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

# Technical Support Document Appendix C: Sandy River Model Scenario Report

August 2024

State of Oregon
DEQ Department of Environmental Quality

TETRA TECH

# MEMO

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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 source sector 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 7$^{th}$ day and is considered the 7DADM for that day. Following transition to a new fish use designation (such as spawning), the first day that the 7DADM is reported occurs on the 7th day after the new fish use designation begins. For example, if spawning begins October 15, the first 7-day period would be October 15 to 21, with the first 7DADM temperature reported on October 21.

## 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 2.1.

## 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.

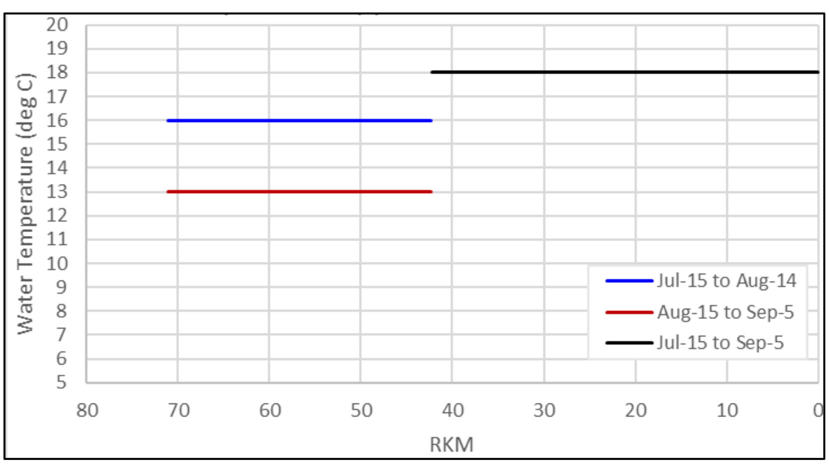


**Figure 2-1:** Applicable BBNC along the Sandy River modeling domain

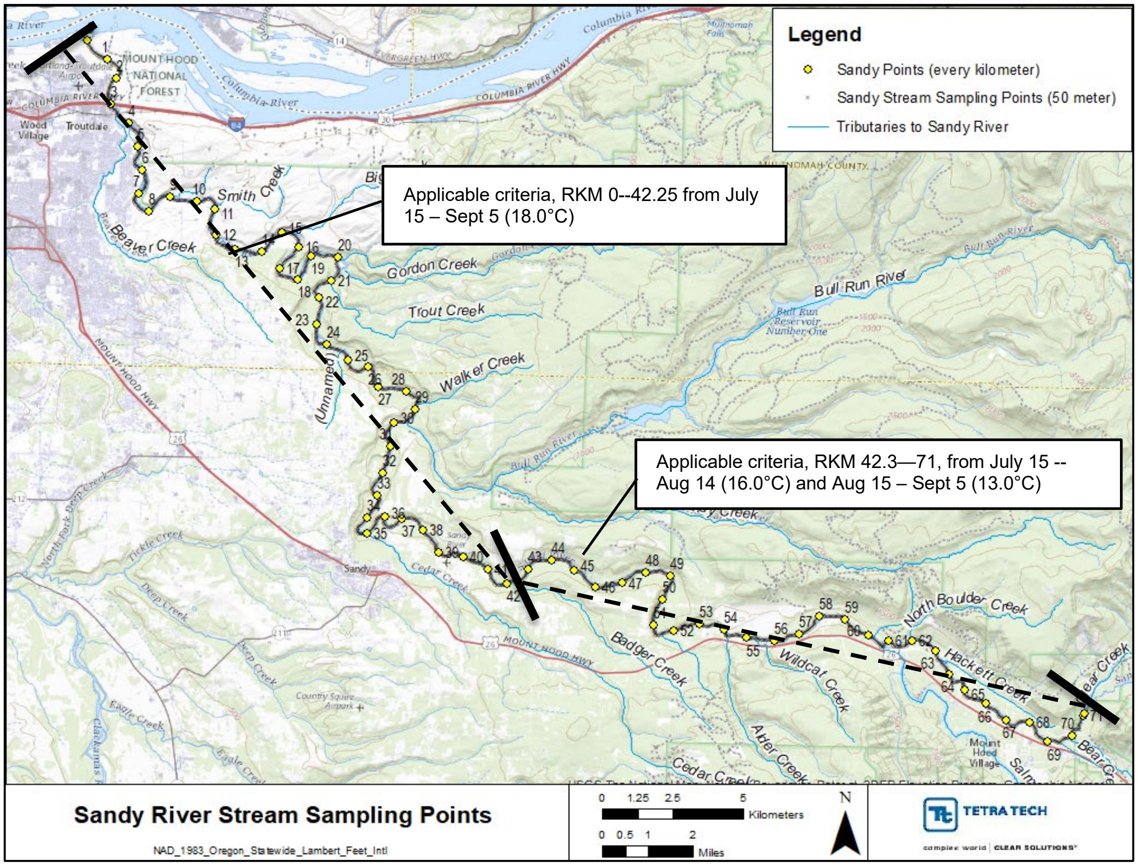


**Figure 2-2:** Sandy River stream sampling points and applicable temperature criteria

# 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 (50 m) 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 is the RKM (31.70km) with the maximum predicted 7DADM temperature change, corresponded with a 0.01°C maximum 7DADM increase on August 29, 2016. No maximum 7DADM increase (i.e., <0.005°C) was predicted at the Sandy River mouth. **Figure 3-2** shows the FPS's modeled impact along the Sandy River model extent.

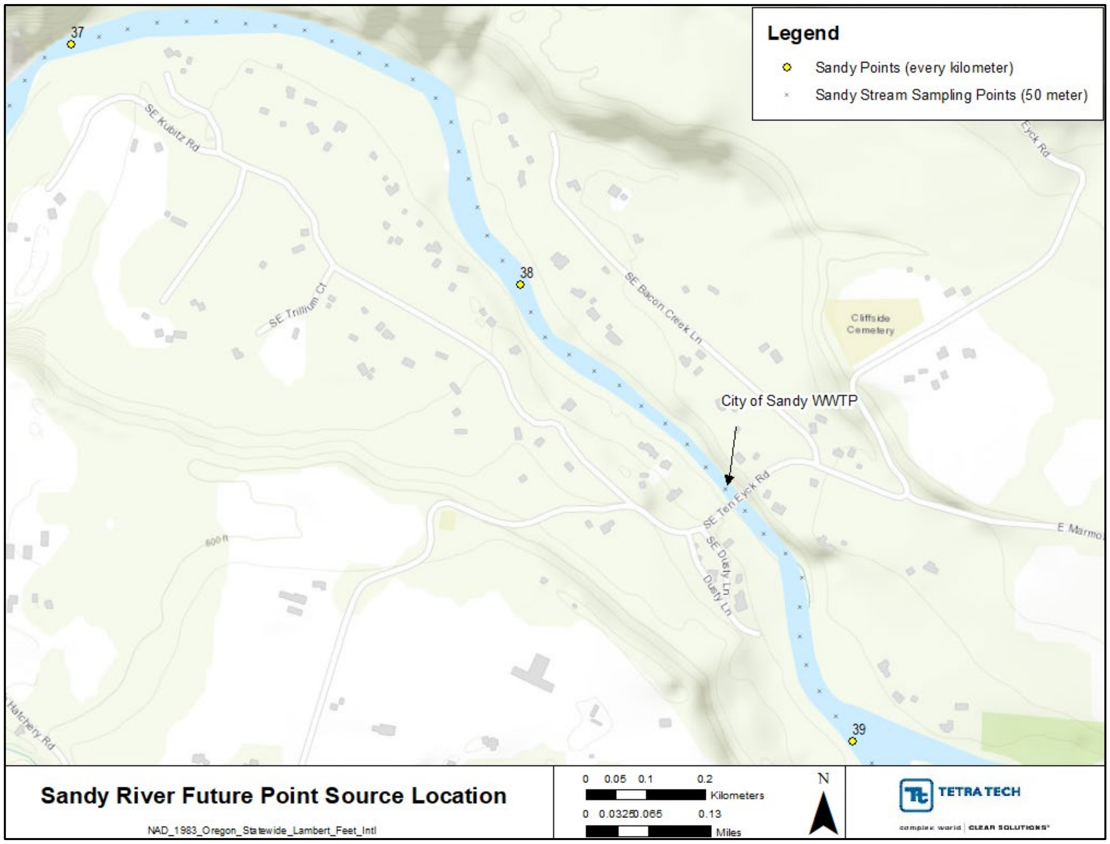


**Figure 3-1:** Location of City of Sandy WWTP proposed future point source

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

| Month | Flow ($m^3/s$) 2026 | Flow ($m^3/s$) 2040 | Effluent temp. (°C) |
|---|---|---|---|
| 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 | Max. 7DADM Date | Max. 7DADM 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 | Mouth | 0 | 07/22/2016 | 0.00 |
| | | POMI | 31.70 | 08/29/2016 | 0.01 |
| | | POMI (0-29.5 km) | 29.50 | 08/31/2016 | 0.01 |
| | | POMI (29.55-69.90 km) | 31.70 | 08/29/2016 | 0.01 |
| | | POMI (69.95-71.05 km) | 71.05 | 07/23/2016 | 0.00 |

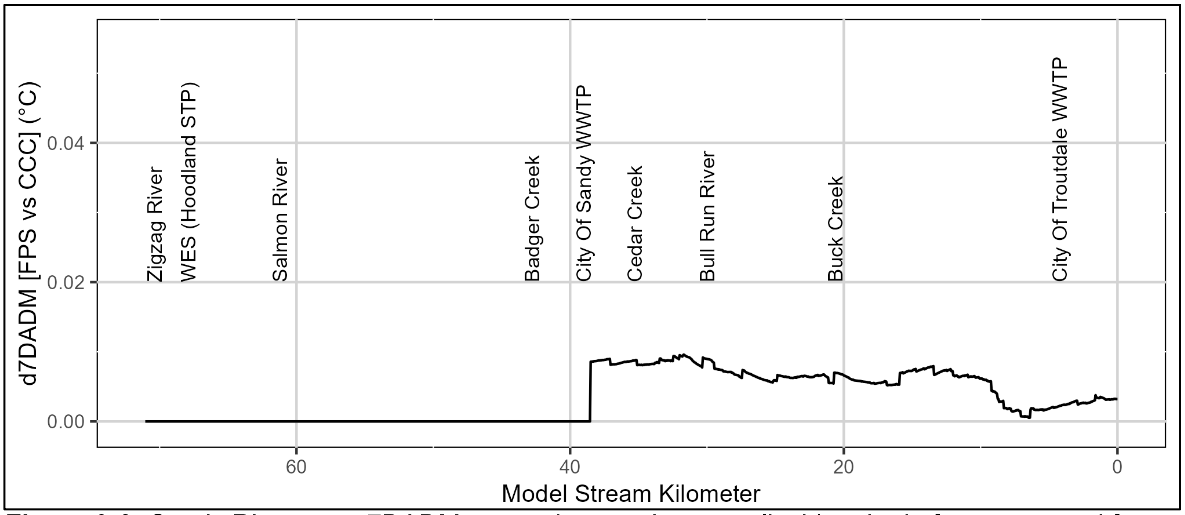


**Figure 3-2:** Sandy River max. 7DADM temp. change above applicable criteria from proposed future point source discharge

# 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 1.60) and 0.02°C at the mouth (**Table 4-1**). Note that differences were only calculated when NoPS scenario temperatures exceeded the BBNC.

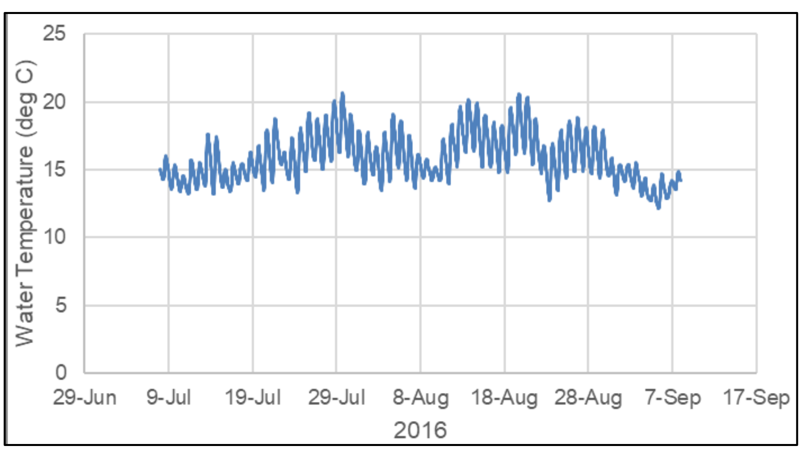


**Figure 4-1:** Model water temp. input for Cedar Cr., 10 ft upstream of ODFW Sandy River fish hatchery outfall

**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 | 23.66 |
| | CCC - NoPS | Mouth | 0 | 09/05/2016 | 0.02 |
| | | POMI | 1.60 | 09/05/2016 | 0.02 |
| | | POMI (0-29.5 km) | 1.60 | 09/05/2016 | 0.02 |
| | | POMI (29.55-69.90 km) | 67.40 | 09/04/2016 | 0.01 |
| | | POMI (69.95-71.05 km) | 71.05 | 07/23/2016 | 0.00 |

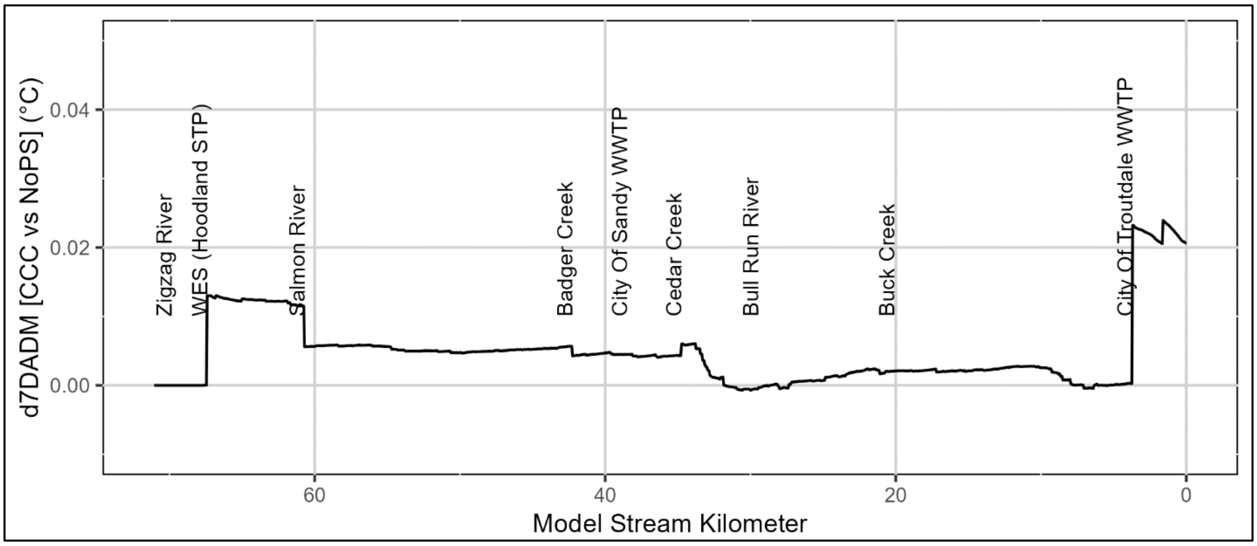


**Figure 4-2:** Sandy River max. 7DADM temp. change above applicable criteria from current point source discharges

# 5.0 TMDL WASTELOAD ALLOCATION SCENARIOS

The wasteload allocations (WLA) scenarios are identical to the CCC model except that NPDES-permitted point source discharges were modified to reflect DEQ-proposed TMDL WLAs. The results of the WLA and CCC scenarios were 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 were 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 were identical except that in WLA_A, the ODFW fish hatchery discharge was located on Cedar Creek near its confluence with the Sandy River, while under WLA_B it was located on the Sandy River at RKM 34.80. Under both WLA scenarios, proposed individual WLAs were applied to each NPDES permittee as an HUA at the associated discharge location (**Table 5-1**) and a proposed cumulative WLA as an HUA (0.12°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 due to cumulative warming. Their respective HUAs were eventually set to 0.06°C, 0.06°C, and 0.09°C to minimize cumulative impacts and standard exceedances (**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 POMI occurred at RKM 3.70 with a maximum cumulative 7DADM increase of 0.12°C on July 23, 2016. At the Sandy River mouth, both WLA_A and WLA_B showed a 0.11°C maximum cumulative 7DADM increase (**Table 5-2**). The max. 7DADM changes between point sources discharging at proposed WLAs versus the current conditions model discharges were also calculated and are presented in **Figure 5-6** and **Figure 5-8** for WLA_A and WLA_B, respectively.

DEQ also evaluated WLAs based on the proposed updates to the fish and aquatic life use designations approved by EQC and submitted to EPA for action. As of August 2024, EPA has not taken action on the proposed updates. If approved, these updates will change the applicable temperature criteria and spawning periods in the Sandy River and other assessment units in the Lower Columbia-Sandy Subbasin. Based on modeling results, the maximum cumulative 7DADM increase is the same as the current temperature criteria.

**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 | 0.09 | 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 |

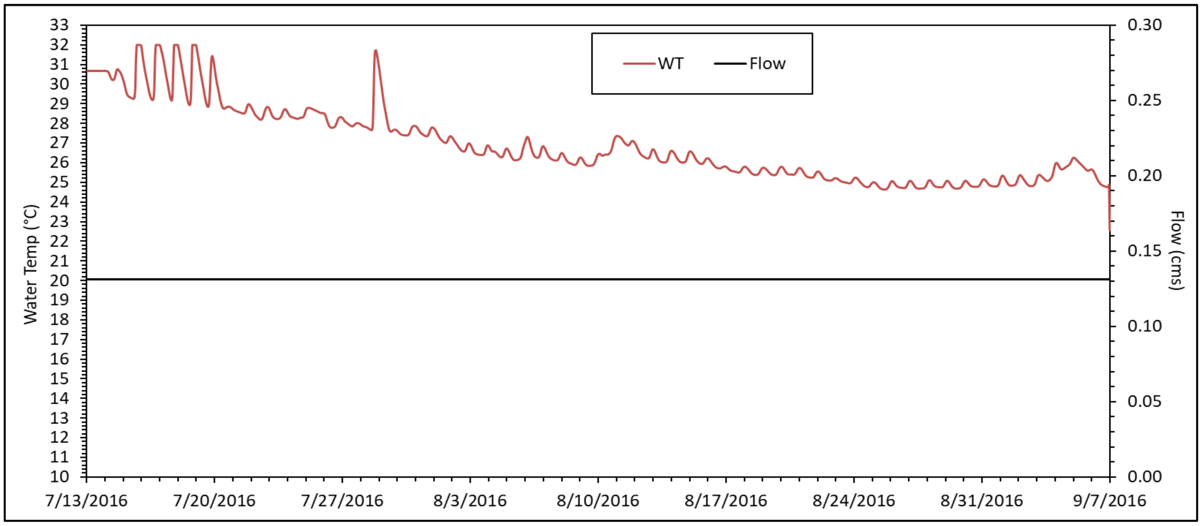


**Figure 5-1:** WLA scenarios: Troutdale WWTP flows and temperatures

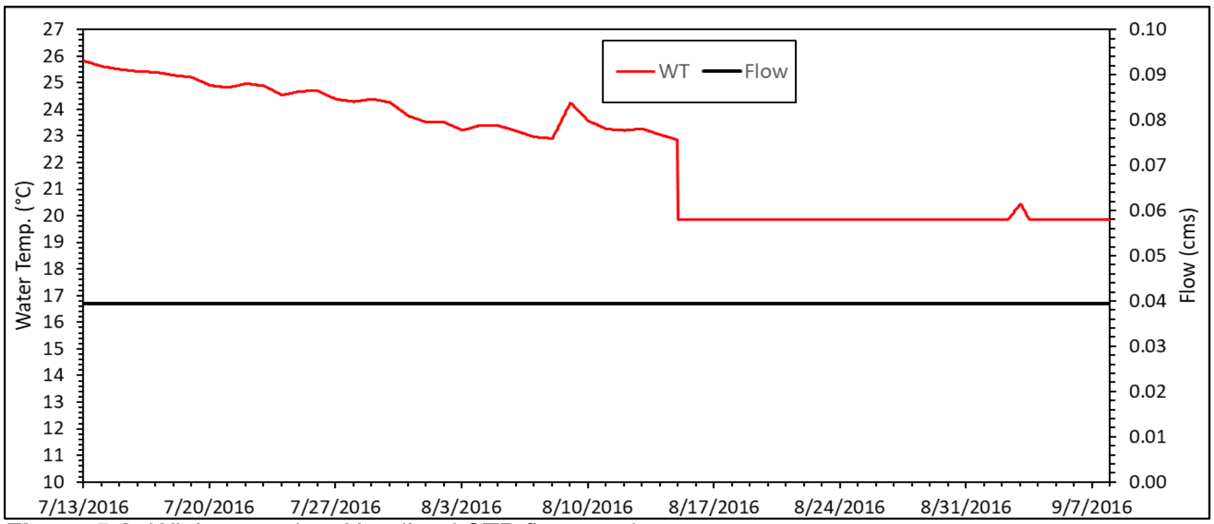


**Figure 5-2:** WLA scenarios: Hoodland STP flows and temperatures

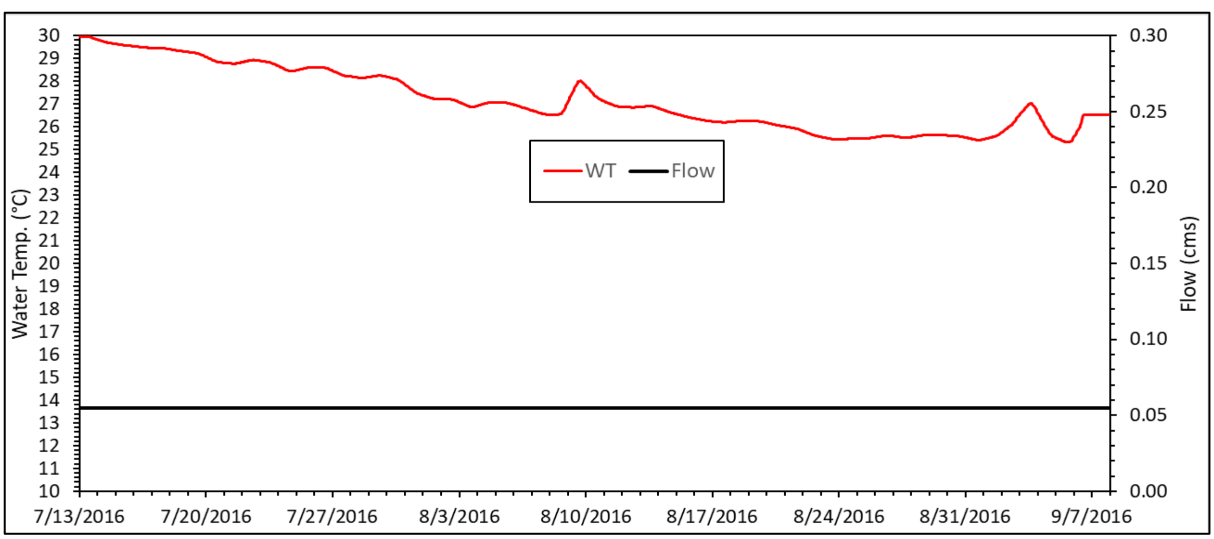


**Figure 5-3:** WLA scenarios: City of Sandy WWTP flows and temperatures

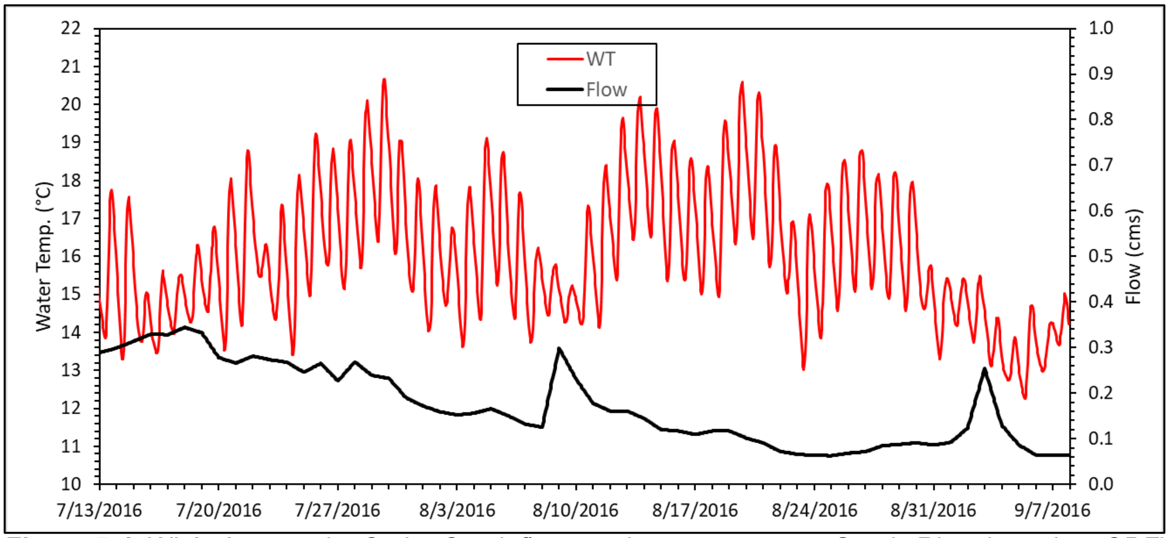


**Figure 5-4.** WLA_A scenario: Cedar Creek flows and temperatures to Sandy River based on ODFW fish hatchery WLA_A discharge rates and temperatures

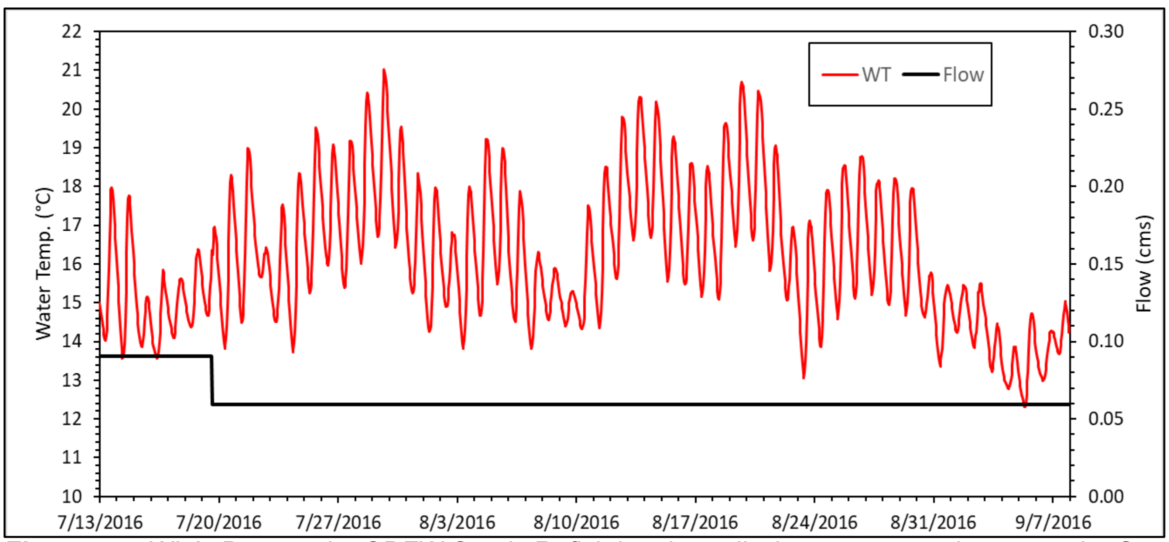


**Figure 5-5:** WLA_B scenario: ODFW Sandy R. fish hatchery discharge rates and temp. to the Sandy R.

**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 | 23.66 |
| Current Conditions | CCC | Mouth | 0 | 08/18/2016 | 23.67 |
| Wasteload Allocation A | WLA_A | Mouth | 0 | 08/18/2016 | 23.71 |
| | WLA_A - NoPS | Mouth | 0 | 07/22/2016 | 0.11 |
| | | POMI | 3.70 | 07/23/2016 | 0.12 |
| | | POMI (0-29.5 km) | 3.70 | 07/23/2016 | 0.12 |
| | | POMI (29.55-69.90 km) | 38.45 | 07/29/2016 | 0.08 |
| | | POMI (69.95-71.05 km) | 71.05 | 07/23/2016 | 0.00 |
| | WLA_A – CCC | Mouth | 0 | 07/21/2016 | 0.10 |
| | | POMI | 3.60 | 07/19/2016 | 0.11 |
| | | POMI (0-29.5 km) | 3.60 | 07/19/2016 | 0.11 |
| | | POMI (29.55-69.90 km) | 38.30 | 07/29/2016 | 0.08 |
| | | POMI (69.95-71.05 km) | 71.05 | 07/23/2016 | 0.00 |
| | WLA_B | Mouth | 0 | 08/18/2016 | 23.71 |

| | | | | | |
|---|---|---|---|---|---|
| Wasteload Allocation B | WLA_B - NoPS | Mouth | 0 | 07/22/2016 | 0.11 |
| | | POMI | 3.70 | 07/23/2016 | 0.12 |
| | | POMI (0-29.5 km) | 3.70 | 07/23/2016 | 0.12 |
| | | POMI (29.55-69.90 km) | 67.40 | 09/04/2016 | 0.09 |
| | | POMI (69.95-71.05 km) | 71.05 | 07/23/2016 | 0.00 |
| | WLA_B - CCC | Mouth | 0 | 07/21/2016 | 0.10 |
| | | POMI | 3.60 | 07/19/2016 | 0.11 |
| | | POMI (0-29.5 km) | 3.60 | 07/19/2016 | 0.11 |
| | | POMI (29.55-69.90 km) | 38.50 | 08/27/2016 | 0.08 |
| | | POMI (69.95-71.05 km) | 71.05 | 07/23/2016 | 0.00 |

**Table 5-3:** Sandy River WLA_A, WLA_B, and NoPS scenarios: Modeled water temperatures and changes (WT, °C), incorporating proposed fish and aquatic life use updates.

| Scenario | Value type | Location | Model km | Date | Max. 7DADM (°C) |
|---|---|---|---|---|---|
| No Point Sources | NoPS | Mouth | 0 | 08/18/2016 | 23.66 |
| Current Conditions | CCC | Mouth | 0 | 08/18/2016 | 23.67 |
| Wasteload Allocation A, under Proposed ALUs | WLA_A | Mouth | 0 | 08/18/2016 | 23.71 |
| | WLA_A - NoPS | Mouth | 0 | 07/22/2016 | 0.11 |
| | | POMI | 3.70 | 07/23/2016 | 0.12 |
| | | POMI (0-29.5 km) | 3.70 | 07/23/2016 | 0.12 |
| | | POMI (29.55-69.90 km) | 38.50 | 08/27/2016 | 0.08 |
| | | POMI (69.95-71.05 km) | 71.05 | 07/23/2016 | 0.00 |
| | WLA_A - CCC | Mouth | 0 | 07/21/2016 | 0.10 |
| | | POMI | 3.60 | 07/19/2016 | 0.11 |
| | | POMI (0-29.5 km) | 3.60 | 07/19/2016 | 0.11 |
| | | POMI (29.55-69.90 km) | 38.50 | 08/27/2016 | 0.08 |
| | | POMI (69.95-71.05 km) | 71.05 | 07/23/2016 | 0.00 |
| Wasteload Allocation B, under Proposed ALUs | WLA_B | Mouth | 0 | 08/18/2016 | 23.71 |
| | WLA_B - NoPS | Mouth | 0 | 07/22/2016 | 0.11 |
| | | POMI | 3.65 | 07/23/2016 | 0.12 |
| | | POMI (0-29.5 km) | 3.65 | 07/23/2016 | 0.12 |
| | | POMI (29.55-69.90 km) | 38.50 | 08/27/2016 | 0.08 |
| | | POMI (69.95-71.05 km) | 71.05 | 07/23/2016 | 0.00 |
| | WLA_B - CCC | Mouth | 0 | 07/21/2016 | 0.10 |
| | | POMI | 3.60 | 07/19/2016 | 0.11 |
| | | POMI (0-29.5 km) | 3.60 | 07/19/2016 | 0.11 |
| | | POMI (29.55-69.90 km) | 38.50 | 08/27/2016 | 0.08 |
| | | POMI (69.95-71.05 km) | 71.05 | 07/23/2016 | 0.00 |

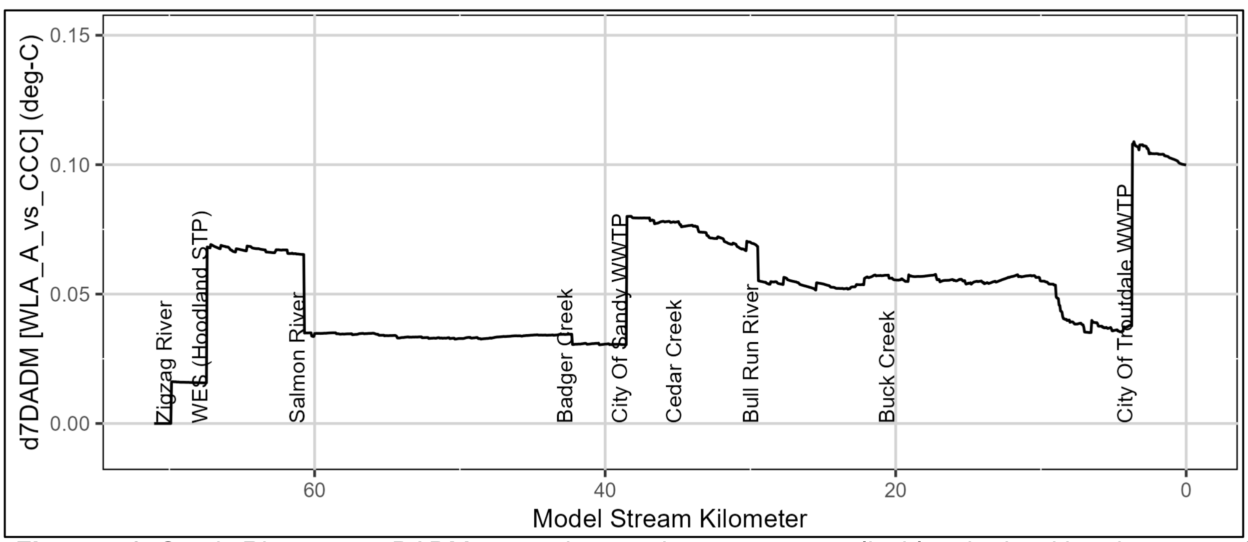


**Figure 5-6:** Sandy River max. 7DADM temp. change above current applicable criteria with point sources' inputs set to proposed WLAs (option A) vs. CCC

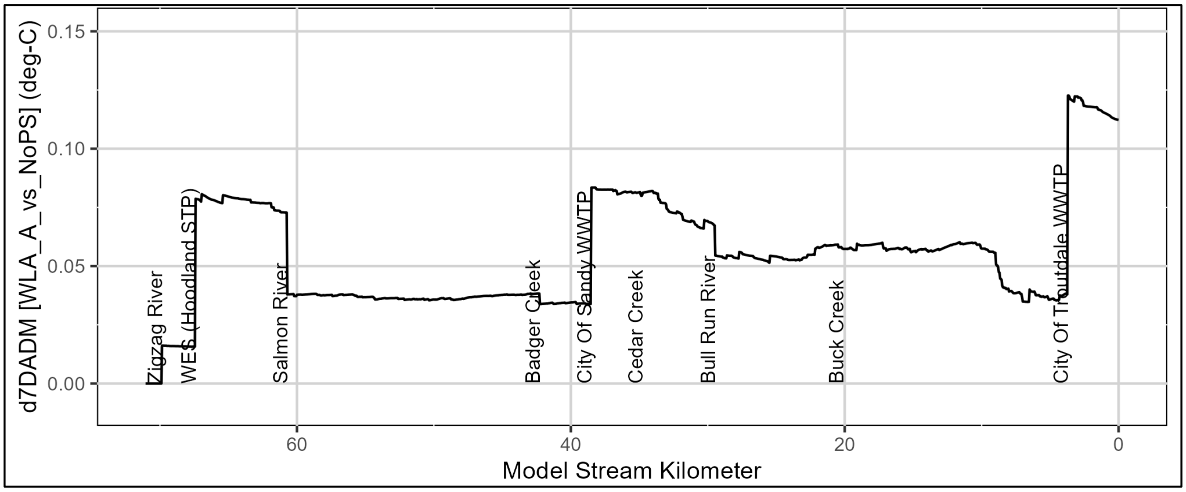


**Figure 5-7:** Sandy River max. 7DADM temp. change above current applicable criteria with point sources' inputs set to proposed WLAs (option A) vs. No Point Sources scenario

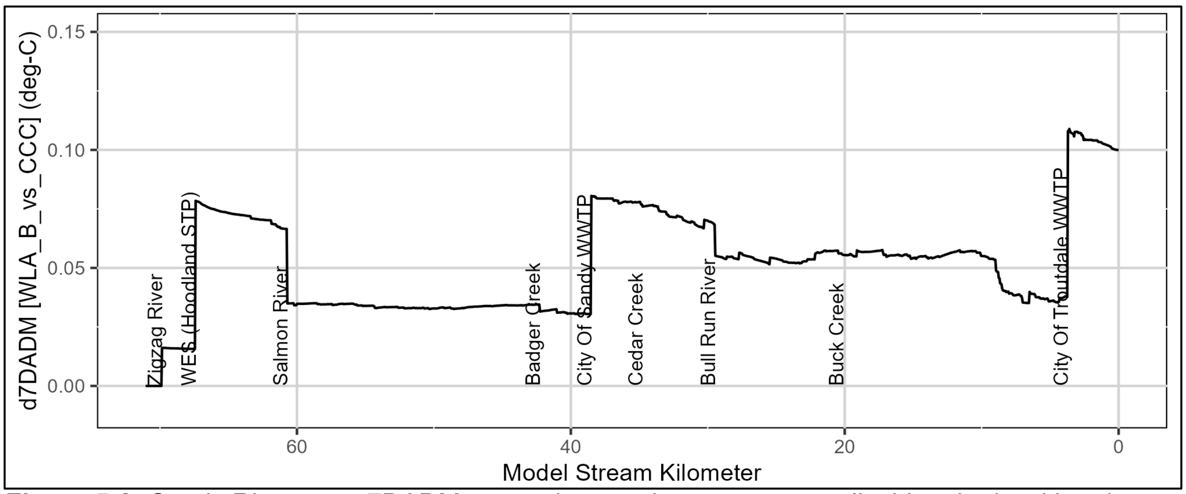


**Figure 5-8:** Sandy River max. 7DADM temp. change above current applicable criteria with point sources' inputs set to proposed WLAs (option B) vs. CCC

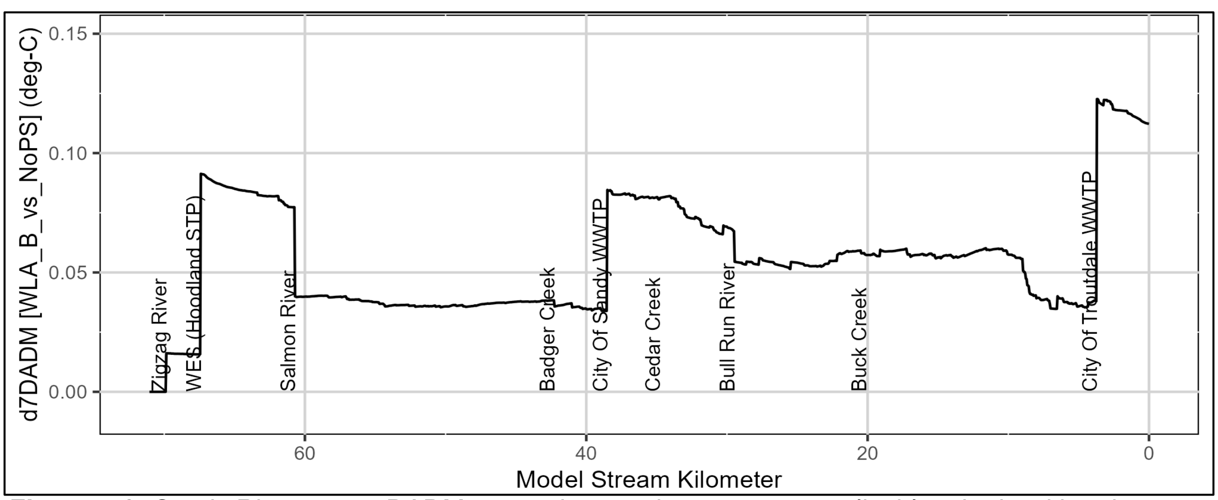


**Figure 5-9:** Sandy River max. 7DADM temp. change above current applicable criteria with point sources' inputs set to proposed WLAs (option B) vs. No Point Sources scenario

# 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). RV_B results are compared to CCC results to determine shade targets and gaps.

**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 Density) 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.

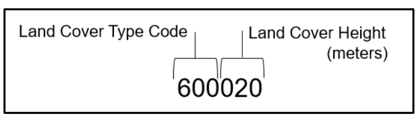


**Figure 6-1:** Example 6-digit code for landcover type and height

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

<table>
<tr><th>Landcover code</th><th>Current Conditions description</th><th>Restored Vegetation “A” scenario description</th><th>Restoration height[2] (m)</th><th>Canopy density (%)</th><th>Overhang (m)</th></tr>
<tr><td>101</td><td>Utility[3]</td><td>Mixed Conifer/Hardwood, High Density</td><td>26.7</td><td>60%</td><td>0.0</td></tr>
<tr><td>102</td><td>Bridge - Over Water[3]</td><td>Water, Active Channel</td><td>0.0</td><td>0%</td><td>0.0</td></tr>
<tr><td>300</td><td>Pastures/Cultivated Field</td><td>Mixed Conifer/Hardwood - High Density</td><td>26.7</td><td>60%</td><td>0.0</td></tr>
<tr><td>301</td><td colspan="2">Water - Non-Active Channel</td><td>0.0</td><td>0%</td><td>0.0</td></tr>
<tr><td>302</td><td colspan="2">Water - Active Channel Bottom</td><td>0.0</td><td>0%</td><td>0.0</td></tr>
<tr><td>305</td><td>Barren - Embankment</td><td rowspan="10">Mixed Conifer/Hardwood - High Density</td><td rowspan="10">26.7</td><td rowspan="10">60%</td><td rowspan="10">0.0</td></tr>
<tr><td>308</td><td>Barren - Clearcut</td></tr>
<tr><td>309</td><td>Barren - Soil</td></tr>
<tr><td>348</td><td>Development – Residential[3]</td></tr>
<tr><td>349</td><td>Development - Industrial/Commercial[3]</td></tr>
<tr><td>352</td><td>Dam/Weir[3]</td></tr>
<tr><td>355</td><td>Canal[3]</td></tr>
<tr><td>400</td><td>Barren - Road[3]</td></tr>
<tr><td>401</td><td>Barren - Forest Road[3]</td></tr>
<tr><td>500</td><td>Mixed Conifer/Hardwood - High Density</td></tr>
<tr><td>550</td><td colspan="2">Mixed Conifer/Hardwood - Medium Density</td><td>26.7</td><td>30%</td><td>0.0</td></tr>
<tr><td>555</td><td colspan="2">Mixed Conifer/Hardwood - Low Density</td><td>26.7</td><td>10%</td><td>0.0</td></tr>
<tr><td>600</td><td colspan="2">Hardwood - High Density</td><td>20.1</td><td>75%</td><td>0.0</td></tr>
<tr><td>650</td><td colspan="2">Hardwood - Low Density</td><td>20.1</td><td>30%</td><td>0.0</td></tr>
</table>

| Landcover code | Current Conditions description | Restored Vegetation "A" scenario description | Restoration height[2] (m) | Canopy density (%) | Overhang (m) |
|---|---|---|---|---|---|
| 700 | Conifer - High Density | | 35.1 | 60% | 0.0 |
| 750 | Conifer - Low Density | | 35.1 | 30% | 0.0 |
| 800 | Shrub - High Density | | 1.8 | 75% | 0.0 |
| 850 | Shrub - Low Density | | 1.8 | 25% | 0.0 |
| 900 | Grasses - upland | Mixed Conifer/Hardwood - High Density | 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 temperature effect associated with the two anthropogenic vegetation restoration scenarios (RV_A and RV_B) was calculated as the maximum of the time-series of differences in 7DADM temperature between the CCC and the respective RV_A or RV_B scenario (**Figure 6-6** shows the RV_B results). 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 the CCC vs. RV_B comparison occurred at RKM 61.10 on August 29, 2016, and corresponded to a 0.97°C maximum 7DADM change. Comparing the RV_A and RV_B scenarios indicated that the unrestored infrastructure in RV_B accounts for a maximum 7DADM warming of 0.05°C at the POMI (RKM 2.80, August 29, 2016).

The resulting impacts on effective shade were 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_B 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_B 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.

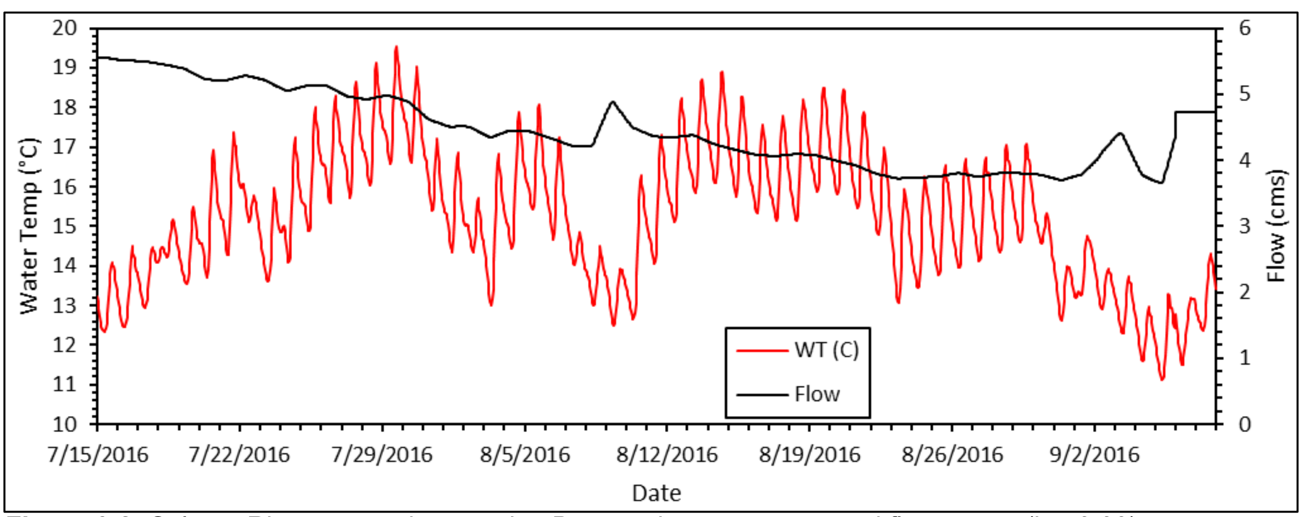

**Figure 6-2:** Salmon River restored vegetation B scenario temperature and flow output (km 0.00)

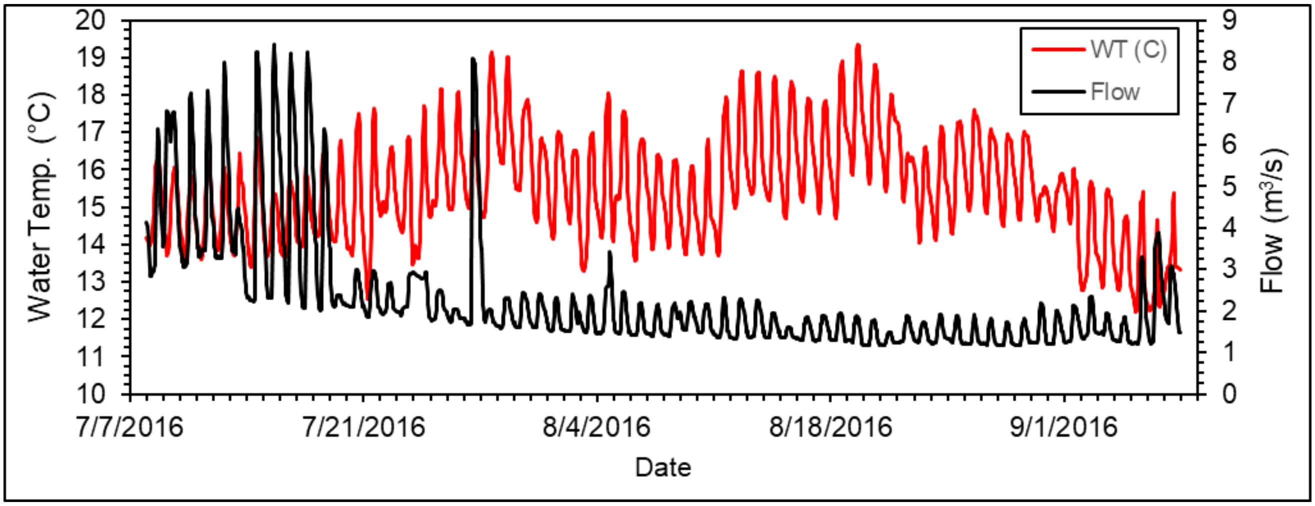

**Figure 6-3:** Bull Run River restored vegetation scenario temperature and flow output (km 0.00)

**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 | 23.30 |
| | CCC – RV_A | Mouth | 0 | 08/31/2016 | 0.48 |
| | | POMI | 61.05 | 08/29/2016 | 1.00 |
| | | POMI (0-29.5 km) | 2.50 | 08/30/2016 | 0.76 |
| | | POMI (29.55-69.90 km) | 61.05 | 08/29/2016 | 1.00 |
| | | POMI (69.95-71.05 km) | 70.00 | 08/30/2016 | 0.27 |
| Restored Vegetation, Modified (RV_B) | RV_B | Mouth | 0 | 08/18/2016 | 23.30 |
| | CCC - RV_B | Mouth | 0 | 08/31/2016 | 0.48 |
| | | POMI | 61.10 | 08/29/2016 | 0.97 |
| | | POMI (0-29.5 km) | 2.45 | 08/30/2016 | 0.72 |
| | | POMI (29.55-69.90 km) | 61.10 | 08/29/2016 | 0.97 |
| | | POMI (69.95-71.05 km) | 70.00 | 08/30/2016 | 0.26 |
| | RV_B – RV_A | Mouth | 0 | 08/07/2016 | 0.00 |
| | | POMI | 2.80 | 08/29/2016 | 0.05 |
| | | POMI (0-29.5 km) | 2.80 | 08/29/2016 | 0.05 |
| | | POMI (29.55-69.90 km) | 61.00 | 08/29/2016 | 0.03 |
| | | POMI (69.95-71.05 km) | 69.95 | 08/25/2016 | 0.01 |

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

| Extent | CCC | RV_B | Shade gap (%) | Stream km assessed | Stream extent (km) at shade gap (%) | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | 0-15% | 16-25% | 26-50% | 51-100% |
| **Study Area** | 18 | 23 | 5 | 71.1 | 66 | 4.8 | 0.3 | 0 |
| City of Portland | 9 | 13 | 4 | 0.7 | 0.7 | 0 | 0 | 0 |
| City of Sandy | 21 | 23 | 2 | 0.7 | 0.7 | 0 | 0 | 0 |
| City of Troutdale | 15 | 19 | 4 | 3.2 | 3.1 | 0.1 | 0 | 0 |
| Clackamas Cty. | 17 | 26 | 9 | 18.3 | 14.8 | 3.1 | 0.3 | 0 |
| Multnomah Cty. | 16 | 18 | 2 | 2.3 | 2.2 | 0 | 0 | 0 |
| ODA | 23 | 28 | 5 | 0.9 | 0.8 | 0 | 0 | 0 |
| ODFW | 22 | 26 | 4 | 1.2 | 1.2 | 0 | 0 | 0 |
| ODF - Private | 19 | 23 | 4 | 25.5 | 24.6 | 0.9 | 0 | 0 |
| OPRD | 6 | 7 | 1 | 0.8 | 0.8 | 0 | 0 | 0 |
| Port of Portland | 3 | 9 | 6 | 0.7 | 0.7 | 0 | 0 | 0 |
| State of Oregon | 13 | 17 | 4 | 0.4 | 0.4 | 0 | 0 | 0 |
| US BLM | 24 | 27 | 3 | 14.3 | 13.8 | 0.4 | 0 | 0 |
| USFS | 3 | 6 | 3 | 1 | 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** | 23 | 23 | 0 | 71.1 | 71 | 0 | 0 | 0 |
| City of Portland | 13 | 12 | -1 | 0.7 | 0 | 0 | 0 | 0 |
| City of Sandy | 23 | 23 | 0 | 0.7 | 0.7 | 0 | 0 | 0 |
| City of Troutdale | 19 | 19 | 0 | 3.2 | 3.2 | 0 | 0 | 0 |
| Clackamas Cty. | 26 | 26 | 0 | 18.3 | 18.3 | 0 | 0 | 0 |
| Multnomah Cty. | 18 | 18 | 0 | 2.3 | 2.3 | 0 | 0 | 0 |
| ODA | 28 | 28 | 0 | 0.9 | 0.9 | 0 | 0 | 0 |
| ODFW | 26 | 26 | 0 | 1.2 | 1.2 | 0 | 0 | 0 |
| ODF - Private | 23 | 23 | 0 | 25.5 | 25.4 | 0 | 0 | 0 |
| OPRD | 7 | 7 | 0 | 0.8 | 0.8 | 0 | 0 | 0 |
| Port of Portland | 9 | 9 | 0 | 0.7 | 0.7 | 0 | 0 | 0 |
| State of Oregon | 17 | 17 | 0 | 0.4 | 0.4 | 0 | 0 | 0 |
| US BLM | 27 | 27 | 0 | 14.3 | 14.3 | 0 | 0 | 0 |
| USFS | 6 | 7 | 1 | 1 | 1 | 0 | 0 | 0 |

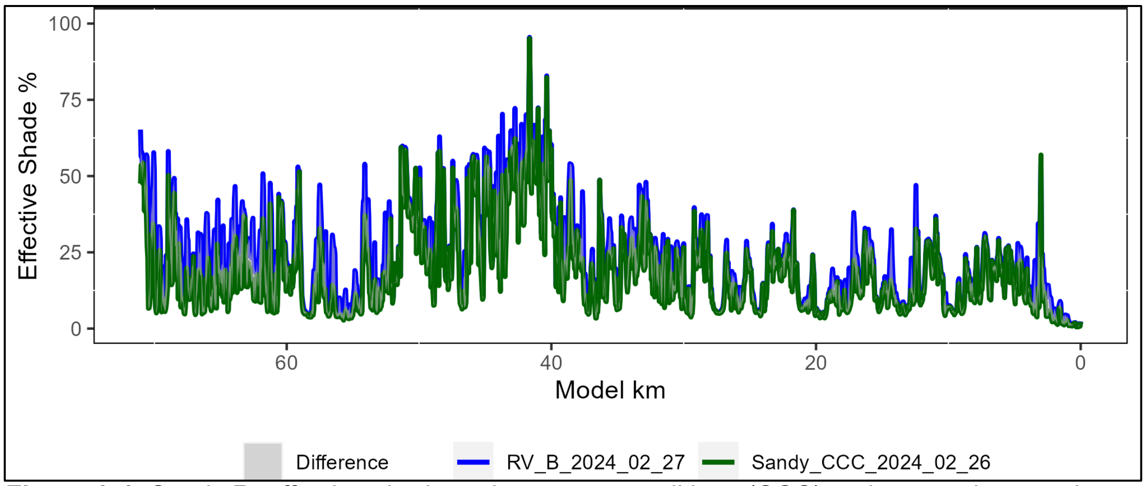


**Figure 6-4:** Sandy R. effective shade under current conditions (CCC) and restored vegetation conditions (RV_B)

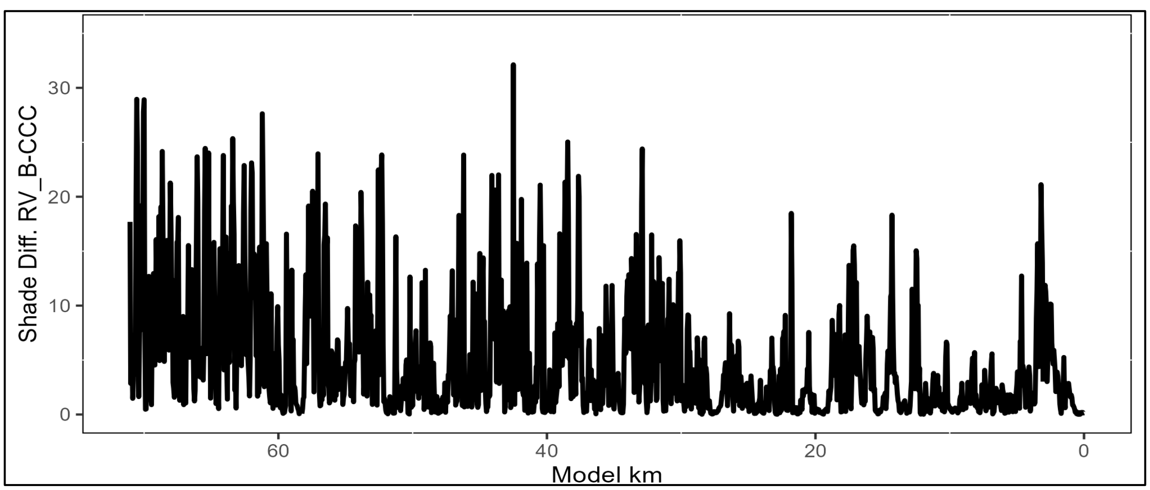


**Figure 6-5**. Sandy River longitudinal effective shade differences (%), RV_B vs. CCC scenarios

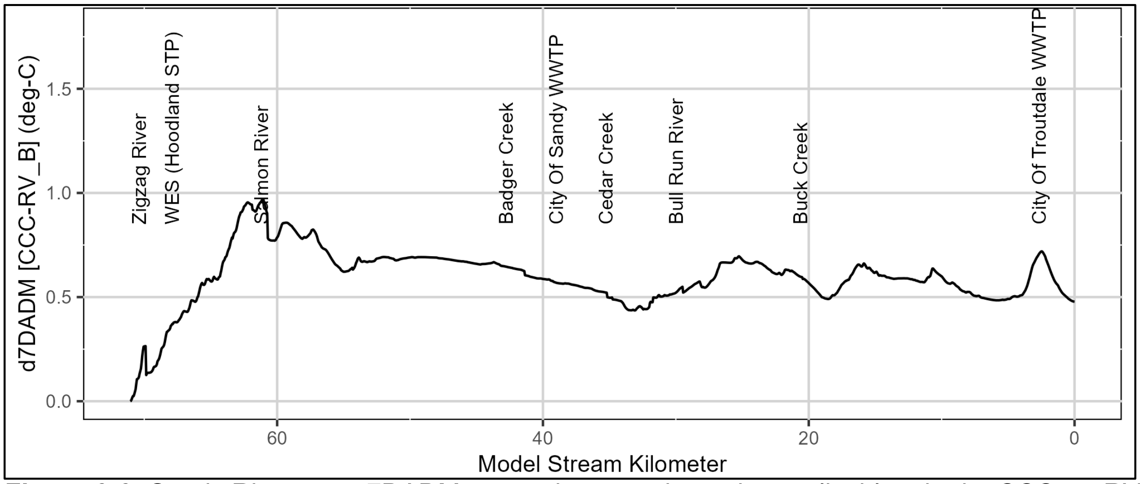


**Figure 6-6:** Sandy River max. 7DADM temp. changes above the applicable criteria, CCC vs. RV_B

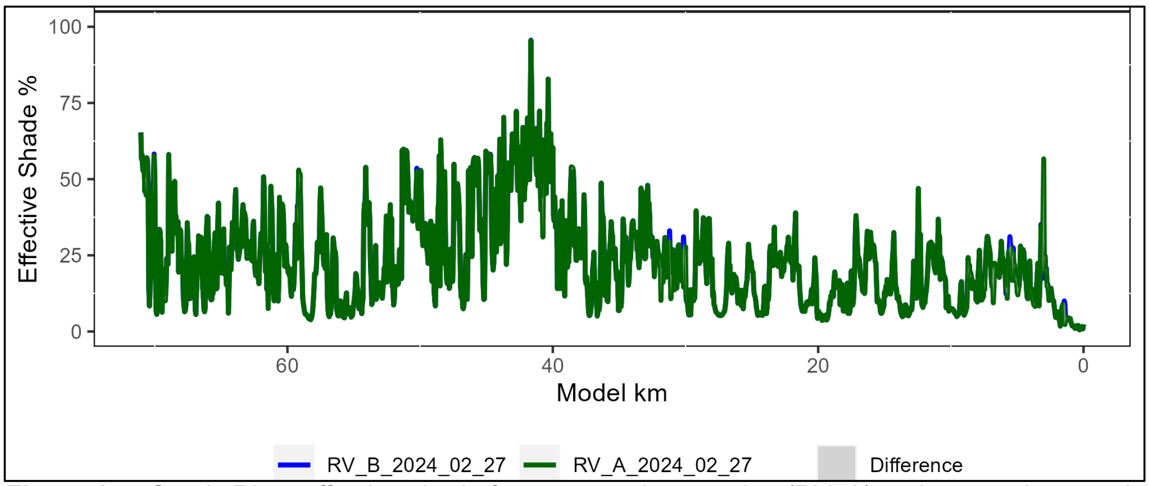


**Figure 6-7:** Sandy River effective shade from restored vegetation (RV_A) and restored vegetation with buildings, transportation, and utility corridors at current shade conditions (RV_B)

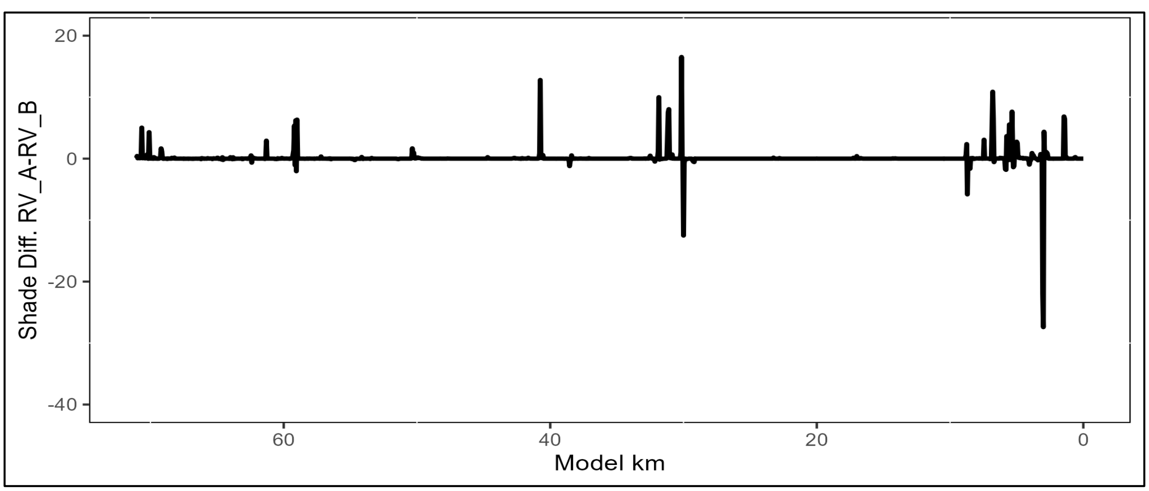


**Figure 6-8:** Sandy River effective shade reduction (%) due to vegetation disturbance or removal from buildings, transportation, and utility corridors (RV A vs. RV B)

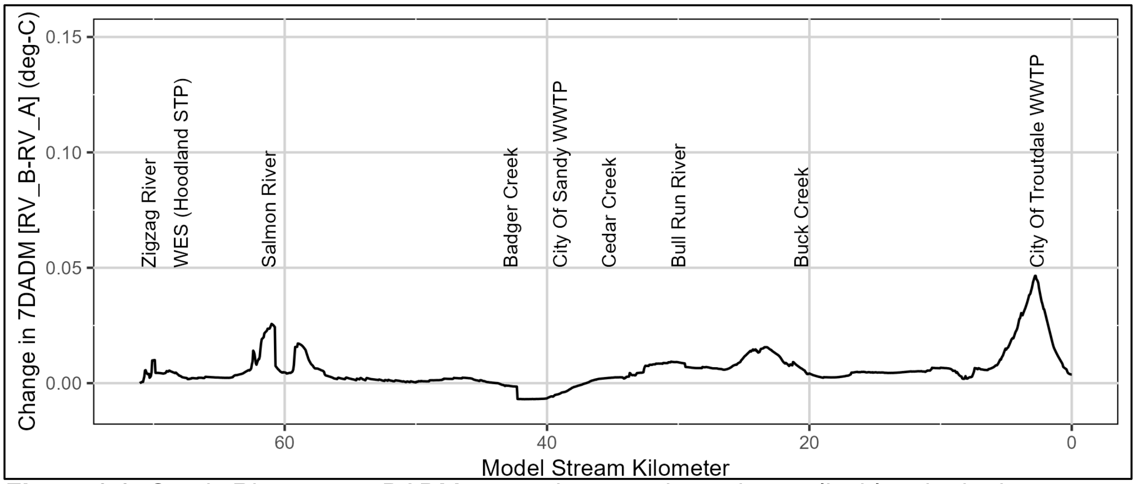


**Figure 6-9:** Sandy River max. 7DADM temp. changes above the applicable criteria due to vegetation disturbance or removal from buildings, transportation, and utility corridors (RV_B vs. RV_A)

# 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 over the model period, a time-series of 7DADM temperature changes due to dam operation was calculated by subtracting the 7DADM temperature of the ND scenario from that of the CCC scenario. Positive 7DADM differences indicate heating effects, while negative differences indicate cooling effects, of current dam operations at various points on the Sandy River. **Figure 7-2** shows the modeled maximum 7DADM differences (impacts) at each model node. Temperature differences are summarized in **Table 7-1**. Note that differences were only calculated when the ND scenario temperature exceeded the BBNC. For most Sandy River nodes between the Bull Run River and the mouth, the max. 7DADM within the model period increased due to current dam operations (POMI: 0.60°C (August 4, 2016, river km: 4.70)), while some nodes showed zero or slightly negative changes. **Figure 7-3** shows 7DADM changes by node and date (July 8 to Sept. 9, 2016).

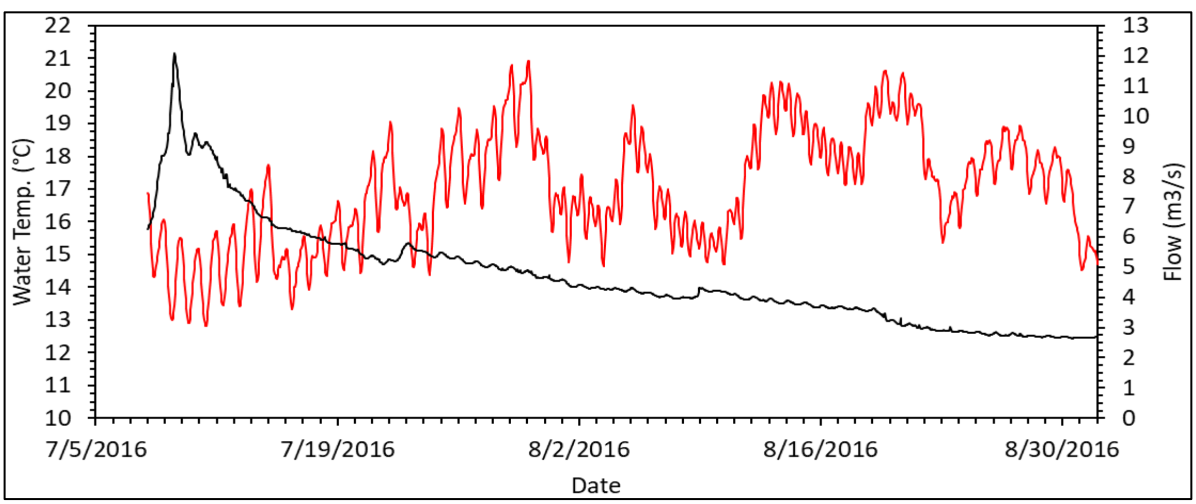


**Figure 7-1:** No dams scenario temperature and flow time-series, Bull Run River mouth.

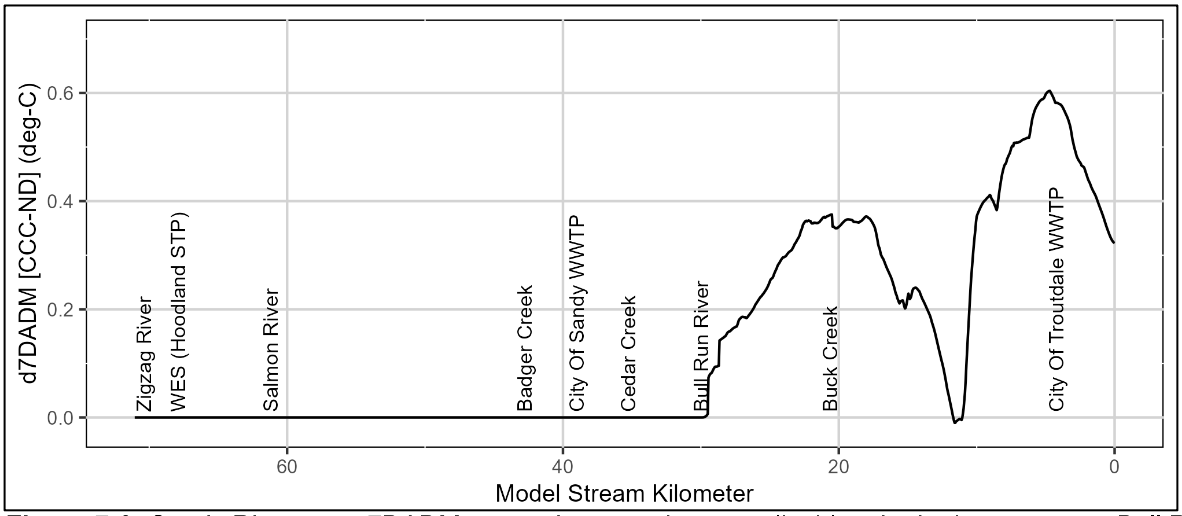


**Figure 7-2:** Sandy River max. 7DADM temp. changes above applicable criteria due to current Bull Run dam and reservoir operations

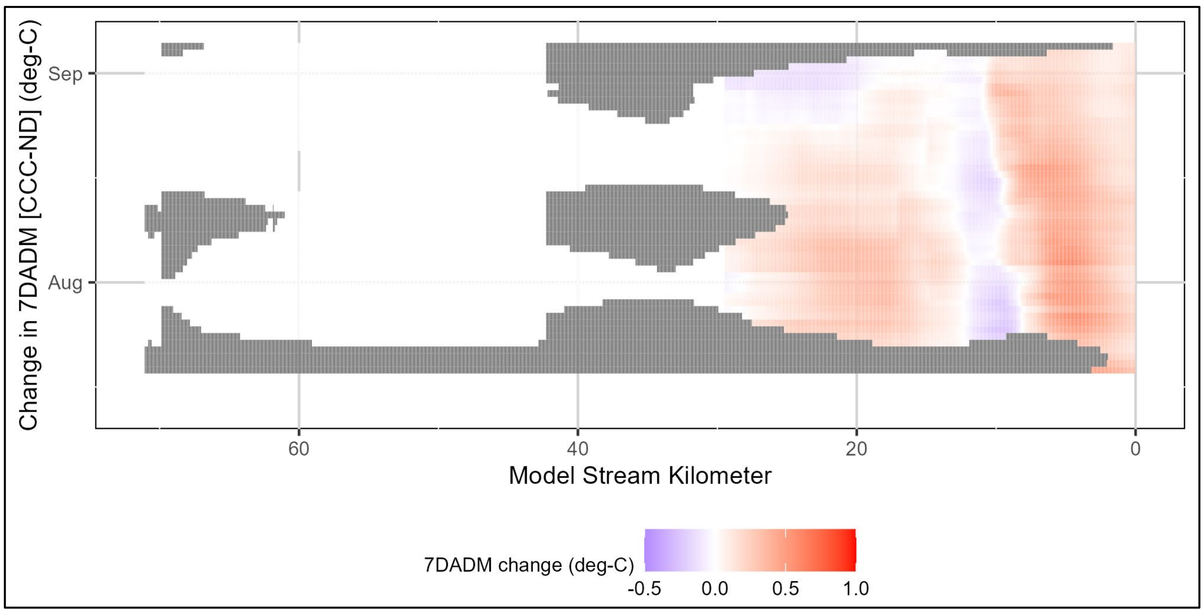


**Figure 7-3:** Sandy R. max. temp. changes above applicable criteria due to current Bull Run dam and reservoir operations by node (x-axis) and date (y-axis, 7/8/2016-9/6/2016). Gray points indicate that 7DADM temperatures were below applicable criteria.

**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 |
| | CCC – ND | Mouth | 0 | 07/19/2016 | 0.32 |
| | | POMI | 4.70 | 08/04/2016 | 0.60 |
| | | POMI (0-29.5 km) | 4.70 | 08/04/2016 | 0.60 |
| | | POMI (29.55-69.90 km) | 29.55 | 07/29/2016 | 0.00 |
| | | POMI (69.95-71.05 km) | 71.05 | 07/23/2016 | 0.00 |

# 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.

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

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 | 18.66 |

# 9.0 CONSUMPTIVE USE (WATER WITHDRAWAL) SCENARIOS

The consumptive use 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. DEQ determined the Reference Location based on the location of available monitoring data (i.e., USGS 14142500). Note that the 0.05°C HUA applies across the entire subbasin, not only at the Reference Location.

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 R. 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 | 18.66 |
| Water Withdrawals A (1.90%) | WW_A | Mouth | 0 | 08/18/2016 | 22.60 |
| | | Ref. | 29.1 | 08/19/2016 | 18.71 |
| | WW_A - NQ | Mouth | 0 | 07/29/2016 | 0.09 |
| | | Ref. | 29.10 | 08/18/2016 | 0.05 |
| Water Withdrawals B (10.1%) | WW_B | Mouth | 0 | 08/18/2016 | 22.88 |
| | | Ref. | 29.1 | 08/19/2016 | 18.95 |
| | WW_B - NQ | Mouth | 0 | 07/31/2016 | 0.51 |
| | | Ref. | 29.1 | 08/18/2016 | 0.30 |
| Water Withdrawals C (Current Est'd) | WW_C | Mouth | 0 | 08/18/2016 | 23.62 |
| | | Ref. | 29.1 | 08/19/2016 | 19.74 |
| | WW_C – NQ | Mouth | 0 | 08/01/2016 | 1.55 |
| | | Ref. | 29.10 | 08/18/2016 | 1.10 |

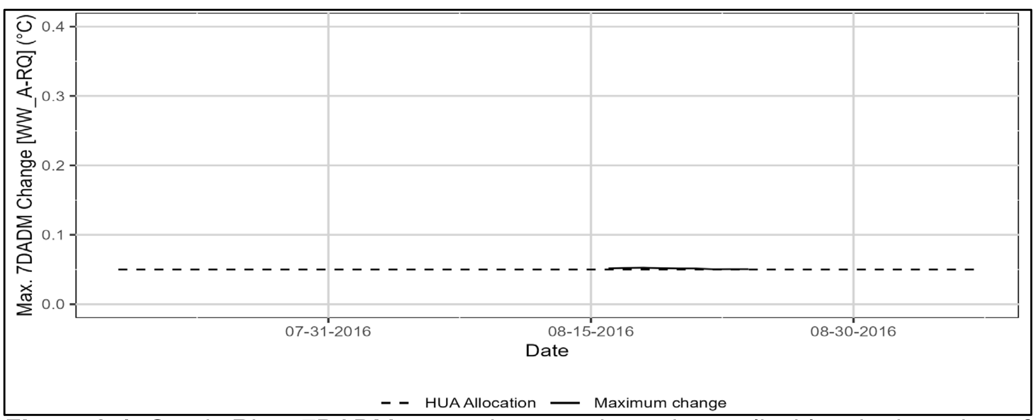


**Figure 9-1:** Sandy River 7DADM temp. changes above the applicable criteria at the reference point (RKM 29.1) from consumptive uses set at 1.90% (WW_A) of natural flow (NQ) by date.

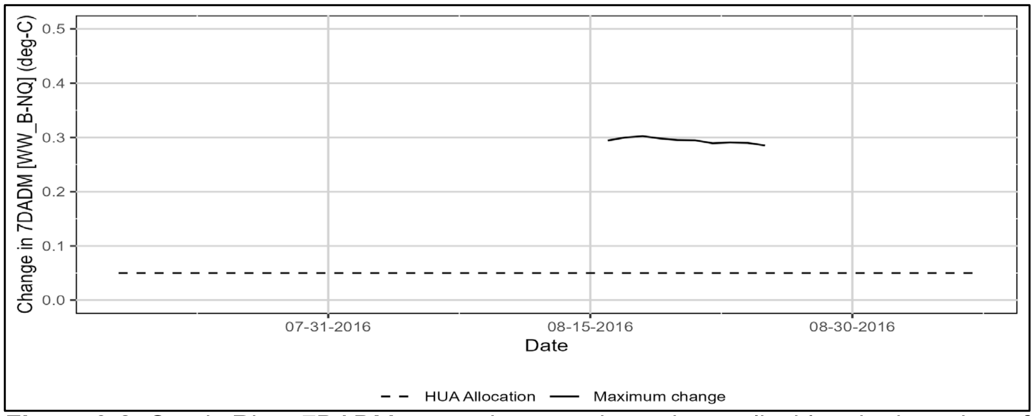


**Figure 9-2:** Sandy River 7DADM temp. changes above the applicable criteria at the reference point (RKM 29.1) from consumptive uses set at 10.1% (WW_B) of natural flow (NQ) by date.

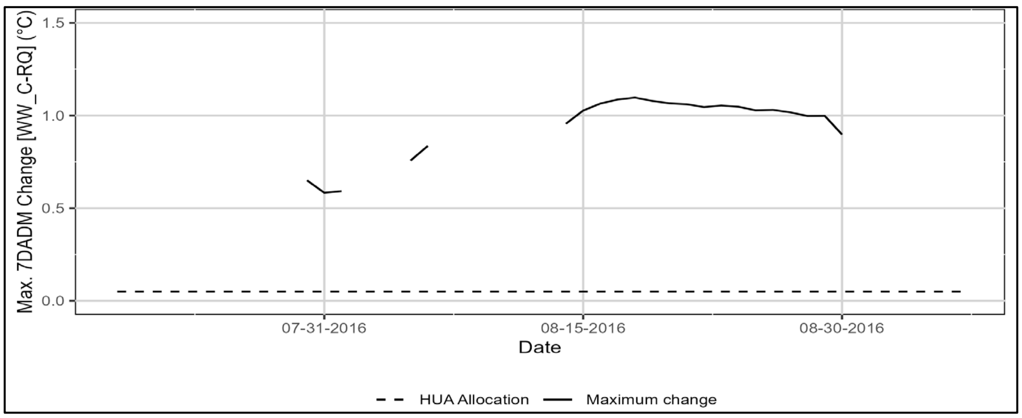


**Figure 9-3:** Sandy River 7DADM temp. changes above the applicable criteria at the reference point (RKM 29.1) from estimated current consumptive uses (WW_C) versus natural flow (NQ) by date.

# 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 5.96°C at the POMI (RKM 54.35) on August 21, 2016, which corresponds to a 7DADM temperature of 18.96°C and applicable temperature criteria of 13.0°C (OAR 340-041-0028(4)(a)). Overall, the maximum 7DADM background scenario water temperature was 22.85°C (RKM 0.00, August 21, 2016), which corresponds to an applicable temperature standard exceedance of 4.85°C (OAR 340-041-0028(4)(c)) (**Figure 10-2**).

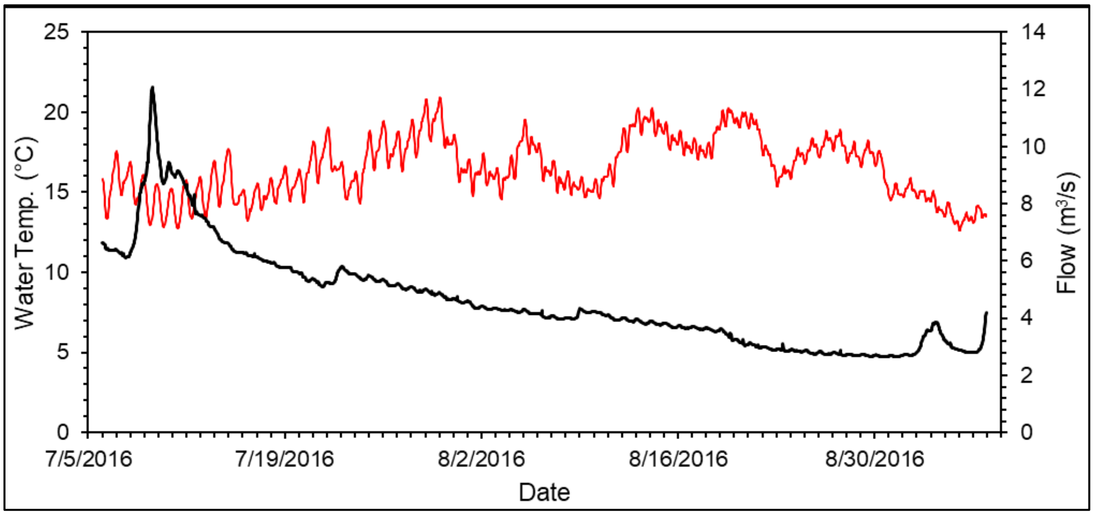


**Figure 10-1:** Bull Run River W2 Background scenario outputs

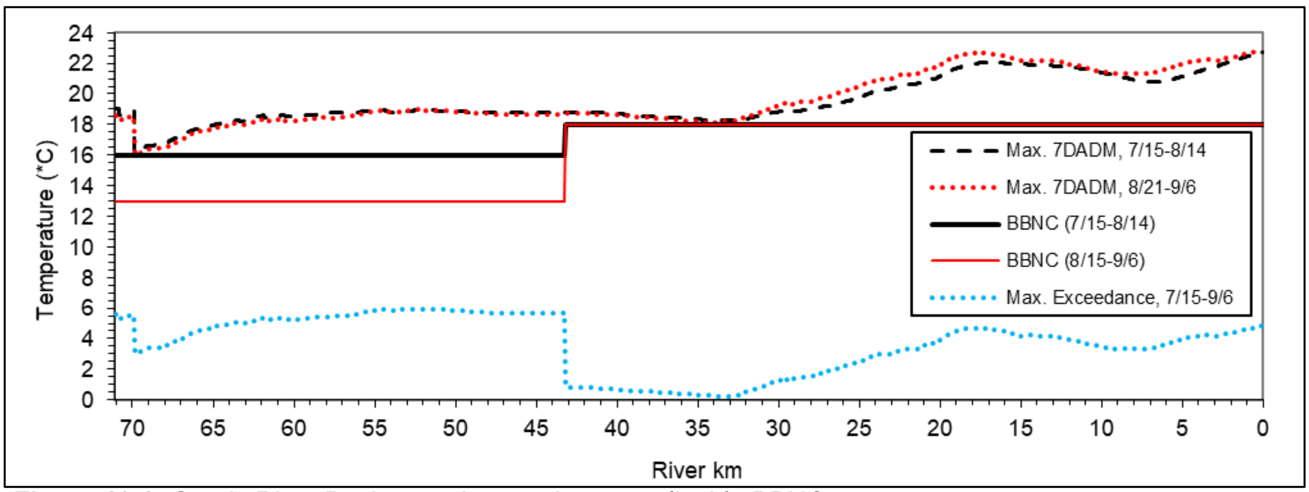


**Figure 10-2:** Sandy River Background scenario vs. applicable BBNC temperatures

# 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 0.96°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 R. 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 | 24.20 |
| | Topo - CCC | Mouth | 0 | 08/31/2016 | 0.69 |

| | | | | | |
|---|---|---|---|---|---|
| | (WT change) | POMI | 21.70 | 08/30/2016 | 0.96 |
| | | POMI (0-29.5 km) | 21.70 | 08/30/2016 | 0.96 |
| | | POMI (29.55-69.90 km) | 34.10 | 08/29/2016 | 0.93 |
| | | POMI (69.95-71.05 km) | 70.55 | 08/30/2016 | 0.12 |

**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 | 18 | 11 | 71.1 | 51.6 | 11.9 | 7.3 | 0.2 |
| City of Portland | 4 | 9 | 5 | 0.7 | 0.7 | 0 | 0 | 0 |
| City of Sandy | 8 | 21 | 13 | 0.7 | 0.3 | 0.3 | 0 | 0 |
| City of Troutdale | 7 | 15 | 8 | 3.2 | 3 | 0.1 | 0 | 0 |
| Clackamas Cty. | 4 | 17 | 13 | 18.3 | 11.8 | 4.8 | 1.6 | 0 |
| Multnomah Cty. | 9 | 16 | 7 | 2.3 | 2.2 | 0 | 0 | 0 |
| ODA | 12 | 23 | 11 | 0.9 | 0.7 | 0.2 | 0 | 0 |
| ODFW | 6 | 22 | 16 | 1.2 | 0.7 | 0.3 | 0.2 | 0 |
| ODF - Private | 8 | 19 | 11 | 25.5 | 19.2 | 4.1 | 2.1 | 0 |
| 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 | 24 | 15 | 14.3 | 8.8 | 2 | 3.3 | 0.2 |
| USFS | 1 | 3 | 2 | 1 | 1 | 0 | 0 | 0 |
| US Gov't. | 9 | 16 | 7 | 0.1 | 0.1 | 0 | 0 | 0 |

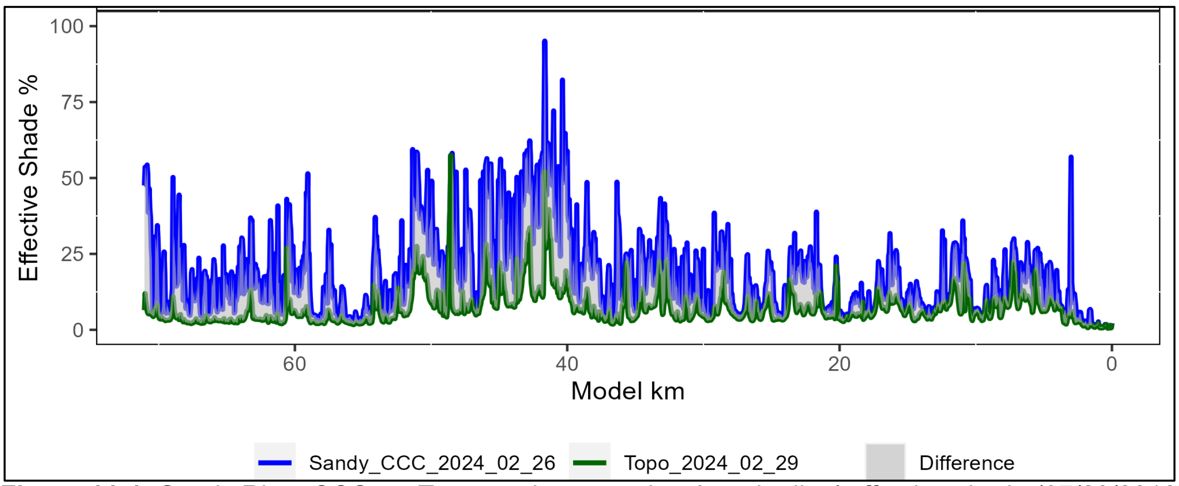

**Figure 11-1:** Sandy River CCC vs. Topography scenarios: Longitudinal effective shade (07/29/2016)

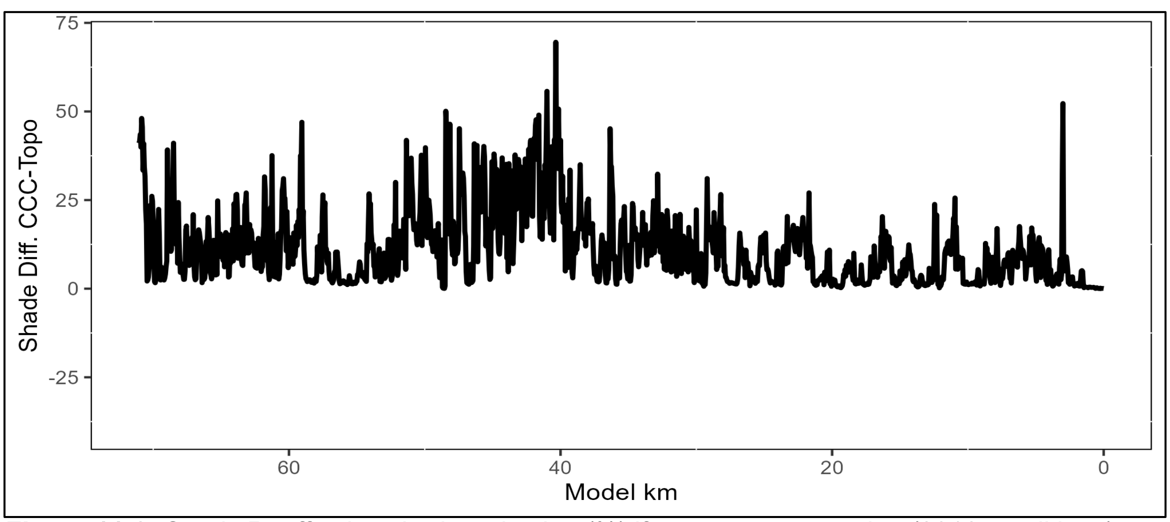

**Figure 11-2:** Sandy R. effective shade reduction (%) if all current vegetation (2016 conditions) were removed

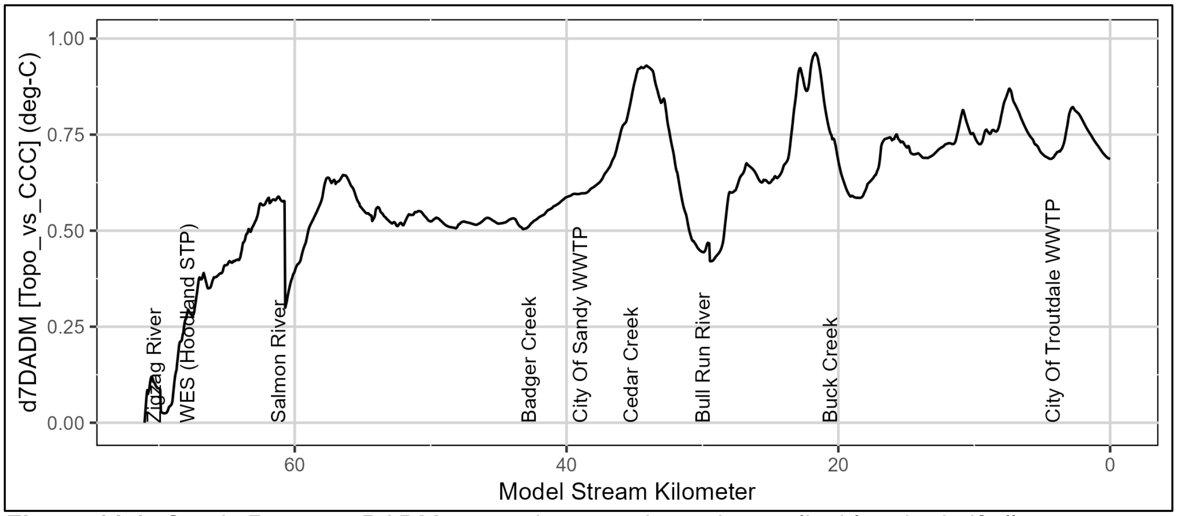


**Figure 11-3:** Sandy R. max. 7DADM temp. changes above the applicable criteria if all current vegetation (2016) were removed.

# 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 were 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 71.05, i.e., the upstream model boundary) on July 23, 2016 (**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 | 21.81 |
| | TT - CCC (WT change) | Mouth | 0 | 07/19/2016 | 2.42 |
| | | POMI | 71.05 | 07/23/2016 | 6.34 |
| | | POMI (0-29.5 km) | 29.50 | 07/28/2016 | 3.88 |
| | | POMI (29.55-69.90 km) | 69.90 | 09/06/2016 | 5.88 |
| | | POMI (69.95-71.05 km) | 71.05 | 07/23/2016 | 6.34 |

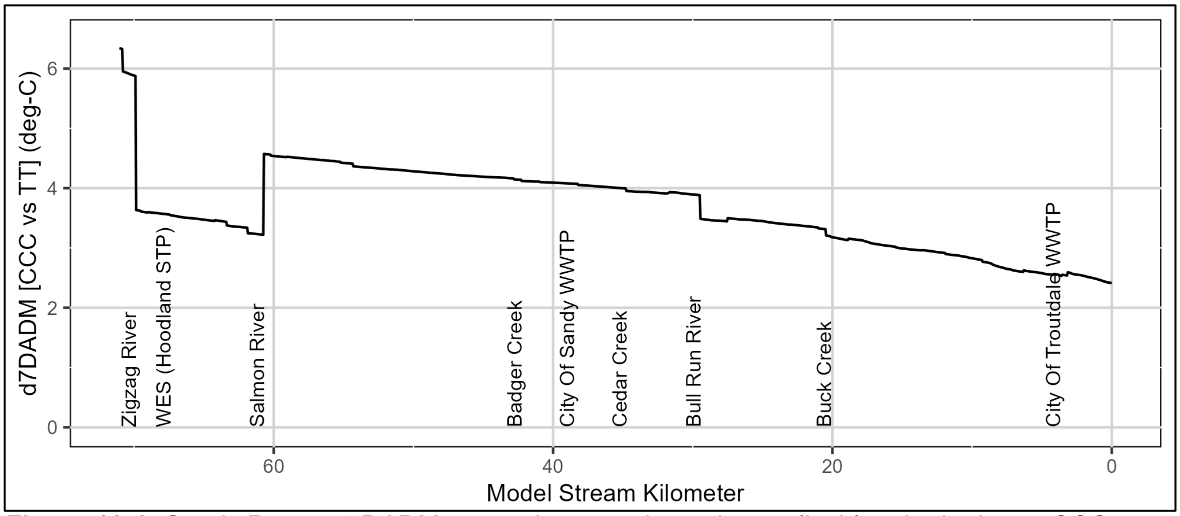


**Figure 12-1:** Sandy R. max. 7DADM temp. changes above the applicable criteria due to CCC exceedances in Sandy R. tributaries

# 13.0 DAM AND RESERVOIR-SPECIFIC WASTELOAD ALLOCATION ASSESSMENT

DEQ modeled a Sandy River "Dam-Only" attainment scenario that represented background conditions except that the Bull Run River tributary inputs to the Sandy River were set to the Sandy River Background scenario inputs for the Bull Run River +0.07°C. The 0.07°C temperature increase was implemented to model conditions under which the Bull Run dam and reservoir operations utilized the entire HUA on the Bull Run River (0.30°C). The Sandy River "Dam-Only" scenario was compared to a Baseline (background) scenario to model the effects of these conditions on Sandy River temperatures.

Specific assumptions of the 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.
- Sandy River tributaries:
    - The Salmon River tributary inputs to the Sandy River were defined as the output from the Salmon Background 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 Background Scenario at the mouth (river km 0.00).
    - The Cedar Creek tributary inputs to the Sandy River were the same as in the Sandy River No Point Sources scenario.
    - All other tributaries and the upstream boundary condition temperatures and flows were set to values used in the CCC model.

Comparison of the Dam-Only scenario to the Baseline scenario (**Figure 13-1**, **Table 13-1**) indicated a maximum 7DADM temperature change of 0.02°C at the POMI (river km 29.45) on July 29, 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) |
| Baseline | Base | Mouth | 0 | 08/18/2016 | 23.16 |
| Dam-Only A | Dam-Only A | Mouth | 0 | 08/18/2016 | 23.17 |
| | Dam-Only - Base (WT change) | Mouth | 0 | 07/19/2016 | 0.02 |
| | | POMI | 29.45 | 07/29/2016 | 0.02 |
| | | POMI (0-29.5 km) | 29.45 | 07/29/2016 | 0.02 |

| | | | | | |
|---|---|---|---|---|---|
| | | POMI (29.55-69.90 km) | 69.90 | 07/23/2016 | 0.00 |
| | | POMI (69.95-71.05 km) | 71.05 | 07/23/2016 | 0.00 |

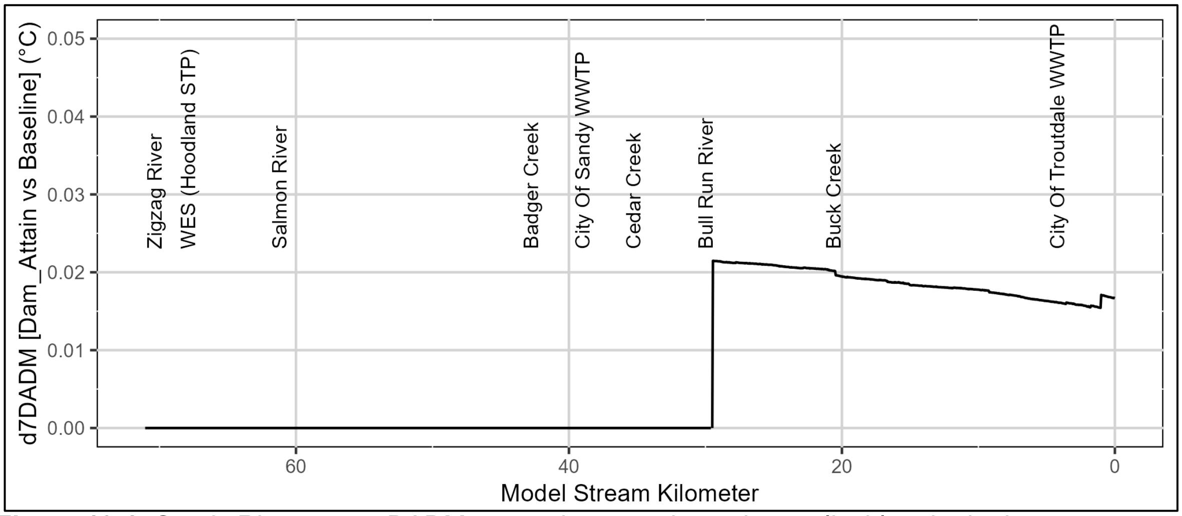


**Figure 13-1:** Sandy River max. 7DADM temp. changes above the applicable criteria due to presence of Bull Run River dams and reservoirs

# 14.0 TRIBUTARY TEMPERATURE (LOAD ALLOCATIONS) ASSESSMENT

DEQ modeled a “Tributary Temperatures Attainment” scenario, which was identical to the Baseline scenario (see Section 13.0) except that the temperatures of most tributaries were increased by +0.07°C throughout the modeling period (note: the upstream boundary condition was increased by +0.03°C vs. the Baseline scenario and the Salmon River was increased by +0.05°C vs. the RV_B scenario). This scenario was compared to the Baseline scenario to determine the Sandy River temperature effects of tributaries discharging at their assigned HUAs. Note that assigned HUAs exclude any Reserve Capacity. No point source discharges were included in this model.

Comparison of the Tributary Temperatures Attainment scenario to the Baseline scenario (**Figure 14-1**, **Table 14-1**) indicated a maximum 7DADM temperature change of 0.05°C at the POMI (river km 29.45) on August 15, 2016, and at the mouth (river km 0.00) of 0.04°C on July 19, 2016.

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

| Scenario | Value type | Location | Max. 7DADM | | |
|---|---|---|---|---|---|
| | | | Model km | Date | WT (°C) |
| Baseline | Base | Mouth | 0 | 08/18/2016 | 23.16 |
| Tributary Attainment (TA) | TA | Mouth | 0 | 08/18/2016 | 23.19 |
| | TA - Base (WT change) | Mouth | 0 | 07/19/2016 | 0.04 |
| | | POMI | 29.45 | 08/15/2016 | 0.05 |
| | | POMI (0-29.5 km) | 29.45 | 08/15/2016 | 0.05 |
| | | POMI (29.55-69.90 km) | 69.85 | 08/26/2016 | 0.05 |
| | | POMI (69.95-71.05 km) | 70.80 | 07/24/2016 | 0.04 |

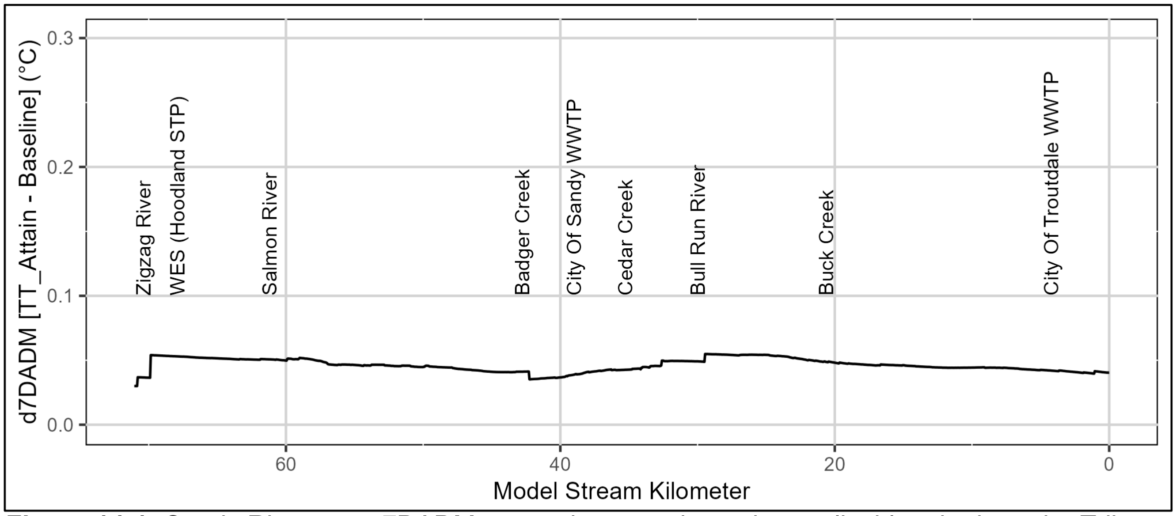


**Figure 14-1:** Sandy River max. 7DADM temp. changes above the applicable criteria under Tributary Temperatures Attainment scenario vs. Baseline.

# 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 HUA (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 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 RV_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.
- Most tributaries' temperatures were increased by +0.07°C vs. the Baseline scenario to account for their assigned human use Load Allocations. Specifically:
    - The Salmon River inputs equaled those of the Sandy River RV_B scenario +0.05°C .
    - The Bull Run River inputs equaled those of the Dam-Only scenario (Section 13.0).
    - The Cedar River inputs equaled (version A) those of the Sandy River CCC scenario (i.e., including the influence of the fish hatchery discharge to the Cedar River) +0.07°C, and (version B) those of the Sandy River WLA_B scenario, (i.e., with relocation of the fish hatchery discharge to the Sandy River) +0.07°C.
    - The upstream boundary condition temperatures equaled those of the Baseline scenario +0.03°C.
    - All other tributaries' temperatures equaled those of the Baseline scenario +0.07°C.
- All other parameters were identical between the Comprehensive Wasteload and Load Allocations Attainment and Baseline scenarios.

For the comparison of the Comprehensive Wasteload and Load Allocations Attainment version A scenario to the Baseline scenario **(Figure 15-1),** the max. 7DADM temperature change was 0.15°C at the POMI (river km 3.10) on September 4, 2016, and 0.14°C at the mouth (river km 0.00) on July 21, 2016. The comparative results of the Comprehensive Wasteload and Load Allocations Attainment version B scenario to the Baseline scenario were similar (**Figure 15-2**), again with a max. 7DADM temperature change of 0.15°C at the POMI (river km 3.10) on September 4, 2016, and 0.14°C at the mouth (river km 0.00) on July 21, 2016.

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

| Scenario | Value type | Location | Max. 7DADM | | |
|---|---|---|---|---|---|
| | | | Model km | Date | WT (°C) |
| Baseline | Base | Mouth | 0 | 08/18/2016 | 23.16 |
| Comprehensive Attainment_A | TT_WLA_A | Mouth | 0 | 08/18/2016 | 23.24 |
| | TT_WLA_A - Base (WT change) | Mouth | 0 | 07/21/2016 | 0.14 |
| | | POMI | 3.10 | 09/04/2016 | 0.15 |
| | | POMI (0-29.5 km) | 3.10 | 09/04/2016 | 0.15 |
| | | POMI (29.55-69.90 km) | 65.95 | 09/05/2016 | 0.14 |
| | | POMI (69.95-71.05 km) | 70.00 | 08/25/2016 | 0.05 |
| Comprehensive Attainment_B | TT_WLA_B | Mouth | 0 | 08/18/2016 | 23.24 |
| | TT_WLA_B - Base (WT change) | Mouth | 0 | 07/21/2016 | 0.14 |
| | | POMI | 3.10 | 09/04/2016 | 0.15 |
| | | POMI (0-29.5 km) | 3.10 | 09/04/2016 | 0.15 |
| | | POMI (29.55-69.90 km) | 65.95 | 09/05/2016 | 0.14 |
| | | POMI (69.95-71.05 km) | 70.00 | 08/25/2016 | 0.05 |

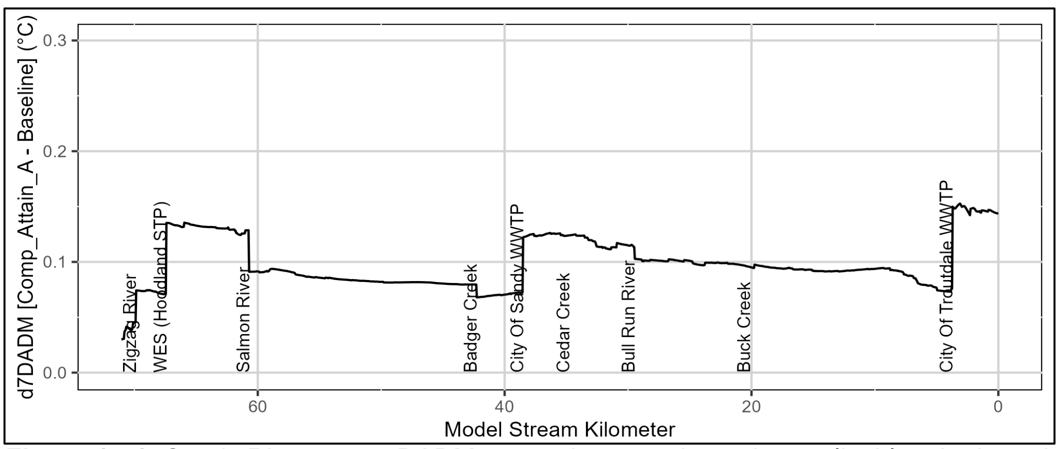


**Figure 15-1:** Sandy River max. 7DADM temp. changes above the applicable criteria under Comprehensive Wasteload and Load Allocations Attainment scenario A vs. Baseline.

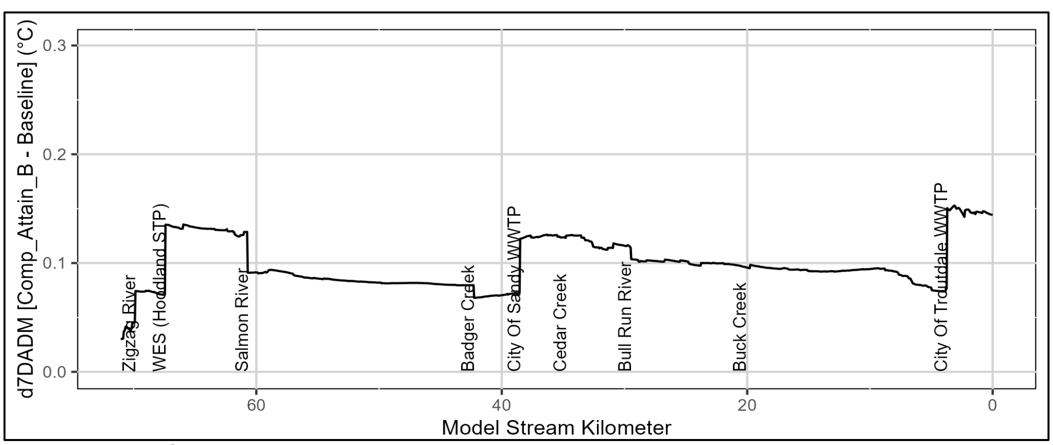


**Figure 15-2:** Sandy River max. 7DADM temp. changes above the applicable criteria under Comprehensive Wasteload and Load Allocations Attainment scenario B vs. Baseline.

# 16.0 REFERENCES


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