Draft Total Maximum Daily Loads for the Lower Columbia-Sandy Subbasin

Technical Support Document

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State of Oregon
DEQ Department of Environmental Quality

This document was prepared by

Ryan Michie, David Fairbairn, Yuan Grund, Alex Liverman

Oregon Department of Environmental Quality
Water Quality Division
700 NE Multnomah Street, Suite 600
Portland Oregon, 97232
Contact: Steve Mrazik
Phone: 503-229-5983 x267
www.oregon.gov/deq

State of Oregon
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1 Introduction

1.1 Document purpose and organization

This document provides comprehensive supporting information on technical analyses completed for the Total Maximum Daily Load (TMDL) and Water Quality Management Plan (WQMP) to address temperature impairments in the waters of the Lower Columbia-Sandy Subbasin. This technical support document (TSD) provides explanation of TMDL concepts and analysis and support for conclusions and requirements included in the Lower Columbia-Sandy Subbasin TMDL and WQMP, which are proposed for adoption by Oregon’s Environmental Quality Commission, by reference, into rule [add OAR 340-042-0090(xx) post adoption].

This TSD is organized into sections with titles matching the TMDL elements required by OAR 340-042-0040(4) in the Lower Columbia-Sandy Subbasin TMDL for temperature. This organization is intended to facilitate readers’ access to information needed for TMDL element-specific determinations.

1.2 Overview of TMDL elements

According to OAR 340-042-0030 Definitions (15): “Total Maximum Daily Load” means a written quantitative plan and analysis for attaining and maintaining water quality standards and includes the elements described in OAR 340-042-0040. Determinations on each element are presented in the Lower Columbia-Sandy Subbasin TMDL for temperature. Technical and policy information supporting those determinations are presented in this TSD at the section headings that correspond to each TMDL element.

In plain language, a TMDL is a water quality budget plan to ensure that a receiving water body can attain the water quality standards that protect its designated beneficial uses. This budget calculates and assigns maximum allowable pollutant loads to discharges from point (end-of-pipe) and nonpoint (diffuse/landscape) sources, in consideration of natural background levels and determinations of a margin of safety and reserve capacity.

A margin of safety (MOS) accounts for the uncertainty in predicting pollutant reduction effectiveness at meeting water quality standards, and can be expressed either explicitly (as a portion of the allocations) or implicitly (by incorporating conservative assumptions into the analyses).

Reserve capacity (RC) sets aside a portion of the loading capacity for future pollutant discharges that may result from growth and new or expanded sources.

A key element of analysis is the amount of pollutant that a waterbody can receive and still meet the applicable water quality standard, and is referred to as the “loading capacity” (LC) of a waterbody. Because the loading capacity must not be exceeded by pollutant loads from all existing sources, plus the margin of safety and reserve capacity, it can be considered the maximum load. Hence, the loading capacity is often referred to as the TMDL. A loading capacity, or TMDL, is calculated on each assessment unit for each applicable temperature criteria in the TMDL project area. An assessment unit is a partition (segment) of the state's waterbodies (streams, river, lakes, estuaries, etc.) into manageable units. The Integrated Report makes assessment conclusions for each assessment unit.

Another key analysis element is allocating portions of the LC (TMDL) to known sources. "Allocations" are quantified maximum pollutant loads distributed among nonpoint, point, and background sources that assure water quality standards will be met. "Load allocations" (LA) are LC portions allocated to (1) nonpoint sources such as urban, agriculture, rural residential or forestry activities; and (2) natural background sources such as soils or wildlife. "Wasteload allocations" (WLA) are LC portions allocated to point sources of pollution, such as permitted discharges from sewage treatment plants, industrial facilities, and/or stormwater systems. As noted above, allocations can also be reserved for future uses, termed "reserve capacity" (RC).

This general TMDL concept is represented by the following equation:

TMDL = ∑Wasteload Allocations + ∑Load Allocations + Reserve Capacity + Margin of Safety

Together, these elements establish the maximum allowed pollutant loads necessary to meet applicable water quality standards for impaired pollutants and protect beneficial uses.

2 TMDL name and location

Per Oregon Administrative Rule 340-042-0040(a), this element describes the geographic area for which the TMDL is developed. The Lower Columbia-Sandy Subbasin is located on the west slopes of the Cascade Range of northwestern Oregon, east of the Portland metropolitan area.

DEQ developed this TMDL to address all Category 5 listed assessment units located Lower Columbia-Sandy Subbasin and to serve as a protection plan for other assessment categories, including unimpaired and unassessed. The TMDL also achieves EPA's Columbia and Lower Snake Rivers temperature TMDL (EPA, 2021) allocation to anthropogenic sources in Columbia River tributaries, including the Sandy River. The loading capacity and allocations, including surrogate measures, and implementation framework apply to all waters in Oregon determined to be waters of the state as defined under ORS 468B.005(10), including all perennial and intermittent streams, located in the Lower Columbia-Sandy Subbasin (17080001). The temperature TMDLs do not include the section of the Columbia River that flows through the Lower Columbia-Sandy Subbasin (17080001). The map in Figure 2-1 provides an overview of where the temperature TMDLs are applicable. Appendix H of the Lower Columbia-Sandy technical support document provides a list of all assessment units addressed by this TMDL.

In Oregon, the Lower Columbia-Sandy Subbasin is comprised of seven smaller 10-digit watersheds as listed in Table 2-1, and 23 12-digit subwatersheds as listed in **Table 2-2.**

Table 2-1: Watersheds within the Lower Columbia-Sandy Subbasin.

HU10 code	Watershed Name
1708000101	Upper Sandy River
1708000102	Zigzag River
1708000103	Salmon River
1708000104	Middle Sandy River
1708000105	Bull Run River
1708000107	Lower Sandy River
1708000108	City of Washougal-Columbia River

Table 2-2: Subwatersheds within the Lower Columbia-Sandy Subbasin.

HU12 code	Subwatershed Name
170800010101	Headwaters Sandy River
170800010102	Clear Creek-Sandy River
170800010201	Still Creek
170800010202	Zigzag Canyon
170800010301	Linney Creek
170800010302	Upper Salmon River
170800010303	Middle Salmon River
170800010304	Lower Salmon River
170800010401	Wildcat Creek-Sandy River
170800010402	Cedar Creek-Sandy River
170800010501	Blazed Alder Creek
170800010502	Upper Bull Run River
170800010503	Middle Bull Run River
170800010504	South Fork Bull Run River
170800010505	Little Sandy River
170800010506	Lower Bull Run River
170800010701	Gordon Creek
170800010702	Trout Creek-Sandy River
170800010703	Beaver Creek-Sandy River
170800010801	Tanner Creek-Columbia River
170800010802	Woodard Creek-Columbia River
170800010803	Bridal Veil Creek-Columbia River
170800010804	Latourell Creek-Columbia River

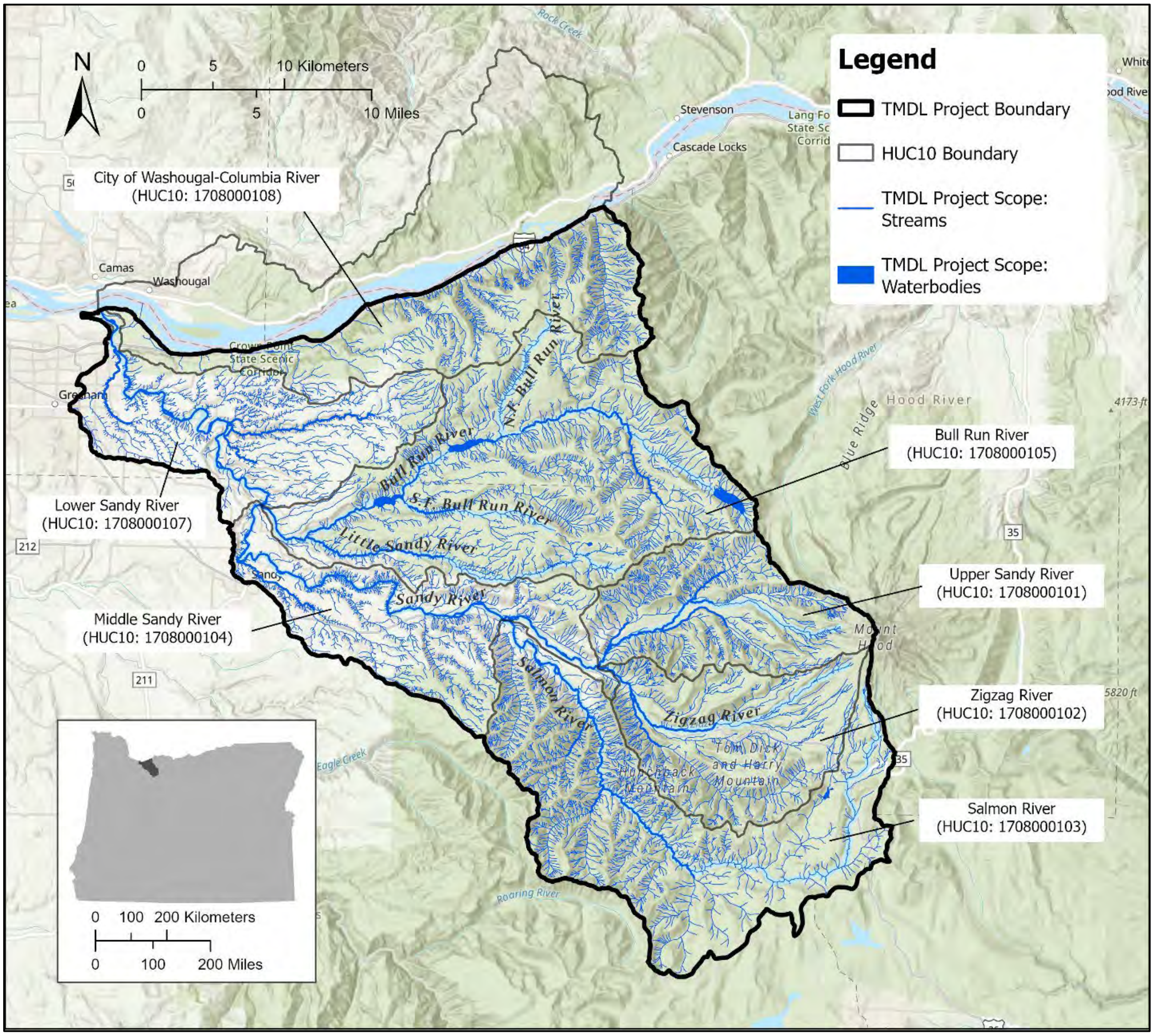

Figure 2-1: Lower Columbia-Sandy Subbasin temperature TMDLs project area overview.

2.1 Impaired waters

Table 2-3 presents stream assessment units within the Lower Columbia-Sandy Subbasin that were listed as impaired for temperature on DEQ’s 2022 Clean Water Act Section 303(d) List (as part of Oregon’s Integrated Report), which was approved by the Environmental Protection Agency on September 1, 2022. Status category designations are prescribed by Sections 305(b) and 303(d) of the Clean Water Act. Assessment units listed in Category 5 (designated use is not supported or a water quality standard is not attained) require development of a TMDL. Locations of these listed segments are depicted on Figure 2-2.

Table 2-3: Lower Columbia-Sandy Subbasin Category 5 temperature impairments on the 2022 Integrated Report.

Assessment Unit Name	Assessment Unit	Use Period
Beaver Creek	OR_SR_1708000107_02_103612	Year round
Beaver Creek	OR_SR_1708000107_02_103612	Spawning
Benson Lake	OR_LK_1708000108_15_100639	Year round
Bull Run River	OR_SR_1708000105_11_103611	Year round
Bull Run River	OR_SR_1708000105_11_103611	Spawning
Cedar Creek	OR_SR_1708000104_02_103607	Year round
Clear Creek	OR_SR_1708000101_02_103597	Year round
Clear Creek	OR_SR_1708000101_02_103597	Spawning
Clear Fork	OR_SR_1708000101_02_103596	Spawning
Gordon Creek	OR_SR_1708000107_02_103615	Spawning
Gordon Creek	OR_SR_1708000107_02_103617	Spawning
HUC12 Name: Beaver Creek-Sandy River	OR_WS_170800010703_02_103703	Spawning
HUC12 Name: Beaver Creek-Sandy River	OR_WS_170800010703_02_103703	Year round
HUC12 Name: Bridal Veil Creek-Columbia River	OR_WS_170800010803_15_103654	Year round
HUC12 Name: Cedar Creek-Sandy River	OR_WS_170800010402_02_103644	Year round
HUC12 Name: Headwaters Sandy River	OR_WS_170800010101_02_103635	Year round
HUC12 Name: Little Sandy River	OR_WS_170800010505_11_103669	Year round
HUC12 Name: Lower Bull Run River	OR_WS_170800010506_11_103650	Year round
HUC12 Name: Lower Salmon River	OR_WS_170800010304_02_103642	Year round
HUC12 Name: Tanner Creek-Columbia River	OR_WS_170800010801_15_103707	Spawning
HUC12 Name: Tanner Creek-Columbia River	OR_WS_170800010801_15_103707	Year round
HUC12 Name: Wildcat Creek-Sandy River	OR_WS_170800010401_02_103643	Spawning
Little Sandy River	OR_SR_1708000105_11_103609	Year round
Little Sandy River	OR_SR_1708000105_11_103609	Spawning
Lost Creek	OR_SR_1708000101_02_103598	Spawning
Salmon River	OR_SR_1708000103_02_103606	Year round
Salmon River	OR_SR_1708000103_02_103606	Spawning
Sandy River	OR_SR_1708000101_02_103595	Year round
Sandy River	OR_SR_1708000101_02_103599	Year round
Sandy River	OR_SR_1708000101_02_103599	Spawning
Sandy River	OR_SR_1708000104_02_103608	Year round
Sandy River	OR_SR_1708000104_02_103608	Spawning
Sandy River	OR_SR_1708000107_02_103616	Year round
South Fork Salmon River	OR_SR_1708000103_02_103604	Spawning
Still Creek	OR_SR_1708000102_02_103601	Spawning
Zigzag River	OR_SR_1708000102_02_103600	Spawning

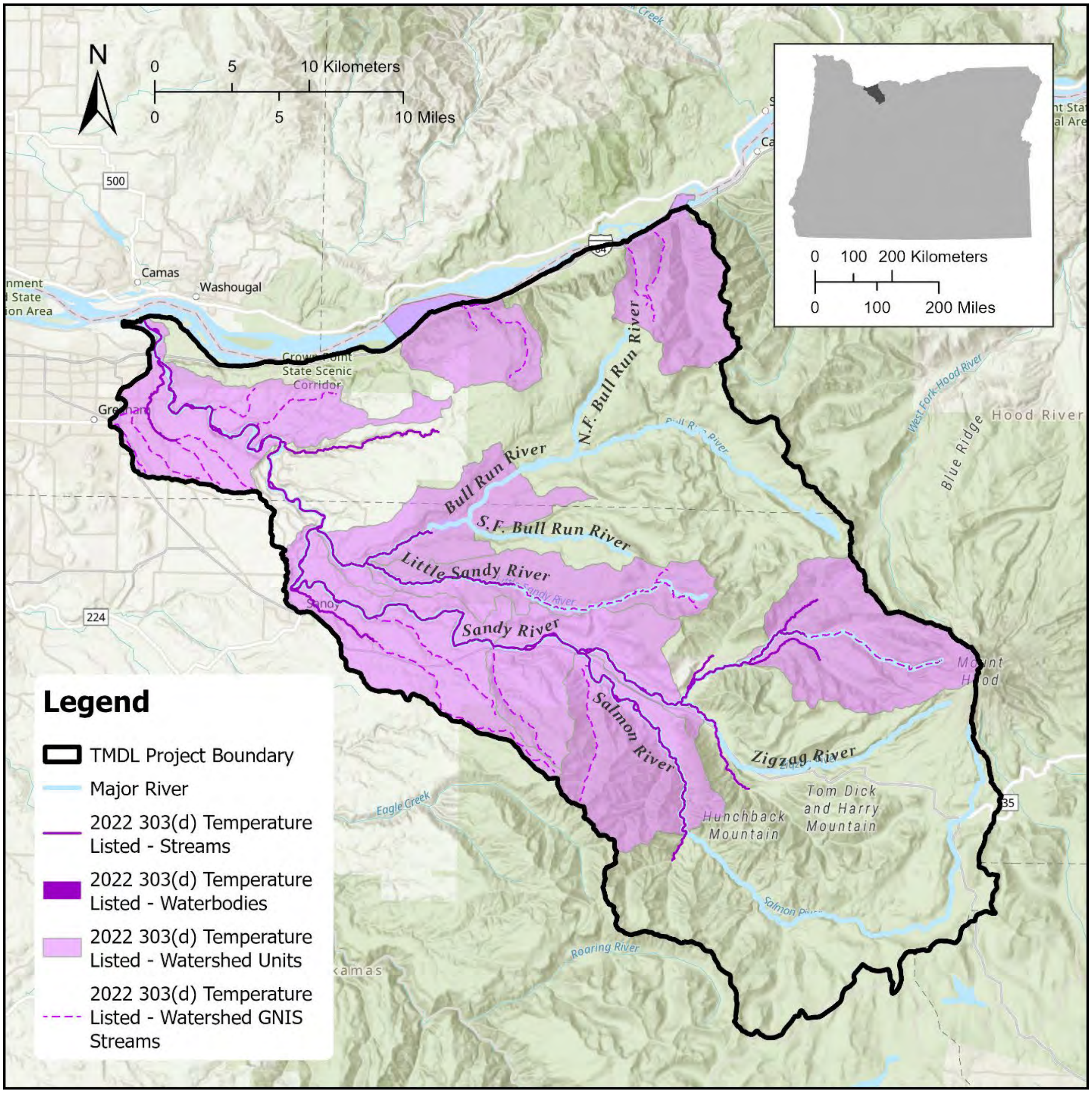

Figure 2-2: Lower Columbia-Sandy Subbasin category 5 temperature impairments on the 2022 Integrated Report.

2.2 Climate

The Lower Columbia-Sandy Subbasin is characterized by a temperate maritime climate with mild temperatures and a relatively high level of precipitation. According to PRISM normals of annual conditions over the past 30 years (1991-2020), average annual precipitation generally varies with elevation and from west to east, ranging from 1,148 mm (45”) near Troutdale to 3,917 mm (154”) near the North Fork Bull Run River (Figure 2-2). Most precipitation occurs from

November-January. Precipitation is lower in July-August. Average annual maximum air temperatures in the Lower Columbia-Sandy Subbasin range from 1.3°C (34°F) at Mt. Hood to about 17°C (63°F) at Troutdale (Figure 2-3). Generally, July and August are the hottest months of the year (average air temperature: 24°C (75.2°F)) (PRISM Climate Group, 2022).

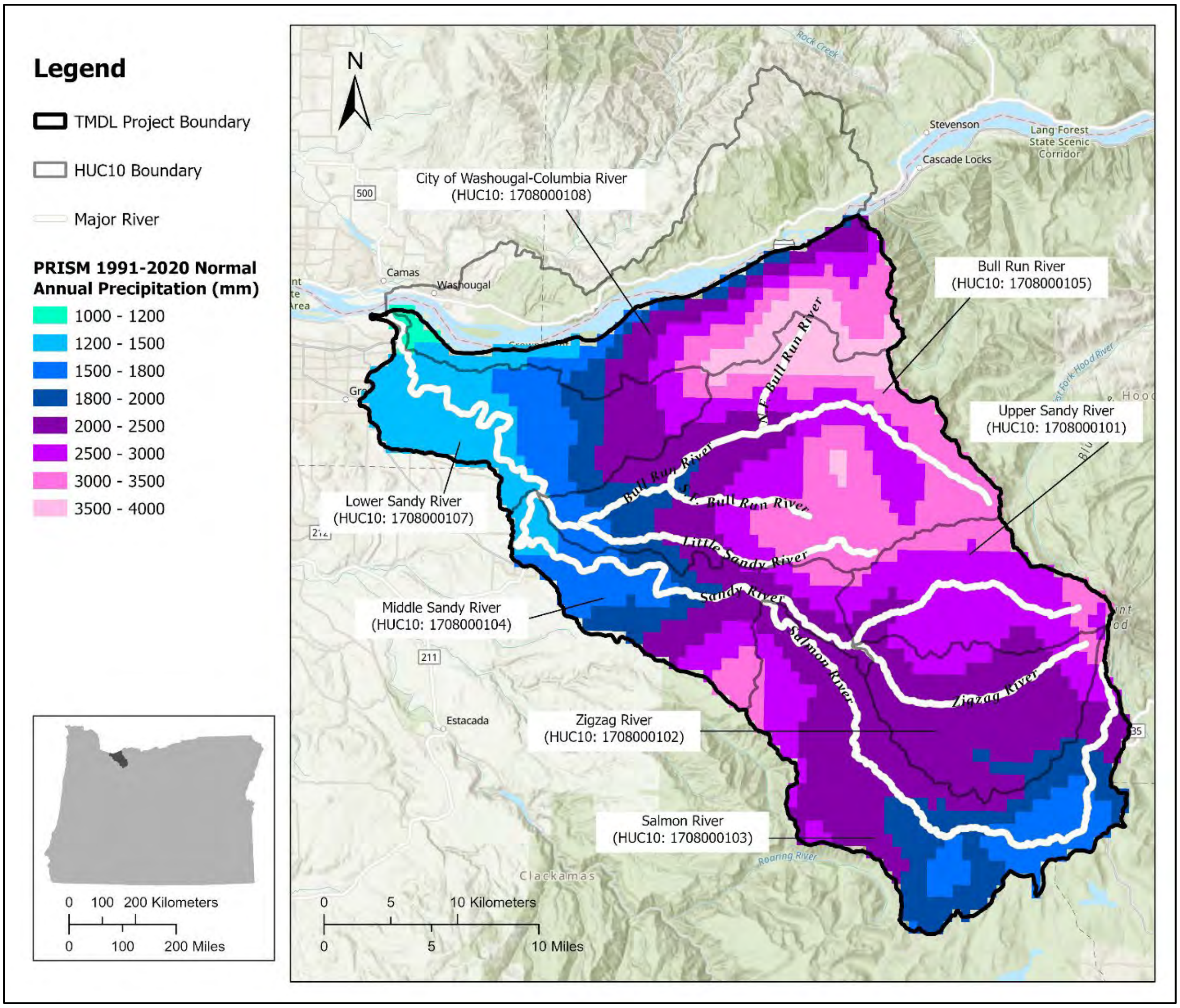

Figure 2-3: PRISM 1991-2020 Normal Annual Precipitation in the Lower Columbia-Sandy Subbasin (Data Source: PRISM Climate Group, 2022).

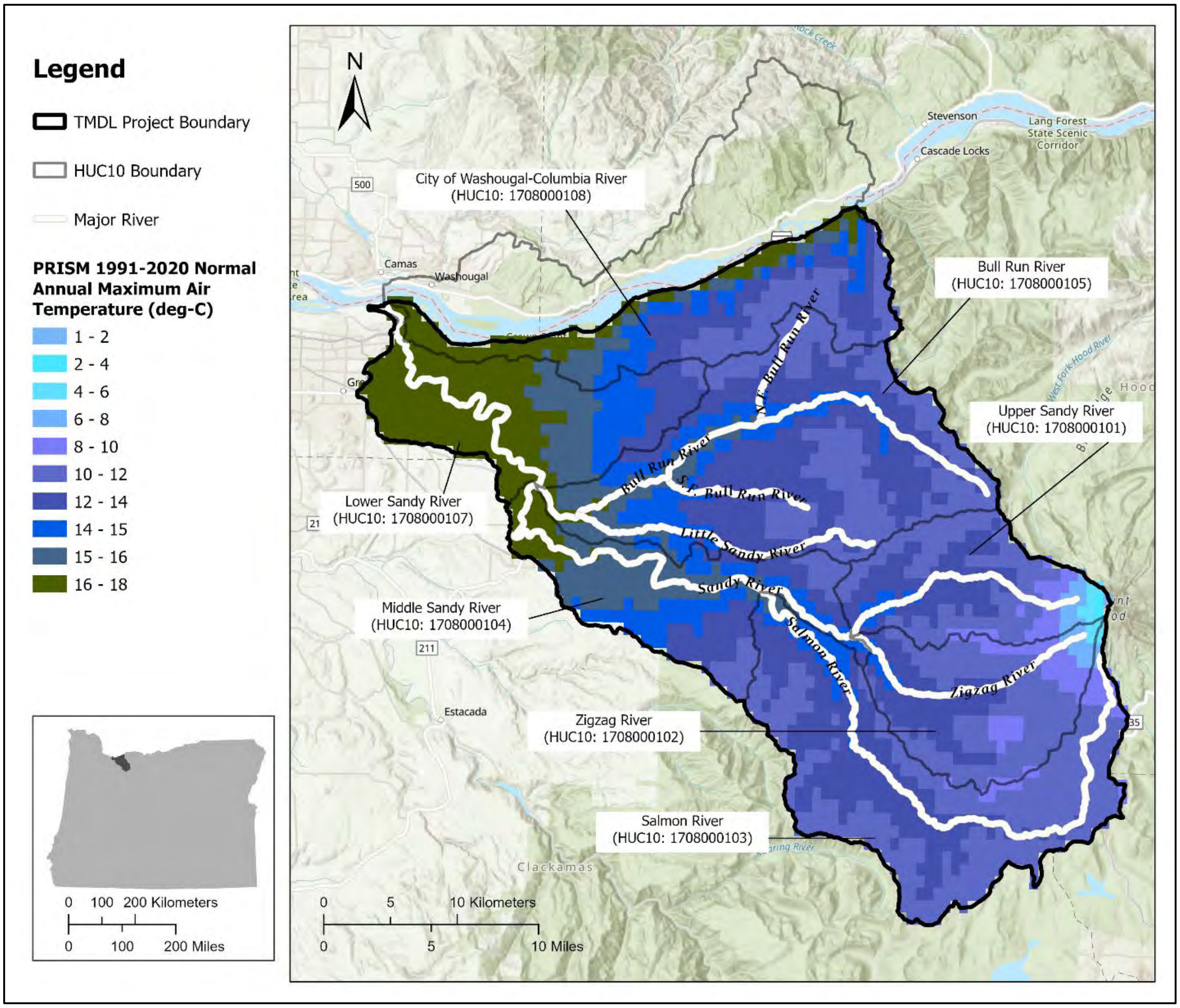

Figure 2-4: PRISM 1991-2020 Normal Annual Maximum Air Temperature in the Lower Columbia-Sandy Subbasin (Data Source: PRISM Climate Group, 2022).

2.3 Hydrology

The Lower Columbia-Sandy Subbasin drains approximately 1,315 km^2 (508 mi^2) in northwestern Oregon. The Sandy River originates from Reid Glacier on the western slopes of Mt. Hood and extends about 90 km (56 mi) before flowing into the Columbia River near Troutdale, OR. The Sandy River is the only major glacial river draining the western Cascades in Oregon. Glacially-derived fine particulate matter known as “glacial flour” gives the Sandy River its distinctive milky-grey color in summer. Major Sandy River tributaries include the Bull Run River, Little Sandy River, Salmon River, and Zigzag River. The Little Sandy River is the largest tributary to the lower Bull Run River.

Figure 2-4 shows the locations of large dams within the TMDL project area. Data for these dams were downloaded from the federal National Inventory of Dams (NID) website, a repository maintained by USACE. The 13 dams shown in Figure 2-4 are either ≥10’ high or have ≥9.2 ac-ft storage capacities. They serve a variety of purposes, including irrigation, water supply, hydroelectric power, and recreation. These dams are owned and operated by local governments, state agencies, private entities, and public utilities. Most of the dams are in the Beaver Creek and Bull Run Watersheds.

The City of Portland manages the dams and reservoirs on the Bull Run River as part of its drinking water supply project; these comprise Bull Run Reservoir & Dam 1, Reservoir & Dam 2, and a dam structure on Bull Run Lake. Dam 1 was the first large dam constructed (completed in 1929) and is the largest by dam height and capacity in the TMDL project area. It is a 200’ high concrete gravity arch dam that created Reservoir 1, which has a 10 billion gallon (38 million m^3) maximum water capacity. It has a selective withdrawal structure that allows water withdrawal at various reservoir depths, which allows some control over discharge temperatures. Reservoir 1’s surface elevation varies between 295-319 m (970-1,045’) above MSL. Dam 2, located downstream of Dam 1, is an earthfill dam project completed in 1962 with a 6.8 billion gallon (26 million m^3) maximum storage capacity. In 2014, a selective withdrawal structure was completed for Dam 2. The City attempts to maximize Reservoir 2 storage volumes throughout the year (including summer). Reservoir 2’s surface elevation varies between 256-262 m (840-860’) above MSL. The project has a Federal Energy Regulatory Commission license to produce electricity (FERC License No. 2821, currently valid until 2029). Water is routed through powerhouses before returning to the Bull Run River; any winter storm overflow is routed over spillways.

Bull Run Lake is a natural lake above the Bull Run River headwaters that was formed by a landslide before European settlement. Although the lake and river have no surface water connection, groundwater seepage contributes significantly to Bull Run River flows. The U.S. Forest Service (USFS) issues a special use permit to the City of Portland to withdraw water from the lake for municipal supplies. The permit restricts withdrawals to ensure that adequate water is available to support the local ecosystem. Thus, lake water is only used in dry years. A 10’ dam structure was installed to increase the lake surface elevation and storage capacity.

The Oregon Department of Water Resources reports that there are approximately 681 active water right permits in the Sandy administrative basin. From May through October, consumptive uses account for 28%-43% of median monthly natural flow at the Sandy River mouth. During most months, there is net negative water availability (Table 2-3).

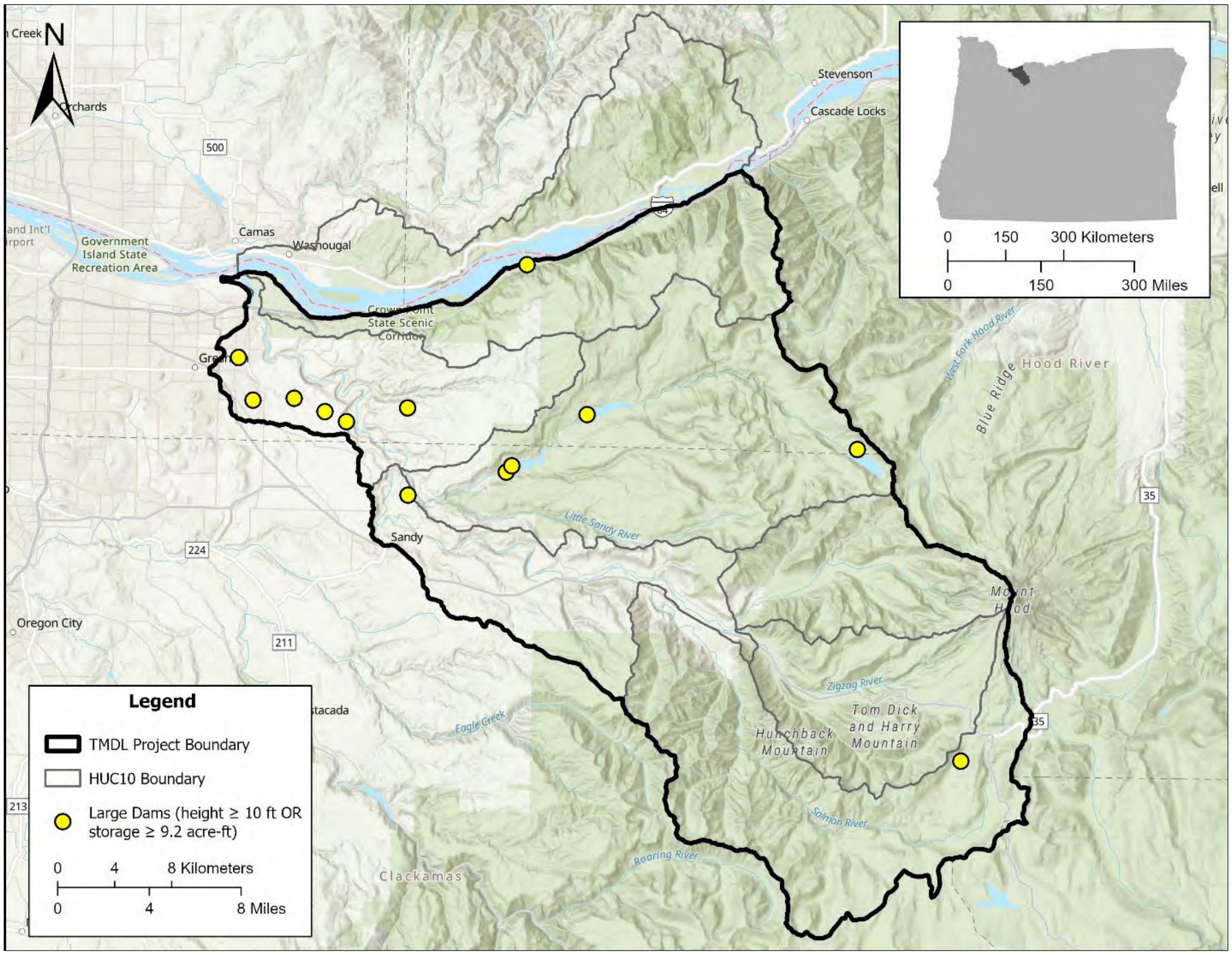

Figure 2-5: Large dams located within the Lower Columbia-Sandy Subbasin temperature TMDL project area.

Table 2-4: Monthly water availability based on the median (50th percentile) exceedance probability at the Sandy River mouth as calculated by Oregon Department of Water Resources, June 2023.

Month	Median natural streamflow (cfs)	Consumptive use (cfs)	Percent of natural streamflow used for consumptive uses (%)	Expected streamflow (cfs)	Reserved streamflow (cfs)	Instream requirement (cfs)	Net water available (cfs)
Jan	3190	1100	34	2090	0	1900	187
Feb	3130	1080	35	2050	0	1900	147
Mar	2760	992	36	1770	0	2000	-232
Apr	3120	1150	37	1970	0	2000	-32
May	2740	1010	37	1730	0	2000	-272
June	1620	533	33	1090	0	1400	-313
July	950	268	28	682	0	800	-118
Aug	633	183	29	450	0	400	49.9

Sept	682	231	34	451	0	500	-48.9
Oct	843	359	43	484	0	650	-166
Nov	2210	978	44	1230	0	1500	-268
Dec	3230	1130	35	2100	0	1500	597

2.4 Land use

The Lower Columbia-Sandy Subbasin is characterized by a variety of land uses (e.g., forested lands, agriculture, and urban development), which are summarized in Table 2-4 and Figure 2-5 based on the 2019 National Land Cover Database (Dewitz and USGS, 2021). Note that Shrub/Scrub and Herbaceous land uses can be in areas where forest clearcuts have occurred and would be classified as forest after regrowth. Most of the land area (approximately 86%) is forested. Timber harvesting and related activities (e.g., road construction) were the primary land uses in forested areas in the 19th-20th centuries, but were dramatically reduced after Northwest Forest Plan implementation in 1994 (SRBWG, 2007). Agricultural land uses (e.g., grazing, hay production, and berry farming) occur primarily in the subbasin's lower regions. Urban development is concentrated along the lower Sandy River, including the cities of Gresham, Sandy, and Troutdale.

Table 2-5: Lower Columbia-Sandy Subbasin land use summary based on the 2019 National Land Cover Database.

2019 NLCD Land Cover	Acres	Percent of total area
Evergreen Forest	284581.3	78.1
Herbaceous	14412.1	4.0
Mixed Forest	13642.8	3.7
Hay/Pasture	12424.7	3.4
Shrub/Scrub	11637.9	3.2
Developed, Open Space	7145.1	2.0
Developed, Low Intensity	3579.4	1.0
Barren Land	3490.3	1.0
Woody Wetlands	3166.9	0.9
Developed, Medium Intensity	3016.3	0.8
Open Water	2540.2	0.7
Emergent Herbaceous Wetlands	1769.4	0.5
Perennial Snow/Ice	1279.9	0.4
Developed, High Intensity	677.9	0.2
Deciduous Forest	579.1	0.2
Cultivated Crops	218.6	0.1

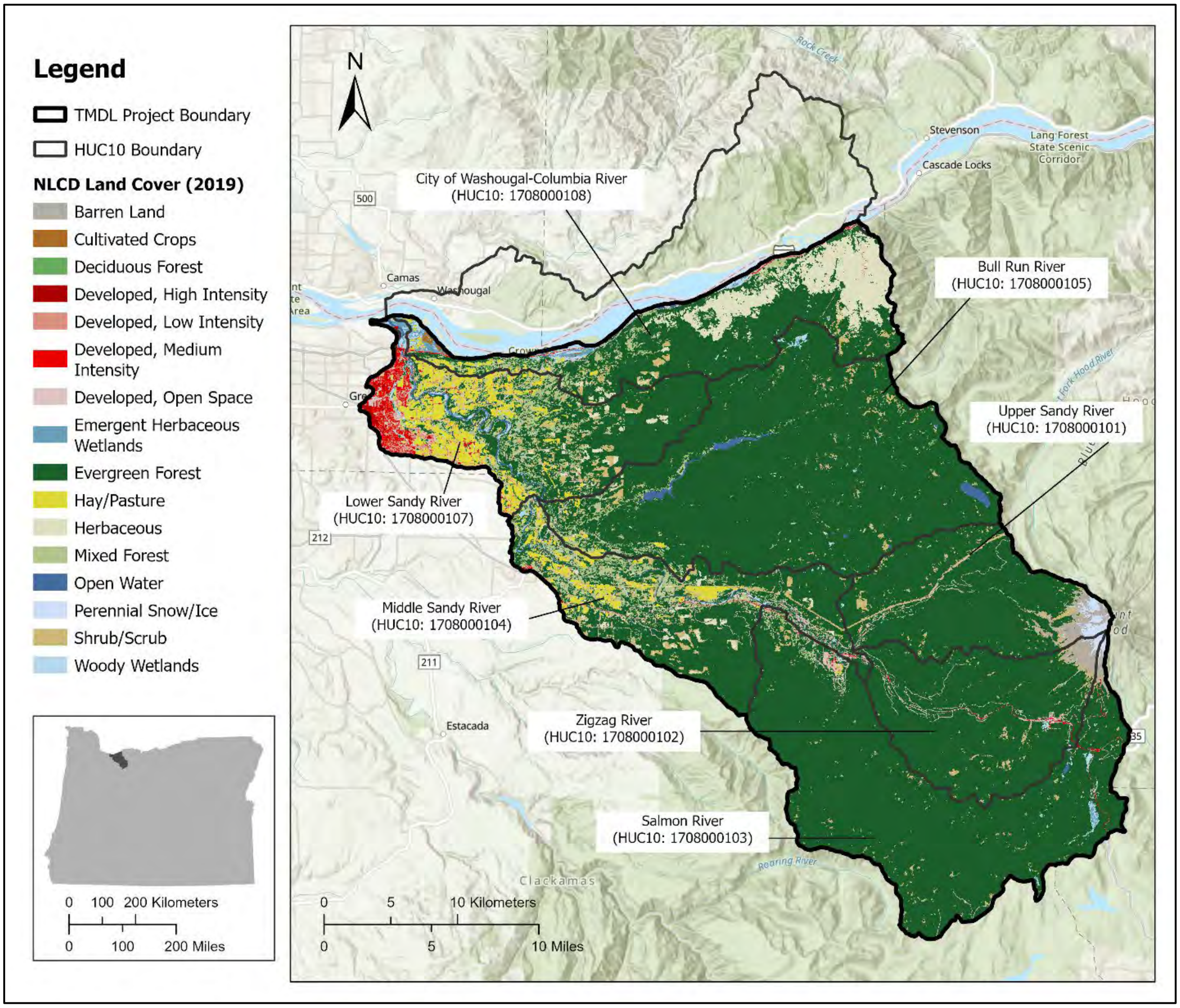

Figure 2-6: Land cover in the Lower Columbia-Sandy Subbasin temperature TMDL project area.

2.5 Land ownership and jurisdiction

The Lower Columbia-Sandy Subbasin is within Multnomah and Clackamas counties. Approximately 70% of the basin consists of Mt. Hood National Forest, which is owned and managed by the USFS; 22% is privately owned; and 4% is owned and managed by the Bureau of Land Management (BLM). The remainder is owned by state, local or regional governments (SRBWG, 2007). The Lower Columbia-Sandy Subbasin land ownership and jurisdiction, also referred to as the designated management agencies (DMAs), are shown in Figure 2-6.

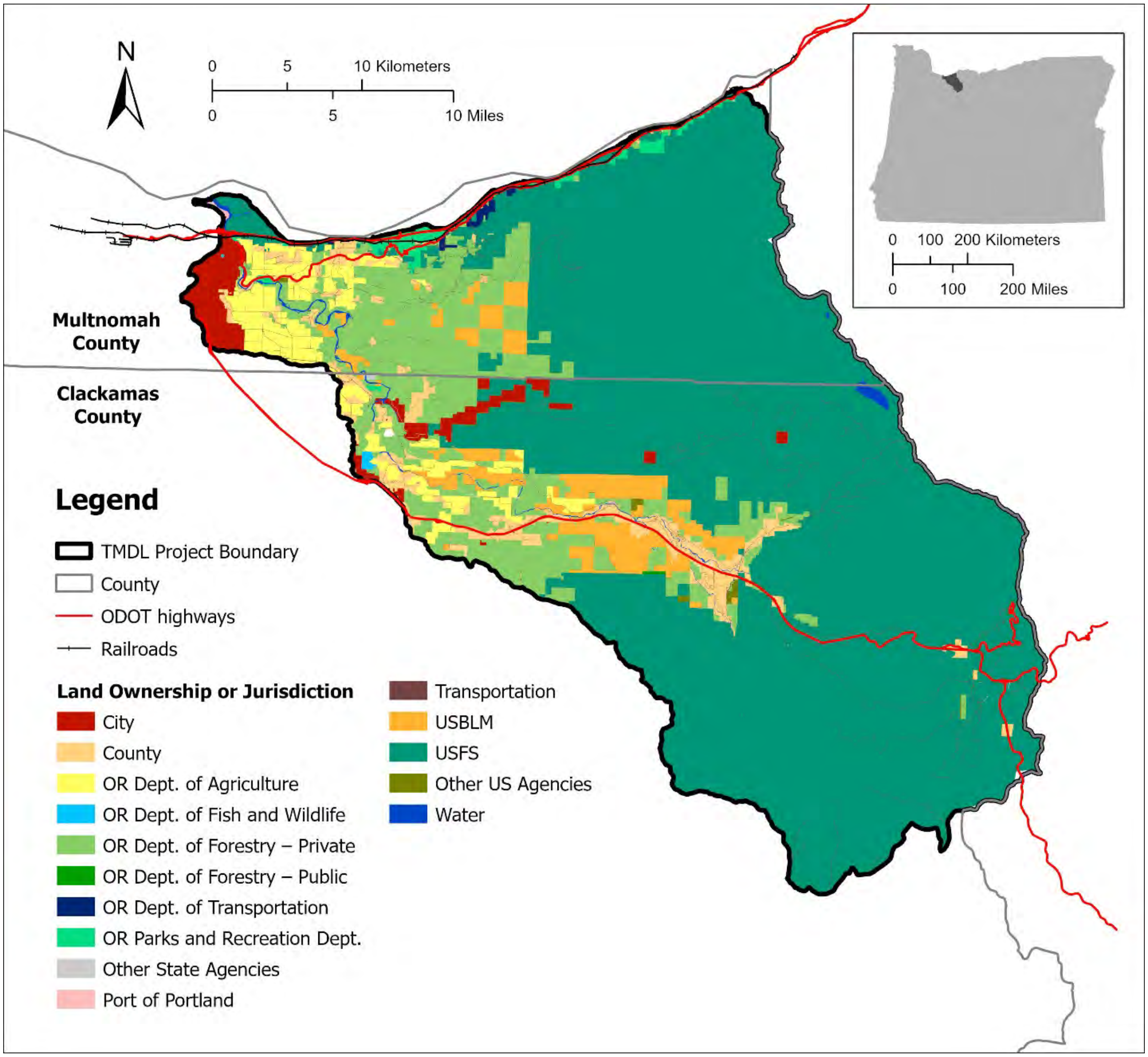

Figure 2-7: Designated management agencies (DMAs) in the Lower Columbia-Sandy Subbasin temperature TMDL project area.

3 Pollutant identification

As stated in OAR 340-042-0040(4)(b), this element identifies the pollutants causing impairment of water quality that are addressed by these TMDLs.

Temperature is the water quality parameter of concern, but heat from thermal loading is the pollutant of concern causing impairment. Heat caused by human activities are of particular concern. Water temperature change (ΔT_w) is a function of the heat transfer in a discrete volume and may be described in terms of changes in heat per unit volume. Conversely, a change in volume can also result in water temperature change for a defined amount of heat exchange.

$$\Delta T_w = \frac{\Delta Heat}{Density \times Specific\ Heat \times \Delta Volume}$$

The pollutants addressed by this temperature TMDL are heat or thermal loads, with surrogate measures of effective shade and percent consumptive use.

EPA regulations (40 CFR 130.2(i)) and OAR 340-042-0040(O)(5)(b) allow for TMDLs to utilize other appropriate measures (or surrogate measures). Surrogate measures are defined in OAR 340-042-0030(14) as “substitute methods or parameters used in a TMDL to represent pollutants.” In accordance with OAR 340-042-0040(5)(b), DEQ used effective shade and a percent consumptive use target as a surrogate measure for thermal loading caused by solar radiation and other fluxes that introduce heat. Implementation of the surrogate measures ensures achievement of necessary pollutant reductions and the nonpoint load allocations for these temperature TMDLs.

4 Temperature water quality standards and beneficial uses

EQC issued, and EPA approved, numeric and narrative water quality standards to protect designated *beneficial use*s in the in the Lower Columbia-Sandy Subbasin (Oregon Administrative Rules OAR 340–041–0344 - 0350, November 2003), and antidegradation policies to protect overall water quality. Table 4-1 specifies the designated beneficial uses in Lower Columbia-Sandy Subbasin surface waters.

Table 4-1: Designated beneficial uses in the Lower Columbia-Sandy Subbasin as identified in OAR 340-041-0286 Table 286A.

Beneficial Uses	Streams Forming Waterfalls Near Columbia River Highway	Sandy River	Bull Run River and all Tributaries	All Other Tributaries to Sandy River
Public Domestic Water Supply		X	X	X
Private Domestic Water Supply		X		X
Industrial Water Supply		X		X
Irrigation		X		X
Livestock Watering		X		X

Beneficial Uses	Streams Forming Waterfalls Near Columbia River Highway	Sandy River	Bull Run River and all Tributaries	All Other Tributaries to Sandy River
Fish and Aquatic Life	X	X	X	X
Wildlife and Hunting	X	X		X
Fishing	X	X		X
Boating		X		X
Water Contact Recreation	X	X		X
Aesthetic Quality	X	X	X	X
Hydro Power		X	X	X
Commercial Navigation & Transportation				

Water quality criteria have been set at a level to protect the most sensitive beneficial uses. These TMDLs are designed such that meeting water quality standards for the most sensitive beneficial uses will be protective of all other uses. Fish and aquatic life are the most sensitive beneficial use for temperature. Oregon's water temperature criteria use salmonids' life cycles as indicators. If temperatures are protective of these indicator species, other species will share in this protection. The locations and periods of criteria applicability are determined from designated fish use maps in rule at OAR 340-041-0286 Figure 286A and Figure 286B. The maps from the rule have been reproduced and shown in Figure 4-1 and Figure 4-2. Figure 4-1 shows various designated fish uses and applicable criteria, while Figure 4-2 shows salmon and steelhead spawning use designation, based on the National Hydrography Dataset (NHD).

The temperature water quality standards for the Lower Columbia-Sandy Subbasins are based on the rolling seven-day average daily maximum (7DADM) and include the following numeric criteria:

- Salmon and steelhead spawning: 13.0°C (55.4°F) (OAR 340-041-0028(4)(a))
- Core cold water habitat: 16.0°C (60.8°F) (OAR 340-041-0028(4)(b))
- Salmon and trout rearing and migration: 18.0°C (64.4°F) (OAR 340-041-0028(4)(c))

The following narrative temperature water quality standards and other rule provisions also apply in the Lower Columbia-Sandy Subbasins:

- Human use allowance (OAR 340-041-0028(12)(b))
- Minimum duties (OAR 340-041-0028(12)(a))
- Natural Lakes (OAR 340-041-0028(6))
- Protecting cold water (OAR 340-041-0028(11))
- Antidegradation (OAR 340-041-0004)

Details of each rule are described in the following sections (4.1 to 4.7).

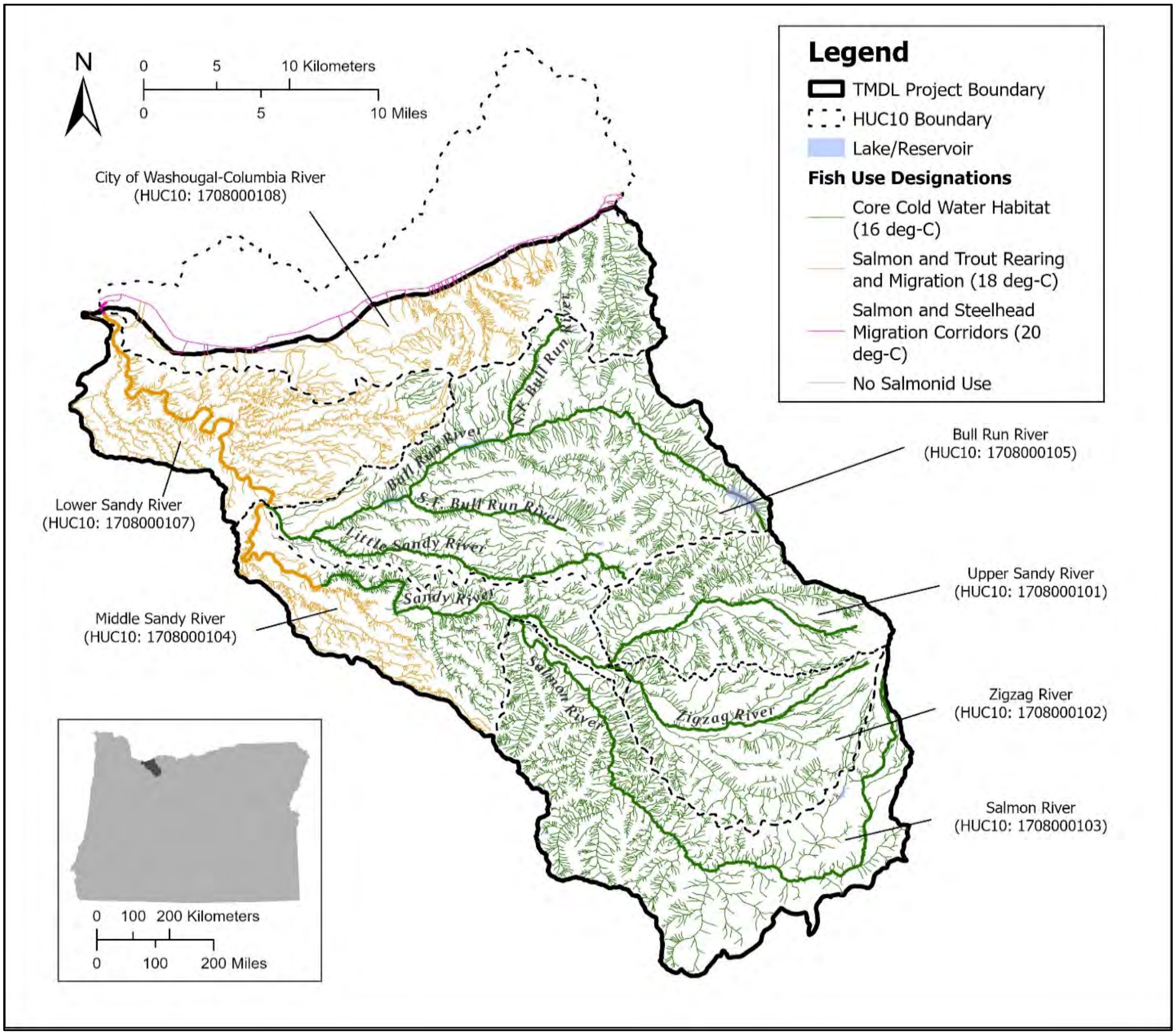

Figure 4-1: Fish use designations in the Lower Columbia-Sandy Subbasin temperature TMDL project area.

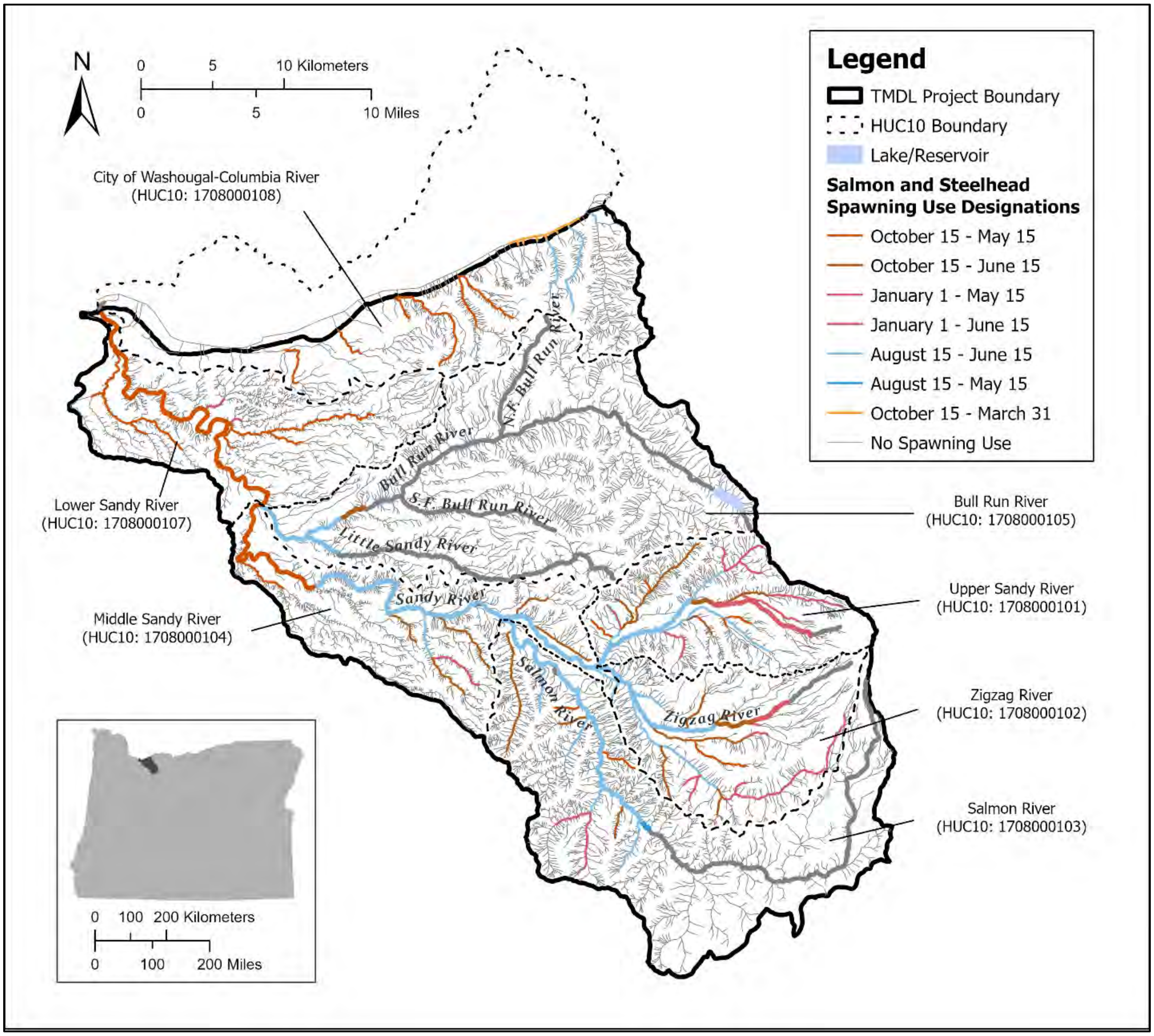

Figure 4-2: Salmon and steelhead spawning use designations in the Lower Columbia-Sandy Subbasin temperature TMDL project area.

4.1 Salmon and steelhead spawning use

OAR 340-041-0028(4)(a) specifies that waters designated as having salmon and steelhead spawning use are identified in rule at OAR 340-041-0286 Figure 286B (shown in Figure 4-2). During the spawning period, these waters may not exceed 13.0°C (55.4°F) expressed as a 7DADM.

4.2 Core cold water habitat use

OAR 340-041-0028(4)(b) specifies that waters designated as having core cold water habitat use are identified in OAR 340-041-0286 Figure 286A (shown in Figure 4-1). These waters may not exceed 16.0°C (60.8°F) expressed as a 7DADM.

4.3 Salmon and trout rearing and migration

OAR 340-041-0028(4)(c) specifies that waters designated as having salmon and trout rearing and migration use are identified in OAR 340-041-0286 Figure 286A (shown in Figure 4-1). These waters may not exceed 18.0°C (64.4°F) expressed as a 7DADM.

4.4 Human use allowance

Oregon water quality standards have provisions for human use (OAR 340-041-0028(12)(b)). The human use allowance is an insignificant addition of heat (0.30°C) authorized in waters that exceed the applicable temperature criteria. Following a temperature TMDL, or other cumulative effects analysis, waste load and load allocations will restrict all NPDES point sources and nonpoint sources to a cumulative increase of no greater than 0.30°C (0.5°F) above the applicable biological criterion after complete mixing in the waterbody, and at the point of maximum impact (POMI). The rationale behind selection of 0.30°C for the human use allowance and how DEQ implements this portion of the standard can be found in DEQ (2003) and the Temperature IMD (DEQ 2008).

4.5 Natural lakes

OAR 340-041-0028(6) specifies that natural lakes may not be warmed by more than 0.30°C (0.5°F) above the natural condition unless a greater increase would not reasonably be expected to adversely affect fish or other aquatic life. Absent a discharge or human modification that would reasonably be expected to increase temperature, DEQ will presume that the ambient temperature of a natural lake is the same as its natural thermal condition.

4.6 Protecting cold water

The “protecting cold water” criterion in OAR 340-041-0028(11) applies to waters of the state that have ambient summer 7DADM temperatures that are always colder than the biologically based criteria. With some exceptions, these waters may not be warmed cumulatively by anthropogenic point and nonpoint sources by more than 0.30°C (0.5°F) above the colder water ambient 7DADM temperature. This applies to all anthropogenic sources taken together at the POMI where salmon, steelhead or bull trout are present. A summary of how DEQ implements this portion of the standard can be found in the protecting cold water IMD (DEQ 2011) and the Temperature IMD (DEQ 2008a).

4.7 Statewide narrative criteria

Statewide narrative criteria at OAR 340-041-0007(1) apply to all waters of the state. The highest and best practicable treatment and/or control of wastes, activities, and flows must in every case be provided to maintain dissolved oxygen and overall water quality at the highest possible levels and maintain water temperatures, coliform bacteria concentrations, dissolved chemical substances, toxic materials, radioactivity, turbidities, color, odor and other deleterious factors at the lowest possible levels.

5 Seasonal variation and critical period for temperature

Per OAR 340-042-0040(4)(j) and 40 Code of Federal Regulation130.7(c)(1), TMDLs must identify any seasonal variation and the critical condition or period of each pollutant, if applicable.

DEQ reviewed available temperature data to determine seasonal temperature variation and the critical period (Table 5-1). The critical period is based on when 7DADM stream temperatures exceed the applicable temperature criteria.

Figure 5-1 through Figure 5-32 show box-and-whisker plots (boxplots) of the seasonal 7DADM temperature variation and the critical period at select monitoring locations identified as having category 5 temperature impairments on the 2022 Integrated Report. When multiple monitoring sites were available, the sites with multiple years of data were selected. Temperature data were grouped by the first and second half of each month. The month was split on the 15th with the first group including all results measured on the 1st through the 14th day and the second group including all results measured on the 15th through the end of the month. The boxplots are Tukey style boxplots with the middle line representing the median and the lower and upper ends of the box representing the temperature range between the first and third quartiles (25th – 75th percentile). The whiskers extend to values no further than 1.5 times the interquartile 7DADM temperature range (i.e., 1.5 times the difference between 25th and 75th percentiles). Any points beyond the whiskers represent individual 7DADM values beyond 1.5 times the interquartile range. The dashed line corresponds to the applicable temperature criteria. The shaded yellow area identifies the period when maximum 7DADM temperatures exceeded the applicable temperature criteria.

These plots show that maximum stream temperatures typically occur in July or August. This period usually coincides with the lowest annual stream flows, maximum solar radiation fluxes, and warmest ambient air temperature conditions. The warmest 7DADM temperatures were observed in the in the Beaver Creek Watershed. Monitoring data at Beaver Creek at Stark Street (Figure 5-2) show the median 7DADM temperature in 2014 and 2015 exceeded 25°C in the first half of July.

The period of temperature criteria exceedance varies based on monitoring location. Monitoring locations in Beaver Creek and on the Bull Run River had the longest periods of exceedance. Near the mouth of Beaver Creek, 7DADM temperatures exceeded the applicable criteria from approximately March 15 through the end of November (Figure 5-1). Exceedances occurred approximately May 1 through November 15 in the Bull Run River at Larson's bridge (Figure 5-12). At other monitoring sites the earliest exceedances occurred in May (e.g., Gordon Creek (Figure 5-22), Big Creek (Figure 5-10), Sandy River (Figure 5-29), and Salmon River (Figure 5-28)), and the latest exceedances occurred at the end of October (e.g., Kelly Creek (Figure 5-9), Bull Run River (Figure 5-11), and Little Sandy River (Figure 5-26)).

DEQ uses the critical period to determine when allocations apply. In setting this period, DEQ relied upon monitoring sites with the longest periods of exceedance. When downstream monitoring sites have longer exceedance periods relative to upstream waters, the longer period is used as the critical period for upstream waterbodies. This is a margin of safety to ensure warming of upstream waters does not contribute to downstream exceedances.

Based on review of available temperature data, the overall critical period is May 1 through October 31 on all waterbodies in the Lower Columbia-Sandy Subbasin except those within the Bull Run River Watershed (HUC 1708000105) and Beaver Creek-Sandy Subwatershed (HUC 170800010703). For waterbodies in the Bull Run River Watershed, the critical period is May 1 through November 15. For waterbodies located in the Beaver Creek-Sandy Subwatershed, the critical period is March 15 through November 15. Allocations presented in the TMDL apply during these periods.

Table 5-1: Water temperature monitoring locations and periods used to determine seasonal temperature variation and critical periods for the Lower Columbia-Sandy Subbasin.

Monitoring Location ID	Monitoring Location	Monitoring Period	Number of 7DADM values
14140000	BULL RUN RIVER NEAR BULL RUN (RIVER ONLY), OR	01/01/02 - 09/30/06	1734
14140020	BULL RUN R AT LARSON'S BRIDGE, NEAR BULL RUN, OR	05/30/06 - 12/31/22	5858
14141500	LITTLE SANDY RIVER NEAR BULL RUN, OR	06/01/06 - 12/31/22	5957
COG_BeaveratGlenO	Beaver Creek @ Glen Otto park	06/08/13 - 10/01/19	680
COG_BeaveratStark	Beaver Creek @ Stark Street	05/17/14 - 10/20/15	309
COG_BeaverUSKelly	Beaver Creek upstream of confluence with Kelly Creek	05/29/15 - 10/05/21	1070
COG_BurlatHogan	Burlingame Creek @ Hogan Road	06/14/12 - 10/01/19	680
COG_KCI1	Kelly Creek downstream of MHCC pond	07/22/08 - 10/05/21	1262
CRGNSA-001	Benson Lake_be20_LTWT	07/01/08 - 08/06/08	37
CRGNSA-008	McCord Water Temp Monitor	07/23/14 - 10/15/14	85
CRGNSA-009	Moffett Water Temperature Monitor	07/23/14 - 10/15/14	85
CRGNSA-011	Multnomah Creek mu15_LTWT	07/01/08 - 10/24/11	325
CRGNSA-012	Multnomah Creek Upper mu40_LTWT	06/04/08 - 08/29/17	200
EMSWCD_BCB	Beaver Creek North Fork @ 302nd Ave	06/20/13 - 10/10/19	558
EMSWCD_Beaver_Cory	Beaver Creek @ confluence of North and South Forks	05/30/14 - 10/10/19	943

Monitoring Location ID	Monitoring Location	Monitoring Period	Number of 7DADM values
EMSWCD_Beaver_Freuler	Beaver Creek South Fork downstream of BCC	05/19/16 - 10/10/19	438
EMSWCD_Big_Black	Big Creek @ Hurlburt Rd.	05/19/16 - 10/10/19	445
MHNF-016	Cedar Cr. Water Temp Probe #1	07/03/12 - 10/03/12	93
MHNF-050	Little Sandy R at Bull Run_LTWT	07/09/04 - 10/06/20	1618
MHNF-052	Little Sandy R Homestead_LTWT	07/07/04 - 10/19/20	2735
MHNF-077	Salmon R at Forest Boundary_LTWT	07/18/04 - 09/25/20	1854
MHNF-078	Salmon River trap WT site	10/26/11 - 06/09/20	2057
MHNF-080	Sandy R at Forest Boundary_LTWT	07/17/04 - 09/13/19	1640
MHNF-099	ZigZag R at Forest Boundary_LTWT	05/17/06 - 09/29/20	1845
PWB_Beavr_Canyn	In Beaver Creek Canyon near site of old upstream footbridge	10/20/11 - 05/06/19	2506
PWB_BR_BWMN_BR	20 feet downstream of Bowman's Bridge	06/29/15 - 10/28/18	352
PWB_BR_DODGE	Approximately 500 feet upstream of Sandy River confluence	08/18/15 - 10/18/17	225
PWB_BR_SS_BR	Approximately 60 feet upstream of Rd 14 (Southside) bridge	07/17/14 - 10/26/18	455
PWB_D2_LampB	Immediately upstream of Lamprey Barrier	02/26/14 - 09/09/20	1880
PWB_Gordon_Mouth	Approximately 600 feet upstream of Gordon Creek Rd bridge	07/08/12 - 11/03/19	2252
PWB_SR_US_BR	Approximately 1,900 ft upstream of Bull Run River confluence	08/18/15 - 10/24/18	332
Sandy_3.0	Sandy River Above Beaver Creek	07/16/16 - 09/22/16	69

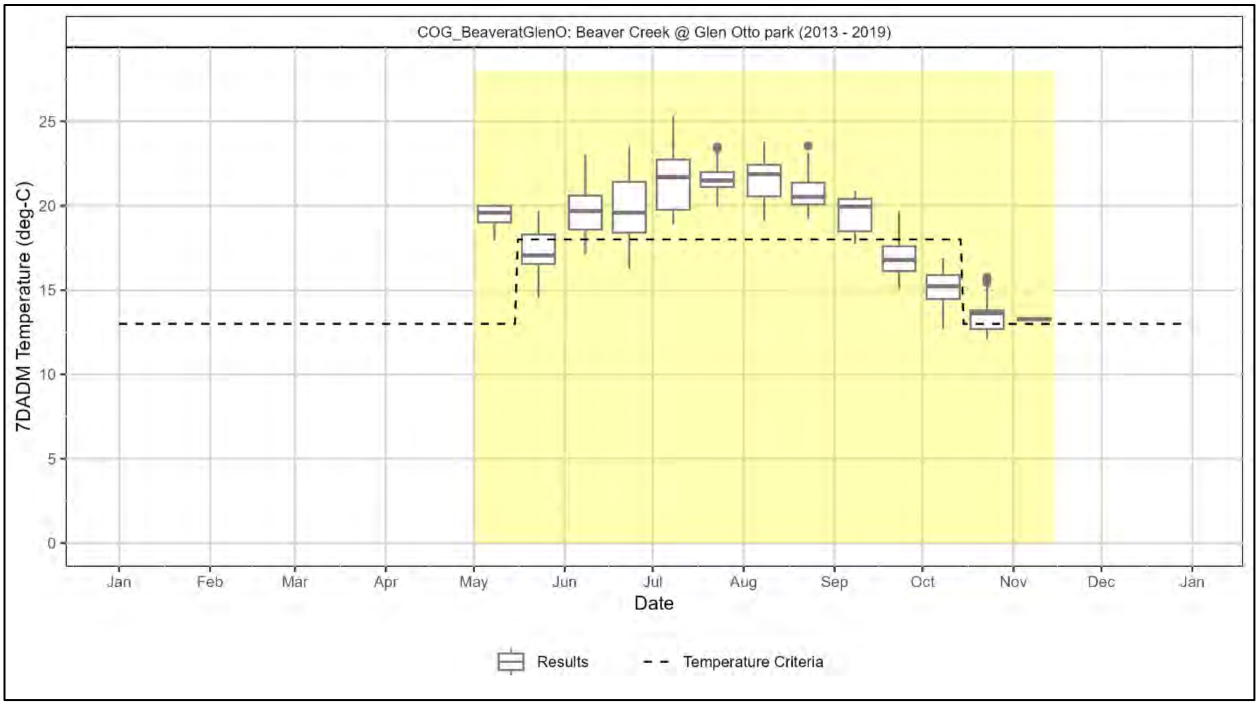

Figure 5-1: Seasonal variation and critical period at the Beaver Creek at Glen Otto Park temperature monitoring site in the Beaver Creek-Sandy Subwatershed (HUC 170800010703).

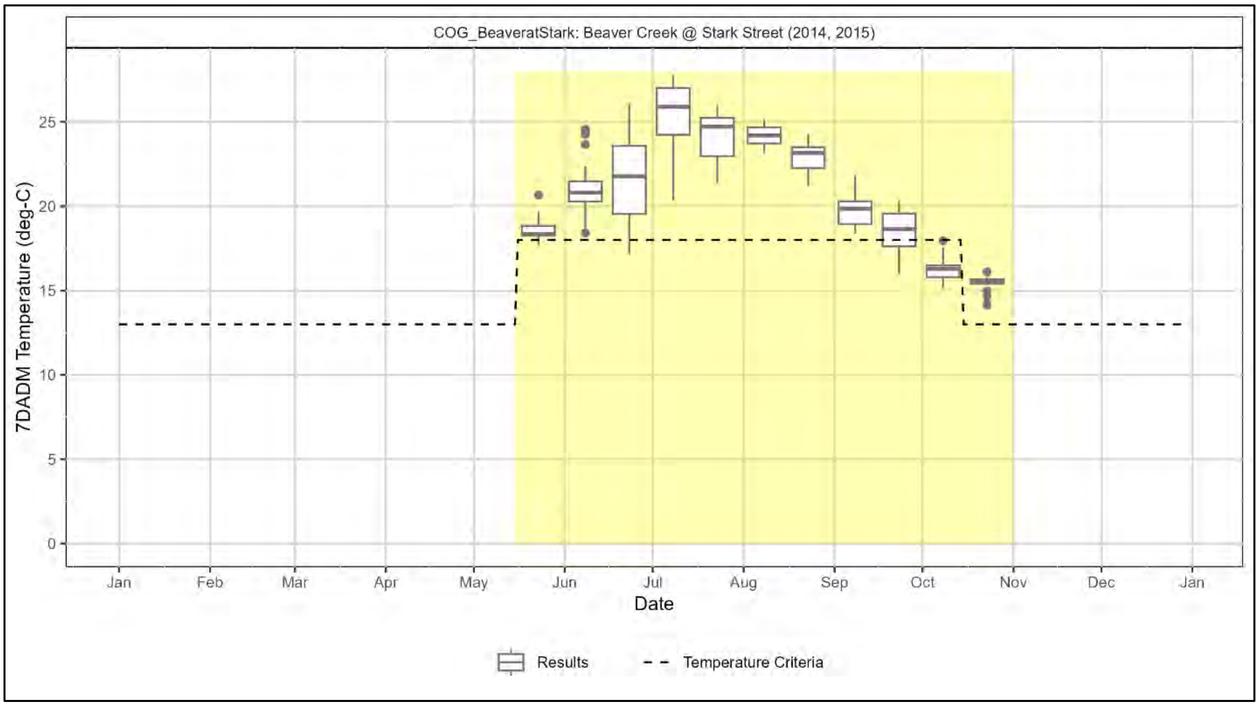

Figure 5-2: Seasonal variation and critical period at the Beaver Creek at Stark Street temperature monitoring site in the Beaver Creek-Sandy Subwatershed (HUC 170800010703).

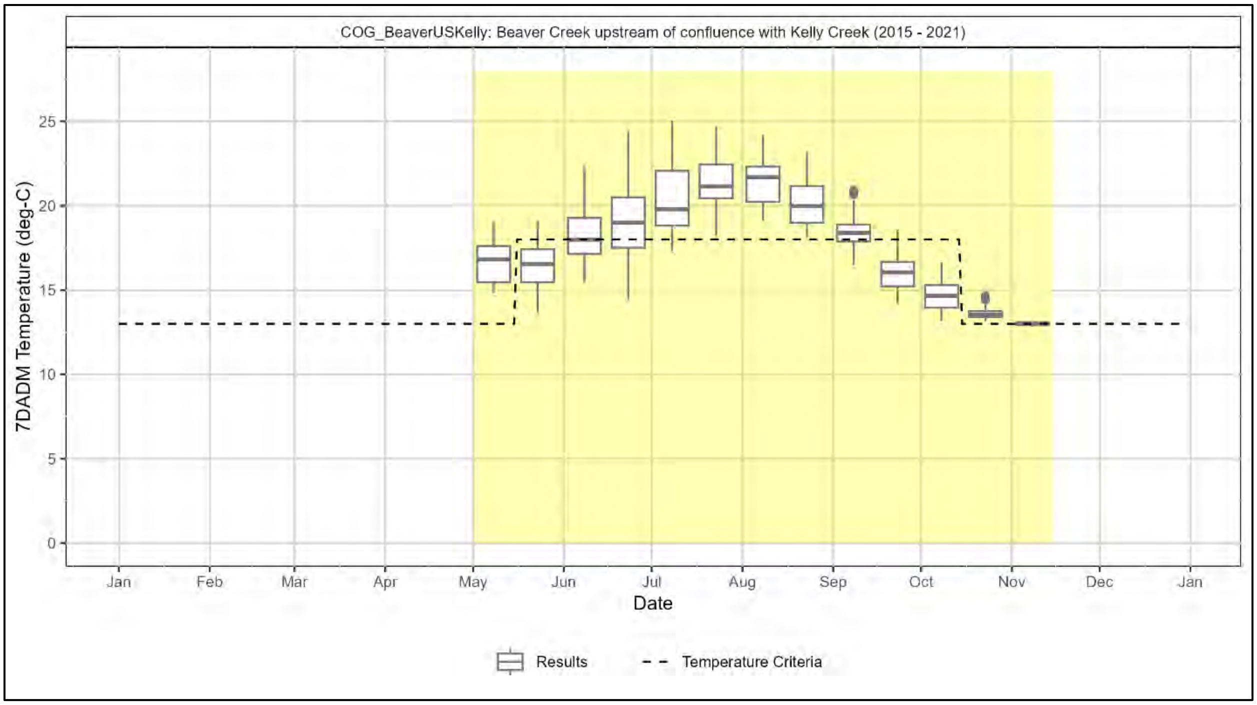

Figure 5-3: Seasonal variation and critical period at the Beaver Creek upstream of Kelly Creek temperature monitoring site in the Beaver Creek-Sandy Subwatershed (HUC 170800010703).

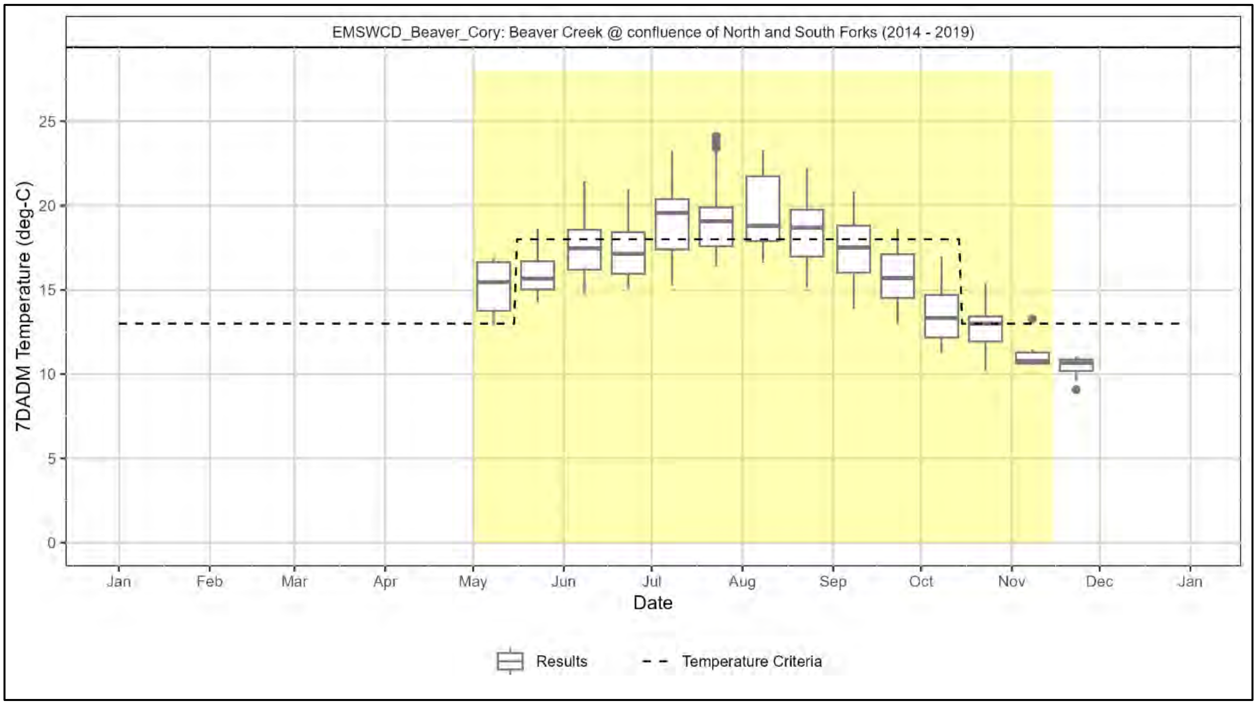

Figure 5-4: Seasonal variation and critical period at the Beaver Creek at the confluence of the North and South Forks temperature monitoring site in the Beaver Creek-Sandy Subwatershed (HUC 170800010703).

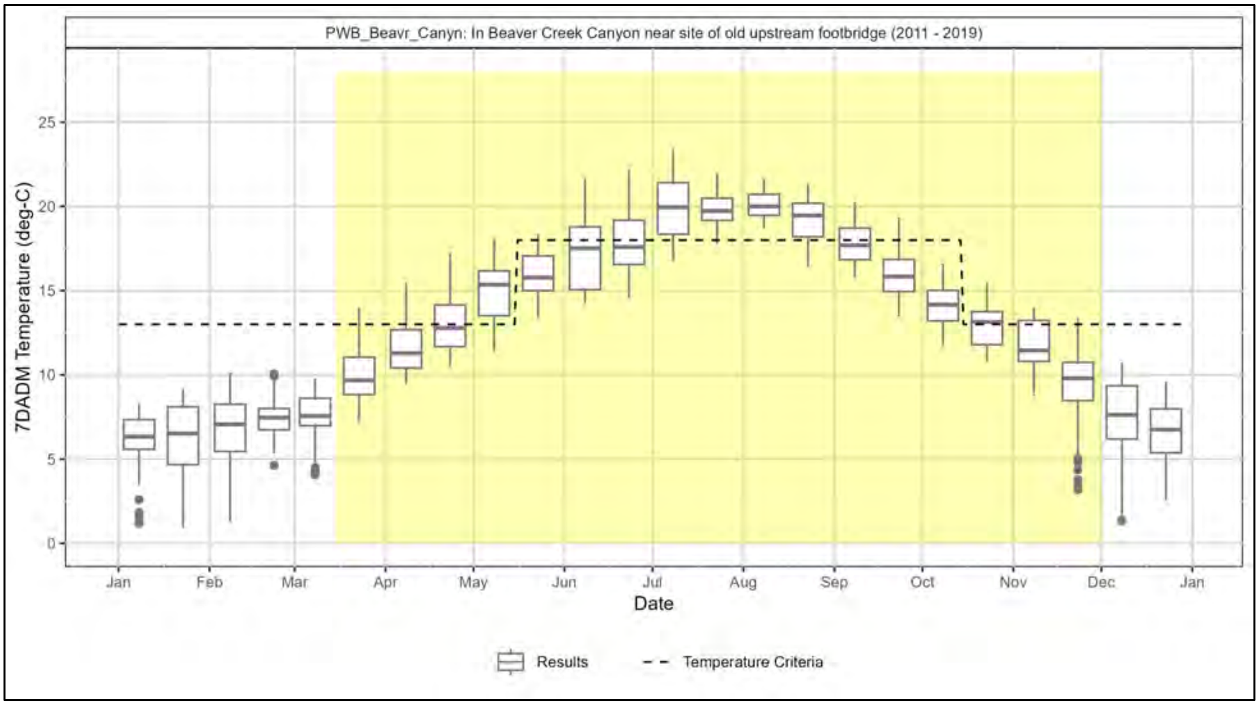

Figure 5-5: Seasonal variation and critical period at the Beaver Creek in Beaver Canyon temperature monitoring site in the Beaver Creek-Sandy Subwatershed (HUC 170800010703).

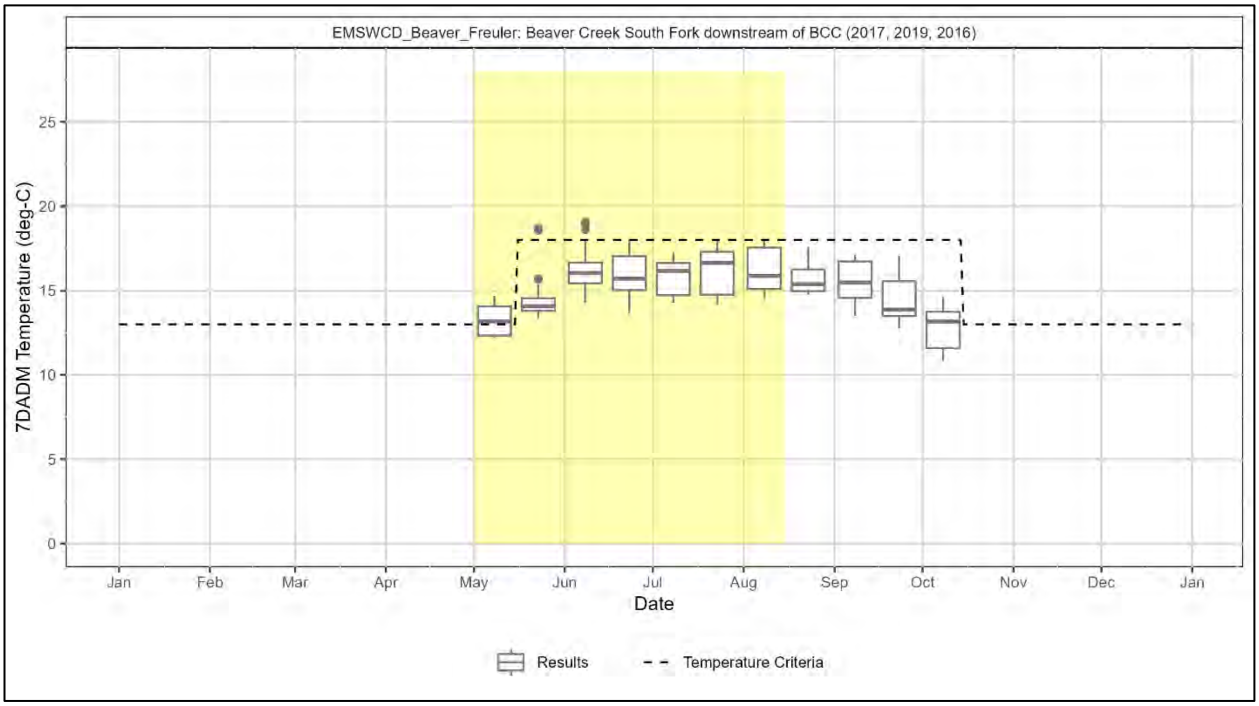

Figure 5-6: Seasonal variation and critical period at the South Fork Beaver Creek downstream of confluence with Middle Fork Beaver Creek temperature monitoring site in the Beaver Creek-Sandy Subwatershed (HUC 170800010703).

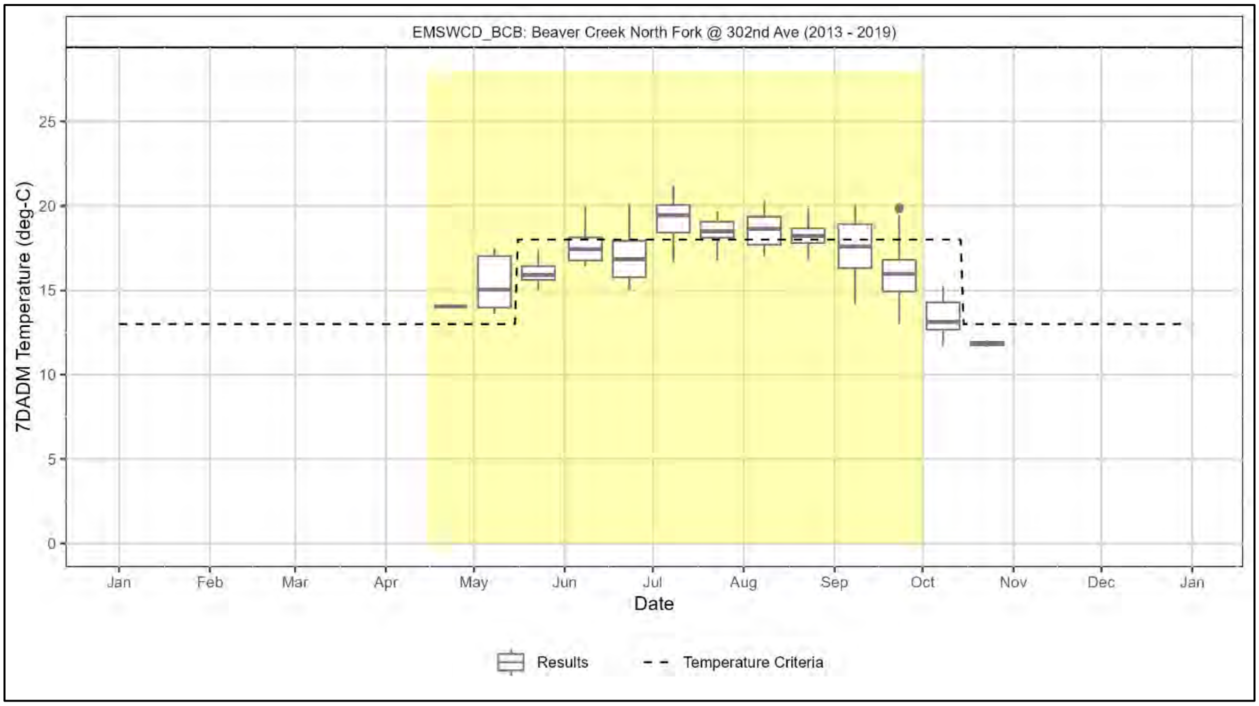

Figure 5-7: Seasonal variation and critical period at the Beaver Creek North Fork at 302nd Avenue temperature monitoring site in the Beaver Creek-Sandy Subwatershed (HUC 170800010703).

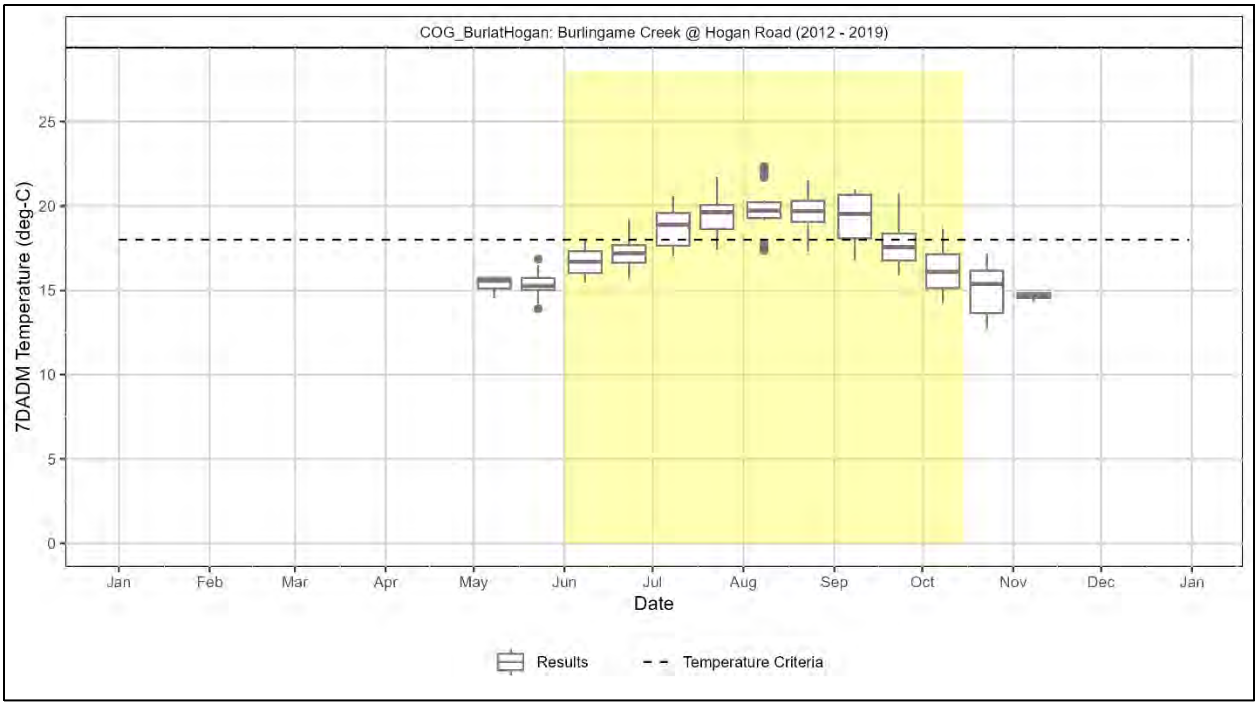

Figure 5-8: Seasonal variation and critical period at the Burlingame Creek at Hogan Road temperature monitoring site in the Beaver Creek-Sandy Subwatershed (HUC 170800010703).

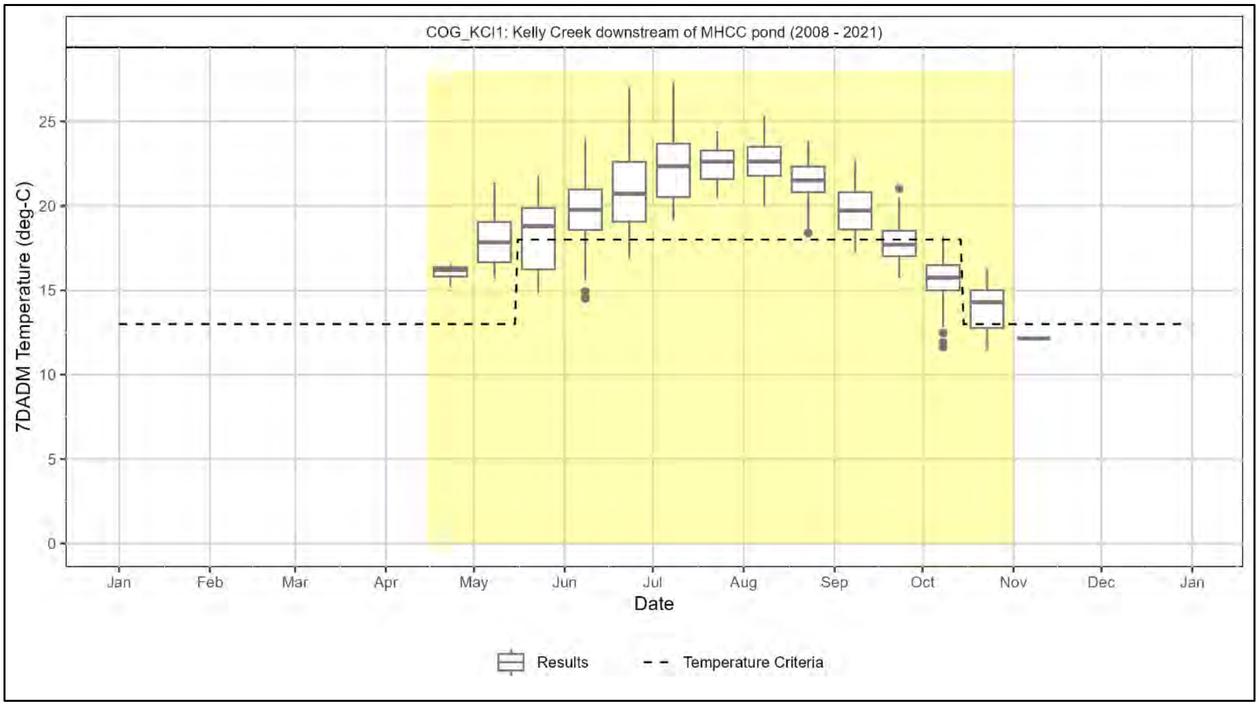

Figure 5-9: Seasonal variation and critical period at the Kelly Creek downstream of Mount Hood Community College Pond temperature monitoring site in the Beaver Creek-Sandy Subwatershed (HUC 170800010703).

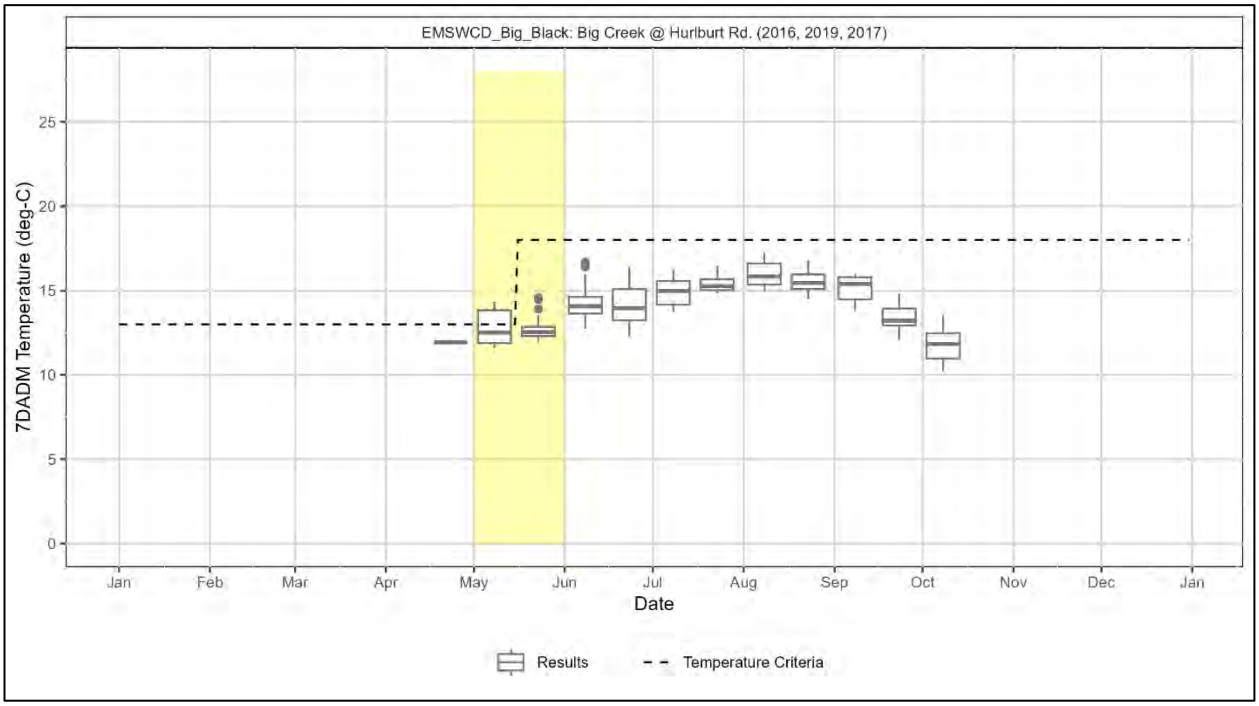

Figure 5-10: Seasonal variation and critical period at the Big Creek at Hurlburt Road temperature monitoring site on Big Creek.

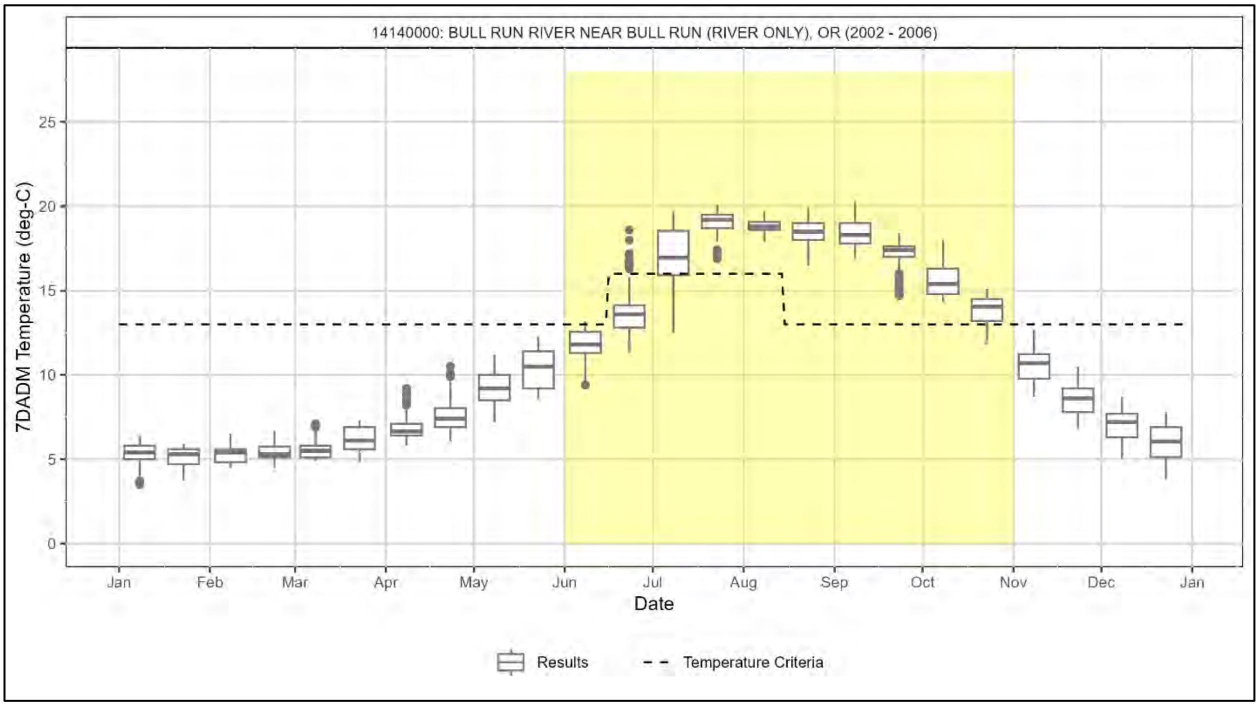

Figure 5-11: Seasonal variation and critical period at the Bull Run River near Bull Run temperature monitoring site on the Bull Run River.

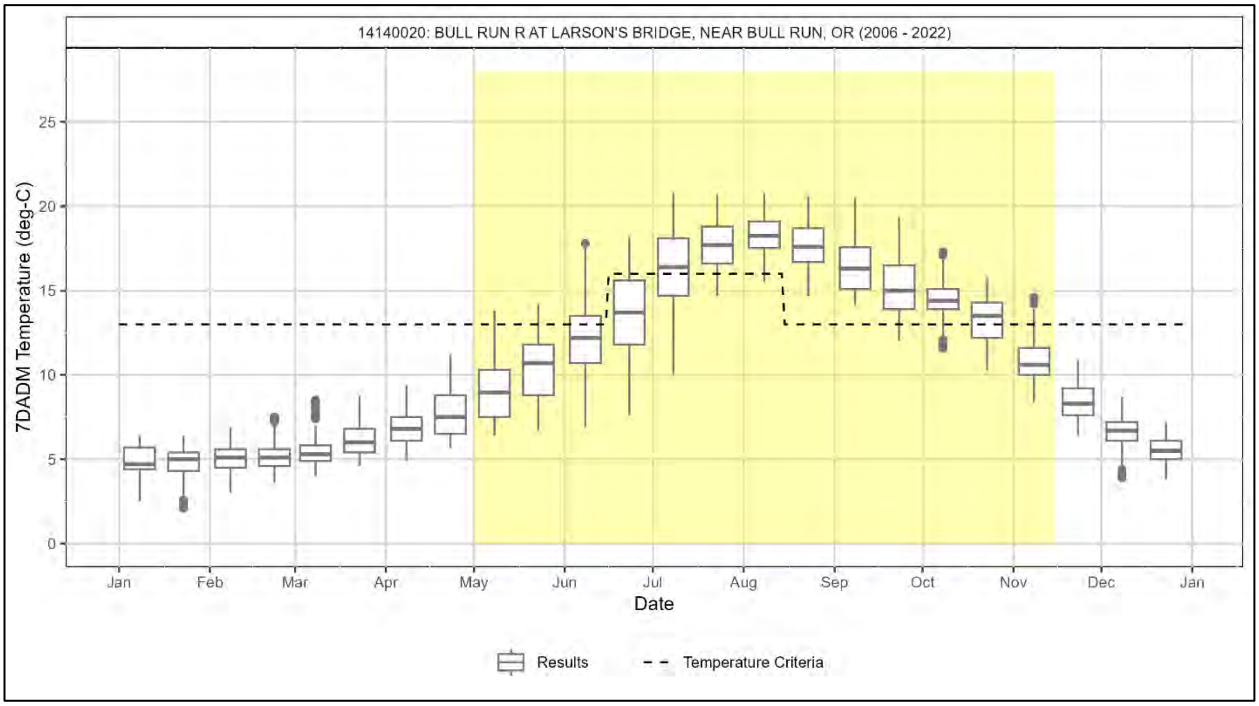

Figure 5-12: Seasonal variation and critical period at the Bull Run River at Larson’s Bridge temperature monitoring site on the Bull Run River.

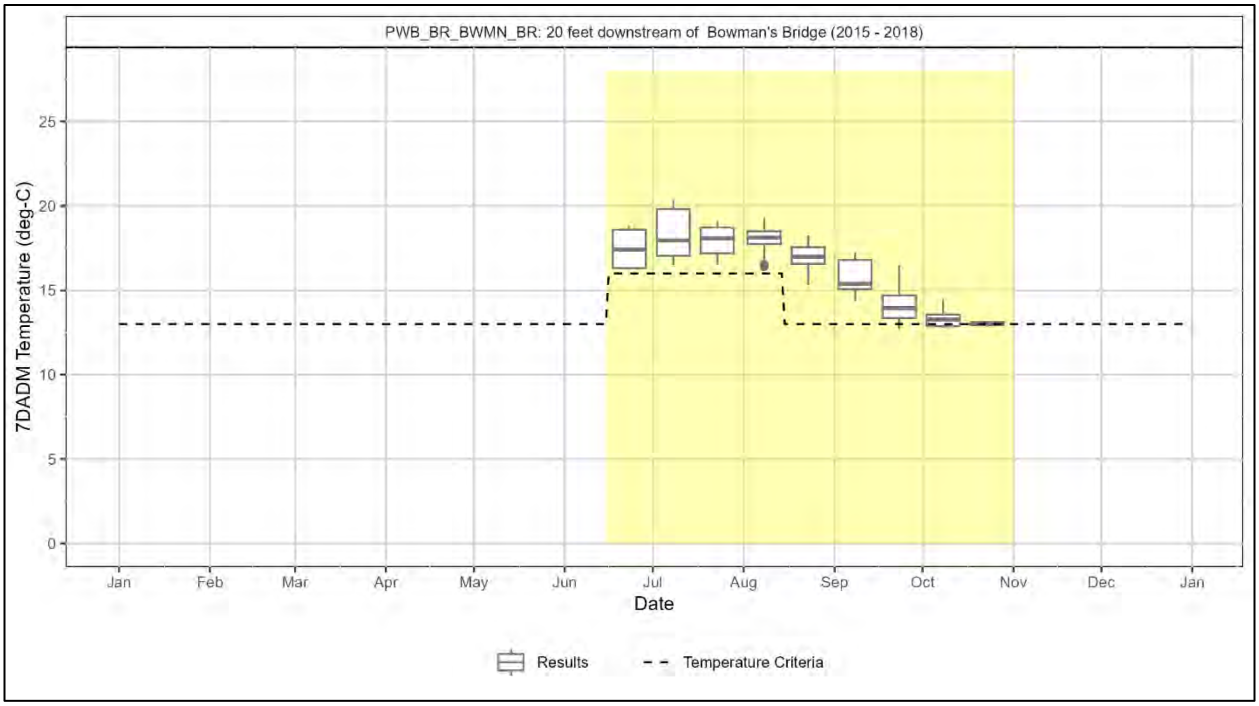

Figure 5-13: Seasonal variation and critical period at the Bull Run River downstream of Bowman's Bridge temperature monitoring site on the Bull Run River.

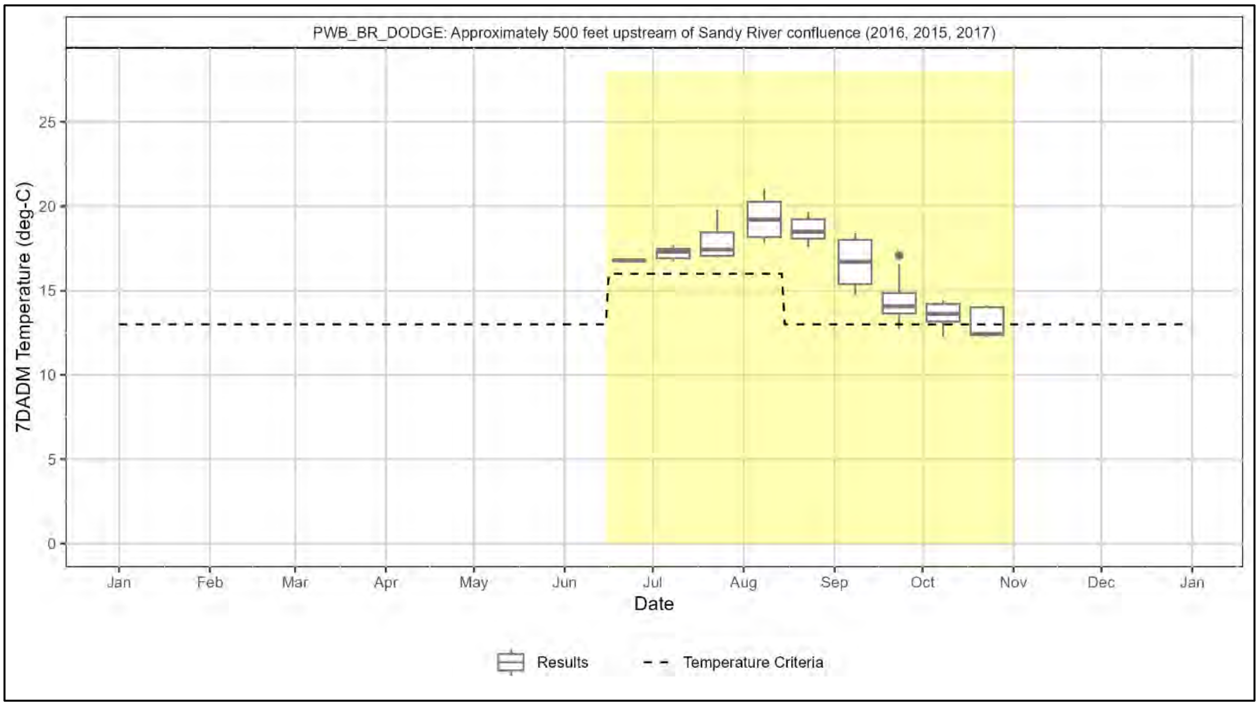

Figure 5-14: Seasonal variation and critical period at the Bull Run River upstream of Sandy River confluence temperature monitoring site on the Bull Run River.

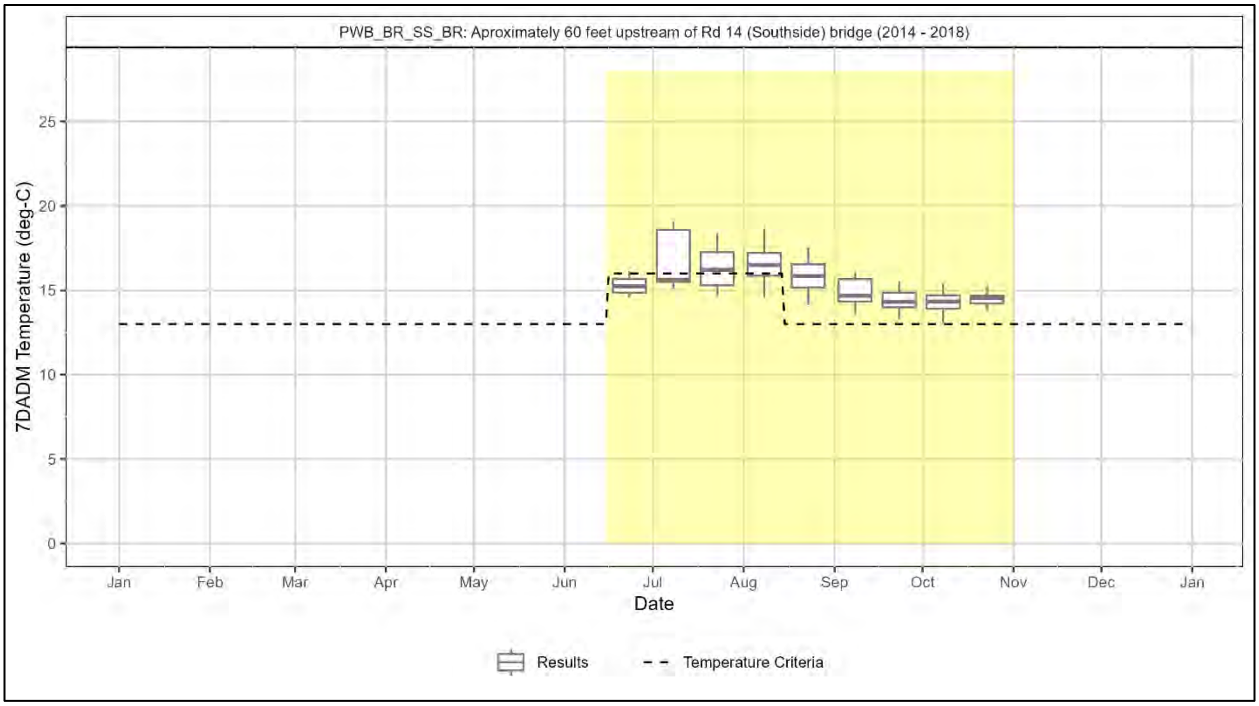

Figure 5-15: Seasonal variation and critical period at the Bull Run River upstream of Road 14 temperature monitoring site on the Bull Run River.

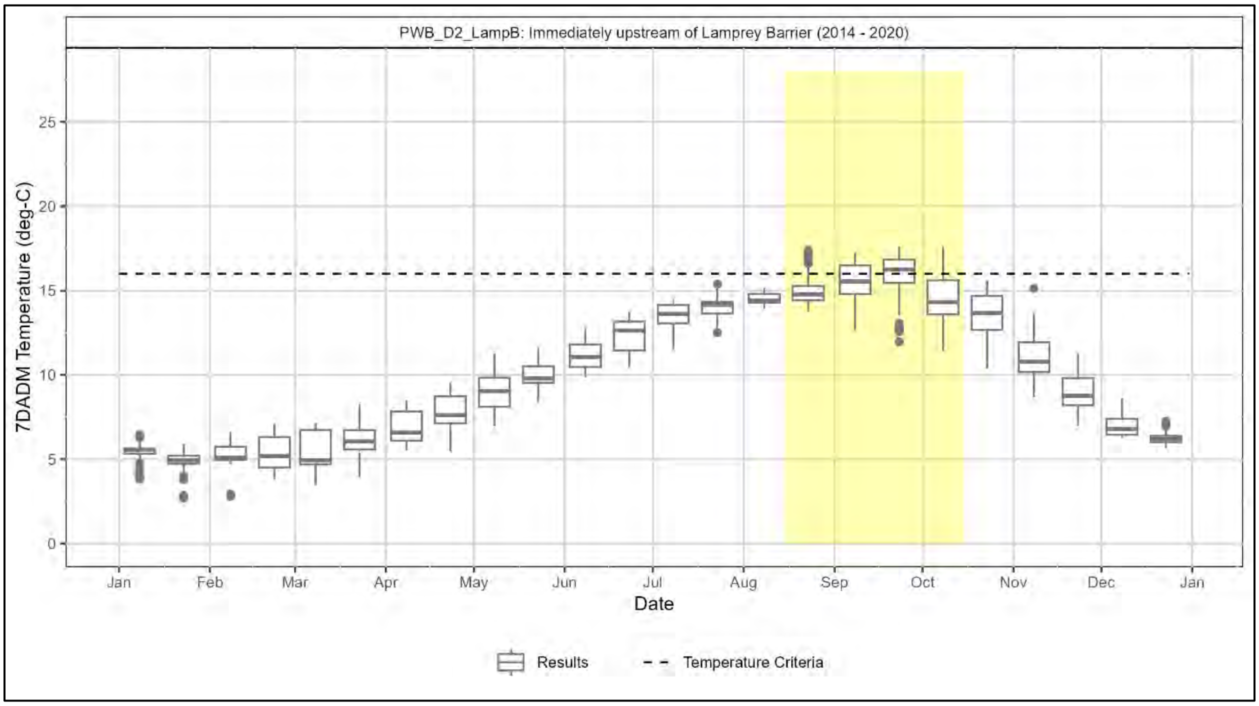

Figure 5-16: Seasonal variation and critical period at the Bull Run River downstream of lamprey barrier temperature monitoring site on the Bull Run River.

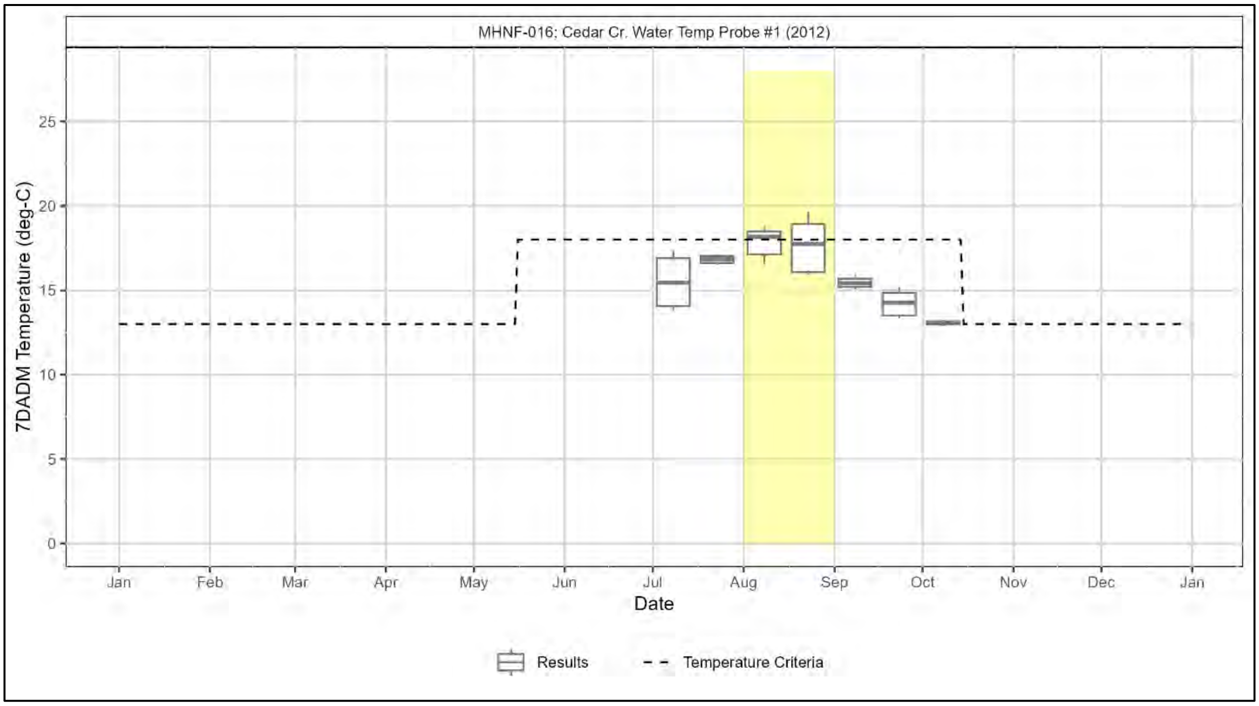

Figure 5-17: Seasonal variation and critical period at the Cedar Creek Water Temp Probe #1 temperature monitoring site on Cedar Creek.

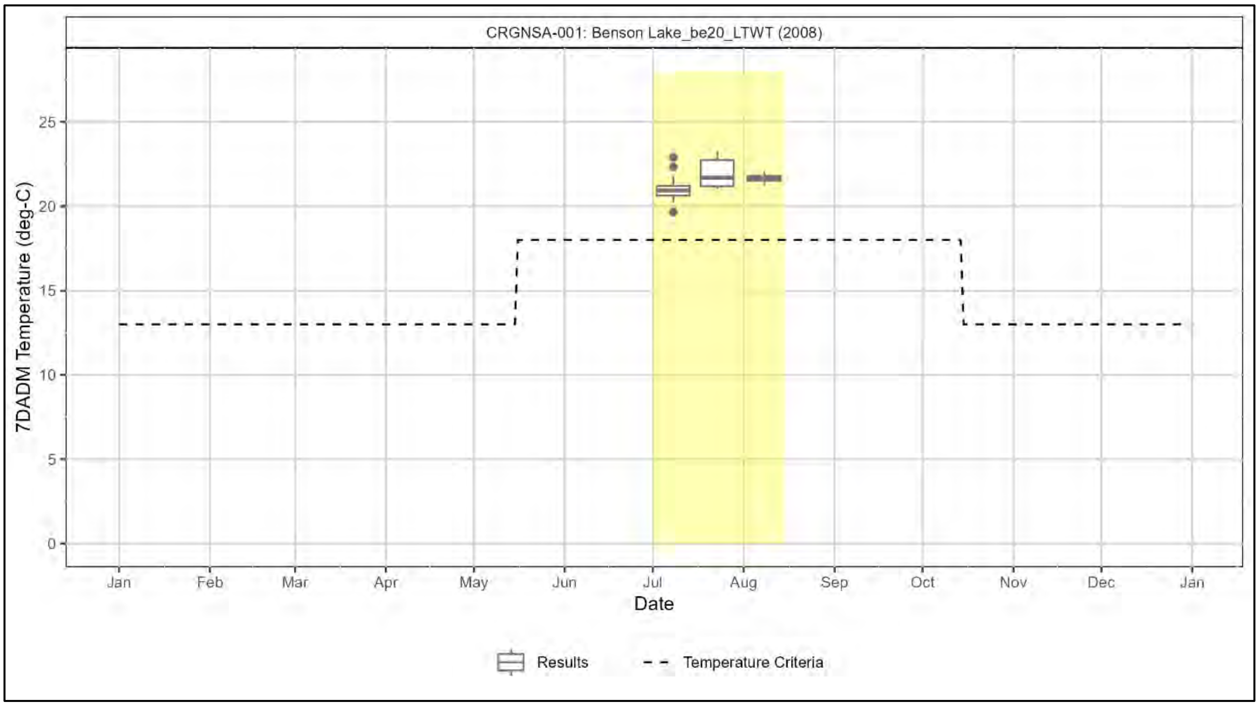

Figure 5-18: Seasonal variation and critical period at the Benson Lake temperature monitoring site on a Columbia gorge tributary flowing into the Columbia River.

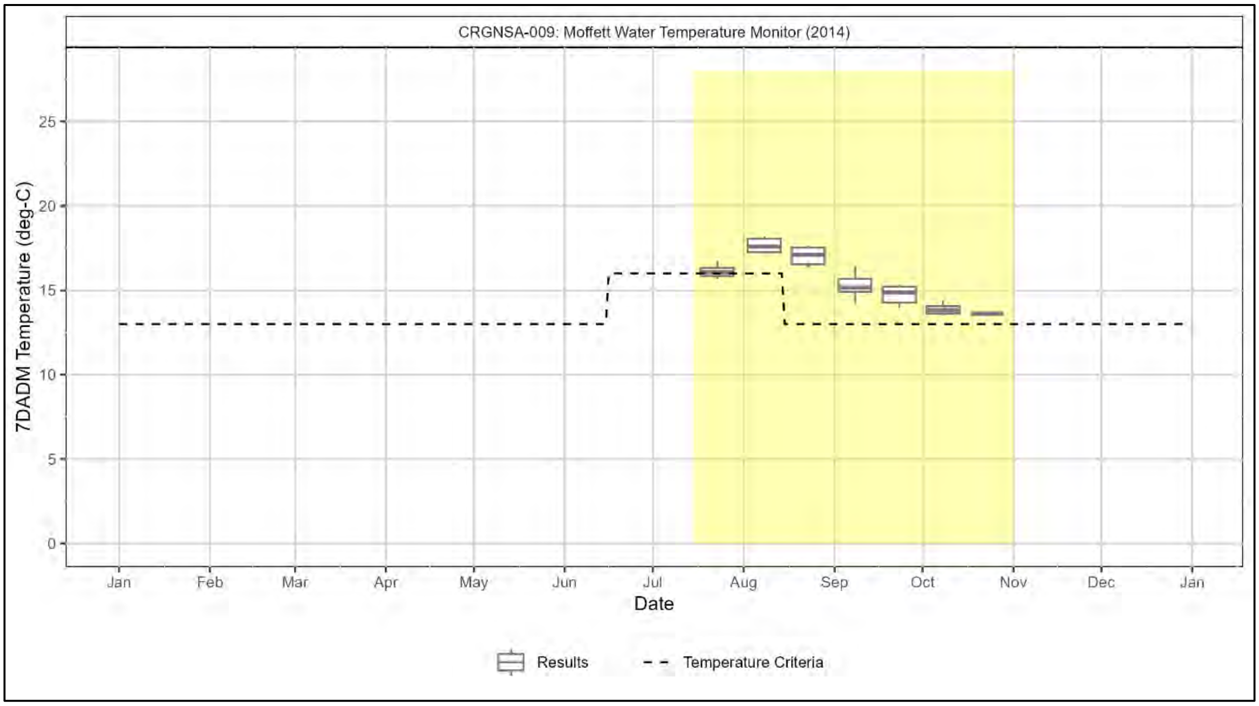

Figure 5-19: Seasonal variation and critical period at the Moffett Creek near mouth temperature monitoring site on the Moffett Creek tributary flowing into the Columbia River.

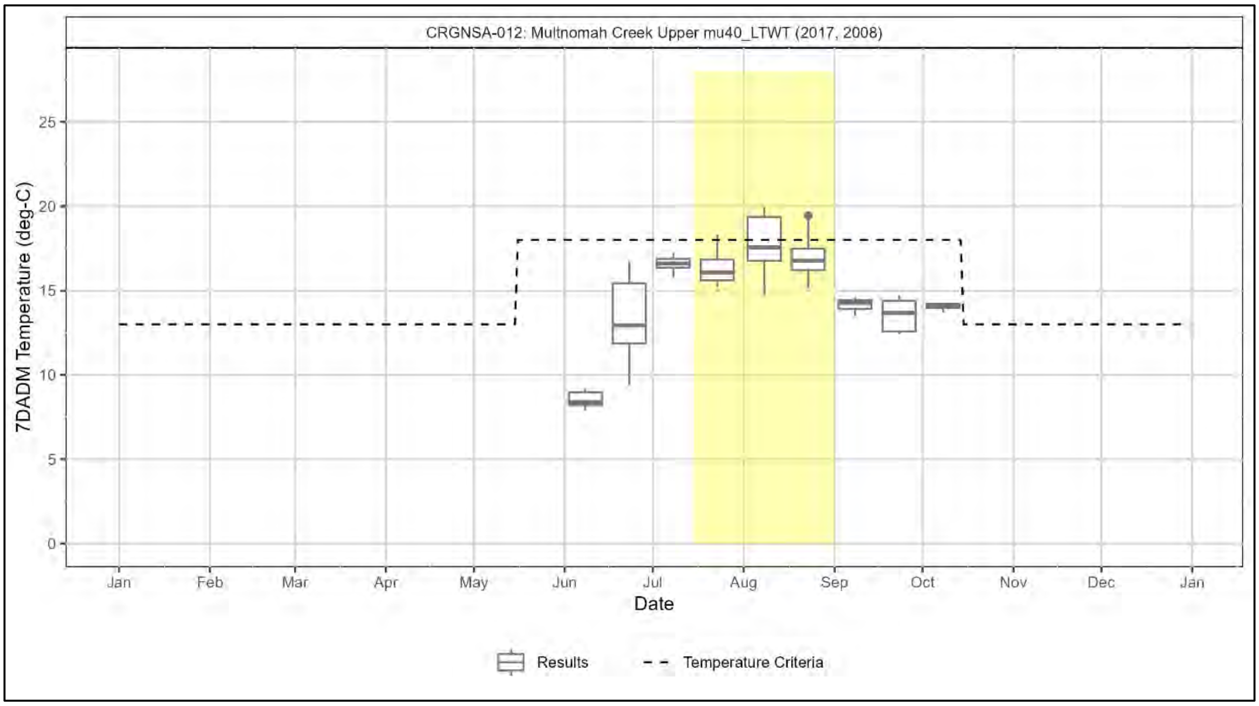

Figure 5-20: Seasonal variation and critical period at the Multnomah Creek upstream of Benson Lake temperature monitoring site on a Columbia gorge tributary flowing into the Columbia River.

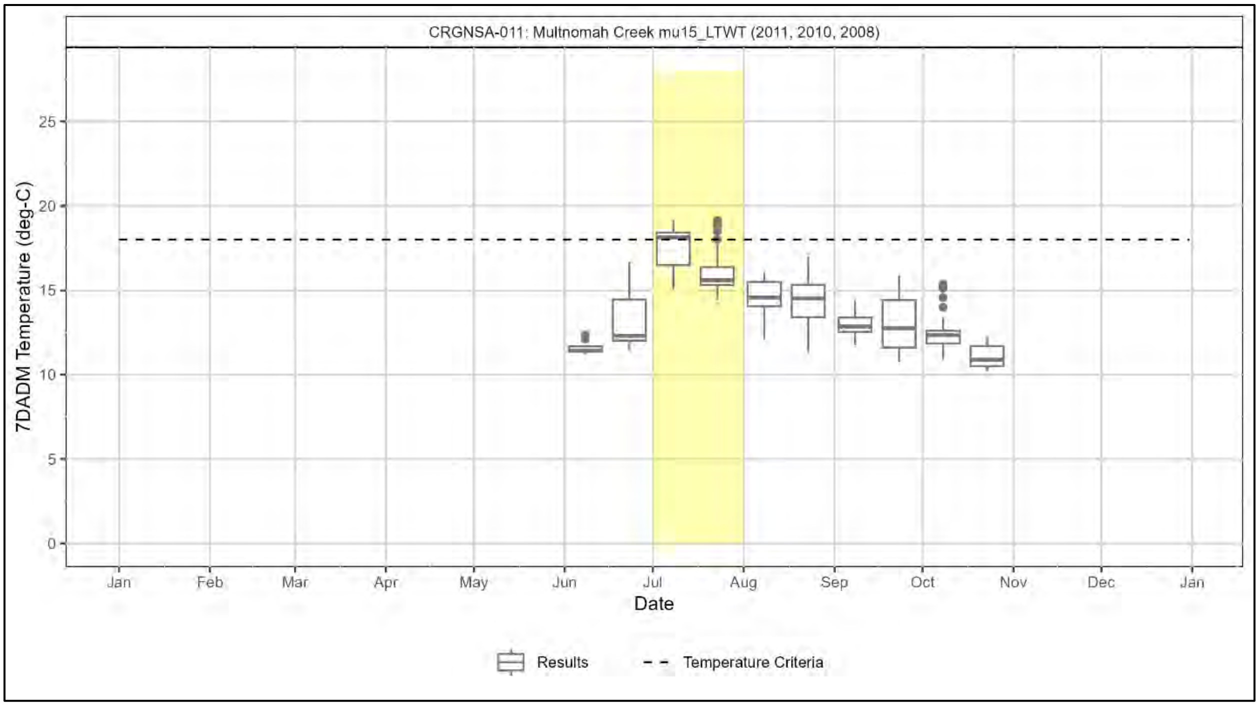

Figure 5-21: Seasonal variation and critical period at the Multnomah Creek downstream of Benson Lake temperature monitoring site on a Columbia gorge tributary flowing into the Columbia River.

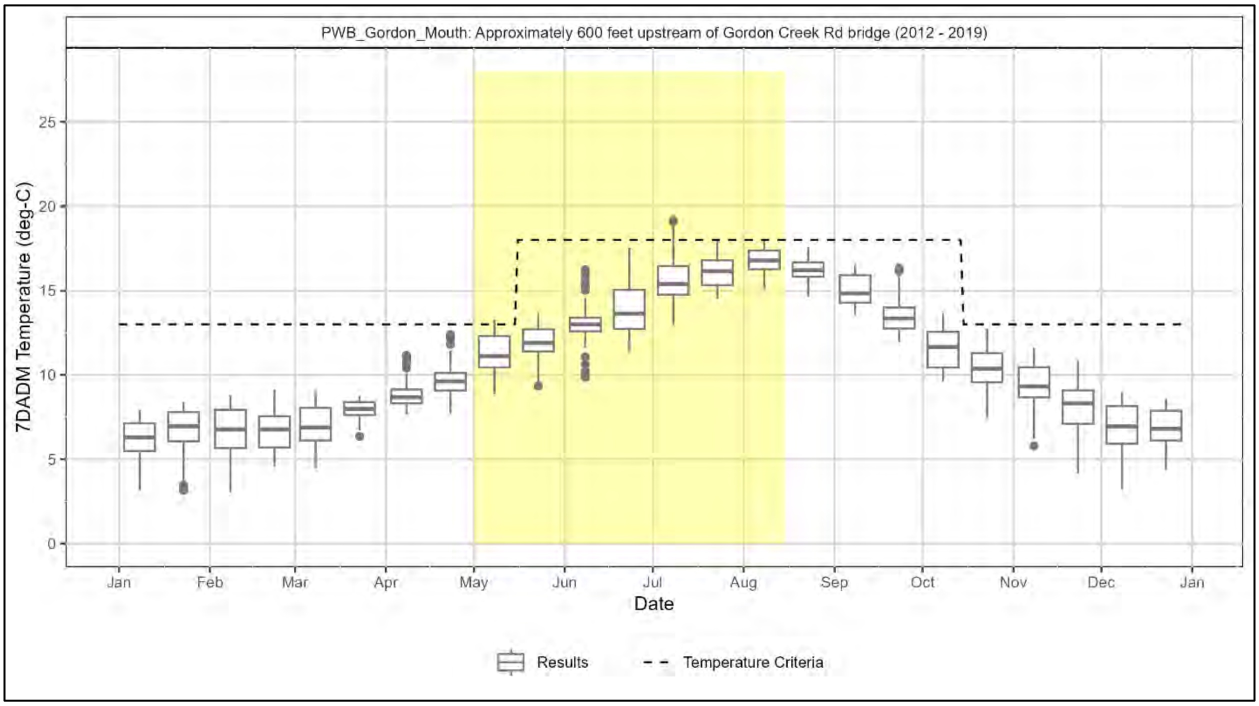

Figure 5-22: Seasonal variation and critical period at the Gordon Creek upstream of mouth temperature monitoring sites on Gordon Creek.

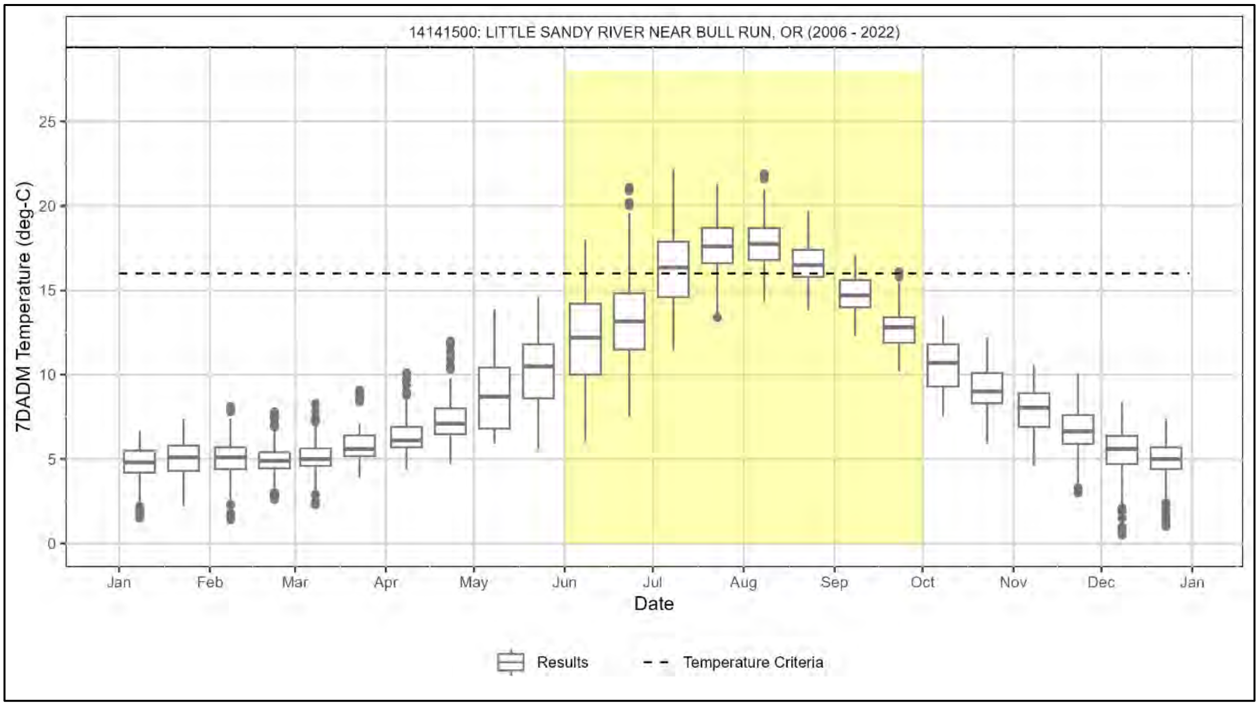

Figure 5-23: Seasonal variation and critical period at the Little Sandy River near Bull Run temperature monitoring site on the Little Sandy River.

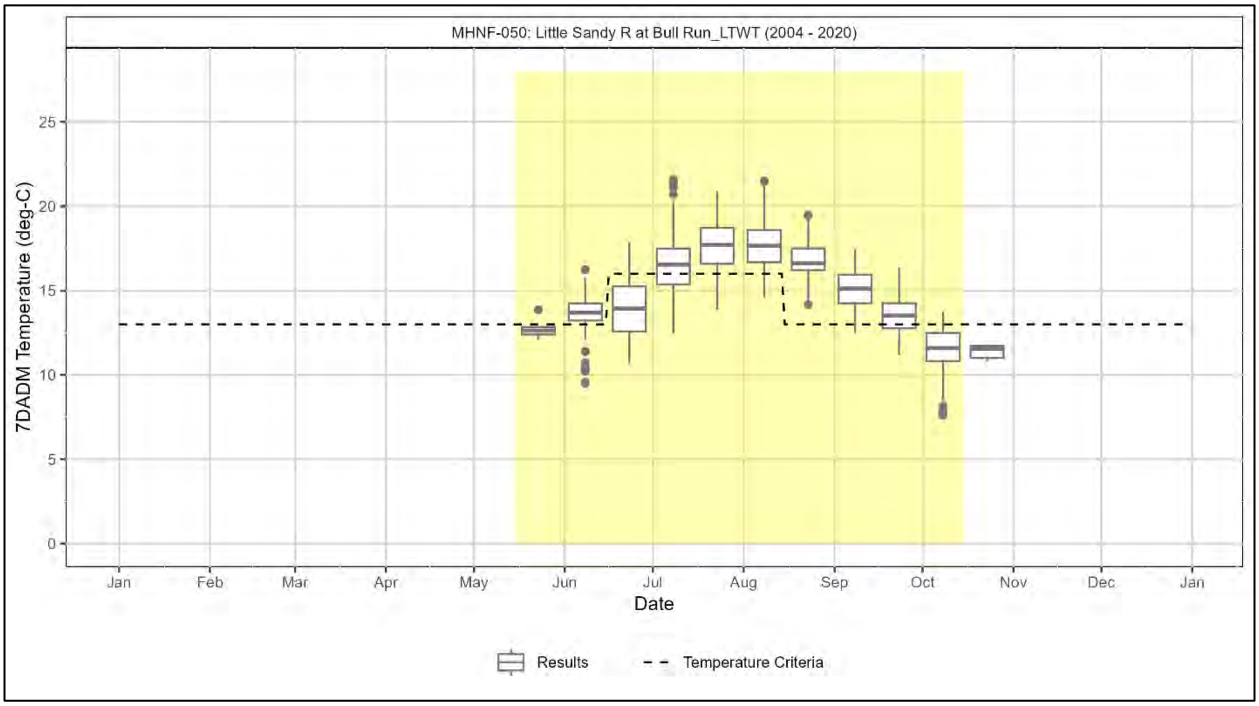

Figure 5-24: Seasonal variation and critical period at the Little Sandy River at the confluence with the Bull Run River temperature monitoring site on the Little Sandy River.

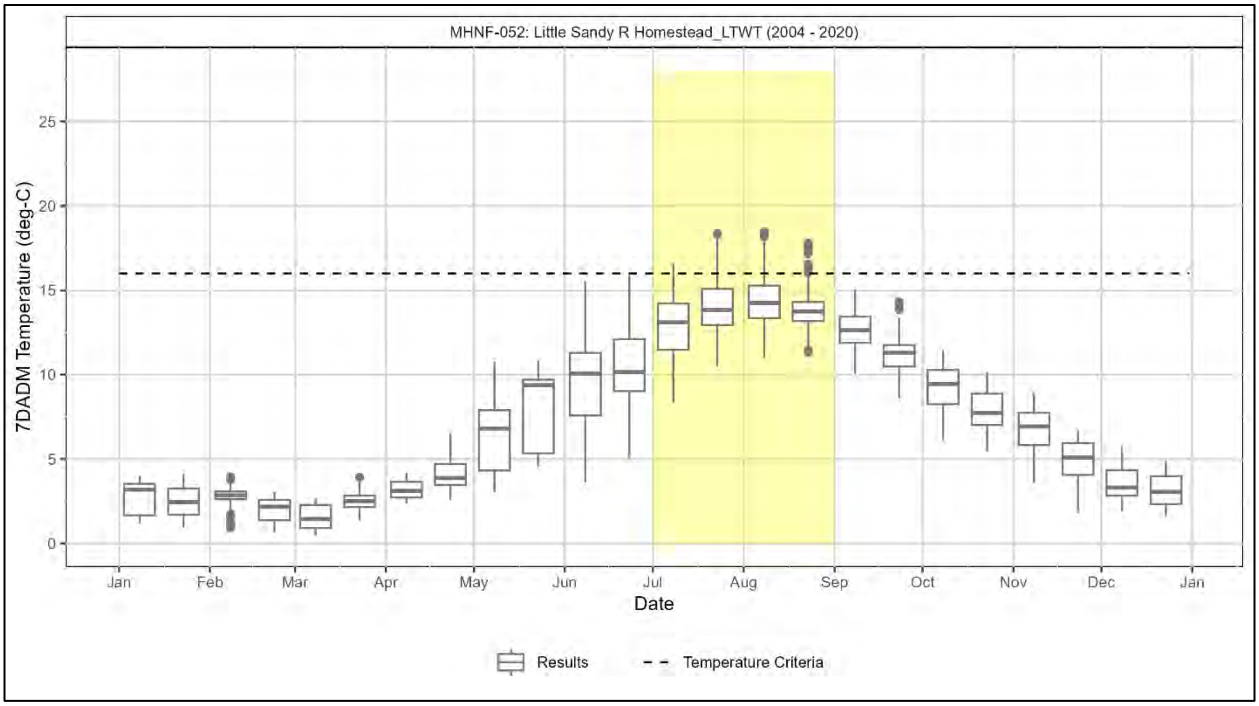

Figure 5-25: Seasonal variation and critical period at the Little Sandy River near Bull Run temperature monitoring site on the Little Sandy River.

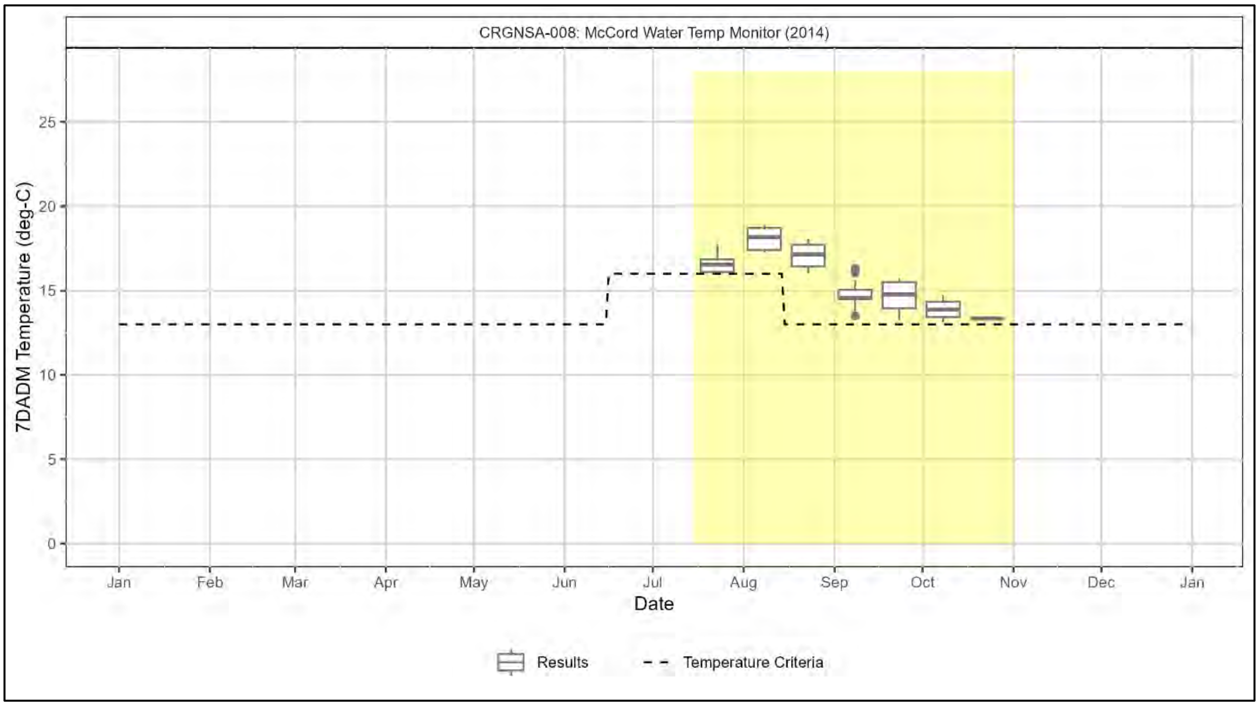

Figure 5-26: Seasonal variation and critical period at the Little Sandy River near Homestead temperature monitoring site on the Little Sandy River.

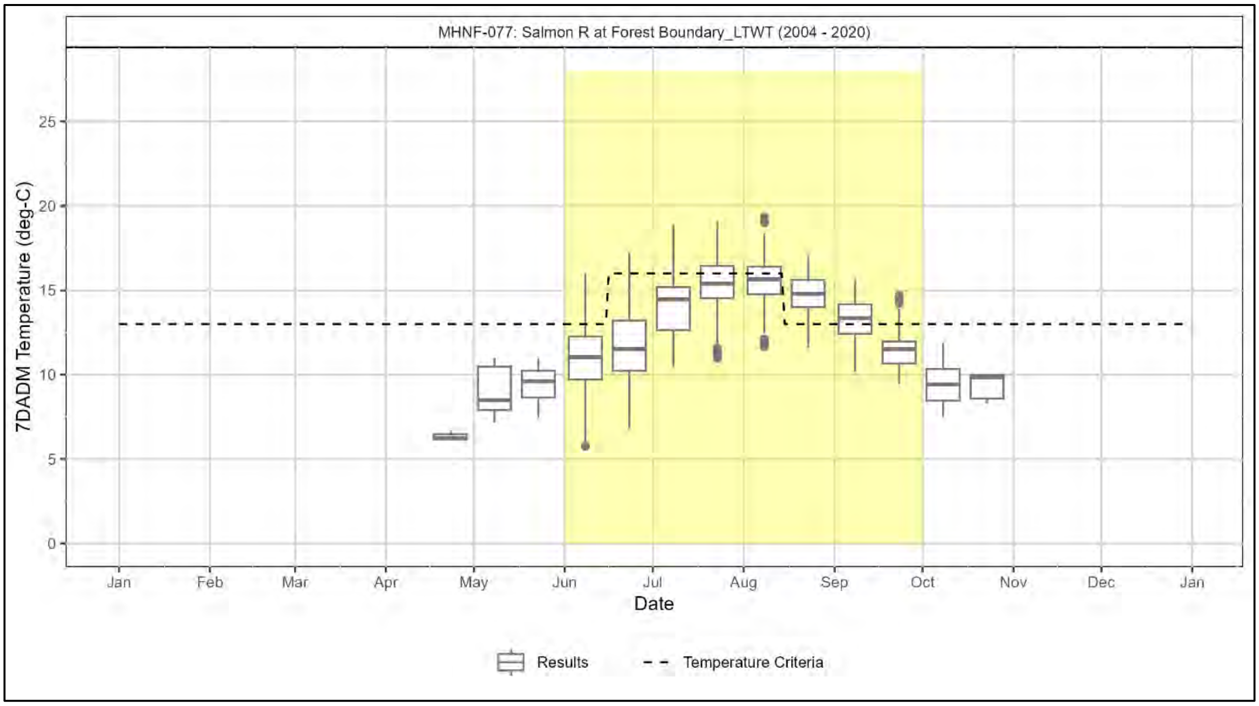

Figure 5-27: Seasonal variation and critical period at the Salmon River at forest boundary temperature monitoring site on the Salmon River.

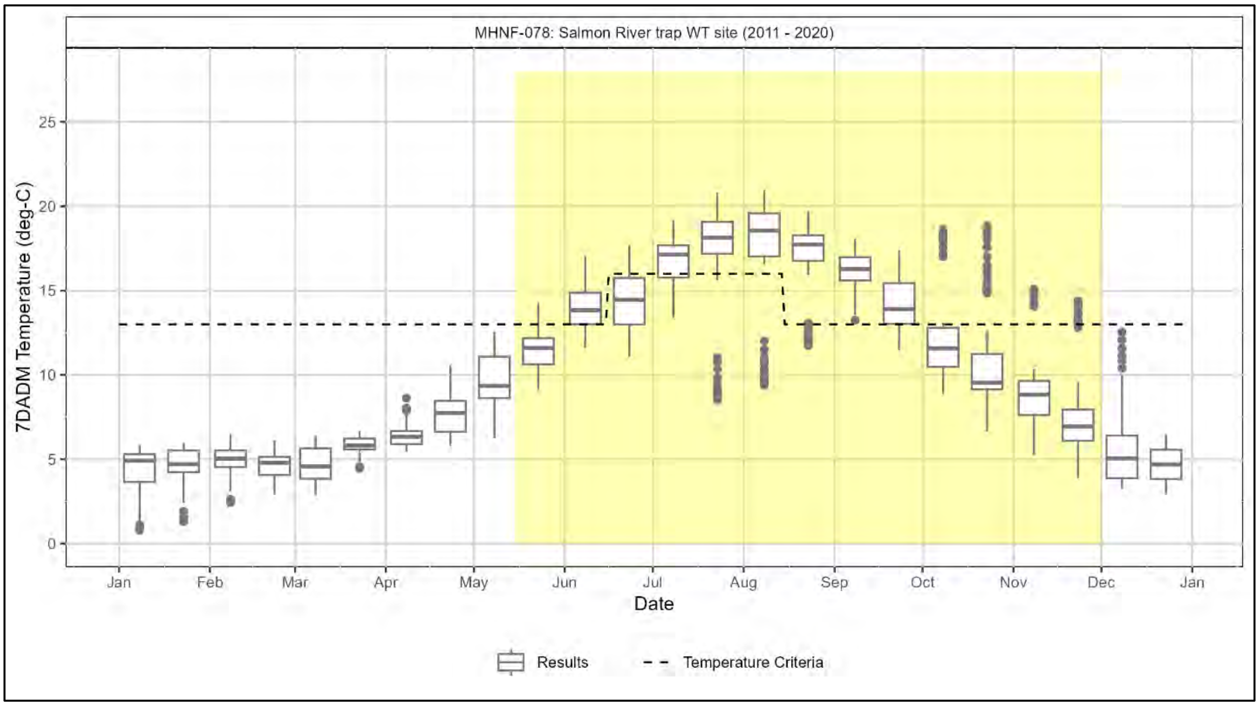

Figure 5-28: Seasonal variation and critical period at the Salmon River trap temperature monitoring site on the Salmon River.

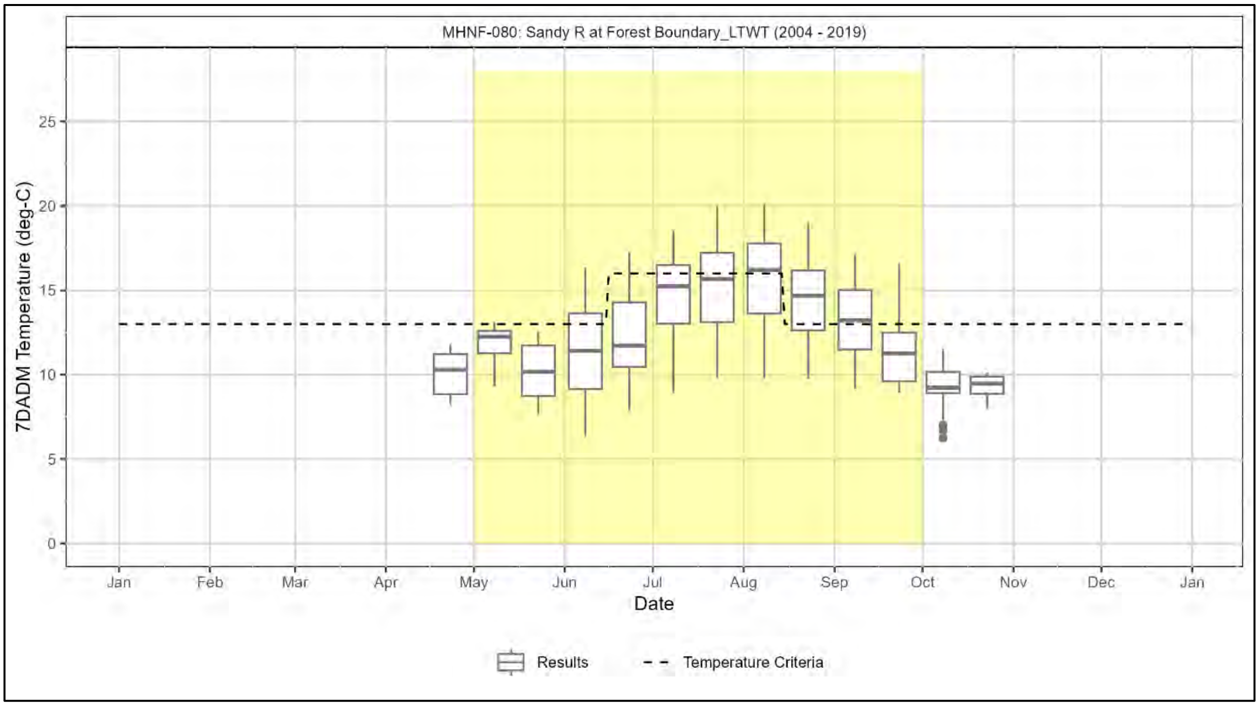

Figure 5-29: Seasonal variation and critical period at the Sandy River at forest boundary temperature monitoring site on the Sandy River.

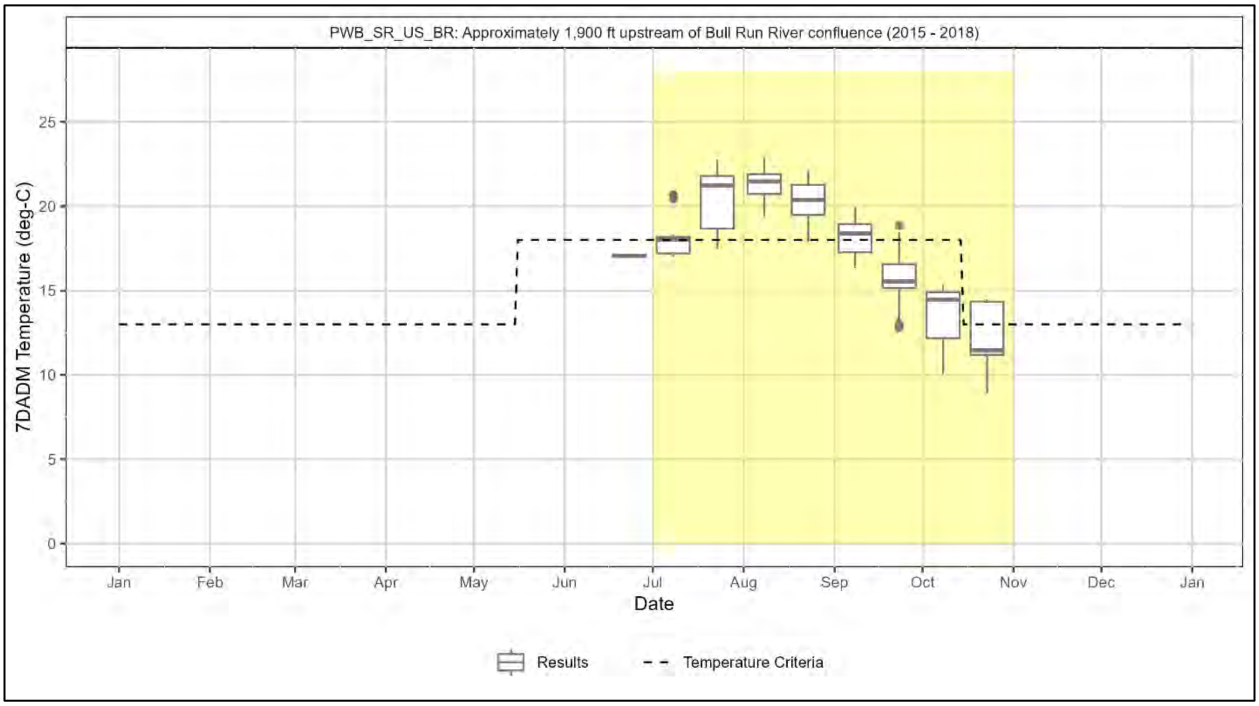

Figure 5-30: Seasonal variation and critical period at the Sandy River upstream of Bull Run River confluence temperature monitoring site on the Sandy River.

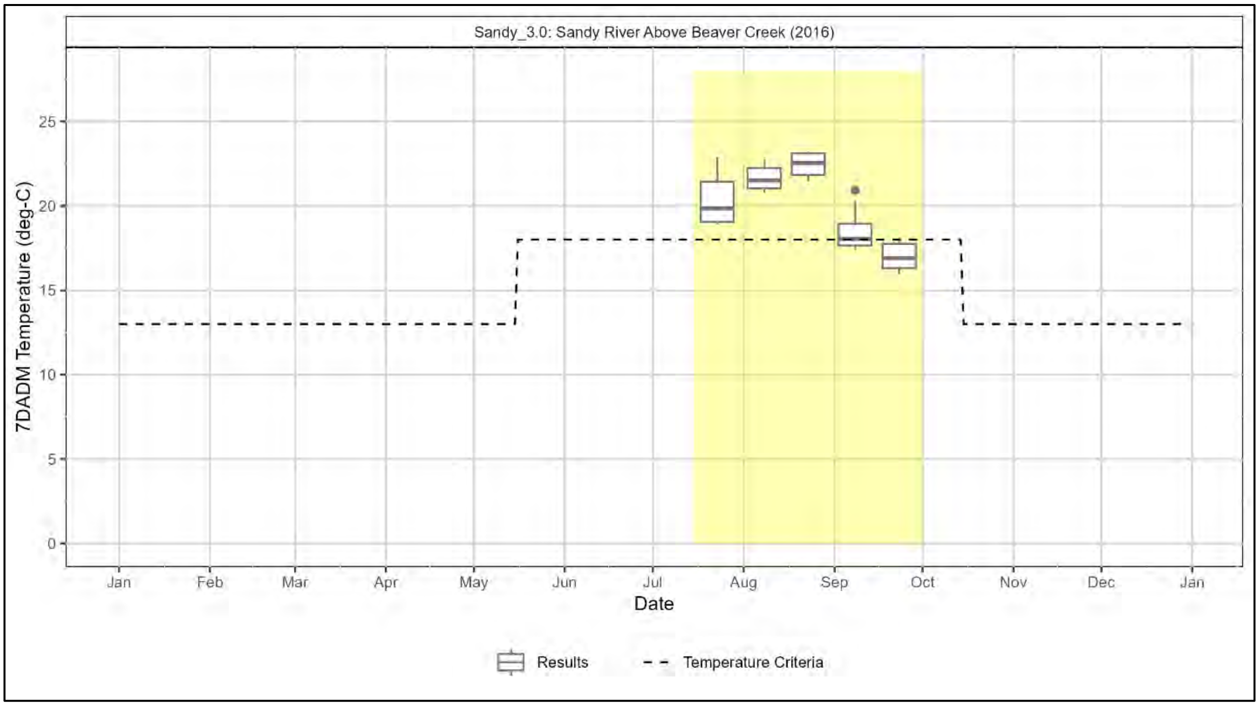

Figure 5-31: Seasonal variation and critical period at the Sandy River above Beaver Creek temperature monitoring site on the Sandy River.

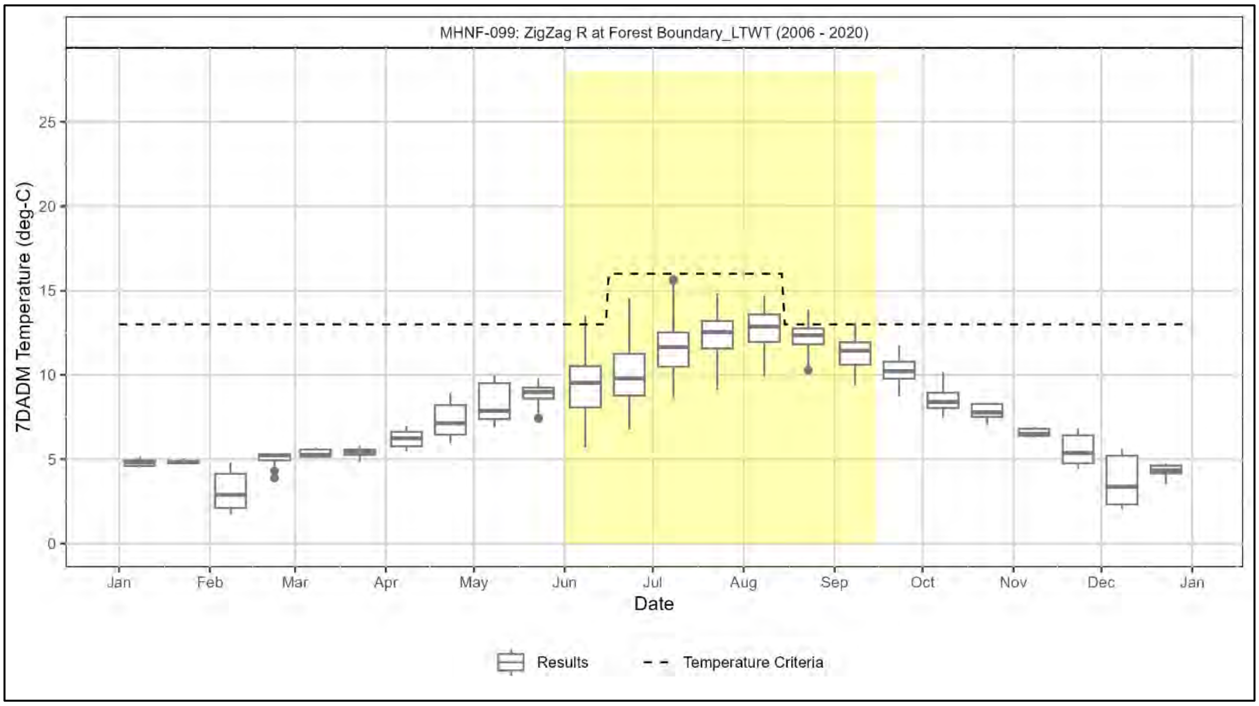

Figure 5-32: Seasonal variation and critical period at the Zig Zag River at forest boundary temperature monitoring site on the Zig Zag River.

6 Temperature water quality data evaluation and analyses

Evaluation and analysis of water quality data to the extent that existing data allow is a critical TMDL element. To understand the water quality impairment, quantify the loading capacity, and assess the ability of various possible scenarios to achieve the TMDL and applicable water quality standards, the analysis requires a predictive component. DEQ uses models to evaluate potential stream warming sources and, to the extent existing data allow, their current and TMDL allocation pollutant loading. Heat Source and CE-QUAL-W2 models were used in this effort and are described in Appendices A-D of this document.

6.1 Analysis overview

The modeling requirements for this project included the abilities to predict/evaluate hourly:

1. Stream temperatures spanning months at ≤500m longitudinal resolution.
2. Solar radiation fluxes and daily effective shade at ≤100m longitudinal resolution.
3. Stream temperature responses due to changes in:
    a. Streamside vegetation,
    b. Water withdrawals and upstream tributaries' stream flows,
    c. Channel morphology
    d. Effluent temperatures and flows discharged from NPDES-permitted facilities.

Figure 6-1 provides an overview of the type of analyses completed for this TMDL. Water quality models were used to support analyses on major streams. These models have specific input and calibration data requirements. Data types and how they supported the TMDL analysis are summarized in Table 6-1 and described more fully in Appendices A-D. All data are available upon request.

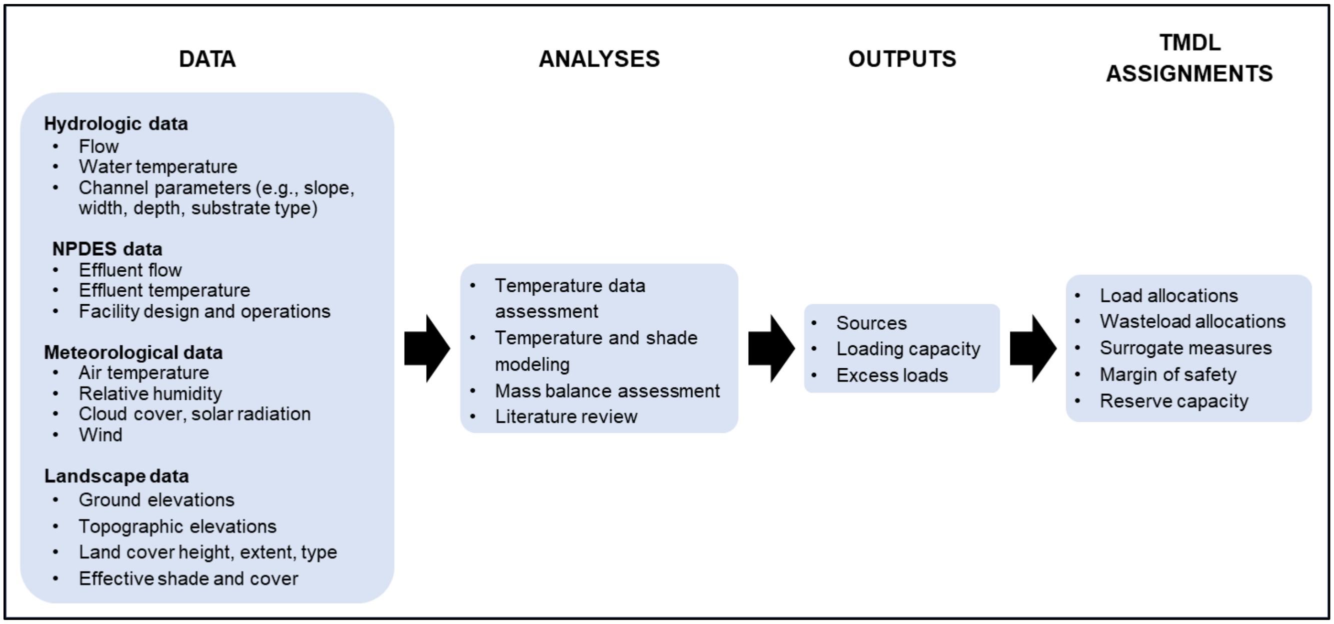

Figure 6-1: Lower Columbia-Sandy River Subbasin temperature analysis overview.

6.2 Data overview

As illustrated in Figure 6-1, data for numerous hydrologic, meteorologic, and landscape/ geographic parameters within the TMDL's spatial and temporal boundaries are required to conduct effective analysis for TMDL development. Section 2 of Appendix B to this document describes these parameters, their applications in this TMDL development, and provides information on the specific datasets and sources utilized for this effort. For the Bull Run River, a CE-QUAL-W2 model previously developed by the City of Portland was updated and used for this TMDL (see Appendix D). For the Sandy River and Salmon River, the following data types were used. All data are available upon request.

Table 6-1: Data types used in Lower Columbia-Sandy Subbasin Temperature TMDL modeling.

Data Source Type	Dataset Types	Data Sources
Field-acquired	• Continuous stream temperature • Stream flow rate: continuous & instantaneous • Point source discharge temperatures & flows	DEQ Ambient Water Quality Monitoring System (AWQMS); USGS National Water Information System (NWIS); DEQ data solicitation responses; Portland Water Bureau; NPDES Discharge Monitoring Reports
GIS and/or remotely sensed	• 3-ft Digital Elevation Model (DEM) • Light Detection and Ranging (LiDAR) • Aerial imagery: Digital Orthophoto Quads (DOQs) • Thermal Infrared Radiometry (TIR) temperature data	Oregon Department of Geology and Mineral Industries (DOGAMI); Oregon LiDAR Consortium (OLC); Watershed Sciences, Inc.
Derived from above data types via:	• Stream position, channel width, channel bottom width, elevation, gradient	DEMs, LiDAR, DOQs (for stream morphology, land cover, topography, & geography); USGS StreamStats,

(a) quantitative methods or (b) proxy substitution (for certain tributary flows & temps.)	• Topographic shade angles • Land cover mapping • Tributary flows & temperatures	historical data, proxy site data, estimated (constant) data (for tributary flows & temperatures if direct 2016 monitoring data were unavailable)

6.3 Model setup and application overview

As described in Appendices A-D, DEQ and its partners configured and calibrated models for the Sandy River, Salmon River, Bull Run River, Little Sandy River, and Zigzag River. The models were adjusted iteratively until acceptable goodness-of-fit was achieved relative to the conditions observed in 2001 (Zigzag and Little Sandy Rivers) or 2016 (Salmon, Bull Run, and Sandy Rivers). These results are provided in the appendices and were used in tandem with applicable water quality standard data to predict (7DADM) standard exceedances and derive the loading capacities, excess loads, and allocations presented in the TMDL report. To predict the effects of various changes in riparian conditions and other management scenarios, the model parameters were adjusted accordingly and the results evaluated to determine if those management strategies would result in attainment of water quality standards.

6.4 The 7Q10 low-flow statistic

The “7Q10” summary low-flow statistic is the lowest seven-day average flow that occurs once every ten years (on average). For the Lower Columbia-Sandy Subbasin temperature TMDL, estimated 7Q10s were used to calculate numeric loading capacities and allocations. DEQ calculated annual 7Q10s for temperature-impaired streams in the Sandy Subbasin (Table 6-2), and for the receiving waterbodies that have NPDES permitted discharges with a wasteload allocation (Table 6-3).

The 7Q10 estimates were based on the following approaches:

1) If sufficient daily mean flow data from USGS or OWRD gaging stations were available for a given waterbody, 7Q10 estimates were calculated using these data. Available flow data were retrieved for up to a 30-year period (1992-10-01 to 2022-09-30). DEQ relied on quality control protocols implemented by USGS and OWRD. Only data with a result status of “Approved” (USGS) or “Published” (OWRD) were included in 7Q10 calculations. 7Q10s were calculated by the method of EPA’s DFLOW program (Rossman, 1990), which computes extreme design flows using the log-Pearson Type III probability distribution. A minimum of 10 years of flow data were used with some exceptions. For ungaged locations, if there were sufficient gage data from confluent streams, 7Q10s were estimated from (a) the sum of mean daily flows (for upstream gages), or (b) the difference of mean daily flows (for downstream gages), prior to application of the DFLOW procedure.

2) If insufficient daily mean flow data from USGS and OWRD stream flow gaging stations were available, the web-based tool StreamStats (USGS) was used to estimate 7Q10s. Details of StreamStats are described below.

3) 7Q10s calculated and reported elsewhere (e.g., consultant studies, water quality permits, TMDLs) may have been used. In such cases, DEQ relied on the source's data quality.

4) For Hoodland STP (WES) (39750), the 7Q10 was calculated based on USGS gage data 14137000 minus 14135500. The 7Q10 period is 1992-10-01 to 2022-09-30. Discharge was not measured during this period on the Salmon River at 14135500 and was estimated using simple linear regression. Both 14137000 and 14135500 have discharge measurements from 1936-09-01 to 1952-09-29. During this period, a simple linear regression was developed to predict Salmon River flow at 14135500 using the flow rate at 14137000 (R2 = 0.98, F(1, 5841) = 376700, p < 0.000). The flow rates were transformed using the natural log prior to fitting. The regression coefficient is 1.115948 and the intercept is -1.933182. Days with missing data were removed. The regression equation is shown in **Equation 6-1**.

$$Q_{14135500} = exp(1.115948 \cdot \ln(Q_{14137000}) - 1.933182) \qquad \textbf{Equation 6-1}$$

where,

$Q_{14135500} =$ The daily mean river flow rate (cfs) at USGS gage 14135500, Sandy River Near Marmot, OR.

$Q_{14137000} =$ The daily mean river flow rate (cfs) at USGS gage 14137000, Salmon River above Boulder Creek near Brightwood, OR.

StreamStats version 4 is a web-based geographic information system (GIS) application developed by the USGS (https://streamstats.usgs.gov/ss/, USGS, 2019). StreamStats has a map-based interface that allows the user to determine drainage area delineations, basin characteristics, and estimates of stream flow statistics for user-selected locations along available streams. The program also provides users with access to stream monitoring data by selecting USGS data-collection stations in the map application and providing access to flow statistics and other information for the stations. StreamStats provides estimates of various stream flow statistics for user-selected sites by solving site-specific regression equations. The regression equations were developed through a process, known as regionalization, which involves use of regression analysis to relate stream flow statistics computed for a group of selected stream gages (usually within a state) to basin characteristics measured for the stream gages. Basin characteristics are used to obtain estimates of the stream flow statistics for ungaged sites.

StreamStats regression equations for Oregon were developed by Cooper (2005) and Risley et al. (2008). These equations were based on basin characteristics and flow statistics (e.g., historical percentile flow-exceedance values and annual and monthly 7Q10s). Flow statistics were computed at 466 gaging stations across Oregon and proximal out-of-state areas. This study area was divided into 10 regions based on ecological, topographic, geologic, hydrologic, and climatic criteria. StreamStats includes 910 annual and monthly regression equations to estimate 7Q10s for ungaged stream sites in the 10 aforementioned regions. These equations were developed for unregulated streams (without major dams, constructed reservoirs, catchment development, or significant diversions/withdrawals). If the equations are applied to ungaged streams subject to such influences, the resultant estimates may require adjustment to approximate actual flows.

The StreamStats user selects a stream location of interest, and the program estimates the associated drainage area and summary flow statistics. For this TMDL, DEQ's procedure specified that selected stream locations should be the most downstream location on each stream for which DEQ required flow estimates; the exception was if DEQ required 7Q10 estimates for NPDES-permitted point source receiving waters, in which case the selected stream location was immediately upstream of the point source outfall. StreamStats also estimates basin characteristics for the selected catchment, including drainage area, mean annual precipitation, mean slope, and climatic characteristics (Cooper, 2005; Risley et al., 2008). If estimates are outside suggested parameter ranges, the warning message "extrapolated with uncertainty" appears in the StreamStats report.

Table 6-2: The 7Q10 low-flow estimates for modeled temperature-impaired rivers in the Lower Columbia-Sandy Subbasin.

Assessment Unit Name	Assessment Unit ID	Estimated 7Q10 (cfs)	Flow Estimation Method	Gage/StreamStats Location	Gage Period
Bull Run River	OR_SR_1708000105_11_103611	20.4	USGS: 14140000	45.437, -122.180	2000-10-01 ~ 2022-09-30
Cedar Creek	OR_SR_1708000104_02_103607	4.9	StreamStats	45.405, -122.253	
Little Sandy River	OR_SR_1708000105_11_103609	10.5	USGS: 14141500	45.415, -122.171	1992-10-01 ~ 2022-08-03
Salmon River	OR_SR_1708000103_02_103606	174	StreamStats	45.376, -122.030	
Sandy River	OR_SR_1708000101_02_103599	50.3	StreamStats	45.349, -121.944	
Sandy River	OR_SR_1708000104_02_103608	215.9	USGS: 14137000	45.400, -122.137	1992-10-01 ~ 2021-11-18
Sandy River	OR_SR_1708000107_02_103616	271.9	USGS: 14142500	45.449, -122.245	1992-10-01 ~ 2022-05-16
Zigzag River	OR_SR_1708000102_02_103600	48.2	StreamStats	45.348, -121.945	

Table 6-3: The 7Q10 low-flow estimates for NPDES permitted discharges receiving a numeric wasteload allocation in this TMDL.

Facility Name (File Number)	Stream	Estimated 7Q10 (cfs)	Flow Estimation Method	Gage/StreamStats Location	Gage Period
City of Troutdale WPCF (89941)	Sandy River	278.4	USGS/OWRD: 14142500 + 14142800	45.449, -122.245	1999-10-01 ~ 2022-09-30
Government Camp STP (34136)	Camp Creek	5.7	Curran-McLeod (1993), Sandy River Basin TMDL (DEQ, 2005)		
Sandy WWTP (78615)	Sandy River*	215.9	USGS: 14137000	45.3996, -122.1373	1992-10-01 ~ 2021-11-18
ODFW Sandy River Fish Hatchery (64550)	Sandy River*	215.9	USGS: 14137000	45.3996, -122.1373	1992-10-01 ~ 2021-11-18

Facility Name (File Number)	Stream	Estimated 7Q10 (cfs)	Flow Estimation Method	Gage/StreamStats Location	Gage Period
ODFW Sandy River Fish Hatchery (64550)	Cedar Creek	4.89	StreamStats	45.405, -122.253	
Hoodland STP (WES) (39750)	Sandy River	158	USGS: 14137000 – 14135500	45.354, -121.973	1992-10-01 ~ 2022-09-30

*Location is for an alternative discharge and is not the current discharge location

7 Pollutant sources and load contributions

A key element of TMDL development is a complete, comprehensive source assessment for the relevant water quality pollutant(s). This includes identification of all relevant point and nonpoint sources to the impaired waterbody, characterization/quantification of their pollutant load contributions, determination of seasonal variation, and delineation of periods when applicable temperature criteria are exceeded at various locations, to the extent that existing data allow. The TMDL report and its appendices describe the significant thermal pollutant sources identified within the Lower Columbia Sandy Subbasin temperature TMDL area and the data sources that DEQ utilized for TMDL modeling.

7.1 Point Sources

Individual NPDES permittees and a 300-J general permit registrant were identified as significant sources of thermal loading to streams in the Lower Columbia-Sandy Subbasin.

7.1.1 Individual NPDES permitted point sources

Four individual NPDES-permitted point source discharges were identified as significant sources of thermal load in the Lower Columbia-Sandy Subbasin (Table 7-1). The current thermal loading from each of these point sources was assessed individually using a mass balance approach (**Equation 8-5** and **Equation 8-6**) with river flows listed in Table 7-1 and effluent flow and temperature data obtained from DMRs or provided by the facilities. The mass balance approach provides estimates of loading at the point of discharge and temperature increases above applicable temperature criteria. To evaluate cumulative impacts of sources that discharge to the Sandy River, the Sandy River model was used.

The City of Sandy WWTP currently holds an individual NPDES permit for discharge to Tickle Creek (Clackamas Subbasin) but is under an EPA consent decree to upgrade and add treatment capacity. The city submitted an NPDES permit application to DEQ to upgrade and construct a new outfall to the Sandy River. The discharge to the Sandy River is estimated to be a significant source of thermal load based on effluent discharge estimates provided to DEQ by the City of Sandy’s contractor, Parametrix.

Table 7-1: Summary of maximum warming and thermal loading at the point of discharge from individual NPDES point sources in the Lower Columbia-Sandy Subbasin project area.

NPDES Permittee WQ File# : EPA Number	Receiving water name	Max. warming at point of discharge (°C)	Max. thermal load (kcals/day)	Notes
Government Camp STP 34136 : OR0027791	Camp Creek	0.16	2,343,823	Effluent data from 2020 DMRs. River flow set at 7Q10.
Hoodland STP (WES) 39750 : OR0031020	Sandy River	0.05	10,215,377	Effluent data from 2016-2017 and 2019-2020 DMRs. River flow set at 7Q10.
City of Troutdale WPCF 89941 : OR0020524	Sandy River	0.05	46,809,085	Effluent data from City of Troutdale and DMRs (2014-2022). River flow based on USGS 14142500 + USGS 14142800.
City of Sandy WWTP 78615 : OR0026573	Sandy River	0.0**4**	25,438,897	Effluent characterization provided by Parametrix and reflects estimated 2040 discharge. River flow set at 7Q10.

7.1.2 General NPDES permitted point sources

There are multiple types of general NPDES permits with registrants in the Lower Columbia-Sandy, including:

- 300-J Industrial Wastewater, NPDES fish hatcheries
- 1200-A Stormwater: NPDES sand & gravel mining
- 1200-C Stormwater: NPDES construction
- 1200-Z Stormwater: NPDES specific Standard Industrial Classification codes
- MS4 – Phase II: Stormwater, NPDES: Municipal Separate Storm Sewer System

The 300-J general permit covers treated discharges from aquatic animal production facilities that produce at least 20,000 pounds of fish per year but have less than 300,000 pounds on hand at any time. There is currently one registrant to the 300-J general permit in the Lower Columbia-Sandy Subbasin project area (Table 7-2). The current thermal loading was assessed using a mass balance approach (**Equation 8-5** and **Equation 8-6**) using data provided by ODFW. The mass balance analysis found maximum temperature increases in Cedar Creek up to 0.36°C.

Table 7-2: Summary of maximum warming and thermal loading at the point of discharge from 300-J general permit registrants in the Lower Columbia-Sandy Subbasin project area.

NPDES Permittee WQ File# : EPA Number	Receiving water name	Max. warming at point of discharge (°C)	Max. thermal load (kcals/day)	Notes

ODFW Sandy River Fish Hatchery 64550 : ORG130009	Cedar Creek	0.36	8,166,805	Effluent data provided by ODFW and reflects data collected in 2016. River flow estimated and set the same as the input to the Sandy River model.

In the Lower Columbia-Sandy, there are approximately 26 registrants on the 1200-A, 1200-C, and 1200-Z permits and one registrant to the general MS4 phase II permit (City of Troutdale). DEQ completed a review of published literature and other studies related to stormwater runoff and stream temperature in Oregon and found there is not sufficient evidence to demonstrate that stormwater discharges authorized under the current municipal (MS4), construction (1200-C) and industrial (1200-A and 1200-Z) general stormwater permits contribute to exceedances of the temperature standard. The substantive findings are summarized below.

A review of literature from studies in the mid-west and east coast of the United States provides evidence that, under certain conditions, runoff from impervious pavement or runoff that is retained in uncovered open ponds can produce short duration warm discharges (Herb et. al. 2008, Jones and Hunt 2009, UNH Stormwater Center 2011, Winston et. al. 2011, Hester and Bauman 2013). Increases in runoff temperature are highly dependent on many factors including air temperature, dewpoint, pavement type, percent impervious and the amount of impervious surface blocked from solar radiation (Nelson and Palmer 2007, Herb et. al. 2008, Thompson et. al. 2008, Winston et. al. 2011, Jones et. al. 2012, Sabouri et. al. 2013, and Zeiger and Hubbert 2015). These warm runoff discharges can create “surges” that produce increases in stream temperature typically for short durations (Hester and Bauman 2013, Wardynski et. al. 2014, Zeiger and Hubbert 2015). However, studies that evaluated stormwater discharges over weekly averaging periods did not indicate exceedances above biologically based critical thresholds (Wardynski et. al. 2014, WDOE 2011a and 2011b).

DEQ evaluated temperature, rainfall, cloud cover, and stream temperature data for warm seasons in three years in the adjacent Miles Creeks area of the Middle Columbia-Hood Subbasin (DEQ 2008b). In this evaluation, DEQ found no consistent patterns between runoff events in urban areas and stream temperature. In Oregon, cooling trends during warm season rain events are much more clearly related to stream temperature than is precipitation. The limited analysis of local stream temperature in response to precipitation suggests no consistent thermal effects, and any increase in temperature would be small and short term relative to the 7-day average criteria.

7.2 Nonpoint and background sources

OAR 340-41-0002 (42) defines nonpoint sources as “diffuse or unconfined sources of pollution where wastes can either enter, or be conveyed by the movement of water, into waters of the state.” Generally, nonpoint thermal sources in the Lower Columbia-Sandy Subbasin include activities associated with agriculture, forestry, dam and reservoir management, and development. Example sources and/or activities that contribute nonpoint thermal loads that increase stream temperature include:

- Human-caused increases in solar radiation loading to streams from stream-side vegetation disturbance or removal;
- Channel modification and widening;
- Dam and reservoir operation;
- Activities that modify flow rate or volume; and,
- Background sources, including natural sources and anthropogenic sources of warming through climate change and other factors.

Anthropogenically influenced thermal loads are targeted for reduction to attain the applicable temperature water quality criteria. The following actions are needed to attain the TMDL allocations:

- Restoration of stream-side vegetation to reduce thermal loading from exposure to solar radiation,
- Management and operation of dams and reservoirs to minimize temperature warming, and,
- Maintenance of minimum instream flows.

7.2.1 Background sources

By definition (OAR 340-042-0030(1)), background sources include all sources of pollution or pollutants not originating from human activities. Background sources may also include anthropogenic sources of a pollutant that DEQ or another Oregon state agency does not have authority to regulate, such as pollutants emanating from another state, tribal lands, or sources otherwise beyond the jurisdiction of the state. Stream temperature warming from climate change is thus considered a background source, as the majority of the climate change-causing pollutants emanate from outside of Oregon.

The background thermal loading a stream receives is influenced by multiple landscape and meteorological characteristics, such as: substrate and channel morphology conditions; streambank and channel elevations; near-stream vegetation; groundwater; hyporheic flow; tributary inflows; precipitation; cloudiness; air temperature; relative humidity and others. Many of these parameters, however, are influenced by anthropogenic factors. As such, it was not possible to develop a model in which all human influences were controlled or accounted for. As a best estimate, background thermal sources were quantified in the modeled rivers by accounting for delineable anthropogenic influences (i.e., dams and reservoirs, vegetation alterations, point source discharges), thus isolating the remaining background sources. In each modeled river, thermal loads from background sources contributed to exceedances of the applicable temperature criteria and therefore were identified as significant sources of thermal loading. Reductions from background sources will be required to attain the applicable temperature criteria. The contribution from background sources for each model stream is summarized in model river sections below (section 7.2.2 through section 7.2.6).

DEQ completed a literature review to assess climate change-driven stream temperature impacts (TSD Appendix F). Based on that review, stream temperature impacts from climate change can range from +0.05°C to +0.27°C per decade on unregulated streams and -0.48°C to +0.52°C per decade on regulated streams. Stream temperature trends in regulated systems are more variable, as upstream flow and temperature management can confound natural long-term warming trends in the data (Isaak et al., 2012).

7.2.2 Dams and reservoirs

Reservoirs attenuate flood flows and hold spring runoff. Stored water is released when reservoir capacity is met or to augment stream flows during the dry months of summer and early fall. As currently constructed and operated, the release of water from many reservoirs modifies natural temperature patterns downstream during late summer and early fall, but also during spring and early summer. The temperature seasonal shifts occur because stored water in reservoirs stratifies, and the reservoirs were typically constructed with regulating outlets near the bottom of each structure.

Seasonal pattern shifts are of concern because water temperature triggers aquatic life activities such as spawning, length of time needed for incubation, and fry emergence. The food supplies (macroinvertebrates) that salmonids rely on are also affected by seasonal temperature shifts. In late summer and early autumn, the reservoirs are drawn down to provide flood storage capacity for the coming winter precipitation. During this time, thermal stratification in the reservoirs breaks down but reservoir water temperatures remain warmer than inflowing upstream tributary temperatures. This is also the season when fall spawning fish have moved into reaches below the reservoirs to wait for spawning. Salmon and trout will hold in the coldest water they can find to wait for stream temperatures to cool enough to trigger their spawning migration.

Alternately, colder winter waters are released during spring and early summer when inflowing upstream tributary temperatures are warmer than stored reservoir waters. This is the season when fall-spawned fry should be emerging, but the colder water shifts the timing of their emergence. Spring spawning is also delayed until winter water temperatures warm up enough to trigger spawning. Late spring spawning can indicate that fry emergence occurs when summer water temperatures are too warm for emerging fry.

DEQ and City of Portland evaluated the thermal effects of the Bull Run Dam and Reservoirs and found that they have a minor but measurable effect on downstream water temperatures. The maximum 7DADM increase on the Bull Run River caused by the dam and reservoir operations is 0.87°C.

In the Lower Willamette and Lower Columbia-Sandy Subbasins, multiple studies have examined the thermal impacts of in-channel ponds on water temperature and found that human built in-channel ponds showed trends on raising downstream temperature (Holzer, 2020; Fairbairn, 2022). For example, Holzer (2020) demonstrated that most in-channel ponds increased the amount of time that a stream segment exceeded the temperature standard by several weeks. Fairbairn (2022) found that human constructed ponds in the Johnson Creek (n=14), Columbia

Slough (n=1) and Sandy River (n=2) Watersheds increased median 7-Day Average Daily Maximum stream temperatures by -1.0 to 6 degrees Celsius. Nine of the seventeen human constructed in channel ponds raised the median 7 Day Average Daily Maximum stream temperature by greater than 1 degree Celsius.

7.2.3 Salmon River

Thermal pollutant sources identified for the Salmon River included reduction or removal of shade-producing streamside vegetation and background sources on the mainstem and its tributaries. A subcategory of anthropogenically reduced shade due to infrastructure (i.e., roads, buildings, bridges, and utility corridors) was also assessed. No significant thermal point sources were identified. Refer to TSD Appendix A for details. Briefly, along the Salmon River model extent:

- Reduced or removed streamside vegetation was associated with a mean effective shade gap of 12%, corresponding to a maximum 7DADM water temperature increase of 1.23°C at the POMI (model km 6.05).
- Streamside vegetation reductions in areas currently protected by Federal, state, or local management plans or ordinances were associated with a mean effective shade gap of 10%, corresponding to a maximum 7DADM water temperature increase of 0.95°C at the POMI (model km 6.30).
- Anthropogenic infrastructure-related shade reductions were associated with a mean effective shade gap of less than 0.5%, corresponding to a maximum 7DADM water temperature increase of 0.05°C at the POMI (model km 9.90).
- Temperature standard exceedances on tributaries to the Salmon River included in the model were associated with a maximum 7DADM water temperature increase of 0.30°C at the POMI (model km 13.10).
- Background factors were associated with a maximum 7DADM water temperature standard exceedance of 5.74°C above the applicable numeric criterion (i.e., the 13.0°C spawning criterion) at the POMI (model km 0.00 to model km 0.15).

7.2.4 Bull Run River

Thermal pollutant sources identified for the Bull Run River included reduction or removal of shade-producing streamside vegetation, dam and reservoir operations, and background sources. Refer to TSD Appendices A and D for details. Briefly, along the Bull Run River model extent:

- Reduction or removal of streamside vegetation was associated with a maximum 7DADM water temperature increase of 0.84°C at model segment 64 (POMI) on 8/18/2016 (see TSD Appendix A, Section 4.5.2 for details).
- Existing dams and reservoirs were associated with a maximum 7DADM water temperature increase of 0.87°C at model segment 99 (POMI, mouth) on 9/7/2016 (see TSD Appendix A, Section 4.5.1 for details).

- The estimated effects of delineable background factors were associated with a maximum 7DADM water temperature standard exceedance of 5.46°C at model segment 7 on 8/20/2016, corresponding to a maximum 7DADM water temperature of 21.46°C (see TSD Appendix A, Section 4.5.3 for details).
- The combined effects of anthropogenic vegetation/shade reductions and dams were associated with a maximum 7DADM water temperature increase (i.e., the maximum difference of current conditions minus background conditions) of 0.90°C at the mouth (model segment 99) on 9/7/2016 (see TSD Appendix A, Section 4.5.3 for details).

7.2.5 Little Sandy River

Thermal pollutant sources identified for the Little Sandy River included reduction or removal of shade-producing streamside vegetation and background sources. Refer to TSD Appendix A for details.

On the Little Sandy River, reduction or removal of streamside vegetation was associated with a mean effective shade gap of 6%, corresponding to a maximum daily water temperature increase of 0.72°C at model kilometer 2.9.

Background factors were associated with a maximum daily water temperature of 20.03°C at the mouth (river kilometer 0.00 (POMI)), corresponding to an applicable temperature standard exceedance of 4.03°C (OAR 340-041-0028(4)(b)). Note that the maximum daily water temperature is not directly comparable to the applicable temperature standard because the standard is based on the maximum 7DADM, which requires at least seven consecutive days of data.

7.2.6 Zigzag River

Thermal pollutant sources identified for the Zigzag River included reduction or removal of shade-producing streamside vegetation and background sources. Refer to TSD Appendix A for details.

On the Zigzag River, reduction or removal of streamside vegetation was associated a mean effective shade gap of 14%, corresponding to a maximum daily water temperature increase of 0.55°C at the mouth (model kilometer 0.0).

Background factors were associated with a maximum daily water temperature of 16.08°C at the mouth (model kilometer 0.00), corresponding to an applicable temperature standard exceedance of 0.08°C (OAR 340-041-0028(4)(b)). Note that the maximum daily water temperature is not directly comparable to the applicable temperature standard because the standard is based on the maximum 7DADM, which requires at least seven consecutive days of data.

7.2.7 Sandy River

Thermal pollutant sources identified for the Sandy River included reduction or removal of shade-producing streamside vegetation, consumptive use water withdrawals, point source discharges, Bull Run dam and reservoir operations, temperature standard exceedances on Sandy River tributaries, and background sources. As with the Salmon River, a subcategory of anthropogenically reduced shade due to civil infrastructure (i.e., roads, bridges, buildings, and utility corridors) was assessed. Refer to TSD Appendices B and C for details. See section 7.1 for a summary of Sandy River thermal loading from point sources. Briefly, along the Sandy River model extent:

- Reduction or removal of streamside vegetation was associated with a mean effective shade gap of 6%, corresponding to a maximum 7DADM water temperature increase of 1.16°C at river km 61.1 on 08/29/2016. Anthropogenic civil infrastructure-related shade reductions were associated with a mean effective shade gap of 1%, corresponding to a maximum 7DADM water temperature increase of 0.06°C at river km 2.95 on 08/29/2016.
- Dam and reservoir operations on the Bull Run River were associated with a maximum 7DADM water temperature increase of 0.27°C at Sandy River km 9.80 on 7/25/2016.
- Tributary temperature standard exceedances were associated with a maximum 7DADM water temperature increase of 6.34°C at river kilometer 71.08 (the upstream model boundary) on 07/23/2016.

Two unique water withdrawal scenarios (WW_A & WW_B) were developed and compared to a natural streamflow model scenario to determine the maximum consumptive withdrawal rates that would still attain, at a stream reference location (stream km 29.10), the (WW_A) HUA for permitted withdrawals (0.05°C), and the (WW_B) overall HUA (0.30°C). An additional water withdrawal scenario that included current consumptive use estimates (WW_C) was developed and compared to the natural streamflow model scenario estimate the impacts of current consumptive uses.

- For WW_A, the maximum withdrawal rate was 1.90%, and associated with a maximum 7DADM water temperature increase of 0.05°C at the reference location on 8/16/2016.
- For WW_B, the maximum withdrawal rate was 10.1%, and associated with a maximum 7DADM water temperature increase of 0.30°C at the reference location on 08/17/2016.
- For WW_C, the estimated withdrawal rates (i.e., 28% (July), 29% (Aug.), and 34% (Sept.)) were associated with a maximum 7DADM water temperature increase of 1.09°C at the reference location on 08/18/2016.

The background conditions scenario was identical to the current conditions model but with no anthropogenic vegetation alterations, dams, or point sources. The background (BG) scenario evaluates the stream temperature response from background sources only. The background scenario was compared to the applicable temperature criteria to estimate temperature standard exceedances due to background (non-anthropogenic) sources.

- The maximum background conditions temperature standard exceedance was 5.78°C at the POMI (river kilometer 54.35) on 8/21/2016 (OAR 340-041-0028(4)(a)). This corresponds to a 7DADM of 18.78°C.
- The maximum 7DADM background scenario water temperature was 22.80°C and occurred at the mouth (km 0.00) on 8/21/2016. This corresponds to an applicable temperature standard exceedance of 4.80°C (OAR 340-041-0028(4)(c)).
- Results indicated that background sources would be associated with temperature standard exceedances on most (i.e., at least 50% of) days within the model period at all Sandy River nodes except those from river kilometers 69.85-65.20 and 43.25-27.35; all model nodes had at least two days that exceeded applicable 7DADM temperature standards. These results indicate that temperature standard exceedances are likely even in the absence of human disturbance.

8 Loading capacity and excess loads

As described in the TMDL report, the pollutant load that a waterbody can receive and still meet water quality standards is called the loading capacity (LC). For temperature, thermal loading capacity is assigned to all assessment units in the Lower Columbia-Sandy Subbasin. Loading capacity is calculated using Equation 8-1.

$$LC = (T_C + HUA) \cdot Q_R \cdot C_F$$ **Equation 8-1**

where,

$LC =$ Loading Capacity (kcal/day).

$T_C =$ The applicable river temperature criterion (°C).

$HUA =$ The 0.30°C human use allowance allocated to point sources, nonpoint sources, margin of safety, or reserve capacity.

$Q_R =$ The daily mean river flow rate (cfs).
When river flow is <= 7Q10, Q_R = 7Q10. When river flow > 7Q10, Q_R is equal to the daily mean river flow.

$C_F =$ Conversion factor using flow in cubic feet per second (cfs): 2,446,665

$$\left(\frac{1\text{ m}}{3.2808\text{ ft}}\right)^3 \cdot \frac{1000\,kg}{1\,m^3} \cdot \frac{86400\,sec}{1\,day} \cdot \frac{1\,kcal}{1\,kg\ \cdot 1\text{°C}} = 2{,}446{,}665$$

Table 8-1 presents loading capacities for select assessment units with an NPDES discharge or that were modeled for the TMDL analysis. The presented loading capacities were calculated based on the 7Q10 low-flow. It is intended that Equation 8-1 be used to calculate the loading capacity for any assessment unit or stream location in the Lower Columbia-Sandy Subbasin not identified in Table 8-1 or when or when river flows are greater than 7Q10. In cases when there are two year-round applicable temperature criteria that apply to the same assessment unit, the more stringent criteria shall be used for the loading capacity.

Table 8-1: Thermal loading capacity (LC) for select assessment units by applicable fish use period at 7Q10 flow.

Assessment Unit Name, ID, and Extent	Annual 7Q10 (cfs)	Year Round Criterion + HUA (°C)	Spawning Criterion + HUA (°C)	7Q10 LC Year Round (kcal/day)	7Q10 LC Spawning (kal/day)
Bull Run River - Bull Run Reservoir Number Two to confluence with Sandy River OR_SR_1708000105_11_103611	20.4	16.3	13.3	813.57E+6	663.83E+6
Cedar Creek - Beaver Creek to confluence with Sandy River OR_SR_1708000104_02_103607	4.9	18.3	13.3	219.39E+6	159.45E+6
Little Sandy River - Bow Creek to confluence with Bull Run River OR_SR_1708000105_11_103609	10.5	16.3	13.3	418.75E+6	341.68E+6
Salmon River - South Fork Salmon River to confluence with Sandy River OR_SR_1708000103_02_103606	174	16.3	13.3	6,939.23E+6	5,662.07E+6
Sandy River - Bull Run River to confluence with Columbia River OR_SR_1708000107_02_103616	278.4	18.3	13.3	12,465.07E+6	9,059.32E+6
Sandy River - Clear Fork to Zigzag River OR_SR_1708000101_02_103599	50.3	18.3	13.3	2,252.13E+6	1,636.79E+6
Sandy River - Zigzag River to Bull Run River OR_SR_1708000104_02_103608	215.9	16.3	13.3	8,610.23E+6	7,025.53E+6
Zigzag River - Still Creek to confluence with Sandy River OR_SR_1708000102_02_103600	48.2	16.3	13.3	1,922.25E+6	1,568.46E+6

The excess load is the difference between the actual pollutant load in a waterbody and the loading capacity of that waterbody. In accordance with OAR 340-042-0040(4)(e), Oregon TMDLs must include the excess load to the extent existing data allow.

Because flow monitoring data were not available at most temperature monitoring locations, it was not possible to calculate the excess thermal load. Instead, the excess temperature and percent load reduction were calculated for each assessment unit where temperature data were available. Temperature data collected in the Lower Columbia-Sandy Subbasin between 1/1/2012 and 12/31/2022 were downloaded from DEQ’s AWQMS database. Following data review and filtering for acceptable data quality there were 84 temperature monitoring stations where excess temperature could be calculated. The maximum excess temperature and corresponding percent reduction were summarized in Table 8-2 for each assessment unit and each temperature criteria applicable on that assessment unit.

The excess temperature is the maximum difference between the monitored 7DADM river temperature and the applicable numeric criterion including the human use allowance. The percent load reduction (Equation 8-2) represents the maximum portion of the actual thermal loading that must be reduced to attain the TMDL loading capacity.

The percent load reduction is mathematically equal to the percent temperature reduction calculated from the monitoring data. This is because the river flow rate used to calculate a thermal load is the same number in the numerator and denominator and is cancelled out when calculating the percent reduction. The percent load reductions shown in Table 8-2 were calculated from temperatures in degrees Celsius.

$$\mathrm{PR} = \frac{(T_R - T_C - \mathrm{HUA})}{T_R} \cdot 100$$

Equation 8-2

where,

$\mathrm{PR} =$ Percent load reduction (%). If PR < 0, PR = 0

$T_R =$ The maximum 7DADM ambient river temperature (^{o}C).

$T_C =$ The applicable river temperature criterion (^{o}C).

$\mathrm{HUA} =$ The 0.30°C human use allowance allocated to point sources, nonpoint sources, margin of safety, or reserve capacity.

Table 8-2: Excess temperature and percent load reduction for various assessment units in the Lower Columbia-Sandy Subbasin.

Assessment Unit Name	Assessment Unit ID	Maximum 7DADM River Temperature (°C)	Applicable Criterion + HUA (°C)	Excess Temperature (°C)	Percent Load Reduction
Beaver Creek	OR_SR_1708000107_02_103612	20.1	13.3	6.8	33.8
Beaver Creek	OR_SR_1708000107_02_103612	27.8	18.3	9.5	34.2
Bull Run River	OR_SR_1708000105_11_103611	20.6	13.3	7.3	35.4
Bull Run River	OR_SR_1708000105_11_103611	21.1	16.3	4.8	22.6
Bull Run River	OR_SR_1708000105_11_103688	17.8	16.3	1.5	8.4
Cedar Creek	OR_SR_1708000104_02_103607	19.7	18.3	1.4	6.9
Clear Creek	OR_SR_1708000101_02_103597	17.4	13.3	4.1	23.5
Clear Creek	OR_SR_1708000101_02_103597	17.8	16.3	1.5	8.2
Clear Fork	OR_SR_1708000101_02_103596	14.7	13.3	1.4	9.2
Clear Fork	OR_SR_1708000101_02_103596	14.9	16.3	0.0	0.0
Gordon Creek	OR_SR_1708000107_02_103615	13.3	13.3	0.0	0.0
Gordon Creek	OR_SR_1708000107_02_103615	19.2	18.3	0.9	4.5
HUC12 Name: Beaver Creek-Sandy River	OR_WS_170800010703_02_103703	21.4	13.3	8.1	37.8
HUC12 Name: Beaver Creek-Sandy River	OR_WS_170800010703_02_103703	26.2	18.3	7.9	30.0
HUC12 Name: Bridal Veil Creek-Columbia River	OR_WS_170800010803_15_103654	19.9	18.3	1.6	8.1
HUC12 Name: Gordon Creek	OR_WS_170800010701_02_103651	13.0	16.3	0.0	0.0
HUC12 Name: Little Sandy River	OR_WS_170800010505_11_103669	24.2	16.3	7.9	32.5

HUC12 Name: Lower Bull Run River	OR_WS_170800010506_11_103650	17.6	16.3	1.3	7.5
HUC12 Name: Middle Bull Run River	OR_WS_170800010503_11_103648	16.9	16.3	0.6	3.6
HUC12 Name: Tanner Creek-Columbia River	OR_WS_170800010801_15_103707	18.1	13.3	4.8	26.3
HUC12 Name: Tanner Creek-Columbia River	OR_WS_170800010801_15_103707	18.9	16.3	2.6	13.9
HUC12 Name: Upper Bull Run River	OR_WS_170800010502_11_103647	7.0	16.3	0.0	0.0
HUC12 Name: Upper Salmon River	OR_WS_170800010302_02_103640	15.7	16.3	0.0	0.0
HUC12 Name: Wildcat Creek-Sandy River	OR_WS_170800010401_02_103643	16.5	13.3	3.2	19.3
HUC12 Name: Wildcat Creek-Sandy River	OR_WS_170800010401_02_103643	15.5	16.3	0.0	0.0
HUC12 Name: Woodard Creek-Columbia River	OR_WS_170800010802_15_103653	17.5	18.3	0.0	0.0
Little Sandy River	OR_SR_1708000105_11_103609	19.1	13.3	5.8	30.3
Little Sandy River	OR_SR_1708000105_11_103609	22.2	16.3	5.9	26.6
Lost Creek	OR_SR_1708000101_02_103598	13.6	13.3	0.3	2.1
Lost Creek	OR_SR_1708000101_02_103598	15.2	16.3	0.0	0.0
Salmon River	OR_SR_1708000103_02_103605	11.4	16.3	0.0	0.0
Salmon River	OR_SR_1708000103_02_103606	19.7	13.3	6.4	32.6
Salmon River	OR_SR_1708000103_02_103606	21.0	16.3	4.7	22.3
Sandy River	OR_SR_1708000101_02_103599	19.4	13.3	6.1	31.5
Sandy River	OR_SR_1708000101_02_103599	20.1	16.3	3.8	19.0
Sandy River	OR_SR_1708000104_02_103608	19.3	13.3	6.0	31.2
Sandy River	OR_SR_1708000104_02_103608	19.5	16.3	3.2	16.3
Sandy River	OR_SR_1708000107_02_103616	14.5	13.3	1.2	8.2
Sandy River	OR_SR_1708000107_02_103616	23.2	18.3	4.9	21.2
South Fork Bull Run River	OR_SR_1708000105_11_103610	18.3	16.3	2.0	10.9
Still Creek	OR_SR_1708000102_02_103601	16.0	13.3	2.7	16.8
Still Creek	OR_SR_1708000102_02_103601	16.3	16.3	0.0	0.2
Zigzag River	OR_SR_1708000102_02_103600	13.9	13.3	0.6	4.3
Zigzag River	OR_SR_1708000102_02_103600	15.7	16.3	0.0	0.0
Zigzag River	OR_SR_1708000102_02_103602	12.1	13.3	0.0	0.0
Zigzag River	OR_SR_1708000102_02_103602	12.5	16.3	0.0	0.0

9 Allocation approach

Figure 9-1 provides three different but interrelated conceptual representations of the total load to a temperature-impaired water. These three representations reflect the general sequence of analyses and results development completed during the TMDL process: load/standard exceedance assessment (left block), source identification (middle block), and TMDL allocations and load reduction (right block). The left block ("Current Conditions 303(d) list") shows the total load, with the bisecting lines representing the loads that would meet the biologically-based numeric criteria and the temperature standard. The middle block ("Source Identification") represents the portions of the total load contributed by the different source categories (point, nonpoint, and background). The right block ("TMDL and Load Reductions") illustrates how the TMDL is distributed among background sources, human use allowances, and excess load.

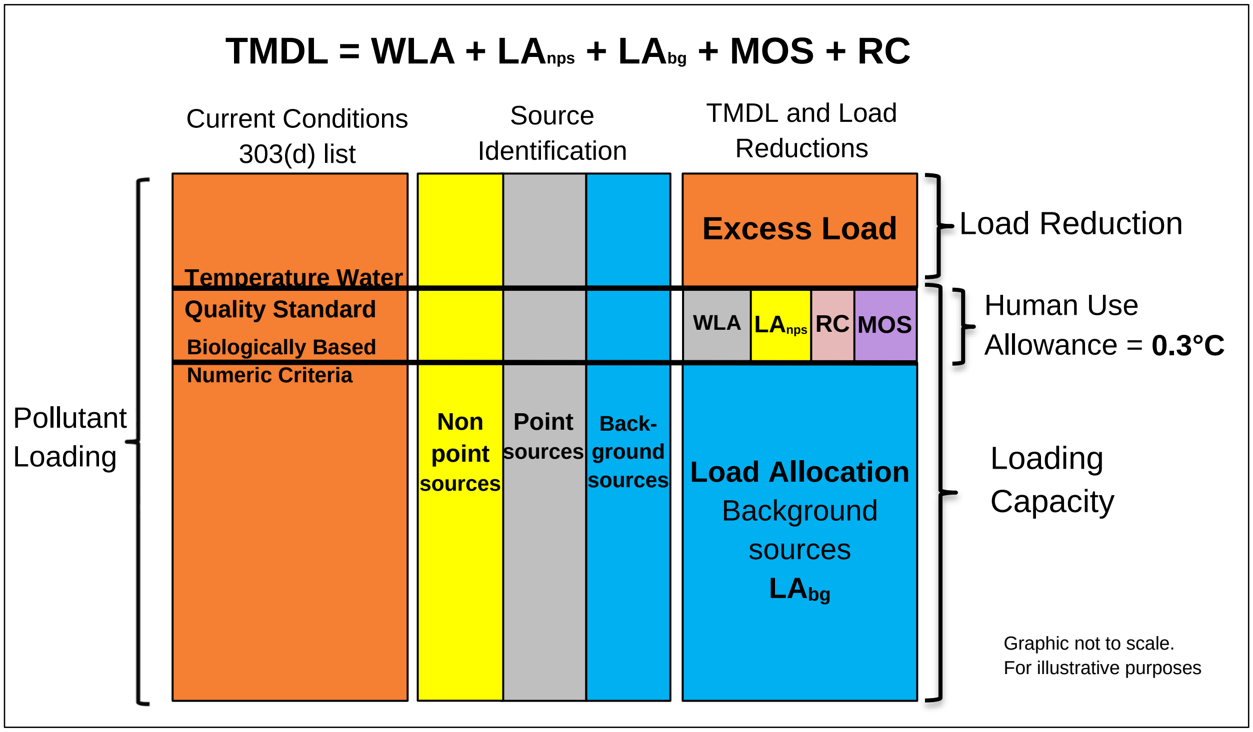

Figure 9-1 Conceptual representation and breakdown of total pollutant loading to a temperature-impaired waterbody.

Wasteload allocations (shown as WLA) are the portion of the TMDL loading capacity allocated to point sources and load allocations (shown as LA$_{nps}$ and LA$_{bg}$) are the portion attributed to nonpoint sources, including background sources. OAR 340-042-0040(6) identifies the factors that DEQ or EQC may consider when distributing wasteload and load allocations.

The factors include:

a) Contributions from sources;
b) Costs of implementing measures;
c) Ease of implementation;
d) Timelines for attainment of water quality standards;
e) Environmental impacts of allocations;
f) Unintended consequences;
g) Reasonable assurances of implementation;

h) Any other relevant factor.

Oregon’s temperature standard provides a framework for how the loading capacity is distributed between human sources of warming and background sources. The human use allowance at OAR 340-041-0028(12)(b)(B) identifies the portion of the loading capacity reserved for human uses. The rule requires that wasteload and load allocations restrict all NPDES point sources and nonpoint sources to a cumulative increase of no greater than 0.30°C (0.5°F) above the applicable criteria after complete mixing in the water body, and at the point of maximum impact (POMI). DEQ assigned a thermal load equivalent to 0.30°C to human sources and the remainder of the loading capacity to background sources.

When distributing the thermal loads associated with a 0.30°C increase, DEQ considered the magnitudes of thermal loads contributed by known sources; the ease of implementing the allocations; and the environmental impact of those thermal load contributions, including their effects on cumulative warming and the impact locations.

For all sources discharging to the Sandy River, DEQ assigned a portion of the human use allowance to each based on a 15% increase above its current temperature impact. This resulted in allocations of 0.05°C to the City of Sandy WWTP and 0.06°C to both the City of Troutdale WPCF and the Hoodland STP. The data available to DEQ did not always include effluent temperature or flow during the spawning period. Allocations to Sandy River tributaries are discussed in the following paragraphs.

On Cedar Creek, DEQ assigned the entire 0.30°C to the ODFW Sandy River Fish Hatchery’s discharge to Cedar Creek. Available effluent discharge data indicated the facility will be in immediate violation even with an allocation of the entire 0.30°C human use allowance. Other source categories on Cedar Creek were assigned a zero human use allowance. This decision was based upon the limited extent of riparian restoration needed upstream, and the complexity and associated cost required for ODFW to achieve the allocation. DEQ also provided an alternative allocation to ODFW for discharge to the Sandy River equal to 0.08°C. This allocation almost doubles the allowed thermal load relative to Cedar Creek.

DEQ evaluated land use activities upstream of the ODFW fish hatchery to assess potential sources of warming. Immediately upstream of ODFW facility for approximately 2 miles, the land uses adjacent to the stream are primarily rural residential. Based on aerial imagery analysis, some locations within this reach appear to lack sufficient riparian vegetation. For another two miles upstream, the land use is a mix of forestry and agriculture. Here, the riparian areas appear relatively intact or in a state of regrowth with limited restoration potential. The land uses transition back to rural residential paralleling Highway 26. Upstream of Highway 26 the USFS manages the majority of land.

Clackamas County manages the streamside vegetation requirements in its rural residential areas. Clackamas County ordinances already require a buffer width between 50’ and 150’ depending on site conditions. Federal management agencies (i.e., BLM, USFS) currently require a 300’ buffer. Based on the Salmon River’s current conditions, DEQ determined that implementation of the currently required buffer widths (100’ for Clackamas County and 300’ for Federal agencies, referred to as “Protected Vegetation B scenario) would result in effective shade values (37%) within two percentage points of shade targets (39%; see TSD Appendix A, Section 4.2.2 for details). In contrast, current Salmon River current effective shade values (27%) account for a maximum 7DADM temperature increase of 0.95°C (at river km 6.30 on 8/26/2016) compared to the Protected Vegetation B scenario. Assuming these requirements are enforced and areas lacking shade are addressed, DEQ determined that these rural residential areas will have limited potential for stream warming. On USFS land in most cases and except for intermittent streams, current streamside vegetation management does not lead to thermal increases (see WQMP Section 5.2.4).

On the Bull Run River, DEQ assigned the entire 0.30°C to the City of Portland for operation and management of the Bull Run dams and reservoirs. The entire human use allowance was assigned because no other significant thermal sources to the Bull Run River are evident. There are a handful of private forestland properties the Bull Run River mouth. If these properties were ever harvested under the current Oregon Forest Practices Act, there could be shade decreases and temperature increases.

The remainder of the Bull Run River watershed is owned by the City of Portland or USFS. There are some areas with young age class trees that do not provide optimal shade, but DEQ expects as these trees mature sufficient shade will be achieved. DEQ determined that, in most cases and except for intermittent streams on USFS lands, the City of Portland and USFS’s current streamside vegetation management in the watershed does not lead to thermal increases (see WQMP Section 5.2.4). On City of Portland-owned lands along the Lower Bull Run River, the city maintains a 200-foot no-cut buffer measured from the river’s average high-water level (City of Portland, 2008).

In the Sandy River, warming from the Bull Run has been assigned 0.01°C of the human use allowance upstream of Troutdale WPCF, and zero downstream of Troutdale WPCF’s outfall to the mouth of the Sandy River. These values were assigned based on the estimated warming impact in the Sandy River from implementation of the surrogate measure temperature targets. The impact is not very large because most of the time, the Bull Run River is cooler than the Sandy River.

On Camp Creek, DEQ allocated 0.20°C to the Government Camp STP. Through analysis of available effluent discharge data from the year 2020, it was determined that a point of discharge wasteload allocation equal to a 0.20°C increase would not result in thermal load reductions. Analysis conducted for this TMDL showed an allocation equal to 0.16°C during low river flows could require thermal load reduction below current operations and put the facility in immediate violation. The allocation is consistent with the current NPDES permit and the 2005 Sandy TMDL.

DEQ allocated up to 0.05°C to diversions and water withdrawal activities (consumptive uses) in most of the subbasin. Based on model results, DEQ estimates a consumptive use flow rate reduction of 1.90 percent will attain this human use allowance. (see TSD Appendix C, Section 9.0). Current consumptive uses are much higher than 1.90 percent. OWRD reports that from May through October, consumptive uses account for 28%-43% of median monthly natural flow at the Sandy River mouth (Table 2-4).

Sandy River modeling showed a maximum 7DADM temperature increase due to existing transportation corridors, buildings, and utility infrastructure of 0.06°C at the POMI (river km 2.95 on 8/29/2016). At the mouth (river km 0.00), the maximum increase was smaller (0.01°C on 8/20/2016). Increased solar loading, generally caused by anthropogenic removal of streamside vegetation, increases 7DADM stream temperature between 0.5°C and 1°C. Temperature increases from existing transportation corridors, buildings, and utility infrastructure may be more complex and costly to address compared to solar loading from areas where there is simply a lack of streamside vegetation. For this reason, DEQ allocated a 0.04°C increase on various streams from solar loading from existing transportation corridors, buildings, and utility infrastructure. For all other anthropogenic sources of solar loading and other nonpoint sources not identified above, DEQ allocated a zero increase. DEQ set aside any remainder of the human use allowance for reserve capacity.

9.1 Point source wasteload allocations (WLAs)

9.1.1 Wasteload allocations

Wasteload allocations for NPDES permitted point sources listed in Table 9-1 were calculated using Equation 9-1.

Wasteload allocations may be implemented in NPDES permits in any of the following ways:

(1) Incorporate the 7Q10-based wasteload allocation in Table 9-1 as a static numeric limit. Permit writers may recalculate the limit using Equation 9-1 with different values for 7Q10 (Q_R), and effluent flow (Q_E), if better estimates are available
(2) Incorporate Equation 9-1 directly into the permit with effluent flow (Q_E), river flow (Q_R), and the wasteload allocation (WLA) being dynamic and calculated on a daily basis. The assigned portion of the human use allowance (∆T) is static and based on the value in Table 9-1.

Table 9-1: Thermal wasteload allocations for point sources.

NPDES Permittee WQ File# : EPA Number	Allocated Human Use Allowance (°C)	WLA period start	WLA period end	Annual 7Q10 River flow (cfs)	Effluent discharge (cfs)	7Q10 WLA[1] (kcals/day)
Government Camp STP 34136 : OR0027791	0.20	5/1	10/31	5.7	0.4	2.98E+6
Hoodland STP (WES) 39750 : OR0031020	0.06	5/1	10/31	158	1.4	23.40E+6

City of Troutdale WPCF 89941 : OR0020524	0.06	5/1	10/31	278.4	4.6	41.54E+6
City of Sandy WWTP 78615 : OR0026573	0.05	5/1	10/31	215.9	1.9	26.64E+6
ODFW Sandy River Fish Hatchery 64550 : ORG130009 Option A – Discharge to Cedar Creek	0.30	5/1	10/31	4.9	3.2	5.95E+6
ODFW Sandy River Fish Hatchery 64550 : ORG130009 Option B – Discharge to Sandy River	0.08	5/1	10/31	215.9	3.2	42.89E+6

[1] Listed WLAs were calculated based on the 7Q10 flow.

Notes: Applicable criterion = Biologically-based numeric criteria WLA = wasteload allocation; kcals/day = kilocalories/day

* When the minimum duties provision at OAR 340-041-0028(12)(a) applies, ODFW Sandy River Fish Hatchery ∆T = 0.0 and the WLA = 0 kilocalories/day. Minimum duties provision does not apply under WLA Option B.

9.1.2 Wasteload allocation equation

Wasteload allocations for NPDES permitted point sources listed in were calculated using Equation 9-1.

$$WLA = (\Delta T) \cdot (Q_E + Q_R) \cdot C_F$$

Equation 9-1

where,

$WLA =$ Wasteload allocation (kilocalories/day).

$\Delta T =$ The assigned portion of the human use allowance and the maximum temperature increase (°C) above the applicable temperature criterion using 100% of river flow not to be exceeded by each individual source from all outfalls combined. When the minimum duties provision at OAR 340-041-0028(12)(a) applies, ∆T = 0.0. Equation 8-10 was used to determine if the minimum duties provision applies.

$Q_E =$ The daily mean effluent flow (cfs).
When effluent flow is in million gallons per day (MGD) convert to cfs:

$$\frac{1{,}000{,}000\ gallons}{1\ day} \cdot \frac{0.13368 ft^3}{1\ gallon} \cdot \frac{1\ day}{86{,}400\ sec} = 1.5472\ ft^3/sec$$

$Q_R =$ The daily mean river flow rate (cfs), upstream (of the NPDES discharge).
When flow is <= 7Q10, Q_R = 7Q10. When flow is > 7Q10, Q_R equals the daily mean river flow, upstream.

$C_F =$ Conversion factor using flow in cubic feet per second (cfs): 2,446,665

$$\left(\frac{1\ \mathrm{m}}{3.2808\ \mathrm{ft}}\right)^3 \cdot \frac{1000\ kg}{1\ m^3} \cdot \frac{86400\ sec}{1\ day} \cdot \frac{1\ kcal}{1\ kg\ \cdot 1℃} = 2{,}446{,}665$$

9.1.3 WLA attainment equation

When evaluating current discharge, DEQ used Equation 9-2 to determine the actual excess thermal load (ETL). The ETL was compared against the wasteload allocation (WLA) from Equation 9-1 to assess attainment.

$$ETL = (T_E - T_C) \cdot Q_E \cdot C_F$$ **Equation 9-2**

where,

$ETL =$ The daily excess thermal load (kilocalories/day)

$T_{C,i} =$ The point of discharge applicable river temperature criterion (°C) (T_c); or when the minimum duties provision at OAR 340-041-0028(12)(a) applies $T_{C,i}$ = the 7DADM measured at the facility intake (T_i). Equation 9-7 was used to determine if the minimum duties provision applies.

$T_E =$ The daily maximum effluent temperature (°C)

$Q_E =$ The daily mean effluent flow (cfs or MGD)

$C_F =$ Conversion factor for flow in cubic feet per second (cfs): 2,446,665

$$\left(\frac{1\text{ m}}{3.2808\text{ ft}}\right)^3 \cdot \frac{1000\,kg}{1\,m^3} \cdot \frac{86400\,sec}{1\,day} \cdot \frac{1\,kcal}{1\,kg\ \cdot 1℃} = 2{,}446{,}665$$

Conversion factor for flow in millions of gallons per day (MGD): 3,785,411

$$\frac{1\,m^3}{264.17\,gal} \cdot \frac{1000\,kg}{1\,m^3} \cdot \frac{1000000\,gal}{1\,million\,gal} \cdot \frac{1\,kcal}{1\text{ kg}\ \cdot 1℃} = 3{,}785{,}441$$

9.1.4 Calculating current change in temperature

Equation 9-3 was used to assess the change in temperature based on point source effluent discharge, river flow, and the applicable temperature criteria.

$$\Delta T_{Current} = \left(\frac{Q_E}{Q_E + Q_R}\right) \cdot (T_E - T_C)$$ **Equation 9-3**

where,

$\Delta T_{Current} =$ The current river temperature increase (°C) above the applicable river temperature criterion using 100% of river flow.

$Q_E =$ The daily mean effluent flow (cfs).
When effluent flow is in million gallons per day (MGD) convert to cfs:

$$\frac{1\,million\,gallons}{1\,day} \cdot \frac{1.5472\,ft^3}{1\,million\,gallons} = 1.5472$$

$Q_R =$ The daily mean river flow rate, upstream (cfs).
When river flow is <= 7Q10, Q_R = 7Q10. When river flow > 7Q10, Q_R is equal to the daily mean river flow, upstream.

$T_E =$ The daily maximum effluent temperature (°C)

$T_C =$ The point of discharge applicable river temperature criterion (°C). When the minimum duties provision at OAR 340-041-0028(12)(a) applies T_C = the 7DADM measured at the facility intake.

9.1.5 Calculating TMDL allocation river temperature

Equation 9-4 was used to determine the ambient river temperature downstream of a point of discharge based on the allocated portion of the human use allowance (ΔT) or wasteload allocation in the TMDL. The equation assumes 100% mixing between river and effluent discharge. The equation was used to assess ODFW's Sandy River Fish Hatchery impact on

Cedar Creek and for development of the Cedar Creek tributary input temperatures for the Sandy River wasteload allocation model scenario (See TSD Appendix C, Section 5.0).

$$T_{R\_WLA} = Q_R \cdot \frac{\left(T_{R\_up} - T_C\right)}{(Q_E + Q_R)} + (T_C + \Delta T)$$

Equation 9-4a (using ΔT)

$$T_{R\_WLA} = T_{R\_up} + \frac{Q_E}{(Q_E + Q_R)} \cdot \left(\left(\frac{WLA}{(Q_R \cdot C_F)} + T_C\right) - T_{R\_up}\right)$$

Equation 9-4b (using WLA)

$$T_{R\_WLA} = T_{R\_up} + \left(\frac{Q_E}{Q_E + Q_R}\right) \cdot \left(T_{E\_WLA} - T_C\right)$$

Equation 9-4c (using effluent temp)

where,

$T_{R\_WLA} =$ Ambient river temperature (°C) downstream of the point of discharge assuming 100% mix.

$\Delta T =$ The assigned portion of the human use allowance and the the maximum temperature increase (°C) above the applicable river temperature criterion using 100% of river flow not to be exceeded by each individual source from all outfalls combined. When the minimum duties provision at OAR 340-041-0028(12)(a) applies, ΔT = 0.0.

$WLA =$ Wasteload allocation (kilocalories/day) from Equation 9-1.

$Q_E =$ The daily mean effluent flow (cfs).
When effluent flow is in million gallons per day (MGD) convert to cfs:

$$\frac{1\,million\,gallons}{1\,day} \cdot \frac{1.5472\,ft^3}{1\,million\,gallons} = 1.5472$$

$Q_R =$ The daily mean river flow rate, upstream (cfs).
When river flow is <= 7Q10, Q_R = 7Q10. When river flow > 7Q10, Q_R is equal to the daily mean river flow, upstream.

$T_{E\_WLA} =$ Daily maximum effluent temperature (°C) allowed under the wasteload allocation from Equation 6-5a or Equation 6-5b.
When T_{E_WLA} is > 32°C, T_{E_WLA} = 32°C as required by the thermal plume limitations in OAR 340-041-0053(2)(d)(B).

$T_C =$ The point of discharge applicable river temperature criterion (°C). When the minimum duties provision at OAR 340-041-0028(12)(a) applies T_C = the 7DADM measured at the facility intake.

$T_{R\_up} =$ Ambient river temperature upstream of the point of discharge (°C).

9.1.6 Calculating acceptable effluent temperatures

Equation 9-5 was used to calculate the daily maximum effluent temperatures (°C) acceptable under allocated portion of the human use allowance (ΔT) and the wasteload allocation (WLA).

$$T_{E\_WLA} = \frac{(Q_E + Q_R) \cdot (T_C + \Delta T) - (Q_R \cdot T_C)}{Q_E}$$

Equation 9-5a (using ΔT)

$$T_{E\_WLA} = \frac{(WLA)}{Q_E \cdot C_F} + T_C$$

Equation 9-5b (using WLA)

where,

$T_{E\_WLA} =$ Daily maximum effluent temperature (°C) allowed under the wasteload allocation.
When T_{E_WLA} is > 32°C, T_{E_WLA} = 32°C as required by the thermal plume limitations in OAR 340-041-0053(2)(d)(B).

$WLA =$ Wasteload allocation (kilocalories/day) from Equation 9-1.

$\Delta T =$ The assigned portion of the human use allowance and the maximum temperature increase (°C) above the applicable river temperature criterion using 100% of river flow not to be exceeded by each individual source from all outfalls combined. When the minimum duties provision at OAR 340-041-0028(12)(a) applies, ∆T = 0.0.

$Q_E =$ The daily mean effluent flow (cfs).
When effluent flow is in million gallons per day (MGD) convert to cfs:

$$\frac{1\,million\;gallons}{1\,day} \cdot \frac{1.5472\,ft^3}{1\,million\;gallons} = 1.5472$$

$Q_R =$ The daily mean river flow rate, upstream (cfs).
When river flow is <= 7Q10, Q_R = 7Q10. When river flow > 7Q10, Q_R is equal to the daily mean river flow, upstream.

$T_{C,i} =$ The point of discharge applicable river temperature criterion (°C) (T_c); or when the minimum duties provision at OAR 340-041-0028(12)(a) applies $T_{C,i}$ = the 7DADM measured at the facility intake (T_i).

$C_F =$ Conversion factor for flow in cubic feet per second (cfs): 2,446,665

$$\left(\frac{1\text{ m}}{3.2808\text{ ft}}\right)^3 \cdot \frac{1000\,kg}{1\,m^3} \cdot \frac{86400\,sec}{1\,day} \cdot \frac{1\,kcal}{1\,kg\;\cdot 1\text{°C}} = 2{,}446{,}665$$

9.1.7 Calculating acceptable effluent flows

Equation 9-6 was used to calculate the daily mean effluent flow (cfs) acceptable under allocated portion of the human use allowance (∆T) and the wasteload allocation (WLA).

$$Q_{E\_WLA} = \frac{(Q_R \cdot T_C) - ((T_C + \Delta T) * Q_R)}{T_C + \Delta T - T_E}$$

Equation 9-6a (using ∆T)

$$Q_{E\_WLA} = \frac{(WLA)}{(T_E - T_C) * C_F}$$

Equation 9-6b (using WLA)

where,

$Q_{E\_WLA} =$ Daily mean effluent flow (cfs) allowed under the wasteload allocation.

WLA = Wasteload allocation (kilocalories/day) from

$\Delta T =$ The assigned portion of the human use allowance and the maximum temperature increase (°C) above the applicable river temperature criterion using 100% of river flow not to be exceeded by each individual source from all outfalls combined. When the minimum duties provision at OAR 340-041-0028(12)(a) applies, ∆T = 0.0.

$T_E =$ The daily maximum effluent temperature (°C).

$Q_R =$ The daily mean river flow rate, upstream (cfs).
When river flow is <= 7Q10, Q_R = 7Q10. When river flow > 7Q10, Q_R is equal to the daily mean river flow, upstream.

$T_{C,i} =$ The point of discharge applicable river temperature criterion (°C) (T_c); or when the minimum duties provision at OAR 340-041-0028(12)(a) applies $T_{C,i}$ = the 7DADM measured at the facility intake ($\mathrm{T_i}$).

$\mathrm{C_F} =$ Conversion factor for flow in cubic feet per second (cfs): 2,446,665

$$\left(\frac{1\text{ m}}{3.2808\text{ ft}}\right)^3 \cdot \frac{1000\,kg}{1\,m^3} \cdot \frac{86400\,sec}{1\,day} \cdot \frac{1\,kcal}{1\,kg\;\cdot 1\text{°C}} = 2{,}446{,}665$$

9.1.8 Determination of when minimum duties provision applies

The minimum duties provision at OAR 340-041-0028(12)(a) states that anthropogenic sources are only responsible for controlling the thermal effects of their own discharge or activity in accordance with its overall heat contribution.

For point sources, DEQ is implementing the minimum duties provision if a facility operation meets acceptable operation and design requirements in regard to flow pass through. Generally, the facility must be operated as a “flow through” facility where intake water moves through the facility and is not processed. The water must also be returned to the same stream where the intake is located. Under these circumstances, the facility cannot add any additional thermal loading to the intake temperatures if the intake temperatures are warmer than discharge temperatures allowed by the wasteload allocation. The purpose is to ensure the facility controls for thermal effects resulting from passing the water through and not from upstream sources.

The minimum duties provision is not used for a facility that processes intake water as part of their industrial or wastewater treatment operations. This may include mixing the intake water with other wastewater or as method to cool equipment.

In the Lower Columbia-Sandy, DEQ determined that ODFW’s Sandy River Fish Hatchery is the only NPDES permitted point source facility that operates as a flow through facility. DEQ used the approach described in Equation 9-7 to implement the minimum duties provision for ODFW’s wasteload allocation option A. Wasteload allocation option B was developed in the event that ODFW moves the discharge location from Cedar Creek to the Sandy River. ODFW holds a water right permit on Cedar Creek and indicated the intake will likely continue to be located on Cedar Creek even if the outfall is moved to the Sandy River. Because the intake and discharge location are on different streams, DEQ will not implement the minimum duties provision under wasteload allocation option B.

The minimum duties provision applies on days when $T_{E\_WLA} < T_i$.

When the minimum duties provision at OAR 340-041-0028(12)(a) applies, $\Delta T = 0.0$. **Equation 9-7**

where,

$T_{E\_WLA} =$ Daily maximum effluent temperature (°C) allowed under the wasteload allocation as calculated using Equation 9-4.

$T_i =$ The daily maximum influent temperature (°C) measured at the facility intake.

9.2 Nonpoint source load allocations (LAs)

Load allocations are assigned to background sources and anthropogenic nonpoint sources on all waters in the Lower Columbia-Sandy Subbasin. Load allocations apply May 1 through October 31 on all waters except the Bull Run River and in the Beaver Creek-Sandy Sub-watershed (HUC 170800010703). On the Bull Run River, load allocations apply May 1 through November 15. Load allocations apply March 15 through November 15 in the Beaver Creek-Sandy Subwatershed.

Load allocations for background sources are calculated using Equation 9-8.

$$LA_{BG} = (T_C) \cdot (Q_R) \cdot C_F$$ **Equation 9-8**

where,

$LA_{BG} =$ Load allocation to background sources (kilocalories/day).

$T_C =$ The applicable temperature criteria, not including the human use allowance. When there are two year-round applicable temperature criteria that apply to the same assessment unit, the more stringent criterion shall be used.

$Q_R =$ The daily average river flow rate (cfs).

$C_F =$ Conversion factor using flow in cubic feet per second (cfs): 2,446,665

$$\left(\frac{1\ \text{m}}{3.2808\ \text{ft}}\right)^3 \cdot \frac{1000\ kg}{1\ m^3} \cdot \frac{86400\ sec}{1\ day} \cdot \frac{1\ kcal}{1\ kg\ \cdot 1℃} = 2{,}446{,}665$$

Table 9-2 presents the 7Q10-based load allocations for background sources on temperature-impaired category 5 assessment units that (a) have current NPDES discharge(s) within the assessment unit extent, and/or (b) were modeled for the TMDL analysis. The load allocations are based on the 7Q10 low river flows and the minimum year-round applicable criterion when two year-round applicable temperature criteria apply to the same assessment unit. Equation 9-8 shall be used to calculate the load allocations assigned to background sources on all other assessment units or stream location in the Lower Columbia-Sandy Subbasin not identified in Table 9-2, or for assessment units identified in Table 9-2 when river flows are greater than 7Q10.

If the applicable temperature criteria are updated and approved by EPA, the background load allocations assigned to any assessment unit or stream location where the temperature criterion changed shall be recalculated using the updated criteria and Equation 9-8.

Table 9-2: Thermal load allocations for background sources.

Assessment Unit	Annual 7Q10 flow (cfs)	Year Round Criterion (°C)	Spawning Criterion (°C)	LA period start	LA period end	7Q10 LA[1] – Year Round (kcal/day)	7Q10 LA[1] – Spawning (kcal/day)
Bull Run River - Bull Run Reservoir Number Two to confluence with Sandy River OR_SR_1708000105_11_103611	20.4	16.0	13.0	5/1	11/15	798.59E+6	648.86E+6
Cedar Creek - Beaver Creek to confluence with Sandy River OR_SR_1708000104_02_103607	4.9	18.0	13.0	5/1	10/31	215.80E+6	155.85E+6
Little Sandy River - Bow Creek to confluence with Bull Run River OR_SR_1708000105_11_103609	10.5	16.0	13.0	5/1	10/31	411.04E+6	333.97E+6
Salmon River - South Fork Salmon River to confluence with Sandy River OR_SR_1708000103_02_103606	174	16.0	13.0	5/1	10/31	6,811.52E+6	5,534.36E+6

Sandy River - Bull Run River to confluence with Columbia River OR_SR_1708000107_02_103616	278.4	18.0	13.0	5/1	10/31	12,260.73E+6	8,854.97E+6
Sandy River - Clear Fork to Zigzag River OR_SR_1708000101_02_103599	50.3	18.0	13.0	5/1	10/31	2,215.21E+6	1,599.87E+6
Sandy River - Zigzag River to Bull Run River OR_SR_1708000104_02_103608	215.9	16.0	13.0	5/1	10/31	8,451.76E+6	6,867.05E+6
Zigzag River - Bow Creek to confluence with Bull Run River OR_SR_1708000102_02_103600	48.2	16.0	13.0	5/1	10/31	1,886.87E+6	1,533.08E+6

[1] Listed LAs were calculated based on the 7Q10 river flow.

Notes: Applicable criterion = Biologically-based numeric criteria (to protect cold water fish); LA = load allocation; kcals/day = kilocalories/day.

Load allocations assigned to anthropogenic nonpoint sources on any assessment unit or stream location in the Lower Columbia-Sandy Subbasin are calculated using Equation 9-9. The portions of the human use allowance (ΔT) assigned to nonpoint source categories are presented in the Lower Columbia-Sandy TMDL (Tables 9-1 through 9 6).

$$LA_{NPS} = (\Delta T) \cdot (Q_R) \cdot C_F$$

Equation 9-9

where,

$LA_{NPS} =$ Load allocation to anthropogenic nonpoint sources (kilocalories/day).

$\Delta T =$ The portion of the human use allowance assigned to each nonpoint source category representing the maximum cumulative temperature increase (^{o}C) from all source activity in the nonpoint source category. When the minimum duties provision at OAR 340-041-0028(12)(a) applies, ΔT = 0.0.

$Q_R =$ The daily average river flow rate (cfs).

$C_F =$ Conversion factor using flow in cubic feet per second (cfs): 2,446,665

$$\left(\frac{1\ \mathrm{m}}{3.2808\ \mathrm{ft}}\right)^3 \cdot \frac{1\ m^3}{35.31\ ft^3} \cdot \frac{1000\ kg}{1\ m^3} \cdot \frac{86400\ sec}{1\ day} \cdot \frac{1\ kcal}{1\ kg\ \cdot 1℃} = 2{,}446{,}665$$

9.3 Surrogate measures

EPA regulations (40 CFR 130.2(i)) and OAR 340-042-0040(O)(5)(b) allow for TMDLs to utilize other appropriate measures (or surrogate measures). This section presents surrogate measures that implement the load allocations.

9.3.1 Dam and reservoir operations

Dam and reservoir operations in the Lower Columbia-Sandy have been allocated a portion of the human use allowance as presented in Table 9-1 through Table 9-5 and the equivalent load allocation as calculated using Equation 9-2. Monitoring stream temperature, rather than a thermal load, is easier and a more meaningful approach for reservoir management. Temperature is mathematically related to excess thermal loading and directly linked to the temperature water quality standard. For these reasons, DEQ is using a surrogate measure to implement the load allocation for dam and reservoir operations. The minimum duties provision in rule at OAR 340-042-0028(12)(a) states that anthropogenic sources are only responsible for controlling the thermal effects of their own discharge or activity in accordance with its overall heat contribution. For dam and reservoir operations, the minimum duties provision is implemented when 7DADM temperatures upstream of the reservoirs exceed the applicable temperature criteria, the dam and reservoir operations must not contribute any additional warming above and beyond those upstream temperatures entering the reservoir. DEQ has developed the following surrogate measure temperature approach to implement the load allocation. The surrogate measure compliance point is located just downstream of the dam or just downstream of where impounded water is returned to the free-flowing stream. The surrogate measure is:

a) The 7DADM temperatures immediately upstream of the reservoirs. If multiple streams flow into the reservoir, 7DADM temperatures upstream of the reservoirs may be calculated as a flow weighted mean of temperatures from each inflowing tributary. With DEQ approval, the estimated free flowing (no dam) temperatures may also be calculated using a model to account for any warming or cooling that would occur through the reservoir reaches absent the dam and reservoir operations and applied as the temperature surrogate measure.

b) On days the surrogate measure calculated or measured under item a) is cooler than the most restrictive applicable temperature criteria anywhere in the assessment unit immediately downstream of the dam, the surrogate 7DADM temperature may be no warmer than the applicable criteria when all of the following are true:

    I. The protecting cold water criterion at OAR 340-041-0028(11) does not apply;
    II. DEQ approves a cumulative effects analysis demonstrating release temperatures warmer than the cooler ambient temperatures will not increase downstream 7DADM temperatures more than the portion of the HUA allocated to the dam and reservoir above the applicable criteria.

For implementation of the low flow conditions provision at OAR 340-041-0028(12)(d), the 7Q10 shall be calculated at a gage upstream of the reservoir or at nearby monitoring gage that isn’t influenced by the dam’s operations.

9.3.1.1 Protecting cold water criterion and dams in the Lower Columbia-Sandy Subbasin

There are approximately 12 instream large dams located within the Lower Columbia-Sandy Subbasin temperature TMDL project area. The list of dams was obtained from the USACE National Inventory of Dams (NID) database. For each of these dams, we were interested in determining whether the Protective Cold Water (PCW) criterion applied to immediate downstream and upstream reaches. As many reservoirs have multiple inflowing streams, the stream contributing the most flow was evaluated to see whether the PCW applied.

Several sources were examined for this analysis. An ArcGIS online map of the Oregon 2022 Integrated Report was first used to determine whether each dam was located along a temperature-impaired waterway, as a Category 5 temperature impairment (either year-round or spawning) precludes qualification for the PCW criterion. As such, if downstream and/or upstream reaches were listed as impaired for temperature, it was noted that the PCW did not apply. However, if the waterbody was listed as attaining for temperature, it was reported that the PCW did apply.

The NorWeST SSN stream temperature models developed by Isaak et al 2017, were also used to determine if the PCW was applicable. These models use covariates derived from NHD and other sources to make temperature predictions to all river and stream reaches in various subregions in the Pacific Northwest. DEQ used the model outputs for the Oregon Coast processing unit. The specific model outputs used were from the MWMT S2_02_11 composite scenario which is the prediction of the 10 year average (2002-2011) August Maximum Weekly Maximum (MWMT) stream temperature. The MWMT is similar to the 7DADM.

The NorWeST model outputs consists of observed (point) temperature data as well as modeled (line) stream temperatures. Where available, NorWeST temperatures upstream and downstream of each reservoir were compared to the year round (non-spawning) 7DADM temperature criterion for that particular reach. If the MWMT S2_02_11 scenario temperatures exceeded the applicable temperature criterion immediately upstream or downstream of the dam and reservoir, it was reported that the PCW did not apply. Conversely, if the MWMT S2_02_11 temperature was less than the criterion both up and downstream, it was noted that the PCW did apply. In the rare instance of a discrepancy between the Integrated Report and the NorWeST data, priority for PCW determination was given to the Integrated Report. One major limitation in the Norwest data is that the model does not make predictions during the fall when the spawning criterion apply.

The applicability of the PCW criterion was not always immediately apparent. In multiple instances, while the NHD stream network showed an upstream reach flowing into a reservoir, no upstream NorWeST data existed. In these cases, it was noted that the applicability of the PCW criterion was unclear. For other dams, there existed a short downstream NHD line with no corresponding NorWeST data until the stream flowed into a connecting stream. In these cases, it was noted that the applicability of the PCW was unclear. For off-channel lagoons associated with treatment systems, N/A was reported. For reservoirs with no inflowing streams such as offstream irrigation ponds, N/A was selected for upstream and Integrated Report/NorWeST data were evaluated for the downstream reach. When it was unclear whether the reservoir connected to a downstream flowline, it was noted that the applicability of the PCW was unclear.

Based on these methods, DEQ determined that the PCW criterion likely applies at two dams in the Lower Columbia-Sandy Subbasin (Table 9-3).

Table 9-3: Dams where the protecting colder water criterion likely applies.

Dam name	NID ID	Dam owner	Latitude	Longitude	Stream	Notes
Bull Run Lake Dam	OR00300	City of Portland	45.4628	-121.8391	Bull Run River	Based on attaining status on DEQ 2022 IR (OR_WS_170800010502_11_103647) and NorWest model S2_02_11 showing MWMT temperatures < 16 deg C
Trillium Lake	OR00350	ODFW	45.2673	-121.7423	Mud Creek	Based on attaining status on DEQ 2022 IR (OR_WS_170800010302_02_103640) and NorWest model S2_02_11 showing MWMT temperatures < 16 deg C

9.3.2 City of Portland Bull Run drinking water and hydroelectric project

The City of Portland Bull Run drinking water and hydroelectric project has been assigned 0.3 °C of the human use allowance and the equivalent load allocation on the Bull Run River as calculated using Equation 9-9. In the Sandy River, warming from the dam and reservoirs has been assigned 0.01°C of the human use allowance upstream of Troutdale WPCF, and zero downstream of Troutdale WPCF outfall.

A temperature data analysis and model based cumulative effects analysis were completed for the TMDL analysis evaluating the sufficiency of the surrogate measure temperature target attaining the assigned human use allowance. Based on the analysis, DEQ has determined that release temperatures below the most restrictive applicable criteria but warmer than ambient temperatures will not increase downstream 7DADM temperatures more than the 0.3 °C human use allowance assigned to the Bull Run project. The model assumed free flowing conditions and attainment of the surrogate measure temperature target.

The transition to the 13°C spawning use varies spatially and temporally in the Bull Run River. To be protective of these downstream spawning uses DEQ used the most restrictive temporal period to determine when to apply the spawning criterion for the surrogate measure target.

Based on these results, the surrogate measure temperature target at the lamprey barrier just downstream Reservoir #2 is:

a) The estimated free flowing (no dam) 7DADM temperatures at the lamprey barrier as calculated using **Equation 9-10**; or

b) On days the surrogate measure calculated under item a) is cooler than the values in I and II, the surrogate 7DADM temperature may be no warmer than values in I and II.

    I. 16.3°C June 16 - August 14
    II. 13.3°C May 1 - June 15 and August 15 - November 15.

If the most restrictive applicable temperature criteria on the Bull Run River between Reservoir #2 and the confluence of the Bull Run River and Sandy River are updated and approved by EPA, the updated criteria and period when they apply shall be used instead.

The low flow conditions provision at OAR 340-041-0028(12)(d) may apply when the daily mean flow at USGS gage 14138850 is less than the 7Q10 of 33 cfs.

DEQ developed a regression equation (**Equation 9-10**) to predict the free flowing (no dam) daily maximum temperatures at the lamprey barrier. The methodology and data for development of the regression is documented in the TSD Appendix E. With DEQ approval, an alternative approach may be used to calculate the free flowing no dam temperatures.

$$T_{Max} = 0.1405173 + 1.1572642\overline{T_{LS}} + -0.3588068 \log \overline{Q_{LS}} + \left(\frac{3.7557135 + 1.1668769 T_{dLS} + -0.5969993 \log \overline{Q_{LS}}}{2}\right)$$

Equation 9-10

Where,

$T_{Max} =$ The no dam daily maximum stream temperature at the lamprey barrier downstream of Reservoir #2.

$\overline{T_{LS}} =$ The daily mean temperature (°C) at USGS Gage 14141500 Little Sandy River Near Bull Run.

$\overline{Q_{LS}} =$ The mean daily discharge (cfs) at USGS Gage 14141500 Little Sandy River Near Bull Run.

$T_{dLS} =$ The daily temperature range (°C) calculated as the daily maximum minus the daily minimum at USGS Gage 14141500 Little Sandy River Near Bull Run.

9.3.3 Site-specific effective shade surrogate measure

For each designated management agency listed in Table 9-4, the effective shade surrogate measure values (current and target) are the means across all model nodes assigned to that designated management agency (**Equation 9-11**). **Equation 9-11** may be used to recalculate the mean effective shade values if designated management agency boundaries change or need correction. **Equation 9-11** may also be used to recalculate the mean effective shade targets based on an updated shade gap assessment following the process and methods outlined in the Water Quality Management Plan Section 5.3.1.

Changes in the target effective shade may result in redistribution of the sector or source responsible for excess load reduction. If the shade target increases, the equivalent portion of the excess load is reassigned from background sources to nonpoint sources. If the shade target decreases, the portion of the excess load is reassigned from nonpoint sources to background sources. The exact portion reassigned can only be determined in locations where temperature models have been developed. In locations without temperature models, the reassignment remains unquantified. Changes to the target effective shade do not impact the loading capacity, human use allowance, or the load allocations. They remain the same as presented in this TMDL.

$$\overline{ES} = \frac{\sum ES_{n_i}}{n_i}$$ **Equation 9-11**

Where,

$\overline{ES} =$ The mean effective shade for designated management agency *i.*

$\sum ES_{n_i} =$ The sum of effective shade from all model nodes or measurement points assigned to designated management agency *i.*

$n_i =$ Total number of model nodes or measurement points assigned to designated management agency *i.*

Table 9-4: Shade surrogate measure targets to meet nonpoint source load allocations on model stream extents.

Designated Management Agency	Stream Name	Current Shade (%)	TMDL Target (%)	Shade Gap
Oregon Department of Forestry - Private	Little Sandy River	74	74	0
U.S. Bureau of Land Management	Little Sandy River	54	66	12
U.S. Forest Service	Little Sandy River	69	71	2
Clackamas County	Zigzag River	32	52	20
Oregon Department of Forestry - Private	Zigzag River	22	37	15
U.S. Forest Service	Zigzag River	50	62	12
Clackamas County	Salmon River	24	37	13
Oregon Department of Forestry - Private	Salmon River	26	40	14
U.S. Bureau of Land Management	Salmon River	26	35	9
U.S. Forest Service	Salmon River	49	59	10
City of Portland	Sandy River	10	13	3
City of Sandy	Sandy River	24	25	1
City of Troutdale	Sandy River	15	20	5
Clackamas County	Sandy River	18	28	10
Multnomah County	Sandy River	16	19	3
Oregon Department of Agriculture	Sandy River	24	29	5
Oregon Department of Fish and Wildlife	Sandy River	22	26	4
Oregon Department of Forestry - Private	Sandy River	19	24	5
Oregon Parks and Recreation Department	Sandy River	6	8	2
Port of Portland	Sandy River	3	9	6
State of Oregon	Sandy River	13	18	5
U.S. Bureau of Land Management	Sandy River	25	29	4
U.S. Forest Service	Sandy River	3	7	4
U.S. Government	Sandy River	16	17	1

9.3.4 General effective shade curve surrogate measure

Effective shade curves are applicable to any stream that does not have site-specific shade targets (Section 9.3.1.4). Effective shade curves represent the maximum possible effective shade for a given vegetation type. The values presented in Figure 9-3 to Figure 9-10 represents the mean effective shade target for different composite vegetation types, stream aspects, and active channel widths. The vegetation height, density, overhang, and buffer width used for each vegetation type are summarized in Table 9-5. See the Technical Support Document, Appendix B for the methodology used to calculate shade curves.

Effective shade may be prevented from reaching effective shade targets by natural factors including local geology, geography, soils, climate, natural disturbance rates, and other natural phenomena. DEQ will not take enforcement actions for effective shade reductions caused by such natural factors.

Table 9-5: Vegetation height, density, overhang, and horizontal distance buffer widths used to derive generalized effective shade curve targets.

Landcover Code	Vegetation Type	Height (m)	Height (feet)	Density (%)	Overhang (m)	Buffer Width (m)
348	Mixed Conifer/Hardwood - High Density	26.7	87.6	60	3.3	36.8
550	Mixed Conifer/Hardwood - Medium Density	26.7	87.6	30	3.3	36.8
600	Hardwood - High Density	20.1	65.9	75	3.0	36.8
700	Conifer - High Density	35.1	115.2	60	3.5	36.8
750	Conifer - Low Density	35.1	115.2	30	3.5	36.8
800	Shrubs – High Density	1.8	5.9	75	0.0	36.8
850	Shrubs – Low Density	1.8	5.9	25	0.0	36.8
950	Grasses/Shrubs - Wetlands	1.6	5.3	75	0.8	36.8

How to use a shade curve:

1. Determine the applicable vegetation type for the stream location you are applying a shade curve to.

2. Determine the stream aspect from north.

   Example: Standing in-stream mid-channel, facing north determine the river's aspect as 0º or 180º from north (this means the river reach runs south to north).

3. Determine the active channel width of the stream reach.

   Example: At your location you measure the active channel width using a tape measure or laser range finder and determine that it is 25 feet.

4. Use the appropriate vegetation shade curve or shade curve table found in the TMDL rule, stream aspect line, and active channel width (x-axis), to determine the percent effective shade of your site (y-axis). This is the non-point source load allocation of the stream reach at system potential vegetation.

Example: You have determined that the appropriate shade curve for your site is high density mixed Conifer/Hardwood (Figure 9-2). Since you are located on a tributary with a North to South stream aspect and an active channel width of 25 feet, you use the dashed line to determine the effective shade. By reading the y- axes, you determine that the effective shade to be ~79% when system potential vegetation is applied to the left and right bank of the stream reach. System potential vegetation defines the average riparian vegetation height as 87.6 feet (26.7 meters), and the stand density (canopy density) as 60%.

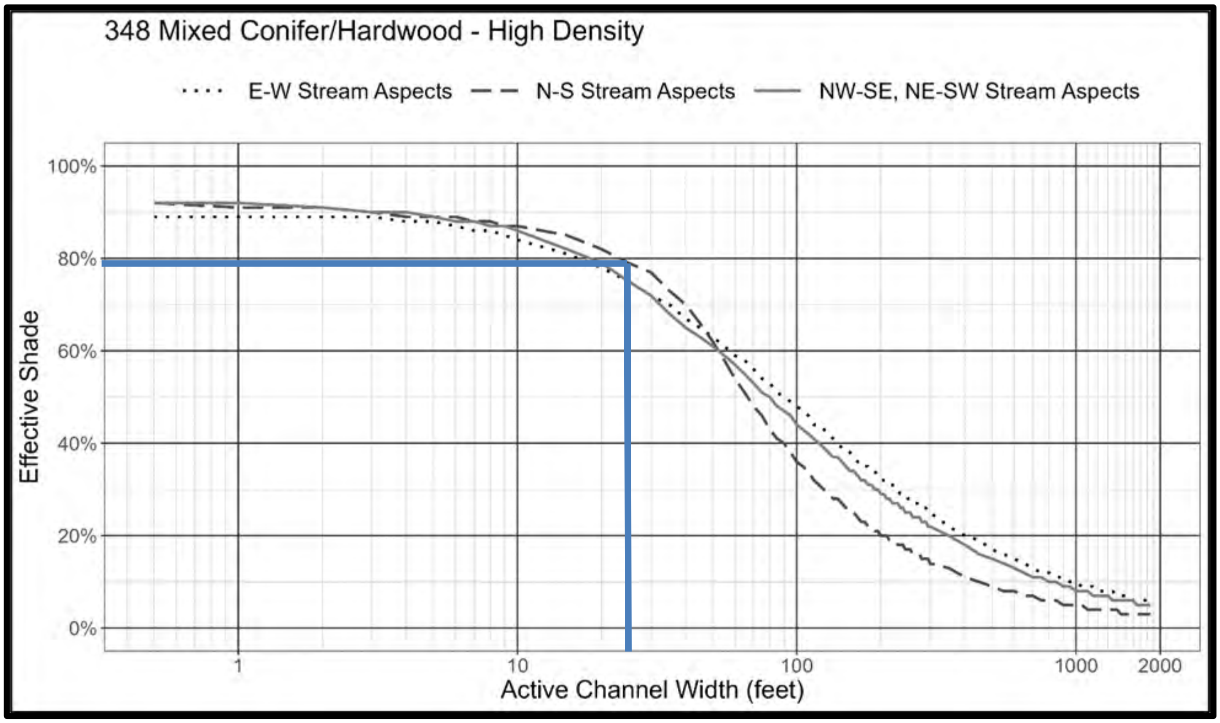

Figure 9-2: Example illustrating use of the shade curve for the Qalc mapping unit based on a north to south aspect and an active channel width of 25 feet.

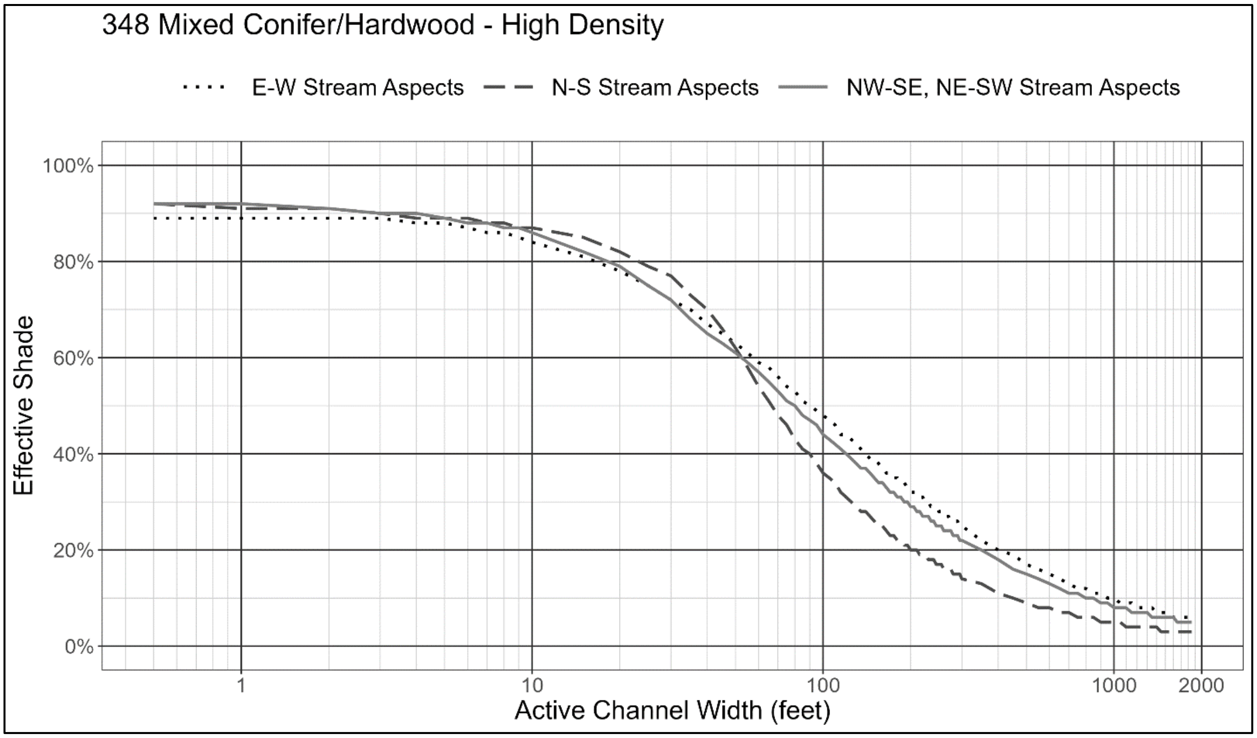

Figure 9-3: Effective shade targets for high density mixed conifer and hardwood stream sites.

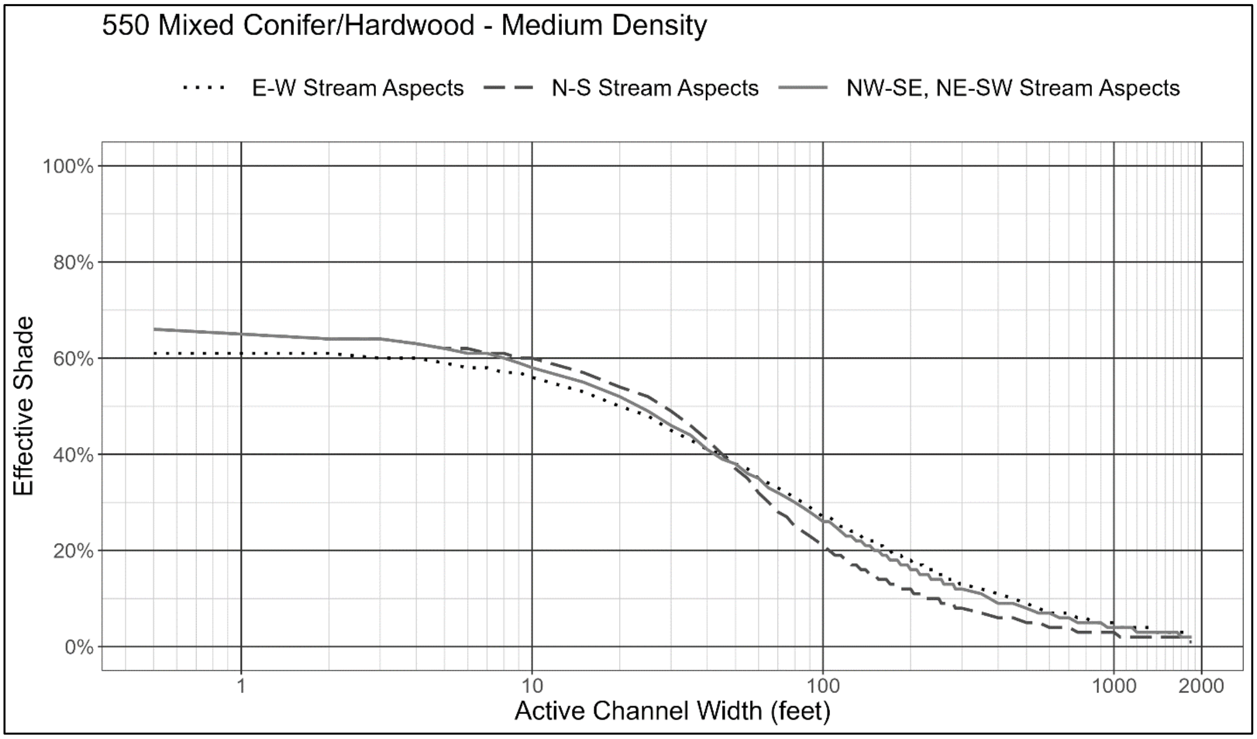

Figure 9-4: Effective shade targets for medium density mixed conifer and hardwood stream sites.

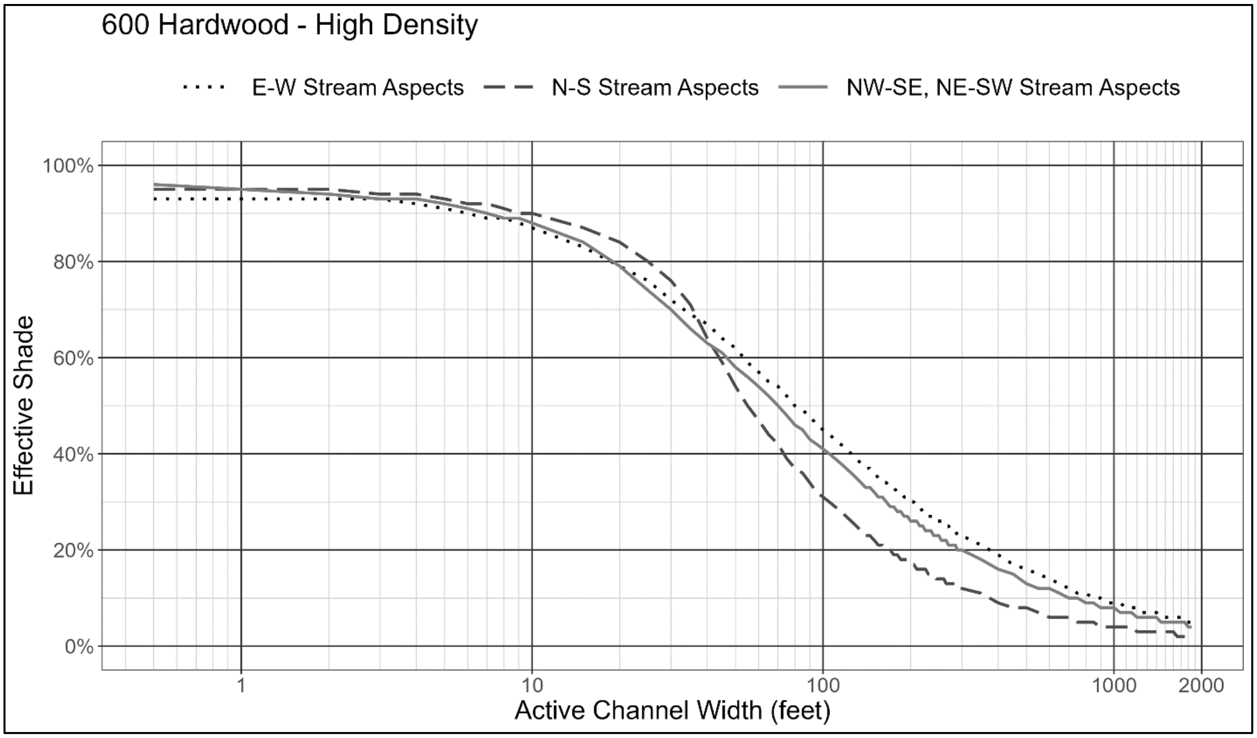

Figure 9-5: Effective shade targets for high density hardwood dominated stream sites.

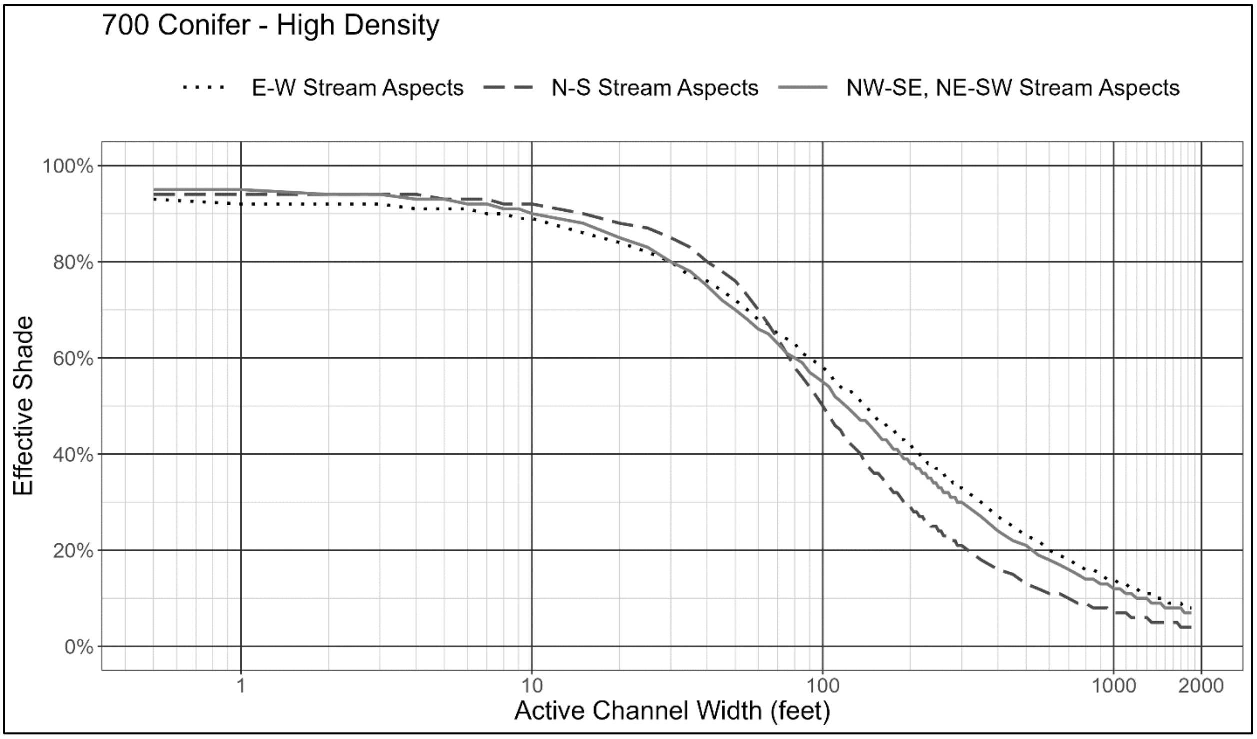

Figure 9-6: Effective shade targets for high density conifer dominated stream sites.

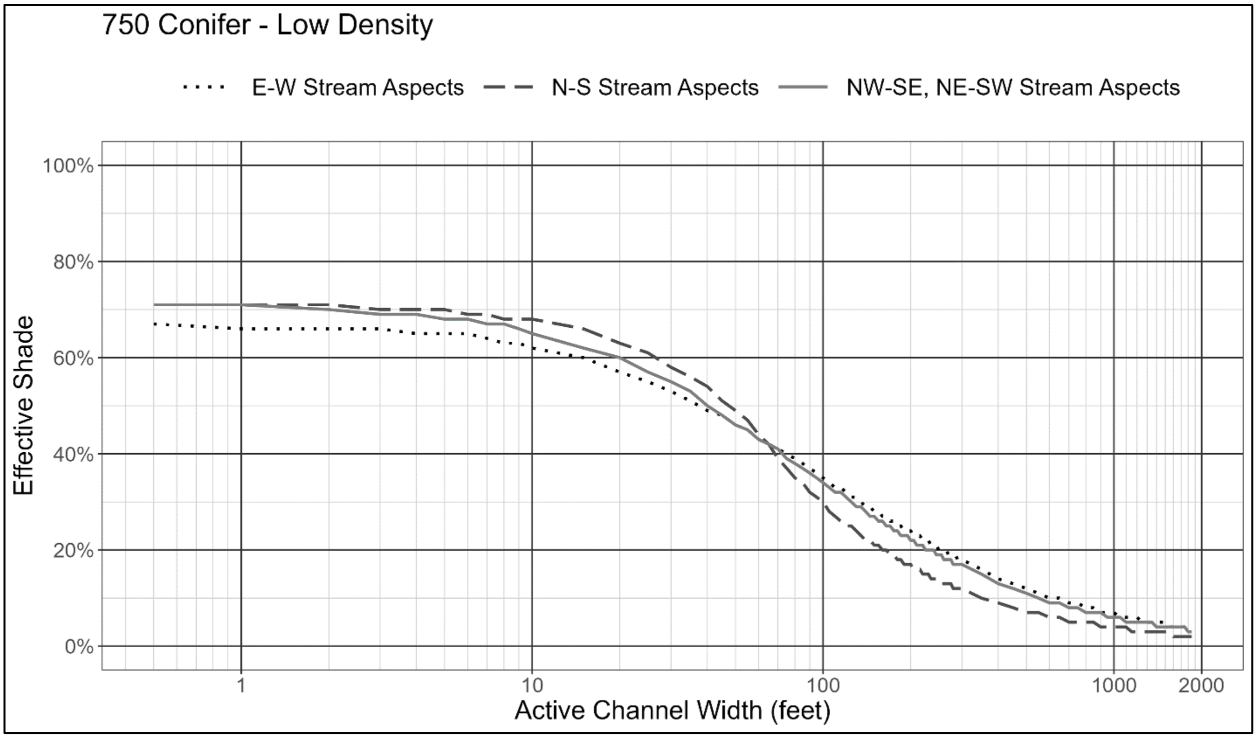

Figure 9-7: Effective shade targets for low density conifer dominated stream sites.

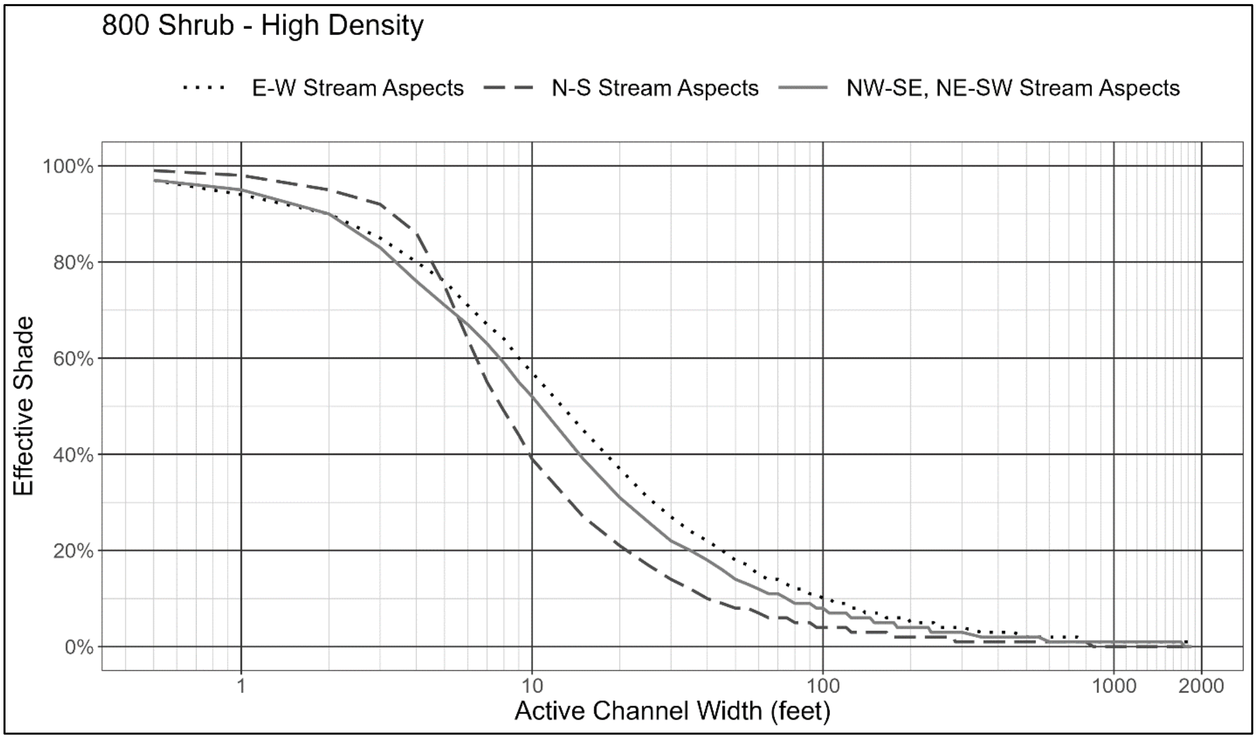

Figure 9-8: Effective shade targets for high density shrub sites.

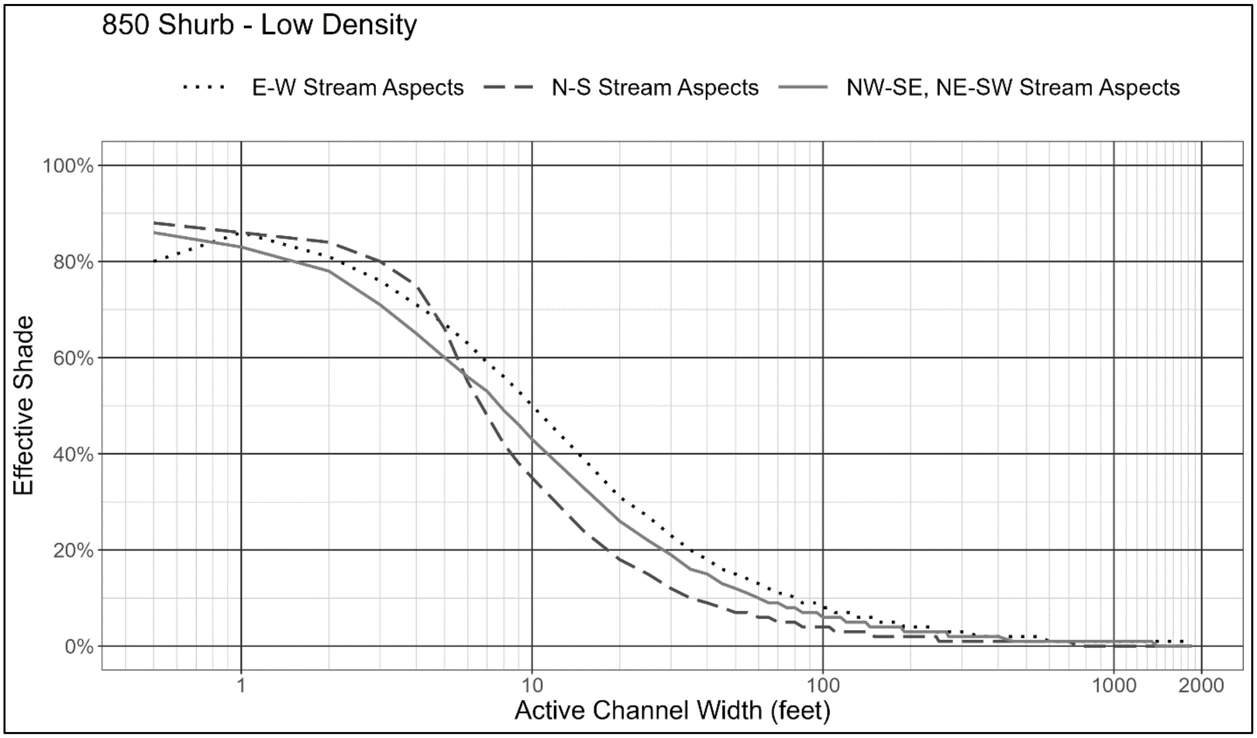

Figure 9-9: Effective shade targets for low density shrub sites.

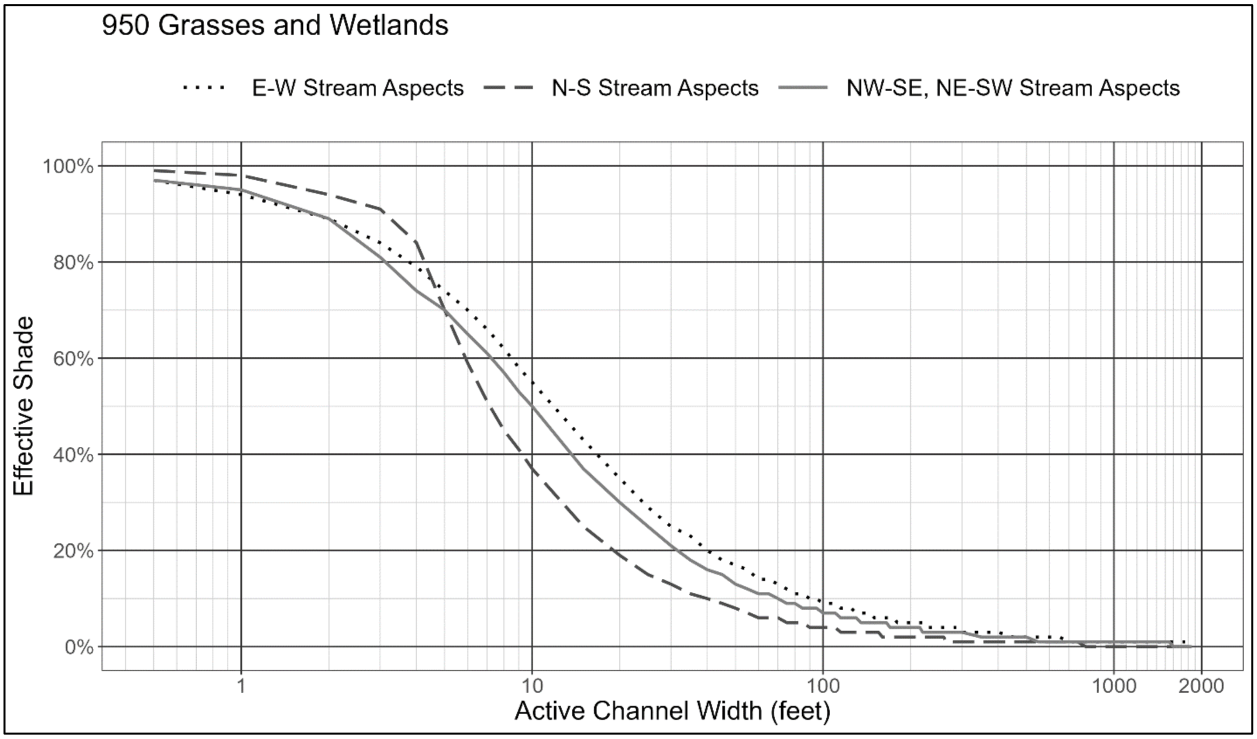

Figure 9-10: Effective shade targets for grass or wetland stream sites.

9.3.5 Percent consumptive use surrogate measure

For most Lower Columbia-Sandy streams, the portion of the human use allowance assigned to water management activities and water withdrawal activities is 0.05°C. DEQ completed modeling to estimate the percent consumptive uses that will attain this allocation (see TSD Appendix C, Section 9.0). The percent consumptive use is the percent of the natural surface flow that does not return to surface water after it has been withdrawn for a water use activity. Modeling indicates that a consumptive use flow rate reduction of 1.90 percent at USGS gage 14142500 – Sandy River below Bull Run will maintain warming from water withdrawal activities at or less than 0.05°C. The natural flow rate was based on the monthly median natural flow.

Table 9-6: Target percent consumptive use flow rate at USGS 14142500 relative to the monthly median natural flow rate at USGS 14142500.

Maximum percent consumptive use	Reference Flow Monitoring Site
1.90	USGS 14142500 – Sandy River below Bull Run

10 Water quality standards attainment

DEQ conducted modeling to determine if and demonstrate that implementation of the various proposed individual Human Use Allowances and Load Allocations on the Sandy River and its tributaries will attain applicable water quality standards in the Sandy River. Numerous models were developed that variously assessed individual TMDL components separately (e.g., separate models for WLAs, LAs, etc.) and comprehensively (e.g., a single model including all proposed WLAs, LAs, MOS, etc.). This section reports on the results of the various models. See TSD Appendices A, C, and D for details.

10.1 Comprehensive wasteload and load allocations assessment

To determine if the combined attainment of the various proposed individual Wasteload and Load Allocations would be sufficient to meet the cumulative Human Use Allowance (0.30°C) and attain applicable water quality standards in the Sandy River, DEQ completed modeling that incorporated all such allocations in a “Comprehensive Wasteload and Load Allocations Attainment” scenario. Two versions of this scenario were modeled; “Comprehensive Attainment_A” represented wasteload allocations with the ODFW Sandy River Fish Hatchery discharging to Cedar Creek, and “Comprehensive Attainment_B” represented wasteload allocations with the ODFW Sandy River Fish Hatchery discharging to the Sandy River. Results of these scenarios were compared to those of a baseline scenario to determine temperature effects and standards attainment in the Sandy River for the 2016 model period.

Briefly, the Comprehensive Baseline scenario assumptions included: no point source discharges, restored vegetation, Salmon River tributary inputs at modeled background temperatures, Bull Run River inputs at modeled Bull Run River No Dams scenario output, Cedar River inputs equal to those in the Sandy River No Point Sources scenario, and all other tributaries equal to current conditions model inputs.

Comprehensive Wasteload and Load Allocations Attainment scenarios (A and B) assumptions included:

- Point sources reflected proposed WLAs (WLA_A and WLA_B, respectively),
- Restored vegetation, except for infrastructure (i.e., roads, buildings, utilities, bridges)
- Tributaries at Comprehensive Baseline temperatures +0.30°C, except:
    - Bull Run River inputs equaled the Bull Run River Surrogate Measure Attainment Scenario output (see TSD Appendix A Section 4.5.4 for details).
    - Cedar River inputs were defined as:
        - Version A: current conditions flows and temperatures (including fish hatchery discharge to the Cedar River), or
        - Version B: the values from the WLA_B scenario, (diversion of fish hatchery discharge to the Sandy River) +0.30°C.
- Upstream boundary condition temperatures at current conditions values +0.03°C.

All other parameters were identical between the Comprehensive Wasteload and Load Allocations Attainment and Comprehensive Baseline scenarios. See TSD Appendix C for details.

Comparing Comprehensive Wasteload and Load Allocations Attainment version A to the Comprehensive Baseline scenario (Figure 9-1), the maximum 7DADM temperature change was 0.29°C at the POMI (river km 38.50, 7/30/2016) and 0.14°C at the mouth (7/21/2016).

Results for Comprehensive Wasteload and Load Allocations Attainment version B were nearly identical (Figure 9-2): the maximum 7DADM temperature change was 0.29°C at the POMI (river km 38.50, 7/30/2016) and 0.14°C at the mouth (7/21/2016).

Thus, under attainment of all WLAs and LAs under either WLA_A or WLA_B specifications on the mainstem and tributaries, the cumulative 0.30°C human use allowance on the Sandy River is not exceeded during the model period.

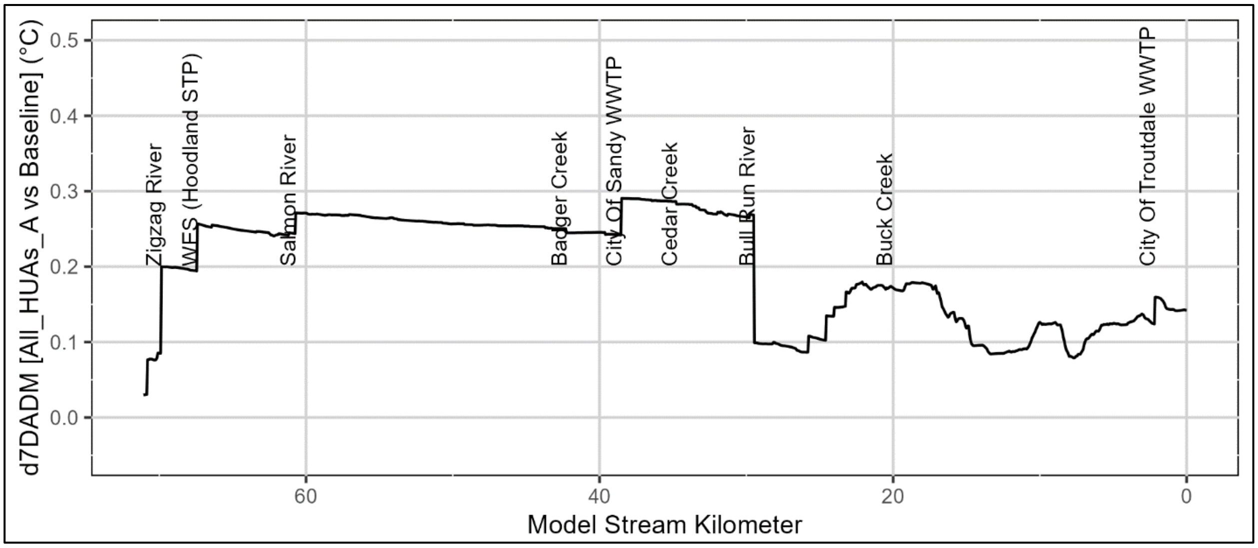

Figure 10-1: Sandy R. max. 7DADM temp. changes above the applicable criteria due to implementation of all human use allocations in the mainstem and tributaries, with wasteload allocations set to WLA_A parameters.

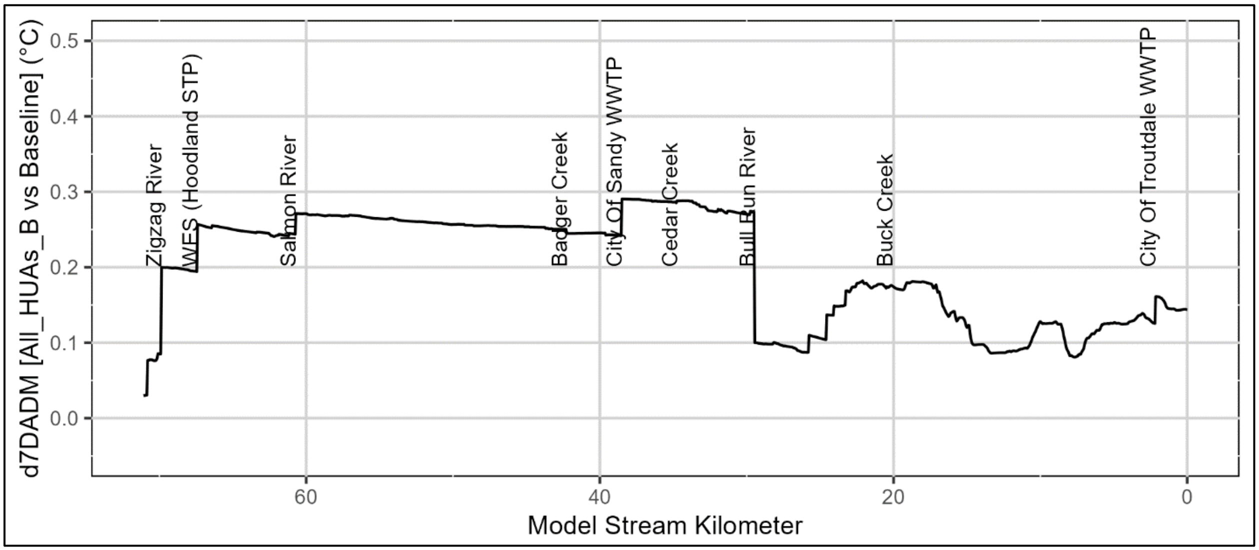

Figure 10-2: Sandy R. max. 7DADM temp. changes above the applicable criteria due to implementation of all human use allocations in the mainstem and tributaries, with wasteload allocations set to WLA_B parameters.

10.2 Wasteload allocation attainment results

Current NPDES-permitted point sources discharges were associated with a maximum cumulative 7DADM water temperature increase of 0.02°C (river km 2.15, 9/2/2016) based on 2016 modeling (Figure 9-3). This assessment excluded the potential new discharge from the City of Sandy WWTP. With this new discharge included, the maximum cumulative 7DADM increase was 0.03°C (river km 1.65, 9/5/2016).

The mass balance analysis, which evaluated temperature increases from point sources across multiple years of effluent and river discharge data, indicated a maximum increase of 0.05°C in the Sandy River among individual sources at their respective points of discharge (Table 7-1).

Attainment of the WLAs in the Sandy River was assessed via two different WLA scenarios: scenario WLA_A included the ODFW fish hatchery discharge at its current (Cedar Creek) location, while scenario WLA_B included the ODFW fish hatchery discharge relocated to the Sandy River (kilometer 34.80). The allocated portion of the HUA expressed as maximum allowable 7DADM water temperature increases are:

- 0.09°C cumulatively for all permittees at the POMI under both WLA_A and WLA_B scenarios.
- 0.06°C at the point of discharge for the Hoodland STP and City of Troutdale WPCF, and 0.05 for the City of Sandy WWTP) under both WLA_A and WLA_B scenarios. This equates to a 15% allowable increase over the current max. warming for each facility.
- 0.20°C for Government Camp STP discharges to Camp Creek under both WLA_A and WLA_B scenarios. This equates to a 15% allowable increase over the current max. warming.
- 0.30°C for the ODFW Sandy River Fish Hatchery at the Cedar Creek point of discharge (scenario WLA_A), and 0.08°C to the potential future Sandy River point of discharge (scenario WLA_B).

With NPDES permittees assigned individual WLAs as per scenario WLA_A, NPDES point sources accounted for a cumulative maximum 7DADM temperature increase of 0.09°C at the POMI (river km 2.15, 7/19/2016) (Figure 9-4). The results were nearly identical with NPDES permittees assigned individual WLAs as per scenario WLA_B (Figure 9-5): NPDES sources accounted for a cumulative maximum 7DADM water temperature increase of 0.09°C at the POMI (river km 2.15, 7/19/2016). Thus, both WLA scenarios meet the 0.09°C cumulative HUA proposed for point sources.

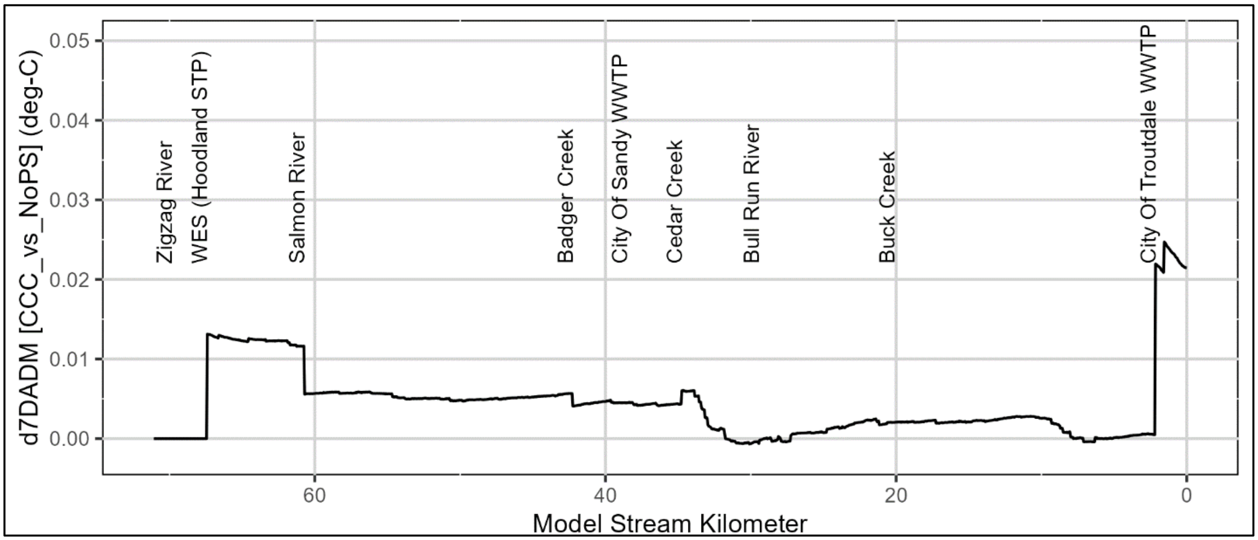

Figure 10-3: Longitudinal max. 7DADM temperature differences, CCC minus NoPS scenarios, Sandy River.

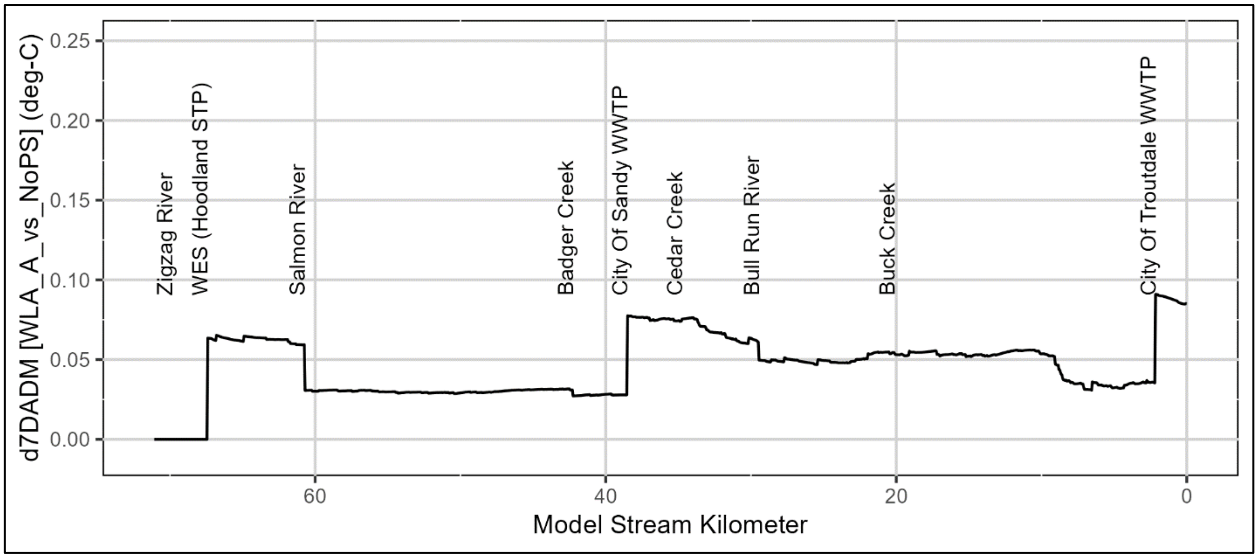

Figure 10-4: Longitudinal max. 7DADM temperature differences, WLA_A minus NoPS scenarios, Sandy River.

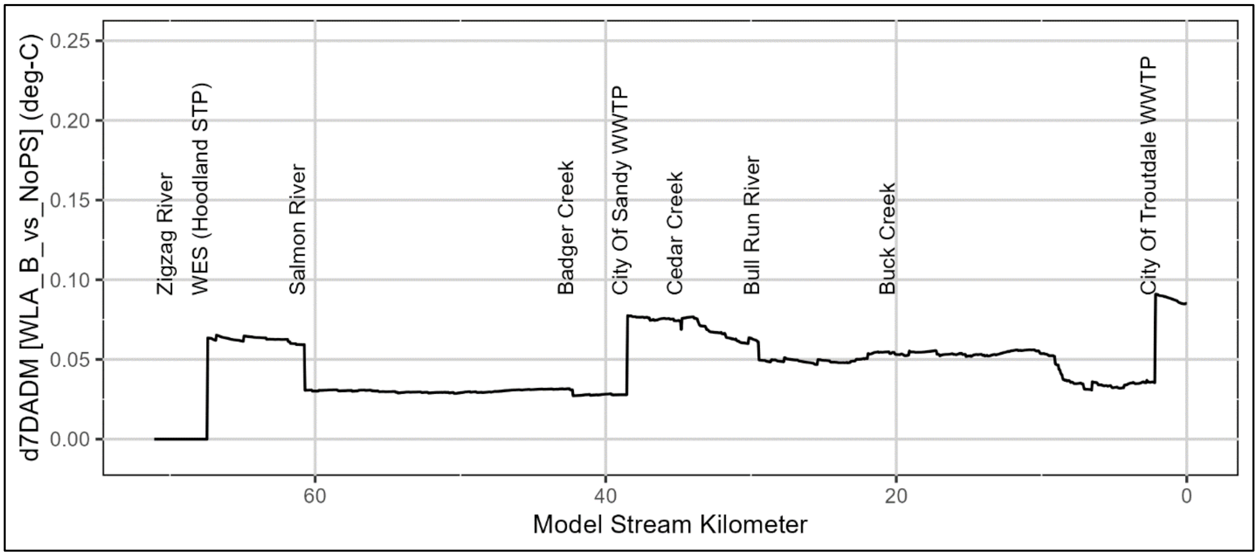

Figure 10-5: Longitudinal max. 7DADM temperature differences, WLA_B minus NoPS scenarios, Sandy River.

10.3 Bull Run Dam and reservoir attainment

To assess the Bull Run River temperature changes due to the Bull Run River dams and reservoirs with discharges reflecting the proposed 0.30°C dam and reservoir human use allowance, DEQ compared the no dam model scenario to the surrogate measure scenario with releases at the dam reflecting the surrogate measure target. (see TSD Appendix C Section 13.0 and TSD Appendix A Section 4.5.4 for details).

Comparing the no dam scenario to the surrogate measure scenario (Figure 10-7) indicated maximum 7DADM temperature changes of 0.30 °C at the lamprey barrier decreasing to 0.07 °C at the mouth. Thus, the surrogate measure scenario demonstrates attainment of the 0.30 °C human use allowance.

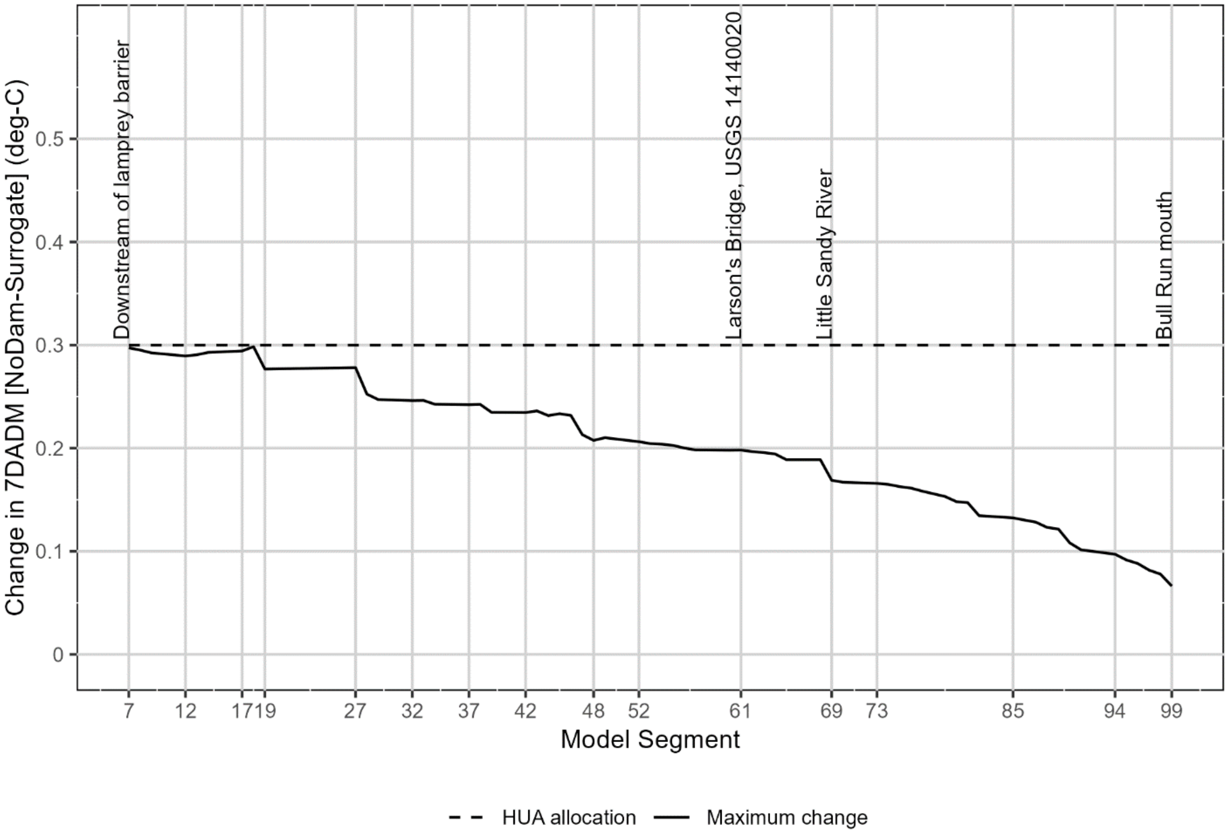

Figure 10-6: Bull Run River max. 7DADM temp. changes above the applicable criteria due to Bull Run River dams and reservoirs with discharges attaining the surrogate measure.

To assess the Sandy River temperature changes due to the Bull Run River dams and reservoirs with discharges reflecting the proposed 0.01°C dam and reservoir human use allowance, DEQ compared the Comprehensive Baseline scenario (Section 10.1) to a “Dam-Only” scenario. The Sandy River “Dam-Only” scenario was identical to the baseline scenario except that the Bull Run River tributary temperature inputs were set as the output from the Bull Run River Surrogate Measure Attainment Scenario at the mouth (see TSD Appendix C Section 13.0 and TSD Appendix A Section 4.5.4 for details).

Comparing the Dam-Only scenario to the baseline scenario (Figure 10-7) indicated maximum 7DADM temperature changes (°C) of 0.01 at the POMI (river km 18.05 8/12/2016) and (-0.01) at the mouth (river km 0.00, 8/13/2016). Thus, under attainment of the proposed dam surrogate measure, the proposed dam and reservoir human use allowance (0.01°C) on the Sandy River is not exceeded during the model period.

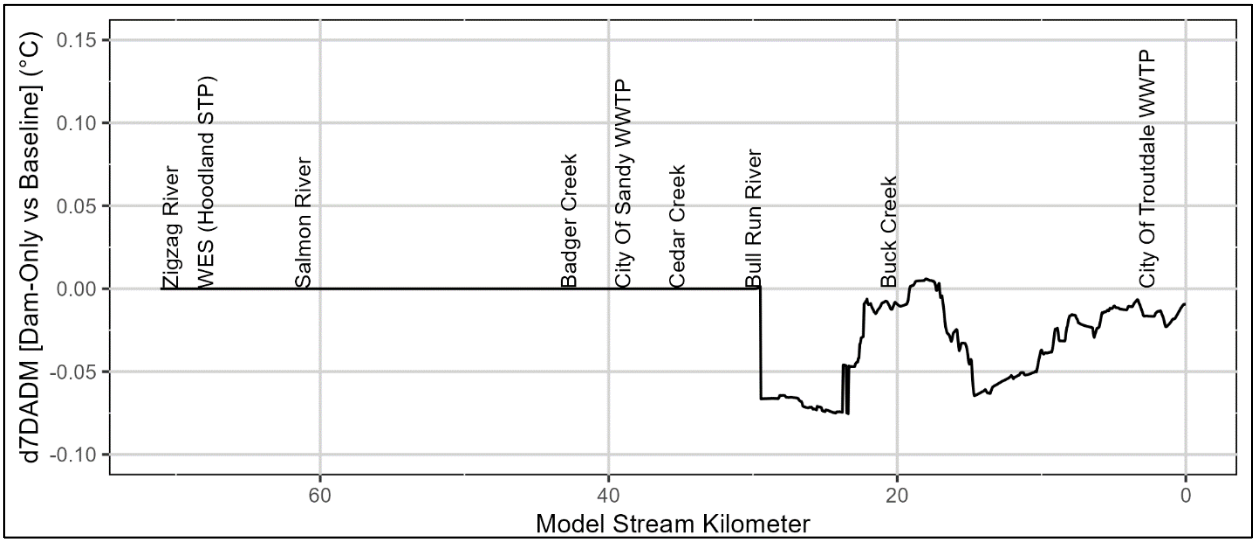

Figure 10-7: Sandy River max. 7DADM temp. changes above the applicable criteria due to presence of Bull Run River dams and reservoirs with discharges attaining the surrogate measure.

10.4 Tributary temperature assessment

To assess the Sandy River temperature changes due to its tributaries accounting for the entire proposed Human Use Allowance (0.30°C) at their mouths, DEQ modeled a “Tributary Temperatures Attainment” scenario and compared this to the Comprehensive Baseline scenario (section 10.1). The Tributary Temperatures Attainment scenario was identical to the baseline scenario except that tributaries’ temperatures were increased by 0.30°C throughout the modeling period; the only exception was that the Bull Run River tributary temperature inputs were set to the Surrogate Measure Attainment model outputs at the mouth. See TSD Appendix C for details.

Comparing the Tributary Temperatures Attainment scenario to the baseline scenario (Figure 10-7) indicated a maximum 7DADM temperature change of 0.24°C at the POMI (river km 60.70, 7/24/2016) and 0.09°C at the mouth (river km 0.00, 8/13/2016).

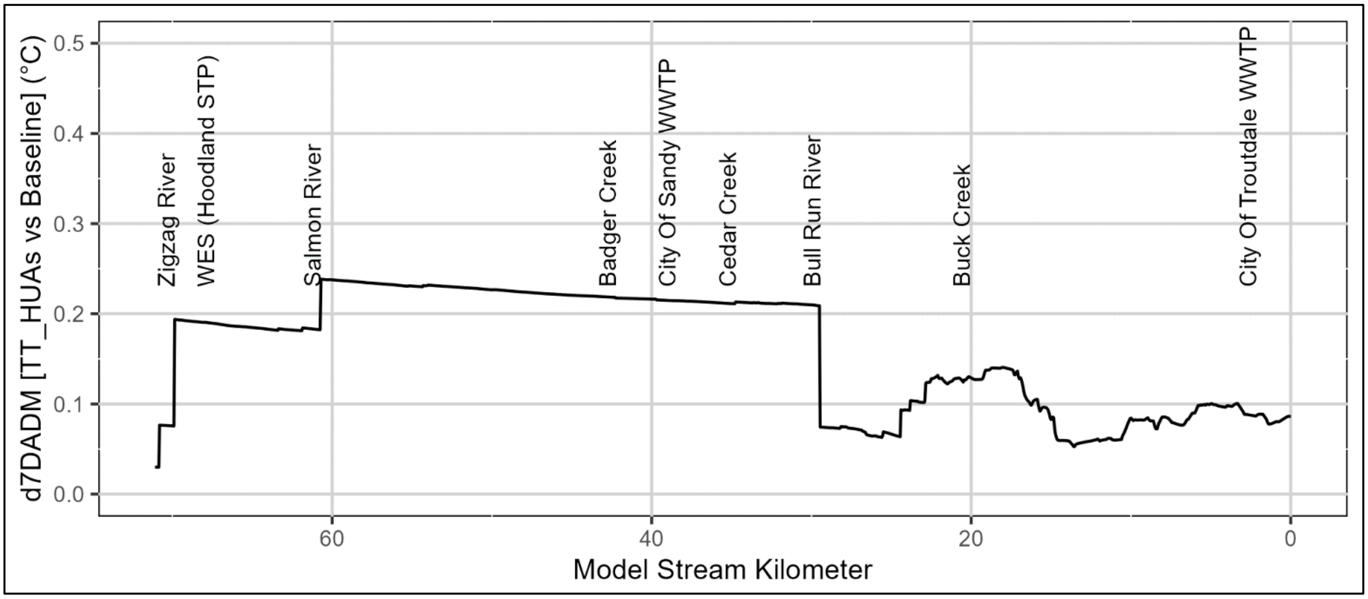

Figure 10-8: Sandy River max. 7DADM temp. changes above the applicable criteria due to tributary discharge temperatures reflecting proposed load allocations.

10.5 Sandy River assessment for Columbia River Temperature TMDL

10.5.1 Background

EPA's Columbia and Lower Snake Rivers temperature TMDL (EPA, 2021) allocated 0.1°C of warming in the Columbia River to anthropogenic sources in Columbia River tributaries. EPA determined that to achieve this allocation, tributary temperatures must be ≤0.5°C above the natural condition at the mouth. Per consultation with EPA, the 0.5°C increase is measured above the daily mean. This is due to the daily timestep of the model simulation. DEQ evaluated Sandy River temperatures for this purpose via comparisons of various model scenarios to determine if temperature changes associated with allocations to anthropogenic sources attain the Columbia River allocation.

10.5.2 Methods and assumptions

DEQ provided allocations that are greater than zero to multiple anthropogenic source categories including point sources, dam and reservoir operations, consumptive uses (water withdrawals), solar loading from existing transportation corridors, existing buildings, and existing utility infrastructure, and reserve capacity. Except for point sources and consumptive uses, DEQ did not develop model scenarios that represent the ground conditions, operations, or other management strategies that attain the other nonpoint source TMDL allocations. The models were focused on assessing current loading only.

To estimate the impact of the other nonpoint source categories, a conversion factor was developed to convert increases above the 7DADM to increases above the daily mean temperatures. This provided an estimate using the allocated portion of the human use allowance. The sum of each sector's increase was evaluated against the Columbia River TMDL allocation of 0.5 °C.

For point sources and consumptive use sectors, the model was used for assessment of the Columbia River TMDL allocation. There was not a single model scenario developed that reflected both point sources and water withdrawals attaining their allocation. Thus, DEQ evaluated the results from each source category and assumed the sum of the results reflect the total change above natural conditions. DEQ completed the following scenario comparisons using the model:

1. Water withdrawal scenario A vs. natural flow
2. TMDL WLA option "A" vs. no (NPDES-permitted) point sources
3. TMDL WLA option "B" vs. no (NPDES-permitted) point sources

The Technical Support Document Appendices A, B, and C provide detailed information on the model scenarios setup and results. The change above the daily mean was computed as follows:

1. Calculate scenario 1 (i.e., natural conditions) daily mean temperatures at each km and day in the model extent.
2. Calculate scenario 2 (i.e., anthropogenically altered conditions) daily mean temperatures at each km and day in the model extent.
3. For each day and model km, subtract step 1 result from step 2 result.
4. From the time-series and longitudinal results of step 3, find the maximum difference at the Sandy River mouth (km: 0.00).

10.5.3 Results

Table 9-1 provides the results of these model scenario comparisons at the Sandy River mouth. The maximum cumulative (accounting for point sources and water withdrawals) temperature change from the daily mean is 0.19°C, based on the sum of the maximum changes for the WLA vs. no point sources scenarios (0.12°C) and the water withdrawal vs. natural flow scenarios (0.07°C).

For the source categories listed in Table 9-1, the maximum model-calculated increases above the daily means are about 1.33 to 1.4 times greater than the equivalent allocated portions of the human use allowance measured above the 7DADM. The maximum factor (1.4) was then applied as a precautionary factor (coefficient) to estimate the maximum increases above the daily means for the remaining source categories (Table 9-2).

After summing the results (Table 9-2), the total estimated increase is 0.37°C and is thus likely to attain the 0.5°C tributary temperature allocation for the Sandy River in the Columbia and Lower Snake Rivers temperature TMDL.

Table 10-1: Max. differences between daily mean temp. under various scenarios, Sandy R. mouth.

Scenario 1	Scenario 2	Related source or source category	Max. increase above daily mean (°C), Scenario 2 minus Scenario 1	Max. increase above daily mean (°C) / Human Use Allowance Allocation (°C)
Natural flow	Water withdrawals B	Water management activities & withdrawals	0.07	1.40
No point sources	WLA option "A"	NPDES point sources (cumulative)	0.12	1.33
No point sources	WLA option "B"	NPDES point sources (cumulative)	0.12	1.33

Table 10-2: Sandy River human use allowance allocations and the equivalent max. increase measured above the daily mean temperature.

Source or source category	Allocated Portion of Human Use Allowance (°C)	Max. increase above the daily mean (°C)
NPDES point sources (cumulative)	0.09	0.13[a]
City of Portland Bull Run dam and reservoir operations	0.05	0.07[b]
Water management activities and water withdrawals	0.05	0.07[a]
Solar loading from existing transportation corridors, buildings, and utility infrastructure	0.02	0.03[b]
Solar loading from other NPS sectors	0.00	0.00[b]
Reserve capacity	0.05	0.07[b]
Total	**0.26**	**0.37**

[a] Model calculated.
[b] Calculated as 1.4 times the source-specific human use allowance.

11 Acknowledgements

This section will be completed for the final TMDL.

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Appendix A: Model Report

Appendix B: Sandy River Model Calibration Report

Appendix C: Sandy River Model Scenario Report

Appendix D: Bull Run Model Report

Appendix E: Bull Run River Surrogate Measure Approach

Appendix F: Climate Change and Stream Temperature in

Oregon: A Literature Synthesis

Appendix G: Stream Buffer Width Literature Review

Appendix H – Assessment Units addressed by Temperature TMDLs for the Lower Columbia-Sandy Subbasin