SUMMARY OF SHORELINE ECOLOGICAL FUNCTIONS AND CONDITIONS IN SNOHOMISH COUNTY

FEBRUARY 2006

Snohomish County

PLANNING & DEVELOPMENT SERVICES

SUMMARY OF SHORELINE ECOLOGICAL FUNCTIONS AND CONDITIONS IN SNOHOMISH COUNTY

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PROJECT DESCRIPTION

The Shoreline Management Act (SMA) requires each jurisdiction, subject to the SMA, to adopt a Shoreline Master Program that regulates shoreline uses and modifications. Preference is given to uses and modifications that depend on a waterfront location, protect the natural functions and ecology of the shoreline, and promote public access to waters of the state. The Snohomish County Shoreline Management Master Program was originally adopted in 1974 and last updated in 1993.

Snohomish County has received a grant from the Washington State Department of Ecology to prepare an update to its Shoreline Management Master Program (SMMP) consistent with the Shoreline Management Act Guidelines (WAC 173-26) adopted in December 2003. The SMMP is an element of the County's Growth Management Act (GMA) comprehensive plan, which means that the goals and policies of the SMMP are also goals and policies of the Comprehensive Plan.

This report is a summary of the analysis of shoreline conditions and ecological functions conducted as part of a comprehensive update to Snohomish County's Shoreline Management Master Program. Requirements for the content of this report are found in Washington Administrative Code (WAC) 173-26-201(3)(d). The purpose of this report is to characterize existing shoreline conditions and to summarize the health of shoreline ecological functions. This report is organized first by water body type (river and streams, lakes and marine shorelines). Rivers and streams are further organized by watershed or water resource inventory area (WRIA). Finally, this report highlights management issues that should be addressed in the Shoreline Management Master Program, and serves as a baseline from which the County can measure "no net loss" of shoreline ecological functions.

WHY UPDATE THE SHORELINE MANAGEMENT MASTER PROGRAM?

Snohomish County's Shoreline Management Master Program was originally adopted over 30 years ago. While it has been amended several times since adoption, it has been ten years since the last amendment in 1994. In the last thirty years, shoreline conditions, shoreline science and technology, and the state and federal regulatory environment have all changed dramatically. This update will ensure that the goals, policies and regulations in the shoreline master program reflect current conditions, technological and scientific advances and regulatory changes.

Changes in Shoreline conditions

Since 1974, land uses and the economic focus of the County have changed, and population has more than doubled. In 1974, the estimated countywide population in Snohomish County was 285,000 (including cities). By 2004, there were and estimated 644,800 people living in the county (not including cities).

Science and technology

In the last 30 years, additional research and study regarding shorelines and shoreline functions, the impacts of shoreline structures and modifications, and the habitat needs of various aquatic and terrestrial species that depend on shorelines has been published. New techniques for flood prevention and erosion control have been developed that have fewer impacts to shoreline ecological functions. Projects to enhance shoreline functions are regularly undertaken by both the public and private sectors. Finally, new data and mapping technology allow shoreline jurisdiction to be mapped more accurately.

Changes in State and federal regulations

Endangered Species Act (ESA)

In 1974, there were no species in Snohomish County listed as threatened or endangered by the federal government under the ESA. The listing of Bald eagles in 1978, Bull trout and Chinook salmon as threatened in 1999, and orcas in 2006, have significant implications for uses and development along shorelines subject to the SMA that were not considered in 1974.

Growth Management Act (GMA)

In 1991, the state adopted the Growth Management Act. The GMA mandates comprehensive land use and transportation planning, and requires consistency between elements of the comprehensive plan. Under the GMA, the goals and policies of the Shoreline Management Master Program became an element of the GMA comprehensive plan. The goals and policies of both plans must be consistent with each other. Snohomish County SMMP has not yet been evaluated and updated to be consistent with the County's GMA Comprehensive Plan.

Shoreline Management Act

In 2003, the State adopted new Shoreline Management Guidelines in WAC 173-26. All counties subject to the SMA are required to update their locally adopted SMPs to be consistent with these guidelines. Snohomish County is an "early adopter," working under a grant contract to update and adopt its SMP consistent with the new guidelines.

SHORELINE INVENTORY

Snohomish County has collected inventory data throughout shoreline jurisdiction pursuant to the requirements of WAC 197-26-201(3)(c). Inventory data is described in a bibliography and tables, and provided on a series of maps. All inventory materials are found on a CD-ROM in Appendix D. The maps found in this document are a summary of the maps found on the CD-ROM.

WHY CHARACTERIZE SHORELINE ECOLOGICAL FUNCTIONS?

One of the policies of the Shoreline Management Act (SMA) is the "protection against adverse effects to the public health, the land, and its vegetation and wildlife, and the waters of the state and their aquatic life, while protecting generally public rights of navigation and corollary rights incidental thereto." This SMA policy is implemented through the Shoreline Management Guidelines (hereinafter referred to as "the Shoreline Guidelines") found in Washington Administrative Code (WAC) Title 173-26. The Shoreline Guidelines require individual shoreline master programs (SMPs) to protect shoreline natural resources by protecting the ecological functions necessary to sustain the natural resources. They also require SMPs to contain provisions to ensure that there is "no net loss" of shoreline ecological functions. This report provides a summary of existing conditions that will form the baseline from which the county can measure "no net loss" of ecological functions.

REGULATORY ENVIRONMENT AND NATURAL RESOURCE PLANNING EFFORTS

Watershed Planning

"Snohomish County is participating in a regional salmon recovery planning initiative known as the "Shared Strategy for Puget Sound". The Shared Strategy initiative includes fourteen watershed salmon recovery planning groups, federal, state, and local governments, as well as private business and interest groups. The goal of the Shared Strategy is to create a regional salmon recovery plan that builds from the individual plans of the 14 Puget Sound Watersheds." Snohomish County is the lead entity for the planning efforts in the Stillaguamish (WRIA 5) and Snohomish (WRIA 7) Basins, and supports efforts in the Skagit and Lake Washington, Sammamish and Cedar River Watersheds (Jones and Stokes 2004).

Endangered Species Act

There are a total of eleven federal and state listed threatened and endangered wildlife species known or presumed to exist in Snohomish County. They include the orca whale, spotted owl, grey wolf, grizzly bear, Oregon spotted frog, sandhill crane, bald eagle, marbled murrelet, bull trout, and Chinook salmon (Puget Sound). The most commonly occurring of those is the bald eagle. Bald eagles are predominantly found along the shores of saltwater, lakes, and rivers. Nearly all bald eagle nests (99 percent) are within a mile of a lake, river or marine shoreline. Grizzly bear are rare, and may only be found in the far eastern portions of the County, on federal lands. The grey wolf and Oregon spotted frog were historically found in Snohomish County, but no sightings of these species have occurred in recent years.

Clean Water Act

The Clean Water Act (CWA) is a federal act, passed in 1972, that contains provisions to restore and maintain the quality of the nation's water. Section 303(d) establishes the Total Maximum Daily Load (TMDL) program. The 303(d) list is a list of water bodies that do not meet state water quality standards. The National Pollutant Discharge Elimination System (NPDES) is a national program that administers permits under the CWA and enforces its pretreatment requirements. Snohomish County, most cities and some private wastewater treatment facilities have NPDES permits for discharges from their stormwater systems and wastewater treatment facilities into waterbodies. Map 5 shows 1998 CWA 303(d) Listings.

All Natural Hazards Plan

Under the direction of the Federal Disaster Mitigation Act of 2000, Snohomish County is preparing a Natural Hazards Mitigation Plan that identifies hazards and prioritizes actions to increase public safety and reduce the potential effects of natural hazards. Hazards include floods, earthquakes, landslides, wildfires, volcanoes, tsunami, and severe weather (snow/ice/storms/tornados/wind) (Jones and Stokes 2004).

Flood Hazard Planning

Snohomish County has several plans and programs designed to prevent flood damage and address hazards from flooding, including the Stillaguamish River Comprehensive Flood Hazard Management Plan, the Cooperative Bank Stabilization Program, and Flood Hazard Permit regulations. Most areas within shoreline jurisdiction are within the 100 year floodplain of either the Snohomish or the Stillaguamish River, and are subject to these plans, programs and requirements. The SMA requires flood hazard planning to be integrated into local shoreline master programs.

GMA Critical Areas Regulations

Snohomish County is required by the GMA to update its critical areas regulations. Best available science for the protection of the functions and values of critical areas must be used to develop the updated critical areas regulations. Critical areas include: 1) wetlands, 2) areas with critical recharging effect on aquifers used for drinking water, 3) fish and wildlife habitat conservation areas, 4) frequently flooded areas, 5) geologically hazardous areas (Jones and Stokes 2004). Under state law, critical areas within shoreline jurisdiction are protected under the requirements of the local Shoreline Management Master Program. The local jurisdictions SMMP is required to provide protection for critical areas equivalent to what is contained in its critical areas regulations.

Comprehensive Planning (Growth Management Act)

Snohomish County just completed an update of its comprehensive plan as required under the GMA. The Snohomish County Shoreline Management Master Program is an element of the comprehensive plan. The GMA requires that all elements of the comprehensive plan be internally consistent.

Salmon Recovery Efforts and Shoreline Management

The listing of Chinook salmon as threatened under the federal endangered species act has resulted in efforts to characterize and assess the state of habitat and other ecological features important to the survival of salmonids throughout Washington, Idaho and Oregon. These efforts in Snohomish County have been conducted by watershed or water resource inventory area (WRIA) by various watershed planning groups and by Snohomish County Public Works Surface Water Management Division. The National Marine Fisheries Service (NMFS 1996) and several of the watershed plans and studies have identified environmental factors important for salmonid survival, and have developed indicators and thresholds to evaluate the conditions at the local level. While these indicators and thresholds were developed for evaluation of habitat for anadromous salmonids, they do provide a general assessment of the shoreline ecological functions in Snohomish County.

Methodology

Characterization of Ecosystem-Wide Processes and Ecological Functions

For this report, existing data, studies and analysis were used to generally characterize ecosystem-wide processes and ecological functions at the watershed level. The key reports are listed at the beginning of each section. At the planning segment level, the characterization of ecological functions relies heavily on the use of indicators. Indicators and the relationship of indicators to ecological functions are described at the end of this section.

PLANNING SEGMENT ANALYSIS METHODOLOGY

Step 1 – Literature and Map Inventory. Based on the inventory requirements of WAC 197-26-201(3)(c), Snohomish County collected documents and data that show or characterize existing conditions in Snohomish County. This data is described in a bibliography and tables, and provided on a series of maps. All inventory materials are found on a CD-ROM in Appendix D. Snohomish County also collected literature that describes indicators for determining the relative health of ecological functions as described in WAC 173-26-201(3)(d)(i)(C). Indicators are described below.

Step 2 – Map Shoreline Jurisdiction. See description below.

Step 3 – Create Shoreline Planning Segments. See Maps 1A and 1b. PDS staff divided shoreline jurisdiction into planning segments based on the following criteria:

Table II-1. Planning Segment Criteria

Waterbody	Segment Criteria
Rivers and Streams	• Existing EDT (Ecosystem Diagnosis and Treatment) model reaches created by Snohomish County Surface Water Management Department. These are based on confinement, gradient, and other channel characteristics. • City boundaries • Confluences • Shoreline structures such as bridges or dams. • Shoreline vegetation and land use patterns
Lakes	• Development patterns, Shoreline modifications, Lot size. • Shoreline vegetation patterns • Wetland areas
Marine shoreline	• Drift cell boundaries • City and tribal boundaries • Subbasin boundaries • Development patterns • Shoreline vegetation patterns

Step 3 – Calculate indicators for planning segments. Using GIS, Snohomish County calculated indicators for each planning segment, where data exists. This provided information on data gaps, since data has not been collected uniformly throughout shoreline jurisdiction.

Step 4 – Data collection. PDS and DIS staff reviewed air photos and inventory maps for each planning segment adding data for riparian conditions, marine sediment processes, land use and shoreline modifications, and to verify data and analysis from existing documents. Methodology for collecting feeder bluff and is contained in Appendix C.

Step 5 – Add Restoration Opportunities. PDS staff created a list of restoration project types based on restoration projects proposed in existing planning documents. Restoration project type appropriate for each planning segments was determined based on conditions in the segment and location of the segment in the watershed.

METHODOLOGY USED TO MAP SHORELINE JURISDICTION

Snohomish County staff used ARCinfo, a geographic information system (GIS) to update the location and extent of shoreline jurisdiction in Snohomish County based on the criteria found in WAC 173- 22-040. For rivers, the county relied on the list of 20 CFS points found in WAC 173-18, as mapped by the Department of Ecology. The methodology that was used is described below by water body type.

<u>Lakes</u>
Snohomish County's water body coverage was used as the base layer for capturing the lakes within shoreline jurisdiction. All lakes were queried out of this coverage. In order to capture all possible lakes within shoreline jurisdiction, all lakes that were 20 acres or larger were selected. Then all lakes that were listed in the WAC were added to this selection. Finally, a 200 foot area was delineated around these lakes to produce the analysis area around lakes. City and tribal jurisdictions were then extracted.

<u>Rivers</u>
Snohomish County's water body and water course coverages were used as the base layers in determining river shoreline jurisdiction. The SMA streams coverage obtained from the Washington Department of Ecology (DOE) was used for selecting the portions of rivers and streams in the county's coverages that flow at 20 cubic feet per second (cfs) or greater. The coverage is based upon current adopted river and stream points listed in WAC 173-18. Snohomish County's coverages were used because of their greater spatial accuracy. A 200 foot area was then delineated around these selected rivers and streams. City jurisdictions were then extracted.

Marine shorelines

Snohomish County's water body coverage was used as the base layer in determining marine shoreline jurisdiction. The ordinary high water mark was queried out of this coverage and then a 200 foot area was delineated. City and tribal jurisdictions were then extracted.

Associated shorelands

Under the SMA, wetlands and floodplains that are associated with waterbodies covered by the Act are also included within shoreline jurisdiction. The methodology used to determine associated areas is described below.

Wetlands

Snohomish County and National Wetland Inventory wetland coverages were combined. Then wetlands that intersected lakes or rivers were selected and added to the shoreline jurisdiction.

Floodplains

Areas where shoreline jurisdiction intersected FEMA 100 year floodplain were added to the shoreline jurisdiction area.

INDICATORS

The characterization of ecological functions for each planning segment relies heavily on the indicators used in the evaluation of habitat conditions for salmonids defined by the National Marine Fisheries Service (NMFS 1996) and by various other salmon conservation documents. Tables II-2, II-3, and II-4 provide a summary of the indicators, thresholds and data sources used in this report to characterize shoreline functions as "healthy," "adversely impacted," or "missing," as required by the Shoreline Guidelines in WAC 173-26-201(3)(d)(i)(II). In general, the term "healthy" corresponds to "properly functioning conditions" as defined by NMFS and used in many existing planning documents. In this document, the term is used where the evaluation criteria were based on the NMFS criteria in the source document. "Properly functioning conditions" means that the physical, chemical, and biological aspects of watershed ecosystems will sustain healthy salmonid populations. Properly functioning conditions generally defines a range of values for several measurable criteria rather than specific, absolute values.

RELATIONSHIP OF INDICATORS TO ECOLOGICAL FUNCTIONS

For the purposes of this analysis, specific studies to definitively determine the health of each of the functions have not been conducted. Instead, data has been collected that serve as "indicators" of the health of these functions. These indicators are described below in relation to ecological functions. The thresholds for what is considered "healthy", "adversely impacted" and "missing" are found in Tables II-1 through II-3.

Maintaining hydrologic flows and natural ranges of flow variability

Movements of water, whether as flowing streams, tides or waves, generate the energy necessary to scour, transport and deposit sediments (Richards 1982; Downing 1983). Storage of water, whether in surface features (ponds and wetlands) or in soils and sediments (shallow groundwater aquifers or hyporheic areas) provides for the near-surface availability of water (e.g., hyporheic flow and groundwater discharge) required by some species in aquatic and riparian areas often through periods of the year when little is available otherwise.

Total forest cover and impervious area can indicate changes in hydrologic flows from natural conditions (Harr et al. 1975; Hicks et al. 1991; Booth 1990; Booth and Reinelt 1993; Booth and Jackson 1997; Booth and Henshaw 2001; Booth et al. 2002). Loss of more than 35% of forest cover (or less than 65% total forest cover) or more than 7% impervious surfaces within a sub-basin are strongly correlated with changes in frequency and magnitude of peak flows in rivers and streams. Peak flows can cause scouring of channels, flooding, and excess sedimentation. Low flows can result in inadequate stream flow for salmonid migration, less dilution of pollutants, and less water available for human consumption. Flooding on lakes may indicate that run-off in the lake's watershed is overwhelming the water storage capacity of the lake.

Attenuating wave, flow and tidal energy

Floodplains are low-lying areas adjacent to rivers that are formed chiefly of river sediment and are subject to flooding. Flooding is a natural process that results in inundation and bank erosion. Floodwaters rise above the natural containment levels in rivers and streams as a result of periods of intense rainfall and/or snowmelt. Bank erosion is the process whereby river and stream banks are scoured or undermined by high velocity erosive flow. Ongoing bank erosion can result in movement or shifting of the channel, called channel migration. Unconstrained floodplains allow overbank flows that moderate floodwater velocity, recharging of groundwater, maintenance of surface water quality, provide habitat for salmonids and other aquatic species, and provide depositional areas for fine sediments (White 1991). The percent of shoreline armored with dikes or levees, and the location of roads, railroads and other corridors are indicators of the extent to which the river has been disconnected from its floodplain and to what extent these functions have been modified. On marine shorelines and lakes, wave and tidal energy is attenuated by beach profile and shoreline vegetation. On all shorelines, it is well documented that shoreline armoring changes the pattern and deflection of wave, current and flow energy, and can cause channel scour and erosion on adjacent unarmored properties. Clearing for shoreline development and armoring reduces shoreline vegetation that naturally stabilizes the shoreline against the erosive forces of wave energy (Gorton et al. 1992).

Developing pools, riffles, and gravel bars

Pools, riffles and gravel bars are important instream habitat features for aquatic species, especially salmonids. Large pools are required by salmon during rearing, spawning, and migration. They provide refuge from velocity, storm events and temperature changes. Channelization of the river due to armoring or diking, or other shoreline hardening, removal of large woody debris and other modifications limit channel forming functions that produce pools, riffles and gravel bars (Haas et al. 2003; Montgomery and Buffington 1997).

Recruitment / transport of woody and organic debris

Large woody debris (LWD) is generally meant to describe fallen riparian wood pieces that exhibit large size and are found in complex wood jams. LWD jams play an important part in creating channel features such as pools, and attenuating flow energy. It is also an important factor in the habitat complexity required by aquatic species (Harmon et al. 1986; Bisson et al. 1987; Leinkaemper and Swanson 1987; Andrus et al. 1988; Bilby and Ward 1989; Robison and Beschta 1990; Bilby and Ward 1991; Fausch and Northcote 1991; Montgomery et al. 1995; Beechie and Sibley 1997; Bilby and Bisson 1998). Frequency of LWD is an indicator of how well eco-system wide processes are functioning. Fifty pieces of LWD per kilometer is considered “properly functioning” conditions by the National Marine Fisheries Service. On average, the majority of LWD is recruited to water from forests growing within 45m (150ft) of water bodies. Thus, the amount and quality of shoreline vegetation is also an indicator of the health of this function. Large logs, imbedded and located in the high intertidal nearshore, alter nearshore wave and tidal patterns and alter deposition patterns of organic litter, or beach wrack and sediments, which support a variety of terrestrial and aquatic insects. Armoring of shorelines is another indicator of the health of this function. Hardened shorelines along rivers slow the movement of channels which, in turn, prevent the input of larger woody debris (Gorton et al. 1992).

Removing excessive nutrients and toxics

The State Clean Water Act establishes minimum standards for water quality to protect a variety of uses from consumption to recreation to habitat. Water bodies and segments of water bodies that do not meet minimum standards for clean water are placed on the “303d” list. The number of segments on the 303d list indicates whether shoreline functions that remove excessive nutrients and toxics are healthy or not. Nitrogen loading and consequent reduction in water quality that result in algae blooms and eutrophication of estuarine lagoons can be primarily attributed (70-90%) to upland residential development and the use of pesticides and herbicides (Lee and Olson, 1985).

Maintenance of water temperatures

The State Clean Water Act establishes minimum standards for temperature necessary to protect habitat functions. The number of segments on the 303d list indicates whether or not ecosystem-wide processes and functions that maintain water temperatures are healthy. The removal of riparian vegetation has resulted in stream temperature increases of 2-10C in June through August in the Pacific Northwest (Beschta et al. 1978). Conversely, the winter stream temperatures are thought to fluctuate significantly lower than normal as well, due to the loss of over story protection. These studies generally support the findings of Brown and Krygier (1970) that for summer periods when stream flow is normally low and air temperatures are high, loss of riparian vegetation results in larger diurnal temperature variations and elevated monthly and annual temperatures.

Microclimate

Riparian areas modify microclimates of terrestrial soils and upper nearshore sediments areas by reducing temperatures of soils and beach sediments, thereby reducing desiccation rates of soils/plants and marine benthic and epibenthic organisms. Riparian vegetation contributes organic debris (leaf litter and large woody debris (LWD)), increasing the habitat structure of the shoreline. The loss of riparian vegetation results in greater temperature extremes, both higher and lower in terrestrial soils and marine sediments. Also, the loss of riparian vegetation from the nearshore results in a decrease of organic debris and associated biota.

Stabilization of banks and sediment

Sediment

On rivers, sediment transported from upland areas and areas from within the channel determines the persistence of channel features such as pools, riffles, and gravel bars. The concentration of fine sediments above 12% in the substrate impact embryo survival and emergence success in Chinook salmon (SIRC 2005). On marine shorelines, sediment from eroding bluffs and banks is necessary to maintain the habitats for many nearshore species, especially forage fish. It is also necessary to maintain beaches and other shoreline features such as spits. Shoreline armoring and its relation to feeder bluffs on the marine shoreline indicates how well sediment processes function.

Bank Stability

Bank stability is important to both human safety and habitat for aquatic species. On rivers, bank instability contributes fine sediment to the channel. Bank erosion above a natural background level can also indicate hydrologic or sediment conditions that are out of balance. Bank instability can be caused by land use activities that result in clearing of riparian vegetation that reduces the ability of the bank to withstand erosive forces; activities that disrupt flow patterns, such as bridges; activities that result in excess sediment delivery; or activities that increase the flow volumes (run-off) causing scouring of the channel bed and banks. On rivers and streams, the National Marine Fisheries Service considers bank instability of less than 10% to be properly functioning, between 10-20% to be "At Risk" and more than 20% to be "Not properly functioning." On marine shorelines, unstable banks contribute sediment to the system that builds and maintains beaches and other shoreline and habitat features. Eroding bluffs and banks that are armored indicate areas where sediment processes are adversely impacted or missing. Intact vegetated buffers have been shown to provide invaluable slope stability. Healthy vegetated buffers provide slope stability by mechanical means via root and stem systems and uptake of soil moisture expire via evapotranspiration, over time promoting a self-perpetuating, efficient and permanent erosion control system (Menashe 1993).

Shoreline vegetation/Nutrient input

Shoreline vegetation adjacent to waterbodies has many important functions. Shoreline vegetation provides shade to keep stream temperatures cool, filters pollutants from run-off, provides large woody debris and organic litter that serves as sources of food and forage for many species, improves bank stability by attenuating wave and current energy, and provides space for migration, shelter and nesting for birds and terrestrial animals. Dead and fallen trees become large woody debris and provide space for hiding and forage for fish, insects and amphibians. Beach wrack (organic/plant material deposited on the beach that is derived from marine and terrestrial sources), provides habitat for grazers (amphipods and other taxa) that process the material into organic material utilized in the detritus based food web, and in turn are themselves utilized as prey for higher taxa.

Space or conditions for reproduction, nesting, forage, hiding

Habitat elements important to a variety of aquatic and terrestrial species include shoreline vegetation, large woody debris, sediment size and type, instream habitat features (pools, riffles, gravel bars) and water temperature and quality. Terrestrial insects are significant in juvenile salmonids diet. Riparian vegetation along marine shorelines is necessary habitat for these insects. Wildlife abundance and variety is due to disturbance elements common in naturally functioning riparian systems that create a mosaic of habitat patches (Greco 1999). Riparian habitats provide large mammals (e.g. opossum, beaver, fox, mink, otter, elk, and deer) with an abundance of prey and carrion, a productive and varied plant community, reduced winter snow accumulations, early spring green-up, aquatic habitat and transportation corridors (Raedeke et al. 1988). Aquatic species such as otter, beaver, nutria, muskrat, and mink are most affected by changes in size and composition of riparian areas (Raedeke 1988).

In general, streams with more complex substrates and velocities contain a more diverse invertebrate population (Karr 1997).

Marine riparian vegetation performs a number of increasingly recognized habitat functions at the interface between aquatic and terrestrial zones (Brennan and Culverwell in prep). Vegetated riparian zones deliver organic matter and invertebrate prey to the near shore (Simenstad and Cordell 2000) and create complex structure that is important for fish (e.g. refuge and spawning) and wildlife (e.g. bird nesting and roosting).

Marine riparian habitats occur at the interface between terrestrial and aquatic ecosystems. Brennan, 2004, indicated that 78.5% of the known wildlife species (amphibians, reptiles and birds) in King County were found to have a strong association with the marine riparian habitat. This percentage of species is suspected of having a dependence, or association with the riparian habitat (e.g. feeding, migration, reproduction, pre/nutrient production).

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Regional and Countywide Context

REGIONAL AND COUNTYWIDE CONTEXT

Snohomish County occupies approximately 2,197 square miles in western Washington State, bounded by Skagit County to the north, King County to the south, Chelan County to the east and Puget Sound to the west. There are 19 cities/towns that occupy 111 square miles; the remaining 2,086 square miles are unincorporated (Jones and Stokes 2004). Snohomish County is the third most populous county in the State, with a population of 644,800 in 2004 (WA State Office of Financial Management). See Maps 2A and 2B (General Reference).

POPULATION AND LAND USE

Existing Population

The estimated population of Snohomish County in 2004 was 644,800. It is estimated that approximately 82% of the population resides in cities and Urban Growth Areas (UGAs) and 18% resides in rural areas. Most existing population and development is located in cities and Urban Growth Areas in the western portion of the County.

Future Population

By the year 2025, the County is planning for an increase in population of 217,700 - 351,400 people for a total of 862,500 - 996,200 people. The Snohomish County Comprehensive Plan anticipates that most of the future population will be accommodated within and adjacent to existing cities and UGAs.

Future Land Use

The Snohomish County General Policy Plan contains the goals, policies and future land use designations of the Comprehensive Plan. The adopted Future Land Use Map maintains a predominance of Urban Low Density Residential in UGAs and Rural Residential and Resource lands outside of UGAs. Urban areas and population centers are predominantely concentrated in the western lowlands of the County, or within small cities in the lower river valleys.

Overall, existing UGAs make up 11% of the land area, rural residential areas make up 10% of the land area, Resource lands (Forestry, Agriculture, and Mineral lands) make up 70% of the land area, and water and other uses make up 9% (Snohomish County Comprehensive Plan 10-year Update). Snohomish County is in the process of the 10-year update of its Comprehensive Plan. This update will change the Future Land Use Map.

PHYSIOGRAPHY

Topography

The topography of Snohomish County is a landscape of highly variable land forms ranging from the rolling lowlands at sea-level, adjacent to Puget Sound, to plateaus and river valleys, to peaks as high as 10,541 feet (Glacier Peak) in the Cascade Mountains along the eastern edge of the County. Western Snohomish County generally consists of a series of glacially formed plateaus bisected by major rivers that drain from the Cascade Mountains into Puget Sound (Jones and Stokes 2004). The eastern portion of the County consists primarily of higher elevation foothills and the Cascade Mountains. Map 3 shows topographic relief for Snohomish County.

Drainage Patterns

All land within Snohomish County drains from east to west, except for WRIAs 8 and 9, into Puget Sound through four major river systems and smaller coastal streams that are part of five Water Resource Inventory Areas (WRIA) identified by Washington State. The headwaters of the Sauk, Suiattle, Skykomish and Stillaguamish Rivers originate within the boundaries of the Mount Baker-Snoqualmie National Forest. The Snohomish River watershed (WRIA 7) is the largest river system, draining 1,856 square miles of the southeastern and central portions of Snohomish and northern King County into Possession Sound near Everett. The Stillaguamish River (WRIA 5) is the second largest system, draining 700 square miles of the northern portion of the County into Port Susan and Skagit Bay near Stanwood. Swamp Creek, North Creek, Little Bear Creek and Bear Creek drain the southwestern portion of the County to the Sammamish River, Lake Washington and Shilshole Bay (WRIA 8). The remote northeastern areas of the County and a small area in northwest County drain to the Skagit River and Skagit Bay (WRIAs 3 and 4) (Snohomish County 10-year Update DEIS).

Geology

The geology of western Snohomish County consists of bedrock overlain by glacial sediments left by the advance and retreat of glaciers, and more recent sand and gravel deposits (alluvium) laid down by modern rivers. Much of the geology of Snohomish County and the Puget Sound was formed by the advance and retreat of glaciers south from British Columbia beginning in the Pleistocene era and ending 13,500 to 15,000 years ago. During the last period of glaciation, the Vashon Glacier deposited large quantities of rock and sediment in compositions called advance outwash, glacial till, and recessional outwash. Advance outwash is the deepest layer, and is exposed only in deeper troughs. It is composed of sand and gravel deposited from the melt water of the advancing glacier, and is the dominant source for groundwater in western Snohomish County. The next layer, Vashon Till, covers the largest surface area of any geologic unit in the western County. Compacted under the weight of glacial ice, Vashon till is a very dense, cohesive and unsorted mixture of sand, silt, clay and gravel that can be up to 100 feet thick. The upper layer of glacial sediments is the less consolidated Vashon Recessional Outwash, formed as melt water from the retreating glacier sorted sands and gravels into depositional beds up to 80 feet thick in many of the County's larger valleys (Jones and Stokes 2004).

Bedrock consisting of older sedimentary, volcanic and intrusive–igneous rocks underlies the glacial sediments and is commonly found near the surface in the eastern portion of the county (Jones and Stokes 2004). Map 4 shows erodible geology.

Soils

There are six major soil groups that predominate in Snohomish County. In the lowland river valleys soil types are generally of the Puget-Sultan-Pilchuck series consisting of nearly level, poorly to well-drained soils on floodplains. These soils formed in alluvium, from sediments laid down by rivers. Most of the rivers within shoreline jurisdiction fall into this category. The upland areas adjacent to Puget Sound are predominantely Alderwood-Everett series of well- to excessively-drained soils on till plains, terraces, and outwash plains. The eastern upland areas are predominantely of the Tokul-Pastik series that are moderately deep-well drained soils on till plains and terraces (General Soil Map of Snohomish County, WA, US Department of Agriculture Soil Conservation Service). The Alderwood-Everett and Tokul-Pastik soil types generally overlay Vashon Till, a very dense, cohesive and unstored mixture of sand, silt, clay, and gravel compacted under the weight of glacial ice. The glacial till acts as an infiltration barrier that can result in a seasonally high water table and lateral subsurface flows atop the till layer. Where the till layer intersects or is near steep slopes, water flowing atop the till layer can create erosion and landslide problems (Jones and Stokes 2004). The foothill areas are comprised of Elwell-Olomont-Skykomish series of very deep and moderately drained soils on mountainsides, ridge tops, terraces, and outwash plains. (General Soil Map of Snohomish County, WA, US Department of Agriculture Soil Conservation Service). Predominant soil types are described in Appendix B, shown on Map 20 and listed by planning segment in the subbasin tables.

CLIMATE

Snohomish County has a mild maritime influenced climate with cool, wet winters and mild summers. Precipitation is strongly influenced by the Cascade Mountains and is therefore highly variable, ranging from 30 inches per year near Puget Sound, to more than 185 inches per year at the crest of the Cascade Mountains on the eastern edge of the County (Pentec 1999). Precipitation does not vary significantly from north to south, except by elevation. Areas at higher elevations tend to receive more precipitation than those closer to sea level.

SHORELINE VEGETATION

European settlement patterns and logging have altered patterns and predominant vegetation types throughout the county primarily along the mainstems and in the lower valleys where most of the population resides and the majority of the urbanized areas are. These areas are now dominated by agricultural crops and small stands and discontinuous bands of hardwoods along the shoreline. The majority of the present riparian zones are either entirely devoid of trees or dominated by young stands of dense red alder or second-growth conifers (SBSRTC 2004, US Army Corps of Engineers 2000, Haas and Collins 2001, and Pentec 1999). Logging and related landuses in the upper basins of the Stillaguamish and Skykomish Rivers have resulted alterations similar to that which has occurred in the lower basins, but not to as great an extent. The upper basins are now characterized by a patchwork of early- to mid-seral forest stands and very little old-growth forest (Purser et al. 2003). Maps 15A and 15B show vegetation cover along major rivers. Maps 4A and 4B show land cover countywide, including areas with mature evergreen forest. Only a few basins contain more than 50% mature evergreen forest of sufficient age and size to contribute large woody debris to the system. They include: Boulder River, Gold Basin, Upper Canyon Creek, and Rapid River. Forest cover in remaining basins is a patchwork of early- to mid-seral forest stands (Purser, et al. 2003).

The following is a description of vegetation types that are found in Snohomish County shoreline jurisdiction based data, definitions, and text found in the EPA poster “Ecoregions of Washington and Oregon” (Pater, et al. 1998) . Each ecoregion has typical vegetation and landcover types which are described below. Text describing where these habitat types are found on Snohomish County rivers, lakes and marine shorelines is located in the sections pertaining to these waterbodies.

North Cascades Lowland Forests

The wet mild climate promotes lush forests that are dominated by Douglas fir and Western hemlock at elevations less than 3,200 feet. Western red cedar, Western hemlock, and Douglas fir are the predominant forest species. The North Fork of the Stillaguamish River, Upper South Fork of the Stillaguamish, Boulder River, Deer Creek, Squire Creek, and French Creek, Upper Skykomish River and Upper Sultan River and their tributaries are all located within this ecoregion.

Eastern Puget Uplands

Both the Puget Lowland and Cascadian vegetation association occur with the latter most common in areas of greatest elevation and precipitation. Douglas fir and Western hemlock forests are the predominant forest cover. Forestry, pasture land and cropland, and rural residential/suburban/urban development are predominant land uses. The Lower South Fork Stillaguamish, Middle and Upper Pilchuck River, Pilchuck Creek, Upper Woods Creek, West Fork Woods Creek, Upper Pilchuck Creek, Lower Sultan River, marine shoreline north of the Snohomish River and most lakes are located within this ecoregion.

Eastern Puget Riverine Lowlands

Western red cedar, Western hemlock, some alder, black cottonwood, big leaf maple, sitka spruce are common tree species. Western red cedar forest, Western hemlock forest and both riverine and wetland habitat were common before the 19th century. Subsequently, many of the wetlands were drained. Pastures, cropland, forests, and urban centers now dominate the landscape. The Lower Stillaguamish mainstem, Stillaguamish Estuary, Snoqualmie mainstem, Snohomish mainstem, Snohomish Estuary, Quilceda Creek, Lower Pilchuck River, Lower Skykomish, and Lower Woods Creek are located in this ecoregion.

Central Puget Lowlands

The central Puget lowland is the heart of Puget Sound both in physical and human terms. Its undulating drift plains are heavily urbanized in the east and more rural and forested in the west. Well-drained, gravelly soils are common and exhibit limited moisture holding capacity and rather low agricultural productivity. Western hemlock, Western red cedar, Douglas fir, red alder, big leaf maple are predominant tree species. North, Swamp, Little Bear Creeks, the marine shoreline south of Everett, Lakes Serene, Stickney and Martha Lake (South) are located in this ecoregion.

Marine Nearshore Vegetation

Aquatic vegetation found in the nearshore marine shoreline include plants found in estuarine marshes such as pickleweed (Salicornia virginica), salt grass (Distichilis spicata) and sedge (Carex Lyngbyei); plants found in subtidal areas such as eelgrass (Zostera marina and Zosteria japonica); and brown, red and green algae found in tidal and subtidal areas such as kelp (Laminaria spp.), sea lettuce (Ulva spp.), rockweed (Fucus spp.) and Sargassam muticum (Scagel et al. 1998 and Dethier 1990). Eelgrass and floating kelp beds provide some of the most productive habitat for marine organisms found in Puget Sound. Eelgrass is an underwater grass that grows in meadows or beds in shallow sandy or muddy subtidal areas. It is critical to the life cycle of salmon, crab, and herring, and provide food and shelter to wide variety other marine animals and birds. Large brown bull kelp grows in forests in rocky subtidal areas, and provides similar shelter and food for many marine animals and birds (Washington Department of Ecology website). Eelgrass and kelp beds, and estuarine marshes are critical saltwater habitats protected by the Shoreline Management Act.

WETLANDS

The county supports a full range of wetland vegetative communities including forested, scrub-shrub, emergent, aquatic bed, and open water. Typical tree species include Western red cedar (Thuja plicata), black cottonwood (Populus balsamifera var. trichocarpa), and red alder (Alnus rubra). Shrubs are generally represented by willow (salix spp.) Douglas spirea (Spirea douglasii), salmonberry (Rubus spectabilis) and red-osier dogwood (cornus sericea). Emergent plants include various sedges, rushes, grasses, and aquatic species (DEIS for the 10-Year Comprehensive Plan Update, 2005). Wetlands are shown on Maps 10A, B, and C.

Historically a variety of wetland types occurred in the lower mainstems of the Stillaguamish and Snohomish Rivers, but these wetlands have been substantially altered by European settlement patterns. Wetlands consisted of extensive salt water and brackish marsh, forested delta wetlands and freshwater wetlands. In intertidal areas, bullrush (*Scirpus maritimus*), Lyngby's sedge (*Carex lyngbyei*) and seaside arrowgrass (*Triglochin maritimum)* dominated (Bortleson 1980). The Snohomish River floodplain had large freshwater wetlands and an extensive cranberry bog (Pentec 1999). Most of the estuarine wetlands in the Stillaguamish estuary and most of the forested delta and floodplain wetlands of the Snohomish and Stillaguamish Rivers were drained and converted into agricultural lands or urbanized in the late 1800s.

The Snohomish and Stillaguamish Estuaries are discussed in more detail in the individual basin discussions.

FISH AND WILDLIFE HABITAT

"Wildlife habitat contains several essential elements: areas for breeding, shelter and foraging for food and water. Some of the more important areas that provide these elements include aquatic areas, riparian areas (upland areas adjacent to aquatic areas) and old growth forests (Snohomish County BAS)."

The following is a description of habitat types that are found in Snohomish County shoreline jurisdiction. Data, definitions and text are adapted from habitat types and associated species described in the CD Matrix "Wildlife-Habitat Relationship in Oregon and Washington" (O'Neill et al. 2000) and from descriptions in the "Reconnaissance Assessment of the State of the Nearshore Ecosystem: Eastern Shore of Central Puget Sound, including Vashon and Maury Islands (WRIAs 8 and 9)" (Williams et al. 2001). Text describing where these habitat types are found on Snohomish County rivers, lakes and marine shorelines is located in the sections pertaining to these waterbodies. Maps 4A and B show general land cover types, Maps10A, 10B and 10C show fish use of streams countywide, and known wildlife habitat is described by subbasin for rivers, by lake, or by planning segment in the section pertaining to these areas.

Marine Nearshore

The marine nearshore habitat in Snohomish County encompasses the area waterward from the high tide line and adjacent upland areas. Variability in nearshore habitats is influenced by degree of wave and current action, availability of sunlight, and presence of vegetation. Nearshore habitats include sand spits, banks and bluffs, marine riparian zones, beaches and critical saltwater habitats as defined by the shoreline management guidelines. Critical saltwater habitat within the Snohomish County nearshore include kelp beds, eelgrass beds, spawning and holding areas for forage fish, such as herring, smelt and sandlance; subsistence, commercial and recreational shellfish beds; mudflats, intertidal habitats with vascular plants, and areas with which a priority species have a primary association. There are 75 species of birds, nine marine mammals and one mammal associated with the nearshore (O'Neill et al. 2001). Based on Washington Department of Fish and Wildlife Priority Habitat and Species data, there are eight species of salmonids, five species of forage fish, six species of groundfish, and 14 species of rockfish associated with the Puget Sound nearshore. Numerous invertebrates use the nearshore including native littleneck, butter clam, Manila clam, geoduck, Olympia oyster, northern abalone, and Dungeness crab (Williams et al. 2001). Federal threatened or endangered species associated with the marine nearshore are the marbled murrelet, bald eagle, and Chinook salmon.

Freshwater aquatic areas and associated riparian areas

These habitats encompass freshwater waterbodies, such as rivers, streams, and lakes and adjacent riparian areas. Riparian areas adjacent to waterbodies provide cover, forage and shade for both terrestrial and aquatic species. Habitat structures and features are also located waterward of the ordinary high water mark in freshwater aquatic areas. On lakes the littoral zone at the edge of lakes is the most productive habitat area with diverse aquatic beds and emergent wetlands. Large woody debris in lakes provides cover and forage for a variety of species. River habitat elements that provide cover, forage and breeding areas for aquatic species include large woody debris jams, riffles, pools and glides. There are 17 amphibians, 115 birds, five reptiles and 23 mammals associated with open water habitats (O'Neill et al. 2001). Freshwater habitats support a variety of aquatic species including five species of pacific salmon, two species of native char (bull trout and Dolly Varden), and several species of anadromous salmonids and non-salmonids (Pacific lamprey and sturgeon), including resident and sea–run cutthroat and steelhead. Other resident freshwater fish species include large mouth bass, black crappie, small mouth bass, pumpkinseed sunfish, yellow perch, blue gill, and green sunfish. Federal threatened or endangered species associated with freshwater aquatic areas are the bald eagle, bull trout, and Chinook salmon.

Bays and Estuaries

Estuarine habitats are created where freshwater rivers enter saltwater. Estuarine habitat is characterized by significant mixing of salt and freshwater from riverine discharges and tidal influences. These areas include the lower reaches of rivers, intertidal sand and mud flats, saltwater and brackish marshes, and open water portions of associated bays. There are three large estuaries in Snohomish County. A small portion of the Skagit river estuary is located north of Stanwood. The Stillaguamish estuary is located south of Stanwood, and the Snohomish estuary is located north and east of the City of Everett at the mouth of the Snohomish River. There are 157 species of birds, 11 mammals, and one reptile associated with this habitat type (O'Neill et al. 2001). The habitat provided by estuaries is especially important in the life histories of anadromous salmonids, including Chinook salmon. Estuaries provide a transition zone that allows anadromous salmonids to adapt to saltwater environments. In addition, the diverse habitat (such as distributary channels, mud flats, and eel grass meadows) provides cover from predators and a wide variety of prey critical to the survival of juvenile salmonids. Federal endangered or threatened species associated with bays and estuaries are Chinook salmon, bald eagle, bull trout and the marbled murrelet.

Wetlands and associated riparian areas

This habitat includes all freshwater wetlands, both forested and herbaceous, and the vegetated areas adjacent to the wetland. Wetlands are characterized by periodic saturation or inundation by water during the growing season. The structure of forested wetlands are characterized by tall broadleaf deciduous trees such as alder, cottonwood and willow and/or conifers such as spruce, cedar, shore pine and white pine. Forested wetlands often occur adjacent to open water and as patches within the lowland-conifer forest. The structure of herbaceous wetlands is generally characterized by a mix of emergent grasses or grass-like plants, cattails, sedges and rushes. Common shrub areas on shorelines in and near wetlands include spirea, willow, dogwood, salmonberry, indian plum, and ninebark. "Natural wetland and riparian areas are biologically diverse and complex ecosystems that contain more plant, mammal, bird, and amphibian species than the surrounding upland areas (Snohomish County Draft BAS, P. 87)." There are 29 amphibians, 16 reptiles, 78 mammals, and 230 birds associated with wetland habitat types found within shoreline jurisdiction (Matrixes for Wildlife-Habitat Relationships in Oregon and Washington). Federal endangered or threatened species associated with wetlands are the sandhill crane, Chinook salmon, bull trout, bald eagle, and the marbled murrelet.

Lowland conifer-hardwoods

This habitat includes forest areas dominated by evergreen conifers and deciduous broadleaf trees. It includes both young (early seral) and old (late seral) stands of trees. The structure of the canopy and understories varies depending on the age of the stand and the nutrient and moisture content of the soils. Within shoreline jurisdiction, this habitat is found throughout the lowland areas primarily on rural hillsides, upland plateaus and areas outside of the floodplains. Patches of this habitat are found mixed with urban and agricultural habitat areas. In areas where this habitat is more extensive, wetlands and riparian areas occur as habitat patches within it. Old-growth and mature forest areas are an extremely important subset of this habitat. They have complex structural components and stand attributes that are different from other forests, including snags and down wood, multi-storied stands and deep canopy. They are important habitat areas for 312 plants, 149 invertebrates, 112 stocks of anadromous salmonids, four species of resident fish, and 90 terrestrial vertebrates. Federal endangered or threatened species associated with lowland conifer-hardwood areas in Snohomish County are Chinook salmon, bull trout, bald eagle, marbled murrelet, and spotted owl.

Agricultural and pasture areas

This habitat type consists of pasture and crop lands that occur primarily in the broad floodplains of the Stillaguamish, Snoqualmie, Snohomish, Skykomish and Pilchuck Rivers. Approximately 16% of land in shoreline jurisdiction is agricultural land. Agriculture and pasture areas contain several different cover types ranging from annual grasses and row crops, to tree farms and mature orchards. Habitat structure may vary annually and by season depending on the crops grown, and various methods of tilling and harvest. Cropland and pasture are the predominant cover types in Snohomish County (77%). There are approximately 220 birds, 90 mammals, 18 reptiles, and 16 amphibians associated with agricultural habitat (O'Neill et al. 2001). The agricultural lands in the Stillaguamish and Snohomish estuaries are especially important overwintering habitat for a variety of birds, including trumpeter swans and snow geese, and other waterfowl and shorebirds (Middaugh, 2005). Federal endangered or threatened species associated with agricultural areas are the sandhill crane and bald eagle.

Urban areas

Urban habitat areas are characterized by buildings, impermeable surfaces, bridges, dams and planting of non-native species. Tree canopy is generally discontinuous and total amount of understory is low. Lawns, hedges and topped trees are common vegetation types. Snags and diseased live trees are generally removed as hazards. Isolated wetlands and stream corridors, and open space have been retained as a result of regulations intended to protect aquatic species and habitat or in parks. In lower density development areas, patches of native vegetation and continuous tree canopy may be found within these areas. There are 149 species of birds, 18 amphibians, 21 reptiles and 76 mammals associated with urban habitat areas. The only federal threatened or endangered species associated with urban areas is the bald eagle. Species associated with wetland, aquatic and open water habitats may be found in patches of these habitats within urban area.

ALTERATIONS TO WATERSHED PROCESSES

"The flow of water, sediment, nutrients and materials into and through shorelines are the driving processes that determine the health of the overall system. Modifying or interrupting these ecosystem-wide processes may affect smaller scale processes (such as bank storage, hyporheic and overbank flows) and ecologic functions that occur within shoreline jurisdiction (Department of Ecology website)."

The following is a general description of alterations to watershed processes countywide. More specific descriptions of alterations to basinwide processes and functions are contained in the section specific to the individual basin.

Surface and groundwater flow

Water is delivered to Snohomish County rivers and streams as rain or snow falling in the eastern portion of the county. Most lakes are fed from precipitation that falls in the surrounding watershed, although there are several lakes that are fed by groundwater. Precipitation that falls on upland areas also percolates into the ground and is captured in aquifers located beneath the broad floodplains of the mainstem Snohomish, Stillaguamish and Skykomish Rivers. Historically, the channels of both the lower mainstem Stillaguamish and Snohomish Rivers migrated or meandered across the floodplain creating diverse habitats and plant communities. Large wetlands in the floodplains filtered water and moderated flow velocities. (Pentec 1999, US Army Corps of Engineers 2001, Haas and Collins 2001)

The most significant changes affecting the flow of water and channel morphology in the county are the result of forestry activities in the upper watersheds, loss of large woody debris throughout the system, and diking/armoring in the mainstem subbasins. Forestry activities have reduced forest cover in the upper watersheds, resulting in an increase of peak flows in the Stillaguamish Basin. Diking and channelization of the lower mainstems of both the Snohomish and Stillaguamish Rivers have disconnected the rivers from their floodplain and adjacent wetlands, reducing the function of the floodplain to moderate the velocity of flows. Dikes, armoring and channel modifications have also confined the lower mainstems to their channel, reducing or eliminating channel migration. (Pentec 1999, US Army Corps of Engineers 2001, Haas and Collins 2001, SIRC 2005)

Throughout the basin, there is a lack of instream large woody debris integral to routing of water and channel and pool forming processes. This has altered pool areas and frequencies, and limited channel complexity. The lack of LWD is attributed to clearing of riparian vegetation and removal of large woody debris jams from the channels for navigation, safety and flood protection purposes (Haas and Collins 2001, US Army Corps of Engineers 2001).

Historically, large wetlands in the floodplain of the lower mainstems moderated flows, and provided recharge to aquifers. In both the lower Snohomish and lower Stillaguamish basins, many have been filled and disconnected from the channel (Pentec 1999, US Army Corps of Engineers 2001, Haas and Collins 2001, SIRC 2005).

Sediment delivery and routing

Rivers and Streams

Sediment is delivered to rivers and streams in the upper basins by both natural and human mechanisms including run-off from logged areas, landslides, and bank erosion. Sediment is transported in river segments with steeper gradients, and finally deposited in the lower gradient portions of the rivers within the channel or upland during flooding. Sediment delivered at higher levels than the natural background level can cause changes in channel location, flooding, width, and alterations to pools and riffles that in turn affect the vegetation pattern and the habitat characteristics necessary to support aquatic and terrestrial species.

In Snohomish County, channelization and diking of the lower mainstem rivers has reduced the frequency of overbank flows, and subsequently reduced the deposition and distribution of sediment across the floodplain. Excess sediment is documented in the Stillaguamish River, where it threatens salmonid survival (SIRC 2005), and in some lowland tributaries to the Skykomish River (Haring 2002).

Marine shorelines

Sediment is delivered to beaches along the marine shoreline from upland bluffs that slough and fall onto the beach. Wind and currents distribute sediment to adjacent beaches ("littoral drift"). The presence of sediment is integral to the formation and variation of nearshore aquatic habitats for plants as well as animals (Williams et al. 2001). Sediment delivery is interrupted by bulkheads and other shoreline structures which prevent sediment from reaching the beach. Transport of sand along the nearshore can be interrupted and by shoreline structures constructed on the beach or in the water (Williams and Thom 2001). Sediment processes in the north portion of the county function to deliver and transport sediment, with few interruptions. Sediment delivery and transport processes south of Everett have been eliminated by the railroad corridor.

Nutrients and toxics delivery and routing

Run-off from agricultural and residential uses, sewage treatment plant outfalls and failing septic systems all contribute to high levels of fecal coliform bacteria, phosphorus and nitrogen into rivers and streams in Snohomish County (SWM 2000a). Riparian vegetation and wetlands capture or slow the entry of pollutants into waterbodies. Logging and clearing of riparian vegetation and filling of wetland areas has further exacerbated water quality problems throughout the County. Water quality is the poorest in the mainstems of the Stillaguamish and Snohomish rivers where the greatest alterations to forest cover, channel complexity, riparian vegetation, and wetlands have occurred.

Large Woody Debris/Organic materials delivery and routing

Delivery of LWD/organic materials is limited primarily by a lack of late seral forest and riparian vegetation throughout shoreline jurisdiction due to historic logging and settlement patterns (Haas et al. 2003, Purser et al. 2003, US Army Corps of Engineers 2001). In addition to a general lack of organic materials available for recruitment, modification, ditching and diking of the mainstem rivers beginning in the mid- to late-1800s altered the natural processes that create a diverse landscape of plant communities and successional stages. The majority of the present riparian zones is either entirely devoid of trees or dominated by young stands of dense red alder or second-growth conifers (US Army Corps of Engineers 2001, Haas and Collins 2001 and Pentec 1999). Removal of log jams for flood protection and navigation has been a regular activity in the lower mainstem rivers. Along the marine shoreline, the Burlington Northern Railroad corridor has disconnected the upland vegetation from the nearshore, effectively eliminating delivery of organic materials for the southern half of the marine shorelines of the County. Along lake shorelines, residential development has limited the availability of organic material on some lakes, other lakes are functioning normally.

RESTORATION OPPORTUNITIES

The individual salmon conservation plans, findings of the Marine Resources Advisory Committee, Noxious Weed Control Board, Snohomish County Lake Management Program and the Drainage Needs Reports have all identified a number of proposed restoration projects and areas with potential for restoration within shoreline jurisdiction. The restoration project types are defined below. Restoration project types appropriate to the conditions found in each planning segment are found in the tables in the applicable waterbody section.

I – Develop and maintain programs to protect and restore shoreline natural resources and functions. Educate and provide assistance to property owners and the general public on how to protect and restore habitat and shoreline functions.

II – Restore riparian areas. Activities include planting of riparian, aquatic and backshore vegetation and maintenance.

III – Protect and restore estuaries. Protect existing mudflats, marshes, scrub- shrub and forested wetlands, and properties with high potential to be restored to tidal function.

IV – Add large woody debris. Place large woody debris jams or beach logs to restore sediment, habitat and channel functions.

V – Restore channel and floodplain conditions. Restore channel configuration, create or reconnect off-channel habitat and blind tidal channels, breach and setback dikes to restore natural floodplain and tidal function.

VI – Protect and restore sediment processes. Protect forest cover, treat forestry roads, remediate landslides, enhance bridges, and beach nourishment.

VII – Restore fish passage. Replace culvert, tidegates, dams and fish ladders and other structures that impede migration.

VIII – Protect and Restore wetlands. Restore hydrology and vegetation in freshwater, estuarine and backshore wetlands.

IX – Acquire/remove shoreline structures. Acquire and remove bulkheads, armoring, residences, marinas, piers, and other structures to restore shoreline function.

X – Protect Existing Habitat. Purchase critical and intact habitat areas outright, purchase easements, or protect them through regulations.

XI – Invasive Weed Control. Remove and prevent noxious and invasive aquatic and riparian vegetation.

SHORELINE JURISDICTION

The SMA applies to all marine waters of the state, all streams and rivers with a mean annual flow of more than 20 cubic feet per second, all lakes and reservoirs 20 acres in area or larger, all associated wetlands, and the upland areas within 200 feet of the Ordinary High Water Mark (OHWM) of these waterbodies. For streams and rivers, SMA jurisdiction includes the river or stream, the floodway plus 200 feet or the entire floodplain, and the portions of the river delta not protected by flood structures. It also includes all wetlands in the floodplain. In Snohomish County, the floodway has not been delineated throughout the county, so the entire floodplain is used. There are 41 lakes in unincorporated Snohomish County subject to the SMA are listed in WAC 173-20-640 and in Appendix A. In addition to the lakes listed by this section of the WAC, there are nine lakes that are not listed in the WAC but are over 20 acres in area. These are also listed in Appendix A, and described in more detail in the lakes section of this report.

There are more than 40 miles of marine, 1,800 miles of river (counting both banks) and 114 miles of lake shorelines in Snohomish County subject to the SMA. Maps 7A and 7B show shoreline jurisdiction and shorelines of statewide significance.

Shorelines of Statewide Significance

The SMA provides a special set of policies for larger and more regionally important water bodies identified as “shorelines of statewide significance.” In addition to the goals and policies of the SMA, seven additional policy directives give additional priority and preferences to uses which 1) recognize and protect the state-wide interest over local interest; 2) Preserve the natural character of the shoreline; 3) result in long-term over short-term benefit; 4) protect the resource and ecology of the shoreline; 5) increase public access to publicly owned areas of the shorelines; 6) increase recreational opportunities for the public in the shoreline; and 7) provide for any other element as defined in RCW 90.58.100 deemed appropriate or necessary (RCW 90.58.020).

Criteria defining Shorelines of Statewide Significance in Snohomish County are found in RCW 90.50.030 and include those areas of Puget Sound and the Strait of Juan de Fuca and adjacent salt waters north to the Canadian line and lying seaward from the line of extreme low tide; lakes, whether natural, artificial, or a combination thereof, with a surface acreage of 1,000 acres or more measured at the ordinary high water mark; natural rivers or segments where the mean annual flow is measured at 1,000 cubic feet per second or more; and shorelands associated with these areas.

The following shorelines are Shorelines of Statewide significance: Lake Stevens, Spada Lake, Sauk River, Stillaguamish River (including North and South Forks), Stillaguamish Estuary, Snoqualmie River, Snohomish River, Snohomish River Estuary, Skykomish River (including North Fork), and all marine shorelines below the line of extreme low tide. Shorelines of Statewide Significance are shown on Maps 7A and 7B.

Land Use

Based on Snohomish County Assessor data from 2003, the primary land uses in shoreline jurisdiction are single-family residential or duplex (64%), resource production (agriculture, forestry, mineral extraction) (20%), undeveloped (8%), parks and other publicly owned land (5%). Commercial, industrial, private recreational, transportation and other uses together make up less than 3% of the land area. The majority of shoreline areas are in rural areas outside of UGAs. Only 2.4% (3,220 acres) of the entire area subject to shoreline jurisdiction is within unincorporated urban growth areas. Maps 9A and 9B show existing land uses within shoreline jurisdiction based on Snohomish County Assessor data.

Cities and Urban Growth Areas

The cities of Woodway, Edmonds, Mukilteo, Everett, Bothell, Mountlake Terrace, Snohomish, Lake Stevens, Sultan, Goldbar, Index, Granite Falls, Arlington, Stanwood and Marysville all have areas subject to the SMA. Of these, Monroe, Sultan, Goldbar, Snohomish, Lake Stevens, Darrington and Granite Falls have unincorporated areas within their UGAs which are subject to the County's Shoreline Master Program.

Rivers and Streams

STILLAGUAMISH RIVER BASIN

GENERAL CONTEXT

Background Documents

Existing conditions in the Stillaguamish Basin are documented in the WRIA 5-Draft Chinook Salmon Recovery Plan, the Limiting Factors Report for WRIA 5, the 2001 Land cover Analysis report, the Stillaguamish River Watershed Temperature Total Maximum Daily Load Study, the Department of Ecology 303d list, Environmental Assessment of the Stillaguamish River Ecosystem Restoration, the Comprehensive Plan 10-year Update DEIS, and the Stillaguamish River Bank and Physical Habitat Survey. The following is a summary of the data and analysis in these reports.

Location

The Stillaguamish Basin drains 700 square miles in the north part of the County. There are 2,198 miles of rivers and streams in the basin, of which 321 miles are shorelines of the state. The four largest tributaries to the Stillaguamish are Pilchuck, Deer, Boulder and Canyon Creeks (SIRC 2005).

Physiography

The Stillaguamish can be divided into three main regions: the North Fork, the South Fork and Mainstem. The two forks join in Arlington, 18 miles from the mouth. Elevations in the watershed range from sea level to 6,841 feet. There are 21 sub-basins in the watershed.

Land use

The watershed includes land in Snohomish County, Skagit County, the cities of Arlington, Stanwood, and Granite Falls and Stillaguamish and Tulalip Tribal Land. Land use within the Stillaguamish basin is 76% forestry, 17% rural, 5% agriculture, and 2% urban (SIRC 2005). Land use within shoreline jurisdiction (a subset of the basin) is shown on Maps 7A and 7B.

Floodplains and Channel Migration Zones

The floodplain of the Stillaguamish River is widest from its delta in Port Susan to its confluence with the North and South Forks. The North Fork has a narrower floodplain, and the South Fork is confined by geology and has a few relatively limited floodplain areas. The entire floodplain is the area within which the river channel migrated over thousands of years. The area within which the channel is likely to migrate within 100 years is called the Channel Migration Zone" or CMZ. The floodplain and channel migration functions are constrained or limited by dikes in the lower mainstem, and by SR 530 and the Whitehorse trail along the North Fork. Maps 8A and 8B show FEMA floodplains and floodways; the channel migration zone; and roads, dikes and other structures that may impact floodplain and channel migration functions.

Fish and wildlife habitat

All habitat types described in the general overview are found in the Stillaguamish watershed, with agricultural, estuarine and lowland conifer forest habitats being the most predominant habitat types. In addition to the birds, mammals, amphibians and reptiles listed earlier, the Stillaguamish watershed supports five species of pacific salmon, two species of native char, two species of anadromous trout, and several non-commercial resident species (US Army Corps of Engineers 2001). Threatened or endangered species found in the Stillaguamish Basin include the bald eagle, Chinook salmon, bull trout, marbled murrelet, sandhill crane, and Grizzly Bear (eastern extent of basin).

PUBLIC ACCESS

Thirteen planning segments (30%) in the Stillaguamish basin have at least one developed or planned public access owned by the County (82%), the Washington State Department of Fish and Wildlife (9%), or a City (9%). Twenty-five planning segments (56%) do not have existing developed access, but are on or adjacent to publicly owned land (County, State or Federal) that could potentially have public access. Forty-five percent of potential access' are County owned, 17% are owned by the Washington Department of Fish and Wildlife, and 13% are owned by the Washington Department of Natural Resources. Three planning segments on the lower South Fork Stillaguamish and three segments on mainstem do not appear to have any existing or potential public access. Specific public access points for each segment are shown on the corresponding inventory map found on the CD accompanying this report.

Table IV-1. County parkland providing public access

WRIA 5-Stillaguamish River	Acreage	Water Frontage
Centennial Trail	49.45	11 stream crossings
Cicero Pond	140	North fork Stillaguamish River
Jordan Bridge	1.35	South fork Stillaguamish River
Loma Lake	1.93	Loma Lake
CT North Trailhead	82.59	Tributary 80
Portage Creek Wildlife Area	160.31	Portage Creek
River Meadows	150.4	South fork Stillaguamish River
River Terrace	0.63	South fork Stillaguamish River
Riverscene	1.7	South fork Stillaguamish River
Robe Canyon	970.84	South fork Stillaguamish River
Silvana River Park	0.5	Stillaguamish River

WRIA 5-Stillaguamish River	Acreage	Water Frontage
Squire Creek	29.73	Squire Creek
Steelhead Haven	0.32	North fork Stillaguamish River
Stilly River Homesites	0.22	South fork Stillaguamish River
Trafton Trailhead	111.95	North fork Stillaguamish River
Twin Rivers County Park	49.35	Stillaguamish River Confluence
Whitehorse Trail	388.11	16 river/stream crossings
Subtotal:	**2,139.38**	

SHORELINE ECOLOGICAL FUNCTIONS

In Snohomish County, analysis of the ecosystem-wide processes and functions for rivers and streams have been conducted and summarized for all of the basins through WRIA planning and salmon recovery documents. The analysis in these documents as it applies to the requirements of the Shoreline Management Act is summarized and presented below. A description of the ecological functions and the indicators, and methodology used to characterize river and stream shorelines is contained in Appendices B and C. The results are summarized below.

Maintaining hydrologic flows and natural ranges of flow variability

Total forest cover in the Stillaguamish Basin is approximately 53%, with individual sub-basin forest cover ranging from 14% to nearly 85% (See Map 11). Loss of more than 35% of forest cover (or less than 65% total forest cover) within a basin is strongly correlated with changes in frequency and magnitude of peak flows. Fifteen of 22 sub-basins have less than 65% forest cover. Mean daily discharge in cfs (cubic feet per second) for the North Fork Stillaguamish ranges from a high of 3,055 in December to a low of 463 in August, with more than 1,500 cfs discharged each month between October and June. Mean daily discharge in cfs (cubic feet per second) for the South Fork Stillaguamish ranges from a high of 1,663 in December to a low of 299 in August, with more than 1,000 cfs discharged each month between October and June.

<u>Peak flows</u>

Records show that peak flows in the North Fork of the Stillaguamish River are increasing in both frequency and magnitude. Changes in peak flow frequencies have been attributed to land use practices resulting in deforestation, filling and draining of wetlands, reduction or elimination of floodplain connectivity due to construction of dikes, levees and revetments, and surface and groundwater withdrawals in areas of direct hydrologic continuity (SIRC 2005).

<u>Low Flows</u>

Potential low instream flows has been identified as factors impacting aquatic habitat in the Stillaguamish -Lower Mainstem, Jorgenson slough/Church Creek, Glade Bekken (Tributary 30 Creek), Pilchuck Creek, Armstrong Creek, Harvey Creek, and the North Fork Stillaguamish, from Oso to Whitehorse (Stillaguamish

– WRIA 5 Draft Chinook Salmon Recovery Plan). The Washington Department of Ecology has proposed a new rule (WAC 173-505) to protect instream flows in the Stillaguamish River Basin. The new rule would limit ground and surface water withdrawals in the basin to protect resources that depend on flowing water – such as fish, wildlife, recreation, navigation, water quality, and livestock watering.

Floodplain connectivity

Unconstrained floodplains provide habitat for salmonids, allow overbank flows that moderate floodwater velocity, and provide depositional areas for fine sediments. The Stillaguamish has been largely disconnected from its floodplain by dikes, levees and other flood control structures and bank modifications. In the lower mainstem Stillaguamish, which has the largest floodplain, 53% of banks are confined by dikes, levees or other armoring (SIRC 2005). Maps 13A and 13B show shoreline armoring countywide. Diking and channelization of the lower mainstem has reduced the function of the floodplain to moderate the velocity of flows, and confined the lower mainstem to its channel, reducing or eliminating channel migration and habitat complexity.

Developing pools, riffles, and gravel bars

All segments in the Stillaguamish River are considered to be “not properly functioning” for pool frequency. Three reaches in the Mainstem and North Fork-9 meet “properly functioning” criteria for pool area (Haas et al. 2003). The lack of pools and channel complexity is likely due to channel modifications in the lower floodplains, and an overall lack of LWD that is integral to the formation of pools and the retention of sediment.

Recruitment/transport of woody and organic debris

Overall, large woody debris is missing throughout the Stillaguamish River Basin. There are four segments in the Stillaguamish River that meet “properly functioning” conditions: Boulder River-1 and 2, Squire Creek-2 and North Fork-9. The upper segments of the North Fork in French-Segelson subbasin had the highest number of LWD jams, nearly five times the frequency found in downstream segments (Haas et al. 2003) and nearly reaching the “properly functioning” threshold. Maps 14A and 14B show frequency of large woody debris. Page II-5 describes properly functioning conditions for large woody debris.

Removing excessive nutrients and toxics

High levels of fecal coliform bacteria, sediment and low levels of dissolved oxygen are the primary cause of water quality problems in the Stillaguamish Watershed. In 1998, 13 river and stream segments did not meet state water quality standards for fecal coliform bacteria, five segments did not meet requirements for dissolved oxygen, one for arsenic and one for pH. The segments or portions of segments not meeting standards for bacteria are North Fork-1, North Fork-4, North Fork-5, Portage Creek, Church Creek, Mainstem-4B, Mainstem-3, Jim Creek, South Fork-1, South Fork-3B, South Fork-4, Old Stilly-1, Hatt-1. Probable sources of bacteria are septic systems, farm animals and pets in the North and South Forks. In the mainstem Stillaguamish, SWM monitoring data indicate that temperature, bacteria, nutrient, and sediment all increase going downstream from Arlington to Marine Drive. Sources of pollutants in the lower watershed are livestock on the banks of the river, agriculture, discharges from sewer treatment plants, and failing septic systems coming from the tributaries. Nutrient loading from fertilizers, manure and septic systems are problems on Portage Creek and Church Creek. Pilchuck Creek has been found to have the best water quality of all of the tributaries to the Lower Stillaguamish River. (SWM 2000a). The State Department of Ecology has developed the Stillaguamish River Watershed Water Cleanup plan, and established Total Maximum Daily Loads for Bacteria, Dissolved Oxygen and Temperature. Based on the 2004/2005 proposed 303d list, an additional 17 segments do not meet fecal coliform bacteria requirements. Map 6 shows the location of 1998 Clean Water Act 303d listings. Implementation of livestock management programs, repairing failing septic systems, and revegetation of sensitive areas would reduce sediment, bacteria and nutrients (SWM 2000a).

Maintenance of water temperatures

In 1998, 12 stream and river segments were not meeting state water quality standards for temperature and were placed on the 303d list. The segments not meeting the criteria in 1998 were Deer Creek near its confluence with the North Fork upstream, Squire Creek, Higgins Creek, Little Deer Creek, Pilchuck Creek near its confluence with the mainstem, several segments of the mainstem, the South Fork upstream of its confluence with Canyon Creek, and near its confluence with the North Fork. Forestry and clearing of riparian vegetation are the probable sources of high temperatures in Pilchuck Creek, Deer Creek, Squire Creek and the Stillaguamish mainstem (SWM 2000a). In 2001, 23 segments were found to not meet state water quality standards for temperature, including Canyon Creek, Deer Creek, Glade Bekken, Jim Creek, Pilchuck Creek, Stillaguamish River, North Fork Stillaguamish River, and the South Fork Stillaguamish River. Revegetation of riparian areas can help reduce water temperatures (DOE 1998). Map 6 shows segments on the Department of Ecology's 303d list, including those listed for high temperatures.

Stabilization of banks and sediment

Sediment

Excessive sedimentation in the Stillaguamish Basin is due to timber harvest and road construction, bank erosion in the North Fork and landslides at Steelhead

Haven and Gold Basin. These land use activities in areas where the natural geology is susceptible to erosion and slope failures have aggravated sediment problems (SWM 2000a). The Lower and Middle North Fork Stillaguamish River, Lower Canyon Creek and the South Fork Stillaguamish drainages exceeded fine sediment criteria (SIRC 2005). Work on federal and private forestlands to stabilize old logging roads will prevent erosion and landslides.

Bank Stability

Bank instability contributes fine sediment to the channel. Bank erosion above a natural background level can also indicate hydrologic or sediment conditions that are out of balance. Segments in the South Fork of the Stillaguamish, except for one, are "properly functioning." In the North Fork of the Stillaguamish River, the majority of segments are "at risk," and only one reach (NF-1) meets properly functioning criteria. The uppermost segments of the North Fork are "not properly functioning." (Haas et al. 2003). Bank instability can be caused by land use activities that result in clearing of riparian vegetation that reduces the ability of the bank to withstand erosive forces; activities that disrupt flow patterns, such as bridges; activities that result in excess sediment delivery; or activities that increase the flow volumes (run-off) causing scouring of the channel bed and banks.

Shoreline vegetation

Shoreline vegetation within shoreline jurisdiction is generally poor throughout the Stillaguamish Basin. Much of the shoreline vegetation has been cleared or harvested in the last century for forestry or agricultural purposes, for residential development and for transportation corridors. Only South Fork-6, on the South Fork of the Stillaguamish has healthy shoreline vegetation having both mature conifers and a wide riparian buffer. Approximately 37% of segments, while not considered healthy due to the age and/or composition of the vegetation, have a continuous riparian corridor adjacent to the river or stream that some habitat, shading and filtering functions. They include Pilchuck Creek-2 and 3, Boulder-2, North Fork-1, 3, 5, 6, 7, 8 and 9, Squire-2 and 3, Canyon -1, 2B,3 and South Fork-3B, 4, 5 and 6. 14% of segments are adversely impacted or have patchy shoreline vegetation. Shoreline vegetation is shown on Maps 15A and 15B and described in the tables at the end of this section.

Space or conditions for reproduction, nesting, forage, hiding

Habitat elements important to a variety of aquatic and terrestrial species include floodplain connectivity, riparian vegetation, large woody debris, sediment size and type, and water temperature and quality. Sediment, water quality, floodplain connectivity and temperature conditions are addressed above. The Stillaguamish estuary and adjacent agricultural lands are important overwintering areas for many species of birds, including trumpeter swans and snow geese (Middaugh, personal communication, 2005). According to WDFW Priority Habitat and

Species (PHS) data, the Lower Stillaguamish sub-basin (shoreline segments Hatt 1-2, Old Stilly-1, Mainstem 1-4B, and Hatt Slough 1-2), the Skagit Flats South (shoreline segments Can 1 and 2), the Boulder River (shoreline segments Boulder 1 & 2) have the highest concentrations of waterfowl and priority habitat areas. The Lower Stillaguamish basin contains more than 2,000 acres of priority habitat area and over 1,000 acres of waterfowl concentrations.

Overall, habitat conditions necessary to support aquatic species appear to be poor throughout the basin. Habitat complexity has been reduced or eliminated by diking and channelization of the lower mainstem and by a lack of large woody debris in the channel. Excess sediment in the river is likely impact embryo survival and emergence success in salmon (SIRC 2005). North Fork Chinook spawn in the middle and upper forks of the North Fork Stillaguamish, and some of the larger tributaries (Boulder, Squire, Deer and French Creeks). South Fork Chinook spawn in tributaries, including Jim Creek and Canyon Creek, and some limited spawning above the Granite Falls fish ladder. Both use the entire river for rearing, with fry spending between one month and a year in freshwater before migrating to the estuary (SIRC 2005).

BASIN SUMMARY

Ecosystem-wide processes and ecological functions that have been altered in the basin include water flow, sediment processes, LWD recruitment and transport, water quantity, water quality and habitat conditions. There are many factors that contribute to the altered conditions, both man-made and natural. Most alterations can be attributed primarily to a combination of land use activities and natural geologic conditions.

Higher, more frequent peak flows are occurring in the Stillaguamish likely due to clearing of vegetation in the upper basins which reduces the ability of the soil and vegetation to moderate and infiltrate surface run-off. Channelization and diking of the lower river below Arlington for agriculture and flood control purposes has limited or eliminated the ability of the river to move within its channel and reduced habitat complexity (SIRC 2005, US Army Corps of Engineers 2001).

The geology in the Stillaguamish basin is susceptible to landslides. Natural and human induced landslides have resulted in excess sediment input in the system, which threatens salmonid survival and affects channel forming functions. Human induced landslides are primarily a result of forestry activities (especially logging roads) (SIRC 2005).

Clearing of riparian vegetation throughout the basin for residential, agricultural and forestry uses has resulted in a lack of LWD available for recruitment. The lack of instream LWD in turn affects the ability of the system to form pools, riffles, gravel bars and other geomorphic features. Clearing of riparian vegetation also contributes to water quality problems, as there is insufficient vegetation to filter run-off before it enters the river in many places.

Restoration activities that could improve ecological functions and eco-system wide processes in the basin include: remediation of landslides, logging roads and other activities that contribute excess sediment; revegetation of riparian areas to provide shade to cool water temperatures, filter run-off and to provide a source of LWD and organic materials; reconnecting floodplain wetlands and tidal sloughs to increase habitat complexity; and reforestation of upper basins to moderate run-off and the velocity of peak flows (SIRC 2005).

SNOHOMISH RIVER BASIN

GENERAL CONTEXT

Background Documents

Existing conditions in the Snohomish Basin are documented in the WRIA 7 Salmon Conservation Plan, Snohomish River Basin Conditions and Issues Report, the 2001 Land cover Analysis report, Snohomish Basin Ecological Analysis for Salmon Conservation, the Comprehensive Plan 10-year Update DEIS, the Department of Ecology 303d list and the Big River Survey. The following text summarizes the data and analysis in these reports.

Location

The Snohomish Basin drains 1,856 square miles in the south part of Snohomish County and the north part of King County. There are 2,718 miles of rivers and streams in the basin, of which 529 miles are shorelines of the state (SBSRF 2005). The three major river systems in the Snohomish Basin are the Snohomish, Skykomish and Snoqualmie. The North Fork and South Fork of the Skykomish join near the Town of Index. The mainstems of the Snoqualmie River and the Skykomish River join south of Monroe, and become the Snohomish River. The Snohomish and Skykomish Rivers and their tributaries are primarily located in Snohomish County. The majority of the Snoqualmie River and its tributaries are located in King County.

Land use

The watershed includes land in Snohomish County and King County. In Snohomish County, it includes the cities of Everett, Monroe, Lake Stevens, Marysville, Snohomish, Sultan, Gold Bar, Index and the Snohomish and Tulalip Tribes. Land use within the Snohomish basin is 75% forestry, 17% rural, 5% agriculture, and 4% urban (Pentec 1999).

Floodplains and Channel Migration Zones

The floodplain of the Snohomish River is widest from its delta in Port Susan to its confluence with the Skykomish River. The river within this portion of the floodplain has a relatively low gradient, and been confined by dikes and channelization. The mainstem of the Skykomish River from its confluence to the City of Goldbar also has a wide floodplain, and a significantly higher gradient. The high gradient and sediment load have resulted in a river with a dynamic channel and a wide channel migration zone between Sultan and Goldbar, called the "braided reach." The entire floodplain is the area within which the river channel migrated over thousands of years. The area within which the channel is likely to migrate within 100 years is called the Channel Migration Zone (CMZ). The floodplain and channel migration functions are constrained or limited by dikes in the lower mainstem, and by SR 2 and the Burlington Northern Railroad.

Maps 8A and B show FEMA floodplains and floodways; the channel migration zone; and roads, dikes and other structures that may impact floodplain and channel migration functions.

Fish and wildlife habitat

All habitat types described in the general overview are found in the Snohomish watershed, with agricultural, estuarine and lowland conifer forest habitats being the most predominant habitat types. In addition to the birds, mammals, amphibians and reptiles listed earlier, the Snohomish watershed supports five species of Pacific salmon, two species of native char (bull trout and Dolly Varden), two species of anadromous trout (cutthroat and steelhead), and other resident fish including rainbow trout, large mouth bass, yellow perch, blue gill, and green sunfish (Pentec 1999). Threatened or endangered species found in the Snohomish Basin include the bald eagle, Chinook salmon, marbled murrelet, sandhill crane, and possibly grizzly bear (eastern extents). According to WDFW PHS data, the Snohomish Estuary, Tulalip and Quilceda Creek subbasin Marshland subbasin, Lake Stevens, lower mainstem Skykomish, Fobes Hill, Everett drainages and Cathcart drainages have the highest concentrations of waterfowl and priority habitat areas. The Snohomish estuary has over 5,000 acres of habitat, of which over 3,000 are waterfowl concentration areas. The Tulalip, Lake Stevens and lower mainstem Skykomish subbasins each have over 2,000 acres of priority habitat areas.

PUBLIC ACCESS

Thirteen planning segments (13%) in the Snohomish basin have at least one developed or planned public access owned by the County (62%), the Washington State Department of Fish and Wildlife (15%), or a City (23%). Twenty-five planning segments (45%) do not have existing developed access, but are on or adjacent to publicly owned land (County, State or Federal) that could potentially have public access. Twenty-four percent of potential access' are County owned, 57% are owned by the Washington Department of Fish and Wildlife, and 9% are owned by Cities. Forty-three planning segments do not appear to have any existing or potential public access. Specific public access points for each segment are shown on the corresponding inventory map found on the CD accompanying this report.

Table IV-4. County parkland providing public access

WRIA 7-Snohomish River	Acreage	Water Frontage
Allen Creek	6.3	Allen Creek
Centennial Trail	390.52	3 crossings
Field's Riffle	62.28	Snohomish River
Flowing Lake	38.08	Flowing Lake
Gissberg Twin Lakes	54.25	Twin Lakes
Heirman Wildlife Park at Thomas' Eddy	373.85	Snohomish River
Index properties	60.64	North fork Skykomish River
Lake Cassidy/Lake Martha wetlands	195.3	Lake Cassidy, Lake Martha
Lake Cochran	0.03	Lake Cochran
Lake Roesiger	37.43	Lake Roesiger
Lord Hill Regional Park	1464.26	Snohomish River
Lundeen Park	8.76	Lundeen Creek
O'Reilly Acres	124.17	Pilchuck River
Pilchuck Community Park	26.43	Pilchuck River
Pilchuck Conservation Area	35.28	Snohomish River
Robe Canyon Trailhead	18.4	
Skylight Tracts	0.35	Skykomish River
Snohomish River Estuary	1314.82	Snohomish River
Sultan Conservation Tracts	0.57	Skykomish River
Sunset Park	0.25	Lake Stevens
Timberbrook/Heatherglen	6.88	Quilceda Creek
Wyatt Regional Park	2.08	Lake Stevens
Subtotal:	**4,220.93**	

SHORELINE ECOLOGICAL FUNCTIONS

In Snohomish County, analysis of the ecosystem-wide processes and functions for rivers and streams have been conducted and summarized for all of the basins through WRIA planning and salmon recovery documents. The analysis in these documents as it applies to the requirements of the Shoreline Management Act is summarized and presented below. A description of the methodology, ecological functions and the indicators used to characterize river and stream shorelines is found in the methodology section.

Maintaining hydrologic flows and natural ranges of flow variability

Forest Cover

Total forest cover in the Snohomish Basin is approximately 53%, with sub-basins ranging from 5% to 83%. Within the basin, total forest cover in the Skykomish River subbasins is the highest at 60%, followed by 54% in the Snoqualmie River subbasins and 29% in the Snohomish subbasins (Purser et al. 2003). See Map 11.

Peak flows

The Snohomish Basin Ecological Analysis for Salmon Conservation analyzed forest cover, road density and impervious surface to determine hydrologic status of subbasins in WRIA 7. Based on this analysis, 51% of subbasins have healthy hydrologic regimes for peak flows, 24% are adversely impacted and 24% are missing. In the Skykomish basin, hydrologic flow regimes are healthy in 90% of the subbasins. In the Snohomish basin, only 26% of subbasins have healthy functions, and in the Snoqualmie basin 32% of subbasins have healthy functions.

Low Flows

The Snohomish Basin has naturally low flows in the summer that impact salmonid productivity (Pentec 1999). Minimum instream flows have been set for the Snohomish Basin by the Washington State Department of Ecology. Potential low instream flow has been identified as a factor impacting aquatic habitat in the following Snohomish County waters: Pilchuck River, mainstem Skykomish and tributaries, Olney Creek, May Creek and the Wallace River (Draft Initial Watershed Assessment WRIA 7 Snohomish River Watershed, March 1995). The only river where human activity (in the form of water withdrawals) is known to cause low flows is the Pilchuck River. The cities of Snohomish and Granite Falls divert drinking water from the Pilchuck River (Pentec 1999). Groundwater in the lower basin is relatively shallow and connected to surface water in the basin. This means that groundwater withdrawals and other land uses that affect aquifer water levels have the potential to affect peak and low flows. Since impervious areas reduce aquifer recharge, land uses with high impervious surface areas are likely result in reduced flows in rivers and streams in the basin (Department of Ecology instream strategy) .

Floodplain connectivity

The Snohomish has been largely disconnected from its floodplain by dikes, levees and other flood control structures and bank modifications. In Snohomish County, only the Beckler River, Foss River, Sultan River, and the Everett drainages are considered to have healthy floodplain processes. There is insufficient data to determine the state of floodplain functions for May Creek, Wallace River, Woods Creek, Rapid River, Cathcart drainages and Dubuque Creek. The floodplain processes in the remaining rivers and tributaries are adversely impacted or missing (SBRTC 2004).

The Skykomish River's “braided reach” remains a dynamic area where channels shift rapidly within the floodplain, eroding banks and cutting new channels. While channel migration has been impacted by SR 2 and bank hardening to protect the cities of Sultan, Gold Bar and Monroe, the floodplain functions in this reach are largely intact and provide important channel and habitat forming functions.

Developing pools, riffles, and gravel bars

In general, there has been a loss of channel complexity, cover, bank stability, and presence of pools in the Snohomish basin, especially in the mainstem rivers in the lower basin. LWD debris presence is critical to creating pools and collecting and retaining sediment and gravels. The overall lack of LWD debris and channelization of the river has resulted in alteration of associated channel conditions including pools, riffles and gravel bars (Haring, 2002).

Based on the WRIA 7 Limiting Factors Report, 10% of shoreline segments have healthy pool conditions, 8% are adversely impacted, pool conditions are missing in 16%, and pool conditions in 65% are unknown.

The upper mainstem Skykomish (segments Skykomish-5, -6, -6A, -7A and -7B) between the cities of Sultan and Goldbar, has multiple channels and excellent spawning riffles for Chinook. Channel complexity is due to the relatively steep gradient and high sediment load, which cause the channels in this segment to shift rapidly, eroding banks and cutting new channels (Haring, 2002).

Recruitment / transport of woody and organic debris

LWD is generally meant to describe fallen riparian wood pieces that exhibit both large size and are found in complex wood jams. LWD is generally absent from most low floodplain areas of mainstem rivers and tributaries, particularly where the streams have been extensively managed through agricultural areas and along roads. Much of the historical LWD was removed from the Snohomish, Snoqualmie, and lower Skykomish Rivers to improve navigation in the late 1800s/early 1900s (Haas and Collins 2001). LWD recruitment potential is severely impaired in these areas by presence of dikes and levees which prevent the channel from shifting and recruiting LWD, and by a general lack of woody riparian vegetation in riparian buffers available to be recruited. LWD presence is also poor in streams in forested areas, particularly where there has been active forest management, due to stream cleanout and past harvest of riparian trees (Haring 2002).

Based on salmon conservation plans, only between 4-14% of planning segments in the Snohomish River Basin are rated as healthy. The majority are rated as adversely impacted (13-19%) or missing (60-62%). The condition of LWD functions and processes in 13% of segments is unknown.

Removing excessive nutrients and toxics

Fecal coliform bacteria and low levels of dissolved oxygen are the primary causes of water quality problems in the Snohomish and Skykomish River watersheds. In 1998, 11 river and stream segments did not meet state water quality standards for fecal coliform bacteria, eight segments did not meet requirements for dissolved oxygen, and three segments for pH. Segments with high bacteria counts include Snohomish Estuary, Quilceda Creek, Snohomish town, Pilchuck-2, Pilchuck-9, French Creek, West Fork Woods Creek (2), and Woods Creek (2), Skykomish-2, and Skykomish-7B. Dissolved oxygen is a problem in the urbanized areas, likely due to fertilizers in the groundwater. Probable sources of pollutants include urban runoff, industrial and commercial runoff, removal of riparian vegetation, animal access, septic systems, manure sprayed on agricultural fields and fertilizers. Based on the 2004/2005 proposed 303d list prepared by the Washington State Department of Ecology, an additional 13 river and stream segments have nutrient or toxic water quality problems. Of these additional segments, seven do not meet pH standards, one does not meet fecal coliform bacteria standards, and five do not meet dissolved oxygen standards. Map 6 shows 1998 Clean Water 303d listings. Implementation of livestock management programs, proper disposal of pet waste, repairing failing septic systems, and revegetation of riparian areas would reduce sediment, bacteria and nutrients. Assessing and rehabilitating detention ponds and increasing storm sewer maintenance can reduce problems resulting from increased storm run off (SWM 2000a).

Maintenance of water temperatures

In 1998, seven stream and river segments did not meet state water quality standards for temperature and were placed on the 303d list. The segments not meeting the criteria in 1998 were in the Snohomish Estuary (2), the Snohomish mainstem, the Pilchuck River, the mouth of the Snoqualmie River, the Wallace River, and the mainstem of the Skykomish. The probable sources of high temperatures are lack of riparian vegetation, outflow from Lake Stevens, and slow moving water in channelized portions of the lower river and estuary (The State of the waters: Water Quality in Snohomish County, 2000). Based on the 2004/05 proposed 303d list, an additional four segments were found to not meet state water quality standards for temperature in Olney Creek, Skykomish River, and the Snoqualmie River. Map 6 shows 1998 Clean Water 303d listings, including temperature. Revegetation of riparian areas will lower temperatures and reduce nutrients and bacteria (SWM 2000a).

Stabilization of banks and sediment

Sediment

Sediment regime in most Snohomish River subbasins is data gap. High sediment levels, exceeding 12% fines, are found in Quilceda/Allen, French Creek and tributaries to the Snohomish River in the Marshland subbasin. Based on the low forest cover in the basins, this is likely due to scouring during peak flows. Degradation of the streambed in the Lower Pilchuck has occurred due to mining that exceeds the deposition rate. Sediment regimes and deposition patterns in the Snohomish Estuary have been altered by upstream development, diking, and dredging of the delta for navigation purposes (SBRTC 2002).

Bank Stability

Bank instability contributes fine sediment to the channel. Bank erosion above a natural background level can also indicate hydrologic or sediment conditions that are out of balance. Snohomish County Surface Water Management surveyed the Snohomish Estuary, Snohomish, Snoqualmie and Skykomish mainstems, and lower segments of the Quilceda and Pilchuck river in 2004. Only four of the surveyed segments could be considered healthy (Ebey Slough-1 and -2, Pilchuck-1 and -3) by these criteria. Five segments are adversely impacted, and 10 segments have unstable banks that may contribute excess sediment. Land use activities causing instability in the Snohomish River basin are not documented, but likely result from clearing of riparian vegetation and diking and channelization that alter flow patterns in the basin.

Shoreline Vegetation

Shoreline vegetation within shoreline jurisdiction is generally poor throughout the Snohomish Basin. Much of the shoreline vegetation has been cleared or harvested in the last century for forestry or agricultural purposes, for residential development and for transportation corridors. Approximately 2% of segments have healthy riparian conditions. Based on the WRIA 7 Limiting Factors Report, the shoreline segments along Little Pilchuck Creek and the upper reaches of the Sultan River are the only segments that have riparian vegetation with tree stands of the density, width, and size considered to be healthy (Haring, 2002). Approximately 31% of segments, while not considered healthy due to composition and/or age, have a continuous riparian corridor adjacent to the river or stream that provide some habitat, shading and filtering functions. These segments include Elwell-1 and 2, South Fork Skykomish-1A, -2B, and -3, Sultan-2, Olney-1 through -4, Skykomish- 7A and -7B, Wallace-3, Snoqualmie-1A. Shoreline vegetation is adversely impacted in 41% of shoreline segments. Shoreline vegetation in 21% of segments is missing. Shoreline vegetation is shown on Maps 15A and 15B.

Space or conditions for reproduction, nesting, forage, hiding

Habitat elements important to a variety of aquatic and terrestrial species include riparian vegetation, large woody debris, sediment size and type, and water temperature and quality. Sediment, water quality and temperature conditions are addressed above. According to WDFW PHS data, the Snohomish Estuary (shoreline segments Snohomish Estuary-1, Steamboat-1, Ebey-1, Ebey-2 Sno-0, Sno-1a, b, c), Tulalip and Quilceda Creek subbasin (shoreline segments Ebey-1, Quilceda-1, Sno-0, and Sno-1a), Marshland subbasin, Lake Stevens, Lower Mainstem Skykomish, Fobes Hill, Everett drainages and Cathcart drainages have the highest concentrations of waterfowl and priority habitat areas. The Snohomish estuary has over 5,000 acres of habitat, of which over 3,000 are waterfowl concentration areas. The Tulalip, Lake Stevens and lower mainstem Skykomish basins each have over 2,000 acres of priority habitat areas.

Most of the Snohomish River basin Chinook spawn in the Skykomish and Snoqualmie mainstems, and the Lower Sultan, Upper South Fork Skykomish, Lower Tolt, and Raging Rivers, although they also use smaller streams with sufficient water flow such as Bridal Veil Creek and Cherry Creek.

BASIN SUMMARY

Ecosystem-wide processes and ecological functions that have been altered in the basin include water flow, LWD recruitment and transport, water quantity, water quality and habitat conditions. There are many factors that contribute to the altered conditions, both man-made and natural.

Channelization and diking of the Snoqualmie River for agriculture and flood control purposes has limited or eliminated the ability of the river to move within its channel west of Monroe, and has reduced habitat complexity in the floodplain and estuary (Pentec 1999, Haring 2002). The Snohomish basin has low flows in the summer partially due to the presence of a shallow aquifer. The presence of a shallow aquifer makes the lower basin more susceptible to low flows resulting from land uses that limit groundwater recharge or withdraw groundwater (Pacific Groundwater Group 1995).

Clearing of riparian vegetation throughout the basin for residential, agricultural and forestry uses has resulted in a lack of LWD available for recruitment. The lack of instream LWD, in turn, affects the ability of the system to form pools, riffles, gravel bars and other geomorphic features. Clearing of riparian vegetation also contributes to water quality problems, as there is insufficient vegetation to filter run-off before it enters the river in many places.

The Snohomish Estuary is vitally important to the life cycle of salmonids in the Snohomish River basin, and returning it to more natural condition and function is an important salmon conservation strategy.

Restoration and preservation activities that could improve ecological functions and eco-system wide processes in the basin include: revegetation of riparian areas to provide shade to cool water temperatures, filter run-off and to provide a source of LWD and organic materials; protect habitat and natural channel functions in the braided reach; reconnect and recreate off-channel habitat in the floodplain and estuary; and utilize low impact development techniques to provide for greater groundwater recharge.

CEDAR- SAMMAMISH RIVER BASIN

GENERAL CONTEXT

The Cedar-Sammamish Basin consists of 692 square miles, and contains two major river systems and several large lakes (Lake Washington, Lake Union and Lake Sammamish). The majority of the WRIA (85%) is located in King County. Only 15% of the basin is located in Snohomish County. In Snohomish County, there are several subbasins that drain to the Sammamish River and Lake Washington: North Creek, Swamp Creek and Little Bear Creek subbasins. The remainder of the WRIA consists of numerous small watersheds ("Puget Sound Drainages") that drain directly to Puget Sound between Mukilteo and the southern boundary of Snohomish County.

There are approximately 13 miles of marine shoreline from Mukilteo to the south boundary with King County, 0.20 miles of North Creek, 1.8 miles of Swamp Creek, and five lakes within shoreline jurisdiction in WRIA 8 in Snohomish County. The marine and lake shorelines are addressed in other sections of this report.

Swamp and North Creeks are located in the highly urbanized Southwest Urban Growth Area. Land use within the Swamp Creek basin is 25% commercial, 25% forest/wetland, 25% low-density residential, 10% rural, and 10% high-density residential.

PUBLIC ACCESS

There is planned public access to the one Swamp Creek shoreline planning segment at the Swamp Creek Marsh. This is a 93-acre property owned by Snohomish County Surface water used for a regional stormwater detention area. This property is planned to be developed to provide public access to Swamp Creek for wildlife viewing with passive trails, interpretive signage and a parking area. On North Creek, within shoreline jurisdiction, public access is planned via the North Creek Greenway. The North Creek Greenway is a vegetated corridor flanking both sides of North Creek, extending from McCollum Park south to Bothell and the Sammamish River. The County Comprehensive Parks Plan proposes acquisition of easements and ownership along the greenway using state matching-grant funds. There are many public access points to North Creek that are not within shoreline jurisdiction. Specific public access points for each segment are shown on the corresponding inventory map found on the CD accompanying this report.

Table IV-7. County parkland providing public access

WRIA 8-Lake Washington Drainage	Acreage	Water Frontage
Brentwood	4.61	Unnamed tributary of North Creek
Locust Way Neighborhood Park	7.08	Swamp Creek
Martha Lake	6.12	Martha Lake
Martha Lake Airport Community Park	30.48	Views of Martha Lake
McCollum Park	74.83	North Creek
North Creek Greenway	13.07	North Creek
North Creek Park	79.25	North Creek
Paradise Valley Conservation Area	663.31	Upper Bear Creek
Silver Creek Park	9.56	Silver Creek
Tambark Creek Community Park	40	Tambark Creek
Total:	**928.31**	

SHORELINE ECOLOGICAL FUNCTIONS

Existing conditions and shoreline functions in the Cedar-Sammamish Basin (WRIA 8) are documented in the WRIA 8 Limiting Factors Analysis and the Snohomish County Drainage Needs Reports. The following text summarizes the data and analysis in these reports.

Maintaining hydrologic flows and natural ranges of flow variability

Forest Cover

Swamp and North Creek subbasins have some of the lowest overall forest cover and highest impervious area in the County. Total forest cover in the Swamp Creek Basin is 10%, with 38% impervious areas. Total forest cover in North Creek is 13%, with 31% impervious area (Purser et al. 2003). See Map 11.

Peak flows

As the forest cover and impervious area percentages indicate, both Swamp and North Creeks receive high flows from surrounding developed areas. Swamp Creek benefits significantly from a network of large wetlands in the middle of the basin that have a dampening effect on flood peaks and provide habitat (SWM 2002a and 2002b). The large wetlands in the lower part of the basin in shoreline jurisdiction also attenuate stormwater flows, but the creek is exhibiting severe scour in spawning gravels due to excessive stormwater flows. Flooding problems were identified at roadway or driveway culverts at a number of locations (SWM 2002a and 2002b). Wetlands in the mainstem of North Creek help to attenuate floodwaters, but it is also experiencing scour due to high stormwater flows (SWM 2002a and 2002b).

Low Flows

Low flows occur in the summer in Swamp and North Creeks, resulting in high temperatures and low dissolved oxygen levels (SWM 2000a). Groundwater is likely to be relatively shallow and connected to surface water in the North Creek and Swamp Creek subbasins (Pacific Groundwater Group, 1995). This means that groundwater withdrawals and other lands uses that affect aquifer water levels have the potential to affect peak and low flows. Since impervious areas reduce aquifer recharge, land uses with high impervious surface areas are likely to result in reduced flows in streams in the subbasins (Pacific Groundwater Group, 1995).

Floodplain connectivity

Both North Creek and Swamp Creek have relatively high amounts of off-channel habitat and wetlands that are connected to the mainstem (SWM 2002a and 2002b), and limited armoring. Orthophotography and inventory maps show a high number of road crossings for the Swamp Creek shoreline reach.

Developing pools, riffles, and gravel bars

North Creek has a pool frequency of 6.8 pools per mile, and Swamp Creek has a frequency of 13 pools per mile. Both are considered “not properly functioning” by NMFS (SWM 2002a and 2002b). Lack of pools, riffles and gravel bars is likely due to scouring during high flows, streambank modifications, and lack of large woody debris.

Recruitment / transport of woody and organic debris

North Creek has LWD density of 6.5 pieces per km, and Swamp Creek has LWD density of 10 pieces per mile, both are considered “not properly functioning” by NMFS. LWD limitations are due to lack of large trees and dense stands within riparian corridors. If the corridors are retained, it is likely that LWD will increase in the future.

Water Quality

Overall water quality in Swamp and North Creeks is degraded throughout the system (SWM 2002a and 2002b). Sampling at several locations has shown that the streams are not meeting standards for fecal coliform bacteria bacteria, dissolved oxygen, and toxic metals. Probable causes of pollutants include residential, commercial, and industrial development, failing septic systems, highway run-off, illegal storm drain connections, spills of hazardous substances, peat mining, chemical storage and waste disposal, and filling of wetlands (SWM 2000a). Segments of the streams are on the Washington Department of Ecology’s 1998 Clean Water Act Section 303(d) list. Assessing and rehabilitating detention ponds, fixing failing septic systems, increasing storm sewer maintenance, proper disposal of pet wastes, revegetation of riparian areas, and identification and removal of illicit discharges of sewage to storm sewers would help improve basin water quality (SWM 2000a).

Maintenance of water temperatures

Stream shade is moderate to low, averaging 63%, on North Creek. This means 47% of the stream length has high potential for increases in stream temperature. Swamp Creek is in slightly better condition, with only 20-29% of the stream length susceptible to high stream temperatures. Sampling by SWM shows that temperatures in Swamp and North Creek violate state standards. Filling of wetlands, impervious surfaces and clearing of riparian vegetation are the probable causes of high temperatures (SWM 2000a). Revegetation of riparian areas and maintaining streamside vegetation, assessing and rehabilitating detention ponds and increasing storm sewer maintenance can all help reduce temperatures (SWM 2000a).

Stabilization of banks and sediment

Bank stability

Only 8.3 percent of banks on North Creek are armored, and bank instability is 3.8%. On Swamp Creek, only 4% is armored, and bank instability is 2%. Both of these are considered as “properly functioning” by NMFS (SWM 2002a and 2002b)

Sediment

Sediment conditions in both Swamp Creek and North Creek are “not properly functioning” due to high percentages of fine sediments due to scour caused by high flows (SWM 2002a and 2002b).

Shoreline vegetation

The 82% of Swamp Creek and 58% of North Creek have a riparian corridor larger than 50 feet. Both streams have a shortage of large coniferous trees and dense stands of trees to contribute LWD to the stream (SWM 2002a and 2002b).

Space for reproduction, nesting, forage, hiding

Habitat types within the Swamp Creek and North Creek shoreline segments include aquatic areas, wetlands and lowland conifer forests. Both Swamp Creek and North Creek have shoreline vegetation and wetlands within shoreline segments that allow for space for reproduction, nesting, forage, and hiding for mammals, birds, amphibians and reptiles species found in these habitat types. Based on WDFW PHS data, both North Creek and Swamp Creek have some limited waterfowl concentration areas. Most aspects of aquatic habitat, including LWD, fine sediment, pools and water quality are poor for species that rely on these habitat features. Swamp Creek and North Creek both support runs of Chinook, Coho, Sockeye, and resident and anadromous Steelhead and Cutthroat Trout. North Creek also supports Kokanee Salmon.

BASIN SUMMARY

Ecosystem-wide processes and ecological functions that have been altered in the basin include water flow, LWD recruitment and transport, water quantity, water quality and habitat conditions. Most alterations to process and functions are related to the high level of development in the North Creek and Swamp Creek subbasins, the most highly developed subbasins in the County (Purser et al. 2003).

High flows in winter cause scouring and excess sedimentation in the channels of both creeks. Low flows in summer impact habitat conditions for salmonids (SWM 2002a and 2002b). It is likely that presence of a shallow aquifer makes the both subbasins more susceptible to high and low flows resulting from land uses with high impervious surface area or that otherwise impact groundwater recharge or groundwater (Pacific Groundwater Group 1995).

Clearing of riparian vegetation throughout both subbasins for intensive residential, industrial and commercial uses has resulted in a lack of LWD available for recruitment. The lack of instream LWD in turn affects the ability of the system to form pools, riffles gravel bars and other geomorphic features. Clearing of riparian vegetation also contributes to water quality problems, as there is insufficient vegetation to filter run-off before it enters the creeks in many places.

Restoration and preservation activities that could improve ecological functions processes in the basin include: revegetation of riparian areas to provide shade to cool water temperatures, filter run-off and to provide a source of LWD and organic materials; reconnect and recreate off-channel habitat; protect remaining wetlands to moderate flows and velocity; and utilize low impact development techniques to provide for greater groundwater recharge.

SKAGIT RIVER BASIN

GENERAL CONTEXT

The Skagit Basin is the largest drainage into Puget Sound, and is located primarily in Skagit County. There are 44 miles of shoreline jurisdiction in three small portions of the basin that extend into Snohomish County and are subject to the SMA: The marine shoreline area adjacent to Skagit Bay northwest of Stanwood (segments Can-1 and Can-2); the headwaters to the Sauk River to the east, near Darrington; and the headwaters of the Suiattle River. There are approximately 3.5 miles of marine shoreline jurisdiction northwest of Stanwood, 6.8 miles of shoreline jurisdiction on the Sauk River, and 19 miles on the Suiattle River.

Skagit Bay

The shoreline jurisdiction adjacent to Skagit Bay consists of agricultural and pasture lands contiguous with the Stillaguamish River delta. The natural shoreline has been extensively diked and drained for agricultural use. The character and use of the shoreline is similar to that found in the lower mainstem of the Stillaguamish and the Stillaguamish estuary, and is addressed in the characterization of the marine shoreline.

Sauk and Suiattle Rivers

"The Sauk River is the largest tributary to the Skagit River with about 59 mainstem miles and numerous large to small tributaries, including the Suiattle and White Chuck Rivers (Phinney and Williams, 1975). All three of these rivers have headwaters in high mountain areas of Snohomish County. Most of the Sauk and Suiattle Rivers are within National Forest boundaries or protected in the National Park, a national recreation area, or a designated wilderness area" (Smith 2001).

The Sauk and Suiattle rivers flow through Snohomish County as separate rivers and join together in Skagit County. The Shoreline jurisdiction on the Sauk River begins where the Sauk leaves the Mount Baker-Snoqualmie National Forest, approximately 2.4 miles south of Darrington, and ends where it crosses into Snohomish County, just after its confluence with Dan Creek. Shoreline jurisdiction extends 1.8 miles up Dan Creek. Shoreline jurisdiction on the Suiattle also begins where the river leaves the Mount Baker-Snoqualmie Forest, and continues south approximately 19 miles, ending as the river crosses Snohomish County's north boundary.

Fish and Wildlife Habitat

Habitat types described in the general overview that are found in the Sauk and Suiattle shoreline segments are aquatic areas, lowland conifer forest, agriculture, wetland and urban areas. Aquatic and lowland conifer forest habitats are the most predominant habitat types. In addition to the birds, mammals, amphibians and reptiles listed earlier, the Sauk and Suiattle Rivers and tributaries provide habitat for anadromous salmonids. Dan Creek is used by Steelhead, Chinook, Coho, chum, and pink salmon . Other tributaries, such as Gravel, Everett, and Prairie Creeks, and a few unnamed streams, are used by chum, Coho, Cutthroat, and/or char (Smith 2001).

Threatened or endangered species that may be found in the Sauk and Suiattle shoreline segments include the bald eagle, Chinook salmon (except Suiattle Chinook), marbled murrelet, sandhill crane, and possibly grizzly bear. Chinook spawn in shoreline segments Sauk-2 and Sauk-3 from late July through early September.

FLOODPLAIN

Both the FEMA floodplain and FEMA floodway for the Sauk River (as defined mapped by FEMA) are wide within shoreline jurisdiction. Orthophotography shows that Sauk-1 is a “braided reach” with multiple channels and dynamic movement, cutting new channels during flooding. The FEMA floodway is nearly as wide as the 100-year floodplain in this segment. The floodway and floodplain adjacent to the City of Darrington and upstream, while still significant, are much narrower.

PUBLIC ACCESS

There is one planning segment, Sauk-3, with developed public access to the Sauk River. Access is at Backman Park, a Snohomish County Park 1.5 miles south of the City of Darrington. Potential access exists at the Sauk Prairie Road Bridge, and on National Forest Lands on the Suiattle. Specific public access points for each segment are shown on the corresponding inventory map found on the CD accompanying this report.

Table IV-10. County parkland providing public access in WRIA 4

Park Property by Basin	Acreage	Water Frontage
WRIA 4-Upper Skagit River		
Backman	1.93	Sauk River
Whitehorse Trail	69.4	Parallel and crossings of North Fork tributaries
Total:	**71.33**	

SHORELINE ECOLOGICAL FUNCTIONS

Existing conditions and shoreline functions in the Skagit Basin are documented in the WRIA 3 and 4 Limiting Factors Analysis, which is organized by Water Analysis Units (WAU) created by the Washington Department of Natural Resources. The following text summarizes the data and analysis in this report relative to the WAUs and Snohomish County's shoreline planning segments.

The shoreline jurisdiction on the Sauk is divided into three shoreline segments: Sauk-1, Sauk-2, and Sauk-3. Sauk-1 stretches from the Snohomish County line to the north boundary of the Town of Darrington UGA. It is located within the Rinker and Dan Creek WAUs (Watershed analysis units). Sauk-2 is the shoreline jurisdiction within the Town of Darrington and its urban growth area, and Sauk-3 is the shoreline jurisdiction south of the Town of Darrington to the Mount Baker-Snoqualmie National Forest. Sauk-2 and -3 are within the Dan Creek and Clear Creek WAUs. There is only one shoreline reach for the Suiattle (Suiattle-1), it is located in the Lime Creek WAU.

Maintaining hydrologic flows and natural ranges of flow variability

There have been no definitive studies of peak and low flows in the Sauk sub-basin.

Peak flow

Analysis of the likelihood of peak flow impairments as a result of land cover and road density have been analyzed for the sub-basin (Smith 2001). Sauk-1 is within the Rinker and Dan Creek WAUs. These WAUs have been classified "poor" for water quantity conditions (Smith 2001). Clear Creek and Lime Creek WAUs are rated as "good" for water quantity functions (Smith 2001). Based on this data, water flow functions for Sauk-1 are considered "missing," for Sauk-2 and -3 are "adversely impacted," and for Suiattle-1 are "healthy."

Low Flow

Low flow conditions are a data gap. There are no known low flow conditions on either the Sauk or the Suiattle Rivers.

Floodplain Connectivity

The Sauk River has an unconfined channel and wide floodplain from the Snohomish County line south to Darrington (Sauk-1). Based on orthophotography and inventory maps, floodplain connectivity appears to be healthy in this reach. The river is dynamic, with few roads or other obstructions to channel migration within the floodplain. The extent of hydromodifications is low, ranging from 0.2 - 0.6%, located sporadically throughout the three segments (Smith 2001). Sauk-2 and Sauk-3 have bridge crossings, development and roads that likely affect floodplain connectivity, although the river is more confined in these shoreline segments. There is little data on floodplain connectivity or armoring on the Suiattle River.

Stabilization of banks and sediment

Sediment
"The Sauk River subbasin has naturally high levels of sedimentation from landslides and glacial inputs. Less than 10% of landslides are human caused. Clear-cut and roads are the predominant cause of human caused landslides (Smith 2001). The Dan and Sauk Prairie water analysis units had estimated sediment rates ranging from 150-199% over natural sediment supply rates, and are rated "poor" for sediment supply rates by the WRIA 3 & 4 limiting factors report. The lower Clear Creek WAU is rated "Fair." Based on this data, sediment functions in Sauk-1 and 2 are considered "missing," and Sauk- 3 is "adversely impacted."

Bank stability
There is no data on erosion rates for banks within either the Sauk or the Suiattle Rivers. Only 0.2 - 0.6% of the Sauk is armored (Smith 2001). This is considered "properly functioning" conditions by NMFS.

Removing excessive nutrients and toxics

There is little water quality data available on the Sauk or Suiattle Rivers.

Maintenance of water temperatures

Water temperatures have not been regularly monitored on the Sauk or Suiattle Rivers.

Shoreline vegetation

Riparian conditions in Rinker Creek and Dan Creek WAUs have been rated "Fair" and conditions in Clear Creek have been rated "Good." Fair ratings are due to lack of coniferous canopy. (Smith 2001) Orthophotography of the area shows very little clearing of shoreline vegetation within Sauk-1, and patchy shoreline vegetation within Sauk-2 and -3 due to development within and south of Darrington. Based on this data, shoreline vegetation is considered "healthy" in Sauk-1, and "adversely impacted" in Sauk-2 and -3.

Riparian conditions in the Suiattle River have been rated "good" for both percent conifer in riparian buffers (70%) and percent of functional riparian stream lengths (90%) (Smith 2001). Shoreline vegetation functions in Suiattle-1 are considered "healthy." Reference Table II-2 and page II-7 for a description of shoreline vegetation functions.

Recruitment and transport of large woody debris

There is little data on LWD frequency on the Sauk and Suiattle Rivers. The Dan Creek and Upper Sauk WAUs are rated as "good" for instream LWD (Smith 2001). Since all three Sauk segments are within or partially within the Dan Creek WAU, LWD frequency is considered "healthy" for these segments. It is likely that the bridge crossing in Sauk-2 disrupts transport of LWD, so this reach is considered "adversely impacted."

Space or conditions for reproduction, nesting, forage, hiding

Habitat types within the Sauk and Suiattle shoreline segments include aquatic areas, wetlands and lowland conifer forests. Lowland conifer forests are the predominant habitat type. All segments of the Sauk and Suiattle have shoreline vegetation that forms a riparian corridor that allows for space for reproduction, nesting, forage, and hiding for mammals, birds, amphibians and reptiles species found in these habitat types. Sauk-2 and -3 have patchy vegetation and cleared areas within the riparian corridor.

In the Sauk and Suiattle, most aspects of aquatic habitat, including LWD, pools and water quality appear to be good or fair for species that rely on these habitat features.

BASIN SUMMARY

Based on limited information, ecological functions and eco-system wide processes appear to generally be in good condition for the portions of the Sauk and Suiattle Rivers within Snohomish County. There is some evidence that sediment and water flow processes within the subbasins contributing to Sauk-1 may be altered by forestry activities and road crossings; there are some limited hydromodifications such as bridges and armoring within the Darrington UGA; and there is a general lack of coniferous cover within riparian areas. However, overall, large woody debris recruitment and transport, floodplain and channel migration processes all appear to be generally intact and habitat conditions are good (Smith 2001).

Restoration or preservation activities that would improve ecological functions and eco-system wide processes include: protection of channel migration and floodplain functions, revegetation of riparian areas with an emphasis on conifers, and remediation of forestry activities that contribute sediment to the system.

Marine Shorelines

MARINE SHORELINES

GENERAL CONTEXT

Background Documents

Existing conditions along Snohomish County marine shorelines are documented in the Reconnaissance assessment of the state of the nearshore ecosystem: eastern shore of central Puget Sound, including Vashon and Maury Islands (WRIAs 8 and 9), the Washington Department of Natural Resources Shorezone Inventory, the Snohomish Estuary Wetland Integration Report, the City of Everett Shoreline Master Program, the Salmonid Limiting Factors Report for WRIA 7, the Snohomish Basin Habitat Conditions Report, Snohomish River Basin Conditions and Issues Report, the 2001 Land cover Analysis report, Snohomish Basin Ecological Analysis for Salmon Conservation, the Department of Ecology 303d list,Stillaguamish River Bank and Physical Habitat Conditions Survey, and the Snohomish County Marine Resources Committee shoreline survey. The following text summarizes the data and analysis in these reports. Maps with more specific detail are found on the inventory maps on the CD-Rom contained in Appendix D.

Physiography

Puget Sound is a series of interconnected, glacially scoured channels stretching from the Strait of Juan de Fuca to Olympia. Puget Sound is generally divided into four major basins: Hood Canal, South Sound, Whidbey Basin and the Main Basin. The main basin is further divided into Admiralty Inlet and the Central Basin. Admiralty Inlet extends from the northern limit of Puget Sound to the south tip of Whidbey Island. The Central Basin extends from the south tip of Whidbey Island to Commencement Bay. Snohomish County marine shorelines are adjacent to Admiralty Inlet and the Central Basin.

Shoreline jurisdiction

Marine shorelines account for approximately 3% of the area subject to the SMA in Snohomish County. Tidal waters subject to the SMA include those lands which extend landward 200 feet of the OHWM and those wetlands which are in proximity to and either influence or are influenced by the tidal waters. Snohomish County shorelines located seaward from the line of extreme low tide are shorelines of statewide significance. Marine shoreline jurisdiction is shown on Maps 7A and 7B.

Land Use

Primary land uses within two hundred feet of marine shorelines are single-family residential and duplex (78%), resource production (7%), undeveloped (7%), and manufacturing (6%). Commercial, industrial, recreational and other uses make up less than two percent of shoreline land uses. Transportation corridors are a significant land use not included in this calculation. Maps 9A and B show shoreline land use, including parks and major public lands. Land use and existing conditions are further described below.

Geology and Soils

The geology of marine shorelines in Snohomish County are typical of what are found on bluffs throughout Puget Sound. In general, the bluffs lining the shoreline consist of Vashon advance outwash (Qva) above transitional beds (Qtb) (Lawton and Pilchuck clay members, Kitsap formation) lying on undifferientiated sediments (Qu) (pre-Frasier non-glacial Olympia Gravel/ Whidbey formation and glacial Possession/Double Bluff marine drift) (USGS 1997). The width of layers varies, in some areas the transitional beds are so shallow that the Vashon advance outwash is nearly sitting upon the pre-frasier sediments. This stratigraphy is commonly implicated in landslides in the Puget Sound area. Many if not most landslides occur along the interface between Vashon outwash and the underlying Lawton Clay due to the relative impermeability of the clay in relation to the advance outwash lying above (Shipman 2001). Landslide activity on the marine shoreline bluffs south of the mouth of the Snohomish River is a regular occurrence, especially south of the City of Edmonds.

Soils along the marine shoreline are predominantely Alderwood-Everett series (NRCS 1983).

Shoreline Modifications

Outside of the cities, Hat Island Marina, Kayak Point, Point Wells, Priest Point and some dock and log storage in the Snohomish estuary, there are very few docks or other overwater structures on marine shorelines in unincorporated Snohomish County. Shoreline armoring is the most prevalent shoreline modification, affecting 67% of all planning segments (SCMRC inventory). The location of shoreline armoring and other modifications are shown on Maps 16A and 16B.

Marine Nearshore Vegetation

Aquatic vegetation found in the nearshore marine shoreline include plants found in estuarine marshes such as pickleweed (Salicornia virginica), salt grass (Distichilis spicata) and sedge (Carex Lyngbyei); plants found in subtidal areas such as eelgrass (Zostera marina and Zosteria japonica); and brown, red and green algae found in tidal and subtidal areas such as kelp (Laminaria spp.), sea lettuce (Ulva spp.), rockweed (Fucus spp.) and Sargassam muticum (Scagel et al 1998 and Dethier 1990). Eelgrass and floating kelp beds provide some of the most productive habitat for marine organisms found in Puget Sound. Eelgrass is an underwater grass that grows in meadows or beds in shallow sandy or muddy subtidal areas. It is critical to the life cycle of salmon, crab, and herring, and provides food and shelter to a wide variety other marine animals and birds. Large brown bull kelp grows in forests in rocky subtidal areas, and provides similar shelter and food for many marine animals and birds (Washington Department of Ecology website). Eelgrass and kelp beds, and estuarine marshes are critical saltwater habitats protected by the Shoreline Management Act. Large eelgrass meadows occur at the mouths of the Snohomish and Stillaguamish Rivers (Skagit Bay), and smaller meadows are scattered along the entire marine shoreline, consistent with the sandy and muddy subtidal areas prevalent along most of the shoreline. Floating kelp beds are more rare, and occur near Edmonds and the south tip of Hat Island (WADNR 1999).

Fish and Wildlife Habitat

Numerous habitat types occur within the nearshore environment of Snohomish County, including eel grass meadows, kelp forests, flats, tidal marshes, subestuaries, sand spits, beaches and backshore, banks and bluffs, and marine riparian vegetation (Department of Ecology). Snohomish County's nearshore habitats are home to a wide variety of plant and animal species. These include eight species of native salmonids, forage fish (smelt, herring and sand lance), ground fish, rockfish, shellfish, shorebirds and marine mammals. Nearly 70% of the more than 200 species in the County are found in or utilize the nearshore environment (Williams et al. 2001).

The most significant and important habitat area is the Snohomish Estuary. The estuary supports seven species of anadromous salmonids, a variety of non-anadromous freshwater and saltwater fish species, abundant forage fish (surf smelt and sand lance), 15 species of mammals, 63 species of birds, and four species of reptiles. It is an important staging and stop-over area for bird migration along the west coast, and a critical habitat in the life history salmonids. Much of the Snohomish Estuary is publicly owned and slated for habitat restoration projects.

Map 17 shows critical saltwater habitats on Snohomish County shorelines.

PUBLIC ACCESS

County parks providing developed access to the shoreline include: Kayak Point, Picnic Point, Meadowdale Park, Nakeeta Beach and Darlington Beach. Only Kayak Point has a dock and boat launch ramp. Public access in the form of trails, canoe launch, and interpretive center is planned on extensive county owned properties in the Snohomish Estuary. New potential for public access along the marine shorelines exists at Point Wells, in the event the site redevelops, and at Washington Department of Fish and Wildlife owned property in segments Can-1 and Can-2 north of Stanwood. Specific public access points for each segment are shown on the corresponding inventory map found on the CD accompanying this report.

Table V-1. County parkland providing public access along the marine shoreline.

Puget Sound Drainages	Acreage	Water Frontage
10th Street Boat Launch	3.72	Possession Sound
Chevron parklands	153.89	Puget Sound
Darlington Beach	51.46	Puget Sound
Kayak Point Regional Park	307.06	Port Susan
Meadowdale Beach Park	105.49	Puget Sound
Nakeeta Beach	43.36	Puget Sound
Picnic Point	53.58	Puget Sound
Possession Sound	22.3	Puget Sound
Priest Point Tract	0.09	Possession Sound
Tidelands	46.82	Puget Sound
Total:	**787.77**	

SHORE DRIFT PATTERNS AND SHORELINE CONDITIONS

Various studies have delineated boundaries for 14 drift cells along Snohomish County's nearshore. Generally, sediment is transported from south to north in most drift cells, consistent with the prevailing winds. The general south to north drift pattern is interrupted by the Edmonds and Mukilteo ferry docks, where there is no appreciable drift (Williams et al. 2001), by the mouth of the Snohomish River, and in the area between Tulalip Bay and Priest Point (WADNR 1999).

Drift Cells

Williams et al. 2001 provides a thorough summary of drift cells. In Puget Sound, sediment is delivered to the system by rivers and eroding bluffs and cliffs. In the nearshore, most sediment is delivered by eroding bluffs and cliffs, carried along the shoreline (long-shore drift) by wind, wave and current action, and deposited on beaches. The patterns of wind, wave and current create "drift cells" along the shoreline. Drift cells are localized closed systems in which sediment is suspended by waves or currents and transported along the shoreline in a repetitious cycle of suspension and deposition. Drift cells are the mechanism that supplies nearshore environments with the majority of sediments required to maintain beaches, sand spits, flats and other coastal landforms (Williams et al. 2001). Shoreline structures or modifications that interrupt or stop sediment delivery or transport at some point in the drift cell can result in accelerated erosion of beaches and other coastal landforms down-drift from the obstruction by "starving" the landforms of sediment (Williams and Thom 2001). There are several accretion land forms such as spits and points scattered along the shoreline, including McKees Beach, Tulare Beach, Tulalip Shores, Kayak Point and Warm Beach, and several on Hat Island. These are identified in the current Shoreline Master Program as "Natural" seaward of the OHWM. Map 1A shows the location of landmarks referenced in subsequent paragraphs.

North of SNO-1

Between the north county boundary and the southern edge of the Stillaguamish River delta, the shoreline is comprised of portions of the Skagit and Stillaguamish River deltas which have been diked, drained and cleared for agricultural fields. Low residential densities and agricultural land uses predominate. No drift cells have been delineated in this area, but it is likely that the Stillaguamish River is a primary influence of shoreline processes.

SNO-1 to SNO-4

South of the Stillaguamish River (Warm Beach) to the Snohomish River the shoreline is characterized by medium and high bank bluffs, sandy spits and beaches, and rural residential development. Development is a mixture of dense residential communities, and residential development on larger 5- and 10-acre parcels. More than half of this area is within the boundaries of the Tulalip Tribes Reservation. The shoreline north of Tulalip Bay is in one long drift cell that moves sediment from south to north, picking up sediment from intermittent bluffs and depositing it on northwest and north facing beaches and spits (McKees Beach, Tulare Beach and Tulalip Shores) between Tulalip Bay and Warm Beach (Keuler 1988 and WADNR 1999). The areas immediately adjacent to and north and south of Tulalip Bay are transporting sediment from the north and south into Tulalip Bay. Just south of Tulalip Bay is a divergent zone where sediment from bluffs erodes and drifts south to Priest Point, where it accumulates.

SNO-1/SNO-4

Snohomish River estuary and Everett Waterfront. The Everett waterfront is intensively developed and modified for water-dependant and industrial uses. The Snohomish Estuary is the mouth of the Snohomish River. It is approximately nine miles long and 3 - 4.5 miles broad at its widest point, encompassing six major islands within its 19.5 square miles. It has been divided into seven ecological management units through the Snohomish Estuary Wetland Integration Plan (SEWIP). EMUs 2 and 3 fall into unincorporated Snohomish County. Historically, the areas within these EMUs, north of Everett and west of I-5, were diked, drained and used for mills, railroad yard, log yards, building supply and gravel barge facilities, and wood chip facilities. There are still remaining industrial activities including log storage. Many of the dikes in this area have been breached allowing tidal inundation through restoration projects. The areas around the mouths of Union and Ebey sloughs and Quilceda Creek have returned to a state somewhat close to original estuarine marsh conditions (City of Everett Shoreline Master Program). Shoreline drift patterns in this area are likely influenced by the river.

SNO-1 – SNO-3

South of the Snohomish River, the shoreline is characterized by steep unstable bluffs, dense urban development and a heavily armored railroad corridor that separates the upland bluffs from the nearshore. The bluffs are intersected by multiple stream gullies ("Everett Drainages") that enter the nearshore via culverts beneath the railroad. The armored railroad corridor significantly impacts public access, water-dependant uses, and all of the shoreline ecological functions. The entire shoreline within these drift cells is within the Southwest Urban Growth Area, including the Cities of Everett, Mukilteo, Edmonds and Woodway. Only three miles of these drift cells are within Snohomish County's shoreline jurisdiction: Point Wells and the Picnic Point area south of Mukilteo and north of Edmonds. The bluffs within this drift cell have a history of small to large landslides (Shipman 2001).

SHORELINE ECOLOGICAL FUNCTIONS

Sediment Processes

The armoring, development, and other shoreline modifications impact sediment processes by limiting sediment delivery, interrupting sediment transport, and changing the size and composition of the substrate. If shoreline bluffs are disconnected from the nearshore by structures, modifications or development, sediment delivery to the nearshore will be reduced or eliminated, resulting in a lack of sediment for downdrift beaches and spits. Docks, groins, and armoring and other structures located seaward of the ordinary high water mark (OHWM) can slow sediment transport, increase erosion or redirect deposition (Williams and Thom 2001). This affects both the property owners and structures downdrift, as well as nearshore habitat character. Shoreline "feeder" bluffs and armoring are shown on Map 18. Feeder bluffs are those that "feed" sediment to the beach. For the purposes of this analysis, they include those that experience small regular slides, as evidenced by unvegetated scars, as well as those that are substantially eroding or experiencing mass wasting. All segments south of the Snohomish estuary have feeder bluffs that have been disconnected from the intertidal area by the Burlington Northern Railroad. Sediment processes in these segments are missing. North of the Snohomish River and on Hat Island, more than half of all feeder bluffs have little or no armoring, except for north and south of Tulalip Bay, and one reach on Hat Island. Segments Sno-1/Sno-2, Sno-4, and Hat Island-4 are considered to have missing functions because more than

50% of feeder bluffs in these segments are disconnected from the nearshore by armoring. Hat Island-5, -6, Sno-1c, Sno-1e, Sno-1f, and Sno-3/Sno-4 are all healthy.

Water Quality

The Snohomish County marine shorelines are influenced by three major rivers (the Snohomish, the Stillaguamish and the Skagit Rivers) and numerous coastal tributaries that drain adjacent uplands. Water quality problems exist in Port Susan (high levels of fecal coliform bacteria) and several tributaries draining to Port Susan (high levels of fecal coliform bacteria) and the Everett Harbor area (contaminated sediments) (DOE 1998). Fecal coliform bacteria contamination of Port Susan has limited its use for shellfish harvesting. See Map 6. High levels of fecal coliform bacteria in Port Susan are likely due to run-off from urban and suburban development and agricultural activities. Implementation of livestock management programs, repairing failing septic systems, and revegetation of sensitive areas would reduce bacteria (SWM 2000a). Contaminated sediments are likely due to industrial activities on the City of Everett shoreline.

Recruitment and transport of Large Wood and Organic Debris

Large woody debris and organic debris are "recruited" when waves erode shoreline areas and undermine trees and other vegetation causing them to fall onto the beach, adding beach logs, driftwood, leaves, insects and other types of organic debris to the system. Large wood and organic debris stabilize beaches and sediment and provide shelter and food for various nearshore species. Shoreline armoring, fill and other modifications prevent recruitment of shoreline vegetation and can limit the transport of large wood to other areas. Clearing for development reduces or eliminates shoreline vegetation available for recruitment. Along Snohomish County shorelines, clearing for shoreline development and armoring (primarily for the BNSF railroad corridor) has eliminated much of the shoreline vegetation available for recruitment on marine shorelines south of the Snohomish River. Approximately five segments are mostly unarmored and have adequate shoreline vegetation available for recruitment. They include Hat Island-6, Sno-0/Sno-1a, Sno-0/Sno-1b, Sno-0/Sno-1c, Sno-1f, and Sno-3/Sno-4. Eighteen segments have little or no vegetation available or are mostly armored. Maps 13A and 15A show shoreline vegetation and armoring.

Attenuating wave and tidal energy

The nearshore is subject to energy by tidal action, currents and waves that erode, transport and deposit sediment in the nearshore. Shoreline vegetation and a natural beach profile attenuate wave and tidal energy. Shoreline vegetation naturally stabilizes banks and influences water current and shoreline shape (Gorton et al. 1992). Storm berms on the backshore portions of beaches serve to deflect and distribute wave energy evenly across the beach. Shoreline armoring changes the profile of the beach, and the pattern and deflection of wave energy. Clearing for shoreline development and armoring reduces shoreline vegetation that naturally stabilizes the shoreline against the erosive forces of the tides and wave energy. Shoreline armoring by reach is shown on Maps 13A and 18. 33% of shoreline segments are less than 20% armored, 26% are 20-50% armored and 41% are more than 50% armored. The segments south of the Snohomish River, north and south of Tulalip Bay, portions of Hat Island and Warm Beach area are the most heavily armored.

Space or conditions for reproduction, nesting, forage, hiding

Critical saltwater habitats provide space or condition for reproduction, nesting, forage, and hiding for most aquatic and terrestrial plants and animals. Critical saltwater habitats include all kelp beds, eelgrass beds, spawning and holding areas for forage fish, including herring, smelt and sandlance; subsistence, commercial and recreational shellfish beds; mudflats, intertidal habitats with vascular plants, and areas with which a priority species have a primary association (WAC 173-26-221(2)(c)(iii)).

The Snohomish County nearshore supports a rich variety of habitat areas and species. Map 17 shows critical saltwater habitats in Snohomish County. All segments contain at least one critical saltwater habitat. Fifteen percent of segments contain one or two critical saltwater habitats. 66% of segments contain three or four critical saltwater habitats. 18% of segments contain five or more critical saltwater habitats. Sno-1e, Hat Island-6, Sno-0/Sno-1c (Snohomish Estuary), Sno-1f, and Sno-1/Sno-2, Port Susan and Skagit Bay have the highest concentration of critical saltwater habitats, priority species habits, and waterfowl concentration areas.

The most significant and important habitat area is the Snohomish Estuary. The estuary supports seven species of anadromous salmonids, a variety of non-anadromous freshwater and saltwater fish species, abundant forage fish (surf smelt and sand lance), 15 species of mammals, 63 species of birds, and four species of reptiles. It is an important staging and stop-over area for bird migration along the west coast.

MARINE SHORELINE SUMMARY

Ecosystem-wide processes and ecological functions that have been altered in the marine shoreline include sediment processes, large woody and organic debris recruitment and transport, water quality, riparian vegetation and habitat conditions.

Shoreline armoring to protect the BNSF railroad has most severely altered sediment processes south of the Snohomish Estuary and Everett. In this area, sediment delivery is limited to several streams that deliver sediment via culverts under the railroad right-of-way. Forage fish spawning still occurs at these limited points of sediment input (Pentilla 2001). North of the Snohomish Estuary and on Hat Island, sediment processes have been altered by armoring to protect residential development in several areas, but still provide important habitat and sediment functions.

Clearing of riparian vegetation along the marine shoreline for residential uses and for bulkheads and other shoreline armoring has resulted in a lack of large woody and organic debris available for recruitment to the system. The lack of debris in turn affects the stability of the beaches as the presence of beach logs and debris can reduce erosion by dissipating wave energy and trapping sediment.

Water quality in Port Susan suffers from high levels of fecal coliform bacteria which affect shellfish harvest. The high levels of fecal coliform bacteria are due to run-off from residential land uses and failing septic systems in the Warm Beach area and agricultural activities in the Stillaguamish River valley.

Restoration and preservation activities that could improve ecological functions and eco-system wide processes in the marine shoreline include: revegetation of riparian areas to provide shade to cool water temperatures, filter run-off and to provide a source of LWD and organic materials; limiting shoreline armoring to allow for continued sediment delivery and to protect nearshore habitat; and improvements to water quality in adjacent upland areas.

Lakes

LAKE SHORELINES

BACKGROUND DOCUMENTS

Existing conditions of Snohomish County lakes is documented in the State of the Lakes Report and in this report. Data in this report comes from existing GIS coverages and data, an inventory of lake conditions conducted by the Snohomish County Surface Water Management Department and a new inventory of shoreline vegetation conducted by the Snohomish County Department of Information Services, GIS division.

CONTEXT

There are 51 lakes, with 114 miles of shoreline, addressed by this report (Appendix A, Table A-1). These include 41 of 47 lakes that are listed in WAC 173-20-640 as falling under the provisions of the SMA. The WAC list includes four lakes that are within cities (Blackman, Silver, Ballinger, and Chaplain), and two that no longer exist or have different names (Hanson Slough, and Evangeline). In addition to the 41 lakes listed in WAC 173-20-640, there are ten lakes that are 20 acres or over and meet the criteria in WAC 173-22-040. These are: Spada Lake (x acres), Martha Lake South (61.5 acres), Ketchum (24.5 acres), Wagner (20.2 acres), Spring (25.4 acres), Conner (21 acres), Getchell Acres (26.8), Swartz (23.5 acres), Mud (26 acres) and Sunset Lakes (40.6 acres). With the exception of Martha Lake (South), none of these lakes is designated in the current Shoreline Master Program.

Land Use

In general, primary land uses on lake shorelines are single-family residential and duplex (75%), resource production (8%), undeveloped (13%), parks and recreation (4%). Transportation corridors are not included in this calculation. Resource production consists of primarily agriculture and forestry uses.

There are several lakes with significant areas of resource production, parks, private recreation, and undeveloped areas that vary from the overall averages. Significant portions of shorelines of Bryant (65%), Dagger (94%), Fontal (98%), Kellog (100%), and Tomtit (100%) lakes are used for resource production. Significant portions of Crystal (43%), Echo (100%), Spada (33%), Sunset (21%), and Woods (40%) lakes are undeveloped. Cassidy (28%), Flowing Lake (11%), Goodwin (3%), Martha South (13%), and Roesiger (4%) lakes have proportionately more public parks than most lakes. Conner (87%), Hannan (91%), Hughes (83%), are all used primarily for private recreational uses such as scout camps, church camps, RV parks and other similar uses.

Public Access

Twenty-four lakes (48%) have at least one developed public access owned by the County, the Washington State Department of Fish and Wildlife, Washington State Department of Natural Resources, or Washington State Parks. Lakes Goodwin, Shoecraft, Roesiger and Stevens are used heavily for public recreation. Nine additional lakes do not have existing developed access, but are on or adjacent to publicly owned land (Federal or State) that could potentially have public access. Lakes with no existing or potential access are: Sunday, Thomas, Armstrong, Cochran, Crystal, Dagger, Fontal, Getchell, Hannan, Hughes, Kellogg, Little, Mud, Spring, Swartz, Tomtit, and Twin Lakes. Maps 9A and 9B show shoreline land use, including parks and major public lands. Public lands and boat launches are shown on the inventory maps.

Shoreline modifications and development

Construction of docks and armoring generally disrupts shoreline and aquatic vegetation and results in the removal of large woody debris. Docks also increase predation of salmonids by bass and other predators, and impact navigability and public use of the waters of the lake (Carrasquero 2001). A little over half of the lakes within shoreline jurisdiction are developed with docks or other overwater structures. The fourteen most developed lakes have less than 50% of shoreline vegetation remaining within 200 feet of the OHWM. Of these, the most developed lakes within shoreline jurisdiction are Goodwin, Stevens, Serene and Bosworth. Each of these lakes are more than 70% developed and has an average of about one dock for every 100 feet of shoreline. There are several lakes with little or no development within 200 feet of the OHWM: Greider, Blanca, Boulder, Copper, East Boardman, Echo Lake, Hughes, Kellogg, Fontal, Little, Sunset, Tomtit and Wallace lakes. Maps 19A and 19B show segments by dock density.

Geology

Lakes in Snohomish County generally fall into four categories that relate to their geologic formation: glacial drift plain lakes, glacial scour lakes, kettle lakes, and impoundment lakes.

The majority of Snohomish County lakes in shoreline jurisdiction are glacially created "glacial drift plain" and "glacial scour" lakes. Glacial drift-plain lakes occupy trough-like depressions cut into outwash plains by continental glaciers. Glacial scour lakes occupy depressions scoured into bedrock by retreating glaciers. Generally, these lakes are elongated from north to south, reflecting the direction of retreat and advance of the Vashon Glacier. Glacial drift-plain lakes tend to be drainage lakes, with at least one inlet and outlet, and their main source of water is stream drainage. Since they are located in glacial drift, groundwater flow can also be considerable (DOE Website).

There are two impoundment lakes: Spada Lake and Spring Lake. Impoundment lakes owe over one-half of their maximum depth to a dam, and tend to be drainage lakes, with at least one inlet and outlet, and where the main source of water is stream drainage. These lakes have greater fluctuations in water levels due to dam regulation.

There are three kettle lakes: Bryant Lake, Echo Lake, and Kellogg Lake. Kettle lakes are circular lakes formed by the melting of large blocks of glacial ice buried in the glacial drift of outwash plains left behind by retreating glaciers. These lakes tend to be very round, and be either seepage or spring lakes with relatively small watersheds. Kettle lakes are more sensitive to nutrient loading and contamination and increases in impervious surfaces.

Soils

Soil types found in and around lakes are predominantely those common to glacial outwash plains and terraces where most lakes are found. These include well drained soils such as the Alderwood, Everett and Tokul series. Hydric mucks and peats, comprised of organic materials such as Mukilteo muck and Orcas peat, are commonly found in and adjacent to lakes due to the regular presence of water. Predominant soil types for each planning segment are found in Table VI-2. Descriptions and characteristics of soils are found in Appendix B.

Fish and Wildlife Habitat

The predominant habitat types described in the general overview found in or near lakes in Snohomish County are aquatic, wetland, urban and lowland conifer forest habitats. Wetland habitats adjacent to lakes are the most significant and productive habitat areas remaining near many lakes. In addition to the species described for these habitats in the overview, Snohomish County lakes support Chinook and Kokanee Salmon, Bull Trout, Cutthroat Trout, and several resident and game fish including Rainbow Trout, Large Mouth Bass, Small Mouth Bass, Yellow Perch, Pumpkinseed Sunfish, Brown Bullhead Catfish, and Black Crappie (Williams and Reynolds 2003). Most lakes are stocked with Rainbow Trout by the WDFW. Lake Stickney is the only lake supporting Chinook Salmon. Bull Trout are presumed to use Flowing, Panther, Stevens, and Cassidy Lakes. Cutthroat Trout are resident in Lake Goodwin and Lake Stevens. Kokanee are found in Lake Stevens and Lake Roesiger. Threatened or endangered species associated with lakes include the Bald Eagle, Grizzly Bear (alpine lakes), Chinook Salmon (Lake Stickney only), and Sandhill Crane (O'Neill et al. 2001).

SHORELINE ECOLOGICAL FUNCTIONS

Maintaining hydrologic flows and natural ranges of flow variability

Lake watershed land cover

Water quality and hydrologic flows to lakes are impacted most by development in the lake's watershed. Description and maps of lake watersheds are found in the 2003 State of the Lakes Report. The following lakes have watersheds estimated to have more than 65% forest or shrub cover: Armstrong, Bosworth, Cassidy, Cochran, Howard, Riley, Roesiger, Spring, Storm, and Swartz (Purser et al. 2003).

Flooding and low flows

Flooding and low flows have not been extensively studied on Snohomish County lakes. Flooding is noted as a problem in Bryant, Crabapple, and Martha (S.) Lakes (Williams and Reynolds 2003).

Attenuating wave energy

On Snohomish County lakes, erosion and attenuation of wave energy have not been studied. It is well documented that shoreline armoring changes the pattern and deflection of wave energy, and can cause erosion on adjacent unarmored properties (Snohomish County Planning and Development Services 2005). Clearing for shoreline development and armoring reduces shoreline vegetation that naturally stabilizes the shoreline against the erosive forces of wave energy.

Snohomish County lakes within shoreline jurisdiction range in size from 20 acres to over 1,000 acres (Lake Stevens and Spada Lake). In general, Snohomish County lakes do not have enough fetch to have high wave energies due to wind. Boat waves on those lakes where motorized boats are allowed are more likely to result in higher wave energy than wind. Motorized boats are allowed on Lake Stevens, Lake Cassidy, Flowing Lake, Lake Goodwin, Lake Roesiger, Ki Lake, and Lake Shoecraft (Williams and Reynolds 2003).

Recruitment/transport of woody and organic debris

In lakes, fallen trees form habitat features for aquatic species. Large woody debris has been estimated on some Snohomish County lakes. Maps 14A and 14B show large woody debris by reach. The following lakes have relatively healthy amounts of large woody debris: Bryant, Cassidy, Chain, Cochran-1, Dagger, Howard, Hughes, Little, Martha North-1, Riley, Roesiger, Spring, Stickney, and Wagner. Construction of docks and bulkheads often result in the removal of existing LWD from lakes, so lake segments with a high number of bulkheads or docks are likely to have little LWD. Maps 19A and 19B show shoreline dock density by reach.

Removing excessive nutrients and toxics

Snohomish County Surface Water Management monitors water quality in Snohomish County Lakes. Blue-green algae blooms, excess waterfowl and declining water clarity are the water quality issues most often found. Blue-green algae blooms are problems in Lake Armstrong, Bryant lake, Howard Lake, Lake Ketchum, Loma Lake, Lake Stevens, and Sunday Lake. Declining water clarity is a problem in Loma Lake, Lake Stevens, and Sunday Lake (Williams and Reynolds 2003). High levels of phosphorus and fecal coliform bacteria are the Clean Water Act 303d list parameters most often not met in Snohomish County lakes. In 1998, four shoreline lakes did not meet state water quality standards- four exceeded phosphorus levels, and one also exceeded fecal coliform bacteria levels. Based on the 2004/05 proposed 303d list prepared by the Washington State Department of Ecology, an additional seven lakes do not meet phosphorus standards, and six lakes do not meet fecal coliform bacteria standards. Impaired lakes as of 1998 were Lake Stevens, Sunday Lake, Lake Ketchum, and Silver Lake (Everett). Additional lakes on the proposed 2004/2005 303d list are: Lake Ki, Martha Lake, Crabapple Lake, Lake Goodwin, Loma Lake and Lake Shoecraft.

High levels of phosphorus and fecal coliform bacteria are likely due to run-off from residential development and clearing of riparian vegetation adjacent to the lakes. Septic systems, fertilizers, animal and pet wastes and detergents related to development all contribute to excess phosphorus and fecal coliform bacteria. Implementation of livestock management programs, proper disposal of pet waste, repairing failing septic systems, and revegetation of riparian areas would reduce bacteria and nutrients (SWM 2000a, Williams and Reynolds 2003).

Storing sediment

There are no lakes within shoreline jurisdiction documented to have sediment storage problems (Williams and Reynolds 2003). Additional studies are necessary to determine the condition of this function.

Shoreline vegetation

There are 15 lakes where the entire shoreline is more than 70% vegetated. They include all of the mountain lakes, and the following lowland and foothill lakes: Bryant, Dagger, Hannan, Hughes, Little, Mud, Spada, Spring, Tomtit, and Woods Lakes. Cassidy, Chain, Cochran, Crabapple, Crystal, Howard, Loma, Martha North, Panther, Riley and Storm lakes each have one reach that is more than 70% vegetated. Shoreline vegetation is shown on Maps 15A and 15B.

Space or conditions for reproduction, nesting, forage, hiding

Predominant habitat types found on Snohomish County lakes include aquatic areas, wetlands and lowland conifer forests. On lakes, important habitat features include significant riparian vegetation, large woody debris and adjacent wetlands. Lakes and lake segments that have shoreline vegetation forming a riparian corridor over more than 70% of the reach and that also have healthy amounts of large woody debris include: Bryant, Cassidy-1, Chain, Cochran-1, Dagger, Howard-1, Hughes, Martha N-1, Riley-2, Storm-1 and Stickney-1. Panther, Stevens, Sunday, Tomtit, Bryant, Wagner, Chain, Crystal, Stickney, Fontal, Thomas, Twin Lakes, Cassidy, Getchell, Kellog, Echo, and Woods Lakes all have one or more segments with large wetlands (5+ acres) that provide valuable habitat areas for both terrestrial and aquatic species. According to WDFW PHS data, Lakes Stevens and Lake Cassidy together have more than 2,000 acres of priority habitat areas.

LAKE SHORELINE SUMMARY

Ecosystem-wide processes and ecological functions that have been altered in the on lake shorelines include large woody and organic debris recruitment and transport, water quality, riparian vegetation and habitat conditions.

Clearing of riparian vegetation along the lake shorelines for residential uses and for docks and other shoreline structures has resulted in a lack of large woody and organic debris available to provide habitat. Clearing of riparian vegetation in the shoreline also contributes to water quality problems, as there is insufficient vegetation to filter run-off before it enters the water.

Water quality in several of the most heavily developed lakes suffers from high levels of fecal coliform bacteria and phosphorus. The high levels of fecal coliform bacteria and phosphorus are due to run-off from residential land uses, including failing septic systems, fertilizers detergents, and agricultural activities (SWM 2000a, Williams and Reynolds 2003).

Development of overwater structures such as docks and boathouses often results in the disturbance of riparian vegetation, aquatic vegetation and the removal of large woody debris that form important habitat features for aquatic species. On lakes with threatened or endangered salmonids, docks can increase predation on juvenile salmonids by predator species such as bass (Carrasquero 2001).

Restoration and preservation activities that could improve ecological functions and eco-system wide processes in the marine shoreline include: revegetation of riparian areas to provide shade to cool water temperatures, filter run-off and to provide a source of LWD and organic materials; limiting shoreline armoring and overwater structures to minimize alterations to riparian vegetation and aquatic habitat; and improvements to water quality draining from adjacent upland areas.

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Glossary

GLOSSARY OF TERMS

ACCRETION: Slow addition to land by water-borne sediment
ADVERSELY IMPACTED: Category used to describe ecological functions that have been impacted by land uses or modifications and are at risk to become or that may no longer be properly functioning.
ALLUVIAL: Term used to describe material deposited by running water.
ANADROMOUS FISH: Fish, such as salmon or steelhead trout, that hatch in fresh water, migrate to and mature in the ocean, and return to fresh water as adults to spawn.
AQUATIC HABITAT: Habitat where a variety of marine or freshwater flora and fauna occur for long periods throughout the year, characterized by standing or flowing water. Examples include rivers, streams, wetlands, tide pools, estuaries, bogs, ponds, seas and oceans.
ARMORING: A general term applied to hardening of shorelines to protect against erosion using bulkheads, revetments and other coastal defense structures of concrete, timber, steel, and masonry.
BASIN: See watershed**.**
BEACH EROSION: Loss of sandy beach area
BEST AVAILABLE SCIENCE: Science that has been peer reviewed, followed a replicable method, uses appropriate statistical or quantifiable methods for analysis, reaches logical conclusions and reasonable inferences, appropriately frames conclusions with respect to the prevailing body of pertinent scientific knowledge, and adequately references assumptions, analytical techniques, and conclusions with citations to relevant, credible literature and other pertinent existing information.
BROADLEAF: A term describing a plant with broad, flat leaves. Examples are maples, oaks and alders.
BULKHEAD: A solid or open pile wall erected generally parallel to and near the ordinary high water mark for the purpose of protecting adjacent uplands from waves or current action.
CANOPY: Upper forest layer consisting of high overarching covering of branches and leaves.

CHANNELIZED: A portion of a river channel that has been enlarged or deepened, and often has armored banks
CHAR: A trout-like species of fish whose subspecies include brook trout, Dolly Vardens, and arctic char, among others.
CONIFER: Cone bearing trees; the "evergreens".
COVER: Any object in the stream that provides protection to fish and other animals. Fish use cover to hide, rest, escape and feed.
CRITICAL SALTWATER HABITAT: Critical saltwater habitats include all kelp beds, eelgrass beds, spawning and holding areas for forage fish, such as herring, smelt and sandlance; subsistence, commercial and recreational shellfish beds; mudflats, intertidal habitats with vascular plants, and areas with which priority species have a primary association. Critical saltwater habitats require a higher level of protection due to the important ecological functions they provide. [WAC 173-26-221(2)(b)(iii)(A)]
CULVERT: Pipe or enclosed channel, open at either end, used to convey water below an obstruction, for example, a culvert which runs under a road to convey stream water from one side of the road to the other.
DECIDUOUS: Trees and plants that shed their leaves at the end of the growing season.
DEFORESTATION: the large-scale removal of trees from a habitat dominated by forest
DEGRADED: A relative category used to describe the condition of ecological functions that have been so impacted by land use or modifications that they no longer function to sustain healthy populations of salmonids.
DIKE/LEVEE: A barrier or embankment constructed to protect land from floodwaters by containing the flow of water in the river channel or keeping out the sea.
DISSOLVED OXYGEN (DO): The amount of oxygen that is dissolved in water. It also refers to a measure of the amount of oxygen available for biochemical activity in water body, and as indicator of the quality of that water.
ECOLOGICAL FUNCTIONS: The work performed or role played by the physical, chemical, and biological processes that contribute to the maintenance of the aquatic and terrestrial environments that constitute the shoreline's natural ecosystem. Also referred to as shoreline functions.
ECOLOGICAL INDICATOR: A measure, or a collection of measures, that describes the condition of an ecosystem or one of its critical components.

ECOSYSTEM: A complex of biological communities and environment that forms a functioning, interrelated unit in nature.
ENDANGERED SPECIES: Under ESA, any species that is likely to become extinct within the foreseeable future throughout all or a significant portion of its range.
ESTUARINE: Living in or pertaining to an estuary
ESTUARY: A somewhat restricted body of water where the flow of freshwater mixes with saltier water transported by tide from the sea. Estuaries are the most productive water bodies in the world. The mouth of the Snohomish River is an estuary.
EVOLUTIONARILY SIGNIFICANT UNIT (ESU): An ESU is population of organisms that is reproductively isolated from other populations of the same species, and represents an important component in the evolutionary legacy of the species. Populations of pacific salmon are broken into ESUs for the purposes of the Endangered Species Act. For example, the Puget Sound Chinook Salmon ESU is currently proposed to be listed as "threatened" under the Endangered Species Act.
FECAL COLIFORM: A group of bacteria that lives in the intestines of warm-blooded animals. Elevated measurements of these bacteria in surface waters may indicate the presence of human and/or animal waste. Health advisories may be posted when measurements indicate an increased risk to humans from exposure.
FEDERAL ENDANGERED SPECIES ACT (ESA): The federal law that prohibits "taking" of species that have been listed as in danger of becoming extinct. "Take" is defined in the Endangered Species Act as harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect any threatened or endangered species. Harm may include significant habitat modification where it actually kills or injures a listed species through impairment of essential behavior (e.g., nesting or reproduction).
FEEDER BLUFF, EROSIONAL BLUFF. Any bluff (or cliff) experiencing periodic erosion from waves, sliding or slumping, whose eroded earth, sand or gravel material is naturally transported (littoral drift) via a driftway to an accretion shoreform. These natural sources of beach material are limited and vital for the long term stability of driftways and accretion shoreforms.
FETCH: The distance wind and waves can travel toward land without being blocked. In areas without obstructions, the wind and seas can build to great strength, but in sheltered areas, such as coves and harbors, the wind and seas can be quite calm.
FINE SEDIMENT: Sediment comprising fine-grained material such as mud or clay particles. The concentration of fine sediments above 12% in the substrate impact embryo survival and emergence success in Chinook salmon.

FLOODPLAIN: lowland areas adjoining lakes, wetlands, and rivers that are susceptible to inundation of water during a flood. For regulatory purposes, the floodplain is the area covered by the 100-year flood or the area that has a 1 percent chance of flooding every year. It is usually divided into districts called the floodway and flood fringe. Areas where the floodway and flood fringe have not been determined are called approximate study areas or general floodplain. Local units of government administer ordinances that guide development in floodplains.
FORAGE FISH: Small fish which breed prolifically and serve as food for predatory fish. Surf smelt and sand lance and are important prey for salmonids and other fish found in the nearshore in Snohomish County.
GROIN: A shore protection structure that interrupts longshore transport of sediment. It is narrow in width (measured parallel to the shore) and extends from a point near the high tide line out into the water. Its length may vary from tens to hundreds of meters. Groins may be classified as permeable (with openings thorough them) or impermeable (a solid or nearly solid structure through which sand cannot pass)
HABITAT: Is the place where something lives. Habitat includes all the things, such as food and shelter, that an organism needs to live at any point in its life. For example, one may talk about "rearing habitat" for juvenile coho salmon, which may be a streamside pond. This habitat is different than the habitat that a coho salmon occupies as an adult in the ocean.
HERBACEOUS: A plant with a non woody stem, having characteristics of an herb; leaf-like in color and texture. The upper parts will die back at the end of the growing season.
HYDROLOGIC FLOW REGIMES: Spatial and temporal variations of the flow of water over and through land.
INSTREAM FLOW: The amount of water remaining in a stream without diversion, that is required to maintain a particular aquatic environment or water use.
INTACT: A category used to describe the condition of one or more ecological functions as properly functioning. See properly functioning.
INTERTIDAL: The zone between the high and low water marks. See also littoral zone.
LARGE WOODY DEBRIS (LWD): Pieces of wood in the stream that are at least 10 centimeters thick and one meter long. LWD forms pools, provides cover, and protects many important habitat areas for fish.
LITTORAL ZONE: The biogeographic zone in a body of fresh water where light penetration is sufficient for the growth of plants; the intertidal zone of the seashore

LONGSHORE CURRENT: A current located in a surf zone, moving generally parallel to the shoreline, generated by waves breaking at an angle with the shoreline, also called alongshore current
LONGSHORE DRIFT: Movement of sediments approximately parallel to the shore.
NATIONAL MARINE FISHERIES SERVICE (NMFS): The NMFS has jurisdiction over anadromous and marine fish and administer the EPA for these species. Anadromous fish are born in fresh water, migrate to the ocean to grow into adults, and then return to fresh water to spawn. Marine fish spend their entire life in salt water.
NONPOINT SOURCE POLLUTION: Occurs when water runs off land or through the ground, picks up pollutants, and deposits them in surface waters or introduces them into groundwater. Pollution that does not come from a single source, such as a pipe or ditch.
NOT PROPERLY FUNCTIONING: See degraded.
OFF-CHANNEL HABITAT: Ponds, channels or wetlands that are connected to the main channel of a stream. Juvenile coho salmon often spend at least part of their fresh water lives in off- channel habitat.
ORDINARY HIGH WATER MARK: on all lakes, streams, and tidal water is that mark that will be found by examining the bed and banks and ascertaining where the presence and action of waters are so common and usual, and so long continued in all ordinary years, as to mark upon the soil a character distinct from that of the abutting upland, in respect to vegetation, as that condition exists on the effective date of the shoreline management act or as it may naturally change thereafter.
ORGANIC DEBRIS: Leaves, branches, berries, insects and other parts of living matter or derived from living matter.
PLANNING SEGMENT OR SEGMENT: Linear segment of the shoreline used as a unit for the purposes of planning and analysis.
POOL: A part of the stream that is usually deeper than the surrounding water and has slower current. Pools are often formed by scouring under or around an obstacle, by plunging over logs or rocks, or by side channels.
POOR: See degraded
PROPERLY FUNCTIONING CONDITIONS: State of the physical, chemical, and biological aspects of watershed ecosystems that will sustain healthy salmonid populations. Properly functioning condition generally defines a range of values for several measurable criteria rather than specific, absolute values. These values are based on the “Matrix of Pathways and Indicators” prepared by NMFS (1996).

RESTORATION: The reestablishment or upgrading of impaired ecological shoreline processes or functions. This may be accomplished through measures including but not limited to revegetation, removal of intrusive shoreline structures and removal or treatment of toxic materials. Restoration does not imply a requirement for returning the shoreline area to aboriginal or pre-European settlement conditions.	
REVETMENTS: A facing of stone to protect an embankment or shore structure against erosion by wave action or currents.	
RIFFLE: Shallow rapids with surface agitation, but no waves.	
RIPARIAN: Pertaining to the banks of a river or other body of fresh water.	
RIVER DELTA: A delta is the mouth of a river where it flows into an ocean, sea, or lake, building outwards (as a deltaic deposit) from sediment carried by the river and deposited as the water current is dissipated. Deltaic deposits of larger, heavily-laden rivers are characterized by the river channel dividing into multiple streams (distributaries), these anastomizing (dividing and coming together again) to form a maze of active and inactive channels.	
ROOTWAD: The mass of roots of a tree. Rootwads of fallen trees in the stream can form large pools and provide excellent cover.	
SALMONID: Fish of the family *Salmonidae*. These include salmon, trout, char, and whitefish.	
SCOUR: Removal of sediment from the stream bed by flowing water.	
SEDIMENT SOURCE: A point or area on a coast from which beach material arises, such as an eroding cliff, feeder bluff or river mouth.	
SEDIMENT TRANSPORT: The main agencies by which sedimentary materials are moved are: gravity; running water (rivers and streams); ice (glaciers); wind and the sea (currents and longshore drift)	
SHORELINE VEGETATION: Living vegetation consisting of canopy and understory growing adjacent to or within 200 feet of the ordinary high water mark.	
SUB-BASINS: A subset of a basin, the drainage basins of the tributaries within a larger river's basin.	
THREATENED SPECIES: Under ESA, any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.	

TOTAL MAXIMUM DAILY LOAD (TMDL): The federal Clean Water Act (CWA) section 303(d) addresses waters that are not "fishable or swimmable" by requiring each state to identify the waters and to develop total maximum daily loads (TMDLs) for them, with oversight from the U.S. Environmental Protection Agency (EPA). A TMDL is an assessment of how much pollution "load" the stream can accept and still meet federal and state water quality standards. A TMDL allocates pollution control responsibilities among pollution sources in a watershed, and is the basis for taking the actions needed to restore a water body. The Washington DOE administers the TMDL process for the EPA in this state. Technically, Total Maximum Daily Load (TMDL) is the sum of the individual wasteload allocations (WLAs) for point sources, load allocations (LAs) for nonpoint sources and natural background, and a margin of safety (MOS). TMDLs can be expressed in terms of mass per time, toxicity, or other appropriate measure that relates to a state's water quality standard.
TRIBUTARY: is a contributory stream, a river that does not reach the sea, but joins another major river (a parent river), to which it contributes its waters, swelling its discharge. A tributary joins another river at a confluence.
UNDERSTORY: The trees and woody shrubs growing beneath the canopy in a stand of trees
WATER RESOURCE INVENTORY AREA (WRIA): A term established by WAC 173.500.040. The state has been divided into 62 geographic regions based on topography and economic conditions. Sometimes a WRIA coincides with a watershed, while in other cases it may include all or part of several watersheds. Or a watershed may be so large that it is divided into more than one WRIA.
WATERSHED: The area of land that water flows across or under on its way to a river, lake or ocean. Includes all surface water and adjacent estuaries and marine areas. A legal framework for watershed boundaries is provided through Washington's designation of Water Resource Inventory Areas (see Watershed Resource Inventory Area).
WETLANDS: means those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands include, but are not limited to swamps, marshes, bogs, and similar areas, as well as artificial wetlands intentionally created from non-wetland areas to mitigate for conversion of wetlands, as permitted by the county. Wetlands do not include those artificial wetlands intentionally created from non-wetland sites, including, but not limited to irrigation and drainage ditches, grass-lined or biofiltering swales, canals, detention facilities, wastewater treatment facilities, farm ponds and landscaping amenities.

ACRONYMS

BAS - Best Available Science

DO – Dissolved Oxygen

DOE – Washington Department of Ecology, also known as "Ecology"

DEIS - Draft Environmental Impact Statement

FEMA - Federal Emergency Management Agency

GMA – Growth Management Act

NMFS – National Marine Fisheries Service

NPDES - National Pollution Discharge Elimination System

SMA – Shoreline Management Act

SMMP – Shoreline Management Master Program

TMDL – Total Maximum Daily Load

UGA - Urban Growth Area

WAU - Water Analysis Unit

WDFW – Washington Department of Fish and Wildlife

WRIA - Water Resource Inventory Area

LWD – Large Woody Debris

APPENDICES

Appendix A:
List of Lakes Subject to SMA

Lake Name	WAC List 173-20-640	Size (Acres)	Designated in current SMP	Lake Type
Armstrong	Y	29.9	Y	Glacial drift plain
Blanca Lake	Y	160	Y	Glacial scour
Bosworth Lake	Y	103.9	Y	Glacial drift plain
Boulder Lake	Y	22.8	Y	Glacial scour
Bryant Lake	Y	20.9	Y	Kettle
Cassidy	Y	130.1	Y	Glacial drift plain
Chain Lake	Y	23.7	Y	Glacial drift plain
Cochran	Y	32.8	Y	Glacial drift plain
Conner Lake	N	21.1	N	Glacial drift plain
Copper Lake	Y	61.1	Y	Glacial scour
Crabapple Lake	Y	37.6	Y	Glacial drift plain
Crystal Lake	Y	52.1	Y	Glacial drift plain
Dagger Lake	Y	30.2	Y	Glacial scour
East Boardman Lake	Y	45.6	Y	Glacial scour
Echo Lake	Y	23.3	Y	Kettle
Flowing Lake	Y	131.8	Y	Glacial drift plain
Fontal	Y	43.1	Y	Glacial scour
Getchell Acres	N	26.8	N	Glacial drift plain
Goodwin	Y	542.2	Y	Glacial drift plain
Greider Lakes	Y	57.8	Y	Glacial scour
Hannan	Y	78.5	Y	Glacial scour
Howard Lake	Y	27.2	Y	Glacial drift plain
Hughes and Bevis	Y	20.8	Y	Glacial drift plain
Kellogg	Y	20.2	Y	Kettle
Ketchum	N	24.5	N	Glacial drift plain
Ki	Y	100.6	Y	Glacial drift plain
Little Lake	Y	23.4	Y	Glacial scour
Loma	Y	23.1	Y	Glacial drift plain
Martha Lake (south)	N	61.8	N	Glacial drift plain
Martha North	Y	61.6	Y	Glacial drift plain
Mud Lake	N	26.1	Y	Glacial scour
Panther Lake	Y	48.5	Y	Glacial drift plain
Purdy Creek Ponds	Y	53.0	Y	???
Riley Lake	Y	32	Y	Glacial drift plain
Roesiger	Y	352.8	Y	Glacial drift plain
Serene	Y	45	Y	Glacial drift plain
Shoecraft	Y	132.3	Y	Glacial drift plain
Spada Lake	Y	1775.8	N	Impoundment
Spring Lake	N	25.4	N	Impoundment
Stevens	Y	1014.3	Y	Glacial drift plain
Stickney Lake	Y	24.8	Y	Glacial drift plain
Storm Lake	Y	75.7	Y	Glacial drift plain
Sunday Lake	Y	45	Y	Glacial drift plain
Sunset Lake	N	40.6	N (Federal)	Glacial scour
Swartz Lake	N	23.5	N	Glacial drift plain
Thomas Lake	Y	100	N	Unknown

Tomtit Lake	Y	25.5	Y	Glacial scour
Wagner Lake	N	20.2	N	Glacial drift plain
Wallace Lake	Y	54.2	Y	Glacial drift plain
Woods Lake	Y	22.4	Y	Glacial drift plain

Appendix B:
Predominant Soil Types in Snohomish County Shoreline Jurisdiction.

Text adapted from the USDA Soil Survey of Snohomish County Area

Series	Description
Alderwood	Moderately well drained soils on till plains. Moderately deep over hardpan. Slight to moderate hazard of erosion depending on slope. Run-off is slow.
Everett	Well drained soils on terraces and outwash plains. Very deep soils, with slight to moderate chance of erosion, depending on slope. Run-off is slow.
Fluvaquents	Very deep, poorly drained, salt affected soils on tidal flats formed in alluvium. Covered at high tide, run-off ponds.
Getchell-Oso	Moderately well drained soils on mountainsides and ridge tops. Formed in glacial till and volcanic ash. Run-off and hazard of erosion are moderate.
Indianola	Very deep well drained soils on terraces and outwash plains. Slight erosion hazard and run-off is slow.
Kitsap	Very deep, moderately well drained soil on terraces. Formed in lacustrine sediment. Erosion hazard ranges from slight to high depending on slope. Run-off ranges from slow to rapid depending on slope. Subject to hillside slippage at slopes >8%.
Menzel	Very deep, well drained soil on terraces formed in alluvium and volcanic ash. Run-off is slow and erosion hazard is slight.
Mukilteo muck	Very deep poorly drained soil in depressional areas. Formed in organic material predominantely sedges. Run-off is ponded.
Nargar	Very deep, well drained soil in on high terraces formed in sandy alluvium and volcanic ash. Run-off is slow to medium depending on slope, erosion hazard is slight to medium depending on slope.
Norma Loam	Very deep, poorly drained soil is in depressional areas and outwash plains. High water table, run-off is ponded and erosion hazard is slight.
Olomont-Elwell	Moderately deep and moderately well drained soil on mountainsides. Run-off is rapid and erosion hazard is high.
Orcas Peat	Very deep, very poorly drained soil in basins on hills formed in sphagnum moss. High water table, run-off is ponded.

Series	Description
Oso-Getchell	Moderately deep and moderately well drained soil on mountainsides. Run-off is rapid and erosion hazard is high.
Pastik	Very deep, moderately well drained soil on terraces formed in lacustrine sediment and volcanic ash. Run-off is slow to rapid depending on slope. Erosion hazard is slight to high depending on slope.
Pilchuck	Very deep, well drained soil on flood plain and formed in alluvium. Run-off is very slow, water table 24-48 inches, flooding common from November to April.
Puget	Very deep soil in depressional areas on floodplains that has been artificially drained. Run-off is slow, erosion hazard is slight. Rare periods of flooding from December to March.
Puyallup	Very deep, well drained soil on stream terraces formed in alluvium. Run-off is slow, erosion hazard is slight.
Riverwash	Very deep, well drained soil on floodplains formed in alluvium. Subject to frequent flooding. Overflow and alteration by severe erosion and deposition are frequent.
Rober	Very deep, moderately well drained soil on terraces. Formed in lacustrine sediment. Erosion hazard ranges from slight to high depending on slope. Run-off ranges from slow to rapid depending on slope. Subject to hillside slippage at slopes >15%.
Skykomish	Very deep, somewhat excessively drained soil on terraces, terrace escarpements and outwash plains formed in glacial outwash and volcanic ash. Run-off is slow and erosion hazard is slight.
Snohomish	Very deep soil on floodplains formed in peat and muck. Soil has been artificially drained. Run-off is very slow, erosion hazard is slow. Water table is between 24 and 48 inches from November to May.
Sulsavar	Very deep, well drained soils on terraces and alluvial fans. Formed in volcanic ash and alluvium. Run-off is slow, erosion hazard slight, flooding is rare.
Sultan	Very deep, moderately well drained soil on floodplains formed in alluvium. Run-off is slow, erosion hazard is slight. Water table is between 24 and 48 inches from November to April.

Terric medisaprists	Very deep, poorly drained soils in depressional areas on till plains formed in organic material and alluvium. Run-off is ponded, and erosion hazard is slight.
Tokul	Moderately deep well drained soil on till plains formed in till and volcanic ash. Erosion hazard ranges from slight to moderate depending on slope. Run-off ranges from slow to medium depending on slope. Seasonal perched water table at 18 to 36 inches.
Xerothents	Areas where surface layer, subsoil, and substratum have been greatly disturbed, removed or replaced with other soil materials.

Appendix C:
Methodology for Mapping Feeder Bluffs on the Marine Shoreline

Conducted by PDS Staff, January 2005

1. Staff reviewed the location of eroding areas shown on the map showing coastal erosion, sediment supply, and longshore transport in the Port Townsend 30- by 60-minute quadrangle, Puget Sound Region, Washington, US Geological Survey (Keuler, R. F. 1988).
2. Eroding areas were added lines to a GIS coverage based on the map.
3. Staff reviewed DOE digital orthophotography 2000-2002 using the DOE website for the entire shoreline north of Everett and identified additional areas that had obvious scarring of vegetation and soil showing due to landsliding and added those areas to the polygons.

APPENDIX D:

SHORELINE INVENTORY CD-ROM

APPENDIX E:
Methodology to Determine Channel Migration Zone (CMZ) in Snohomish County

October 1, 2004

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<u>Introduction</u>

To assist the County in the review and update of the Critical Area Regulations, the Shoreline Management Master Program and related County plans, policies, and regulations, it is important to have a channel migration zone described and mapped in a justifiable and repeatable way. This paper documents the initial assumptions and principles, data sources, and methods used to describe and map the CMZ.

<u>Initial Assumptions and Governing Principles</u>

The initial assumptions and principles used in the creation of the CMZ dataset include:

- This will be an analytical product of GIS (i.e., it will result from the overlay of GIS data and use GIS tools and extensions available in ArcView and ArcInfo);
- It will rely only on existing GIS datasets under the control of Snohomish County Information Services;
- While recognizing that some important datasets do not cover the entire County, this project will attempt to minimize the number of datasets needed to accomplish the project; and
- The project will be constructed in modules, the base CMZ, additions to the base CMZ, and subtractions from the base CMZ, to facilitate easy future updates and to support derivative products and uses.
- In accordance with Ecology guidelines, the method and product will seek to map a 100-year channel migration zone.

<u>Data Sources</u>

For the base CMZ module, the FEMA 100 year floodplain mapping (a GIS theme on the County's network) is the primary source of data. In addition, such basic themes as the digital orthophotography that currently exists on the Snohomish County network (1933, 1984, 1990, 2002-3), routed streambank GIS theme, and waterbodies are included for quality assurance.

For the additions to the CMZ module, the County's Subbasin Surficial Geology GIS theme will be consulted to determine whether the migration zone abuts or intersects erodible geology. For the subtractions to the base CMZ, major roads, railroads, dikes and levees, Urban Growth Area boundaries, and municipal boundaries, all GIS themes on the County's network, can be consulted.

Methods

In areas where the coverage exists, the FEMA derivative 100 year floodplain will be the base CMZ. Digital orthophotography that currently exists on the Snohomish County network (1933, 1984, 1990, 2003) will be used to calculate channel migration rates by comparison with the routed streambank GIS theme. Reaches included in the analysis are the lower Stillaguamish River, Pilchuck Creek, the NF and SF Stillaguamish Rivers, the Snohomish River, the lower Skykomish River, the "Braided Reach" of the Skykomish River, the Pilchuck River, the Sultan River, the Wallace River and the NF and SF Skykomish Rivers in Snohomish County.

To determine the mean channel migration rate the current routed streambank was compared to the earliest aerial photos and the difference measured every 1000 feet along the center streamline. These differences were summed through the above reaches and the mean distance determined. This distance is then divided by the number of years separating the photos (1933, 1984, or 1990) and the routed shoreline (usually based on 1998 WA Department of Natural Resource digital orthophotography) to derive an average channel migration rate over the (relatively) recent past. The annual rate is then multiplied by 100 to create the zone of potential migration on either side of the current channel shorelines (hereafter called the "buffer").

An intersection is performed with this buffer and the County's Subbasin Surficial Geology coverage to determine whether and to what extent the surficial geology in the valley will be eroded by the channel in the next 100 years. All or part of the erodible geology unit was then added to the base CMZ (in the current case we only include that part which intersects the calculated buffer zone adjacent to the current channel).

A zone approach was adopted to distinguish the potential migration zones on the basis of the conditions under which the channel may migrate. Four zones were delineated: 1) in the buffer zone and in the 100 year floodplain; 2) outside the buffer but within the 100 year floodplain; 3) in the buffer, outside the 100 year floodplain, but in area of highly erodible geology; 4) in the buffer, outside the 100 year floodplain, but in area of moderately erodible geology, and 5) surrounded by 100 year flood plain in areas with highly erodible geology..

Results

Digital orthophotography from 1933 and 1990 has been compared to a shorelines (riverbank) theme developed partly from the 1998 Washington Department of Natural Resources digital orthophotography, partly from USDI-Geological Survey 7.5 minute quadrangle digital maps and partly from 2002-4 field mapping using Global Positioning System (GPS) technology. Separate channel migration rates were calculated for the lower Stillaguamish River, Pilchuck Creek, the NF and SF Stillaguamish Rivers, the Snohomish River, the lower Skykomish River, the “Braided Reach” of the Skykomish River, the Pilchuck River, the Sultan River, the Wallace River and the NF and SF Skykomish Rivers in Snohomish County. The average annual migration rate generally ranged from 0.5 to 3 feet per year. The exception to this was the “Braided Reach” of the Skykomish River which was calculated to have an mean annual migration rate of 18 feet per year (using 1984 digital orthophotography instead of 1990). “Buffers” (i.e., calculated potential migration zones over next 100 years, the zone of highest hazard) of 100-300 feet on each side of the rivers were identified, except in the Braided Reach which has a potential migration zone of 1800 feet on each side of the current active channel.

In most cases the mean annual migration rate and thus the buffer should be considered to be the minimum mean annual migration rate. This is due to the fact that only two photos or information sources were used to calculate the migration rates. The channels are assumed to have moved uni-directionally and incrementally, that is, in one direction and non-catastrophically. One can easily see that additional photo resources may show that the channels have moved back and forth and would move during periodic high flow events, not bit by bit over the years. Thus the actual migration rate is likely greater than those calculated for this exercise.

Highly erodible and moderately erodible surficial geology units are found in Table 1.

Table 1. Erodibility of Surficial Geology mapping units in Snohomish County.

Mapping Unit	**Erodibility**
Alluvium	High
Mass Wasting	High
Vashon recessional outwash	High
Vashon recessional lacustrine	High
Artificial (e.g., fill)	Moderate
Lahar	Moderate
Peat Deposits	Moderate
Vashon advance outwash	Moderate
Vashon till	Moderate
Pre-Fraser glacial (e.g., Possession drift)	Moderate
Pre-Fraser non-glacial (e.g., Olympia gravel)	Moderate

The acres within each channel migration zone is presented in Table 2. The map of the migration zones is presented as Figure 1.

Table 2. Area within each channel migration zone.

Zone	Area
In buffer, in floodplain	
In floodplain	
In buffer, out floodplain, highly erodible	
In buffer, out floodplain, moderately erodible	

Summary and Possible Next Steps

Assumptions, principles, data sources, and methods for determining a repeatable, efficiently drawn CMZ which incorporates direction received from Snohomish County Planning and Development Services and guidelines from Washington Department of Ecology have been documented as an accompaniment to the CMZ data/map. The organization, data sources used, and methods used increase the chance that future revisions or updates to the CMZ can be reliably and efficiently incorporated.

Possible next steps can be grouped into two categories. The first category includes steps that can be taken to improve the calculation of mean annual migration rate. This could be done by georeferencing additional digital photos and General Land Office shorelines from the late 1800's which have already been scanned and mosaicked. Georeferencing ties the photos to common benchmarks (among themes and other photos) and thus improve the resolution of migration distance. Additionally, the reaches could be further broken up and separate migration rates calculated for an increased number of reaches. An alternative, more conservative approach would be to calculate a maximum migration rate, assuming catastrophic migration, and using that to create the buffer zone.

Additional resources could be developed or committed to the acquisition of LIDAR (Light Detection and Ranging) coverage for all the rivers of interest to improve the identification of areas where the channel has been in the discernible past. Finally, fieldwork could be implemented as additional supporting information consistent with the Ecology publication, "A framework for delineating channel migration zones." Each of these steps would need to be prefaced by a commitment of additional staff and fiscal resources, as well as time.

The second category includes efforts to expound upon and clarify policy direction on the definition and management of channel migration zones in Snohomish County. This could possibly affect any of the methods currently used, but could be especially important in delineating floodplain areas which should be subtracted from the base CMZ.