | Aug 20 to Oct 12, 2008 |
| Sum Exceedance Value (SEV) | 16.3 | 3.83 | 5.26 | 3.15 | Apr 22 to Jun 21, 2009 |



## Site Description

Hydrogeomorphic Reach: C

Coordinates (UTM, NAD83 meters):

Northing: 5117057 Easting: 468019

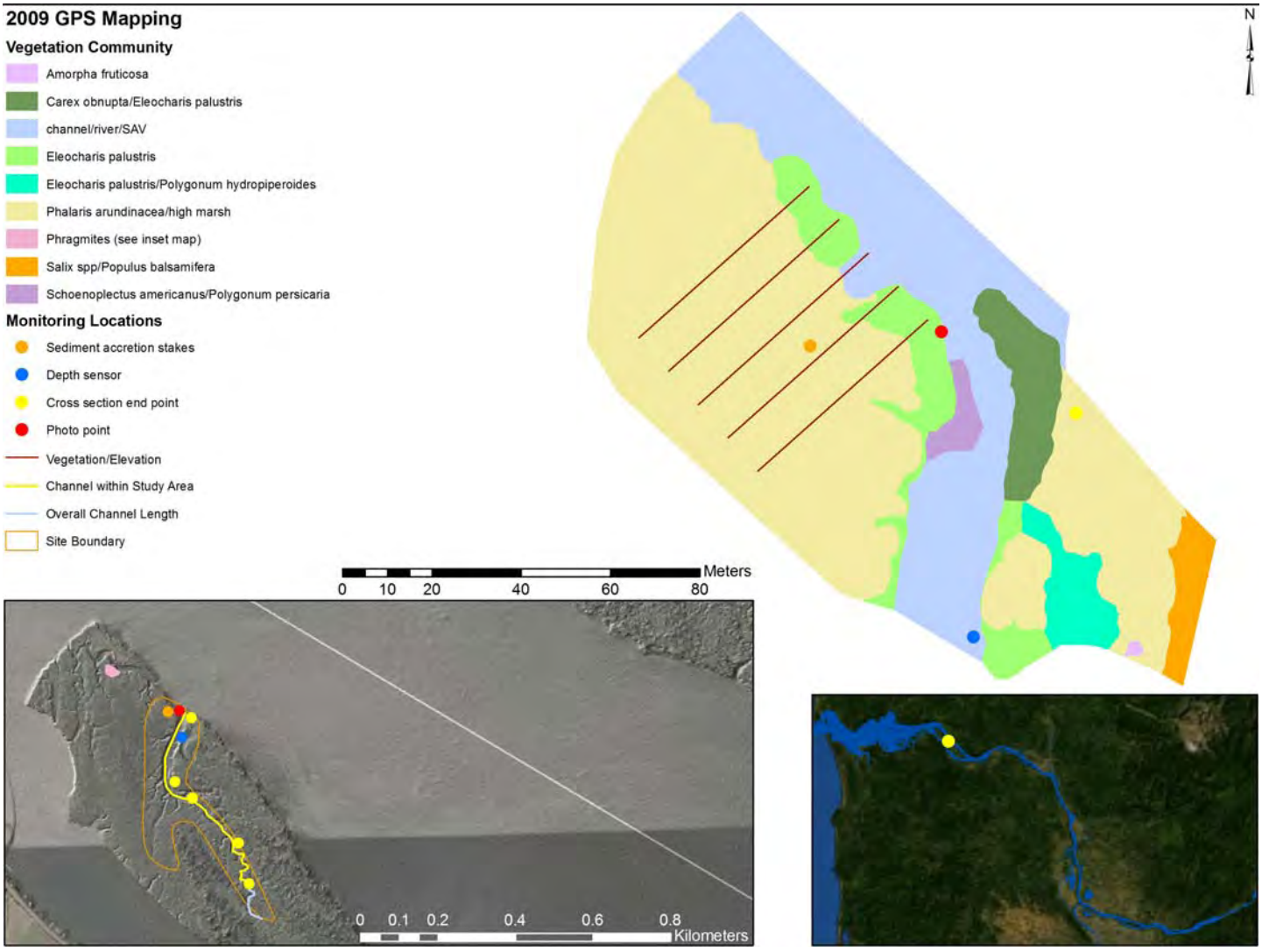
Distance from Columbia River mouth: 61 rkm

Distance from main channel: 0 meters

Type: Marsh

Total Site Area: 6.7 ha Study Area: 1.20 ha

Total channel length: 730 m Channel surveyed: 605 m Channel slope: 1.34 m/km



## Site Information

Ryan Island is located at the northern (downstream) corner of Puget Island near Cathlamet, Washington. Ownership of the island is unknown at this time; however, a conservation easement may exist on the island. The site is an extensive undisturbed wetland with well developed tidal channels. The site is near the mouth of one of the tidal channels where it empties into Cathlamet channel the other side of the tidal channel grades up to the forested portion of the island. The site appears to be affected by the strong energies of the main channel as evidenced by bank erosion in the sample area.

## Elevation

Lowest marsh (NAVD88, m): 0.68

Highest marsh (NAVD88, m): 2.46

Lowest marsh (CRD, m): 0.31

Highest marsh (CRD, m): 2.09

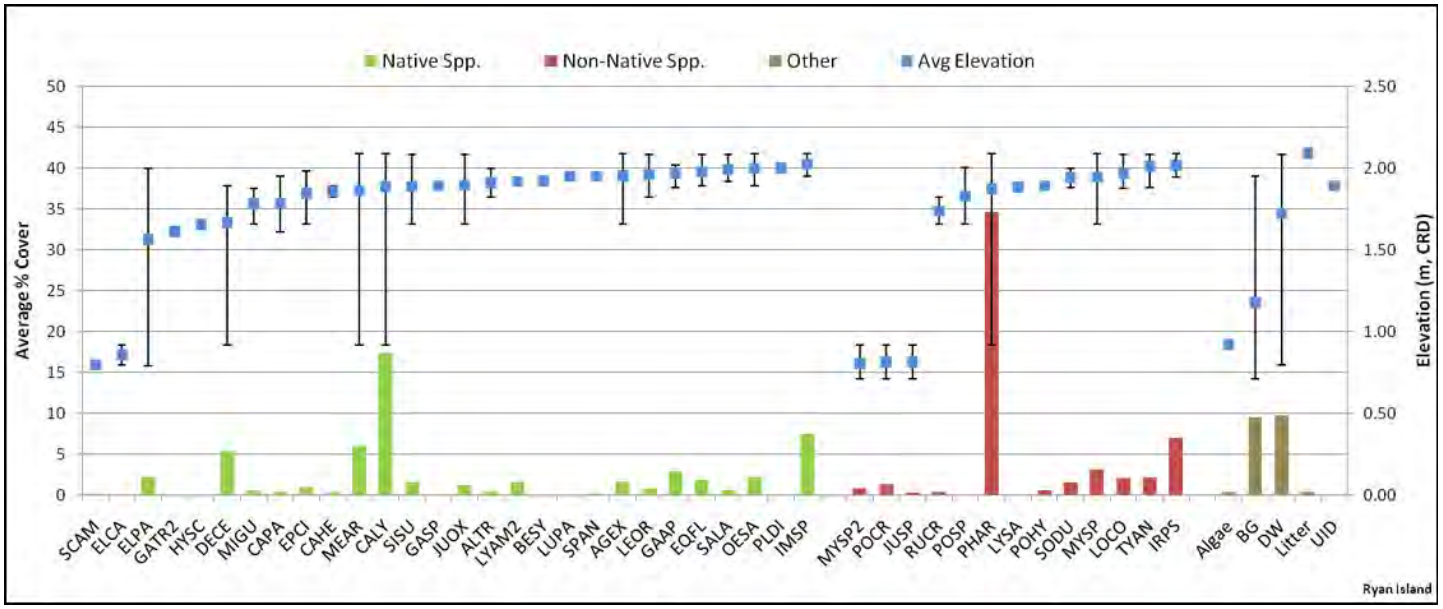
## Vegetation

Number of Native species: 28

% Native Cover: 56.88

Number of Non-native species: 13

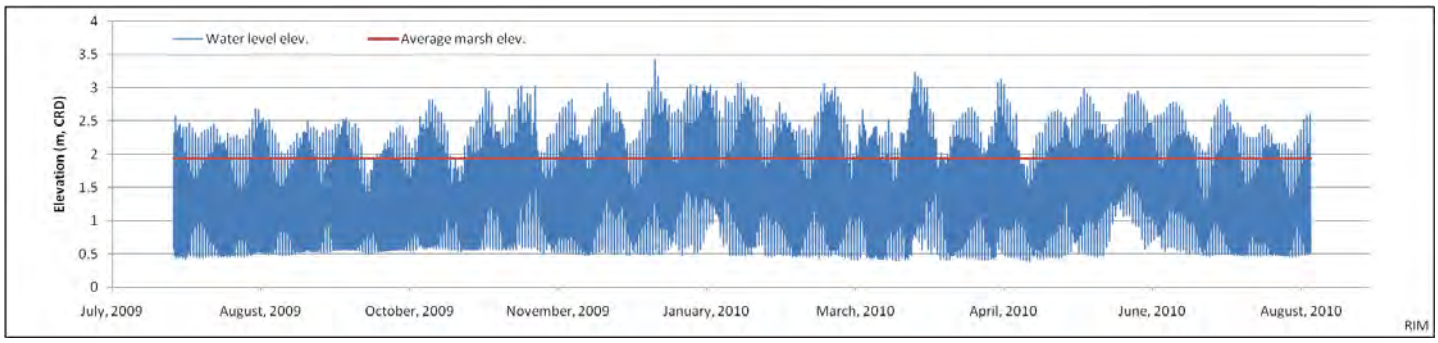
% Non-native Cover: 54.28

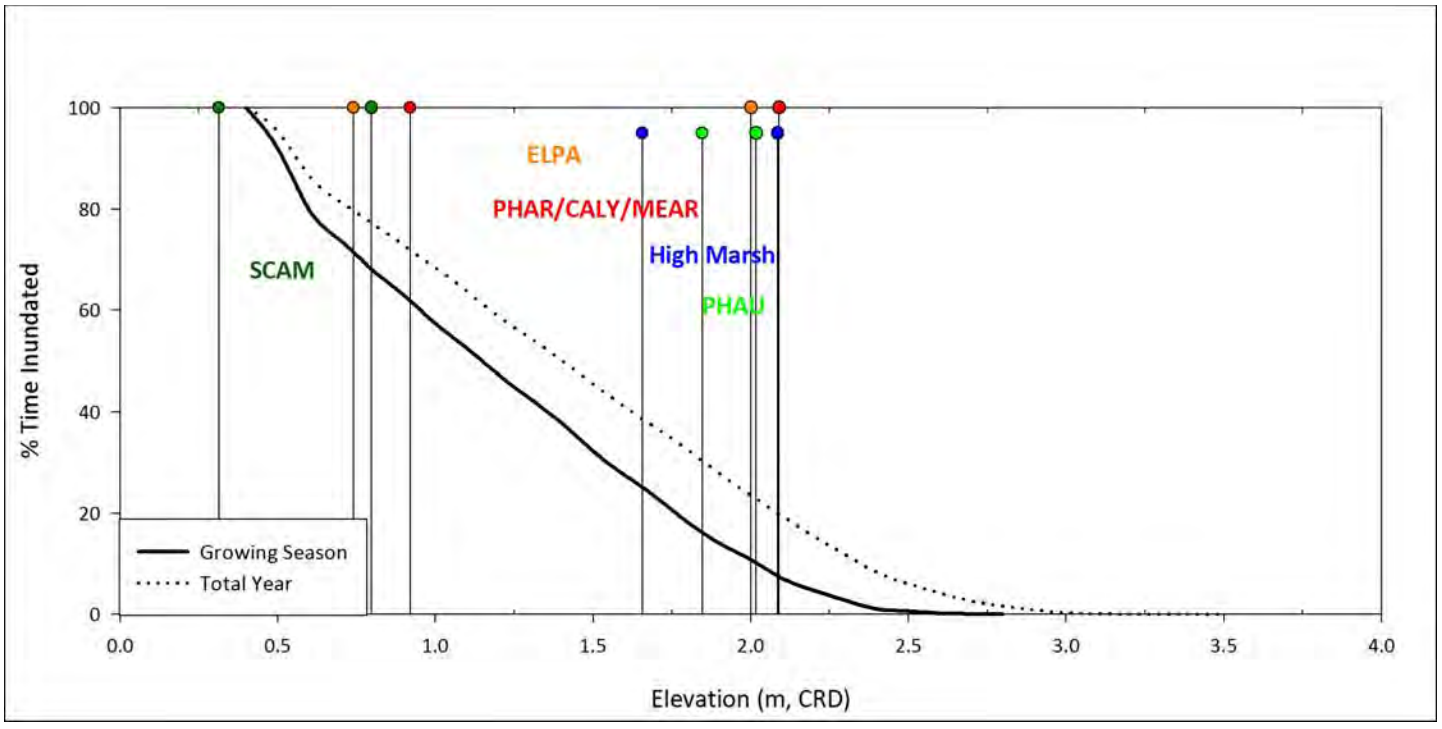


## Inundation

| | Std | Marsh |
|---|---|---|
| Average Elev (m, CRD) | 1.89 | 1.93 |
| Sum Exceedance Value (SEV) | 10.5 | 9.25 |

Modified Growing Season:
Aug 20 to Oct 12, 2009
Apr 22 to Jun 21, 2010




## Sediment

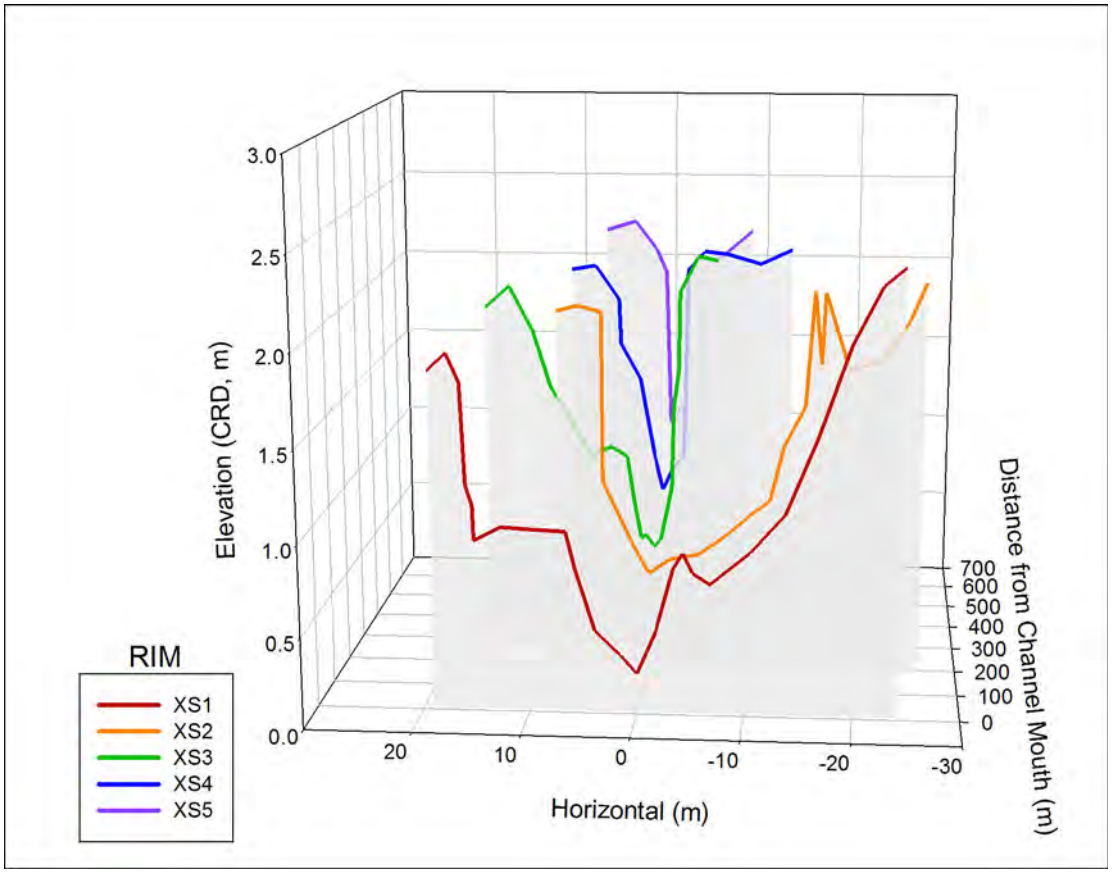
Sediment accretion rate: 0.19 cm per year

Elevation at sediment stakes: 1.89 m, CRD

## Channels

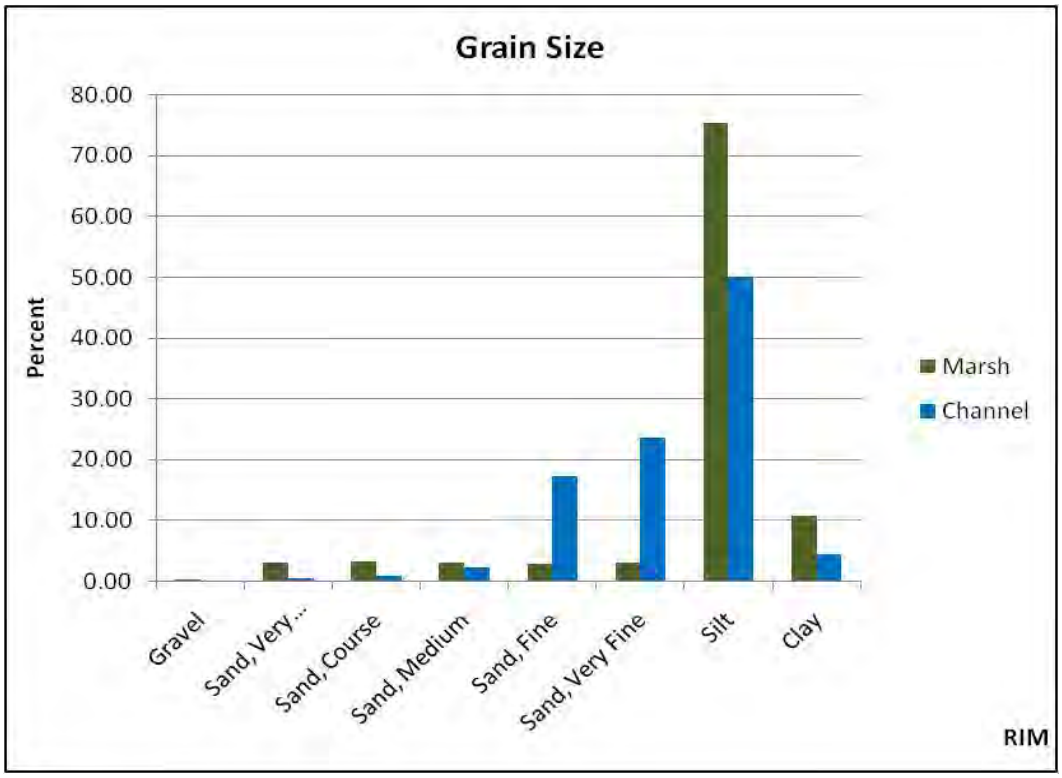
| | | Physical Metrics | | | | | | Inundation | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Year | | Growing Season | |
| | Cross Section | Bank Elevation (m) | Thalweg Elevation (m) | Channel Depth (m) | Cross Section Area ($m^2$) | Channel Width (m) | Width: Depth Ratio | Time WL > Thalweg (%) | Time WL > Bank (%) | Time WL > Thalweg (%) | Time WL > Bank (%) |
| RIM | 1 | 1.93 | 0.21 | 1.72 | 36.6 | 36.5 | 21.3 | 100 | 26 | 100 | 13 |
| | 2 | 2.02 | 0.54 | 1.47 | 24.7 | 29.7 | 20.2 | 82 | 23 | 74 | 10 |
| | 3 | 2.09 | 0.60 | 1.49 | 13.9 | 17.1 | 11.5 | 79 | 20 | 71 | 7 |
| | 4 | 2.08 | 0.76 | 1.32 | 6.6 | 9.4 | 7.1 | 72 | 20 | 63 | 8 |
| | 5 | 1.97 | 1.03 | 0.95 | 2.9 | 4.0 | 4.2 | 60 | 25 | 48 | 11 |

### Cross Sections



## Sediment

Total Organic Carbon (TOC) in channel: 1.14 in wetland: 4.66



## Site Description

Hydrogeomorphic Reach: C

Coordinates (UTM, NAD83 meters):

Northing: 5112971 Easting: 472905

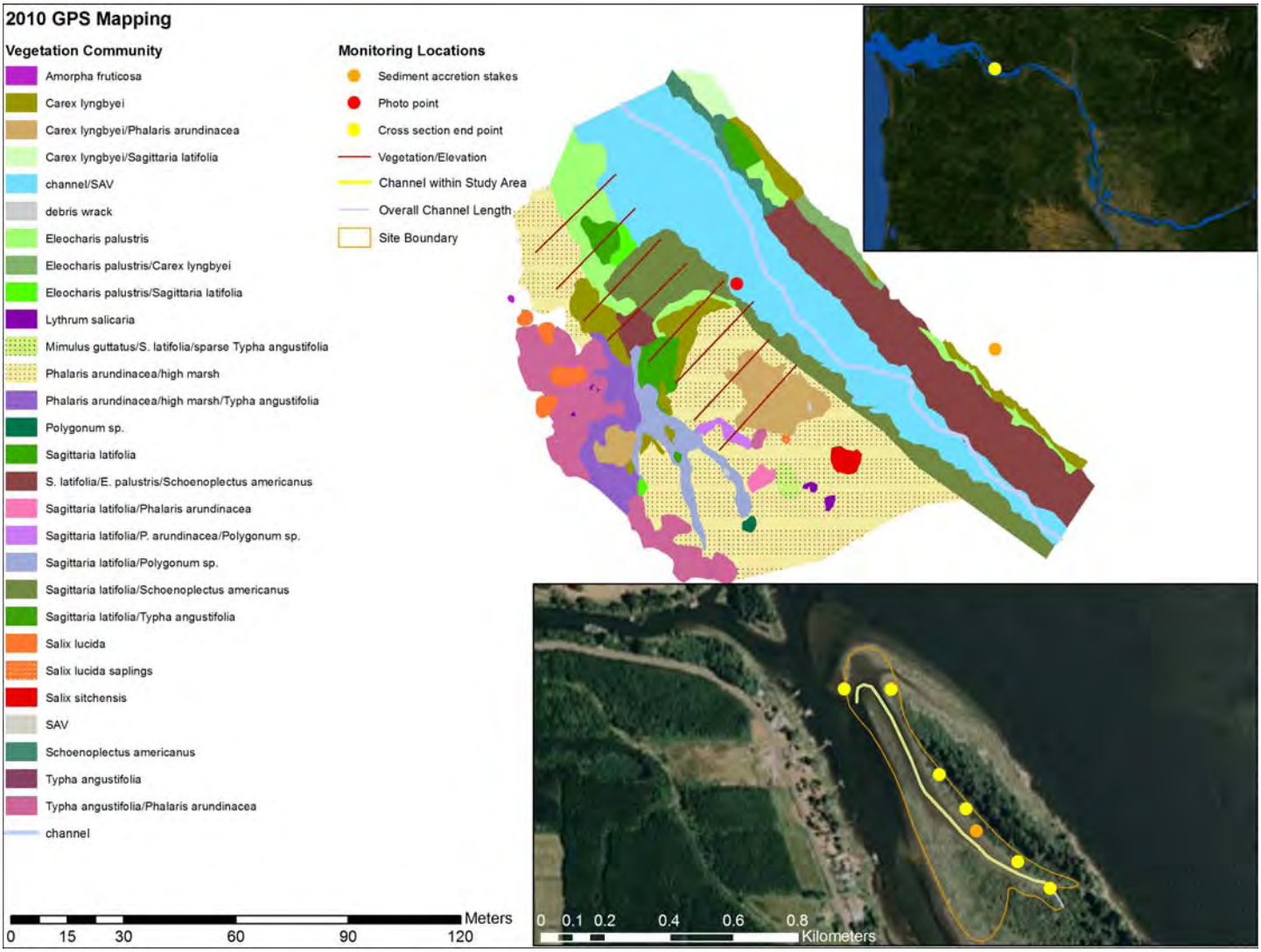
Distance from Columbia River mouth: 71 rkm

Distance from main channel: 532 meters

Type: Marsh

Total Site Area: 8.5 ha Study Area: 0.92 ha

Total channel length: 717 m Channel surveyed: 668 m Channel slope: 1.12 m/km



## Site Information

Jackson Island is located adjacent to Puget Island near Cathlamet, Washington. Ownership is unknown at this time. The site we focused on is a very shallow-water slough with depths less than a meter located approximately 0.3 km from Cathlamet Channel. The emergent vegetation, a mix of low marsh, high marsh, and reed canary grass, is located on both sides of the slough, grading up to willows, shrubs, and trees. Jackson Island was not present on historic maps from the 1880s and has likely been created with dredge material over the years.

## Elevation

Lowest marsh (NAVD88, m): 1.34

Highest marsh (NAVD88, m): 2.32

Lowest marsh (CRD, m): 0.90

Highest marsh (CRD, m): 1.88

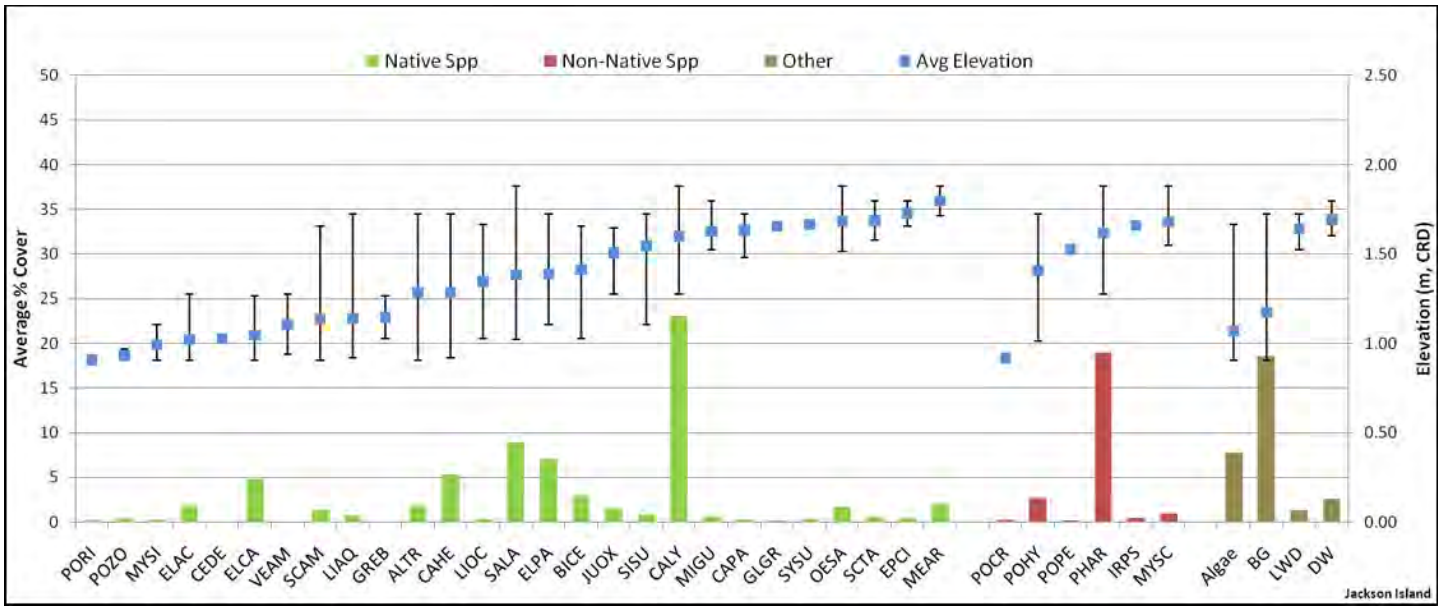
## Vegetation

Number of Native species: 27

% Native Cover: 67.52

Number of Non-native species: 6

% Non-native Cover: 23.39



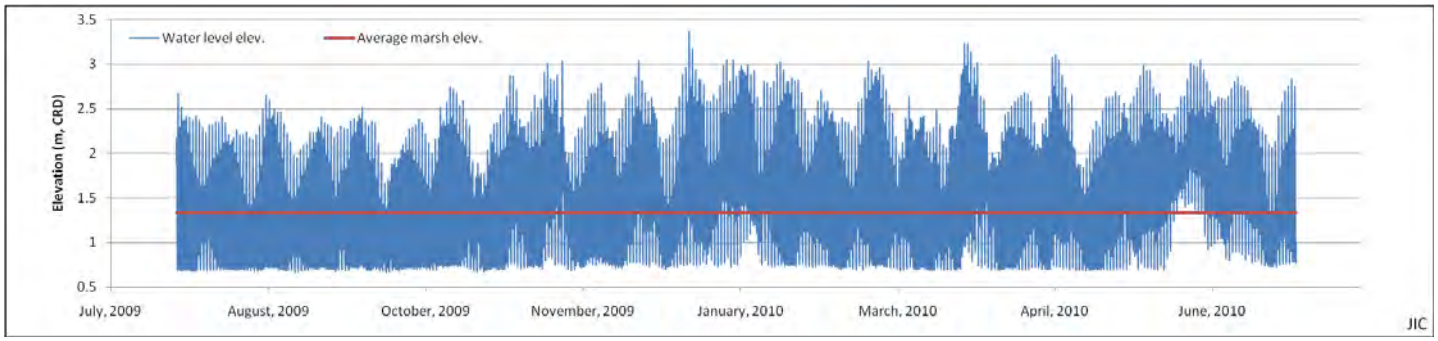

## Inundation

| | Std | Marsh |
|---|---|---|
| Average Elev (m, CRD) | 1.89 | 1.33 |
| Sum Exceedance Value (SEV) | 11.4 | 37.9 |

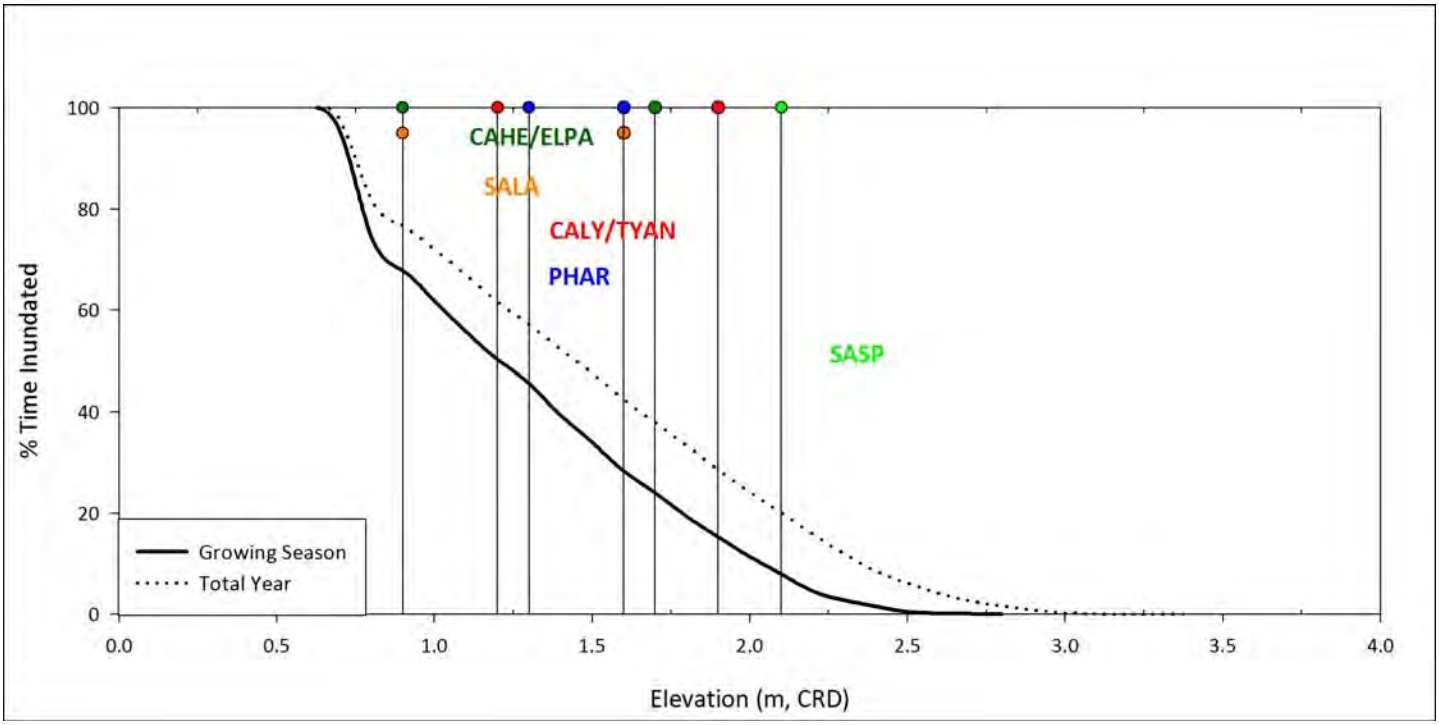
Modified Growing Season:

Aug 20 to Oct 12, 2009

Apr 22 to Jun 21, 2010



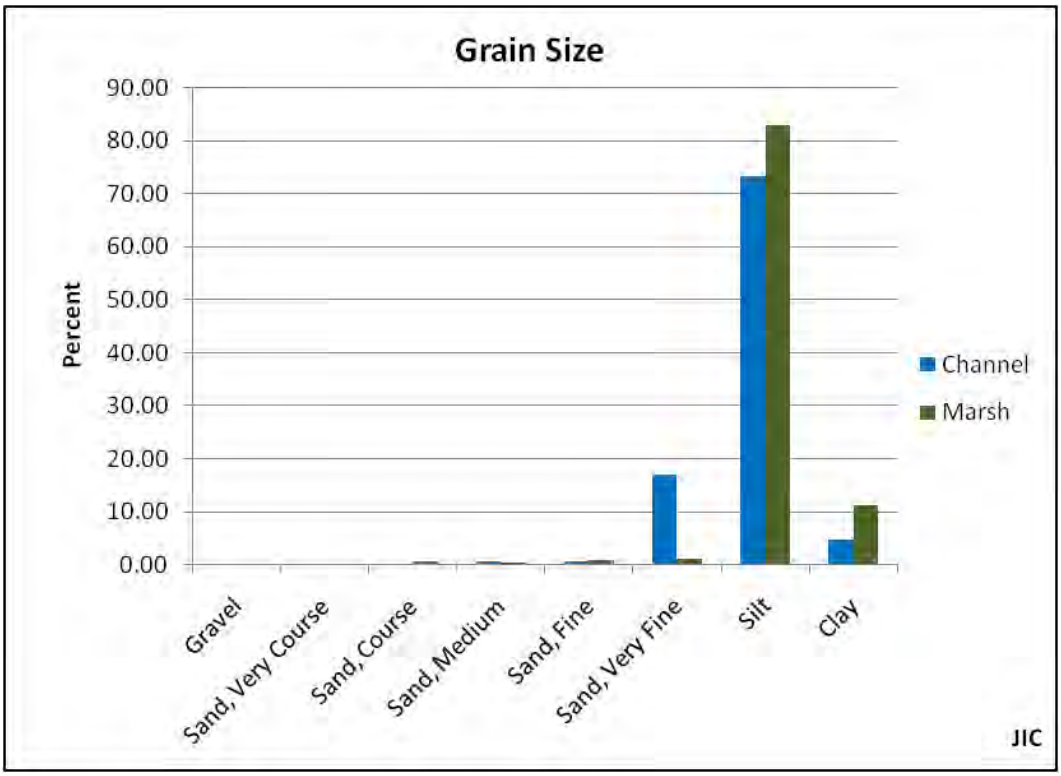
## Inundation (cont.)




## Sediment

Sediment accretion rate: 0.92 cm per year Elevation at sediment stakes: 1.98 m, CRD

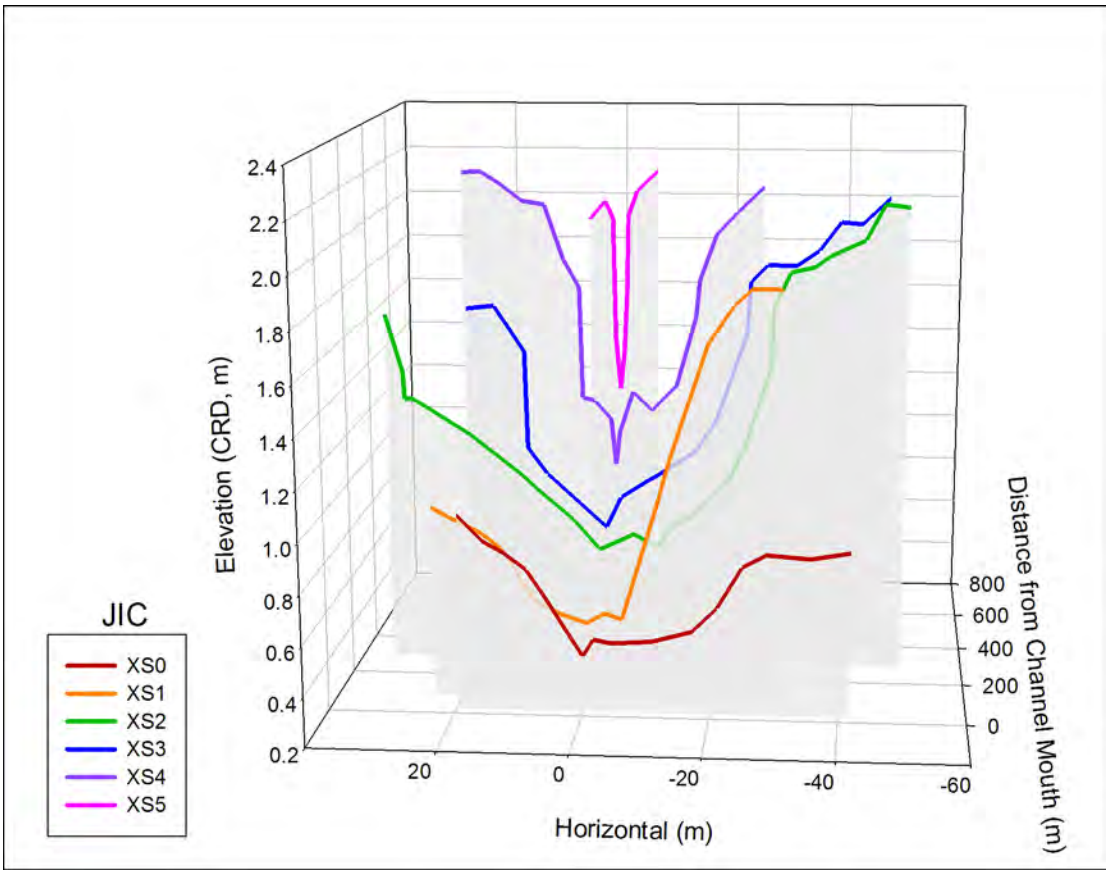
Total Organic Carbon (TOC) in channel: 4.83 in wetland: 0.63



## Channels

| | | Physical Metrics | | | | | | Inundation | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Year | | Growing Season | |
| | Cross Section | Bank Elevation (m) | Thalweg Elevation (m) | Channel Depth (m) | Cross Section Area ($m^2$) | Channel Width (m) | Width: Depth Ratio | Time WL > Thalweg (%) | Time WL > Bank (%) | Time WL > Thalweg (%) | Time WL > Bank (%) |
| JIC | 0 | 0.84 | 0.43 | 0.41 | 9.6 | 47.7 | 115.9 | 100 | 80 | 100 | 72 |
| | 1 | 0.81 | 0.51 | 0.30 | 4.7 | 22.4 | 74.7 | 100 | 81 | 100 | 74 |
| | 2 | 1.42 | 0.68 | 0.74 | 27.3 | 60.0 | 81.0 | 80 | 51 | 73 | 38 |
| | 3 | 1.46 | 0.70 | 0.76 | 18.1 | 36.3 | 48.0 | 79 | 49 | 72 | 36 |
| | 4 | 1.66 | 0.88 | 0.78 | 9.8 | 20.9 | 26.7 | 71 | 40 | 60 | 25 |
| | 5 | 1.93 | 1.17 | 0.76 | 1.4 | 2.7 | 3.6 | 56 | 27 | 44 | 14 |

### Cross Sections



## Site Description

Hydrogeomorphic Reach: C

Coordinates (UTM, NAD83 meters):

Northing: 5111789 Easting: 473851

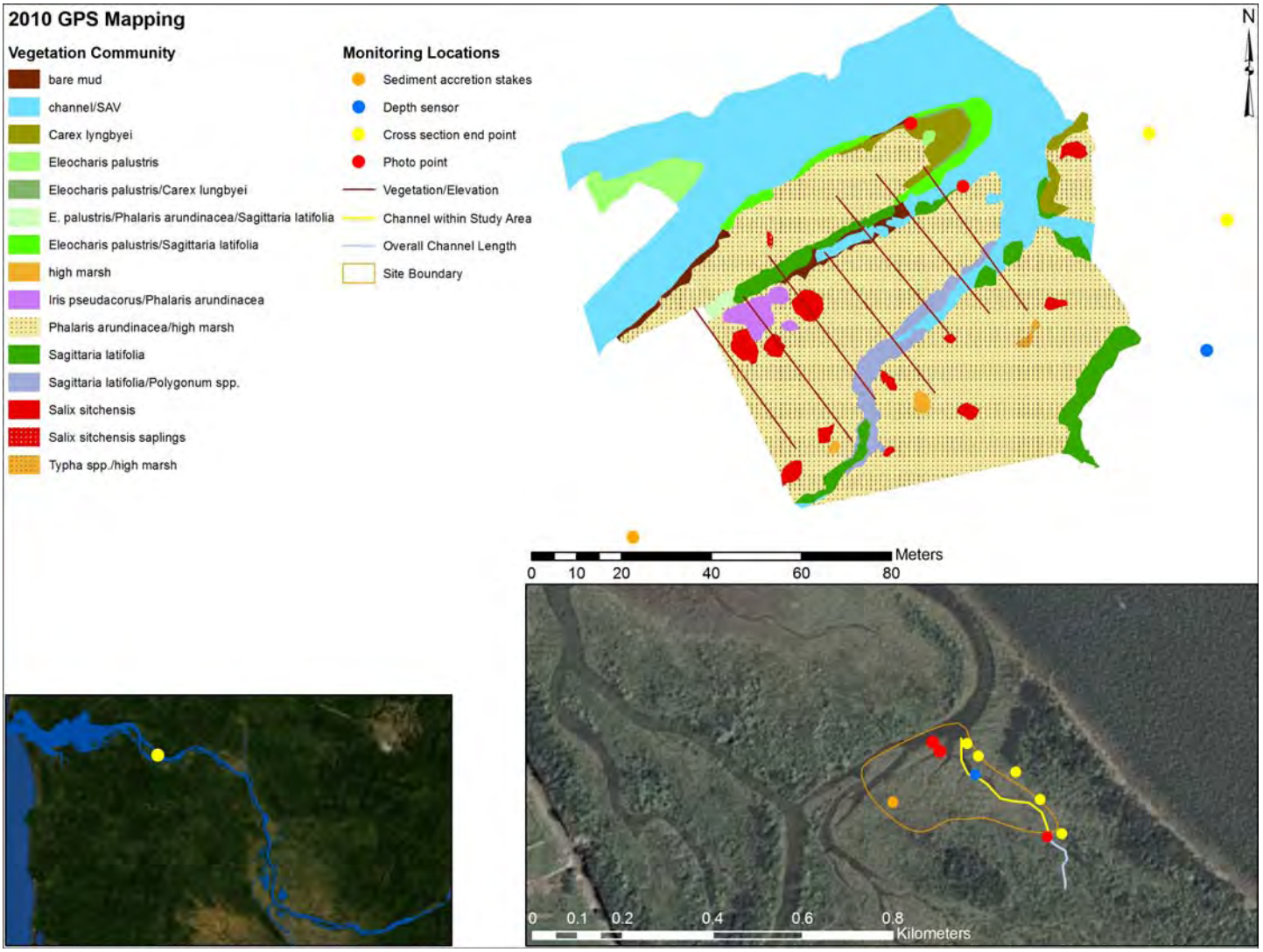
Distance from Columbia River mouth: 72 rkm

Distance from main channel: 742 meters

Type: Marsh

Total Site Area: 2.9 ha Study Area: 0.60 ha

Total channel length: 324 m Channel surveyed: 231 m Channel slope: 1.24 m/km



## Site Information

Whites Island is located on the southern (upstream) end of Puget Island, near Cathlamet, Washington. A portion of the island is owned by Washington Department of Fish and Wildlife (WDFW) and is maintained as Columbia white-tailed deer habitat. The monitoring site, located at the confluence of a large tidal channel and an extensive slough system, is approximately 0.7 km from the Cathlamet Channel. The site is characterized by primarily high marsh and a few willows, with numerous small tidal channels. Whites Island is not present on historical maps from the 1880s and has likely been created with dredge material over the years.

## Elevation

Lowest marsh (NAVD88, m): 1.29

Highest marsh (NAVD88, m): 2.73

Lowest marsh (CRD, m): 0.86

Highest marsh (CRD, m): 2.30

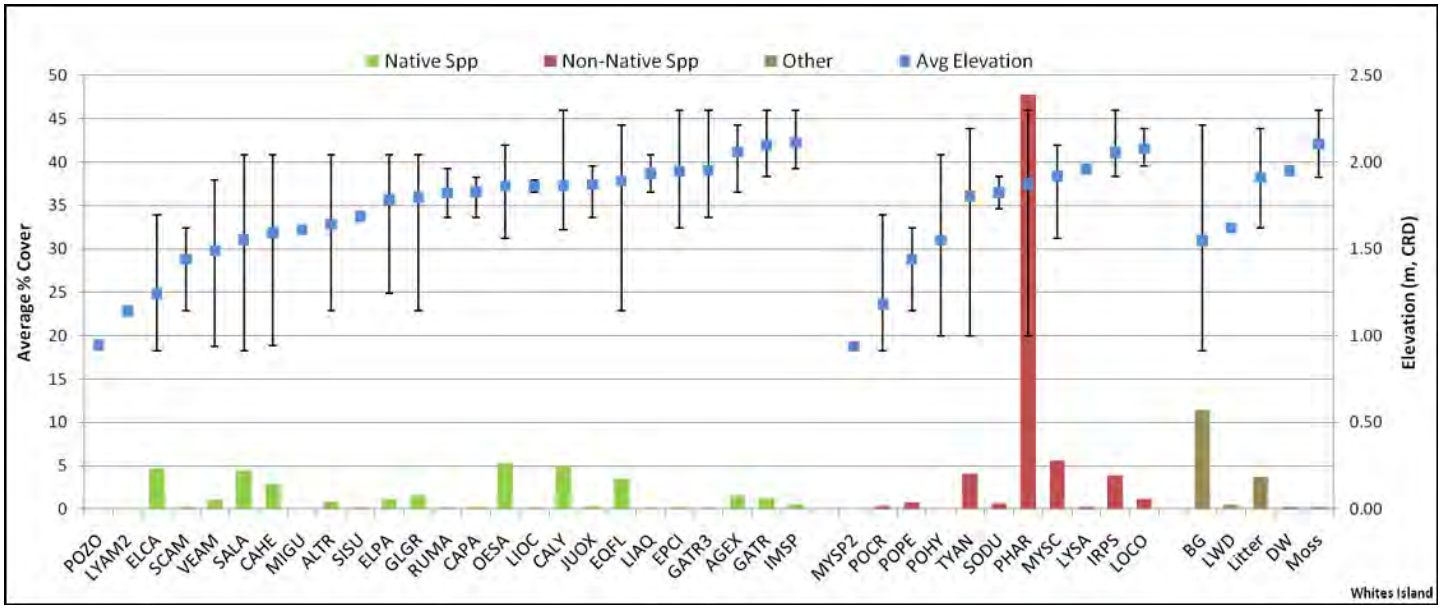
## Vegetation

Number of Native species: 25

% Native Cover: 36.53

Number of Non-native species: 11

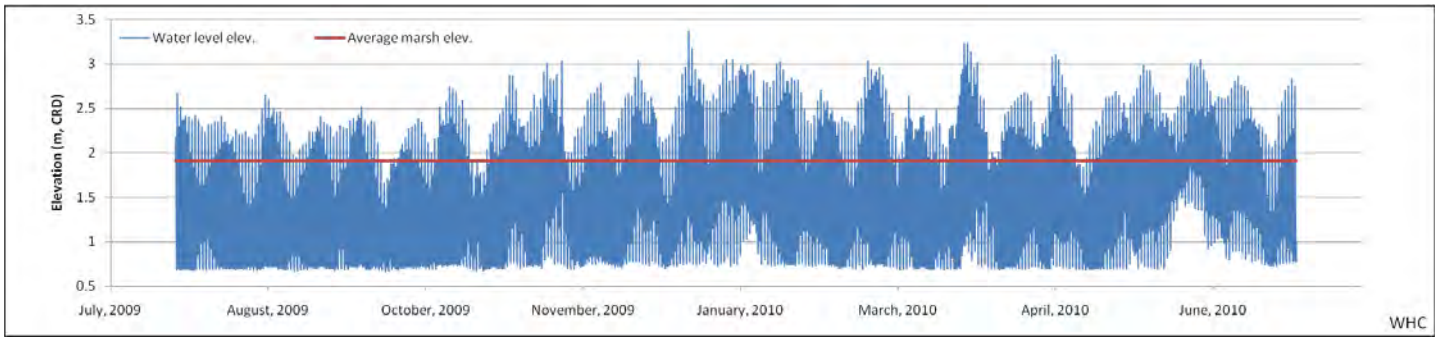
% Non-native Cover: 64.76

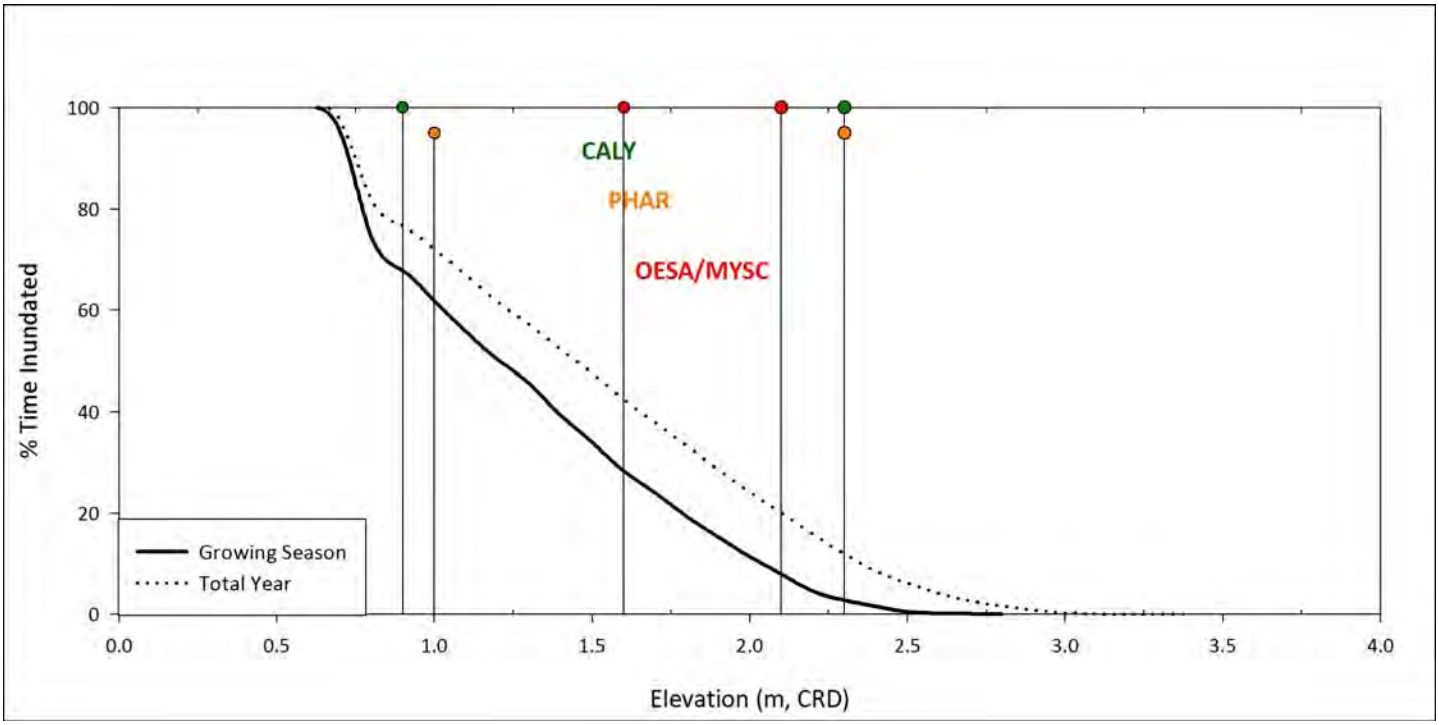


## Inundation

| | Std | Marsh |
|---|---|---|
| Average Elev (m, CRD) | 1.89 | 1.90 |
| Sum Exceedance Value (SEV) | 11.4 | 10.9 |

Modified Growing Season:
Aug 20 to Oct 12, 2009
Apr 22 to Jun 21, 2010



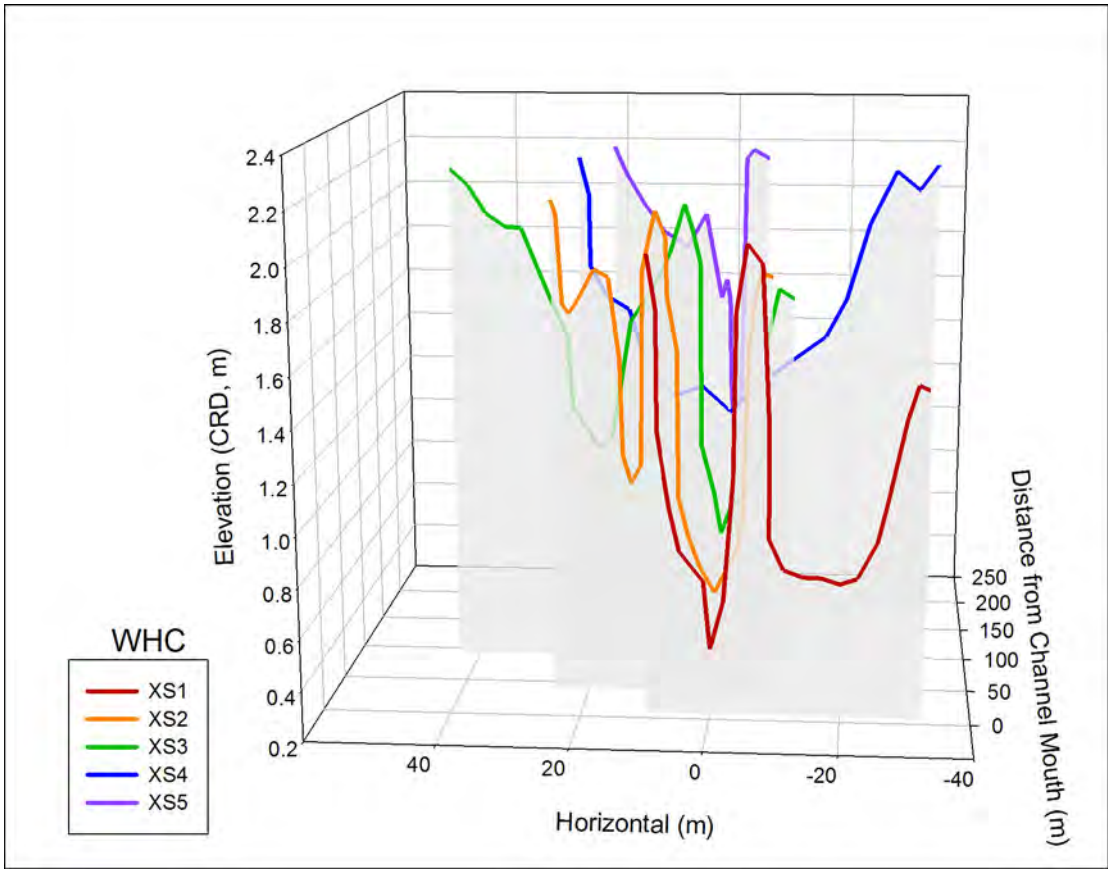

## Sediment

Sediment accretion rate: 1.03 cm per year Elevation at sediment stakes: 1.96 m, CRD

## Channels

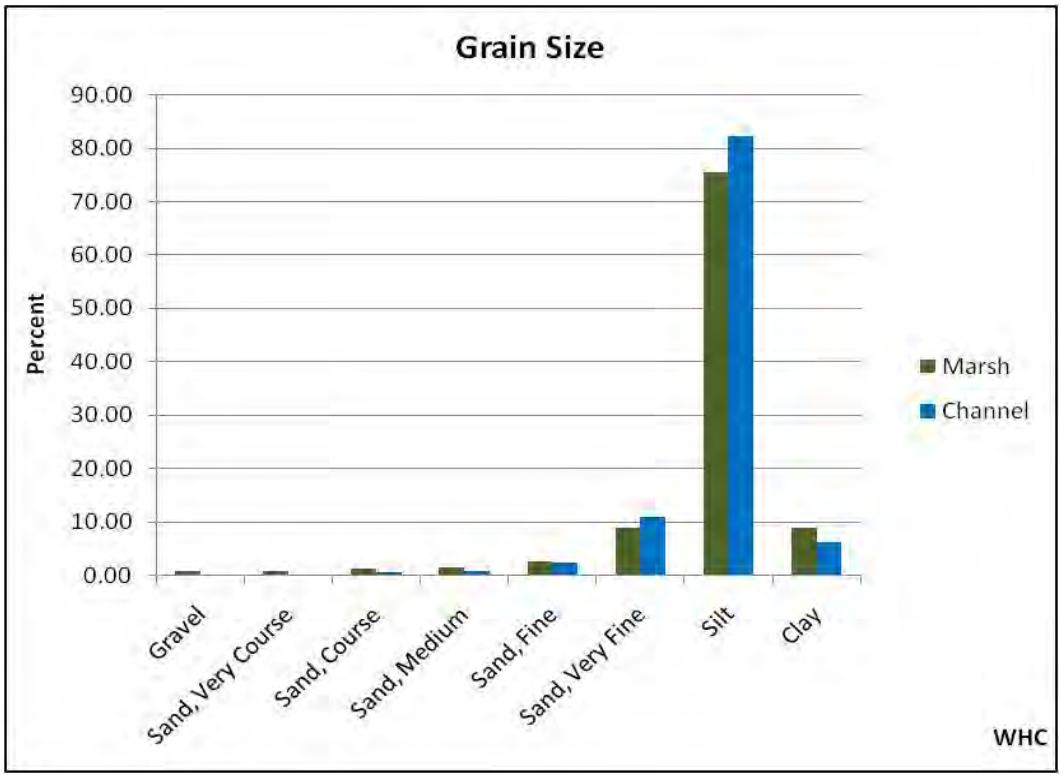
| | | Physical Metrics | | | | | | Inundation | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Year | | Growing Season | |
| | Cross Section | Bank Elevation (m) | Thalweg Elevation (m) | Channel Depth (m) | Cross Section Area ($m^2$) | Channel Width (m) | Width: Depth Ratio | Time WL > Thalweg (%) | Time WL > Bank (%) | Time WL > Thalweg (%) | Time WL > Bank (%) |
| WHC | 1 | 1.51 | 0.46 | 1.05 | 21.8 | 39.5 | 37.6 | 100 | 47 | 100 | 33 |
| | 2 | 1.88 | 0.61 | 1.27 | 15.9 | 31.0 | 24.4 | 86 | 30 | 79 | 16 |
| | 3 | 1.75 | 0.74 | 1.01 | 9.0 | 37.7 | 37.3 | 77 | 36 | 69 | 22 |
| | 4 | 2.03 | 1.09 | 0.94 | 32.0 | 50.0 | 53.5 | 60 | 23 | 49 | 11 |
| | 5 | 1.60 | 0.75 | 0.85 | 1.3 | 3.0 | 3.6 | 77 | 43 | 68 | 28 |

### Cross Sections



## Sediment

Total Organic Carbon (TOC) in channel: 1.41 in wetland: 2.63



## Site Description

Hydrogeomorphic Reach: C

Coordinates (UTM, NAD83 meters):

Northing: 5107662 Easting: 473595

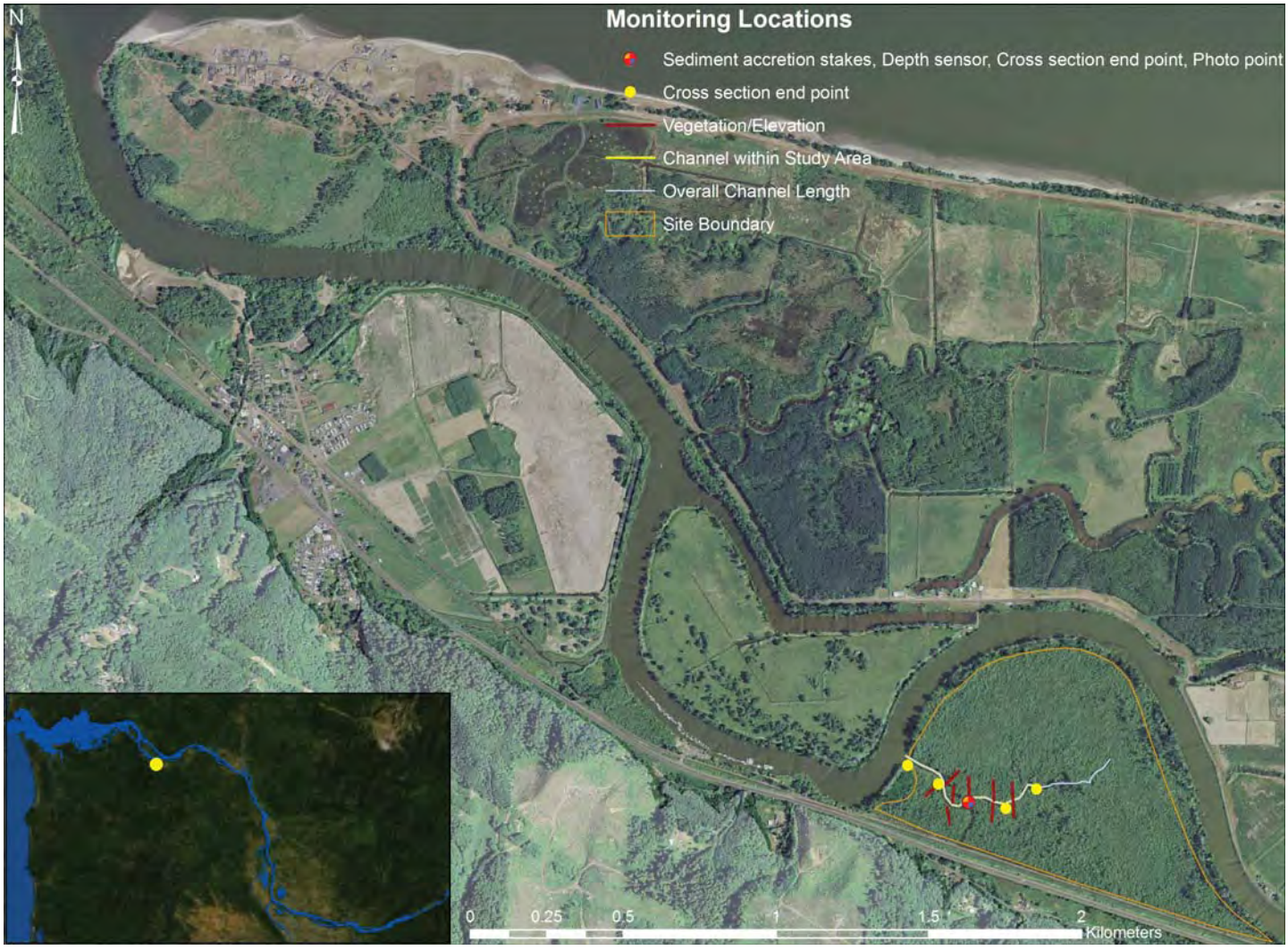
Distance from Columbia River mouth: 73 rkm

Distance from main channel: 4443 meters

Type: Shrub/Scrub

Total Site Area: 57.1 ha Study Area: 5.73 ha

Total channel length: 843 m Channel surveyed: 563 m Channel slope: 7.16 m/km



## Site Information

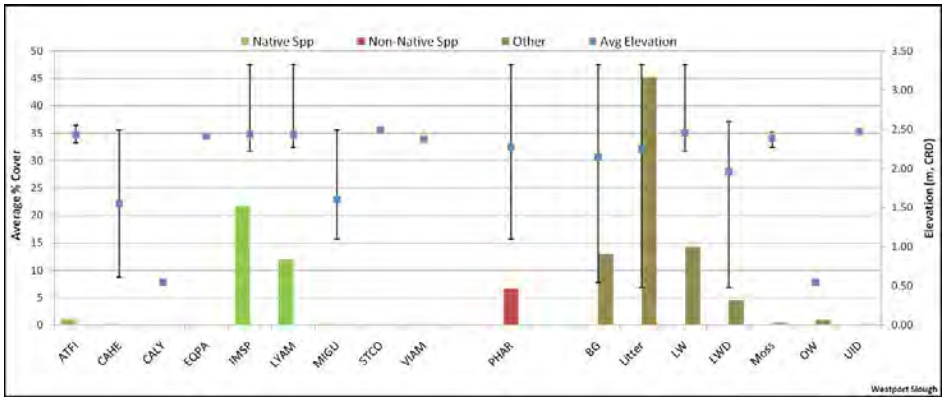
The Westport Slough site is located on both sides of a slough that empties into Westport Slough, near Westport, Oregon. The site has a deep tidal channel with overhanging dogwood and willow and fringing cottonwoods. The site is the only undiked area along the entire length of Westport Slough. The site is owned by the US Department of Fish and Wildlife.

## Elevation

| | Herb | | Shrub | |
|---|---|---|---|---|
| | Lowest | Highest | Lowest | Highest |
| CRD, m | 0.54 | 3.33 | 2.15 | 2.91 |
| NAVD88, m | 0.97 | 3.76 | 2.58 | 3.33 |

## Vegetation

| | Herb | Shrub |
|---|---|---|
| Number of Native species | 19 | 12 |
| % Cover Native species | 35.39 | 109.7 |
| Number of Non-native species | 1 | 0 |
| % Cover Non-native species | 6.65 | 0 |

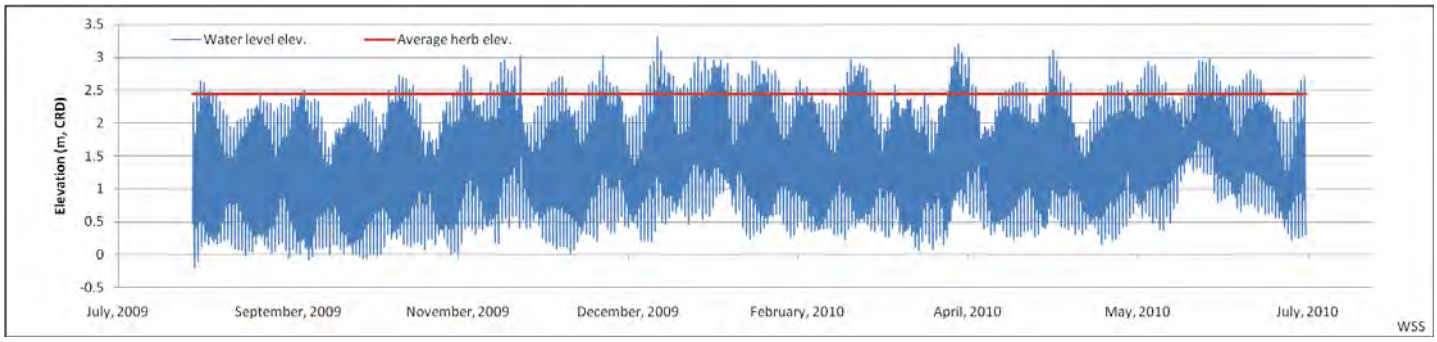



| Species | Density Stems/ha | Cover % |
|---|---|---|
| COSE | 1722 | 28.9 |
| LOIN | 278 | 0.3 |
| RIDI | 222 | 0.2 |
| RONU | 111 | 0.8 |
| ROPI | 1778 | 8.5 |
| RUSP | 1667 | 5.0 |
| RUUR | 10722 | 3.3 |
| SALU | 333 | 22.9 |
| SASI | 1333 | 27.3 |
| SPDO | 2222 | 11.6 |
| SYAL | 500 | 0.9 |

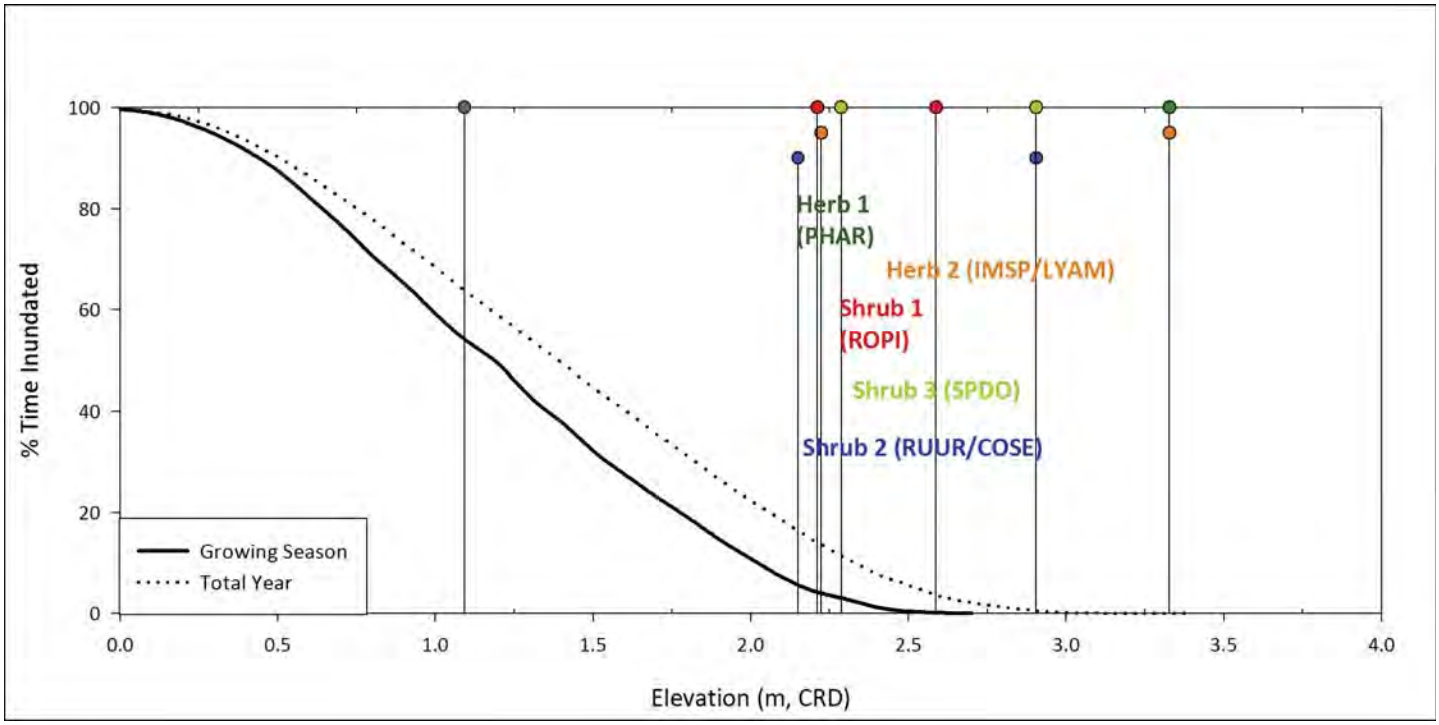
## Inundation

| | Std | Herb | Shrub |
|---|---|---|---|
| Average Elev (m, CRD) | 1.89 | 2.44 | 2.47 |
| Sum Exceedance Value (SEV) | 9.92 | 1.02 | 0.90 |

Modified Growing Season:
Aug 20 to Oct 12, 2009
Apr 22 to Jun 21, 2010



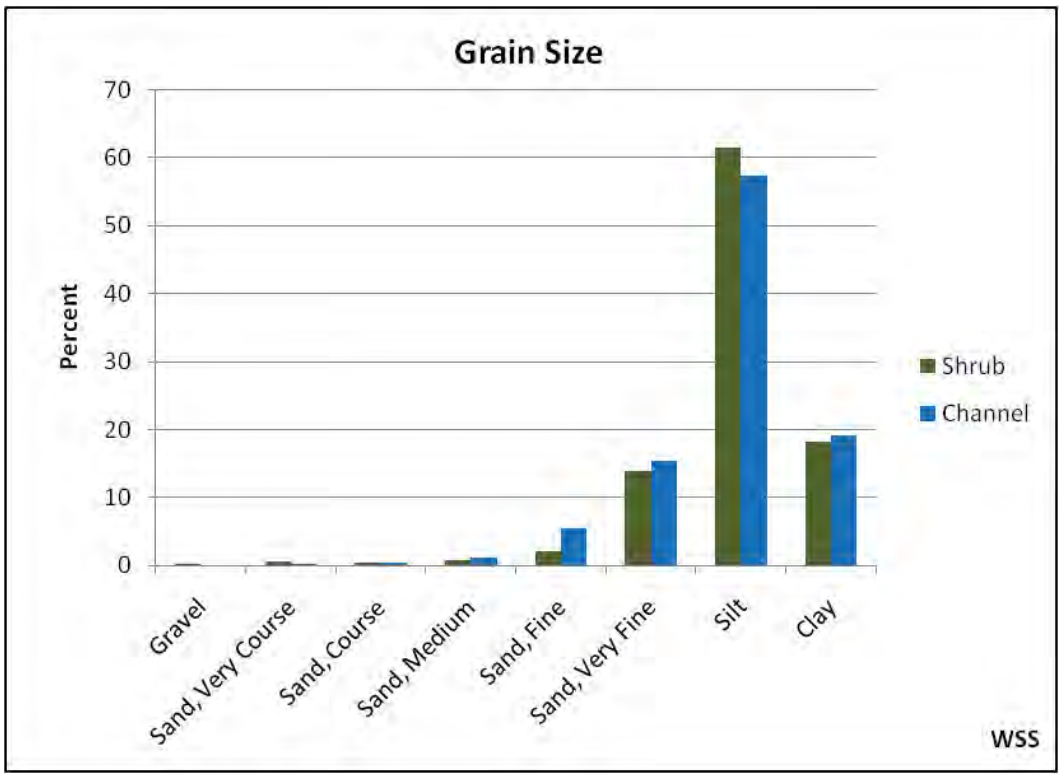
## Inundation (cont.)




## Sediment

Sediment accretion rate: 2.82 cm per year Elevation at sediment stakes: 2.63 m, CRD

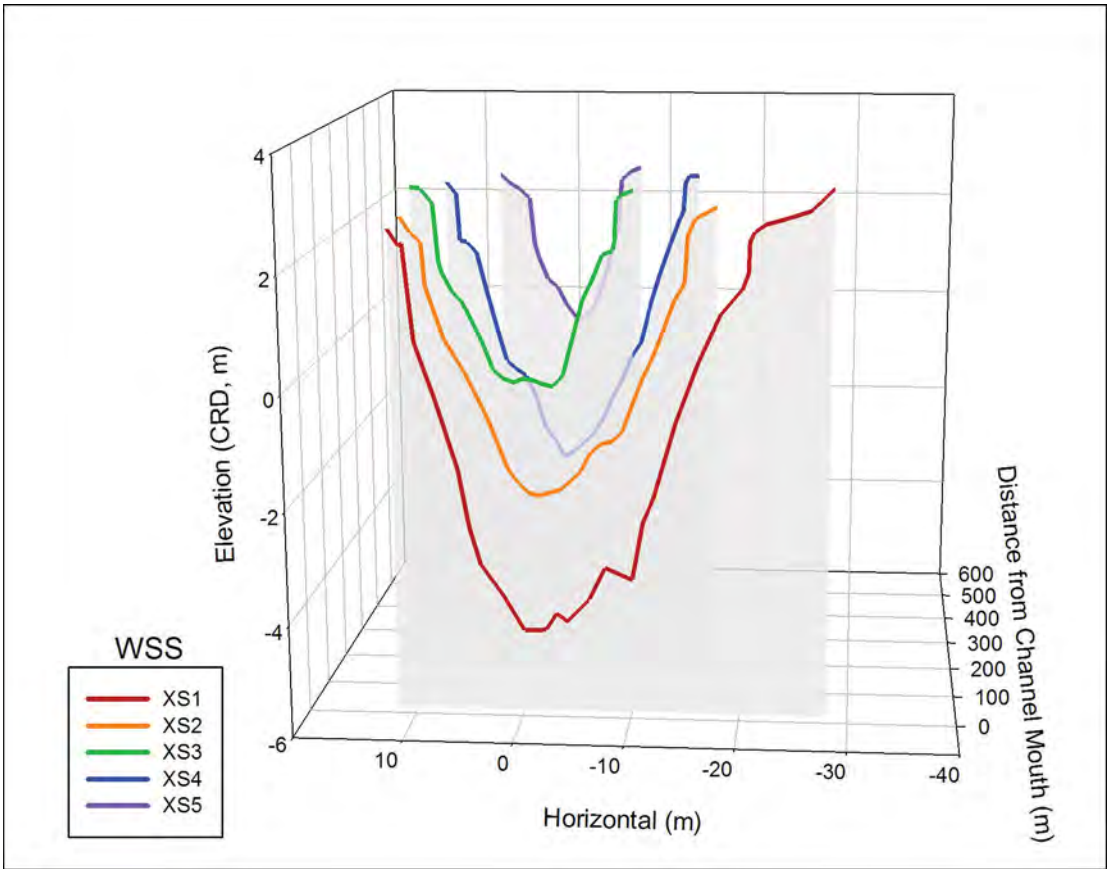
Total Organic Carbon (TOC) in channel: 4.13 in wetland: 7.47



## Channels

| | | Physical Metrics | | | | | | Inundation | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Year | | Growing Season | |
| | Cross Section | Bank Elevation (m) | Thalweg Elevation (m) | Channel Depth (m) | Cross Section Area ($m^2$) | Channel Width (m) | Width: Depth Ratio | Time WL > Thalweg (%) | Time WL > Bank (%) | Time WL > Thalweg (%) | Time WL > Bank (%) |
| WSS | 1 | 2.29 | -4.54 | 6.83 | 136.8 | 31.3 | 4.6 | 100 | 12 | 100 | 3 |
| | 2 | 1.97 | -2.66 | 4.63 | 77.3 | 25.2 | 5.5 | 100 | 24 | 100 | 12 |
| | 3 | 2.36 | -1.10 | 3.46 | 43.7 | 18.2 | 5.3 | 100 | 9 | 100 | 2 |
| | 4 | 2.28 | -2.92 | 5.20 | 73.6 | 23.5 | 4.5 | 100 | 12 | 100 | 3 |
| | 5 | 1.92 | -0.51 | 2.43 | 16.6 | 9.7 | 4.0 | 100 | 26 | 100 | 15 |

### Cross Sections



## Site Description

Hydrogeomorphic Reach: C

Coordinates (UTM, NAD83 meters):

Northing: 5109662 Easting: 478151

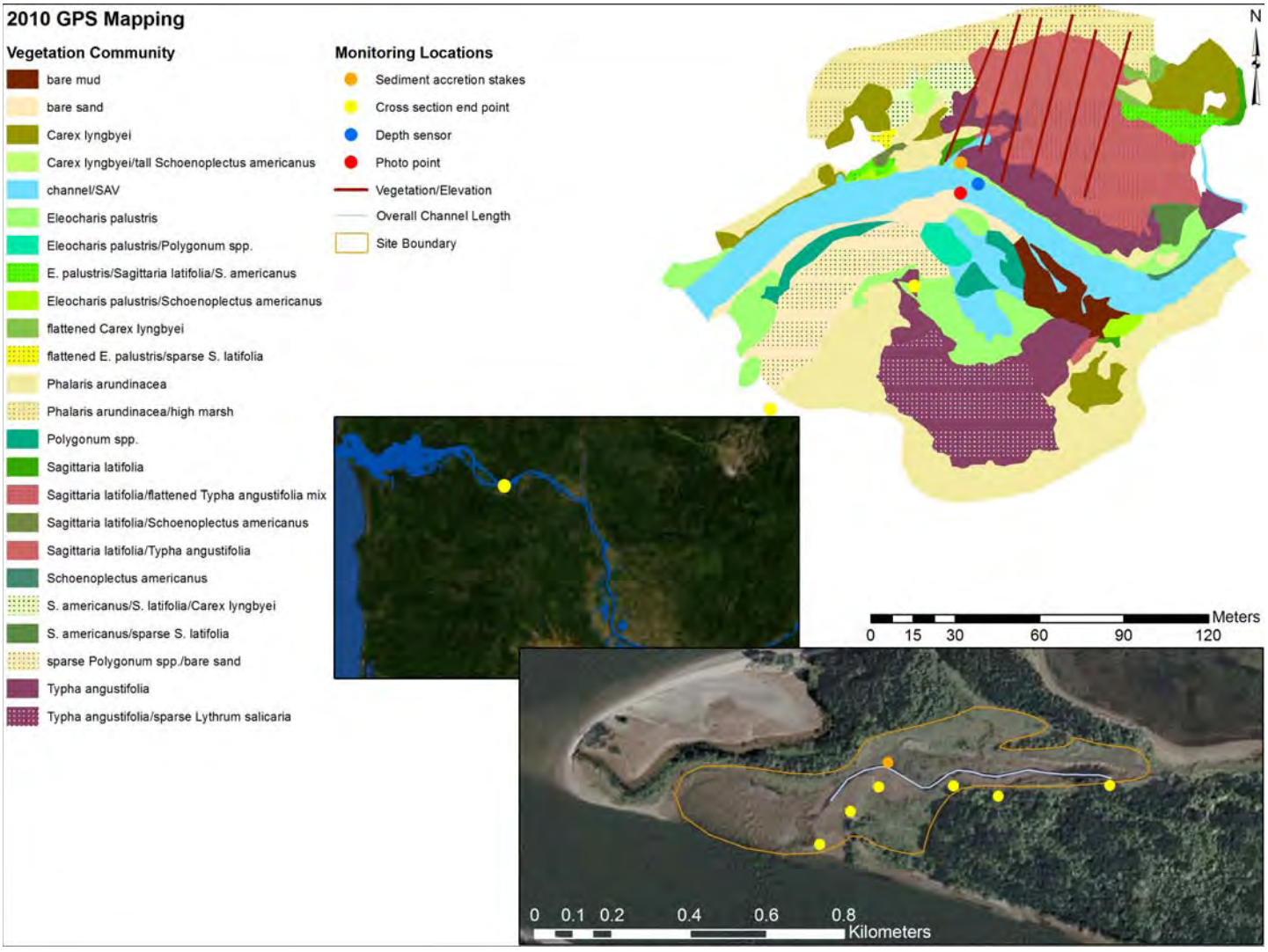
Distance from Columbia River mouth: 77 rkm

Distance from main channel: 248 meters

Type: Created

Total Site Area: 10.8 ha Study Area: 1.23 ha

Total channel length: 549 m Channel surveyed: 547 m Channel slope: 0.75 m/km



## Site Information

Wallace Island is upstream of Puget Island. While most of Wallace Island was present on the historic maps (from the 1880s), the portion of the island monitored appears to have been created adjacent to the main island with a shallow channel/slough separating it from Wallace Island. The monitoring site is along the north side of the channel and is characterized by a slight depressional area formed from a small tidal channel. Much of the vegetation in the depression was flattened, likely due to recent high tides prior to monitoring.

## Elevation

Lowest marsh (NAVD88, m): 1.34

Highest marsh (NAVD88, m): 2.92

Lowest marsh (CRD, m): 0.86

Highest marsh (CRD, m): 2.44

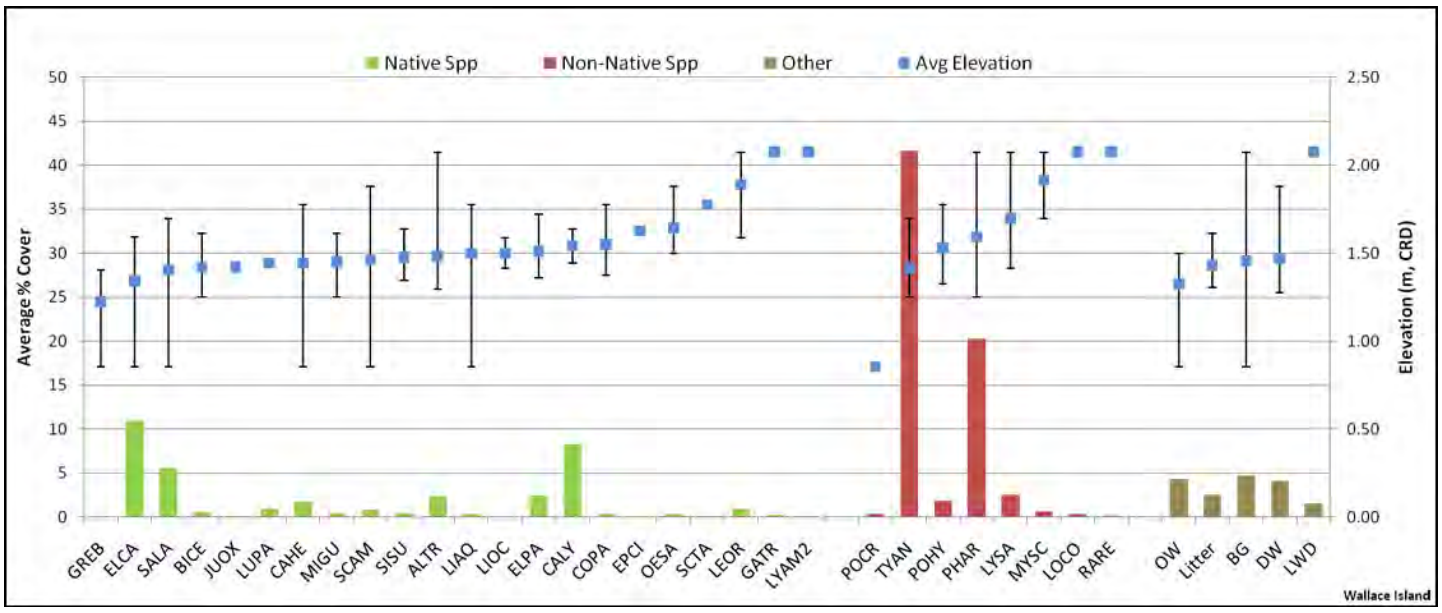
## Vegetation

Number of Native species: 22

% Native Cover: 37.66

Number of Non-native species: 8

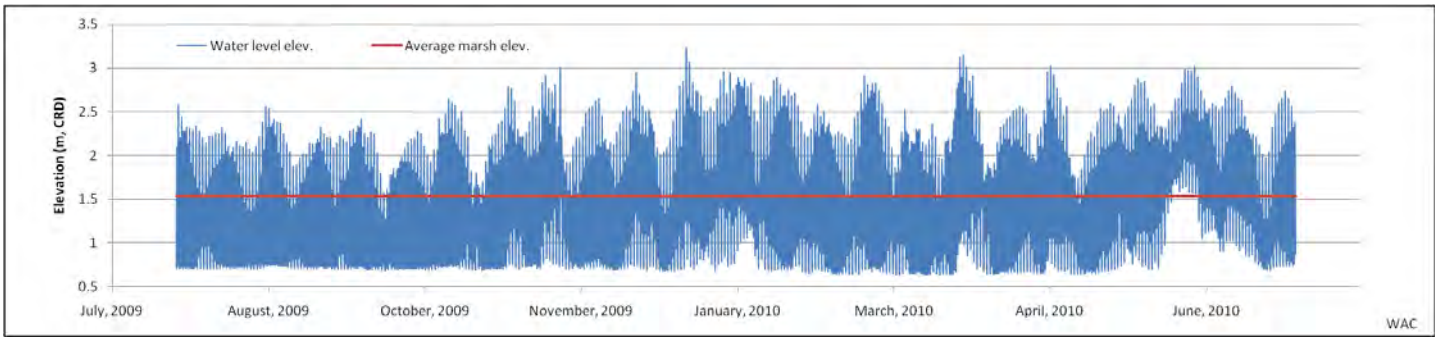
% Non-native Cover: 67.78

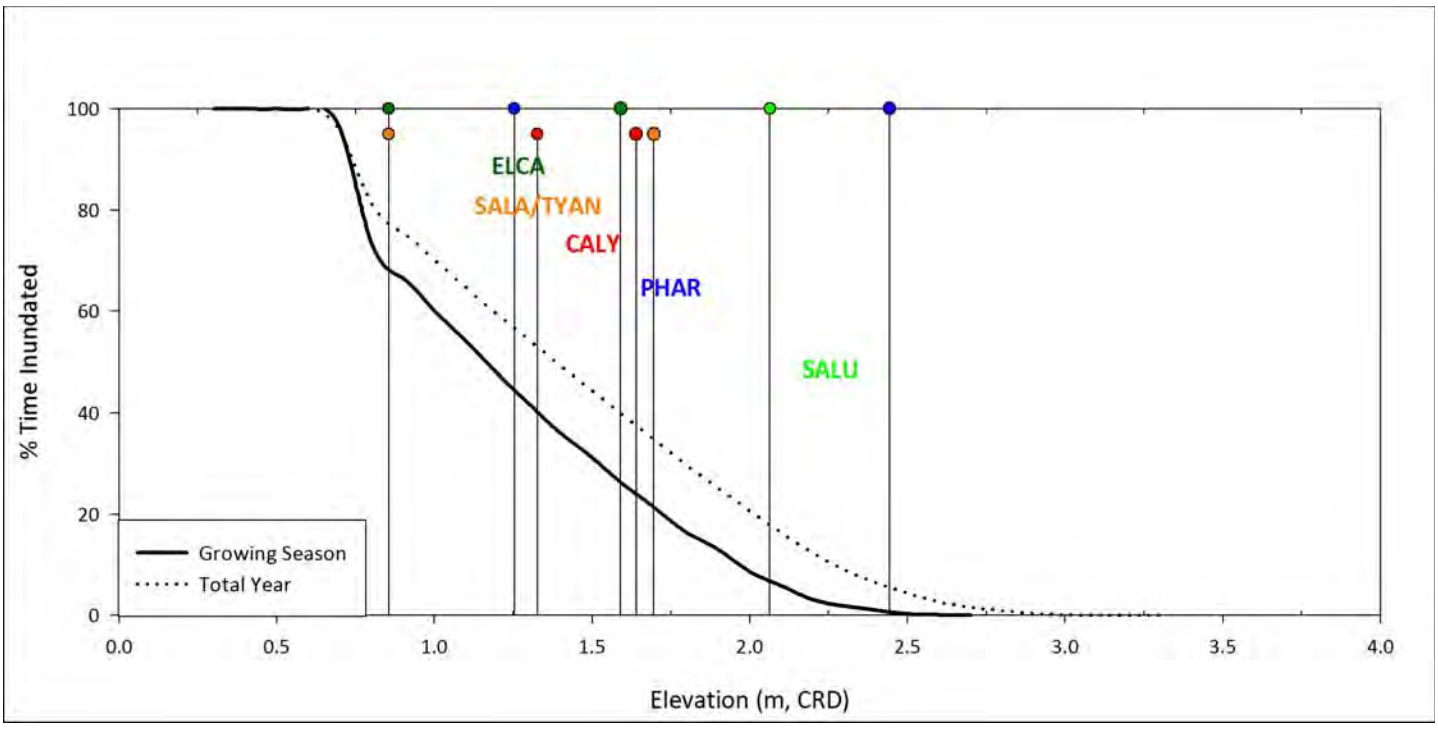


## Inundation

| | Std | Marsh |
|---|---|---|
| Average Elev (m, CRD) | 1.89 | 1.53 |
| Sum Exceedance Value (SEV) | 9.69 | 23.7 |

Modified Growing Season:
Aug 20 to Oct 12, 2009
Apr 22 to Jun 21, 2010




## Sediment

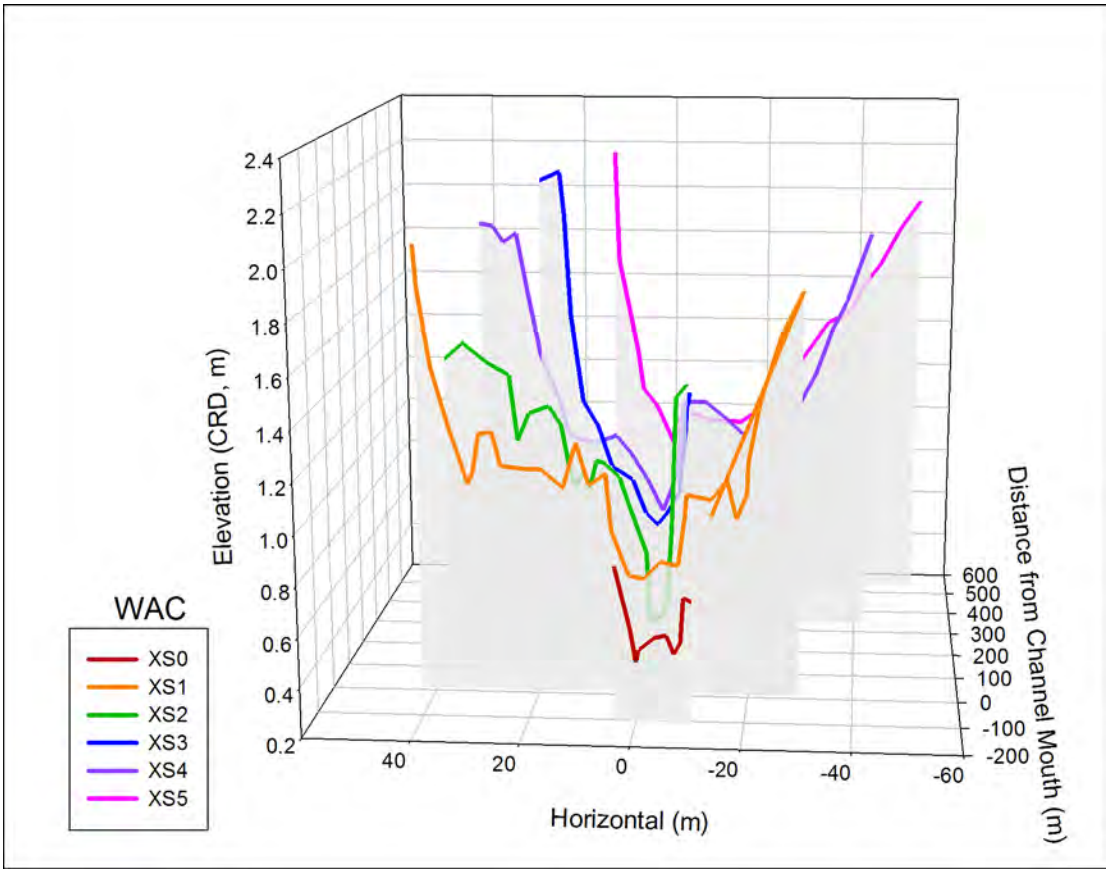
Sediment accretion rate: 1.33 cm per year

Elevation at sediment stakes: 1.36 m, CRD

## Channels

| | | Physical Metrics | | | | | | Inundation | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Year | | Growing Season | |
| | Cross Section | Bank Elevation (m) | Thalweg Elevation (m) | Channel Depth (m) | Cross Section Area ($m^2$) | Channel Width (m) | Width: Depth Ratio | Time WL > Thalweg (%) | Time WL > Bank (%) | Time WL > Thalweg (%) | Time WL > Bank (%) |
| WAC | 0 | 0.70 | 0.44 | 0.26 | 1.8 | 11.3 | 43.3 | 100 | 95 | 100 | 96 |
| | 1 | 1.83 | 0.67 | 1.16 | 51.3 | 72.1 | 62.2 | 80 | 28 | 72 | 16 |
| | 2 | 1.33 | 0.39 | 0.94 | 11.4 | 32.0 | 33.9 | 100 | 53 | 100 | 40 |
| | 3 | 1.28 | 0.71 | 0.57 | 7.5 | 21.7 | 37.9 | 78 | 55 | 70 | 43 |
| | 4 | 1.90 | 0.69 | 1.20 | 52.3 | 72.1 | 59.9 | 79 | 25 | 70 | 13 |
| | 5 | 1.42 | 0.85 | 0.57 | 14.7 | 42.6 | 75.3 | 70 | 48 | 60 | 35 |

### Cross Sections



## Site Description

Hydrogeomorphic Reach: C

Coordinates (UTM, NAD83 meters):

Northing: 5108740 Easting: 481816

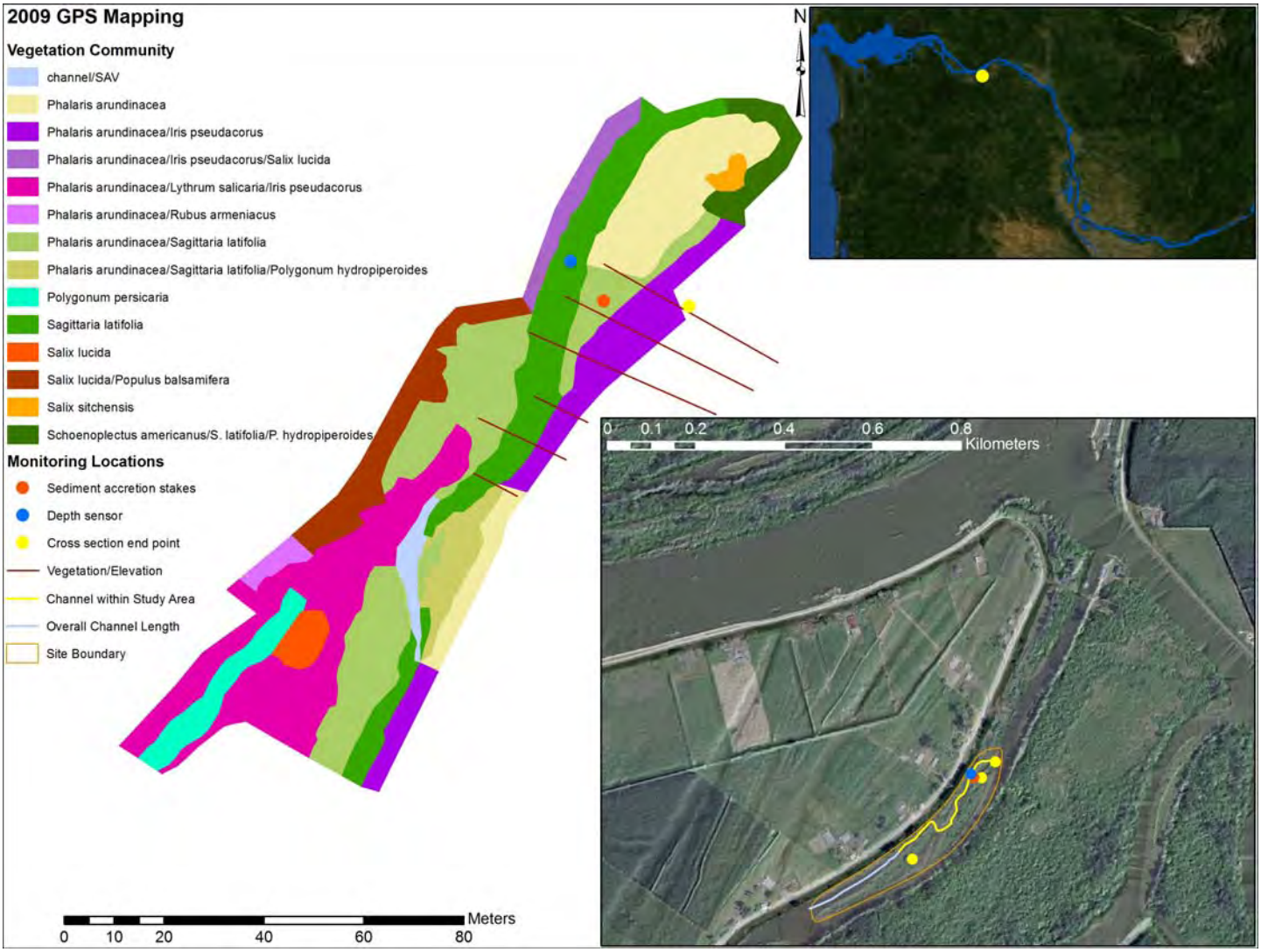
Distance from Columbia River mouth: 80 rkm

Distance from main channel: 9500 meters

Type: Marsh

Total Site Area: 4.1 ha Study Area: 0.48 ha

Total channel length: 605 m Channel surveyed: 361 m Channel slope: 1.40 m/km



## Site Information

Clatskanie River was re-channeled for flood control and transport at Anunde Island in the early 1900s leaving an oxbow channel slowly filling with sediment. The emergent marsh formed here grades up to a dike road. This site is near a tidal reconnection project between the Clatskanie River and Westport Slough.

## Elevation

Lowest marsh (NAVD88, m): 1.38

Highest marsh (NAVD88, m): 2.83

Lowest marsh (CRD, m): 0.87

Highest marsh (CRD, m): 2.32

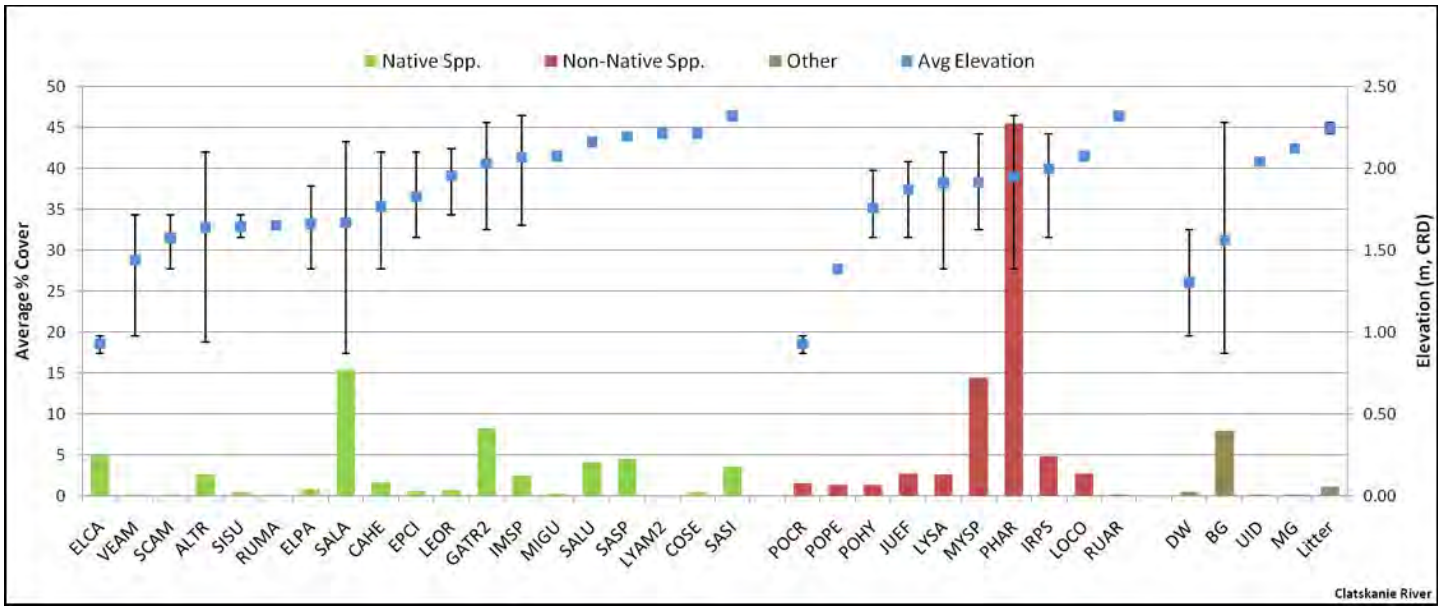
## Vegetation

Number of Native species: 19

% Native Cover: 51.59

Number of Non-native species: 11

% Non-native Cover: 77.32



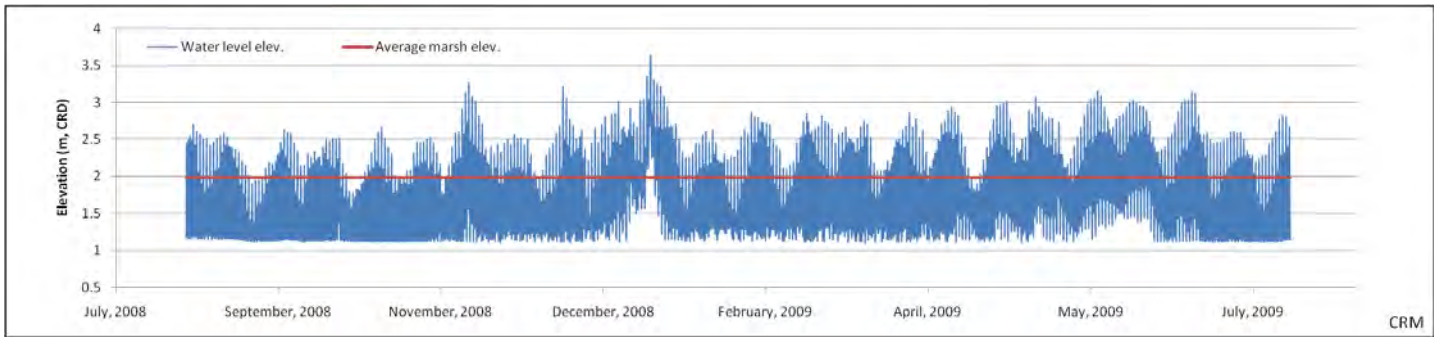

## Inundation

| | Std | Marsh |
|---|---|---|
| Average Elev (m, CRD) | 1.89 | 1.98 |
| Sum Exceedance Value (SEV) | 16.8 | 13.3 |

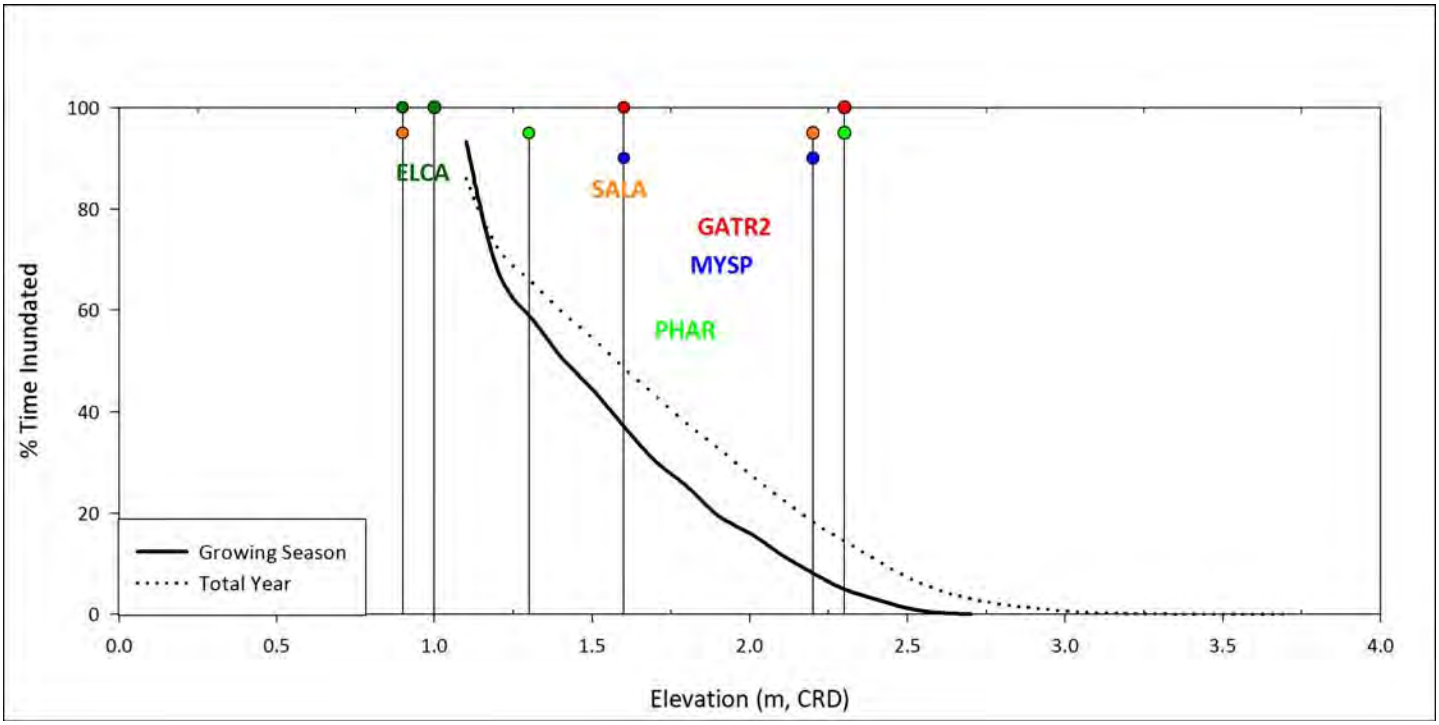
Modified Growing Season:

Aug 20 to Oct 12, 2008

Apr 22 to Jun 21, 2009



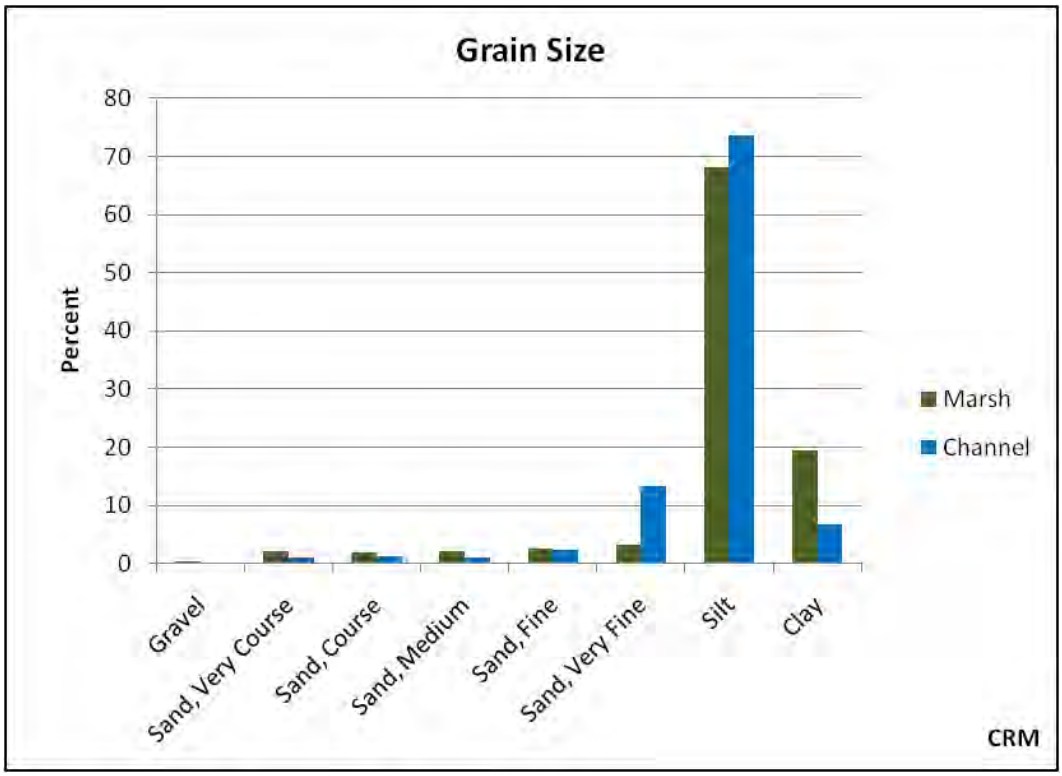
## Inundation (cont.)




## Sediment

Sediment accretion rate: -1.12 cm per year Elevation at sediment stakes: 2.17 m, CRD

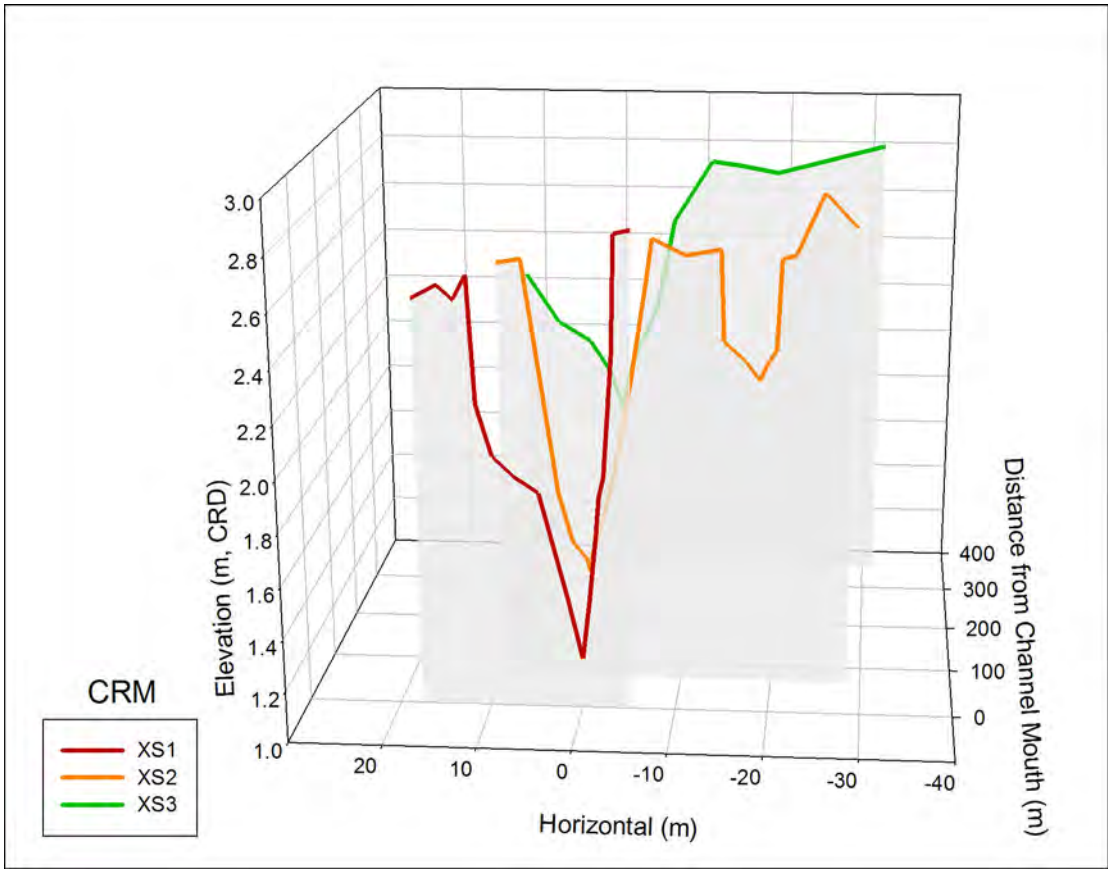
Total Organic Carbon (TOC) in channel: 2.42 in wetland: 3.89



## Channels

| | | Physical Metrics | | | | | | Inundation | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Year | | Growing Season | |
| | Cross Section | Bank Elevation (m) | Thalweg Elevation (m) | Channel Depth (m) | Cross Section Area ($m^2$) | Channel Width (m) | Width: Depth Ratio | Time WL > Thalweg (%) | Time WL > Bank (%) | Time WL > Thalweg (%) | Time WL > Bank (%) |
| CRM | 1 | 2.14 | 0.69 | 1.46 | 12.9 | 15.2 | 10.4 | 86 | 21 | 93 | 10 |
| | 2 | 2.12 | 0.92 | 1.19 | 14.1 | 16.2 | 13.5 | 86 | 22 | 93 | 11 |
| | 3 | 1.47 | 1.19 | 0.28 | 0.7 | 6.3 | 22.4 | 63 | 56 | 56 | 46 |

### Cross Sections



## Site Description

Hydrogeomorphic Reach: C

Coordinates (UTM, NAD83 meters):

Northing: 5114355 Easting: 488466

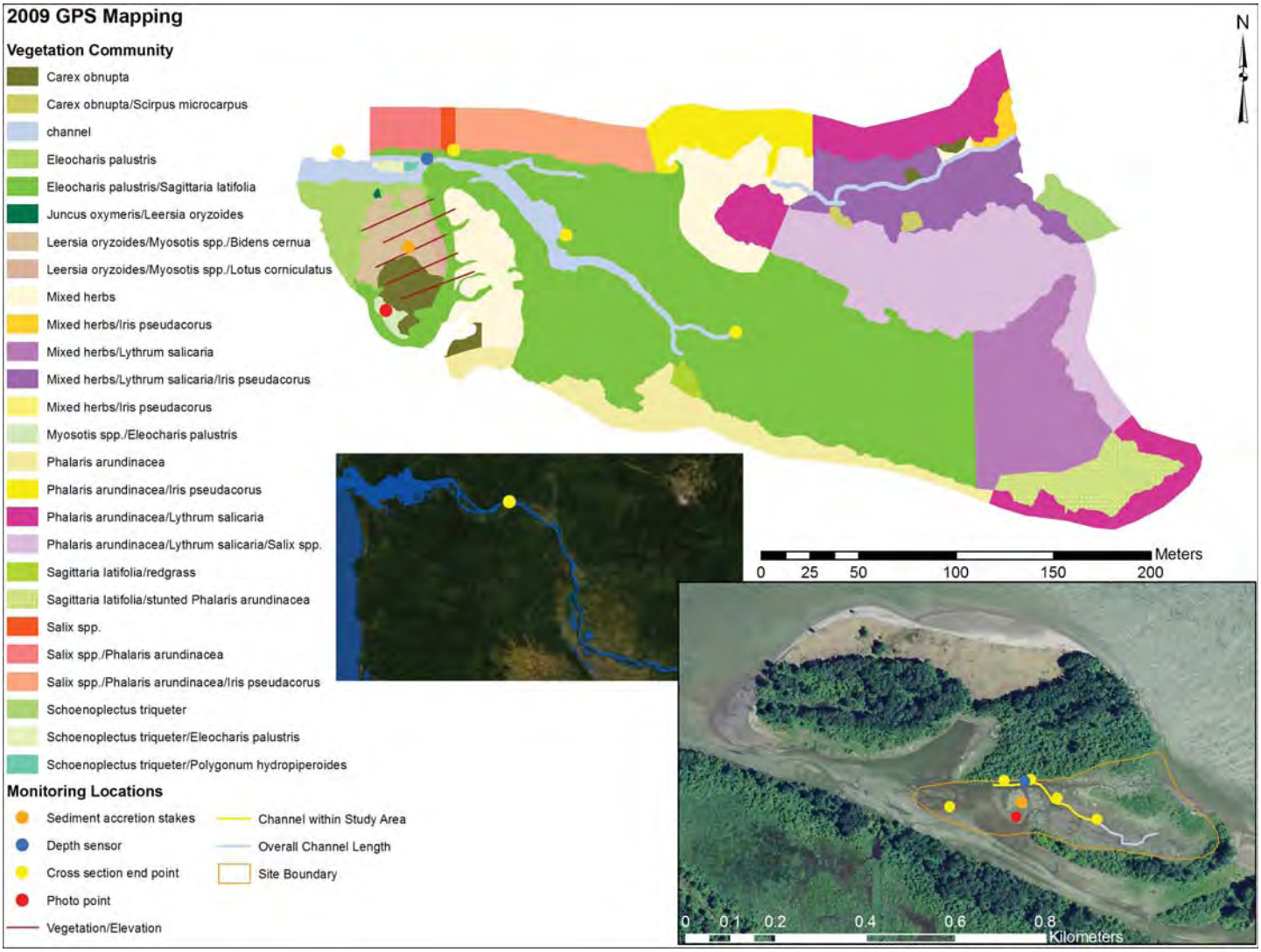
Distance from Columbia River mouth: 89 rkm

Distance from main channel: 30 meters

Type: Created

Total Site Area: 9.2 ha Study Area: 3.89 ha

Total channel length: 432 m Channel surveyed: 265 m Channel slope: 3.66 m/km



## Site Information

Gull lsland is an island partially created from dredge material. The island is a main channel site located near Crims Island and was the reference site for the US Army Corps of Engineers sponsored restoration work that occurred on Crims Island in 2005. The marsh monitoring site is a low elevation flow-through area between 2 uplands areas.

## Elevation

Lowest marsh (NAVD88, m): 1.69

Highest marsh (NAVD88, m): 2.62

Lowest marsh (CRD, m): 1.03

Highest marsh (CRD, m): 1.96

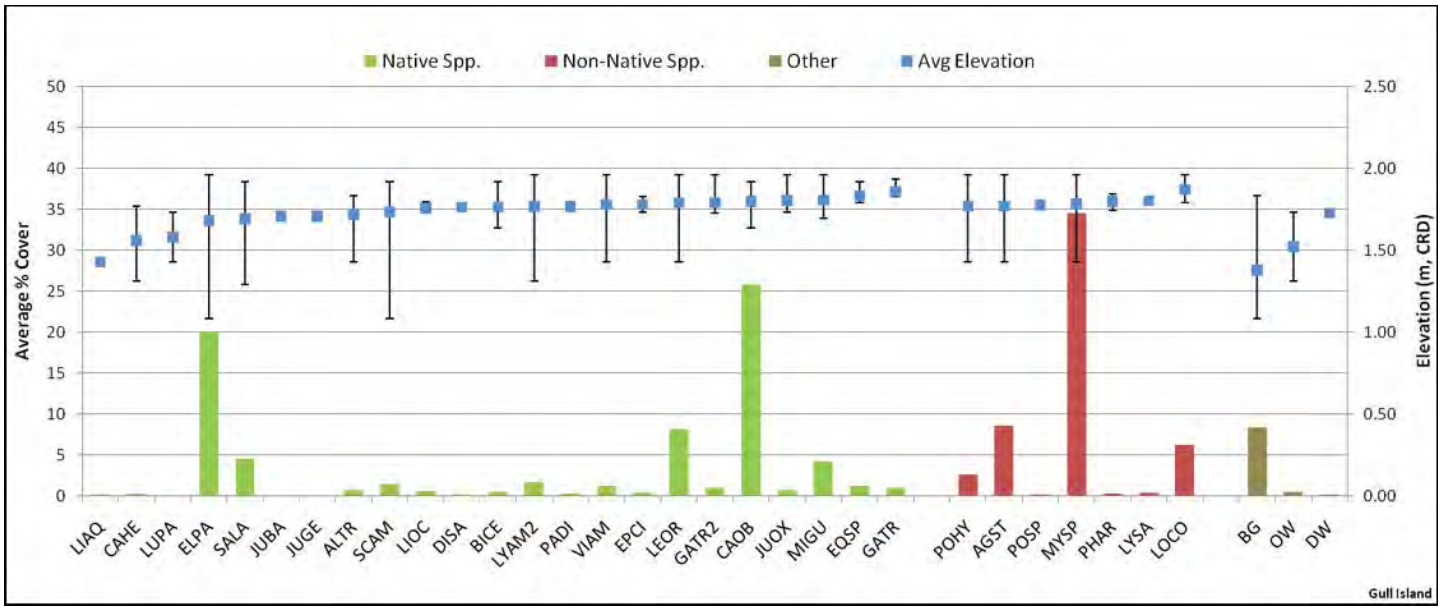
## Vegetation

Number of Native species: 23

% Native Cover: 74.60

Number of Non-native species: 7

% Non-native Cover: 52.77



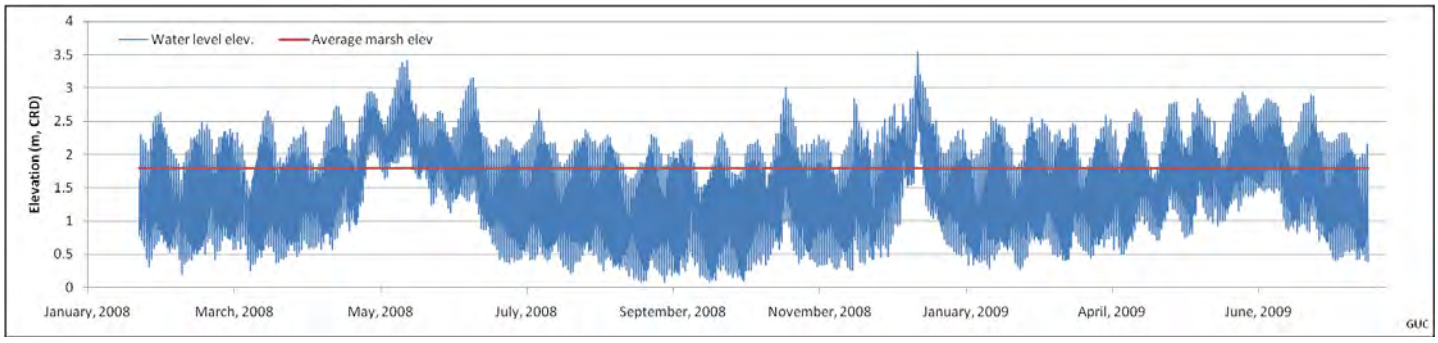

## Inundation

| | Std | Marsh |
|---|---|---|
| Average Elev (m, CRD) | 1.89 | 1.80 |
| Sum Exceedance Value (SEV) | 10.2 | 13.1 |

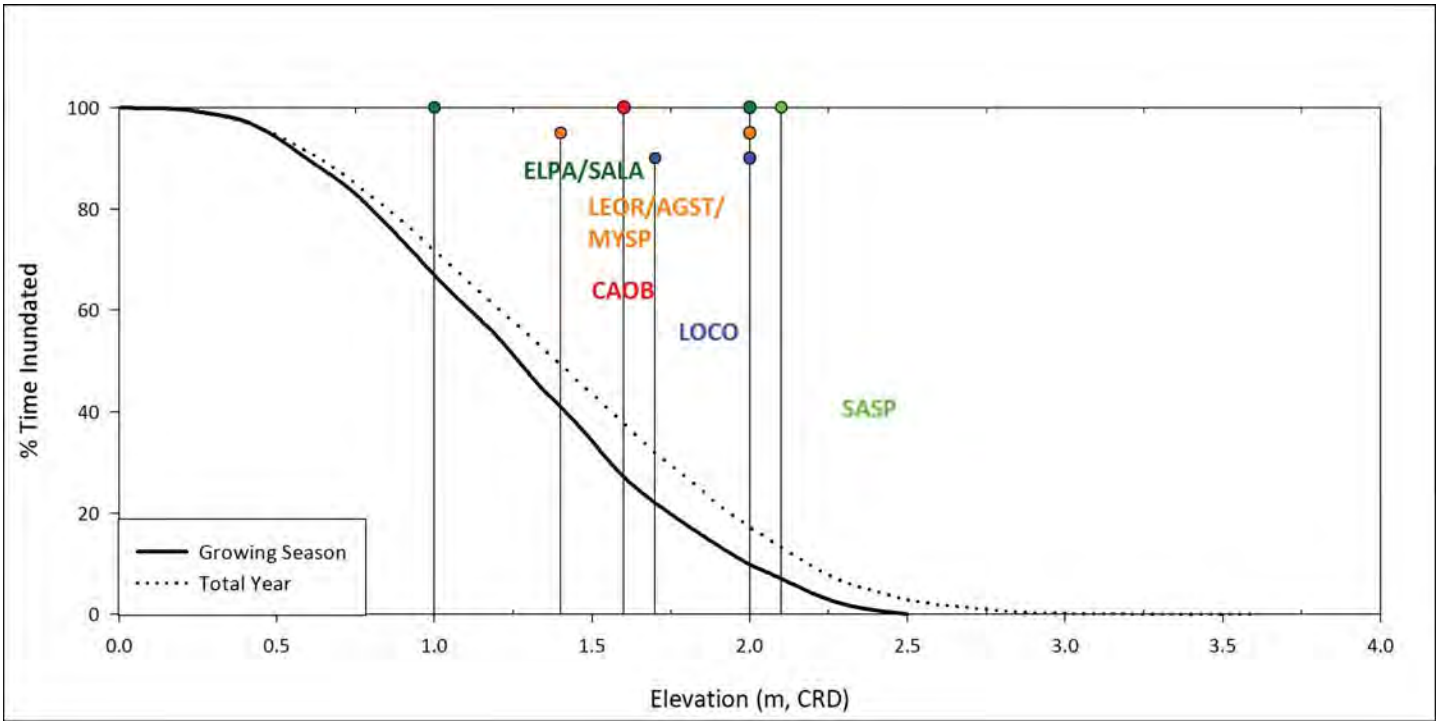
Modified Growing Season:

Aug 20 to Oct 12, 2008

Apr 22 to Jun 21, 2009



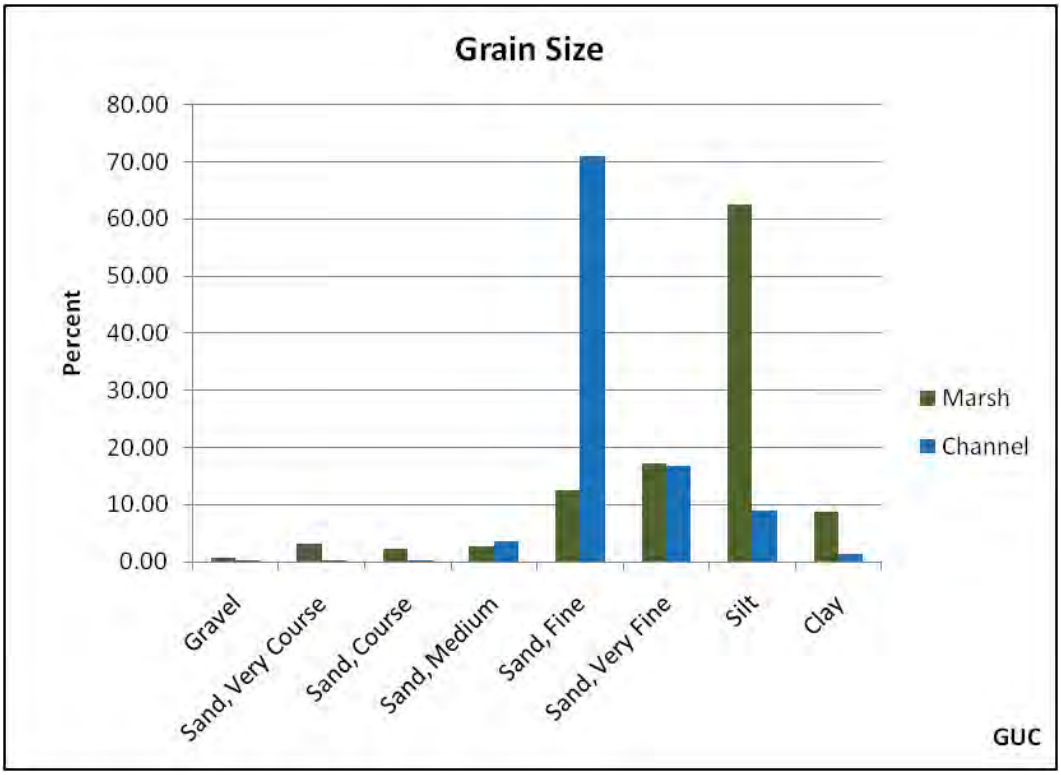
## Inundation (cont.)




## Sediment

Sediment accretion rate: 0.37 cm per year Elevation at sediment stakes: 1.86 m, CRD

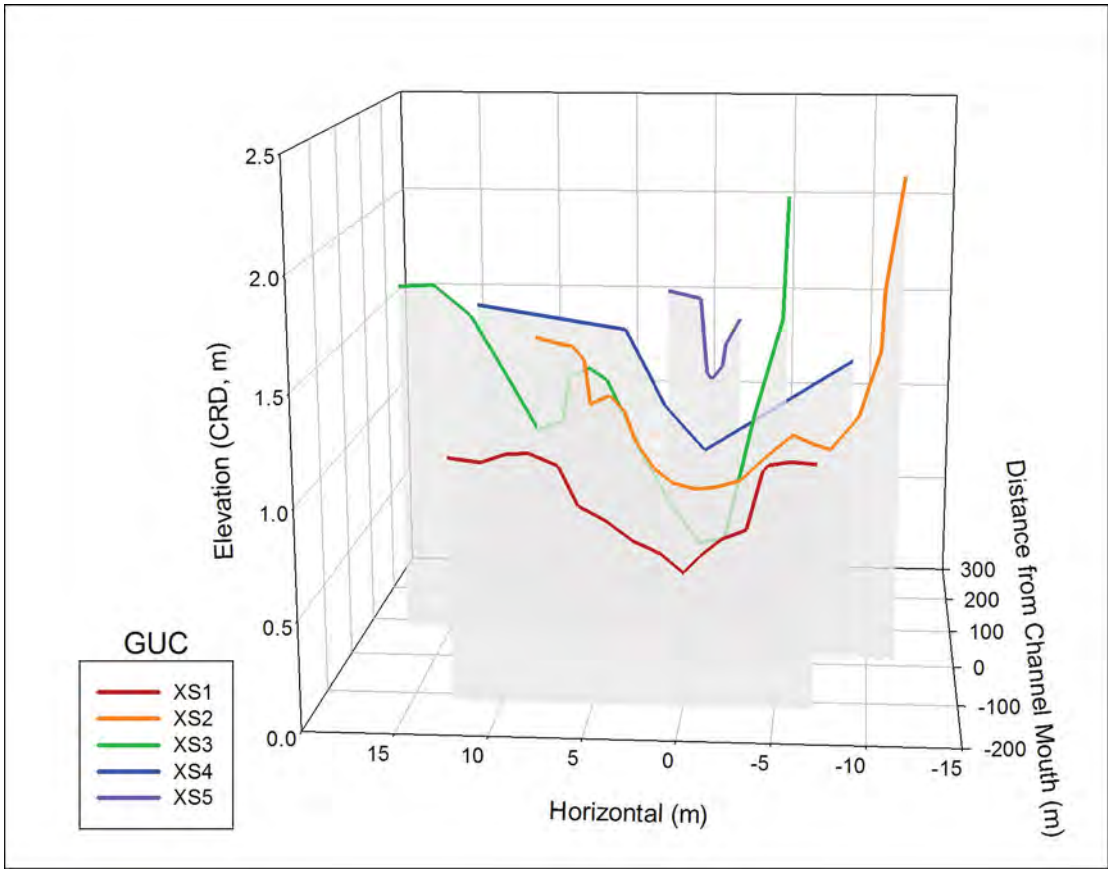
Total Organic Carbon (TOC) in channel: 0.36 in wetland: 4.03



## Channels

| | | Physical Metrics | | | | | | Inundation | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Year | | Growing Season | |
| | Cross Section | Bank Elevation (m) | Thalweg Elevation (m) | Channel Depth (m) | Cross Section Area ($m^2$) | Channel Width (m) | Width: Depth Ratio | Time WL > Thalweg (%) | Time WL > Bank (%) | Time WL > Thalweg (%) | Time WL > Bank (%) |
| GUC | 1 | 1.09 | 0.62 | 0.46 | 3.1 | 11.0 | 23.6 | 84 | 67 | 81 | 62 |
| | 2 | 1.41 | 0.80 | 0.61 | 6.8 | 16.6 | 27.4 | 75 | 49 | 71 | 40 |
| | 3 | 1.56 | 0.45 | 1.10 | 10.1 | 18.3 | 16.6 | 91 | 40 | 90 | 30 |
| | 4 | 1.28 | 0.81 | 0.46 | 3.1 | 12.9 | 27.8 | 74 | 56 | 70 | 49 |
| | 5 | 1.24 | 1.06 | 0.18 | 0.2 | 1.3 | 7.3 | 60 | 58 | 54 | 52 |

## Cross Sections



## Site Description

Hydrogeomorphic Reach: C

Coordinates (UTM, NAD83 meters):

Northing: 5113047 Easting: 496812

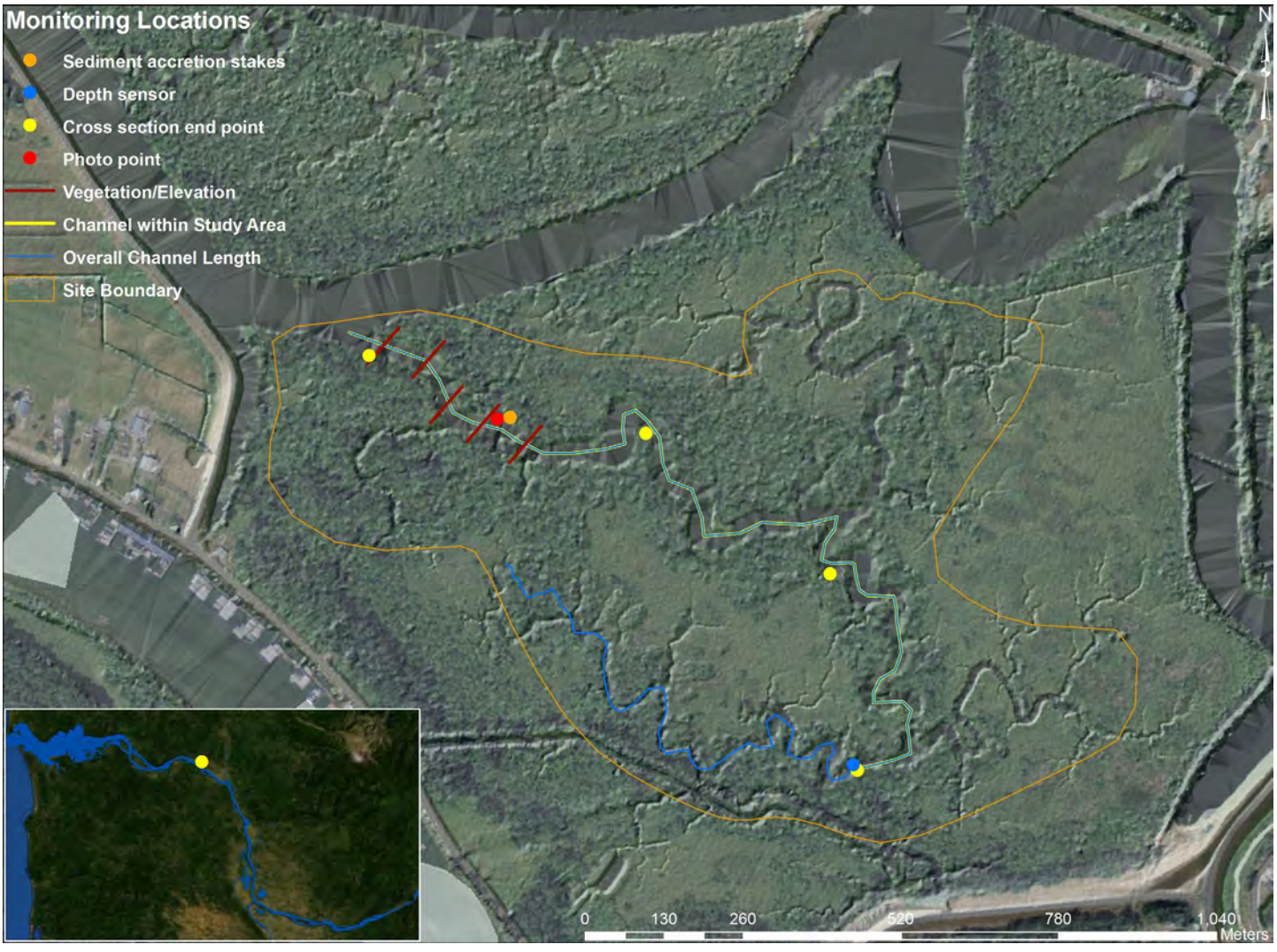
Distance from Columbia River mouth: 98 rkm

Distance from main channel: 5959 meters

Type: Riparian Wetland

Total Site Area: 80.8 ha Study Area: 5.23 ha

Total channel length: 2877 m Channel surveyed: 1738 m Channel slope: 1.03 m/km



## Site Information

Coal Creek, located in Washington, is a small tributary to the Columbia River near Longview. The Coal Creek site encompassed the riparian areas on both sides of a channel that inputs into Coal Creek Slough, ~ 6 km from the confluence with the Columbia River. The site is owned by the Columbia Land Trust.

## Elevation

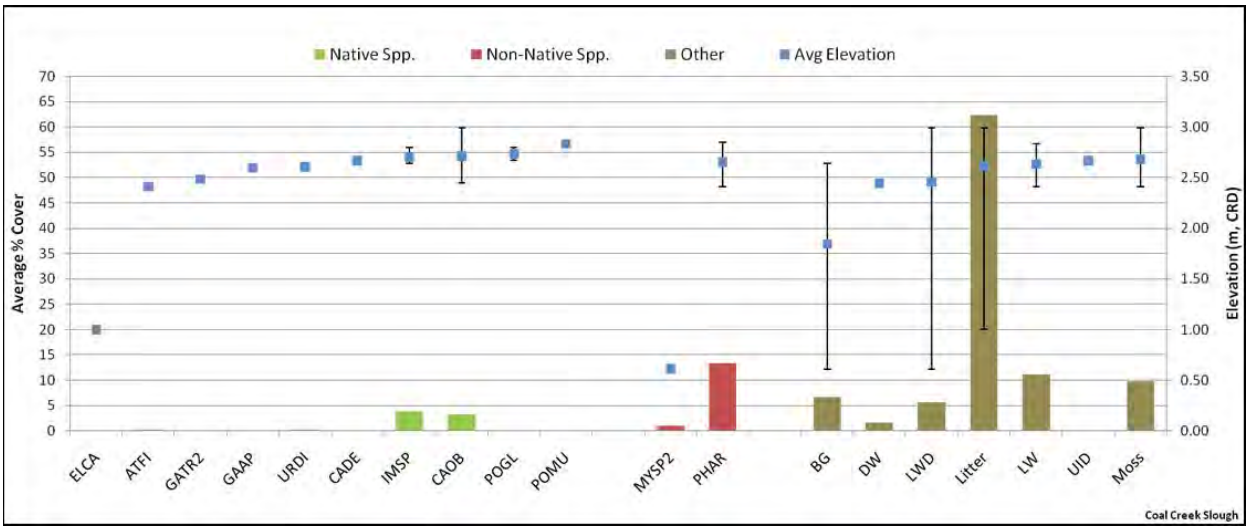
| | Herb | | Shrub | | Tree | |
|---|---|---|---|---|---|---|
| | Lowest | Highest | Lowest | Highest | Lowest | Highest |
| CRD, m | 2.41 | 2.99 | 1.81 | 3.14 | 1.81 | 3.14 |
| NAVD88, m | 3.20 | 3.78 | 2.60 | 3.93 | 2.60 | 3.93 |

## Vegetation

| | Herb | Shrub | Tree |
|---|---|---|---|
| Number of Native Species | 10 | 11 | 7 |
| % Cover Native Species | 7.9 | 53.65 | NA |
| Number of Non-native Species | 2 | 0 | 0 |
| % Cover Non-native Species | 14.33 | 0 | NA |

| Species | Density Stems/ha | Relative Frequency % | Relative Density % | Relative Dominance % | Elevation (m, CRD) Min | Max |
|---|---|---|---|---|---|---|
| Coal Creek Slough | | | | | | |
| ALRU | 5 | 1.6 | 0.2 | 0.1 | 2.73 | 2.73 |
| COCO | 61 | 1.6 | 2.0 | 0.1 | 2.59 | 2.59 |
| CRDO | 203 | 4.8 | 6.7 | 0.1 | 1.81 | 2.60 |
| FRLA | 278 | 28.6 | 9.2 | 23.2 | 2.38 | 3.13 |
| MAFU | 769 | 20.6 | 25.4 | 2.1 | 1.81 | 3.14 |
| POBA | 1660 | 25.4 | 54.9 | 57.2 | 1.81 | 2.93 |
| PREM | 0 | 1.6 | 0.0 | 0.4 | 2.48 | 2.48 |
| Snag | 47 | 9.5 | 1.6 | 16.8 | 2.41 | 3.13 |
| No trees | na | 6.3 | na | na | na | na |

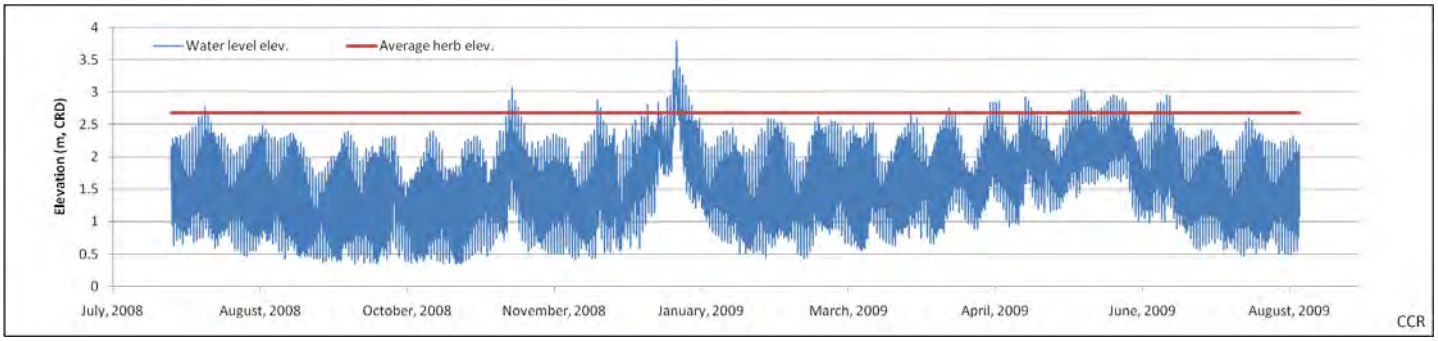
| Species | Density (stems/ha) | Cover (%) |
|---|---|---|
| COSE | 1765 | 18.5 |
| CRDO | 1412 | 2.4 |
| LOIN | 1706 | 4.4 |
| RONU | 4706 | 6.9 |
| ROPI | 118 | 0.1 |
| RUUR | 38706 | 6.5 |
| SPDO | 2706 | 5.2 |
| SYAL | 13176 | 7.8 |
| COSE | 1765 | 18.5 |
| RILA | 1412 | 2.4 |
| RUAR | 1706 | 4.4 |
| RUSP | 4706 | 6.9 |
| RUUR | 118 | 0.1 |
| SARA | 38706 | 6.5 |
| SYAL | 2706 | 5.2 |

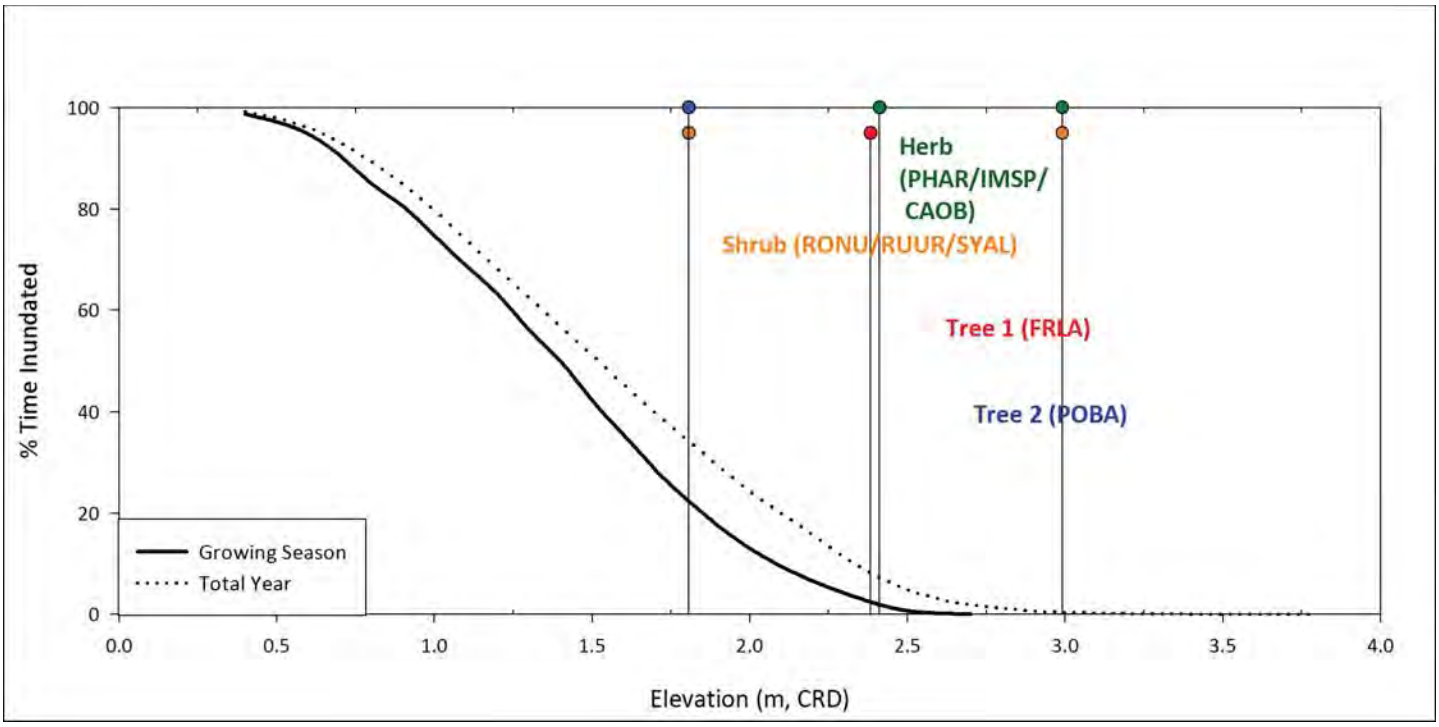


## Inundation

| | Std | Herb | Shrub | Tree |
|---|---|---|---|---|
| Average Elev (m, CRD) | 1.89 | 2.68 | 2.77 | 2.58 |
| Sum Exceedance Value (SEV) | 15.6 | 0.39 | 0.16 | 0.81 |

Modified Growing Season:
Aug 20 to Oct 12, 2008
Apr 22 to Jun 21, 2009




## Sediment

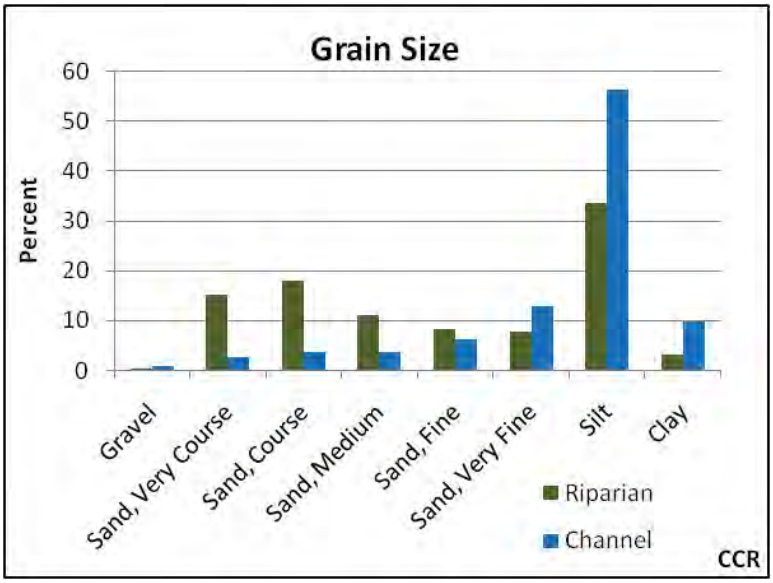
Sediment accretion rate: 0.84 cm per year

Elevation at sediment stakes: 2.85 m, CRD

Total Organic Carbon (TOC)

in channel: 3.05

in wetland: 4.29

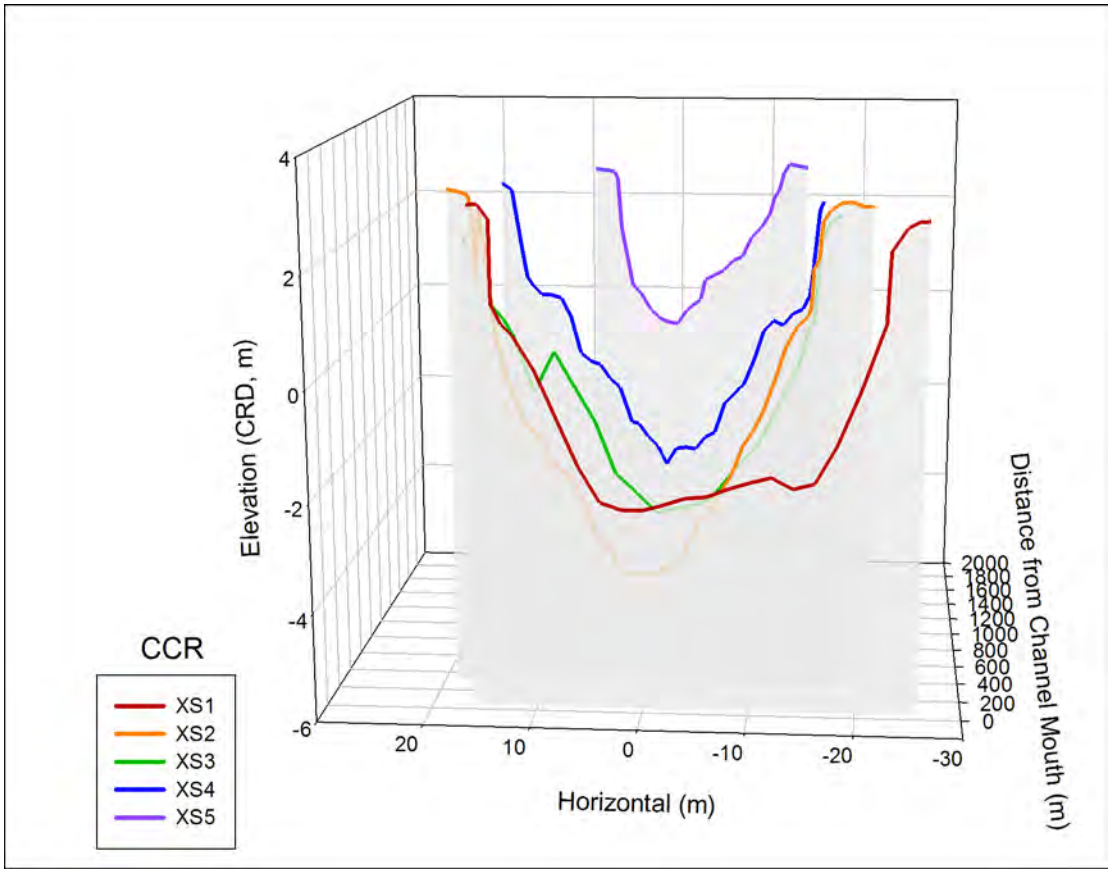


## Channels

| | | Physical Metrics | | | | | | Inundation | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Year | | Growing Season | |
| | Cross Section | Bank Elevation (m) | Thalweg Elevation (m) | Channel Depth (m) | Cross Section Area ($m^2$) | Channel Width (m) | Width: Depth Ratio | Time WL > Thalweg (%) | Time WL > Bank (%) | Time WL > Thalweg (%) | Time WL > Bank (%) |
| CCR | 1 (mouth) | 2.86 | -2.31 | 5.17 | 151.1 | 39.1 | 7.6 | 99 | 1 | 99 | 0 |
| | 2 | 2.98 | -3.88 | 6.86 | 153.3 | 34.9 | 5.1 | 99 | 0 | 99 | 0 |
| | 3 | 2.08 | -3.11 | 5.19 | 116.5 | 34.9 | 6.7 | 99 | 21 | 99 | 10 |
| | 4 | 2.25 | -2.83 | 5.08 | 96.9 | 31.3 | 6.2 | 99 | 14 | 99 | 5 |
| | 5 | 2.63 | -0.53 | 3.15 | 37.4 | 18.5 | 5.9 | 99 | 3 | 99 | 0 |

NOTE: The thalweg in this channel was likely inundated 100%, however the sensor, located in the upper part of the Slough, was exposed 1% of the time.

## Cross Sections



## Site Description

Hydrogeomorphic Reach: C

Coordinates (UTM, NAD83 meters):

Northing: 5109036 Easting: 497840

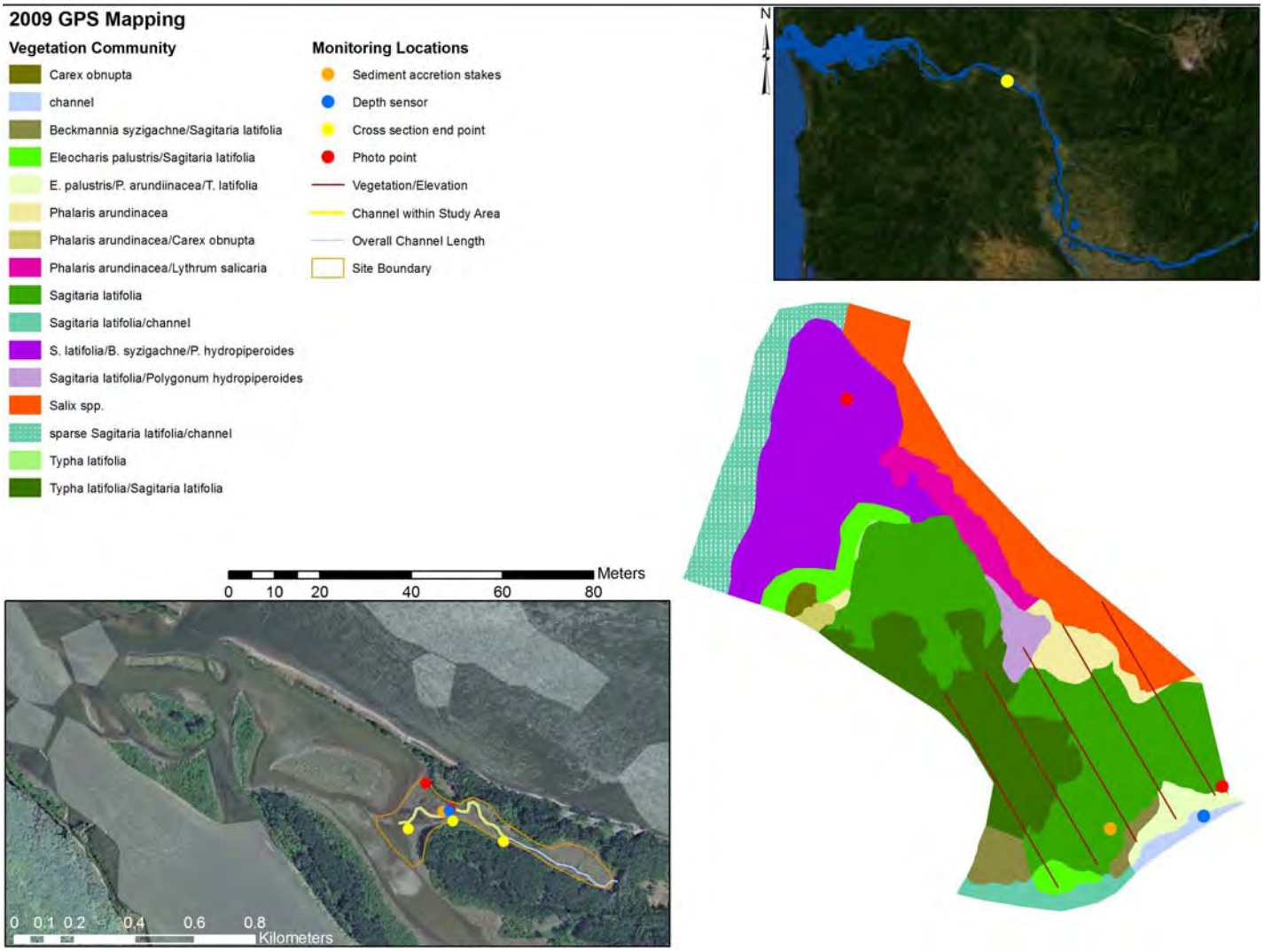
Distance from Columbia River mouth: 100 rkm

Distance from main channel: 1316 meters

Type: Created

Total Site Area: 7.7 ha Study Area: 0.72 ha

Total channel length: 910 m Channel surveyed: 484 m Channel slope: -0.05 m/km



## Site Information

Lord Island is near Longview, Washington and is owned by Columbia Land Trust. The island was not present on historic maps (from the 1880s) and has a history of dredge material placement. The interior of the island has an extensive area of shallow water, mudflats, and emergent wetlands. The study site is located on the interior of the island and is connected to the River through a series of very shallow channels and flats.

## Elevation

Lowest marsh (NAVD88, m): 1.85

Highest marsh (NAVD88, m): 2.68

Lowest marsh (CRD, m): 1.04

Highest marsh (CRD, m): 1.87

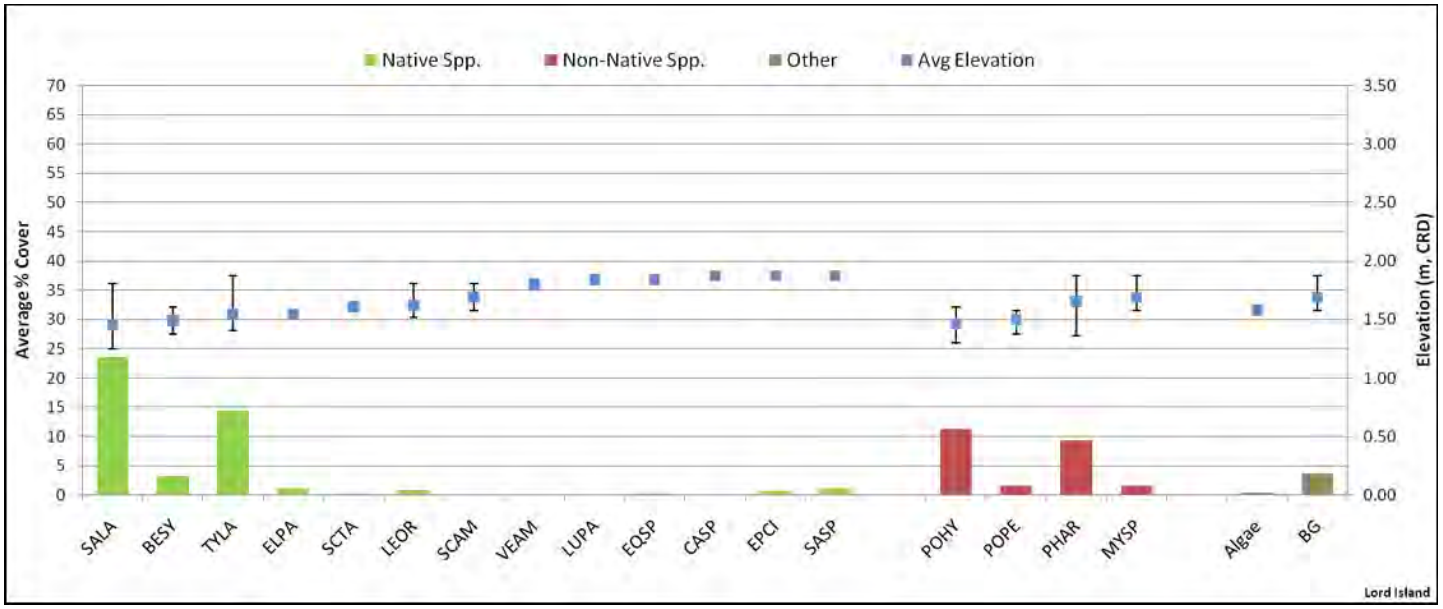
## Vegetation

Number of Native species: 13

% Native Cover: 45.78

Number of Non-native species: 4

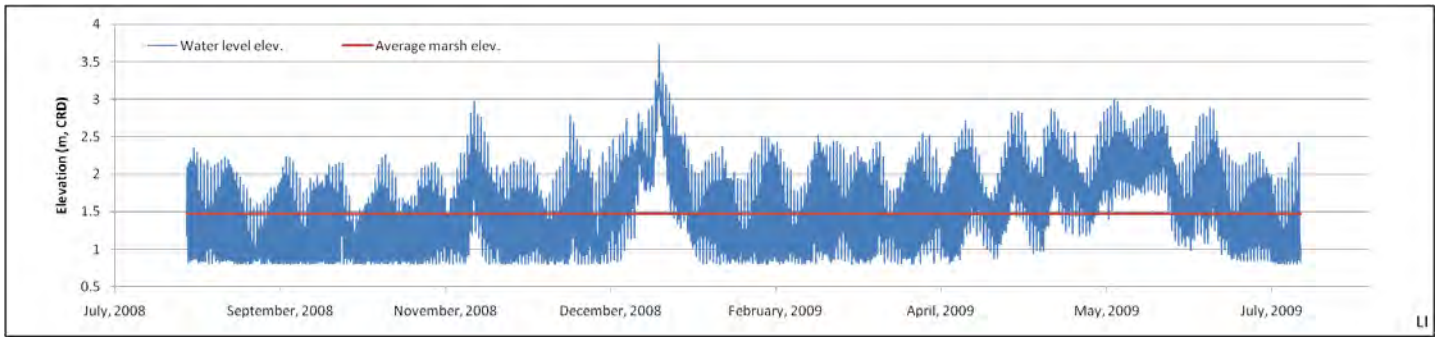
% Non-native Cover: 23.74

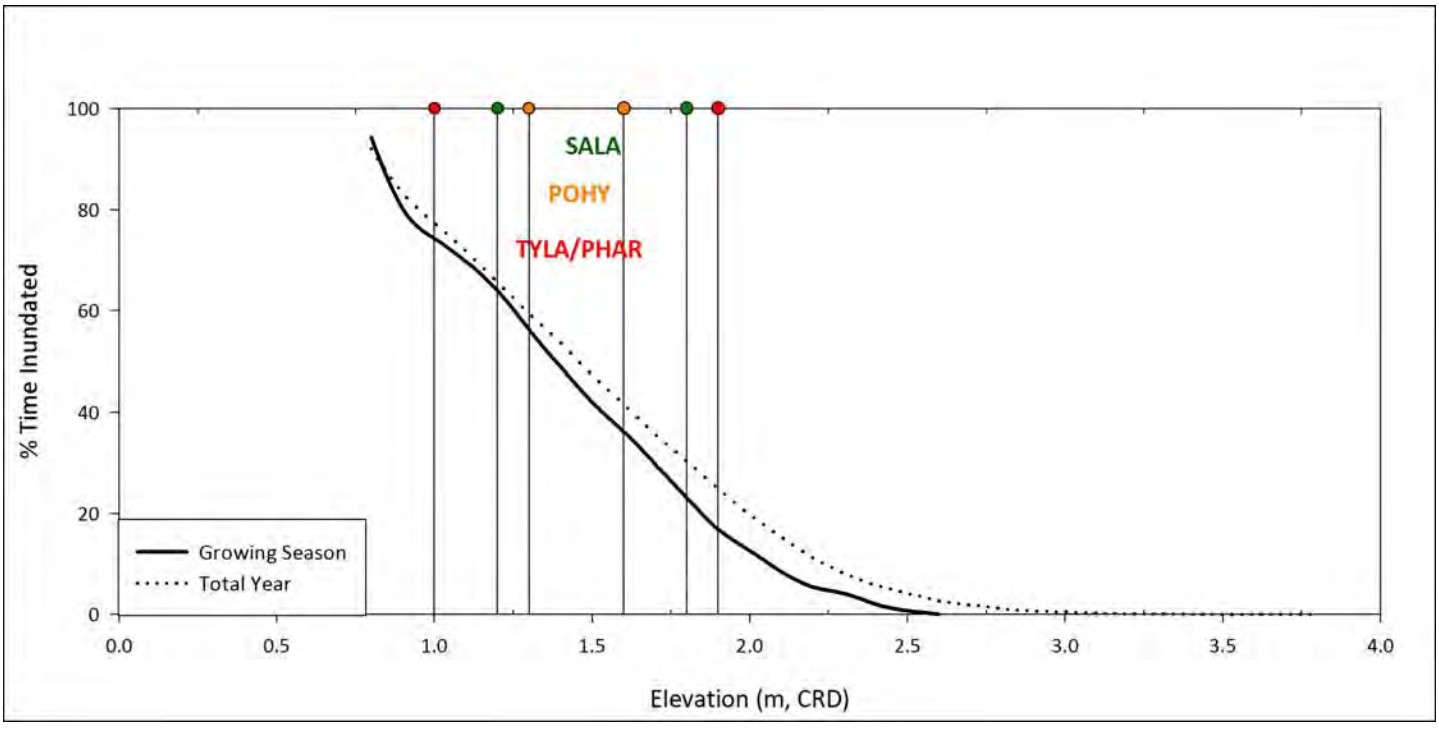


## Inundation

| | Std | Marsh |
|---|---|---|
| Average Elev (m, CRD) | 1.89 | 1.47 |
| Sum Exceedance Value (SEV) | 12.8 | 35.0 |

Modified Growing Season:
Aug 20 to Oct 12, 2008
Apr 22 to Jun 21, 2009

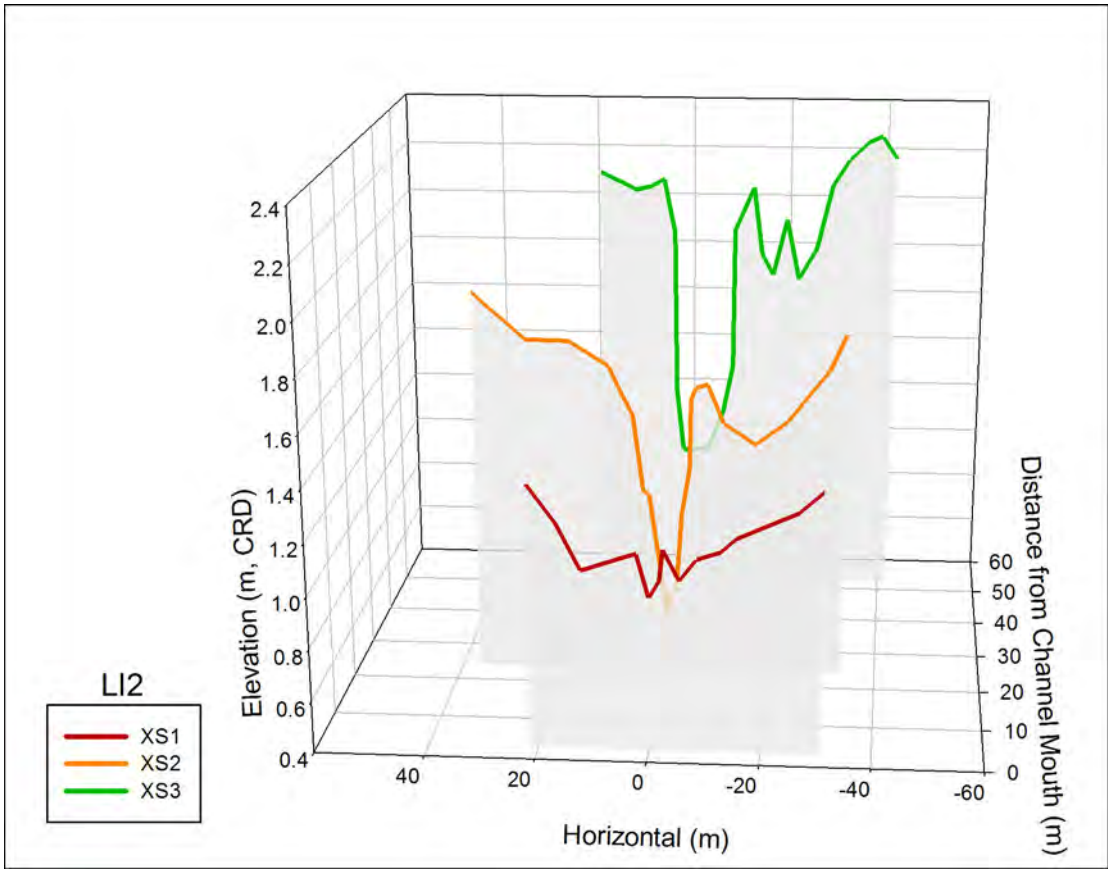


## Channels

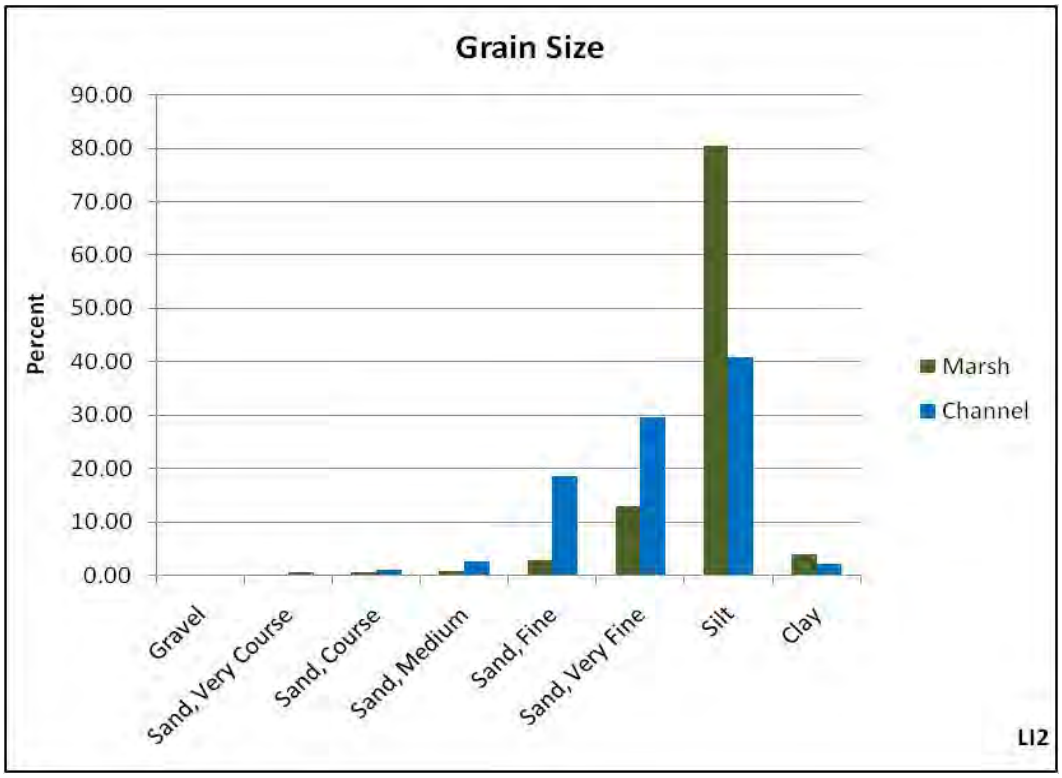
| | | Physical Metrics | | | | | | Inundation | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Year | | Growing Season | |
| | Cross Section | Bank Elevation (m) | Thalweg Elevation (m) | Channel Depth (m) | Cross Section Area ($m^2$) | Channel Width (m) | Width: Depth Ratio | Time WL > Thalweg (%) | Time WL > Bank (%) | Time WL > Thalweg (%) | Time WL > Bank (%) |
| LI2 | 1 | 1.15 | 0.99 | 0.17 | 1.1 | 13.1 | 79.1 | 70 | 69 | 67 | 67 |
| | 2 | 1.49 | 0.63 | 0.86 | 5.5 | 12.5 | 14.5 | 92 | 48 | 94 | 43 |
| | 3 | 1.90 | 0.96 | 0.94 | 10.1 | 12.4 | 13.2 | 71 | 25 | 69 | 17 |

### Cross Sections



## Sediment

Total Organic Carbon (TOC) in channel: 1.60 in wetland: 2.21



## Site Description

Hydrogeomorphic Reach: C

Coordinates (UTM, NAD83 meters):

Northing: 5106983 Easting: 500280

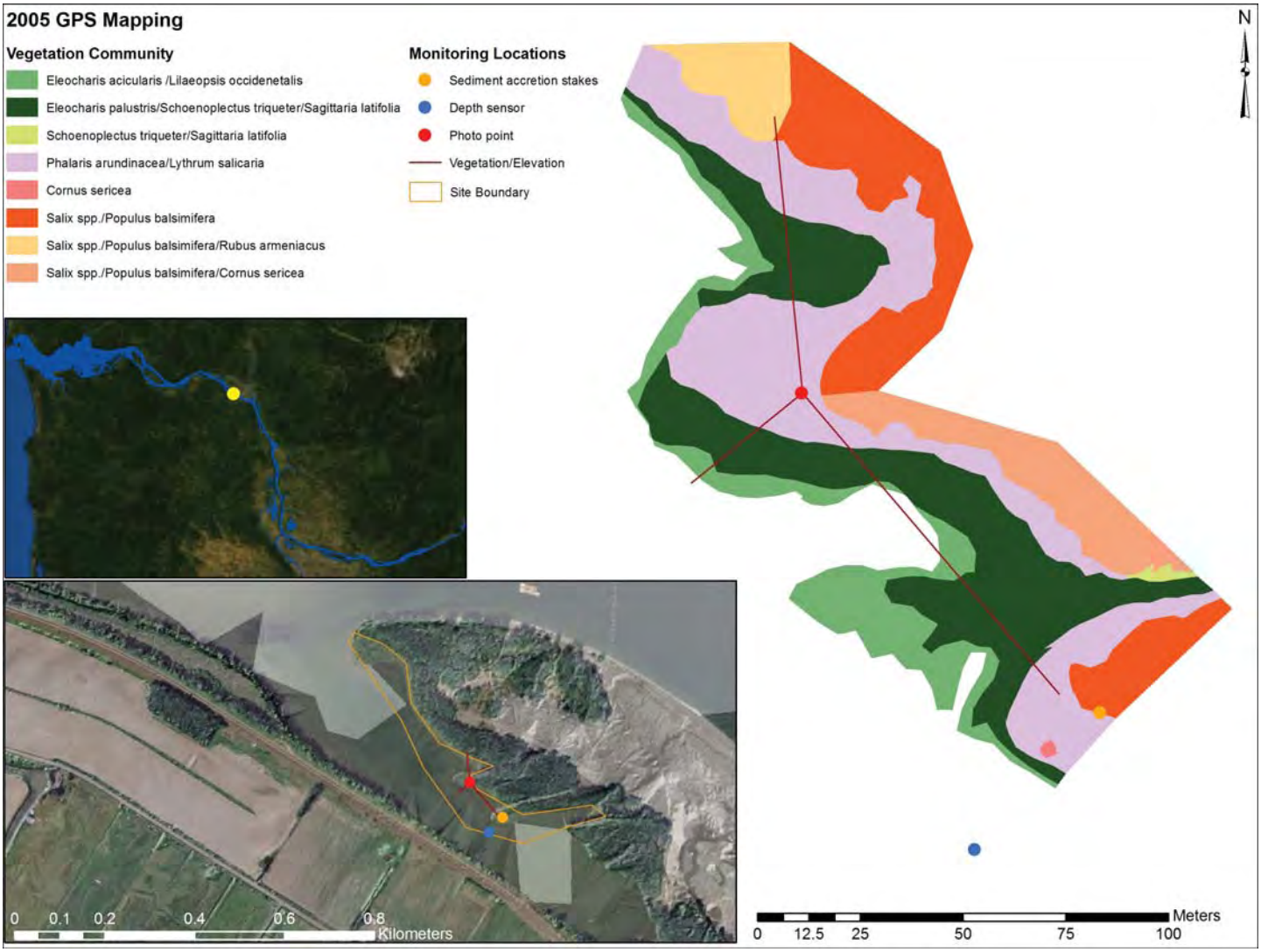
Distance from Columbia River mouth: 104 rkm

Distance from main channel: 4675 meters

Type: Created

Total Site Area: 4.7 ha Study Area: 2.63 ha

Total channel length: NA Channel surveyed: NA Channel slope: NA



## Site Information

Dibblee Slough is located near Dibblee's Beach and Dibblee Point in Rainier, Oregon. The site is a mainland slough with a fringing emergent marsh backed by cottonwood and willow trees. The site was created from dredge material and was not present on the historic maps from the 1880's. Dibblee's Beach is an active dredge material deposition site; the most recent deposition is visible on the site map above. The area is owned by the State of Oregon and managed by the Division of State Lands. There are numerous trails throughout the wooded area, which are popular for walking and horseback riding, however the recent dredge material activity may have reduced access to some areas.

## Elevation

Lowest marsh (NAVD88, m): 1.74

Highest marsh (NAVD88, m): 2.82

Lowest marsh (CRD, m): 0.88

Highest marsh (CRD, m): 1.96

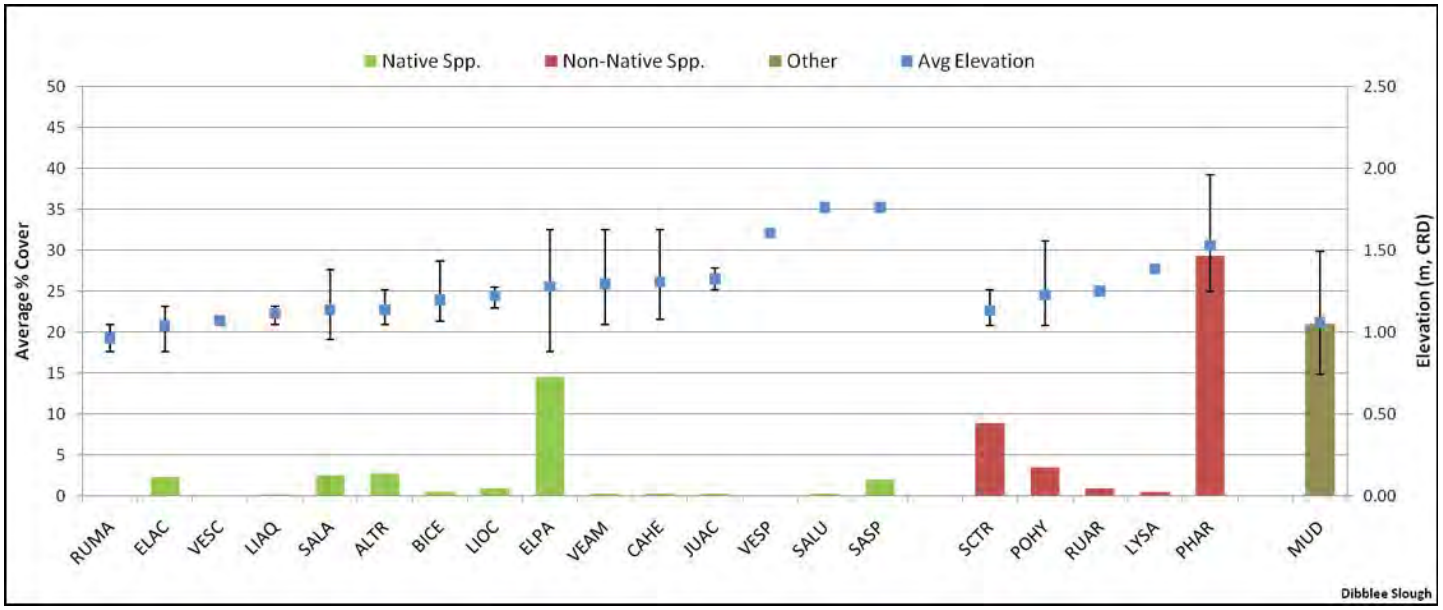
## Vegetation

Number of Native species: 15

% Native Cover: 27.12

Number of Non-native species: 5

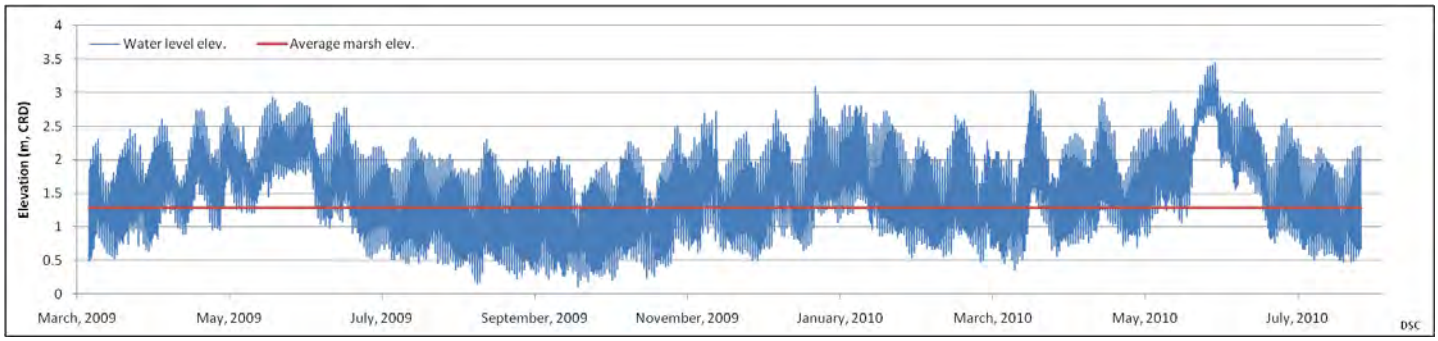
% Non-native Cover: 43.22

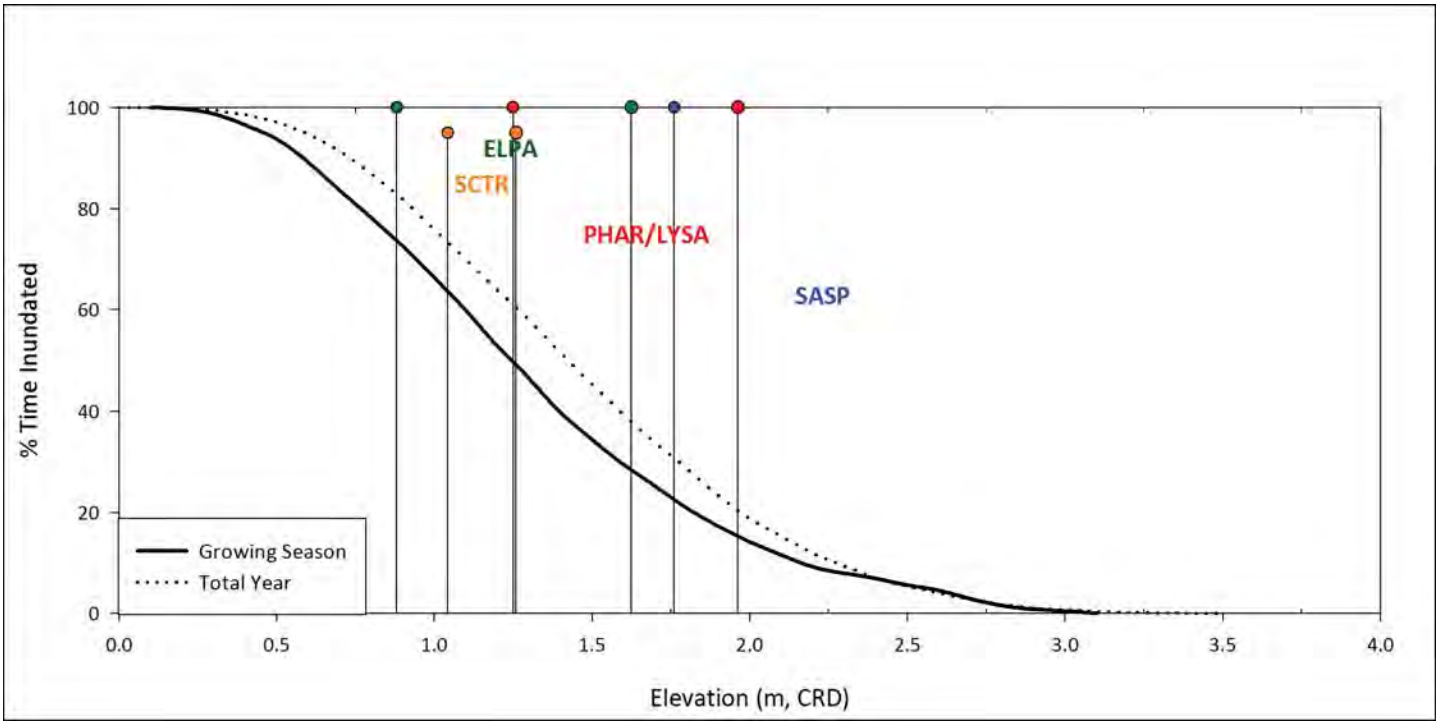


## Inundation

| | Std | Marsh |
|---|---|---|
| Average Elev (m, CRD) | 1.89 | 1.28 |
| Sum Exceedance Value (SEV) | 17.0 | 47.3 |

Modified Growing Season:
Aug 20 to Oct 12, 2009
Apr 22 to Jun 21, 2010




## Sediment

Sediment accretion rate: 0.17 cm per year

Elevation at sediment stakes: 1.79 m, CRD

## Site Description

Hydrogeomorphic Reach: D

Coordinates (UTM, NAD83 meters):

Northing: 5102716 Easting: 509507

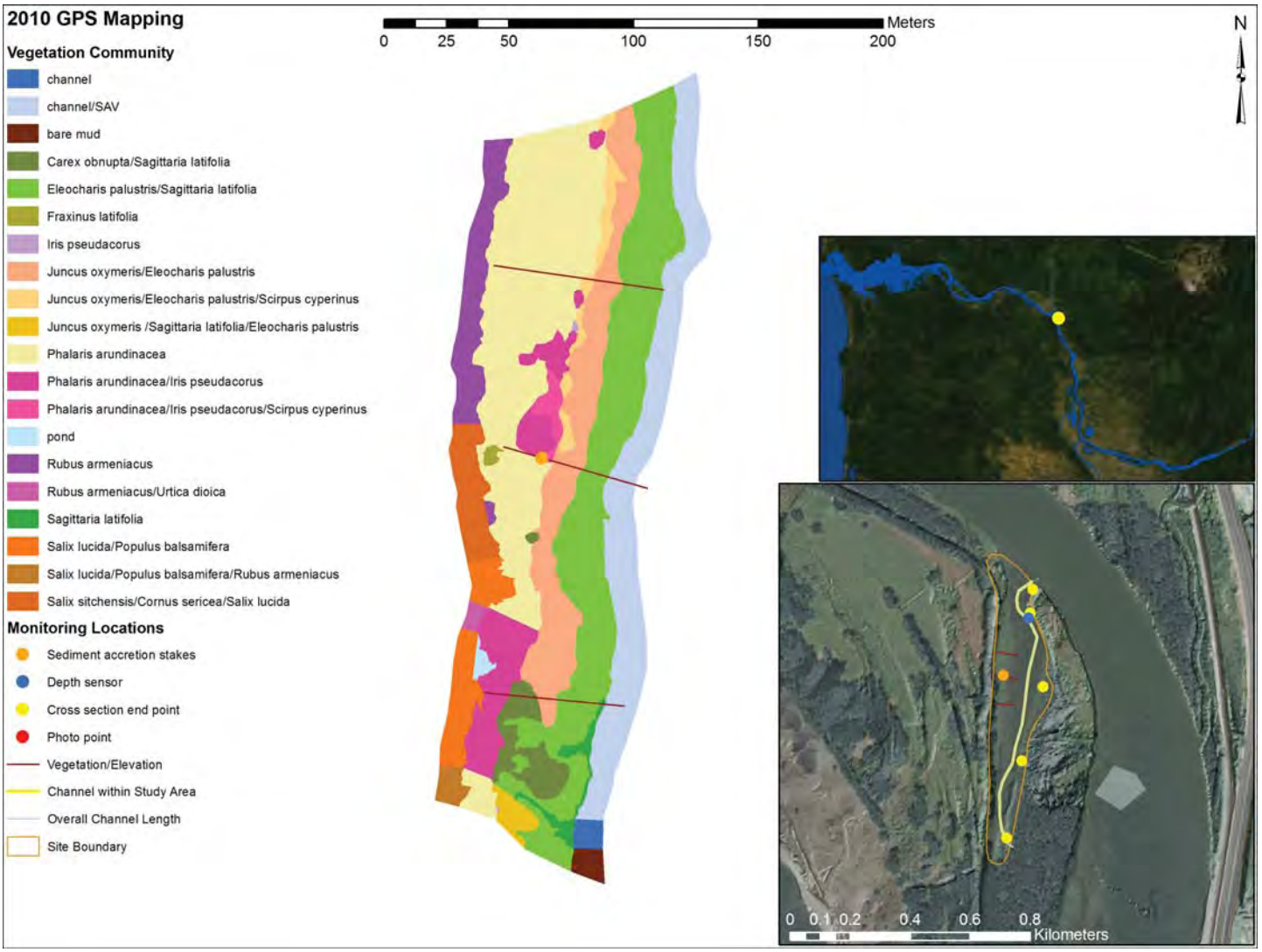
Distance from Columbia River mouth: 113 rkm

Distance from main channel: 197 meters

Type: Marsh

Total Site Area: 13.4 ha Study Area: 2.04 ha

Total channel length: 963 m Channel surveyed: 928 m Channel slope: 2.10 m/km



## Site Information

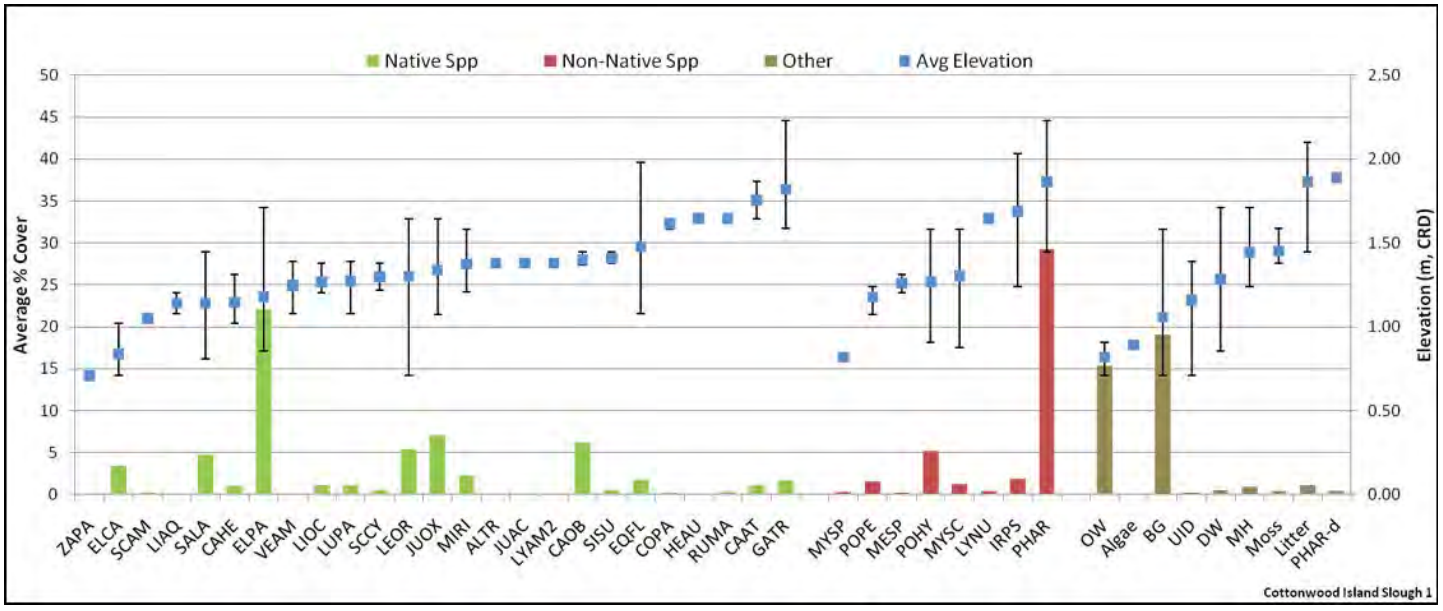
Cottonwood Island is located near Longview, WA upstream from the confluence of the Cowlitz River. Primarily created from dredge material, it is currently managed for white-tailed deer habitat by a consortium of four Washington ports. The monitoring site is in a large shallow slough on the off-channel side of the island.

Lowest marsh (CRD, m): 0.71 Highest marsh (CRD, m): 2.31

## Vegetation

Number of Native species: 25 % Native Cover: 61.20

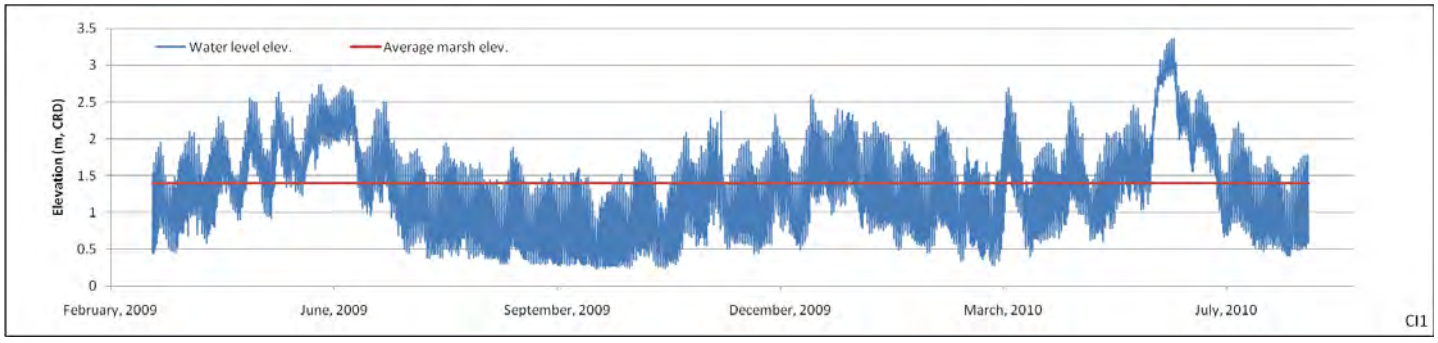
Number of Non-native species: 8 % Non-native Cover: 39.93



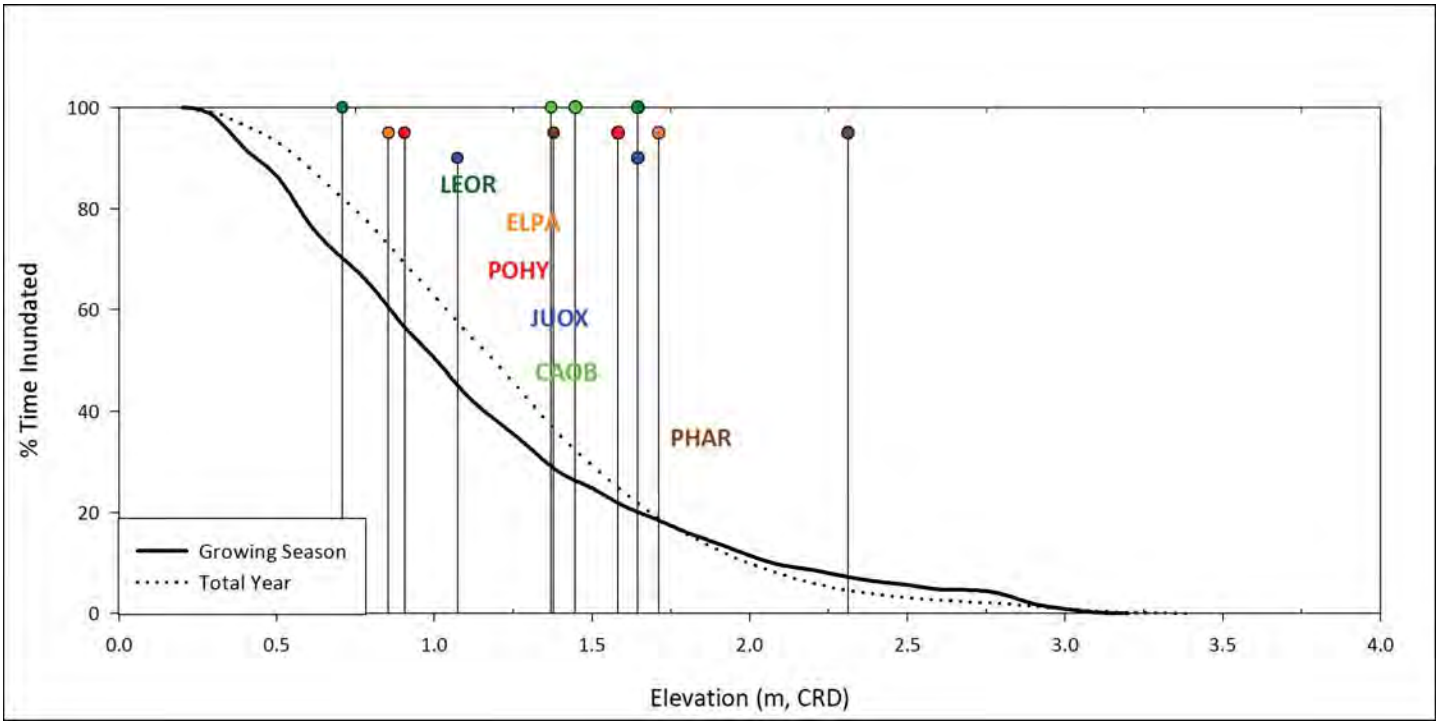

## Inundation

| | Std | Marsh |
|---|---|---|
| Average Elev (m, CRD) | 1.89 | 1.40 |
| Sum Exceedance Value (SEV) | 14.0 | 29.9 |

Modified Growing Season:
Aug 20 to Oct 12, 2009
Apr 22 to Jun 21, 2010



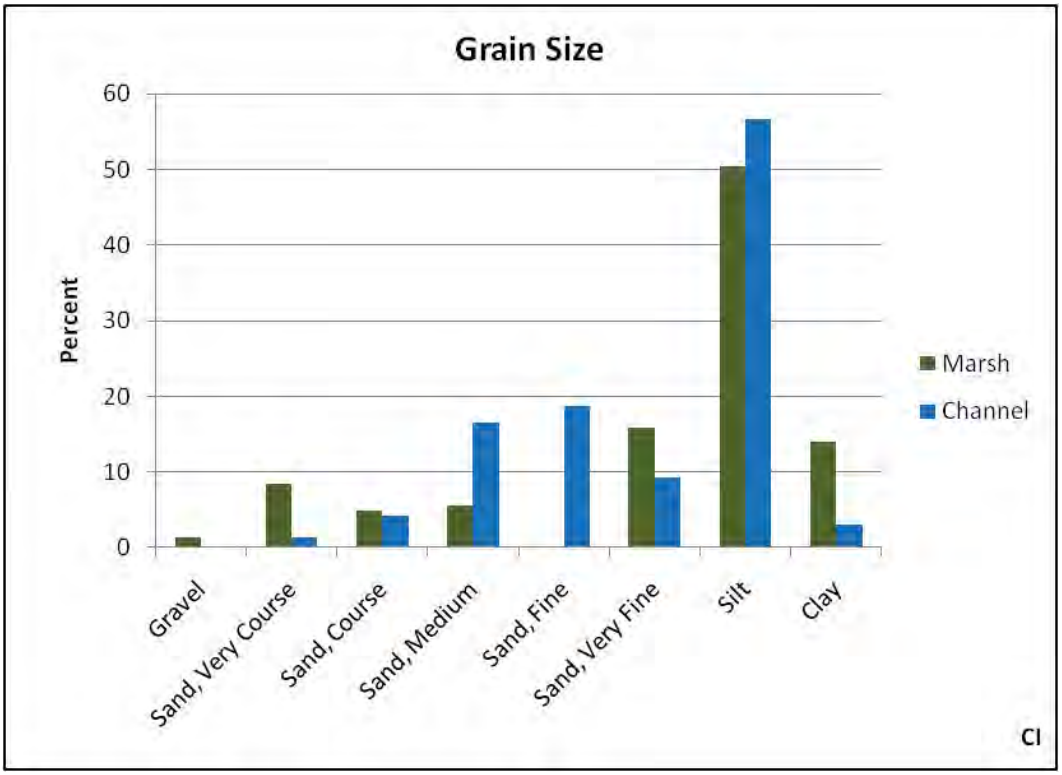
## Inundation (cont.)




## Sediment

Sediment accretion rate: 0.50 cm per year Elevation at sediment stakes: 1.56 m, CRD

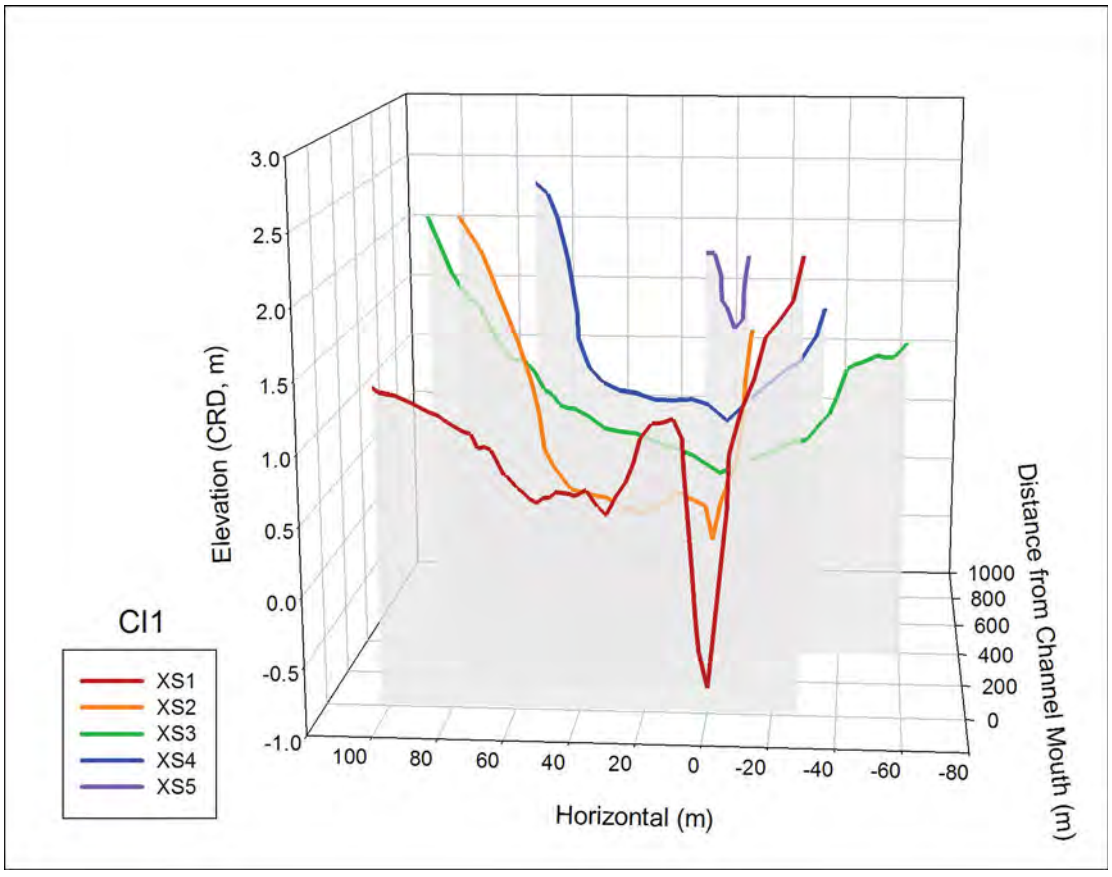
Total Organic Carbon (TOC) in channel: 2.48 in wetland: 0.54



## Channels

| | | Physical Metrics | | | | | | Inundation | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Year | | Growing Season | |
| | Cross Section | Bank Elevation (m) | Thalweg Elevation (m) | Channel Depth (m) | Cross Section Area ($m^2$) | Channel Width (m) | Width: Depth Ratio | Time WL > Thalweg (%) | Time WL > Bank (%) | Time WL > Thalweg (%) | Time WL > Bank (%) |
| CI1 | 1 | 0.88 | -0.83 | 1.71 | 26.7 | 73.0 | 42.8 | 100 | 71 | 100 | 58 |
| | 2 | 0.74 | 0.13 | 0.62 | 18.7 | 60.1 | 97.6 | 100 | 80 | 99 | 69 |
| | 3 | 0.88 | 0.40 | 0.48 | 21.6 | 86.6 | 180.4 | 91 | 71 | 82 | 58 |
| | 4 | 0.88 | 0.59 | 0.29 | 7.1 | 56.9 | 196.7 | 80 | 71 | 69 | 58 |
| | 5 | 1.46 | 1.13 | 0.33 | 1.8 | 8.1 | 24.6 | 44 | 32 | 34 | 26 |

### Cross Sections



## Site Description

Hydrogeomorphic Reach: D

Coordinates (UTM, NAD83 meters):

Northing: 5101674 Easting: 509760

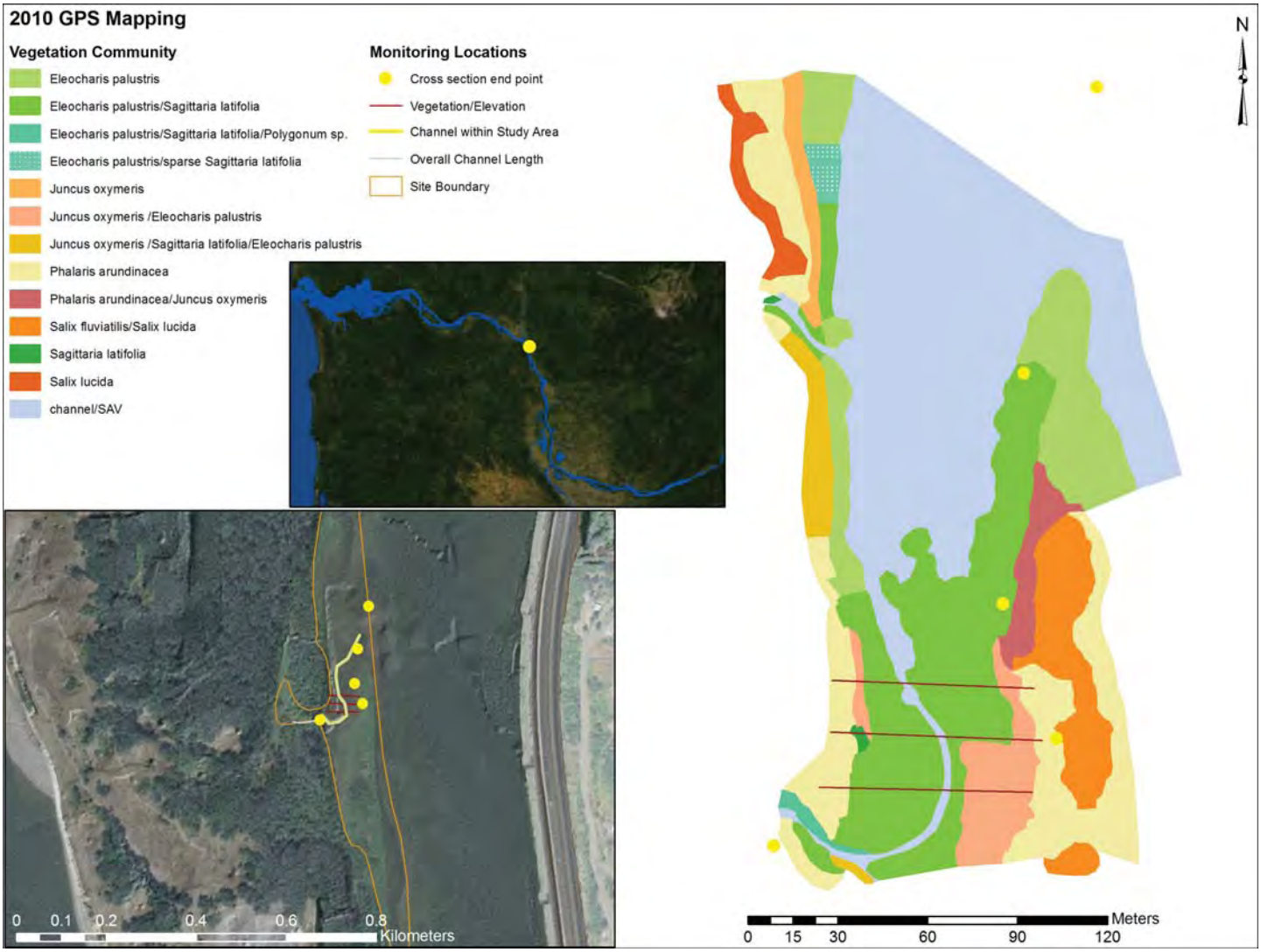
Distance from Columbia River mouth: 114 rkm

Distance from main channel: 0 meters

Type: Marsh

Total Site Area: 11.7 ha Study Area: 2.56 ha

Total channel length: 340 m Channel surveyed: 288 m Channel slope: -0.28 m/km



## Site Information

Cottonwood Island is an island complex located between Kalama and Longview and owned by four Columbia River port authorities. In 2008, the Cowlitz Tribe was granted use of most of the island as a refuge for Columbia River white-tailed deer. The upstream end and the main channel side of the island are active dredge material deposition areas. Most of the island has been formed from the placement of dredge material. The monitoring site is an emergent marsh in a large shallow area on the off-channel side of the island. Emergent species grade up from the channel to willow (Salix spp.) and cottonwoods (Populus balsamifera).

## Elevation

Lowest marsh (NAVD88, m): 1.60

Highest marsh (NAVD88, m): 2.41

Lowest marsh (CRD, m): 0.55

Highest marsh (CRD, m): 1.36

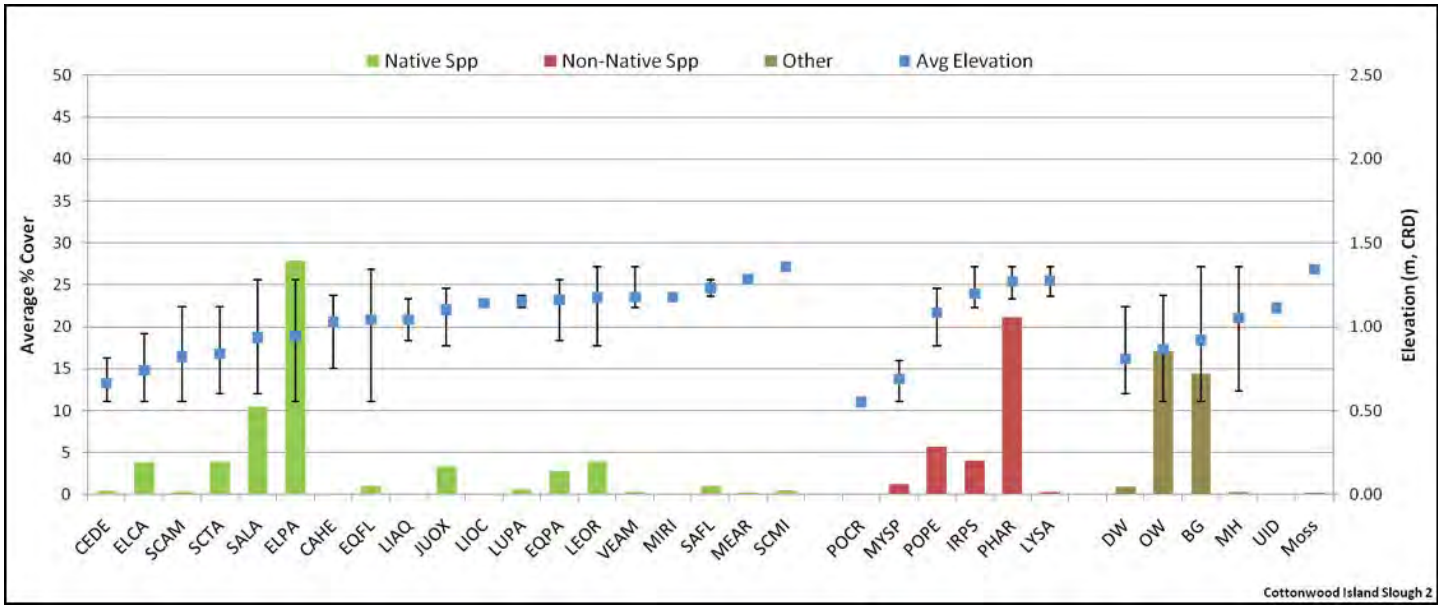
## Vegetation

Number of Native species: 19

% Native Cover: 60.84

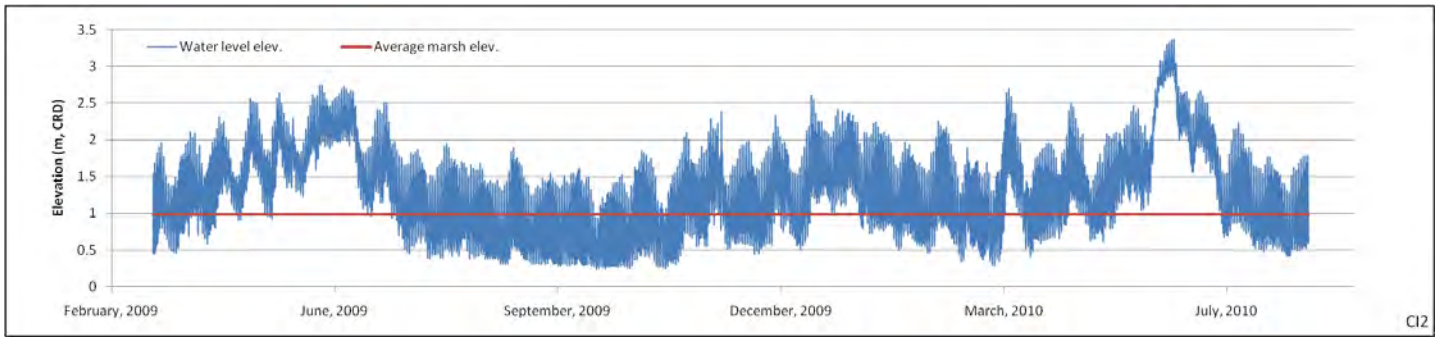
Number of Non-native species: 6

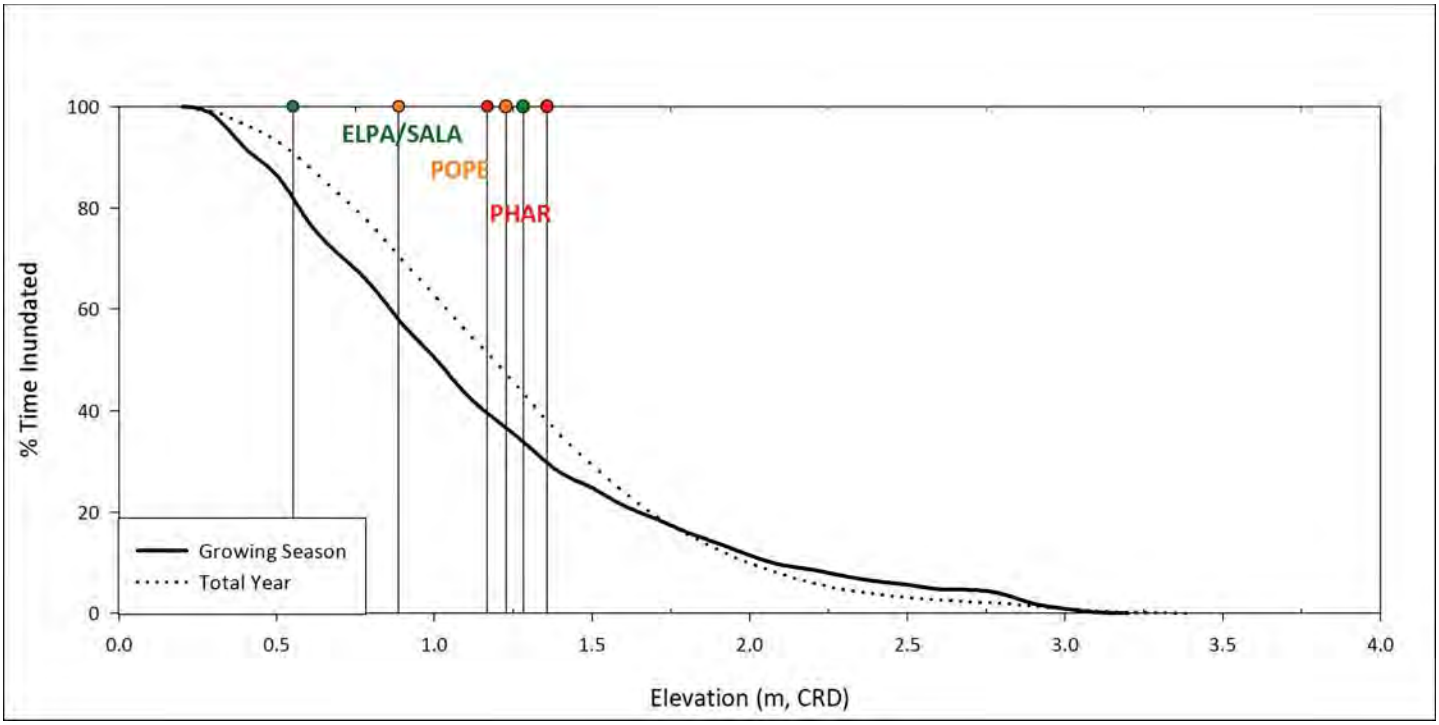
% Non-native Cover: 32.32



## Inundation

| | Std | Marsh | Modified Growing Season: |
|---|---|---|---|
| Average Elev (m, CRD) | 1.89 | 0.98 | Aug 20 to Oct 12, 2009 |
| Sum Exceedance Value (SEV) | 14.0 | 54.0 | Apr 22 to Jun 21, 2010 |

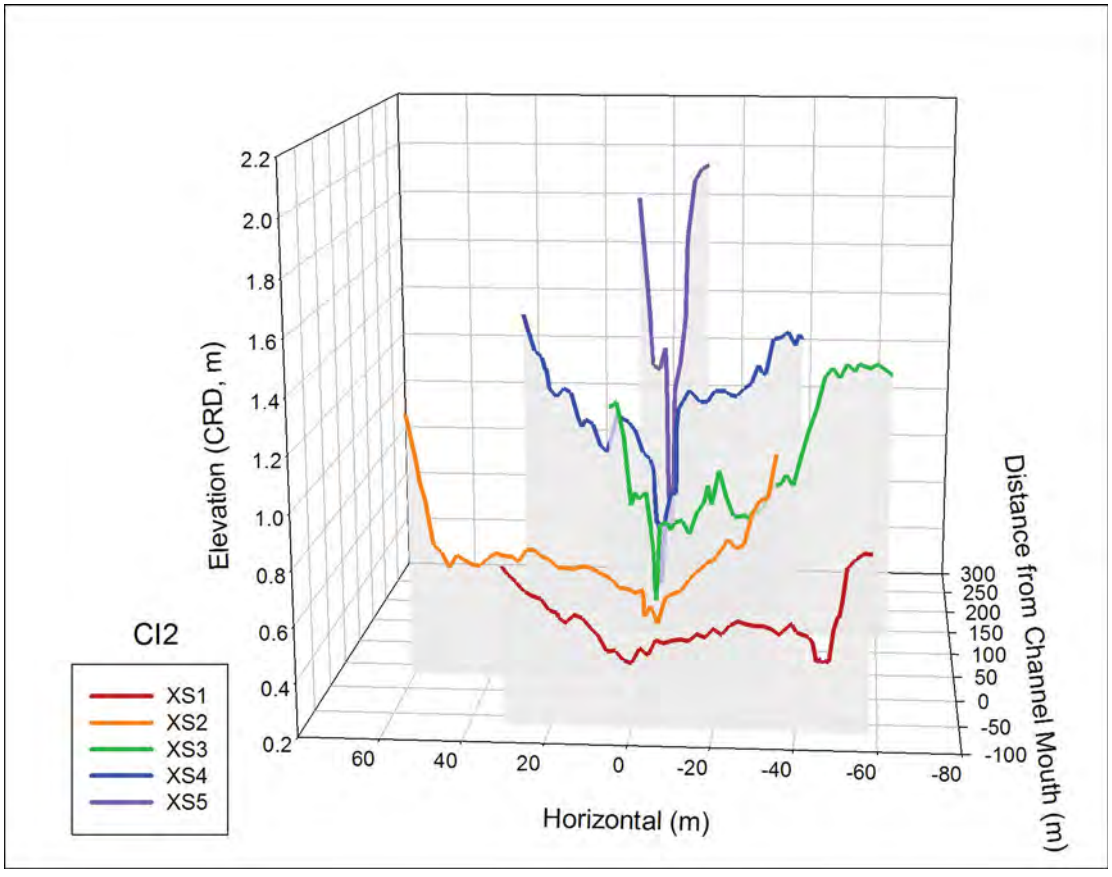


## Channels

| | | Physical Metrics | | | | | | Inundation | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Year | | Growing Season | |
| | Cross Section | Bank Elevation (m) | Thalweg Elevation (m) | Channel Depth (m) | Cross Section Area ($m^2$) | Channel Width (m) | Width: Depth Ratio | Time WL > Thalweg (%) | Time WL > Bank (%) | Time WL > Thalweg (%) | Time WL > Bank (%) |
| CI2 | 1 | 0.60 | 0.44 | 0.16 | 4.0 | 67.3 | 420.6 | 89 | 88 | 79 | 78 |
| | 2 | 0.61 | 0.44 | 0.17 | 1.9 | 63.7 | 374.5 | 89 | 88 | 78 | 77 |
| | 3 | 0.66 | 0.33 | 0.33 | 0.6 | 9.0 | 27.6 | 94 | 85 | 87 | 74 |
| | 4 | 0.79 | 0.32 | 0.47 | 1.2 | 6.4 | 13.7 | 94 | 77 | 88 | 65 |
| | 5 | 1.00 | 0.36 | 0.65 | 1.0 | 2.3 | 3.6 | 93 | 63 | 86 | 50 |

### Cross Sections



## Site Description

Hydrogeomorphic Reach: E

Coordinates (UTM, NAD83 meters):

Northing: 5094980 Easting: 510350

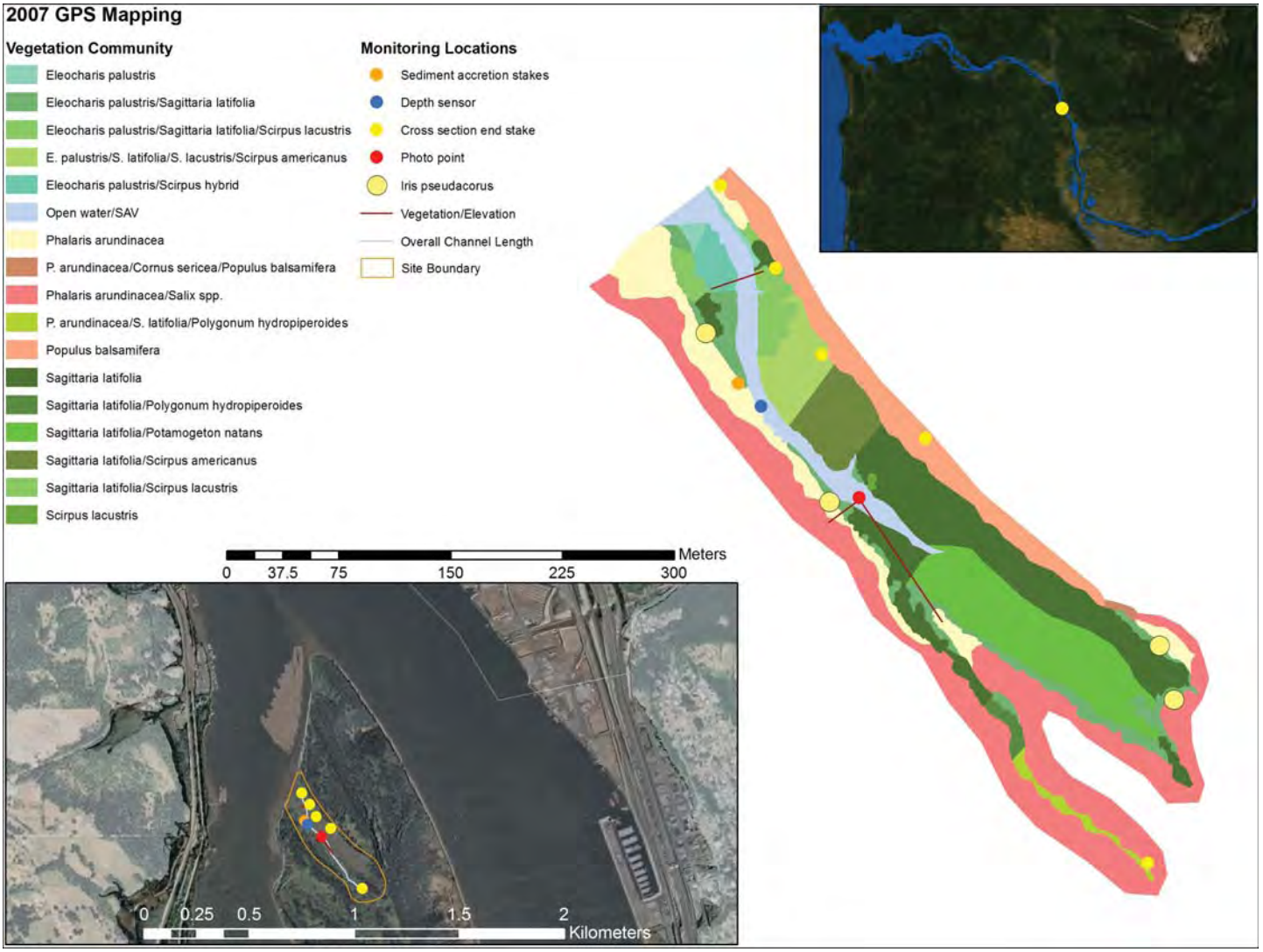
Distance from Columbia River mouth: 121 rkm

Distance from main channel: 0 meters

Type: Created

Total Site Area: 10.9 ha Study Area: 3.82 ha

Total channel length: 551 m Channel surveyed: 551 m Channel slope: 0.29 m/km



## Site Information

Sandy Island (1) is located across from Kalama, WA. The study site was located on the west side of the island approximately mid-island. The site is an expansive shallow wetland and channel with fine (mud/silt) sediments that extends almost a kilometer from the mouth of the slough. While Sandy Island was present on an 1877 map, the island is much larger today and includes two emergent marsh areas that were not present historically. The increase in area is likely due to the installation of pile dikes and placement of dredge material.

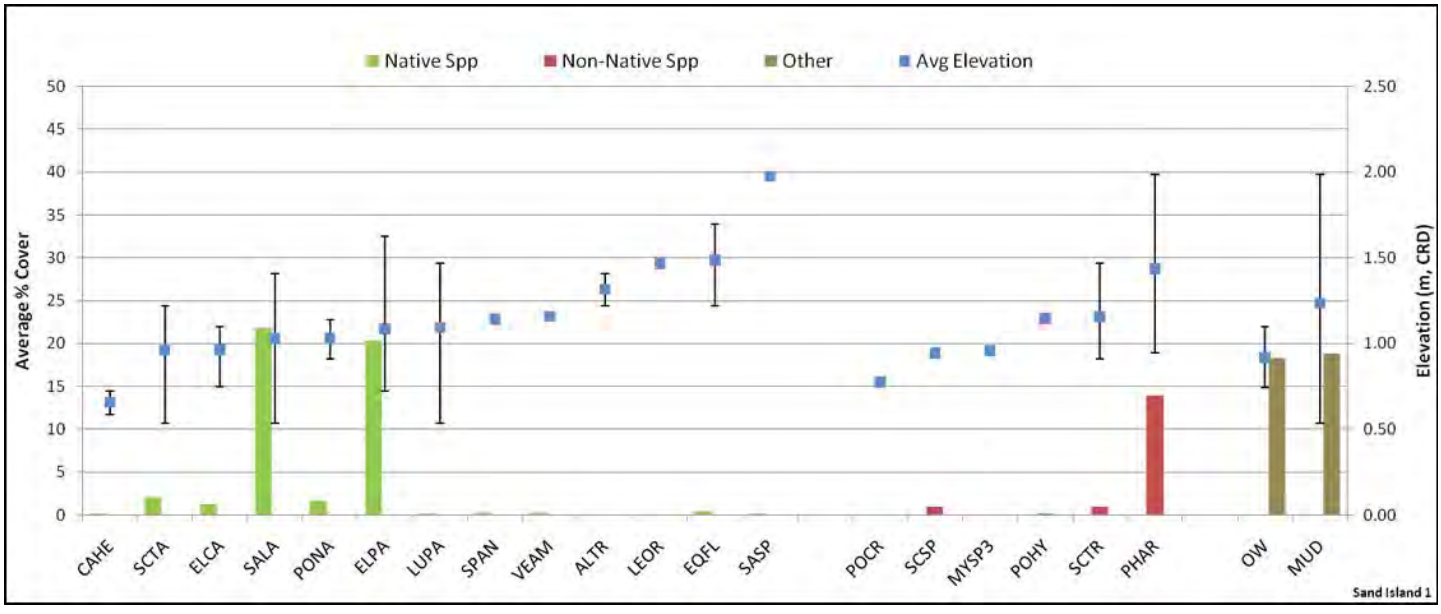
## Elevation

| | NAVD88, m | | CRD, m | |
|---|---|---|---|---|
| | Lowest | Highest | Lowest | Highest |
| Marsh | 1.92 | 3.39 | 0.79 | 2.31 |
| SALA | 1.92 | 2.80 | 0.84 | 1.72 |
| ELPA | 1.87 | 2.41 | 0.79 | 1.32 |
| PHAR | 2.05 | 3.39 | 0.97 | 2.31 |
| SASP | 3.38 | NA | 2.30 | NA |

## Vegetation

Number of Native species: 13 % Native Cover: 48.73

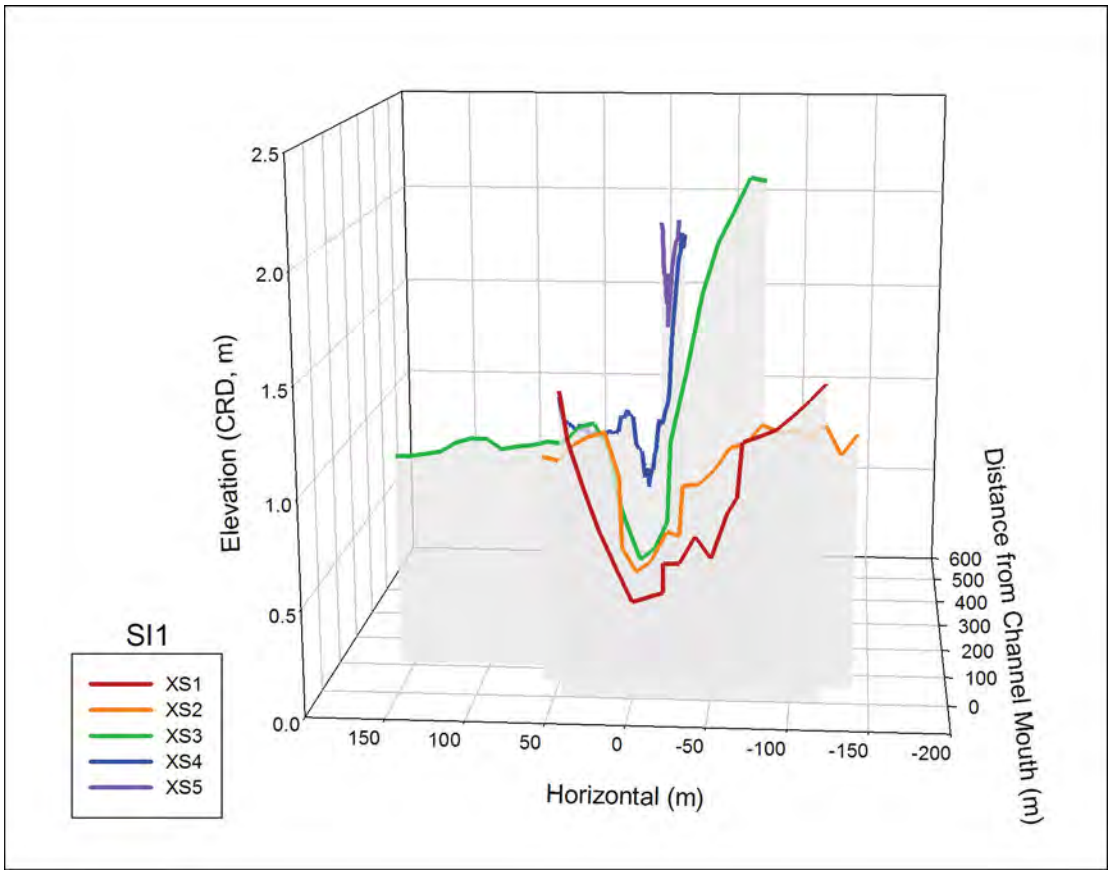
Number of Non-native species: 6 % Non-native Cover: 16.02



## Channels

| | Physical Metrics | | | | | | |
|---|---|---|---|---|---|---|---|
| | Cross Section | Bank Elevation (m) | Thalweg Elevation (m) | Channel Depth (m) | Cross Section Area ($m^2$) | Channel Width (m) | Width: Depth Ratio |
| SI1 | 1 | 1.20 | 0.46 | 0.74 | 16.0 | 33.3 | 44.7 |
| | 2 | 1.18 | 0.53 | 0.65 | 8.8 | 28.9 | 44.4 |
| | 3 | 1.18 | 0.53 | 0.65 | 6.2 | 16.0 | 24.8 |
| | 4 | 1.12 | 0.75 | 0.38 | 4.4 | 26.3 | 69.5 |
| | 5 | 1.85 | 1.30 | 0.55 | 3.0 | 12.9 | 23.4 |

### Cross Sections



## Site Description

Hydrogeomorphic Reach: E

Coordinates (UTM, NAD83 meters):

Northing: 5094048 Easting: 510573

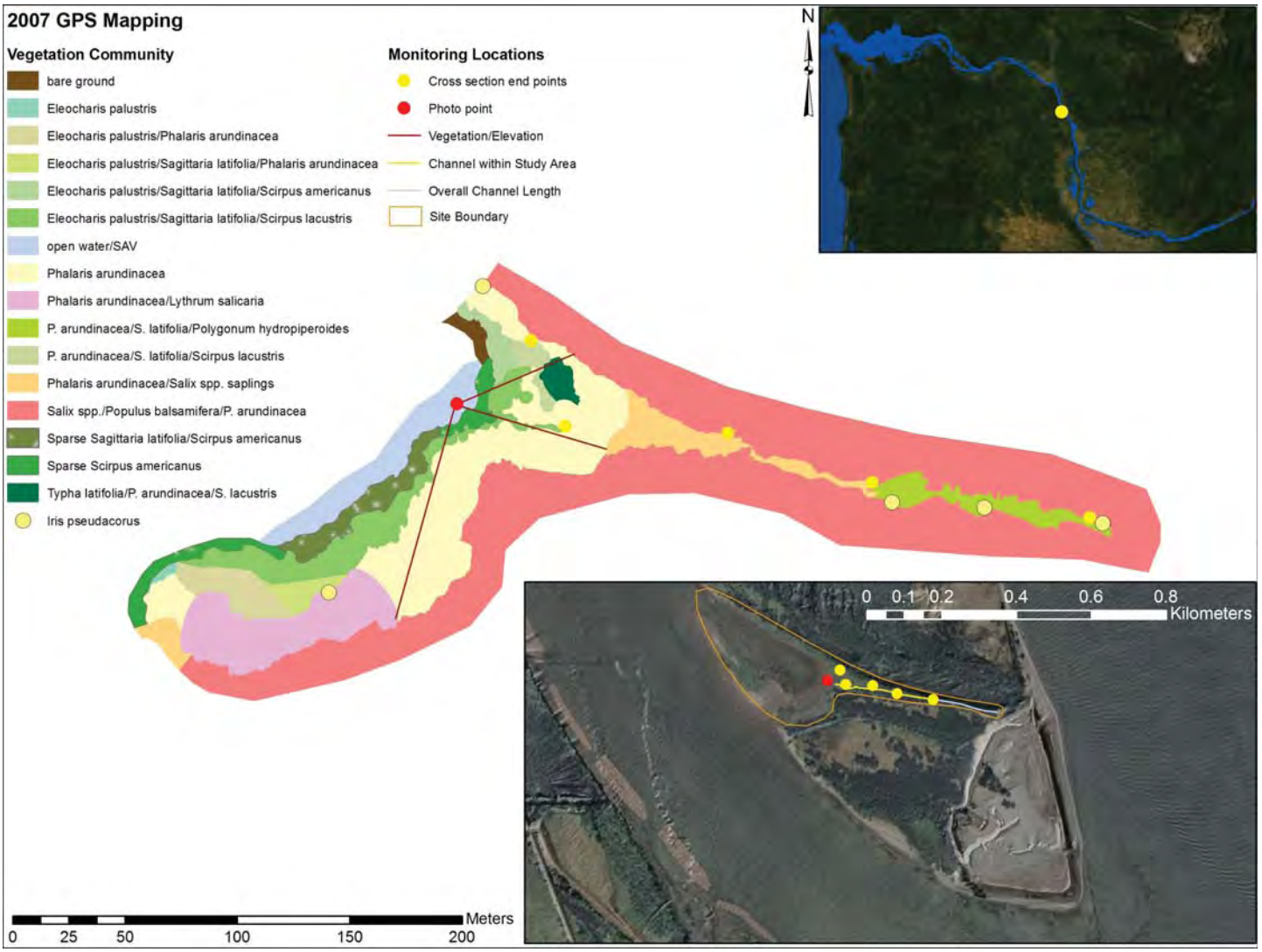
Distance from Columbia River mouth: 123 rkm

Distance from main channel: 0 meters

Type: Created

Total Site Area: 9.6 ha Study Area: 1.23 ha

Total channel length: 443 m Channel surveyed: 270 m Channel slope: 1.76 m/km



## Site Information

Sandy Island (2) is located across from Kalama, WA, with the study site located at the south end of the Island. The majority of the surveyed site sits at the head of a wide inlet/slough, with a small channel extending away from the mouth of the slough. Sediments here are coarser than those at Sandy Island 1. While Sandy Island was present on an 1877 map, the island is much larger today; the increase in area is likely due to the installation of pile dikes and placement of dredge material. Directly south of the site is an active dredged material deposition area.

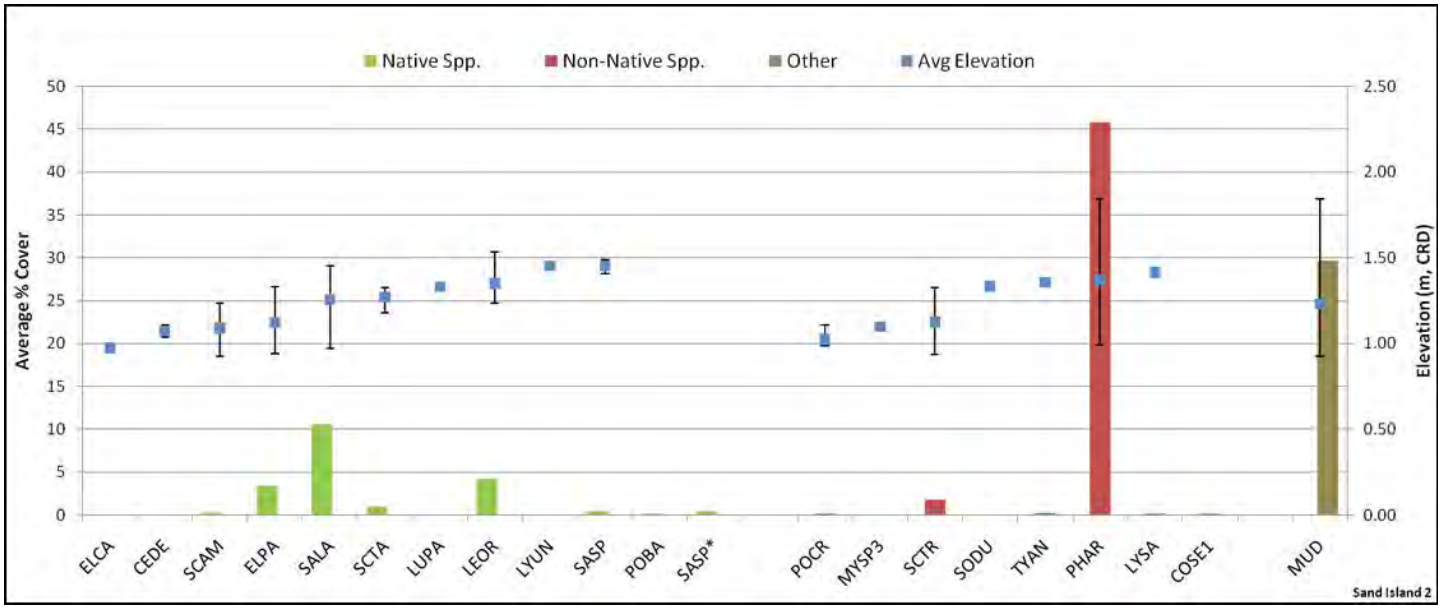
## Elevation

| | NAVD88, m | | CRD, m | |
|---|---|---|---|---|
| | Lowest | Highest | Lowest | Highest |
| Marsh | 2.00 | 2.67 | 0.89 | 1.56 |
| SALA | 2.00 | 2.47 | 0.89 | 1.36 |
| ELPA | 2.00 | 2.42 | 0.89 | 1.30 |
| PHAR | 2.13 | 3.18 | 1.02 | 2.07 |
| TYSP | 2.43 | 2.46 | 1.32 | 1.35 |
| SASP | 2.67 | NA | 1.56 | NA |

## Vegetation

Number of Native species: 12 % Native Cover: 20.69

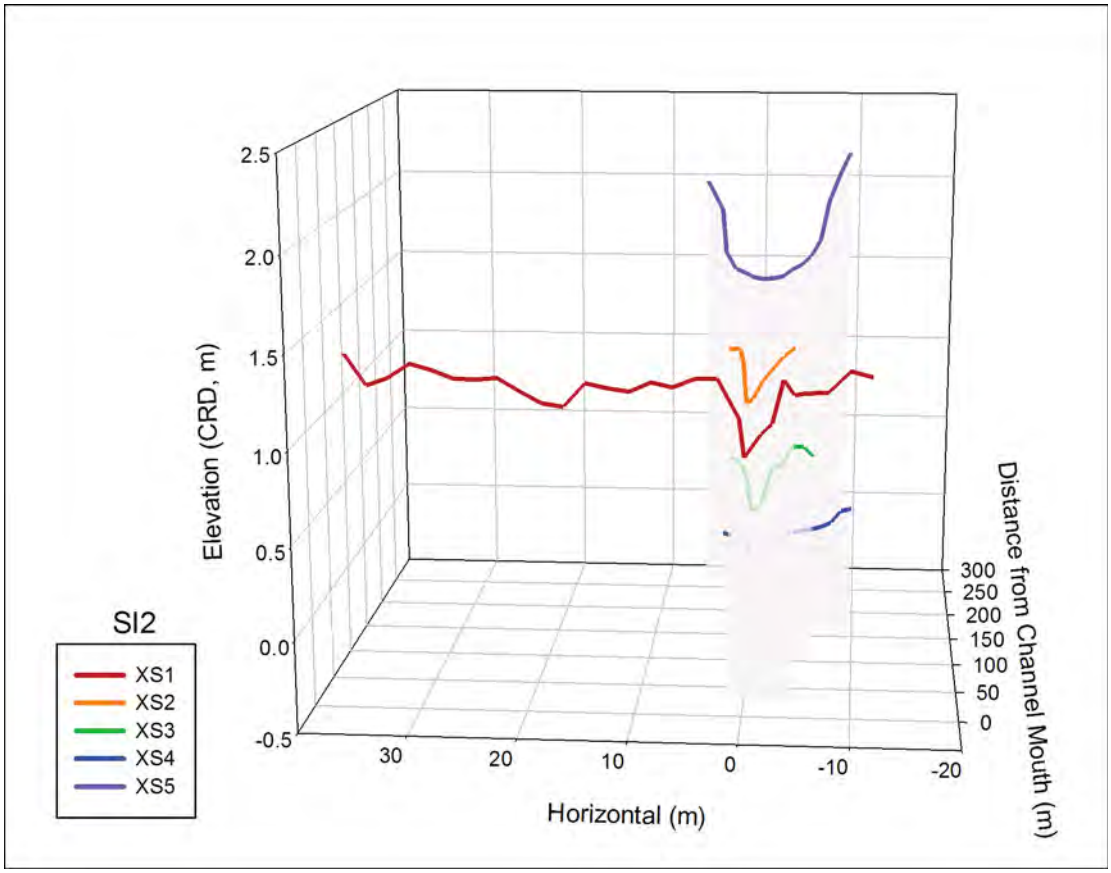
Number of Non-native species: 8 % Non-native Cover: 48.38



## Channels

| | Physical Metrics | | | | | | |
|---|---|---|---|---|---|---|---|
| | Cross Section | Bank Elevation (m) | Thalweg Elevation (m) | Channel Depth (m) | Cross Section Area ($m^2$) | Channel Width (m) | Width: Depth Ratio |
| SI2 | 1 | 1.31 | 0.89 | 0.42 | 2.6 | 6.0 | 14.4 |
| | 2 | 1.43 | 1.14 | 0.29 | 0.6 | 4.8 | 16.6 |
| | 3 | 0.61 | 0.36 | 0.25 | 0.4 | 2.9 | 11.6 |
| | 4 | 0.05 | -0.13 | 0.18 | 0.3 | 3.6 | 20.1 |
| | 5 | 1.82 | 1.40 | 0.42 | 3.7 | 11.0 | 26.3 |

### Cross Sections



## Site Description

Hydrogeomorphic Reach: E

Coordinates (UTM, NAD83 meters):

Northing: 5086713 Easting: 514322

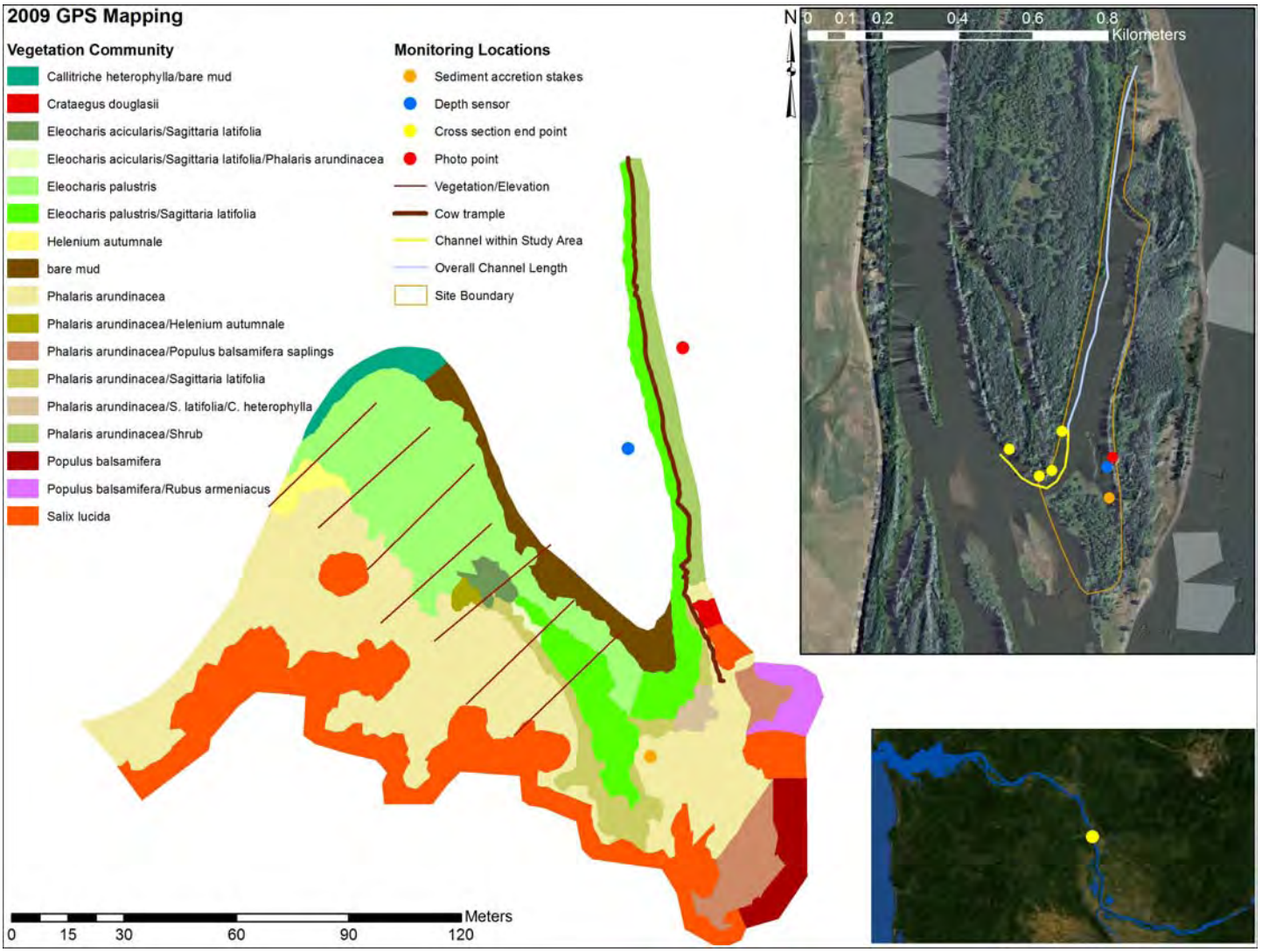
Distance from Columbia River mouth: 131 rkm

Distance from main channel: 707 meters

Type: Created

Total Site Area: 15.7 ha Study Area: 0.99 ha

Total channel length: 1330 m Channel surveyed: 329 m Channel slope: -0.44 m/km



## Site Information

Goat Island, located near Deer Island, Oregon, is a dredge material island created in the last 50 years and now in private ownership. The monitoring site, located at the upstream end of the island, includes a fringing emergent marsh. Steep banks surround the slough on most sides, dominated by cottonwood.

## Elevation

Lowest marsh (NAVD88, m): 2.04

Highest marsh (NAVD88, m): 3.43

Lowest marsh (CRD, m): 0.84

Highest marsh (CRD, m): 2.23

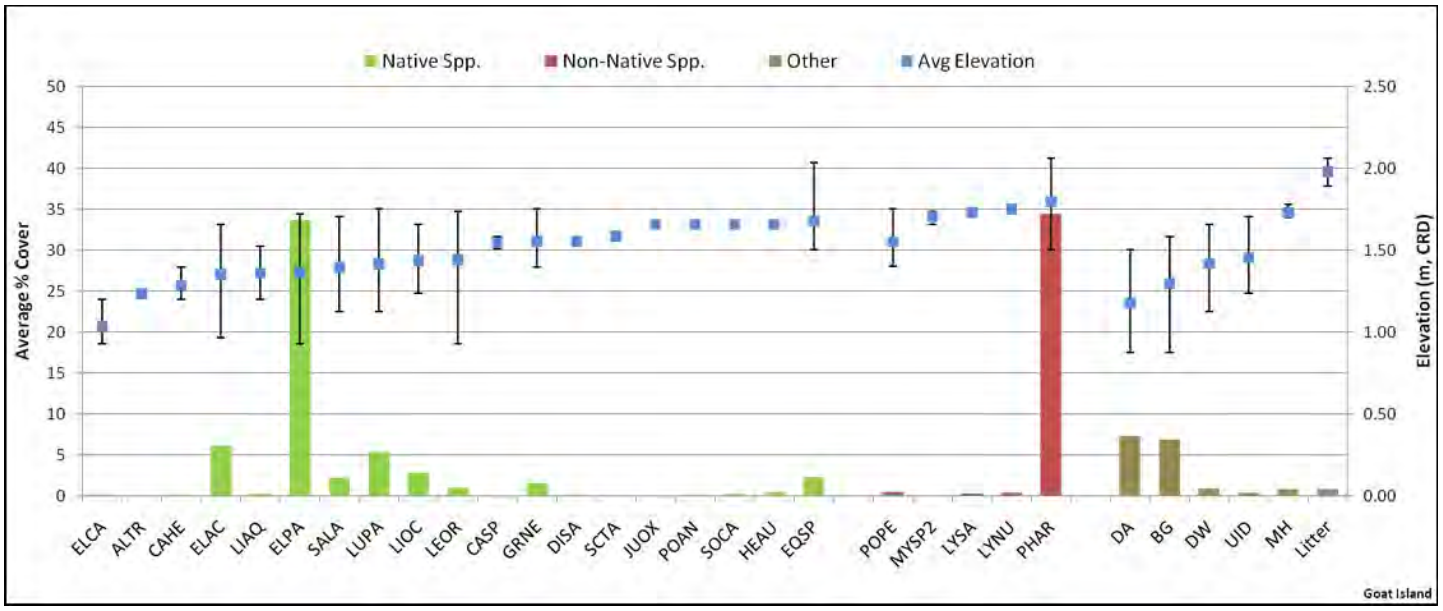
## Vegetation

Number of Native species: 19

% Native Cover: 57.06

Number of Non-native species: 5

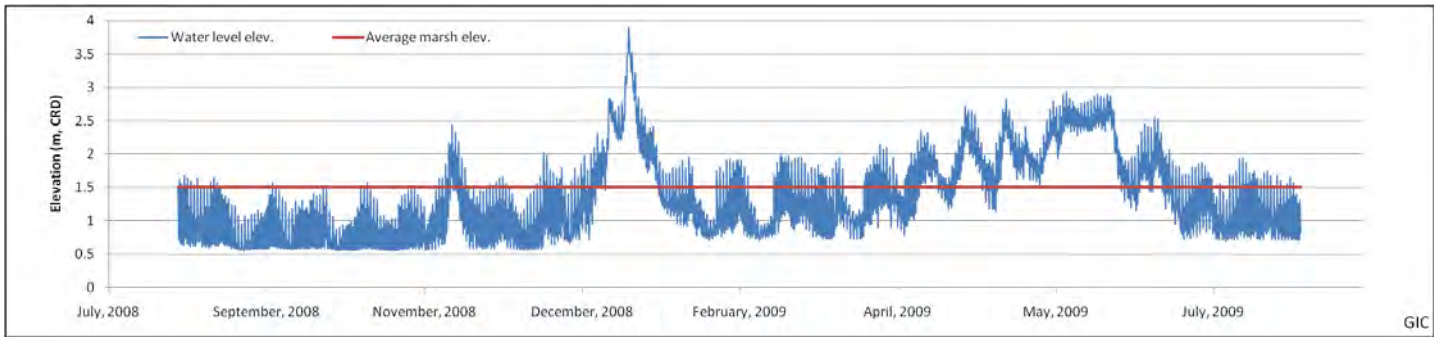
% Non-native Cover: 35.69



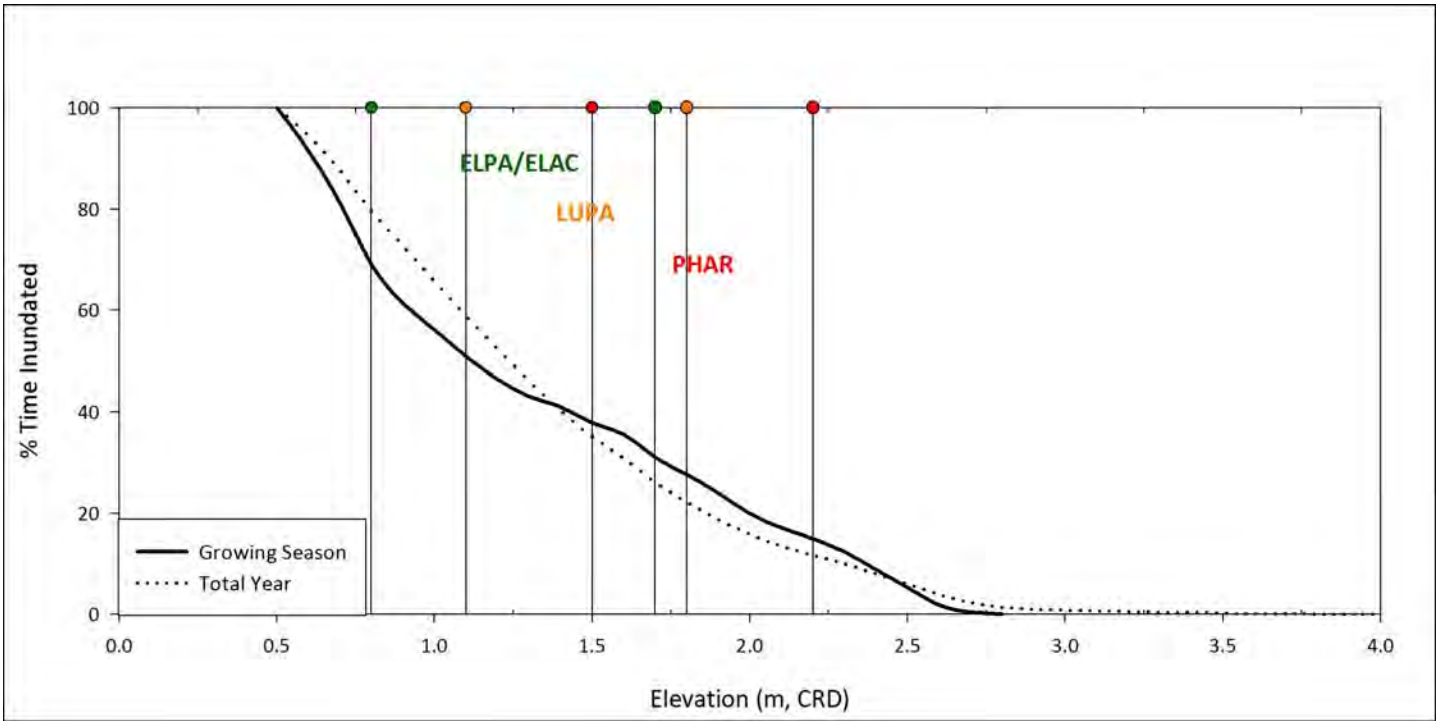

## Inundation

| | Std | Marsh |
|---|---|---|
| Average Elev (m, CRD) | 1.89 | 1.51 |
| Sum Exceedance Value (SEV) | 19.2 | 38.6 |

Modified Growing Season:
Aug 20 to Oct 12, 2008
Apr 22 to Jun 21, 2009



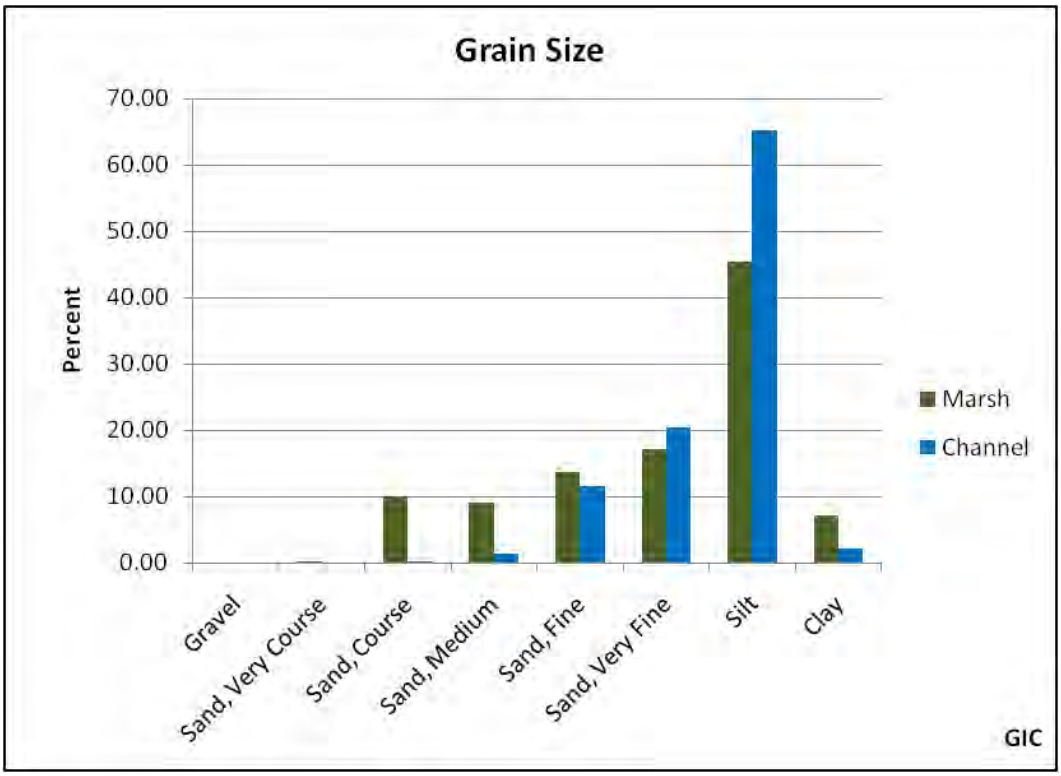
## Inundation (cont.)




## Sediment

Sediment accretion rate: 0.07 cm per year Elevation at sediment stakes: 1.61 m, CRD

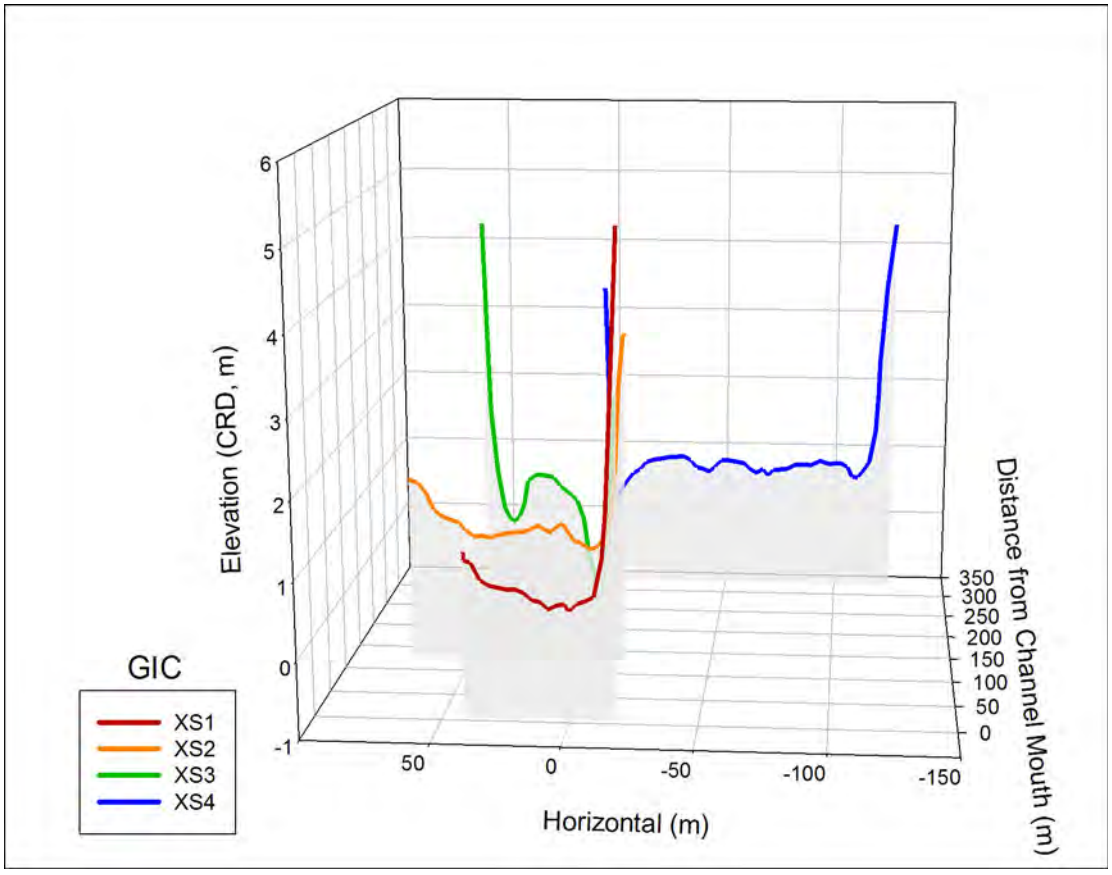
Total Organic Carbon (TOC) in channel: 1.47 in wetland: 2.25



## Channels

| | | Physical Metrics | | | | | | Inundation | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Year | | Growing Season | |
| | Cross Section | Bank Elevation (m) | Thalweg Elevation (m) | Channel Depth (m) | Cross Section Area ($m^2$) | Channel Width (m) | Width: Depth Ratio | Time WL > Thalweg (%) | Time WL > Bank (%) | Time WL > Thalweg (%) | Time WL > Bank (%) |
| GIC | 1 | 1.11 | 0.39 | 0.72 | 26.0 | 54.2 | 75.2 | 100 | 58 | 100 | 50 |
| | 2 | 1.39 | 0.53 | 0.85 | 48.7 | 81.4 | 95.3 | 89 | 41 | 82 | 41 |
| | 3 | 2.23 | -0.67 | 2.90 | 79.3 | 52.5 | 18.1 | 100 | 11 | 100 | 14 |
| | 4 | 3.36 | 0.25 | 3.11 | 321.7 | 127.0 | 40.8 | 100 | 0 | 100 | 0 |

### Cross Sections



## Site Description

Hydrogeomorphic Reach: E

Coordinates (UTM, NAD83 meters):

Northing: 5076877 Easting: 517291

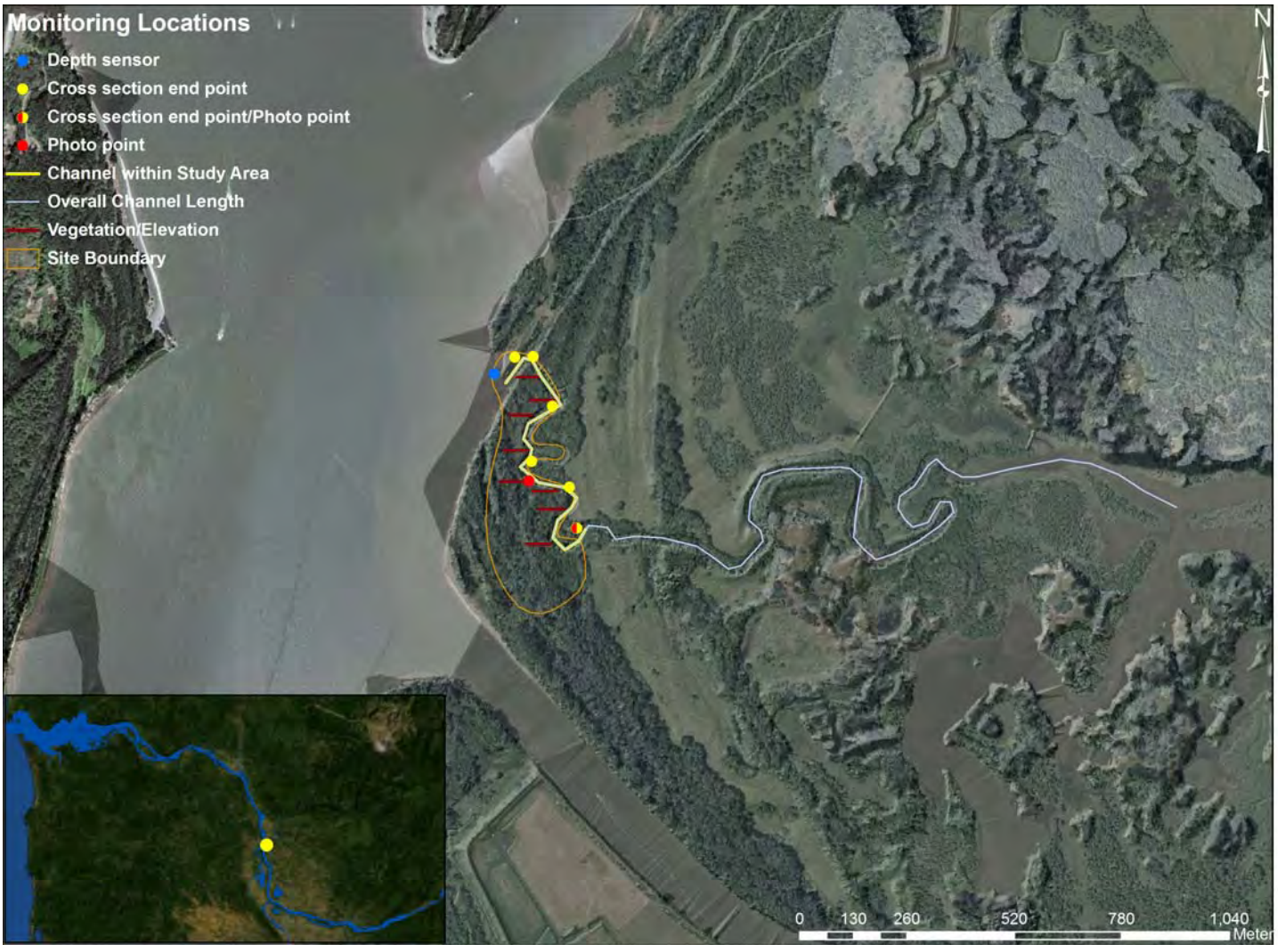
Distance from Columbia River mouth: 141 rkm

Distance from main channel: 0 meters

Type: Riparian Wetland

Total Site Area: 9.7 ha Study Area: 3.31 ha

Total channel length: 3194 m Channel surveyed: 829 m Channel slope: 0.47 m/km



## Site Information

Gee Creek is a small tributary to the Columbia River near the confluence of the Lewis River in Washington. The monitoring site encompassed the riparian area from the mouth to 700 m upstream. Only the south side was monitored due to cattle grazing on the north side. The site is part of the USFWS Ridgefield NWR.

## Elevation

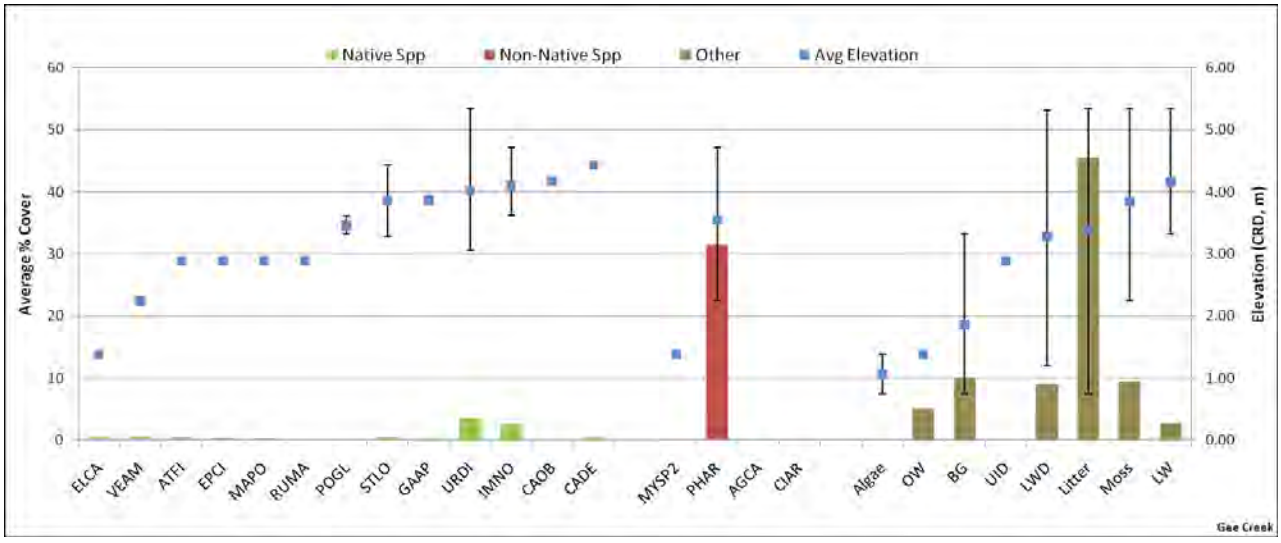
| | Herb | | Shrub | | Tree | |
|---|---|---|---|---|---|---|
| | Lowest | Highest | Lowest | Highest | Lowest | Highest |
| CRD, m | 2.25 | 5.34 | 2.99 | 5.69 | 2.99 | 5.59 |
| NAVD88, m | 3.50 | 6.60 | 4.24 | 6.94 | 4.24 | 6.85 |

## Vegetation

| | Herb | Shrub | Tree |
|---|---|---|---|
| Number of Native species | 13 | 7 | 3 |
| % Cover Native species | 10.05 | 67.9 | NA |
| Number of Non-native species | 4 | 1 | 0 |
| % Cover Non-native species | 31.71 | 0.3 | NA |

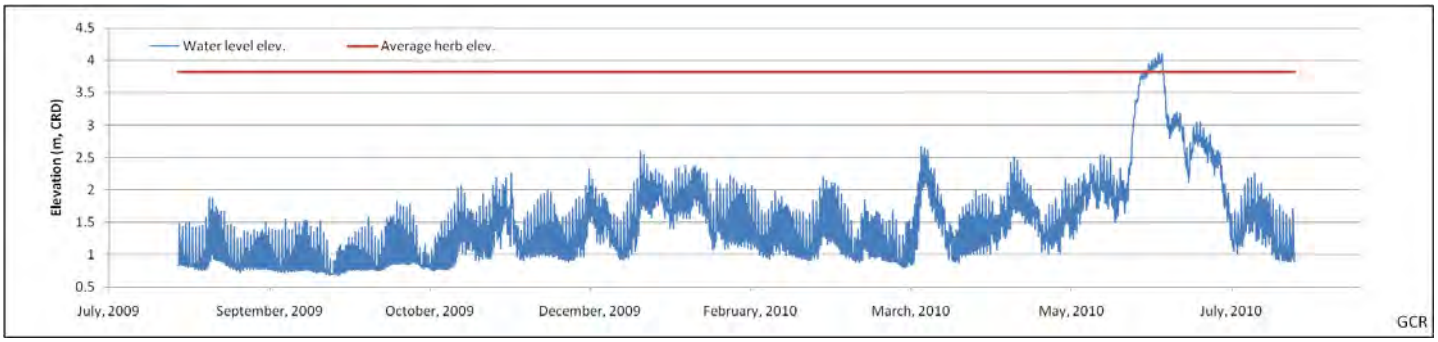
| Species | Density Stems/ha | Relative Frequency % | Relative Density % | Relative Dominance % | Elevation (m, CRD) Min | Max |
|---|---|---|---|---|---|---|
| Gee Creek | | | | | | |
| FRLA | 428 | 63.3 | 48.7 | 85.4 | 2.99 | 4.94 |
| MAFU | 29 | 6.7 | 3.3 | 0.1 | 4.04 | 5.59 |
| POBA | 388 | 13.3 | 44.1 | 5.3 | 3.62 | 4.70 |
| Snag | 35 | 16.7 | 3.9 | 9.2 | 3.38 | 5.59 |

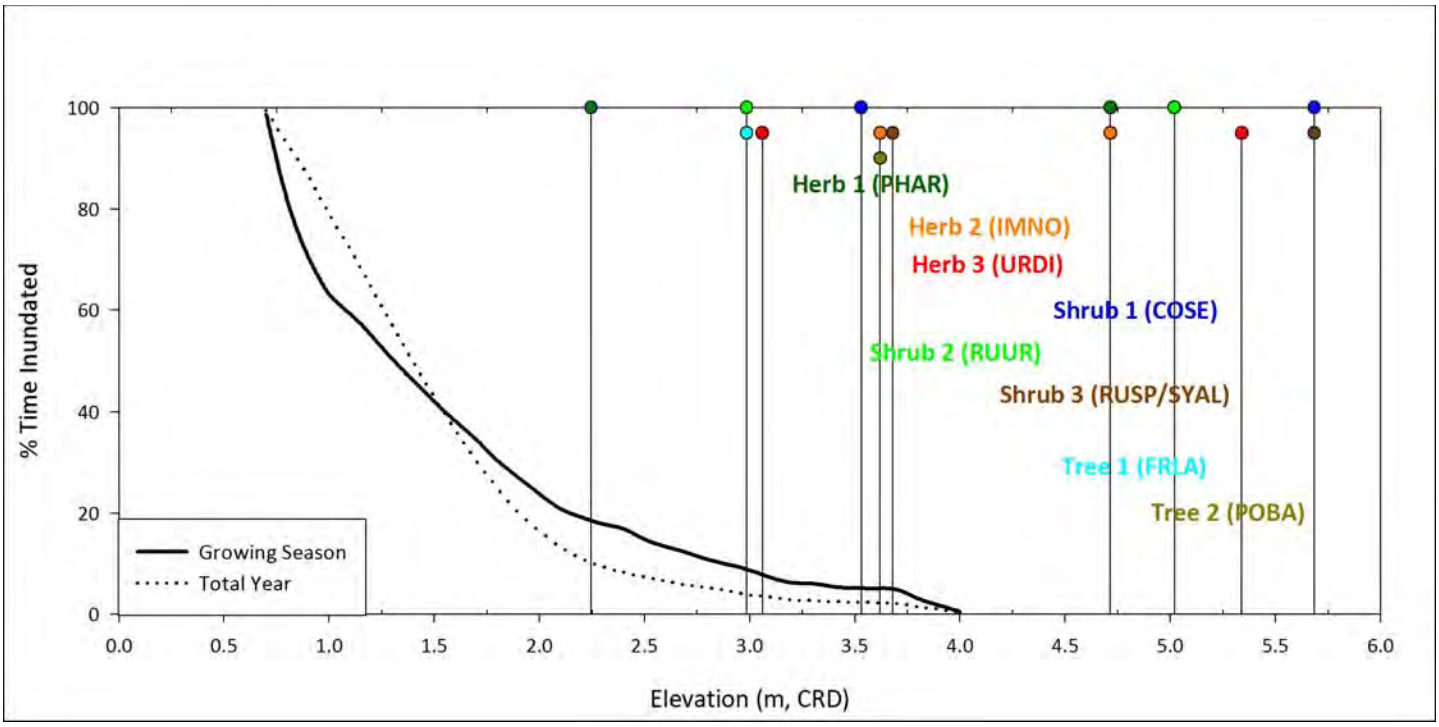
| Species | Density (stems/ha) | Cover (%) |
|---|---|---|
| COSE | 1765 | 18.5 |
| CRDO | 1412 | 2.4 |
| LOIN | 1706 | 4.4 |
| RONU | 4706 | 6.9 |
| ROPI | 118 | 0.1 |
| RUUR | 38706 | 6.5 |
| SPDO | 2706 | 5.2 |
| SYAL | 13176 | 7.8 |
| COSE | 6600 | 36.8 |
| RILA | 1200 | 0.4 |
| RUAR | 200 | 0.3 |
| RUSP | 4200 | 6.2 |
| RUUR | 22733 | 17.8 |
| SARA | 200 | 0.3 |
| SYAL | 4733 | 6.3 |



## Inundation

| | Std | Herb | Shrub | Tree | Modified Growing Season: |
|---|---|---|---|---|---|
| Average Elev (m, CRD) | 1.89 | 3.82 | 4.20 | 3.78 | Aug 20 to Oct 12, 2009 |
| Sum Exceedance Value (SEV) | 30.4 | 0.63 | 0.00 | 0.85 | Apr 22 to Jun 21, 2010 |




## Sediment

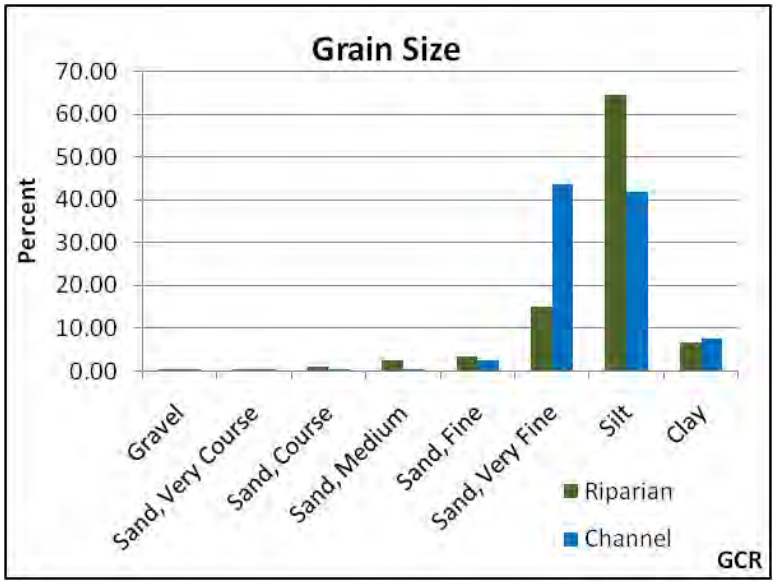
Sediment accretion rate: NA cm per year

Elevation at sediment stakes: NA m, CRD

Total Organic Carbon (TOC)

in channel: 0.63

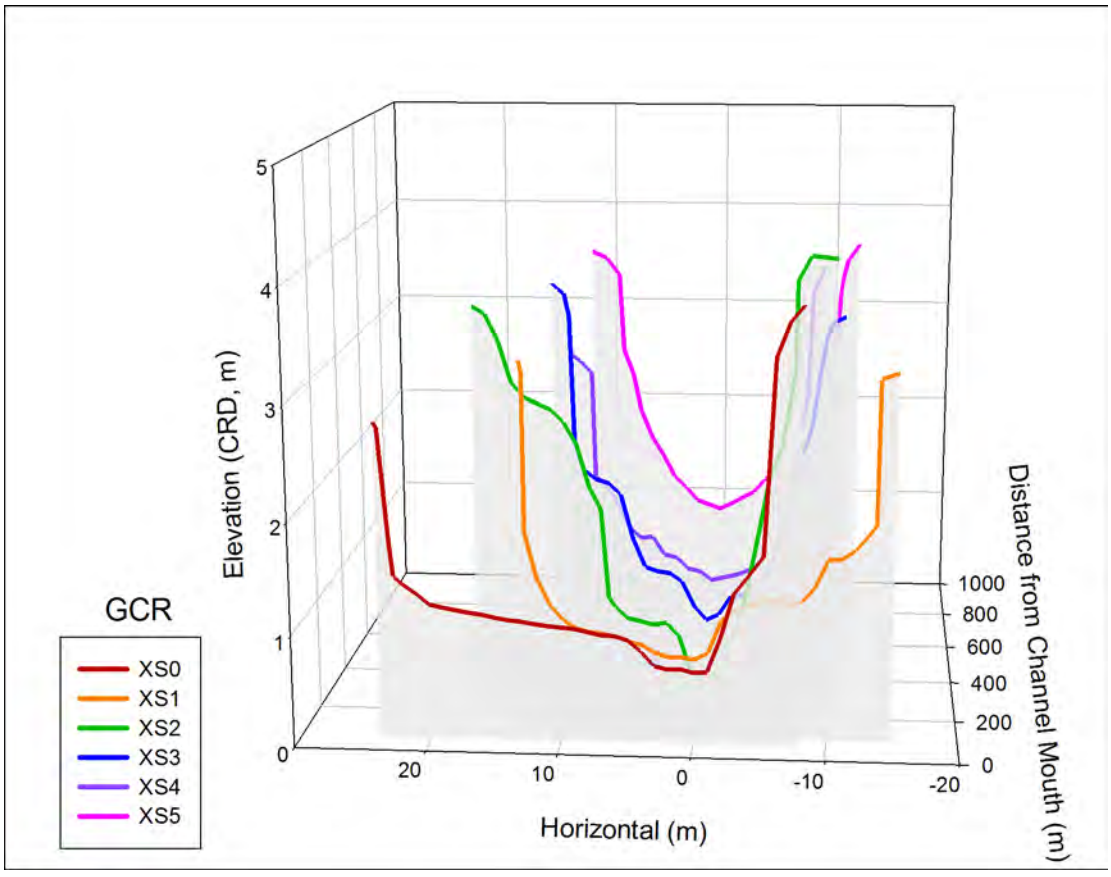
in wetland: 4.14



## Channels

| | | Physical Metrics | | | | | | Inundation | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Year | | Growing Season | |
| | Cross Section | Bank Elevation (m) | Thalweg Elevation (m) | Channel Depth (m) | Cross Section Area ($m^2$) | Channel Width (m) | Width: Depth Ratio | Time WL > Thalweg (%) | Time WL > Bank (%) | Time WL > Thalweg (%) | Time WL > Bank (%) |
| GCR | 0 | 2.76 | 0.65 | 2.11 | 48.6 | 29.4 | 13.9 | 93 | 5 | 83 | 11 |
| | 1 | 3.21 | 0.71 | 2.50 | 55.0 | 27.0 | 10.8 | 89 | 3 | 73 | 6 |
| | 2 | 3.63 | 0.25 | 3.38 | 47.1 | 25.0 | 7.4 | 100 | 2 | 99 | 5 |
| | 3 | 3.37 | 0.55 | 2.82 | 41.5 | 21.1 | 7.5 | 99 | 3 | 99 | 6 |
| | 4 | 2.69 | 0.68 | 2.01 | 29.2 | 18.1 | 9.0 | 91 | 6 | 76 | 12 |
| | 5 | 3.42 | 1.04 | 2.39 | 34.6 | 19.6 | 8.2 | 66 | 2 | 56 | 5 |

## Cross Sections



## Site Description

Hydrogeomorphic Reach: F

Coordinates (UTM, NAD83 meters):

Northing: 5075924 Easting: 513882

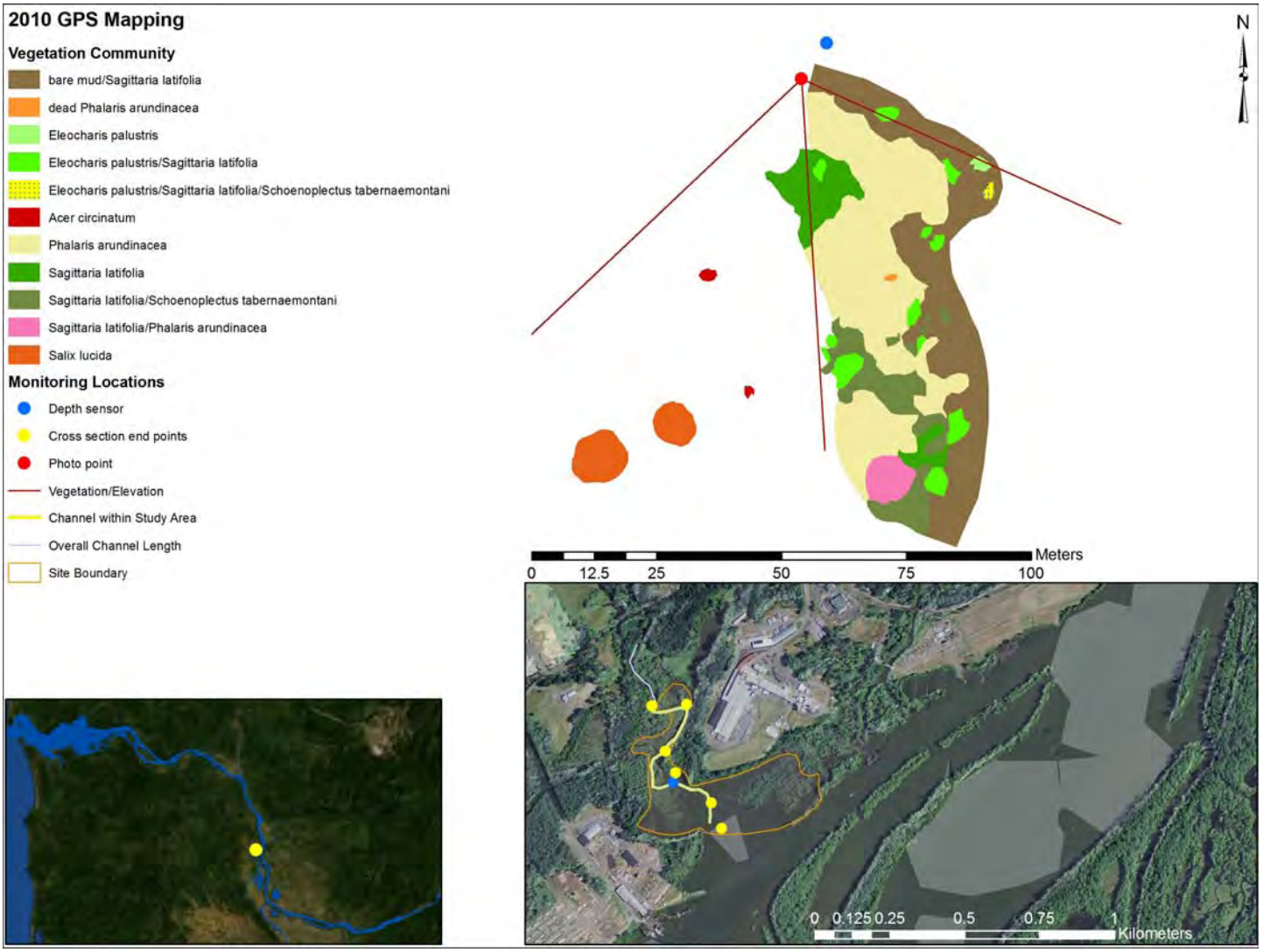
Distance from Columbia River mouth: 143 rkm

Distance from main channel: 3822 meters

Type: Marsh

Total Site Area: 13.6 ha Study Area: 0.27 ha

Total channel length: 974 m Channel surveyed: 735 m Channel slope: -0.07 m/km



## Site Information

The monitoring site in Scappoose Bay is located at the mouth of McNulty Creek. The site is bracketed on 2 sides by large industrial areas which have likely contributed contaminants to the site in the past. The monitoring site is comprised of a large emergent marsh that grades from steeper banks to extensive mud flats at the mouth of the Creek.

## Elevation

Lowest marsh (NAVD88, m): 2.23

Highest marsh (NAVD88, m): 2.91

Lowest marsh (CRD, m): 0.94

Highest marsh (CRD, m): 1.62

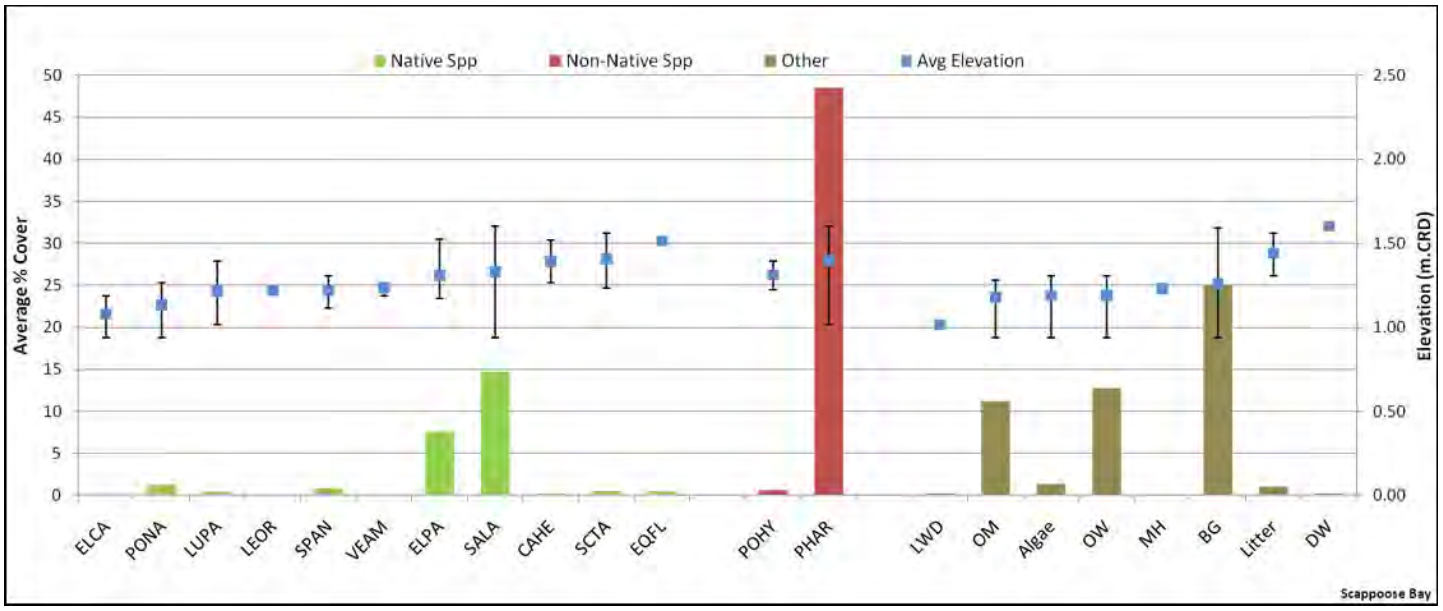
## Vegetation

Number of Native species: 11

% Native Cover: 26.16

Number of Non-native species: 3

% Non-native Cover: 49.16



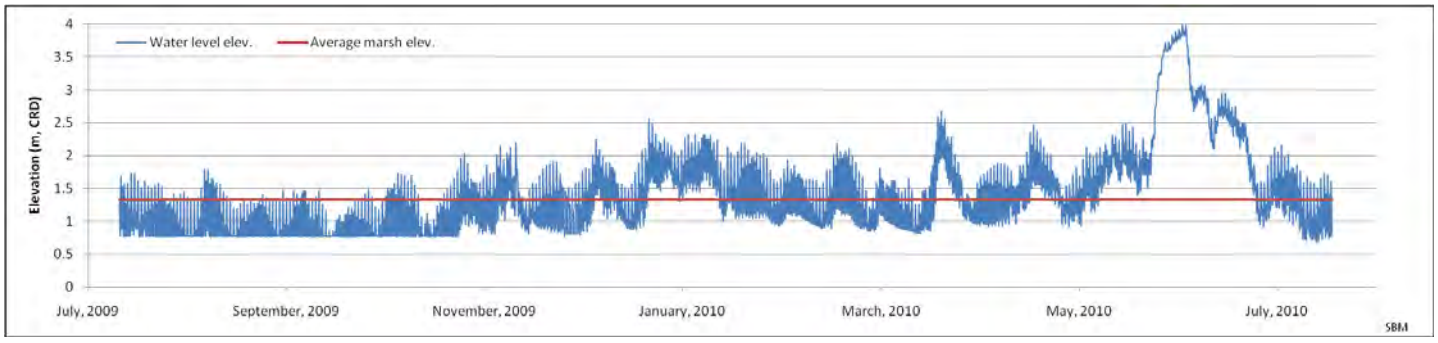

## Inundation

| | Std | Marsh |
|---|---|---|
| Average Elev (m, CRD) | 1.89 | 1.33 |
| Sum Exceedance Value (SEV) | 26.9 | 50.9 |

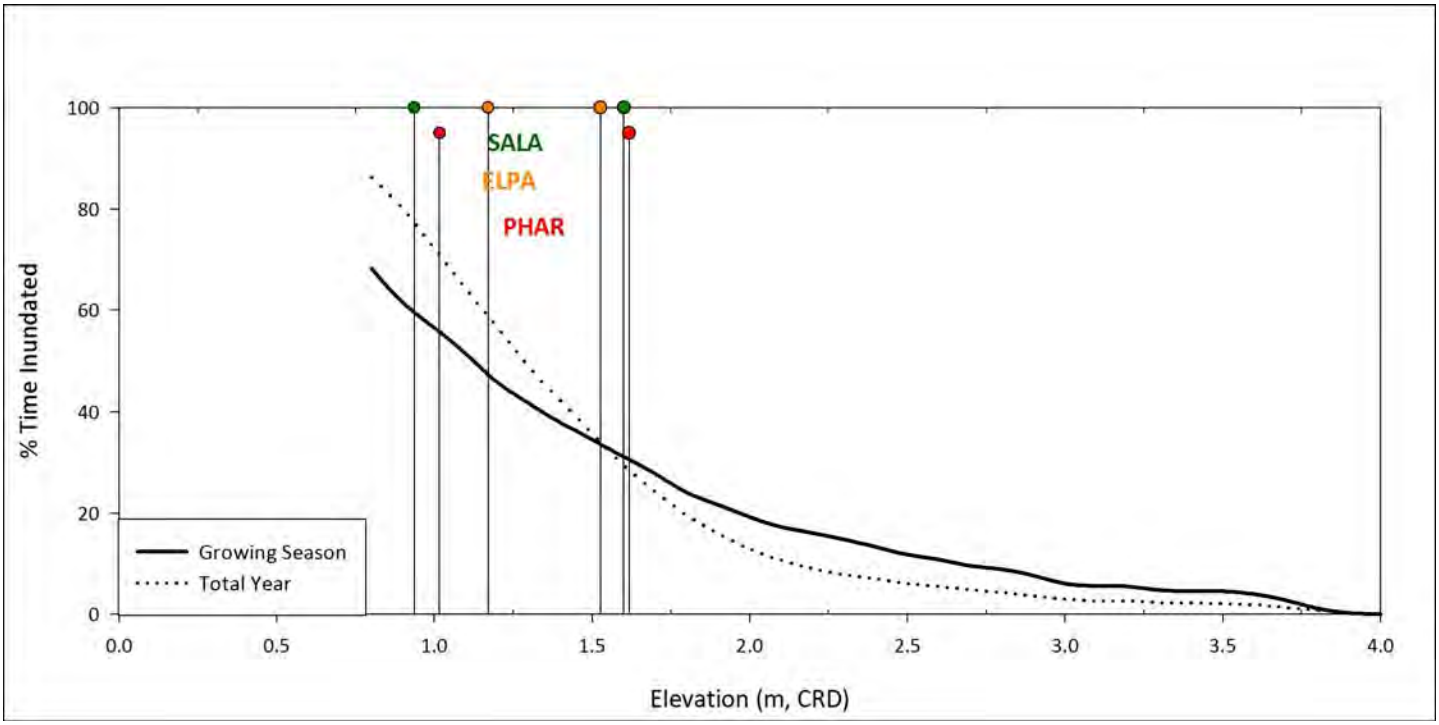
Modified Growing Season:

Aug 20 to Oct 12, 2009

Apr 22 to Jun 21, 2010

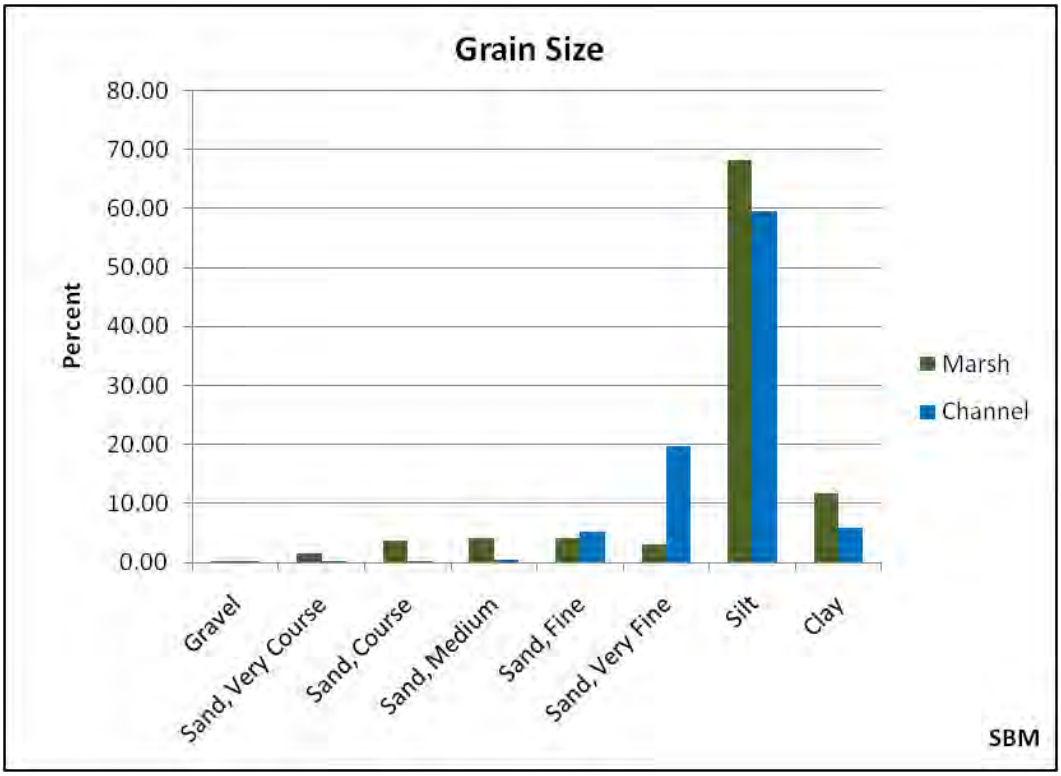


## Inundation (cont.)




## Sediment

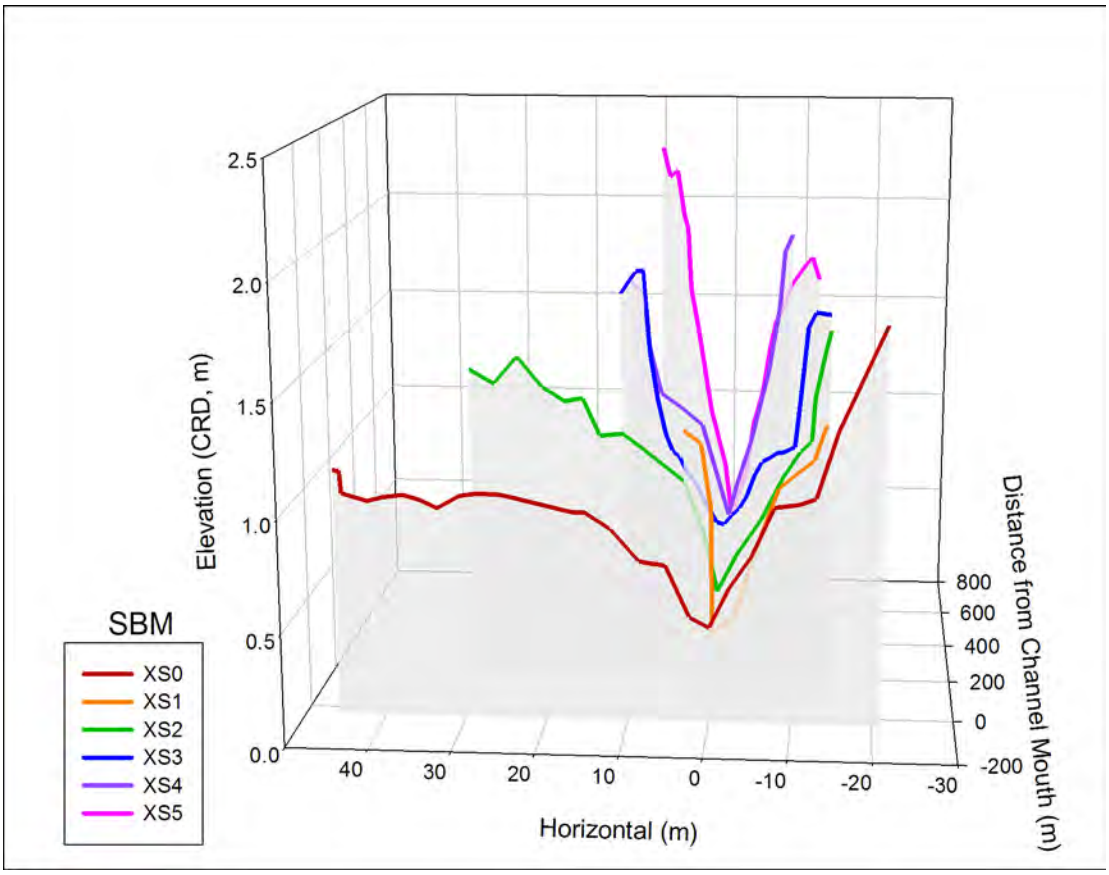
Total Organic Carbon (TOC) in channel: 3.67 in wetland: 5.13



## Channels

| | | Physical Metrics | | | | | | Inundation | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Year | | Growing Season | |
| | Cross Section | Bank Elevation (m) | Thalweg Elevation (m) | Channel Depth (m) | Cross Section Area ($m^2$) | Channel Width (m) | Width: Depth Ratio | Time WL > Thalweg (%) | Time WL > Bank (%) | Time WL > Thalweg (%) | Time WL > Bank (%) |
| SBM | 0 | 0.99 | 0.43 | 0.56 | 6.9 | 54.3 | 97.4 | 99 | 73 | 99 | 57 |
| | 1 | 0.90 | 0.32 | 0.57 | 2.6 | 7.4 | 12.9 | 99 | 80 | 99 | 62 |
| | 2 | 1.29 | 0.40 | 0.90 | 11.6 | 29.6 | 33.0 | 99 | 49 | 99 | 42 |
| | 3 | 1.52 | 0.56 | 0.97 | 14.1 | 21.4 | 22.1 | 99 | 34 | 99 | 34 |
| | 4 | 1.59 | 0.49 | 1.10 | 11.7 | 18.9 | 17.1 | 99 | 30 | 99 | 31 |
| | 5 | 1.73 | 0.38 | 1.35 | 10.7 | 17.3 | 12.8 | 99 | 23 | 99 | 27 |

### Cross Sections



## Site Description

Hydrogeomorphic Reach: F

Coordinates (UTM, NAD83 meters):

Northing: 5072874 Easting: 514541

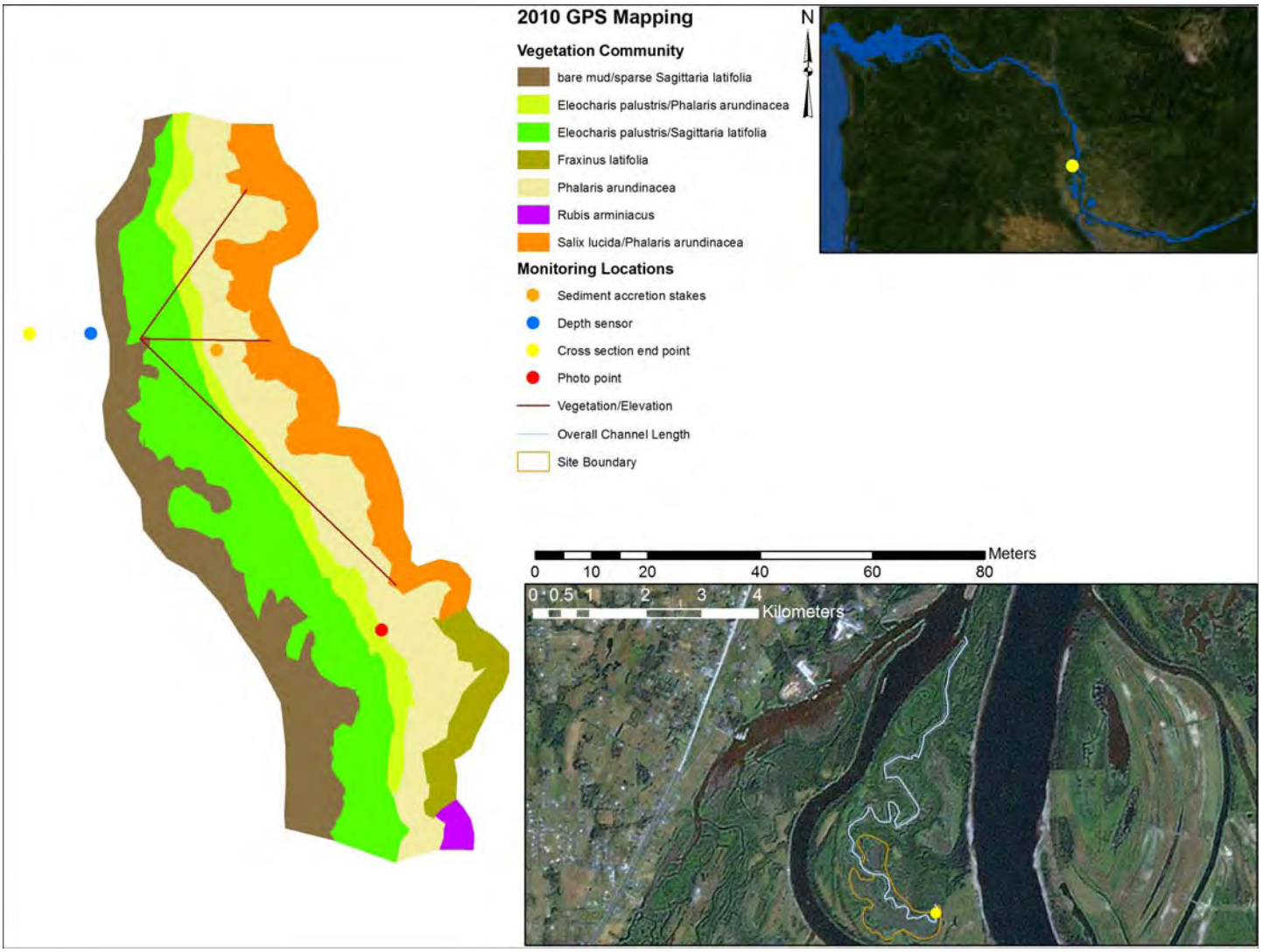
Distance from Columbia River mouth: 145 rkm

Distance from main channel: 10120 meters

Type: Marsh

Total Site Area: 64.0 ha Study Area: 0.39 ha

Total channel length: 7087 m Channel surveyed: 6986 m Channel slope: NA



## Site Information

Cunningham Lake is located on Sauvie Island in the Oregon DFW Wildlife Area at the end of Cunningham Slough approximately 6.4 km from the mainstem of the Columbia River. The site is a fringing emergent marsh bordering the extremely shallow "lake" that in some years is covered with wapato (Sagittaria latifolia). Cunningham Lake has been surveyed annually since 2005 as part of the LCREP Ecosystem Monitoring Program.

## Elevation

Lowest marsh (NAVD88, m): 2.28

Highest marsh (NAVD88, m): 3.01

Lowest marsh (CRD, m): 0.99

Highest marsh (CRD, m): 1.72

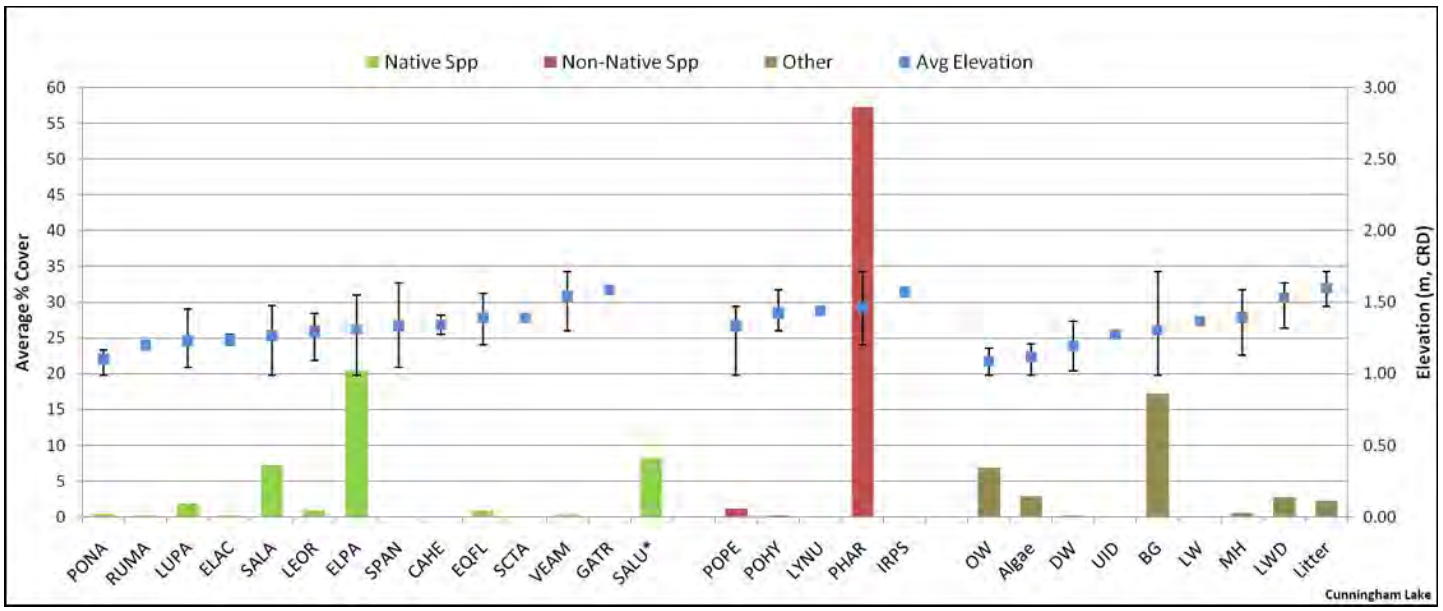
## Vegetation

Number of Native species: 14

% Native Cover: 40.84

Number of Non-native species: 5

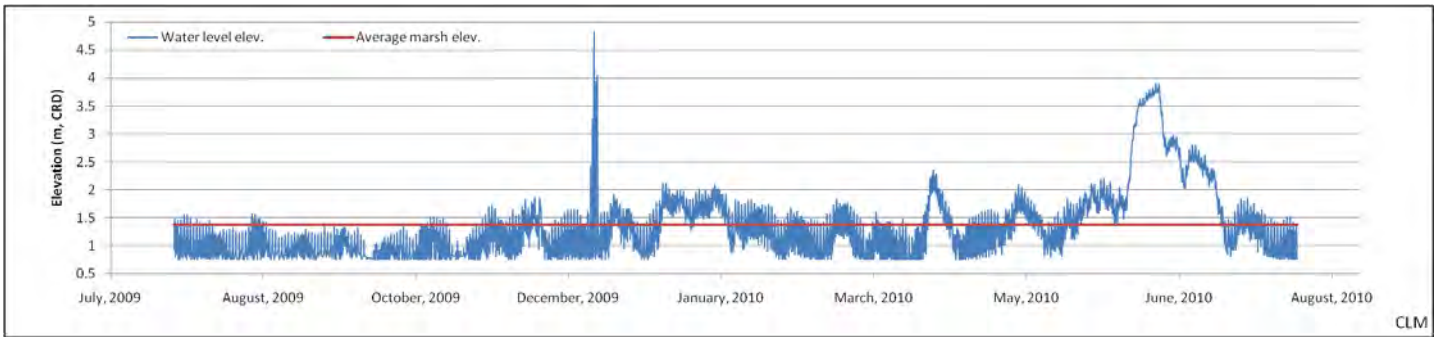
% Non-native Cover: 58.63

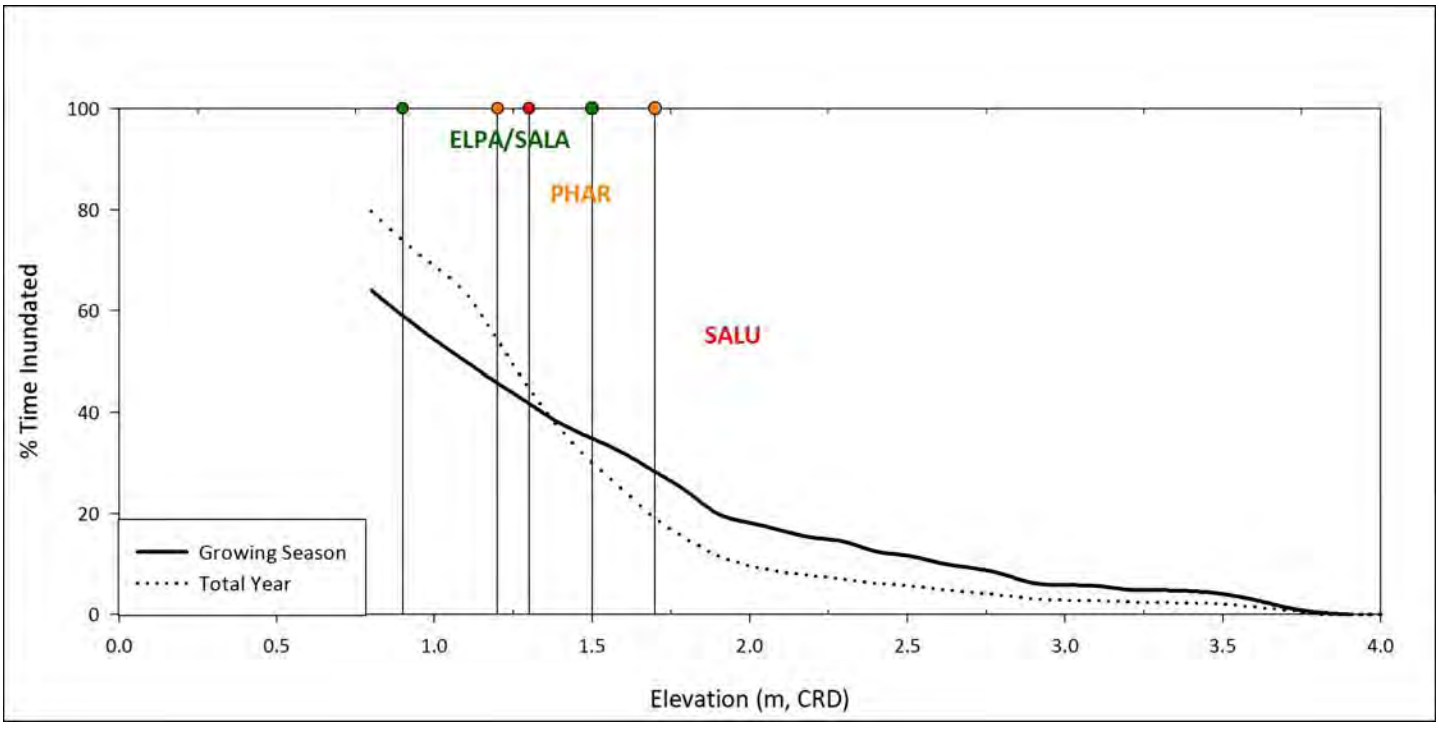


## Inundation

| | Std | Marsh |
|---|---|---|
| Average Elev (m, CRD) | 1.89 | 1.37 |
| Sum Exceedance Value (SEV) | 23.6 | 43.1 |

Modified Growing Season:
Aug 20 to Oct 12, 2009
Apr 22 to Jun 21, 2010



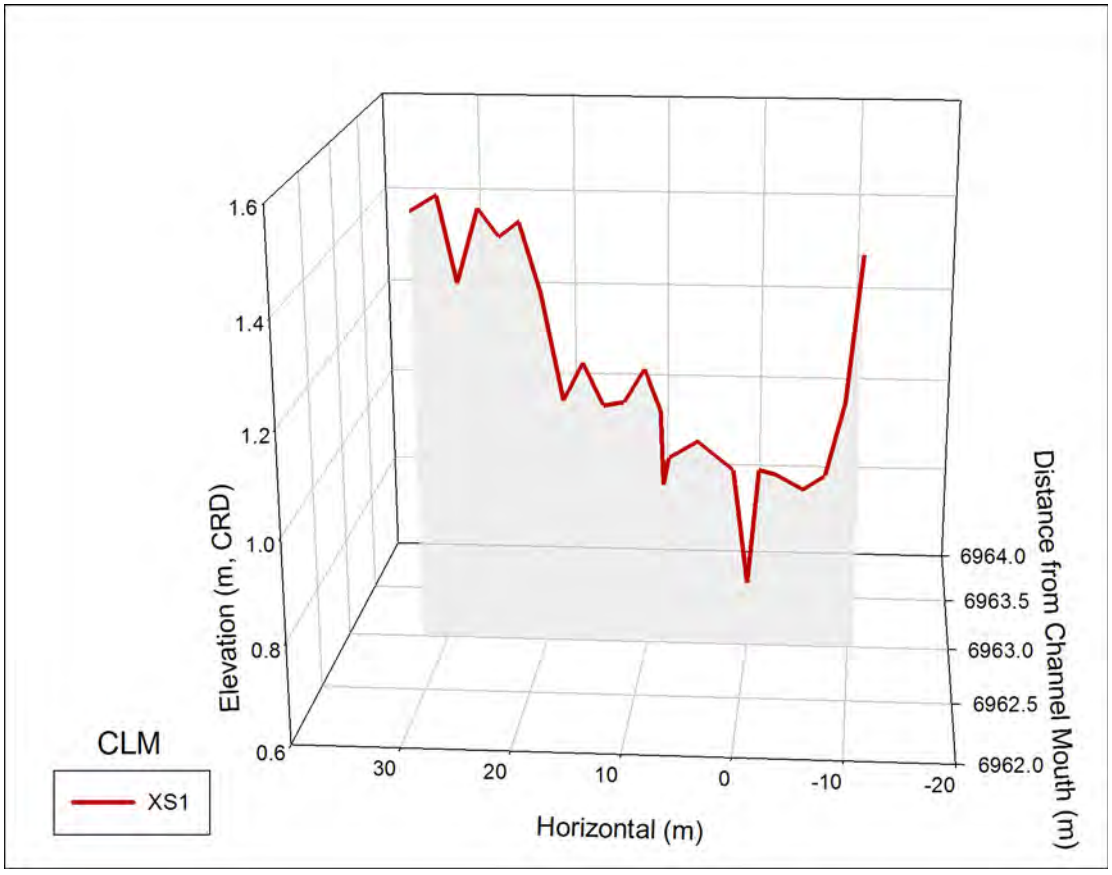

## Sediment

Sediment accretion rate: 1.88 cm per year Elevation at sediment stakes: 1.45 m, CRD

## Channels

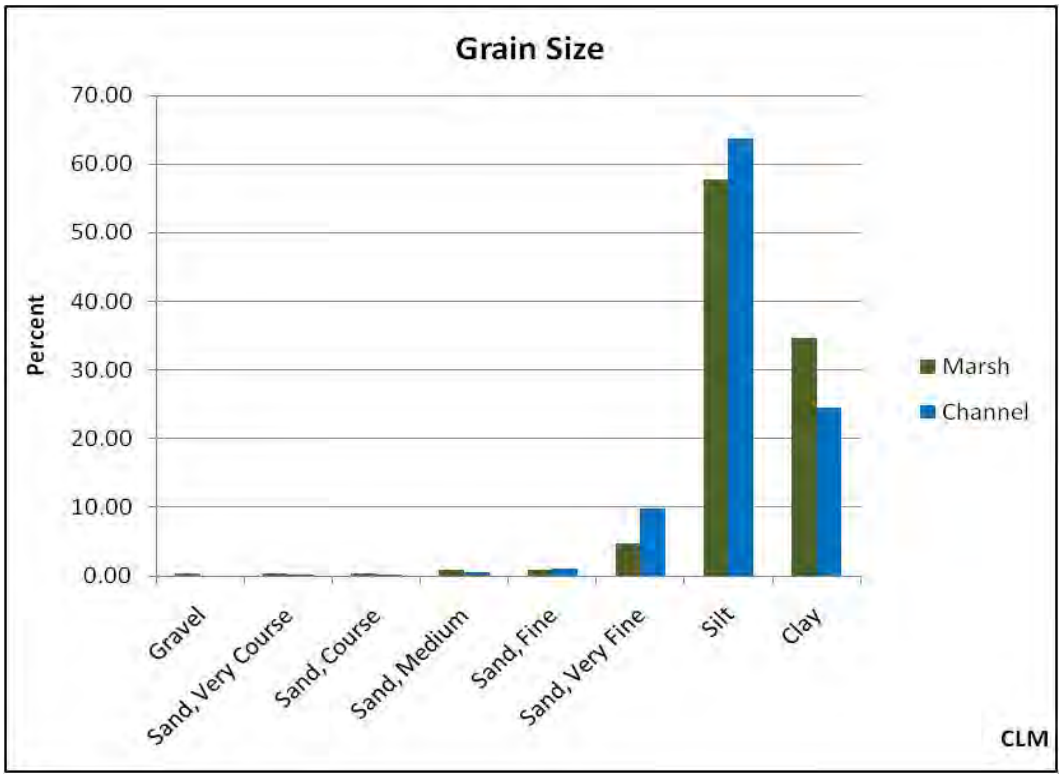
| | Physical Metrics | | | | | | | Inundation | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Year | | Growing Season | |
| | Cross Section | Bank Elevation (m) | Thalweg Elevation (m) | Channel Depth (m) | Cross Section Area ($m^2$) | Channel Width (m) | Width: Depth Ratio | Time WL > Thalweg (%) | Time WL > Bank (%) | Time WL > Thalweg (%) | Time WL > Bank (%) |
| CLM | 1 | 1.17 | 0.73 | 0.44 | 3.7 | 19.7 | 45.1 | 75 | 57 | 60 | 47 |

### Cross Sections



## Sediment

Total Organic Carbon (TOC) in channel: 7.30 in wetland: 9.54



## Site Description

Hydrogeomorphic Reach: F

Coordinates (UTM, NAD83 meters):

Northing: 5070175 Easting: 519154

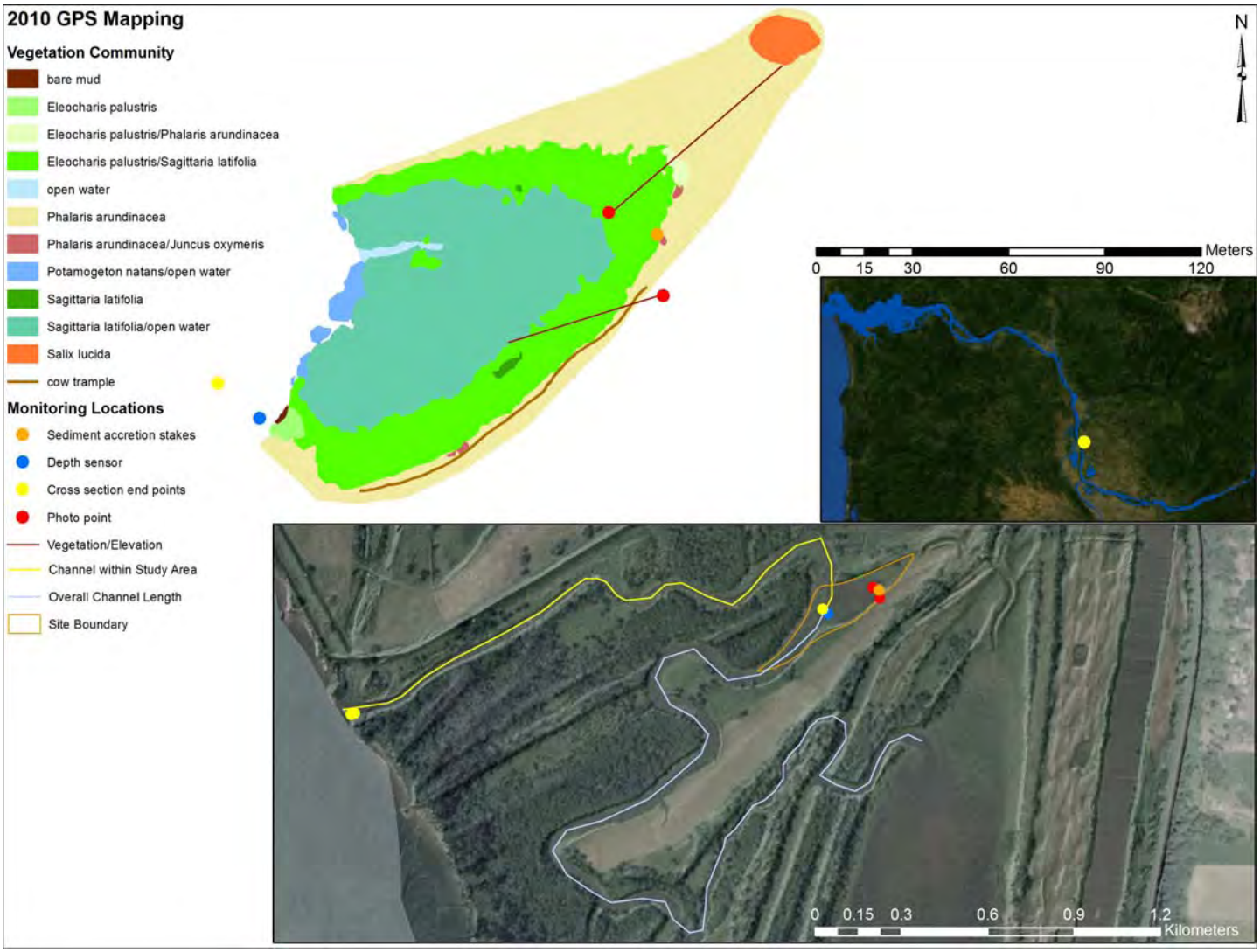
Distance from Columbia River mouth: 149 rkm

Distance from main channel: 2109 meters

Type: Marsh

Total Site Area: 2.61 ha Study Area: 1.21 ha

Total channel length: 4387 m Channel surveyed: 1550 m Channel slope: -0.11 m/km



## Site Information

Campbell Slough, is located on the Ridgefield National Wildlife Refuge in Washington. The monitoring site is an emergent marsh adjacent to the slough approximately 1.4 km from the mainstem of the Columbia River. The site grades from wapato up to reed canary grass and is adjacent to fenced in pasture land. Extensive grazing occurred at the site in 2007, when cows inadvertently entered the site, but has been recovering since then. Campbell Slough has been surveyed annually since 2005 as part of the LCREP Ecosystem Monitoring Program.

## Elevation

Lowest marsh (NAVD88, m): 2.45

Highest marsh (NAVD88, m): 4.02

Lowest marsh (CRD, m): 1.15

Highest marsh (CRD, m): 2.71

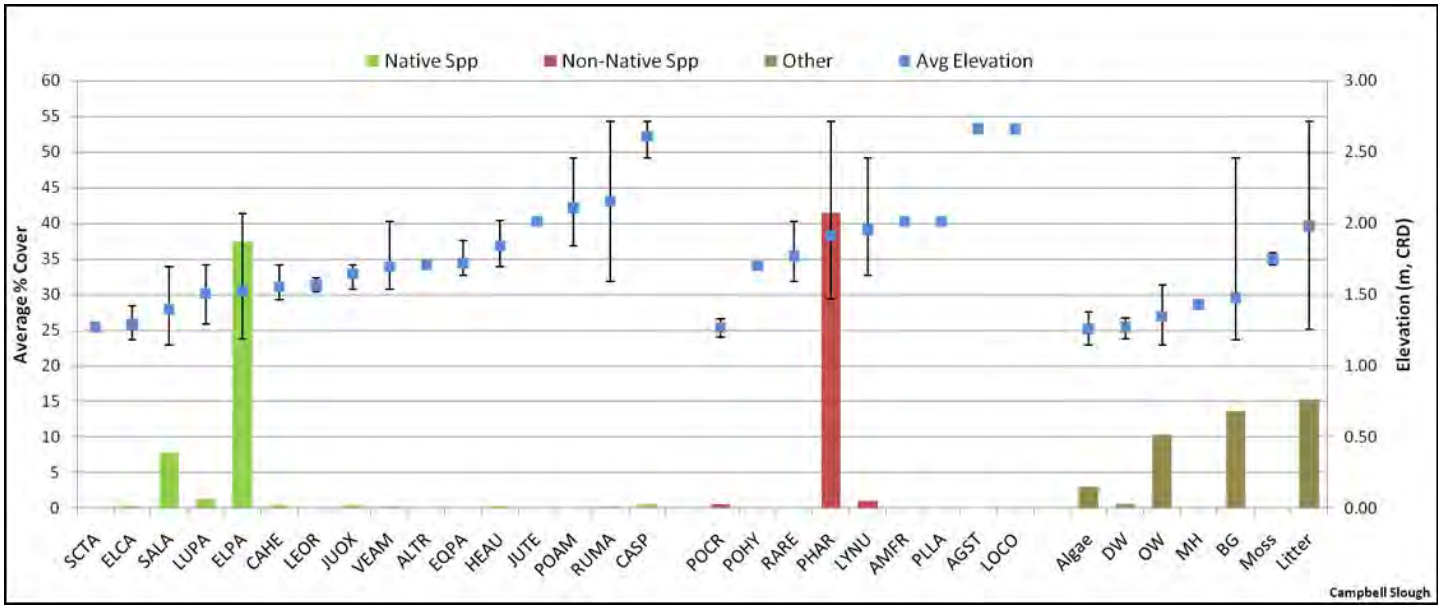
## Vegetation

Number of Native species: 16

% Native Cover: 49.89

Number of Non-native species: 9

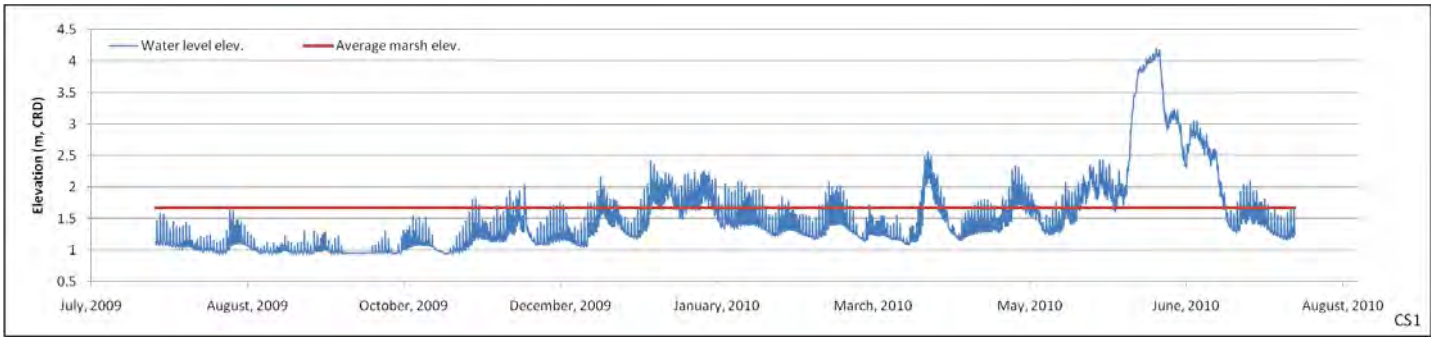
% Non-native Cover: 43.71

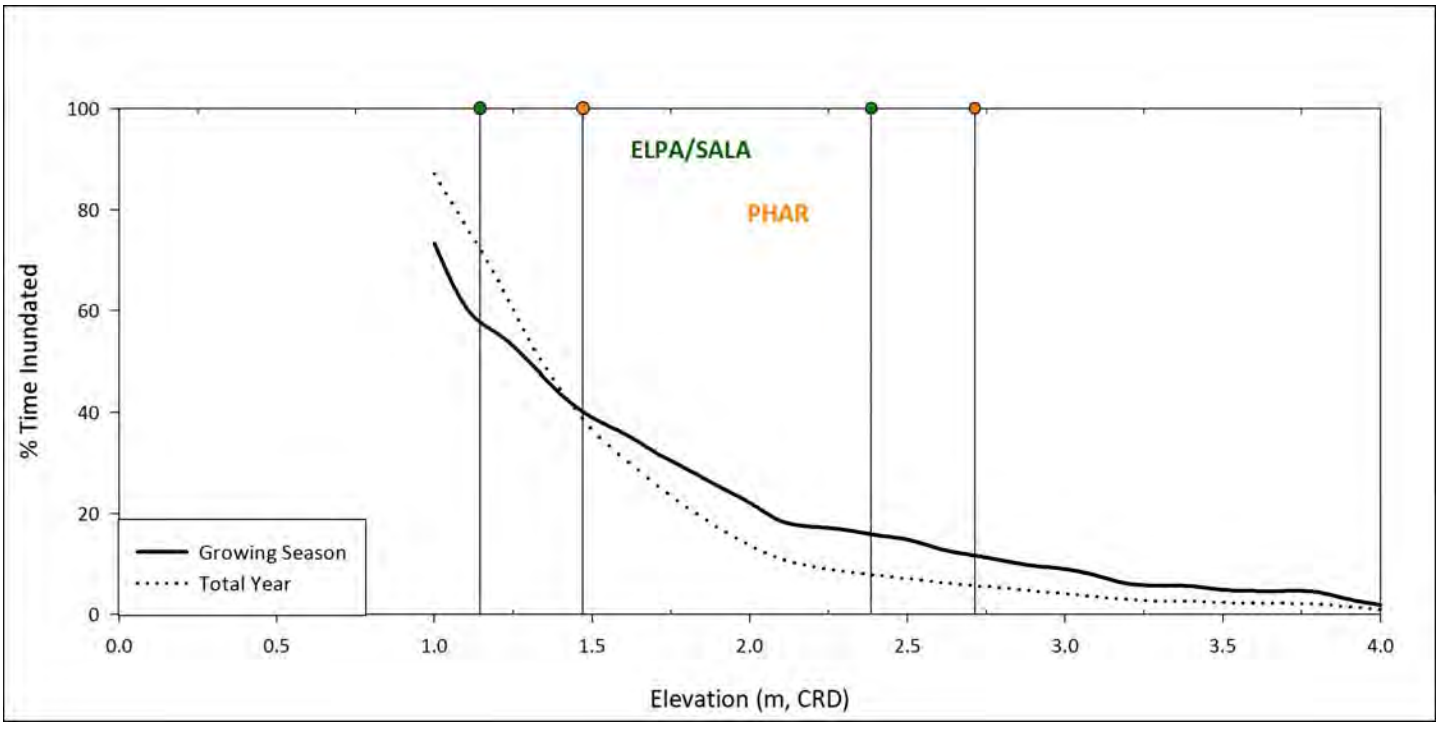


## Inundation

| | Std | Marsh |
|---|---|---|
| Average Elev (m, CRD) | 1.89 | 1.67 |
| Sum Exceedance Value (SEV) | 31.3 | 39.7 |

Modified Growing Season:
Aug 20 to Oct 12, 2009
Apr 22 to Jun 21, 2010




## Sediment

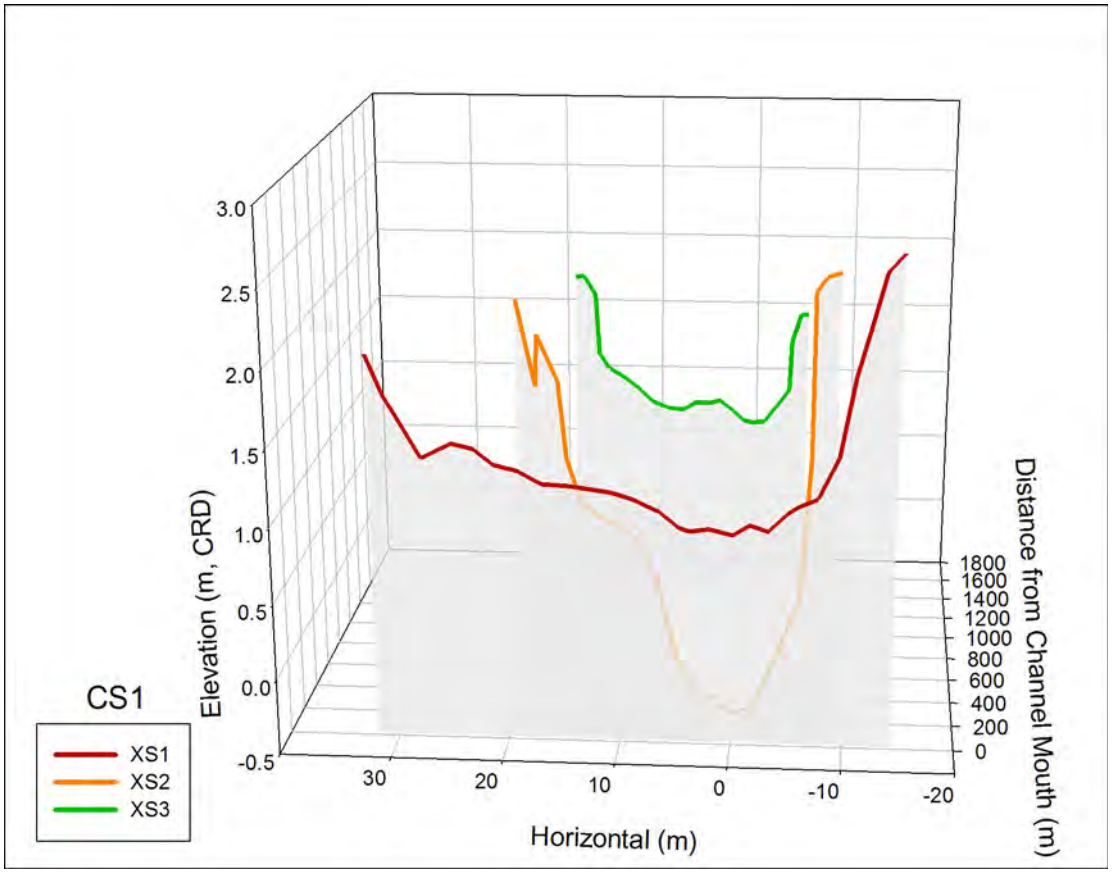
Sediment accretion rate: 0.40 cm per year

Elevation at sediment stakes: 1.51 m, CRD

## Channels

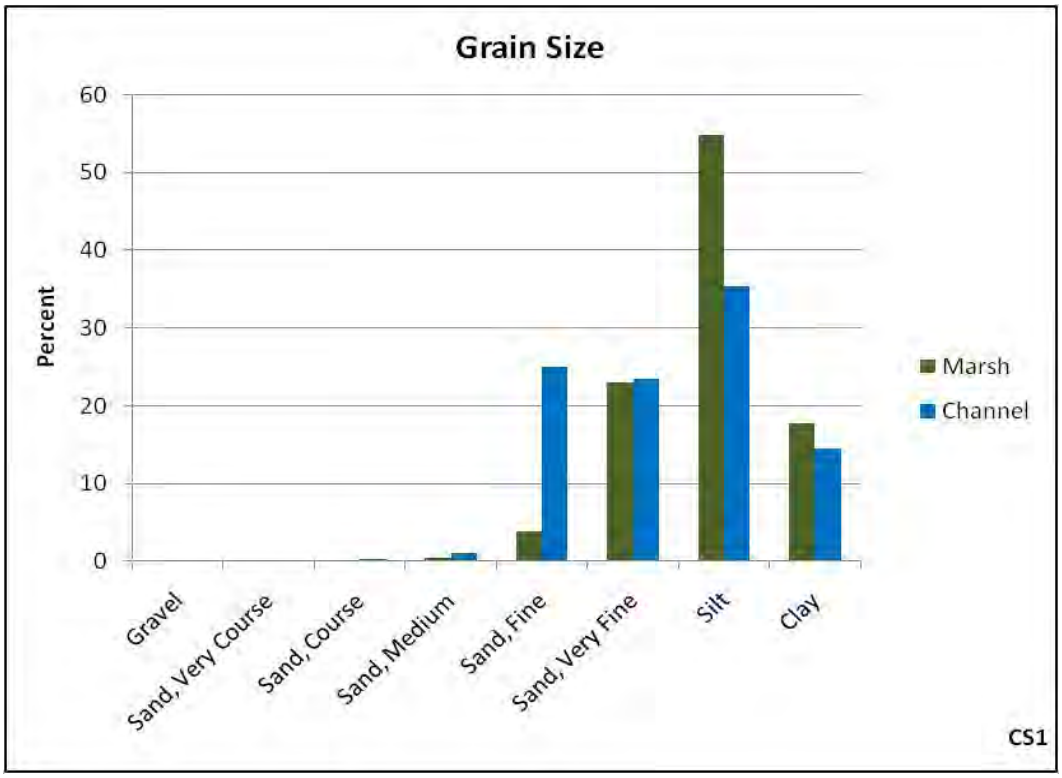
| | | Physical Metrics | | | | | | Inundation | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Year | | Growing Season | |
| | Cross Section | Bank Elevation (m) | Thalweg Elevation (m) | Channel Depth (m) | Cross Section Area ($m^2$) | Channel Width (m) | Width: Depth Ratio | Time WL > Thalweg (%) | Time WL > Bank (%) | Time WL > Thalweg (%) | Time WL > Bank (%) |
| CS1 | 1 | 2.01 | 0.89 | 1.12 | 33.9 | 43.0 | 38.5 | 83 | 13 | 67 | 22 |
| | 2 | 1.85 | -0.31 | 2.16 | 31.9 | 22.2 | 10.3 | 99 | 19 | 98 | 27 |
| | 3 | 1.34 | 0.73 | 0.61 | 8.9 | 19.9 | 32.5 | 99 | 50 | 98 | 47 |

### Cross Sections



## Sediment

Total Organic Carbon (TOC) in channel: 4.19 in wetland: 5.17



## Site Description

Hydrogeomorphic Reach: F

Coordinates (UTM, NAD83 meters):

Northing: 5064833 Easting: 517703

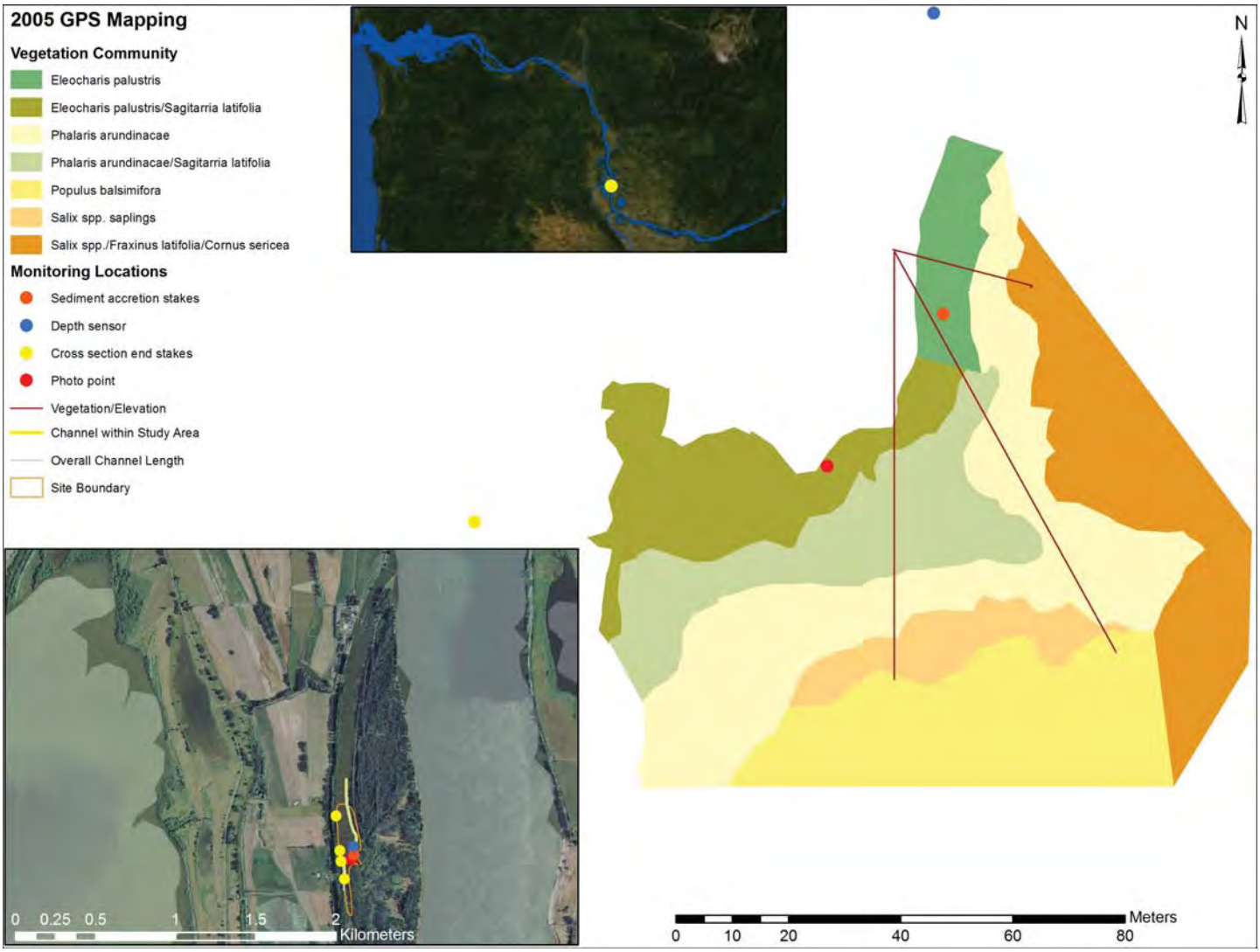
Distance from Columbia River mouth: 154 rkm

Distance from main channel: 1870 meters

Type: Marsh

Total Site Area: 5.3 ha Study Area: 0.53 ha

Total channel length: 748 m Channel surveyed: 681 m Channel slope: 0.84 m/km



## Site Information

Sauvie Slough is a finger slough off the main channel on the east side of Sauvie Island. The mouth of the slough is home to a yacht club mooring area and RV park. The location of the monitoring site is at the shallow, upper end of the slough, where a shallow emergent marsh is surrounded by willow, and cottonwoods. This area is under the management of the Oregon Department of Fish and Wildlife Sauvie Island Refuge.

## Elevation

Lowest marsh (NAVD88, m): 2.37

Highest marsh (NAVD88, m): 3.28

Lowest marsh (CRD, m): 1.03

Highest marsh (CRD, m): 1.95

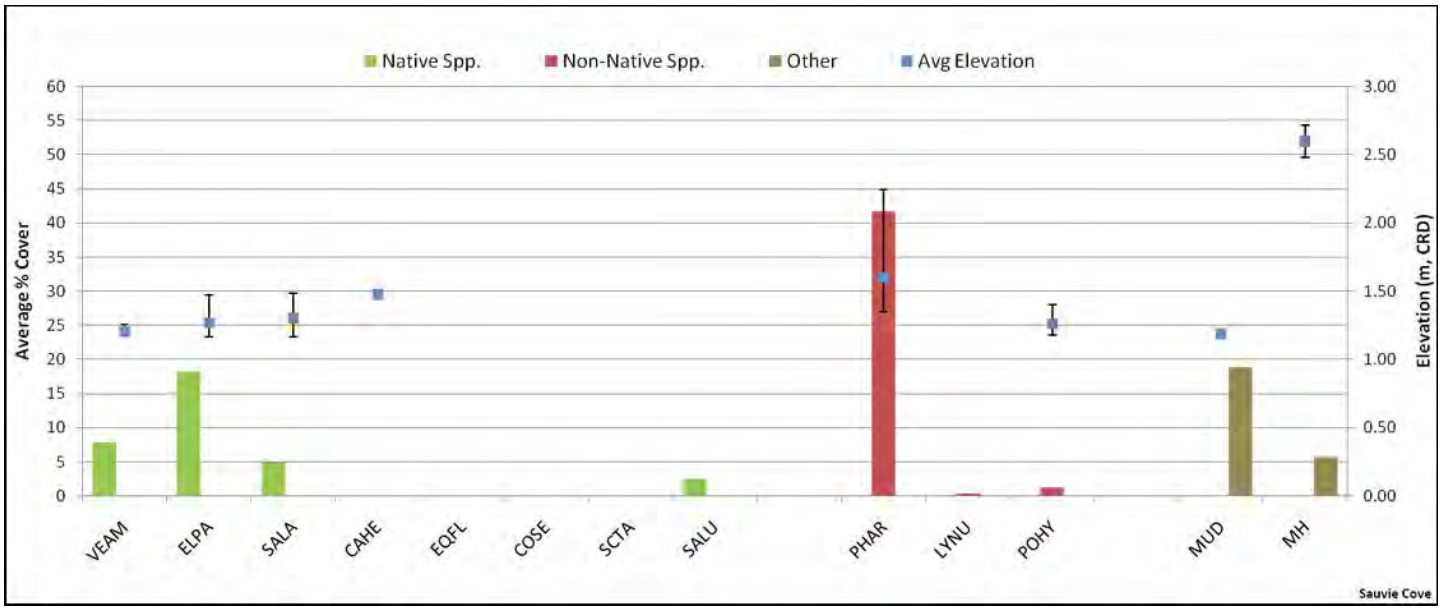
## Vegetation

Number of Native species: 8

% Native Cover: 33.70

Number of Non-native species: 3

% Non-native Cover: 43.28



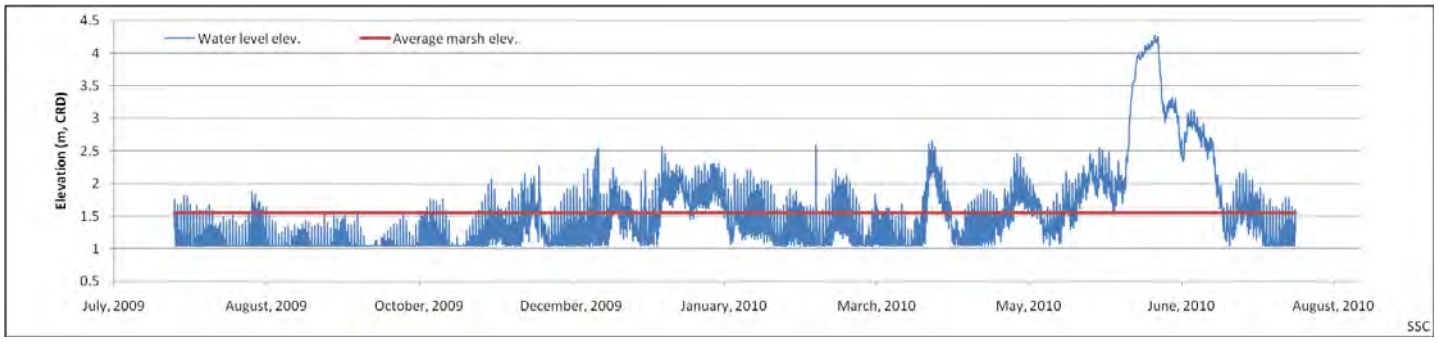

## Inundation

| | Std | Marsh |
|---|---|---|
| Average Elev (m, CRD) | 1.89 | 1.55 |
| Sum Exceedance Value (SEV) | 33.5 | 48.5 |

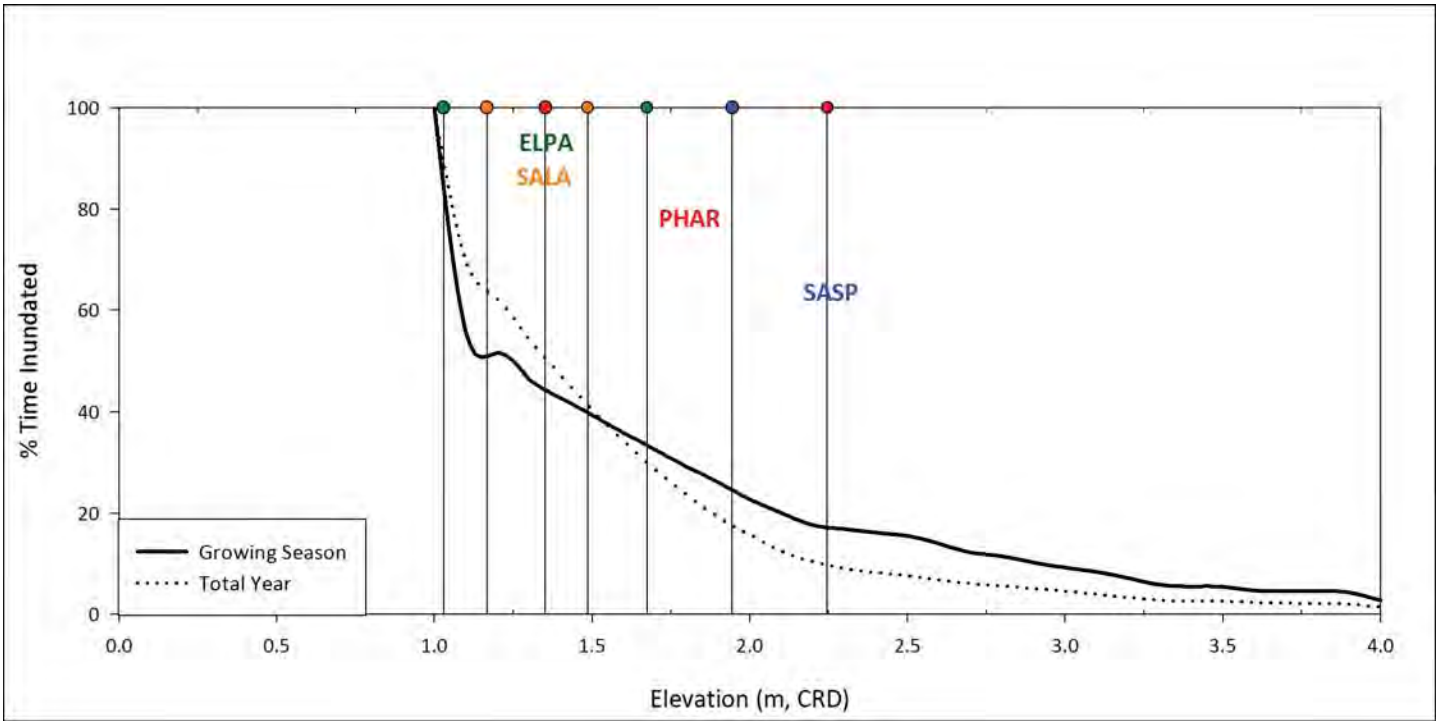
Modified Growing Season:

Aug 20 to Oct 12, 2009

Apr 22 to Jun 21, 2010



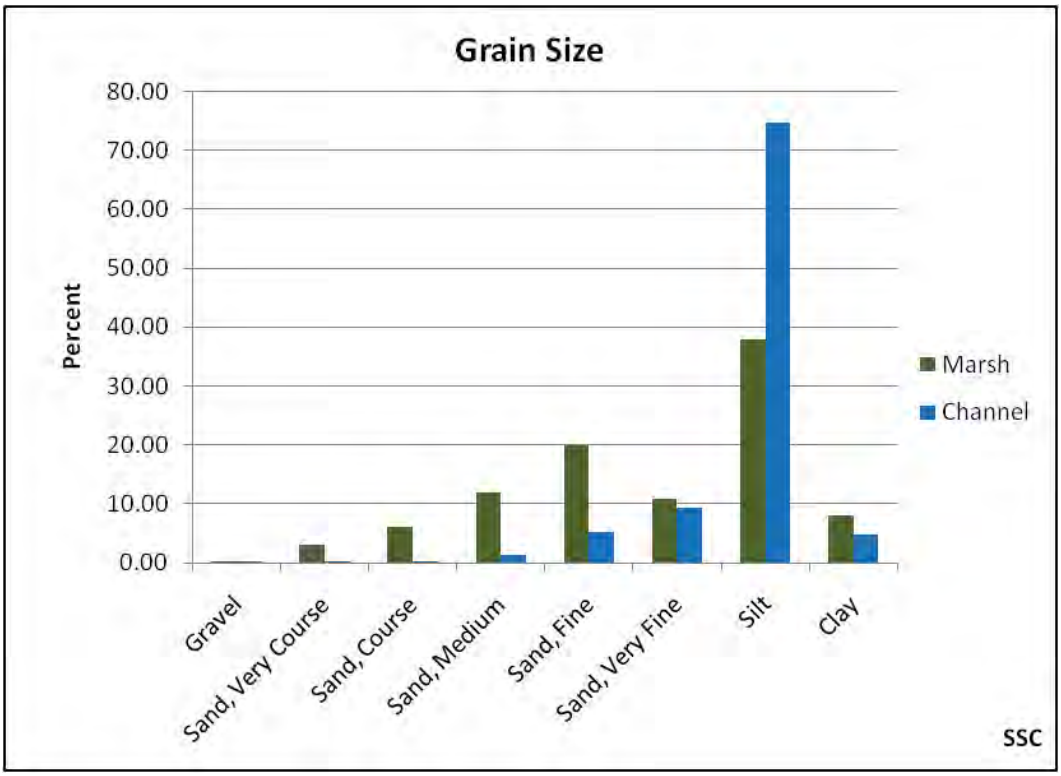
## Inundation (cont.)




## Sediment

Sediment accretion rate: 2.52 cm per year Elevation at sediment stakes: 1.43 m, CRD

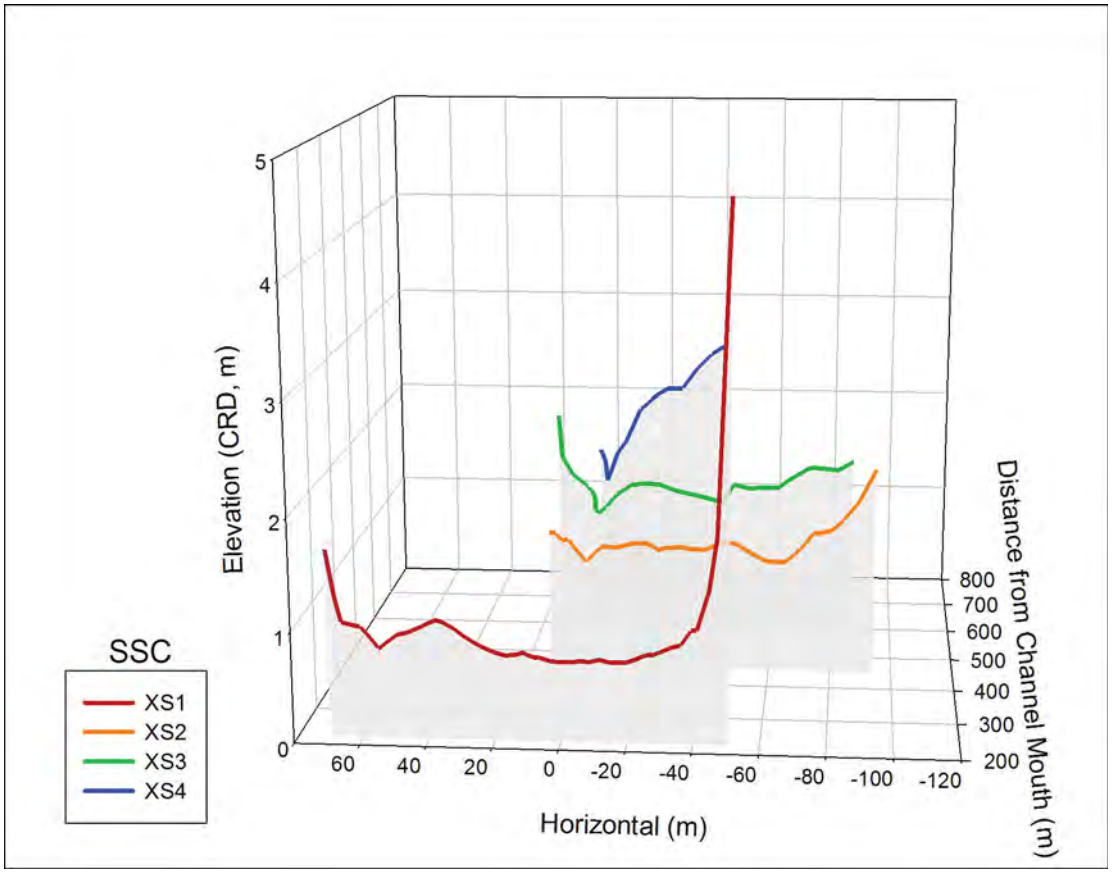
Total Organic Carbon (TOC) in channel: 2.32 in wetland: 2.63



## Channels

| | Physical Metrics | | | | | | | Inundation | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Year | | Growing Season | |
| | Cross Section | Bank Elevation (m) | Thalweg Elevation (m) | Channel Depth (m) | Cross Section Area ($m^2$) | Channel Width (m) | Width: Depth Ratio | Time WL > Thalweg (%) | Time WL > Bank (%) | Time WL > Thalweg (%) | Time WL > Bank (%) |
| SSC | 1 | 1.03 | 0.72 | 0.31 | 19.4 | 107.2 | 342.6 | 100 | 100 | 100 | 100 |
| | 2 | 1.17 | 1.02 | 0.15 | 2.0 | 9.2 | 61.4 | 100 | 65 | 100 | 53 |
| | 3 | 1.33 | 1.19 | 0.14 | 0.4 | 5.9 | 42.9 | 51 | 52 | 45 | 45 |
| | 4 | 1.49 | 1.29 | 0.20 | 0.3 | 3.3 | 16.6 | 45 | 41 | 41 | 40 |

### Cross Sections



## Site Description

Hydrogeomorphic Reach: G

Coordinates (UTM, NAD83 meters):

Northing: 5045599 Easting: 542578

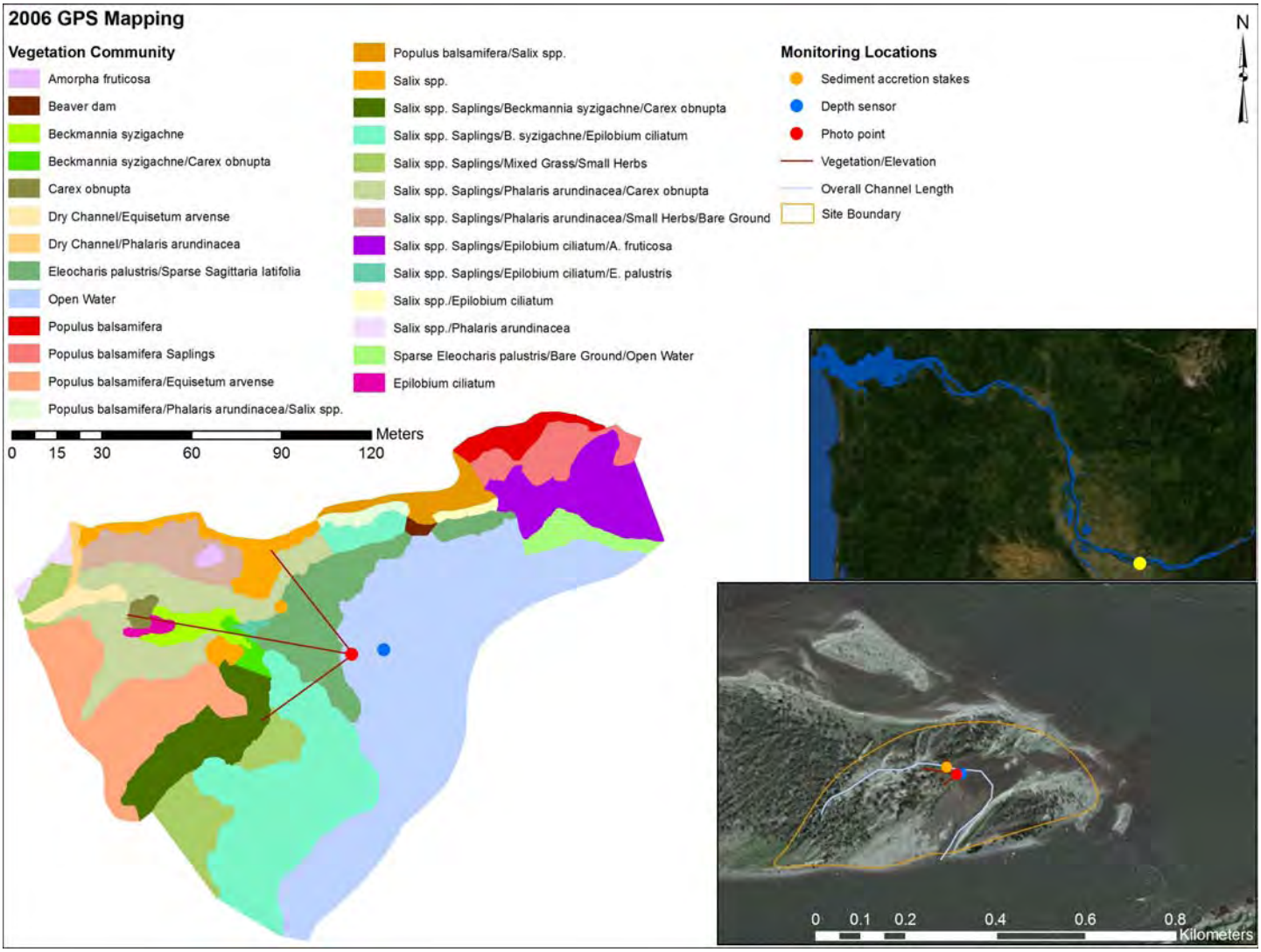
Distance from Columbia River mouth: 190 rkm

Distance from main channel: 0 meters

Type: Created

Total Site Area: 15.0 ha Study Area: 1.93 ha

Total channel length: 731 m Channel surveyed: 0 m Channel slope: NA



## Site Information

McGuire Island is located near Portland, Oregon. It was purchased by the Port of Portland in 1969 and is currently held to prevent flight path issues with the nearby airport but is managed by Oregon State Parks and Recreation. The island was created from dredge material and is surrounded by pile structures to maintain the navigation channel. The monitoring site is an off-channel emergent marsh grading up to cottonwoods with a seasonal channel.

## Elevation

Lowest marsh (NAVD88, m): 2.90

Highest marsh (NAVD88, m): 3.69

Lowest marsh (CRD, m): 0.89

Highest marsh (CRD, m): 1.68

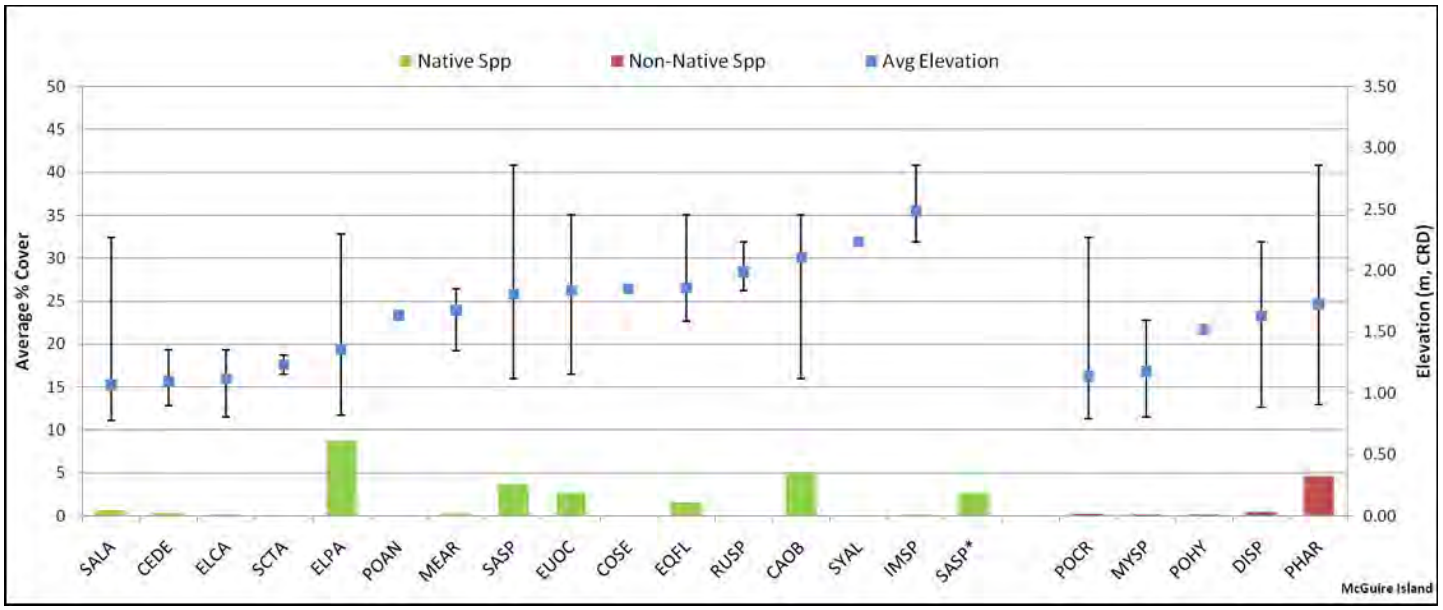
## Vegetation

Number of Native species: 16

% Native Cover: 23.66

Number of Non-native species: 5

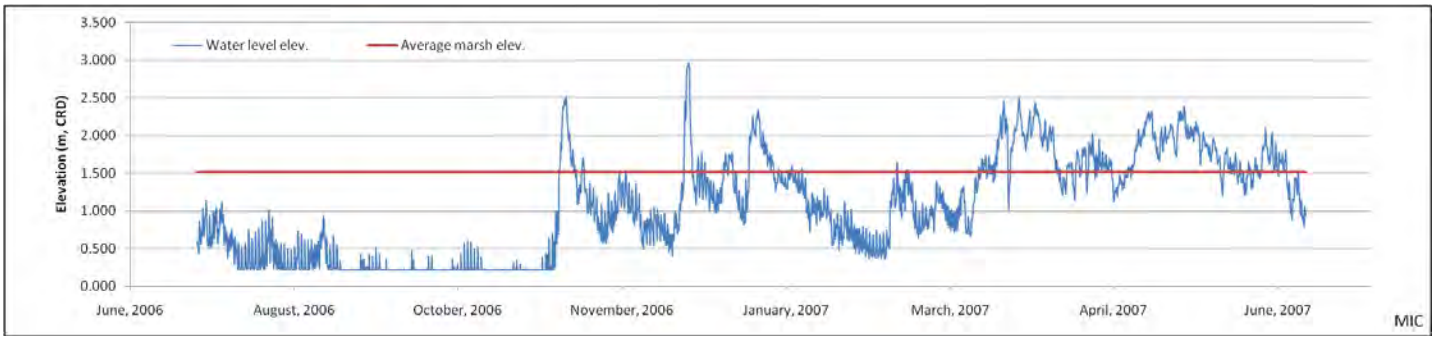
% Non-native Cover: 5.67

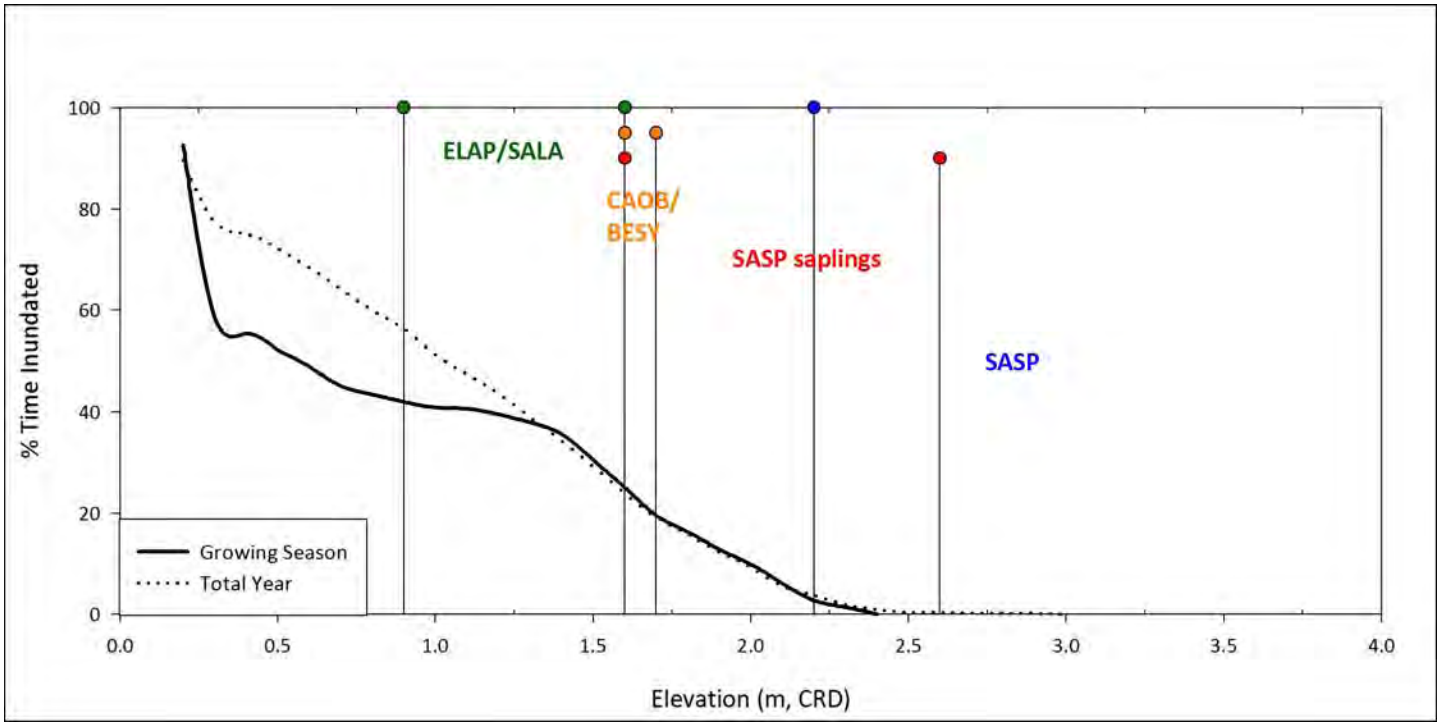


## Inundation

| | Std | Marsh |
|---|---|---|
| Average Elev (m, CRD) | 1.89 | 1.51 |
| Sum Exceedance Value (SEV) | 3.45 | 15.0 |

Modified Growing Season:
Aug 20 to Oct 12, 2006
Apr 22 to Jun 21, 2007



## Site Description

Hydrogeomorphic Reach: G

Coordinates (UTM, NAD83 meters):

Northing: 5047518 Easting: 546963

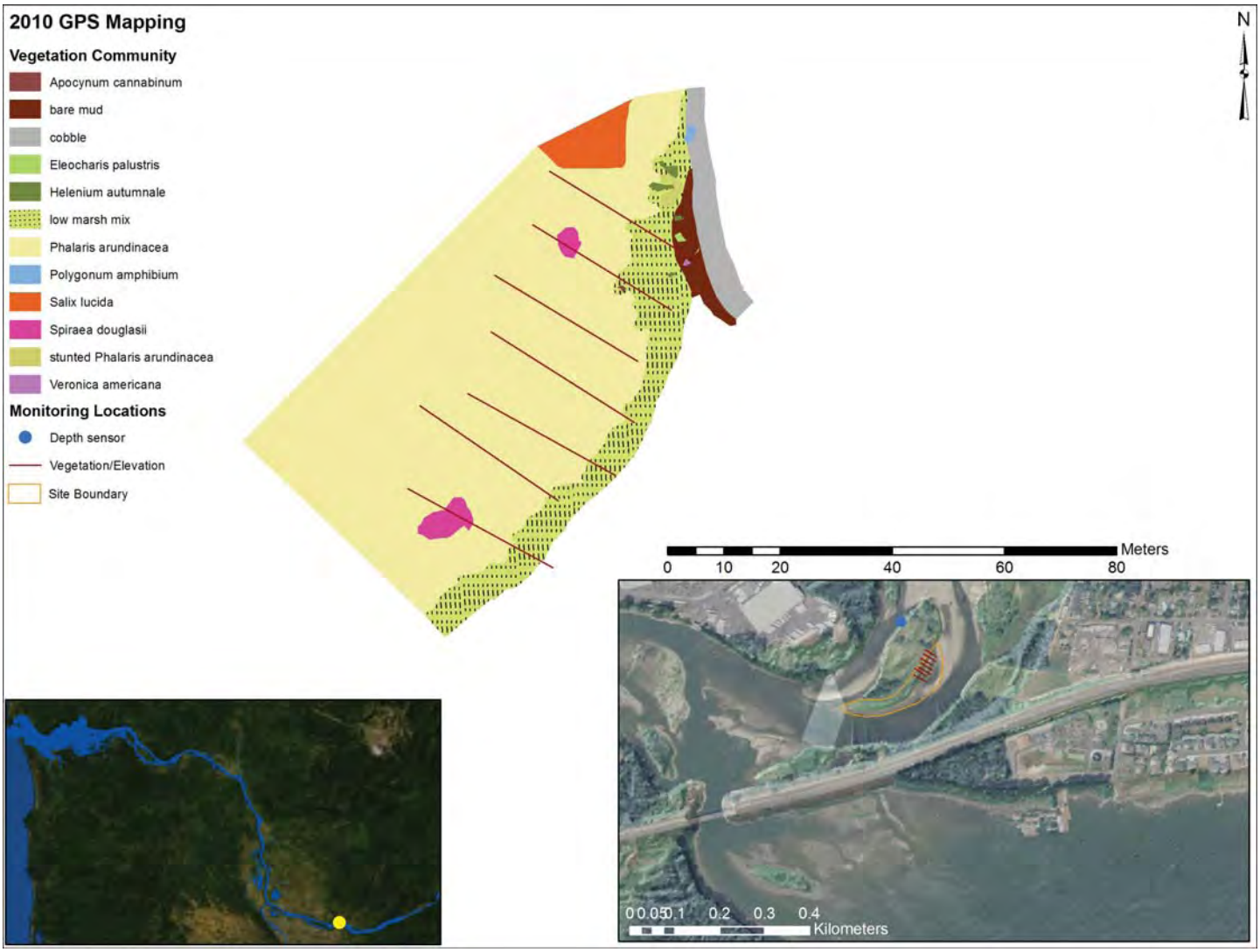
Distance from Columbia River mouth: 195 rkm

Distance from main channel: 654 meters

Type: Marsh

Total Site Area: 1.1 ha Study Area: 0.43 ha

Total channel length: 0 m Channel surveyed: 0 m Channel slope: NA



## Site Information

The monitoring site was located on Bead Island near the Washougal River mouth. The island sits in the middle of the Washougal River which flows past an industrial site between the towns of Camas and Washougal in Washington. The emergent marsh at this site is small and grades up from the river cobble to Phalaris arundinacea and cottonwoods.

## Elevation

Lowest marsh (NAVD88, m): 3.31

Highest marsh (NAVD88, m): 5.69

Lowest marsh (CRD, m): 1.19

Highest marsh (CRD, m): 3.56

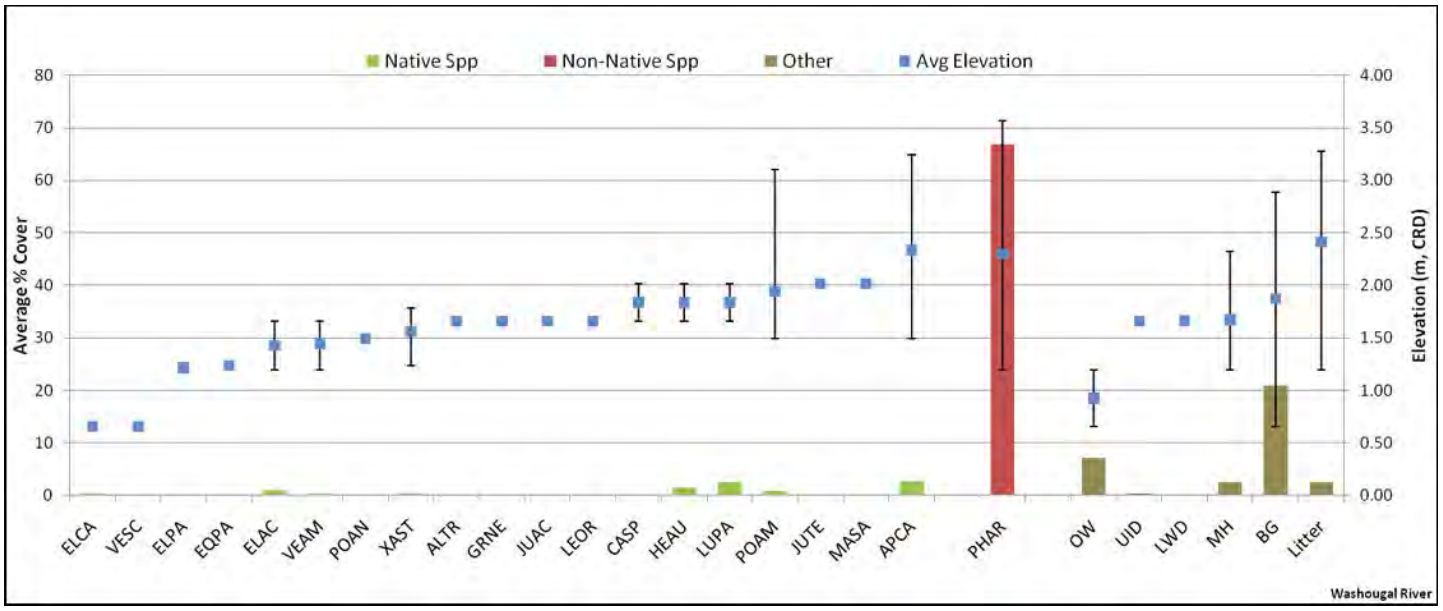
## Vegetation

Number of Native species: 19

% Native Cover: 10.46

Number of Non-native species: 1

% Non-native Cover: 66.82



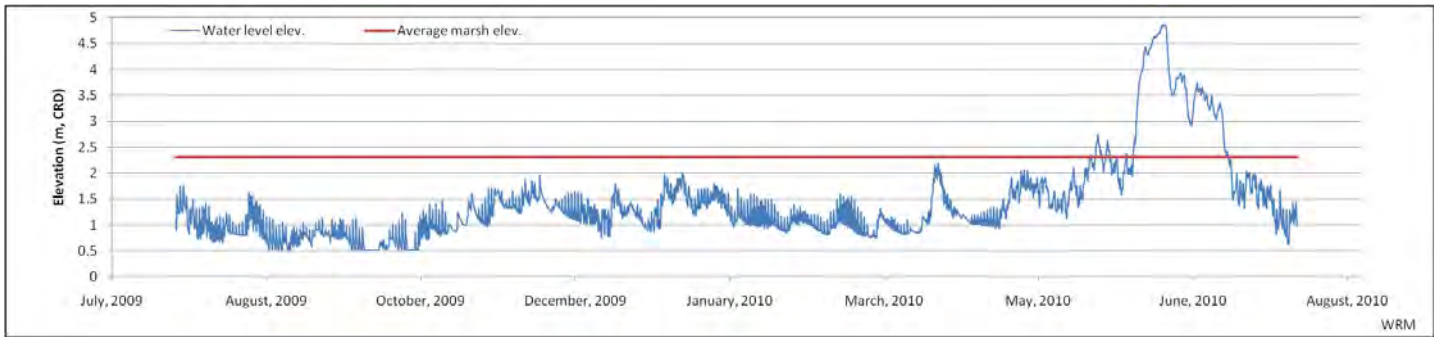

## Inundation

| | Std | Marsh |
|---|---|---|
| Average Elev (m, CRD) | 1.89 | 2.31 |
| Sum Exceedance Value (SEV) | 45.0 | 32.6 |

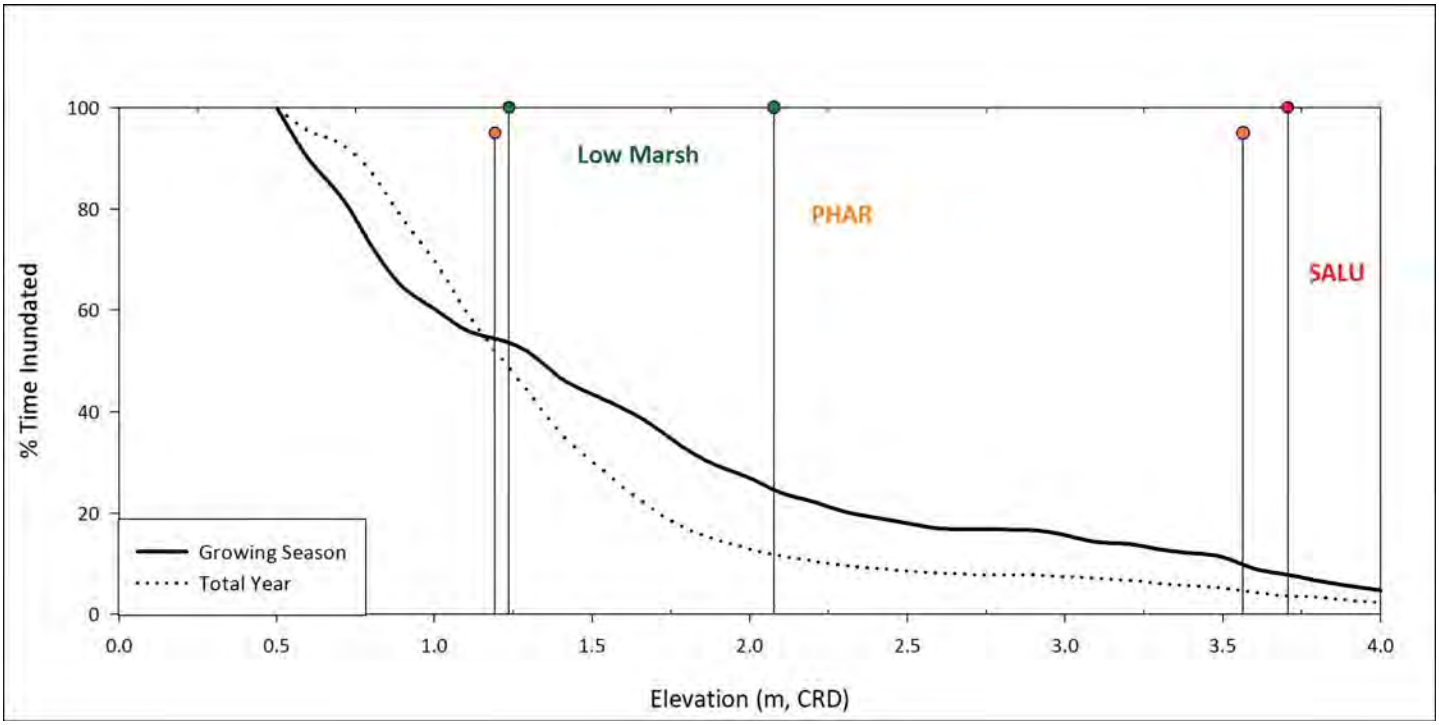
Modified Growing Season:

Aug 20 to Oct 12, 2009

Apr 22 to Jun 21, 2010

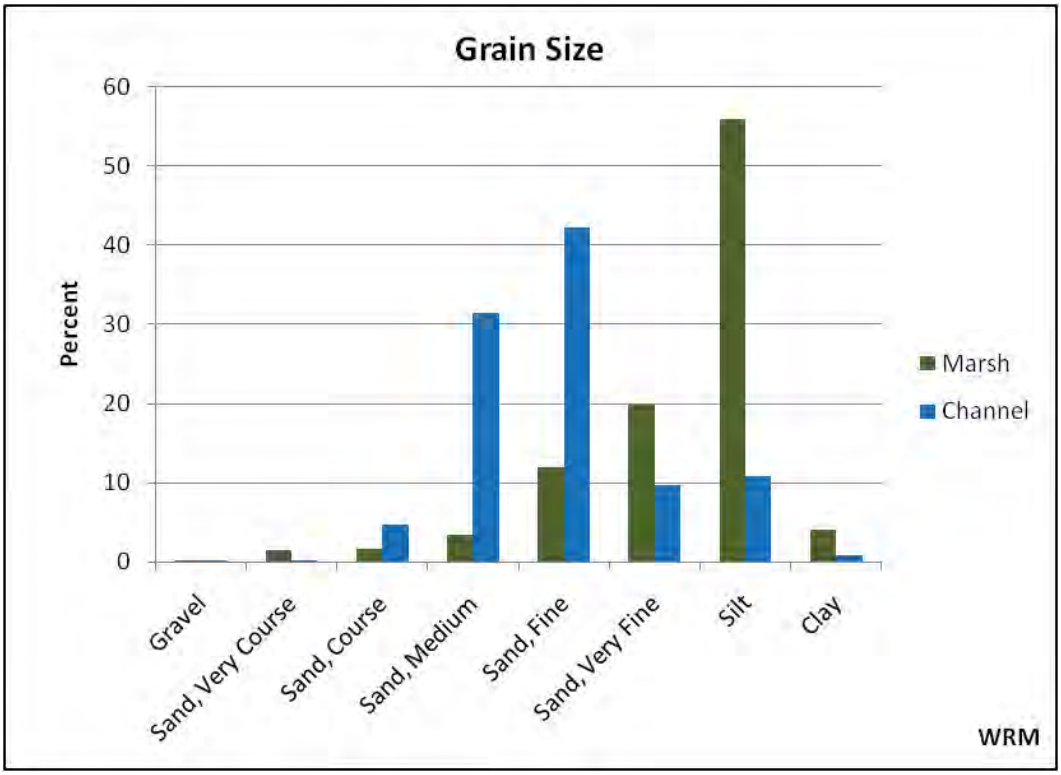


## Inundation (cont.)




## Sediment

Total Organic Carbon (TOC) in channel: 1.28 in wetland: 4.05



## Site Description

Hydrogeomorphic Reach: G

Coordinates (UTM, NAD83 meters):

Northing: 5045652 Easting: 549789

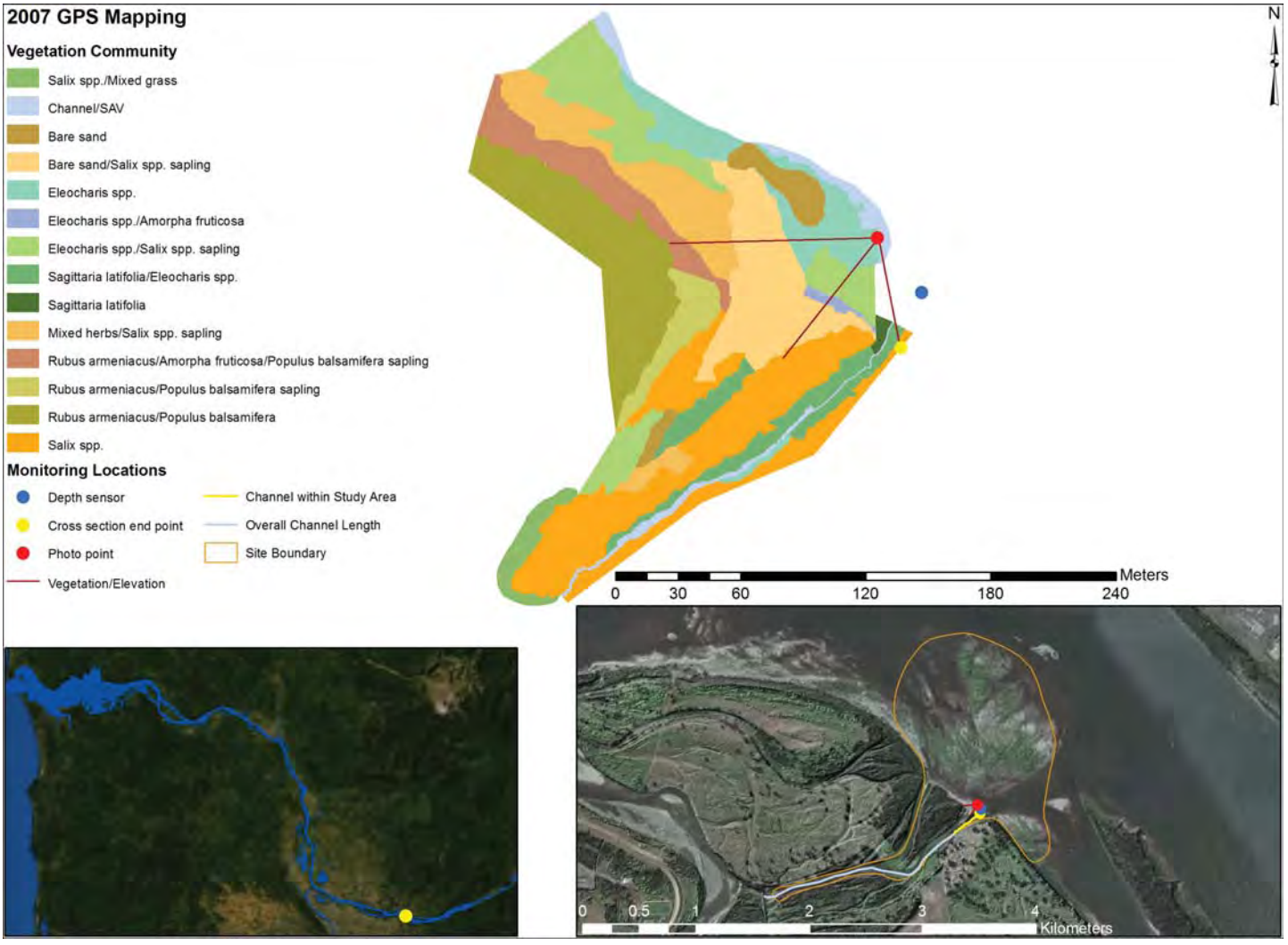
Distance from Columbia River mouth: 198 rkm

Distance from main channel: 0 meters

Type: Marsh

Total Site Area: 109.0 ha Study Area: 1.77 ha

Total channel length: 1525 m Channel surveyed: 213 m Channel slope: NA



## Site Information

The Old Sandy Mouth site is a wetland area formed behind the complex of islands that used to make up the Sandy River delta near Portland, Oregon. The Sandy River originally had two outlets, but the upper one was diked by Portland General Electric for servicing power lines that crossed the delta. This area is frequented by hikers from the Lewis and Clark State Park on the Sandy River. The monitoring site is a fringing emergent wetland that is primarily disconnected from the mainstem of the Columbia during the low water season in the fall.

## Elevation

Lowest marsh (NAVD88, m): 2.90

Highest marsh (NAVD88, m): 3.94

Lowest marsh (CRD, m): 0.72

Highest marsh (CRD, m): 1.76

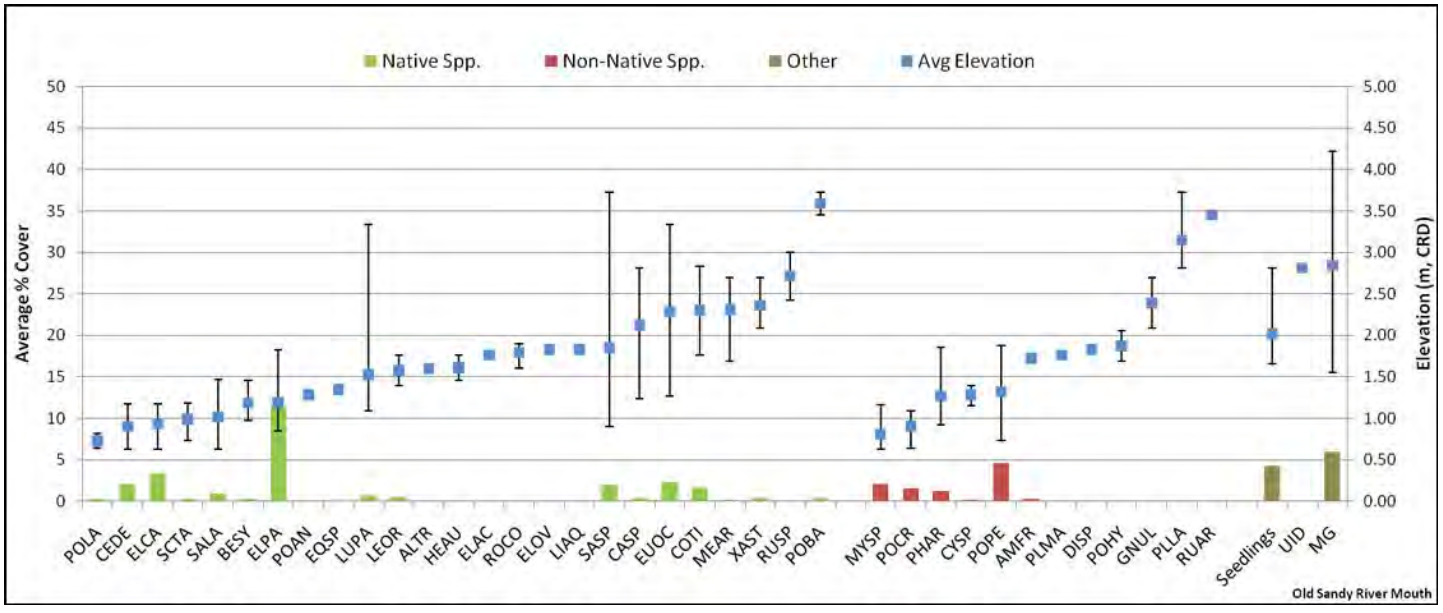
## Vegetation

Number of Native species: 25

% Native Cover: 27.86

Number of Non-native species: 13

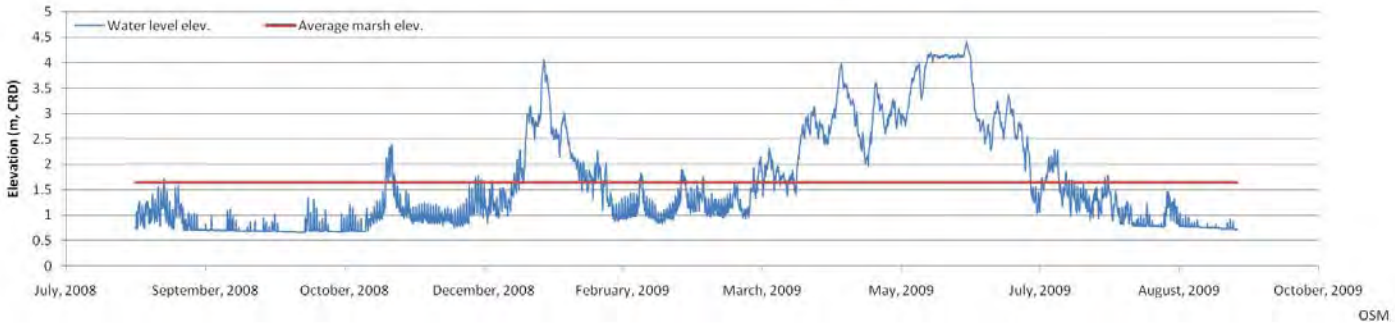
% Non-native Cover: 10.77

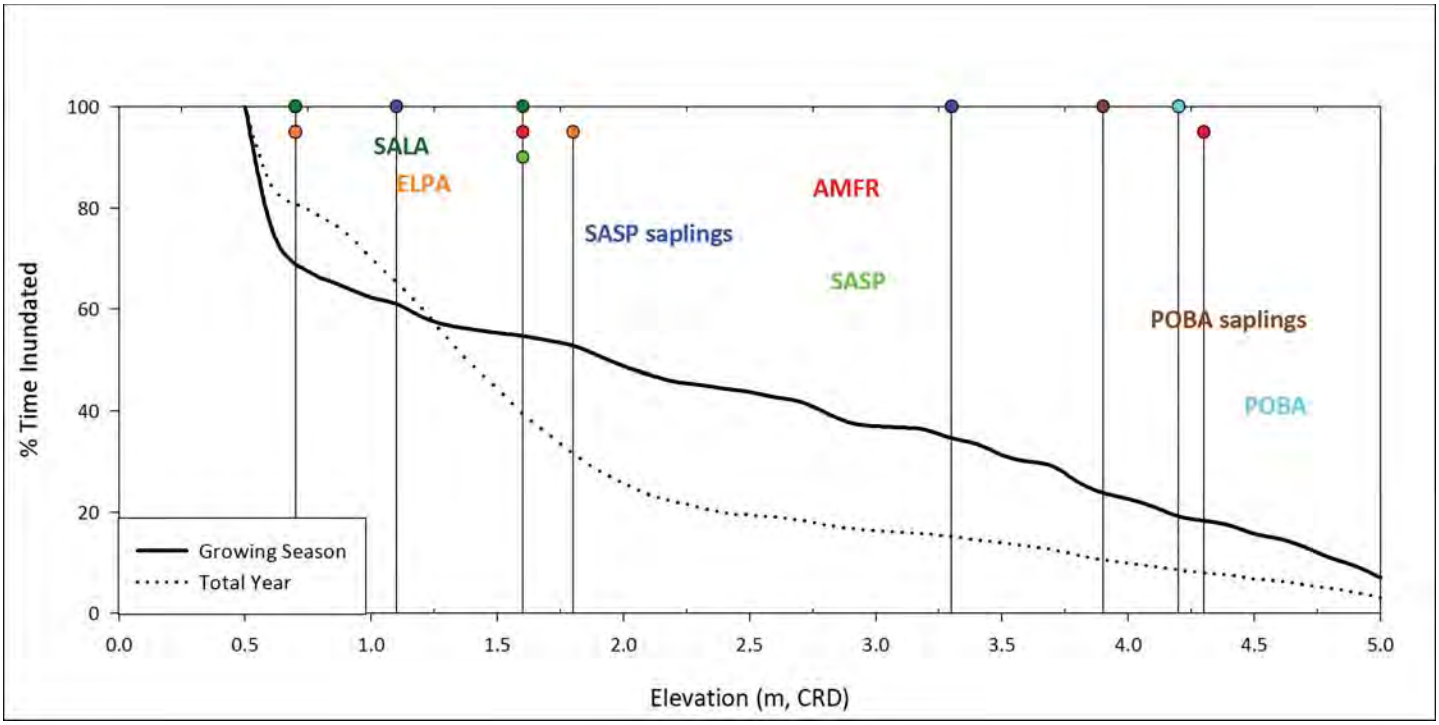


## Inundation

| | Std | Marsh |
|---|---|---|
| Average Elev (m, CRD) | 1.89 | 1.64 |
| Sum Exceedance Value (SEV) | 89.1 | 104 |

Modified Growing Season:
Aug 20 to Oct 12, 2008
Apr 22 to Jun 21, 2009

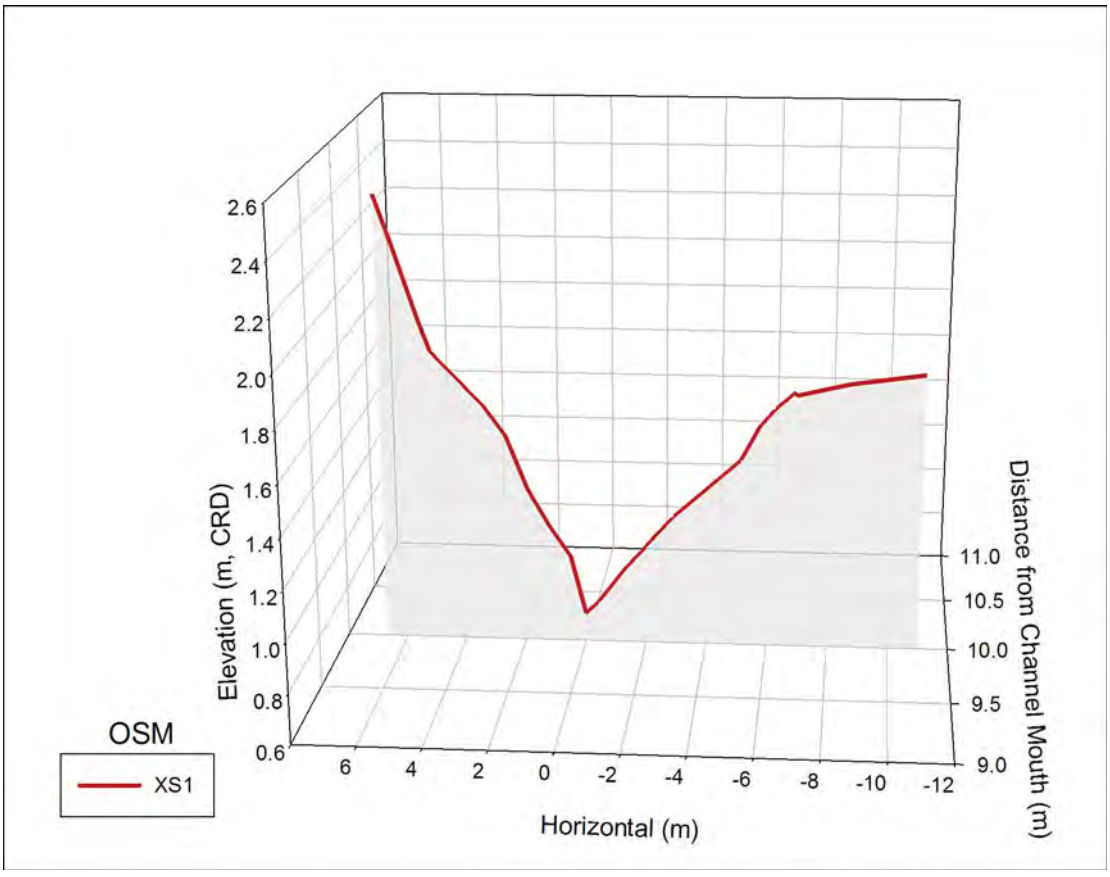


## Channels

| | Physical Metrics | | | | | | | Inundation | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Year | | Growing Season | |
| | Cross Section | Bank Elevation (m) | Thalweg Elevation (m) | Channel Depth (m) | Cross Section Area ($m^2$) | Channel Width (m) | Width:Depth Ratio | Time WL > Thalweg (%) | Time WL > Bank (%) | Time WL > Thalweg (%) | Time WL > Bank (%) |
| OSM | 1 | 1.65 | 0.72 | 0.93 | 4.7 | 10.7 | 11.5 | 76 | 35 | 74 | 34 |

### Cross Sections



## Site Description

Hydrogeomorphic Reach: G

Coordinates (UTM, NAD83 meters):

Northing: 5043698 Easting: 551767

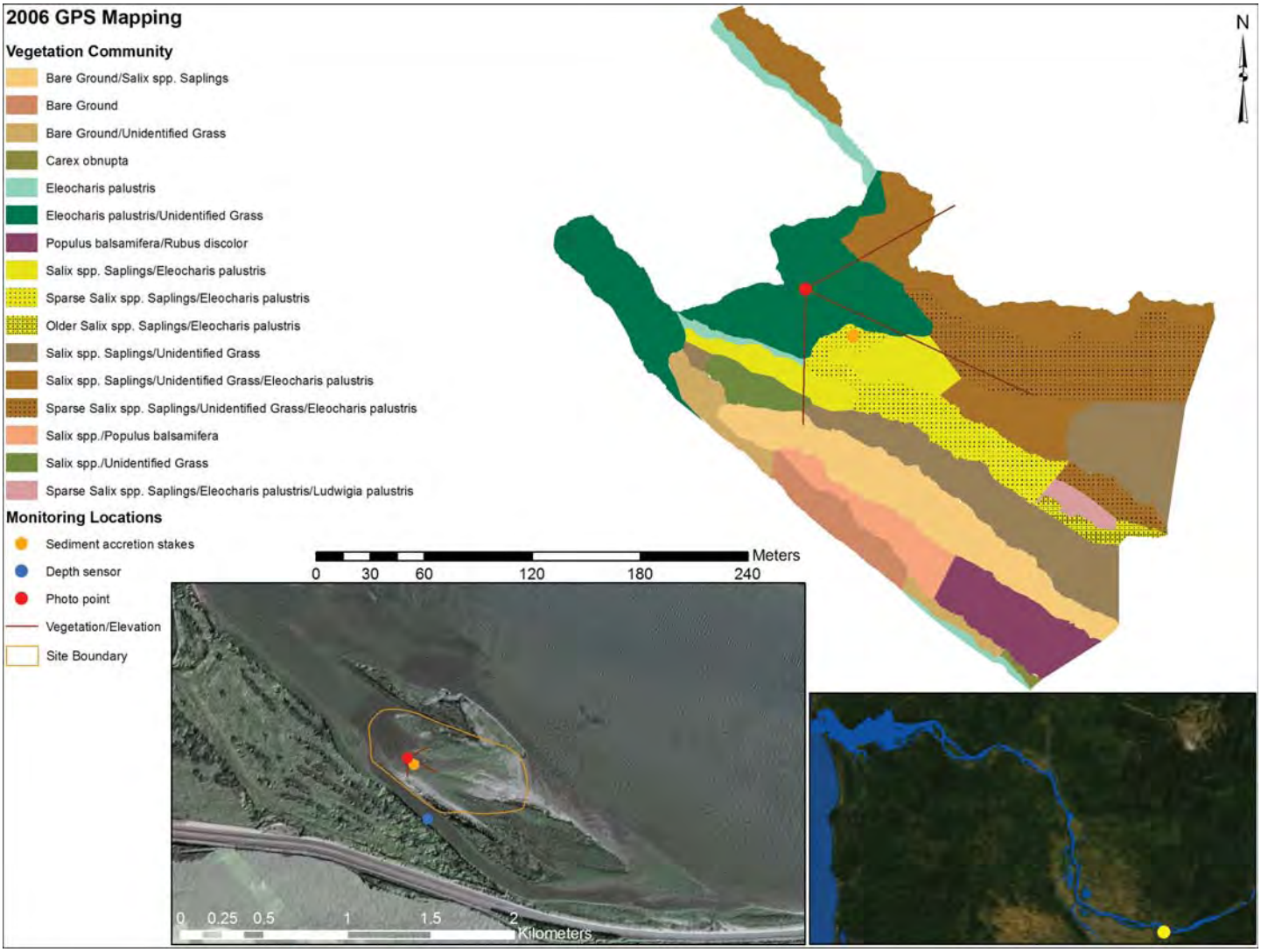
Distance from Columbia River mouth: 201 rkm

Distance from main channel: 0 meters

Type: Created

Total Site Area: 20.1 ha Study Area: 4.73 ha

Total channel length: 0 m Channel surveyed: 0 m Channel slope: NA



## Site Information

Chatham Island, located upstream from the mouth of the Sandy River in Oregon, is owned by Multnomah County and has been listed as an Oregon Natural Heritage Resource site. The Chatham Island site is located in an inlet along the island shoreline in an area of low energy, though with direct connection to the Columbia River. Connectivity is likely limited at the site during low river flows due to pile structures and extensive flats surrounding the island. The site is characterized by emergent marsh and willow saplings grading up to mature willows and cottonwoods.

## Elevation

Lowest marsh (NAVD88, m): 3.40

Highest marsh (NAVD88, m): 3.94

Lowest marsh (CRD, m): 1.16

Highest marsh (CRD, m): 1.70

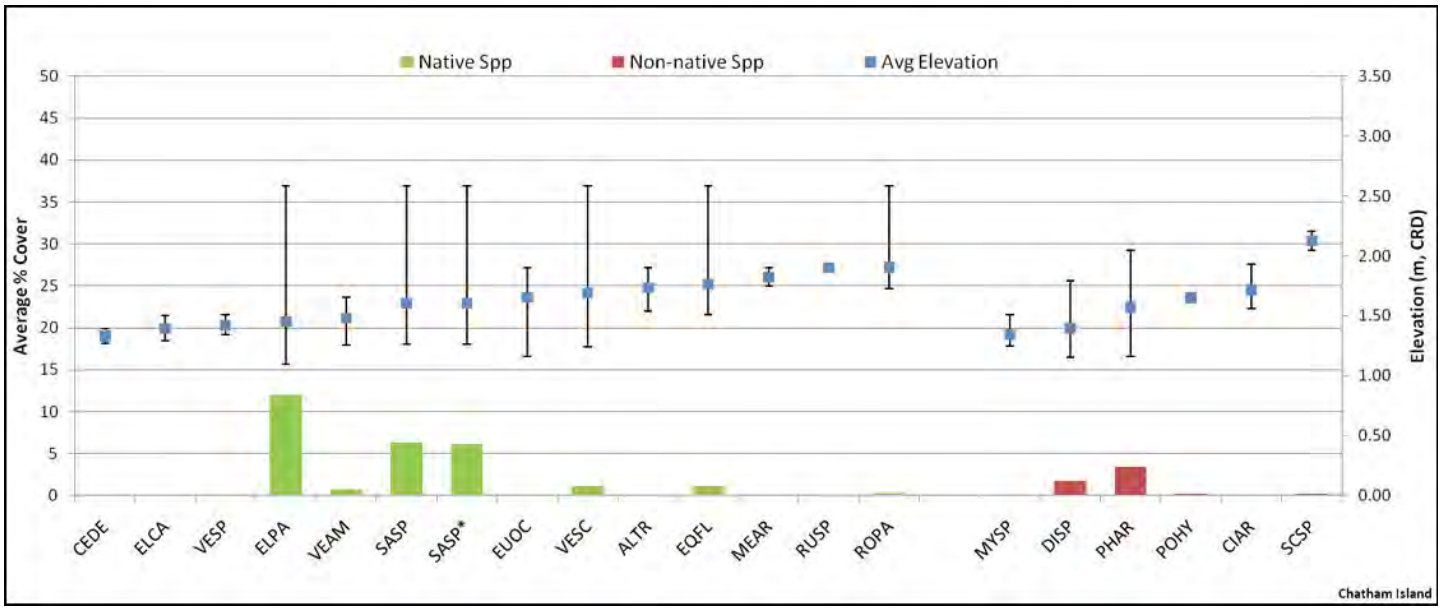
## Vegetation

Number of Native species: 14

% Native Cover: 28.03

Number of Non-native species: 6

% Non-native Cover: 5.76




## Sediment

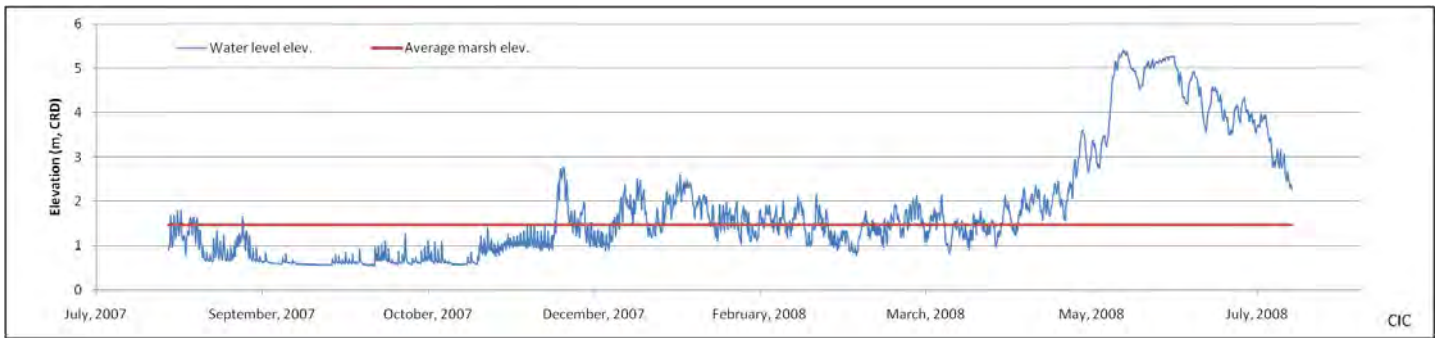
Sediment accretion rate: -0.22 cm per year

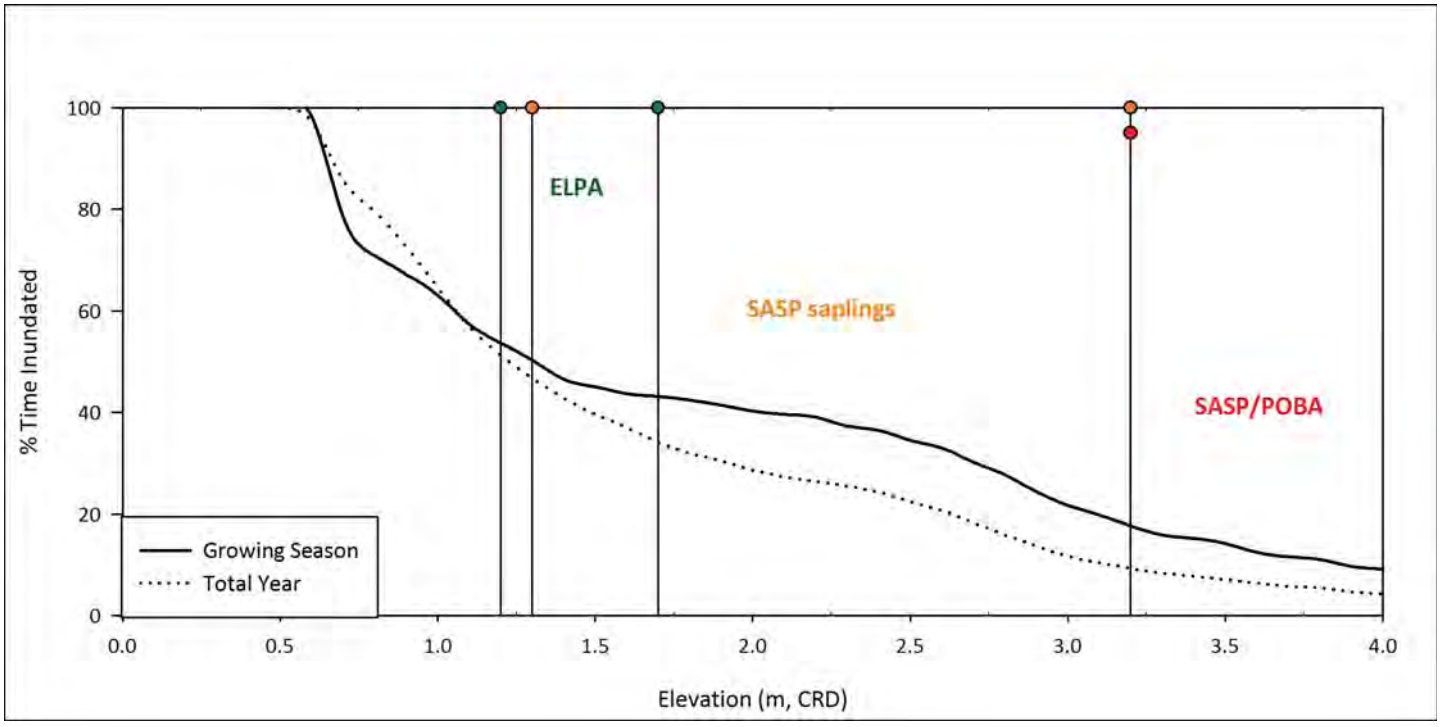
Elevation at sediment stakes: 1.33 m, CRD

## Inundation

| | Std | Marsh |
|---|---|---|
| Average Elev (m, CRD) | 1.89 | 1.46 |
| Sum Exceedance Value (SEV) | 85.7 | 112 |

Modified Growing Season:
Aug 20 to Oct 12, 2008
Apr 22 to Jun 21, 2009



## Site Description

Hydrogeomorphic Reach: H

Coordinates (UTM, NAD83 meters):

Northing: 5044722 Easting: 561649

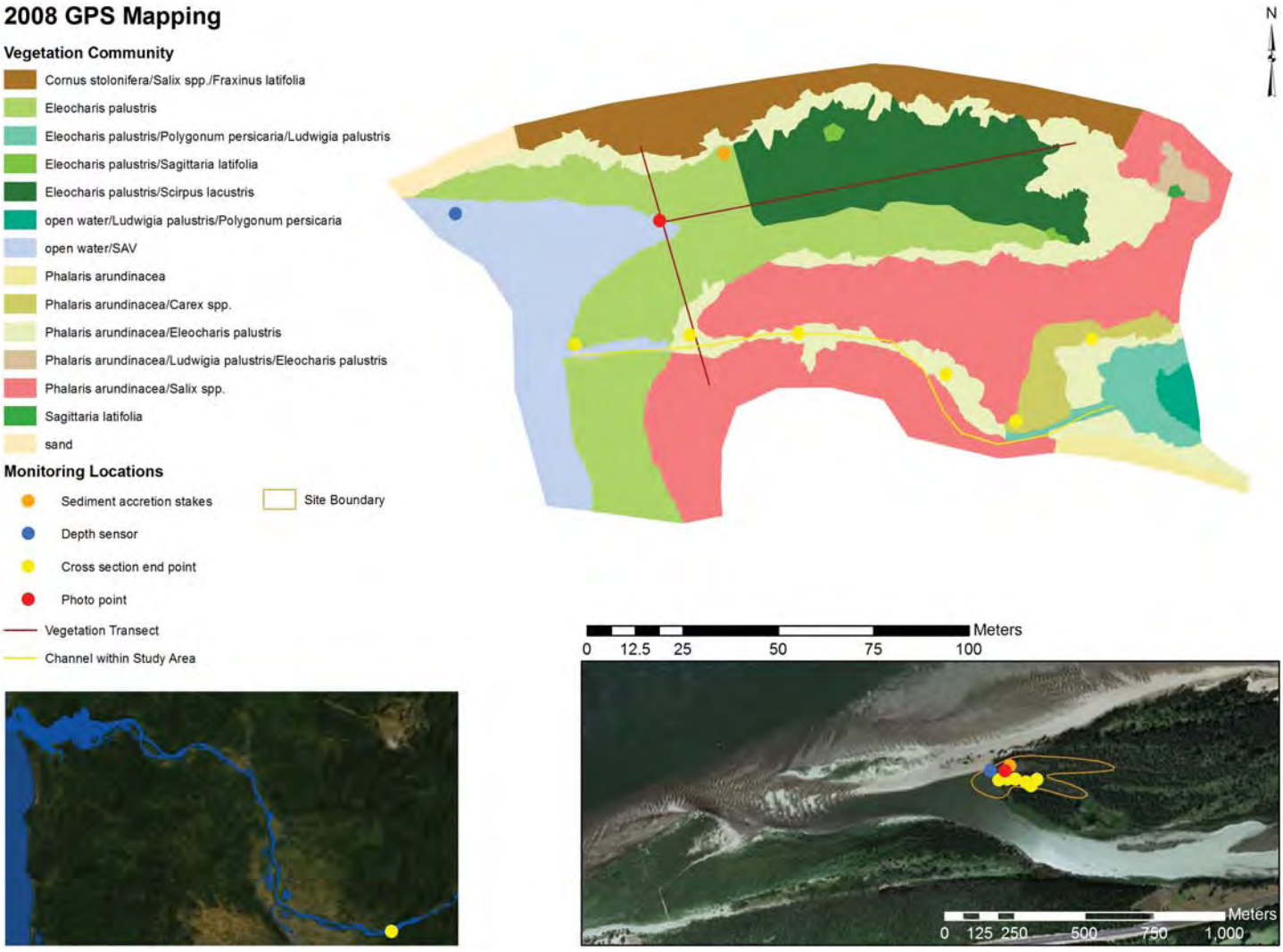
Distance from Columbia River mouth: 211 rkm

Distance from main channel: 0 meters

Type: Marsh

Total Site Area: 4.5 ha Study Area: 1.66 ha

Total channel length: 157 m Channel surveyed: 157 m Channel slope: 4.16 m/km



## Site Information

Sand Island is located along the mainstem of the Columbia River at and is part of Rooster Rock State Park. The island is predominantly forest and shrub wetlands that are periodically flooded during high water. An emergent marsh and ponded area at the downstream end of the island was the location of the sample area. True to its name, Sand Island has sandy sediments and a high, steep banked bluff to the north of the sampling area. This Island may have been present historically: Christy and Putera (1992) state Sand Island is the "last remaining unstabilized sand dunes on lower Columbia River; active burial of cottonwood forest; regionally significant, many historic losses."

## Elevation

Lowest marsh (NAVD88, m): 3.23

Highest marsh (NAVD88, m): 4.71

Lowest marsh (CRD, m): 0.66

Highest marsh (CRD, m): 2.14

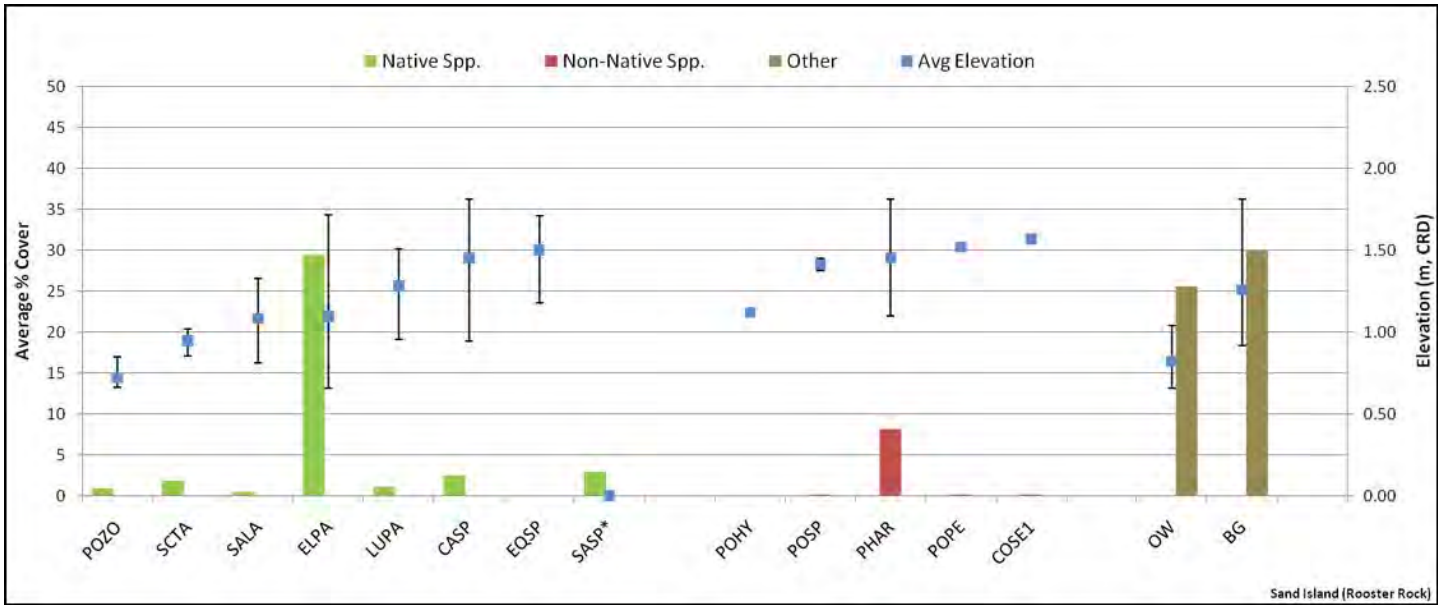
## Vegetation

Number of species: 8

% Native Cover: 39.62

Number of Non-native species: 5

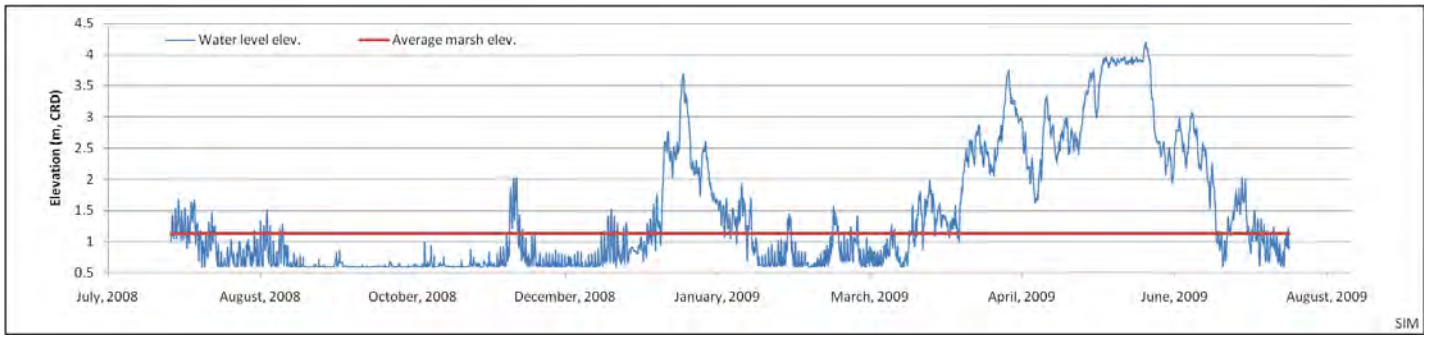
% Non-native Cover: 8.62

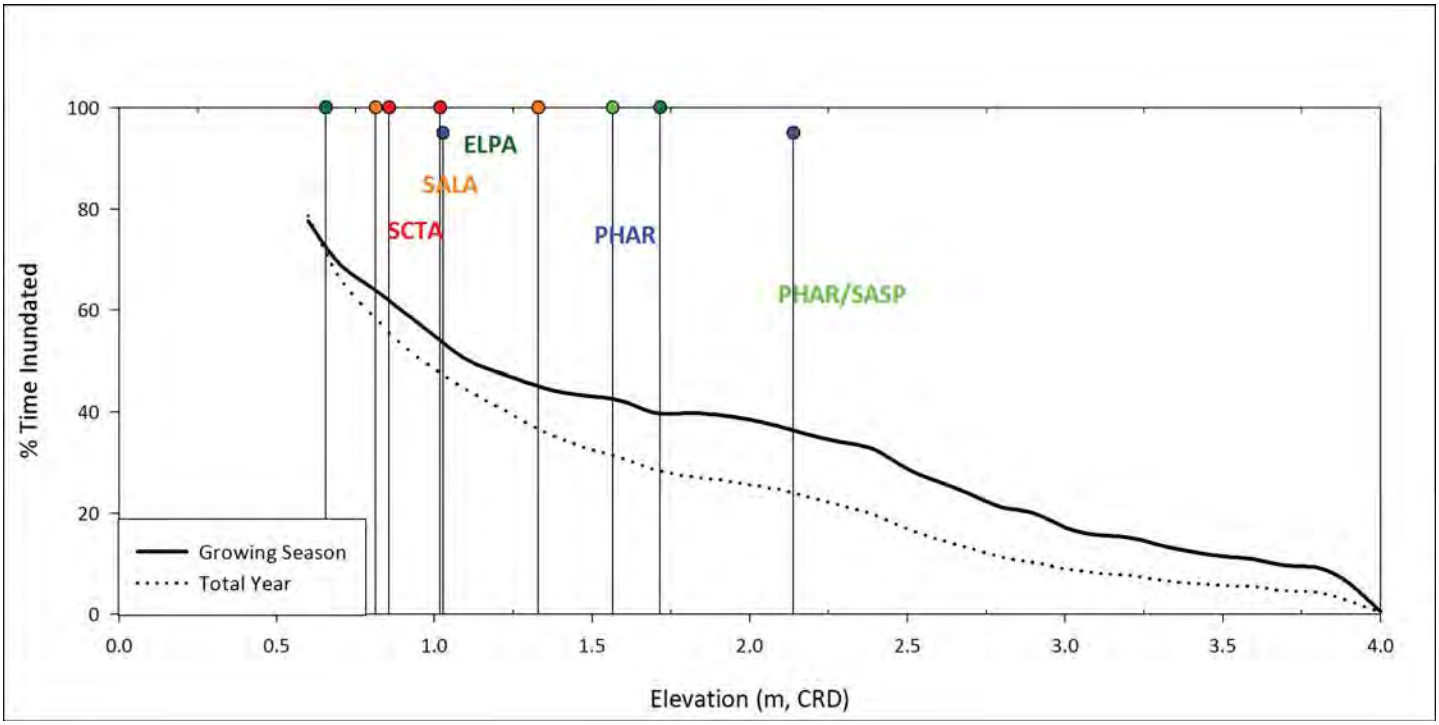


## Inundation

| | Std | Marsh |
|---|---|---|
| Average Elev (m, CRD) | 1.89 | 1.13 |
| Sum Exceedance Value (SEV) | 72.5 | 119 |

Modified Growing Season:
Aug 20 to Oct 12, 2008
Apr 22 to Jun 21, 2009




## Sediment

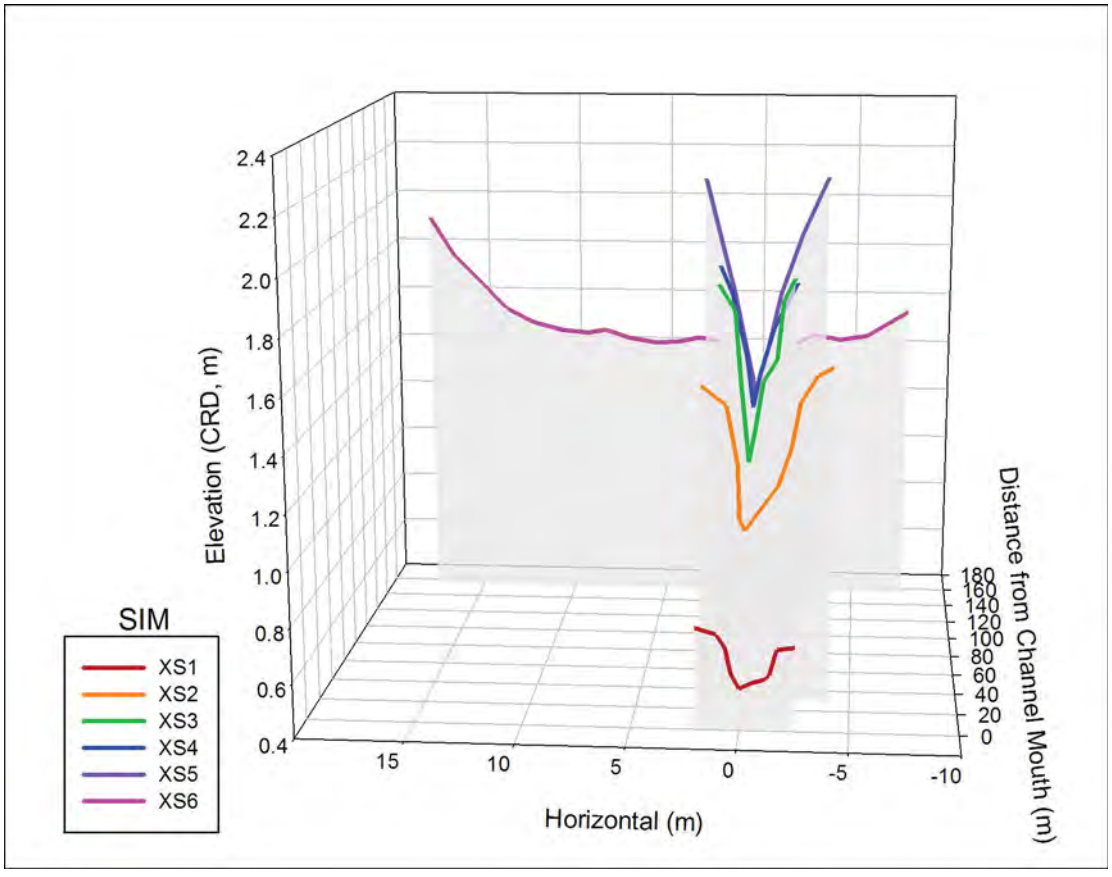
Sediment accretion rate: -7.76 cm per year

Elevation at sediment stakes: NA m, CRD

## Channels

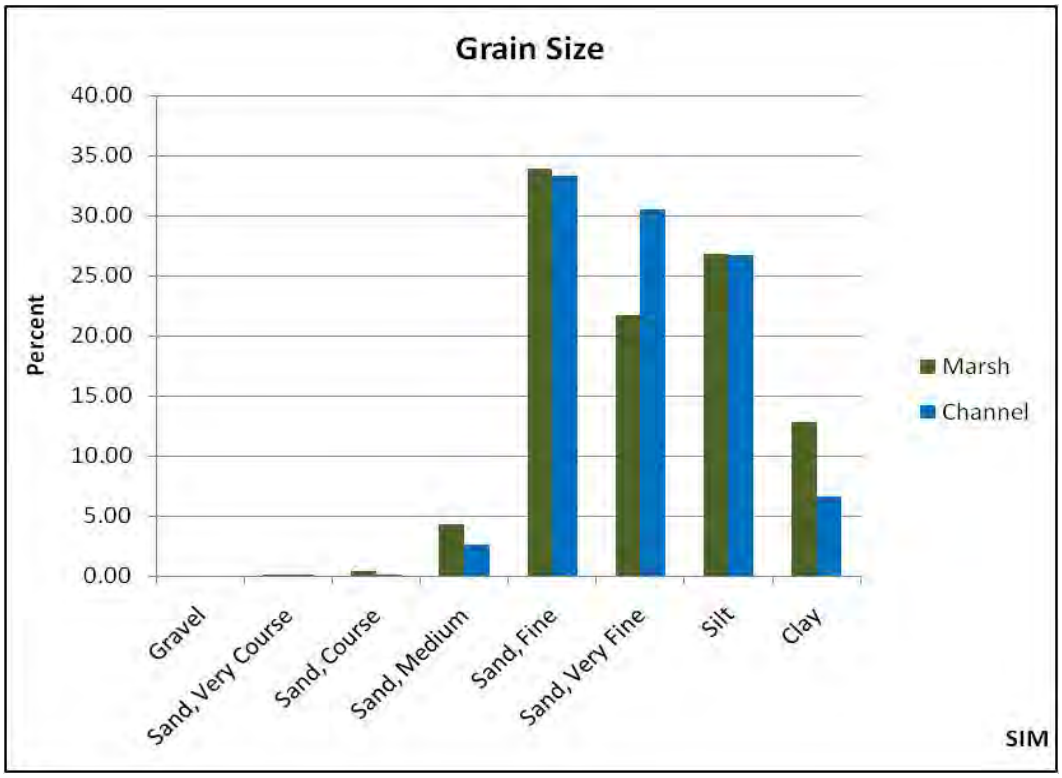
| | | Physical Metrics | | | | | | Inundation | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Year | | Growing Season | |
| | Cross Section | Bank Elevation (m) | Thalweg Elevation (m) | Channel Depth (m) | Cross Section Area ($m^2$) | Channel Width (m) | Width: Depth Ratio | Time WL > Thalweg (%) | Time WL > Bank (%) | Time WL > Thalweg (%) | Time WL > Bank (%) |
| SIM | 1 | 0.70 | 0.55 | 0.15 | 0.3 | 1.7 | 11.1 | 84 | 66 | 83 | 69 |
| | 2 | 1.55 | 1.03 | 0.52 | 1.2 | 5.1 | 9.7 | 42 | 32 | 48 | 43 |
| | 3 | 1.85 | 1.20 | 0.65 | 0.9 | 3.5 | 5.3 | 36 | 27 | 45 | 40 |
| | 4 | 1.79 | 1.31 | 0.48 | 0.7 | 3.5 | 7.3 | 33 | 27 | 43 | 40 |
| | 5 | 2.13 | 1.27 | 0.86 | 2.4 | 6.2 | 7.2 | 34 | 24 | 44 | 37 |
| | 6 | 1.45 | 1.20 | 0.25 | 0.5 | 5.6 | 22.3 | 36 | 33 | 45 | 43 |

## Cross Sections



## Sediment

Total Organic Carbon (TOC) in channel: 2.59 in wetland: 4.22



## Site Description

Hydrogeomorphic Reach: H

Coordinates (UTM, NAD83 meters):

Northing: 5050398 Easting: 571388

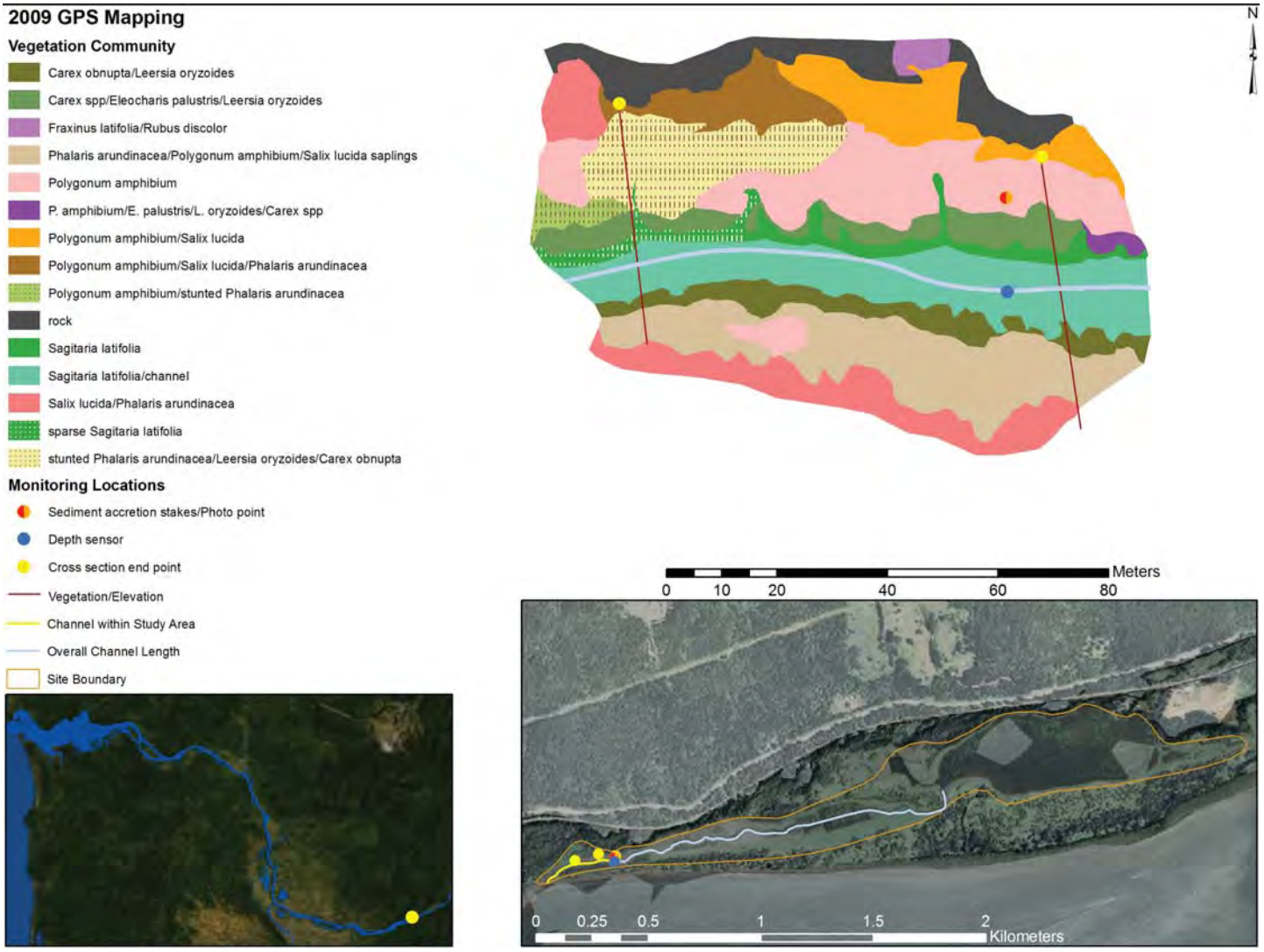
Distance from Columbia River mouth: 221 rkm

Distance from main channel: 0 meters

Type: Marsh

Total Site Area: 69.1 ha Study Area: 0.49 ha

Total channel length: 1973 m Channel surveyed: 342 m Channel slope: 1.25 m/km



## Site Information

Franz Lake is part of the Pierce National Wildlife Refuge. The site has an expansive area of emergent marsh extending 2 km from the mouth of the slough to a large, shallow ponded area. The sample site was located approximately 350 m from the channel mouth. Several beaver dams have created a series of ponds along the length of the channel resulting in large areas of shallow-water wetland with fringing bank gradually sloping to upland.

## Elevation

Lowest marsh (NAVD88, m): 3.91

Highest marsh (NAVD88, m): 4.85

Lowest marsh (CRD, m): 1.19

Highest marsh (CRD, m): 2.14

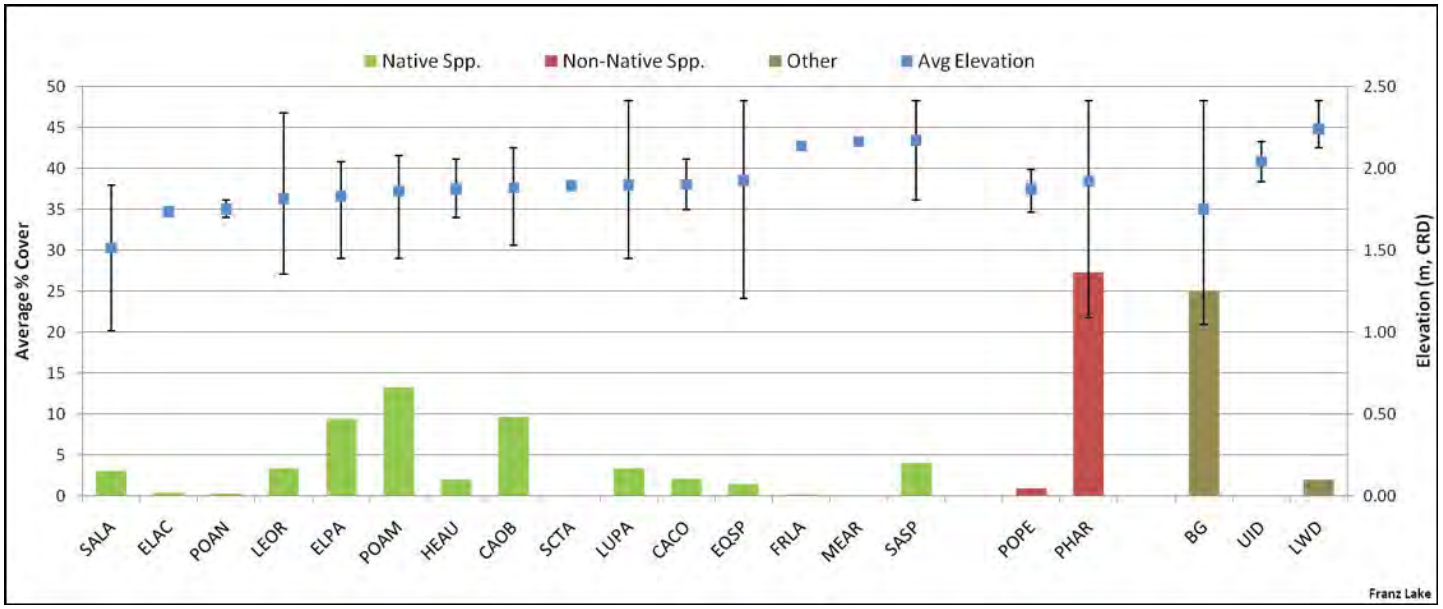
## Vegetation

Number of Native species: 15

% Native Cover: 52.67

Number of Non-native species: 2

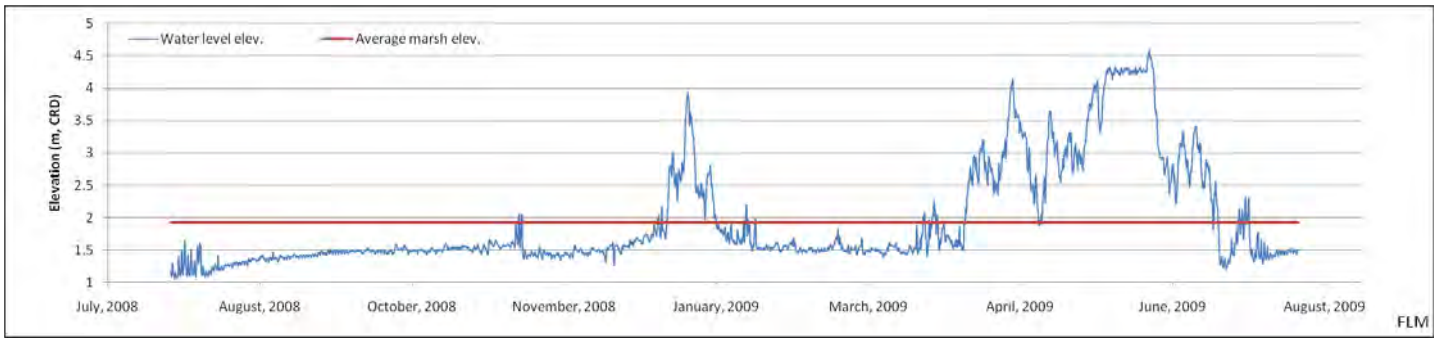
% Non-native Cover: 28.18

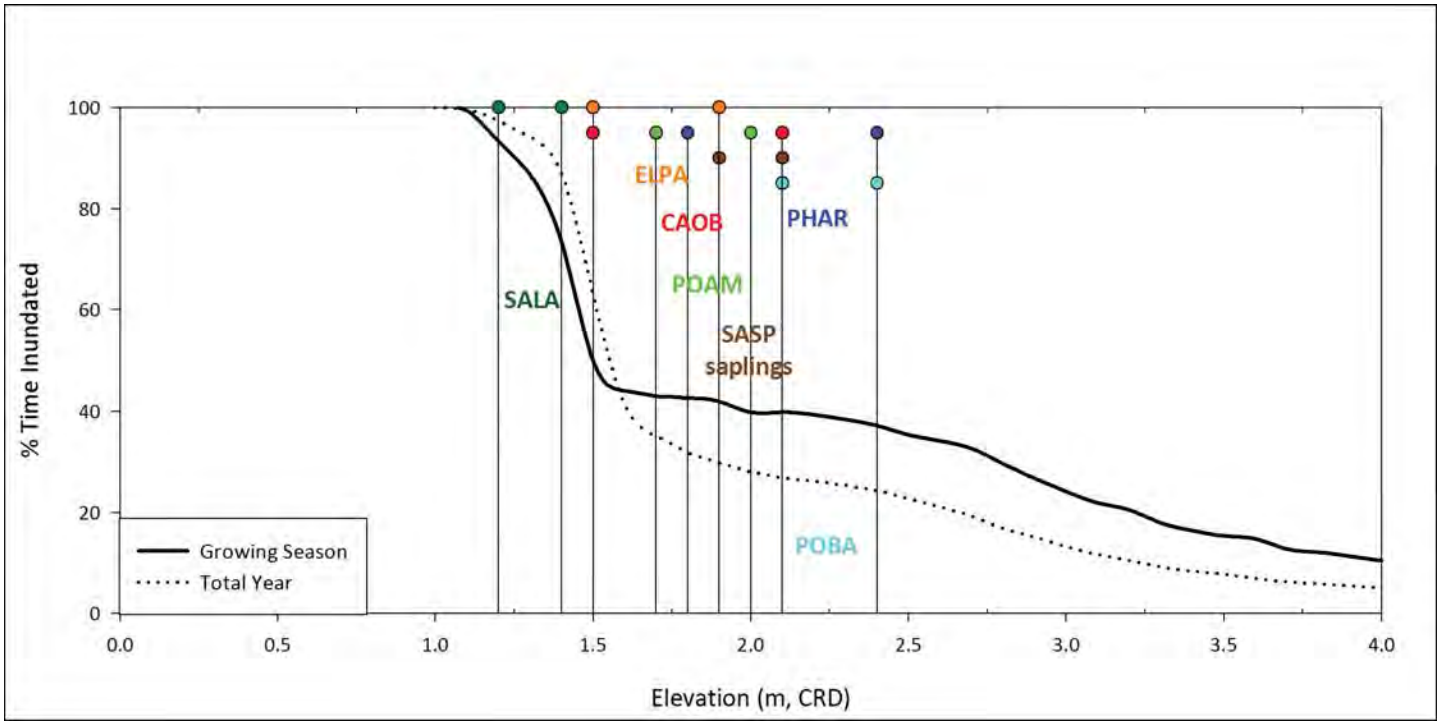


## Inundation

| | Std | Marsh |
|---|---|---|
| Average Elev (m, CRD) | 1.89 | 1.93 |
| Sum Exceedance Value (SEV) | 92.7 | 90.2 |

Modified Growing Season:
Aug 20 to Oct 12, 2008
Apr 22 to Jun 21, 2009

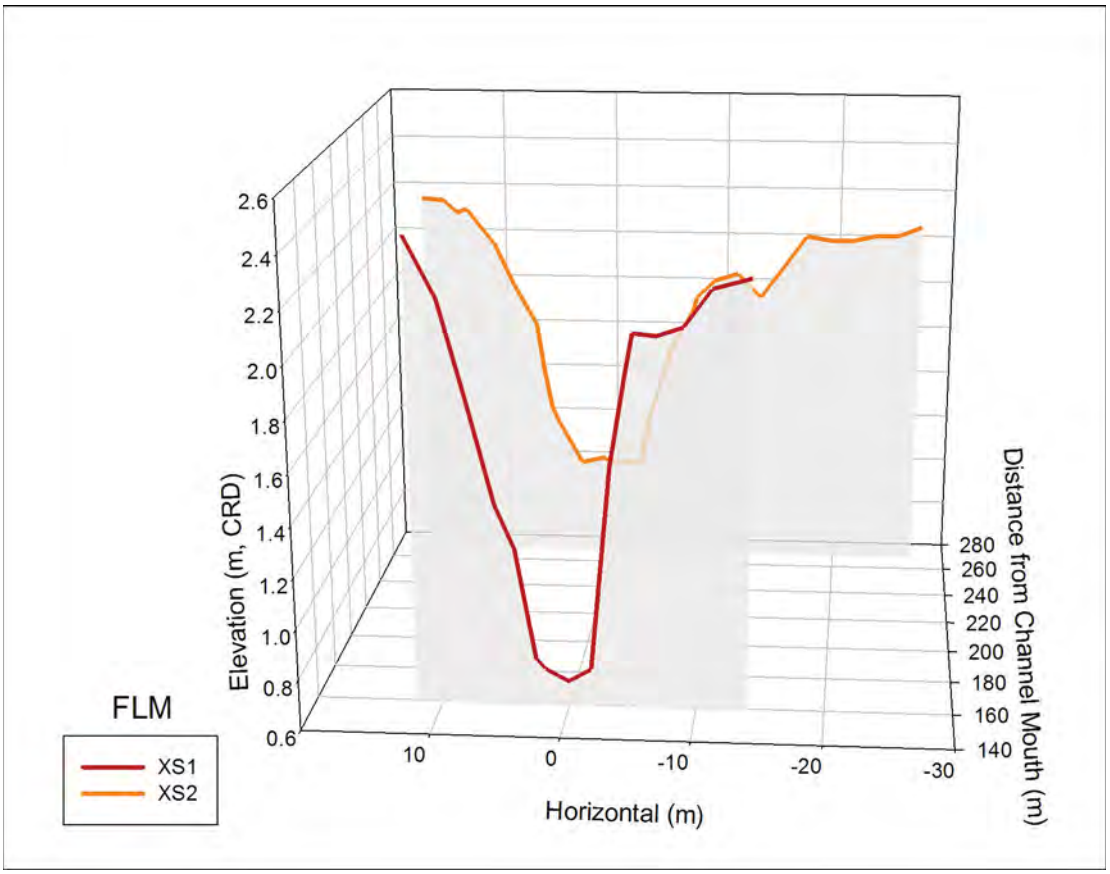


## Channels

| | Physical Metrics | | | | | | | Inundation | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Year | | Growing Season | |
| | Cross Section | Bank Elevation (m) | Thalweg Elevation (m) | Channel Depth (m) | Cross Section Area ($m^2$) | Channel Width (m) | Width: Depth Ratio | Time WL > Thalweg (%) | Time WL > Bank (%) | Time WL > Thalweg (%) | Time WL > Bank (%) |
| FLM | 1 | 2.06 | 0.70 | 1.36 | 11.4 | 14.1 | 10.4 | 100 | 27 | 100 | 40 |
| | 2 | 1.76 | 1.00 | 0.75 | 7.7 | 15.9 | 21.0 | 98 | 33 | 96 | 43 |

### Cross Sections



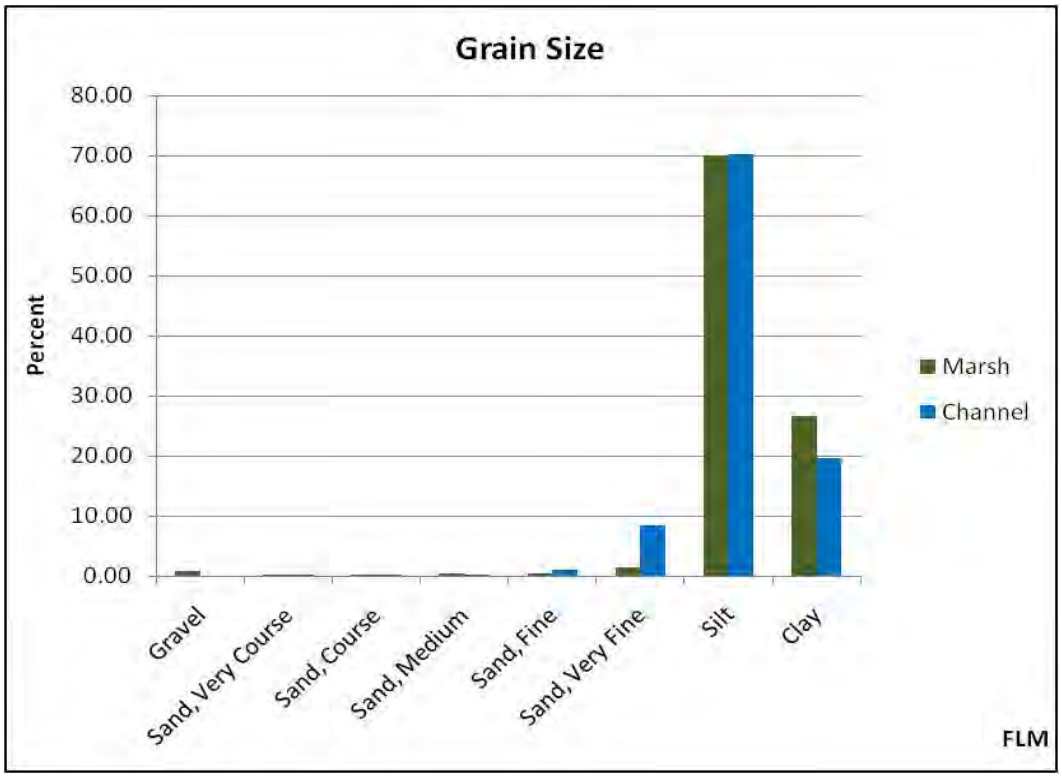

## Sediment

Sediment accretion rate: 0.49 cm per year

Elevation at sediment stakes: 1.84 m, CRD

## Sediment

Total Organic Carbon (TOC) in channel: 5.47 in wetland: 7.16



## Site Description

Hydrogeomorphic Reach: H

Coordinates (UTM, NAD83 meters):

Northing: 5052414 Easting: 577124

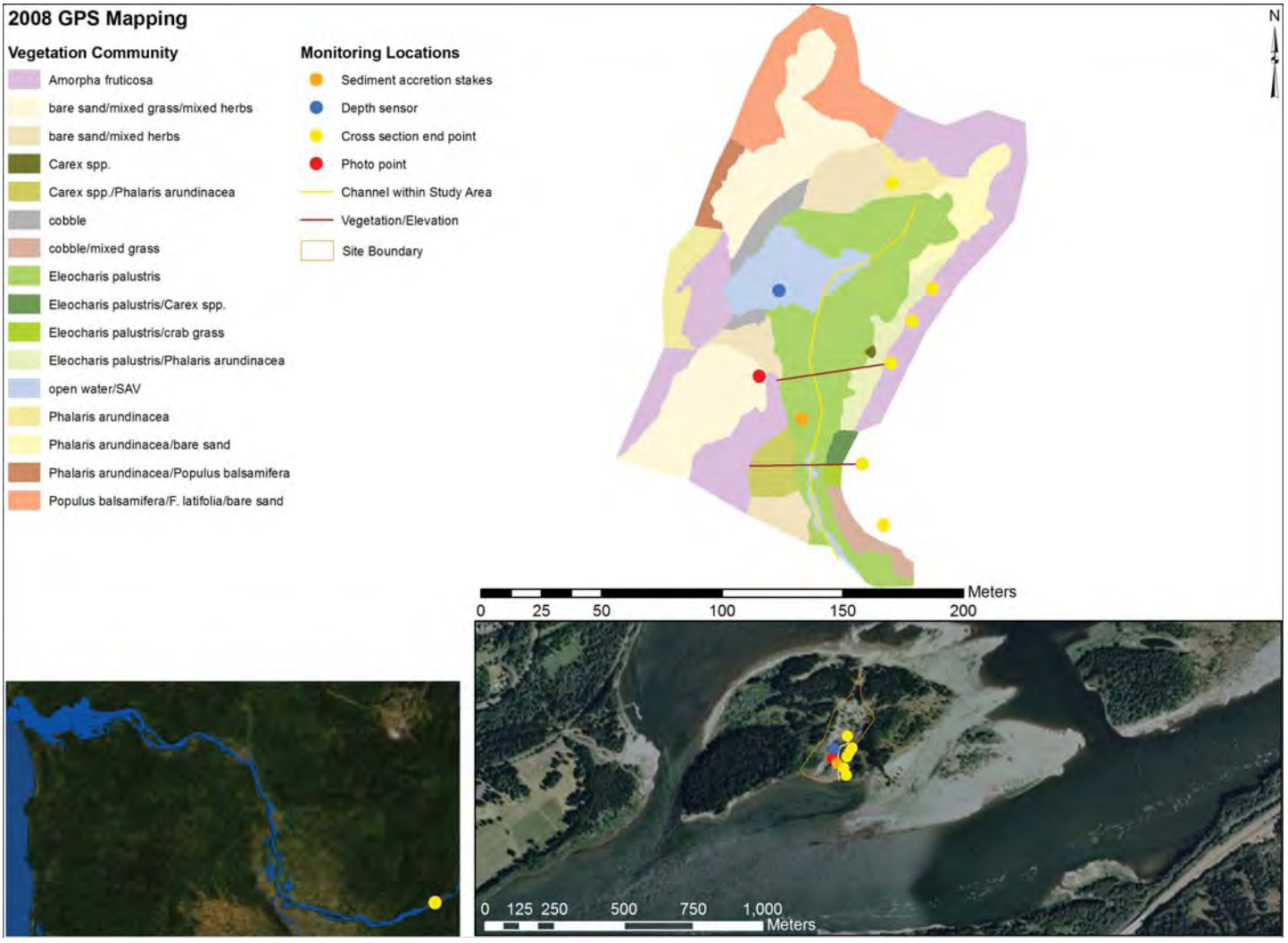
Distance from Columbia River mouth: 228 rkm

Distance from main channel: 0 meters

Type: Marsh

Total Site Area: 4.1 ha Study Area: 0.86 ha

Total channel length: 170 m Channel surveyed: 170 m Channel slope: 0.93 m/km



## Site Information

Pierce Island, owned by the Nature Conservancy, is a mainstem island. The site is broadly characterized by forested and shrub/scrub areas that are periodically flooded during high water, with a lower emergent marsh and ponded area. The sample area at this site, located in the emergent marsh, had sand/cobble sediments and a gradual bank rising to the upland portions of the island.

## Elevation

Lowest marsh (NAVD88, m): 3.47

Highest marsh (NAVD88, m): 6.27

Lowest marsh (CRD, m): 0.66

Highest marsh (CRD, m): 3.45

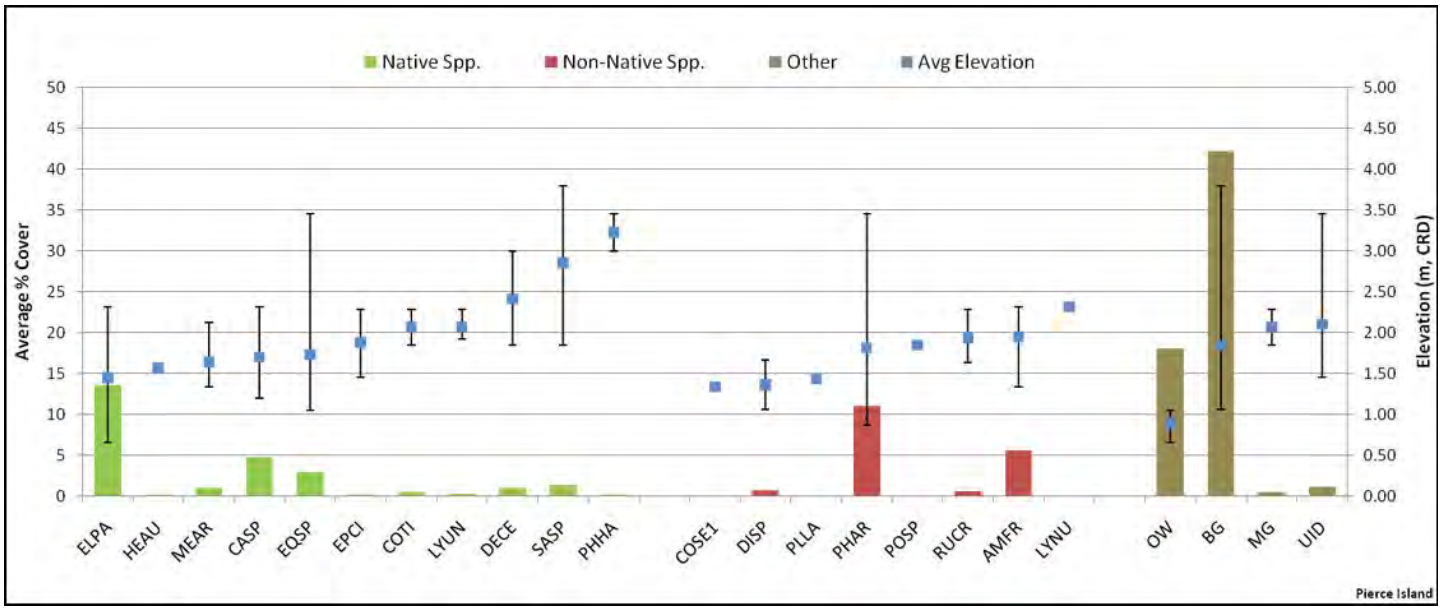
## Vegetation

Number of species: 11

% Native Cover: 26.05

Number of Non-native species: 9

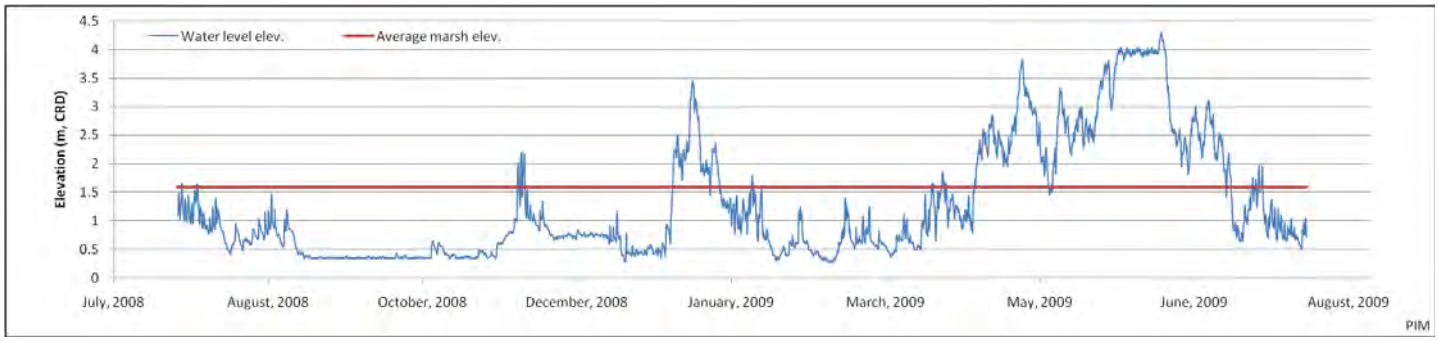
% Non-native Cover: 18.33

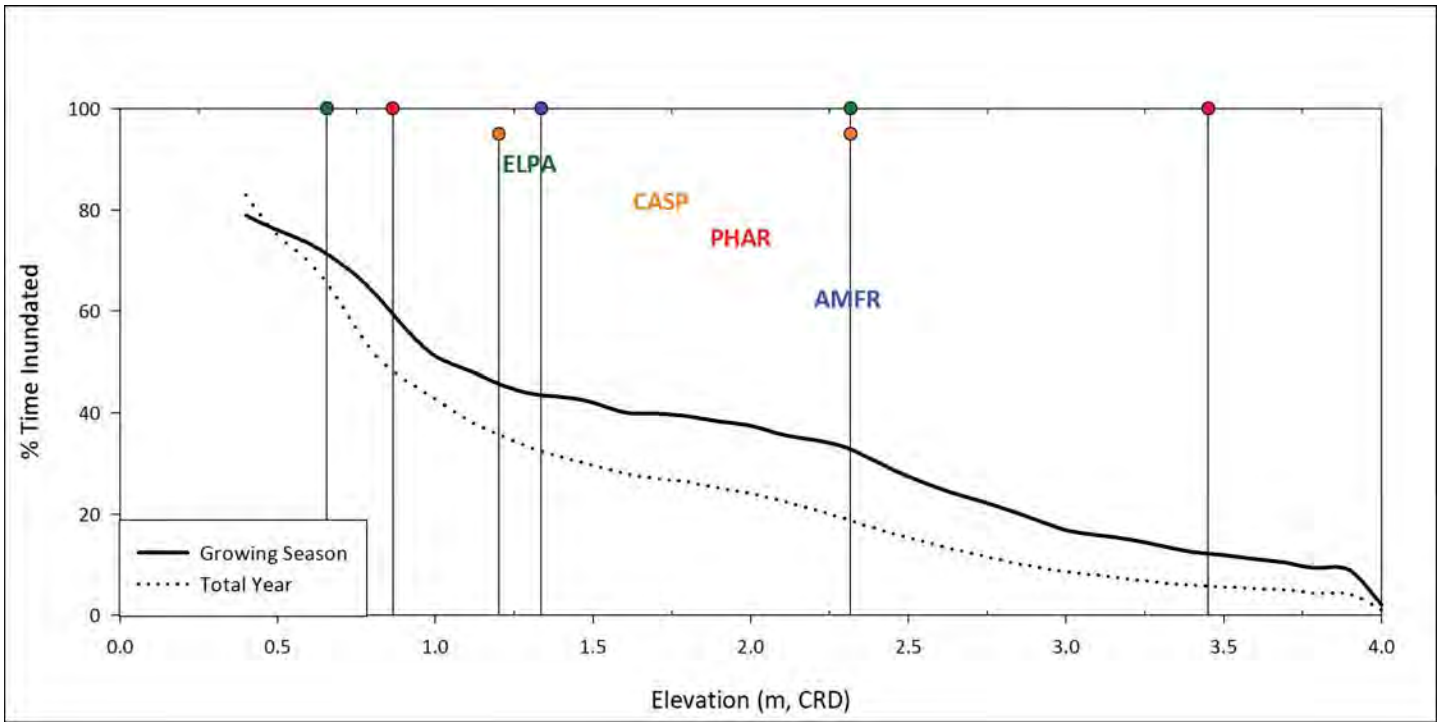


## Inundation

| | Std | Marsh |
|---|---|---|
| Average Elev (m, CRD) | 1.89 | 1.59 |
| Sum Exceedance Value (SEV) | 72.0 | 90.0 |

Modified Growing Season:
Aug 20 to Oct 12, 2008
Apr 22 to Jun 21, 2009




## Sediment

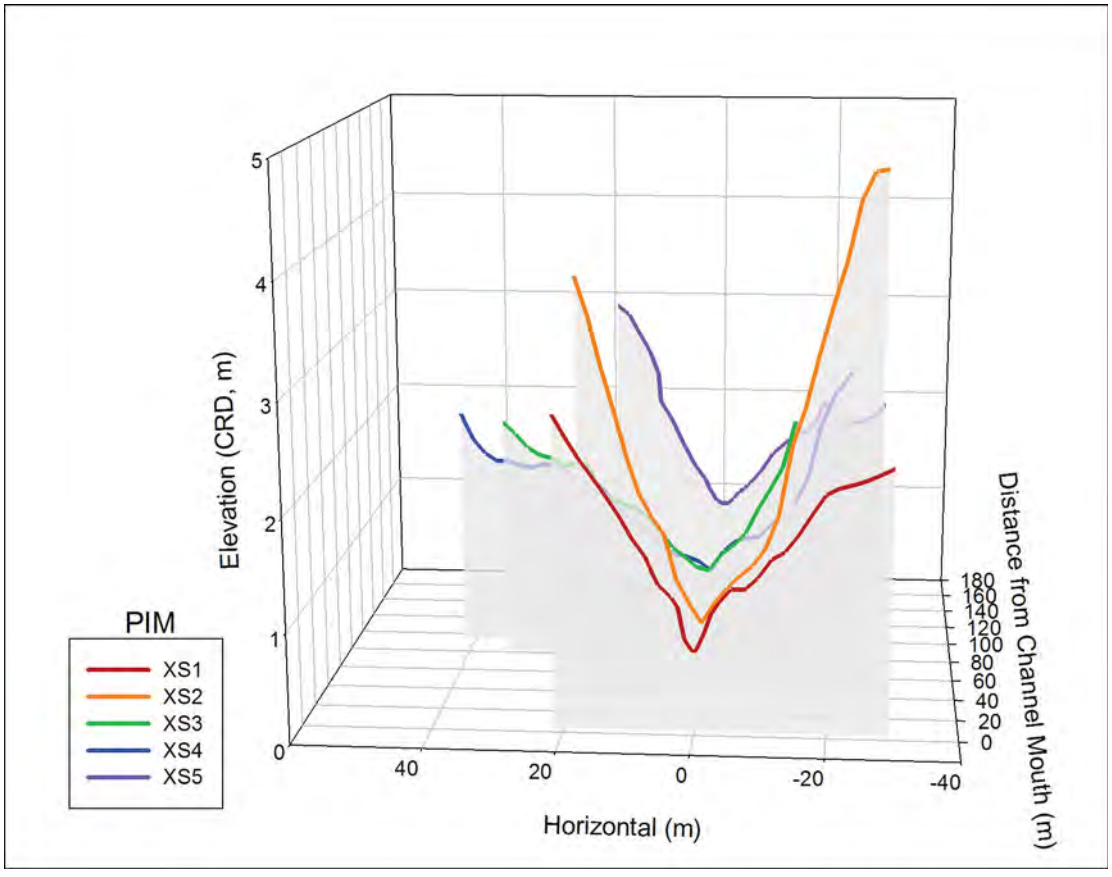
Sediment accretion rate: 1.60 cm per year

Elevation at sediment stakes: NA m, CRD

## Channels

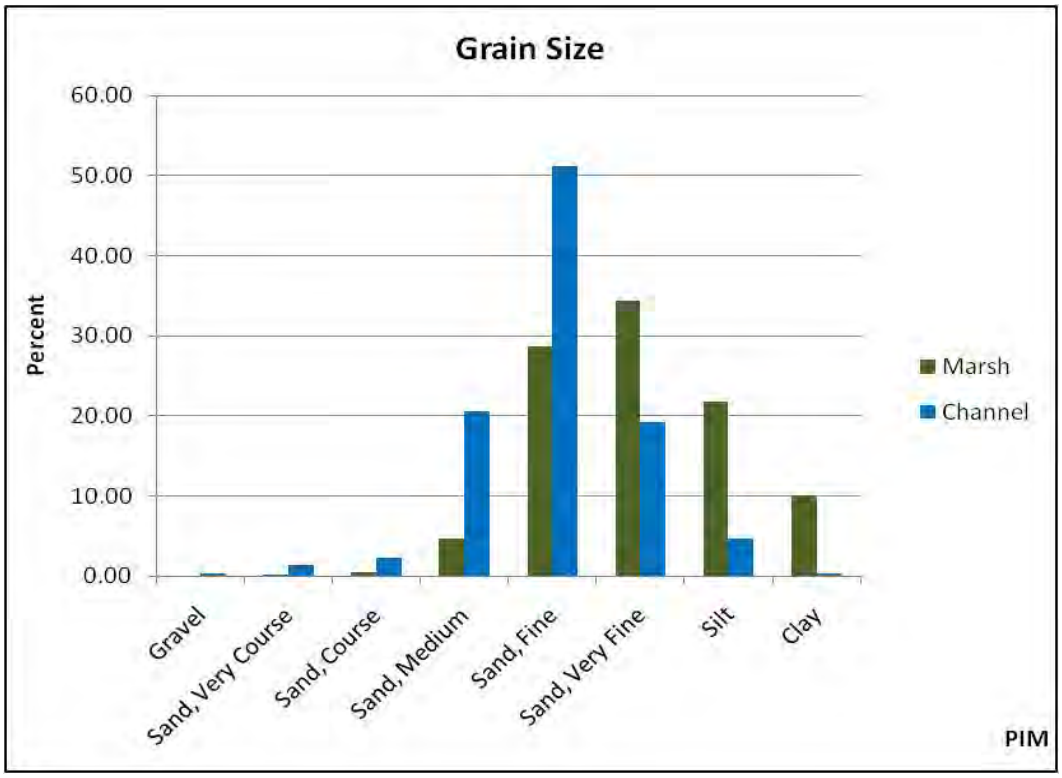
| | | Physical Metrics | | | | | | Inundation | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Year | | Growing Season | |
| | Cross Section | Bank Elevation (m) | Thalweg Elevation (m) | Channel Depth (m) | Cross Section Area ($m^2$) | Channel Width (m) | Width: Depth Ratio | Time WL > Thalweg (%) | Time WL > Bank (%) | Time WL > Thalweg (%) | Time WL > Bank (%) |
| PIM | 1 (mouth) | 1.59 | 0.71 | 0.88 | 7.6 | 20.3 | 23.1 | 48 | 28 | 60 | 40 |
| | 2 | 1.59 | 0.66 | 0.93 | 9.4 | 18.9 | 20.2 | 52 | 28 | 64 | 40 |
| | 3 | 1.59 | 0.84 | 0.76 | 10.6 | 27.7 | 36.7 | 43 | 28 | 52 | 40 |
| | 4 | 1.59 | 0.72 | 0.87 | 17.3 | 35.5 | 40.8 | 48 | 28 | 59 | 40 |
| | 5 | 1.59 | 0.87 | 0.72 | 8.0 | 20.5 | 28.5 | 42 | 28 | 51 | 40 |

### Cross Sections



## Sediment

Total Organic Carbon (TOC) in channel: 1.33 in wetland: 3.20



# Appendix C

# Vegetation Species List

| Code | Scientific Name | Common Name | Status | Category | Native | Invasive /Weedy | NOTES | Previous Species Code |
|---|---|---|---|---|---|---|---|---|
| ACCI | *Acer circinatum* | Vine maple | FAC- | Shrub | yes | | | |
| ADAL | *Adiantum aleuticum* | Aleutian Maidenhair fern | FAC | Fern | yes | | formerly *Adiantum pedatum* (ADPE) | ADPE |
| AGCA | *Agrostis capillaris* | Colonial bentgrass | FAC | Grass | no | | | |
| AGEX | *Agrostis exarata* | spike bentgrass | FACW | Grass | yes | | | |
| AGGI | *Agrostis gigantea* | redtop; black bentgrass | NI | Grass | no | | | |
| AGOR | *Agrostis oregonensis* | Oregon bentgrass | FAC | Grass | yes | | | |
| AGST | *Agrostis stolonifera L.* | creeping bentgrass | FAC | Grass | no | yes | | |
| ALTR | *Alisma triviale* | northern water plaintain | OBL | Herb | yes | | formerly Alisma plantago-aquatica var. americanum | ALPL |
| ALRU | *Alnus rubra* | Red alder | FAC | Tree | yes | | | |
| ALPR | *Alopecurus pratensis* | Meadow foxtail | FACW | Grass | no | | | |
| AMAL | *Amelanchier alnifolia* | Saskatoon serviceberry | FACU | Shrub | yes | | | |
| AMFR | *Amorpha fruticosa* | indigo bush | FACW | Shrub | no | yes | | |
| ANAR | *Angelica arguta* | Sharptooth angelica | FACW | Herb | yes | | | |
| ANGE | *Angelica genuflexa* | Kneeling angelica | FACW | Herb | yes | | | |
| APCA | *Apocynum cannabinum* | dogbane, Indian hemp | FAC+ | Herb | yes | | | |
| ARDI | *Aruncus dioicus* | Goat's beard | FACU+ | Herb | yes | | | |
| ASTR | *Asplenium trichomanes-ramosum* | Green spleenwort | FACU | Herb | yes | | formerly *Asplenium viride* (ASVI) | ASVI |
| ATFI | *Athyrium filix-femina* | Lady fern | FAC | Fern | yes | | | |
| ATPA | *Atriplex patula* | spear saltbush | FACW | Herb | yes | | | |
| BESY | *Beckmannia syzigachne* | American sloughgrass | OBL | Grass | yes | | | |
| BICE | *Bidens cernua* | Nodding beggars-ticks | FACW+ | Herb | yes | yes | | |
| BIFR | *Bidens frondosa* | devil's beggartick | FACW+ | Herb | yes | | | |
| BLSP | *Blechnum spicant* | Deer fern | FAC+ | Fern | yes | | | |
| CACA | *Calamagrostis canadensis* | bluejoint | FACW+ | Grass | yes | | | |
| CASP2 | *Calamagrostis spp.* | reedgrass | | Grass | yes | | | |
| CAHE | *Callitriche heterophylla* | Water starwort | OBL | Herb | yes | | | |
| CAPA | *Caltha palustris* | Yellow marsh marigold | OBL | Herb | yes | | | |
| CAAN | *Cardamine angulata* | Angled bittercress | FACW | Herb | yes | | | |
| CAPE | *Cardamine pensylvanica* | Pennsylvania bittercress | FACW | Herb | no | | | |
| CAAP | *Carex aperta* | Columbia sedge | FACW | Sedge | yes | | nearly exterpated in CR | |
| CAAT | *Carex athrostachya* | slender-beak sedge | FACW | Sedge | yes | | | |
| CACO | *Carex comosa* | Bearded sedge | OBL | Sedge | yes | | sensitive spp in WA | |
| CADE2 | *Carex densa* | dense dedge | OBL | Sedge | yes | | threatened | |
| CADE | *Carex deweyana* | Dewey sedge | FAC+ | Sedge | yes | | | |
| CADI | *Carex disperma* | Soft-leaved sedge | FACW | Sedge | yes | | | |
| CAEC | *Carex echinata* | star sedge | NI | Sedge | yes | | | |
| CALY | *Carex lyngbyei* | Lyngby sedge | OBL | Sedge | yes | | | |
| CAOB | *Carex obnupta* | Slough sedge | OBL | Sedge | yes | | | |
| CASP | *Carex sp.* | Carex | mixed | Sedge | yes | | | |
| CAST | *Carex stipata* | Sawbeak sedge | FACW | Sedge | yes | | | |
| CAVE | *Carex vesicaria* | inflated sedge, blister sedge | OBL | Sedge | yes | | | |
| CAAM | *Castilleja ambigua* | paint-brush owl-clover; johnny-nip | FACW+ | Herb | yes | | | ORCA |
| CEDE | *Ceratophyllum demersum* | Coontail | OBL | Herb | yes | | SAV | |
| CHAN | *Chamerion angustifolium* | Fireweed | FACU+ | Herb | yes | | formerly *Epilobium angustifolium* | EPAN |
| CHAL | *Chenopodium album* | lambsquarters | FAC | Herb | no | yes | possibly var. striatum, which is native | |
| CIDO | *Cicuta douglasii* | Western water-hemlock | OBL | Herb | yes | yes | | |
| CIAR | *Cirsium arvense var. horridum* | Canada thistle | FACU+ | Herb | no | yes | | |
| CIVU | *Cirsium vulgare* | bull thistle | FACU | Herb | no | yes | | |
| CLSI | *Claytonia sibirica* | Candy flower; Siberian spring beauty | FAC | Herb | yes | | | |
| COPA | *Comarum palustre* | purple marshlocks, marsh cinquefoil | OBL | Herb | yes | | formerly *Potentilla palustris* | POPA |
| COMA | *Conium maculatum* | Poison hemlock | FAC+ | Herb | no | | | |
| COAR | *Convolvulus arvensis* | Morning glory; Field bindweed | UPL | Herb | no | yes | | |
| COSE1 | *Convolvulus sepium* | Hedge bindweed | FAC | Herb | no | | formerly COSE | COSE |
| COTI | *Coreopsis tinctoria* | golden tickseed | FACU | Herb | yes | | | |
| COCA | *Cornus canadensis* | bunchberry | FAC | Shrub | yes | | | |
| COSE | *Cornus sericea* | Red-osier dogwood | FACW | Shrub | yes | | formerly COST | COST |
| COCO | *Cotula coronopifolia* | common brassbuttons | FACW+ | Herb | no | | | |
| COCO2 | *Corylus cornuta* | beaked hazelnut | FACU | Tree | yes | | | |
| CRDO | *Crataegus douglasii* | black hawthorn | FAC | Shrub | yes | | | |
| CYSP | *Cyperus sp.* | flatsedge | | Herb | mixed | | | |
| CYST | *Cyperus strigosus* | Strawcolor flatsedge; nutsedge | FACW | Sedge | yes | | | |
| DAGL | *Dactylis glomerata* | Orchard-grass | FACU | Grass | no | | | |
| DECE | *Deschampsia cespitosa* | Tufted hairgrass | FACW | Grass | yes | | | |
| DIIS | *Digitaria ischaemum* | smooth crabgrass | FACU | Grass | no | | | |
| DISA | *Digitaria sanguinalis* | hairy crabgrass | FACU | Grass | yes | | | |
| DISP | *Digitaria sp.* | crabgrass | FACU | Grass | mixed | | | |
| DISP2 | *Distichlis spicata* | saltgrass | FACW | Grass | yes | | | |
| ELAC | *Eleocharis acicularis* | Needle spikerush | OBL | Sedge | yes | | | |
| ELOV | *Eleocharis ovata* | Ovoid spikerush | OBL | Sedge | yes | | | |
| ELPA | *Eleocharis palustris* | Common spikerush | OBL | Sedge | yes | | | |
| ELPAR | *Eleocharis parvula* | Dwarf spikerush | OBL | Sedge | yes | | | |
| ELSP | *Eleocharis spp.* | Spikerush | OBL | Sedge | yes | | | |
| ELCA | *Elodea canadensis* | Canada waterweed | OBL | Herb | yes | | SAV | |
| ELNU | *Elodea nuttallii* | Nuttall's waterweed, western waterweed | OBL | Herb | yes | | SAV | |
| ELRE | *Elymus repens* | Quackgrass | FAC- | Grass | no | | | |
| EPCI | *Epilobium ciliatum* | Willow herb | FACW- | Herb | yes | | | |
| EQFL | *Equisetum fluviatile* | Water horsetail | OBL | Fern | yes | | | |
| EQHY | *Equisetum hyemale* | scouringrush horsetail | FACW | Fern | yes | | | |
| EQPA | *Equisetum palustre* | marsh horsetail | FACW | Fern | yes | | | |

| Code | Scientific Name | Common Name | Status | Category | Native | Invasive /Weedy | NOTES | Previous Species Code |
|---|---|---|---|---|---|---|---|---|
| EQSP | *Equisetum spp.* | Horsetail | mixed | Fern | yes | | | |
| EQTE | *Equisetum telmateia* | giant horsetail | FACW | Fern | yes | | | |
| EUOC | *Euthamia occidentalis* | western goldentop | FACW* | Herb | yes | | | |
| FRPU | *Frangula purshiana* | Cascara | FAC- | Tree | yes | | formerly Rhamnus purshiana (RHPU) | RHPU |
| FRLA | *Fraxinus latifolia* | Oregon ash | FACW | Tree | yes | | | |
| FUDI | *Fucus distichus* | Rockweed | OBL | Algae | yes | | | |
| GAAP | *Galium aparine* | Cleavers bedstraw | FACU | Herb | yes | yes | hairy nutlets | |
| GASP | *Galium spp* | Pacific bedstraw; cleavers; small bedstraw | mixed | Herb | yes | | | |
| GATR | *Galium trifidum* var. pacificum | Pacific bedstraw | FACW | Herb | yes | | smooth nutlets | |
| GATR2 | *Galium triflorum* | fragrant bedstraw | FACU | Herb | yes | | hairy nutlets, usually partial shade | |
| GATR3 | *Galium trifidum* | small bedstraw | FACW+ | Herb | yes | | smooth nutlets, smaller than var. pacificum | |
| GASH | *Gaultheria shallon* | Salal | FACU | Shrub | yes | | | |
| GEMA | *Geum macrophyllum* | Largeleaf avens | FACW- | Herb | yes | | | |
| GLMA | *Glaux maritima* | sea milkwort | FACW+ | Herb | yes | | | |
| GLHE | *Glechoma hederacea* | Creeping Charlie | FACU+ | Herb | no | yes | | |
| GLGR | *Glyceria grandis* | American mannagrass | OBL | Grass | yes | | | |
| GLST | *Glyceria striata* | Fowl mannagrass | OBL | Grass | yes | | formerly *G. elata* | GLEL |
| GNUL | *Gnaphalium uliginosum* | Marsh cudweed | FAC+ | Herb | no | | | |
| GREB | *Gratiola ebracteata* | bractless hedgehyssop | OBL | Herb | yes | | | |
| GRNE | *Gratiola neglecta* | American Hedge-hyssop | OBL | Herb | yes | | | |
| HEHE | *Hedera helix* | English ivy | UPL | Herb | no | yes | | |
| HEAU | *Helenium autumnale* | common sneezeweed | FACW | Herb | yes | | | |
| HEMA | *Heracleum maximum* | Cow-parsnip | FAC+ | Herb | yes | | formerly *Heracleum lanatum* | HELA |
| HOLA | *Holcus lanatus* | Common velvetgrass | FAC | Grass | no | | | |
| HOBR | *Hordeum brachyantherum* | Meadow barley | FACW- | Grass | yes | | | |
| HYRA2 | *Hydrocotyle ranunculoides* | Water pennywort | OBL | Herb | yes | | | |
| HYSC | *Hypericum scouleri* | Western St. Johns wort | FAC | Herb | yes | | Also called Hypericum formosum HYFO (should be HYSC according to USDA database | HYFO |
| HYRA | *Hypochaeris radicata* | Spotted cat's ear | FACU | Herb | no | | | |
| ILAQ | *Ilex aquifolium* | English holly | UPL | Tree | no | | | |
| ILSP | *Ilex sp.* | Holly | UPL | Tree | no | | | |
| IMSP | *Impatiens capensis,Impatiens noli-tangere* | Spotted touch-me-not, Common touch-me-not | FACW | Herb | yes | | | |
| IRPS | *Iris pseudacorus* | Yellow iris | OBL | Herb | no | | | |
| JUAC | *Juncus acuminatus* | Tapertip rush | OBL | Rush | yes | | | |
| JUBA | *Juncus balticus* | Baltic rush | FACW+ | Rush | yes | | | |
| JUBU | *Juncus bufonius* | Toad rush | FACW | Rush | yes | | | |
| JUEF | *Juncus effusus* | Soft rush | FACW | Rush | mixed | | | |
| JUEN | *Juncus ensifolius* | Daggerleaf rush | FACW | Rush | yes | | | |
| JUFA | *Juncus falcatus* | Sickleleaf rush | FACW- | Rush | yes | | | |
| JUGE | *Juncus gerardii* | saltmeadow rush | FACW+ | Rush | yes | | | |
| JUNE | *Juncus nevadensis* | Sierra rush | FACW | Rush | yes | | | |
| JUOX | *Juncus oxymeris* | Pointed rush | FACW+ | Rush | yes | | | |
| JUSP | *Juncus spp.* | Rush | mixed | Rush | mixed | | | |
| JUSU | *Juncus supiniformis* | Spreading rush | OBL | Rush | yes | | | |
| JUTE | *Juncus Tenuis* | slender rush, poverty rush | FACW- | Rush | yes | | Campbell Slough 2010 | |
| LAPA | *Lathyrus palustris* | Marsh peavine | OBL | Herb | yes | | | |
| LEOR | *Leersia oryzoides* | Rice cutgrass | OBL | Grass | yes | | | |
| LEMI | *Lemna minor* | Duckweed | OBL | Herb | yes | | | |
| LEMO | Leymus mollis | American dunegrass | UPL | Grass | yes | | Trestle Bay 2008 | |
| LEVU | *Leucanthemum vulgare* | oxeye daisy | UPL | Herb | no | yes | noxious weed | |
| LIOC | *Lilaeopsis occidentalis* | Western lilaeopsis | OBL | Herb | yes | | | |
| LIAQ | *Limosella aquatica* | Water mudwort | OBL | Herb | yes | | | |
| LOIN | *Lonicera involucrata* | Black twinberry | FAC+ | Shrub | yes | | | |
| LOCO | *Lotus corniculatus* | Birdsfoot trefoil | FAC | Herb | no | | | |
| LUPA | *Ludwigia palustris* | False loosestrife | OBL | Herb | yes | | | |
| LUPO | *Lupinus polyphyllus* | Large-leaved lupine | FAC+ | Herb | yes | | from Welch Is. | |
| LYAM2 | *Lycopus americanus* | American water horehound | OBL | Herb | yes | | | |
| LYSP | *Lycopus sp.* | Bugleweed; horehound | OBL | Herb | yes | | | |
| LYUN | *Lycopus uniflorus* | Northern bugleweed | OBL | Herb | yes | | | |
| LYAM | *Lysichiton americanus* | Skunk cabbage | OBL | Herb | yes | | | |
| LYNU | *Lysimachia nummularia L.* | Moneywort, Creeping Jenny | FACW | Herb | no | | | |
| LYSA | *Lythrum salicaria* | Purple loosestrife | FACW+ | Herb | no | yes | | |
| MASA | *Madia sativa* | coast tarweed | UPL | Herb | yes | | | |
| MADI | *Maianthemum dilatatum* | Wild lily-of-the-valley | FAC | Herb | yes | | | |
| MARA | *Maianthemum racemosum* | Large false lily of the valley | UPL | Herb | yes | | formerly *Smilacina racemosa* | |
| MAFU | *Malus fusca* | Pacific crab apple | FACW | Tree | yes | | | |
| MAPO | *Marchantia polymorpha* | Lung liverwort | na | NV | yes | | Gee Creek 2010 | |
| MEAR | *Mentha arvensis* | wild mint | FACW- | Herb | yes | | pointy serrations | |
| MESP3 | *Mentha spicata L.* | spearmint | OBL | Herb | no | | rounded serrations | |
| MESP | *Mentha spp.* | Mint (field mint, spearmint) | mixed | Herb | mixed | | | |
| MIAL | *Mimulus alsinoides* | Chickweed monkey-flower | OBL | Herb | yes | | | |
| MIGU | *Mimulus guttatus* | Yellow monkeyflower | OBL | Herb | yes | | | |
| MILE | *Mimulus lewisii* | great purple monkey flower | FACW+ | Herb | yes | | | |
| MIRI | *Mimulus ringens* | Allegheny monkeyflower | OBL | Herb | yes | | Cottonwood Island 2010 | |
| MITR | *Mitella trifida* | Three-toothed mitrewort | na | Herb | yes | | | |
| MYLA | *Myosotis laxa* | Small forget-me-not | OBL | Herb | yes | | | |
| MYSP | *Myosotis laxa, M. scorpioides* | Small forget-me-not, Common forget-me-not | mixed | Herb | mixed | | | |
| MYSC | *Myosotis scorpioides* | Common forget-me-not | FACW | Herb | no | | | |

| Code | Scientific Name | Common Name | Status | Category | Native | Invasive /Weedy | NOTES | Previous Species Code |
|---|---|---|---|---|---|---|---|---|
| MYAQ | *Myriophyllum aquaticum* | Parrot-feather milfoil | OBL | Herb | no | yes | SAV | |
| MYHI | *Myriophyllum hippuroides* | western milfoil | OBL | Herb | yes | | SAV | |
| MYSP3 | *Myriophyllum spicatum* | Eurasian water milfoil | OBL | Herb | no | yes | SAV | |
| MYSP2 | *Myriophyllum spp.* | Milfoil | OBL | Herb | mixed | | | |
| MYSI | *Myriophyllum sibiricum* | northern milfoil, short spike milfoil | OBL | Herb | yes | | SAV | |
| NULU | *Nuphar lutea* | Yellow pond-lily | OBL | Herb | yes | | | |
| OECE | *Oemleria cerasiformis* | Indian-plum | FACU | Shrub | yes | | | |
| OESA | *Oenanthe sarmentosa* | Water parsley | OBL | Herb | yes | | | |
| OXOR | *Oxalis oregana* | Redwood sorrel | UPL | Herb | yes | | | |
| PACA | *Panicum capillare* | witchgrass | FACU+ | Grass | yes | | | |
| PAOC | *Panicum occidentale/Dichanthelium acuminatum* | western panicgrass | FACW | Grass | yes | | | |
| PAVI | *Parentucellia viscosa* | Yellow parentucellia | FAC- | Herb | no | | | |
| PADI | *Paspalum distichum* | Knotgrass | FACW | Grass | yes | | | |
| PENE | *Pellia neesiana* | Ring pellia | | Liverwort | yes | | | |
| PHHA | *Phacelia hastata* | silver-leaf phacelia | UPL | Herb | yes | | | |
| PHAR | *Phalaris arundinacea* | Reed canary grass | FACW | Grass | no | yes | | |
| PHCA | *Physocarpus capitatus* | Pacific ninebark | FACW- | Shrub | yes | | | |
| PISI | *Picea sitchensis* | Sitka spruce | FAC | Tree | yes | | | |
| PLLA | *Plantago lanceolata var. lanceolata* | Rib plantain | FAC | Herb | no | | | |
| PLMA | *Plantago major* | common plantain | FACU+ | Herb | no | | | |
| PLDI | *Platanthera dilatata* | white bog orchid | FACW+ | Herb | yes | | | |
| POAN2 | *Poa annua* | annual bluegrass | FAC | Grass | no | | | |
| POAM | *Polygonum amphibium* | water ladysthumb, water smartweed | OBL | Herb | yes | | | |
| POCU | *Polygonum cuspidatum* | Japanese knotweed | FACU | Herb | no | yes | | |
| POHY | *Polygonum hydropiper, P. hydropiperoides* | Waterpepper, mild waterpepper, swamp smartweed | OBL | Herb | mixed | | POHY and POHY2 combined into this category | |
| POLA | *Polygonum lapathifolium* | curly top knotweed | FACW | Herb | yes | | | |
| POPE | *Polygonum persicaria* | Spotted ladysthumb | FACW | Herb | no | yes | | |
| POSP | *Polygonum sp.* | Knotweed, Smartweed | mixed | Herb | mixed | | | |
| POGL | *Polypodium glycyrrhiza* | Licorice fern | FACU | Fern | yes | | | |
| POMU | *Polystichum munitum* | Sword fern | FACU | Fern | yes | | | |
| POBA | *Populus balsamifera* | black cottonwood | FAC | Tree | yes | | | |
| POCR | *Potamogeton crispus* | Curly leaf pondweed | OBL | Herb | no | yes | SAV | |
| PONA | *Potamogeton natans* | Floating-leaved pondweed | OBL | Herb | yes | | SAV | |
| POPU | *Potamogeton pusillus* | Small pondweed | OBL | Herb | yes | | SAV | |
| PORI | *Potamogeton richardsonii* | Richardson's pondweed | OBL | Herb | yes | | SAV | |
| POSP2 | *Potamogeton sp.* | Pondweed | OBL | Herb | mixed | | | |
| POZO | *Potamogeton zosteriformis* | Eelgrass pondweed | OBL | Herb | yes | | SAV | |
| POAN | *Potentilla anserina ssp. Pacifica/Argentina egedii ssp. Egedii* | Pacific silverweed | OBL | Herb | yes | | also known as *Argentina egedii spp. Egedii* | |
| PRVU | *Prunella vulgaris* | Self heal | FACU+ | Herb | yes | | | |
| PREM | *Prunus emarginata* | Bitter cherry | FACU | Tree | yes | | | |
| PSCA | *Pseudognaphalium canescens* | Slender cudweed; Wright's cudweed | UPL | Herb | yes | | formerly *Gnaphalium microcephalum* | GNMI |
| PTAQ | *Pteridium aquilinum* | Bracken fern | FACU | Fern | yes | | | |
| PUPU | *Puccinellia pumila* | dwarf alkaligrass | FACW+ | Herb | yes | | | |
| RACY | *Ranunculus cymbalaria* | Alkali buttercup | OBL | Herb | yes | | | |
| RAFL | *Ranunculus flammula* | Small creeping buttercup | FACW | Herb | yes | | | |
| RARE | *Ranunculus repens* | Creeping buttercup | FACW | Herb | no | | | |
| RASC | *Ranunculus sceleratus* | Celery-leaved buttercup | OBL | Herb | yes | | | |
| RAUN | *Ranunculus uncinatus* | Woodland buttercup | FAC- | Herb | yes | | | |
| RIBR | *Ribes bracteosum* | Stink currant | FAC | Shrub | yes | | | |
| RIDI | *Ribes divaricatum* | Wax currant, coast black currant | FAC | Shrub | yes | | | |
| RILA | *Ribes lacustre* | Swamp gooseberry | FAC+ | Shrub | yes | | | |
| RIFL | *Riccia fluitans* | Liverwort | na | Liverwort | yes | | | |
| RINA | *Ricciocarpos natans* | Purple fringed liverwort | na | Liverwort | yes | | | |
| ROSP | *Rorippa calycina, R.curvisiliqua* | Yellow cress | mixed | Herb | yes | | | |
| ROCO | *Rorippa columbiae* | Columbian yellowcress | OBL | Herb | yes | | Threatened in Washington state | ROCA |
| ROCU | *Rorippa curvisiliqua* | curvepod yellow cress | OBL | Herb | yes | | | |
| RONA | *Rorippa nasturtium-aquaticum/Nasturtium officinale* | Watercress | OBL | Herb | no | | | |
| ROPA | *Rorippa palustris* | Marsh yellow-cress | OBL | Herb | yes | | | |
| RONU | *Rosa nutkana* | Nootka rose | FAC | Shrub | yes | | | |
| ROPI | *Rosa pisocarpa* | Clustered wild rose, peafruit rose, swamp rose | FAC | Shrub | yes | | | |
| RUAR | *Rubus armeniacus* | Himalayan blackberry | FACU | Shrub | no | | formerly *Rubus discolor* | RUDI |
| RULA | *Rubus laciniatus* | Evergreen blackberry | FACU+ | Shrub | no | | | |
| RUPA | *Rubus parviflorus* | Thimbleberry | FAC- | Shrub | yes | | | |
| RUSP | *Rubus spectabilis* | Salmonberry | FAC+ | Shrub | yes | | | |
| RUUR | *Rubus ursinus* | Trailing blackberry | FACU | Shrub | yes | | | |
| RUAC | *Rumex acetosella* | common sheep sorrel | FACU+ | Herb | no | yes | | |
| RUAQ | *Rumex aquaticus* | Western dock | FACW+ | Herb | yes | | formerly *Rumex occidentalis* | RUOC |
| RUCR | *Rumex crispus* | Curly dock | FAC+ | Herb | no | | | |
| RUMA | *Rumex maritimus* | Golden dock, seaside dock | FACW+ | Herb | yes | | | |
| RUMA2 | *Ruppia maritima* | Widgeongrass | OBL | Herb | yes | | SAV | |
| SALA | *Sagittaria latifolia* | Wapato | OBL | Herb | yes | | | |
| SAVI | *Salicornia virginica* | pickleweed | OBL | Herb | yes | | | |
| SAFL | *Salix fluviatilis* | Columbia River willow, river willow | OBL | Shrub | yes | | Cottonwood Island 2; 2010 | |
| SALU | *Salix lucida* | Pacific willow | FACW+ | Shrub | yes | | | |
| SASI | *Salix sitchensis* | Sitka willow | FACW | Shrub | yes | | | |
| SASP | *Salix spp.* | Willow | mixed | Shrub | yes | | | |

| Code | Scientific Name | Common Name | Status | Category | Native | Invasive /Weedy | NOTES | Previous Species Code |
|---|---|---|---|---|---|---|---|---|
| SARA | *Sambucus racemosa* | Red elderberry | FACU | Shrub | yes | | | |
| SCAC | *Schoenoplectus acutus* | Hardstem bulrush, tule | OBL | Sedge | yes | | formerly Scirpus acutus (SCAC) | SCAC |
| SCAM | *Schoenoplectus americanus* | American bulrush, threesquare bulrush | OBL | Sedge | yes | | formerly Scirpus americanus (SCAM) | SCAM |
| SCMA | *Schoenoplectus maritimus* | Seacoast bulrush | OBL | Sedge | yes | | formerly Scirpus maritimus (SCMA) | SCMA |
| SCSP | *Schoenoplectus spp.* | hybrid sedge | OBL | Sedge | mixed | | used when spp appears to have hybridized or has no identifying features | |
| SCTA | *Schoenoplectus tabernaemontani* | Softstem bulrush, tule | OBL | Sedge | Yes | | formerly Scirpus lacustris (SCLA) | SCLA |
| SCTR | *Schoenoplectus triqueter* | Threesquare tule | OBL | Sedge | no | | formerly Scirpus triqueter (SCTR) | SCTR |
| SCCY | *Scirpus cyperinus* | woolly sedge | OBL | Sedge | yes | | | |
| SCMI | *Scirpus microcarpus* | Small-fruited bulrush | OBL | Sedge | yes | | | |
| SCLA | *Scrophularia lanceolata* | Lance-leaf figwort | FAC | Herb | yes | | formerly SCLA2 | SCLA2 |
| SISU | *Sium suave* | Hemlock waterparsnip | OBL | Herb | yes | | | |
| SODU | *Solanum dulcamara* | Bittersweet nightshade | FAC+ | Herb | no | | | |
| SOCA | *Solidago canadensis* | Canada goldenrod | FACU | Herb | yes | | | |
| SPAN | *Sparganium angustifolium* | Narrowleaf burreed | OBL | Herb | yes | | | SPEM |
| SPDO | *Spiraea douglasii* | Douglas spiraea | FACW | Shrub | yes | | | |
| STCO | *Stachys cooleyae* | Cooley's hedge-nettle | FACW | Herb | yes | | | |
| STCR | *Stellaria crispa* | Curled starwort | FAC+ | Herb | yes | | | |
| STLO | *Stellaria longifolia* | Longleaf starwort | FACW | Herb | yes | | | |
| SYAL | *Symphoricarpos albus* | Common snowberry | FACU | Shrub | yes | | | |
| SYSU | *Symphyotrichum subspicatum* | Douglas aster | FACW | Herb | yes | | formerly *Aster subspicatus* (ASSU) | ASSU |
| TAOF | *Taraxacum officinale* | Common dandelion | FACU | Herb | no | | | |
| TEGR | *Tellima grandiflora* | Fringe cup | UPL | Herb | yes | | | |
| THPL | *Thuja plicata* | Western redcedar | FAC | Tree | yes | | | |
| TITR | *Tiarella trifoliata* | Foamflower | FAC- | Herb | yes | | | |
| TOME | *Tolmiea menziesii* | Piggy-back plant | FAC | Herb | yes | | | |
| TRAR | *Trifolium arvense* | rabbitfoot clover | UPL | Herb | no | yes | | |
| TRSP | *Trifolium pratense, T. repens, T. dubium* | Red clover, white clover, small hop-clover | mixed | Herb | no | | | |
| TRWO | *Trifolium wormskioldii* | Springbank clover | FACW+ | Herb | yes | | | |
| TRMA | *Triglochin maritima* | Seaside arrowgrass | OBL | Arrow-grass | yes | | | |
| TSHE | *Tsuga heterophylla* | Western hemlock | FACU- | Tree | yes | | | |
| TYAN | *Typha angustifolia* | Narrowleaf cattail | OBL | Herb | no | | | |
| TYSP | *Typha angustifolia, T. latifolia* | Narrowleaf cattail, common cattail | OBL | Herb | mixed | | | |
| TYLA | *Typha latifolia* | Common cattail | OBL | Herb | yes | | | |
| URDI | *Urtica dioica* | Stinging Nettle | FAC+ | Herb | yes | | | |
| UTVU | *Utricularia vulgaris* | Common bladderwort | OBL | Herb | yes | | carnivorous | |
| VAPA | *Vaccinium parvifolium* | Red huckleberry | FACU | Shrub | yes | | | |
| VECA | *Veratrum californicum* | California false hellebore | FACW+ | Herb | yes | | | |
| VETH | *Verbascum thapsus* | Common mullein | UPL | Herb | no | | | |
| VEAM | *Veronica americana* | American speedwell | OBL | Herb | yes | | | |
| VEAN | *Veronica anagallis-aquatica* | water speedwell | OBL | Herb | yes | | | |
| VESC | *Veronica scutellata* | marsh speedwell | OBL | Herb | yes | | | |
| VESP | *Veronica spp.* | speedwell | OBL | Herb | yes | | | |
| VIED | *Viburnum edule* | Highbush cranberry | FACW | Shrub | yes | | | |
| VIAM | *Vicia americana* | American vetch | FAC | Herb | yes | | | |
| VISP | *Vicia spp* | Vetch | | Herb | mixed | | | |
| WOSP | *Wolffia spp.* | Watermeal | OBL | Herb | yes | | | |
| XAST | *Xanthium strumarium* | rough cocklebur | FAC | Herb | yes | | | |
| ZAPA | *Zannichellia palustris* | horned pondweed | OBL | Herb | yes | | SAV | |
| ZOJA | *Zostera japonica* | Japanese eelgrass | OBL | Herb | no | | SAV | |
| ZOMA | *Zostera marina* | eelgrass | OBL | Herb | yes | | SAV | |
| | | | | | | | | |
| **Other Codes Used during Vegetation Monitoring:** | | | | | | | | |
| BG | | bare ground | | | | | | |
| DA | | drift algae | | | | | | |
| DW | | drift wrack | | | | | | |
| FGA | | filamentous green algae | OBL | Algae | | | | |
| litter | | litter | | | | | | |
| LW | | live wood | | | | | | |
| LWD | | large woody debris | | | | | | |
| MG | | mixed Grass | mixed | Grass | mixed | | | |
| MGA | | matting green algae | OBL | Algae | | | | |
| MH | | mixed herbs | | Herb | | | | |
| MOSS | | moss | na | Moss | yes | | | |
| OM | | organic matter | na | mixed | mixed | | | |
| OW | | open water | | | | | | |
| SMG | | small mixed grass | | Grass | | | | |
| SMH | | small mixed herbs | | Herb | | | | |