THE PHYSICAL SETTING

THE RIVER ENVIRONMENT

The Clackamas River begins on the western slope of the Cascade Mountain range near Ollalie Lake between Mt. Hood and Mt. Jefferson (Figure 1). From an elevation of about 4,500 feet, it cuts through the watershed, first to the northwest and then west. After a distance of about 83 miles, it joins the lower Willamette River 1.5 miles below Willamette Falls. Several major tributaries flow into the Clackamas, including Clear Creek, Deep Creek and Eagle Creek in the lower basin, and the North Fork, South Fork, Fish Creek, Roaring River, Oak Grove Fork and Collawash River in the upper basin (Figure 2).

The upper Clackamas flows through a canyon contained by steep talus slopes and exposed rocks. It and many of its tributaries follow major fault lines that form steep mountain ridges. Many of these reaches, including the upper Clackamas, are too swift and steep for salmon production and support primarily steelhead and resident trout.

The river slows briefly in the Big Bottom area at river mile (RM) 72.8 where it braids through huge logjams and beaver dams. This meandering reach of the Clackamas provides highly diverse habitat for fish production. Below Big Bottom (RM 65) the river again gathers speed as it deepens and passes through nearly vertical cliffs. A highway parallels the river's north bank. From RM 65 to RM 57, the river contains few pools, but good fish habitat exists near its banks and in riffle areas and side channels where pockets of spawning gravel have settled. Many tributaries that enter this reach have steep drops and large waterfalls that prevent anadromous fish passage.

Near RM 56.8, the Clackamas becomes wider and faster as it gains new streamflow from the Collawash River. Between the mouth of the Collawash River and the North Fork Reservoir, the river features large rapids and deep pools — including the famous "Killer Fang", a series of rapids that have claimed the lives of several boaters and swimmers. From "Killer Fang" to the reservoir, the river rushes from one rapid to another. This river section contains the Oak Grove hydroelectric power plant. The plant generates power with water diverted from the Oak Grove Fork and then releases the water into the Clackamas River just below where the Oak Grove Fork joins the Clackamas. This river section also contains several dramatic features, such as "the Narrows", where the river has carved a narrow chute through the basalt.

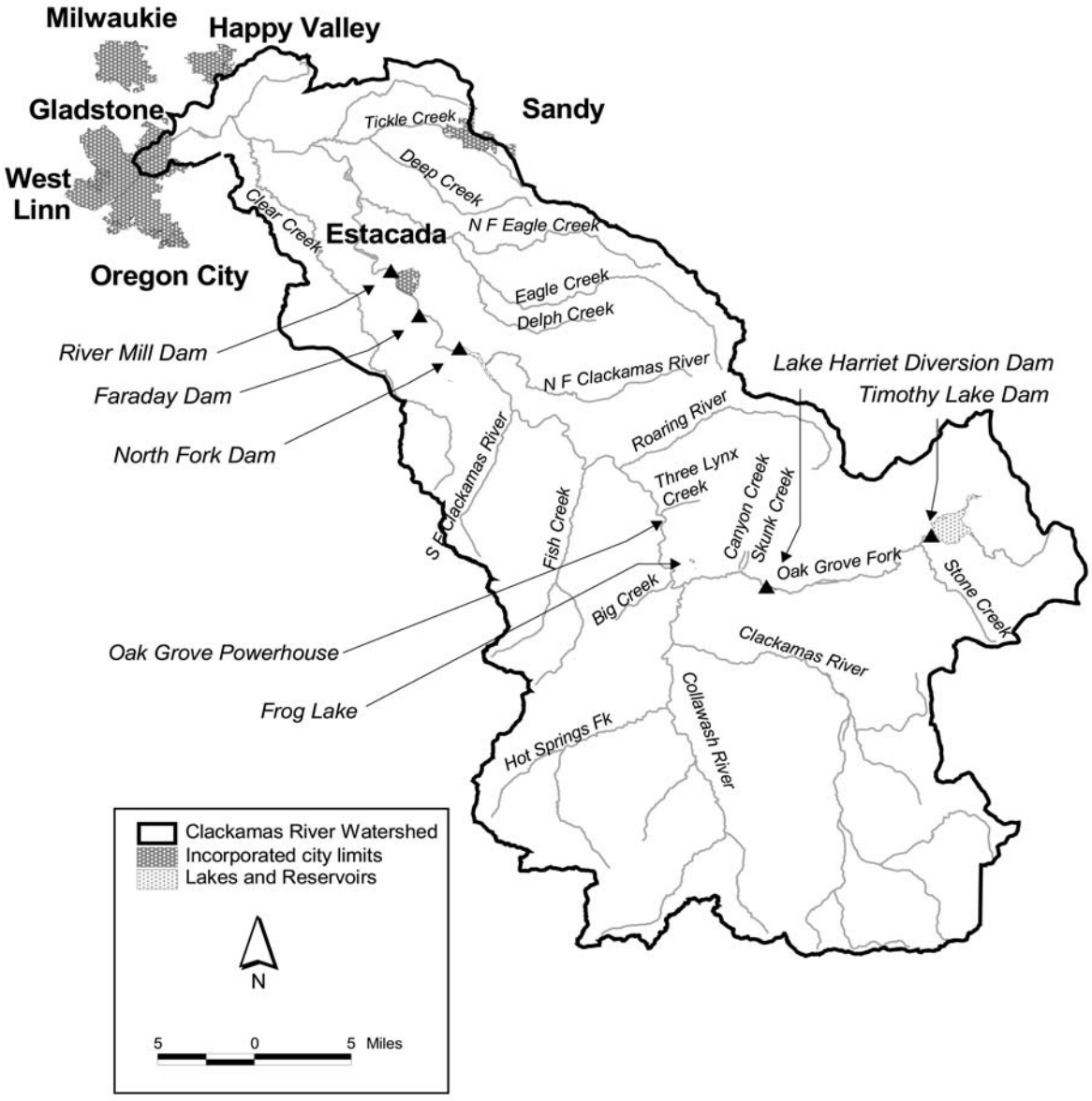

Figure 1. The Clackamas River Basin

The Clackamas River becomes slow as it flows through the North Fork Reservoir (RM 32), but is soon recast as it leaves the reservoir and enters a deep gorge encased by rock cliffs. Near McIver Park, it is again transformed, this time becoming a quiet river, slowly meandering through surrounding farmlands to join with the Willamette River near Oregon City.

Several reaches of the Clackamas are protected by federal and state laws because of their outstanding beauty. The 47-mile reach of the Clackamas River from its headwaters to Big Cliff just upstream of North Fork Reservoir is included as part of the Federal Wild and Rivers System (USFS 1992). This, and several other reaches of the Clackamas River system, are also included in the Oregon Scenic Waterway System. These include the reach of the Clackamas from the Ollalie Lake Scenic Area Boundary to the North Fork Reservoir (RM 82 to RM 32), the South Fork Clackamas (RM 4 to the confluence with the mainstem), and the North Fork Clackamas River (source to North Fork Reservoir, 12 miles). The Clackamas from Carver (RM 8) to River Mill Dam (RM 23) is a "recreation river area" under Oregon's Scenic Waterway Program.

LAND USE

Most of the upper and middle sections of the Clackamas River Basin, about 72 percent of the watershed, is publicly owned. The Mt. Hood National Forest manages 70 percent of the basin and the Bureau of Land Management manages about 2 percent. Two sections of the Mt. Hood National Forest are protected as wilderness areas. The Bull of the Woods Wilderness Area preserves 34,900 acres of undisturbed forest land in the upper Collawash system. The western portion of the Salmon-Huckleberry Wilderness encompasses the headwaters of Eagle Creek. Another large tract of forest land in the upper basin is managed by the Confederated Tribes of the Warm Springs Indian Reservation. Tribal lands (2 percent of the basin) are found in the upper Clackamas and in the Oak Grove Fork drainage.

Lands in the lower drainage, representing about 26 percent of the total basin, are generally privately owned. The river flows through the communities of Estacada, Barton, Carver and Gladstone. Many people reside in the lower drainage because of its beauty and recreation opportunities and commute to work in the nearby Portland metropolitan area. Agricultural lands cover about 1/8 of the drainage and produce berries, tree fruit, field crops, Christmas trees and livestock. Several private wood lots are also scattered through lower subbasin forests.

CLIMATE

The basin's climate adjusts quickly in response to changes in elevation. In the lower drainage, the climate is temperate. The average temperature at Estacada, near RM 24, ranges from a low of 33°F in January to a high of about 80°F in July and August. The lower reaches receive about 61 inches of precipitation annually, with nearly 8 inches of snow. Winter conditions are more severe in the basin's higher elevations. The headwaters receive substantial snow and rainfall, amounting to about 130 inches of

precipitation a year. Average daily temperatures near Timothy Lake in the upper drainage range from 23°F in January to about 69°F in July and August.

HYDROLOGY

Unlike many river systems, the Clackamas River receives large amounts of both surface runoff and groundwater and maintains good, cool streamflows throughout the year. Like a sponge, the extensive groundwater system in the upper watershed absorbs much of the precipitation falling on the area. These groundwater reserves slowly release flow into the Clackamas River and tributaries, maintaining a strong consistent base flow in the upper Clackamas. Consequently, flows in the upper mainstem increase only gradually during peak rainstorms and snowmelt periods. The average monthly minimum low flow and average monthly minimum high flow in the Clackamas River differ only by 391 cubic feet per second (cfs) at the gauge just below Big Bottom (RM 65). This is a small difference considering the size of the watershed.

Some rivers in the Clackamas system are more volatile. Streamflows in several tributaries (including Fish Creek and the North Fork, Roaring and Oak Grove rivers) rise quickly when the area receives large amounts of rain (or rain-on-snow) because of shallow soils and steep topography in their watersheds. Flows in such areas are driven more by precipitation than by groundwater releases and respond faster to changes in climatic conditions. After a large rainfall, for instance, flows in Fish Creek are higher than in the upper Clackamas River where much of the rainfall is absorbed into the ground. Maximum discharge flow for the Clackamas is 90,000 cubic feet per second — 150 times the minimum natural discharge and 33 times the 2,700 cubic feet per second average flow rate.

In many parts of the watershed, timber harvest and road construction have increased the risk, both in frequency and magnitude, of rain-on-snow flood events. For example, the hydrologic regime has changed in about half of the upper watershed because of timber harvest and road construction (USFS 1995). These activities have increased the amount of openings in the forest environment and have left many areas less capable of intercepting overland flow. Riparian areas have also been affected by land management activities, including dispersed recreation, and are less able to reduce the effects of these floods.

Streamflows in the Clackamas climbed to a record high in December 1964 when a warm winter storm moved through the region. Flows in the river rose rapidly as ample snowmelt and rainfall entered the system. The river reached and then surpassed previous high flow records to peak at

86,900 cfs and a gauge height of 28.36 feet at Estacada (RM 23.1) — a level 50 percent greater than the record set back in 1907. A second flood a month later in January 1965 washed the Cazadero Dam away and scoured a large portion of the channel. In comparison, the river peaked at 68,900 cfs and a gauge height of 27.57 feet during the flood of 1996 (USGS 1996).

During the 1964 flood, North Fork Reservoir accumulated more than 100 acres of debris. Flood-deposited material was retained in the lake by a double line of log booms installed to prevent a blockage of the spillway. Floodwaters deposited many trees with limbs and roots in the lake. Overall, wood waste in the debris accumulation was far greater than that encountered in any previous flood of historical record. To remove the timber from the lake, the company negotiated a timber purchase contract with the U.S. Forest Service. About 1.5 million board feet of timber were salvaged and sold to sawmills. Floodwaters also deposited a heavy load of silt in the North Fork forebay. Rocks, sand and silt filled the lower end of the North Fork fish ladder, and a slide above Faraday Dam cut through the highway and destroyed 200 feet of fishway structure.

Water Withdrawals

Substantial amounts of water may be withdrawn from the Clackamas River to meet municipal, industrial, power generation and agricultural needs (Table 1). These withdrawals could decrease flows in the Clackamas system below the levels needed for fish migration and production. However, there is no evidence that low flows are a problem. To protect instream flows, minimum streamflows were established for the Clackamas basin. These instream flows are set at levels needed to support the basin's salmon and steelhead populations.

Table 1. Surface Water Withdrawals, USGS 1985.

User	Water Use (acre feet)	Water Rights (acre feet/year)	Water Rights (cfs)
Municipal	33,000	0	112
Domestic	NA	0	1
Recreational	NA	0	2
Industrial	22	0	152
Agricultural (total)	145	59	262
Total	33,247	59	529

WATER QUALITY

Overall, water quality in the Clackamas River is considered excellent. Samples by the Oregon Department of Environmental Quality since 1990 show that the mainstem and tributaries have very low concentrations of sodium, potassium, phosphorous and other elements that reduce water quality. The mainstem Clackamas River above the mouth of the Collawash River and many tributaries also exhibit cool temperatures throughout the year because of groundwater releases. The measured water temperatures in the basin in 1994 approximate the optimum range of preferred temperatures for salmonids (USFS 1995). Samples show that, of all stream systems above North Fork Dam, the mainstem Clackamas River maintains the most stable and coolest temperature regime, while the Collawash River is often the warmest and has the largest temperature fluctuations (USFS 1995).

Sedimentation, however, can be a problem in some parts of the watershed, particularly during periods of high flow. This problem is greatest below areas disturbed through road construction, timber harvest or other activities. Heavy rains and snowmelt often carry large amounts of sediment from such areas into streams and rivers. The sediment is then suspended by swift flows and moved down the system where it is deposited in slower waters. The North Fork Reservoir has become a settling location for much of the sediment that enters the upper river system.

Bacteria may also reduce water quality in some stream reaches. While sampling for bacteria in the system has not been conducted, extensive dispersed camping along some reaches of the Clackamas may raise bacteria levels in the river immediately below the sites.

SUMMARY

Generally, the physical character of the Clackamas River and tributaries, especially in the upper basin, provides some of the best habitat for salmon and steelhead found in the Northwest. Salmon and steelhead have thrived in the river system's clear waters with an abundance of spawning and rearing area. As is discussed in the coming sections, these high-quality habitat conditions were discovered by fish propagators in the mid-1800s. The river's exceptional qualities led an early resident of the area, L.T. Barin, to declare in 1885:

> *"I have been on all the rivers and tributaries of the Columbia from the Cascades to Priest's Rapids, to which the Chinook salmon go . . . and I do not hesitate to say that the Clackamas River, with its clear, cold water, its rapids, and its long, shallow gravel beds, is the most natural and favorite region for salmon spawning (Barin 1885).*"