ATTACHMENT D - BITTERROOT RIVER TMDL PLANNING AREA MISSOULA MS4 TEMPERATURE AND THERMAL LOADING ASSESSMENT

BITTERROOT RIVER

TMDL PLANNING AREA

MISSOULA MS4 TEMPERATURE AND THERMAL LOADING ASSESSMENT

JANUARY 11, 2011

PREPARED BY:
MONTANA DEPARTMENT OF ENVIRONMENTAL QUALITY
WATER QUALITY PLANNING BUREAU
1520 E. 6TH AVE
HELENA, MT. 59601

Significant Contributors

Darrin Kron, Erik Makus, Eric Sivers

The City of Missoula meets requirements for a small municipal separate storm sewer system (MS4). This effort provides a coarse estimate of the thermal inputs to the Bitterroot River from the City of Missoula (MS4) area. A portion of this MS4 permitted area lies within the Bitterroot Watershed. This permit (MTR040007) is combined and includes the following entities: City of Missoula, Missoula County, Montana Department of Transportation (MDT), and the University of Montana.

Much of the city drains to the Clark Fork River, yet a portion drains to the Bitterroot River. Also, much of the MS4 area in the Bitterroot Watershed is serviced by dry wells. There are two discrete surface sewer discharge locations that drain to the Bitterroot River. One was constructed by Montana Department of Transportation and another was developed by the City of Missoula. Other areas of the MS4 may provide limited surface runoff to a Bitterroot River tributary south of the two discharge locations and an irrigation system to the north of the two discharge locations, yet these areas likely do not provide significant stormwater runoff. The two major outfalls collect most of the MS4 surface water discharge draining to the Bitterroot River (**Map 1**). These outfalls also collect baseflow and runoff from natural areas above the city.

The discharge location on the north side of HWY 93 was built by Montana Department of Transportation. MDT used the rational method to determine peak runoff volume when a sewer main was added under Reserve Street during reconstruction. MDT estimates a two year flood event would produce a peak flow of approximately 29 cfs and a ten year event would produce a peak flow of approximately 57 cfs at this location. No comparable small (~2yr) runoff event data was available for the other outfall location at the time of this report, yet large event estimates were comparable to larger storm events of the HWY 93 location. DEQ estimates that doubling the peak two-year HWY 93 outfall (58 cfs) estimate would account for the other outfall, plus the other two potential contributive areas described above. The smallest event modeled by MDT is used to represent a storm that reoccurs periodically, yet is sizable.

DEQ then estimated the initial wash off volume of potential heat contribution to the Bitterroot River from a typical summer thunderstorm by estimating the first 20% of runoff volume of the two year event using a time of concentration of 1.5 hours and a simple geometric assessment. The initial wash off is assessed because most summer thunderstorms cooled air temps considerably, approaching in-stream water temperatures, within an hour via evaporation and sunlight interception. Therefore, the initial urban wash off pollutant theory likely applies to thermal load and temperature impacts to surface water. The results indicate a flow of 36 cfs is associated with the highest associated flow of the first 20% runoff volume during a two year event from all surface water contributions of the MS4.

Weather data from the Missoula airport weather station was assessed to determine air temperatures, and thus rainfall temperatures during mid-summer (July through August) thunderstorms where air temperatures were above 75 and 80˚F and rainfall was greater than a 1/10th of an inch for the total storm event. Over a four year period, three such events were found with air temperatures above 80˚F and five were found with air temperatures above 75˚F. Air temperatures dropped 10-16˚F during the first hour of each storm event and were usually near 70˚F by the end of the first hour during days where temperatures were initially above 80˚F (**Table 1**).

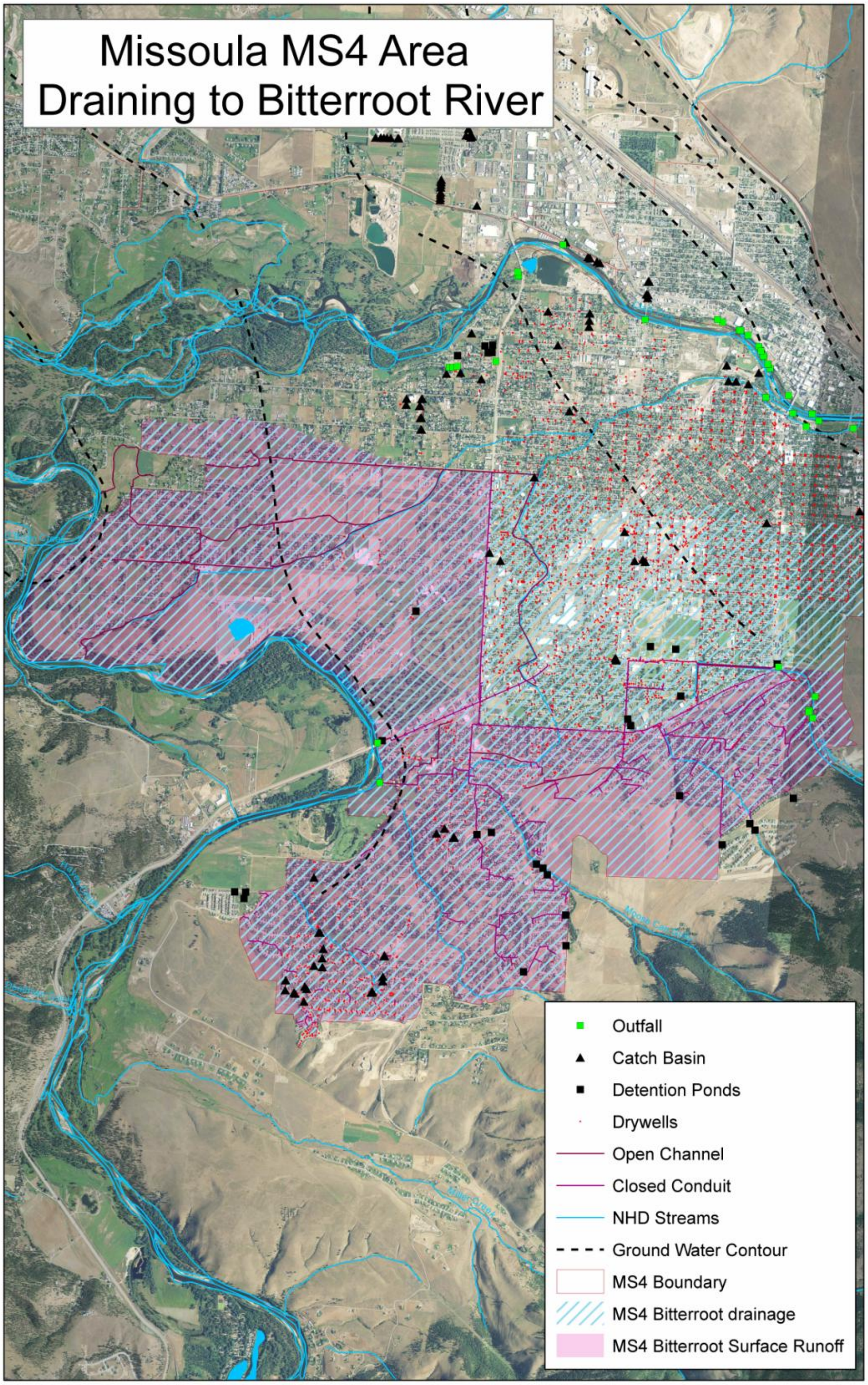
Table 1. Summer (July-August, 2007-2010) Storm Events with greater than $^{1}/_{10}{}^{th}$ in rainfall on days with 80˚F air temperature

7/26/2009			7/31/2010			8/18/2010		
Hour	**Temp (F)**	**Precip (in)**	**Hour**	**Temp (F)**	**Precip (in)**	**Hour**	**Temp (F)**	**Precip (in)**
0	62		0	63		0	59	
1	66		1	64		1	60	
2	62		2	63		2	57	
3	63		3	61		3	60	
4	62		4	58		4	57	
5	61		5	58		5	54	
6	59		6	60		6	54	
7	63		7	60		7	57	
8	68		8	67		8	62	
9	70		9	73		9	67	
10	75		10	78		10	71	
11	78		11	80		11	74	
12	79		12	82		12	80	
13	81		13	86		13	87	
14	82		14	88		14	87	
15	85	T	15	77	0.01	15	88	
16	83		16	72	0.14	16	81	T
17	84		17	72		17	71	0.13
18	82		18	68	0.09	18	69	0.02
19	80	T	19	66	0.01	19	64	0.02
20	64	0.59	20	65		20	65	
21	63	T	21	65		21	63	
22	62		22	64		22	61	
23	61		23	64		23	60	
24	62	0.01	24	63		24	59	

An effort in Minnesota was conducted to determine the runoff temperatures from paved areas (Janke et. al, 2006). Initial rainfall temperatures in this effort were estimated at 70˚F and run across 100m of asphalt pavement with an initial temperature of 80˚F. Over the first hour, the water was warmed on average, about 6˚F (Janke et. al, 2006). The area drained by the outfalls is estimated at about 20% imperviousness. Runoff from other types of surfaces that do not collect as much heat as asphalt contribute to runoff, such as rooftops, bare ground and concrete (Herb et. al, 2007). Also, pervious areas may contribute limited runoff volumes. Yet, impervious areas will likely result in much of the first flush runoff. Therefore, the cited heating effect is applied to half of the first flush of urban runoff. This coarse estimate accounts for percentage of impervious area, asphalt composition of the impervious area compared to other impervious surfaces, and that first flush is most likely derived largely, but not entirely from, impervious areas. Results indicate average urban runoff temperatures during typical summer storms would be about 73˚F during the first flush when entering stormwater conduits. Alternatively, some heat is attenuated via open channels and especially in buried conduits where ground temperatures are closer to 55˚F. Therefore, 72˚F will be used to represent stormwater temperatures for mixing calculations to determine thermal impacts to the Bitterroot River.

Using the estimates provided above and modeling and monitoring results for the Bitterroot River thermal conditions, simple mixing calculations were completed to simulate the thermal affect of the MS4 area upon the Bitterroot River at 7Q10 flow (392 cfs). The resulting thermal change in the Bitterroot River would be about a 0.23˚F increase in temperature at extreme low flow. At typical summer stream flows (550), the increase in temperature would be about 0.17˚F. However, the increase would be very short lived and fish would be provided a recovery shortly after the event due to cooling conditions from the storm itself.

Due to the short duration, the infrequency, and the relative magnitude of these storm events, it is important to consider the relatively small effect these have on the Bitterroot River fishery. Unlike other WWTP point sources in the watershed, the MS4 stormwater discharge is not a continuously flowing. When storms do occur, the thermally elevated runoff dissipates after one or two hours. Significant rainfall events occurring when air temperatures are or have been above 80^{o}F are relatively rare, occurring approximately once per summer in the four years of hourly rainfall data reviewed. Separately, a storm of the magnitude required to produce this volume of runoff occurs on average once every two years (i.e. the 2-year storm). Combine these two, and it is likely that large storms capable of producing thermally elevated discharges occur a few times per decade. The runoff produced by these storms is also going to be mitigated by the very fact that they are major storms. The remaining 80% of the runoff hydrograph from the MS4 area (everything after the first flush) is much larger than the first flush volume and is not thermally elevated. Additionally, the Bitterroot River will increase in discharge following a large storm event, thus dissipating thermal effects from the MS4 area. Storms also cool air temperatures, which are a primary influence of instream temperature. Due to these factors, it is likely that this source will not severely affect the fishery. Yet, controlling first flush urban surface runoff volume from entering the Bitterroot River should be a concern due to the moderate magnitude of heating that may occur.



Map1. Missoula Area MS4 map.

Janke, B., Herb, W.R., Mohseni, O., and H. Stefan, 2006. Quasi 2-D model for runoff temperature from a paved surface, St. Anthony Falls Laboratory Report 477, 78 pp

Herb, W.R., Janke, B., Mohseni, O., and H.G. Stefan, 2007. Estimation of runoff temperatures and heat export from different land and water surfaces, St. Anthony Falls Laboratory Project Report 488, 34 pp.