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Appendix C:
Sandy River Model Scenario Report

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

To:	Ryan Michie, David Fairbairn, Ben Cope, Peter Leinenbach, Jayshika Ramrakha
From:	Aileen Molloy, Sen Bai, Mustafa Faizullabhoy
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Subject:	Sandy River Scenarios

WTR Mid-Atlantic
10306 Eaton Place, Suite 340, Fairfax, VA 22030
Tel 703-385-6000 tetratech.com

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1.0 OVERVIEW

This document - Appendix C to the Technical Support Document (TSD) for the Lower Columbia-Sandy Subbasin (17080001) temperature TMDL replacement project - summarizes the numerical modeling and analytic methods applicable to the portion of the TMDL related to the Sandy River scenarios. This includes the development, results, and comparisons of the various model scenarios used to support the Sandy River Temperature TMDL. The Sandy River Heat Source Temperature model (Tetra Tech, 2022) was used for scenarios simulation. The extent of the model domain for the Sandy River was from the mouth at the Columbia River to just upstream of Clear Creek, covering a stretch of 71.08 river kilometers (RKM). The model was configured and calibrated for the period from July 15, 2016, through September 06, 2016. This period covered the critical summer and spawning periods; the base model is referred to as the “Calibrated Current Conditions” (CCC) model and is described in Appendix B to the TSD for the Lower Columbia-Sandy Subbasin (17080001) temperature TMDL replacement project. **Table 1-1** lists the additional scenarios evaluated for the Sandy River mainstem. The following sections discuss general analytical parameters and describe the configuration, results and comparisons of the individual scenarios.

Table 1-1: Sandy River scenarios descriptive summary

Scenario #	Scenario	ID	Equivalent to CCC except:
2	Future Point Source	FPS	With new planned point source (City of Sandy WWTP) as modified tributary input
3	No Point Sources	NoPS	No NPDES-permitted point source discharges
4	TMDL Wasteload Allocations	WLA_A; WLA_B	NPDES-permitted point source discharges reflect proposed WLAs
5	Restored Veg. A	RV_A	Fully restored veg. in all human-affected areas
	Restored Veg. B	RV_B	Fully restored veg. in all human-affected areas except existing infrastructure (i.e., bldgs, roads, utility corridors)
6	No Dams	ND	Bull Run R. tributary inputs reflect Bull Run R. no dam model outputs.
7	Natural Flow	NQ	Boundary & tributary flows reflect median natural monthly flows (i.e., no anthropogenic riparian veg. changes or water withdrawals)
8	Water Withdrawals	WW_A; WW_B	Same as NQ but accounts for consumptive use withdrawals of: (A) 1.9%; (B) 10.10%.
9	Background	BG	Equivalent to combined Restored Veg. A & No Dams scenarios.
11	Topography	Topo	All veg. heights & densities are set to 0 (zero)
12	Tributary Temps.	TT	For any tributaries with applicable temp. standard exceedances in the model period, their entire temp. dataset is reduced by the max. exceedance.

2.0 MODEL SCENARIO ANALYSIS AND INTERPRETATION METHODS

2.1 SIGNIFICANT DIGITS AND ROUNDING

The TMDL analysis and interpretation of all model and scenario results accounted for significant digits and rounding. To evaluate human use allowance (HUA) attainment, Oregon Department of Environmental Quality (DEQ) calculates and records values to the hundredths (0.01°C). Because DEQ assigns some HUAs to the hundredths, attainment must be tracked with equal precision. The TMDL analysis follows the rounding procedures outlined in a DEQ permit-related internal management directive (IMD) on rounding and significant digits (DEQ, 2013). This IMD says that for “calculated values” (which includes model results), if the digit being dropped is a “5,” it is rounded up. For example, if an HUA allocation is set at 0.05°C and the model shows warming equal to 0.054°C, the value is rounded down to 0.05°C and the result is attainment. If the model shows warming equal to 0.055°C, the value is rounded up to 0.06°C and the result is non-attainment.

2.2 CALCULATING THE 7-DAY AVERAGE DAILY MAX. TEMPERATURE

For each scenario the 7-day average maximum (7DADM) temperature was calculated using the hourly model output. The 7DADM was calculated using the procedure outlined in DEQ's Temperature IMD (DEQ, 2008). As outlined in this IMD, the 7DADM temperature is calculated by (i) calculating the daily maximum for each day, then (ii) calculating a 7-day rolling average of the daily maximums, the result for which lands on the 7th day and is considered the 7DADM for that day.

2.3 COMPARING TEMPERATURE BETWEEN TWO SCENARIOS

When comparing the hourly results from two model scenarios to determine the temperature changes, the following steps were taken:

1. Calculate the 7DADM temperatures for scenario 1 at every model node for every day of the model period.
2. Calculate the 7DADM temperatures for scenario 2 at every model node for every day of the model period.
3. For allocation scenarios, the HUA is defined as the maximum allowable increase above the applicable biologically-based numeric criteria (BBNC). Thus, to determine the maximum temperature change in relation to HUAs, only days when the BBNC was exceeded were considered and thus days when 7DADM river temperatures did not exceed the BBNC were excluded. Note that the BBNC varied spatially and temporally and this was accounted for in the assessment.
4. Compute the difference between the 7DADM temperatures of scenario 1 and scenario 2 only for days that exceed the BBNC.
5. Round the differences to two decimals Celsius, based on the adopted rounding procedure discussed in Section 1.1.

2.4 BIOLOGICALLY-BASED NUMERIC CRITERIA

The applicable temperature criteria for the Sandy River are:

- Salmon and Steelhead Spawning: 13.0°C August 15 – September 5 (OAR 340-041-0028(4)(a))
- Core Cold Water Habitat: 16.0°C, July 15 – August 14 (OAR 340-041-0028(4)(b))
- Salmon and Trout Rearing and Migration: 18.0°C July 15 – September 5 (OAR 340-041-0028(4)(c))

The BBNC vary spatially and temporally and are evaluated based on the 7DADM. **Figure 2-1** illustrates the BBNC along the Sandy River model extent. **Figure 2-2** shows the Sandy River stream sampling points and the BBNC application locations.

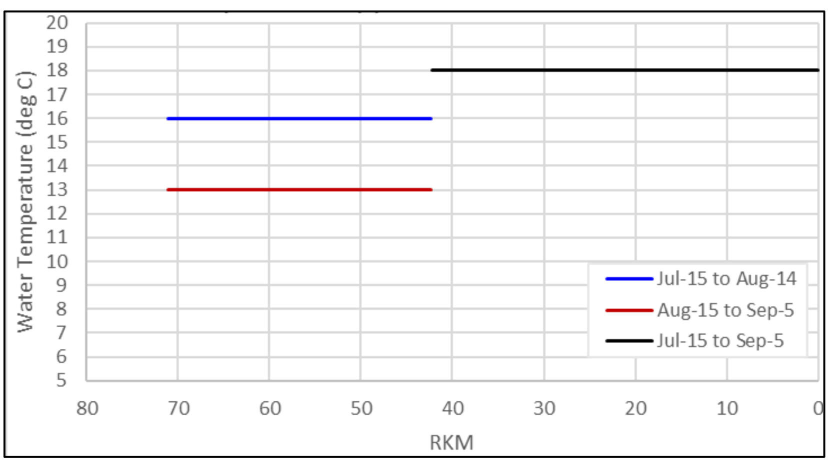

Figure 2-1: Applicable BBNC along the Sandy River modeling domain

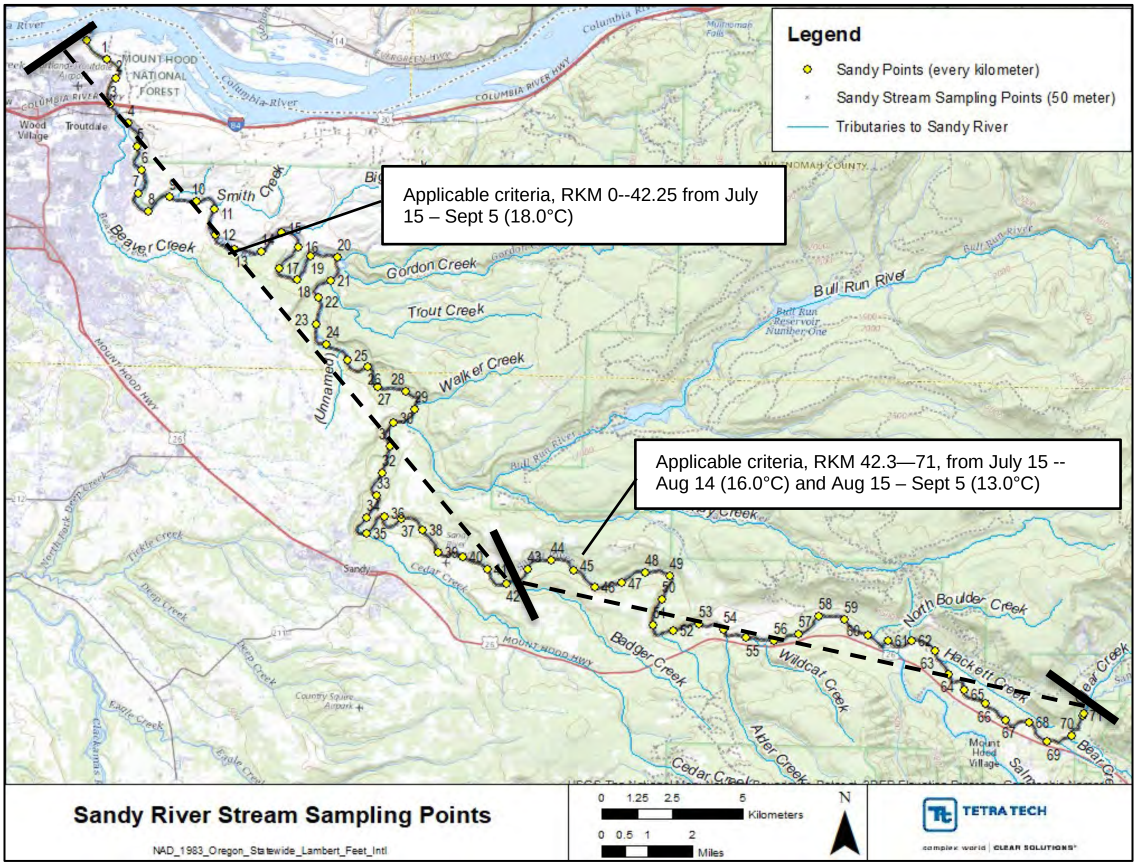

Figure 2-2: Sandy River stream sampling points and applicable temperature criteria

3.0 FUTURE POINT SOURCE SCENARIO

The future point source (FPS) scenario is identical to the CCC model except that a proposed City of Sandy WWTP discharge was added to the model at RKM 38.5 (**Figure 3-1**). The City of Sandy provided estimated effluent flow and temperature data for the for years 2026 and 2040 (Table 3-1). Per the City of Sandy's consultant, the provided effluent temperatures corresponded to year 2040 flows. The corresponding model effluent flow and temperatures were set to the 2040 values (**Table 3-1**). The FPS and CCC scenarios' results were compared to determine the instream temperature effect of the proposed City of Sandy WWTP discharge and if its addition would result in additional exceedances of applicable instream temperature criteria and the HUA.

At each (50m) node, the maximum 7DADM change associated with the FPS for the model period was calculated as described in section 2.3. Per **Table 3-2**, the point of maximum impact (POMI) for the FPS scenario, which corresponds to the RKM (38.50km) with the maximum predicted 7DADM temperature change, corresponded with a 0.01°C maximum 7DADM increase. No maximum 7DADM increase (<0.005°C) was predicted at the Sandy River mouth. **Figure 3-2** shows the FPS's modeled impact at its discharge location and further downstream.

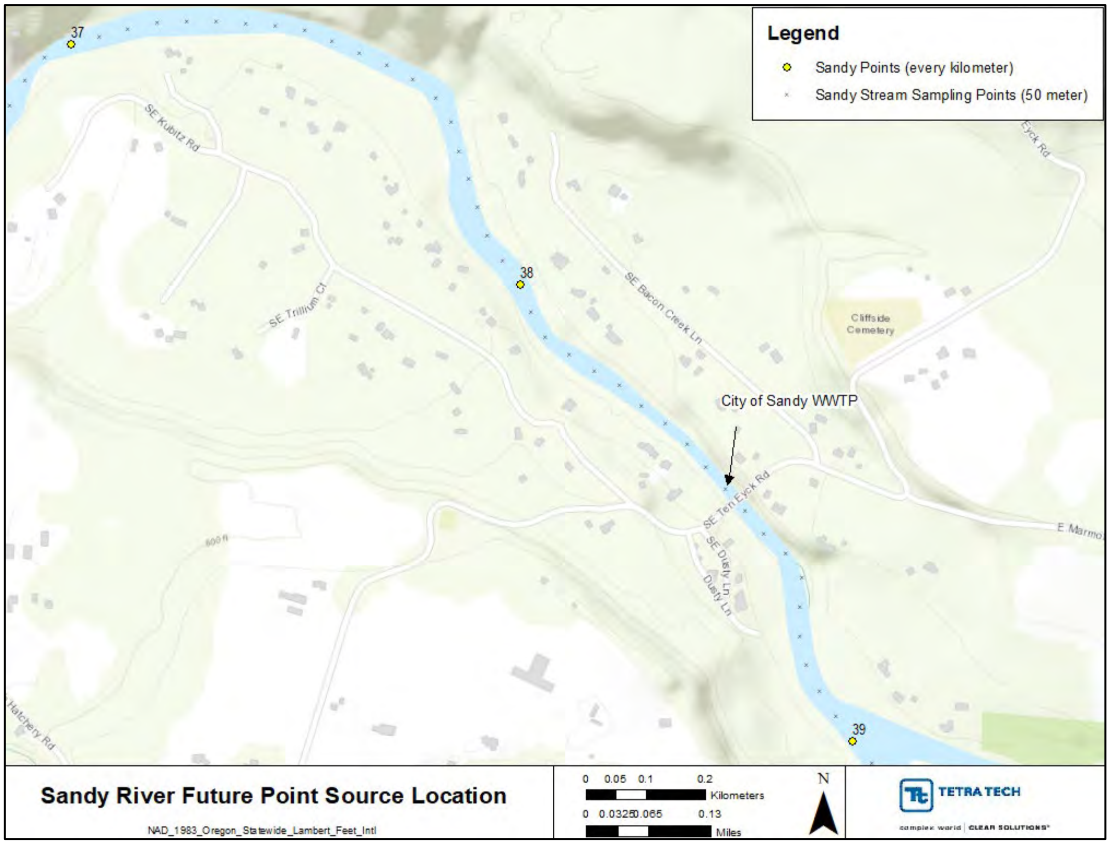

Figure 3-1: Location of City of Sandy WWTP proposed future point source

Table 3-1: Estimated City of Sandy WWTP effluent flow and temperature

Month	Flow (m^3/s)		Effluent Temp (°C)
	2026	**2040**	
January	0.051	0.060	14.3
February	0.047	0.056	14.0
March	0.052	0.061	14.7
April	0.046	0.061	15.5
May	0.042	0.055	17.6
June	0.037	0.046	18.7
July	0.032	0.037	20.0
August	0.030	0.035	20.6
September	0.031	0.036	20.2
October	0.046	0.055	19.4
November	0.055	0.076	17.4
December	0.053	0.068	15.5

Table 3-2: Sandy River CCC vs. FPS scenarios: Modeled water temperatures and changes **(WT, °C)**

Scenario	Value Type	Location	Max. 7DADM		
			Model km	**Date**	**WT (°C)**
Current Cond.	CCC	Mouth	0	08/18/2016	23.67
Future Point Source	FPS	Mouth	0	08/18/2016	23.67
	FPS minus CCC (WT change)	Mouth	0	07/19/2016	0.00
		POMI	38.50	07/29/2016	0.01

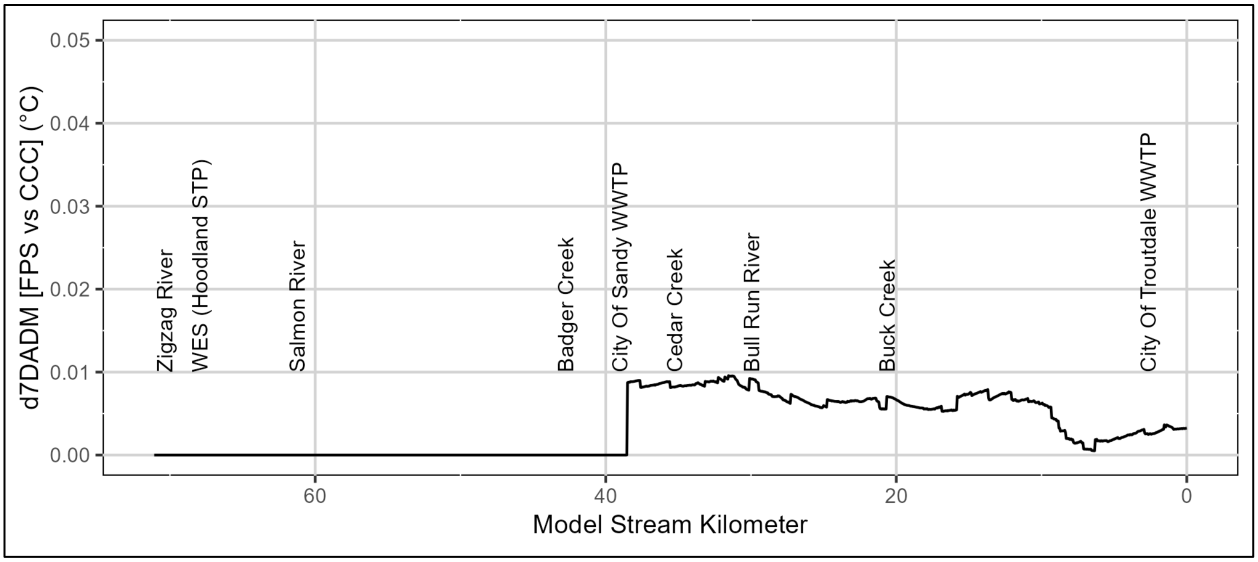

Figure 3-2: Sandy River max. 7DADM temp. change above applicable criteria from proposed future point source discharge

4.0 NO POINT SOURCES SCENARIO

The no point sources (NoPS) scenario is identical to the CCC model except that all NPDES-permitted point source discharges (**Table 5-1**) are removed, generally by setting their tributary flow inputs to zero in this Sandy River scenario model. The only exception was for configuration of the ODFW Sandy River Fish Hatchery; here, the Cedar Creek tributary temperature inputs were updated to remove the hatchery's influence. Specifically, temperatures measured upstream of the hatchery outfall, identified as "ambient temperatures" in ODFW-provided data, were used as Cedar Creek tributary temperatures (**Figure 4-1**) instead of the temperatures from downstream of the hatchery as in the CCC model.

The maximum 7DADM change from NPDES-permitted point sources was determined by comparing the CCC model and NoPS scenario results. **Figure 4-2** shows the various point source impacts at their discharge locations and downstream. The maximum 7DADM change was 0.02°C at the POMI (RKM 2.15) and 0.02°C at the mouth (**Table 4-1**). Note that differences were only calculated when the NoPS scenario 7DADM exceeded the BBNC.

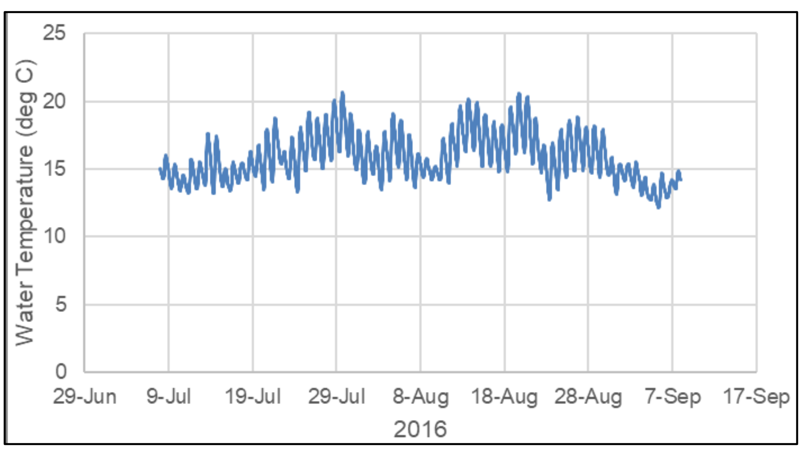

Figure 4-1: Model water temp. input for Cedar Cr., 10' upstream of ODFW Sandy River fish hatchery outfall

Table 4-1: CCC vs. NoPS scenarios: Modeled water temperatures and changes (WT, °C)

Scenario	Value Type	Location	Max. 7DADM

			Model km	Date	WT (°C)
Current Cond.	CCC	Mouth	0	08/18/2016	23.67
No Point Sources	NoPS	Mouth	0	08/18/2016	23.67
	CCC minus NoPS (WT change)	Mouth	0	09/04/2016	0.02
		POMI	2.15	09/02/2016	0.02

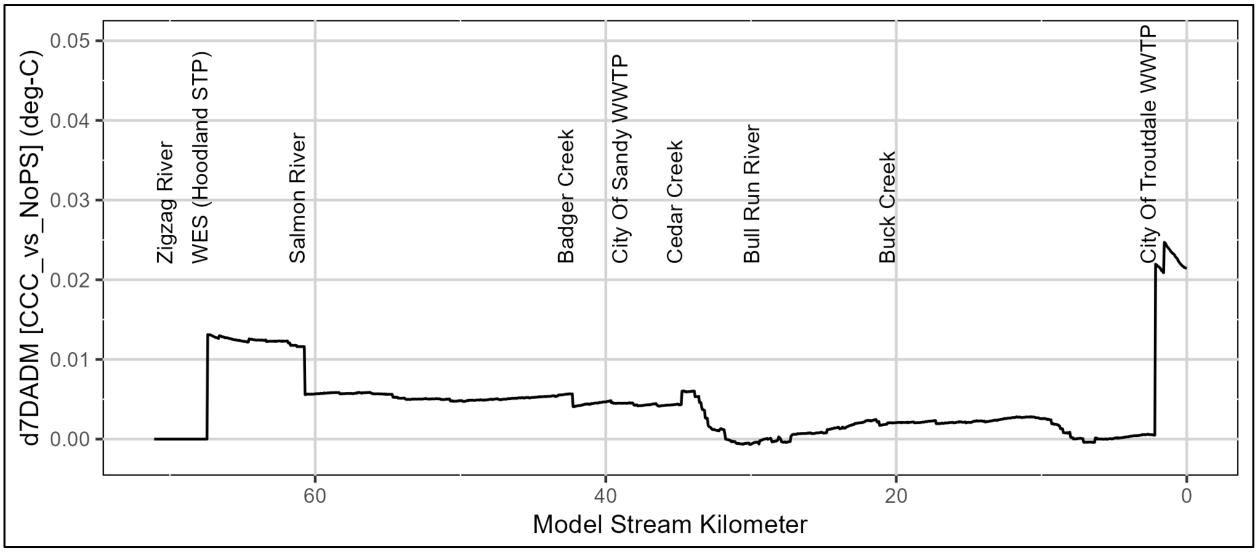

Figure 4-2: Sandy River max. 7DADM temp. change above applicable criteria from current point source discharges

5.0 TMDL WASTELOAD ALLOCATION SCENARIOS

The wasteload allocations (WLA) scenarios are identical to the CCC model except that NPDES-permitted point source discharges are modified to reflect DEQ-proposed TMDL WLAs. The results of the WLA and CCC scenarios are compared to determine the instream temperature effects of NPDES-permitted point sources that meet proposed TMDL WLAs (expressed as HUAs) versus the CCC-estimated point source discharges. Additionally, the results of the WLA and NoPS scenarios are compared to determine the instream temperature effects of achieving HUAs versus having no permitted point source discharges in the system.

Two unique WLA scenarios were assessed (WLA_A and WLA_B); the configurations of the two WLA scenarios are identical except that in WLA_A, the ODFW fish hatchery discharge is located on Cedar Creek near its confluence with the Sandy River, while under WLA_B it is located on the Sandy River at RKM 34.80. Under both WLA scenarios, proposed individual WLAs are applied to each NPDES permittee as a HUA at the associated discharge location (**Table 5-1**) and a proposed cumulative WLA as an HUA (0.13°C) at the POMI.

If possible, individual permittees’ point of discharge HUAs should be: defined to minimize immediate noncompliance issues; consistent across permittees; and similar to the 2005 TMDL. Initially, individual HUAs were set to 0.10°C for the Hoodland, City of Sandy, and City of Troutdale treatment facilities, but via iterative review it was determined that these should be reduced, and they were eventually set to 15% above their current maximum 7DADM warming to minimize cumulative impacts and to equitably and consistently distribute HUAs (**Table 5-1**). Acceptable point source effluent temperatures (i.e., those that would not lead to instream temperatures above the BBNC plus HUA) were determined by DEQ based on relevant equations provided in the main TSD, specifically Equation 9-5, which calculated acceptable effluent temperatures for the various point sources, and Equation 9-4, which calculated TMDL WLA temperatures for Cedar Creek considering ODFW fish hatchery influences. Except for the ODFW Sandy River Fish Hatchery, the effluent flows for all permitted point sources were based on average (mean) dry-weather facility design flow. For the ODFW Sandy River Fish Hatchery, the effluent discharge flow value was the maximum effluent discharge characterized from discharge data provided by ODFW. Average dry weather facility design flows were obtained from the current NPDES permit or permit evaluation report. Effluent temperatures were calculated to produce a maximum 7DADM change consistent with the WLAs; however, on days when the calculated effluent temperatures were >32.0°C, instream temperatures were capped at 32.0°C per DEQ mixing zone rules (OAR 340-041-0053).

Figure 5-1, **Figure 5-2**, and **Figure 5-3** show the flow and back-calculated temperatures for the respective Troutdale WWTP, Hoodland STP, and City of Sandy WWTP discharges that meet their respective HUAs at each point of discharge in the TMDL WLA scenario. Similarly, **Figure 5-4** shows the flow and calculated temperatures for the Cedar Creek tributary input that account for the allowed ODFW hatchery effluent HUA (0.30°C in Cedar Creek) in the WLA_A scenario.

To simulate the fish hatchery impact on the Sandy River in WLA_A, the reported fish hatchery effluent temperatures were used except when they exceeded the WLA, in which case the effluent temperatures were reduced to attain the WLA. DEQ accounted for implementation of the minimum duties provision in the modeling (Technical Support Document, Section 9.1.8, Equation 9-7). DEQ assumed that, unlike point sources such as wastewater treatment plants, the fish hatchery operations do not result in large increases to effluent temperatures compared to intake temperatures because the fish hatchery is a flow-through facility that does not process the influent.

Figure 5-5 shows the ODFW fish hatchery effluent flow and maximum calculated temperatures that would meet the allowed ODFW hatchery effluent HUA (0.08°C in the Sandy River) under WLA_B. In WLA_B, Cedar Creek tributary temperatures equaled those measured upstream of the hatchery outfall (**Figure 4-1**), identified as "ambient temperatures" in ODFW data.

At each node, the maximum 7DADM impact due to point sources discharging at the proposed WLAs under current applicable criteria for the model period was calculated as the maximum of the time-series of differences between the 7DADM results of the WLA and NoPS scenarios (**Figure 5-7** and **Figure 5-9** for WLA options A and B, respectively). Note that the 7DADM difference was calculated only when the NoPS scenario temperature exceeded the BBNC. Under both the WLA_A and WLA_B scenarios, the respective POMIs occurred at RKM 2.15 with a maximum cumulative 7DADM increases of 0.09. At the Sandy River mouth, the respective maximum cumulative 7DADM increases were 0.09°C (**Table 5-2**). The max. 7DADM changes between point sources discharging at proposed WLAs versus current conditions were also calculated and presented in **Figure 5-6** and **Figure 5-8** for WLA options A and B, respectively. **Table 5-2** summarizes the comparisons among the WLA_A, WLA_B, CCC, and NoPS scenarios based on current applicable BBNC, and **Table 5-3** summarizes the same based on proposed BBNC changes. Note that the max.7DADM changes were identical for these scenarios under either the current or proposed BBNCs.

Table 5-1: Assumptions to calculate effluent temperatures for Sandy River WLA model scenarios A and B

NPDES Permittee WQ File# : EPA #	Allocated HUA (°C)	Applicable criterion (°C)	Period start	Period end	7Q10, m^3/s	Effluent flow, m^3/s
Hoodland STP (WES) 89941 : OR0031020	0.06	16.0	5/1	8/14	4.47	0.040
		13.0	8/15	10/31		
City of Troutdale WWTP 39750 : OR0020524	0.06	18.0	5/1	10/14	7.88	0.13
		13.0	10/15	10/31		
City of Sandy WWTP 102492 : OR0026573	0.05	18.0	5/1	10/14	6.11	0.054
		13.0	10/15	10/31		
ODFW Sandy R. Fish Hatchery 64550 : ORG130009	0.30 (WLA_A); 0.08 (WLA_B)	18.0	5/1	10/14	0.14 (WLA_A); 6.11 (WLA_B)	0.091
		13.0	10/15	10/31		0.099

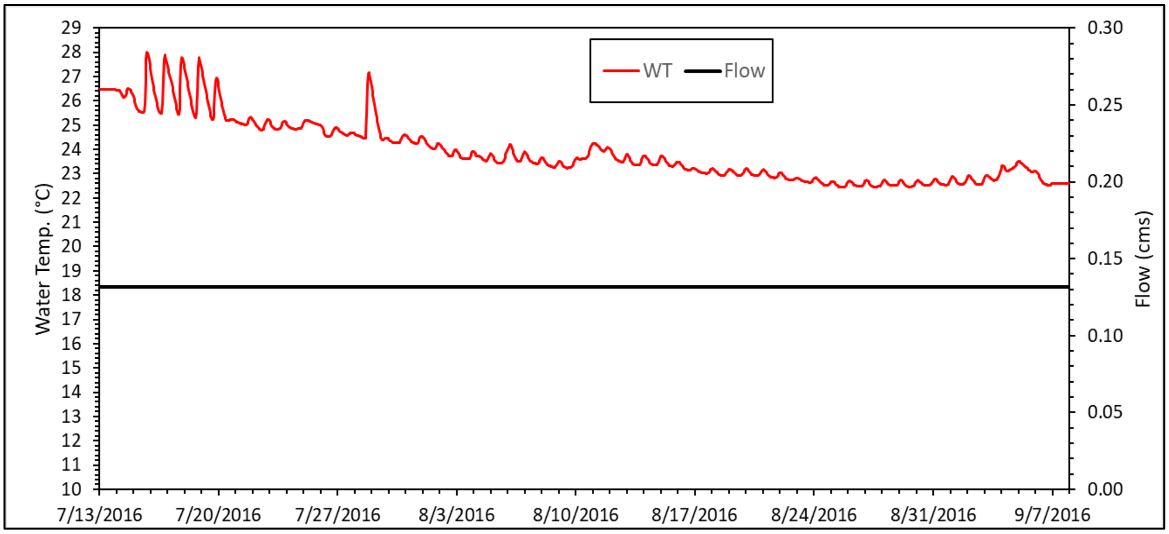

Figure 5-1: WLA scenarios: Troutdale WWTP flows and temperatures

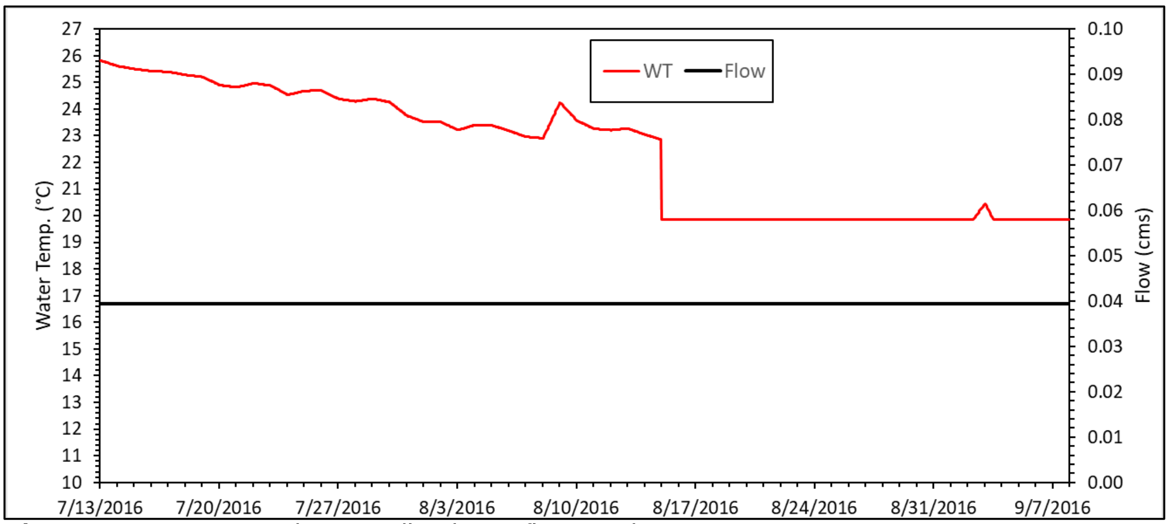

Figure 5-2: WLA scenarios: Hoodland STP flows and temperatures

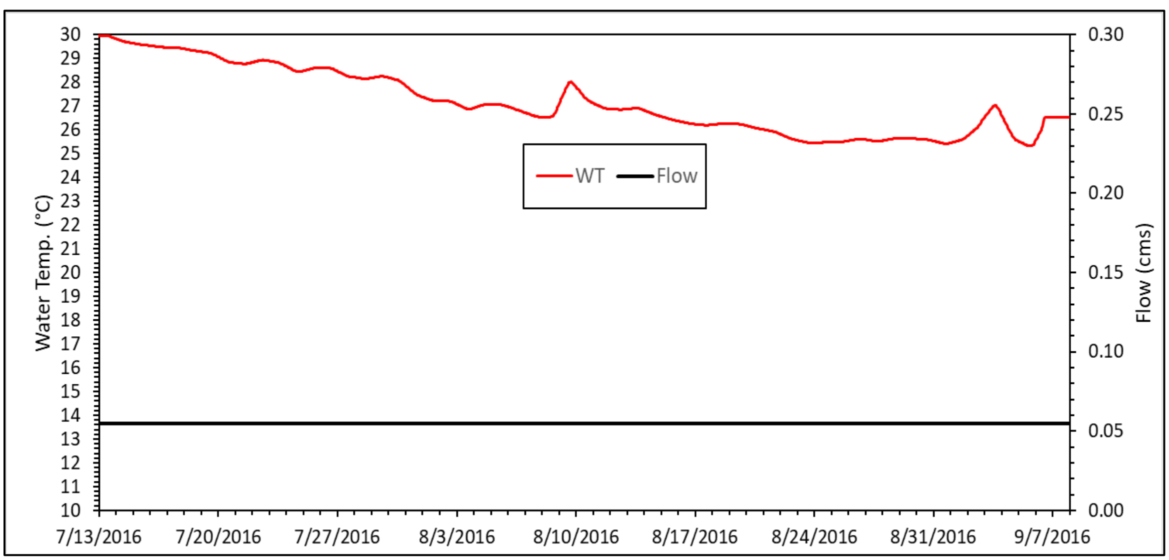

Figure 5-3: WLA scenarios: City of Sandy WWTP flows and temperatures

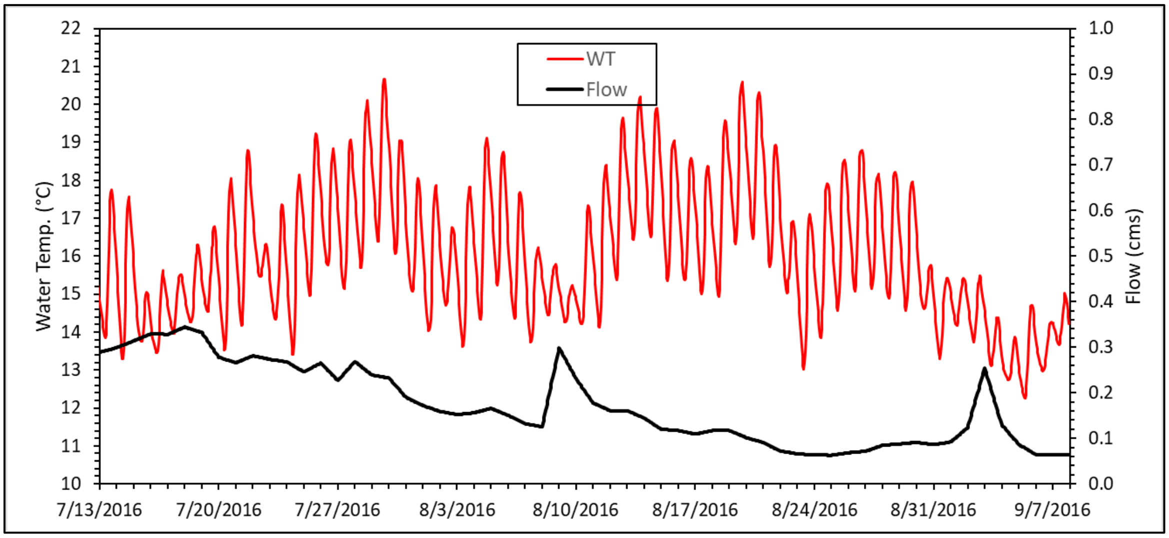

Figure 5-4. WLA_A scenario: Cedar Creek flows and temperatures to Sandy River based on ODFW fish hatchery WLA_A discharge rates and temperatures

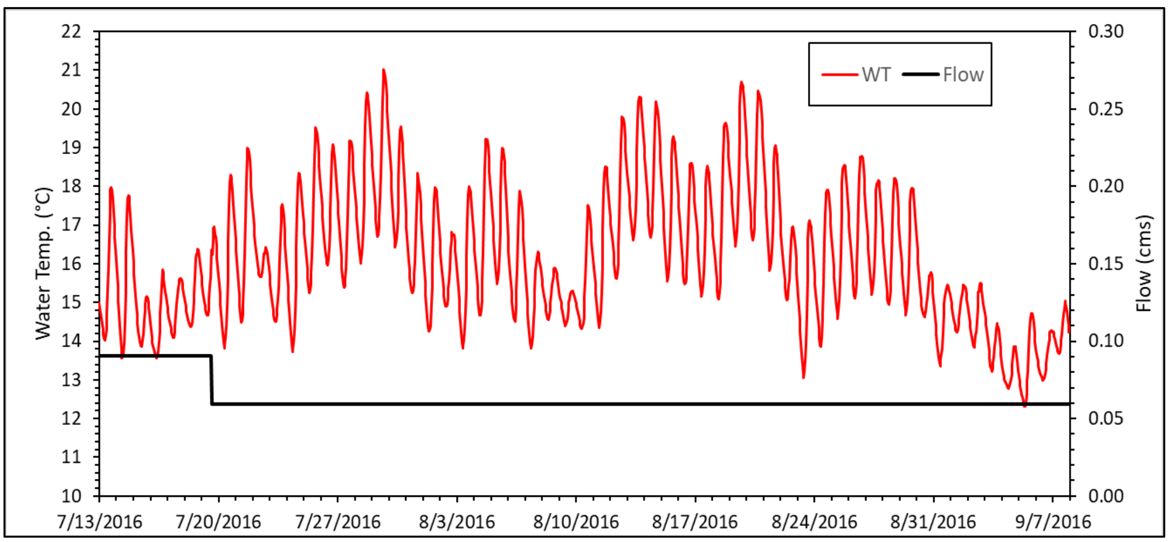

Figure 5-5: WLA_B scenario: ODFW Sandy River fish hatchery discharge rates and temperatures to the Sandy River.

Table 5-2: Sandy River WLA_A, WLA_B, CCC, and NoPS scenarios: Modeled water temperatures and changes (WT, °C), incorporating current applicable BBNC.

Scenario	Value Type	Location	Model km	Date	Max. 7DADM (°C)
No Point Sources	NoPS	Mouth	0	08/18/2016	23.67
Current Conditions	CCC	Mouth	0	08/18/2016	23.67
Wasteload Allocation A	WLA_A	Mouth	0	08/18/2016	23.68
	WLA_A minus NoPS (WT change)	Mouth	0	07/21/2016	0.09
		POMI	2.15	07/19/2016	0.09
	WLA_A minus CCC (WT change)	Mouth	0	07/19/2016	0.07
		POMI	2.15	07/19/2016	0.08
Wasteload Allocation B	WLA_B	Mouth	0	08/18/2016	23.68
	WLA_B minus NoPS (WT change)	Mouth	0	07/21/2016	0.09
		POMI	2.15	07/19/2016	0.09
		Mouth	0	07/19/2016	0.07

	WLA_B minus CCC (WT change)	POMI	2.15	07/19/2016	0.08

Table 5-3: Sandy River WLA_A, WLA_B, and NoPS scenarios: Modeled water temperatures and changes (WT, °C), incorporating proposed BBNC.

Scenario	Value Type	Location	Model km	Date	Max. 7DADM (°C)
No Point Sources	NoPS	Mouth	0	08/18/2016	23.67
Current Conditions	CCC	Mouth	0	08/18/2016	23.67
Wasteload Allocation A	WLA_A	Mouth	0	08/18/2016	23.68
	WLA_A minus NoPS (WT change)	Mouth	0	07/21/2016	0.09
		POMI	2.15	07/19/2016	0.09
	WLA_A minus CCC (WT change)	Mouth	0	07/19/2016	0.07
		POMI	2.15	07/19/2016	0.08
Wasteload Allocation B	WLA_B	Mouth	0	08/18/2016	23.68
	WLA_B minus NoPS (WT change)	Mouth	0	07/21/2016	0.09
		POMI	2.15	07/19/2016	0.09
	WLA_B minus CCC (WT change)	Mouth	0	07/19/2016	0.07
		POMI	2.15	07/19/2016	0.08

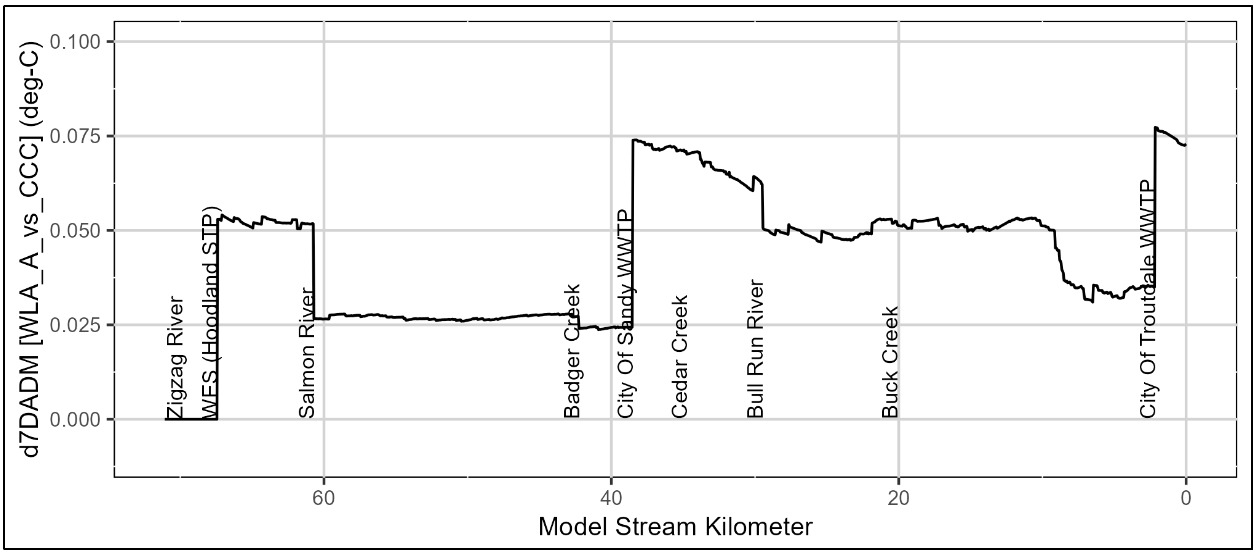

Figure 5-6: Sandy River max. 7DADM temp. change above current applicable criteria with point sources' inputs set to proposed WLAs (option A) vs. CCC

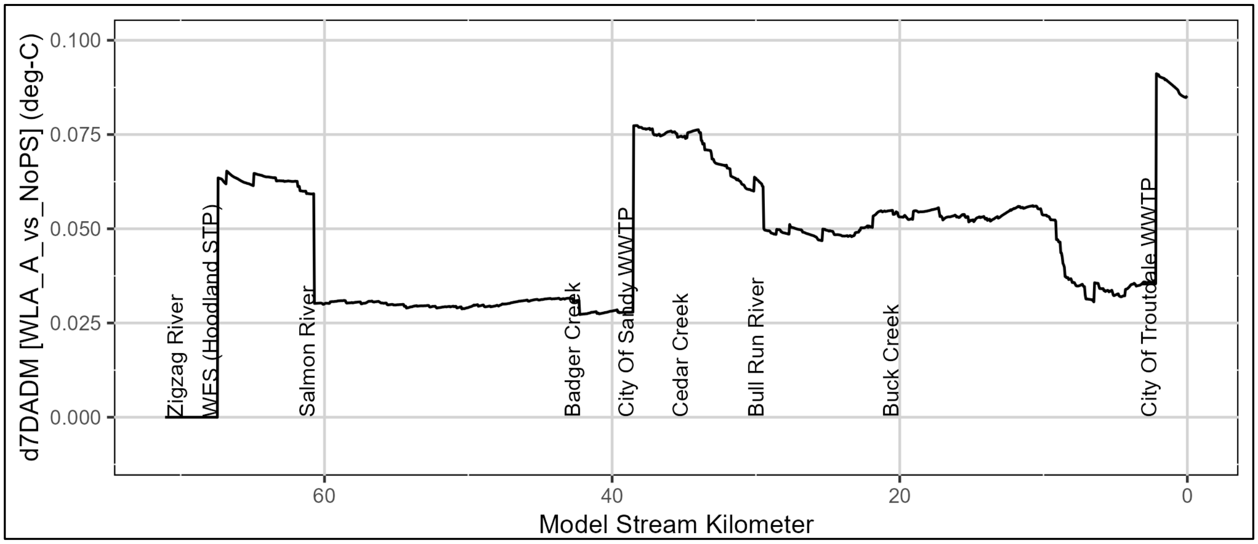

Figure 5-7: Sandy River max. 7DADM temp. change above current applicable criteria with point sources' inputs set to proposed WLAs (option A) vs. No Point Sources scenario

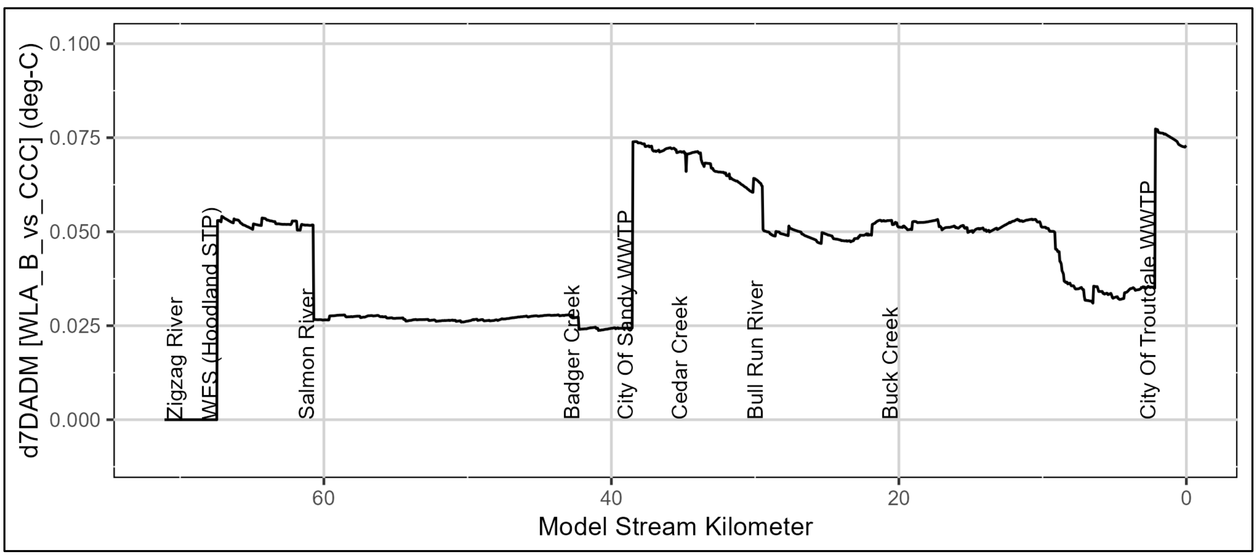

Figure 5-8: Sandy River max. 7DADM temp. change above current applicable criteria with point sources' inputs set to proposed WLAs (option B) vs. CCC

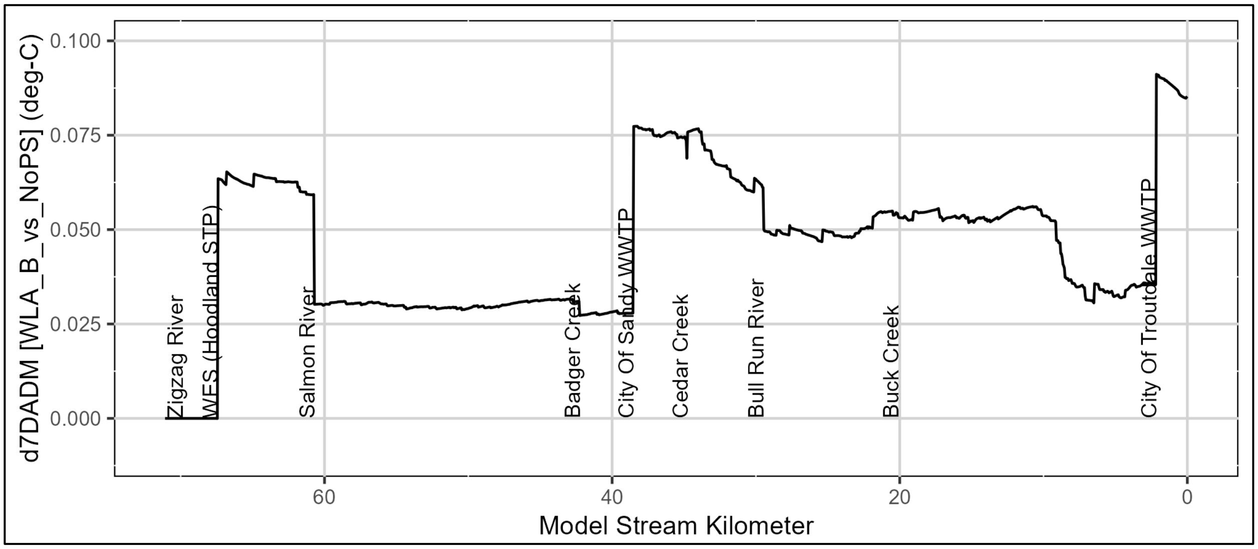

Figure 5-9: Sandy River max. 7DADM temp. change above current applicable criteria with point sources' inputs set to proposed WLAs (option B) vs. No Point Sources scenario

6.0 RESTORED VEGETATION SCENARIOS

The restored vegetation scenarios (RV_A, RV_B) are equivalent to the CCC model setup for all parameters except landcover code assignments and vegetation heights and densities. The purpose of these scenarios is to assess the effects of current human-related vegetation alteration on instream temperatures in the model extent. A corollary purpose is to assess the potential improvements to instream water quality (temperature) that may be achieved with different degrees of vegetation restoration. Scenario RV_A represents landcover as if all human-related vegetation alterations were restored to pre-development conditions. Scenario RV_B is identical to RV_A except that landcover areas associated with human infrastructure (i.e., buildings, roads, bridges, and utility corridors (**Table 6-1**)) retained the same codes, heights, and densities as in the CCC model (i.e., they were not restored). RV_A results are compared to CCC results to quantify the instream temperature effects of current anthropogenic riparian vegetation alteration. RV_A and RV_B results are compared to quantify instream temperature effects of existing infrastructure-associated riparian vegetation alteration and determine if it meets the infrastructure-specific HUA (0.04°C).

Table 6-1 provides information on all landcover types included in the CCC models and how their parameters were adjusted for the RV_A scenario. As discussed in the Sandy River Temperature Model Configuration and Calibration Report (TSD Appendix B), TTools sampled the landcover raster in 8-m increments along 7 cardinal directions from each instream model node and applied a code to each sampled point. Current condition landcover used in the model is a 6-digit concatenation of two 3-digit codes: landcover type and landcover height (m) as determined from LiDAR. For example, **Figure 6-1** shows such a code with the current condition landcover type (600 - Hardwood - High Dense) and height (020) concatenated as landcover code 600020. HS8 uses the landcover type code to look up the restored vegetation type, height, cover, and overhang values and thereby calculate effective shade values along the model extent. In the restored vegetation scenarios, the greater of the two vegetation heights (i.e., current LiDAR and restoration heights) (**Table 6-1**) was used.

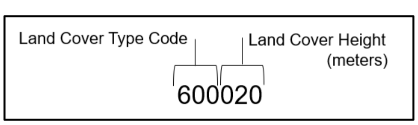

Figure 6-1: Example 6-digit code for landcover type and height

Table 6-1: Landcover and associated codes, restored vegetation type, height, density, and overhang values[1]

Landcover Code	Current Conditions Description	Restored Vegetation "A" Scenario Description	Restoration Height[2] (m)	Canopy Density (%)	Overhang (m)
101	Utility[3]	Mixed Conifer/Hardwood, High Density	26.7	60%	0.0
102	Bridge - Over Water[3]	Water, Active Channel	0.0	0%	0.0
300	Pastures/Cultivated Field	Mixed Conifer/Hardwood - High Dense	26.7	60%	0.0
301	Water - Non Active Channel		0.0	0%	0.0
302	Water - Active Channel Bottom		0.0	0%	0.0
305	Barren - Embankment	Mixed Conifer/Hardwood - High Dense	26.7	60%	0.0
308	Barren - Clearcut				
309	Barren - Soil				
348	Development – Residential[3]				
349	Development - Industrial/Commercial[3]				
352	Dam/Weir[3]				
355	Canal[3]				
400	Barren - Road[3]				
401	Barren - Forest Road[3]				
500	Mixed Conifer/Hardwood - High Dense				
550	Mixed Conifer/Hardwood - Medium Dense		26.7	30%	0.0
555	Mixed Conifer/Hardwood - Low Dense		26.7	10%	0.0
600	Hardwood - High Dense		20.1	75%	0.0
650	Hardwood - Low Dense		20.1	30%	0.0
700	Conifer - High Dense		35.1	60%	0.0
750	Conifer - Low Dense		35.1	30%	0.0
800	Upland shrubs - High Dense		1.8	75%	0.0
850	Upland Shrubs - Low Dense		1.8	25%	0.0
900	Grasses - upland	Mixed Conifer/Hardwood - High Dense	26.7	60%	0.0
950	Grasses - wetland		1.6	75%	0.0

[1] Parameters changed for restored vegetation scenario "A" from current conditions have with light-orange fill; others remain as current.

[2] Values in this column are the minimum restoration heights by land cover type. Where the existing LiDAR-derived vegetation height was greater than the default restoration height, the existing vegetation height was retained.

[3] For RV_B scenario, this land cover type remained as it was under the CCC model, i.e., it was not "restored."

Along with the restored vegetation data calculated along the Sandy River model extent, these Sandy River scenarios included updated tributary inputs for the Salmon River (**Figure 6-2**) and Bull Run River (**Figure 6-3**) based on the respective restored vegetation scenario results provided by DEQ and the City of Portland.

At each node, the maximum 7DADM warming from anthropogenic vegetation reduction was calculated as the maximum of the time-series of differences in 7DADM temperature between the CCC and RV_A scenario (**Figure 6-6**). Note that the 7DADM difference was calculated only when the CCC scenario temperature exceeded the BBNC. Per **Table 6-2:** Sandy River CCC, RV_A, and RV_B scenarios: Modeled water temperatures and changes (WT, °C), the POMI for this comparison occurred at RKM 61.1 on 8/29/2016 and corresponded to a 1.17°C maximum 7DADM increase. Comparing the RV_A and RV_B scenarios indicates that the unrestored infrastructure in RV_B accounts for a maximum 7DADM warming of 0.19°C at the POMI (RKM 10.75, 8/29/2016).

The resulting impact on effective shade was also calculated (**Table 6-3**). For a non-cloudy day (July 29, 2016) in the simulation period, the shade deficit was the difference between daily shade results from the CCC and restored vegetation scenarios at each node. **Figure 6-5** presents the differences in daily average shade results between the RV_A and CCC results for July 29, 2019; the spatial variability along the model extent indicates a greater shade deficit upstream vs. downstream for the CCC model vs. the RV_A scenario. **Figure 6-8** presents the differences in daily average shade results between the RV_A and RV_B. Most of the RV_B shade deficits (vs. RV_A) occur in the downstream portion of the model extent and are due to electrical utility easements along with other infrastructure and development that lack vegetation.

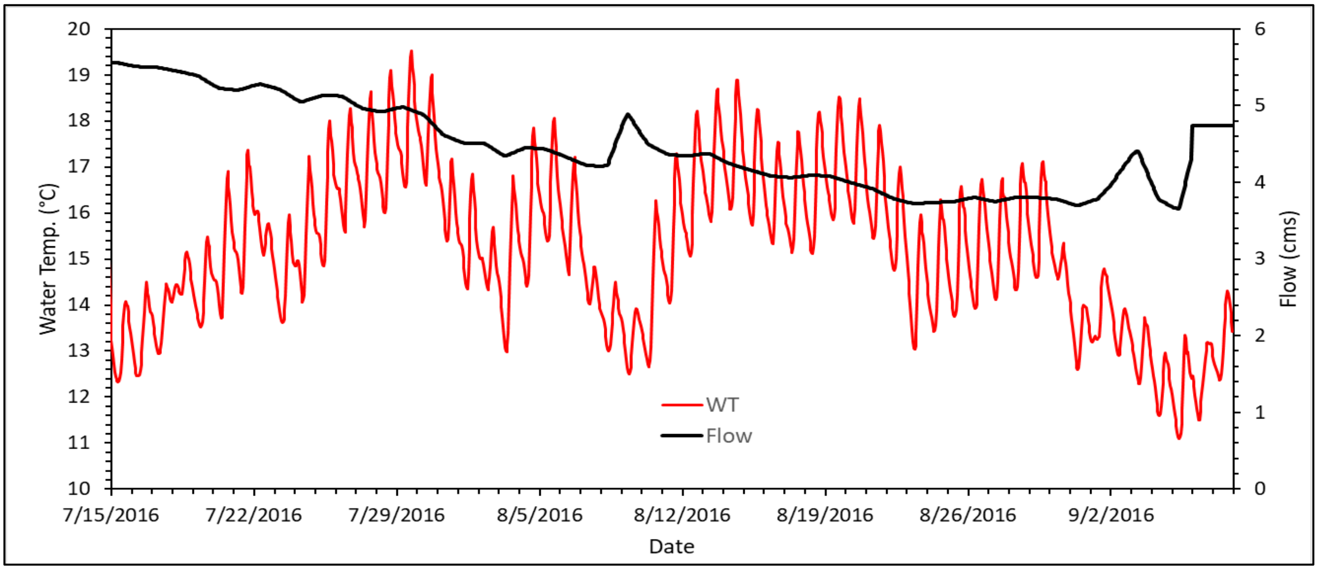

Figure 6-2: Salmon River restored vegetation A scenario temperature and flow output (km 0.00)

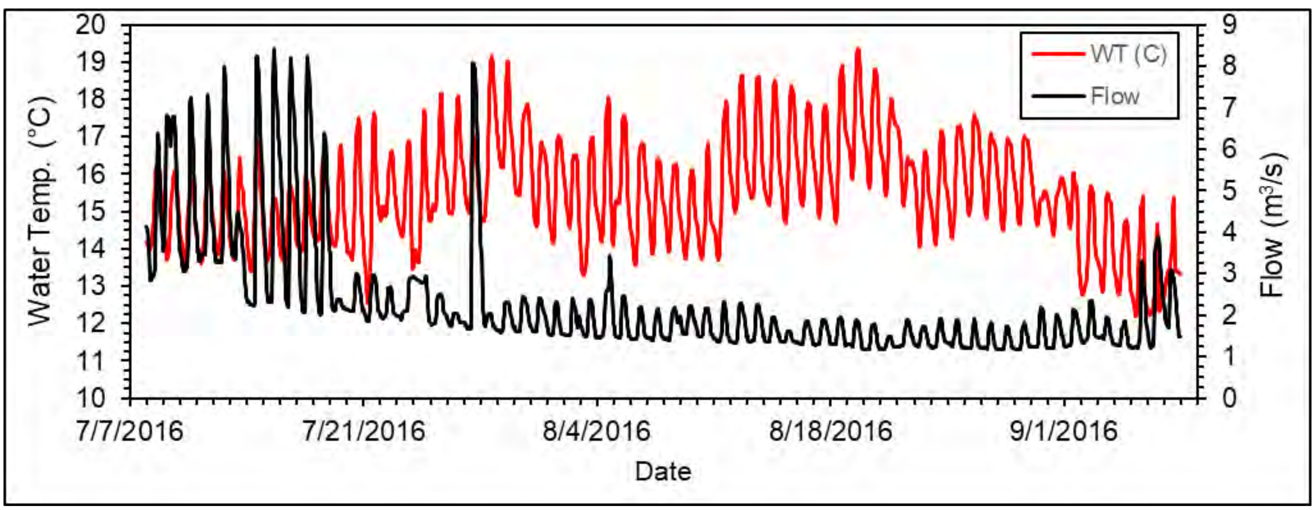

Figure 6-3: Bull Run River restored vegetation scenario temperature and flow output (km 0.00)

Table 6-2: Sandy River CCC, RV_A, and RV_B scenarios: Modeled water temperatures and changes (WT, °C)

Scenario	Value Type	Location	Max. 7DADM		
			Model km	**Date**	**WT (°C)**
Current Cond.	CCC	Mouth	0	08/18/2016	23.67
Restored Vegetation (RV_A)	RV_A	Mouth	0	08/18/2016	23.25
	CCC minus RV_A (WT change)	Mouth	0	08/31/2016	0.52
		POMI	61.1	08/29/2016	1.16
Restored Vegetation, Modified (RV_B)	RV_B	Mouth	0	08/18/2016	23.26
	RV_B minus RV_A (WT change)	Mouth	0	07/25/2016	0.01
		POMI	2.95	08/26/2016	0.07

Table 6-3: Sandy River CCC, RV_A, and RV_B scenarios: Modeled effective shade and gaps by DMA

Extent	CCC	RV_A	Shade Gap (%)	Stream km Assessed	Stream extent (km) at shade gap (%)			
					0-15%	**16-25%**	**26-50%**	**51-100%**
Study Area	19	25	6	71.1	64.2	5.9	0.9	0
City of Portland	10	13	3	0.7	0.7	0	0	0

City of Sandy	24	25	1	0.7	0.7	0	0	0
City of Troutdale	15	20	5	3.2	3.1	0.1	0	0
Clackamas Cty.	18	28	10	18.3	13.6	4.1	0.6	0
Multnomah Cty.	16	19	3	2.3	2.2	0	0	0
ODA	24	29	5	0.9	0.8	0	0	0
ODFW	22	26	4	1.2	1.2	0	0	0
ODF - Private	19	24	5	25.5	24.4	0.8	0.2	0
OPRD	6	8	2	0.8	0.8	0	0	0
Port of Portland	3	9	6	0.7	0.7	0	0	0
State of Oregon	13	18	5	0.4	0.4	0	0	0
US BLM	25	29	4	14.3	13.5	0.7	0.1	0
USFS	3	7	4	1	1	0	0	0
US Gov't.	16	17	1	0.1	0.1	0	0	0

Extent	**RV_B**	**RV_A**	**Shade Gap (%)**	**Stream km Assessed**	**Stream extent (km) at shade gap (%)**			
					0-15%	**16-25%**	**26-50%**	**51-100%**
Study Area	24	25	1	71.1	71	0	0	0
City of Portland	13	13	0	0.7	0.7	0	0	0
City of Sandy	25	25	0	0.7	0.7	0	0	0
City of Troutdale	19	20	1	3.2	3.2	0	0	0
Clackamas Cty.	28	28	0	18.3	18.3	0	0	0
Multnomah Cty.	18	19	1	2.3	2.3	0	0	0
ODA	29	29	0	0.9	0.9	0	0	0
ODFW	26	26	0	1.2	1.2	0	0	0
ODF - Private	23	24	1	25.5	25.4	0	0	0
OPRD	8	8	0	0.8	0.8	0	0	0
Port of Portland	8	9	1	0.7	0.7	0	0	0
State of Oregon	18	18	0	0.4	0.4	0	0	0
US BLM	29	29	0	14.3	14.3	0	0	0
USFS	6	7	1	1	1	0	0	0
US Gov't.	17	17	0	0.1	0.1	0	0	0

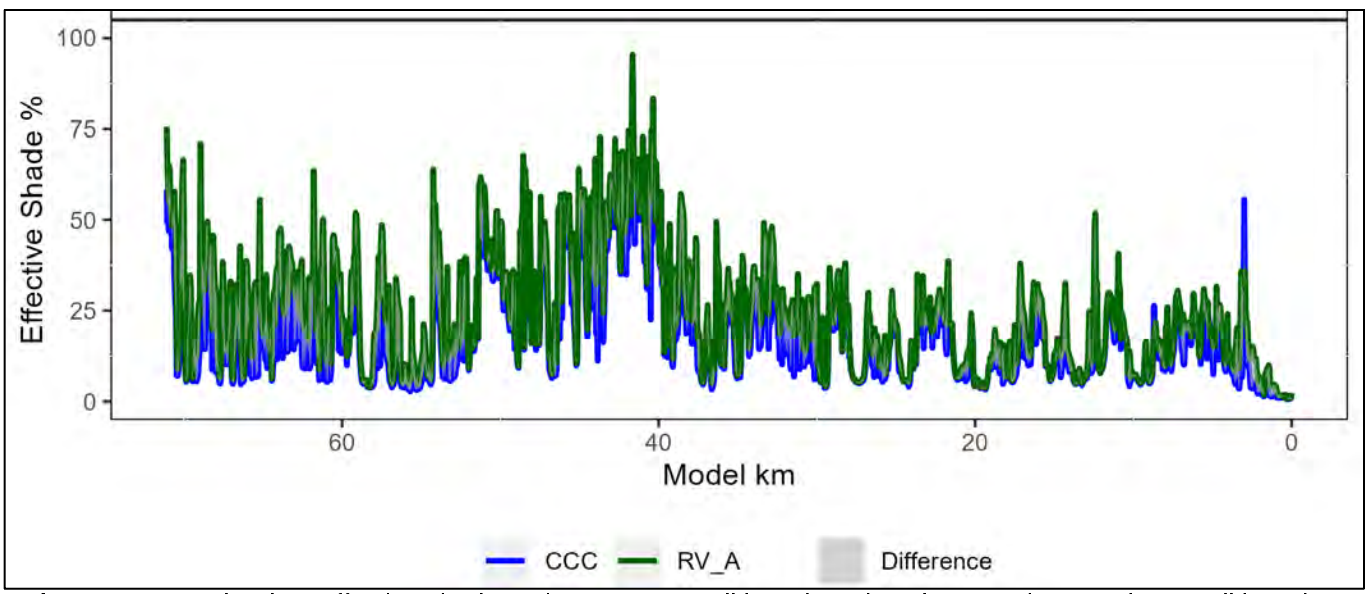

Figure 6-4: Sandy River effective shade under current conditions (CCC) and restored vegetation conditions (RV_A)

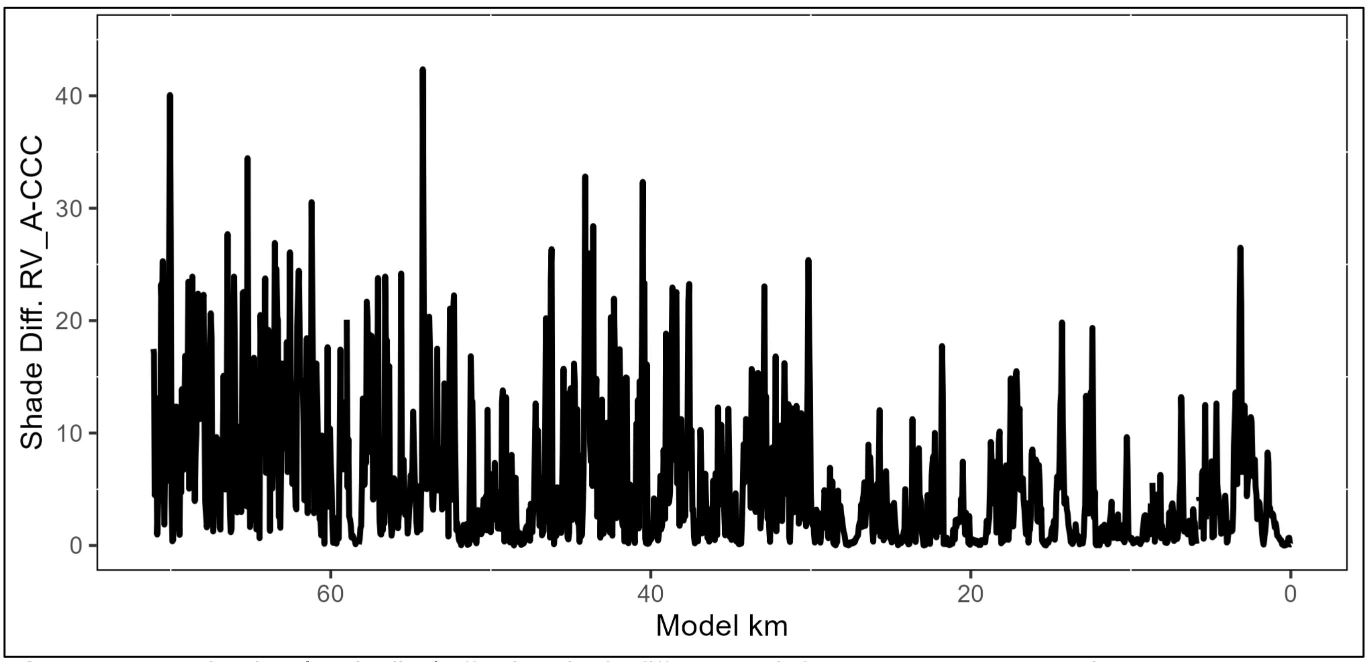

Figure 6-5. Sandy River longitudinal effective shade differences (%), RV_A vs. CCC scenarios

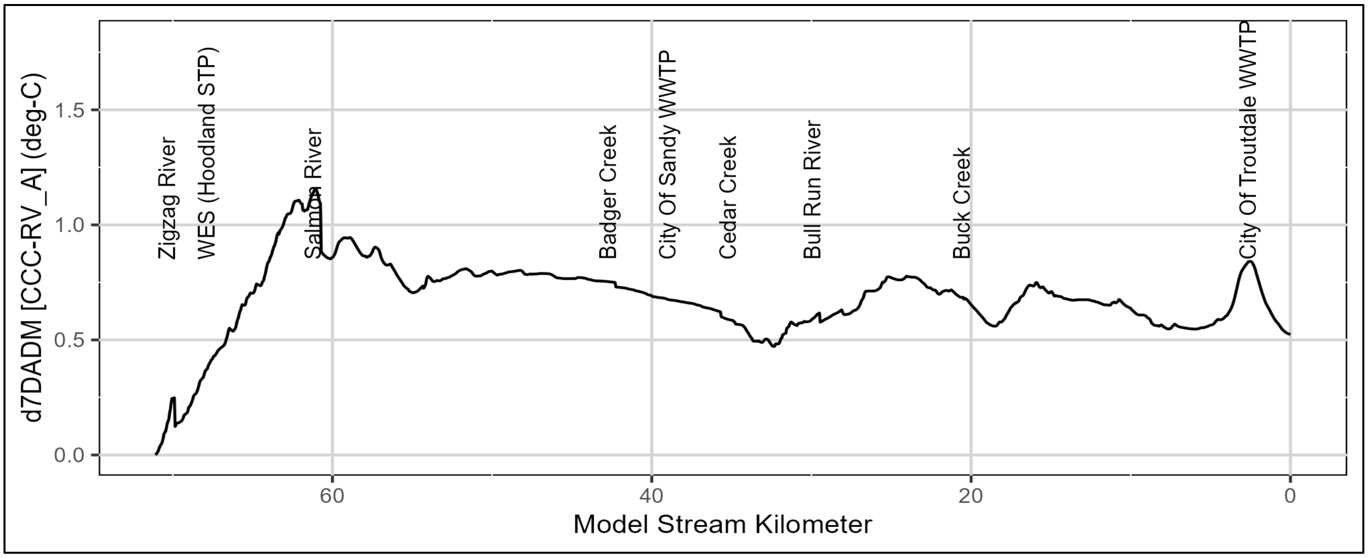

Figure 6-6: Sandy River max. 7DADM temp. changes above the applicable criteria, CCC vs. RV_A

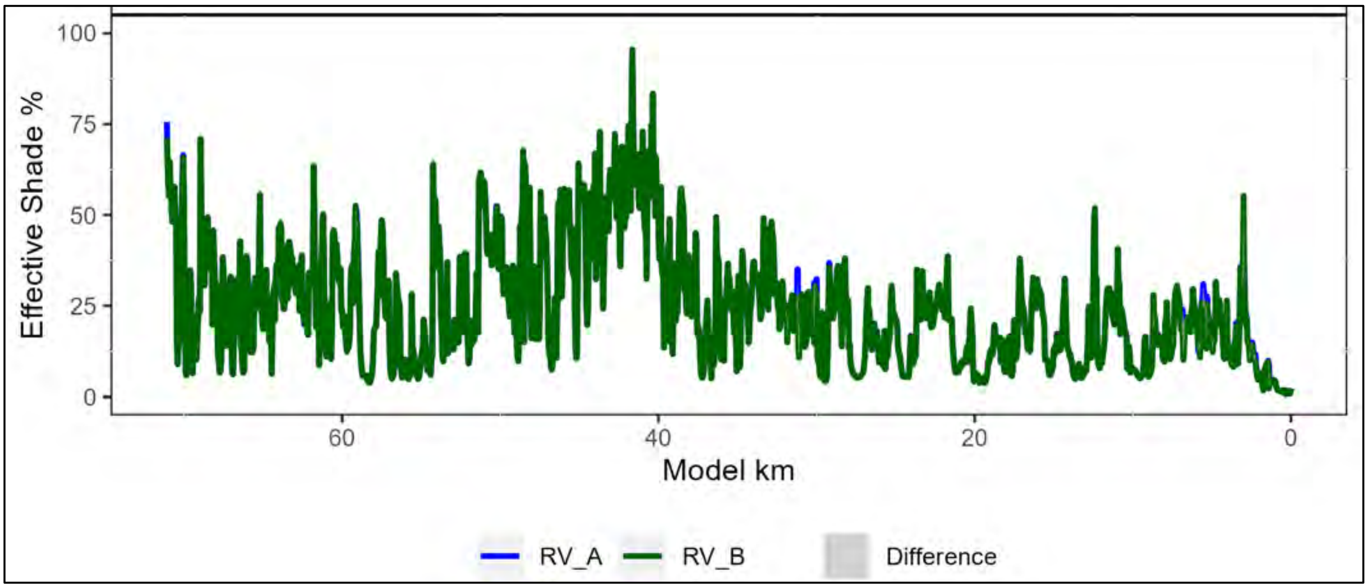

Figure 6-7: Sandy River effective shade from restored vegetation (RV_A) and restored vegetation with buildings, transportation, and utility corridors at current shade conditions (RV_B)

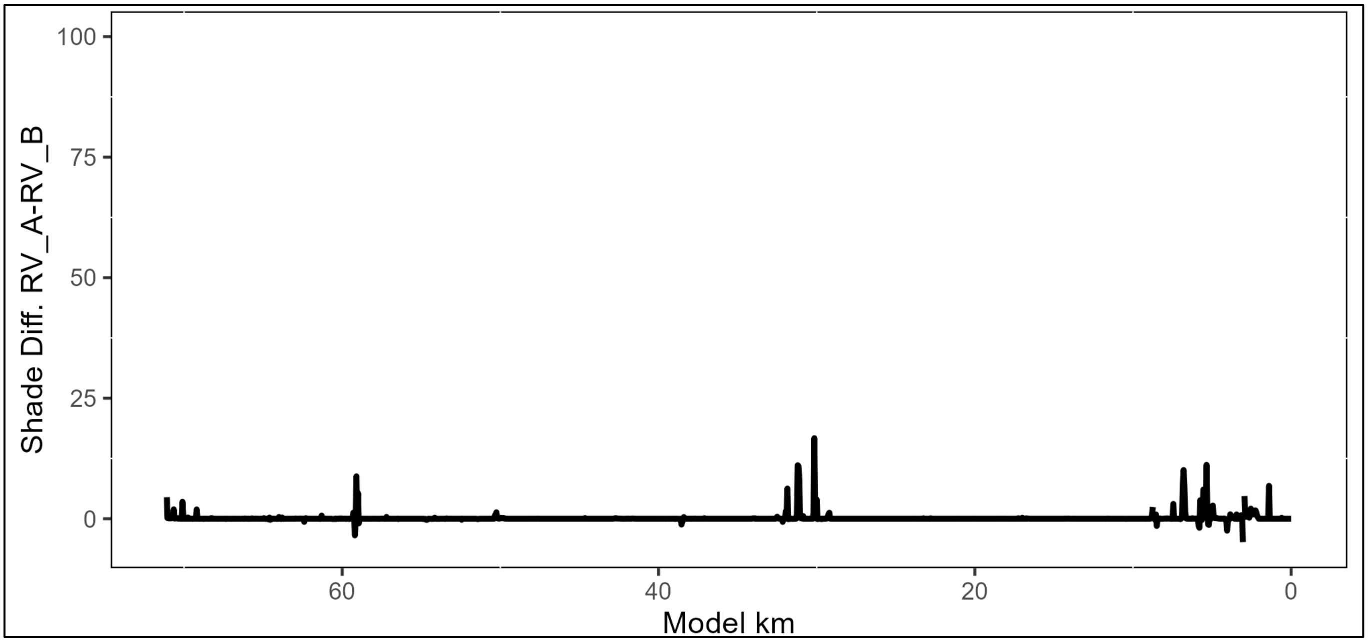

Figure 6-8: Sandy River effective shade reduction (%) due to vegetation disturbance or removal from buildings, transportation, and utility corridors (RV_A minus RV_B)

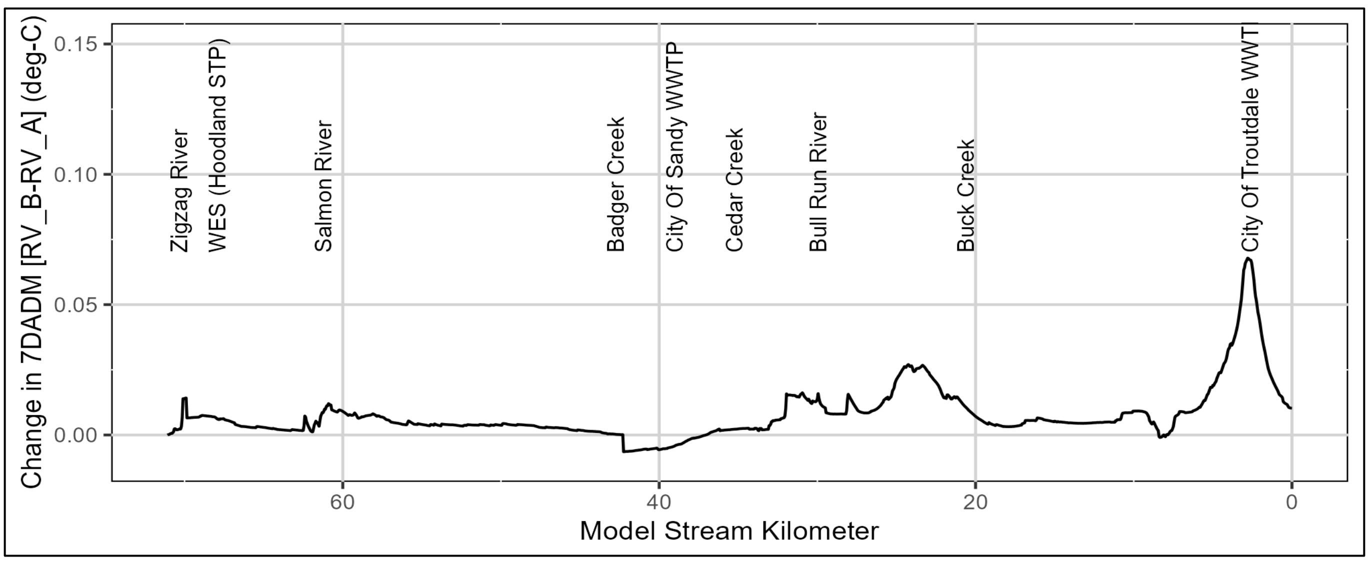

Figure 6-9: Sandy River max. 7DADM temp. changes above the applicable criteria due to vegetation disturbance or removal from buildings, transportation, and utility corridors (RV_B minus RV_A)

7.0 NO DAMS SCENARIO

The no dams (ND) scenario estimates the Sandy River stream temperatures without the Bull Run Dams and Reservoirs #1 and #2. This scenario is identical to the CCC model except that the Bull Run River tributary inputs were set to the Bull Run River W-2 no dam scenario temperature and flow outputs provided by the City of Portland (**Figure 7-1**).

For each Sandy River node throughout the model period, a time-series of 7DADM temperature changes due to dam operation was calculated as the difference in 7DADM temperature between the ND and the CCC scenarios

(**Figure 7-2**). **Figure 7-3** shows the modeled maximum 7DADM differences (impacts) at each model node. Temperature differences are summarized in **Table 7-1**. Note that the difference is calculated only when the ND scenario temperature exceeds the BBNC. Positive 7DADM differences indicates the increase (heating effect) that dam operations have on the Sandy River. Negative differences indicate that the dam operations have a relative cooling effect at the relevant nodes and days. For most Sandy River nodes between the Bull Run River and the mouth, the mean 7DADM over the model period increased due to dam operations (max. 7DADM change: 0.27°C on 7/25/2016 at river km: 9.80), while cooling occurred on average at some locations, e.g., between RKM 9 and the mouth (**Figure 7-3**).

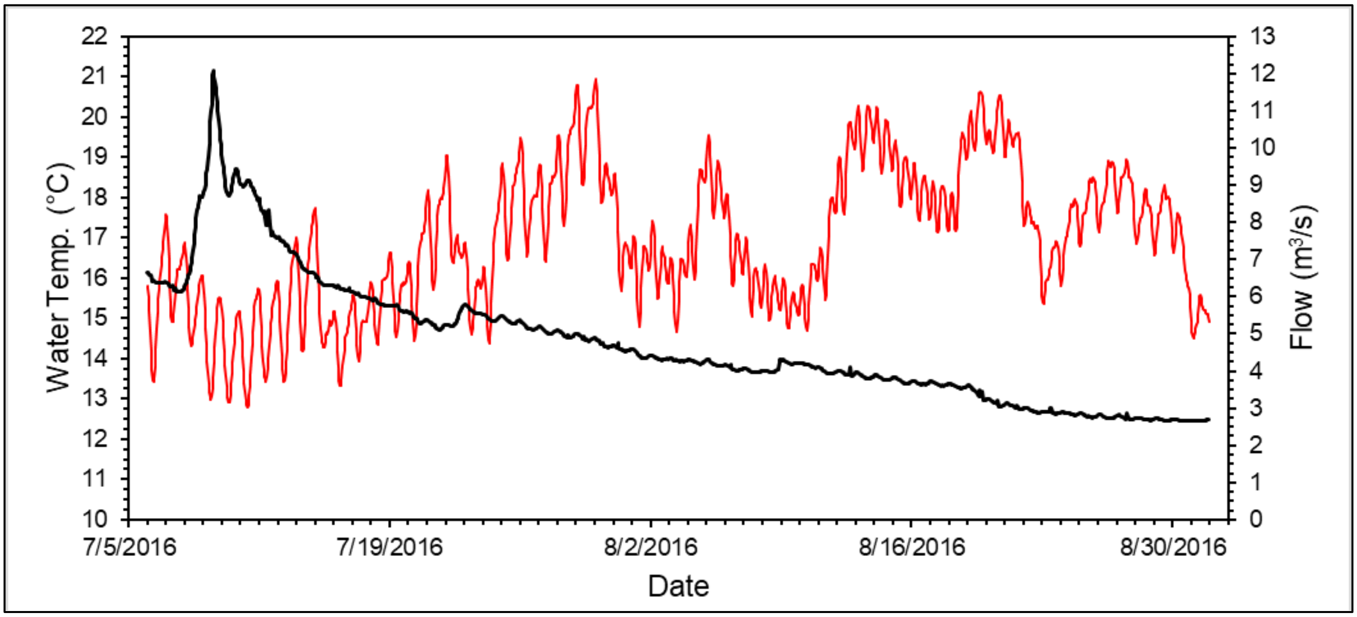

Figure 7-1: No dams scenario temperature and flow at the mouth of Bull Run River.

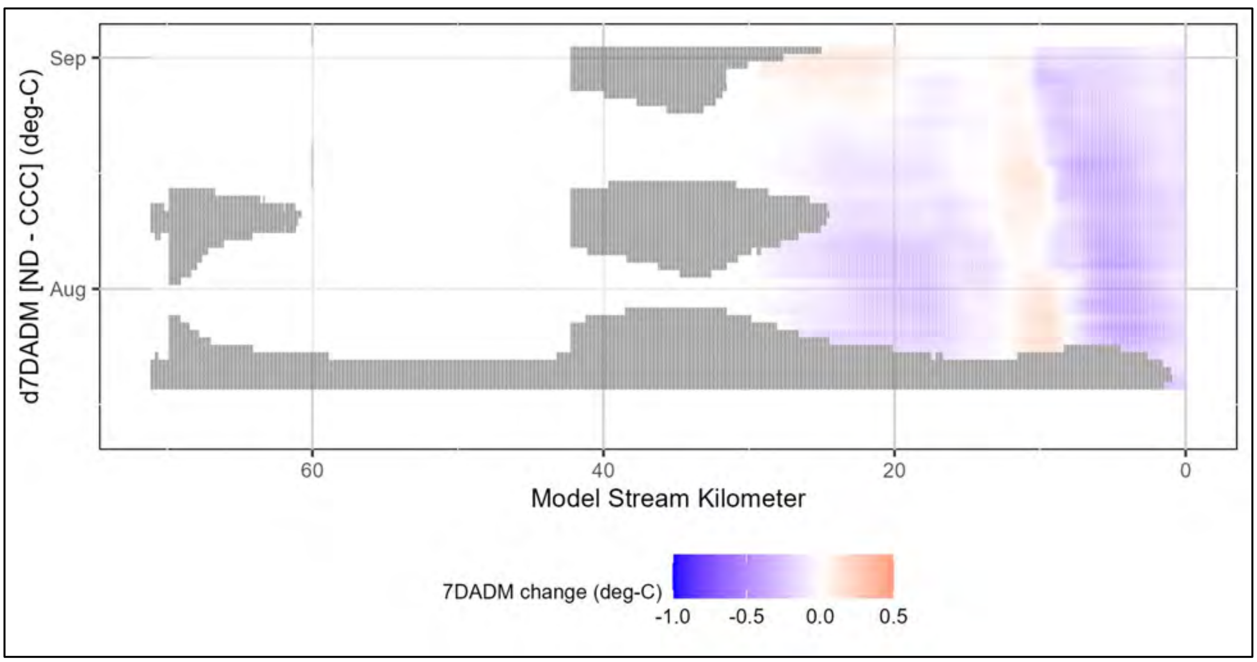

Figure 7-2: Sandy River max. 7DADM temp. changes above applicable criteria from Bull Run dam and reservoir operations. Periods in gray are when the 7DADM temperature are cooler than the applicable criteria.

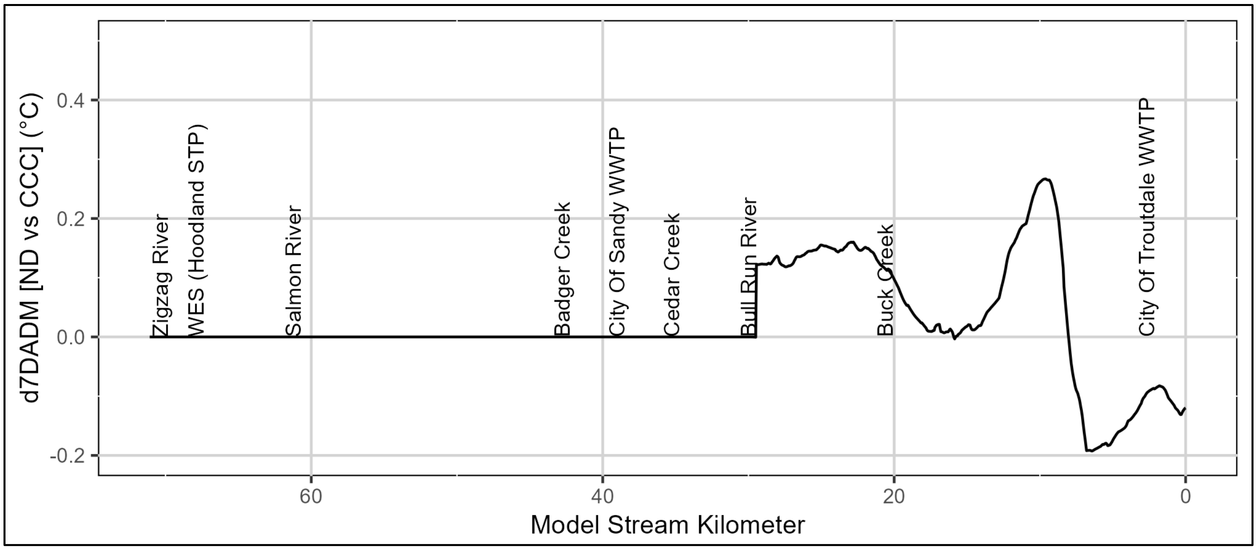

Figure 7-3: Sandy River max. 7DADM temp. changes from Bull Run dam and reservoir operations

Table 7-1: Sandy River ND vs. CCC scenarios: Modeled water temp. changes (WT, °C)

Scenario	Value Type	Location	Max. 7DADM		
			Model km	Date	WT (°C)
Current Cond.	CCC	Mouth	0	08/18/2016	23.67
No Dams	ND	Mouth	0	08/18/2016	23.50
	ND minus CCC (WT change)	Mouth	0	07/22/2016	-0.12
		POMI	9.80	07/25/2016	0.27

8.0 NATURAL STREAMFLOW SCENARIO

The natural streamflow (NQ) scenario evaluates the instream temperature response if all tributary and mainstem flows equal their respective median monthly natural flows. This scenario does not include point sources (effluent flows were set to zero). Natural flow was estimated by USGS (Risley, et al 2009) and obtained from the USGS StreamStats Program (USGS, 2019). StreamStats was used to generate a monthly (May – October) estimated flow-duration report for the modeled stream at a selected reference point within the model extent. The selected reference point was the most downstream USGS flow gage on the Sandy River (USGS 14142500 – Sandy River below Bull Run, RKM 29.10). **Table 8-1** shows the estimated monthly median natural flows at the site for the TMDL period. The months of July, August, and September were used in the model scenario and correspond to the modeling period.

The boundary condition and tributary flow inputs for the NQ scenario were calculated using **Equation 8-1** below. **Equation 8-1** assumes that each tributary's relative contribution is the same as in the CCC model. **Table 8-2** includes HS8 water temperature results at the mouth and reference locations for this scenario, which were compared to different consumptive water withdrawal scenarios in Section 9.0.

Table 8-1: Monthly median (50th percentile duration) natural flow statistics at USGS14142500 (StreamStats)

Month	Flow (ft^3/s)	Flow (m^3/s)
May	2070	58.62
June	1300	36.81
July	1020	28.88
August	557	15.77
September	483	13.68
October	414	11.72

Equation 8-1:

The natural streamflow scenario tributary flow rate at timestep *i,* assuming the relative flow contribution is the same as the current condition model.

$$Q_{Ni\_trib} = Q_{Ci\_trib} \cdot \left(1 + \frac{Q_{N\_ref} - Q_{Ci\_ref}}{Q_{Ci\_ref}}\right)$$

where,

Q_{Ni_trib} = The natural stream flow scenario tributary flow rate at timestep *i.*

Q_{Ci_trib} = The baseline condition tributary flow rate at timestep *i.*.

Q_{N_ref} = The monthly median natural flow rate at the reference location as derived from USGS StreamStats (USGS, 2019).

Q_{Ci_ref} = The current condition flow rate at the reference location at timestep *i.*

Table 8-2: Sandy River modeled water temp. (WT, °C), NQ scenario

Scenario	Value Type	Location	Max. 7DADM		
			Model km	Date	WT (°C)
Natural Flow	NQ	Mouth	0	08/18/2016	22.54
	NQ	Ref.	29.1	08/19/2016	18.64

9.0 WATER WITHDRAWAL SCENARIOS

The water withdrawal scenarios (WW_A, WW_B, WW_C) are identical to the NQ model setup except that all boundary, tributary, and hence instream flows are modified iteratively to reflect various rates of consumptive water withdrawals. The purpose of the WW_A and WW_B model iterations is to determine the maximum consumptive withdrawal rates (as a percentage of natural flow) that would still attain (A) the HUA for permitted withdrawals (0.05°C) at a stream reference location (USGS 14142500 – Sandy River below Bull Run, RKM 29.10) and (B) the overall HUA (0.30°C) at the same reference location. The purpose of the WW_C model iteration is to determine the temperature changes associated with estimated current consumptive withdrawals, i.e. 28% (July), 29% (Aug.), and 34% (Sept.). The percent consumptive withdrawal rate is equal for all tributaries. Results of this scenario and the NQ scenario are compared to quantify the instream temperature effects of water withdrawals at the reference gage.

Reductions of 1.90% (WW_A, **Figure 9-1**) and 10.1% (WW_B, **Figure 9-2**) were required to attain the 0.05°C and 0.30°C HUA, respectively. The 7DADM warming from water withdrawals was determined by finding the difference in 7DADM temperature between the WW and NQ scenarios at the reference location (**Table 9-1**).

Table 9-1: Sandy River CCC, NQ, WW_A, WW_B, and WW_C scenarios: Modeled water temp. and changes (WT, °C)

Scenario	Value Type	Location	7DADM		
			Model km	Date	WT (°C)
Current Cond.	CCC	Mouth	0	08/18/2016	23.67
Natural Flow	NQ	Mouth	0	08/18/2016	22.54
		Ref.	29.1	08/19/2016	18.64
Water Withdrawals A (1.90%)	WW_A	Mouth	0	08/18/2016	22.60
		Ref.	29.1	08/19/2016	18.70
	WW_A - NQ (WT change)	Mouth	0	07/29/2016	0.09
		POMI	5.90	08/18/2016	0.11
		Ref.	29.10	08/16/2016	0.05
Water Withdrawals B (10.1%)	WW_B	Mouth	0	08/18/2016	22.88
		Ref.	29.1	08/19/2016	18.94
	WW_B - NQ (WT change)	Mouth	0	07/31/2016	0.51
		POMI	5.90	08/18/2016	0.60
		Ref.	29.1	08/17/2016	0.30
Water Withdrawals C (Current Est'd)	WW_C	Mouth	0	08/18/2016	23.62
		Ref.	29.1	08/19/2016	19.72

	WW_C – NQ (WT change)	Mouth	0	07/31/2016	1.54
		POMI	5.90	08/18/2016	1.92
		Ref.	29.10	08/18/2016	1.09

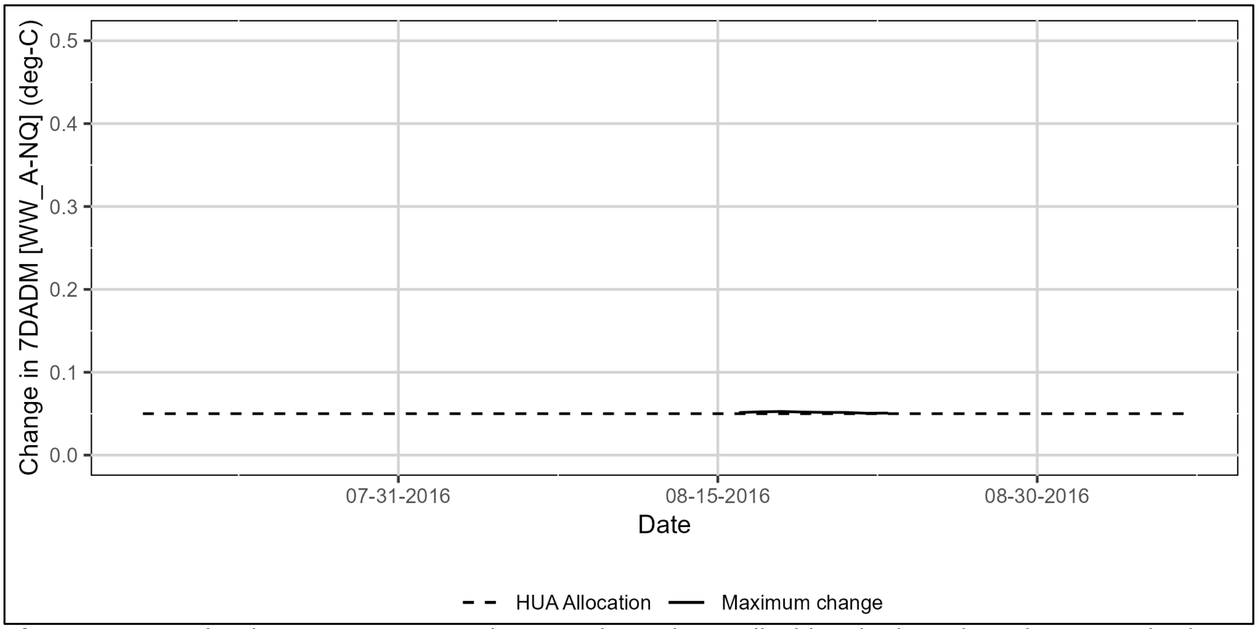

Figure 9-1: Sandy River 7DADM temp. changes above the applicable criteria at the reference point (RKM 29.1) from consumptive uses set at 1.90% (WW_A) of natural flow (NQ) by date.

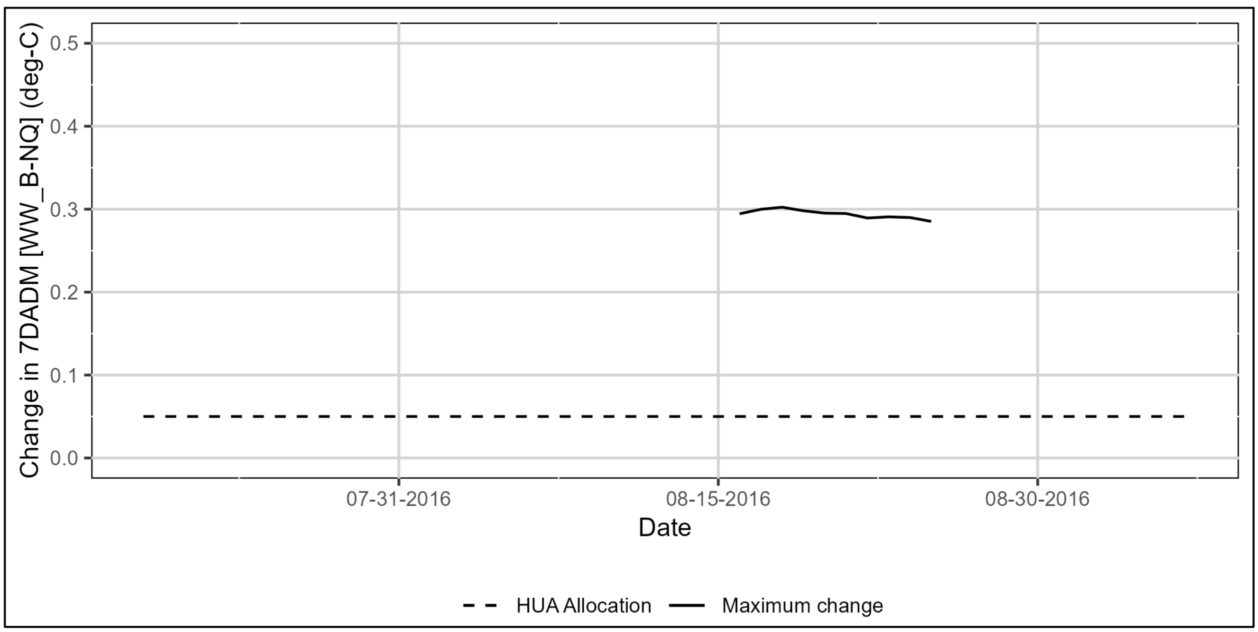

Figure 9-2: Sandy River 7DADM temp. changes above the applicable criteria at the reference point (RKM 29.1) from consumptive uses set at 10.1% (WW_B) of natural flow (NQ) by date.

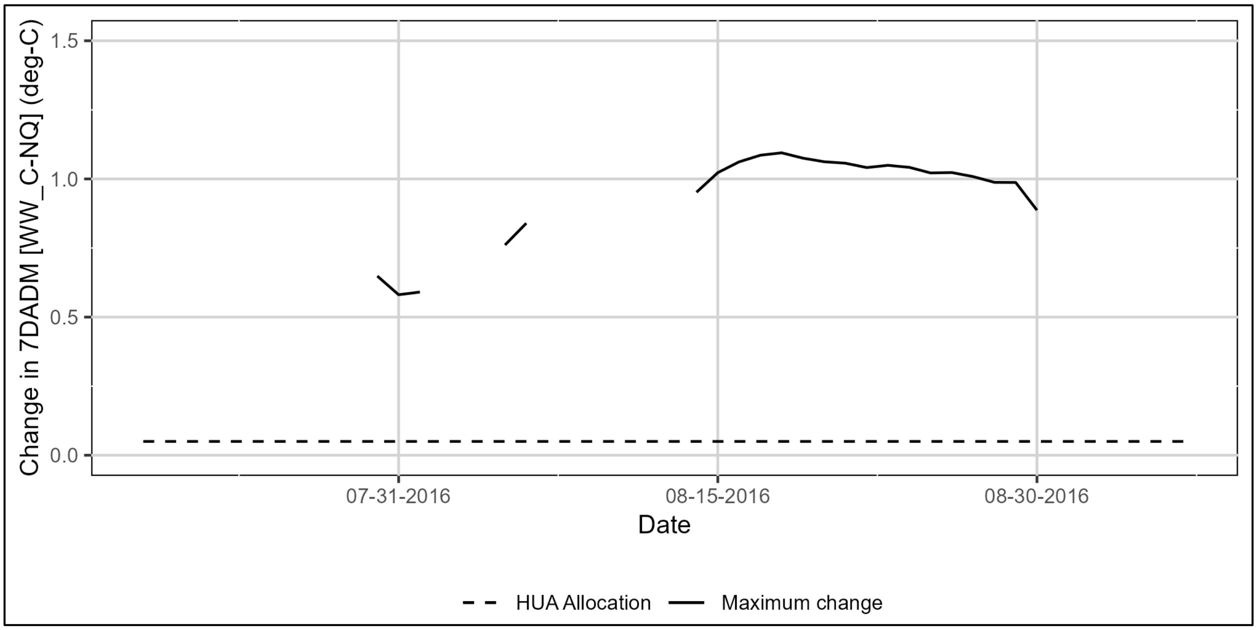

Figure 9-3: Sandy River 7DADM temp. changes above the applicable criteria at the reference point (RKM 29.1) from estimated current consumptive uses (WW_C) versus natural flow (NQ) by date.

10.0 BACKGROUND SCENARIO

The background (BG) scenario evaluates the stream temperature response from background sources only. The BG conditions scenario was developed to estimate the magnitude of background excess load relative to anthropogenic load. Background sources include all sources of thermal loading not originating from human activities. This scenario is built upon the Sandy River restored vegetation scenario but with all point source discharges set to zero. Also, the Bull Run River tributary inputs for this Sandy River scenario were set based on the results of the Bull Run River BG scenario (**Figure 10-1**), which combined the no dams and restored vegetation scenarios and were provided by the City of Portland. Likewise, the Salmon River inputs were set based on the Salmon River restored vegetation model results (**Figure 6-2**).

The BG scenario results were compared to the applicable BBNC to identify the extent and magnitude of temperature exceedances that would occur in the absence of anthropogenic influences, i.e., due to background factors (**Figure 10-2**). The maximum 7DADM temperature exceedance under background conditions was 5.78°C at the POMI (RKM 54.35) on 8/21/2016 (**Figure 10-2**), which corresponds to a 7DADM temperature of 18.78°C and applicable temperature criteria of 13.0°C (OAR 340-041-0028(4)(a)).

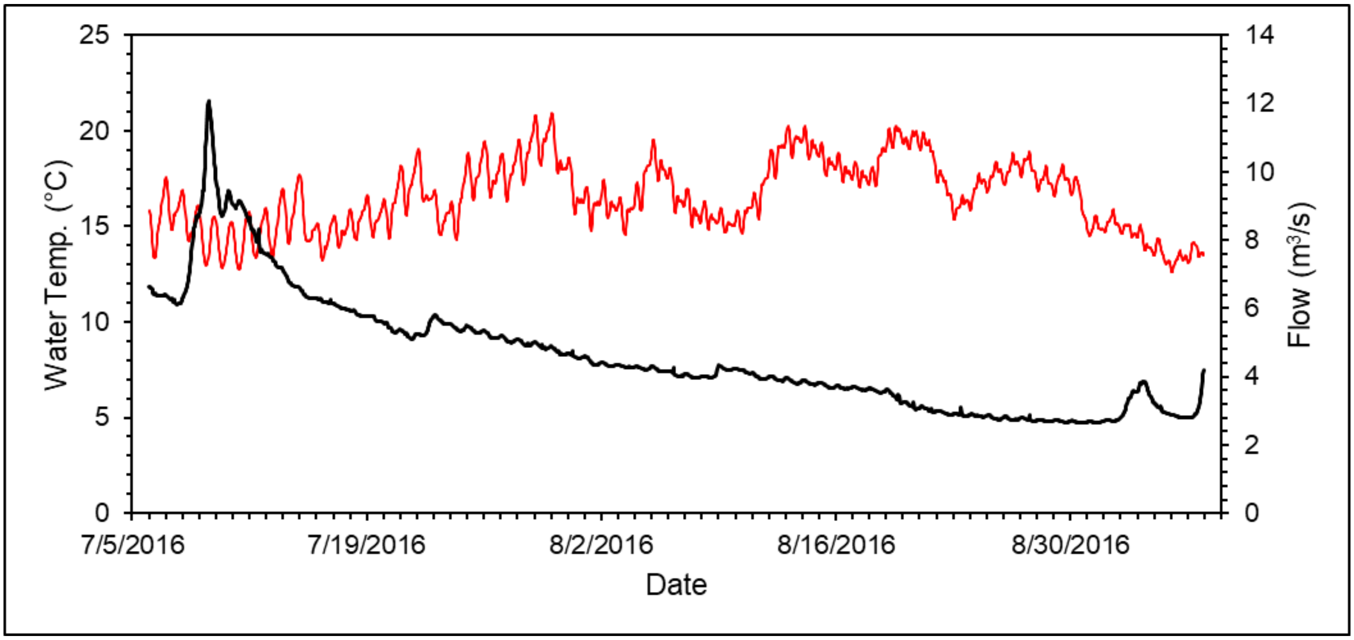

Figure 10-1: Bull Run River W2 Background scenario outputs

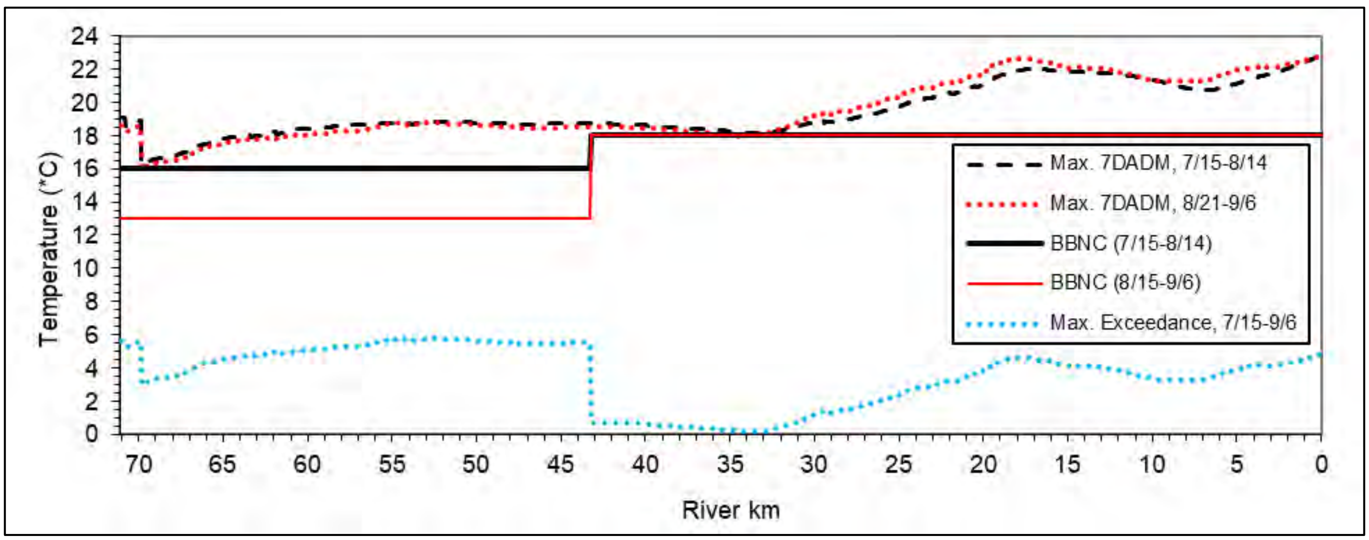

Figure 10-2: Sandy River Background scenario vs. applicable BBNC temperatures

11.0 TOPOGRAPIC SHADE SCENARIO

The topographic (Topo) shade scenario evaluates the shade and stream temperature response from removing all current (vegetative) shading. This scenario is equivalent to the CCC model setup for all parameters except that all vegetation heights and are densities are set to 0 (zero). Results of the Topo and CCC models were compared to determine the maximum 7DADM temperature increase above current 7DADM temperatures with the removal of all vegetation.

The results indicated the mean effective shade would decline by almost 2/3 (**Table 11-2**), from 19% (CCC) to 7% (Topo scenario), across the Sandy River model area, and the maximum 7DADM temperatures would increase by 1.03°C at the POMI (RKM 21.80) (**Table 11-1,Figure 11-3**). **Figure 11-1** and **Figure 11-2** show the longitudinal effective shade (%) for each scenario and their shade differences, respectively.

Table 11-1: Sandy River Topography vs. CCC scenarios: Modeled water temperatures and differences (WT, °C)

Scenario	Value Type	Location	Max. 7DADM		
			Model km	Date	WT (°C)
Current Cond.	CCC	Mouth	0	08/18/2016	23.67
Topography	Topo	Mouth	0	08/18/2016	24.23
	Topo minus CCC (WT change)	Mouth	0	08/30/2016	0.71
		POMI	21.80	08/30/2016	1.03

Table 11-2: Sandy River Topography vs. CCC scenarios: Modeled effective shade (%) by DMA.

Extent	Topo	CCC	Shade Gap (%)	Stream km Assessed	Stream extent (km) at shade gap (%)			
					0-15%	16-25%	26-50%	51-100%
Study Area	7	19	12	71.1	50	12.3	8.2	0.5
City of Portland	4	10	6	0.7	0.6	0.1	0	0
City of Sandy	8	24	16	0.7	0.2	0.2	0.1	0
City of Troutdale	7	15	8	3.2	3	0.2	0	0
Clackamas Cty.	5	18	13	18.3	11.3	4.8	2.2	0
Multnomah Cty.	9	16	7	2.3	2.2	0.1	0	0
ODA	12	24	12	0.9	0.6	0.3	0	0
ODFW	6	22	16	1.2	0.7	0.3	0.2	0
ODF - Private	8	19	11	25.5	18.8	4.4	2.2	0.1
OPRD	5	6	1	0.8	0.8	0	0	0
Port of Portland	2	3	1	0.7	0.7	0	0	0
State of Oregon	4	13	9	0.4	0.4	0	0	0
US BLM	9	25	16	14.3	8.7	1.8	3.5	0.3
USFS	1	3	2	1	1	0	0	0
US Gov't.	9	16	7	0.1	0.1	0	0	0

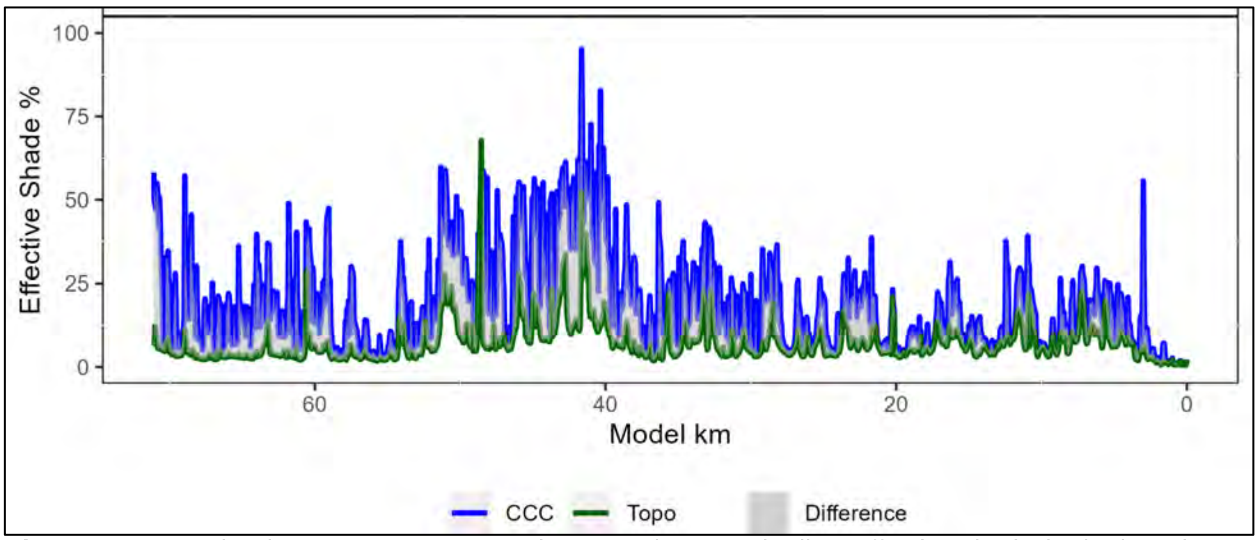

Figure 11-1: Sandy River CCC vs. Topography scenarios: Longitudinal effective shade (07/29/2016)

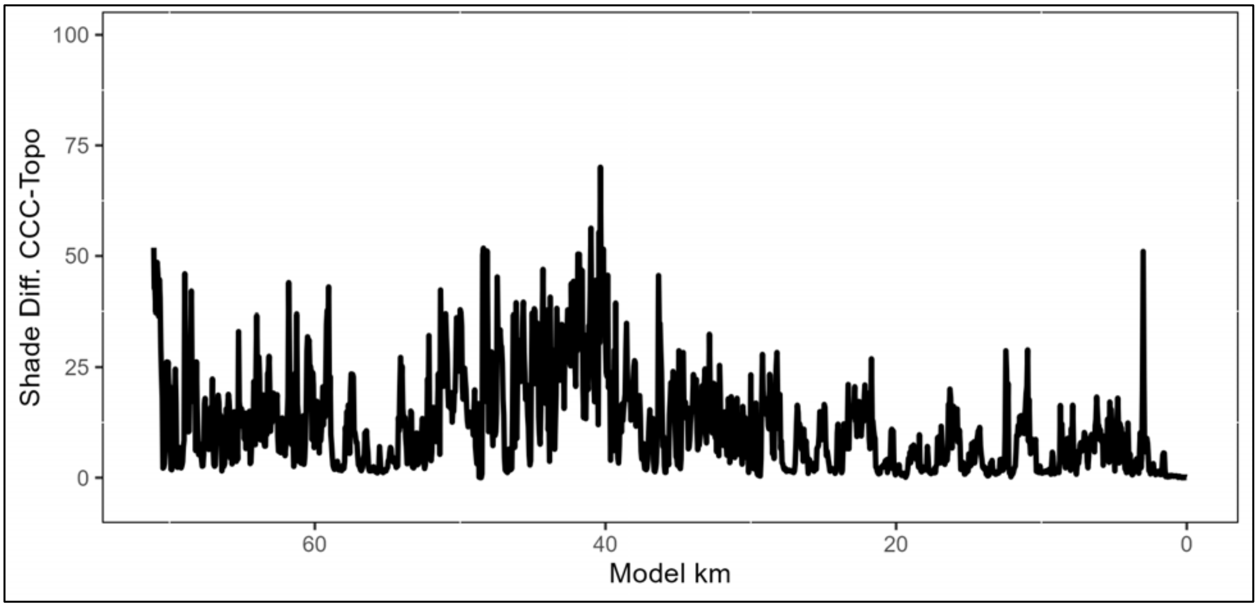

Figure 11-2: Sandy River effective shade reduction (%) if all current vegetation (2016 conditions) were removed

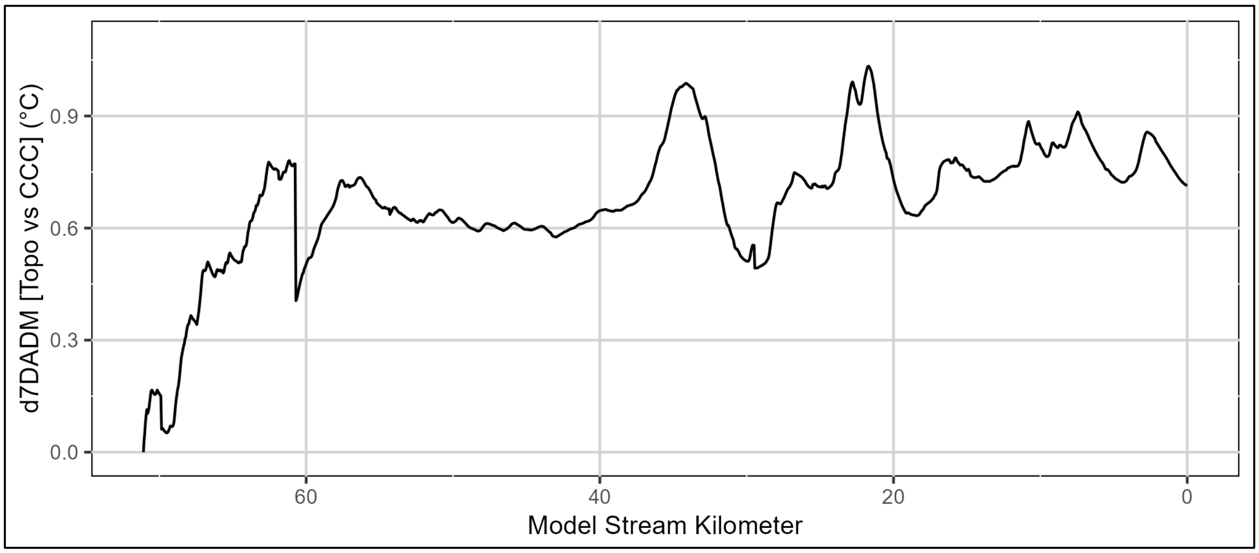

Figure 11-3: Sandy River max. 7DADM temp. changes above the applicable criteria if all current vegetation (2016) were removed.

12.0 TRIBUTARY TEMPERATURES SCENARIO

The tributary temperatures (TT) scenario is equivalent to the CCC model setup for all parameters except for any tributaries that were associated with applicable temperature standard exceedances in the model extents and period. For any such tributaries, their entire temperature dataset, which was used as a model tributary input, was reduced by the maximum exceedance that occurred in that tributary during the model period. The results of this scenario and the CCC model are compared to quantify the instream temperature effects of tributary temperature standard exceedances on the modeled streams. The results indicated a max. 7DADM change of 6.34°C at the POMI (RKM 71.08, i.e., the upstream model boundary) on 2016-07-23 (**Table 12-1**, **Figure 12-1**).

Table 12-1: Sandy River TT vs. CCC scenarios: Modeled water temperatures and changes (WT, °C)

Scenario	Value Type	Location	Max. 7DADM		
			Model km	Date	WT (°C)
Current Cond.	CCC	Mouth	0	08/18/2016	23.67
Tributary Temperatures (TT)	TT	Mouth	0	08/18/2016	21.78
	TT minus CCC (WT change)	Mouth	0	07/19/2016	2.44
		POMI	71.08	07/23/2016	6.34

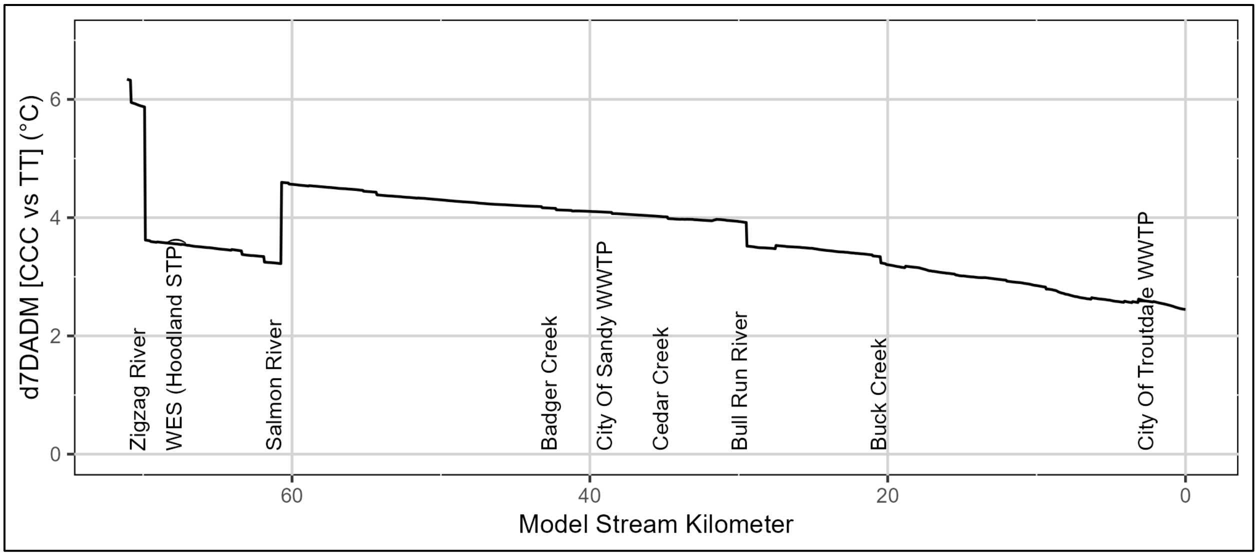

Figure 12-1: Sandy R. max. 7DADM temp. changes above the applicable criteria due to CCC exceedances in Sandy R. tributaries

13.0 DAM AND RESERVOIR-SPECIFIC WASTELOAD ALLOCATION ASSESSMENT

DEQ modeled a "Dam-Only" scenario that represented background conditions except that the Bull Run River tributary inputs to the Sandy River were instead based the output of a Bull Run River scenario in which dam and reservoir temperature outputs attain the applicable surrogate measure (see TSD Appendix A Section 4.5.4 for Bull Run River scenario details). The Sandy River "Dam-Only" scenario was compared to a Comprehensive Baseline (background) scenario to model the effects of the Bull Run River dams and reservoirs on Sandy River temperatures.

Specific assumptions of the Comprehensive Baseline scenario were:

- Point sources' discharges were set to zero flow, i.e., no point source discharges individual proposed wasteload allocations.
- Sandy River model land cover parameters were set to those of the Restored Vegetation A scenario.
- Tributaries:
    - The Salmon River tributary inputs to the Sandy River were defined as the output from the Salmon River Restored Vegetation A scenario at the mouth (river km 0.00).
    - The Bull Run River tributary inputs to the Sandy River were defined as the output from the Bull Run River No Dam Scenario at the mouth (river km 0.00).

- o The Cedar River tributary inputs to the Sandy River were the same as in the Sandy River No Point Sources scenario.
- o All other tributaries and the upstream boundary condition temperatures and flows were set to values used in the current calibrated conditions model.

The only difference between the Dam-Only scenario and the Comprehensive Baseline scenario was that the Bull Run River tributary temperature inputs to the Sandy River were defined as the output from the Bull Run River Surrogate Measure Attainment Scenario at the mouth (see TSD Appendix A Section 4.5.4 for details).

Comparison of the Dam-Only scenario to the Comprehensive Baseline scenario (**Figure 13-1**, **Table 13-1**) indicated a maximum 7DADM temperature change of 0.01°C at the POMI (river km 18.10) on 8/12/2016, and (-0.01)°C at the mouth on 8/13/2016.

Table 13-1: Sandy River Dam-Only vs. Baseline scenario: Modeled water temperatures and changes (WT, °C)

Scenario	Value Type	Location	Max. 7DADM		
			Model km	Date	WT (°C)
Comprehensive Baseline	Base	Mouth	0	08/18/2016	23.13
Dam-Only A	Dam-Only A	Mouth	0	08/18/2016	22.97
	Dam-Only minus Base (WT change)	Mouth	0	8/13/2016	-0.01
		POMI	18.1	8/12/2016	0.01

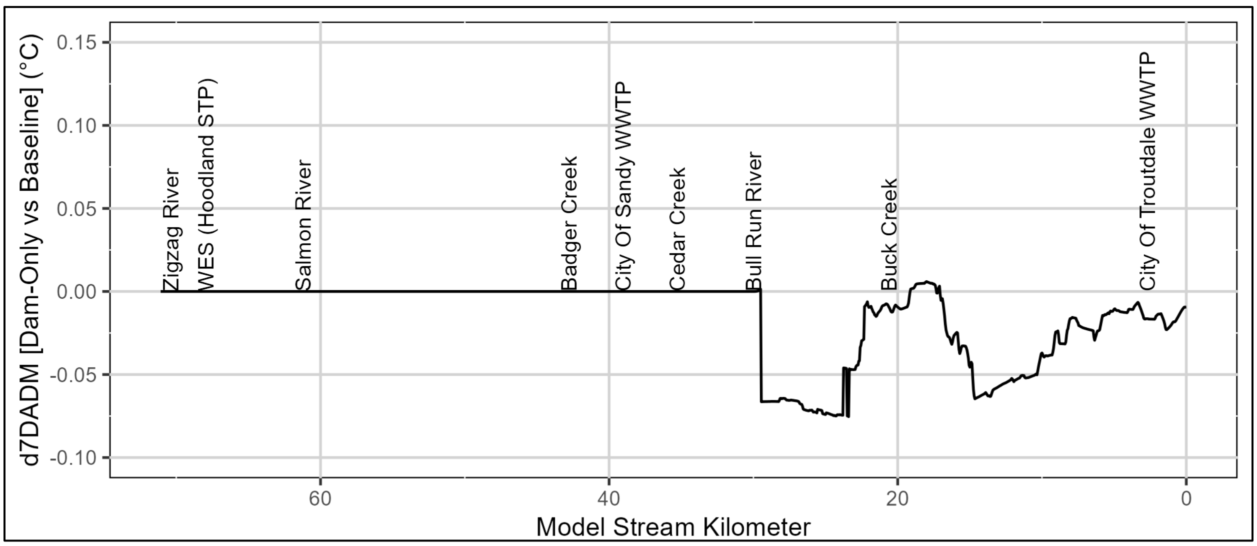

Figure 13-1: Sandy River max. 7DADM temp. changes above the applicable criteria due to presence of Bull Run River dams and reservoirs

14.0 TRIBUTARY TEMPERATURE (LOAD ALLOCATIONS) ASSESSMENT

DEQ modeled a “Tributary Temperatures Attainment” scenario that represented background conditions except that most tributaries’ temperatures increased by 0.30°C throughout the modeling period (except the Bull Run River, which had temperatures representing attainment of the surrogate measure). This Tributary Temperatures Attainment scenario was compared to the Comprehensive Baseline scenario (section 13.0) to model the effects of tributaries discharging at the entire Human Use Allowance (0.30°C above background) on the Sandy River temperatures. No point source discharges were included in this model. The only difference between the Comprehensive Baseline and Tributary Temperatures Attainment scenarios was that in the latter all tributaries’ temperatures were set to the values from the Comprehensive Wasteload and Load Allocations Attainment version B scenario (details in Section 15.0).

Comparison of the Tributary Temperatures Attainment scenario to the Comprehensive Baseline scenario (**Figure 14-1**, **Table 14-1**) indicated a maximum 7DADM temperature change of 0.24°C at the POMI (river km 60.70) on 7/24/2016, and at the mouth (river km 0.00) of 0.09°C on 8/13/2016.

Table 14-1: Sandy River Tributary Attainment vs. Comprehensive Baseline scenarios: Modeled water temp. and changes (WT, °C)

Scenario	Value Type	Location	Max. 7DADM		
			Model km	Date	WT (°C)
Comprehensive Baseline	Base	Mouth	0	08/18/2016	23.13
Tributary Attainment (TA)	TA	Mouth	0	08/18/2016	23.06
	TA minus Base (WT change)	Mouth	0	08/13/2016	0.09
		POMI	60.70	07/24/2016	0.24

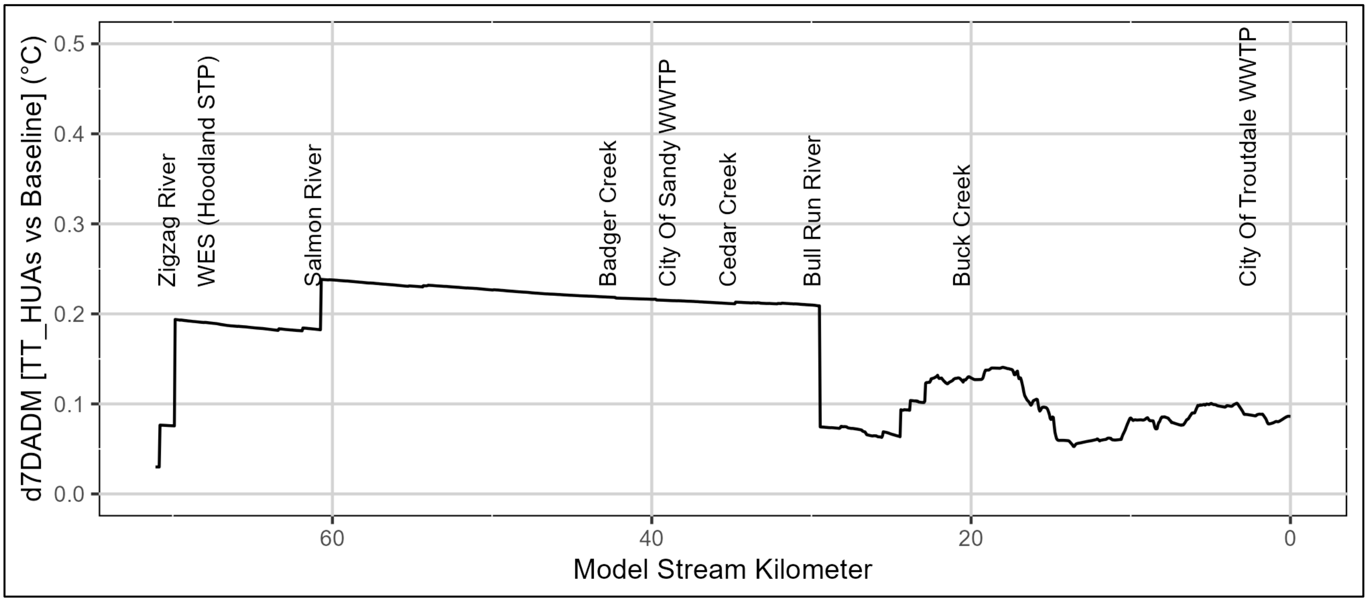

Figure 14-1: Sandy River max. 7DADM temp. changes above the applicable criteria under Tributary Temperatures Attainment scenario A vs. Baseline.

15.0 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 the Comprehensive Baseline scenario (section 13.0) to determine temperature effects and standards attainment in the Sandy River for the 2016 model period.

Specific assumptions of the Comprehensive Wasteload and Load Allocations Attainment scenarios (A and B) were:

- Point sources' discharges were set to reflect individual proposed wasteload allocation flows and temperatures, with versions A and B reflecting WLA_A and WLA_B allocations, respectively. Again, the difference between WLA_A and WLA_B is to which river the ODFW Sandy River Fish Hatchery discharges (Cedar Creek or the Sandy River).
- Sandy River model land cover parameters were set to those of the Restored Vegetation B scenario, i.e., all human-related vegetation alterations except those related to infrastructure (i.e., buildings, roads, bridges, utilities) were restored to estimated undisturbed conditions.
- Tributaries' temperatures were generally increased by 0.30°C to account for the Load Allocation for human uses on tributaries to the mainstem. Specifically:

    - The Salmon River tributary inputs to the Sandy River were defined as the output from the Salmon River Background Scenario at the mouth (river km 0.00) plus 0.30°C .
    - The Bull Run River tributary temperature inputs to the Sandy River were defined as the output from the Bull Run River Surrogate Measure Attainment Scenario at the mouth (see TSD Appendix A Section 4.5.4 for details for details).
    - The Cedar River tributary inputs to the Sandy River were defined as (version A) the current conditions flow and temperature values from the Cedar River at the mouth (i.e., including the influence of the fish hatchery point source discharge to the Cedar River), and (version B) the Cedar River tributary values from the WLA_B scenario, (i.e., temperatures at background conditions and flows reflecting relocation of the fish hatchery discharge from the Cedar River to the Sandy River) plus 0.30°C.
    - All other tributaries' temperatures were set to the current calibrated conditions model values plus 0.30°C.
    - The upstream boundary condition temperatures were set to the current calibrated conditions model values plus 0.03°C.
- All other parameters were identical between the Comprehensive Wasteload and Load Allocations Attainment and Comprehensive Baseline scenarios.

For the comparison of the Comprehensive Wasteload and Load Allocations Attainment version A scenario to the Comprehensive Baseline scenari**o (Figure 15-1),** the max. 7DADM temperature change was 0.29°C at the POMI (river km 38.50) on 7/30/2016, and 0.14°C at the mouth (river km 0.00) on 7/21/2016. The results the comparison of the Comprehensive Wasteload and Load Allocations Attainment version B scenario to the Comprehensive Baseline scenario were similar (**Figure 15-2**), again with a max. 7DADM temperature change of 0.29°C at the POMI (river km 38.50) on 7/30/2016, and 0.14°C at the mouth (river km 0.00) on 7/21/2016.

Table 15-1: Sandy River Comprehensive Wasteload and Load Allocations Attainment (versions A & B) vs. Comprehensive Baseline scenarios: Modeled water temp. and changes (WT, °C)

Scenario	Value Type	Location	Max. 7DADM		
			Model km	Date	WT (°C)
Comprehensive Baseline	Base	Mouth	0	08/18/2016	23.13
Comprehensive Attainment_A	TT_WLA_A	Mouth	0	08/18/2016	23.09
	TT_WLA_A minus Base (WT change)	Mouth	0	07/21/2016	0.14
		POMI	38.50	07/30/2016	0.29
Comprehensive Attainment_B	TT_WLA_B	Mouth	0	08/18/2016	23.09
	TT_WLA_B minus Base (WT change)	Mouth	0	07/21/2016	0.14
		POMI	38.50	07/30/2016	0.29

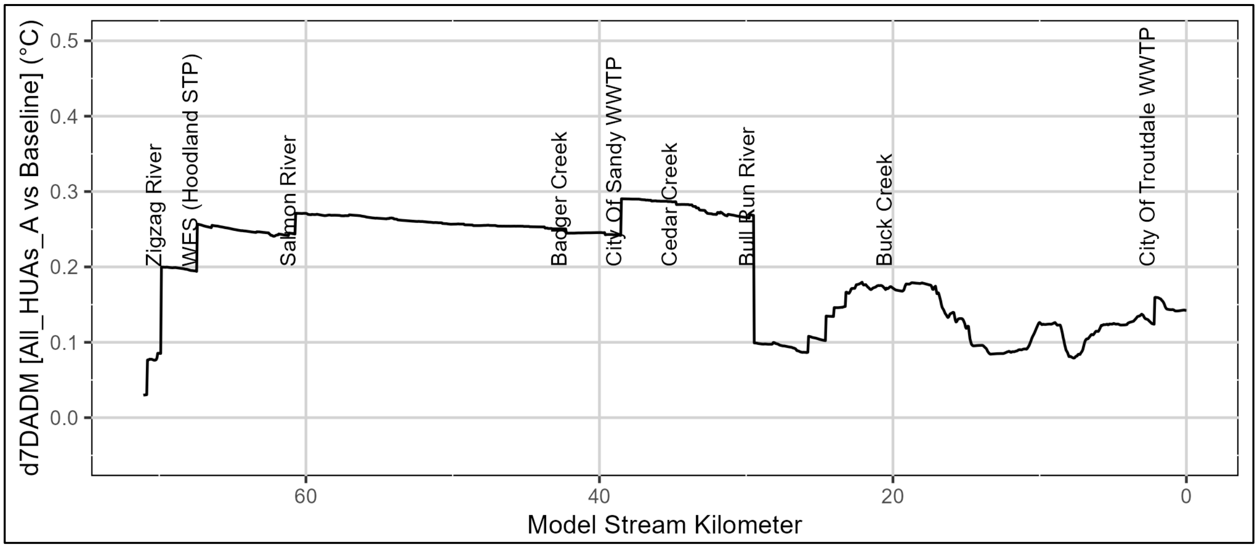

Figure 15-1: Sandy River max. 7DADM temp. changes above the applicable criteria under Comprehensive Wasteload and Load Allocations Attainment scenario A vs. Baseline.

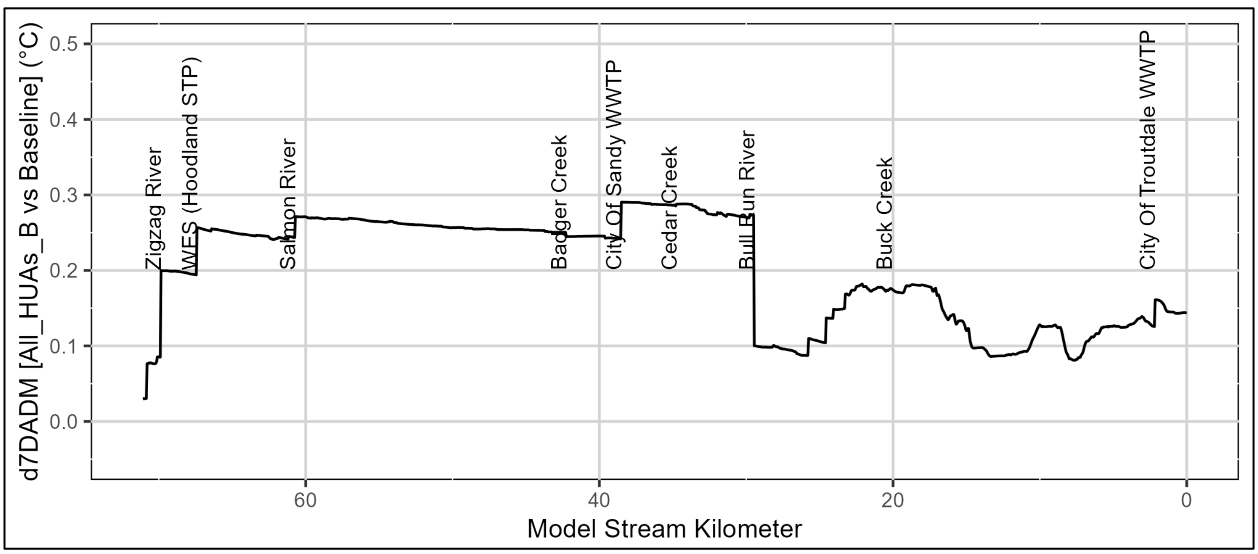

Figure 15-2: Sandy River max. 7DADM temp. changes above the applicable criteria under Comprehensive Wasteload and Load Allocations Attainment scenario B vs. Baseline.

16.0 REFERENCES

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