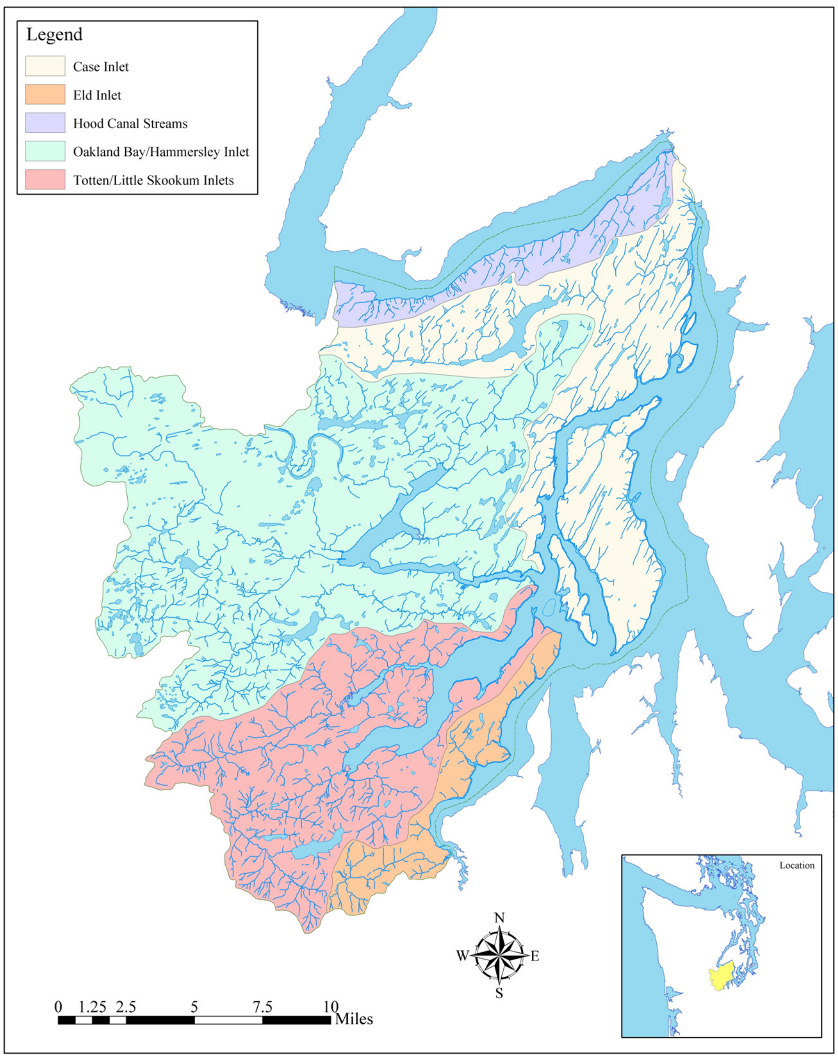
Washington State Conservation Commission

SALMONID HABITAT LIMITING FACTORS WATER RESOURCE INVENTORY AREA 14, KENNEDY-GOLDSBOROUGH BASIN



FINAL REPORT
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Chum salmon spawning in Kennedy Creek fall 2000.
Photo Courtesy of the Allyn Salmon Enhancement Group.

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ABBREVIATIONS AND ACRONYMS

ASEG: Allyn Salmon Enhancement Group
CFS: Cubic Feet per Second
CREP: Conservation Reserve Enhancement Program
CRP: Conservation Reserve Program
DO: Dissolved Oxygen
DOE: Washington Department of Ecology
EQIP: Environmental Quality Incentives Program
ESA: Endangered Species Act
FSA: Farm Service Agency (USDA)
IFIM: Instream Flow Incremental Methodology
LB: Left Bank of stream (looking downstream)
LWD: Large Woody Debris
MCD: Mason Conservation District
NRCS: USDA Natural Resource Conservation Service (formerly SCS)
NMFS: National Marine Fisheries Service
NWIFC: Northwest Indian Fisheries Commission
RB: Right Bank of stream (looking downstream)
RCW: Revised Code of Washington
RM: River Mile
SASSI: Salmon and Steelhead Stock Inventory (WDFW 1992)
SaSI: Salmonid Stock Inventory (WDFW 1998-present)
SCS: USDA Soil Conservation Service (now NRCS)
SSHIAP: Salmon and Steelhead Habitat Inventory and Assessment Project (NWIFC)
SRFB: Washington State Salmon Recovery Funding Board
TSS: Total Suspended Solids
USACE: United States Army Corps of Engineers
USDA: United States Department of Agriculture
USFS: United States Forest Service
USFWS: United States Fish and Wildlife Service
WAC: Washington Administrative Code
WAU: Watershed Administrative Unit
WCC: Washington State Conservation Commission
WDF: Washington Department of Fisheries
WDFW: Washington Department of Fish and Wildlife
WHIP: Wildlife Habitat Incentives Program
WRIA: Water Resource Inventory Area

EXECUTIVE SUMMARY

This report describes and assesses salmonid habitat in the Kennedy-Goldsborough Basin, Water Resource Inventory Area (WRIA) 14. The region encompasses the extreme southwest terminus of Puget Sound, including a portion of Eld Inlet, the entirety of Totten Inlet, Little Skookum Inlet, Oakland Bay and Hammersley Inlet, Pickering Passage, and a portion of Case Inlet. This report examines salmonid habitat only. No attempt has been made to evaluate harvest or hatchery issues. These important factors in the decline of anadromous salmonids are being dealt with by other entities. The report is a summary of existing knowledge from both published and unpublished literature, data, and interviews of people with technical expertise in the region. The WRIA 14 limiting factors report is intended for use in prioritization of salmonid habitat restoration/protection projects. It is not a recovery plan for salmonids, although it could be a component of such a plan. Habitat conditions (primarily in freshwater) are described, then assessed based on standards developed from published sources and consultations with local natural resource agency personnel. Causes of habitat degradation are addressed in a general sense. General restoration/protection recommendations are included for the entire WRIA.

Water Resource Inventory Area 14 covers about 381 square miles of the southwest terminus of Puget Sound. The area is characterized by numerous independent tributary streams that drain to several inlets within the Sound. No major river system is present. Lakes and wetlands are widespread throughout the area (Washington Department of Fisheries 1975). The terrain and drainage network are largely the result of past glacial episodes that gauged out the inlets and deposited and reworked large amounts of gravel, sand, and clay sediments (Molenaar and Noble 1970). Climate is generally mild with wet winters and cool, dry summers (Thurston County Planning Department 1989). With the exception of the Black Hills in the extreme southwest portion of the WRIA, the majority of the area is low elevation hills and valleys. The streams draining this region are rainfall-dominated and subject to low summer flows because of the lack of snow pack. However, the porous glacial sediments common throughout the basin encourage connectivity between surface waters and groundwater aquifers. Groundwater, wetlands, and beaver ponds all contribute to maintaining summer stream flows (Molenaar and Noble 1970).

Logging has been the dominant industry in the area since the arrival of Euro-American settlers in the 1850s. Old-growth, or late seral, coniferous forests dominated the region at that time. Trees 14 feet in diameter were common (Deegan 1960). Today the vast majority of WRIA 14 is dominated by early and mid-seral forests. Late seral forests cover only 1% of the region (Washington Department of Fish and Wildlife 1996). Riparian canopy closure throughout WRIA 14 is generally inadequate to maintain state water quality temperature standards (Schuett-Hames *et al.* 1996). Streambank condition was generally characterized as fair to poor. The glacial sediments common to WRIA 14 are susceptible to erosion unless they are stabilized by riparian vegetation (Washington State Department of Natural Resources and Simpson Timber Company 1995).

Disruptions of floodplain connectivity have occurred on some streams, but in general floodplain connectivity was characterized as good to fair (TAG 2002). Eroding streambanks and runoff from logging roads, highways, and residential development have contributed fine sediment to streams throughout WRIA 14. In general, substrate embeddedness levels exceed state standards throughout the region (Schuett-Hames *et al.* 1996).

Historically large woody debris (LWD) in streams was viewed as a timber commodity, a flood hazard and a barrier to navigation and fish passage. Wood was often removed from streams to address these concerns (Sedell and Luchessa 1982). Stream cleaning efforts are known to have occurred on Mill Creek (Kramer 1955) and may have occurred on other streams in WRIA 14. Today, total LWD abundance is considered acceptable in some streams, but deficient in others. Key LWD piece abundance is generally below state standards throughout the region (Schuett-Hames *et al.* 1996).

Pool frequency varies, but in general, pools are moderately abundant. Although pools are generally shallow, they often comprise a large proportion of stream surface area (Schuett-Hames *et al.* 1996). Wetlands, lakes, and beaver ponds provide off-channel habitat throughout the WRIA (Taylor *et al.* 2000). Water quality information was sparse, but the data available indicated that several streams did not meet state water temperature and dissolved oxygen standards during the summer months (Squaxin Island Tribe 2002, unpublished work). Stream flows during the summer months are generally low. On several streams, flows fell below state minimum flow standards (Squaxin Island Tribe 2002, unpublished work).

Damming of wetlands to create man-made lakes and shoreline modifications have been a common practice in WRIA 14 (TAG 2002). These activities along with conversion of forestland to agricultural or residential land uses have altered the natural flow regime of many streams in the region. Anadromous fish escapement (particularly chum salmon) to streams in WRIA 14 is generally considered sufficient to meet the nutrient requirements of the ecosystem (Baranski 2002, personal communication). However, exotic warm water fish have been introduced to many of the lakes in the WRIA, particularly within the Oakland Bay/Hammersley Inlet Subbasin, causing competition and predation problems with native salmonids (Burns 2002, personal communication).

WRIA 14 RECOMMENDATIONS

Wetlands should be protected from damming, filling, and dredging activities.

Riparian buffers should be protected to provide shade, stabilize streambanks, and provide large woody debris to enhance channel complexity.

Large woody debris should be left in streams.

Assess fish passage at the barriers identified as "Unknown Barriers" on Map 12.

Monitor biological processes including spawner escapement, exotic fish species presence, and beaver abundance.

Monitor stream flows throughout the year to evaluate flow regimes.

Monitor water temperatures and dissolved oxygen levels during the summer months.

Monitor salmonid habitat characteristics including LWD abundance, pool frequency and quality, substrate embeddedness, and floodplain connectivity.

Inventory riparian buffer characteristics including species composition, stand age, buffer width, and canopy closure.

Improve land use regulations including the Critical Area Ordinance and the Shoreline Master Program. Enforce land use regulations.

Educate landowners about the importance of maintaining natural riparian vegetation, leaving LWD in streams, and leaving banks unarmored.

Table 1. WRIA 14 Salmon and Steelhead Production Streams.

Stream Name	Stream Number	Confluence	Receiving Body	Bank
Benson Lake outlet	14.0066	7.1	Deer Creek	R
Campbell Creek	14.0069		Chapman Cove	
Canyon Creek	14.0045	0.3	Shelton Creek	L
Coffee Creek	14.0036	1.65	Goldsborough Creek	R
"County Line Creek"	14.0010	0.1	Schneider Creek	L
Cranberry Creek	14.0051		Oakland Bay	
Deer Creek	14.0027		Deer Harbor	
Deer Creek	14.0057		Oakland Bay	
"Elson Creek"	14.0025		Little Skookum Inlet	
Goldsborough Creek	14.0035		Oakland Bay	
Helser Creek	14.0124		Eld Inlet	L
Hiawata Creek	14.0085		Pickering Passage	
Jarrell Creek	14.0122		Jarrell Cove	
Johns Creek	14.0049		Oakland Bay	
Jones Creek	14.0080		Pickering Passage	
Kennedy Creek	14.0012		Totten Inlet	
Little Skookum Creek	14.0021		Skookum Creek	L
Lynch Creek	14.0026		Upper Lynch Cove	
Malaney Creek	14.0067		Oakland Bay	
"McDonald Creek"	14.0009b	1.55	Schneider Creek	L
Mill-Gosnell Creek System	14.0029		Hammersley Inlet	
N.F. Goldsborough Creek	14.0037		Goldsborough Creek	L
N.F. Helser Creek	14.0124b	0.13	Helser Creek	L
Panhandle Lake outlet	14.0041		S.F. Goldsborough Creek	L
Perry Creek	14.0001		Mudd Bay	L
Prickett Lake outlet	14.0098	7.5	Sherwood Creek	L
“Reitdorf Creek”	14.0021A		Skookum Creek	L
Rock Creek	14.0032		Gosnell Creek	L
Schneider Creek	14.0009		Totten Inlet	
S.F. Helser Creek	14.0124a	0.13	Helser Creek	R
Shelton Creek	14.0044		Oakland Bay	
Sherwood Creek	14.0094		North Bay	
Skookum Creek	14.0020		Little Skookum Inlet	
Snodgrass Creek	14.0127		Bowman Cove	
Spring Creek	14.0058	0.5	Deer Creek	L
Summit Lake System	14.0014		Kennedy Creek	R
Timber Lake	14.0072	2.6	Campbell Creek	L
Trask Lake outlet	14.0099	13.4	Schumocher Creek	L
Uncle John Creek	14.0068		Chapman Cove	
Winter Creek	14.0038		N.F. Goldsborough Creek	R

Note: Source (Washington Department of Fisheries 1975). Stream numbers greater than 14.0122 do not appear in the stream catalog. These numbers were assigned for purposes of creating the fish distribution maps for this report only.

INTRODUCTION

How to Use This Document

This report is made available in a digital format known as portable document format (pdf). This allows anyone with a computer (regardless of platform) and free Adobe Acrobat Reader ® 5.0 (or greater) software to read and print the document. If you are reading the report on your computer, you can take advantage of features commonly found on web pages. Blue underlined text appears throughout the document. These hyperlinks will take you directly to tables within the report and maps included separately on the CD-ROM. Cross-references *(within the text)* to tables and figures may also be clicked *(although they are not underlined blue text)* to take you directly to the referenced item. Definitions of some terms used in the text can be accessed by clicking this link ([def.]). The maps and report can be viewed simultaneously by manually opening a map from the CD-ROM *(located in the directory named PDF_Maps)* while you are reading the narrative. The Acrobat software also allows you to search for your topic of interest. Adobe Acrobat Reader is available at:

http://www.adobe.com/products/acrobat/readstep.html.

Salmonid Habitat Limiting Factors Background

The successful recovery of naturally spawning salmon [def.] populations depends upon directing actions simultaneously at harvest, hatcheries, habitat and hydroelectric power, the 4H's. The 1998 state legislative session produced a number of bills aimed at salmon recovery. Engrossed Substitute House Bill (ESHB) 2496 *(later codified to RCW 77)* was a key piece of the 1998 Legislature's salmon recovery effort, with the focus directed at salmon habitat issues.

Engrossed Substitute House Bill (ESHB) 2496 in part:

- Directs the Conservation Commission in consultation with local government and the tribes to invite private, federal, state, tribal and local government personnel with appropriate expertise to act as a technical advisory group;
- Directs the technical advisory group (TAG) to identify limiting factors for salmonids and to respond to the limiting factors relating to habitat pursuant to section 8 sub 2 of this act;
- Defines limiting factors as "conditions that limit the ability of habitat to fully sustain populations of salmon;"
- Defines salmon as all members of the family salmonidae, which are capable of self-sustaining, natural production.

The overall goal of the Conservation Commission's limiting factors project is to identify habitat factors limiting production of salmon in the state. It is important to note that the responsibilities given to the Conservation Commission in ESHB 2496 do not constitute a full limiting factors analysis. The hatchery, hydroelectric power, and harvest limiting factors are being dealt with in other forums.

Habitat and Salmonid Production in the Kennedy-Goldsborough Basin

The mud flats and productive waters of the numerous inlets present in the Kennedy-Goldsborough Basin, Water Resource Inventory Area (WRIA) 14, provide a rich production area for anadromous def. salmonids def. and shellfish. Tidal flushing of the inlets is limited by their location in deep south Puget Sound as well as their narrow size (Washington Department of Fisheries 1975). The majority of streams, with the exception of the southern portion of the basin draining the Black Hills, flow through low gradient terrain dominated by glacial till and outwash deposited as the Vashon Glacier retreated up the Puget Trough at the end of the last Ice Age. The geology led to formation of many lakes and bogs in areas where the glacial till is close to the surface (Molenaar and Noble 1970). The low gradient streams are ideally suited for production of chum, coho, and coastal cutthroat. Small numbers of fall chinook are present *(the co-managers believe these fish are strays from hatchery production)* but their distribution is severely limited by low stream flows in the late summer and early fall when they return to spawn. Low stream flows also limit winter steelhead production by reducing instream rearing habitat (Washington Department of Fish and Wildlife and Western Washington Treaty Tribes 1994).

Chum Salmon *(Oncorhynchus keta)* Life History

South Puget Sound chum typically spawn over a four to five month period from September to March. Chum enter rivers at the slightest increase in stream flow, but late in the spawning season high flows are not essential. Chum are strong swimmers, but not leapers, often reluctant to enter long span fish ladders, and are typically found below the first significant barrier on a stream. They prefer to spawn immediately above turbulent areas or in areas of groundwater upwelling. Eggs are generally buried 20 to 50 cm (~ 8 to 20 inches) deep in the substrate. Premature emergence occurs when eggs are buried less than 20 cm deep. Chum have adapted to spawn in lesser water depths and velocities than pink salmon and some of the other members of the genius *Oncorhynchus*. Late chum stocks often select spawning sites near springs above 4ºC (~ 39ºF), protecting the eggs from freezing and resulting in relatively consistent emergence timing from year to year. Intertidal spawning provides a similar benefit because the redd def. is warmed by marine waters during each tidal cycle. After hatching the chum alevins def. move downward in the gravel. The fish have an elongated body that allows them to move through the substrate better than coho, chinook, and steelhead alevins. They remain in the gravel from 6 to 25 days (Salo 1998).

Fry def. emerge from the gravel after about 5 months (generally from March through May), typically at night and immediately head downstream to the estuary, feeding along the way. They linger in the estuary while making the transition from fresh to salt water. The fry do not school strongly and are typically found in a scattered distribution. They typically feed on chironomids, mayfly larvae, caddisfly larvae, and other benthic invertebrates (Salo 1998).

Chum are second only to chinook in their dependence upon estuaries. The timing of entry to sea water is often correlated with warming of nearshore waters and the associated plankton blooms. The juveniles feed primarily on zooplankton including copepods and amphipods. The fry feed extensively over submerged tide flats. This allows them to exploit both freshwater and marine food webs. Juveniles move offshore when they reach 45 to 55 mm (~ 1.8 to 2.2 inches) fork length, enabling them to feed on larger prey and avoid predators. Their prey consists of a variety of zooplankton, krill, and fish larvae. Chum mature in the Gulf of Alaska and Bering Sea before returning to spawn as three to five-year-olds. Three and four-year-olds make up the bulk of runs in South Puget Sound streams (Salo 1998).

Coho Salmon *(Oncorhynchus kisutch)* Life History

Adult coho begin to enter streams when water temperatures decrease and flows increase, often making short explorations into the stream and then returning to saltwater. Upstream migration typically takes place during the day and is triggered by a large increase in flow, especially when combined with a high tide. Most coho return to spawn at three years of age. They typically spend four to six months incubating, up to fifteen months rearing in freshwater, then sixteen months feeding in the ocean. Coho spawn in a variety of stream types, including small coastal streams, large rivers, and remote tributaries. They will spawn just about anywhere that suitable gravel (15 cm or smaller in diameter) is present. Sites with groundwater seepage are preferred. The redd is typically located at the head of a riffle to promote good oxygen circulation. The eggs generally hatch in 40 to 60 days depending upon temperature. The alevins initially move downward in the gravel, likely an adaptation to prevent premature emergence of individuals that hatch close to the surface of the streambed (Sandercock 1998).

Fry about 30 mm in length emerge from the gravel about two to three weeks after hatching. Emergence occurs primarily at night. Fry that emerge first are typically larger than later emerging fry. These individuals tend to make up a large proportion of the fingerling population because they are able to out-compete smaller individuals for territories and prey. Following emergence, the fry hide in the substrate during daylight hours. After a few days they begin to swim along the banks and use whatever cover is available. Backwaters, side channels, and small streams are preferred areas, particularly in shaded areas with overhead cover. The fry may move upstream or downstream and occupy areas inaccessible to adult coho. Some coho rear in lakes, but the majority rear in streams where they establish and aggressively defend territories. They may be found in both pools and riffles, but are best adapted to pool habitat. Trout out-compete coho in riffles. The fry are active during daylight hours, defending their territories and making frequent dashes to capture prey (and foreign objects perceived as prey). They settle to the bottom during the night to rest (Sandercock 1998).

Small individuals are often harassed, chased, and nipped by the larger individuals. Complex instream habitat composed of large rocks, large woody debris, and vegetation is important to rearing coho because production is limited by the number of suitable territories present. Displaced fry often end up in less favorable habitat where they are vulnerable to predation. They may also be driven downstream clear to the estuary. Fish that enter the estuary during the first spring or summer of life do not generally survive to adulthood. Coho are visual feeders and prefer food moving in suspension or on the surface. They rarely feed on non-moving food or along the stream bottom. The juveniles usually rear in slower sections of the stream that allow them to capture prey with a minimum of effort. Small streams are the most productive coho areas because they provide more marginal slack water habitat than large streams. The midstream portion of large streams is generally unsuitable for juvenile coho, therefore any food drifting through this area is unavailable (Sandercock 1998).

Fingerlings def. move into off-channel habitat when fall freshets begin. Instream cover, side channels, small intermittent streams, and ponds provide shelter from winter storms that could sweep the fish out of the system. They also provide refuge from predators at a time when the fingerlings' swimming ability is limited by cold water temperatures. Beaver ponds provide shelter to avoid high flows during winter and low flows in the summer. However, small coho in ponds are more susceptible to predation from cutthroat trout. When juvenile coho rear in conditions with moderate water temperatures and abundant prey, they grow rapidly. The fry are about 30 mm long at emergence in March. They grow to 60 to 70 mm by September. By March of the second year, the fingerlings are 80 to 95 mm long. The juveniles are about 100 to 130 mm in length by May when they smolt. Exposure to water temperatures of 25ºC (77ºF) or greater is fatal to juvenile coho (Sandercock 1998).

In freshwater, juveniles are subject to predation by numerous animals including: cutthroat and rainbow trout, char, whitefish, sculpins, fish ducks, herons, mink, and otter. Garter snakes, dippers (water ouzel), robins, and crows are also significant consumers of juvenile coho. Coho smolts def. begin to migrate downstream in the spring. Fish size, stream flows, water temperature, dissolved oxygen levels, photo-period, and forage availability have all been identified as factors that trigger migration (Shapovalov and Taft 1954). The outmigration generally peaks in May, with most movement occurring at night. The fish grow rapidly in the nearshore waters of the estuary feeding on invertebrates. After attaining a larger size, they shift to feeding on fish, krill, and crab larvae (Sandercock 1998).

Fall Chinook Salmon *(Oncorhynchus tshawytscha)* Life History

Ocean type (fall) chinook typically migrate to sea during the first year of life, normally within three months of emergence. They spend the majority of their life in coastal waters and return to the natal stream in the fall a few days or weeks prior to spawning. In contrast, stream type (spring) chinook rear for one or more years in fresh water prior to migrating to sea where they undertake extensive ocean migrations. They return to the natal stream in the spring or summer, several months prior to spawning (Healey 1998).

Although chinook are generally considered to prefer deeper and faster spawning areas than other species in the genus *Oncorhynchus*, measurements recorded in the literature do not suggest that chinook avoid shallow water and low flows. Their large body size may allow them to hold position in faster currents and displace larger spawning substrates than other Pacific salmon, hence the perceived preference for deeper and faster water. Chinook have been observed spawning in water ranging from ~ 2 inches (5 centimeters) to 15 feet (~ 4.6 meters) deep. They appear to select spawning sites with high subgravel flows. This preference may be related to the increased sensitivity of chinook eggs to fluctuations in dissolved oxygen levels when compared to other species of Pacific salmon (chinook produce the largest eggs, yielding a small surface-to-volume ratio) (Healey 1998).

Chinook fry appear to have more difficulty emerging from small substrate than large substrate. Most fry emergence occurs at night. Following emergence the fry move downstream, also principally at night. The fry may continue the downstream migration to the estuary, or take up residence in the stream for a few weeks to a year or more depending upon the life history strategy. Fry migrants typically range in size from 30 to 45 mm fork length. Fingerling migrants are larger, with a range of 50 to 120 mm fork length. While rearing in fresh water, chinook feed primarily on larval and adult insects and zooplankton (Healey 1998).

Chinook fry feed in estuarine nearshore areas until they reach about 70 mm fork length, at which time they disperse to marine areas. Chinook rearing in estuarine areas are opportunistic feeders and will consume a variety of prey ranging from chironomid larvae and zooplankton to mysids (opossum shrimps) and juvenile fish. Most fall chinook do not migrate more than 1,000 km (about 620 miles) from their home stream during their ocean residence. Fish, particularly herring and sand lance, are the primary prey of chinook during their ocean growth phase. However, invertebrates including euphausiids (krill), squid, and crab larvae are also important at times (Healey 1998).

Winter Steelhead Trout *(Oncorhynchus mykiss)* Life History

Adult winter steelhead generally enter freshwater from November through March. Spawning usually takes place within four months of freshwater entry. The majority of returning adult steelhead are three to four years of age. These fish typically display three distinct life histories: (1) two years in freshwater and one year at sea (about 50%), (2) two years in freshwater and two years in saltwater (about 30%), and (3) three years in freshwater and one year at sea (about 10%). Survival of steelhead to first spawning improves with increased juvenile size at outmigration, hence the prevalence of two or three years of freshwater rearing in the three major life histories. Small groups of adult steelhead enter the stream as water levels rise following storms. The fish generally migrate upstream during daylight hours. Spawning sites are typically located near the head of a riffle (pool tailout). The redd is constructed in medium to small size gravel and is composed of several egg pockets or "pits." Each pit is typically four inches to one foot deep and about 15 inches in diameter. After egg deposition and fertilization the female covers the pit by moving upstream a few feet and excavating another pit. In the process, the disturbed gravel is washed downstream, covering the prior excavation. The completed redd is about 60 square feet in size (Shapovalov and Taft 1954).

Resident rainbow trout (and cutthroat trout, see below) often congregate near spawning steelhead. These fish are commonly thought to be feeding on dislodged eggs, but the majority are sexually mature males that are likely attempting to participate in the spawning act similar to immature (jack) Pacific salmon. Resident rainbow trout males have been observed spawning with female steelhead in the absence of a male steelhead (Shapovalov and Taft 1954). This behavior may be an important life history strategy that is likely less common today than it was historically (McMillan 2001). Cutthroat trout also readily interbreed with steelhead (e.g. Anon 1921, Hawkins 1997, Johnson *et al.* 1999).

Unlike Pacific salmon, not all steelhead die following spawning. Some spawned-out steelhead called "kelts" migrate downstream and return to the ocean. These fish are able to mature and spawn again. Steelhead eggs incubate for 19 to 80 days depending upon water temperature (60ºF and 40ºF respectively) and in the absence of high substrate embeddedness are believed to have a hatching success of 80 to 90%. The alevins are about 18 mm in length. Fry 23 to 26 mm in length typically emerge from the gravel two to three weeks after hatching. The fry initially congregate in schools, but eventually disperse up and down the stream, with each individual staking out a territory (similar to coho). By late summer, juvenile steelhead have moved to the swifter portions of the stream. During the fall and winter months, they take shelter in backwaters and eddies to prevent being swept downstream in floodwaters. Larval insects are the principal forage of fry and fingerling steelhead. As the juveniles grow, they consume larger prey including fish. Dislodged salmonid eggs are also important food items during the late fall and winter months (Shapovalov and Taft 1954).

Juvenile steelhead have a diverse suite of life histories, with fish migrating downstream from young-of-the-year (YOY) to four years of age. The bulk of downstream migration takes place in the spring and summer. Young-of-the-year through age two juveniles make up the bulk of downstream migrants with age three and four fish only a small proportion of the outmigration. The typical life history involves migration to the ocean at two years of age, but environmental conditions and sexual development can cause changes in the behavior pattern. Age one and YOY juveniles often remain in the lower portion of the stream or estuary for an additional year prior to migrating to the ocean. Age two and older fish typically migrate to the ocean immediately. The saltwater feeding habits of steelhead are likely similar to coho, with small fish feeding on invertebrates and larger fish feeding on fish (Shapovalov and Taft 1954).

Coastal Cutthroat Trout *(Oncorhynchus clarki clarki)* Life History

Coastal cutthroat spawn from late winter through late spring in low gradient reaches of small tributary streams or the lower reaches of larger streams. These streams are typically small with summer low flows often between 0.1 m^3/s and 0.3 m^3/s (~ 3.5 to 10.6 cfs) (Johnston 1982, cited in Trotter 1997). Pea to walnut size gravel is the preferred spawning substrate. Redds are typically constructed in pool tailouts 15 to 45 cm (~ 6 to 18 inches) deep. The deep water of the pool may be used as escape cover. If larger salmonids such as coho are present, cutthroat will migrate upstream above the reaches used by salmon. Repeat spawning female coastal cutthroat produce more eggs of a larger size than first-spawning females. The larger eggs develop into larger alevins that have higher survival than small alevins. Emergence from the gravel typically peaks in mid-April, but may extend from March through June. Newly emerged fry are about 25 mm (~ 1 inch) long. The juveniles spend their first few weeks in lateral habitats including lowvelocity backwaters, side channels, and other areas of cover along the channel margin (Trotter 1997).

During the summer months, young-of-the-year (Age-0) cutthroat prefer to rear in pools and other slow-water habitats. However, if coho juveniles are present, cutthroat are often displaced into riffles. Coho emerge earlier and at a larger size than cutthroat. They are able to out-compete cutthroat because of their larger size, aggressive behavior, and body morphology better adapted to pool habitat. Juvenile steelhead may displace juvenile cutthroat from riffles in a similar fashion. Steelhead are more aggressive with a body better adapted to riffle habitat than cutthroat. Interactions between young-of-the-year coho, steelhead, and cutthroat during the summer rearing period may set a natural limit on cutthroat production in streams where all three species are present. Stream-rearing juvenile coastal cutthroat may be feeding generalists, consuming whatever prey is available. Age-0 cutthroat consume both benthic (bottom dwelling) and drift organisms. Age-1 and older cutthroat often eat coho fry up to 50 to 60 mm (~ 2 inches). Cutthroat parr, smolts, and kelts (spawned adults) eat a variety of items including: insect larvae, sand shrimp, and small fish. Territoriality and agonistic behavior between juvenile salmonids decreases with the approach of winter. The juveniles overwinter in deep pools associated with large woody debris and undercut banks, as well as boulders and cobbles that provide interstitial cover. Off-channel pools, side channels, and lakes are also used where available (Trotter 1997).

Puget Sound coastal cutthroat typically smolt at age 2 with an average length of 160 mm (~ 6 inches). Seaward migration begins as early as March and continues through mid-July, with a peak in late May to early June. Anadromy is not well developed in coastal cutthroat trout. They spend little time in saltwater and often remain in the tidewater and estuarine reaches of their home streams. While in saltwater, cutthroat generally travel along the shoreline within 50 km (~ 31 miles) of the home stream and are reluctant to cross deep open water. They grow about 25 mm (~ 1 inch) per month while foraging in salt water. Marine survival of coastal cutthroat is as much as 40% higher than other Pacific salmonids. Predation by Pacific hake, spiny dogfish, harbor seals, and adult salmon likely accounts for the majority of mortality (Trotter 1997).

Coastal cutthroat seldom over winter in salt water. They often return to freshwater the same year they migrated to sea, but not all of these fish are spawners. Few female coastal cutthroat mature sexually before age 4. The immature fish over winter in freshwater then return to saltwater a second time to forage. These fish spawn following their second return to freshwater (Trotter 1997). In Puget Sound only 20 to 27% of first-return females spawned, while nearly all of the first-return males spawned (Johnston 1982, cited in Trotter 1997). In large streams (summer low flows > 1.4 m^3/s, ~ 49 cfs) fish enter freshwater from July through November with a peak in September and October. In small streams (summer low flows < 0.6 m^3/s, ~ 21 cfs) that flow directly to saltwater, cutthroat enter freshwater from December through March with a peak in December and January. Coastal cutthroat survive spawning quite well (Trotter 1997). Kelts return to saltwater from late March through early April, about one month earlier than cutthroat smolt outmigration. This timing places the adults in position to feed on outmigrating juvenile salmonids, particularly pink and chum salmon (Trotter 1997).

BASIN HISTORY

Prior to the arrival of European settlers, several bands of Native Americans were the principal inhabitants of the WRIA 14 area. The Squi-Aitl lived along Eld Inlet, the Sawamish/T'Peeksin lived along Totten Inlet, the Sa-Heh-Wa-Mish lived along Hammersley Inlet, and the Squawksin lived along Case Inlet. The waters of south Puget Sound were very important to their cultures. Salmon and shellfish provided food, while the numerous inlets provided travel routes via canoe. These bands were collectively referred to as the Squaxin Island Tribe during negotiation of the Medicine Creek Treaty (Squaxin Island Tribe 2002). They were a peaceful people that lived alongside the white settlers and frequently traded with them. The Squaxin Island Tribe ceded the area to the United States by signing the Medicine Creek Treaty on December 26, 1854. Their reservation was located on Squaxin Island (Deegan 1960). When settlers arrived, they found a landscape dominated by expansive stands of old-growth coniferous trees. Douglas-fir, western hemlock, western redcedar, and Sitka spruce were all present. These vast forests were the main attraction for the first settlers. Fir trees grew so tall that the first limbs were often 100 to 150 feet above the ground. Logs 14 feet in diameter were common in the early days. Colonel Michael Simmons established the first mill in Mason County near the mouth of Mill Creek in 1853. Another mill was constructed by Joe Sherwood near the mouth of Sherwood Creek in 1854. The Willey Mill was constructed in 1871 at the mouth of Johns Creek, and in 1883, William Kneeland built a small mill in the Shelton Valley and floated lumber down a flume to tidewater (Deegan 1960).

Many of the trees had such a large swell at the base that loggers employed "spring boards" to climb higher up the trunk for easier cutting. Notches were cut with an axe and the springboard was wedged in, providing a platform for the logger to stand on. An axe was used to cut an initial notch in the tree to control the direction of falling, then the trunk was cut with a saw (the "misery whip" of logging lore). Oxen were used to drag the huge logs to water, limiting most of the early activity to within a mile of water. As the logging industry grew and became more competitive new methods were employed to increase efficiency. Sol Simpson was the first logger to employ draft horse teams instead of oxen. The larger operators eventually followed suit to remain competitive. Steam donkeys later replaced horse teams. Skid roads (a cleared grade surfaced with small logs) were the most popular method of dragging logs to a central point. The skid road was greased (by a man called a grease monkey) to make it easier to pull the logs. In 1886, the Port Blakely Mill Company constructed a railroad that stretched from Kamilche Point at the mouth of Little Skookum Inlet to Montesano. This railroad was called the Blakely Road and was the shortest route from Puget Sound to Grays Harbor. Sol Simpson later bought the Blakely railroad. Simpson also owned a railroad (constructed in 1884) that began at Shelton and eventually terminated at Camp Grisdale near the present site of Wynoochee Lake in the Olympic National Forest (Deegan 1960). The Simpson Timber Company realized they were running out of timber, so they entered into a unique agreement with the U.S. Forest Service. The Cooperative Sustained Yield Agreement specified that Simpson would manage it's timber lands in accordance with Forest Service rules in exchange for guaranteed sales of equal acreages of timber from the National Forest (Thomas 1985). The agreement was terminated by mutual consent in June 2002

(Simpson Timber Company 2002). In 1892, another railroad was constructed from Shelton up the Shelton Valley to Grays Harbor. Logging along this railroad opened up land for agricultural production (Deegan 1960). The cutover lands were often cleared of stumps and converted to farmland. For example, in one year alone, farmers in the Shelton area purchased 40 tons of stump blasting powder (Thomas 1985).

David Shelton (the namesake of the largest city in the basin) and his family crossed the Great Plains with an ox team and covered wagon and arrived near Portland in 1847. Five years later, they moved to Olympia. The Shelton family moved to a donation land claim of 640 acres at the present site of Shelton in 1853. They later added an additional 171 acres from a homestead claim and purchase. Shelton was a member of the first legislative assembly of Washington Territory. At the time, Thurston County included what is today Mason County. Concerns with the difficulty of traveling from the settlements in the northern portion of the county to Olympia led to the idea of creating a separate county. In 1854, David Shelton introduced a bill to split Thurston County thus creating Sa-heh-wamish or Sawamish County. In 1864 the county was renamed Mason County in honor of Charles Mason, who was first secretary of Washington Territory and often acting governor when Governor Stevens was absent. Arkada (now Arcadia) was established in 1853. Kamilche (now Old Kamilche) was established in 1854. David Shelton platted the town site of Shelton (originally called Sheltonville) in 1884 (Deegan 1960).

In 1923, Goldsborough Creek produced a sizable flood, inundating Shelton from Seventh Street downstream to Oakland Bay. In response, the stream was channelized into a straight channel with steeper banks. Land on both sides of the stream was then filled and developed. In 1924, two mills were built on the Shelton waterfront. A wall of pilings was driven across the bay front and the lower tidelands were dredged to fill about 30 acres on the landward side of the pilings. The two mills were located just south of the mouth of Goldsborough Creek. In 1926, the Rainier Pulp and Paper Company built a pulp mill next to the two lumber mills already present on the Shelton waterfront. The site was cleared and 4,000 fir piles (cut near Lake Isabella) were driven. Additional dredging of the tidelands took place. The pulp mill was dedicated to rayon production. Rayon became so popular that the company name was later changed to Rayonier, a combination of rayon and Rainier (Thomas 1985).

The pulp production process produced a waste product called spent sulfite liquor. Traditionally this waste was released into a nearby water body, but this plant was located on a narrow tidal basin and people were concerned about protecting oyster production. A pipeline five-miles long was built to the mouth of Mill Creek. Storage tanks were constructed on-site so the waste liquor could be released only on outgoing tides. In 1930, oyster growers sued Rainier for $500,000 claiming the sulfite waste liquor was harmful to oysters. In response, a pipeline was built three-miles inland to dispose of the waste in Goose Lake. Eventually settling and evaporation ponds were constructed to contain the waste and let it disperse. The company attempted to make use of the waste product by concentrating it into a thick syrup. By 1934, sulfite waste liquor was being used to settle dust on roads as far away as New Jersey. Unfortunately, the venture didn't work out, so the waste liquor was again pumped to the settling ponds in 1936. Ten years later, it was found that the waste disposal ponds were seeping into groundwater and the creek. To eliminate the problem the waste liquor was evaporated into a thick syrup and burned (Thomas 1985).

Goldsborough Creek again produced major floods in 1932 and 1935. The stream channel was thoroughly cleaned and armored to protect the city and its residents. In the mid-1940s, Simpson Timber Company built a bulkhead across the portion of Oakland Bay north of Goldsborough Creek and dredged gravel from the tidelands to fill behind the structure. A locomotive roundhouse and machine shop were then constructed on the fill. In 1946, an additional building was constructed to lightly shred and cook Douglas-fir waste. The fibers were then pressed into a thick sheet and dried to make building tile and insulating board (Thomas 1985).

Although timber production was *(and remains)* the dominant industry in WRIA 14, oyster production was a valuable local commodity. Oysters proved so popular that the beds in Oyster Bay were depleted by 1887, less than ten years after harvest began. The bay was reseeded and production resumed. By 1902, 25,000 sacks of oysters per year were harvested from the waters of Mason County (Deegan 1960). Timber production continues to be the main industry in WRIA 14. Shellfish production is an important industry as well (Wallace 2002).

BASIN DESCRIPTION

The Kennedy-Goldsborough Basin (WRIA 14) covers about 381 square miles of southwest Puget Sound (Map 1). The area is drained by many small independent streams; no major river system is present. Streams generally flow north and east from rolling hills located between the inlets of southern Puget Sound and the Olympic Mountains to the north. One hundred thirty-nine independent streams, traversing approximately 240 linear miles have been identified. Inlets and mudflats deposited at stream confluences provide a variety of marine habitats. Slow tidal interchange within the long, enclosed water bodies of Eld Inlet and Mud Bay, Totten Inlet and Oyster Bay, Skookum Inlet, Hammersley Inlet and Oakland Bay, and upper Case Inlet and North Bay provides nutrient enriched waters at stream outlets. Streams are generally lowland types with headwaters originating from springs, surface water drainage, wetlands, beaver ponds, or small lakes. Upper watersheds are typically moderately to heavily forested with large acreages of second and third growth coniferous trees. Most streams originate in steep ravines, gradually transition to broad valley bottoms dominated by alder and brush, then flow through tide flats. Rural and urban development are usually associated with the lower portions of streams near salt water bays (Washington Department of Fisheries 1975).

Geology

Basalt from the Cresent Formation forms the Black Hills. Uplift along a north-south trend created the present day Cascade and Olympic Mountains and an accompanying downwarp created the Puget Trough. Unconsolidated sediments were deposited in the trough, creating the present day ground water reservoir. The Vashon Glacier originating in the Coast Range of British Columbia pushed into the Puget Trough, advancing and retreating several times. The glacier terminated in southeastern Mason County. The ice disappeared about 14,000 years ago, and at its maximum thickness was 1,200 to 2,000 feet thick, covering all but the highest portions of the Black Hills. The glaciations deposited sediments as both advanced [def.] and recessional outwash [def.]. These deposits were sorted by streams flowing from the terminus of the glacier. A mixture of clay, sand, gravel, and cobbles was "smeared" along as the ice slid across the landscape. This glacial till forms a confining layer of hardpan throughout the area. Morainal deposits [def.] were dumped during rapid melting of the glacier. The ice cut deep troughs in the landscape that became lakes as the glacier melted. Lacustrine [def.] sediments were deposited in these depressions (Molenaar and Noble 1970). Puget Sound and Hood Canal were originally a large multi-armed freshwater lake called Lake Russell. The freshwater was replaced by saltwater when the glacier retreated north of the Strait of Juan de Fuca (Bretz 1910, cited in Molenaar and Noble 1970). Extensive deltas formed at the heads of Hammersley Inlet, Oakland Bay, Skookum Inlet, and Oyster Bay. Peat and silt accumulated in ponds formed on the irregular surface of the glacial plains. A thin mantle of soil developed over the majority of the area (Molenaar and Noble 1970).

Climate

The region is characterized by the West Coast marine climate. Summers are relatively dry and cool. Winters are mild, wet, and cloudy. Daily air temperatures generally vary about 15ºF in the winter and 25 to 30ºF in the summer. Average annual precipitation is about 55 inches. Rainfall is generally a light to moderate drizzle rather than brief heavy downpours. Winds are generally from the southwest. Snowfall from 10 to 15 inches occurs from November through April in the higher elevations of the Black Hills (Thurston County Planning Department 1989).

Hydrology

Precipitation is the principal source of groundwater recharge in Mason County. Much of the precipitation that falls in the Black Hills runs off because of the impermeable rock that dominates the landform. This causes many headwater streams to go dry during the summer months. Precipitation that falls on the unconsolidated sediment of the glacial plain tends to percolate into the groundwater, providing perennial flow to lowland streams. Groundwater provides the majority of late summer flow to area streams (Molenaar and Noble 1970). The WRIA 14 Watershed Planning Unit (mandated under House Bill 2514) completed an analysis of historical records on instream flows for seven streams: Kennedy, Goldsborough, Skookum, Mill, Johns, Cranberry, and Deer Creeks (Golder Associates 2002). The consultant found that flows in these streams frequently fell below the statutory minimum levels for the available period of record in the 1950's and 60's.

Table 2. Statutory Minimum Flows for Select WRIA 14 Streams (WAC 173-514-030).

Instantaneous flow (cubic feet per second)

	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
Stream	1	15	1	15	1	15	1	15	1	15	1	15	1	15	1	15	1	15	1	15	1	15	1	15
Perry Creek	30	30	30	30	30	30	21	14	10	6.8	4.6	3.2	2.2	1.5	1	1	1	1	1	2.5	5.4	13	30	30
Kennedy Creek	60	60	60	60	60	60	60	46	35	27	20	16	12	9	7	7	7	7	7	14	29	60	60	60
Skookum Creek	40	40	40	40	40	40	40	40	26	16.5	11	7	4.6	3	3	3	3	3	3	5.6	15	40	40	40
Mill Creek	65	65	65	65	65	65	65	65	55	46	40	33	28	24	20	20	20	20	20	20	35	65	65	65
Goldsborough Creek	50	50	50	85	85	85	85	85	85	85	85	69	55	52	48	45	45	45	45	50	50	50	50	50
Johns Creek	45	45	45	45	45	45	45	45	34	26	20	15.5	12	9	7	7	7	7	7	7	18	45	45	45
Cranberry Creek	50	50	50	50	50	50	50	40	31	23.5	18	14	10.5	8	8	8	8	8	8	15	28	50	50	50
Deer Creek	55	55	55	55	55	55	55	46	39	33	28	23.5	20	20	20	20	20	20	20	20	33	55	55	55
Sherwood Creek	60	60	60	60	60	60	60	60	48	37	29	23	17.5	14	11	11	11	11	11	19	34	60	60	60
Schumocher Creek	20	20	20	20	20	20	20	20	17	14	12	10	8.6	7.2	6	6	6	6	6	6	11	20	20	20

Source: (State of Washington 1988)
Note: Underlined text indicates closure to all consumptive uses.

Table 3. WRIA 14 Streams Closed to Further Appropriations (WAC 173-514-040).

Stream	Tributary to	Closure Period
Campbell Creek	Chapman Cove (Oakland Bay)	May 1-October 31
Elson Creek	Skookum Inlet	May 1-October 31
Fawn Lake Outlet	Skookum Inlet	May 1-October 31
Jones Creek	Pickering Passage	May 1-October 31
Jarrell Creek	Jarrell Cove	May 1-October 31
Little Creek	Skookum Creek	May 1-October 31
Malaney Creek	Oakland Bay	May 1-October 31
Shelton Creek	Oakland Bay	May 1-October 31
Uncle John Creek	Chapman Cove (Oakland Bay)	May 1-October 31
Perry Creek	Eld Inlet	May 1-October 31
Kennedy Creek	Skookum Inlet	May 1-November 15
Johns Creek	Oakland Bay	September 16-November 15
Cranberry Creek	Oakland Bay	September 16-November 15
Deer Creek	Oakland Bay	September 16-November 15
Sherwood Creek	Case Inlet	September 16-November 15

Source: (State of Washington 1988)

Vegetation

Early seral hardwood forests and mid seral conifer forests are the dominant land covers, each occupying about 28% of WRIA 14. Saltwater covers about 13% of the basin. Early seral conifer forests occupy about 9% of the basin, while mixed-early seral forests cover about 5%. Late seral conifer forests and non-forested lands each cover about 1% of the basin (Washington Department of Fish and Wildlife 1996). See Map 6.

Land Use and Salmonid Habitat Conditions

High density residential development occupies only 1.1% of the basin, primarily in the Shelton area (Washington Department of Fish and Wildlife 1996). See Map 6. In 2001, the population of Mason County was 49,600 people, 8,470 of which lived in the Shelton area (Wallace 2002). Road density for the entire WRIA is 4.6 miles per square mile (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2002).

Large woody debris abundance is considered acceptable in some watersheds, but deficient in others. However, in general, key pieces of large woody debris are lacking throughout WRIA 14 (Schuett-Hames *et al.* 1996). Low key piece abundance is likely the result of historic logging practices from the late 1800s to the early 1900s that removed large conifers throughout the area. No record of splash damming in WRIA 14 was located, but it was a common practice throughout the Pacific Northwest (Sedell and Luchessa 1982), and is therefore suspected to have occurred in WRIA 14. Stream cleaning efforts undertaken to improve fish passage and reduce flood concerns are known to have occurred on Mill Creek (Kramer 1955) and may have occurred on other streams in the WRIA. Woody debris removal was commonplace throughout the state prior to biologists realizing the important role LWD serves in maintaining fish habitat (Sedell and Luchessa 1982). A quote from Kramer (1955) lends insight to the prevailing philosophy of the time: "Logging debris in a stream has a tendency to cover gravel beds with silt and sand making them unfit for spawning purposes. Removal of these jammed areas will return the stream to productive use. High water in cleared streams will gradually fill pools and potholes in the stream bed (Kramer 1955, pg. 2)."

Second and third growth trees are the dominant vegetation in the majority of riparian communities throughout WRIA 14 (Washington State Department of Natural Resources and Simpson Timber Company 1995, Schuett-Hames *et al.* 1996). In many cases, deciduous trees such as alder are the dominant tree species. Although these trees do provide LWD, the pieces are not as large as the LWD recruited from late successional coniferous forests that historically dominated the region (Booth 1991). Some streams contain remnant pieces of late successional woody debris exceeding one meter in diameter (Stevie 2002, personal communication). Coniferous LWD remains in streams longer than deciduous LWD because of its large size (Murphy and Koski 1989) and superior resistance to decay (Swanson and Lienkaemper 1978). Simpson Timber Company owns the majority of commercial timberlands in WRIA 14. They are in the process of implementing a Habitat Conservation Plan (HCP) intended to protect the habitat of threatened and endangered species. The plan includes prescriptions for improving riparian buffer conditions and increasing LWD abundance. Implementation of this plan has the potential to improve riparian buffer and LWD conditions in the future (Simpson Timber Company 2000). Deep pools are uncommon throughout the WRIA, likely the result of low LWD key piece abundance. No historic description of pool conditions was located, but one would presume that LWD recruited from the old-growth trees historically present would have created deep pools.

Thick vegetative cover limits surface erosion in most areas. Streambank erosion is believed to contribute the majority of fine sediment to WRIA 14 streams. Logging roads, highways, and residential development contribute lesser quantities of fine sediment (e.g. Washington State Department of Natural Resources and Simpson Timber Company 1995, Schuett-Hames *et al.* 1996). Impacts from impervious surfaces are largely confined to the City of Shelton, principally the lower portions of Goldsborough and Shelton Creeks (Brown and Caldwell 1990). Portions of shorelines along many of the area lakes and inlets are heavily developed for residential purposes. In many cases, riparian vegetation has been cleared to enhance views (Kuttel 2002, personal observations). Shorelines along the inlets have been armored with concrete and riprap to protect residences (e.g. Anchor Environmental 2002). Fecal coliform contamination from live stock and failing septic systems is a common problem throughout the WRIA (Brown and Caldwell 1990, Washington Department of Ecology 1996, and 2000).

SALMONID STOCK STATUS

Chum Salmon

The independent streams of WRIA 14 are well suited to the production of chum salmon. Chum fry migrate to sea immediately following emergence, so the estuary and marine waters of southern Puget Sound are extremely important to their survival. Juveniles emerge and emigrate to the sea from late February through May (Washington Department of Fisheries 1975).

Summer Chum

South Puget Sound summer chum stocks begin arriving in the south Sound from early August to September. Spawning typically occurs from early September through October. The early run timing creates a temporal separation between the fall chum stocks that spawn in the same streams. Case Inlet and Hammersley Inlet summer chum stocks have been supplemented with hatchery production from Coulter and Johns Creek Hatcheries respectively. The supplementation programs were discontinued in 1992 (Washington Department of Fish and Wildlife and Western Washington Treaty Tribes 1994). These supplementation programs both utilized local native summer chum stocks (Baranski 2002, personal communication). South Puget Sound summer chum stocks were heavily impacted by mid-Puget Sound coho net fisheries (Washington Department of Fish and Wildlife and Western Washington Treaty Tribes 1994), but this is no longer the case (Baranski 2002, personal communication). The escapement goal for even numbered years is 32,000. Escapement for odd numbered years is targeted at 9,300 (Washington Department of Fish and Wildlife and Western Washington Treaty Tribes 1994).

Hammersley Inlet Stock

Summer chum abundance in streams that depend upon natural production is relatively low, with the exceptions of Johns, Cranberry and Deer Creeks. The Hammersley Inlet stock was rated "healthy" in 1992 (Washington Department of Fish and Wildlife and Western Washington Treaty Tribes 1994). Escapements ranged from 150 to 18,700 from 1968 to 1992, with a mean escapement of 5,400 for that period. Wild spawning escapements to Johns Creek dropped when the hatchery rack was installed in 1977 and continued to drop until 1981 while broodstock was collected. Subsequent increases in the Johns Creek run size may have resulted from the supplementation program. It was speculated that run size might drop since the hatchery program was discontinued in 1992 (Washington Department of Fish and Wildlife and Western Washington Treaty Tribes 1994). However, harvest impacts of the mid-Sound coho fisheries have been reduced dramatically in recent years and escapements have ranged from 12,000 to 59,300 between 1993 and 2000, with a mean escapement of 26,300 over that period (Baranski 2002, personal communication).

Case Inlet Stock

Case Inlet summer chum production is concentrated in Coulter (outside WRIA 14) and Sherwood Creeks. The Coulter Creek Hatchery was used to supplement wild spawning in Case Inlet. Supplementation made a major contribution to run size, but was discontinued in 1992. The Sherwood Creek run is maintained primarily by wild production. Escapement has been stable over the past 20 years. The stock was characterized as "healthy" in 1992 (Washington Department of Fish and Wildlife and Western Washington Treaty Tribes 1994). Sherwood Creek fish may stray into Coulter Creek. Spawning occurs from September to late October. The early run timing creates a temporal separation from fall stocks that spawn in the same streams. The Coulter Creek hatchery broodstock was developed from native Coulter Creek fish, so the hatchery stock is considered native. Escapement ranged from 400 to 16,300 from 1968 to 1992, with a mean escapement of 5,500 for that period (Washington Department of Fish and Wildlife and Western Washington Treaty Tribes 1994). Harvest impacts of the mid-Sound coho fisheries have been reduced dramatically in recent years and escapements have ranged from 1,600 to 43,400 between 1993 and 2000, with a mean escapement of 14,100 for that period (Baranski 2002, personal communication).

Fall Chum

Fall chum enter south Puget Sound between early October and early January. Spawning occurs from late October through January. Spawn timing varies among stocks. Totten Inlet, Eld Inlet, Goldsborough/Shelton Creek, and Case Inlet fall chum are distinct stocks based on geographic isolation and unique genetics. Johns/Mill Creek, Skookum Inlet, and Upper Skookum Inlet fall chum stocks were separated based on geographic isolation. Upper Skookum Creek chum may be native fish, while the Skookum Inlet stock is of native and hatchery origin (Washington Department of Fish and Wildlife and Western Washington Treaty Tribes 1994).

Eld Inlet, Upper Skookum Creek, Totten Inlet, Goldsborough/Shelton Creek, and Case Inlet fall chum stocks are all of native origin because they have not been affected by hatchery plants. Elson Creek Hatchery fall chum were developed from a composite of Elson Creek and Johns Creek fall chum. These fish were released into the streams of Skookum Inlet and Cranberry Creek. Therefore, these stocks are characterized as mixed stocks (Washington Department of Fish and Wildlife and Western Washington Treaty Tribes 1994), although it should be noted that efforts were made to distinguish Elson Creek broodstocks by spawn timing, with Elson-timed fish utilized in Skookum Inlet releases and Johns Creek-timed fish utilized in Cranberry Creek (Baranski 2002, personal communication). Even-year South Puget Sound fall chum escapement is set at 55,700 fish, while odd-year escapement is targeted at 44,000 (Washington Department of Fish and Wildlife and Western Washington Treaty Tribes 1994).

Eld Inlet Stock

The primary fall chum spawning streams in Eld Inlet are McLane, Swift (both in WRIA 13), and Perry Creeks. Spawning occurs from late-November to early January, relatively broad compared to other fall chum stocks. The stock is unique genetically from other Puget Sound chum stocks (Washington Department of Fish and Wildlife and Western Washington Treaty Tribes 1994). Chum were not planted in either Swift or Perry Creeks. Hood Canal chum were planted in McLane Creek from 1976 to 1983. The stock was characterized as "healthy" in 1992. Escapement from 1968 to 1992 ranged from 4,300 to 37,600 fish and averaged 14,800 for that period. Stock abundance was stable and showed signs of increasing (Washington Department of Fish and Wildlife and Western Washington Treaty Tribes 1994). More recent escapements have been good, ranging from 26,600 to 89,900 between 1993 and 2000, with a mean escapement of 50,400 for that period (Baranski 2002, personal communication).

Totten Inlet Stock

Wild spawning in Kennedy Creek accounts for the majority of fall chum production from Totten Inlet. Spawning begins in November with the peak in mid-November, early for fall chum. This timing separates the fish from Skookum Creek stocks. Kennedy Creek fall chum are genetically unique when compared to other Puget Sound chum. The stock was considered "healthy" in 1992 (Washington Department of Fish and Wildlife and Western Washington Treaty Tribes 1994). Escapement from 1968 to 1992 ranged from 1,100 to 35,000, averaging 10,700 fish. Escapement declined in the late 1970s when a hatchery rack was installed to collect broodstock for a South Sound chum enhancement program. The program was discontinued and the run recovered, averaging about 16,000 fish from 1984 to 1992 (Washington Department of Fish and Wildlife and Western Washington Treaty Tribes 1994). More recent escapements have been good, ranging from 19,200 to 85,300 between 1993 and 2000. Mean escapement for that period was 38,700 (Baranski 2002, personal communication).

Skookum Inlet Stock

Skookum Inlet fall chum spawn in lower Skookum Creek and its tributaries. Elson Creek Hatchery chum releases and natural spawning in Little Creek and Reitdorf Creek contribute the majority of production for the stock. Fall chum from Little and Reitdorf Creeks are closely related to the Elson Creek Hatchery stock. The stock is likely a hybrid, or the hatchery stock replaced the native population. The stock was classified as "healthy" in 1992. Escapement from 1968 to 1992 ranged from 100 to 6,700 fish, averaging 1,900 fish (Washington Department of Fish and Wildlife and Western Washington Treaty Tribes 1994). More recent escapements have been good, ranging from 700 to 13,300 between 1993 and 2000, with a mean escapement of 7,000 fish (Baranski 2002, personal communication).

Upper Skookum Creek fall chum are primarily wild fish. Prior to hatchery influences there were two spawning peaks; the first in December, followed by a smaller peak in January. The two-phase spawn timing is still present. Hatchery plants from Elson Creek may have affected the early portion of the run, but the later portion is believed to be primarily native fish. The stock was characterized as "healthy." Escapement from 1968 to 1992 ranged from 200 to 4,400 fish, with an average of 1,400. Escapement increased from 1984 to 1992 (Washington Department of Fish and Wildlife and Western Washington Treaty Tribes 1994). Recent escapements have been good, ranging from 1,000 to 36,100 between 1993 and 2000. Mean escapement was 11,900 (Baranski 2002, personal communication).

Hammersley Inlet Stocks

Johns and Mill Creeks are the main fall chum production streams in Hammersley Inlet. Both streams support wild spawning. The Mill Creek fish spawn from November to

December, while Johns Creek fish spawn from November to February with a peak in December. A remnant native run may still be present in Mill Creek. The broad spawn timing of Johns Creek fish suggests that they are a mix of various introduced stocks. Fish from Hood Canal and Minter were stocked historically. The stock was characterized as "healthy" in 1992 (Washington Department of Fish and Wildlife and Western Washington Treaty Tribes 1994). Escapement from 1968 to 1992 ranged from 3,000 to 40,000 fish, with an average of 11,300. Escapement had been stable with the exception of the record escapement *(at that time)* of 40,000 fish in 1987 (Washington Department of Fish and Wildlife and Western Washington Treaty Tribes 1994). More recent escapements have been good, ranging from 5,200 to 85,300 between 1993 and 2000, with a mean escapement of 26,300 (Baranski 2002, personal communication).

Goldsborough Creek and Shelton Creek fall chum are considered the same stock because of similar run timing and the close proximity of the two streams. The fish spawn from early December to early February, about a month later than other Hammersley Inlet fall chum. The stock is genetically unique when compared to other Puget Sound chum stocks. Hatchery fish from Elson Creek were stocked in Shelton Creek, but no information exists regarding the success of the plants. The stock is still considered native because of its unique late run timing. The stock was characterized as "healthy" in 1992. Escapement from 1968 to 1992 ranged from 200 (Shelton Creek only) to 16,600 (Goldsborough and Shelton Creeks combined), and averaged 2,000 fish for the period (Washington Department of Fish and Wildlife and Western Washington Treaty Tribes 1994). More recent escapements have ranged from 65 to 6,600 between 1993 and 2000, with a mean escapement of 2,100 fish. Shelton Creek production has declined to just a few fish per year, likely the result of the continuing urbanization of that stream. The recent removal of a blockage (Goldsborough Dam) on Goldsborough Creek may increase fall chum production in that stream by opening up more habitat (Baranski 2002, personal communication). See Table 4 and Figure 1.

Table 4. Chum Escapement to Oakland Bay/Hammersley Inlet 1987 to 1998.

Year	*Mill Creek*	*Goldsborough Creek*	*Shelton Creek*	*Johns Creek*	*Cranberry Creek*	*Deer Creek*	*Malaney Creek*	*Uncle John Creek*	*Campbell Creek*
1987	5,383	13,741	431	7,800	4,345	629	42	0	2
1988	4,391	16,132	1,100	9,068	6,578	2,821	3	2	NS
1989	840	5,679	1,242	15,176	5,802	1,346	11	1	NS
1990	6,717	1,502	913	9,031	6,125	1,790	36	NS	NS
1991	2,200	2,708	1,085	7,823	2,296	1,091	23	NS	NS
1992	16,469	2,263	28	10,066	4,490	2,512	11	NS	NS
1993	16,373	4,872	749	9,242	5,693	3,750	0	6	NS
1994	15,437	1,302	101	6,282	5,609	2,544	NS	NS	NS
1995	1,233	2,378	100	4,309	3,401	1,421	0	NS	NS
1996	29,369	546	2	8,996	2,394	2,746	NS	NS	NS
1997	5,811	393	44	3,077	5,115	1,036	0	NS	42
1998	NS	NS	NS	12	NS	NS	NS	NS	NS
Mean	9,475	4,683	527	7,574	4,713	1,971	14	2	22

Data Source: (Taylor *et al.* 2000). Note: NS = No survey data.

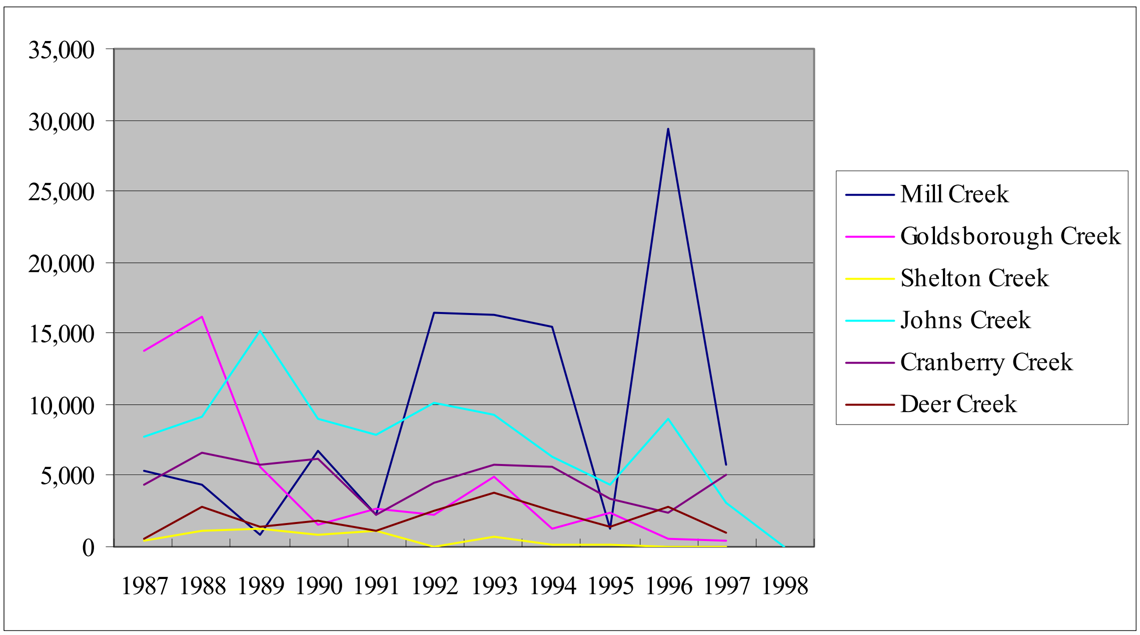

Figure 1. Chum Escapement to Oakland Bay/Hammersley Inlet 1987 to 1998 (Taylor *et al.* 2000), *note that Malaney, Uncle John, and Campbell Creeks are not shown in the graph because escapements were too low to be viewed at this scale.*

Case Inlet Stock

Sherwood, Coulter and Rocky Creeks (latter two both outside WRIA) are the primary fall chum streams in Case Inlet. Spawning occurs from early December to mid-January, creating a temporal separation between the Case Inlet summer and fall chum stocks. Case Inlet fall chum are genetically unique from other Puget Sound chum stocks. Hatchery releases were made in most Case Inlet streams. Hatchery plants to Sherwood Creek were made with native broodstock, so the stock is still considered native. The stock was characterized as "healthy" in 1992. Escapement from 1968 to 1992 ranged from 500 to 6,000 fish, with a mean escapement of 1,900. Escapement slightly increased from 1979 on (Washington Department of Fish and Wildlife and Western Washington Treaty Tribes 1994). More recent escapements have been good, ranging from 400 to 12,600 between 1993 and 2000, with an average escapement of 6,100 for the period (Baranski 2002, personal communication). See Map 7 for chum distribution.

Coho Salmon

All accessible independent tributaries in WRIA 14 support coho production. Significant runs are present in Kennedy, Skookum, Mill, Goldsborough, Johns, Deer, Cranberry and Sherwood Creeks (Washington Department of Fisheries 1975, Baranski 2002, personal communication). Coho typically enter freshwater from mid-September to mid-November and spawn from late October to mid-December. Substantial releases of hatchery coho yearlings occurred from the early 1950s to the mid-1970s (Washington Department of Fish and Wildlife and Western Washington Treaty Tribes 1994). Fingerling/fry plants continued until 1998 (Baranski 2002, personal communication). This stock is likely a mix of native and non-native stocks. No genetic distinctions have been noted between fish spawning in the various drainages of the basin (Washington Department of Fish and Wildlife and Western Washington Treaty Tribes 1994). Juveniles rear throughout accessible stream reaches, usually spending more than one year in freshwater, then migrating to sea early in their second year. The estuarine and marine environments of the WRIA provide important habitat for coho outmigrants (Washington Department of Fisheries 1975).

Escapement ranged from 1,000 to 8,000 and averaged 4,800 from 1966 to 1971 (Washington Department of Fisheries 1975). Native south sound coho stocks were declared "nonviable" in the 1970s, at which time emphasis was placed on hatchery production and high harvest rates. Coho escapement declined considerably (Taylor *et al.* 1999). The natural escapement goal for Management Area 13B (which includes portions of WRIA 13, as well as WRIA 14) is 8,700 fish (Baranski 2002, personal communication). However, the primary management objective in the basin is to minimize surplus hatchery returns through high harvest rates — reducing the likelihood of attaining the natural escapement goal (Washington Department of Fish and Wildlife and Western Washington Treaty Tribes 1994).

Escapements between 1970 and 1992 ranged from 400 to 13,400 fish, averaging 5,600. More recent escapements (1993-2000) have demonstrated a generally declining trend, ranging from 800 to 7,300. Mean escapement was 3,500 fish. Additionally, since the advent of mass marking of hatchery-origin coho, there have been numbers of mark recoveries on the spawning grounds. Indications are that significant numbers of hatchery strays are contributing to the natural spawning population in WRIA 14. However, the impacts cannot be adequately assessed without increased sampling of the natural spawners in this area (Baranski 2002, personal communication).

Green River (Pierce County) and Minter Creek stocks were the primary sources of hatchery coho production in the basin. The coho in this basin are likely a mix of native and non-native stocks. The stock was characterized as "healthy" in 1992 (Washington Department of Fish and Wildlife and Western Washington Treaty Tribes 1994). Generally declining escapements, especially in light of the contribution of stray hatchery fish to those escapements, indicate that natural coho production in WRIA 14 may be depressed (Baranski 2002, personal communication). See Map 8 for coho distribution.

Fall Chinook Salmon

Since 1986, fall chinook have been observed spawning in about a dozen WRIA 14 streams. In most cases, the numbers have been single digit observations, with Goldsborough, Johns, Deer and Sherwood creeks demonstrating the highest utilization in the WRIA. Excepting Skookum Creek returns *(see discussion below)*, the total observed return ranged from 3 to 121 fish between 1986 and 2001, with a mean return of 44 chinook per year. Note that these are likely conservative estimates of escapement because WRIA 14 stream surveys outside of Sherwood, Deer and Goldsborough creeks are not designed to systematically assess chinook escapement. Escapement indicators in other WRIA streams are generally peak live plus dead counts, which may underestimate total chinook utilization. In the current revision (in process) of the 1992 SASSI (Washington Department of Fish and Wildlife and Western Washington Treaty Tribes 1994), it is likely that the South Sound Tributaries fall chinook stock will not be rated. The rationale supporting this action is that the co-managers believe: (1) The independent tributaries in south Puget Sound are not typical chinook habitat because of small stream size and low flows during the late summer/early fall spawning season. (2) The current low escapements are likely the result of past hatchery plants or straying from either current production at south Puget Sound hatcheries or viable south Sound natural populations. (3) Neither WDFW nor the Squaxin Island Tribe want to be in the position of advocating production/protection of fish that likely were not historically self-sustaining populations and would have little chance of perpetuating themselves through natural production. Two examples, Minter Creek (although outside WRIA 14, it is a typical south Sound independent tributary) and Skookum Creek, provide insight into the limited natural fall chinook production potential in south Puget Sound tributaries. In an assessment of Minter Creek fish stocks during the 1930s, WDF reported that,

> Other migrant and resident populations of fish utilize Minter Creek and, with the silver salmon, form a complex of interspecific relationships. Substantial runs of chum salmon, *Oncorhynchus keta,* steelhead trout, *Salmo gairdneri*, and cutthroat trout, *Salmo clarki*, enter Minter Creek. A small run of pink salmon, *Oncorhynchus gorbuscha*, enters the stream on odd-numbered years. **Chinook**

salmon, *Oncorhynchus tshawytscha*, have been introduced in recent years to ascertain whether a run of this species can be established and maintained from fish hatched and reared artificially [emphasis added] (Salo and Baliff 1958)**.**

It can be concluded that there was no chinook production in Minter Creek prior to the commencement of hatchery production in that basin (Baranski 2002, personal communication).

Elson Creek Hatchery released fall chinook fingerlings for eight years (brood years 1979-1986). Due to extremely low flows in Elson Creek during the chinook return and spawning time periods, most fish returned to Skookum Creek. In most years, the Squaxin Island Tribe operated a weir in Skookum Creek in order to collect the broodstock necessary to operate the on-station program at Elson Creek. When the chinook program was discontinued at Elson Creek, along with the associated broodstocking, chinook escapement to Skookum Creek grew, going over 1,000 spawners in two successive years (1989 and 1990). Even though Skookum Creek had fall chinook spawning escapements of over 200 fish in five successive years, the species did not sustain itself in this basin (Figure 2). Department of Fish and Wildlife stopped conducting chinook spawning surveys in Skookum Creek five years after the plants were discontinued because escapement levels did not warrant continued monitoring (Baranski 2002, personal communication).

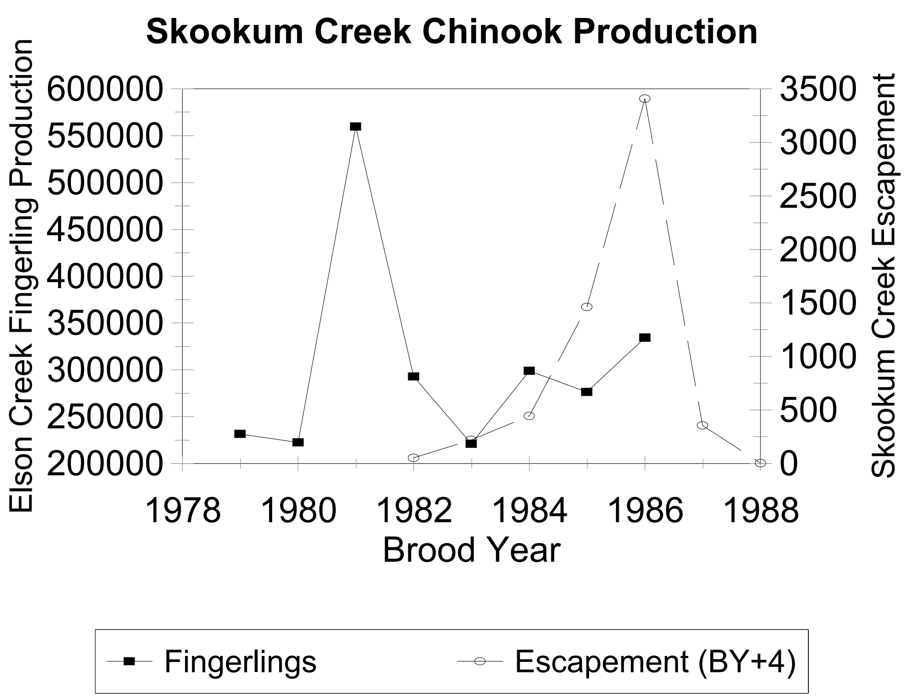

Figure 2. Skookum Creek hatchery chinook releases versus adult returns 1979 to 1988 (Washington Department of Fish and Wildlife 1999, unpublished work).

Between 1987 and 1992, about 2,000 adult chinook were counted in spawning ground surveys of Little Skookum Inlet tributaries. No adult chinook were counted after 1992 (Washington Department of Fish and Wildlife 1998, cited in Taylor *et al.* 1999). See Map 9 for streams with recent chinook observations.

Winter Steelhead Trout

Winter steelhead in WRIA 14 typically enter freshwater from December through mid-March and spawn from early February to early April. Stock status throughout WRIA 14 was characterized as "unknown" by WDFW in 1992 because escapement was *(and presently is)* not monitored. Saltwater survival of Puget Sound steelhead was poor during the early 1990s (Washington Department of Fish and Wildlife and Western Washington Treaty Tribes 1994). Steelhead stock status remains "unknown" throughout WRIA 14 and hatchery smolt plants no longer occur (Baranski 2002, personal communication). Sport fishing regulations vary between streams. Currently all Oakland Bay and Hammersley Inlet tributaries, with the exceptions of Goldsborough and Mill Creeks, are closed to fishing. Perry, Kennedy, Skookum, and Sherwood Creeks are also open to sport fishing. Wild steelhead release is required on all of these streams (Washington Department of Fish and Wildlife 2002).

Perry and McLane Creeks (WRIA 13) are the two winter steelhead streams found in Eld Inlet. Low summer flows in Perry Creek limit the stream's ability to produce a two-year-old steelhead smolt. No tribal or sport fisheries targeted these fish and no hatchery smolts were stocked here. Totten Inlet winter steelhead spawn in Skookum, Kennedy, and Schneider Creeks. Low summer flows limit rearing habitat and spawning habitat is limited as well. Hatchery smolts were planted in Kennedy Creek (Washington Department of Fish and Wildlife and Western Washington Treaty Tribes 1994).

Winter steelhead are present in Mill, Goldsborough, Johns, Cranberry, Deer, Spring, Malaney, Uncle John, and Campbell Creeks. Extensive water withdrawals from Goldsborough Creek at Goldsborough Dam during periods of low flow limited rearing of juvenile steelhead in the lower 2.3 miles of stream (the dam was removed in 2001). Sherwood, Coulter, and Rocky Creeks are home to Case Inlet winter steelhead. Few of these streams were planted with hatchery smolts (Washington Department of Fish and Wildlife and Western Washington Treaty Tribes 1994). See Map 10 for winter steelhead distribution.

Coastal Cutthroat Trout

Coastal cutthroat are the most widely distributed salmonid in WRIA 14. The anadromous form is likely found in most of the independent tributaries of South Puget Sound, but presence and distribution in freshwater is likely quite seasonal because of summer and fall low flows. Fish are expected to enter freshwater as flows increase with the onset of winter. The fluvial form likely inhabits all medium-sized streams and adfluvial fish may be present in as many as 12 lakes. The resident life history is present in virtually all perennial streams in western south Puget Sound. The stock is maintained by wild production. Stock status was "unknown" in 2000 (Blakley *et al.* 2000). Hatchery cutthroat have not been released in south Puget Sound streams with the exception of the Deschutes River and McAllister Creek. Hatchery reared coho fry may compete with juvenile cutthroat for limited space and prey during the low flow summer-fall period. Hatchery coho fry were stocked in most streams in past years. WDFW recently significantly reduced off-station fry plants, especially in south Puget Sound. Hatchery steelhead are not released into these streams with the exception of the Deschutes River (Blakley *et al.* 2000). Few formal inventories of coastal cutthroat distribution, abundance, and habitat conditions have occurred in the area. Hunter (1980) and Peoples *et al.* (1988) are two notable examples. No current (as of 2000) quantitative data on abundance or survival were available (Blakley *et al.* 2000). Most observations of cutthroat occur incidentally during salmon spawning ground surveys or monitoring of smolt traps (Hunter 2002, personal communication). Currently all Oakland Bay and Hammersley Inlet tributaries, with the exceptions of Goldsborough and Mill Creeks, are closed to fishing. Perry, Kennedy, Skookum, and Sherwood Creeks are also open to sport fishing. Wild cutthroat may be retained on all of these streams (Washington Department of Fish and Wildlife 2002). See Map 11 for coastal cutthroat distribution.

Bull Trout/Dolly Varden Char

Bull trout *(Salvelinus confluentus)* and Dolly Varden *(S. malma)* are not known to be present in the WRIA. No record of historic presence is known to exist. Bull trout and Dolly Varden are typically found in snowmelt-dominated streams that maintain cold water temperatures year-round *(at least in headwater tributaries)*. The rainfall-dominated streams of WRIA 14 do not provide this type of habitat.

HABITAT LIMITING FACTORS IDENTIFICATION

This report was developed by synthesizing written habitat descriptions, data derived from field assessments of habitat, and personal communications from natural resource professionals with knowledge of the Kennedy-Goldsborough Basin. Many of these personnel served in various capacities on the Technical Advisory Group (TAG), which contributed large amounts of literature, data, and technical review to this project. The report is intended for use as a tool to guide and prioritize salmonid habitat restoration projects. It is a compilation of all the information available at the time of writing. The report is a working document and should be viewed as a characterization of habitat conditions in the year 2002. Habitat conditions will undoubtedly change over time and data gaps will be filled periodically. The reader is encouraged to consult the "Co-Managers" (Washington Department of Fish and Wildlife and Squaxin Island Tribe) to verify the validity of habitat conditions as time progresses. Habitat descriptions, assessments, and TAG knowledge were used to describe the current habitat conditions on stream reaches throughout the region. These descriptions were compared to the Kennedy-Goldsborough (WRIA 14) salmonid habitat rating criteria (Table 6), resulting in a good, fair, or poor rating for habitat quality averaged throughout the entirety of each watershed [def.] (Table 7). A summary of habitat limiting factors is found in (Table 8). It is important to note that information on habitat conditions was often limited, and in some cases non-existent. The professional expertise of the TAG was used to fill in some of the "data gaps." However, in some cases no information was available. In these cases the habitat condition appears as a data gap (DG) in (Table 7). The habitat descriptions and habitat ratings were used to develop recommendations. These recommendations are not intended as regulatory mandates. They are actions that are necessary to restore and/or protect salmonid populations in the Kennedy-Goldsborough Basin. Implementation of some of the recommendations will require creative thinking, compromise, and in some cases sacrifices.

Comments on Data

This report is a compilation of data gathered from multiple entities. In some cases, the entities used different methods during habitat assessments. Much of the data were gathered by personnel from the Squaxin Island Tribe and compiled in various reports (e.g. Flores *et al.* 1991, Schuett-Hames *et al.* 1996, Taylor *et al.* 1999, Taylor *et al.* 2000). These studies followed methodologies established in the Timber, Fish, and Wildlife manual. Data from other sources (e.g. Allyn Salmon Enhancement Group 2002, unpublished work) were gathered using similar, but slightly different methodologies. Every attempt has been made to treat data equally so conditions can be compared across watersheds within the WRIA.

Habitat Limiting Factors Assessed

Fish Passage

Artificial obstructions including dams and culverts can block salmonid migration up and down streams. Depending on the location and longevity of the barrier, the negative effect may be limited to a portion of only one generation, or in extreme cases, the barrier may cause the extirpation [def.] of an entire run of fish. Manmade structures that may hinder salmonid migration in the Kennedy-Goldsborough Basin include dams and failed culverts. Natural waterfalls and cascades are common in headwater areas (Figure 3).

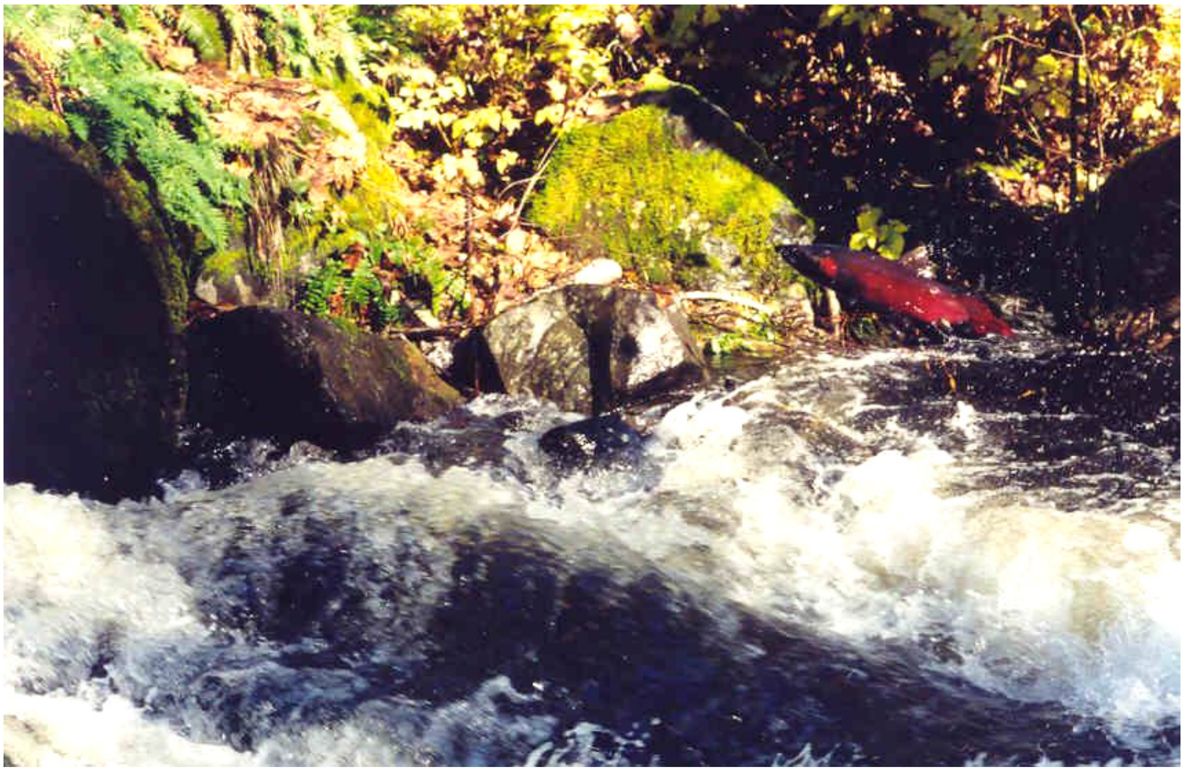

Figure 3. Coho salmon attempting to pass through a culvert at the U.S. Navy railroad bridge on Sherwood Creek (RM 6.8). The undersized culverts caused high water velocities, limiting passage of adults upstream. Photo courtesy of Allyn Salmon Enhancement Group.

Riparian Buffers

Riparian zones are the interface between the aquatic and terrestrial environments. This zone is normally covered with lush vegetation ranging in composition from grasses and forbs to shrubs and large trees depending upon the location within a watershed. Riparian zones have several important functions in maintaining natural riverine processes. Tree and shrub roots hold streambanks together (Montgomery and Buffington 2001) with a "root matrix." This matrix stabilizes channels, enabling the formation of undercut banks (excellent fish habitat) and reduces erosion (fine sediment smothers juvenile salmonids developing in streambed gravels) (Bjornn and Reiser 1991). Overhanging tree canopies shade water (Naiman *et al.* 2001), maintaining the cool temperatures salmonids need to thrive (Bjornn and Reiser 1991).

Leaf litter falling into the stream is an important component of primary production within the aquatic community (Bisson and Bilby 2001), although Murphy (2001) asserts that production by aquatic plants and algae makes a larger contribution. Microinvertebrates (i.e. zooplankton) and macroinvertebrates (larval insects, aquatic snails, etc.) feed on the decomposing organic material. Fish and other animals in turn feed on the smaller organisms (Bisson and Bilby 2001). Mature trees in the riparian zone also provide important function when they are knocked into streams by floods, windthrow, or landslides. These woody materials are known as large woody debris (LWD). Large woody debris stabilizes streambeds and banks, captures spawning gravels, encourages pool formation, provides resting and hiding cover for salmonids, and creates habitat for insects and other forage important to salmonids (Bilby and Bisson 2001). Finally vegetation within the riparian zone filters soil and pollutants from stormwater runoff (Knutson and Naef 1997, Welch *et al.* 2001) and reduces flood damage by slowing down flood waters, thereby dissipating energy and capturing soil carried in the flood waters (Naiman *et al.* 2001) (Figure 4).

Figure 4. Riparian vegetation along Sherwood Creek, spring 2000. Note the coniferous trees and the trees leaning over the stream, a future source of LWD. Photo courtesy of the Allyn Salmon Enhancement Group.

Streambank Condition

Natural streambank stability maintains the integrity of riverine processes. The root masses of riparian vegetation and large woody debris stabilize streambanks (Figure 5). Riparian zones can maintain or repair themselves if they are located on a stable bank. Vegetation has a difficult time recovering from flood damages or other disturbances if it is continually undermined by a failing bank (Naiman *et al.* 2001). Stable streambanks also ensure an adequate channel depth. A given volume of water is deeper in a narrow channel than in a wide channel. Depth maintains the cool temperatures and hiding cover needed by salmonids. Rapidly eroding banks tend to lead to development of overly wide and shallow channels (Platts 1991). Eroding streambanks can contribute large amounts of fine sediment to the water column as well as large amounts of coarse sediment that is deposited in the stream channel (aggraded), thus leading to subsurface flows (Hicks *et al.* 1991, Ziemer and Lisle 2001). Fine sediment appears to have little negative effect on adult salmonids (unless levels are chronically high), but it smothers developing juvenile salmonids buried in bottom substrate and fills interstices between gravels, cobbles, and boulders that provide important winter cover (Bjornn and Reiser 1991) (See Substrate Embeddedness).

Figure 5. Tree roots enhance bank stability and lead to formation of undercut banks, instream cover for salmonids. Photographed late August 2002, upstream from former Simpson Dam site on Goldsborough Creek.

Floodplain Connectivity

Floodplains provide an area for dissipation of energy in floodwaters. The floodplain has a larger surface area, and generally flatter slope than the stream channel. Once floodwaters spill onto the floodplain, the water spreads out, loses energy, and deposits fine sediment. Collisions between water and riparian vegetation reduce energy even further. Confining streamflow through channelization, and diking increases stream energy (and the potential for serious flooding downstream) by negating the benefits of water dispersing onto the floodplain (Ziemer and Lisle 2001). Increased stream energy causes bank erosion that leads to over-widening of the channel and aggradation of sediment. It can also cause channel incision that leads to loss of spawning gravels and lowering of the water table (Rosgen 1996).

Floodplains are often host to ponds, wetlands, and side channels. When connected to the stream, these off-channel areas provide both adult and juvenile salmonids refugia during floods (Benda *et al.* 2001), and may be used by rearing salmonids for long periods of time depending upon the species (See Off-Channel Habitat). Functional floodplains moderate instream flow peaks by substantially increasing the area available for water storage (Ziemer and Lisle 2001). Water seeps into the groundwater table during floods, recharging wetlands, off-channel areas and shallow aquifers. Wetlands and aquifers in turn release water to the stream during the summer months through a process called hydraulic continuity (Water Facts Group 1997). This process ensures adequate flows for salmonids during the summer months, and reduces the possibility of high-energy flood events that can destroy salmonid redds during the winter months. Floods are a natural riverine process that is vital to maintaining stream function. Flood flows flush fine sediment from spawning gravel, create pools and riffles by reshaping the streambed, deposit fine sediment on the floodplain, and move large woody debris from the floodplain to the stream channel (Benda *et al.* 2001). However, frequent catastrophic floods are not a natural phenomenon. These events are typically caused by human-induced changes in watershed cover such as extensive logging, extension of the channel network by high road densities, or alterations of channel morphology (Ziemer and Lisle 2001).

Width/Depth Ratio

The width/depth ratio refers to the average width of the river channel at a given cross-section divided by the average depth at that same cross-section. In other words, it determines if the channel is wide and shallow (high width/depth ratio) or narrow and deep (low width/depth ratio). In general, a narrow deep channel is more favorable to salmonids than a wide shallow channel. Deep water provides hiding cover and maintains cool water temperatures, while shallow water provides little or no cover (depending upon the life stage) and tends to gather heat with an expansive surface area exposed to the sun. The width/depth ratio also provides clues about a stream's current state of channel evolution. A low width/depth ratio indicates a stable channel that has reached the end point of channel evolution *(generally highly sinuous)*, or possibly an unstable channel that is downcutting rapidly in response to channel disturbances elsewhere within the watershed *(generally relatively straight)*. Conversely, a very high width/depth ratio usually indicates unstable streambanks and rapid deposition of sediments. This situation might naturally occur in a low gradient area such as a river outlet or delta, or it could be a response to changes in watershed character including removal of riparian vegetation and increased runoff caused by large scale changes in the vegetative cover of a watershed (i.e. logging, grazing, agriculture, fire, impervious surfaces) (Rosgen 1996).

Substrate Embeddedness

Substrate embeddedness is the product of fine sediment washed into streams. Eroding streambanks, forestland, roads, and urban developments all contribute to fine sediment inputs to streams in the Kennedy-Goldsborough Basin. Ideal salmonid spawning habitat has very little substrate embeddedness (Figure 6). When fine sediment settles to the bottom it cements gravels and cobbles together forming a type of "pavement." This pavement makes it difficult for female salmonids to excavate their nest or redd. Highly embedded substrate also prevents juvenile or sub-adult salmonids from entering or exiting interstices in the substrate that provide important winter cover. An abundance of fine sediment reduces the amount of water able to circulate through the gravel deposited over the eggs in the redd. This water infiltration is critical to oxygen delivery to the developing salmonids and removal of fish wastes from the nest (Bjornn and Reiser 1991, Hicks *et al.* 1991).

Figure 6. Clean-unembedded gravel provides quality salmonid spawning habitat. Chinook salmon spawning in Sherwood Creek September 2002. Photos courtesy of the Allyn Salmon Enhancement Group.

<u>Large Woody Debris</u>

Large woody debris or (LWD) is an important component of stream habitat. Large trees that fall into streams, or are carried in by landslides and floods stabilize streambeds, collecting spawning gravels and encouraging pool formation. Woody debris also provides cover for salmonids and their prey (Figure 7). In the past woody debris was removed to aid navigation, transport logs downstream, speed floodwaters downstream, or remove barriers to salmonid migration. Large woody debris is lacking in many streams because of these activities (Sedell *et al.* 2000) and the reduction or modification of riparian vegetation (Knutson and Naef 1997). Unfortunately woody debris recruitment is a long-term process since it first requires the presence of a functioning riparian zone comprised of large trees, and second, a means of getting the tree into the stream (i.e. flood, wind storm, landslide, beaver falling a tree, etc.) (Benda *et al.* 2001). Prior to extensive timber harvest an estimated 60 to 70% of Pacific Northwest forests were composed of late successional trees (>200 years old) (Franklin and Spies 1984, Booth 1991). Recent surveys of commercial timberlands in western Washington revealed a majority of riparian zones dominated by immature trees (mean diameter at breast height was 8 to 12 inches). Red alder was the dominant tree species (Carlson 1991). Coniferous trees produce the most desirable woody debris both in terms of size (Murphy and Koski 1989) and longevity. Western redcedar provides the most decay-resistant woody debris, followed by Douglas-fir, western hemlock, and red alder (Swanson and Lienkaemper 1978).

Figure 7. This logjam on Sherwood Creek has created a pool with instream and overhead cover and is stabilizing the stream banks. Photo courtesy of the Allyn Salmon Enhancement Group.

Pool Frequency

Pools are important habitat for salmonids and their prey. Salmonids use pools for resting during migration, rearing, hiding cover, feeding, and spawning in tailouts or current edges. Pools are characterized by calm water and can range in size from one foot deep and a few feet of surface area to 10 feet or greater in depth with a substantial surface area depending upon the size of the stream.

Pool Quality

Important features of pools are size, depth, and cover (both instream and overhead). Generally speaking, the more size, depth, and cover that are present, the higher the quality of the pool. Large-deep pools with lots of cover provide many hiding areas, ample forage, and cool water temperatures. An abundance of pools interspersed with riffles combine to create ideal salmonid habitat (Figure 8).

Figure 8. Though only about three feet deep, this pool exhibits many elements of a quality pool. The fallen tree provides instream cover while riparian vegetation provides overhead cover and shade. The pool is much deeper than the surrounding water. Photographed in late August 2002 upstream from the former Simpson Dam site on Goldsborough Creek.

Off-Channel Habitat

Beaver ponds, wetlands, oxbow ponds, and side channels connected to the main river channel are all forms of off-channel habitat. Juvenile salmonids (especially coho salmon, and cutthroat trout, and to a lesser extent, rainbow/steelhead trout) seek out this type of habitat for rearing, particularly during winter high flows. Off-channel areas provide an abundance of food with fewer predators than would typically be found in the river. These areas also generally have reduced current and large amounts of vegetative and/or woody cover, allowing juvenile salmonids to hide from predators and conserve energy (Sandercock 1998). Diking, and channelization of rivers, conversion of riparian zones to pasture and cropland, floodplain development, and extermination of beaver all play a roll in destruction of off-channel habitat (Figure 9).

Figure 9. This beaver pond in the Sherwood Creek Watershed is an example of off-channel habitat. Ponds such as this are excellent rearing habitat for coho salmon and cutthroat trout. Abundant woody debris provides cover, while the pond provides shelter from low summer and high winter stream flows. Photo courtesy of the Allyn Salmon Enhancement Group.

Water Quality

Salmonids require cold and clean water for optimal survival. Temperature, dissolved oxygen (DO) concentration, total suspended solids (TSS), pH, and other variables are all important elements of water quality. Water temperature requirements vary depending upon salmonid lifestage and species, but in general, a range of 50-57°F (10-14°C) is preferred. Long-term exposure to temperatures greater than 75°F (24°C) is fatal to salmonids (Bjornn and Reiser 1991). Salmonids require a minimum dissolved oxygen concentration of 5 mg/L (also read as [ppm] or parts per million) for survival (Bjornn and Reiser 1991). Washington State water quality standards require a value of 8 mg/L of DO for protection of fish resources in Class A waters and 9.5 mg/L in Class AA waters (WAC 173-201A). Total suspended solids (TSS) refers to the weight of particles including soil, and algae suspended in a given volume of the water column (Michaud 1991). The U.S. Fish and Wildlife Service recommends a maximum TSS level of 80 mg/L to protect salmonid fish (Fish and Wildlife Service 1995). Other water quality parameters including pH, the concentration of hydrogen ions in water, and chemical pollution can degrade habitat quality.

Water Quantity/Dewatering

Streams in WRIA 14 are rainfall dominated. The generally low elevation of the majority of the basin limits winter snow pack. The summer months bring naturally low stream flows that are further reduced by groundwater withdrawals along some streams (Stevie 2002, personal communication). Most rainfall occurs from October through May. Summers are relatively dry and ground water supplies are almost entirely recharged from precipitation. Much of the precipitation that falls in the Black Hills runs off because of the impermeable nature of the basalt rock. This causes many headwater streams to go dry during the summer months. Precipitation that falls on the unconsolidated sediment of the glacial plain tends to percolate into the groundwater, providing perennial flow to lowland streams. Groundwater provides the majority of late summer flow to area streams (Molenaar and Noble 1970). The natural climate, degraded watershed conditions, and surface and groundwater withdrawals may all contribute to low and/or subsurface flows. If flows are too low or channels are completely dewatered, little or no quality habitat remains for salmonids. Low summer flows limit salmonid rearing habitat throughout the WRIA (Washington Department of Fisheries 1975, Blakley *et al.* 2000, Golder Associates 2002). As flows decrease, water temperatures usually increase. Migration is hindered or completely blocked and fish are more vulnerable to predation and competition for limited space (Figure 10).

Figure 10. Flows in late September 2002 in a stream in the Sherwood Creek Watershed. The small wetted area and shallow depth provide little salmonid rearing habitat. Photo courtesy of the Allyn Salmon Enhancement Group.

Change in Flow Regime

A change in flow regime refers to the current flow conditions affected by human management versus the natural flow conditions that were present in the basin prior to Euro-American settlement. It is possible to infer that a change in flow regime has occurred in many watersheds because land cover has been altered from historic conditions and in some cases, water is removed for residential, commercial, and irrigation purposes. However, in many cases it is not possible to determine the magnitude of the flow regime change because historic stream flow data are sparse or non-existent. Extensive logging and construction of impervious surfaces have likely altered the natural flow regime in WRIA 14 by increasing runoff and peak stream flows during the winter months.

Biological Processes

Biological processes include the presence of introduced plant or animal species that may have a negative effect on salmonids (i.e. reed canary grass, brook trout, smallmouth bass) as well as the absence of native species that were historically present. Introduced plants and noxious weeds can out-compete native vegetation, reducing the quality of riparian plant communities (Knutson and Naef 1997). Introduced fish species may out-compete, hybridize with, or eat native salmonids. Removal of native species can disrupt ecosystem functions (McClain *et al.* 2001). For example, beaver create and maintain significant amounts of salmonid rearing habitat through dam construction. Beaver ponds are excellent salmonid rearing habitat and they gradually release water to streams, helping to maintain summer flows (Lichatowich 1999). Unfortunately, some people view beaver dams as barriers to salmonid migration and flood nuisances and therefore either destroy the dam or trap the beaver (TAG 2002). Anadromous salmonids returning from the ocean are a valuable source of nutrients to watersheds which are often nutrient limited (McClain *et al.* 2001). Nutrients from decomposing salmon carcasses are a critical component of aquatic (Bisson and Bilby 2001) and terrestrial food webs (Reeves *et al.* 2001) (Figure 11). Anadromous fish escapement goals for WRIA 14 are not based on meeting the nutrient needs of the ecosystem (Baranski 2002, personal communication). Introduced spiny-rays (bluegill, crappie, yellow perch, rock bass, smallmouth bass, and largemouth bass) are present in nearly every lake within WRIA 14. These fish prey on juvenile salmonids. The egg masses of spiny-rays are gelatinous, enabling them to cling to the feet of waterfowl and pass through the digestive tract of predators. This gelatinous character enables the eggs to be transferred throughout lakes in the WRIA (Burns 2002, personal communication).

Figure 11. Chum salmon carcasses in Anderson Lake Creek. Decomposing anadromous fish carcasses contribute ocean-derived nutrients to freshwater ecosystems. Photo courtesy of the Allyn Salmon Enhancement Group.

Estuary/Nearshore

Estuaries are areas where freshwater and saltwater mix. These areas are crucial for acclimation of juvenile and adult anadromous salmonids making the transition from life in freshwater to saltwater and vice versa. Tide flats are productive ecosystems. Juvenile salmonids grow rapidly by feeding on zooplankton and invertebrates produced on the mud flats, salt marshes, and eelgrass meadows (Shapovalov and Taft 1954, Hall *et al.* 1997, Groot and Margolis 1998). Eelgrass is second only to sugar cane in terms of productivity. One square meter of eelgrass meadow produces 581 grams of dry matter per year (Phillips 1972, cited in Kruckeberg 1998). Eelgrass meadows are host to a diverse community of organisms including attached algae, invertebrates, and fish. The plants provide numerous microhabitats and hiding cover for the animals that live within the meadow (Kruckeberg 1998). Rise and fall of tides provide numerous opportunities for rearing salmonids to feed on both terrestrial and aquatic prey (Groot and Margolis 1998). See Figure 12. Adult anadromous salmonids congregate in estuaries preparing to reenter freshwater. During this time, their body morphology changes in preparation for spawning. They also undergo physiological changes that allow them to regulate blood salinity in freshwater (Shapovalov and Taft 1954, Hall *et al.* 1997, Groot and Margolis 1998).

The marine shorelines of WRIA 14 offer spectacular views, and are consequently popular home sites. Developments can have negative impacts on shoreline habitat function. Riparian vegetation is often cleared, causing reduced bank stability, reduced shade, and reduced large woody debris recruitment. In some cases dikes and tide gates are built to eliminate tidal influence. Riprap, wood, and concrete are frequently used to stabilize a failing bank, or prevent bank failure in the first place. Shoreline armoring alters natural erosion and deposition patterns, increasing substrate size and altering plant community composition and primary production. This yields a net loss of organic matter and altered nutrient cycling (Shreffler *et al.* 1995). Armoring increases erosion rates on beaches, thus converting the beach from a depositional area that accumulates sediment and organic matter to an area that loses these elements on an annual or seasonal basis. Changing a sand/mudflat to gravel can significantly alter nutrient cycling. Surf smelt and Pacific sand lance spawn on beaches composed of sand and small gravel, habitat that is lost when wave energy and erosion are increased by shoreline armoring (Shreffler *et al.* 1995). From 1911-12 to 1977, southern Puget Sound showed the second largest increase of kelp distribution, 332%, in Puget Sound. An increase in kelp distribution suggests that depositional beaches were converted to gravel/cobble substrates that provide an attachment surface for kelp (Shreffler *et al.* 1995). Thurston County's shoreline is among the most extensively armored in Puget Sound. As of 1993, about 30% of the 117 miles of shoreline were armored (Morrison *et al.* 1993, cited in Shreffler *et al.* 1995).

In many instances, residents install bank-hardening structures because adjacent landowners have already installed a similar structure. They therefore assume that an artificial structure is necessary to protect their property. This is not the case if riparian vegetation and large woody debris are left along the shoreline. Tree roots and logs will provide the necessary bank stability and natural erosion and deposition processes will be maintained, protecting beaches that are important forage fish spawning areas (Stevie 2002, personal communication). The WDFW protects these spawning areas with a "no net loss" policy that centers on preventing destruction of the spawning substrate through burial or disruption of sediment supply caused by armoring and filling projects (Penttila 2001). With the exception of the Oakland Bay/Hammersley Inlet Subbasin, estuary/nearshore habitat conditions have not been quantitatively inventoried in WRIA 14. For this reason, estuary/nearshore habitat conditions were not rated in the habitat assessment Table 7.

Figure 12. Kennedy Creek Estuary. Note the emergent vegetation and multiple tidal channels. Photo courtesy of the Squaxin Island Tribe.

ELD INLET SUBBASIN HABITAT LIMITING FACTORS

Eld Inlet Subbasin Description

The Eld Inlet Subbasin drains about 20 square miles, not including McLane and Swift Creeks which are in WRIA 13 (Map 2). Perry Creek is the southern most stream in WRIA 14. The stream originates in several valleys along State Route 8 and flows 4.3 miles to Mud Bay. The mouth is characterized by extensive marshes and mud flats. Marine shorelines, mud flats, and estuarine habitat support production of shellfish, marine fish, and anadromous fish (Washington Department of Fisheries 1975).

Perry Creek (14.0001) and Tributaries

Habitat Ratings

Fish Passage

A falls blocks anadromy at river mile 1.2 (Washington Department of Fisheries 1975). A culvert at RM 0.3 on stream 14.0002 is a complete barrier (Northwest Indian Fisheries Commission 2002). This culvert is scheduled for replacement in 2003 (Winecka 2002, personal communication). Several impassable culverts are present upstream of the falls on Perry Creek, where coastal cutthroat are presumed to be present (Northwest Indian Fisheries Commission 2002). See Map 12. Fish passage was rated poor.

Riparian Buffers

How does this analysis compare to Evan's?

Riparian vegetation has been removed along the lower mile of Perry Creek where numerous homes have been built (Fraser 2002, personal communication). Schuett-Hames *et al.* (1996) measured canopy closure on five reaches of Perry Creek and one tributary. Canopy closure on the lower mile of stream was 47%, below the target value of 86% necessary to maintain Class A water quality temperature standards. Canopy closure above RM 1 ranged from 84% to 93%. Mean canopy closure on the four reaches upstream was 90%, greater than the mean target value of 76% necessary to maintain Class A water quality temperature standards. Canopy closure on stream 14.0002 was 97%, greater than the target value of 82% needed to maintain Class A water quality temperature standards (Schuett-Hames *et al.* 1996). Riparian condition was a data gap. Riparian canopy closure was rated good to poor. more details on this rating system.

Streambank Condition

Unconsolidated sediments deposited by glaciers have the potential to contribute a large amount of fine and coarse sediment to Perry Creek. These sediments erode easily. Bank erosion was noted along the stream reach adjacent to State Route 8 (Washington State Department of Natural Resources and Simpson Timber Company 1995). Some portions of the lower mile of stream have been channelized to protect homes (Fraser 2002, personal communication). Streambank condition was rated fair to poor.

Floodplain Connectivity

State Route 8 limits floodplain connectivity from RM 1.7 to RM 4.5 (Stevie 2002, personal communication). Floodplain connectivity was rated poor.

Width/Depth Ratio

Schuett-Hames *et al.* (1996) reported width/depth ratios ranging from 15.9 to 46.0. The mean width/depth ratio (weighted by stream reach length) was 29.2. Width/depth ratio was not rated.

Substrate Embeddedness

The mean percentage of fine sediment less than 0.85 mm was 10.4% (Schuett-Hames *et al.* 1996). Substrate embeddedness was rated good.

Large Woody Debris

Schuett-Hames *et al.* (1996) reported a range of 0.798 to 4.202 pieces of large woody debris per channel width on the mainstem. The weighted mean (by stream reach length) was 1.7 pieces per channel width. Unnamed tributary 14.0002 had 1.445 pieces of woody debris per channel width. Although LWD was relatively abundant, key pieces were rare. Abundance ranged from 0.000 to 0.132 pieces per channel width. The mean (weighted by stream reach length) was 0.049 pieces per channel width. Tributary 14.0002 had 0.125 key pieces per channel width. Total large woody debris abundance was rated good to poor, while key piece abundance was rated poor.

Pool Frequency

Pool frequency on the mainstem ranged from 2.98 to 10.35 channel widths per pool. Pools occurred at a mean frequency (weighted by stream reach length) of 4.67 channel widths per pool on the mainstem. Pools were uncommon on tributary 14.0002 with a spacing of 44.12 channel widths per pool (Schuett-Hames *et al.* 1996). Pool frequency was rated fair to poor.

Pool Quality

Mean residual pool depth (weighted by stream reach length) was 0.46 meters (1.51 feet) on Perry Creek. Pool surface area ranged from 25.2% to 82.1% on the mainstem. Weighted mean pool surface area was 47.7% on the mainstem. Tributary 14.0002 had a mean residual pool depth of 0.21 meters (0.69 feet). Pools comprised only 2.7% of stream surface area (Schuett-Hames *et al.* 1996). Pool quality was rated good to poor.

Off-Channel Habitat

No information was available.

Water Quality

Canopy closure measurements predicted that water temperatures would not exceed the Class A standard of 18°C (64.4°F) on Perry Creek or tributary 14.0002 (Schuett-Hames *et al.* 1996). Perry Creek was included on the 1998 303(d) list for exceeding pH criteria (Washington Department of Ecology 2000). No information was available on temperature and dissolved oxygen levels.

Water Quantity/Dewatering

Peoples *et al.* (1988) reported a September 1986 low flow of 0.7 cfs. No measurement location was specified. Water quantity was a data gap.

Change in Flow Regime

Agricultural conversion and road construction have increased peak flow 10 to 25% (Washington State Department of Natural Resources and Simpson Timber Company 1995). Change in flow regime was rated fair.

Biological Processes

Beaver are present, but no information is available on population status (TAG 2002). Chum escapements averaged almost 17,000 fish per year between 1991 and 2000 (Baranski 2002, personal communication). Marine-origin nutrient inputs resulting from these escapements are likely adequate to provide the nutrient needs of the ecosystem, as described by (Michael 2002). Biological processes were rated good.

Eld Inlet Tributaries (14.0003-14.0007)

Habitat Ratings

Fish Passage

An uncharacterized culvert is present at the mouth of Young Cove Creek (14.0004) (Northwest Indian Fisheries Commission 2002). A culvert at the mouth of Frye Cove Creek (14.0005) may impede passage (Fraser 2002, personal communication). A culvert at the mouth of Helser Creek is a complete barrier (Northwest Indian Fisheries Commission 2002). See Map 12. Fish passage was rated fair to poor.

Riparian Buffers

The riparian plant community along Young and Frye Cove Creeks is dominated by a mix of coniferous and deciduous trees (Fraser 2002, personal communication). Riparian condition and canopy closure were both data gaps.

Streambank Condition

No information was available.

Floodplain Connectivity

No information was available.

Width/Depth Ratio

No information was available.

Substrate Embeddedness

Substrate in Young and Frye Cove Creeks is predominately sand and fines. Small patches of gravel provide some spawning substrate (Fraser 2002, personal communication). Substrate embeddedness was rated poor.

Large Woody Debris

No information was available.

Pool Frequency

No information was available.

Pool Quality

The majority of pools in Young and Frye Cove Creeks are less than six-inches deep (Fraser 2002, personal communication). No information was available on percent pool surface area.

Off-Channel Habitat

No information was available.

Water Quality

No information was available.

Water Quantity/Dewatering

Young Cove Creek and Frye Cove Creek are both perennial streams (Fraser 2002, personal communication). No flow information was available.

Change in Flow Regime

No information was available.

Biological Processes

No information was available.

Estuary/Nearshore

Eld Inlet was listed on the 1996 303(d) list for high levels of fecal coliform bacteria (Washington Department of Ecology 1996). No quantitative habitat inventories are known to have taken place in this area.

TOTTEN/LITTLE SKOOKUM INLET SUBBASIN HABITAT LIMITING FACTORS

Totten/Little Skookum Inlet Subbasin Description

The Totten/Little Skookum Inlet Subbasin drains 80 square miles (Map 3). Commercial forestland covers about 70% of the area. Rural/agricultural land covers 28%. This includes woodlots (13%), rural residential (10%), and pastureland (4%). Urban residential development (more than one home per 1.5 acres) is a small land use. Most of this development is concentrated along shorelines, including Summit Lake, Fawn Lake and the inlets. Commercial and industrial property is concentrated near Kamilche, Taylor Town and Griffin (Soil Conservation Service *et al.* 1988). Aquaculture is centered in Oyster Bay and Little Skookum Inlet. Tidelands capable of shellfish production occupy 2,900 acres of the inlets. The total acreage of tidelands is 6,140 acres. About 700 acres of wetlands are present in the watershed. Water quality has not been identified as a major limiting factor for anadromous fish in this watershed. Both inlets have extensive sediment deposits on the tide flats. These deposits may have covered historic spawning habitat for shellfish and marine fish. Sediment deposition has caused problems in the past (Soil Conservation Service *et al.* 1988). The extensive sediment deposits at the head of each inlet are believed to have occurred over the last 80 to 100 years from natural causes and timber harvest in the Kennedy, Schneider, and Skookum Creek watersheds (Jeff Dickison, Squaxin Island Tribe, Personal Communication 1987, cited in Soil Conservation Service *et al.* 1988).

Kennedy Creek originates from Summit Lake and several small tributaries in the north slopes of the Black Hills, then flows more than 10 miles to Oyster Bay. A series of falls, cascades, and logjams that drop more than 60 feet in 300 yards block anadromous fish passage near river mile 2.5. Simpson Timber Company and the Washington State Department of Natural Resources own the majority of the watershed, restricting development to the shoreline of Summit Lake. The headwaters are heavily forested with conifers, while deciduous trees and pasture land dominate the broad valley bottom (Washington Department of Fisheries 1975).

Schneider Creek is a low gradient, intermittent stream that begins on Schneider's Prairie northeasterly of Summit Lake. The stream flows about 5.3 miles to the east toward U.S. Highway 101, then northwesterly to tide flats along Oyster Bay. Land cover consists of a mix of coniferous and deciduous trees interspersed with pasture lands (Washington Department of Fisheries 1975).

Skookum Creek begins from ground water seepage near Stimson Station on the Northern Pacific Railroad. The stream flows northwesterly through the Kamilche Valley paralleling State Highway 108 before draining into Skookum Inlet. Pasture land dominates the valley floor (Washington Department of Fisheries 1975).

Schneider Creek (14.0009) and McDonald Creek (14.0009b)

Habitat Ratings

Fish Passage

No complete barriers are known to be present. Six uncharacterized culverts are present. Anadromous fish are present up to the fifth culvert (Northwest Indian Fisheries Commission 2002). A fishway was installed on McDonald Creek (Holiday Valley Creek) under U.S. Highway 101 in 1986 (Burns 2002, personal communication). See Map 12. Fish passage was rated fair.

Riparian Buffers

Canopy closure on Schneider Creek ranged from 81% to 92%. Mean canopy closure on Schneider Creek was 86.5%, below the mean target level of 98% necessary to maintain Class AA water quality temperature standards (Schuett-Hames *et al.* 1996). Canopy closure on McDonald Creek was 96%, below the target level of 97% necessary to maintain Class AA water quality temperature standards (Schuett-Hames *et al.* 1996). The riparian buffer on Schneider Creek is dominated by deciduous vegetation. Numerous small farms are present in the watershed, creating minimal riparian buffers along some stream reaches (Fraser 2002, personal communication). Riparian condition was a data gap. Riparian canopy closure was rated poor.

Streambank Condition

Glaciers deposited large amounts of unconsolidated material, rich in both fine and coarse sediments. These deposits are highly erodible. Bank erosion was noted on the reach adjacent to U.S. Highway 101 (Washington State Department of Natural Resources and Simpson Timber Company 1995). Streambank condition was rated fair.

Floodplain Connectivity

The stream has been extensively channelized through agricultural lands upstream from U.S. Highway 101 (RM 3). However, the stream still has access to the floodplain. Flooding rarely occurs downstream from Highway 101 (Fraser 2002, personal communication). Floodplain connectivity was rated fair.

Width/Depth Ratio

Schuett-Hames *et al.* (1996) reported width/depth ratios ranging from 21.5 to 30.0. The mean width/depth ratio (weighted by stream reach length) was 22.4. Width/depth ratio was not rated.

Substrate Embeddedness

The mean percentage of fine sediment less than 0.85 mm was 22.6% (Schuett-Hames *et al.* 1996). Substrate embeddedness was rated poor.

Large Woody Debris

Large woody debris pieces per channel width ranged from 1.261 to 2.812 on Schneider Creek. The weighted mean (by stream reach length) was 1.4 pieces per channel width.

McDonald Creek, a small tributary had 0.558 pieces per channel width. Key pieces of LWD were relatively rare in Schneider Creek ranging from 0.023 to 0.095 pieces per channel width. Weighted mean (by stream reach length) of key pieces was 0.031 pieces per channel width. McDonald Creek had 0.072 pieces per channel width (Schuett-Hames *et al.* 1996). Total large woody debris abundance was rated good to poor. Key piece abundance was rated poor.

Pool Frequency

Mean pool frequency (weighted by stream reach length) was 2.74 channel widths per pool. McDonald Creek had a spacing of 5.56 channel widths per pool (Schuett-Hames *et al.* 1996). Pool frequency was rated fair to poor.

Pool Quality

Mean residual pool depth (weighted by stream reach length) was 0.38 meters (1.1 feet) on Schneider Creek. Pool surface area on Schneider Creek ranged from 44.9% to 69.6%. Pools occupied a mean of 47.5% of stream surface area. McDonald Creek had a mean residual pool depth of 0.26 meters (0.85 feet). Pools comprised 31.0% of stream surface area (Schuett-Hames *et al.* 1996) on McDonald Creek. Pool quality was rated good to fair.

Off-Channel Habitat

Some off-channel habitat is present in the low-gradient reach upstream from Highway 101 (Fraser 2002, personal communication). Numerous beaver dams backwater culverts on this reach (Winecka 2002, personal communication). Little information was available on off-channel habitat.

Water Quality

Canopy closure measurements predicted that water temperatures would exceed the Class AA standard of 16°C (60.8°F) on Schneider Creek and McDonald Creek a small tributary (Schuett-Hames *et al.* 1996). Schneider Creek was listed on the 303(d) list in 1996 for high levels of fecal coliform bacteria and in 1998 for exceeding pH criteria (Washington Department of Ecology 1996, Washington Department of Ecology 2000). No water temperature or dissolved oxygen data were available.

Water Quantity/Dewatering

In the summer months, Schneider Creek goes dry from RM 1.0 upstream. However, isolated pools are present to provide salmonid habitat (Fraser 2002, personal communication). Water quantity/dewatering was rated fair.

Change in Flow Regime

Agricultural conversion and road construction have increased peak flow 10% to 25% (Washington State Department of Natural Resources and Simpson Timber Company 1995). Change in flow regime was rated fair.

Biological Processes

Beaver are present, but no information was available on population status (TAG 2002). Chum escapements averaged nearly 2,000 fish per year between 1991 and 2000 (Baranski 2002, personal communication). Marine-origin nutrient inputs resulting from these escapements are likely adequate to provide the nutrient needs of the ecosystem, as described by (Michael 2002). Biological processes were rated good.

"County Line Creek" (14.0010)

Habitat Ratings

Fish Passage

A culvert at RM 0.5 is a partial barrier to anadromous fish. Two uncharacterized culverts are present downstream (Northwest Indian Fisheries Commission 2002). Coho and chum are able to pass through these culverts (TAG 2002). See Map 12. Fish passage was rated fair.

Riparian Buffers

Canopy closure was 91%, below the target level of 98% necessary to maintain Class AA water quality temperature standards (Schuett-Hames *et al.* 1996). The riparian buffer along County Line Creek is predominately deciduous vegetation (Fraser 2002, personal communication). Riparian condition was a data gap. Riparian canopy closure was rated poor.

Streambank Condition

No information was available.

Floodplain Connectivity

No information was available.

Width/Depth Ratio

Schuett-Hames *et al.* (1996) reported a width/depth ratio of 21.2. Width/depth ratio was not rated.

Substrate Embeddedness

Construction of U.S. Highway 101 destroyed the preferred chum spawning area in County Line Creek (Burns 2002, personal communication). No information was available on substrate embeddedness.

Large Woody Debris

Schuett-Hames *et al.* (1996) reported 0.576 pieces of LWD per channel width. Only 0.096 key pieces per channel width were present. Instream cover is generally lacking in County Line Creek, likely because of minimal coniferous vegetation in the riparian forest (Fraser 2002, personal communication). Total LWD and key piece abundance were both rated poor.

Pool Frequency

Pool frequency was 3.97 channel widths per pool (Schuett-Hames *et al.* 1996). Pools are generally uncommon (Fraser 2002, personal communication), likely because of low LWD abundance. Pool frequency was rated fair.

Pool Quality

Mean residual pool depth was 0.31 meters (1.0 feet). Pools comprised 40.3% of stream surface area (Schuett-Hames *et al.* 1996). Pool quality was rated good to fair.

Off-Channel Habitat

No information was available.

Water Quality

Canopy closure measurements predicted that water temperatures would exceed the Class AA standard of 16°C (60.8°F) (Schuett-Hames *et al.* 1996). No temperature or dissolved oxygen data were available.

Water Quantity/Dewatering

No information was available.

Change in Flow Regime

Agricultural conversion and road construction have increased peak flow 10% to 25% (Washington State Department of Natural Resources and Simpson Timber Company 1995). Change in flow regime was rated fair.

Biological Processes

Chum escapements averaged almost 1,000 fish per year between 1991 and 2000 (Baranski 2002, personal communication). Marine-origin nutrient inputs resulting from these escapements are likely adequate to provide the nutrient needs of the ecosystem, as described by (Michael 2002). Biological processes were rated good.

Kennedy Creek (14.0012) and Tributaries

Habitat Ratings

Fish Passage

A series of natural falls and cascades that drop in excess of 60 feet in about 300 yards block anadromy at river mile 2.5 (Washington Department of Fisheries 1975). Two culverts are present on tributaries of Kennedy Creek below the falls. The culvert on the left bank tributary is a complete barrier, while the culvert on the right bank tributary is uncharacterized. Several impassable culverts are located above the falls where coastal cutthroat are presumed to be present (Northwest Indian Fisheries Commission 2002). See Map 12. Fish passage was rated fair to poor.

Riparian Buffers

Schuett-Hames *et al.* (1996) reported canopy closure values for eight reaches of Kennedy Creek, and three tributaries (14.0012, 14.0013, and 14.0014-Summit Lake Outlet). Canopy closure values on the mainstem ranged from 18% to 88%. Mean canopy closure on mainstem Kennedy Creek was 65%, below the mean target level of 95% necessary to maintain Class AA water quality temperature standards. Canopy closure on stream 14.0013 was 82%, below the target level of 94% necessary to maintain Class AA water quality temperature standards. Canopy closure on stream 14.0014 (Summit Lake Outlet) was 89%, greater than the target level of 88% necessary to maintain Class AA water quality temperature standards (Schuett-Hames *et al.* 1996). About 27% of fish bearing streams in the Kennedy Creek Watershed were found to have canopy closure levels below the shade levels necessary to meet Class AA state water quality temperature standards (Washington State Department of Natural Resources and Simpson Timber Company 1995). About 68% of riparian areas were able to provide adequate LWD recruitment. Long-term projections predicted that 90% of riparian areas would provide adequate LWD in the future (Washington State Department of Natural Resources and Simpson Timber Company 1995). No information on riparian condition was available. Riparian canopy closure was rated poor.

Streambank Condition

Unconsolidated glacial material rich in fine and coarse sediments dominates the geology of Kennedy Creek. This material is highly erodible. Downstream from the falls (RM 2.5) 65% of banks were actively eroding (Washington State Department of Natural Resources and Simpson Timber Company 1995). Streambank condition was rated poor.

Floodplain Connectivity

No information was available.

Width/Depth Ratio

Schuett-Hames *et al.* (1996) reported width/depth ratios ranging from 14.5 to 41.9. The mean width/depth ratio (weighted by stream reach length) was 30.2. Width/depth ratio was not rated.

Substrate Embeddedness

Surface erosion from logging has been minimal. The high rate of revegetation likely reduces erosion. Sediment is rarely delivered to streams. There are an estimated 141 miles of roads in the Watershed Administrative Unit (WAU). Very few roads have the potential to deliver sediment to streams. However, the Upper and Middle Kennedy Creek subbasins are important sources of sediment delivery from roads to streams. Kennedy Creek is downcutting through sediments deposited by advancing and retreating glaciers. This downcutting provides a natural fine and coarse sediment load to the stream. Bank erosion appears to contribute the majority of sediment to the system. A sediment budget developed during the watershed analysis indicates that it takes 60 to 260 years for bedload to travel from the falls on Kennedy Creek to Totten Inlet (~ 2.5 miles). The effects of logging and wildfires prior to the 1940s are likely still being manifested today. Substantial quantities of sediment produced during the earlier disturbances are likely still present (Washington State Department of Natural Resources and Simpson Timber Company 1995). Mean percentage of fine sediment less than 0.85 mm ranged from 13.6% to 16.2% on the mainstem. An unnamed tributary had a mean fine sediment level of 18.8% (Schuett-Hames *et al.* 1996). Substrate embeddedness was rated fair to poor.

Large Woody Debris

Many streams in the WAU were characterized by low key LWD piece abundance. Deciduous material was the dominant woody debris. Little or no recruitment was occurring in areas cleared for agricultural or urban use (Washington State Department of Natural Resources and Simpson Timber Company 1995). Large woody debris abundance ranged from 1.200 to 8.100 pieces per channel width on the Kennedy Creek mainstem. The mean abundance (weighted by stream reach length) was 3.7 pieces per channel width. Unnamed tributary 14.0013 had 2.738 pieces per channel width. The outlet from Summit Lake (14.0014) had 1.196 pieces per channel width. Although LWD was relatively plentiful in Kennedy Creek, key pieces were rare. Key piece abundance ranged from 0.000 to 0.243 pieces per channel width. Mean abundance (weighted by stream reach length) of key pieces was only 0.088 pieces per channel width. Unnamed tributary 14.0013 had 0.399 key pieces per channel width. The outlet from Summit Lake had 0.153 key pieces per channel width (Schuett-Hames *et al.* 1996). Total large woody debris abundance was rated good to fair. Key piece abundance was rated fair to poor.

Pool Frequency

Pool frequency on mainstem Kennedy Creek ranged from 1.89 to 3.57 channel widths per pool. Weighted (by stream reach length) mean pool spacing was 2.24 channel widths per pool on the mainstem. Tributary 14.0013 had a pool frequency of 5.54 channel widths per pool. The outlet from Summit Lake had one pool for every 6.52 channel widths (Schuett-Hames *et al.* 1996). Pool frequency was rated good to poor.

Pool Quality

Mean (weighted by stream reach length) residual pool depth was 0.45 meters (1.48 feet) on mainstem Kennedy Creek. Pool surface area on the Kennedy Creek mainstem ranged from 46.3% to 74.8%. Weighted mean pool surface area on the mainstem was 53.9%. Tributary 14.0013 had a mean residual pool depth of 0.46 meters (1.51 feet). Pools comprised 53.1% of the stream surface. The outlet from Summit Lake had a mean residual pool depth of 0.25 meters (0.82 feet). Pools covered 26.9% of stream surface area (Schuett-Hames *et al.* 1996). Pool quality was rated good to poor.

Off-Channel Habitat

No information was available.

Water Quality

Spot temperature monitoring of lower Kennedy Creek suggested that temperatures hovered near the standard of 16°C (60.8°F) (Washington State Department of Natural Resources and Simpson Timber Company 1995). Canopy closure measurements predicted that water temperatures would exceed the Class AA standard of 16°C throughout Kennedy Creek and its tributaries with the exception of the outlet from

Summit Lake, which met the target canopy closure (Schuett-Hames *et al.* 1996). Kennedy Creek was included on the 1998 303(d) list for exceeding pH criteria (Washington Department of Ecology 2000). No temperature or dissolved oxygen data were available.

Water Quantity/Dewatering

Peoples *et al.* (1988) reported a September 1986 low flow of 3.2 cfs. No measurement location was specified. No other flow information was located.

Change in Flow Regime

Data from a USGS gage near the falls at RM 2.5 are available, but debris jams commonly formed at the head of the cascades. This caused water to back up at the gage site, casting serious doubt as to the validity of the data. Washington State Department of Natural Resources and Simpson Timber Company (1995) suggested ignoring the data until a methodology is developed to account for the apparent discrepancies. Agricultural conversion and road construction have increased peak flow 10 to 25% (Washington State Department of Natural Resources and Simpson Timber Company 1995). Change in flow regime was rated fair.

Biological Processes

Chum escapements averaged nearly 24,000 fish per year between 1991 and 2000 (Baranski 2002, personal communication). Marine-origin nutrient inputs resulting from these escapements are likely adequate to provide the nutrient needs of the ecosystem, as described by (Michael 2002). There is significant beaver activity in this stream, with low head dams constructed in the anadromous zone during the summer low flow period. These dams provide low flow rearing habitat and are made passable by elevated flows in the fall and winter, so they do not hinder upstream adult migration (Baranski 2002, personal communication). Biological processes were rated good.

"Snodgrass Creek" (14.0123)

Habitat Ratings

Fish Passage

An uncharacterized culvert is present at the mouth of Snodgrass Creek (Northwest Indian Fisheries Commission 2002). See Map 12. No other information was available.

Riparian Buffers

The riparian zone is vegetated with a of a mix of coniferous and deciduous trees (Fraser 2002, personal communication). No quantitative descriptions of riparian condition or riparian canopy closure were available.

Streambank Condition

No information was available.

Floodplain Connectivity

Floodplains are naturally limited by the steep draw that Snodgrass Creek flows through (Fraser 2002, personal communication).

Width/Depth Ratio

No information was available.

Substrate Embeddedness

Spawning gravel is relatively common from the pond downstream to the mouth (Fraser 2002, personal communication). No information on substrate embeddedness was available.

Large Woody Debris

Large woody debris is generally lacking in Snodgrass Creek (Fraser 2002, personal communication). Large woody debris total and key piece abundance were both rated poor.

Pool Frequency

Pools are uncommon because of the high stream gradient and lack of LWD (Fraser 2002, personal communication). Pool frequency was rated poor.

Pool Quality

Where present, pools are generally less than six-inches deep (Fraser 2002, personal communication). No information was available on percent pool surface area.

Off-Channel Habitat

The surrounding steep slopes limit off-channel habitat on Snodgrass Creek (Fraser 2002, personal communication).

Water Quality

No information was available.

Water Quantity/Dewatering

No information was available.

Change in Flow Regime

No information was available.

Biological Processes

No information was available.

Skookum Creek (14.0020) and Tributaries

Habitat Ratings

Fish Passage

No barriers are known to be present on the mainstem of Skookum Creek. A culvert at the mouth of a right bank tributary entering Skookum Creek at RM 3.3 is a complete barrier. Several other complete barriers are present on tributary streams (Northwest Indian Fisheries Commission 2002). Several fishways are present in the Skookum Creek Watershed. One is present at the U.S. Highway 101 crossing on the mainstem. Four are present on the lower 0.8 mile of Little Skookum Creek. An additional fishway is present at the State Route 108 crossing (RM 0.3) of stream 14.0023 (McDonald Creek) (Burns 2002, personal communication). See Map 12. Fish passage was rated fair.

Riparian Buffers

Extensive removal of riparian vegetation for agricultural purposes has occurred along the mainstem of Skookum Creek (Taylor *et al.* 1999). Canopy closure was 89%, below the target level of 96% necessary to maintain Class AA water quality temperature standards (Schuett-Hames *et al.* 1996). No information was available on riparian condition. Riparian canopy closure was rated poor.

Streambank Condition

Flores *et al.* (1991) identified over six-miles of eroded channel bank, mainly in low gradient reaches characterized by fine textured alluvial soils. Mass wasting ranged from 1,117 to 4,397 square feet of mass wasting per mile of channel. Slope failures generally occurred in areas adjacent to steep slopes and terraces or incised reaches with oversteepened banks. Vegetation removal and grazing worsened the problem (Flores *et al.* 1991). Streambank condition was rated poor.

Floodplain Connectivity

The channel of Skookum Creek is incised eight to 20 feet deep from just above the mouth upstream to RM 2.2 (Konovsky 2002, personal communication). Floodplain connectivity was rated poor.

Width/Depth Ratio

Schuett-Hames *et al.* (1996) reported a width/depth ratio of 14.3. Width/depth ratio was not rated.

Substrate Embeddedness

Mean percentage of fine sediment less than 0.85 mm was 16.5% (Schuett-Hames *et al.* 1996). Bank erosion, both natural and human-caused may be a major source of fine sediment in Skookum Creek. Banks have become oversteepened because of channel incision, unrestricted livestock access, and removal of riparian vegetation (Taylor *et al.* 1999). Substrate embeddedness was rated fair.

Large Woody Debris

Skookum Creek had 2.658 pieces of LWD per channel width. Key pieces occurred at only 0.098 pieces per channel width (Schuett-Hames *et al.* 1996). Total LWD abundance was rated good, but key piece abundance was rated poor.

Pool Frequency

Pools occurred at a spacing of one pool per 2.86 channel widths (Schuett-Hames *et al.* 1996). Pool frequency was rated fair.

Pool Quality

Mean residual pool depth was 0.40 meters (1.31 feet). Pools comprised 37.3% of stream surface (Schuett-Hames *et al.* 1996). Pool quality was rated poor.

Off-Channel Habitat

No information was available.

Water Quality

Canopy closure measurements predicted that water temperatures would exceed the Class AA standard of 16°C (Schuett-Hames *et al.* 1996). Skookum Creek was listed on the 1998 303(d) list for fecal coliform contamination (Washington Department of Ecology 2000). Two water samples gathered from Skookum Creek in October 1995 fell below the Class AA dissolved oxygen standard of 9.5 mg/L (8.8 and 9.3 mg/L). Sixteen additional samples collected during the summer months from 1995 through 2002 all contained a minimum of 9.8 mg/L of dissolved oxygen. Three samples taken from Little Skookum Creek contained less than 9.5 mg/L of DO (1995: 5.9 & 7.9 mg/L, 1997: 8.9 mg/L). Twenty-one additional samples gathered during the summer months from 1995 through 2002 contained a minimum of 9.5 mg/L of dissolved oxygen (Squaxin Island Tribe 2002, unpublished work). No temperature data were available. Dissolved oxygen levels were rated good to poor.

Water Quantity/Dewatering

Peoples *et al.* (1988) reported a September 1986 low flow of 2.1 cfs. No measurement location was specified. The minimum flow of 3.0 cfs between July 15 and October 1 (WAC 173-514-030) is rarely met (Taylor *et al.* 1999). In April 1967 flow was 1.56 cfs, and in August 1976 flow was 1.07 cfs (Williams and Riis 1989, cited in Taylor *et al.* 1999). Flow measurements at RM 1.0 from September 29, 1998 to October 5, 1998 ranged from 1.418 cfs to 3.260 cfs with a mean flow of 2.395 cfs (Taylor *et al.* 1999). Ground water use is estimated at 250 acre-feet per year, while recharge is estimated at 400 acre-feet per year, for a net recharge of 150 acre-feet per year. Between 4 and 8 acre-feet per year are diverted from surface water (Bielefeld and Wilson 1994, cited in Taylor *et al.* 1999). Nearly all of Mason County's potable water is derived from groundwater withdrawals. The shallow aquifers in the Little Skookum Inlet Watershed are hydraulically connected with streams. These aquifers are the source for most wells in the area. Withdrawals ultimately and sometimes immediately result in decreased streamflows (Taylor *et al.* 1999). The mean seven day low flows at RM 3.0 from August through October 1998, 1999, 2000, 2001, and 2002 were 2.4, 0.5, 9.6, 2.4, and 2.8 cfs respectively (Squaxin Island Tribe 2002, unpublished work). The values of 2.8, 2.4 and 0.5 cfs are below the minimum instream flow of 3.0 cfs (Table 2) established in WAC 173-514 (State of Washington 1988). Water quantity/dewatering was rated poor.

Change in Flow Regime

No information was available.

Biological Processes

The parasitic kidney fluke *Nanophyetus salmonicola* is present in Skookum Creek (Taylor *et al.* 1999). This fluke is commonly found in Pacific Northwest streams and often carries *Neorickettsia helminthoeca*, the organism responsible for salmon poisoning in dogs (Anon 2002). Beaver are present, but no information was available on population status (TAG 2002). Chum escapements averaged over 13,000 fish per year between 1991 and 2000 (Baranski 2002, personal communication). Marine-origin nutrient inputs resulting from these escapements are likely adequate to provide the nutrient needs of the ecosystem, as described by (Michael 2002). There is significant beaver activity in this stream, with low head dams constructed in the anadromous zone during the summer low flow period. These dams provide low flow rearing habitat and are made passable by elevated fall and winter flows, so they do not hinder upstream adult migration (Baranski 2002, personal communication). Biological processes were rated good.

Skookum Inlet Tributaries (north and south shore)

Habitat Ratings

Fish Passage

Culverts along Lynch Road and Kamilche Point Road block fish passage to streams draining into Skookum Inlet (Taylor *et al.* 1999, Northwest Indian Fisheries Commission 2002). The Elson Creek Hatchery intake is a partial barrier (Stevie 2002, personal communication). A 20' high falls at RM 0.2 of the third stream on the south shore, east of the terminus of Little Skookum Inlet blocks anadromous fish (Burns 2002, personal communication). See Map 12. Fish passage was rated poor.

Riparian Buffers

Alders and small conifers dominate the riparian community of Elson Creek (Fraser 2002, personal communication). A remnant stand of spruce is present at the mouth of Elson Creek (Stevie 2002, personal communication). Small deciduous vegetation is the dominant riparian plant along Lynch Creek (Fraser 2002, personal communication). No quantitative data on riparian condition or riparian canopy closure were available.

Streambank Condition

No information was available.

Floodplain Connectivity

No information was available.

Width/Depth Ratio

No information was available.

Substrate Embeddedness

Substrate in Elson Creek is highly embedded (Fraser 2002, personal communication). Lynch Creek has numerous hardpan cascades. In 1988, WDFW enhanced about 330 sq. meters of spawning habitat through gravel supplementation on the three salmon-bearing streams on the south shore of Little Skookum Inlet (Burns 2002, personal communication). No information was available on substrate embeddedness.

Large Woody Debris

Low LWD abundance is suspected to be a factor in loss of spawning substrate in the higher gradient streams draining the south shore of Little Skookum Inlet. Sediment depletion in these streams has limited chum spawning. WDFW conducted several gravel replacement projects to improve conditions (Taylor *et al.* 1999). Woody debris is uncommon in Elson Creek (Fraser 2002, personal communication). Total large woody debris abundance and key piece abundance were both rated poor.

Pool Frequency

Pools are relatively uncommon in Elson and Lynch Creeks (Fraser 2002, personal communication). Pool frequency was rated poor.

Pool Quality

Pools in Lynch Creek are generally less than one-foot deep. Elson Creek generally has pools less than six-inches deep (Fraser 2002, personal communication). No information was available on percent pool surface area.

Off-Channel Habitat

Both Elson and Lynch Creeks have limited off-channel habitat (Fraser 2002, personal communication). Off-channel habitat was rated poor.

Water Quality

No information was available.

Water Quantity/Dewatering

Management of Fawn Lake in the summer months may cause insufficient flows in Lynch Creek (Fraser 2002, personal communication). Water quantity/dewatering was rated poor.

Change in Flow Regime

Fawn Lake was created in the 1960s by damming an open water wetland. The lake is regulated to prevent flooding of adjacent homes (Taylor *et al.* 1999). Management of Fawn Lake in the summer months may cause insufficient flows in Lynch Creek (Fraser 2002, personal communication). Change in flow regime was rated poor.

Biological Processes

Comprehensive stock assessment surveys are conducted on only one independent tributary to Skookum Inlet, stream 14.0026 (Baranski 2002, personal communication). If chum escapements to this stream are typical of other tributaries in this basin, it is likely that marine-origin nutrient inputs resulting from these escapements are adequate to provide the nutrient needs of the ecosystem, as described by (Michael 2002). Biological processes were rated good.

Estuary/Nearshore

The mouth of Skookum Creek is home to a well-developed estuary characterized by estuarine emergent wetlands with deep pools that provide quality habitat for juvenile salmonids. About 74 acres of this area are protected within a Natural Area Preserve managed by the Washington Department of Natural Resources (Taylor *et al.* 1999).

Sampling by the Thurston County Health Department in 1984-85 found no exceedances of Class A Marine criteria for fecal coliform. However, four out of five freshwater stations exceeded Class A standards. Kennedy Creek met the freshwater standards. Schneider Creek, Cleeves Creek, and Burns Creek all exceeded Class A fecal coliform standards. Livestock appeared to be the source of contamination. A study by Mason County Health Department found that the major sources of freshwater to Little Skookum Inlet failed to meet Class A fecal coliform standards. However, marine water quality was only impacted during rainfall when bacterial loading increased substantially. There are at least 30 private docks on Little Skookum Inlet and over 170 on Totten Inlet (Soil Conservation Service *et al.* 1988). No quantitative habitat inventories are known to have occurred in this area.

OAKLAND BAY/HAMMERSLEY INLET SUBBASIN HABITAT LIMITING FACTORS

Oakland Bay/Hammersley Inlet Subbasin Description

The Oakland Bay/Hammersley Inlet Subbasin covers about 161 square miles, *including the areas of Oakland Bay and Hammersley Inlet* (Map 4). Mill Creek originates from the outflow of Lake Isabella and Gosnell Creek. The outflow from Forbes Lake (near Arcadia) provides a small amount of flow. The stream enters the south shore of Hammersley Inlet midway between Arcadia and Shelton. The watershed provides 16.0 miles of low gradient stream habitat, all of which is accessible to anadromous salmonids (Washington Department of Fisheries 1975).

Goldsborough Creek originates from springs, surface drainage, and small lakes. The South Fork begins about three miles south of the town of Dayton and west of Dayton Peak. The spring-fed North Fork begins about two miles northeast of Dayton. Winter Creek joins the North Fork about one mile north of Dayton. Shallow gradient plateaus covered with second growth conifers dominate the North Fork drainage. Winter Creek is characterized by rolling plateaus with heavy stands of second growth conifers. The South Fork is primarily marshlands with heavy growth of deciduous vegetation and some conifers on nearby hills. The North and South Forks join near the outlet of a small lake in Egypt Valley. Goldsborough Dam was located at RM 2.3 (removed in 2001). Another dam was historically located at RM 5.2, but had been removed by 1975. Coffee Creek is a spring-fed stream that forms above beaver dams about two miles up Shelton Valley. The Goldsborough Creek Watershed contains about 14.0 miles of stream (Washington Department of Fisheries 1975).

Johns Creek originates in a large wetland complex at Johns Lake before flowing 8.3 miles to Oakland Bay at Bay Shore. The upper watershed is characterized by wetlands bordered by Christmas tree plantations. The lower watershed is a mix of deciduous and coniferous trees (Washington Department of Fisheries 1975).

Cranberry Creek drains mostly logged terrain converted to Christmas tree farms. The stream flows 9.7 miles before emptying into the northern portion of Oakland Bay. Cranberry Lake, about 1.5 miles long (170 acres) is located at about RM 4.7. The lake is surrounded by about 96 acres of marshes and springs. Three intermittent streams flow into the lake from bog lakes up to a mile northward. The outlet flows about one-half mile before entering Lake Limerick, a manmade lake formed by a 15-foot-high dam at RM 3.5 on Cranberry Creek (Washington Department of Fisheries 1975).

Deer Creek originates as springs and the outflow from Benson Lake. The stream flows through Christmas tree plantations and wetlands before entering Oakland Bay about 1/4 mile east of Cranberry Creek. Five small tributaries enter between RM 3 and RM 6 (Washington Department of Fisheries 1975).

Campbell Creek originates as overflow from Phillips Lake and a large wetland above RM 3. The stream flows 4.5 miles before entering the estuary at the end of Chapman Cove. Two short right bank tributaries provide winter and spring flows to Campbell Creek. The stream has a moderate gradient (Washington Department of Fisheries 1975). Livestock grazing has denuded the riparian zone along Campbell and Uncle John Creeks. Uncle John Creek has also been extensively channelized (Stevie 2002, personal communication).

Gosnell Creek (14.0029) and Tributaries

Habitat Ratings

Fish Passage

A culvert at RM 2.6 is a barrier. Anadromous fish are known to be present above this barrier (Northwest Indian Fisheries Commission 2002). The culvert is scheduled for replacement in 2003 (Winecka 2002, personal communication). Two culverts on tributaries to Rock Creek are impassable. Salmon and steelhead are not known to be present in these two tributaries of Rock Creek, but coastal cutthroat are presumed to be present (Northwest Indian Fisheries Commission 2002). See Map 12. Fish passage was rated fair.

Riparian Buffers

Portions of the riparian zone have been cleared (Taylor *et al.* 2000). The lower two miles of Gosnell Creek are dominated by agricultural land use. Riparian vegetation is generally lacking in this reach. Conditions improve upstream in forestlands. Rock Creek has a marginal riparian buffer (Fraser 2002, personal communication). Schuett-Hames *et al.* (1996) reported canopy closure of 67%, below the target value of 82% needed to maintain Class A water temperature standards. No quantitative information was available on riparian condition. Riparian canopy closure was rated poor.

Streambank Condition

The stream channel has been used as a dump site (Taylor *et al.* 2000). Fine-grained soils dominate the lower two miles of channel. Removal of riparian vegetation has led to increased susceptibility to bank erosion (Fraser 2002, personal communication). Streambank condition was rated fair.

Floodplain Connectivity

Some channel incision is present on the lower two miles flowing through pasturelands (Winecka 2002, personal communication). Floodplain connectivity was rated fair.

Width/Depth Ratio

Schuett-Hames *et al.* (1996) reported a width/depth ratio of 15.0. Width/depth ratio was not rated.

Substrate Embeddedness

Mean percentage of fine sediment less than 0.85 mm was 25.3% (Schuett-Hames *et al.* 1996). Spawning gravel is plentiful in Rock Creek (Fraser 2002, personal communication). Substrate embeddedness was rated poor.

Large Woody Debris

Gosnell Creek had 1.734 pieces of LWD per channel width. Key pieces occurred at 0.232 pieces per channel width (Schuett-Hames *et al.* 1996). Instream cover is marginal in Rock Creek (Fraser 2002, personal communication). Total large woody debris abundance and key piece abundance were both rated fair.

Pool Frequency

Pool frequency was 2.12 channel widths per pool (Schuett-Hames *et al.* 1996). Pool frequency was rated fair.

Pool Quality

Mean residual pool depth was 0.40 meters (1.31 feet). Pools comprised 40.3% of stream surface area (Schuett-Hames *et al.* 1996). Pool quality was rated fair.

Off-Channel Habitat

A wetland approximately 86 acres in size (Washington State Conservation Commission and Northwest Indian Fisheries Commission 2002) is present at the inlet to Lake Isabella. Taylor *et al.* (2000) used the National Wetlands Inventory maps (Cowardin *et al.* 1979) to identify a total of ~984 acres of wetlands in the Mill Creek Watershed. Off-channel habitat was rated good.

Water Quality

Canopy closure measurements predicted that water temperatures would exceed the Class A standard of 18°C (Schuett-Hames *et al.* 1996). However, the highest daily maximum water temperatures recorded in the summers of 2000 and 2001 were 15.2°C and 14.9°C respectively (Squaxin Island Tribe 2002, unpublished work). Summer water temperatures as high as 20°C to 22°C may be a thermal barrier in Lake Isabella (Taylor *et al.* 2000). Temperature was rated good. No dissolved oxygen data were available.

Water Quantity/Dewatering

No information was available.

Change in Flow Regime

No information was available.

Biological Processes

Non-native warm water fish in Lake Isabella prey on juvenile salmonids (Burns 2002, personal communication). Beaver are present, but no information was available on population status (TAG 2002). Comprehensive stock assessment surveys are conducted on only one tributary to Gosnell Creek, Rock Creek (stream 14.0032) (Baranski 2002, personal communication). If chum and coho escapements into this stream are typical of this basin, it is likely that marine-origin nutrient inputs resulting from these escapements are not adequate to provide the nutrient needs of the ecosystem, as described by (Michael 2002). However, there are significant inputs. There is significant beaver activity in this system, with low head dams constructed in the anadromous zone during the summer low flow period. These dams provide low flow rearing habitat and are made passable by elevated fall and winter flows, so they do not hinder upstream adult migration (Baranski 2002, personal communication). Biological processes were rated fair.

Mill Creek (14.0029) and Tributaries

Habitat Ratings

Fish Passage

No barriers are present on mainstem Mill Creek or its salmon and steelhead producing tributaries (Northwest Indian Fisheries Commission 2002). See Map 12. Fish passage was rated good.

Riparian Buffers

Riparian buffers along Mill Creek are a mix of coniferous and deciduous vegetation (Fraser 2002, personal communication). Canopy closure was 52%, below the target level of 89% needed to maintain Class A water quality temperature standards (Schuett-Hames *et al.* 1996). No quantitative information on riparian condition was available. Riparian canopy closure was rated poor.

Streambank Condition

Extensive bank erosion has taken place on the agricultural reach from river mile two through river mile six. Soils are generally fine-grained and erode easily if not stabilized by riparian vegetation (Fraser 2002, personal communication). Streambank condition was rated poor.

Floodplain Connectivity

The stream has full access to the floodplain in some areas (Stevie 2002, personal communication). Floodplain connectivity was rated fair.

Width/Depth Ratio

Schuett-Hames *et al.* (1996) reported a width/depth ratio of 24.2. Width/depth ratio was not rated.

Substrate Embeddedness

Mean fine sediment less than 0.85 mm was 18.1% (Schuett-Hames *et al.* 1996). Recreational stream crossings and eroding pasture land are contributing fine sediment to the stream (Taylor *et al.* 2000). Substrate embeddedness was rated poor.

Large Woody Debris

Schuett-Hames *et al.* (1996) reported 1.361 pieces of LWD per channel width on Mill Creek. Key pieces occurred at 0.031 pieces per channel width. Total LWD abundance was rated fair, while key piece abundance was rated poor.

Pool Frequency

Spacing was 2.62 channel widths per pool (Schuett-Hames *et al.* 1996). Pool frequency was rated fair.

Pool Quality

Mean residual pool depth was 0.62 meters (2.0 feet). Pools occupied 83.9% of stream surface area (Schuett-Hames *et al.* 1996). Pool quality was rated good.

Off-Channel Habitat

Taylor *et al.* (2000) used the National Wetlands Inventory maps (Cowardin *et al.* 1979) to identify a total of ~984 acres of wetlands in the watershed. A large wetland complex is present at the outlet of Isabella Lake. Off-channel habitat was rated good.

Water Quality

Canopy closure measurements predicted that water temperatures would exceed the Class A standard of 18°C (Schuett-Hames *et al.* 1996). Daily maximum water temperatures exceeded 18°C almost daily from July through mid-September 2000 and 2001 throughout Mill Creek (three sites). Temperatures often reached 19°C to 22°C (Squaxin Island Tribe 2002, unpublished work). Taylor *et al.* (2000) reported three instances of dissolved oxygen levels below the Class A standard of 8.0 mg/L and late August water temperatures ranging from 18.8°C to 21.5°C (65.8°F to 70.7°F). Twelve additional water samples gathered during the summer months from 1995 through 2002 contained a minimum of 8.1 mg/L of dissolved oxygen (Squaxin Island Tribe 2002, unpublished work). Temperature was rated poor. Dissolved oxygen levels were rated good to poor.

Water Quantity/Dewatering

Peoples *et al.* (1988) reported a September 1986 low flow of 12.9 cfs. No measurement location was specified. Annual ground water use on Mill Creek was estimated at 1,612 acre-feet per year (2.2 cfs). Estimated annual surface water withdrawal on Mill Creek was 801 acre-feet (1.1 cfs). Total water use on Mill Creek was estimated at 3.3 cfs (Taylor *et al.* 2000). Taylor *et al.* (2000) calculated a two year-seven day low flow of 6.3 cfs. The mean seven day low flows at RM 3.1 in August and September of 2000, 2001 and 2002 were 16.3, 8.4, and 14.1 cfs respectively (Squaxin Island Tribe 2002, unpublished work). All three values are below the minimum flow of 20.0 cfs (Table 2) established in WAC 173-514 (State of Washington 1988). Water quantity/dewatering was rated poor.

Change in Flow Regime

No information was available.

Biological Processes

Introduced warm water fish in Lake Isabella prey on juvenile salmonids, particularly chum fry (Burns 2002, personal communication). Beaver are present, but no information was available on population status (TAG 2002). Chum escapements averaged nearly 10,000 fish per year between 1991 and 2000 (Baranski 2002, personal communication). Marine-origin nutrient inputs resulting from these escapements are likely not adequate to provide the nutrient needs of the ecosystem, as described by (Michael 2002). Although escapement is not at optimal levels, there are significant nutrient inputs (Baranski 2002, personal communication). Biological processes were rated fair.

Goldsborough Creek (14.0035) and Tributaries

Habitat Ratings

Fish Passage

Goldsborough Dam, formerly located at RM 2.5, was a complete barrier to chum, but coho and steelhead were able to use the dam's fishway. The dam was removed in the fall of 2001. A series of weirs were installed to correct the gradient of the streambed. Rootwads and logs were added to provide instream habitat complexity (TAG 2002). Several impassable culverts are present on tributaries of the North and South Forks of Goldsborough Creek. Most of these barriers have minimal channel length above them. Several culverts under Shelton Valley Road and Deegan Road on the upper portion of Coffee Creek and tributaries are impassable (Northwest Indian Fisheries Commission 2002). See Map 12. Fish passage was rated fair.

Riparian Buffers

Riparian clearing and unrestricted livestock access have damaged riparian vegetation along Coffee Creek. Riparian vegetation has also been cleared along South Fork Goldsborough Creek (Taylor *et al.* 2000). Canopy closure on Goldsborough Creek ranged from 48% to 54%. Mean canopy closure on Goldsborough Creek was 51%, below the mean target level of 81% necessary to maintain Class A water quality temperature standards (Schuett-Hames *et al.* 1996). A riparian revegetation project has been implemented at the former site of Goldsborough Dam to reestablish vegetation in areas disturbed during construction of the fish passage project. No quantitative data were available on riparian condition. Riparian canopy closure was rated poor.

Streambank Condition

Large portions of the channel from Highway 101 downstream were channelized and armored with riprap following floods in 1926, 1932, and 1935 (Thomas 1985). Brown and Caldwell (1990) described banks in the reach through Shelton as "stable" and "well channelized." Streambank condition was rated poor.

Floodplain Connectivity

Goldsborough Creek produced damaging floods in 1923, 1932, and 1935. Following the 1923 flood, the stream was channelized into a straighter and deeper channel from Seventh

Avenue to the mouth. Land on both sides of the stream was then filled and developed. In response to the 1935 floods, "The creek bed was … given another cleaning and banks raised with more rock (Thomas 1985, pg 37)." Flood control projects have disconnected the floodplain on the majority of the reach from Highway 101 (RM 2) downstream (Thomas 1985). The Simpson Timber railroad line limits channel migration from Highway 101 upstream to about RM 4.5 (Stevie 2002, personal communication). Extensive floodplains are present from RM 6 upstream to Trap Lake (RM 8). Some channelization has occurred on agricultural lands on Coffee Creek (Fraser 2002, personal communication). Floodplain connectivity was rated good to poor.

Width/Depth Ratio

Schuett-Hames *et al.* (1996) reported width/depth ratios of 26.4 and 27.3. Mean width/depth ratio (weighted according to stream reach length) was 27.0. Width/depth ratio was not rated.

Substrate Embeddedness

Mean percentage of fine sediment less than 0.85 mm was 16.4% (Schuett-Hames *et al.* 1996). Spawning gravel is plentiful from RM 1 upstream to RM 6 (Fraser 2002, personal communication). Substrate embeddedness was rated fair.

Large Woody Debris

Schuett-Hames *et al.* (1996) reported 3.741 to 12.446 pieces of woody debris per channel width on the reach between the Shelton-Matlock Road and Coffee Creek. The weighted mean (by stream reach length) was 10.021 pieces per channel width. Although woody debris was plentiful, key pieces were rare. Key piece abundance ranged from 0.108 to 0.167 pieces per channel width. Weighted mean abundance (by stream reach length) of key pieces was 0.124 pieces per channel width. Large woody debris is suspected to be rare or non-existent on the majority of the channelized reach downstream from Highway 101. Instream cover (including LWD) is generally lacking from RM 6 downstream (Fraser 2002, personal communication). Total LWD abundance was rated good to poor, while key piece abundance was rated fair poor.

Pool Frequency

Pool frequency ranged from 2.50 to 2.96 channel widths per pool. Weighted mean pool frequency was 2.83 channel widths per pool (Schuett-Hames *et al.* 1996). Pools are common from RM 6 upstream (Fraser 2002, personal communication). Pool frequency was rated fair.

Pool Quality

Weighted mean residual pool depth was 0.53 meters (1.74 feet). Pool surface area ranged from 46.4% to 71.9%. Pools occupied a weighted mean of 64.8% of stream surface area (Schuett-Hames *et al.* 1996). Pool quality was rated good to fair.

Off-Channel Habitat

Beaver ponds and wetlands in the upper portion of the watershed provide abundant off-channel habitat (TAG 2002). Taylor *et al.* (2000) used the National Wetlands Inventory maps (Cowardin *et al.* 1979) to identify a total of ~2,056 acres of wetlands in the watershed. Off-channel habitat was rated good.

Water Quality

The Rayonier pulp mill disposed of sulfite waste liquor in Goose Lake and evaporation ponds in that vicinity from 1930 until 1946 when it was discovered that the waste was seeping into ground water and the stream. After 1946, the waste liquor was incinerated (Thomas 1985). Ground water near this site was still contaminated as of 1990 (Brown and Caldwell 1990). Goldsborough Creek is a major contributor to fecal coliform contamination of Oakland Bay. Livestock operations may be contributing to the problem, but an overflow diversion from Shelton Creek (which receives large amounts of stormwater runoff contaminated with fecal coliform) and overflows from the City of Shelton sewage system are believed to be the main sources of bacteria (Brown and Caldwell 1990). Goldsborough Creek was included on the 1996 and 1998 303(d) lists for high levels of fecal coliform bacteria (Washington Department of Ecology 1996, Washington Department of Ecology 2000). Canopy closure measurements predicted that water temperatures would exceed the Class A standard of 18°C (Schuett-Hames *et al.* 1996). However, the highest daily maximum water temperature recorded during the summers of 2000 and 2001 was 17.7°C (Squaxin Island Tribe 2002, unpublished work). Nineteen water samples were collected from Goldsborough Creek in the summer months from 1995 through 2002. All samples contained a minimum of 8.4 mg/L of dissolved oxygen (Squaxin Island Tribe 2002, unpublished work). Temperature and dissolved oxygen levels were both rated good.

Water Quantity/Dewatering

Peoples *et al.* (1988) reported a September 1986 low flow of 18.3 cfs. No measurement location was specified. Flows measured from January 1987 to 1988 ranged from 19 cfs in mid-September to 240 cfs in March. This did not include the 18 to 26 cfs being diverted at Goldsborough Dam. Flood flows have been recorded up to 1,400 cfs. Coffee Creek had 8.5 cfs of flow in May and 3.7 cfs in mid-September (Brown and Caldwell 1990). Annual ground water use on Goldsborough Creek was estimated at 8,729 acre-feet per year (12 cfs). Estimated annual surface water withdrawal on Goldsborough Creek was 13,229 acre-feet (18 cfs). Total water use on Goldsborough Creek was estimated at 30.0 cfs (Taylor *et al.* 2000). Taylor *et al.* (2000) calculated a two year-seven day low flow of 21.0 cfs for Goldsborough Creek and 1.4 cfs for Coffee Creek. Surface water withdrawals are a contributing factor to low summer flows in Coffee Creek (Taylor *et al.* 2000). The mean seven day low flows at RM 0.23 in August and September of 2000, 2001 and 2002 were 37.7, 23.7 and 32.6 cfs respectively (Squaxin Island Tribe 2002, unpublished work). All three values are below the minimum flow of 45 cfs (Table 2) established in WAC 173-514 (State of Washington 1988). Water quantity/dewatering was rated poor.

Change in Flow Regime

The mouth of Goldsborough Creek was changed substantially by dredging and filling to create the mill sites currently present on the Shelton waterfront (Thomas 1985). These channel and tideland modifications have eliminated the intertidal transition zone that would naturally be present (Taylor *et al.* 2000, Anchor Environmental 2002). Change in flow regime was rated poor.

Biological Processes
Beaver are present, but no information was available on population status (TAG 2002). Beaver dams are common along upper Goldsborough Creek and the North and South Forks (Brown and Caldwell 1990). Marine-origin nutrient inputs resulting from basin escapements are likely not adequate to provide the nutrient needs of the ecosystem (Baranski 2002, personal communication) as described by (Michael 2002). Although escapement is not optimal, there are significant nutrient inputs (Baranski 2002, personal communication). Biological processes were rated fair.

Shelton Creek (14.0044)

Habitat Ratings

Fish Passage
A culvert at the City of Shelton stormwater facility (RM 1.0) on Shelton Creek is a complete barrier to anadromous fish. Six additional culverts are known to be present below this barrier, but all appear to be passable. One uncharacterized culvert is present on Canyon Creek. Coho are known to be present above this culvert (Northwest Indian Fisheries Commission 2002). See Map 12. Fish passage was rated poor.

Riparian Buffers
Brown and Caldwell (1990) characterized riparian vegetation on upper Canyon Creek as "good." Alder, maple, conifers, vine maple, berry bushes, and ferns were common. Shelton Creek is channelized from Seventh Avenue downstream and flows through several culverts and conduits. No riparian vegetation is present along the channelized reach (Stevie 2002, personal communication). No quantitative data were available on riparian condition. Riparian canopy closure on the lower mile of Shelton Creek was rated poor.

Streambank Condition
Much of the stormwater and runoff from the Capital Hill area is drained into Canyon Creek. Stormwater outlets at the canyon rim have caused moderate to severe erosion of the canyon walls. Several large slumps were observed. The stream is channelized throughout the city of Shelton where flows are conveyed through armored ditches, conduits, and culverts (Brown and Caldwell 1990, Taylor *et al.* 2000, TAG 2002). Streambank condition was rated poor.

Floodplain Connectivity
Shelton Creek has been channelized through the City of Shelton, particularly extensive RM 0.4 to RM 0.9. A diversion pipeline at Seventh Avenue diverts flows greater than 55

cfs to Goldsborough Creek (Brown and Caldwell 1990). Floodplain connectivity was rated poor.

Width/Depth Ratio

The stream is not overly wide and shallow (Stevie 2002, personal communication). Width/depth ratio was not rated.

Substrate Embeddedness

No information was available.

Large Woody Debris

Large woody debris was plentiful on upper Canyon Creek (Brown and Caldwell 1990). Woody debris is non-existent in the lower mile of Shelton Creek where salmonid spawning takes place. Small quantities of woody debris are present upstream from the storm water facility at RM 1.0 (Stevie 2002, personal communication). Large woody debris total and key piece abundance were both rate poor.

Pool Frequency

Pools are nearly non-existent through the channelized reach of Shelton Creek (Stevie 2002, personal communication). Pool frequency was rated poor.

Pool Quality

The channelized reach of Shelton Creek has little to no quality pool habitat (Stevie 2002, personal communication). Pool quality was rated poor.

Off-Channel Habitat

Taylor *et al.* (2000) used the National Wetlands Inventory maps (Cowardin *et al.* 1979) to identify a total of ~232 acres of wetlands in the watershed. Off-channel habitat was rated poor because of the channelized nature of lower Shelton Creek.

Water Quality

Shelton Creek exceeded Class A fecal coliform levels throughout sampling conducted by DOE. Septic tank effluent leaking into Shelton Creek is believed to be a significant contributor of bacteria to Oakland Bay. Overflows of the sewage system may also contribute since the creek flows through sewered areas of the city. Several septic systems on the rim of the canyon along upper Canyon Creek appeared to be failing, or close to failing (Brown and Caldwell 1990). Shelton Creek was included on the 1996 and 1998 303(d) lists for high levels of fecal coliform bacteria (Washington Department of Ecology 1996, Washington Department of Ecology 2000). No temperature or dissolved oxygen data were available.

Water Quantity/Dewatering

The aquifer that feeds Shelton Creek provides the municipal water supply for the City of Shelton. The diversion has removed a large portion of the perennial flow, making the upper 2.6 miles an intermittent stream. The stream enters a debris basin and diversion at about RM 0.5 that diverts flows over 55 cfs into Goldsborough Creek through a pressure pipeline that runs along Seventh Avenue. Downstream from Seventh Avenue, Shelton Creek travels through many culverts and collects the majority of stormwater runoff for this part of Shelton (Brown and Caldwell 1990). Taylor *et al.* (2000) calculated a two year-seven day low flow of 0.7 cfs. Water quantity/dewatering was rated poor.

Change in Flow Regime

Shelton Creek is extensively channelized through ditches and conduits throughout the City of Shelton (Brown and Caldwell 1990, Taylor *et al.* 2000). Dredging and filling along the Shelton waterfront have substantially altered channel morphology at the mouth of Shelton Creek (Anchor Environmental 2002). Change in flow regime was rated poor.

Biological Processes

Beaver are rare in the highly altered Shelton Creek system. Anadromous fish are blocked at RM 1.0 of Shelton Creek, eliminating escapement to the headwaters (TAG 2002). Chum escapement averaged under 200 fish per year between 1991 and 2000 (Baranski 2002, personal communication). Marine-origin nutrient inputs resulting from these escapements are likely not adequate to meet the nutrient needs of the ecosystem (Baranski 2002, personal communication) as described by (Michael 2002). Biological processes were rated poor.

Johns Creek (14.0049)

Habitat Ratings

Fish Passage

The WDFW Johns Creek hatchery has been closed since 1997. A series of stream-width concrete controls form the bypass fishway at the hatchery intake. One or two of the controls are low flow barriers for early (i.e. summer) chum salmon (Barber *et al.* 1997). Six uncharacterized culverts are present on Johns Creek. Anadromous fish are known to pass all of the culverts (Northwest Indian Fisheries Commission 2002). See Map 12. Fish passage was rated fair.

Riparian Buffers

Canopy closure was 71%, below the target level of 76% needed to maintain Class A water quality temperature standards (Schuett-Hames *et al.* 1996). No riparian condition information was available. Riparian canopy closure was rated poor.

Streambank Condition

Some channelization and bank armoring have occurred in a residential area near RM 3.5. About ¼ mile of stream has been channelized and armored to protect the intake at the WDFW Johns Creek Hatchery (Fraser 2002, personal communication). Streambank condition was rated fair.

Floodplain Connectivity

From RM 0.3 upstream to RM 2.2, Johns Creek flows through a steep draw that naturally limits floodplain size. From RM 2.2 upstream the surrounding topography of McEwan Prairie is relatively flat. This reach is characterized by extensive wetlands (Stevie 2002, personal communication). See Figure 13. Floodplain connectivity was rated good.

Figure 13. Wetland on upper Johns Creek. Photo courtesy of the Squaxin Island Tribe.

Width/Depth Ratio

Schuett-Hames *et al.* (1996) reported a width/depth ratio of 30.3. Width/depth ratio was not rated.

Substrate Embeddedness

Mean percentage of fine sediment less than 0.85 mm was 14.0% (Schuett-Hames *et al.* 1996). In 1995, mass wasting at Bay Shore Sand and Gravel along Johns Creek increased fine sediment levels, damaging chum redds in the stream and shellfish beds in Oakland Bay. As of 1999 it appeared that erosion was still a chronic problem (Taylor *et al.* 2000). Spawning substrate is plentiful in the higher gradient reaches downstream from RM 2.2 (Fraser 2002, personal communication). Substrate embeddedness was rated fair.

Large Woody Debris

Large woody debris abundance was 5.328 pieces per channel width. Key pieces occurred at a rate of 0.066 pieces per channel width (Schuett-Hames *et al.* 1996). Woody debris is lacking in the reaches upstream from the reach inventoried by Schuett-Hames *et al.* (1996) (Stevie 2002, personal communication). Large woody debris total abundance was rated good to poor. Key piece abundance was rated poor.

Pool Frequency

Pool spacing was 2.18 channel widths per pool (Schuett-Hames *et al.* 1996). Pool frequency was rated fair.

Pool Quality

Mean residual pool depth was 0.44 meters (1.44 feet). Pools comprised 18.0% of stream surface area (Schuett-Hames *et al.* 1996). Pool quality was rated poor.

Off-Channel Habitat

Taylor *et al.* (2000) used the National Wetlands Inventory maps (Cowardin *et al.* 1979) to identify a total of 854 acres of wetlands in the watershed. Off-channel habitat was rated good.

Water Quality

Canopy closure measurements predicted that water temperatures would exceed the Class A standard of 18°C (Schuett-Hames *et al.* 1996). The highest daily maximum water temperature recorded at Bayshore Golf Course in the summer of 2001 was 16.3°C. Daily maximum water temperatures at the Johns Creek Drive gage frequently exceeded 18.0°C from mid-July to mid-August 2000. Conditions were similar in 2001 (15 daily maximums over 18°C) (Squaxin Island Tribe 2002, unpublished work). One water sample taken at McEwan Prairie Road in late September 1997 contained only 6.7 mg/L of DO. Fourteen other samples gathered in the summer months from 1995 through 2002 all contained a minimum of 8.0 mg/L of dissolved oxygen (Squaxin Island Tribe 2002, unpublished work). Temperature was rated poor. Dissolved oxygen levels were rated good to poor.

Water Quantity/Dewatering

Taylor *et al.* (2000) calculated a two year-seven day low flow of 3.0 cfs. The mean seven day low flows at RM 2.5 in August and September of 2000, 2001 and 2002 were 9.6, 2.8 and 6.7 cfs respectively (Squaxin Island Tribe 2002, unpublished work). The values of 2.8 and 6.7 cfs are below the minimum instream flow of 7.0 cfs (Table 2) established in WAC 173-514 (State of Washington 1988). Water quantity/dewatering was rated poor.

Change in Flow Regime

No information was available.

Biological Processes

The parasitic kidney fluke *Nanophyetus salmonicola* is present in Johns Creek (Taylor *et al.* 2000). This fluke is commonly found in Pacific Northwest streams and often carries *Neorickettsia helminthoeca*, the organism responsible for salmon poisoning in dogs (Anon 2002). Beaver are present, but no information was available on population status (TAG 2002). Chum escapement averaged nearly 24,000 fish per year between 1991 and 2000 (Baranski 2002, personal communication). Marine-origin nutrient inputs resulting from these escapements are likely adequate to provide the nutrient needs of the basin ecosystem (Baranski 2002, personal communication) as described by (Michael 2002).

However, most of the chum spawning activity takes place from RM 2 downstream. There is significant beaver activity in this stream, with low head dams constructed in the anadromous zone during the summer low flow period. These dams provide low flow rearing habitat and are made passable by elevated fall and winter flows, so they do not hinder upstream adult migration (Baranski 2002, personal communication). Biological processes were rated fair below RM 2, but poor upstream.

Cranberry Creek (14.0051)

Habitat Ratings

Fish Passage

The dam at the outlet of Lake Limerick (RM 3.5) has a semi-functional fish ladder. A culvert at RM 4.2 is a complete barrier to chum, but coho are able to pass through the culvert (Burns 2002, personal communication). Several other barriers are present on tributary streams (Northwest Indian Fisheries Commission 2002). See Map 12. Fish passage was rated fair.

Riparian Buffers

From the mouth to RM 2.8, the riparian buffer is dominated by deciduous vegetation. Numerous residences are present along the stream from RM 2.8 upstream to Lake Limerick (RM 3.5) (Fraser 2002, personal communication). Canopy closure was 80%, greater than the target value of 75% needed to maintain Class A water quality temperature standards (Schuett-Hames *et al.* 1996). No quantitative riparian condition information was available. Riparian canopy closure was rated good.

Streambank Condition

Taylor *et al.* (2000) reported mass wasting in the lower channel near the railroad line. Information was insufficient to rate streambank condition.

Floodplain Connectivity

The stream has been channelized in some reaches downstream from Lake Limerick (Taylor *et al.* 2000). Floodplain connectivity was rated fair.

Width/Depth Ratio

Schuett-Hames *et al.* (1996) reported a width/depth ratio of 17.4. Width/depth ratio was not rated.

Substrate Embeddedness

Mean percentage of fine sediment less than 0.85 mm was 16.2% (Schuett-Hames *et al.* 1996). Spawning substrate is plentiful (Fraser 2002, personal communication). Substrate embeddedness was rated fair.

Large Woody Debris

Cranberry Creek had 5.871 pieces of LWD per channel width. Key pieces occurred at 0.204 pieces per channel width (Schuett-Hames *et al.* 1996). Although stream-side residents remove LWD from the channel (particularly from RM 2.8 to RM 3.5), instream cover is still relatively common (Fraser 2002, personal communication). Woody debris is lacking in some reaches (Stevie 2002, personal communication). Large woody debris total abundance was rated good to fair. Key piece abundance was rated fair.

Pool Frequency

Pools occurred at a spacing of one pool per 2.52 channel widths (Schuett-Hames *et al.* 1996). Pool frequency was rated fair.

Pool Quality

Mean residual pool depth was 0.43 meters (1.41 feet). Pools covered 45.0% of stream surface area (Schuett-Hames *et al.* 1996). Pool quality was rated good.

Off-Channel Habitat

Taylor *et al.* (2000) used the National Wetlands Inventory maps (Cowardin *et al.* 1979) to identify a total of ~1,146 acres of wetlands in the watershed. Off-channel habitat was rated good.

Water Quality

Daily maximum water temperatures at the State Route 3 crossing exceeded the Class A standard of 18.0°C every day from mid-July through mid-August 2000. Conditions improved in 2001, with daily maximums exceeding the standard 17 days from July through August. Conditions upstream at three additional monitoring stations deteriorated substantially in comparison to the station at State Route 3. Daily maximum water temperatures exceeded 18.0°C nearly every day from July through September 2000 and 2001 and often reached 22°C to 24°C (Squaxin Island Tribe 2002, unpublished work). Taylor *et al.* (2000) reported two instances of dissolved oxygen levels below the Class A standard of 8.0 mg/L, 6.8 and 7.8 mg/L in 1997 (Squaxin Island Tribe 2002, unpublished work), and water temperatures in late August and early September ranging from 19.1°C to 22.2°C (66.4°F to 72.0°F). Sixteen additional water samples taken during the summer months from 1995 to 2002 all contained a minimum of 8.7 mg/L of dissolved oxygen (Squaxin Island Tribe 2002, unpublished work). Temperature was rated poor. Dissolved oxygen levels were rated good to poor.

Water Quantity/Dewatering

Taylor *et al.* (2000) calculated a two year-seven day low flow of 3.6 cfs. The mean seven day low flows at RM 0.5 in August and September of 2000, 2001 and 2002 were 9.0, 9.3 and 7.8 cfs respectively (Squaxin Island Tribe 2002, unpublished work). The 7.8 cfs flow is below the minimum flow of 8.0 cfs (Table 2) established in WAC 173-514 (State of Washington 1988). Water quantity/dewatering was rated poor.

Change in Flow Regime

Lake Limerick was created by damming a wetland (Washington Department of Fisheries 1975). Regulation of outflow during the summer months may have negative effects on habitat conditions from RM 3.5 downstream (Stevie 2002, personal communication). Change in flow regime was rated poor.

Biological Processes

Warm water fish have been introduced to both Cranberry Lake and Lake Limerick. These fish consume juvenile salmonids, especially chum fry (Burns 2002, personal communication). Beaver are present, but no information was available on population status (TAG 2002). Chum escapements averaged almost 9,000 fish per year between 1991 and 2000 (Baranski 2002, personal communication). Marine-origin nutrient inputs resulting from these escapements are likely adequate to provide the nutrient needs of the ecosystem (Baranski 2002, personal communication) as described by (Michael 2002). Most of the chum spawning activity takes place below Lake Limerick. There is significant beaver activity in this stream, with low head dams constructed in the anadromous zone during the summer low flow period. These dams provide low flow rearing habitat and are made passable by elevated fall and winter flows, so they do not hinder upstream adult migration (Baranski 2002, personal communication). Biological processes were rated fair below RM 3.5 (Lake Limerick outlet), but poor upstream.

Deer Creek (14.0057) and Tributaries

Habitat Ratings

Fish Passage

A partially blocking culvert at RM 0.15 on Spring Creek historically impeded anadromous fish passage (Northwest Indian Fisheries Commission 2002). The culvert was replaced in the fall of 2002 (TAG 2002). A culvert is a complete barrier to anadromous fish passage at RM 0.8 on stream 14.0064. Several other barriers are present on tributaries of Deer Creek (Northwest Indian Fisheries Commission 2002). See Map 12. Fish passage was rated fair.

Riparian Buffers

Riparian vegetation has been cleared along Mason Lake Road (Taylor *et al.* 2000). Canopy closure was 30%, well below the target level of 90% needed to maintain Class A water quality temperature standards (Schuett-Hames *et al.* 1996). No quantitative riparian condition information was available. Riparian canopy closure was rated poor.

Streambank Condition

Taylor *et al.* (2000) reported bank erosion along Mason Lake Road and upstream from Highway 3. Homes are relatively close to the stream bank on the lower 1.5 miles of Deer Creek. Severe erosion and bank armoring have taken place on this reach (Fraser 2002, personal communication). Streambank condition was rated poor.

Floodplain Connectivity

Extensive ponded and emergent wetlands are present from RM 1.5 upstream (Fraser 2002, personal communication). Floodplain connectivity was rated good.

Width/Depth Ratio

Schuett-Hames *et al.* (1996) reported a width/depth ratio of 27.0. Width/depth ratio was not rated.

Substrate Embeddedness

Mean percentage of fine sediment less than 0.85 mm was 30.8% (Schuett-Hames *et al.* 1996). Substrate embeddedness was rated poor.

Large Woody Debris

In the 1950s and 1960s, WDF used a bulldozer to clear all large woody debris from the channel of Deer Creek (Burns 2002, personal communication). Deer Creek had 1.306 pieces of LWD per channel width. Key pieces occurred at only 0.145 pieces per channel width (Schuett-Hames *et al.* 1996). Scattered woody debris and undercut banks provide salmonid rearing habitat (Fraser 2002, personal communication). Large woody debris total abundance was rated fair, but key piece abundance was poor.

Pool Frequency

Pools were present at a frequency of one pool per 1.27 channel widths (Schuett-Hames *et al.* 1996). Pool frequency was rated good.

Pool Quality

Mean residual pool depth was 0.43 meters (1.41 feet). Pools comprised 74% of stream surface area (Schuett-Hames *et al.* 1996). Pool quality was rated good.

Off-Channel Habitat

Taylor *et al.* (2000) used the National Wetlands Inventory maps (Cowardin *et al.* 1979) to identify a total of ~638 acres of wetlands in the watershed. These wetlands provide quality salmonid rearing habitat (Fraser 2002, personal communication). Off-channel habitat was rated good.

Water Quality

Canopy closure measurements predicted that water temperatures would exceed the Class A standard of 18°C (Schuett-Hames *et al.* 1996). Five dissolved oxygen samples gathered in the summer months from 1995 to 2002 contained a minimum of 9.1 mg/L each (Squaxin Island Tribe 2002, unpublished work). No temperature data were available. Dissolved oxygen levels were rated good.

Water Quantity/Dewatering

Taylor *et al.* (2000) calculated a two year-seven day low flow of 2.9 cfs. Information was insufficient to establish a rating.

Change in Flow Regime
No information was available.

Biological Processes
Chum escapements averaged less than 2,000 fish per year between 1991 and 2000 (Baranski 2002, personal communication). Marine-origin nutrient inputs resulting from these escapements are likely inadequate to meet the nutrient needs of the ecosystem (Baranski 2002, personal communication) as described by (Michael 2002). However, most of the chum spawning activity takes place in the lower two miles. There is significant beaver activity in this stream, with low head dams constructed in the anadromous zone during the summer low flow period. These dams provide low flow rearing habitat and are made passable by elevated fall and winter flows, so they do not hinder upstream adult migration (Baranski 2002, personal communication). Biological processes were rated fair from RM 2 downstream, but poor upstream.

Malaney Creek (14.0067)

Habitat Ratings

Fish Passage
A culvert under Agate Road (RM 0.5) is a barrier at most flows (Northwest Indian Fisheries Commission 2002). A project is being proposed for funding by the SRFB in the fall of 2002 to correct this problem (Winecka 2002, personal communication). See Map 12. Fish passage was rated poor.

Riparian Buffers
Canopy closure on the lower 0.5 miles of Malaney Creek was 47%, well below the target value of 90% needed to maintain Class A water quality temperature standards (Schuett-Hames *et al.* 1996). Upstream from Agate road, the riparian zone is dominated by Himalayan blackberry, red alder, and immature conifers (TAG 2002). No quantitative riparian condition information was available. Riparian canopy closure was rated poor.

Streambank Condition
Some reaches are channelized and armored with riprap (Taylor *et al.* 2000), particularly from Spencer Lake downstream about one mile (Fraser 2002, personal communication). Streambank condition was rated poor.

Floodplain Connectivity
The stream has access to the floodplain with the exception of the mile of channelized stream below Spencer Lake (Fraser 2002, personal communication). Floodplain connectivity was rated fair.

Width/Depth Ratio
Schuett-Hames *et al.* (1996) reported a width/depth ratio of 20.0. Width/depth ratio was not rated.

Substrate Embeddedness

Mean percentage of fine sediment less than 0.85 mm was 17.1% (Schuett-Hames *et al.* 1996). Substrate embeddedness was rated poor.

Large Woody Debris

Woody debris occurred at a rate of 1.796 pieces per channel width. Key pieces were moderately abundant at 0.215 pieces per channel width (Schuett-Hames *et al.* 1996). Upstream from Agate Road, large woody debris is lacking (Stevie 2002, personal communication). Total LWD abundance was fair to poor. Key piece abundance was fair.

Pool Frequency

Pools were present at a rate of one pool per 3.75 channel widths (Schuett-Hames *et al.* 1996). Pool frequency was rated fair.

Pool Quality

Mean residual pool depth was 0.39 meters (1.28 feet). Pools occupied 55.5% of stream surface area (Schuett-Hames *et al.* 1996). Pool quality was rated good.

Off-Channel Habitat

Taylor *et al.* (2000) used the National Wetlands Inventory maps (Cowardin *et al.* 1979) to identify a total of ~360 acres of wetlands in the watershed. Off-channel habitat was rated good.

Water Quality

Canopy closure measurements predicted that water temperatures would exceed the Class A standard of 18°C (Schuett-Hames *et al.* 1996). Five dissolved oxygen samples gathered in the summer months from 1995 to 2002 contained a minimum of 9.5 mg/L each (Squaxin Island Tribe 2002, unpublished work). No temperature data were available. Dissolved oxygen levels were rated good.

Water Quantity/Dewatering

Estimated summer flows are as low as 1 cfs. The two year-seven day low flow was calculated at 0.7 cfs (Taylor *et al.* 2000). Information was insufficient to establish a rating.

Change in Flow Regime

No information was available.

Biological Processes

Warm water fish have been introduced to Spencer Lake. These fish feed on juvenile salmonids, particularly chum fry (Burns 2002, personal communication). Beaver are present, but no information was available on population status (TAG 2002). Biological processes were rated poor.

Uncle John Creek (14.0068)

Habitat Ratings

Fish Passage

A barrier at RM 1.0 is impassable. An impassable barrier is located at RM 0.8 of stream 14.0068 (Northwest Indian Fisheries Commission 2002). Salmon and steelhead are not known to be present in this tributary, but coastal cutthroat are presumed to be present. See Map 12. Fish passage was rated poor.

Riparian Buffers

Riparian vegetation has been removed in some areas (Taylor *et al.* 2000). In general, riparian buffers along Uncle John Creek have been degraded by agricultural practices (Fraser 2002, personal communication). Quantitative riparian condition and riparian canopy closure data were not available.

Streambank Condition

Residents in one area have used the stream channel as a refuse dump. Corrugated metal roofing has been used to stabilize streambanks (Taylor *et al.* 2000). The stream has been channelized and areas of bank slumping have been noted (Fraser 2002, personal communication). Streambank condition was rated poor.

Floodplain Connectivity

The channel has been severely altered by ditching along Agate Loop Road (Taylor *et al.* 2000). Uncle John Creek has been extensively rerouted. The upper portion flows through a County maintained ditch with no instream or overhead cover (Stevie 2002, personal communication). Floodplain connectivity was rated poor.

Width/Depth Ratio

No information was available.

Substrate Embeddedness

Spawning substrate is rare. Streambed composition is primarily clay and fine sediment (Fraser 2002, personal communication). Substrate embeddedness was rated poor.

Large Woody Debris

Woody debris is rare in Uncle John Creek (Fraser 2002, personal communication), likely the result of degraded riparian conditions. Large woody debris total and key piece abundance were both rated poor.

Pool Frequency

Pools are uncommon on Uncle John Creek (Stevie 2002, personal communication).

Pool Quality

Pools are uncommon on Uncle John Creek (Stevie 2002, personal communication).

Off-Channel Habitat

Taylor *et al.* (2000) used the National Wetlands Inventory maps (Cowardin *et al.* 1979) to identify a total of ~26 acres of wetlands in the watershed. Off-channel habitat was rated fair.

Water Quality

Uncle John Creek was included on the 1996 and 1998 303(d) lists for high levels of fecal coliform bacteria (Washington Department of Ecology 1996, Washington Department of Ecology 2000). Taylor *et al.* (2000) reported two instances of dissolved oxygen levels below the Class A standard of 8.0 mg/L and water temperatures in late August and late September ranging from 18.5ºC to 22.1ºC (65.3ºF to 71.8ºF). An additional low DO reading (6.3 mg/L) was recorded in late August 2002 at the Agate Road culvert. Dissolved oxygen levels remained above 8.0 mg/L in the remaining eight samples gathered in the summer months from 1995 to 2002 (Squaxin Island Tribe 2002, unpublished work). Temperature was rated poor. Dissolved oxygen levels were rated good to poor.

Water Quantity/Dewatering

Taylor *et al.* (2000) calculated a two year-seven day low flow of 0.3 cfs. Information was insufficient to establish a rating.

Change in Flow Regime

No information was available.

Biological Processes

No information was available.

Campbell Creek (14.0069)

Habitat Ratings

Fish Passage

The dam at the outlet of Timber Lake is impassable (Northwest Indian Fisheries Commission 2002). Salmon and steelhead are not known to reach this barrier, but coastal cutthroat are presumed present throughout Campbell Creek. An impassable culvert is located at RM 1.0 on stream 14.0070 (Northwest Indian Fisheries Commission 2002). Salmon and steelhead are not known to be present in stream 14.0070, but coastal cutthroat are presumed to be present. See Map 12. Fish passage was rated fair.

Riparian Buffers

Schuett-Hames *et al.* (1996) measured canopy closure on two reaches of Campbell Creek. Canopy closure ranged from 18% to 31%. Mean canopy closure was 25%, well below the target level of 90% necessary to maintain Class A water quality temperature standards. Livestock grazing has caused severe degradation of the riparian zone near the mouth of Campbell Creek (Stevie 2002, personal communication). No quantitative riparian condition information was available. Riparian canopy closure was rated poor.

Streambank Condition

From Agate Road downstream, banks are relatively stable (Fraser 2002, personal communication). Streambank condition was rated fair.

Floodplain Connectivity

Campbell Creek does not flood often. Downstream from Agate Road the stream has full access to the floodplain (Fraser 2002, personal communication). Floodplain connectivity was rated good.

Width/Depth Ratio

Schuett-Hames *et al.* (1996) reported width/depth ratios of 13.8 and 17.7. Mean width/depth ratio (weighted according to stream reach length) was 16.2. Width/depth ratio was not rated.

Substrate Embeddedness

Mean percentage of fine sediment less than 0.85 mm was 35.1% (Schuett-Hames *et al.* 1996). Substrate embeddedness was rated poor.

Large Woody Debris

Schuett-Hames *et al.* (1996) reported woody debris levels ranging from 0.581 to 1.426 pieces per channel width. Mean abundance (weighted by stream reach length) was 1.104. Key piece abundance ranged from 0.063 to 0.225 pieces per channel width. Weighted mean abundance (by stream reach length) of key pieces was 0.163 pieces per channel width. Large woody debris total and key piece abundance were both rated fair to poor.

Pool Frequency

Pool frequency ranged from 2.92 to 4.98 channel widths per pool. Weighted mean (by stream reach length) pool spacing was 3.7 channel widths per pool (Schuett-Hames *et al.* 1996). Pool frequency was rated fair to poor.

Pool Quality

Weighted mean residual pool depth was 0.34 meters (1.12 feet). Pools occupied a mean stream surface area of 67.0% (Schuett-Hames *et al.* 1996). Pool quality was rated good.

Off-Channel Habitat

Taylor *et al.* (2000) used the National Wetlands Inventory maps (Cowardin *et al.* 1979) to identify a total of ~344 acres of wetlands in the watershed. Off-channel habitat was rated good.

Water Quality

Canopy closure measurements predicted that water temperatures would exceed the Class A standard of 18°C (Schuett-Hames *et al.* 1996). Taylor *et al.* (2000) reported a late September water temperature of 18.8°C (65.8°F). Campbell Creek was included on the

1996 and 1998 303(d) lists for high levels of fecal coliform (Washington Department of Ecology 1996, Washington Department of Ecology 2000). Dissolved oxygen fell to 6.6 mg/L in late August 2002 at the Agate Loop Road bridge. In all other cases from 1995 to 2002 (8 samples) DO remained above 8.0 mg/L in the summer months at this site as well as upstream at the Agate Road culvert (Squaxin Island Tribe 2002, unpublished work). Temperature was rated poor. Dissolved oxygen levels were rated good to poor.

Water Quantity/Dewatering

Taylor *et al.* (2000) calculated a two year-seven day low flow of 0.8 cfs. Information was insufficient to establish a rating.

Change in Flow Regime

No information was available.

Biological Processes

Warm water fish have been introduced into Timber Lakes. These fish consume juvenile salmonids, especially chum fry (Burns 2002, personal communication). Beaver are present, but no information on population status was available (TAG 2002). Biological processes were rated poor.

Estuary/Nearshore

Currently Oakland Bay and Hammersley Inlet are the only estuary/nearshore systems that have been surveyed in WRIA 14 (Stevie 2002, personal communication). Taylor *et al.* (2000) used the National Wetlands Inventory maps (Cowardin *et al.* 1979) to identify a total of ~214 acres of wetlands associated with small tributaries of Oakland Bay and Hammersley Inlet. They also identified 51 acres of estuary in the same area. Cumulatively, about 28,000 feet (5.3 miles) of bulkheads are present along the shorelines of Oakland Bay and Hammersley Inlet (Washington Department of Ecology 1980, cited in Taylor *et al.* 2000). Shelton Harbor, Oakland Bay, and Hammersley Inlet were listed on the 1996 and 1998 303(d) lists for high levels of fecal coliform bacteria. Oakland Bay was also listed in 1996 for low levels of dissolved oxygen (Washington Department of Ecology 1996, Washington Department of Ecology 2000). From a point source pollution standpoint, water quality in Oakland Bay has improved greatly since enactment of the Clean Water Act of 1972 (Anchor Environmental 2002).

The head of Oakland Bay and mouth of Hammersley Inlet are less modified than the central portion of the region near Shelton and western Hammersley Inlet. A large estuarine mudflat with emergent marsh is present at the head of Oakland Bay and extends from Deer Creek south over one mile to the mouth of Johns Creek. Chapman Cove also contains an estuarine mudflat with emergent marsh. Two small mudflats are present in Hammersley Inlet; one is just east of Eagle point, and the other is at the mouth of Mill Creek. Shorelines along the western two-thirds of Hammersley Inlet and western Oakland Bay are extensively armored with concrete and wooden bulkheads and riprap.

The mouths of Goldsborough and Shelton Creeks have been channelized through the industrial area along the Shelton waterfront (Anchor Environmental 2002).

Overhanging riparian vegetation was more plentiful along the eastern one-third of Hammersley Inlet and eastern Oakland Bay than in western Oakland Bay and the western two-thirds of Hammersley Inlet where shoreline armoring was prevalent. Overhanging vegetation was typically present along less than 25% of the armored shorelines. Nine out of 10 unmodified sample sites on Hammersley Inlet and Oakland Bay had overhanging riparian vegetation along 100% of the shoreline. Six of 10 modified sites had overhanging vegetation along 5% or less of the shoreline (Anchor Environmental 2002).

Unmodified sand and gravel beaches in Oakland Bay and Hammersley Inlet appeared to provide habitat more conducive to juvenile salmonid production than areas with modified shorelines. Large woody debris abundance ranged from 15 to 66 pieces per site at unmodified stations on Hammersley Inlet. Less than 15 pieces of LWD were found at all other sand and gravel beach sites with the exception of one near the head of Oakland Bay (Anchor Environmental 2002).

CASE INLET/PICKERING PASSAGE SUBBASIN HABITAT LIMITING FACTORS

Case Inlet/Pickering Passage Subbasin Description

The Case Inlet/Pickering Passage Subbasin covers about 97 square miles (including the area of inlets, *not including the small streams draining to Hood Canal. These streams are officially part of WRIA 14, but they will not be addressed in this report. They will be included in the WRIA 16 limiting factors report as requested by the Hood Canal Coordinating Council)* (Map 5). Sherwood Creek is the largest stream system in WRIA 14, containing 18.3 miles of channel. The creek empties into Case Inlet at North Bay near the town of Allyn. Average flow is 15 to 25 cfs. Outlet flows from Mason and Prickett Lakes are the origin of the stream. Shumocher Creek and four tributaries provide inlet flow for Mason Lake. Trask Lake (18 acres) provides flow to the first tributary of Shumocher Creek at RM 13 (immediately above the inlet to Mason Lake). Mason Lake covers 977 acres and is four miles long. Prickett Lake is 3/4 mile long and covers 73 acres. A small mill pond is located at about RM 1.0 on Sherwood Creek. Dense stands of second growth conifers and cultivated Christmas trees dominate the watershed above RM 3. The lower end of Sherwood Creek flows through steep ravines vegetated by alder, maple, and ferns (Washington Department of Fisheries 1975).

Schumocher Creek (14.0094) and Tributaries

Habitat Ratings

Fish Passage

Culverts at RM 0.2 historically blocked passage (Northwest Indian Fisheries Commission 2002). The culverts were washed out during floods in 1996. A temporary bridge replaced the failed culverts until a new bridge was completed in the fall of 2002 (TAG 2002). An impassable culvert is located at RM 0.14 on stream 14.0104. Another impassable culvert is located at RM 0.3 on the left bank tributary immediately downstream from stream 14.0104. Salmon and steelhead are not known to use either stream, but coastal cutthroat are presumed to be present. A dam and trash rack are located at the outlet of Trask Lake (14.0099) (Northwest Indian Fisheries Commission 2002). The barrier at Trask Lake is impassable (Stevie 2002, personal communication). See Map 12. Fish passage was rated fair.

Riparian Buffers

The lower portion of Schumocher Creek flows through the Simpson Timber Company recreation area. Native riparian vegetation has been completed denuded and replaced with a lawn. Upstream the riparian buffer is comprised of a mix of coniferous and deciduous trees. Some large conifers are present (Stevie 2002, personal communication). Information was insufficient to rate riparian condition or riparian canopy closure.

Figure 14. Riparian zone along Schumocher Creek below the pipeline crossing (RM 1.6). Photo courtesy of the Allyn Salmon Enhancement Group.

Streambank Condition

Banks along the reach in the Simpson Timber Company recreation area have been armored with riprap. Upstream, the channel functions naturally and is connected to numerous wetlands (Stevie 2002, personal communication). Streambank condition was rated fair.

Floodplain Connectivity

Schumocher Creek flows through numerous wetlands (TAG 2002). Floodplain connectivity was rated good.

Figure 15. Floodplain of lower Schumocher Creek. Note the large expanse of wetlands and multiple channels. Photo courtesy of the Allyn Salmon Enhancement Group.

Width/Depth Ratio

No information was available.

Substrate Embeddedness

No information was available.

Large Woody Debris

No information was available.

Pool Frequency

No information was available.

Pool Quality

No information was available.

Off-Channel Habitat

Numerous wetlands and beaver ponds provide off-channel habitat (TAG 2002). Off-channel habitat was rated good.

Water Quality

No information was available.

Water Quantity/Dewatering

No information was available.

Change in Flow Regime

No information was available.

Biological Processes

Warm water fish have been introduced to Mason Lake. These fish prey on juvenile salmonids, especially chum fry (Burns 2002, personal communication). Beaver are present, but no information was available on population status (TAG 2002). There are limited coho escapements and periodic chum escapements above Mason Lake. It is likely that marine-origin nutrient inputs resulting from these escapements are inadequate to meet the nutrient needs of the ecosystem (Baranski 2002, personal communication) as described by (Michael 2002). There is significant beaver activity in this stream, with low head dams constructed in the anadromous zone during the summer low flow period. These dams provide low flow rearing habitat and are made passable by elevated fall and winter flows, so they do not hinder upstream adult migration in most years (Baranski 2002, personal communication). Biological processes were rated poor.

Sherwood Creek (14.0094) and Tributaries

Habitat Ratings

Fish Passage

Two undersized culverts under the U.S. Navy railroad line (RM 6.8) historically impeded passage of anadromous fish (Northwest Indian Fisheries Commission 2002) (Figure 16). The culverts were replaced with a bridge in the fall of 2002 (TAG 2002) (Figure 17). A culvert at the mouth of Anderson Lake Creek (14.0095) was historically a barrier to anadromous fish (Northwest Indian Fisheries Commission 2002). The culvert was replaced with a passable structure in the fall of 2002 (TAG 2002). Several barriers are present on stream 14.0098 (Prickett Lake outlet). Anadromous fish are present up to the second barrier. See Map 12. Fish passage was rated fair.

Figure 16. Culverts under the U.S. Navy railroad crossing on Sherwood Creek (RM 6.8) prior to replacement with a bridge in fall of 2002. Photo courtesy of the Allyn Salmon Enhancement Group.

Figure 17. U.S. Navy railroad bridge at RM 6.8 on Sherwood Creek constructed in fall 2002. Compare to Figure 16. Photo courtesy of the Allyn Salmon Enhancement Group.

Riparian Buffers

The riparian buffer along Sherwood Creek is generally well vegetated. However, from RM 1 (Mill Pond) downstream, homes have been built close to the stream, severely altering riparian buffer function (Stevie 2002, personal communication). Anderson Lake Creek (14.0095) has a well vegetated riparian forest buffer (Burns 2002, personal communication). Information was insufficient to establish a rating for riparian condition and riparian canopy closure.

Streambank Condition

In general, banks are relatively stable because of dense riparian vegetation (Fraser 2002, personal communication). However banks on the lower mile of stream have been degraded by residential development (Stevie 2002, personal communication). Streambank condition was rated fair.

Floodplain Connectivity

Extensive residential development has occurred on the floodplain from RM 1 downstream (Stevie 2002, personal communication). Floodplain connectivity was rated fair.

Width/Depth Ratio

Mean width/depth ratio from RM 1.0 to RM 8.0 (1,260 meters surveyed) was 25.6 (Allyn Salmon Enhancement Group 2002, unpublished work). Width/depth ratio was not rated.

Substrate Embeddedness

Between RM 1.0 (the Mill Pond) and RM 8.0 (1,260 meters surveyed), gravel and sand were the dominant substrates. Rubble was common in some reaches. Boulders were uncommon (Allyn Salmon Enhancement Group 2002, unpublished work). Information was insufficient to establish a rating for substrate embeddedness.

Large Woody Debris

Woody debris is plentiful in Sherwood Creek. Between approximately RM 1.0 (the Mill Pond) and RM 8.0, LWD abundance was 4.54 pieces per channel width or 0.52 pieces per meter of channel length (1,260 meters of channel sampled). Rootwads occurred at an abundance of 0.05 per channel width. Debris jam abundance was 0.14 per channel width. Key piece abundance was 0.37 per channel width. The majority of woody debris was deciduous material (Allyn Salmon Enhancement Group 2002, unpublished work). Total large woody debris abundance and key piece abundance were both rated good.

Pool Frequency

Pools occurred at a frequency of 6.1 channel widths per pool. The mean stream width was 8.7 meters. The 1,260 meters surveyed were comprised of 19.8% pools, 54.8% riffles, and 25.3% glides (Allyn Salmon Enhancement Group 2002, unpublished work). Pool frequency was rated poor.

Pool Quality

Pools (19 counted) averaged 0.63 meters (2.1 feet) deep on the 1,260 meters of stream surveyed (Allyn Salmon Enhancement Group 2002, unpublished work). Woody debris, undercut banks, and overhanging riparian vegetation provide quality pool habitat (Fraser 2002, personal communication). Pool surface area information was not available. Therefore, a rating was not established.

Off-Channel Habitat

Numerous side channels, wetlands, and beaver ponds provide off-channel habitat (TAG 2002). Off-channel habitat was rated good.

Water Quality

Water temperature in mid-July 2002 near RM 8.0 (Sites 6 US and 7 US, about 1 mile below Mason Lake) was 22ºC. Temperature downstream near RM 3.5 (Sites 11 and 12) in mid-July 2002 was 20ºC. In early September 2002, water temperature at RM 1.5 (Bug site 1) and RM 5.5 (Bug site 2) was 13ºC. Dissolved oxygen concentration was 8.4 mg/L at both sites (Allyn Salmon Enhancement Group 2002, unpublished work). Temperature was rated poor. Dissolved oxygen levels were rated good.

Water Quantity/Dewatering

Flow data suggest that surface flows in Sherwood Creek are significantly influenced by hydraulic continuity with groundwater aquifers. For example, in mid-May 2002 flow at RM 1.5 (Site 2) was 97 cfs and downstream ¼ mile (Site 1) flow dropped to 55 cfs (suggesting movement of surface water into groundwater). This pattern was repeated at several other sites (Allyn Salmon Enhancement Group 2002, unpublished work). Flows in early September 2002 near RM 1.5 and RM 5.5 were 25.3 and 19.5 cfs respectively (Allyn Salmon Enhancement Group 2002, unpublished work). Although summer flows are low, as they are throughout the WRIA, they are adequate to support salmonid rearing (Fraser 2002, personal communication). Water quantity/dewatering was rated good.

Change in Flow Regime

No information was available.

Biological Processes

Warm water fish have been introduced to Lakes throughout the Sherwood Creek Watershed. These fish feed on juvenile salmonids, particularly chum fry (Burns 2002, personal communication). Beaver are present, but no information was available on population status (TAG 2002). Chum escapement averaged 5,500 fish per year between 1991 and 2000 (Baranski 2002, personal communication). Marine-origin nutrient inputs resulting from these escapements are likely adequate to meet the nutrient needs of the ecosystem (Baranski 2002, personal communication) as described by (Michael 2002). In most years, the majority of chum spawning takes place in the lower river. There is significant beaver activity in this stream, with low head dams constructed in the anadromous zone during the summer low flow period. These dams provide low flow rearing habitat and are made passable by elevated fall and winter flows, so they do not hinder upstream adult migration (Baranski 2002, personal communication). Biological processes were rated fair.

Pickering Passage Tributaries (14.0079-14.0093)

Habitat Ratings

Fish Passage

A barrier is present at the mouth of stream 14.0079. An uncharacterized barrier at RM 0.1 and two culverts (RM 0.3 and 1.0) are present on Jones Creek. Anadromous fish are present up to the culvert at RM 1.0. A barrier is present at RM 0.25 on Hiawata Creek (14.0084). Another barrier is located at RM 0.16 on stream 14.0085. Anadromous fish are present above both of these barriers. Several barriers are present on stream 14.0087. A complete barrier is present on stream 14.0088. Barriers are present near the mouths of streams 14.0089 and 14.0091. A barrier is present at RM 0.8 on stream 14.0093. Anadromous fish are present above this barrier (Northwest Indian Fisheries Commission 2002). See Map 12. Fish passage was rated fair.

Riparian Buffers

The riparian zone along Jones Creek is well vegetated (Fraser 2002, personal communication). Circa 1985, stream 14.0084 (Hiawata Creek) had a riparian forest comprised of old-growth trees. The drainage was later logged extensively, removing a large portion of the riparian buffer. Streams 14.0089 through 14.0093 all had well vegetated riparian buffers in the mid-1980s (Burns 2002, personal communication). Information was insufficient to establish a rating.

Streambank Condition

No information was available.

Floodplain Connectivity

No information was available.

Width/Depth Ratio

No information was available.

Substrate Embeddedness

Extensive logging in the Hiawata Creek drainage led to elevated inputs of fine sediment. Streams 14.0089 through 14.0093 had excellent quality spawning substrate in the mid-1980s (Burns 2002, personal communication). Sand, small gravel, and fines are the dominant substrates in streams 14.0084 (Hiawata Creek), 14.0087, and Jones Creek (Fraser 2002, personal communication). Substrate embeddedness was rated poor.

Large Woody Debris
Woody debris is rare in stream 14.0087 and Jones Creek (Fraser 2002, personal communication). Large woody debris total and key piece abundance were both rated poor.

Pool Frequency
No information was available.

Pool Quality
No information was available.

Off-Channel Habitat
No information was available.

Water Quality
No information was available.

Water Quantity/Dewatering
Stream 14.0087 has perennial flow (Fraser 2002, personal communication). Information was insufficient to establish a rating.

Change in Flow Regime
No information was available.

Biological Processes
Comprehensive stock assessment surveys are conducted on only three independent tributaries to Pickering Passage (14.0080, 14.0083 and 14.0084) (Baranski 2002, personal communication). If chum escapements into these streams are typical of other tributaries in this basin, it is likely that marine-origin nutrient inputs resulting from these escapements are adequate to meet the nutrient needs of the ecosystem (Baranski 2002, personal communication) as described by (Michael 2002). Biological processes were rated good.

Hartstene Island Streams (14.0109-14.0122)

Habitat Ratings

Fish Passage
Five culvert barriers are known to be present on Hartstene Island. Three of these culverts are complete barriers to fish passage (Northwest Indian Fisheries Commission 2002). Salmon and steelhead are not known to use these streams, but coastal cutthroat are presumed to be present. See Map 12. Fish passage was rated poor.

Riparian Buffers
No information was available.

Streambank Condition
No information was available.

Floodplain Connectivity
No information was available.

Width/Depth Ratio
No information was available.

Substrate Embeddedness
No information was available.

Large Woody Debris
No information was available.

Pool Frequency
No information was available.

Pool Quality
No information was available.

Off-Channel Habitat
No information was available.

Water Quality
No information was available.

Water Quantity/Dewatering
No information was available.

Change in Flow Regime
No information was available.

Biological Processes
No information was available.

Estuary/Nearshore

No information was available.

SALMONID HABITAT CONDITION RATING STANDARDS FOR IDENTIFYING LIMITING FACTORS

Under the Salmon Recovery Act (passed by the legislature as House Bill 2496, and later revised by Senate Bill 5595), the Washington Conservation Commission (WCC) is charged with identifying the habitat factors limiting the production of salmonids throughout most of the state. This information should guide lead entity groups and the Salmon Recovery Funding Board in prioritizing salmonid habitat restoration and protection projects seeking state and federal funds. Identifying habitat limiting factors requires a set of standards that can be used to compare the significance of different factors and consistently evaluate habitat conditions in each WRIA throughout the state.

In order to develop a set of standards to rate salmonid habitat conditions, several tribal, state, and federal documents that use some type of habitat rating system were reviewed (Table 5). The goal was to identify appropriate rating standards for as many types of habitat limiting factors as possible, with an emphasis on those that could be applied to readily available data. Based on the review, it was decided to rate habitat conditions into three categories: Good, Fair, and Poor. For habitat factors that had wide agreement on how to rate habitat condition, the accepted standard was adopted by the WCC. For factors that had a range of standards, one or more of them were adopted. Where no standard could be found, a default rating standard was developed by WCC, with the expectation that it will be modified or replaced as better data become available.

Table 5. Salmonid Habitat Rating Criteria Source Documents.

Code	Document	Organization
Hood Canal	Hood Canal/Eastern Strait of Juan de Fuca Summer Chum Habitat Recovery Plan, Final Draft (1999)	Point No Point Treaty Council, Skokomish Tribe, Port Gamble S'Klallam Tribe, Jamestown S'Klallam Tribe, and Washington Department of Fish and Wildlife
ManTech	An Ecosystem Approach to Salmonid Conservation, vol. 1 (1995)	ManTech Environmental Research Services for the National Marine Fisheries Service, the US Environmental Protection Agency, and the US Fish and Wildlife Service
NMFS	Coastal Salmon Conservation: Working Guidance for Comprehensive Salmon Restoration Initiatives on the Pacific Coast (1996)	National Marine Fisheries Service
PHS	Priority Habitat Management Recommendations: Riparian (1995)	Washington Department of Fish and Wildlife
Skagit	Skagit Watershed Council Habitat Protection and Restoration Strategy (1998)	Skagit Watershed Council
WSA	Watershed Analysis Manual, v4.0 (1997)	Washington Forest Practices Board
USFWS Guidelines	A Framework to Assist in Making Endangered Species Act Determinations of Effect for Individual or Grouped Actions at the Bull Trout Subpopulation Watershed Scale	U.S. Fish and Wildlife Service
NMFS Criteria	Juvenile Fish Screen Criteria and the Addendum for Juvenile Fish Screen Criteria for Pump Intakes.	National Marine Fisheries Service
TAG 2002	The assessment of conditions is based on the professional knowledge and judgment of the Technical Advisory Group.	2496 WRIA 14 Habitat Limiting Factors Technical Advisory Group (See Acknowledgements)
WAC	Washington Administrative Code	State of Washington
WSP	Wild Salmonid Policy (1997)	Washington Department of Fish and Wildlife

The ratings adopted by the WCC are presented in Table 6. These ratings are intended to be used as a coarse screen to identify the most significant habitat limiting factors in a WRIA, not as thresholds for regulatory purposes. They will provide a level of consistency between WRIAs that allows habitat conditions to be compared across the state. However, where data is unavailable or where analysis of data has not been conducted, the professional expertise of the TAG is used. In some cases, there may be local conditions that warrant deviation from the rating standards presented here. Additional rating standards will be included as they become available and will supersede the standards used in this report.

Table 6. WCC Salmonid Habitat Condition Rating Criteria for WRIA 14.

Habitat Factor	Parameter/Unit	Channel Type	Poor	Fair	Good	Source
Fish Passage	Man-made physical barriers (address subsurface flows or dewatering where they impede fish passage under water quantity attributes)	All	Man-made barriers present in the reach restrict upstream and/or downstream fish passage at a range of flows.	Man-made barriers present in the reach restrict upstream and/or downstream fish passage at base/low flows.	Man-made barriers present in the reach allow adequate upstream and downstream fish passage at all flows.	USFWS Guidelines
Riparian Condition	(1) Riparian buffer width (measured horizontally from the channel migration zone on each side of the stream) (2) Riparian composition	Type 1-3 and untyped salmonid streams >5 feet wide	(1) <75' or <50% of site potential tree height (whichever is greater) OR (2) Dominated by hardwoods, shrubs, or nonnative species (<30% conifer) unless these species were dominant historically	(1) 75'-150' or 50-100% of site potential tree height (whichever is greater) AND (2) Dominated by conifers or a mix of conifers and hardwoods (≥30% conifer) of any age unless hardwoods were dominant historically.	(1) >150' or site potential tree height (whichever is greater) AND (2) Dominated by mature conifers (≥70% conifer) unless hardwoods were dominant historically	WCC/WSP
	(1) Buffer width (2) Riparian composition	Type 4 and untyped perennial streams <5' wide	(1) <50' (2) Same as above	(1) 50'-100' (2) Same as above	(1) >100' (2) Same as above	WCC/WSP
	(1) Buffer width (2) Riparian composition	Type 5 and all other untyped streams	(1) <25' (2) Same as above	(1) 25'-50' (2) Same as above	(1) >50' (2) Same as above	WCC/WSP
Riparian Canopy Closure	Percent riparian canopy closure needed based on State water quality classification and stream elevation	All	Riparian canopy closure less than the value needed to maintain State water quality standard	Not applicable	Riparian canopy closure greater than or equal to the value needed to maintain State water quality standard	WAC-222-30-040 (Washington Forest Practices Board 2000)

Table 6. Continued.

Habitat Factor	Parameter/Unit	Channel Type	Poor	Fair	Good	Source
Streambank Condition	% of stream reach in stable natural condition	All	<80% natural stability	80-90% natural stability	>90% natural stability	NMFS/WSP
Floodplain Connectivity	Stream and off-channel habitat length with lost floodplain connectivity due to incision, roads, dikes, flood protection, or other	All	Severe reduction in hydrologic connectivity between off-channel, wetland, floodplain and riparian areas; wetlands extent drastically reduced and riparian vegetation/succession altered significantly.	Reduced linkage of wetland, floodplains and riparian areas to main channel; overbank flows are reduced relative to historic frequency, as evidenced by moderate degradation of wetland function and riparian vegetation/succession.	Off-channel areas are frequently hydrologically linked to main channel; overbank flows occur and maintain wetland functions, riparian vegetation and succession.	USFWS Guidelines
Width/Depth Ratio	Ratio of bankfull width to average bankfull depth (Rosgen 1996) (i.e. width divided by average depth)	All	Width/depth ratio varies depending upon channel morphology. A stream typically exhibits several channel morphologies over its length depending upon gradient, geology, vegetative cover, etc (Rosgen 1996). While width/depth ratios are described in the narrative, the TAG did not feel it was appropriate to rate this parameter as good, fair, or poor for an entire stream.			TAG 2002
Substrate Embeddedness	Fines <0.85 mm in spawning gravel	All-Western Washington	>17%	11-17%	≤11%	WSP/WSA/NMFS/ Hood Canal
Large Woody Debris	Pieces/meter channel length	≤4% gradient, <15 meters wide	<0.2	0.2-0.4	>0.4	Hood Canal/Skagit
	Use Watershed Analysis piece and key piece standards listed below when data are available.					
	Pieces/channel width	<20 m wide	<1	1-2	2-4	WSP/WSA
	Key pieces/channel width*	<10 m wide	<0.15	0.15-0.30	>0.30	WSP/WSA
	Key pieces/channel width*	10-20 m wide	<0.20	0.20-0.50	>0.50	WSP/WSA
	* Minimum size to qualify as a key piece:	Bankfull width (meters)	Diameter (meters)	Length (meters)		
		0-5	0.4	8		
		6-10	0.55	10		
		11-15	0.65	18		
		16-20	0.7	24		

Table 6. Continued.

Habitat Factor	Parameter/Unit	Channel Type	Poor	Fair	Good	Source
Percent Pool	% pool by surface area	<2% gradient, <15 meters wide	<40%	40-55%	>55%	WSP/WSA
	% pool by surface area	2-5% gradient, <15 meters wide	<30%	30-40%	>40%	
	% pool by surface area	>5% gradient, <15 meters wide	<20%	20-30%	>30%	
	% pool by surface area	>15 meters wide	<35%	35-50%	>50%	Hood Canal
Pool Frequency	Channel widths per pool	<15 meters wide	>4	2-4	<2	WSP/WSA
Off-channel Habitat	Area within the channel migration zone.	Reaches with average gradient <2%	Reach has no ponds, oxbows, backwaters, or other off-channel areas	Reach has <5 ponds, oxbows, backwaters, and other off-channel areas with cover per mile; but side-channel areas are generally high energy areas	Reach has >5 ponds, oxbows, backwaters, and other off-channel areas with cover per mile; and side-channels are low energy areas	USFWS Guidelines TAG 2002

Table 6. Continued.

Habitat Factor	Parameter	Channel Type	Poor	Fair	Good	Source
Temperature	Degrees Celsius (Degrees Fahrenheit)	All	Maximum water temperatures exceed State Standard *Class A*: >18ºC (64.4ºF) *Class AA*: >16ºC (60.8ºF)	Not applicable	Maximum water temperatures meet State Standard *Class A*: ≤18ºC (64.4ºF) *Class AA*: ≤16ºC (60.8ºF)	WAC 173-201A-030 (State of Washington 1992)
Dissolved Oxygen	mg/L	All	Dissolved oxygen levels below State Standard *Class A*: <8 mg/L *Class AA*: <9.5 mg/L	Not applicable	Dissolved oxygen levels meet or exceed State Standard *Class A*: ≥8 mg/L *Class AA*: ≥9.5 mg/L	WAC 173-201A-030 (State of Washington 1992)
Water Quantity/ Dewatering	Presence/absence in a stream reach	All	No flows during some portion of the year or inadequate for all lifestages	Inadequate flows for some lifestages during some portion of the year	Adequate flows for all lifestages present year-round	TAG 2002
Change in Flow Regime	Change in Peak/Base Flows	All	Pronounced changes in peak flow, base flow and/or flow timing relative to an undisturbed watershed of similar size, geology and geography	Some evidence of altered peak flow, base flow and/or flow timing relative to an undisturbed watershed of similar size, geology and geography	Watershed hydrograph indicates peak flow, base flow and flow timing characteristics comparable to an undisturbed watershed of similar size, geology and geography	USFWS Guidelines
Biological Processes	Lack of nutrient input from anadromous spawners, exotic animal species present, etc.	All	No anadromous carcasses and there is likely exotic species competition	Few anadromous carcasses or there is exotic species competition	Many anadromous carcasses and no exotic species competition	TAG 2002

SALMONID HABITAT ASSESSMENT BY STREAM REACH

The narrative descriptions for streams draining into each of the four inlets discussed earlier in this report were compared to the rating criteria found in Table 6 to assess salmonid habitat conditions across the Kennedy-Goldsborough Basin. Each stream discussed in the report has a corresponding assessment in Table 7. With the exception of the Oakland Bay/Hammersley Inlet Subbasin, estuary/nearshore habitat conditions have not been quantitatively inventoried in WRIA 14. For this reason, estuary/nearshore habitat conditions were not rated in the habitat assessment.

Table 7. Salmonid Habitat Assessment by Stream Reach

Key:

P = Average habitat condition considered poor (Not Properly Functioning)

F = Average habitat condition considered fair (At Risk)

G = Average habitat condition considered good (Properly Functioning)

1= Quantitative studies or published reports documenting habitat condition

2 = Professional knowledge of the WRIA 14 TAG members

S = Suspected

DG = Data Gap: habitat on the stream or reach has not been evaluated; TAG members had little or no knowledge of habitat conditions. The parameter was not rated.

NB = Natural Barrier

NAT = Natural Condition

N/A = Not Applicable

N/E = Not Evaluated

(A) = Pool quality rating based on percent pool surface area only, pool depth and cover were not considered by the TAG

Stream Name	Fish Passage	Riparian Condition	Riparian Canopy Closure	Streambank Condition	Floodplain Connectivity	Substrate Embed.	LWD Total	LWD Key Pieces	Pool Freq.	Pool Qual. **(A)**	Off-channel Habitat	Water Quality		Water Quantity/ Dewatering	Change in Flow Regime	Biological Processes
												Temp.	DO			
Eld Inlet Subbasin																
Perry Creek	P1	DG	G-P1	F-P1,2	P2	G1	G-P1	P1	F-P1	G-P1	DG	DG	DG	DG	F1	G2
Eld Inlet Tributaries	F-P1	DG	DG	DG	DG	P2	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG
Totten/Little Skookum Inlet Subbasin																
Schneider Creek	F1	DG	P1	F1	F2	P1	G-P1	P1	F-P1	G-F1	DG	DG	DG	F2	F1	G2
County Line Creek	F1	DG	P1	DG	DG	DG	P1	P1	F1	G1	DG	DG	DG	DG	F1	G2
Kennedy Creek	F-P1	DG	P1	P1	DG	F-P1	G-F1	F-P1	G-P1	G-P1	DG	DG	DG	DG	F1	G2
Snodgrass Creek	DG	DG	DG	DG	N/A	DG	P2	P2	P2	DG	N/A	DG	DG	DG	DG	DG

Table 7. Continued.

Stream Name	Fish Passage	Riparian Condition	Riparian Canopy Closure	Streambank Condition	Floodplain Connectivity	Substrate Embed.	LWD Total	LWD Key Pieces	Pool Freq.	Pool Qual. **(A)**	Off-channel Habitat	Water Quality		Water Quantity/ Dewatering	Change in Flow Regime	Biological Processes
												Temp.	DO			
Totten/Little Skookum Inlet Subbasin Cont'd.																
Skookum Creek	F1	DG	P1	P1	P2	F1	G1	P1	F1	P1	DG	DG	G-P1	P1	DG	G2
Skookum Inlet Tributaries	P1	DG	DG	DG	DG	DG	P1	P1	P2	DG	P2	DG	DG	P2	P2	G2
Oakland Bay Hammersley Inlet Subbasin																
Gosnell Creek	F1	DG	P1	F2	F2	P1	F1	F1	F1	F1	G1	G1	DG	DG	DG	F2
Mill Creek	G1	DG	P1	P2	F2	P1	F1	P1	F1	G1	G1	P1	G-P1	P1	DG	F2
Goldsborough Creek	F1	DG	P1	P1	G2-P1	F1	G1-P2	F1-P1	F1	G-F1	G1	G1	G1	P1	P1	F1,2
Shelton Creek	P1	DG	P2	P1	P1	DG	P2	P2	P2	P2	P2	DG	DG	P1	P1	P2
Johns Creek	F1	DG	P1	F1	G2	F1	G1-P2	P1	F1	P1	G1	P1	G-P1	P1	DG	F-P2
Cranberry Creek	F1	DG	G1	DG	F1	F1	G1-F2	F1	F1	G1	G1	P1	G-P1	P2	P2	F-P2
Deer Creek	F1	DG	P1	P1	G2	P1	F1	P1	G1	G1	G1	DG	G1	DG	DG	F-P2
Malaney Creek	P1	DG	P1	P1	F2	P1	F1-P2	F1	F1	G1	G1	DG	G1	DG	DG	P2

Table 7. Continued.

Stream Name	Fish Passage	Riparian Condition	Riparian Canopy Closure	Streambank Condition	Floodplain Connectivity	Substrate Embed.	LWD Total	LWD Key Pieces	Pool Freq.	Pool Qual. **(A)**	Off-channel Habitat	Water Quality		Water Quantity/ Dewatering	Change in Flow Regime	Biological Processes
												Temp.	DO			
Oakland Bay Hammersley Inlet Subbasin Cont'd.																
Uncle John Creek	P1	DG	DG	P1	P1	P2	P2	P2	P2	P2	F1	P1	G-P1	DG	DG	DG
Campbell Creek	F1	DG	P1	F2	G2	P1	F-P1	F-P1	F-P1	G1	G1	P1	G-P1	DG	DG	P2
Case Inlet Pickering Passage Subbasin																
Schumocher Creek	F1	DG	DG	F2	G2	DG	DG	DG	DG	DG	G2	DG	DG	DG	DG	P2
Sherwood Creek	F1	DG	DG	F2	F2	DG	G1	G1	P1	DG	G2	P1	G1	G1,2	DG	F2
Pickering Passage Tributaries	F1	DG	DG	DG	DG	P2	P2	P2	DG	DG	DG	DG	DG	DG	DG	G2
Hartstene Island Streams	P1	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG

HABITAT LIMITING FACTORS, POTENTIAL CAUSES, AND RECOMMENDATIONS

A habitat parameter was considered limiting if it was rated “poor” in Table 7. Habitat limiting factors for WRIA 14 are summarized in Table 8. This table attempts to identify probable causes for the poor habitat conditions. Recommendations to improve habitat conditions are included as well.

Table 8. Habitat Limiting Factors, Potential Causes, and Recommendations

Habitat Limiting Factor	**Stream Reach (Rated Poor in** Table 7**)** Note: Key to stream reaches is located at bottom of table	**Potential Human-Induced Causes**	**Recommendations**
Fish Passage	1, 2, 5, 8, 12, 16, 17, 22	Dams Failed culverts Grade control structures	Install fish passage structures Replace failed culverts Replace grade control structures
Riparian Canopy Closure	1, 3-5, 7, 9-13, 15, 16, 18	Residential/urban development Grazing Logging	Improve land use regulations and enforcement Fence livestock out of riparian zones Replant native riparian vegetation, particularly conifers
Streambank Condition	1, 5, 7, 10-12, 15-17	Removal of riparian vegetation Channel modifications including: dikes, riprap, bridges, channel relocation, and culverts	Remove or setback dikes, remove riprap Restore meandering channel geometry Replant native riparian vegetation, particularly conifers
Floodplain Connectivity	1, 7, 11, 12, 17	Construction of dikes and levees Channel modifications including: straightening and riprap Conversion of wetlands to agricultural land	Improve land use regulations and enforcement Prevent development on floodplains and along channel banks Remove or setback dikes, remove riprap Restore meandering channel geometry
Substrate Embeddedness	2, 3, 9, 10, 15-18, 21	Fine sediment eroded from unstable banks Fine sediment eroded from forest lands and roads Fine sediment eroded from urban development	Replant native riparian vegetation Follow guidelines in "Forests and Fish Report" Build fewer roads and maintain existing roads Prevent development on floodplains and along channel banks
Large Woody Debris Total	1, 3, 4, 6, 8, 11-13, 16-18, 21	Removal of wood from stream channels Removal of large trees in riparian zone Dikes and levees restrict access to riparian vegetation	Preserve large coniferous trees in riparian zones Place LWD in spawning and rearing reaches Restore meandering channels Leave LWD in channels and replant native riparian vegetation, particularly conifers
Large Woody Debris Key Pieces	1, 3-8, 10-13, 15, 17, 18, 21		
Pool Frequency	1, 3, 5, 6, 8, 12, 17, 18, 20	Lack of large woody debris Channel modifications including: dikes, riprap, bridges, channel relocation and culverts	Preserve large coniferous trees in riparian zones Place LWD in spawning and rearing reaches Restore meandering channel geometry Leave LWD in channels and replant native riparian vegetation, particularly conifers
Pool Quality	1, 5, 7, 12, 13, 17	Lack of large woody debris Channel modifications including: dikes, riprap, bridges, channel relocation and culverts	Place LWD in spawning and rearing reaches Restore meandering channel geometry Leave LWD in channels and replant native riparian vegetation
Off-channel Habitat	8, 12	Construction of dikes and levees Channel modifications including: channelization, riprap Filling of wetlands	Improve land use regulations and enforcement Prohibit dikes/levees and filling of wetlands Remove or setback dikes, remove riprap Replant native riparian vegetation
Temperature	10, 13, 14, 17, 18, 20	Low summer stream flows Lack of riparian vegetation to provide shade Damming wetlands to form lakes	Increase summer instream flows Replant native riparian vegetation, particularly coniferous trees/protect riparian buffers Maintain natural wetland function (i.e. do not create lakes) Enforce water quality regulations
Dissolved Oxygen	7, 10, 13, 14, 17, 18		

Table 8. Continued.

Habitat Limiting Factor	**Stream Reach (Rated Poor in** Table 7**)** Note: Key to stream reaches is located at bottom of table	**Potential Human-Induced Causes**	**Recommendations**
Water Quantity/ Dewatering	7, 8, 10-14	Ground water withdrawals Surface water withdrawals Deforestation Construction of impervious surfaces Accelerated deposition of coarse sediment	Increase summer instream flows Limit development Restore floodplain connectivity Reduce surface water losses on losing reaches Maintain forest cover Enforce water quantity regulations
Change in Flow Regime	8, 11, 12, 14	Ground water and surface water withdrawals, logging, channel modifications	Increase summer instream flows Limit development Restore meandering channel geometry Enforce water quantity regulations
Biological Processes	12-16, 18, 19	Introduction of exotic animals, trapping of beaver, reduced returns of anadromous fish	Eradicate exotic fish and riparian plant species Seed upper watersheds, where anadromous fish were historically present, with pathogen-free hatchery carcasses Allow beaver populations to rebuild

Key to Reach Numbers:

1. Perry Creek (14.0001)
2. Eld Inlet Tributaries (14.0003-14.0007)
3. Schneider Creek (14.0009) and McDonald Creek (14.0009b)
4. “County Line Creek” (14.0010)
5. Kennedy Creek (14.0012)
6. “Snodgrass Creek” (14.0123)
7. Skookum Creek (14.0020) and Tributaries
8. Skookum Inlet Tributaries (north and south shore)
9. Gosnell Creek (14.0029) and Tributaries
10. Mill Creek (14.0029) and Tributaries
11. Goldsborough Creek (14.0035) and Tributaries
12. Shelton Creek (14.0044)
13. Johns Creek (14.0049)
14. Cranberry Creek (14.0051)
15. Deer Creek (14.0057) and Tributaries
16. Malaney Creek (14.0067)
17. Uncle John Creek (14.0068)
18. Campbell Creek (14.0069)
19. Schumocher Creek (14.0094) and Tributaries
20. Sherwood Creek (14.0094) and Tributaries
21. Pickering Passage Tributaries (14.0079-14.0093)
22. Hartstene Island Streams (14.0109-14.0122)

DATA GAPS

Abundance of steelhead and abundance and distribution of coastal cutthroat trout are not monitored at this time. Coastal cutthroat trout distribution is not clearly defined. These fish are known to be present in many watersheds, but no dedicated survey efforts have been undertaken to establish the extent of their presence.

Beaver population status information is not known to exist at this time.

Little information has been collected on habitat conditions in the Case Inlet/Pickering Passage Subbasin. Sherwood/Schumocher Creeks are major anadromous fish production streams, but information on habitat conditions is sparse.

Riparian buffer width, stand age, and species composition have not been inventoried in WRIA 14.

Many structures at stream/road crossings need to be evaluated regarding fish passage criteria. These structures are identified as "Unknown Barriers" on Map 12.

Stream flow data were sparse to non-existent on many streams.

Water temperature and dissolved oxygen data were sparse with the exception of the Oakland Bay/Hammersley Inlet Subbasin.

Damming wetlands to create man-made lakes may have adverse impacts on stream flows and water temperatures in the summer months. These impacts are not well understood.

With the exception of the Oakland Bay/Hammersley Inlet Subbasin, habitat conditions in the nearshore area of WRIA 14 have not been evaluated through field study.

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APPENDIX A: GLOSSARY

Adfluvial: Life history strategy in which adult fish spawn and juveniles subsequently rear in streams, but migrate to lakes for feeding as subadults and adults. Compare to *fluvial*.

Advanced outwash: Sediments sorted and deposited by a stream draining the terminus of an advancing glacier.

Alevin: Juvenile salmonid that has hatched from the egg and remains hidden in the gravel feeding on its yolk sac.

Aggradation: The geologic process of filling and raising the level of the streambed or floodplain by deposition of material eroded and transported from other areas.

Anadromous fish: Species that hatch in freshwater, mature in saltwater, and return to freshwater to spawn.

Aquifer: Water-bearing rock formation or other subsurface layer.

Basin: The area of land that drains water, sediment and dissolved materials to a common point along a stream channel. For the purposes of this report refers to the entirety of Water Resource Inventory Area 14.

Biological Diversity (biodiversity): Variety and variability among living organisms and the ecological complexes in which they occur; encompasses different ecosystems, species, and genes.

Biotic Integrity: Capability of supporting and maintaining a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of natural habitat of the region; a system's ability to generate and maintain adaptive biotic elements through natural evolutionary processes.

Braided stream: Stream that forms an interlacing network of branching and recombining channels separated by branch islands or channel bars.

Buffer: An area of intact vegetation maintained between human activities and a particular natural feature, such as a stream. The buffer reduces potential negative impacts by providing an area around the feature that is unaffected by this activity.

Carrying capacity: Maximum average number or biomass of organisms that can be sustained in a habitat over the long term. Usually refers to a particular species, but can be applied to more than one species.

Channelization: Straightening the meanders of a river; often accompanied by placing riprap or concrete along banks to stabilize the system.

Channelized stream: A stream that has been straightened, runs through pipes or revetments, or is otherwise artificially altered from its natural, meandering course.

Channel Stability: Tendency of a stream channel to remain within its existing location and alignment.

Check dams: Series of small dams placed in gullies or small streams in an effort to control erosion. Commonly built during the 1900s.

Co-managers: The Washington Department of Fish and Wildlife and the Squaxin Island Tribe.

Confluence: Point at which two water bodies join. Often referred to as the "mouth" of a stream or river.

Connectivity: Unbroken linkages in a landscape, often referred to in the context of mainstem connection with side-channels.

Critical Stock: A stock of fish experiencing production levels so low that permanent damage to the stock is likely or has already occurred.

Depressed Stock: A stock of fish whose production is below expected levels based on available habitat and natural variations in survival levels, but above the level where permanent damage to the stock is likely.

Debris torrent: Rapid movements of material, including sediment and woody debris, within a stream channel. Debris torrents frequently begin as debris slides on adjacent hillslopes.

Degradation: The lowering of the streambed or widening of the stream channel by erosion. The breakdown and removal of soil, rock, and organic debris.

Deposition: The settlement of material out of the water column and onto the streambed or floodplain.

Distributaries: Divergent channels of a stream typically occurring in a delta or estuary.

Diversity: Variation that occurs in plant and animal taxa (i.e., species composition), habitats, or ecosystems. See *species richness.*

Ecological restoration: Involves replacing lost or damaged biological elements (populations, species) and reestablishing ecological processes (dispersal, succession) at historical rates.

Ecosystem: Biological community together with the chemical and physical environment with which it interacts.

Ecosystem management: Management that integrates ecological relationships with sociopolitical values toward the general goal of protecting or returning ecosystem integrity over the long term.

Endangered Species Act: A 1973 Act of Congress that mandated that endangered and threatened species of fish, wildlife, and plants be protected and restored.

Endangered Species: Means any species which is in danger of extinction throughout all or a significant portion of its range other than a species of the Class Insecta determined by the Secretary to constitute a pest whose protection under the provisions of the Endangered Species Act would present an overwhelming and overriding risk to man.

Escapement: Those fish that have survived all sources of mortality (natural predation, disease, physiological damage, and fisheries) and return to reproduce.

Estuarine: A partly enclosed coastal body of water that has free connection to open sea, and within which seawater is measurably diluted by fresh river water.

Eutrophic: Water body rich in dissolved nutrients, photosynthetically productive, and often deficient in oxygen during warm periods. Compare *oligotrophic.*

Evolutionary Significant Unit (ESU): A definition of a species used by National Marine Fisheries Service (NMFS) in administering the Endangered Species Act. An ESU is a population (or group of populations) that is reproductively isolated from other conspecific population units, and (2) represents an important component in the evolutionary legacy of the species.

Extirpation: The elimination of a species from a particular local area.

Extinction: The elimination of a species throughout all or a significant portion of its range.

Fingerling: Juvenile salmonid that has grown from the fry stage to a length about the length of a finger.

Flood: An abrupt increase in water discharge; typically flows that overtop streambanks.

Floodplain: A level area adjacent to a stream, constructed through deposition of sediments during the present climate and subject to overland flow during moderate flow events. The floodplain may be abandoned if the climate becomes more arid and is then referred to as a terrace (Leopold 1994).

Flow regime: Characteristics of stream discharge over time. Natural flow regime is the regime that occurred historically.

Fluvial: Pertaining to streams or rivers; also, organisms that migrate between main rivers and tributaries. Compare to *adfluvial*.

Fry: Juvenile salmonid that has absorbed its yolk sac and swum up out of the gravel to actively feed in the stream.

Gabion: Wire basket filled with stones, used to stabilize streambanks, control erosion, and divert stream flow.

Genetic Diversity Unit (GDU) is defined as: A group of genetically similar stocks that is genetically distinct from other such groups. The stocks typically exhibit similar life histories and occupy ecologically, geographically, and geologically similar habitats. A GDU may consist of a single stock.

Geomorphology: Study of the form and origins of surface features of the Earth.

Glides: Stream habitat having a slow, relatively shallow run of water with little or no surface turbulence.

Healthy Stock: A stock of fish experiencing production levels consistent with its available habitat and within the natural variations in survival for the stock.

Hydrograph: Chart of water levels over time.

Hydrology: Study of the properties, distribution, and effects of water on the Earth's surface, subsurface, and atmosphere.

Instream Flow Incremental Methodology: Flow modeling methodology used to determine incremental gains in fish habitat, for individual species, at different flow levels.

Intermittent stream: Stream that has interrupted flow or does not flow continuously. Compare *perennial strea*m.

Interspecific interactions: Interactions between different species.

Intraspecific interactions: Interactions within a species.

Iteroparous fish: Fish (such as steelhead) that are capable of repeat spawning. Spawned-out steelhead returning to the ocean are called "kelts." Compare to *semelparous*.

Kelt: A spawned-out fish (such as a steelhead or cutthroat trout) returning to the ocean.

Lacustrine sediments: Fine silts and clays that settled out of suspension and accumulated on the bottom of a pond or lake.

Large Woody Debris (LWD): Large woody material that has fallen to the ground or into a stream. An important part of the structural diversity of streams. Usually refers to pieces at least 20 inches (51 cm) in diameter.

Limiting Factor: Single factor that limits a system or population from reaching its highest potential.

Macroinvertebrates: Invertebrates large enough to be seen with the naked eye (e.g., most aquatic insects, snails, and amphipods).

Mass failure: Movement of aggregates of soil, rock and vegetation down slope in response to gravity.

Morainal sediments: Unconsolidated piles of boulders, cobbles, gravels, sands, and clays deposited at the terminus of a rapidly melting glacier.

Native: Occurring naturally in a habitat or region; not introduced by humans.

Non-Point Source Pollution: Polluted runoff from sources that cannot be defined as discrete points, such as areas of timber harvesting, surface mining, agriculture, and livestock grazing.

Parr: Young trout or salmon actively feeding in freshwater; usually refers to young anadromous salmonids before they migrate to the sea. See *smolt.*

Piscivorous: Feeding habitat that includes consumption of fish.

Plunge pool: Basin scoured out by vertically falling water.

Rain-on-snow events: The rapid melting of snow as a result of rainfall and warming ambient air temperatures. The combined effect of rainfall and snow melt can cause high overland stream flows resulting in severe hillslope and channel erosion.

Rearing habitat: Areas required for the successful survival to adulthood by young animals.

Recessional outwash: Sediments sorted and deposited by a stream draining from the terminus of a receding glacier.

Recovery: The return of an ecosystem to a defined condition after a disturbance.

Redd: A collection of nests or egg pockets characterized by clean gravel and a depression in the streambed created by the digging actions of a spawning female salmonid.

Resident fish: Fish species that complete their entire life cycle in the same geographic area. All lifestages are found in the same habitat. In contrast, anadromous, adfluvial, and fluvial fish lifestages are found in different habitats.

Residual pool depth: The depth of a pool if it is isolated within a dry streambed. Visualize a pool scoured in the streambed. There is water flowing over the streambed upstream and downstream and filling the pool. Now stop the flow of water. Residual pool depth is the depth of water remaining in the isolated pool after the flow of water is stopped.

Riffle: Stream habitat having a broken or choppy surface (white water), moderate or swift current, and shallow depth.

Riparian: Type of wetland transition zone between aquatic habitats and upland areas. Typically, lush vegetation along a stream or river.

Riprap: Large rocks, broken concrete, or other structure used to stabilize streambanks and other slopes.

Rootwad: Exposed root system of an uprooted or washed-out tree.

Salmonid: Fish of the family Salmonidae, including the Salmoninae (salmon, trout, and char), Coregoniane (whitefish), and Thymallinae (graylings). Characterized by streamlined body, forked tail, and adipose fin. Typically inhabit cold waters.

Salmon: For purposes of this report, refers to all species of the genus *Oncorhynchus* (i.e. chinook, coho, chum, pink, sockeye, rainbow/steelhead trout, and coastal cutthroat trout). The enabling legislation (RCW 77) refers to all members of the family Salmonidae (see "Salmonid" above). Whitefish will not be discussed, and grayling and char (bull trout and Dolly Varden) are not known to be present in WRIA 14.

Sediment: Material carried in suspension by water, which will eventually settle to the bottom.

Semelparous: Fish (such as the five species of Pacific salmon that occur in Washington) that spawn only once, then die. Compare with *iteroparous*.

Side channel: A portion of an active channel that does not carry the bulk of stream flow. Side channels may carry water only during high flows, but are still considered part of the total active channel.

Sinuosity: Degree to which a stream channel curves or meanders laterally across the land surface.

Slope stability: The degree to which a slope resists the downward pull of gravity.

Smolt: Juvenile salmon migrating seaward; a young anadromous trout, salmon, or char undergoing physiological changes that will allow it to adapt from life in freshwater to life in the sea.

Stock: Group of fish that is genetically self-sustaining and isolated geographically or temporally during reproduction. Generally, a local population of fish. More specifically, a local population – especially that of salmon, steelhead (rainbow trout), or other anadromous fish – that originate from specific watersheds as juveniles and generally return to their birth stream to spawn as adults.

Stream reach: Section of a stream between two points.

Subbasin: For purposes of this report the drainages of Eld Inlet, Totten/Little Skookum Inlet, Oakland Bay/Hammersley Inlet, and Case Inlet/Pickering Passage.

Terrace: An abandoned floodplain created during a wetter climate (for example, a period of rapidly receding glaciers).

Thalweg: Portion of a stream or river with deepest water and greatest flow.

Threatened Species: Any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

Toe width: A method used to estimate instream flows necessary to provide habitat for salmon and steelhead. It was developed in the 1970s in western Washington by the U.S. Geological Survey (USGS), in cooperation with the Washington Department of Fisheries (WDF) and the Washington Department of Game (WDG). The method is based on statistical regressions of habitat, as measured in pilot studies based on actual fish habitat selection, on stream channel widths measured between the toes of the banks. Toes of the bank in riffle areas are indicated by change in cross-section slope, change in substrate, and sometimes by vegetation change. The toe width (usually an average of multiple measurements) is plugged into formulas for juveniles and spawners of different species of salmon and steelhead.

Watershed: Entire area that contributes both surface and ground water to a particular, stream, lake or ocean. Scale can vary dramatically depending upon the size of the receiving water body analyzed. For purposes of this report refers to individual streams and all of the associated tributaries within the drainage.

Watershed rehabilitation: Used primarily to indicate improvement of watershed condition or certain habitats within the watershed. Compare *watershed restoratio*n.

Watershed restoration: Reestablishing the structure and function of an ecosystem, including its natural diversity; a comprehensive, long-term program to return watershed health, riparian ecosystems, and fish habitats to a close approximation of their condition prior to human disturbance.

Watershed-scale approach: Consideration of the entire watershed in a project or plan.

Weir: Device across a stream to divert fish into a trap or to raise the water level or divert its flow. Also a notch or depression in a dam or other water barrier through which the flow of water is measured or regulated.

Wild Stock: A stock that is sustained by natural spawning and rearing in the natural habitat.

APPENDIX B: MAPS

Map 1: WRIA 14 Kennedy-Goldsborough Basin

Map 2: WRIA 14 Eld Inlet Subbasin

Map 3: WRIA 14 Totten/Little Skookum Inlet Subbasin

Map 4: WRIA 14 Oakland Bay/Hammersley Inlet Subbasin

Map 5: WRIA 14 Case Inlet/Pickering Passage Subbasin

Map 6: WRIA 14 Land Use

Map 7: WRIA 14 Chum Distribution

Map 8: WRIA 14 Coho Distribution

Map 9: WRIA 14 Fall Chinook Distribution

Map 10: WRIA 14 Winter Steelhead Distribution

Map 11: WRIA 14 Coastal Cutthroat Distribution

Map 12: WRIA 14 Fish Passage Barriers