

Snohomish River Basin Ecological Analysis for Salmonid Conservation

Snohomish Basin Salmonid Recovery Technical Committee



May 2004

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in cooperation with NOAA Fisheries

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Contributors

Andy Haas, Snohomish County Surface Water Management Division (SWM), Chair of EASC Work Group of the Snohomish Basin Salmonid Recovery Technical Committee

Krista Bartz, National Marine Fisheries Service, Northwest Fisheries Science Center (NWFSC)

Greg Blair, Mobrand Biometrics

Suzanne Brunzell, Snohomish County SWM

Mike Chamblin, Washington Department of Fish and Wildlife (WDFW)

Jon Houghton, Pentec Environmental, Inc. (representing City and Port of Everett)

Stephanie Kaknes, Snohomish County SWM

Sandy Kilroy, King County Department of Natural Resources and Parks (DNRP)

Denise Krownbell, Seattle City Light

Kerry Lagueux, National Marine Fisheries Service, NWFSC

Gino Lucchetti, King County DNRP

Martha Neuman, Snohomish County SWM

L. Ted Parker, Snohomish County SWM

Scott Powell, Seattle City Light

Kit Rawson, Tulalip Tribes

Mindy Rowse, National Marine Fisheries Service, NWFSC

Mary Ruckelshaus, National Marine Fisheries Service, NWFSC

Michael Rustay, Snohomish County SWM

Beth Sanderson, National Marine Fisheries Service, NWFSC

Mark Scheurell, National Marine Fisheries Service, NWFSC

James Schroeder, King County DNRP

Fran Solomon, King County DNRP

Jim Starkes, Pentec Environmental, Inc.

Tom Ventur, King County DNRP

Contributors, continued

Snohomish Basin Salmonid Recovery Technical Committee Members

Andy Haas, Snohomish County SWM (Co-Chair)

James Schroeder, King County DNRP (Co-Chair)

Bob Aldrich, Snohomish County SWM

Jamie Bails, Snohomish Conservation District

Keith Binkley, Snohomish County Public Utility District

Mike Chamblin, WDFW

Barry Gall, U.S. Forest Service

Jon Houghton, Pentec Environmental, Inc. (representing City and Port of Everett)

Sandy Kilroy, King County DNRP

Curt Kraemer, WDFW

Denise Krownbell, Seattle City Light

Kurt Nelson, Tulalip Tribes

Martha Neuman, Snohomish County SWM

Scott Powell, Seattle City Light

Kit Rawson, Tulalip Tribes

Mindy Rowse, National Marine Fisheries Service, NWFSC

Anne Savery, Tulalip Tribes

James Schroeder, King County DNRP

Fran Solomon, King County DNRP

Dave Steiner, Stillaguamish-Snohomish Fisheries Enhancement Task Force

Ralph Svrjcek, Washington Department of Ecology

Obtaining Copies

Snohomish County Surface Water Management Division

2731 Wetmore Avenue, Suite 300

Everett, WA 98201-3581

Phone: 425-388-3464

Phone: 800-562-4367

Fax: 425-388-6455

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INTRODUCTION

OVERVIEW OF DOCUMENT

The Snohomish Basin Salmonid Recovery Technical Committee (SBSRTC) developed this Ecological Analysis for Salmonid Conservation (EASC) through a series of workshops, independent analyses, and committee meetings during 2002 and 2003. In the context of the Tri-County salmon recovery framework, the EASC is known as the “Strategic Assessment.” The goal of the EASC is to provide a solid technical foundation for the Snohomish Basin Salmonid Conservation Plan (the Plan) to be developed in 2004 and 2005. This watershed is also called Water Resources Inventory Area (WRIA) 7. The objectives of the EASC are to:

- 1) Integrate existing and ongoing inventories and analyses into one framework;
- 2) Update the near term chinook salmon conservation strategy to incorporate new data, broaden to include other salmonid species, and provide long-term, basin-wide guidance; and
- 3) Develop and test recovery strategies to assist the Snohomish Basin Salmon Recovery Forum (the Forum) in crafting conservation alternatives and in selecting a preferred alternative for the Plan.

The EASC identifies chinook salmon (*Oncorhynchus tshawytscha*), bull trout char (*Salvelinus confluentus*), and coho salmon (*Oncorhynchus kisutch*) as proxy species to represent all anadromous salmonids in the Snohomish River Basin. These species have diverse habitat requirements and occupy the full geographic range of anadromous salmonids in the basin. Thus, we assume a strategy that addresses these species will adequately address the needs of all anadromous salmonids. We acknowledge that further analysis is needed to test this assumption.

This document focuses on strategy development and assumes that the readers are familiar with the Snohomish River Basin and the general life history habitat requirements of salmonids. The EASC reflects our current state of knowledge and is subject to change as we continue to learn from research, restoration, monitoring, and model refinement.

The EASC is a collaborative effort between the SBSRTC and the Puget Sound Technical Recovery Team (TRT), which refers to the EASC as the Case Study. The TRT has a similar role to the SBSRTC, but provides scientific advice on a broader regional scale to the Shared Strategy in the development of recovery plans for listed Puget Sound chinook and Hood Canal summer chum. The TRT selected the Snohomish River Basin as a case study to test the principles and general guidance in its “Watershed Guidance” document (available on the Shared Salmon Strategy web page) in an actual watershed with an established watershed group. The results of the case study will form the technical basis for a recovery plan for Snohomish River Basin chinook and will provide information for revising the “Watershed Guidance” document to make it more useful for other watersheds. The TRT focus is on describing the status of chinook populations and making the link between population performance and three “Hs” of salmon recovery: harvest, hatchery and habitat management. (The fourth “H,” hydropower, is not considered to be a significantly alterable factor in the Snohomish River Basin.)

The TRT evaluates chinook population status as a function of four Viable Salmonid Population (VSP) parameters: abundance, productivity (or growth rate), diversity, and spatial structure (McElhany et al. 2000). Abundance is the number of individuals in the population at a given life stage or time; productivity or growth rate is the actual or expected ratio of abundance in the next generation to current abundance; spatial structure refers to how the abundance at any life stage is distributed among available or potentially available habitats; and diversity is the variety of life histories, sizes, and other

characteristics expressed by individuals within a population. Each of these population attributes affects the likelihood that a population will persist into the future, or its viability. In the context of this document, the term viability is broadened for consistency with the Snohomish Basin Salmon Recovery Forum (Forum) and goal to include the ability of a population or populations to persist over time *at harvestable levels*.

The EASC is comprised of eight steps of analysis and synthesis (Figure 1). Steps 1 through 4 provide an analytical framework for data on current use of the basin by chinook and other salmonids, stream habitat conditions, watershed process conditions, and modeled estimates of potential chinook use. In Steps 5 and 6, these four datasets are used to identify priority areas and actions. In Step 7, the SBSRTC will craft fish-based strategies which are recovery alternatives consisting of specific sequences, types, and quantities of actions that could be used to preserve and restore needed amounts of habitat within a subbasin or group of subbasins. Types and quantities of actions will vary among fish-based strategies to provide a range of outcomes. The Policy Development Committee (PDC) will examine various approaches for achieving the habitat conditions for each fish-based strategy and will identify areas of conflict. In Step 8, alternatives will be modeled using Ecosystem Diagnosis and Treatment (EDT) and SHIRAZ - two models designed to express recovery actions in terms of population performance.

In its current form, this document describes the methods used to complete Steps 1 through 8 of the analysis. It should be noted that the product has been summarized here from the perspective of the SBSRTC. The results from Step 8 are under development and will be completed and integrated into this document over the next several months. We anticipate that an addendum to this document will be available later in the spring of 2004, describing results from two models (i.e., EDT and SHIRAZ) linking the effects of habitat, harvest and hatchery management to fish population responses. Results from these models already are helping to shape alternative suites of habitat actions for consideration by the Forum. The addendum to this document will clearly describe these results and the scientific basis for the differences in salmon population status that they predict. These results will be applied, along with policy judgments by the Forum, to help the Forum in choosing an alternative set of actions that will form the basis for the plan.

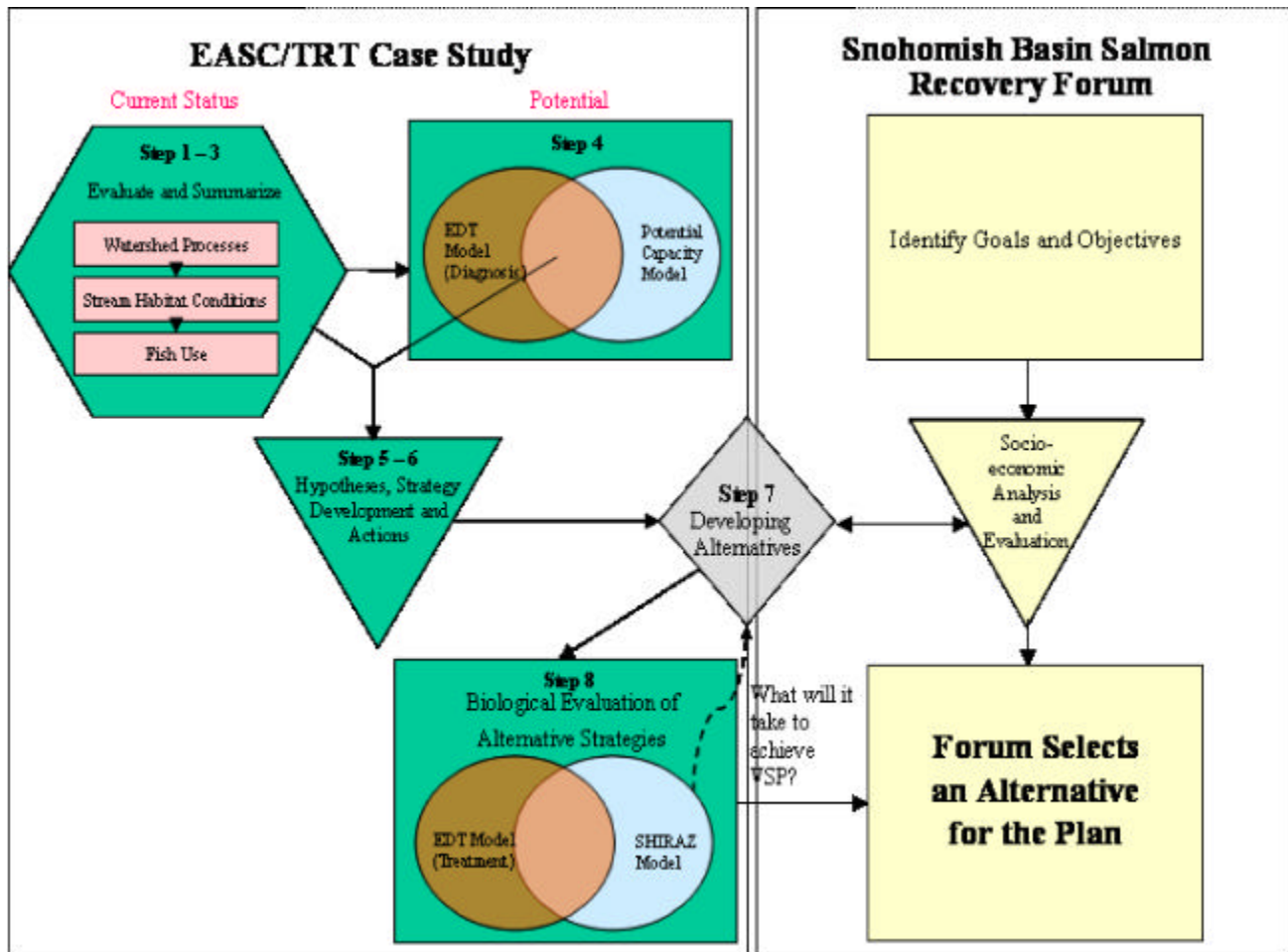


Figure 1-1. EASC Organization Framework

OVERVIEW OF STEPS 1-8

The first four steps of the analysis summarize core pieces of information that are critical to the development of a long-term salmonid conservation strategy:

Step 1: Step 1 tables summarize relative current chinook, bull trout, and coho use in the basin to determine where spawning and rearing are concentrated. Data sources include spawner surveys and juvenile sampling data. These tables provide the basis for updating “focus areas” to include multiple species of salmonids, to incorporate new information, and to identify the data underlying designation of specific geographic areas as high, moderate or low use.

Step 2: Step 2 is an evaluation of subbasin habitat conditions. Current habitat conditions provide guidance on which habitat elements require conservation actions. Information on stream habitat conditions also provides a baseline for evaluating improvement or degradation over time. In this analysis, the results of the Habitat Conditions Review (HCR); (SBSRTC 2002) and the Limiting Factors Analysis (LFA); (Haring 2002) are integrated into one table. The level of certainty associated with each habitat condition “call” is included in the table.

Step 3: Step 3 is an analysis of the underlying watershed processes that drive habitat conditions and influence population performance. This analysis was performed by NOAA Fisheries staff and follows a template similar to the approach used in research performed in the Skagit watershed (Beamer et al. 2000). Step 3 is necessary to help develop recovery actions that address the root causes of population decline rather than just the symptoms. In many cases, the most critical projects and long-term fixes will be located upstream of areas of high fish use and where indicators of habitat problems are evident.

Step 4: The analysis in Step 4 summarizes the difference between current and historical potential for fish use and makes the link between habitat and population performance. It provides the context for where restoration could occur and what is possible. The EDT model (Mobrand Biometrics 2000a) and the SHIRAZ and Potential Capacity models developed by NOAA Fisheries (Sanderson et al. in press) are used to estimate the current ability and future potential for habitat to support adult and juvenile chinook. Comparison of results from these models will provide greater confidence in the outcome.

The building blocks of a strategy are compiled in Steps 1 through 4 and then integrated to identify focus areas and an action plan in Steps 5 and 6.

Step 5: Step 5 synthesizes data from Steps 1 and 4 to identify the geographic areas that are most critical for protection and restoration for the three proxy species. High priority areas have high current use (Step 1) and/or high potential use (Step 4). The bottom line is identifying the areas of focus that will give the greatest return in terms of protecting and improving population performance.

Step 6: Step 6 integrates the results of all previous analyses to generate hypotheses, organize subbasins into strategy groups, and identify and rank actions to address the main factors limiting recovery. Hypotheses are developed on the basin and subbasin strategy group scales. Actions and their relative priority are identified among subbasin strategy groups and within each individual subbasin.

Fish-based strategies, and in turn plan alternatives (decided upon by the Forum based on the fish-based strategies and socioeconomic analysis) are developed and modeled in terms of population performance in Steps 7 and 8.

Step 7: The Forum provided guidance that it would like fish-based strategies developed to reach a range of targets. The Shared Strategy planning target range for chinook will be used as guidance. In Step 7, the SBSRTC will work with the PDC to develop a test case strategy designed to achieve viable salmonid populations and the current path scenario based on the analyses in Steps 1 through 6. They will be used as a starting point for alternative development and refinement. Alternative fish-based strategies will be comprised of quantities of actions and habitat gains within and aimed at priority areas. The SHIRAZ model will be used to hone in on types of actions and levels of effort that will meet the population targets over specific time frames. The methods and cost estimates for achieving the habitat quantities will be identified as part of a socioeconomic analysis being conducted by the PDC at the request of the Forum.

Step 8: In Step 8, the final plan alternatives that will be considered by the Forum through the alternatives analysis will be evaluated using both the EDT and SHIRAZ models. Results will be presented in terms of population performance parameters: abundance, productivity, diversity, and spatial structure (in progress).

Following is a more detailed description of the methods for each of the eight steps. Results are presented in the Step tables and maps.

STEP 1. RELATIVE CURRENT SALMONID USE ANALYSIS

DESCRIPTION

Step 1 compiles and analyzes existing data from salmonid surveys in the Snohomish River Basin to determine high, moderate, and low current relative use by subbasin for chinook salmon, bull trout, and coho salmon. Documentation of relative levels of current use is an important first step in this process because such documentation provides guidance on immediate preservation needs and baseline information for comparison with modeled fish potential in future steps.

METHODS

Chinook Salmon: Current Relative Use

The Skykomish and Snoqualmie populations described by the Puget Sound TRT (Ruckelshaus et al. 2003) are thought to represent the historic population structure of chinook salmon in the Snohomish Basin. The Skykomish population includes all chinook that spawn in the Skykomish River and its tributaries and in the Snohomish River and its tributaries, including the Pilchuck River. The Snoqualmie population includes all the chinook that spawn in the Snoqualmie River and its tributaries.

Natural spawning escapement data from the Washington Department of Fish and Wildlife (WDFW) spawner survey database were used to analyze current relative use of these chinook populations (D. Hendrick, WDFW, personal communication). The WDFW serves as the central repository for spawner survey information collected by WDFW survey crews, tribal fisheries staffs, and other agencies. This database is one of the shared information sources maintained by the co-managers under the Puget Sound Salmon Management Plan. Its principal use is to serve as the basis for agreed estimates of annual natural spawning escapement numbers for the entire basin.

Chinook salmon escapement estimates are derived from aerial, boat, and foot surveys of redds, which are expanded to fish numbers using a constant factor of 2.5. Smith and Castle (1994) documented the survey methods and the computation of spawning escapement estimates from the survey data. In the Snohomish Basin, a significant exception to the rule that redds are surveyed is in the South Fork Skykomish River above Sunset Falls. Here, the chinook spawning escapement number is the count of the fish transported above this natural barrier to upstream migration. All chinook spawning escapement estimates or counts include all ages of fish returning to the spawning grounds.

Although the spawning escapement methodology was developed for the purpose of estimating the natural escapement of fish to the whole Snohomish River system, it is possible to derive separate estimates for individual survey segments. Unfortunately, the survey segments used for chinook escapement estimation do not correlate precisely with the subbasins or EDT reaches used in the EASC. As much as possible, available estimates for individual river segments were matched to the EASC subbasins. Where survey reaches spanned more than one subbasin, we report combined estimates. We did not attempt to break these down to the level of the EDT reach because that spatial scale was only available in a few cases. The Step 1-1 Table shows annual estimates of redds and calculated spawning escapement numbers by subbasin.

Some of the chinook salmon in natural spawning areas are first generation hatchery-origin fish, i.e. they are the survivors of juvenile salmon released from an artificial production facility. The principal facilities contributing hatchery-origin chinook salmon to the Snohomish Basin are the Wallace River hatchery, which releases fish into the Wallace River four miles upstream of its confluence with the Skykomish River, and the Bernie Kai-Kai Gobin Hatchery, which releases fish into Tulalip Bay, located immediately northwest of the Snohomish River estuary. From brood years 1993 through 1997 all chinook from these two facilities were thermally mass marked, and, since 1997, there has been a comprehensive sampling program collecting otoliths from chinook salmon carcasses throughout the system. The otoliths are examined in the laboratory for the presence of a thermal mark. Estimates of the contribution rate of hatchery fish, using thermal otolith marks for Wallace River and Bernie Kai-Kai Gobin hatcheries and coded-wire tags for other hatcheries with minor contributions, are currently available for return years 1997 through 2001 (Rawson et al. 2001, Rawson and Kraemer in prep.). Hatchery contribution estimates were used, stratified by subbasin or aggregated subbasins, to derive the annual estimates of natural origin escapement (Step 1-1 Table).

In order to divide the subbasins into areas of high, medium, and low abundance, we averaged the subbasin natural origin escapement estimates for 1997 through 2001. For each of the Snoqualmie and Skykomish chinook populations, we then computed the proportion that the subbasin average comprised of the total estimated average escapement. To moderate the possible influence of a single high year on the classification, we used geometric means to average the 1997-2001 escapements. The subbasins did not differ in their relative abundance ranking using geometric or arithmetic means. Subbasins with greater than 12% of the total spawning escapement were arbitrarily classified as “High,” those with between 8% and 12% as “medium,” those with less than 8% as “Low,” and those with no spawning escapement as “None” (Step 1-1 Table).

Bull Trout: Current Relative Use

Introduction

Anadromous, fluvial, and resident life history forms of bull trout are found in the Snohomish Basin, but the total population is not known (WDFW 1998). The population, however, is considered much smaller than chinook or coho salmon populations in the basin. Multi-year data on habitat use are largely limited to redd counts in the upper basin and adult counts at a fish trap. These datasets provide a good indication of the number of spawning fish, but relatively little is documented or known regarding the movements of fluvial fish, juvenile rearing, or subadult overwintering in the basin. These are principal data gaps since char are believed to wander and display highly opportunistic foraging behavior, accessing substantial areas of mainstem streams and tributaries from the upper basin to the estuary. Some recent sampling data and ongoing acoustic tagging data have also been collected in the lower Snohomish Basin and adjacent marine nearshore.

Given the paucity of data for many life history phases of bull trout, it was difficult to assign “High,” “Moderate,” “Known Presence,” and “Presumed Presence” use categories for life history phases other than spawning. The “High” and “Moderate” use categories are associated with data sources or direct observations by WDFW personnel. The “Known Presence” use category is defined as subbasins connecting areas of known use. The “Presumed Presence” use category is defined as those habitats to which the species has access (i.e., no barriers), and where habitat conditions meet the requirements of the particular life history phase. Kraemer (1999) defined the potential distribution of foraging char as that portion of the basin that is accessible to anadromous salmonids.

Datasets

The following datasets were used to determine current relative use of the Snohomish Basin by bull trout:

- Redd count data from a WDFW Index Reach on the upper North Fork Skykomish River. This dataset is composed of bull trout redd counts from 1988 to 2002 in the reach between Bear Creek Falls and Deer Creek Falls in the upper North Fork Skykomish River.
- Fish trap counts of adult bull trout at Sunset Falls on the South Fork Skykomish River from 1994 to 2002.
- WDFW spot observations of bull trout redds in tributary streams outside of the WDFW Index Reach.
- The Pentec Environmental (2002) reconnaissance sampling and fixed station sampling over two winters in the Snohomish estuary.
- An ongoing acoustic tagging study of bull trout in the Snohomish River and adjacent marine nearshore. Study sponsor: U.S. Army Corps of Engineers.
- Limiting Factors Report (Haring 2002) bull trout distribution maps showing known and presumed distribution within much of the Snohomish Basin.
- King County Bull Trout Surveys (Berge et al. 2001) showing observed distribution within the Tolt, Snoqualmie, and Skykomish Rivers in King County.

Spawning

Since bull trout spawn in a few select areas of the Snohomish Basin and since a relatively robust dataset of redd counts is available, a systematic categorization of spawning into “High”, “Moderate,” and “Low” use was not conducted. Rather, “High” use was assigned to the upper North Fork Skykomish subbasin where most of the bull trout in the entire Snohomish Basin spawn. Within this subbasin, an index reach between Bear Creek Falls and Deer Creek Falls is surveyed annually by WDFW. From 1997 to 2001, a mean of 202 redds per year was counted in this index reach (WDFW 1998; C. Kraemer, WDFW, personal communication 2/13/02). In addition to mainstem spawning, moderate levels of bull trout spawning occur in Upper North Fork Skykomish tributaries: Troublesome, West Cady, Goblin, and Salmon creeks. Usually no more than 20 redds are observed in any one of these stream in a given year. The Foss River, the only other significant documented spawning population outside the Upper North Fork Skykomish subbasin, was also classified as “High.” The Beckler River was classified as “Moderate” due to a recent observation of spawners by WDFW. No streams were categorized as “Known Presence” or “Presumed Presence” for bull trout spawning (Step 1-2 Table).

Rearing

Very few data on the rearing of juvenile bull trout are available for the Snohomish Basin. Creel surveys, tagging studies in the Skagit and Snohomish Basins, and anecdotal observations suggest that fish observed outside of headwater streams are at least two years of age and at least 155 mm in length (Pentec 2002; Kraemer, C. WDFW, personal communication 3/11/02). This suggests that most juvenile rearing occurs in natal upper watershed streams; thus rearing streams were given the same “High” and “Moderate” designation as spawning streams (Step 1-2 Table).

Overwintering

Unlike the salmon species, the anadromous form of bull trout have annual late-winter/spring migrations to marine areas beginning at ages 2 or 3. Immature fish that are not old enough to spawn (subadults) migrate back into freshwater in late summer or fall. These fish usually remain in the lower basin to overwinter, rather than migrating to upper basin natal streams with the adult fish. Bull trout overwintering areas have not been studied extensively in the Snohomish Basin, but sampling data over the winters of 2001 and 2002 identified areas in the Snohomish estuary and the Lower Snohomish/Marshland subbasin between RM 12 and 16 as an overwintering area in the basin (Pentec 2002). Based on these data, these subbasins were designated as “High” use for overwintering bull trout.

Based on anecdotal information and informal creel surveys, areas within the lower Skykomish River subbasin are also likely used for overwintering by immature bull trout (Kraemer, C. WDFW, personal communication 3/11/02). Based on these observations, the lower Skykomish River subbasin is designated as “Moderate” use for overwintering bull trout. “Presumed Presence” is defined as all areas within the Snohomish Basin to which bull trout have access given their opportunistic foraging behavior and the presence of anadromous, fluvial, and resident forms within the basin (Step 1-2 Table).

Foraging

As reported, foraging behavior of bull trout is highly opportunistic, but few actual studies of foraging patterns have been conducted. Acoustic tagging data show that the Snohomish estuary and surrounding marine nearshore are used by the anadromous form for prolonged periods during the spring and early summer. Unpublished data collected by WDFW and preliminary data from the ongoing bull trout tagging study show that substantial growth occurs during this period with growth rates as high as 1 mm/day in marine areas (Kraemer, C. WDFW, personal communication 3/11/02). These data indicate the importance of the marine residence period for the anadromous form; therefore, the Snohomish estuary and marine nearshore have been designated as “High” use areas. Subbasins connecting known areas of spawning, rearing, and overwintering are identified as “Known Presence.” Forage use is designated as “Presumed Presence” in all other areas of the Snohomish Basin to which the fish have access given their opportunistic foraging behavior and the presence of anadromous, fluvial, and resident forms within the basin (Step 1-2 Table).

Coho Salmon: Current Relative Use

Introduction

Coho salmon utilize small, low gradient tributary streams for spawning and rearing. Adults are noted for their ability to ascend very small channels to spawn, sometimes only a foot wide and a few inches deep. Juvenile coho salmon typically rear for one year in freshwater and prefer quiet side channels, backwaters, and pools of their natal streams and downstream waters. The juveniles then outmigrate to saltwater in the spring of their second year.

Adult Spawner Relative Abundance and Distribution

A 50-year record of coho salmon spawning survey observations (about 15,000 records basinwide) is available for many stream reaches in the Snohomish River Basin. Because coho salmon are so broadly distributed, they are difficult to monitor comprehensively for spawner abundance. WDFW and the Tulalip Tribes currently survey 53 “index reaches” and record live and dead fish counts. Typically each index reach is surveyed every 7 to 10 days throughout the entire spawning period. Supplemental surveys, which include observations on additional reaches in each subbasin, are conducted also (preferably near the peak of spawning) to help determine the general distribution of spawners in the basin. Supplemental surveys are conducted as available time, personnel, funds and weather allow, so there is considerable annual variation in the number and extent of supplemental spawning surveys, and they are no longer relied upon for escapement estimation (Flint 1989).

The current escapement survey methodology was designed and the database is used by resource managers to determine annual escapement of coho in the entire Snohomish River Basin for the purpose of harvest management. Escapement estimates are based on the assumption that fish live in the stream for a certain number of days before they spawn and die. From live counts made during weekly index surveys, an escapement curve is generated that expresses the number of “fish days” for each index reach for the entire spawning period. This corresponds to the sum of the number of days each fish could have been observed on the spawning grounds. The year 1977 is considered a “base year” for coho salmon escapement

estimation because extensive effort was devoted to spawner surveys and marked recoveries in that year, which allowed development of escapement curves and an associated escapement estimate. The number of fish days calculated from index surveys in subsequent years is compared to the 1977 baseline, thus allowing spawning escapement estimates to be derived and kept in context despite annual variations in the level of sample effort.

Thus, while a tremendous data source exists to provide information on abundance of coho salmon in the Snohomish River Basin, it is acknowledged that there are difficulties in utilizing these data for our current purpose of identifying relative abundance of coho salmon around the basin. There are 53 index reaches with a total length of about 29.5 miles and there are an estimated 400 miles of tributary streams utilized by coho around the basin (Zillges 1977). In other words, only about 7% of the basin consistently has actual observations of spawning densities. Also, there is some inherent bias in the database due to the criteria used for selecting the index reaches, which include: (a) they were known coho spawning reaches; (b) they were easily accessed; and (c) they were geographically distributed so that it was feasible to maximize the distance a surveyor could cover in a day. Such criteria limit the utility of the data for purposes other than those originally intended.

Methods

Acknowledging the caveats stated above, data from the escapement database were used to help derive an indication of relative abundance of coho salmon in WRIA 7 subbasins (Step 1-3 Table). Calculations of “fish-days” were made, derived from the index reach spawner escapement data, and used to categorize subbasins for relative abundance of coho salmon spawners. In addition, the supplemental escapement survey data were used to note presence or absence of coho salmon spawners in the subbasins lacking index reaches. Subbasins are organized in the Step 1-3 Table to represent the four coho salmon stocks identified by WDFW and Western Washington Treaty Tribes salmon harvest co-managers: Skykomish, South Fork Skykomish, Snoqualmie, and Snohomish.

Fish-days averaged for the years 1993-2002 were examined by index reach. These years include a wide range of estimated escapement returns (mean=114,411, range = 31,000 to 261,848), and represent the typical variability in population dynamics in the basin in recent years. The average fish-day values for multiple index reaches occurring in each subbasin were summed and converted to fish-days/survey mile, producing a list of 19 subbasins that contain one or more index reaches. Data were then categorized as: “High” (>5,000 fish-days per mile per subbasin); “Medium” (1,000 to 5,000 fish-days per mile per subbasin); and “Known Presence” (<1,000 fish-days per mile per subbasin).

Supplemental spawner surveys were also examined. In nearly all subbasins there were at least several supplemental coho spawner observations recorded for one or more years, from 1976-2001, although more observations were clustered in the 1970s and 1980s than in later years. Thus “Known Presence” was also assigned when supplemental survey observations recorded presence or when presence had been established in the WRIA 7 LFA (Haring, 2002) (Step 1-3 Table, Figure 1-2).

Two additional categories were included: “None”, indicating subbasins that are not accessible to coho salmon, and “Unknown”, indicating no information about coho salmon spawning was available. An observation of “no fish” may occur for various reasons and may leave some doubt about the importance of a reach for spawning, but this does not necessarily mean that the reach is not utilized by coho salmon for spawning. For example, no live coho were observed during 11 index surveys on the East Fork Griffin Trib 07.0372 in 1993. However, in 1994 this same index reach had a peak live count of coho corresponding to 805 fish per mile, which was the highest density of coho spawning recorded for all index reaches in WRIA 7 that year.

It should also be noted that many coho salmon are transported each year above the natural migration barrier at Sunset Falls on the South Fork Skykomish River. In the index reach 1993-2002 fish-days

compilation, these accounted for 63% of Skykomish coho salmon escapement. Although no index reaches are included above Sunset Falls, supplemental surveys conducted in the six subbasins above the falls indicate that coho salmon utilize each of these subbasins for spawning.

We stress that these categories are arbitrarily defined based only on their distribution relative to one another (Figure 1-2). Figure 1-2 indicates clearly that there is broad, general coho salmon use across the entire Snohomish Basin at a somewhat consistent level. However, a few subbasins stand out as being “higher” in spawner abundance.

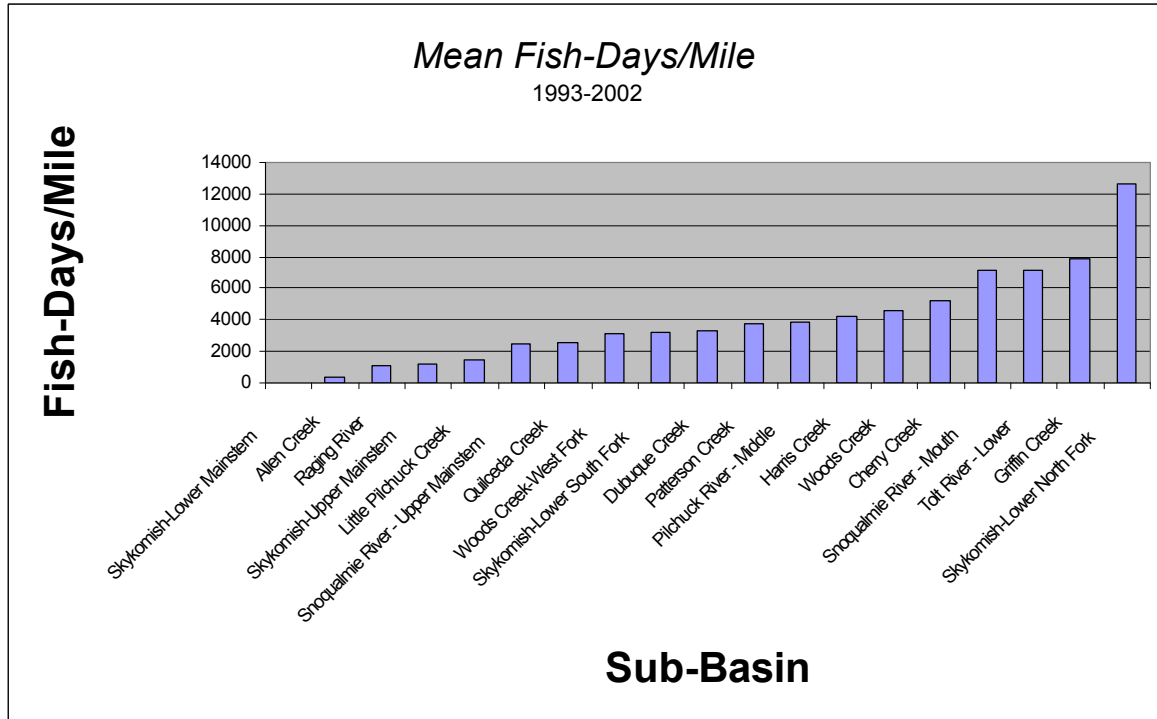


Figure 1-2. Mean fish-days per mile by subbasin in the Snohomish River Basin.

In an effort to also put this analysis in the context of other large river basins (WRIAs) around Puget Sound, a second method of summarizing the escapement data was undertaken. This involved using individual peak live counts in the index reaches between the years 1993 and 2001. Annual peak live coho salmon counts were converted to fish per mile (fpm) based on the length of the index reach. Thus, if multiple surveys of the same reach were conducted in one year, only the survey with the highest count of live coho was selected. Fpm metrics from the peak live counts were then compared both across subbasins within the Snohomish River Basin, and across WRIAs. Within the Snohomish River Basin, 46 (of 53 total) index reaches had surveys conducted in each year, thus producing comparable estimates of fpm. These 46 index reaches are combined and displayed by subbasin in the same manner as the fish-day information (Step 1-3 Table). The total length of surveys ranged from 25.5 to 27.0 miles annually. This analysis shows nearly the same information in terms of relative abundance by subbasin, but slight differences related to the data included in each method of analysis result in some different rankings. Therefore, “Medium” and “High” rankings of relative abundance are only presented based on the fish-days analysis.

Recommendation

As noted above, WDFW and the Western Washington Treaty Tribes (i.e., the co-managers) have expended major efforts to produce a valuable record of coho spawner abundance spanning more than 50 years. These data were collected primarily via a standardized method designed specifically to inform harvest management decisions for Puget Sound coho salmon.

By contrast, the SBSRTC and others now seek to evaluate coho salmon utilization throughout the Snohomish River Basin for the purpose of understanding ecological relationships between coho salmon and habitats needed for production, including the population viability parameters of abundance, productivity, diversity and spatial structure. This information is crucial for developing recommendations for habitat protection and restoration, as well as species conservation. Given the limitations of the current escapement methodology for this broader purpose, we recommend that the sampling methodology should be evaluated and re-designed to accommodate these broader objectives in the future.

Additionally, juvenile coho salmon abundance and distribution data are particularly sparse in the Snohomish River Basin. New data collection efforts in this area would be useful in the future.

Finally, a comparison across WRIAs was done to show how the coho salmon spawner densities in WRIA 7 compare with coho spawner densities in other WRIAs around Puget Sound in recent years. Basinwide mean fpm data from these escapement survey data indicate a consistently higher level of abundance of coho salmon in WRIA 7 than in other WRIAs (Table 1-1). Thus the broad geographic distribution of coho salmon spawners within the basin, and the higher abundance relative to other basins in the region, indicate that the spatial structure and diversity of this coho population will be critical factors in future salmon conservation planning in a regional context.

Table 1-1. Estimates of fish-per-mile for Puget Sound basins derived from peak live counts of coho spawners in index reach surveys, 1993-2001.
Note: these fpm estimates are not adjusted for different levels of effort of surveys in each basin.

WRIA	2001 Mean fpm	2000 Mean fpm	1999 Mean fpm	1998 Mean fpm	1997 Mean fpm	1996 Mean fpm	1995 Mean fpm	1994 Mean fpm	1993 Mean fpm	1993- 2001 Mean fpm
01	6	1	4	2	56	41	64	45	93	35
03	84	97	22	60	31	19	68	156	61	66
05	190	202	68	169	77	50	107	103	66	115
07	284	108	94	208	89	86	138	127	75	134
08	17	27	16	7	29	71	137	2	20	36
10	58	37	51	47	106	77	26	36	26	52
11	40	32	14	12	49	18	76	83	56	42
13	5	22	1	5	11	3	6	62	8	14
15	172	87	20	86	104	41	68	67	28	75
16	313	74	31	149	80	53	55	68	35	95

Juvenile Rearing Relative Abundance and Distribution

Very few data are available on the rearing of juvenile coho salmon in the Snohomish River Basin. Various smolt trapping operations give some estimates of total outmigration in those years when traps were operated, but there is no comprehensive information for comparing subbasins in terms of coho abundance. For this reason, smolt trap information is not included in this summary. Other juvenile rearing abundance data are very limited as well. However, juvenile rearing is known to occur in tributary, mainstem, and off-channel habitats where any slow water pockets exist. Thus, based on the assumption that juvenile coho salmon rear in slow water habitats downstream of where they were spawned, we have designated a category of "P" for presumed rearing in Step 1-3 Table. In addition, sampling efforts conducted in estuary and nearshore habitats in 2002 and 2003 have yielded data on juvenile coho salmon utilization of these habitats. The preliminary data establish that juvenile coho rearing does occur in these areas but the full extent of this utilization and its effect on the population are not yet known. It is also known that coho salmon juveniles do migrate upstream from mainstem habitats in autumn to overwinter in off-channel ponds, headwater marshes, and tributaries. However, there are no specific data in the Snohomish River Basin at this time to make statements of relative importance among subbasins based on rearing abundance. Thus, there were no efforts at this time to evaluate subbasins for high, medium, or known presence utilization categories for coho rearing.

Step 6-1 Table. Strategy Development - Basinwide

							Ranked actions among subbasin strategy groups*										
Geo-spatial group	Subbasin strategy groups	Chinook/bull trout use and potential class	Current watershed process condition class	Subbasins contained within group	Description	Hypothesis	Preservation - proximate to aquatic habitat	Preservation - to support hydrologic and sediment processes	Remove anthropogenic instream barriers along or adjacent to priority reaches	Reconnect off channel habitats	Restore shoreline conditions	Restore hydrologic processes (for peakflow and baseflow)	Restore sediment processes	Riparian enhancement	Address water quality impacts	Marine derived nutrient enhancement	Instream structural enhancement (i.e. ELJs)
Nearshore	Nearshore restoration	High	Moderately Degraded	Nearshore	Shoreline from Mukilteo to Kayak Point including Puget Sound out to 30 m depth below MLLW and upland areas to the top of coastal bluffs.	Additional restoration of the Puget Sound nearshore environment was identified in the preliminary EDT analysis as necessary for achieving population performance levels that fall within the Shared Strategy planning range. Reducing the extent of the modifications in sediment delivery and transport, riparian conditions, and shoreline conditions will provide a significant improvement in population productivity in the nearshore environment.	1				1		1	1	2		
Estuary	Estuary restoration	High	Degraded	Estuary	Critical habitat for juvenile salmonid to rear and make the fresh to salt water transition. Defined here as the mainstem, sloughs and marshes between Possession Sound and the divergence of Ebey Slough from the mainstem.	Preliminary modeling with EDT identified the estuary as one of the most important places to focus preservation and restoration actions for both chinook populations. The loss of 85 percent of the historic tidal marsh area, loss of edge habitat complexity along major slough channels, and habitat fragmentation have depressed population performance. Addressing these problems will provide significant improvements in abundance, productivity and diversity for chinook and bull trout populations, as well as for other species.	1		1	1	1			1	2		2
Mainstems	Mainstems - primary restoration	High	Moderately Degraded or Degraded	Skykomish River - Lower Mainstem, Skykomish River Upper Mainstem, Skykomish River - South Fork, Skykomish River - Upper South Fork, Sultan River - Lower, Snoqualmie River - Mid Mainstem, Snoqualmie River Upper Mainstem, Pilchuck River - Middle, Upper Snohomish/Cathcart, Lower Snohomish/Marshland, Tolt River Lower, Raging River	Large rivers with floodplains in the mid and lower basin. Critical spawning and rearing areas for chinook and other species. Also, critical habitat for sub-adult bull trout and foraging habitat for adult bull trout exhibiting a fluvial life history strategy. Agriculture, transportation corridors and urban development are the dominant land uses.	Along with the estuary, these subbasins have been identified as having the highest potential gains with restoration and highest potential losses if further degradation occurs. While spawning habitat quality has been impacted in some locations by altered sediment and flow regimes, the loss of rearing habitat quantity and quality is the largest issue affecting population performance. These basins provide rearing habitat for juveniles emerging within the basin and from areas in the upper watershed. Setting back and removing armoring, restoring access to isolated habitats and replanting riparian forests will provide the greatest returns in chinook population performance of any restoration actions in the freshwater environment.	1	1	1	1	1		data gap	1	2		2
	Mainstems - secondary restoration	Moderate	Moderately Degraded	May Creek/Lower Wallace, Skykomish River - Lower North Fork, Skykomish River - Lower South Fork, Woods Creek - Lower, Snoqualmie River Mouth, Tolt River - South Fork Below Dam, Pilchuck River - Lower, Coal Creek -Lower	Small rivers with floodplains and large mainstem rivers. Channel conditions impacted by urban and rural development, forestry and transportation corridors.	Although not as critical as in first tier mainstems, restoring riparian forests and floodplain connectivity, correcting fish passage barriers, and preventing urban sprawl within these areas will be necessary to achieve population performance levels within the Shared Strategy target range. Maintaining and restoring habitat within these areas will be particularly important for spatial structure.	2	1	2	2	2	1	data gap	2	3		3
Lowland tributaries	Rural streams - primary restoration	Moderate	Moderately Degraded	Woods Creek - West Fork, Cherry Creek	Large rural tributaries that contain or have the potential to support moderate levels of chinook spawning. Also important for coho.	These are the most important subbasins for chinook within the tributary geospatial group. They have a similar level of importance in a basinwide strategy to the mainstem - second tier class in terms of spawning. However, the channels are smaller and more confined, and likely only provide rearing habitat to juvenile emerging within these subbasins. Restoring riparian forests and floodplain connectivity, correcting fish passage barriers, and preventing urban sprawl within these areas will be necessary to achieve population performance levels within the Shared Strategy target range. Maintaining and restoring habitat within these areas will be particularly important for spatial structure.	2	1	2		2	1	data gap	2	3		3
	Rural streams - secondary restoration	Low	Moderately Degraded	Bear Creek, Woods Creek, Ames Creek, Harris Creek, Patterson Creek, Debuque Creek, Little Pilchuck Creek, French Creek, Tulalip/Battle Creeks*	Smaller rural tributaries that are rapidly developing. Used by chinook at low levels, but are important for coho.	Protecting and restoring watershed processes and restoring accessibility within these subbasins is important for multi-species protection and to support suitable conditions downstream for chinook spawning and rearing.	3	1	3		3	1	data gap	3	3		4
	Urban stream restoration	Low	Degraded	Lake Stevens Drainages, Everett Coastal Drainages, Fobes Hill, Quilceda Creek, Allen Creek, Sunnyside Drainages	Subbasins flanking the Snohomish estuary that have high levels of development or development pressures. Used by coho and cutthroat, but little to no chinook spawning. Lower reaches provide rearing habitat for chinook.	Watershed processes have been substantially altered within this subbasin strategy group. Managing these areas to prevent downstream impacts will be adequate for a basinwide chinook strategy if substantial restoration efforts are undertaken in other areas. Maintaining and restoring riparian forests and fixing culverts within this group may allow these waterbodies to continue to support small populations of resident trout, coho, and occasionally chinook. Quilceda Creek, an exception within this group, still supports significant coho production.	3		3		3			3	3		4
Headwaters	Headwaters -primary protection	High	Intact	Skykomish River - Upper North Fork, Foss River	Subbasins in the upper watershed that are accessed by anadromous fishes and have intact watershed process. Some forestry and recreational impacts. Contain only bull trout spawning habitat and moderate levels of chinook spawning.	Because they contain the only bull trout spawning within the Snohomish basin, preservation of watershed process conditions within these subbasins is critical. A few opportunities exist to reconnect habitat and improve conditions along the channel edge. These actions will also provide multispecies benefits.	1	1			1					2	

Step 6-1 Table. Strategy Development - Basinwide

							Ranked actions among subbasin strategy groups*										
Geo-spatial group	Subbasin strategy groups	Chinook/bull trout use and potential class	Current watershed process condition class	Subbasins contained within group	Description	Hypothesis	Preservation - proximate to aquatic habitat	Preservation - to support hydrologic and sediment processes	Remove anthropogenic instream barriers along or adjacent to priority reaches	Reconnect off channel habitats	Restore shoreline conditions	Restore hydrologic processes (for peakflow and baseflow)	Restore sediment processes	Riparian enhancement	Address water quality impacts	Marine derived nutrient enhancement	Instream structural enhancement (i.e. ELJs)
	Headwaters-secondary restoration	Moderate	Moderately Degraded	Griffin Creek, Tolt River - North Fork, Beckler River, Pilchuck River - Upper, Tokul Creek*	Subbasins located primarily in the cascade foothills. Forestry is the dominant land use. Diking and rural residential development in lower portions of subwatersheds. Moderate use or potential for chinook and significant use by coho.	Restoring watershed process is important for supporting spawning and rearing that is occurring within these subbasins and in downstream reaches. Significant opportunities also exist to improve spawning and rearing through the reconnection of habitat. Actions within these subbasins will provide a response in terms of population performance on par with the Rural streams - chinook/process focus group and significant multispecies benefits.	2	1	2	2	2	1	1	2	3	3	3
	Headwaters - secondary protection	Low	Intact	Tye River, Wallace River - Upper, Olney Creek, Rapid River, Miller River	Intact subbasins in the upper watershed that have low levels of chinook use.	Preservation of watershed processes is important for supporting watershed processes in downstream reaches with high current use or potential.	3	1	3	3	3				3		
	Headwaters - protection above natural barriers	Resident population only	Intact	Snoqualmie River - Upper North Fork, Pratt River, Taylor River, Snoqualmie River - Upper Middle Fork	Above Snoqualmie Falls and located primarily within the Alpine Lakes Wilderness . Watershed processes are largely intact.	Preservation of intact watershed process conditions will protect habitat for resident trout above Snoqualmie Falls and maintain the conditions that support high quality spawning and rearing habitat for anadromous salmonids downstream in the mainstem Snoqualmie. Restoration opportunities exist, but are a lower priority because the majority of habitat is intact. Improving fish passage will increase the quantity of habitat available to resident trout.		1									5
	Headwaters - restoration above falls and dams	Resident population only	Moderately Degraded	Tolt River - South Fork above Dam, Sultan River - Upper, Snoqualmie River - Upper South Fork, Snoqualmie River - Lower Middle Fork, Tate Creek, Coal Creek - Upper, Snoqualmie River - Lower North Fork, Snoqualmie River - Lower South Fork	Areas without anadromous fish access and moderately degraded conditions.	Reforestation, decommissioning of forest roads, and riparian enhancment will help to improve instream conditions in focus reaches downstream. Improving fish passage will increase the quantity of habitat available to resident trout.		1	4		4	1	1	3	3		5

*Prioritization across Snohomish Basin 1 (high) > 5(low). If the box is shaded, the action is not applicable, appropriate or necessary.

Note: Like subbasins are organized into subbasin strategy groups based on three characteristics: geo-spatial class, chinook and bull trout use and potential class and watershed process condition class. Hypotheses are generated for each subbasin strategy group to define their unique role in a basin-wide strategy. Additional prescriptions are recommended for coho along small streams. Snohomish coho populations are distributed broadly across the basin and are critical for maintaining healthy and harvestable runs in a regional context.

Step 1-2 Table. Bull Trout Abundance and Distribution

Subbasin	Stream Name	Spawning 1997-2002	Rearing	Overwintering	Foraging*	EASC rating	Data Sources
		High = 1 Moderate = 2 Known Presence = 3 Presumed Presence = 4 None = 5	High = 1 Moderate = 2 Known Presence = 3 Presumed Presence = 4 None = 5	High = 1 Moderate = 2 Known Presence = 3 Presumed Presence = 4 None = 5	High = 1 Moderate = 2 Known Presence = 3 Presumed Presence = 4 None = 5	High = A Moderate = B Known Presence = C Presumed Presence = C* None = D	i.e. spawner surveys, smolt trapping, snorkel surveys, otolith research, observations, spawner-recruit relationship
Bear Creek		5	5	5	4	C*	
Beckler River		2	2	4	4	B	spawning observed in 2002; assumed rearing since documented spawning
Foss River		1 - spot redd counts	2	4	4	A	observations; assumed rearing since documented spawning
May Creek/Lower Wallace River		5	4	4	4	C*	anecdotal information and/or recreational catch
Miller River		5	5	4	4	C*	anecdotal information and/or recreational catch
Olney Creek		5	5	5	4	C*	
Rapid River		5	5	5	4	C*	
Skykomish River - Lower Mainstem		5	5	2	4	B	mobile tracking data; observations
Skykomish River - Upper Mainstem		5	5	4	3	C	anecdotal information and/or recreational catch
Skykomish River - Lower North Fork		5	4	4	3	C	anecdotal information and/or recreational catch
Skykomish River - Upper North Fork		1 - 202 redds	1	4	4	A	yearly redd counts - index reach; some snorkel data
	Goblin Creek	2 -spot redd counts	2	4	4	C*	observations; assumed rearing since documented spawning
	Salmon Creek	2 - spot redd counts	2	4	4	C*	observations; assumed rearing since documented spawning
	Troublesome Creek	2 - No redd counts	2	4	4	C*	population above barrier.
	West Cady Creek	2 - spot redd counts	2	4	4	C*	observations; assumed rearing since documented spawning
Skykomish River - Lower South Fork		5	5	4	3	C	anecdotal information and/or recreational catch
Skykomish River - South Fork		5	4	4	3	C	adults/subadults observed at WDFW trap, Sunset Falls
Skykomish River - Upper South Fork		5	4	4	3	C	spawning observed in Foss and Beckler; presumed rearing/overwinter/forage
Sultan River - Lower		5	4	4	4	C*	Not observed, but presumed
Sultan River - Upper		5	5	5	5	D	never observed above reservoir
Tye River		5	5	5	4	C*	
Wallace River - Upper		5	5	5	4	C*	
Woods Creek		5	5	4	4	C*	Not observed, but presumed foraging/overwinter
Woods Creek - Lower		5	5	4	4	C*	Not observed, but presumed foraging/overwinter
Woods Creek - West Fork		5	5	4	4	C*	Not observed, but presumed foraging/overwinter
Ames Creek		5	5	5	4	C*	
Cherry Creek		5	5	5	4	C*	
Coal Creek - Lower		5	5	5	4	C*	
Coal Creek - Upper		5	5	5	5	D	
Griffin Creek		5	5	5	4	C*	
Harris Creek		5	5	5	4	C*	
Patterson Creek		5	5	5	4	C*	
Pratt River		5	5	5	5	D	
Raging River		5	5	4	4	C*	Not observed, but presumed foraging/overwinter
Snoqualmie River - Mouth		5	5	4	4	C*	Not observed, but presumed foraging/overwinter
Snoqualmie River - Mid-Mainstem		5	5	4	4	C*	Not observed, but presumed foraging/overwinter
Snoqualmie River - Upper Mainstem		5	5	4	4	C*	Not observed, but presumed foraging/overwinter
Snoqualmie River - Lower South Fork		5	5	5	5	D	
Snoqualmie River - Upper South Fork		5	5	5	5	D	
Snoqualmie River - Lower Middle Fork		5	5	5	5	D	
Snoqualmie River - Upper Middle Fork		5	5	5	5	D	
Snoqualmie River - Lower North Fork		5	5	5	5	D	
Snoqualmie River - Upper North Fork		5	5	5	5	D	
Tate Creek		5	5	5	5	D	
Taylor River		5	5	5	5	D	
Tokul Creek		5	5	4	4	C*	Not observed, but presumed foraging/overwinter
Tolt River - Lower		5	5	4	4	C*	Washington Trout has observed
Tolt River - North Fork		5	5	4	4	C*	Not observed, but presumed foraging/overwinter
Tolt River - South Fork Above Dam		5	5	5	5	D	
Tolt River - South Fork Below Dam		5	5	4	4	C*	Not observed, but presumed foraging/overwinter

Step 1-2 Table. Bull Trout Abundance and Distribution

Subbasin	Stream Name	Spawning 1997-2002	Rearing	Overwintering	Foraging*	EASC rating	Data Sources
		High = 1 Moderate = 2 Known Presence = 3 Presumed Presence = 4 None = 5	High = 1 Moderate = 2 Known Presence = 3 Presumed Presence = 4 None = 5	High = 1 Moderate = 2 Known Presence = 3 Presumed Presence = 4 None = 5	High = 1 Moderate = 2 Known Presence = 3 Presumed Presence = 4 None = 5	High = A Moderate = B Known Presence = C Presumed Presence = C* None = D	i.e. spawner surveys, smolt trapping, snorkel surveys, otolith research, observations, spawner-recruit relationship
Upper Snohomish/Cathcart		5	5	1	1	A	acoustic tagging data; sampling data during winters of 2001 and 2002
Dubuque Creek		5	5	5	4	C*	
Everett Coastal Drainages		5	5	5	4	C*	
Fobes Hill		5	5	5	4	C*	
French Creek		5	5	5	4	C*	
Lake Stevens Drainages		5	5	5	4	C*	
Little Pilchuck Creek		5	5	5	4	C*	
Lower Snohomish/Marshland Drainages		5	5	1	1	A	acoustic tagging data; sampling data during winters of 2001 and 2002
Pilchuck River - Lower		5	5	4	4	C*	anecdotal information and/or recreational catch
Pilchuck River - Middle		5	5	4	4	C*	anecdotal information and/or recreational catch
Pilchuck River - Upper		5	5	4	4	C*	anecdotal information and/or recreational catch
Quilceda/Allen Creeks		5	5	5	4	C*	
Sunnyside Drainages		5	5	5	4	C*	
Tulalip and Battle creeks		5	5	5	5	D	
Nearshore		5	5	5	1	A	acoustic tagging data; sampling data during winters of 2001 and 2002
Snohomish Estuary		5	5	1	1	A	acoustic tagging data; sampling data during winters of 2001 and 2002

* USFW identifies these additional subbasins as presumed bull trout foraging habitat based on coho distribution.

Note: based on spawning, rearing, over-wintering, foraging data and best professional judgement

Step 1-3 Table. Coho Abundance and Distribution

						Adult Escapement Data										Rearing	Rating		
						Index Reach: Area under the curve, fish-days/mile				Index Reach: Peak count, fish/mile (FPM)									
Watersheds ²	Subbasin	Individual Stream Index Reaches				Subbasin				Individual Stream Reach Index Reaches				Subbasin					
	bold text = contains index reach	Stream Name	Stream # (7.xxxx)	Index Reach Boundaries (river miles)	Survey Length (miles)	Coho Abundance (mean fish-days 1993-2002)	Cumulative Coho Abundance (mean fish-days 1993-2002)	Cumulative Survey Length (miles)	Relative Abundance (fish-days/mile)	Survey Length (miles)	Sum of Peak Live Counts (1993-2001)	Coho Abundance (mean FPM 1993-2001)	FPM Range (1993-2001)	Cumulative Coho Abundance (mean FPM 1993-2001)	Cumulative Survey Length (miles)	Smolt trap preliminary estimates 2001-2003 ⁵	Adult Spawner Abundance Category (by Fish-Days/Mile) ⁶	Juvenile Rearing Distribution ⁷	EASC Rating ⁸ High = A Moderate = B Known Presence = C None = D
Skykomish River																			
	Bear Creek																K	P	C
	May Creek																K	P	C
	Olney Creek																K	P	C
	Skykomish-Lower Mainstem	Foye#1	0819	0.2-0.9	0.7	77	89	1.3	68	0.7	40	6	0 54	3	1.30		K	P	C
		High Rock#2	0820	0.3-0.7	0.4	6				0.4	4	1	0 10						
		Riley Sl #2	0822	0.5-0.7	0.2	6				0.2	4	2	0 20						
	Skykomish-Upper Mainstem	Sky Slough	0961	0.2-1.6	1.4	1,182	3,023	1.7	1,778					252	0.30		M	P	B
		Deer Cr	0979	0.0-0.1	0.1	335				0.1	409	454	60 1180						
		Ames Cr		0.0-0.2	0.2	1,506				0.2	89	49	10 140						
	Skykomish-Lower North Fork	side channel		3.0-3.3	0.3	317	5,047	0.4	12,618					268	0.40		H	P	A
		Lewis Cr	0983	0.0-0.1	0.1	4,730				0.4	966	268	38 838						
	Skykomish-Upper North Fork																K	P	C
	Skykomish-Lower South Fork	Bridal Veil#1	1248	0.0-0.3	0.3	1,249	2,268	0.7	3,240	0.4	672	196	10 1088	170	0.60		M	P	B
		Bridal Veil#2	1248	0.3-0.5	0.2	85				0.2	260	144	25 345						
		Payton		0.0-0.2	0.2	934													
	Skykomish-South Fork																K	P	C
	Sultan River - Lower																K	P	C
	Sultan River - Upper																N		D
	Woods Creek-West Fork	Carpenter Cr	0836	6.3-6.5	0.2	499	1,259	0.4	3,148	0.2	221	123	0 315	143	0.40		M	P	B
		C. Trib		0.0-0.2	0.2	760				0.2	291	162	0 430						
	Woods Creek	Eager Beaver	0820	0.0-0.6	0.6	2,736	2,736	0.6	4,560	0.6	755	140	10 412	140	0.60		M	P	B
	Woods Creek - Lower																K	P	C
	Wallace River - Upper																K	P	C
Subtotal Skykomish River					5.1		14,422	4.1	3,518	3.6	3711			163	3.60				
South Fork Skykomish River ³																			
	Beckler River																K	P	C
	Foss River																K	P	C
	Miller River																K	P	C
	Rapid River																K	P	C
	Skykomish River Upper South Fork																K	P	C
	Tye River																K	P	C
Subtotal South Fork Skykomish River							24,576												
Total Skykomish and South Fork Skykomish Rivers							38,998									1389469			
Snoqualmie River																			
	Ames Creek																K	P	C
	Cherry Creek	Powerline	0244	0.0-0.3	0.3	1,249	4,165	0.8	5,206	0.3	506	187	97 287	199	0.80		H	P	A
		Pond	0247	0.0-0.5	0.5	2,916				0.5	949	211	80 438						
	Coal Creek - Lower																K	P	C
	Coal Creek - Upper																N	P	D
	Griffin Creek	Griffin	0364	9.5-9.8	0.3	2,173	19,572	2.5	7,829	0.3	1120	415	110 803	356	2.10		H	P	A
		Grizzly	0369	0.0-1.0	1.0	8,453				0.6	3087	397	0 1220						
		E Fk Griffin	0371	0.0-1.0	1.0	7,997				1.0	2998	333	118 776						
		LDT	0372	0.0-0.2	0.2	949				0.2	504	280	0 805						
	Harris Creek	Harris #1	0283	4.5-5.3	0.8	5,283	13,826	3.3	4,190	0.8	1655	202	2 441	129	2.60		M	P	B
		Harris #2	0283	5.3-6.2	0.9	4,459				0.4	231	64	0 210						
		Gravel Pit	0285B	0.0-0.4	0.4	324				0.8	1250	174	40 463						
		Lake Joy	0285C	0.0-0.8	0.8	2,797				0.4	445	124	15 393						
		Orange MI	0285D	0.0-0.4	0.4	963				0.2	143	79	15 285						
	Patterson Creek	Patterson	0376	7.7-8.0	0.3	232	11,011	2.9	3,797	0.3	78	29	0 200	124	1.40		M	P	B
		Canyon #1	0382	0.0-0.9	0.9	3,031				0.9	468	58	20 124						
		Canyon #2	0382	0.9-2.0	1.1	4,343													
		Dry#1	0383	0.0-0.2	0.2	2,225				0.2	511	284	50 830						
		Dry#2	0383	0.2-0.6	0.4	1,180													
	Pratt River																N		D
	Raging River	Lake #1	0393	0.0-0.7	0.7	604	2,119	1.9	1,115	0.7	138	22	7 36	22	1.70		M	P	B
		Lake #2	0393	1.1-1.3	0.2	411													
		Deep	0396	0.0-1.0	1.0	1,104				1.0	198	22	10 46						
	Snoqualmie River - Mouth	Peoples	0236	0.5-0.9	0.4	2,852	2,852	0.4	7,130	0.4	779	216	85 595	216	0.40		H	P	A
	Snoqualmie River - Mid Mainstem	Big Rock	0281							0.8	227	32	0 125	32	0.80		K	P	C
	Snoqualmie River - Upper Mainstem	Langlois	0292	0.9-1.3	0.4	977	977	0.4	2,443	0.4	528	147	0 550	147	0.40		M	P	B
	Snoqualmie River - Lower South Fork																N		D
	Snoqualmie River - Upper South Fork																N		D
	Snoqualmie River - Lower Middle Fork																N		D
	Snoqualmie River - Upper Middle Fork																N		D
	Snoqualmie River - Lower North Fork																N		D

Step 1-3 Table. Coho Abundance and Distribution

						Adult Escapement Data											Rearing	Rating		
						Index Reach: Area under the curve, fish-days/mile				Index Reach: Peak count, fish/mile (FPM)										
Watersheds ²	Subbasin	Individual Stream Index Reaches				Subbasin				Individual Stream Reach Index Reaches				Subbasin						
	bold text = contains index reach	Stream Name	Stream # (7.xxxx)	Index Reach Boundaries (river miles)	Survey Length (miles)	Coho Abundance (mean fish-days 1993-2002)	Cumulative Coho Abundance (mean fish-days 1993-2002)	Cumulative Survey Length (miles)	Relative Abundance (fish-days/mile)	Survey Length (miles)	Sum of Peak Live Counts (1993-2001)	Coho Abundance (mean FPM 1993-2001)	FPM Range (1993-2001)		Cumulative Coho Abundance (mean FPM 1993-2001)	Cumulative Survey Length (miles)	Smolt trap preliminary estimates 2001-2003 ⁵	Adult Spawner Abundance Category (by Fish-Days/Mile) ⁶	Juvenile Rearing Distribution ⁷	EASC Rating ⁸ High = A Moderate = B Known Presence = C None = D
	Snoqualmie River - Upper North Fork																	N		D
	Tate Creek																	N		D
	Taylor River																	N		D
	Tokul Creek																	K	P	C
	Tolt River - Lower	E Fk Stossel #1	0301	0.0-0.3	0.3	2,089	3,568	0.5	7,136	0.3	705	251	0	1067	251	0.30		H	P	A
		E Fk Stossel #2	0301	0.3-0.5	0.2	1,479														
	Tolt River - North Fork																	K	P	C
	Tolt River - South Fork above Dam																	N		D
	Tolt River - South Fork below Dam																	K	P	C
Subtotal Snoqualmie River					12.7		58,090	18.8	3,090	10.5	16,520.0	176.4					579931			
Snohomish River																				
	Allen Creek	Allen	0068	5.2-5.6	0.4	95	354	1.1	322	0.4	63	18	0	50	16	1.10		K	P	C
		Nelson	0078	0.6-0.8	0.2	51				0.2	20	11	0	45						
		Ross	0079	0.0-0.5	0.5	208				0.5	79	18	0	68						
	Upper Snohomish/Cathcart																	K	P	C
	Dubuque Creek	Dubuque	0139	1.5-3.8	2.3	8,906	15,509	4.7	3,300	2.3	2962	143	26	375	120	4.70		M	P	B
		Panther	0140	0.8-3.2	2.4	6,603				2.4	2078	96	18	246						
	Everett Coastal Drainages																	K	P	C
	Fobes Hill																	K	P	C
	French Creek																	K	P	C
	Lake Stevens Drainages																	K	P	C
	Little Pilchuck Creek	Catherine Cr	0148	0.0-1.6	1.6	2,392	2,392	1.6	1,495	1.6	990	69	12	196	69	1.60		M	P	B
	Lower Snohomish/Marshland																	K	P	C
	Pilchuck River - Lower																	K	P	C
	Pilchuck River - Middle	Bosworth Lake Cr	0163	0.0-1.4	1.4	4,833	8,112	2.1	3,863	1.4	1557	124	29	293	213	2.60		M	P	B
		Worthy Cr	0166	3.4-3.7	0.3	1,162				0.3	389	144	40	207						
		Worthy A	0166	0.0-0.2	0.2	931				0.2	390	217	50	415						
		Worthy B	0166	0.0-0.2	0.2	1,186				0.2	464	258	130	570						
		Boyd Lake Cr	0164							0.2	444	247	105	450						
		Boyd Lake Cr Trib	0164							0.3	778	288	117	680						
	Pilchuck River - Upper																	K	P	C
	Quilceda Creek	Middle Fork Quilceda	0058	2.3-3.3	1.0	2,602	3,556	1.4	2,540	1.0	653	73	0	190	106	1.40		M	P	B
		Edgecomb	0060	2.4-2.6	0.2	667				0.2	331	184	15	565						
		Straad	0063	1.1-1.3	0.2	287				0.2	112	62	25	95						
	Sunnyside Drainages																	K	P	C
	Tulalip and Battle Creeks																	N		D
	Snohomish Estuary																		P	A
	Nearshore																		P	A
Subtotal Snohomish River					10.9		29,923	3.7	8,087	11.4	11,310.0	130.1								
Total Snohomish Basin (average fish days/year)							127,011													
Estimated Snohomish Basin escapement (average 1993-2000)⁴							81,907													

¹Data based on annual escapement spawning surveys. Fish-day calculations are based on "Index Surveys" and are not a measure of abundance, per se, but allow observations throughout a spawning season to be integrated. Fish-days are averaged over the period 1993-2002.

²Watersheds are grouped to correspond to the four coho stocks identified by Washington Department of Fish and Wildlife and Western Washington Treaty Tribes for management purposes (Skykomish, South Fork Skykomish, Snoqualmie, and Snohomish).

³Coho are transported above Sunset Falls on the South Fork Skykomish River each year. Total fish are counted, but there are no index reaches above the falls. Supplemental surveys in some tributaries provide some indication of distribution.

⁴Snohomish Basin escapement estimates are made annually with an area under the curve analysis using fish-day data and relationship to the 1977 base year estimates.

⁵Snoqualmie smolt trap estimate from 2002-2003 only

⁶Relative abundance categories: "K" <1,000 fish-days/mi or known present from Supplemental Escapement Survey data or from WRIA 7 Limiting Factors Analysis; "M" =1000-5000 fish-days/mi; "H" >5000 fish-days/mi; "N" =not accessible.

⁷"P"=presumed present in areas downstream of known spawning locations and/or from trapping data and estuary and nearshore beach seine data.

⁸High=A (>5,000 fish-days/mile) Moderate=B (1,000-5,000 fish-days/mile) Known Presence=C (<1,000 fish-days/mile or known presence from supplemental surveys) None=D (not accessible)

Note: Coho salmon are distributed broadly across the Snohomish River basin. High, moderate, and some known presence calls were based on fish-days/mile derived from index reach spawner escapement. Supplemental survey data were used to identify presence. The abundance of subbasins in the known presence class indicates the need for further coho data collection and analysis. It should not be inferred that all subbasins marked as known presence have low coho use. It is also important to note that, in a regional context, coho production in the Snohomish River basin is high relative to other basins.

Step 1 - Map 1

Current Relative Chinook Use by Subbasin

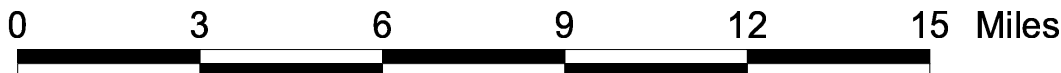
Relative Current Chinook Use
(by Population)

- High - >12% total spawning escapement
- Moderate - 8 to 12% total spawning escapement
- Low < 8% total spawning escapement
- None

Rivers

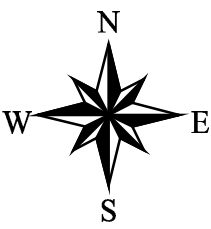
Escapement data for all South Fork Skykomish headwater tributaries (Beckler, Rapid, Tye, Foss, Miller) is reported in the Upper South Fork Skykomish Subwatershed

** based primarily on spawner escapement data*



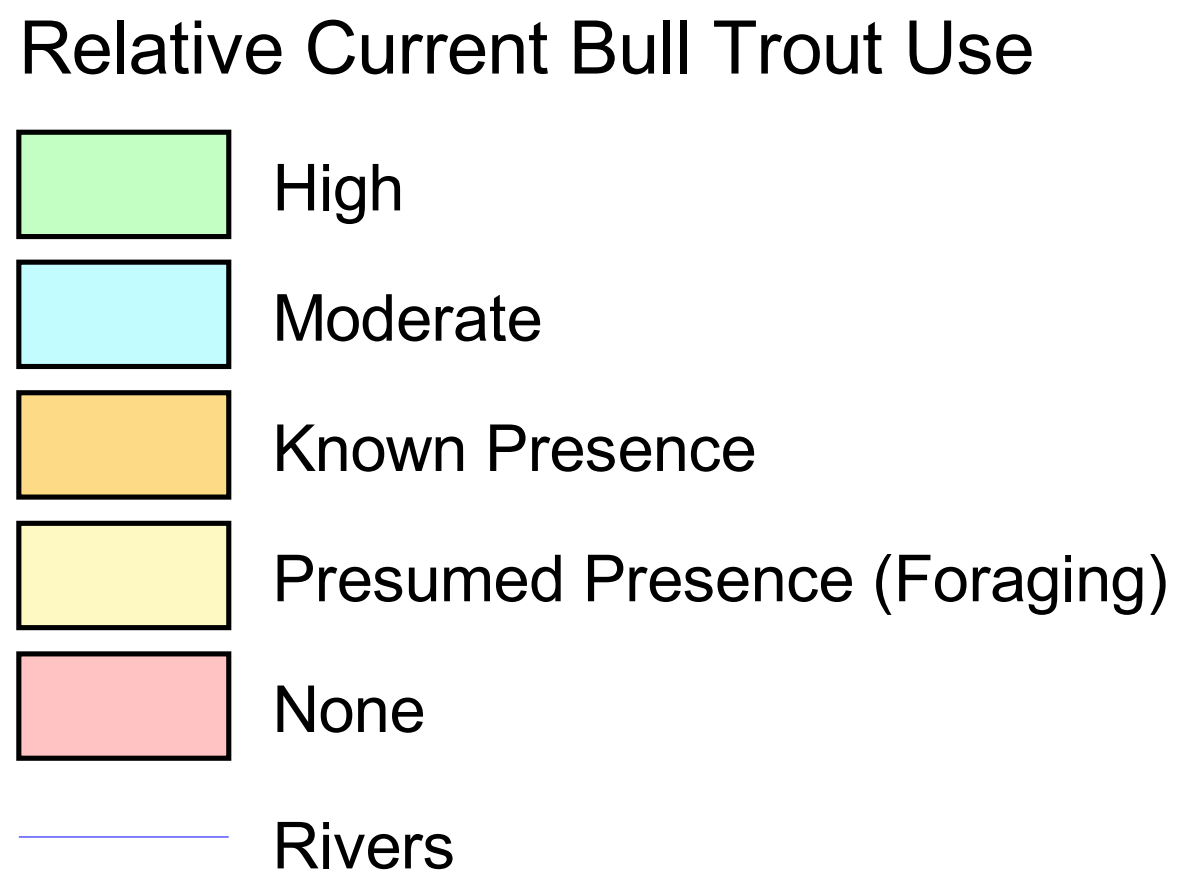
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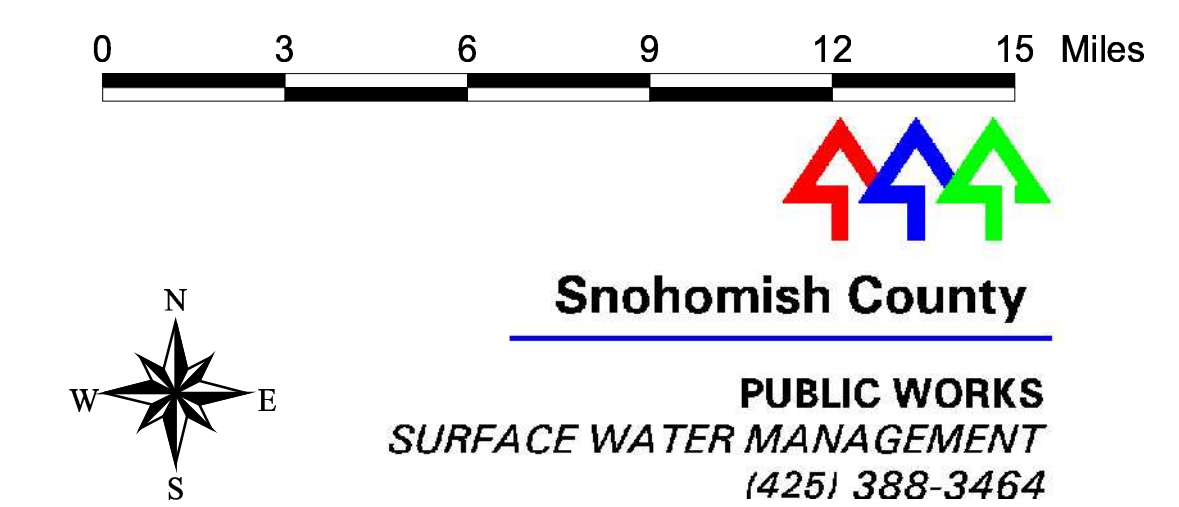


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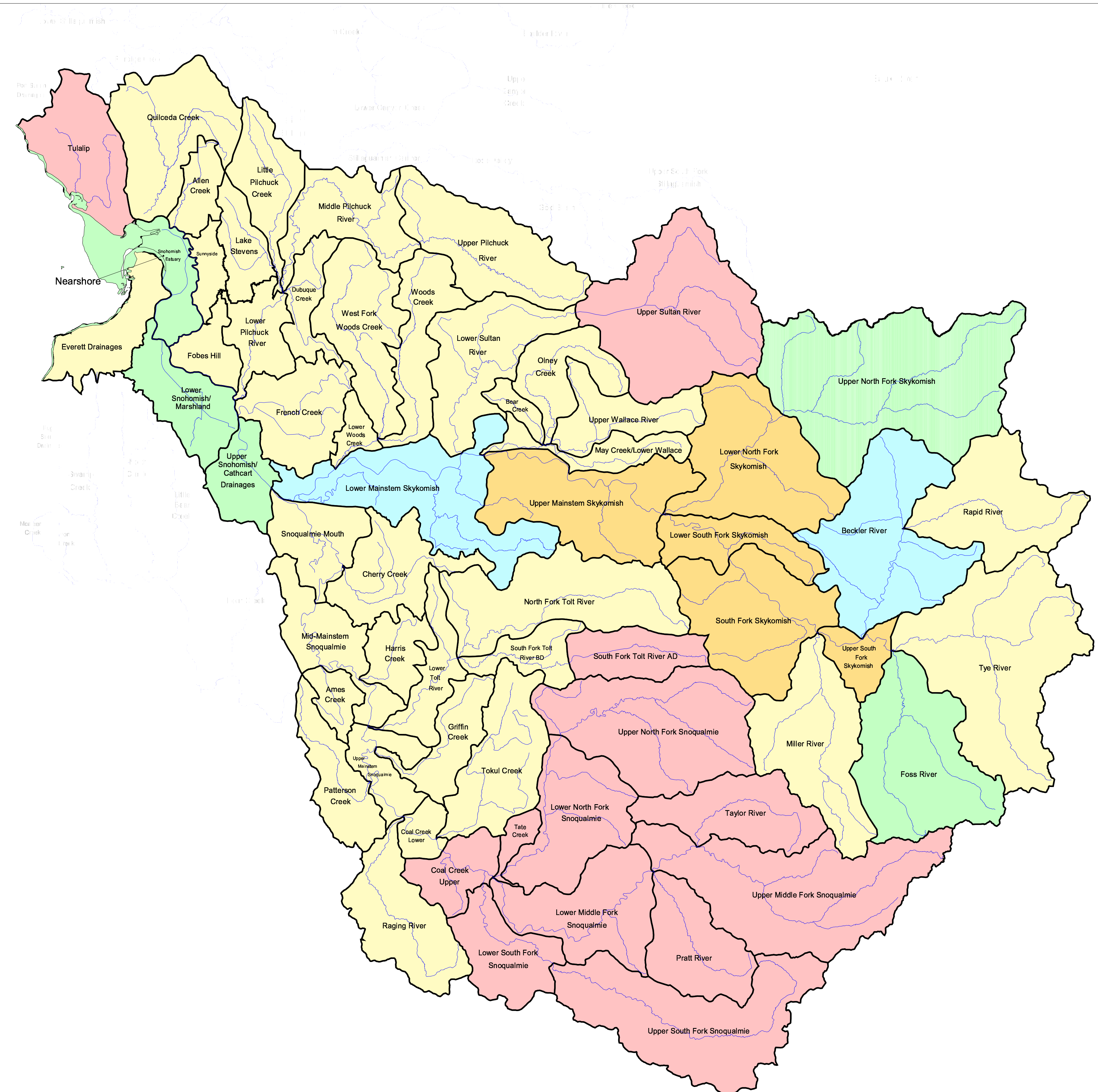
Step 1 - Map 2 Current Relative Bull Trout Use by Subbasin



**Based on spawning, rearing, over-wintering, and foraging data and best professional judgement*

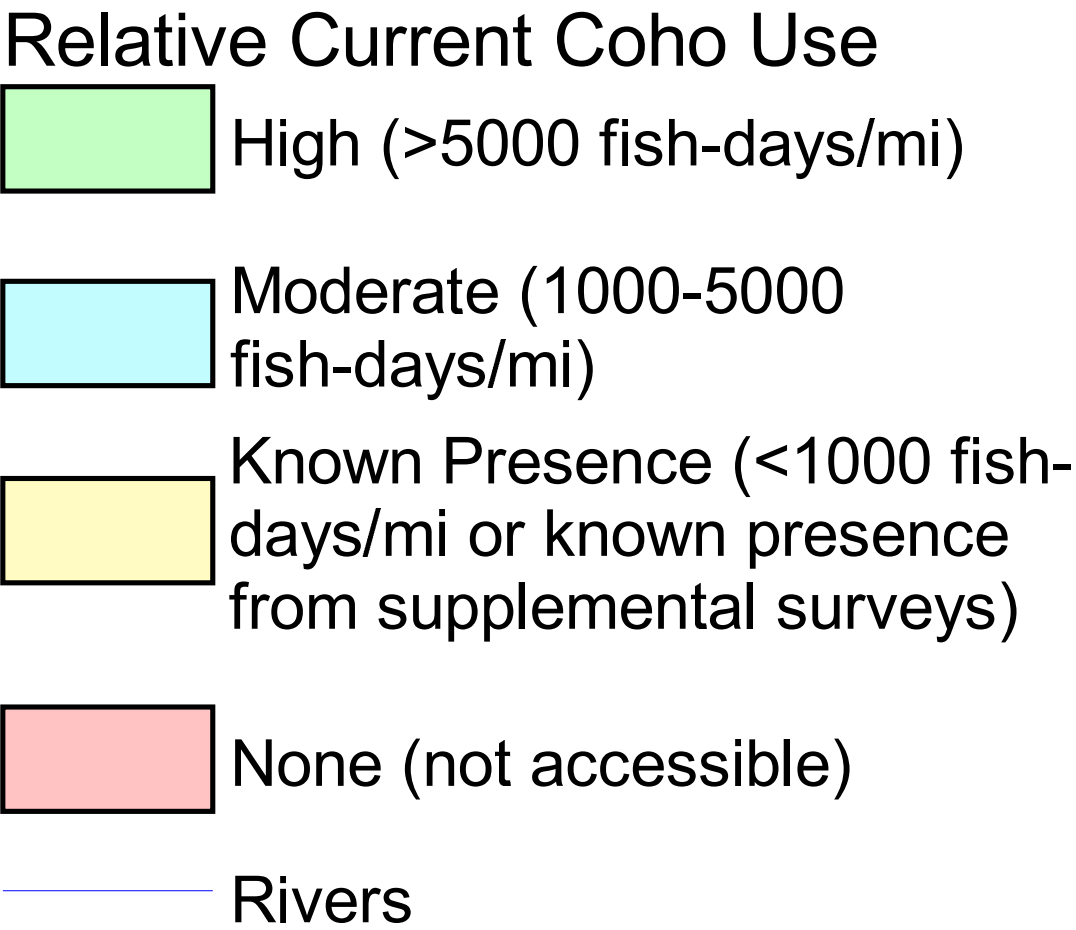


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Step 1 - Map 3

Current Relative Coho Use by Subbasin

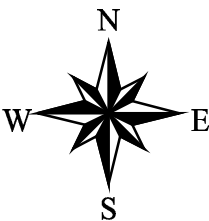


**Coho salmon are distributed broadly across the Snohomish River basin. High, moderate, and some known presence calls were based on fish-days/mi derived from index reach spawner escapement. Juvenile sampling data from the estuary were also used. Supplemental survey data were used to identify presence. The abundance of subbasins in the known presence class indicates the need for further coho data collection and analysis. It should not be inferred that all subbasins marked as known presence have low coho use. It is also important to note that in a region context, coho production in the Snohomish River basin is high relative to other basins.*

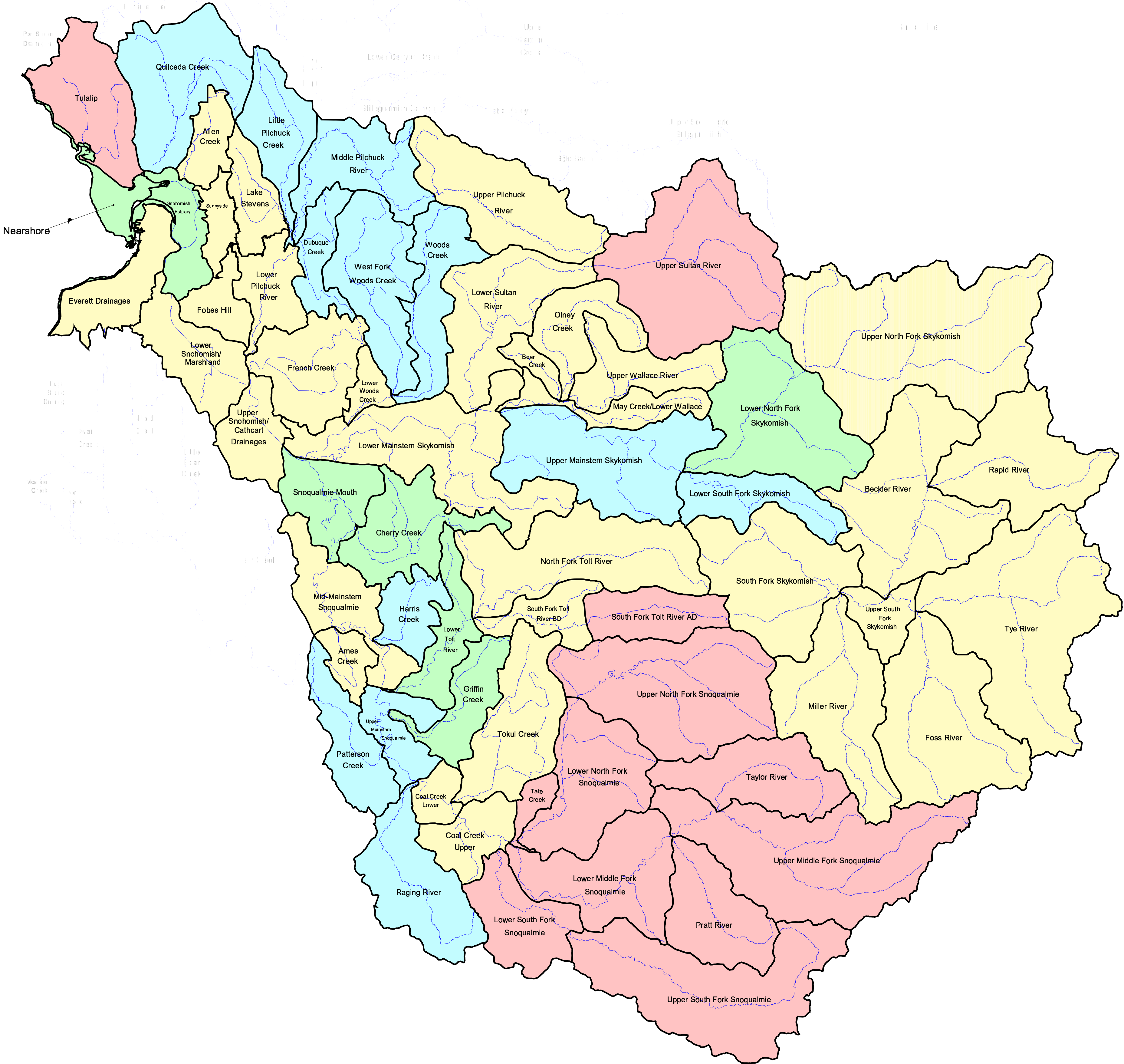


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STEP 2. CURRENT STREAM HABITAT CONDITIONS

DESCRIPTION

Step 2 is an evaluation of existing data on stream habitat conditions available to salmonids and other aquatic species. Documentation of current stream habitat conditions provides guidance on restoration needs and a baseline for evaluating improvement or degradation in the future. Habitat parameters summarized here include anthropogenic barriers to fish migration, percent fine sediment in spawning gravels, water quality, abundance of large woody debris (LWD), maturity and width of riparian vegetation, off-channel and side channel habitat, and extent of shoreline armoring. Instream habitat conditions are a function of watershed processes such as the delivery, routing, and storage of sediment, water, and wood, and reach-level morphological controls such as valley constriction, logjams, and streambed/bank materials. The quantity and quality of instream habitat, along with harvest and hatchery practices, determine the abundance, productivity, diversity, and spatial structure of salmonid populations in the Snohomish River Basin. The goal of this analysis is to integrate the Habitat Conditions Review (HCR)(SBSRTC 2002) with the State Conservation Commission's Salmonid Habitat Limiting Factors Analysis (LFA)(Haring 2002) to provide data at a finer resolution (reach scale) where it exists, assign a level of certainty to each data entry, and add transparency to modeling exercises.

METHODS

In this analysis we began with the habitat conditions matrix produced for the HCR. The text in the HCR and the LFA were reviewed for reach scale information. When data were available on a reach scale, they were incorporated into the table (Step 2 Table). A level of certainty was assigned to each data entry. To avoid confusion and redundancy, hydrology (peak flow) was addressed in the watershed process analysis in Step 3 rather than here.

The HCR was completed by the SBSRTC in 2002. Conducted on a subbasin scale, the HCR evaluated six habitat conditions in each subbasin and compared current habitat function to regional performance criteria. Each habitat condition received a rating of "intact," "moderately degraded," "degraded," or "data gap." Ratings were based on quantitative data specific to performance criteria. Performance criteria specific to the Estuary and Nearshore subbasins were developed to better characterize these unique environments. Best professional judgment was not used to make habitat condition designations in the HCR. Please refer to the HCR (SBSRTC 2002) document for specific performance criteria and methods used in the analysis.

The Washington State Conservation Commission's LFA (Haring 2002) was completed subsequent to the HCR. The SBSRTC acted as the Technical Advisory Group (TAG) for the production of this document. The LFA summarized habitat conditions across the Snohomish River Basin using the State of Washington's stream numbering system as the organizational structure. The LFA incorporated qualitative data and best professional judgment into the analysis.

Condition

Intact (I) – Watershed processes and habitat structure reflect a natural state and provide optimum conditions to support salmonid populations (SBSRTC 2002).

Moderately Degraded (MD) – Watershed processes and habitat structure have diverged from natural conditions and/or create some impairment to the natural productivity of salmonids (SBSRTC 2002).

Degraded (D) – Watershed processes and habitat structure have substantially diverged from natural conditions and/or provide severe impairment to the natural productivity of salmonids (SBSRTC 2002).

No Data (ND) – There are no known data specific to the performance criteria and therefore no specific designation in the HCR, LFA, or EDT reports (SBSRTC 2002).

Level of Certainty

High (1) – supported by quantitative data related to performance criteria in the HCR.

Medium (2) – supported by derived data or quantitative data related to criteria that were not selected as performance criteria in the HCR.

Low (3) – best professional judgment as reported in the LFA report or verbal description in the HCR.

Step 2 Table. Current Stream Habitat Conditions

Subbasin	EDT Reach	Instream Artificial Barriers to Habitat	Sediment	Hydrology	Water Quality	Wetlands/Riparian Zone & Shoreline Vegetation/LWD	Shoreline Condition & Floodplain Connectivity	Source
		D1	DG	DG	DG	DG	DG	HCR
Beckler River		I1	D1	DG	MD1	D1	I1	HCR
	Beckler_1	I1	D1	DG	I1	D1	MD3	LFA p. 279
	Beckler_2	I1	D1	DG	I3	D1	MD3	LFA p. 279
Foss River		I1	I1	DG	I1	MD1	I1	HCR
	Foss_1	I1	I3	DG	I1	I3	I3	LFA p. 282
	WFFoss_1	DG	DG	DG	DG	DG	DG	None
May Creek/Lower Wallace River		D1	DG	I3	MD1	DG	DG	HCR
	Wallace_1	I1	DG	MD3	MD1	MD3	DG	LFA p. 236
Miller River		I1	MD1	I1	I1	DG	I1	HCR
	Miller_1	I1	I3	I3	I1	DG	MD2	LFA p. 274
Olney Creek		DG	DG	DG	DG	DG	DG	HCR
Rapid River		I1	D1	DG	I1	DG	DG	HCR
	Rapid_1	I1	D1	DG	I1	DG	DG	HCR p37
Skykomish River - Lower Mainstem		D1	DG	I2	D1	D1	MD1	HCR
	Elwell_1	D1	DG	I3	DG	DG	DG	LFA p. 224-225
	Skykomish_1	I1	DG	DG	D1	D1	MD1	LFA p. 201-205, Purser & Simmonds, HCR 39-42
	Skykomish_2	I1	DG	DG	MD1	D1	MD1	LFA, Purser & Simmonds, HCR
	Skykomish_3	I1	DG	DG	MD3	D1	MD1	LFA, Purser & Simmonds, HCR
	Skykomish_4	I1	DG	DG	MD3	D1	MD1	LFA, Purser & Simmonds, HCR
	Skykomish_5	I1	DG	DG	MD3	D1	MD1	LFA, Purser & Simmonds, HCR
Skykomish River - Upper Mainstem		D1	DG	I2	MD1	D1	D1	HCR
	Skykomish_6	I1	DG	I3	MD3	D1	D2	LFA, Purser & Simmonds, HCR
	Skykomish_7	I1	DG	I3	MD1	DG	DG	LFA, Purser & Simmonds, HCR
Skykomish River - Lower North Fork		MD1	DG	I2	DG	D1	D1	HCR
	NFSkykomish_1	I1	I3	I3	I2	D1	D3	SNOHOMISH CO. DATA, LFA, HCR
Skykomish River - Upper North Fork		I1	MD1	DG	DG	MD1	MD1	HCR
	NFSkykomish_2A	I1	I2	I3	DG	D2	MD1	SNOHOMISH CO. DATA, LFA, HCR
	NFSkykomish_2B	I1	D2	I3	DG	D2	MD2	SNOHOMISH CO. DATA, LFA, HCR
	Bear Creek Falls							
Skykomish River - Lower South Fork		MD1	DG	DG	I1	DG	D1	HCR
	BridalVeil_1	I1	DG	DG	DG	DG	DG	LFA p. 267-268
	SFSkykomish_1	I1	DG	I2	DG	D3	D1	LFA p. 264-267, Purser & Simmonds 2001, HCR
	SFSkykomish_2	I1	DG	I2	DG	D3	D1	LFA p. 264-267, Purser & Simmonds 2001, HCR
Skykomish River - South Fork		MD1	DG	I2	MD1	MD1	D1	HCR
	SFSkykomish_3	I1	DG	I2	MD3	D3	D1	LFA p. 264-267, Purser & Simmonds 2001, HCR
Skykomish River - Upper South Fork		MD1	DG	I2	MD1	MD1	D1	HCR
	SFSkykomish_4	I1	DG	I2	MD3	D3	D1	LFA p. 264-267, Purser & Simmonds 2001, HCR
	SFSkykomish_5	I1	DG	I2	MD3	D3	D1	LFA p. 264-267, Purser & Simmonds 2001, HCR
Sultan River - Lower		D1	D1	D1	I1	I1	I1	HCR
	Sultan_1	I1	D3	D1	I1	D2	MD3	LFA p.227
	Sultan_2	I1	D3	D1	I1	I1	I3	LFA p.227
Sultan River - Upper		D1	DG	I2	I1	DG	DG	HCR
	Sultan_3	D1	D1	D2	I1	I3	I3	HCR
Tye River		I1	DG	DG	MD1	DG	DG	HCR
	Tye_1	I1	D3	DG	MD1	DG	DG	LFA, 283-285, HCR, 58-59
Wallace River - Upper		D1	DG	I2	DG	MD1	DG	HCR
	Wallace_2	D1	DG	MD3	MD2	MD1	DG	LFA, 236-238, HCR, 60, 303DLIST
Woods Creek		D1	D1	I2	DG	DG	DG	HCR

Step 2 Table. Current Stream Habitat Conditions

Subbasin	EDT Reach	Instream Artificial Barriers to Habitat	Sediment	Hydrology	Water Quality	Wetlands/Riparian Zone & Shoreline Vegetation/LWD	Shoreline Condition & Floodplain Connectivity	Source
	Woods_2	I1	MD3	I2	MD2	DG	DG	LFA-213, PURSER & SIMMONDS 2001, 303D LIST,HCR
Woods Creek - Lower		MD1	D1	MD2	MD1	DG	DG	HCR
	Woods_1	I1	D2	I2	MD2	DG	DG	LFA-213, PURSER & SIMMONDS 2001, 303D LIST, HCR
Woods Creek - West Fork		D1	D1	I2	DG	DG	DG	HCR
	WFWoods_1	I1	D2	I3	MD3	DG	DG	LFA-213, PURSER & SIMMONDS 2001, HCR
	WFWoods_2	I1	D2	I3	MD3	DG	DG	LFA-213, PURSER & SIMMONDS 2001, HCR
	WFWoods_3	I1	D2	I3	MD2	DG	DG	LFA-213, PURSER & SIMMONDS 2001, HCR
Ames Creek		D1	DG	I2	DG	D1	MD1	HCR
Cherry Creek		D1	DG	I2	D1	D1	D1	HCR
	Cherry_1	D1	DG	DG	MD3	D1	D1	LFA p148
Coal Creek - Lower		DG	DG	I2	D1	D1	D1	HCR
Coal Creek - Upper		DG	DG	I2	DG	D1	DG	HCR
Griffin Creek		D1	D1	DG	I1	MD1	MD1	HCR
	Griffin_1	D1	D1	DG	MD1	MD2	MD1	HCR, LFA pp. 177-180, Solomon and Boles 2002
Harris Creek		D1	DG	I2	DG	D1	MD1	HCR
Patterson Creek		D1	D1	I2	D1	D1	DG	HCR
	Patterson_1	D1	D2	DG	D1	D1	DG	HCR, LFA pp. 182-185
Pratt River		DG	DG	DG	DG	I1	I1	HCR
Raging River		D1	MD1	DG	DG	D1	D1	HCR
	Raging_1	I1	D3	D3	MD3	D3	D1	LFA P186
	Raging_2	I1	D3	DG	DG	DG	DG	LFA p. 187
Snoqualmie River - Mouth		D1	DG	I1	D1	D1	D1	HCR
	Snoqualmie_1A	I1	DG	DG	DG	D1	D1	LFA
	Snoqualmie_1B	I1	DG	DG	DG	D1	D1	LFA
Snoqualmie River - Mid-Mainstem		D1	MD1	I2	D1	D1	D1	HCR
	Snoqualmie_2A	I1	DG	MD2	D1	D1	D1	Solomon and Boles, 2002
	Snoqualmie_2B	I1	DG	MD2	D1	D1	D1	SBSRTC
	Snoqualmie_3	I1	DG	MD2	D1	D1	D1	SBSRTC
Snoqualmie River - Upper Mainstem		D1	MD1	I2	D1	D1	D1	HCR
	Snoqualmie_4	D1	MD1	MD1	D1	D1	D1	HCR, Solomon and Boles, 2002
	Snoqualmie_5	D1	MD1	MD1	D1	D1	D1	HCR, Solomon and Boles, 2002
	Snoqualmie_6	D1	MD1	MD1	D1	I2	MD1	HCR, Solomon and Boles, 2002
	Snoqualmie_7	D1	DG	MD1	I1	DG	DG	HCR, LFA p.140
Snoqualmie River - Lower South Fork		DG	DG	I2	D1	D1	MD1	HCR
Snoqualmie River - Upper South Fork		DG	DG	DG	D1	MD1	MD2	HCR
Snoqualmie River -Lower Middle Fork		MD1	DG	DG	DG	D1	MD1	HCR
Snoqualmie River - Upper Middle Fork		DG	DG	DG	DG	I1	I2	HCR
Snoqualmie River - Lower North Fork		DG	DG	DG	DG	DG	MD1	HCR
Snoqualmie River - Upper North Fork		DG	DG	DG	DG	DG	DG	HCR
Tate Creek		DG	DG	DG	DG	D1	DG	HCR
Taylor River		DG	DG	DG	DG	MD1	I2	HCR
Tokul Creek		D1	MD2	DG	I1	I1	I1	HCR
	Tokul_1	I1	MD2	DG	DG	MD2	MD2	HCR, LFA pp. 195-197
	Tokul_2	D1	MD2	DG	I1	MD2	I1	HCR, LFA pp. 195-197
Tolt River - Lower		I1	MD1	MD1	I1	DG	D1	HCR
	Tolt_1	I1	D3	D3	I1	D3	D1	LFA, Solomon and Boles, 2002
	Tolt_2	I1	D3	D3	I1	MD2	I3	LFA p169
Tolt River - North Fork		MD1	DG	I1	I1	D1	I1	HCR
	Tolt_3	MD1	DG	I1	I1	D1	I1	HCR, LFA pp. 167-175

Step 2 Table. Current Stream Habitat Conditions

Subbasin	EDT Reach	Instream Artificial Barriers to Habitat	Sediment	Hydrology	Water Quality	Wetlands/Riparian Zone & Shoreline Vegetation/LWD	Shoreline Condition & Floodplain Connectivity	Source
Tolt River - South Fork above Dam		MD1	D1	DG	DG	D1	DG	HCR
Tolt River - South Fork Below Dam		I1	D1	D1	I1	D1	I1	HCR
	SFTolt_1	I1	D1	D1	I1	D1	I1	HCR, LFA pp. 167-175
	SFTolt_2	I1	D1	D1	I1	D1	I1	HCR, LFA pp. 167-175
Upper Snohomish/Cathcart		D1	DG	I2	D1	D1	DG	HCR
	Snohomish_2	I1	DG	DG	D1	DG	D3	HCR, LFA, Snohomish Co. Data, 3o3D
Dubuque Creek		DG	DG	I2	D1	D1	DG	HCR
Everett Coastal Drainages		DG	DG	D2	MD1	D1	I1	HCR
Fobes Hill		D1	D1	D2	DG	D1	D1	HCR
French Creek		D1	D1	MD2	D1	D1	D1	HCR
Lake Stevens Drainages		MD1	D1	D1	MD1	D1	MD1	HCR
Little Pilchuck Creek		DG	DG	I2	DG	D1	DG	HCR
Lower Snohomish/Marshland		D1	D1	D2	D1	D1	D1	HCR
Pilchuck River - Lower		MD1	MD1	I3	D1	D1	D1	HCR
	Pilchuck_1	I1	MD3	MD3	MD2	D2	D1	LFA-100, SRWHC-136
	Pilchuck_2	I1	MD3	MD3	MD2	D1	D2	LFA-100-101, GERSID ET AL. TULALIP TRIBES
	Pilchuck_3	I1	MD3	MD3	MD2	MD1	MD3	LFA-99-100, SRWHC-136, TULALIP TRIBE DATA
Pilchuck River - Middle		MD1	DG	MD1	D1	D1	MD1	HCR
	Pilchuck_4	I1	MD3	MD1	MD1	MD2	MD3	LFA-98-101, SRWHC-136, 303D LIST
	Pilchuck_5	I1	DG	DG	MD1	MD3	MD3	LFA-98, SRWHC-138
	Pilchuck_6	I1	DG	DG	MD1	MD3	DG	LFA-98, SRWHC-138, LOCH-42
Pilchuck River - Upper		D1	DG	DG	I1	MD1	MD1	HCR
	Pilchuck_7	D1	DG	MD3	I1	MD3	MD3	LFA-98-1100, LOCH-27, SRWHC-140
	Pilchuck_8	D1	DG	I3	I1	MD3	MD3	LFA-98-100, LOCH-27&42, SRWHC-140
	Pilchuck_9	D1	DG	I3	I1	MD3	MD3	LFA-98-101, LOCH-27 & 42, SRWHC-140
Quilceda/Allen Creek		MD1	D1	D2	D1	D1	D1	HCR
	MFQuilceda_1	I1	D3	D2	D1	D3	D3	LFA p80
	Quilceda_1	I1	D3	D2	D1	MD2	MD3	LFA p80
	Quilceda_2	I1	D3	D2	D1	D3	D3	LFA p80
Sunnyside Drainages		D1	DG	D2	DG	D1	DG	HCR
Tulalip and Battle Creeks		DG	DG	I1	I1	D1	DG	HCR
Nearshore		I1	D1	DG	D1	D1	D1	HCR
Snohomish Estuary		D1	D1	D1	D1	D1	D1	HCR
	Snohomish 1	D1	D1	D1	D1	D1	D1	

Condition

I = Intact

MD = Moderately Degraded

D = Degraded

DG = Data Gap

Level of Certainty

1 = High

2 = Medium

3 = Low

Text in bold italics indicates inconsistencies. Inconsistencies between habitat conditions calls on a subbasin and reach scale occur when data with a lower level of certainty is reported on a reach scale. Subbasin scale habitat c

STEP 3. WATERSHED PROCESS ANALYSIS

Step 3 of the EASC is to evaluate and synthesize the degree of functioning of landscape-forming processes in the Snohomish River Basin. Information from this step helps to identify potential sources of habitat degradation, thus distinguishing actions most likely to benefit salmonid populations (SWC 1998). In particular, results from these process analyses are used to identify subwatershed strategy groups that categorize subwatersheds based on their degree of current or potential fish use and the degree to which their processes are impaired (see Step 7).

DESCRIPTION

Landscape factors and land use activities affect watershed processes, including stream flow, channel formation, sediment supply and transport, and riparian vegetative succession. Such processes in turn affect aquatic habitat conditions, including water quality, bed material size, and location of large woody debris. Salmon population status reflects the direct and indirect effects of aquatic habitat conditions and landscape-forming processes (Figure 3-1). Because of the potential direct and indirect links between landscape-forming processes and salmon population status, such processes are a critical component of a conservation and recovery strategy for salmon populations.

In Step 3 of the EASC, the NOAA Fisheries Staff conducted an analysis to estimate the relative condition of three major landscape-forming processes in each subbasin: peak-flow hydrology, riparian functions, and coarse sediment supply. These estimates followed the approach of Beamer et al. (2000), using widely available GIS data layers as coarse-level screens to identify areas with potentially impaired functioning of landscape-forming processes. Land cover, geology, and forest road density were used to indicate the current condition of peak flow hydrology, riparian function, and sediment supply within the Snohomish River Basin¹. We summarize results from these analyses at the subbasin scale (Step 3 Table) because it is over larger geographic scales that such processes operate (Beechie and Bolton 1999, Beamer et al. 2000, Roni et al. 2002). We were unable to include the Snohomish River estuary in this analysis because we did not have suitable data layers to determine the condition of the processes in the estuary.

METHODS

Peak Flow Hydrology

Peak flows elevated above historical levels can alter the morphology of stream channels, leading to redd scour and decreased habitat complexity (SWC 1998). Redd scour and decreased complexity, in turn, can reduce the survival and capacity of both juvenile and adult salmonids (McNeil 1964, Stevens and Miller 1983, Waldichuck 1993, Seiler 2000). The peak flow hydrology screen used in this analysis estimated

¹ This analysis used landscape-level data to evaluate the relative condition of watershed processes in the Snohomish Basin. Many of the data layers used in this analysis were derived from Landsat imagery, which can depict a single object if it is at least 900 square meters in area. Consequently, many objects, single trees, individual wetlands, parking lots, are not of this substantial size; thus an individual "pixel" on the dataset can contain a mixture of many features in the landscape. This mixture of features in one "pixel" can lead to misclassification of features. Additionally, some features reflect light similarly, which can lead to confusion between features for the interpreter and leads to many different land cover types represented by a single category on a map. These limitations are inherent in the data sources and these analyses should always be followed up by field studies to validate these screens.

changes in peak flows relative to historical conditions². Since salmon populations were viable under historical conditions, we assumed that departures from this baseline hydrograph could be deleterious to salmon. The magnitude of departure assumed to be deleterious is determined from field-based inventories reported in the literature.

Lowland subbasins in the Snohomish River Basin are more urbanized than upland subbasins, but they are less impacted by recent forestry practices. This distinction made it necessary to define lowland and upland subbasins precisely, enabling different indicators of peak flow hydrology to be applied in each area. Our definitions relied on two criteria: land use zoning and elevation. We defined upland subbasins as those with at least 50% of their area in the Forest Production Zone or a mean elevation $\geq 1,000$ ft (305 m) (Figure 3-2, Figure 3-3, Figure 3-4). Conversely, we defined lowland subbasins as those with $<50\%$ of their area in the Forest Production Zone (Figure 3-2) and a mean elevation $<1,000$ ft (305 m) (Figure 3-3). Percentage of area within the forested zone was determined by intersecting subbasin and Forest Production Zone GIS data layers for the Snohomish River Basin. Mean elevation values for the subbasin were extracted from the 10m Digital Elevation Model (DEM).

Peak Flow in Lowland Subbasins

Several studies have shown that indicators of urbanization signify degraded habitat conditions for salmon (May 1996, Booth and Jackson 1997, Moscrip and Montgomery 1997). Both total impervious area (TIA) and effective impervious area (EIA) are indicators of urbanization, but EIA accounts only for the impervious area that has a direct connection to stream reaches (Booth and Jackson 1997). Consequently, EIA is a better indicator than TIA for impaired peak flows and impacted stream channels.

We derived EIA by classifying an August 2001 Landsat scene, then mapping the medium and high-density development land cover categories as defined by Purser et al. (2003). Medium density development refers to urban and suburban residential or commercial land use classes and includes roads, roofs, lawns, landscaping, and bare ground. High-density development refers to urban residential, commercial, and industrial land use classes and includes roads, roofs, parking lots, and sand/gravel bars. Purser et al. (2002) found a strong correlation between these two categories and mapped TIA. They also refined the relationships between medium and high-density development and impervious area based on Dinicola's (1989) work on rainfall and runoff in western Washington. We used the following relationship to determine the amount of EIA in the landscape:

$$\% \text{ EIA} = [0.36(\% \text{ MDDA})] + [0.72(\% \text{ HDDA})]$$

where MDDA = medium density development area and HDDA = high-density development area.

After deriving EIA in the landscape, we used hydrologic modeling to determine the amount of EIA encountered by overland and in-stream flows. Hydrologic modeling is a geospatial technique that predicts flow in a watershed based on an existing DEM. The DEM employed in this analysis represented elevation values in 20-m by 20-m cells. It was used to model the direction of overland flow and to determine the amount of EIA encountered on the path into the stream. In this process, the direction of water flow was determined by comparing the slopes of the eight surrounding cells. Consequently, we ascertained the area that would flow into each 20-m cell (i.e., the flow accumulation grid).

² The hydrologic analysis focused on peak flows however; landscape-level variables (i.e. forest cover, impervious surface) also impact low flows. Thus, a subbasin with degraded peak flow hydrology will likely have degraded baseflow hydrology. Additionally, the peak flow analysis did not include wetlands, which can significantly affect water storage and transport conditions in the watershed, and thus the hydrology.

The direction and accumulation of flow were used along with EIA to determine the relative peak flow condition of the stream reaches in each subbasin within the lowland zone. Using the DEM and the EIA estimated across the landscape, we calculated the amount of flow influenced by EIA into each 20-m by 20-m cell (i.e., weighted flow accumulation) and the total number of cells upstream of each cell that contribute flow to that cell (i.e., flow accumulation). The percentage of total flow that is affected by EIA in each cell is calculated by dividing the weighted flow by the accumulation flow.

To classify levels of peak flow functioning, we tallied the total length of stream reaches influenced by different levels of percent EIA-influenced flow in each subbasin. To do this, we classified reaches into “intact,” “moderately degraded,” and “degraded” peak flow functioning based on work by Booth and Jackson (1997). They found that channels had consistently “degraded” hydrologic function when the magnitude of two-year floods under current conditions was greater than or equal to the ten-year historical flood magnitude under “forested” conditions. Additionally, they found that watersheds with $\geq 10\%$ impervious area corresponded to degraded channels, while watersheds with $\leq 3\%$ impervious area corresponded to areas of high species abundance and diversity. Based on these results we defined “intact” stream reaches as having $\leq 3\%$ EIA-influenced flow, “moderately degraded” reaches as ranging from $>3\%$ to 10% EIA-influenced flow, and “degraded” reaches as having $>10\%$ EIA-influenced flow. Once reaches were classified into one of the three function categories, we calculated the total length of streams in each category for each subbasin, and mapped the percentage of the total stream length in the degraded category for each subbasin (Figure 3-5).

Peak Flow in Upland Subbasins

Beamer et al. (2000) cited two common indicators of peak flow-impaired subbasins in upland areas: forest roads and hydrologically immature vegetation. These indicators were developed from positive correlations between peak flow frequency, forest road density, and the incidence of forestry practices (Jones and Grant 1995, Beamer and Pess 1999).

In our analysis, road density was determined first by intersecting a road data layer (Lunetta et al. 1997) and a Snohomish subbasin data layer, then by summing the kilometers of road in each subbasin and dividing by subbasin area. Hydrologically immature vegetation was determined by reclassifying an existing land cover map (Purser et al. 2002) based on definitions of mature and immature vegetation in Purser et al. (2002) and Beamer et al. (2000). Subsequently, the reclassified land cover map and the subbasin map were intersected to determine the area of hydrologically immature vegetation within each subbasin.

To classify levels of peak flow functioning in each subbasin, we used a published relationship between land use/land cover and peak flow that was developed for the Stillaguamish River (Beamer et al. 2000). Peak flow-impaired subbasins, defined as having five-year historical flood magnitudes at two-year frequencies, correlated with subbasins that had $>50\%$ of their area in hydrologically immature vegetation and road densities $>2 \text{ km/km}^2$ (Beamer et al. 2000). Subbasins were classified as “degraded” where hydrologically immature vegetation and road density exceeded these criteria, “moderately degraded,” if one criterion was exceeded, and “intact” if neither criterion was exceeded.

Riparian Function

The riparian function screen evaluates the relative condition of riparian forests and the ability of those forests to contribute LWD to streams. LWD impacts stream habitat conditions by altering channel form, influencing sediment routing, and controlling particulate organic matter storage (Bilby and Bisson 1998). These impacts can affect the distribution, abundance, and carrying capacity of salmonids (Beechie and Sibley 1997, SWC 1998), forming a link between LWD recruitment and salmonid viability. In addition to LWD, litterfall, shading, and root strength are included in this screen as processes related to riparian function (Forest Ecosystem Management Team (FEMAT) 1993).

The FEMAT assembled by the Clinton administration classified riparian function based on buffer widths adjacent to Pacific Northwest streams (FEMAT 1993). FEMAT identified degrees of function for four processes related to riparian buffer width: LWD recruitment, litterfall, shading, and root strength. The Skagit Watershed Council (SWC) identified a stream reach as “intact” if the buffer width on either bank exceeded 40 m, a width capable of producing at least 80% of the potential late seral LWD recruitment (Figure 3-6, SWC 1998). Likewise, a reach was considered “moderately degraded” if the buffer width fell between 20 and 40 m, because this range was able to produce only 50–80% of the potential LWD recruitment. Lastly, a stream reach with a buffer width <20 m was classified as “degraded,” since this width was limited to producing <50% of the potential late seral LWD recruitment.

Our riparian function estimates were based, in part, on DEM-derived stream networks generated from headwaters with drainage areas of at least 0.4 km² (Figure 3-7). Estimates were also based on a Landsat-derived land cover map of the Snohomish River Basin (Lunetta et al. 1997), the accuracy of which was evaluated by Beamer et al. (2000). Results of the evaluation indicated that stream reaches classified in late seral and mid seral categories had buffer widths = 40 m 100% and 92% of the time, respectively. Reaches classified in early seral categories, on the other hand, had buffer widths = 40 m only 4% of the time (Table 3-1).

For our analysis, levels of riparian function were defined using associations between buffer width and riparian process conditions as developed by the SWC (1998). We intersected the stream network data with the land cover map and computed the land cover category crossed by each reach. Next, we intersected the combined stream network/land cover layer with a subbasin layer and summed the length of stream in each land cover category by subbasin. From these lengths, we determined the percentage of “intact,” “moderately degraded” and “degraded” reaches in each subbasin using Table 3-1.

Table 3-1. Field-based inventory of riparian condition in LANDSAT-classified land cover categories in the Skagit River Basin (Beamer et al. 2000).

Percentages indicate the percentage of the reaches within each inventoried land cover class that exhibited a particular riparian condition. Sample sizes for each land cover category indicate the number of sites inventoried.

		Land Cover Categories				
		Late Seral (n=24)	Mid-Seral (n=13)	Early-Seral (n=24)	Other Lands in Forested Areas (n=96)	Non-Forest (n=77)
Riparian Condition Based upon field inventory	Degraded	0%	8%	8%	42%	90%
	Moderately Degraded	0%	0%	4%	15%	6%
	Intact	100%	92%	88%	43%	4%

Sediment Supply

The majority of sediment supplied to stream channels in the forested mountain watersheds near Puget Sound arrives through soil creep, surface erosion, or mass wasting (Paulson 1997). Consequently, we used the sediment screen only for the upland subbasins, because we are predicting the percentage increase in sediment supply caused by mass wasting in forested mountain subbasins. The average supply from mass wasting in such watersheds is typically less than 100 m³/km²/yr (Sidle et al. 1985), although this rate may increase significantly in the wake of timber harvest and road building (Paulson 1997). Large increases in coarse sediment supply can aggrade stream channels, filling in pools, and diminishing the quantity and quality of salmonid habitat (Lisle 1982, SWC 1998). In addition, large increases in total sediment supply can augment the percentages of fine sediment in channel beds, reducing salmonid survival during egg incubation (Dietrich et al. 1989, SWC 1998)³.

We used sediment supply rates measured in the Skagit River basin to predict rates in the Snohomish River Basin (Table 3-2). These rates were based on geology and land use impacts and were calculated as the average rate in each subbasin relative to the predicted natural rate. Subbasins with an average rate <100 m³/km²/yr were classified as “intact,” as were subbasins with an average rate >100 m³/km²/yr but <1.5 times the natural rate. Subbasins with both an average rate >100 m³/km²/yr and at least 1.5 times the natural rate were classified as “degraded.”

To perform this screen we aggregated the classes from a 1:100,000-scale geologic map (Washington DNR 2001) into four categories: alluvium, surficial deposits, low-grade metamorphic rock, and high-grade metamorphic rock (Paulson 1997). We also aggregated the classes from a 1993 Landsat-based land cover map (Lunetta et al. 1997) into three categories: forested areas, other lands in forested areas, and non-forest. Unfortunately, with Landsat-based classifications, alpine and urban areas appear very similar,

³ The sediment supply analysis only focused on the potential for increased mass wasting events using geology and land cover as predictors. The sediment supply analysis did not account for how sediment from landslides enters and is routed downstream, and thus is useful primarily as a rating of the potential hazards due to coarse sediments.

and shrubland areas are often misclassified as clear cuts, or as non-vegetated areas in forested lands. To alleviate these potential sources of error, we identified all of the polygons within wilderness areas as places where the current sediment supply rates represented natural conditions.

We intersected the aggregated geologic and land cover maps with a subbasin map using GIS. Then, for each subbasin, the current sediment supply rate was calculated by multiplying the estimated rate (given the geologic and land use classes in Table 3-2) with the subbasin area. The historical sediment supply rate was calculated by multiplying the natural rate with the subbasin area. Finally, the estimated factor of increase in sediment supply was calculated as the ratio of the current and historical rates. Both the estimated factor of increase and the current rate were used to categorize subbasins as “intact” or “degraded.”

Table 3-2. Average sediment supply rates for each lithologic unit and the factor of increase in each land cover category
(from Beamer et al. 2000, p 25).

	Lithologic Group			
	Alluvium	Surficial Deposits	Low-Grade Metamorphic	High-Grade Metamorphic
Natural Sediment Supply Rate (m ³ /km ² /yr)	0 ^a	33 ^b	130 ^c	53 ^d
Land cover factor for Early seral, mid-seral, and late-seral.	1	1	1	1
Land cover factor for other lands in forest (clearcut to hardwood)	1	3 ^e	4 ^e	6 ^e
Land cover factor for water and non-forest	0	0	0	0

a Alluvial areas are predominantly floodplains. No mass wasting occurs

b Sediment supply rate for forest >20 years old in a subbasin dominated by glacial sediments (Paulson 1997)

c Sediment supply rate for forest >20 years old in three subbasins dominated by phyllite and sandstone (Paulson 1997)

d Sediment supply rate for forest >20 years old in subbasins dominated by granitic and high-grade metamorphic rocks (Paulson 1997)

e Relative increase in mass wasting rate where forests are 20 years old (Paulson 1997)

FUTURE ANALYSES

We plan to use the updated Landsat classification from Purser et al. (2003) to revise our analyses of sediment supply and riparian function. Prior to any revisions, field surveys will be necessary to ground-truth the updated classification. In addition, Gersib et al. (2003) are compiling analyses of watershed processes in the Snohomish River Basin. Their analyses characterize changes from historical temperatures, land uses, peak flows, base flows, sediment supplies, LWD conditions, and nutrient and heavy metal loads. We plan to compare our analyses with those of Gersib et al. and, where possible, to combine the results from both studies to increase understanding of landscape-forming processes.

These models capture the general condition of the processes in each subbasin, but can inaccurately categorize some subbasins because of the simple and coarse-scale nature of the statistical and GIS models used, unique geology, land cover variables not included (e.g., wetlands), or errors inherent in the data (see footnote 1). The results from these screens are used as indicators of potential problems with the functioning of landscape-forming processes. The EASC approach is built on the belief that field inventories should always be used to validate these screen results before specific actions are adopted for salmon recovery.

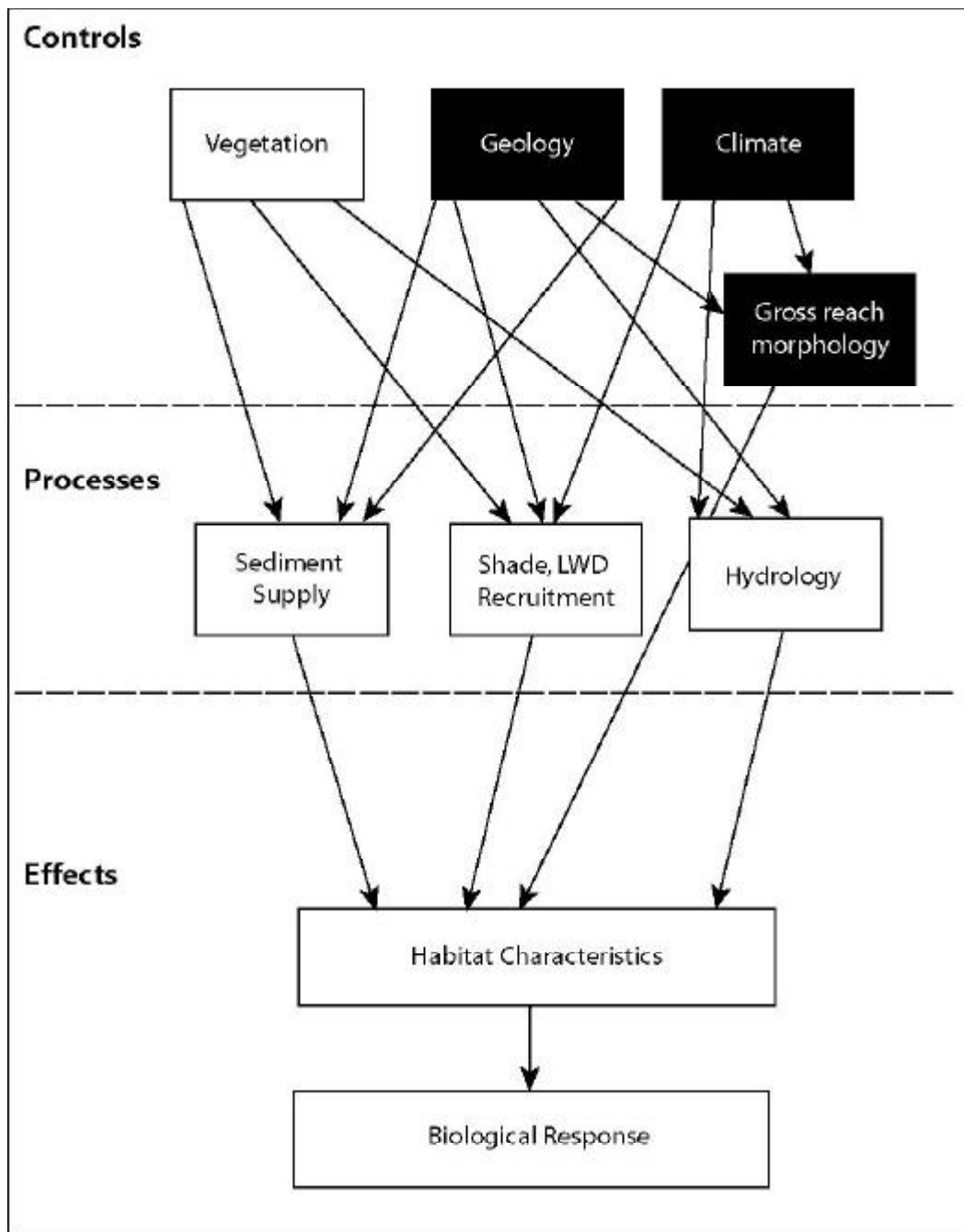


Figure 3-1. A conceptual diagram of the large-scale controls on watershed processes and their effects within a landscape.

The black boxes represent controls that land use does not affect (figure adapted from Beechie and Bolton 1999).

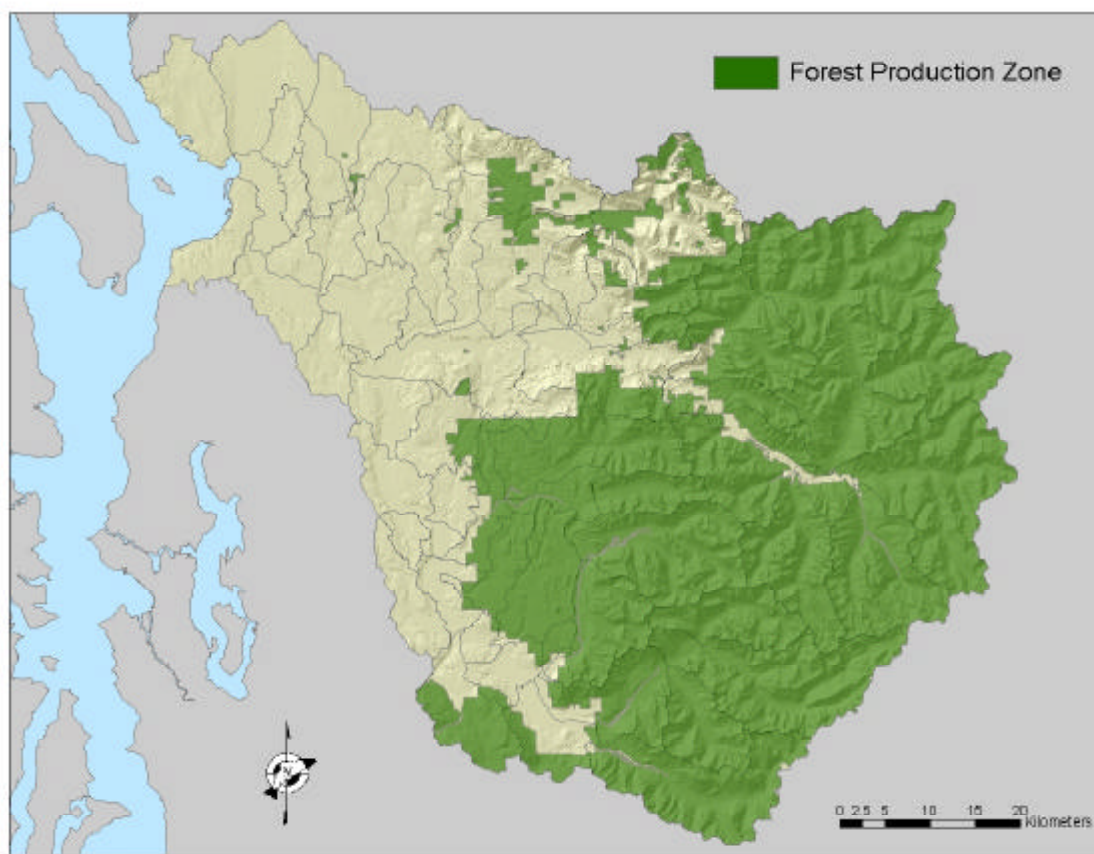


Figure 3-2. The forest production zone and subbasins within the Snohomish River Basin (source: Snohomish County).

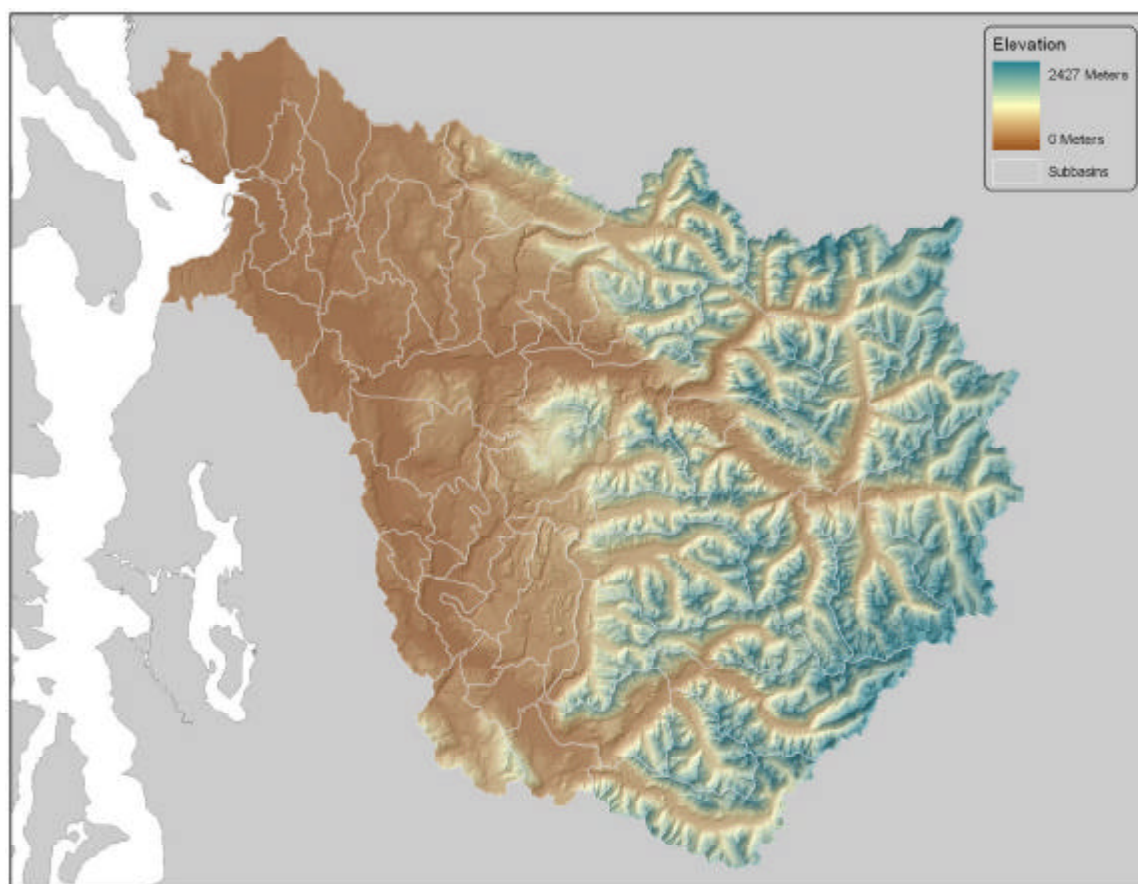


Figure 3-3. Elevation and subbasins in the Snohomish River Basin.

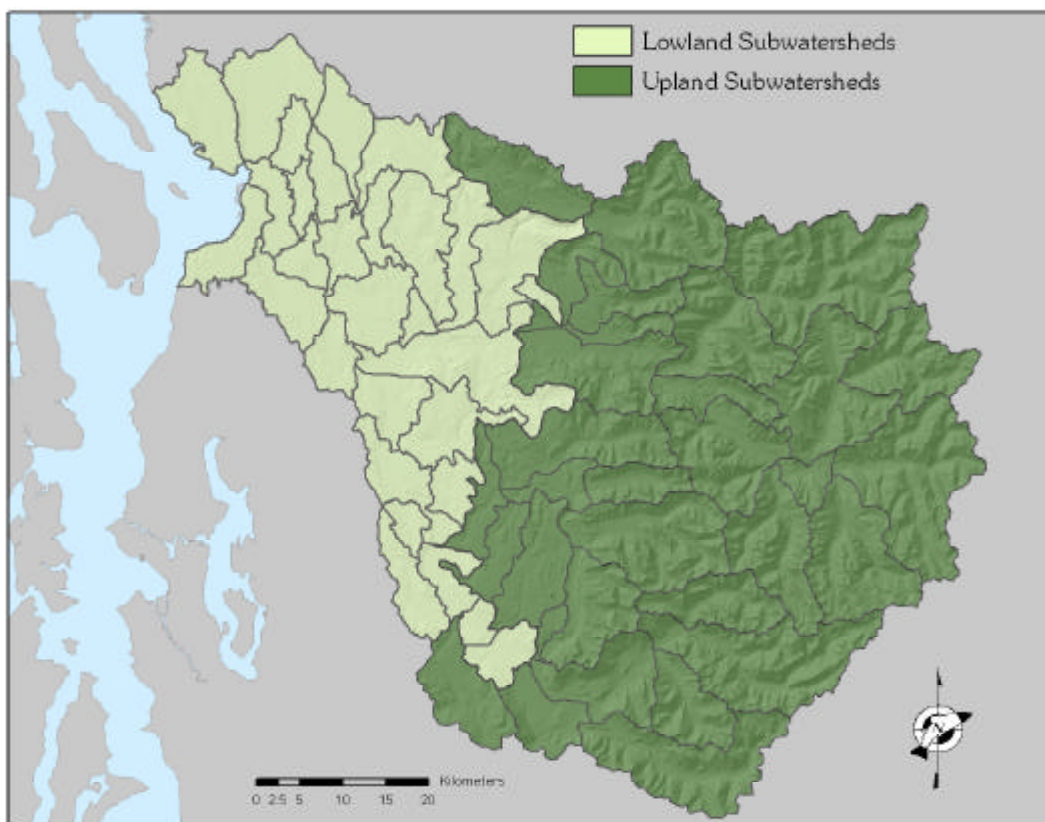


Figure 3-4. Upland and lowland subbasin distinction used for peak flow analysis in the Snohomish River Basin.

Subbasins were delineated based upon the percentage of their area in the forest production zone and average elevation.

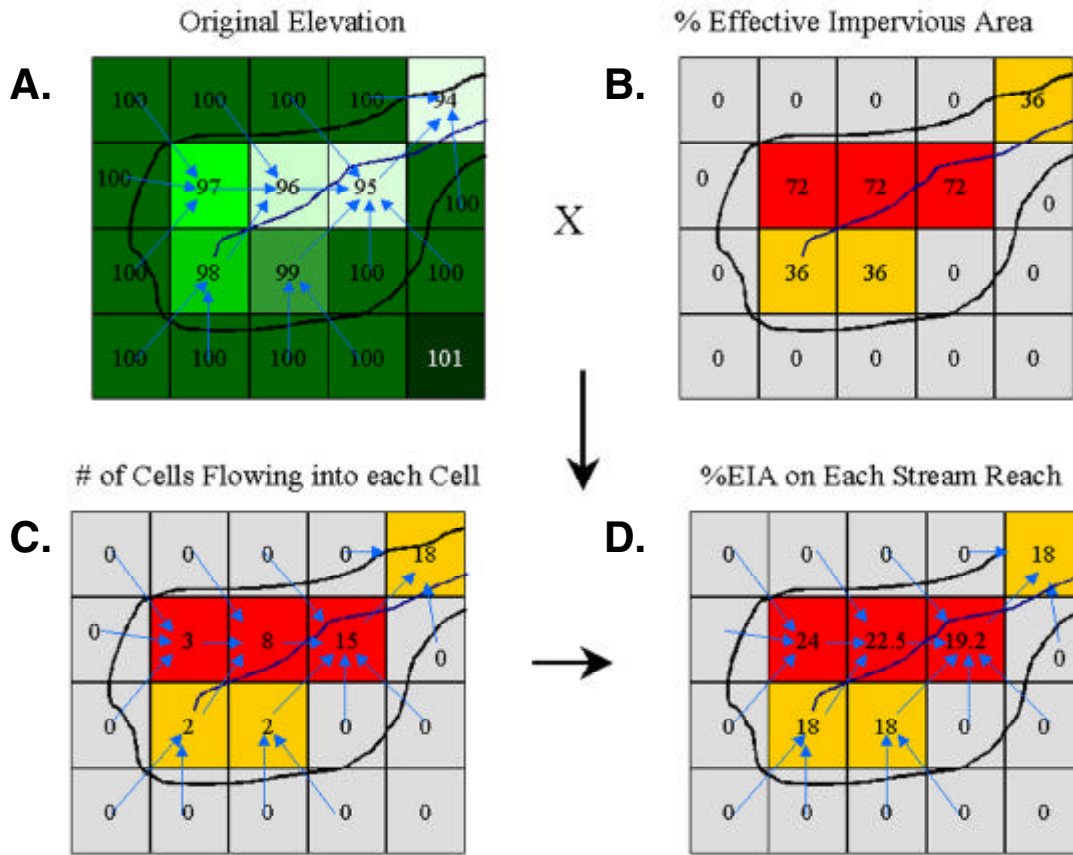


Figure 3-5. Steps in the flow analysis for calculating the Effective Impervious Area (EIA) in each stream reach.

Diagram A shows how the original elevation from the Digital Elevation Model (DEM) is used to determine the direction of flow through and into each cell. Diagram B is an example of the EIA grid that is used as a weight in the calculation of total EIA. Diagram C shows the number of cells whose flow accumulates in each cell. Diagram D shows the calculation of the percent of EIA that is affecting each stream reach.

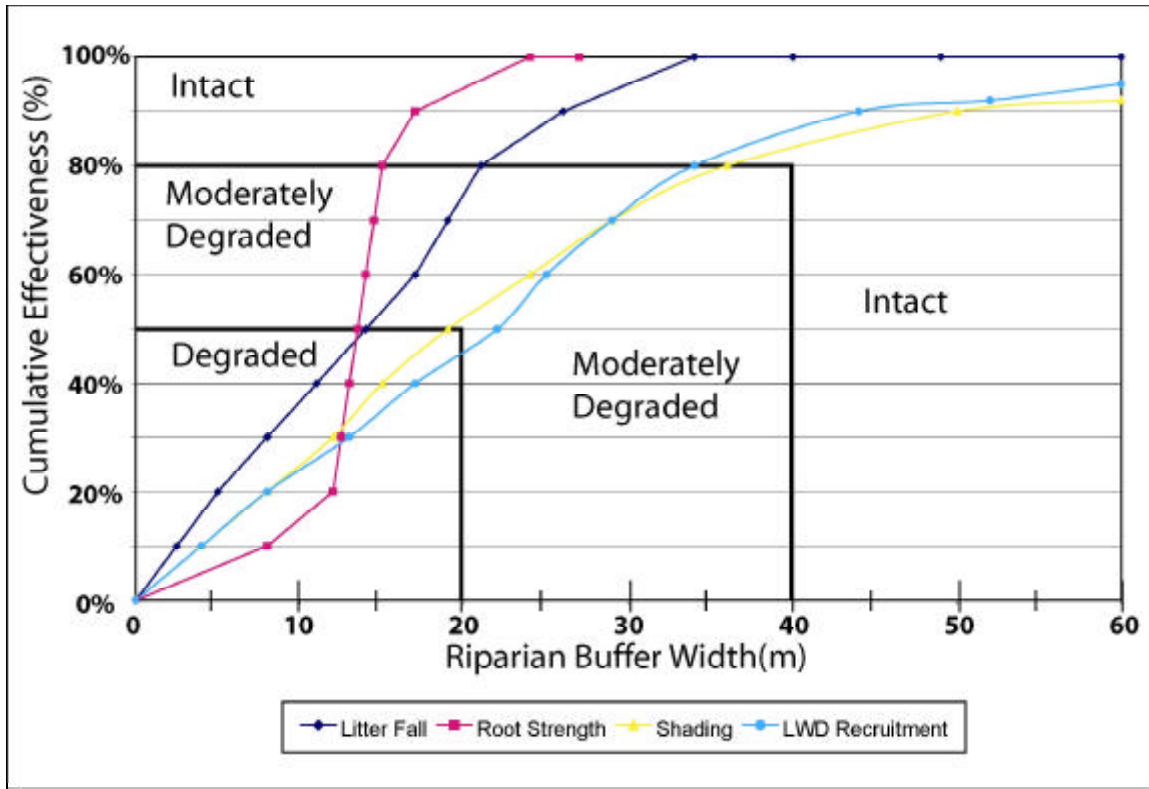


Figure 3-6. The cumulative effectiveness of riparian buffer widths in producing aquatic habitat functions in non-migrating channels (Figure from SWC 1998). Functions depicted are: litter fall, root strength, shading, and LWD recruitment. The categories in this figure were changed to match the categories in the analysis. "Intact" in this document refers to the "functioning" category in the SWC document.

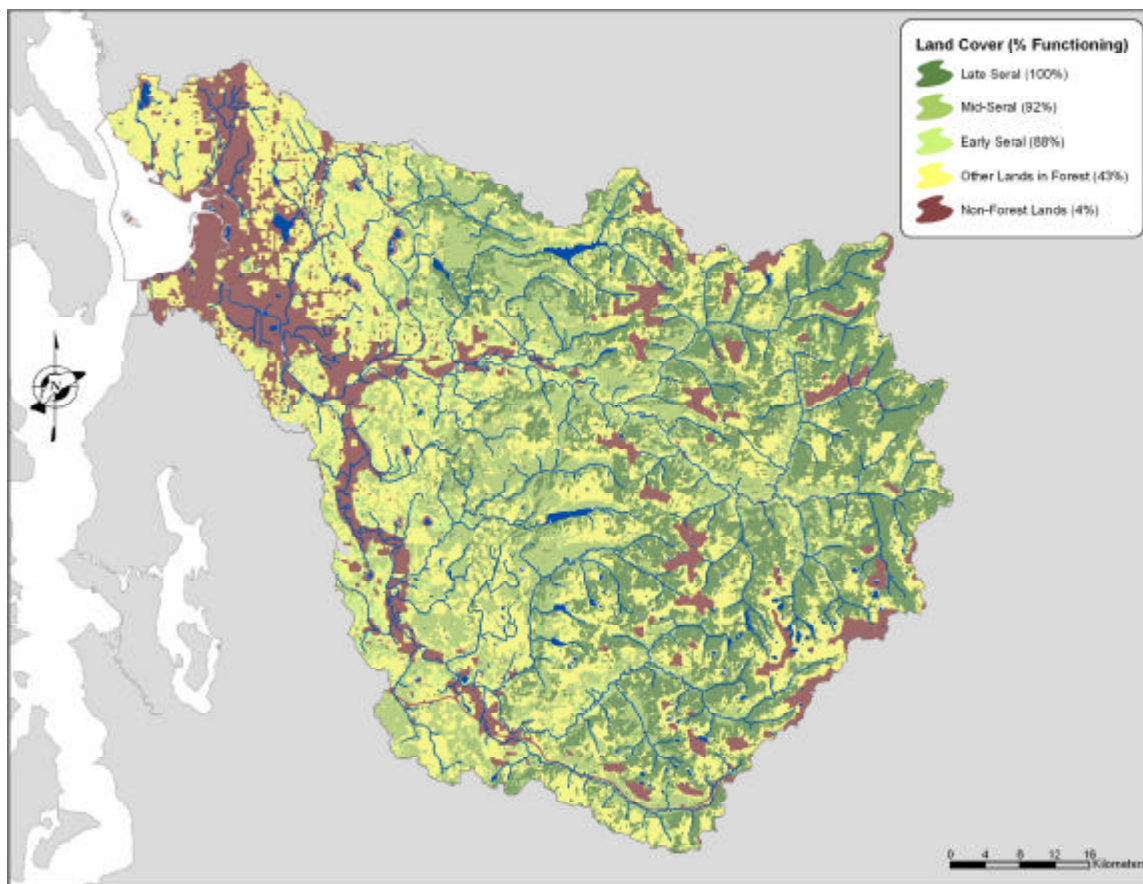


Figure 3-7. Land cover classifications and the major stream network used to estimate the percentage of stream reaches that have a functioning riparian zone in each subbasin (land cover from Lunetta et al. 1997, network of major streams generated by Sanderson et al. in press).

Step 3 Table. Watershed Process Conditions

Subbasin	Hydrology (peak flow*)					Riparian function**				Sediment supply (Increased potential for mass wasting)	Combined process score
	Upland Subbasins (>50% Hyd Imm Veg and >2km/km2 road density = "degraded", one or the other = "mod. degraded", neither = "intact")	Lowland Subbasins (>10% EIA = "degraded", 4-10% EIA = "mod degraded, <4% = "intact")			EASC Rating	All Subbasins			EASC Rating	Only applicable to upland subbasins	EASC Rating
		% Intact	% Moderately Degraded	% Degraded	"Intact" >80% reaches intact "Moderately Degraded" between 50 and 80% reaches intact "Degraded" <50% reaches intact	% Intact	% Moderately Degraded	% Degraded	"Intact" 80% intact "Moderately Degraded" between 50 and 80% intact "Degraded" <50% intact	Modeled sediment input based on geology/LULC (AVG Sediment Rate > 100 m3/km2/yr and/ or 1.5 X Natural Rate = "Degraded", < 100 m^3/km^2/yr = "Intact, >100 m^3/km^2/yr but <1.5X nat. rate = "intact")	A= All processes intact B= One or more processes not intact C = All processes degraded
Bear Creek		100	0	0	Intact	52	12	35	Moderately Degraded		B
Beckler River	Intact				Intact	84	4	13	Intact	Degraded	B
Foss River	Intact				Intact	77	4	19	Intact1	Intact	A
May Creek/Lower Wallace River	Mod. Degraded(Roads)				Moderately Degraded	52	7	41	Moderately Degraded	Intact	B
Miller River	Intact				Intact	80	4	16	Intact	Intact	A
Olney Creek	Intact				Intact	81	4	15	Intact	Intact	A
Rapid River	Intact				Intact	85	2	13	Intact	Intact	A
Skykomish River - Lower Mainstem		87	11	2	Intact	50	8	42	Moderately Degraded		B
Skykomish River - Upper Mainstem	Intact				Intact	72	6	22	Moderately Degraded	Degraded	B
Skykomish River - Lower North Fork	Intact				Intact	71	5	25	Moderately Degraded	Degraded	B
Skykomish River - Upper North Fork	Intact				Intact	82	4	14	Intact	Intact	A
Skykomish River - Lower South Fork	Intact				Intact	77	5	17	Moderately Degraded	Degraded	B
Skykomish River - South Fork	Intact				Intact	72	5	22	Moderately Degraded	Degraded	B
Skykomish River - Upper South Fork	Mod. Degraded(Roads)				Moderately Degraded	72	5	22	Moderately Degraded	Intact	B
Sultan River - Lower		98	1	1	Intact	79	4	17	Moderately Degraded		B
Sultan River - Upper	Intact				Intact	72	6	23	Moderately Degraded	Degraded	B
Tye River	Intact				Intact	87	3	10	Intact	Degraded	B
Wallace River - Upper	Intact				Intact	82	3	15	Intact	Degraded	B
Woods Creek		97	3	0	Intact	66	7	27	Moderately Degraded		B
Woods Creek - Lower		98	1	1	Intact	24	7	69	Degraded		B
Woods Creek - West Fork		100	0	0	Intact	54	10	35	Moderately Degraded		B
Ames Creek		94	6	0	Intact	38	6	56	Degraded		B
Cherry Creek		94	4	2	Intact	64	7	29	Moderately Degraded		B
Coal Creek - Lower		53	25	22	Moderately Degraded	56	6	38	Moderately Degraded		B
Coal Creek - Upper		55	30	15	Moderately Degraded	43	10	47	Degraded		B
Griffin Creek	Degraded				Degraded	72	6	23	Moderately Degraded	Intact	B
Harris Creek		93	7	0	Intact	59	7	34	Moderately Degraded		B
Patterson Creek		73	24	3	Moderately Degraded	53	8	39	Moderately Degraded		B
Pratt River	Intact				Intact	91	1	7	Intact	Intact	A
Raging River	Degraded				Degraded	68	6	26	Moderately Degraded	Intact	B
Snoqualmie River - Mouth		94	6	1	Intact	37	8	55	Degraded		B
Snoqualmie River - Mid-Mainstem		78	15	7	Moderately Degraded	29	7	65	Degraded		B
Snoqualmie River - Upper Mainstem		96	3	1	Intact	31	8	61	Degraded		B
Snoqualmie River - Lower South Fork	Degraded				Degraded	46	8	47	Degraded	Intact	B
Snoqualmie River - Upper South Fork	Mod. Degraded(Roads)				Moderately Degraded	65	7	29	Moderately Degraded	Degraded	B
Snoqualmie River -Lower Middle Fork	Mod. Degraded(Roads)				Moderately Degraded	68	7	24	Moderately Degraded	Degraded	B
Snoqualmie River - Upper Middle Fork	Intact				Intact	80	4	16	Intact	Intact	A
Snoqualmie River - Lower North Fork	Mod. Degraded(Roads)				Moderately Degraded	82	3	15	Intact	Intact	B
Snoqualmie River - Upper North Fork	Intact				Intact	85	3	12	Intact	Intact	A
Tate Creek	Degraded				Degraded	52	12	36	Moderately Degraded	Intact	B
Taylor River	Intact				Intact	82	4	14	Intact	Intact	A
Tokul Creek	Degraded				Degraded	65	9	26	Moderately Degraded	Intact	B
Tolt River - Lower	Degraded				Degraded	66	8	27	Moderately Degraded	Intact	B
Tolt River - North Fork	Mod. Degraded(Roads)				Moderately Degraded	80	4	15	Intact	Degraded	B
Tolt River - South Fork above Dam	Mod. Degraded(Roads)				Moderately Degraded	75	6	20	Moderately Degraded	Degraded	B
Tolt River - South Fork Below Dam	Degraded				Degraded	74	6	20	Moderately Degraded	Intact	B
Upper Snohomish/Cathcart		21	73	6	Degraded	38	10	52	Degraded		C

Step 3 Table. Watershed Process Conditions

Subbasin	Hydrology (peak flow*)					Riparian function**				Sediment supply (Increased potential for mass wasting)	Combined process score
	Upland Subbasins (>50% Hyd Imm Veg and >2km/km2 road density = "degraded", one or the other = "mod. degraded", neither = "intact")	Lowland Subbasins (>10% EIA = "degraded", 4-10% EIA = "mod degraded, <4% = "intact")			EASC Rating	All Subbasins			EASC Rating	Only applicable to upland subbasins	EASC Rating
		% Intact	% Moderately Degraded	% Degraded	"Intact" >80% reaches intact "Moderately Degraded" between 50 and 80% reaches intact "Degraded" <50% reaches intact	% Intact	% Moderately Degraded	% Degraded	"Intact" 80% intact "Moderately Degraded" between 50 and 80% intact "Degraded" <50% intact	Modeled sediment input based on geology/LULC (AVG Sediment Rate > 100 m3/km2/yr and/ or 1.5 X Natural Rate = "Degraded", < 100 m^3/km^2/yr = "Intact, >100 m^3/km^2/yr but <1.5X nat. rate = "intact")	A= All processes intact B= One or more processes not intact C = All processes degraded
Dubuque Creek		99	1	0	Intact	42	11	46	Degraded		B
Everett Coastal Drainages		0	0	100	Degraded	15	8	77	Degraded		C
Fobes Hill		29	37	34	Degraded	12	8	80	Degraded		C
French Creek		56	23	21	Moderately Degraded	26	8	66	Degraded		B
Lake Stevens Drainages		37	35	28	Degraded	31	11	58	Degraded		C
Little Pilchuck Creek		88	12	0	Intact	41	12	47	Degraded		B
Lower Snohomish/Marshland		5	43	53	Degraded	23	7	70	Degraded		C
Pilchuck River - Lower		27	62	11	Degraded	27	10	64	Degraded		C
Pilchuck River - Middle		93	6	1	Intact	48	11	41	Degraded		B
Pilchuck River - Upper	Intact				Intact	85	3	12	Intact	Degraded	B
Quilceda Creek		42	24	34	Degraded	20	9	71	Degraded		C
Allen Creek		26	13	61	Degraded	11	7	82	Degraded		C
Sunnyside Drainages		6	47	47	Degraded	27	11	62	Degraded		C
Tulalip and Battle Creeks		70	29	1	Moderately Degraded	39	13	49	Degraded		B
											B

*Peak flow is defined as intact for stream reaches with greater than 10% Effective Impervious Area in the lowland subbasins and with a road density of less than 2km² of roads/km and less than 50% immature vegetation for upland subbasins.

**Intact denotes areas with a predicted buffer width of at least 40 meters.

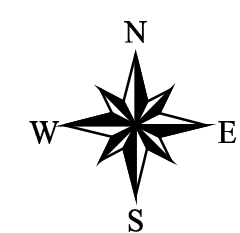
¹ called as intact even though it is 3% below the threshold because 77% of the subbasin is in the Alpine Lakes Wilderness

Intact (>80% of reaches intact)

Moderately Degraded (between 50% and 80% of reaches intact)

Degraded (<50% of reaches intact)

Rivers



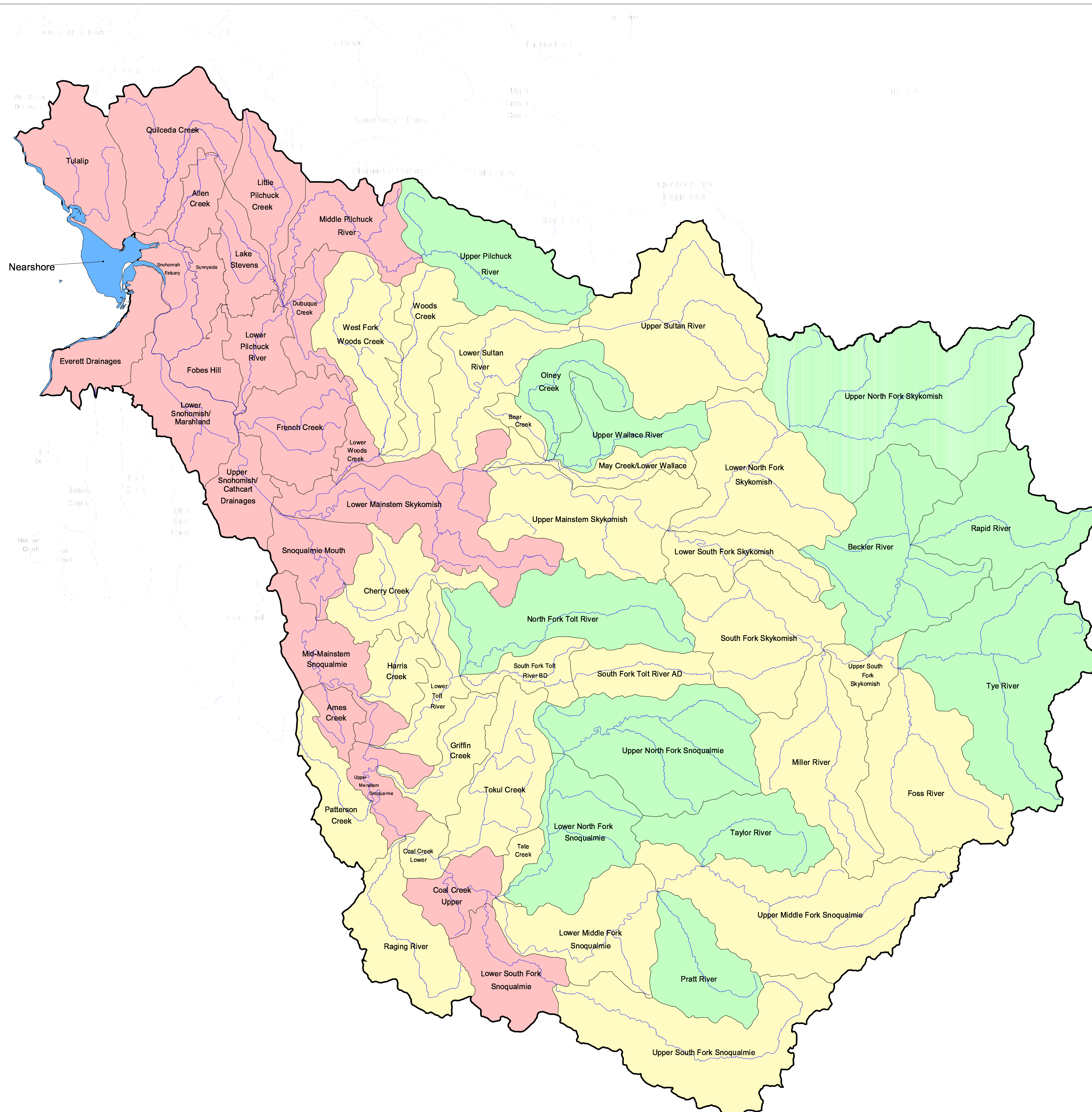
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 Intact (>80% intact)
 Moderately Degraded (between 50 and 80% intact)
 Degraded (<50% intact)
 Rivers



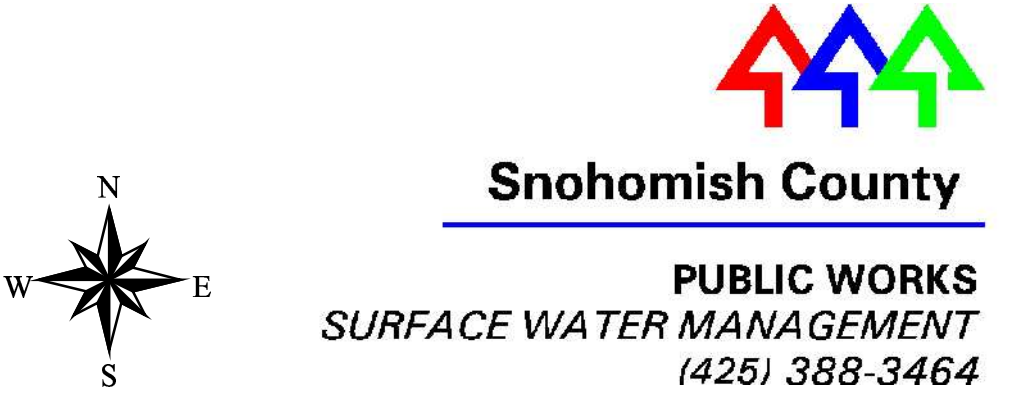
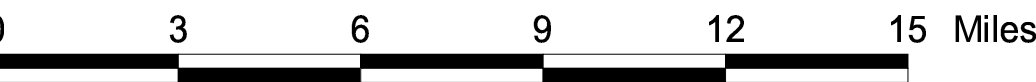
Project name: i:\pw\swm\spwsxb\andy haas\EASC.apr Plot date: October 30, 2003; ripproc smb



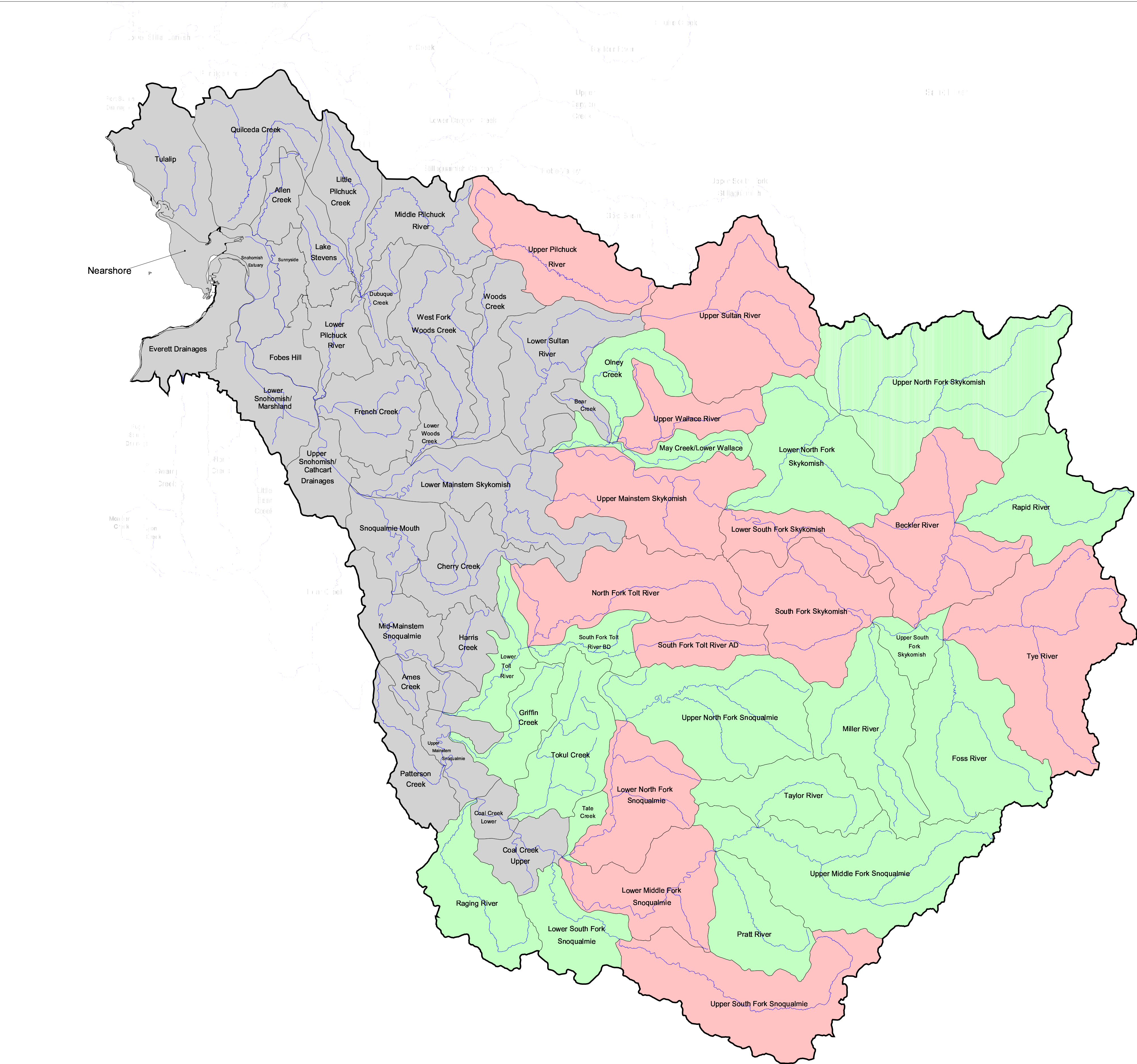
Step 3 - Map 3 Sediment Processes

Sediment Processes

- Intact (< 100 m³/km²/yr
or > 100m³ /km² /yr if <1.5
times the modeled natural
rate of sediment production)
- Degraded (> 100m³/km²/yr
and/or >1.5 times the
modeled natural rate of
sediment production)
- Model not applied in
Puget Lowland subbasins
- Rivers



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STEP 4. CHANGE BETWEEN HISTORICAL AND CURRENT POTENTIAL TO SUPPORT CHINOOK SALMON

INTRODUCTION

Step 4 examines the difference between the current and historical potential of the habitat to support chinook salmon. Two tools are used in this modeling exercise: the EDT model (Mobrand Biometrics 2000a) and the Potential Capacity model developed by NOAA Fisheries (Sanderson et al. in press). The Step 4-1 Table summarizes the first part of a two-phased process to link restoration and preservation actions to population performance. This is the diagnosis step of EDT. It sets the context for where restoration could occur and what is possible, and provides guidance on the types and locations of actions to include in the strategy. The second component is the evaluation of suites of actions in terms of population viability criteria. This process occurs in Step 8 of the EASC.

EDT MODEL

Description

EDT is a system for rating the quality, quantity, and diversity of habitat along a stream, relative to the needs of a focal species such as chinook salmon. The methodology includes a conceptual framework for decision-making and a set of modeling tools that organize environmental information and rate the habitat elements in regard to the focal species. In other words, it describes how the fish would rate conditions in a stream based on our scientific understanding of their needs. EDT has been used extensively in the Pacific Northwest for a number of years in a variety of settings.

The value of EDT is that it can estimate the potential for a stream under a set of conditions such as those that occur now, those that prevailed in the past, or those that might occur in the future. The result is a scientifically based assessment of conditions and a prioritization of restoration and protection needs.

Because each segment or reach of a stream is rated individually, we can systematically examine conditions along a stream from the perspective of the fish. In particular, EDT can identify the “restoration value” and the “protection value” of each reach. This may be useful in setting priorities so that recovery and protection actions will occur in times and places where the potential for benefit is highest.

Methods

The basic concepts and methods of EDT are described by Mobrand et al. (1997). Computational formulas and detailed explanations of the workings of the EDT model are in a report that is available from Mobrand Biometrics, Inc. (2000a).

The EDT model simulates the steady state spawner-recruit relationship for a salmon population by projecting the performance of numerous life history trajectories using a life history model that employs a series of spawner-recruit curves. Muslim and Hilborn (1986) showed that if survival in each life stage is either density-independent or follows a Beverton-Holt spawner-recruit relationship, then the full life cycle will follow a Beverton-Holt spawner-recruit relationship (see, for example, Ricker 1975) with cumulative

productivity and capacity parameters that can be derived from the productivity and capacity parameters for the individual life stages. The EDT model calculates productivity (the density-independent reproductive rate) by multiplying productivity of the successive stages throughout the life history trajectory. Cumulative capacity is a function of the stage-specific productivities and capacities:

$$C_N = \frac{P_N}{\sum_{i=1}^N \frac{P_i}{c_i}}$$

where c_i is the habitat capacity for stage i , P_n is the cumulative productivity of n successive stages, and P_i is the cumulative productivity of i successive stages.

Population performance in EDT is usually expressed in terms of three of the attributes used by NMFS to describe a viable salmonid population (McElhany et al. 2000): abundance, productivity, and diversity. Abundance is expressed in term of capacity, which is the maximum or asymptotic value of the Beverton-Holt spawner-recruit curve; productivity is recruits per spawner at low density, which is the slope of the curve as the escapement approaches zero; and diversity is the percent of life history trajectories in the population that are viable. Population capacity is simply the average of the cumulative capacities of all the trajectories (including trajectories with a productivity of less than one) multiplied by the length of spawning habitat, in meters, for the population.

In EDT, each life history trajectory takes the fish through a pathway described in both space and time. The spatial scale is the reach; all reaches within the Snohomish system are listed in the left hand column of the Step 4-1 Table. The temporal scale for the Snohomish EDT analysis was monthly.

A viable life history trajectory is one for which the productivity of the trajectory is greater than the replacement level (i.e., exceeds one recruit per spawner). Productivity of the population is calculated by combining all of the viable life history trajectories for a population to produce a single population productivity:

$$P = \frac{\sum_t P_t W_t}{\sum_t W_t}$$

where P_t is the trajectory productivity and W_t is a measure of frequency of use for trajectory t . We assume that, in the long term, the frequency of use of the different trajectory pathways would be related to both quality and quantity of habitat available. The equilibrium population size, which can be calculated for each trajectory, is a function of both. The model therefore assumes that the weights (W_t) are proportional to the equilibrium population size (Equation 5) of each trajectory.

The Step 4-1 Table was developed from the diagnosis step of an EDT analysis. In this step, population performance is first assessed from a reconstruction of historic conditions in the basin (this is also sometimes referred to as the “template” condition). Historic conditions are simulated by reconstructing life-stage survivals by relating them to habitat conditions as they are presumed to have existed before European colonization of the area (typically prior to 1850). The habitat-survival relationships follow a set of rules, which are partially documented in a handout available from Mobrand Biometrics, Inc. (2000b). The descriptions of habitat and environmental attributes for the Snohomish system under historic conditions were developed in a series of workshops with fisheries biologists and others with local knowledge of the system. The rules relating environmental attributes to life stage survival were based on

the following (in decreasing order of priority): local studies, studies in other areas, generalized literature values, best professional judgment, and assumed or hypothetical values. Rules used to develop survival conclusions were developed as part of a larger EDT modeling effort for chinook salmon. The same rules are used in all basins in which the EDT model has been applied.

In addition to the template characterization of the environment, input values for the current condition were developed in the same workshops. The difference in population performance between the template and current condition represents the loss in performance due to degradation of the environment. To complete the diagnosis step, the model is used to evaluate the effect on population performance that occurs when a particular reach, or group of reaches (referred to as a geographic area), was fully restored to historical conditions (restoration analysis) or hypothetically degraded such that the reach can no longer support salmon except for short periods (preservation analysis). By restoring or degrading one reach, or geographic area, at a time, the potential gain to the entire population from improving that one area can be assessed or alternatively, the loss in population performance if that reach, or geographic area were unable to support chinook can be assessed. The degree of potential improvement or loss is expressed in the Step 4-1 Table as a percent gain (or loss) for each of the VSP parameters measured: abundance, productivity, and diversity, as described above. Thus, for example, a 25% increase in abundance after restoring a reach means that the entire population increased by 25% of the current condition if that reach or geographic area alone were restored from current to historic habitat conditions while the rest of the reaches remained in current conditions. The restoration diagnosis is used to provide guidance to planners on where to focus habitat restoration activities; the preservation analysis should be used to provide guidance for developing protection strategies. Areas may rank high in both analyses. In other words, an area may be a strong candidate for protection (partial function and high use) and a strong candidate for restoration (high potential and high use).

ADULT SPAWNING POTENTIAL CAPACITY MODEL

Description

We conducted analyses to estimate potential capacity for adult chinook spawners in the Snohomish River Basin as part of Step 4 of the EASC. *Potential capacity* represents a rough estimate of the maximum number of adult spawners that a certain area could support, given estimates of habitat quality and quantity and fish densities associated with specific habitat areas. Conceptually, these estimates represent upper bounds on *realized capacity* (i.e., the number of adults that a given habitat actually does support), which is affected by survival throughout the salmon life cycle. Because our estimates of adult density in different habitat types may not be reflective of historical densities, the potential capacities we estimate may be lower than those maxima that existed historically.

In this section, we describe the methods we have used to estimate current and historical potential capacity of adult chinook salmon in the Snohomish River Basin. Estimating current and historical potential adult capacity involved two steps. First, for each subbasin we estimated the amount of habitat in different predicted stream types and gradient classes, under current and historical conditions. Second, we applied fish densities derived from empirical studies reported in the literature to those habitat quantities using a series of equations and assumptions. The specific equations and methods are described in Appendix 7.1.2.

METHODS

Our analyses are based on:

1. relatively low resolution GIS data (DEM and land cover),
2. predicted stream type based on estimated channel gradient and adjacent land use,
3. stream width predicted by a regression model, and
4. average spawner densities within reaches of given size and type.

Because predicted stream type, stream size, and average spawner densities are based on data from a large number of sites, they can relatively accurately estimate total spawning population sizes over large river basins (e.g., total stream length on the order of 10^2 km or more). For the same reasons, these models are inaccurate at small scales (e.g., reaches on the order of 1 km or less). That is, very few reaches will actually have “average” habitat characteristics or spawner densities. Therefore, GIS-based predictions of spawner densities within reaches are unlikely to be accurate because the model will always predict the average. However, as the prediction area increases, predicted spawner abundance will better approximate actual spawner abundance because actual abundances summed across a large number of reaches will approach the average. Our purpose in this analysis is not to predict reach-level abundance, but to estimate changes in spawner abundance at the scale of populations (areas of approximately 1,000 km²).

The Spawning Habitat Index Model

To assess the potential of individual stream segments to support chinook spawning, we developed a simple model based on preceding studies that show: (1) chinook spawner density is related to channel type (Montgomery and Buffington 1997, Montgomery et al. 1999); and (2) channel type can be predicted from coarse-resolution GIS data (Lunetta et al. 1997). The model first classifies each reach by channel type based on stream gradient and riparian condition (Table 4-1). Channels <1% slope are pool-riffle channels when wood abundance is low, or forced pool-riffle channels when wood abundance is high. Channels of 1-4% slope are plane-bed channels when wood abundance is low, or forced pool-riffle channels when wood abundance is high. Channels >4% slope are step-pool and cascade channels regardless of wood abundance. Because we do not know wood abundance for any reach, we predict channel type based on channel slope and riparian condition (which is correlated with wood abundance) as in Lunetta et al. (1997).

Once channel type is predicted, the model assigns a spawning habitat suitability index (SHSI) based on channel type and bankfull width (w_{bf}). Montgomery et al. (1999) show that median spawner densities are high in pool-riffle and forced pool-riffle channels and very low in plane-bed and step-pool channels (Table 4-2). Therefore, we begin by assigning an SHSI of zero to all step-pool channels (>4% slope) (Table 4-3). SHSI ratings in channels with slope less than 4% are also based on Table 4-2, but with modifications based on channel width. Spawner surveys in Puget Sound indicate that chinook salmon are usually not found in streams <5m w_{bf} , so we next assign an SHSI of zero to all channels <5m wide⁴. In channels 10-25 m wide (where the empirical data are most applicable), SHSI is high in pool-riffle and forced pool-riffle channels and low in plane-bed channels. In channels 5-10 m wide, we reduced high SHSI ratings to moderate in channels with slope <1% and to low in channels with slope between 1 and 4% (based on unpublished spawner data indicating that chinook salmon rarely spawn in streams of that

⁴ The 5-m channel-width cut-off we used may leave out some smaller streams containing chinook spawners. Chinook have been observed spawning in Quilceda Creek, Patterson Creek, Griffin Creek, and Cherry Creek, all of which may be at or below the 5m threshold (K. Nelson, Tulalip Tribes, pers. comm.).

size in Puget Sound). In the largest channels (>25 m wide) we assigned an SHSI of high to channels with slope <1% (chinook tend to spawn in this channel type and size in large numbers unless the substrate is sand or silt) and moderate in channels with slope between 1 and 4% (bed material often too large for chinook spawning).

Table 4-1. Matrix of predicted channel types based on channel slope and riparian forest class (Lunetta et al. 1997).

	Channel slope		
	<1%	1-4%	>4%
Low wood abundance (early, middle, and late seral forest)	Pool-riffle	Plane-bed	Step-pool
High wood abundance (other forest and non-forest)	Forced pool-riffle	Forced pool-riffle	Step-pool

Table 4-2. Redd frequency associated with channel types (based on Montgomery et al. 1999).

	Redds/km		
	10 th percentile	Median	90 th percentile
Pool-riffle	8	26	81
Forced pool-riffle	7	25	59
Plane-bed	0	0	10
Step-pool	0	0	14

Table 4-3. Spawning habitat suitability index (SHSI) ratings. Zeros represent no spawning potential. Text in *italics* indicates primary basis for SHSI rating.

	Gradient		
	<1%	1-4%	>4%
≥25 m	High <i>High pool frequency</i>	Moderate <i>Forced pool-riffle is moderate (bed material too large)</i>	0
10 -24.99 m	High <i>High pool frequency</i>	High-low <i>Forced pool-riffle is high, plane bed is low</i>	0
5 - 9.99 m	Moderate <i>Channel too small</i>	Low <i>Channel too small</i>	0

Accessibility

Barrier datasets were used to determine the accessibility of stream reaches for historically and currently spawning chinook salmon. Currently accessible stream reaches were determined below blocking dams and culverts, and below natural barriers (falls and cascades). Conversely, historically accessible stream reaches were below natural barriers and above blocking dams and culverts.

Results

Mean spawner densities observed in different habitat types have relatively high variance around the mean. For each channel type, the range of spawner abundance estimates can be described by the 10th and 90th percentiles of the distribution (Table 4-4). The results from this analysis are presented in the Step 4-2 Table (Change in Potential Capacity). The data represented are the result of using the median data values for variables from the distributions (i.e., of number of spawners per redd and redds/km). The data presented include: (1) current potential capacity of spawners; (2) historical potential capacity of spawners; (3) percent change of the abundance of spawners (percent decrease in capacity comparing current relative to historical capacity); and (4) percent increase in potential capacity in the Snohomish Basin with a return to historical potential capacity in each individual subbasin. By comparing values in this last category (#4), we can identify subbasins where restoring historical capacity will result in the greatest increases in total Snohomish Basin capacity.

Table 4-4. Estimates of the median, 10th, and 90th percentile densities of chinook redds in different channel types (adapted from Montgomery et al. 1999).

	Abundance estimate (redds/km)		
	10 th	Median	90 th
Pool riffle	8	26	81
Forced pool riffle	7	25	59
Plane-bed	0	0	10
Step pool	0	0	14

CAVEATS

Each component in the analysis introduces some error in the estimates of potential spawner capacity:

1. Relatively low-resolution GIS data mean that stream locations and lengths can have substantial errors. In general these data will tend to under-predict length of spawnable stream due to lack of detail in hydrography (i.e., streams typically meander more than maps show, and many side channels may be missing).
2. The stream network was generated from a DEM because stream widths and gradients were derived from attributes associated with DEMs. However, DEMs might not represent the true location of streams and do not account for multiple channels.

3. Predicted stream type has errors that have been quantified in Lunetta et al. (1997). Specifically, the slope prediction model has a commission error rate of 24% and an omission error rate of 4%. That is, 96% of reaches that are identified as having a slope of <0.04 actually do have a slope of <0.04 , but 24% of reaches with an actual slope of <0.04 are not captured by the model. Additional error is induced when predicting channel type based on riparian condition as described in Lunetta et al. (1997).
4. Stream size predictions have errors associated with them, due to the variable nature of the data and the underlying variability in the relationship itself.

Step 4-1 Table. EDT Diagnosis Results May 2002: Difference Between Historical and Current Potential for Chinook Use

Subbasin	EDT Reach	Change in Potential (gain with restoration)						Change in Potential (loss with degradation)					
		Snoqualmie			Skykomish			Snoqualmie			Skykomish		
		Δ Abundance	Δ Productivity	Δ Diversity	Δ Abundance	Δ Productivity	Δ Diversity	Δ Abundance	Δ Productivity	Δ Diversity	Δ Abundance	Δ Productivity	Δ Diversity
Bear Creek													
Beckler River													
	Beckler_1				1.7%(11)	11.6%(6)	0%(22)				2.2%(12)	4.3%(12)	8.1%(4)
	Beckler_2				1.7%(11)	11.6%(6)	0%(22)				2.2%(12)	4.3%(12)	8.1%(4)
Foss River													
	Foss_1				0.3%(23)	1.4%(22)	0%(22)				0.8%(17)	2.9%(14)	4.3%(14)
	WFFoss_1				0.3%(23)	1.4%(22)	0%(22)				0.8%(17)	2.9%(14)	4.3%(14)
May Creek/Lower Wallace River													
	Wallace_1												
Miller River													
	Miller_1				0.1%(25)	2.7%(21)	0%(22)				0.8%(18)	5.8%(10)	2.5%(18)
Olney Creek													
Rapid River													
	Rapid_1				0.1%(26)	0.8%(25)	0.2%(16)				0.3%(23)	0.4%(20)	1.9%(22)
Skykomish River - Lower Mainstem													
	Elwell_1				0.3%(22)	1.2%(23)	0%(22)				0.6%(21)	1.0%(16)	2.1%(21)
	Skykomish_1				23.8%(2)	71%(1)	1.2%(13)				29.4%(2)	24.8%(1)	13.5%(1)
	Skykomish_2				23.8%(2)	71%(1)	1.2%(13)				29.4%(2)	24.8%(1)	13.5%(1)
	Skykomish_3				23.8%(2)	71%(1)	1.2%(13)				29.4%(2)	24.8%(1)	13.5%(1)
	Skykomish_4				7.1%(7)	45.8%(2)	0.9%(14)				18.3%(4)	24.2%(2)	11.4%(3)
	Skykomish_5				7.1%(7)	45.8%(2)	0.9%(14)				18.3%(4)	24.2%(2)	11.4%(3)
Skykomish River - Upper Mainstem													
	Skykomish_6				7.1%(7)	45.8%(2)	0.9%(14)				18.3%(4)	24.2%(2)	11.4%(3)
	Skykomish_7				7.1%(7)	45.8%(2)	0.9%(14)				18.3%(4)	24.2%(2)	11.4%(3)
Skykomish River - Lower North Fork													
	NFSkykomish_1				1.5%(14)	10.8%(9)	0%(22)				3.9%(7)	10.4%(7)	5.8%911)
Skykomish River - Upper North Fork													
	Bear Cr falls				0.8%(20)	7.2%(12)	0%(22)				3.0%(8)	10.6%(6)	6.8%(9)
	NFSkykomish_2A				0.8%(20)	7.2%(12)	0%(22)				3.0%(8)	10.6%(6)	6.8%(9)
	NFSkykomish_2B				0.8%(20)	7.2%(12)	0%(22)				3.0%(8)	10.6%(6)	6.8%(9)
Skykomish River - Lower South Fork													
	BridalVeil_1				1.3%(15)	3.3%(16)	0.8%(15)				5.3%(6)	3.3%(13)	5.3%(12)
	Sunset Falls				1.3%(15)	3.3%(16)	0.8%(15)				5.3%(6)	3.3%(13)	5.3%(12)
	SFSkykomish_1				1.3%(15)	3.3%(16)	0.8%(15)				5.3%(6)	3.3%(13)	5.3%(12)
	SFSkykomish_2				1.3%(15)	3.3%(16)	0.8%(15)				5.3%(6)	3.3%(13)	5.3%(12)
Skykomish River - South Fork													
	SFSkykomish_3				1.6%(13)	17.2%(3)	0.1%(18)				7.5%(5)	15.1%(4)	6.9%(8)
Skykomish River - Upper South Fork													
	SFSkykomish_4				1.2%(17)	11.2%(7)	0%(19)				2.8%(10)	6.0%(9)	3.9%(15)
	SFSkykomish_5				1.2%(17)	11.2%(7)	0%(19)				2.8%(10)	6.0%(9)	3.9%(15)
Sultan River - Lower													
	Sultan_1				5.4%(8)	12.0%(5)	4.1%(8)				2.9%(9)	11.8%(%)	6.4%(10)
	Sultan_2				5.4%(8)	12.0%(5)	4.1%(8)				2.9%(9)	11.8%(%)	6.4%(10)
Sultan River - Upper													
	Sultan Diversion Dam				5.4%(8)	12.0%(5)	4.1%(8)				2.9%(9)	11.8%(%)	6.4%(10)
	Sultan_3				5.4%(8)	12.0%(5)	4.1%(8)				2.9%(9)	11.8%(%)	6.4%(10)
Tye River													
	Tye_1				0.4%(21)	3.9%(15)	0%(19)				0.6%(20)	1.0%(16)	2.9%(17)

Step 4-1 Table. EDT Diagnosis Results May 2002: Difference Between Historical and Current Potential for Chinook Use

Subbasin	EDT Reach	Change in Potential (gain with restoration)						Change in Potential (loss with degradation)					
		Snoqualmie			Skykomish			Snoqualmie			Skykomish		
		Δ Abundance	Δ Productivity	Δ Diversity	Δ Abundance	Δ Productivity	Δ Diversity	Δ Abundance	Δ Productivity	Δ Diversity	Δ Abundance	Δ Productivity	Δ Diversity
Wallace River - Upper													
	Wallace_1				1.3%(16)	9.7%(10)	0%(22)				2.0%(14)	5.2%(11)	5.2%(13)
	Wallace_2				1.3%(16)	9.7%(10)	0%(22)				2.0%(14)	5.2%(11)	5.2%(13)
Woods Creek													
	Woods_2				0.2%(24)	1.0%(24)	0%(19)				0.4%(22)	0.6%(18)	2.5%(18)
Woods Creek - Lower													
	Woods_1				1.7%(11)	2.9%(20)	1.4%(10)				0.9%(16)	0.2%(21)	1.5%(23)
Woods Creek - West Fork													
	WFWoods_1				1.0%(18)	3.1%(17)	0.2%(16)				0.7%(19)	0.6%(18)	7.8%(5)
	WFWoods_2				1.0%(18)	3.1%(17)	0.2%(16)				0.7%(19)	0.6%(18)	7.8%(5)
	WFWoods_3				1.0%(18)	3.1%(17)	0.2%(16)				0.7%(19)	0.6%(18)	7.8%(5)
Ames Creek													
Cherry Creek													
	Cherry_1	7.5%(8)	25.3%(6)	0.9%(12)				1.3%(9)	1.9%(11)	4.9%(10)			
Coal Creek - Lower													
	Snoqualmie_6												
	Snoqualmie_7												
Coal Creek - Upper													
Griffin Creek													
	Griffin_1	1.4%(13)	6.3%(9)	0%(14)				1.2%(10)	5.1%(9)	2.9%(12)			
Harris Creek													
Patterson Creek													
	Patterson_1	1.5%(12)	5.7%(10)	2.0(9)				1.1%(11)	0.6%(12)	3.3%(11)			
Pratt River													
Raging River													
	Raging_1	11.2%(7)	32%(5)	12.2%(5)				1.9%(8)	3.5%(10)	17.6%(5)			
	Raging_2	11.2%(7)	32%(5)	12.2%(5)				1.9%(8)	3.5%(10)	17.6%(5)			
Snoqualmie River - Mouth													
mouth to trib 0223 (RM 0 - 1.1)	Snoqualmie_1A	70.9%(2)	75.9%(3)	23.8%(4)				26.7%(3)	13.9%(6)	11.5%(7)			
Trib 0223 to Cherry Cr (RM 1.1-6.7)	Snoqualmie_1B	70.9%(2)	75.9%(3)	23.8%(4)				26.7%(3)	13.9%(6)	11.5%(7)			
Snoqualmie River - Mid-Mainstem													
Cherry Cr to Tuck Cr (RM 6.7-10.3)	Snoqualmie_2A	70.9%(2)	75.9%(3)	23.8%(4)				26.7%(3)	13.9%(6)	11.5%(7)			
Tuck Cr to near Sikes Lk (RM 10.3-20.5)	Snoqualmie_2B	99.9%(1)	163.9%(1)	29.7%(1)				43%(1)	35.8%(1)	25.2%(2)			
near Sikes Lk to Tolt R. (RM 20.5 -24.9)	Snoqualmie_3	99.9%(1)	163.9%(1)	29.7%(1)				43%(1)	35.8%(1)	25.2%(2)			
Snoqualmie River - Upper Mainstem													
Tolt R. to 1.7 mi upstrm Patterson Cr (RM 24.9-26.7)	Snoqualmie_4	63.9%(3)	138.3%(2)	24.7%(3)				16.4%(4)	18%(5)	23.4%(3)			
1.7 mi upstrm Patterson Cr. To Raging R.(RM 26.7-28.5)	Snoqualmie_5	63.9%(3)	138.3%(2)	24.7%(3)				16.4%(4)	18%(5)	23.4%(3)			
Raging River	Snoqualmie_6	63.9%(3)	138.3%(2)	24.7%(3)				16.4%(4)	18%(5)	23.4%(3)			
	Snoqualmie_7	63.9%(3)	138.3%(2)	24.7%(3)				16.4%(4)	18%(5)	23.4%(3)			
Snoqualmie River - Lower South Fork													
Snoqualmie River - Upper South Fork													
Snoqualmie River -Lower Middle Fork													
Snoqualmie River - Upper Middle Fork													
Snoqualmie River - Lower North Fork													
Snoqualmie River - Upper North Fork													
Tate Creek													
Taylor River													
Tokul Creek													

Step 4-1 Table. EDT Diagnosis Results May 2002: Difference Between Historical and Current Potential for Chinook Use

Subbasin	EDT Reach	Change in Potential (gain with restoration)						Change in Potential (loss with degradation)					
		Snoqualmie			Skykomish			Snoqualmie			Skykomish		
		Δ Abundance	Δ Productivity	Δ Diversity	Δ Abundance	Δ Productivity	Δ Diversity	Δ Abundance	Δ Productivity	Δ Diversity	Δ Abundance	Δ Productivity	Δ Diversity
	Tokul_1	3.2%(11)	3.2%(12)	2.9%(8)				0%(13)	0%(13)	0%(13)			
	Tokul_2	3.2%(11)	3.2%(12)	2.9%(8)				0%(13)	0%(13)	0%(13)			
Tolt River - Lower													
	Tolt_1	18.3%(6)	67.7%(4)	0.0%(16)				3.8%(6)	19%(3)	15.9%(6)			
	Tolt_2	18.3%(6)	67.7%(4)	0.0%(16)				3.8%(6)	19%(3)	15.9%(6)			
Tolt River - North Fork													
	Tolt_3	0.3%(15)	2.2%(14)	0%(14)				1%(12)	6%(8)	5.7%(8)			
Tolt River - South Fork above Dam													
Tolt River - South Fork Below Dam													
	SFTolt_1	1.0%(14)	5.7%(10)	0.1%(13)				2.7%(7)	18.4%(4)	19.4%(4)			
	SFTolt_2	1.0%(14)	5.7%(10)	0.1%(13)				2.7%(7)	18.4%(4)	19.4%(4)			
Upper Snohomish/Cathcart													
Thomas Eddy to confl. Sky and Snoq. (RM 17.1-21.4)	Snohomish_2	4.6%(9)	2.2%(14)	1.1%(11)	12.6%(4)	14.9%(4)	1.5%(9)	15.7%(5)	7%(7)	6.2%(9)	23.8%(3)	10.4%(7)	7%(7)
Dubuque Creek													
Everett Coastal Drainages													
Fobes Hill													
French Creek													
Lake Stevens Drainages													
Little Pilchuck Creek													
Lower Snohomish/Marshland													
Top of estuary (upstrm of Fr. Cr. RM 15.2) to Thomas Eddy (RM 17.1)	Snoh-1	4.6%(9)	2.2%(14)	1.1%(11)	12.6%(4)	14.9%(4)	1.5%(9)	15.7%(5)	7%(7)	6.2%(9)	23.8%(3)	10.4%(7)	7%(7)
Pilchuck River - Lower													
	Pilchuck_1				7.5%(6)	7.2%(12)	5.6%(7)				2.2%(13)	0.2%(21)	2.4%(20)
	Pilchuck_2				7.5%(6)	7.2%(12)	5.6%(7)				2.2%(13)	0.2%(21)	2.4%(20)
	Pilchuck_3				7.5%(6)	7.2%(12)	5.6%(7)				2.2%(13)	0.2%(21)	2.4%(20)
Pilchuck River - Middle													
	Pilchuck_4				8.8%(5)	11.0%(8)	11.5%(1)				2.3%(11)	1.9%(15)	7.4%(6)
	Pilchuck_5				8.8%(5)	11.0%(8)	11.5%(1)				2.3%(11)	1.9%(15)	7.4%(6)
	Pilchuck_6				8.8%(5)	11.0%(8)	11.5%(1)				2.3%(11)	1.9%(15)	7.4%(6)
Pilchuck River - Upper													
	Pilchuck_7				4.8%(9)	3.1%(17)	7.3%(5)				0%(24)	0%(24)	0%(24)
	Pilchuck_8				4.8%(9)	3.1%(17)	7.3%(5)				0%(24)	0%(24)	0%(24)
	Pilchuck_9				4.8%(9)	3.1%(17)	7.3%(5)				0%(24)	0%(24)	0%(24)
Quilceda/Allen Creek													
	MFQuilceda_1				0.8%(19)	0%(26)	1.4%(11)				0.9%(15)	0.2%(21)	3.3%(16)
	Quilceda_1				0.8%(19)	0%(26)	1.4%(11)				0.9%(15)	0.2%(21)	3.3%(16)
	Quilceda_2				0.8%(19)	0%(26)	1.4%(11)				0.9%(15)	0.2%(21)	3.3%(16)
Sunnyside Drainages													
Tulalip and Battle Creeks													
Nearshore													
Snohomish Estuary													
	Snoh Est	57.8%(4)	20.9%(7)	8.7%(6)	54.1%(1)	5.2%(14)	8.2%(4)	40%(2)	27.8%(2)	25.6%(1)	36.3%(1)	20.1%(3)	12.7%(2)

Step 4-2 Table. Potential Capacity Results: Difference Between Current and Historical Potential for Chinook Spawning

Subbasin	Current Potential Capacity- # of Spawners*	Historic Potential Capacity- # of Spawners*	D Abundance (% Change of spawners relative to historic abundance within each subwatershed)	D Abundance (% Change of spawners relative to historic abundance within each subwatershed)	Rank (% Reduction in Spawners (Column E))	Rank (% Increase in Total Population (Column F))
Bear Creek	95	130	27.3%	0.0%	16	19
Beckler River	0	0	0.0%	0.0%	32	32
Foss River	0	0	0.0%	0.0%	32	32
May Creek/Lower Wallace River	1,262	1,795	29.7%	0.7%	15	14
Miller River	0	0	0.0%	0.0%	32	32
Olney Creek	943	957	1.5%	0.0%	28	27
Rapid River	0	0	0.0%	0.0%	32	32
Skykomish River - Lower Mainstem	17,284	27,299	36.7%	12.7%	11	1
Skykomish River - Upper Mainstem	12,495	19,960	37.4%	9.5%	6	2
Skykomish River - Lower North Fork	4,180	6,672	37.4%	3.2%	7	4
Skykomish River - Upper North Fork	2,483	3,826	35.1%	1.7%	12	10
Skykomish River - Lower South Fork	1,435	2,298	37.6%	1.1%	2	13
Skykomish River - South Fork	0	0	0.0%	0.0%	32	32
Skykomish River - Upper South Fork	0	0	0.0%	0.0%	32	32
Sultan River - Lower	2,926	4,649	37.1%	2.2%	9	7
Sultan River - Upper	0	0	0.0%	0.0%	32	32
Tye River	0	0	0.0%	0.0%	32	32
Wallace River - Upper	457	477	4.1%	0.0%	25	24
Woods Creek	423	455	7.0%	0.0%	20	21
Woods Creek - Lower	372	397	6.2%	0.0%	22	23
Woods Creek - West Fork	1,142	1,159	1.5%	0.0%	27	26
Ames Creek	112	112	0.0%	0.0%	32	32
Cherry Creek	740	765	3.3%	0.0%	26	22
Coal Creek - Lower	3,029	4,850	37.5%	2.3%	4	6
Coal Creek - Upper	0	0	0.0%	0.0%	32	32
Griffin Creek	649	691	6.1%	0.1%	23	18
Harris Creek	356	356	0.0%	0.0%	32	32
Patterson Creek	516	522	1.3%	0.0%	30	29
Pratt River	0	0	0.0%	0.0%	32	32
Raging River	967	1,045	7.5%	0.1%	19	16
Snoqualmie River - Mouth	26	40	34.5%	0.0%	13	28
Snoqualmie River - Mid-Mainstem	3,848	6,163	37.6%	2.9%	3	5
Snoqualmie River - Upper Mainstem	1,821	2,915	37.5%	1.4%	5	12
Snoqualmie River - Lower South Fork	0	0	0.0%	0.0%	32	32
Snoqualmie River - Upper South Fork	0	0	0.0%	0.0%	32	32
Snoqualmie River -Lower Middle Fork	0	0	0.0%	0.0%	32	32

Step 4-2 Table. Potential Capacity Results: Difference Between Current and Historical Potential for Chinook Spawning

Subbasin	Current Potential Capacity- # of Spawners*	Historic Potential Capacity- # of Spawners*	D Abundance (% Change of spawners relative to historic abundance within each subwatershed)	D Abundance (% Change of spawners relative to historic abundance within each subwatershed)	Rank (% Reduction in Spawners (Column E))	Rank (% Increase in Total Population (Column F))
Snoqualmie River - Upper Middle Fork	0	0	0.0%	0.0%	32	32
Snoqualmie River - Lower North Fork	0	0	0.0%	0.0%	32	32
Snoqualmie River - Upper North Fork	0	0	0.0%	0.0%	32	32
Tate Creek	0	0	0.0%	0.0%	32	32
Taylor River	0	0	0.0%	0.0%	32	32
Tokul Creek	31	37	15.8%	0.0%	18	30
Tolt River - Lower	2,229	3,540	37.0%	1.7%	10	11
Tolt River - North Fork	432	526	17.9%	0.1%	17	15
Tolt River - South Fork above Dam	0	0	0.0%	0.0%	32	32
Tolt River - South Fork Below Dam	683	716	4.6%	0.0%	24	20
Upper Snohomish/Cathcart Drainages	8,018	12,788	37.3%	6.0%	8	3
Dubuque Creek	192	192	0.0%	0.0%	32	32
Everett Coastal Drainages	0	0	0.0%	0.0%	32	32
Fobes Hill	0	0	0.0%	0.0%	32	32
French Creek	942	942	0.0%	0.0%	32	32
Lake Stevens Drainages	291	292	0.1%	0.0%	31	31
Little Pilchuck Creek	747	799	6.5%	0.1%	21	17
Lower Snohomish/Marshland	0	0	0.0%	0.0%	32	32
Pilchuck River - Lower	2,654	4,253	37.6%	2.0%	1	8
Pilchuck River - Middle	3,308	4,809	31.2%	1.9%	14	9
Pilchuck River - Upper	1,291	1,309	1.4%	0.0%	29	25
Quilceda/Allen Creek	152	152	0.0%	0.0%	32	32
Sunnyside Drainages	0	0	0.0%	0.0%	32	32
Tulalip and Battle Creeks	450	450	0.0%	0.0%	32	32
Nearshore	0	0	0.0%	0.0%	32	32
Snohomish Estuary	0	0	0.0%	0.0%	32	32
TOTAL	78,980	118,337				

* Used median values for the variable inputs (# of redds/km, # of spawners/redd). Confidence intervals will be added in future editions.

Step 4 Potential Chinook Use with Restoration & Preservation by Subbasin

Potential Chinook Use

High (EDT category A)

Moderate (EDT categories B & C)

Low (EDT categories D & E)

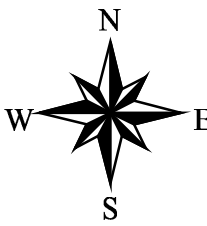
None (not modeled)

Rivers

* Generalized results of the EDT diagnosis
commissioned by the Tulalip Tribes
(May 2002)

03691215 Miles


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STEP 5. SALMONID USE AND POTENTIAL SYNTHESIS

DESCRIPTION

Step 5 integrates data from Steps 1 and 4 to identify subbasins that are most critical to target with protection and restoration measures for sustaining and improving population performance for salmonids in the Snohomish River Basin. High priority subbasins are defined through this analysis as those having high relative current use (Step 1) and/or high potential (Step 4). An assessment of potential is only available at this time for chinook salmon. High potential means that the habitat-population models indicate that protective or restorative measures would have a high relative impact on one or more of three population performance measures: abundance, productivity and diversity. In the absence of a population performance model for bull trout char or coho salmon, high priority subbasins are identified solely based on relative current use. Additional modeling of population performance for these species is highly recommended.

METHODS

These methods describe the approach for data synthesis in the Step 5 Table.

Relative Current Use

Different methods were used to identify relative current use classes for each of the three proxy species. Variations in the approach reflect data availability. Step 1 of the EASC outlines a detailed methodology. Relative current use is summarized in four classes:

High Use (A) – Documented high use currently relative to other subbasins.

Moderate Use (B) – Documented moderate use currently relative to other subbasins.

Low Use (C) – Documented low use currently relative to other subbasins or presumed use. Subbasins with presumed use are marked with an asterisk.

None (D) – No known or presumed use currently.

Potential – Gain with Restoration and Losses with Degradation

This analysis has only been conducted for chinook salmon in the Snohomish River Basin. In the EDT model, “percent change” represents the change in the whole population expected in a hypothetical situation where the particular reach of interest is fully degraded or restored to the historical baseline while the remainder of the watershed remains at the current condition.

This is different from the Potential Capacity model where the percent change represents the change in the capacity of that one reach alone if that reach were restored from the current condition to the historical template. In general, both measures give information about the relative benefit of restoring habitat in different reaches. However, because one focuses on the whole population while the other focuses on the specific reach alone, the formats of the results are not directly comparable. Table 5-1 summarizes the results of the EDT diagnosis generated by Mobrand Biometrics Inc. (2002) for the Tulalip Tribes. It

shows modeled relative gains and losses in terms of abundance, productivity, and diversity on a subbasin scale. Each subbasin is ranked numerically for restoration and preservation benefit for each VSP parameter and by population.

Mobrand Biometrics Inc. (2002) summarizes relative gains in five benefit categories (A-E). These categories are combined into four in the EASC analysis:

High Potential (A) – EDT category A.

Medium Potential (B) – EDT categories B and C.

Low Potential (C) – EDT categories D and E.

None (D) – no modeled benefit from restoration.

This simplification allows us to move forward with strategy development at a manageable scale. A shortcoming of this approach is that it is not evident in subsequent tables, which of the VSP parameters resulted in the high, medium, or low potential call. Hypothesis statements for subbasin strategy groups, which refer back to EDT results in terms of VSP parameters, provide a partial remedy. For subbasin specific details, however, it will be necessary to return to this step.

RESULTS

Results of the priority area analysis are summarized in the Step 5 Table and Map 5-1.

CAVEATS

- Due to data limitations, coho priorities are incorporated in Step 6 through the hypotheses and recommended actions.
- The links between subbasin priority calls and VSP parameters are less evident in subsequent steps. Therefore, it is necessary to refer back to this step to check which VSP parameters were the underlying basis for the calls.
- The EDT and Potential Capacity results are not directly comparable. Since the EDT analyses looked at three VSP parameters, it was used to help identify the priority areas, rather than the potential capacity modeling. The juvenile and adult Potential Capacity analyses are integral components of the SHIRAZ modeling that is described in steps 7 and 8.

Table 5-1. Relative Importance of Geographic Areas for Preservation and Restoration Measures (Mobrand Biometrics, Inc. 2002)***Snoqualmie Chinook EDT analysis***

Geographic Area	Preserve Benefit category	Restore Benefit category	Abundance	Productivity	Diversity Index
Marine Areas Outside Puget Sound	NA	D			
Marine Areas Puget Sound	NA	C			
Snohomish Estuary	A	B			
Snohomish mainstem	B	D			
Snoqualmie Mouth	B	B			
Mid-Mainstem Snoqualmie	A	A			
Upper Mainstem Snoqualmie	B	A			
Cherry Creek	C	C			
Lower Tolt River	B	C			
North Fork Tolt River	C	E			
South Fork Tolt River	B	D			
Griffin Creek	C	D			
Patterson Creek	D	D			
Raging River	B	B			
Tolul Creek	E	D			

Skykomish Chinook EDT analysis

Geographic Area	Preserve Benefit category	Restore Benefit category	Abundance	Productivity	Diversity Index
Marine Areas Outside Puget Sound	NA	B			
Marine Areas Puget Sound	NA	A			
Snohomish Estuary	A	A			
Snohomish mainstem	A	A			
Quilceda Creek	D	D			
Lower Pilchuck	D	B			
Middle Pilchuck	C	A			
Upper Pilchuck	E	B			
Lower mainstem Skykomish	A	A			
Upper mainstem Skykomish	A	B			
Lower Woods Creek	E	C			
Woods Creek	D	D			
West Fork Woods Creek	C	C			
Elwell Creek	D	D			
Lower Sultan River	B	B			
Wallace River	C	C			
Lower North Fork Skykomish	B	C			
Upper North Fork Skykomish	B	D			
Lower South Fork Skykomish	C	C			
Mid-mainstem South Fork Skykomish	A	B			
Upper mainstem South Fork Skykomish	C	C			
Miller River	D	E			
Beckler River	B	B			
Rapid River	E	D			
Foss River	D	D			
Tye River	D	D			

Step 5 Table. Salmonid Use and Potential Summary Table

Subbasin	EDT Reach	Chinook																	Bull Trout	Coho
			Skykomish population									Snoqualmie population								All stocks
		Relative current use (both populations)	EDT Change in potential (gain with restoration)			EDT Change in potential (loss with degradation)			EDT Change in potential (gain with restoration)				EDT Change in potential (loss with degradation)				Relative current use	Relative current use		
			Class	Rank - impact of restoration on VSP			Class	Rank - impact of degradation on VSP			Class	Rank - impact of restoration on VSP			Class	Rank - impact of degradation on VSP				
				A, B, C or D	A, B, C or D	Abun		Prod	Dive	A, B, C or D		Abun	Prod	Dive		A, B, C or D			Abun	Prod
Skykomish River																				
Bear Creek		D	D				D				NA	NA	NA	NA	NA	NA	NA	NA	C*	C
Beckler River		C*	B				B				NA	NA	NA	NA	NA	NA	NA	NA	B	C
	Beckler_1			11	6	22		12	12	4										
	Beckler_2			11	6	22		12	12	4										
Foss River		C*	C				C				NA	NA	NA	NA	NA	NA	NA	NA	A	C
	Foss_1			23	22	22		17	14	14										
	WFFoss_1			23	22	22		17	14	14										
May Creek/Lower Wallace River		B	B				B				NA	NA	NA	NA	NA	NA	NA	NA	C*	C
	Wallace_1			16	10	22		14	11	13										
Miller River		C*	C				C				NA	NA	NA	NA	NA	NA	NA	NA	C*	C
	Miller_1			25	21	25		18	10	18										
Olney Creek		D	D				D				NA	NA	NA	NA	NA	NA	NA	NA	C*	C
Rapid River		C*	C				C				NA	NA	NA	NA	NA	NA	NA	NA	C*	C
	Rapid_1			26	25	16		23	20	22										
Skykomish River - Lower Mainstem		A	A				A				NA	NA	NA	NA	NA	NA	NA	NA	B	C
	Elwell_1		C	22	23	22	C	21	16	21										
	Sky_1			2	1	13		2	1	1										
	Sky_2			2	1	13		2	1	1										
	Sky_3			2	1	13		2	1	1										
	Sky_4			7	2	14		4	2	3										
	Sky_5			7	2	14		4	2	3										
Skykomish River - Upper Mainstem		C*	B				A				NA	NA	NA	NA	NA	NA	NA	NA	C	B
	Sky_6			7	2	14		4	2	3										
	Sky_7			7	2	14		4	2	3										
Skykomish River - Lower North Fork		C	B				B				NA	NA	NA	NA	NA	NA	NA	NA	C	A
	NFSky_1			14	9	22		7	7	11										
Skykomish River - Upper North Fork		C*	C				B				NA	NA	NA	NA	NA	NA	NA	NA	A	C
	NFSky_2A			20	12	22		8	6	9										
	NFSky_2B			20	12	22		8	6	9										
	Bear Cr Falls			20	12	22		8	6	9										
Skykomish River - Lower South Fork		B	B				B				NA	NA	NA	NA	NA	NA	NA	NA	C	C
	BridalVeil_1			15	16	15		6	13	12										
	SFSky_1			15	16	15		6	13	12										
	SFSky_2			15	16	15		6	13	12										

Step 5 Table. Salmonid Use and Potential Summary Table

Subbasin	EDT Reach	Chinook																	Bull Trout	Coho
			Skykomish population								Snoqualmie population									All stocks
		Relative current use (both populations)	EDT Change in potential (gain with restoration)				EDT Change in potential (loss with degradation)				EDT Change in potential (gain with restoration)				EDT Change in potential (loss with degradation)				Relative current use	Relative current use
		Class	Class	Rank - impact of restoration on VSP			Class	Rank - impact of degradation on VSP			Class	Rank - impact of restoration on VSP			Class	Rank - impact of degradation on VSP				
		A, B, C or D	A, B, C or D	Abun	Prod	Dive	A, B, C or D	Abun	Prod	Dive	A, B, C or D	Abun	Prod	Dive	A, B, C or D	Abun	Prod	Dive	A, B, C, C* or D	A, B,C or D
Skykomish River - South Fork		C*	B				A				NA	NA	NA	NA	NA	NA	NA	NA	C	C
	SFSky_3			13	3	18		5	4	8										
Skykomish River - Upper South Fork		A	B				B				NA	NA	NA	NA	NA	NA	NA	NA	C	C
	SFSky_4			17	7	19		10	9	15										
	SFSky_5			17	7	19		10	9	15										
Sultan River - Lower		A	B				B				NA	NA	NA	NA	NA	NA	NA	NA	C*	C
	Sultan_1			8	5	8		9	5	10										
	Sultan_2			8	5	8		9	5	10										
Sultan River - Upper		D	D				D				NA	NA	NA	NA	NA	NA	NA	NA	D	D
	Sultan_3			8	5	8		9	5	10										
Tye River		C*	C				C				NA	NA	NA	NA	NA	NA	NA	NA	C*	C
	Tye_1			21	15	19		20	16	17										
Wallace River - Upper		D	D				D				NA	NA	NA	NA	NA	NA	NA	NA	C*	C
	Wallace_2			16	10	22		14	11	13										
Woods Creek		C*	C				C				NA	NA	NA	NA	NA	NA	NA	NA	C*	B
	Woods_2			24	24	19		22	18	18										
Woods Creek - Lower		C*	B				C				NA	NA	NA	NA	NA	NA	NA	NA	C*	C
	Woods_1			11	20	10		16	21	23										
Woods Creek - West Fork		C*	B				B				NA	NA	NA	NA	NA	NA	NA	NA	C*	B
	WFWoods_1			18	17	16		19	18	5										
	WFWoods_2			18	17	16		19	18	5										
	WFWoods_3			18	17	16		19	18	5										
Snoqualmie River																				
Ames Creek		D	NA	NA	NA	NA	NA	NA	NA	NA	D				D				C*	C
Cherry Creek		C*	NA	NA	NA	NA	NA	NA	NA	NA	B				B				C*	A
	Cherry_1											8	6	12		9	11	10		
Coal Creek - Lower		D	NA	NA	NA	NA	NA	NA	NA	NA	D				D				C*	C
	Snoq_6											3	2	3		4	5	3		
	Snoq_7											3	2	3		4	5	3		
Coal Creek - Upper		D	NA	NA	NA	NA	NA	NA	NA	NA	D				D				D	D
Griffin Creek		C*	NA	NA	NA	NA	NA	NA	NA	NA	C				B				C*	A

Step 5 Table. Salmonid Use and Potential Summary Table

Subbasin	EDT Reach	Chinook																	Bull Trout	Coho
			Skykomish population								Snoqualmie population									All stocks
		Relative current use (both populations)	EDT Change in potential (gain with restoration)				EDT Change in potential (loss with degradation)				EDT Change in potential (gain with restoration)				EDT Change in potential (loss with degradation)				Relative current use	Relative current use
		Class	Class	Rank - impact of restoration on VSP			Class	Rank - impact of degradation on VSP			Class	Rank - impact of restoration on VSP			Class	Rank - impact of degradation on VSP				
		A, B, C or D	A, B, C or D	Abun	Prod	Dive	A, B, C or D	Abun	Prod	Dive	A, B, C or D	Abun	Prod	Dive	A, B, C or D	Abun	Prod	Dive	A, B, C, C* or D	A, B,C or D
	Griffin_1											13	9	14		10	9	12		
Harris Creek		C*	NA	NA	NA	NA	NA	NA	NA	NA	D				D				C*	B
Patterson Creek		C*	NA	NA	NA	NA	NA	NA	NA	NA	C				C				C*	B
	Patterson_1											12	10	9		11	12	11		
Pratt River		D	NA	NA	NA	NA	NA	NA	NA	NA	D				D				D	D
Raging River		B	NA	NA	NA	NA	NA	NA	NA	NA	B				B				C*	B
	Raging_1											7	5	5		8	10	5		
	Raging_2											7	5	5		8	10	5		
Snoqualmie River - Mouth		C*	NA	NA	NA	NA	NA	NA	NA	NA	B				B				C*	H
	Snoq_1A											2	3	4		3	6	7		
	Snoq_1B											2	3	4		3	6	7		
Snoqualmie River - Mid-Mainstem		B	NA	NA	NA	NA	NA	NA	NA	NA	A				A				C*	C
	Snoq_2A											2	3	4		3	6	7		
	Snoq_2B											1	1	1		1	1	2		
	Snoq_3											1	1	1		1	1	2		
Snoqualmie River - Upper Mainstem		C*	NA	NA	NA	NA	NA	NA	NA	NA	A				B				C*	B
	Snoq_4											3	2	3		4	5	3		
	Snoq_5											3	2	3		4	5	3		
Snoqualmie River - Lower South Fork		D	NA	NA	NA	NA	NA	NA	NA	NA	D				D				D	D
Snoqualmie River - Upper South Fork		D	NA	NA	NA	NA	NA	NA	NA	NA	D				D				D	D
Snoqualmie River - Lower Middle Fork		D	NA	NA	NA	NA	NA	NA	NA	NA	D				D				D	D
Snoqualmie River - Upper Middle Fork		D	NA	NA	NA	NA	NA	NA	NA	NA	D				D				D	D
Snoqualmie River - Lower North Fork		D	NA	NA	NA	NA	NA	NA	NA	NA	D				D				D	D
Snoqualmie River - Upper North Fork		D	NA	NA	NA	NA	NA	NA	NA	NA	D				D				D	D
Tate Creek		D	NA	NA	NA	NA	NA	NA	NA	NA	D				D				D	D
Taylor River		D	NA	NA	NA	NA	NA	NA	NA	NA	D				D				D	D

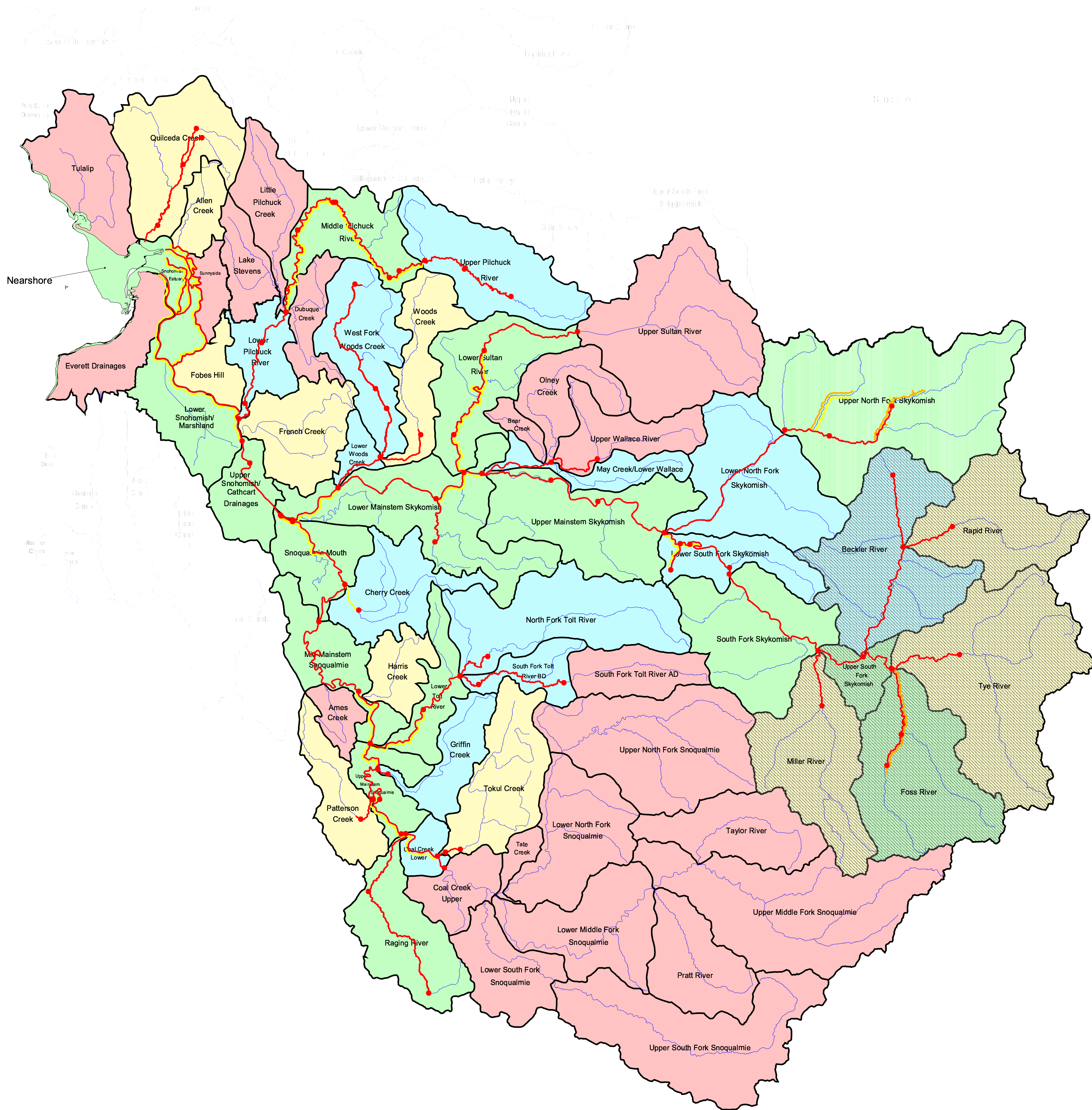
Step 5 Table. Salmonid Use and Potential Summary Table

Subbasin	EDT Reach	Chinook																	Bull Trout	Coho
			Skykomish population								Snoqualmie population									All stocks
		Relative current use (both populations)	EDT Change in potential (gain with restoration)				EDT Change in potential (loss with degradation)				EDT Change in potential (gain with restoration)				EDT Change in potential (loss with degradation)				Relative current use	Relative current use
		Class	Class	Rank - impact of restoration on VSP			Class	Rank - impact of degradation on VSP			Class	Rank - impact of restoration on VSP			Class	Rank - impact of degradation on VSP				
		A, B, C or D	A, B, C or D	Abun	Prod	Dive	A, B, C or D	Abun	Prod	Dive	A, B, C or D	Abun	Prod	Dive	A, B, C or D	Abun	Prod	Dive	A, B, C, C* or D	A, B, C or D
Tokul Creek		C	NA	NA	NA	NA	NA	NA	NA	NA	C				C				C*	C
	Tokul_1											11	12	8		13	13	13		
	Tokul_2											11	12	8		13	13	13		
Tolt River - Lower		B	NA	NA	NA	NA	NA	NA	NA	NA	B				B				C*	A
	Tolt_1											6	4	16		6	3	6		
	Tolt_2											6	4	16		6	3	6		
Tolt River - North Fork		C*	NA	NA	NA	NA	NA	NA	NA	NA	C				B				C*	C
	Tolt_3											15	14	14		12	8	8		
Tolt River - South Fork above Dam		D	NA	NA	NA	NA	NA	NA	NA	NA	D				D				D	D
Tolt River - South Fork Below Dam		C	NA	NA	NA	NA	NA	NA	NA	NA	C				B				C*	C
	SFTolt_1											14	10	13		7	4	4		
	SFTolt_2											14	10	13		7	4	4		
Snohomish River ¹																				
Upper Snohomish /Cathcart		C*	A				A				C				B				A	C
	Snoh_2			4	4	9		3	7	7		9	14	11		5	7	9		
Dubuque Creek		D	D				D				D				D				C*	B
Everett Coastal Drainages		D	D				D				D				D				C*	C
Fobes Hill		D	D				D				D				D				C*	C
French Creek		C	D				D				D				D				C*	C
Lake Stevens Drainages		D	D				D				D				D				C*	C
Little Pilchuck Creek		D	D				D				D				D				C*	B
Lower Snohomish/Marshland		C	A				A				B				A				C*	C
	Snoh 1 upstrm			4	4	9		3	7	7										
Pilchuck River - Lower		C	B				C				D				D				C*	C
	Pilchuck_1			6	12	7		12	21	20										
	Pilchuck_2			6	12	7		13	21	20										
	Pilchuck_3			6	12	7		13	21	20										
Pilchuck River - Middle		C*	A				B				D				D				C*	B
	Pilchuck_4			5	8	1		11	15	6										

Step 5 Table. Salmonid Use and Potential Summary Table

Subbasin	EDT Reach	Chinook																		Bull Trout	Coho	
			Skykomish population									Snoqualmie population										All stocks
		Relative current use (both populations)	EDT Change in potential (gain with restoration)			EDT Change in potential (loss with degradation)			EDT Change in potential (gain with restoration)			EDT Change in potential (loss with degradation)			Relative current use	Relative current use						
			Class	Rank - impact of restoration on VSP			Class	Rank - impact of degradation on VSP			Class	Rank - impact of restoration on VSP					Class	Rank - impact of degradation on VSP				
				A, B, C or D	A, B, C or D	Abun		Prod	Dive	A, B, C or D		Abun	Prod	Dive				A, B, C or D	Abun	Prod	Dive	A, B, C, C* or D
	Pilchuck_5			5	8	1		11	15	6												
	Pilchuck_6			5	8	1		11	15	6												
Pilchuck River - Upper		C*	B				C				D				D				C*	C		
	Pilchuck_7			9	17	5		24	24	24												
	Pilchuck_8			9	17	5		24	24	24												
	Pilchuck_9			9	17	5		24	24	24												
Quilceda/Allen Creek		C*	C				C				D				D				C*	B		
	MFQuil_1			19	26	11		15	21	16												
	Quil_1			19	26	11		15	21	16												
	Quil_2			19	26	11		15	21	16												
Sunnyside Drainages		D	D				D				D				D				C*	C		
Tulalip and Battle Creeks		D	D				D				D				D				D	D		
Nearshore		A	A				No Analysis				B				No Analysis				A	A		
Snohomish Estuary		A	A				A				B				A				A	A		
	Snoh 1 dnstrm			1	14	4		1	3	2		4	7	6		2	2	1				

¹Used by both chinook populations. Spawning is lumped with the Skykomish population.



SNOHOMISH COUNTY

SURFACE WATER MANAGEMENT

Step 5 Bull Trout & Chinook Priority Use & Potential by subbasin

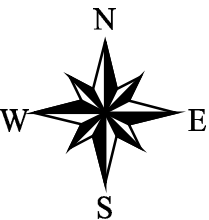
Chinook Priority Areas

- High
- Moderate
- Low
- None
- Chinook escapement data for all South Fork Skykomish headwater tributaries (Beckler, Rapid, Tye, Foss, Miller) is reported in the Upper South Fork Skykomish Subwatershed
- Chinook EDT Reaches
- Bull Trout Spawning Reaches
- Primary Focus Reaches
- Rivers

** Based on highest score for relative current chinook use, relative current bull trout used, and chinook potential*



Snohomish County



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STEP 6. HYPOTHESES, STRATEGY GROUPS, AND ACTIONS

DESCRIPTION

Step 6 integrates the results of all previous analyses to generate hypotheses, organize subbasins into strategy groups, and identify and rank action classes within subbasins and among subbasin strategy groups to address the main factors limiting salmonid recovery. The analysis is conducted on a subbasin scale because restoration actions are targeted primarily at watershed processes, and on a subbasin strategy group scale (defined below) to bring hypothesis generation and strategy development down to a manageable scale. Additionally, with a focus on simplification, actions to address the main factors limiting recovery are organized in broad action classes. Different types of projects and various policy choices (e.g., regulatory, non-regulatory programs or capital) for addressing them are possible within each action class.

The generation of hypotheses is a central component of Step 6. Hypotheses help to guide the development of an overall strategy for recovering salmon (Puget Sound TRT, 2003). Hypothesis development can occur at multiple scales: in this exercise, two scales are used – the basin scale and the subbasin strategy group scale. On the basin scale, hypothesis narratives are provided for population structure and the potential effects of habitat, harvest, and hatchery management on salmon population status. In other words, the hypotheses provide best estimates as to how improvements in habitat condition and processes will lead to improvements in the four salmon population parameters critical to viability: abundance, productivity, spatial structure, and diversity. Habitat-based hypotheses are also developed for each of the 11 subbasin strategy groups. The hypotheses are used to guide alternative development in Step 7 and are evaluated in Step 8 using the EDT and SHIRAZ models. Hypotheses underlying the habitat strategies needed for the recovery of salmon populations in the Snohomish River Basin will be tested and refined with empirical information on salmon population response gained from a good monitoring and evaluation plan (Puget Sound TRT 2003).

The objective of classifying subbasins into subbasin strategy groups is to provide a simple road map for salmonid conservation across the entire Snohomish River Basin. Like subbasins are grouped based on three characteristics: geospatial class, chinook and bull trout use and potential class, and watershed process condition class (Map 6-1). Each subbasin group has a unique role in a basinwide strategy. Some subbasin groups will focus on preservation, while others will focus on restoration. Some will contain critical habitat, while others will provide watershed process support to critical habitat downstream. Some will have great potential gains with restoration, while others will have limited potential. Some will play a central role, while others will have a supporting role. While the roles will vary among subbasin strategy groups, all will have a role to play in supporting healthy and harvestable salmonid populations in the Snohomish River Basin.

Following hypothesis generation and the organization of subbasins into subbasin strategy groups, on-the-ground actions to improve habitat conditions and, in turn, the viability of salmonid populations, are proposed and ranked among subbasin strategy groups (Step 6-1 Table) and within individual subbasins (Step 6-2 Table). Potentially appropriate actions within individual subbasins, simplified as general action classes, are identified based primarily on instream habitat conditions (Step 2) and watershed process conditions (Step 3), although additional criteria are used to identify appropriate locations for off-channel habitat reconnection and marine-derived nutrient enhancement projects. An action's rank indicates its potential "bang" in terms of VSP. The Forum will decide ultimate priorities based on an action's rank

along with other factors such as logistics, constraints, and other political and socioeconomic considerations.

While there is substantial overlap in habitat utilization by coho salmon with ESA listed salmonids, coho salmon spawning and rearing occur more broadly and in smaller streams. To encourage adequate protection of habitat used by coho salmon, high and moderate use coho subbasins are identified, and additional prescriptions along small streams are recommended in these areas.

CAVEATS

- The quantity and quality of habitat within specific reaches may vary substantially within a subbasin. Available data have been summarized on a reach scale as part of the EDT modeling effort. Further reach scale analysis is recommended to refine the strategy.
- The strategy provides greater specificity for chinook salmon and bull trout than for other species. As further data are collected, analyzed, and modeled for coho salmon and other species, the strategy should be refined through adaptive management.
- Priorities among and within subbasin strategy groups are based on available data and analyses. As more data become available, the priorities should be refined through adaptive management.

BASIN SCALE HYPOTHESES

Hypothesis development occurs on two scales in this analysis: the basin scale and the subbasin strategy group scale. On the basin scale, hypothesis narratives are provided for population structure and the potential effects of habitat, harvest, and hatchery management on salmon population status. On the subbasin strategy group scale, more specific hypotheses are articulated for habitat. The hypotheses described below are the assumptions based on the analysis of available data and are designed to guide development of a strategy to recover salmon in the Snohomish River Basin. These hypotheses will be tested through a solid monitoring and evaluation plan, and actions across the “Hs” (i.e., habitat, hatchery and harvest management) may need to be adjusted as model predictions are refined and salmon population responses are observed over time (Puget Sound TRT 2003).

Chinook Population Structure

The Skykomish and Snoqualmie populations described by the Puget Sound TRT (Ruckelshaus et al. 2003) represent the historic population structure of chinook salmon in the Snohomish River Basin. As indicated in the Step 1 analysis, the Skykomish population includes all chinook that spawn in the Skykomish River and its tributaries and in the Snohomish River and its tributaries, including the Pilchuck River. The Snoqualmie population includes all chinook that spawn in the Snoqualmie River and its tributaries.

Habitat

The quantity and quality of aquatic habitat and the watershed process conditions that create and sustain high quality habitat have been substantially altered across the Snohomish River Basin. This has occurred over a period of many decades, through many public and private actions that have changed land use/land cover across the landscape and altered the character and condition of stream corridors and floodplains. While habitat quantity and quality affect capacity and survival throughout the salmonid life cycle, the loss of rearing habitat quantity and quality along mainstems and within the estuary and nearshore environment is thought to be the primary factor affecting population performance for Snohomish Basin chinook

salmon. Actions that improve floodplain connectivity and habitat complexity in the vicinity of and downstream from chinook spawning areas are predicted to have the highest effectiveness in terms of population performance improvements.

Actions in these areas alone, however, will not lead to recovery of all components of viable populations for all salmonids. For example, spatial structure and diversity targets for chinook salmon will not likely be met without significant additional protective and restorative efforts to enhance spawning conditions and egg-to-fry survival within large tributary subbasins. Actions that improve spatial structure and diversity buffer populations against catastrophic disturbance and thus are critical for viability over the long-term. Furthermore, healthy and harvestable coho salmon populations are unlikely over the long-term without measures to maintain access, adequate flows, sediment conditions, LWD loading, nutrient levels, and temperatures in lowland tributaries where coho spawn and rear and in headwater subbasins with habitat process contributions to areas downstream. Likewise, the viability of bull trout in the Snohomish Basin depends on preservation of watershed processes and habitat conditions in the limited spawning areas in the Upper North Fork Skykomish and Foss River subbasins.

An ecosystem approach to salmonid recovery is critical. Watershed processes initiated throughout the river basin strongly influence habitat capacity and conditions downstream. Furthermore, multiple habitat factors may be at work in limiting the population or may shift in relative importance as conditions vary over time. For example, rearing habitat in the estuary and lower mainstem may currently be seeded to capacity, thereby limiting population size. In future years, however, an increase in rearing capacity through restoration or a decrease in the number of outmigrants due to low survival to emergence caused by extensive scouring of redds may shift the bottleneck upstream.

For these reasons the most successful, lowest risk strategy for salmonid recovery in the Snohomish River Basin will include restoration and preservation actions focused on watershed processes across the basin, with special emphasis on rearing habitat improvements in the mainstems, estuary and nearshore environment. All subbasins have a role to play in a salmon conservation and recovery strategy.

Chinook Harvest

Exploitation rates on the Skykomish and Snoqualmie chinook populations have declined from nearly 80% in the late 1970s to 20-25% today. It is likely that the higher end of this range exceeded the harvestable surplus production from these populations, at least during periods of low and moderate marine survival, thus contributing to the observed declines in spawning escapement numbers. Based on recent analyses of spawner-recruit data, annual exploitation rates below 24% will allow these populations to increase in abundance towards the recovery goals if other factors, such as freshwater and estuarine habitat quality and quantity and ocean survival rates improve. In addition, there may have been other impacts of high harvest rates on population vigor; these include reduced fish size, average age, and fecundity associated with past high exploitation rates. Maintaining annual exploitation rates below 24% will result in increased average age at spawning, increased average size, increased average fecundity, and representation of all age classes in the population.

Hatcheries

Artificial propagation programs operated in Snohomish Basin freshwater and nearshore-marine areas to produce fish for fisheries harvest augmentation purposes⁵ may have resulted in adverse ecological,

⁵ Four main hatchery facilities in the Basin area – Wallace River, Bernie Kai-Kai Gobin, Reiter Pond, and Tokul Creek - have collectively released ~13.4 million juvenile salmonids each year, of which 3.6 million were chinook, 1.35 million were coho, 8.0 million were chum, and 0.452 million were steelhead.

genetic, and demographic impacts that affected the viability of native, natural-origin fish populations. Activities associated with hatchery programs, including physical operation, broodstock collection, juvenile fish rearing and release, and resultant adult fish production, may harm wild fish populations through: migration delay or blockage; incidental removal of returning adults; amplification and transmittal of fish disease pathogens; food resource competition; predation; decreased genetic diversity and fitness through hatchery adult straying and interbreeding with wild fish in natural spawning areas; and exacerbation of harvest-related effects. Of these potential hazards to wild fish population viability, those that may be specifically applicable to Snohomish Basin hatchery programs have included: production of non-native chinook salmon that posed genetic introgression risks to native chinook salmon populations, potentially affecting their diversity and productivity; predation by newly released hatchery origin steelhead and coho salmon yearlings on rearing or emigrating wild juvenile chinook salmon, leading to decreases in wild population abundance; delay or blockage of migrating adult chinook salmon through hatchery weir operations in the Wallace River and on Tokul Creek, potentially affecting population spatial structure, productivity and abundance; incidental removal of wild chinook salmon collected at the Wallace River Hatchery weir for use as hatchery broodstock, decreasing population abundance; and overharvest of wild chinook salmon in marine and freshwater area fisheries directed at returning Snohomish Basin hatchery-origin adult fish, also decreasing population abundance.

Hatchery and harvest reform measures implemented by the fish resource managers have minimized the risk of adverse effects for most of these basin-specific hazards. Non-native chinook salmon propagated as a primary harvest augmentation stock have been replaced with Skykomish-origin stock, substantially decreasing the risk of population diversity reduction and fitness effects on native chinook salmon populations. Salmon migration delay and blockage effects at hatchery weirs have been addressed through weir reconfiguration and implementation of trapping protocols providing for timely upstream passage of wild adult salmon needed to adequately seed upstream areas. Removal effects on wild chinook salmon have been minimized through mass marking of hatchery-origin chinook salmon, allowing either visual identification and release of unmarked, wild fish or time-area management that can be documented to target hatchery fish with minimal impact on wild fish. Harvest levels on Snohomish wild chinook in fisheries directed at hatchery fish are maintained, through catch monitoring programs, within conservative overall exploitation rate guidelines applied under the harvest management plan. These harvest guidelines are expected to lead to increased wild salmon population viability. Potential predation risks to wild juvenile fish posed by hatchery-origin yearlings, especially by relatively large steelhead yearlings released in April, have not as yet been addressed through reform measures. Studies are needed to identify predation levels associated with the yearling salmon production programs, and management responses that may be necessary to minimize effects on wild salmon population abundances.

METHODS

Subbasin Strategy Groups

Sixty-two subbasins are combined into 11 subbasin strategy groups based on three variables: geospatial class, fish use and potential class, and watershed process condition class as defined below. Subbasins within these groups will play a similar role in a basinwide conservation strategy. Hypotheses were generated for each strategy group. Recommended actions and their sequence within and among groups are also identified (Step 6-1 Table and Step 6-2 Table).

Geospatial Class

This is a coarse scale subbasin grouping based on landform and location. Classes include nearshore, estuary, mainstems, lowland tributaries, and headwaters. Subbasins within geospatial classes play a similar role in supporting salmon life histories and have similar geomorphic features.

Nearshore – shoreline from Mukilteo to Kayak Point including Puget Sound out to 30 m depth below mean lower low water (MLLW) and upland areas within 200 feet of ordinary high water (OHW) or to the top of coastal bluffs, whichever is greater.

Estuary – fresh/salt water mixing zone where the Snohomish River enters Puget Sound. For this analysis, it is delineated at the upstream end where Ebey Slough breaks off from the mainstem and at the downstream at an imaginary line stretching between Priest Point, the north tip of Jetty Island, and Preston Point.

Mainstems – subbasins that contain large rivers and the lower portion of major tributaries with floodplains. For this analysis, any subbasin with other subbasins flowing into it is considered a mainstem subbasin.

Lowland Tributaries – tributary streams with a mean elevation of less than 1,000 meters.

Headwaters – tributary streams with a mean elevation greater than or equal to 1,000 meters.

Fish Use and Potential Class

The rating in this class is based on the highest rating for chinook use, chinook potential, or bull trout use as reported in the Step Table.

High Use or Potential – contains a reach or reaches with high use, high potential, or both.

Moderate Use or Potential – contains a reach or reaches with moderate use, moderate potential or both.

Low Use or Potential – contains a reach or reaches with low use, low potential, or both.

Resident Population Only – located outside the historical and current range of the anadromous fish. Subbasins above Sunset Falls on the South Fork Skykomish River are accessible due to trap and haul operations, and thus are not included in this category.

Watershed Process Condition Class

This is based on the combined scores of the hydrology, riparian, and sediment analyses in Step 3. A subbasin is classified as “intact” for hydrology or riparian conditions if 80% or more of the subbasin is “intact” based on the watershed process modeling. A subbasin is classified as “moderately degraded” for hydrology or riparian conditions if at least 50% but less than 80% of the subbasin is “intact.” A subbasin is classified as “degraded” for hydrology or riparian conditions if less than 50% of the subbasin is “intact.” The sediment process analysis was only applied in subbasins with a mean elevation greater than or equal to 1,000 meters. Subbasins with less than or equal to 1.5 times the modeled natural rate of sediment production were classified as “intact.” Subbasins with greater than 1.5 times the modeled natural rate of sediment production were classified as “degraded.”

Intact – All watershed processes assessed are “intact” within the subbasin.

Moderately Degraded – Hydrology, riparian, and/or sediment processes are “moderately degraded.” All three are neither “intact” nor “degraded.”

Degraded – All watershed processes assessed are “degraded” within the subbasin.

Primary Focus Reaches

Primary focus reaches identify current spawning concentrations for listed species. Primary focus reaches include mainstems within “focus areas” identified by the SBSRTC for the Near Term Action Agenda (NTAA), and key spawning reaches for bull trout in the Upper North Fork Skykomish and Foss River subbasins that were identified by WDFW.

Focus Reaches

These are chinook reaches that were identified for the EDT analysis that was commissioned by the Tulalip Tribes (Mobrand Biometrics, Inc. 2002) plus key spawning reaches for bull trout in the Upper North Fork Skykomish and Foss River subbasins that were identified by WDFW. While these reaches encompass the vast majority of chinook and bull trout spawning and rearing, it should be noted that chinook occur on a limited basis outside this range. Thus, the absence of an EDT reach should not be interpreted as meaning that chinook or bull trout are not present within other reaches or subbasins. Maps produced as part of the WRIA 7 LFA report (Haring 2002) provide a more comprehensive representation of known distribution.

Action Classes and Rank among Subbasin Strategy Groups

Eleven action classes were identified as a means for organizing and simplifying strategy development. In Step 6-1 Table, recommended actions are identified and ranked among subbasin strategy groups based on geospatial characteristics, current and potential level of use by chinook salmon and bull trout, and the condition of watershed processes. First, actions were identified as recommended or not recommended. If a specific action was not recommended based on available data, the cell in the table was shaded. Cells were shaded when restoration actions were not necessary because conditions were intact, inconsistent with the geospatial characteristics, or unlikely to be successful given the existing level of development. The reason the action is not recommended – intact (I), not applicable (NA), unlikely to produce the desired outcome (U) – is identified within the cell. Unshaded boxes then received a score of 1 through 5 (1 is most important and 5 is least important) to reflect the relative importance of those actions within subbasin strategy groups. Scoring is described below.

It is important to note that the Step 6-1 Table is on a coarser scale than the Step 6-2 Table. A high ranked action in the Step 6-1 Table means that addressing a specific habitat problem is a priority where it exists within the subbasin strategy group. While in most cases the identified habitat problem will occur in all subbasins within the strategy group, this may not always be the case.

Preservation Proximate to Aquatic Habitat – Protects existing habitat quantity and quality in areas of high relative current use or potential use. Actions protect areas of habitat complexity and riparian functions and provide room for channel movement. Preservation of existing high quality habitat is critical for preventing further population decline, but it is important to note that preservation does not improve population performance.

The recommended sequence is based on the rating for chinook and bull trout use and potential class, and is rated 1 through 3 for high, moderate, and low use/potential subbasin strategy groups, respectively. Areas that are inaccessible to anadromous species are shaded in the table. Their role in a basinwide strategy is primarily to provide watershed process support and cool, clean water for focus reaches downstream.

Preservation to Support Sediment and Hydrologic Processes (for Peak Flow and Base Flow) Protects watershed functions such as the delivery and routing of water and sediment that create and maintain habitat quantity and quality in focus reaches downstream. Actions protect large areas of hydrologically mature forest, floodplains, and wetlands.

This is ranked as a first tier action in most areas across the basin because protecting underlying watershed processes is critical for protecting high quality habitat downstream. The Urban Streams subbasin strategy group is ranked as a second tier action because hydrologic processes have been substantially degraded and opportunities to preserve watershed process function are limited. Preservation in urban streams will focus on the riparian vegetation and wetlands along stream corridors. While significant opportunities are limited, exceptional sites in urban areas, particularly ones that are under threat and that are in the headwaters of streams that support viable coho runs, should also be considered as first tier sites for preservation.

Two unique subbasin strategy groups are shaded because the definition does not apply. The Nearshore subbasin strategy group is shaded because there is no upland component that is not covered under the definition of “proximate habitat.” The Estuary subbasin strategy group is shaded because protection of hydrologic and sediment processes is covered by “Reconnect off-channel habitats.” Undoubtedly some upstream basins will have a greater influence on downstream habitat conditions, but the data are not currently available.

Remove Anthropogenic Instream Barriers – Increases spawning and rearing habitat capacity by restoring accessibility to streams that have been fully or partially disconnected by impassible culverts and other barriers.

This action class refers specifically to barriers along or adjacent (within ½ mile) to high use and potential reaches for chinook and bull trout. The recommended sequence is based on ratings for chinook and bull trout use and potential class, and is rated 1 through 4 for high, moderate, and low use, and resident only subbasin strategy groups, respectively. The Estuary subbasin strategy group is shaded because barriers will be addressed through restoration of tidal marsh. In addition to culverts in close proximity to chinook and bull trout reaches, hundreds of culverts block or restrict access to habitat for coho salmon and resident trout

Reconnect Off-Channel Habitats – Increases rearing habitat and in some cases spawning habitat by restoring accessibility to floodplain habitats such as side channels, sloughs and wetlands.

This is recommended in the estuary, along mainstem reaches, and in large tributaries. The recommended sequence is based on the chinook and bull trout use and potential classes, and is rated 1 through 3 for high, moderate, and low use/potential, respectively. Lowland tributaries are shaded because they generally lack substantial floodplain habitat. Headwater areas above natural barriers are shaded because most off-channel habitats remain connected, and reconnection of the few isolated off-channel habitats will have limited benefit in a multispecies, basinwide strategy.

Restore Shoreline Conditions – Increases the quantity and complexity of habitat in mainstems by modifying, setting back, and removing bank armoring.

The recommended sequence is based on ratings for chinook and bull trout use and potential class, and is rated 1 through 4 for high, moderate, and low use, and resident only subbasin strategy groups, respectively.

Restore Hydrologic Processes – Restores a more natural timing, frequency, and duration of peak flows and low (base) flows through reforestation, wetland restoration, floodplain reconnection, decommissioning of forest roads, and impervious surface reduction.

This is recommended across the basin regardless of fish use because hydrologic processes are critical for creating and maintaining high quality habitat downstream over the long term, and salmon adapted over thousands of years to the unique hydrologic conditions of the Snohomish River Basin. However, restoring substantially altered hydrologic processes to better match the peak flows, low flows, and hydrologic characteristics that were present historically is a difficult task. It will require landscape scale

actions to reduce direct runoff to streams, increase wetland area, and reforest. The Nearshore and Estuary are shaded for peak flow and base flow hydrology because actions within these subbasin strategy groups will not impact downstream subbasins in the same way. Other aspects of hydrology in these areas such as tidal exchange are addressed by other habitat actions. The Urban Streams subbasin strategy group is shaded because hydrologic processes have been substantially degraded and opportunities to restore a natural hydrologic regime are limited. A strategy for the Urban Streams strategy groups will need to acknowledge the limitations created by substantial watershed modifications. For example, culverts should be oversized to accommodate large, and potentially increasing peak flows. Several subbasin strategy groups in the headwaters are shaded because hydrologic processes are already intact.

Restore Sediment Processes – Restores sediment process functions that deliver coarse and fine sediment to the aquatic system through reforestation, wetland restoration, floodplain reconnection, decommissioning of forest roads, and impervious surface reduction. Actions are particularly important where impacts are occurring on steep slopes and unstable landforms.

This is recommended across the basin regardless of fish use because sediment processes are critical for creating and maintaining high quality habitat downstream over the long term. While this analysis is focused on stream habitat, alterations in the nearshore have reduced natural sediment delivery to beaches. The Urban Streams subbasin strategy group is shaded because sediment processes have been substantially degraded, and opportunities to restore a natural sediment regime are limited.

Riparian Enhancement – Replants and enhances riparian forests to create a protective buffer between the channel and land use actions, and provides shade, cover, nutrient recruitment, LWD recruitment, and bank stability.

The recommended sequence is based on the chinook and bull trout use and potential class, and is rated 1 through 4 for high, moderate, and low use, and resident only subbasin strategy groups, respectively. Several subbasin strategy groups in the headwaters are shaded for riparian processes because conditions are already intact.

Address Water Quality Impacts – Reduces water quality impacts through livestock fencing, farm plans, biofiltration of stormwater, shading, and reducing illicit discharges.

The recommended sequence is based on ratings for chinook and bull trout use and potential class, and is rated 1 through 4 for high, moderate, and low use, and resident only subbasin strategy groups, respectively.

Nutrient Enhancement – Increases nutrient levels in nutrient-limited freshwater environments through salmon carcass placement. Salmon carcasses provide an important input of marine-derived nutrients. As the spawner escapement has declined, the level of nutrients has also declined. In areas of the watershed with low nutrient levels that once had large run sizes, salmon carcass placement provides a short-term nutrient boost to facilitate the rebuilding of run sizes.

This is a recommended experiment as an interim solution in subbasin strategy groups within the anadromous zone where there has been a substantial reduction in salmonid abundance and water quality conditions are good. Only two subbasin strategy groups located in the headwaters meet these criteria. In the other subbasin strategy groups, there is potential that nutrient enhancement may exacerbate existing water quality problems. Nutrient enhancement is never ranked first tier because it is a temporary fix that addresses a symptom of declining salmon runs rather than a root cause.

Instream Structure Enhancement – Over time, restoration of watershed processes will restore channel complexity naturally, but in areas where there is a dearth of LWD and riparian forests are degraded, the installation of channel structures may be necessary to increase habitat quality as a near-term action. Constructed logjams may also act to jump-start natural channel migration and wood recruitment.

This is recommended in subbasin strategy groups with both “degraded” or “moderately degraded” channel conditions *and* degraded riparian conditions. The recommended sequence is based on ratings for chinook and bull trout use and potential class, and is rated 2 through 5 for high, moderate, and low use, and resident only subbasin strategy groups, respectively. Instream structure enhancement is never ranked first tier because it is not a sustainable solution over the long term.

Action Classes and Rank within Individual Subbasins

In the Step 6-2 Table, actions are identified and ranked on a coarse scale within each subbasin. The rank indicates the predicted potential “bang” relative to other actions in terms of population viability over the long term. It is based on four principles: (1) Actions that are likely to improve conditions in high use and high potential areas for chinook salmon and bull trout char are ranked over actions that address other geographic areas and species; (2) Actions that are aimed at restoration of watershed processes or reconnection of isolated habitats are ranked over actions that are more temporary in nature; (3) Actions that are not self-sustaining should only be used in areas where other options are not available or to provide a short-term fix while long-term solutions are implemented; and (4) Preservation is always a top priority because protecting existing functions is cheaper, easier, and more likely to result in the desired long-term population response than restoring lost functions (SBSRTC 1999; Spence et al. 1996). Preservation does not improve conditions and population performance, but rather prevents further decline.

If data indicate that an action is not needed or appropriate given current watershed conditions, it is marked (by shading the cell) as no action. Source data are identified in parentheses next to the action class title.

Preservation Proximate to Aquatic Habitat

Rank 1 – The subbasin contains one or more focus reaches. Preservation of high quality areas (i.e., intact riparian forest within the channel migration zone, wetlands) proximate to aquatic habitat for the purpose of protecting habitat complexity is recommended first along focus reaches, and second along other fish-bearing waters within the subbasin. An example of identification of existing high quality salmon habitat that should be preserved along a focus reach, the Snohomish Estuary, is provided by the Snohomish Estuary Wetland Integration Plan (SEWIP City of Everett et al. 1997) and the SEWIP Salmon Overlay (City of Everett and Pentec 2001). The Salmon Overlay divided the estuary and adjacent nearshore into 132 assessment units (AU) and ranked the relative ecological function provided by existing habitat for juvenile salmonids. The City of Everett subsequently has protected all those areas ranked in the top quartile within its urban growth boundary. The remaining higher quality habitats (AU) within Snohomish County could be targeted for juvenile protections. This type of approach could be applied to identify priorities in other high use and potential areas.

Rank 2 – The subbasin does not contain a focus reach, but may contain critical habitat for other salmonid species. Preservation of high quality areas proximate to aquatic habitat for the purpose of protecting complexity is recommended along fish-bearing waters within the subbasin.

Preservation to Support Sediment and Hydrologic Processes (for Peak Flow and Base Flow)

Rank 1 – Preservation actions that protect the controlling processes of hydrology and sediment are ranked first tier in all subbasins where these processes are “intact” or “moderately degraded” and along the mainstems. Preserving existing functions is easier than restoring lost functions. Watershed processes create and maintain the habitat conditions that sustain fish populations. Whether in the headwaters, lowland tributaries or along mainstems that provide primary rearing and spawning habitat for chinook, preservation actions that protect the driving watershed processes such as hydrology, sediment, and riparian/LWD recruitment are critical actions.

Rank 2 – In urban lowland streams with “degraded” hydrologic and sediment processes, opportunities are limited for protecting these functions across the subbasin. Therefore, from a basinwide perspective, preservation in urbanized streams away from wetland and stream corridors has a lower benefit relative to the cost. While this will generally be the case, exceptional sites in urban areas, particularly ones that are under threat and that are in the headwaters of streams that support viable coho runs, should also be considered as rank 1 sites for preservation.

Remove Anthropogenic Instream Barriers (Step 2 and Culvert Database)

Rank 1 – This rank is assigned if access to habitat is “degraded” within the subbasin and areas blocked are on or adjacent to a focus reach. If the anthropogenic instream barriers were identified as a data gap in Step 2, then results of an ongoing culvert analysis by Snohomish County were used to fill the data gap.

Rank 2 – This rank is assigned if access to habitat is “moderately degraded” within the subbasin or access to habitat is “degraded” within the subbasin, but areas blocked are not on or adjacent to a focus reach. If the anthropogenic instream barriers were identified as a data gap in Step 2, then results of an ongoing culvert analysis by Snohomish County were used to fill the data gap.

Data Gap (DG) – No barriers have been identified and little or no culvert passability inventory has occurred⁶.

Reconnect Off-Channel Habitats (Step 2 plus HCR, LFA, and NTAA)

Rank 1 – Contains one or more focus reaches, and opportunities to reconnect habitat within the floodplain have been identified.

Rank 2 – Does not contain a focus reach, and opportunities to reconnect habitat within the floodplain have been identified.

No Action (Shaded) – Protection is needed to maintain functioning conditions, but no restoration actions are recommended at this time. No major opportunities have been identified and are not likely to exist because the subbasin is relatively pristine, or channels within the subbasin are entrenched and lacking floodplains. Areas that are not accessible to anadromous fish have been included in this category.

Data gap (DG) – No information has been compiled on disconnected off-channel habitat in the subbasin.

Restore Shoreline Conditions (Step 2)

Rank 1 – There are one or more focus reaches and the shoreline conditions are “degraded” or “moderately degraded.”

Rank 2 – Shoreline conditions are “degraded” or “moderately degraded” along fish-bearing waters within the subbasin but not specifically along focus reaches.

No Action (Shaded) – Protection is needed to maintain functioning conditions, but no restoration actions are recommended at this time. Shoreline conditions have been surveyed and are “intact.”

⁶ Even in areas with known blockages, the number of blocking culverts is likely to be a significant underestimate. Hundreds of culverts throughout the basin have never been surveyed. Culvert passability is a major data gap on a basin scale.

Data Gap (DG) – No information has been compiled on shoreline conditions in the subbasin.

Restore Hydrologic Processes (Step 3)

Rank 1 – Peak flow hydrology is “intact” in 50 to 80% of the subbasin based on the watershed process modeling in Step 3. This analysis replaces the hydrology habitat condition rating in the HCR.

No Action (Shaded) – Protection is needed to maintain functioning conditions, but no restoration actions are recommended at this time. Hydrologic processes are “intact” in over 80% of the subbasin area. Urban lowland streams with hydrologic processes that are less than 50% intact are also in this category because there are limited opportunities to restore hydrologic processes in these situations.

Restore Sediment Processes (Step 3)

Rank 1 – Sediment processes are “degraded” within the subbasin based on the watershed process modeling in Step 3, or specific problem areas are identified based on quantitative data reported in the HCR and/or LFA.

No Action (Shaded) – Protection is needed to maintain functioning conditions, but no restoration actions are recommended at this time. Sediment processes are “intact” within the subbasin based on the watershed process modeling in Step 3, and no specific problem areas are identified based on quantitative data reported in the HCR and LFA.

Data Gap (DG) – No information has been compiled on sediment processes in the subbasin. Due to modeling limitations, sediment processes were only modeled in basins with a mean elevation greater than or equal to 1,000 meters. Sediment data in lowland subbasins is limited and sporadic.

Riparian Enhancement (Step 3)

Rank 1 – Subbasin contains one or more focus reaches and riparian conditions are “moderately degraded” or “degraded” along the focus reaches based on the analysis in Step 3.

Rank 2 – Subbasin contains “moderately degraded” or “degraded” riparian habitat, but the habitat does not occur along focus reaches.

No Action (Shaded) – Protection is needed to maintain functioning conditions, but no restoration actions are recommended at this time. Riparian conditions are “intact” within the subbasin based on the analysis in Step 3.

Address Water Quality Impacts (Step 2)

Rank 1 – Subbasin contains one or more focus reaches and water quality is “moderately degraded” or “degraded.”

Rank 2 – Water quality is “moderately degraded” or “degraded” within the subbasin, but water quality problems are not found along focus reaches, or where there is uncertainty regarding the extent to which water quality conditions reflect human impacts or are naturally occurring.

No Action (Shaded) – Protection is needed to maintain functioning conditions, but no restoration actions are recommended at this time. Water quality conditions have been surveyed and are “intact.”

Data Gap (DG) – No information has been compiled on water quality within the subbasin.

Nutrient Enhancement (Steps 2 and 4)

Rank 1 – Not applicable. Nutrient enhancement will never be a first tier action because it addresses a symptom of depressed salmonid runs rather than a root cause. Addition of salmon carcasses to waterbodies in a subbasin provides nutrient enhancement for only one year and therefore is not self-sustaining.

Rank 2 – Subbasin contains reaches with low escapement relative to historic conditions and does not have water quality problems.

No Action (Shaded) – Subbasin does not meet the second tier criteria.

Instream Structure Enhancement (Steps 2 and 3)

Rank 1 – Not applicable. Placing LWD in rivers and streams will never be a first tier action because it addresses a symptom of depressed salmonid runs rather than a root cause. Instream structure placement will not likely be self-sustaining, and therefore will not improve habitat over the long-term.

Rank 2 – LWD abundance (Step 2) and riparian conditions (Step 3) are “moderately degraded” or “degraded” within the subbasin based on the analyses in Steps 2 and 3. LWD placement is recommended as a short term action as part of a long-term plan to restore LWD recruitment.

No Action (Shaded) Protection is needed to maintain functioning conditions, but no restoration actions are recommended at this time. LWD abundance and/or riparian conditions are “intact.”

Data Gap (DG) – Data do not exist on LWD abundance.

RESULTS

Results of this action plan analysis are summarized in Step 6-1 Table; Step 6-2 Table; Maps 6-1, 6-2, and 6-3; and below. The hypothesized role of each subbasin strategy group is identified below. The prioritization scheme below is organized to show the priorities *among* subbasin strategy groups. Therefore, it is possible for a subbasin strategy group to have second tier priorities but no first tier priorities on a basin scale. In this example, the second tier priority would be the highest priority *within* the subbasin strategy group.

Subbasin Strategy Group Descriptions, Hypotheses, and Recommended Actions

Nearshore – Restoration

- Geospatial class: Nearshore; Subbasins: Nearshore
- Chinook use and potential use classification: High
- Watershed process condition: Moderately degraded
- Coho use: High
- Recovery need: Substantial improvement over current condition
- General strategy: Habitat/process restoration

Description: The nearshore is the interface between air, land, freshwater and saltwater. The nearshore subbasin encompasses the marine waters of Puget Sound out to a depth of -30 meters mean low low water (MLLW) (photic zone) from Mukilteo to Kayak Point, Hat Island, as well as the corresponding shorelines

and upland areas to the top of coastal bluffs. The nearshore provides critical habitat for multiple life history stages of chinook and bull trout, and spawning habitat for forage fish that lay their eggs in eelgrass and on the beach. Land use is residential, commercial, and industrial. Ownership along the shoreline includes: private, Tulalip Tribes, City of Everett, Port of Everett, U.S. Navy, and Burlington Northern Railroad. The Snohomish Estuary, often considered part of the nearshore, has been delineated as a distinct subbasin. The waterbodies in the nearshore are Port Gardner, eastern Possession Sound, southern Port Susan, the mouth of the lower Snohomish River channel, the west shore of Jetty Island, and Hat (Gedney) Island.

The nearshore north of the Snohomish Estuary is in considerably better condition than the shoreline to the south. Relatively unimpeded feeder bluffs exist between Priest Point and Mission Beach. The shoreline north of Potlatch Beach is also relatively unimpacted as is much of the shoreline of Hat Island. Significant sand lance spawning occurs around the entire circumference of the island. At the mouth of the delta, extensive eelgrass beds cover over 1,000 acres.

Hydrology in this subbasin is driven by tidal circulation. Sediment delivery, transport and deposition occur within drift cells. Sediment delivery and transport, riparian conditions, and shoreline conditions have been extensively modified in the nearshore environment, most notably as a result of the Burlington Northern railroad and also as a result of bulkheads, riprap, piers, and dredging. These modifications have degraded upper beach habitat used by forage fish for spawning and reduced low gradient, low energy environments used by salmonids (SBSRTC 2002, Haring 2002). Sediments in portions of the East Waterway contain high levels of toxic metals and organic chemicals that do not meet State of Washington sediment quality standards (SBSRTC 2002).

Hypothesis: Additional restoration of the Puget Sound nearshore environment was identified in the EDT analysis as necessary to bridge the gap between the population performance levels under modeled scenarios and the Shared Strategy planning range (Mobrاند Biometrics, Inc. 2002). Sensitivity analysis of the SHIRAZ model also indicates that improvements in juvenile nearshore survival will have a significant positive impact. Reducing the extent of the modifications in sediment delivery and transport, riparian conditions, and shoreline conditions will provide a significant improvement in productivity and salmonid survival in the nearshore environment.

Recommended Actions

First Priority

- Preservation – i.e., protect areas of undeveloped shoreline, protect spawning areas for forage fish, retain forest cover along the Puget Sound shoreline and in coastal drainages, prevent fill or dredging within the photic zone, protect eelgrass beds on the delta front.
- Restore shoreline conditions – i.e., remove armoring and bulkheads, lessen slopes of armored banks, use bioengineering techniques in place of riprap.
- Restore sediment processes – i.e., remove barriers to sediment transport, increase connectivity between coastal bluffs and the marine environment.
- Riparian enhancement – i.e., replant deforested areas of the Puget Sound shoreline and coastal drainages with native vegetation.

Second Priority

- Address water quality impacts – i.e., fix leaking septic systems, implement farm plans, correct illicit discharges, remove contaminated sediment.

Other Actions (not prioritized)

- Control invasive species.

Estuary – Restoration

- Geospatial classification: Estuary; Subbasins in this group: Estuary
- Chinook/bull trout use and potential classification: High
- Watershed process condition: Degraded
- Coho use: High
- Recovery need: Substantial improvement over current condition
- General strategy: Habitat/process restoration

Description

The Snohomish River Estuary includes the Snohomish River mainstem, three distributary sloughs, and marshes between Possession Sound and the divergence of Ebey Slough from the mainstem. The hydrology of this subbasin is driven by tidal circulation. Land use is agricultural, residential, commercial, and industrial. Hundreds of acres are in public ownership. The estuary, a highly productive and diverse environment, provides unique and critical habitat for chinook and other salmonids for rearing and making the freshwater to saltwater transition (smoltification). Bull trout overwinter and forage in the estuary as well.

Levees that have disconnected the Snohomish River from tidelands and marshes have dramatically altered the hydrology of the estuary, resulting in a loss of tidal marsh and blind tidal channels. Eighty-five percent of the historic area of tidal marsh is no longer accessible to salmonids. Extensive diking, riparian clearing, and wood removal have altered habitat conditions in the channel margins (Snohomish Basin Salmon Recovery Forum 2001). Other factors degrading habitat conditions include impassible tidegates and pump stations, log rafting, altered sediment deposition, and poor water quality. Degraded water quality is manifested in high temperatures, low dissolved oxygen levels, and high fecal coliform counts that do not meet State of Washington water quality standards. Estuarine sediments contain high levels of toxic metals and organic chemicals that do not meet State of Washington sediment quality standards (SRBSRTC 2002).

There have been recent positive trends. Several areas on North Spencer Island breached naturally in the 1960s and 1970s. Recent actions have reconnected over 100 acres of tidal marsh, and planning and design work is underway to restore hundreds more (City of Everett and Pentec 2000). Two useful estuary-wide planning efforts have been completed that evaluate a large number of potential restoration actions. These plans (Haas 2001; City of Everett and Pentec 2001) provide guidance and rankings of the most effective project actions that could be taken to restore estuarine habitat for salmon.

Hypothesis: Preliminary modeling with EDT and SHIRAZ has identified the estuary as one of the most important places to focus preservation and restoration actions for both chinook and bull trout populations. The loss of 85% of the historic tidal marsh area, loss of edge habitat complexity along major slough channels, and habitat fragmentation have depressed population performance. Addressing these problems will provide significant improvements in abundance, productivity and diversity for chinook and bull trout populations, as well as for other species. Two useful estuary-wide planning efforts have been completed that evaluate a large number of potential restoration actions. These plans (Haas 2001; City of Everett and

Pentec 2001) provide guidance and rankings of the most effective project actions that could be taken to restore estuarine habitat for salmon.

Recommended Actions:

First Priority

- Preservation – i.e., protect existing tidal marsh, maintain restoration opportunities through protection of properties with high potential to be restored to tidal marsh.
- Improve fish passage and tidal exchange on tide-gated streams entering the estuary.
- Reconnect off-channel habitats – i.e., restore tidal marsh, reconnect large blind tidal channels and distributary sloughs isolated behind dikes, improve connectivity among sloughs and marsh habitats.
- Restore shoreline conditions – i.e., set back dikes from the channel edge, remove dikes as part of tidal marsh restoration projects, incorporate LWD.
- Riparian enhancement – i.e., replant native vegetation along channel margins, relict dikes, and sloughs and creeks draining into distributary sloughs and the mainstem.

Second Priority

- Address water quality impacts – i.e., prevent illicit discharges, livestock fencing along channels that drain to the estuary.
- Instream structural enhancement – i.e., Place LWD to enhance edge habitat conditions in marshes and along the edges of mainstem and distributary sloughs.

Other Actions (not prioritized)

- Reduce log-rafting – i.e., buy log-rafting rights from critical areas.

Mainstems – Primary Restoration

- Geospatial classification: Mainstems; Subbasins in this group: Skykomish River – Lower Mainstem, Skykomish River – Upper Mainstem, Skykomish River – South Fork, Skykomish River – Upper South Fork, Sultan River – Lower, Snoqualmie River – Mouth, Snoqualmie River – Mid Mainstem, Snoqualmie River – Upper Mainstem, Pilchuck River – Middle, Upper Snohomish/Cathcart, Lower Snohomish/Marshland, Tolt River – Lower, and Raging River
- Chinook/bull trout use and potential classification: High
- Watershed process condition: Moderately Degraded or Degraded
- Coho use: High: Snoqualmie River – Mouth, Tolt River – Lower; Moderate: Skykomish River – Upper Mainstem, Snoqualmie River – Upper Mainstem, Pilchuck River – Middle, Raging River; Known presence: Skykomish River – Lower Mainstem, Skykomish River – South Fork, Skykomish River – Upper South Fork, Sultan River – Lower, Snoqualmie River – Mid Mainstem, Upper Snohomish/Cathcart, Lower Snohomish/Marshland
- Recovery need: Substantial improvement over current condition
- General strategy: Habitat/process restoration

Description

The waterbodies in this category are large rivers with floodplains in the mid and lower basin. The rivers flow west/northwest out of the Cascade Mountains through broad alluvial valleys of the Puget Lowland. High monthly flows occur from November through January due to winter rains and increased meltwater from rain-on-snow events, and from May through June due to high elevation snowmelt. Annual low flows occur in August and September. Land use is predominantly agricultural and rural residential with some urban and commercial development in cities along the rivers.

This subbasin strategy group contains the core chinook spawning and freshwater rearing in the Snohomish River Basin. Bull trout exhibiting fluvial and anadromous life history strategies use mainstems for rearing, overwintering habitat for subadults, and adult foraging. They are also the primary areas for pink salmon spawning. Coho spawning upstream in small streams use mainstem and associated off-channel habitat for rearing. All anadromous salmonid species use mainstems for migration and holding pools (Pentec Environmental and NW GIS 1999, Snohomish Basin Salmon Recovery Forum 2001, Haring 2002).

Dikes, bank armoring, roads, railroads, and bridges confine these mainstem rivers, disconnect off-channel habitat, reduce edge habitat complexity, and increase peak flows downstream. Riparian forests have also been substantially reduced. Other habitat problems in this subbasin strategy group include excessive erosion of streambanks, dearth of LWD, and degraded water quality, i.e., high temperature, low dissolved oxygen, high fecal coliform counts, and high levels of toxic metals (SBSRTC 2002, Solomon and Boles 2002, Haring 2002).

Hypothesis

Along with the estuary and nearshore environments, preliminary modeling efforts have identified subbasins within this group as having the highest potential gains with restoration and highest potential losses if further degradation occurs. Current spawning capacity is thought to be adequate. While spawning habitat quality has been impacted in some locations by altered sediment and flow regimes, the loss of rearing habitat quantity and quality is the primary factor affecting population performance. Setting back and removing armoring, restoring access to isolated habitats, replanting riparian forests, and implementing agricultural best management practices (BMPs) will provide the greatest returns in population performance of any restoration actions in the freshwater environment. Major improvements in habitat conditions within this subbasin strategy group will be necessary to produce an outcome in terms of abundance and productivity within the Shared Strategy planning range.

Recommended Actions

First Priority

- Preservation (along focus reaches) – i.e., protect intact riparian forest, protect oxbows, prevent floodplain development or fill, maintain opportunities for rivers to migrate within their channel migration zones.
- Preservation to support sediment and hydrologic processes (for peak flow and base flow) – i.e., large-scale actions to retain wetlands, floodplains, and forest cover, and limits on water withdrawals.
- Remove human-made instream barriers along or adjacent to priority reaches – i.e., fix blocking culverts, pump-stations, flood-gates and tide-gates to provide access by salmonids.
- Reconnect off-channel habitats – i.e., set back or remove dikes to allow for channel migration and to reconnect off-channel features such as oxbows and side channels.
- Restore shoreline conditions – i.e., remove riprap, incorporate LWD into armored banks.

- Restore sediment and hydrologic processes (for peak flow and base flow) – i.e., increase wetland functions and values, reconnect floodplains, reforestation, and remove impervious surfaces.
- Riparian enhancement.

Second priority

- Address water quality impacts – i.e., prevent illicit discharges, implement agricultural BMPs and farm plans.
- Instream structural enhancement – i.e., installation of engineered log jams.

Other Actions (not prioritized)

- Culvert replacement on small streams– i.e., prioritize and replace blocking culverts on coho streams based on available habitat upstream. Coho use has been documented at high and moderate levels on index reaches within the Upper Mainstem Skykomish, Upper Mainstem Snoqualmie, Middle Pilchuck, Lower Tolt, and Raging River subbasins. Other streams may also have high potential gains for coho that have not yet been documented.

Mainstems – secondary restoration

- Geospatial classification: Mainstems; Subbasins: May Creek/Lower Wallace, Skykomish River – Lower North Fork, Skykomish River – Lower South Fork, Woods Creek – Lower, Tolt River – South Fork Below Dam, Pilchuck River – Lower; Coal Creek – Lower
- Chinook/bull trout use and potential class: Moderate
- Watershed process condition: Moderately Degraded
- Coho use: High: Skykomish River – Lower North Fork; Moderate: Skykomish River – Lower South Fork; Known presence: May Creek/Lower Wallace, Woods Creek – Lower, Tolt River – South Fork Below Dam, Pilchuck River – Lower; Coal Creek – Lower
- Recovery need: Moderate improvement over current condition
- General strategy: Habitat/process restoration

Description

These subbasins contain small rivers with floodplains and large mainstem river reaches that have lower levels of current chinook spawning or spawning potential relative to mainstem rivers in the primary group. High monthly flows occur from November through January due to winter rains and increased meltwater from rain-on-snow events, and from May through June due to high elevation snowmelt. Annual low flows occur in August and September. Land use is a mix of rural residential, agriculture and forestry with some urban and commercial development and transportation corridors in cities along the rivers.

Subbasins in this strategy group contain satellite chinook spawning and rearing areas, as well as spawning and rearing habitat for other salmonids and presumed foraging habitat for bull trout (Pentec Environmental and NW GIS 1999, Snohomish Basin Salmon Recovery Forum 2001, Haring 2002). Habitat problems include decreased fish passage due to human-made barriers such as culverts (primarily affecting coho); loss of floodplain connectivity due to dikes, bank hardening, roads, railroads, and bridges; excessive erosion of streambanks; and loss of riparian vegetation. A paucity of LWD, low flows

(particularly the Pilchuck River) and degraded water quality due to high temperature, nutrient levels, and fecal coliform counts are problems in some of these waterbodies (SBSRTC 2002, Haring 2002).

Hypothesis

Subbasins in the mainstem – secondary restoration strategy group have similar habitat issues to the previous group. Although actions within this group are not likely to achieve as great of a response in terms of chinook abundance and productivity in the short-term, restoring riparian forests and floodplain connectivity, correcting fish passage barriers, and reducing the negative impacts of urbanization and forest clearing within these areas will provide significant long-term benefits in terms of chinook salmon viability, particularly for spatial structure and diversity. It should also be noted that low flows are thought to limit production in the Lower Pilchuck subbasin, and may also be a problem in other small rivers. Actions within these subbasins provide direct and downstream benefits for all salmonid species. Many core chinook spawning reaches occur directly downstream. Without recovery actions in this group, it will be unlikely that population performance will recover to the target levels identified by Shared Strategy.

Recommended Actions

First Priority

- Preservation to support sediment and hydrologic processes (for peak flow and base flow) – i.e., large-scale actions to retain wetlands, floodplains, and forest cover, and limits on water withdrawals.
- Restore sediment and hydrologic processes (for peak flow and base flow) – i.e., increase wetland functions and values, reconnect floodplains, reforest, and remove impervious surfaces.

Second Priority

- Preservation (along focus reaches) – i.e., protect intact riparian forest, protect oxbows, prevent floodplain development or fill, maintain opportunities for rivers to migrate within their channel migration zones.
- Remove human-made instream barriers along or adjacent to priority reaches – i.e., fix blocking culverts, weirs, pump-stations and flood-gates to provide access by salmonids.
- Restore shoreline conditions – i.e., remove riprap, incorporate LWD into armored banks.
- Riparian enhancement.

Third Priority

- Address water quality impacts – i.e., prevent illicit discharges, implement agricultural BMPs and farm plans.
- Instream structural enhancement – i.e., install engineered log jams.

Other Actions (not prioritized)

- Culvert replacement on small streams– i.e., prioritize and replace blocking culverts on coho streams based on available habitat upstream. Skykomish River – Lower North Fork, Skykomish River – Lower South Fork, Snoqualmie River – Mouth subbasins contain index reaches that have high and moderate coho use. Other streams may also have high potential for coho that has not been documented.

Rural Streams – primary restoration

- Geospatial class: Lowland tributaries; Subbasins: Woods Creek – West Fork, Cherry Creek
- Chinook/bull trout use and potential classification: Moderate
- Watershed process condition: Moderately degraded
- Coho use: High: Cherry Creek; Moderate: Woods Creek – West Fork
- Recovery need: Moderate improvement over current condition
- General strategy: Habitat/process restoration

Description

The West Fork of Woods Creek and Cherry Creek are large rural tributaries to the Skykomish River and Snoqualmie River, respectively. Mean monthly flows in these creeks increase from September through January as rainfall increases, and then decrease to a low point in August (Pentec Environmental and NW GIS 1999). Land use is agricultural and rural residential in the lower part of the subbasins and forestry upstream. These waterbodies contain or have the potential to support moderate levels of chinook spawning and are also important for coho spawning and rearing. There is presumed foraging and overwintering habitat for bull trout as well.

Habitat problems include decreased fish passage due to human-made barriers such as culverts; increased bank erosion and deposition of fine sediments in spawning gravel (Woods Creek – West Fork only); degraded water quality due to high temperature and fecal coliform counts that violate State of Washington water quality standards; immature or no riparian vegetation along agricultural lands; paucity of LWD; loss of wetlands; and loss of floodplain connectivity due to dikes (Cherry Creek only) (SBSRTC 2002, Haring 2002).

Hypothesis

Of the lowland tributary class, these subbasins have the highest potential to support chinook salmon. They have a similar level of importance as part of a basinwide strategy to the mainstem – secondary restoration group. Although not as critical as in the mainstem-primary restoration class and estuary, restoring riparian forests, addressing sediment problems, correcting fish passage barriers, restricting livestock access to streams, reconnecting isolated habitats, and restoring habitat complexity within this group will be important for chinook population viability. Maintaining and restoring habitat within these areas will be particularly important for spatial structure and diversity. In addition to providing chinook benefits, these subbasins are critical for coho salmon. Blocking culverts, a well-documented problem, is a major priority to address for coho. Actions in this subbasin strategy group provide direct and downstream benefits to all salmonid species.

Recommended Actions

First Priority

- Preservation to support sediment and hydrologic processes (for peak flow and base flow) – i.e., large-scale actions to retain wetlands, floodplains, and forest cover, and limits on water withdrawals.
- Restore sediment and hydrologic processes (for peak flow and base flow) – i.e., restore wetland functions and values, reforest, remove impervious surfaces.

Second Priority

- Preservation (along focus reaches) – i.e., protect intact riparian forest, floodplains and inner gorges, and maintain opportunities for rivers to migrate within their channel migration zones.
- Remove human-made instream barriers along or adjacent to priority reaches – i.e., fix blocking culverts to provide access by salmonids.
- Restore shoreline conditions – i.e., remove riprap, incorporate LWD into armored banks.
- Riparian enhancement.

Third Priority

- Address water quality impacts – i.e., prevent illicit discharges, implement agricultural BMPs and farm plans.
- Instream structural enhancement – i.e., install engineered LWD.

Other Actions (not prioritized)

- Culvert replacement on small streams – i.e., prioritize and replace blocking culverts on coho streams based on available habitat upstream. Cherry Creek has been identified as a high-use coho subbasin and Woods Creek – West Fork a moderate use subbasin.

Rural Streams – secondary restoration

- Geospatial classification: Lowland tributaries; Subbasins: Bear Creek, Woods Creek, Ames Creek, Harris Creek, Patterson Creek, Dubuque Creek, Little Pilchuck Creek, French Creek, Tulalip/Battle Creeks
- Chinook/bull trout use and potential classification: Low
- Watershed process condition: Moderately degraded
- Coho use: Moderate: Woods Creek, Harris Creek, Patterson Creek, Dubuque Creek; Known presence: Bear Creek, Ames Creek, Little Pilchuck Creek, French Creek; None: Tulalip/Battle Creeks
- Recovery need: Minor improvement over current condition
- General strategy: Process restoration

Description

These creeks are smaller rural tributaries to mainstem rivers. Mean monthly flows increase from September through January as rainfall increases, and then decrease to a low point in August (Pentec Environmental and NW GIS 1999). This group of subbasins is undergoing rapid development, with increasing conversion of forested land to agricultural, rural residential, and suburban residential land uses. The creeks are used by chinook at low levels, but are very important for coho salmon spawning and rearing. Bull trout are presumed to forage in many of the subbasins as well.

Habitat problems in this group include decreased fish passage due to human-made barriers such as culverts, dams, and pump stations; increased bank erosion and deposition of fine sediments in spawning gravel; degraded water quality due to high temperature, low dissolved oxygen, high nutrient levels, high copper and lead levels (Patterson Creek only); and high fecal coliform counts that violate State of Washington water quality standards; loss of riparian vegetation; paucity of LWD; loss of floodplain wetlands; and loss of floodplain connectivity/function due to levees, bank armoring,

channelization/ditching, and road encroachment (SBSRTC 2002; Haring 2002; Solomon and Boles 2002).

Hypothesis

Subbasins within this group provide habitat critical to coho salmon, and to a lesser extent, salmonid species listed under the ESA. Protecting and restoring watershed processes through forest retention and limiting impervious surface is important for multi-species protection and to create and maintain suitable conditions downstream for chinook spawning and rearing. Addressing barriers across this subbasin strategy group, and in particular, at the mouth of French Creek, Tulalip Creek, and Battle Creek, would provide substantial benefits for wild salmonids.

Recommended Actions:

First Priority

- Preservation to support sediment and hydrologic processes (for peak flow and base flow) – i.e., large-scale actions to retain wetlands, floodplains, and forest cover, and limits on water withdrawals.
- Restore sediment and hydrologic processes (for peak flow and base flow) – i.e., restore wetland functions and values, reforestation, remove impervious surface.

Second Priority

- None listed

Third Priority

- Preservation (along focus reaches) – i.e., protect intact riparian forest, floodplains and inner gorges, and maintain opportunities for rivers to migrate within their channel migration zones.
- Remove human-made instream barriers along or adjacent to priority reaches – i.e., fix blocking culverts.
- Restore shoreline conditions – i.e., remove riprap, incorporate LWD into armored banks.
- Riparian enhancement.
- Address water quality impacts – i.e., prevent illicit discharges, agricultural BMPs, farm plans.

Fourth Priority

- Instream structural enhancement – i.e., installation of LWD.

Other Actions (not prioritized)

- Culvert replacement on small streams – i.e., prioritize and replace blocking culverts on coho streams based on available habitat upstream. Woods Creek, Harris Creek, Patterson Creek, and Dubuque Creek subbasins contain index reaches with high or moderate coho use. Other creeks such as French Creek, and Tulalip and Battle creeks have high potential if barriers at the mouths of these subbasins are addressed.

Urban Streams – Restoration

- Geospatial Classification: Lowland tributaries; Subbasins: Lake Stevens Drainages, Everett Coastal Drainages, Fobes Hill, Quilceda Creek, Allen Creek, Sunnyside Drainages
- Chinook/bull trout use and potential classification: Low
- Watershed process condition: Degraded
- Coho use: Moderate: Quilceda Creek; Known presence: Lake Stevens Drainages, Everett Coastal Drainages, Fobes Hill, Allen Creek, Sunnyside Drainages
- Recovery need: Maintain current habitat level and functions
- General strategy: Instream/riparian habitat restoration

Description

These Puget lowland subbasins flank the Snohomish River Estuary and have the highest levels of land development and development pressure in the basin. Land use is predominantly urban and rural residential development. There is little to no chinook spawning, but the lower reaches provide rearing habitat for chinook. Coho salmon and other salmonids use these subbasins as well (Pentec Environmental and NW GIS 1999).

Habitat problems in this group include decreased fish passage due to human-made barriers such as culverts; increased bank erosion and deposition/embeddedness of fine sediments in spawning gravel; increased peak flows and decreased low flows due to high percentage effective impervious area; degraded water quality due to high temperature, low dissolved oxygen, high nutrient levels, high lead levels (Everett Coastal Drainages only), and high fecal coliform counts that do not meet State of Washington water quality standards; loss of riparian vegetation and floodplain wetlands; paucity of LWD; and loss of floodplain connectivity due to dikes, bank armoring and stream channelization/ditching (SBSRTC 2002, Haring 2002).

Hypothesis

Watershed processes have been substantially altered within this subbasin strategy group. Managing these subbasins to prevent downstream impacts will be adequate for a basinwide chinook recovery strategy if substantial restoration efforts are undertaken in other areas. Particular care should be taken to protect habitat quality (i.e., water quality, temperature, sediment transport) and diversity where creeks enter the estuary and nearshore environment. Maintaining and restoring riparian forests and fixing culverts within this group may allow these waterbodies to continue to support small populations of resident trout, coho, and occasionally chinook salmon. Quilceda Creek and Lake Stevens drainages, exceptions within this group due to abundant wetlands, still support significant coho production. With additional protective measures to retain remaining wetlands, riparian forests, and forest cover, these two subbasins can support coho runs in perpetuity.

Recommended Actions:

First Priority

- None listed

Second Priority

- None listed

Third Priority

- Preservation (along focus reaches) – i.e., protect intact riparian forest, floodplains and inner gorges, and maintain opportunities for rivers to migrate within their channel migration zones.
- Remove human-made instream barriers along or adjacent to priority reaches – i.e., fix blocking culverts.
- Restore shoreline conditions – i.e., remove riprap, incorporate LWD into armored banks.
- Riparian enhancement.
- Address water quality impacts – i.e., prevent illicit discharges, biofilter surface water runoff from impervious surfaces.

Fourth Priority

- Instream structural enhancement – i.e., install LWD.

Other Actions (not prioritized)

- Culvert replacement on small streams – i.e., prioritize and replace blocking culverts on coho streams based on available habitat upstream. Quilceda Creek and Lake Stevens subbasins are the big coho producers within this subbasin strategy group.

Headwaters – Primary Protection

- Geospatial classification: Headwaters; Subbasins: Skykomish River – Upper North Fork, Foss River
- Chinook/bull trout use and potential class: High
- Watershed process conditions: Intact
- Coho use: Known presence: Skykomish River – Upper North Fork, Foss River
- Recovery need: Minor improvement over current conditions.
- General strategy: Maintain preservation of existing habitat and watershed process

Description

These subbasins are located in the headwaters of the Skykomish River and are located almost entirely on federal lands. This subbasin strategy group encompasses the primary spawning and rearing habitat for bull trout as well as critical habitat for chinook. Bull trout spawning occurs in Foss River and North Fork Skykomish mainstems and in Goblin, Salmon, Troublesome, and West Cady creeks (Upper North Fork Skykomish subbasin) Access to the Foss River by anadromous salmonids is provided artificially. WDFW runs a trap and haul operation at Sunset Falls, a natural barrier on the South Fork Skykomish River. Watershed process conditions are intact.

Hypothesis

Preservation of watershed process conditions in this subbasin strategy group is critical for maintaining viable bull trout populations in the Snohomish River Basin because it contains nearly all of the bull trout spawning in the basin. Protection of watershed processes also supports chinook and coho spawning in the subbasins and downstream. A few opportunities exist to improve conditions along channel edges, but generally the strategy is to preserve habitat that is already functioning well.

Recommended Actions

First Priority

- Preservation (along focus reaches) – i.e., protect intact riparian forest, protect multi-threaded channels, maintain opportunities for rivers to migrate within their channel migration zones.
- Preservation to support sediment and hydrologic processes (for peak flow and base flow) – i.e., large-scale actions to retain floodplains, wetlands, and forest cover.
- Restore shoreline conditions – i.e., remove bank armor that is no longer needed along decommissioned roads.

Second Priority

- Marine-derived nutrient enhancement – i.e., salmon carcass placement (NF Skykomish only).

Headwaters – Secondary Protection

- Geospatial Group: Headwaters; Subbasins: Griffin Creek, Tolt River – North Fork, Beckler River, Pilchuck River – Upper, Tokul Creek, Tye River, Wallace River – Upper
- Chinook/bull trout use and potential class: Moderate
- Watershed process conditions: Moderately degraded
- Coho use: High: Griffin Creek; Known presence: Tolt River – North Fork, Beckler River, Pilchuck River – Upper, Tokul Creek, Tye River, Wallace River – Upper
- Recovery need: Moderate improvement over current conditions
- General strategy: Habitat/process restoration

Description

These subbasins contain upper to mid elevation streams and small rivers. High monthly flows occur from November through January due to winter rains and increased meltwater from rain-on-snow events, and in May through June due to snowmelt. Annual low flows occur in August and September. Located entirely or partially in the forest production zone, there are some forest and recreational land use impacts to these waters. Current chinook use is low but with potential to support larger runs. Coho use is significant.

Hypothesis

Actions in these subbasins will provide a response in terms of chinook population performance on par with the rural streams – primary restoration strategy group and could have significant multi-species benefits. They contain significant coho habitat and would likely sustain larger runs if blocking culverts

and other habitat problems are addressed. Restoring watershed process is important for supporting spawning and rearing that occurs in these subbasins and in downstream reaches.

Recommended Actions:

First Priority

- Preservation to support sediment and hydrologic processes (for peak flow and base flow) – i.e., large-scale actions to retain floodplains, wetlands and forest cover.
- Restore sediment and hydrologic processes (for peak flow and base flow) – i.e., restore wetland functions and values, reforestation, removal of impervious surface, and decommissioning of forest roads.

Second Priority

- Preservation (along focus reaches) – i.e., protect intact riparian forest, protect multi-threaded channels, maintain opportunities for rivers to migrate within their channel migration zones.
- Remove human-made instream barriers along or adjacent to priority reaches – i.e., fix blocking culverts.
- Reconnect off-channel habitats – i.e., reconnect side-channels isolated by logging roads.
- Restore shoreline conditions – i.e., remove bank armor that is no longer needed for decommissioned roads.
- Riparian enhancement.

Third Priority

- Address water quality impacts – i.e., increase shade to reduce temperatures.
- Marine-derived nutrient enhancement.
- Instream structural enhancement – i.e., LWD placement in select reaches with documented low levels of LWD and degraded riparian forest conditions.

Other Actions (not prioritized)

- Culvert replacement on small streams – i.e., prioritize and replace blocking culverts on coho streams based on available habitat upstream. The Griffin Creek subbasin contains an index reach with moderate coho use. Other streams may also have high potential, but the extent of coho use has not been well documented.

Headwaters – Secondary Protection

- Geospatial group: Headwaters; Subbasins: Miller River, Olney Creek, Rapid River
- Chinook/bull trout current use and potential classification: Low
- Watershed process condition: Intact
- Coho use: Known presence: Miller River, Olney Creek, Rapid River
- Recovery need: Preserve existing habitat and processes
- General strategy: Preservation

Description

Varied elevation streams and rivers in the Skykomish Watershed drain into low-elevation rivers. High monthly flows occur from November through January due to winter rains and increased meltwater from rain-on-snow events, and from May through June due to higher elevation snowmelt. Annual low flows occur in August and September. Located entirely (Miller, Rapid) or partially (Olney Creek) in the forest production zone, timber harvest is the predominant impact to the watershed although low levels of forestry are taking place currently. Current chinook use is low (SBSRTC 2002). Coho are present; the extent of use is not well documented.

Hypothesis

Watershed process conditions are largely intact in this subbasin strategy group. Preservation of intact watershed process conditions will help to maintain high quality spawning habitat in these subbasins and downstream.

Recommended Actions:

First Priority

- Preservation to support sediment and hydrologic processes (for peak flow and base flow) – i.e., large-scale actions to retain floodplains, wetlands, and forest cover.

Second Priority

- None listed

Third Priority

- Preservation (along focus reaches) – i.e., protect intact riparian forest, protect multi-threaded channels, and maintain opportunities for rivers to migrate within their channel migration zones.
- Remove human-made instream barriers along or adjacent to priority reaches – i.e., fix blocking culverts.
- Reconnect off-channel habitats – i.e., reconnect side-channels isolated by forest roads.
- Restore shoreline conditions – i.e., remove bank armor that is no longer needed for decommissioned roads.
- Address water quality impacts – i.e., increase shade.

Other Actions (not prioritized)

- Culvert replacement on small streams – i.e., prioritize and replace blocking culverts on coho streams based on available habitat upstream. Coho use is known, but the extent of use has not been well documented.

Headwaters – Protection Above Natural Barriers

- Geospatial Group: Headwaters; Subbasins: Snoqualmie River – Upper North Fork, Snoqualmie River – Upper Middle Fork, Pratt River, Taylor River
- Use and potential classification: Resident population only
- Watershed process condition: Intact
- Coho use: None
- Recovery need: Preserve existing habitat and processes
- General strategy: Preservation

Description

Middle elevation rivers in the Snoqualmie Watershed drain into low elevation rivers. High monthly flows occur from November through January due to winter rains and from May through June due to higher elevation snowmelt. Annual low flows occur in August and September. While located entirely in the forest production zone, timber harvest only occurs in the Upper North Fork Snoqualmie, as the other subbasins are located in the Alpine Lakes Wilderness Area (Snohomish Basin Salmonid Recovery Technical Committee 2002). All of these subbasins are located above Snoqualmie Falls; therefore the only native fish present are resident populations.

Hypothesis

Watershed process conditions are largely intact within this subbasin strategy group. Preservation of intact watershed process conditions will protect habitat for resident trout above Snoqualmie Falls and maintain the conditions that support high-quality spawning and rearing habitat for anadromous salmonids downstream in the mainstem Snoqualmie. Restoration opportunities exist, but are a lower priority because the majority of habitat is intact. Improving fish passage will increase the quantity of habitat available to resident trout.

Recommended Actions:

First Priority

- Preservation to support sediment and hydrologic processes (for peak flow and base flow) – i.e., large-scale actions to retain floodplains, wetlands, and forest cover.

Second Priority

- None listed

Third Priority

- None listed

Fourth Priority

- None listed

Fifth Priority

- Instream structural enhancement – (i.e., LWD placement in moderately degraded areas of the Upper North Fork Snoqualmie subbasin).

Headwaters – Restoration Above Falls and Dams

- Geospatial Group: Headwaters; Subbasins: Tolt River – South Fork above Dam, Sultan River – Upper, Snoqualmie River – Upper South Fork, Snoqualmie River – Lower Middle Fork, Tate Creek, Coal Creek – Upper, Snoqualmie River – Lower North Fork, Snoqualmie River – Lower South Fork
- Use and potential classification: Resident population only
- Watershed process condition: Moderately degraded
- Coho use: None
- Recovery need: Minor improvement over current conditions
- General strategy: Process restoration

Description

Varied elevation streams and rivers in the Skykomish and Snoqualmie watersheds drain into low elevation rivers. High monthly flows occur from November through January due to winter rains and increased meltwater from rain-on-snow events, and from May through June due to higher elevation snowmelt. Annual low flows occur in August and September. Located entirely (South Fork Tolt River, Snoqualmie River-Lower North, Lower Middle, and Upper South Forks, Tate Creek, and Upper Coal Creek) or partially (Lower South Fork Snoqualmie and Upper Sultan River) in the forest production zone, timber harvest is the predominant impact to these subbasins along with rural residential and urban uses in the lower levels of the subbasins. These subbasins have no anadromous salmonid use and two subbasins (South Fork Tolt River and Upper Sultan River) are above dams, with the South Fork Tolt dam located above a natural anadromous fish barrier (SBSRTC 2002). Current native fish use is by resident populations. Watershed process conditions are moderately degraded within this subbasin strategy group (Haring 2002).

Hypothesis

Reforestation, decommissioning of forest roads, and riparian enhancement will help to improve instream conditions in focus reaches downstream in the mainstem Snoqualmie River, lower Tolt River, and lower Sultan River, thereby contributing to improvements in chinook population performance. Improving fish passage will increase the quantity and connectivity of habitat available to resident trout.

Recommended Actions:

First Priority

- Preservation to support sediment and hydrologic processes (for peak flow and base flow) – i.e., large-scale actions to retain floodplains, wetlands, and forest cover.
- Restore sediment and hydrologic processes (for peak flow and base flow) – i.e., restore wetland functions and values, reforest, remove impervious surface, and decommission forest roads.

Second Priority

- None listed

Third Priority

- Riparian enhancement.
- Address water quality impacts – i.e., addressing illicit discharges, improve biofiltration of runoff from major highways and other impervious surfaces in the Lower South Fork Snoqualmie subbasin.

Fourth Priority

- Remove human-made instream barriers – i.e., culvert replacement

Step 6-1 Table. Strategy Development - Basinwide

							Ranked actions among subbasin strategy groups*										
Geo-spatial group	Subbasin strategy groups	Chinook/bull trout use and potential class	Current watershed process condition class	Subbasins contained within group	Description	Hypothesis	Preservation - proximate to aquatic habitat	Preservation - to support hydrologic and sediment processes	Remove anthropogenic instream barriers along or adjacent to priority reaches	Reconnect off channel habitats	Restore shoreline conditions	Restore hydrologic processes (for peakflow and baseflow)	Restore sediment processes	Riparian enhancement	Address water quality impacts	Marine derived nutrient enhancement	Instream structural enhancement (i.e. ELJs)
Nearshore	Nearshore restoration	High	Moderately Degraded	Nearshore	Shoreline from Mukilteo to Kayak Point including Puget Sound out to 30 m depth below MLLW and upland areas to the top of coastal bluffs.	Additional restoration of the Puget Sound nearshore environment was identified in the preliminary EDT analysis as necessary for achieving population performance levels that fall within the Shared Strategy planning range. Reducing the extent of the modifications in sediment delivery and transport, riparian conditions, and shoreline conditions will provide a significant improvement in population productivity in the nearshore environment.	1				1		1	1	2		
Estuary	Estuary restoration	High	Degraded	Estuary	Critical habitat for juvenile salmonid to rear and make the fresh to salt water transition. Defined here as the mainstem, sloughs and marshes between Possession Sound and the divergence of Ebey Slough from the mainstem.	Preliminary modeling with EDT identified the estuary as one of the most important places to focus preservation and restoration actions for both chinook populations. The loss of 85 percent of the historic tidal marsh area, loss of edge habitat complexity along major slough channels, and habitat fragmentation have depressed population performance. Addressing these problems will provide significant improvements in abundance, productivity and diversity for chinook and bull trout populations, as well as for other species.	1		1	1	1			1	2		2
Mainstems	Mainstems - primary restoration	High	Moderately Degraded or Degraded	Skykomish River - Lower Mainstem, Skykomish River Upper Mainstem, Skykomish River - South Fork, Skykomish River - Upper South Fork, Sultan River - Lower, Snoqualmie River - Mid Mainstem, Snoqualmie River Upper Mainstem, Pilchuck River - Middle, Upper Snohomish/Cathcart, Lower Snohomish/Marshland, Tolt River - Lower, Raging River	Large rivers with floodplains in the mid and lower basin. Critical spawning and rearing areas for chinook and other species. Also, critical habitat for sub-adult bull trout and foraging habitat for adult bull trout exhibiting a fluvial life history strategy. Agriculture, transportation corridors and urban development are the dominant land uses.	Along with the estuary, these subbasins have been identified as having the highest potential gains with restoration and highest potential losses if further degradation occurs. While spawning habitat quality has been impacted in some locations by altered sediment and flow regimes, the loss of rearing habitat quantity and quality is the largest issue affecting population performance. These basins provide rearing habitat for juveniles emerging within the basin and from areas in the upper watershed. Setting back and removing armoring, restoring access to isolated habitats and replanting riparian forests will provide the greatest returns in chinook population performance of any restoration actions in the freshwater environment.	1	1	1	1	1		data gap	1	2		2
	Mainstems - secondary restoration	Moderate	Moderately Degraded	May Creek/Lower Wallace, Skykomish River - Lower North Fork, Skykomish River - Lower South Fork, Woods Creek - Lower, Snoqualmie River Mouth, Tolt River - South Fork Below Dam, Pilchuck River - Lower, Coal Creek -Lower	Small rivers with floodplains and large mainstem rivers. Channel conditions impacted by urban and rural development, forestry and transportation corridors.	Although not as critical as in first tier mainstems, restoring riparian forests and floodplain connectivity, correcting fish passage barriers, and preventing urban sprawl within these areas will be necessary to achieve population performance levels within the Shared Strategy target range. Maintaining and restoring habitat within these areas will be particularly important for spatial structure.	2	1	2	2	2	1	data gap	2	3		3
Lowland tributaries	Rural streams - primary restoration	Moderate	Moderately Degraded	Woods Creek - West Fork, Cherry Creek	Large rural tributaries that contain or have the potential to support moderate levels of chinook spawning. Also important for coho.	These are the most important subbasins for chinook within the tributary geospatial group. They have a similar level of importance in a basinwide strategy to the mainstem - second tier class in terms of spawning. However, the channels are smaller and more confined, and likely only provide rearing habitat to juvenile emerging within these subbasins. Restoring riparian forests and floodplain connectivity, correcting fish passage barriers, and preventing urban sprawl within these areas will be necessary to achieve population performance levels within the Shared Strategy target range. Maintaining and restoring habitat within these areas will be particularly important for spatial structure.	2	1	2		2	1	data gap	2	3		3
	Rural streams - secondary restoration	Low	Moderately Degraded	Bear Creek, Woods Creek, Ames Creek, Harris Creek, Patterson Creek, Debuque Creek, Little Pilchuck Creek, French Creek, Tulalip/Battle Creeks*	Smaller rural tributaries that are rapidly developing. Used by chinook at low levels, but are important for coho.	Protecting and restoring watershed processes and restoring accessibility within these subbasins is important for multi-species protection and to support suitable conditions downstream for chinook spawning and rearing.	3	1	3		3	1	data gap	3	3		4
	Urban stream restoration	Low	Degraded	Lake Stevens Drainages, Everett Coastal Drainages, Fobes Hill, Quilceda Creek, Allen Creek, Sunnyside Drainages	Subbasins flanking the Snohomish estuary that have high levels of development or development pressures. Used by coho and cutthroat, but little to no chinook spawning. Lower reaches provide rearing habitat for chinook.	Watershed processes have been substantially altered within this subbasin strategy group. Managing these areas to prevent downstream impacts will be adequate for a basinwide chinook strategy if substantial restoration efforts are undertaken in other areas. Maintaining and restoring riparian forests and fixing culverts within this group may allow these waterbodies to continue to support small populations of resident trout, coho, and occasionally chinook. Quilceda Creek, an exception within this group, still supports significant coho production.	3		3		3			3	3		4
Headwaters	Headwaters -primary protection	High	Intact	Skykomish River - Upper North Fork, Foss River	Subbasins in the upper watershed that are accessed by anadromous fishes and have intact watershed process. Some forestry and recreational impacts. Contain only bull trout spawning habitat and moderate levels of chinook spawning.	Because they contain the only bull trout spawning within the Snohomish basin, preservation of watershed process conditions within these subbasins is critical. A few opportunities exist to reconnect habitat and improve conditions along the channel edge. These actions will also provide multispecies benefits.	1	1			1					2	

Step 6-1 Table. Strategy Development - Basinwide

							Ranked actions among subbasin strategy groups*										
Geo-spatial group	Subbasin strategy groups	Chinook/bull trout use and potential class	Current watershed process condition class	Subbasins contained within group	Description	Hypothesis	Preservation - proximate to aquatic habitat	Preservation - to support hydrologic and sediment processes	Remove anthropogenic instream barriers along or adjacent to priority reaches	Reconnect off channel habitats	Restore shoreline conditions	Restore hydrologic processes (for peakflow and baseflow)	Restore sediment processes	Riparian enhancement	Address water quality impacts	Marine derived nutrient enhancement	Instream structural enhancement (i.e. ELJs)
	Headwaters-secondary restoration	Moderate	Moderately Degraded	Griffin Creek, Tolt River - North Fork, Beckler River, Pilchuck River - Upper, Tokul Creek*	Subbasins located primarily in the cascade foothills. Forestry is the dominant land use. Diking and rural residential development in lower portions of subwatersheds. Moderate use or potential for chinook and significant use by coho.	Restoring watershed process is important for supporting spawning and rearing that is occurring within these subbasins and in downstream reaches. Significant opportunities also exist to improve spawning and rearing through the reconnection of habitat. Actions within these subbasins will provide a response in terms of population performance on par with the Rural streams - chinook/process focus group and significant multispecies benefits.	2	1	2	2	2	1	1	2	3	3	3
	Headwaters - secondary protection	Low	Intact	Tye River, Wallace River - Upper, Olney Creek, Rapid River, Miller River	Intact subbasins in the upper watershed that have low levels of chinook use.	Preservation of watershed processes is important for supporting watershed processes in downstream reaches with high current use or potential.	3	1	3	3	3				3		
	Headwaters - protection above natural barriers	Resident population only	Intact	Snoqualmie River - Upper North Fork, Pratt River, Taylor River, Snoqualmie River - Upper Middle Fork	Above Snoqualmie Falls and located primarily within the Alpine Lakes Wilderness . Watershed processes are largely intact.	Preservation of intact watershed process conditions will protect habitat for resident trout above Snoqualmie Falls and maintain the conditions that support high quality spawning and rearing habitat for anadromous salmonids downstream in the mainstem Snoqualmie. Restoration opportunities exist, but are a lower priority because the majority of habitat is intact. Improving fish passage will increase the quantity of habitat available to resident trout.		1									5
	Headwaters - restoration above falls and dams	Resident population only	Moderately Degraded	Tolt River - South Fork above Dam, Sultan River - Upper, Snoqualmie River - Upper South Fork, Snoqualmie River - Lower Middle Fork, Tate Creek, Coal Creek - Upper, Snoqualmie River - Lower North Fork, Snoqualmie River - Lower South Fork	Areas without anadromous fish access and moderately degraded conditions.	Reforestation, decommissioning of forest roads, and riparian enhancment will help to improve instream conditions in focus reaches downstream. Improving fish passage will increase the quantity of habitat available to resident trout.		1	4		4	1	1	3	3		5

*Prioritization across Snohomish Basin 1 (high) > 5(low). If the box is shaded, the action is not applicable, appropriate or necessary.

Note: Like subbasins are organized into subbasin strategy groups based on three characteristics: geo-spatial class, chinook and bull trout use and potential class and watershed process condition class. Hypotheses are generated for each subbasin strategy group to define their unique role in a basin-wide strategy. Additional prescriptions are recommended for coho along small streams. Snohomish coho populations are distributed broadly across the basin and are critical for maintaining healthy and harvestable runs in a regional context.

Step 6-2 Table. Strategy Development - Subbasin Scale

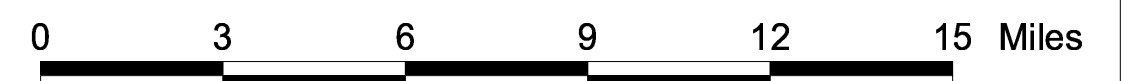
Subbasin	Subbasin strategy groups					Primary focus reaches	Focus reaches	Ranked actions <u>within</u> subbasins (Bold text in this section identifies high/extreme potential gains from restoration in EDT analysis (May 2002))											
Component	Geospatial class	Chinook/bull trout use and potential priority class			Watershed process current condition class	Subbasin strategy group			Preservation (proximate to aquatic habitat)	Preservation (to support hydrologic and sediment process)	Remove anthropogenic instream barriers	Reconnect off-channel habitats	Restore edge habitat condition	Restore hydrologic processes	Restore sediment processes	Riparian enhancement	Address water quality impacts	Nutrient enhancement	Instream structural enhancement
		Chinook	Bull Trout	Combined BT/Chinook						i.e. acquiring large forest and wetland sites	(from step 2 and culvert database)	(from NTAA, HCR and LFA)	(from step 2)	(from step 3)	(from step 3 and/or step 2)	(from step 3)	(from step 2)	(from step 4 and WQ data)	(from step 2 and step 3)
Classification	Est/Near, Mainstem, Lowland Tributary, Headwater	Class A, B, C or D	Class A, B, C or D	Class A, B, C or D	A - hydrology, riparian and sediment conditions all intact B - one or more (but not all three) watershed process conditions moderately degraded or degraded C - hydrology, riparian and sediment conditions all degraded		Focus reaches identified in the NTAA and bull trout spawning reaches in the Upper North Fork Sky and Foss River subbasins identified by WDFW	EDT chinook reaches and bull trout spawning reaches in the Upper North Fork Sky and Foss River subbasins identified by WDFW	1 = first tier - if subbasin contains priority reaches 2 = second tier - if subwatershed does not contain priority reaches	Always a first tier priority	1 = first tier - barriers along or adjacent to a priority reach 2 = second tier - barriers along fish bearing waters	1 = first tier - disconnected habitat along a priority reach 2 = second tier - disconnected habitat in the anadromous zone	1 = first tier - <i>Degraded</i> or <i>Mod Degraded</i> conditions along a priority reach 2 = second tier - <i>Degraded</i> or <i>Mod Degraded</i> within the subwatershed	1 = first tier - <i>Degraded</i> or <i>Mod Degraded</i> conditions within the subwatershed	1 = first tier - <i>Degraded</i> or <i>Mod Degraded</i> conditions within the subwatershed	1 = first tier - <i>Degraded</i> or <i>Mod Degraded</i> conditions along a priority reach 2 = second tier - <i>Degraded</i> or <i>Mod Degraded</i> within the subwatershed	1 = first tier - <i>Degraded</i> or <i>Mod Degraded</i> conditions along a priority reach	2 = second tier - high or moderate change in potential and no current nutrient related problems	2 = dearth of LWD in a priority reach and <i>Degraded</i> or <i>Mod Degraded</i> riparian conditions
Nearshore	Nearshore	A	A	A	N/D	Nearshore restoration		Shoreline Mukilteo to Kayak Point	1	1			1		DG	1	2		DG
Snohomish Estuary	Estuary	A	A	A	C	Estuary restoration	Mainstem and sloughs RM 0-8.1	Mainstem and sloughs RM 0-8.1	1			1	1		DG	1	2		2
Raging River	Headwater	B	C	B	B	Mainstem-primary restoration		Mainstem RM 0-12.7	2	1	2	1	1	1	1	1	DG		2
Skykomish River - Lower Mainstem	Mainstem	A	B	A	B	Mainstem-primary restoration	Mainstem RM 0-6.2, 10.3-13.9	Mainstem 0-13.9	1	1	2	1	1		DG	1	2		2
Skykomish River - Upper Mainstem	Mainstem	A ^p	C	A	B	Mainstem-primary restoration	Mainstem RM 13.9-18.4	Mainstem 13.9-28.9	1	1	2		1		1	1	2		DG
Skykomish River - South Fork	Mainstem	A ^p	C	A	B	Mainstem-primary restoration		Mainstem RM 6.1-14.2	1	1	2	1	1		1	1	2		DG
Skykomish River - Upper South Fork	Mainstem	A ^c	C	A	B	Mainstem-primary restoration		Mainstem RM 14.2-19.9	1	1	2		1		1	1	2		DG
Sultan River - Lower	Mainstem	A ^c	C	A	B	Mainstem-primary restoration	Mainstem RM 0-9.7	Mainstem RM 0-9.7	1	1	2	1		1*	DG	1			DG
Snoqualmie River - Mid-Mainstem	Mainstem	A ^p	C	A	B	Mainstem-primary restoration	Mainstem RM 21.3 - 24.8	Mainstem RM 9.9 - 24.8	1	1	2	1	1	1	DG	1	1		2
Snoqualmie River - Upper Mainstem	Mainstem	A ^p	C	A	B	Mainstem-primary restoration	Mainstem RM 24.8-27.3, 32.1-38.6	Mainstem RM 24.8-38.6	1	1	1	1	1		DG	1	1		2
Pilchuck River - Middle	Mainstem	A ^p	C	A	B	Mainstem-primary restoration		Mainstem RM 8.5-28.8	1	1	2	1	1	1	DG	1	2		2
Upper Snohomish/Cathcart	Mainstem	A ^p	A	A	C	Mainstem-primary restoration	Mainstem RM 13.9-19.7	Mainstem RM 13.9-19.7	1	1	2	1	1	1	DG	1	2		2
Lower Snohomish/Marshland	Mainstem	A ^p	C*	A	C	Mainstem-primary restoration		Mainstem RM 8.1-13.9	1	1	1	1	1	1	DG	1	1		2
Tolt River - Lower	Mainstem	A ^c	C	B	B	Mainstem-primary restoration	Mainstem RM 0-5.0	Mainstem RM 0-8.4	2	1		1	1	1	1	1			2
Skykomish River - Lower South Fork	Mainstem	B	C	B	B	Mainstem-secondary restoration	Mainstem RM 0-3.3, BV creek RM 0-1.7	Mainstem RM 0-6.1, BV RM 0-1.7	2	1	2	DG	2		1	2			DG
Woods Creek - Lower	Mainstem	B ^p	C	B	B	Mainstem-secondary restoration		Mainstem RM 0-6	2	1	2	2	DG		DG	2	2		2
Snoqualmie River - Mouth	Mainstem	B ^p	C	B	B	Mainstem-secondary restoration	Mainstem RM 0-4.3	Mainstem RM 0-9.9	2	1	1	2	2		DG	2	2		2
Tolt River - South Fork Below Dam	Mainstem	B ^p	C*	B	B	Mainstem-secondary restoration		Mainstem RM 0-12.0	2	1			1	1	1	1		2	
Pilchuck River - Lower	Mainstem	B ^p	C	A	C	Mainstem-secondary restoration		Mainstem RM 0-8.5	2	1	2	1	2	1	DG	2	2		2
Coal Creek - Lower	Mainstem	B	C*	B	B	Mainstem-secondary restoration		None	2	1	DG		2	1	DG	2	2		2
May Creek/Lower Wallace River	Mainstem	B	C	B	B	Mainstem-secondary restoration		Mainstem RM 0-4.6	2	1	2	DG	DG	1		2	2		2
Skykomish River - Lower North Fork	Mainstem	B ^p	C	B	B	Mainstem-secondary restoration		Mainstem RM 0-10.1	2	1	2	DG	2		1	2		DG	
Woods Creek - West Fork	Tributary	B ^p	C	B	B	Rural streams-primary restoration		Mainstem RM 0-8.1	2	1	2		DG		DG	2	DG		DG
Cherry Creek	Tributary	B ^p	C*	B	B	Rural streams-primary restoration		Mainstem RM 0-1.9	2	1	1	1	1		DG	1	1		2
Bear Creek	Tributary	D	C*	B	B	Rural streams-secondary restoration		None	2	1	2		DG		DG	2	DG		DG
Woods Creek	Tributary	C	C	B	B	Rural streams-secondary restoration		Mainstem RM 3.7-7.6	2	1	2		DG		DG	2	2		2
Ames Creek	Tributary	D	C*	C	B	Rural streams-secondary restoration		None	2	1	2	2	2		DG	2	DG		
Harris Creek	Tributary	C ^c	C*	A	B	Rural streams-secondary restoration		None	2	1	2	2	2		DG	2	DG		
Patterson Creek	Tributary	C	C*	B	B	Rural streams-secondary restoration		None	2	1	1	DG	DG	1	1	1	1		2
Dubuque Creek	Tributary	D	C*	B	B	Rural streams-secondary restoration		None	2	1	DG		DG		DG	2	2		2
French Creek	Tributary	C	C*	C	B	Rural streams-secondary restoration		None	2	1	1	1	2	1	DG	2	1		2
Little Pilchuck Creek	Tributary	D	C*	B	B	Rural streams-secondary restoration		None	2	1	DG		DG		DG	2	DG		2
Tulalip and Battle Creeks	Tributary	D	D	D	B	Rural streams-secondary restoration		None	2	1	1		DG	1	DG	2			
Lake Stevens Drainages	Tributary	D	C*	B	C	Urban stream restoration		None	2	1	2		DG		DG	2	2		2
Everett Coastal Drainages	Tributary	D	C*	C	C	Urban stream restoration		None	2	1	DG		DG		DG	2	2		2
Fobes Hill	Tributary	D	C*	C	C	Urban stream restoration		None	2	1	2		2		DG	2	2		2
Quilceda/Allen Creek	Tributary	C	C*	B	C	Urban stream restoration		Mainstem RM 0.8-8.0, MF RM 0-2.5	2	1	2		2		DG	2	2		2
Sunnyside Drainages	Tributary	D	C*	C	C	Urban stream restoration		None	2	1	2		DG		DG	2	2		2
Skykomish River - Upper North Fork	Headwater	B ^p	A	A	A	Headwaters-primary protection	Mainstem RM 16.2-20.7, Goblin Cr RM 0-0.6, Salmon Cr RM 0-0.6, West Cady RM 0-0.25, Troublesome Cr RM 0-3.2	Goblin Cr RM 10.1 - 20.7, Goblin Cr RM 0-0.6, West Cady RM 0-0.25, Troublesome Creek RM 0-3.2	1	1			1					2	

Step 6-2 Table. Strategy Development - Subbasin Scale

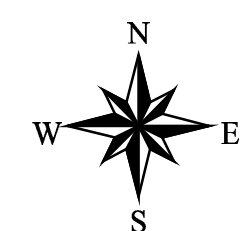
Subbasin	Subbasin strategy groups					Primary focus reaches	Focus reaches	Ranked actions <u>within</u> subbasins (Bold text in this section identifies high/extreme potential gains from restoration in EDT analysis (May 2002))											
Component	Geospatial class	Chinook/bull trout use and potential priority class			Watershed process current condition class	Subbasin strategy group			Preservation (proximate to aquatic habitat)	Preservation (to support hydrologic and sediment process)	Remove anthropogenic instream barriers	Reconnect off-channel habitats	Restore edge habitat condition	Restore hydrologic processes	Restore sediment processes	Riparian enhancement	Address water quality impacts	Nutrient enhancement	Instream structural enhancement
		Chinook	Bull Trout	Combined BT/Chinook					i.e. acquiring large forest and wetland sites	(from step 2 and culvert database)	(from NTAA, HCR and LFA)	(from step 2)	(from step 3)	(from step 3 and/or step 2)	(from step 3)	(from step 2)	(from step 4 and WQ data)	(from step 2 and step 3)	
Classification	Est/Near, Mainstem, Lowland Tributary, Headwater	Class A, B, C or D	Class A, B, C or D	Class A, B, C or D	A - hydrology, riparian and sediment conditions all intact B - one or more (but not all three) watershed process conditions moderately degraded or degraded C - hydrology, riparian and sediment conditions all degraded		Focus reaches identified in the NTAA and bull trout spawning reaches in the Upper North Fork Sky and Foss River subbasins identified by WDFW	EDT chinook reaches and bull trout spawning reaches in the Upper North Fork Sky and Foss River subbasins identified by WDFW	1 = first tier - if subbasin contains priority reaches 2 = second tier - if subwatershed does not contain priority reaches	Always a first tier priority	1 = first tier - barriers along or adjacent to a priority reach 2 = second tier - barriers along fish bearing waters	1 = first tier - disconnected habitat along a priority reach 2 = second tier -disconnected habitat in the anadromous zone	1 = first tier - <i>Degraded</i> or <i>Mod Degraded</i> conditions along a priority reach 2 = second tier - <i>Degraded</i> or <i>Mod Degraded</i> within the subwatershed	1 = first tier - <i>Degraded</i> or <i>Mod Degraded</i> conditions within the subwatershed	1 = first tier - <i>Degraded</i> or <i>Mod Degraded</i> conditions within the subwatershed	1 = first tier - <i>Degraded</i> or <i>Mod Degraded</i> conditions along a priority reach 2 = second tier - <i>Degraded</i> or <i>Mod Degraded</i> within the subwatershed	1 = first tier - <i>Degraded</i> or <i>Mod Degraded</i> conditions along a priority reach	2 = second tier - high or moderate change in potential and no current nutrient related problems	2 = dearth of LWD in a priority reach and <i>Degraded</i> or <i>Mod Degraded</i> riparian conditions
Foss River	Headwater	C	B	B	A	Headwaters-primary protection		Mainstem RM 0-4.7, WF RM 0-2.2	2	1									
Beckler River	Headwater	B ^p	C	B	B	Headwaters-secondary restoration		Mainstem RM 0-12.1	2	1					1		2		
Pilchuck River - Upper	Headwater	B ^p	C	B	B	Headwaters-secondary restoration		Mainstem RM 28.8-36.6	2	1	1		2		DG			2	
Griffin Creek	Headwater	B ^p	C*	A	B	Headwaters-secondary restoration		Mainstem RM 0-1.0	2	1	1	1	1	1	1	1	1		2
Tolt River - North Fork	Headwater	B ^p	C	B	B	Headwaters-secondary restoration		Mainstem RM 0-3.0	2	1	2	2	1	1	DG				2
Miller River	Headwater	C	C	A	A	Headwaters-secondary restoration		Mainstem RM 0-3.6	2	1					DG		2		
Tokul Creek	Headwater	C	C	C	B	Headwaters-secondary restoration		Mainstem RM 0-2.4	2	1	1	2	1	1	1	2			
Tye River	Headwater	C	C*	C	B	Headwaters-secondary protection		Mainstem RM 0-4.8	2	1			DG		1		2		
Wallace River - Upper	Headwater	D	C*	A	B	Headwaters-secondary protection		None	2	1	2				1		DG		
Olney Creek	Headwater	D	C*	B	A	Headwaters-secondary protection		None	2	1	DG				DG		DG		
Rapid River	Headwater	C	C*	B	A	Headwaters-secondary protection		Mainstem RM 0-3.5	2	1					DG		DG		
Snoqualmie River - Upper Middle Fork	Headwater	D	D	D	A	Headwaters-protection above natural barriers		None	2	1	DG				1		DG		
Snoqualmie River - Upper North Fork	Headwater	D	D	D	A	Headwaters-protection above natural barriers		None	2	1	DG				DG		DG		
Taylor River	Headwater	D	D	D	A	Headwaters-protection above natural barriers		None	2	1	DG				DG		DG		
Pratt River	Headwater	D	D	D	A	Headwaters-protection above natural barriers		None	2	1	DG				DG		DG		
Tolt River - South Fork above Dam	Headwater	D	D	D	B	Headwaters- restoration above falls & dams		None	2	1	2			1	1	2	DG		2
Sultan River - Upper	Headwater	D	D	D	B	Headwaters- restoration above falls & dams		None	2	1	1				1	2			
Snoqualmie River - Upper South Fork	Headwater	D	D	D	B	Headwaters- restoration above falls & dams		None	2	1	DG			1	1	2	2		2
Snoqualmie River -Lower Middle Fork	Headwater	D	D	D	B	Headwaters- restoration above falls & dams		None	2	1	2			1	DG	2	DH		2
Tate Creek	Headwater	D	D	D	B	Headwaters- restoration above falls & dams		None	2	1	DG			1	DG	2	DG		DG
Coal Creek - Upper	Headwater	D ^p	D	D	B	Headwaters- restoration above falls & dams		None	2	1	DG			1	DG	DG	DG		DG
Snoqualmie River - Lower North Fork	Headwater	D	D	D	B	Headwaters- restoration above falls & dams		None	2	1	DG			1	DG		DG		DG
Snoqualmie River - Lower South Fork	Headwater	D	D	D	B	Headwaters- restoration above falls & dams		None	2	1	DG			1	DG	1	1		2

DG = Data Gap

	Estuary
	Headwaters
	Mainstems
	Lowland Tributaries
	Nearshore
	Rivers



Snohomish County



PUBLIC WORKS
SURFACE WATER MANAGEMENT
(425) 388-3464

Project name: i:\pw\swm\spwsxb\andy haas\EASC.apr Plot date: October 30, 2003; h20process smb

 Intact (All three processes intact)
 Moderately Degraded (One or two processes moderately degraded or degraded)
 Degraded (All three processes degraded)
 Rivers



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STEP 7. DEVELOPING ALTERNATIVES

DESCRIPTION

In Step 7, four alternatives were developed for evaluation based on hypotheses from the EASC in a collaborative effort involving staff from the SBSRTC and the Policy Development Committee. A summary is provided below, but for specifics regarding the plan alternatives, please refer to the Snohomish River Basin Salmon Conservation Plan.

Alternatives are comprised of habitat conditions targets and a strategic implementation strategy (Step 6 priorities) accompanied by a menu of proposed actions (short- and long-term) and a toolbox (capital projects, non-regulatory programs, incentives and regulations). With the exception of the current path, all alternatives are predicted to achieve viable and harvestable salmonid populations over the long-term. Each has a multi-species focus. In support of the recovery hypotheses, each includes substantial recovery actions focused at the large, low-gradient mainstem rivers, estuary and nearshore, as well as additional actions in other subbasins to provide for greater chinook spatial structure and diversity, provide benefits for other salmonids and protections of watershed processes. Subbasin strategy groups provide the primary organizational scale. As described in detail in Step 6, the SBSRTC organized the 62 subbasins in the Snohomish River Basin into 11 subbasin strategy groups and identified priorities among and within groups. The test case strategy alternative, our hypothesized strategy to achieve full recovery with a very low risk of extinction, was evaluated using the SHIRAZ model to confirm that population status was in the range for population viability. In the final step (Step 8), all four alternatives are evaluated using both the SHIRAZ and EDT models.

METHODS

Long-term goal setting is a critical component of alternative development because salmon recovery will require significant habitat improvements and watershed process restoration will take time. Alternatives are expressed in terms of target levels for each habitat condition category within each subbasin strategy group (Step 7 Table). Target levels vary among groups based on their hypothesized relative importance and role in a basin-wide strategy (see Step 6). Habitat condition categories at the reach scale include riparian forest, anthropogenic instream barriers, off-channel habitat, edge habitat, and instream habitat structure (Step 7 Table). Habitat condition categories at the subbasin scale include anthropogenic instream barriers, forest cover, impervious surface, and road density (Step 7 Table). Relationships between habitat condition categories and habitat attributes used as model inputs are identified explicitly (Appendix 1). Current habitat conditions were quantified for comparison relative to target conditions using the watershed process analysis (Step 3), land cover classification and analysis (Purser et al., 2003), and additional GIS-based analyses.

As a starting point, one alternative was developed and modeled to answer the question – What will it take to achieve full recovery? It is the hypothesized habitat condition targets necessary to achieve all four aspects of viable and harvestable salmonid populations in the Snohomish River Basin – abundance, productivity, diversity, and spatial structure for all species with a very low risk of extinction (<1% in 100 years). In other words it is the hypothesized focus and level of effort to achieve the high end of the Shared Strategy planning range for abundance and productivity, as well as significant spatial structure and diversity gains (a specific planning range was not provided by Shared Strategy for these VSP parameters). It is referred to as the test case strategy (Alternative #4) because it was used to establish the upper bookend on which additional alternatives were developed. In the test case strategy, target levels for intact (functioning) habitat for each habitat condition category were selected for each subbasin strategy group.

Hypotheses from the EASC, results from the EDT analysis commissioned by the Tulalip Tribes, and criteria referenced from regional studies and selected for the HCR (SBSRTC 2002) were used as guidance for setting target levels thought likely to produce desired levels of population performance. The SHIRAZ model (see Step 8) was used to test the hypothesized level of effort necessary to achieve full chinook salmon recovery with a very low risk of extinction. Preliminary results confirmed that the hypothesis was reasonable. Socioeconomic constraints were not considered in this alternative.

At the other end of the continuum, an alternative was developed and modeled to predict future conditions of habitat, and in turn the viability of salmonid populations with a continuation of the current trajectory. The current path alternative (Alternative #1) is based on the current level of restoration project implementation focused in key areas, anticipated degrading actions such as road expansion, an evaluation of proposed comprehensive plan changes, and rates of change in land cover. While the current path reflects a significant improvement that has been made post-ESA listing, it is not predicted to be a substantial enough shift to achieve viable and harvestable populations.

Once the bookend alternatives were in place, two additional alternatives were constructed. The first of the middle alternatives (Alternative #2) reflects a moderate level of additional effort over the current path and is aimed at achieving viable and harvestable populations with a risk of extinction less than 10% in 100 years. Target levels were generally set halfway between the predicted level under the current path and the test case strategy targets. The second of the middle alternatives (Alternative #3) reflects a moderate-high level of additional action over the current path and is aimed at achieving viable and harvestable populations with a risk of extinction less than 5% in 100 years. Target levels were generally set at the current path predicted conditions plus 75% of the difference between the predicted level under the current path and the test case strategy targets. In both cases, exceptions were made and documented to account for substantial socioeconomic constraints such as the railroad along the Puget Sound nearshore. Both offer substantial opportunities to address socioeconomic constraints and other community goals.

In addition to setting long-range targets, it is critical to identify near-term goals and specific actions for meeting the first benchmark (10 years). To provide this specificity, a menu of proposed actions within each subbasin strategy group has been compiled that will accompany the alternatives. The menu lists specific capital projects, non-regulatory programs, and regulations that will help move watershed conditions from their current state toward the target conditions. The location, extent, level of support, estimated cost and habitat factors addressed are identified for each project. While not explicitly prioritized, the list can be sorted by project type for consistency with the prioritization scheme in Step 6.

The menu can also be sorted by current level of support. For example, actions with a high level of current support could be sorted onto a list of actions that the Forum will work toward implementing over a five- to ten-year time frame to meet the first benchmark. Actions with a lower level of support or no support currently could be further generalized and placed on a long-term list. The Forum would commit to work toward building consensus on these projects and supporting research, monitoring, feasibility, design, outreach and funding for projects on the long-term list. Through adaptive management, the Forum would track progress toward the goal and move more projects onto the short-term list.

While a menu of proposed projects is a useful tool to help guide actions, alternatives should not be viewed as comprised exclusively of projects in the menu. Over-reliance on project lists could jeopardize the process by removing flexibility. For example, it would be unwise to reject a project that is not on the list (i.e. perhaps because it occurred in an area that hadn't been surveyed at the time the menu was developed) even though it is nearly identical in focus to a listed project and could be implemented more cheaply. It is also unrealistic to expect the Forum to achieve full consensus today on all the specific actions to be implemented over a 25- or 50-year time frame. Land ownership, governments, public values, and the state of knowledge change over time. Through monitoring and adaptive management, consensus will be reached on more projects, and they will be moved onto the five- to ten-year plan.

CURRENT CONDITIONS AND THE TEST CASE STRATEGY

The Step 7 Table shows the target conditions, and in the case of the current path, the predicted future conditions relative to current conditions. A description of the process for developing the test case strategy, the starting point for alternative development, is provided below. It documents the method for estimating current habitat conditions and includes the rationale for habitat targets along high use and potential chinook and bull trout reaches and on a subbasin scale. The current path assumptions are based on a policy analysis and are included in the Snohomish River Basin Salmon Conservation Plan

Chinook and Bull Trout Reach-Scale Habitat Condition Categories

Protecting and restoring habitat along mainstem reaches, the estuary and nearshore provides direct benefits to ESA listed species – chinook salmon and bull trout and all anadromous salmonids. This section describes protection and restoration targets for chinook and bull trout focus reaches.

Riparian Forest

Current Condition

An analysis of Landsat satellite imagery was used to estimate land cover including riparian conditions along focus reaches (Purser et al. 2003). Purser et al. evaluated spectral reflectance classes developed by the Puget Sound Regional Synthesis Model (PRISM) project team and grouped them into 11 land cover classes: mature evergreen forest, medium evergreen forest, deciduous stands, shrub/small trees, grass, bare ground, medium density development, high density development, alpine rock/talus slope, open water, and unknown (shadow, cloud). An error matrix was created to evaluate accuracy. Five by five pixel blocks were randomly selected and compared to orthophotography at a scale of between 1:6000 and 1:3000 to determine whether predicted class matched the actual class. Results yielded an overall accuracy of 92.2% with a low of 85.7% for the high density development class and 86.1% for the shrub/small tree class.

Hydrologic mature or “intact” forest is comprised of the sum of three land cover classes: mature evergreen forest, medium evergreen forest, and deciduous stands. Mature evergreen forest has the potential to contribute LWD in excess of 60 cm in diameter and 15.2 m in length. Overlay analysis indicates that U.S. Forest Service stand age data classifies cells in this land cover class as being at least 100 years old. Medium evergreen forest contributes wood over 10 cm in diameter and 2 m in length but smaller than 60 cm in diameter and 15.2 m in length. Overlay analysis indicated that U.S. Forest Service stand age data classifies cells in this land cover class as being 27 to 99 years old. Deciduous stands contribute woody debris of similar size to the medium evergreen forest class.

Target Condition

Riparian forests provide shade, nutrients, LWD, and a buffer between upland activities and the aquatic environment. Riparian forests also provide shade for forage fish spawning and serve as buffers in the nearshore. A target level of 80% intact riparian forest is set for focus reaches in the mainstem – first tier group. This target is derived from two HCR measures for intact riparian conditions (NOAA 1996). One measure is based on riparian forest width. The other is based on intact riparian reserves, defined as contiguous areas within the riparian zone that meet potential natural composition, mean stem diameter, and canopy cover standards. The estuary riparian forest target only applies in the upper 2/3 of the estuary that was forested historically (upstream of SR2 and along Ebey Slough). Emergent and scrub-shrub vegetation interspersed with a few trees covered the lower third of the estuary. Subbasin strategy groups with intact conditions are set to maintain their current level. Target levels for all other groups are based on their relative use or potential when compared to the first tier groups and best professional judgment.

Anthropogenic Instream Barriers

Current Condition

Data on known blocking culverts was compiled by subbasin; specifically for this analysis, the data included fish barriers within ½ mile of chinook and bull trout high use and potential reaches. It is important to note that the analysis does not include many tidegates, floodgates, and weirs that block salmonid habitat. Culvert data were combined by Rob Simmonds in Snohomish County's Department of Information Services from all known sources: WDFW, Washington Trout, Adopt-A-Stream, Washington Department of Natural Resources (WA DNR), and U.S. Forest Service – Mt. Baker-Snoqualmie National Forest.

Data are in the form of digitized points with associated attributes, including a value describing how passable the culvert is to fish. These values range from 0% (completely impassible) to 100% (completely passable, i.e., not a barrier). The preliminary analysis identified 396 inventoried culverts, 269 of which were classified as fish barriers. It is important to recognize that many culverts in the basin have not been inventoried and thus were not included in this analysis.

Blocking culverts were organized in an access database and snapped to the stream layer where the streams intersect roads, identified on orthophotos. The GIS trace functionality was used to identify stream segments located upstream of each blocking culvert. Upstream stream segments were characterized by ownership, slope, future land use, and proximity to reaches with high current use or potential for chinook and bull trout char. The WA DNR transportation layer was overlain with the Snohomish County streams coverage to calculate the number of times the two layers intersect. The result provides a rough estimate of the number of culverts in the basin.

Target Condition

This habitat condition category encompasses anthropogenic instream barriers on the mainstems and on tributary streams within 0.5 mile of chinook or bull trout focus reaches. The 0.5 mile distance was selected because juvenile chinook have been documented to migrate (up to approximately 0.5 mile and 1% gradient) into the lower reaches of non-natal streams to rear and take refuge during peak flows (Bradford et al. 2001, Murray & Rosenau 1989, Perry et al. 2003, Scrivener et al. 1994). A high target of 95% (length of blocked habitat restored to accessibility) was selected for the most critical groups, because reconnecting habitat directly increases capacity. The target was set at less than 100% to acknowledge the diminishing returns gained by reconnecting short lengths of habitat blocked by culverts. Target levels for all other groups are based on their relative use or potential when compared to the first tier classes and best professional judgment. In other words, lower targets were set for subbasin strategy groups with lower relative salmonid use or potential, because the potential gains were perceived to be less significant.

Off-Channel Habitat

Current Condition

Off-channel habitat refers to side channels, sloughs, ponds, and small streams within the floodplain. The area of off-channel habitat that has been lost was estimated. “Lost” refers to areas that are isolated by dikes or other structures, drained, and/or filled. It includes areas that are fully or partially blocked. In the Snohomish Estuary and along the mainstem of the Snohomish River, Haas and Collins (2001) was used as a primary source for the historic and current estimate. In the Snoqualmie floodplain, the area of historic floodplain channel features was estimated by Collins and Sheikh (2003). The usable habitat area within palustrine wetlands was estimated at 20%. The current accessibility of these features by salmonids was conducted through field reconnaissance and review by King County biologists. No historical analysis has been conducted for the Skykomish River. A rough calculation of historically and currently accessible off-channel habitat, which is likely to be an underestimate, was estimated from Snohomish County’s streams and ponds hydrolayer. Snohomish County biologists assessed the current accessibility of habitat based on field experience in the area. The area of small streams connecting off-channel features with the mainstem was estimated at a uniform width of 5 m.

Target Condition

Bull trout and juvenile chinook have been documented at low densities in off-channel habitats (Anderson 1999, Fraley and Shepard 1989, King County Department of Natural Resources 2000, Jeanes and Hilgert 2003, Swales and Levings 1989), and coho use these habitats extensively during spring runoff and for summer and winter rearing (Swales and Levings 1989). Off-channel habitat is dynamic in unmanaged systems ? forming, disconnecting, and re-forming again as wood and sediment accumulate and as water finds the path of least resistance. In managed systems, much of this habitat has been cut off from the channel, blocking the natural processes that created it. Reconnecting off-channel habitat (and ideally the processes that form it) will increase habitat complexity and rearing capacity. Target levels between 50% and 80% (isolated habitat area reconnected) have been selected based on current relative use and potential, and on best professional judgment for subbasin strategy groups with this habitat type. In other words, targets at the higher end of the range were set for subbasin strategy groups with higher relative salmonid use or potential, because the potential gains were perceived to be more significant. Targets at the lower end of the range were set for subbasin strategy groups with lower relative salmonid use or potential, because the potential gains were perceived to be less significant.

Edge Habitat

Current Condition

Edge habitat is the slackwater margin along mainstem rivers. Shoreline hardening refers to dikes, levees, berms, riprap and rubble armored banks, and vertical bulkheads. Natural banks are banks that have not been hardened. Several inventories have documented bank hardening along some of the larger river reaches. These studies were summarized in the HCR and are reported here. Most but not all of the mainstems have been surveyed for bank conditions on a coarse scale.

Target Condition

Shoreline hardening reduces rearing capacity and productivity by reducing the availability and accessibility of edge habitat and decreasing cover along the channel edge (Beamer and Henderson 1998, Spence et al. 1996, Ward and Wiens 2001, and Ward et al. 1999). Edge habitat is critical for juvenile salmonids, particularly for chinook, because they rear primarily in mainstem rivers along the edges of the riverbanks rather than in the channel thalweg (Hayman et al. 1996). Surveys of natural and modified banks along the Snohomish River show that woody debris (rootwads, debris piles and single pieces) as a percentage of channel edge habitat along natural banks is twice as abundant as along modified banks

(Haas and Collins 2001). Rootwads are more than three times as abundant, and debris piles are more than four times as abundant. This is significant because coho pre-smolts in winter, coho parr in summer, and sub-yearling chinook are two, four, and five times as abundant, respectively, when observed in association with wood cover, relative to riprap. The HCR defines “intact” and “moderately degraded” edge habitat as >90% natural banks and 80 to 90% natural banks, respectively (based on NOAA 1996). For Fish-Based Strategy 1, the target is set at 90% in first tier subbasin strategy groups and at 80% in other areas. Edge habitat restoration could take various forms, including removal of bank armoring, setback of dikes from the channel edge, or incorporation of LWD into the modified bank. Installing LWD does not restore a watershed process, but this action maintains habitat until LWD recruitment begins to occur naturally.

Habitat Structure

Current Condition

Habitat structure refers to LWD and instream channel complexity. Current instream habitat conditions have been documented through various studies. These data have been compiled and input into the registered stream reach dataset used in the EDT analysis. While the restoration of watershed processes will be most effective in restoring habitat over the long-term, the placement of LWD and installation of engineered logjams provides an important near-term measure along reaches with both poor LWD loading and poor riparian conditions. The percentage of stream reaches that have both poor LWD loading (EDT attribute score of ≥ 2.5) and poor riparian conditions (<50% intact) out of the total number of reaches within the subbasin strategy group was calculated and reported.

Target Condition

In general, the EASC encourages restoration that addresses the root causes of problems over activities that fix symptoms. For example, lack of riparian forests is the root cause of a scarcity of LWD, while the scarcity is a symptom. However, because treating this symptom by addressing the cause will require time ? at least 50 years for newly established riparian forests to contribute LWD? structural fixes for the symptom may be appropriate in some locations. Generally these will be locations with high relative current use or potential that have newly established riparian forests and minimal habitat complexity. Structural fixes here refer to engineered logjams and other features designed to increase habitat complexity. For Fish-Based Strategy 1, instream structures will be added along 5% of the length of EDT and bull trout reaches in high use/potential subbasin strategy groups, and along 2% of the length in moderate use subbasin strategy groups, focusing in areas where riparian conditions and instream conditions are both degraded or moderately degraded.

Subbasin-Scale Habitat Condition Categories

Protecting and restoring conditions on a subbasin scale supports watershed processes and provides benefits to coho and other species using smaller streams. In addition to the chinook and bull trout focus reaches in the estuary and lower mainstem rivers, smaller tributary and headwater subbasins provide critical habitat for coho. Subbasins identified as having high relative current coho use (based on spawning data) are the Wallace River-Upper, Miller River, Snoqualmie River-Mouth, Griffin Creek, Harris Creek, and Pilchuck River-Lower. The subbasins with moderate relative current coho use are Bear Creek, Olney Creek, Skykomish River-Lower Mainstem, Skykomish River-Upper Mainstem, Skykomish River-Lower North Fork, Skykomish River-Lower South Fork, Skykomish River - South Fork, Woods Creek, Beckler River, Foss River, Rapid River, Skykomish River-Upper South Fork, Cherry Creek, Patterson Creek, Raging River, Snoqualmie River-Mid-Mainstem, Snoqualmie River-Upper Mainstem, and Tolt River-Lower.

Riparian Forest

Current Condition

The percent of “intact” riparian forest was calculated along all streams within each individual subbasin and summarized on a subbasin strategy group scale. The primary data source was Purser et al. (2003). Please refer to the riparian forest current condition subheading in the previous section for a description of the method.

Target Condition

In addition to riparian forest enhancement along chinook and bull trout reaches, a minimum target level of 65% intact conditions for riparian forest cover was set along other fish-bearing streams in order to protect watershed processes and habitat for other salmonids. In subbasins with the highest coho use, the target level of riparian forest cover was set at 80% along all fish-bearing waters. In subbasins with moderate coho use, the target level of riparian forest cover was set at 70% along all fish-bearing waters.

Anthropogenic Instream Barriers

Current Condition

Culverts that are fish barriers were analyzed within each individual subbasin and summarized on a subbasin strategy group scale. Please refer to the anthropogenic instream barriers current condition subheading in the previous section for a description of the method.

Target Condition

Thousands of culverts in the Snohomish River Basin block or restrict access to coho habitat. As many as possible should be replaced, with priority given to those blocking habitat in high use coho subbasins, followed by those blocking habitat in moderate use coho subbasins. A detailed inventory of priority culvert replacements within these subbasins is recommended and should be based on the quantity and production potential of habitat that is currently blocked.

Forest Cover

Current Condition

An analysis of Landsat satellite imagery was used to estimate hydrologically mature forest cover on a subbasin scale (Purser et al. 2003). The sum of mature evergreen forest, medium evergreen forest, and deciduous stands was used to estimate total forest cover. Targets are presented as a percentage of the subbasin area that was forested historically. Please refer to the riparian forest current conditions subheading in the previous section for a description of the method.

Target Condition

Hydrologically mature forest cover is negatively correlated with peak flow runoff and positively correlated with channel stability (Booth et al. 2002, Spence et al. 1996). Retaining and restoring forest cover, and restricting urbanization impacts such as impervious area and road crossings, are considered critical steps toward protecting watershed processes and stream conditions. A planning target to maintain channel stability of 65% mature forest cover and 10% EIA has been reported in the literature and implemented locally (Booth et al. 2001). This paper warns, however, that the 65%/10% standard does not separate a condition of “no impact” from that of “some impact,” but rather “some impact” from that of “gross and easily perceived impact.” Analyses conducted for the Issaquah Creek Basin Plan found that 65% forest cover and 4% EIA (~7% total impervious area (TIA)) more closely approximated a threshold

condition of channel stability where the current two-year discharge equaled the ten-year historic discharge (Booth et al. 2001). Additional analysis suggested that 65% forest cover was plausible but not definitive as a threshold for channel stability (Booth et al. 2001). Based on this paper, a minimum target level of 65% forest cover was selected for non-urban subbasin strategy groups, and a more protective target level of 75% was set for subbasin strategy groups with high use or potential for chinook and bull trout.

Impervious Surface

Current Condition

An analysis of Landsat satellite imagery was used to estimate TIA on a subbasin scale (Purser et al. 2003). Impervious surface was calculated using the high density development and medium density development land cover classes based on the following equations:

$$(1) \% \text{ Total Impervious Area} = 0.9(\% \text{ High Density Development}) + 0.45(\% \text{ Medium Density Development})$$

$$(2) \% \text{ Effective Impervious Area} = 0.72(\% \text{ High Density Development}) \text{ and } 0.36(\% \text{ Medium Density Development}).$$

Natural impervious area such as rock outcrop, open water, and channel deposits was separated out into its own land cover class. Please refer to the riparian forest current conditions subheading in the previous section for further description of the method for analyzing the Landsat imagery. Impervious surface targets have been set for only Puget lowland subbasins.

Target Condition

Increases in TIA and EIA are positively correlated with reductions in hydrologic function and water quality, as well as declines in physical habitat conditions and the abundance and diversity of stream biota (Booth et al. 2002, Finkenbine et al. 2000, Morley 2001, Spence et al. 1996). As mentioned above, standards have been reported for managing forest cover and impervious surface together. For rural subbasin strategy groups in the Puget Lowland, we propose target levels of <7% TIA based on a review by Spence et al. (1996). They cite numerous reports of geomorphic, hydrologic, and biological effects becoming evident between 7% and 12% TIA, and substantial above 12% TIA. Seven percent TIA approximates the 4% EIA threshold cited above, as well as the 3% EIA threshold used in the Step 3 watershed process analysis of the EASC.

Road Density

Current Condition

Road density (mi/mi²) was calculated on a subbasin scale using the WA DNR road layer and the Snohomish County ESA subbasins layer for headwater basins (i.e., mean elevation >1,000 m).

Target Condition

Forest roads add drainage density and increase peak flows and sediment supplies (Spence et al. 1996). The degree of impact depends on a variety of factors including slope, soil type, and level of maintenance. NOAA (1996) reports degradation above a threshold of two miles of roads per square mile. Based on this report, a target level of two miles of roads per square mile was selected for headwater subbasin strategy groups, with decommissioning recommended in groups that exceed this target.

CAVEATS

- The test case strategy is the predicted level necessary to achieve full recovery for all salmonid populations. Preliminary modeling with the SHIRAZ model has indicated this is reasonable; however, the final version of the model had not been completed when the test case strategy alternative was developed.
- The SHIRAZ model evaluates chinook salmon population performance only. Habitat condition targets to achieve viable populations for other salmonids are based on best professional judgment. Further modeling of coho population performance is recommended.

Step 7 Table. Alternative Habitat Targets

		Habitat conditions along focus reaches										Habitat conditions across subbasins							
		Riparian Forest		Anthropogenic Instream Barriers		Off-channel Habitat		Edge Habitat		Habitat Structure		Anthropogenic Instream Barriers		Forest Cover		Impervious Surface		Road Density	
		Intact is defined as mature evergreen, medium evergreen and deciduous classes (Purser and Simmonds 2003)		Snohomish County DIS analyzed all known and surveyed culverts. Many more blocking culverts likely exist than are reported here. Miles of habitat upstream of both partial and total barriers is reported here. Weirs and tide-gates are not included in the analysis. Barriers reported here are within 1/2 mile of a focus reach.		Off-channel habitat refers to side-channels, sloughs, ponds, and small tributary habitat within the floodplain. In the estuary off-channel habitat refers to tidal marsh including blind tidal channels.		Edge habitat is the slackwater margin along mainstem rivers used for rearing by juvenile salmonids. A natural bank is a bank that has not been armored or diked.		Habitat structure refers to LWD and complexity. Restoring watershed processes will be the most effective approach over the longterm. The installation of ELJs in areas with depleted LWD and low recruitment potential will be an important nearterm measure in some areas.		Snohomish County DIS analyzed all known and surveyed culverts. Many more blocking culverts likely exist than are reported here. Miles of habitat upstream of both partial and total barriers is reported here. Weirs and tide-gates are not included in the analysis.		Hydrologically mature evergreen and deciduous stands within historically forested areas (Purser and Simmonds 2003) .		Purser and Simmonds 2003. Impervious surface targets have been set for only lowland subbasins.		Washington State’s Department of Natural Resources road layer and Snohomish County’s ESA subbasins layer. Road density targets have been set for upland basins only.	
Alternatives	Subbasin Strategy Groups	CURRENT % intact	TARGET % intact and protected	CURRENT miles of habitat upstream of full or partial barriers on or within 1/2 mile of focus reaches	TARGET % length blocked habitat restored to accessibility	CURRENT acres disconnected and/or drained	TARGET % of isolated area reconnected target level	CURRENT % natural bank conditions	TARGET % natural bank conditions target level	CURRENT # (%) of chinook/bull trout focus reaches with less than 50% intact riparian forests and low levels of LWD (EDT rating >2)	TARGET # (%) of degraded reaches brought up to more natural level of LWD and complexity through construction of ELJs and wood placement	CURRENT miles of habitat upstream of full or partial barriers on or within 1/2 mile of focus reaches	TARGET % length blocked habitat restored to accessibility	CURRENT % current forest cover	TARGET % forest cover	CURRENT % anthropogenic total impervious surface	TARGET % anthropogenic total impervious surface	CURRENT road density(miles of road)	TARGET road density (miles decommissioned)
Alternative 1 Current Path Current level of protection and restoration projected out 25 years into the future. Continued degradation from road expansion and rates of land cover change.			Predicted Condition		Predicted Condition		Predicted Condition		Predicted Condition		Predicted Condition		Predicted Condition		Predicted Condition		Predicted Condition		Predicted Condition
	Nearshore restoration	31	31%	N/A	N/A	N/A	0%	60	60%	1(100%)	0.1(10%)	N/A	None	N/A	None	N/A	None	N/A	None
	Estuary restoration	11	11%	N/A	N/A	8270	25%	38	41%	1(100%)	0.1(10%)	N/A	None	N/A	None	9	9%	N/A	None
	Mainstem-primary restoration	56	56%	2	10%	1514	10%	69	67%	11 (30%)	1.1 (10%)	22	10%	50	41%	3.3	7%	N/A	None
	Mainstem-secondary restoration	74	74%	0	10%	68	5%	78	76%	5(24%)	0.5(10%)	0	10%	59	55%	2.7	7%	N/A	None
	Rural streams-primary restoration	62	62%	2	10%	129	0%	N/D	None	0(0%)	0%	14	10%	45	35%	0.9	2%	N/A	None
	Rural streams-secondary restoration	60	60%	0	10%	533	0%	N/D	None	0(0%)	0%	19	10%	36	20%	3.4	9%	N/A	None
	Urban streams restoration	20	20%	2	10%	0	0%	N/D	None	4(100%)	0.4(10%)	42	10%	13	5%	22.8	49%	N/A	None
	Headwaters-primary protection	80	80%	0	10%	0	0%	N/D	None	0(0%)	0%	0	10%	77	80%	0.0	0%	0.8(126)	0.8
	Headwaters-secondary restoration	79	79%	1	10%	4	0%	N/D	None	0(0%)	0%	8	10%	69	71%	0.3	0%	3.4(691)	3.3(25)
	Headwaters-secondary protection	84	84%	0	10%	5	0%	N/D	None	0(0%)	0%	0	10%	76	80%	0.0	0%	1.4(301)	1.4
	Headwaters-protection above natural barriers	N/A	None	N/A	None	19	0%	N/D	None	0(0%)	0%	0	10%	78	80%	0.0	0%	1.2(236)	1.2
	Headwaters-restoration above falls and dams	N/A	None	N/A	None	72	0%	N/D	None	0(0%)	0%	6	10%	67	80%	1.2	2%	3.1(850)	3.1(25)

Step 7 Table. Alternative Habitat Targets

		Habitat conditions along focus reaches										Habitat conditions across subbasins							
		Riparian Forest		Anthropogenic Instream Barriers		Off-channel Habitat		Edge Habitat		Habitat Structure		Anthropogenic Instream Barriers		Forest Cover		Impervious Surface		Road Density	
Intact is defined as mature evergreen, medium evergreen and deciduous classes (Purser and Simmonds 2003)		Snohomish County DIS analyzed all known and surveyed culverts. Many more blocking culverts likely exist than are reported here. Miles of habitat upstream of both partial and total barriers is reported here. Weirs and tide-gates are not included in the analysis. Barriers reported here are within 1/2 mile of a focus reach.		Off-channel habitat refers to side-channels, sloughs, ponds, and small tributary habitat within the floodplain. In the estuary off-channel habitat refers to tidal marsh including blind tidal channels.		Edge habitat is the slackwater margin along mainstem rivers used for rearing by juvenile salmonids. A natural bank is a bank that has not been armored or diked.		Habitat structure refers to LWD and complexity. Restoring watershed processes will be the most effective approach over the longterm. The installation of ELJs in areas with depleted LWD and low recruitment potential will be an important nearterm measure in some areas.		Snohomish County DIS analyzed all known and surveyed culverts. Many more blocking culverts likely exist than are reported here. Miles of habitat upstream of both partial and total barriers is reported here. Weirs and tide-gates are not included in the analysis.		Hydrologically mature evergreen and deciduous stands within historically forested areas (Purser and Simmonds 2003) .		Purser and Simmonds 2003. Impervious surface targets have been set for only lowland subbasins.		Washington State’s Department of Natural Resources road layer and Snohomish County’s ESA subbasins layer. Road density targets have been set for upland basins only.			
Alternatives	Subbasin Strategy Groups	CURRENT % intact	TARGET % intact and protected	CURRENT miles of habitat upstream of full or partial barriers on or within 1/2 mile of focus reaches	TARGET % length blocked habitat restored to accessibility	CURRENT acres disconnected and/or drained	TARGET % of isolated area reconnected target level	CURRENT % natural bank conditions	TARGET % natural bank conditions target level	CURRENT # (%) of chinook/bull trout focus reaches with less than 50% intact riparian forests and low levels of LWD (EDT rating >2)	TARGET # (%) of degraded reaches brought up to more natural level of LWD and complexity through construction of ELJs and wood placement	CURRENT miles of habitat upstream of full or partial barriers on or within 1/2 mile of focus reaches	TARGET % length blocked habitat restored to accessibility	CURRENT % current forest cover	TARGET % forest cover	CURRENT % anthropogenic total impervious surface	TARGET % anthropogenic total impervious surface	CURRENT road density(miles of road)	TARGET road density (miles decommissioned)
Alternative 2 Moderate improvement over current path Current path plus approximately 50% of the difference between current path and test case target habitat conditions.																			
	Nearshore restoration	31	51%	N/A	None	N/A	0%	60	75%	1(100%)	0.5(45%)	N/A	None	N/A	None	N/A	None	N/A	None
	Estuary restoration	11	31%	N/A	None	8270	48%	38	66%	1(100%)	0.5(45%)	N/A	None	N/A	None	9	9%	N/A	None
	Mainstem-primary restoration	56	68%	2	53%	1514	40%	69	79%	11 (30%)	5(45%)	22	45%	50	53%	3	7%	N/A	None
	Mainstem-secondary restoration	74	75%	0	48%	68	28%	78	80%	5(24%)	2.3(45%)	0	45%	59	60%	3	7%	N/A	None
	Rural streams-primary restoration	62	66%	2	48%	129	25%	N/D	None	0(0%)	0%	14	45%	45	50%	1	4%	N/A	None
	Rural streams-secondary restoration	60	60%	0	45%	533	25%	N/D	None	0(0%)	0%	19	45%	36	43%	3	8%	N/A	None
	Urban streams restoration	20	40%	2	45%	0	0%	N/D	None	4(100%)	1.8(45%)	42	45%	13	28%	23	37%	N/A	None
	Headwaters-primary protection	80	80%	0	53%	0	0%	N/D	None	0(0%)	0%	0	45%	77	80%	0	1%	0.8(126)	0.8
	Headwaters-secondary restoration	79	80%	1	48%	4	0%	N/D	None	0(0%)	0%	8	45%	69	73%	0	1%	3.4(691)	2.7(150)
	Headwaters-secondary protection	84	84%	0	45%	5	0%	N/D	None	0(0%)	0%	0	45%	76	80%	0	1%	1.4(301)	1.4
	Headwaters-protection above natural barriers	N/A	None	N/A	None	19	0%	N/D	None	0(0%)	0%	0	35%	78	80%	0	1%	1.2(236)	1.2
	Headwaters-restoration above falls and dams	N/A	None	N/A	None	72	0%	N/D	None	0(0%)	0%	6	35%	67	80%	1	2%	3.1(850)	2.6(145)

Step 7 Table. Alternative Habitat Targets

		Habitat conditions along focus reaches										Habitat conditions across subbasins							
		Riparian Forest		Anthropogenic Instream Barriers		Off-channel Habitat		Edge Habitat		Habitat Structure		Anthropogenic Instream Barriers		Forest Cover		Impervious Surface		Road Density	
		Intact is defined as mature evergreen, medium evergreen and deciduous classes (Purser and Simmonds 2003)	Snohomish County DIS analyzed all known and surveyed culverts. Many more blocking culverts likely exist than are reported here. Miles of habitat upstream of both partial and total barriers is reported here. Weirs and tide-gates are not included in the analysis. Barriers reported here are within 1/2 mile of a focus reach.		Off-channel habitat refers to side-channels, sloughs, ponds, and small tributary habitat within the floodplain. In the estuary off-channel habitat refers to tidal marsh including blind tidal channels.		Edge habitat is the slackwater margin along mainstem rivers used for rearing by juvenile salmonids. A natural bank is a bank that has not been armored or diked.		Habitat structure refers to LWD and complexity. Restoring watershed processes will be the most effective approach over the longterm. The installation of ELJs in areas with depleted LWD and low recruitment potential will be an important nearterm measure in some areas.		Snohomish County DIS analyzed all known and surveyed culverts. Many more blocking culverts likely exist than are reported here. Miles of habitat upstream of both partial and total barriers is reported here. Weirs and tide-gates are not included in the analysis.		Hydrologically mature evergreen and deciduous stands within historically forested areas (Purser and Simmonds 2003) .		Purser and Simmonds 2003. Impervious surface targets have been set for only lowland subbasins.		Washington State’s Department of Natural Resources road layer and Snohomish County’s ESA subbasins layer. Road density targets have been set for upland basins only.		
Alternatives	Subbasin Strategy Groups	CURRENT % intact	TARGET % intact and protected	CURRENT miles of habitat upstream of full or partial barriers on or within 1/2 mile of focus reaches	TARGET % length blocked habitat restored to accessibility	CURRENT acres disconnected and/or drained	TARGET % of isolated area reconnected target level	CURRENT % natural bank conditions	TARGET % natural bank conditions target level	CURRENT # (%) of chinook/bull trout focus reaches with less than 50% intact riparian forests and low levels of LWD (EDT rating >2)	TARGET # (%) of degraded reaches brought up to more natural level of LWD and complexity through construction of ELJs and wood placement	CURRENT miles of habitat upstream of full or partial barriers on or within 1/2 mile of focus reaches	TARGET % length blocked habitat restored to accessibility	CURRENT % current forest cover	TARGET % forest cover	CURRENT % anthropogenic total impervious surface	TARGET % anthropogenic total impervious surface	CURRENT road density(miles of road)	TARGET road density (miles decommissioned)
Alternative 3 - Moderate-high improvement over current path – Current path plus approximately 75% of the difference between current path and test case target habitat conditions.																			
	Nearshore restoration	31	60%	N/A	None	N/A	0%	60	83%	1(100%)	0.6(62.5%)	N/A	None	N/A	None	N/A	None	N/A	None
	Estuary restoration	11	40%	N/A	None	8270	59%	38	78%	1(100%)	0.6(62.5%)	N/A	None	N/A	None	9	9%	N/A	None
	Mainstem-primary restoration	56	74%	2	74%	1514	55%	69	84%	11 (30%)	7.1 (62.5%)	22	63%	50	59%	3	7%	N/A	None
	Mainstem-secondary restoration	74	75%	0	66%	68	39%	78	81%	5(24%)	3.1(62.5%)	0	63%	59	62%	3	7%	N/A	None
	Rural streams-primary restoration	62	68%	2	66%	129	38%	N/D	None	0(0%)	0%	14	63%	45	58%	1	6%	N/A	None
	Rural streams-secondary restoration	60	60%	0	63%	533	38%	N/D	None	0(0%)	0%	19	63%	36	54%	3	8%	N/A	None
	Urban streams restoration	20	50%	2	63%	0	0%	N/D	None	4(100%)	2.5(62.5%)	42	63%	13	39%	23	31%	N/A	None
	Headwaters-primary protection	80	80%	0	74%	0	0%	N/D	None	0(0%)	0%	0	63%	77	80%	0	1%	0.8(126)	0.8
	Headwaters-secondary restoration	79	80%	1	66%	4	0%	N/D	None	0(0%)	0%	8	63%	69	74%	0	1%	3.4(691)	2.3(224)
	Headwaters-secondary protection	84	84%	0	63%	5	0%	N/D	None	0(0%)	0%	0	63%	76	80%	0	1%	1.4(301)	1.4
	Headwaters-protection above natural barriers	N/A	None	N/A	None	19	0%	N/D	None	0(0%)	0%	0	48%	78	80%	0	1%	1.2(236)	1.2
	Headwaters-restoration above falls and dams	N/A	None	N/A	None	72	0%	N/D	None	0(0%)	0%	6	48%	67	80%	1	1%	3.1(850)	2.3(218)

Step 7 Table. Alternative Habitat Targets

		Habitat conditions along focus reaches										Habitat conditions across subbasins							
		Riparian Forest		Anthropogenic Instream Barriers		Off-channel Habitat		Edge Habitat		Habitat Structure		Anthropogenic Instream Barriers		Forest Cover		Impervious Surface		Road Density	
		Intact is defined as mature evergreen, medium evergreen and deciduous classes (Purser and Simmonds 2003)	Snohomish County DIS analyzed all known and surveyed culverts. Many more blocking culverts likely exist than are reported here. Miles of habitat upstream of both partial and total barriers is reported here. Weirs and tide-gates are not included in the analysis. Barriers reported here are within 1/2 mile of a focus reach.		Off-channel habitat refers to side-channels, sloughs, ponds, and small tributary habitat within the floodplain. In the estuary off-channel habitat refers to tidal marsh including blind tidal channels.		Edge habitat is the slackwater margin along mainstem rivers used for rearing by juvenile salmonids. A natural bank is a bank that has not been armored or diked.		Habitat structure refers to LWD and complexity. Restoring watershed processes will be the most effective approach over the longterm. The installation of ELJs in areas with depleted LWD and low recruitment potential will be an important nearterm measure in some areas.		Snohomish County DIS analyzed all known and surveyed culverts. Many more blocking culverts likely exist than are reported here. Miles of habitat upstream of both partial and total barriers is reported here. Weirs and tide-gates are not included in the analysis.		Hydrologically mature evergreen and deciduous stands within historically forested areas (Purser and Simmonds 2003) .		Purser and Simmonds 2003. Impervious surface targets have been set for only lowland subbasins.		Washington State’s Department of Natural Resources road layer and Snohomish County’s ESA subbasins layer. Road density targets have been set for upland basins only.		
Alternatives	Subbasin Strategy Groups	CURRENT % intact	TARGET % intact and protected	CURRENT miles of habitat upstream of full or partial barriers on or within 1/2 mile of focus reaches	TARGET % length blocked habitat restored to accessibility	CURRENT acres disconnected and/or drained	TARGET % of isolated area reconnected target level	CURRENT % natural bank conditions	TARGET % natural bank conditions target level	CURRENT # (%) of chinook/bull trout focus reaches with less than 50% intact riparian forests and low levels of LWD (EDT rating >2)	TARGET # (%) of degraded reaches brought up to more natural level of LWD and complexity through construction of ELJs and wood placement	CURRENT miles of habitat upstream of full or partial barriers on or within 1/2 mile of focus reaches	TARGET % length blocked habitat restored to accessibility	CURRENT % current forest cover	TARGET % forest cover	CURRENT % anthropogenic total impervious surface	TARGET % anthropogenic total impervious surface	CURRENT road density(miles of road)	TARGET road density (miles decommissioned)
Alternative 4 - Test Case Hypothesized distribution of focus and level of effort within subbasin strategy groups necessary to achieve an outcoming at the high end of the Shared Strategy planning range. Also hypothesized to achieve high levels of diversity and spatial structure, as well as adequate protections protections for other salmonids. SHIRAZ results support the hypothesis.																			
	Nearshore restoration	31	70%	N/A	N/A	N/A	0%	60	90%	1(100%)	0.8(80%)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	None
	Estuary restoration	11	50%	N/A	N/A	8270	70%	38	90%	1(100%)	0.8(80%)	N/A	N/A	N/A	N/A	9	7%	N/A	None
	Mainstem-primary restoration	56	80%	2	95%	1514	70%	69	90%	11 (30%)	8.8(80%)	22	80%	50	65%	3	7%	N/A	None
	Mainstem-secondary restoration	74	75%	0	85%	68	50%	78	82%	5(24%)	4(80%)	0	80%	59	65%	3	7%	N/A	None
	Rural streams-primary restoration	62	70%	2	85%	129	50%	N/D	None	0(0%)	0%	14	80%	45	65%	1	7%	N/A	None
	Rural streams-secondary restoration	60	60%	0	80%	533	50%	N/D	None	0(0%)	0%	19	80%	36	65%	3	7%	N/A	None
	Urban streams restoration	20	60%	2	80%	0	0%	N/D	None	4(100%)	3.2(80%)	42	80%	13	50%	23	25%	N/A	None
	Headwaters-primary protection	80	80%	0	95%	0	0%	N/D	None	0(0%)	0%	0	80%	77	80%	0	1%	0.8(126)	0.8
	Headwaters-secondary restoration	79	80%	1	85%	4	0%	N/D	None	0(0%)	0%	8	80%	69	75%	0	1%	3.4(691)	2(324)
	Headwaters-secondary protection	84	84%	0	80%	5	0%	N/D	None	0(0%)	0%	0	80%	76	80%	0	1%	1.4(301)	1.4
	Headwaters-protection above natural barriers	N/A	N/A	N/A	N/A	19	0%	N/D	None	0(0%)	0%	0	60%	78	80%	0	1%	1.2(236)	1.2
	Headwaters-restoration above falls and dams	N/A	N/A	N/A	N/A	72	0%	N/D	None	0(0%)	0%	6	60%	67	80%	1	1%	3.1(850)	2(316)

	Areas where achieving the target may be unrealistic.
	These cells were estimated using best professional judgement because the method, which relied on a simple linear rate of change projected out 25 years, resulted in a number above 100 or below 0.

STEP 8: BIOLOGICAL EVALUATION OF CONSERVATION PLAN ALTERNATIVES

DESCRIPTION

Step 8 is the biological evaluation of Snohomish Basin Salmonid Conservation Plan alternatives. Each alternative will be presented in terms of the parameters of viable salmonid populations (VSP) – abundance, productivity, diversity and spatial structure – and habitat conditions levels, reported on a subbasin strategy group scale, thought necessary to achieve the biological response. In the absence of habitat/production modeling completed for other salmonids in the Snohomish River Basin, alternatives will be evaluated qualitatively for coho salmon and bull trout char. Given the broad range and diversity of habitat requirements for chinook salmon, coho salmon, and bull trout char, it is assumed that a plan that is expected to achieve healthy and harvestable (chinook and coho) levels for these proxy species will provide for viability of all salmonid stocks within the Snohomish River Basin.

Chinook population performance will be presented for each alternative using both the SHIRAZ and EDT models. Step 8 will include a summary of each modeling approach, including documentation, assumptions and caveats. The two-model approach will provide a side-by-side comparison and reality check on the results. If the modeling results are substantially different, the SBSRTC may critique both and endorse one approach over the other. When complete, results of the modeling will be added as an appendix to this report and/or the Plan.

Initial results from the SHIRAZ model will be on a coarse scale and limited to a time sequence that uses target conditions as the starting point from which population performance levels stabilize. As the model is refined, harvest, hatchery and additional habitat factors will be integrated, and the time sequence will be extended from current conditions to the target level of population performance. Short term, benchmark habitat condition levels needed to meet desired levels of population performance within a given time frame can then be developed. The final estimated fish population response from the conservation alternatives that will be considered by the Forum will be modeled in Step 8, the final step of the EASC, using both the EDT and SHIRAZ models.

Subbasin strategy groups identified as most critical for chinook salmon and bull trout char are also important for coho salmon. Coho, however, differ from the other proxy species in that they use a broad range of small tributary habitats for spawning and rearing. To address these habitats, additional prescriptions will be identified for subbasins identified in Step 1 as having high or moderate use by coho salmon. Data and model results needed either to evaluate the historic capacity to support coho salmon or to express the results of proposed actions in terms of coho population performance will not be available during the time frame of this analysis. Instead, the benefit to coho salmon of various fish-based strategies will be expressed in relative terms based on best professional judgment.

SHIRAZ MODEL

Note: As mentioned in the overview to this EASC document, the results from SHIRAZ that will be used by the Forum in choosing among alternative suites of habitat actions will not be reported in this document. The technical group conducting the SHIRAZ modeling is working closely with the SBSRTC to translate several alternatives into inputs for the SHIRAZ model. The results from this modeling will be reported as an addendum to this document and are expected to be available later in the spring of 2004. We include here a general description of the SHIRAZ model and our methods of parameterization to date.

Some of the details of the inputs described here may change by the final version, but we expect such changes to be minor.

The SHIRAZ model is being used in Step 8 of the EASC process to predict fish population responses to habitat conditions in the Snohomish River Basin. We use these model predictions to help evaluate alternative suites of actions to achieve salmon recovery. An alternative will be chosen by the Forum, and will become the basis for the watershed recovery plan for salmonids.

Model Overview

The SHIRAZ model can link the effects of habitat condition, hatchery stocks and harvest management to salmon population responses through a dynamic life cycle modeling approach (Hilborn 2002.) SHIRAZ has three main parts: a description of habitat conditions (e.g., sediment, temperature, flow), a set of functional relationships linking habitat conditions to productivity or capacity of fish at particular life stages, and a population dynamic model that moves fish through the landscape and accounts for their survival through time. This population dynamic model computes the number of individuals at a given life stage as:

$$N_{s+1} = \frac{N_s}{\frac{1}{p} + \frac{1}{c} N_s}$$

Where N_s is the number of individuals at life stage s , p is productivity, and c is capacity (Mousalli and Hilborn 1986). The productivity and capacity values for each life stage are a specified function of habitat conditions.

SHIRAZ allows for multiple stocks that can be used to represent (1) different life history types (e.g., ocean type vs. stream type chinook), (2) wild vs. hatchery fish, and (3) potentially different species. Stocks can interact in the model by affecting one another's productivity or capacity; or by individuals moving from one stock to another (e.g., hatchery-born fish that spawn naturally and therefore become part of the wild stock).

SHIRAZ is spatially explicit, so that habitat conditions, hatchery-wild or different stock interactions, harvest levels, and fish productivity and capacity are tracked through specific areas in the modeled watershed (e.g., reaches, subbasins, estuary). SHIRAZ can also explicitly incorporate temporal variation in habitat and fish population responses through stochasticity in environmental and demographic variables and through deterministic changes in the environment over time. In other words, habitat, hatchery, and harvest effects on fish can vary stochastically in the model, as can demographic vital rates (e.g., fecundity, age distribution, maturation rates) affecting survival in the life cycle model. Furthermore, the rate and magnitude of change in habitat, hatchery or harvest levels over time can be specified in the model, so that fish population responses to different patterns of change in the "H's" can be explored (e.g., lag times due to riparian planting, gradual reduction in hatchery releases or harvest rates). The outputs of SHIRAZ are the number of fish by area, life stage, year and stock. A more detailed explanation of the model and the contents of input modules are provided in Hilborn (2002).

Application of SHIRAZ in the Snohomish River Basin

The salmon-habitat modeling we are conducting in support of salmon recovery planning in the Snohomish River Basin involves setting up multiple habitat inputs to the SHIRAZ model. Each of these inputs describes a unique view of the habitat conditions in the basin to help provide benchmarks against which a recovery alternative can be evaluated: a current path, several alternatives describing different

habitat quantities and qualities throughout the basin, and an historical condition. For each set of habitat conditions, the resulting population dynamics will be summarized, and these can be evaluated against the recovery goals for salmon in the basin. The outputs from SHIRAZ include a description from each alternative of what the predicted status of the populations will be for the four VSP parameters described by NMFS as necessary components of a healthy salmon population (McElhany et al. 2000). The VSP parameters are: abundance (expressed as spawner and juvenile capacities), productivity (expressed as stage-specific survivals, recruits: spawner, or population growth rate), spatial structure (expressed as the distribution of individuals throughout the Basin as adults and juveniles, and the patchiness of that distribution), and diversity (expressed as likely life history types or trajectories and the diversity of habitat types they can access.)

In its current formulation, SHIRAZ tracks productivity and capacity for nine life history stages through the 48 subbasins occurring in the anadromous zone of the Snohomish River Basin. At present, chinook in the basin are being modeled as a single stock, for which individual Skykomish and Snoqualmie population parameters can be input and summarized as outputs. Parameter values are summarized in Tables 8-1 and 8-2.

Productivity

Tables 8-1 and 8-2 depict the stage-specific survival rates used to parameterize the current version of SHIRAZ. Survival from eggs to fry is modeled as a stochastic function of three habitat conditions: fine sediment, incubation temperature, and flood recurrence interval (see *Appendix 1*). Similarly, survival from river entry to adult spawning is modeled as a function of pre-spawning temperature. Survival from the remaining life history stages is not explicitly modeled as a function of habitat in the current version of the model. Rather, survival rates are constant values derived from Greene et al. (*in press*). Age distribution of adults and maturation rates in the ocean are derived from the Puget Sound TRT database (Puget Sound TRT 2003).

Table 8-1. Survival rates Used to Parameterize the Current version of SHIRAZ in the Snohomish River Basin.

S ? s+1	p _{s? s+1}
Spawner ? egg	Rate _{pre-spawning temperature}
Egg ? fry	Rate _{incubation temperature} * rate _{fine sediment} * rate _{flood recurrence}
Fry ? smolt	Constant rate = 0.306
Smolt ? ocean-1	Constant rate = 0.619 * 0.038
Ocean-1 ? ocean-2	Constant rate = 0.6
Ocean-2 ? ocean-3	Constant rate = 0.7
Ocean-3 ? ocean-4	Constant rate = 0.8
Ocean-4 ? spawner	Constant rate = 0.9

Capacity

Tables 8-2 and 8-3 depict the capacity values used to parameterize the current version of SHIRAZ. Capacities for adult spawning and juvenile rearing are specified for each subbasin in the model. Capacities are estimated as the potential for each subbasin to support a particular density of spawners or juveniles, depending on the accessibility of habitats and their predicted quality (see *Step 4* and *Appendix 1* for description of methods for calculating adult and juvenile potential capacity, respectively).

The results from the adult and juvenile potential capacity analyses are reported as distributions of possible fish densities. These distributions are used in each model iteration to create variability in potential capacity at those life stages.

Table 8-2. Capacity Values Used to Parameterize the Current Version of SHIRAZ in the Snohomish River Basin.

s+1	C_{s+1}
Spawner	Adult capacity (see Step 4)
Egg	$(5,000 \text{ eggs / spawner}) \cdot (\text{Adult capacity} / 2)^a$
Fry	Juvenile capacity (not including estuary; Appendix 7.1)
Smolt	Juvenile capacity (Appendix 7.1)
Ocean-1	Assumed infinite
Ocean-2	Assumed infinite
Ocean-3	Assumed infinite
Ocean-4	Assumed infinite
Ocean-5	Assumed infinite

^a Egg capacity is based on adult fecundity (approximated from Greene et al. (*in press*)), adult capacity (from EASC Step 4), and an assumed sex ratio of 1:1.

Habitat Conditions

Habitat conditions specified for each subbasin are: the percentage of fine sediments in the streambed (SBSRTC 2002), mean water temperature during the 3 month egg incubation period from October to December, mean water temperature during the 5 month pre-spawning/spawning period from June to November (Washington Department of Ecology 2003), and the recurrence interval of peak flows occurring during the egg incubation period (USGS 2003). Empirical data exist only for a subset of all of the subbasins that are modeled in SHIRAZ. To fill in habitat attributes for subbasins under alternative habitat conditions in the basin, we are using a series of statistical models relating physical, biological and land use/land cover variables to the existing field data in the basin. The final addendum to this report will show the relationships we use to populate the habitat attributes in each subbasin for the SHIRAZ modeling. Each of these habitat conditions affects stage-specific survival through functional relationships derived from the literature (see *Appendix 1*).

Initial Results

We used the initial rounds of SHIRAZ results to help generate alternative suites of actions in the subbasin strategy groups. For sensitivity analyses, we changed stage-specific survivals (i.e., productivities) or capacities relative to current conditions, using values of survivals and capacities observed for chinook or indicated by analyses such as the potential capacity estimates. We examined the resulting changes in population abundance and productivity due to numerical changes in stage-specific productivity or capacity in the model. These results helped determine which sets of actions in Step 7 were most likely to result in population abundance or productivity values within the recovery planning range for the Snohomish River Basin populations. Our initial sensitivity analyses suggested that improvements in juvenile capacity and survival in freshwater mainstems, estuary and nearshore habitats

will result in the greatest changes to spawner numbers in the Snohomish Basin. These results are preliminary and do not include the potential effects of improvements to landscape-forming processes in upland subbasins.

The next set of modeling we conducted was to explicitly incorporate alternative habitat conditions into different model runs. In order to support salmon recovery planning in the Snohomish River Basin, we produced five different sets of habitat inputs to the SHIRAZ model. These sets are based on the alternatives outlined in the Step 7 Table (i.e., current path, three alternative improvements on this path, and an historical condition). Each alternative describes a unique view of the habitat conditions in the basin to help provide benchmarks against which a suite of recovery actions can be evaluated. For each alternative, SHIRAZ generates a separate set of outputs, which includes a description of the predicted status of the Snoqualmie and Skykomish populations for the four VSP parameters.

Next Steps

An especially challenging part of the SHIRAZ and EDT modeling in Step 8 is in providing clear linkages between changes in habitat-related actions and concomitant changes in habitat conditions. We will discuss how each of the habitat condition categories described in Step 7 is translated into changes in habitat inputs to SHIRAZ in the addendum to this document.

In order to accurately evaluate the potential effects of alternative habitat actions on chinook populations, the integrated effects of hatchery, harvest, and habitat management must be included in the modeling. We are working to incorporate population structure, both for the “wild” Skykomish and Snoqualmie populations, and for three additional hatchery stocks: the Wallace River hatchery subyearlings, Wallace River hatchery yearlings, and the Tulalip hatchery subyearlings. Furthermore, we are including the effects of harvest as described in the co-managers’ Puget Sound Harvest Management Plan.

Table 8-3. Parameter Values Affecting the Productivity and Capacity of Each Life Stage for the SHIRAZ Application to the Snohomish River Basin.

Life stage	Productivity (p)	Life stage	Capacity (c)
Spawners-eggs	1.0	Eggs	$5,000 \cdot C_{\text{spawner}}^1$
Eggs-fry	$f(\text{temp, flow, sediment})^2$	Fry	$g(\text{habitat})^3$
Fry-smolt	0.306	Smolts	$g(\text{habitat})^3$
Smolts to 1-ocean	0.024	1-ocean (jack)	8
O1-O2	0.6	2-ocean	8
O2-O3	0.7	3-ocean	8
O3-O4	0.8	4-ocean	8
O4-O5	0.9	5-ocean	8

¹ The egg capacity equals an index of spawner fecundity (5,000 eggs per female) times the estimated spawner capacity from B. Sanderson, K. Lagueux, and J. Davies (unpublished manuscript; see EASC Step 4).

² The egg-fry survival is modeled as a function of temperature, flow, and sediment load (see EASC Appendix 1). For some model runs, we have also assumed this to be a constant value = 0.457 (C. Greene et al., in press).

³ Fry capacity calculations are described in *Appendix 1*.

RECOMMENDATIONS FOR FUTURE UPDATES

The following additional analyses are recommended to update the EASC and help refine the Snohomish River Basin salmonid conservation strategy. Information resulting from these future updates can be integrated into implementation of the salmonid conservation plan as it is adaptively managed.

MULTI-SPECIES ANALYSIS

Further analysis is needed to determine if using chinook salmon, bull trout, and coho salmon as proxy species for all salmonids adequately addresses other species, especially steelhead trout. If steelhead trout and other salmon, trout, and native char species are not adequately addressed with the current approach, then relative current use by these species (Step 1) should be discussed to determine where spawning and rearing of these species are concentrated. The information from Step 1 should then be applied to update the other steps of the EASC.

ANALYSIS OF BASE FLOW CONDITIONS

Base flow conditions are likely to become a larger issue in salmonid conservation and recovery in the Snohomish River Basin due to increasing urbanization and land development, further water withdrawals, and global warming. Analysis of base flow conditions in the basin, similar to the analysis of peak flow conditions that was performed in the EASC, should include the following elements:

- Use land cover, geology, and forest road density to evaluate the current condition of base flow hydrology (intact, moderately degraded or degraded) in each subbasin. Analyze low base flows (base flows reduced below historical levels) as a potential limiting factor for salmonid habitat quantity and quality, including accessibility of stream reaches.
- Analyze how current base flow conditions influence the salmonid recovery strategy.
- Analyze impacts of restoration action classes (Step 7) on base flows.

COHO SALMON ABUNDANCE AND DISTRIBUTION

Additional data are needed on juvenile coho salmon abundance and distribution in order to more fully understand ecological relationships between coho salmon and habitats needed for production, and to develop recommendations for habitat protection and restoration as well as species conservation. This analysis should include additional modeling for coho.

JUVENILE HABITAT CAPACITY

More information is needed to describe habitat preferences and survival values for juvenile salmonids. As this information is developed, additional analyses can be performed to evaluate and prioritize opportunities to restore rearing habitat.

ANALYSES OF WATERSHED PROCESS CONDITIONS

The most recent Landsat classification (Purser et al., 2003) should be ground-truthed and then applied to update analyses of sediment supply, riparian function, and upland peak flow. The results from these analyses should be compared with the results from Washington Department of Ecology analyses (Gersib et al., 2003) to increase understanding of landscape-forming processes in WRIA 7.

WETLAND IMPACTS

The hydrologic model (see Step 3) does not take into account the effect of wetlands on conditions observed on the ground and how the distribution of wetlands may affect hydrological conditions downstream. Therefore, further analysis is needed of the impacts of wetlands on hydrologic conditions in subbasins of the Snohomish River Basin. The hydrologic condition ratings (intact, moderately degraded, degraded) could be revised as a result of this analysis.

DATA GAPS

More information and research are needed to address data gaps in the EASC and its supporting documentation. As the Snohomish River Basin salmonid conservation plan is adaptively managed, resolution of data gaps should be a priority in allocating research priority and funding.

APPENDIX 1 METHODS FOR SHIRAZ INPUTS

JUVENILE POTENTIAL CAPACITY

Description

Estimates of the capacity of habitats to support juvenile rearing in each subbasin are needed in Step 8 of the EASC. The juvenile potential capacity model (rearing) follows the same principles as the adult potential capacity model (spawning) (see *Step 4*). In this section, we describe first how we modeled changes in the amount of different juvenile rearing habitat types under different conditions, and second how we estimated potential juvenile capacities under current and historical conditions in each subbasin. As part of analyses in support of Step 8, we also are using this analysis to estimate the potential capacity of habitats to support juvenile rearing under various alternative future states of the basin—those analyses will be fully described in an addendum that will be available later in the spring of 2004.

Similar to the adult potential capacity analysis, our approach to estimating the intrinsic potential of habitats to support juveniles had two main steps: first, we quantified the amount of different types of juvenile rearing habitat, and second, we estimated the number of juvenile chinook those habitat types could collectively support. The step of classifying juvenile rearing habitat types was guided by the availability of data on juvenile rearing densities in different habitat types. Appendix 1 summarizes the information we used to assign juvenile densities to different habitat types. We partitioned the habitat analysis into three components of potential habitats used in juvenile rearing: freshwater habitats, off-channel habitats, and the estuary. We summarized the habitat data for each subbasin to the finest spatial resolution possible (habitat reach or habitat unit area), to match the juvenile density data.

Freshwater Habitat

In the freshwater habitat types, we first determined the currently and historically accessible stream reaches with 4% slope using a DEM derived for the adult potential capacity analysis (see *Step 4*). Current and historically accessible habitats were identified using natural and anthropogenic barrier data layers (Snohomish County Culvert Database, WDFW's SSHEAR Dam Database, and Northwest Indian Fisheries Commission's SSHIAP natural barrier database). Then we delineated large mainstems (>50 m bankfull width), small mainstems (10-50 m bankfull width), and tributaries (<10 m bankfull width) using the estimated bankfull width equation from the adult potential capacity analysis (see *Step 4*).

The distinction between large mainstems and small mainstems was important in this analysis because, for large mainstems, we further partitioned the habitat data into pools, glides, and edge habitat. Juvenile salmonids tend to favor shallow, low velocity edge habitat rather than the channel thalweg in larger streams (Beechie et al. unpublished manuscript). The edge habitat was characterized by specific habitat units, including bars, banks, and backwaters to match the juvenile density data (Table 7.1.1.1).

Large Mainstems

Using methods described in the adult potential capacity analysis (see *Step 4*), we summarized the reach area for mainstem habitats >50 m bankfull width and $\leq 4\%$ gradient that were accessible historically and currently. Reach area was calculated by multiplying the estimated wetted width (see *Step 4*) with the reach length. NWFSC staff summarized the percentage of total reach area found in each habitat unit type (i.e., edge, bank, bar, backwater, pool, riffle, and glide) by two discharge classes (<10,000 cfs and >10,000 cfs) in the Skagit River (Holsinger unpublished report, Appendix 2). In the Snohomish analysis,

we used the percentages from Appendix 2 first to determine the amount of edge habitat (bars, banks, and backwaters) in each subbasin, then to calculate the remaining channel habitat area (pools, riffles, and glides) within each subbasin.

Small Mainstems

Habitat unit data (i.e., the percentage of reach area in pools, riffles, and glides) are limited for small mainstems. Consequently, we were unable to partition small mainstem reach areas into smaller units. We summarized the reach areas in this category that are accessible currently and historically for each subbasin.

Tributaries

Percentages of pools and riffles in tributaries were calculated by Beechie et al. (1994) in the Skagit River Basin for current stream reaches and index reaches (i.e., areas that are relatively pristine). We multiplied these percentages by the reach areas in each subbasin to estimate current and historic habitat unit areas in Snohomish River Basin tributaries.

Lakes

We identified the lakes that are connected to the current and historical distribution of freshwater habitat for juvenile chinook salmon (see above). In lake habitats, juvenile chinook favor shallow habitats closer to the shore, until the juvenile chinook outmigrate (Fresh 2000a, Fresh 2000b, Piaskowski and Tabor 2001). Piaskowski and Tabor (2001) found that juvenile chinook occupied varying widths of the edge habitat of south Lake Washington depending on lakeshore gradient. Specifically, if the gradient was $\leq 20\%$, chinook occupied a mean width (i.e., distance from shore) of 3.7 m; otherwise they occupied a mean width of 1.6 m. Since we did not have bathymetric data for each lake, we averaged these two widths to classify usable habitat. We then partitioned the lakes into three size classes: $<500 \text{ m}^2$, 500 m^2 to 5 ha , and $>5 \text{ ha}$ in area. The usable habitat was calculated by multiplying the perimeter of the lake by the average width to estimate the usable area of lakes in each subbasin.

Off-Channel Habitat

Current and historical off-channel habitat areas were calculated differently. Snohomish County estimated the area of currently accessible off-channel habitat by identifying waterbodies within the 100-year floodplain, then asking local biologists to determine whether each waterbody was currently accessible (see *Step 7 Table*). Tributaries connecting the accessible off-channel waterbodies to the main channel were selected in the analysis. A width of 5 m was assumed for all the tributaries to determine an area estimate. Historical off-channel habitat was mapped by Collins and Sheikh (2003). We defined historical off-channel habitat as accessible if it was adjacent to the channel or connected by a tributary. The area of current and historical off-channel habitat was summarized separately for each subbasin.

Estuary

To quantify current and historical estuarine habitat, we used National Wetland Inventory (NWI) maps and the Collins and Sheikh (2003) dataset, respectively. We partitioned the estuary into the three main habitat types: riverine tidal, estuarine scrub-shrub, and estuarine emergent (Haas and Collins 2001). Within each habitat type we estimated the amount of usable habitat for main channels, distributary channels, and blind-tidal channels. Main channels and distributary channels are mapped explicitly in the NWI maps and the Collins and Sheikh (2003) data. Since juvenile salmon preferentially use channel margins within main and distributary channels, we calculated the amount of area within 10 meters from the bank (Haas and Collins 2001). Blind-tidal channel area was calculated by using the estimated area of blind tidal

channels in each habitat unit type from Appendix 3. Current and historical habitat channel estimates were summarized within each habitat type.

Appendix Table 1. Summary of Mean Juvenile Densities (chinook/m²) by Habitat Type

Habitat type	Habitat unit or size	Density	Variance	Sources ^a
Freshwater - large mainstems	Bar	0.330	?	1
Freshwater - large mainstems	Bank - natural	0.884	?	1
Freshwater - large mainstems	Bank - hydromodified	0.388	?	1
Freshwater - large mainstems	Backwater	0.529	0.595	1, 2, 3
Freshwater - large mainstems	Pool	0.026	0.003	3, 4, 5
Freshwater - large mainstems	Glide	0.042	0.004	3, 4, 5
Freshwater - large mainstems	Riffle	0.001	0.000	3, 4, 5
Freshwater - small mainstems	(all)	0.225	0.118	4, 5, 6, 7
Freshwater - tributaries	Pool	0.702	0.974	8
Freshwater - tributaries	Riffle	0.181	0.040	8
Freshwater - lake	<500 m ²	0.009	?	2
Freshwater - lake	500 m ² - 5 ha	0.059	0.005	9
Freshwater - lake	>5 ha	0.092	?	10
Freshwater - off-channel	?	0.032	0.001	1, 2
Estuary	Riverine tidal	0.108	0.014	1, 11
Estuary	Estuarine scrub-shrub	0.628	0.729	12, 13
Estuary	Estuarine emergent marsh	0.215	0.059	1, 12-16

^a 1 = Hayman et al. 1996; 2 = Murphy et al. 1989; 3 = G. Pess unpublished data; 4 = Jonasson et al. 1997; 5 = Keefe et al. 1995; 6 = Johnson et al. 1992; 7 = Lister & Genoe 1970; 8 = Sekulich 1980; 9 = Swales & Levings 1989; 10 = Tabor and Piaskowski 2002; 11 = Levy et al. 1979; 12 = Beamer and LaRock 1998; 13 = Korman et al. 1997; 14 = Congleton and Smith 1976; 15 = Congleton et al. 1982; 16 = Dunford 1972.

Appendix Table 2. Percentage of Total Reach Area that is Comprised of Each Habitat Unit Type from the Skagit River Basin in Different Discharge Classes.

We applied these percentages in classifying specific habitat types according to what discharge class each reach was in.

	Large Mainstems				Tributaries	
	Discharge		Current	Historic	Current	Historic
Total Edge	<10,000 cfs	>10,000 cfs				
	37.45% ^a	15.35% ^a				
	69.60% ^a	60.50% ^a				
	4.85% ^a	4.80% ^a				
	25.55% ^a	34.70% ^a				
Pools			8.70% ^a	47.00% ^a	52.40% ^b	67.80% ^b
Riffles			15.30% ^a	26.00% ^a	47.60% ^b	32.20% ^b
Glides			12.40% ^a	26.00% ^a		

^a Holsinger, L. 2002.

^b Beechie et al. 1994.

Appendix Table 3. Percent of Total Area in Different Estuarine Habitat Types that is Made Up of Blind Tidal Channels (Haas and Collins 2001)

Habitat Type	Percent Area Blind Tidal Channels
Riverine Tidal	3.0%
Estuarine Scrub Shrub	5.6%
Estuarine Emergent Marsh	10.5%

ADULT SPAWNING POTENTIAL CAPACITY

This analysis quantifies the amount of potential habitat accessible to spawners, now and historically, throughout the Snohomish Basin. In addition, we estimate the potential capacity of those habitats for adult chinook. The major steps in the analysis include: (1) delineating a stream network using DEMs, (2) estimating characteristics of each stream segment such as channel width, gradient and accessibility, (3) quantifying the amount of habitat in various size and gradient classes, and (4) applying fish density data to those quantities to estimate the capacity of those habitats.

STEPS 1 AND 2:

The data layers required to generate a stream network and associated variables are listed in Appendix Table 4. DEMs were used to generate the stream network in which each stream is composed of a series of segments. Secondary variables for each stream segment were determined by subtracting the elevation at the beginning of the stream segment from the elevation at the end of the stream segment (gradient), by overlaying seral stage data (seral stage), or by using regression equations that relate channel width to drainage area and average upslope precipitation (wetted and bankfull width). These regression equations were developed using bankfull width and wetted width measurements (Leopold et al. 1964) collected from 1998 aerial photos for the Snohomish Basin. Appendix Table 5 lists the regression equations used to estimate bankfull width and wetted width (r^2 values of 0.85 for bankfull width and 0.88 for wetted width). Aerial photographic measurements have not yet been compared to field measurements to determine their accuracy, but previous work indicates that photo measurements tend to underestimate bankfull width by an average of 6 m (Appendix Figure 1).

To determine the accessibility of all stream segments in our stream networks for adult chinook, we used the following approach to create anthropogenic and natural exclusion areas, and to flag segments as accessible or inaccessible:

- 1) Filtered anthropogenic and natural barrier data to include only those barriers identified as impediments to chinook spawner movement.
- 2) Visually checked the barrier points.
- 3) Created exclusion catchments from the natural and anthropogenic barrier points. These catchments define all portions of watersheds that are inaccessible to chinook.
- 4) Used the exclusion catchment polygons to code stream segments according to their accessibility (unimpeded, natural blockage, anthropogenic blockage, both natural and anthropogenic).

STEP 3: SUMMARIZING THE HABITAT DATA

Within each subbasin, the total amount of habitat available to spawners was summed for current and historical conditions. This habitat was divided into differing size and gradient classes that reflect preferred/less preferred spawning areas for adult chinook (i.e., spawners prefer large, low-gradient streams, see Appendix Table 6). For large mainstem reaches, the amount of habitat was summed using areal estimates of habitat. For smaller streams (5 to 25 m), the length of habitat was summed. The distinction between length and area was needed for estimating potential capacity (see Step 4).

Caveats

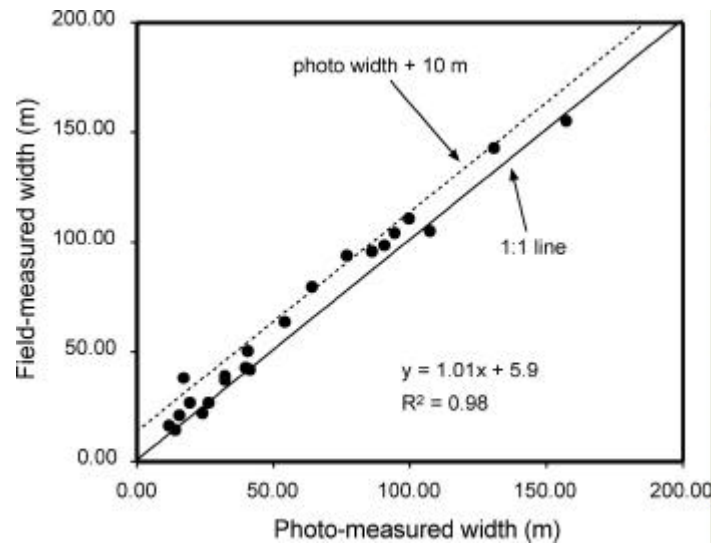
- 1) Lower limits of chinook spawning: Using bankfull width and gradient does not account for spawning substrate, therefore, we are unable to reproduce the lower limit of spawning. To alleviate this problem with the model, we used the experience and knowledge of the Snohomish River Basin Technical Committee to define the lower cutoff for chinook spawners.
- 2) Off-channel habitat: Chinook do occasionally utilize off-channel habitat for spawning. We are in the process of developing methods for quantifying the amount of off-channel habitat per unit of mainstem habitat.
- 3) Multiple Channels: Derived stream networks do not account for multiple channels in the stream valley; thus we are in the process of deriving a correction factor for this limitation.

Appendix Table 4. List of Data Layers Used to Generate and Populate Stream Networks.

Data Layer	Description	Sources
10-meter DEMs	10 meter digital elevation models from the USGS http://waqda.lib.washington.edu/data/washdata.html	Washington Geospatial Data Archive
Average Precipitation	Gridded average annual precipitation http://www.ocs.orst.edu/prism/	Spatial Climate Analysis Service
Seral Stage	Forest cover data layer from Lunetta et al. 1997	US EPA (originally derived from 1992 Landsat data)
Lakes and waterbodies	Snohomish County Waterbody layer	Snohomish County
Natural Barriers	Natural barrier database http://www.nwifc.wa.gov/sshiap2/products.asp	Salmon and Steelhead Habitat Inventory and Assessment Program
Dams	Dam database and SSHIAP barrier database http://www.nwifc.wa.gov/sshiap2/products.asp http://www.streamnet.org/online-data/GISData.html	StreamNet and Salmon and Steelhead Habitat Inventory and Assessment Program
Culverts	Snohomish County Culvert Database	Snohomish County

Appendix Table 5. List of Formulas Used to Estimate Stream Channel Characteristics

Attribute	Formula	Source
Estimated Bankfull Width (m)	$10 (-1.381 + 0.483 * \text{Log}_{10}(\text{DrainageArea}(\text{km}^2)) + 0.743 * \text{Log}_{10}(\text{AveAnnPrec}(\text{in})))$	Davies et al. (In Prep)
Estimated Wetted Width (m)	$10 (-1.8 + 0.591 * \text{Log}_{10}(\text{DrainageArea}(\text{km}^2)) + .722 * \text{Log}_{10}(\text{AveAnnPrec}(\text{in})))$	Davies et al. (In Prep)



Appendix Figure 1. Relationship of channel width measured from aerial photographs and bankfull channel width measured in the field (L. Holsinger and T. Beechie, Northwest Fisheries Science Center, unpublished data).

STEP 4: ADULT POTENTIAL CAPACITY ESTIMATES

We summed the amount of stream habitat in three gradient and bankfull width classes (Appendix Table 6). For large mainstem habitats (>25 m and <4% gradient), areas were calculated for each stream segment by multiplying bankfull width by the segment length. Within each subbasin, the total stream area for streams >25m was summed to produce an estimate of the total area of such habitat in gradients ≤4% (i.e., A, Appendix Table 6). For small and mid-sized streams (5-25 m), we summed the length of habitat in each gradient class for each subbasin (i.e., B&C, Appendix Table 6). We quantified the amount of habitat in each gradient/bankfull width class for current and historical conditions. Habitats currently blocked by anthropogenic barriers were included in historical estimates.

In general, capacity was estimated by multiplying the amount of habitat in each of the three gradient/bankfull width classes by the number of spawners in each habitat class as reported in the literature. We estimated potential capacity for current and historical conditions. Data and equations used to calculate the number of potential spawners for each size/gradient class are described below. To account for uncertainties in our estimates, we calculated the mean, median and 10th and 90th percentile for each variable used to calculate potential capacity. Potential capacity estimates are then reported as the median with 10th and 90th percentile confidence intervals. Data used to calculate potential capacity are presented in Appendix Table 7.

Mainstem Habitats (A)

Potential capacity estimates for mainstems were based on the assumption that only a fraction of the total stream area in gradients ≤4% is spawnable (Holsinger and Pess, in press). The potential number of spawners was estimated using the total stream area in each subbasin; the percent of that area that is

predicted to be suitable for spawning, the size of an individual redd (14.1m^2) was used, based on redd size data from the Stillaguamish Watershed), and the number of fish per redd (equation *i*). This is a coarse level analysis of spawning habitat and estimates spawning potential, not actual spawning.

Holsinger and Pess (in press) estimated that 6.24% of mainstem stream area is suitable for chinook spawning, using maps of chinook spawning areas in the Skagit River Basin. The area of these spawning sites was summed, and then divided by the total mainstem area to calculate the percent of total mainstem habitat that is spawnable. Redd area data were summarized from the North Fork Stillaguamish River (the estimates for redds per kilometer are from Montgomery et al., 1999) and estimates of the number of spawners per redd were calculated using data from the Snohomish and Stillaguamish River basins (Holsinger and Pess, in press).

$$\# \text{ spawners} = \frac{(\text{stream area}) * (\% \text{ spawnable})}{\text{redd area}} * (\# \text{ fish/redd}) \quad (i)$$

Small, Low-Gradient Streams (B)

Potential adult capacity estimates for small, low-gradient streams were calculated by multiplying the length of stream habitat in each subbasin by the number of redds/km and the number of spawners per redd (equation *ii*). Data for the number of redds/km were from empirical estimates from the North Fork Stillaguamish River (Montgomery et al. 1999).

$$\# \text{ spawners} = (\text{stream length}) * (\# \text{ spawners per redd}) * (\# \text{ redds/km}) \quad (ii)$$

Small, Mid-Gradient Streams (C)

To estimate potential adult capacity for small, mid-gradient streams, we calculated the predicted length of forced pool riffle/pool riffle (FPR/PR) and plane bed (PB) habitat in four different classes of seral stage (length_i where 'i' corresponds to each of the four classes) (Montgomery et al. 1999). These four riparian classes included non-forested habitat and early, mid and late-seral stage. The percentages of forced pool riffle and plane bed habitats for each of the riparian classes were estimated using data from Lunetta et al. (1997). Historical capacity estimates assumed that 92% of stream segments were FPR/PR habitat and the remaining 8% of stream length was plane bed habitat (Lunetta et al. 1997). We combined data for FPR and PR habitats for historical estimates because data from the Lunetta et al. (1997) analysis grouped these habitat types. Redd densities for forested (FPR/PR) and non-forested (PB) reaches were from Montgomery et al. (1999). Equations *iii* and *iv* were used to estimate the potential capacity in forested and non-forested riparian habitats.

Forested-riparian:

$$\# \text{ Spawners} = (\text{length}_i) * \% \text{FPR}_i * \# \text{ redds/km}_{\text{FPR/PR}} * \# \text{ spawners/redd} \quad (iii)$$

Non-forested-riparian:

$$\# \text{ Spawners} = (\text{length}_i) * \% \text{PB}_i * \# \text{ redds/km}_{\text{PB}} * \# \text{ spawners/redd} \quad (iv)$$

Results

Results are reported in the Step 4 Table. Columns include current potential capacity, historical potential capacity, the percentage change in potential capacity within each subbasin (a localized measure of

change), and the percentage change from historical potential capacity relative to the total number of current potential spawners summed for the entire WRIA (a relative measure of change across subbasins).

Appendix Table 6. Gradient and Bankfull Width Classes Used to Estimate Adult Potential Capacity for Mainstem Streams (A), Small, Low-Gradient Streams (B) and Small, High Gradient Streams (C).

		Gradient		
		<1%	1-4%	>4%
Bankfull Width	>25m	A		0
	5-25m	B	C	0
	<5m	0	0	0

Appendix Table 7. Data Used to Calculate Potential Capacity for Current and Historical Conditions.

Redds/km are listed for forced-pool riffle (FPR), plane bed (PB), pool-riffle (PR), step pool (SP), and all of these habitats combined (ALL). Historical estimates of redds/km are the same as the FPR/PR.

	Redds / km						Historical	Redd area (m ²)	Spawners /redd
	FPR	PB	FPR/PR	PR	SP	ALL			
90 th	58	6	61.3	81	11	54.26	61.3	4.9	3.5
Median	29.6	0	31.2	52.6	0	6.10	31.2	14.1	1.9
Mean		1.77	36.4	56	2.5	17.9	36.4	15.25	2.33
10 th	7	0	7.97	38	0	0.0	7.97	27.9	1.35

RATIONALE FOR FUNCTIONAL RELATIONSHIPS LINKING HABITAT CONDITIONS TO LIFE STAGE- SPECIFIC SURVIVAL OF CHINOOK

DESCRIPTION

The functional relationships modeled in the current version of SHIRAZ include three habitat variables affecting egg-to-fry survival: incubation temperature, fine sediment, and flood recurrence interval. In this section, we briefly document the basis for these functional relationships, as well as the basis for several relationships that we hope to include in future iterations of SHIRAZ.

Functional Relationships Included in Current Version of SHIRAZ

Incubation Temperature ? Egg-to-Fry Survival

Although optimal water temperatures during incubation are likely to vary between stocks, chinook eggs generally require temperatures between 5.0° and 14.4 °C for survival (Bjornn and Reiser 1991). SHIRAZ uses a series of line segments based on data from Olson et al. (1970) to link incubation temperature and egg-to-fry survival. These line segments connect the points (0, 0.0001), (5, 0.95), (15, 0.95), (19, 0.0001) and (>19, 0.0001), where the x-coordinate = temperature (°C) and the y-coordinate = egg-to-fry survival.

Fine Sediment ? Egg-to-Fry Survival

Gravel voids in salmonid redds enable the influx of dissolved oxygen, the efflux of metabolic wastes and, eventually, the emergence of alevin. Excessive levels of fine sediment can obstruct gravel voids, reducing the rate of egg-to-fry survival (Meehan and Swantson 1977, Beschta and Jackson 1979). SHIRAZ currently uses two relationships to link fine sediment and egg-to-fry survival. The first relationship is based on data reported by Hall and Lantz (1969) for fines that are 1-3 mm in diameter:

- if % fines <50, egg-to-fry survival = $-0.0176 * (\% \text{ fines}) + 0.98$.
- if % fines >50, egg-to-fry survival = 0.10.

The second relationship is based on data reported by Tappel and Bjornn (1983) for fines < 9.5 mm in diameter:

- if % fines is 0-35, egg-to-fry survival = 0.95.
- if % fines is 36-75, egg-to-fry survival = $-0.0237 * (\% \text{ fines}) + 1.7812$.
- if % fines is 76-100, egg-to-fry survival = 0.

Flood Recurrence Interval ? Egg-to-Fry Survival

Severe peak flows can reduce egg-to-fry survival by silting over or scouring out redds (Sidle 1988, Vronskii and Leman 1991). However, because relationships between peak flows and egg-to-fry survival are location-dependent (e.g. Seiler 2000, Seiler et al. 2002), flood recurrence interval is a more useful predictor variable when considering multiple subbasins. Recurrence interval is defined as the average number of years between consecutive incidents of annual peak flow equal to or greater than a certain magnitude (Sumioka et al. 1998). Beamer and Pess (1999) developed a general model relating recurrence interval to chinook egg-to-migrant fry survival in the Skagit River Basin:

$$\text{egg-to-migrant fry survival} = (0.1285 * e^{-0.0446 * \text{recurrence interval (yrs)}}) (r^2 = 0.97).$$

Pre-Spawning Temperature ? Spawner-to-Egg Survival

Warm freshwater temperatures pose a thermal challenge to adult salmonids. This challenge may have various sublethal effects including delayed migration, depleted energy reserves, reduced swimming capability, and increased susceptibility to disease (McCullough et al. 2001). It also may induce direct mortality. Cramer et al. (1985) reported that pre-spawning mortality of wild spring chinook increased from 5% to 35% as the mean maximum water temperature increased from 16.2 °C to 18.5 °C, while the mortality of hatchery chinook increased from 15% to 80%. Cramer (2001) developed the following relationship based on those data:

- if mean max temp. (T) <16 °C, pre-spawning survival = 1.
- if mean max temp. (T) >16 °C, pre-spawning survival = 1 – [(T-16) * 0.15].

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GLOSSARY

Adaptive management	The process of implementing policy decisions as scientifically driven management experiments that test predictions and assumptions in management plans, and using the resulting information to improve the plans.
Age zero fish	A fish that is in its first year of life. Also known as sub-yearlings.
Aggradation, aggrade	The geologic process by which streambeds, floodplains, and the bottoms of other waterbodies are raised in elevation by the deposition and accumulation of material eroded and transported from other areas. It is the opposite of <i>degradation</i> .
Alevin	The larval stage of salmonid development that occurs after the egg has hatched, when the juvenile fish lives in the voids in the streambed gravel for a period of time up to several months until its yolk sac is absorbed.
Anadromous	Species that are hatched in freshwater, mature in saltwater, and return to freshwater to reproduce.
Aquatic insects	Insects that live their larval stages in water.
Artificial production	Fish production that depends on spawning, incubation, hatching, or rearing in a hatchery or rearing pen.
Bank armoring, bank hardening	The artificial application of various materials to protect streambanks from erosion. Also, the formation of an erosion-resistant layer of relatively large particles on the surface of a streambank.
Bedload	Sediment moving on or near the streambed and frequently in contact with it.
Bedload transport	The movement of sediment on or near the streambed.
Benthic	Pertaining to the bottom (of estuaries, rivers, streams, and lakes).
Benthic invertebrates	Bottom-dwelling invertebrates. Typically, bottom-dwelling aquatic insect larvae.
Biodiversity, biological diversity	Variety and variability among living organisms and the ecological complexes in which they occur; encompasses different ecosystems, species, and genes.
Bioengineering	Combining structural, biological, and ecological concepts to construct living structures for erosion, sediment, or flood control.
Braided channel	A stream or river that forms an interlacing network of branching and recombining channels separated by islands or channel bars.
Braided reach	A section of a braided channel (<i>See braided channel</i>).

Bull trout	<i>Salvelinus confluentus</i> . A species of native char that is found in the Snohomish River Basin in both resident and anadromous forms, and is listed as “threatened” under the federal Endangered Species Act. Spawning areas are often associated with cold water springs, groundwater infiltration, and the coldest streams in a given watershed. Bull trout may hybridize with Dolly Varden, a closely related species of native char.
Channel migration area	The area defined by the historic, changing meanders of a stream.
Channel morphology	The form and structure of a stream channel.
Chinook salmon	<i>Oncorhynchus tshawytscha</i> . Also known as king salmon or blackmouth salmon. The Puget Sound population of this species (see <i>evolutionary significant unit</i>) is listed as “threatened” under the federal Endangered Species Act. Chinook salmon are distinguished from other salmon by their large size. The species <i>generally</i> spawns in September and October in main channels of moderate to large-sized rivers and streams. Chinook salmon are classed as “stream-type” which typically spend one or more years in freshwater before migrating to sea, or as “ocean-type” which migrate to sea during the first year of life. Chinook salmon typically live three to six years but may reach eight years of age before spawning.
Coho salmon	<i>Oncorhynchus kisutch</i> . Also known as silver salmon. Coho salmon are distinguished by black spots on their back and the upper lobe of their tail, and the absence of black pigment along the base of their teeth and lower jaw. This species spawns between October and January in low gradient, small and moderate-sized tributaries and generally rears in low gradient, small and moderate-sized tributaries and side channels of mainstem rivers with a large amount of pool habitat. Coho salmon also use ponds, lakes, and sloughs, especially as refuge from high flows during the winter. Juveniles spend approximately one year in freshwater before migrating to estuaries (March to May) and out to sea. They return to freshwater to spawn at between two to five years of age; the majority of the coho salmon in Puget Sound return to spawn at age three.
Data Gap (habitat condition)	There is no known data and therefore no specific “call” in the HCR, LFA or EDT reports.
Deciduous	Pertaining to any of a large family of shrubs and trees whose leaves shed annually, such as maples, birches, cottonwoods, and alders.
Degradation, degrade	The geologic process by which streambeds and floodplains are lowered in elevation by the hydraulic removal of material. It is the opposite of <i>aggradation</i> .
Degraded (habitat condition)	Watershed processes and habitat structure have substantially diverged from natural conditions and/or provide severe impairment to the natural productivity of salmonids.
Deposition	The settlement or accumulation of suspended or bedload material out of the water column and onto the streambed or floodplain. This occurs when the energy of flowing water and channel gradient are unable to transport the sediment further.
Digital Elevation Model (DEM)	A model used in the lowland peak flow analysis to model direction of overland flow and to determine the amount of effective impervious area encountered on the path to a stream.

Discharge	The volume of water flowing in a stream at a given place and within a given period of time, usually expressed as cubic meters per second or cubic feet per second (cfs).
Dolly Varden	<i>Salvelinus malma</i> . Dolly Varden are a species of char found in the Snohomish River Basin in resident and anadromous forms. They typically live in small tributaries and tend to prefer colder waters. They may hybridize with bull trout. Anadromous forms may live two to three years in freshwater and up to seven years at sea.
Ecological Analysis for Salmonid Conservation (EASC)	The compilation and analysis of new and existing ecological information about the Snohomish River Basin that will provide the scientific foundation for the Snohomish River Basin Salmonid Conservation Plan. Also called the TRT Case Study.
Ecosystem	A biological community and the chemical and physical environment with which it interacts.
Ecosystem Diagnosis and Treatment (EDT)	A model used to predict habitat response to actions that either preserve or degrade chinook salmon habitat.
Egg to emergent survival	Refers to the survival of fish that have passed through the egg and alevin phases of development and have reached the fry phase.
Endangered Species Act, ESA	A 1973 Act of Congress mandating the protection and restoration of endangered and threatened species of fish, wildlife, and plants.
Escapement	Those fish that have survived all fisheries and natural predation to make up a spawning population.
Escapement goal	A predetermined number of salmonids that are not harvested and will be the parent spawners for a wild or hatchery stock of fish.
Estuary	A partly enclosed coastal body of water that has free connection to open sea, and within which seawater is measurably diluted by fresh river water.
Evolutionary significant unit, ESU	A population or group of populations of a species that is reproductively isolated from other population units, and represents an important component in the evolutionary legacy of the species. An example of an ESU is Puget Sound chinook salmon.
Fish-Days	The sum of the number of days a fish is observed on natural spawning grounds.
Fish passage barrier	Any structure that impedes the upstream or downstream movement of fish.
Fishery	The act, process, or occupation of attempting to catch fish, whether they are retained or released.
Flood flow	A high rate and volume of water flow that exceeds channel capacity and results in flooding of floodplain areas.
Flooding	The covering or inundation of land with water.
Floodplain	A low, relatively flat area that is periodically flooded by the lateral overflow of a stream or river.

Fluvial	Pertaining to streams or rivers.
Fry	Young salmonids that have emerged from the gravel and are up to one month of age. The fry phase precedes the parr phase.
Genetic diversity	All of the genetic variation within a group. The genetic diversity of a species includes both genetic differences between individuals in a breeding population and genetic differences among different breeding populations.
Geomorphology	A branch of geology that deals with the origin and nature of landforms.
Gradient	The slope or rate of change in vertical elevation per unit of horizontal distance of a river channel bed.
Habitat Conditions Review (HCR)	A document produced by the SBSRTC in 2002 that characterizes chinook salmon habitat conditions in 62 subbasins of the Snohomish River Basin.
Harvest management	The process of setting regulations for the commercial, tribal, and recreational fisheries to reach management goals.
Holding area	See <i>holding habitat</i> .
Holding habitat	Any habitat that fish use for rest between periods of activity. Generally characterized by flow, low water temperatures, pools, eddies, or slow water formed by logs, boulders, logjams, etc.
Hydrograph	A graph showing, for a given point on a stream, the discharge, stage, velocity, or other property of water over time.
Hydrology	The study of the properties, distribution, and effects of water on the Earth's surface, subsurface, and atmosphere.
Impervious surface	Surfaces such as pavement, compacted gravel, and roofs that prevent or reduce the infiltration of surface water into soils.
Index reach	A reach of a river where spawning has been regularly monitored over a certain period of time. Data from index reaches can be extrapolated to provide an estimate for spawning across a larger system.
In-redd mortality	Mortality of eggs or newly hatched fish prior to their emergence from gravel stream substrates.
Intact (habitat condition)	Watershed processes and habitat structure reflect a natural status and provide optimum conditions
Limiting Factors Analysis (LFA)	A document prepared by the Washington Conservation Commission in 2002 to identify habitat conditions that are limiting salmonid populations in the Snohomish River Basin.
Log rafting	The practice of transporting or storing large numbers of logs by floating and towing them in rivers and sloughs.
Large woody debris (LWD)	Large logs (generally twelve inches diameter or larger) and root-wads that fell in or near a stream and became part of the riparian and aquatic habitat. Also known as large organic debris.

Lowland Subbasins	Subbasins with less than 50% of their area in the Forest Production Zone and a mean elevation less than 1000 meters.
Macroinvertebrates	Invertebrate animals large enough to be seen with the naked eye (e.g. most aquatic insects, snails, and amphipods).
Mainstem	The principal stream or channel for any drainage basin.
Mass wasting	Landslide processes, including debris falls, slides, avalanches, flows, and torrents, rockfalls, rockslides, slumps and earthflows, and the small scale slumping, collapse and unraveling of road cuts and fills. Mass wasting can result in transport of large quantities of sediment to rivers and streams.
Meander	An individual bend or curve in a stream channel created by the natural tendency of a stream to curve and move laterally across the land surface.
Mitigation	Activities taken to offset the impairment of natural resources.
Moderately Degraded (habitat condition)	Watershed processes and habitat structure have diverged from natural conditions and/or create some impairment to the natural productivity of salmonids.
Native stock	An indigenous stock of fish that has not been substantially affected by genetic interactions with non-native stock or by other factors and is still present in all or part of its original range.
National Marine Fisheries Service, NMFS	The federal agency responsible for administering the Endangered Species Act for marine mammals and marine and anadromous fish.
Natural production	Fish production that is sustained by natural spawning and rearing in natural habitat.
Natural spawning	Fish spawning in a river as opposed to a hatchery.
Ocean-type	See <i>chinook salmon</i> .
Off-channel habitat	Any relatively calm portion of a stream outside of the main flow such as a side channel, slough, dead-end channel, or wetland.
Off-channel rearing area	Any off-channel habitat used by salmonids during their freshwater growth phase before they migrate to sea.
Over-wintering habitat	Freshwater habitat favored by salmonids for winter rearing. Generally characterized by flows that are not extreme, quiet waters, sloughs, side channels, ponds, eddies etc.
Oxbow	A looping river bend or meander cut off from the main flow by a new channel. A crescent-shaped lake formed by the detachment of a river bend from the main channel.
PARR	A young salmonid that is actively feeding in freshwater. Usually refers to young anadromous salmonids before they migrate to the sea. The parr state precedes the smolt state. See <i>smolt</i> .
Pool	A relatively deep, calm section of a stream.

Policy Development Committee (PDC)	A committee of the Snohomish Basin Salmon Recovery Forum charged with developing policy options and guidance in the conservation planning process. The PDC consists of policy-makers and staff from local, state and tribal governments and special interest groups.
Potential Capacity Model	A model developed by NOAA Fisheries as part of the EASC/TRT Case Study that uses habitat parameters to calculate the potential for a subbasin to support spawning chinook salmon.
Reach	Any specified section of a stream's length.
Rearing habitat, rearing area	Habitat favored by juvenile salmonids for growth and development before migrating to sea. Generally characterized by shady pools and quiet water, ponds and sloughs.
Redd	Fish nests made in gravel (particularly by salmonids) consisting of a depression that is created and then covered after eggs are laid.
Redd scour	The removal of the gravel that forms a redd by high water flows. Redd scour typically results in the removal and destruction of eggs buried in the redd.
Resident salmonids	Those salmonid species that spend their entire lives in freshwater.
Riffle	A stream segment having a broken or choppy surface (white water), moderate or swift current, and shallow depth often broken by the presence of rocks and boulders.
Riparian	Pertaining to anything connected with or adjacent to a stream or other waterbody. A transition zone between aquatic habitat and upland areas that has a direct effect on the stream.
Riprap	Large rocks, broken concrete or other structures used to stabilize streambanks and other slopes.
River Mile, RM	The distance in miles from the mouth of a river.
Riverine	Pertaining to river or stream systems.
Rootwad	The exposed root system of an uprooted or washed-out tree.
Run	The sum of stocks of a single salmonid species that migrate to a particular region, river, or stream of origin at a particular season.
Salmonid	Any fish of the taxonomic family Salmonidae, including salmon, trout, char, whitefish and grayling.
Sampling	The act of taking samples of substances or organisms (fish, water, soil, etc) in the field for later testing and evaluation.
Scour	The removal of material by the erosive action of moving water.
Side channel	A channel aside from but connected to the main channel and running roughly parallel to the main channel. Characterized by lower flows than the main channel. See <i>slough</i> and <i>off-channel</i> .
Siltation	The deposition of fine suspended materials in a waterbody, usually as a result of a reduction in water velocity.

Skykomish River forks	The North Fork and the South Fork of the Skykomish River upstream of their confluence near the City of Index.
Skykomish River mainstem	The segment of the Skykomish River downstream of the confluence of the North Fork and the South Fork near Index, and upstream of the confluence of the Skykomish River and the Snoqualmie River west of Monroe.
Slough	(1) Low, swampy ground or an overflow channel where water flows sluggishly for considerable distances; (2) A side channel; (3) A section of abandoned stream channel containing water all or most of the year, but with flow only at high water; (4) A creek or sluggish body of water in a bottom-land, floodplain or estuary.
Smolt	A juvenile salmonid that is migrating seaward. A young anadromous salmon, trout or char undergoing physiological changes that will allow it to change from life in freshwater to life in the sea. The smolt state follows the parr state. See <i>parr</i> .
Snohomish Basin Salmonid Recovery Technical Committee (SBSRTC)	The committee of regional expert scientists from local, state, tribal, and federal agencies responsible for developing the scientific foundation for salmonid recovery efforts in WRIA 7.
Snohomish River estuary	The Snohomish River and its associated side channels and sloughs downstream of the upstream end of Ebey Slough. For some purposes, the estuary is considered to extend as far upstream as French Creek.
Snohomish River mainstem	The segment of the Snohomish River downstream of the confluence of the Skykomish River and the Snoqualmie River west of Monroe, and upstream of Ebey Slough, west of Snohomish.
Snoqualmie River	The entirety of the Snoqualmie River upstream of the confluence of the Skykomish River and the Snoqualmie River west of Monroe.
Snorkeling survey	A method of visually surveying fish presence by viewing the fish through a snorkeling mask.
Spawning	The act of laying and fertilizing eggs. Generally, the act of redd (nest) building, laying and fertilizing eggs, and burying the eggs.
Spawner escapement	See <i>escapement</i> .
Spawners	See <i>escapement</i> .
Spawning grounds, spawning area	Specific stream reaches where spawning occurs.
Spawning habitat	Habitat favored by salmonids for spawning. Generally characterized by clean gravel and a low percentage of fine sediment.
Stock	A group of fish that is genetically self-sustaining and isolated geographically or temporally during reproduction. Generally, a local population of fish. More specifically, a local population – especially that of salmon, steelhead trout (rainbow trout), or other anadromous fish – that originates from specific watersheds as juveniles and generally returns to its birth streams to spawn as adults.
Stream-type	See <i>chinook salmon</i> .

Subbasin	Same as <i>Subbasin</i> .
Subbasin Strategy Groups	A step of the EASC wherein subbasins are grouped by current or potential chinook and bull trout use and habitat conditions resulting in 12 groups of the 62 subbasins of WRIA 7.
Substrate	The mineral and organic material that forms the bed of a stream.
Subbasin	One of the smaller watersheds that combine to form a larger watershed.
Technical Advisory Group (TAG)	The SBSRTC was the technical group (or TAG) that supported the Washington Conservation Commission in preparation of the LFA.
Technical Recovery Team (TRT)	A regional body of scientists responsible for providing scientific advice on a broad scale to WRIA groups developing recovery plans for listed Puget Sound chinook salmon.
TRT Case Study	Also known as the Ecological Analysis for Salmonid Conservation (EASC), the TRT Case Study is the product of the Snohomish Basin Salmonid Recovery Technical Committee's partnership with TRT staff to compile and analyze the scientific foundation for the Snohomish River Basin Conservation Plan for Salmon Habitat.
Tributary	A stream feeding, joining, or flowing into a larger stream.
Turbidity	Relative water clarity, measured by the extent to which light passing through water is reduced by suspended and dissolved materials.
United States Fish and Wildlife Service (USFWS)	The federal agency responsible for administering the Endangered Species Act for freshwater fish and wildlife.
Upland Subbasins	Subbasins with at least 50% of their area in the Forest Production Zone and a mean elevation greater than 1000 meters.
Washington Department of Fish and Wildlife, WDFW	The state agency responsible for co-managing fisheries in Washington State in cooperation with treaty tribes.
Watershed	The total land area that drains to any single river or stream. Also known as a basin or catchment.
Watershed Guidance Document	A document developed by the Puget Sound TRT that provides consistent guidance to the WRIA groups developing local conservation plans for Puget Sound chinook salmon.
Water Resource Inventory Area, WRIA	A land management unit defined by the boundaries of watersheds.
Water Resource Inventory Area 7	The Snohomish River Watershed, including the Snohomish, Skykomish and Snoqualmie river basins.
Yearling	A fish that has lived more than one year and is in its second year of life.