Lower Columbia Salmon Recovery And Fish & Wildlife Subbasin Plan

Volume II – Subbasin Plan
Chapter I – Washougal

Salmon-Washougal and Lewis Rivers (WRIAS 27-28)

Watershed Management Plan

Chapter 6 Appendix – Management of Fish Habitat Conditions

Lower Columbia Fish Recovery Board

December 15, 2004

Preface

This is one in a series of volumes that together comprise a Recovery and Subbasin Plan for Washington lower Columbia River salmon and steelhead:

--	Plan Overview	*Overview of the planning process and regional and subbasin elements of the plan.*
Vol. I	Regional Plan	*Regional framework for recovery identifying species, limiting factors and threats, the scientific foundation for recovery, biological objectives, strategies, measures, and implementation.*
Vol. II	Subbasin Plans	*Subbasin vision, assessments, and management plan for each of 12 Washington lower Columbia River subbasins consistent with the Regional Plan. These volumes describe implementation of the regional plan at the subbasin level.*
		II.A. Lower Columbia Mainstem and Estuary *II.B. Estuary Tributaries* *II.C. Grays Subbasin* *II.D. Elochoman Subbasin* *II.E. Cowlitz Subbasin* *II.F. Kalama Subbasin* *II.G. Lewis Subbasin* *II.H. Lower Columbia Tributaries* *II.I. Washougal Subbasin* *II.J. Wind Subbasin* *II.K. Little White Salmon Subbasin* *II.L. Columbia Gorge Tributaries*
Appdx. A	Focal Fish Species	*Species overviews and status assessments for lower Columbia River Chinook salmon, coho salmon, chum salmon, steelhead, and bull trout.*
Appdx. B	Other Species	*Descriptions, status, and limiting factors of other fish and wildlife species of interest to recovery and subbasin planning.*
Appdx. C	Program Directory	*Descriptions of federal, state, local, tribal, and non-governmental programs and projects that affect or are affected by recovery and subbasin planning.*
Appdx. D	Economic Framework	*Potential costs and economic considerations for recovery and subbasin planning.*
Appdx. E	Assessment Methods	*Methods and detailed discussions of assessments completed as part of this planning process.*

This plan was developed by of the Lower Columbia Fish Recovery Board and its consultants under the Guidance of the Lower Columbia Recovery Plan Steering Committee, a cooperative partnership between federal, state and local governments, tribes and concerned citizens.

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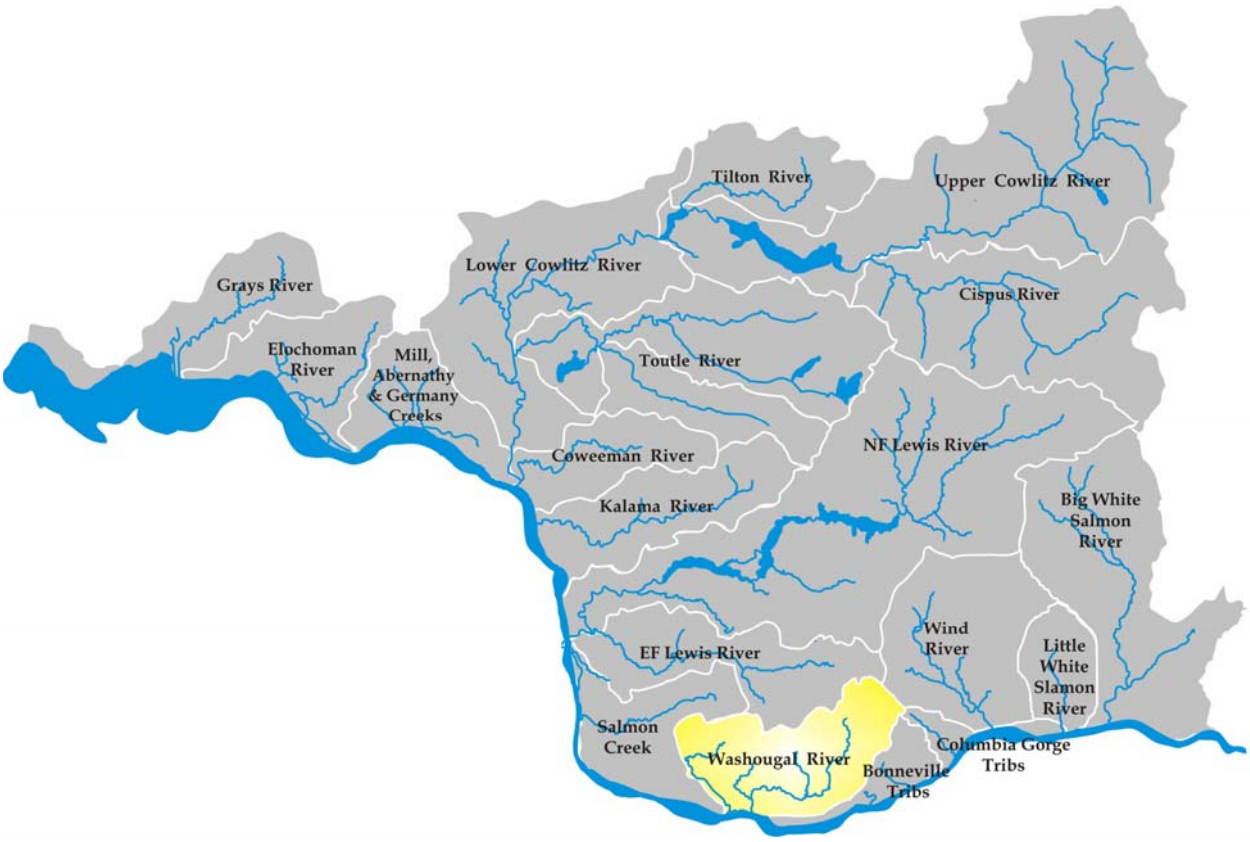
Subbasin Plan Vol. II.I.
Washougal Subbasin



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1.0 Washougal River – Executive Summary

This plan describes a vision, strategy, and actions for recovery of listed salmon, steelhead, and trout species to healthy and harvestable levels, and mitigation of the effects of the Columbia River hydropower system in Washington lower Columbia River subbasins. Recovery of listed species and hydropower mitigation is accomplished at a regional scale. This plan for the Washougal River Subbasin describes implementation of the regional approach within this subbasin, as well as assessments of local fish populations, limiting factors, and ongoing activities that underlie local recovery or mitigation actions. The plan was developed in a partnership between the Lower Columbia Fish Recovery Board (Board), Northwest Power and Conservation Council, federal agencies, state agencies, tribal nations, local governments, and others.

The Washougal River is one of eleven major subbasins in the Washington portion of the Lower Columbia Region. The subbasin historically supported thousands of fall Chinook, chum, coho, and summer and winter steelhead. Today, numbers of naturally spawning salmon and steelhead have plummeted to levels far below historical numbers. Chinook, chum, and steelhead have been listed as threatened under the Endangered Species Act and coho is proposed for listing. The decline has occurred over decades and the reasons are many. Freshwater and estuary habitat quality has been reduced by agricultural and forestry practices. Key habitats have been isolated or eliminated by dredging and channel modifications and diking, filling, or draining floodplains and wetlands. Altered habitat conditions have increased predation. Competition and interbreeding with domesticated or nonlocal hatchery fish has reduced productivity. Hydropower operation on the mainstem Columbia has altered flows, habitat, and migration conditions. Fish are harvested in fresh and saltwater fisheries.

Washougal River fall Chinook, chum, and summer steelhead will need to be restored to a high level of viability and coho and winter steelhead will need to be restored to a medium viability level to meet regional recovery objectives. This means that the populations are productive, abundant, exhibit multiple life history strategies, and utilize significant portions of the subbasin.

In recent years, agencies, local governments, and other entities have actively addressed the various threats to salmon and steelhead, but much remains to be done. One thing is clear: no single threat is responsible for the decline in these populations. All threats and limiting factors must be reduced if recovery is to be achieved. An effective recovery plan must also reflect a realistic balance within physical, technical, social, cultural and economic constraints. The decisions that govern how this balance is attained will shape the region's future in terms of watershed health, economic vitality, and quality of life.

This plan represents the current best estimation of necessary actions for recovery and mitigation based on thorough research and analysis of the various threats and limiting factors that impact Washougal River fish populations. Specific strategies, measures, actions and priorities have been developed to address these threats and limiting factors. The specified strategies identify the best long term and short term avenues for achieving fish restoration and mitigation goals. While it is understood that data, models, and theories have their limitations and growing knowledge will certainly spawn new strategies, the Board is confident that by implementation of the recommended actions in this plan, the population goals in the Washougal River Basin can be achieved. Success will depend on implementation of these strategies at the program and project level. It remains uncertain what level of effort will need to be invested in

each area of impact to ensure the desired result. The answer to the question of precisely how much is enough is currently beyond our understanding of the species and ecosystems and can only be answered through ongoing monitoring and adaptive management against the backdrop of what is socially possible.

1.1 Key Priorities

Many actions, programs, and projects will make necessary contributions to recovery and mitigation in the Washougal Basin. The following list identifies the most immediate priorities.

1. Protect Intact Forests in Headwater Basins

The upper mainstem headwaters and headwaters of the West Fork (aka North Fork) Washougal that are located in State and National Forest lands are heavily forested with relatively intact landscape conditions that support functioning watershed processes. Streams are unaltered, road densities are low, and riparian areas and uplands are characterized by mature forests. Much of this area is still recovering from large fires in the early 1900s. Protection of intact landscape conditions will be necessary to allow continued ecosystem recovery and to support healthy downstream habitat. Existing legal designations and management policy are expected to continue to offer protection to these lands.

2. Manage Forest Lands to Protect and Restore Watershed Processes

Much of the Washougal Basin is managed for commercial timber production and has experienced intensive past forest practices activities. Proper forest management is critical to recovery of habitat forming processes. Past forest practices, combined with the effects of large early 20th century fires, have reduced fish habitat quantity and quality by altering stream flow, increasing fine sediment, and degrading riparian zones. A distinguishing characteristic of the mainstem Washougal is a lack of suitable spawning gravels, a trait that has been contributed to historical fires, splash-dam logging, and flooding. In addition, forest road culverts have blocked fish passage in small tributary streams. Effective implementation of new forest practices through the Department of Natural Resources' Habitat Conservation Plan (State-owned lands), Forest Practices Rules (private lands), and the Northwest Forest Plan (federal lands) are expected to substantially improve conditions by restoring passage, protecting riparian conditions, reducing fine sediment inputs, lowering water temperatures, improving flows, and restoring habitat diversity. Improvements will benefit all species, particularly steelhead and coho.

3. Manage Growth and Development to Protect Watershed Processes and Habitat Conditions

The human population in the basin is relatively low, but it is projected to grow by at least fifty percent in the next twenty years. The local economy is also in transition with reduced reliance on forest products and farming. Population growth will primarily occur in lower river valleys and along the major stream corridors. This growth will result in the conversion of forestry and agricultural land uses to residential uses, with potential impacts to habitat conditions. Land-use changes will provide a variety of risks to terrestrial and aquatic habitats. Careful land-use planning will be necessary to protect and restore natural fish populations and habitats and will also present opportunities to preserve the rural character and local economic base of the basin.

4. Restore Passage at Culverts and Other Barriers

There are several culverts and other barriers that limit fish passage in the Washougal Basin. Correction of passage obstructions could provide access to several potential miles of stream

habitat. The Wildboy Dam on Wildboy Creek (tributary to the West Fork Washougal) blocks at least 1.7 miles of habitat and needs further evaluation as to the potential for providing fish passage. Further assessment of other passage barriers is also needed throughout the subbasin.

5. Restore Lowland Floodplain Function, Riparian Function and Stream Habitat Diversity

The lower mainstem Washougal, lower Little Washougal and Lacamas Creek historically had active floodplain valleys that have been altered through channel modifications to facilitate and protect urban, rural residential and agricultural development. Dike building, bank stabilization, and riparian vegetation removal have heavily impacted fish habitat in these areas. Removing or modifying channel control and containment structures to reconnect the stream and its floodplain, where this is feasible and can be done without increasing risks of substantial flood damage, will restore normal habitat-forming processes to reestablish habitat complexity, off-channel habitats, and conditions favorable to fish spawning and rearing. These improvements will be particularly beneficial to chum, fall Chinook, and coho. Partially restoring normal floodplain functions will also help control downstream catastrophic flooding and provide wetland and riparian habitats critical to other fish, wildlife, and plant species. Existing floodplain function and riparian habitats will be protected through local land use ordinances, partnerships with landowners, and the acquisition of land, where appropriate. Restoration will be achieved by working with willing landowners, non-governmental organizations, conservation districts, and state and federal agencies.

6. Address Immediate Risks with Short-term Habitat Fixes

Restoration of normal watershed processes that allow a basin to restore itself over time has proven to be the most effective strategy for long term habitat improvements. However, restoration of some critical habitats may take decades to occur. In the near term, it is important to initiate short-term fixes to address current critical low numbers of some species. Examples in the Washougal basin include building chum salmon spawning channels and constructing coho overwintering habitat such as alcoves, side channels, and log jams. Benefits of structural enhancements are often temporary but will help bridge the period until normal habitat-forming processes are reestablished.

7. Align Hatchery Priorities with Conservation Objectives

Hatcheries throughout the Columbia basin historically focused on producing fish for fisheries as mitigation for hydropower development and widespread habitat degradation. Emphasis of hatchery production without regard for natural populations can pose risks to natural population viability. Hatchery priorities must be aligned to conserve natural populations, enhance natural fish recovery, and avoid impeding progress toward recovery while continuing to provide some fishing benefits. The Washougal River hatchery programs will produce and/or acclimate fall Chinook, coho, and summer and winter steelhead for use in the Washougal subbasin, as well as summer and winter steelhead for use in other lower Columbia basins. Hatchery produced fish will be used to provide harvest opportunities in a manner that does not pose significant risk to natural population rebuilding efforts.

8. Manage Fishery Impacts so they do not Impede Progress Toward Recovery

This near-term strategy involves limiting fishery impacts on natural populations to ameliorate extinction risks until a combination of measures can restore fishable natural populations. There is no directed Columbia River or tributary harvest of ESA-listed Washougal River salmon and

steelhead. This practice will continue until the populations are sufficiently recovered to withstand such pressure and remain self-sustaining. Some Washougal River salmon and steelhead are incidentally taken in mainstem Columbia River and ocean mixed stock fisheries for strong wild and hatchery runs of fall Chinook and coho. These fisheries will be managed with strict limits to ensure this incidental take does not threaten the recovery of wild populations including those from the Washougal. Steelhead and chum will continue to be protected from significant fishery impacts in the Columbia River and are not subject to ocean fisheries. Selective fisheries for marked hatchery steelhead and coho (and fall Chinook after mass marking occurs) will be a critical tool for limiting wild fish impacts. State and federal legislative bodies will be encouraged to develop funding necessary to implement mass-marking of fall Chinook, thus enabling a selective fishery with lower impacts on wild fish. State and federal fisheries managers will better incorporate Lower Columbia indicator populations into fisheries impact models.

9. Reduce Out-of-Subbasin Impacts so that the Benefits of In-Basin Actions can be Realized

Washougal River salmon and steelhead are exposed to a variety of human and natural threats in migrations outside of the subbasin. Human impacts include drastic habitat changes in the Columbia River estuary, effects of Columbia Basin hydropower operation on mainstem, estuary, and nearshore ocean conditions, interactions with introduced animal and plant species, and altered natural predation patterns by northern pikeminnow, birds, seals, and sea lions. A variety of restoration and management actions are needed to reduce these out-of-subbasin effects so that the benefits in-subbasin actions can be realized. To ensure equivalent sharing of the recovery and mitigation burden, impacts in each area of effect (habitat, hydropower, etc.) should be reduced in proportion to their significance to species of interest.

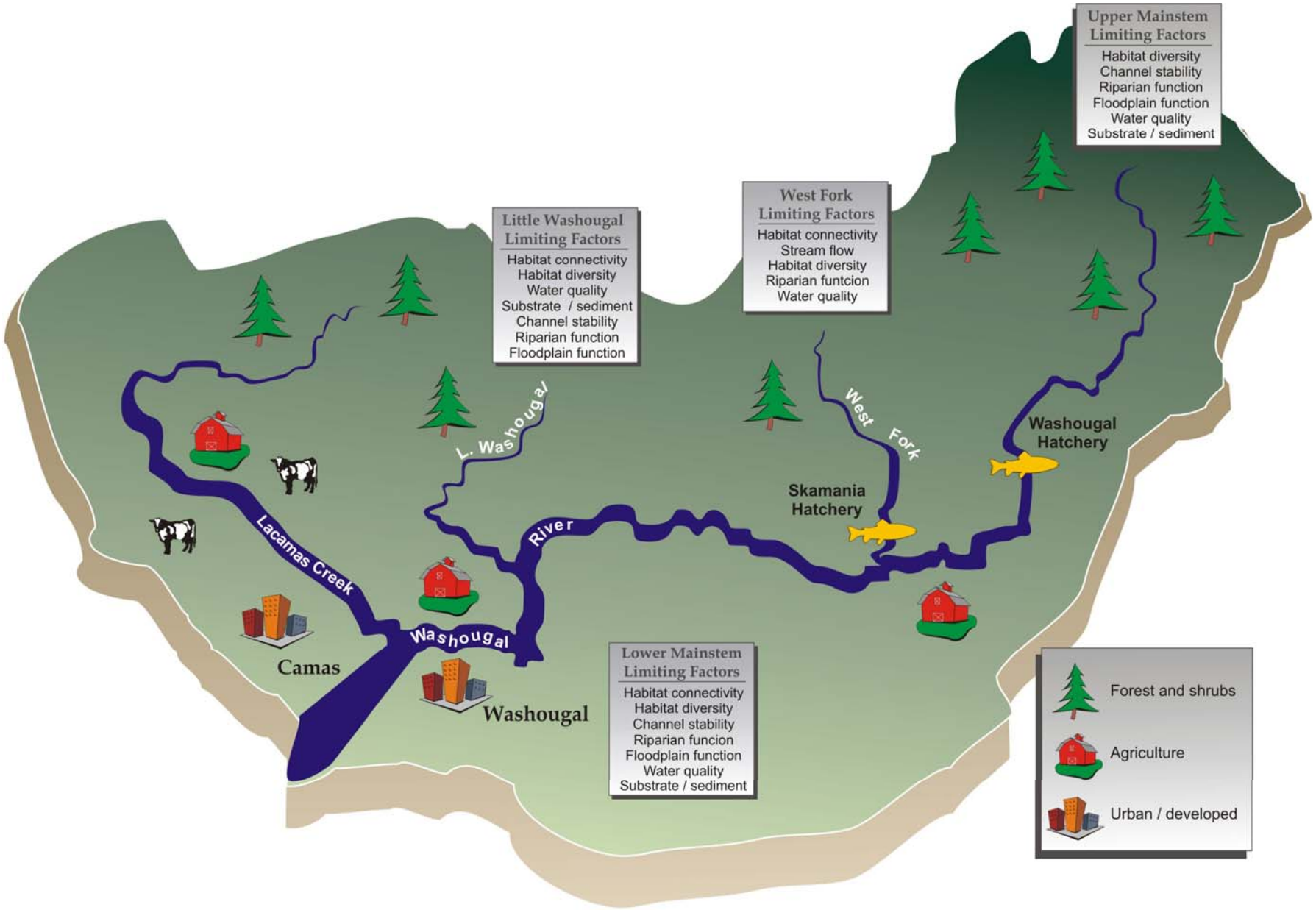


Figure 1. Key features of the Washougal River Subbasin including a summary of limiting fish habitat factors in different areas and the status and relative distribution of focal salmonid species.

2.0 Background

This plan describes a vision and framework for rebuilding salmon and steelhead populations in Washington's Washougal River Subbasin. The plan addresses subbasin elements of a regional recovery plan for Chinook salmon, chum salmon, coho salmon, steelhead, and bull trout listed or under consideration for listing as Threatened under the federal Endangered Species Act (ESA). The plan also serves as the subbasin plan for the Northwest Power and Conservation Council (NPCC) Fish and Wildlife Program to address effects of construction and operation of the Federal Columbia River Power System.

Development of this plan was led and coordinated by the Washington Lower Columbia River Fish Recovery Board (LCFRB). The Board was established by state statue (RCW 77.85.200) in 1998 to oversee and coordinate salmon and steelhead recovery efforts in the lower Columbia region of Washington. It is comprised of representatives from the state legislature, city and county governments, the Cowlitz Tribe, private property owners, hydro project operators, the environmental community, and concerned citizens. A variety of partners representing federal agencies, Tribal Governments, Washington state agencies, regional organizations, and local governments participated in the process through involvement on the LCFRB, a Recovery Planning Steering Committee, planning working groups, public outreach, and other coordinated efforts.

The planning process integrated four interrelated initiatives to produce a single Recovery/Subbasin Plan for Washington subbasins of the lower Columbia:

- Endangered Species Act recovery planning for listed salmon and trout.
- Northwest Power and Conservation Council (NPCC) fish and wildlife subbasin planning for eight full and three partial subbasins.
- Watershed planning pursuant to the Washington Watershed Management Act, RCW 90-82.
- Habitat protection and restoration pursuant to the Washington Salmon Recovery Act, RCW 77.85.

This integrated approach ensures consistency and compatibility of goals, objectives, strategies, priorities and actions; eliminates redundancy in the collection and analysis of data; and establishes the framework for a partnership of federal, state, tribal and local governments under which agencies can effectively and efficiently coordinate planning and implement efforts.

The plan includes an assessment of limiting factors and threats to key fish species, an inventory of related projects and programs, and a management plan to guide actions to address specific factors and threats. The assessment includes a description of the subbasin, focal fish species, current conditions, and evaluations of factors affecting focal fish species inside and outside the subbasin. This assessment forms the scientific and technical foundation for developing a subbasin vision, objectives, strategies, and measures. The inventory summarizes current and planned fish and habitat protection, restoration, and artificial production activities and programs. This inventory illustrates current management direction and existing tools for plan implementation. The management plan details biological objectives, strategies, measures, actions, and expected effects consistent with the planning process goals and the corresponding subbasin vision.

3.0 Assessment

3.1 Subbasin Description

3.1.1 *Topography & Geology*

The headwaters of the Washougal River lie primarily in Skamania County. The river flows mostly southwest through Clark County and enters the Columbia River at RM 121, near the town of Camas, Washington. The drainage area is approximately 240 square miles. The subbasin is part of WRIA 28.

The upper mainstem of the Washougal flows through a narrow, deep canyon until it reaches Salmon Falls at RM 14.5. Below this, the river valley widens, with the lower two miles lying within the broad Columbia River floodplain lowlands. Elevations range from 3,200 feet in the headwaters of Bear Creek to nearly sea level at the Columbia. Due to steep and rugged conditions in most of the basin, development is limited to the lower valley within the Columbia River floodplain. Fish passage was historically blocked to most anadromous fish except steelhead at Salmon Falls (RM 14.5) until a fish ladder was built there in the 1950s. Anadromous fish currently reach only as far as Dougan Falls at RM 21, although summer steelhead regularly negotiate the falls and continue further upstream.

Surface geology in the basin is comprised of volcanic material in the headwater areas and sedimentary material in the lower basin. Alluvium ranging from boulders to sand was deposited in areas north and east of Washougal during repeated catastrophic flooding of the Columbia River during late Pleistocene ice ages. The coarsest sediments were deposited close to the Columbia and finer sediments were deposited further inland. The sand and silt make up of the lower basin is Columbia River floodplain alluvium deposited in more recent times.

3.1.2 *Climate*

The climate is typified by cool, wet winters and warm, dry summers. Temperatures are moderated by mild, moist air flowing up the Columbia from the Pacific. Precipitation levels are high due to orographic effects. Mean annual precipitation is 85 inches at the Skamania Hatchery (WRCC 2003). Winter temperatures seldom fall below freezing, resulting in low and transient volumes of snowfall.

3.1.3 *Land Use, Ownership, and Cover*

Most of the basin is forested and managed for timber production. Of the basin's land area, 61% is privately owned and most of the remainder is State Forest land. A small portion of the upper basin lies within the Gifford Pinchot National Forest, comprising approximately 8% of the total basin area. Not including the Lacamas Creek basin, most of the private land is owned by private commercial timber companies, except for agricultural land in the lower river valleys, scattered rural residential development, and the urban areas in and around the towns of Washougal and Camas. The Lacamas Creek drainage is made up largely of private land in rural residential or agricultural uses, with the westernmost portion of the basin within the expanding Vancouver metropolitan area. The State of Washington owns, and the Washington State Department of Natural Resources (DNR) manages the beds of all navigable waters within the subbasin. Any proposed use of those lands must be approved in advance by the DNR.

Past timber harvest and large fires (e.g. Yacolt Burn, 1902) have had lasting impacts to the forest vegetation across much of the basin. Residential development has increased dramatically in the Lacamas Creek basin and along the lower 20 miles of the Washougal and in the Little

Washougal watershed. Commercial and industrial development dominates the lower basin within the Columbia River floodplain. Land use and land cover in the Washougal River subbasin are illustrated by Figure 2 and Figure 3. Figure 2 displays the pattern of landownership for the basin. Figure 3 displays the pattern of land cover / land-use.

3.1.4 *Development Trends*

The year 2000 population of the Lacamas Creek basin of 23,800 persons is expected to increase by 35,000 persons by 2020. The population of the remainder of the Washougal subbasin is expected to increase from 12,800 to 34,000 persons (LCFRB 2001). These substantial population increases reflect the eastward expansion of the Vancouver metropolitan area and may serve to increase impacts on watershed processes.

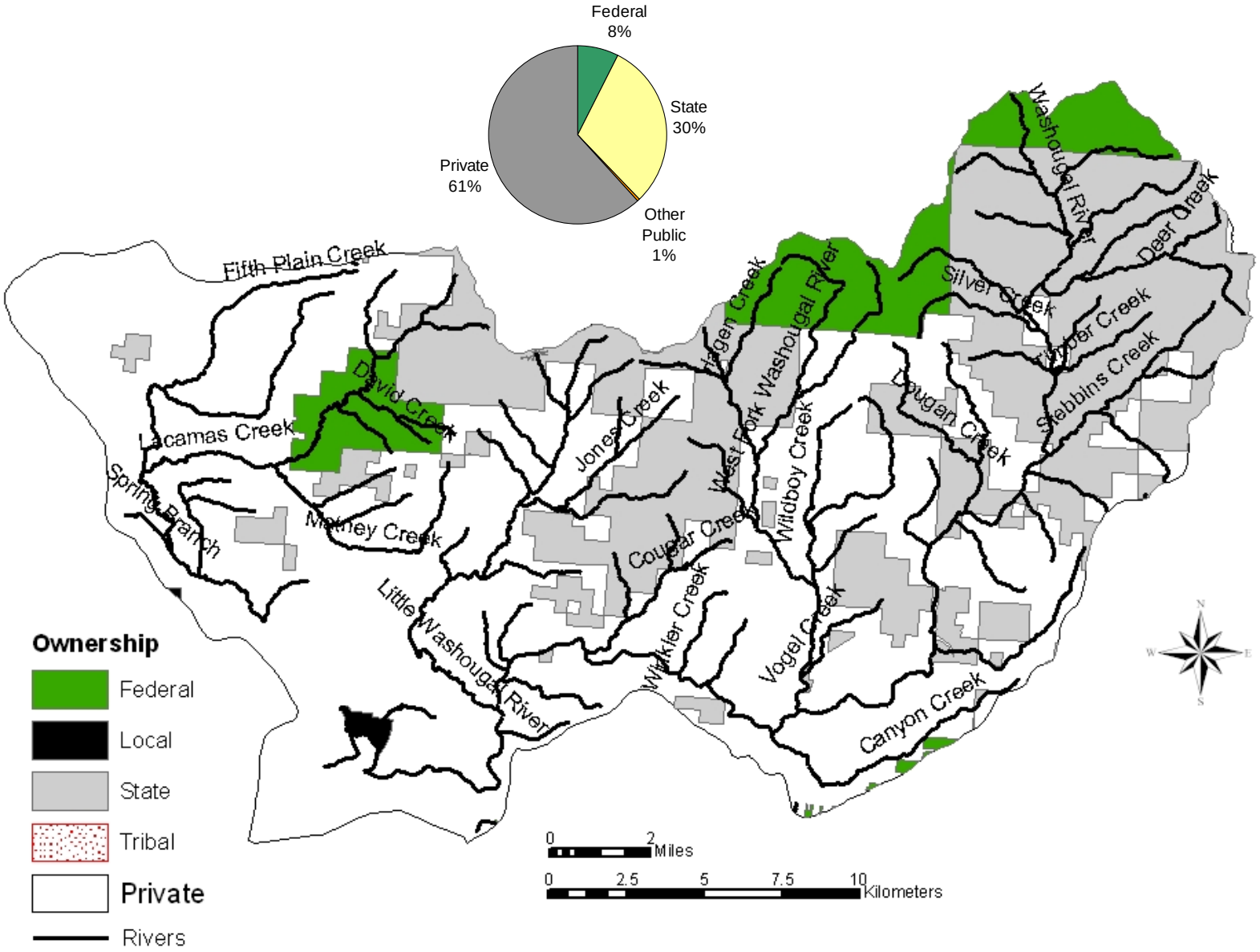


Figure 2. Landownership within the Washougal Subbasin. Mapped data is WDNR data that was obtained from the Interior Columbia Basin Ecosystem Management Project (ICBEMP).

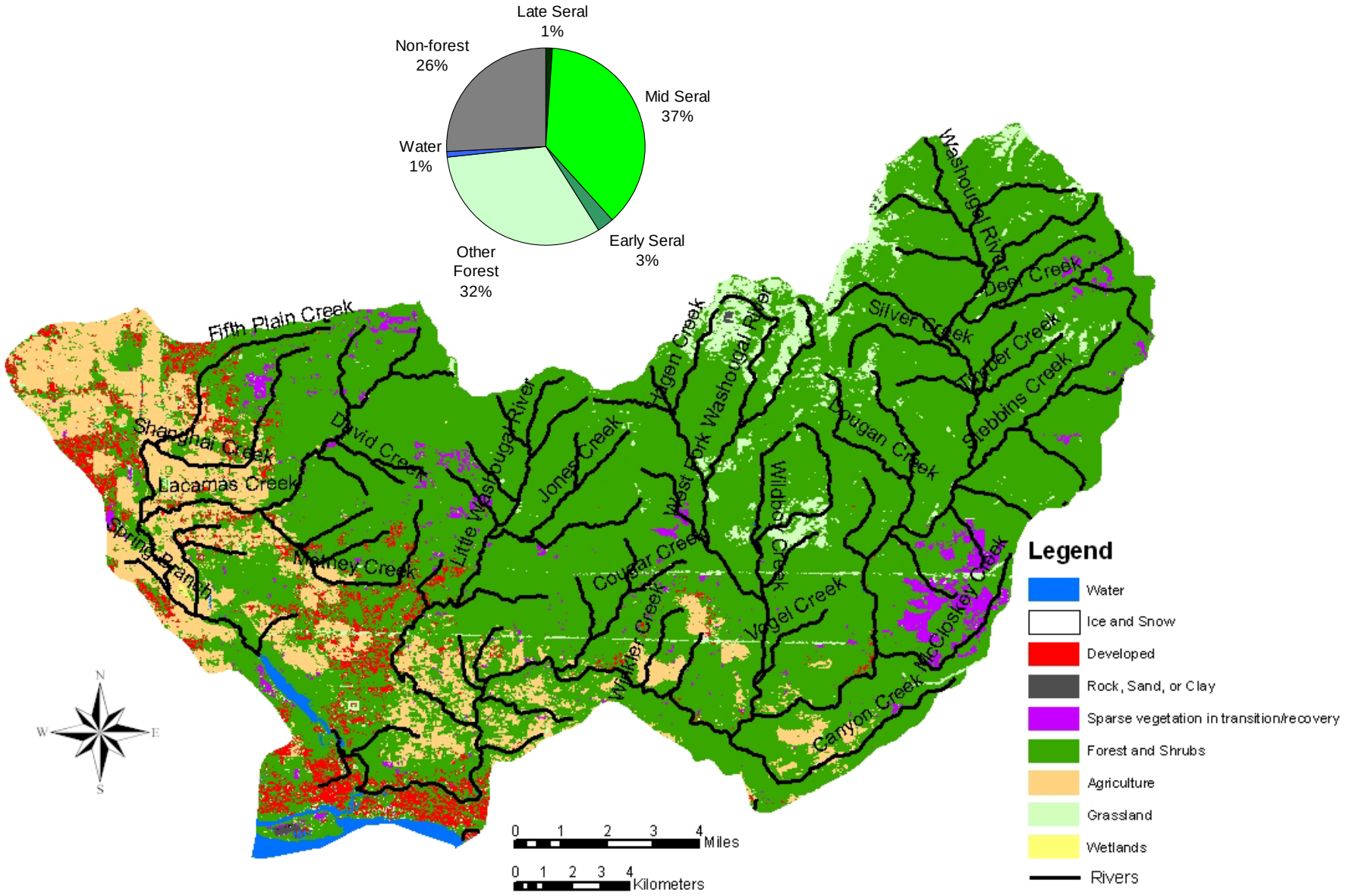


Figure 3. Land cover within the Washougal Subbasin. Vegetation cover (pie chart) derived from Landsat data based on methods in Lunetta et al. (1997). Mapped data was obtained from the USGS National Land Cover Dataset (NLCD).

3.2 Focal and Other Species of Interest

Listed salmon, steelhead, and trout species are focal species of this planning effort for the Washougal Subbasin. Other species of interest were also identified as appropriate. Species were selected because they are listed or under consideration for listing under the U.S. Endangered Species Act or because viability or use is significantly affected by the Federal Columbia Hydropower system. Federal hydropower system effects are not significant within the Washougal River basin although anadromous species are subject to effects in the Columbia River, estuary, and nearshore ocean. The Washougal ecosystem supports and depends on a wide variety of fish and wildlife in addition to designated species. A comprehensive ecosystem-based approach to salmon and steelhead recovery will provide significant benefits to other native species through restoration of landscape-level processes and habitat conditions. Other fish and wildlife species not directly addressed by this plan are subject to a variety of other Federal, State, and local planning or management activities.

Focal salmonid species in Washougal River watersheds include fall Chinook, summer and winter steelhead, chum and coho. Bull trout do not occur in the subbasin. Salmon and steelhead numbers have declined to only a fraction of historical levels (Table 1). Extinction risks are significant for all focal species – the current health or viability level are very low for coho, low for chum, and just above low for fall chinook, and summer and winter steelhead. Returns of fall Chinook, chum, and summer and winter steelhead include both natural and hatchery produced fish.

Table 1. Status of focal salmond and steelhead populations in the Washougal River subbasin.

Focal Species	ESA Status	Hatchery Component[1]	Historical numbers[2]	Recent numbers[3]	Current viability[4]	Extinction risk[5]
Fall Chinook	Threatened	Yes	3,000-9,000	2,000-4,500	Low+	30%
Chum	Threatened	No	25,000-40,000	<1,000	Low	50%
Coho	Proposed	Yes	5,000-35,000	Unknown	Low	70%
Summer Steelhead	Threatened	Yes	2,000-8,000	100-200	Low+	30%
Winter Steelhead	Threatened	Yes	2,000-9,500	100-800	Low+	40%

[1] Significant numbers of hatchery fish are released in the subbasin.
[2] Historical population size inferred from presumed habitat conditions using Ecosystem Diagnosis and Treatment Model and NOAA rough calculations..
[3] Approximate current annual range in number of naturally-produced fish returning to the subbasin.
[4] Propsects for long term persistence based on criteria developed by the NOAA Technical Recovery Team.
[5] Probability of extinction within 100 years corresponding to estimated viability.

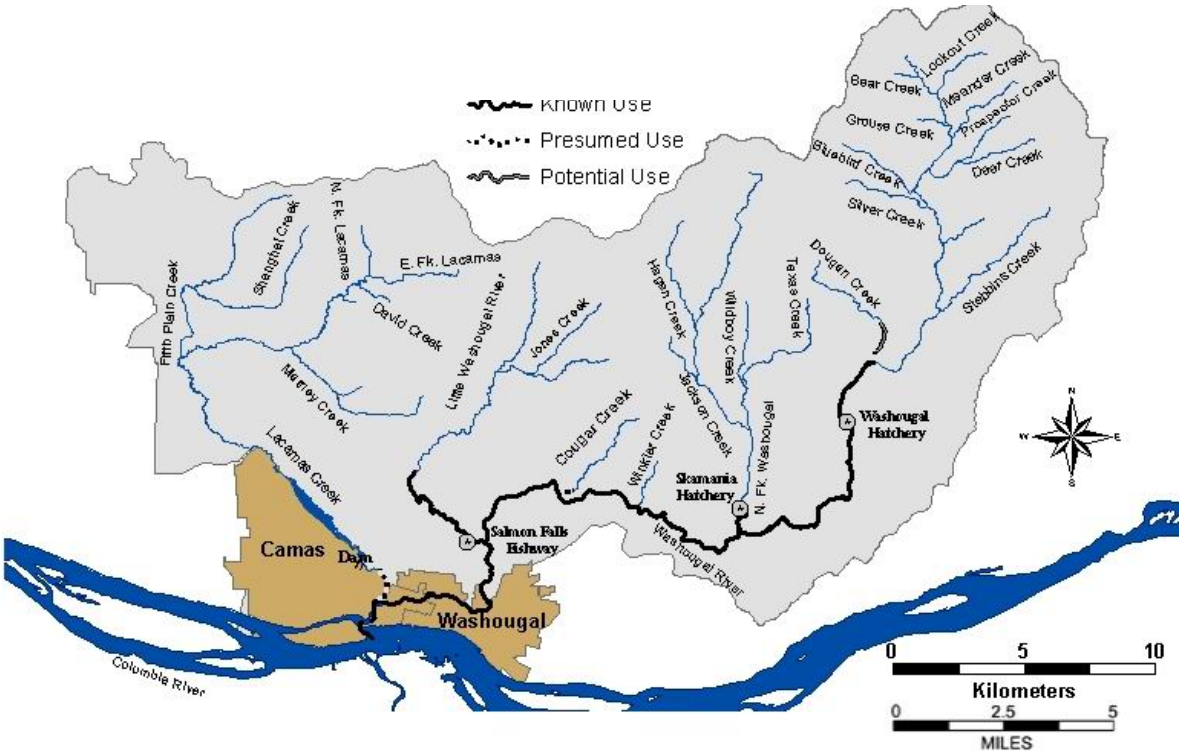
Other species of interest in the Washougal Subbasin include coastal cutthroat trout and Pacific lamprey. These species have been affected by many of the same habitat factors that have reduced numbers of anadromous salmonids.

Brief summaries of the population characteristics and status follow. Additional information on life history, population characteristics, and status assessments may be found in Appendix A (focal species) and B (other species).

3.2.1 *Fall Chinook—Washougal Subbasin*

ESA: Threatened 1999 **SASSI: Healthy 2002**

The historical Washougal adult population is estimated from 3,000-9,000 fish. The current natural spawning number is 2,000-4,500, but the majority of the returns are hatchery fall Chinook released as juveniles from the Washougal Hatchery. Natural spawning occurs primarily in four miles of the mainstem Washougal from Salmon Falls Bridge (RM 15) to the Fish and Wildlife access area. Spawning upstream of Salmon Falls can be significant in years with early fall rain. Juvenile rearing occurs near and downstream of the spawning areas. Juveniles migrate from the Washougal in the spring and early summer of their first year.

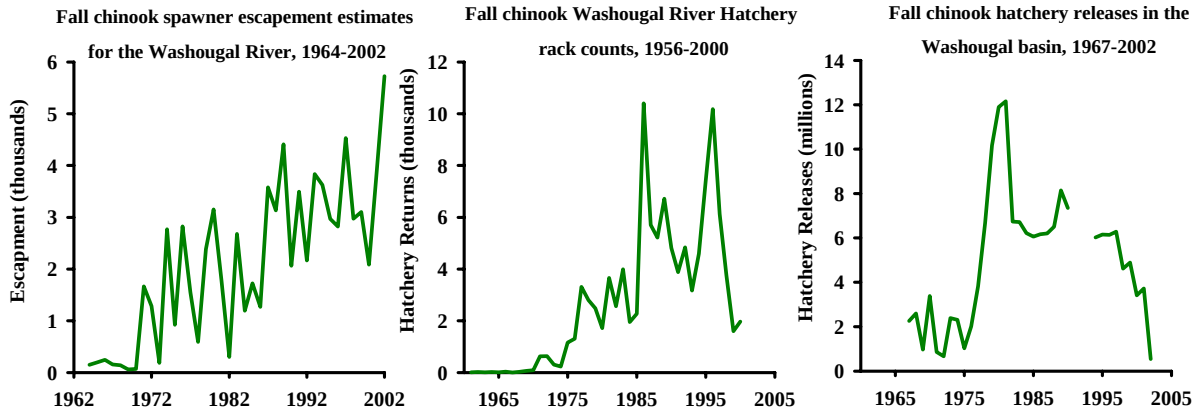


Distribution

- Natural spawning occurs in the mainstem Washougal primarily between Salmon Falls Bridge (RM 15) and the fish and wildlife access area (~4 miles)
- A ladder was constructed at Salmon Falls in the late 1950s, providing fish access up to Dougan Falls (RM 21.6)
- Annual distribution of natural spawners in the mainstem Washougal is dependent on amount of rainfall from mid-September to mid-October

Life History

- Fall chinook upstream migration in the Washougal River occurs from late September to mid-November, depending on early rainfall
- Spawning in the Washougal River occurs between late September to mid-November
- Age ranges from 2-year old jacks to 6-year old adults, with dominant adult ages of 3 and 4 (averages are 24.8% and 55.2%, respectively)
- Fry emerge in March/April, depending on time of egg deposition and water temperature; fall chinook fry spend the spring in fresh water, and emigrate in the summer as sub-yearlings



Diversity

- Considered a tule population in the lower Columbia River Evolutionarily Significant Unit (ESU)
- The Washougal fall chinook stock designated based on distinct spawning distribution
- Genetic analyses of Washougal fall chinook in 1995 and 1996 indicated they are significantly different from other lower Columbia River chinook stocks, except for Lewis River bright fall chinook

Abundance

- WDFW (1951) estimated fall chinook escapement to the Washougal basin was 3,000 fish
- Washougal River spawning escapements from 1964-2001 ranged from 70-4,669 (average 2,000)
- Hatchery production accounts for most fall chinook returning to the Washougal River

Productivity & Persistence

- NMFS Status Assessment for the Washougal River indicated a 0.0 risk of 90% decline in 25 years, 90% decline in 50 years, or extinction in 50 years
- A moderate level of natural production occurs, as illustrated by a WDFW estimate of 5,000,000 natural juvenile fall chinook emigrating from the Washougal basin in 1980
- Hatchery origin spawners that do not convert to the hatchery comprise a significant portion of the natural spawners
- The number of hatchery fish in the natural spawning population is increased in years when rain fall is not sufficient to provide river flows conducive for fish passage to the Washougal Hatchery

Hatchery

- The Washougal Hatchery (completed in 1958) is located about RM 16.0
- Hatchery releases of fall chinook in the Washougal basin began in the 1950s; numerous lower Columbia broodstock sources were used in the past for Washougal egg take
- Washougal Hatchery returns are generally spawned later than other Columbia River tule stocks; the later time developed over years of selection for the later timed fish because of conditions for passage to the hatchery often delayed until freshets in late October
- The current program releases 3.5 million fall chinook sub-yearlings annually; no outside basin stock have been used in recent years
- Washougal fall chinook releases are displayed for the years 1967-2002

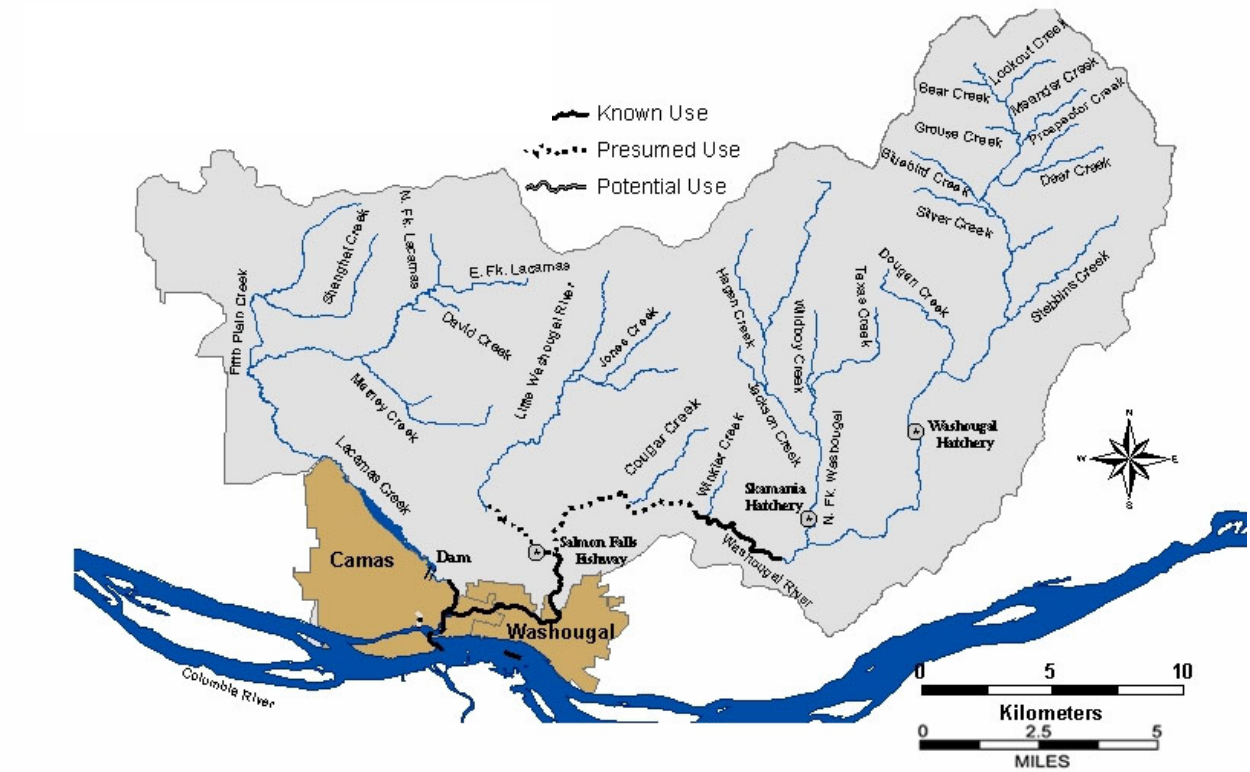
Harvest

- Fall chinook are harvested in ocean commercial and recreational fisheries from Oregon to Alaska, in addition to Columbia River commercial gill net and sport fisheries
- Lower Columbia tule fall chinook are important contributors to the Washington ocean sport and troll fisheries and to the Columbia River estuary sport fishery
- Columbia River commercial harvest occurs primarily in September, but tule chinook flesh quality is low once the fish move from salt water; the price is low compared to higher quality bright stock chinook
- Ocean and mainstem Columbia combined harvest is limited to 49% as a result of ESA limits on Coweemean tule fall chinook
- Current annual harvest rate dependent on management response to annual abundance in PSC (U.S/Canada), PFMC (U.S. ocean), and Columbia River Compact forums
- Coded wire tag (CWT) data analysis of the 1989-1994 brood years indicates a Washougal fall chinook harvest rate of 28% during the mid 1990s
- The majority of 1989-94 brood Washougal fall chinook harvest occurred in Southern British Columbia (35.0%), Alaska (22%), Columbia River (16%), and Washington ocean (14%) fisheries
- Sport harvest in the Washougal River averaged 477 fall chinook annually from 1977-1987

3.2.2 *Chum—Washougal Subbasin*

ESA: Threatened 1999 **SASSI: NA**

The historical Washougal adult population is estimated from 25,000-40,000. Current natural spawning is less than 100 fish in the Washougal and less than 1,000 fish in the Washougal area, including the mainstem Columbia and tributaries near I-205 Bridge. Spawning occurs in the lower reaches of the mainstem Washougal, Little Washougal, and Lacamas Creek. A potentially related population spawns in the mainstem Columbia and tributaries near the I-205 Bridge. Spawning occurs from late November through December. Natural spawning chum in the Washougal are all naturally produced as no hatchery chum are released in the area. Juveniles rear in the lower reaches for a short period in the early spring and quickly migrate to the Columbia.



Distribution

- Spawning is believed to occur in the lower reaches of the mainstem Washougal River
- Spawning is believed to occur in the Little Washougal and Lacamas Creek
- Spawning also occurs in the mainstem Columbia and small tributaries just downstream of the Washougal River mouth near I-205 Bridge.

Life History

- Lower Columbia River chum salmon run from mid-October through November; peak spawner abundance occurs in late November
- Dominant age classes of adults are age 3 and 4
- Fry emerge in early spring; chum emigrate as age-0 smolts with little freshwater rearing time

Diversity

- There are no recorded hatchery releases into the Washougal River

Abundance

- In 1951, estimated escapement to the Washougal River was a minimum of 1,000 chum per year
- Spawning ground surveys for other salmonids have resulted in chum observations; in 1998, WDFW found one chum in the Washougal; in 2000, one chum was found in Lacamas Creek (a lower tributary, RM 0.8)
- Chum spawning population estimates in 2002 totaled 715 in the Washougal and vicinity, including 24 in the lower mainstem Washougal, 21 in LaCamas Creek, 628 in the mainstem Columbia, 30 in Hatchery Creek, and 12 in Joseph Creek.

Productivity & Persistence

- Chum salmon natural production is low

Hatchery

- Chum salmon have not been released in the Washougal River

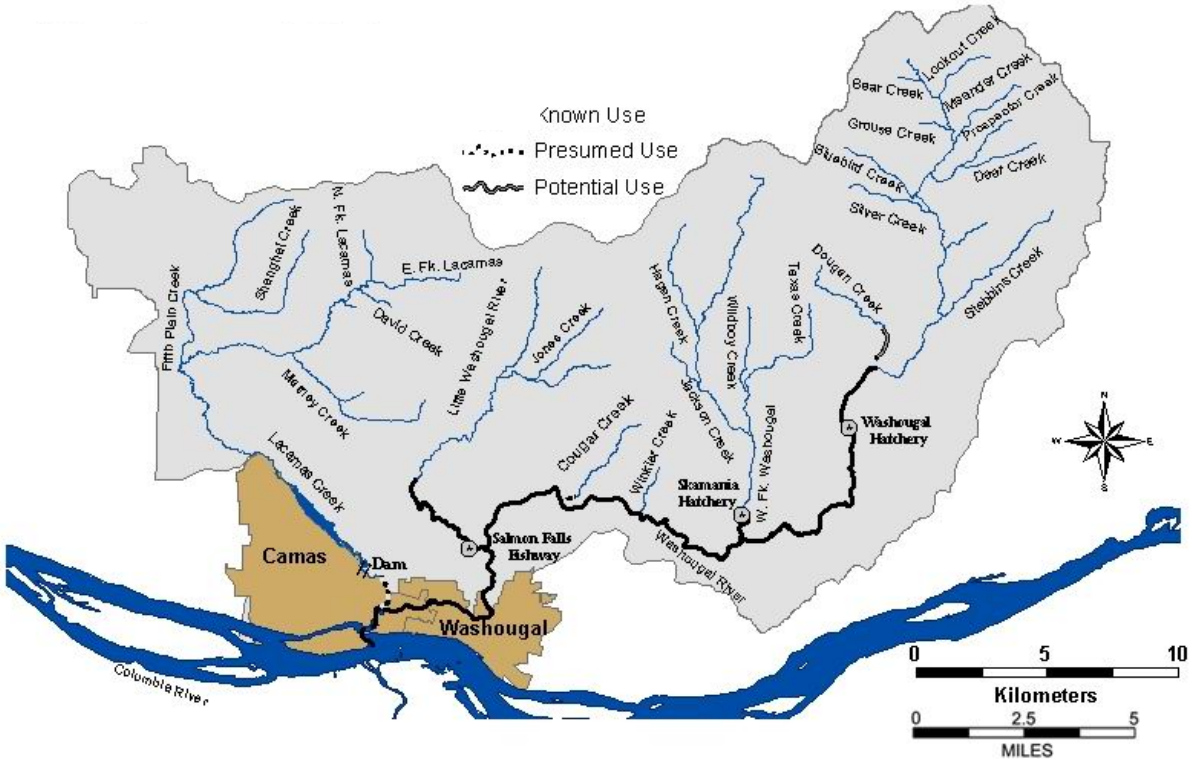
Harvest

- Currently very limited chum harvest occurs in the ocean and Columbia River and is incidental to fisheries directed at other species
- Columbia River commercial fishery historically harvested chum salmon in large numbers (80,000 to 650,000 in years prior to 1943); from 1965-1992 landings averaged less than 2,000 chum, and since 1993 less then 100 chum
- In the 1990s November commercial fisheries were curtailed and retention of chum was prohibited in Columbia River sport fisheries
- The ESA limits incidental harvest of Columbia River chum to less then 5% of the annual return

3.2.3 *Coho—Washougal Subbasin*

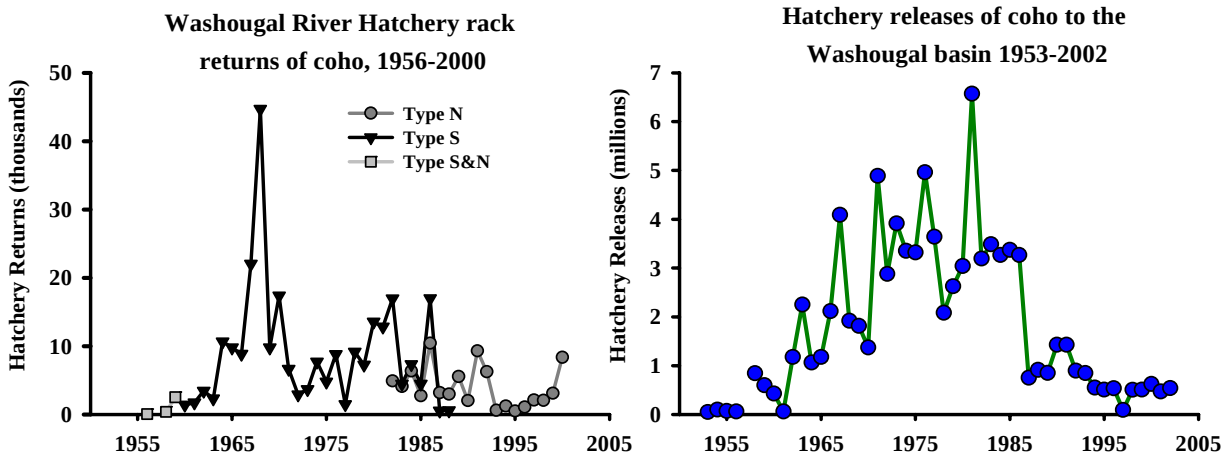
ESA: Candidate 1995 **SASSI: Unknown 2002**

The historical Washougal adult population is estimated from 5,000-35,000, with the majority of returns late stock which spawn from late November to March. Some early stock coho were also historically present with spawning occurring primarily in early to mid November. Current returns are unknown but assumed to be very low. A number of hatchery produced fish spawn naturally. Natural spawning can occur in most areas of the basin upstream to Dougan Falls, but the principal spawning area is the Little Washougal River. Juvenile rearing occurs upstream and downstream of spawning areas. Juveniles rear for a full year in the Washougal Basin before migrating as yearlings in the spring.



Distribution

- Managers refer to early stock coho as Type S due to their ocean distribution generally south of the Columbia River
- Managers refer to late stock coho as Type N due to their ocean distribution generally north of the Columbia River
- Natural spawning is thought to occur in most areas accessible to coho, but principally in the Little Washougal River with 7.5 miles of stream area habitat
- The West Fork Washougal River and Winkler Creek are also potential production areas
- The mainstem Washougal is not a primary coho spawning area but has some production potential downstream of Salmon Falls (RM 17.5)
- A ladder was constructed at Salmon Falls in the late 1950s, providing fish access up to Dougan Falls (RM 21.6)



Life History

- Adults enter the Washougal River from early September and continue through December
- Peak spawning for early stock occurs in mid-October to November
- Peak spawning for late stock occurs in December and January
- Adults return as 2-year old jacks (age 1.1) or 3-year old adults (age 1.2)
- Fry emerge in late winter/early spring, spend one year in fresh water, and emigrate as age-1 smolts the following spring

Diversity

- Late stock coho (or Type N) were historically produced in the Washougal basin with spawning occurring from late November to March
- Early stock coho (or Type S) were also historically produced in the Washougal basin but in less numbers then the late stock
- Columbia River early and late stock coho produced from Washington hatcheries are genetically similar

Abundance

- Washougal River wild coho run is a fraction of its historical size
- In 1949, it was estimated that the Washougal had spawning area for 6,000 pair of salmon; 5,000 below Salmon Falls and 1,000 between Salmon and Dougan Falls
- In 1951, WDF estimated coho escapement to the basin was 3,000 fish
- Hatchery production accounts for most coho returning to the Washougal River

Productivity & Persistence

- Natural coho production is presumed to be very low
- Coho production limited to lower river tributaries downstream of Dougan Falls
- Natural production of coho has persisted at low levels in the Little Washougal River

Hatchery

- The Washougal Hatchery (completed in 1958) is located about RM 16.0. Hatchery has produced early and late coho in the past but current program produces only late stock
- Coho have been planted in the Washougal basin since 1958; extensive hatchery coho releases have occurred since 1967

- Current program rears 2.5 million late coho but only releases 0.5 million into the Washougal River; the remaining 2 million are released into the Klickitat River as per a management plan agreement with the Columbia River tribes.

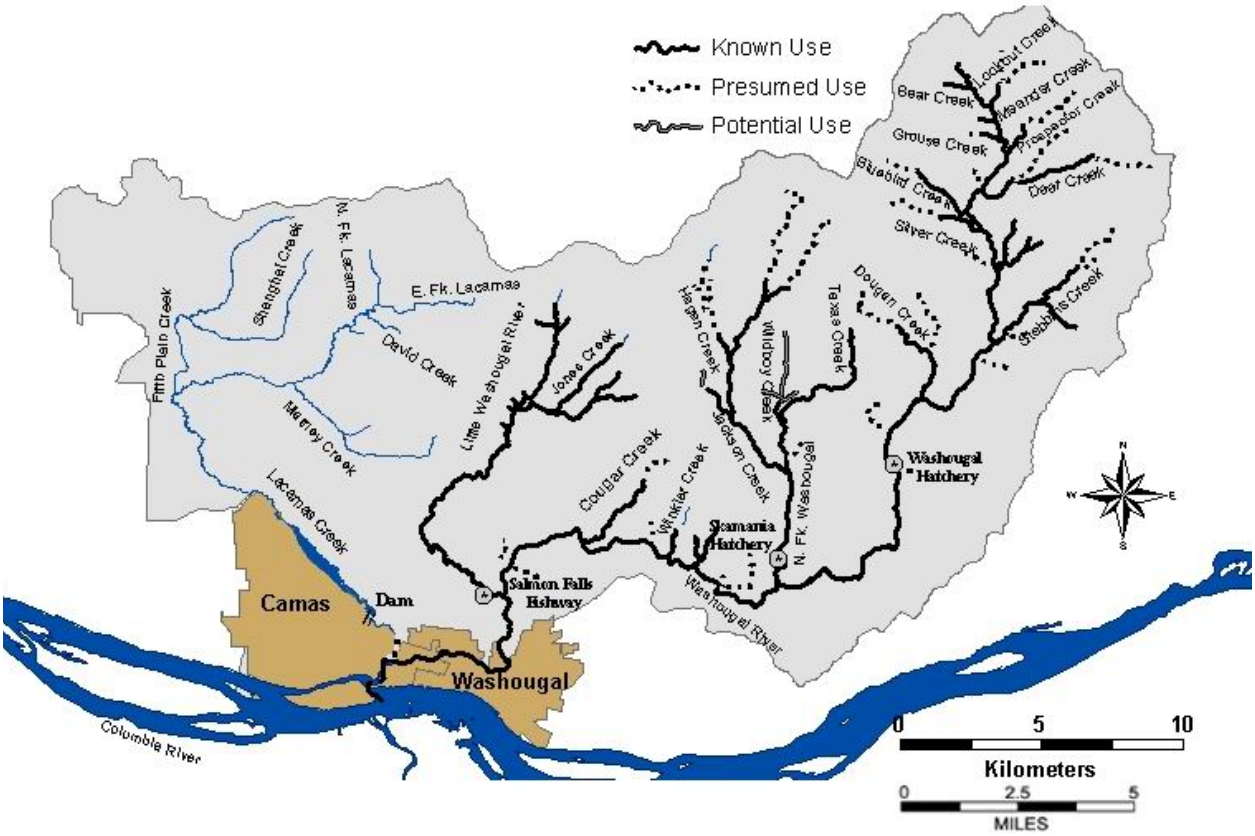
Harvest

- Until recent years, natural produced coho were managed like hatchery fish and subjected to similar harvest rates; ocean and Columbia River combined harvest rates ranged from 70% to over 90% during 1970-83
- Ocean fisheries were reduced in the mid 1980s to protect several Puget Sound and Washington coastal wild coho populations
- Columbia River commercial coho fishing in November was eliminated in the 1990s to reduce harvest of late Clackamas wild coho
- Since 1999, returning Columbia River hatchery coho have been mass marked with an adipose fin clip to enable fisheries to selectively harvest hatchery coho and release wild coho
- Hatchery coho can contribute significantly to the lower Columbia River gill net fishery; commercial harvest of early coho in September is constrained by fall chinook and Sandy River coho management; commercial harvest of late coho is focused in October during the peak abundance of hatchery late coho
- Naturally-produced lower Columbia river coho are beneficiaries of harvest limits aimed at Federal ESA listed Oregon coastal coho and Oregon State listed Clackamas and Sandy River coho
- During 1999-2002, fisheries harvest of ESA listed coho was less than 15% each year
- A substantial estuary sport fishery exists between Buoy 10 and the Astoria-Megler Bridge; majority of the catch is early hatchery coho, but late hatchery coho harvest can also be substantial
- An average of 924 coho (1979-1986) were harvested annually in the Washougal River sport fishery
- A special snag fishery for disabled fishermen was present near the hatchery until 1986 to harvest surplus hatchery fish; harvest from 1979-1986 averaged 1,193 coho annually
- CWT data analysis of 1995-97 brood Washougal Hatchery late coho indicates 71% were captured in a fishery and 29% were accounted for in escapement
- Fishery CWT recoveries of Washougal late coho are distributed between Columbia River (57%), Washington ocean (30%), and Oregon ocean (13%) sampling areas

3.2.4 *Summer Steelhead—Washougal Subbasin*

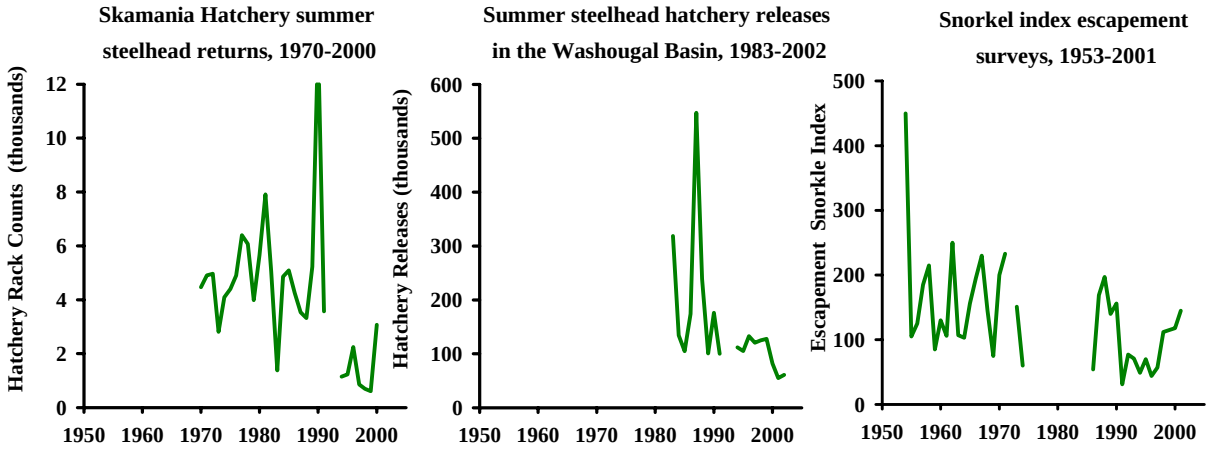
ESA: Threatened 1998	SASSI: Unknown 2002

The historical Washougal adult population is estimated from 2,000- 8,000 fish. Current natural spawning returns range from 100-200 fish. In-breeding with Skamania Hatchery produced steelhead is thought to be low because of differences in spawn timing. Spawning occurs throughout the Washougal Basin, extending to the mainstem Washougal and tributaries upstream of Dougan Falls, the Little Washougal, and the North Fork Washougal. Spawn timing is generally from early march to early June. Juvenile rearing occurs both downstream and upstream of the spawning areas. Juveniles rear for a full year or more before migrating from the Washougal.



Distribution

- Spawning occurs throughout the mainstem Washougal River, including the tributaries of the West Fork Washougal, the Little Washougal River, and Stebbins and Cougar Creeks
- Several small dams that blocked/impeded steelhead migration have been removed or by-passed, providing access to more of the basin
- Dougan Falls at RM 21 is considered a low water barrier to steelhead; above Dougan Falls, the stream is characterized by a series of falls and cascades



Life History

- Adult migration timing for Washougal summer steelhead is from May through November
- Spawning timing on the Washougal is generally from early March to early June
- The dominant age class is 2.2, although minimal age composition data are available
- Wild steelhead fry emerge from April through July; juveniles generally rear in fresh water for two years; emigration occurs from March to June, with peak migration from mid-April to mid-May

Diversity

- Stock designated based on distinct spawning distribution and early run timing
- Skamania Hatchery summer steelhead broodstock were developed from native Washougal and Klickitat River steelhead
- After 1980 Mt. St. Helens eruption, straying Cowlitz River steelhead may have spawned with native Washougal stocks
- Genetic sampling in 1993 provided little information for determining stock distinctiveness

Abundance

- Between 1925-1933, steelhead run size was estimated at 2,500 fish
- In 1936, 539 steelhead were documented in the Washougal River during escapement surveys
- Snorkel index counts estimated wild steelhead escapement from 1953-2001 ranged from 31 to 500
- Hatchery summer steelhead usually comprise the majority of the spawning escapement; Skamania Hatchery returns have ranged from 1,380 to 13,567 from 1970-1991
- Escapement goal for the Washougal is 1,210 wild adult steelhead

Productivity & Persistence

- NMFS Status Assessment indicated a 0.89 risk of 90% decline in 25 years and a 1.0 risk of 90% decline in 50 years; the risk of extinction in 50 years was not applicable

Hatchery

- The Washougal Hatchery (on the mainstem) does not produce summer steelhead
- Skamania Hatchery is located about 1 mile from the mouth of the West Fork; summer steelhead have been released in the basin since the 1950s
- Summer steelhead from the Skamania Hatchery are normally released as smolts directly to the West Fork or mainstem Washougal; release data are displayed from 1983-2002

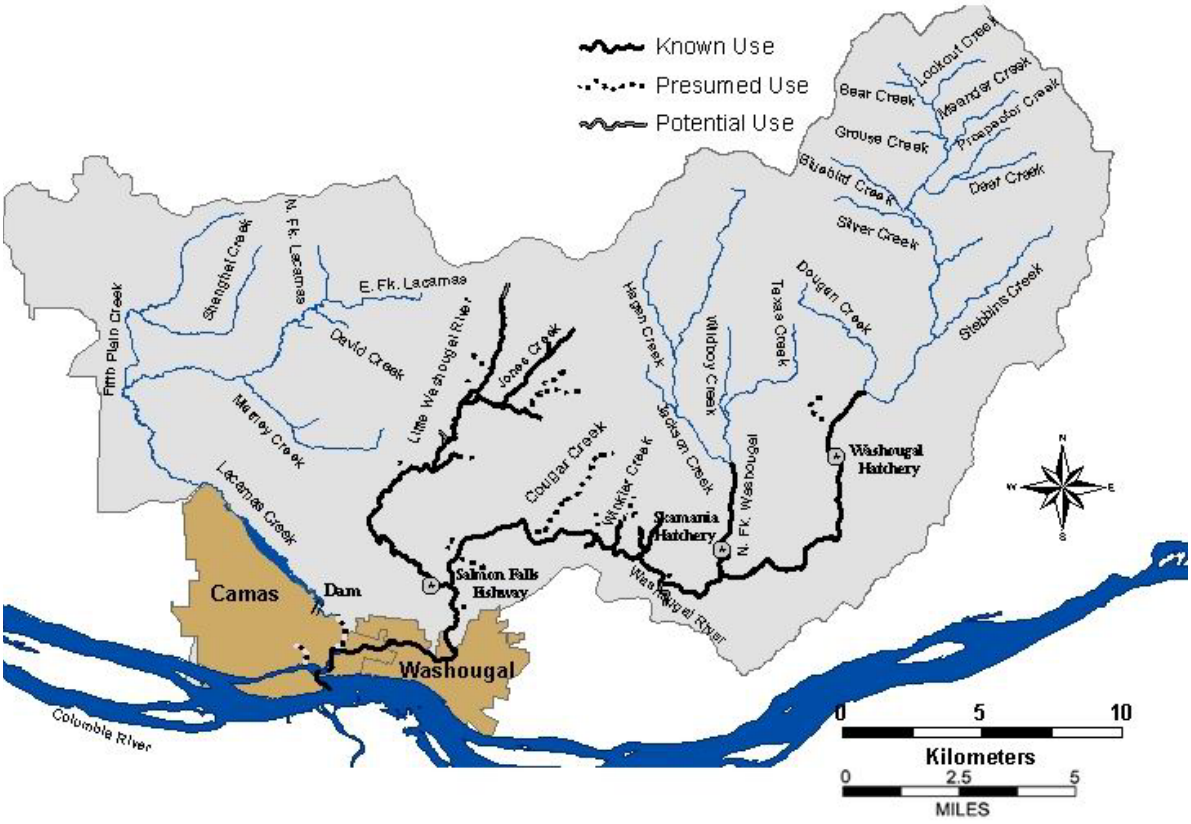
Harvest

- No directed fisheries target Washougal summer steelhead; incidental mortality can occur during the Columbia River fall commercial and summer sport fisheries
- Summer steelhead sport harvest in the Washougal River from 1964-1990 ranged from 272 to 5,699; average annual sport harvest from 1983-1990 was 1,560 fish; since 1986, regulations limit harvest to hatchery fish only
- ESA limits fishery impact on wild Washougal summer steelhead in the mainstem Columbia River and in the Washougal River as per the Fishery Management and Evaluation Plan approved by NOAA Fisheries in 2003.

3.2.5 *Winter Steelhead—Washougal Subbasin*

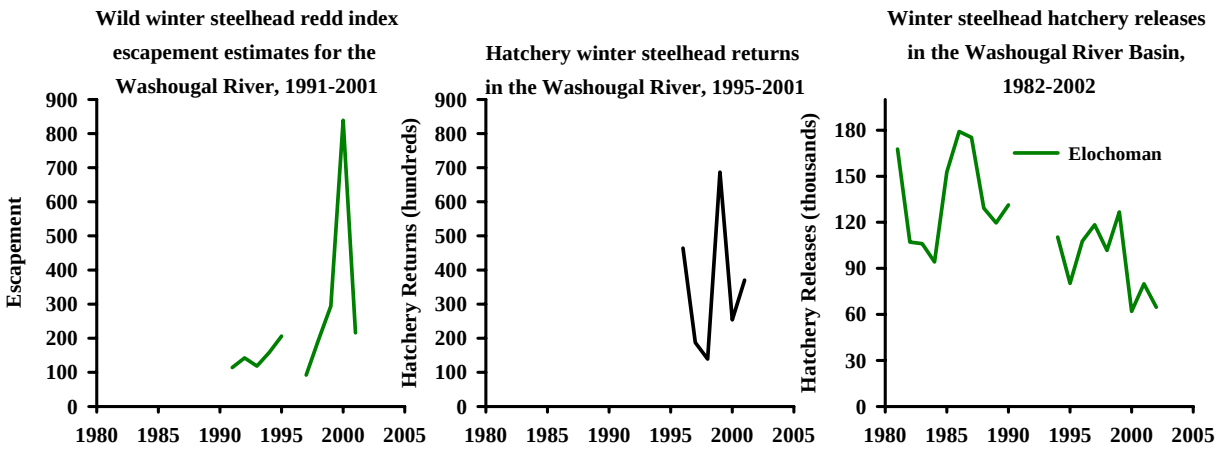
ESA: Threatened 1998	SASSI: Depressed 2002

The historical Washougal adult population is estimated from 2,000-9,500 fish. Current natural spawning returns range from 100-800 fish. In-breeding with Skamania Hatchery produced steelhead is thought to be low because of differences in spawn timing. Spawning occurs primarily in the mainstem Washougal upstream to Dougan Falls, the Little Washougal, North Fork Washougal and tributaries. Spawning time is early March to early June. Juvenile rearing occurs both downstream and upstream of the spawning areas. Juveniles rear for a full year or more before migrating from the Washougal.



Distribution

- Spawning occurs throughout the mainstem Washougal River, including the tributaries of the West Fork Washougal, the Little Washougal River, and Stebbins and Cougar Creeks
- Several small dams that blocked/impeded steelhead migration have been removed or by-passed, providing access to more of the basin
- Dougan Falls at RM 21 is considered a low water barrier to steelhead; above Dougan Falls, the stream is characterized by a series of falls and cascades



Life History

- Adult migration timing for Washougal winter steelhead is from December through April
- Spawning timing on the Washougal is generally from early March to early June
- Limited age composition data for Washougal River winter steelhead suggest that most adults are 2-ocean fish
- Wild steelhead fry emerge from March through May; juveniles generally rear in fresh water for two years; juvenile emigration occurs from April to May, with peak migration in early May

Diversity

- Washougal winter steelhead stock is designated based on distinct spawning distribution and late run timing.
- Wild stock interbreeding with Skamania Hatchery brood stock is thought to be low because of differences in spawn timing.
- After 1980 Mt. St. Helens eruption, straying Cowlitz River steelhead may have spawned with native Washougal stocks.

Abundance

- In 1936, 539 steelhead were documented in the Washougal River during escapement surveys
- Winter steelhead redd index escapement counts for the Washougal River from 1991-2001 ranged from 92 to 839 (average 237)
- Escapement goal for the Washougal River is 841 wild adult steelhead; escapement goal has been met once since 1991
- Hatchery origin fish comprise most of the winter steelhead run on the Washougal

Productivity & Persistence

- Winter steelhead natural production is expected to be low

Hatchery

- The Washougal Hatchery (on the mainstem) does not produce winter steelhead
- Skamania Hatchery is located about 1 mile from the mouth of the West Fork; winter steelhead have been released in the basin since the 1950s; production of winter steelhead smolts was approximately 260,000 annually in the early 1990s; current winter steelhead releases are approximately 110,000 smolts annually

- Winter steelhead from the Skamania Hatchery are normally released as smolts directly to the West Fork or mainstem Washougal; release data are available from 1982-2002
- Hatchery fish contribute little to natural winter steelhead production in the Washougal River basin

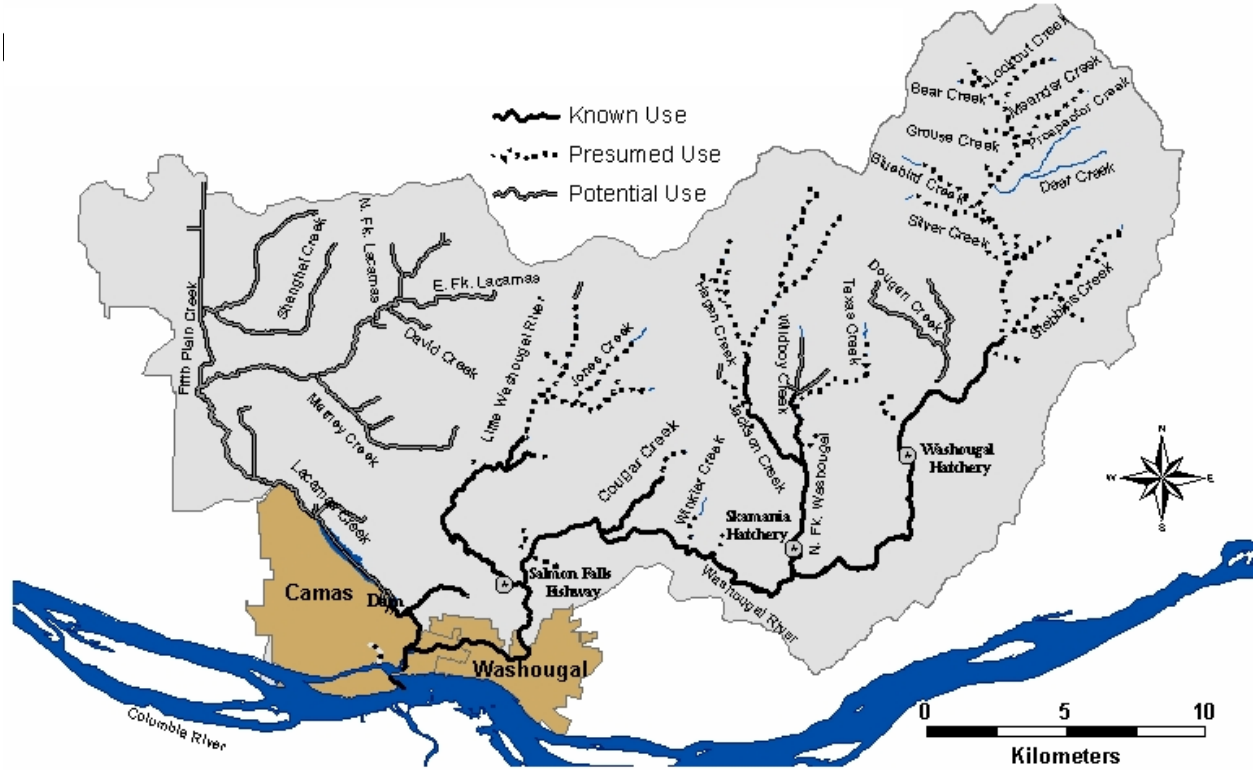
Harvest

- No directed commercial or tribal fisheries target Washougal winter steelhead; incidental harvest currently occurs during the lower Columbia River spring chinook gillnet fisheries
- Treaty Indian harvest does not occur in the Washougal River basin
- Winter steelhead sport harvest (hatchery and wild) in the Washougal River from 1980-1990 ranged from 1,377 to 3,195 fish; since 1991 and 1992, respectively, regulations limit harvest on the mainstem and West Fork Washougal to hatchery fish only
- ESA limits fishery impact on wild winter steelhead in the mainstem Columbia River and in the Washougal River as per the Fishery Management and Evaluation Plan approved by NOAA Fisheries in 2003

3.2.6 *Cutthroat Trout—Washougal River Subbasin*

ESA: Not Listed **SASSI: Unknown**

Coastal cutthroat abundance in the Washougal has not been quantified but the population is considered depressed. Cutthroat trout have been observed throughout the basin upstream to Dougan Falls and in Lacamas Lake. Anadromous, fluvial, and resident forms of cutthroat trout are found in the basin. Anadromous cutthroat enter the Washougal from July-December and spawn from December through June. Most juveniles rear 2-4 years before migrating from their natal stream. A hatchery cutthroat program was discontinued in 1999.



Distribution

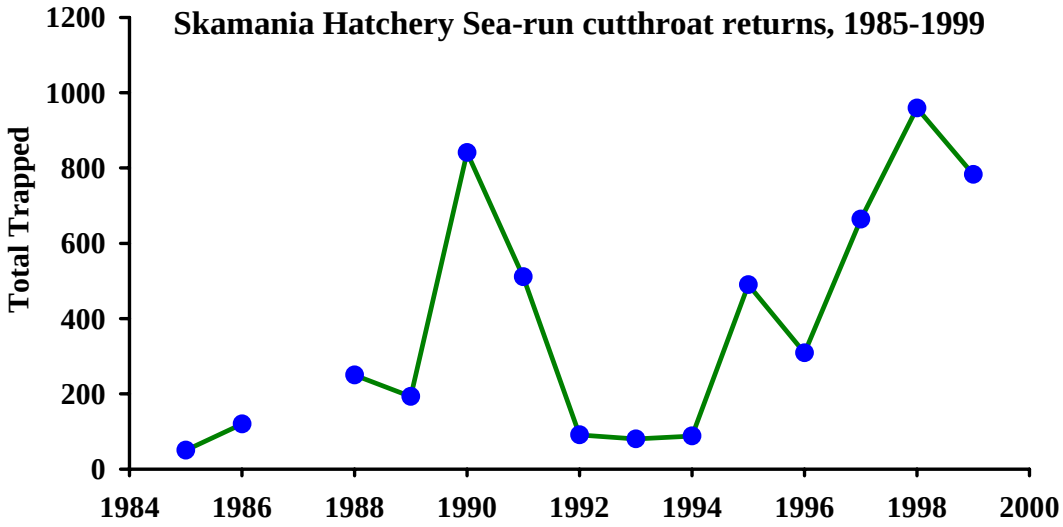
- Anadromous forms are found up to Dougan Falls
- Advfluvial fish exist in Lacamas Lake
- Resident and fluvial forms are documented throughout the system

Life History

- Anadromous, fluvial, adfluvial and resident forms are present
- Anadromous river entry is from July through December
- Anadromous spawning occurs from December through June
- Resident spawn timing is from February through June

Diversity

- No genetic sampling or analysis has been conducted
- Genetic relationship to other stocks and stock complexes is unknown



Abundance

- Insufficient quantitative data are available to identify wild cutthroat abundance or survival trends
- Adult sea-run cutthroat returns to Skamania Hatchery range from 50-959 fish for the period 1985-1998
- Anecdotal information from local residents suggest that the stock is Depressed

Hatchery

- Washougal and Skamania Hatcheries releases coho, chinook and steelhead into the subbasin each year
- Skamania Hatchery cutthroat trout program was discontinued in 1999

Harvest

- Not harvested in ocean commercial or recreational fisheries
- Angler harvest for adipose fin clipped hatchery fish occurs in mainstem Columbia summer fisheries downstream of the Washougal River
- Wild Washougal cutthroat (unmarked) must be released in mainstem Columbia River and Washougal River sport fisheries

3.2.7 *Other Species*

Pacific lamprey – Information on lamprey abundance is limited and does not exist for the Washougal population. However, based on declining trends measured at Bonneville Dam and Willamette Falls it is assumed that Pacific lamprey have also declined in the Washougal river. The adult lamprey return from the ocean to spawn in the spring and summer. Spawning likely occurs in the small to mid-size streams of the basins. Juveniles rear in freshwater up to 6 years before migrating to the ocean.

3.3 Subbasin Habitat Conditions

This section describes the current condition of aquatic and terrestrial habitats within the subbasin. Descriptions are included for habitat features of particular significance to focal salmonid species including watershed hydrology, passage obstructions, water quality, key habitat availability, substrate and sediment, woody debris, channel stability, riparian function, and floodplain function. These descriptions will form the basis for subsequent assessments of the effects of habitat conditions on focal salmonids and opportunities for improvement.

3.3.1 *Watershed Hydrology*

The basin is rain-dominated, with little stream flow contributed by snowmelt. Peak flows generally occur in winter months and low flows occur in late summer (Figure 4). Flows regularly exceed 1,000 cfs November to April and typically fall below 100 cfs in late summer. The 37-year average discharge is 873 cfs, with a highest-recorded flow of 40,000 cfs in December 1977. The flashy nature of the stream has been attributed to basin topography, denuded vegetation due to large fires, and human alterations to watershed processes (WDF 1990). Major tributaries to the Washougal include Lacamas Creek, the Little Washougal River, Canyon Creek, the West Fork Washougal River, and Dougan Creek.

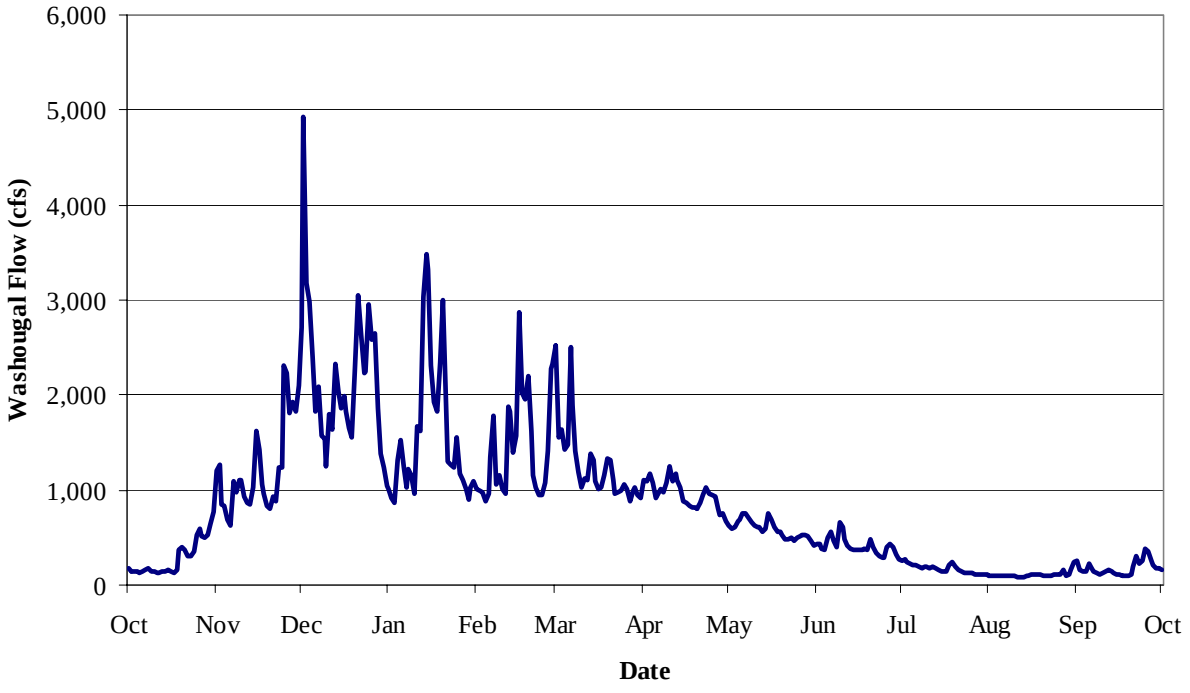


Figure 4. Average daily flows for the Washougal River (1972-1981). Peak flows are primarily related to winter and spring rain, with some high peaks occuring due to winter rain-on-snow. Flows fall below 100 cfs in late summer. USGS Stream Gage #14143500; Washougal River near Washougal, Wash.

Vegetation conditions, impervious surfaces, and high road densities in portions of the Washougal basin have potentially impacted runoff regimes. The Integrated Watershed Assessment (IWA), which is presented in greater detail later in this chapter, rates 14 of the 29 subwatersheds in the basin as "impaired" with respect to conditions that influence runoff properties. Nine of the subwatersheds are rated as "moderately impaired" and 6 are rated as "functional". The greatest impairments are concentrated in the low elevation subwatersheds and in portions of the upper Lacamas drainage. Intact hydrologic conditions are located primarily in the upper mainstem Washougal headwaters. These results are consistent with an analysis by Lewis County GIS (2000) that identified only the upper Washougal basin as meeting the criteria of a hydrologically functioning watershed.

Instream flow studies have been conducted on several stream segments to assess potential problems with low flows (Caldwell et al. 1999). The IFIM was applied to the Washougal River at approximately RM 3.5. Below optimal flows were identified for chinook and steelhead rearing beginning in July and lasting into October. Other streams were assessed using the Toe-Width method. Data from the Little Washougal River indicated below optimal flows for chinook spawning in the fall and juvenile rearing June through October. Data from the NF Washougal revealed that flows didn't reach optimal for juvenile rearing until October and were below optimal for salmon spawning in the fall. Other areas with low flow concerns include the lower Washougal River, Camas Slough, the Washougal River above Dugan Falls, Texas Creek, Wildboy Creek, Schoolhouse Creek, and Slough Creek (Wade 2001).

In the Lacamas Creek drainage, the current and projected consumptive water use is believed to represent a significant portion of watershed hydrology, although insufficient data exists for a valid comparison of water use and streamflow. For the remainder of the Washougal subbasin, consumptive use appears to represent greater than 10% of base flows and the projected year 2020 water use may approach 25% of summer base flow, assuming full hydraulic connection between ground water and stream flow. There are currently low-flow restrictions for some surface water rights and the subbasin is near closure for further surface water rights appropriation (LCFRB 2001).

3.3.2 *Passage Obstructions*

Salmon Falls, at RM 14.5 was the upstream limit of most anadromous fish except steelhead, until a fishway was built in the 1950s to facilitate passage. Currently, Dugan Falls at RM 21 blocks salmon and most winter steelhead, though summer steelhead consistently ascend into the upper reaches. Small dams, weirs, and water diversions restrict access on the mainstem at the Washougal Hatchery, Vogel Creek (water intake for Skamania Hatchery), Jones Creek, Boulder Creek, and Wild Boy Creek. Seven culverts have also been identified that provide partial or complete blockages. A detailed description of passage barriers can be found in the WRIA 28 Limiting Factors Report (Wade 2001).

3.3.3 *Water Quality*

Water quality concerns in the basin include temperature, pH, fecal coliform, and DO. Lacamas Creek and several tributaries were listed on the 1998 state 303(d) list for exceedances of water quality standards (WDOE 1998). Lacamas Creek below Round Lake has elevated DO and temperature. In the 1970s, Lacamas Lake was identified as having eutrophication problems due to phosphorous loading. The Lacamas Lake Restoration Project has assisted many landowners with the adoption of agricultural Best Management Practices in order to correct this problem (Wade 2001).

Water temperatures consistently exceeded 64°F (17.8°C) during the summer at the Washougal Salmon Hatchery between 1987 and 1991. The Clark Skamania Flyfishers and Washington Trout staff measured high water temperatures in several upper basin tributaries between 1997 and 1999. Exposed bedrock, low flows, poor riparian canopy cover, and livestock watering detention systems are suspected of contributing to elevated water temperatures. Though only limited data exists, water temperatures in the lower river are also believed to be high. Elevated turbidity is seen as a potential problem in the Little Washougal, Jones, and Dougan Creeks (Wade 2001).

Historically, discharges from the paper mill created water quality problems in the Camas Slough. As late as the 1960s, concern over sulfite discharges led to the release of fish from the salmon hatchery on vacation weekends when the mill was closed (WDF 1990). Wastewater is now treated at facilities on Lady's Island though pollutants that have accumulated in sediments could still be a problem. There is also a concern about the Skamania and Washougal Salmon Hatcheries' release of potentially harmful effluent containing antibiotics and diseases (Wade 2001).

Nutrient levels are believed to be limited due to the lack of salmon carcasses as a result of low escapement levels for most species.

3.3.4 *Key Habitat Availability*

Though little monitoring data exists, observations indicate that adequate pool habitat is generally lacking throughout the basin due to low large woody debris (LWD) concentrations and past channel scouring from splash-dam logging. Only a few, bedrock-formed, pools are located on the lower and middle mainstem, however, low flows and recreational use limits the ability of these pools to provide adequate steelhead rearing and adult holding. Pool abundance and quality is considered poor in the Little Washougal, Jones Creek, Boulder Creek, NF Washougal, and EF Washougal (Wade 2001).

Side channel habitat is similarly lacking, especially on the lower mainstem that has received extensive diking and riprap. Wade (2001) outlines several areas where decent side channel habitat exists and where there may be potential to restore historical off-channel habitats. Due to steep gradients and natural confinement, very little side channel habitat was ever available in the upper basin, with only a few exceptions. The Salmon Hatchery at RM 20 apparently is situated on a historical wetland from which it currently diverts water. There may be some side channel restoration potential at this site (Wade 2001).

Habitat unit fragmentation may result from the high number of stream crossings in portions of the basin. The Little Washougal, Upper Washougal, and Silverstar basins have over 6 stream crossings per square mile, potentially reducing channel complexity and altering sediment routing processes (Wade 2001).

3.3.5 *Substrate & Sediment*

Many reports mention a lack of spawning gravel as a major limiting factor in the Washougal basin. In the lower reaches, gravel was actually mined from the channel. In the rest of the basin, lack of gravel is attributed to removal of LWD, splash damming, and the hydrologic effects of the Yacolt Burn (1902) and logging. Much of the middle and upper mainstem consists of bedrock and boulder dominated channels. Dams on Lacamas and Wildboy Creeks have eliminated spawning gravel recruitment to downstream reaches (Wade 2001).

Sediment production may be elevated in some areas due to high (> 3 mi/mi^2) road densities, stream-adjacent roads, recreational vehicle use, vegetation removal, residential development, and cattle impacts to stream banks. Sediment supply conditions were evaluated as part of the IWA watershed process modeling, which is presented later in this chapter. Nineteen of the 29 subwatersheds were given a rating of "moderately impaired" with respect to conditions influencing sediment supply; the remainder were rated as "functional". High road densities on steep slopes and/or unstable soils are the primary driver of impaired conditions.

Although the overall road density is moderate (2.65 mi/mi^2), high road densities exist in the Lacamas Creek basin (3.28 mi/mi^2) and the little Washougal basin (3.36 mi/mi^2). The proliferation of stream-adjacent roads (29 miles within the Little Washougal alone) may also increase sediment delivery. Recreational vehicle access to powerline corridors and off-limit trails is seen as a potential source of fine sediment delivery to streams. Clearing of vegetation through logging or other practices is believed to increase sediment production throughout the watershed, particularly at sites in the Dougan Creek and Jones Creek basins. Residential development is suspected of increasing sediment accumulations in the Little Washougal basin and cattle impacts may be contributing fine sediments to Winkler Creek (Wade 2001).

Sediment production from private forest roads is expected to decline over the next 15 years as roads are updated to meet the new forest practices standards, which include ditchline disconnect from streams and culvert upgrades. The frequency of mass wasting events should also decline due to the new regulations, which require geotechnical review and mitigation measures to minimize the impact of forest practices activities on unstable slopes.

3.3.6 *Woody Debris*

Low quantities of LWD throughout the system are attributed to splash damming, past active removal, and low recruitment potential due to fires and logging. Quantities are especially low in the Little Washougal River. Portions of the upper Little Washougal, upper mainstem, and upper West Fork have riparian forests that are in good condition and may deliver much-needed LWD to streams in the near future (Wade 2001).

3.3.7 *Channel Stability*

Bank stability is generally considered good throughout the watershed though isolated areas of instability exist. A large, unstable hillside downstream from the Vernon Road Bridge appears to be associated with a road cut and subsequent clearing of vegetation. It is believed that a slide here could present a significant risk to river habitats though the immediacy of the problem is unknown. Other areas of instability are associated with motor-cross activities, cattle access, failed culverts, and vegetation removal. A complete description can be found in the Limiting Factors Analysis (Wade 2001). In some instances, increased erosion may be providing needed spawning gravels to downstream channels.

3.3.8 *Riparian Function*

According to IWA watershed process modeling, which is presented in greater detail later in this chapter, 7 of the 29 subwatersheds have "impaired" riparian conditions,18 are "moderately impaired", and 4 are "functional". The greatest impairments are located along the lower mainstem and in the Lacamas Creek basin, whereas functional conditions are located in the headwaters of the mainstem and the West Fork.

Riparian forests along the lower mainstem and the Camas Slough have been cleared for industrial uses, residential uses, and road corridors and only a few places contain native deciduous species. Conditions improve as you move up the basin, except in portions of the West Fork and Dougan Creek, which are still recovering from past fires. Riparian conditions in Boulder, Jones, EF Jones, Winkler Creek, and Texas Creek are considered poor (Wade 2001).

Riparian function is expected to improve over time on private forestlands. This is due to the requirements under the Washington State Forest Practices Rules (Washington Administrative Code Chapter 222). Riparian protection has increased dramatically today compared to past regulations and practices.

3.3.9 *Floodplain Function*

Past splash damming, logging, and reduced vegetation cover following the Yacolt Burn (1902) has resulted in channel scour and incision in many places on the mainstem, creating a channel that is disconnected with its floodplain and side-channel habitats. This reduction in habitat may be impacting overwinter survival of some species (Wade 2001).

Much of the lower mainstem (including Camas Slough) and the lower Little Washougal have experienced floodplain and side channel loss due to diking and channelization associated with industrial, transportation, residential, mining, and agricultural activities. The lower reach extending from the mouth to the Little Washougal River (RM 5.6) has been especially impacted by past and on-going floodplain development. Channel incision has also been observed in many of these areas. Wade (2001) provides an in-depth description of the location of channelization features.

3.4 Stream Habitat Limitations

A systematic link between habitat conditions and salmonid population performance is needed to identify the net effect of habitat changes, specific stream sections where problems occur, and specific habitat conditions that account for the problems in each stream reach. In order to help identify the links between fish and habitat conditions, the Ecosystem Diagnosis and Treatment (EDT) model was applied to Washougal River fall Chinook, chum, coho, and summer and winter steelhead. A thorough description of the EDT model, and its application to lower Columbia salmonid populations, can be found in Appendix E.

Three general categories of EDT output are discussed in this section: population analysis, reach analysis, and habitat factor analysis. Population analysis has the broadest scope of all model outputs. It is useful for evaluating the reasonableness of results, assessing broad trends in population performance, comparing among populations, and for comparing past, present, and desired conditions against recovery planning objectives. Reach analysis provides a greater level of detail. Reach analysis rates specific reaches according to how degradation or restoration within the reach affects overall population performance. This level of output is useful for identifying general categories of management (i.e. preservation and/or restoration), and for focusing recovery strategies in appropriate portions of a subbasin. The habitat factor analysis section provides the greatest level of detail. Reach specific habitat attributes are rated according to their relative degree of impact on population performance. This level of output is most useful for practitioners who will be developing and implementing specific recovery actions.

3.4.1 *Population Analysis*

Population assessments under different habitat conditions are useful for comparing fish trends and establishing recovery goals. Fish population levels under current and potential habitat conditions were inferred using the EDT model based on habitat characteristics of each stream reach and a synthesis of habitat effects on fish life cycle processes.

Habitat-based assessments were completed in the Washougal River subbasin for chum, fall chinook, coho, winter steelhead, and summer steelhead. For all modeled populations, adult productivity has declined sharply from historical levels (Table 2). Fall chinook productivity has declined by 63%, while chum, coho, winter steelhead, and summer steelhead productivities have declined by 85%, 80%, 89%, and 79%, respectively. Adult abundance has also decreased for all species (Figure 5). The decline in abundance has been least for fall chinook, currently at 53% of historical levels, and most severe for chum, currently at 4% of historical levels. Species diversity (as measured by the diversity index) has remained relatively stable for fall chinook and summer steelhead (Table 2), while declining anywhere from 30-50% for the rest of the species.

Trends in both smolt productivity and smolt abundance are similar, with current estimates far below historical levels (Table 2). Coho and winter steelhead have seen the largest decline in smolt productivity, to 17 and 20% of historical levels, respectively. Chum and coho have seen the largest decline in smolt abundance, to 7% and 18% of historical levels, respectively.

Model results indicate that restoration of properly functioning (PFC) habitat conditions throughout the basin would significantly benefit all species (Table 2). Restoration of PFC would provide the greatest benefit to chum and coho. Adult chum abundance would increase over 450% from current levels, while adult coho abundance would increase over 300% from current levels. Similarly, chum smolt abundance would increase over 550% from current levels, while coho smolt abundance would increase over 380% from current levels.

Table 2. Washougal Subbasin -- Population productivity, abundance, and diversity (of both smolts and adults) based on EDT analysis of current (P or patient), historical (T or template)[1], and properly functioning (PFC) habitat conditions.

	Adult Abundance			Adult Productivity			Diversity Index			Smolt Abundance			Smolt Productivity		
Species	**P**	**PFC**	**T[1]**	**P**	**PFC**	**T[1]**	**P**	**PFC**	**T[1]**	**P**	**PFC**	**T[1]**	**P**	**PFC**	T[1]
Fall Chinook	1,624	2,810	3,037	3.8	8.0	10.2	0.96	1.00	1.00	282,145	507,734	559,240	488	971	1,221
Chum	699	3,971	18,072	1.6	7.1	10.5	0.69	1.00	1.00	338,274	2,255,690	4,703,217	532	1,024	1,175
Coho	824	3,362	3,934	2.2	7.6	10.5	0.47	0.89	0.98	19,934	96,963	113,303	51	211	293
Winter Steelhead	500	909	1,947	3.8	12.6	33.8	0.72	1.00	1.00	7,065	13,699	15,906	69	242	352
Summer Steelhead	639	876	2,177	4.3	6.7	20.5	0.95	1.00	1.00	12,035	15,871	21,187	81	122	200

[1] Estimate represents historical conditions in the subbasin and current conditions in the mainstem and estuary.

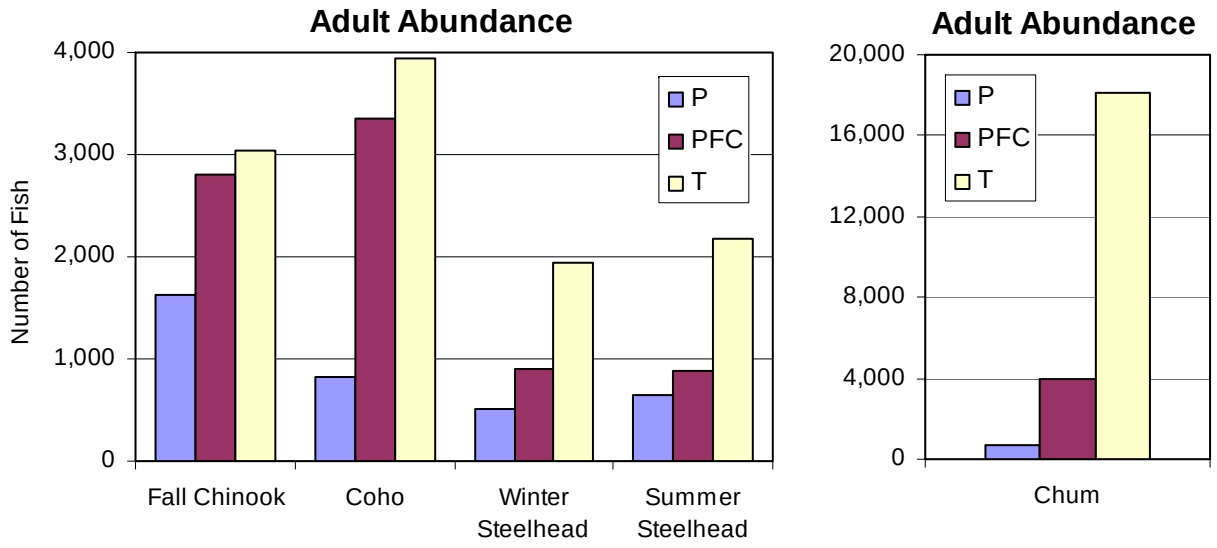


Figure 5. Adult abundance of Washougal River fall chinook, coho, winter steelhead and chum based on EDT analysis of current (P or patient), historical (T or template), and properly functioning (PFC) habitat conditions.

3.4.2 *Stream Reach Analysis*

Habitat conditions and suitability for fish are better in some portions of a subbasin than in others. The reach analysis of the EDT model uses estimates of the difference in projected population performance between current/patient and historical/template habitat conditions to identify core and degraded fish production areas. Core production areas, where habitat degradation would have a large negative impact on the population, are assigned a high value for preservation. Likewise, currently degraded areas that provide significant potential for restoration are assigned a high value for restoration. Collectively, these values are used to prioritize the reaches within a given subbasin.

Important reaches for fall chinook are primarily located in the lower and middle mainstem areas (Washougal 3- 9) (Figure 7). Reach Washougal 3 has the highest restoration value of any fall chinook reach, while reach Washougal 9 has the highest preservation value for any fall chinook reach.

Chum, although functionally extinct from the subbasin, have high priority reaches located in the extreme lower sections of the mainstem (Washougal tidal 1 and 2) (Figure 8). These reaches show a strong habitat restoration emphasis. It is important to note that Lower Lacamas Creek, although not included in this model run, has recently been found to contain chum (Rawding pers. comm. 2002), and should therefore be considered for restoration efforts.

High priority reaches for coho are located in sections of the lower (Washougal 3 and 4), middle (Washougal 8 and 9), and Little Washougal (Little Washougal 2C and 2E) (Figure 9). The majority of modeled coho reaches show a strong habitat restoration emphasis, with Little Washougal 2E having the highest restoration value of any coho reach

Summer steelhead, which are able to ascend Dougan Falls at RM 22, utilize the greatest portion of subbasin reaches. Winter steelhead make extensive use of the lower and middle mainstem and tributaries. In order to avoid spurious results in EDT modeling, winter and summer steelhead were identified as using non-overlapping reaches during critical life stages. In reality, there is more overlap between these populations than is suggested by the reach priority results. Fall chinook primarily use the lower mainstem and major tributaries, whereas chum historically used only the lower few mainstem reaches. See Figure 6 for a map of EDT reaches within the Washougal subbasin.

For summer steelhead, high priority reaches lie in the upper (Washougal 14-16) and headwater (Washougal 17) sections, as well as in the lower WF Washougal (WF Washougal 1B and 2) (Figure 10). These areas provide significant spawning and rearing habitats. All high priority reaches, except Washougal 1B, show a habitat preservation emphasis. Washougal 1B shows a combined preservation and restoration emphasis.

High priority winter steelhead reaches include sections of the lower mainstem (Washougal 5), lower WF Washougal (WF Washougal 1), and the Little Washougal (Figure 11). These areas encompass the primary winter steelhead spawning and rearing sites. The majority of these reaches show a habitat restoration emphasis, however, the reaches of the lower Little Washougal (Little Washougal 1-3) show a combined habitat preservation and restoration emphasis.

Figure 6. Washougal subbasin with EDT reaches identified. For readability, not all reaches are labeled.

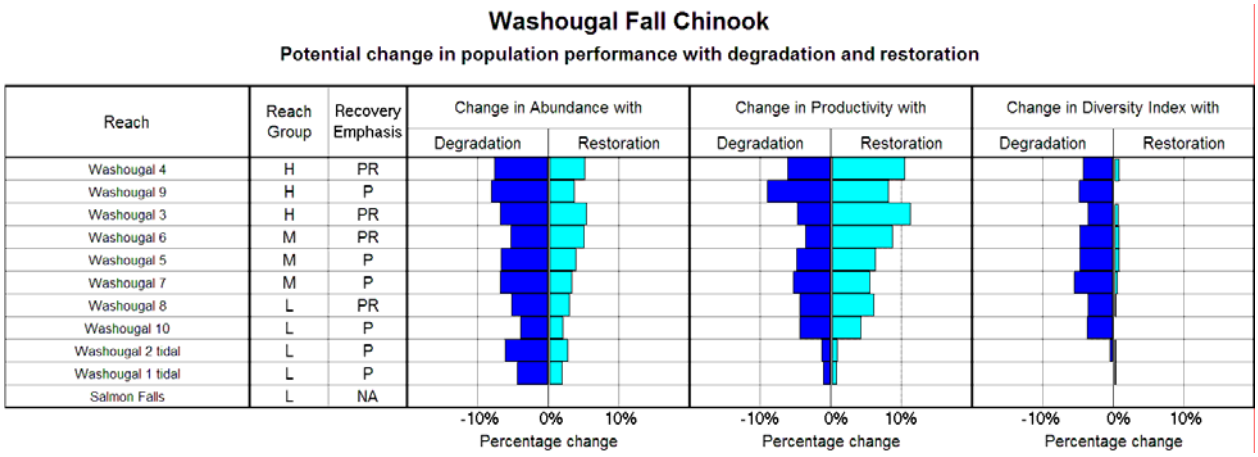


Figure 7. Washougal River subbasin fall Chinook ladder diagram. The rungs on the ladder represent the reaches and the three ladders contain a preservation value and restoration potential based on abundance, productivity, and diversity. The units in each rung are the percent change from the current population. For each reach, a reach group designation and recovery emphasis designation is given. Percentage change values are expressed as the change per 1000 meters of stream length within the reach. See Appendix E Chapter 6 for more information on EDT ladder diagrams. Some low priority reaches are not included for display purposes.

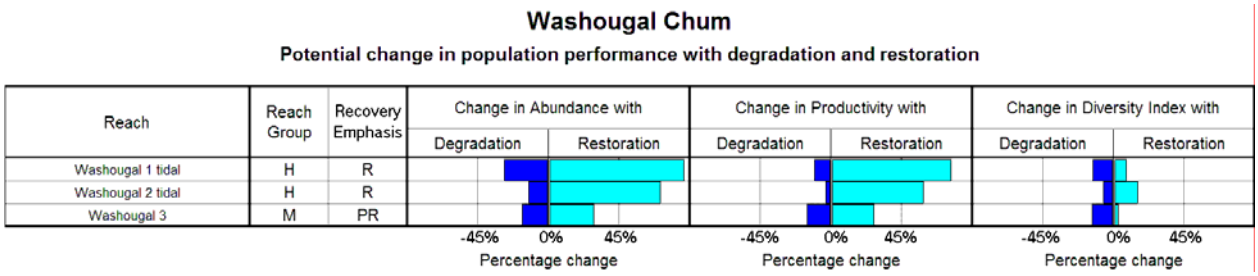


Figure 8. Washougal subbasin chum ladder diagram.

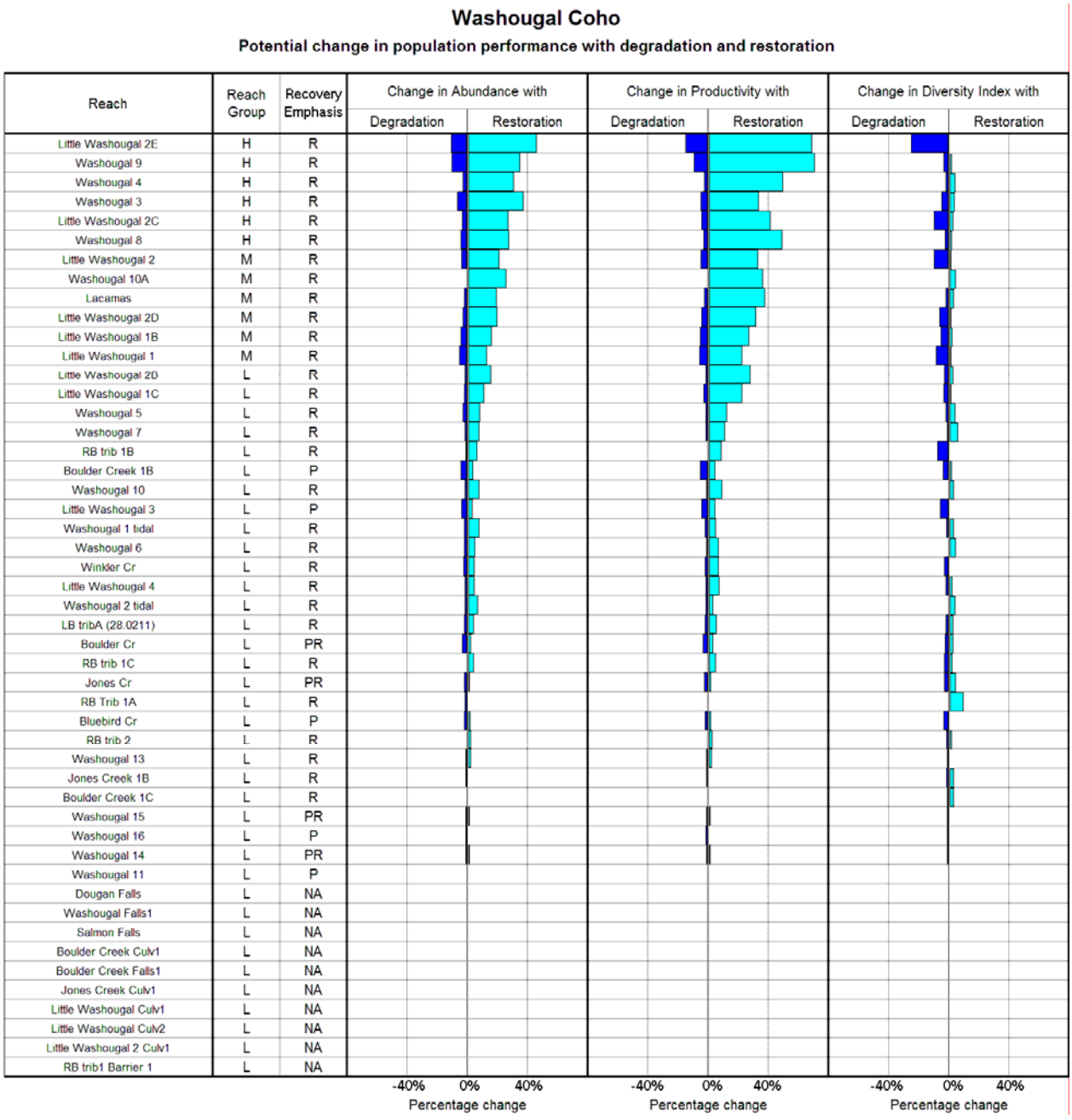


Figure 9.Washougal subbasin coho ladder diagram.

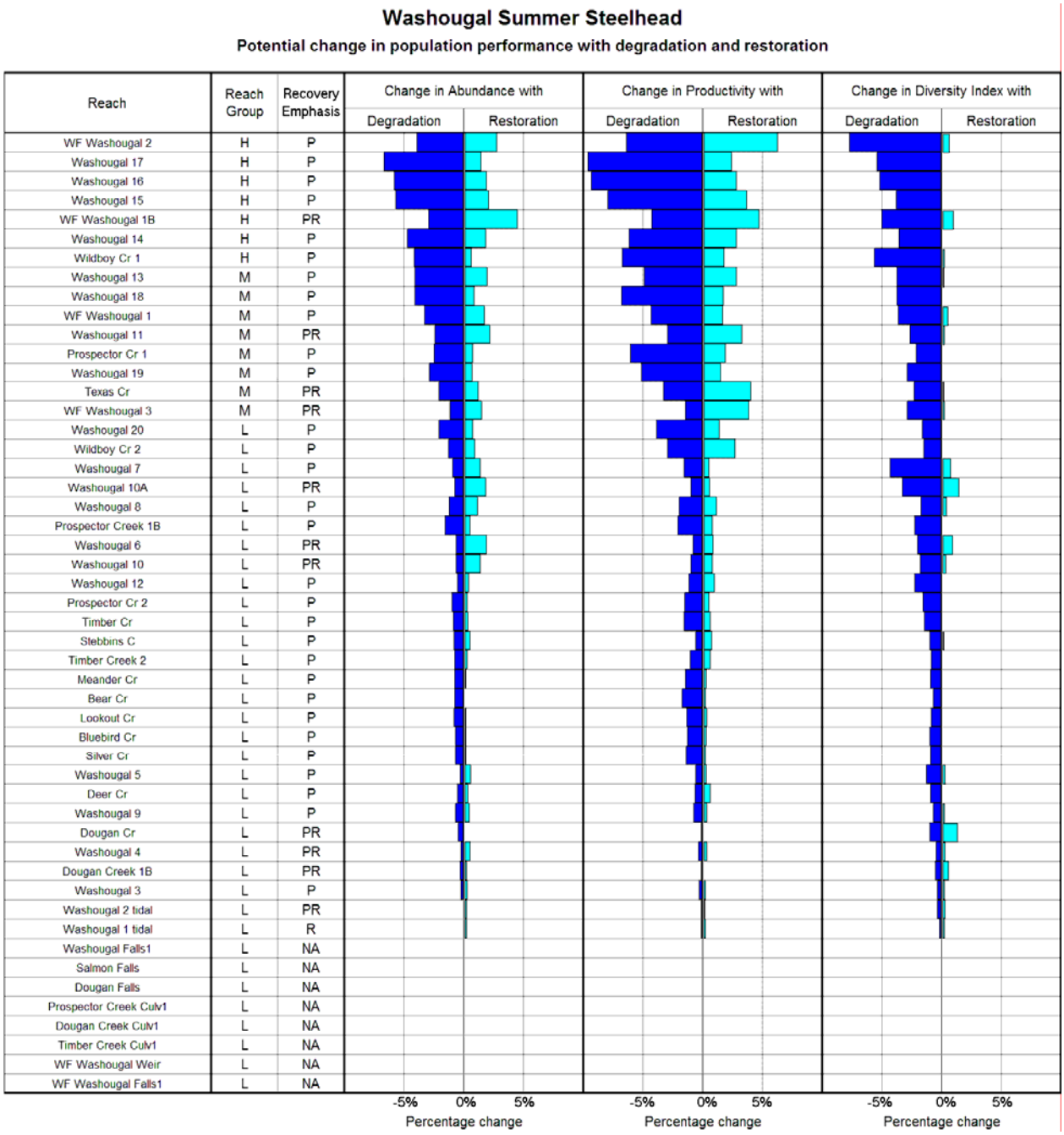


Figure 10. Washougal subbasin summer steelhead ladder diagram.

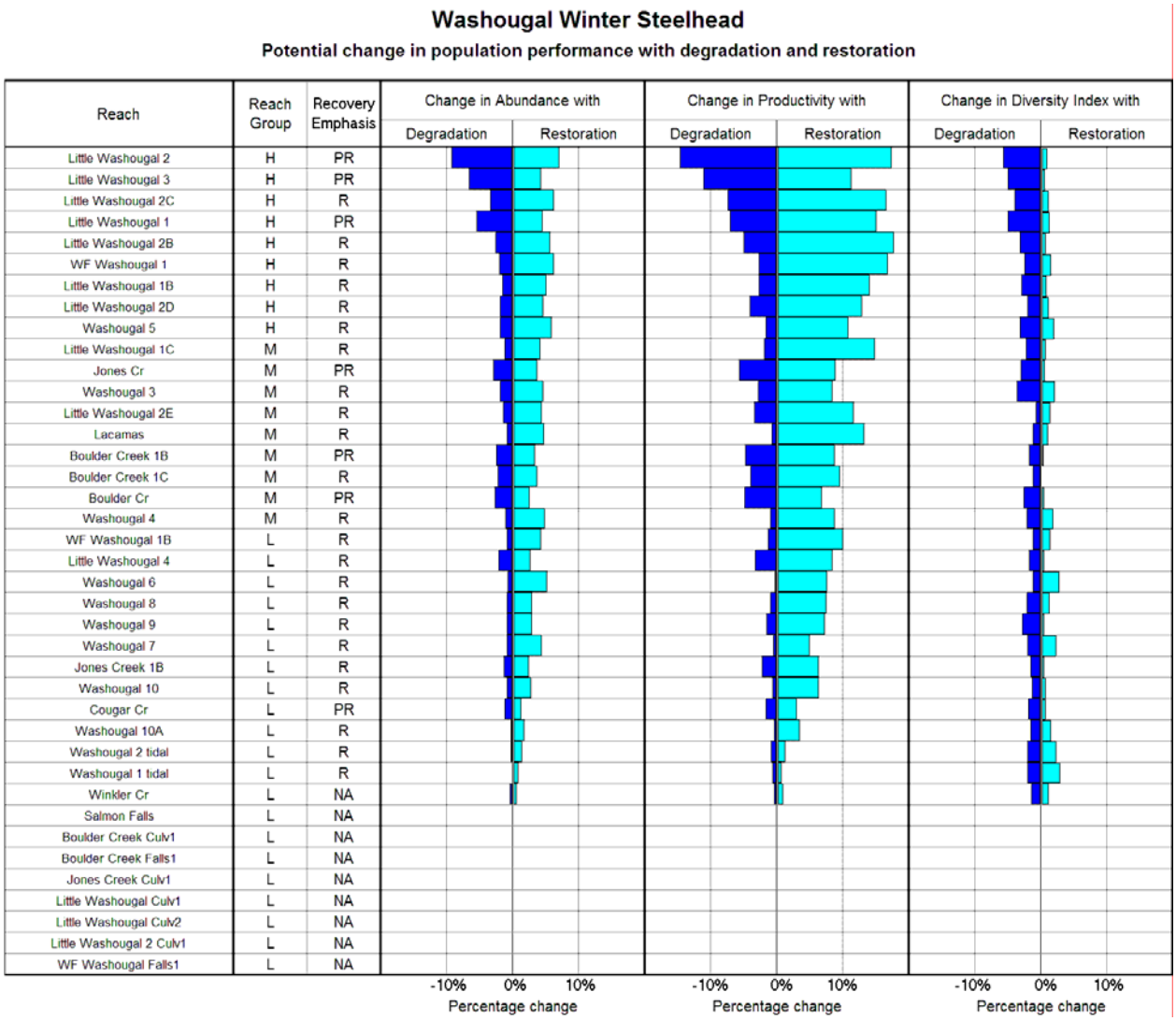


Figure 11. Washougal subbasin winter steelhead ladder diagram

3.4.3 *Habitat Factor Analysis*

The Habitat Factor Analysis of EDT identifies the most important habitat factors affecting fish in each reach. Whereas the EDT reach analysis identifies reaches where changes are likely to significantly affect the fish, the Habitat Factor Analysis identifies specific stream reach conditions that may be modified to produce an effect. Like all EDT analyses, the habitat factor analysis compares current/patient and historical/template habitat conditions. For each reach, EDT generates what is referred to as a "consumer reports diagram", which identifies the degree to which individual habitat factors are acting to suppress population performance. The effect of each habitat factor is identified for each life stage that occurs in the reach and the relative importance of each life stage is indicated. For additional information and examples of this analysis, see Appendix E. Inclusion of the consumer report diagram for each reach is beyond the scope of this document. A summary of the most critical life stages and the habitat factors affecting them are displayed for each species in Table 3.

Table 3. Summary of the primary limiting factors affecting life stages of focal salmonid species. Results are summarized from EDT Analysis.

Species and Lifestage		*Primary factors*	*Secondary factors*	*Tertiary factors*
Washougal Fall Chinook				
most critical	Egg incubation	channel stability, sediment	harassment, temperature	
second	Spawning	temperature		
third	Fry colonization	habitat diversity, food	channel stability, flow	key habitat, sediment, predation
Washougal Chum				
most critical	Egg incubation	channel stability, sediment	harassment	
second	Prespawning holding	habitat diversity, harassment	flow	
third	Spawning	habitat diversity, harassment		
Washougal Coho				
most critical	0-age summer rearing	habitat diversity, temperature	flow, channel stability, food, predation, pathogens	sediment, key habitat
second	Egg incubation	channel stability, sediment	temperature, key habitat	
third	0-age winter rearing	habitat diversity	channel stability, flow	food, predation
Washougal Summer Steelhead				
most critical	1-age summer rearing	flow, habitat diversity, temperature	competition (hatchery), predation	food, pathogens
second	0-age summer rearing	flow, habitat diversity, temperature	competition (hatchery), predation	food, pathogens
third	0,1-age winter rearing	flow, habitat diversity, channel stability		
Washougal Winter Steelhead				
most critical	0-age summer rearing	flow, temperature	habitat diversity, pathogens, predation	competition (hatchery), food, sediment
second	Egg incubation	sediment, temperature	channel stability	harassment, pathogens
third	Fry colonization	temperature, flow	habitat diversity, predation	channel stability, pathogens

The consumer reports diagrams have also been summarized to show the relative importance of habitat factors by reach. The summary figures are referred to as habitat factor analysis diagrams and are displayed for each species below. The reaches are ordered according to their combined restoration and preservation rank. The reach with the greatest potential benefit is listed at the top. The dots represent the relative degree to which overall population abundance would be affected if the habitat attributes were restored to historical conditions.

Restoration efforts for fall Chinook should focus foremost on restoring channel stability, habitat diversity, sediment, and temperature conditions in the lower and middle mainstem (Figure 12). Sediment from upper basin sources settles out in low gradient portions of these reaches, which are important chinook spawning areas. Low LWD levels affect habitat diversity and channel stability. Channel stability is further impacted by changes to the flow regime. Many of these lower mainstem reaches suffer from bed scour. Riparian canopy cover (shade) has been reduced within the residential/highway corridor that follows the west bank of the lower river, thus increasing temperatures. Relatively minor impacts of predation, competition, and pathogens are related to the Washougal Hatchery program.

Chum salmon habitat in the lower river suffers from a lack of habitat diversity, increased sedimentation, and harassment (Figure 13). Habitat diversity has been lost due to low LWD levels and artificial confinement. Sediment impacts stem from upper basin sources, as the sediment tends to settle out in these lower portions of the basin. Harassment is due to the hatchery program and angling for hatchery fish.

Coho habitat in the Washougal subbasin is impacted by impaired conditions related to sediment, habitat diversity, key habitat, temperature, and channel stability (Figure 14). The causes of these impacts are similar to those discussed above for the other species.

As described previously, the greatest restoration potential for Washougal summer steelhead is in the upper mainstem, with substantial benefits also gained by restoring habitat in the WF Washougal. In these reaches, the greatest impacts to summer steelhead appear to be from a loss of habitat diversity, altered temperature and flow regimes, and sedimentation (Figure 15). Habitat diversity in these reaches is primarily impacted by a lack of instream LWD and degraded riparian function. Severe burns in the early and mid 20th century, combined with subsequent intense logging, have reduced the recruitment rate of stable LWD. In addition, some of these reaches may still be recovering from splash damming that scoured channels and reduced bank stability. Impacts to the flow regime are primarily a result of the high road density (>3 mi/mi^2) in some subwatersheds as well as the lack of mature forest cover. Degraded riparian conditions, scoured channels, and lack of large woody debris contribute to the degraded channel stability, key habitat, and food in these reaches. The headwater reaches (Washougal 16-20) suffer from many of the same impacts as the upper Washougal reaches. These headwater reaches, however, are less affected by flow regime changes due to a roadless basin upstream of reaches 19 and 20. Furthermore, in the last couple of years, the WDNR has obliterated many roads in the upper basin, resulting in a substantial reduction of road densities in the basin upstream of reach 16. Sediment and flow conditions are expected to improve as these areas recover.

In contrast to summer steelhead restoration priorities, restoration of winter steelhead habitat should focus on the lower Washougal and lower Little Washougal reaches. Sedimentation, temperature, and key habitat are the primary factors limiting performance of winter steelhead in the Washougal (Figure 16). Denuded riparian vegetation at streamside residences and along the highway that parallels the river contributes to these impacts, as does a general lack of instream LWD. Flow impacts arising from upper basin road and vegetation

conditions are also a concern. Furthermore, there is a large amount of agricultural land along the lower Little Washougal and reaches suffer from low stream shade, low instream LWD, and sedimentation.

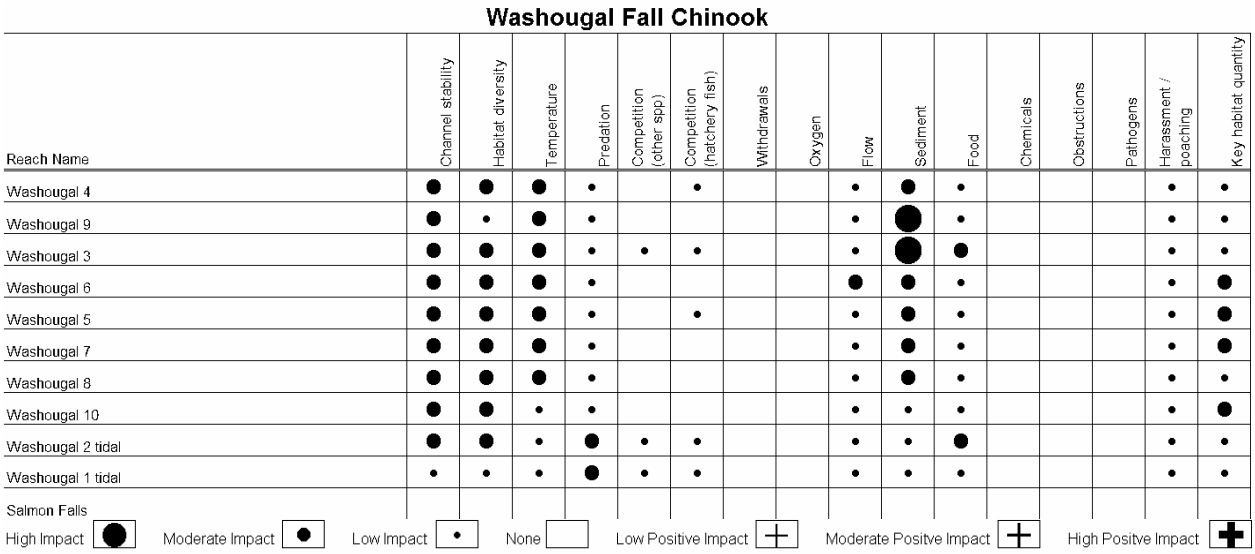


Figure 12. Washougal River subbasin fall Chinook habitat factor analysis diagram. Diagram displays the relative impact of habitat factors in specific reaches. The reaches are ordered according to their restoration and preservation rank, which factors in their potential benefit to overall population abundance, productivity, and diversity. The reach with the greatest potential benefit is listed at the top. The dots represent the relative degree to which overall population abundance would be affected if the habitat attributes were restored to template conditions. See Appendix E Chapter 6 for more information on habitat factor analysis diagrams. Some low priority reaches are not included for display purposes.

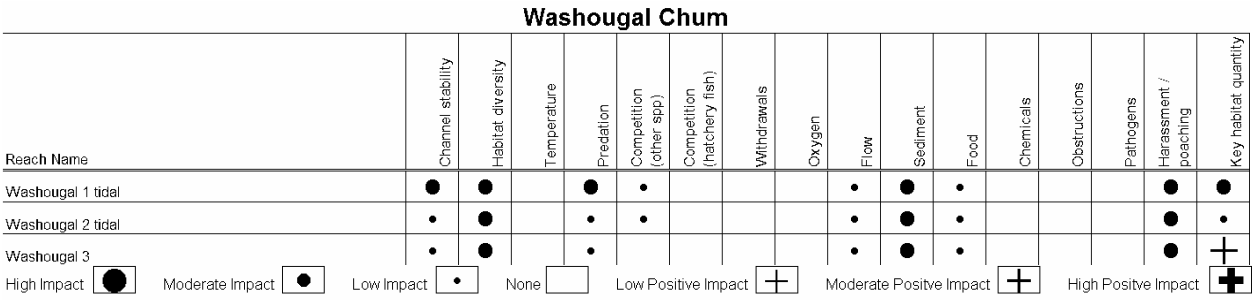


Figure 13. Washougal subbasin chum habitat factor analysis diagram

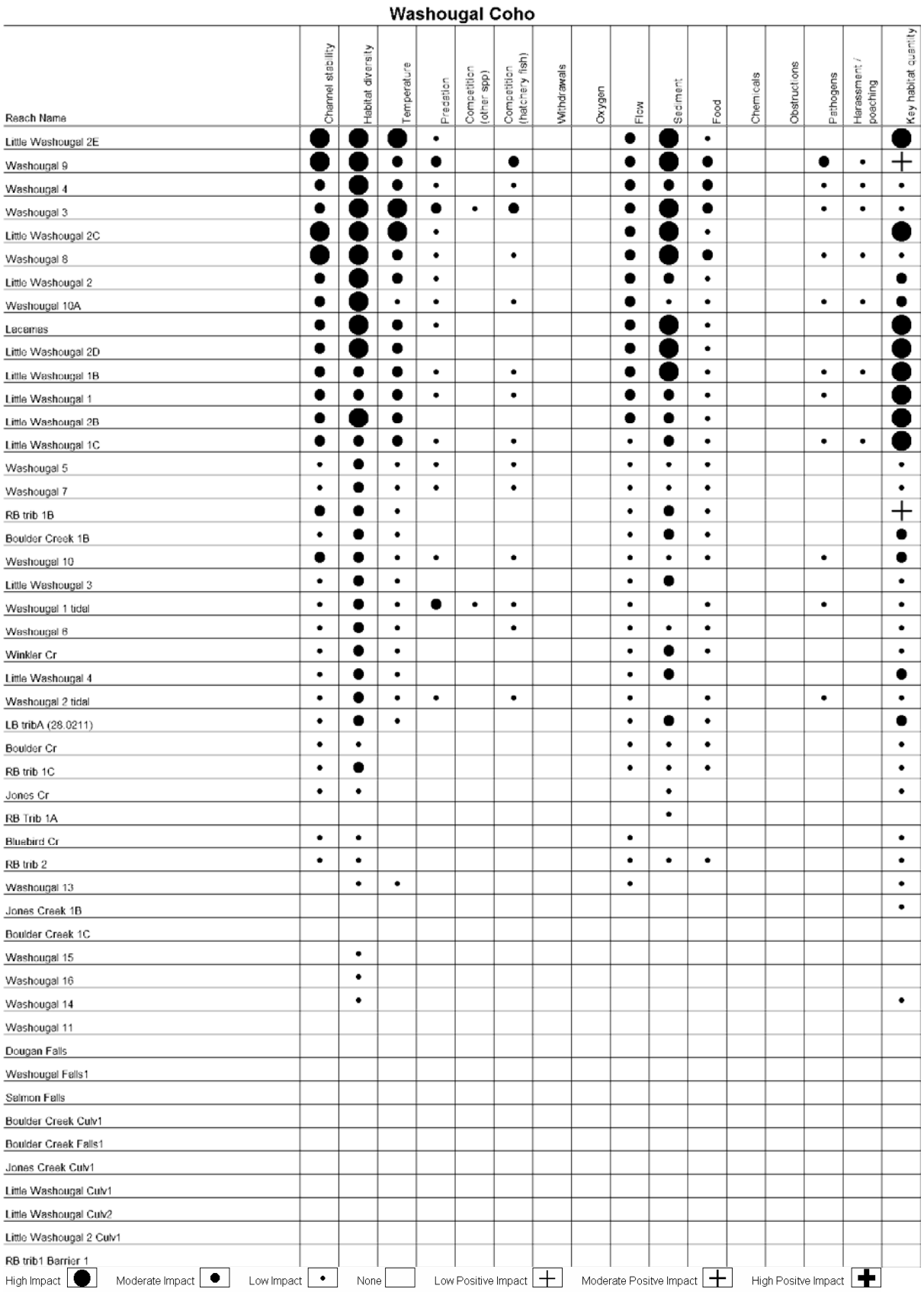


Figure 14. Washougal subbasin coho habitat factor analysis diagram.

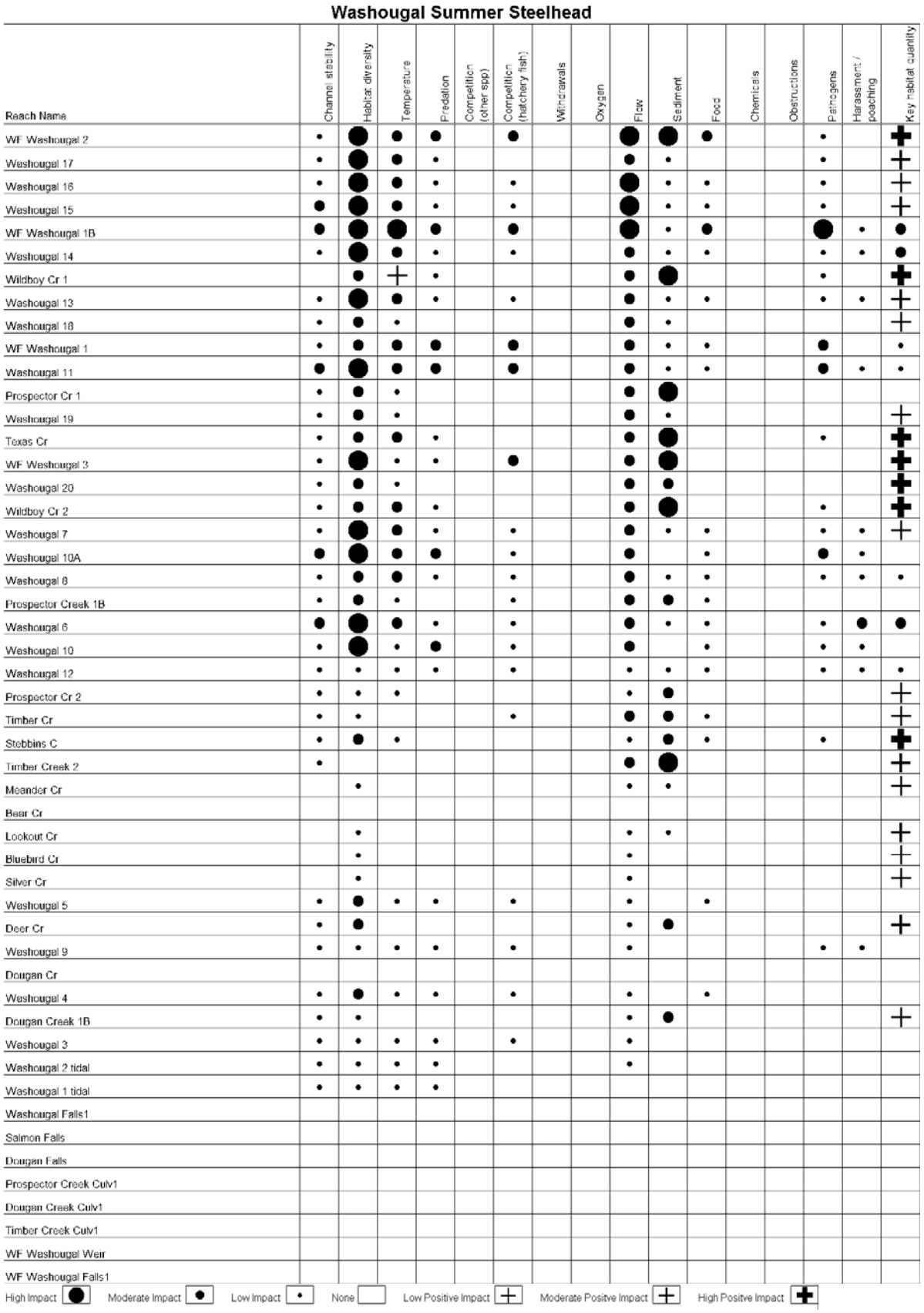


Figure 15. Washougal subbasin summer steelhead habitat factor analysis diagram

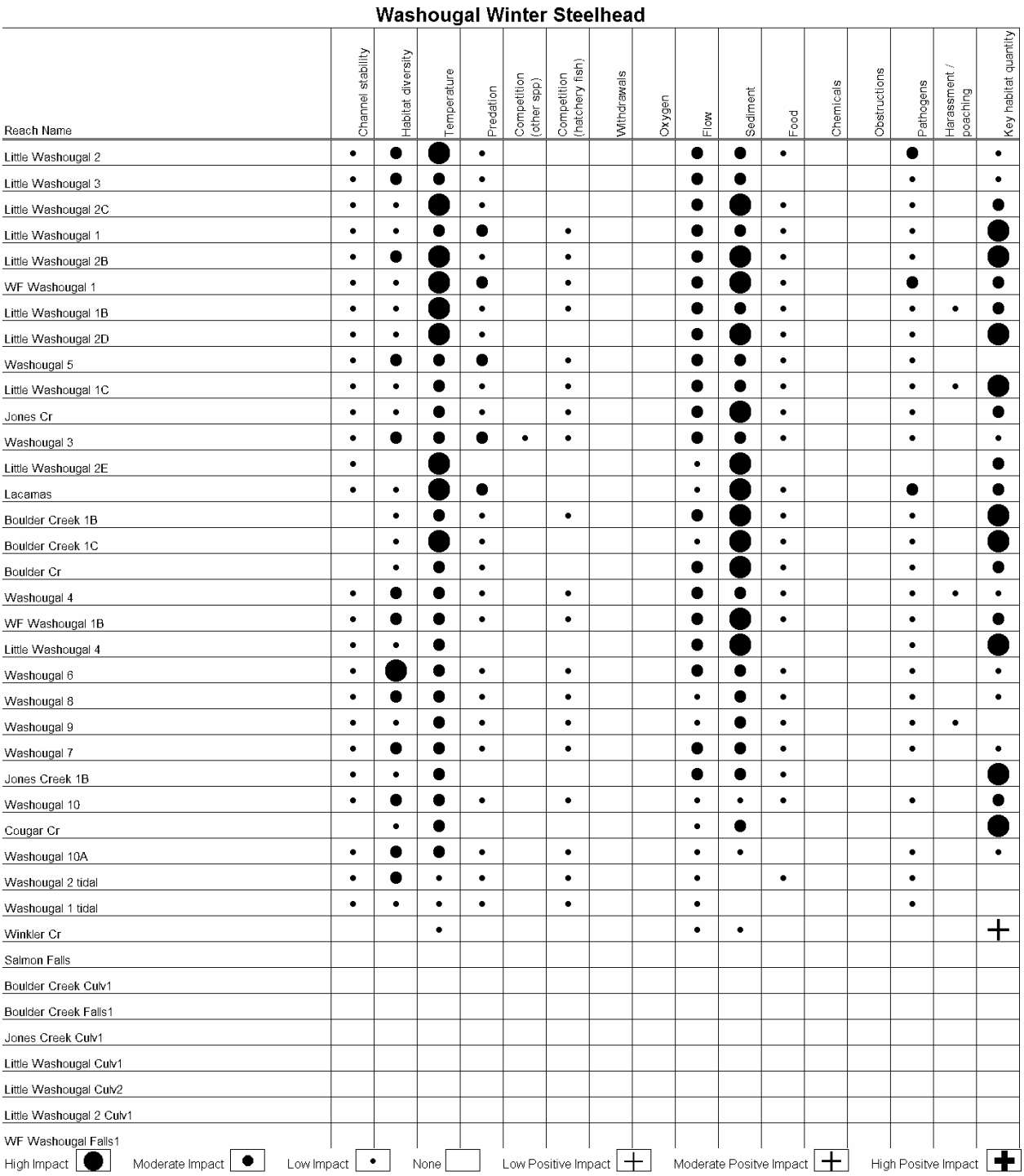


Figure 16. Washougal subbasin winter steelhead habitat factor analysis diagram.

3.5 Watershed Process Limitations

This section describes watershed process limitations that contribute to stream habitat conditions significant to focal fish species. Reach level stream habitat conditions are influenced by systemic watershed processes. Limiting factors such as temperature, high and low flows, sediment input, and large woody debris recruitment are often affected by upstream conditions and by contributing landscape factors. Accordingly, restoration of degraded channel habitat may require action outside the targeted reach, often extending into riparian and hillslope (upland) areas that are believed to influence the condition of aquatic habitats.

Watershed process impairments that affect stream habitat conditions were evaluated using a watershed process screening tool termed the Integrated Watershed Assessment (IWA). The IWA is a GIS-based assessment that evaluates watershed impairments at the subwatershed scale (3,000 to 12,000 acres). The tool uses landscape conditions (i.e. road density, impervious surfaces, vegetation, soil erodability, and topography) to identify the level of impairment of 1) riparian function, 2) sediment supply conditions, and 3) hydrology (runoff) conditions. For sediment and hydrology, the level of impairment is determined for local conditions (i.e. within subwatersheds, not including upstream drainage area) and at the watershed level (i.e. integrating the entire drainage area upstream of each subwatershed). See Appendix E for additional information on the IWA.

The Washougal River watershed comprises 29 subwatersheds covering a total of approximately 137,600 acres. IWA results for the Washougal River watershed are shown in Table 4. A reference map showing the location of each subwatershed in the basin is presented in Figure 17. Map of the Washougal basin showing the location of the IWA subwatersheds.. Maps of the distribution of local and watershed level IWA results are displayed in Figure 18. IWA subwatershed impairment ratings by category for the Washougal basin.

3.5.1 *Hydrology*

Current Conditions.— Hydrologic conditions across the Washougal River watershed range from functional to impaired, with functional subwatersheds located in headwaters areas in the upper mainstem and upper West Fork. Conditions become increasingly impaired on a downstream gradient. Hydrologically impaired subwatersheds are primarily concentrated in the moderate to low elevation areas of the mainstem Washougal River and the lower Little Washougal River, as well as some tributary streams. An exception to this pattern is the Lacamas Creek drainage, which has several hydrologically impaired headwaters subwatersheds.

Hydrologically intact conditions in headwaters subwatersheds appear to buffer downstream conditions. These subwatersheds include the headwaters of the Washougal (60103), Bluebird Creek (60102), the upper mainstem (60101), Stebbins Creek (60202), Silver Creek (60204), and Hagen Creek in the West Fork Washougal headwaters (60304). The upper mainstem subwatershed (60101) is especially important for summer steelhead. The majority (90%) of the land area in these upper subwatersheds is publicly owned, and managed by either the USFS or WDNR. These subwatersheds are susceptible to potential hydrologic impacts because of high rain-on-snow area (72%). However, mature forest cover in these subwatersheds averages 69% and road densities are relatively low (all < 3 mi/mi^2).

Impaired watershed level conditions in the lower West Fork Washougal River (60301) are strongly influenced by impaired hydrologic conditions in the Wildboy Creek drainage (60303) and moderately impaired conditions locally and in the upper West Fork Washougal River (60302). Relatively intact hydrologic conditions in Hagen Creek (60304) appear to be an

important buffer. The upper West Fork (60302) is primarily public lands (64%) administered by USFS or WDNR. However, current land cover conditions are poor, with only 21% of subwatershed area in hydrologically mature forest. The upper West Fork has 67% of its area in the rain-on-snow zone, and therefore is more sensitive to hydrologic degradation. Current road densities are moderate (2.1 mi/mi^2). Wildboy Creek is largely in private land holdings (81%), the majority being active timber lands. Mature forest cover is low (27%) and road densities are high (4.9 mi/mi^2).

The Cougar Creek drainage (60505) and the upper Little Washougal River (60506) are both terminal (i.e., no upstream subwatersheds) and relatively low elevation, with less than 25% of area in the rain-on-snow zone. They are almost evenly divided between public and private lands. Hydrologic conditions in the Cougar Creek drainage are impaired, because of relatively low mature forest cover (39%), and moderately high road densities (3.3 mi/mi^2). The majority of privately held lands, comprising nearly 50% of total area, are zoned for commercial forestry. Approximately 4% is zoned for development but currently vacant. The upper Little Washougal River (60506) is moderately impaired as a result of a high percentage of mature vegetation (64%) and public lands ownership (62%), but also high road densities (5.4 mi/mi^2).

The middle mainstem Washougal River subwatersheds (60201 and 60401) contain important habitat for multiple species. These subwatersheds are moderately impaired and impaired at the local level, respectively, but appear to be buffered by hydrologically functional upstream subwatersheds, resulting in functional and moderately impaired watershed level ratings, respectively. Degraded hydrologic conditions in the Dougan Creek drainage (60203) contribute to the moderately impaired watershed level rating in subwatershed 60401. With regard to local conditions, the majority of subwatershed 60201 is owned by WDNR, and currently has 63% mature forest cover. Road densities are relatively high (3.4 mi/mi^2). Approximately 56% of this subwatershed is in the rain-on-snow zone. Subwatershed 60401 is 26% publicly owned, has only 26% mature forest cover, and has relatively high road densities at 4.5 mi/mi^2. Approximately 31% of this subwatershed is in the rain-on-snow zone; 47% is publicly owned. Road densities are moderately high at 4.2 mi/mi^2, and hydrologically mature forest coverage is relatively low (37%). The remainder of land ownership in these two subwatersheds is primarily in private timber holdings.

Hydrologic conditions in the lower mainstem Washougal River (60504 and 60501) are rated as impaired at both the local and the watershed levels. Locally impaired ratings result primarily from high road densities, impervious surface, and poor forest cover associated with development within and surrounding the towns of Camas and Washougal. A high percentage of these subwatersheds (64%) is zoned for development but currently vacant. The lower mainstem Washougal River has been developed and channelized; impervious surface rates are increasing as development expands. Hydrologic conditions in these subwatersheds are also affected by impaired conditions in the West Fork and Little Washougal Rivers.

Predicted Future Trends.— Trends in hydrologic conditions are expected to remain stable or improve gradually in the headwaters subwatersheds (including 60101, 60102, 60103, 60202, 60204, Upper WF 60302, Wildboy Creek 60303, 60304). Hydrology trends in these subwatersheds are based on the high percentage of public lands, the low intensity of forest practices, and maturing of forest cover.

Hydrology conditions in the mainstem subwatersheds (60201 and 60401) are expected to trend stable because of the opposing effects of improving headwater conditions and locally high

road densities. However, hydrologic conditions in Cougar Creek and the upper Little Washougal River may degrade further over the next 20 years because of the potential for development.

Given the high percentage of developable (i.e., zoned but currently vacant) land in the lower mainstem Washougal River (60504 and 60501), and the currently impaired conditions, the predicted trend is for hydrologic conditions to degrade further. This predicted trend also applies to the West Fork Washougal River (60301) because of continually increasing development adjacent to the stream channel.

Table 4. IWA results for the Washougal River Watershed

Subwatershed[a]	Local Process Conditions[b]			Watershed Level Process Conditions[c]		Upstream Subwatersheds[d]
	Hydrology	Sediment	Riparian	Hydrology	Sediment	
60101	F	M	F	F	M	60103
60102	F	F	F	F	F	none
60103	F	M	M	F	M	none
60201	M	M	M	F	M	60101, 60102, 60103, 60202, 60204
60202	F	M	F	F	M	none
60203	I	M	M	I	M	none
60204	F	F	M	F	F	none
60301	M	F	M	I	M	60302, 60303, 60304
60302	M	F	M	M	F	none
60303	I	M	M	I	M	none
60401	I	M	M	M	M	60101, 60102, 60103, 60201, 60202, 60203, 60204
60402	I	M	M	I	M	none
60501	I	M	I	I	M	60101, 60102, 60103, 60502, 60503, 60504, 60505, 60506, 60401, 60402, 60201, 60202, 60203, 60204, 60301, 60302, 60303, 60304
60502	I	M	M	I	M	60503, 60506
60503	M	F	M	M	F	none
60504	I	M	M	I	M	60101, 60102, 60103, 60401, 60402, 60201, 60202, 60203, 60204, 60301, 60302, 60303, 60304
60505	I	M	M	I	M	none
60506	M	M	M	M	M	none
60601	I	M	I	M	M	60101, 60102, 60103, 60502, 60503, 60504, 60505, 60506, 60401, 60402, 60201, 60202, 60203, 60204, 60301, 60302, 60303, 60304, 60602, 60603, 60604, 60605, 60606, 60607, 60608, 60609, 60610
60602	M	F	M	I	M	60603, 60604, 60605, 60606, 60607, 60608, 60609, 60610
60603	M	F	I	I	M	60604, 60605, 60606, 60607, 60608, 60609, 60610
60604	I	M	I	I	M	none
60605	M	M	M	M	M	none

Subwatershed[a]	Local Process Conditions[b]			Watershed Level Process Conditions[c]		Upstream Subwatersheds[d]
	Hydrology	Sediment	Riparian	Hydrology	Sediment	
60606	I	M	M	I	M	none
60607	M	F	I	I	F	60608, 60609, 60610
60608	I	F	I	I	F	none
60609	I	M	I	I	M	none
60610	I	M	M	I	M	none

Notes:
[a] LCFRB subwatershed identification code abbreviation. All codes are 14 digits starting with 170800010#####.
[b] IWA results for watershed processes at the subwatershed level (i.e., not considering upstream effects). This information is used to identify areas that are potential sources of degraded conditions for watershed processes, abbreviated as follows:
F: Functional
M: Moderately impaired
I: Impaired
[c] IWA results for watershed processes at the watershed level (i.e., considering upstream effects). These results integrate the contribution from all upstream subwatersheds to watershed processes and are used to identify the probable condition of these processes in subwatersheds where key reaches are present.
[d] Subwatersheds upstream from this subwatershed.

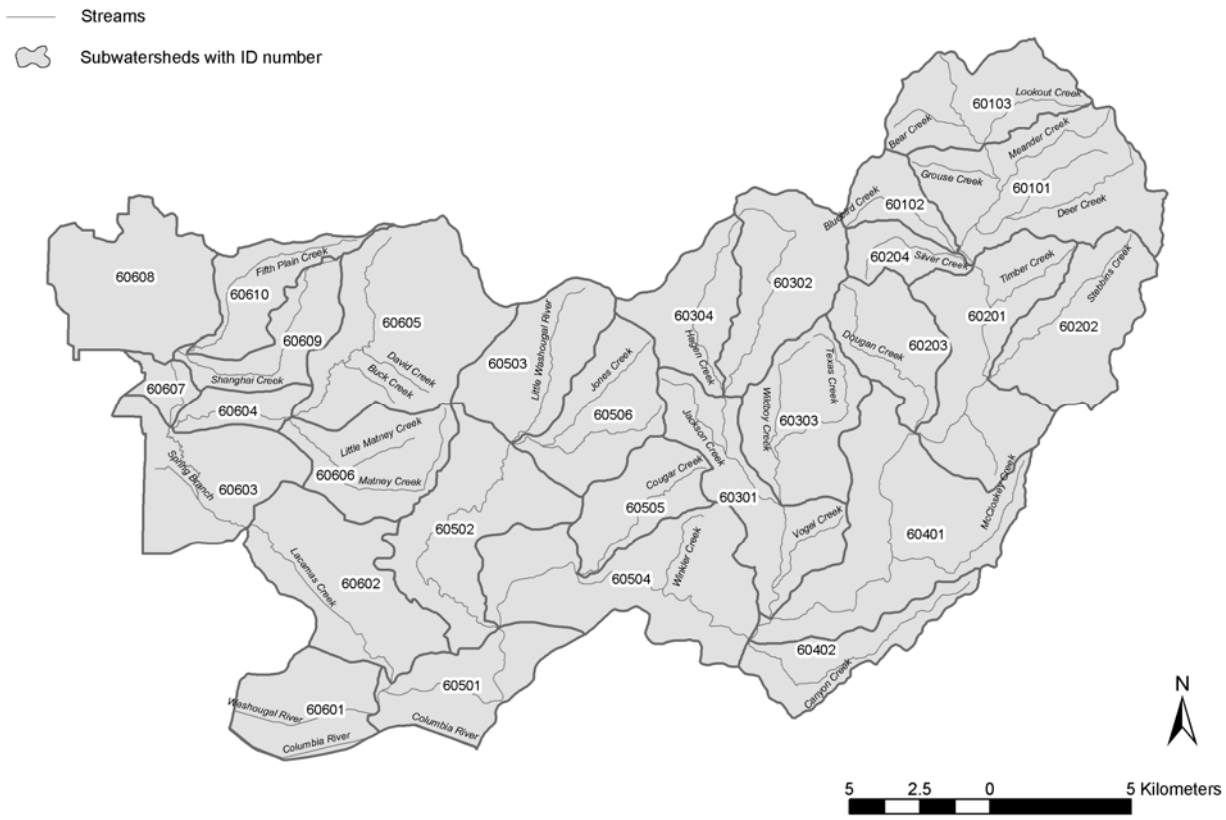


Figure 17. Map of the Washougal basin showing the location of the IWA subwatersheds.

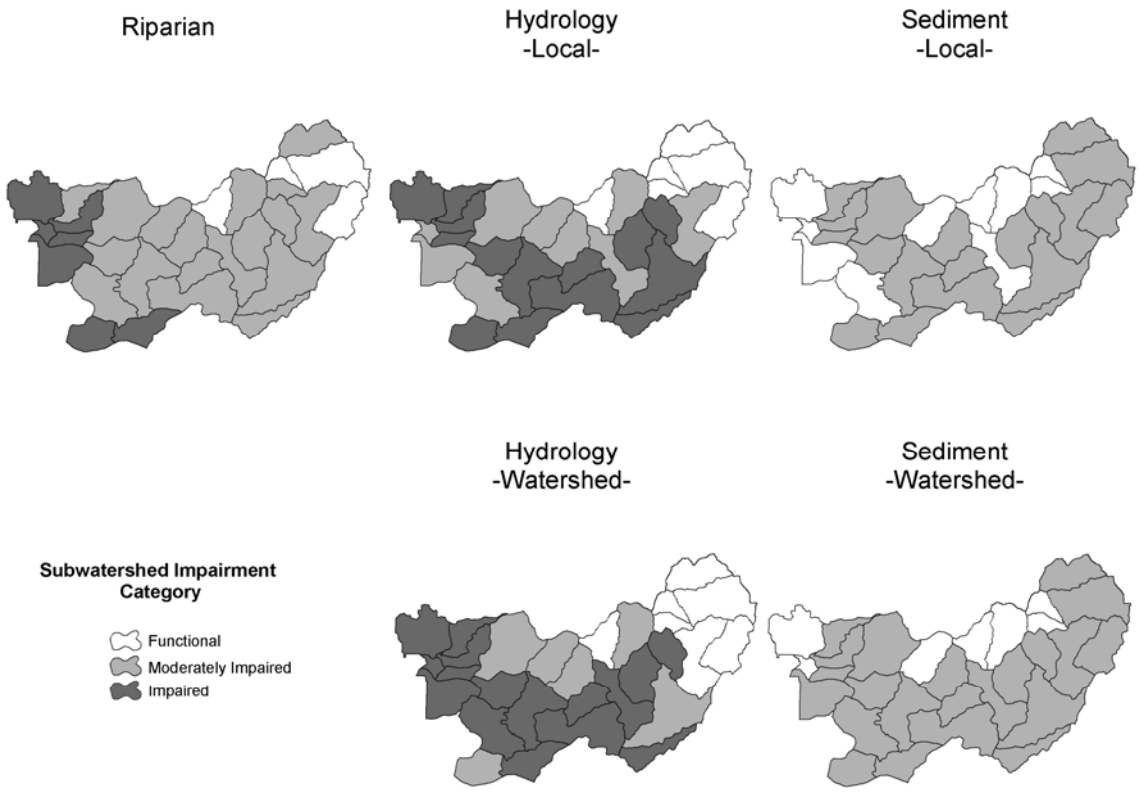


Figure 18. IWA subwatershed impairment ratings by category for the Washougal basin

3.5.2 *Sediment Supply*

Current Conditions.— The majority of subwatersheds have moderately impaired sediment supply conditions, with functional sediment conditions occurring mostly in headwaters tributaries, the lower West Fork Washougal (60301), and the lower Lacamas Creek drainage (60602, 60603). All sediment functional subwatersheds have very low natural erodability ratings, based on geology type and slope class, averaging less than 10 on a scale of 0-126. This suggests that these subwatersheds would not be large sources of sediment impacts under disturbed conditions. Road densities and streamside road densities in these subwatersheds are also relatively low. Moderately impaired sediment conditions are present in all subwatersheds important to anadromous fish. These problems are likely to be exacerbated in subwatersheds where hydrologic conditions are also impaired.

Four headwaters subwatersheds (60102, 60204, 60302 and 60304) have locally functional sediment conditions. Three of these, the upper Washougal (60102), Silver Creek (60204), and Hagen Creek (60304) are also rated hydrologically functional. These subwatersheds will buffer sediment conditions in important downstream subwatersheds.

Other headwaters and tributary subwatersheds have moderately impaired or impaired sediment conditions, including the Washougal headwaters (60103), Stebbins Creek (60202), Dougan Creek (60203) and Wildboy Creek (60303). All of these subwatersheds have low natural erodability ratings, ranging from 12-13, except for Dougan Creek which has a low moderate rating of 29. Road densities in Dougan and Wildboy Creeks exceed 4 mi/mi^2, and stream crossing density is also relatively high at 2.8 crossings/stream mile, leading to the hydrologically impaired rating. Stebbins Creek and the Washougal headwaters have lower road and stream crossing densities (2.7 and 1.1 mi/mi^2, and 2.0 and 0.3 crossings/stream mile, respectively). Streamside road density in the Washougal headwaters is very low.

Sediment conditions in the Cougar and Little Washougal subwatersheds (60505 and 60506) are moderately impaired. Natural erodability in these subwatersheds is quite low (less than 3); however, road densities in these subwatersheds contribute to moderate impairments. Moderate to high streamside road densities are additional sources of sediment in these watersheds.

Important mainstem subwatersheds in the Washougal system are all moderately impaired for sediment at both local and watershed levels. Consistent with the majority of the watershed, the natural erodability of these subwatersheds is relatively low (less than 27). The fact that functional sediment conditions fail to mitigate locally impaired conditions in downstream subwatersheds suggests that local sources are primary drivers. The WF Washougal (60301) has a moderately high density of streamside roads (0.5 miles/stream mile); however, many of these roads are surfaced county roads that contribute less sediment than unsurfaced roads.

Predicted Future Trends.— Most sediment functional subwatersheds (i.e. headwaters) have been designated as such because of a high percentage of public land ownership and a relatively low level of current impacts; these conditions are not expected to change. Thus, the trend in sediment conditions for the current functional subwatersheds is expected to remain relatively constant over the next 20 years.

Most mid-elevation subwatersheds throughout the basin have moderately impaired sediment conditions; trends in sediment conditions are expected to be constant over the next 20 years. The predicted trend is based on the assumption that existing land uses will continue in the future (specifically, the likelihood for ongoing timber harvests on privately held lands and

associated vehicle traffic on unsurfaced roads). Sediment conditions in these subwatersheds have the potential for improvement if timber harvests are limited.

Trends in sediment conditions in mainstem subwatersheds are expected to remain relatively constant (i.e. moderately impaired) or degrade further because of ongoing timber harvest on privately held lands, high road densities in upland areas, moderately high streamside road densities (ranging from 0.4 to 0.6 miles/stream mile), and the potential for increased development. Given the potential for development, sediment conditions in the Cougar, Little Washougal, and lower mainstem subwatersheds are susceptible to further degradation.

3.5.3 *Riparian Condition*

Current Conditions.— Moderately impaired riparian conditions predominate throughout the watershed, with only four functional subwatersheds in the headwaters of the mainstem and West Fork Washougal River. Impaired riparian conditions are present in five of nine subwatersheds in the Lacamas Creek drainage and in the developing subwatersheds around Washougal and Camas.

The four subwatersheds having functional riparian conditions (>80% functional riparian vegetation) include Hagen Creek (60304), Bluebird Creek (60102), Stebbins Creek (60202), and the upper mainstem Washougal (60101). These four subwatersheds are also rated hydrologically functional, and two (Bluebird Creek and Hagen Creek) are also functional for sediment.

Riparian conditions in all other subwatersheds are rated as moderately impaired, including the tributary subwatersheds of Cougar Creek (60505) and the headwaters of the Little Washougal River (60506).

Predicted Future Trends.— Currently functional riparian conditions in the upper watershed (Hagen Creek 60304, Bluebird Creek 60102, Stebbins Creek 60202, and the upper mainstem 60101) are expected to continue to improve over the next 20 years due to regulatory protections and functional hydrologic conditions.

The middle mainstem Washougal (60201, 60401) and the West Fork Washougal (60301) have large areas of public and private lands managed for timber harvest; the predicted trend in these subwatersheds is for riparian conditions to remain relatively constant. Some riparian recovery is expected on timber lands where streamside roads are not present, but these gains are expected to be offset by increasing streamside development (streamside road densities in these subwatersheds currently averages 0.5 miles/stream mile).

Riparian conditions in the lower mainstem Washougal (60504 and 60501) are expected to trend downward over the next 20 years, as development continues around the towns of Camas and Washougal. Channelization in these subwatersheds limits the potential for riparian recovery. Degrading riparian trends are also expected in Cougar Creek (60505), which has 24% of its area zoned for development but is currently vacant. Zoning information was not available for the Little Washougal headwaters (60506), but the proximity to other developable lands in the area suggests the potential for similar downward trends in riparian conditions.

3.6 Other Factors and Limitations

3.6.1 *Hatcheries*

Hatcheries currently release over 50 million salmon and steelhead per year in Washington lower Columbia River subbasins. Many of these fish are released to mitigate for loss of habitat. Hatcheries can provide valuable mitigation and conservation benefits but may also cause significant adverse impacts if not prudently and properly employed. Risks to wild fish include genetic deterioration, reduced fitness and survival, ecological effects such as competition or predation, facility effects on passage and water quality, mixed stock fishery effects, and confounding the accuracy of wild population status estimates. This section describes hatchery programs in the Washougal subbasin and discusses their potential effects.

Washougal Hatchery

The Washougal Hatchery is at about RM 16 of the mainstem and was completed in 1958. It produces fall Chinook for harvest opportunity and coho for harvest and for transfer to the Klickitat River as per an agreement with the Columbia River treaty Indian tribes. Current annual releases average 3.5 million sub-yearling fall Chinook and 3 million late-run coho smolts, although only 500,000 coho smolts are released in the Washougal basin (Figure 19). The remaining 2.5 million coho smolts produced at the Washougal Hatchery are released in the Klickitat River as part of the *US v. Oregon* agreement with the Columbia River treaty Indian Tribes. The Washougal Hatchery is also utilized for a chum enhancement program to assist in the rebuilding of the lower Gorge chum populations. The main hatchery threats are domestication of natural fall Chinook and coho and potential ecological interactions between hatchery and natural juvenile salmon.

Skamania Hatchery

The Skamania Hatchery on the NF Washougal River approximately one mile from the confluence with the mainstem, has produced winter and summer steelhead for harvest opportunity since 1956. The hatchery produces 309,000 summer smolts and 190,000 winter steelhead smolts. Steelhead smolts produced at the Skamania Hatchery are released in multiple basins throughout the lower Columbia River; annual release goals for the Washougal River are 60,000 smolts each of summer and winter steelhead (Figure 19). Skamania Hatchery steelhead are a composite stock and are genetically different from the naturally-produced steelhead in the Washougal. The main threats from hatchery steelhead are potential domestication of the naturally produced steelhead as a result of adult interactions or ecological interactions between natural juvenile salmon and hatchery released juvenile steelhead

Table 5. Current Washougal subbasin hatchery production.

Hatchery	Release Location	Fall Chinook	Coho	Chum	Winter Steelhead	Summer Steelhead
Washougal	Washougal	4,000,000	500,000			
	Other basins		2,500,000	100,000		
Skamania	Washougal				60,000	60,000
	Other basins				130,000	224,000

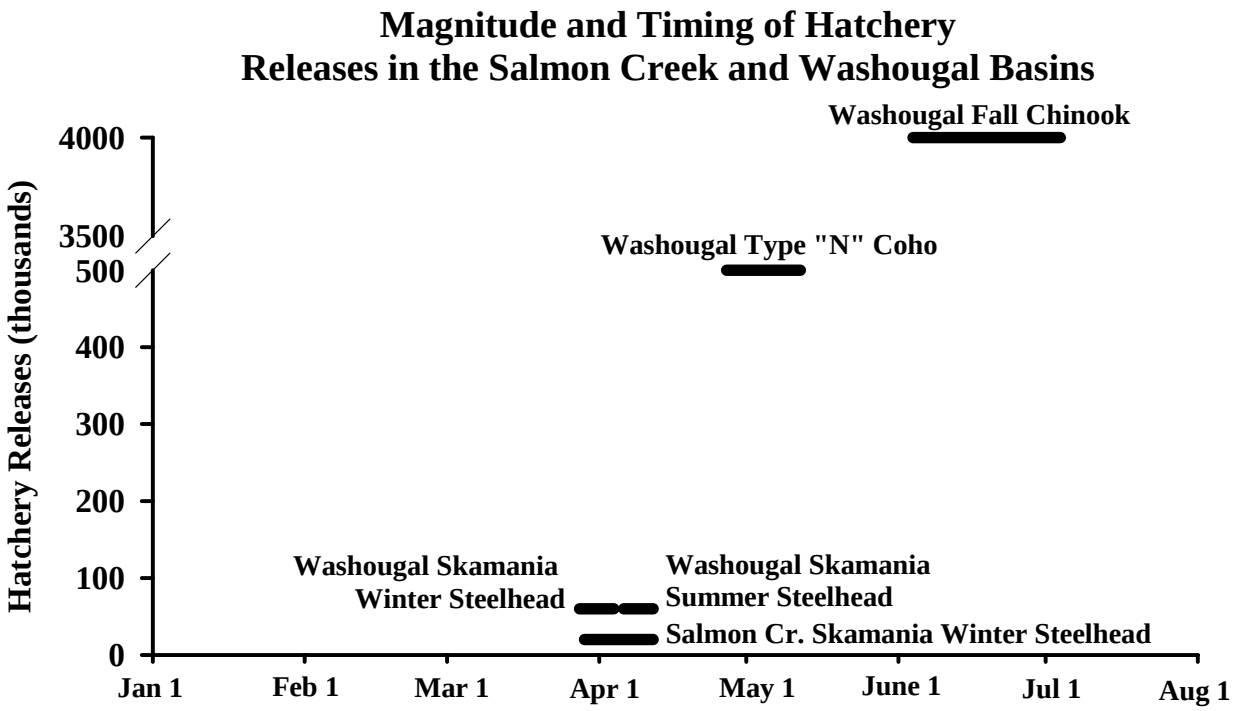


Figure 19. Magnitude and timing of hatchery releases in the Salmon Creek and Washougal River basins by species, based on 2003 brood production goals.

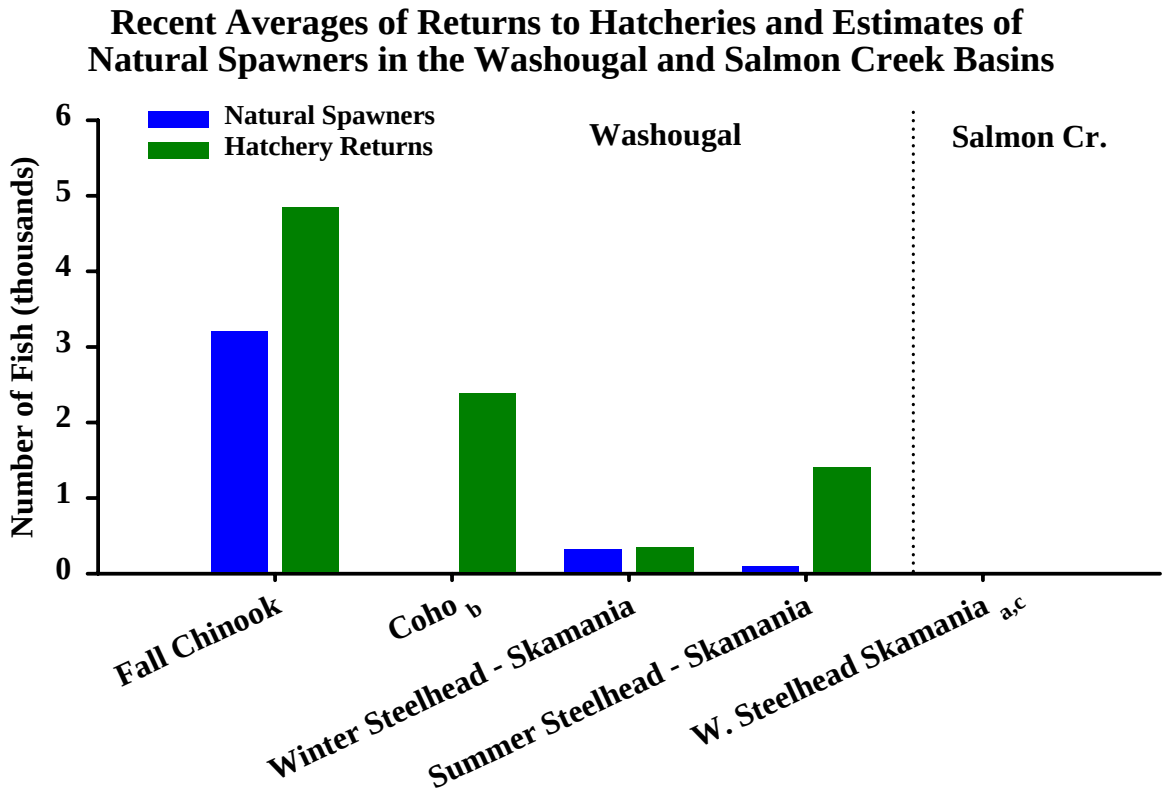


Figure 20. Recent average hatchery returns and estimates of natural spawning escapement in the Salmon Creek and Washougal River basins by species. The years used to calculate averages varied by species, based on available data. The data used to calculate average hatchery returns and natural escapement for a particular species and basin were derived from the same years in all cases. All data were from 1992 to the present. Calculation of each average utilized a minimum of 5 years of data..

Hatchery Effects

Genetics—Broodstock for the Washougal Hatchery fall Chinook hatchery program originated from multiple lower Columbia River fall chinook stocks. There have been significant transfers of fall Chinook over the years from Spring Creek NFH, Cowlitz Hatchery, Toutle Hatchery, and Kalama Hatchery. Current broodstock collection comes from adults returning to the hatchery. Genetic analysis of Washougal fall chinook in 1995 and 1996 indicated that they were significantly different from other lower Columbia River chinook stocks, except for Lewis River bright fall chinook; this result is perplexing as Washougal fall chinook are considered a tule population.

Broodstock for the Washougal Hatchery coho hatchery program originated from local Washougal early-run coho, with some imported Toutle River early run coho stock used. In 1985, Cowlitz River late-run coho stock was introduced to the Washougal Hatchery broodstock. Since 1987, broodstock has been collected from late-run coho returning to the hatchery: except for 1993 when Lewis River late-run coho were used to supplement the Washougal Hatchery shortfall. Broodstock for the 2.5 million coho smolts released annually to the Klickitat River comes primarily from Lewis River late-run coho stocks. Any lower Columbia River Type-N coho stock has been deemed acceptable broodstock for the Washougal Type-N coho hatchery program.

Broodstock for Skamania Hatchery winter steelhead program originated from local Washougal River winter steelhead; current broodstock comes from adults returning to the hatchery. Shortfalls have been supplemented from Beaver Creek Hatchery winter steelhead stocks, which originated primarily from Chambers Creek and Cowlitz River stocks.

Broodstock for the Skamania Hatchery's summer steelhead program originated from wild fish taken from the Washougal and Klickitat rivers. Current broodstock collection comes from adults returning to the hatchery. Genetic sampling in 1993 was inconclusive in determining the distinctiveness of the Washougal summer steelhead stock. The Skamania summer steelhead stock is the source of nearly all summer steelhead smolt releases on the Washington side of the lower Columbia River, except for the Cowlitz and Lewis rivers.

Interactions—Hatchery production accounts for most adult fall Chinook returning to the Washougal River (Figure 20). Hatchery-origin fish comprise a significant portion of the natural spawners; this proportion is higher when water flow is low and insufficient to provide for passage to the Washougal Hatchery. A substantial amount of natural production occurs in the system; WDFW estimated 5 million natural juvenile fall chinook emigrated from the Washougal River in 1980 so there may be competition for food and space between naturally produced fall chinook and the average 4 million hatchery fall chinook released annually. Large-scale releases of hatchery fish may attract predators, but the effect on naturally produced salmonids is not clear. The impact of hatchey fall chinook releases on naturally produced is limited by the length of time the hatchery smolts spend in the basin during emigration.

Hatchery production accounts for most adult coho salmon returning to the Washougal River (Figure 20); very few wild coho are present, resulting in minimal interaction between adult wild and hatchery coho salmon. Hatchery coho smolts are released volitionally as smolts and clear the river quickly, so competition for food resources with natural salmonids is likely minimal. Some limited natural production of coho has persisted in the Little Washougal River; this tributary is geographically separated from the Washougal Hatchery and any interaction between hatchery fish and naturally produced coho from the Little Washougal would be limited

to the lower mainstem. Large-scale releases of hatchery fish may attract predators, but the effect on naturally produced salmonids is not clear.

Hatchery production accounts for most adult winter steelhead returning to the Washougal River (Figure 20)). Hatchery-origin fish comprise a substantial portion of the natural spawners. However, spawn timing of wild fish and naturally spawning hatchery fish is different; therefore, there is likely minimal interaction between adult wild and hatchery winter steelhead. Hatchery winter steelhead smolts are released volitionally and clear the river quickly, so competition for food resources with natural salmonids is probably minimal. Also, wild steelhead smolt emigration appears to be timed slightly later than the hatchery releases. Only minor residualization of steelhead smolts has been observed on the Washougal River.

Hatchery production accounts for most adult summer steelhead returning to the Washougal River, although substantial numbers of wild summer steelhead can be present some years (Figure 20). However, because spawn timing of wild fish and naturally spawning hatchery fish is different, little interaction between adult wild and hatchery summer steelhead is thought to occur. Spawn timing between hatchery summer and wild winter steelhead is more similar and there is more potential for interaction between these fish. Hatchery summer steelhead smolts are released volitionally and clear the river quickly, so competition for food resources with natural salmonids is expected to be minimal. Also, wild steelhead smolt emigration appears to be timed slightly later than the hatchery releases. Only minor amounts of residualization of steelhead smolts have been observed on the Washougal River.

Water Quality/Disease—The water source and disease treatment protocol for the Washougal Hatchery were not specified in the available hatchery operational plan. It is assumed that water for the hatchery comes from the Washougal River. Fungus and disease treatment at the Washougal River hatchery is likely similar to other Washington hatcheries; fungus control is presumably achieved with formalin treatments and disease treated with the advice of the area fish health specialist and according to procedures of the Co-Managers Fish Health Policy.

Water for the Skamania Hatchery comes from two sources: the North Fork Washougal River and Vogel Creek. Hatchery water rights total 11,670 gpm but the facility uses an average of 9,800 gpm. Vogel Creek water is used for incubation and early rearing, while Washougal River water is used for all other operations, such as final rearing and adult holding. Hatchery effluent is monitored under the hatchery's NPDES permit. At the adult collection facility, personnel and equipment are sanitized by chlorine disinfection. Fungus in the holding facility is controlled with formalin treatments. During the incubation phase, formalin treatments are used to control ecto-parasites and fungus and eggs and equipment are surface disinfected with iodophor. Fish health is monitored continuously by hatchery staff and the area fish health specialist visits monthly. Disease control is conducted according to the Fish Health Policy. The area fish health specialist inspects fish prior to release and recommends treatment when necessary; control of fish pathogens is done according to the Fish Disease Control Policy. IHN is a major problem in the hatchery and can limit production in some years.

Mixed Harvest—The Washougal River Hatchery provides harvest opportunity to mitigate for fall chinook and coho salmon lost as a result of hydroelectric development in the lower Columbia River basin. Historically, exploitation rates of hatchery and wild fall chinook likely were similar. Fall chinook are an important target species in ocean and Columbia River commercial and recreational fisheries, as well as tributary recreational fisheries. CWT data analysis of the 1989–1994 brood years of Washougal fall chinook indicated a 28% exploitation

rate on fall chinook; 72% of the adult return was accounted for in escapement. Exploitation of wild fish during the same period likely is similar. Hatchery and wild fall chinook harvest rates remain similar but are now constrained by ESA harvest limitations.

The purpose of the Washougal River Hatchery coho salmon hatchery program is to provide harvest opportunity to mitigate for Columbia River coho salmon lost to hydroelectric development in the basin. The coho program is specifically intended to provide coho for harvest in treaty Indian fisheries in Zone 6 and in the Klickitat River, as well as non-Indian fisheries in the ocean, Columbia River, and in the Washougal River. Historically, naturally produced coho from the Columbia River were managed like hatchery fish and subjected to similar exploitation rates. Ocean and Columbia River combined harvest of Columbia River-produced coho ranged from 70% to over 90% from 1970–83. Ocean fisheries were limited beginning in the mid-1980s and Columbia River commercial fisheries were adjusted in the early 1990s to protect several wild coho stocks. Columbia River coho exploitation rates during 1997 and 1998 averaged 48.8%. CWT data analysis of the 1995–1997 brood years of Washougal River Type-N coho indicated a 71% exploitation rate on late run hatchery coho; 29% of the adult hatchery return was accounted for in escapement. Most of the Washougal River Type-N coho harvest occurred in the Columbia River. With the advent of selective fisheries for hatchery fish in 1998, exploitation of wild coho is low, while hatchery fish can be harvested at a higher rate. Washougal wild coho also benefit from ESA harvest limits for Oregon Coastal natural coho in ocean fisheries and for Oregon lower Columbia Natural Coho in Columbia River fisheries

At the Skamania Hatchery, the summer and winter steelhead hatchery programs provide harvest opportunity to mitigate for summer and winter steelhead lost as a result of hydroelectric development in the lower Columbia River basin. Fisheries that may benefit from these programs include lower Columbia and Washougal River sport fisheries. Prior to selective fishery regulations, exploitation rates of wild and hatchery winter steelhead were likely similar. Mainstem Columbia River sport fisheries became selective for hatchery steelhead in 1984 and the Washougal became selective during 1986–1992. and harvest regulations are aimed at limiting harvest of wild steelhead to fewer than 10%. The sport fishery impact in the Washougal is estimated at 5% for wild winter steelhead and 4% for wild summer steelhead. The hatchery steelhead harvest rate in the Washougal sport fishery is estimated to be 40% for both winter and summer steelhead.

Passage—The adult collection facility at the Washougal Hatchery consists of a weir across the river leading to a ladder and holding pond system. Adults enter the ladder volitionally and are contained in holding ponds until broodstock collection. Adults surplus to annual broodstock needs are distributed throughout the basin for nutrient enhancement of the freshwater rearing environment. In some years, low water flow in the mainstem Washougal River is not conducive to fish passage and broodstock needs are not met.

The adult collection facility at the Skamania Hatchery consists of a ladder, trap, and holding pond system. The ladder is approximately 80 ft long and the trap is approximately 20 ft x 20 ft. Adults enter the ladder volitionally and are routed to one of three holding ponds until broodstock collection. Many fish bypass the hatchery collection facility. Adults surplus to annual broodstock needs may be returned to the river (if in robust condition), planted in landlocked lakes for sport harvest, distributed to food banks, or distributed throughout the basin for nutrient enhancement of the freshwater rearing environment.

Supplementation—No Washougal hatchery program has supplementation as a primary goal. However, hatchery fall chinook and summer steelhead have successfully spawned in the Washougal River; annual natural production varies annually.

Biological Risk Assessment

The evaluation of hatchery programs and implementation of hatchery reform in the Lower Columbia is occurring through several processes. These include: 1) the LCFRB recovery planning process; 2) Hatchery Genetic Management Plan (HGMP) preparation for ESA permitting; 3) FERC related plans on the Cowlitz River and Lewis River; and 4) the federally mandated Artificial Production Review and Evaluation (APRE) process. Through each of these processes, WDFW is applying a consistent framework to identify the hatchery program enhancements that will maximize fishing-related economic benefits and promote attainment of regional recovery goals. Developing hatcheries into an integrated, productive, stock recovery tool requires a policy framework for considering the acceptable risks of artificial propagation, and a scientific assessment of the benefits and risks of each proposed hatchery program. WDFW developed the Benefit-Risk Assessment Procedure (BRAP) to provide that framework. The BRAP evaluates hatchery programs in the ecological context of the watershed, with integrated assessment and decisions for hatcheries, harvest, and habitat. The risk assessment procedure consists of five basic steps, grouped into two blocks:

Policy Framework

- Assess population status of wild populations
- Develop risk tolerance profiles for all stock conditions
- Assign risk tolerance profiles to all stocks

Risk Assessment

- Conduct risk assessments for all hatchery programs
- Identify appropriate management actions to reduce risk

Following the identification of risks through the assessment process, a strategy is developed to describe a general approach for addressing those risks. Building upon those strategies, program-specific actions and an adaptive management plan are developed as the final steps in the WDFW framework for hatchery reform.

Table 6 identifies hazards levels associated with risks involved with hatchery programs in the Washougal River Basin. Table 7 identifies preliminary strategies proposed to address risks identified in the BRAP for the same populations.

The BRAP risk assessments and strategies to reduce risk have been key in providing the biological context to develop the hatchery recovery measures for lower Columbia River sub-basins.

Table 6. Preliminary BRAP for hatchery programs affecting populations in the Washougal River Basin

Symbol	Description
○	Risk of hazard consistent with current risk tolerance profile.
?	Magnitude of risk associated with hazard unknown.
●	Risk of hazard exceeds current risk tolerance profile.
	Hazard not relevant to population

	Hatchery Program		Risk Assessment of Hazards											
			Genetic			Ecological			Demographic		Facility			
Washougal Population	Name	Release (millions)	Effective Population Size	Domestication	Diversity	Predation	Competition	Disease	Survival Rate	Reproductive Success	Catastrophic Loss	Passage	Screening	Water Quality
Fall Chinook	Washougal Fall Chinook	4.000	○	●	○	○	?	○	○	?	○	●	●	○
	Skamania W. Steelhead	0.060				?	?	○				●	●	○
	Washougal Coho Type N	0.500				?	?	○				●	●	○
Chum	Washougal Fall Chinook	4.000				?	?	○				●	●	○
	Skamania W. Steelhead	0.060				?	?	○				●	●	○
	Washougal Coho Type N	0.500				?	?	○				●	●	○
Summer Steelhead	Washougal Fall Chinook	4.000				○	○	○				●	●	○
	Skamania W. Steelhead	0.060				?	?	○				●	●	○
	Washougal Coho Type N	0.500				?	?	○				●	●	○
	Skamania S. Steelhead	0.060	○	○	?	?	?	○				●	●	○
Winter Steelhead	Washougal Fall Chinook	4.000				○	?	○				●	●	○
	Skamania W. Steelhead	0.060				?	?	○				●	●	○
	Washougal Coho Type N	0.500				?	?	○				●	●	○

Table 7. Preliminary strategies proposed to address risks identified in the BRAP for Washougal River Basin populations

	Hatchery Program		Risk Assessment of Hazards													
			Address Genetic Risks					Address Ecological Risks				Address Demographic Risks		Address Facility Risks		
Washougal Population	Name	Release (millions)	Mating Procedure	Integrated Program	Segregated Program	Research/ Monitoring	Broodstock Source	Number Released	Release Procedure	Disease Containment	Research/ Monitoring	Culture Procedure	Research/ Monitoring	Reliability	Improve Passage	Improve Screening	Pollution Abatement
Fall Chinook	Washougal Fall Chinook	4.000		●	●	●							●		●	●	
	Skamania W. Steelhead 1+	0.060						●	●		●				●	●	
	Washougal Coho Type N	0.500						●	●		●				●	●	
	Skamania S. Steelhead 1+	0.060						●	●		●				●	●	

Impact Assessment

The potential significance of negative hatchery impacts within the subbasin on natural populations was estimated with a simple index based on: 1) intra-specific effects resulting from depression in wild population productivity that can result from interbreeding with less fit hatchery fish and 2) inter-specific effects resulting from predation of juvenile salmonids of other species. The index reflects only a portion of net hatchery effects but can provide some sense of the magnitude of key hatchery risks relative to other limiting factors. Fitness effects are among the most significant intra-specific hatchery risks and can also be realistically quantified based on hatchery fraction in the natural spawning population and assumed fitness of the hatchery fish relative to the native wild population. Predation is among the most significant inter-specific effects and can be estimated from hatchery release numbers by species. This index assumed that equilibrium conditions have been reached for the hatchery fraction in the wild and for relative fitness of hatchery and wild fish. This simplifying assumption was necessary because more detailed information is lacking on how far the current situation is from equilibrium. The index does not consider the numerical benefits of hatchery spawners to natural population numbers,

ecological interactions between hatchery and wild fish other than predation, or out-of-basin interactions, all of which are difficult to quantify. Appendix E contains a detailed description of the method and rationale behind this index.

The indexed potential for negative impacts of hatchery spawners on wild population fitness in the Washougal River subbasin is 17% for fall Chinook,and 46% for coho, However, the high incidence of fall chinook and coho hatchery spawners suggests that the fitness of natural and hatchery fish is now probably quite similar and natural populations might decline substantially without continued hatchery subsidy under current habitat conditions. The fitness impacts are estimated to be 17.5% for summer steelhead and 0% for winter steelhead. The summer steelhead impacts are associated with hatchery steelhead spawning in the North Fork Washougal, where Skamania Hatchery is located. Natural spawning of hatchery steelhead does not occur in the upper mainstem Washougal. Interspecific impacts from predation appear to be 1% or less for all species.

Table 8. Presumed reductions in wild population fitness as a result of natural hatchery spawners and survival as a result of interactions with other hatchery species for Washougal River salmon and steelhead populations.

Population	Annual releases[a]	Hatchery fraction[b]	Fitness category[c]	Assumed fitness[d]	Fitness impact[e]	Interacting releases[f]	Interspecies impact[g]
Fall Chinook	4,000,000	0.57	2	0.7	0.17	620,000	0.03
Chum	0[h]	0	--	--	0	120,000	0.006
Coho	500,000[i]	0.91	3	0.5	0.46	620,000	0.01
Summer Steelhead	60,000	0.25	4	0.3	0.175	0	0
Winter Steelhead	60,000	0	--	--	0	0	0

[a] Annual release goals.
[b] Proportion of natural spawners that are first generation hatchery fish.
[c] Broodstock category: 1 = derived from native local stock, 2 = domesticated stock of native local origin, 3 = originates from same ESU but substantial divergence may have occurred, 4 = out-of-ESU origin or origin uncertain
[d] Productivity of naturally-spawning hatchery fish relative to native wild fish prior to significant hatchery influence. Because population-specific fitness estimates are not available for most lower Columbia River populations, we applied hypothetical rates comparable to those reported in the literature and the nature of local hatchery program practices.
[e] Index based on hatchery fraction and assumed fitness.
[f] Number of other hatchery releases with a potential to prey on the species of interest. Includes steelhead and coho for fall chinook and coho. Includes steelhead for chum.
[g] Predation impact based on interacting releases and assumed species-specific predation rates.
[h] There are no records of hatchery chum releases in the basin.
[i] The Washougal River Hatchery releases late coho salmon (type N); broodstock is normally derived from Washougal or Lewis River hatchery returns

3.6.2 *Harvest*

Fishing generally affects salmon populations through directed and incidental harvest, catch and release mortality, and size, age, and run timing alterations because of uneven fishing on different run components. From a population biology perspective, these affects can result in reduced survival (fewer spawners) and can alter age, size, run timing, fecundity, and genetic characteristics. Fewer spawners result in fewer eggs for future generations and diminish marine-derived nutrients delivered via dying adults, now known to be significant to the growth and survival of juvenile salmon in aquatic ecosystems. The degree to which harvest-related limiting factors influence productivity varies by species and location.

Most harvest of wild Columbia River salmon and steelhead occurs incidental to the harvest of hatchery fish and healthy wild stocks in the Columbia estuary, mainstem, and ocean. Fish are caught in the Canada/Alaska ocean, U.S. West Coast ocean, lower Columbia River commercial and recreational, tributary recreational, and in-river treaty Indian (including commercial, ceremonial, and subsistence) fisheries. Total exploitation rates have decreased for lower Columbia salmon and steelhead, especially since the 1970s as increasingly stringent protection measures were adopted for declining natural populations.

Current fishing impact rates on lower Columbia River naturally-spawning salmon populations ranges from 2.5% for chum salmon to 45% for tule fall Chinook (Table 9). These rates include estimates of direct harvest mortality as well as estimates of incidental mortality in catch and release fisheries. Fishery impact rates for hatchery produced coho, and steelhead are higher than for naturally-spawning fish of the same species because of selective fishing regulations. These rates generally reflect recent year (2001-2003) fishery regulations and quotas controlled by weak stock impact limits and annual abundance of healthy targeted fish. Actual harvest rates will vary for each year dependent on annual stock status of multiple west coast salmon populations, however, these rates generally reflect expected impacts of harvest on lower Columbia naturally-spawning and hatchery salmon and steelhead under current harvest management plans.

Table 9. Approximate annual exploitation rates (% harvested) for naturally-spawning lower Columbia salmon and steelhead under current management controls (represents 2001-2003 fishing period).

	AK./Can. Ocean	West Coast Ocean	Col. R. Comm.	Col. R. Sport	Trib. Sport	**Wild Total**	Hatchery Total	Historic Highs
Fall Chinook (Tule)	15	15	5	5	5	**45**	45	80
Chum	0	0	1.5	0	1	**2.5**	2.5	60
Coho	<1	9	6	2	1	**18**	51	85
Steelhead	0	<1	3	0.5	5	**8.5**	70	75

Columbia River fall Chinook are subject to freshwater and ocean fisheries from Alaska to their rivers of origin in fisheries targeting abundant Chinook stocks originating from Alaska, Canada, Washington, Oregon, and California. Columbia tule fall Chinook harvest is constrained by a Recovery Exploitation Rate (RER) developed by NOAA Fisheries for management of Coweeman naturally-spawning fall Chinook. Some tributary sport fisheries are closed to the retention of Chinook to protect naturally produced fall chinook populations. Harvest of lower Columbia bright fall Chinook is managed to achieve an escapement goal of 5,700 natural spawners in the North Fork Lewis.

Rates are very low for chum salmon, which are not encountered by ocean fisheries and return to freshwater in late fall when significant Columbia River commercial fisheries no longer occur. Chum are no longer targeted in Columbia commercial seasons and retention of chum is prohibited in Columbia River and Washougal River sport fisheries. Chum are impacted incidental to fisheries directed at coho and winter steelhead.

Harvest of Washougal coho occurs in the ocean commercial and recreational fisheries off the Washington and Oregon coasts and Columbia River as well as recreational fisheries in the Grays basin. Wild coho impacts are limited by fishery management to retain marked hatchery fish and release unmarked wild fish.

Steelhead, like chum, are not encountered by ocean fisheries and non-Indian commercial steelhead fisheries are prohibited in the Columbia River. Incidental mortality of steelhead occurs in freshwater commercial fisheries directed at Chinook and coho and freshwater sport fisheries directed at hatchery steelhead and salmon. All recreational fisheries are managed to selectively harvest fin-marked hatchery steelhead and commercial fisheries cannot retain hatchery or wild steelhead.

Access to harvestable surpluses of strong stocks in the Columbia River and ocean is regulated by impact limits on weak populations mixed with the strong. Weak stock management of Columbia River fisheries became increasingly prevalent in the 1960s and 1970s in response to continuing declines of upriver runs affected by mainstem dam construction. In the 1980s coordinated ocean and freshwater weak stock management commenced. More fishery restrictions followed ESA listings in the 1990s. Each fishery is controlled by a series of regulating factors. Many of the regulating factors that affect harvest impacts on Columbia River stocks are associated with treaties, laws, policies, or guidelines established for the management of other stocks or combined stocks, but indirectly control impacts of Columbia River fish as well. Listed fish generally comprise a small percentage of the total fish caught by any fishery. Every listed fish may correspond to tens, hundreds, or thousands of other stocks in the total catch. As a result of weak stock constraints, surpluses of hatchery and strong naturally-spawning runs often go unharvested. Small reductions in fishing rates on listed populations can translate to large reductions in catch of other stocks and recreational trips to communities which provide access to fishing, with significant economic consequences.

Selective fisheries for adipose fin-clipped hatchery spring Chinook (since 2001), coho (since 1999), and steelhead (since 1984) have substantially reduced fishing mortality rates for naturally-spawning populations and allowed concentration of fisheries on abundant hatchery fish. Selective fisheries occur in the Columbia River and tributaries, for spring Chinook and steelhead, and in the ocean, Columbia River, and tributaries for coho. Columbia River hatchery fall Chinook are not marked for selective fisheries, but likely will be in the future because of recent legislation enacted by Congress.

3.6.3 *Mainstem and Estuary Habitat*

Conditions in the Columbia River mainstem, estuary, and plume affect all anadromous salmonid populations within the Columbia Basin. Juvenile and adult salmon may be found in the mainstem and estuary at all times of the year, as different species, life history strategies and size classes continually rear or move through these waters. A variety of human activities in the mainstem and estuary have decreased both the quantity and quality of habitat used by juvenile salmonids. These include floodplain development; loss of side channel habitat, wetlands and marshes; and alteration of flows due to upstream hydro operations and irrigation withdrawals.

Effects on salmonids of habitat changes in the mainstem and estuary are complex and poorly understood. Effects are similar for Washougal populations to those of most other subbasin salmonid populations. Effects are likely to be greater for chum and fall Chinook which rear for extended periods in the mainstem and estuary than for steelhead and coho which move through more quickly. Estimates of the impacts of human-caused changes in mainstem and estuary habitat conditions are available based on changes in river flow, temperature, and predation as represented by EDT analyses for the NPCC Multispecies Framework Approach (Marcot et al. 2002). These estimates generally translate into a 10-60% reduction in salmonid productivity

depending on species (Appendix E). Estuary effects are described more fully in the estuary subbasin volume of this plan (Volume II-A).

3.6.4 *Hydropower Construction and Operation*

There are no hydro-electric dams in the Washougal River Basin. However, Washougal species are affected by changes in Columbia River mainstem and estuary related to Columbia basin hydropower development and operation. The mainstem Columbia River and estuary provide important habitats for anadromous species during juvenile and adult migrations between spawning and rearing streams and the ocean where they grow and mature. These habitats are particularly important for fall chinook and chum which rear extensively in the Columbia mainstem and estuary. Aquatic habitats have been fundamentally altered throughout the Columbia River basin by the construction and operation of a complex of tributary and mainstem dams and reservoirs for power generation, navigation, and flood control.

The hydropower infrastructure and flow regulation affects adult migration, juvenile migration, mainstem spawning success, estuarine rearing, water temperature, water clarity, gas supersaturation, and predation. Dams block or impede passage of anadromous juveniles and adults. Columbia River spring flows are greatly reduced from historical levels as water is stored for power generation and irrigation, while summer and winter flows have increased. These flow changes affect juvenile and adult migration, and have radically altered habitat forming processes. Flow regulation and reservoir construction have increased average water temperature in the Columbia River mainstem and summer temperatures regularly exceed optimums for salmon. Supersaturation of water with atmospheric gases, primarily nitrogen, when water is spilled over high dams causes gas bubble disease. Predation by fish, bird, and marine mammals has been exacerbated by habitat changes. The net effect of these direct and indirect effects is difficult to quantify but is expected to be less significant for populations originating from lower Columbia River subbasins than for upriver salmonid populations. Additional information on hydropower effects can be found in the Regional Recovery and Subbasin Plan Volume I.

3.6.5 *Ecological Interactions*

Ecological interactions focus on how salmon and steelhead, other fish species, and wildlife interact with each other and the subbasin ecosystem. Salmon and steelhead are affected throughout their lifecycle by ecological interactions with non native species, food web components, and predators. Each of these factors can be exacerbated by human activities either by direct actions or indirect effects of habitat alternation. Effects of non-native species on salmon, effects of salmon on system productivity, and effects of native predators on salmon are difficult to quantify. Strong evidence exists in the scientific literature on the potential for significant interactions but effects are often context- or case-specific.

Predation is one interaction where effects can be estimated although interpretation can be complicated. In the lower Columbia River, northern pikeminnow, Caspian tern, and marine mammal predation on salmon has been estimated at approximately 5%, 10-30%, and 3-12%, respectively of total salmon numbers (see Appendix E for additional details). Predation has always been a source of salmon mortality but predation rates by some species have been exacerbated by human activities.

3.6.6 *Ocean Conditions*

Salmonid numbers and survival rates in the ocean vary with ocean conditions and low productivity periods increase extinction risks of populations stressed by human impacts. The ocean is subject to annual and longer-term climate cycles just as the land is subject to periodic droughts and floods. The El Niño weather pattern produces warm ocean temperatures and warm, dry conditions throughout the Pacific Northwest. The La Niña weather patterns is typified by cool ocean temperatures and cool/wet weather patterns on land. Recent history is dominated by a high frequency of warm dry years, along with some of the largest El Niños on record—particularly in 1982-83 and 1997-98. In contrast, the 1960s and early 1970s were dominated by a cool, wet regime. Many climatologists suspect that the conditions observed since 1998 may herald a return to the cool wet regime that prevailed during the 1960s and early 1970s.

Abrupt declines in salmon populations throughout the Pacific Northwest coincided with a regime shift to predominantly warm dry conditions from 1975 to 1998 (Beamish and Bouillon 1993, Hare et al 1999, McKinnell et al. 2001, Pyper et al. 2001). Warm dry regimes result in generally lower survival rates and abundance, and they also increase variability in survival and wide swings in salmon abundance. Some of the largest Columbia River fish runs in recorded history occurred during 1985–1987 and 2001–2002 after strong El Niño conditions in 1982–83 and 1997–98 were followed by several years of cool wet conditions.

The reduced productivity that accompanied an extended series of warm dry conditions after 1975 has, together with numerous anthropogenic impacts, brought many weak Pacific Northwest salmon stocks to the brink of extinction and precipitated widespread ESA listings. Salmon numbers naturally ebb and flow as ocean conditions vary. Healthy salmon populations are productive enough to withstand these natural fluctuations. Weak salmon populations may disappear or lose the genetic diversity needed to withstand the next cycle of low ocean productivity (Lawson 1993).

Recent improvements in ocean survival may portend a regime shift to generally more favorable conditions for salmon. The large spike in recent runs and a cool, wet climate would provide a respite for many salmon populations driven to critical low levels by recent conditions. The National Research Council (1996) concluded: *"Any favorable changes in ocean conditions—which could occur and could increase the productivity of some salmon populations for a time—should be regarded as opportunities for improving management techniques. They should not be regarded as reasons to abandon or reduce rehabilitation efforts, because conditions will change again"*. Additional details on the nature and effects of variable ocean conditions on salmonids can be found in the Regional Recovery and Subbasin Plan Volume I.

3.7 Summary of Human Impacts on Salmon and Steelhead

Stream habitat, estuary/mainstem habitat, harvest, hatchery and ecological interactions have all contributed to reductions in productivity, numbers, and population viability. Pie charts in Figure 21 describe the relative magnitude of potentially-manageable human impacts in each category of limiting factor for Washougal Basin salmon and steelhead. Impact values were developed for a base period corresponding to species listing dates. This depiction is useful for identifying which factors are most significant for each species and where improvements might be expected to provide substantial benefits. Larger pie slices indicate greater significance and scope for improvement in an impact for a given species. These numbers also serve as a working hypothesis for factors limiting salmonid numbers and viability.

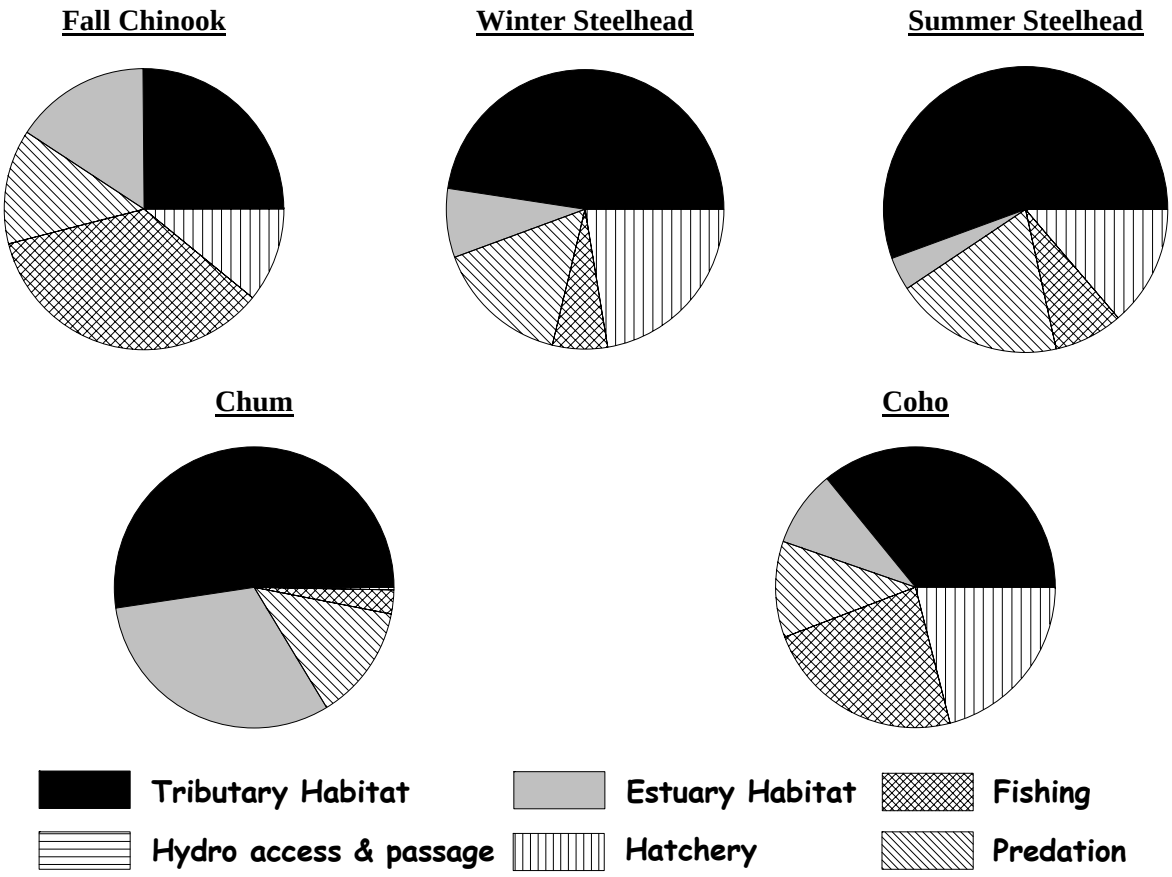


Figure 21. Relative contribution of potentially manageable impacts on Washougal River salmonid populations.

This assessment indicates that current salmonid status is the result of large impacts distributed among several factors. No single factor accounts for a majority of effects on all species. Thus, substantial improvements in salmonid numbers and viability will require significant improvements in several factors. Loss of tributary habitat quality and quantity accounts for the largest relative impact on all species except for fall Chinook in which fishing effects dominate. Harvest also has a sizeable effect on coho but is less important for chum and summer and winter steelhead. Hatchery impacts are substantial for all species except chum. Loss of estuary habitat quality and quantity has had a large impact on chum, a moderate impact

on fall Chinook and a relatively small impact on coho and steelhead. Predation impacts are moderate for all species though summer steelhead appear to be slightly more susceptible to predation impacts than all other species in this subbasin. Hydrosystem access and passage impacts appear to be relatively minor for all species.

Impacts were defined as the proportional reduction in average numbers or productivity associated with each effect. Tributary and estuary habitat impacts are the differences between the pre-development historical baseline and current conditions. Hydro impacts identify the percentage of historical habitat blocked by impassable dams and the mortality associated with juvenile and adult passage of other dams. Fishing impacts are the direct and indirect mortality in ocean and freshwater fisheries. Hatchery impacts include the equilibrium effects of reduced natural population productivity caused by natural spawning of less-fit hatchery fish and also effects of inter-specific predation by larger hatchery smolts on smaller wild juveniles. Hatchery impacts do not include other potentially negative indirect effects or potentially beneficial effects of augmentation of natural production. Predation includes mortality from northern pikeminnow, Caspian terns, and marine mammals in the Columbia River mainstem and estuary. Predation is not a direct human impact but was included because of widespread interest in its relative significance. Methods and data for these analyses are detailed in Appendix E.

Potentially-manageable human impacts were estimated for each factor based on the best available scientific information. Proportions are standardized to a total of 1.0 for plotting purposes. The index is intended to illustrate order-of-magnitude rather than fine-scale differences. Only the subset of factors we can potentially manage were included in this index – natural mortality factors beyond our control (e.g. naturally-occuring ocean mortality) are excluded. Not every factor of interest is included in this index – only readily-quantifiable impacts are included.

4.0 Key Programs and Projects

This section provides brief summaries of current federal, state, local, and non-governmental programs and projects pertinent to recovery, management, and mitigation measures and actions in this subbasin. These descriptions provide a context for descriptions of specific actions and responsibilities in the management plan portion of this subbasin plan. More detailed descriptions of these programs and projects can be found in the Comprehensive Program Directory (Appendix C).

4.1 Federal Programs

4.1.1 *NOAA Fisheries*

NOAA Fisheries is responsible for conserving, protecting and managing pacific salmon, ground fish, halibut, marine mammals and habitats under the Endangered Species Act, the Marine Mammal Protection Act, the Magnusen-Stevens Act, and enforcement authorities. NOAA administers the ESA under Section 4 (listing requirements), Section 7 (federal actions), and Section 10 (non-federal actions).

4.1.2 *US Army Corps of Engineers*

The U.S. Army Corps of Engineers (USACE) is the Federal government's largest water resources development and management agency. USACE programs applicable to Lower Columbia Fish & Wildlife include: 1) Section 1135 – provides for the modification of the structure or operation of a past USACE project, 2) Section 206 – authorizes the implementation of aquatic ecosystem restoration and protection projects, 3) Hydroelectric Program – applies to the construction and operation of power facilities and their environmental impact, 4) Regulatory Program – administration of Section 10 of the Rivers and Harbors Act and Section 404 of the Clean Water Act.

4.1.3 *Environmental Protection Agency*

The Environmental Protection Agency (EPA) is responsible for the implementation of the Clean Water Act (CWA). The broad goal of the CWA is to restore and maintain the chemical, physical, and biological integrity of the nation's waters so that they can support the protection and propagation of fish, shellfish, and wildlife and recreation in and on the water. The CWA requires that water quality standards (WQS) be set for surface waters. WQS are aimed at translating the broad goals of the CWA into waterbody-specific objectives and apply only to the surface waters (rivers, lakes, estuaries, coastal waters, and wetlands) of the United States.

4.1.4 *United States Forest Service*

The Unites States Forest Service (USFS) manages federal forest lands within the Gifford Pinchot National Forest (GPNF). The GPNF operates under the Gifford Pinchot Forest Plan (GPFP). Management prescriptions within the GPFP have been guided by the 1994 Northwest Forest Plan, which calls for management of forests according to a suite of management designations including Reserves (e.g. late successional forests, riparian forests), Adaptively-Managed Areas, and Matrix Lands. Most timber harvest occurs in Matrix Lands. The GPNF implements a wide range of ecosystem restoration activities.

4.1.5 *Natural Resources Conservation Service*

Formerly the Soil Conservation Service, the USDA Natural Resources Conservation Service (NRCS) works with landowners to conserve natural resources on private lands. The NRCS accomplishes this through various programs including, but not limited to, the Conservation Technical Assistance Program, Soil Survey Program, Conservation Reserve Enhancement Program, and the Wetlands Reserve Program. The NRCS works closely with local Conservation Districts; providing technical assistance and support.

4.1.6 *Northwest Power and Conservation Council*

The Northwest Power and Conservation Council, an interstate compact of Idaho, Montana, Oregon, and Washington, has specific responsibility in the Northwest Power Act of 1980 to mitigate the effects of the hydropower system on fish and wildlife of the Columbia River Basin. The Council does this through its Columbia River Basin Fish and Wildlife Program, which is funded by the Bonneville Power Administration. Beginning in Fiscal Year 2006, funding is guided by locally developed subbasin plans that are expected to be formally adopted in the Council's Fish and Wildlife Program in December 2004.

4.2 State Programs

4.2.1 *Washington Department of Natural Resources*

The Washington Department of Natural Resources governs forest practices on non-federal lands and is steward to state owned aquatic lands. Management of DNR public forest lands is governed by tenets of their proposed Habitat Conservation Plan (HCP). Management of private industrial forestlands is subject to Forest Practices regulations that include both protective and restorative measures.

4.2.2 *Washington Department of Fish & Wildlife*

WDFW's Habitat Division supports a variety of programs that address salmonids and other wildlife and resident fish species. These programs are organized around habitat conditions (Science Division, Priority Habitats and Species, and the Salmon and Steelhead Habitat Inventory and Assessment Program); habitat restoration (Landowner Incentive Program, Lead Entity Program, and the Conservation and Reinvestment Act Program, as well as technical assistance in the form of publications and technical resources); and habitat protection (Landowner Assistance, GMA, SEPA planning, Hydraulic Project Approval, and Joint Aquatic Resource Permit Applications).

4.2.3 *Washington Department of Ecology*

The Department of Ecology (DOE) oversees: the Water Resources program to manage water resources to meet current and future needs of the natural environment and Washington's communities; the Water Quality program to restore and protect Washington's water supplies by preventing and reducing pollution; and Shoreline and the Environmental Assistance program for implementing the Shorelines Management Act, the State Environmental Protection Act, the Watershed Planning Act, and 401 Certification of ACOE Permits.

4.2.4 *Washington Department of Transportation*

The Washington State Department of Transportation (WSDOT) must ensure compliance with environmental laws and statutes when designing and executing transportation projects. Programs that consider and mitigate for impacts to salmonid habitat include: the Fish Passage Barrier Removal program; the Regional Road Maintenance ESA Section 4d Program, the Integrated Vegetation Management & Roadside Development Program; Environmental

Mitigation Program; the Stormwater Retrofit Program; and the Chronic Environmental Deficiency Program.

4.2.5 *Interagency Committee for Outdoor Recreation*

Created through the enactment of the Salmon Recovery Act (Washington State Legislature, 1999), the Salmon Recovery Funding Board provides grant funds to protect or restore salmon habitat and assist related activities with local watershed groups known as lead entities. SRFB has helped finance over 500 salmon recovery projects statewide. The Aquatic Lands Enhancement Account (ALEA) was established in 1984 and is used to provide grant support for the purchase, improvement, or protection of aquatic lands for public purposes, and for providing and improving access to such lands. The Washington Wildlife and Recreation Program (WWRP), established in 1990 and administered by the Interagency Committee for Outdoor Recreation, provides funding assistance for a broad range of land protection, park development, preservation/conservation, and outdoor recreation facilities.

4.2.6 *Lower Columbia Fish Recovery Board*

The Lower Columbia Fish Recovery Board encompasses five counties in the Lower Columbia River Region. The 15-member board has four main programs, including habitat protection and restoration activities, watershed planning for water quantity, quality, habitat, and instream flows, facilitating the development of an integrated recovery plan for the Washington portion of the lower Columbia Evolutionarily Significant Units, and conducting public outreach activities.

4.3 Local Government Programs

4.3.1 *Clark County*

Clark County is conducting Comprehensive Planning under the State's Growth Management Act. Clark County manages natural resources under various programs including Critical Areas Ordinance, ESA Program, Road Operations, Parks Operations, Stormwater Management, and the Conservation Futures Program.

4.3.2 *Skamania County*

Skamania County is not planning under the State's Growth Management Act in its Comprehensive Planning process. Skamania County manages natural resources primarily through a Critical Areas Ordinance. Skamania County has adopted special land use and environmental regulations implementing the Columbia River Gorge National Scenic Area Act for some areas within their jurisdiction.

4.3.3 *City of Camas*

The City of Camas adopted its comprehensive plan in 1994, and updated it in March of 2004. Natural resource impacts are managed primarily through critical areas protections.

4.3.4 *City of Washougal*

The City of Washougal's Comprehensive Plan was developed according to the provisions of the Growth Management Act. The Plan specifies critical areas in need of protection.

4.3.5 *Clark Conservation District*

Clark Conservation District provides technical assistance, cost-share assistance, and project monitoring in Clark County. Clark CD assists agricultural landowners in the development of farm plans and in the participation in the Conservation Reserve Enhancement Program. Farm plans optimize use, protect sensitive areas, and conserve resources.

4.3.6 *Underwood Conservation District*

The Underwood CD provides technical assistance, cost-share assistance, project and water quality monitoring, community involvement and education, and support of local stakeholder groups within the district, which incorporates all of Skamania County. UCD implements a wide variety of programs, including conservation and restoration projects, water quality monitoring, a spring tree sales program, education and outreach activities, and support for local watershed committees. The UCD has done very little work in the Washougal Basin; this area offers an opportunity for expansion of their services in cooperation with Clark CD.

4.4 Non-governmental Programs

4.4.1 *Columbia Land Trust*

The Columbia Land Trust is a private, non-profit organization founded in 1990 to work exclusively with willing landowners to find ways to conserve the scenic and natural values of the land and water. Landowners donate the development rights or full ownership of their land to the Land Trust. CLT manages the land under a stewardship plan and, if necessary, will legally defend its conservation values.

4.4.2 *Lower Columbia Fish Enhancement Group*

The Washington State Legislature created the Regional Fisheries Enhancement Group Program in 1990 to involve local communities, citizen volunteers, and landowners in the state's salmon recovery efforts. RFEGs help lead their communities in successful restoration, education and monitoring projects. Every group is a separate, nonprofit organization led by their own board of directors and operational funding from a portion of commercial and recreational fishing license fees administered by the WDFW, and other sources. The mission of the Lower Columbia RFEG (LCFEG) is to restore salmon runs in the lower Columbia River region through habitat restoration, education and outreach, and developing regional and local partnerships.

4.5 NPCC Fish & Wildlife Program Projects

There are no NPCC Fish & Wildlife Program Projects in the Washougal Subbasin.

4.6 Washington Salmon Recovery Funding Board Projects

Type	Project Name	Subbasin
Acquisition	Schoolhouse Creek	Washougal
Restoration	Washougal River: Slough Creek Riparian	Washougal
Restoration	Larson Creek Fish Passage	Washougal
Study	Washougal Assessment	Washougal

5.0 Management Plan

5.1 Vision

Washington lower Columbia salmon, steelhead, and bull trout are recovered to healthy, harvestable levels that will sustain productive sport, commercial, and tribal fisheries through the restoration and protection of the ecosystems upon which they depend and the implementation of supportive hatchery and harvest practices.

The health of other native fish and wildlife species in the lower Columbia will be enhanced and sustained through the protection of the ecosystems upon which they depend, the control of non-native species, and the restoration of balanced predator/prey relationships.

The Washougal Subbasin will play a key role in the regional recovery of salmon and steelhead. Recovery goals call for restoring fall Chinook, summer steelhead, and chum populations to a high or better viability level. This level will provide for a 95% or better probability of populations survival over 100 years. Coho will be restored to a moderate level of viability or a 75 to 95% probability of persistence over 100 years. Salmonid recovery efforts will provide broad ecosystem benefits to a variety of subbasin fish and wildlife species. Recovery will be accomplished through a combination of improvements in subbasin, Columbia River mainstem, and estuary habitat conditions as well as careful management of hatcheries, fisheries, and ecological interactions among species.

Habitat protection or restoration will involve a wide range of Federal, State, Local, and non-governmental programs and projects. Success will depend on effective programs as well as a dedicated commitment to salmon recovery across a broad section of society.

Some hatchery programs will be realigned to focus on protection, conservation, and recovery of native fish. The need for hatchery measures will decrease as productive natural habitats are restored. Where consistent with recovery, other hatchery programs will continue to provide fish for fishery benefits for mitigation purposes in the interim until habitat conditions are restored to levels adequate to sustain healthy, harvestable natural populations.

Directed fishing on sensitive wild populations will be eliminated and incidental impacts of mixed stock fisheries in the Columbia River and ocean will be regulated and limited consistent with wild fish recovery needs. Until recovery is achieved, fishery opportunities will be focused on hatchery fish and harvestable surpluses of healthy wild stocks.

Columbia basin hydropower effects on Washougal subbasin salmonids will be addressed by mainstem Columbia and estuary habitat restoration measures. Hatchery facilities in the Washougal River will also be called upon to produce fish to help mitigate for hydropower impacts on upriver stocks where compatible with wild fish recovery.

This plan uses a planning period or horizon of 25 years. The goal is to achieve recovery of the listed salmon species and the biological objectives for other fish and wildlife species of interest within this time period. It is recognized, however, that sufficient restoration of habitat conditions and watershed processes for all species of interest will likely take 75 years or more.

5.2 Biological Objectives

Biological objectives for Washougal subbasin salmonid populations are based on recovery criteria developed by scientists on the Willamette/Lower Columbia Technical Recovery Team convened by NOAA Fisheries. Criteria involve a hierarchy of ESU, Strata, and Population standards. A recovery scenario describing population-scale biological objectives for all species in all three strata in the lower Columbia ESUs was developed through a collaborative process with stakeholders based on biological significance, expected progress as a result of existing programs, the absence of apparent impediments, and the existence of other management opportunities. Under the preferred alternative, individual populations will variously contribute to recovery according to habitat quality and the population's perceived capacity to rebuild. Criteria, objectives, and the regional recovery scenario are described in greater detail in the Regional Recovery and Subbasin Plan Volume I.

Focal populations in the Washougal subbasin are targeted to improve to a level that contributes to recovery of the species. The scenario differentiates the role of populations by designating primary, contributin, and stabilizing categories. *Primary populations* are those that would be restored to high of better probabilities of persistence. *Contributin populations* are those where low to medium improvements will be needed to achieve stratum-wide average of moderate persistence probability. *Stabilizing populations* are those maintained at current levels. Recovery goals call for restoring fall Chinook, chum, and summer steelhead populations to a high or better viability level. This level will provide for a 95% or better probability of population survival over 100 years. Coho and winter steelhead will be restored to a moderate level of viability or a 75 to 95% probability of persistence over 100 years. Cutthroat will benefit from improvements in stream habitat conditions for anadromous species. Lamprey are also expected to benefit from habitat improvements in the estuary, Columbia River mainstem, and Washougal subbasin although specific spawning and rearing habitat requirements are not well known. Bull trout do not occur in the subbasin.

Table 10. Current viability status of Washougal populations and the biological objective status that is necessary to meet the recovery criteria for the Coastal strata and the lower Columbia ESU.

	ESA	Hatchery	Current		Objective	
Species	**Status**	**Component**	**Viability**	**Numbers**	**Viability**	**Numbers**
Fall Chinook	Threatened	Yes	Low+	2,000-4,500	High[P]	5,800
Chum	Threatened	No	Low	<1,000	High+[P]	1,100-9,400
Coho	Candidate	Yes	Low	unknown	Medium[C]	300
Summer Steelhead	Threatened	Yes	Low+	100-200	High+[P]	500-900
Winter Steelhead	Threatened	Yes	Low+	100-800	Medium[C]	400-600

P = Primary population in recovery scenario
C = Contributing population in recovery scenario
S = Stabilizing population in recovery scenario

5.3 Integrated Strategy

An Integrated Regional Strategy for recovery emphasizes that: 1) it is feasible to recover Washington lower Columbia natural salmon and steelhead to healthy and harvestable levels; 2) substantial improvements in salmon and steelhead numbers, productivity, distribution, and diversity will be required; 3) recovery cannot be achieved based solely on improvements in any one factor; 4) existing programs are insufficient to reach recovery goals, 5) all manageable effects on fish and habitat conditions must contribute to recovery, 6) actions needed for salmon recovery will have broader ecosystem benefits for all fish and wildlife species of interest, and 7) strategies and measures likely to contribute to recovery can be identified but estimates of the incremental improvements resulting from each specific action are highly uncertain. The strategy is described in greater detail in the Regional Recovery and Subbasin Plan Volume I.

The Integrated Strategy recognizes the importance of implementing measures and actions that address each limiting factor and risk category, prescribing improvements in each factor/threat category in proportion to its magnitude of contribution to salmon declines, identifying an appropriate balance of strategies and measures that address regional, upstream, and downstream threats, and focusing near term actions on species at-risk of extinction while also ensuring a long term balance with other species and the ecosystem.

Population productivity improvement increments identify proportional improvements in productivity needed to recover populations from current status to medium, high, and very high levels of population viability consistent with the recovery scenario. Productivity is defined as the inherent population replacement rate and is typically expressed by models as a median rate of population increase (PCC model) or a recruit per spawner rate (EDT model). Corresponding improvements in spawner numbers, juvenile outmigrants, population spatial struction, genetic and life history diversity, and habitat are implicit in productivity improvements.

Improvement targets were developed for each impact factor based on desired population productivity improvements and estimates of potentially manageable impacts (see Section 3.7). Impacts are estimates of the proportional reduction in population productivity associated with human-caused and other potentially manageable impacts from stream habitats, estuary/mainstem habitats, hydropower, harvest, hatcheries, and selected predators. Reduction targets were driven by regional strategy of equitably allocating recovery responsibilities among the six manageable impact factors. Given the ultimate uncertainty in the effects of recovery actions and the need to implement an adaptive recovery program, this approximation should be adequate for developing order-of-magnitude estimates to which recovery actions can be scaled consistent with the current best available science and data. Objectives and targets will need to be confirmed or refined during plan implementation based on new information and refinements in methodology.

The following table (**Error! Reference source not found.**) identifies population and factor-specific improvements consistent with the biological objectives for this subbasin. Per factor increments are less than the population net because factor affects are compounded at different life stages and density dependence is largely limited to freshwater tributary habitat. For example, productivity of Washougal River fall chinook must increase by 30% to reach population viability goals. This requires impact reductions equivalent to a 7% improvement in productivity or survival for each of six factor categories. Thus, tribuary habitat impacts on fall Chinook must decrease from a 47% to a31% impact in order to achieve the required 7% increase in tributary

habitat potential from the current 53% of the historical potential to 69% of the historical potential.

Table 11. Productivity improvements consistent with biological objectives for the Washougal subbasin.

Species	Net increase	Per factor	Baseline impacts					
			Trib.	Estuary	Hydro.	Pred.	Harvest	Hatch.
Fall Chinook	30%	7%	0.47	0.29	0.00	0.24	0.65	0.20
Chum	350%	11%	0.96	0.58	0.00	0.24	0.05	0.01
Coho	na	na	na	na	na	na	na	na
Summer Steelhead	50%	14%	0.71	0.05	0.00	0.24	0.10	0.18
Winter Steelhead	0%	10%	0.74	0.12	0.00	0.24	0.10	0.35

5.4 Tributary Habitat

Habitat assessment results were synthesized in order to develop specific prioritized measures and actions that are believed to offer the greatest opportunity for species recovery in the subbasin. As a first step toward measure and action development, habitat assessment results were integrated to develop a multi-species view of 1) priority areas, 2) factors limiting recovery, and 3) contributing land-use threats. For the purpose of this assessment, limiting factors are defined as the biological and physical conditions serving to suppress salmonid population performance, whereas threats are the land-use activities contributing to those factors. Limiting Factors refer to local (reach-scale) conditions believed to be directly impacting fish. Threats, on the other hand, may be local or non-local. Non-local threats may impact instream limiting factors in a number of ways, including: 1) through their effects on habitat-forming processes – such as the case of forest road impacts on reach-scale fine sediment loads, 2) due to an impact in a contributing stream reach – such as riparian degradation reducing wood recruitment to a downstream reach, or 3) by blocking fish passage to an upstream reach.

Priority areas and limiting factors were determined through the technical assessment, including primarily EDT analysis and the Integrated Watershed Assessment (IWA). As described later in this section, priority areas are also determined by the relative importance of subbasin focal fish populations to regional recovery objectives. This information allows for scaling of subbasin recovery effort in order to best accomplish recovery at the regional scale. Land-use threats were determined from a variety of sources including Washington Conservation Commission Limiting Factors Analyses, the IWA, the State 303(d) list, air photo analysis, the Barrier Assessment, personal knowledge of investigators, or known cause-effect relationships between stream conditions and land-uses.

Priority areas, limiting factors and threats were used to develop a prioritized suite of habitat measures. Measures are based solely on biological and physical conditions. For each measure, the key programs that address the measure are identified and the sufficiency of existing programs to satisfy the measure is discussed. The measures, in conjunction with the program sufficiency considerations, were then used to identify specific actions necessary to fill gaps in measure implementation. Actions differ from measures in that they address program deficiencies as well as biophysical habitat conditions. The process for developing measures and actions is illustrated in Figure 22 and each component is presented in detail in the sections that follow.

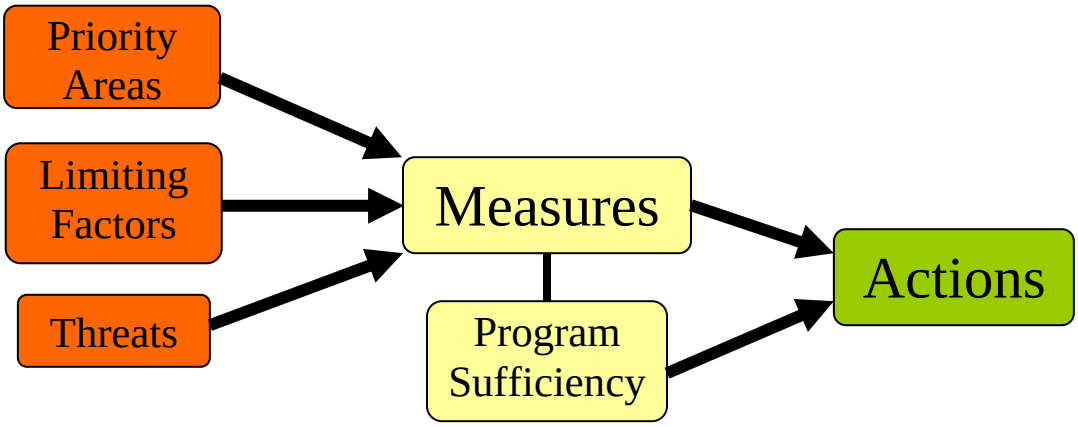


Figure 22. Flow chart illustrating the development of subbasin measures and actions.

5.4.1 *Priority Areas, Limiting Factors and Threats*

Priority habitat areas and factors in the subbasin are discussed below in two sections. The first section contains a generalized (coarse-scale) summary of conditions throughout the basin. The second section is a more detailed summary that presents specific reach and subwatershed priorities.

Summary

Decades of human activity in the Washougal River Subbasin have significantly altered watershed processes and reduced both the quality and quantity of habitat needed to sustain viable populations of salmon and steelhead. Moreover, with the exception of fall Chinook, stream habitat conditions within the Washougal Subbasin have a high impact on the health and viability of salmon and steelhead relative to other limiting factors. The following bullets provide a brief overview of each of the priority areas in the basin. These descriptions are a summary of the reach-scale priorities that are presented in the next section. These descriptions summarize the species most affected, the primary limiting factors, the contributing land-use threats, and the general type of measures that will be necessary for recovery. A tabular summary of the key limiting factors and land-use threats can be found in Table 12.

- **Lower mainstem Washougal** *(reaches Washougal reach 1-tidal to Washougal reach 3)* – Urban and suburban development in the lower Washougal mainstem has significantly altered and degraded watershed processes and habitat conditions. These areas are critically important for chum and fall Chinook spawning and fry colonization. The restoration and protection of the Washougal reach flowing through the town of Washougal provides high potential for fall Chinook. The tidally influenced reaches are the most important for chum. Riparian and floodplain functions are degraded in these areas due to streamside development and channelization features associated with residential/urban development, agriculture, and roadways. Needed habitat measures in the lower mainstem will involve protection of remaining functional habitat, riparian restoration, re-establishing connections between the stream channel and floodplain areas, storm water controls, and measures that address the potential impacts from expanding urban and suburban development around Washougal and Camas.
- **Middle mainstem Washougal** *(reaches Washougal 4 – 9)* – The middle mainstem is important for fall Chinook and coho spawning, incubation, and fry colonization. It is also used by steelhead for rearing. As the human population continues to grow in Clark County, this mixed-

use area of rural residents and small farms and woodlands is likely to experience conversion to more intensive residential use. Riparian areas have been degraded through streamside development and roads. Sediments, lack of habitat diversity, and temperature are the most significant limiting factors in this area. County land use protections will be necessary to protect habitat in these areas should lands be converted from forest to residential.

- **Upper mainstem Washougal** *(reaches Washougal 11 – 17)* – Upper mainstem reaches are important summer and winter rearing areas for summer steelhead. The habitat conditions and watershed processes associated with these reaches are influenced primarily by actions on public and private timberland. While these lands have relatively intact landscape conditions, sediment supply processes are thought to be moderately impaired due to the prevalence of forest roads on unstable slopes. The potential for effective passive restoration is high through upgrading or obliterating roads and improving drainage systems. Policies to enable such actions are underway on private, state, and federal forest lands. Restoration of riparian function is also important. Preservation of existing functional conditions is the primary emphasis on these lands. Forest management policy currently being implemented by the USFS and WA DNR, as well as forest practice regulations for private lands, are expected to provide continuing protections of watershed processes.
- **West Fork Washougal** *(reaches WF Washougal 1-3; Wildboy Creek 1; Texas Creek)* – The West Fork Washougal is important for summer steelhead spawning and rearing. Winter steelhead also make limited use of these reaches. Most of the basin is in private or state forestland with a small amount of crop and pasture land in the lower portion of the basin. Portions of the headwaters (i.e., Hagen Creek basin) have intact forest conditions, while most other areas have been extensively harvested and heavily roaded. Effective habitat measures in the West Fork will involve watershed process restoration and preservation associated with forest practices, much of which is addressed in current forest practices policy and regulations. An additional habitat concern in the West Fork Basin is a dam on Wildboy Creek, which blocks several miles of potentially productive habitat.
- **Little Washougal** *(reaches Little Washougal 1A-1B, 2-3)* – The Little Washougal Basin provides important habitat for winter steelhead adult holding, spawning, and rearing. Most other species (especially coho) also use these reaches. The basin is mixed use and is comprised mostly of private and state forest land with agricultural uses and rural residential development within the lower river valley. The City of Camas water withdrawals from Jones and Boulder creeks create an increased risk of critically low summer flows. Effective habitat measures in the Little Washougal will involve riparian restoration, re-establishing connections between the stream channel and floodplains, growth management, water withdrawal management, and watershed process restoration and preservation on forest lands.

Table 12. Salmonid habitat limiting factors and threats in priority areas. Priority areas include the lower mainstem (LM), middle mainstem (MM), upper mainstem (UM), West Fork (WF), and Little Washougal (LW) portions of the Washougal Subbasin. Linkages between each threat and limiting factor are not displayed – each threat directly and indirectly affects a variety of habitat factors

Limiting Factors						Threats					
	LM	**MM**	**UM**	**WF**	**LW**		**LM**	**MM**	**UM**	**WF**	**LW**
Habitat connectivity						***Agriculture/grazing***					
Blockages to off-channel habitats	✓					Clearing of vegetation	✓	✓			✓
Blockages to stream habitats				✓		Riparian grazing	✓	✓			✓
Habitat diversity						Floodplain filling	✓	✓			✓
Lack of stable instream woody debris	✓	✓	✓	✓	✓	***Urban and rural development***					
Altered habitat unit composition	✓	✓	✓	✓	✓	Clearing of vegetation	✓	✓			✓
Loss of off-channel or side-channel habitats	✓	✓			✓	Floodplain filling	✓	✓			✓
Channel stability						Increased impervious surfaces	✓	✓			✓
Bed and bank erosion	✓		✓		✓	Increased drainage network	✓	✓			✓
Riparian function						Roads – riparian/floodplain impacts	✓	✓			✓
Reduced stream canopy cover	✓	✓	✓	✓	✓	Leaking septic systems					✓
Reduced bank/soil stability	✓	✓	✓	✓	✓	***Forest practices***					
Exotic and/or noxious species	✓	✓			✓	Timber harvests: sediment supply	✓	✓	✓	✓	✓
Reduced wood recruitment	✓	✓	✓	✓	✓	Timber harvests: impacts to runoff	✓	✓		✓	✓
Floodplain function						Riparian harvests			✓	✓	✓
Altered nutrient exchange processes	✓				✓	Forest roads: impacts to sediment supply	✓	✓	✓	✓	✓
Reduced flood flow dampening	✓				✓	Forest roads: impacts to runoff	✓	✓		✓	✓
Restricted channel migration	✓				✓	Forest roads: riparian/floodplain impacts				✓	✓
Disrupted hyporheic processes	✓				✓	Catastrophic wildfire (historical)			✓	✓	✓
Stream flow						Splash-dam logging (historical)		✓	✓		
Altered magnitude, duration, rate of change	✓	✓		✓	✓	***Channel manipulations***					
Water quality						Bank hardening	✓	✓			✓
Altered stream temperature regime	✓	✓	✓	✓	✓	Channel straightening	✓	✓			✓
Excessive turbidity	✓					Artificial confinement	✓	✓			✓
Bacteria					✓	Passage obstruction (dams)				✓	
Substrate and sediment						***Water withdrawals***					
Lack of adequate spawning substrate	✓	✓	✓			Livestock, irrigation, or municipal uses	✓	✓			✓
Excessive fine sediment	✓	✓		✓	✓						

Specific Reach and Subwatershed Priorities

Specific reaches and subwatersheds have been prioritized based on the plan's biological objectives, fish distribution, critical life history stages, current habitat conditions, and potential fish population performance. Reaches have been placed into Tiers (1-4), with Tier 1 reaches representing the areas where recovery measures would yield the greatest benefits towards accomplishing the biological objectives. The reach tiering factors in each fish population's importance relative to regional recovery objectives, as well as the relative importance of reaches within the populations themselves. Reach tiers are most useful for identifying habitat recovery measures in channels, floodplains, and riparian areas. Reach-scale priorities were initially identified within individual populations (species) through the EDT Restoration and Preservation Analysis. This resulted in reaches grouped into categories of high, medium, and low priority for each population (see Stream Habitat Limitations section). Within a subbasin, reach rankings for all of the modeled populations were combined, using population designations as a weighting factor. Population designations for this subbasin are described in the Biological Objectives section. The population designations are 'primary', 'contributing', and 'stabilizing'; reflecting the level of emphasis that needs to be placed on population recovery in order to meet ESA recovery criteria.

Spatial priorities were also identified at the subwatershed scale. Subwatershed-scale priorities were directly determined by reach-scale priorities, such that a Group A subwatershed contains one or more Tier 1 reaches. Scaling up from reaches to the subwatershed level was done in recognition that actions to protect and restore critical reaches might need to occur in adjacent and/or upstream upland areas. For example, high sediment loads in a Tier 1 reach may originate in an upstream contributing subwatershed where sediment supply conditions are impaired because of current land use practices. Subwatershed-scale priorities can be used in conjunction with the IWA to identify watershed process restoration and preservation opportunities. The specific rules for designating reach tiers and subwatershed groups are presented in Table 13. Reach tier designations for this basin are included in Table 14. Reach tiers and subwatershed groups are displayed on a map in Figure 23. A summary of reach- and-subwatershed-scale limiting factors is included in Table 15.

Table 13. Rules for designating reach tier and subwatershed group priorities. See Biological Objectives section for information on population designations.

Designation	Rule
Reaches	
Tier 1:	All high priority reaches (based on EDT) for one or more primary populations.
Tier 2:	All reaches not included in Tier 1 and which are medium priority reaches for one or more primary species and/or all high priority reaches for one or more contributing populations.
Tier 3:	All reaches not included in Tiers 1 and 2 and which are medium priority reaches for contributing populations and/or high priority reaches for stabilizing populations.
Tier 4:	Reaches not included in Tiers 1, 2, and 3 and which are medium priority reaches for stabilizing populations and/or low priority reaches for all populations.
Subwatersheds	
Group A:	Includes one or more Tier 1 reaches.
Group B:	Includes one or more Tier 2 reaches, but no Tier 1 reaches.
Group C:	Includes one or more Tier 3 reaches, but no Tier 1 or 2 reaches.
Group D:	Includes only Tier 4 reaches.

Table 14. Reach Tiers in the Washougal River Subbasin

Tier 1	Tier 2	Tier 3	Tier 4
Washougal 1 tidal	Little Washougal 1	Boulder Cr	Bear Cr
Washougal 14	Little Washougal 1B	Boulder Creek 1B	Bluebird Cr
Washougal 15	Little Washougal 2	Boulder Creek 1C	Boulder Creek Culv1
Washougal 16	Little Washougal 2B	Jones Cr	Boulder Creek Falls1
Washougal 17	Little Washougal 2C	Lacamas	Cougar Cr
Washougal 2 tidal	Little Washougal 2D	Little Washougal 1C	Deer Cr
Washougal 3	Little Washougal 2E	Washougal 10A	Dougan Cr
Washougal 4	Little Washougal 3		Dougan Creek 1B
Washougal 9	Prospector Cr 1		Dougan Creek Culv1
WF Washougal 1B	Texas Cr		Dougan Falls
WF Washougal 2	Washougal 11		Jones Creek 1B
Wildboy Cr 1	Washougal 13		Jones Creek Culv1
	Washougal 18		LB tribA (28.0211)
	Washougal 19		Little Washougal 2 Culv1
	Washougal 5		Little Washougal 4
	Washougal 6		Little Washougal Culv1
	Washougal 7		Little Washougal Culv2
	Washougal 8		Lookout Cr
	WF Washougal 1		Meander Cr
	WF Washougal 3		Prospector Cr 2
			Prospector Creek 1B
			Prospector Creek Culv1
			RB Trib 1A
			RB trib 1B
			RB trib 1C
			RB trib 2
			RB trib1 Barrier 1
			Salmon Falls
			Silver Cr
			Stebbins C
			Timber Cr
			Timber Creek 2
			Timber Creek Culv1
			Washougal 10
			Washougal 12
			Washougal 20
			Washougal Falls1
			WF Washougal Falls1
			WF Washougal Weir
			Wildboy Cr 2
			Winkler Cr

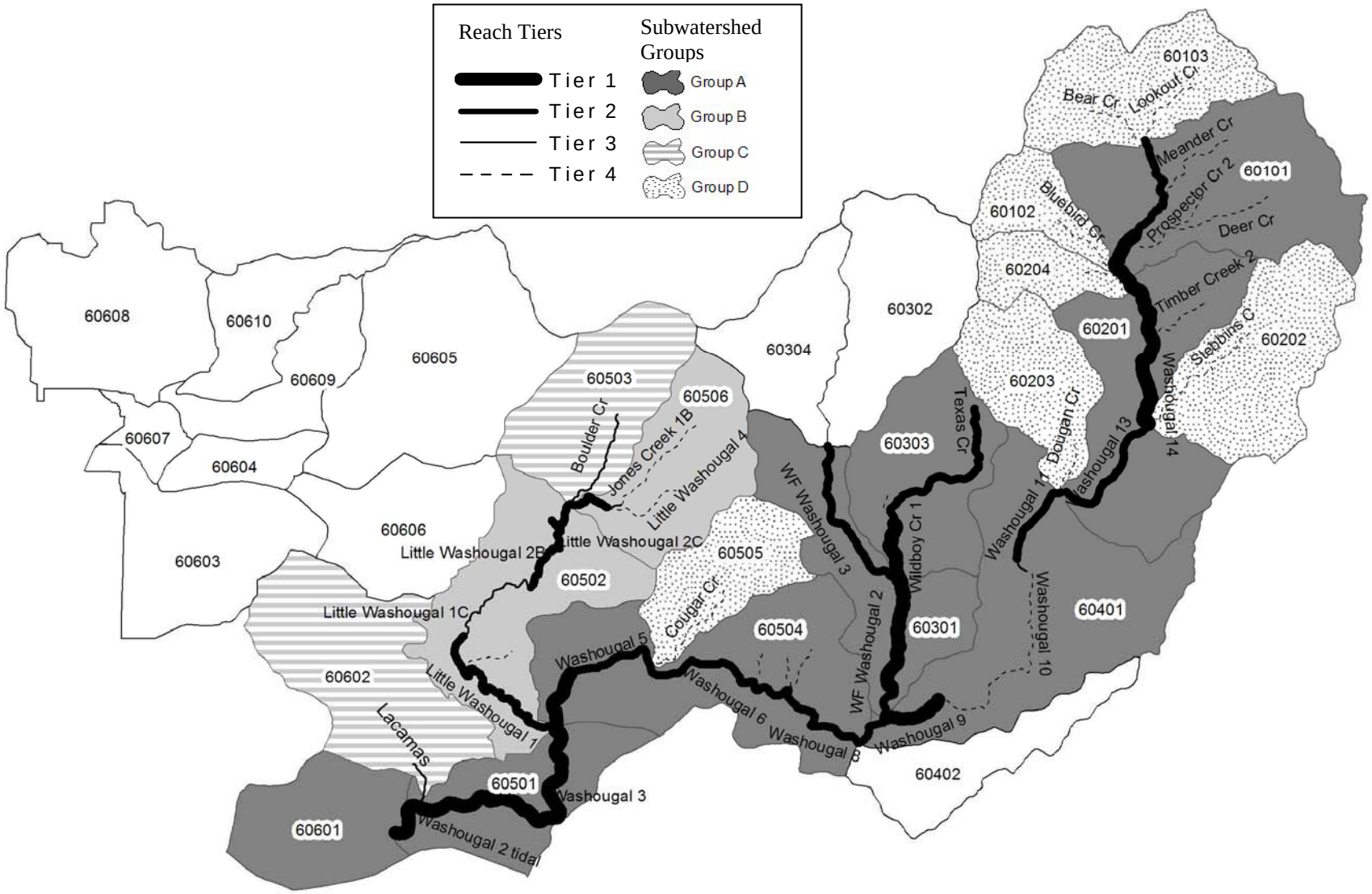


Figure 23. Reach tiers and subwatershed groups in the Washougal Subbasin. Tier 1 reaches and Group A subwatersheds represent the areas where recovery actions would yield the greatest benefits with respect to species recovery objectives. The subwatershed groups are based on Reach Tiers. Priorities at the reach scale are useful for identifying stream corridor recovery measures. Priorities at the subwatershed scale are useful for identifying watershed process recovery measures. Watershed process recovery measures for stream reaches will need to occur within the surrounding (local) subwatershed as well as in upstream contributing subwatersheds.

Table 15. Summary Table of reach- and subwatershed-scale limiting factors in priority areas. The table is organized by subwatershed groups, beginning with the highest priority group. Species-specific reach priorities, critical life stages, high impact habitat factors, and recovery emphasis (P=preservation, R=restoration, PR=restoration and preservation) are included. Watershed process impairments: F=functional, M=moderately impaired, I=impaired. Species abbreviations: ChS=spring Chinook, ChF=fall Chinook, StS=summer steelhead, StW=winter steelhead.

Sub-watershed Group	Subwatersheds	Reaches within subwatershed	Species present	High priority reaches by species	Critical life stages	High impact habitat factors	Restoration or preservation emphasis	Watershed processes (local)			Watershed processes (watershed)	
								Hydrology	Sediment	Riparian	Hydrology	Sediment
A	60101	Deer Cr Meander Cr Prospector Cr 1 Prospector Cr 2 Prospector Creek 1B Prospector Creek Culv1 Washougal 16 Washougal 17 Washougal 18 Washougal 19	StS	Washougal 16 Washougal 17	summer rearing winter rearing	habitat diversiy flow	P	F	M	F	F	M
			Coho									
	60201	Dougan Falls Timber Cr Timber Creek 2 Timber Creek Culv1 Washougal 12 Washougal 13 Washougal 14 Washougal 15	StS	Washougal 14 Washougal 15	summer rearing winter rearing	habitat diversiy flow	P	M	M	M	F	M
			Coho									
	60301	WF Washougal 1 WF Washougal 1B WF Washougal 2 WF Washougal 3 WF Washougal Falls1 WF Washougal Weir	StS	WF Washougal 1B WF Washougal 2	egg incubation summer rearing winter rearing	habitat diversiy temperature flow sediment pathogens	PR	M	F	M	I	M
			StW	WF Washougal 1	egg incubation fry colonization summer rearing	temperature sediment	R					
	60303	Texas Cr Wildboy Cr 1 Wildboy Cr 2	StS	Wildboy Cr 1	egg incubation summer rearing winter rearing	none	P	I	M	M	I	M
	60501	Washougal 1 tidal Washougal 2 tidal Washougal 3	StS					I	M	I	I	M
			Chum	Washougal 1 tidal Washougal 2 tidal	spawning egg incubation fry colonization adult holding	none	R					
			ChF	Washougal 3	spawning egg incubation fry colonization	sediment	PR					
			StW									
			Coho	Washougal 3	egg incubation summer rearing winter rearing	habitat diversity temperature sediment	R					
	60601	Washougal 1 tidal	StS					I	M	I	M	M
			Chum	Washougal 1 tidal	spawning egg incubation fry colonization adult holding	none	R					
			ChF									
			StW									
			Coho									
	60401	Salmon Falls Washougal 10 Washougal 10A Washougal 11 Washougal 9 Washougal Falls1	StS					I	M	M	M	M
			ChF	Washougal 9	spawning egg incubation fry colonization	sediment	P					
			StW									
			Coho	Washougal 9	egg incubation summer rearing winter rearing	habitat diversity temperature sediment	R					
	60504	RB trib 1A RB trib 1B RB trib 1C RB trib 2 RB trib1 Barrier 1 Washougal 4 Washougal 5 Washougal 6 Washougal 7 Washougal 8 Winkler Cr	StS					I	M	M	I	M
			ChF	Washougal 4	spawning egg incubation fry colonization	none	PR					
			StW	Washougal 5	egg incubation fry colonization summer rearing winter rearing	none	R					
			Coho	Washougal 4 Washougal 8	egg incubation fry colonization summer rearing winter rearing	channel stability habitat diversity sediment	R					

Sub-watershed Group	Subwatersheds	Reaches within subwatershed	Species present	High priority reaches by species	Critical life stages	High impact habitat factors	Restoration or preservation emphasis	Watershed processes (local)			Watershed processes (watershed)	
								Hydrology	Sediment	Riparian	Hydrology	Sediment
B	60502	LB tribA (28.0211)	StS					I	M	M	I	M
		Little Washougal 1 Little Washougal 1B Little Washougal 1C Little Washougal 2 Little Washougal 2 Culv1 Little Washougal 2B	StW	Little Washougal 1 Little Washougal 1B Little Washougal 2 Little Washougal 2B Little Washougal 2C Little Washougal 2D	egg incubation fry colonization summer rearing winter rearing adult holding	temperature sediment key habitat quantity	PR					
		Little Washougal 2C Little Washougal 2D Little Washougal 2E Little Washougal Culv1 Little Washougal Culv2	Coho	Little Washougal 2C Little Washougal 2E	egg incubation fry colonization summer rearing winter rearing	channel stability habitat diversity temperature sediment key habitat quantity	R					
	60506	Jones Cr Jones Creek 1B Jones Creek Culv1 Little Washougal 3	StW	Little Washougal 3	egg incubation fry colonization summer rearing winter rearing	none	PR	M	M	M	M	M
		Little Washougal 4	Coho									
C	60503	Boulder Cr Boulder Creek 1B Boulder Creek 1C Boulder Creek Culv1 Boulder Creek Falls1	StW Coho					M	F	M	M	F
	60602	Lacamas	StW					M	F	M	I	M
			Coho									
D	60102	Bluebird Cr	StS					F	F	F	F	F
			Coho									
	60103	Bear Cr Degraded Lookout Cr Washougal 20	StS					F	M	M	F	M
	60202	Stebbins C	StS					F	M	F	F	M
	60203	Dougan Cr Dougan Creek 1B Dougan Creek Culv1	StS					I	M	M	I	M
	60204	Silver Cr	StS					F	F	M	F	F
	60505	Cougar Cr	StW					I	M	M	I	M

5.4.2 *Habitat Measures*

Measures are means to achieve the regional strategies that are applicable to the Washougal subbasin and necessary to accomplish the biological objectives for focal fish species. Measures are based on the technical assessments for this subbasin (Section 3.0) as well as on the synthesis of priority areas, limiting factors, and threats presented earlier in this section. The measures applicable to the Washougal Subbasin are presented in priority order in Table 16. Each measure has a set of submeasures that define the measure in greater detail and add specificity to the particular circumstances occurring within the subbasin. The table for each measure and associated submeasures indicates the limiting factors that are addressed, the contributing threats that are addressed, the species that would be most affected, and a short discussion. Priority locations are given for some measures. Priority locations typically refer to either stream reaches or subwatersheds, depending on the measure. Addressing measures in the highest priority areas first will provide the greatest opportunity for effectively accomplishing the biological objectives.

Following the list of priority locations is a list of the programs that are the most relevant to the measure. Each program is qualitatively evaluated as to whether it is sufficient or needs expansion with respect to the measure. This exercise provides an indication of how effectively the measure is already covered by existing programs, policy, or projects; and therefore indicates where there is a gap in measure implementation. This information is summarized a discussion of in Program Sufficiency and Gaps.

The measures themselves are prioritized based on the results of the technical assessment and in consideration of principles of ecosystem restoration (e.g. NRC 1992, Roni et al. 2002). These principles the hypothesis that the most efficient way to achieve ecosystem recovery in the face of uncertainty is to focus on the following priorities for approaches: 1) protect existing functional habitats and the processes that sustain them, 2) allow no further degradation of habitat or supporting processes, 3) re-connect isolated habitat, 4) restore watershed processes (ecosystem function), 5) restore habitat structure, and 6) create new habitat where it is not recoverable. These priorities have been adjusted for the specific circumstances occurring in the Washougal Subbasin. These priorities are adjusted depending on the results of the technical assessment and on the specific circumstances occurring in the basin. For example, re-connecting isolated habitat could be adjusted to a lower priority if there is little impact to the population created from passage barriers.

5.4.3 *Habitat Actions*

The prioritized measures and associated gaps are used to develop specific Actions for the subbasin. These are presented in Table 17. Actions are different than the measures in a number of ways: 1) actions have a greater degree of specificity than measures, 2) actions consider existing programs and are therefore not based strictly on biophysical conditions, 3) actions refer to the agency or entity that would be responsible for carrying out the action, and 4) actions are related to an expected outcome with respect to the biological objectives. Actions are not presented in priority order, but instead represent the suite of activities that are all necessary for recovery of listed species. The priority for implementation of these actions will consider the priority of the measures they relate to, the “size” of the gap they are intended to fill, and feasibility considerations.

Table 16. Prioritized measures for the Washougal Subbasin

#1 – Protect stream corridor structure and function

Submeasures	Factors Addressed	Threats Addressed	Target Species	Discussion
A. Protect floodplain function and channel migration processes B. Protect riparian function C. Protect access to habitats D. Protect instream flows through management of water withdrawals E. Protect channel structure and stability F. Protect water quality G. Protect the natural stream flow regime	Potentially addresses many limiting factors	Potentially addresses many limiting factors	All Species	Important productive habitats for steelhead that are currently in good condition are located in the upper mainstem Washougal and in the West Fork Washougal basin. These reaches are supported by relatively functional watershed sediment, flow, and riparian processes. The lower mainstem reaches provide critically important habitat that has been heavily impacted by adjacent land-uses and channel modifications. Preventing additional habitat degradation in this area is necessary for population persistence.

Priority Locations

1st- Tier 1 or 2 reaches with functional riparian conditions
Reaches: Washougal 16-19
2nd- Tier 1 or 2 reaches in mixed-use lands at risk of further degradation
Reaches: Washougal 1 tidal, 2 tidal, 3 – 9; WF Washougal 1; Little Washougal 1, 1B, 2 - 4
3rd- Remaining Tier 1 and 2 reaches

Key Programs

Agency	Program Name	Sufficient	Needs Expansion
NOAA Fisheries	ESA Section 7 and Section 10	✓	
US Army Corps of Engineers (USACE)	Dredge & fill permitting (Clean Water Act sect. 404); Navigable waterways protection (Rivers & Harbors Act Sect, 10)	✓	
USFS	Northwest Forest Plan	✓	
WA Department of Natural Resources (WDNR)	State Lands HCP, Forest Practices Rules, Riparian Easement Program, Aquatic Lands Authorization	✓	
WA Department of Fish and Wildlife (WDFW)	Hydraulics Projects Approval	✓	
Clark County	Comprehensive Planning		✓
Skamania County	Comprehensive Planning		✓
City of Camas	Comprehensive Planning, Water Supply		✓
City of Washougal	Comprehensive Planning, Water Supply		✓
Clark Conservation District / NRCS	Agricultural land habitat protection programs		✓
Underwood Conservation District / NRCS	Agricultural land habitat protection programs		✓
Noxious Weed Control Boards (State and County level)	Noxious Weed Education, Enforcement, Control		✓
Non-Governmental Organizations (NGOs) (e.g. Columbia Land Trust) and public agencies	Land acquisition and easements		✓

Program Sufficiency and Gaps
Alterations to stream corridor structure that may impact aquatic habitats are regulated through the WDFW Hydraulics Project Approval (HPA) permitting program. Other regulatory protections are provided through USACE permitting, ESA consultations, HCPs, DNR Aquatics Lands Authorization, and local government ordinances. Riparian areas within private timberlands are protected through the Forest Practices Rules (FPR) administered by WDNR. The FPRs came out of an extensive review process and are believed to adequately protect riparian areas with respect to stream shading, bank stability, and LWD recruitment. The program is new, however, and careful monitoring of the effect of the regulations is necessary, particularly effects on subwatershed hydrology and sediment delivery. Land-use conversion and development are increasing throughout the basin and local government ordinances must ensure that new development occurs in a matter that protects key habitats. Conversion of land-use from forest or agriculture to residential use has the potential to increase impairment of aquatic habitat, particularly when residential development is paired with flood control measures. Local governments can limit potentially harmful land-use conversions by thoughtfully directing growth through comprehensive planning and tax incentives, by providing consistent protection of critical areas across jurisdictions, and by preventing development in floodplains. In cases where existing programs are unable to provide sufficient resource protections, conservation easements and land acquisition may be necessary.

#2 – Protect hillslope processes

Submeasures	Factors Addressed	Threats Addressed	Target Species	Discussion
A. Manage forest practices to minimize impacts to sediment supply processes, runoff regime, and water quality B. Manage agricultural practices to minimize impacts to sediment supply processes, runoff regime, and water quality C. Manage growth and development to minimize impacts to sediment supply processes, runoff regime, and water quality	• Excessive fine sediment • Excessive turbidity • Embedded substrates • Stream flow – altered magnitude, duration, or rate of change of flows • Water quality impairment	• Timber harvest – impacts to sediment supply, water quality, and runoff processes • Forest roads – impacts to sediment supply, water quality, and runoff processes • Agricultural practices – impacts to sediment supply, water quality, and runoff processes • Development – impacts to sediment supply, water quality, and runoff processes	All species	There currently are relatively functional hillslope sediment and hydrology processes in portions of the headwaters and the West Fork Washougal basin. In other areas, hillslope runoff and sediment delivery processes have been degraded due to past intensive timber harvest, road building, and fires. Limiting additional degradation will be necessary to prevent further habitat impairment.

Priority Locations

1st- Functional subwatersheds contributing to Tier 1 or 2 reaches (functional for sediment *or* flow according to the IWA – local rating)
Subwatersheds: 60304, 60204, 60102, 60103, 60101, 60202, 60302, 60503, 60301, 60608, 60607, 60603, 60602

2nd- All other functional subwatersheds plus Moderately Impaired subwatersheds contributing to Tier 1 or 2 reaches
Subwatersheds: All remaining subwatersheds

Key Programs

Agency	Program Name	Sufficient	Needs Expansion
WDNR	Forest Practices Rules, State Lands HCP	✓	
USFS	Northwest Forest Plan	✓	
Clark County	Comprehensive Planning		✓
Skamania County	Comprehensive Planning		✓
City of Camas	Comprehensive Planning		✓
City of Washougal	Comprehensive Planning		✓
Clark Conservation District / NRCS	Agricultural land habitat protection programs		✓
Underwood Conservation District / NRCS	Agricultural land habitat protection programs		✓

Program Sufficiency and Gaps

Hillslope processes on federal forest lands are protected through the provisions of the Northwest Forest Plan. State forest lands are protected through the State Forest Lands HCP. Hillslope processes on private forest lands are protected through Forest Practices Rules administered by the WDNR. These rules, developed as part of the Forests & Fish Agreement, are believed to be adequate for protecting watershed sediment supply, runoff processes, and water quality on private forest lands. Small private landowners may be unable to meet some of the requirements on a timeline commensurate with large industrial landowners. Financial assistance to small owners would enable greater and quicker compliance. On non-forest lands (agriculture and developed), local government comprehensive planning is the primary nexus for protection of hillslope processes. Local governments can control impacts through zoning that protects existing uses, through stormwater management ordinances, and through tax incentives to prevent agricultural and forest lands from becoming developed. These protections are especially important in the Washougal basin due to expanding growth. There are few to no regulatory protections of hillslope processes that relate to agricultural practices; such deficiencies need to be addressed through local or state authorities. Protecting hillslope processes on agricultural lands would also benefit from the expansion of technical assistance and landowner incentive programs (NRCS, Conservation Districts).

#3- Restore degraded hillslope processes on forest, agricultural, and developed lands

Submeasures	Factors Addressed	Threats Addressed	Target Species	Discussion
A. Upgrade or remove problem forest roads B. Reforest heavily cut areas not recovering naturally C. Employ agricultural Best Management Practices with respect to contaminant use, erosion, and runoff D. Reduce watershed imperviousness E. Reduce effective stormwater runoff from developed areas	• Excessive fine sediment • Excessive turbidity • Embedded substrates • Stream flow – altered magnitude, duration, or rate of change of flows • Water quality impairment	• Timber harvest – impacts to sediment supply, water quality, and runoff processes • Forest roads – impacts to sediment supply, water quality, and runoff processes • Agricultural practices – impacts to sediment supply, water quality, and runoff processes • Development – impacts to water quality and runoff processes	All species	Hillslope runoff and sediment delivery processes have been degraded as a result of past intensive timber harvest, road building, agriculture, residential development, and urbanization. These processes must be addressed for reach-level habitat recovery to be successful.

Priority Locations

1st- Moderately impaired or impaired subwatersheds contributing to Tier 1 reaches (mod. impaired or impaired for sediment *or* flow according to IWA – local rating)
Subwatersheds: All subwatersheds except 60304, 60204, 60102

Key Programs

Agency	Program Name	Sufficient	Needs Expansion
WDNR	State Lands HCP, Forest Practices Rules, Habitat Projects	✓	
USFS	Northwest Forest Plan, Habitat Projects	✓	
WDFW	Habitat Program		✓
Clark Conservation District / NRCS	Agricultural land habitat restoration programs		✓
Underwood Conservation District / NRCS	Agricultural land habitat restoration programs		✓
NGOs, tribes, agencies, landowners	Habitat Projects		✓
Clark County	Stormwater Management		✓
Skamania County	Stormwater Management		✓
City of Camas	Stormwater Management		✓
City of Washougal	Stormwater Management		✓

Program Sufficiency and Gaps

Forest management programs including the Northwest Forest Plan (federal timber lands), the new Forest Practices Rules (private timber lands), and the WDNR HCP (state timber lands) are expected to afford protections that will passively and actively restore degraded hillslope conditions. Timber harvest rules are expected to passively restore sediment and runoff processes. The road maintenance and abandonment requirements for private timber lands are expected to actively address road-related impairments within a 15 year time-frame. While these strategies are believed to be largely adequate to protect watershed processes, the degree of implementation and the effectiveness of the prescriptions will not be fully known for at least another 15 or 20 years. Of particular concern is the capacity of some forest land owners, especially small forest owners, to conduct the necessary road improvements (or removal) in the required timeframe. Additional financial and technical assistance would enable small forest landowners to conduct the necessary improvements in a timeline parallel to large industrial timber land owners. Ecological restoration of existing developed and agricultural lands occurs relatively infrequently and there are no programs that specifically require restoration in these areas. Restoring existing developed and farmed lands can involve retrofitting facilities with new materials, replacing existing systems, adopting new management practices, and creating or re-configuring landscaping. Means of increasing restoration activity include increasing landowner participation through education and incentive programs, building support for projects on public lands/facilities, requiring Best Management Practices through permitting and ordinances, and increasing available funding for entities to conduct projects.

#4 - Restore riparian conditions throughout the basin

Submeasures	Factors Addressed	Threats Addressed	Target Species	Discussion
A. Restore the natural riparian plant community B. Exclude livestock from riparian areas C. Eradicate invasive plant species from riparian areas	• Reduced stream canopy cover • Altered stream temperature regime • Reduced bank/soil stability • Reduced wood recruitment • Lack of stable instream woody debris • Exotic and/or invasive species • Bacteria	• Timber harvest – riparian harvests • Riparian grazing • Clearing of vegetation due to agriculture and residential development	All species	Riparian areas have been degraded throughout the basin and recovery of riparian vegetation is necessary in both forest and mixed-use areas. Much of this recovery is expected to occur passively on forest lands due to legal protections of riparian buffers. Active measures, such as hardwood-to-conifer conversion, may be necessary in some areas. The increasing abundance of exotic and invasive species is of particular concern. Riparian restoration projects are relatively inexpensive and are often supported by landowners.

Priority Locations

1st- Tier 1 reaches
2nd- Tier 2 reaches
3rd- Tier 3 reaches
4th- Tier 4 reaches

Key Programs

Agency	Program Name	Sufficient	Needs Expansion
WDNR	State Lands HCP, Forest Practices Rules, Habitat Projects	✓	
USFS	Northwest Forest Plan, Habitat Projects	✓	
WDFW	Habitat Program		✓
Clark Conservation District / NRCS	Agricultural land habitat restoration programs		✓
Underwood Conservation District / NRCS	Agricultural land habitat restoration programs		✓
NGOs, tribes, Conservation Districts, agencies, landowners	Habitat Projects		✓
Noxious Weed Control Boards (State and County level)	Noxious Weed Education, Control, Enforcement		✓

Program Sufficiency and Gaps

There are no regulatory mechanisms for actively restoring riparian conditions; however, existing programs will afford protections that will allow for the *passive* restoration of riparian forests. These protections are believed to be adequate for riparian areas on forest lands that are subject to the Northwest Forest Plan, Forest Practices Rules or the State forest lands HCP. Other lands receive variable levels of protection and passive restoration through the Clark and Skamania Counties Comprehensive Plans. Many degraded riparian zones in urban, agricultural, rural residential, or transportation corridors will not passively restore with existing regulatory protections and will require active measures. Riparian restoration in these areas may entail livestock exclusion, tree planting, road relocation, invasive species eradication, and adjusting current land-use in the riparian zone. Means of increasing restoration activity include building partnerships with landowners, increasing landowner participation in conservation programs, allowing restoration projects to serve as mitigation for other activities, and increasing funding for NGOs, government entities, and landowners to conduct restoration projects.

#5 – Restore degraded water quality with emphasis on temperature impairments

Submeasures	Factors Addressed	Threats Addressed	Target Species	Discussion
A. Exclude livestock from riparian areas B. Increase riparian shading C. Decrease channel width-to-depth ratios D. Reduce delivery of chemical contaminants to streams E. Address leaking septic systems	• Bacteria • Altered stream temperature regime • Chemical contaminants	• Timber harvest – riparian harvests • Riparian grazing • Leaking septic systems • Clearing of vegetation due to rural development and agriculture • Chemical contaminants from agricultural and developed lands	All species	There are several stream segments listed on the 2002-2004 draft 303(d) list for temperature and dissolved oxygen impairment. There are also a few reaches listed for fecal coliform bacteria impairment, which is more of a human health concern than a fish health concern. Reach Washougal 8 is listed for bacteria impairment. Most of the water quality impaired stream segments are located in the Lacamas Creek basin. Reduced riparian canopy cover is a contributor to temperature impairment. Livestock grazing and leaking septic systems are likely responsible for elevated bacteria levels. The degree of impact of agricultural pollutants is unknown and needs further assessment.

Priority Locations

1st- Tier 1 or 2 reaches with 303(d) listings (2002-2004 draft list)
Reaches: Washougal 8 (bacteria)
2nd- Other reaches with 303(d) listings
Reaches: Lacamas Cr (temperature, bacteria, dissolved oxygen); Matney Cr (temperature, bacteria); Shanghai Cr (temperature); Fifth Plain Cr (temperature, dissolved oxygen) – Matney, Shanghai, and Fifth Plain are located within the Lacamas Creek Basin
3rd- All remaining reaches

Key Programs

Agency	Program Name	Sufficient	Needs Expansion
Washington Department of Ecology	Water Quality Program		✓
WDNR	State Lands HCP, Forest Practices Rules	✓	
WDFW	Habitat Program		✓
Clark Conservation District / NRCS	Agricultural land habitat restoration programs, Centennial Clean Water		✓
Underwood Conservation District / NRCS	Agricultural land habitat restoration programs, Centennial Clean Water		✓
Lower Columbia Fish Enhancement Group	Habitat Projects		✓
NGOs, tribes, Conservation Districts, agencies, landowners	Habitat Projects		✓
Clark County Health Department	Septic System Program		✓
Skamania County Health Department	Septic System Program		✓

Program Sufficiency and Gaps

The WDOE Water Quality Program manages the State 303(d) list of impaired water bodies. There are several listings in the Washougal Subbasin, primarily in the Lacamas Basin (WDOE 2004). A Water Quality Clean-up Plan (TMDL) is required by the WDOE for each parameter and it is anticipated that the TMDL will adequately set forth strategies to address the water quality impairments. It will be important that the strategies specified in the TMDLs are implementable and adequately funded. The 303(d) listings are believed to address the primary water quality concerns; however, other impairments may exist that the current monitoring effort is unable to detect. Additional monitoring is needed to fully understand the degree of water quality impairment in the basin.

#6 – Provide for adequate instream flows during critical periods

Submeasures	Factors Addressed	Threats Addressed	Target Species	Discussion
A. Protect instream flows through water rights closures and enforcement B. Restore instream flows through acquisition of existing water rights C. Restore instream flows through implementation of water conservation measures	• Stream flow – maintain or improve flows during low-flow Summer months	• Water withdrawals	All species	Expanding growth has increased pressures for ground and surface water withdrawals. It is important that withdrawals are managed carefully to minimize impacts on aquatic resources. Of particular concern are municipal withdrawals from Jones and Boulder Creeks. There are also concerns with illegal withdrawals occurring throughout the basin. This measure applies to instream flows associated with water withdrawals and diversions, generally a concern only during low flow periods. Hillslope processes also affect low flows but these issues are addressed in separate measures.

Priority Locations

1st- Little Washougal Basin (municipal withdrawals from Jones and Boulder Creeks)
2nd- Lacamas Basin
3rd- Remainder of Basin

Key Programs

Agency	Program Name	Sufficient	Needs Expansion
Washington Department of Ecology	Water Resources Program		✓
WRIA 27/28 Watershed Planning Unit	Watershed Planning	✓	
City of Camas	Water Supply Program		✓
City of Washougal	Water Supply Program		✓

Program Sufficiency and Gaps

The Water Resources Program of the WDOE, in cooperation with the WDFW and other entities, manages water rights and instream flow protections. A collaborative process for setting and managing instream flows was launched in 1998 with the Watershed Planning Act (HB 2514), which called for the establishment of local watershed planning groups who's objective was to recommend instream flow guidelines to WDOE through a collaborative process.

The current status of this planning effort is to adopt a watershed plan by December 2004. Instream flow management in the Washougal Subbasin will be conducted using the recommendations of the WRIA 27/28 Planning Unit, which is coordinated by the LCFRB. Draft products of the WRIA 27/28 watershed planning effort can be found on the LCFRB website: www.lcfrb.gen.wa.us. The recommendations of the planning unit have been developed in close coordination with recovery planning and the instream flow prescriptions developed by this group are anticipated to adequately protect instream flows necessary to support healthy fish populations. The measures specified above are consistent with the Planning Unit's recommended strategies. Water supply for the City of Camas is limited and expansion may affect instream flows in the Washougal Basin. Ecology should implement the recommendations of the WRIA 27/28 Planning Unit relative to instream flow rule development.

#7 – Restore access to habitat blocked by artificial barriers

Submeasures	Factors Addressed	Threats Addressed	Target Species	Discussion
A. Restore access to isolated habitats blocked by culverts, dams, or other barriers	• Blockages to channel habitats • Blockages to off-channel habitats	• Dams, culverts, in-stream structures	Steelhead	A dam on Wildboy Creek blocks at least 1.7 miles of potential habitat. There are several other known blockages on small tributaries, including blockages associated with water intake facilities on Jones and Boulder Creeks. Passage restoration projects should focus only on cases where it can be demonstrated that there is good potential benefit and reasonable project costs.

Priority Locations

1st- Wildboy Creek (Wildboy Creek Dam)
2nd- Other small tributaries with blockages

Key Programs

Agency	Program Name	Sufficient	Needs Expansion
WDNR	Forest Practices Rules, Family Forest Fish Program, State Forest Lands HCP	✓	
WDFW	Habitat Program		✓
Washington Department of Transportation / WDFW	Fish Passage Program	✓	
Lower Columbia Fish Enhancement Group	Habitat Projects		✓
NGOs, tribes, Conservation Districts, agencies, landowners	Habitat Projects		✓
Skamania County	Roads Maintenance		✓
Clark County	Roads Maintenance		✓

Program Sufficiency and Gaps

The Forest Practices Rules require forest landowners to restore fish passage at artificial barriers by 2016. Small forest landowners are given the option to enroll in the Family Forest Fish Program in order to receive financial assistance to fix blockages. The Washington State Department of Transportation, in a cooperative program with WDFW, manages a program to inventory and correct blockages associated with state highways. The Salmon Recovery Funding Board, through the Lower Columbia Fish Recovery Board, funds barrier removal projects. Past efforts have corrected blockages and have identified others in need of repair. Additional funding is needed to correct remaining blockages, particularly the Wildboy Dam on Wildboy Creek. Further monitoring and assessment is needed to ensure that all potential blockages have been identified and prioritized.

#8 - Restore floodplain function and channel migration processes in the mainstem and major tributaries

Submeasures	Factors Addressed	Threats Addressed	Target Species	Discussion
A. Set back, breach, or remove artificial confinement structures	• Bed and bank erosion • Altered habitat unit composition • Restricted channel migration • Disrupted hyporheic processes • Reduced flood flow dampening • Altered nutrient exchange processes • Channel incision • Loss of off-channel and/or side-channel habitat • Blockages to off-channel habitats	• Floodplain filling • Channel straightening • Artificial confinement	All species	There has been degradation of floodplain connectivity and constriction of channel migration zones along the lower mainstem downstream of the WF Washougal, especially in and around the town of Washougal. Significant degradation has also occurred on the lower and middle Little Washougal River. Selective breaching, setting back, or removing confining structures would help to restore floodplain and CMZ function as well as facilitate the creation of off-channel and side channel habitats. There are feasibility issues with implementation due to private lands, existing infrastructure already in place, potential flood risk to property, and large expense.

Priority Locations

1st- Tier 1 reaches with hydro-modifications (obtained from EDT ratings)
Reaches: Washougal 1-tidal, 2-tidal, 3-4; WF Washougal 1B
2nd- Tier 2 reaches with hydro-modifications
Reaches: Washougal 5-7; Little Washougal 1, 1B, 2, 2B
3rd- Other reaches with hydro-modifications
Reaches: Washougal 10A; Deer Cr; Dougan Cr; Dougan Cr 1B; RB trib 1A-1C, 2; LB tribA; Lacamas Creek

Key Programs

Agency	Program Name	Sufficient	Needs Expansion
WDFW	Habitat Program		✓
USACE	Water Resources Development Act (Sect. 1135 & Sect. 206)		✓
Lower Columbia Fish Enhancement Group	Habitat Projects		✓
NGOs, tribes, Conservation Districts, agencies, landowners	Habitat Projects		✓
WDNR	Aquatic Lands Authorization	✓	

Program Sufficiency and Gaps

There currently are no programs that set forth strategies for restoring floodplain function and channel migration processes in the Washougal Basin. Without programmatic changes, projects are likely to occur only seldom as opportunities arise and only if financing is made available. Means of increasing restoration activity include building partnerships with landowners, increasing landowner participation in conservation programs, allowing restoration projects to serve as mitigation for other activities, and increasing funding for NGOs and government entities to conduct projects. Floodplain restoration projects are often expensive, large-scale efforts that require partnerships among many agencies, NGOs, and landowners. Building partnerships is a necessary first step toward floodplain and CMZ restoration.

#9 - Restore channel structure and stability

Submeasures	Factors Addressed	Threats Addressed	Target Species	Discussion
A. Place stable woody debris in streams to enhance cover, pool formation, bank stability, and sediment sorting B. Structurally modify channel morphology to create suitable habitat C. Restore natural rates of erosion and mass wasting within river corridors	• Lack of stable instream woody debris • Altered habitat unit composition • Reduced bank/soil stability • Excessive fine sediment • Excessive turbidity • Embedded substrates	• None (symptom-focused restoration strategy)	All species	Channel structure and stability have been degraded by past riparian timber harvest, splash dam logging, removal of LWD from channels, and channel confinement. Large wood installation projects could benefit habitat conditions in many areas although watershed processes contributing to wood deficiencies should be considered and addressed prior to placing wood in streams. Other structural enhancements to stream channels may be warranted in some places, especially in lowland alluvial reaches that have been simplified through channel straightening and confinement.

Priority Locations

1st- Tier 1 reaches
2nd- Tier 2 reaches
3rd- Tier 3 reaches
4th- Tier 4 reaches

Key Programs

Agency	Program Name	Sufficient	Needs Expansion
NGOs, tribes, agencies, landowners	Habitat Projects		✓
USFS	Northwest forest Plan, Habitat Projects	✓	
WDNR	Habitat Projects		✓
WDFW	Habitat Program		✓
USACE	Water Resources Development Act (Sect. 1135 & Sect. 206)		✓
Lower Columbia Fish Enhancement Group	Habitat Projects		✓
Clark Conservation District / NRCS	Agricultural land habitat restoration programs		✓
Underwood Conservation District / NRCS	Agricultural land habitat restoration programs		✓

Program Sufficiency and Gaps

There are no regulatory mechanisms for actively restoring channel stability and structure. Passive restoration is expected to slowly occur as a result of protections afforded to riparian areas and hillslope processes. Past projects have largely been opportunistic and have been completed due to the efforts of local NGOs, landowners, and government agencies; such projects are likely to continue in a piecemeal fashion as opportunities arise and if financing is made available. The lack of LWD in stream channels, and the importance of wood for habitat of listed species, places an emphasis on LWD supplementation projects. Means of increasing restoration activity include building partnerships with landowners, increasing landowner participation in conservation programs, allowing restoration projects to serve as mitigation for other activities, and increasing funding for NGOs, government entities, and landowners to conduct restoration projects.

#10 – Create/restore off-channel and side-channel habitat

Submeasures	Factors Addressed	Threats Addressed	Target Species	Discussion
A. Restore historical off-channel and side-channel habitats where they have been eliminated B. Create new channel or off-channel habitats (i.e. spawning channels)	• Loss of off-channel and/or side-channel habitat	• Floodplain filling • Channel straightening • Artificial confinement	chum, coho	There has been significant loss of off-channel and side-channel habitats, especially along the lower mainstem that has been extensively channelized. This has severely limited chum spawning habitat and coho overwintering habitat. Targeted restoration or creation of habitats would increase available habitat where full floodplain and CMZ restoration is not possible.

Priority Locations

1st- Lower mainstem Washougal
2nd- Other reaches that may have potential for off-channel and side-channel habitat restoration or creation

Key Programs

Agency	Program Name	Sufficient	Needs Expansion
WDFW	Habitat Program		✓
NGOs, tribes, Conservation Districts, agencies, landowners	Habitat Projects		✓
Lower Columbia Fish Enhancement Group	Habitat Projects		✓
USACE	Water Resources Development Act (Sect. 1135 & Sect. 206)		✓

Program Sufficiency and Gaps

There are no regulatory mechanisms for creating or restoring off-channel and side-channel habitat. Means of increasing restoration activity include building partnerships with landowners, increasing landowner participation in conservation programs, allowing restoration projects to serve as mitigation for other activities, and increasing funding for NGOs, government entities, and landowners to conduct restoration projects.

Table 17. Habitat actions for the Washougal Subbasin.

Action	Status	Responsible Entity	Measures Addressed	Spatial Coverage of Target Area[1]	Expected Biophysical Response[2]	Certainty of Outcome[3]
Wash 1. Expand standards in County and City Comprehensive Plans to afford high levels of protections of ecologically important areas (i.e. stream channels, riparian zones, floodplains, CMZs, wetlands, unstable geology)	**Expansion of existing program or activity**	**Clark County, Skamania County, City of Washougal, City of Camas, WDOE**	**1 & 2**	**High: Applies to all private lands under county jurisdiction**	**High: Protection of water quality, riparian function, stream channel structure (e.g. LWD), floodplain function, CMZs, wetland function, runoff processes, and sediment supply processes**	**High**
Wash 2. Manage future growth and development patterns to ensure the protection of watershed processes. This includes limiting the conversion of agriculture and timber lands to developed uses through zoning regulations and tax incentives (except in city urban growth boundaries)	**Expansion of existing program or activity**	**Clark County, Skamania County, City of Washougal, City of Camas**	**1 & 2**	**High: Applies to all private lands under county jurisdiction**	**High: Protection of water quality, riparian function, stream channel structure (e.g. LWD), floodplain function, CMZs, wetland function, runoff processes, and sediment supply processes**	**High**
Wash 3. Conduct floodplain restoration where feasible along the lower mainstem and in major tributaries that have experienced channel confinement. Build partnerships with landowners and agencies and provide financial incentives	**New program or activity**	**NRCS, Clark CD, UCD, NGOs, WDFW, LCFRB, USACE, LCFEG**	**4, 5, 7, 8 & 9**	**Medium: Lower mainstem Washougal, Little Washougal, and Lacamas Creek**	**Medium: Restoration of floodplain function, habitat diversity, and habitat availability.**	**High**
Wash 4. Prevent floodplain impacts from new development through land use controls and Best Management Practices	**New program or activity**	**Clark County, Skamania County, City of Washougal, City of Camas, WDOE**	**1**	**Medium: Applies to privately owned floodprone lands under local government jurisdiction**	**High: Protection of floodplain function, CMZ processes, and off-channel/side-channel habitat. Prevention of reduced habitat diversity and key habitat availability**	**High**
Wash 5. Increase funding available to purchase easements or property in sensitive areas in order to protect watershed function where existing programs are inadequate	**Expansion of existing program or activity**	**LCFRB, NGOs, WDFW, USFWS, BPA (NPCC)**	**1 & 2**	**Medium: Residential, agricultural, or forest lands at risk of further degradation**	**High: Protection of riparian function, floodplain function, water quality, wetland function, and runoff and sediment supply processes**	**High**
Wash 6. Review and adjust operations to ensure compliance with the Endangered Species Act; examples include roads, parks, and weed management	**Expansion of existing program or activity**	**Clark County, Skamania County, Camas, Washougal**	**1, 3, 4, & 5**	**Low: Applies to lands under public jurisdiction**	**Medium: Protection of water quality, greater streambank stability, reduction in road-related fine sediment delivery, restoration and preservation of fish access to habitats**	**High**
Wash 7. Increase technical assistance to landowners and increase landowner participation in conservation programs that protect and restore habitat and habitat-forming processes. Includes increasing the incentives (financial or otherwise) and increasing program marketing and outreach	**Expansion of existing program or activity**	**NRCS, CCD, UCD, WDNR, WDFW, Clark County, Skamania County**	**All measures**	**High: Private lands. Applies to lands in agriculture, rural residential, and forestland uses throughout the basin**	**High: Increased landowner stewardship of habitat. Potential improvement in all factors**	**Medium**
Wash 8. Continue to manage federal forest lands according to the Northwest Forest Plan	**Activity is currently in place**	**USFS**	**1, 2, 3, 4, 5 & 7**	**Low: National Forest lands in the upper basin**	**High: Increase in instream LWD; reduced stream temperature extremes; greater streambank stability; reduction in road-related fine sediment delivery; decreased peak flow**	**High**

[1] Relative amount of basin affected by action
[2] Expected response of action implementation
[3] Relative certainty that expected results will occur as a result of full implementation of action

Action	Status	Responsible Entity	Measures Addressed	Spatial Coverage of Target Area[1]	Expected Biophysical Response[2]	Certainty of Outcome[3]
					volumes; restoration and preservation of fish access to habitats	
Wash 9. Fully implement and enforce the Forest Practices Rules (FPRs) on private timber lands in order to afford protections to riparian areas, sediment processes, runoff processes, water quality, and access to habitats	Activity is currently in place	WDNR	1, 2, 3, 4, 5 & 7	Medium: Private commercial timber lands	High: Increase in instream LWD; reduced stream temperature extremes; greater streambank stability; reduction in road-related fine sediment delivery; decreased peak flow volumes; restoration and preservation of fish access to habitats	Medium
Wash 10. Implement the prescriptions of the WRIA 27/28 Watershed Planning Unit regarding instream flows. Develop a regional water source in the Vancouver Lake Lowlands (or Steigerwald area) within 10 years	Activity is currently in place	WDOE, WDFW, WRIA 27/28 Planning Unit, City of Camas, City of Washougal	6	High: Entire basin	High: Adequate instream flows to support life stages of salmonids and other aquatic biota.	High
Wash 11. Increase the level of implementation of voluntary habitat enhancement projects in high priority reaches and subwatersheds. This includes building partnerships, providing incentives to landowners, and increasing funding	Expansion of existing program or activity	LCFRB, BPA (NPCC), NGOs, WDFW, NRCS, Clark CD, UCD, LCFEG	3, 4, 5, 7, 8, 9 & 10	High: Priority stream reaches and subwatersheds throughout the basin	Medium: Improved conditions related to water quality, LWD quantities, bank stability, key habitat availability, habitat diversity, riparian function, floodplain function, sediment availability, & channel migration processes	Medium
Wash 12. Increase technical support and funding to small forest landowners faced with implementation of Forest and Fish requirements for fixing roads and barriers to ensure full and timely compliance with regulations	Expansion of existing program or activity	WDNR	1, 2, 3, 4, 5 & 7	Medium: Small private timberland owners	High: Reduction in road-related fine sediment delivery; restoration and preservation of fish access to habitats	Medium
Wash 13. Conduct forest practices on state lands in accordance with the Habitat Conservation Plan in order to afford protections to riparian areas, sediment processes, runoff processes, water quality, and access to habitats	Activity is currently in place	WDNR	1, 2, 3, 4, 5 & 7	Medium: State timber lands in the Washougal Basin (approximately 30% of the basin area)	High: Increase in instream LWD; reduced stream temperature extremes; greater streambank stability; reduction in road-related fine sediment delivery; decreased peak flow volumes; restoration and preservation of fish access to habitats. Response is medium because of location and quantity of state lands	Medium
Wash 14. Protect and restore native plant communities from the effects of invasive species	Expansion of existing program or activity	Weed Control Boards (local and state); NRCS, Clark CD, UCD, LCFEG	1 & 4	High: Greatest risk is in agriculture and residential use areas	Medium: restoration and protection of native plant communities necessary to support watershed and riparian function	Low
Wash 15. Assess the impact of fish passage barriers throughout the basin and restore access to potentially productive habitats	Expansion of existing program or activity	WDFW, WDNR, Clark County, Skamania County WSDOT, LCFEG	7	Medium: Several miles of stream are potentially blocked by artificial barriers	Medium: Increased spawning and rearing capacity due to access to blocked habitat. Habitat is marginal in most cases	Medium
Wash 16. Assess, upgrade, and replace on-site sewage systems that may be contributing to water quality impairment	Expansion of existing program or activity	Clark County, Skamania County, Clark CD, UCD, LCFEG	5	High: Private agricultural and rural residential lands	Medium: Protection and restoration of water quality (bacteria)	Low
Wash 17. Create and/or restore lost side-channel/off-channel habitat for chum spawning and coho overwintering	New program or activity	LCFRB, BPA (NPCC), NGOs, WDFW, NRCS, Clark CD, UCD, LCFEG	10	Low: Lower mainstem Washougal	High: Increased habitat availability for spawning and rearing	Low

5.5 Hatcheries

5.5.1 *Subbasin Hatchery Strategy*

The desired future state of fish production within the Washougal River Basin includes natural salmon and steelhead populations that are improving on a trajectory to recovery and hatchery programs that either enhance the natural fish recovery trajectory or are operated to not impede progress towards recovery. Hatchery recovery measures in each subbasin are tailored to the specific ecological and biological circumstances for each species in the subbasin. The recovery strategy includes a mixture of conservation programs and mitigation programs. Mitigation programs involve areas or practices selected for consistency with natural population conservation and recovery objectives. A summary of the types of natural production enhancement strategies and fishery enhancement strategies to be implemented in the Washougal River Basin are displayed by species in Table 18. More detailed descriptions and discussion of the regional hatchery strategy can be found in the Regional Recovery and Subbasin Plan Volume I.

Table 18. Summary of natural production and fishery enhancement strategies to be implemented in the Washougal River Basin.

		Species					
		Fall Chinook	Spring Chinook	Coho	Chum	Winter Steelhead	Summer Steelhead
Natural Production Enhancement	Supplementation				✓		
	Hatch/Nat Conservation [1/]	✓					
	Isolation					✓2/	✓2/
	Refuge						
Fishery Enhancement	Hatchery Production	✓		✓		✓	✓

[1/] Hatchery and natural population management strategy coordinated to meet biological recovery objectives. Strategy may include integration and/or Isolation over time. Strategies will be unique to biological and ecological circumstances in each watershed.
2/Upper Washougal area above the Washougal Salmon Hatchery.

Conservation-based hatchery programs include strategies and measures which are specifically intended to enhance or protect production of a particular wild fish population within the basin. A unique conservation strategy is developed for each species and watershed depending on the status of the natural population, the biological relationship between the hatchery and natural populations, ecological attributes of the watershed, and logistical opportunities to jointly manage the populations. Four types of hatchery conservation strategies may be employed:

Natural Refuge Watersheds: In this strategy, certain sub-basins are designated as wild-fish-only areas for a particular species. The refuge areas include watersheds where populations have persisted with minimum hatchery influence and areas that may have a history of hatchery production but would not be subjected to future hatchery influence as part of the recovery strategy. More refuge areas may be added over time as wild populations recover. These refugia provide an opportunity to monitor population trends independent of the confounding influence of hatchery fish and will be key indicators of natural population status within the ESU. This strategy is not planned for the Washougal Basin,

Hatchery Supplementation: This strategy utilizes hatchery production as a tool to assist in rebuilding depressed natural populations. Supplementation would occur in selected areas that are producing natural fish at levels significantly below current capacity or capacity is expected to increase as a result of immediate benefits of habitat or passage improvements. This is intended to be a temporary measure to jump start critically low populations and to bolster natural fish numbers above critical levels in selected areas until habitat is restored to levels where a population can be self sustaining. This strategy would include chum in the Washougal Basin.

Hatchery/Natural Isolation: This strategy is focused on physically separating hatchery adult fish from naturally-produced adult fish to avoid or minimize spawning interactions to allow natural adaptive processes to restore native population diversity and productivity. The strategy may be implemented in the entire watershed or more often in a section of the watershed upstream of a barrier or trap where the hatchery fish can be removed. This strategy is currently aimed at hatchery steelhead in watersheds with trapping capabilities. The strategy may also become part of spring and fall chinook as well as coho strategy in certain watersheds in the future as unique wild runs develop. This definition refers only to programs where fish are physically sorted using a barrier or trap. This strategy would be implemented for winter and summer steelhead in the upper Washougal basin, upstream of the Washougal Hatchery. Some fishery mitigation programs, particularly for steelhead, are managed to isolate hatchery and wild stocks based on run timing and release locations.

Hatchery/Natural Merged Conservation Strategy: This strategy addresses the case where natural and hatchery fish have been homogenized over time such that they are principally all one stock that includes the native genetic material for the basin. Many spring chinook, fall chinook, and coho populations in the lower Columbia currently fall into this category. In many cases, the composite stock productivity is no longer sufficient to support a self-sustaining natural population especially in the face of habitat degradation. The hatchery program will be critical to maintaining any population until habitat can be improved and a strictly natural population can be re-established. This merged strategy is intended to transition these mixed populations to a self-supporting natural population that is not subsidized by hatchery production or subject to deleterious hatchery impacts. Elements include separate management of hatchery and natural subpopulations, regulation of hatchery fish in natural areas, incorporation of natural fish into hatchery broodstock, and annual abundance-driven distribution. Corresponding programs are expected to evolve over time dependent on changes in the populations and in the habitat productivity. This strategy is primarily aimed at chinook salmon in areas where harvest production occurs and would be implemented for fall chinook in the Washougal Basin.

Not every lower Columbia River hatchery program will be turned into a conservation program. The majority of funding for lower Columbia basin hatchery operations (including the Washougal Basin hatcheries) is for producing salmon and steelhead for harvest to mitigate for lost harvest of natural production due to hydro development and habitat degradation. Programs for fishery enhancement will continue during the recovery period, but will be managed to minimize risks and ensure they do not compromise recovery objectives for natural populations. It is expected that the need to produce compensatory fish for harvest through artificial production will reduce in the future as natural populations recover and become harvestable. There are fishery enhancement programs for fall chinook, coho, winter steelhead, and summer steelhead in the Washougal Basin.

The Washougal Basin Hatchery Complex will be operated to include natural production enhancement strategies for the Washougal River as well as support natural chum enhancement in the lower Gorge. and Washougal area tributaries. The Washougal River Complex will continue to support fall Chinook, steelhead and coho fisheries with hatchery releases in the Washougal Basin, and also produce winter and summer steelhead for fisheries in other lower Columbia tributaries and coho for fisheries in the Klickitat River.. This plan adds three new conservation programs to Washougal River Hatchery Complex (Table 19).

Table 19. A summary of conservation and harvest strategies to be implemented through Washougal and Skamania hatchery programs.

		Stock
Natural Production Enhancement	Supplementation	Washougal Area Chum√
		Lower Gorge Chum
	Hatch/Nat Conservation 1/	Fall Chinook√
	Isolation	Winter Steelhead2/
		Summer Steelhead2/
	Broodstock development	Washougal Area Chum √
Fishery Enhancement	In-basin releases	Washougal Late Coho
	(final rearing at a Washougal Complex)	Washougal Fall Chinook
		Skamania Winter Steelhead
		Skamania Summer Steelhead
	Out of Basin Releases	Skamania Summer Steelhead: EF Lewis, NF
	(rearing at a Washougal Complex)	Lewis, SF Toutle, NF Toutle, Kalama.
		Skamania Winter Steelhead: EF Lewis, Salmon Creek.
		Lewis Late Coho: Klickitat

1/ May include integrated and/or isolated strategy over time.
2/ Isolation in the upper Washougal above the Salmon Hatchery.
√ Denotes new program

5.5.2 *Hatchery Measures and Actions*

Hatchery strategies and measures are focused on evaluating and reducing biological risks consistent with the conservation strategies identified for each natural population. Artificial production programs within Washougal River facilities have been evaluated in detail through the WDFW Benefit-Risk Assessment Procedure (BRAP) relative to risks to natural populations. The BRAP results were utilized to inform the development of these program actions specific to the Washougal River Basin (Table 20). The Sub-Basin plan hatchery recovery actions were developed in coordination with WDFW and at the same time as the Hatchery and Genetic Management Plans (HGMP) were developed by WDFW for each hatchery program. As a result, the hatchery actions represented in this document will provide direction for specific actions which will be detailed in the HGMPs submitted by WDFW for public review and for NOAA fisheries approval. It is expected that the HGMPs and these recovery actions will be complimentary and provide a coordinated strategy for the Washougal River Basin hatchery programs. Further explanation of specific strategies and measures for hatcheries can be found in the Regional Recovery and Subbasin Plan Volume I.

Table 20. Hatchery program actions to be implemented in the Washougal River Basin.

Action	Hatchery Program Addressed	Natural Populations Addressed	Limiting Factors Addressed	Threats Addressed	Expected Outcome
• Unique conservation strategy is developed for Washougal fall Chinook based on status of natural population and biological relationship between natural and hatchery populations. Options may include integration and/or segregation strategies over time as developed to meet recovery objectives. Actions may include: • Deliberate and consistent infusion of natural produced adults into the hatchery program. • Install a weir in the lower Washougal River to separate hatchery and natural produced fish to control proportions of hatchery and natural fish on the spawning grounds and in the hatchery. • Matrix system developed to determine annual distribution of wild and hatchery adults based on biological relationship and annual abundance	Washougal Hatchery fall Chinook	Washougal fall Chinook	Domestication, Diversity Abundance	In-breeding Non-local genetic traits	• Increased genetic diversity in natural and hatchery populations • Improved productivity and increased abundance in the natural produced fall chinook population • Hatchery production is managed consistent with natural population recovery objectives and to provide harvest opportunity.
• Continue to mass mark steelhead and coho hatchery releases to provide the means to identify hatchery fish for selective fisheries and to distinguish between hatchery and wild fish in the Washougal basin • Establish a mass marking program for fall Chinook to enable selective fishing options and to accomplish measure 1.	Washougal Hatchery coho, steelhead, and fall Chinook.	Washougal winter and summer steelhead. Washougal coho, and Washougal fall Chinook	Domestication, Diversity, Abundance	In-breeding Harvest	• Maintain lower harvest impacts for natural Washougal coho and steelhead compared to hatchery production • Provide the opportunity to develop fishing regulations which accomplish a lower harvest impact for wild Washougal fall Chinook compared to Washougal Hatchery fall Chinook. • Enable visual identification of hatchery and wild returns to provide the means to account for and manage the natural and wild escapement consistent with biological objectives
• Develop a chum brood stock utilizing natural returns to the Washougal area. This could include Washougal River as well as Columbia River and tributary populations immediately downstream of the Washougal River (depending on DNA analysis). Utilize broodstock for supplementation and risk management. • Continue to utilize Washougal hatchery for supplementation and risk management of the lower Gorge chum population •	Continues current chum enhancement program and develops new chum enhancement programs	Lower Gorge and Washougal area chum populations	Abundance, Spatial distribution	Low numbers of natural spawners Ecologically appropriate natural brood stock	• Establish an appropriate chum brood stock to supplement and manage near-term risks associated with low abundance of local populations. Increases abundance and distribution of Washougal area chum populations. • Provide a mechanism to assist in the rebuilding of the Duncan Creek chum population and to mitigate for reduced spawning access for lower gorge populations in Hamilton and Hardy creeks and in the mainstem Columbia near Ives Island during low flow years.
• Hatchery produced steelhead, coho, and fall Chinook will be scheduled for release during the time when the maximum numbers of fish are smolted and prepared to emigrate rapidly. releases	Washougal Hatchery steelhead, coho, and fall Chinook	Washougal fall Chinook, chum, and coho	Predation, Competition	Hatchery smolt residence time in the Washougal River.	• Minimal residence time of hatchery released juvenile resulting in reduced ecological interactions between hatchery and wild juvenile. Displacement of natural

Action	Hatchery Program Addressed	Natural Populations Addressed	Limiting Factors Addressed	Threats Addressed	Expected Outcome
• Juvenile rearing strategies will be implemented to provide a fish growth schedule which coincides with an optimum release time for hatchery production success and to minimize time spent in the Washougal River •					fall chinook from preferred habitat by larger hatchery fall chinook will be minimized. • Improved survival of wild juveniles, resulting in increased productivity and abundance
• Investigate location and feasibility of a weir site in the lower Washougal to enable sorting of adult fall Chinook returns • Adequate function of the weir at the Washougal salmon hatchery to enable efficient collection of hatchery coho and fall Chinook and passage and access to the upper Washougal habitats for wild steelhead and coho. • Adequate function of the ladder and trap at Skamania Hatchery to enable efficient collection of hatchery steelhead and passage and access to the upper North Fork Washougal habitats for wild steelhead and cutthroat trout. • Hatchery effluent discharge complies with NPDES permit monitoring requirements. Fish health monitored and treated as per co-mangers fish health policy • Adequate function of screens at Skamania and Washougal hatcheries	All species	All species	Access, Habitat quality, survival	Fish barriers, water quality, In-take screens	• Ability to implement integrated hatchery and natural brood stock programs by efficient collection systems. • Access to natural spawning habitats for natural returning fish • Hatchery fish disease controlled and water quality standards upheld to avoid impact to habitat quality in the Washougal River downstream of the hatchery. • In-take screens are effective in avoiding mortality of wild fall Chinook, steelhead, or coho juveniles
** Monitoring and evaluation, adaptive management	All species	All species	Hatchery production performance, Natural production performance	All of above	• Clear standards for performance and adequate monitoring programs to evaluate actions. • Adaptive management strategy reacts to information and provides clear path for adjustment or change to meet performance standard

** Extension or improvement of existing actions-may require additional funding*

*** New measure-will likely require additional funding*

5.6 Harvest

Fisheries are both an impact that reduces fish numbers and an objective of recovery. The long-term vision is to restore healthy, harvestable natural salmonid populations in many areas of the lower Columbia basin. The near-term strategy involves reducing fishery impacts on natural populations to ameliorate extinction risks until a combination of actions can restore natural population productivity to levels where increased fishing may resume. The regional strategy for interim reductions in fishery impacts involves: 1) elimination of directed fisheries on natural populations, 2) regulation of mixed stock fisheries for healthy hatchery and natural populations to limit and minimize indirect impacts on natural populations, 3) scaling of allowable indirect impacts for consistency with recovery, 4) annual abundance-based management to provide added protection in years of low abundance while allowing greater fishing opportunity consistent with recovery in years with much higher abundance, and 5) mass marking of hatchery fish for identification and selective fisheries.

Actions to address harvest impacts are generally focused at a regional level to cover fishery impacts accrued to lower Columbia salmon as they migrate along the Pacific Coast and through the mainstem Columbia River. Fisheries are no longer directed at weak natural populations but incidentally catch these fish while targeting healthy wild and hatchery stocks. Subbasin fisheries affecting natural populations have been largely eliminated. Fishery management has shifted from a focus on maximum sustainable harvest of the strong stocks to ensuring protection of the weak stocks. Weak stock protections often preclude access to large numbers of otherwise harvestable fish in strong stocks.

Fishery impact limits to protect ESA-listed weak populations are generally based on risk assessments that identify points where fisheries do not pose jeopardy to the continued persistence of a listed group of fish. In many cases, these assessments identify the point where additional fishery reductions provide little reduction in extinction risks. A population may continue to be at significant risk of extinction but those risks are no longer substantially affected by the specified fishing levels. Often, no level of fishery reduction will be adequate to meet naturally-spawning population escapement goals related to population viability. The elimination of harvest will not in itself lead to the recovery of a population. However, prudent and careful management of harvest can help close the gap in a coordinated effort to achieve recovery.

Fishery actions specific to the subbasins are addressed through the Washington State Fish and Wildlife sport fishing regulatory process. This public process includes an annual review focused on emergency type regulatory changes and a comprehensive review of sport fishing regulations which occurs every two years. This regulatory process includes development of fishing rules through the Washington Administrative Code (WAC) which are focused on protecting weak stock populations while providing appropriate access to harvestable populations. The actions consider the specific circumstances in each area of each subbasin and respond with rules that fit the relative risk to the weak populations in a given time and area of the subbasin. Following is a general summary of the fishery regulatory and protective actions specific to the Washougal River (Table 21). More complete details can be found in the WDFW Sport Fishing Rules Pamphlet.

Table 21. Summary regulatory and protective fishery actions in the Washougal basin

Species	General Fishing	Explanation	Other Protective Fishing Actions	Explanation
Fall Chinook	Open for fall Chinook	Hatchery fish are produced for harvest. Hatchery fish are not mass marked	Night closures, gear restrictions, area closures, and release requirements during spawning time	Protects fall chinook in areas of high concentration and while spawning
chum	Closed to retention	Protects natural chum. Hatchery chum are not produced for harvest		
coho	Retain only adipose fin-clip marked coho	Selective fishery for hatchery coho, unmarked wild coho must be released	Lower basin tributaries and Upper watershed closed to salmon and steelhead	Protects wild spawners in the upper Washougal and tributary creeks.
Winter steelhead	Retain only adipose fin-clip marked steelhead	Selective fishery for hatchery steelhead, unmarked wild steelhead must be released	Spring closures in the upper watershed and minimum size restrictions in affect	Spring closure Protects adult wild steelhead during spawning and minimum size protects juvenile steelhead
Summer Steelhead	Retain only adipose fin-clip marked steelhead	Selective fishery for hatchery steelhead, unmarked wild steelhead must be released	Spring closures in the upper watershed and North Fork Washougal, and minimum size restrictions	Protects adult summer steelhead during spawning and juveniles

Regional actions cover species from multiple watersheds which share the same migration routes and timing, resulting in similar fishery exposure. Regional strategies and measures for harvest are detailed in the Regional Recovery and Subbasin Plan Volume I. A number of regional strategies for harvest involve implementation of actions within specific subbasins. In-basin fishery management is generally applicable to steelhead and salmon while regional management is more applicable to salmon. Regional Harvest measures with significant application to the Washougal Subbasin populations are summarized Table 22:

Table 22. Regional harvest actions from Volume I, Chapter 7 with significant application to the Washougal River Subbasin populations.

Action	Description	Responsible Parties	Programs	Comments
**F.A8	Develop a regional mass marking program for tule fall Chinook	WDFW, NOAA, USFWS, Col. Tribes	U.S. Congress, Washington Fish and Wildlife Commission, U.S. v. Oregon, PSC	Retention of salmon is prohibited in Grays River sport fisheries, however marking of other hatchery tule Chinook would provide regional selective fishing options.
**F.A12	Monitor chum handle rate in winter steelhead and late coho tributary sport fisheries.	WDFW	WDFW Creel Program	State agencies would include chum incidental handle assessments as part of their annual tributary sport fishery sampling plan.
*F.A13	Monitor and evaluate commercial and sport impacts to naturally-spawning steelhead in salmon and hatchery steelhead target fisheries.	WDFW, ODFW	Columbia River Compact, BPA Fish and Wildlife Program, PFMC	Includes monitoring of naturally-spawning steelhead encounter rates in fisheries and refinement of long-term catch and release handling mortality estimates. Would include assessment of the current monitoring programs and determine their adequacy in formulating naturally-spawning steelhead incidental mortality estimates.
*F.A14	Continue to improve gear and regulations to minimize incidental impacts to naturally-spawning steelhead.	WDFW, ODFW	Columbia River Compact, BPA Fish and Wildlife Program	Regulatory agencies should continue to refine gear, handle and release methods, and seasonal options to minimize mortality of naturally-spawning steelhead in commercial and sport fisheries.
*F.A20	Maintain selective sport fisheries in ocean, Columbia River, and tributaries and monitor naturally-spawning stock impacts.	WDFW, NOAA, ODFW, USFWS	Columbia River Compact, PFMC	Mass marking of lower Columbia River coho and steelhead has enabled successful ocean and freshwater selective fisheries to be implemented since 1998. Marking programs should be continued and fisheries monitored to provide improved estimates of naturally-spawning salmon and steelhead release mortality.

* Extension or improvement of existing action
** New action

5.7 Hydropower

No dams hydropower facilities exist in the Washougal subbasin, hence, no in-basin hydropower actions are identified. Washougal River anadromous fish populations will benefit from regional hydropower measures recovery measures and actions identified in regional plans to address habitat effects in the mainstem and estuary.

5.8 Mainstem and Estuary Habitat

Washougal River anadromous fish populations will also benefit from regional recovery strategies and measures identified to address habitat conditions and threats in the Columbia River mainstem and estuary. Regional recovery plan strategies involve: 1) avoiding large scale habitat changes where risks are known or uncertain, 2) mitigating small-scale local habitat impacts to ensure no net loss, 3) protecting functioning habitats while restoring impaired habitats to functional conditions, 4) striving to understand, protect, and restore habitat-forming processes, 5) moving habitat conditions in the direction of the historical template which is presumed to be more consistent with restoring viable populations, and 6) improving understanding of salmonid habitats use in the Columbia River mainstem and estuary and their response to habitat changes. A series of specific measures are detailed in the regional plan for each of these strategies.

5.9 Ecological Interactions

For the purposes of this plan, ecological interactions refer to the relationships of salmon and steelhead with other elements of the ecosystem. Regional strategies and measures pertaining to exotic non-native species, effects of salmon on system productivity, and native predators of salmon are detailed and discussed at length in the Regional Recovery and Subbasin Plan Volume I and are not reprised at length in each subbasin plan. Strategies include 1) avoiding, eliminating introductions of new exotic species and managing effects of existing exotic species, 2) recognizing the significance of salmon to the productivity of other species and the salmon themselves, and 3) managing predation by selected species while also maintaining a viable balance of predator populations. A series of specific measures are detailed in the regional plan for each of these strategies. Implementation will occur at the regional and subbasin scale.

5.10 Monitoring, Research, & Evaluation

Biological status monitoring quantifies progress toward ESU recovery objectives and also establishes a baseline for evaluating causal relationships between limiting factors and a population response. Status monitoring involves routine and intensive efforts. Routine monitoring of biological data consists of adult spawning escapement estimates, whereas routine monitoring for habitat data consists of a suite of water quality and quantity measurements.

Intensive monitoring supplements routine monitoring for populations and basins requiring additional information. Intensive monitoring for biological data consists of life-cycle population assessments, juvenile and adult abundance estimates and adult run-reconstruction. Intensive monitoring for habitat data includes stream/riparian surveys, and continuous stream flow assessment. The need for additional water quality sampling may be identified. Rather than prescribing one monitoring strategy, three scenarios are proposed ranging in level of effort and cost from high to low (Level 1-3 respectively). Given the fact that routine monitoring is ongoing, only intensive monitoring varies between each level.

An in-depth discussion of the monitoring, research and evaluation (M, R & E) approach for the Lower Columbia Region is presented in the Regional Recovery and Management Plan. It

includes site selection rationale, cost considerations and potential funding sources. The following tables summarize the biological and habitat monitoring efforts specific to the Washougal Basin.

Table 23. Summary of the biological monitoring plan for Washougal River populations.

Washougal: Lower Columbia Biological Monitoring Plan					
Monitoring Type	Fall Chinook	Chum	Coho	Winter Steelhead	Summer Steelhead
Routine	AA	AA	AA	AA	AA
Intensive					
Level 1	✓	✓			✓
Level 2		✓			✓
Level 3		✓			

AA Annual adult abundance estimates
✓ Adult and juvenile intensive biological monitoring occurs periodically on a rotation schedule (every 9 years for 3-year duration)
× Adult and juvenile intensive biological monitoring occurs annually

Table 24. Summary of the habitat monitoring plan for Washougal River populations.

Washougal: Lower Columbia Habitat Monitoring Plan				
Monitoring Type	**Watershed**	**Existing stream / riparian habitat**	**Water quantity[3] (level of coverage)**	**Water quality [2] (level of coverage)**
Routine [1] (level of coverage)	Baseline complete	Poor	Stream Gage-Moderate IFA-Good	WDOE-Poor USGS-Moderate Temperature-Good
Intensive				
Level 1		✓	✓	
Level 2		✓	✓	
Level 3			✓	

IFAComprehensive Instream Flow Assessment (i.e. Instream Flow Incremental Methodology)
[1] Routine surveys for habitat data do not imply ongoing monitoring
[2] Intensive monitoring for water quality to be determined
[3] Water quantity monitoring may include stream gauge installation, IFA or low flow surveys

6.0 References

Arp, A.H., J.H. Rose, S.K. Olhausen. 1971. Contribution of Columbia River hatcheries to harvest of 1963 brood fall chinook salmon. Nation Marine Fisheries Service (NMFS), Portland, OR.

Beamish, R.J. and D.R. Bouillon. 1993. Pacific salmon production trends in relation to climate. Canadian Journal of Fisheries and Aquatic Science 50:1002-1016

Bryant, F.G. 1949. A survey of the Columbia River and its tributaries with special reference to its fishery resources--Part II Washington streams from the mouth of the Columbia to and including the Klickitat River (Area I). U.S. Fish and Wildlife Service (USFWS). Special Science Report 62:110.

Bureau of Commercial Fisheries. 1970. Contribution of Columbia River hatcheries to harvest of 1962 brood fall chinook salmon (Oncorhynchus tshawytscha). Bureau of Commercial Fisheries, Portland, OR.

Caldwell, B., J. Shedd, H. Beecher. 1999. Washougal River fish habitat analysis using the instream flow incremental methodology and the toe-width method for WRIAs 25, 26, 28, and 29. Washington Department of Ecology (WDOE), V: 99-153 Open File.

Fiscus, H. 1991. 1990 chum escapement to Columbia River tributaries. Washington Department of Fisheries (WDF).

Grant, S., J. Hard, R. Iwamoto, R., O. Johnson, R. Kope, C. Mahnken, M. Schiewe, W. Waknitz, R. Waples, J. Williams. 1999. Status review update for chum salmon from Hood Canal summer-run and Columbia River ESU's. National Marine Fisheries Service (NMFS).

Hare, S.R., N.J. Mantua and R.C. Francis. 1999. Inverse production regimes: Alaska and West Coast Pacific salmon. Fisheries 24(1):6-14.

Harlan, K. 1999. Washington Columbia River and tributary stream survey sampling results, 1998. Washington Department of fish and Wildlife (WDFW). Columbia River Progress Report 99-15, Vancouver, WA.

Hopley, C. Jr. 1980. Cowlitz spring chinook rearing density study. Washington Department of Fisheries (WDF), Salmon Culture Division.

Hymer, J. 1993. Estimating the natural spawning chum population in the Grays River Basin, 1944-1991. Washington Department of Fisheries (WDF), Columbia River Laboratory Progress Report 93-17, Battle Ground, WA.

Hymer, J., R. Pettit, M. Wastel, P. Hahn, K. Hatch. 1992. Stock summary reports for Columbia River anadromous salmonids, Volume III: Washington subbasins below McNary Dam. Bonneville Power Administration (BPA), Portland, OR.

Keller, K. 1999. 1998 Columbia River chum return. Washington Department of Fish and Wildlife (WDFW), Columbia River Progress Report 99-8, Vancouver, WA.

Lawson, P.W. 1993. Cycles in ocean productivity, trends in habitat quality, and the restoration of salmon runs in Oregon. Fisheries 18(8):6-10.

LeFleur, C. 1987. Columbia River and tributary stream sruvey sampling results, 1986. Washington Department of Fisheries (WDF), Progress Report 87-8, Battle Ground, WA.

LeFleur, C. 1988. Columbia River and tributary stream survey sampling results, 1987. Washington Department of Fisheries (WDF), Progress Report, 88-17, Battle Ground, WA.

Leider, S. 1997. Status of sea-run cutthroat trout in Washington. Oregon Chapter, American Fisheries Society. In: J.D. Hall, P.A. Bisson, and R.E. Gresswell (eds) Sea-run cutthroat trout: biology, management, and future conservation. pp. 68-76. Corvallis, OR.

Lewis County GIS (Geographic Information Systems). 2000. Salmon-Washougal and Lewis Rivers Watershed Planning – WRIAs 27 and 28 – Watershed Management Plan.

Lisle, T., A. Lehre, H. Martinson, D. Meyer, K. Nolan, R. Smith. 1982. Stream channel adjustments after the 1980 Mount St. Helens eruptions Proceedings of a symposium on erosion control in volcanic areas. Proceedings of a symposium on erosion control in volcanic areas. Seattle, WA.

Lower Columbia Fish Recovery Board (LCFRB) 2001. Level 1 Watershed Technical Assessment for WRIAs 25 and 26. Prepared by Economic and Engineering Services for the LCFRB. Longview, Washington.

Lower Columbia Fish Recovery Board (LCFRB). 2004. Salmon-Washougal and Lewis Rivers Watershed Planning - WRIAs 27 and 28. Watershed Management Plan September 2004 DRAFT.

Lunetta, R.S., B.L. Cosentina, D.R. Montogomery, E.M. Beamer, and T.J. Beechie. 1997. GIS-Based Evaluation of Salmon Habitat in the Pacific Northwest. Photogram. Eng. & Rem. Sens. 63(10): 1219-1229.

Marcot, B.G., W.E. McConnaha, P.H. Whitney, T.A. O'Neil, P.J. Paquet, L. Mobrand, G.R. Blair, L.C. Lestelle, K.M. Malone and K.E. Jenkins. 2002. A multi-species framework approach for the Columbia River Basin

Marriott, D. et. al. . 2002. Lower Columbia River and Columbia River Estuary Subbasin Summary. Northwest Power Planning Council.

McKinnell, S.M., C.C. Wood, D.T. Rutherford, K.D. Hyatt and D.W. Welch. 2001. The demise of Owikeno Lake sockeye salmon. North American Journal of Fisheries Management 21:774-791.

Mikkelsen, N. 1991. Escapement reports for Columbia Rive hatcheries, all species, from 1960-1990. Washington Department of Fisheries (WDF).

National Research Council (NRC). 1992. Restoration of aquatic systems. National Academy Press, Washington, D.C., USA.

National Research Council (NRC). 1996. Upstream: Salmon and society in the Pacific Northwest. National Academy Press, Washington, D.C.

Pyper, B.J., F.J. Mueter, R.M. Peterman, D.J. Blackbourn and C.C. Wood. 2001. Spatial convariation in survival rates of Northeast Pacific pink salmon (Oncorhynchus gorbuscha). Canadian Journal of Fisheries and Aquatic Sciences 58:1501-1515.

Rawding pers. comm. 2002. Personal communication with Dan Rawding, Fish Biologist with Washington Dept. of Fish & Wildlife, Vancouver, WA.

Roni, P., T.J. Beechie, R.E. Bilby, F.E. Leonetti, M.M. Pollock and G.R. Pess. 2002. A review of stream restoration techniques and a hierarchical strategy for prioritizing restoration in Pacific Northwest Watersheds. North American Journal of Fisheries Management 22:1-20. American Fisheries Society.

Rothfus, L.O., W.D. Ward, E. Jewell. 1957. Grays River steelhead trout population study, December 1955 through April 1956. Washington Department of Fisheries (WDF).

Tracy, H.B., C.E. Stockley. 1967. 1966 Report of Lower Columbia River tributary fall chinook salmon stream population study. Washington Department of Fisheries (WDF).

Wade, G. 2001. Salmon and Steelhead habitat Limiting Factors, Water Resource Inventory Area 25. Washington State Conservation Commission. Water Resource Inventory Area 25.

Wahle, R.J., A.H. Arp, A.H., S.K. Olhausen. 1972. Contribution of Columbia River hatcheries to harvest of 1964 brood fall chinook salmon (Oncorhynchus tshawytscha). National Marine Fisheries Service (NMFS), Economic Feasibility Report Vol:2, Portland, OR.

Wahle, R.J., R.R. Vreeland. 1978. Bioeconomic contribution of Columbia River hatchery fall chinook salmon, 1961 through 1964. National Marine Fisheries Service (NMFS). Fishery Bulletin 1978(1).

Wahle, R.J., R.R. Vreeland, R.H. Lander. 1973. Bioeconomic contribution of Columbia River hatchery coho salmon, 1965 and 1966 broods, to the Pacific salmon fisheries. National Marine Fisheries Service (NMFS), Portland, OR.

Wahle, R.J., R.R. Vreeland, R.H. Lander. 1974. Bioeconomic contribution of Columbia River hatchery coho salmon, 1965 and 1966 broods, to the Pacific Salmon Fisheries. Fishery Bulletin 72(1).

Washington Department of Ecology (WDOE). 1998. Final 1998 List of Threatened and Impaired Water Bodies - Section 303(d) list. WDOE Water Quality Program. Olympia, WA.

Washington Department of Ecology (WDOE) 2004. 2002/2004. Draft 303(d) List of threatened and impaired water bodies .

Washington Department of Fisheries (WDF). 1990. Washougal River Subbasin Salmon and Steelhead Production Plan. Columbia Basin System Planning. Northwest Power Planning Council.

Washington Department of Fish and Wildlife (WDFW). 1951. Lower Columbia River fisheries development program, Washougal River Area.

Washington Department of Fish and Wildlife (WDFW). 1996. Lower Columbia River WDFW hatchery records. Washington Department of Fish and Wildlife (WDFW).

Washington Department of Fish and Wildlife (WDFW). 1997. Preliminary stock status update for steelhead in the Lower Columbia River. Washington Department of Fish and Wildlife (WDFW), Vancouver, WA.

Wendler, H.O., E.H. LeMier, L.O. Rothfus, E.L. Preston, W.D. Ward, R.E. Birtchet. 1956. Columbia River Progress Report, January through April, 1956. Washington Department of Fisheries (WDF).

Western Regional Climate Center (WRCC). 2003. National Oceanic and Atmospheric Organization - National Climatic Data Center. URL: http://www.wrcc.dri.edu/index.html.

Woodard, B. 1997. Columbia River Tributary sport Harvest for 1994 and 1995. Washington Department of Fish and Wildlife (WDFW), Battle Ground, WA.

Worlund, D.D., R.J. Wahle, P.D. Zimmer. 1969. Contribution of Columbia River hatcheries to harvest of fall chinook salmon (Oncorhynchus tshawytscha). Fishery Bulletin 67(2).