THE PHYSICAL SETTING

THE RIVER SYSTEM

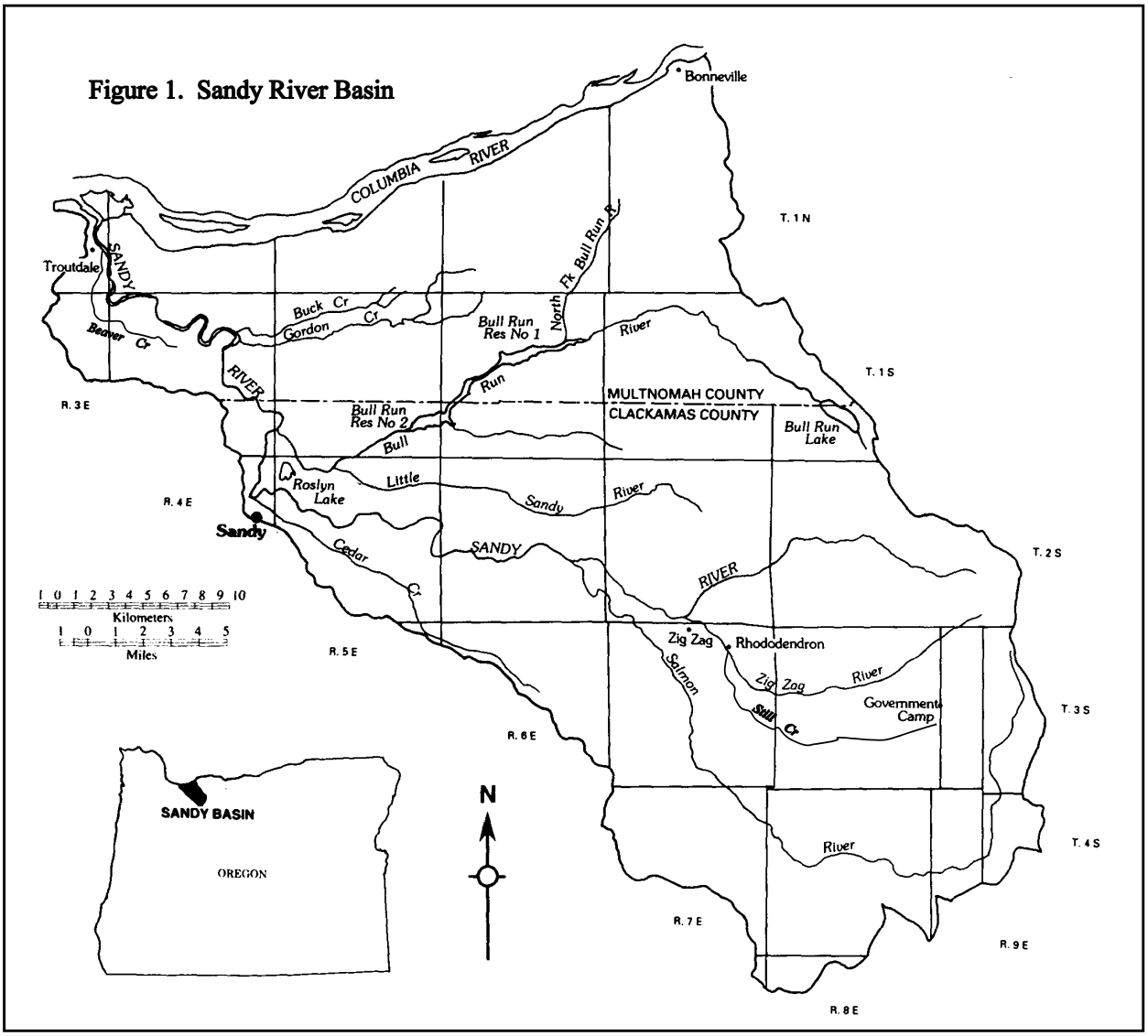
High on the west slope of Mt. Hood, the Sandy begins as a small intermittent stream. Gathering rainfall and snowmelt, it winds more than 55 miles toward the northwest where it joins the Columbia River. Its watershed covers an area of about 508 square miles. Major tributaries to the Sandy River include the Zigzag River, Still Creek and Salmon River in the upper basin, and the Bull Run River, Gordon Creek and Beaver Creek in the lower basin (Figure 1).

From its headwaters above the treeline at an elevation of about 6,200 feet, the Sandy drops sharply, reaching an elevation of 1,600 feet in the first 13 miles. The river's gradient exceeds 1,000 feet per mile in several places. The upper Sandy River and several tributaries, including the upper Zigzag and Salmon rivers, carve through miles of unstable volcanic ash and rock deposits before reaching less steep ground. Several of these reaches, including the upper Sandy above the Clear Fork, the upper Zigzag River and Clear Creek, have reaches that are too steep for fish production. Waterfalls also obstruct fish migration on the Salmon River above RM 14.

Leaving this steep upper reach, much of which lies within the Mt. Hood Wilderness Area, the Sandy River slows as it crosses a broad flat plain above its confluence with the Zigzag River (RM 43). This part of the glacially-carved upper river valley, known as Old Maid Flats, has been partially filled by past volcanic flows. The area displays soil conditions and vegetation, such as lodgepole pine and edible mushrooms, that are rare elsewhere within the Mt. Hood National Forest. The Sandy River widens below Old Maid Flats and the mouth of the Zigzag River and slows again as it nears Marmot Dam (RM 30) (Figure 2). Soils here are generally unstable, composed of loose alluvial rock and very susceptible to erosion during high flows.

Below Marmot Dam the Sandy enters a five-mile-long scenic narrow gorge with steep canyon walls and constrained chutes. Deep pools in this reach provide good, cool rearing habitat for migrating spring chinook. The river becomes wider below Revenue Bridge (RM 24) and bends between high bluffs that rise more than 200 feet in some areas.

At Dodge Park (RM 18.5) the Sandy merges with the Bull Run River and descends into the rugged and remote Sandy River Gorge. The upper stretch of the gorge displays long steep rapids and large pools contained by high bluffs. Below Indian John Island (RM 15) the river channel begins to meander. This reach of the river, which includes Oxbow Regional Park (RM 13), contains significant fall chinook



spawning and rearing habitat. The Sandy River continues to slowly twist and bend toward Dabney State Park (RM 6). The scenic 12.5-mile reach between Dodge Park and Dabney State Park is designated a federal Wild and Scenic River and a state Scenic Waterway.

Below Dabney Park, the Sandy River again widens as it slowly meanders to its confluence with the Columbia River. This river reach has shifted often over the years during periods of high flow. Much of the reach is now armored with riprap to protect private property and roads. The reach contains many large sand deposits that historically provided spawning habitat for the great schools of smelt that once returned annually to the Sandy River. Nearing its confluence with the Columbia River, the Sandy River becomes shallow as it flows through a large delta of sand and other fine sediments that have accumulated

over thousands of years. Flows at the river's mouth are affected by tidal influence from the Columbia River and are believed to provide adequate fish passage even during summer months (ODFW 1997). The Sandy River Delta is part of the Columbia River Gorge Scenic Area.

LAND USE

Forests cover about 78 percent of the Sandy River Basin, including most of the upper and middle watershed. About three-quarters of this forested land is in public ownership and managed as part of the Mt. Hood National Forest. The watershed contains several wilderness areas. These include the Salmon-Huckleberry Wilderness Area (44,600 acres, with one small corner draining a Clackamas River tributary) and the Mt. Hood Wilderness Area (47,160 acres). In addition, the Bull Run River drainage is protected to provide high-quality drinking water for the city of Portland.

Fertile plateaus and rolling hills cover much of the lower watershed. These lands are generally privately owned and support timber, agriculture or residential uses. Above the town of Sandy, most private lands support timber production, Christmas trees and some livestock use. Private forest lands in the basin cover 71,000 acres and stretch from the Sandy River to public forest lands in the middle watershed and east of the Sandy River in the lower watershed. Below the town of Sandy, agricultural uses are common, with widespread nursery stock production on the plateaus east and north of Gresham and south of Troutdale. The hills north of the lower Sandy River also support some agricultural use.

CLIMATE

Climatic patterns in the Sandy drainage vary from alpine conditions to those typically found along the shores of the lower Columbia River. This variation is reflected in precipitation and temperature records for the basin. Annual precipitation ranges from 70 inches near the river's mouth to 110 inches near its headwaters (ODFW 1997). The lower and middle portions of the Sandy River Basin generally experience seasonally mild temperatures and wet winters. At higher elevations, temperatures drop significantly and much of the precipitation falls as snow. For example, in the Bull Run subbasin, it rarely snows at elevations below 2,000 feet, but often accumulates to a depth of 6-10 feet in areas above 4,000 feet. Several glaciers, including the Reid, Zigzag and Sandy glaciers, have developed on the west and northwest slopes of Mt. Hood, which receives up to 300 inches of snow each year. The watershed's middle and lower areas receive more rainfall than snow. Most of the rainfall occurs between November and January.

These variations in temperature and precipitation play a significant role in determining patterns of streamflow. In watersheds with large snow accumulation, flows usually peak in late spring when streams swell with snowmelt. Streamflows in lower elevation watersheds receive mostly rainfall and may peak several times during the winter in response to storm events (USFS 1996).

Samplings of trees covering a large geographic area in the Columbia River Basin suggest that climatic changes may have affected conditions within the Sandy River watershed — and elsewhere in the region — during the late 1800s and early 1900s. Studies show that the region received a higher level of precipitation around 1900. This wet period was followed by a drier climate through the 1920s, 1930s and 1940s. Reconstruction of historic temperatures in the Andrew Forest in Oregon's Central Cascades shows periods of cool temperatures in 1892-1920 and warmer temperatures in 1921-1946 (Lichatowich and Mobrand 1995). Such large-scale climatic changes likely affected the quality of fish habitat in both freshwater and marine environments during 1900-1940 (Lichatowich and Mobrand 1995).

HYDROLOGY

The snows falling on Mount Hood, combined with glacier ice melts, usually maintain good streamflows in the Sandy River all year. The glaciers and heavy snowpack store water over the winter months and supplement flows in the spring and summer. Large groundwater contributions associated with basin size and gains in elevation may also contribute to runoff.

Glacial influence is particularly noticeable in the upper Sandy and several tributaries, including the Salmon, Muddy Fork and Zigzag rivers, which are fed by glacial melt. In these river systems, moderate and low flows are tempered by the glaciers. They are not as "flashy" or quick to respond to runoff.

Streamflows fluctuate more in the lower Sandy, which also collects flows from many lower elevation tributaries, such as the Little Sandy River, that receive more rainfall than snow. As a result, streamflows in the lower Sandy River can range widely between days, particularly during the rainy, mid-winter months. The river typically runs higher from March through May, the spring snowmelt season. Average monthly flows in the Sandy at its confluence with the Bull Run River (RM 18.5), the lowest gauge site on the river, range from a low flow of 377 cfs in September to a high flow of 3,437 cfs in February. Peak flows generally happen during major storm events, such as during the flood of February 1964 when the highest flow ever, 84,400 cfs at a height of 22.3 ft, was recorded at the gauge. A high flow of 68,600 cfs was measured at the gauge during the Flood of 1996, at a height of 22.59 ft (USGS 1996). No gauge station exists below RM 18.5, but the Sandy was carrying an estimated flow of 85,000 cfs when it entered

the Columbia River during this flood. This topped the estimated high flow of 82,000 cfs during the 1964 flood (ODFW 1997).

Water allocations for agriculture and other out-of-stream uses are limited along much of the river by geography. As discussed previously, below Marmot Dam the Sandy River enters a gorge and is contained by high walls where land use is confined. Above Marmot Dam, water is primarily removed from the river for domestic purposes. Water right allocations in the Alder Creek and Cedar Creek drainages, however, exceed available streamflows. In Alder Creek, the city of Sandy holds the largest water right for its municipal water supply. Once the city removes its allocated supply, little water remains in the lower section of Alder Creek below the diversion. Water allocations generally do not affect flows in Cedar Creek since a large portion of the water rights in the Cedar Creek subbasin are for fisheries and may not be removed from the stream.

Below Marmot Dam, water diversions to the Bull Run River powerhouse alter the Sandy River's natural flow regime. Up to 800 cfs may be diverted from the Sandy and Little Sandy rivers in any combination for the project, with up to approximately 600 cfs taken from the Sandy River. Water diverted at Marmot Dam (RM 30) is released into the lower Bull Run River at the powerhouse and flows back into the Sandy at the confluence of the Bull Run and Sandy rivers (RM 18.5).

Before minimum streamflows were established for the river in 1973, flow diversions for power production sometimes left little water in the Sandy below Marmot Dam. Low flows in the 11-mile reach kept many spring chinook and other species from migrating upstream from early summer through early fall. Peaking operations at the facility also affected fish by causing wide fluctuations in the flow below the dam. Large daily, and sometimes hourly, changes in flow were typical (ODFW 1997).

Since 1974, minimum flows have been maintained in the Sandy River below Marmot Dam to provide fish passage and increase rearing areas. Minimum streamflow requirements for the Sandy River below Marmot Dam are:

- 200 cfs (June 16 through October 15)
- 400 cfs (October 16 through October 31)
- 460 cfs (November 1 through June 15)

The improved flows provide spring chinook and other fish with adequate water for upstream migration in summer and fall. They also create additional rearing area in the river below the dam. In addition, peaking operations at the dam are now controlled to reduce wide fluctuations in streamflows.

To provide minimum streamflows in the Sandy River but still meet hydropower needs, Portland General Electric normally diverts all the water from the Little Sandy, where the average flow is about 140 cfs. As a result, flows in the 1.7-mile stretch of the Little Sandy below the diversion drop to between 2 cfs and 14 cfs, which is provided through leakage and accretion. If more water is needed, up to 600 cfs can be diverted from the Sandy River once minimum flow requirements are met. Efforts are made not to spill any water past the Little Sandy diversion dam that might falsely attract fish to the stream. Water diverted at Marmot Dam is released into the Bull Run River about one mile below the mouth of the Little Sandy. The Bull Run River then joins the Sandy River about one mile below the powerhouse. The diversions alter flows in the Sandy River more during the months of June through October when less Little Sandy River water is available.

Before the early 1920s, streamflows from the Bull Run Basin contributed a significant volume of water to the lower Sandy River. Now most of the water produced in the basin is stored and diverted out of the basin, providing the Portland metropolitan area with high-quality drinking water. The city of Portland also sells surplus water annually to Portland General Electric for power production at its powerhouse on the lower Bull Run River. Water in the basin collects in the city's storage reservoirs through the spring and summer months. Surplus water in the basin is spilled in the fall and winter months after the reservoirs are filled. Decreased flows from the Bull Run River reduce the amount of available spawning and rearing habitat in the lower Sandy River during dry summer months. Streamflow diversions from the Bull Run River also contribute to higher water temperatures in the lower Sandy River (ODFW 1997).

WATER QUALITY

During spring and summer months, streamflows in the upper Sandy and Zigzag rivers are often turbid from the melting of either snow or glaciers on Mt. Hood. Fine suspended sediment, known as glacial silt or "flour" is particularly noticeable in the Sandy River mainstem from mid-to-late summer. This sediment results from the grinding of rocks under the weight of the glaciers. The Sandy River has one of the highest percentages of glacial melt of all major Oregon rivers. Some fish specialists believe that high levels of glacial flour in a stream reach — such as in the Muddy Fork of the Sandy River, upper Sandy River and the Zigzag River — reduce salmon and steelhead production, and that the turbid reaches serve primarily as corridors to better habitat in nearby clearwater tributaries (ODFW 1997).

Sedimentation concerns exist in several parts of the drainage, especially in those areas that contain unstable and easily erodible soils. For instance, several tributaries to the upper Sandy River flow through the unstable volcanic deposits on Mt. Hood. These tributaries, such as the Muddy Fork of the Sandy River (appropriately named) and Lost Creek gather large amounts of sediment as they carve through the

steep, easily erodible drainages. The areas introduce large amounts of sediment into the stream system that settles out in lower gradient areas.

Water quality problems in some Sandy River tributaries can be attributed to land use practices. For example, turbidity, erosion and poor stream structure in the Lost and Clear creek drainages are largely attributed to landslides and debris torrents caused by road building, timber harvest and fires in the drainages (USFS 1996). Erosion from agricultural lands in the lower system also affects water quality and limits potential spawning and rearing area. Erosion and resulting turbidity weaken stream stability and reduce the quality of fish habitat. Sediment in a stream channel alters the structure and width of the streambanks and adjacent riparian zones. Spawning and rearing habitat is also affected when the sediment settles over spawning gravels.

Water temperatures in the upper Sandy and many of its tributaries remain cool most of the year because of snowmelt from the glaciers. Stream temperature readings, while limited, show that water temperatures in the upper basin typically range from 55E to 65EF in the summer (ODFW 1997). The water becomes even cooler near the headwaters where snowmelt enters the system. These temperatures favor fish production and survival in many Sandy River streams.

High summer water temperatures are evident in some upper basin streams. Data from the Storage and Retrieval (STORET) Database, which is maintained by the Environmental Protection Agency, shows that water temperatures exceed the state standard for salmonid spawning, egg incubation and fry emergence in several Sandy River tributaries, including Clear, Chance and Alder creeks, and the middle and lower sections of the Clear Fork (USFS 1996).

Stream temperatures are also higher in the lower basin. Below Marmot Dam, water in the Sandy River usually ranges from 60E to 70EF, but temperatures may exceed 70EF during summer months when long, hot weather persists. Some lower river tributaries, including Beaver Creek, also display high water temperatures in late summer. During winter months, water temperatures in the Sandy River range between 40E and 50EF.

In addition, a thermal difference sometimes occurs at the confluence of the Bull Run and Sandy rivers. For instance, in August 1993 water temperatures rose to as high as 70EF in the Sandy River just above its confluence with the Bull Run River. At the same time, flows in the lower Bull Run River only reached a temperature of 63EF. Flows in the lower Bull Run River likely remain cooler than flows in the Sandy River because they are largely made up of water diverted from the Sandy at Marmot Dam. Natural streamflows in the lower Bull Run are otherwise significantly reduced as the city of Portland stores most

of the water upstream for municipal purposes. Once the water leaves the Sandy River at Marmot Dam, it enters a network of flumes and underground canals that prevent water temperatures from rising. The water is exposed to the sun for a short time in Roslyn Lake but thermal gains are minor. Water remaining in the Sandy River is exposed to the thermal effects of sunlight for a longer period (ODFW 1997).

Sodium chloride is a water quality concern in the Sandy River during certain times of the year. Sodium chloride is applied in spring and summer months at the rate of 600,000 to 1,200,000 lb per year to maintain skiing conditions on the face of Mt. Hood (USFS 1996). Chloride and specific conductance levels are elevated moderately above background levels in streams that drain the salted areas. Most of the snowfield drains into the Salmon River, and a small amount drains into Still Creek, a Zigzag River tributary. The effect of these salt concentrations on fish production is unknown. The concentrations decrease downstream as the flow is diluted with additional surface and groundwater.

SUMMARY

Generally, natural physical conditions in the Sandy River Basin provide good to excellent habitat for fish. Salmon and steelhead thrive in the river system's clear waters with ample spawning and rearing area. People have also recognized the value of the Sandy basin's natural resources. As is discussed in the coming sections, mounting demands for timber, salmon, power, water and other resources in the basin over the last 150 years have significantly impacted the Sandy River system and its salmon and steelhead runs.