

Appendix E

Basis for Natural Thermal Potential Estimation for Allocations

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PUDDING RIVER NATURAL THERMAL POTENTIAL ESTIMATION

DEQ represented current conditions by reviewing hourly temperatures measured between late June and mid October in the Pudding River at three locations near the City of Woodburn. Seven-day average daily maximum (7DADM) temperatures for those three monitoring stations are shown in Figure E- 1. Hourly data for the Site 11530, which is the only station for which data was available for the entire period, is also shown (for the other two stations, data was not available for certain very low flow periods). As shown, 7DADM temperatures exceed the 18°C biologically-based numeric criteria from June through mid-September.

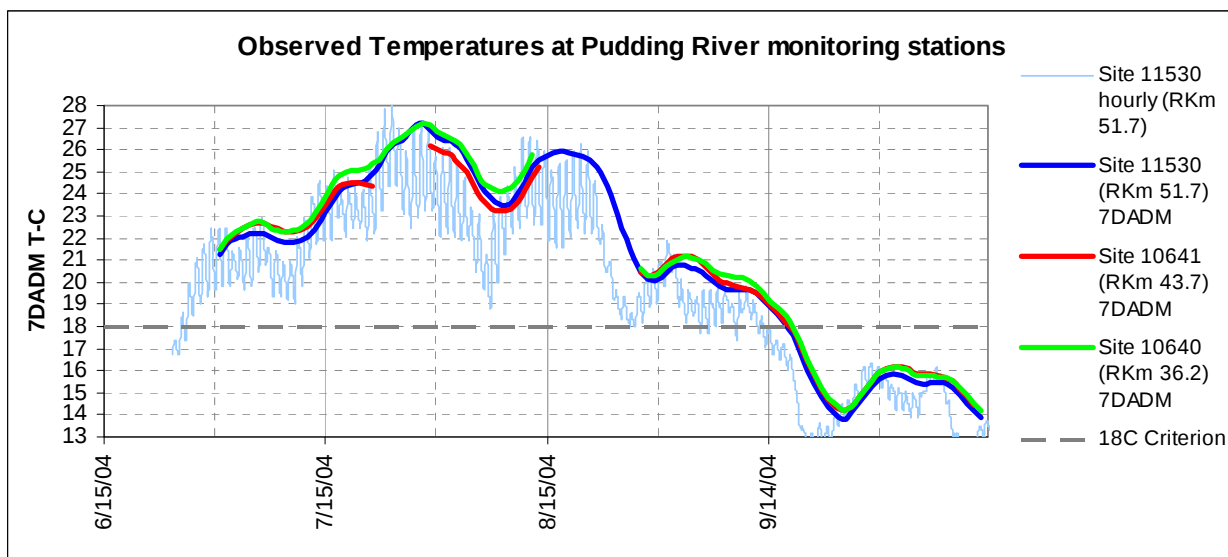


Figure E- 1: Observed temperatures at three Pudding River monitoring stations.

Model calculated current calibrated condition (CCC) and natural thermal potential (NTP) 7DADM temperatures for the three monitoring sites are shown in Figure E- 2, along with observed temperatures. A close-up view of the two weeks modeled is shown in Figure E- 3.

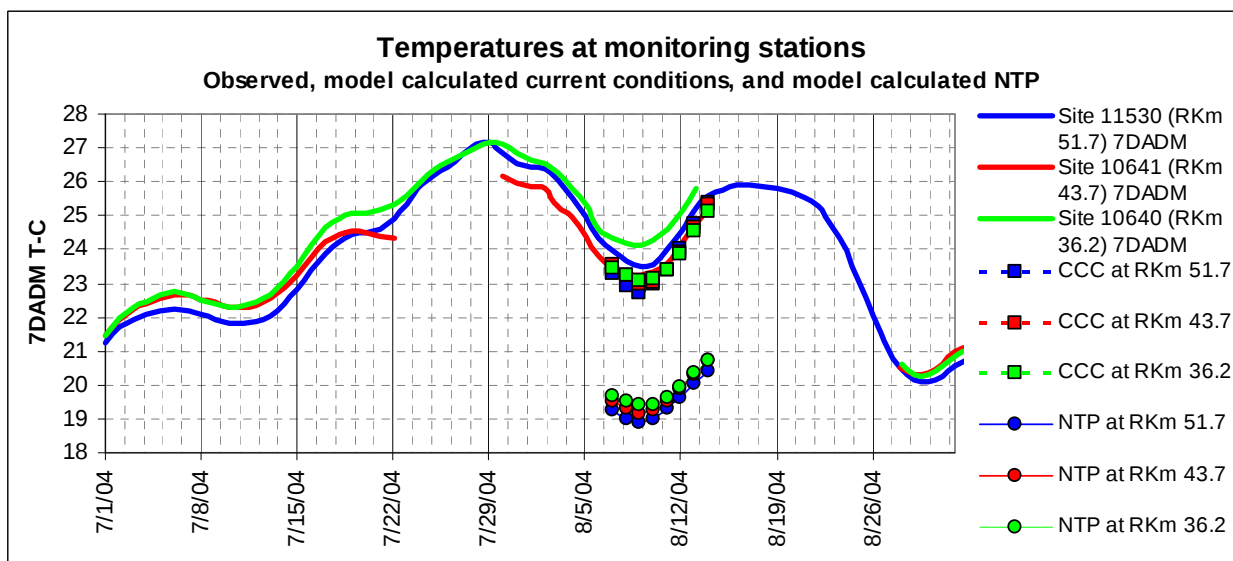


Figure E- 2: Model calculated temperatures at three Pudding River monitoring station locations.

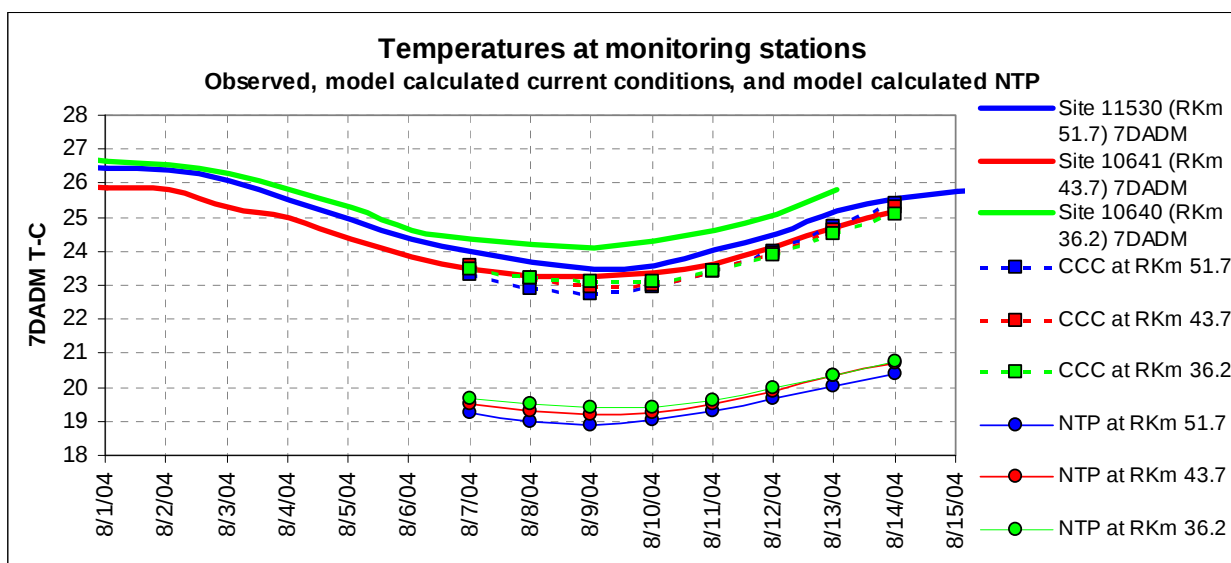


Figure E- 3: Model calculated temperatures at three Pudding River monitoring station locations.

The difference between the model-calculated CCC (average of the 7DADM August 8 – 14) and the model-calculated NTP (average of 7DADM August 8 – 14) for the three monitored locations and the two point source locations are shown in Row 3 of Table E- 1. This difference indicates the reduction in temperature expected to occur in moving from current to NTP conditions.

Table E- 1: Model derived differences between current and natural thermal potential river temperatures.

		RKm 51.7 (Site 11530)	JLR, LLC/Bruce Pac	RKm 43.7 (Site 10641)	Woodburn	RKm 36.2 (Site 10640)
1	Average model calculated CCC temperatures	23.68	23.63	23.75	23.89	23.72
2	Average model calculated NTP temperatures	19.44	19.61	19.71	19.89	19.84
3	Model Calculated $T_{R,CCC}$ to $T_{R,NTP}$ Reduction Amount, 7DADM T °C	-4.24	-4.03	-4.04	-4.00	-3.88

In order to adjust for modeling error and estimate NTP temperatures for all of July and August, differences between model calculated NTP and model calculated current condition temperatures for the two weeks modeled were applied to observed temperatures for all days in July and August.

DEQ based its estimate of observed July and August temperatures on Pudding River temperatures measured in each of three years (2001, 2002, 2004) at Aurora (RKm 12.4, LASAR No. 10917). Since data for 2004 is not available at the Aurora gage before early August 2004, temperature measured at a nearby station, Pudding River at Arndt Road (RKm 7.7, LASAR No. 10362), was used to estimate temperatures at Aurora when Aurora data is not available. Temperature measured at the two stations is quite similar, as shown by a plot of 7DADM temperature at site 10917 vs. 10362 (Figure E- 4) and the high coefficient of determination ($R^2 = 0.9979$). Therefore, the regression equation (shown on plot) can be used to estimate temperature at Aurora (RKm 12.4) from temperature at Arndt Road (RKm 7.7).

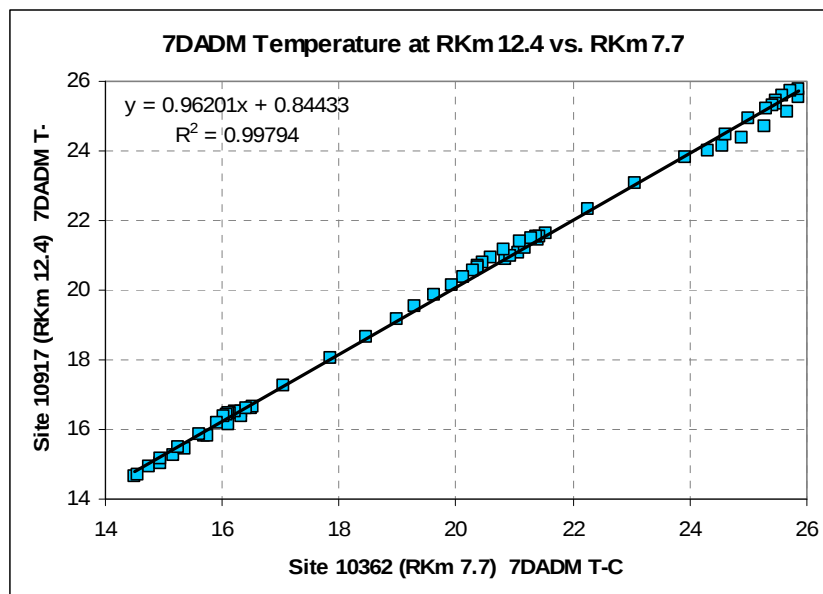


Figure E- 4: Correlation of 7DADM temperature at Aurora to temperature at RKm 7.7

7DADM temperatures for the three years are plotted in Figure E- 5, with values from July 1 through August 10, 2004, estimated via the regression equation in Figure 1E-4. The upper 90th percentiles for every two-week period are indicated with a dashed line in Figure E- 5. As shown in Figure E- 5, 7DADM temperatures vary in response to seasonal, meteorological and other influences, with warmest temperatures occurring during the period from July 15 to August 31. While the times at which maximum temperatures occur vary from year to year, maximum temperatures are similar for all three years. Since the 90th percentiles are very similar for each of the three two-week periods from July 15 to August 31, the July 15 to August 31 time period is treated as a single homogeneous period for purposes of deriving an applicable NTP temperature. 90th percentile 7DADM temperatures, with all data from July 15 to August 31 combined, are shown in Figure E- 6.

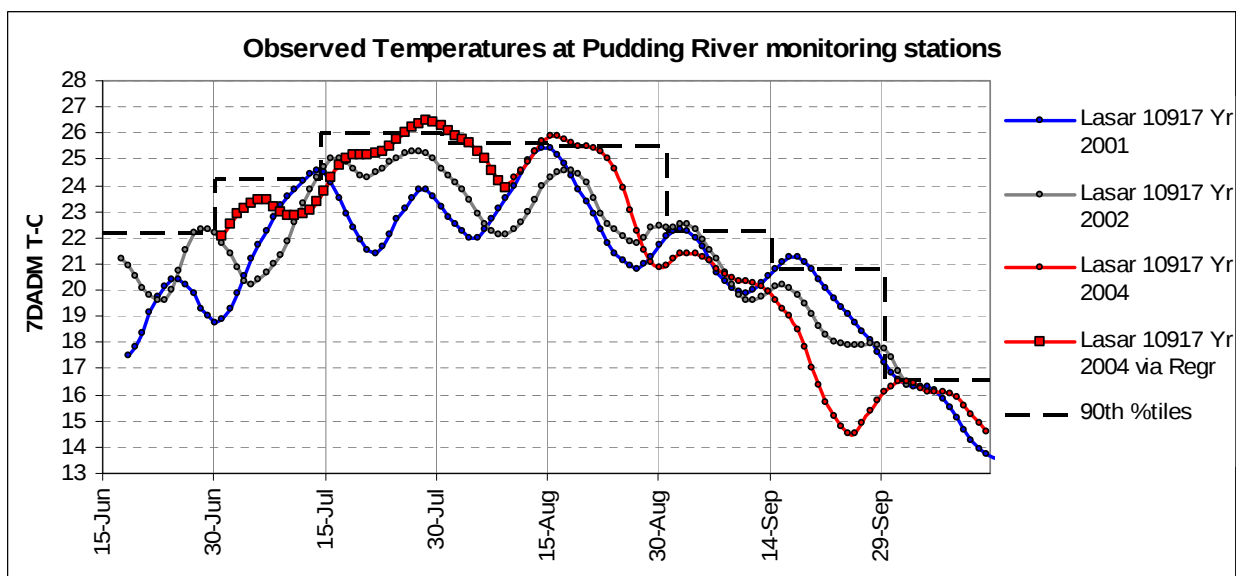


Figure E- 5: Ambient river temperatures and seasonal 90th percentiles.

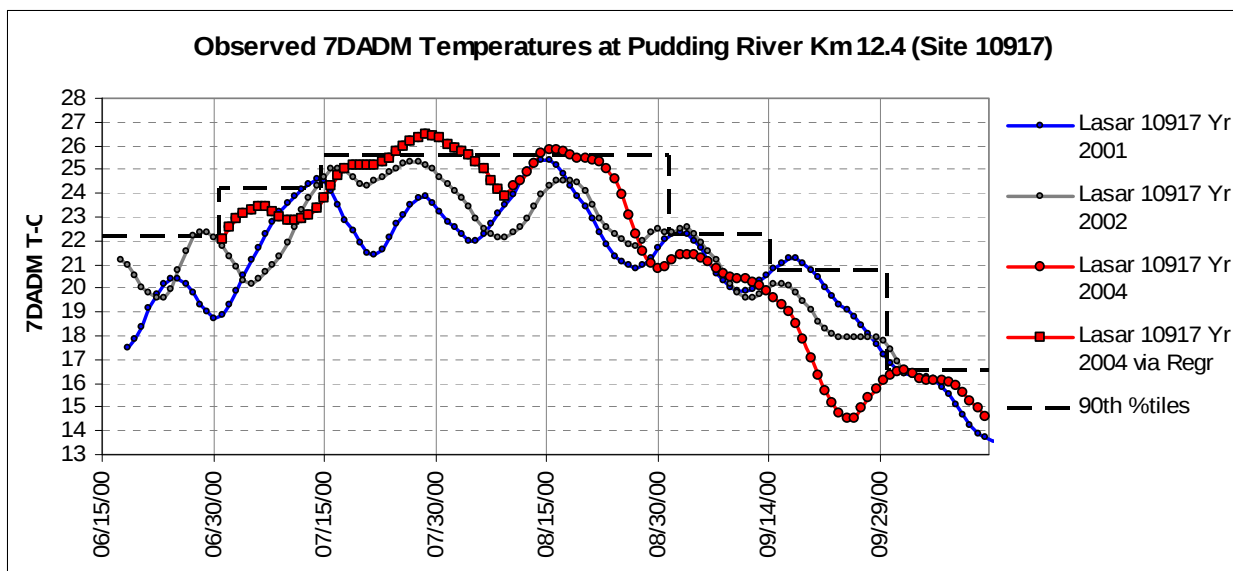


Figure E- 6: Ambient river temperatures and seasonal 90th percentiles (with July 15 to Aug 31 combined).

90th and 75th percentile ambient temperatures at the Aurora gage for each time period are tabulated in Table E- 2. DEQ proposes that use of the 90th percentile to derive the NTP provides a sufficient margin-of-safety because three years of data are used for the analysis.

Table E- 2: Statistics for Aurora gage 7DADM temperature.

Time Period	75 th Percentiles	90 th Percentiles
June 15 to June 30	20.84	22.17
July 1 to July 15	23.41	24.24
July 15 to August 31	25.07	25.60
September 1 to September 15	21.42	22.28
September 15 to September 30	19.70	20.78
October 1 to October 15	16.39	16.54

At the sites near point sources where NTP temperatures must be derived (RKm 51.7, RKm 43.7, and RKm 36.2), only data from 2004 is available. Therefore, to estimate 90th percentiles for these sites based on multiple years of data rather than just a single year, DEQ correlated 2004 temperatures measured at sites near the point sources with temperature measured at the Aurora gage (RKm 12.4). As shown by Figure E- 7, daily maximum temperatures at the sites near the point sources are similar to temperatures measured at the lower river sites. The correlations are presented in Figure E- 8 to Figure E- 10. Fewer high temperature data are available for RKm 43.7 and RKm 36.2 because of occasional failures of these thermistors during low flows. but, even so, coefficients of determination, R^2 , exceed 0.99 for all three correlations (an $R^2 = 1$ would be a perfect correlation).

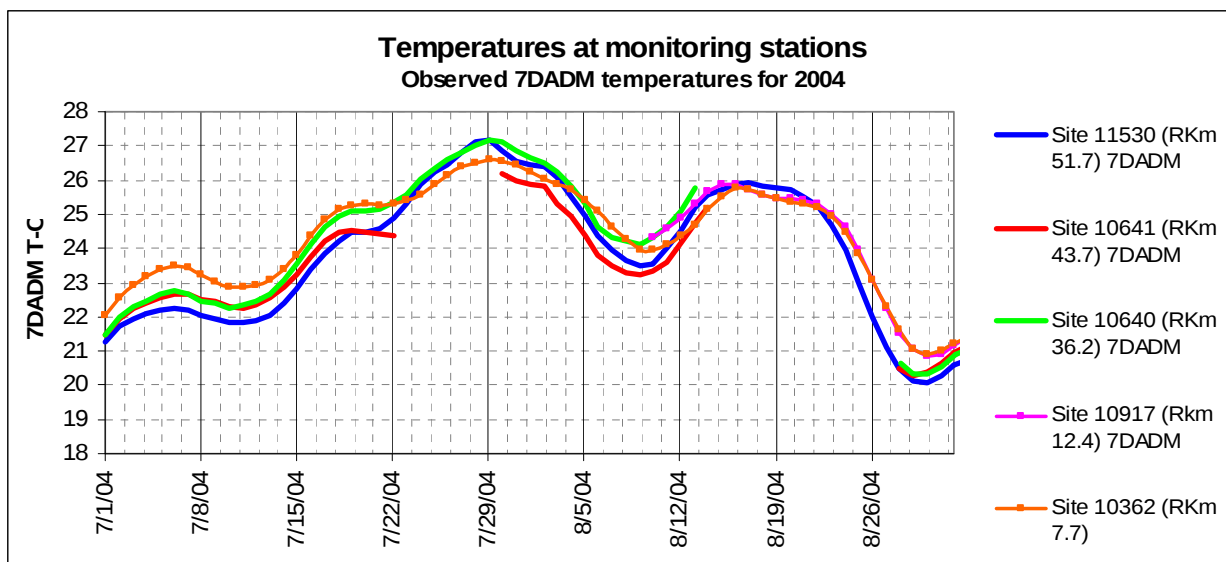


Figure E- 7: Ambient 7DADM temperatures for various sites for 2004.

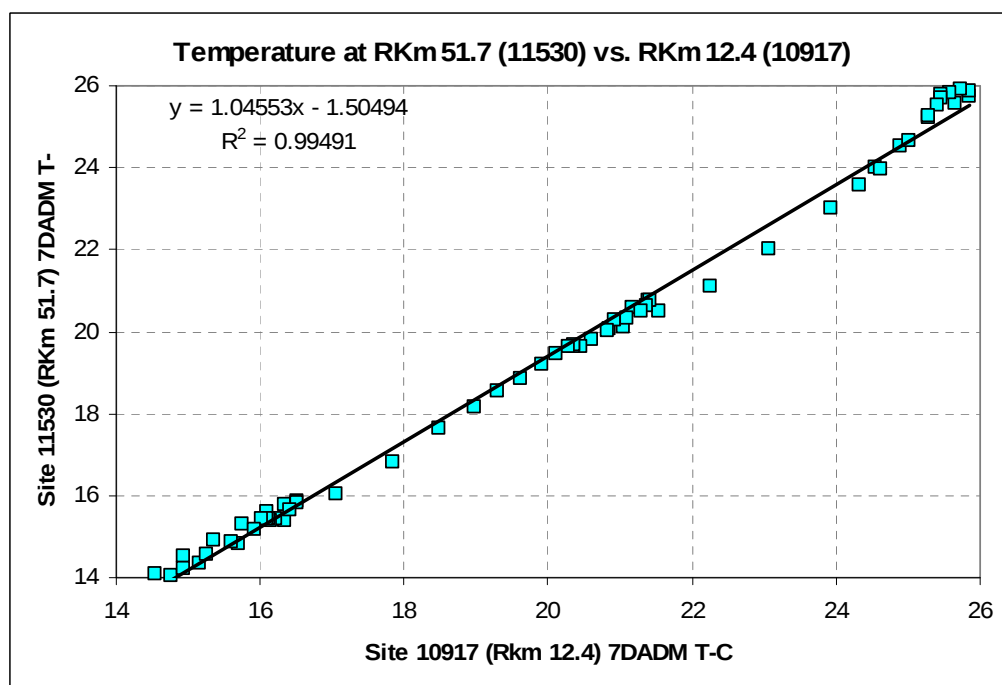


Figure E- 8: Correlation of temperature at Rkm 51.7 to temperature at Aurora.

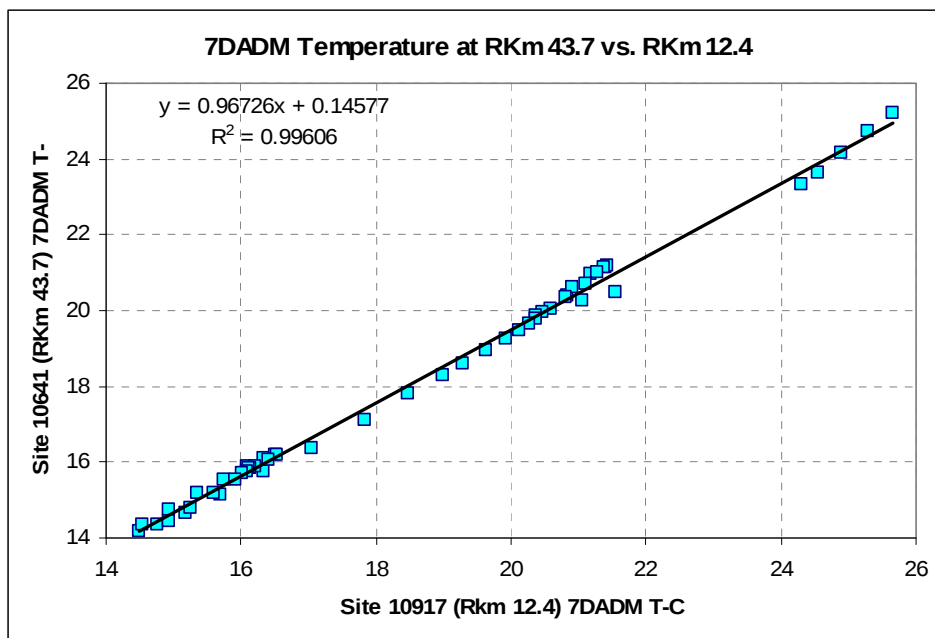


Figure E- 9: Correlation of temperature at Rkm 43.7 to temperature at Aurora.

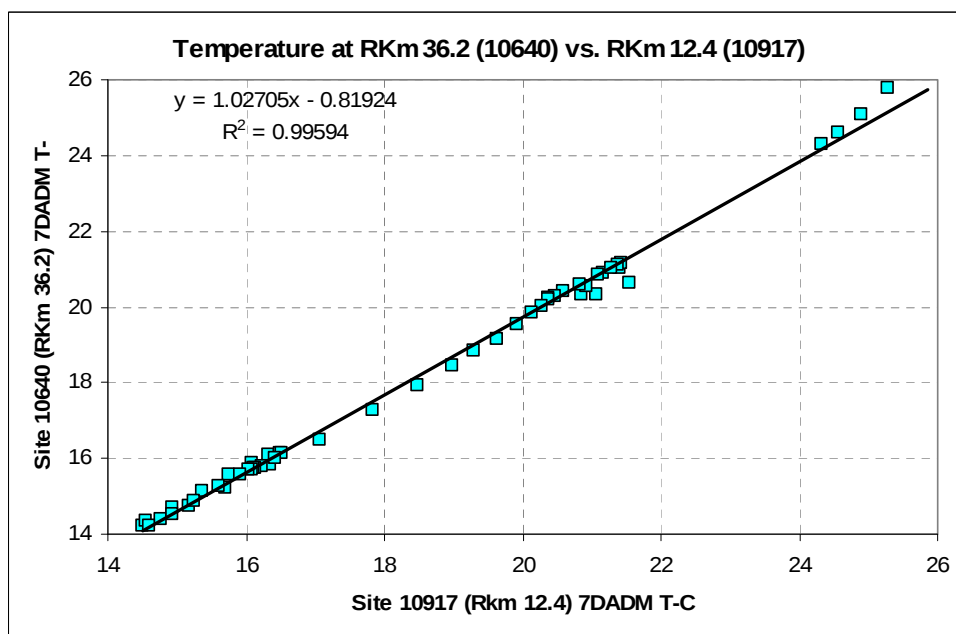


Figure E- 10: Correlation of temperature at Rkm 36.2 to temperature at Aurora.

The 90th percentile measured temperature at the Aurora gage for the period July 15 – August 30 is 25.60. Entering this to the regression equations provides the values shown in Table 1E-3, Row 4. As shown, temperatures were similar for the three sites and ranged from 24.9 to 25.5 °C. Differences between model calculated CCC and NTP temperatures (Table E- 3, Row 3) were applied to the estimated 90th percentile ambient temperatures (Table E- 3, Row 4) to derive estimated 90th percentile NTP temperatures for the monitoring sites (Table E- 3, Row 5). This accounts for deviations between observed and model calculated temperatures and, therefore, corrects for modeling error. NTP temperatures at the effluent discharge locations were then

estimated via linear interpolation (Table E- 3, Row 5, values for JLR, LLC/Bruce Pac and Woodburn). Since these values of 20.9 and 21.6°C exceed the 18°C biologically-based numeric criteria, they become the applicable criteria.

Table E- 3: Applicable NTP temperatures (°C) – July 15 to August 31.

		RKm 51.7 (Site 11530)	JLR, LLC/Bruce Pac	RKm 43.7 (Site 10641)	City of Woodburn WWTP	RKm 36.2 (Site 10640)
1	Average model calculated CCC temperatures	23.68	23.63	23.75	23.89	23.72
2	Average model calculated NTP temperatures	19.44	19.61	19.71	19.89	19.84
3	Model Calculated $T_{R,CCC}$ to $T_{R,NTP}$ Reduction Amount, 7DADM temperature	-4.24	-4.03	-4.04	-4.00	-3.88
4	90th %tile observed 7DADM July 15 to August 31 Temperature	25.26	NA	24.90	NA	25.47
5	7DADM NTP Temperatures	21.02	20.9	20.86	21.6	21.59

The same approach was used for other time periods between June 1 and September 30. For the June 15 to June 30 time period, the measured 90th percentile ambient temperature at Aurora is 22.17°C. Entering this value to the regression equations results in the values shown in Table E- 4, Row 2. Applying the model derived differences between current and NTP temperatures to these values results in NTP temperatures for each of the point sources (Table E- 4, Row 3). Note that since the value at JLR, LLC/Bruce Pac is less than 18°C, 18°C is the applicable criterion.

Table E- 4: Applicable NTP temperatures (°C) – June 15 to June 30.

		RKm 51.7 (Site 11530)	JLR, LLC/Bruce Pac	RKm 43.7 (Site 10641)	City of Woodburn WWTP	RKm 36.2 (Site 10640)
1	Model Calculated $T_{R,CCC}$ to $T_{R,NTP}$ Reduction Amount, 7DADM Temperature	-4.24	-4.03	-4.04	-4.00	-3.88
2	90th %tile observed 7DADM July 1 to July 15 temperature	21.68	NA	21.59	NA	21.95
3	7DADM NTP Temperatures	17.44	17.5	17.55	18.1	18.07

For the July 1 to July 14 time period, the measured 90th percentile ambient temperature at Aurora is 24.24°C. Entering this value to the regression equations results in the values shown in Table E- 5, Row 2. Applying the model derived differences between current and NTP temperatures to these values results in NTP temperatures for each of the point sources (Table E-5, Row 3).

Table E- 5: Applicable NTP temperatures – July 1 to July 14.

		RKm 51.7 (Site 11530)	JLR, LLC/Bruce Pac	RKm 43.7 (Site 10641)	City of Woodburn WWTP	RKm 36.2 (Site 10640)
1	Model Calculated $T_{R,CCC}$ to $T_{R,NTP}$ Reduction Amount, 7DADM Temperature	-4.24	-4.03	-4.04	-4.00	-3.88
2	90th %tile observed 7DADM	23.84	NA	23.60	NA	24.08

	July 1 to July 14 Temperature					
3	7DADM NTP Temperatures	19.60	19.6	19.56	20.1	20.20

For the Sept 1 to Sept 15 time period the measured 90th percentile ambient temperature at Aurora is 22.28°C. Entering this value to the regression equations results in the values shown in Table E- 6, Row 2. Applying the model derived differences between current and NTP temperatures to these values results in NTP temperatures for each of the point sources (Table E- 6, Row 3). Note that as for June 15 to June 30, since the value at JLR, LLC/Bruce Pac is less than 18°C, 18°C is the applicable criterion. This is also the case for the rest of the year from September 15 through June 15 at both JLR, LLC/Bruce Pac and Woodburn. Applicable criteria for the Pudding River for the location of the City of Woodburn WWTP discharge are shown in Figure E-11 along with current ambient river temperatures.

Table E- 6: Applicable NTP temperatures – September 1 to September 15.

		RKm 51.7 (Site 11530)	JLR, LLC/Bruce Pac	RKm 43.7 (Site 10641)	City of Woodburn WWTP	RKm 36.2 (Site 10640)
1	Model Calculated $T_{R,CCC}$ to $T_{R,NTP}$ Reduction Amount, 7DADM Temperature	-4.24	-4.03	-4.04	-4.00	-3.88
2	90th %tile observed 7DADM July 1 to July 14 Temperature	21.79	NA	21.70	NA	22.06
3	7DADM NTP Temperatures	17.55	17.7	17.66	18.2	18.18

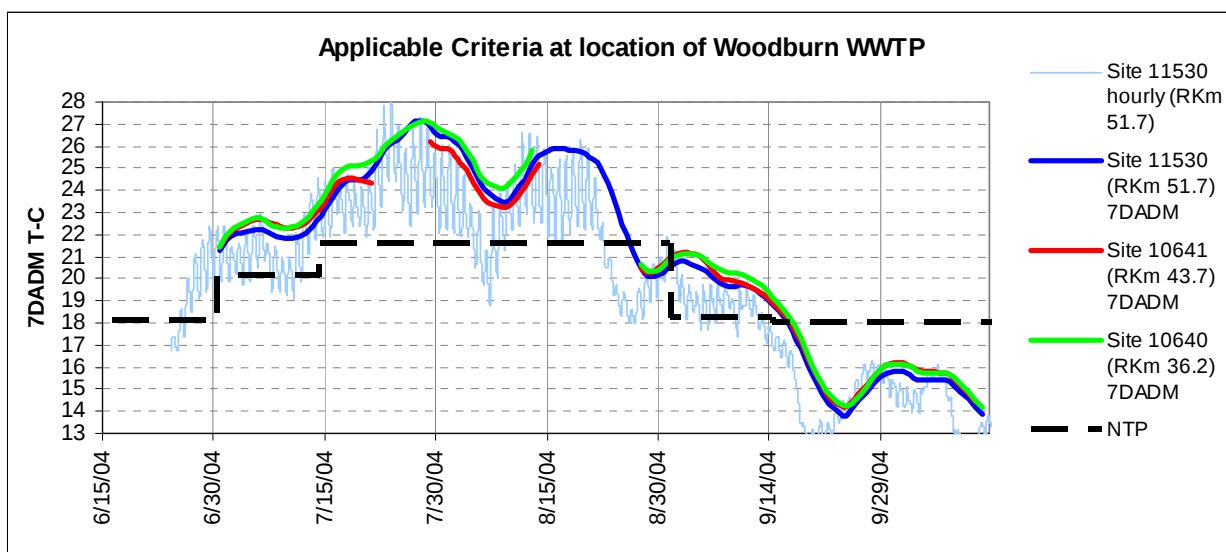


Figure E- 11: Applicable criteria for Pudding River at location of City of Woodburn discharge.

MOLALLA RIVER NATURAL THERMAL POTENTIAL ESTIMATION

DEQ used similar methodology to estimate the NTP for locations in the Molalla River, as used for the Pudding River, but considered the higher uncertainty associated with the Molalla River temperature model and the additional spawning criteria that apply in the Molalla River and its tributaries. DEQ estimated NTP values before and after the two-week model period, with appropriate margins-of-safety, for all seasons in which the 18°C or 13°C biological criteria would potentially be exceeded. The uncertainty associated with the Molalla River model is slightly

greater than that associated with the Pudding River model and only two years of continuous current temperatures were available (2002 and 2004), so DEQ used a larger margin of safety in estimating NTP between June 1 and September 30.

Rather than subtracting the average differences between current calibration condition (CCC) temperatures and NTP temperatures (for the model period) from the 90th percentile of observed current temperatures, DEQ subtracted the maximum difference between CCC modeled temperatures and NTP temperatures from the median of observed temperatures. Figure E- 12 shows the observed continuous temperature data from the Molalla River at Knights Bridge Road (river mile 1.5) from 2002 and 2004. The median temperature for each two week period is indicated with a dashed line in the figure.

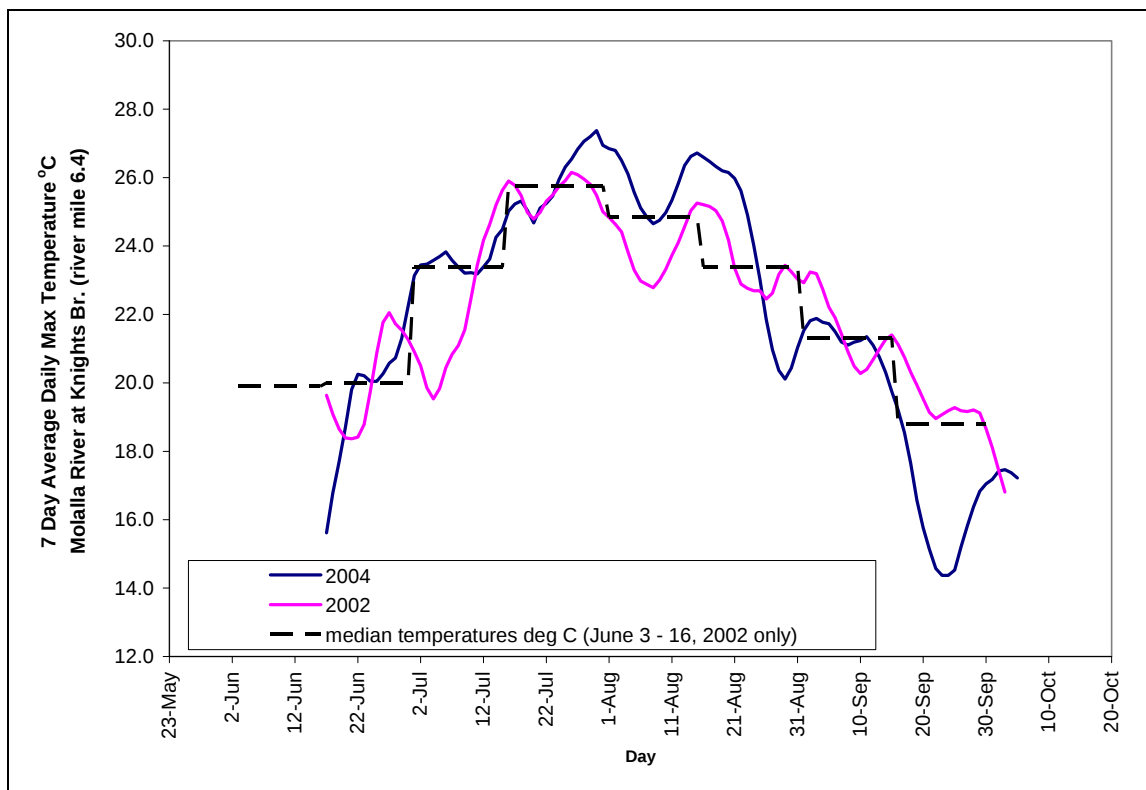


Figure E- 12: Observed temperatures at Molalla River at Knights Bridge (river mile 6.4) in 2002 and 2004. Median temperatures (°C) indicated with dashed line.

Temperatures measured at Molalla River at Knights Bridge Rd. in 2004 were used to predict median temperatures at other locations on the Molalla River based on the regression equations shown in Figure E- 13 and Figure E- 14. The maximum temperature difference between the calibrated condition model and the natural thermal potential model (2.8 °C) is subtracted from the median observed temperatures to obtain the NTP at a particular monitoring location. The median observed temperature and the NTP temperatures for locations between monitoring sites were derived by linear interpolation.

Tables Table E- 7 through Table E- 10 summarize the NTP temperatures derived at three locations on the Molalla River and interpolated values at river mile 17, where Sanders Wood Products, Inc./RSG is located and at river mile 21.6, where the Molalla Drinking Water Treatment Plant is located. Table E- 11 summarizes the applicable temperature criteria that apply at Molalla River mile 17. Table E- 12 summarizes the applicable temperature criteria that apply at Molalla River mile 21.6. Spawning season at river mile 21.6 extends from October 15 – June 15.

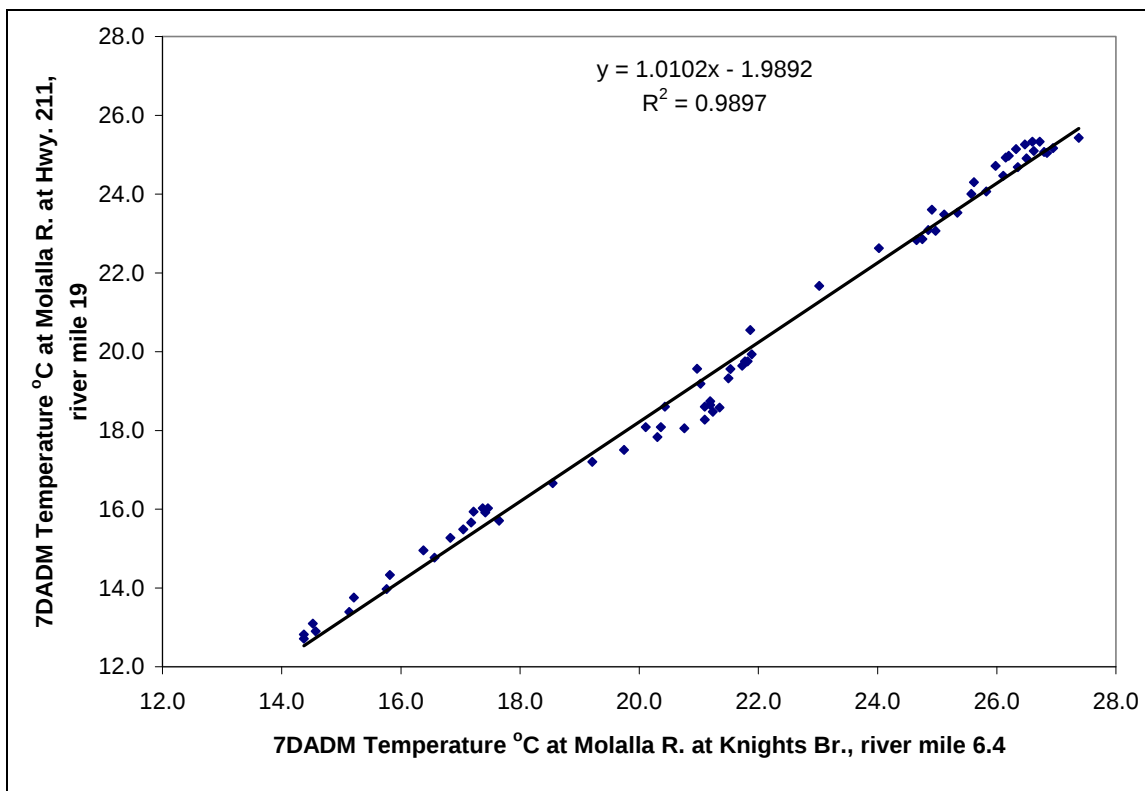


Figure E- 13: Comparison of 2004 7DADM temperatures from Molalla River at Knights Bridge Rd. (river mile 6.4) and Molalla River at Hwy. 211 (river mile 19).

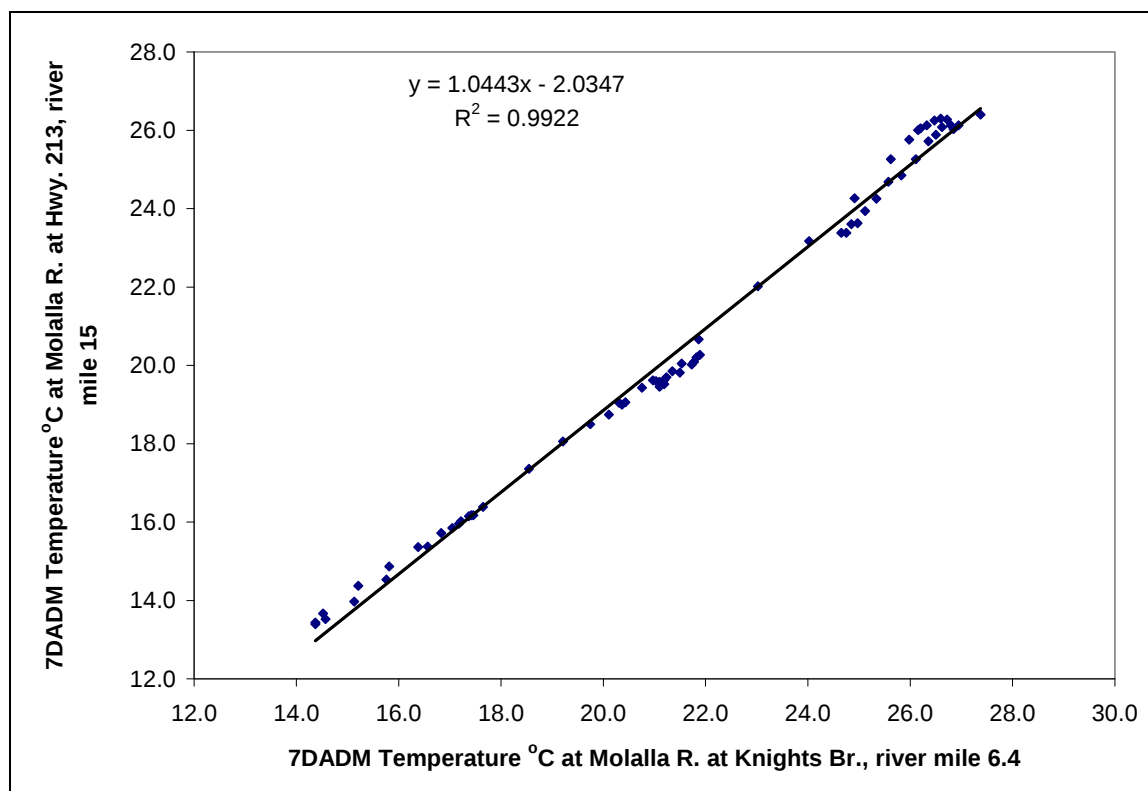


Figure E- 14: Comparison of 2004 7DADM temperatures from Molalla River at Knights Bridge Rd. (river mile 1.5) and Molalla River at Hwy. 213 (river mile 6.4).

Table E- 7: Applicable NTP temperatures July 1 – 15.

	Molalla River at Hwy. 213 (RM 15)	Sanders/RSG (River Mile 17)	Molalla River at Hwy. 211 (River Mile 19)	Molalla DWP (River Mile 21.6)	Molalla River u/s North Fork (River Mile 26.5)
Maximum difference CCC – NTP (T °C)	2.8		2.8		2.8
median observed 7DADM July 1- 15 Temperature (T °C)	22.4		21.6		19.9
7DADM NTP Temperatures (T °C) July 1 - 15	19.6	19.2	18.8	18.2	17.1

Table E- 8: Applicable NTP temperatures July 16 - 31.

	Molalla River at Hwy. 213 (RM 15)	Sanders/RSG (River Mile 17)	Molalla River at Hwy. 211 (River Mile 19)	Molalla DWP (River Mile 21.6)	Molalla River u/s North Fork (River Mile 26.5)
Maximum difference CCC – NTP (T °C)	2.8		2.8		2.8
median observed 7DADM July 16 - 31 Temperature (T °C)	24.7		23.9		22.0
7DADM NTP Temperatures July 16 – 31 (T °C)	21.9	21.5	21.1	20.4	19.2

Table E- 9: Applicable NTP temperatures August 1 - 15.

	Molalla River at Hwy. 213 (RM 15)	Sanders/RSG (River Mile 17)	Molalla River at Hwy. 211 (River Mile 19)	Molalla DWP (River Mile 21.6)	Molalla River u/s North Fork (River Mile 26.5)
Maximum difference CCC – NTP (T °C)	2.8		2.8		2.8
median observed 7DADM August 1 - 15 Temperature (T °C)	23.9		23.1		21.3
7DADM NTP Temperatures August 1 -15 (T °C)	21.1	20.7	20.3	19.7	18.5

Table E- 10: Applicable NTP temperatures August 16 - 31.

	Molalla River At Hwy. 213 (RM 15)	Sanders/RSG (River Mile 17)	Molalla River at Hwy. 211 (River Mile 19)	Molalla DWP (River Mile 21.6)	Molalla River u/s North Fork (River Mile 26.5)
Maximum difference CCC – NTP (T °C)	2.8		2.8		2.8
median observed 7DADM August 16 - 31 Temperature (T °C)	22.3		21.5		19.8
7DADM NTP Temperatures August 16 -31 (T °C)	19.5	19.1	18.7	18.1	17.0

Table E- 11: Summary of applicable temperature criteria at river mile 17 on the Molalla River.

Time period	Applicable Criteria, T_c (°C)
October 15 – May 15	13.0
June 15 to June 30	18.0
July 1 to July 15	19.2
July 16 to July 31	21.5
August 1 - 15	20.7
August 16 - 31	19.1
September 1 to October 14	18.0

Table E- 12: Summary of applicable temperature criteria at interpolated for river mile 21.6 on the Molalla River.

Spawning is October 15 – June 15.

Time period	Applicable Criteria, T_c (°C)
October 15 – June 15	13.0
June 16 to June 30	16.0
July 1 to July 15	18.2
July 16 to July 31	20.4
August 1 - 15	19.7
August 16 - 31	18.1
September 1 to October 14	16.0