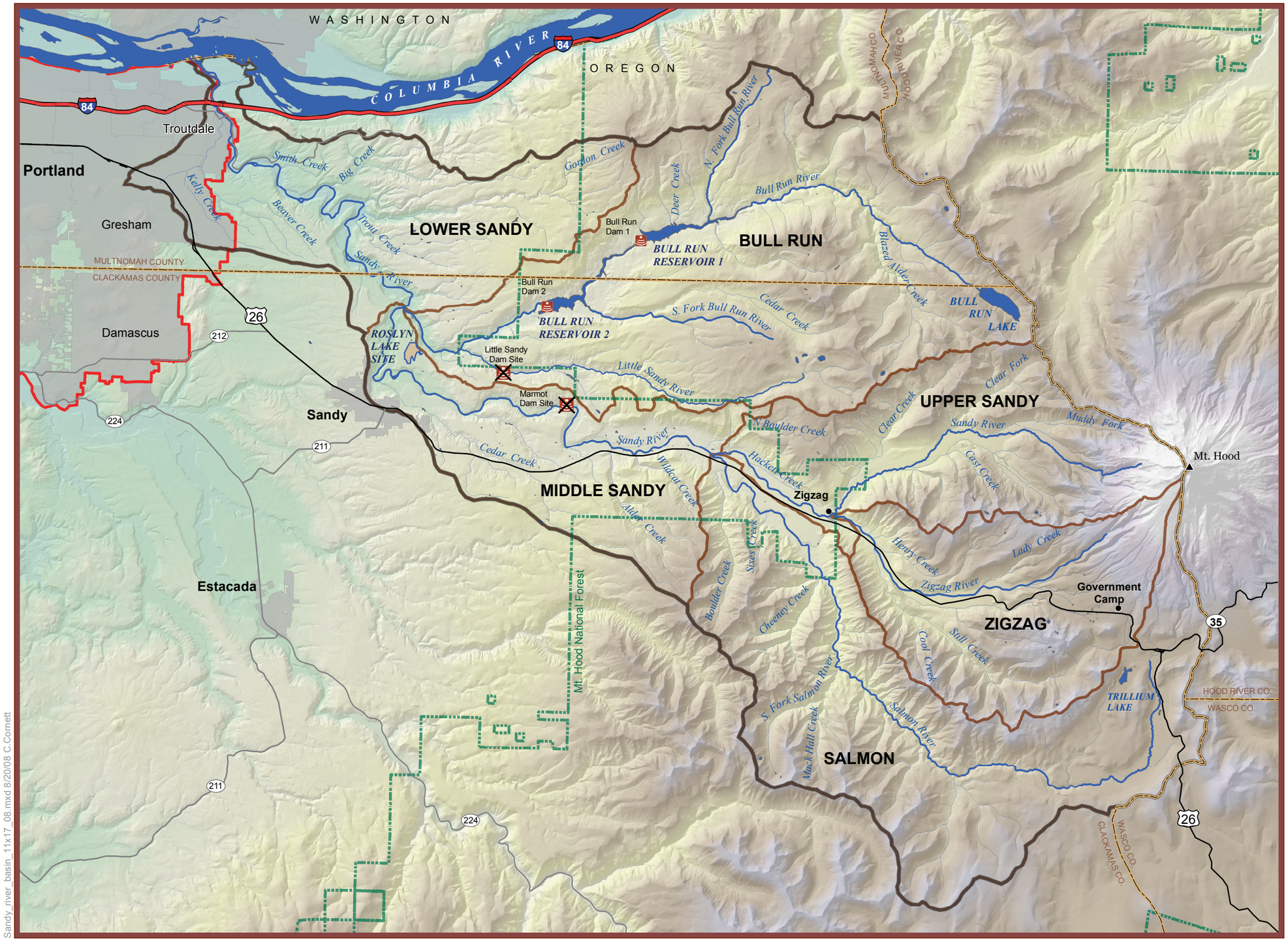
Chapter 4. Landscape Conditions

4. Landscape Conditions

4.1 Environmental Setting

This chapter provides a general description of environmental and cultural conditions in the Sandy River Basin (Figure 4-1) as context for the Habitat Conservation Plan (HCP). For each topic discussed, the larger Sandy River Basin is described first, followed by a section specific to the Bull Run watershed. In addition, Section 4.3 provides a detailed description of the current habitat conditions in each of the six watersheds within the Sandy River Basin, including fish distribution (habitat access) and channel conditions. The descriptions and maps in this chapter are primarily based on the information appearing in the *Sandy River Basin Characterization Report* (Sandy River Basin Partners 2005).



Key Boundaries

- Sandy River Basin
- Watershed Boundaries
- County Boundaries
- Urban Areas
- Urban Growth Boundary
- Mt. Hood National Forest

Roads

- Interstate Highway
- U. S. Highways
- State Highways

Site Features

- Dams
- Former Dam Site
- Rivers and Streams
- Lakes
- Former Lake Site

N

Projection:
State Plane Oregon North
North American Datum 1983

Scale = 1:213,688

Miles
0 0.5 1 2 3 4 5 6

Kilometers
0 1.25 2.5 5 7.5 10

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Figure 4-1. Watersheds of the Sandy River Basin

4.1.1 Climate

Sandy River Basin

The Sandy River Basin has a maritime climate characterized by seasonally mild temperatures, wet winters, a long frost-free period, dry summers, and narrow daily fluctuations in temperature (Sandy River Basin Partners 2005).

Annual precipitation generally increases from west to east and with elevation, ranging from 30 inches near the mouth of the Sandy River at Troutdale (elevation 30 feet) to 140 inches at Mount Hood (elevation 11,237 feet). Table 4-1 summarizes precipitation variations within the Basin's watersheds. The heaviest precipitation occurs from November through January, and the lowest in July and August.

Table 4-1. Precipitation in the Sandy River Basin

Watershed	Annual Precipitation Range (inches)	
	Low	High
Lower Sandy River[a]	45 (at Troutdale)	62
Middle Sandy River[b]	91	127
Upper Sandy River[c]	70 (at west end of watershed)	~140 (near summit of Mount Hood)
Bull Run River[d]	52	143
Zigzag River[c]	65 (at the upper Still Creek drainage)	130
Salmon River[c]	35 (at east end of watershed)	130 (at source)

Sources:

[a] Oregon Climate Service – Troutdale Airport.

[b] Natural Resource Conservation Service – South Fork Bull Run River SNOTEL site.

[c] U.S. Forest Service Watershed Analysis documents—low at west end of watershed; high near Mount Hood summit.

[d] Represents long-term average of Bull Run station (Robbins 2004, personal communication; cited in Sandy River Basin Partners 2005).

Both temperature and precipitation vary with altitude, with higher elevations receiving much of the precipitation as snow (Oregon Department of Environmental Quality [ODEQ] 2005). Snowfall on Mount Hood averages more than 300 inches a year. High elevation snow often does not completely thaw until the end of summer. Snow accumulations, combined with stored glacier ice, act as reservoirs that release cool water flows throughout the summer. Snow and glacier melt improve summer base flows and reduce water temperatures in some of the Basin's watersheds.

Recorded air temperatures in the Sandy River Basin area (as a 30-year monthly average for January) range from a low of about 33 °F in Portland (measured at Portland International Airport, approximately 10 miles west of Troutdale) to a low of 22 °F in Government Camp. Average monthly highs are 81 °F (in July/August) in Troutdale (measured at the Portland International Airport and 70 °F (July) in Government Camp (Loy et al. 2001).

Bull Run

The Bull Run watershed is located at low to middle elevations in the Basin (260 to 4,750 feet). Most precipitation falls as rain, not snow. Snow accumulations are rare below 2,000 feet. Average maximum accumulations (measured as water equivalent) at the two higher-elevation SNOTEL sites are 13.4 inches (North Fork, 320-foot elevation) and 25.5 inches (Blazed Alder, 3,650-foot elevation), respectively.

Spring rains in the watershed last into June. Summers are mild and dry. Fall rains typically begin in September but can be sporadic, with limited precipitation until mid-October. Significant fall rains sometimes hold off until as late as December. Mean annual precipitation is 80 inches at the Headworks and 140 inches at the North Fork SNOTEL site.

Winter storms can be intense, dropping as much as 6.8 inches of rain in a 24-hour period (e.g., the 1994 Thanksgiving storm) and 10 to 15 inches in multi-day storms (e.g., 1994 and 1996). Storm tracks across the watershed are affected by prevailing winds and the topographic effects of the Columbia Gorge, Mount Hood, and other surrounding ridges oriented predominantly east-west.

See also Section 4.1.5 and Chapter 10 for information about potential impacts of climate change in Bull Run.

4.1.2 Topography and Geomorphology

Sandy River Basin

The topography of the Sandy River Basin is varied, with high-gradient relief in the upper reaches of the Basin, moderate gradients in the middle reaches, and relatively low gradients in the lower reaches (Table 4-2). The average gradient in the upper Basin is about 288 feet per mile (5.5 percent slope), but it may exceed 1,000 feet per mile (19 percent slope) (Oregon Department of Fish and Wildlife [ODFW] 2002). Elevations in the Basin range from a high of 11,240 feet above sea level at the glaciers of Mount Hood, to a low of 40 feet at the confluence with the Columbia River.

Table 4-2. Elevation Ranges in the Sandy River Basin

Watershed	Elevation Range (feet)
Lower Sandy River	40–3,920
Middle Sandy River	240–4,160
Upper Sandy River	554–11,047
Bull Run River	240–4,680
Zigzag River	1,400–11,240
Salmon River	1,100–10,000

Source: 2003 SCSGIS file 1:100k Sandy Basin streams with EDT reach delineation.

Along its route to the Columbia River, the Sandy River cuts through a series of formations consisting primarily of basalt and andesite flows, pyroclastics, landslide and/or mudflow material, and glacial deposits. Because much of this material is relatively stable yet somewhat easy to erode, the Sandy River has cut deep narrow canyons along many of its segments. The river is relatively confined within these canyons and exhibits little lateral movement. However, in moderate or gentle stream gradient areas, such as near the mouth (River Mile [RM] 0—RM 2.5) and in the vicinity of Mensinger Bottom (approximately RM 32.0 – RM 35.5), the Sandy River has been known to change its course, often rapidly (Oregon Division of State Lands [ODSL] 2002).

Bull Run

The mainstem Bull Run River is about 25 miles long. With the exception of the reservoirs, the river flows mostly through confined and moderately confined basalt canyons to its mouth at the Sandy River. Overall, the stream gradient is fairly low and averages approximately 1.5 to 2.5 percent (U.S. Forest Service [USFS] 1999). Riffles dominate the mainstem Bull Run channels. The USFS (1997) concluded that anadromous fish-bearing streams in the watershed exhibited a high percentage of riffle and large pool habitat but were limited in side-channel habitat. The USFS also hypothesized that habitat conditions in the watershed favored steelhead and Chinook salmon more than coho salmon.

The lower Bull Run River (RM 0–RM 5.8), which is currently accessible to anadromous fish, is dominated by bedrock and large boulders. Spawning gravels are scarce and probably limit the production of anadromous salmonids. Much of the lower river is riffle habitat but the pools are large in volume. Habitat conditions for juvenile salmonids in this section of the river are only fair due to the lack of habitat structure and cover (R2 Resource Consultants 1998b).

4.1.3 Geologic Landscape and Geologic Hazards

Sandy River Basin

The Sandy River Basin is composed of two major geologic provinces: the geologically young High Cascades Province and the older Western Cascades Province (USFS 1979). The Basin has been formed by a sequence of volcanic eruptions, uplifting, bedrock deformations, weathering, and erosion, with more volcanic eruptions followed by glaciation, and finally, more weathering and erosion. These geologic processes have left behind a mixed and highly varied combination of bedrock covered by equally varied surficial materials (USFS 1979). Lava flows and pyroclastic rock make up most of the bedrock found in the Basin.

Geologic hazards in the Sandy River Basin include volcanic eruption, earthquakes, and landslides. Mount Hood is an active volcano that, like other Cascade volcanoes, may only be resting. Were Mount Hood to erupt, it could trigger landslides, mudflows, and lava flows that could inundate stream habitat and create barriers to fish migration.

The topography of most of the present-day valley bottom throughout the Sandy River Basin is a product of three significant eruptive events from Crater Rock on Mount Hood. These eruptions occurred within the last 10,000 to 15,000 years and produced lahars. Lahars are fast-moving mudflows that result when hot volcanic material melts snow and ice from the slopes of the volcano. Past lahars have traveled as far as the confluence of the Columbia River, leaving terraces up to 150 meters deep. One such major event occurred in the late 1700s and created the Old Maid Flat area, together with deep silt deposits at the mouth of the Sandy River. The deposits were so extensive that when Lewis and Clark came upon them during their expedition years later, they named the river "Quicksand" River. Another large-scale, lahar-related sediment release was observed as recently as June 2002. This release, likely caused by rapid snowmelt, dramatically increased turbidity levels throughout the mainstem Sandy River (ODEQ 2005).

The ongoing influence of past laharic events, Mount Hood glaciers, and the Basin's underlying lithology result in naturally high sediment loading in the Sandy River. Tributaries to the upper Sandy and Zigzag rivers receive large amounts of sediment, particularly during spring and summer months, from glaciers and steep unstable slopes on the western flank of Mount Hood. Fine suspended sediment, known as glacial silt or flour, is particularly noticeable in the Sandy River mainstem during mid-to-late summer. The Sandy River has one of the highest percentages of glacial melt of all major Oregon rivers (see additional information on Sandy River Basin glacial conditions in Section 4.1.4).

Seismic hazard within the Sandy River Basin is relatively low compared to the rest of western Oregon (Loy et al. 2001). The U. S. Geological Survey (USGS) has mapped faults in the Sandy River Basin. These traverse the Basin in a northeast-southwest position and are located within the Bull Run (upper portion), upper Sandy River, and Salmon River (lower portion) watersheds.

Bull Run

Protected from glacial and laharic influences, the Bull Run watershed has a more stable valley floor and reduced sediment yields. Columbia River Basalts form much of the bedrock layer. The Troutdale Formation (sedimentary, 200-foot thickness) is present west of the confluence of the Bull Run and Little Sandy rivers. Quarternary landslide deposits are present in the northern valley walls of the lower river. The Rhododendron Formation is also present in the lower Bull Run area and the Little Sandy. This formation is subject to erosion, though it is well cemented in some cases. Less than 2 percent of the total watershed area has been identified as highly susceptible to landslides (USFS 1997).

4.1.4 Hydrography

Sandy River Basin

The Sandy River Basin drains approximately 508 square miles (325,000 acres), flowing generally east to west. The mainstem Sandy River travels 56 miles before flowing into the Columbia River at RM 120.5 near the City of Troutdale. The Basin consists of five USGS fifth-field Hydrologic Unit Code watersheds: the upper Sandy River, middle Sandy River, lower Sandy River, Bull Run River, and Salmon River. The fifth-field Salmon River watershed encompasses the Zigzag River and Salmon River watersheds. Approximately 680 miles of streams have been mapped within the Basin.

The Sandy River and several of its major tributaries originate from the Sandy, Palmer, Reid, and Zigzag glaciers on the western slopes of Mount Hood at an approximate elevation of 6,200 feet above sea level. Glacial streams receive substantial coarse and fine sediment loads and exhibit turbid conditions, due to suspended glacial flour during the summer months. These types of streams feature "flashy" hydrologic regimes, dynamic stream channels, and cold summer stream temperatures. Some of these factors offer less stable habitat conditions for fish production than nonglacial streams, but the influence of glacial conditions on fish production in the Sandy River Basin is as yet unknown. Glacial tributaries in the Basin include Sandy River, Muddy Fork of the Sandy River, and Zigzag River. Clearwater tributaries include Salmon River, South Fork Salmon River, Boulder Creek, Bull Run River, Clear Creek, Camp Creek, Lost Creek, Still Creek, and Sandy River Clear Fork.[1]

The Zigzag and Salmon rivers are the two glacial-origin rivers in the Basin where habitat conservation measures will be implemented. The Zigzag River is a steep-gradient stream from the headwaters at Zigzag Glacier to the lower two miles, where it transforms to a more moderate gradient depositional area for sediment. Most glaciers on the south-facing slopes have largely vanished as a result of climatic changes over the past several thousand years. The associated streams are not glacially influenced at present and do not receive sediment loads similar to other glacial streams. The Salmon River originates from the Palmer Glacier on the south slope of Mount Hood and empties into the Sandy River at RM 38. The Salmon

[1] The Salmon River is a glacial-origin river that, unlike many other streams in the upper Sandy River Basin, does not receive large amounts of glacial sedimentation and remains clear throughout the summer.

River usually runs clear all year and provides miles of spawning and rearing habitat for both anadromous and resident fish species.

Following a major flood in 1964, the Army Corps of Engineers and local communities combined efforts to create artificial channels in several miles of the lower reaches of the Salmon, Zigzag, and Sandy rivers, and Still Creek. Heavy equipment was used to reconfigure and straighten the stream channels and remove most large obstructions and boulders from the streambeds. Large woody debris was cut up and removed. Berms were built with rocks to harden and contain the stream banks.

Though well intended, the channelization projects affected the timing, variability, and duration of floodplain and wetland inundation in the area. The berms and instream channelization work affected riparian vegetation, reduced instream habitat complexity, and blocked many side channels. The side channels and associated backwater areas were especially important as refuge for winter-rearing juvenile anadromous fish. Channelization also increased flow velocities, which scoured spawning gravels from portions of the streambed (ODFW 1997).

Bull Run

Bull Run River enters the Sandy River at Dodge Park (RM 18.5) near the City of Sandy. The mainstem Bull Run River is approximately 25 miles long and originates from springs below Bull Run Lake (elevation 3,180 feet), a large natural lake to the northwest of Mount Hood. The watershed drains approximately 140 square miles, or about one-fifth of the Sandy River Basin land area. The Little Sandy River is a large tributary stream that empties into the Bull Run River at about RM 2.9 (3.4 miles below the diversion dam at the Headworks).

4.1.5 Water Quantity and Water Rights

Sandy River Basin

The Sandy River is similar to many other western Cascade Mountain streams. Flow varies greatly on a daily and seasonal basis, depending on the amount of rain falling, the rate of snowpack and glacier melt, and the rate of withdrawal or diversion for a variety of uses. Minimum stream flows generally occur during September or October. Peak flows in the Basin most often occur in December and January and are often associated with rain-on-snow events (ODFW 2002).

Seasonal high and low stream flows vary throughout the Basin and are generally influenced by storm events and snowmelt. Streamflow in the upper Sandy River and Bull Run River watersheds is characterized by low flows in the late summer (August and September) and high flows from storm events from October through April. Highest stream flows in the Zigzag River watershed occur in May and June from snowmelt runoff (USFS 1995b, 1996, 1997). Average discharges in the Salmon River are also substantially influenced by rates of snow accumulation and snowmelt. Rain-on-snow events occur in transitional snow zone elevations of the Basin (typically in December and January) and can also occur in the Zigzag

River watershed. Peak flows in the mainstem Sandy River generally happen during major rain-on-snow storm events, as was true for the flood of December 1964.

USGS measures discharge at many locations in the Sandy River Basin. Key USGS measurement stations provide real-time data available via the USGS web site (http://waterdata.usgs.gov/nwis/rt). These stations include the following:

- USGS 14137000: Sandy River near Marmot
- USGS 14137001: Sandy River Diversion above Marmot Dam site
- USGS 14137002: Sandy River below Marmot Dam site
- USGS 14141500: Little Sandy River near Bull Run River
- USGS 14142500: Sandy River below the Bull Run River

The primary sources of measured flow data for the Sandy River are USGS Gauge No. 14142500 (0.1 mile downstream from the confluence of Bull Run River and the Sandy River) and USGS Gauge No. 14137000 (0.3 mile above the Marmot Dam site). Both gauges provide data on daily mean discharge in cubic feet per second (cfs). The monthly averages of daily mean flows at these two stations for the period from 1911 to 2002 are depicted in Figures 4-2 and 4-3. Gauge No. 14142500 reflects cumulative discharge for most of the Sandy River Basin (some tributaries such as Beaver, Gordon, and Trout creeks are downstream of the gauge and are not represented in the data).

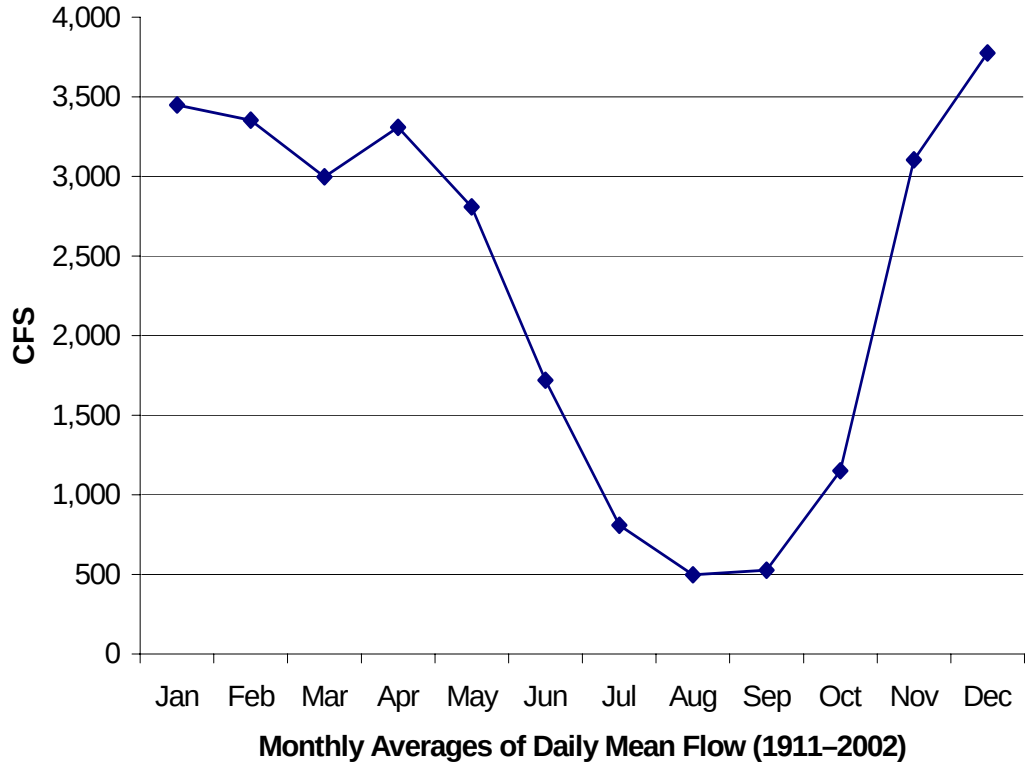


Figure 4-2. Monthly Averages of Daily Mean Flow in the Sandy River Below the Bull Run Confluence, 1911–2002 (USGS Gauge No. 14142500)

Source: USGS 2004a

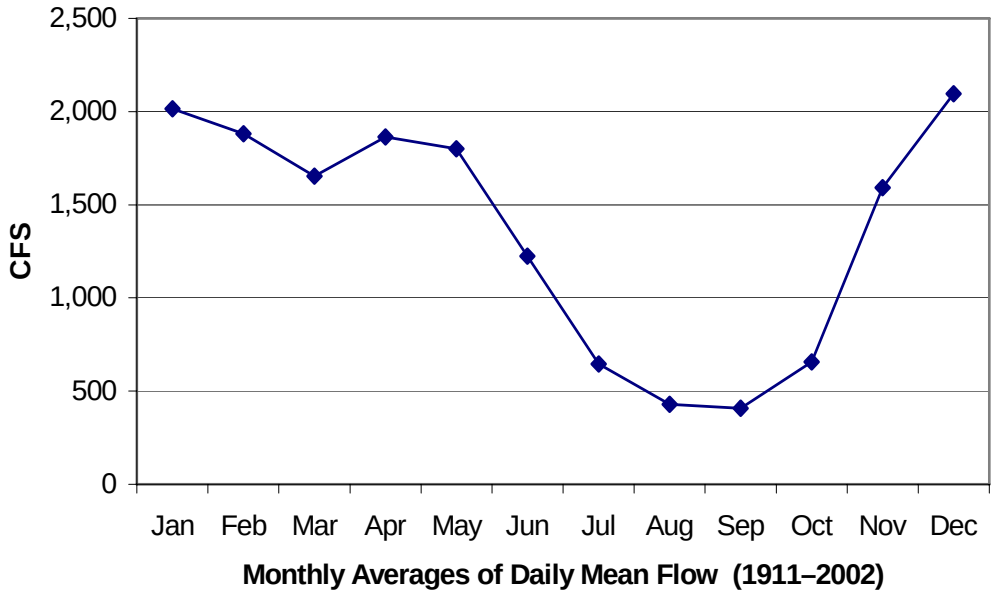


Figure 4-3. Monthly Averages of Daily Mean Flow in the Sandy River Above Marmot Dam Site, 1911–2002 (USGS Gauge No. 14137000)

Source: USGS 2004b

Flows in the Sandy River are variable, ranging widely between days and months within water years. The minimum instantaneous flow was 45 cfs in September 1962. The maximum was 84,400 cfs, which occurred in December 1964 (ODSL 2002). The next four highest flood flows were 65,800 cfs in February 1996, 58,000 cfs in March 1931, 57,600 cfs in November 1999, and 52,700 cfs in February 1986.

Flows during the dry period, occurring from June to October, are similar at stations 14142500 and 14137000. Discharge at the lower gauge (14142500) is greater than at the upper gauge (14137000) during the rainy period from November to May. Daily mean flow exceedences, by month, for Gauge Nos. 14142500 and 14137000 are listed in Table 4-3.

Table 4-3. Likelihood the Sandy River Flow Will Equal or Exceed the Flow Projections at USGS Gauge Nos. 14142500 and 14137000

	Gauge No. 14142500[a]			Gauge No. 14137000[b]		
Month	**10%**	**50%**	**90%**	**10%**	**50%**	**90%**
January	6,740	2,450	1,110	3,910	1,400	700
February	6,680	2,370	1,210	3,570	1,380	730
March	5,330	2,520	1,370	2,730	1,390	875
April	4,960	3,000	1,700	2,810	1,710	1,020
May	4,500	2,590	1,270	2,800	1,660	948
June	3,130	1,420	769	1,940	1,020	631
July	1,250	702	464	932	584	420
August	678	476	347	560	406	314
September	782	429	302	540	360	281
October	2,610	571	295	1,290	400	265
November	6,870	1,930	456	3,370	1,020	357
December	7,500	2,440	1,060	4,100	1,400	625

Note: Percentages indicate the percent of the time that flows are estimated to equal or exceed the specified flow amount.

[a] Gauge No. 14142500 is on the Sandy River, 0.1 mile downstream of the mouth of the Bull Run River.

[b] Gauge No. 14137000 is on the Sandy River, 0.3 mile upstream of Marmot Dam site.

The Oregon Water Resources Department (OWRD) modeled natural flows for the Sandy River Basin. Modeled natural flows (at a 50-percent and 80-percent exceedence level) at four locations on the Sandy River are presented in Table 4-4.

Table 4-4. Modeled Natural Average Monthly Flows at Four Locations on the Sandy River (cfs)[a,b]

	Below Confluence of Salmon River (+/- RM 37.5)		Above Confluence of Bull Run River (+/- RM 19.0)		Below Confluence of Bull Run River (+/- RM 18.0)		At Confluence of Columbia River (+/- RM 1.0)	
Month	**50%**	**80%**	**50%**	**80%**	**50%**	**80%**	**50%**	**80%**
Jan	1,412	823	1,720	989	2,780	1,536	3,190	1,810
Feb	1,411	959	1,680	1,120	2,720	1,745	3,130	2,040
Mar	1,293	968	1,500	1,110	2,450	1,750	2,760	2,000
Apr	1,561	1,097	1,770	1,240	2,880	1,961	3,120	2,190
May	1,507	1,129	1,680	1,230	2,649	1,900	2,740	1,940
Jun	955	716	1,030	772	1,519	1,075	1,620	1,190
Jul	567	447	608	490	830	650	950	726
Aug	416	344	424	364	562	487	633	539
Sep	394	311	406	331	594	458	682	503
Oct	413	328	449	339	766	510	843	561
Nov	940	536	1,190	609	2,126	1,062	2,210	1,160
Dec	1,466	880	1,740	1,010	2,830	1,625	3,230	1,880

Source: Oregon Department of State Lands 2002.

[a]Flow estimates are based on model developed by the Oregon Water Resources Department.
[b]Model assumes no consumptive uses or flow regulation and normal rainfall conditions.

Flow regimes in the Sandy River Basin have been affected by land use practices as well as by dams and diversion structures built over the past century. Natural discharge patterns in the Sandy River Basin have been altered primarily by the following:

- Diversion of water from the Sandy River (Marmot Dam at RM 30) and Little Sandy River (Little Sandy Diversion Dam at RM 1.7) for hydropower
- Storage and diversion of water from the Bull Run River for City of Portland's (City's) municipal water supply (Headworks Dam at RM 6)
- Diversion of water from the Sandy Hatchery weir on Cedar Creek at RM 0.05
- Withdrawal of water from Alder Creek to partially supply the City of Sandy's municipal requirements

Under Oregon State law, the storage of water by an impoundment and the diversion of water from a stream or groundwater aquifer must be permitted and must be put to beneficial use. State records (OWRD 2004) indicate a total of 7,880 cfs of appropriated water in the Sandy River Basin (not including the City's statutory right described below). The three largest uses for this water (all three non-consumptive) are power production, anadromous and resident fish rearing, and recreational boating (Sandy River Basin Partners 2005).

Bull Run

Table 4-5 lists estimated natural flows in the lower Bull Run River. The natural flows are defined as the monthly median Bull Run base flows that would have been in the river if no dams or diversions existed in the Bull Run. The City estimated the natural flows by using gauged tributary inflows to the reservoirs and then increasing them by 20 percent to account for the additional drainage areas not represented by the gauges. The resulting flow estimate was then increased by 4.9 percent to account for the drainage area from Bull Run Dam 2 to USGS Gauge No. 14140000 on the lower Bull Run River.

Table 4-5. Estimated Natural Flows in the Lower Bull Run River at USGS Gauge No. 14140000 (RM 4.7)

	Percentage[a]										
Month	**0**	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
January	19,821	2905	1,817	1,277	974	782	657	518	430	341	169
February	16,072	2420	1,529	1,186	955	785	667	558	469	368	159
March	9,560	1774	1,292	1,067	901	780	675	574	492	409	180
April	12,828	1620	1,283	1,119	991	896	803	710	596	493	175
May	6,340	1478	1,186	1,006	867	755	657	568	467	357	128
June	5,224	1040	749	599	486	408	354	303	255	201	91
July	2,465	362	274	232	203	180	164	148	131	117	73
August	2,382	216	164	144	131	122	110	105	97	88	52
September	6,214	427	266	196	156	128	112	101	91	84	42
October	9,696	1258	737	491	346	255	200	149	122	89	60
November	15,964	2620	1,711	1,261	980	771	619	479	355	243	65
December	22,327	2,947	1,877	1,316	1,053	857	709	586	488	362	110

Source: Monthly flows for the upper reach of the lower Bull Run River (1940-2004).
[a]Percent of the time flows are estimated to equal or exceed the specified flow amount.

Recent operation of the Bull Run water supply system has affected the magnitude and pattern of flow in the lower river, particularly during the summer and early fall. From early July to mid-October, most of the water entering the Bull Run reservoirs is diverted through Portland's water supply conduits. During the late fall and winter months, after the Bull Run reservoirs are filled, surplus water is spilled. There are currently no minimum instream flows in the lower Bull Run River.

Until early 2008, flow from the Little Sandy River was diverted at the Little Sandy Dam and then through a flume to Roslyn Lake, the forebay to the Portland General Electric (PGE) Bull Run Powerhouse at RM 1.5 on the Bull Run River. The Little Sandy Dam is scheduled for decommissioning and removal in 2008, which will restore natural flow conditions to the full

length of the Little Sandy River and will add flow to the lower Bull Run River below the Little Sandy confluence.

In 1909, the state legislature enacted ORS 538.420, which states that "the exclusive rights to the use of waters of the Bull Run and Little Sandy Rivers are granted to the City of Portland." PGE's pre-1909 claim to water from the Little Sandy River will be converted to instream use, per state statute, after the Little Sandy Dam is decommissioned. See Chapter 2 for additional background on Bull Run and Little Sandy water rights.

Climate Change

The City has designed its HCP to take into account reasonably predicted climate changes and potential changes in the precipitation patterns and streamflow in the Bull Run watershed. The City has kept climate records for more than 60 years and continues to assess climate data and related research. University of Washington climate researchers recently evaluated effects of climate change on the Bull Run watershed and the city's water supply (University of Washington 2002). They concluded that, over the long term, winter precipitation will likely increase and effects on flow from spring snowmelt will likely decrease. They also concluded that the average duration of reservoir drawdown was likely to increase. Over the next several decades, however, the Bull Run hydrograph will probably not change significantly. See Chapter 10 for additional information on climate change in Bull Run.

4.1.6 Water Quality

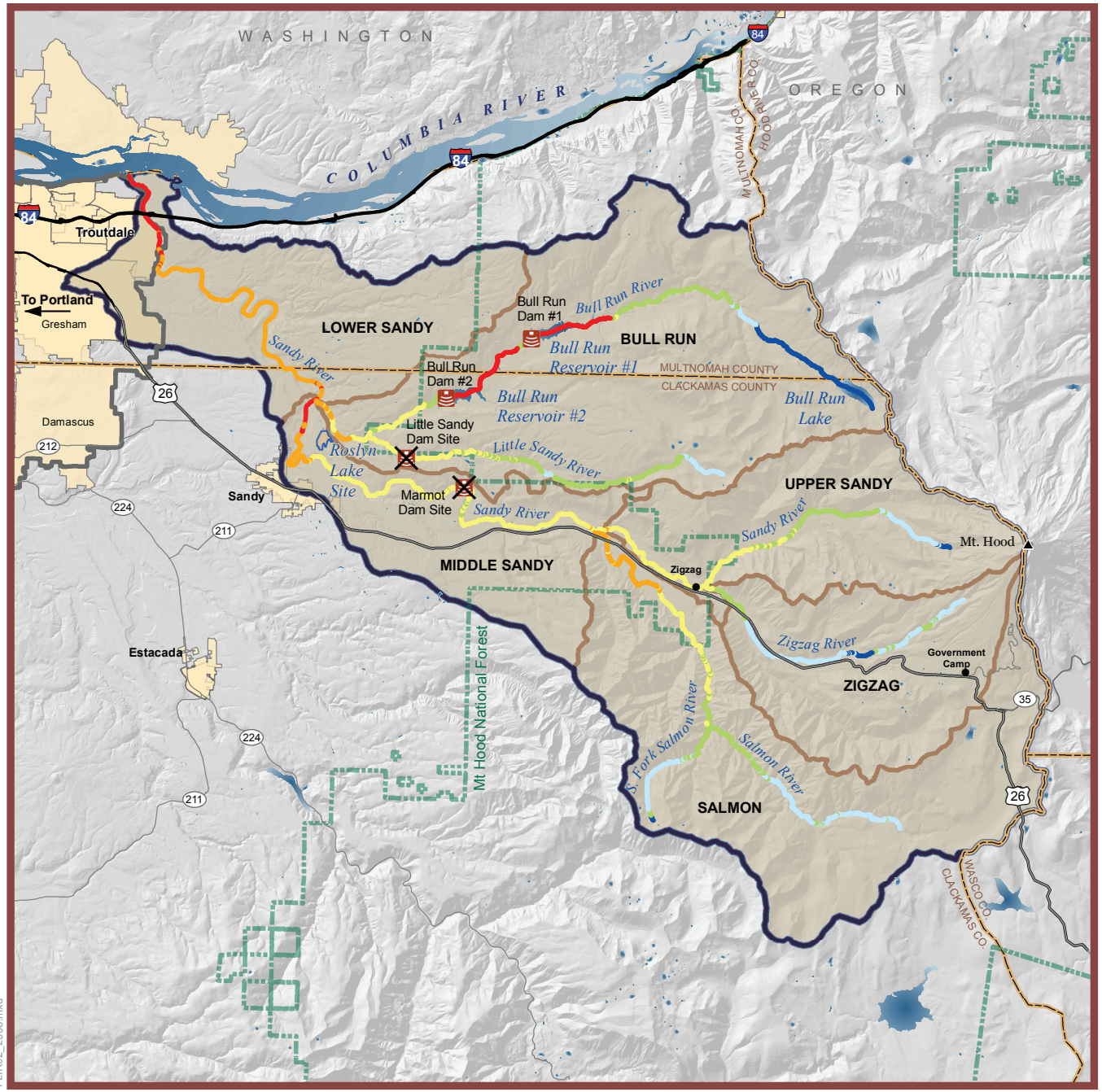
Sandy River Basin

Collection of water quality data for the Sandy River Basin has been sporadic. The exceptions are the Bull Run River watershed (where water quality is extensively monitored as a municipal water source) and an ambient water quality sampling site near the mouth of the Sandy River (at Troutdale Bridge, monitored by ODEQ bimonthly). Water quality conditions in the Sandy River Basin are generally good, and are suitable to support salmonids (ODEQ 2005; and Sandy River Basin Partners 2005).

In general, tributaries in the upper portion of the Sandy River Basin maintain cooler temperatures than the mainstems of the major rivers (Salmon, Sandy, and Bull Run). Air temperatures are cooler at higher elevations, and narrower channel widths afford more shade from riparian trees. Lower elevation tributaries undergo warmer air temperatures, lower gradients and slower flows, and wider channels.

ODEQ collected instream monitoring data and Forward Looking Infrared Radar (FLIR) data in 2001. According to the data, water temperatures in four river segments (totaling 45.9 river miles) exceed numeric criteria of the state temperature water quality standard (16 °C for rearing; 13 °C for spawning) and are therefore considered water quality limited. The FLIR water temperature data (ODEQ 2005) are presented in Figure 4.4.

ODEQ completed a Water Quality Management Plan in 2005 (ODEQ 2005). The plan provides a strategy for reducing pollutant discharges to comply with the total maximum



FLIR02_2008.mxd

Key Boundaries

- Sandy River Basin
- Watershed Boundaries
- County Boundaries
- City Limits
- Urban Growth Boundary
- Mt. Hood National Forest

Roads

- Interstate Highway
- U.S. Highways
- State Highways

Site Features

- Dam
- Former Dam Site
- Lakes
- Former Lake Site

Water Temperatures (FLIR)

- Less than 10 ° C
- 10 - 13 ° C
- 13 - 16 ° C
- 16 - 18 ° C
- 18 - 21 ° C
- Greater than 21 ° C

N

Projection:
State Plane Oregon North
North American Datum 1983

Scale = 1:371,700

Miles
0 1 2 4 6 8

Kilometers
0 1.5 3 6 9 12 15

Figure 4-4. Relative Water Temperatures in Sandy River Basin Streams and Tributaries

daily load (TMDL) allocations determined for the Sandy River and required by the federal Clean Water Act. Water temperature measures in the plan include (but are not limited to) temperature control in permitted discharges and riparian area enhancement and protection (i.e., shading).

Bull Run

Water temperature conditions in the lower Bull Run River are within the suitable range for most of the year. Bull Run is, however, naturally warm during the summer and early fall months, and of limited suitability for some fish species (City of Portland 2004b, ODEQ 2005). Warm conditions occur because of the east-west orientation of the channel (resulting in prolonged sun exposure despite good-quality riparian conditions) and the lack of glacial influence and related cooling. The degree of groundwater-related cooling in the watershed is not known, although subsurface flow from Bull Run Lake to the springs forming the mainstem Bull Run River has a demonstrated cooling effect on upper (above dam) river temperatures. Bedrock-dominated channels in the lower river likely limit groundwater exchange, and the channel width, shallow cross-sectional depth, elevation, and overall distance from the topographic divide likely contribute to naturally warm conditions.

ODEQ has listed the lower Bull River as water quality limited for summer water temperatures. Maximum daily water temperatures in recent decades have routinely exceeded temperatures preferred for salmonid rearing and spawning in the late summer and fall. Figure 4-5 shows the trend in the daily mean, maximum, and minimum water temperatures measured in the lower Bull Run River during 2001 and 2002. The horizontal lines delineate the ODEQ current water temperature criteria for salmonids.

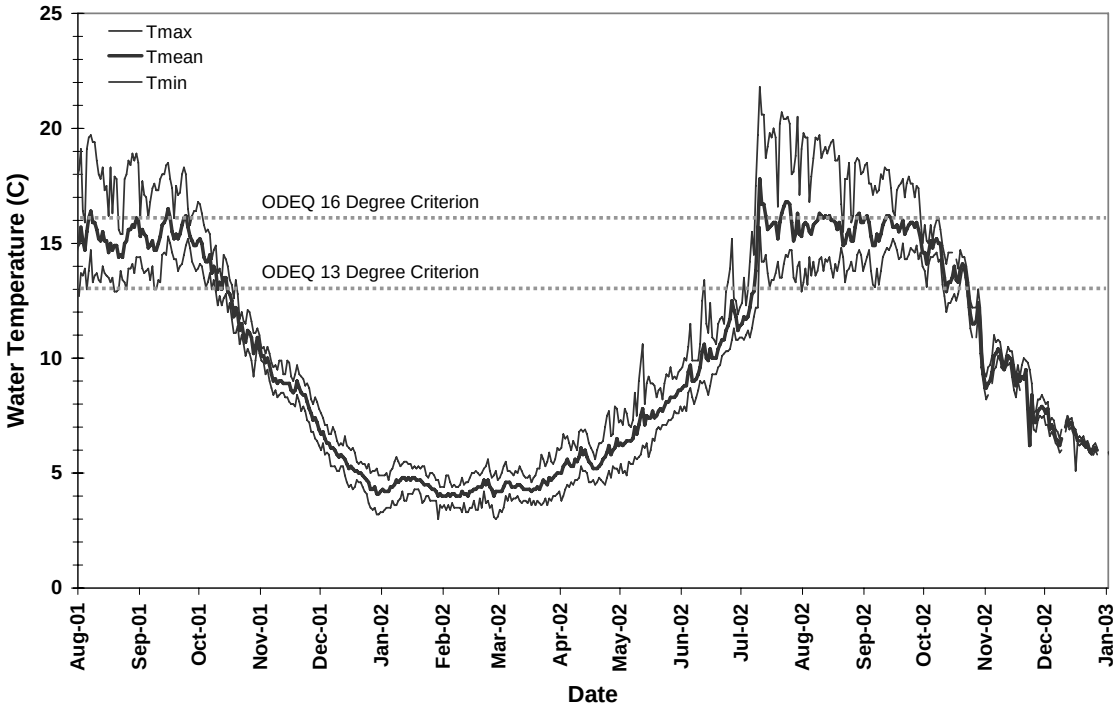


Figure 4-5. Lower Bull Run Water Temperatures, 2001–2002

Source: CH2M HILL 2003a

The Oregon statewide, biologically based (numeric) criteria for water temperature are 16 °C for salmonid rearing and 13 °C for salmonid spawning (ODEQ 2005). The physical characteristics of the lower Bull Run watershed (east-west orientation and bedrock substrate) accentuate solar heating in mid-summer and make these numeric temperature criteria unattainable, even without the influence of the City's water supply operation (Leighton 2002). In anticipation of this type of situation, the Oregon standard includes a "natural conditions" provision. The natural conditions standard (OAR 340-041-028) states:

"Where DEQ determines that the natural conditions of all or a portion of a subbasin exceed the biologically-based criteria, the natural condition supersedes the biologically based criteria, and the natural condition is deemed to be the applicable temperature criteria for that water body."

Natural conditions in the Bull Run River were analyzed by ODEQ and the City to assist in the development of a TMDL for the Sandy River and tributaries (ODEQ 2005). Portland State University and the City used a model of river flow and temperature conditions to characterize thermal conditions in the absence of the City's water system. Actual water temperatures in the lower Bull Run River were also measured over a range of conditions, and regression models were created based on those data.

ODEQ reviewed available USFS stream temperature data for the adjacent Little Sandy River and then measured water temperatures to confirm the USFS data. The City also collected Little Sandy River temperature data. These analyses indicated that natural Bull Run temperatures (at Larson's Bridge) and Little Sandy temperatures follow a similar pattern in response to weather and suggested the Little Sandy could serve as a real-time surrogate for

water temperature compliance for the lower Bull Run. ODEQ developed a "correction factor" to account for the physical differences between the Bull Run and Little Sandy rivers (e.g., smaller basin size in the Little Sandy and faster temperature travel times).

Appendix G provides the Temperature Management Plan (TMP) required by DEQ to demonstrate compliance with the Sandy River TMDL. The TMP relies on the flow and temperature-related conservation measures included in Chapter 7.

4.1.7 Wetlands

Sandy River Basin

Wetlands are an important resource that provide cover and food sources for fish and filter pollutants. National Wetland Inventory (NWI) mapping reveals there are roughly 6,439 acres of wetlands in the Sandy River Basin, representing only about 2 percent of the Basin area. Eroded by abundant rainfall and dissected by numerous streams, the majority of the Basin has moderately steep topographic relief. Exceptions are the spring-created meadows on gentle slopes at the headwaters of the Salmon River and the riparian wetlands where the gradient lessens along the lower Sandy River, particularly the delta at its confluence with the Columbia River. The distribution of wetland areas among the six watersheds is indicated in Table 4-6.

Table 4-6. Wetland Distribution in the Sandy River Basin

Watershed	Wetland Acres	Wetland Acres as Percentage of Each Watershed
Upper Sandy River	427	1
Middle Sandy River	844	2
Lower Sandy River	1,534	3
Bull Run River	2,100	2
Zigzag River	349	1
Salmon River	1,185	2
Total	6,439	

Source: GIS calculations based on National Wetland Inventory mapping.

The Sandy River delta and several other sites along the lower Sandy River contain extensive areas of wet meadow, small ponds, and riparian forest. These are watered by rainfall and river overflow, and are maintained by subsurface river flow. They are classified as riverine wetlands, with some areas classified as palustrine emergent wetlands (Cowardin et al. 1979). Gallery forests of black cottonwood (*Populus trichocarpa*) predominate in some sections, but the majority of wetland acreage at the Sandy River delta is now covered with introduced reed canarygrass (*Phalaris arundinacea*), native sedges, and other herbaceous plants, as well as some willows and shrubs still abundant (CH2M HILL 2005).

Bull Run

The Bull Run River watershed has the largest number of NWI wetlands mapped in the Sandy River Basin due to its areas of moderately gentle topography. The largest wetland complexes are at the head of the Little Sandy River, the head of the North Fork Bull Run River, and around Big Bend Mountain in the Blazed Alder Creek drainage. Most of these wetlands are in areas where springs emerge on topographic benches. Water from the springs collects, is augmented by rainfall and snowmelt, and forms wet meadows or ponds before running off steeper slopes to form streams.

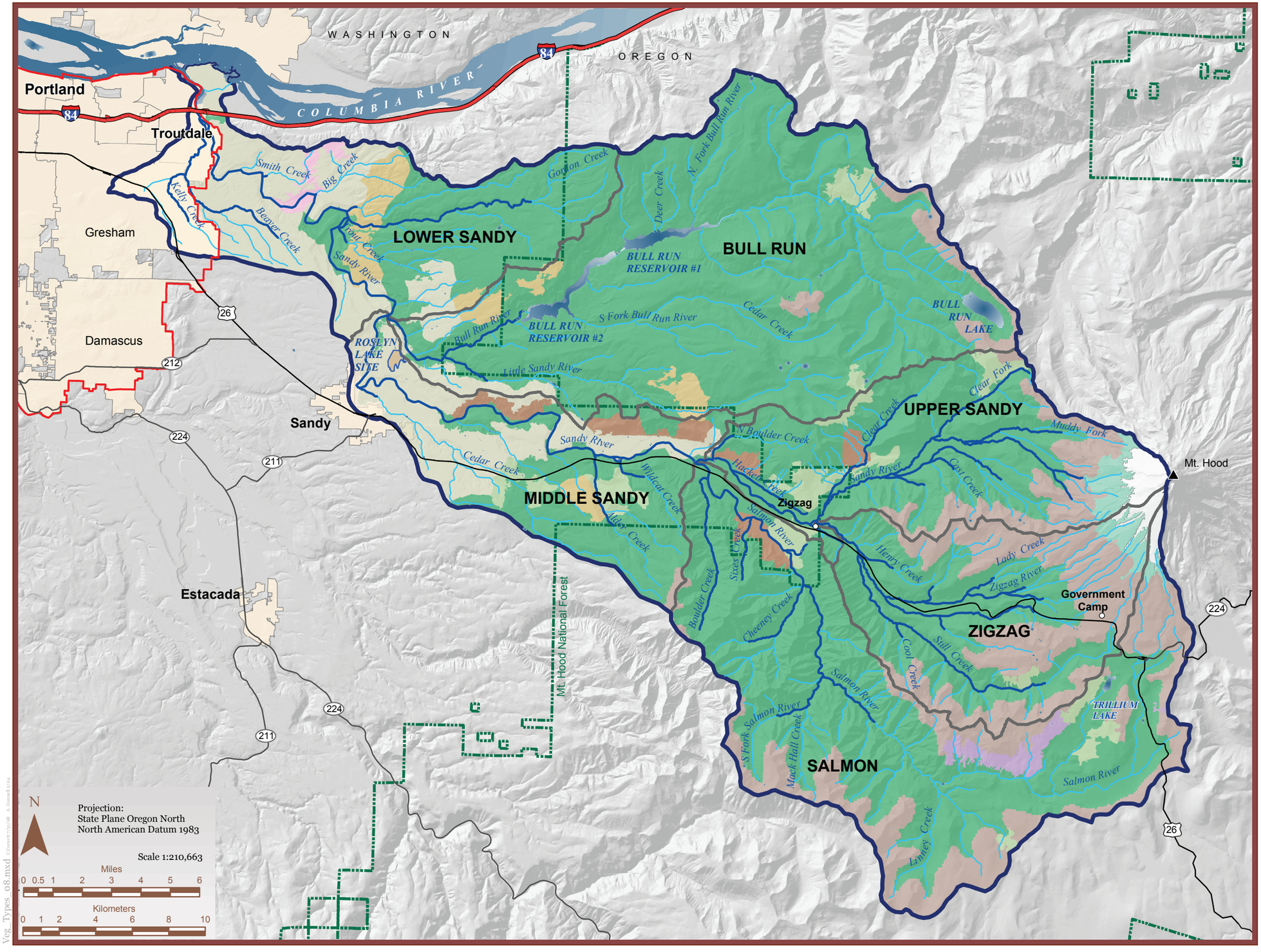
Scrub-shrub and riverine wetlands also occur in the upper Bull Run watershed, but they only cover small acreages. Scattered pockets of palustrine scrub-shrub wetlands or forested wetlands occur in the Camp Creek drainage, and one wetland is at Walker Prairie. These wetlands are on flat terrain in conifer forest, particularly where seeps emerge at the base of steeper slopes. They are dominated by shrubs, with sedges and other herbaceous plants present. Riverine wetlands are found on several old river benches that are now inundated when reservoirs 1 and 2 are full, as well as depositional bars of silt and fine woody debris at the heads of the reservoirs. These wetlands are dominated by sedges and other herbaceous plants, with willow (*Salix* spp.) in some sections.

NWI lists one freshwater forested/scrub wetland in the lower Bull Run watershed. It is a six-acre wetland at the mouth of the Bull Run River on the north side of the river across from Dodge Park.

4.1.8 Vegetation

Sandy River Basin

Over 86 percent of the Sandy River Basin is forested, either deciduous or coniferous. Coniferous forests are more prevalent. The remaining area of the Basin is urban, agricultural, or nonvegetated. The vegetative cover of the Basin is characterized by 12 cover-type categories, as defined by the Oregon Natural Heritage Program. These vegetative cover types are shown where they occur throughout the Basin in Figure 4-6.



Key Boundaries

- Sandy Basin
- Sandy Sub-basins
- City Limits
- Urban Growth Boundary
- Mt. Hood National Forest

Roads

- Interstate Highway
- U.S. Highways
- State Highways

Stream Network

- Anadromous fish-bearing waters
- Other surface water
- Open Water
- Former Lake Site

Vegetation Cover Types

- Agriculture
- Alpine Fell-Snowfields
- Cottonwood Riparian Gallery
- Douglas Fir-W. Hemlock-W. Red Cedar Forest
- Grass-shrub-sapling or Regenerating young forest
- Mixed Conifer/ Mixed Deciduous Forest
- Red Alder-Big Leaf Maple Forest
- Subalpine Fir-Lodgepole Pine Montane Conifer
- Subalpine Parkland
- True Fir-Hemlock Montane Forest

Veg_Types_08.mxd CConnell 7/31/08 A. Gunnell 2/04

Figure 4-6. Sandy River Basin Vegetation Cover Types

The type and condition of riparian forests vary among the Basin's watersheds and river reaches. The typical riparian species in the Sandy River Basin include willow, alder, maple, cedar, hemlock, Douglas-fir, and true firs; all are species that thrive along stream bank riparian zones (Franklin and Dyrness 1973). Willow and alder are the predominant pioneering species on gravel bars and disturbed stream bank sites. Douglas-fir, cedar, hemlock, and true firs are key transition and climax species that provide stabilizing streamside structure, large wood (LW) recruitment, and stream shading.

Riparian conditions on forestlands in the Basin are generally in good condition (see Sandy River Basin Characterization Report, 2005, for additional information). Stream shading is good in the middle and upper reaches of the Sandy River, keeping temperatures down and providing habitat for fish and wildlife. The Salmon-Huckleberry Wilderness area covers approximately 36,000 acres of the Salmon River watershed; the Mt. Hood Wilderness area (approximately 36,000 acres) spans the watershed boundary of the upper Sandy and Zigzag river watersheds.

The riparian habitat in the Basin has been affected by human influences. Situated within minutes of the Portland metropolitan area, the lower river is heavily used for recreation. Agriculture and residential development have altered or disturbed some riparian habitat areas and also caused stream bank erosion.

Bull Run

The Bull Run watershed is largely coniferous forest, and much of it is more than 150 years old. Limited timber harvest began in the Bull Run watershed in the 1800s near the headwaters of Bear Creek (USFS 1997). Prior to 1958, approximately 1,200 acres were cleared for the sites of Bull Run Reservoirs No. 1 and No. 2 (USFS 1997). From 1958 to 1973, timber on 15,980 acres of the watershed (about 20 percent) was harvested (USFS 1997). Timber harvest was subsequently limited to salvage logging after a large windstorm in 1983. During the period 1900–1997, 110 fires were recorded in the watershed (USFS 1997). None of the fires exceeded 1,000 acres. The largest one, the 1971 Linket Fire, burned 960 acres (USFS 1997).

The narrow floodplains along the Bull Run river channel, resulting from the confined basalt canyons, have produced riparian zones that are dominated by conifers with some bigleaf and vine maple, alder, and willow (USFS 1999). The riparian zones of the Bull Run River are usually dominated by hemlock, Douglas-fir, and cedar.

4.1.9 Fish and Wildlife

Sandy River Basin

The Sandy River Basin supports a diverse assemblage of native and introduced fish species from its headwaters to its mouth. The native species of Chinook and coho salmon, steelhead, eulachon (also called smelt), coastal cutthroat trout, and lamprey are known to occur in the Basin. These species are described in detail in Chapter 5 along with maps of current and historical distribution of the four primary covered species. Other native fish species of

ecological or cultural significance that may be found in the Sandy River Basin include chum salmon (*Oncorhynchus keta),* mountain whitefish (*Prosopium williamsoni*), eulachon (*Thaleichthys pacificus),* resident rainbow trout (*Oncorhynchus mykiss*), and bull trout (*Salvelinus confluentus*).

Historically, annual Columbia River harvest of chum salmon reached 500,000 fish; but today, populations in Oregon tributaries to the Columbia, including those in the Sandy River Basin, are extinct (ODFW 2005). The few fish observed in Oregon are probably strays from runs returning to the Washington tributaries of the lower Columbia. Estuarine and lower river habitat degradation have been implicated as likely causes (ODFW 2005).

Mountain whitefish are ecologically important to the health of the Sandy River Basin and its fish resources (ODFW 1997). Whitefish eggs and fry provide a food source for overwintering native fish stocks. Although biological information about whitefish is limited, they are most commonly found in mainstem rivers and large tributaries. According to ODFW (1997), whitefish populations in the Basin appear to be healthy.

Eulachon (smelt) historically ascended the Columbia River by the millions to spawn in the lower mainstem and tributaries, including the Sandy River. Smelt returns to the Sandy River are inconsistent, with large runs in some years and no smelt observed in others (ODFW 1997). When present, the smelt return to spawn in the Sandy River between February and April. They spawn in sandy-silty substrates commonly found in the lower river near the mouth.

Resident rainbow trout are indigenous to the Sandy River, and important populations are documented as existing above anadromous barriers in the Little Sandy River and upper Gordon Creek (ODFW 1997). Rainbow trout are also found throughout the middle and lower reaches of the mainstem Sandy, Bull Run, Salmon, and Little Sandy rivers. Rainbow trout have not been documented above Final Falls (near RM 14) on the Salmon River or above the falls at RM 21 on the Bull Run River. Historically, ODFW stocked rainbow trout in the upper Sandy River watershed. Stocking was discontinued in 1995 to reduce competition with native fish stocks.

Bull trout were historically documented in the Clackamas River Basin and are currently found in the Hood River watershed. The historical presence of bull trout in the Sandy River Basin has been debated. Confirmed sightings of bull trout have occurred in the Sandy River Basin (Bachmann, pers. comm., 2002). Photographs were taken of an angler-caught bull trout on January 23, 2002, and ODFW staff reported a bull trout in the Marmot Dam fish trap in May 2000 (Schneider, pers. comm., 2002). A 1960 report (Leonards 1960; cited in USFS 1996) also refers to bull trout in the Sandy River Basin, but documented proof is lacking.

The Columbia River bull trout distinct population segment (DPS) was federally listed as threatened on June 10, 1998, by the U.S. Fish and Wildlife Service (USFWS). The Columbia River bull trout DPS includes all bull trout populations located within the Columbia River Basin and its tributaries in the United States (excluding bull trout found in the Jarbidge River, Nevada). The Sandy River was not identified in this listing as supporting a bull trout population (National Marine Fisheries Service [NMFS] 1998b).

ODFW introduced brook trout (*Salvelinus fontinalis*) into high elevation lakes (e.g., Cast, Dumbbell, Palmer, and Blue lakes) via airplane back in the late 1950s and early 1960s. ODFW also introduced grayling into Goodfellow Lakes, although the planting was unsuccessful. The bulk of nonsalmonid game fish found in the Sandy River Basin were introduced in the late 1800s to early 1900s except for white sturgeon (*Acipenser transmontanus*), which are indigenous to the Columbia River system.

The majority of the introduced species are found in the lower Sandy River near the delta, where velocities are typically slower and water temperatures are generally warmer than other locations in the Basin. ODFW (1997) describes the major management concern associated with introduced fish as predation on native fish stocks. Physical attributes of the Sandy River (i.e., high velocity and cool water temperatures) appear to be limiting the colonization of warm-water predatory fish introduced to the lowermost reaches of the Basin.

In addition to fish, the Sandy River Basin also provides diverse habitats for a wide variety of wildlife species. The Basin is located in the Pacific flyway and is used by migratory birds as resting or nesting grounds during migration. A rich diversity of amphibian and reptile species is found in the Basin's rivers, streams, marshes, and ponds. Mammal species living in the Basin include Roosevelt elk, black-tailed deer, black bear, coyote, cougar, bobcat, otter, raccoon, beaver, mink, and wolverine. The habitats adjacent to the rivers and tributaries provide important travel corridors for wildlife movement and dispersal.

Bull Run

The Bull Run watershed supports fall and spring Chinook, coho salmon, steelhead, rainbow trout, cutthroat trout, and various other fish species. Anadromous fish are limited in their distribution to the lower Bull Run River downstream of Dam 2. Pacific lamprey have been observed in the lower river while the reservoirs support cutthroat and rainbow trout, and cutthroat/rainbow hybrids. Cutthroat trout are also found in Bull Run Lake, which is isolated from the headwaters of the Bull Run River by a landslide that occurred approximately 15,000 years ago. Because the population of cutthroat is isolated, the City is not requesting coverage for the Bull Run Lake cutthroat in this HCP.

Several other species addressed in the HCP utilize habitats in the Bull Run watershed. Various amphibians such as the northern red-legged frog, the coastal tailed frog, Cope's giant salamander, Cascade torrent salamander, and the Oregon slender salamander rely on habitat in the Bull Run. The watershed also has important upland habitat for bald eagles and spotted owls.

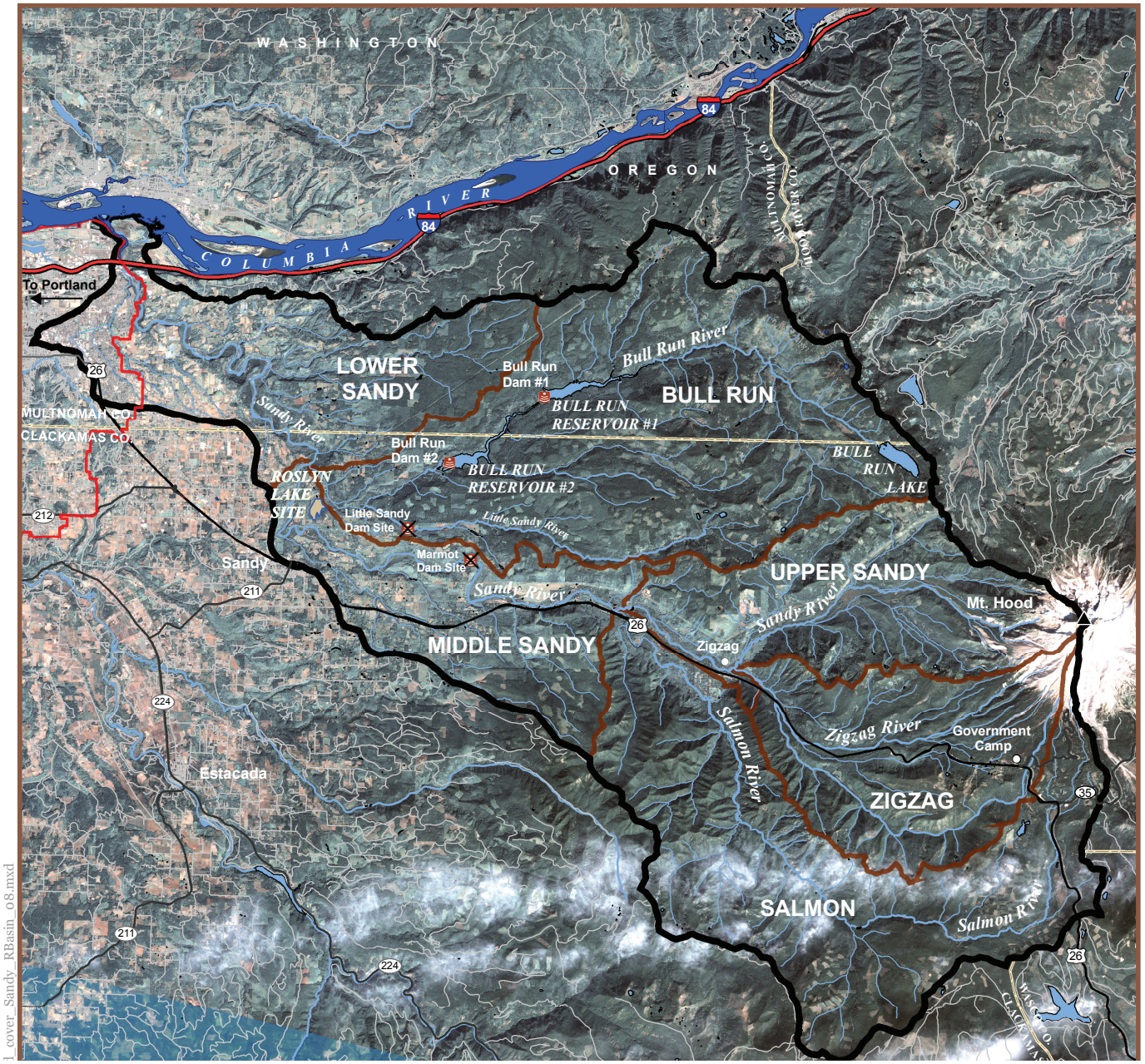
4.2 Cultural Setting

Early human activity in the Sandy River Basin was largely limited to subsistence living, travel, and dispersed hunting and gathering. By the middle of the 1800s, the majority of human activity in the area concentrated on agriculture, timber production, and fish harvest. Dams were constructed in the early 1900s to provide municipal water supply and generate hydropower. Communities near the mouth of the Sandy (Troutdale and Gresham) and along the Highway 26 corridor continue to grow today.

4.2.1 Current Land Use

Sandy River Basin

The overwhelming majority of the Sandy River Basin is covered by private and public forests, with federal forests constituting about 75 percent of the Basin. Urban and agricultural areas are concentrated at the lower part of the Basin, including portions of the incorporated cities of Sandy, Troutdale, and Gresham. Agricultural areas are used to grow row crops, berries, and nursery stock, and to support livestock. Land cover is generally indicated by the satellite photo provided in Figure 4-7. Land ownership is listed in Table 4-7.



Key Boundaries

- Watersheds of the Sandy River Basin
- Sandy River Basin
- Urban Growth Boundary

Roads

- Interstate Highway
- U.S. Highway
- State Highways
- Minor Roads

Site Features

- Dam
- Former Dam Site
- Rivers and Streams
- Lakes
- Former Lake Site

N

Projection:
State Plane, Oregon North
North American Datum 1983

1:349,042

Miles
0 1 2 4 6 8 10

Kilometers
0 1.5 3 6 9 12 15

Figure 4-7. Land Cover and Existing Uses in the Sandy River Basin

Table 4-7. Land Ownership in the Sandy River Basin

Ownership Type	Total Acres	Percent Composition
Federal		
Bureau of Land Management	13,666	4
U. S. Forest Service	221,428	70
State		
State of Oregon	845	< 1
Local/Regional		
City	264	> 1
County	1,714	> 1
Portland Water Bureau	5,108	2
Metro	1,622	> 1
Private Lands		
Conservation Group	684	< 1
Portland General Electric	1,466	< 1
Other Private Owners	68,713	22

Source: Metro tax lot information, 2003

The Basin is used as a water supply source, an electric power source, and a recreational haven for hikers, skiers, fishing and camping enthusiasts, boaters, swimmers, and mountain bicyclists. More than 58 miles of streams within the Basin are designated Wild, Scenic, or Recreational under the federal Wild and Scenic Rivers Act. Almost 20,000 acres of land are protected within these river corridors (USFS 1989).

Salmon and steelhead runs support popular sport fisheries in the Sandy River Basin. Fishing regulations put special emphasis on the survival of wild fish in the Basin. The mainstem Sandy River upstream to the Marmot Dam site is open for harvest of adipose-fin-clipped steelhead year-round, adipose-fin-clipped Chinook salmon from February 1 to October 31, and adipose-fin-clipped coho salmon from August 1 to October 31.

Winter steelhead are the most popular game fish in the Sandy River. Before catch-and-release regulations were started in 1990, in-basin harvest of winter steelhead significantly affected spawning and escapement of wild winter steelhead into the upper Basin. The spring Chinook salmon run also supports a substantial sport fishery in the river below the Marmot Dam site. Spring Chinook are a large-bodied, high-quality food fish. They are caught in the early part of their run when the fish are still in good physical condition. Fall Chinook fishing is generally limited by natural conditions, since by the time the adults return to the Sandy River to spawn their condition and meat quality have deteriorated.

Hatchery fish are no longer planted in the upper Basin above the Marmot Dam site (RM 30). In 2006, a trap at the dam's fish ladder prevented hatchery steelhead and coho salmon from

entering the river above Marmot Dam. With the decommissioning and removal of Marmot Dam, ODFW changed practices for releasing juvenile hatchery fish to control straying of returning adults. For example, hatchery winter steelhead are released at popular angling spots such as Oxbow and Dabney parks on the lower river.

Bull Run

President Benjamin Harrison designated the Bull Run watershed as a national forest reserve in 1892, anticipating development of the water supply for the City. Water from the Bull Run River was first diverted to Portland in 1895. Since the turn of the twentieth century, the water system has been developed to serve the water needs of the Portland metropolitan area. Two large dams were constructed for water storage—the first in 1929 and the second in 1964. In the 1980s, the dams were retrofitted to generate hydropower.

Access to the Bull Run Watershed Management Unit is restricted by federal law. Recreational uses (e.g., fishing and boating) are not allowed. Facilities include water system infrastructure, access roads, and a variety of monitoring and communication equipment installations related to water system operation. No private residences or commercial facilities exist inside the management unit boundary.

Land uses downstream of the management unit boundary include a small number of private residences, the PGE Bull Run Powerhouse, Camp Namanu (a residential summer camp), and Dodge Park (a picnic and fishing area owned and operated by the City).

4.2.2 Land Management and Regulation

Sandy River Basin

More than 70 percent of the Sandy River Basin is national forest land, under the jurisdiction of the Mt. Hood National Forest. Some checkerboard lands in the middle Basin are administered by the Bureau of Land Management (BLM). All of these federal lands are managed according to the Northwest Forest Plan. Unincorporated private land along the Highway 26 corridor and middle mainstem Sandy River as far upstream as Zigzag is in Clackamas County. Unincorporated private land along the lower mainstem Sandy River and related tributaries is in Multnomah County. Management of nonfederal forestlands is regulated by the Oregon Department of Forestry (ODF). Portions of the cities of Sandy, Troutdale, and Gresham are also located in the Basin.

USFS Land Management

Management activities in the Mt. Hood National Forest are guided by the Northwest Forest Plan (USFS 1994b) and the Mt. Hood National Forest Land and Resource Management Plan (LRMP) (USFS 1990). A reconciliation document drafted in 1995 indicates that all standards and guidelines in the Mt. Hood National Forest LRMP apply unless superseded by the Northwest Forest Plan standards. When standards and guidelines from both documents apply, the more restrictive applies or one that provides greater benefits to late-successional

forest-related species. Late Successional Reserve is the dominant land allocation within Mt. Hood National Forest lands located in the Sandy River Basin.

BLM Land Management

BLM land management activities comply with Northwest Forest Plan requirements, and are also managed according to the Salem District BLM Resources Management Plan. BLM, in conjunction with private organizations such as Western Rivers Conservancy and The Nature Conservancy, manages about 20 miles of Wild and Scenic Rivers within the Sandy River and Salmon River watersheds, in addition to 9,000 acres in the Highway 26 corridor (ODEQ 2005). BLM is proceeding to acquire land in the middle Sandy River/ Salmon River corridors under the direction of The Conservation and Land Tenure Strategy for the Sandy River and Mt. Hood Corridor and the Oregon Resources Conservation Act of 1996.

Nonfederal Forest Lands (State Forest Practices Rules)

ODF regulates the management of riparian and upland forest on nonfederal lands. The Oregon Forest Practices Act (ORS Chapter 527) and associated rules prescribe measures intended to protect natural resources. Riparian management requirements are based on the type, size, and beneficial use of a water body. Stream size is classified as small, medium, or large based on average annual flow. Buffer widths vary from 50 to 100 feet.

Best management practices for riparian management areas include tree harvest prohibitions; understory vegetation retention; snags and downed wood retention; basal area retention targets; live conifers retention; precommercial thinning, and other activities to maintain the growth and survival of conifers; and stream buffers. Restrictions are also imposed on the application of chemicals (e.g., pesticides, herbicides, fertilizers).

Nonforested Riparian Lands (County and Municipal Zoning)

Local government land use regulations are in place to protect rivers, streams, and water quality in the Sandy River Basin. Regulations vary by jurisdiction, but all the cities and counties have regulations that govern how development occurs in riparian areas. The following jurisdictions have land use authorities within the Basin: cities of Sandy, Troutdale, and Gresham; and Multnomah and Clackamas counties. The urban growth boundary also extends into the Basin and is managed by Metro, a directly elected regional government.

Land use regulations are governed by Oregon's statewide land use goals. Programs to comply with these land use goals are developed and codified in comprehensive plans and zoning ordinances adopted by the jurisdictions. Goal 5 deals with protection of natural resources, scenic and historic areas, and open spaces. Goal 6 deals with the quality of air, water, and land resources of the state. Floodplain management and other natural hazards are included in Goal 7.

While all the jurisdictions have different plans and ordinances, the objectives in each case are to protect the riparian resources in the Basin and maintain water quality. The primary mechanisms are establishing development setbacks based on stream size and slope, maintaining trees, controlling erosion, and planting native vegetation.

Bull Run

Approximately 90 percent of the Bull Run watershed is on national forest land and is managed in accordance with Northwest Forest Plan provisions, as well as statutes specifically applicable to Bull Run that strictly regulate timber harvest. A federal law, Public Law 95-200, was passed in 1977 as a result of public controversies about timber harvest that took place primarily between 1958 and 1973. PL 95-200 restricts access to the watershed and restricts forest management practices. Federal lands in the Bull Run and Little Sandy watersheds are also subject to the provisions of two recent statutes—the 1996 Oregon Resource Conservation Act (ORCA) and the 2001 Little Sandy Protection Act. ORCA amended P.L. 95-200 and prohibited timber cutting except as needed in two cases: to protect water quality and quantity, and to operate the City's water supply and hydropower facilities. The Little Sandy Protection Act added 2,550 acres of federal land to the Bull Run Watershed Management Unit and extended the watershed protections that apply in the unit to these acres. These statutes supersede the direction provided in the Northwest Forest Plan.

City-owned lands along the lower Bull Run River, together with downstream private lands, are managed in compliance with Clackamas County laws and ordinances and State of Oregon laws and regulations. City-owned land is also managed according to City Council ordinances and policies. The City limits tree harvest on its lands to that necessary for the maintenance and protection of the water system. The City has not allowed commercial timber harvest on its lands for over 30 years.

4.3 Current Habitat Conditions in the HCP Area

Habitat information in this section is organized according to the six watersheds in the Sandy River Basin.

- Lower Sandy River
- Middle Sandy River
- Upper Sandy River
- Salmon River
- Zigzag River
- Bull Run River

Much of the following text comes from ODFW's Sandy River Fish Management Plan (ODFW 2001), Stillwater Sciences (2000), the Sandy River Basin Characterization Report (Sandy River Basin Partners 2005), and various watershed analyses completed by USFS for the Mt. Hood National Forest (Zigzag Watershed Analysis: USFS 1995b; upper Sandy Watershed Analysis: USFS 1996; Salmon River Watershed Analysis: USFS 1995a, Bull Run Watershed Analysis: USFS 1997).

Habitat information in each of the six watersheds is provided as context for the habitat conservation measures in Chapter 7 and the analysis of effects in Chapter 8. Land-use patterns, habitat access, and channel conditions are described as well as the current and historical distribution of fall Chinook, spring Chinook, winter steelhead, and coho salmon. Table 4-8 provides an estimate of the current and historical distribution of fall and spring Chinook, winter steelhead, and coho.[2] The stream miles listed in this table are derived from a geographic information system (GIS) interpretation of a 1:100,000-scale map. The species distribution used in the current conditions described in Chapter 5 is by individual stream reach; the stream reach mileages are based on stream surveys and are therefore more detailed than the stream miles by watershed listed in Table 4-8. The detailed stream reach mileages were used in the analysis of effects that appears in Chapter 8. Appendix C shows the distribution of the four primary salmonids species on a reach-by-reach basis.

The current habitat conditions information also provides the broad context for the species-specific information and maps in Chapter 5.

[2] The stream miles are an estimate because not all of the culvert information in the Basin was available.

Table 4-8. Estimated Stream Miles for Current and Historical Anadromous Fish Distribution in the Sandy River Basin[a,b]

Watershed	Total Stream Miles in Watershed	Current Anadromous Fish Distribution	Fall Chinook		Spring Chinook		Winter Steelhead		Coho	
			Current	Historical	Current	Historical	Current	Historical	Current	Historical
Lower Sandy River	107	36	20	20	20	20	36	36	35	35
Middle Sandy River	65	24	12	20	20	20	24	37	24	37
Upper Sandy River	107	44	0	23	29	29	44	44	30	30
Salmon River	130	28	0	21	22	22	28	28	28	28
Zigzag River	100	30	0	18	23	23	30	30	23	23
Bull Run	170	8	8	40	8	40	8	49	8	40
Basin Total	679	170	40	142	122	154	170	224	148	193

Source: Sandy River Basin Characterization Report 2005.

[a]These stream mile designations were made by the Sandy River technical team composed of staff from the Sandy River Basin Partners.

[b]The team made the designations during the development of the Sandy River stream reach database and by GIS interpretation of a 1:100,000-scale map. These estimates of mileage might not be correct. If data were unavailable on the presence of fish barriers or the passability of juveniles and adults to migrate past known barriers, the technical team assumed complete passage because the analysis was focused on estimating the quality and quantity of stream habitat in the Basin. Historical distribution of each species was based on the known habitat preferences of each species and the professional opinion of the technical team.

4.3.1 Lower Sandy River Watershed

The lower Sandy River watershed (Figure 4-8) is the most urbanized of the six watersheds in the Sandy River Basin, and it contains the most agricultural lands (Sandy River Basin Watershed Council 1999). Aquatic habitat degradation is widespread in the lower watershed. Although some natural channel conditions persist, much of the stream banks of the mainstem lower Sandy River are armored with riprap to prevent erosion of private property and roads. Channel modifications are evident along the west bank of the lower Sandy River near Troutdale. The mouth of the Sandy River was channelized and rerouted in the past, but agencies are now undertaking efforts to return the lower Sandy River to its original channel at the mouth of the river (Virginia Kelly, USFS, pers. comm., May 2006). Substantial habitat diversity and complexity were lost in the lower Sandy River as meanders, oxbows, and side channels were disconnected and LW was removed.

Lower Basin tributaries have also been heavily influenced by ongoing development. Buck Creek was affected by debris flows during major floods in 1964 and 1996. Additionally, a poorly designed culvert on Buck Creek has been considered a partial passage barrier to upstream migrating fish since the 1950s (ODFW 1997). Beaver Creek has been heavily impacted by urbanization and nursery stock production facilities (ODFW 1997).

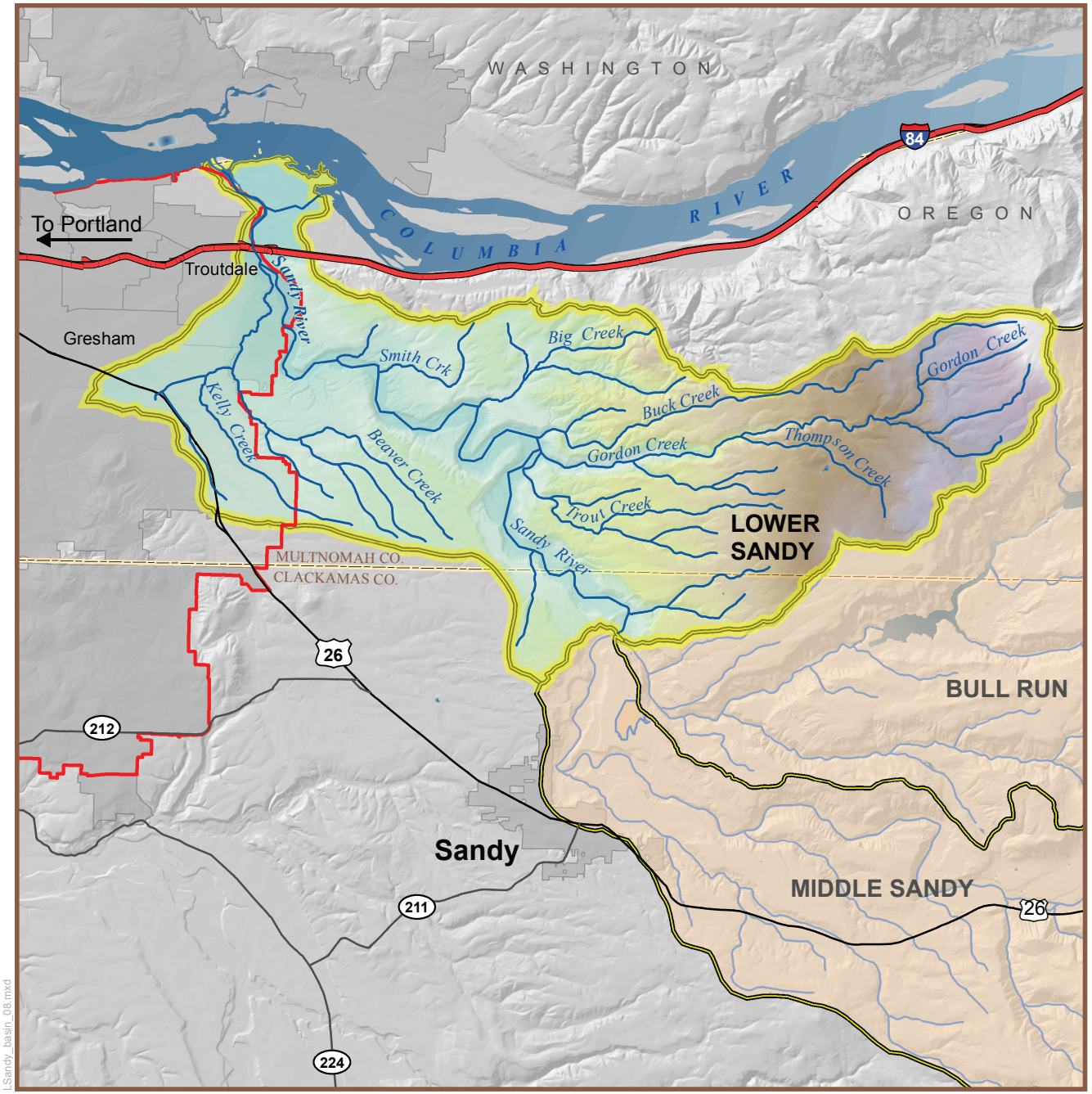
Gordon and Trout creeks are still in relatively good shape. These tributaries are utilized by steelhead, coho, and fall Chinook for spawning and rearing.

Habitat Access

The mainstem Sandy River in this watershed is unobstructed for fish passage. Several tributaries, notably Beaver and Buck creeks, contain culverts that affect fish passage.

The Sandy River and its tributaries in the lower Sandy River watershed support the bulk of the fall Chinook salmon productivity in the Sandy River Basin. The lower Sandy River also functions as an important migration corridor for juvenile and adult salmonid fishes. Gordon Creek is the only remaining free-flowing, unobstructed tributary in this watershed. It is an important spawning tributary for threatened Lower River Wild Sandy River fall Chinook and winter steelhead trout (ODFW 1997). Trout Creek has a natural barrier to fish passage (four-meter-high falls) about 1,500 meters from the mouth (SRBWC 1999). Trout, Buck, and Beaver creeks are important to anadromous fish productivity in the lower Sandy River watershed.

It is difficult to assess the number of stream miles in the lower Sandy River watershed currently used by anadromous fish compared with what was available historically. For Table 4-8, the Sandy River Basin Agreement Technical Team (SRBTT) assumed that all 36 stream miles in the lower Sandy River watershed currently utilized by anadromous fish are used by steelhead and coho salmon. Historically, both species used the same number of stream miles in the watershed (See Appendix C for the full current and historical distribution). Fall and spring Chinook currently use about 20 stream miles in the lower Sandy River watershed, the



Key Boundaries

- Watersheds of the Sandy River Basin
- Lower Sandy River Watershed
- Urban Areas
- Urban Growth Boundary
- County Line

Roads

- Interstate Highways
- U.S. Highways
- State Highways

Site Features

- Rivers and Streams
- Lakes
- Former Lake Site

N

Projection:
State Plane Oregon North
North American Datum 1983

1:179,660

Miles
0 0.5 1 2 3 4 5 6

Kilometers
0 1 2 4 6 8 10

Figure 4-8. Lower Sandy River Watershed

same number of miles used historically. Anadromous cutthroat trout are assumed to use the lower Sandy River (below the Marmot Dam site), although there have been few recent observations. Resident cutthroat trout are well distributed throughout the watershed.

Channel Conditions

PGE (2002) conducted an evaluation of habitat elements and channel conditions in portions of the lower Sandy River watershed. Indicators of properly functioning habitat elements evaluated included substrate, LW, pool frequency, pool quality, and off-channel habitats. The lower Sandy River watershed was divided into two reaches for this evaluation: the Sandy River from Dabney Park to Dodge Park (RM 6.6 --RM 18.5), and the reach from the mouth to Dabney Park (RM 0—RM 6.6).

The reach from RM 6.6—RM 18.5 begins at Dabney Park and extends to Dodge Park at the Bull Run River confluence. This reach is characterized by a low-channel gradient relative to other reaches upstream. The dominant habitat types in this reach are pools and riffles. Streambed substrates are composed primarily of cobbles, gravels, and sand. Cobble/gravel bars, side channels, overflow channels, and island features are more abundant and of larger magnitude compared to upstream reaches in the river. The percentage of channels and bars with sand accumulations is also much higher in the low-gradient lower Sandy River mainstem than it is farther upstream. In some portions of the reach, the active bed is saturated with sand and the potential for additional fine sediment storage is low (PGE 2002). The reach provides the majority of suitable mainstem spawning habitat for fall Chinook salmon in the Sandy River Basin (PGE 2002). An abundance of pool, riffle, and side-channel habitats provides good summer and winter rearing conditions for juvenile steelhead trout, Chinook, and coho salmon.

The reach from the mouth of the Sandy River to Dabney Park (RM 0--RM 6.6) has the lowest channel gradient within the mainstem Sandy River. The dominant habitat types are pools and riffles. Channel substrates are composed primarily of sand and gravel. Bed mobility is high, and the sand content in the subsurface is very high (PGE 2002). The mouth of the Sandy River forms a broad shallow delta at its confluence with the Columbia River. Depositional dynamics of the delta are strongly influenced by the backwater effect of the Columbia River and by a lack of high-water events in the spring caused by dam operations on the Columbia (PGE 2002; SRBWC 1999).

Concerns about fish passage into the Sandy River during seasonal low-flow periods led to alterations in the natural stream channel throughout the 1900s. A rock dam and a levee were constructed in the 1930s to provide fish passage that was often considered restricted during periods of low flow. Dredging of the main channel has also been conducted periodically to facilitate fish passage. This reach contains limited spawning habitat for Chinook salmon and steelhead trout near Lewis and Clark State Park. Suitable rearing habitat exists for steelhead trout, Chinook, and coho salmon, primarily in the uppermost portions of the reach. The lowermost portions of the Sandy River and delta are used as a migration corridor for salmonid fishes, and spawning and rearing habitat is limited. Historically, however, the Sandy River delta probably provided excellent off-channel rearing habitat for most of the salmonids that utilize the watershed.

Two important tributaries to the lower Sandy River also support anadromous salmonids that have been targeted by the City for conservation measures. Gordon Creek has well-vegetated side slopes, a bottom composition dominated by cobbles and gravel, but little large wood in the active stream channel. The lower end of Trout Creek has a very low stream gradient, and the creek parallels the mainstem Sandy River for approximately one-quarter mile. The lower stream provides good low-velocity habitat for salmonids.

4.3.2 Middle Sandy River Watershed

The middle Sandy River watershed (Figure 4-9) begins near the confluence with the Salmon River at about RM 37.5 and continues downstream to RM 18.5 at the confluence with the Bull Run River (Dodge Park). Major tributaries in the watershed include Alder and Cedar creeks. The watershed is located entirely in Clackamas County. Land ownership in the watershed includes USFS (Mt. Hood National Forest), BLM, State of Oregon, Clackamas County, and private holdings.

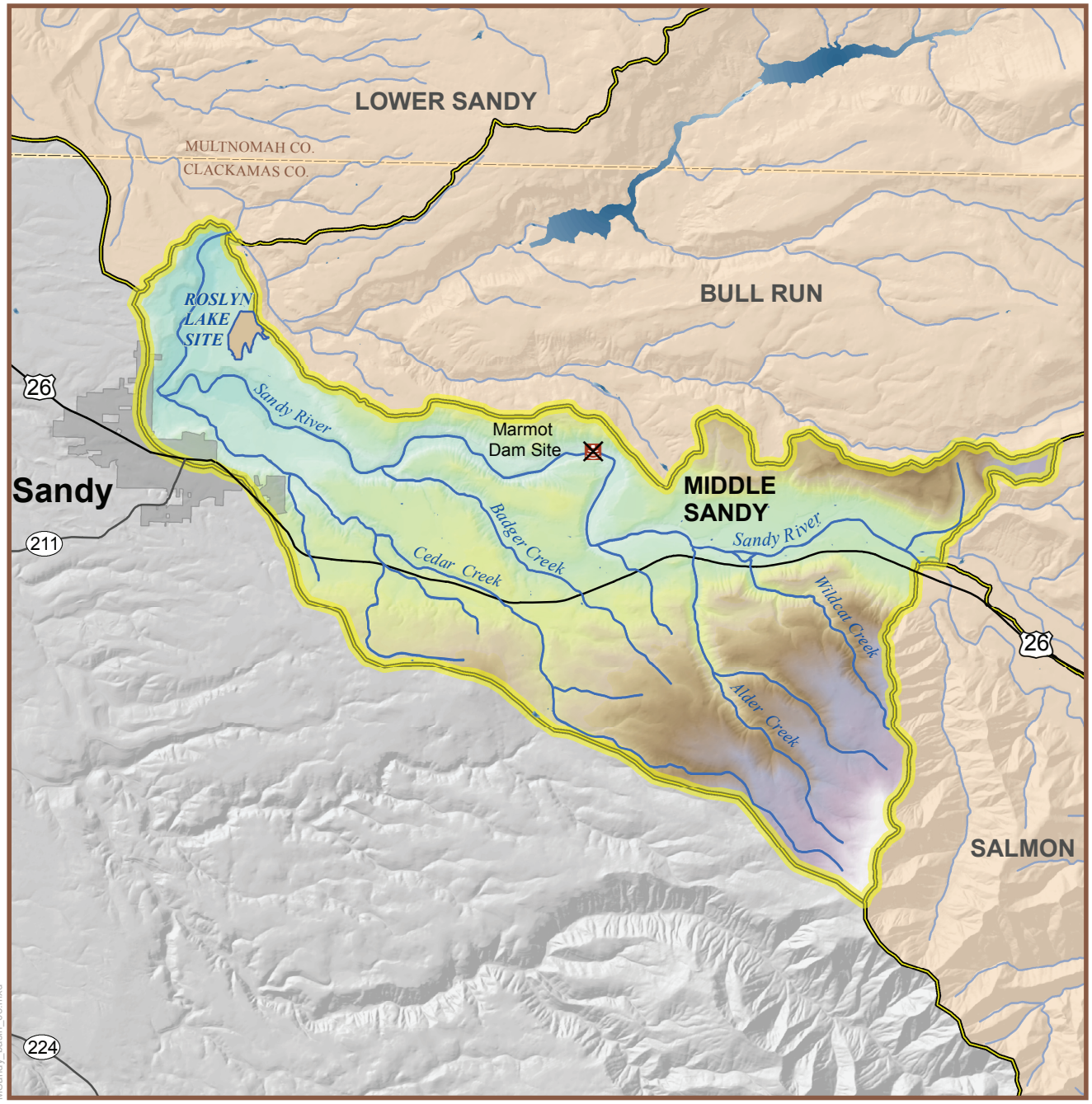
Land and water use in the watershed varies widely, including timber harvest, agriculture, rural residential home sites, transportation, power generation and transmission, recreation, and municipal water supply.

Habitat Access

The middle Sandy River watershed functions primarily as a migration corridor for juvenile and adult salmonid fishes, but it also provides spawning habitat for Chinook salmon and rearing habitat for a variety of resident and anadromous salmonids (S.P. Cramer & Associates Inc. 1998). Until Marmot Dam (RM 30) was decommissioned in the summer of 2007, it was the only dam located in the middle Sandy River. Fish passage facilities were provided at Marmot Dam for migratory fish to have access to the upper watershed.

Tributaries supporting anadromous fish species in the middle Sandy River watershed are limited. Portions of Cedar Creek, Wildcat Creek, and Alder Creek, which are accessible to migratory salmonids, support natural production of steelhead, salmon (primarily coho), and resident trout. Resident trout are likely present in Cedar Creek, Alder Creek, and other small streams above barriers to anadromous fish, although their abundance is not well documented.

Passage barriers in the middle Sandy River watershed limit fish habitat. Sandy Hatchery, the only fish hatchery in the Sandy River Basin, is located on Cedar Creek. Significant reductions in aquatic habitat have occurred as a result of hatchery construction and operation. A weir constructed at the Sandy Hatchery about 0.5 mile upstream from the mouth of Cedar Creek has prevented upstream fish passage since the early 1950s. Approximately 12 miles of upper Cedar Creek are blocked from fish usage. USFS (1996) identified a partial artificial barrier on Alder Creek under the U.S. Highway 26 bridge, although steelhead have been documented upstream of this barrier. At least one other passage barrier exists on Alder Creek at the City of Sandy's water diversion. USFS (1996) also identified a passage barrier on an unnamed tributary in the Mensinger Bottom area of the Sandy River. In 1997 ODFW concluded that the juvenile fish screens and bypass facility at Marmot Dam were below agency criteria and that some impingement, entrainment, and migration delay was probably continuing to occur (ODFW 1997).



Key Boundaries

- Watersheds of the Sandy River Basin
- Middle Sandy River Watershed
- Urban Areas
- County Line

Roads

- Interstate Highways
- U.S. Highways
- State Highways

Site Features

- Rivers and Streams
- Former Dam Site
- Lakes
- Former Lake Site

N

Projection:
State Plane Oregon North
North American Datum 1983

1:152,010

Miles
0 0.5 1 2 3 4 5

Kilometers
0 1 2 4 6 8

Figure 4-9. Middle Sandy River Watershed

The SRBTT estimated anadromous fish currently use about 24 stream miles of habitat in the middle Sandy River Watershed (see Table 5-1). This total represents about 14 percent of the total stream miles (170 miles) currently used by anadromous fish in the Sandy River Basin. Anadromous fish in the middle Sandy River watershed historically used about 37 stream miles of habitat. The stream mileage estimates for this watershed do not reflect the latest passage improvements made by the Mt. Hood National Forest and other agencies.

Steelhead trout and coho salmon utilize all 24 of the accessible stream miles in the watershed. Both species used about 37 stream miles in the watershed historically. Fall Chinook currently use about 12 stream miles in the middle Sandy River watershed, compared to about 20 miles used historically. Spring Chinook currently use about 20 stream miles in the middle Sandy River watershed, approximately the same number of miles used historically. Anadromous cutthroat trout are assumed to use only the portion of the middle Sandy River watershed below the Marmot Dam site, but resident cutthroat trout are well distributed throughout the watershed.

Channel Conditions

Fish habitat has been altered in some areas of the middle Sandy River watershed. Following the flood of 1964, federal, state, and many other public and private entities worked cooperatively to straighten and deepen the channel along portions of the middle Sandy River. Some habitat diversity and complexity were lost as meanders, oxbows, and side channels were disconnected and remaining LW was removed.

Habitat types for the middle Sandy River watershed were evaluated in detail by USFS (1996) for those areas located within the boundaries of the Mt. Hood National Forest. This area primarily included the upper stream reaches of Alder and Cedar creeks above potential passage barriers to anadromous salmonid fishes. Aquatic habitat data for the portions of the middle Sandy River watershed located outside of the Mt. Hood National Forest were briefly summarized by USFS (1996), SRBWC (1999), and PGE (2002). A detailed study of physical habitat features was conducted by S.P. Cramer & Associates Inc. (1998) for portions of the mainstem Sandy River.

S.P. Cramer & Associates (1998) divided the mainstem Sandy River into four river reaches based on differences in habitat features and stream flow. The reaches are described below in a downstream direction.

The uppermost reach of the middle Sandy River (mouth of the Salmon River to the mouth of Whiskey Creek, RM 37.4—RM 31.8) was predominantly riffle habitat (69 percent), followed by glide habitat (21 percent), pool habitat (10 percent), and side-channel habitat (0.52 percent). The stream gradient averaged 0.9 percent and the substrate was mostly rock and sand. LW (defined by S.P. Cramer & Associates as being greater than 12 inches in diameter, 25 feet from the base) abundance was less than 2.5 pieces per mile. Based on aquatic habitat characteristics, anadromous fish use in this reach is primarily limited to migration, although S.P. Cramer & Associates documented unspecified juvenile salmonid fishes holding behind boulders.

Photo courtesy of Ethan Jewett, Oregon Trout.

The middle Sandy River from Whiskey Creek to the Marmot Dam site (RM 31.8—RM 30.1), was influenced by the presence of the dam. Stream gradient was only 0.2 percent compared with 0.9 and 0.8 percent, respectively, in adjacent upstream and downstream reaches. This reach had the highest percentage of pool (53 percent) and side-channel habitat (17 percent) and the lowest gradient of all reaches in the middle Sandy River watershed. This reach also had the greatest large wood abundance, averaging 22.5 pieces per mile. The majority of Chinook salmon production in the mainstem Sandy River above Marmot Dam was estimated to occur in this reach due to its shallow stream gradients, high percentage of pool and side-channel habitat, and high abundance of available spawning gravels.

S.P. Cramer Associates did not survey the Marmot gorge reach of the middle Sandy River from RM 30.1—RM 24.5 due to safety concerns; however, information for this reach does exist (Stillwater Sciences 2002; ODFW 2001). Downstream of the Marmot Dam site, the Sandy River flows for about five miles through a scenic narrow gorge that has steep canyon walls, constrained chutes, and deep trench-like pools. Human access to this section of the river is limited to only a few places where steep trails drop down to the river. The canyon walls consist primarily of basalts, sandstone sediments, and compacted volcanic ash conglomerates. The hard banks are usually welded volcanic bedrock of the Rhododendron Formation (Stillwater Sciences 2000). The reach is characterized by a one percent gradient, high confinement, and step-pool morphology, with only patch cobble/boulder deposits and long, deep bedrock pools that are separated by coarse-bedded riffles and boulder rapids. Large (house-sized) boulders are present in the channel, likely originating from the canyon walls. The stream channel is mainly composed of large and small boulders because the narrow channel likely transports the smaller sediments and cobbles. Even though spawning

habitat is probably limited in the canyon reach, deep pools provide late-migrating spring Chinook with good summer holding habitat. Pools may also be used for juvenile rearing. Riffles with coarse bed material also may provide rearing habitat for steelhead, but winter rearing is likely limited because of the high flows and shear stresses in the gorge.

The lowermost reach of the middle Sandy River (Revenue Bridge to the mouth of the Bull Run River, RM 24.5—RM 18.5) has an average gradient of 0.8 percent. Riffles were the dominant habitat type (52 percent), followed by pools (35 percent), and glides (13 percent). Side channels represented nine percent of the channel length. LW abundance in this reach was the lowest of all the reaches surveyed by S.P. Cramer & Associates (1998), averaging less than two pieces per mile. Gravels suitable for spawning substrate were limited in this reach because of high water velocities (PGE 2002). Cobble/boulder and cobble/gravel were the dominant substrates, reflecting the wide active channel and increased depositional potential over this reach (PGE 2002). A variety of species probably utilize this reach for various spawning, rearing, and migration strategies.

ODEQ assessed stream structure as part of the 1988 non-point source assessment (USFS 1996). Stream structure problems in the 1988 assessment were identified as moderate or severe for the portion of the mainstem Sandy River located in the middle Sandy River watershed. Insufficient stream structure, defined as the inadequacy of one or more physical components of a stream (e.g., stream bank, LW, pools, gravels), was anticipated to reduce channel stability, habitat, or flow-regulating characteristics (USFS 1996).

Several important tributaries flow into the Sandy River in the middle portion of the Basin, and the City is planning to implement conservation measures in several of them. The tributaries are Cedar, Alder, and Wildcat creeks. Cedar Creek is one of the largest low-gradient tributaries to the middle Sandy River and historically probably provided important habitat for several anadromous fish species. Alder and Wildcat creeks currently are utilized by steelhead and coho, and perhaps other species such as cutthroat.

USFS (1996) assessed habitat types for surveyed reaches of Alder and Cedar creeks using queries from the SMART database. Riffle habitat was the dominant habitat type for Cedar Creek (60 percent); pools made up approximately 25 percent of the stream length surveyed; and side channels accounted for about 10 percent of the area surveyed. Alder Creek was approximately 80 percent riffle, 15 percent pool, and less than 10 percent side-channel habitat. Based on this assessment, if anadromous fish passage was available in the upper reaches of Alder Creek, riffle habitat would favor steelhead and resident trout use over Chinook and coho salmon.

Pool frequency (number of pools per mile of stream) and pool area (square feet of pools per mile of stream) were calculated for the upper reaches of Alder and Cedar creeks by USFS (1996) from queries of the Stream Management, Analysis, and Tracking (SMART) database. Pool frequency and area were compared to the range of natural variation (established from unmanaged areas in the Mt. Hood Wilderness and Fir Creek subwatershed of the Bull Run watershed), and USFS Policy Implementation Guide (PIG) standards were used to assess habitat quality. [3] Pool frequency in Alder Creek was within the range of natural variation

[3] USFS compared habitat conditions to the range of variability in such conditions observed at reference sites in the region that were considered representative of relatively natural, undisturbed, or unmanaged conditions. USFS used habitat

(RNV), but below PIG standards. Pool volume was also within the RNV, but below the median value. Therefore, pools appeared to be relatively abundant in Alder Creek but were small on average. Pool frequency in Cedar Creek was above the RNV and PIG standards, and pool volume was well above the median RNV. Pool habitat appears to be high quality in Cedar Creek within the boundaries of the Mt. Hood National Forest.

4.3.3 Upper Sandy River Watershed

The upper Sandy River watershed (Figure 4-10) begins at an elevation of 11,047 feet at its eastern border on Mount Hood's summit and descends to an elevation of about 1,100 feet at its western border near the mouth of the Salmon River at RM 37.5. The upper Sandy River from its headwaters to the boundary of the Mt. Hood National Forest (12.4 miles) was designated as a National Wild and Scenic River in 1988 (USFS 1996). The upper Sandy River drops quickly in elevation as it flows through unstable volcanic rock and ash deposits in its upper reaches. According to the USFS (1996), 14,944 acres in the upper watershed are located in the Mt. Hood Wilderness Area.

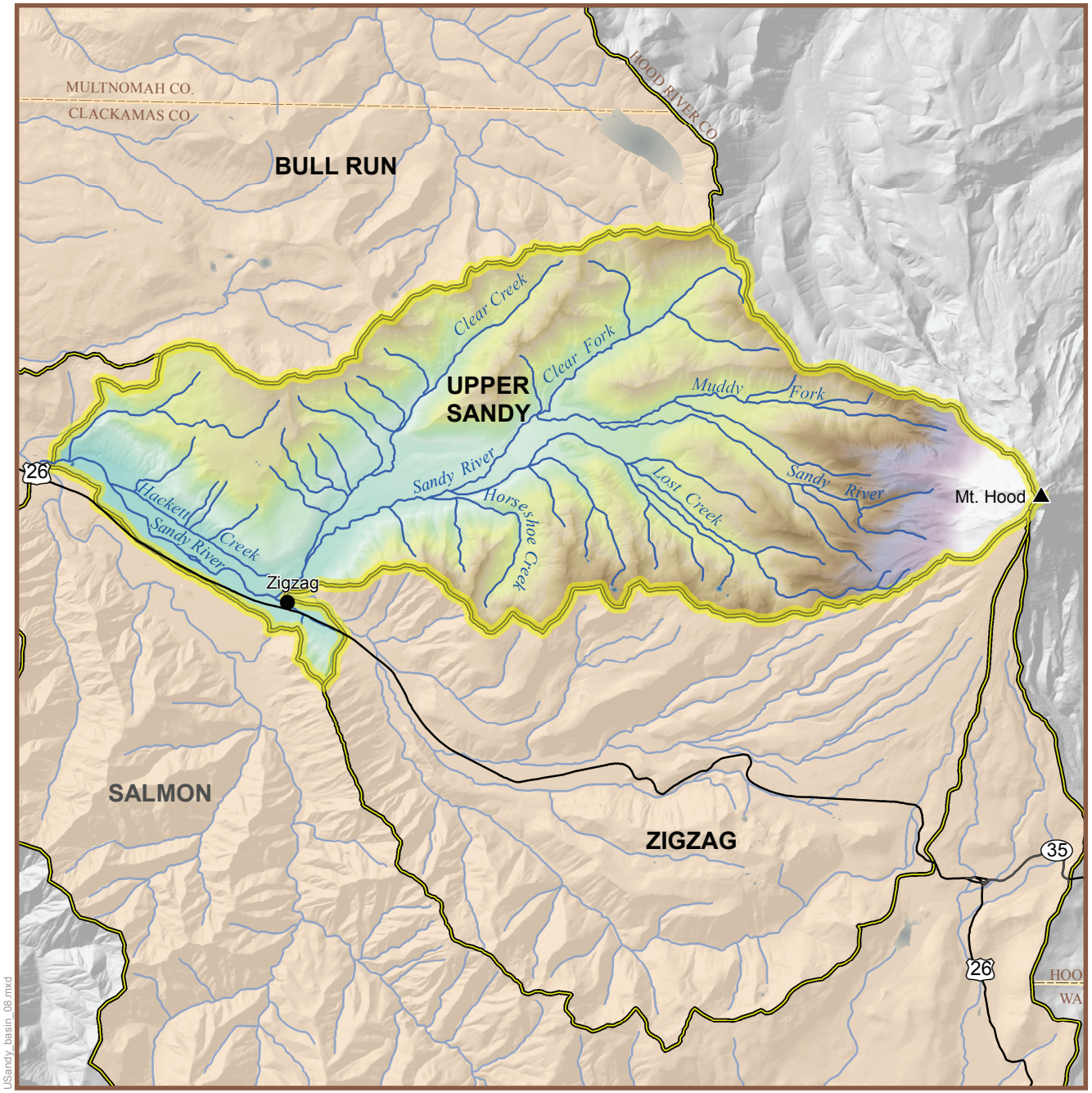
Primary sources of surface water in the watershed include glacial melt, spring-fed tributaries, and several high Cascade lakes. Large tributaries in the watershed include Muddy and Clear forks of the Sandy River, and Rushing Water, Lost, Cast, Clear, and Hackett creeks. Land ownership in the watershed includes private holdings and land owned by USFS (Mt. Hood National Forest), BLM, and Clackamas County.

According to USFS (1996), portions of the upper Sandy River have been straightened, channelized, and armored following extensive flood damage caused by the 1964 flood and due to development that has occurred along the reach from Zigzag to Brightwood.[4] USFS (1996) also identified structures placed in Clear Creek by private landowners to armor the stream banks from erosion. As a result of these activities and others, the lower 3.2 miles have been channelized, and subsequent down-cutting of the channel has been observed.

Sediment sources vary by location within the watershed. Mass wasting, surface erosion, stream channels, and glacier melt are principal sources of sediment production. Streams originating from the northwest, west, and southwest facing slopes of Mount Hood typically are glacial-fed. Glacial streams receive substantial coarse and fine sediment loads and exhibit turbid conditions due to suspended glacial flour, particularly during the summer months. Hillslope and channel erosion in some tributaries in the steeply sloping upper reaches of the Basin have been attributed to mass wasting and debris torrents, primarily in the Muddy Fork drainage (USFS 1996). Such erosion has been generally attributed to timber harvest, fire burn, and road construction (USFS 1996), although such activities have been minimal in the past decade (Shively, USFS, pers. comm., 2003). Clear Creek, Clear Fork, Horseshoe Creek, and the upper Sandy River have the highest potential sediment production, primarily as a result of roads. Sediment inputs from stream channels are high in most streams in the upper

standards based on *Columbia River Basin Anadromous Fish Policy Implementation Guide* (PIG) objectives. These include habitat standards to aid selection on habitat enhancement projects for streams used by anadromous fish (USFS 1991).

[4] In November 2006, the Sandy River also experienced a flood event. As a result, several areas in the Sandy River Basin are under review by ODFW to determine the extent of the changes to the habitat.



Key Boundaries

- Watersheds of the Sandy River Basin
- Upper Sandy River Watershed
- County Line

Roads

- Interstate Highways
- U. S. Highways
- State Highways

Site Features

- Rivers and Streams
- Lakes

N

Projection:
State Plane Oregon North
North American Datum 1983

1:160,773

Miles
0 0.5 1 2 3 4 5

Kilometers
0 1 2 4 6 8

Figure 4-10. Upper Sandy River Watershed

Sandy River watershed. The high stream bank failure potential is evident in the mudflow deposits that the Sandy River and Muddy Fork Sandy River pass through in the upper reaches of the watershed (USFS 1996).

Habitat Access

Stream passage barriers in the upper Sandy River and tributaries are primarily of natural origin (i.e., barrier falls), but one small hydropower facility built on Minikahda Creek (a tributary of Clear Creek) is a passage barrier to anadromous fish (USFS 1996). The SRBTT estimated that the upper Sandy River watershed contains about 44 stream miles of habitat that are currently used by anadromous fish (Table 4-8), the most of any watershed in the Sandy River Basin. This total represents about 26 percent of the total stream miles (170 miles) currently used by anadromous fish in the Basin. However, the stream mileage estimates for this watershed probably do not reflect the latest passage improvements made by the Mt. Hood National Forest or other agencies.

Of the 44 stream miles, all are used by steelhead—about the same number of miles as the species used historically. Spring Chinook and coho salmon currently use about 29 and 30 stream miles, respectively, in the upper Sandy River watershed—also about the same number of miles as used historically. Fall Chinook do not currently use areas in this watershed, although historically the habitat might have supported use of about 23 stream miles. Anadromous (sea-run) cutthroat trout are assumed no longer to occur in the upper Sandy River watershed, but resident cutthroat trout are well distributed throughout the watershed.

Channel Conditions

The upper Sandy River travels from its source at elevation 6,200 feet on the western flank of Mount Hood to an elevation of 1,600 feet at its confluence with the Salmon River, which is 13 miles downstream (Northwest Power Planning Council [NWPPC] 1990). The upper Sandy River has a high stream gradient and carves through unstable volcanic ash and rock deposits. The average gradient in the upper Basin is about 10 percent. The headwaters of the Sandy River are above tree line, where there is little vegetation to stabilize stream banks, and sediment inputs and bedload movement are high. Fish production in these high-elevation stream reaches is limited by a high gradient and water turbidity.

Farther down the Sandy River, near the towns of Rhododendron and Zigzag (RM 38—RM 43), the stream substrates are typically composed of loose alluvial rock. The stream gradient is moderate and consistent, averaging about 1.3 percent from the Zigzag River downstream to Sleepy Hollow Bridge, which is slightly downstream of the Salmon River. The bottom substrates in this stream reach are mostly small boulders, cobbles, and gravel. Glacial sediment deposits may be thick where the stream gradient lessens, and spawning gravels are often embedded with fine sediments at those locations. In this reach, high flows still significantly affect channel form. In contrast, the adjacent Salmon River is dominated by mostly basaltic lava rock and channels are generally more constrained and less prone to lateral scour during floods (NWPPC 1990; USFS 1999).

During the summer dry season, glacial runoff releases large quantities of sediments into the upper Sandy River and Muddy Fork, resulting in increased turbidity downstream. However, streamflow releases from high-elevation glaciers and snowpack provide cool water temperatures and adequate flows for summer and fall migratory fish seeking clear-water spawning tributaries upstream, such as the Clear Fork of the Sandy River, Lost Creek, Clear Creek, and Hackett Creek; all are important spawning and rearing tributaries in the upper Sandy River watershed. Many other small tributaries located in the upper watershed contribute to the overall natural production of anadromous and resident fish in the Sandy River Basin.

North Boulder Creek is also an important tributary to the upper Sandy River, and the City is proposing to implement conservation measures in this stream. The stream channel averages seven percent gradient in the lower reach, and the bottom substrate is dominated by boulders. The stream channel is also lacking large wood, and sedimentation levels are high due to road runoff and poor riparian conditions.

Data on aquatic habitat types, pool abundance, LW in the upper Sandy River watershed are available from the Stream Management, Analysis, Reporting, and Tracking (SMART) database for streams within the boundaries of the Mt. Hood National Forest. USFS (1996) conducted queries of the SMART database to establish the dominant habitat types present in the upper Sandy River watershed. The upper Sandy River and Muddy Fork have little to no pool habitat and are predominantly riffle habitat, with limited side channels. Clear Fork, Lost Creek, and Clear Creek are all similar in vegetation type and stream order stratification. Habitat types in these streams are approximately 70 percent riffle, with generally 25 percent or less pool habitat and 15 percent or less side-channel habitat.

Pool frequency was calculated by USFS (1996) using the SMART database. The assessment was used to compare pool quantity to RNV and PIG standards. Stream reaches from unmanaged areas in the Mt. Hood Wilderness and the Fir Creek subwatershed of the Bull Run were used to establish the RNV for pools and LW. Pool frequency was within or above the RNV for all streams in the upper Sandy River watershed, with the exception of the mainstem upper Sandy River. However, all of the streams in the upper Sandy River watershed were below the standards. The upper Sandy River is located in the Mt. Hood Wilderness Area, so it is likely that the present state of the stream is representative of relatively natural, undisturbed conditions. A lack of pool habitat could be attributed to the natural geology of this section of stream. The upper Sandy River flows through extensive mudflow deposits, leaving little opportunity for pool formation (USFS 1996).

To further evaluate the availability of pool habitat in the upper Sandy River watershed, pool volume was assessed as a measure of square feet of pools per mile of stream. Pool volume was determined by USFS (1996) to be above the median for RNV or above the RNV for nearly all streams assessed in the Sandy River Basin. The exceptions were Muddy Fork and the upper Sandy River mainstem. Muddy Fork was at the low end of the RNV; the upper Sandy River was outside and below the RNV. The lack of abundance of pool habitat and pool area in larger streams in the upper Sandy River watershed probably indicates limited suitable habitat for Chinook salmon. The pool frequency and pool area in smaller tributaries appear to be suitable for habitat requirements of coho salmon, steelhead, and resident trout.

4.3.4 Salmon River Watershed

The Salmon River originates from the Palmer Glacier on the south slope of Mount Hood and empties into the Sandy River at RM 38. Since glaciers on the south-facing slopes have mostly vanished as a result of climate changes over the past several thousand years, streams in the watershed are not currently glacially influenced. Consequently, Salmon River watershed streams do not receive sediment loads similar to glacial streams. The Salmon River usually runs clear all year and provides significant miles of spawning and rearing habitat for both anadromous and resident fish species. Figure 4-11, on the following page, is a map of the Salmon River watershed.

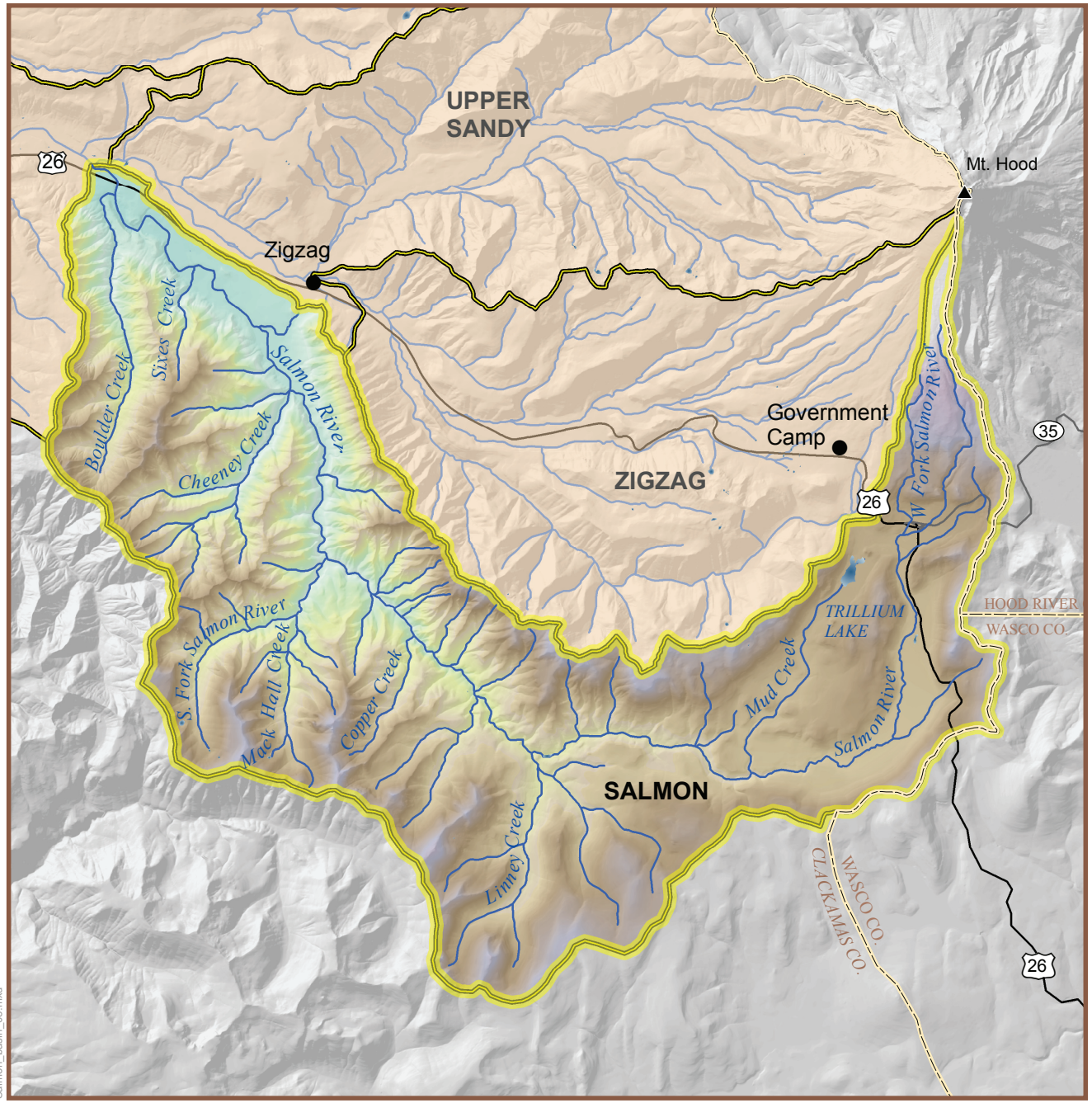
The Salmon River watershed encompasses approximately 74,240 acres (116 square miles) in Clackamas County (USFS 1995a). Elevations within the watershed range from about 10,000 feet at its headwaters on the south slope of Mount Hood to 1,100 feet at its confluence with the Sandy River at Brightwood. From its headwaters on the Palmer Snowfield, the river flows for 33 miles, through the Salmon-Huckleberry Wilderness and through a mix of BLM, Clackamas County, and private lands. USFS manages the upper 25 miles within the Mt. Hood National Forest. The lowermost eight miles are managed by BLM. Major tributary streams in the watershed include the West Fork and South Fork Salmon River, and Mud, Linney, Cheeney, Mack Hall, and Boulder creeks.

Habitat Access

The Salmon River is free-flowing throughout its entire length and was designated a Federal Wild and Scenic River in 1988. Final Falls, a 60-foot-high cascade located at about RM 14 on the Salmon River, is the upstream limit of anadromous fish distribution. The lower 14 miles of the Salmon River provide some of the most diverse and productive salmon and steelhead habitat in the Sandy River Basin. The lower Salmon River also serves as an important migration corridor for upstream migrating adults and downstream migrating juveniles. Important tributaries to the lower Salmon River that support anadromous fish include the South Fork Salmon River and Boulder, Cheeney, and Mack Hall creeks. The uppermost 20 miles above Final Falls contains excellent habitat conditions for resident salmonids.

Anadromous fish, including spring Chinook, coho salmon, and winter steelhead trout, currently use about 28 stream miles of habitat in the Salmon River watershed. This total represents about 16 percent of the stream miles (170 miles) in the Sandy River Basin accessible to anadromous fish species. Historically, anadromous fish used approximately the same number of stream miles of habitat in the watershed.

Currently, fall Chinook salmon do not use the Salmon River watershed. It is estimated that fall Chinook used about 21 miles historically (CH2M HILL 2005). Coastal cutthroat trout are assumed no longer to occur in the Salmon River watershed, but resident cutthroat trout are well distributed throughout the watershed.



Key Boundaries

- Watersheds of the Sandy River Basin
- Salmon River Watershed
- County Line

Roads

- U.S. Highways
- State Highways

Site Features

- Rivers and Streams
- Lakes

N

Projection:
State Plane Oregon North
North American Datum 1983

1:186,227

Miles
0 0.5 1 2 3 4 5 6

Kilometers
0 1.25 2.5 5 7.5 10

Figure 4-11. Salmon River Watershed

Channel Conditions

USFS (1995a) has rated the habitat conditions for the lower 14 miles of the Salmon River as generally good. Water quality is excellent for the production of salmonids because the river is usually clear and cool in the summer. This is in contrast to some of the other large tributaries to the Sandy River that transport large amounts of glacial flour in the summer. The Salmon River and its tributaries have a great diversity of habitat types, ranging from low-gradient, wide meandering river channels to small high-gradient creeks. Most of the Salmon River watershed is dominated by moderate-sized stream reaches with boulder and rubble substrate, riffle-dominated, with frequent large pools due to the presence of bedrock outcrops, large boulders, or old-growth trees that have fallen into the stream. The various habitat types support the production of steelhead and trout, coho, and Chinook salmon.

Large floods have degraded the habitat in recent years. Floods in 1964, the 1970s, and the late 1990s scoured the channel and removed much of the LW from the system.[5] Following some of these floods, the Army Corps of Engineers, USFS, and other agencies and private individuals removed any remaining logs and boulders from the mainstem Sandy River channel from its mouth to the confluence with the South Fork of the Salmon River (USFS 1995a). The channel was also deepened and straightened throughout this area, which cut off meanders, oxbows, and side channels. Very important habitat was lost, and those actions still affect the mainstem Salmon River today.

The first 7.4 miles of the Salmon River are on private land. Approximately 50 percent of the banks have been stabilized with riprap by landowners in this reach, which has a stream gradient of approximately one percent. Because of the channelization, the stream is characterized by long stretches of relatively deep riffle habitat.

From RM 7.4—RM 14.3 (Final Falls), the Salmon River is on federal land (Mt. Hood National Forest). The average stream gradient is about 1.6 percent and the dominant stream substrate is small cobbles.

As described by USFS (1995a), the typical habitat for the watershed is a moderate-sized stream with boulder and rubble substrate. The streams are riffle-dominated, with frequent large pools created by bedrock outcrops, large boulders, or old-growth trees in the stream. Aquatic habitat types were evaluated to assess habitat quality for anadromous and resident fish using information from the SMART database. Based on USFS (1995a) assessments, riffle habitat was the dominant habitat type in the Salmon River watershed. Habitat types in the watershed accessible to anadromous salmonid fishes were compared with habitat types in the South Fork of the McKenzie River to establish RNV. Side-channel frequency was lower on the Salmon River from the mouth upstream to the South Fork Salmon River compared to RNV. However, riffles and pools were in the same range for the two basins. Side channels were more prevalent in the lower Salmon River prior to habitat alterations following the floods of 1964 and 1974. For the portions of the watershed supporting resident fish, a diversity of adequate habitats exists for all life stages of the species.

[5] Flooding occurred in tributaries in the Sandy River Basin in November 2006. As of February 2007, the area is under review by ODFW to assess the habitat changes that resulted from this event.

USFS (1995a) conducted an assessment of pool frequency in terms of the number of pools per mile of stream for the Salmon River and major tributaries within the watershed. Pool frequencies were compared to the RNV and PIG standards. RNV was approximated from data about the Lewis River in the Gifford Pinchot National Forest, which USFS (1995a) concluded was the closest approximation to pool conditions in the Salmon River.

For the purpose of the assessment, the watershed was divided into three major reaches (USFS 1995a). The lower reach consisted of the lower Salmon River from RM 0.0—RM 7.2. The middle reach consisted of the mainstem Salmon River from RM 7.2—RM 18.2, including Boulder, Cheeney, and Mack Hall creeks, and the South Fork Salmon River. The upper reach consisted entirely of resident fish habitat, including the Salmon River from RM 18.2—RM 26.9, as well as Linney, Draw, Inch, String, and Mud creeks. Pool frequency in the lower, middle, and upper reaches was determined to lie outside the RNV and below PIG standards, with two exceptions: Boulder Creek, which was within the RNV and just below PIG standards; and Mud Creek, which met both standards. In general, USFS (1995a) attributed substandard pool frequencies throughout most of the middle and lower reaches of the watershed to channelization efforts following large-scale floods in the 1960s and 1970s. Substandard frequencies in the middle and upper reaches, not impacted by channelization efforts, were attributed to the presence of high channel gradients throughout most of the upper watershed.

USFS (1995a) suggested that sediment delivery from existing roads, highway sanding, and mass wasting were the largest contributors to potential sediment in the Salmon River Watershed. However, mass wasting was considered to be the primary source of sediment delivery exclusively in the lower watershed. The West Fork and East Fork Salmon River subwatersheds have the highest potential for sediment delivery from highway sanding, at over 2,000 tons per year, while the upper Salmon River watershed has a potential sediment delivery of about 377 tons per year (USFS 1995a). Specifically, Highway 35 from the junction with Highway 26 to the watershed boundary has the highest potential for sediment delivery of any road in the watershed.

Over the years, many small low-gradient tributaries and wetlands located on private land in the watershed have been channelized, drained, and filled (USFS 1995a). Historically, these streams and wetlands were important to coho salmon spawning and rearing in the Salmon River watershed. At least one significant wetland complex exists in the Welches area at the Wildwood Recreation Site (USFS 1995a). Timber harvest, fire, recreation, urbanization, livestock grazing, and sediment inputs from road sanding have all impacted aquatic habitat in the watershed.

4.3.5 Zigzag River Watershed

The Zigzag River watershed (Figure 4-12) covers about 37,730 acres in Clackamas County (USFS 1995b). Most of the watershed is in the Mt. Hood National Forest, and about 11,216 acres are wilderness areas and 1,690 acres are alpine areas. About 1,248 acres are developed and 988 acres are in private ownership. Highway 26 essentially bisects the watershed. Elevations in the watershed range from 1,400 to 10,000 feet.

The Zigzag River originates from Zigzag Glacier, carves its way through volcanic mudflow deposits, and terminates in alluvium near its confluence with the Sandy River. The Zigzag River is a steep-gradient stream from the headwaters to the lower two miles, where it transforms to a more moderate-gradient sediment depositional area. Large tributary streams in the watershed include the Little Zigzag River and Lady, Devils, Camp, Henry, and Still creeks.

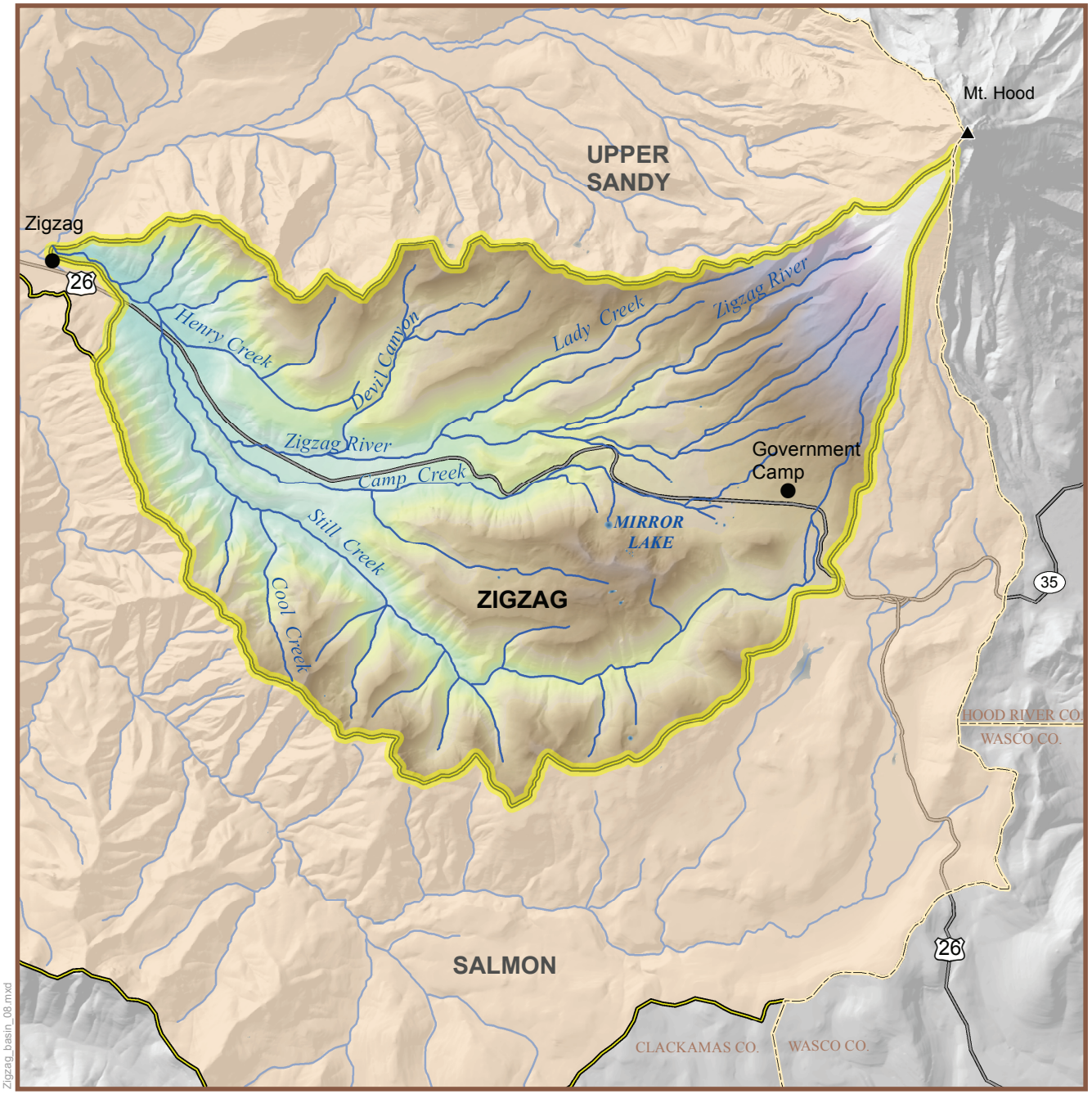
Only about three percent of the watershed area is developed. However, developments such as the Highway 26 corridor, several small towns (e.g., Welches, Rhododendron, Zigzag), summer homes, and ski areas occur in concentrated areas near or adjacent to the Zigzag River. River and floodplain habitat in these areas has been affected by development-related factors such as channelization, road sediment, highway sanding, and recreation activities.

Habitat Access

The SRBTT estimated anadromous fish currently use about 30 stream miles of habitat the Zigzag River watershed (see Table 4-8). This total represents about 18 percent of the total stream miles (170 miles) currently used in the Sandy River Basin. Historically, anadromous fish likely had access to more stream miles in the watershed. Human-made structures have blocked access to some streams. USFS (1995b) reported that access to fish habitat in the watershed was blocked at various locations by migration barriers. Some of these barriers have since been corrected. Culvert barriers remain at Henry Creek and the upper Little Zigzag River. Lady Creek is partially blocked by old dams and fill material at its mouth (one mile), although fish passage has been improved in the area by adding step pools. The Oregon Department of Transportation (ODOT) identified several road culverts in need of repair to allow for improved fish passage conditions. The Mt. Hood National Forest has an ongoing program to improve these fish passage problems.

The Zigzag River and its tributaries provide important and productive spawning and rearing habitat for native salmon and steelhead in the watershed. The Zigzag River also serves as an important migratory corridor for anadromous fish to reach tributary habitats. Still and Camp creeks are recognized for providing high quality spawning and rearing habitat for salmon and steelhead and are important natural production areas (ODFW 1997). Smaller tributaries in the watershed also make a significant contribution to overall natural fish production (ODFW 1997).

All 30 miles of habitat currently utilized in the Zigzag River watershed are used by steelhead trout. This total is the same number of stream miles in the watershed used historically by steelhead. Spring Chinook and coho currently use about 23 stream miles in the Zigzag River watershed, which is also the same number of miles as used historically. Fall Chinook do not currently utilize the Zigzag River watershed. Fall Chinook are estimated to have used about 18 miles historically. Anadromous cutthroat trout are assumed no longer to occur in the Zigzag River, but resident cutthroat trout are well distributed throughout the watershed.



Key Boundaries

- Watersheds of the Sandy River Basin
- Zigzag River Watershed
- County Line

Roads

- Interstate Highways
- U.S. Highways
- State Highways

Site Features

- Rivers and Streams
- Lakes

N

Projection:
State Plane Oregon North
North American Datum 1983

1:132,053

Miles
0 0.5 1 2 3 4

Kilometers
0 0.5 1 2 3 4 5 6

Figure 4-12. Zigzag River Watershed

Channel Conditions

Habitat conditions for salmonids in the Zigzag River watershed range from low to high quality (USFS 1995a). The mainstem Zigzag River and its tributaries have a broad diversity of habitat types, ranging from low-gradient, wide, meandering river channels to small, high-gradient, glacier-fed creeks. The typical habitat for the watershed is a moderate to small-sized stream with boulder and rubble substrate, moderate to steep gradients, moderate to low levels of pools, and in-channel large woody debris.

The 1964 flood scoured channels and swept much of the large woody material out of the Zigzag system (USFS 1995b). After the flood, the Army Corps of Engineers, USFS, other public agencies, and private individuals removed remaining large logs and boulders from sections of Still Creek, Camp Creek, and the Zigzag River. The Zigzag River was deepened and straightened, which cut off meanders, oxbows, and side channels. Substantial amounts of aquatic habitat were lost, and the diversity and quality of aquatic habitat were reduced by these actions.

USFS (1995b) calculated sediment sources in the watershed with a high potential for delivery to perennial streams. These sources included road sediment, highway sanding, recreation activities, and timber harvest. Existing roads and highway sanding were found to be the largest contributors of potential sediment in the watershed. Though overall road density appears low, most roads have been placed directly adjacent to major streams and tributaries. Highway 26 and Still Creek Road (FS 2612) have the highest potential for sediment delivery in the watershed. Many unstable stream reaches in lower Camp Creek and the lower Zigzag River are high-risk areas for bank erosion and channel migration (USFS 1995b).

Fish habitat has been degraded in some areas. RM 2.2—RM 7.3 on the Zigzag River is a stream reach with high potential for disturbance, sediment supply, and/or bank erosion potential. This reach is located immediately upstream of an area of high quality habitat for anadromous fish (USFS 1995b). Timber harvest, fire, recreation, and sediment from roads and highway sanding have all affected aquatic habitat in the watershed.

Habitat types for the Zigzag River watershed were evaluated by USFS (1995b) using data from the SMART database relating to the presence and quantity of mesohabitat types (e.g., riffles, glides, pools, side channels). Riffle habitat was the dominant habitat type throughout the watershed. The mix of habitat types was similar to the relatively undisturbed Bull Run River watershed (USFS 1995b). The major difference between the watersheds was lower levels of pool habitat in the anadromous reaches of the Zigzag River compared with those in the Bull Run River watershed. USFS (1995b) concluded that the lower levels of pool habitat in the anadromous reaches favor steelhead trout in the Zigzag River over both coho and Chinook salmon. A mixture of habitat types in the portion of the watershed supporting resident fish provided adequate habitat for existing species. For instance, there were plenty of riffles and glides for resident rainbow trout, and glides and pools for cutthroat and brook trout.

Pool frequency (number of pools per mile of stream) calculated from queries of the SMART database were compared with pool frequency using the RNV and PIG standards (USFS 1995b). Of the watersheds assessed in the Regional Ecosystem Assessment Project, USFS

(1995b) concluded that the RNV for the Lewis River in the Gifford Pinchot National Forest in southwest Washington was the best approximation for stream type and vegetation conditions in the Zigzag River watershed. Excluding Wind Creek, the frequency of pools in the Zigzag River watershed was at or below the RNV. The frequency of pools was at the lower end of the RNV in Camp Creek and below the range in Cool, Lady, and Still creeks and the Little Zigzag and Zigzag rivers, as well as below PIG standards.

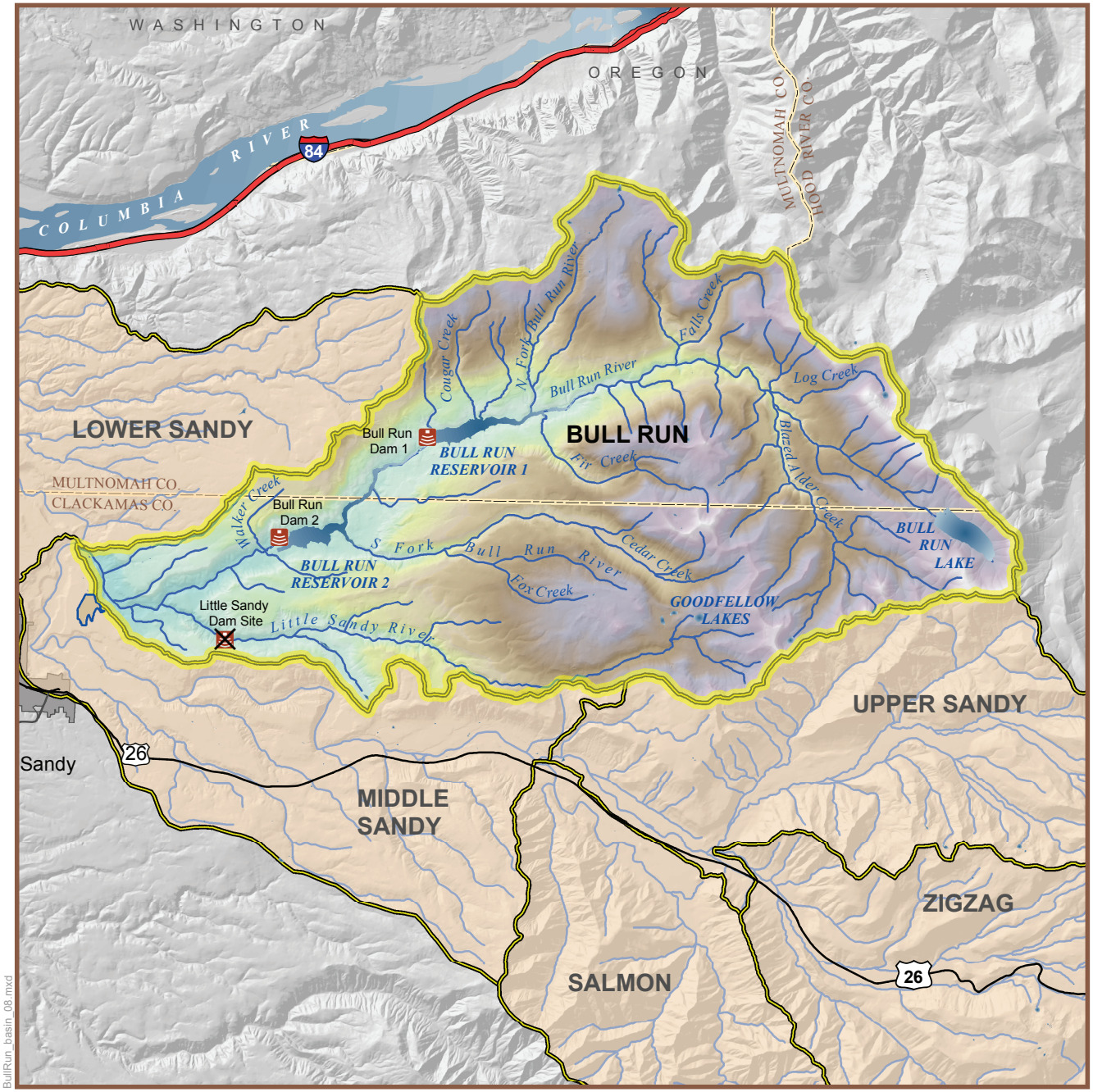
To further assess the quantity of pool habitat in the Zigzag River watershed, USFS (1995b) also determined total area of pools (square feet of pools per mile of stream) for various stream reaches. The pool areas were greatest in the large stream reaches (the lower portions of Camp Creek, Still Creek, and the Zigzag River). The small, steep gradient reaches in the watershed (Cool Creek, Little Zigzag River, Henry Creek, and Wind Creek) had the lower pool areas. Wind Creek exhibited the highest frequency of pools in the watershed, yet one of the lowest with respect to pool area. USFS (1995b) attributed the low level of pool habitat in much of the Zigzag River watershed to the transport of pool-forming LW out of the system by large floods in 1964 and 1972. Shortly after the flooding, USFS, the Army Corps of Engineers, and other entities removed remaining LW and boulders to improve stream flow capacity.

4.3.6 Bull Run River Watershed

The Bull Run River watershed (Figure 4-13) encompasses 88,962 acres (139 square miles) and includes nine subwatersheds (USFS 1997). A total of 78,899 acres of the watershed is under federal (USFS and BLM) ownership; 4,426 acres are owned by the City of Portland; 595 acres are owned by PGE until the planned dam decommissioning is complete; and 5,042 acres of the watershed are owned by private entities. Elevations in the watershed range from 260 to 4,750 feet. Annual precipitation ranges from 52 to 143 inches; however, snowfall is rare below 2,000 feet (USFS 1997).

Bull Run River is a large, clear-water tributary, unaffected by Mount Hood glaciers, that enters the Sandy River at Dodge Park (RM 18.5) near the City of Sandy. The mainstem is approximately 25 miles long and originates from springs below Bull Run Lake (elevation 3,180 feet), a large natural lake to the northwest of Mount Hood. Many large tributary streams also contribute significantly to the flows produced in the Bull Run watershed. Historically, flows from the Bull Run watershed represented approximately a third of the average annual flow in the Sandy River entering the Columbia River.

Important tributary streams draining into the Bull Run River watershed include the North and South forks of the Bull Run River, the Little Sandy River, and Blazed Alder, Fir, Cougar, and Camp creeks. The Little Sandy River is a large tributary stream emptying into the Bull Run River at RM 3 (four miles below the City's Headworks Dam).



Key Boundaries

- Watersheds of the Sandy River Basin
- Bull Run River Watershed
- Urban Areas
- County Line

Roads

- Interstate Highways
- U.S. Highways
- State Highways

Site Features

- Dam
- Former Dam Site
- Rivers and Streams
- Lakes
- Former Lake Site

N

Projection:
State Plane Oregon North
North American Datum 1983

1:228,271

Miles
0 0.5 1 2 3 4 5 6

Kilometers
0 1.25 2.5 5 7.5 10

Figure 4-13. Bull Run River Watershed

Habitat Access

Anadromous fish historically used about 49 stream miles in the Bull Run River watershed, which includes 10 miles of stream for the Little Sandy River (see Table 4-8). Of the 39 stream miles for the Bull Run River portion, approximately nine miles are now inundated by Bull Run reservoirs. Steelhead and lamprey probably had access to all 49 miles of streams. Coho, Chinook (spring and fall) salmon, and coastal cutthroat trout probably had access to approximately 40 out of the 49 miles in the watershed.

Anadromous fish currently use about 7.5 stream miles of stream habitat in the Bull Run River watershed. Of this total, approximately 5.8 miles are in the lower Bull Run River downstream of the Headworks, with an additional 1.7 miles in the Little Sandy River. This distance represents about 4.7 percent of the total stream miles (170 miles) currently used by anadromous fish in the Sandy River Basin.

The Bull Run and Little Sandy rivers provide limited migration, spawning, and rearing habitat for anadromous and resident fish species in the Bull Run River watershed downstream of hydroelectric and water diversion projects. Fish passage is blocked at RM 5.8 on the lower Bull Run River and at RM 1.7 on the Little Sandy River. Other tributaries to the lower Bull Run River have limited productivity potential for anadromous fish due to steep gradients or natural waterfalls (City of Portland 2002). Additionally, a culvert in Walker Creek blocks access to about 500 feet of this lower Bull Run River tributary (City of Portland 2002).

Fall and spring Chinook, coho, and steelhead currently use all of the accessible 7.5 stream miles in the Bull Run River watershed. Anadromous cutthroat trout are assumed to use the lower Sandy River (below the Marmot Dam site), including the lower Bull Run River, although there have been few recent observations. Resident cutthroat trout are well distributed throughout the watershed.

Important habitat for resident, fluvial, and adfluvial forms of coastal cutthroat trout is known to exist upstream of dams in the upper Bull Run and Little Sandy rivers. These cutthroat trout populations have been protected by the lack of competition from anadromous fish in both subwatersheds and the curtailment of recreational fishing since the late 1800s in the upper Bull Run River watershed.

Channel Conditions

USFS (1997) evaluated habitat types for the Bull Run River watershed using data from the SMART database relating to the presence and quantity of channel habitat types (e.g., riffles, glides, pools, side channels). With the exception of the upper Little Sandy River, riffles dominated the habitat composition for mainstem channels in the watershed. USFS (1997) concluded that anadromous fish-bearing streams in the watershed exhibited a high percentage of riffle and large pool habitat but were limited in side-channel habitat. The agency hypothesized that habitat conditions favored steelhead trout and Chinook salmon over coho salmon. Suitable habitat for rainbow trout and other resident fish species appeared to exist in the Little Sandy River, where riffle, pool, and glide habitats account for 43, 33, and 15 percent of total habitat, respectively. The upper Bull Run River exhibited a

high percentage of riffle habitat suitable for resident cutthroat trout, but it lacks adequate pool and glide habitat for other species. The habitat in the upper Bull Run, with the exception of the inundated area, is close to historical condition.

Sediment production in the watershed was assessed by USFS (1997) and attributed to three principal causes: mass wasting, land disturbances, and stream channel geomorphic processes (e.g., flow-induced channel erosion and sediment transport). Landslide mapping in the Bull Run River watershed identified less than two percent of the total watershed area as highly susceptible to landslides. Land disturbances in the Bull Run River watershed were not found to be large contributors to the watershed's sediment budget. USFS (1997) concluded stream channel geomorphic processes were the dominant source of sediment in the watershed.

Spawning gravels are scarce in the lower Bull Run River and probably limit the production of anadromous salmonid fishes in the river (R2 Resource Consultants 1998b). High water velocities occurring during peak flow periods reduce gravel quantity. Much of the river is situated in a canyon, and it is confined to a relatively narrow channel by steep bedrock walls. River velocities can become high enough to mobilize and transport gravel and larger streambed materials.

River discharge and depth also influence the availability of spawning gravels because the number of gravel patches with sufficient spawning depth increases directly with stream flow. As an example, in 1997 a total of 21 gravel patches in the lower Bull Run River were predicted to be suitable for steelhead spawning under early spring flow conditions (R2 Resource Consultants 1998b). A total surface area of 3,580 square feet of suitable gravel was estimated to support up to 96 steelhead redds under median flow conditions during the spring spawning period. However, many of these redds were likely subject to desiccation due to subsequent dewatering during low flow periods. R2 Resource Consultants (1998b) predicted only 15 of these redds would be viable throughout the fry emergence period. Although subsequent provisional minimum flow release for the lower Bull Run River and a gravel supplementation by the City have dramatically increased the available spawning gravels and likelihood of fry recruitment from anadromous fish spawning, the quantity of gravel may still limit the production potential of the lower reaches.

USFS (1997) calculated pool frequencies as a measure of the number of pools per mile of stream. Pool frequency in the Bull Run River watershed was obtained from queries of the SMART database and then compared to the RNV and PIG standards. The RNV was approximated from unmanaged stream reaches by stream order across the Sandy River Basin (USFS 1997). Of the 11 streams assessed, only Blazed Alder Creek and the South Fork Bull Run River met PIG standards. All streams assessed were within the RNV for pool frequency except for the upper Bull Run River. The Little Sandy River and lower Bull Run River were within the RNV, but at the low end.

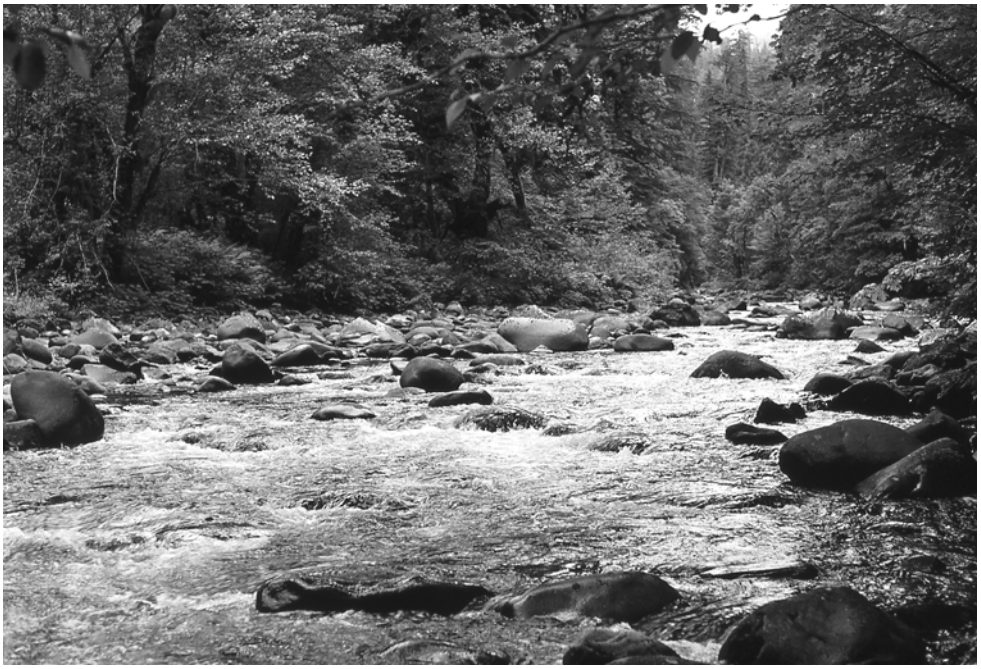


Photo courtesy of Char Corkran.

To further quantify pool habitat in the Bull Run River watershed, USFS (1997) assessed pool volume as a measure of square feet of pools per mile of stream. The upper and lower Bull Run River and the Little Sandy River were at the low end or outside of the RNV for pool frequency. However, they were at the high end or above the RNV for pool volume. This result indicates pool frequency is low but pools are large in volume and presumably of high quality (USFS 1997). Of the other nine streams assessed for pool volume, only two (Fir Creek and Otter Creek) were below the RNV.

The portion of the watershed accessible to anadromous salmonid fishes generally has low pool counts but high pool volumes. This situation typically provides good habitat for Chinook salmon because of the presence of large mainstem pools. The portion of the watershed utilized by resident fish appears to have adequate pool habitat for rainbow (upper Little Sandy River) and cutthroat (upper Bull Run River) trout.

Water management in the Bull Run River watershed has altered the hydrological profile of both the 5.8-mile reach of the lower Bull Run River downstream of Headworks Dam and the 1.7-mile reach of the Little Sandy River downstream of the Little Sandy Diversion Dam. PGE limits spill events in the Little Sandy River to the greatest extent possible (PGE 2002). Spilling water over the dam drastically increases flows and can attract anadromous fish into the Little Sandy River. When flows subsequently decrease, the channel is dewatered and fish can become stranded.

Water diverted from the Sandy River was combined with Little Sandy River water and transported through a series of canals and flumes into Roslyn Lake for power generation at PGE's Bull Run Hydroelectric Project (RM 1.7). Because the combined Sandy/Little Sandy water source was discharged to the lower Bull Run River, anadromous salmonids initially homing to the Sandy River may have been attracted to the Bull Run River. Straying due to false attraction could adversely influence spawning success if fish migrate upstream past

PGE's Bull Run Powerhouse in spring or early summer months. These fish may be exposed to reduced summer base flows, high water temperatures, and limited spawning habitat (PGE 2002). Fish migrating back downstream in search of suitable spawning habitat can experience migration delay and lost fitness. As noted elsewhere in the HCP, PGE's hydroelectric project is being decommissioned and this diversion of water from the Sandy River to the Bull Run River will no longer occur after early 2008.

In the Bull Run River, approximately 20 percent of the water annually draining to Headworks Dam is transported out of the watershed for municipal water supply (SRBWC 1999). Consumptive water use reduces base stream flows in the Bull Run River, thereby affecting habitat during the summer and fall when adult and juvenile steelhead trout and Chinook salmon are present in the river. In 2002, the lower Bull Run River from the mouth to RM 5 was included on the ODEQ 303(d) list as water quality limited for water temperatures exceeding summer salmonid fish-rearing standards, and mentioned in the Water Quality Management Plan mentioned previously (ODEQ 2005).

Streamflow in the lower Bull Run River is largely controlled by water releases from both the Headworks (RM 5.8) and PGE's Bull Run Powerhouse (RM 1.6). Flows between the Headworks and the powerhouse (4.2 miles) are reduced by the diversion of water for municipal use and by storage of water in the two Bull Run reservoirs. The diversions have their greatest influence on hydrological conditions in this section of the river during the low flow season (July through October) annually. River flow between the PGE Bull Run Powerhouse and the confluence of the Bull Run and Sandy rivers is generally higher than flows expected to occur under natural conditions, and it is subject to wide flow variation resulting from hydropower peaking operations. When PGE's hydroelectric project is decommissioned, flows will be affected only by the City's upstream water supply operations.

Streamflows in the lower Bull Run River affect fish production in several ways. Low flows increase water temperatures for fish rearing in the summer months. Low flows also affect habitat availability. However, juvenile survey data suggest that habitat availability related to flow might not be the key factor limiting juvenile production in the lower Bull Run River. Rearing densities of juvenile fish are low in the lower Bull Run River. Based on data collected for three years (Clearwater BioStudies 1997; Beak 2000b), juvenile steelhead densities were only 20 percent of those from other comparable streams in the region. These data were collected from 1997 to 1999 when base flow conditions in the summer were 5 to 7 cfs. Very few fish were present to fill the available habitat. These results may indicate that either the habitat is underseeded or combinations of other environmental variables, such as water temperature, are controlling fish production.

R2 Resource Consultants (1998b) evaluated spawning flows for anadromous salmonids in the lower Bull Run River and found that flows during the winter and spring are generally within or exceed the range of flows predicted to provide optimal available spawning habitat for steelhead and cutthroat trout. An analysis of spawning gravel in the lower Bull Run River (R2 Resource Consultants 1998b), however, indicated that lack of suitable spawning gravel may be limiting production of steelhead. A gravel supplementation program to further increase spawning production potential was recommended for consideration.