EDMONDS MARSH BASELINE MONITORING STUDY FINAL

Prepared for

Edmonds City Council
121 - 5th Avenue North
Edmonds, WA

September 13, 2019

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Acronyms

Audubon	Pilchuck Audubon Society
B-IBI	Benthic Index of Biotic Integrity
bgs	below ground surface
BNSF	Burlington Northern Santa Fe
BPC	bird point count
BTEX	benzene, toluene, ethylbenzene and xylene constituents
CFU	colony forming unit
City	City of Edmonds City Council
cPAH	carcinogenic polycyclic aromatic hydrocarbon
CTD	conductivity, temperature, and depth
DO	dissolved oxygen
Ecology	Washington State Department of Ecology
EPA	US Environmental Protection Agency
FAC	facultative
FACU	facultative upland
FACW	facultative wetland
FS	feasibility study
Hatchery	Willow Creek fish hatchery
ID	identification
ISGP	Industrial Stormwater General Permit
LWD	large woody debris
Marsh	Edmonds Marsh
msl	mean sea level
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
NTU	nephelometric turbidity unit
OBL	obligate
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
ppt	parts per thousand

psu	practical salinity unit
PVC	polyvinyl chloride
QC	quality control
SD	secure digital
SR	State Route
SU	standard unit
SVOC	semivolatile organic compound
TOC	total organic carbon
TPH	total petroleum hydrocarbons
UPL	upland
USDA	US Department of Agriculture
VOC	volatile organic compound
WAC	Washington Administrative Code
Windward	Windward Environmental LLC
WOC	weed of concern
WQC	water quality criteria
WRIA	Water Resources Inventory Area
WSS	web soil survey
WU	Weather Underground

1 Executive Summary

The Edmonds Marsh (Marsh) is the only remaining salt marsh within the nearshore habitat zone of Watershed Resources Inventory Area (WRIA) 8 (the Lake Washington/Cedar/Sammamish Watershed) (SRFB 2014, 2018). Despite its location in the center of an urban area, the Marsh provides habitat for a number of different plant and animal species, as well as other ecological functions. In order to better understand and document the baseline conditions of the Marsh and its buffer areas, as well as the ecological functions being provided by those habitats, the City of Edmonds City Council (City) engaged Windward Environmental LLC (Windward) to conduct a year-long baseline study. The study was conducted between July 2018 and June 2019, and data collection events were performed once per season during the year.

The study included monitoring of both physical and biological parameters. The physical parameters monitored were water quality and water levels within the Marsh and its tributary creeks (Willow and Shellabarger Creeks), and characteristics of Marsh sediment and soil from the Marsh's buffer zones. The biological parameters monitored were vegetation and large woody debris (LWD)[1] within the Marsh and its buffer zones, and the presence of invertebrates, birds, and other wildlife. In addition, the baseline study included an overview of data and other information collected within the Marsh and its buffer areas by other parties, including members of the community.

The Marsh provides a refuge for wildlife, and many different species were documented within the Marsh and its buffer areas throughout the baseline monitoring year. Several types of birds, including songbirds, shorebirds, wading birds, and raptors, were identified. Some species, such as red-winged blackbirds, common yellowthroats, marsh wrens, and killdeers, were regularly observed strictly within the Marsh interior; others, such as song sparrows and chickadees, were common in both the Marsh and its buffer areas. Several species of birds were documented as breeding within the Marsh and its adjacent buffer habitats. The mammal species most commonly observed throughout the baseline monitoring year were coyote and black-tailed deer, both of which frequent the forested habitat on the south side of the Marsh; coyote also use the Marsh interior. Deer with fawns were observed in the south buffer zone in the summers of both 2018 and 2019.

The Marsh also supports a number of different invertebrate species that provide a variety of ecological functions, including plant pollination; the breakdown of decaying organic material; and food sources for other invertebrates, fish, birds, and mammals. The types of invertebrates sampled within the Marsh and its buffer areas included flies, springtails, and beetles, all of which have been shown to be important prey items for juvenile salmon.

[1] LWD is large pieces of dead wood, either standing or fallen on the ground.

The western portion of the Marsh is dominated by emergent, salt-tolerant native vegetation, which is intermixed with mudflat habitat. The eastern portion of the Marsh is dominated by freshwater species, predominantly cattail (*Typha* spp.). There are patches of invasive plant species within the Marsh, most notably a large infestation of bittersweet nightshade in the southern portion of the Marsh (adjacent to the south and southeast buffer zones), and two patches of common reed in the western portion of the Marsh. Control of these species and other invasive plants should be a goal of future habitat restoration work.

The Marsh buffer zones, where vegetated, contain dense stands of woody vegetation and provide a visual screen between the Marsh interior and the surrounding developed areas and roadways. The understory vegetation (i.e., the layer of growth beneath the tree canopy) is dominated by invasive species in the southeast buffer zone of the Marsh and the north buffer zone of Shellabarger Marsh. The ability of these buffer zones to provide ecological functions—primarily habitat functions—would be improved by controlling the invasive species and planting native trees, shrubs, and groundcover plants. Active habitat restoration efforts to control invasive vegetation and install native plants are already underway in the north and south buffer zones. The south buffer zone contains the most diverse native plant community of all the buffer areas surveyed, providing a local example of a relatively intact, diverse native riparian forest that could be mimicked in other buffer areas through active restoration efforts.

In general, there is a lack of LWD both within the Marsh and its buffer areas. LWD within these habitat types provides a number of habitat functions: It is a source of organic material released slowly over time to the underlying soil or sediment; it provides a cooling effect by shading the immediate area surrounding it, helping to create different microclimates; and perhaps most importantly, it provides habitat for numerous invertebrate, reptile, amphibian, bird, and mammal species. The placement of LWD within the Marsh and its buffer areas, which could perhaps be achieved as part of the Edmonds Marsh Estuary Restoration Project, would help boost these ecological functions.

The Marsh and its tributary creeks generally have good water quality in terms of cool water temperatures and sufficient levels of dissolved oxygen (DO) to support salmon and other fish species. However, water quality in some areas has been impacted by typical urban pollutants, including fecal coliform bacteria, petroleum hydrocarbons, and related chemicals. During the warmer times of the year, water temperatures also rise above water quality criteria (WQC) in many areas of the Marsh; however, water temperatures are typically cooler in the southern portion of the Marsh where Willow Creek enters, indicating that shading by riparian vegetation in the south buffer zone is provided a water quality benefit.

Low DO levels have been detected along the northern edge of the Marsh on several occasions, possibly indicating poor water circulation in this area. One of the primary actions to be performed as part of the Edmonds Marsh Estuary Restoration Project is the daylighting of Willow Creek where it flows out of the Marsh into Puget Sound. Daylighting the creek, in concert with other habitat improvements to be made in the Marsh interior, will hopefully improve water circulation within the Marsh and help maintain sufficient DO levels in all areas.

The hydraulics and salinity of the Marsh are controlled by downstream drainage infrastructure, which includes long pipe runs, culverts, and a one-way tide gate. Channelization of Willow Creek along the southern edge of the Marsh limits any mixing of fresh and salt water. The system is characterized by wide swings in salinity, from full-strength Puget Sound water (ca. 32 parts per thousand [ppt]) to nearly fresh water (< 1 ppt). Tidal exchange is also constrained by inadequately sized stormwater conveyances and the tide gate. However, holding the tide gate open during low rainfall seasons has allowed some of the characteristics of the salt marsh to begin to recover (e.g., mean salinity increases to 11.4 ppt have been recorded).

The Marsh represents a rare nearshore estuarine pocket marsh. In its current condition, it provides a number of ecological functions, as described. After implementation of the Edmonds Marsh Estuary Restoration Project, the ecological functions provided by the Marsh will be enhanced, and the Marsh will once again have the opportunity to provide habitat for juvenile salmonids and other migratory fish. In addition to providing enhanced habitat functions beneficial to fish and wildlife, a restored Marsh system would provide the City of Edmonds, as well as the larger community, with the opportunity to observe and appreciate the roles that nearshore estuarine marshes, tidal streams, and adjacent riparian forests play in fostering the native flora and fauna of the Pacific Northwest, and how they can do so even within an urban area.

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2 Introduction

The City engaged Windward to conduct a year-long study of the Marsh in order to help establish baseline conditions in the Marsh and its adjacent buffer areas, and to help evaluate the ecological functions being provided by those habitats. The Marsh is a tidally influenced[2] wetland occupying approximately 29 acres in the heart of Edmonds, Washington (Map 1); it is the remnant of a much larger estuarine wetland that was once located along the shores of Puget Sound (Murkin et al., as cited in Sea-Run Consulting et al. 2007). Historically, the Marsh was a pocket estuary more than 100 acres in size and protected by a barrier sand spit (Shannon & Wilson 2015). It extended from Point Edmonds (located at the southern end of Marina Beach Park) north to Brackett's Landing near the Washington State Department of Transportation ferry terminal.

[2] The Marsh is tidally influenced when the tide gate downstream of the Marsh is open, typically in the spring and summer months. Since 2018, the City has opened the tide gate for periods of time throughout the fall and winter months, tides and storm flows permitting, to allow tidal influx into the Marsh during these months as well.

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N

0 0.05 0.1 Miles

0 400 800 Feet

Map 1. Edmonds and Shellabarger Marshes vicinity map

Prepared by mikey, 7/16/2019; W:\Projects\Edmonds Marsh\Data\GIS\Maps and Analyses\Buffer_Zone_Evaluation\Map 1_6862_Edmonds and Shellabarger Marsh Vicinity Map.mxd

The western portion of the Marsh contains mudflat habitat and tidal channels and supports salt marsh plants. The eastern portion of the Marsh is a predominantly freshwater system fed by two tributary creeks: Willow Creek and Shellabarger Creek (Map 1). The drainage basin of Willow Creek is approximately 393 acres in size and encompasses residential land to the south and east of the Marsh (Shannon & Wilson 2015). The drainage basin of Shellabarger Creek is approximately 378 acres in size and encompasses residential and commercial land to the north, east, and south of the Marsh. Shellabarger Marsh is a small freshwater marsh located to the east of the Marsh. Shellabarger Marsh was once part of the Marsh, but the two were separated when State Route (SR)-104 was constructed. The two marshes are still hydraulically connected via a pair of culverts running under SR-104. Both the Marsh and Shellabarger Marsh provide valuable habitat to birds and other wildlife, in addition to conveying large quantities of stormwater and surface water.

This document describes the results of the year-long baseline monitoring study (hereafter referred to as the baseline study) of the Marsh, Shellabarger Marsh, and the buffer zones of the two marshes. The development of the baseline study and the monitoring methods employed were described in the *Edmonds Marsh Baseline Monitoring Plan* (hereafter referred to as the monitoring plan) (Windward 2018a). The overarching goals of the baseline study were 1) to quantify and describe current conditions within both marshes and their adjacent buffer zones, in order to establish a baseline against which future changes can be measured, and 2) to provide information about the ecological functions currently being performed by the marshes and their buffer zones.

The baseline study was conducted over the course of one year, from July 2018 through June 2019, with data collection events being performed once per season during the year. Both physical and biological parameters were monitored in order to provide a baseline against which future changes within the Marsh—generated by projects such as the Edmonds Marsh Estuary Restoration Project, the Dayton Street pump station, vegetation enhancement, and other future land use changes within the Marsh's drainage basin—can be evaluated. In addition to data gathered as part of this study, this report provides an overview of data/information collection efforts conducted within the Marsh and its buffer areas by other parties and by members of the community.

Section 3 of this document builds upon the survey methods described in the monitoring plan (Windward 2018a) to illustrate how the monitoring study was implemented. Section 4 provides the results of the monitoring study, Section 5 provides information about the Marsh based upon studies conducted by other parties, and Section 6 describes information gathered by members of the community. Section 7 includes a discussion of the baseline conditions and ecological functions of the Marsh and its buffer areas, based upon the information compiled from the baseline study and other sources.

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3 Methods

The baseline study included monitoring of both physical and biological parameters over the course of one year. The rationale for the parameters selected for inclusion in the baseline study was explained in the monitoring plan (Windward 2018a), which also provided the methods to be followed for each monitoring parameter. The following subsections provide additional detail about the methods implemented throughout the monitoring year, as well as descriptions of any deviations from the methods as described in the monitoring plan.

Monitoring was performed once per season: Summer monitoring was conducted over several dates in July 2018; fall monitoring was conducted over several dates in October 2018; winter monitoring was conducted over several dates in January 2019; and spring monitoring was conducted over several dates in April 2019.[3] Monitoring locations were mapped using hand-held GPS units. Most of the monitoring stations established during the summer 2018 event were mapped using a DR-Geo7x-s unit. The discrete water quality monitoring stations were mapped using a Magellan eXplorist 210 GPS unit. Baseline data were recorded on the data sheets presented in the monitoring plan (Windward 2018a) and/or within field logbooks. Copies of completed data sheets are provided in Appendix A, and copies of all logbook pages are included in Appendix B.

3.1 Monitoring for Physical Parameters

Monitoring the physical parameters of a wetland system—including its hydrology (water levels), water quality, and sediment and soil characteristics—helps provide information about how that wetland functions and provides water storage, water quality improvements, substrates suitable to support plant growth, and habitat structure. In addition, a baseline dataset documenting these parameters can be useful in identifying and quantifying future changes to wetland systems. As part of the baseline study, water quality monitoring was performed, as was characterization of soil from the buffer areas and sediment from the Marsh.

3.1.1 Water quality monitoring

As part of the baseline study, water quality monitoring was conducted manually once per season using hand-held water quality meters (i.e., discrete water quality monitoring). Monitoring was also conducted continuously throughout the year using automated water conductivity, temperature, and depth (CTD) data loggers. Discrete water quality monitoring methods are described in Section 3.1.1.1, and the continuous monitoring with CTD loggers is discussed in Section 3.1.1.2.

[3] Spring bird surveys were performed on May 7, 2019.

3.1.1.1 Discrete water quality monitoring

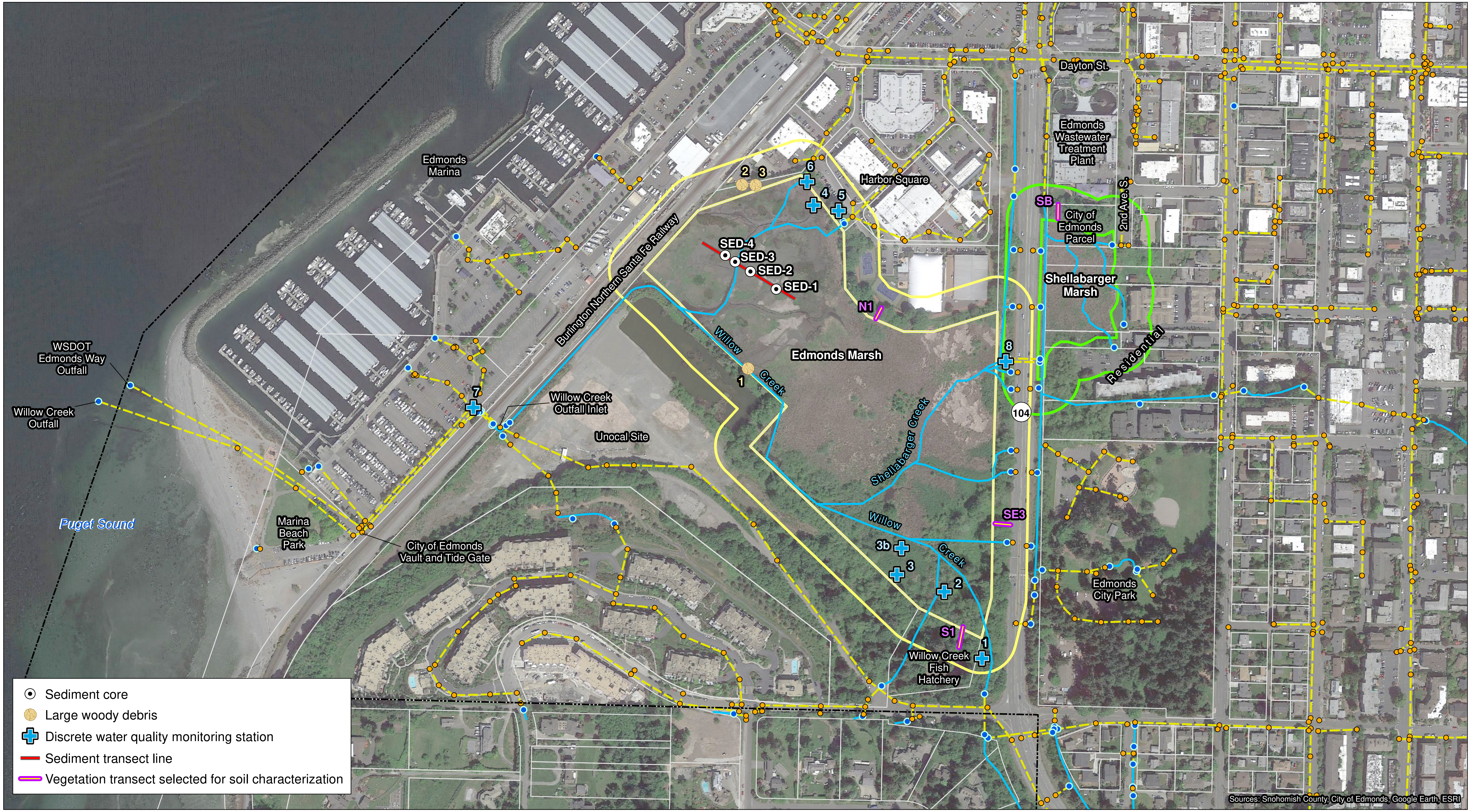
Pursuant to the monitoring plan (Windward 2018a), measurements of select water quality parameters were collected at nine locations[4] within the Marsh's primary tidal channels and near areas where surface water or stormwater enters the Marsh. Measurements were collected each season over the course of one year using a YSI© ProDSS® water quality meter (borrowed from the Edmonds Stream Team). Water temperature, pH, conductivity, DO, and turbidity data were collected each season at all nine monitoring locations. Water level data were also collected at each location, using a ruler attached to a wide, flat base (in order to prevent the ruler from sinking below the surface of the substrate). The discrete water quality monitoring stations are described in Table 3-1 and shown on Map 2.

Table 3-1. Discrete water quality monitoring station descriptions

Water Quality Monitoring Location No.	Water Quality Monitoring Location Description
1	Willow Creek within the Hatchery property, just upstream of the bridge, where two logs cross the creek
2	Hatchery property at the edge of the riparian forest canopy, just downstream of where the two branches of Willow Creek come together
3	area of shallow sheet-flow within cattail/nightshade vegetation, north of wooded portion of Hatchery property
3b	north of Location 3, near red alder tree covered in bittersweet nightshade
4	tidal/drainage channel at northwest corner of marsh, under large Pacific willow and patch of hardstem bulrush
5	southeast Harbor Square outfall
6	northwest Harbor Square outfall, under first landing of westernmost boardwalk
7	fenced outlet basin, near Edmonds Marina
8	Shellabarger/SR-104 culvert (west side of roadway)

Hatchery – Willow Creek fish hatchery
SR – State Route

[4] Location 3b was added during the winter monitoring event; measurements were collected at this location during the winter and spring monitoring events only.



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N

0 0.05 0.1 Miles

0 250 500 Feet

- Storm structure
- Storm culvert
- Storm line
- Storm ditch/creek
- Shellabarger Marsh w/ 125-ft buffer
- Edmonds Marsh w/ 125-ft buffer
- Parcel
- City of Edmonds boundary

Map 2. Edmonds Marsh baseline study physical monitoring parameter stations

Prepared by mikey, 9/12/2019; W:\Projects\Edmonds Marsh\Data\GIS\Maps and Analyses\Monitoring plan\Actual locations\Map 2_6884a_Actual Physical Monitoring Parameter Stations.mxd

Water quality measurements were collected during each season; dates are provided in Table 3-2. Table 3-2 also provides information about tidal stages and the amount of rainfall that occurred during the 48 hours preceding each monitoring event, as these factors influence salinity and other water quality parameters, as discussed further in Section 4.1.

Table 3-2. Water quality monitoring event information

Monitoring Event	Date(s)	Times	Tidal Stage[a]	Approximate Precipitation Previous 48 Hours[b]
Summer	07/17/2018	12:20–16:25	low tide	0 cm (0 in.)
Fall	10/18/2018	09:05–12:30	rising tide	0.25 cm (0.1 in.)
Winter	01/17/2019	14:08–16:34	falling tide (started near high tide)	0.29 cm (0.09 in.)
Spring	04/15/2019	10:53–12:10	rising tide	0.41 cm (0.16 in.)
	04/16/2019	09:47–11:14	rising tide (started near high tide)	0.18 cm (0.07 in.)

[a] Source: NOAA (2019)
[b] Source: WU (2019)
NOAA – National Oceanic and Atmospheric Administration
WU – Weather Underground

Two deviations from the monitoring plan (Windward 2018a) occurred during the discrete water quality monitoring. First, the water quality field forms presented in Appendix A of monitoring plan were not filled out in the field. Instead, notes and water quality measurements were recorded in the field log book (Appendix B of this document), as this was a more convenient way to record all of the necessary information in one place. Second, in addition to measurements collected using the YSI© ProDSS® water quality meter, pH measurements were collected using a Hach sensION1 pH meter during the summer, fall, and spring monitoring events, and a HF Scientific, Inc.© MircoTPW turbidimeter was used to collected turbidity measurements during all four monitoring events. These other meters were useful at locations where it was difficult to fully submerge the YSI© ProDSS® water quality meter probe due to shallow water or other space restrictions. The water quality measurements collected during the four events are presented in Section 4.1.

3.1.1.2 Continuous water quality monitoring

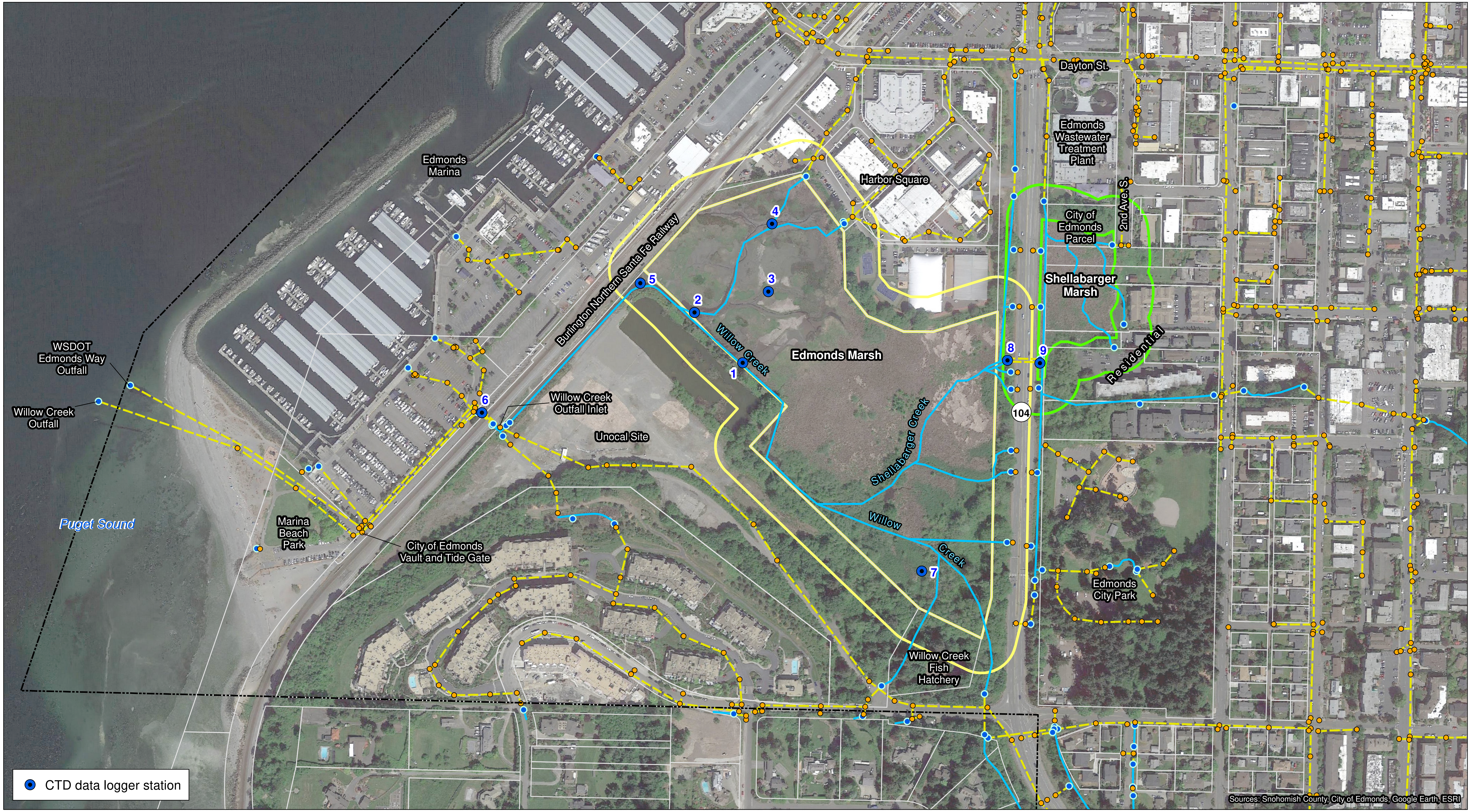
To support this study, the City purchased seven CTD data loggers and two barometric pressure loggers, all of which were deployed throughout the baseline monitoring year at a total of nine different locations (some of the loggers were used for only part of the year at certain locations and then moved to new locations). The conductivity and temperature data gathered by the data loggers allowed for the calculation of salinity;

therefore, the CTD data loggers were used to examine the ranges of water levels and salinity within the Marsh under varying tidal stages and different seasonal conditions. Water elevation was corrected for atmospheric pressure variations recorded by the barometric loggers. The logger stations are shown on Map 3, and the deployment dates for the CTD logger stations are listed in Table 3-3.

Table 3-3. CTD data logger deployment dates by station

Logger ID No.	Deployment Date	Deactivation Date	Description of Location
1	7/17/2018	7/1/2019	in tidal channel in southern portion of Marsh
2	7/17/2018	3/7/2019	where main tidal channel connects to Willow Creek
3	7/17/2018	7/1/2019	within central Marsh mudflat area
4	7/17/2018	7/1/2019	in tidal channel in northern portion of Marsh
5	7/17/2018	7/1/2019	within Willow Creek where creek turns southwest immediately downstream from Marsh
6	8/23/2018	1/8/2019	within fenced Marsh outlet basin
7	1/8/2019	7/1/2019	in cattail Marsh just north of Hatchery
8	1/8/2019	7/1/2019	on west side of SR-104 culvert
9	3/7/2019	7/1/2019	on east side of SR-104 culvert

CTD – conductivity, temperature, and depth
Hatchery – Willow Creek fish hatchery
ID – identification
Marsh – Edmonds Marsh



Windward environmental LLC

N

0 0.05 0.1 Miles

0 250 500 Feet

- Storm structure
- Storm culvert
- Storm line
- Storm ditch/creek
- Shellabarger Marsh w/ 125-ft buffer
- Edmonds Marsh w/ 125-ft buffer
- Parcel
- City of Edmonds boundary

Map 3. Edmonds Marsh baseline study CTD logger stations

Prepared by mikey, 9/12/2019; W:\Projects\Edmonds Marsh\Data\GIS\Maps and Analyses\Monitoring plan\Actual locations\Map 3_7075 Actual CTD Logger Stations.mxd

One of the goals of the baseline study was to examine water salinity and depth within the Marsh when the downstream tide "flap gate "was chained open compared to when it was allowed to flap open and closed with the tide. Table 3-4 lists the tide gate state for the baseline monitoring year. The CTD logger data are also discussed within the context of the tide gate status in Section 7.1.

Table 3-4. Tide gate opening/closing dates

Tide Gate Status	Start Date	End Date	Comments
Closed	7/17/2018	8/27/2018	Chain on tide gate had broken and gate was closed.
Opened	8/27/2018	10/5/2018	Gate was repaired by City of Edmonds Public Works staff on 8/27/2018 and opened.
Closed	10/5/2018	10/16/2018	seasonal closure
Opened	10/16/2018	10/24/2018	-
Closed	10/24/2018	12/3/2018	seasonal closure
Opened	12/3/2018	12/7/2018	-
Closed	12/7/2018	2/25/2019	seasonal closure
Opened	2/25/2019	7/1/2019	-

Deviations from the monitoring plan (Windward 2018a) relating to installation and operation of the CTD loggers were as follows:

- The monitoring plan called for deploying five of the seven CTD loggers and reserving two as spares. However, ultimately all seven loggers were deployed in order to gather as much information as possible from different areas of the Marsh.
- The loggers were anchored in place using ¾-in. polyvinyl (PVC) pipe casings instead of copper pipe, and each pipe casing was professionally surveyed to provide precise geographic coordinates and elevation data for the logger stations. Surveying was performed by DHA Surveyors.
- Once the loggers were confirmed to be operating reliably, they were maintained and their data downloaded once every two to three months. The long battery life, absence of biofouling of the sensors, and high data storage capacity of these loggers allowed for such a maintenance schedule.

3.1.2 Soil and sediment observations and measurements

As part of the baseline study, upland soils from the buffer zones of the Marsh and Shellabarger Marsh were characterized, as were mudflat sediments from within the Marsh. Both upland soil and mudflat sediment were characterized using field techniques like texture and hydric soil feature evaluations, and both were analyzed for conventional parameters following the methods described in the monitoring plan

(Windward 2018a). Deviations from these methods, as well as the specific monitoring station locations, are described in further detail in the following subsections.

3.1.2.1 Upland soil characterization in buffer zones

Upland soil characterization field surveys were conducted at four locations: One soil characterization station was established within each of the three buffer zones of the Marsh (north, south, and southeast), and one was established within the Shellabarger Marsh north buffer zone (Map 2 and Table 3-5). Field techniques were used to assess soils during both the fall and spring monitoring events in order to capture variability present during drier and wetter times of the year. Soil samples were collected during the fall monitoring event and submitted for laboratory analyses. The soil monitoring stations were placed randomly within one of the vegetation monitoring plots established along the vegetation monitoring transect lines in the buffer zones. Vegetation monitoring plots and transects are described further in Section 3.2.1, and the transect lines along which the soil characterization stations were established are shown on Map 2.

Table 3-5. Upland soil characterization stations

Location	Location Description
North Buffer Zone	North Buffer Zone, Transect N1 (N1)
Southeast Buffer Zone	Southeast Buffer Zone, Transect 3 (SE3)
South Buffer Zone	South Buffer Zone (Hatchery), Transect 1 (S1)
Shellabarger Marsh	Shellabarger Marsh, north buffer zone transect (SB)

Hatchery – Willow Creek fish hatchery
ID – identification

3.1.2.2 Mudflat sediment characterizations within the Marsh

Marsh sediments were evaluated during the fall monitoring event using both field techniques and laboratory analyses. Four sediment monitoring stations were established along a northwest-to-southeast-oriented transect line within the mudflat portion of the Marsh (Map 2). The transect line was oriented to follow a salinity gradient from estuarine to freshwater conditions within the Marsh.

Sediment samples were collected using a clear 3-in.-diameter Lexan™ core tube, manually driven into the substrate with a rubber mallet. Although the monitoring plan called for collecting sediment samples to a depth of about 15-in, characterization of interior marsh sediment profiles could only be done to a maximum depth of 9-in due to the loose, unconsolidated nature of the sediment, and inundation of the sampling pits with water, which prevented a deeper profile from being characterized.

After the core tube had been extracted, its outer surface was cleaned to allow for visual observation of the sediment within. The depth of any distinct sediment layer was measured, and other physical characteristics were recorded on the sediment collection form (in Appendix A). Sediment samples were then collected from the top 4 in.[5] of the core, homogenized in a stainless steel bowl, transferred into clean jars, and submitted to a laboratory for pH, total organic carbon (TOC), and grain size analysis. There were no deviations from the monitoring plan (Windward 2018a) during the mudflat sediment characterization and sampling.

3.2 Monitoring for Biological Parameters

The biological parameters surveyed as part of the baseline study were vegetation and LWD, invertebrates, birds, and other wildlife. These parameters were monitored to provide information about the habitat functions currently being provided by the Marsh and its buffer zones. The established vegetation communities were monitored in order to more thoroughly describe the plant composition of those habitat areas, and to identify invasive species that may require control. The presence and quantity of LWD within the Marsh and its buffer zones was monitored to provide an understanding of the overall quantity of large wood, which is an important habitat feature for many wildlife species, and which can also help provide other functions like shading/water cooling and sediment/soil retention. Information on invertebrates present within the buffer zones was gathered for use as an indicator of available food sources for predators such as birds and fish. Monitoring for birds and wildlife was conducted to provide information about the species currently using the Marsh.

3.2.1 Vegetation surveys

Vegetation surveys were conducted within the Marsh and its buffer zones to document community composition and vegetation structure. The baseline vegetation monitoring provided a snapshot of current conditions in the Marsh and its buffer zones. This information can be compared to data collected in the future to document changes that have occurred as a result of natural plant growth, decline, and species composition changes, or as a result of human activities such as active habitat restoration efforts. An additional goal of the vegetation monitoring was to help identify and document any patches of invasive species in need of management.[6]

3.2.1.1 Marsh vegetation surveys

Qualitative vegetation surveys were performed to document the dominant[7] plant species present within the Marsh interior, and to identify the transition zone between

[5] The top 10 cm (4 in.) of the sediment is considered to the biologically active zone (EPA 2015).

[6] The City's Parks Department is also planning for invasive species management within the Marsh and buffer areas. As part of the planning process, the City conducted an aerial drone survey of the Marsh to help identify patches of invasive species.

[7] Dominant species are those that are most abundant in the community or patch.

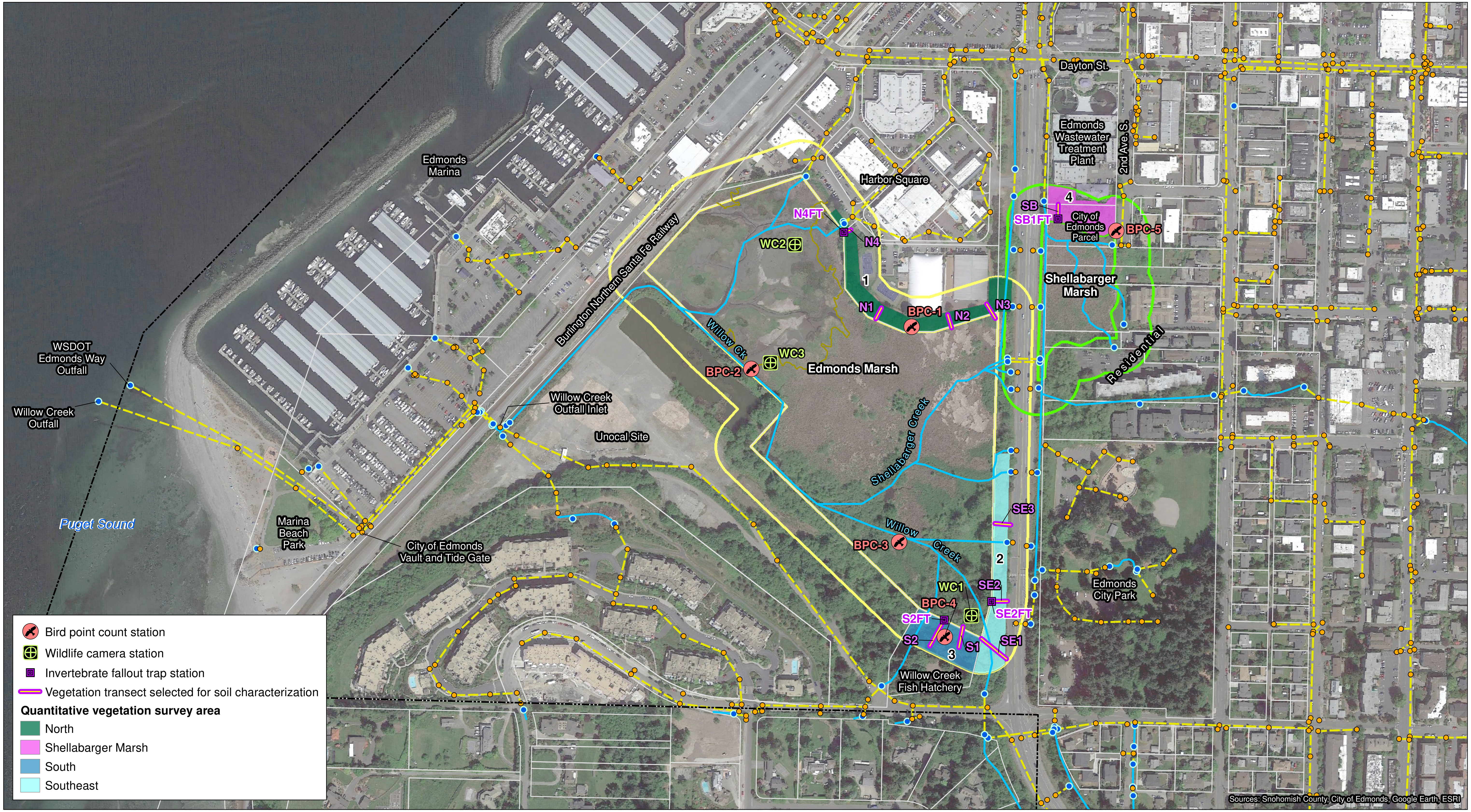
salt-tolerant species and species more indicative of freshwater conditions (e.g., cattail). Vegetation patches were mapped by walking around distinct patches while holding the DR-Geo7x-s GPS unit, when possible. When vegetation growth was dense enough to preclude walking around the patch perimeter, a high-resolution aerial photograph was used to help delineate patches, and the species composition of the patches was surveyed from surrounding areas, to the extent possible. This method was used to record the locations of invasive plant species as well as patches of different native plant communities.

The Marsh vegetation surveys were conducted during the summer 2018 monitoring event, when the sedges, grasses, rushes, and other vegetation within the Marsh were at peak growth, and when many species were in flower (thus aiding plant identification). Additional follow-up survey work was performed during the fall and spring monitoring events to help confirm findings from the summer survey.

3.2.1.2 Buffer zone vegetation surveys

Vegetation within the buffer zones was quantitatively evaluated by establishing vegetation sampling transect lines in the north, south, and southeast[8] buffer zones of the Marsh (Map 4). These buffer zones were selected for sampling because they are owned by either the City or other landowners who granted access for this study. The majority of the Shellabarger Marsh buffer is located on privately owned residential property; therefore, surveys of the Shellabarger Marsh buffer zones were limited to the north buffer zone, which lies on property owned by the City. The transect end points were marked using the DR-Geo7x-s GPS unit.

[8] The northern portion of the eastern buffer zone of the Marsh is very narrow and consists primarily of Himalayan blackberry (*Rubus armeniacus*) and Scotch broom (*Cytisus scoparius*). The vegetation sampling transect for the eastern buffer zone was therefore located in the southern portion of the zone, where the vegetated portion of the buffer zone widens and becomes more diverse in terms of plant species present.



Prepared by mikey, 9/12/2019; W:\Projects\Edmonds Marsh\Data\GIS\Maps and Analyses\Monitoring plan\Actual locations\Map 4_6885a_Actual Biological Monitoring Parameter Stations.mxd

Windward environmental LLC

N

0 0.05 0.1 Miles

0 250 500 Feet

- Storm structure
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- Edmonds Marsh w/ 125-ft buffer
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- City of Edmonds boundary

Map 4. Edmonds Marsh baseline study biological monitoring parameter stations

Quantitative vegetation data were collected from the buffer zones during the summer and spring monitoring events. Quantitative vegetation samples were divided into three vertical stratum classes: tree, sapling/shrub, and herbaceous. Tree and shrub species were inventoried as part of the herbaceous stratum when they were present as seedlings or as new, low-growing growth. Densitometer readings were also taken to estimate canopy closure within the buffer zone transects. The densitometer used consisted of a spherical, concave mirror engraved with a grid of squares to delineate an overhead plot.

The monitoring plan (Windward 2018a) called for establishing three vegetation transect lines in the north buffer zone: one in the Shellabarger Marsh north buffer zone, one in the south buffer zone, and two in the southeast buffer zone. Ultimately, four transects were established in the north buffer zone, two were established in the south buffer zone, and three were established in the southeast buffer zone.[9] The additional transects were added because the random placement of the initial transects caused some to be placed in relatively narrow locations where the transects could not extend the full 40 m (125 ft) intended, due to physical obstructions or site boundary limitations. Therefore, additional transects were added to provide more coverage within these zones. There were no other deviations from the sampling methods listed in the monitoring plan. The vegetation data sheets are provided in Appendix A.

Deviations from (and additional sampling details beyond those provided in) the monitoring plan (Windward 2018a) relating to vegetation surveys were as follows:

- Vegetation in the herbaceous strata were defined if they were below knee height (~2-ft).
- Vegetation in the scrub-shrub strata were quantitatively assessed if they were above knee height (~2-ft), but below shoulder height (~5-ft).
- Only the herbaceous stratum was sampled twice (during the summer and spring monitoring events). The herbaceous stratum was sampled during both seasons because herbaceous vegetation cover was expected to be different during different parts of the growing season. The tree and shrub/sapling strata were sampled during the summer monitoring event only as the species composition in these vegetation layers was not expected to change between seasons.

3.2.1.3 Large woody debris surveys

All pieces of LWD encountered within the Marsh interior during vegetation or other surveys were recorded in the field logbook, and GPS coordinates were recorded (using the Magellan eXplorist 210) for those locations. Within the buffer zones, all pieces of

[9] Only one transect was established in the Shellabarger Marsh north buffer zone, as planned.

LWD encountered within the vegetation belt transects were inventoried; data for these LWD pieces were recorded on the vegetation data sheets (Appendix A).

3.2.2 Invertebrate surveys

During both the summer and spring monitoring events, invertebrate fallout traps were set to collect insects from the air and buffer zone vegetation. One vegetation transect from each of the buffer zones was randomly selected for fallout trap placement (Map 4). Three replicate fallout traps were placed along each selected transect, near the transition between the buffer zones and the Marsh edge. Invertebrates captured within the traps after a 24-hour deployment period were removed and preserved in 85% ethanol. They were later examined under a dissecting microscope (AmScope 7X-45X Dissecting Circuit Stereo Microscope) and identified to the taxonomic Order level.[10] Field data collection sheets and the taxonomic identification forms for the invertebrate samples are provided in Appendix A. There were no deviations from the monitoring plan (Windward 2018a) for the fallout trap sampling.

Additionally, the monitoring plan (Windward 2018a) described collecting and processing sediment core samples from the mudflat habitat of the Marsh interior in order to collect both benthic and water column invertebrates. Organisms in the sediment samples were to be examined and identified to the Order level. While the sediment core samples were collected and processed, the organism identification step did not occur. Attempts were made to sort and identify invertebrates within the samples; however, the process was very difficult given the high proportion of fine organic material within the samples. Also, aquatic invertebrate data from the Marsh, Willow Creek, and Shellabarger Creek that had been collected as part of the Willow Creek Daylighting project[11] studies became available. These data were provided by a certified taxonomic lab and were therefore relied upon for information pertaining to the baseline condition of the aquatic invertebrate community. The invertebrate data from the Willow Creek Daylighting study are discussed in Section 5.2.

3.2.3 Bird surveys

Bird point count (BPC) surveys were conducted once per season (during periods of relatively calm, clear weather) at five locations throughout the Marsh and its buffer zones, as described in Table 3-6 and shown on Map 4. The survey stations were located within or adjacent to the buffer zones of the Marsh and Shellabarger Marsh in

[10] While some invertebrates could be identified to a lower taxonomic level (as indicated in the "notes" portion of the invertebrate data tables), the official identification was limited to the Order level, as identification was not performed by certified taxonomists.

[11] The Edmonds Marsh Estuary Restoration Project was formerly referred to as the Willow Creek Daylighting project. The older name is used when discussing previous studies that referenced it as such.

order to survey areas of varying buffer habitat type[12] and quality, as well as areas with differing degrees of nearby human use. The survey stations were mapped using the DR-Geo7x-s GPS unit, and rebar stakes with bright orange caps were used as field markers to ensure that the same point count stations were used each season.[13]

Table 3-6. BPC station descriptions and survey dates

Location ID	Location Description	Survey Dates
BPC-1	Harbor Square boardwalk lookout	7/19/2018 10/23/2018 1/28/2019 5/7/2019
BPC--2	Marsh interior adjacent to Willow Creek	
BPC3	northwest of Hatchery in Marsh	
BPC-4	Hatchery riparian habitat	
BPC-5	off 2nd Avenue South near Shellabarger Marsh	

BPC – bird point count
Hatchery – Willow Creek fish hatchery
Marsh – Edmonds Marsh

Monitoring began around sunrise and lasted five minutes at each point count station. Birds were counted if seen or heard, either in the air or on the ground/water, within a 50-m (164-ft) radius of the point count location. Bird counts were classified as seen (interacting with habitat within 50 m), heard (believed to be vocalizing within 50 m), or fly over (seen flying over habitat but not interacting with the habitat within 50 m). As much as possible, notes were also made regarding the behaviors being displayed by the individual birds recorded during the point count survey. The point count data sheets are provided in Appendix A. There were no deviations from the monitoring plan (Windward 2018a) with respect to the bird surveys.

3.2.4 Other wildlife observations

Three wildlife cameras were deployed throughout the baseline monitoring year in order to generate a better inventory of wildlife using the area. Two cameras were placed within the Marsh: one at the north end of the large mudflat area in the western portion of the Marsh, and one at the south end of the mudflat area (Map 4).[14] The third camera was placed within the wooded habitat of the south buffer zone. The two cameras used within the Marsh interior were Stealth Cam© Dual Sensor STC-DS4K wildlife cameras, which do not generate any flashing or glowing lights, even when taking night photos. The camera placed within the south buffer zone was a Bushnell©

[12] Due to the lengths of the point count station radii (50 m), the stations also extended into the Marsh and, in the case of the Shellabarger Marsh station, into the surrounding neighborhood.

[13] The rebar stake marking the Shellabarger Marsh north buffer zone BPC station went missing after the summer monitoring event; a nearby street sign was used in its place, as the sign was located in nearly the same spot as the rebar stake had been.

[14] The south mudflat camera and the south buffer zone camera were both repositioned at least once during the monitoring year; however, the distances between the initial locations and the subsequent locations were small enough (generally 10 to 15 ft) that the new locations were not mapped.

20MP Trophy Cam Low Glow, HD Aggressor, which generates a low-level glow when taking night photos. The south buffer zone trail camera was positioned near the terminus of one of the Willow Creek fish hatchery (Hatchery) trails and was mounted to a tree. The two cameras in the Marsh were mounted on large metal stakes driven into the substrate. All cameras were locked to their mounts and their locations mapped using the DR-Geo7x-s GPS unit.

The wildlife cameras were maintained and their secure digital (SD) cards downloaded at least once per season. All batteries were replaced during the winter 2019 monitoring event. The cameras performed well throughout the monitoring year. In addition to wildlife captured by the trail cameras, wildlife (i.e., birds, amphibians, reptiles, and mammals) incidentally observed during the seasonal monitoring events were identified to the species level whenever possible and recorded in the field notebook (see Appendix B).

3.3 Photo Point Monitoring

Although 12 photo point monitoring locations were proposed in the monitoring plan (Windward 2018a), 13 locations were ultimately established throughout the Marsh and buffer zones to visually document baseline habitat conditions and capture seasonal variability within these areas. Table 3-7 and Map 5 present the photo point monitoring stations. Photo point photos were taken once per season in multiple cardinal directions to document current conditions and supplement the quantitative data collected over the course of the baseline monitoring year. Photo point monitoring forms are provided in Appendix A.

Table 3-7. Photo point monitoring station locations

Photo Point Station	Photo Point Station Description	Photo Direction(s)
A	northern marsh interior, intertidal mudflat area	0–360° view
B	western edge of Marsh	E, SE, S
C	boardwalk lookout at west end of Marsh trail	E, S, SW
D	main Marsh trail boardwalk lookout at northernmost corner of Marsh	SE, S, SW
E	Marsh trail boardwalk lookout west of Harbor Square Athletic Club	NW, SW
F	Marsh trail boardwalk lookout south of Harbor Square Athletic Club	SE, SW
G	along SR-104 east of Harbor Square Athletic Club	SW
H	along SR-104 on west side of Shellabarger Marsh	NE
I	along SR-104 at Milepost 25	NW, W, S
J	southern Marsh interior, north of Hatchery	0–360° view
K	Willow Creek, near Hatchery	W, N, NE
L	Point Edwards overlook off Pine Drive	E, NE
M	Point Edwards overlook stormwater detention pond	W

Hatchery – Willow Creek fish hatchery
Marsh – Edmonds Marsh
SR – State Route

Windward environmental LLC

N
0 0.05 0.1 Miles
0 250 500 Feet

City of Edmonds boundary

Map 5. Edmonds Marsh baseline study photo point monitoring stations

Prepared by mikey, 9/12/2019; W:\Projects\Edmonds Marsh\Data\GIS\Maps and Analyses\Monitoring plan\Actual locations\Map 5_6881a_Actual Photo Point Monitoring Stations.mxd

3.4 DATA MANAGEMENT

All field activities were recorded on field forms, which the field coordinator checked for missing information at the end of each field day and amended as necessary. A quality control (QC) check was done to ensure that all data were transferred accurately from the field forms to the project database. Field forms are included in Appendix A and have been archived in the Windward library.

Each time the CTD loggers were serviced, a station data file was downloaded in the field to a secure laptop using Diver-Office 2018.2 software. The CTD logger data were then QC checked by the technical lead for the project. Once reviewed, the data were uploaded to the project's Microsoft® Access database. A combination of automated scripts and manual checks were then performed to verify the accuracy of the import process. Any revisions identified as part of the validation process were applied to the database prior to exporting data for project team use. Data were exported for distribution to the project team as Microsoft® Excel files. The project's complete Access database will be provided as a deliverable to the client.

As is typical, the raw data downloaded from the field-deployed CTDs contained some dubious values. For example, water heights were reported as ≤ 0 cm, indicating that the sensors were above the water surface. Graphical techniques and visual inspection were used to identify the questionable data points, which were subsequently edited from the time series and excluded from calculated salinity statistics.

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4 Results

The results for the physical monitoring parameters are presented in Section 4.1 (Discrete Water Quality Monitoring), Section 4.2 (Continuous Water Depth and Salinity Monitoring), Section 4.3 (Soil Observations and Analysis), and Section 4.4 (Sediment Observations and Analysis). The results for the biological monitoring parameters are presented in Section 4.5 (Vegetation Surveys), Section 4.6 (LWD Surveys), Section 4.7 (Invertebrate Surveys), Section 4.8 (Bird Surveys), and Section 4.9 (Other Wildlife Observations). Section 4.10 discusses the photo point monitoring.

4.1 Discrete Water Quality Monitoring

Tables 4-1 and 4-2 present the results of the discrete water quality monitoring for Stations 1 through 4 and 5 through 8 (Map 2), respectively. As applicable, the water quality monitoring results were compared to Washington State Department of Ecology's (Ecology's) marine and freshwater surface WQC, as presented in Washington Administrative Code (WAC) 173 201A 200 and WAC 173 201A 210. Results from samples with salinity less than 0.5 ppt[15] were compared to the freshwater WQC for salmonid spawning, rearing, and migration. Results from samples with salinity greater than 0.5 ppt were compared to "good quality" marine WQC.

[15] In 1978, the Practical Salinity Scale, which uses a ratio of measured conductivity to the conductivity of a standard potassium chlorine solution to determine salinity, was adopted by oceanographers (Thermo Scientific 2011). This scale is referred to as PSS-78 and has no units, as it measures ratios, but it does report salinity in practical salinity units (psu); 1 psu is equivalent to 1 ppt. The salinity measurements being taken in the Marsh were calculated as psu from conductivity and temperature but reported herein as ppt for comparison with regulatory standards.

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Table 4-1. Water quality monitoring results: Stations 1–4

Parameter	Units	WQC		1				2				3				3b[a]		4			
		Marine	Freshwater	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Winter	Spring	Summer[b]	Fall	Winter	Spring[c]
Temperature	°F	66.2	63.5	59.6	51.3	48.5	49.2	59.9	52.5	48.4	49.6	60.4	51.4	48.2	49.7	48.8	50.4	70.7[b]	59.4	46.1	51.4
DO	%	-	-	99.2	98.8	96.8	98.7	98.8	99.6	95.9	99.2	89.6	94.0	85.7	90.8	90.0	73.3	nc[b]	91.5	82.2	104.9
DO	mg/L	5.0	8.0	9.93	10.96	11.14	11.26	9.85	10.87	11.04	11.26	8.88	10.42	9.90	10.31	10.31	8.20	nc[b]	8.94	9.76	10.18
Conductivity	µS/cm	-	-	194.7	169.6	155.1	78.7	195.7	171.6	155.1	163.9	196.8	169.5	153.5	163.8	155.8	162.4	nc[b]	5200	276.7	27103
Salinity	ppt	-	-	0.11	0.11	0.11	0.05	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	nc[b]	3.38	0.20	23.46
pH	SU	7-8.5[d]	6.5-8.5[e]	7.67	7.89	7.02	6.90	8.01	8.35	7.13	7.39	7.78	8.14	7.12	7.88	7.02	7.44	6.50	**<u>6.42</u>**	6.80	**<u>6.71</u>**
Turbidity	NTU	+10[f]	+5[g]	2.5	1.1	2.2	2.0	3.4	1.3	2.3	5.6	3.8	3.2	17.6	2.3	13.5	4.0	14.4	12	5.7	**<u>139</u>**
Water depth	in.	-	-	6.75	6.0	5.5	4	6	5.7	9.1	5.5	5.5	4	1.8	1	3.3	1.5	2.25	3.75[h]	14.2	6.5

Results greater than (for temperature), less than (for DO), or outside the range (for pH) of the WQC are **<u>bold and underlined.</u>**

[a] Monitoring location 3b was added during the winter monitoring event.

[b] Only pH, turbidity, water depth, and temperature were recorded at Location 4 in the summer. There was no flow (water was stagnant) and the values measured by the YSI ProDSS meter fluctuated significantly, so additional measurements were not collected from that meter. The temperature reading of 70.7°F represents just one of several fluctuating readings.

[c] Water was stagnant during the spring monitoring event at Location 4. A bacterial sheen was observed on the water surface.

[d] The pH WQC for "good quality" marine water is: pH must be within the range of 7.0 to 8.5, with a human-caused variation within this range of less than 0.5 units.

[e] The pH WQC for salmonid spawning, rearing, and migration in freshwater is: pH must be within the range of 6.5 to 8.5, with a human-caused variation within this range of less than 0.2 units.

[f] The turbidity WQC for "good quality" water is: Turbidity must not exceed 10 NTU over background when the background is 50 NTU or less, or a 20% increase in turbidity when the background turbidity is more than 50 NTU. Background turbidity is not well established; turbidity results were compared to a threshold of 25 NTU.

[g] The turbidity WQC for salmonid spawning, rearing, and migration in freshwater is: Turbidity must not exceed 5 NTU over background when the background is 50 NTU of less, or a 10% increase in turbidity when the background turbidity is more than 50 NTU. Background turbidity is not well established; turbidity results were compared to a threshold of 25 NTU.

[h] Water depth was recorded as approximately 3.5 to 4 in.

DO – dissolved oxygen
nc – not collected
NTU – nephelometric turbidity unit
ppt – parts per thousand
SU – standard unit
WQC – water quality criteria

Table 4-2. Water quality monitoring results: Stations 5–8

Parameter	Units	WQC		5				6				7				8			
		Marine	Freshwater	Summer[a]	Fall[a]	Winter	Spring[a]	Summer	Fall[a]	Winter[a]	Spring[a]	Summer	Fall	Winter	Spring	Summer	Fall[a]	Winter	Spring
Temperature	°F	66.2	63.5	**<u>68.0</u>**	60.1	46.9	52.1	**<u>72.1</u>**	60.7	45.8	52.6	**<u>74.9</u>**	54.3	46.7	49.0	**<u>63.7</u>**	53.9	48.8	51.5
DO	%	-	-	5.2	3.4	42.4	5.4	9.3	6.7	46.8	26.5	131.7	79.0	87.4	81.0	87.7	92.9	85.4	91.3
DO	mg/L	5.0	8.0	**<u>0.47</u>**	**<u>0.34</u>**	**<u>4.97</u>**	**<u>0.59</u>**	**<u>0.81</u>**	**<u>0.62</u>**	**<u>5.57</u>**	**<u>2.89</u>**	11.11	6.94	10.28	8.26	8.38	9.97	9.78	10.09
Conductivity	µS/cm	-	-	542	560	464.8	459.8	266.1	424.5	319.5	275.1	878	36242	239.8	20350	243.4	217.6	185.6	202.0
Salinity	ppt	-	-	0.29	0.33	0.33	0.34	0.13	0.25	0.23	0.23	0.44	31.05	0.17	17.85	0.14	0.14	0.13	0.13
pH	SU	7-8.5[b]	6.5-8.5[c]	6.68	6.84	6.55	7.25	7.04	7.28	6.76	7.26	8.20	7.54	7.06	**<u>6.19</u>**	8.28	7.85	7.32	7.83
Turbidity	NTU	+10[d]	+5[e]	8.2	4.9	13.8	12.9	20.3	21	6.6	8.4	3.8	12	9.3	2.3	2.2	1.4	2.2	1.3
Water depth	in.	-	-	19	>12	24.4	20	9.5	>12	16.1	13	4.5	>24	17.3	12	13	12	12.2	14

Results greater than (for temperature), less than (for dissolved oxygen), or outside the range (for pH) of the WQC are **<u>bold and underlined.</u>**

[a] No flow was observed (i.e., water was stagnant) at this location during this monitoring event.

[b] The pH WQC for “good quality” marine water is: pH must be within the range of 7.0 to 8.5, with a human-caused variation within this range of less than 0.5 units.

[c] The pH WQC for salmonid spawning, rearing, and migration in freshwater is: pH must be within the range of 6.5 to 8.5, with a human-caused variation within this range of less than 0.2 units.

[d] The turbidity WQC for “good quality” water is: Turbidity must not exceed 10 NTU over background when the background is 50 NTU or less, or a 20% increase in turbidity when the background turbidity is more than 50 NTU. Background turbidity is not well established; turbidity results were compared to a threshold of 25 NTU.

[e] The turbidity WQC for salmonid spawning, rearing, and migration in freshwater is: Turbidity must not exceed, 5 NTU over background when the background is 50 NTU of less; or a 10% increase in turbidity when the background turbidity is more than 50 NTU. Background turbidity is not well established; turbidity results were compared to a threshold of 25 NTU.

DO – dissolved oxygen
NTU – nephelometric turbidity unit
ppt – parts per thousand
WQC – water quality criteria
SU – standard unit
WQC – water quality criteria

In general, Washington State WQC were met at most of the water quality monitoring stations throughout the baseline monitoring year; however, the comparisons to criteria were not clear-cut for pH and turbidity. Both the marine and freshwater criteria for these parameters involve comparison to background values. WAC 173-201A-020 defines "background" as a condition of a water body "outside the area of influence of the discharge under consideration." Background conditions are generally measured upgradient of or outside the area of influence, which in the case of the Marsh, could be where water flows into the Marsh uninfluenced by stormwater or wastewater inputs. The pH WQC for "good quality" marine water requires that the pH be between 7.0 and 8.5, with a human-caused variation of less than 0.5 units within that range (WAC 173-201A-210). For salmonid spawning, rearing, and migration in freshwater, the WQC is that pH be between 6.5 and 8.5, with a human-caused variation of less than 0.2 units within that range (WAC 173-201A-200). The turbidity WQC for "good quality" marine water requires that turbidity not exceed 10 nephelometric turbidity units (NTU) over background when the background turbidity level is 50 NTU or less, or that there be no more than a 20% increase in turbidity when the background turbidity is more than 50 NTU (WAC 173-201A-210). The turbidity WQC for salmonid spawning, rearing, and migration in freshwater requires that turbidity not exceed 5 NTU over background when the background is 50 NTU or less, or that there be no more than a 10% increase in turbidity when the background turbidity is more than 50 NTU (WAC 173-201A-200).

Background pH and turbidity values for the single-point monitoring locations at the Marsh are not well established. Therefore, pH results were simply compared to the ranges provided in the criteria; human-caused variation was not considered. pH at the baseline monitoring stations ranged from 6.19 to 8.35 and was generally stable at each station throughout the four monitoring events (Figure 4-1). Greater pH variation among seasons was observed at Station 7 (the fenced outlet basin downstream from the Marsh), where pH varied by more than 2 standard units (SU) over the four monitoring periods. At all other stations, pH varied less than 1 SU among the four monitoring periods. pH measurements were outside of (below) the criteria range for three readings: two readings collected at Station 4 (fall and spring events) and one reading collected at Station 7 (spring event) (Tables 4-1 and 4-2). The tide gate was open during the fall and spring events; water was flowing into the Marsh from Station 7. Stations 4 and 7 are tidally influenced.

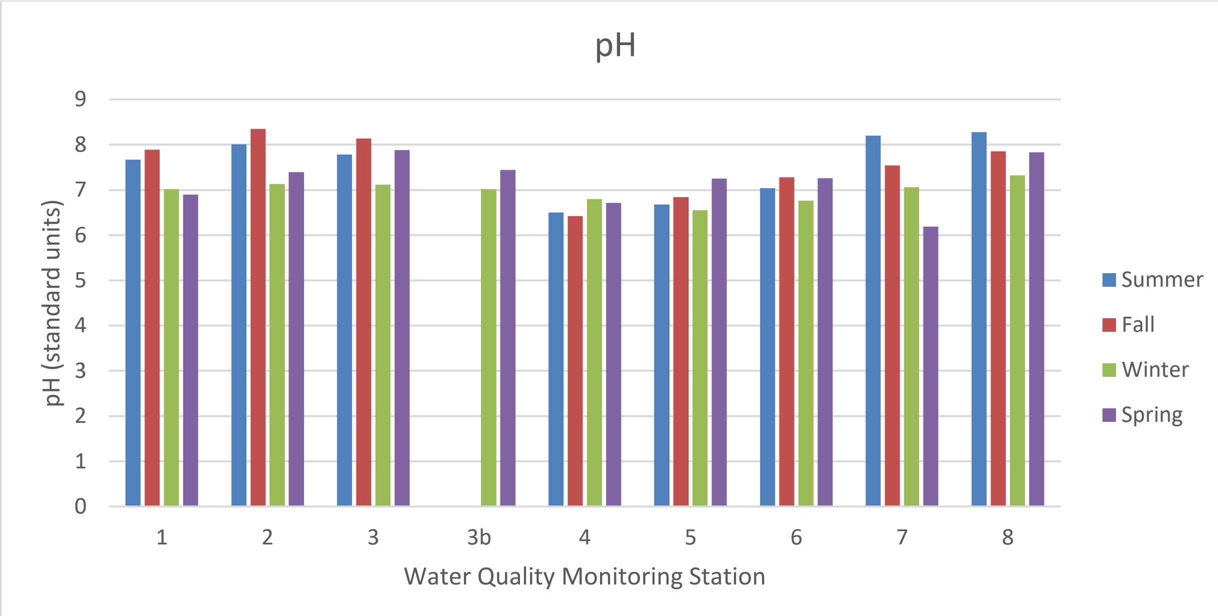

Figure 4-1.Graphical presentation of pH measurements

Turbidity measurements were generally low (Figure 4-2); however, because background turbidity values have not been established for the Marsh, it is not clear whether or not the measured turbidity values would meet WQC. As an additional form of comparison, all results were below the National Pollutant Discharge Elimination System (NPDES) Industrial Stormwater General Permit (ISGP) turbidity benchmark of 25 NTU, with the exception of the spring event turbidity reading for Station 4 (i.e., 139 NTU) (Table 4-2). The water at Station 4 during the spring monitoring event was stagnant and a bacterial sheen was observed on the water surface, which may have contributed to the relatively high turbidity reading.

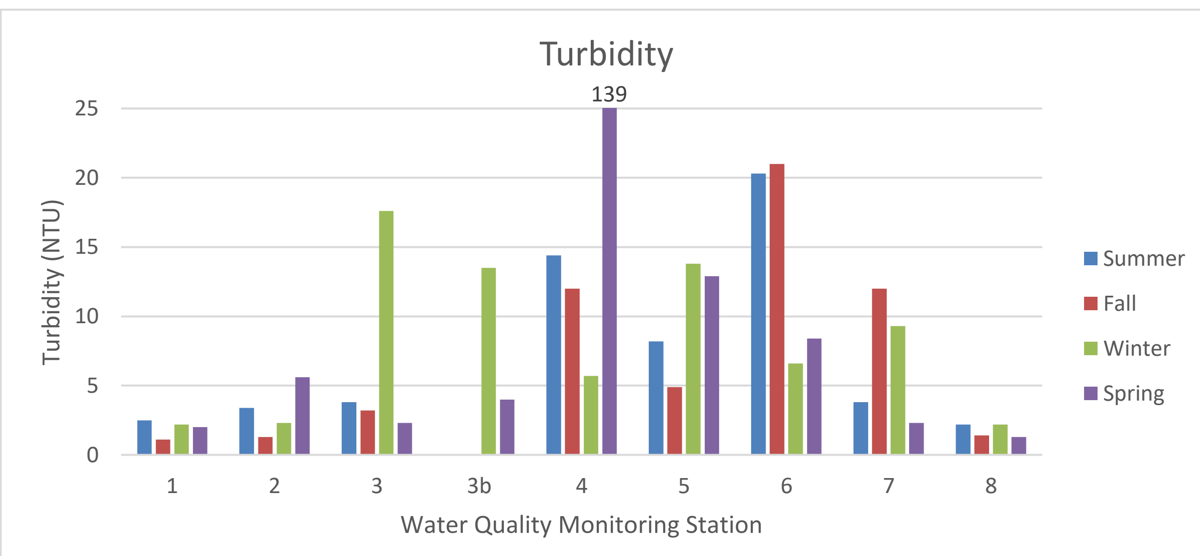

Figure 4-2.Graphical presentation of turbidity measurements

Temperature measurements followed the expected pattern: The highest water temperature measurements were collected during the summer monitoring event, and the lowest measurements were collected during the winter monitoring event (Figure 4-3). Water temperature measurements were relatively similar during the winter and spring monitoring events at each location. Water temperature measurements collected at Stations 1, 2, and 3 were almost identical to each other during all four monitoring events, and were typically lower than at the other monitoring stations in the summer and fall. Stations 1 and 2 are located within Willow Creek in the riparian habitat of the south buffer zone, and Station 3 is located just to the north of the riparian habitat within the freshwater, cattail-dominated portion of the Marsh (Table 3-2). The WQC for temperature was exceeded in four instances: at Stations 5, 6, 7, and 8, all during the summer monitoring event (Table 4-2). This is not surprising, given the high air temperature of 78°F recorded during the monitoring event.

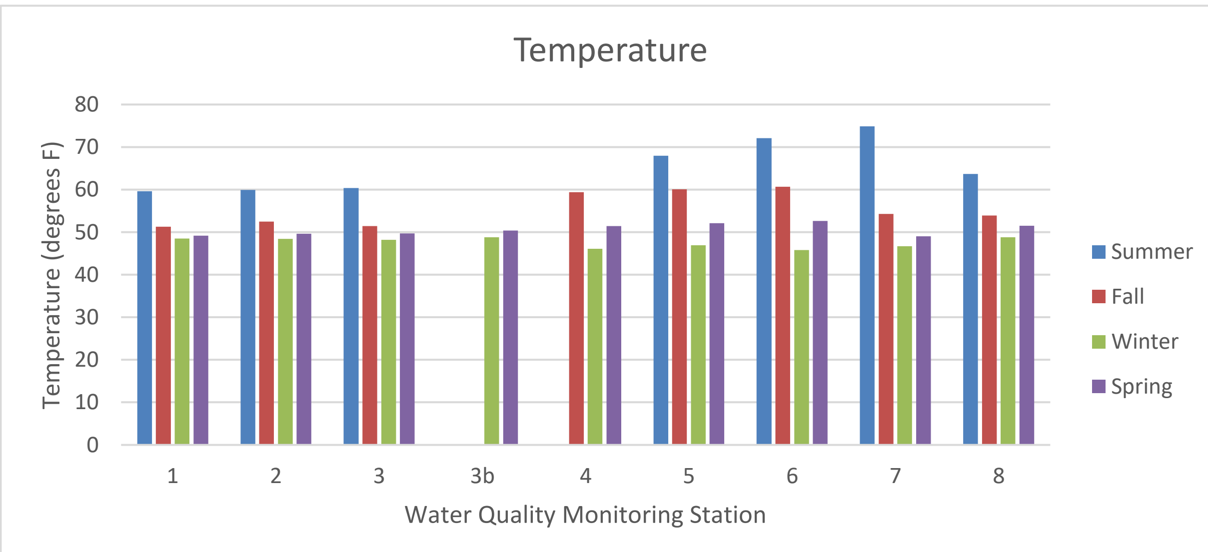

Figure 4-3.Graphical presentation of temperature measurements

DO was generally stable throughout the year and similar among monitoring stations (Figure 4-4). It was much lower at Stations 5 and 6 than at the other monitoring locations; water at Stations 5 and 6 was often observed to be stagnant during monitoring events. There was also variability at Station 7 (the fenced Marsh outlet basin), where lower DO measurements corresponded to the high-salinity events. The DO WQC are one-day minimums. These minimums were met at all water quality monitoring stations except Stations 5 and 6 (the outfalls from Harbor Square).

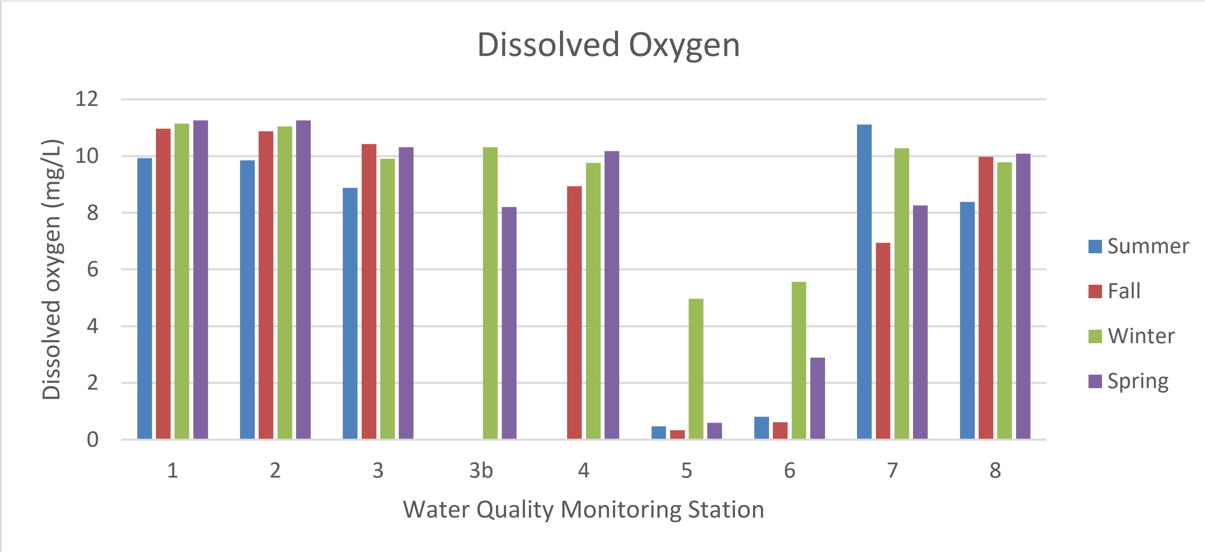

Figure 4-4.Graphical presentation of DO measurements

The effects of tidal influence are noticeable at Stations 4 and 7 (Figure 4-5). Station 4 is located near Harbor Square but within a natural tidal channel of the Marsh (Map 2). Station 7 is located within the fenced Marsh outlet basin near the marina. These locations were tidally influenced during the fall and spring monitoring events, when the tide gate was open (Table 3-4). The influence is evident in the conductivity and salinity measurements (Figure 4-5), which were higher at these monitoring locations during the fall and spring (when the tide gate was open, Table 3-4) than during the summer and winter (when the tide gate was closed, Table 3-5).

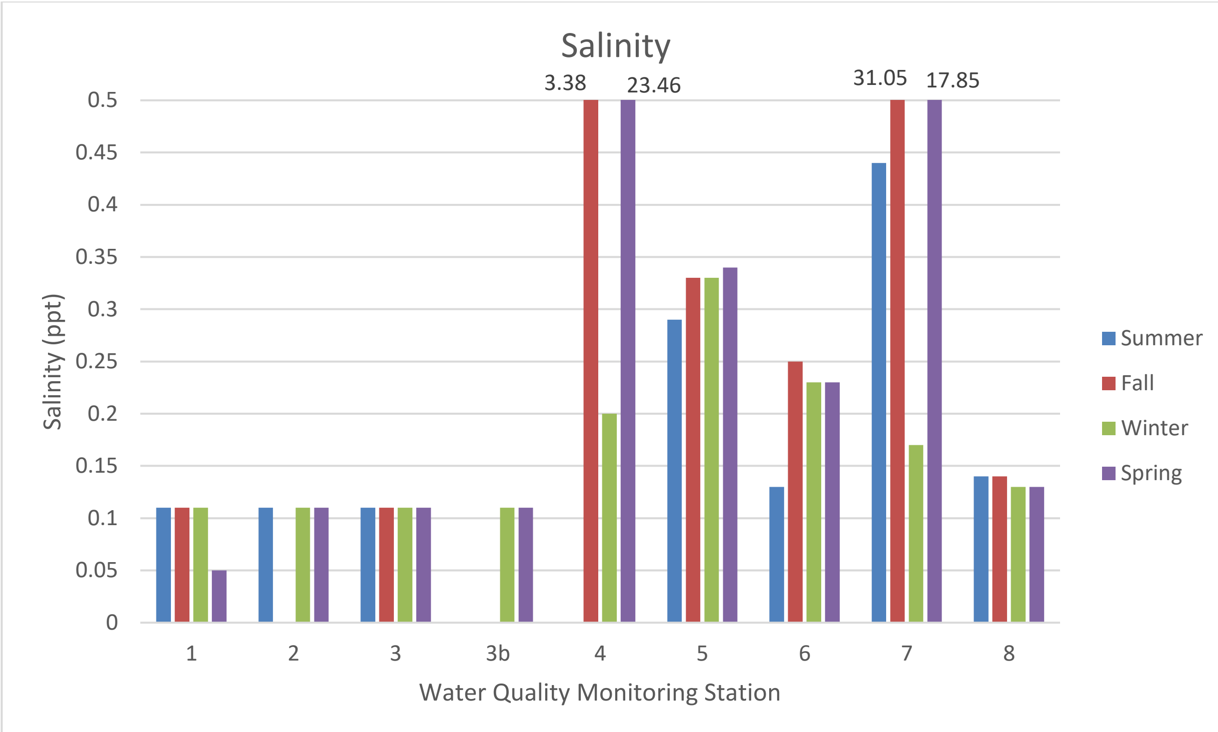

Figure 4-5.Graphical presentation of salinity results

4.2 CONTINUOUS WATER DEPTH AND SALINITY MONITORING

As described in Section 3.1.1.2, salinity, water temperature, and water depth in the Marsh were recorded with CTD data loggers between July 2018 and July 2019 (Map 3). The Marsh's water depth and salinity are tightly linked, with the greatest salinity occurring at high tide with an open tide gate (Figure 4-6).

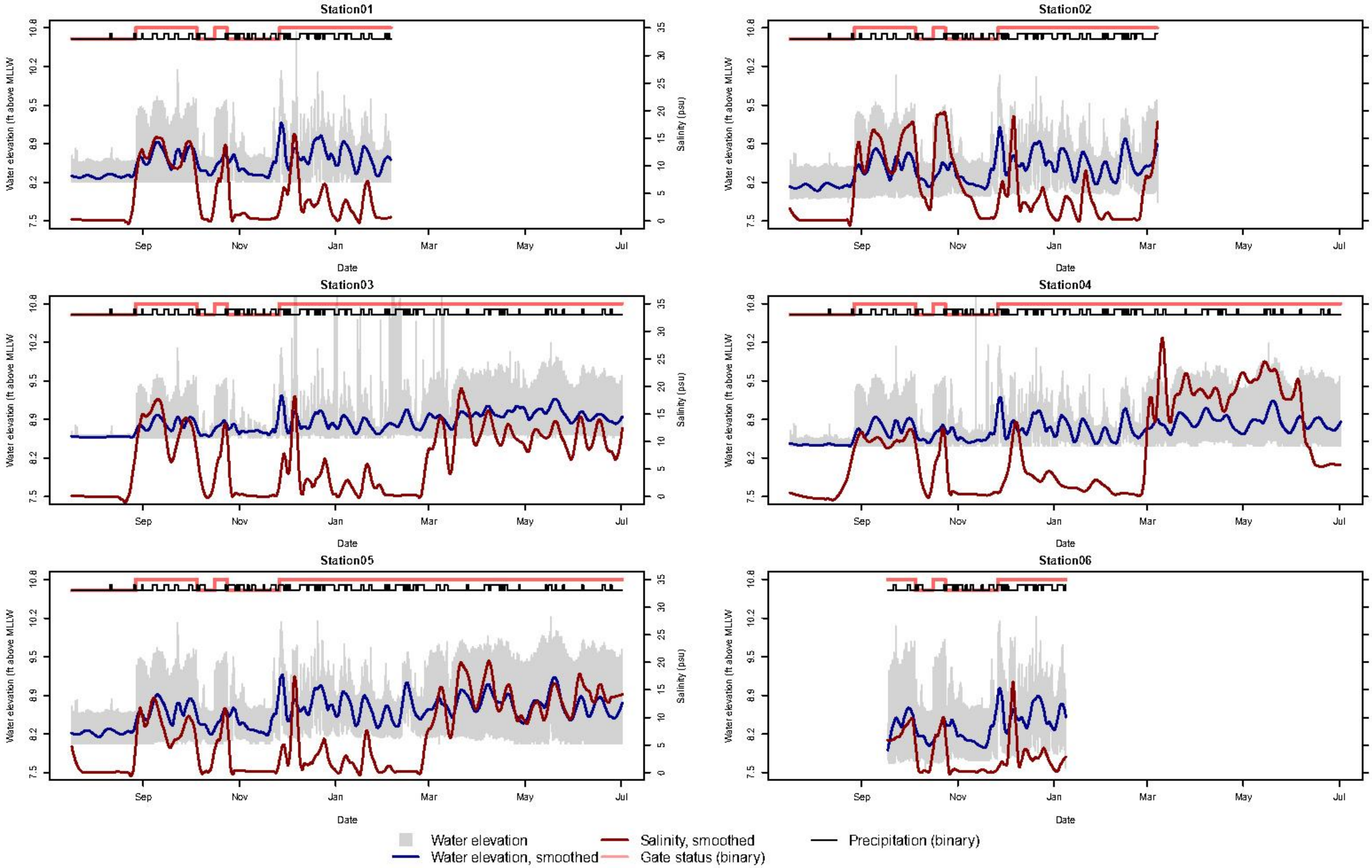

Figure 4-6.Relationships among salinity, water level, rainfall, and gate status in the lower Marsh

The Marsh tidal regime is largely controlled by the state of the one-way tide gate located at the landward end of the pipe under Admiral Way (Figure 4-7). Under standard operation, the tide gate allows water in the Marsh to drain when the pressure of the water that has accumulated within the marsh exceeds that of the tide, thus opening the flap ("open" tide gate status in Table 4-3); backflow is precluded when the tide pressure exceeds the internal pressure in the marsh and the flap closes ('closed" tide gate status in Table 4-3). However, the tide gate does not always completely seal and leaks, sometimes significantly ("open?" tide gate status in Table 4-3). At the request of the Edmonds Marsh Task Force, City Public Works chains the tide gate open during periods of little rainfall, permitting two-way flow and allowing the tide to move saltwater from the Puget Sound into the Marsh ("open" tide gate status in Table 4-3).

Table 4-3. Marsh water level and salinity summary statistics from CTD deployment

Location	Tide Gate Status	Station Elevation (ft above msl)	Water Elevation (ft relative to msl)				Salinity (ppt), Excluding "Dry" Conditions				
			N	Minimum	Maximum	Mean	N	Minimum	Maximum	Mean	Standard Deviation
Station 1	closed	1.8	12,175	1.78	3.12	1.93	8,283	0.01	30.88	0.63	1.67
Station 1	open?	1.8	10,149	1.78	4.32	2.24	8,354	0.04	30.06	3.65	6.47
Station 1	opened	1.8	6,770	1.78	3.68	2.23	5,004	0.01	32.58	11.89	7.93
Station 2	closed	1.4	12,175	1.43	3.02	1.77	12,174	0.10	22.13	2.71	4.12
Station 2	open?	1.4	14,574	1.43	3.59	2.11	14,572	0.10	29.56	3.71	4.99
Station 2	opened	1.4	6,759	1.50	3.59	2.08	6,759	0.18	22.37	14.15	5.02
Station 3	closed	2.1	12,175	2.12	3.09	2.18	6,838	0.00	32.36	0.40	1.76
Station 3	open?	2.1	30,504	2.12	4.74	2.46	29,301	0.00	32.68	7.78	9.23
Station 3	opened	2.1	6,760	2.12	3.65	2.36	4,735	0.00	32.89	12.09	7.97
Station 4	closed	2.0	12,160	1.98	4.59	2.06	6,670	0.01	22.07	0.83	1.75
Station 4	open?	2.0	31,275	1.98	3.72	2.34	27,286	0.13	33.57	11.23	8.71
Station 4	opened	2.0	6,758	1.98	3.67	2.30	4,351	0.01	28.36	10.30	5.20
Station 5	closed	1.6	12,176	1.61	3.08	1.86	10,544	0.05	29.42	0.36	1.57
Station 5	open?	1.6	31,285	1.61	3.76	2.26	30,100	0.03	31.11	8.47	10.22
Station 5	opened	1.6	6,757	1.61	3.67	2.18	6,251	0.10	29.36	8.81	6.83

CTD – conductivity, temperature, and depth
msl – mean sea level
N – number of records
ppt – parts per thousand

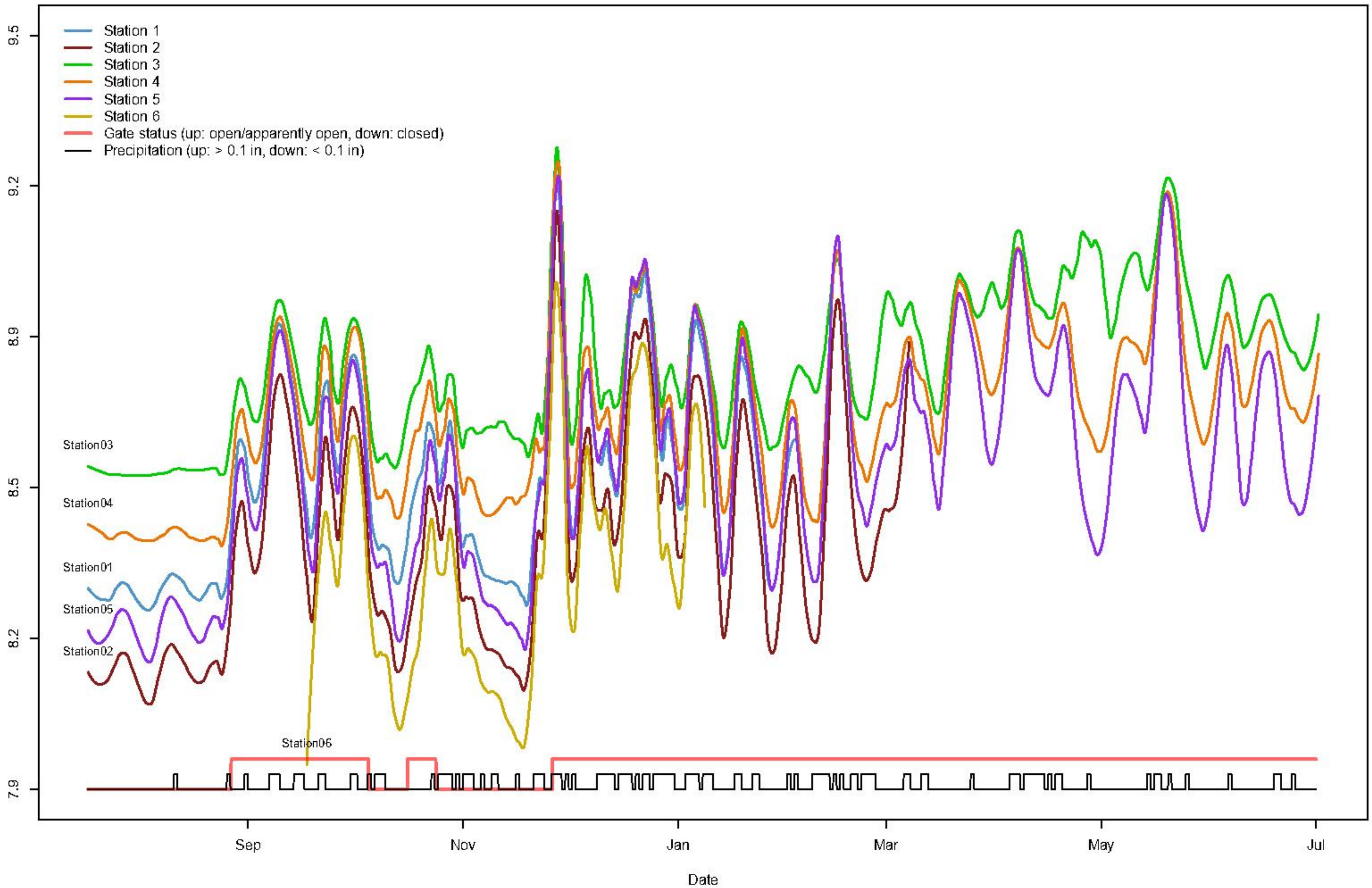

Figure 4-7.Water level in relation to rainfall and gate status

When the baseline study began in mid-July 2018, it was thought that the one-way tide gate was chained open; however, recorded conductivity (salinity) was low or negligible at all locations and the tide signal was very muted (varying by only a few inches). After a review of these data and a site visit with City staff to inspect the tide gate, it was discovered that the chain holding the flap open had failed and the tide gate had inadvertently closed. The chain was replaced and the tide gate reopened toward the end of August 2018. Once the flap gate was chained open, strong water level fluctuation and salinity variation were recorded at Stations 1 through 6 (Map 3) (Figures 4-7 and 4-8).

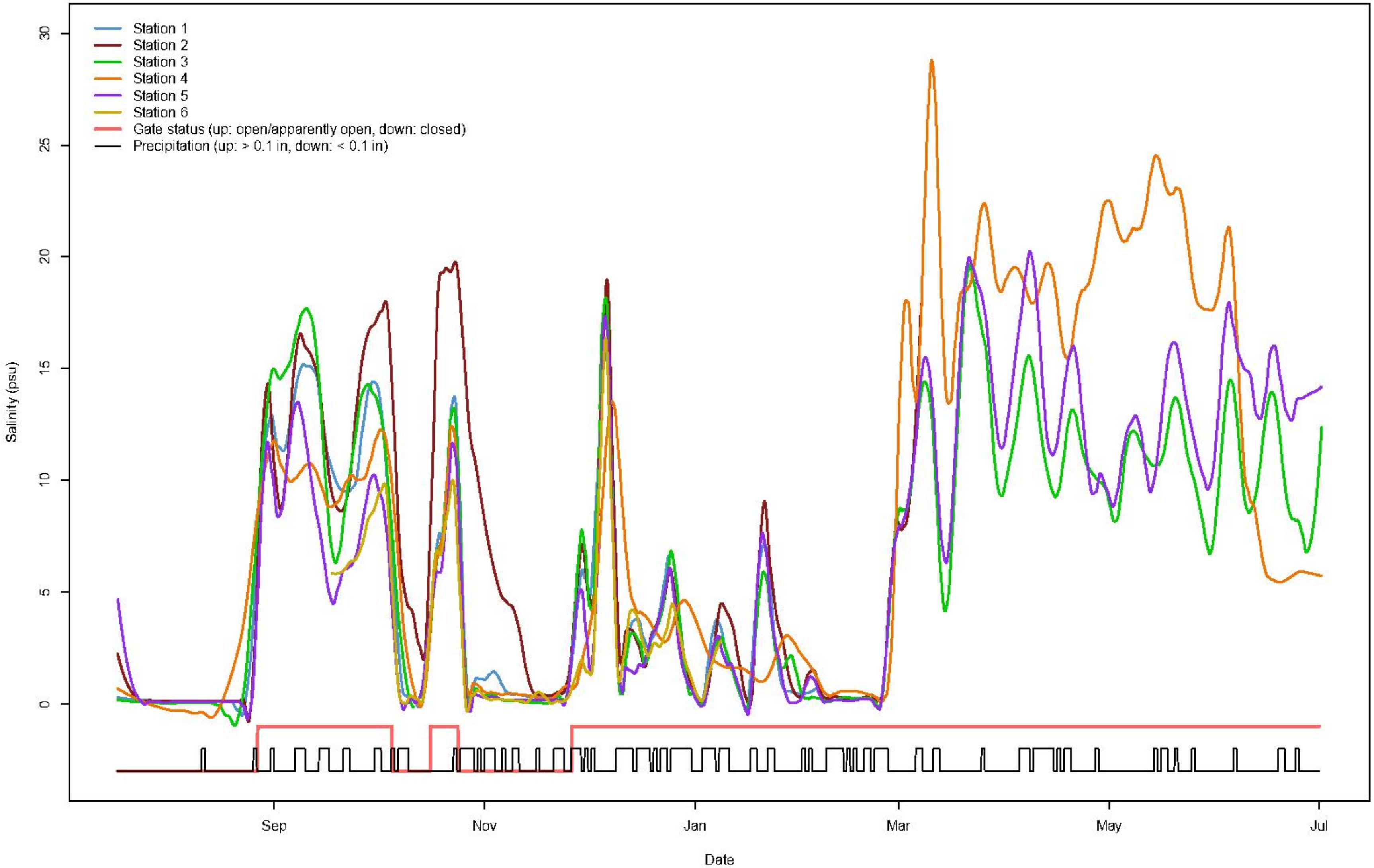

Figure 4-8.Salinity in relation to rainfall and gate status

4.3 UPLAND SOIL OBSERVATIONS AND ANALYSIS

Buffer zone soils were sampled and analyzed to better understand characteristics related to the functions of the wetland buffer zones. Laboratory analyses of the organic matter content, grain size/texture distribution, bulk density, and pH of buffer soil samples were performed, and the results of these analyses are provided in Appendix C. These metrics provide useful information about soil suitability for supporting native plants and invertebrates, as well as information on hydraulic conductivity and water infiltration rates, both of which are important components in determining how well buffer zones can provide stormwater flow control and water quality improvements (Castelle et al. 1992).

The US Department of Agriculture's (USDA) Natural Resources Conservation Service (NRCS) Web Soil Survey (WSS) has characterized and mapped soil units within Edmonds and Shellabarger Marshes, as well as their surrounding upland areas (see the soil series map provided in Appendix D). According to the WSS, Alderwood gravelly sandy loam (identified as Area 3 on the map in Appendix D), Alderwood-Everett gravelly sandy loams (Area 5 on the map), and Everett very gravelly sandy loam (Area 17 on the map) are all found in and at the margins of the uplands surrounding Edmonds and Shellabarger Marshes. These soil types are found on terraces and outwash plains formed by glacial outwash; they drain moderately well, and their surface layer is gravelly sandy loam. Kitsap silt loam (Areas 27 and 28 on the map), which is located further upland as terraced deposits, is a moderately well-draining soil. The WSSs also identified much of the area adjacent to the Marsh as "urban land;" a designation that typically includes areas where soils have been disturbed and where structures are now present.

Table 4-4 and Figure 4-9 show the laboratory results for the upland buffer zone soil samples. Results varied among buffer locations, yet overall they followed the same general pattern, with sand and gravel comprising a large proportion of the samples. These results are consistent with the descriptions of the Alderwood, Alderwood-Everett, and Everett soil series. Total sand content ranged from 48.2% in the north buffer zone to 68.9% in the south buffer zone at the Hatchery property. Total gravel content ranged from 12.2% in the south buffer zone to 36.8% in the north buffer zone. There were smaller proportions of finer-grained silt and clay particles than of sand and gravel content in all samples. Percent total fines (silt and clay grain size fractions) ranged from 9.2% in the Shellabarger Marsh north buffer zone to 18.9% in the south buffer zone.

Table 4-4. Laboratory results for upland soil samples

Location	Grain Size Distribution (%)[a]									Wet Chemistry		
	Gravel	Coarse Sand	Medium Sand	Fine Sand	Coarse Silt	Medium Silt	Fine Silt	Clay	Total Fines[b]	Bulk Density[c] (g/cm^3)	pH	TOC (%)
North Buffer Zone (N1)	36.8	34	7.8	6.4	10.7	0.30	2.0	1.9	14.9	0.66	6.57	35.6
Southeast Buffer Zone (SE3)	19.6	27.6	25.3	14.4	3.7	2.6	4.1	2.7	13.2	1.05	4.57	2.40
South Buffer Zone (S1)	12.2	10.6	24.4	33.9	5.5	4.1	5.9	3.5	18.9	1.37	5.86	3.41
Shellabarger Marsh[d] (SB)	25.5	30.0	28.6	6.7	4.1	0.90	2.9	1.3	9.2	0.91	6.21	18.0

[a] Grain size distribution categories are based on sieve sizes, as follows:

Gravel: > 2,000 µm
Coarse Sand: 2,000–500 µm
Medium Sand: 500–250 µm
Fine Sand: 250–62.5 µm
Coarse Silt: 62.5–31.0 µm
Medium Silt: 15.6–31.0 µm
Fine Silt: 15.6–3.9 µm
Clay: < 1.0–3.9 µm

[b] Total fines is the sum of the clay and silt grain size fractions (technically, it is defined as the grain sizes > 62 µm in size).

[c] This is the dry bulk density, which is the weight of undried soil per given unit of volume; it was reported by the laboratory in pounds per cubic foot and converted to grams per cubic centimeter.

[d] The result reported for the Shellabarger Marsh north buffer zone (identified as Soil-2 in the laboratory report) is the average of three results reported by the laboratory, as this sample was chosen for triplicate analysis, which is part of QC analyses.

QC – quality control

TOC – total organic carbon

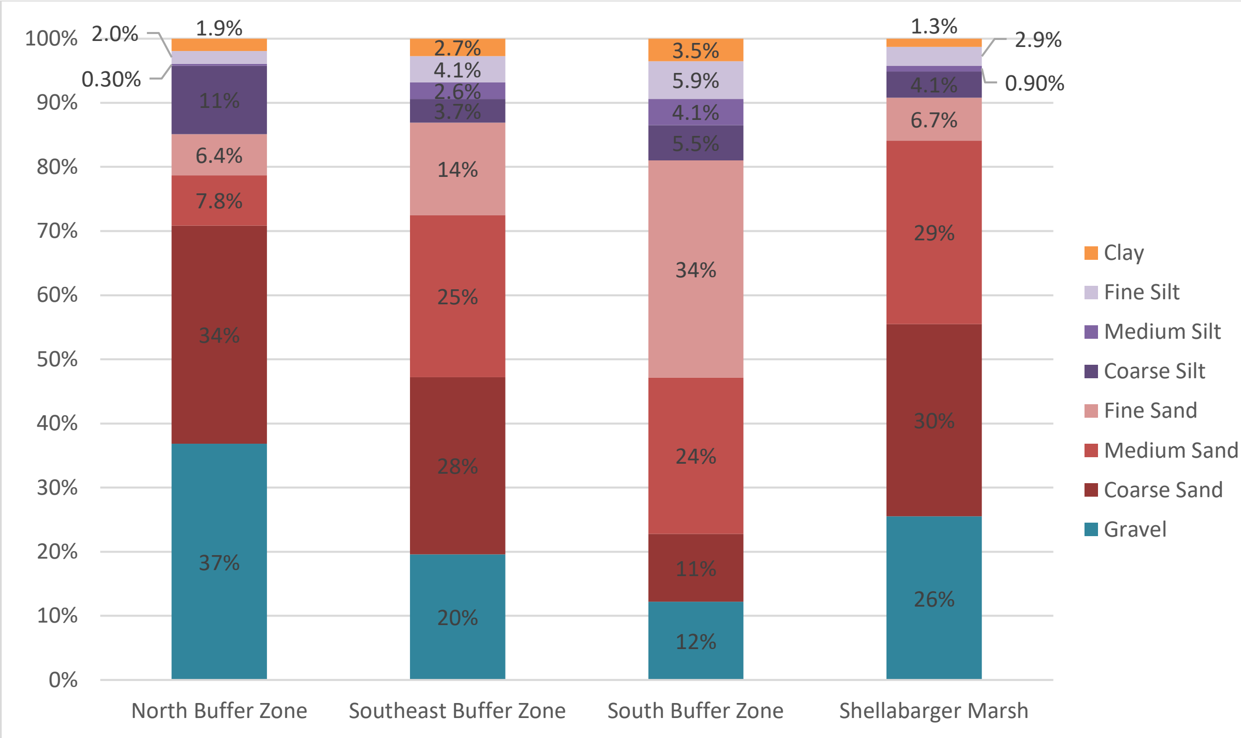

Figure 4-9.Laboratory results of buffer soils

4.3.1 Bulk density

Bulk density is a measure of the mass of soil within a given volume; it provides information about the soil's level of compaction and capacity to transmit water. These characteristics are important in determining the ability of the soil to allow water to infiltrate and support plant growth. Bulk density varies depending on soil texture, percent moisture of the soil, and the amount of organic matter in the soil, as well as the packing arrangement/aggregation of soil particles (USDA 2008). The greater the bulk density, the more space within a given below-ground unit of volume is taken up by soil particles, leaving less space for air and water. Soil porosity decreases as bulk density increases. Bulk density measurements within the range of 1.40 to 1.65 g/cm^3 have been found to restrict the growth of woody plants, with variation depending upon soil type (Schueler 2000; Alberty et al. 1984). All of the soil samples from the buffer zones had dry bulk density measurements of less than 1.40 g/cm^3.

4.3.2 Organic matter and pH

The organic matter content of soils and sediments is often interrelated to the pH of these substrates. Decomposition of organic matter can contribute to acidification of the substrate (i.e., organic acids are released during the breakdown of vegetation in some wetlands systems) (Horner and Raedeke 1989). The organic matter content and pH of buffer zone soils were measured to provide information about soil processes and the bioavailability of nutrients and other ions in these substrates. The quantity of organic matter in soil or sediment influences how well the substrate can absorb, incorporate, and otherwise retain a range of ions, some of which are important plant nutrients (e.g., nitrogen and phosphorus), but others of which are potentially harmful pollutants (e.g., heavy metals) (Horner and Raedeke 1989). Organic matter content in upland soil also contributes to the water-holding capacity of the soil and to its ability to develop soil structure, which aids in aeration of the soil and its ability to infiltrate water. Therefore, a sufficient quantity of organic matter is important for healthy plant growth.

Soil pH is a measure of the acidity or alkalinity of soil and is generally determined by climate—specifically temperature and amount of rainfall, as these factors affect the weathering and leaching of minerals in soil (USDA 1999). Wetland organic soils tend to be slightly acidic, while mineral soils (such as the buffer zone soils) are generally more neutral (Mitsch and Gosselink 2015), although upland soils in Western Washington tend to be slightly acidic (i.e., have a pH less than 7) due to heavy precipitation, which contributes to soil leaching (Hart et al. 2013; McCauley et al. 2017). A pH value between 6 and 7.5 is considered optimal for the growth of crops and many landscape plants; however, many native plants of the Pacific Northwest are adapted to more acidic soil conditions.

The pH values of the buffer soils ranged from 4.57 (in the southeast buffer zone) to 6.57 (in the north buffer zone) (Table 4-4). The pH of the southeast buffer zone soil (4.57) is considered very strongly acidic, the pH of the south buffer zone soil is considered moderately acidic, and the pHs of the north buffer zone and Shellabarger Marsh north buffer zone soils are considered slightly acidic (Debose and Klungland 2002). Alderwood soils have been documented as strongly acidic in the top soil horizons, while Everett soils are slightly to moderately acidic (SCS 1973) In addition, Mukilteo muck, which is also present within portions of the buffer zones, is a very strongly acid soil (see additional discussion of Mukilteo muck in Section 4.4). Therefore, the low pH values observed in the southeast and south buffer zones likely represent naturally acidic soil conditions. The more neutral pH values observed in the north and Shellabarger Marsh buffer zones may be due to the presence of fill soils in these areas, or they may simply be part of the natural variation in soil acidity (particularly as the buffer zones are located in transitional areas between different soil types).

Soil TOC content ranged from 2.4 to 35.6% in the buffer soils, with the lowest percentages in the southeast and south buffer zones (2.40 and 3.41%, respectively), and higher percentages in the north buffer zone of Shellabarger Marsh (18.0%) and the north buffer zone of the Marsh (35.6%). Mineral soils typically have an organic matter content of less than approximately 20 to 35% (Mitsch and Gosselink 2007); in natural (i.e., undisturbed) mineral soils in Washington State, an organic matter content of approximately 5% is typical (Hipple 2019). The organic matter content of the north buffer zone of Shellabarger Marsh and the north buffer zone of the Marsh were both much higher than 5%. Samples from these two buffer zones also had the lowest bulk density measurements (Table 4-4). Bulk density tends to decrease as soil organic matter content increases (USDA 2008).

The top 3 in. of the Shellabarger Marsh north buffer zone soil profile were observed to be sapric and mucky, and a relatively high water table was also observed (Table 4-5). Sapric and mucky soils indicate the presence of decaying organic matter, and a high water table/soil saturation allows for the development of anoxic conditions wherein organic matter can be preserved, resulting in a higher soil TOC content. Similarly, a high water table and signs of anoxic soil conditions were observed within the north buffer zone of the Marsh (Table 4-5), possibly helping to explain the relatively high TOC content of the soil sample from this area. Finally, the soils of both the north buffer zone of Shellabarger Marsh and the north buffer zone of the Marsh may have higher TOC percentages due to their proximity to the lower-elevation/depressional areas of the adjacent marsh habitat, which contains peaty Mukilteo muck soils with high organic matter content. It is possible that the adjacent organic soils have become intermixed to some degree with the mineral loam soils at the northern Marsh edges, or that the buffer zones simply represent a transition from Mukilteo muck to Everett-Alderwood soil types.

Table 4-5. Field observations for upland soil samples – fall 2018 and spring 2019

Location	Depth (in)	Matrix		Redox Features			Soil Texture	Additional Observations of Soil Profile	Observations of Hydrology
		Color	%	Color	%	Type/Location			
Fall 2018									
North Buffer Zone (Transect N1[a])	0–10	10 YR 2/2	90	not present	-	-	silt loam	dense root mat; 10% root mat	no surface water present; water table present (at 7 in. bgs after 30 minutes); capillary fringe present (at 6 in. bgs); sulfur smell (indicating anoxic conditions) present
	10–20	2.5 Y 4/1	50	not present	-	-	sandy loam		
		2.5 Y 3/1	50	not present	-	-	sandy loam		
Southeast Buffer Zone (Transect SE3[b])	0–5	7.5 YR 2.5/1	95	not present	-	-	sandy loam	invertebrates, woody debris	no surface water present; no water table or capillary fringe (i.e., no wetland hydrology)
	5–11	7.5 YR 3/1	100	not present	-	-	sandy loam	no gravel, woody debris present	
	11–20	7.5 YR 3/3	65	not present	-	-	loamy sand		
		10 YR 3/4	35	not present	-	-	loamy sand		
South Buffer Zone (Transect S1[c])	0–3	2.5 Y 2.5/1	85	not present	-	-	clay loam	woody debris, roots, invertebrates present	no surface water present; water table present (at 10 in. bgs after 30 minutes); capillary fringe present (at 9 in. bgs)
	3–9	2.5 Y 4/1	98	2.5 Y 2.5/1	2	depletion in pore lining	loam	roots present	
	9–20	5 Y 5/1	65	5 Y 3/1	35	reduced matrix	sandy loam	trace small gravel present	
Shellabarger Marsh (Transect SB[d])	0–3	5 Y 2.5/2	100	not present	-	-	silty clay loam	woody debris, sapric (somewhat slippery), mucky mineral soil	no surface water present; water table present (at 4 in. bgs after 30 minutes); capillary fringe present (at 4 in. bgs)
	3–5	10 YR 2/1	100	not present	-	-	clay loam	gravel present, small gravel to cobble size	
	5–20	2.5 Y 4/1	70	not present	-	-	loamy sand	30% unconsolidated gravel	

Location	Depth (in)	Matrix		Redox Features			Soil Texture	Additional Observations of Soil Profile	Observations of Hydrology
		Color	%	Color	%	Type/Location			
Spring 2019									
North Buffer Zone (Transect N1[a])	0–3	10 YR 3/1	65	not present	-	-	silty clay	root mat approximately 35%, slippery organic matter present	no surface water present; water table present (at 27 in. bgs after 30 minutes); capillary fringe present (at 9 in. bgs)
	3–6	5 YR 2.5/1	65	not present	-	-	silty clay loam	root mat approximately 35%	
	6–9	10 YR 3/1	75	not present	-	-	clay loam	root mat approximately 25%, no pore linings	
	9–12	5 YR 3/1	90	7.5 YR 4/6	10	pore linings	sandy loam		
	12–13	Gley 2 4/10B	75	7.5 YR 4/4	25	pore linings	sandy loam		
Southeast Buffer Zone (Transect SE3[b])	0–3	2.5 Y 3/1	100	not present	-	-	sandy clay loam	roots and rootlets present	no surface water present; no water table present; capillary fringe present (at 13 in. bgs)
	3-4	2.5 Y 3/2	100	not present	-	-	loamy sand	pebbles approximately 1 cm in size	
	4–6	10 YR 4/4	60	not present	-	-	loamy sand	more pebbles than in higher level, ranging in size from approximately 2–2.5 cm	
		10 YR 4/6	40	not present	-	-			
South Buffer Zone (Transect S1[c])	0–3	5 Y 4/1	60	not present	-	-	clay loam	40% root mass	surface water present; water table present (at 5 in. bgs); capillary fringe present (at 3.5 in. bgs)
	3–15	5 Y 3/1	85	not present	-	-	sandy loam	15% root mass; earthworms 0–5 in. long present	
Shellabarger Marsh (Transect SB[d])	0–6	5 Y 2.5/2	100	not present	-	-	clay loam	roots present, no rocks, worms, no pore linings or concretions	no surface water present; water table present (at 6.25 in. bgs); capillary fringe present (at 5.5 in. bgs)
	6–12	5 Y 4/1	100	not present	-	-	sandy loam	variety of gravel and sand, approximately 30% gravel and small pebbles, jagged/angular	

[a] Location ID is N1b on field data sheets in Appendix A.
[b] Location ID is SE3b on field data sheets in Appendix A.
[c] Location ID is S1b on field data sheets in Appendix A.
[d] Shellabarger Marsh north buffer zone.

bgs – below ground surface ID – identification

Upland soil profiles were observed and described during both the fall and spring monitoring events (Table 4-5). These profiles were used to determine if the soils met the hydric soil indicators described by USDA and NRCS (2010). Soils within the Marsh's buffer zones met the loamy gleyed matrix (F2) (north buffer zone of the Marsh), depleted matrix (F3) (southeast buffer zone of the Marsh and north buffer zone of Shellabarger Marsh), and sandy redox (S5) (south buffer zone of the Marsh) hydric soil indicators (USACE 2010).

Buffer soils were examined for the presence or absence of hydric soil indicators in order to demonstrate the transitional nature of the buffers from wetland to upland habitat types. In addition, the presence of hydric soils indicates that several natural geochemical cycles—involving nitrogen, sulfur, carbon, and phosphorous—are occurring simultaneously within the soil matrix (Mitsch and Gosselink 2007). The cycles allow the wetlands to serve as sinks, sources, and transformers of these nutrients. For example, the presence of gleyed soils is typically an indicator of reduced iron and manganese and an overall anoxic (i.e., oxygen-poor) environment. Iron and manganese are more soluble and more easily available to organisms in these reduced forms (Mitsch and Gosselink 2007).

Information about the hydrology of the upland buffer zones was also gathered by observing the soil test pits for the presence or absence of (and depth to) surface water, presence of absence of (and depth to) the water table and/or capillary fringe (soil saturation), and the presence or absence of reduced minerals in the soil matrix (related to soil colors). Wetland hydrology indicators observed included a high water table (A2), soil saturation (A3), and a hydrogen sulfide odor (C1) (indicative of saturated, anoxic soil conditions) (USACE 2010).

4.4 Marsh Sediment Observations and Analysis

Marsh sediments were sampled and analyzed to better understand characteristics related to the function of these substrates; the results of the analyses are provided in Appendix C. The USDA's NRCS WSS has characterized and mapped soil units within Edmonds and Shellabarger Marshes. The Marsh interior is composed of Mukilteo muck (see the map in Appendix D, Area 34), which is typical of depressional formations. The parent material of Mukilteo muck is herbaceous organic material derived primarily from sedge vegetation (Debose and Klungland 2002). It is a very poorly drained, hydric soil, and the water table is usually at or near the surface between October and May.

Table 4-6 and Figure 4-10 show the laboratory analysis results for the Marsh sediment samples. In general, grain size distributions were similar at locations Sed-2 and Sed-4 and at locations Sed-1 and Sed-3 (Map 2). At locations Sed-2 and Sed-4, samples contained high percentages of total fines (69.7 and 62.5%, respectively) and small percentages of gravel (6.5 and 8.2%, respectively). Locations Sed-2 and Sed-4 also had higher percentages of total silt than did the other two locations. Locations Sed-1 and

Sed-3 had smaller percentages of total fines (20 and 35%, respectively) and larger percentages of gravel (36.3 and 41.3%, respectively) compared to Locations Sed-2 and Sed-4. The similarity in sediment grain size distribution between locations Sed-1 and Sed-3 and locations Sed-2 and Sed-4 can likely be attributed to the elevations of the sampling locations. Samples from locations Sed-2 and Sed-4 were collected from areas of the Marsh that are regularly inundated and do not contain marsh vegetation, while samples from locations Sed-1 and Sed-3 were collected from sediments at a slightly higher elevation that are not inundated as often and that contain some vegetation patches. Total sand content made up between 20 and 30% of the grain size distribution of all sediment samples except the sample from location Sed-1, which had a total sand content of 43.9%. The sample from location Sed-1 also had a relatively smaller percentage of clay (7.2%) compared to the other samples (16% or higher) (Table 4-6).

Table 4-6. Laboratory results for Marsh sediment samples

Location	Grain Size Distribution (%)[a]									Wet Chemistry	
	Gravel	Coarse Sand	Medium Sand	Fine Sand	Coarse Silt	Medium Silt	Fine Silt	Clay	Total Fines[b]	pH	TOC
Sed-1	36.3	29.2	6.7	8.0	1.8	8.0	2.9	7.2	19.8	6.32	13.1
Sed-2	6.5	9.3	4.6	9.9	18.8	18.9	15.5	16.5	69.7	6.43	7.07
Sed-3	41.6	14.8	4.1	5.0	3.0	6.6	7.7	17.1	34.5	4.32	9.56
Sed-4	8.2	14.4	7.9	7.0	6.1	16.8	20.6	19.1	62.5	5.18	8.16

[a] Grain size distribution categories are based on sieve sizes as follows:
Gravel: > 2,000 µm
Coarse Sand: 2,000–500 µm
Medium Sand: 500–250 µm
Fine Sand: 250–62.5 µm
Coarse Silt: 62.5–31.0 µm
Medium Silt: 15.6–31.0 µm
Fine Silt: 15.6–3.9 µm
Clay: < 1.0–3.9 µm

[b] Total fines is the sum of the clay and silt grain size fractions (technically, it is defined as the grain sizes < 62 µm in size).

Marsh – Edmonds Marsh

TOC – total organic carbon

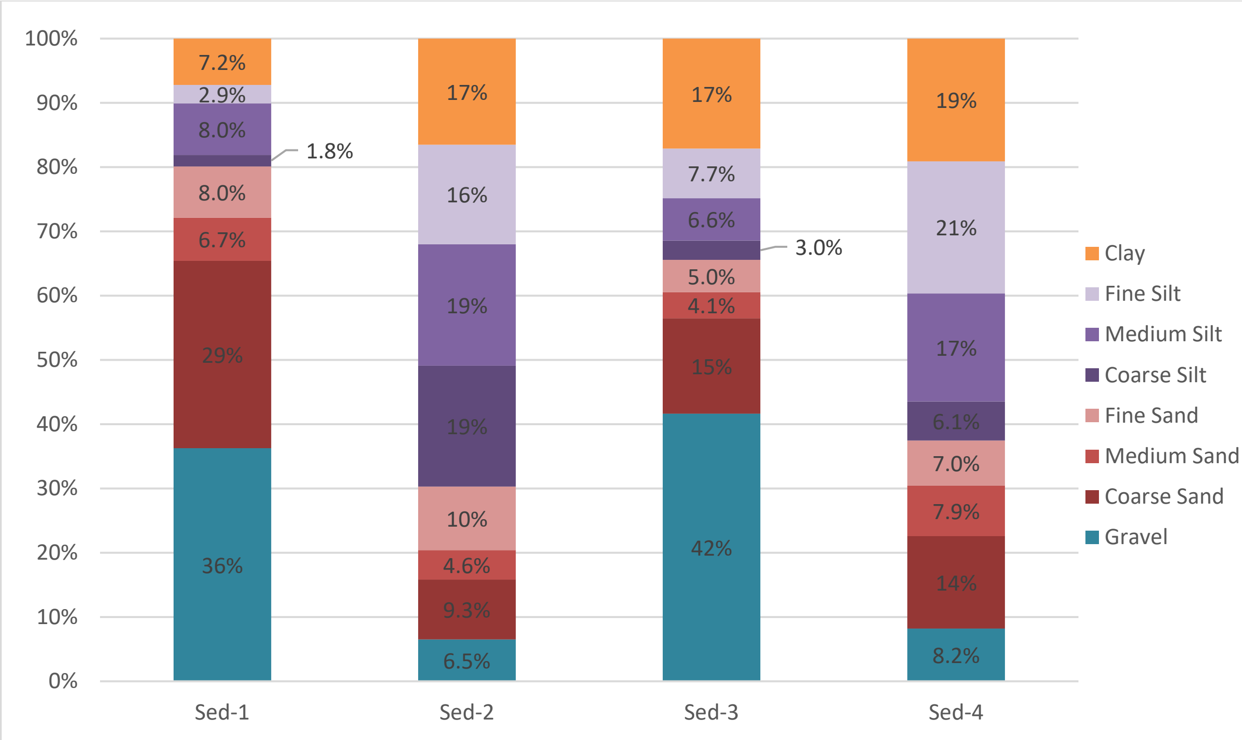

Figure 4-10. Laboratory results for Marsh sediment

4.4.1 pH and organic matter

Organic soils are generally acidic and have an organic content of greater than 20 to 35% (Mitsch and Gosselink 2007). Mukilteo muck has been identified as a very strongly acid soil to a depth of 54 in. below ground surface (bgs), and as containing a large proportion of plant fibers (between 40 and 78% in the top 35 in. of the soil profile) and root material (Debose and Klungland 2002). Consistent with the description of this soil type, the sediment samples collected as part of the baseline study had acidic pH values ranging from 4.32 to 6.43 (Table 4-6).

TOC content of marsh sediment was relatively consistent, ranging from 7.07 to 13.1% by weight. Consistent with the description of Mukilteo muck, large quantities of organic matter/detritus and root mass were also observed visually in the baseline sediment samples from the Marsh (Table 4-7).

Table 4-7. Fall 2018 field observations for Marsh sediment samples

Location	Depth (in)	Matrix		Redox Features			Field Observations of Sediment Profile Characteristics
		Color	%	Color	%	Type/Location	
Sed-1	0 –2	5 Y 2.5/1	100	not present	-	-	fine top layer unconsolidated silt
	2 – 9	2.5 Y 4/3	75	not present	-	-	25% root mass, organic matter, clayey
Sed-2	0 – 0.5	10 YR 2/1	100	not present	-	-	fluffy organic layer, unconsolidated, organic/slippery, trace silt
	0.5 – 2	10 YR 3/2	75	not present	-	-	25% root mass, silt, no pore linings
	2 – 6	5 Y 4/1	95	not present	-	-	5% root mass, silt
Sed-3	0 – 3.5	10 YR 3/3	75	not present	-	-	25% root mass, slippery texture, histic, no pore lining features
	3.5 – 7	2.5 Y 3/1	90	5 Y 2.5/1	10	pore linings	10% root mass, silt
Sed-4	0 – 1	2.5 YR 3/2	100	not present	-	-	organic, dense root mat, slippery, macro pores
	1 – 8	5Y 4/1	100	not present	-	-	silty clay, organic matter

Marsh – Edmonds Marsh

Marsh interior sediment profiles were observed and described during the fall monitoring event (Table 4-7). Profile observations were generally limited to between 6 and 9 in. bgs due to the loose, unconsolidated nature of the sediments as well as a high water table, which in turn limited the ability to fully examine the sediments for hydric soil field indicators. However, previous studies conducted by Shannon & Wilson (2017) found that soils within the Marsh interior met the histic epipedon[16] (A2) hydric soil indicator. Observations made during the baseline study also found that sediments primarily consisted of organic soils with a chroma of two or less, confirming prior findings. The organic material present in the sediment profiles was in varying levels of decay, and the presence of visible organic fibers indicated that the sediment would be designated as saprist histosols[17].

4.5 MARSH VEGETATION SURVEYS

The vegetation of the Marsh interior was dominated by salt-tolerant species throughout most of the western side and freshwater species on the eastern side, with a fairly clear boundary between the two areas (Map 6). Vegetation on the eastern side of the Marsh consisted predominantly of cattail stands, with interspersed islands of willow (*Salix* spp.) and red alder (*Alnus rubra*). There were also large quantities of bittersweet nightshade (*Solanum dulcamara*), Himalayan blackberry, and reed canarygrass (*Phalaris arundinacea*) growing along and within the cattail stands, all of which are invasive species. The growth of these species was concentrated near the boundary between the riparian forests of the south and southeast buffer zones and the more open, cattail-dominated portion of the Marsh.

[16] Histic epipedon is a hydric soil field indicator that meets the criteria of an organic soil underlain by a mineral soil with a chroma of two or less according to USACE (2010).

[17] Typically, saprist histosol is "muck" defined as an organic-derived soil having two-thirds or more of the material decomposed and less than one-third of plant fibers identifiable.

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Patch ID No.	Species Present Within Patch
1	seaside arrowgrass and cosmopolitan bulrush
2	brass buttons growing along mudflat perimeter
3	Lyngbye's sedge
4	cattail and hardstem bulrush; cosmopolitan bulrush growing along mudflat perimeter
5	hardstem bulrush
6	hardstem bulrush
7	common reed
8	saltgrass, Pacific silverweed
9	saltgrass
10	cosmopolitan bulrush
11	cosmopolitan bulrush, seaside arrowgrass
12	baltic rush, saltgrass, Pacific silverweed, meadow barley
13	Pacific silverweed
14	narrow band of reed canarygrass and Himalayan blackberry along wooden boardwalk
15	cattail and bittersweet nightshade
16	native shrub buffer (e.g., snowberry, roses, red-flowering currant) - planted
17	Japanese knotweed, hops, reed canarygrass, small-fruited bulrush growing adjacent to boardwalk
18	cosmopolitan bulrush, Pacific silverweed, saltgrass
19	saltgrass
20	cattail and common reed (common reed in western portion of patch)
21	saltgrass, Pacific silverweed, baltic rush, Lyngbye's sedge, small patch cosmopolitan bulrush, brass buttons, spear saltbush and pickleweed along mudflat perimeter
22	spear saltbush, saltgrass
23	spear saltbush, saltgrass, meadow barley
24	spear saltbush, saltgrass, meadow barley
25	hardstem bulrush, creeping bentgrass
26	cattail

Windward environmental LLC

N

0 0.01 0.02 Miles

0 50 100 Feet

Unique vegetation patches

Major vegetation transition line

Map 6. Edmonds Marsh baseline study marsh interior vegetation survey

Prepared by mikey, 7/16/2019; W:\Projects\Edmonds Marsh\Data\GIS\Maps and Analyses\Data Report\Map 6_6979_Marsh interior vegetation survey.mxd

The western portion of the Marsh contained a mix of several different (mostly native) salt-tolerant plant species (Table 4-8), which grew in patches around and interspersed within the mudflat areas (Map 6). In many cases, each patch was dominated by just a few species. Cattail species, which are typically found in freshwater environments but can tolerate saltier conditions when mature, were observed in patches in the western portion of the Marsh as well, particularly along the northern boundary (Patches 4, 14, 15, and 20 on Map 6). Invasive species observed within the western portion of the Marsh included a large patch of common reed (*Phragmites australis*) (Patch No. 7 on Map 6); a narrow band of reed canarygrass and Himalayan blackberry growing adjacent to the wooden boardwalk (Patch No. 14 on Map 6); a patch of bittersweet nightshade growing near the base of the wooden boardwalk (Patch No. 15 on Map 6); and an additional patch of common reed, Japanese knotweed (*Polygonum cuspidatum*), and reed canarygrass growing along the northwest portion of the Marsh just beyond the terminus of the wooden boardwalk (Patch Nos. 17 and 20 on Map 6).

Table 4-8. Plant species identified in the western portion of the Marsh

Species Common Name	Species Scientific Name	Ecological Setting/Native vs. Non-native Status
Baltic rush	*Juncus arcticus* or *Juncus balticus*	native; obligate wetland plant; moderately salt tolerant (Stevens and Hoag 2003)
Cattail	*Typha* spp.	Both native and introduced types are present (WA NWCB 2019b); seeds and seedlings have low salinity tolerance while older plants bearing rhizomes are salt tolerant (Beare and Zedler 1987). Cattails tend to become invasive in wetlands when the wetlands are disturbed by changes in hydrology, nutrient levels, and/or salinity, often resulting in dense, monotypic cattail stands (Stevens and Hoag 2006); for example, cattail has been known to replace hardstem bulrush when water levels in a wetland are lowered for an extended time period (Tilley 2012).
Bittersweet nightshade	*Solanum dulcamara*	non-native and invasive weed; facultative
Common brassbuttons	*Cotula coronopifolia*	introduced but not considered to be invasive; obligate wetland plant; highly salt tolerant
Common reed	*Phragmites australis*	introduced, invasive weed rated Class B by the Snohomish County Noxious Weed Board; highly salt tolerant but reportedly controllable via multiple (at least 3) years of flooding with water at least 3 ft deep (Tilley and St. John 2012a)
Cosmopolitan bulrush	*Bolboschoenus maritimus*	native; obligate wetland plant; forms large, dense stands in salt marshes; can also occur in freshwater marshes but is usually a pioneering species eventually replaced by others in these habitats; tolerates a range of soil/sediment textures from fine clay to sand (Tilley and St. John 2012b)
Creeping bentgrass	*Agrostis stolonifera*	introduced but non-invasive; facultative; high salinity tolerance; adapted to medium- and fine-textured soils
Hardstem bulrush	*Schoenoplectus acutus*	native; obligate wetland plant; usually grows in standing water between 4 in. and 5 ft deep; tolerant of brackish conditions; grows on a range of substrate types (from coarse-grained soils to peat); can grow up to 10 ft tall (Tilley 2012; Gleason et al. 2009)
Himalayan blackberry	*Rubus armeniacus*	non-native, invasive weed; facultative
Common hops	*Humulus lupulus*	Both native and introduced populations, FACU rating
Japanese knotweed	*Polygonum cuspidatum*	Introduced, invasive weed rated Class B by the Snohomish County Noxious Weed Board; FACU rating;
Lyngbye's sedge	*Carex lyngbyei*	Native; obligate wetland plant; moderate salinity tolerance
Meadow barley	*Hordeum brachyantherum*	Native; FACW rating; moderate salinity tolerance; adapted to all textures of soil; grows on a range of soil types, from coarse sand to clay (Darris 2008)

Species Common Name	Species Scientific Name	Ecological Setting/Native vs. Non-native Status
Narrowleaf cattail	*Typha angustifolia*	An introduced species according to the Washington State Noxious Weed Control Board (WA NWCB 2019b); the species is an obligate wetland plant with moderate tolerance for salinity. Seeds and seedlings have low salinity tolerance while older plants bearing rhizomes are salt tolerant (Beare and Zedler 1987); cattails tend to become invasive in wetlands when they are disturbed by changes in hydrology, nutrient levels, and/or salinity, often resulting in dense, monotypic cattail stands (Stevens and Hoag 2006); for example, cattail has been known to replace hardstem bulrush when water levels in a wetland are lowered for an extended time period (Tilley 2012); *T. angustifolia* generally grows in deeper water than does *T. latifolia* (Stevens and Hoag 2006).
Pacific silverweed	*Argentina egedii*	native; tolerant of brackish conditions and typically grows in high tidal marshes (at or above mean higher high water), but can also be found in freshwater meadows and wetlands; spreads vigorously (Stevens 2007)
Pickleweed	*Salicornia depressa*	native; obligate wetland plant; highly salt tolerant; common in salt marshes (in the low marsh zone)
Reed canarygrass	*Phalaris arundinacea*	introduced, invasive weed; adapted to medium- and fine-textured soils
Saltgrass	*Distichlis spicata*	native, FACW rating; adapted to medium- and fine-textured soils; high salt and drought tolerance; common in estuaries, salt marshes (in the high marsh zone), salt flats, and back dune shoreline areas; killed by prolonged inundation (Skaradek and Miller 2010)
Seaside arrowgrass	*Triglochin maritima*	native; obligate wetland plant; mudflat colonizer common in salt marshes (in the low marsh zone) (Cooke 1997)
Spear saltbush	*Atriplex patula*	introduced; FACW rating; highly salt tolerant

Primary reference: USDA Plants Database (2019).
FACU – facultative upland
FACW – facultative wetland
Marsh – Edmonds Marsh
USDA – US Department of Agriculture

Other invasive species observed within the Marsh in smaller (i.e., non-dominant) quantities included purple loosestrife (*Lythrum salicaria*), which was scattered in small quantities throughout the Marsh and Shellabarger Marsh; field bindweed (*Convolvulus arvensis*), which was observed along the wooden boardwalk and in the transition between the riparian/forested vegetation and cattail vegetation along the north buffer zone; and bittersweet nightshade, which was growing along much of the northern boundary of the Marsh.[18] Scotch broom shrubs and English ivy (*Hedera helix*) were scattered along the south side of Willow Creek, where the creek runs in a relatively straight channel along the south side of the Marsh. Native vegetation observed in this area included pine trees,[19] black twinberry (*Lonicera involucrate*), salmonberry (*Rubus spectabilis*), and willow.

4.6 BUFFER ZONE VEGETATION SURVEYS

Vegetation within the buffer zones was quantitatively evaluated by establishing four transect lines in the north buffer zone, three in the southeast buffer zone, two in the south buffer zone, and one in the north buffer zone of Shellabarger Marsh (Map 4). Data from the individual transects were averaged by buffer zone to generate the results presented in this section. Additionally, densitometer readings were taken within every herbaceous stratum monitoring plot and were averaged first by transect and then by zone. Section 4.6.1 presents the sampling results for the tree canopy stratum, and Section 4.6.2 presents the results for the scrub/shrub and herbaceous vegetation strata.

The *Western Mountains, Valleys & Coast 2016 Regional Wetland Plant List* is an inventory of wetland plants and their assigned wetland indicator statuses. An indicator status reflects the likelihood that a particular species will occur in a wetland or upland area (Lichvar et al. 2016). There are five indicator statuses:

- **Obligate (OBL)** – Almost always occur in wetlands
- **Facultative wet (FACW)** – Usually occur in wetlands, but may occur in non-wetlands
- **Facultative (FAC)** – Occur in wetlands and non-wetlands
- **Facultative upland (FACU)** – Usually occur in non-wetlands, but may occur in wetlands
- **Upland (UPL)** – Almost never occur in wetlands

[18] For reference, the bittersweet nightshade extends from approximately Photo Point F west to Photo Point D (Map 5).

[19] One of the pine trees has died, leaving a standing snag that is used by many different bird species for perching/roosting.

These designations were used to quantitatively characterize vegetation present as wetland dominant species, allowing buffer zone vegetation to be qualitatively assessed.

4.6.1 Tree canopy stratum

The tree canopy stratum was assessed through measurements of overstory percent cover using a spherical densitometer, and also by inventorying and measuring all overstory trees present within the belt transects (Table 4-9). Densiometer data were collected in both the summer and spring monitoring events in order to capture seasonal differences in canopy closure. The tree data collected within the belt transects allowed for the calculation of basal area – a measure of the cross-section of trees' trunks generally at "breast height" (a height of 4 to 5 ft above the ground). Together the densitometer and transect measurements provide information about the density of the tree canopy within the different buffer zones, as well as the species that comprise that canopy.

Table 4-9. Average overstory density and canopy trees species observed within the buffer zones

Buffer Zone	Overstory Percent Cover (Summer 2018)[a]	Overstory Percent Cover (Spring 2019)[a]	Tree Species Sampled		Basal Area[b]	Wetland Indicator Status[c]	Native Status[d]
			Species Common Name	Species Scientific Name			
North buffer zone	82%	85%	Scouler's willow	*Salix scouleriana*	0.092 m^2	FAC	native
			red alder	*Alnus rubra*	0.23 m^2	FAC	native
Southeast buffer zone	95%	80%	common hawthorn	*Crataegus monogyna*	0.030 m^2	FAC	introduced[e]
South buffer zone	94%	77%	red alder	*Alnus rubra*	0.31 m^2	FAC	native
Shellabarger Marsh north buffer zone	95%	81%	red alder	*Alnus rubra*	0.021 m^2	FAC	native

a Measured using a densitometer.

b Basal area is the area of the cross-section of a tree's trunk generally at "breast height:" 4 to 5 ft above the ground (or in this case, the cross-section area of all tree trunks of the same species within a vegetation sampling transect).

c Wetland indicator status according to Lichvar et al. (2016).

d Native status according to NRCS (USDA 2019).

e Common hawthorn is a Class C invasive species according to the Washington State Noxious Weed Control Board (WA NWCB 2019a).

FAC – facultative

NRCS – Natural Resources Conservation Service

The overstory percent cover measurements were all above 77%, indicating that the vegetated portions[20] of all the buffer zones were relatively well-covered by tree canopy. The differences in overstory percent cover between the summer and spring monitoring events can be attributed to seasonal factors; not all trees had fully leafed out during the spring monitoring event. In the north buffer zone, red alder comprised the majority of the overstory tree basal area within the sampling transects, followed by Scouler's willow (*Salix scouleriana*). In the southeast buffer zone, common hawthorn (*Crataegus monogyna*) was the only overstory tree species within the transects, and in the south buffer zone and the north buffer zone of Shellabarger Marsh, red alder was the only overstory tree species within the transects.

4.6.2 Scrub/shrub and herbaceous strata

Beneath the canopy stratum are the scrub/shrub (understory) and herbaceous (groundcover) strata of vegetation. Section 4.6.2.1 presents the scrub/shrub and herbaceous strata sampling results for the north buffer zone, Section 4.6.2.2 presents the results for the southeast buffer zone, Section 4.6.2.3 presents the results for the south buffer zone, and Section 4.6.2.4 presents the results for the north buffer zone of Shellabarger Marsh.

4.6.2.1 North buffer zone

Water parsley (*Oenanthe sarmentosa*) and broadleaf cattail (*Typha latifolia*) were the dominant[21] species in the herbaceous stratum of the north buffer zone; giant horsetail, sword fern (*Polystichum munitum*), fireweed, sticky willy, and Canada bluegrass were also common (Table 4-10). Scouler's willow (45%) had the highest percent cover in the shrub/sapling stratum, followed by Himalayan blackberry (23%). In addition to Himalayan blackberry, other invasive species identified in the north buffer zone were bittersweet nightshade, English ivy, and field bindweed. Vegetation in the north buffer zone passed the hydrophytic dominance test according to (USACE 2010) at 75% designation of OBL, FACW, or FAC species.

Table 4-10. Herbaceous and shrub/sapling vegetation of the north buffer zone

Species Common Name	Species Scientific Name	Wetland Indicator Status[a]	Native Status[b]	Washington Noxious Weed Classification[c]	Relative Cover (%)[d]
Herbaceous Stratum					
Summer 2018					
Water parsley	*Oenanthe sarmentosa*	OBL	native	na	33%[e]

[20] The vegetation transects were placed within the portions of the buffer zones that contained vegetation, as opposed to developed upland areas or areas containing lawns, roadways, etc.

[21] Species with 20% or greater relative percent cover are considered to be dominant for the purposes of the transect data.

Species Common Name	Species Scientific Name	Wetland Indicator Status[a]	Native Status[b]	Washington Noxious Weed Classification[c]	Relative Cover (%)[d]
Giant horsetail	*Equisetum telmateia*	FACW	native	na	14%[e]
Fireweed	*Chamaenerion angustifolium*	FACU	native	na	13%[e]
Canada bluegrass	*Poa compressa*	FACU	introduced	na	13%
Bittersweet nightshade	*Solanum dulcamara*	FAC	introduced	WOC	9.2%
Stickywilly	*Galium aparine*	FACU	native	na	6.5%
Lady fern	*Athyrium filix-femina*	FAC	native	na	2.8%
English ivy	*Hedera helix*	FACU	introduced	na	2.8%
Field bindweed	*Convolvulus arvensis*	FACU	introduced	C	2.0%
Himalayan blackberry	*Rubus armeniacus*	FAC	introduced	C	2.0%
Field horsetail	*Equisetum arvense*	FAC	native	na	1.0%
White-top aster	*Aster cultus*	FACU	introduced	na	0.18%
Sword fern	*Polystichum munitum*	FACU	native	na	0.18%
Pin oak	*Quercus palustris*	FACW	introduced	na	0.18%
Sitka willow	*Salix sitchensis*	FACW	native	na	0.18%
Spring 2019					
Water parsley	*Oenanthe sarmentosa*	OBL	native	na	22%[e]
Broadleaf cattail	*Typha latifolia*	OBL	native	na	21%[e]
Sword fern	*Polystichum munitum*	FACU	native	na	19%[e]
Stickywilly	*Galium aparine*	FACU	native	na	12%
Giant horsetail	*Equisetum telmateia*	FACW	native	na	11%
Field horsetail	*Equisetum arvense*	FAC	native	na	3.6%
Twinberry honeysuckle	*Lonicera involucrata*	FAC	native	na	3.6%
Fireweed	*Chamaenerion angustifolium*	FACU	native	na	2.1%
Lady fern	*Athyrium filix-femina*	FAC	native	na	1.1%
Canada bluegrass	*Poa compressa*	FACU	introduced	na	1.1%
English ivy	*Hedra helix*	FACU	introduced	na	1.1%
Field bindweed	*Convolvulus arvensis*	FACU	introduced	C	0.64%
Himalayan blackberry	*Rubus armeniacus*	FAC	introduced	C	0.64%
Sitka willow	*Salix sitchensis*	FACW	native	na	0.21%
Shrub/Sapling Stratum					
Scouler's willow	*Salix scouleriana*	FAC	native	na	45%[e]
Himalayan blackberry	*Rubus armeniacus*	FAC	introduced	C	23%[e]
Sword fern	*Polystichum munitum*	FACU	native	na	6.4%
Giant horsetail	*Equisetum telmateia*	FACW	native	na	5.3%
Broadleaf cattail	*Typha latifolia*	OBL	native	na	5.2%
White-top aster	*Aster cultus*	0	introduced	na	3.0%
Water parsley	*Oenanthe sarmentosa*	OBL	native	na	2.8%
Lady fern	*Athyrium filix-femina*	FAC	na	na	2.6%
Evergreen huckleberry	*Vaccinium ovatum*	FACU	native	na	2.0%

Species Common Name	Species Scientific Name	Wetland Indicator Status[a]	Native Status[b]	Washington Noxious Weed Classification[c]	Relative Cover (%)[d]
Vine maple	*Acer circinatum*	FAC	native	na	1.2%
Red alder	*Alnus rubra*	FAC	na	na	1.1%
Bittersweet nightshade	*Solanum dulcamara*	FAC	introduced	WOC	1.1%
Twinberry honeysuckle	*Lonicera involucrata*	FAC	native	na	0.90%
Field horsetail	*Equisetum arvense*	FAC	native	na	0.20%

[a] Wetland indicator status according to Lichvar et al. (2016).

[b] Native status according to NRCS (USDA 2019).

[c] Designation according to the Washington State Noxious Weed Control Board (WA NWCB 2019a). Weeds designated as Class C are “noxious weeds (that) are widespread in Washington or are of special interest to the agricultural industry.”

[d] Relative percent cover is a measure of the percent of vegetated area within a given stratum that is covered by a specific species.

[e] Dominant species using the 50/20 rule (Lichvar et al. 2016).

OBL – obligate
FAC – facultative
FACU – facultative upland
FACW – facultative wetland
na – not applicable
NRCS – Natural Resources Conservation Service
UPL – upland
WOC – weed of concern

4.6.2.2 Southeast buffer zone

Himalayan blackberry dominated both the herbaceous and shrub strata in the southeast buffer zone (Table 4-11), indicating that Himalayan blackberry is well-established and continuing to seed in and spread in this zone. Native trailing blackberry (*Rubus ursinus*) and salmonberry seedlings were also common in the herbaceous stratum, and salmonberry covered approximately 17% of the shrub/sapling stratum. In addition to Himalayan blackberry, other invasive species identified in the southeast buffer zone were reed canarygrass and common hawthorn. Common hawthorn seedlings were observed in the herbaceous stratum and saplings were observed in the shrub/sapling stratum. These are no doubt being produced by the overstory common hawthorn trees present within the southeast buffer zone (Table 4-11). Vegetation in this zone passed the hydrophytic dominance test according to (USACE 2010) at 75% designation of OBL, FACW, or FAC species.

Table 4-11. Herbaceous and shrub/sapling vegetation of the southeast buffer zone

Species Common Name	Species Scientific Name	Indicator Status[a]	Native Status[b]	Washington Noxious Weed Classification[c]	Relative Cover (%)[d]
Herbaceous Stratum[e]					
Summer 2018					
Himalayan blackberry	*Rubus armeniacus*	FAC	introduced	C	34%[e]
Trailing blackberry	*Rubus ursinus*	FACU	native	na	32%[e]
Salmonberry	*Rubus spectabilis*	FAC	native	na	13%

Species Common Name	Species Scientific Name	Indicator Status[a]	Native Status[b]	Washington Noxious Weed Classification[c]	Relative Cover (%)[d]
Reed canarygrass	*Phalaris arundinacea*	FACW	introduced[f]	C	11%
Giant horsetail	*Equisetum telmateia*	FACW	native	na	5.0%
Stinging nettle	*Urtica dioica*	FAC	native	na	4.8%
Osoberry	*Oemleria cerasiformis*	FACU	native	na	1.0%
Spring 2019					
Himalayan blackberry	*Rubus armeniacus*	FAC	introduced	C	59%[e]
Salmonberry	*Rubus spectabilis*	FAC	native	na	15%
Osoberry	*Oemleria cerasiformis*	FACU	native	na	8.5%
Stinging nettle	*Urtica dioica*	FAC	native	na	7.1%
Trailing blackberry	*Rubus ursinus*	FACU	native	na	6.0%
Common hawthorn	*Crataegus monogyna*	FAC	introduced	C	2.7%
Reed canarygrass	*Phalaris arundinacea*	FACW	introduced[f]	C	0.80%
Field horsetail	*Equisetum arvense*	FAC	native	na	0.50%
Giant horsetail	*Equisetum telmateia*	FACW	native	na	0.30%
Shrub/Sapling Stratum					
Himalayan blackberry	*Rubus armeniacus*	FAC	introduced	C	58%[e]
Salmonberry	*Rubus spectabilis*	FAC	native	na	17%
Reed canarygrass	*Phalaris arundinacea*	FACW	introduced[f]	C	9.0%
Stinging nettle	*Urtica dioica*	FAC	native	na	5.1%
Giant horsetail	*Equisetum telmateia*	FACW	native	na	4.1%
Osoberry	*Oemleria cerasiformis*	FACU	native	na	3.0%
Lady fern	*Athyrium filix-femina*	FAC	native	na	1.6%
Sword fern	*Polystichum munitum*	FACU	native	na	1.1%
Trailing blackberry	*Rubus ursinus*	FACU	native	na	0.96%
Common hawthorn	*Crataegus monogyna*	FAC	introduced	C	0.20%

[a] Wetland indicator status according to Lichvar et al. (2016).
[b] Native status according to NRCS (USDA 2019).
[c] Designation according to the Washington State Noxious Weed Control Board (WA NWCB 2019a).
[d] Relative percent cover is a measure of the percent of vegetated area within a given stratum that is covered by a specific species.
[e] Dominant species using the 50/20 rule (Lichvar et al. 2016).
[f] Some cultivars of reed canarygrass may be native to North America (WA NWCB 1995); however, European cultivars were introduced for forage and hay, and given the invasive nature of the species in the Pacific Northwest, it is considered to be an introduced species for the purposes of this inventory.

OBL – obligate
FAC – facultative
FACU – facultative upland
FACW – facultative wetland
na – not applicable
NRCS – Natural Resources Conservation Service
UPL – upland
WOC – weed of concern

4.6.2.3 South buffer zone

The south buffer zone had the most diverse native plant community within the herbaceous and shrub/sapling strata of all the buffer zones, with 22 native species identified in the herbaceous stratum, and 15 native species identified in the shrub/sapling stratum (Table 4-12). American skunkcabbage (*Lysichiton americanus*) was the dominant species in the herbaceous layer in the summer (46% cover), and youth-on-age (*Tolmiea menziesii*) was the dominant species in the spring (27% cover), demonstrating seasonal variation in the herbaceous stratum composition. The shrub stratum was dominated by salmonberry (35%). Invasive species in the south buffer zone included: Himalayan blackberry (with approximately 10% cover in the shrub/sapling stratum); reed canarygygrass (present at approximately 9% cover in the shrub/sapling stratum and lower percentages in the herbaceous stratum); cherry laurel (*Prunus laurocerasus*), English ivy, lesser herb Robert (*Geranium robertianum*), and English holly (*Ilex aquifolium*) (present in very small quantities). Vegetation in this zone passed the hydrophytic dominance test according to (USACE 2010) at 78% designation of OBL, FACW, or FAC species.

Table 4-12. Herbaceous and shrub/sapling vegetation of the south buffer zone

Species Common Name	Species Scientific Name	Indicator Status[a]	Native Status[b]	Washington Noxious Weed Classification[c]	Relative Cover (%)[d]
Herbaceous Stratum[e]					
Summer 2018					
American skunkcabbage	*Lysichiton americanus*	OBL	native	na	46%[e]
Lady fern	*Athyrium filix-femina*	FAC	native	na	8.6%[e]
Trailing blackberry	*Rubus ursinus*	FACU	native	na	8.6%
Salmonberry	*Rubus spectabilis*	FAC	native	na	7.4%
Slough sedge	*Carex obnupta*	OBL	native	na	5.3%
Giant horsetail	*Equisetum telmateia*	FACW	native	na	5.1%
Reed canarygrass	*Phalaris arundinacea*	FACW	introduced[f]	C	3.6%
Northern bracken fern	*Pteridium aquilinum*	FACU	native	na	3.2%
Creeping buttercup	*Ranunculus repens*	FAC	introduced	WOC	3.2%
Himalayan blackberry	*Rubus armeniacus*	FAC	introduced	C	2.3%
Pacific willow	*Salix lasiandra*	FACW	native	na	2.1%
Stinging nettle	*Urtica dioica*	FAC	native	na	2.1%
Osoberry	*Oemleria cerasiformis*	FACU	native	na	1.1%
Sword fern	*Polystichum munitum*	FACU	native	na	1.1%
Thimbleberry	*Rubus parviflorus*	FACU	native	na	1.1%
Spring 2019					
Youth-on-age	*Tolmiea menziesii*	FAC	native	na	27%[e]
American skunkcabbage	*Lysichiton americanus*	OBL	native	na	11%[e]
Cherry laurel	*Prunus laurocerasus*	FACU	introduced	WOC	11%[e]
Creeping buttercup	*Ranunculus repens*	FAC	introduced	WOC	10%[e]

Species Common Name	Species Scientific Name	Indicator Status[a]	Native Status[b]	Washington Noxious Weed Classification[c]	Relative Cover (%)[d]
Lady fern	*Athyrium filix-femina*	FAC	native	na	7.5%
Himalayan blackberry	*Rubus armeniacus*	FAC	introduced	C	6.1%
Salmonberry	*Rubus spectabilis*	FAC	native	na	6.1%
Slough sedge	*Carex obnupta*	OBL	native	na	6.0%
Reed canarygrass	*Phalaris arundinacea*	FACW	introduced[f]	C	4.4%
English holly	*Ilex aquifolium*	FACU	introduced	WOC	2.0%
Shotweed	*Cardamine oligosperma*	FACU	native	na	1.5%
Vine maple	*Acer circinatum*	FAC	native	na	1.3%
Lesser herb Robert	*Geranium robertianum*	FACU	introduced	B	1.3%
Pacific willow	*Salix lasiandra*	FACW	native	na	1.3%
Stink currant	*Ribes bracteosum*	FAC	native	na	0.80%
English ivy	*Hedera helix*	FACU	introduced	na	0.67%
Trailing blackberry	*Rubus ursinus*	FACU	native	na	0.67%
Giant horsetail	*Equisetum telmateia*	FACW	native	na	0.53%
Field horsetail	*Equisetum arvense*	FAC	native	na	0.27%
Deer fern	*Blechnum spicant*	FAC	native	na	0.13%
Black hawthorn	*Crataegus douglasii*	FAC	native	na	0.13%
Stickywilly	*Galium aparine*	FACU	native	na	0.13%
Shrub / Sapling Stratum					
Salmonberry	*Rubus spectabilis*	FAC	native	na	35%[e]
Himalayan blackberry	*Rubus armeniacus*	FAC	introduced	C	11%[e]
Reed canarygrass	*Phalaris arundinacea*	FACW	introduced[f]	C	9.0%[e]
Trailing blackberry	*Rubus ursinus*	FACU	native	na	7.7%
Clustered rose	*Rosa pisocarpa*	FAC	native	na	6.4%
Stink currant	*Ribes bracteosum*	FAC	native	na	6.3%
Pacific willow	*Salix lasiandra*	FACW	native	na	4.4%
Western red-cedar	*Thuja plicata*	FAC	native	na	3.8%
Osoberry	*Oemleria cerasiformis*	FACU	native	na	3.4%
Northern bracken fern	*Pteridium aquilinum*	FACU	native	na	3.1%
English holly	*Ilex aquifolium*	FACU	introduced	WOC	1.8%
Cherry laurel	*Prunus laurocerasus*	FACU	introduced	WOC	1.8%
Slough sedge	*Carex obnupta*	OBL	native	na	1.8%
Oregon crab apple	*Malus fusca*	FACW	native	na	1.7%
Red osier dogwood	*Cornus alba*	FACW	native	na	1.4%
Nootka rose	*Rosa nutkana*	FAC	native	na	0.48%
Mannagrass	*Glyceria sp.*	OBL	native	na	0.38%

Species Common Name	Species Scientific Name	Indicator Status[a]	Native Status[b]	Washington Noxious Weed Classification[c]	Relative Cover (%)[d]
Giant horsetail	*Equisetum telmateia*	FACW	native	na	0.32%
Lady fern	*Athyrium filix-femina*	FAC	native	na	0.25%

[a] Wetland indicator status according to Lichvar et al. (2016).
[b] Native status according to NRCS (USDA 2019).
[c] Designation according to the Washington State Noxious Weed Control Board (WA NWCB 2019a).
[d] Relative percent cover is a measure of the percent of vegetated area within a given stratum that is covered by a specific species.
[e] Dominant species using the 50/20 rule (Lichvar et al. 2016).
[f] Some cultivars of reed canarygrass may be native to North America (WA NWCB 1995); however, European cultivars were introduced for forage and hay, and given the invasive nature of the species in the Pacific Northwest, it is considered to be an introduced species for the purposes of this inventory.

OBL – obligate
FAC – facultative
FACU – facultative upland
FACW – facultative wetland
na – not applicable
NRCS – Natural Resources Conservation Service
UPL – upland
WOC – weed of concern

4.6.2.4 Shellabarger Marsh north buffer zone

Invasive and other weedy vegetation dominates the herbaceous and shrub/sapling strata of the north buffer zone of Shellabarger Marsh. Purple loosestrife and bittersweet nightshade were found to be dominant in the herbaceous stratum in the summer; bittersweet nightshade and field bindweed were dominant in this stratum in the spring (Table 4-13). Himalayan blackberry comprised more than 50% of the vegetative cover in the shrub/sapling stratum, with reed canarygrass comprising another nearly 10%. Native species identified in the north buffer zone of Shellabarger Marsh were red alder and broadleaf cattail. Vegetation in this zone passed the hydrophytic dominance test according to (USACE 2010) at 100% designation of OBL, FACW, or FAC species.

Table 4-13. Herbaceous and shrub/sapling vegetation of the north buffer zone of Shellabarger Marsh

Species Common Name	Species Scientific Name	Indicator Status[a]	Native Status[b]	Washington Noxious Weed Classification[c]	Relative Cover (%)[d]
Herbaceous Stratum[e]					
Summer 2018					
Purple loosestrife	*Lythrum salicaria*	OBL	introduced	B	37%[e]
Bittersweet nightshade	*Solanum dulcamara*	FAC	introduced	WOC	32%[e]
Lady fern	*Athyrium filix-femina*	FAC	native	na	13%
Field bindweed	*Convolvulus arvensis*	FACU	introduced	C	11%
Reed canarygrass	*Phalaris arundinacea*	FACW	introduced[f]	C	5.3%
Red alder	*Alnus rubra*	FAC	native	na	2.6%

Species Common Name	Species Scientific Name	Indicator Status[a]	Native Status[b]	Washington Noxious Weed Classification[c]	Relative Cover (%)[d]
Spring 2019					
Bittersweet nightshade	*Solanum dulcamara*	FAC	introduced	WOC	65%[e]
Field bindweed	*Convolvulus arvensis*	FACU	introduced	C	22%
Himalayan blackberry	*Rubus armeniacus*	FAC	introduced	C	8.7%
Broadleaf cattail	*Typha latifolia*	OBL	native	na	4.3%
Shrub/Sapling Stratum					
Himalayan blackberry	*Rubus armeniacus*	FAC	introduced	C	57%[e]
Field bindweed	*Convolvulus arvensis*	FACU	introduced	C	16%
Purple loosestrife	*Lythrum salicaria*	OBL	introduced	B	13%
Reed canarygrass	*Phalaris arundinacea*	FACW	introduced[f]	C	9.4%
Broadleaf cattail	*Typha latifolia*	OBL	native	na	3.9%

[a] Wetland indicator status according to Lichvar et al. (2016).

[b] Native status according to NRCS (USDA 2019).

[c] Designation according to the Washington State Noxious Weed Control Board (WA NWCB 2019a).

[d] Relative percent cover is a measure of the percent of vegetated area within a given stratum that is covered by a specific species.

[e] Dominant species using the 50/20 rule (Lichvar et al. 2016).

[f] Some cultivars of reed canarygrass may be native to North America (WA NWCB 1995); however, European cultivars were introduced for forage and hay, and given the invasive nature of the species in the Pacific Northwest, it is considered to be an introduced species for the purposes of this inventory.

OBL – obligate
FAC – facultative
FACU – facultative upland
FACW – facultative wetland
na – not applicable
NRCS – Natural Resources Conservation Service
UPL – upland
WOC – weed of concern

4.7 LARGE WOODY DEBRIS SURVEYS

Surveys for LWD were conducted simultaneously with vegetation surveys. Very few pieces of LWD were found in the western portion of the Marsh interior; pieces that were encountered are shown on Map 2. There appeared to be more pieces of LWD in the eastern portion of the Marsh, particularly around the edge of the Marsh where emergent vegetation meets the surrounding riparian/buffer habitat. These pieces of LWD were very difficult to inventory, however, given the density of the vegetation growing around and covering them.

Pieces of LWD encountered in the vegetation transects in the buffer zones were inventoried during the quantitative vegetation surveys (Table 4-14). One log was identified within each of the transects (S1 and S2) in the south buffer zone, two pieces of LWD (one stump and one log) were encountered in the north buffer zone of Shellabarger Marsh (SB1), three pieces of LWD were identified within the second transect in the southeast buffer zone (SE2), and one piece of LWD was encountered in the north buffer zone (Transect N3). No LWD pieces were encountered in Transects SE1, SE3, N1, N2, or N4.

Table 4-14. Inventory of LWD pieces identified within the vegetation transects

Transect No.	Location	Type	Length (m)	Diameter at Midpoint (cm)	Decay Class	Wood Type	Species
S1	S1 transect @ 10.45 m	log[a]	10.54	12.0	4	D	red alder (likely)
S2	S2 transect	log[a]	35	27.5	1	D	red alder
SB1	SB1 transect@ 13.7 m	stump	3	na	1	D	red alder
SB1	SB1 transect @ 10.0 m	log	8.75	13.7	1	D	red alder
SE2	SE2 transect @ 17.1 m	log	7.5	8.3[b]	3	D	not determined
SE2	SE2 transect @ 10 m	log	12	11.7	2	D	not determined
SE2	SE2 transect @ 10.4 m	log	6	9.7[b]	2	D	not determined
N3	N3 transect @ 6.0 m	log	2.9	13.7	4	D	not determined

a Log was located within the creek channel and had many woodpecker holes in it.
b Diameter at midpoint was slightly less than the 10-cm minimum typically used as the definition of LWD.
D – deciduous
LWD – large woody debris

4.8 INVERTEBRATE SURVEYS

The baseline study invertebrate fallout trap stations were located at the Marsh-ward ends of select vegetation transects (one transect from each buffer zone) (Map 4). Three replicate samples were collected from each station during two seasons: summer and spring. This section contains summary tables of the invertebrate fallout trap data; complete data tables (wherein each specimen captured is presented separately) are included in Appendix D. Table 4-15 lists the full suite of invertebrate Orders identified in either season using the fallout traps, as well as the common name of examples of invertebrates that are included within that Order for ease of reference.

Table 4-15. Orders of invertebrates identified within baseline study fallout trap samples

Order	Examples/Common Names
Acari[a]	mites and ticks
Araneae	spiders
Blattodea	cockroaches and termites
Coleoptera	beetles
Collembola	springtails
Dermaptera	earwigs
Diptera	flies
Gastropoda	slugs and snails
Hemiptera	“true bugs:” cicadas, aphids, etc.
Hymenoptera	bees, ants, and wasps
Isopoda	woodlice

Order	Examples/Common Names
Lepidoptera	moths and butterflies
Odonata	dragonflies
Opiliones	harvestmen
Orthoptera	grasshoppers, locusts, and crickets
Plecoptera	stoneflies
Pseudoscorpiones	book scorpions
Psocoptera	booklice and barklice
Trichoptera	caddisflies

[a] Acari is a Subclass; Orders of observed mites are uncertain.

The north buffer zone fallout trap was situated along vegetation Transect N4 (Map 4). A total of 23 invertebrate specimens were captured within the three replicate fallout traps in the north buffer zone in the summer, and a total of 36 specimens were captured in spring (Table 4-16). Overall, the diversity of invertebrate samples was greater in the summer than in spring, with approximately twice the number of Orders present in summer. Between eight and nine different Orders were identified in the summer (including Araneae, Collembola, Dipetera, Hemiptera, Isopoda, Orthoptera, Psocoptera, and Trichoptera), and four to five different Orders were identified in the spring (Araneae, Dipetera, Hymenoptera, and Odonata). A single specimen of an unidentified Order was collected in each season. Flies (Order Diptera) comprised the largest proportion (83%) of the spring sample but only 22% of the summer sample.

Table 4-16. Summary of fallout trap invertebrate data for the north buffer zone

Replicate	Order	No. of Specimens	Size Range	Notes
Summer Samples				
1	Araneae	1	5–6 mm	spider
1	Collembola	4	2.5–3 mm	springtails
1	Hemiptera	3	0.5–4 mm	one nymph
1	Isopoda	1	8 mm	woodlouse
1	unidentified grub	1	8 mm	likely Lepidoptera
2	Collembola	1	2 mm	springtail
2	Diptera	4	3–7 mm	likely non-biting midges and Anthomyiidae[a]
2	Orthoptera	1	4 mm	immature, wingless
3	Collembola	2	0.5–2 mm	springtails
3	Diptera	1	1.5 mm	midge
3	Isopoda	1	10 mm	woodlouse
3	Psocoptera	2	2 mm	barklice, winged

Replicate	Order	No. of Specimens	Size Range	Notes
3	Trichoptera	1	1.5 mm	caddisfly
	Total No. of Specimens:	23		
	Total No. of Orders:	8–9		
Spring Samples				
1	Araneae	2	2 mm	spiders
1	Diptera	14	2–4 mm	variety of flies including non-biting midges and black flies
1	Hymenoptera	1	1 mm	
1	Unidentified	1	<1 mm	looks like a springtail or bristletail
2	Diptera	12	2–10 mm	variety of flies including crane flies and black flies
3	Diptera	4	2–4 mm	variety of flies including black flies
3	Hymenoptera	1	2 mm	
3	Odonata	1	nr	specimen broken
	Total No. of Specimens:	36		
	Total No. of Orders:	4–5		

[a] Preliminary identification made with assistance from Dr. Merril Peterson, who indicated that further examination of the specimen would be needed to confirm this identification.

nr – not recorded

The southeast buffer zone fallout trap was situated along vegetation transect SE2 (Map 4). Overall tallies of invertebrates captured in the sample replicates were similar between seasons, with a total of 34 specimens captured in the summer and a total of 32 captured in spring (Table 4-17). The diversity of invertebrate samples was also similar between seasons, with between 8 and 12 different Orders identified in the summer (including Araneae, Coleoptera, Collembola, Diptera, Gastropoda, Hemiptera, Hymenoptera, and Plecoptera, as well as a few specimens of unidentified Order) and 10 different Orders identified in spring sampling (Araneae, Coleoptera, Collembola, Dermaptera, Diptera, Gastropoda, Isopoda, Opiliones, Pseudoscorpiones, and Psocoptera). Flies (Order Diptera) comprised the majority of the spring sample (63%) but only 26% of the summer sample.

Table 4-17. Summary of fallout trap invertebrate data for the southeast buffer zone

Replicate	Order	No. of Specimens	Size Range	Notes
Summer Samples				
1	Araneae	3	3–6 mm	spiders
1	Collembola	3	<1–1 mm	springtails
1	Diptera	2	2–3 mm	flies
1	Gastropoda	1	12 mm	slug
1	Hemiptera	1	Nr	damsel bug

Replicate	Order	No. of Specimens	Size Range	Notes
2	Araneae	4	1–4 mm	
2	Coleoptera	1	5 mm	beetle
2	Diptera	3	0.5–1 mm	various flies, two hunchback
2	Hymenoptera	1	1 mm	ant
2	Unidentified	3	1–4 mm	one grub, one instar
3	Araneae	2	nr	spiders
3	Coleoptera	1	nr	beetle
3	Collembola	1	1–2 mm	springtail
3	Diptera	4	3–5 mm	various flies, one crane fly
3	Gastropoda	1	15 mm	
3	Plecoptera	1	Nr	stonefly
3	unidentified larvae	2	Nr	
	Total No. of Specimens:	34		
	Total No. of Orders:	8–12		
Spring Samples				
1	Diptera	5	3–4 mm	various flies including midges
1	Gastropoda	1	15 mm	slug
1	Isopoda	2	8 mm	European sowbugs
2	Araneae	1	7 mm	spider
2	Collembola	1	2 mm	
2	Dermaptera	1	15 mm	pseudoscorpion clinging to antenna
2	Diptera	10	5–10 mm	variety of flies, likely including crane flies, non-biting midges, and Anthomyiidae[a]
2	Gastropoda	1	20 mm	slug
2	Opiliones	1	5 mm	harvestman
2	Pseudoscorpiones	1	2 mm	house pseudoscorpion, clinging to antenna of Dermaptera specimen
2	Psocoptera	1	1 mm	booklouse or barklouse
3	Coleoptera	1	3 mm	beetle
3	Diptera	5	2–10 mm	variety of flies, likely including midges and Anthomyiidae[a]
3	Gastropoda	1	15 mm	slug
	Total No. of Specimens:	32		
	Total No. of Orders:	10		

[a] Preliminary identification made with assistance from Dr. Merril Peterson, who indicated that further examination of the specimen would be needed to confirm this identification.

nr – not recorded

The south buffer zone fallout trap was situated along vegetation transect S2 (Map 4). Approximately twice as many invertebrates were captured during summer sampling compared to spring sampling. Overall tallies of invertebrates captured were 59 in summer and 27 in spring (Table 4-18). Approximately twice the number of invertebrate Orders were identified in summer compared to spring as well; between 9 and 10 Orders were observed in the summer samples (including Acari, Araneae, Coleoptera, Collembola, Diptera, Gastropoda, Hemiptera, Opiliones, and Plecoptera, as well as a larva of unidentified Order), and 4 Orders were observed in the spring samples (Araneae, Coleoptera, Diptera, and Psocoptera). Flies (Order Diptera) comprised the majority of the samples during both seasons, with 76% of the summer sample containing flies and 78% of the spring sample containing flies.

Table 4-18. Summary of fallout trap invertebrate data for the south buffer zone

Replicate	Order	No. of Specimens	Size Range	Notes
Summer Samples				
1	Coleoptera	1	2–3 mm	possibly Meloidae (blister beetle)
1	Collembola	1	nr	globular springtail
1	Diptera	9	1–10 mm	variety of flies
1	Gastropoda	1	nr	slug
1	Hemiptera	1	7 mm	most likely *Philaenus spumarius* (meadow spittlebug)[a]
1	Opiliones	2	nr	harvestmen
1	Plecoptera	1	nr	stonefly
2	Diptera	20	1–6 mm	variety of flies, including gnats and midges
2	Hemiptera	1	nr	aphid
2	Plecoptera	1	nr	stonefly
2	Unidentified larva	1	nr	
3	Acari	1	nr	mite[b]
3	Araneae	1	0.5 mm	spider
3	Collembola	1	nr	springtail
3	Diptera	16	1–5 mm	variety of flies, including mosquitos, non-biting midges, and crane flies
3	Gastropoda	1	17 mm	slug
Total No. of Specimens:		59		
Total No. of Orders:		9–10		
Spring Samples				
1	Araneae	3	1–4 mm	spiders
1	Diptera	7	1–3 mm	variety of flies, including midges and black flies
1	Psocoptera	1	1 mm	booklouse or barklouse
2	Coleoptera	1	12 mm	beetle
2	Diptera	5	3–8 mm	variety of flies, likely including midges and Anthomyiidae[a]

Replicate	Order	No. of Specimens	Size Range	Notes
3	Araneae	1	7 mm	spider
3	Diptera	9	2–4 mm	variety of flies, including midges
	Total No. of Specimens:	27		
	Total No. of Orders:	4		

[a] Preliminary identification made with assistance from Dr. Merril Peterson, who indicated that further examination of the specimen would be needed to confirm this identification.

[b] Acari is a Subclass; Order of observed mite is uncertain.

nr – not recorded

The Shellabarger Marsh north buffer zone fallout trap was situated along vegetation transect SB (Map 4). The summer tally of invertebrates captured at this fallout trap station was by far the highest of all stations and seasons: 435 specimens from between 11 and 13 Orders (Table 4-19). In the spring samples, 57 specimens from between 4 and 5 Orders (including Araneae, Collembola, Diptera, and Hymenoptera) were captured. Flies (Order Diptera) comprised the majority of the samples in both the summer (88%) and spring (86%).

Table 4-19. Summary of fallout trap invertebrate data for the Shellabarger Marsh north buffer zone

Replicate	Order	No. of Specimens	Size Range	Notes
Summer Samples				
1	Acari[a]	1	< 1 mm	mite
1	Araneae	2	3–6 mm	spiders
1	Coleoptera	1	4 mm	beetle
1	Collembola	4	< 1–2.5 mm	springtails
1	Diptera	142	< 1–8 mm	variety of flies, including several non-biting midges
1	Gastropoda	2	4–5 mm	
1	Hemiptera	2	1 mm	aphids
1	Lepidoptera	1	5 mm	
1	Trichoptera	1	< 1 mm	caddisfly
1	Unidentified	2	< 1 mm–nr	one unidentified adult insect, one larva
2	Araneae	1	6 mm	spider
2	Blattodea	2	3–4 mm	termites, one winged
2	Coleoptera	1	2 mm	beetle
2	Collembola	6	< 1–2 mm	springtails
2	Diptera	139	1–25 mm	variety of flies, including midges, crane flies, mosquitos, and likely Anthomyiidae[b]
2	Gastropoda	2	5–15 mm	snails
2	Hemiptera	3	2–7 mm	one aphid, one likely *Philaenus spumarius* (meadow spittlebug)[b]

Replicate	Order	No. of Specimens	Size Range	Notes
2	Hymenoptera	1	5 mm	
3	Araneae	3	2–5 mm	spiders
3	Coleoptera	7	1.5–4.5 mm	beetles
3	Collembola	2	1 mm	springtails
3	Diptera	103	1.5–25 mm	variety of flies, including midges, crane flies, and mosquitos
3	Gastropoda	1	7 mm	
3	Hemiptera	4	1–5 mm	aphids
3	Unidentified	2	1.5 mm–nr	one adult insect, one larva
Total No. of Specimens:		435		
Total No. of Orders:		11–13		
Spring Samples				
1	Araneae	1	2 mm	spider
1	Collembola	1	2 mm	springtail
1	Diptera	13	2–25 mm	variety of flies, including crane flies and non-biting midges
1	Hymenoptera	2	7–12 mm	bees
1	Unidentified	1	3 mm	2 pairs of wings
2	Collembola	1	2–3 mm	springtail
2	Diptera	22	1–20 mm	variety of flies, including crane flies and midges
3	Araneae	2	7–8 mm	spiders
3	Diptera	14	3–15 mm	variety of flies, including crane flies
Total No. of Specimens:		57		
Total No. of Orders:		4–5		

[a] Acari is a Subclass; Order of observed mite is uncertain.

[b] Preliminary identification made with assistance from Dr. Merril Peterson, who indicated that further examination of the specimen would be needed to confirm this identification.

nr – not recorded

4.9 BIRD SURVEYS

The baseline study bird survey stations were located within or adjacent to buffer areas of the Marsh and Shellabarger Marsh (Map 4). BPC Station 1 (BPC-1) was located within the north buffer zone, at one of the Harbor Square boardwalk lookouts. Each season, between five and nine different species of birds were recorded at this location during the five-minute point count survey period (Table 4-20). Overall season tallies of individual birds ranged from 7 to 11, with the most species and the highest count of individual birds occurring during the spring survey. Birds surveyed at this location included sparrows (song sparrow [*Melospiza melodia*], golden-crowned sparrow [*Zonotrichia atricapilla*], and spotted towhee [*Pipilo maculatus*]), wrens (marsh wren [*Cistothorus palustris*], Bewick's wren [*Thryomanes bewickii*]), Anna's hummingbird

(*Calypte anna*), warblers (common yellowthroat [*Geothlypis trichas*], yellow-rumped warbler [*Setophaga coronate*]), black-capped chickadee (*Poecile atricapillus*), red-winged blackbird (*Agelaius phoeniceus*), American robin (*Turdus migratorius*), and American crow (*Corvus brachyrhynchos*). Additional species observed from BPC-1 outside of the formal five-minute survey times/radius included spotted towhees and a golden-crowned kinglet (*Regulus satrapa*), both during the winter survey (Table 4-20).

Table 4-20. Survey results for BPC-1 (Harbor Square boardwalk lookout)

Survey Date	Sunrise Time	Survey Begin Time	Survey End Time	Weather Conditions	Human Activity	Species Common Name	Species Scientific Name	Notes
7/19/2018	5:30	5:40	5:45	mostly clear, high overcast clouds, no precipitation, light wind, 58°F	people coming and going from athletic club at Harbor Square but little activity along boardwalk	common yellowthroat	*Geothlypis trichas*	2 heard
						marsh wren	*Cistothorus palustris*	1 heard
						song sparrow	*Melospiza melodia*	1 heard
						American crow	*Corvus brachyrhynchos*	1 seen; 1 heard
						Anna's hummingbird	*Calypte anna*	1 fly-over, east to west
							Total Species Count:	**5**
							Total Individual Count:	**7**
10/23/2018	7:41	9:03	9:08	foggy but no precipitation (sun breaks later in survey time period), very slight breeze, 46°F	no activity on trail; airplane flying over	song sparrow	*Melospiza melodia*	1 heard calling from cattails; 2 more seen foraging in alder trees in buffer
						black-capped chickadee	*Poecile atricapillus*	2 heard
						American robin	*Turdus migratorius*	2 heard
						gull (unidentified)	Family Laridae	1 heard
						golden-crowned sparrow	*Zonotrichia atricapilla*	1 heard
							Total Species Count:	**5**
							Total Individual Count:	**9**
1/28/2019	7:42	8:05	8:10	high cloud cover, slight fog lifting (but visibility >50 m), no precipitation, no wind, 39°F	ferry horn blasted a few times throughout survey period	Anna's hummingbird	*Calypte anna*	1 heard
						song sparrow	*Melospiza melodia*	1 heard
						American robin	*Turdus migratorius*	2 heard
						marsh wren	*Cistothorus palustris*	1 seen and heard
						red-winged blackbird	*Agelaius phoeniceus*	1 heard
						golden-crowned sparrow	*Zonotrichia atricapilla*	1 heard
						yellow-rumped warbler	*Setophaga coronata*	1 seen and heard (female)
							Total Species Count:	**7**
							Total Individual Count:	**8**
								Other observations[a]: saw 2 spotted towhees (*Pipilo maculatus*) and 1 golden-crowned kinglet (*Regulus satrapa*) just before starting survey

Survey Date	Sunrise Time	Survey Begin Time	Survey End Time	Weather Conditions	Human Activity	Species Common Name	Species Scientific Name	Notes
5/7/2019	5:41	6:08	6:13	clear, no precipitation, no wind, 50°F	train passed blowing horn during survey	common yellowthroat	*Geothlypis trichas*	1 heard
						black-capped chickadee	*Poecile atricapillus*	1 seen and heard; entered small snag nesting cavity (willow dead branch) within buffer
						American robin	*Turdus migratorius*	1 heard
						red-winged blackbird	*Agelaius phoeniceus*	1 heard
						marsh wren	*Cistothorus palustris*	2–3 heard
						Bewick's wren	*Thryomanes bewickii*	seen in same willow as black-capped chickadee nesting cavity
						spotted towhee	*Pipilo maculatus*	1 heard in buffer zone, close to buildings of Harbor Square
						Anna's hummingbird	*Calypte anna*	1 heard
						golden-crowned sparrow	*Zonotrichia atricapilla*	1 heard
							Total Species Count:	**9**
							Total Individual Count:	**10–11**

[a] Other observations were those that were made either right before or right after the formal survey period, or while traversing the Marsh or buffer areas in between point count stations.

BPC – bird point count   Marsh – Edmonds Marsh

BPC-2 was located along the southwest border of the Marsh adjacent to Willow Creek and the Unocal Site (Map 4). Each season, between four and eight different species of birds were recorded at this location during the five-minute point count survey period; the most species were observed during the summer and spring surveys (Table 4-21). Overall season tallies of individual birds ranged from 5 to between 14 and 16, with the highest count of individual birds occurring during the spring survey. Birds surveyed at this location included wrens (marsh wren, Bewick's wren), sparrows (song sparrow, and golden-crowned sparrow, and spotted towhee), Anna's hummingbird, common yellowthroat, American goldfinch (*Spinus tristis)*, American crow, tree swallow (*Tachycineta bicolor*), black-capped chickadee, red-winged blackbird, belted kingfisher (*Megaceryle alcyon)*, great blue heron (*Ardea herodias)*, mallard duck (*Anas platyrhynchos*), and a northern harrier (*Circus hudsonius)*. Additional species observed from BPC-2 outside of the formal five-minute survey times/radius included red-winged blackbirds and great blue herons during the winter survey and mallard ducks and a red-tailed hawk (*Buteo jamaicensis*) during the spring survey (Table 4-21).

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Table 4-21. Survey results for BPC-2 (Marsh interior adjacent to Willow Creek)

Survey Date	Sunrise Time	Survey Begin Time	Survey End Time	Weather Conditions	Human Activity	Species Common Name	Species Scientific Name	Notes
7/19/2018	5:30	5:51	5:56	mostly clear, high overcast clouds, no precipitation, light wind, 58°F	none within point count radius/area	marsh wren	*Cistothorus palustris*	1 seen; 1 heard in hardstem bulrush patch
						American crow	*Corvus brachyrhynchos*	1 seen in snag above creek; 2 fly-overs
						tree swallow	*Tachycineta bicolor*	3 seen
						belted kingfisher	*Megaceryle alcyon*	1 heard from Unocal Site
						common yellowthroat	*Geothlypis trichas*	1 heard in hardstem bulrush patch
						black-capped chickadee	*Poecile atricapillus*	1 heard
						mallard	*Anas platyrhynchos*	2 seen in creek
						song sparrow	*Melospiza melodia*	1 heard
						Canada goose	*Branta canadensis*	2 fly-overs
							Total Species Count:	**8[a]**
							Total Individual Count:	**12[a]**
10/23/2018	7:41	9:21	9:26	foggy but no precipitation (sun breaks later in survey time period), very slight breeze, 46°F	dog barking in distance, train passed just before survey started	song sparrow	*Melospiza melodia*	1 heard
						Anna's hummingbird	*Calypte anna*	1 seen foraging high in pine tree along creek; 1 heard
						northern harrier	*Circus hudsonius*	1 seen perched in snag along creek, near west end of survey station; juvenile (orangish breast)
						American goldfinch	*Spinus tristis*	3 heard
						gull (unidentified)	Family Laridae	5 fly-overs
							Total Species Count:	**4[a]**
							Total Individual Count:	**7[a]**
								Other observations:[b] great blue heron heard just before survey started; red-winged blackbird heard just after survey ended

Survey Date	Sunrise Time	Survey Begin Time	Survey End Time	Weather Conditions	Human Activity	Species Common Name	Species Scientific Name	Notes
1/28/2019	7:42	8:30	8:35	high cloud cover, slight fog lifting (but visibility >50 m), no precipitation, no wind, 39°F	dog barking in distance, noisy work on railroad tracks, audible traffic on SR-104	song sparrow	*Melospiza melodia*	1 heard
						great blue heron	*Ardea herodias*	1 seen in pine tree adjacent to creek
						Bewick's wren	*Thryomanes bewickii*	2 heard from Unocal side of creek
						golden-crowned sparrow	*Zonotrichia atricapilla*	1 heard
						American crow	*Corvus brachyrhynchos*	1 fly-over
							Total Species Count:	**4[a]**
							Total Individual Count:	**5[a]**
								Other observations:[b] Heard red-winged blackbird singing from Unocal Site side of creek just before starting survey; two additional great blue herons observed after survey ended (pair flew in from the southwest to perch in pine tree growing along Willow Creek)
5/7/2019	5:41	6:25	6:30	clear, no precipitation, no wind, 50°F	none	American crow	*Corvus brachyrhynchos*	1 seen and heard in pine tree along Willow Creek; scolding
						common yellowthroat	*Geothlypis trichas*	1 heard
						marsh wren	*Cistothorus palustris*	2–3 heard
						red-winged blackbird	*Agelaius phoeniceus*	1 seen and heard in pine tree along Willow Creek and then flying up to Unocal Site, scolding; then another 3–4 birds observed
						tree swallow	*Tachycineta bicolor*	3 seen flying over Marsh
						song sparrow	*Melospiza melodia*	1 seen hopping along wood in creek
						spotted towhee	*Pipilo maculatus*	1 perched in pine snag along creek
						Anna's hummingbird	*Calypte anna*	1 seen perched in same pine tree where towhee had been
						bald eagle	*Haliaeetus leucocephalus*	1 fly-over
							Total Species Count:	**8[c]**
							Total Individual Count:	**14-16[c]**
								Other observations:[b] Red-tailed hawk (*Buteo jamaicensis*) seen and heard while traversing Marsh to point count station; hawk being chased by crow near/toward Hatchery; also observed several mallards within Marsh and one in Willow Creek

[a] Tally does not include fly-overs.
[b] Other observations were those made either right before or right after the formal survey period, or while traversing the Marsh or buffer areas in between point count stations.
[c] Tally does not include fly-overs except for tree swallows that were interacting with the Marsh (foraging).
BPC – bird point count
Hatchery – Willow Creek fish hatchery
Marsh – Edmonds Marsh
SR – State Route

BPC-3 was located northwest of the Hatchery within the cattail-dominated portion of the Marsh, near Willow Creek (Map 4). Three different species of birds were observed at this location during the five-minute point count survey period in the summer, and six species were observed within the survey period during each of the other seasons (Table 4-22). Overall season tallies of individual birds ranged from 4 to between 17 and 18, with the highest count of individual birds occurring during the winter survey (when a flock of several golden-crowned sparrows contributed to the high count). Birds surveyed at this location included wrens (marsh wren, Bewick's wren), sparrows (song sparrow and golden-crowned sparrow), Anna's hummingbird, American robin, American crow, black-capped chickadee, red-winged blackbird, ruby-crowned kinglet (*Regulus calendula)*, and woodpeckers (downy woodpecker [*Dryobates pubescens*] and northern flicker [*Colaptes auratus*]). Additional species observed from BPC-3 outside of the formal five-minute survey times/radius included a flock of 8 to 10 pine siskin (*Spinus pinus*) observed in the riparian vegetation along Willow Creek during the winter survey, a Virginia rail (*Rallus limicola*) observed during the winter survey, and a red-breasted nuthatch (*Sitta canadensis*) and a common yellowthroat observed during the spring survey (Table 4-22). An old bushtit (*Psaltriparus minimus*) nest was also observed during the winter survey, hanging from bittersweet nightshade vines that were growing on a scrubby alder tree near the survey station marker.

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Table 4-22. Survey results for BPC-3 (northwest of Hatchery within Marsh)

Survey Date	Sunrise Time	Survey Begin Time	Survey End Time	Weather Conditions	Human Activity	Species Common Name	Species Scientific Name	Notes
7/19/2018	5:30	7:03	7:08	mostly clear, high overcast clouds, no precipitation, light wind, 58° F	none within point count radius/area	marsh wren	*Cistothorus palustris*	2 heard
						Bewick's wren	*Thryomanes bewickii*	1 heard
						American crow	*Corvus brachyrhynchos*	3 fly-overs, northeast to southwest
						Anna's hummingbird	*Calypte anna*	1 fly-over
							Total Species Count:	**3[a]**
							Total Individual Count:	**4[a]**
10/23/2018	7:41	8:07	8:12	foggy but no precipitation (sun breaks later in survey time period), very slight breeze, 46° F	none	marsh wren	*Cistothorus palustris*	1 heard
						American robin	*Turdus migratorius*	1 heard; 1 fly-over
						song sparrow	*Melospiza melodia*	1 heard
						Anna's hummingbird	*Calypte anna*	1 heard
						northern flicker	*Colaptes auratus*	2 seen in riparian tree northeast of survey station
						duck (unidentified)	Family Anatidae	2 fly-overs, northeast to southwest
						downy woodpecker	*Dryobates pubescens*	1 heard
							Total Species Count:	**6[a]**
							Total Individual Count:	**7[a]**
1/28/2019	7:42	9:25	9:30	high cloud cover, slight fog lifting (but visibility >50 m), no precipitation, no wind, 39° F	SR-104 traffic noise; boat horn blasts in distance	golden-crowned sparrow	*Zonotrichia atricapilla*	8 seen perching in alder covered in bittersweet nightshade, eating nightshade berries
						marsh wren	*Cistothorus palustris*	2 heard
						song sparrow	*Melospiza melodia*	2 heard
						red-winged blackbird	*Agelaius phoeniceus*	1 heard
						black-capped chickadee	*Poecile atricapillus*	3 to 4 heard
						ruby-crowned kinglet	*Regulus calendula*	1 seen; male flashing red crown
							Total Species Count:	**6**
							Total Individual Count:	**17–18**
								Other observations:[b] old bushtit nest hanging on bittersweet nightshade vines climbing scrubby alder tree near survey station marker; small flock of 8–10 pine siskin (*Spinus pinus*) observed in riparian vegetation along Willow Creek just after survey ended; heard Virginia rail (*Rallus limicola*) grunt calls in cattail after formal survey ended

Survey Date	Sunrise Time	Survey Begin Time	Survey End Time	Weather Conditions	Human Activity	Species Common Name	Species Scientific Name	Notes
5/7/2019	5:41	7:10	7:15	clear, no precipitation, no wind, 50° F	traffic noise from SR-104, train whistle	marsh wren	*Cistothorus palustris*	3 heard
						song sparrow	*Melospiza melodia*	2 heard
						American robin	*Turdus migratorius*	1 heard
						red-winged blackbird	*Agelaius phoeniceus*	1 heard
						black-capped chickadee	*Poecile atricapillus*	2 heard
						American crow	*Corvus brachyrhynchos*	3 seen and heard
							Total Species Count:	**6**
							Total Individual Count:	**12**
								Other observations:[b] just after survey ended, red-breasted nuthatch (*Sitta canadensis*) heard from riparian habitat and common yellowthroat (*Geothlypis trichas)* seen in willow to west of survey station marker

[a] Tally does not include fly-overs.

[b] Other observations were those made either right before or right after the formal survey period, or while traversing the Marsh or buffer areas in between point count stations.

BPC – bird point count

Hatchery – Willow Creek fish hatchery

Marsh – Edmonds Marsh

SR – State Route

BPC-4 was located within the wooded riparian habitat of the Hatchery, near Willow Creek (Map 4). Each season, between four and six different species of birds were recorded at this location during the five-minute point count survey period (Table 4-23). Overall season tallies of individual birds ranged from five to eight. Birds surveyed at this location included black-capped chickadee, sparrows (song sparrow and spotted towhee), Bewick's wren, Pacific-slope flycatcher (*Empidonax difficilis*), American robin, American crow, golden-crowned kinglet, and woodpeckers (downy woodpecker and northern flicker). Additional species observed from BPC-4 outside of the formal five-minute survey times/radius included a varied thrush (*Ixoreus naevius*) (observed along the forest floor of the Willow Creek floodplain during the winter survey) and a red-tailed hawk (audible cry) during the spring survey (Table 4-23).

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Table 4-23. Survey results for BPC-4 (Hatchery riparian habitat)

Survey Date	Sunrise Time	Survey Begin Time	Survey End Time	Weather Conditions	Human Activity	Species Common Name	Species Scientific Name	Notes
7/19/2018	5:30	6:50	6:55	mostly clear, high overcast clouds, no precipitation, light wind, 58°F	none other than traffic noise from SR-104	spotted towhee	*Pipilo maculatus*	1 seen; 2 heard (3 birds total)
						Pacific-slope flycatcher	*Empidonax difficilis*	1 heard
						black-capped chickadee	*Poecile atricapillus*	1 heard
						song sparrow	*Melospiza melodia*	1 heard
						golden-crowned kinglet	*Regulus satrapa*	1 heard
						American crow	*Corvus brachyrhynchos*	1 heard
							Total Species Count:	**6**
							Total Individual Count:	**8**
10/23/2018	7:41	7:54	7:59	foggy but no precipitation (sun breaks later in survey time period), very slight breeze, 46°F	dog barking from highway; traffic noise from SR-104	American robin	*Turdus migratorius*	1 heard
						black-capped chickadee	*Poecile atricapillus*	2 heard
						northern flicker	*Colaptes auratus*	1 heard
						song sparrow	*Melospiza melodia*	1 seen and heard
							Total Species Count:	**4**
							Total Individual Count:	**5**
1/28/2019	7:42	9:07	9:12	high cloud cover, slight fog lifting (but visibility >50 m), no precipitation, no wind, 39°F	SR-104 traffic noise; outflow from Hatchery holding pond loud	black-capped chickadee	*Poecile atricapillus*	1 heard
						song sparrow	*Melospiza melodia*	2 heard
						American crow	*Corvus brachyrhynchos*	3 fly-overs
						American robin	*Turdus migratorius*	1 heard
						golden-crowned kinglet	*Regulus satrapa*	1 heard
							Total Species Count:	**4[a]**
							Total Individual Count:	**5[a]**
								Other observations:[b] varied thrush (*Ixoreus naevius*) hopping along riparian forest floor adjacent to Willow Creek just after completing survey
5/7/2019	5:41	6:55	7:00	clear, no precipitation, no wind, 50° F	Traffic noise from SR-104; Hatchery holding pond discharging; no other people present	song sparrow	*Melospiza melodia*	3 heard
						American crow	*Corvus brachyrhynchos*	1 heard
						downy woodpecker	*Dryobates pubescens*	1 heard
						Bewick's wren	*Thryomanes bewickii*	1 heard
							Total Species Count:	**4**
							Total Individual Count:	**6**
								Other observations:[b] red-tailed hawk cry just before survey started

[a] Tally does not include fly-overs.

[b] Other observations were those made either right before or right after the formal survey period, or while traversing the Marsh or buffer areas in between point count stations.

BPC – bird point count   Hatchery – Willow Creek fish hatchery   Marsh – Edmonds Marsh   SR – State Route

BPC-5 was located adjacent to the north buffer zone of Shellabarger Marsh along 2nd Avenue South (Map 4). Each season, between three and nine different species of birds were recorded at this location during the five-minute point count survey period (Table 4-24). Overall season tallies of individual birds ranged from 4 to 17, with the fewest species and individuals being observed during the fall survey, and the most species and individuals being observed during the winter and spring surveys. Birds surveyed at this location included wrens (marsh wren, Bewick's wren), sparrows (song sparrow, white-crowned sparrow [*Zonotrichia leucophrys*], dark-eyed junco [*Junco hyemalis*] and spotted towhee), Wilson's warbler (*Cardellina pusilla*), Anna's hummingbird, finches (American goldfinch and house finch [*Haemorhous mexicanus*]), red-winged blackbird, American robin, American crow, and a gull.

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Table 4-24. Survey results for BPC-5 (off 2nd Avenue South near Shellabarger Marsh)

Survey Date	Sunrise Time	Survey Begin Time	Survey End Time	Weather Conditions	Human Activity	Species Common Name	Species Scientific Name	Notes
7/19/2018	5:30	6:35	6:40	mostly clear, high overcast clouds, no precipitation, light wind, 58°F	none within point count radius/area	red-winged blackbird	*Agelaius phoeniceus*	1 heard
						marsh wren	*Cistothorus palustris*	3 heard from interior of Shellabarger Marsh
						Bewick's wren	*Thryomanes bewickii*	1 heard
						Anna's hummingbird	*Calypte anna*	1 fly-over
						American crow	*Corvus brachyrhynchos*	1 seen perched in alder in Shellabarger Marsh north buffer zone
						great blue heron	*Ardea herodias*	1 fly-over, northeast to southwest
						American goldfinch	*Spinus tristis*	2 fly-overs, vocalizing
							Total Species Count:	**4[a]**
							Total Individual Count:	**6[a]**
10/23/2018	7:41	7:33	7:38	foggy but no precipitation (sun breaks later in survey time period), very slight breeze, 46°F	traffic noise from SR-104, no vehicle or pedestrian traffic on 2nd Avenue South during survey	song sparrow	*Melospiza melodia*	2 heard
						American crow	*Corvus brachyrhynchos*	7 fly-overs, east to west
						gull (unidentified)	Family Laridae	1 heard calling; unsure of species
						house finch	*Haemorhous mexicanus*	1 heard
							Total Species Count:	**3[a]**
							Total Individual Count:	**4[a]**
1/28/2019	7:42	7:47	7:51	high cloud cover, slight fog lifting (but visibility >50 m), no precipitation, no wind, 39°F	none	Anna's hummingbird	*Calypte anna*	2 seen and heard in yard of neighboring home
						American crow	*Corvus brachyrhynchos*	1 heard
						dark-eyed junco	*Junco hyemalis*	1 heard
						red-winged blackbird	*Agelaius phoeniceus*	2 heard from Shellabarger Marsh
						American robin	*Turdus migratorius*	2–3 heard
						song sparrow	*Melospiza melodia*	1 heard
						spotted towhee	*Pipilo maculatus*	1 heard
						white-crowned sparrow	*Zonotrichia leucophrys*	flock of 6 seen in berry-bearing shrub in neighboring yard
							Total Species Count:	**8**
							Total Individual Count:	**16–17**

Survey Date	Sunrise Time	Survey Begin Time	Survey End Time	Weather Conditions	Human Activity	Species Common Name	Species Scientific Name	Notes
5/7/2019	5:41	5:50	5:55	clear, no precipitation, no wind, 50°F	traffic noise from SR-104	marsh wren	*Cistothorus palustris*	3–4 heard from Shellabarger Marsh interior
						white-crowned sparrow	*Zonotrichia leucophrys*	1 heard from Shellabarger Marsh
						red-winged blackbird	*Agelaius phoeniceus*	approximately 2 heard from Shellabarger Marsh
						American robin	*Turdus migratorius*	3 flying from northeast toward Shellabarger Marsh
						spotted towhee	*Pipilo maculatus*	1 heard from neighboring yard
						house finch	*Haemorhous mexicanus*	1 heard from Pine Street end vegetation
						Anna's hummingbird	*Calypte anna*	1 heard
						Wilson's warbler	*Cardellina pusilla*	1 heard from Shellabarger Marsh north buffer zone
						American crow	*Corvus brachyrhynchos*	1 flying over buffer into Shellabarger Marsh
							Total Species Count:	**9**
							Total Individual Count:	**14–15**
								Other observations[b]: spotted towhee observed in buffer vegetation just before starting survey

[a] Tally does not include fly-overs.

[b] Other observations were those made either right before or right after the formal survey period, or while traversing the Marsh or buffer areas in between point count stations.

BPC – bird point count
Hatchery – Willow Creek fish hatchery
Marsh – Edmonds Marsh
SR – State Route

4.10 OTHER WILDLIFE OBSERVATIONS

Hundreds of photos were taken by the three wildlife cameras (WC1, WC2, and WC3 on Map 4) over the course of the baseline monitoring year; the photos that best display wildlife use of the Marsh and south buffer zone are included in Appendix E. Some overall observations from the wildlife camera photos were:

- Wildlife camera WC1 captured heavy use of the south buffer zone by Columbian black-tailed deer, (*Odocoileus hemionus columbianus*),[22] coyote (*Canis latrans*), and other mammals such as rabbits and raccoons. Columbian black-tailed deer and coyote were photographed using the forested habitat of the south buffer zone during every season. Adult deer with fawns were photographed in August 2018 and June 2019, and bucks with antlers were photographed in October and November 2018 and June 2019.
- Birds were also captured on wildlife camera WC1 (in the south buffer zone). Kinglets, black-capped chickadees, and song sparrows (as well as other birds that could not be easily identified) were all photographed.
- A variety of shorebirds were photographed using the mudflat habitat of the Marsh to forage during low tide; however, the exact species generally could not be identified from the wildlife camera photos.
- Wildlife camera photos from cameras WC2 and WC3 showed great blue heron to be common in the mudflat areas of the Marsh at all times of the year. They forage in the portion of Willow Creek flowing along the southern boundary of the Marsh.
- Flocks of Canada geese and other waterfowl were also commonly photographed in the Marsh. Waterfowl use the mudflat areas during high tide and/or periods of high freshwater flow, when the Marsh is filled with water.

Incidental wildlife observations made while field work was being conducted for the baseline study were recorded in the field logbooks (Appendix B) as much as possible. Some highlights of the incidental wildlife observations were:

- Coyote tracks were commonly observed in the Marsh, and a group of coyotes was heard yipping from the Marsh interior during the October 2018 fall bird surveys. During the winter bird surveys in January 2019, a coyote was observed lying on a patch of saltgrass and Pacific silverweed (*Argentina egedii*) growing in the Marsh. The coyote ran into the cattails growing along Willow Creek and headed into the western portion of the Marsh when approached.
- Deer tracks were observed in the south buffer zone on numerous occasions and in the Marsh in July 2018.

[22] This is a subspecies of mule deer.

- A juvenile raccoon was observed sleeping on a leaning snag located just within the Marsh interior adjacent to the south buffer zone in October 2018.
- Large piles of waterfowl feathers were commonly observed in the Marsh, suggesting that one or more predator species is preying upon birds in the Marsh.
- Killdeer (*Charadrius vociferus*) were observed to be numerous and common in the mudflat areas of the Marsh, where they rest and forage throughout the year. Great blue heron and mallards were also commonly observed in the Marsh.
- Several different species of swallow—including barn swallows (*Hirundo rustica*), tree swallows, violet-green swallows (*Tachycineta thalassina*), and purple martin (*Progne* subis) were observed flying over and foraging within the Marsh and perched on the nest boxes that have been placed in the Marsh.
- The south buffer zone was observed to be heavily used by a variety of bird species, and several different species of woodpecker (i.e., pileated woodpecker [*Dryocopus pileatus*], downy woodpecker, northern flicker, and red-breasted sapsucker [*Sphyrapicus ruber*]) were observed either directly (i.e., seen or heard) or indirectly (e.g., sapsucker holes observed on standing snags). Numerous other species were identified in this area, most of which are represented in the bird point count survey data provided in Section 4.8. Additional species of birds that were observed incidentally in the south buffer zone, but not surveyed during the formal point count surveys, included varied thrush, Swainson's thrush (*Catharus ustulatus*), and brown creeper (*Certhia Americana*). Two brown creepers were observed foraging on a standing snag within the south buffer zone adjacent to Willow Creek in July 2018. One of the birds captured and ate a moth that had been resting on the snag.
- Several bird species were observed, either directly or indirectly, to be breeding in the Marsh or buffer areas:
  - A song sparrow was observed carrying nesting material in the south buffer zone in April 2018.
  - The shell of an American robin egg was observed in the south buffer zone in May 2018.
  - A female mallard with four ducklings was observed in Willow Creek within the south buffer zone in July 2019.
  - An adult spotted sandpiper and spotted sandpiper chick (*Actitis macularius*) were observed near the north mudflat wildlife camera in July 2019.
  - An Anna's hummingbird was observed gathering nesting material from a cattail head in January 2019.

    - An occupied marsh wren nest was observed in the cattails in the eastern portion of the Marsh in April 2019.
    - A black-capped chickadee was observed entering a cavity nest (hollow, dead branch of a willow) in May 2019.
- A rufous hummingbird (*Selasphorus rufus*) was heard flying above the southeast buffer zone in April 2019.
- Garter snakes (*Thamnophis* spp.) were observed in the north buffer zone of Shellabarger Marsh in July 2018, and two red-tailed hawks, one of which had a garter snake in its talons, were observed flying above the southeast buffer zone in April 2019.
- A mass of large amphibian eggs was observed within Shellabarger Creek, immediately upstream (east) of the SR-104 culvert in April 2019.
- Butterflies and dragonflies were observed landing on the exposed mudflat areas of the Marsh. In October 2018, numerous large orb-weaver spiders (Araneidae) and slugs were observed in the western portion of the Marsh.

4.11 PHOTO POINT MONITORING

The seasonal photo point photos taken over the course of the baseline monitoring year are presented in Appendix F. They serve as a visual record of existing baseline conditions within the Marsh, Shellabarger Marsh, and their buffer areas. These photos also provide documentation of short-term, temporary (i.e., seasonal) changes in vegetation community and structure, as well as mudflat conditions.

During the baseline monitoring year, the photos show that the Marsh and buffer vegetation is at peak productivity during spring and summer, in transition to dormancy in autumn, and dormant in winter. The extent of mudflat exposure and water levels within the Marsh are also documented in these photos, revealing more exposure not only during low-tide periods, but also during summer and autumn, as well as periods of little or no precipitation or freshwater input. Continued photo point monitoring would provide a record of longer-term changes in the area.

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5 Studies by Other Parties

The monitoring plan (Windward 2018a) summarized data and other information gathered within or near the Marsh by parties other than Windward, such as the Edmonds Stream Team water quality monitoring, and water quality monitoring that had been conducted to date by Shannon & Wilson as part of the Willow Creek Daylighting feasibility studies. During the baseline monitoring year, additional studies were conducted, and studies summarized in the monitoring plan continued to collect additional information. The following subsections provide an overview of available additional data and information collected by other parties throughout the baseline monitoring year (from approximately June 2018 to June 2019). For an overview of data and information collected prior to June 2018, review the summaries in the monitoring plan.

5.1 Edmonds Stream Team

Since the fall of 2015, members of the Edmonds Stream Team have been collecting monthly water quality data from the Marsh and Willow and Shellabarger Creeks.[23] The Edmonds Stream Team consists of students from Edmonds-Woodway High School who are participating in the Students Saving Salmon club, as well as citizen scientists from the City community (Edmonds Stream Team 2016). One of the team's goals is to gather baseline water monitoring data from the Marsh, Willow Creek, and Shellabarger Creek prior to the daylighting of Willow Creek. Much of the data collected by the Edmonds Stream Team prior to 2017, which are summarized in the monitoring plan (Windward 2018a), met Washington State WQC and indicated good water quality. However, a few water quality data points did not meet these criteria. Water temperatures exceeded the maximum temperature threshold at the Marsh outlet basin in the spring and summer of 2016. DO concentrations measured in samples collected from the northern and eastern portions of the Marsh interior were below the minimum threshold during all seasons, except for in the eastern portion of the Marsh where Shellabarger Creek enters at the SR-104 culvert. Measured pH was below the acceptable range in samples collected from the northern portion of the Marsh interior on numerous occasions. Petroleum hydrocarbons and benzene, toluene, ethylbenzene and xylene constituents (BTEX) were detected in some samples, and individual carcinogenic polycyclic aromatic hydrocarbons (cPAHs) were detected at concentrations higher than water quality standards based on human health criteria. Most of these exceedances were detected in samples collected along the northern portion of the Marsh interior. Fecal coliform counts were generally higher after rain events. Fecal coliforms were detected at concentrations greater than 100 colonies/100 mL in samples collected from the Marsh's fenced outlet basin, the

[23] Data have also been collected from Shell Creek but are not discussed herein, as Shell Creek is within a separate drainage basin from the Marsh.

Shellabarger Marsh outlet, lower Shellabarger Creek, and the portion of Shellabarger Creek that flows under SR-104.

The Edmonds Stream Team collected additional water quality data quarterly and during storm events in 2017 and 2018 (Edmonds Stream Team 2018). Water temperature, DO, pH, conductivity, nitrates, salinity, fecal coliform bacteria, polycyclic aromatic hydrcarobs (PAHs), and metals data were compiled from samples collected from select water quality monitoring locations in and near the Marsh.

Recorded temperatures in water collected from Shellabarger and Willow Creeks were below the maximum temperature threshold of 63.5°F for salmonid spawning, rearing, and migration from WAC 173-201A-200, indicating good water quality in terms of temperature (Edmonds Stream Team 2018). Water temperatures in the creeks (including Hindley and Shell Creeks)[24] averaged 51.0°F in the fall, 47.0°F in the winter, 52.6°F in the spring, and 56.8°F in the summer. The average water temperatures of the samples collected in the Marsh were higher than those in the creeks: 52.7°F in the fall, 45.8°F in the winter, 55.2°F in the spring, and 62.4°F in the summer. The temperatures from samples collected over the summer months from the east and west Harbor Square culverts (near the baseline study water quality monitoring Stations 4, 5, and 6) and the Marsh outlet exceeded the 63.5° F temperature threshold. Samples collected from the Marsh outlet exceeded the threshold in the spring and summer months.

Average DO concentrations were greater than the minimum threshold of 8.0 mg/L for salmonid spawning, rearing, and migration in samples collected from Shellabarger and Willow Creeks (Edmonds Stream Team 2018), indicating good water quality in terms of DO. DO concentrations in samples collected from the Marsh were generally below the 8.0 mg/L threshold, except in samples collected at the Marsh outlet and the eastern edge of the Marsh at the Highway 104 culvert (where Shellabarger Creek enters the Marsh).

All pH measurements collected in the creeks were within the acceptable range of 6.5 to 8.5 (Edmonds Stream Team 2018). Water samples collected from the Marsh had an average pH of 7.0 (neutral) and were generally within the acceptable pH range, with the exception of several samples collected along the north end of the Marsh near Harbor Square, which had pH readings of less than 6.5.

According to the Edmonds Stream Team report (Edmonds Stream Team 2018), conductivity measurements stayed relatively constant in samples collected from the creeks, except in samples collected during rain events, which had lower conductivity levels. Conductivity measurements in samples collected from the Marsh increased, as expected, when the tide gate was open and salinity levels were higher.

[24] Water temperature averages were provided for Willow, Shellabarger, Hindley, and Shell Creeks together.

Nitrate concentrations in samples collected from the creeks were generally lower than 2.0 mg/L in 2015 – 2017, and have been increasing since about spring 2017 (Edmonds Stream Team 2018). Nitrate concentrations in samples collected from the Marsh increased when the tide gate was open. Potassium nitrate can occur naturally in seawater (Edmonds Stream Team 2016).

Salinity in samples collected from the Marsh outlet basin averaged 0.15 ppt while the tide gate was closed (i.e., mid-October through mid-March) (Edmonds Stream Team 2018). Salinity was higher in samples collected from the Marsh outlet while the tide gate was open. Salinity in samples collected along the northern end of the Marsh and from the Highway 104 culvert did not increase when the tide gate was open.

Fecal coliform bacteria were detected at concentrations greater than 100 colonies/100 mL (i.e., the Washington State primary contact recreation bacteria threshold for freshwater; see WAC 173-201A-200) in samples collected from lower Willow Creek and lower Shellabarger Creek (Edmonds Stream Team 2018). Fecal coliform concentrations were higher after rain events. Samples with fecal coliform concentrations exceeding 8,000 colonies/100 mL of water were collected from Willow Creek in the fall of 2017 and spring of 2018.

Select water samples collected from the Marsh, Willow Creek, and Shellabarger Creek were analyzed for PAHs, metals, and total petroleum hydrocarbons (TPH) and BTEX constituents (Edmonds Stream Team 2018). Of the 59 samples analyzed for PAHs, 39 (66%) had concentrations that exceeded the Washington State WQC for human health of at least 1 of the 5 cPAHs. Benzo(a)pyrene was detected at concentrations greater than the WQC in 34 of the 39 samples. Some samples were analyzed for metals; zinc and copper were the metals most frequently detected. TPH and BTEX were detected in some, but not all, of the water samples submitted for analysis. The Edmonds Stream Team continues to monitor water quality in the Marsh and its tributary creeks.

5.2 Willow Creek Daylighting Study

Shannon & Wilson performed testing of the water quality, sediment chemistry, and aquatic invertebrate community within the Marsh and its tributary creeks in 2016 and 2017 as part of planning for the Edmonds Marsh Estuary Restoration/Willow Creek daylighting project (Shannon & Wilson 2019). The methods and results of these studies are summarized in the following subsections. Water level, temperature, and conductivity data collected from the Marsh between 2012 and 2015 by Shannon & Wilson as part of the feasibility study (FS) for the daylighting project (Shannon & Wilson 2015) were summarized in the monitoring plan (Windward 2018a). Samples collected between 2012 and 2017 were collected from the following seven locations (Shannon & Wilson 2017, 2019):

- WC-01 at Marina Beach Park
- WC-02 just upstream of the Willow Creek outfall inlet

- WC-03 near the northernmost point of the Marsh
- WC-04 in the northern branch of Shellabarger Creek, west of SR-104
- WC-05 in the Marsh, near the intersection of Shellabarger and Willow Creeks
- WC-06 near the Hatchery
- WC-07 in Shellabarger Creek, east of SR-104

5.2.1 Water quality

Water quality samples were collected once per season (for a total of four sampling events) from December 2016 through September 2017. Samples were collected within Willow Creek, Shellabarger Creek, and the Marsh, as well as along the shoreline of Marina Beach Park (Map 1). Samples were analyzed in the field for temperature, DO, conductivity, total dissolved solids, salinity, pH and oxidation reduction potential. Laboratory tests were performed for a suite of metals, fecal coliform, chloride, total hardness, and total suspended solids. Water quality sample results were compared to Washington State surface WQC.

Results were generally compared to Washington State fresh and marine WQC for the protection of aquatic life.[25] In general, water quality was found to be acceptable with the exceptions of DO and fecal coliform. Fecal coliform exceedances[26] were noted at least once at every location to varying degrees (in some cases, at concentrations twice the criteria); at WC-02 (just upstream of the Willow Creek outfall inlet and the Marsh outlet basin), fecal coliform concentrations exceeded criteria during three of the four sampling events. DO was found to be less than criteria[27] in December 2016 at station WC-03 (near the northernmost point of the Marsh and the Harbor Square outfalls), and pH was less than criteria[28] at WC-02 and WC-03 during two independent sampling events (Shannon & Wilson 2019).

5.2.2 Sediment chemistry

Sediment samples were collected in June 2017 at the same stations where water quality was monitored (Shannon & Wilson 2019). These samples were submitted for laboratory analyses of volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), butyltins, diesel-range organics, pesticides, polychlorinated

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[25] The "core summer salmonid habitat" category of criteria was used for freshwater criteria that vary based on salmonid habitat use.

[26] Fecal coliform concentrations were compared to the "extraordinary primary contact recreation" WQC for freshwater (50 colony forming units [CFU]/100 mL) and to the "primary contact recreation" WQC for marine water (14 CFU/100 mL).

[27] DO concentrations were compared to the "core summer salmonid habitat" WQC for freshwater (9.5 mg/L) and to the "extraordinary" aquatic life use WQC for marine water (7.0 mg/L).

[28] For freshwater, pH results were compared to an acceptability range of 6.5 to 8.5, with a human-caused variation of less than 0.2 units. For marine water, pH results were compared to an acceptability range of 7.0 to 8.5, with a human-caused variation of less than 0.2 units.

biphenyl (PCBs), metals, and wet chemistry (ammonia, nitrates, sulfides, total solids, and TOC). Sediment chemistry results were compared to Ecology sediment management standards.

Nickel was detected at concentrations greater than criteria at several stations: WC-03, WC-04, WC-05, and WC-06. Carbon disulfide (a VOC) concentrations exceeded criteria (US Environmental Protection Agency [EPA] Region II freshwater sediment criteria) at all sampling locations. Several different SVOCs, including PAHs,[29] were detected at concentrations greater than criteria, and at least one SVOC exceedance occurred at every sampling station. Station WC-03 had the highest and most frequent exceedances, including the only exceedances of tributyltin, diesel- and gas-range organics, and sulfide.

5.2.3 Aquatic invertebrates

Macroinvertebrate samples were collected at the same stations as water quality and sediment chemistry samples in September 2017 and sent to Rhithron Laboratories for taxonomic analysis. The full taxonomic evaluation report is included in Appendix G. In general, samples had either "poor" or "very poor" Benthic Index of Biotic Integrity (B-IBI[30]) scores, both of which are indicative of poor water quality (Shannon & Wilson 2019). Specifically, "poor" B-IBI scores indicate depressed macroinvertebrate species diversity, with most species being tolerant of poor water quality; however, such samples still contain a small number of species that are intolerant of poor water quality. "Very poor" B-IBI scores indicate very low diversity and a predominance of species that are highly tolerant to poor water quality.

The taxonomic evaluation results provide additional detail about the invertebrate species present within the Marsh, Willow Creek, Shellabarger Creek, and Puget Sound immediately downstream from the Marsh. The sample from Station WC-01, located in Puget Sound close to Marina Beach Park, contained a total of 225 individual invertebrate specimens. The sample contained nematode, polychaete, and oligochaete worms; bivalves; cockles (Cardiidae); clams (Veneridae); gastropods; amphipods; shrimp (*Caprella* sp.); decapods; isopods; and crustaceans (Cumacea, Copepoda and Ostracoda). No insects were found in the Puget Sound sample.

[29] PAHs detected in at least one sample at concentrations greater than the criteria include: naphthalene, 2-methylnaphthalene, acenaphthene, dibenzofuran, fluorene, phenanthrene, anthracene, fluoranthene, pyrene, benzo(a)anthracene, chrysene, total benzofluoranthenes, benzo(a)pyrene, indeno(1,2,3-cd)pyrene, dibenzo(a,h)anthracene, benzo(g,h,i)perylene, and acenaphthylene.

[30] The B-IBI rating is a measurement system created to evaluate stream health based on the invertebrate populations present. The Puget Sound Lowlands B-IBI—which consists of metrics (such as total taxa richness, and percent tolerant taxa etc.) that are given a score that can then be calculated into a B-IBI rating—was used in this study.

The sample from Station WC-02, located in the Willow Creek channel downstream from the Marsh, contained a total of 616 specimens.[31] The sample contained oligochaete worms, decapods, amphipods (Anisogammaridae), isopods (*Gnorimosphaeroma* sp.), copepods, ostracod crustaceans, and both biting and non-biting midge fly larva (*Dasyhelea* sp. and *Chironomus* sp.).

The sample from Station WC-03, located at the north end of the Marsh near Harbor Square, contained a total of 187 specimens. The sample contained oligochaete worms; snails (Physidae and Planorbidae); water fleas (Cladocera); crustaceans (Copepoda and *Crangonyx* sp.); and mosquito (Culicidae), biting midge (Ceratopogoninae), non-biting midge (*Chironomus* sp., *Polypedilum* sp., and *Procladius* sp.), and aquatic nematoceran fly (*Dixella* sp.) larvae.

The sample from Station WC-04, located in Shellabarger Creek within the eastern portion of the Marsh, contained only two specimens: one water sowbug (*Caecidotea* sp.) and one biting midge (Ceratopogoninae) larva.

The sample from Station WC-05, located within the central portion of the eastern side of the Marsh, contained a total of 31 specimens. Four species of non-biting midge larvae were identified (i.e., *Polypedilum* sp., *Rheotanytarsus* sp., *Parametriocnemus* sp., and *Prodiamesa* sp.), as well as a stonefly larva (*Malenka* sp.), several leeches (Erpobdellidae), an oligochaete worm, and freshwater fingernail clams (Sphaeriidae).

The sample from Station WC-06, located in Willow Creek within the Hatchery, contained a total of 538 specimens.[22] Larvae of mayflies (i.e., Baetis tricaudatus complex and *Cinygma* sp.), stoneflies (i.e., *Sweltsa* sp., *Malenka* sp., and *Zapada cinctipes*), caddisfly (*Parapsyche* sp.), non-biting midges (i.e., *Micropsectra* sp., *Brillia* sp., *Parametriocnemus* sp., and *Tvetenia Bavarica Gr*.), a crane fly (*Dicranota* sp.), black flies (*Simulium* spp.), drain flies (Psychodidae), and meniscus midge flies (*Dixa* sp.) were found in the sample, as well as flatworms (Trepaxonemata), nematode and oligochaete worms, freshwater fingernail clams (Sphaeriidae), crustaceans (*Crangonyx* sp.), and a mite or tick (Acari).

The sample from Station WC-07, located in upper Shellabarger Creek slightly southeast of Shellabarger Marsh, contained a total of 401 specimens. The species assemblage was similar to that of the Station WC-06 sample and contained larvae of mayflies (i.e., Baetis tricaudatus complex and *Tricorythodes* sp.), stoneflies (*Malenka* sp.), caddisfly (*Parapsyche* sp.), non-biting midges (i.e., Eukiefferiella Claripennis Gr. and Tvetenia Bavarica Gr.), black flies (*Simulium* spp.), and drain flies (Psychodidae), as well as flatworms (Trepaxonemata), nematode and oligochaete worms, a leech (Erpobdellidae), freshwater fingernail clams (Sphaeriidae), crustaceans (*Crangonyx* sp.), and mites or ticks (Acari).

[31] There may have been more individuals in the sample; typically, the taxonomic laboratory will count approximately 500 individuals per sample.

5.3 PILCHUCK AUDUBON SOCIETY AVIAN USE STUDY

The Pilchuck Audubon Society (Audubon) has started a 10-year study of how birds use and interact with the variety of microhabitats provided by the Marsh and its buffer areas (Pilchuck Audubon Society 2019). One of the goals of the study is to be able to make informed recommendations on how best to manage the Marsh and its surrounding habitats for birds. The study began in December 2018 and is scheduled to continue until December 2028. Point count surveys are conducted twice per month at seven different locations by a group of volunteer surveyors. Interim reports on the study's findings will be published in the future; this section provides a very high-level overview of the bird use observations made to date. The raw data provided to date for the study, as well as a map of the survey locations and the study data sheet (which provides definitions of the codes used in the data file), are included in Appendix H.

The Audubon study includes two survey locations within and adjacent to the Hatchery (survey IDs ED.004 and ED.005).[32] Species that have been observed at the Hatchery locations to date include: woodpeckers (northern flicker, red-breasted sapsucker, downy woodpecker, and pileated woodpecker); bushtits and chickadees (black-capped and chestnut-backed chickadees [*Poecile rufescens*]); kinglets (golden-crowned and ruby-crowned); sparrows (golden-crowned sparrow, savannah sparrow [*Passerculus sandwichensis*], song sparrow, dark-eyed junco, and spotted towhee); warblers (common yellowthroat, orange-crowned warbler [*Oreothlypis celata*], yellow-rumped warbler, and Townsend's warbler [*Setophaga townsendi*]); wrens (Bewick's wren, marsh wren, and Pacific wren [*Troglodytes pacificus*]); finches (American goldfinch and purple finch [*Haemorhous purpureus*]); Anna's hummingbird; brown creeper; Pacific-slope flycatcher; red-breasted nuthatch; tree swallow; American crow; Steller's jay (*Cyanocitta stelleri*); red-winged blackbird; red-tailed hawk; great blue heron; Virginia rail; Canada goose (*Branta canadensis*); ducks (gadwall [*Mareca strepera*] and mallard); and gulls (glaucous-winged gull [*Larus glaucescens*] and western × glaucous-winged gull hybrids).

Two of the Audubon survey locations are situated within or adjacent to the Unocal Site (survey IDs ED.002 and ED.003). Both are located within areas of forested or scrub-shrub vegetation. Species that have been observed at these locations to date include: Northern flicker; bushtits and chickadees (black-capped and chestnut-backed chickadees); kinglets (golden-crowned and ruby-crowned kinglets); sparrows (white-crowned sparrow, golden-crowned sparrow, savannah sparrow [*Passerculus sandwichensis*], song sparrow, dark-eyed junco, and spotted towhee); warblers (yellow-rumped warbler and common yellowthroat); wrens (Bewick's wren and marsh wren); finches (American goldfinch, house finch, and purple finch); Anna's hummingbird; brown creeper; Pacific-slope flycatcher; American crow; Steller's jay;

[32] One of these locations (survey ID ED.004) is the same as location BPC-3 from the baseline study.

red-winged blackbird; hawks (Cooper's hawk [*Accipiter cooperii*] and red-tailed hawk); bald eagle (*Haliaeetus leucocephalus*); great blue heron; Canada goose; and Virginia rail.

Two of the Audubon survey locations are situated along the eastern half of the north buffer zone, adjacent to the Harbor Square property (survey IDs ED.006 and ED.007). Species that have been observed at these locations to date include: northern flicker; black-capped chickadee; kinglets (ruby-crowned and golden-crowned kinglets); sparrows (white-crowned sparrow, golden-crowned sparrow, song sparrow, dark-eyed junco, and spotted towhee); warblers (common yellowthroat and yellow-rumped warbler); wrens (Bewick's wren and marsh wren); finches (American goldfinch and house finch); Anna's hummingbird; Pacific-slope flycatcher; swallows (barn swallow, tree swallow, and violet-green swallow); American crow; red-winged blackbird; European starling (*Sturnus vulgaris)*; rock pigeon (*Columba livia*); red-tailed hawk; great blue heron; Virginia rail; killdeer, geese (Canada goose and greater white-fronted goose [*Anser albifrons*]); ducks (American wigeon [*Mareca Americana*], gadwall, green-winged teal [*Anas crecca*], and mallard); and western × glaucous-winged gull hybrids.

One of the Audubon survey locations is situated along the wooden boardwalk at the north end of the Marsh (survey ID ED.001). Species that have been observed at this location to date include: black-capped chickadee; sparrows (white-crowned sparrow, song sparrow, dark-eyed junco, and spotted towhee); common yellowthroat; marsh wren; finches (American goldfinch and house finch); Anna's hummingbird; swallows (barn swallow, northern rough-winged swallow [*Stelgidopteryx serripennis*], tree swallow, and violet-green swallow); American crow; red-winged blackbird; European starling; bald eagle; great blue heron; killdeer, Canada goose; ducks (American wigeon, gadwall, green-winged teal, and mallard); and gulls (herring gull [*Larus argentatus*], mew gull [*Larus canus*], glaucous-winged gull, and western × glaucous-winged gull hybrids.

6 Observations and Information Collected by the Community

One of the goals of the baseline study was to create a forum whereby community members could contribute information to the study and help document the Marsh's baseline conditions. This goal was intended to allow the public to apply its curiosity and contribute its talents to the study, and to allow citizen scientists to provide information that would not otherwise be available due to time, geographic, or resource constraints. Community input was achieved through the use of a City-created Flickr page (https://www.flickr.com/groups/edmondsmarshmadness/) where community members could post photos of wildlife and scenery taken within the Marsh and buffer areas. At select photo point stations, laminated placards were posted with instructions for community members on how to contribute photos to the monitoring program at any time throughout the monitoring period. The photo point photos taken by community members were posted to the Flickr page along with their wildlife and scenery photos. Photos posted to Flickr are presented in Appendix I.

In addition to the photos posted on Flickr, certain individuals provided their observations to the baseline study through other forums/formats. Dr. David Richman provided *A Report on the Insects and Arachnids of Edmonds Marsh*, along with an accompanying set of photographs; both are presented in Appendix I. Edmonds, Washington, photographer Bill Anderson provided a number of bird and other wildlife photos, as well as photos showing scenery from the Marsh in years prior to the baseline monitoring year (Appendix I). Appendix I also provides a list of 190 species of birds observed in the Marsh over the past 30 years and compiled by Edmonds-area residents Carol Riddell and Ted Peterson. The wildlife and other kinds of observations provided by the community are drawn upon in the discussion provided in Section 7.3.

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7 Discussion

The following sections further discuss the baseline conditions of the Marsh and its buffer areas, based on the data collected as part of this study and data and observations collected by other parties and the community, as discussed in Sections 5 and 6. The ecological functions currently being performed by the Marsh and buffer habitats are also discussed.

7.1 WATER QUALITY, SALINITY, DEPTH AND CIRCULATION

Water quality within the Marsh and its tributary creeks is generally good, with some exceptions. Within lower Willow Creek and in the southern portion of the Marsh (water quality stations 1, 2, 3, and 3b on Map 2), none of the WQC were exceeded for any of the parameters monitored during the baseline study. These water quality stations were located within the forested habitat at the south end of the Marsh and in the Marsh interior just north of the forested buffer edge. In seasons when water temperatures exceeded WQC at other stations (i.e., summer and fall), water temperatures remained cooler and met WQC at Stations 1 through 3b (Tables 4-1 and 4-2). These results indicate that the forested riparian habitat surrounding Willow Creek and the south side of the Marsh helps to preserve water quality, particularly by providing shade essential to maintaining low water temperatures during warm weather.

Water quality data collected by other parties (the Edmonds Stream Team and Shannon & Wilson) also indicate relatively good water quality in lower Willow Creek (within the south buffer zone). The only exception was fecal coliform bacteria, which were detected at concentrations exceeding WQC during some monitoring events by the Edmonds Stream Team. Fecal coliform counts tended to be higher after rain events, indicating that the bacteria are likely flushed into the creek from the surrounding drainage basin. The droppings of wildlife that use the Marsh and its buffer areas, such as waterfowl and coyotes, may also contribute to fecal coliform loads.

Water quality monitoring conducted as part of the baseline study identified several WQC exceedances along the northern edge of the Marsh, adjacent to Harbor Square and the Harbor Square outfalls: Summer water temperatures were above WQC, DO concentrations were below WQC throughout the year, pH values were acidic in the spring and fall, and there was a turbidity exceedance at Station 4 in the spring (Section 4.1).

Water quality monitoring conducted by other parties confirms the existence of water qualities issues in the northern portion of the Marsh. Low DO concentrations were detected during all seasons by the Edmonds Stream Team, and low pH readings were measured in this area (Section 5.1). Fecal coliform bacteria, as well as chemicals including petroleum hydrocarbons, cPAHs, and BTEX constituents, were also detected at concentrations exceeding WQC in water samples collected along the northern edge of the Marsh (Sections 5.1 and 5.2.1).

The stormwater outfalls from Harbor Square enter the north edge of the Marsh via unlined channels that flow into the patches of Marsh vegetation. The water in these channels was generally observed to be stagnant, and bacterial sheens were sometimes observed on the water surface. It appears that these channels are not well-connected to the Marsh interior in terms of water circulation. One reason for this may be a topographic high spot within the Marsh interior (see LiDAR map provided in Appendix D), which appears to hinder water from Willow Creek and the southwestern portion of the Marsh from flowing into this area (Section 4.2). Another factor reducing circulation may be that these channels are located beneath trees and shrubs, which may contribute to a reduction in the "breeziness" of the air-water interface, resulting in reduced oxygen exchange. Water within the outfall channels may flow and circulate only during stormwater discharge events.

Lack of water circulation in the outfall channels likely contributes to low DO in this area. Other factors may include the large loads of plant detritus at Stations 5 and 6, which cause high oxygen demand, and the shaded water, which reduces the ability of algae to produce oxygen. The reason for the low pH values of water in the northern portion of the Marsh may be related to the acidity of the underlying Mukilteo muck soils.

Water quality in Shellabarger Creek where it enters the east side of the Marsh (on the west end of the SR-104 culvert) was monitored as part of the baseline study (Station 8 on Map 2). The only water quality exceedance identified at this station as part of the baseline study was water temperature during the summer monitoring event (Table 4-2). In addition, low DO levels were detected in some areas along the eastern boundary of the Marsh by the Edmonds Stream Team (Section 5.1), and fecal coliform bacteria were detected at concentrations exceeding WQC in Shellabarger Creek (where it flows through the eastern portion of the Marsh) by Shannon & Wilson (Section 5.2.1).

Water quality monitoring was also conducted within the fenced Marsh outlet basin downstream from the Marsh as part of the baseline study (Station 7 on Map 2), by the Edmonds Stream Team, and by Shannon & Wilson. Water quality exceedances observed at this location included spring and summer water temperatures (documented by baseline study monitoring in summer and by the Edmonds Stream Team in spring and summer) and low pH (documented during the spring baseline study monitoring event [Table 4-2] and during all four seasons by Shannon & Wilson [Section 5.2.1]). Fecal coliform bacteria were also detected at concentrations exceeding WQC at this location by the Edmonds Stream Team (Section 5.1) and by Shannon & Wilson.

7.2 Continuous Water Depth and Salinity Monitoring

When the tide gate was closed, mean salinity was less than 1 ppt (i.e., freshwater), but when the tide gate was open, mean salinity was 11.4 ppt, approximately 10 ppt higher

(Table 4-3). This change in salinity likely significantly affects plant communities in the Marsh. For example, when the tide gate was inadvertently closed during the 2018 growing season (prior to August 27, 2018; Table 3-4), visitors to the Marsh observed denser than normal growth of cattails, bulrushes, and other vegetation along the northern and western edges of the Marsh. These conditions are shown on Photographs 123 and 124 (2018 conditions) and 125 and 126 (2019 conditions) in Appendix I.1. When the tide gate is allowed to close but is apparently leaking, a range of intermediate conditions occur (Appendix D).

Salinities were always very low (i.e., freshwater) at Stations 7, 8, and 9 in the eastern portion of the Marsh and within Shellabarger Creek (Map 3) and the tidal signal was almost non-existent, so it is unlikely that these areas are impacted by tidal inflow (Figure 7-1). Precipitation in the Willow and Shellabarger Creek watersheds appears to influence water levels at these stations, which are upslope of the extensive cattail monoculture on the east side of the tidal flats in the lower wetland (Figure 4-8) (Map 3). No influence of precipitation on water level at other stations was apparent.

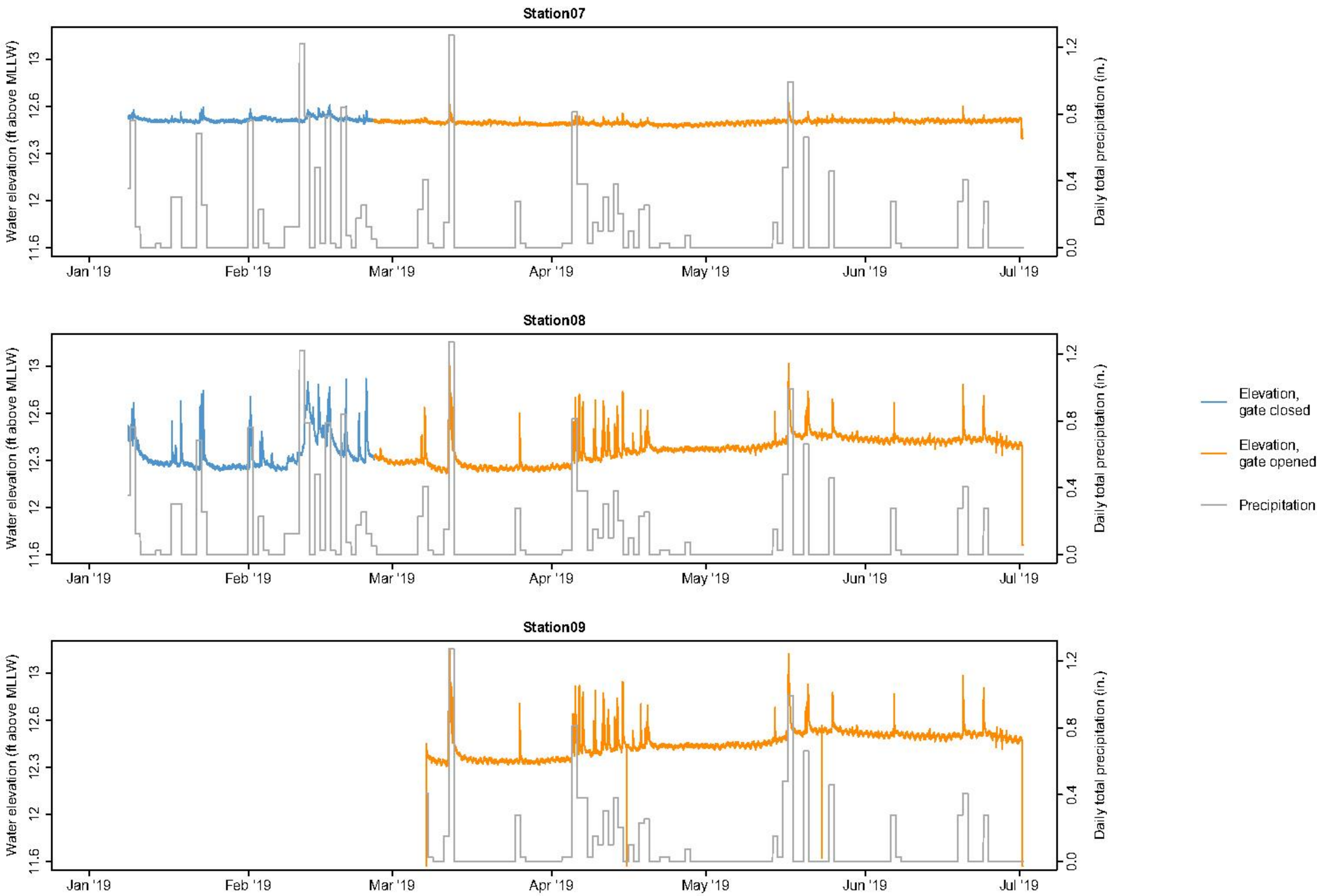


Figure 7-1.Water level responses to rainfall in the upper Marsh

Tides primarily drive salinity changes in the Marsh (Figure 4-6): When high tides push high-salinity water into the Marsh, inflow from Willow and Shellabarger Creeks is temporarily impeded. When the tide recedes, the freshwater piled up in the creeks is released and flows west into the lower part of the Marsh. Salinity is highly variable over time at Stations 1 through 6 (Map 3), generally ranging from near freshwater to close to Puget Sound salinity (approximately 30 ppt) over the course of a tide cycle (Figure 4-7). Stations 3 and 4 show a smaller salinity range, because these stations are in a small sub-basin separated by a slight ridge in local topography (see the LiDAR map provided in Appendix D). Figures 7-2a, c, and d show the effect of the ridge as a tide minimum "flat line" at about 250 to 260 cm above mean lower low water (MLLW). These stations tend to have relatively stable, higher salinities (on average over time). Additionally, because lower Willow Creek is channelized (straight), freshwater released upon tidal retreat is efficiently transported downstream and does not encroach on Stations 3 and 4, which are peripheral to the longitudinal axis of the Marsh. Saline waters, therefore, have longer residence times in the areas of Stations 3 and 4, resulting in greater infiltration into wetland soil/sediment (and/or greater contact time with CTD data loggers). The vegetation of the open flats, which is dominated by more salt-tolerant species (saltgrass [*Distichlis spicata*] and pickleweed [*Salicornia depressa*]), likely reflects this higher salinity.

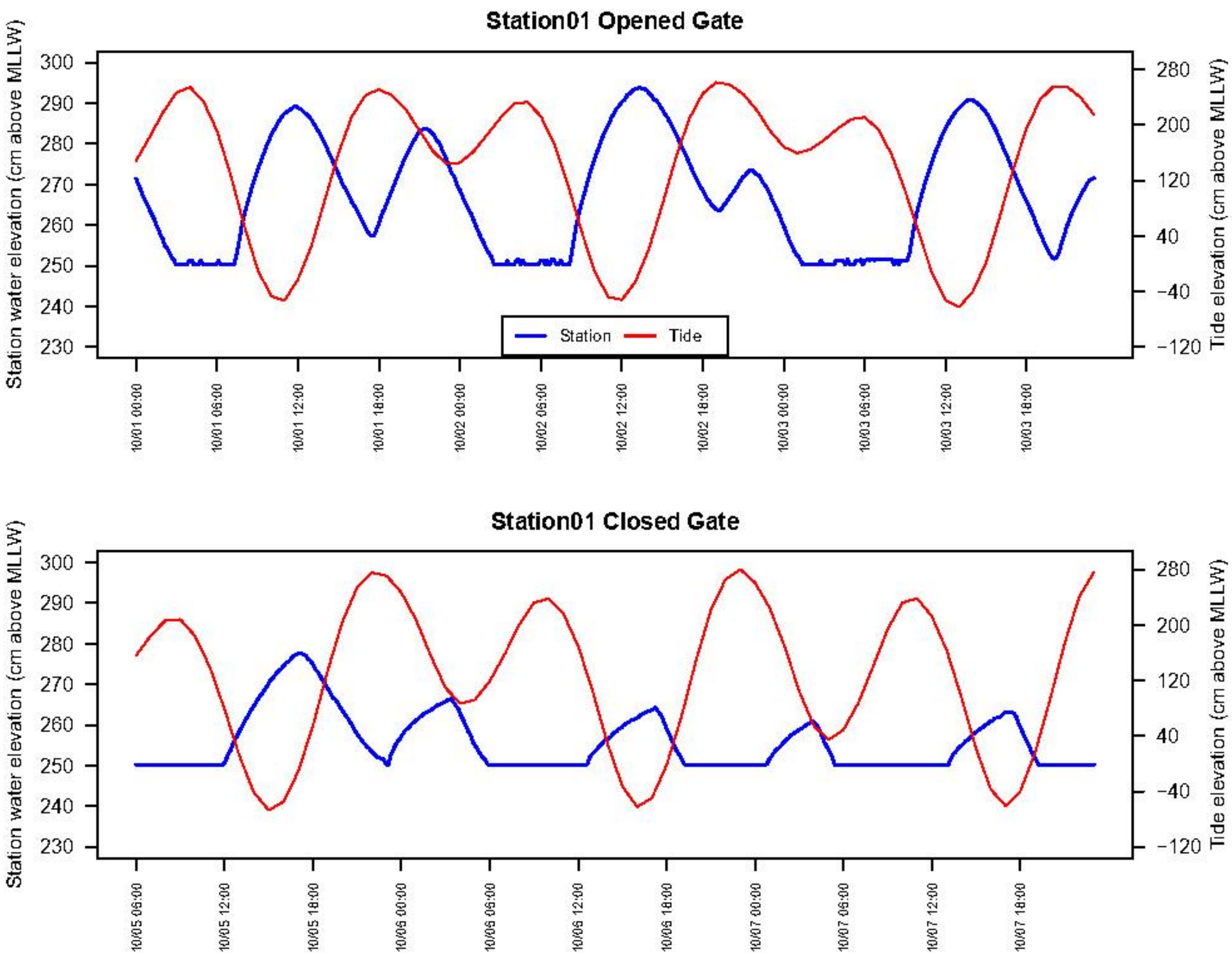


Figure 7-2a. Relationship between Elliott Bay tide signal and Edmonds Marsh Station 1 signal

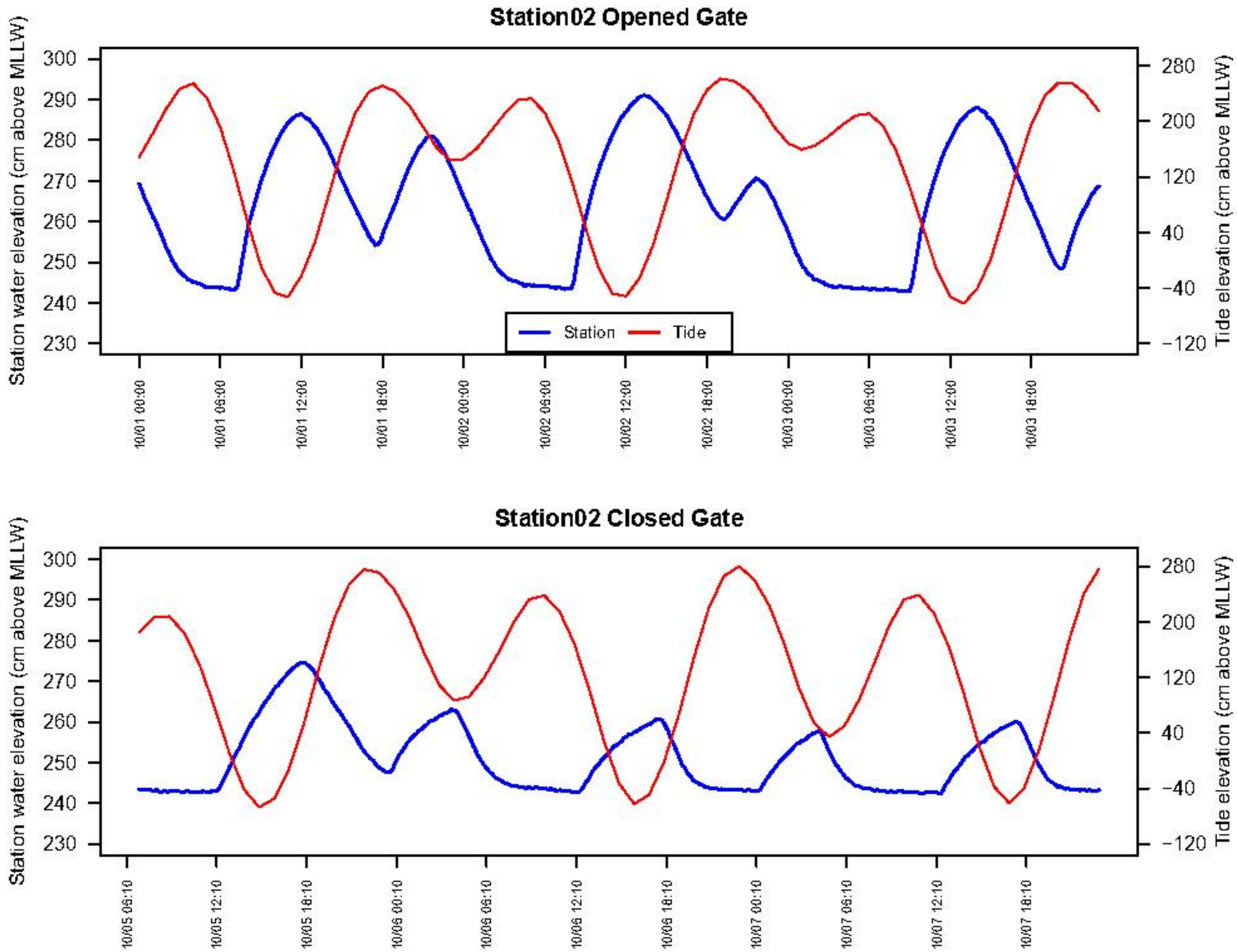
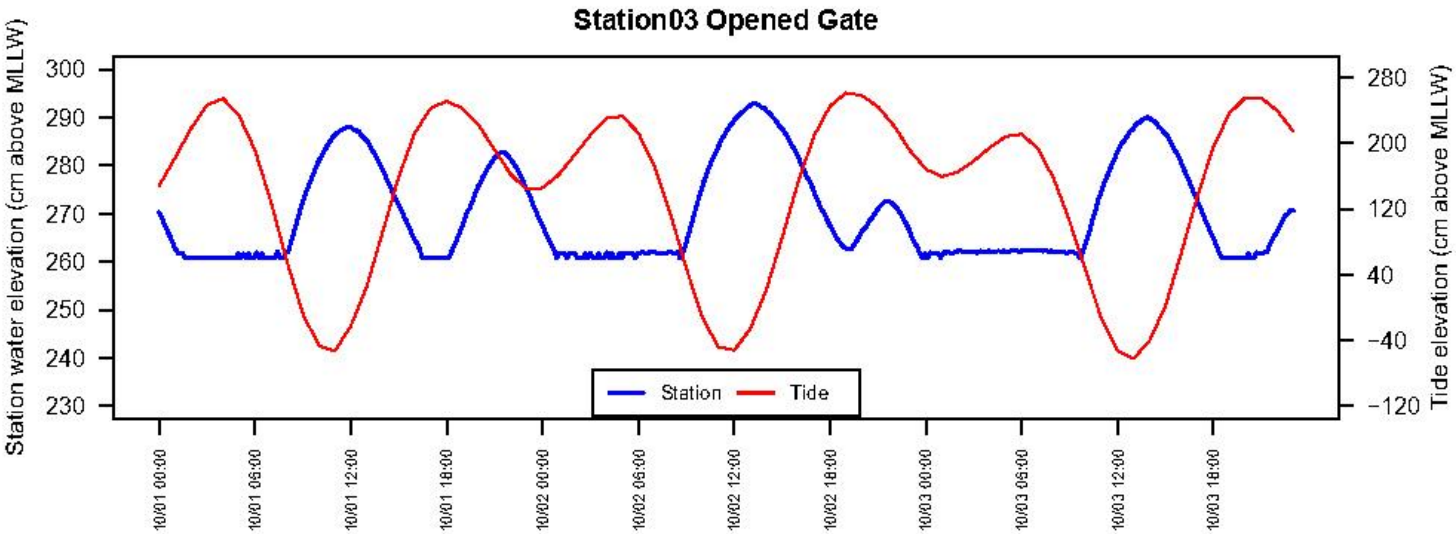


Figure 7-2b. Relationship between Elliott Bay tide signal and Edmonds Marsh Station 2 signal



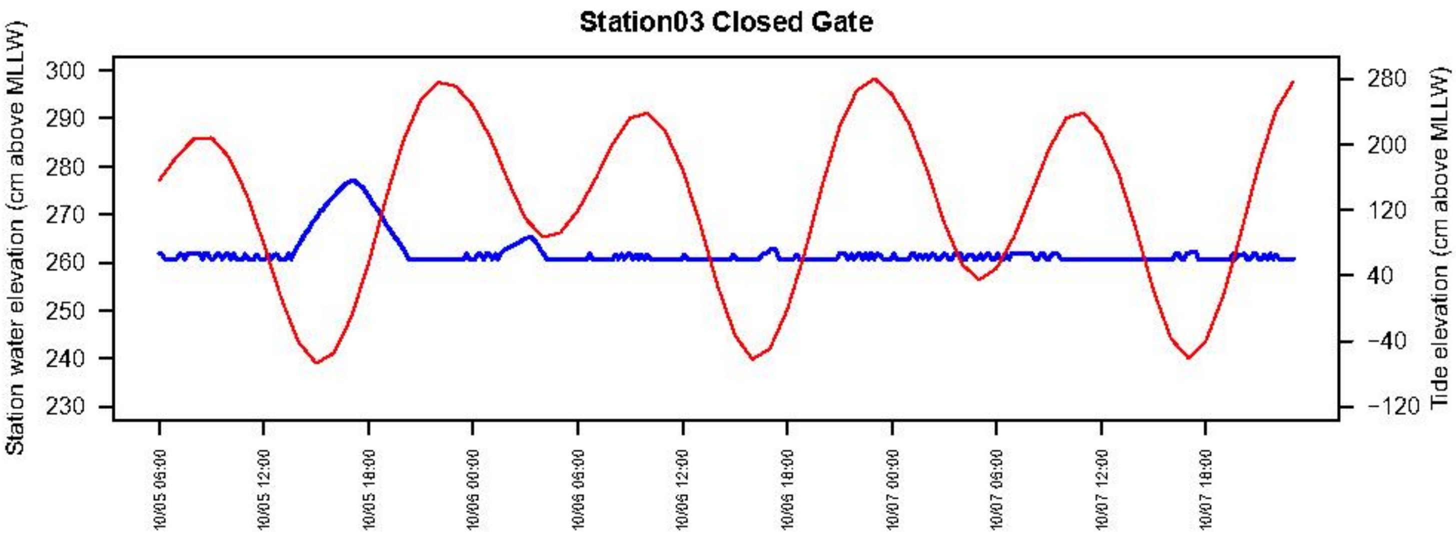


Figure 7-2c. Relationship between Elliott Bay tide signal and Edmonds Marsh Station 3 signal

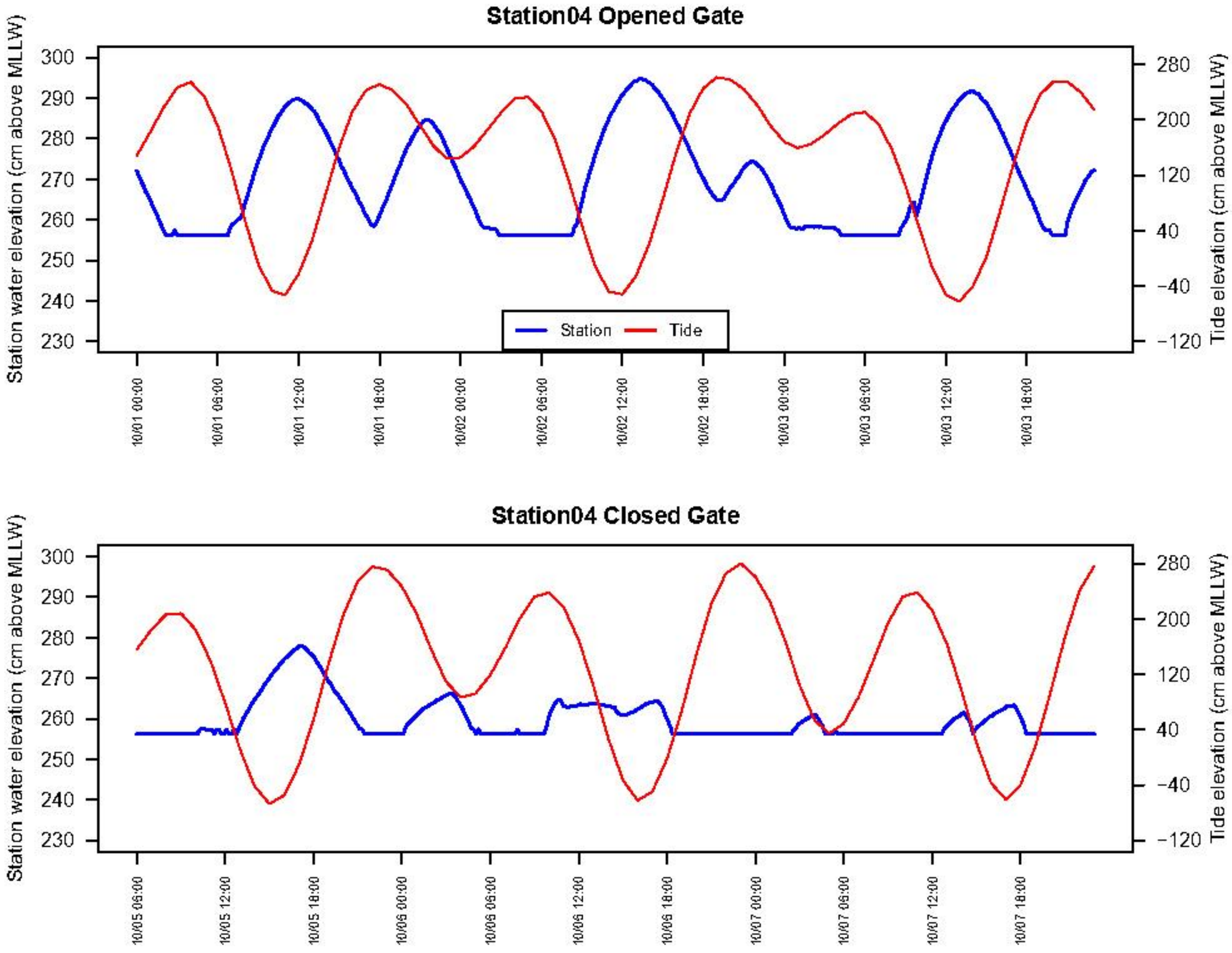


Figure 7-2d. Relationship between Elliott Bay tide signal and Edmonds Marsh Station 4 signal

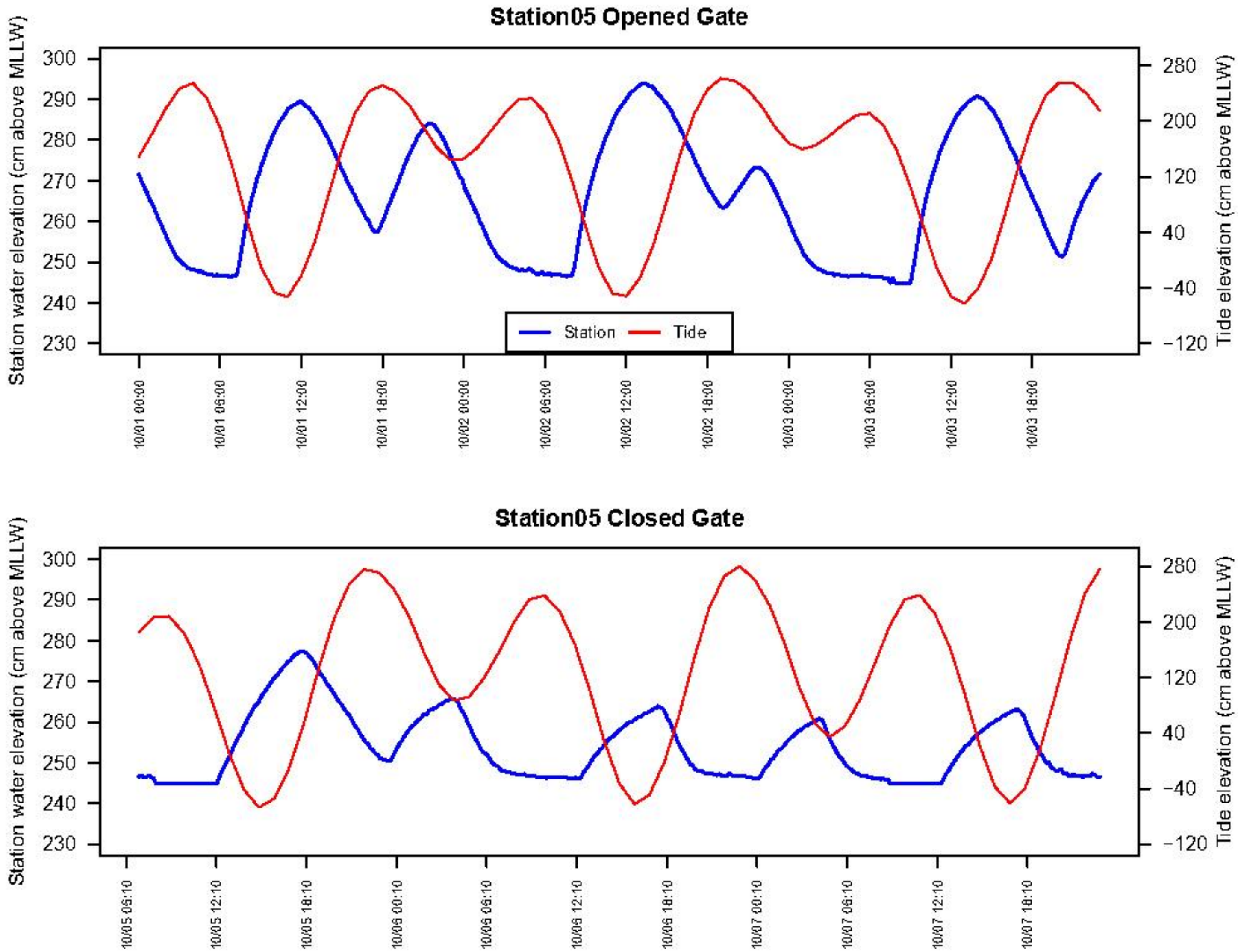


Figure 7-2e. Relationship between Elliott Bay tide signal and Edmonds Marsh Station 5 signal

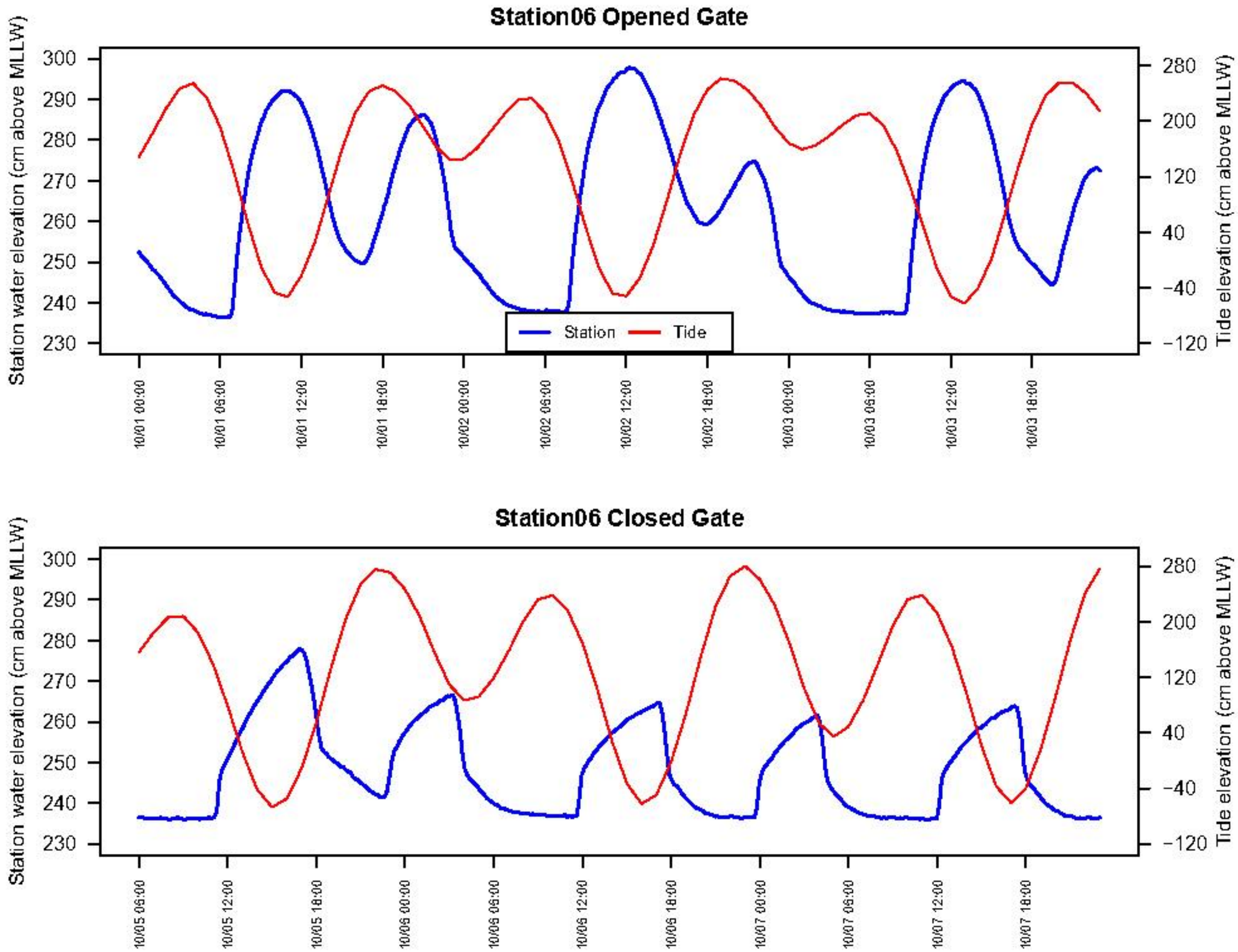


Figure 7-2f. Relationship between Elliott Bay tide signal and Edmonds Marsh Station 6 signal

Stations 8 and 9 appear to be quite similar to one another; they follow near-identical trends in water elevation, although during rain events, Station 9 water elevations rise temporarily compared to those of Station 8 (Figure 7-1). This difference appears to demonstrate a flow restriction during high-precipitation rain events that can be attributed to the culverts under Highway 104, which hinders rainfall water from passing under the road to Station 8. These pipes can transport a limited amount of water per unit time (e.g., cubic feet per second). Extraordinary rapid rainfall events produce a rain at a rate greater than what the pipes can transport causing water to accumulate on the east side of Highway 104. Our field efforts captured only a few higher-precipitation rainfall events. The greatest difference between Station 8 and 9 water elevations was observed on March 12, 2019 (ca. 02:30), with 1.27 in. of rain; lesser differences occurred with less rain (see Figure 7-3 for details).

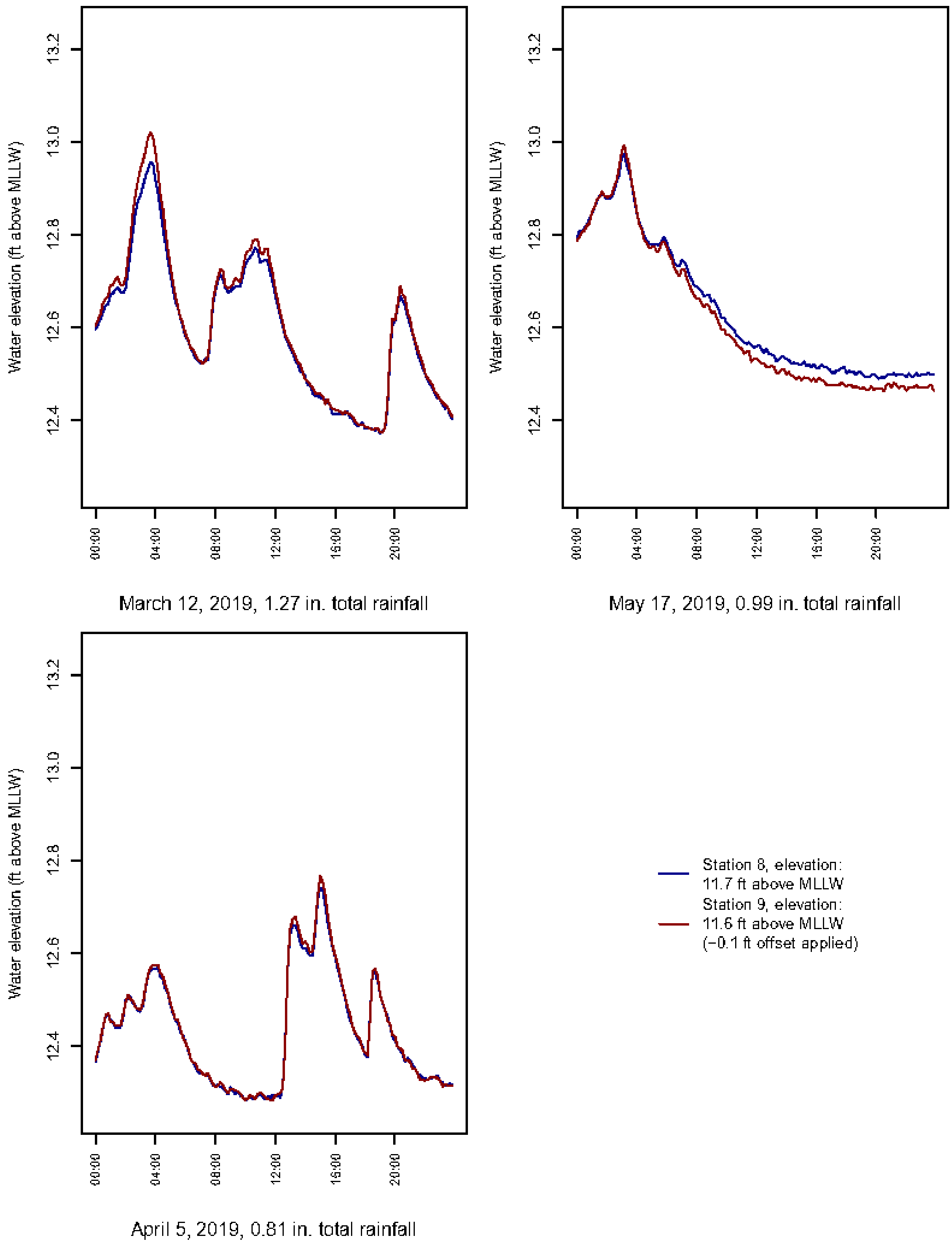


Figure 7-3.Examples of water level changes in response to rainfall events

During field efforts, a tide phase differences were observed between the Marsh and the National Oceanic and Atmospheric Administration's (NOAA's) Elliot Bay elevation data (Figure 7-2a through 7-2f). This difference has not been fully explained, but is likely related to inadequacy of the downstream piping to transport flows in and out of the Marsh rapidly enough to fully transmit the tide signal. Casual field observation noted that the lowest water levels in the Marsh did not occur until well after the predicted low tide level.

7.3 Soil, Sediment, Vegetation, and LWD within the Marsh and Buffer Zones

The following subsections discuss the current condition of the soil, sediment, vegetation, and LWD within the Marsh and its buffer areas. The subsections also provide information on the functions that these features provide, recommendations for enhancing native vegetation and LWD quantities, and a discussion related to the expected effect of the Edmonds Marsh Estuary Restoration Project on Marsh vegetation. Section 7.3.6 includes additional discussion related to the habitat value provided by the Marsh's vegetation and other habitat features.

7.3.1 Buffer zone soils

Buffer zone soils are considered of suitable quality to support native plant growth, invertebrate populations, and water infiltration. Bulk density measurements ranging from 1.40 to 1.65 g/cm^3 have been found to restrict the growth of woody plant roots, with variation depending upon soil type (Schueler 2000; Alberty et al. 1984). For sandy loam soils, a bulk density of 1.7 g/cm^3 or greater is considered to limit root growth (Schueler 2000). All of the soil samples from the buffer zones had dry bulk density measurements less than 1.40 g/cm^3, indicating that they are not restrictive to woody plant root growth. Buffer zone soils also provide habitat for worms and other invertebrates that were observed in the top several inches of soil in the southeast and south buffer zones, as well as the north buffer zone of Shellabarger Marsh (Table 4-5).

Urban soils, which are generally more compacted than soils in undisturbed, natural areas, have reduced soil porosity and therefore a diminished ability to allow water to infiltrate the soil and hold water (Schueler 2000). As a result, compacted urban soils can contribute to urban stormwater runoff. Often, urban lawns have bulk densities ranging from 1.5 to 1.9 g/cm^3, urban fill soils have bulk densities ranging from 1.8 to 2.0 g/cm^3, and rights-of-way and building pads have bulk densities ranging from 1.5 to 1.8 g/cm^3. The highest bulk density measurement of 1.37 g/cm^3 was in the south buffer zone. As this value is well below the 1.5 g/cm^3 threshold, it is expected that the vegetated portions of the Marsh and Shellabarger Marsh buffer zones are allowing water infiltration.

Buffer zone soils typically had silty/sandy loam textures and large proportions of sand and gravel (Table 4-5 and Figure 4-9), as well as high TOC contents along the north buffer zones of the Marsh and Shellabarger Marsh. The buffer zones are located within or near transitional areas between the depressional Mukilteo muck soil unit and the more upland Alderwood-Everett and Everett units, as well as areas of urban land, which may explain the trend of sandy/gravelly soils with high organic matter content.

Soils containing approximately 5% organic matter are considered ideal in terms of fertility for woody plant growth in permanent landscapes (i.e., landscapes not regularly harvested like agricultural fields) (Chalker-Scott 2019). Although the TOC content of the south and southeast buffer zones was a bit below 5% (3.41% and 2.40%, respectively), plants were growing well in these zones and did not show obvious signs of nutrient deficiency. If habitat restoration efforts are implemented in these zones (such as the removal of invasive plants and planting of native plants), top-dressing the planting area with a thick layer of wood chips would provide a source of organic matter that would be broken down and incorporated into the soil over time.[33] Wood chip mulch also helps retain soil moisture and prevent the growth of weeds. This practice is already being implemented at the Hatchery property within the south buffer zone.

The TOC content of both the north buffer zone and the Shellabarger Marsh north buffer zone was much higher than 5% (35.6% and 18.0%, respectively). Soils within the north buffer zone consist of Mukilteo muck and urban land; however, the portion of the buffer zone from which the baseline study soil samples were collected was within the Mukilteo muck unit (see soil map in Appendix D). The Shellabarger Marsh north buffer zone is also mapped in the Mukilteo muck soil unit. The naturally high organic matter content of Mukilteo muck likely contributed to the high TOC values in these buffer zones.

Buffer zone soils ranged from slightly to very strongly acidic (Table 4-4). The two lowest (i.e., most acidic) pH values were for soils from the south and southeast buffer zones. Soils within the south buffer zone consist of both Everett gravelly sandy loam (in the southern portion of the zone) and Mukilteo muck (in the northern portion of the zone), while soil within the southeast buffer zone consists of Mukilteo muck (see the soil map in Appendix D). The low pH values of the south and southeast buffer zones are therefore likely attributable to the presence of Mukilteo muck, which has been identified as very strongly acid.

Regardless of the nuances of the different factors that influence the TOC content and pH of soils in the different buffer areas, all buffer zones (where vegetated) support dense plant growth. Many Pacific Northwest native plants are well adapted to acidic soils, and soil pH does not appear to be hindering native plant growth within the buffer zones; however, the acidity of the soils in the south and southeast buffer zones should be considered when planning native plant installation as part of any habitat restoration efforts. If additional native species (beyond those already growing within these zones)

[33] Wood chip mulch should be used in upland areas only, not wetlands.

are to be added to planting plans, the tolerance of those species to acidic soils should be considered.

7.3.2 North buffer zone vegetation and LWD

Vegetation in the north buffer zone consists of both native and non-native species, and a relatively dense tree canopy rings the eastern two-thirds of this buffer zone. The understory includes a variety of native shrubs, many of which have been planted as part of recent habitat restoration efforts. The dominant plant species sampled in the north buffer zone as part of the baseline study[34] were red alder and Scouler's willow in the tree canopy, Scouler's willow and Himalayan blackberry in the understory, and water parsley and broadleaf cattail in the herbaceous stratum (Tables 4-9 and 4-10). In addition to Himalayan blackberry, invasive species identified in the north buffer zone were bittersweet nightshade, English ivy, and field bindweed.

Recommendations related to vegetation in the north buffer zone are to continue removing invasive species (particularly Himalayan blackberry) and installing a diverse mix of native species within the understory. Understory plantings should include native shade-tolerant trees (such as western red cedar [*Thuja plicata*], Oregon ash [*Fraxinus latifolia*], bigleaf maple [*Acer macrophyllum*], and western hemlock [*Tsuga heterophylla*]) that will eventually be able to replace the alder and willow overstory as it naturally ages and declines.

The north buffer zone vegetation provides a visual screen between human activity and the Marsh interior. This screen would be enhanced by continuing to plant native species in the understory; however, planting should be done in a manner that maintains wildlife-viewing corridors from the pedestrian pathway, wooden boardwalk, and established lookout points, in order to allow wildlife viewing and photography without requiring observers to enter the Marsh interior.

Only one piece of LWD was identified within the north buffer zone vegetation transects (Table 4-14); based on additional qualitative evaluations, very little LWD was observed in other portions of the zone, with the exception of the very edge of the Marsh, where there appeared to be some pieces from the adjacent buffer trees that had accumulated within the cattail stands. LWD provides valuable habitat for a variety of different species, a source of organic matter input to sediment and soil, and other functions (Windward 2018b). It may be possible to increase the quantity of LWD in the forested portion of the north buffer zone through the manual placement of LWD. Such work could possibly occur concurrently with the Edmonds Marsh Estuary Restoration Project, if LWD were already being transported to the area and distributed with heavy machinery as part of the effort. The forested buffer and edge of the Marsh are relatively

[34] Additional, qualitative description of the north buffer zone is available in the Evaluation of Edmonds Marsh and Shellabarger Marsh Buffer Zones report (Windward 2018c).

accessible in this zone, given the proximity of the Harbor Square parking lot and the paved pedestrian walkway.

7.3.3 Southeast buffer zone vegetation and LWD

Vegetation in the southeast buffer zone sampled as part of the baseline study consisted of common hawthorn in the overstory and a predominance of Himalayan blackberry in both the shrub and herbaceous vegetation strata (Table 4-11). Trailing blackberry and salmonberry, both native species, were also common in the shrub and herbaceous strata; however, no native tree species were recorded in the sampling transects of the southeast buffer zone, indicating the importance of active restoration efforts to remove invasive species (which also include reed canarygrass and common hawthorn) and install native plants.

Qualitative observations of the southeast buffer zone were made in April 2018 (Windward 2018c). These observations noted a mix of native tree species, including red alder, water birch (*Betula occidentalis*), Douglas fir (*Pseudotsuga menziesii*), bigleaf maple, and western hemlock, present in the southeast buffer zone, all of which would be appropriate species to consider for any future planting efforts in this zone, as well as additional native trees like western red cedar and Oregon ash (which prefers wetter areas). Native trees in the understory will eventually be able to extend into and help diversify the tree canopy. LWD is present within the southeast buffer zone (Table 4-14), and some of the red alder trees in this zone are dying, providing standing snag habitat for birds, insects, and other wildlife.

The northern and central portions of the Marsh's east buffer zone were also qualitatively evaluated in April 2018, but due to their narrow nature, they were not selected for vegetation transect placement during the baseline study. In April 2018, this area was noted to contain a relatively narrow but dense band of woody vegetation that included red alder and Douglas fir in the overstory and Himalayan blackberry, Scotch broom, and Pacific willow (*Salix lasiandra*) in the understory (Windward 2018c). Near the location where Shellabarger Creek passes under SR-104 via the double culverts (Map 2), cattails were observed extending from the Marsh all the way to the sidewalk along the highway. Bittersweet nightshade, Himalayan blackberry, and reed canarygrass (all invasive species) were also observed in this area, as were native black gooseberry (*Ribes divaricatum*) and salmonberry.

Habitat restoration efforts could be conducted in the northern and central portions of the east buffer zone, with a focus on removing invasive species and planting native species; however, this area would likely be more difficult to work within, given its narrowness and proximity to a busy highway. It is recommended that any habitat restoration efforts in this area be conducted by qualified personnel.

7.3.4 South buffer zone vegetation and LWD

Of all the buffer zones, the south buffer zone had the most diverse native plant community within the herbaceous and shrub/sapling strata, with 22 native species identified in the herbaceous stratum and 15 native species identified in the shrub/sapling stratum (Table 4-12). Vegetation sampled as part of the baseline study consisted of red alder in the canopy, a predominance of salmonberry in the shrub stratum, and a predominance of American skunkcabbage and youth-on-age in the herbaceous stratum. Many other native species were inventoried within the vegetation transects as well, and red alder, bigleaf maple, Douglas fir, western red cedar, and western hemlock were observed in the tree canopy during qualitative observations conducted in the south buffer zone in April 2018 (Windward 2018c). Invasive species in the south buffer zone included Himalayan blackberry, reed canargygrass, cherry laurel, English ivy, lesser herb Robert, and English holly; however, all of these were present at approximately 10% cover or less. The relatively large size of this buffer zone, along with the intact forest cover, has likely helped protect the south buffer zone from invasion by weedy plant species. Active vegetation management efforts performed at the Hatchery have also no doubt contributed to the low invasive species percent cover.

In addition to a diverse mix of native plants, the south buffer zone contains a relatively large amount of LWD, particularly standing snags. Although only two pieces of LWD (both logs on the ground) were identified within the vegetation transects (Table 4-14), many standing snags were observed at the edge of the forested habitat, where the forest transitions into emergent Marsh habitat. Most of these standing snags appeared to have once been red alder or bigleaf maple trees. It is unclear why many of these trees have declined in this area; it may be due to a change in flooding regime or the trees reaching the end of their natural lifespans. Regardless, the snags and other LWD provide habitat for woodpeckers and other wildlife.

The primary recommendations related to the south buffer zone are to control invasive species in the understory, and to prevent bittersweet nightshade and reed canarygrass, which are present in the Marsh adjacent to the south buffer zone, from invading the high-quality forested habitat of this area. Efforts are already underway to control invasive plants and install native plants at the Hatchery, and new native plantings were installed during the baseline monitoring year. Given the density and diversity of native plants in the south buffer zone, invasive species control alone would likely be sufficient to fully restore the native forest community (as native species would seed in and spread naturally). However, active planting of native species will speed up the natural regeneration process and further enhance plant diversity. Pieces of LWD should be left in place as much as possible.

The diversity of native plants present in the south buffer zone appears to be largely "natural," meaning that for the most part, the plants here appear to reflect a remaining intact forest still dominated by native plants. As such, this community may provide a good example on which to base planting schemes for restoration efforts elsewhere in the buffer zones of the Marsh and Shellabarger Marsh. This area might also be able to provide native, local planting stock for such restoration efforts, if seeds or cuttings could be harvested conservatively and propagated for out-planting.

The southwest buffer zone of the Marsh, which is located on the Unocal Site, was not included in the baseline study, as the property was not accessible for this purpose. However, the area was qualitatively evaluated in April 2018, as possible, from surrounding, publicly accessible land (Windward 2018c). The forested portion of the southeast buffer zone appears to have a composition similar to that of the south buffer zone: tree species observed included bigleaf maple, red alder, Douglas fir, and western red cedar.

7.3.5 Shellabarger Marsh north buffer zone vegetation and LWD

Invasive and other weedy vegetation dominated the herbaceous and shrub strata of the north buffer zone of Shellabarger Marsh.[35] Invasive species identified within the vegetation transect included purple loosestrife, field bindweed, bittersweet nightshade, Himalayan blackberry, and reed canarygrass (Table 4-13). Native species identified were red alder (the only tree species within the vegetation transect) and broadleaf cattail. Other native species (i.e., Scouler's willow, Pacific willow, osoberry [*Oemleria cerasiformis*], evergreen huckleberry [*Vaccinium ovatum*], and sword fern) were observed in the north buffer zone of Shellabarger Marsh during a qualitative evaluation of the zone made in April 2018 (Windward 2018c). Additional non-native/invasive species observed included cherry laurel, English holly, and English ivy, the last growing not only on the ground but also climbing some of the trees.

Vegetation enhancements in this buffer zone could include the removal of non-native species and installation of native shrubs, groundcover plants, and shade-tolerant trees. As some of the red alder trees in this area are in decline, providing a source of understory tree seedlings that will ultimately grow to replace the red alders would be important to ensure forest succession. There is some LWD in the north buffer zone of Shellabarger Marsh (two pieces derived from red alder trees were identified along the single vegetation transect through this zone [Table 4-14]); however, any additional LWD that could be placed as part of other habitat restoration efforts would be beneficial.

7.3.6 Sediments, vegetation and LWD of the Marsh interior

Marsh sediments were observed to be consistent with the description of Mukilteo muck: acidic pH values, relatively high TOC content, and large quantities of visible organic matter/detritus and root mass (Tables 4-6 and 4-7). Organic-rich wetland soils provide carbon sequestration (Batzer and Sharitz 2006); the high TOC content and visible

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[35] A qualitative description of the other buffer zones of Shellabarger Marsh is available in the *Evaluation of Edmonds Marsh and Shellabarger Marsh Buffer Zones* report (Windward 2018c).

organic matter within the Marsh's sediments show that they are providing this function. The sediments support dense stands of native marsh plants interspersed with open mudflat areas (Map 6). Salt-tolerant vegetation is dominant in the western portion of the Marsh, while cattail is dominant in the eastern portion (Section 4.5).

Restrictions on the growth of native salt marsh plants within the Marsh are understood to be related to changes in the salinity gradient (influenced by operation of the downstream tide gate [see Sections 4.2 and 7.1], as well as to competition from invasive species such as common reed. In general, the lower limits of salt marsh vegetation zones are created by the physical stress of tidal inundation, while the upper limits are created by competition for nutrients, sunlight, and space (Hood 2007). Changes in the hydrology and salinity regime of the Marsh are anticipated to occur as a result of the Edmonds Marsh Estuary Restoration Project and daylighting of Willow Creek (particularly if the existing tide gate is removed and either not replaced or replaced with a configuration that allows more tidal water flow into the Marsh).

The vegetation community is also expected to shift in response to changes in hydrology and salinity post-restoration, particularly in the western lobe of the Marsh, which is most influenced by tidal flows. For example, salt marsh vegetation is expected to expand, while freshwater-associated species such as cattail are expected to decline in some areas, as cattails have been shown to have greatly reduced growth rates at salinities of 10 ppt and above (Beare and Zedler 1987). However, given mature cattail's ability to tolerate saline water, active removal may be necessary in order to create open space where salt-tolerant Marsh vegetation can colonize and expand. Recommendations related to the control of cattail were provided in the *Evaluation of the Edmonds Marsh Estuary Restoration Project* report (Windward 2019).The baseline conditions of the Marsh vegetation (as documented on Map 6) will allow for a future evaluation of changes to the plant community.

The existing Marsh vegetation provides a number of ecological functions, including habitat for birds and other wildlife, sediment erosion control, and water quality improvement (Table 7-1). Most of the plant species within the Marsh are native; however, some invasive species, such as common reed and Japanese knotweed, are also present (Map 6 and Table 4-8). Japanese knotweed and one of the two patches of common reed are located near the terminus of the wooden boardwalk and adjacent to the Burlington Northern Santa Fe (BNSF) right-of-way. The railway may represent a source of weed seeds; this area may need close monitoring for and control of invasive plant species. Recommendations related to the control of common reed were provided in the *Evaluation of the Edmonds Marsh Estuary Restoration Project* report (Windward 2019). Section 7.4 includes additional discussion related to the habitat value provided by the Marsh's vegetation and other habitat features.

Table 7-1. Ecological function of plant species identified within the Marsh

Species Common Name	Species Scientific Name	Ecological Role/Function
Baltic rush	*Juncus arcticus or Juncus balticus*	sediment retention, erosion control, possibly nitrogen fixation (Cooke 1997)
Broadleaf cattail and narrowleaf cattail	*Typha latifolia* and *Typha angustifolia* (Tilley and St. John 2012a)	seeds generally not eaten by wildlife but geese and muskrats will eat stems and roots; used for shelter and nesting sites by red-winged blackbirds, yellow-headed blackbirds, and marsh wrens (Stevens and Hoag 2006); Marsh photo-documentation shows that birds such as chickadees eat insect larvae dwelling inside the flower spikes (Appendix I); provides water quality functions, removing pollutants through filtering (Guard 1995)
Common brassbuttons	*Cotula coronopifolia*	seeds a food source for waterfowl (Mall and Rollins 1972)
Common reed	*Phragmites australis*	despite being an invasive weed, provides nesting cover for shorebirds and waterfowl; waterfowl eat its seeds (Tilley and St. John 2012a)
Cosmopolitan bulrush	*Bolboschoenus maritimus*	provides erosion control; rhizomes associated with bacteria beneficial in regards to water treatment; seeds a food source for water fowl; above-ground growth nesting cover for birds; young shoots and rootstock eaten and used as building material by beaver and muskrats (Tilley and St. John 2012b)
Creeping bentgrass	*Agrostis stolonifera*	moderate palatability for graze animals
Hardstem bulrush	*Schoenoplectus acutus*	poor palatability for graze animals; waterfowl eat seeds; dense growth provides high-quality nesting habitat for waterfowl and other wetland birds; root stock eaten by beaver and muskrat; muskrat use stems for building; dense root mat stabilizes soils and provides erosion control; rhizomes provide habitat for bacteria beneficial for water quality; aphids known to feed on stems (Tilley 2012)
Lyngbye's sedge	*Carex lyngbyei*	provides food for insects, birds, and some mammals; provides nesting material for birds and erosion and sediment control
Meadow barley	*Hordeum brachyantherum*	valuable forage for deer in spring but low palatability for browsing and grazing animals when mature; potential to help impede spread of reed canarygrass; easy to establish and often included in wetland and salt marsh restoration seed mixes (Darris 2008)
Pacific silverweed	*Argentina egedii*	provides erosion control; songbirds eat seeds; small mammals eat seeds and foliage (Stevens 2007)
Pickleweed	*Salicornia depressa*	usually a pioneering colonizer in bare areas within salt marshes (Bakker 2017)
Reed canarygrass	*Phalaris arundinacea*	despite being an invasive species, provides moderate palatability for graze animals; provides cover and nesting habitat for some bird species; seeds eaten by many bird species (NRCS 2006); can provide nutrient uptake to help treat wastewater but needs to be routinely cut (with biomass removed) in order to maintain nutrient uptake performance (NRCS 2006)
Saltgrass	*Distichlis spicata*	fair to good forage value; eaten by geese and other waterfowl; provides nesting cover for birds, as well as cover for marine invertebrates and fish; resistant to trampling; provides erosion control (Skaradek and Miller 2010)

Species Common Name	Species Scientific Name	Ecological Role/Function
Seaside arrowgrass	*Triglochin maritima*	toxic (containing cyanogenic glycosides) and should not be eaten by humans or livestock (Fretwell and Starzomski 2014)
Spear saltbush	*Atriplex patula*	songbirds such as sparrows likely eat seeds; leaves eaten by a variety of insects (Hilty 2017)

Very few pieces of LWD were identified in the western portion of the Marsh interior; pieces that were encountered are shown on Map 2. While the eastern portion of the Marsh interior was difficult to survey (due to dense vegetation cover), there appeared to be more pieces of LWD in that portion of the Marsh, particularly around the Marsh edge. LWD provides many ecological functions within estuarine marshes, including inputs of detritus that help support the estuarine food web, shelter (from both high-velocity currents and predators), egg attachment sites for fish, roosting and hunting platforms for birds, and habitat islands that can be colonized by vegetation (Hood 2007; Eissinger 2007). It may be possible to place additional pieces of LWD within the Marsh during implementation of the Edmonds Marsh Estuary Restoration Project. It would be preferable to place LWD within the Marsh using equipment that is either staged in upland areas or already accessing the Marsh for other construction purposes, in order to prevent compaction of Marsh sediments beyond the extent necessary to complete the other earthwork associated with the project.

7.4 Invertebrate and Wildlife Use of Marsh and Buffer Habitats

Despite its location in the center of a highly urbanized area, the Marsh, along with its buffer zones, provides habitat for a large number of wildlife species, as was documented throughout the course of the baseline monitoring year. In general, the species that use the Marsh appear to be relatively well adapted to the human activities conducted around the Marsh and the noises they generate. Some species use the Marsh year-round, while others are seasonal visitors. The Marsh is used as breeding, foraging, and resting habitat for a suite of bird and mammal species. It also supports many different types of insects and other invertebrates. In addition, Willow and Shellabarger Creeks provide habitat for fish and amphibians.[36] The specific habitat requirements of the species that use the Marsh and its buffer areas, as well as direct observations of how wildlife interacts with these habitats, help provide valuable information about the habitat functions that the Marsh provides, as well as guidance for how habitat functions could be improved through habitat enhancements and restoration. The discussion that follows draws upon the data and observations collected as part of the baseline study, collected by other parties (Section 5 and Appendices H and I), and collected by members of the community (Section 6 and Appendix I).

[36] While the presence of fish was not directly monitored as part of the baseline study, juvenile salmonids were observed in Willow Creek in the south buffer zone (at the Hatchery) on several occasions and in Willow Creek where it runs along the southern portion of the Marsh during summer data collection, and use of Willow Creek by fish has been documented in reference material.

7.4.1 Invertebrates

There was a noticeable trend in the aquatic invertebrate community composition moving from sampling stations more influenced by tidal flow to stations more influenced by freshwater flows (Section 5.2.3 and Appendix G). Ostracod crustaceans (81%) and amphipods (13%) made up the largest components of the sample collected from the portion of Willow Creek downstream from the Marsh (Station WC-02); there were very few insects in the sample (a few biting and non-biting midge fly larva). Along the northern boundary of the Marsh, adjacent to Harbor Square (Station WC-03), crustaceans (36%) and mosquitos (38%) made up the majority of the sample. Leeches (32%), freshwater fingernail clams (26%), and non-biting midge fly larva (35%) composed the majority of the sample from the eastern portion of the Marsh where Willow Creek traverses the Marsh (Station WC-05). Crustaceans (38%), non-biting midges and other types of flies (20%), mayfly larvae (14%), oligochaete worms (13%), and stonefly larvae (11%) all made up large components of the sample from Willow Creek within the Hatchery (Station WC-06). Black flies (60%), crustaceans (11%), and mayflies (11%) composed the largest portions of the sample from upper Shellabarger Creek (Station WC-07).

Flies were the most common invertebrates identified in the fallout trap samples collected as part of the baseline study during most seasons, with the exceptions of the summer samples from the north and southeast buffer zones (Section 4.9). Other Orders commonly identified included Araneae (spiders), Collembola (springtails), and Gastropoda (slugs and snails).

The number of invertebrates captured, as well as the invertebrate Orders represented in the fallout trap samples, was no doubt influenced by the timing of the sampling (the season, and even the precise timing within each season). For example, the summer samples from the north buffer zone of Shellabarger Marsh contained a very large number of flies (384 out of a total sample size of 435), many of which appeared to be the same species of non-biting midges and a species of Anthomyiidae. Additionally, many of the flies were almost the exact same size (see tables in Appendix D). It is possible that the summer fallout traps captured large batches of these flies not long after they emerged from their pupal stage.

Dr. David Richman provided a report on the insects and other invertebrates that he observed in the buffer areas around Edmonds Marsh, along with photographs; these are included in Appendix I. Over a period of three years, 8 species of dragonflies (Order Odonata), 1 grasshopper species and 1 katydid species (Order Orthoptera), 2 species of true bugs (Order Hemiptera), 4 species of beetles (Order Coleoptera), 8 species of moths and butterflies (Order Lepidoptera), at least 7 species of the flies (Order Diptera), 12 species of bees, wasps, and ants (Order Hymenoptera), 4 species of spiders (Order Araneae), and 2 species of the harvestmen (Order Opiliones) were identified. In addition, there are many other species of invertebrates present within the Marsh, Shellabarger Marsh, and their buffer areas than have been documented to date.

Insects and other invertebrates provide numerous ecological functions. They help promote plant diversity through pollination, as well as through herbivory control (which prevents individual plant species from becoming over abundant and out competing other species) (Peterson 2018). In addition, invertebrates provide important functions in breaking down plant material and other detritus, allowing it to be consumed and used within the food chain. For example, midge larvae eat small food items and algae from marsh and mudflat surfaces, and fingernail clams and mosquito larvae filter algae, detritus, and microorganisms, including bacteria, from water (Batzer and Sharitz 2006). Species such as Trichoptera (caddisflies) help by shredding detrital material into smaller pieces that can then be more easily broken down by fungi and bacteria (Batzer and Sharitz 2006; Peterson 2018). Invertebrates also provide a critical trophic link between primary producers (e.g., macrophytes and algae) and other animal species, as invertebrates are important prey items for a variety of fish, bird, and other wildlife species.

Invertebrate prey preferred by Chinook (*Oncorhynchus tshawytscha*) and coho (*Oncorhynchus kisutch*) salmon in freshwater tributaries include larval and terrestrial midges (*Chironomidae*), stonefly nymphs (Plecoptera), mayfly nymphs (Ephemeroptera), black flies (*Simuliidae*), springtails (Collembola), other flies (*Empididae*), aphids (*Aphidae*), and beetles (Coleoptera) (Plotnikoff 2006; as cited in Windward 2007). Representatives from all of these groups have been identified within the Marsh and its buffer areas.

In studies of salmonid diets conducted in the Lower Duwamish River (Cordell et al. 2001; Cordell et al. 2011), important prey items for juvenile Chinook salmon included annelid polychaete worms, amphipods (*Americorophium* spp.), insect larvae, crustaceans of the Order Cumacean, adult flies, insects of the Order Hymenoptera, collembolans (springtails, Order Collembola), psyllids (Order Hemiptera), and water fleas (Order Cladocera). Important prey items for juvenile chum salmon (*Oncorhynchus keta*) included fly larvae and adult flies, aphids, benthic crustaceans (including amphipods and tanaids), psyllids, harpacticoid copedpods, collembolans (springtails, Order Collembola), water fleas (Order Cladocera), and zooplankton. Chironomid (non-biting midge) flies (as larvae, pupae, and adults) were important to dietary items for both salmon species. Again, many of these groups were identified in the Marsh, either in fallout trap samples, as part of the aquatic invertebrate sampling (Appendix G), or both.

While B-IBI scores indicate that the aquatic invertebrate community is stressed by poor water quality, the invertebrate samples collected from Willow Creek downstream from the Marsh, Willow Creek within the Hatchery, and Shellabarger Creek upstream from SR-104 contained large numbers of invertebrates (400 individuals or more). Samples collected from the Marsh interior contained fewer individuals, with 187 invertebrates in the sample from the northern boundary of the Marsh (Station WC-03), 31 in the sample from Willow Creek within the eastern portion of the Marsh (Station WC-05), and only 2 in the sample collected from Shellabarger Creek within the eastern portion of the Marsh (Station WC-04).

One possible factor contributing to the low density of aquatic invertebrates within the Marsh is operation of the tide gate. As the composition and abundance of the benthic invertebrate community are linked to salinity (Sapiens 2014), it is very possible that dramatic fluctuations in sediment porewater salinities[37] in the estuarine portion of the Marsh are stressing the benthic invertebrate community. It is also possible that the dense growth of cattails in the eastern portion of the Marsh is contributing to a depressed aquatic invertebrate community. Studies have shown that invertebrate populations increase when cattail stands are thinned (Murkin et al. 1982, as cited in Batzer and Sharitz 2006), and that many aquatic invertebrates rely more on microphytes (like algae) than on macrophytes (like cattails) as food sources in wetlands (Batzer and Sharitz 2006). On the other hand, photos of the Marsh have shown birds pulling insect larvae from cattail flower heads (Appendix I), and the highest numbers of invertebrates from the fallout trap samples came from the Shellabarger Marsh north buffer zone, where riparian vegetation meets cattail vegetation. Undoubtedly, wetland food webs are complex and influenced by innumerable site-specific factors.

7.4.2 Fish, amphibians, and reptiles

Monitoring for fish, amphibians, and reptiles was not directly addressed in the baseline study. However, incidental observations made during the baseline monitoring year, as well as information from reference documents, provide data about the presence of these groups of animals in the Marsh and its buffer zones and Willow and Shellabarger Creeks.

Willow Creek historically supported coho salmon, chum salmon, resident and sea-run cutthroat trout (*Oncorhynchus clarkii*), sculpins, and threespine stickleback (*Gasterosteus aculeatus*) (Sea-Run Consulting et al. 2007; Shannon & Wilson 2015).[38] Since the early 2000s (when the Willow Creek outfall pipe was lengthened and submerged deeper into the Puget Sound), reportedly very small numbers of adult salmon and sea-run cutthroat trout have been able to find the submerged pipe and migrate up into Willow Creek, and none have been observed for the past several years (Shannon & Wilson 2015). However, in 2008, thousands of threespine stickleback, a pair of prickly sculpin (*Cottus asper*), and a single starry flounder (*Platichthys stellatus*) were captured in the lower portion of Willow Creek adjacent to the Unocal Site and the BNSF railway line (Arcadis 2010).[39] In addition, coho salmon are reared at the Hatchery, and small numbers are incidentally released to Willow Creek, which could provide suitable rearing habitat, as coho spend at least one year rearing in streams (Fresh 2006).

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[37] As the salinity of water in the western portion of the Marsh fluctuates between approximately 0 and 33 ppt (mean 11.4) when the tide gate is open, and between 0 and 32 (mean 0.99) when it is closed, it is assumed that porewater salinities fluctuate similarly (see Table 4-1).

[38] Fish were observed within Willow Creek; it is not clear whether they were also observed in the Marsh's tidal channels or in Shellabarger Creek.

[39] The fish were captured and removed from this portion of Willow Creek because it was undergoing remediation by Chevron Corp.

Garter snakes were observed on a number of occasions within the Marsh's buffer areas (particularly the south and southeast buffer zones), and on one occasion a red-tailed hawk was observed flying with a garter snake in its talons, illustrating another food web connection of the Marsh. In addition, a mass of amphibian eggs was observed in Shellabarger Creek just upstream from the SR-104 culvert; these could have been frog, toad, or salamander eggs.

Table 7-2 provides information about the general habitat requirements and diets of coho salmon, three-spine stickleback, and garter snakes. The Marsh and its buffer zones, in conjunction with Willow and Shellabarger Creeks, are able to provide these habitat requirements.

Table 7-2. Habitat requirements, diet, and foraging information for coho salmon, three-spine stickleback, and garter snakes

Species	Ecological Role	General Habitat Requirements	Diet/Foraging Behavior
Coho salmon (*Onchorhynchus kisutch*)	migratory juvenile fish	Coho generally use the deepest water in pools and LWD for cover; for juveniles, cover seems to be more important in winter than in summer (Wydoski and Whitney 2003). At a DO level of < 5 mg/L, the hatching success of fry is impacted; reduced swimming speeds have been noted at DO levels of < 7 mg/L at 10 to 20°C (Hassler 1987).	Coho in streams feed primarily on insects (Diptera larvae, pupae, and adults; mayflies; and stoneflies), worms, fish eggs, spiders, and fish (Wydoski and Whitney 2003). In estuarine habitats, flies, aphids, mysid shrimp, and gammarid amphipods have been shown to comprise a large proportion of juvenile coho diets (Miller and Simenstad 1997).
Three-spined stickleback (*Gasterosteus aculeatus*)	small, schooling forage fish	Three-spined sticklebacks are weak swimmers displaced by high flow, generally associated with aquatic vegetation, and found close to the bottoms of streams. They are abundant in the slow, brackish water of shallow sloughs and estuaries (Wydoski and Whitney 2003). The species tolerates a range of salinities, and there are marine, anadromous, and freshwater populations (Love 2011). In a study of fish use of pocket estuaries conducted in north Skagit County and the Whidbey Basin, three-spined stickleback were 1 of the 6 most commonly captured fish species (Beamer et al. 2006).	A generalist feeder (visual predator), the three-spined stickleback has a diet primarily of small crustaceans (e.g., amphipods, mysid shrimps, and copepods), insect larvae, snails, worms, terrestrial insects, and fish eggs (Wydoski and Whitney 2003; Love 2011).
Garter snake (*Thamnophis* spp.)	low-level predator	Garter snakes prefer moist, grassy environments that are close to water such as marshes, meadows, or woodlands. They require cover in the form of debris, logs, or rocks for protection from predators and to ambush prey (Zimmerman 2013; Gleaton 2019).	Garter snakes feed on smaller organisms including earthworms, amphibians, insects, small fish, or small mammals or birds (Zimmerman 2013; Gleaton 2019).

DO – dissolved oxygen
LWD – large woody debris

7.4.3 Birds

Birds are the most prominent and well-documented of the wildlife that uses the Marsh. Their presence was surveyed as part of the baseline study and is being studied by Audubon and community members. Numerous species from a number of different groups—including invertivorous, piscivorous, predatory, and scavenging birds—were observed in the Marsh and buffer zones. Some of these are year-round residents and others are seasonal visitors. Birds use the Marsh and buffer zones for resting, foraging, and breeding.

Birds common throughout the Marsh and buffer areas during all seasons of the year include American crow, American robin, Anna's hummingbird, Bewick's wren, black-capped chickadee, golden-crowned sparrow, and spotted towhee (Section 4.8). Red-winged blackbirds and marsh wren are common in the Marsh interior year-round, and common yellowthroats are common in the interior in the spring and summer.

A number of different shorebird species also use the mudflat and emergent habitats of the Marsh. While some of these species are only seasonal visitors, others—such as killdeer and Wilson's snipe (*Gallinago delicate*)—remain year-round (Riddell and Peterson 2016). Between January 2018 and May 2019, killdeer, semipalmated plover (*Charadrius semipalmatus*), Wilson's snipe, Virginia rail, Wilson's phalarope (*Phalaropus tricolor*), least sandpiper (*Calidris minutilla*), pectoral sandpiper (*Calidris melanotos*), spotted sandpiper, long-billed dowitcher (*Limnodromus scolopaceus*), greater yellowlegs (sandpiper) (*Tringa melanoleuca*), and Baird's sandpiper (*Calidris bairdii*) were photographed in the Marsh (Appendix I). Shorebirds are generally invertivorous, indicating that the invertebrate community of the Marsh and mudflat areas is sufficient to help fulfill their dietary requirements, at least seasonally. Table 7-3 provides information about the habitat requirements, diet, and foraging behaviors of some of the bird species observed, demonstrating food chain linkages among the invertebrates, fish, reptiles, and birds of the Marsh.

Table 7-3. Habitat requirements, diet and foraging information for a subset of the bird species that use the Marsh

Species	Ecological Role	General Habitat Requirements	Diet/Foraging Behavior
Bald eagle (*Haliaeetus leucocephalus*)	top predator	Bald eagles prefer large, open trees near water. Eagles need perch trees that are stout enough to support their weight and are isolated from human disturbance (Stinson et al. 2001).	Bald eagles are opportunistic feeders that obtain prey through active hunting, carrion feeding, or piracy (i.e., stealing prey from other animals). Their diet varies based on local prey sources available. The bald eagle will capture live fish swimming near the water surface or in shallow water; in the winter, waterfowl and shorebirds are important food sources (EPA 1993). It also eats mammals such as rabbits and squirrels.
Great blue heron (*Ardea Herodias*)	top predator	Great blue herons rely on nearshore habitats, and saltwater and freshwater marshes are important foraging grounds throughout the year (Eissinger 2007). Inland marshes, streams, and riparian forests also provide shelter and roosting areas. The species uses estuarine habitats year-round for foraging, loafing, staging, and dispersal of young. Breeding colonies are located within mature nearshore forests, where trees are large and stout enough to support the nests herons build from large sticks. Breeding sites are also selected for their proximity to foraging grounds, preferably eelgrass meadows, and protection from human disturbance.	The great blue heron's diet consists of fish, invertebrates, small mammals, and occasionally amphibians and reptiles (Eissinger 2007). Small mammals such as voles are particularly important prey items in the winter and for juvenile herons (which are not yet efficient at fishing). Three-spined stickleback is a targeted prey item, particularly during the breeding season. Great blue herons will forage from pieces of LWD and boulders during high tide.
Killdeer (*Charadrius vociferus*)	invertivorous bird	Killdeer use open areas, such as mudflats, short-grass meadows, wetland lagoons, and reservoirs. They are also found in human-modified habitat such as agricultural and athletic fields, golf courses, or graveled lots/rooftops (Jackson and Jackson 2000). Nests are placed in open, mostly unvegetated areas with soft substrates (Ehrlich et al. 1988).	Killdeer eat terrestrial invertebrates, worms, grasshoppers, beetles, and snails and forage in open flats with no cover or in shallow water (Jackson and Jackson 2000).
Mallard (*Anas platyrhynchos*)	omnivorous forage bird	Mallards use marshes, forested wetlands, grain fields, ponds, rivers, lakes, bays, and city parks. They may occur in any kind of aquatic habitat but favor freshwater in all seasons; they are only sparingly found on coastal waters, mainly in winter and in sheltered bays and estuaries (Kaufman 2019).	Mallards forage in nearshore environments and graze on land. They are omnivorous, with a diet composed of mostly plant material (seeds, stems, roots of sedges, grasses, pondweeds, waste grain); they also consume insects, crustaceans, mollusks, earthworms, and small fish. Young mallard ducklings consume mostly aquatic insects (Kaufman 2019).

Species	Ecological Role	General Habitat Requirements	Diet/Foraging Behavior
Marsh wren (*Cistothorus palustris*)	invertivorous bird	The marsh wren uses cover and nesting habitat provided by wetland plants such as cattails, bulrushes, cordgrasses, sedges, etc., and avoids abundant woody vegetation (Gutzwiller and Anderson 1987).	The marsh wren preys upon insects and spiders taken from vegetation and the marsh floor and also catches flies. Common insect prey include the Orders Coleoptera (beetles), Diptera (flies), Hemipteran (true bugs), and Odanta (grasshoppers and crickets).
Pileated woodpecker (*Dryocopus pileatus*)	invertivorous bird that creates cavities in standing dead wood	Pileated woodpeckers are found in a variety of forest types including coniferous, deciduous, and old growth forests (The Cornell Lab of Ornithology 2017a). They specifically require dead, rotting wood (snags or dead branches) to excavate for roosts and nesting sites. Larger trees are necessary to accommodate the size of nests (Audubon 2019).	The pileated woodpecker's diet consists primarily of insects found in dead wood, such as carpenter ants and beetle larvae; its diet is supplemented by other insects as well as various forest berries and nuts (Aubry and Raley 2002).
Song sparrow (*Melospiza melodia*)	invertivorous bird	Habitat types used by song sparrows vary greatly, but most subspecies occupy and nest in areas consisting of shrubs growing on moist ground along streams, sloughs, marshes, or coastlines (Ehrlich et al. 1988; Arcese et al. 2002). The species is often found within edge habitat (e.g., edges of forests, lakes, streams, etc.) (The Cornell Lab of Ornithology 2017b).	The song sparrow diet changes seasonally, from primarily seeds, fruits, and invertebrates in the non-breeding season to primarily insects and small invertebrates during breeding season. Feeding occurs through a variety of capture techniques (Arcese et al. 2002).
Spotted sandpiper (*Actitis macularius*)	invertivorous bird	Spotted sandpiper feed along the sandy or muddy edges of water bodies and require semi-open vegetation with high invertebrate biomass (Oring et al. 1983). They breed in open habitats along the margins of water bodies (Oring and Lank 1986) but also amongst grasses, mosses, shrubs, and even logs within forested habitat (Ehrlich et al. 1988).	Adult flying insects are the main component of the spotted sandpiper diet; smaller proportions include crustaceans, leeches, mollusks, small fish, and carrion (Oring et al. 1983).

LWD – large woody debris

Piscivorous birds observed in the Marsh during the baseline monitoring year included belted kingfisher (heard at the Unocal Site from BPC-2) and great blue heron. Great blue heron were photographed foraging in Willow Creek and were frequent visitors to the Marsh interior (Appendices E and I). In the winter, this species roosts in groups in the Marsh and likely searches for prey such as rodents, which are important food sources in the winter (Table 7-3). Predatory species observed in the Marsh included red-tailed hawk, Cooper's hawk, bald eagle, northern harrier, and merlin (*Falco columbarius*). Bald eagles visit the Marsh to hunt/scavenge and drink water (Appendix I).

Bird species that have been documented breeding and/or rearing young in the Marsh or its buffer areas include American robin, mallard, Canada geese, great blue heron, spotted sandpiper, marsh wren, red-winged blackbird, violet-green swallow, tree swallow, black-capped chickadee, bushtit, and American crow (Sections 4.8 and 4.9, Appendix I). Additionally, Anna's hummingbird, bushtit, and marsh wren were observed gathering fluff from cattail heads or other nesting materials from buffer areas during the baseline monitoring year (Appendix I).

The narrow band of riparian habitat adjacent to the south side of Willow Creek where the creek runs along the south side of the Marsh (near BPC-2) was used during the baseline monitoring year by a number of different bird species for perching, resting, surveying, and foraging (Section 4.8). In particular, a dead pine tree snag in this area was used for perching by a variety of species, from Anna's hummingbirds to great blue heron. The level of bird activity in this area was no doubt influenced by the presence of the fish-bearing creek, riparian vegetation, Marsh habitat, and the Unocal pond, all in close proximity to one another, and underscores the importance of this area as habitat for a variety of bird species.

The south buffer zone is heavily used by woodpeckers, and in general, this was the only area where woodpeckers were observed during the baseline monitoring year; pileated woodpecker, downy woodpecker, northern flicker, and red-breasted sapsucker were observed in this area (Sections 4.8 and 4.10 and Appendix I). The south buffer zone contains a high density of standing snags and other LWD, particularly at the Marsh edge, which is undoubtedly the primary factor contributing to the greater abundance of woodpeckers in this area. The pileated woodpecker, for example, depends upon large standing snags/dead branches in which to excavate nesting cavities and roots (Table 7-3). The presence of standing snags and woodpeckers in the south buffer zone indicates that woodpeckers are likely providing additional important habitat features in this zone by excavating cavities that can later be used by other cavity-nesting birds and mammals (which themselves have limited abilities to excavate wood).

7.4.4 Mammals

The mammals most commonly observed throughout the baseline monitoring year were coyotes and black-tailed deer, species that use the Marsh and its buffer habitats year-round (Section 4.9, Appendices B, E, and I). The dietary and habitat requirements of these two species are listed in Table 7-4. The deer generally seem to stay within the forested buffer habitat, although deer tracks were observed within the Marsh on one occasion. The south and southeast buffer zones appear to be heavily used travel corridors, and black-tailed deer breed within or near these habitat areas, as evidenced by the presence of fawns within the south buffer zone in the summers of both 2018 and 2019. The south buffer zone meets the habitat requirements of an ideal fawning area for black-tailed deer and provides browse year-round (Table 7-4). It also provides the type of second – growth forested/riparian habitat typically relied upon by urban coyotes. Other mammal species observed during the baseline study were rabbits (observed within the Marsh and the north and south buffer zones), squirrels (observed in the north and south buffer zones), and raccoons (observed in the forested habitat of the south buffer zone).

Table 7-4. Habitat requirements, diet and foraging information for coyote and black-tailed deer

Species	Ecological Role	General Habitat Requirements	Diet/Foraging Behavior
Columbian black-tailed deer (*Odocoileus hemionus columbianus*) – subspecies of mule deer	browsing/grazing mammal	Columbian black-tailed deer use wooded areas for browsing and cover/shelter; they also use edge habitats and feed in more open areas at night. A diversity of habitats/seral forest stages in close association with one another is important to provide the cover and foraging habitat necessary for Columbian black-tailed deer (Innes 2013; Larrison 1976; Quinn 1997). Habitat areas that are 1 to 5 acres in size; contain low shrubs and small trees 0.6 to 1.8 m (2 to 6 ft) high, gradual slopes, and approximately 50% canopy cover; and are in close proximity to water provide ideal fawning areas (Innes 2013).	Columbian black-tailed deer browse year-round upon a variety of woody plants, including western red cedar, salmonberry, willows, and thimbleberry; they also graze upon ferns, mosses, forbs, and grasses during the growing season. They eat some species of lichens and mushrooms (Innes 2013; USDA 1971).
Coyote (*Canis latrans*)	carnivorous and carrion-eating mammal; highly adaptable	In urbanized areas, coyotes are closely associated with patches of secondary growth forest that remain in riparian areas and parks (Quinn 1997); they establish dens under rock outcroppings or large boulders, or as burrows in earthen banks (Larrison 1976).	A coyote's diet consists of a variety of prey items, including small rodents (e.g., moles, voles), squirrels, rabbits, birds, and deer; they also eat fruit (primarily apples and cherries in Western Washington) (Quinn 1997; Urban Coyote Research Project 2019; Gehrt 2007).

The wildlife that uses the Marsh generally seems to have adapted to the surrounding human activities and noises, including the BNSF railroad tracks, ferry horn blasts, and SR-104 traffic. Birds and other animals do not appear to be flushed or obviously stressed by these activities. However, the animals are distressed by people entering and traversing the Marsh. For example, during baseline monitoring activities, a coyote was flushed from its resting place, a juvenile bald eagle perched above Willow Creek gave agitated cries, flocks of killdeer exhibited stress (as evidenced by more frequent, rapid calls), and red-winged blackbirds scolded surveyors (during the breeding season) (Sections 4.8 and 4.9).

Currently, it seems that visitors to the Marsh are respectful of this wildlife sanctuary and generally stay on the designated walking paths and out of the Marsh interior. These practices should continue to be encouraged and reinforced, if necessary, with additional signage or other forms of outreach. Buffer zone plantings could also be enhanced to help protect the Marsh interior from disturbance; however, sufficient view corridors should be maintained so that wildlife viewers/photographers and other visitors can still see the Marsh from the sidelines without having to enter it directly.

8 Conclusions

The Marsh represents a rare nearshore estuarine pocket marsh. In its current condition, it provides a number of ecological functions, as described in this document. After implementation of the Edmonds Marsh Estuary Restoration Project, the ecological functions provided by the Marsh will be enhanced, and the Marsh will once again have the opportunity to provide habitat for juvenile salmonids and other migratory fish. In addition to providing enhanced habitat functions beneficial to fish and wildlife, a restored Marsh system would provide the City of Edmonds, as well as the larger community, with the opportunity to observe and appreciate the roles that nearshore estuarine marshes, tidal streams, and adjacent riparian forests play in fostering the native flora and fauna of the Pacific Northwest, and how they can do so even within an urban area.

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9 References

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