DRAFT Skagit River Flood Risk Reduction Study, Environmental Without-Project Condition Report

Skagit River Basin
Skagit County, Washington
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Prepared by
Seattle District
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I. INTRODUCTION

The Skagit River basin has a drainage area of 3,140 square miles (Figure 1). The northern end of the basin extends 28 miles into Canada and covers 400 square miles. The headwaters of the Skagit arise in the steep Cascade Mountains of Canada and flow west and south into the United States. The river continues to flow through steep mountains for the next 40 miles where it passes through Ross, Diablo, and Gorge Dams owned by Seattle City Light above the town of Newhalem. The river continues for approximately 70 miles through less precipitous mountain valleys and the small towns of Marblemount (2000 population 251), Concrete (2000 population 760), Hamilton (2000 population 309) and Lyman (2000 population 409) before emerging in the vicinity of Sedro-Woolley (2000 population 8,658) (US Census Bureau 2010a). The river then meanders for about 25 miles through the coastal lowlands between the cities of Burlington (2000 population 6,757) and Mount Vernon (2006-2008 population 30,745) before discharging into Skagit Bay (US Census Bureau 2010a and b). Population in the watershed is concentrated in the lowland delta area with only a few small towns in the upper basin (Sedro Woolley being the largest). Before it reaches the bay, the river crosses a broad outwash plain and divides into two principle branches, the north and south forks, which are 7.3 miles and 8.1 miles long, respectively, and which normally carry 60 percent and 40 percent of the flow, respectively. This report will cover the entire watershed encompassing both the Upper and Lower Basins of the Skagit River.

Several flood control projects provide flood protection in the Skagit basin. These include a system of levees in the lower basin and flood control reservoirs in the upper basin, totally 45 miles of non-Federal levees. Both Ross Dam on the Skagit, and Upper Baker Dam on the Baker River, are operated on a formal basis for flood control and provide a significant reduction to large and small floods. These dams control 38 percent of the Skagit basin's drainage area; the remaining 62 percent is uncontrolled. Other hydroelectric and re-regulatory dams situated on the Skagit and Baker Rivers provide incidental reduction of flood flows during smaller events.

The upstream portion of the watershed is dominated by timber production and wilderness. There are five major dams in this section which provide hydroelectric generation and some flood control: Upper Baker, Lower Baker, Ross, Diablo, and Gorges. The Sauk, Suiattle, and Cascade Rivers, tributaries to the Skagit River, are in the Wild and Scenic River system, as is the Skagit River from Ross Lake to Sedro-Woolley.

The Skagit delta area is one of the most productive agricultural areas in the world. However, in recent years, growing population pressure in the Puget Sound region has resulted in conversion of some of this farmland to urban uses. Extensive diking of the lower river dating back to the last part of the 19^{th} century, along with historic land clearing for agriculture, significantly altered the natural environment and physical processes in the delta.

Flooding on the river has been a constant problem. Significant flood events in Skagit County have been estimated as early as 1815 and have occurred as recently as 2006.

Flooding is somewhat less severe since the 1920s, when dams were constructed on the Baker and Skagit Rivers providing some retention and upstream storage of flood waters. There has also been an extensive program of levee construction along the Skagit River downstream from Sedro-Woolley

Because much of the urban and agricultural land lies in the lowlands, flooding can cause significant damage. The Skagit River has occasionally overflowed the low divide between Sedro-Woolley and Burlington, and added to the flooding in the Samish River Basin; although, that has not happened since 1921. Upriver, communities such as the towns of Lyman and Hamilton have also experienced flood problems; Hamilton was inundated with flood waters many times in the 20th century, most recently in 2006.

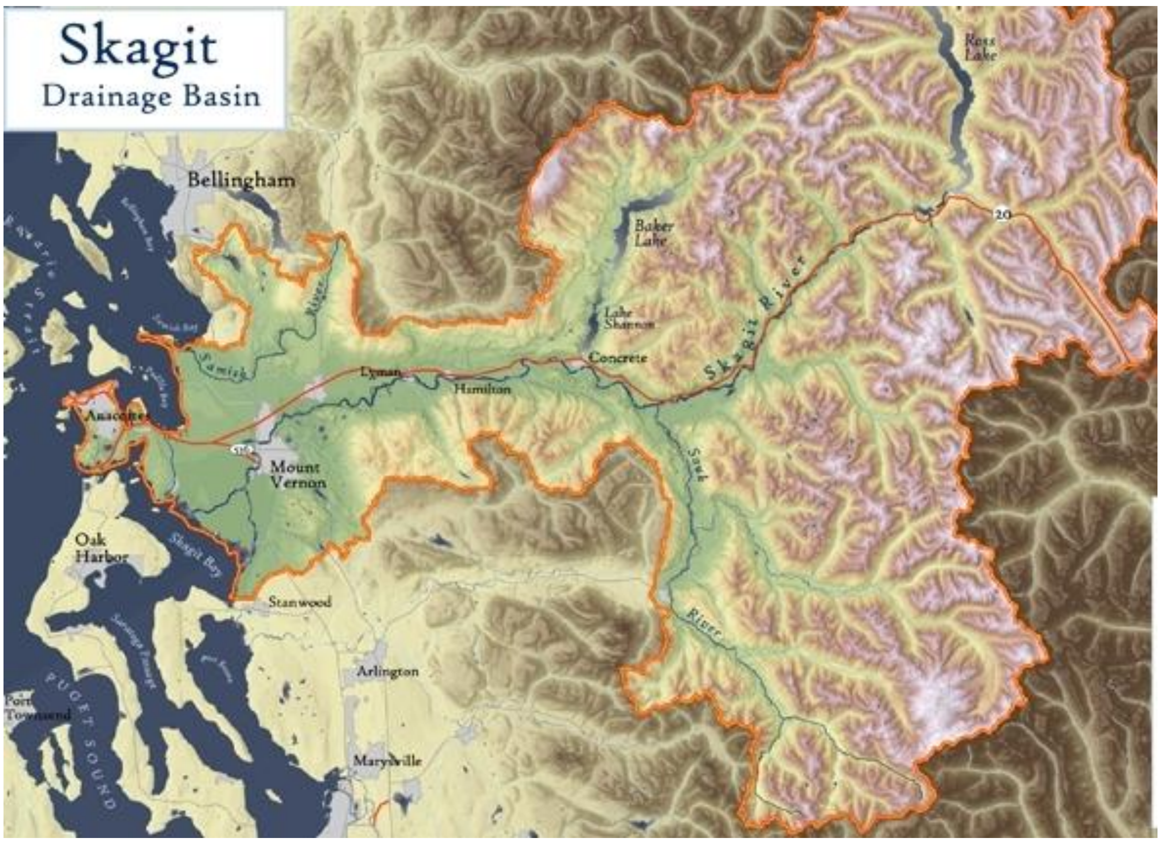

Figure 1. Skagit River Basin (Pacific Coast Watershed Partnership 2008)

Despite the major alterations in the physical and biological processes occurring in the river system, the Skagit River still remains the major producer of salmonids in the northern Puget Sound. The delta is also a major wintering area for waterfowl and raptors, as well as a migration stopover for shorebirds.

II. ENVIRONMENTAL BASELINE CONDITIONS

A. Physical Resources

1. Topography/Watershed Description

The Skagit River originates in a network of narrow, precipitous mountain canyons in Canada and flows west and south into the United States where it continues 135 miles to Puget Sound. The crest of the Cascades forms the eastern boundary of the basin with altitudes ranging up to 8,000 feet (ft). From the Cascades, the river flows through gorges of glacier peaks to lower mountains, where its banks are heavily wooded with conifers and it meanders around island stands of cottonwoods and alders, and then expands into the farm delta of the Skagit Valley. The valley varies in width from less than one mile in upper reaches to about 2 miles at Sedro-Woolley to more than 15 miles at the broad delta outwash plain, which encompasses 68,000 acres of floodplain. At Fir Island, the river divides into two principal distributaries of nearly equal length. During the usual range of river discharge, about 60 percent of the flow is carried by the North Fork and 40 percent by the South Fork. The entire floor of the Skagit River Valley and the deltas of the Samish and Skagit Rivers comprise the flood plain. The major portion of the flood plain within the study area is developed farmsteads, large portions of the commercial area of Mt. Vernon, and the urban area of Burlington; the remainder is mostly un-cleared bottomland and wetlands.

From Gorge Dam to Newhalem (River Mile [RM] 94) the Skagit River plunges 250 ft in elevation in less than 3 miles. Downstream of Newhalen the river's slope flattens substantially to approximately 8 ft per mile between Newhalen and Concrete (RM 56). Numerous tributaries enter the Skagit River in this reach. Many of those tributaries are relatively small, consisting of steep heavily forested basins with drainage areas of less than 20 square miles that discharge directly into the Skagit River. However, there are three large drainage basins: the free-flowing Cascade and Sauk Rivers, and the regulated Baker River.

The Cascade River has a drainage area of 185 square miles and enters the Skagit River at RM 78.1, just upstream of the town of Marblemount. The Cascade River run of 29 river miles north and west from South Cascade Glacier on Sentinel Peak to the Skagit River. The basin ranges in elevation from 300 to 8,500 ft. The Cascade River is classified as a Wild and Scenic River. The basin is mostly forested and the river opens from a roughly 400-foot wide canyon at RM 3.3 to a 2,800-foot wide floodplain at its mouth. The Cascade River is the second largest contributor to the sediment to the Skagit River.

The Sauk River is the largest tributary to the Skagit River and flows into it on the left bank at RM 67.2. The Sauk River is also designated a Wild and Scenic River. The Sauk River originates near Monte Cristo Peak and flows generally north for over 50 miles. The Sauk River has a drainage area of 732 square miles, which is over 25 percent of the total drainage area of the Skagit River at their confluence. It is also approximately 50 percent of the total uncontrolled sediment contributing area in the basin. There are two large tributuaries that flow into the Sauk River from Glacier Peak. The largest in the Suiattle River (346 square mile drainage area), which flows in from the east at RM 13.2 and is over 40 miles in length. The White Chuck River (86.2 square mile drainage area) flows in from the east at RM 31.9. The elevations in the basin range from 10,541 ft to

210 ft at the mouth. The high elevation headwater areas have sparse vegetation and several peaks are glaciated. The middle and lower watershed is forested. The lower reaches of the rivers have braided and meandering channels with unstable banks. The Sauk River watershed is the largest contributor to the sediment to the Skagit River.

The Baker River enters the Skagit River from the north at RM 56.5, at the town of Concrete. The Baker River has a drainage area of 298 square miles. The basin has several high peaks including Mount Baker, Mount Skuksan, Whatcom Peak, and Bacon Peak. The runoff from 297 square miles drains into Lake Shannon or Baker Lake. The temporary storage of flood discharges in those lakes greatly reduces flood peaks and the sediment yield from the Baker River.

From Concrete (RM 56) to Sedro-Woolley (RM 23) a few small tributaries enter the Skagit River from both banks. Those tributaries originate in the forested, lower elevation foothills of the Cascade Mountains. Potentially larger tributary flows from Mount Baker are intercepted by the South Fork of the Nooksack River. The valley floor has somewhat irregular topography and is typically a half-mile to a mile wide. Most of the valley floor is utilized for agriculture.

Downstream from Sedro-Woolley (RM 23), the Skagit River crosses a broad outwash plain before discharging into Skagit Bay in Puget Sound. The floodplain stretches north-south about 19 miles, from Samish Bay on the north, to Camano Island on the south. The floodplain is a rich agricultural area. The cities of Burlington, Mount Vernon, and La Connor are located on this floodplain. Nookachamps Creek is the only significant tributary in this reach. Immediately downstream from Mount Vernon, the river divides into two distributaries, the North and South Forks. These two distributaries carry about 60 percent and 40 percent of the normal flows of the Skagit River, respectively.

2. Geology

The eastern mountainous region of the upper Skagit Basin consists of ancient metamorphic rocks, largely phyllites, slates, shales, schists, and gneisses together with intrusive granitic rocks and later andesitic lavas and pyroclastic deposits associated with Mount Baker and Glacier Peak. The valleys are generally steep sided and frequently flat floored. Alpine glaciers have contributed to the steepness of the valley sides and to the depth of the valley bottoms. Over ten thousand years ago the upper Skagit Valley and the peaks were severely glaciated, removing not only the soil, but much of the loose rock. Glaciation exerted a powerful influence on the geomorphology of the Skagit River basin. Drainage patterns in the basin have many peculiar features, including long interconnected valleys, breached hydrologic divides, bisected valleys, and low-elevation mid-valley divides occupied by lakes and wetlands. The Skagit basin was likely much smaller prior to Quaternary glaciation. Geological evidence suggests overflow of proglacial lakes breached the North Cascades crest at Skagit Gorge and caused the lower Skagit River to capture upper Skagit valley (Riedel et al. 2007).

The lower Skagit Basin was glaciated during the Pleistocene Era by a lobe of continental ice moving south from Canada and alpine glaciers retreating from Mt. Baker and Glacier Peak. These ice formations rounded nearby bedrock knobs and ridges and left behind a varying sequence of glacial deposits. Since the deglaciation, approximately 10,000 years ago, the Skagit River built a broad delta alluvial plain covering older hills of bedrock and glacial drift in a thick deposit of alluvial silt, fine sand, and clay. Though the Skagit River now exists in the southern portion of the delta alluvial plain, prehistoric exits into Samish and Padilla Bays are evident from present topography. The plain is generally ten to 20 feet above the mean sea level. Ground water levels are close to the surface. Beds of gravel are centered around the Burlington area, close to one of the older hills, which protrude through the plain. Because of man's attempt to control the river, the deposition by the river of silt, sand, and debris onto the delta alluvial flood plain at high-flow stages has been greatly reduced, resulting in increased deposition on the channel bottom and more rapid extension of the active delta into Skagit Bay.

Many river channels created during the glacial melt have continued to aggrade, and as a result of that glacial action, the bedrock bottoms of most canyons are covered with glacial alluvium. These deposits are a heterogeneous mixture of sand and gravel together with variable quantities of silt and clay depending on the mode of deposition. Some of these deposits are highly susceptible to land sliding when saturated. The floodplain of the Skagit River below Concrete is composed of sands and gravels that diminish to sands, silts, and some clays further downstream. Below Hamilton, fine-grained floodplain sediments predominate.

Two volcanoes, Mt. Baker and Glacier Peak, are located in the upper watershed. Previous eruptions of Glacier Peak have generated lahars that traveled through the Skagit River to Puget Sound. Mt. Baker eruptions have deposited pyroclastic and lahar material in the Baker River watershed, but have not deposited substantial volumes material in the Skagit River floodplain (Gardner et al. 1995). Future large eruptions could form thick fills of lahars and pyroclastic-flow deposits in the upper valleys near the volcano. Lahars from Glacier Peak could reach the delta, or there could be induced flooding due to temporary damming of watercourses in the upper watershed. Subsequent incision of volcanic deposits could fill riverbeds farther downstream with sediment for many years after the eruption, thereby affecting the capacity of stream channels and locally increasing flood heights (Waitt et al. 1995). These effects would be especially significant for the extensive low-lying areas of the Skagit river floodplain and delta. Although not a direct volcanic hazard, the increased susceptibility of lowland areas downstream of volcanoes to earthquake generated liquefaction is enhanced by the thick deposits of volcanic lahars, sand, gravel and generally saturated conditions in many of those areas.

3. Soils

The Skagit River basin from the delta to just above Marblemount (RM 78) can be divided into four broad physiographic areas: (1) the low precipitation uplands, which include several islands; (2) the flood plain-delta; (3) the high precipitation uplands; and (4) the mountains. These areas are further subdivided into nine general soil map units: (1)

Skagit-Sumas-Field; (2) Larush-Pilchuck; (3) Barneston-Dystric Xerorthents-Indinaola; (4) Tokul-Skipopa-Dystric Xerorchrepts; (5) Vanzandt-Montborne-Squires; (6) Chuckanut-Cathcart; (7) Bow-Coveland-Swinomish; (8) Skykomish-Jug-Saxon; and (9) Wollard-Kindy-Diobsud. No survey has been conducted upstream of RM 78 to the Canadian border in the Mount Baker-Snoqualmie National Forest; therefore no soil data is available.

The soils in the surveyed area range widely in texture, drainage, and other characteristics. The physiographic areas and associated soils in the lower basin include: the floodplain with associated map unit 1 and the high precipitation uplands with associated map unit 7. The physiographic areas and associated soils in the upper basin include: the floodplain with associated map unit 2; the high precipitation uplands with associated map units 3 and 5; and the mountains with associated map units 8 and 9 (Klungland and McArthur 1989).

General map unit 1 is comprised primarily of Skagit, Sumas and Field soils. This map unit is in the central and western parts of the survey area in the immediate floodplain and delta of the Skagit River. Slope is zero to three percent. Elevation is sea level to 50 feet. The average annual precipitation is 32 to 40 inches, the average annual air temperature is about 51 degrees F, and the average frost-free season is 160 to 220 days.

> Skagit soils are very deep and naturally poorly drained, but they have been artificially drained and protected in most areas. Undrained areas of Skagit soils are high in salt content. These soils formed in recent alluvium and volcanic ash. The surface layer is silt loam about 12 inches thick. The upper 38 inches of the underlying material is silt loam and silty clay loam, and the lower part to a depth of 60 inches or more is very fine sandy loam. Skagit soil is classified as "superactive" and has a high cation exchange capacity (USDA 2006 and 2008).
>
> Sumas soils are very deep and naturally poorly drained, but they have been artificially drained and protected in most areas. These soils formed in alluvium. The surface layer, to a depth of about 13 inches, is silt loam over silty clay loam. The upper 17 inches of the underlying material is silt loam and loamy sand, and the lower part to a depth of 60 inches or more is coarse sand.
>
> Field soils are very deep and moderately well drained. They formed in recent alluvium and volcanic ash. The surface layer and upper part of the underlying material are silt loam about 21 inches thick. The lower part of the underlying material to a depth of 60 inches or more is stratified fine sand to very fine sandy loam. These soils are frequently flooded.

General map unit 2 is comprised primarily of Larush and Pilchuck soils. This map unit is in the central and eastern parts of the survey area in the immediate floodplain of the Skagit River. Slope is 0 to 5 percent. Elevation is 20 to 500 feet. The average annual precipitation is 55 to 70 inches, the average annual air temperature is about 52 degrees F, and the average frost-free season is 160 to 220 days.

Larush soils are occasionally flooded flood plains and low terraces along the Skagit and Sauk Rivers. The soils are very deep and well drained, and formed in alluvium. Generally, the surface is covered with a mat of needles, leaves, and twigs. The surface layer is fine sandy loam or silt loam about 15 inches thick. The subsoil is very fine sandy loam and silt loam about 19 inches thick. The substratum to a depth of 60 inches or more is fine sand and silt loam.

Pilchuck soils are on frequently flooded flood plains along the Skagit and Sauk Rivers. These soils are very deep, excessively drained and were formed in alluvium. The surface layer is loamy sand about 3 inches thick. The upper 40 inches of the underlying material is fine sand and sand, and the lower part to a depth of 60 inches or more is gravelly sand.

General map unit 3 is comprised primarily of Barneston, Dystric Xerorthents, and Indinaola soils. This map unit is in the central and eastern parts of the survey area, along the major drainage ways of the Skagit River from approximately the confluence of Grandy Creek (RM 45) upstream past the confluence with the Sauk River (RM 71). Slope is 0 to 80 percent. Elevation is 200 to 1,200 feet. The average annual precipitation is 50 to 70 inches, the average annual air temperature is about 50 degrees F, and the average frost-free season is 160 to 220 days.

Barneston soils are on glacial outwash terraces and terrace escarpments. The soils are very deep and somewhat excessively drained. They formed in loess and volcanic ash underlain by glacial outwash. The surface is covered with a mat of needles and twigs. The surface layer and subsoil are gravelly loam, very gravelly sandy loam, or very cobbly sandy loam about 20 inches thick. The substratum to a depth of 60 inches or more is very cobbly loamy sand, very gravelly loamy coarse sand, or extremely gravelly sand.

Dystric Xerorthents are on steep to extremely steep terrace escarpments. The soils are very deep and excessively drained. They formed in glacial outwash. The surface is covered with a mat of needles, leaves, and twigs. The surface layer is gravelly sandy loam about 4 inches thick. The subsoil is gravelly loamy sand about 31 inches thick. The substratum to a depth of 60 inches or more is stratified very gravelly sand and gravelly sand.

Indianola soils are on terraces. The soils are very deep and somewhat excessively drained. They formed in sandy glacial outwash. The surface is covered with a mat of needles, leaves, and twigs. The surface layer is dark brown sandy loam about 6 inches thick. The upper 25 inches of the subsoil is loamy sand. The lower 24 inches of the subsoil and the substratum to a depth of 60 inches or more are sand.

General map unit 5 is comprised primarily of Vanzandt, Montborne, and Squires soils. This map unit is in the central and eastern parts of the survey area, found throughout the subject area. Slope is 0 to 65 percent. Elevation is 250 to 1,500 feet. The average annual precipitation is 55 to 75 inches, the average annual air temperature is 43 to 50 degrees F, and the average frost-free season is 120 to 200 days.

Vanzandt soils are on glacially modified plains and low mountainsides. The soils are moderately deep and moderately well drained. They formed in volcanic ash and glacial till. The surface is covered with a mat of needles, leaves, and twigs. The surface layer and subsoil are very gravelly loam about 25 inches thick. The substratum is very gravelly sandy loam about 11 inches thick over dense glacial till. Depth to dense glacial till ranges from 20 to 40 inches.

Montborne soils are on glaciated mountainsides. The soils are moderately deep and moderately well drained. They formed in glacial till and volcanic ash. The surface is covered with a mat of needles, leaves, and twigs. The surface layer is very gravelly loam about 6 inches thick. The subsoil and substratum are extremely gravelly loam about 26 inches thick over dense glacial till. Depth to dense glacial till ranges from 20 to 40 inches.

Squires soils are on glacially modified mountainsides. The soils are moderately deep and well drained. They formed in colluvium derived from phyllite, volcanic ash, and glacial till. The surface is covered with a mat of needles, leaves, and twigs. The surface layer and subsoil are very gravelly silt loam about 17 inches thick. The substratum is very gravelly loam 15 inches thick over phyllite. Depth to phyllite ranges from 20 to 40 inches.

General map unit 7 is comprised primarily of Bow, Coveland and Swinomish soils. This map unit is in the western upland parts of the survey area and includes some islands. Slope is zero to 30 percent. Elevation is sea level to 1,500 feet. The average annual precipitation is 20 to 40 inches, the average annual air temperature is about 50 degrees F, and the average frost-free season is 160 to 220 days.

Bow soils are on glacial remnant terraces. The soils are very deep and somewhat poorly drained. They formed in glacial drift over glaciolacustrine sediment with a mantle of volcanic ash. The surface is covered with a mat of leaves and twigs. The surface layer and upper part of the subsoil are gravelly loam about 8 inches thick. The lower part of the subsoil to a depth of 60 inches or more is clay loam over silty clay.

Coveland soils are in swales on glaciated hills. The soils are very deep and somewhat poorly drained. They formed in glaciolacustrine sediment. The surface is covered with a mat of needles, leaves, and twigs. The surface layer is gravelly loam over very gravelly sandy loam about 14 inches thick. The subsoil and substratum to a depth of 60 inches or more are silty clay.

Swinomish soils are on glaciated hills. The soils are moderately deep and moderately well drained. They formed in glacial till with an admixture of loess and volcanic ash. The surface is covered with a mat of needles, leaves, and twigs.

The surface layer and upper part of the subsoil are gravelly loam about 20 inches thick. The lower part of the subsoil and the substratum are very gravelly fine sandy loam over very gravelly sandy loam about 11 inches thick over dense glacial till. Depth to dense glacial till ranges from 25 to 40 inches.

General map unit 8 is comprised primarily of Skykomish, Jug and Saxon soils. This map unit is in the south-central and north-central parts of the survey area, in particular north of Concrete and south of Lyman. Slope is zero to 65 percent. Elevation is 800 to 2,000 feet. The average annual precipitation is 70 to 75 inches, the average annual air temperature is 43 or 44 degrees F, and the average frost-free season is 100 to 125 days.

Skykomish soils are on terraces, terrace escarpments, and hills. The soils are very deep and somewhat excessively drained. They formed in volcanic ash and glacial outwash. The surface is covered with a mat of needles, leaves, and twigs. The surface layer and subsoil are very gravelly sandy loam about 17 inches thick. The substratum to a depth of 60 inches or more is very gravelly loamy sand.

Jug soils are on terraces. The soils are very deep and somewhat excessively drained. They formed in volcanic ash and glacial outwash. The surface is covered with a mat of needles, leaves, and twigs. The surface layer is very gravelly loam about seven inches thick. The subsoil is extremely cobbly sandy loam over extremely cobbly loamy sand about 34 inches thick. The substratum to a depth of 60 inches or more is extremely cobbly sand.

Saxon soils are on terraces and hills. The soils are very deep and moderately well drained. They formed in volcanic ash underlain by glaciolacustrine sediment. The surface is covered with a mat of needles, leaves and twigs. The surface layer, subsoil, and upper part of the substratum are silt loam about 21 inches thick. The lower part of the substratum to a depth of 60 inches or more is silty clay loam.

General map unit 9 is comprised primarily of Wollard, Kindy, and Diobsud soils. This map unit is in the central and eastern parts of the survey area on higher elevation slopes and terraces. Slope is three to 65 percent. Elevation is mainly 1,800 to 4,200 feet. The average annual precipitation is 80 to 90 inches, the average annual air temperature is 38 to 43 degrees F, and the average frost-free season is 90 to 120 days.

Wollard soils are on glacially modified mountainsides. The soils are moderately deep and moderately well drained. They formed in volcanic ash and glacial till derived dominantly from phyllite. The surface is covered with a mat of needles, leaves, and twigs. The surface layer and upper part of the subsoil are gravelly silt loam about 8 inches thick. The lower part of the subsoil and the substratum are gravelly loam 24 inches thick over dense glacial till. Depth to dense glacial till ranges from 20 to 40 inches.

Kindy soils are on glacially modified mountainsides. The soils are moderately deep and moderately well drained. They formed in volcanic ash, loess, and glacial till. The surface is covered with a mat of leaves, needles, and twigs. The surface layer is gravelly silt loam about 4 inches thick. The subsoil is very gravelly silt loam 15 inches thick. The substratum is very gravelly loam 7 inches thick over dense glacial till. Depth to dense glacial till ranges from 20 to 40 inches.

Diobsud soils are on glacially modified mountainsides. The soils are moderately deep and moderately well drained. They formed in volcanic ash and glacial till derived dominantly from phyllite. The surface is covered with a mat of needles, leaves, and twigs. The surface layer is gravelly silt loam about 4 inches thick. The subsoil and substratum to a depth of 28 inches are gravelly loam over dense glacial till. Depth to dense glacial till ranges from 20 to 40 inches.

The existing levee materials along the delta reaches are very similar to the foundation soil in most cases and are predominantly fine sands and silty sands of loose-to-medium relative density. There is documented evidence of volcanic lahar material underlying the towns of Lyman, Hamilton, Sedro-Woolley, Burlington and La Conner. Primary uses for these soils are agricultural cropping, pasture land and recreation.

4. Geomorphology

A major portion of the Skagit River basin lies on the western slopes of the Cascade Range. Most of the eastern basin is mountainous, with 22 peaks higher than 8,000 feet. Many of those peaks are topped by glaciers. The two most prominent topographical features in the basin are Mount Baker at an elevation of l0,778 feet on the western boundary of the Baker River basin, and Glacier Peak at an elevation of l0,568 feet in the Sauk River basin.

The Skagit River can be divided into five geomorphic reaches. In the upper basin, the Skagit River occupies the narrow, steep-walled canyon upstream of the Cascade River. The middle river extends from the confluence of the Cascade River downstream to Sedro-Woolley. As the valley floor widens through this reach and the channel becomes more sinuous and complex. The lower river runs from Sedro-Woolley to the estuary. The lower river is confined to a single channel with hardened banklines. Downstream of Mount Vernon, the river splits into two distributary estuary channels, before discharging into Skagit Bay on Puget Sound.

The upper reach covers the channel upstream of the Cascade River (RM 78). The channel form in this reach is controlled by the steep North Cascade Mountain geology. Most of the channel upstream of Gorge Dam (RM 97) is submerged by reservoirs. From Gorge Dam downstream to the Cascade River (RM 78), the river flows freely through a narrow bedrock confined channel in a series of rapids and deep pools. The Skagit River has a slope of 10 ft/mi in this lower reach. The riverbed is composed of bedrock, boulders, cobbles and gravel.

The middle reach extends from the Cascade River (RM 78) downstream to near Burlington (approximately RM 19). This is the most active stretch of the river, with complex channel forms and only intermittent bank protection. The lower part of this reach was described by Pentec (2002) in the Phase 1 geomorphology report for the Skagit River Flood Damage Reduction Feasibility Study. In this reach, the river flows on a mountain valley floor that gradually widens in the downstream direction. The Cascade and Sauk Rivers contribute large sediment loads to this reach of the Skagit River. The riverbed in the Cascade-Baker River reach is composed of boulders, cobbles, and gravel. The stream gradient falls from over 6 ft/mi upstream of Concrete to about 2 ft/mi upstream of Sedro-Woolley (approximately RM 23) and then steepens again to around 5 ft/mi at the downstream end of the reach. The bed becomes finer downstream and is mostly gravel with some sand near Sedro-Woolley. The floodplain soils tend to be sand, silt and clay.

The channel begins to meander and becomes more complex downstream of the Sauk River. Side channels become more frequent as the valley widens and the slope flattens between Hamilton and Sedro-Woolley. There are numerous side channels, oxbows and overbank erosion scars created during large floods of the past. Some meanders have been cutoff. Bank protection is intermittent throughout the entire reach, generally occurring along Highway 20 or adjacent to riverside communities.

The lower reach runs from RM 19, slightly upstream of Burlington, downstream to RM 8, where the river splits into the North and South Forks. Within this reach the river occupies a single channel, typically 600-700 ft wide with 20-30 ft high banks. This reach has been extensively modified with levees, bank protection, and dredging over the past 100 years or more. Levees line both sides of the river, with minimal setback distances. The banks are continuously armored with riprap. No eroding banks were observed within this reach and the river occupies essentially the same location as 100 years ago (Pentec 2002).

The geomorphology of the Lower Skagit River is described in the report entitled "Geomorphology and Sediment Transport Study of Skagit River Flood Hazard Mitigation Project Skagit County, Washington Phase 1 Interim Report" (Cherry and Jackson 2002). Based on review of existing literature and field studies, the authors divided the Skagit River from RM 0.0 to RM 30.0 into 6 reaches:

1) North Fork (RM 0 to 8.0)
2) South Fork (RM 0 to 8.0)
3) River confluence to Burlington (RM 8.0 to 19.0)
4) Burlington to Sedro-Woolley (RM 19.0 to 21.9)
5) Sedro-Woolley (RM 21.9 to 23.5)
6) Sedro-Woolley to Cockreham Island (RM 23.5 to 30.0)

Reaches 1 and 2 represent the estuarine portion of the river, tidally influenced but highly altered by diking. Reach 1, the North Fork, is tightly confined with many distributary channels, including Dry Slough and Browns Slough, which were cut off by the U.S. Army Corps of Engineers (Corps) near the turn of the 20th century. Reach 2, the South Fork, while constrained by dikes, is wider and has several large intact distributary channels with expansive riparian vegetation on the lower part of the reach. Large woody debris (LWD) is abundant in the vicinity of Freshwater Slough due to recent restoration efforts (Earthwatch Institute 2002), but is lacking overall (Collins 2000). Both channels are low gradient. Historically, it has been estimated that tidal wetlands of the Skagit estuary covered an area of approximately 25,766 acres, and the current extent is 1,941 acres. This calculates to a loss of approximately 23,825 acres of estuary habitat - more than 37 square miles, or 93 percent of historic coverage (Dean et al. 2000).

Reach 3 begins at the confluence of the North and South Forks and continues upstream to the town of Burlington. In this reach, the river is tightly constrained by dikes on both banks, locking the channel into the same planform present approximately 100 years ago. There is very little LWD in this reach and riparian vegetation is limited. Though the main channel is passable at all times of the year, certain side channels become isolated and/or cut off during low-flow periods. The only significant tributary in Reach 3 is Nookachamps Creek which enters the mainstem on the left bank at RM 18.4. At the upstream end of this reach, the riverbed material changes from sand to sand and gravel. Studies show that the channel bottom has been aggrading in recent years (West 2001).

Upstream of Reach 3, Reaches 4 and 5 represent the transition from the deltaic portion of the river to a higher gradient system coming from the mountains. Reach 4 is relatively unconstrained with several cutoff meanders. LWD quantities are greater. Reach 5 is dominated by bedrock and is higher gradient than downstream. Above Sedro-Woolley, the river transitions into a highly sinuous system, with many side channels and meanders. LWD is common and sediment is coarser in this reach.

Channel conditions in the lower mainstem have changed significantly from historical records. Both aggradation and degradation have been observed in various locations, channel widths and the occurrence of in-stream islands have been modified, and certain channel segments and tributaries have been substantially realigned or structurally modified. Additionally, levees and bank revetments permanently altered the natural stream dynamics.

In 1975, the Washington Department of Fisheries stream catalog identified the lower Skagit River as having long glides and deep pools. However, since that study, a loss of pool area was identified and associated with the historic removal and reduction of input of LWD and increases in sediment supply (Collins 2000). The current channel morphology (i.e. smooth banks) makes it difficult for any remaining LWD to form jams and associated pools. The system’s constrained configuration and recent aggradations may also contribute to the loss of pools. The majority of existing pools are found in areas of high shear stress (Cherry and Jackson 2002). The increases in sediment supply are due to mass wasting (landslides) and surface erosion due to forest management activities in the Cascades, and soil creep (SWC 1998). However, there are also natural inputs such as glacial and volcanic conditions that are attributed to higher sediment loads

5. Climate

Precipitation over the basin varies greatly from a mean annual amount of 32 inches in the vicinity of the mouth of the Skagit River which lies in a topographical rain shadow, to an average of 180 inches or more on the higher elevations of the Cascade Range. Mean annual snowfall varies from 4.4 inches at Anacortes to 647 inches at Mount Baker Lodge. Average winter temperatures vary from 26.9°F at Mt. Baker Lodge (4,150 feet) to 34.5°F at La Conner, and average summer temperatures vary from 56.7°F at Mt. Baker Lodge to 61.7°F at La Conner.

The lower basin has a mild, wet, maritime climate caused by air masses originating over the Pacific Ocean which influence both the temperature and precipitation regimes. During the winter, the Skagit Basin, lying directly in the storm path of cyclonic disturbances from the Pacific, is subject to a definite rainy season, with numerous storms often in quick succession. During the short summers, the weather is warm and relatively dry as the winter low pressure system is displaced by a semi permanent high pressure system. The mean length of the growing season is 193 days.

B. Biological Resources

1. Vegetation

a. Basin Vegetation

Almost 90 percent of the Upper Skagit basin above Sedro Woolley is either designated as national forest or national park. Approximately 56 percent of Water Resource Inventory Area (WRIA) 4 (Upper Skagit) and 2 percent of WRIA 3 (Lower Skagit) lies within the boundaries of Mount Baker National Forest. Another 31 percent of WRIA 4 lies within the boundaries of North Cascades National Park. Large tracks of both old-growth and secondary growth coniferous forests dominate the landscape. North Cascades National Park classifies forests found on the western slopes of the Cascades into four major types: Western Hemlock Forest at 0-2000 feet, Pacific Silver Fir Forest at 2000-4000 feet, Mountain Hemlock Forest at 4000-5500 feet, and Subalpine at 5000-7000+ feet. Trees found within the park boundaries include mostly conifers such as western hemlock, western red cedar, pacific silver fir, Douglas fir, western white pine, and Sitka spruce, and some deciduous species such as cottonwood, Alpine willow, cascade willow, Northwestern paper birch, big leaf maple, bitter cherry, Sitka and red alder, and red osier dogwood (NPS 2008).

b. Riparian Vegetation

The lower Skagit river basin lies in the Eastern Puget Riverine Lowlands ecoregion (EPA 1996). This ecoregion is composed of floodplains and terraces, historically dominated by Western red cedar and Western hemlock forest. Riparian and riverine wetland habitats were common prior to settlement. Pastures, cropland, and urban centers now dominate the landscape.

Today, the majority of the riparian zones below Sedro-Woolley are either entirely devoid of trees or consist of sparse, narrow, and patchy strips of small to medium sized cottonwood, willow, and alder. Approximately 48 miles of levee participate in the PL 84-99 program and are therefore subject to the Corps levee vegetation maintenance requirements. The riparian vegetation that is downstream of Sedro-Woolley is located on these levees. This required vegetation removal results in the majority of the banks being covered with grasses and invasive species (i.e. blackberry, knotweed, and reed canary grass). Upstream of the delta, 32 miles (62 percent) of the mainstem channel edge was hardened with riprap within about 200 feet of the channel's edge.

A screening of riparian vegetation conditions in floodplain habitats throughout the Skagit basin found significant impairment in most of the reaches surveyed (refer to Figure 2) (Beamer et al. 2000). Both historic and current conditions show that landscape alteration resulted in a riparian zone on the lower mainstem that is fragmented, poorly connected, and provides inadequate protection of habitats and refugia for sensitive aquatic species such as salmon. Lack of riparian vegetation results in reduced potential for LWD input into the lower reaches of the river, further compromising salmonid habitat.

In many areas below Sedro–Woolley, the historic establishment of dikes and levees disconnected the river from the floodplains, reducing the river to a single, non-migratory channel. Furthermore, these floodplain habitats were significantly altered over the past 100 plus years due to road building, bank hardening, hydropower operations, timber harvest in riparian zones and contributing upland areas, and rural development. By 1990, 16 diking districts had been created to maintain approximately 56 miles of levees and 39 miles of sea dikes in the Skagit River delta (Halverson 1999). Examination of GIS maps (from the Corps and Skagit River Cooperative) show downstream of Sedro-Woolley, from approximately RM 25, the mainstem channel is hardened with riprap within about 200 feet of the channel's edge in an almost contiguous system of levees and revetments.

Limited examples of beneficial riparian habitat are found in the lower reaches. One example is Cottonwood Island, a 170 acre parcel at the confluence of the North and South Fork, which is representative of a historic habitat type (prior to logging and development) and provides valuable habitat for a variety of forest birds and raptors, primarily buteos and eagles (Garrett et al. 2006).

Since the northwestern portion of the Upper Skagit basin lies in either national park or national forest, the riparian corridor from Marblemount upstream to Ross dam consists almost entirely of conifer dominated forest, with deciduous trees and shrubs the primary cover along the river and on sand bars. Above Ross dam is Ross Lake which falls completely within the boundaries of North Cascades National Park, and therefore its shores also consists of conifer dominated forest. From Sedro Woolley to Marblemount the riparian area alternates from patches of agriculture and small towns with narrow strips of trees along the river bank to larger patches of primarily deciduous forests typical of the lowland floodplain. Deciduous trees, such as black cottonwood and big leaf maple, and shrub habitat, such as willows and salmonberry, are more prevalent in these disturbed areas of the riparian zone where the gradient is lower and coniferous stands increase as disturbance decreases and the gradient is higher. Agriculture and small towns become less common in this stretch with increasing river mile. The three major tributaries of the Upper Skagit River, the Baker River (including Lake Shannon and Baker Lake), the Sauk River, and the Cascade River, also have riparian areas that are lined with deciduous tree and shrub riparian zones.

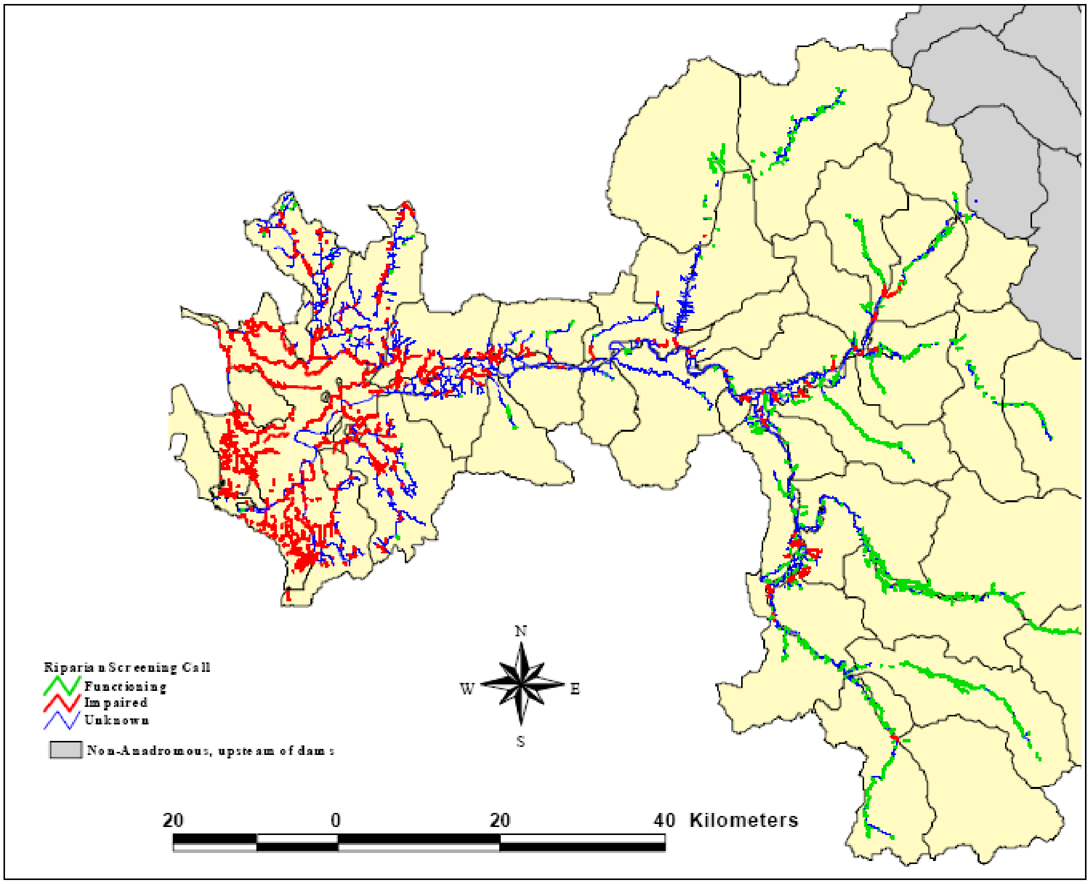

Figure 2. Riparian buffer widths are likely impaired or functioning; based on Landsat data (Lunetta et al. 1997 *in* Beamer et al. 2000).

c. Estuary and Salt Marsh Vegetation

The Skagit River delta was originally a very large salt marsh/tidal wetland complex covering over 50 square miles (Dean et al. 2000). By the late 1800s dikes were being constructed throughout the delta to drain the lowlands for agriculture. Today, little remains of this vast tidal habitat. The remaining salt marsh vegetation is typical of that found in the Puget Sound region. Areas regularly inundated with salt water are dominated by salt grass, pickleweed, gumweed, jaumea, and arrow grass. Regions higher up on the beach more brackish in nature are dominated by tufted hair grass, dune grass and sedges.

Eelgrass and kelp dominate the shallow sub-tidal zone and provide countless cultural and ecosystem values; including providing habitat for hundreds of species of invertebrates, shelter and refugia for dozens of fish and commercial invertebrate species, including juvenile salmon, and providing an enormous amount of primary production in nearshore waters (Mumford 2007). Of special note in the delta is the expansive, high-density eelgrass meadow (9,500 acres) within Padilla Bay, the largest contiguous eelgrass meadow in the State of Washington, and one of the largest on the west coast (Bulthuis et al. 2006).

d. Large Woody Debris

In the upper reach, there is no transport of large woody debris (LWD) from above the dams by either natural or human processes. LWD is common in the middle reach (RM 78 – RM 19) (Pentec 2002). LWD exists along the middle reach shoreline, both in water and as recruitable trees. Concentrations of LWD can be found at the upstream end of islands, such as those at RM's 35 and 58, or the entrance to side channels, such as at RM 64. Assessment of LWD in the lower Skagit River indicates that there is a lack of large wood in the system (Collins 2000). While LWD is generated in large quantities in the upper basin, there are few areas in the lower reach (RM 19 – RM 8) where the LWD can become anchored to the bank due to the predominance of smooth banks (riprap) and removal of LWD through flood fight effort. There are some localized areas, such as Freshwater Slough, where LWD collects.

e. Off-Channel Habitat

Many beaver ponds, side channels, and sloughs once used by salmon have been disconnected from the main river channel as a result of diking and other agricultural practices and bank revetments. In the last century, the lower Skagit basin has lost approximately 45 percent of the historic side slough habitat (424,200 m^2) that provided critical rearing and refuge functions in the floodplain (Beechie et al. 1994). The Skagit basin has lost approximately 72 percent of historic estuarine delta habitat, including a loss of 68 percent of estuarine emergent habitat, 66 percent of transitional estuarine forested habitat, and 84 percent of riverine tidal habitat (Beamer et al. 2002, Collins and Montgomery 2001). The Skagit delta has lost approximately 75 percent of its distributary channel habitat (Beechie et al. 2001). A reduction in the number of side channels and sloughs, changes and reductions in the quality of riparian vegetation, and a reduction in the number of high quality stream channel pools significantly reduced the amount of available refugia for juvenile salmonids.

In general, off-channel habitat becomes scarce further up into the watershed due to increases in the slope of the valley walls and increased gradient. Upstream of the town of Concrete, there is a braided section of river before the river morphology transitions almost solely to primary channel extending up to Diablo, Gorges, and Ross dams. Sections of braided channel and secondary off channel habitat are present between the towns of Concrete and Sedro Woolley, with increasing occurrence as the river progresses downstream. Over the last century the Skagit River has lost a large proportion of it's off channel habitat due to the diking of the river and land use practices, most of this loss has been in the lower Skagit Basin in the floodplain and delta area (Beamer et. al. 2002, Beechie 1994, Collins and Sheikh 2002). However, agriculture does occur along the banks of the Skagit River above Sedro Woolley and it is likely that some off channel habitat has been lost as a result.

2. Wildlife

Large mammals found in the Upper Skagit Basin include elk, black-tailed deer, black bear, mountain lion, coyote, mountain goat, and wolverine. Federally listed grizzly bear, gray wolf, and Canada lynx are also known to inhabit the area (see "Threatened and Endangered Species" for more details). Other mammal species such as river otter, beaver, raccoon, American marten, mink, and the occasional harbor seal also utilize the Upper Skagit basin. Common small mammals are Townsend chipmunks, trowbridge shrew, deer mouse, snowshoe hare, Douglas squirrel, and a variety of bats.

There are numerous species of birds that use the Skagit Basin as either over-wintering grounds or as permanent residents which are composed of raptors, waterfowl, shorebirds, game birds, and songbirds. A subset of these birds include snow geese, common mergansers, buffleheads, trumpeter swans, belted kingfishers, great blue herons, double crested cormorants, ring-billed gulls, ruffed grouse, osprey, golden and bald eagles, many species of owls, and at least 87 species of song birds. Federally listed marbled murrelets and northern spotted owls also utilize the forests of the Upper Skagit (see "Threatened and Endangered Species" for more details).

A large population of bald eagles over winters along the upper Skagit River, making up one of the two largest seasonal concentrations of bald eagles in the lower 48 states. In general, the bald eagle wintering season extends peaks along the Skagit from mid December to late January. The eagles are drawn to the area by the large numbers of spawned out salmon in the upper Skagit watershed. Up to 579 eagles were counted in the upper Skagit River area (Skagit River Bald Eagle Awareness Team 2006). Most of the area eagles are migrants; however, resident bald eagles do occur in the areas. Bald eagle nesting typically occurs between early January and mid-August.

Reptile and amphibian species in the Upper Skagit basin include western terrestrial garter snake, common garter snake, northern alligator lizard, Cascade frog, Oregon spotted frog (a Federal species of concern), northern red legged frog, Pacific chorus frog, tailed frog, western toad, northwestern salamander, and northern rough-skinned newt.

The Skagit River Delta area is considered critical wildlife habitat, particularly outstanding as a waterfowl wintering area due to mild climate and good habitats, such as expansive freshwater marshes, saltwater marshes, and intertidal flats. Dikes along its numerous sloughs have created upland areas for agriculture. In these areas, such as the Skagit Wildlife Recreation Area between Tom Moore Slough, Freshwater Slough, and the Hayton Reserve, crops are produced which are beneficial to waterfowl and other wildlife. Few winter residents breed in the project area (in spring most leave for breeding areas further north). Wintering waterfowl common along the area sloughs in Skagit Bay and upland on farms during the peak months of October and November include ducks, geese, and swans. Dabbling ducks, such as mallard, pintail, American widgeon, and green-winged teal, are numerous, and utilize estuarine and agricultural areas.

Snow geese are present in the fall and winter months in the Skagit Delta. In past years, up to 50,000 have wintered in Skagit Flats. Swans (mainly trumpeters, but also more than a thousand tundras) visit the Skagit Estuary, feeding mainly on vegetation in shallows and agricultural fields. The trumpeter swan, once an endangered species, has increased in numbers in Skagit County from a 1963 population of 20 to several thousand today. The major wintering roosting area for this species is the Nookachamps Creek drainage (DeBays Slough and Judy Reservoir).

Freshwater riparian habitat is important for waterfowl. The numerous sloughs adjacent to Skagit Bay are highly productive for mallards and wood ducks. Moore Slough, near Milltown, provides productive habitat for waterfowl.

Wading birds, such as great blue heron, utilize the estuary areas year round. Shorebirds use flooded agricultural fields and estuaries mainly during migration and in winter. Mainly dunlin and black bellied plover winter in the Skagit delta. Several species of birds of prey are found in the project area including bald eagle, red-tailed hawk, rough-legged hawk (winter only), Northern harrier, gyrfalcon (winter only), peregrine falcon, merlin, Coopers hawk, sharp-shinned hawk, and osprey. The Skagit Delta provides habitat for one of the largest wintering populations of raptors in the contiguous United States.

Large upland mammals, such as black tailed deer, can be found on Hart Island and are occasional visitors to the estuary, although this type of habitat is not favored by this species. The abundance of small mammals in the Skagit Delta accounts for the presence of raptors in the area. Semi aquatic mammals such as muskrat, mink, and beaver inhabit the sloughs. In addition, nutria, large, destructive, semi-aquatic, non-native rodents are confirmed present in the Skagit Valley. Nutria cause severe damage to native wildlife habitat and dikes due to their indiscriminate consumption of vegetation and burrowing techniques.

A large population of bald eagles over winters along the upper Skagit River, making up one of the two largest seasonal concentrations of bald eagles in the lower 48 states. In general, the bald eagle wintering season peaks along the Skagit from mid December to late January. The eagles are drawn to the area by the large numbers of spawned out salmon in the upper Skagit watershed. Up to 579 eagles were counted in the upper Skagit River area (Skagit River Bald Eagle Awareness Team 2006). Most of the area eagles are migrants; however, resident bald eagles do occur in the areas. Bald eagle nesting typically occurs between early January and mid-August.

Reptile and amphibian species in the Lower Skagit basin include northwestern garter snake, western terrestrial garter snake, common garter snake, northern alligator lizard, northern red legged frog, bullfrog, Pacific tree frog western toad, long-toed salamander, northwestern salamander, and northern rough-skinned newt.

3. Fish

The Skagit River and the Skagit Estuary are critically important to all five species of Pacific salmon as well as steelhead and sea-run cutthroat (Table 1). There are numerous runs that utilize both the mainstem Skagit and several of its tributaries, most of which spawn in the reaches above Sedro Woolley. The Skagit River and its tributaries also host the largest population of Puget Sound bull trout in Puget Sound Basin (Conner, Seattle City Light, pers. comm.). The lower reaches of the Skagit River serve as a transportation route for spawning adults and provides rearing environment for juvenile anadromous species during their outmigration to the sea, while the upper reaches of the Skagit River from Sedro Woolley up to Gorges dam, the Sauk River, the Cascade River, Lake Shannon and Lake Baker along with other upper tributaries compromise the majority of the spawning habitat. In these more natural upper sections of the river, suitable habitat features are still available for spawning and rearing, however the historic loss of tidal wetland and channel habitat has been identified as one of the most significant limiting factors in the recovery of Skagit Chinook (SWC 2005; WCC 2003). Research by the Skagit River System Cooperative and others has shown that the reduced amount of estuarine habitat is likely limiting the production of Chinook (Beamer et al. 2003, Beamer et al. 2002, Beamer et al. 2000, Congleton et al. 1981). Today, less than 27 percent of estuarine habitat remains (WCC 2003), with the greatest loss being in riverine tidal habitat (less than 16 percent remaining). Most of the historic estuarine habitat was lost after diking isolated the habitat from riverine and tidal processes

Resident fish species found in the Skagit river system include rainbow trout, Kokanee, mountain whitefish, Salish and largescale suckers, three-spine sticklebacks, brown trout, brook tout, lake trout, western brook lamprey, and torrent, prickly, and coastrange sculpin. Very little spawning occurs in the lower reaches of the Skagit River, although documented pink and mainstem steelhead and Chinook spawning areas fall within the lower portions of the watershed (WDFW and WWTIT 2003 draft). Spawning does occur in the Carpenter and Fisher Creek drainages and in Nookachamps Creek. In the more natural upper sections of the river, suitable habitat features are available for spawning and rearing. Sieler et al. (1999) found that egg-to-migrant survival rates were dependent on flow.

In 1992, six populations of steelhead were described in the Skagit Basin: three populations of winter steelhead and three populations of summer steelhead. All of the winter steelhead populations are listed as being native origin with wild production. The winter steelhead population declined from a healthy status in the 1992 Washington State Salmon and Steelhead Stock Inventory (SASSI), to a depressed status in the 2003 Salmonid Stock Inventory (SaSI) Spatial Dataset (WDFW and WWTIT 1994, WDFW and WWTIT 2003 draft).

Table 1. Summary of Salmon Data for WRIAs 3 and 4 (WDFW and WWTIT, 2003 draft; SWC 2005)

Stock	Origin	Production Type	Stock Status
CHINOOK			
Samish/MS Nooksack	Non-native	Composite	Unknown
Upper Skagit Mainstem/Tribs	Native	Wild	Depressed
Lower Sauk	Native	Wild	Depressed
Upper Sauk	Native	Wild	Depressed
Suiattle	Native	Wild	Healthy
Upper Cascade	Native	Wild	Depressed
COHO			
Samish	Mixed	Wild	Healthy
Skagit	Native	Composite	Healthy
Baker	Mixed	Composite	Healthy
CHUM-FALL			
Mainstem Skagit	Native	Wild	Healthy
Sauk	Native	Wild	Healthy
Samish/Indpendent	Mixed	Composite	Healthy
PINK			
Skagit	Native	Wild	Healthy
SOCKEYE			
Baker	Native	Cultured	Healthy
STEELHEAD-SUMMER			
Finney Creek	Native	Wild	Unknown
Sauk	Native	Wild	Unknown
Cascade	Unknown	Wild	Unknown
STEELHEAD-WINTER			
Samish	Native	Wild	Healthy
Mainstem Skagit	Native	Wild	Depressed
Sauk	Native	Wild	Unknown
Cascade	Native	Wild	Unknown

4. Invertebrate Communities

According to Plotnikoff (1992), benthic invertebrate communities typical of rivers in the Cascade regions are dominated by stonefly and mayfly larvae, with very limited representation by other taxa. These Cascade invertebrate assemblages are characterized as scraper-collector-gatherer communities.

Communities typical of rivers in the Puget Sound lowlands are dominated by stonefly, caddisfly, and common midge, mosquito, and blackfly larvae. Other taxa present include beetle larvae, amphipods, and aquatic isopods. These lowland invertebrate assemblages are characterized as shredder-gatherer communities.

Invertebrates found in the estuary and salt marsh area include oligocheate and polycheate worms, fly larvae, and crustaceans such as aquatic isopods, amphipods, and copepods (Cordell et al. 1998). Bays and salt marshes of Puget Sound are home to a variety of bivalves (including clams, cockles, and mussels), snails, anemones, and crustaceans such as shrimp, crab, and aquatic isopods. Numerous invertebrate taxa (both micro and macroscopic) including hydroids, jellyfish, snails, nudibrachs, sea stars, sea cucumbers, copopods, isopods and crabs are dependent on the shallow eelgrass beds found in Skagit and Padilla bays (Kozloff 1983).

5. Threatened and Endangered Species

Numerous species of plant, fish and wildlife species occur in the Skagit Basin including several threatened and endangered species that have the potential to occur in the project areas (Table 2).

Table 2. Listed Species

SPECIES	SCIENTIFIC NAME	STATUS	CRITICAL HABITAT
Puget Sound Chinook Salmon	*Oncorhynchus tshawytscha*	Threatened	Designated-Skagit River
Coastal/Puget Sound Bull Trout	*Salvelinus confluentus*	Threatened	Designated-Skagit River
Puget Sound Steelhead	*Oncorhynchus mykiss*	Threatened	No Designation
Marbled Murrelet	*Brachyramphus marmoratus*	Threatened	Designated-Upper Skagit Basin
Northern Spotted Owl	*Strix occidentalis*	Threatened	Designated-Upper Skagit Basin
Grizzly Bear	*Ursus arctos*	Threatened	No Designation
Gray Wolf	*Canis lupus*	Endangered	No Designation
Canada Lynx	*Lynx canadensis*	Threatened	Designated-not in Skagit Co.

a. Puget Sound Chinook Salmon

Six stocks of Puget Sound Chinook Salmon occur in the upper Skagit most of which are ocean type. The lower Skagit Chinook population was classified as depressed in both the 1992 SASSI and the 2002 SaSI. Spawning occurs from early September to mid-November (WDFW and WWTIT 1994, WDFW and WWTIT 2003 draft). The lower Skagit Chinook spawns in the mainstem Skagit River and in tributaries downstream of the Sauk River confluence; most of the spawning occurs in the mainstem Skagit River between Sedro-Woolley and the Sauk River (WDFW and WWTIT 2003 draft). Upper Skagit Chinook spawn in the mainstem Skagit River and in tributaries upstream of the Sauk confluence up to Newhalem. The upper Skagit stock status went from healthy in 1992 to depressed in 2002. Spawning occurs mid-August through October. The lower Sauk Chinook population spawns in the Sauk River from the mouth upstream to the Darrington Bridge (RM 21.2). Its status was classified as depressed in both the 1992 and 2002 population inventories (WDFW and WWTIT 1994, WDFW and WWTIT 2003 draft). The lower Sauk population spawns earlier, beginning in late August and continuing to early October, than the mainstem Skagit populations. Upper Sauk Chinook spawn upstream of the Darrington Bridge and into the North and South Forks of the Sauk River. The status changed from healthy in 1992, to depressed in 2003 (WDFW and WWTIT 1994, WDFW and WWTIT 2003 draft). Spawning occurs from late July through early September. Suiattle Chinook have the same early spawn timing as upper Sauk Chinook. The Suiattle population spawns in the mainstem Suiattle River and in the

Big, Tenas, Straight, Circle, Buck, Lime, Downey, Sulphur, and Milk Creeks. Its population status changed from depressed in 1992, to healthy in 2003. Upper Cascade Chinook spawn in the mainstem Cascade River above RM 7.8, in the lower reaches of the North and South Forks of the Cascade River, and in Marble, Found, Kindy, and Sonny Boy Creeks. Its population status changed from unknown in 1992, to depressed in 2003. Spawning occurs from late July through early September.

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Critical habitat has been designated for the entire Lower Skagit and Upper Skagit River. Critical habitat primary constituent elements (PCEs) include freshwater spawning sites, freshwater rearing sites, and freshwater migration corridors. Additional PCEs were developed for estuarine and marine habitats.

The Skagit River System Cooperative (SRSC) and Washington Department of Fish and Wildlife (WDFW) developed the Skagit Chinook Recovery Plan to aid in the recovery of the six stocks of Puget Sound Chinook in the Skagit basin (2005). The general approach to restoration is to restore all the habitat types Chinook use throughout their life. Habitat restoration opportunities include: spawning habitat and egg incubation conditions; freshwater rearing habitat in large river floodplain, tributaries, and non-tidal delta; tidal delta rearing habitat; and nearshore rearing habitat. A number of projects identified in this recovery plan have been implemented or proposed in all various habitat types. (SRSC and WDFW 2005).

b. Coastal/Puget Sound Bull Trout

The Skagit River supports the largest natural population of bull trout/Dolly Varden in Puget Sound. Of this population, lower Skagit bull trout were identified as a distinct stock based on their geographic location; an area which includes all of the Skagit River and its tributaries located below the Gorge Dam, excluding the Baker River (WDFW 1998). Anadromous, fluvial, adfluvial, and resident life history forms are all found in the Skagit River system, at times spawning at the same time and place. Spawning usually takes place during September and October, and occurs in upriver areas that are less than 8°C (WDFW 1998). Bull trout are apex predators that locate where prey is abundant. Bull trout will also follow prey around, such as migrating juvenile salmon.

Based on sampling by the Skagit River System Cooperative (Beamer and Henderson 2004), bull trout were found to use delta blind tidal channels, but did not directly use smaller and shallower channels, or channels more distant from river distributaries. Trends in annual abundance remained constant. The presence of bull trout varies significantly throughout the year, with the primary period from April through August, with a peak in June. Bull trout in the Skagit are known to migrate to both Puget Sound and other river systems, including the Stillaguamish and Snohomish, in search of food; although the majority of these migrants return to the Skagit to spawn (Geotz, F., pers. comm. 2008).

Bull trout are also present in Skagit Bay; however, their presence in shallow intertidal habitat was very low compared to the deeper intertidal-subtidal fringe. Bull trout are present in the deeper intertidal-subtidal habitats year round. Peak abundance in the bay occurs in May or June, with recent data showing a second peak in fall.

Critical habitat was designated for the entire Lower Skagit and Upper Skagit River to the portions of Ross Lake and its tributaries that lie within the boundaries of the United States. Critical habitat PCEs determined essential to the conservation of bull trout include water temperatures between 36°F and 59°F, complex stream channels, appropriate substrate for spawning and rearing success, a natural hydrograph, sufficient water quality and quantity including subsurface connectivity, migratory corridors, abundant food base, and lack of nonnative predatory or competitive species.

There is a draft recovery plan for Coastal-Puget Sound Distinct Population Segment of Bull Trout (USFWS 2004). The USFWS' stated goal for bull trout in the bull trout recovery plan is as follows: "To ensure the long-term persistence of self-sustaining, complex interacting groups of bull trout distributed across the Coastal-Puget Sound Distinct Population Segment, so that the species can be delisted." (2004) Since many of the actions to recover Chinook are also expected to help Coastal/Puget Sound bull trout, the Puget Sound Salmon Recovery Plan also supports bull trout recovery (NMFS 2007). Both the bull trout and salmon recovery plans advocates taking an ecosystem approach to recovery. The completed and proposed projects for Chinook in the Skagit River basin are expected to benefit bull trout as well.

c. Puget Sound Steelhead

All six stocks of Skagit River steelhead (3 summer and 3 winter) utilize and transit the project area. All but one of these stocks are native, and considered to be distinct based on geographic separation. Steelhead in the Skagit River system spawn in both the mainstem and tributaries from the anadromous zones to the headwaters. Skagit mainstem winter steelhead spawning takes place in the mainstem Skagit from just above Mount Vernon up to Gorges Dam and all the major tributaries in between including the Nookachamps, Sauk and Cascade Rivers, and Lake Shannon and Baker Lake. Spawning occurs from early March to early June. Mainstem Skagit winter steelhead stock status has gone from healthy in 1992 to depressed in 2002 (WDFW and WWTIT 1994; WDFW and WWTIT 2003 draft). Finney Creek summer steelhead are thought to spawn in Finney Creek up to the falls at river mile 11.7, however, precise location are unknown. Spawn timing and stock status are also unknown. Sauk summer run steelhead spawn in the North Fork and South Fork of the Sauk River to just below the forks. Spawning occurs from mid-April to early June, and stock status in unknown. Sauk winter run steelhead takes place in the Sauk, Suiattle, and Whitechuck rivers and their tributaries. Spawn time occurs from mid-March to mid-July and the stock status in unknown Although, there is some fishing pressure on wild steelhead stocks the majority lies on hatchery fish that are planted in the river annually. Cascade summer run steelhead is thought to take place in the upper reaches of the Cascade River and its forks, however exact location are unknown. Spawning occurs from mid-January to early May, and stock status is unknown. Cascade winter run steelhead spawning locations are unknown, as is the spawning time (although it is thought to occur in early March through late June. The stock status is also unknown (WDFW and WWTIT 1994; WDFW and WWTIT 2003 draft). Although there is some fishing pressure on wild stocks of Skagit River steelhead the majority lies on hatchery stocked fish. Critical habitat has not yet been designated for Puget Sound Steelhead. Summer steelhead run through the Skagit system from May to October, and winter steelhead run from November to April. Although there is some fishing pressure on wild steelhead in the Skagit River system, the majority lies on hatchery fish that are planted in the river annually. Of the six wild stocks of steelhead in the Skagit system five of them have an unknown stock status. The remaining stock is the winter run of the mainstem Skagit River and has gone from healthy in 1992 to depressed in 2003 (WDFW and WWTIT 2003 draft). Critical habitat has not yet been designated for Puget Sound steelhead. Currently, there is no recovery plan for Puget Sound steelhead.

d. Marbled Murrelet

Murrelets inhabit shallow marine waters and nest in mature old-growth forests. Critical habitat has been designated to include upland forested stands containing large trees (greater than 32 inches) in diameter with potential platforms for nesting (greater than 33 feet) and the surrounding forested areas within 0.5 mile of these stands with a canopy height of at least 1/2 the site-potential height (USFWS 1996). All nest locations in Washington have been located in old-growth trees that were greater than 32 inches in diameter at breast height (dbh) (Ralph et al. 1995). Nest stand characteristics generally include a second story of the forest canopy that reaches or exceeds the height of the nest limb, thereby providing a protective enclosure surrounding the nest site. A single, large, closed-crowned tree, which provides its own protective cover over the nest site may also be used by murrelets (Ralph et al. 1995). Large, moss-covered limbs (greater than 7 inches diameter) in tall trees are utilized for egg-laying. Marbled murrelet nests have been located in stands as small as approximately seven acres (Hamer and Nelson 1995) and are generally within 50 miles of marine waters. In Washington, marbled murrelet abundance was found to be highest in areas where old-growth/mature forest comprised more than 30 percent of the landscape. Murrelet nesting habitat is characteristic of the forested mountain landscape in the upper Skagit basin. US Forest Service surveys indicate that the northern half of the Mount Baker-Snoqualmie National Forest accounts for 50 percent of the nesting habitat and 85 percent of the detections in the entire forest (USFS 2002). Numerous confirmed occurrences of marbled murrelets have occurred over the past two decades in both Whatcom and Skagit counties (WDFW 2008). Critical habitat for the marbled murrelet has been designated throughout the Upper Skagit basin (USFWS 1996). On July 31, 2008, USFWS proposed a revision to critical habitat designation, based on new information; however even if adopted, the revised critical habitat designation does not affect designated critical habitat in the State of Washington (2009). The recovery plan for marbled murrelet was developed in 1997 and a number of recovery actions such as additional research and creation of conservation zones have been implemented (USFWS 1997).

e. Spotted Owl

Spotted owls can be found throughout the west slope of the Washington Cascades below elevations of 4,200 feet. Preferred owl habitat is composed of closed-canopy coniferous forests with multi-layered, multi-species canopies dominated by mature and/or old-growth trees (USFWS 2008). Habitat characteristics include moderate to high canopy closure (60-80 percent); large (greater than 30” dbh) overstory trees; substantial amounts of standing snags, in-stand decadence, and coarse woody debris of various sizes and decay classes scattered on the forest floor (Gore et al. 1987, Thomas et al. 1990). Critical habitat is characterized as large continuous blocks of coniferous/mixed-hardwood forests that contained one or more of the primary constituent elements (primarily nesting and roosting, but also foraging and dispersal). It is usually equivalent to structures of Douglas fir stands 80 or more years of age (USFWS 2008). Designated critical habitat for the northern spotted owl is found throughout the upper Skagit basin (USFWS 2008). Numerous confirmed occurrences of the spotted owl over the past two decades are documented in both Whatcom and Skagit counties (WDFW 2008).

The USFWS is developing the 2010 draft revised Recovery Plan for the Northern Spotted Owl (2010). Currently, the most wide-range threats to the spotted owl are the competition with barred owls, continuous loss of suitable habitat, and loss of amount and distribution of suitable habitat as a result of past activities. Thus, recovery actions for spotted owl include range-wide habitat modeling, habitat and active forest management, barred owl management, and continued research and monitoring. (USFWS 2010)

f. Grizzly Bear

Estimates according to Ingles (1974), were approximately ten grizzlies in Washington State with these few remaining in remote areas of the North Cascades. WDFW priority habitat lists both Whatcom and Skagit (both of which encompass the upper Skagit basin) along with all their neighboring habitats as potential grizzly bear habitat (WDFW 2008). Recent estimates of grizzly bear population in the North Cascades range from 12 to 50 individuals (Almack et al. 1993, MacCracken and O'Laughlin 1998). According to the National Park Service approximately 10 - 20 grizzly bears live within Washington's North Cascades Grizzly Bear Recovery Area, *roughly* defined as the area between Interstate 90 in the south, up the Columbia and Okanogan Rivers on the east to the international boundary; then back south generally along the Mount Baker-Snoqualmie National Forest's western boundary (which is the western portion of both Skagit and Whatcom counties beginning just east of the towns of Lyman and Glacier). All five of the major dams on the Skagit River system fall within this recovery area. In British Columbia's North Cascades Grizzly Bear Population Unit (bounded by the Trans-Canada Highway, Highways 8, 5A and 3 and the international border), the minimum population estimate is 17 grizzly bears (NPS 2008a). However, it is difficult to get exact estimates of grizzly bears as their territories can be several hundred square miles and their behavior is secretive. A study using DNA analysis of fur snags via barbed wire and scent lures showed only one grizzly present at the snag sites over the course of three years in the North Cascades and suggested that natural recovery seemed unlikely (Romain-Bondi et al. 2004).

Grizzly bear sightings in the North Cascades Ecosystem are classified as categories 1-4, with class 1 being the most reliable (verified by a biologist, photograph, and/or carcass) and 4 being the least (a sighting initially reported as a grizzly but later confirmed to be another species). Between 1983 and 1991, there were 20 Class 1 sightings, 82 Class 2 sightings, and 102 Class 3 sightings. In 1996, a bear biologist saw a grizzly bear on the south side of Glacier Peak in the Glacier Peak Wilderness Area. This is the last recorded Class 1 observation (Grizzly Bear Outreach Project 2008). According to the WDFW priority habitat database confirmed grizzly bear occurrences have been reported numerous times around Ross Lake in the 1970's, 80's, and 90's. They have also been occurrences at Diablo Dam in 1983, 1987, 1992, and 1993. The database also reports single confirmed occurrences near the North Fork Sauk River, the Cascade River, Bacon Creek west of Baker Lake, and Ruby Creek near the Okanogan County border (WDFW 2008).

The grizzly bear recovery plan has been developed by the USFWS outlining the goals and implementation of actions necessary to recover the species (USFWS 1993). Current efforts towards recovery are focusing on habitat protection through a strategy of no net loss of core habitat, information and education efforts, and enhanced sanitation for proper garbage and food storage in bear habitat (USFWS 2010a).

g. Gray Wolf

According to Ingles, 1974, the gray wolf is present in a small area in the North cascades, although rare, and in hard, cold winters they may come down to lower elevations for food. The northern part of the Upper Skagit Basin falls within this distribution. Washington Department of Fish and Wildlife also confirm the presence of wolves in the North Cascades. They are regularly sighted in southern British Columbia just north of

North Cascades National Park. WDFW lists both Whatcom and Skagit County (both of which encompass the Upper Skagit watershed) along with all their neighboring counties as priority habitat for wolves (WDFW 2008). The data base indicates many occurrences of gray wolves over the last two decades, many of which were within close proximity of Ross Lake. In 1991, wolves with pups were observed near Hozomeen at the north end of Ross Lake. Other confirmed occurrences in the watershed include Baker Lake in 1984 and 1992, the Sauk River in 1992, Suiattle River in 1989, and the mainstem Skagit near Briar and Copper Creeks in 1988 and 1992, respectively (WDFW 2008). Locations of other sightings in the North Cascades include McAlester Pass, Pasayten Wilderness and Twisp River drainage of the Okanogan National Forest, Glacier Peak Wilderness, and Stevens Pass (NPS 2008b). A more recent sighting of a gray wolf pair and pups, and howling surveys in July of 2008 have verified their presence in western Okanogon County just adjacent to Skagit and Whatcom counties (WDFW 2008).

USFWS has developed a recovery plan for the northern rocky mountain wolf which applies to mainly the states of Idaho, Montana, Wyoming, and Colorado (1987). This recovery plan does not appear to include the State of Washington; though the historical distribution of the wolf included eastern portion of Washington (1987). Ongoing research and monitoring, and public education efforts are occurring in the North Cascades in Washington to assist in recovery actions (USFWS 2009a).

h. Canada Lynx

Lynx require dry forests where lodgepole pine is the dominant tree species. These areas are more typical of the east slopes of the Cascades. Lynx are rarely found below elevations of 4,000 feet, which is well above the elevations of the five major dams in the Upper Skagit Basin. In 2001, the population of lynx in Washington State was estimated at fewer than 100 individuals (Stinson 2001). A small population of lynx inhabits the Pasayten Wilderness east of Ross Lake in the Okanogan National Forest (NPS 2007). Critical habitat for Canada Lynx has been designated on the eastern slopes of the Cascades in Okanogan County- just east of Skagit and Whatcom counties (USFWS 2006). On February 25, 2009, USFWS published the final rule for the revised designation critical habitat for Canada Lynx; this rule does not change the critical habitat designation for the State of Washington (2009b). However, the WDFW priority habitat and species list includes both Whatcom and Skagit counties as priority habitat for Lynx and there are several confirmed occurrences most of which are along the eastern most portions of the two counties along the Okanogan County border. In 2000 there were confirmed lynx occurrences on the west slopes of the cascades near Devils Dome and Buckskin Ridge just four miles and seven miles east of Ross Lake, respectively (WDFW 2008). Numerous anecdotal reports of lynx have occurred around Baker Lake and Mount Baker (USFWS 2001). To date, there is no recovery plan for the lynx. USFWS has developed a recovery outline which services as an interim strategy to guide recovery effects (2005).

6. Wetlands and Other Waters of the U.S.

National Wetland Inventory (NWI) maps identify many wetlands adjacent to the Upper Skagit River and at the confluences of tributaries (Sauk and Cascade Rivers and smaller creeks), as is to be expected. Primarily these wetlands are mapped as palustrine emergent (PEM), scrub-shrub (PSS) or forested (PFO) wetlands depending on location. In addition, pockets of wetlands are mapped in the surrounding landscape (away from the river) throughout the upper basin. Of particular note is a large complex which extends from south of Minkler (near Ross and Skiyou Islands) to south of Lyman to Hamilton. Additionally, in the areas south of Rockport to Marblemount and around the Sauk confluence a large wetland complex is identified, composed of remnant meanders and channels. Upstream of Marblemount fewer wetlands are mapped, whether this is a function of steeper terrain resulting in formation of fewer hydrologic processes leading to wetland formation or simply lack of wetland determination/delineation data is unknown. Those wetlands that are mapped upstream of Marblemount are primarily adjacent to lakes or streams which flow into Ross or Diablo Lakes, in particular Big Beaver and Goodell Creek (USFWS 2006a).

In general, NWI maps were drawn using aerial photo analysis of vegetation patterns, visible hydrology and geographic position. Due to limitations of this type of aerial photo interpretation inaccuracies are common – often wetlands exist in areas not identified by NWI maps. This is particularly common in areas where human disturbance (agricultural practices or development) dominate the landscape, in the Upper Skagit this would be around the towns of Sedro Woolley, Lyman, Hamilton, Concrete, Rockport and Marblemount. In light of these possible errors, field verification of NWI maps is required to accurately identify wetlands throughout the Upper Skagit basin since no other region-wide wetland inventory has been conducted to date.

The historic extent of vegetated tidal wetlands for the Skagit was approximately 25,766 acres, and the current extent is 1,941 acres, indicating the Skagit delta has lost approximately 23,825 acres of estuary habitat — more than 37 square miles, or 93 percent of historic coverage (White et al. undated).

National Wetland Inventory (NWI) maps identify pockets of wetland areas on both sides of the dikes in the Skagit delta. However, the majority of lowlands in the delta exhibit wetland characteristics. In most cases, the intensive agricultural practices, including the construction of dozens of levees and dikes, have caused these lands to be effectively drained and thus would be designated as prior converted cropland (Kilcoyne, pers. comm., 2006). In general, NWI maps were drawn using aerial photo analysis of vegetation patterns, visible hydrology and geographic position. Due to limitations of this type of aerial photo interpretation inaccuracies are common – often wetlands exist in areas not identified by NWI maps. This is particularly common in areas where human disturbance (agricultural practices or development) dominate the landscape, this would encompass the vast majority of the lower Skagit basin.

A wetland survey of the delta conducted by Shapiro and Associates for the Corps of Engineers in 1978 identified 3,450 acres of estuarine wetland, 120 acres of riverine wetland, and 3,150 acres of palustrine wetlands adjacent to the Skagit River in the delta. This study did not attempt to identify wetlands that were converted to agricultural uses. Beyond the sea dikes at Fir Island is a large expanse (~2,500 acres) of vegetated wetlands (Shapiro 1978).

In light of the possible errors of NWI maps, the radical development changes that have occurred in the lower Skagit since the 1978 wetland inventory, and changes in wetland regulation, it is suggested a new inventory be conducted to establish more accurate wetland data in the lower basin.

Beyond the vegetated wetlands on Fir Island, are approximately 6,600 acres of eelgrass beds (Hood, G., pers. comm., 2008) and approximately 10,000 acres of unvegetated intertidal flats. Padilla Bay lies to the north of the project area. In historic times, floodwaters from the Skagit reached Padilla Bay on a regular basis; however, dikes constructed along the river now prevent Skagit River flows from reaching the bay. This change results in sedentary conditions within the bay, causing an increase in size of eelgrass beds. Padilla Bay now has approximately 8,000 acres of eelgrass, making it one of the largest eelgrass concentrations on the west coast of North America.

C. Water Resources

1. Water Quantity

a. Flood Characteristics

Because of its geographic location, the Skagit River Basin is subject to winter rain floods and annual high water due to snowmelt runoff during the spring or early summer as a result of a seasonal rise in temperatures. The snowmelt is characterized by its relatively slow rise and long duration. High water from snowmelt reached damage flood stage in 1937, 1939, and 1959. During the snowmelts, reservoirs that are used for power fill, frequently reducing the peak discharges. Floods resulting from severe rain events usually occur in November or December, but may occur as early as October or as late as February. In the winter, a light snowpack is frequently formed over most of the basin. A heavy rain fall, accompanied by warm winds, completes the sequence which produces major floods. The heavy rain fall and accompanying snowmelt result in a high rate of runoff, as the ground is already nearly saturated from earlier precipitation.

Runoff patterns were fundamentally altered in many portions of the basin due to urbanization, road building, near-eradication of beaver populations, and timber harvesting. All of these activities tend to change water infiltration and storage within the watershed such that high flows become flashier, and low flow conditions are exacerbated. Widespread logging, particularly in the headwaters, appears to have contributed to more severe effects of rain-on-snow events that have repercussions throughout the channel systems and floodplains of the basin. Many smaller flood events that once scoured the river and inundated the adjacent flood plain no longer occur (Collins 2000).

b. Water Rights

In 2001, the Washington State Department of Ecology (Ecology) adopted an in-stream flow rule for the Skagit River basin that establishes minimum flows for the Skagit River at the Mount Vernon gauge. The minimum flows vary from 10,000 cfs to 13,000 cfs, depending on the time of year. The rule requires all surface water and groundwater users in the Skagit Basin, with a priority date later than the effective rule date, to curtail water use during times of year when the minimum flows are not achieved, unless it can be shown that such diversions or withdrawals do not affect flows in the Skagit River. These minimum flows are commonly not achieved during various times of the year, particularly in late summer and early fall. This rule was appealed in Thurston County Superior Court. As a result of the appeal, Ecology issued two proposed amendments to the rule to address future water needs in the County. An amended rule was adopted in May 2006 calling for the creation of reservations of a limited amount of water for specific future uses that are not subject to the existing in-stream flows and allowing for future withdrawal even when minimum flows are exceeded (WDOE 2006).

2. Water Quality

The Skagit River is designed for aquatic life uses as core summer salmonid habitat (WAC 173-201A-602). This use is characterized by use from June 15 to September for salmonid spawning or emergence, or adult holding; use as important summer rearing habitat by one or more salmonids; or foraging by adult and sub-adult native char. Other common characteristic aquatic life uses for waters in this category include spawning outside of the summer season, rearing, and migration by salmonids. Water quality standards (i.e., temperature, dissolved oxygen, and turbidity) are established based on this aquatic life use designation. In addition, the Skagit River is designated for primary contact recreational uses, all water supply uses, and all miscellaneous uses.

In general the upper reaches of the Skagit meet state water quality standards. There are two areas in the upper Skagit basin that are on the Ecology's 303d list for temperature and fecal coliform (WDOE 2008a).

Currently, areas of the Skagit River are designated as a category 5 for presence of PCBs and high pH and Skagit Bay is listed for fecal coliform. Several sloughs in the delta are designated as category 5 for fecal coliform, pH, dissolved oxygen, and temperature. A category 5 designation means that data show that these water quality standards were violated and there is no total maximum daily load (TMDL) or pollution control plan in place. Category 5 sites become a part of the Washington Department of Ecology's 303d list submitted to the EPA. In addition, several of the tributaries to the Skagit River (including Nookachamps Creek, Carpenter Creek, and Hansen Creek) are on the 303d list for temperature and dissolved oxygen (WDOE 2008).The North Fork, South Fork, and several tributaries of the Skagit River are designated as category 4A for fecal coliform. A designation of 4A means that this water body has a pollution problem that is being addressed by an approved TMDL. The Skagit River is designated as a category 2 for PCBs and 2,3,7,8 TCDD. A designation of category 2 means that data show that these standards are of concern in this water body.

Data collected from Skagit County's 2007 monitoring report indicate that many Skagit County streams, within and outside of the agricultural areas, do not meet state water quality standards for fecal coliform, temperature, and/or dissolved oxygen. Most of the substandard water quality occurs in tributaries to the Skagit River and in the Samish Basin, while the Skagit River itself meets standards on most occasions (Skagit County 2008).

a. Temperature

The maximum temperature criterion for the Skagit, as a designated core summer salmonid habitat, is 16°C (7-day average of the daily maximum temperatures). Mainstem temperatures are within a suitable range for salmonids. However, there are several sloughs in the delta area that are on the 303d list for temperature (WDOE 2008). According to Skagit County's 2007 water quality report most watercourses in the Skagit County Monitoring Program exceeded state temperature standards at some point during the summer (Skagit County 2008).

The Ecology's 2008 303d list (designated as a category 5) includes the mainstem Skagit within WRIA 4 (Upper Skagit) for temperature near river mile 55. Also, Finney and Jackman Creeks were listed as a waters of concern (category 2) for temperature. According to the Skagit County 2007 Water Quality Monitoring Report, 5 out of the 8 sites that were monitored above Sedro Woolley exceeded state standards of a 7 day maximum of 16C, all of these sites are tributaries (Skagit County 2008). The mainstem Skagit monitoring station in this station did not exceed the 7 day maximum.

b. Fecal coliform

Various waste sources affect the quality of the Skagit River. High coliform counts are usually the result of failing on-site sewage systems, municipal wastes, livestock operations, and pets. On occasion wildlife can contribute to elevated levels of fecal coliform (Skagit County 2008). Ecology initiated a water quality study in 1995 as part of the TMDL process, and produced a Cleanup Plan in 2000. The Cleanup Plan concluded that reduction in combined sewer overflows (CSOs) from municipalities in the basin was the single most important needed action (Ecology 2000). Since that time, CSOs have been reduced by at least 90 percent and data collected by Skagit County in 2007 indicates that fecal coliform levels met state standards in the Skagit River (Skagit County 2008). As a result of the TMDL, the lower Skagit River and tributaries have been removed from the 303d list (now called Category 5) for fecal coliform and placed in Category 4b, indicating ongoing TMDL activities. However, there are still areas in Skagit Bay and sloughs in the delta that are on the 2008 are designated as category 5 for fecal coliform (WDOE 2008).

The 2008 Skagit County Monitoring Report indicates that all four Skagit River sites and Swinomish Channel met the state standard for fecal coliform for all four years of the project (2004-2007). However, most of the other sites in the Skagit County Monitoring Program did not meet the standard. There were no sampling sites in Skagit Bay during the course of this study (Skagit County 2008).

The Ecology's 2008 303d list includes Prairie Creek for fecal coliform. Prairie Creek is a tributary of the Sauk River near the town of Darrington. Another tributary, Red Cabin Creek, has been designated as a category 2 (waters of concern). According to the Skagit County 2007 Water Quality Monitoring Plan, 2 out of the 8 sites exceeded state standards for fecal coliform. Both of these sites are tributaries (Skagit County 2008).

c. Dissolved Oxygen

Dissolved oxygen is often affected by both temperature and algal blooms. Algal blooms occur due to increased light and nutrient inputs causing diurnal variation in dissolved oxygen levels. When algal blooms die off decomposition can lead to very low oxygen levels. Increased nutrient inputs are often a result of agricultural practices (Spatharis et al. 2007, Makarewicz et al. 2007, Barlow 2007). Several sloughs in the delta and other tributaries along the Skagit are on Ecology's 303d list (category 5) for 2008. A section of the Skagit River around river mile 55 is designated as a category 2 (waters of concern) for 2008 (WDOE 2008).

According to the Skagit County 2008 monitoring report many streams in the Skagit County Monitoring Program meet oxygen standards all or most of the year. In some of the streams, oxygen levels show steep declines in summer. These declines are usually associated with very low flows. Roughly 25 percent of the sites monitored in the study fell consistently below the state standard over the course of 4 years. However, many of these sites are sloughs and ditches (Skagit County 2008). There are no waters above Sedro Woolley designated as category 5 (303d list) by Ecology for dissolved oxygen, however there are three small tributary creeks, Finney, Suiattle, and Goodell, designated as a category 2 (waters of concern). According to the Skagit County 2007 Water Quality Monitoring Plan, only one of the monitoring sites, which was on a tributary, upstream of Sedro Woolley had an average DO that fell below the state standard of 9.5 mg/L (Skagit County 2008).

d. Sediment/Turbidity

Increased turbidity is a result of logging practices and urban development in the watershed that increases surface runoff. In recent years, sediment inputs have been a significant problem in the watershed with the main contributors being forest practices, agricultural practices, and development and urban runoff from development. Downstream reaches of the Skagit River have been aggrading in recent years (Cherry and Jackson 2002) and changes in river hydraulics and flow has affected sediment transport.

During periods of summer warm temperatures and rain, high turbidity in the Skagit River can be attributed further to a natural condition of "glacial flour". Glacial flour consists of clay-sized particles of rock suspended in the river water, giving the water a cloudy appearance. Heavy turbidity in Skagit Bay is largely due to excessive siltation from the surface water runoff of the Skagit and Samish Rivers that results from flood events and glacial melt.

The Skagit Watershed Council's (SWC) Strategy Application found that 23 percent and 46 percent of the basin is likely impaired in regards to peak flow hydrology and sediment supply, respectively. Numerous sub-basins and tributaries in the lower Skagit have been found to have poor or degraded riparian, peak flow, road density, and sediment supply conditions in both the Conservation Commission's Limiting Factors report and the SWC's Strategy Application (Beamer et al. 2000, WCC 2003). These assessments also found degraded conditions in the Lower Skagit sub-basins, particularly for sediment supply and riparian conditions, but not to the same extent as the Upper Skagit, primarily because of less intense human development and the extensive amount of federally protected land. Large increases in coarse sediment supply tend to fill pools and aggrade channels, resulting in reduced habitat complexity and reduced rearing capacity for some salmonids (Beechie et al. 2003). Large increases in total sediment supply to a channel also tend to increase the proportion of fine sediments in channel beds, which may reduce survival of incubating eggs and change benthic invertebrate production (Beechie et al. 2003). Increased peak flows result in an increased frequency of channel forming and bed mobilizing flow events leading to channel destabilization (widening, aggradation, or incision), less complex habitat, and increased bed scour depths significantly affecting salmonid and other aquatic organisms (SWC 1998). Research shows these impaired watershed processes (sediment supply and peak flow hydrology) are limiting egg to fry survival for Chinook and likely other species (Seiler et al. 1998, Beamer and Pess 1999, Beamer et al. 2000).

There are no 303d listings or category 2 designations for the Upper Skagit Basin by Ecology for turbidity. However, logging practices in the Upper watershed contribute, along with other land use factors, to turbidity both downstream and in Skagit Bay. The SWC's Strategy Application found degraded conditions in the Upper Skagit sub-basins, particularly for sediment supply and riparian conditions, but not to the same extent as the lower Skagit, primarily because of less intense human development and the extensive amount of federally protected land.

e. Chemical Contamination/Nutrients

Non-point source pollution is the primary source of contamination for the lower basin, and results from agricultural practices, onsite sewage disposal, birds, wildlife, development and urban runoff, and livestock waste. Chronic, and in some cases acute levels of total recoverable lead, copper, zinc and cadmium were found at various sites in the lower Skagit Basin. The relatively low levels found could have adverse effects on salmonids. However, the low levels detected cannot necessarily be attributed to anthropogenic sources. The Skagit River is also a category 5 (303d) list for PCB's in fish tissue and ammonia, and a category 2 (area of concern) for 2,3,7,8 TCDD. The Skagit County 2007 Annual Monitoring Report indicates that state exceedences may occur for ammonia on rare occasions.

There are no 303d listings or category 2 designations for chemical contamination (which are mainly pesticides) and/or nutrients by Ecology for the Upper Skagit River or any of its tributaries. However, plots of agricultural land occur along the Upper Skagit River from Sedro Woolley to Marblemount (just upstream of the confluence with the Cascade River) so elevated nutrient loads are likely. The Skagit County 2007 Annual Monitoring Report's most upstream station is just upstream of the town of Hamilton (Skagit County 2008). Values of total nitrogen, total phosphorus, and ammonia are 0.08, 0.02, and 0.02 mg/l respectively, which is quite low in comparison with some of the downstream monitoring sites on the mainstem Skagit and its tributaries and sloughs.

D. Cultural Resources

The Skagit Delta contains important cultural resources associated with the original native use of the region, potentially represented in archaeological sites and traditional cultural properties, as well as historic era settlement patterns expressed primarily as domestic, agricultural, and commercial buildings and structures.

The Delta and adjacent uplands have been used and occupied by human populations for a considerable span of time. Although the exact duration is not known precisely, evidence that supports an estimate of 12,000 years was discovered elsewhere in the Puget Sound region and on the Olympic Peninsula. The oldest cultural resources found in the Skagit Delta area date to less than 5,000 years ago.

Before the 1850s, the Skagit Delta constituted a part of the territory associated with several culturally similar Indian groups. The northern delta was occupied by the Swinomish and Samish. The North Fork and adjacent areas were inhabited by the Lower Skagits. The South Fork was Kikiallu territory. The Upper Skagits resided in the area north and east of Mount Vernon. Euro-American settlement and dislocation of the resident Indian populations did not begin until the late 1850s. The Point Elliot Treaty of 1855 required most of the local Indians to resettle outside the delta on either the Swinomish or Tulalip Reservations.

The first Euro-American homestead along the Skagit River was settled in 1859. In 1863, the first trading post in the delta was opened at the point of divergence between the North and South Forks of the river. Six years later, the post became the site of Skagit City, the earliest river town. As the area's population grew, many additional towns were founded. Today, Mount Vernon, Burlington, and Sedro-Woolley remain as important centers of population and commerce. The early settlers quickly recognized the need for dikes to protect their holdings against the Skagit River's frequent floods. Initially, levees were the responsibility of individual land owners, but the magnitude of the task soon prompted collective action and diking districts were formed in the late 1890s. As the levee system developed, the crests of these structures served as paths and later roads. Private ferries provided cross river transport. The Great Northern Railroad, now the Burlington Northern Santa Fe, was extended to Conway in 1889. Agriculture was initially, and continues to be, the principal economic activity in the delta. Logging operations began around 1865, but on the lowlands the resource was expended before 1920.

Reconnaissance, survey, and excavation of prehistoric cultural resources have been carried out sporadically in the Skagit Delta, although the vast potential of the delta's cultural resources, both prehistoric and historic, has largely remained unexplored. Although numerous project-related cultural resources projects have occurred in the Skagit Valley, no systematic survey has produced a comprehensive inventory of prehistoric or historic archaeological sites, or traditional cultural properties. Owing to cultural resources work associated with a prior Corps study and other work along the river, more sites have been recorded along the river downstream of Mt. Vernon on the North and South Forks than in other reaches or in proposed diversion areas. Currently, two properties within the Skagit Delta are listed in the National Register of Historic Places: the town of La Conner and the Skagit City School. In addition, the Fishtown Archeological District, a constellation of three prehistoric sites at the mouth of the North Fork, was nominated to the register. The Washington State Register of Historic Places includes the Old Skagit County Courthouse in Mount Vernon and the Methodist Church in Fir. The Washington State Inventory of Historic Places includes the town sites of Fir, Sterling, and Skagit City. During the summer and fall of 1978, the Corps contracted with Seattle Central Community College to conduct a cultural resources reconnaissance of the project area of the proposed Skagit River Levee Project. The reconnaissance identified 54 cultural resource sites, 20 prehistoric sites, and 34 historic sites. The prehistoric sites are largely habitation shell middens; the historic sites include elements of towns, farms, refuse areas, a cemetery, granary, and logging establishments.

Delta formation processes of meandering and progradation and other land forming processes have been active since human occupation of the region first began after the glaciers departed from the lowlands. Shifting of the river channel and deposition of sediment mean that sites on older buried landforms and surfaces can be expected nearly anywhere within the floodplain. Given the incomplete coverage of the Skagit Valley, there is a high likelihood that additional sites will be discovered. Due to the counterclockwise migration of the main channel from north to south, the northern portion of the delta potentially contains a greater age range of sites (e.g., older lithic sites on ridges and terraces and older buried sites near the Samish River) than the relatively younger deposits associated with the current North and South Fork. In addition, there is the potential for well preserved sites capped by lahars from Glacier Peak and sites with important information about paleo-seismic events (Salo, L. 2001 pers. comm.).

Regarding historic era resources, some inventory work has been undertaken in the County, and some investigations have been conducted by Certified Local Governments. While historic property inventories – and register listings – have occurred mostly within urban areas and commercial historic districts, less attention has been focused on the rural agricultural properties of the Delta. A significant oral history project on historic land use in the Skagit watershed was undertaken with a series of volunteers provided through the Earthwatch Institute, and with the support of the Skagit Environmental Endowment Commission. This study produced audio and transcript records of these interviews.

E. Socioeconomics

Data from 2006 identified that 84.4 percent of the Skagit County population is white. The remainder of the population identified themselves as black, American Indian, Alaska Native, Native Hawaiian, Pacific Islander, Asian, Hispanic or a combination. Based on census data, the largest population centers in the study area were Mt. Vernon (30,745), Burlington (6,757) and Sedro-Woolley (8,658) (U.S. Census Bureau 2010a and b). Total county population was estimated to be 113,859 (U.S. Census Bureau 2010b).

For Skagit County, the median household income (in 2008 inflation-adjusted dollars) is $52,554; approximately 7.7 percent of family and approximately 12.3 percent of individuals are below the poverty level. Approximately 84.5 percent of Skagit County's population (25 years old and older) have completed high school and approximately 23.1 percent have completed a Bachelor's degree or higher. (U.S. Census Bureau 2010b).

Population in the upper basin is sparse and centered around the small towns which line Highway 20, including Lyman, Hamilton, Concrete, Marblemount and Newhalem. Agriculture and logging are the primary activities around these small towns, with the exception of Newhalem which is composed of Seattle City Light employees who maintain the dams. The vast majority of land above Marblemount is heavily forested and used primarily for recreation. Most of this land is protected as either National Forest or National Park. The largest population centers are in the middle and lower reaches with county government offices mainly located in Mount Vernon. Agriculture is an important activity in the lower basin.

A 2005 study identified 12,544 residential and 1,639 non-residential (i.e., agricultural, commercial, public, and industrial) properties with a total floor space of 11,210,860 square feet in the floodplain of the study area (Corps 2005). The study area contains over 71,000 acres of agricultural lands that are subject to flooding. The average proportion of agricultural land harvested is approximately 68.8 percent, based on the most recent 2002 U.S. Department of Agriculture Census of Agriculture and 2003 Extension Office reports. During the initial analysis, eleven crops were listed as the principal types for Skagit County (based on the 1996 report from the Washington Agricultural Statistics Service) comprising a total 45,360 harvested acres. Since that report, the harvested acreage and crop type have changed. Harvested acreage is down to 45,200 acres and both carrots and sweet corn have gone out of production. Production of green peas has been reduced by over 50 percent, while production of crops such as potatoes, cucumbers and raspberries has increased in total acreage. Approximately 50 percent of the acreage is in potatoes and hay.

F. Air Quality and Noise

1. Air Quality

According to Environmental Protection Agency (EPA) Region X records, Skagit County is in attainment for the six criteria air pollutants. Although Skagit County has good air quality, there are periods when localized air quality can deteriorate. This usually occurs during times of stable weather when there is an absence of wind. Periodically, particulates can become an air pollutant of concern. (EPA 2007, EPA 2007a).

2. Noise

Noise levels in the project area vary widely. The urban areas of the study, Mt. Vernon, Burlington, and Sedro-Woolley, have higher noise levels associated with larger populations and associated commercial and residential development and traffic. The agricultural areas in the delta and forested areas in the upper basin have lower noise levels associated with rural areas

G. Solid and Hazardous Waste (HTRW)

According to the Ecology there are several sites identified in both Sedro Woolley and Hamilton that have been identified as a "leaking underground tank site", many of which are gas stations. The majority of these sites are in the "cleanup started" status which means that the responsible party has initiated cleanup , but full cleanup has not yet occurred. Proximity of these sites to the river is not disclosed. There are many state listed confirmed and suspected hazardous waste sites, mostly confined to the towns of Sedro Woolley, Hamilton, and Lyman. None of these sites are directly on the Skagit River or any of its tributaries, with the exception of Puget Sound Energy's Upper Baker River Generation Station located on the Baker River. These sites are all either in the process remediation or have initiated a remediation plan (WDOE 2008b).

As of 2008, there were numerous sites identified in the lower basin as "Hazardous Sites" by Ecology (2008a). Most of these sites are located in or near Mount Vernon and Anacortes, and are associated with fuel or diesel pollutants, most likely leaky tanks or pipelines at gas stations or similar. The majority of sites are awaiting remedial action or in the process of clean-up but it is not yet complete.

No US EPA superfund sites are located in the Skagit River Basin.

III. FUTURE WITHOUT-PROJECT CONDITION ASSUMPTIONS

The purpose of this section is to present the assessment of the most likely future conditions in the Skagit River Basin without an authorized Corps project. To have a uniform period for future assessments, the Corps defines the planning period as spanning 50 years beyond the first benefits that could be expected to occur once an authorized project is implemented. For this project, we expect that period to start in 2015 and extend to 2065. However, we acknowledge that this is a long, uncertain period and many datasets available for our use in forecasting future conditions do not match the prescribed planning period. Thus, much like the other planning periods used in our analysis for historic and current conditions, we have used a range of years to represent future conditions. The future conditions are expected to range between 2050 and 2070.

The study team has spent much effort assembling quantitative information where possible but acknowledges that much of the information we have developed and that we have garnered from other studies is either qualitative or dependent upon professional judgment. We qualify the information and data in the sections where it is described.

Estimation of future without project conditions is based on extrapolation of current trends, and does not account for changes in policy. Environmental change (e.g. climate change) will have to be considered in flood damage reduction planning as it impacts flow regime, major flooding events, and restoration strategies.

The recent Biological Opinion dated 22 September 2008 issued by the National Marine Fisheries Service (NMFS) regarding Federal Emergency Management Agency's (FEMA) flood insurance program may play a role in development as well. In this Biological Opinion, NMFS lists several reasonable and prudent alternatives (RPA) in which FEMA's current flood insurance program should be altered such that it doesn't jeopardize the continued existence of Puget Sound Chinook salmon, Puget Sound steelhead, Hood Canal summer chum, and Southern resident killer whales. FEMA has begun implementing the RPAs with the exception of RPA Element 5 sub-elements A, B, or D: Addressing the Effects of Levee Vegetation Maintenance and Certain Types of Structures in the Floodplain. FEMA will not be implementing RPA Element 5 sub-elements A and D because it is beyond FEMA's statutory authority and discretion. For RPA Element 5 sub-element B, FEMA cannot implement it because it would be a duplication of programs, prohibited by Section 312 of the Stafford Act and 44 CFR 206.191. Wetlands are also at risk, despite future restoration actions.

Continued maintenance and construction of levees as it exists now, by both the Corps and the County, would further constrain the river, possibly in higher reaches of the upper basin. Additional or rehabilitated levees may create less bank complexity, eliminate benthic invertebrate habitat, increase scarcity of off-channel habitat, increase river speeds during high flow events, further reduce LWD retention and create shorter and thinner riparian corridors, particularly if existing Corps levee vegetation standards are continued. This would directly affect ESA listed species that depend on cold, clean water, organic detritus and benthic invertebrates for food, and LWD and bank complexity for cover.

There would continue to be losses of salmonids due to high regulated flows and existing pressures present in the floodplain, estuary, and marine environments that are likely to persist, if not worsen due to human population growth and the effects of climate change discussed previously.

Sea level rise may further alter habitat as salt water influenced ecosystems are forced farther inland by rising seas, reducing existing freshwater habitats and further constraining already limited salmonid and wildlife habitat. The extension of salt water inland may alter existing land use patterns, in particular agriculture as less land may be suitable for farming. This could lead to additional sea walls and dikes being built to exclude salt water from land. In the upper basin, forest species composition may be altered due to changes in seasonal water availability, warmer air temperatures, increased pest occurrence and invasive species colonization, and changes to fire regimes. Changes in forest species composition will directly affect wildlife and fish through modification to habitat and food sources.

IV. FUTURE WITHOUT-PROJECT CONDITIONS – ENVIRONMENTAL

The without-project condition is defined as the condition most likely to prevail in the future if no project is undertaken.

Several of the resources evaluated above (topography, geology, and soils) would not change without implementation of the project and it is assumed that the conditions as described above would remain relatively constant in the foreseeable future. The remaining resources (geomorphology, climate, biological resources, water resources, cultural resources, socioeconomics, air quality and noise, and solid and hazardous waste) could be affected by continued flooding or implementation of policy guidance and the assumptions of the condition of these resources in the foreseeable future are described below.

A. Physical Resources

1. Topography and Watershed Description

No major changes are expected to the topography of the Skagit River Basin.

2. Geology

Geology of the Skagit River Basin is not expected to change. However, it is expected that many of the river channels created during the glacial melt will continue to aggrade and will remain highly susceptible to land sliding when saturated. Also, the potential for future large eruptions of Glacier Peak and Mt. Baker could form thick fills of lahars and pyroclastic-flow deposits in the upper valleys near the volcano. Lahars from Glacier Peak could reach the delta, or there could be induced flooding due to temporary damming of watercourses in the upper watershed. Subsequent incision of volcanic deposits could fill riverbeds farther downstream with sediment for many years after the eruption, thereby affecting the capacity of stream channels and locally increasing flood heights (Waitt et al. 1995). These effects would be especially significant for the extensive low-lying areas of the Skagit river floodplain and delta. Although not a direct volcanic hazard, there would be increased susceptibility of lowland areas downstream of volcanoes to earthquake generated liquefaction, which would be enhanced by thick deposits of volcanic lahars, sand, gravel and generally saturated conditions in many of those areas.

3. Soils

Future changes to soils in the basin are expected to be minimal. Urbanization pressures in the lower basin may cause highly productive and fertile agricultural soils as well as wetlands to be converted for future developments. In addition, some agricultural soils in the lower basin may become unproductive due to saltwater intrusion attributed to sea level rise. However, most of the agricultural land is protected by sea dikes and would not be subject to inundation (Glick et al. 2007). In the upper basin, continued timber production may increase erosion potential. Although, no survey has been conducted upstream of RM 78 to the Canadian border in the Mount Baker-Snoqualmie National Forest; no major alterations to the soils are anticipated.

4. Geomorphology

Studies show that the channel bottom has been aggrading in recent years (West 2001). Channel conditions in the lower mainstem have changed significantly from historical records. The North Fork of the river had an average increase in overall bed elevation of 1.6 ft and the South Fork had an average increase in overall bed elevation of 1.0 ft, with a range of 0.4 to 1.8 ft between 1975 and 1999 (Corps 2008). The average annual sediment yield at Mount Vernon is in the range of 0.6 to 2.8 mcy/yr (Corps 2008). The major sources of sediment are the unregulated Cascade and Sauk rivers. Both aggradation and degradation have been observed in various locations, channel widths and the occurrence of in-stream islands have been modified, and certain channel segments and tributaries have been substantially realigned or structurally modified; however, deposition at the mouth of a river or delta is a natural process. Additionally, levees and bank revetments permanently altered the natural stream dynamics. Since the completion of the levee system, sediment discharges have concentrated at the mouths of the North and South Forks. Sand from the river is deposited throughout the delta, while silts and clays are transport beyond the delta (Corps 2008). Increases in development in urban areas and future development on unincorporated County land will increase impervious surface coverage. Knutson and Naef (1997) found that alterations in bank stability and increased erosion can result from as little as ten percent impervious surface coverage. Resulting future erosion could lead to stream channel alterations, changes in hydrology leading to shifts in macroinvertebrate community composition, changes in stream temperatures and base flows and increases in flood frequency and volume (The Watershed Company 2007).

In 1975, the Washington Department of Fisheries stream catalog identified the lower Skagit River as having long glides and deep pools. However, since that study, a loss of pool area was identified and associated with the historic removal and reduction of input of LWD and increases in sediment supply (Collins 2000). The current channel morphology (i.e. smooth banks) makes it difficult for any remaining LWD to form jams and associated pools. The system's constrained configuration and recent aggradations may also contribute to the loss of pools. The majority of existing pools are found in areas of high shear stress (Cherry and Jackson 2002). The increases in sediment supply are due to mass wasting (landslides) and surface erosion due to forest management activities in the Cascades, and soil creep (SWC 1998). However, there are also natural inputs such as glacial and volcanic conditions that are attributed to higher sediment loads

Temperature alterations due to climate shifts could affect the timing and volume of streamflow. The Skagit River which experiences mid-winter temperatures close to freezing and is sensitive to changes in snowfall, will likely have enhanced winter peak flows due to increases in precipitation and reduced spring and summer flows due to reductions in snowpack (Casola et al. 2005).

5. Climate

Models from the University of Washington (UW) Climate Impacts Group indicate that over the next century, the Pacific Northwest area will likely see a trend toward wetter warmer winters and hotter dryer summers in response to climate change. However, these large scale models have difficulty resolving mountain climates such as the Cascades and the Upper Skagit basin, so exact scenarios are difficult to predict. Currently, the UW Climate Impacts Group is working on meso-scale models that may be able to resolve smaller scale climates (UW Climate Impacts Group 2008).

It is speculated that the Skagit River system may see higher flows in the winter as the majority of the precipitation would fall as rain and not snow, and lower flows in the summer due to lack of rain and snow melt. Initially, glacial melt would increase, but over time would decrease as the glacier retreats. Not only would this scenario lead to a different flow regime than what is seen in the Skagit today, but will likely lead to increases in water temperatures within the river (Hamlet and Lumberd UW Climate Impacts Group 2008 pers. comm.).

In addition to changes in precipitation and air temperatures, sea level rise estimates in Puget Sound range from low estimates of 16 cm (6") to very high estimates of 128 cm (50") by the end of the 21st century (Mote et al. 2008). This range incorporates higher sea level rises expected in the south around Olympia and Tacoma and lower expected rises in the north around Friday Harbor and Bellingham Bay (UW Climate Impacts Group 2008). The Swinomish Indian Tribal Community projected sea level-rise impacts and accompanying tidal surges and impacts to its reservation and infrastructure. Figure 3, provides a graphic illustration of sea level rise impacts (yellow) and tidal surge areas (red) on both SR-20 and the Swinomish Village and La Conner area, which would most likely apply to low-lying shorelines throughout the Skagit basin (SITC 2009).

Figure 3. Potential sea level rise inundation and tidal surge zones on SR-20 (top) and the Swinomish Village and La Conner area (bottom) (SITC 2009).

B. Biological Resources

1. Vegetation

Several factors are expected to contribute to continued losses of vegetation in the Skagit Basin which include: maintenance and construction of levees, development and climate change. Levees will continue to constrain the river and will limit vegetation based on continuance of Corps levee vegetation standards. Reductions in vegetation would further reduce LWD retention and create shorter and thinner riparian corridors. Even though permitting processes are in place to address loss of habitat impacts, those permitting actions usually focus on a project specific basis, not a basin-wide approach; thus, the general trend would be a continued decline in the habitat quality and quantity (Beechie et al. 1994).

a. Basin Vegetation

As the overall upper basin is heavily forested, climate change could have a significant effect on forest species composition and fire regimes. Under current models, wetter winters and dryer summers are predicted in the Pacific Northwest region. Climate warming may first show up in forests as increased growth, which occurs as warmer temperatures, increased carbon dioxide, and more precipitation encourage higher rates of photosynthesis (Rapp 2004, Casola et al. 2005). This increased woody vegetation expansion and growth could lead to higher fire occurrence, as the increased amount of fuel load cures through the longer, drier, and warmer summers.

Climate trends for the West predict that by the end of the 21st century, the average annual area burned in Washington could increase by a factor of two to five (Casola et al. 2005). West of the Cascade crest summer soils moisture is predicted to have substantial declines and west-side forests that have not been considered to be fire prone may expect increased fire activity (Littell et al. 2009 *in* Climate Impacts Group 2009). Studies support linkages between climate and fire and climate and pests (specifically mountain pine beetles). Fungi and arboreal diseases that are not currently present in colder climatic forests could emerge as temperatures shift (SITC 2009). Climate driven disturbance could act as the primary driver for future changes to forests of Washington (Littell et al. 2009 *in* Climate Impacts Group 2009). Littell and Binder (2007) link future forest impacts to changes in summer and winter temperature and precipitation, snow pack duration and regional hydrology. A summary of both positive and negative climate change triggers to pacific northwest forests is presented in Table 3 below.

Table 3. Summary of potential future impacts to PNW forests from changing climate. (Reproduced from Littell and Binder 2007).

Projected Change	Potential Forest Impact	Impact (+ or -)
Warmer summer air temperatures (Higher potential evapotranspiration	Increased growth and regeneration for trees/forests that are temperature limited (high elevation/subalpine forests)	Positive
	Decreased growth, vigor, and regeneration for trees/forests that are water limited (all low elevation/montane forests)	Negative
	Lower fuel moisture	Negative
	Increased incidence of fires and increased area of fires that occur	Negative
	Increased respiration and declines in carbon assimilation	Negative
Warmer winter temperatures	Longer growing season	Positive or Negative

Projected Change	Potential Forest Impact	Impact (+ or -)
		(elevation dependent)
	Longer fire season due to shorter snowpack persistence	Negative
	More favorable over-wintering conditions for insects with episodic population dynamics	Negative
Higher winter streamflows	Riparian flooding and erosion (potential road impacts)	Negative
	Flooding impacts to other resources forest managers consider such as spawning habitat, campgrounds, recreation, etc.	Positive or Negative
Warmer spring temperatures and lower snowpack	Longer fire season due to earlier soil moisture depletion	Negative
Lower summer streamflows	Indirect effects for forest managers charged with protecting anadromous and resident fish populations	Negative
Synergistic effects and multiple stressors	Increased winter favors insects and increased summer temperature decreases tree vigor which leads to more successful insect attacks and more insect disturbance	Negative
	Increased disturbance plus changes in climatic zones leads to potential for rapid shifts in species ranges (or genetic variability within species)	Positive or Negative

b. Riparian Vegetation

Riparian habitat will continue to be impacted by the presence of levees and bank protection downstream of Sedro-Woolley. Future conditions will most likely be the result of further riparian habitat degradation particularly in the lower basin including fragmentation and inadequate protection for sensitive species. No major alterations to riparian vegetation are anticipated in the areas of the upper basin that are either national park or national forest upstream to Ross dam. Loss of riparian vegetation in the Skagit basin will result in loss of wildlife and fish habitat, higher water temperatures, less organic river input which provides fish food, less recruitable LWD, and an increase in the presence of invasive species. Future losses of riparian vegetation will likely result in reduced potential for LWD input into the lower reaches of the river, further compromising salmonid habitat. Hydrological characteristics are directly linked to the success of riparian zones. Flow variability and channel width fluctuations are necessary for biodiversity of riparian systems have been altered by civil engineering works and hydroelectric developments and will most likely continue to decline (Naiman and Decamps 1997). Even without further disturbance, this condition is unlikely to improve significantly in the near future due to the existing levee and revetment system and associated policies.

Climate change may greatly alter the vegetation communities in the Lower Skagit basin. Increased winter precipitation and summer drought, longer growing seasons, and warmer temperatures may result in changes in plant species and increased pest populations throughout the basin. Invasive species may proliferate and fill previously unaffected niches as native species are stressed and displaced by more generalist species.

Climate change may greatly alter the vegetation communities in the Upper Skagit basin. Increased winter precipitation and summer drought, longer growing seasons, and warmer temperatures may result in changes in plant species and increased pest populations throughout the basin. Invasive species may proliferate and fill previously unaffected niches as native species are stressed and displaced by more generalist species.

c. Estuary and Salt Marsh Vegetation

Habitat viability in tidelands and marine habitat require specific levels and frequencies of inundation as well as salinity (SITC 2009). The Swinomish Climate Change Initiative (2009) estimated habitat losses by 2100 based on high estimate sea level rise of 59 inches and reported 87 percent loss of tidal freshwater marsh, 99 percent loss of estuarine beach and 97 percent loss of brackish marsh. Sea level rise will likely shift the eelgrass beds, mudflats, and salt, brackish, and freshwater marshes landward. This shift will be difficult on the landward side due to the development that abuts the marshes leading to an overall decline in brackish and freshwater habitat. Blockages such as steep banks, bulkheads, rip-rap and other shoreline armoring will inhibit habitat migration. Most of the brackish marsh in Skagit Bay today would be converted to salt marsh and estuarine beach habitats would be converted to open water or tidal flats (Glick et al. 2007, Tohver and Mantua undated). It is speculated that eelgrass beds may benefit due to an increase in shallow saltwater habitat and estuarine emergent marshes will increase (Hood 2008).

d. Large Woody Debris

Continued loss of recruitable LWD could be contributed to continued losses of riparian vegetation in the upper basin and USACE implementation of levee vegetation standards would result in loss of wildlife and fish habitat, higher water temperatures, less organic river input which provides fish food, less recruitable LWD, and an increase in the presence of invasive species. Naiman and Decamps (1997), found that LWD plays a significant role in streambank stabilization particularly in headwater streams. Reductions in LWD would contribute to further losses in essential habitat for fish and macroinvertebrates and reduce protection of plant propagules from erosion, abrasion, drought and herbivory (Naiman and Decamps 1997).

e. Off-Channel Habitat

The off-channel habitat loss seen over the last century to the Skagit River is expected to continue due to continued diking of the river and land use practices in the lower Skagit Basin floodplain and delta areas (Beamer et al. 2002, Beechie 1994, Collins and Sheikh 2002).

2. Wildlife

Climate change may lead to a much different microclimate and river system than what is seen today. Alteration in vegetation communities due to changes in precipitation, temperature, pest and forest fire regimes are possible. Not only would this change affect the physical habitat that wildlife in the upper Skagit currently occupy but it could also further decrease populations of already declining anadromous fish, which will in turn impact a variety of marine and freshwater fish, birds, and mammals which are reliant upon them. It will also affect the distribution and abundance of benthic invertebrates within the river due to changes in flow and temperature. Details about specific impacts of climate change on fish populations in the Skagit are discussed below.

Climate change may lead to a much different river and delta system than what is seen today. Sea level rise will likely shift the subtidal, intertidal, and freshwater marshes landward. This shift will be difficult on the landward side due to the constraints of development that abuts the marshes leading to an overall decline in brackish and freshwater habitat as more land is converted to the subtidal zone. This loss of freshwater marsh could potentially affect amphibians, small mammals, and reptiles that inhabit these areas as well as migrating and residential birds and waterfowl. Additionally, this could potentially further decrease populations of already declining anadromous fish, which will in turn impact a variety of marine and freshwater fish, birds, reptiles, amphibians, and mammals which are reliant upon them. It will also affect the distribution and abundance of benthic invertebrate within the river, the estuary, and the bay due to changes in salinity and temperature. Details about specific impacts of climate change on fish populations in the Skagit are discussed below.

3. Fish

Beechie et al. (1994) estimated that 115 km of side-channel and distributary sloughs have been eliminated in the Skagit River basin, which is a of 52 percent in slough rearing habitat. Off-channel habitat as detailed above in Section B.6.e will likely continue to decline in the future. Increases in urban development (Section E below) have been linked to declines in fish species diversity and dominance of cutthroat trout (The Watershed Company 2007). Continued construction and maintenance of levees and revetments as well as USACE vegetation standards will negatively influence water temperature by reducing shade, increasing relative humidity, altering channel dimensions and reducing overhead cover in the future.

Climate change in the Skagit Basin is likely to present future obstacles for salmonids in the Skagit system that could be severe. Skagit River salmonids have already experienced a variety of pressures caused by the diking of the river, construction of dams, insufficient riparian vegetation and large woody debris recruitment, and the development of the floodplain. The combination of these existing pressures with the scenario of warmer wetter winters and hotter dryer summers could lead to elevated summer and early fall water temperatures due to a lack of buffering from snow and glacial melt. Increased temperatures may be intolerable to salmonids. Bull trout populations in the Skagit River system would be particularly affected by these elevated temperatures since they require water no warmer than 48˚F for spawning and no warmer than 53˚F for rearing (WDOE 2008).

Increased potential for greater frequency of high flows and floods during the winter, earlier onset of spring freshet and prolonged high temperature low flow summers could interfere with cold water fish habitat and survival rates (Casola et al. 2005). High flow or inundation events could lead to fish stranding. Loss of habitats such as tidal swamp and brackish marsh could affect survival of juvenile salmonids particularly for rearing and migration (SITC 2009).

Predicted sea level rise would cause the freshwater and brackish marshes to retreat landward due to saltwater intrusion with little room to encroach on already developed land. This additional reduction of brackish habitat, required for smoltification and acclimation to changes in salinity, is estimated to range from 77-97 percent (Glick et al. 2007); further limiting the production of anadramous fish in the Skagit Basin. Estuarine beaches provide forage fish spawning habitat and food for salmon and other species including shorebirds. In many areas of Puget Sound, erosion of estuarine beaches are backed by dikes, bulkheads and armoring such as rip-rap and will inhibit landward migration of habitat (SITC 2009).

4. Invertebrate Communities

Invertebrate species have been declining in Puget Sound due to both habitat loss and degradation. The most likely future scenario is a continuation of invertebrate nearshore habitat decline including rocky shorelines, beaches, embayments, river deltas, intertidal zones and man-made structures and subsequent declines in invertebrate populations. Climate change may affect invertebrate assemblages throughout the Skagit system due to changes in temperature, flow regime, and sea level rise.

5. Threatened and Endangered Species

Climate change will have the same impacts on listed species as described above, however, impacts to listed species may be more severe due to low population numbers.

6. Wetlands and Other Waters of the U.S.

The decline in extent and quality of wetlands is expected to continue due to continued development as well as the continued maintenance and construction of levees that constrain the river and limit inundation to palustrine and riverine wetlands. Increased urbanization will create more air and noise pollution; create the need for more infrastructure (including roads, water and electrical supply) and could result in further fill of remaining wetlands and deforestation of surrounding lands. Even though permitting processes are in place to address wetland impacts, those permitting actions usually focus on a project specific basis, not a basin-wide approach; thus, the general trend would be a continued decline in the wetland quality and quantity (Beechie et al. 1994). Wetlands functions that could be lost include, flood attenuation and storage, water quality improvements, and wildlife and fish habitat.

Climate change, and the associated changes in precipitation and groundwater patterns, may result in large scale changes to wetland complexes and the functions they provide. Increased intensity of flood events may alter the sedimentation deposition and erosion patterns. Changes in precipitation patterns may alter groundwater recharge/discharge rates and locations, and reduced summer river flow may alter the vegetation communities and animal habitats in these wetlands (Kusler 2005). Upland wetlands could be affected by declines in freshwater or groundwater supplies as well as declines in water quality (i.e. increased salinity, increased stormwater) driven both by urbanization and climactic shifts (SITC 2009). Negative impacts to wetlands would likely contribute to negative impacts to fish and wildlife.

Predicted sea level rise would impact freshwater tidal marshes and brackish marshes. Storm surges and higher levels of inundation would increase salinity to these systems. If migration of these systems is blocked by development or man-made structures they may transition to salt marshes or transitional marshes (SITC 2009).

C. Water Resources

1. Water Quantity

a. Flood Characteristics

Predictions indicate that the Skagit River system may see higher flows in the winter as the majority of the precipitation would fall as rain and not snow, and lower flows in the summer due to lack of rain and snow melt. Tohver and Mantua (undated) simulated Skagit River flows for three future time horizons based on historical (1970-1999) flow and a scenario where population growth peaks at 2050 and the 90 percent probability sea level rise ranged from 8-19 inches (Figure 4). They found diminishing snowpack and increased temperatures would lead to lower peak flows in the summer and higher winter peak flows as precipitation increases. Initially, glacial melt would increase, but over time would decrease as the glacier retreats. Simulated flows for the 2040's for the Skagit River indicate that streamflow patterns are temperature dependent (Mantua 2005). Expected changes in precipitation due to climate change, as described above, could intensify the pattern of flooding in the fall and winter and extreme low flow conditions in the summer (Figure 5) (Mantua 2005, Casola et al. 2005).

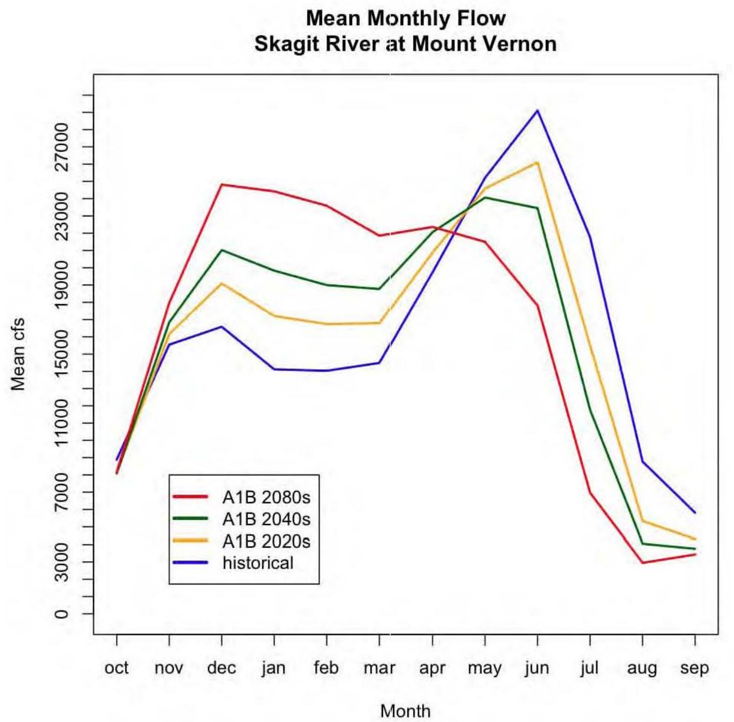

Figure 4. Hydrograph of the Skagit River at Mount Vernon comparing patterns of historical flow to three future time horizons based on a scenario of peaked population growth in 2050 and sea level rise range between 8-19 inches (90 percent probability) (Tohver and Mantua Undated).

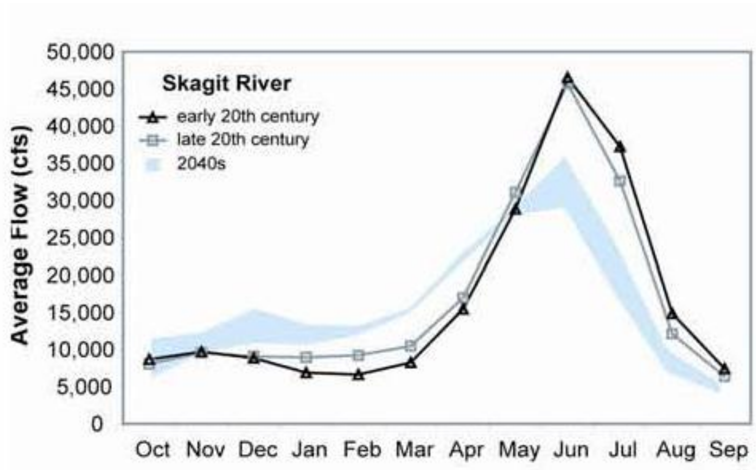

Figure 5. Projected changes in monthly streamflow for the Skagit River based on increasing climate temperatures for the 2040's (+3.6 to +5.4 F) (Casola et al. 2005)

b. Water Rights

Future changes to water rights would follow the 2001 Ecology in-stream flow rules and any subsequent amendments that alter minimum flow requirements.

2. Water Quality

The result of expected urban development could negatively affect the existing environment. Reductions in forest cover and increases in impervious surfaces typically found in urban watersheds have been found to substantially impair watershed storage capabilities (The Watershed Company 2007). Impervious surface coverage increases could reduce soil infiltration and increase velocity, volume and frequency of surface water flows and subsequently increase sediment and pollutant delivery to streams.

Sediment inputs to streams can contribute to declines in water quality and are supplied by both bank erosion and upland processes (The Watershed Company 2007). Continued construction and maintenance of levee and revetment systems and associated vegetation maintenance policies is expected to contribute to future bank erosion processes. Agricultural land may be converted to residential or commercial use creating more stormwater runoff and declines in water quality. Development in rural areas could lead to additional septic systems which often contribute to poor water quality in streams and tributaries that drain into the Skagit. Most of the substandard water quality occurs in tributaries to the Skagit River and in the Samish Basin, while the Skagit River itself meets standards on most occasions (Skagit County 2008). Overall, a decline of water quality is expected to continue.

D. Cultural Resources

Archaeology:

The diverse geography of the Skagit River Watershed is known to contain the historic record of native peoples who lived along the river and its tributaries, from densely wooded upper elevations to the lowland delta. Archaeological sites have been recorded in the region that provide information about both permanent and semi-permanent living activities, hunting, gathering, and fishing in both marine and freshwater environments. Historic archaeological sites and features may also be present that stand to inform about earliest white settlement of the area and about important economies and industries that have sustained the area, and for which there is only a corporate record.

To date, a small percentage of likely archaeological sites have been identified and recorded, and there is the additional potential that traditional cultural properties with religious significance to native peoples exist. The watershed's history of logging, urban and agricultural settlement and intensive industrial activities has dramatically changed the behavior of the river in the past century or more, subjecting the area to extreme and moderate flooding. Flood events pose a threat to archaeological sites by way of erosion and sloughing actions which carry away significant cultural materials and features and thereby compromise their integrity, or bury them entirely in layers of sediment. Therefore, without the project, continued flooding cycles in the Skagit Watershed may damage or destroy archaeological sites which have the potential to yield valuable information about the history and life ways of those who lived in the region before and after white contact.

Historic Built Environment:
The watershed contains one of western Washington's earliest patterns of white settlement, beginning with exploration and railroad incursion into the area, and extending to waterfront shipping, fishing and canning activities, and inland agricultural development. Numerous historic buildings, structures, objects, and landscapes exist in the area, including both small urban conclaves with historic districts listed in the National Register of Historic Places, and individual properties such as farmsteads. The lower watershed in fact contains one of the state's richest stocks of historic agricultural buildings, many associated with Scandinavia migration in to the area. Included in this potential inventory are historic hydroelectric and flood control properties such as dams, barrier dams, levees, and dykes.

Presently there is incomplete inventory data about the historic built environment of the watershed. Some recordation and designation to historical registers has occurred in major communities, as well as identification and evaluation of certain farms, barns, and related agricultural structures. The hydroelectric facilities and accompanying town sites in the upper watershed have been listed in the National Register and are managed cooperatively between Seattle City Light and the National Park Service.

Continued lack of project will subject vulnerable historic buildings and structures, many of wood frame construction, to deterioration and severe damage. This scenario of neglect will in turn compel a monetary de-valuing, neglect, and ultimately an abandonment of historic buildings and structures, and a loss of tourism and other economic development associated with heritage.

E. Socioeconomics

Future socioeconomic conditions in Skagit County are affected by a number of external variables that are difficult to predict. The county population will continue to increase. Currently the population of Skagit County is 116,397, most of which is located within the lower basin (Sedro Woolley and below). By 2030 the population is projected to range from 140,000-220,000 (Washington Office of Financial Management 2007). The Skagit County Comprehensive Plan (2007) is projecting a 45 percent increase in population for 2025 based on the 2000 population. The growth projections for 2025 indicate that highest growth rates will be seen in Mount Vernon, Sedro Woolley and the smaller East County towns of Hamilton and Concrete. This increase will likely take place in the lower basin due to the presence of North Cascades National Park and Mount Baker-Snoqualmie National Forest in the upper basin. However, due to the location of Mt. Vernon and Burlington, and the lack of an endless supply of developable land in the lower basin it is expected urbanization pressure will continue to be felt in the floodplain, as the urban growth boundary pushes out from the cities. Ultimately growth rates will be determined by availability of natural resources (i.e. water) and infrastructure.

The economic base for the County is based largely on natural resource industries including agriculture, forestry and commercial fishing. Agriculture is the largest industry and will most likely remain the primary industry in the future. Currently, the study area contains over 71,000 acres of agricultural lands that are subject to flooding and roughly 45,200 harvested acres. Increases in population and development may result in losses of agricultural land and a reduction in the total harvested acres. Climate change projections indicate the possibility of increased agricultural pests and diseases driven by warmer temperatures. Increases in temperatures in the PNW could impact the agricultural base in the County by increasing the number of insect life cycles per year, expanding pest ranges, altered pathogen development rates and modified crop resistance to pathogens (Casola et al. 2005).

Forests dominate the County land base (~ 53 percent in 2007); however, since the timber harvest peak in 1986 both jobs and harvest yields have been decreasing (Skagit County 2007). As stated above in Section B.6.a, climate shifts could have major impacts to forests in the Skagit basin. Disease outbreaks, fire and shifting geographic ranges area all factors that could impact the long-term viability of timber harvesting.

The commercial fishing industry has remained an important industry to the County but in recent years economic viability has significantly decreased in recent years to over fishing, low market prices and catch restrictions (Skagit County 2007). These trends are expected to continue for the future, however as stated above, socioeconomic conditions are driven by a number of external variables that could influence these trends. The future viability for the commercial fishing industry is directly linked to policies developed for species protection and specific populations of each species and is discussed in greater detail in Sections B.8 and B.10.

F. Air Quality and Noise

1. Air Quality

Air pollution will increase as urbanization and development occur in the urban areas specifically Mt. Vernon, Burlington and Sedro Woolley. Associated effects of urbanization include the need for more infrastructure such as roads which will increase motor vehicle use and emissions. Particulates can become an air pollutant of concern periodically (EPA 2007, EPA 2007a) and this may increase with future development and commerce.

Climate shifts and increased temperatures would likely increase ozone and air pollutants that are deposited on the earth's surface. Low-level atmospheric temperature inversions can inhibit the vertical movement of air and subsequently increase pollutant concentrations near the ground (Iacobellis et al. 2009). Temperature inversions and warmer winters could lead to increased ground level fog which can be 40 times more acidic than water (SITC 2009). Future ozone changes are subject to regional variability, however have been found to be strongly influenced by changes in temperature and humidity (Zeng et al. 2008). Under normal conditions, high ozone episodes generally occur on the warmest sunny days in the late spring and summer. Coniferous forests are a large source of volatile organic compounds (VOC) and produce more on high temperature days (SITC 2009). Increasing temperatures could lead to more VOC's and subsequently increase the rate of ozone synthesis.

2. Noise

Increased urbanization and development will likely increase noise pollution, especially in the urban areas such Mt. Vernon, Burlington and Sedro Woolley. Increasing population will create the need for more infrastructure, including roads. It is anticipated that noise in the upper basin and areas that remain agricultural will be maintained.

G. Solid and Hazardous Waste (HTRW)

The majority of HTRW sites identified by Ecology, which are currently in the "cleanup started" status that have been identified as a "leaking underground tank site" would continue to undergo cleanup. It is assumed, that sites currently in the process of remediation or that have initiated a remedial action plan, as well as site that are awaiting remedial action would be completed at some point in the future and not dependent on implementation of a Corps project. It is also likely that additional sites not currently identified will be identified and need to undergo remedial action.

V. DATA GAPS

Existing wetland inventories of the Skagit Basin are deficient and need to be updated. The only known survey was conducted in 1978. Due to extreme changes in population and land use in the lower basin the existing data is likely to contain significant errors.

Sediment data is lacking for high flow events. This information needs to be collected to help refine the sediment budget for the river and the geomorphic and hydraulic analysis of the system.

A cultural resources inventory will need to be conducted along project alignments to compensate for gaps in existing surveys. The likelihood of finding significant cultural resources will be high. Historic structures in the project area will also have to be identified in the inventory.

An inventory of riparian habitat will need to be updated. The last riparian survey was conducted a number of years ago and population and land use changes have occurred since the last survey.

No soil survey has been conducted by NRCS in areas designated as National Park or Forest in the upper basin, all areas upstream of RM 78.
In the future, climate change models will become more refined to predict small scale climate scenarios.

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