APPENDIX A

A BRIEF DESCRIPTION OF MAJOR RIVER SYSTEMS IN KING COUNTY WITH NOTES ON FISH UTILIZATION AND SALMONID HABITAT REQUIREMENTS

This appendix discusses the characteristics of the rivers within each of the four designated Water Resource Inventory Areas (WRIA) in King County. The following material was compiled from the State of Washington Water Resource Inventory and Washington Department of Fisheries *Catalog of Washington Streams and Salmon Utilization, Volume 1, Puget Sound Region* (Williams et al. 1975). Additional information was included from Region IV of the Washington Department of Wildlife (WDW) and numerous local sources. Also included in this appendix is a discussion of the salmonid habitat requirements and use in large streams and rivers.

WATER RESOURCE INVENTORY AREAS

The streams of King County are cataloged in four Water Resource Inventory Areas (WRIA). These are (Figure A.1):

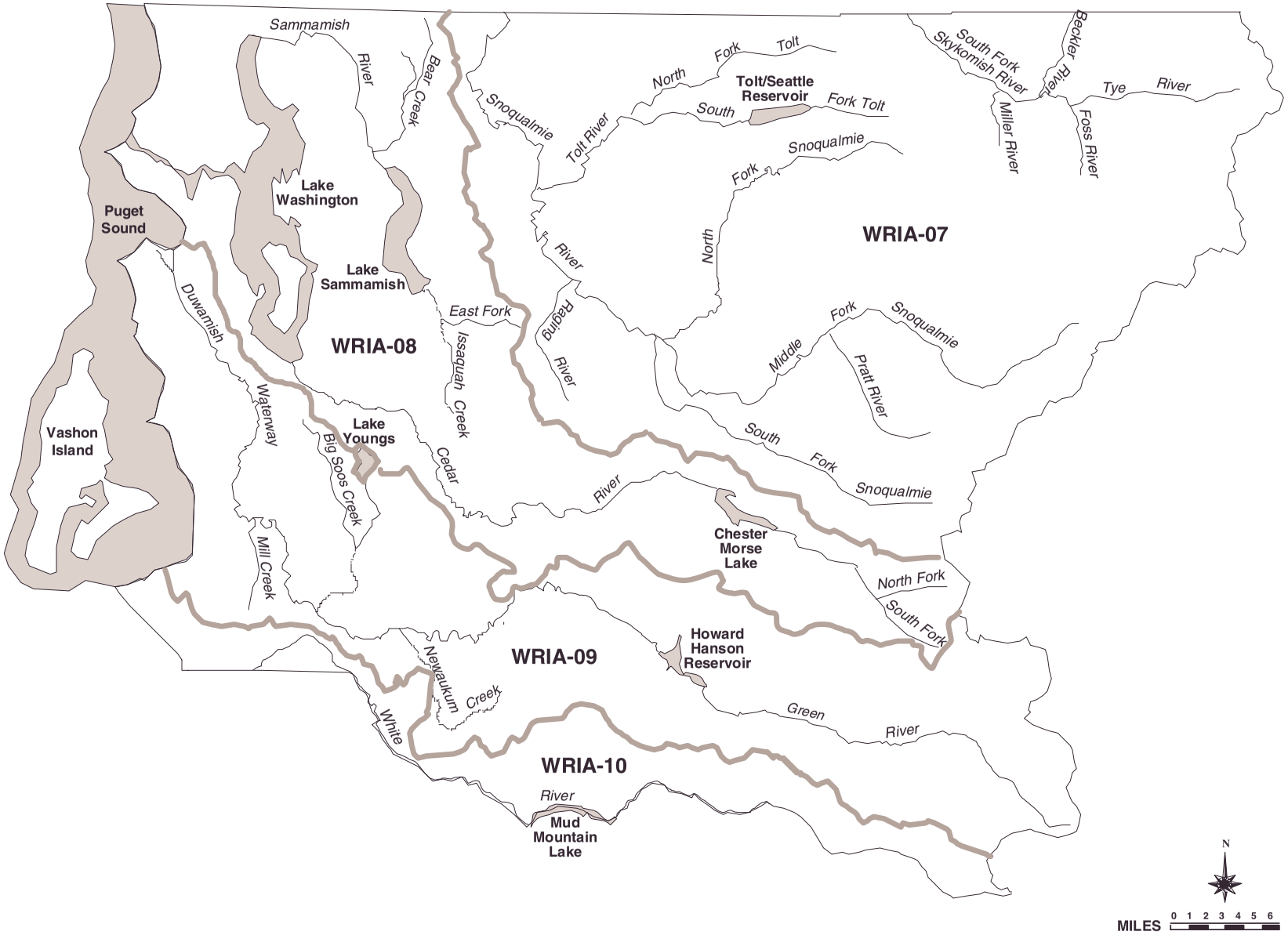
— Snohomish Basin (WRIA 07). This includes that portion of the South Fork Skykomish River and its tributaries in King County, plus the Snoqualmie River system.

— Lake Washington Basin (WRIA 08) consists of the Sammamish River system, Cedar River system, and eight smaller streams that enter Lake Washington independently.

— Duwamish Basin (WRIA 09) includes the Green-Duwamish River and five smaller drainages that enter Puget Sound independently.

— Puyallup Basin (WRIA 10). Includes reaches of the White River and its tributaries, including the Greenwater River, in King County, and that portion of Hylebos Creek in King County.

Figure A.1 Water resource inventory areas (WRIAs) of King County.



SOUTH FORK SKYKOMISH RIVER DRAINAGE (WRIA 07)

Description

South Fork Skykomish River originates in the rugged, forested, steeply sloped country of the high Cascade Mountains. Formed by the confluence of the **Tye** and **Foss Rivers** 11 miles below Stevens Pass, it flows generally west and northwest across the northeastern corner of King County past the community of Baring where it enters Snohomish County. Its principal tributaries in King County are the **Miller**, **Beckler**, and **Foss Rivers**, plus **Money** and **Index Creeks**. These are all moderate size tributaries with significant populations of resident and anadromous fish. These upper drainages have mountain characteristics including moderately steep gradient and extensive large rock and cascade areas with considerable pool and riffle areas sufficient to sustain good populations of fish. Altogether, this system accounts for 454 linear miles of stream in King County.

Fish Utilization

Historically, none of the King County portion of the South Fork Skykomish drainage supported anadromous fish. In a 2.5 mile reach beginning about two miles downstream from the King-Snohomish county line, the South Fork Skykomish flows over three major falls: Eagle Falls (28-foot drop), Canyon Falls (48-foot drop), and Sunset Falls (88-foot drop). This complex formed a natural barrier to upstream migration that prevented anadromous fish from reaching the King County portion of the drainage. After a fishway trap-and-haul facility was constructed at Sunset Falls in the late 1950's, anadromous fish were introduced to the upper drainage. As a result, an excellent fishery for large resident rainbow trout (fish up to 17 inches reported by locals) was largely displaced as the number of anadromous fish increased.

The South Fork Skykomish system in King County is now used by spring and fall chinook and coho salmon, and by summer and winter steelhead. This reach also has resident rainbow and cutthroat trout, although not in the numbers and size range once reported. Whitefish are also present, and perhaps a few Dolly Varden char. Adult chinook, coho salmon and steelhead ascend the drainage as far as Alpine Falls on the Tye River; chinook salmon and steelhead spawn mostly in mainstem reaches throughout the system. Coho use every accessible stream and tributary, including the lowermost reaches of the small, steep tributaries high in the drainage. Juvenile fish rear throughout these accessible waters.

SNOQUALMIE RIVER DRAINAGE (WRIA 07)

Description

South Fork Snoqualmie River begins near Snoqualmie Pass and flows generally northwest for 35 miles to Snoqualmie Falls. It flows mostly through mountainous terrain with steep gradients and many cascade areas and falls. There are, however, extensive good quality pool-riffle sequences in the lower reaches where the gradient becomes less steep. Together with its short, mostly steep mountain tributaries, the South Fork Snoqualmie accounts for 112 linear stream miles in King County. The river is paralleled in areas by the I-90 freeway.

Middle Fork Snoqualmie River starts in the Mt. Daniel-Mt. Roosevelt-Big Snow Mountain area of the high Cascades and flows west and southwest 40 miles to its confluence with the North Fork five miles upstream of Snoqualmie Falls. Principal tributaries are the **Taylor** and **Pratt Rivers**, **Burntboot**, **Dingford**, **Cripple**, and **Granite Creeks**. The upper 10 miles of river flows through a very narrow valley with steep mountain side slopes. Although the slopes remain steep, the valley broadens and narrows intermittently through the next nine miles, then broadens more and slopes gently back to steeper hillsides. Near North Bend, the valley becomes quite broad and flat. In the headwater region, the stream flows swiftly within a confined channel over mostly a steep gradient with numerous cascades and high gradient riffles. The gradient then moderates for about 19 miles. Here the channel offers a good pool-riffle balance with numerous broad, lengthy riffles and several deep pools. The gradient steepens again in the next eight miles with areas of riffles and low cascades separated by large pools. The lower four miles have a moderate to gentle gradient with good pool-riffle balance and many broad low gradient riffles. Both the **Pratt** and **Taylor Rivers** contain lengthy reaches with moderate gradients and good pool-riffle balance with gravel-rubble bottom substrates. Most other tributaries have steep mountainous characteristics with numerous cascades and limited pools and riffles. Altogether, the Middle Fork system accounts for 240 linear stream miles in King County.

North Fork Snoqualmie River originates in the Lennox Mountain area of the high Cascades and flows 26 miles to its confluence with the Middle Fork. The combined Middle and North Forks join the South Fork about five miles upstream of Snoqualmie Falls. Principal tributaries are **Lennox**, **Sunday**, **Deep**, **Calligan**, and **Hancock Creeks**. The upper six miles of the North Fork have steep mountainous characteristics with a narrow valley, steep slopes, and high stream gradient with numerous cascades and high gradient riffles and few pools. In the seven miles downstream from Lennox Creek, the valley is broad, flat, and covered with mainly deciduous vegetation. The gradient here is gentle to moderate, and the channel exhibits considerable splitting. There are numerous pools and many long, slow glides in this reach. Gradient is moderate over the next eight miles with a few low cascades, but overall good pool-riffle conditions. Downstream from Hancock Creek, the river enters a ravine and flows over a series of cascades, some exceeding four feet. The stream here is narrowly confined with numerous high gradient riffles separated by pools. Upon exiting the gorge, the gradient moderates and the stream exhibits good pool-riffle balance with gravel-rubble bottom. Most North Fork tributaries are steep, with many cascades and high gradient riffles. **Deep** and **Sunday Creeks** have lengthy reaches of moderate gradient and good pool-riffle sections with gravel-rubble bottoms. Altogether, the North Fork and its tributaries account for 156 linear stream miles in King County.

Main Snoqualmie River downstream from the forks flows generally northwest and north to the King-Snohomish County line just past the town of Duvall. The mainstem and all of its tributaries in this King County reach (not including the forks) account for an additional 309 linear miles of stream. Principal tributaries are **Tokul Creek**, **Raging River**, **Tolt River**, **Griffin Creek**, **Patterson Creek**, **Skunk Creek**, **Harris Creek**, and **Ames Creek**. The five miles of main Snoqualmie from the forks to Snoqualmie Falls have a moderate gradient with good pool-riffle conditions. Some riprapping has occurred in this area. Downstream from the falls, the river winds in shallow bends, oxbows, and meanders across the valley floor. The valley averages 1.5 miles in width with hillsides rising to about 400 ft. Many large side sloughs formed by overflow waters are found mostly on the east side below Fall City. The gradient is extremely low. While long gravel riffles appear in places, especially just downstream of the Tolt River, the river is mostly slow and slough-like with diked banks and a bottom of heavy mud and silt. Land use is mostly agricultural, although urbanization is rapidly encroaching.

Tolt River begins in the Cascade Range, the North Fork near Red Mountain and the South Fork near a divide opposite Money Creek (South Fork Skykomish drainage). The South Fork's upper six to seven miles are inside the City of Seattle municipal watershed. Flows in the South Fork, and in the main Tolt below, are controlled by spillway releases from Seattle's water supply reservoir. A large falls just below Seattle's dam blocks upstream migration of anadromous fish on the South Fork. Downstream from this falls, for its remaining eight miles, the South Fork gradient is moderate to steep with mostly fast riffles and cascades, particularly in a short canyon section about two-thirds of the way down. The substrate is mainly cobbles and boulders with short gravel riffles and patches. Clearcut logging has been extensive outside the municipal watershed. The North Fork's upper six miles are steep with numerous cascades and a few short pool-riffle sequences. The next six miles are moderate gradient with some channel splitting and a number of good pool-riffle sequences. A three to four mile canyon follows with a steep gradient and many cascades and high gradient riffles. One falls in this reach exceeds 25 feet and is a migration barrier to anadromous fish. Two miles of moderate gradient follow to the confluence with the South Fork. Downstream from the confluence, the main Tolt flows nine miles to the Snoqualmie River. The Tolt River valley begins to widen here and stream gradient gradually decreases. The first four miles of channel are fast riffle in character with a boulder, cobble, and gravel substrate. The lower five miles contain increasing sections of gravel riffles and generally good pool-riffle balance. Channel splitting and overflow side channels occur in this reach. **Stossel Creek**, which is a principal tributary, provides 4.5 miles of accessible stream.

Raging River originates near the 3000 ft. level on the southwest slope of Rattlesnake Mountain and flows northwest 10 miles to the town of Preston, then turns northeast for 4.5 miles to its confluence with the Snoqualmie River at Fall City. **Lake Creek** and **Deep Creek** are principal tributaries. The upper reaches of Raging River descend through deep ravines to near the 900 ft. elevation where the gradient moderates. Most of the upper watershed is in second growth timber. In the lower gradient section, there are good pool-riffle sequences interspersed with large cobble and boulders. Flood control dikes have been constructed along the lower few miles. Raging River has a reputation for fast runoff and flash flooding. Mean annual flow is 146 cfs; summer low flows are 9 -15 cfs.

Fish Utilization

There is no natural use of the Snoqualmie system by anadromous fish above Snoqualmie Falls on the Snoqualmie River or upstream of impassable falls on both the North Fork and South Fork Tolt River. The Washington Department of Fisheries has planted hatchery propagated salmon above Snoqualmie Falls on occasion in the past and has proposed several times that salmon be introduced into the excellent "unutilized" habitat above the falls. Use of all areas above impassable barriers by resident rainbow and cutthroat trout is extensive, especially the three forks of the Snoqualmie River and the two forks of the Tolt. The Middle Fork Snoqualmie River has been called the finest remaining resident trout fishery on the west side of the Cascade Mountains.

Downstream from Snoqualmie Falls, the system is used by spring and fall chinook, coho, pink, and chum salmon, winter and summer steelhead, and searun cutthroat trout. Spring chinook salmon, although not numerous, spawn in the upper portions of the Snoqualmie and Tolt Rivers. Fall chinook spawn in approximately 11 miles of the main Snoqualmie River above the town of Duvall, and in about 12 miles of tributary, principally the Raging and Tolt Rivers and in Tokul and Griffin Creeks. Coho salmon use virtually every accessible stream and tributary, with major use occurring in the Raging and Tolt Rivers, and in Tokul, Griffin, Harris, Patterson, Ames, Skunk, Lake, and Deep Creeks. Chum salmon use the

mainstem Snoqualmie, most intensely in the reach just below the mouth of the Tolt and again below Fall City. Some chum salmon also spawn in Harris and Ames Creeks. Pink salmon spawn in the same areas of the mainstem as the chums, and prior to 1975 were also observed in the lower portions of Raging River. Winter steelhead use primarily mainstem reaches for spawning, although this run is heavily supplemented from the WDW hatchery on Tokul Creek. While summer steelhead home to the Tolt River for spawning, they may use the main Snoqualmie in the reach from Tokul Creek to Snoqualmie Falls as a thermal refuge in the summer (K. Beardslee, Washington Trout, personal communication). The Tolt River summer steelhead is listed by the American Fisheries Society as at high risk of extinction and may be petitioned for listing under the U. S. Endangered Species Act. Steelhead are also found in the Raging River. The extent of searun cutthroat use in the system is not known, but in other river systems these fish use all accessible tributaries in lower gradient reaches.

LAKE WASHINGTON DRAINAGE (WRIA 08)

Description

This drainage consists of all waters flowing into Lake Washington and thence through Lake Union and the Salmon Bay waterway to Puget Sound at Shilshole Bay. The major components of the drainage are the Sammamish River complex, the Cedar River, and a group of independent drainages around the north and east sides of Lake Washington.

Prior to 1916, when the government locks and Lake Washington ship canal were completed, this entire drainage flowed to the Duwamish-Green River drainage (WRIA. 9) via Black River at the south end of Lake Washington. The Cedar River discharged into Black River immediately downstream from the lake, which then flowed into the Duwamish River and thence to Puget Sound at Elliott Bay.

The **Sammamish River complex** includes the **Sammamish River** and its tributaries, **Big Bear**, **Little Bear**, **North**, and **Swamp Creeks**, as well as **Lake Sammamish** and its principal tributaries, **Issaquah Creek**, **Tibbets Creek**, and **Laughing Jacob Creek**.

Issaquah Creek begins in the moderately steep foothill slopes near Hobart and meanders generally north to Lake Sammamish. It provides the greatest amount of good pool-riffle area of any of the Lake Sammamish tributaries. Cleared farmlands and intermittent deciduous groves border the stream with urban development occurring in many areas. While **Tibbets** and **Laughing Jacob Creeks** are similar in characteristics to Issaquah Creek, their accessible lengths are shorter. Again, urbanization of these watersheds has intensified in recent years.

Sammamish River runs north and west from Lake Sammamish 12 miles to Lake Washington. Its entire length was channelized for flood control in 1964. Flow is sluggish and the bottom is heavily silted and infested with milfoil. **Big Bear Creek**, 12.5 miles long, originating in Paradise Valley, lies in a flat valley about a mile in width. The stream gradient is gentle and the unaltered reaches have abundant pool-riffle-glide areas, with excellent gravel above the York Road crossing at Avondale. Bear Creek has several tributaries: **Evans Creek**, **Mackey Creek**, **Cottage Lake Creek**, **Seidel Creek**, and **Struve Creek**. The entire Bear Creek watershed is experiencing intense urbanization, as are those of **Swamp**, **North**, and **Little Bear Creeks** which all lie in close proximity to one another in the lower six-mile section of Sammamish River. These are typical lowland streams flowing from gentle hillsides and

gradually meandering through rolling hills, wetland areas, and bottomlands. The small farms and pasturelands that once were prevalent have given way to urbanization (residential developments, large shopping centers, and the like). Swamp Creek has been channelized in the lower two miles above Kenmore.

Cedar River originates in high mountain country near Stampede Pass and flows west-northwest nearly 50 miles to its present confluence with Lake Washington at Renton. The upper 10 miles flow through steep-sloped, narrow, forested mountain terrain. In this reach, the river has numerous high gradient riffles and cascades with few pools or lower gradient riffles. Two water storage reservoirs, Chester Morris and Cedar Lake, are in the next nine miles. Downstream from Cedar Lake to the City of Seattle water diversion dam at Landsburg, a distance of 14 miles, the forested valley is alternately shallow and broad. The river has many gentle gradient reaches with good pool-riffle areas. The diversion dam is a total barrier to upstream migration of anadromous fish. Downstream from the barrier, the river flows five miles to Maple Valley with several high gradient areas of mostly boulder and only intermittent areas of good pool-riffle sequences. Downstream from Maple Valley the river meanders over a shallow, relatively broad valley and the stream takes on good pool-riffle character with excellent spawning and rearing habitat for fish. The area is increasingly urbanized, and the lower three miles is heavily industrialized. Tributaries accessible to fish are **Rock**, **Downs and Madsen Creeks**.

Independent drainages

There are eight independent drainages. At the north end of Lake Washington between Sand Point and Kirkland are **Thornton Creek**, **McAleer Creek**, **Lyons Creek**, and **Juanita Creek**. Thornton, McAleer and Lyons Creeks are all relatively short (four to seven miles), lowland streams originating in broad valleys at the 300-400 foot elevation then narrowing to more confined ravines in the lower reaches. Juanita Creek, 14 miles long, flows south from Norway Hill south of Bothell to Juanita Bay through an area of heavy development. Juanita Creek is a low gradient stream, but its tributaries are steep and contain falls. Juanita Creek substrate is pea gravel, sand and silt with larger gravels through the lower reaches. Along the east shore of Lake Washington are **Mercer Slough**, **Coal Creek**, **May Creek**, and **one unnamed stream**. Mercer Slough is formed by **Kelsey Creek**, which heads at Larsen Lake in Lake Hills and flows 4.6 miles through a concentrated industrial, business, and residential area. **Sturtevant Creek**, which originates at Sturtevant Lake in Bellevue and flows 1.3 miles also through intense development. Coal Creek flows seven miles from the Newport Hills-Newcastle area through a steep ravine with several impassable falls. This stream passes through a 457-foot culvert at Highway 405. May Creek originates at Lake Kathleen and flows west 8.6 miles to Lake Washington through a mostly urbanized watershed.

Fish Utilization

Chinook, coho, and sockeye salmon use the Lake Washington drainage, as do steelhead, searun cutthroat trout, and resident races of rainbow and cutthroat trout and whitefish. Fall chinook salmon use much of the accessible stream length of the Cedar River and larger Lake Sammamish tributaries including Issaquah Creek and Big Bear Creek. Coho salmon use virtually all accessible streams including Cedar River and its tributaries, Sammamish River tributaries, Lake Sammamish tributaries, and each of the eight independent Lake Washington drainages. While adult sockeye salmon principally use the Cedar River and its tributaries plus the Issaquah Creek and Big Bear Creek drainages for

spawning, some spawning has occurred in all of the accessible streams of the Lake Washington drainage. In addition, some sockeye spawning occurs along Lake Washington and Lake Sammamish beaches. It is worth noting that juvenile coho and chinook salmon as well as sockeye salmon use Lake Washington, Lake Union, and the Salmon Bay waterway for rearing. While lake rearing is not unusual for sockeye salmon, it may indicate a unique adaptation for stocks of coho and chinook salmon in the Lake Washington system. Steelhead spawn in the Cedar River and larger tributaries of the Lake Sammamish system. Although searun cutthroat trout utilization has been reported and should occur, their use of the system is not well documented. There are also lake-resident cutthroat trout that utilize Lake Washington tributaries for spawning and rearing, and each system has resident trout populations of varying numerical strength.

DUWAMISH-GREEN RIVER DRAINAGE (WRIA 09)

Description

This drainage now consists of one large river system, the **Green River**, which in its lower 10 miles, is also known as the **Duwamish River**. The dual name occurs because prior to 1916, the Green River joined here with the Black River (which then carried the flow of the entire Lake Washington and Cedar River drainages) to form the Duwamish. The Green-Duwamish River system accounts for over 643 lineal miles of stream in King County. In addition to the Green-Duwamish River, five small independent drainages also enter Puget Sound. These include **Longfellow Creek** which enters Elliott Bay near the mouth of the Duwamish, and **Miller**, **Bow**, **Lake**, **Joe's**, and one unnamed creek that enter Puget Sound between Alki Point and Dash Point.

Green River heads in the high Cascades on Blowout Mountain about 30 miles northeast of Mt. Rainier, and flows generally west and northwest for 25 miles through mostly narrow valley, steeply sloped, forested terrain before coming to gentler slopes and broader valleys. In this rugged, moderately steep-gradient run, the Green River receives tributary flow from **Sunday**, **Sawmill**, **Champion**, **Smay**, and **Charlie Creeks** and from the **North Fork Green River**. Just below the confluence of the North Fork is Howard Hanson Dam, a flood control facility completed in 1962, and three miles below that is the City of Tacoma water diversion facility, which represents the present upper limit of anadromous fish migration. The upper drainage is managed as a municipal watershed. Downstream from the water diversion, Green River remains a moderately steep gradient river as it flows another 25 miles through the Green River Gorge, emerging at Flaming Geyser Park. The upper part of this reach, just downstream from the water diversion, is a boulder zone that lacks gravel recruitment. Downstream from the gorge, the river meanders for about 10 miles over a broad valley floor largely agricultural in character. Important tributries in this reach are **Newaukum**, **Crisp**, **Burns**, and **Soos Creeks**. The river continues to meander through a valley where urbanization and industrialization have rapidly replaced former farmland. The cities of Auburn and Kent are located here. Near Kent, the river gradient diminished considerably and the remainder of the Green-Duwamish is characterized by slow flows. Here the streambanks have been extensively leveed and channelized. The lower Duwamish has been moved several times since the turn of the century to accommodate industrialization.

The independent drainages are all relatively short and each experiences periods of low or intermittent flow. **Longfellow Creek** is a moderate gradient stream over its entire length, but the others flow to the

Sound over steeper terrain and have only limited areas near their mouths which are accessible to anadromous fish.

Fish Utilization

Spring and fall chinook and coho salmon, steelhead, and searun cutthroat trout use the Green-Duwamish basin. Anadromous Dolly Varden char have also been reported. Odd-year runs of pink salmon that once used the Green-Duwamish basin have been extinct since the mid-1930's. Although chum salmon also used this system, all recent escapement counts of wild fish have been zero and the wild stock is probably now extinct. Hatchery chum salmon are now released from the Soos Creek hatchery. The system is also utilized by resident stocks of rainbow and cutthroat trout and by whitefish. The City of Tacoma water diversion facility represents the present upper limit of anadromous fish migration in the system. A trap and haul operation has been established to pass anadromous salmonids upstream of Howard Hansen Dam.

The independent Puget Sound drainages within this WRIA are or were used to some extent by coho and chum salmon and searun cutthroat trout, but the magnitude of present use is unknown.

WHITE RIVER DRAINAGE (WRIA 10)

Description

White River originates from Emmons Glacier on the northeast face of Mt. Rainier and flows north more than 25 miles to Greenwater, where it forms a portion of the southern boundary of King County. **Greenwater River**, another part of the southern boundary of King County, begins on Castle Mountain north of Naches Pass and flows generally northwest for 21 miles to its confluence with the White River. From the town of Greenwater, the White River flows west for 22 miles toward Enumclaw, loops north toward Auburn, then turns south again to exit King County and join the Puyallup River at Sumner. In this reach, the river is also known as the Stuck River. Historically, the White River switched drainages from time to time in this section. Prior to 1906, the river flowed around the southeast edge of Auburn into the Green River. In 1906, a flood diverted the stream south into the Puyallup, a situation that was made permanent in 1915 when a dike was built across the old Stuck River channel.

Greenwater River drops rapidly from its headwaters through a steep, narrow, forested valley, over numerous cascades and a predominately bedrock and boulder stream bottom. Downstream from **Burns Creek**, a principal tributary in this upper reach, the gradient decreases to moderate and the channel takes a more winding course to Greenwater. Although the channel remains confined, it has several channel splits and a good pool-riffle ratio. Streambanks are generally stable, consisting of earth or rock cuts or gravel-cobble beaches. The watershed has been extensively logged.

White River is a swift moving, glacial stream that carries a heavy load of silt from the Emmons Glacier. Downstream from Greenwater, its streambed consists of boulders, cobble, and large gravel. Sixteen miles downstream from Greenwater is Mud Mountain Dam, a flood control structure with a narrow, four-mile reservoir. Principal King County tributaries in this reach are **Clay Creek**, **Cyclone Creek**, **West Twin** and **East Twin Creeks**. Downstream from Mud Mountain Dam, the river channel

is confined in a narrow, steep-sided canyon for three miles before the valley widens. Principal King County tributaries in this reach are **Boise Creek** and **Red Creek.** Boise Creek, approximately six miles in length, originates upstream of a Weyerhaeuser sawmill complex and flows through an almost 1000 ft. culvert under the mill, then through a well-defined channel cut deeply in the largely agricultural plateau. It contains good gravel and has a good pool-riffle ratio. Approximately five miles downstream from Mud Mountain Dam, Puget Sound Power & Light Company diverts water from the White River into Lake Tapps. Discharge from Lake Tapps returns to the White River near Sumner in Pierce County. The river downstream from Enumclaw meanders across a broad valley to Auburn and contains increasing amounts of reasonably good spawning and rearing habitat. However, the stream does transport heavy silt loads from an annual flushing operation at Mud Mountain Dam and the water diversion operation.

East Fork Hylebos Creek originates at Lake Killarney about four miles north of the King County line northeast of Federal Way. **West Fork Hylebos Creek** heads in the new City of Federal Way near the Sea-Tac Mall. The two forks flow south and join near the King County line, where the mainstem turns west, and flows into the Hylebos Waterway and Commencement Bay.

Fish Utilization

Utilization of the lower 20 miles of White River is mostly for migration and perhaps freshwater rearing of juvenile fish, although some chinook, chum and pink salmon spawning occurs in reaches upstream to the PP & L water diversion. While this diversion is a total blockage to upstream migration of anadromous fish, a trap and haul operation transports fish above Mud Mountain Dam where they are typically released near Greenwater to spawn and rear in the upper watershed. Coho salmon utilize all accessible areas of Boise Creek, and chum salmon spawn in its lower mile. Resident trout are also present in Boise Creek. Chinook salmon and steelhead use the upper White River, and coho salmon ascend all accessible tributaries. The Greenwater River upstream as far as Burns Creek served as one of the principal spawning areas for spring chinook salmon in the White River drainage; this run is now at high risk of extinction and all returning adults are trapped for captive breeding and rearing. Steelhead, coho, and resident trout also use the Greenwater River.

Hylebos Creek is utilized by coho and chum salmon, and perhaps also by searun and resident cutthroat trout. Present use is adversely affected by industrialization and heavy pollution in Hylebos Waterway and lower Commencement Bay, and the extensive development activity presently occurring in Federal Way area.

SALMONID HABITAT REQUIREMENTS AND USE IN LARGE STREAMS AND RIVERS

Upstream Migration of Adults

In this stage of the salmonid life-cycle, streams serve mainly as corridors along which fish pass to reach spawning areas. Most salmonids migrate during intermediate streamflows. While high flows may exceed the swimming abilities of the fish, excessively low flows and shallow water depth may block migration.

The ability of adult salmonids to pass obstructions is often underestimated. Given suitable conditions, upstream-migrating salmonids pass many obstacles that appear to be barriers. Many falls that are impassable under one set of flow conditions may be readily passed when flows change. Larger species such as chinook, coho, and steelhead have commonly been observed leaping obstacles six to nine feet in height (Stuart 1962), whereas barriers exceeding 4.5 feet can be an impediment for smaller species and for chum salmon, which are sometimes stymied by obstacles other salmonids pass with ease (Everest et al. 1985).

Other impediments to upstream migration include unfavorable water temperatures, high turbidity, and poor water quality. Generally speaking, water temperatures in the range of 3° to 20° C (38° to 68° F) are acceptable to fish during spawning migrations. Because most anadromous stocks have evolved with the temperature patterns of their home streams, significant abrupt deviations from normal patterns can stop migration and adversely affect fish survival (Bell 1986; Bjornn and Reiser 1991). Migrating salmonids also cease to migrate in waters with high silt loads (Cordone and Kelley 1961; Bell 1986). Turbid water also absorbs more radiation than clear water and thus may promote a thermal barrier to migration (Reiser and Bjornn 1979). Reduced dissolved oxygen concentrations can disrupt or prevent migration by adversely affecting the swimming performance of the fish, or by eliciting an avoidance reaction.

Spawning

Pacific salmonids seek out areas in streams where gravels of suitable size, permeability, and stability have been deposited. While these areas are typically found in transition zones between pools and riffles (tailouts of pools), suitable spawning areas may also be found in secondary channels, along channel margins in large rivers, and in the inlets and outlets of lakes. Each species has its own preferences. Pink and chum salmon usually choose areas not far upstream of saltwater, chinook salmon and steelhead select sites in the mainstem or more robust tributaries, coho salmon and searun cutthroat trout seek smaller tributaries off the mainstem, sockeye salmon prefer mainstem rivers or lake inlets or outlets, and Dolly Varden and bull trout head for the highest, coldest tributaries. Each species also has its own preference for size range of gravels, velocity, and depth of water.

Water temperature is also an important factor. Each stock appears to have a unique time and temperature for spawning that maximizes the survival of the offspring in that particular situation. In the case of fall spawners, for example, newly spawned embryos must reach a critical stage of development before the water becomes too cold. Also, fry emergence must occur at a suitable time the following spring. For spring spawners, spawning must not occur before the water has warmed sufficiently for normal development of the embryos. If the temperature suddenly drops again, spawning activity may cease.

The amount of space required per spawning pair depends on the size and behavior of the fish, and on the amount and quality of available substrate. Redds generally range in size from five to more than nine square feet for anadromous salmonids, and from one to eight square feet for smaller non-anadromous salmonids. The area suitable for spawning (defined by depth, velocity, substrate size, and other intangibles) is usually much less than the total area of gravel substrate in a stream.

Incubation

Incubation and spawning are inextricably linked, not just because adult fish deposit eggs in fixed locations, but also because selection of the spawning site fixes the incubation environment. During redd construction and spawning, fine sediments and organic matter within the substrate are swept out and washed away downstream, leaving the redd environment as favorable for the embryos immediately after construction as it will ever be. From this point on, sufficient water must circulate throughout the egg pocket to supply the embryos with oxygen and to carry away waste products. Permeability and the apparent velocity of water through the redd are commonly used measures of the suitability of the redd to support incubation. If either of these parameters decreases, embryo survival also decreases. Both parameters are reduced by subsequent deposition of fine sediment. Although the redd substrate must remain permeable enough to support complete development of the embryos, it must not be so loose and unstable as to give way in high flows.

Water quality and temperature are also important. While embryos may survive when oxygen levels are below saturation, development is retarded. Within-gravel, oxygen concentrations depend on many factors: water temperature, surface and intragravel water exchange, apparent velocity of water in the redd, substrate permeability, and the demand for oxygen of any organic matter either already present or transported into the redd. Water temperature affects the rate of embryo and alevin development (as explained above) and also the solubility of oxygen in water (the higher the temperature, the lower the concentration of oxygen).

Emergence and Fry Dispersal

Some juvenile salmonids, specifically pink and chum salmon, do not rear in freshwater but move quickly to saltwater upon emergence. Juveniles of most salmonid species, however, must quickly find habitat suited to their small size. Because of their small size, young salmon and trout cannot maintain feeding stations in even moderately flowing water (velocities greater than 0.25 feet/sec can easily move these fish downstream). Recently emerged fry need to find refuge from high flows and predators, and locations that provide access to small items of drifting food. They find such places along the stream margins in small eddies, and in protected backwaters and secondary channel pools.

Shortly after emergence there is often a general movement of fry downstream that spreads the population within the drainage. These small fish will occupy suitable habitat as they encounter it. Because of their small size and limited swimming ability, they cannot easily ascend steeper tributaries. Habitat types colonized during this process include stream margins, secondary channel systems, very low gradient tributaries, and sloughs.

Summer Rearing

As the season progresses and they become larger, young fish move to stations away from the channel margins to areas with more and larger food items where they establish and defend territories against intruders. Each species has its own stream reach and habitat unit preferences for territory establishment. While each species occupies its own niche, differential habitat use may be forced in some cases by competitive displacement of one species by another.

The availability of food and the availability of space define territory size. While territories need to be large enough to include adequate space, food, and areas for resting and hiding, each individual fish ultimately determines the size of territory it needs. The more sites that are available, the more fish the reach can accommodate

Cover, in the form of a boulder, cobble, log, or even turbulent water or bubbles, provides the fish with haven from predators and competitors. The type of cover sought, and the way it is used, varies among salmonid species and also with the age of the fish. Young fish occupy relatively shallow, slow-moving water in areas closer to overhead cover than do older fish. As they age, individuals of some species, such as Dolly Varden and bull trout, seek out calmer, deeper water where they orient themselves very closely with the bottom substrate and undercut banks. Coho salmon prefer slower pools, as do cutthroat trout when they are the sole salmonid in the reach. By contrast, juvenile steelhead and rainbow trout seek out the swifter areas to establish their territories. Rainbow and cutthroat trout, while still remaining near objects, will assume foraging sites well above the substrate. Salmonids seem to feel most secure when they can neither see nor be seen by other fish. Logs, boulders, cobble, large debris, or topography of the streambed—anything that can screen fish from one another's view—divides a stream into territories that individual fish may occupy. This visual isolation factor can also influence the size and number of territories a stream reach can support. A diverse topography provides more and smaller territories than less rough areas (Kalleberg 1958).

Water temperatures also influence the summer rearing of juvenile salmonids. Summer temperatures may exceed physiological stress thresholds, and, occasionally, lethal levels. To cope with high temperatures, salmonids may temporarily use cool-water refuges typically associated with groundwater inputs, subgravel streamflow, or the mouths of cool tributaries.

Overwintering

Productive summer rearing locations may not be suitable for overwintering. Metabolism and activity of salmonids slow as water temperatures decline. With the onset of winter, appetites diminish and behavior has less to do with obtaining food and defending foraging sites than with securing refuge. Territoriality typically breaks down at this time. Death or injury in winter can result from rapid and catastrophic changes in flow — not only high flows, but low flows as well during extreme cold spells. Overwintering salmonids move into deeper water than they inhabit in summer, and into habitats characterized by low water velocities. They seek out upturned tree roots, logs, cutbanks and debris, often in side channels, wetlands, ponds, and sloughs off the main channel. Younger fish often seek shelter under or very close to small cobble. Because the number of fish that salmonid-producing streams can harbor in winter may be limited by the availability of winter habitat, watershed management projects should carefully consider the overwintering needs of juvenile and adult salmonids and work toward meeting these needs.

Smolt Migration

At the onset of the physiological change that prepares juvenile fish for life in saltwater, territorial behavior again breaks down and the fish often congregate in schools in large pools. As these changes progress, the smolts begin to move downstream, passively, traveling mostly at night, relying on the streamflow to carry them to saltwater. Cover along channel margins (e.g., woody debris, interstices among boulders) provide protection for smolts during daylight hours.