SKOKOMISH RIVER BASIN
MASON COUNTY, WASHINGTON
ECOSYSTEM RESTORATION

APPENDIX C

WETLANDS INVENTORY

Integrated Feasibility Report and Environmental Impact Statement

US Army Corps
of Engineers®
Seattle District

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WETLAND INVENTORY AND EVALUATION FOR THE SKOKOMISH BASIN

SKOKOMISH GENERAL INVESTIGATION

Prepared for

U.S. Army Corps of Engineers

Seattle District

Prepared by

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Final Draft

July 2011

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LIST OF ACRONYMS AND ABBREVIATIONS

Corps	U.S. Army Corps of Engineers
General Investigation	Skokomish River Basin Ecosystem Restoration and Flood Risk Management General Investigation
HGM	hydrogeomorphic classification
LiDAR	Light Detection and Ranging
LWD	large woody debris
MLLW	mean lower low water
MVI	modified vegetative index
NDVI	normalized difference vegetation index
NRCS	Natural Resource Conservation Service
NWI	National Wetland Inventory
PEM	palustrine emergent
PFO	palustrine forested
POW	palustrine open water
PSS	palustrine scrub-shrub
SR	state route
TVI	transformed vegetation index
USFWS	U.S. Fish and Wildlife Service
VI	vegetative index

1 INTRODUCTION

This inventory of wetland habitats in the lower Skokomish River valley was conducted by Anchor QEA, LLC (Anchor QEA) at the request of the U.S. Army Corps of Engineers (Corps) to support the Corps' Skokomish River Basin Ecosystem Restoration General Investigation (the General Investigation). The Skokomish River is located on the eastern slopes of the Olympic Peninsula in Mason County, Washington, and flows in to Hood Canal along a fjord with a pronounced bend (Figure 1). The General Investigation addresses ecosystem restoration in the Skokomish River watershed. Mason County, the Skokomish Tribal Nation, and the Corps, along with several other state, federal, and local governmental entities, have been working to develop a plan for restoring the Skokomish River watershed ecosystem. The initial goals of the General Investigation are the creation of a sustainable and restored river channel and the restoration of habitat to aid recovery of endangered salmon species. This wetland inventory documents the existing wetlands and wetland habitats in the Skokomish River Watershed in support of the General Investigation.

Wetlands play an important role in the large river valleys of the Puget Lowlands. Puget Lowlands rivers located in broad low gradient valleys, such as the Skokomish River in the project study area (Figure 2), were characterized prior to human development by a single channel with numerous ox bow lakes and vast floodplain wetlands (Collins et al. 2003). These floodplain wetlands did and still do play a critical role in the morphology, hydrology, and ecology of the lower Skokomish River valley. Wetlands provide flood storage and absorb water run-off, both of which can lessen the peak height of floods. Wetlands also provide key habitats that are critical for a number of species including federally listed endangered species found in the study area. Furthermore, wetlands beneficially impact water quality by absorbing nutrients and pollutants before they enter the Skokomish River. By extension, these water quality functions benefit the water quality of Hood Canal, which suffers from low levels of dissolved oxygen exacerbated by nitrogen loading (Newton 2008).

The previous and most recent inventory of wetlands in the lower Skokomish River valley was the National Wetland Inventory (NWI) that was based on high altitude (1:12,000), color infrared imagery acquired in the 1980s and the soil survey report of Mason County (NRCS 2010; Figure 3). The dynamic channel migration pattern of the Skokomish River and efforts to restore wetlands and drain agricultural areas have made this data set largely obsolete. Numerous wetland areas in the Skokomish River watershed are not accurately mapped by the NWI. Some of these misclassified areas can be revealed easily by reviewing recently collected contemporary high altitude imagery. To assist in meeting the goals of the General Investigation, wetland areas inventoried in the study area at the time of this report are documented herein. This report was developed using existing aerial topography surveys (stereo interpretation and Light Detection and Ranging [LiDAR]) and mission-specific, low altitude, color infrared imagery. The methods used to determine wetland areas are based on U.S. Fish and Wildlife Service (USFWS) protocols for wetland inventory (USFWS 2009)

This investigation identified nearly 1,000 more acres of wetlands than the NWI including substantially more of all wetland classes with the exception of palustrine forested (PFO) and palustrine open water (POW). The changes can be attributed to several factors, including channel migration of the Skokomish River and its tributaries, land use changes in the floodplain including significant wetland restoration efforts, differences in source data and technology, and the more intensive field investigation associated with this effort. Channel aggradation by several feet over the last 40 years has also resulted in higher groundwater elevation and increased wetland area.

2 BACKGROUND INFORMATION

The Skokomish River watershed drains an area of approximately 247 square miles, with 80 miles of mainstem and over 260 miles of mapped tributaries. It drains the southeast corner of the Olympic Mountains, including portions of Olympic National Park and Olympic National Forest. Elevations of peaks along the watershed boundary range to over 6,000 feet, while most of the lower valley is below 100 feet in elevation. The watershed consists of three major sub-basins: the North Fork, South Fork, and Vance Creek. These systems do not merge until entering the lower Skokomish Valley and floodplain. The North Fork originates in Olympic National Park and flows through Lake Cushman, where a substantial flow is diverted through a spillway to the City of Tacoma Power Generating Facility on Hood Canal. The remaining flow continues down the North Fork and is managed in accordance with existing agreements between Tacoma Power and other parties. The South Fork also originates in Olympic National Park, but flows through a larger proportion of public and private commercial forest before entering the residential areas of the lower Skokomish Valley. The North Fork and South Fork join to form the mainstem about 9 miles upstream of the river mouth. Vance Creek flows through public and private commercial forest until reaching the South Fork less than 1 mile above the confluence with the North Fork.

The Skokomish River has the largest estuary and intertidal delta in the Hood Canal Basin. The delta includes a broad estuarine wetland complex and also supports extensive submerged aquatic vegetation including eelgrass (*Zostera* sp.) beds. The delta is considered critical for numerous species, including salmonids from Skokomish River and other lower Hood Canal systems such as the Tahuya River and Mission Creek. The project area for this wetland inventory includes the entire lower river valley of the Skokomish, including the delta to the approximate limits of the photic zone (-30-feet MLLW). This includes the entire mainstem from valley wall to valley wall as well as the lowest 4 miles of Vance Creek, the lowest 2 miles of the South Fork, and the lowest 1.5 miles of the North Fork (see Figure 1)

2.1 Land Use History

The study area was occupied by native tribes and generally undeveloped until Euro-American settlers began inhabiting the land in the 1840s. At this time, the new settlers began to convert the tidal wetlands and floodplains to land suitable for farming and living.

Conversion of the land happened early and extensively leaving little evidence of conditions prior to settlement (Collins and Sheikh 2005). When European settlers arrived, the land had not been logged and cultivated by farming by the indigenous people that lived there. Most of the currently developed land in the study area is associated with farming and homes descending from the original European settlers. Farming began with the earliest arrival of European immigrants in the early 1800s. Farming took off in the late 1800s and early 1900s, and continues to dominate the land use in the area today (Wilma 2006). Recently, dike breaching projects near the mouth of the Skokomish River have been used to restore agricultural lands to tidal marsh systems.

2.1.1 Roads

There are several main roads that extend throughout the study area. State Route (SR) 101 crosses the Skokomish floodplain about 4 miles upstream of the mouth and then follows the edge of the floodplain to the north continuing, out of the study area, up Hood Canal. SR 106 follows the east valley wall near the mouth of the river, then crosses the valley and merges with SR 101 near the Skokomish Tribal Center. These are the only major traffic routes within the study area. West Skokomish Valley Road runs east and west through the study area until it intersects SR 101. North Skokomish Indian Flats Road runs from SR 101 east toward the delta of the Skokomish River and the Hood Canal. There are numerous scattered smaller paved, gravel, or dirt roads throughout the study area. Most of the paved roads are associated with residences and farms. Many of the dirt roads are also associated with residences and farms, as well as with current and past forestry practices such as logging.

2.1.2 Forest

There are large tracts of evergreen forest surrounding the study area and approximately 1,140 acres of evergreen forest stands within the study area. Many of these forested areas are on the slopes above the valley floor. The area adjacent to the active floodplain is scattered with scrub-shrub forest, defined by woody vegetation less than 6 meters (20 feet) high. There are also areas of deciduous forest dominated mostly by big leaf maple (*Acer macrophyllum*) immediately adjacent to the active floodplain and scrub-shrub forest.

Logging in the watershed to clear space for farming and ranching began in the early 1800s. In the 1880s, the timber industry boomed and logging operations hit full stride when mechanical means were developed to assist in logging and transport. The study area is now heavily deforested due to past logging demands (Wilma 2006). Logging slowed in the 1980s when the Forest Service restricted timber harvesting to protect the northern spotted owl (*Strix occidentalis caurina*).

Currently, the largest forest stands in the study area that are not in industrial timber production include lowland hardwood stands and protected watershed areas dominated by Douglas fir (*Psuedotsuga menziesii*) and Western hemlock (*Tsuga heterophylla*). Also of note are several tracts of land in the floodplain and adjacent to it that are used for commercial Christmas tree farming.

2.1.3 Land Cover Change

Historical aerial photography analyses of the study area reveal noteworthy changes in land cover within the study area. These changes are reported as observed from aerial imagery inspection and are not based on demographic or socioeconomic study. The trend of clearing of forest lands has continued over the last 40 years. In 1938, there were about 1,300 acres in non-forestry agriculture. That number rose to as much as 2,000 acres from the 1960s through the 1980s. The areas that have been deforested in the past several decades are largely associated with historical oxbows and other low–lying (and typically wetland) areas that may not have been suitable for farming without investment in drainage. Other changes such as road building and new structures were relatively limited during this time.

More recent (over the last 20 years) land cover changes are dominated by conversion from agriculture to other land cover. These changes include the conversion of agricultural lands in the lowest portion of the valley back to estuarine marsh habitat by breaching dikes and restoring tidal hydrology to these lands. There are also areas along the mainstem that have reverted from agriculture back to forest. Presumably, many of these areas have become too wet to sustain crops. Currently, there are about 1,640 acres of land used for non-forestry agriculture. Other areas may simply be associated with new residential parcels that are not actively farmed. There are significantly more structures now than in the 1938 imagery, although the trend of increasing residential density appears not to have persisted through the most recent decades.

2.1.4 Current Land Use

Today, the study area contains scattered areas of medium- and high-intensity development. Most of this development is associated with farming and the floodplain is still farmed today. The highest density development in the study area is the Skokomish Tribal Center, which consists of a casino, office buildings, schools, and residences. Development in this area covers approximately 130 acres.

There are currently approximately 1,640 acres of agricultural lands in the study area. Of these 1,640 acres, about 216 acres, or 13 percent, were identified as wetlands. This estimate may be low due to the difficulty of identifying agricultural wetlands based on visual inspection. Several agricultural fields not identified as wetland in this study showed evidence of standing water, but were not included as wetlands due to a lack of hydrophytic vegetation. Weeds and other “volunteer” vegetation were typically used rather than planted crops in making this distinction.

Another unique land cover in the lower Skokomish Valley is Christmas tree farms. More than 50 acres of Christmas tree farms were identified. This number includes all small trees planted in rows, but other areas had numerous small conifers that could be either young commercial forests or Christmas tree farms.

2.2 Hydrology

The South and the North forks of the Skokomish River flow into the study area and join together as the mainstem Skokomish River, which runs through the remainder of the study area to Hood Canal. Kirkland, Weaver, and Purdy creeks as well as many smaller tributaries flow into the study area from the south to join the Skokomish River. Vance Creek and Fir Creek flow from the north into the south fork of the Skokomish River in the study area before it joins the north fork. Several unnamed tributaries also flow from the north into the study area and join the Skokomish River.

The Skokomish River Valley has experienced notable flooding, sedimentation, and erosion both in its alluvial valley and deltaic environment. While there has been some lateral erosion in the upper valley that has been problematic for some landowners, the biggest problem has been the increased flooding in the lower valley. This increased flooding appears to be related to aggradation in the main channel of the Skokomish River leading to a loss of conveyance for the largest annual flows (Bountry et al. 2009) and higher groundwater elevations. River banks continue to be overtopped each year by smaller and smaller peak discharges, resulting in levee breaches, deep inundation of farmlands and roads, and flood damage to structures in the valley floor (Bountry et al. 2009). Recent geologic evidence also suggests that the uncommonly high rate of channel aggradation and associated flooding in the lower valley could be attributed to tectonic activity (Polenz et al. 2010). This is likely exacerbated by timber harvesting, particularly in the upper watershed of the South Fork, which has increased the supply of fine sediment washing down from the upper watershed and depositing in the floodplain and channel of the lower valley (Bountry et al. 2009).

Solutions to date have come mostly from mechanical means such as the placement of levees to prevent channel avulsions and flooding in the bottomlands along the river and riprap or logs with cables to stabilize banks or lessen the rate of lateral migration.

2.3 Climate and Groundwater

Like many areas within the Puget Sound basin, the Skokomish River Valley has a mild climate. The Puget Sound and Pacific Ocean influence prevailing winds and reduce periods of extreme heat and cold (Ness 1960). Mean daily maximum temperatures range from just over 45° F in December through February to just over 75° F in August (WRCC 2006). Mean daily minimum temperatures range from about 35° F from December through February to around 50° F in August (WRCC 2008).

Annual precipitation in the Skokomish River Valley varies along the reach of the river. In the northeast, annual average precipitation is approximately 65 inches. In the temperate rainforests near the Olympic Mountains, annual precipitation exceeds 250 inches (WRCC 2006; EnviroVision 2003; Golder 2002). The wettest month of the year is December, and the driest month is July (WRCC 2008). Snowfall in the Skokomish River Valley is typically well under 30 inches and stays on the ground for a relatively short period of time. For example, in the nearby city of Shelton, the average annual snowfall from 1931 to1999 was 9 inches (WRCC 2006). The exception is near the headwaters of the Skokomish River in the Olympic Mountains, which experiences significant winter snowfall. Though severe weather is rare, Puget Sound Region typically has relatively high humidity and has significant cloud cover. In the nearby city of Olympia, the average number of cloudy days is 228 (WRCC 2008).

In the mountainous headwaters of the Skokomish River, the rocky terrain is characterized by sedimentary and basalt rocks with little groundwater storage capacity. Runoff in these areas quickly follows precipitation. In the coastal plain and lower floodplains and estuaries, alluvial and glacial sediments are the site of significant groundwater flow (EnviroVision 2003).

2.4 Habitat

The lower Skokomish River Valley and the adjoining higher altitude forest lands provide habitat for a number of fish and wildlife species native to Western Washington. Impacts to habitat from land uses such as forestry and agriculture have altered these habitats somewhat, but the area still maintains a diversity of species and habitats.

2.4.1 Fish and Shellfish

The Skokomish River watershed provides habitat for a variety of finfish and shellfish species. Depressed fall Chinook salmon (*Oncorhynchus tshawytscha*) populations can be found in Vance Creek and the Skokomish River. Healthy populations of coho salmon (*Oncorhynchus kisutch*) are found in the Skokomish River and most of its tributaries throughout the study area. Fall chum (*O. keta*) can be found in several tributaries and sections of the Skokomish River in the fall. Pink salmon (*O. gorbuscha*) inhabit Vance Creek, the Skokomish River, and most of the small tributaries that enter the study area. The main fork of the Skokomish River hosts a population of summer steelhead (*O. mykiss*). Depressed populations of winter steelhead can also be found in the Skokomish River and Vance Creek. Resident cutthroat (*O. clarkii*) can also be found throughout the study area (see Figure 4) (WDFW 2010a, 2011).

Lamprey (*Petromyzon marinus*) are commonly found in streams and tidal marsh areas of the Skokomish River. Sculpin (*Cottus confuses*) can be found in the Skokomish River and in the streams and tributaries in the Skokomish floodplain. These species serve as important prey in the diet of larger fish such as trout and salmon.

Small areas near in the tidal waters of the Hood Canal host hardshell clam (*Mercenaria mercenaria*), oyster (*Crassostrea virginica*) beds, and Dungeness crabs (*Cancer magister*). These areas provide free connections with salt water, bluffs, reach substrates, marshes, and eelgrass (WDFW 2010a).

2.4.2 Wildlife

The field investigation conducted as part of this study was not designed specifically to identify the fauna present in the lower Skokomish Valley. It did, however, provide an opportunity to record wildlife sightings, tracks, or other wildlife sign encountered. Most of the species encountered are relatively common in the Puget Lowlands and typically found in the habitats encountered. The wildlife encountered included three species of amphibians, 12 species of mammals, 34 species of birds, and one species of reptile. A complete list of these species is included as Appendix B.

The remainder of this section describes species commonly found in the habitats associated with the study area. The following information about specific wildlife species is generally organized by the habitat types found within the river floodplain and nearshore ecosystems. The first section discusses species generally adapted to wide open areas and multiple habitats types within the study area. Additional species and species groups are also discussed by habitat types found within the study area.

2.4.2.1 Multiple Habitat Species (Forests, Freshwater, Marine)

2.4.2.1.1 Bald Eagles

Bald eagles (*Haliaeetus leucocephalus*) and their nesting areas can be found throughout the study area. They typically select areas with low human disturbance, suitable forest structure, and plenty of prey. They tend to nest along fishable waters because fish are a dominant source of food. When trout and salmon are spawning, those fish make up a large portion of their diet. Bald eagle nests have been identified along the Skokomish River and in some of the large wetland complexes (WDFW 2010a) (see Figure 5).

2.4.2.1.2 Ospreys

The study area contains suitable osprey (*Pandion haliaetus*) habitat, which is always closely associated with bodies of water and a wide variety of fish for food. Ospreys typically forage in wetland, tidal, and agricultural areas near water. Nests are commonly found in dead or open-topped trees located close to the water. The study area provides suitable osprey habitat year round. An osprey nest has been observed south of the salt marsh near a power line on the Skokomish Delta (WDFW 2010; USFWS 2000).

2.4.2.1.3 Great Blue Herons

Great blue herons (*Ardea herodias*) inhabit sheltered, shallow bays and inlets, sloughs, marshes, wet meadows, shores, and rivers with nearby foraging areas. The study area provides a variety of habitats for these birds. When feeding, they are usually found in slow-moving or calm salt, fresh, and brackish water. The marine shoreline habitat of the study area provides habitat for great blue herons. Great blue herons usually nest in trees or bushes that stand in or near water (Seattle Audubon Society 2008). Their nests have been documented in the saltwater marsh area of the project near the Hood Canal. In 2003, 29 nests were reported (WDFW 2011).

2.4.2.1.4 Wood Ducks

The study area offers a diversity of habitats that wood ducks (*Aix sponsa)* use to meet their food and nesting needs, including moist-soil emergent wetlands, forested wetlands, coastal marshes with beds of submerged aquatic vegetation, and flooded agricultural fields. Wood ducks are secondary cavity nesters and require medium to large snags within riparian areas for nesting and roosting.

2.4.2.2 Nearshore and Marine Shoreline Species (Includes Estuary Species)

2.4.2.2.1 Harbor Seals

Harbor seals *(Phoca vitulina)* use specific shoreline areas on a regular basis to haul-out of the water and rest. These resting areas are called seal haul-outs and include: beaches, rocky areas, log booms, and floats. Some haul-outs are used regularly, while others may be used seasonally or occasionally. Time spent on the haul-outs is essential for seals' survival as they rest, dry out, interact, and regulate their body temperatures. In addition to resting, harbor seals give birth to and nurse their pups on the haul-outs, and undergo an annual molt of their pelage or fur (WDFW 2011).

2.4.2.2.2 Shorebirds

The estuary at the mouth of the Skokomish River creates wetland habitat for shorebirds that are routinely found in the nearshore and marine shoreline areas of the study area. The estuary provides prime food such as crustaceans, mollusks, marine worms, insects, and invertebrates. Shorebird nests are often placed on open areas such as gravel beaches, and stony stream banks (Ecology 2011).

2.4.2.2.3 Mixed Waterfowl

The nearshore and estuaries provide overwintering habitats that consist of roosting and foraging areas for waterfowl. Roosting areas include large bodies of water that provide secure places to loaf, sleep, and forage. Foraging areas include wetlands, tidal marshes, nearshore waters, and occasional agricultural fields. Waterfowl rely on a diverse diet of submerged aquatic vegetation, terrestrial vegetation, benthic organisms, fish, and other food sources during the winter.

2.4.2.3 Forested, Floodplain Vegetation, Stream Islands Species

2.4.2.3.1 Cascades Frog

The forested floodplain within the project site is suitable habitat for the cascade frog (*Rana cascadae*). Cascade frogs inhabit wet areas in open coniferous forests that include small streams and pools. Eggs are laid in the shallow open areas along the banks of the Skokomish River. Tadpoles are bottom feeders that prefer muddy or silty substrates and shallow water (WDNR 2009).

2.4.2.3.2 Band-tailed Pigeon

The wet coniferous forests along the Skokomish floodplain host a population of band-tailed pigeons (*Columba fasciata*). These pigeons are vegetarian, with most of their diet consisting of grain seeds, wild and domestic fruits, acorns, pine nuts and buds, and flowers of trees and shrubs. Band-tailed pigeons prefer open sites along the forest edges. Their nests are usually located in trees 15 to 40 feet off the ground (Cornell Lab of Ornithology 2009a).

2.4.2.3.3 Wintering Elk

Meadow and forested land in the study area provides important wintering areas for elk (*Cervus elaphus*). When vegetation at higher elevations becomes covered in snow, elk migrate into the study area. The vegetation in the lowland areas of the floodplain provides grasses, sprouts, and branches from shrubs and trees for elk to eat (WDFW 2010)

2.4.2.3.4 Harlequin Ducks

The forested areas along the Skokomish River provide suitable breeding areas for the harlequin duck (*Histrionicus histrionicus*). These ducks prefer fast-moving streams and the gravelly banks for foraging on insects, fish, and marine invertebrates and the gravelly banks for their breeding areas (Cornell Lab of Ornithology 2009b).

3 TOPOGRAPHY AND SOILS

This section includes a review of existing information related to the topographic and soil conditions of the lower Skokomish Valley. These conditions are related to resources that contribute to wetland formation, loss, and habitat quality.

3.1 Geologic and Geomorphic History

The Skokomish River Valley is located at the southeastern end of the Olympic Peninsula near the southernmost extent of the Hood Canal. The Skokomish River flows east from its headwaters in the Olympic Mountains and descends through steep gorges and cascading pools to the Skokomish Valley, which occupies the lowermost 10 miles of the Skokomish drainage. The Skokomish River Valley is situated in between the Olympic Mountains and the Puget Lowlands. The Skokomish River Valley was carved by ice and subglacial fluvial erosion during the Last Glacial Maximum when the continental ice sheet had advanced south and westward into the headwaters of the Skokomish River Valley (Bountry et al. 2009).

The surficial geology of the Skokomish Valley is generally dominated by relatively recent (Holocene to recent Pleistocene) glacial alluvium. This material has accumulated to depths of about 70 feet over the past 8,500 years. This is interrupted by a feature first identified by Brian Collins (Hageruud 2006) and later described by Polenz et al. (2010) as the *lucky dog* berm. The landform consists of a gentle berm that trends roughly northwest to southeast approximately 1.5 miles inland from Hood Canal, resulting from a minor anticline associated with a thrust fault. The topographic crest of the landform lies adjacent to a southwest-facing escarpment and decreases in elevation from 35 feet at its northwest end to 15 feet at its southeast end, where it either plunges beneath or is truncated by the modern Skokomish Channel. Above (southwest of) the lucky dog berm lies a Holocene peat deposit about 1 mile long and 1.5 miles across (the width of the valley). Below (northeast of) the lucky dog structure the area around the active channel is dominated by alluvial marsh sediments. These sediments extend all the way to the tideflats, which are generally finer grained. Farther from the currently active channel (the northwest side of the valley's mouth), the lucky dog anticline exposes older alluvium. This is replaced by a second peat outcrop closer to the current shore of Hood Canal that is bounded on the canal side by older beach deposits.

Recent and older marsh deposits exist between the older beach deposits and the current shoreline beach deposits.

The surficial geology of the slopes above the valley floor contains a mix of glacial deposits from the Vashon Stade of the Fraser glaciation with some outcrops of pre-Fraser deposits. The slopes above the valley also exhibit evidence of Holocene landslide and mass wasting, these are particularly apparent on bare earth LiDAR shaded relief images (see Figure 6). Polenz et al. (2010) note that the base of the Vashon advanced outwash is commonly associated with productive springs. This formation is exposed in many locations along the valley walls. Much of the higher terrace above the valley walls is comprised of lodgment till from the Vashon glaciation.

3.2 Soils

Soils in the lower third of the study area at the mouth of the Hood Canal consist of gravelly loam, silt loam, peat, and peat overlaid by shallow gravel (see Figure 3). At the delta of the Hood Canal and the Skokomish River there is a band of soils consisting of tidal marsh, Mukilteo peat, and Tacoma peat. The next soil layer going inland from the canal consists of Pilchuck gravelly loamy sand, Skokomish silt loam, and grove gravelly loam. The next band consists of Dungeness fine sandy loam, grove gravelly sandy loam, and Indianola loamy sand. The top of the lower third of the study area consists of Puget silt loam, Orcas peat, Mukilteo peat, and Skokomish silt loam. From there the top two thirds of the study area are dominated by Dungeness silt loam and Dungeness fine sandy loam with Puget silt loam, Shelton gravelly loam, and Pilchuck loamy sand scattered throughout. There is a band of Hoodsport gravelly loam that enters the study area adjacent to the North Skokomish River and stretches along the northern edge of the study area to the east and west. Along the South Skokomish River and the Skokomish River there is a band of riverwash on both sides for the entire length of the upstream (western) two thirds of the study area. Most of these soil types are poorly drained except for gravelly loam, which is excessively well drained. All these soils are hydric. The upstream two thirds of the study area consist mostly of fine sandy loam and silt loam. Both of these soils are moderately well drained and not hydric. There is an area of riverwash adjacent to the channel of the Skokomish River to the Hood Canal; it is excessively drained and hydric (NRCS 2010).

Hydric soils are those soils that are sufficiently wet in the upper part to develop anaerobic conditions during the growing season (NRCS 2010). Tidal marsh areas are water saturated, very poorly drained, and intermittently or permanently covered by water. Peat materials are unconsolidated and largely undecomposed organic matter that has accumulated under excess moisture. Gravelly soil material has 15 to 35 percent rounded or angular rock fragments that are not prominently flattened. Loamy soils are 7 to 27 percent clay particles, 28 to 50 percent silt particles, and less than 52 percent sand particles. Sandy material is individual rock or mineral fragments from 0.05 to 2.0 millimeters in diameter that makes up 85 percent or more of the soil's composition and is not more than 10 percent clay. Silt is material that is 80 percent or more individual mineral particles that range in diameter from 0.002 to 0.05 millimeter (NRCS 2010). All of these classified soil types are hydric soils.

Soil series identified within the study area that are typically hydric include: Mukilteo, Orcas, Puget, Riverwash, Skokomish, Tacoma, and Tidal Marsh. Series that are not commonly associated with hydric conditions include: Alderwood, Dungeness, Everett, Grove, Hoodsport, Indianola, Rough Mountainous Lands, and Shelton. The Pilchuck series contains both hydric and non-hydric soils.

The following descriptions of the soil series identified within the study area are excerpted from the most recent soil survey conducted by the Soil Conservation Service (1960) and updated by the Natural Resource Conservation Service (NRCS 2010). The following table lists the soils series mapped within the study area.

Table 1
Mapped Soil Series in the Study Area

Non-Hydric Soils	Area in Acres	Hydric Soils	Area in Acres
Alderwood Group	36	Mukilteo Group	30
Dungeness Group	257	Orcas Group	7
Everett Group	2	Pilchuck Group	31
Grove Group	59	Puget Group[1]	57
Hoodsport Group	52	Skokomish Group	84
Indianola Group	8	Tacoma Group	25
Lystair Group	<1	Tidal Marsh[2]	22
Pilchuck Group[1]	32		
Shelton Group	40		
Riverwash	48		
Total Acreage	**534**	**Total Acreage**	**256**

Notes:
1: The Pilchuck Group contains both hydric and non-hydric soils.
2: Does not include intertidal and subtidal portions of the study area.

3.2.1 The Mukilteo Series

The Mukilteo series consists of deep, very poorly drained soils formed in deep organic deposits. Mukilteo soils are mainly in depressional areas on glacial uplands, while some are in river valleys with slopes between 0 and 2 percent. The organic material in which this soil formed ranges in thickness from 52 inches to more than 10 feet. These soils are usually saturated with water and are strongly acid or very strongly acid. Fibers within the soils are mostly sedge and moss (NRCS 2010).

3.2.2 The Tacoma Series

The Tacoma series consists of very deep, very poorly drained soils formed in alluvium on tidal flats, floodplains, and deltas with slopes between 0 and 2 percent. These soils are saturated with water and have a water table near the surface during the winter months and wet periods throughout the year unless they have been artificially drained. The soil is more than 60 inches deep, but rooting depth, other than hydrophytes, is limited by the water table. Some pedons have layers of muck 1 to 4 inches thick with a cumulative total of less than 16 inches. The weighted organic carbon content is less than 12 percent in the control section. The particle-size control section has 10 to 18 percent clay by weighted average. Below the Ap horizon, reaction is extremely acid to strongly acid throughout (NRCS 2010).

3.2.3 The Pilchuck Series

The Pilchuck series consists of very deep, excessively drained, and somewhat excessively drained soils that formed in gravelly and sandy alluvium. Pilchuck soils are on floodplains with slopes between 0 and 8 percent (NRCS 2010).

3.2.4 The Skokomish Series

The Skokomish series consists of very deep, poorly drained soils formed in alluvium on floodplains with slopes between 0 and 3 percent. These are the Grove soils and the Dungeness Variant soils. Grove soils are on terraces and are well drained and sandy-skeletal. Dungeness Variant soils have a udic moisture regime and are moderately well drained (NRCS 2010).

3.2.5 The Grove Series

The Grove series consists of deep, somewhat excessively drained soils formed in glacial outwash. Grove soils are on terraces and terrace escarpments at elevations of near sea level to 500 feet with slopes between 0 and 50 percent. Coarse fragments, dominantly pebbles, in the particle-size control section range from 55 to 75 percent by volume (USDA 2010). The soil ranges from strongly acid to moderately acid. Some pedons have a thin A horizon (NRCS 2010).

3.2.6 The Indianola Series

The Indianola series consists of very deep, somewhat excessively drained soils formed in sandy glacial drift. Indianola soils are on hills, terraces, terrace escarpments, eskers, and kames of drift or outwash plains at elevations of near sea level to 1,000 feet with slopes between 0 and 70 percent. Depths to diagnostic horizons and features start from the mineral soil surface (NRCS 2010).

3.2.7 The Orcas Series

The Orcas series consists of very deep, very poorly drained organic soils formed from sphagnum moss. Orcas soils occupy depressions on the glacial drift plains and have slopes between 0 and 2 percent. Orcas soils are in depressions on glacial outwash plains at elevations between 0 and 1,000 feet. The soils formed in sphagnum moss with some herbaceous plants. The water table is near the surface most of the year (NRCS 2010).

3.2.8 The Puget Series

The Puget series consists of very deep, poorly drained soils that formed in recent alluvium on floodplains and low river terraces with slopes between 0 and 3 percent. The particle-size control section lacks coarse fragments, has less than l5 percent fine and coarser sand, and has l8 to 35 percent clay (NRCS 2010).

3.2.9 The Shelton Series

The Shelton series consists of moderately deep, moderately well-drained soils that formed in glacial till. Shelton soils are on undulating to rolling glacial moraines. Depth to the Csim horizon ranges between 20 and 40 inches. Rock fragments in the control section exceed 40 percent and average less than 75 percent (NRCS 2010).

3.2.10 The Hoodsport Series

The Hoodsport series consists of moderately well-drained, moderately deep soils formed in glacial till on plains and foothills from sea level to 500 feet. These soils are usually moist, but they are dry in some parts between 8 and 24 inches for 45 to 60 cumulative days. The particle-size control section averages more than 50 percent coarse fragments. The soil ranges from moderately acid to very strongly acid. Depth to the strongly cemented till ranges between 20 and 40 inches (NRCS 2010).

4 METHODS

The wetland analysis was conducted in two phases. First, a GIS-based heads-up digitizing effort was used to identify potential wetland habitats based on 1-foot resolution, ortho-rectified color + infrared imagery acquired on April 23, 2011, that covered the entire study area. The second phase consisted of field verification and adjustment of wetland habitats and boundaries using printed maps (1-inch: 500-foot). Field verification efforts relied heavily on vegetation community assessments and visual hydrology indicators. In general, soils were not investigated or typed.

4.1 GIS-Based Interpretation Methods

Several data sources were used to facilitate the heads-up digitizing of wetland habitats using ArcGIS 10.0 desktop software. These data sources included topography, imagery, and hydrology. Personnel performing the digitizing had training, skills, and experience in GIS imagery interpretation and wetland delineation.

Topographic information was in the form of contours and two versions of a hillshade created from a terrain dataset (Cagney 2010). This terrain dataset was derived based on 1994 photogrammetric Contours (Walker and Associates 1994). LiDAR bare earth points from 2001 (Polenz et al. 2010) and top-of-bank to top–of-bank cross section surveys conducted by the Corps in October 2007. This terrain was also analyzed to define closed depressions (sinks) and to display areas of extremely low slope.

Imagery was displayed in several variations, including true color (RGB) and color infrared (iRGB). Color infrared was the most commonly used, followed by true color. In some cases, neither imagery set provided adequate differentiation between wetland and upland habitats and a project-specific variation on standard vegetation index techniques was used.

Typically, the normalized difference vegetation index (NDVI) is calculated based on the following formula (PSLC and TerraPoint 2002):

$$NDVI = \frac{IR - Red}{IR + Red}$$

The Transformed Vegetation Index (TVI) is calculated based on the following formula (PSLC and Terrapoint 2002):

$$TVI = \left[\frac{IR - Red}{IR + Red} + 0.5\right]^{1/2} * 100$$

Neither of these methods provided optimal differentiation of wetland and upland habitats for use in this assessment. A modified vegetation index (MVI) was adapted for use on the project. That VI was calculated based on the following formula:

$$VI = \log_{10}[\frac{IR - Red + 256}{IR + Red}]$$

This VI provided better differentiation of the wetness of areas than those vegetation indices mentioned above. The results of this analysis were used in conjunction with green and blue or infrared and green for display purposes.

Other useful, but lower resolution, imagery was also employed to provide recent site history and show seasonal change. This imagery came from a variety of sources including NAIP 2006 and 2009, Google Earth, and Esri.

Hydrology information was obtained from the terrain data set for the mainstem and SalmonScape (WDFW 2010b) for smaller tributaries.

GIS analysts were trained to identify the spectral signatures of confirmed wetland and upland habitats that were documented during a preliminary reconnaissance of the study area. Where spectral signatures were not conclusive in defining the boundary between upland and wetland habitats, topographic cues were used. Available hydrology information was somewhat outdated and served primarily to identify riverine wetland habitats not associated with the mainstem river.

Initial wetland classification was also completed during this phase. This included identification of the wetland system and sub-system and, where possible, the class (Cowardin et. al. 1979). In several cases, the appropriate wetland class could not be definitively determined using only remotely sensed data, and multiple classes were ascribed to the habitats for the field maps (e.g., forested, scrub-shrub). The results of the initial digitizing effort were reviewed by senior staff twice and updated each time prior to creating field maps for the second phase of the analysis.

4.2 Field Based Interpretation Methods

Field crews used to verify on-the-ground wetland conditions were staffed by two persons, at least one of whom was a senior wetland scientist with 10 or more years of wetland delineation and habitat assessment experience. The crews were equipped with 1 inch:500 foot (1:6,000 inch) scale color and color infrared maps showing the results of the GIS-based analysis. GPS was initially used to locate wetland habitat boundaries, but crews found that they could accurately locate locations on the paper maps without significant difficulty, due to the quality of the imagery.

To perform the floodplain investigation, Anchor QEA biologists identified and documented vegetation communities and habitats within the study area by reviewing existing information, performing an aerial photograph analysis, and conducting reconnaissance-level site visits in April, June, and July, 2011. Because the study area is a very large geographic area with a variety of land uses, parcel sizes, and property ownerships, access within the study area ranged from accessible to no access. Rights of entry to private properties were coordinated and obtained through Mason Conservation District and Mason County. Access to large land holdings and key areas of interest were prioritized to maximize the efficiency of the field effort. Property access was granted by some land owners and denied by others. Physical features such as topography, vegetation density, and waterbodies such as streams and drainages also played a significant role in the ability to traverse parcels within the study area.

Information regarding dominant vegetation communities and habitats in the study area was documented through visual observations (sometimes with binoculars) while walking within parcels or sections of parcels and along public roads. Because a thorough assessment of the entire study area was not practical nor met the goals of the investigation, observations were made while traversing segments of the study and used to both make broad assumptions of large segments of habitat within the study area and compare field observations with the aerial photo analysis. For example, an investigation of a parcel that is 200 feet wide and 1,500 feet long would typically include traversing the 200-foot width to identify habitats, walking a few hundred feet in a perpendicular direction, and then returning to the starting location. Under this approach, vegetation and habitat conditions within parcels could be documented without a more time-consuming process of surveying entire parcels. While this approach allowed for covering large areas within the study area, there is also the possibility that small wetland or upland areas within the study area may have been misidentified.

Preliminary habitat polygons were identified during the investigation based on air photo analysis and corresponded to easily observable variations in the vegetation communities. These analysis segments were outlined on aerial photographs in the field as habitat polygons. Information, such as vegetation communities and hydrology features, was collected within the individual polygons. Data collection measures, such as digging sample plots to identify soil characteristics, were not performed, and wetland boundaries were not flagged or surveyed. Additional analysis typically performed as part of the wetland delineation process, such as wetland ratings and wetland functions and values assessments, were also not performed as part of this investigation. All wildlife species, tracks, and signs observed during the site visits were documented. All observations were qualitative in nature; no quantitative wildlife surveys were performed. Photographs were also taken to document vegetation and habitat conditions of the study area.

Both wetland and upland habitat units have been identified for this analysis, although the upland habitats represent only a subset of all upland areas, whereas the wetland areas identified are intended to be as complete as possible and include all wetlands in the study area. A few areas dominated by upland forested also contained small forested or emergent, depressional wetlands (typically less than 1,000 square feet) that were too indistinct too identify from the imagery, and too numerous to identify in the field. These are identified in the upland habitat unit dataset as upland/palustrine forested wetland (PFO). The upland habitats identified in the field were useful as a reference when comparing upland and wetland areas of very similar spectral signature during in-office assessment and quality assurance review.

Wetland community types are also discussed, according to the USFWS classification developed by Cowardin et al. (1979) for use in the NWI. Wetland community types found during this investigation were as follows:

- Palustrine forested (PFO) – These wetlands have at least 30 percent cover of woody vegetation that is more than 20 feet high.
- Palustrine scrub-shrub (PSS) – These wetlands have at least 30 percent cover of woody vegetation that is less than 20 feet high.
- Palustrine emergent (PEM) – These wetlands have erect, rooted, herbaceous vegetation present for most of the growing season in most years.
- Palustrine open water (POW) – These wetlands are characterized by open water, such as ponds.

Confidence levels in the polygons established during the site visits and aerial photo analysis have also been identified as part of this investigation to provide a measure of confidence in the habitat assessment. Polygons that were verified with full access in the field are given a high confidence, while areas with limited or no access, or that relied heavily on aerial photo interpretation, are given a less confident or low ranking. Table 1 provides definitions of the confidence rankings.

Wherever possible, vegetation communities were identified in the field for a large subset of the wetland habitats as well as studied upland areas. The dominant vegetation for these areas was recorded and included in Appendix A. Additional vegetation species identified are included in Appendix A. Wildlife observations were also made during the field effort and are included in Appendix B. These were not attributed to specific habitats, and were not evaluated for frequency.

Following the site visits, updates to the GIS methodology were made based on information identified in the field. Habitat units (representing both upland and wetland habitats) were defined by polygons, with each identified polygon representing a specific vegetation community or other distinguishing features. For this investigation, habitat units were identified using a tiered classification system to differentiate the variety of vegetation communities within the study area. Habitat units at the first level are identified as upland (Up) or wetland (W) habitats. The second level is based on forest (1), scrub-shrub or shrub (2), or emergent or grass/herbaceous (3) cover. The third and final level is given a letter designation (e.g., a, b, c) based on a distinctive characteristic, typically associated with the dominant vegetation community. For example, upland riparian forest dominated by big leaf maple is identified as habitat unit Up1a and a riparian emergent wetland system dominated by black cottonwood (*Populus trichocarpa*) in a mosaic with emergent and scrub-shrub species is identified as W3a. Table 1 provides a list of all habitat units identified during the investigation.

Table 2
Habitat Unit Definitions

Habitat Unit	Wetland/Upland	Category	Sub-Category and Species Codes[1]
Up1a	Upland	Forest Deciduous Riparian	Big leaf maple (*Acer macrophyllum*, ACMA) dominant
Up1b	Upland	Forest Deciduous Riparian	Red alder (*Alnus rubra*, ALRU) and black cottonwood (*Populus balsmifera*, POBA) dominant. Some small patches dominated by slough sedge (*Carex obnupta*, CAOB)
Up1c	Upland	Forest Riparian Coniferous	Big leaf maple(*Acer macrophyllum*, ACMA) and Douglas fir (*Psuedotsuga menziesii*, PSME) dominant
Up1d	Upland	Forest Coniferous	Coniferous dominant with Douglas fir (*Psuedotsuga menziesii*, PSME) and Western red cedar (*Thuja plicata*, THPL)
Up1e	Upland	Forest Coniferous	Recent clear cut
Up1f	Upland	Fill prism	Placed fill prisms in estuary, for road use and remnant diking for agricultural practices
Up2a	Upland	Forest Tree Farm	Douglas fir (Psuedotsuga menziesii, PSME) tree farms, variable heights/age classes
Up3a	Upland	Grassland	Meadow buttercup (*Ranunculus acris*, RAAC)

Habitat Unit	Wetland/Upland	Category	Sub-Category and Species Codes[1]
			dominant with grasses, appears to be upland
Up3b	Upland	Grassland	Grass species, unmowed, greater than 2 feet tall
Up3c	Upland	Grassland	Livestock activity, grazed, mosaic with bare ground
W1a	Wetland	PFO Riparian	Mosaic with PSS and PEM
W2a	Wetland	PSS Riparian	Mosaic with PFO and PEM
W3a	Wetland	PEM Riparian	Mosaic with PFO and PSS
W3b	Wetland	PEM Grassland	Common rush (*Juncus effuse*, JUEF) and meadow buttercup (*Ranunculus acris*, RAAC) dominant with grasses, appears to be a wetland/upland mosaic
W3c	Wetland	PEM Grassland	Common rush (*Juncus effuse*, JUEF) dominant with grasses, appears dominant wetland with possible upland patches
W3d	Wetland	PEM Salt Tolerant	Estuary salt marsh
W4a	Wetland	POW	Open water

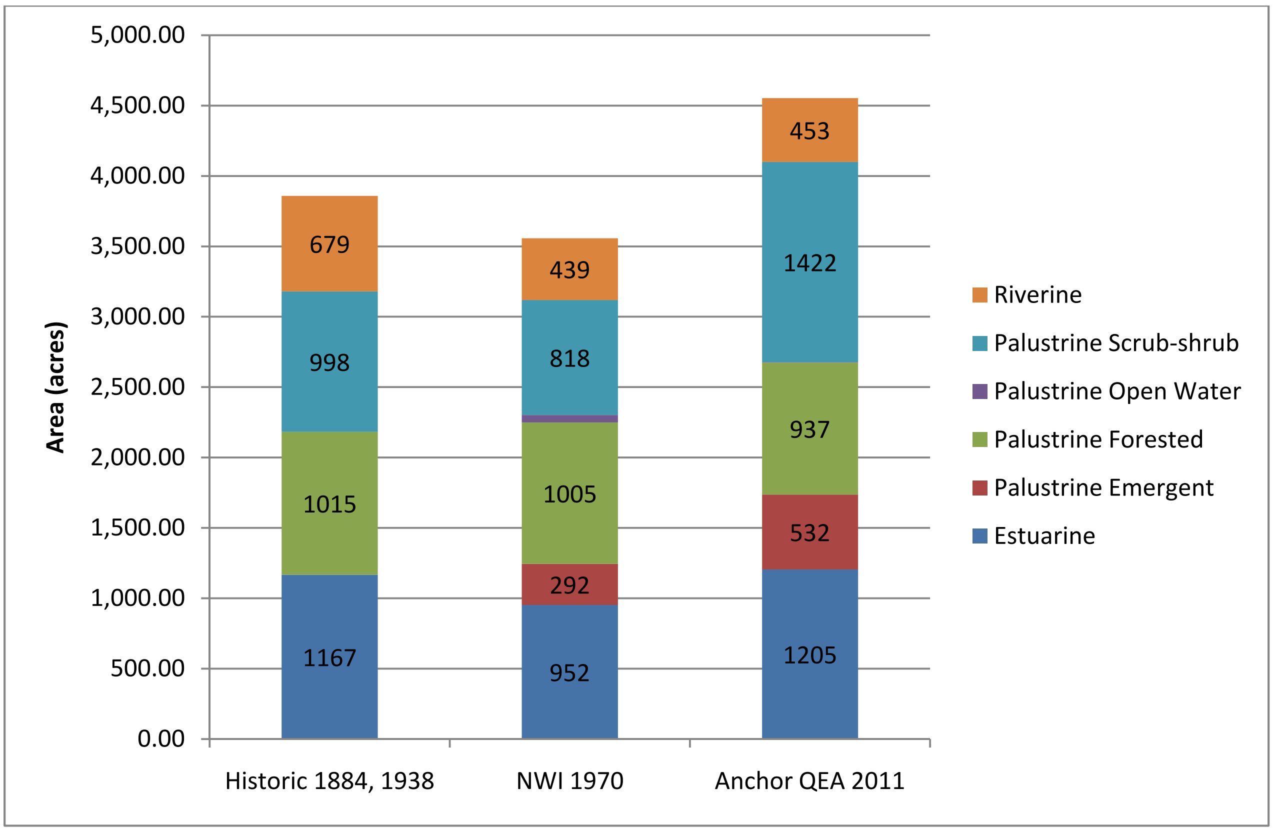
Notes:

1 Species codes (e.g., ACMA, ALRU, etc.) correspond to those used in Appendix A.

Following the field investigation, all identified habitat boundaries were reviewed and updated as necessary in the GIS dataset and then rechecked by both members of the field crew responsible for the particular area. The upland and wetland polygons were split into two separate datasets and are provided as attachments to this report.

5 ANALYSIS RESULTS AND INTERPRETATION

This analysis resulted in the mapping of 231 individual wetland habitat polygons covering 4,553 acres within the study area and an additional 995 acres of subtidal wetland in the Skokomish river delta that are outside of the Corps' study area. This compares to 165 identified polygons covering 3,558 acres in the NWI, and 260 polygons covering 4,790 acres in the historical wetland inventory assessment. The following graph shows the relative amount of wetland in each inventory based on wetland system and sub-system.



Note: This graph is based on the USACE provided project boundary, which does not include the entire subtidal portion of this study. Actual acreage of Estuarine wetland mapped by Anchor QEA 2011 is 2,200 acres.

5.1 Results

Upstream of the SR 101 crossing, wetlands are concentrated along the active channels of the Skokomish River and existing oxbows and side channels. Other wetlands associated with springs flow from near the base of the valley walls. A few small wetlands appear to be associated with relic channels in the Skokomish floodplain.

Downstream of the SR 101 crossing, wetlands dominate the valley floor from valley wall to valley wall except in the immediate area of the Skokomish Tribal Center. These wetlands are primarily PSS wetlands with areas of PFO and emergent mitigation. At the mouth of the river these are replaced by estuarine wetlands and unvegetated tidal flats.

5.1.1 Wetland Classification

Wetland habitats were classified based on the system described in *Classification of Wetlands and Deepwater Habitats of the United States* (Cowardin et. al. 1979). This system employs a hierarchical system of classification that is summarized as it applies to the study area below.

5.1.1.1 Estuarine Systems

Estuarine wetlands are found in the area where the Skokomish River enters the Puget Sound (see Figure 7). Analysis of historical maps by Collins and Sheikh (2005) indicate that up to 75 percent of estuarine wetlands were dominated by emergent vegetation. Estuarine scrub-shrub wetlands making up about 13 percent of the complex as compared to current wetland maps showing no scrub-shrub wetlands in the complex (Collins and Sheikh 2005). Recent projects have been initiated to breach dikes around islands in the lower estuary to restore tidal indentation of historic salt marsh areas. These breached areas make up the majority of the PSS wetlands in the estuary.

Estuarine systems are further subdivided as subtidal (generally below MLLW) and intertidal (generally above MLLW and influenced by salinity from Hood Canal). Subtidal habitats were not further interpreted to class or community in this project, but were mapped by Garono et al. 2004). Intertidal habitats were mapped by wetland class based on imagery and very limited field verification due to access issues.

Field investigation to determine the extent of eelgrass in the subtidal estuary was conducted. Eelgrass beds were specifically identified due to their unique habitat value. Eelgrass co-occurs with many small vertebrate and invertebrate organisms that provide prey for larger species, including juvenile salmon who use the area heavily during their outmigration. Eelgrass beds also provide protective cover for migrating salmon, other fish, and many other kinds of marine life. Additionally, eelgrass supplies organic material to nearshore areas, and its roots stabilize sediments.

This investigation involved walking at approximately MLLW and identifying area waterward where eelgrass was present in large meadows or patches. It was assumed for mapping purposes that these eelgrass meadows extended to deeper water between -10 feet and -30 feet MLLW. The shallow estuary of the Skokomish River ends abruptly where the deltaic shelf gives way to the depth (greater than 200 feet) of Hood Canal.

5.1.2 Palustrine Systems

Palustrine wetlands include non-tidal wetlands dominated by trees, shrubs, persistent emergents, emergent mosses or lichens, and all such wetlands that occur in tidal areas where salinity due to ocean-derived salts is below 0.5 parts per thousand. Palustrine wetlands dominate the bottom two thirds of the study area (see Figure 7). These wetlands exist across the entire valley floor in the lower reaches of the valley and are associated with old oxbows and other depressions farther upstream. They are also commonly associated with springs along the valley walls and the valley floor at the toe of slope.

Palustrine wetlands within the study area were further subdivided by wetland class. PSS wetlands were the most commonly found class in the study area. PSS wetlands included some large marshes including the 800–plus-acre system that is located just upstream of the Lucky Dog Fault and SR 101. This depressional system also contains open water, emergent, and forested components. Common vegetation includes various species of willows (e.g., *Salix lasiandra, Salix scouleriana*) and large areas of Douglas spirea (*Spirea douglasii*). Lower, wetter areas contained cattail (*Typha latifolia*) and emergent gramminoids (e.g., *Scirpus* sp., *Juncus* sp.). Other PSS wetlands in the study area are a mix of depressional, riverine, and slope wetlands with an overall average size of 20 acres.

PFO wetlands are widely distributed across much of the study area. They are commonly associated with the riparian corridor of the mainstem and Vance Creek, and are also common near the valley walls where seeps fed wetlands are common. The most common tree species found in the study area was red alder (*Alnus rubra*), which was commonly associated with black cottonwood and Western red cedar (*Thuja picata*). Common understory species in forested wetlands include willows (e.g., *Salix lasiandra, Salix scouleriana.*), red-osier dogwood (*Cornus stolonifera*), and reed canarygrass (*Phalaris arundinacea*).

PEM wetlands were typically found in the center of the study area, upstream of the larger palustrine scrub-shrub complexes. These wetlands were commonly depressional or slope wetlands and located away from any active channels. Many PEM wetlands were associated with agricultural lands and often were associated with relic channels and other minor depressions in the landscape. The most common species encountered in PEM were reed canarygrass, slough sedge (*Carex obnupta*), soft rush (*Juncus effusus*), and colonial bentgrass (*Agrostis capillaris*).

The least common palustrine class of wetlands encountered was POW; these were typically oxbow wetlands that no longer had a continuous connection to a stream but maintained a water depth sufficiently deep to prevent the dominance of emergent vegetation. All POW wetlands analyzed were depressional and largely unvegetated in the spring of 2011. Floating aquatic vegetation (e.g., duckweed [*Leman minor*]) may appear later in the season. Along the margins, emergent vegetation adapted to continuous inundation, such as cattail, was encountered.

5.1.3 Riverine Systems

Riverine wetlands in the Cowardin classification schema are limited to those wetlands associated with the channel of the Skokomish River and its tributaries within the study area (see Figure 7). Historical maps show the area consisting of nearly 13 percent riverine tidal wetlands. Current maps show that the area of riverine tidal wetlands has grown to 25 percent (Collins and Sheikh 2005). Riverine wetlands mapped in this effort totaled approximately 450 acres, including 100 acres with tidal influence and 350 acres of lower perennial streams, although the range of tidal influence was estimated for this effort. These riverine wetlands are all associated with unconsolidated bottom (active channel) in the mainstem Skokomish River and associated minor channels.

In contrast to riverine wetlands in the Cowardin classification system, this study identified wetlands riverine wetlands under the hydrogeomorphic classification (HGM) system (Brinson 1993). Eighty-six acres of PFO and PSS wetland were identified as most closely associated with riverine hydrology. These wetlands are predominantly associated with the riparian corridors of the lower South Fork Skokomish River and Vance Creek and the mainstem Skokomish River upstream of SR 101. A review of recent aerial photography from the last four decades indicates a trend of increasing wetland area on either side of the active channel associated with riverine hydrology. Lateral migration of channels has also produced wetland areas associated with side channels, and other riverine features (e.g., bars, deltas, and oxbows) during this period.

5.1.4 Comparison to Earlier Inventories

The results of this investigation (see Figure 8) were compared to the historical wetland inventory described previously (see Figure 9) and the NWI (see Figure 10) (USFWS 2011)

5.1.4.1 Comparison to 1884 Mapping and 1938 Imagery

Analysis of historical maps by Collins and Sheikh (2005) was supplemented by digitization of identifiable wetland areas on 1938 aerial images as part of this study to create a wetland map based on the earliest available data. In the upper portion of the study area, Vance Creek and the North and South forks of the Skokomish River all follow markedly different alignments than they do presently. The confluence of all three tributaries is near the present day confluence of the North and South forks. In the 1.5-mile-long reach below this confluence, the channel is very wide (up to 2,000 feet), with a braided morphology indicating that rapid deposition of sediment is occurring and the channel is actively migrating. Several forested, oxbow wetlands are identifiable on either side of the channel in the 1938 images.

The majority of the wetlands identified in the 1938 images upstream of present day SR 101 are forested, while a few are scrub-shrub. The 1938 imagery is from summertime and emergent wetlands in the upper floodplain may not be identifiable, but may be present in the agricultural lands.

In the areas between present day SR 101 and SR 106, channel migrations between 1938 and 2011 are fewer. In general, wetland areas are more consistent, with the exception of areas behind a levee (or training dikes), such as on the left bank of the river just downstream of SR 101 that were presumably constructed after 1938 to provide suitable drainage for pasture or other agricultural uses. Other attempts at agriculture in this area appear to have been abandoned, specifically just upstream of the large scrub-shrub wetland (identified as #44 on Figure 11c). In the areas between SR 106 and Hood Canal, the changes between 1884 (as described in analysis of historical maps by Collins and Sheikh [2005]) and 2011 are relatively minor. The majority of the differences may be attributed to map interpretation. Channel locations are generally similar on the 1884 maps, 1938 imagery, and recent imagery. Conversion of delta wetlands to agriculture is identifiable on the 1938 imagery, although many of these areas have since been restored to estuarine wetlands.

5.1.4.2 Comparison to National Wetland Inventory Mapping

NWI data or the Lower Skokomish Valley (USFWS 2010) was based on color infrared imagery acquired in the early 1980s. This provides a comparison of the changes to wetland areas that have occurred in the past three decades. It is important to note that the methodologies of the two studies differ. This study made use of higher resolution imagery and extensive field reconnaissance not generally conducted as part of the NWI.

Above the confluence of the North and South forks, the channel alignments for riverine wetland locations are generally consistent. The 2011 imagery reveals several large riparian forested wetland (PFO) along Vane Creek and the South Fork Skokomish that are not identified in the NWI. Several small channels were also identified from the 2011 imagery. On the lower North Fork Skokomish River some areas identified as scrub-shrub in the NWI (PSS) were mapped as forested (PFO) in 2011 owing to the establishment of young trees in higher areas of the delta.

This mapping effort shows considerably more wetland areas in the reach between the confluence of the North and South forks and SR 101. These include wetland riverine, depressional, and slope wetlands that are associated generally with the channel and the larger riparian corridor. There are also extensive areas of emergent (PEM) slope and depressional wetlands identified across the floodplain, with smaller units of PSS and PFO wetlands as well. These represent a major increase in wetland area between the two inventories.

The total wetland area between SR 101 and SR 106 appears relatively consistent between the NWI and this inventory. There are, however, notable differences in the vegetation classification. This appears to be related to several phenomena. First, some forested areas around the large PSS wetland (identified as 44 on Figure 11c) have died off and been replaced by PSS and emergent vegetation, probably as a result of increased wetness and persistent standing water. In other areas, PEM has replace PSS vegetation; again, this is likely due to rising water levels that no longer support woody vegetation. Some small areas of wetlands were also identified that do not appear in the NWI, either because these areas were not wet enough to support wetlands in the 1980s, or because of differences in technique and scale of the two assessments.

The most notable changes in the area between SR 106 and Hood Canal are related to restoration efforts that have restored wetlands in the delta of the Skokomish River. These efforts appear to have also resulted in the conversion of wetlands from palustrine to emergent systems; however, this difference may also be attributed to differences in mapping technique.

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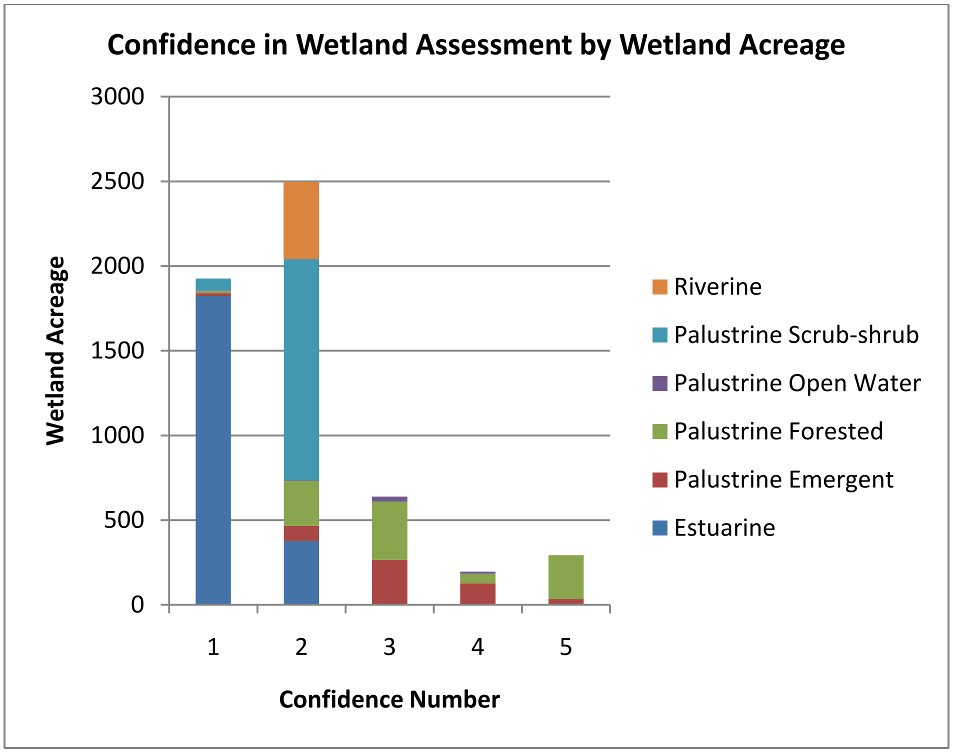
6 ESTIMATE OF ANALYSIS ACCURACY AND REPEATABILITY

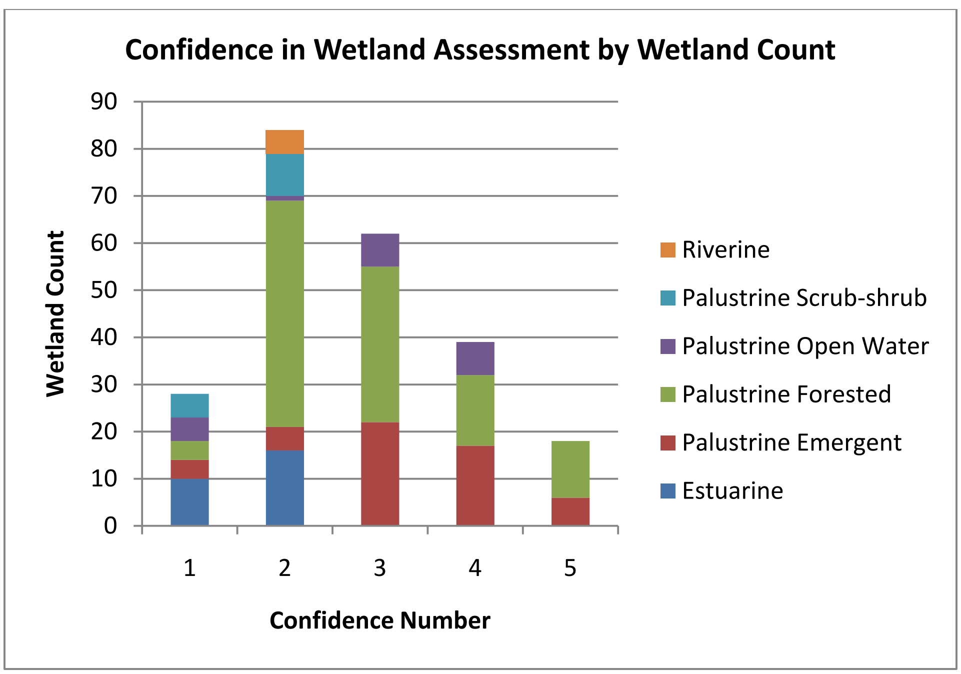
Field verification was used to the extent practicable, but was limited by site access (some areas are relatively inaccessible) and by landowner willingness to allow site access. Therefore a confidence was established for each polygon based on best professional judgment of the accuracy of the methods employed in determining the polygon boundary. These ranged between 95 percent and 70 percent (Table 2). These results are further represented in the following graphs.

Table 3
Confidence Ranking Definitions

Confidence Number	Confidence Description	Estimate of Accuracy[1]	Confidence Definition
1	High	95%	Investigation included parcel access and thorough analysis of area.
2	High	95%	Investigation limited to estuarine and riverine systems and one very large palustrine system, all characterized by very distinct topographic and spectral signatures. A representative subset of these polygons were investigated during field verification.
3	Medium to High	85%	Investigation included limited parcel access. Analysis included comparing observations with high confidence areas with similar habitats and aerial photo interpretation.
4	Medium	80%	Investigation limited to visual observations from adjacent parcels or public roads. Analysis included comparing observations with higher confidence areas with similar habitats and aerial photo interpretation.
5	Low	70%	No access and no opportunity for observations from adjacent parcels. Analysis limited to aerial photo interpretation.

Notes:
1 Estimate that areas within the polygon are jurisdictional wetland and areas proximate to the polygon are uplands.





Notes:

(1) Investigation included parcel access and thorough analysis of area.

(2) Limited to estuarine and riverine systems and one very large palustrine system characterized by very distinct topographic and spectral signatures. A representative subset of these polygons was investigated during field verification.

(3) Investigation included limited parcel access. Analysis included comparing observations with high confidence areas with similar habitats and aerial photo interpretation.
(4) Investigation limited to visual observations from adjacent parcels or public roads. Analysis included comparing observations with higher confidence areas with similar habitats and aerial photo interpretation.
(5) No access and no opportunity for observations from adjacent parcels. Analysis is limited to aerial photo interpretation.

7 OPPORTUNITIES FOR RESTORATION

The same data sources used for the wetland inventory were also reviewed by experienced geomorphologists and restoration ecologists with experience in river and floodplain restoration. Several opportunities for restoration were identified. These are shown in the annotated graphics on Figures 12a through 12d.

The opportunities for habitat restoration are intended to be integrated with restoration of natural process. The mainstem Skokomish River is highly dynamic and depositional in nature, regardless of ongoing geologic processes (change in base level at the mouth) and anthropogenic modification. Successful restoration projects must consider the geomorphic setting and approach conceptual project development from a systematic point of view, working with ongoing processes to achieve long-term benefits and minimize the potential for project failure. Restoration actions should address the following:

- Dispersion of floodwaters, and dissipation of energy in the channel and along banks
- Promoting natural distribution of sediment load
- Allowing the channel to achieve a more natural planform by eliminating constraints on channel migration where possible.
- Where it is not possible to remove these constraints, opportunities should be sought to address the of hardened banks by distributing erosive energy
- Creating channel complexity by adding roughness (e.g., large woody debris [LWD]) and diversifying the channel planform (e.g., side channels)

The first priority for restoration should focus on maximizing opportunities for natural channel migration. High rates of sediment deposition in the channel have resulted in a river that requires a very wide, somewhat shallow, active channel. Lateral constraints on the river in the form of levees and revetments have limited habitat, especially off-channel habitat in the river. Ideally, the maximum channel migration zone width available, given infrastructure constraints, will provide more opportunity for restoration of habitat than smaller specific projects that do not address the constraints on channel migration.

The second priority for restoration after removing constraints on channel migration would be adding instream complexity with LWD. Based on the aerial photos, there appears to be very little wood in the reach. Upstream, near the channel confluences where deposition is greatest and the active channel is relatively wide, LWD would split flow and encourage forested islands and riparian habitat to develop over time, and would also encourage the scour of pools. Downstream, where the channel is more confined, LWD would add refuge and cover for fish and encourage more diversity in bedform to develop.

There are also numerous opportunities to create off-channel areas, but maintaining fish access to those channels over the long term will be a concern. Off-channel habitat would provide important rearing habitat and refugia during the frequent high flow events that occur in the system. This wetland inventory identifies numerous long, linear wetlands in relic channels on the valley floor that could be reconnected to the mainstem. These connections could be maintained, at least temporarily, with engineered log jams used to create scour near the channel mouths.

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APPENDIX A
INDEX OF VEGETATION OBSERVED DURING FIELD VERIFICATION

Appendix A
Vegetation Data

Scientific Name	Common Name	Indicator	2a	2b	2c	2d	4a	4b	4c	4d	4e	4f	4g	4h	4i	6a	6b	6c	7a	7b	7c	7d	8a	8b	8c	9a	9b	10a	10b	11a	11b	11c	11d	11e	11f	12a	12b	13a	13b	14a	14b	14c	15a	15b	16a	16c	16d	16e	16f	16g	18a	18b	18c	18d	18e	20a	21a	21b	19	20	21	22	i	ii	iii	iv	v
Trees																																																																			
Abies procera	Noble fir	NI																																								x																											
Acer macrophylum	Big-leaf maple	FACU	x	x		x	x				x			x	x	x		x			x	x	x	x					x	x			x	x							x		x											x			x	x									
Alnus rubra	Red alder	FAC	x	x	x	x	x		x			x				x					x	x		x	x		x	x		x			x	x			x			x		x	x	x		x	x	x										x	x									
Crataegus douglasii	Black hawthorn	FAC																									x													x																												
Fraxinus latifolia	Oregon ash	FACW																																																																	
Malus domestica	Domestic apple	NI																																																																	
Picea sitchensis	Sitka spruce	FAC															x																				x																														
Populus trichocarpa	Black cottonwood	FAC		x	x																			x	x			x		x			x	x										x					x																				
Prunus emarginata	Bitter cherry	FACU																																						x		x									x		x															
Pseudotsuga menziesii	Douglas fir	FACU	x	x																			x																		x																											
Rhamnus purshiana	Cascara	FAC-		x														x					x																																													
Salix lasiandra	Pacific willow	FACW+						x	x			x						x			x				x			x		x			x	x								x		x	x	x	x	x	x									x										
Salix scouleriana	Scouler willow	FAC							x												x				x			x		x			x	x								x		x	x	x	x		x									x										
Thuja plicata	Western red cedar	FAC		x							x			x	x							x	x	x			x		x								x																																
Tsuga heterophylla	Western hemlock	FACU-																																																																
Shrubs																																																																			
Acer circinatum	Vine maple	FAC-	x		x	x					x			x	x						x	x	x	x																x																												
Cornus sericea	Red-osier dogwood	FACW															x				x									x			x				x					x	x	x		x			x									x	x									
Corylus cornuta	Beaked hazelnut	FACU	x															x				x	x	x																x																												
Cytisus scoparius	Scot's broom	UPL																																								x																								
Gaultheria shallon	Salal	FACU																					x																																												
Hedera hibernica	English ivy	UPL																			x			x					x																																						
Ilex aquifolium	Holly	FACU																																																																	
Kalmia spp.	Laurel	UPL																																																																	
Lonicera involucrata	Twinberry	FAC+																																								x																								
Mahonia aquifolium	Tall Oregon grape	UPL				x																	x																																												
Oemleria cerasiformis	Indian plum	FACU	x	x	x						x			x	x									x					x											x																	x										
Philadelphus lewisii	Mock orange	FACU																						x																			x																								
Polygonum cuspidatum	Japanese knotweed	FACU																				x		x									x																																		
Rosa nutkana	Nootka rose	FAC														x	x	x						x			x													x		x	x								x		x															
Rubus armeniacus	Himalayan blackberry	FACU		x	x											x		x			x	x					x			x			x	x						x	x	x	x														x										
Rubus parviflorus	Western thimbleberry	FAC-			x						x			x	x								x	x					x													x																									
Rubus spectabilis	Salmonberry	FAC+	x		x	x					x			x	x						x	x		x					x	x			x	x								x																x									
Rubus ursinus	Trailing blackberry	FACU				x																	x	x															x																											
Sambucus racemosa	Red elderberry	FACU			x						x			x	x						x	x								x			x							x		x																x									
Spiraea douglasii	Spirea	FACW																																								x																								
Symphoricarpos albus	Snowberry	FACU	x	x	x		x				x			x	x									x			x													x		x														x	x									
Vaccinium ovatum	Evergreen huckleberry	UPL																					x																																											
Vaccinium parvifolium	Red huckleberry	UPL																					x																																											
Grass, Ferns, & Herbaceous																																																																			
Agrostis capillaris	Colonial bentgrass	FAC														x	x	x																	x																													x	x	x		x
Athyrium filix-femina	Lady fern	FAC+							x												x							x		x			x				x							x																x									
Atriplex patula	Fat-hen saltbush	FACW																																	x																															
Carex deweyana	Dewey sedge	FACU																																																																	
Carex obnupta	Slough sedge	OBL																x										x									x								x		x		x																			
Cirsium arvense	Canadian thistle	FACU+														x	x	x																												x																				
Epilobium watsonii	Watson's willow-herb	FACU-																																																																
Equisetum arvense	Field horsetail	FAC																																														x																		
Equisetum telmateia	Giant horsetail	FACW																					x																																											
Festuca rubra	Red fescue	FAC+														x	x	x																	x												x				x	x	x													x	x	x		x
Grasses Misc.																									x					x	x			x							x					x																			x	x	x	x	x
Grindelia integrifolia	Entire-leaved gumweed	FACW																																	x		x																	x												
Holcus lanatus	Common velvet grass	FAC														x	x	x																														x																x		x
Iris pseudoacorus	Yellow-flag iris	OBL																									x		x			x										x																								
Jaumea carnosa	Fleshy jaumea	OBL																																		x	x													x															
Juncus acuminatus	Tapertip rush	OBL																																	x														x				x												
Juncus effusus	Soft rush	FACW																x								x					x	x			x										x					x							x								x			x
Lotus corniculatus	Birds-foot trefoil	FAC																																														x																		
Lysichiton americanus	Skunk cabbage	OBL							x																			x		x			x										x														x	x									
Maianthemum dilatatum	False-lily-of-the-valley	FAC																																																																
Nuphar polysepalum	Yellow water lilly	OBL																																								x																								

Appendix A
Vegetation Data

Scientific Name	Common Name	Indicator	2a	2b	2c	2d	4a	4b	4c	4d	4e	4f	4g	4h	4i	6a	6b	6c	7a	7b	7c	7d	8a	8b	8c	9a	9b	10a	10b	11a	11b	11c	11d	11e	11f	12a	12b	13a	13b	14a	14b	14c	15a	15b	16a	16c	16d	16e	16f	16g	18a	18b	18c	18d	18e	20a	21a	21b	19	20	21	22	i	ii	iii	iv	v
Oenanthe sarmentosa	Water-parsley	OBL																																																																	
Phalaris arundinacea	Reed canarygrass	FACW						x				x						x			x						x			x	x		x	x									x	x		x	x		x	x						x	x										
Phleum pratense	Timothy grass	FAC-														x	x	x																																																	
Plantago lanceolata	English plantain	FAC																																																																	
Plantago major	Common plantain	FACU+																																																																	
Plantago maritima	Sea plantain	FACW+																																				x	x													x			x												
Poa pratensis	Kentucky bluegrass	FAC																																	x																												x	x	x		x
Polystichum munitum	Sword fern	FACU		x	x	x	x				x			x	x								x						x											x																			x									
Potentilla anserina	Silverweed	OBL																																		x			x													x															
Pteridium aquilinum	Bracken fern	FACU																					x												x																													x			
Puccinellia nutkaensis	Pacific alkali grass	OBL																																				x	x													x			x												
Ranunculus acris	Tall buttercup	FACW-																								x					x	x			x															x													x	x			
Ranunculus repens	Creeping buttercup	FACW																			x									x			x																							x											
Rorippa palustris	Marsh yellowcress	OBL																																																																	
Salicornia virginica	Pickleweed	OBL																																				x	x													x			x												
Scirpus acutus	Hardstem bulrush	OBL																										x																																								
Scirpus americanus	Common threesquare	OBL																																								x																									
Scirpus microcarpus	Small-fruited bulrush	OBL																																									x		x	x	x		x	x						x											
Tanacetum vulgare	Common tansy	UPL																																																																	
Taraxacum officinale	Common dandelion	FACU														x	x	x																																													x				x
Tolmiea menziesii	Piggyback plant	FAC																																																																	
Trifolium pratense	Red clover	FACU																																																													x				x
Trifolium repens	White clover	FAC														x	x	x																																													x		x		
Trillium ovatum	Western trillium	FACU																																																																	
Typha latifolia	Cattail	OBL																x										x		x			x			x						x	x						x								x										
Urtica dioica	Stinging nettle	FAC+																												x			x																																		

APPENDIX B
WILDLIFE OBSERVATIONS DURING FIELD VERIFICATION

Appendix B
Wildlife Species, Track, or Sign Observed During the Investigation

Scientific Name	Common Name
Amphibians	
Northwestern salamander	*Ambystoma gracile*
Pacific chorus frog	*Pseudacris regilla*
Pacific giant salamander	*Dicamptodon tenebrosus*
Mammals	
Beaver	*Castor canadensis*
Coyote	*Canis latrans*
Deer mouse	*Peromyscus maniculatus*
Eastern gray squirrel	*Sciurus carolinensis*
European rabbit	*Oryctolagus cuniculus*
House mouse	*Mus musculus*
Long-tailed weasel	*Mustela frenata*
Mule deer	*Odocoileus hemionus*
Raccoon	*Procyon lotor*
River otter	*Lutra canadensis*
Townsend's mole	*Scapanus townsendii*
Western red-backed vole	*Clethrionomys occidentalis*
Reptiles	
Western garter snake	*Thamnophis elegans*
Birds	
American crow	*Corvus brachyrhynchos*
American dipper	*Cinclus mexicanus*
American goldfinch	*Carduelis tristis*
American robin	*Turdus migratorius*
Bald eagle	*Haliaeetus leucocephalus*
Barn swallow	*Hirundo rustica*
Belted kingfisher	*Ceryle alcyon*
Black-capped chickadee	*Parus articapillus*
Bushtit	*Psaltriparus minimus*
California gull	*Larus californicus*
California quail	*Callipepla californica*
Canada goose	*Branta canadensis*
Common yellowthroat	*Geothlypis trichas*
Dark-eyed junco	*Junco hyemalis*
Double-crested cormorant	*Phalacrocorax auritus*
Downy woodpecker	*Picoides pubescens*
European starling	*Sturnus vulgaris*
Gadwall	*Anas strepera*
Glaucous-winged gull	*Larus glaucescens*
Golden-crowned kinglet	*Regulus satrapa*
Great blue heron	*Ardea herodias*
House sparrow	*Passer domesticus*
Killdeer	*Charadrius vociferus*
Mallard	*Anas platyrhynchos*
Marsh wren	*Cistothorus palustris*
Osprey	*Pandion haliaetus*
Red-breasted sapsucker	*Sphyrapicus ruber*

Appendix B

Wildlife Species, Track, or Sign Observed During the Investigation

Scientific Name	Common Name
Red-tailed hawk	*Buteo jamaicensis*
Red-winged blackbird	*Agelaius phoeniceus*
Rock dove	*Columba livia*
Rufous hummingbird	*Selasphorus rufus*
Spotted towhee	*Pipilo erythrophthalmus*
Steller's jay	*Cyanocitta stelleri*
White-breasted nuthatch	*Sitta caralinensis*