Technical Memorandum BCWA

Date: February 16, 2018
To: Bear Creek Watershed Association
From: Russell N. Clayshulte, Manager

Re: BCWA TM 2017.07 Barr Milton TMDL Summary

Contents

Figure 1 BCWA Site 45 is located below the Weir in the Outfall Trace

Figure 2 BCWA Site 45 Sampling Location below Weir.

Purpose or Site 45 Monitoring

The Bear Creek Watershed is in the defined "data" shed for the BMW pH/DO TMDL. The Bear Creek Watershed boundary is defined in *BCWA Policy 13 Watershed Boundary*. Discharge from Bear Creek Reservoir is identified as a "point" source and input to the BMW pH/DO TMDL and model. As such, the BCWA site 45 is identified as a source that contributes about 1.8 % of the external load of Total Phosphorus (See Table 1). The BMW pH/DO TMDL defines the contribution of Total Phosphorus from Bear Creek for both Barr Lake and Milton Reservoir at 1,167 kg/year or 2,672.7 pounds/year. The Association uses site 45 data to estimate Bear Creek Reservoir mass-balance loading and discharge.

Phosphorus Compliance with BMW TMDL

In the period from 2000 through 2017, the average Total Phosphorus at BCWA site 45 was 2,801 pound/year (Table 2). Problematic years are 2007, 2013, 2015 and 2016. In 2007, the flow predictions were used for the downstream Sheridan gage (Table 2 and Figure 3). Although the Association believes the actual flow at site 45 was less than measured at Sheridan, the total load would still exceed the target of 2,672.7 pound/year.

In September 2013, an exceptional flood event occurred within Bear Creek Watershed and the reservoir became a major flood control structure. The rains began in earnest on September 9, 2013 in the upper watershed. The U.S. Army Corps of Engineers shut the outflow gates on Bear Creek Reservoir on September 13, 2013. The pool rose from 1,817 acre-feet to about 15,000 acre-feet (5 trillion gallons) on September 22, 2013. The surface area was about 500 acres or 70% of surface acre capacity. Although Bear Creek Reservoir returned to normal pool by the end of October, the water quality in the reservoir may be altered for years to come. Because of the flooding event, the reservoir received a massive nutrient load from the watershed flushing. A substantial amount of nutrients was discharged into lower Bear Creek during operational flood discharges from Bear Creek Reservoir. During the 45-day event, 5,026 pounds of total phosphorus and 36,500 pounds of total nitrogen was released from the reservoir. The Association estimates 10,000 pounds of total phosphorus was retained within the reservoir and incorporated into the massive sediment deposits.

The Total Phosphorus load target at BCWA site 45 was met in 11 out of 18 years of reviewed data. The target Total Phosphorus listed in the BMW pH/DO TMDL can be met under most hydrologic conditions and within the expectations of the BCWA management program. The BMW pH/DO TMDL expects any reduction in this target Total Phosphorus load will occur by in-canal treatment in the Barr-Milton Watershed prior to discharge into those waterbodies.

2017 Flow Estimate

The average inflow into Bear Creek Reservoir from both Turkey Creek & Bear Creek (1987-2017) was 30,870 acre-feet per year. The highest flow was in 2015 with 118,925 acre-feet flowed through the reservoir. In 2017, 18,080 acre-feet flowed from the reservoir. There is a state DNR staff gage above the weir, which allows the Association to monitor flow at the monitoring station.

Figure 3 Sediment and Nutrient Load Associated with Spring Flows

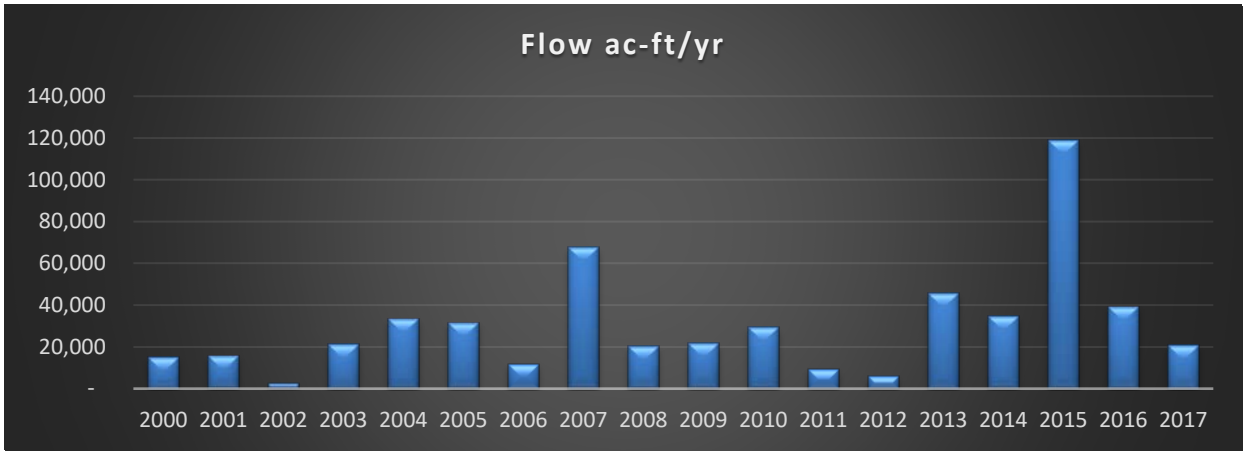

Figure 4 Flow Trend at BCWA Site 45

2017 Nutrients

The Association collects Total Nitrogen/ Total Phosphorus pairs for 12 months/year (unless no flow or completely frozen) at BCWA site 45. The Association maintains a spreadsheet (*BCWA MSD06 Site 45 Data Summary*) for BCWA site 45 that contains water quality data and nutrient loading estimates (Summary data is shown in Table 3, spreadsheet available upon request).

In 2017 the average Total Phosphorus discharged from the reservoir as measured at BCWA site 45 was 38.7 ug/l. this equates to about 3,050 pounds/year. Figure 5 and table 2 shows the Total Phosphorus loading at BCWA site 45. Figure 5 also shows the compliance record for total Phosphorus.

Since nitrogen is an issue, the Association estimated the nitrate loading at BCWA site 45 from 2000-2016 and Total Nitrogen from (2011-2017). In 2017 the average Total Nitrogen concentration discharged from the reservoir as measured at BCWA site 45 was 724.7 ug/l. This equates to about 36,460 pounds/year. Figure 6 and Table 2 shows the Total Nitrogen loading at BCWA site 45.

Table 1 Model Prediction Compared with BCWA Data

Source	Average Conc. (ug/l)	Total TP TMAL Load		Barr Load		% of Total Load	Milton		% of Total Load
		Kg/yr.	Pounds/Year	Kg/yr.	Pounds/Year		Kg/yr.	Pounds/Year	
Model Bear Creek Site 45	32-80	1,167	2,673	1,091	2,505	1.60%	76	167.5	0.20%
BCWA Bear Creek Site 45	38.1	1271	2,801						

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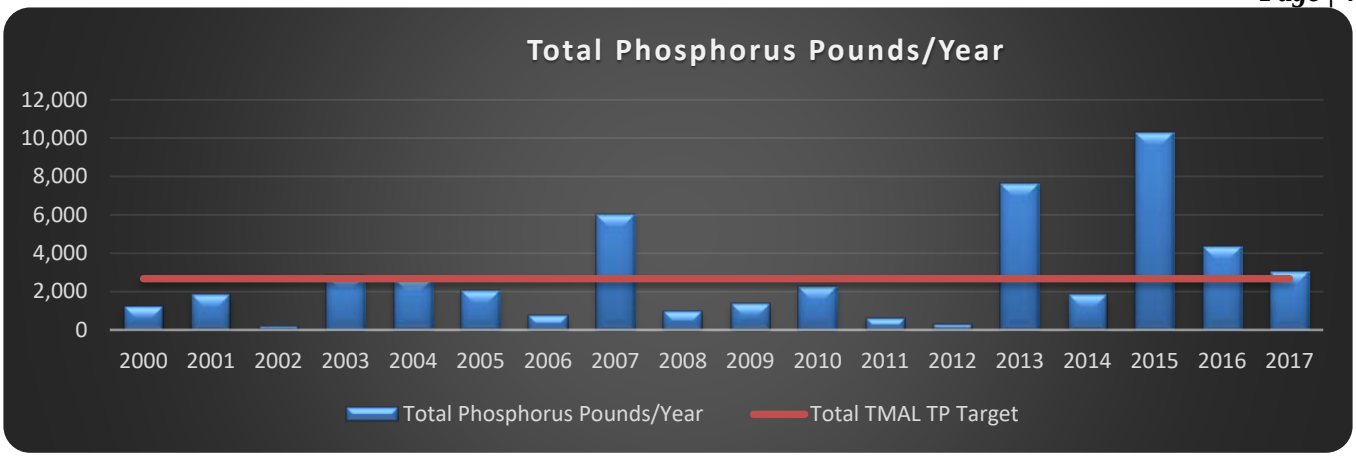

Figure 5 **Total Phosphorus Trend**

Table 2 **Phosphorus and Nitrogen Load Estimates Per Year**

	Total Phosphorus Pounds/Year	Nitrate Pounds/Year	Total Nitrogen Pounds/year
2000	1,243	23,146	
2001	1,847	17,736	
2002	187	3,182	
2003	2,856	2,856	
2004	2,667	3,569	
2005	2,094	22,936	
2006	776	6,837	
2007	6,047	57,496	
2008	991	16,470	
2009	1,361	18,576	
2010	2,259	32,148	
2011	624	3,467	10,632
2012	260	4,315	7,897
2013	7,627	22,576	80,028
2014	1,841	27,821	63,229
2015	10,320	84,081	172,116
2016	4,369		84,580
2017	3,051		36,460
Average	**2,801**	**21,701**	**66,780**

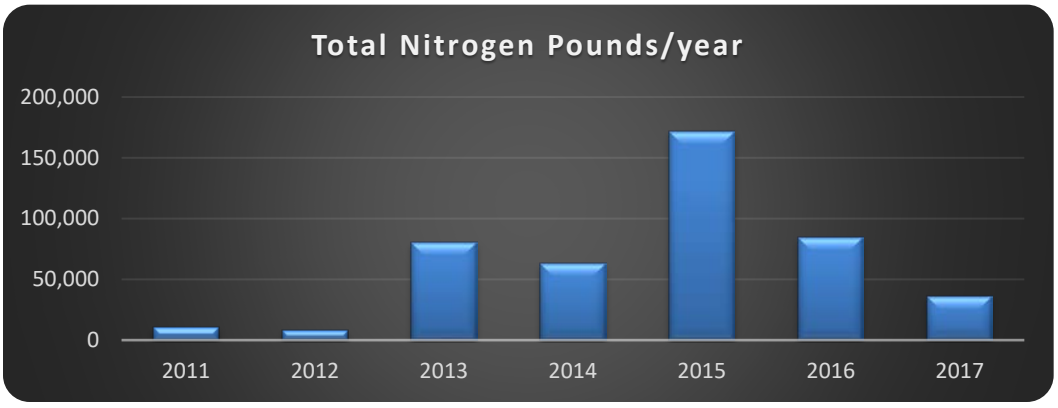

Figure 6 **Total Nitrogen Trend**

Table 3 Summary Data 2010-2017

	Avg	Median	Maximum	SD	Minimum
Temperature, ºC	**14.1**	14.6	85.1	8.8	1.3
Total Suspended Solids, mg/L	**8.5**	6.6	94.7	8.9	0.0
Specific Conductance us/cm	**389.0**	371.0	779.0	136.2	147.0
Fecal Coliforms, colonies per 100 ml (Geo Mean)	**7**				
E. coli cts/100 ml (Geo Mean) 2004-2017	**3**				
Dissolved Oxygen, mg/L	**9.1**	9.0	15.5	2.0	3.3
pH	**8.3**	8.3	9.4	0.4	7.0
Total ammonia-nitrogen, ug/L	**55.2**	39.9	403.0	55.7	3.0
Nitrate-nitrogen, ug/L	**268.9**	187.9	1700.2	254.1	0.0
Soluble Reactive Phosphorus (SRP), ug/l	**12.5**	6.6	76.4	14.0	0.1
Total Dissolved Phosphorus (TDP), ug/l	**19.0**	13.6	96.0	16.5	2.0
Total Particulate Phosphorus (TPP), ug/l	**17.3**	12.4	136.8	19.2	2.6
Total Phosphorus (Total P), ug/l	**38.7**	29.8	259.0	32.1	2.0
Total Nitrogen, ug/l	**724.6**	652.0	2241.0	278.8	342.0

E. coli Trend BCWA Site 45

Table 4 shows the E. coli geometric mean data at BCWA site 45 from 2004-2017. Figure 7 compares E. coli data at BCWA site 45 with the downstream Wadsworth BCWA site 90. There is no E. coli problem associated with discharge from Bear Creek Reservoir.

Table 4 E. coli Geometric Mean Summary

BCWA Site 45 E. Coli Geometric mean cts/100ml

	J-F	M-A	M-J	J-A	S-O	N-D	Annual
2004-2014							3
2012						1	
2013	1	6	2	9	2	1	2
2014	2	2	5	2	1	14	3
2015	3	3	8	2	1	6	3
2016	1	2	2	9	6	7	3
2017	1	1	5	11	1	1	2

LBCW Site BCL5 E. coli (MPN/100ml)

	J-F	M-A	M-J	J-A	S-O	N-D	Annual
2013			62	36	54		46

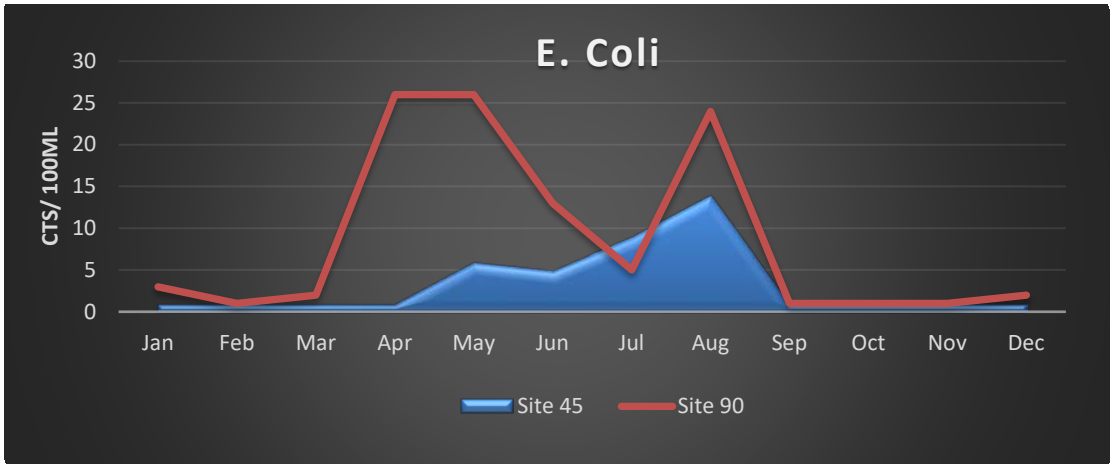

Figure 7 E.coli at Site 45 vs. Site 90 at Wadsworth