ATTACHMENT C – MODELING STREAMFLOW AND WATER TEMPERATURE IN THE BITTERROOT RIVER, MONTANA – ADDENDUM A

MODELING STREAMFLOW AND WATER TEMPERATURE IN THE BITTERROOT RIVER, MONTANA – ADDENDUM A.

Darrin Kron and Kyle Flynn

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Water Quality Planning Bureau
Watershed Modeling Program
1520 East Sixth Avenue, PO Box 200901
Helena, MT 59620-0901
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SUMMARY

A QUAL2K model was completed to support temperature TMDL development for the Bitterroot River and several of its tributaries by the Montana Department of Environmental Quality (Kasch et al, 2009). Model calibration was completed and restoration scenarios were simulated during a prior effort. This addendum adds an additional wastewater treatment plant discharge scenario to the prior effort. The results of this addendum are used to demonstrate the effects of future wastewater conditions upon the Bitterroot River and will be used as a technical basis for the Bitterroot River TMDL wasteload allocation (WLA) approach.

1.0 INTRODUCTION

A QUAL2K model was competed to support TMDL development for the Bitterroot River and several of its tributaries by the Montana Department of Environmental Quality (Kasch et al, 2009). An additional scenario was needed for TMDL analysis. This addendum represents a scenario to determine the thermal impacts of future wastewater treatment plant (WWTP) effluent conditions to the Bitterroot River. Results will be used for technical justification of thermal WLAs to the Bitterroot River.

2.0 METHODS AND MATERIALS

This addendum uses the same study area and exact model as described in the report *Modeling Streamflow and Water Temperature in the Bitterroot River* (Kasch, M. et al, 2009). All climate, shade, water discharge, water temperature, stream network and calibrated model parameters were identical to those used during the 2009 modeling effort. The baseline comparison in this report is the same as the calibrated baseline model scenario with all the WWTP discharges turned off provided in *Table 10-23* of *Kasch et al, 2009*.

Additionally, mixing calculations for existing peak hourly WWTP discharge rates mixed with a 7Q10 instream flow condition during average summer afternoons are provided in **Table 2-1** for comparison to the additional WWTP discharge scenario provided below. Although, this is not the condition which the additional scenario is compared to within the model framework for this report, the mixing calculations are a useful tool for comparison of existing thermal effects to future effects if WWTP sources were to discharge at WLA conditions.

Table 2-1. Data and mixing calculations for existing WWTP discharge at hourly peak flow conditions

	Darby	Hamilton	Stevensville	Lolo
Upstream Discharge at 7Q10 (cfs)	120	152	159	392
Upstream Temperature (F˚)	63.4	66.7	68.5	70.2
Effluent Discharge hourly Peak Flow (cfs)	1.18	3.54	2.12	1.23
Effluent Temperature (F˚)	69.0	70.5	69.0	70.5
Mixed Instream Temperature (F˚)	63.5	66.8	69.5	70.2
Mixed Instream Δ T due to Effluent (F˚)	0.055	0.087	-0.007	0.001

A single additional QUAL2K model scenario was completed in this addendum. The scenario is based upon efforts to determine TMDL thermal wasteload allocations (WLAs) for the Bitterroot River. The WLAs will include individual thermal wasteload allocations to Darby, Hamilton, Stevensville, and Lolo, and in this scenario, all WWTPs were allowed to discharge at double their current rate or their current design flow, whichever was greater (i.e. Effluent Peak Flow from **Table 2-2**). For this scenario, hourly peak discharge rates were estimated based upon average monthly conditions and technical guidance from *DEQ Circular 2*, Figure 1 and used for discharge scenarios since hourly conditions may affect the fishery. **Table 2-2** provides model input conditions of each effluent along with mixing calculation results for 7Q10 instream flow condition.

Table 2-2. WWTP scenario input data for estimated future increased discharge rates and mixing calculations for a 7Q10 flow				
	Darby	Hamilton	Stevensville	Lolo
Upstream Discharge at 7Q10 (cfs)	120	152	159	392
Upstream Temperature (F˚)	63.4	66.7	68.5	70.2
Effluent Discharge hourly Peak Flow (cfs)	2.36	10.30	4.25	2.47
Effluent Temperature (F˚)	69.0	70.5	69.0	70.5
Mixed Instream Temperature (F˚)	63.5	66.9	69.5	70.2
Mixed Instream Δ T due to Effluent (F˚)	0.108	0.241	-0.013	0.002

The mixing calculations provide some utility regarding the effects of each discharge upon critical low-flow conditions. Yet it is also prudent to run the proposed WLA scenario within the temperature QUAL2K model to represent interactions between discharges and compare results to a condition without WWTP discharges. The modeled stream flow condition described in *Kasch et al, 2009* differs from the 7Q10, but is typical of a moderately dry water year during summer low flow conditions. Therefore, the mixing calculation results in **Table 2-1** are provided to identify the initial effects of the wastewater effluents upon instream temperatures at a critical low flow. These do not however reflect cumulative system impacts. Undoubtedly, affects from additional heat load, heat attenuation from the stream, and volumetric heat capacity of the stream are of importance. Hence, the QUAL2K model scenario was completed to determine the cumulative impacts of wastewater sources and associated changes in volumetric heat capacity of the Bitterroot River. The combined results from both the mixing calculations at 7Q10 critical flow and the additional QUAL2K WWTP modeling scenario will be used in conjunction as a technical basis for justification of thermal wasteload allocations to the Bitterroot River.

3.0 RESULTS AND DISCUSSION

When comparing modeling results from the additional WWTP scenario to a scenario where no WWTP sources are present, the total cumulative thermal impact from all WWTP WLAs was determined. Modeling results indicate the initial thermal shift due to each effluent when compared to the condition with no WWTP effluents is small (approximately <±0.15 degrees C) (**Figure 3-1**). The modeled initial thermal impacts are fairly small magnitude and are somewhat similar to those found at critical low flow 7Q10 conditions provided in **Table 2-2** despite the fact that there was a much higher stream discharge rate in the modeled scenario. Likewise, depending on whether the receiving water temperature was above or below that of the wastewater discharge, there was either an initial increase or decrease in temperature due to the difference in temperatures.

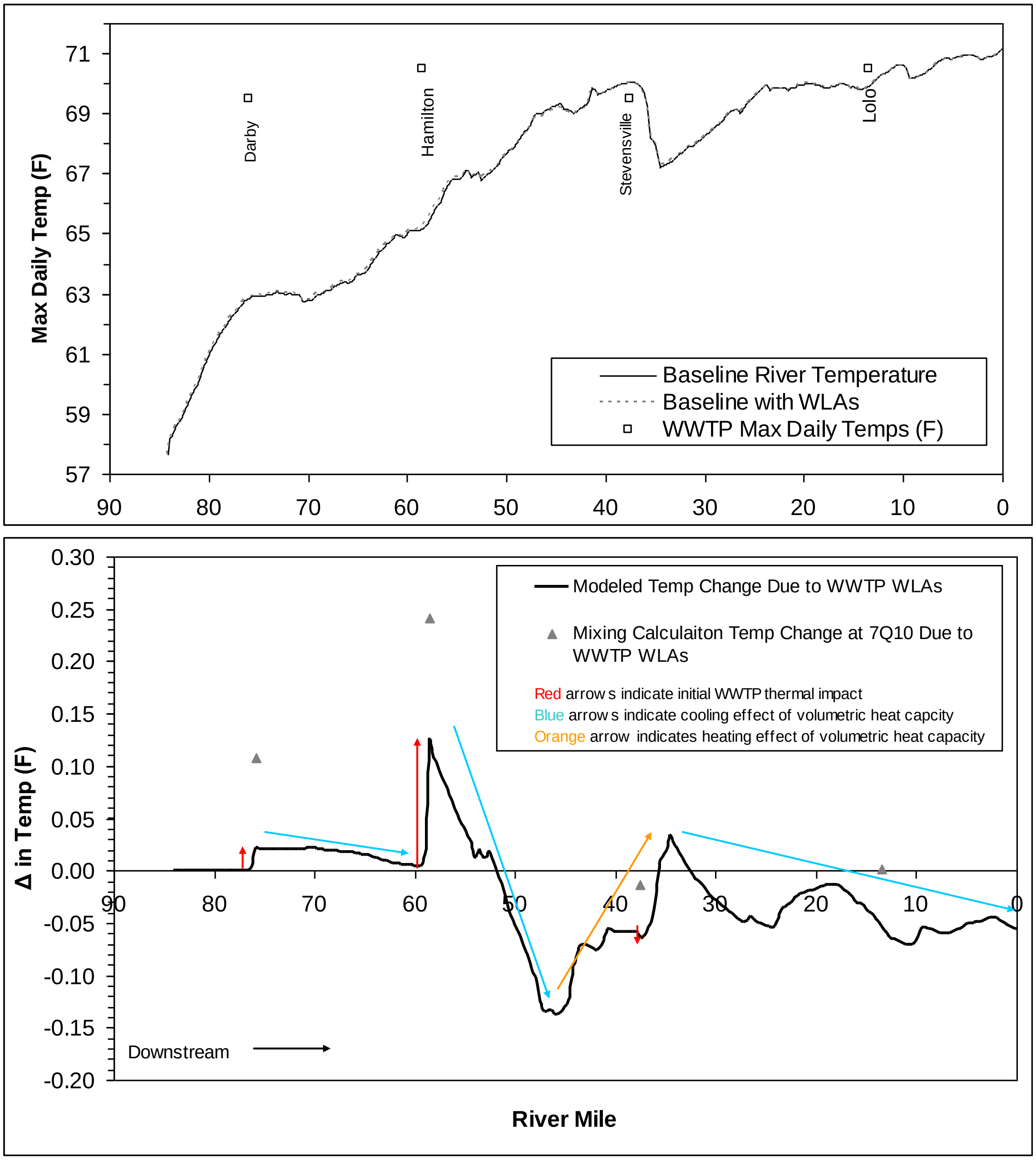

Figure 3-1. Comparison of QUAL2K modeling result scenarios using daily maximum temperatures: Baseline without WWTP discharges to Baseline with proposed WWTP WLAs conditions.

Yet, after the initial wastewater and associated heat load was added, some interesting effects occurred which were attributed to the added volumetric heat capacity of the receiving water (i.e. more volume which requires more heat or cooling to manifest associated changes). So, given the same nonpoint solar and passive heat inputs along the stream corridor, the increased volume of water provided via the effluents has the potential to reduce temperatures as water flows downstream. This is illustrated in blue in **Figure 3-1**. Alternatively stated, the more water present in the stream with the same heat applied from solar radiation equates to lower instream temperatures as it flows downstream. Yet an overall cooling affect only occurs after the initial heat influence from the point source can be overcome by this affect. Another influencing factor comes into play when interpreting the comparison of the two scenarios. The increased instream flow due to added effluent volume reduces the cooling effect of cold groundwater influences near Stevensville. This effect is produced by a larger volume of warmer stream flow which reduces the overall cooling influence by reducing the proportion of cool groundwater at this point. This effect is noted by an orange arrow in **Figure 3-1**.

3.1 Summary

The complex interactions between WWTP initial thermal loads and changes to volumetric heat capacity provide both heating and cooling affects upon instream temperatures. The results of the mixing calculations and modeling results indicate that if WWTPs were to double existing discharge rates or discharge up to their existing design capacity, whichever is higher, they would likely only heat the stream to approximately their initial thermal impact at each discharge point. Cumulatively at the modeled discharge rates the WWTPs influences would cumulatively stay well below ½°F. As heat load allocations are developed for the TMDL, they will consider the results from this modeling effort along with initial mixing conditions at 7Q10.

4.0 REFERENCES

Kasch, M., Flynn, K. Starr, B, Kron, D. 2009. Modeling Streamflow and Water Temperature in the Bitterroot River, Montana. TMDL Technical Report. Montana Department of Environmental Quality.

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