Bear Creek Watershed Association

2017 Annual Report

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The Bear Creek Watershed Association protects & restores water & environmental quality within the Bear Creek Watershed from the effects of land use

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I. WQCC Summary

The Bear Creek Watershed is a specific geographic area identified in the Bear Creek Watershed State Control Regulation (Regulation #74, 5 CCR 1002-74) that requires special water quality management. The Bear Creek Watershed Association is the local water quality group responsible for implementation of monitoring and tracking water quality in the Bear Creek Watershed.

Regulation #74 identifies the Association's annual reporting requirements for presentation to the Water Quality Control Commission (WQCC). The Bear Creek Watershed Association Annual Report includes five reporting requirements as listed in the control regulation: 1) Summarize status of water quality in the watershed for the previous calendar year. 2) Provide information on the wastewater treatment facilities loading and compliance with permit limitations. 3) Nonpoint source loading and appropriate best management practices. 4) Demonstrate through in-stream and reservoir data analyses the status of water quality goals and standards for the watershed. 5) Characterize any active phosphorus trading programs.

1. Status of Water Quality

The average inflow into Bear Creek Reservoir from both Turkey Creek & Bear Creek (1987-2012) was 27,100 acre-feet per year. From 2013-2017 the average inflow into Bear Creek Reservoir was 50,864 acre-feet. The 2017 inflow is estimated at 20,626 acre-feet (Figure 1) with most of the flow in May and June (55% of the annual total flow). There was no flood stage (> 2,000 ac-ft) for BCR. In August-September 2017, the U.S. Army Corps of Engineers lowered BCR by about 300 ac-ft for repair work on the dam.

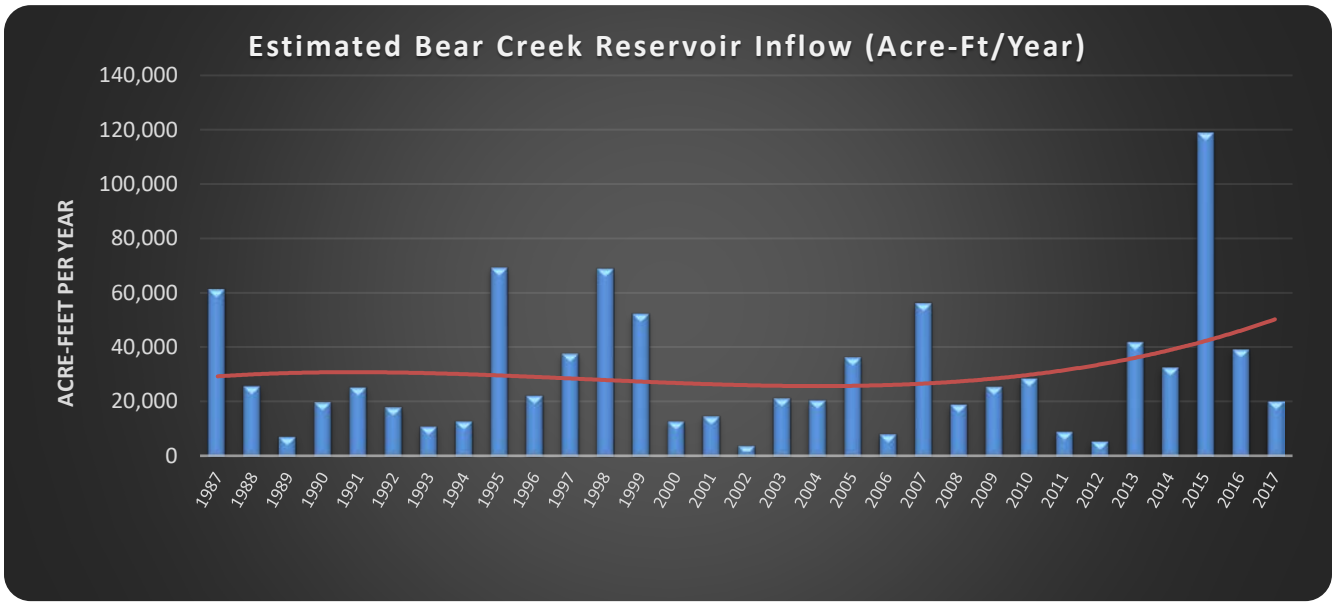


Figure 1 Estimated Bear Creek Reservoir Inflow 1987-2017

The estimated annual discharge from Bear Creek was about 15,165 acre-feet (55%) and 5,460 acre-feet (45%) from Turkey Creek. The internal total phosphorus loading within Bear Creek Reservoir has not diminished over the last 10-years (Figure 2). The total phosphorus deposition into reservoir bottom sediments has been about 35,600 pounds since 2008.

The reservoir continues to experience late summer phytoplankton blooms (2017 peak density of *Microcystis aeruginosa*, Peak Biovolume (um3/mL) = 2,268,627; *BCWA TM 2017.09 BCR Phytoplankton Summary*), which are linked to the internal nutrient loading problem. *BCWA Fact Sheet 57 Cyanotoxins* provides information on the potential toxic risk from high concentrations of bluegreens and *BCWA Fact Sheet 58 Cyanobacteria Guide BCR* can be used be visually identify major species. The BCWA has identified some strategies to address the internal loading problem (*BCWA Policy 20 Preferred Management Strategies EGL and BCR*).

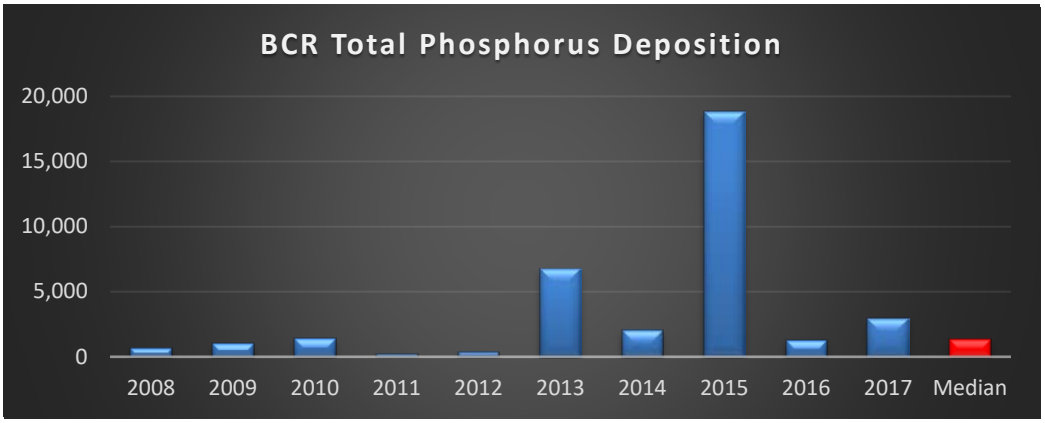


Figure 2 **Annual Total Phosphorus Deposition into Bear Creek Reservoir Bottom Sediments**

The total phosphorus load from the watershed comes from a combination of wastewater treatment plant point source loads, other sources (e.g., onsite disposal systems; see *BCWA Policy 11 Vault & SS Disposal Systems*), nonpoint sources (e.g., onsite wastewater treatment systems, stabling operations [*BCWA Policy 4 BC Manure Management*], roads, public lands, illegal dumping [BCWA *Policy 18 Illegal Dumping*], and regulated stormwater runoff). The estimated total phosphorus load in 2017 from all sources reaching the reservoir was 6,034 pounds (79% from Bear Creek). There was about 48,411 pounds of total nitrogen loading into the reservoir with 55% derived from the Bear Creek drainage.

The Association monitors watershed nutrients by major stream segments beginning near Mt. Evans (segment 7) and extending downstream to Bear Creek Reservoir. 2017 was an average nutrient monitoring year with 77% of the total phosphorus (Figure 3) and 55% of the total nitrogen (Figure 4) load occurring in the April-May spring runoff period. Most nutrient load comes from the urbanized corridor of segment 1a (above Evergreen Lake to the Clear Creek County Line), and segment 1e, which is the mainstem of Bear Creek from Evergreen Lake to the Harriman Ditch Diversion.

There was about 1,592 pounds of total phosphorus passed through Evergreen Lake, with an additional 250 pounds added from the Cub Creek drainage. Additional total phosphorus loading into Bear Creek between Evergreen to Morrison was over 20,960 pounds during the monitoring season. Mt. Vernon Creek contributed about 875 pounds of total phosphorus. The BCWA has established specific monitoring sites to better characterize specific tributary drainages with elevated total phosphorus loading and develop improved management strategies for these areas (*BCWA Policy 15 Nonpoint Source Strategies and BMPs*). The BCWA also improved integrated planning efforts with other agencies to help resolve several identified pollutants loading problems (*BCWA Policy 29 BCWA Integration with Other Planning Efforts*).

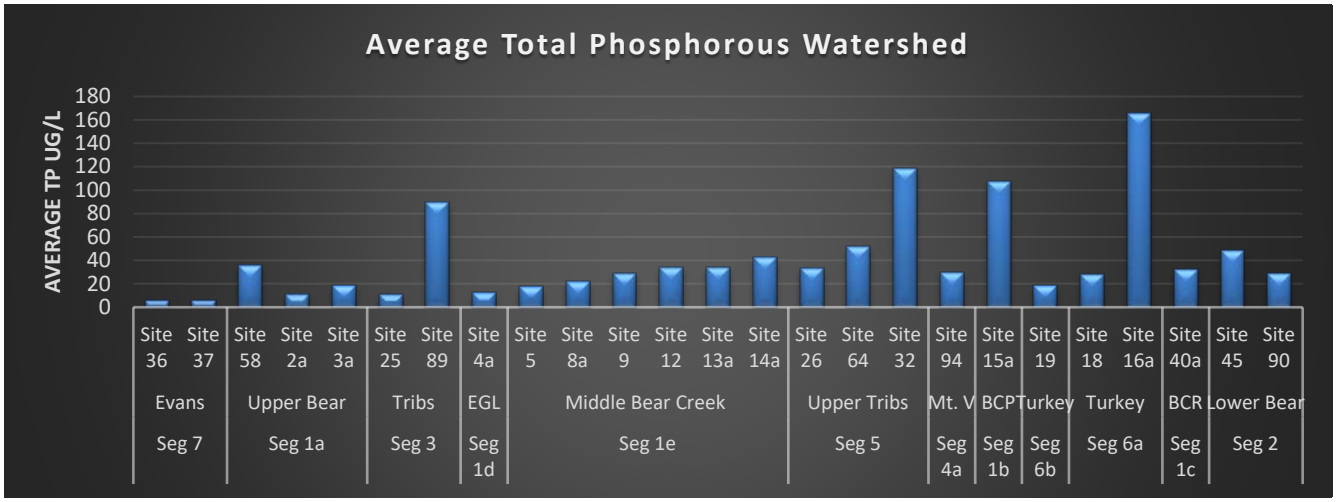


Figure 3 **Total Phosphorus Loading by Stream Segments in the Watershed**

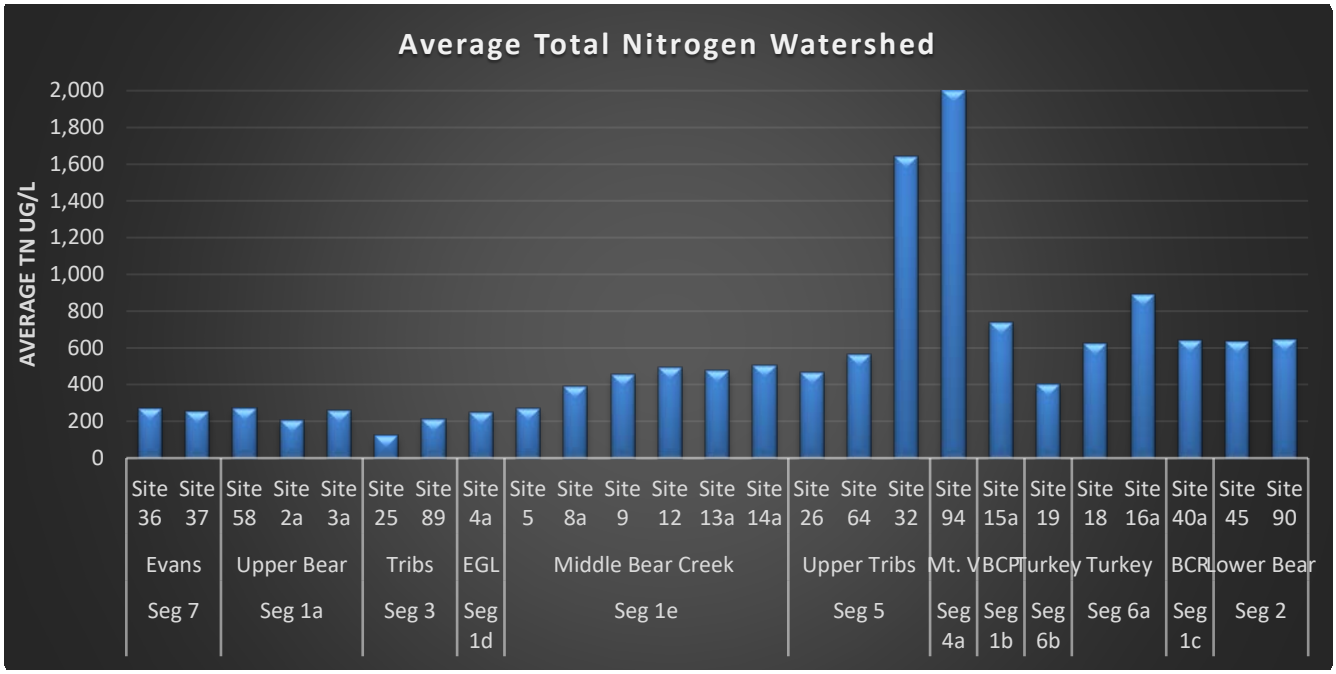


Figure 4 Total Nitrogen Loading by Stream Segment in the Watershed

2. Wastewater Treatment Facilities Loading and Compliance

In 2017, wastewater dischargers reduced total phosphorus waste load contributions to just 1,091.5 pounds annually. BCWA analysis of the total phosphorus data record indicates that only about 20-35% of this total phosphorus load from permitted dischargers reaches the Bear Creek Reservoir. Significant permit compliance problems were reported for the Brook Forest Inn and Geneva Glen for total phosphorus, which are being addressed under compliance orders with the Water Quality Control Division. The Brook Forest Inn no longer participates in the Association cost share program and is not in compliance with Bear Creek Control Regulation #74.

The Bear Creek Cabins and the Singing River Ranch permitted wastewater treatment facilities are formally closed and converted to onsite wastewater treatment systems. They also no longer participate in the Association cost share program. The Tiny Town operation continues hauling wastewater off site and the treatment facility is non-operational. The Jefferson County Mt. Evans Outdoor Laboratory has a new wastewater facility that began operation in 2016. Some of the smallest dischargers are finding it difficult to meet the total phosphorus permit limit of 1.0 mg/l, but they do meet their annual wasteload allocations.

Regulation 85 monitoring and reporting that took effect in 2014, continues as a watershed program. The program collects nutrient monitoring data for most surface discharging wastewater dischargers. Larger WWTFs chose to participate in BCWA watershed level Regulation 85 sampling and reporting in conjunction with stream sampling for data comparability.

3. Nonpoint Source Loading

The BCWA tracks nutrient loading in the watershed. The studies detail information on OWTS, horse properties and pastures, and unpaved roads. This data includes screening level analysis in EPA BASINS GWLF-E to estimate non-point source contributions. Results and watershed data from the last 10-years indicate the annual nonpoint phosphorus base-flow load from all sources in the watershed ranges from 5,000 to 6,000 pounds, annually. A single major flood event in the watershed can generate 1,000 to 30,000 pounds of total phosphorus. Clearly, only a fraction of this load transports to the Bear Creek Reservoir on an annual basis (Table 1).

The point source load of total phosphorus in 2017 (Table 1) was 1,092 pounds (18%), while the nonpoint source load reaching Bear Creek Reservoir was about 4,942 pounds (82%). On average over 18 years of data record, only about 30% of the total phosphorus load reaching Bear Creek Reservoir is attributable to point sources

(Figure 5). Some of the nonpoint source load reduction can be attributed to improved Jefferson and Clear Creek county management practices for road maintenance, construction practices, stormwater controls and land use controls. This 2017 nonpoint source phosphorus loading was heavily influenced by spring runoff period.

Table 1 Point Source versus Nonpoint Source Phosphorus Loading, Bear Creek Reservoir

	2017 Total Phosphorus Loading (Pounds)				
	Total TP Load	PS	%PS	NPS	%NPS
Turkey Creek Drainage	1,292	84	1.4%	1,208	93%
Bear Creek Drainage	4,742	1,007	16.7%	3,734	79%
Discharged into Reservoir	6,034	1,092	18.1%	4,942	82%
Site 45 Outflow BCR	3,051				
BCR Total Phosphorus Deposition	2,983				
Site 90 - Lower Bear Creek	2,081				

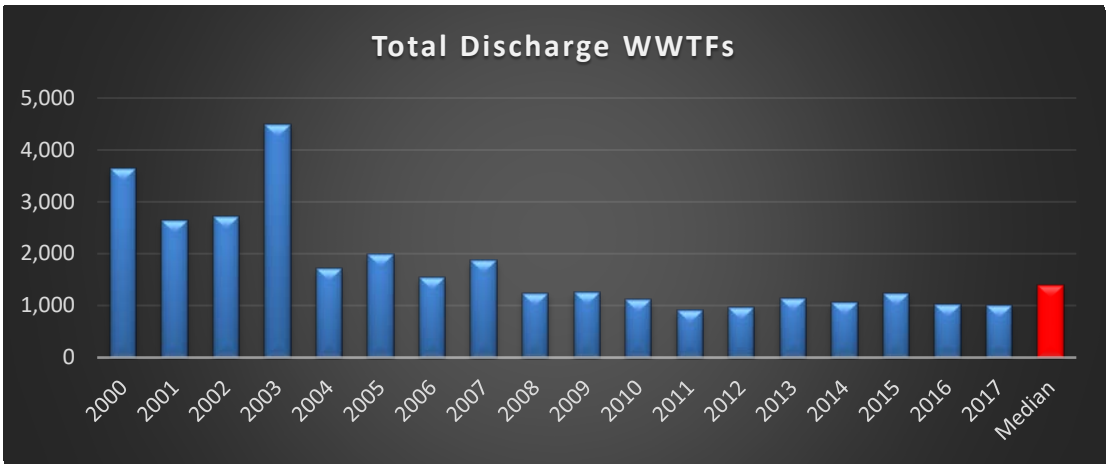


Figure 5 Point Source Load Reaching BCR

The nutrient data shows three areas along the mainstem of Bear Creek where elevated nonpoint source nutrients are commonly measured: the mainstem of Bear Creek between Golden Willow and the Keys on the green (Upper Bear Creek), downtown Evergreen, and below Idledale. The Tributaries with elevated nutrient loading are Yankee Creek drainage, Troublesome drainage, Cub Creek drainage and Mt. Vernon drainage. Upper Bear Creek, Troublesome and Mt. Vernon are addressed in *BCWA WQSD02 Upper Bear*, *BCWA WQSD01 Troublesome* and *BCWA WQSD04 Mt Vernon*.

The April-May watershed sampling period above Evergreen Lake represented a higher flow condition on both the mainstem and tributaries throughout the upper watershed. In this higher flow period, Yankee Creek was the largest tributary source of total phosphorus (50%) load. Under historic flow conditions, this tributary is only about 7-8% of both the TP and TN load to Bear Creek.

The BCWA special studies have shown an estimated 30-75% of the total phosphorus on the Troublesome Drainage comes from a cluster of homes on OWTS located at the lower confluence of Stagecoach and the northern drainage system. This same area contributes 90-111% of the total nitrogen load in the middle drainage. A single horse stabling operation in lower Troublesome contributes about 25-60% of the TP load and about 12% of the TN load reaching Bear Creek.

A special study of Cub Creek from 2013-2016 showed this tributary discharge from 250 to 3,040 pounds of total phosphorus per monitoring season into Bear Creek downstream of Evergreen Lake. The seasonal average total phosphorus load in upstream waters is 304 pounds with the downstream average substantially increasing to 1,378 pounds. There are an estimated 5,450 people in the Cub Creek drainage that utilize OWTS. The phosphorus load in this drainage is likely a result of seepage from these OWTS located within the alluvial corridor.

The Association online system is a permanent management policy (BCWA Policy 21, December 2013). Watershed plan and administration policies were developed by the Association, related to: priority zones, park latrines, plan development, watershed boundaries, data collection, nonpoint source loading and strategies, membership, recycling, illegal dumping, trading eligibility, and reservoir management strategies (See the BCWA *PGO1 Master Index List* and *PGO2 Document Categories,> 20 categories of documents*). Association policies (35) are an essential component of the Association's interactive online *watershed plan*. The Association's adaptive electronic watershed plan (www.bearcreekwatershed.org) helps to continually improve watershed-planning efforts and provide tools and information to understand watershed dynamics. The Association keeps the community informed about water quality, watershed programs and management activities through a quarterly newsletter.

4. Status of Water Quality Goals and Standards

The Association has 36-years of active service to the watershed in Clear Creek, Jefferson and Park Counties. The Association has 33-years of data and studies to support watershed science. During this time, the Association has removed or immobilized about 375 tons of phosphorus in the watershed. The 86 volunteer-years of effort by Association membership has helped waters in the watershed meet standards and classified uses.

In 2015, the Water Quality Control Commission revised the chlorophyll standard to 12.2 µg/L. The exceedance threshold of 12.2 µg/L was derived with a "translator" developed with data from Bear Creek Reservoir. The translator connects the concentration at the allowable exceedance frequency (once in five years) to the typical concentration at the mesotrophic-eutrophic boundary (8 µg/L). The Commission also revised the phosphorus standard to 22.2 µg/L. The standard is calculated in two steps based on the methodology used to develop statewide nutrient criteria for the 2012 Nutrient hearing. The first step involves the creation of a statistical "linkage" between phosphorus and chlorophyll based on summer average concentrations measured in Bear Creek Reservoir. The linkage is used to define the phosphorus concentration corresponding to the mesotrophic-eutrophic boundary in the reservoir; that concentration is 16 µg/L. The second step involves a translator for phosphorus that performs the same function described for the chlorophyll translator. The concentration at the exceedance threshold is 22.2 µg/L.

The 2017 average seasonal total phosphorus of 61.8 µg/L in Bear Creek Reservoir far exceeds the 22.2 µg/L goal-standard. Average seasonal chlorophyll-a of 22.5 µg/L exceeds the 12.2 µg/L standard. The trophic status of the reservoir remains at the Eutrophic-Hypertrophic boundary based on Carlson and Walker indices. Seasonal average reservoir temperature in the top 2-meters of the water column generally remained below 22° Celsius. There were no exceedances of the *Weekly Average Temperature* (WAT) or the *Daily Maximum Temperature* (DM). A new aeration system was installed in Bear Creek Reservoir (*BCWA Fact Sheet 47 New BCR Aeration System*). The Association is monitoring the effectiveness of the aeration configuration and oxygen transfer during the growing season. Lake aeration maintained dissolved oxygen levels at or above 6 mg/L throughout most of the growing season. There was one low oxygen excursion in early August. There was recreational fishing throughout the year.

In Bear Creek and Turkey Creek segments, there were several temperature compliance problems in the cold shoulder season with 5 WAT exceedances and 27 DM exceedances. The warm season had no WAT exceedances and one DM exceedance. Sampling and monitoring was performed at 38 sites within the watershed at varying intervals. Measurements of pH and DO showed 98% compliance for pH and 98% compliance for Dissolved Oxygen. There was 93% compliance for the proposed Total Nitrogen of 1250 ug/L and 95% compliance for the proposed Total Phosphorus of 110 ug/L below the treatment facilities. There was an exceedance of new total phosphorus standard measured at the site-specific Summit Lake pollution plume (*BCWA TM 2016.02 UBCW Summary*).

5. Phosphorus Trading Program

There was no active total phosphorus trading by Association membership in 2017 (See Table 23 in the *BCWA 2017 Annual Report* for a status of trading activity summary). The Association has established four trading policies to improve future trading programs (*BCWA Policy 1 Trading Program, BCWA Policy 19 Nutrient Trading Program Eligibility, BCWA Policy 26 Point to Point Trade Administration, and BCWA Policy 35*

Membership Entity Termination and Permit Closure). The Association Coyote Gulch restoration project has established the annual available total phosphorus trade pounds consistent with the Association trade program at 84 pounds (*BCWA TM 2016.03 Coyote Gulch Summary*). The project has effectively reduced total phosphorus loading by about 75% on an annual basis (Figure 6).

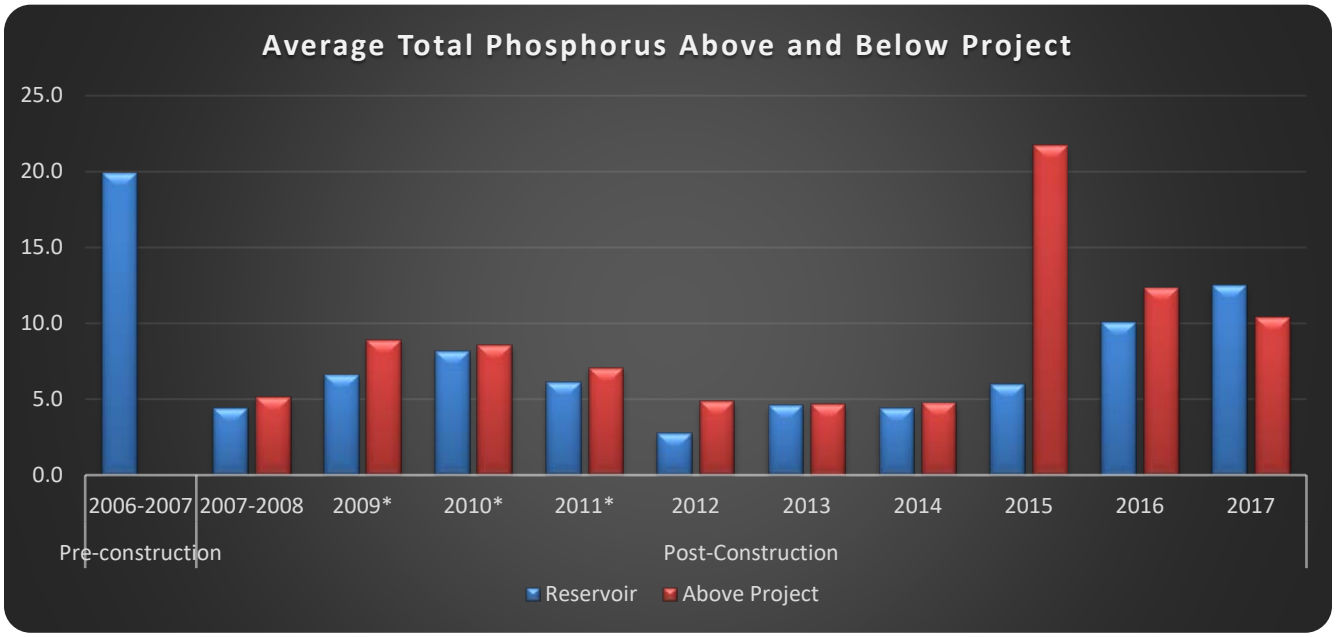


Figure 6 Total Phosphorus Reduction at Coyote Gulch Restoration Site

II. Bear Creek Watershed Association Program

The Bear Creek Watershed (Figure 6) is a specific geographic area identified in the Bear Creek Watershed State Control Regulation (Regulation #74, 5 CCR 1002-74) (Control Regulation) requiring special water quality management. The watershed includes all tributary water flows that discharge into Bear Creek Reservoir (*BCWA Policy 13 Watershed Boundary*). The watershed extends from the Mount Evans Wilderness on the western end to the Town of Morrison on the eastern end (*BCWA Map 01 Watershed Boundary*). The two major tributaries are Bear Creek and Turkey Creek. The goal of the Control Regulation is to attain site-specific water quality standards and classifications through control of total phosphorus and chlorophyll (*BCWA Fact Sheet 10 Control Regulation 74*). The Bear Creek Watershed Association (Association) oversees implementation of the Control Regulation (*BCWA Fact Sheet 1 BCWA Overview*; *BCWA Policy 12 Vision Mission & Targets*).

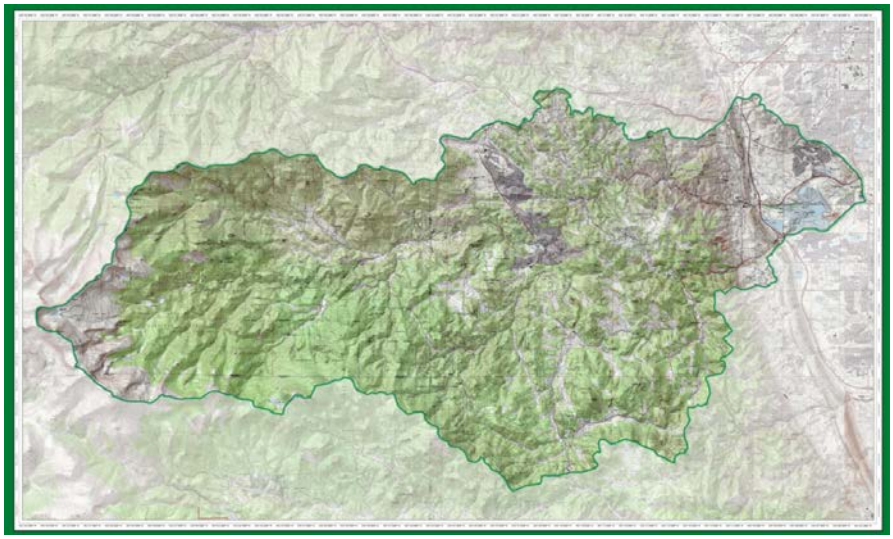


Figure 7 Bear Creek Watershed

The Association is the local water quality agency responsible for implementation of monitoring and tracking water quality in the Bear Creek Watershed (*BCWA Policy 13 Watershed Boundary*). The Association membership includes counties, local general-purpose governments, special districts (wastewater dischargers), associate agencies, and local citizen groups (Table 2). The Association membership monitors point sources and tracks nonpoint source practices, programs and loadings within the watershed. The Association management and implementation programs are at a watershed level (*BCWA Policy 28 BCWA Watershed Plan*).

The Association provides watershed reporting as posted on the Association Website www.bearcreekwatershed.org, which serves to keep federal, state, local governments and others informed on the state of the watershed. The Control Regulation defines specific reporting requirements, which helps the Association keep the Water Quality Control Commission and Water Quality Control Division staff updated on progress of the Association in implementing the Control Regulation (*BCWA Policy 29 BCWA Integration with Other Planning Efforts*).

Table 2 Association Membership, Dischargers and Participation

Members & Participants	Wastewater Discharger	2017 Participation
Counties		
Jefferson County		Active
Clear Creek County		Active
City and Towns		
City of Lakewood		Active
Town of Morrison	Yes	Active
Water & Sanitation Districts		
Aspen Park Metropolitan District	Yes	Active
Conifer Sanitation Association	Yes	Active
Evergreen Metropolitan District	Yes	Active
Forrest Hills Metropolitan District	Yes	Active
Genesee Water & Sanitation District	Yes	Active
Geneva Glen	Yes	Dues Paid, Not Active
Jefferson County School District	Yes	Active
Kittredge Water & Sanitation District	Yes	Active
Tiny Town Foundation, Inc.	Yes	Dues Paid, Not Active
West Jefferson County Metropolitan District	Yes	Active
Other Member		
Denver Water Department		Active
Participant Agencies		
Denver Environmental Health		Attended
U.S. Army Corps of Engineers		Not Active
Jefferson Conservation District		Active
WQCD		Attended

[1] – Active membership is defined as attending 2 or more Board and/or TRS meetings (*BCWA PGO32 By-Laws*).

III. Status of Water Quality in the Reservoirs and Watershed

Monitoring Program Update

The BCWA monitoring plan details the 2017 reservoir and watershed monitoring programs as approved by the BCWA Board and submitted to the Water Quality Control Division staff (WQCD). This monitoring plan serves as a supplement to the adopted Association Quality Assurance Project Plan (Bear Creek Watershed Association, 2006). The 2017 monitoring program (version 2017.01 and version 2017.02) details changes, updates, major continuation studies and monitoring program elements. The *BCWA Policy 14 Data Collection in the Bear Creek Watershed* defines expectations for other groups or agencies that conduct overlapping monitoring activities within the watershed.

The routine monitoring program (P1) focuses on Turkey Creek drainage and Bear Creek drainage inputs, and discharge from Bear Creek Reservoir into lower Bear Creek with a central pool characterization of the reservoir near the dam (Figure 8; BCWA site 40). The outlet structure is near BCWA site 41 with Bear Creek inflow near BCWA site 44 and Turkey Creek inflow near BCWA site 43 (Site 43 and site 44 were not monitored in 2017). The reservoir chemistry and biological characterization monitoring occurs at BCWA site 40. Vertical probe samples for specific conductance, temperature, dissolved oxygen, and pH measured at ½ and 1-meter intervals at all reservoir sites. The current monitoring program optimizes data generation to evaluate reservoir inflow loading, chemical and biological changes within the reservoir, and reservoir outflow, while minimizing monitoring cost. Figure 9 shows all monitoring stations within Bear Creek Park. The Association maintains maps of recent sampling sites and wastewater treatment plant locations on the Association web site.

Figure 8 **Reservoir Monitoring Stations; Site 40 is the Routine P1 Station (2015 image)**

Figure 9 **Monitoring Stations in Bear Creek Lake Park**

Watershed Studies

Stream Flow Studies

The BCWA obtains stream flow data at multiple stations throughout the watershed. Manual flows were measured with most watershed-sampling events. For watershed sites, manual flows measured at up to 17 sites during the May to November timeframe. Year-round flows measured at the Kerr-Swede sites and P1 sites. The Association installed stream staff gages were destroyed by the September 2013 flood and they have not been replaced. The Association also conducts tributary stream flow studies.

Hydrology

The BCWA evaluates the basin hydrology. In 2017, the total estimated annual discharge into Bear Creek Reservoir was about 20,626 acre-feet (Figure 10) with about 18,081 acre-feet flow-through and 22% evaporation and infiltration. The Reservoir wasn't in flood stage in 2017 (Figure 11) and drawn-down for about one-month.

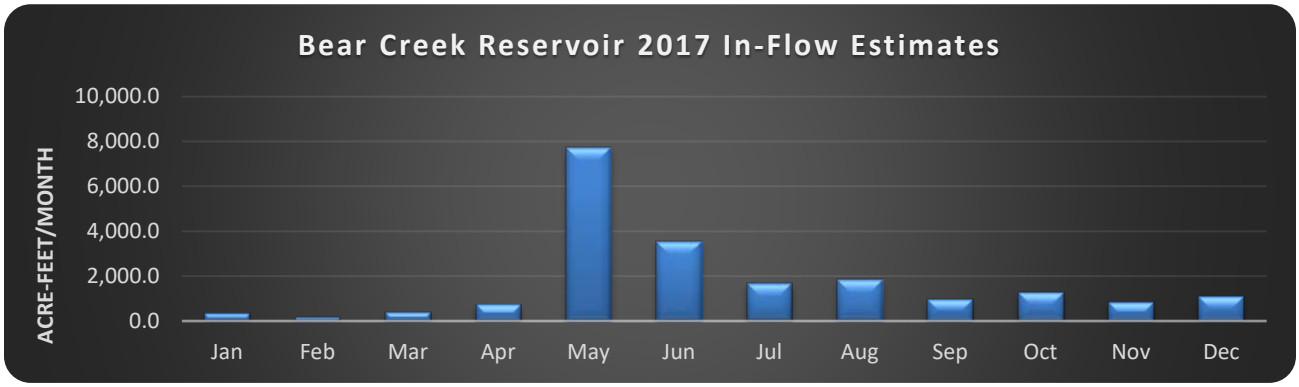


Figure 10 In-Flow Estimates by Month into Bear Creek Reservoir

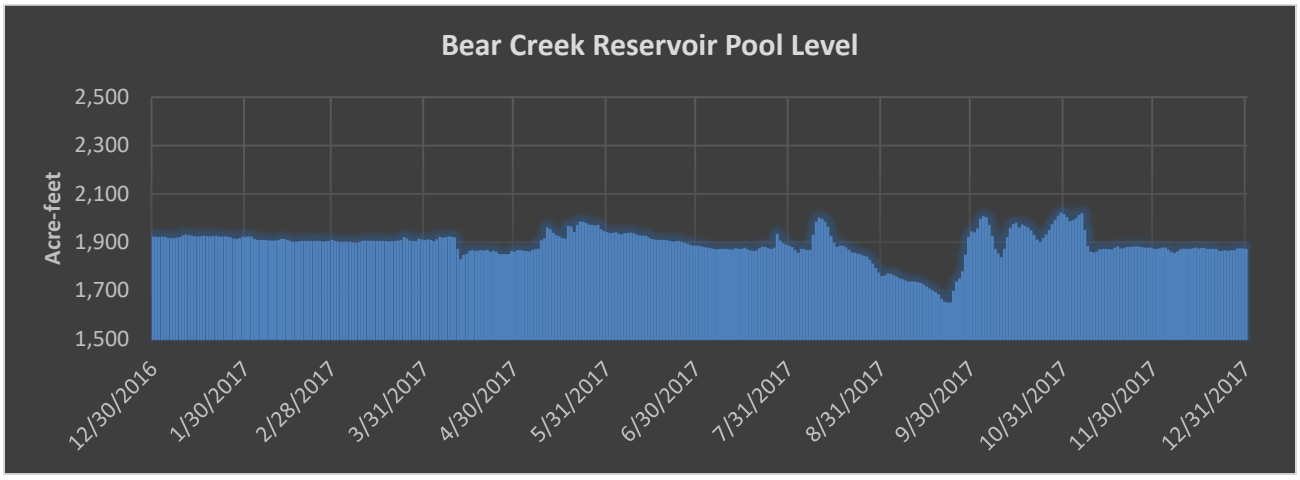


Figure 11 Flood Stage in Bear Creek Reservoir

Bear Creek flow diverts at the Harriman Ditch in Morrison, and a portion of the Turkey Creek flow diverts for water uses. Bear Creek flow diverts into the Arnett-Harriman during the irrigation season. The Arnett-Harriman ditch reduces flows in lower Bear Creek below 10 cfs in the operational season about 35% of the time. The ditch systems can completely dewater lower Bear Creek for periods of up 15 consecutive days. For example, in 2015, the Harriman diverted water for about 275 days with about 5,000 acre-feet of removal as reported by Denver Water Department. Lower Bear Creek was dewatered (<5 cfs flow) for about 50 days or 15% of the time.

The BCWA analyzed the nutrient load removal from the Harriman Ditch (Table 3). The diversion reduces the total phosphorus load to Bear Creek Reservoir by about 20%. The 2017 diversion record is like the reported 1992-2016 data record.

Table 3 **Harriman Ditch Nutrient Load Removal**

DWD Harriman Ditch					
Segment	BCWA Site	Season May-October			
		Nitrate Pounds	TN Pounds	TP Pounds	Ac-Ft
Seg 1e	Site 14a	12,468	25,806	3,275	24,885
Seg 4a	Site 34	2,803	4,572	85	1,468
Total Above Harriman		15,271	30,378	3,360	26,353
Seg 1b	Site 15a	11,536	25,095	2,652	16,519
Removal Harriman		3,735	5,283	708	9,834
% Removal		24%	17%	19%	37%

Comparing in-flow estimates at the Morrison gaging station (2017, 23850 ac-feet) and at the BCWA site in Bear Creek Park (2017, 15,165 ac-feet) provides an estimate of the amount of water diverted from the watershed by the Arnett-Harriman Canal and Ward Ditch. For example, in 2017 the Bear Creek water use diversions reduced flow to the reservoir by about 8,685 ac-ft (-36 %).

The reservoir inflow represents flows below the water diversions and is not representative of the total watershed water flows. Figure 12 compares the 2017 reservoir monthly inflow estimates from Bear Creek (74%) and Turkey Creek (26%). Peak spring and stormwater runoff occurred in May 2017. Figure 13 shows the Bear Creek in-flow estimates (1987-2017) above Bear Creek Reservoir, in Bear Creek Park. Figure 14 shows the flow estimates at the Evergreen station. Additionally, the longer time trends shown in Figures 13 and 14 depict a basic linear trend of declining flow in Bear Creek.

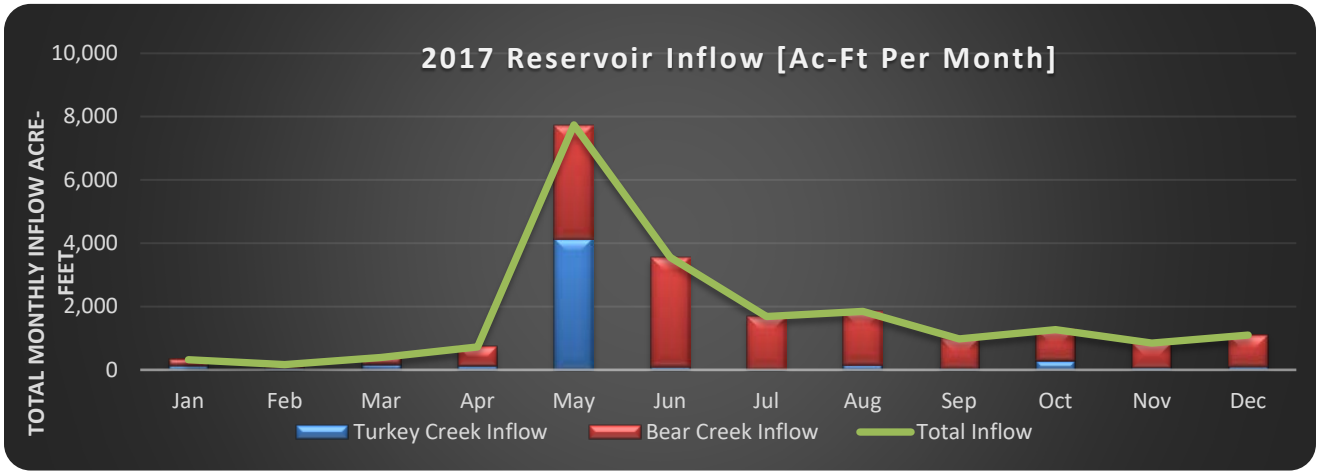


Figure 12 **Annual Flows into Bear Creek Reservoir**

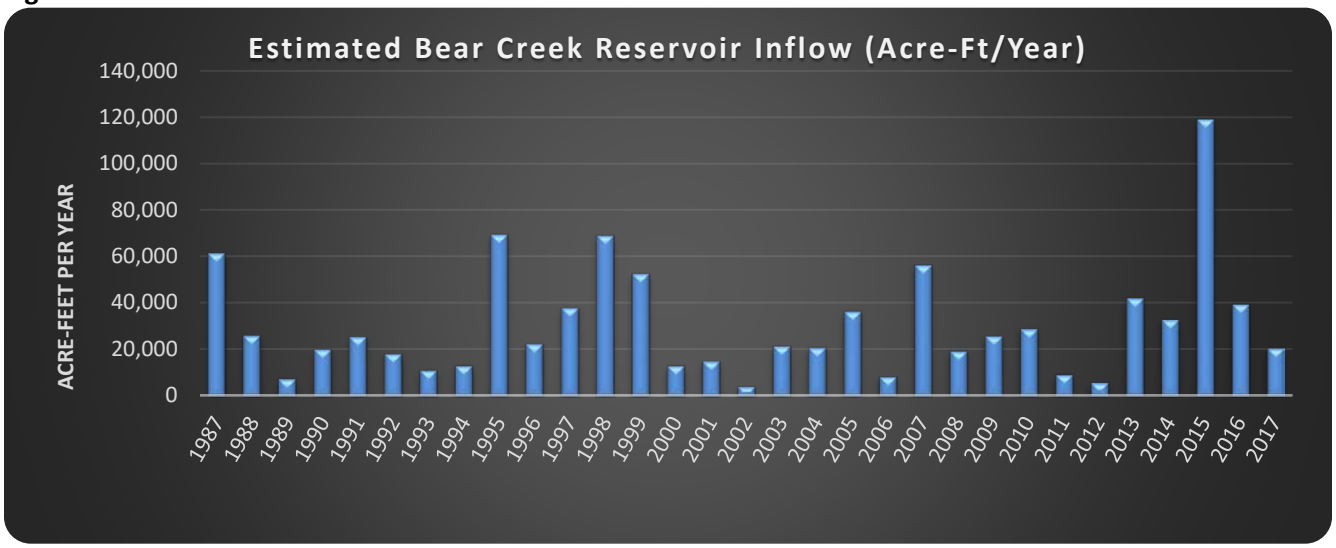


Figure 13 **Bear Creek Reservoir Inflow Estimates**

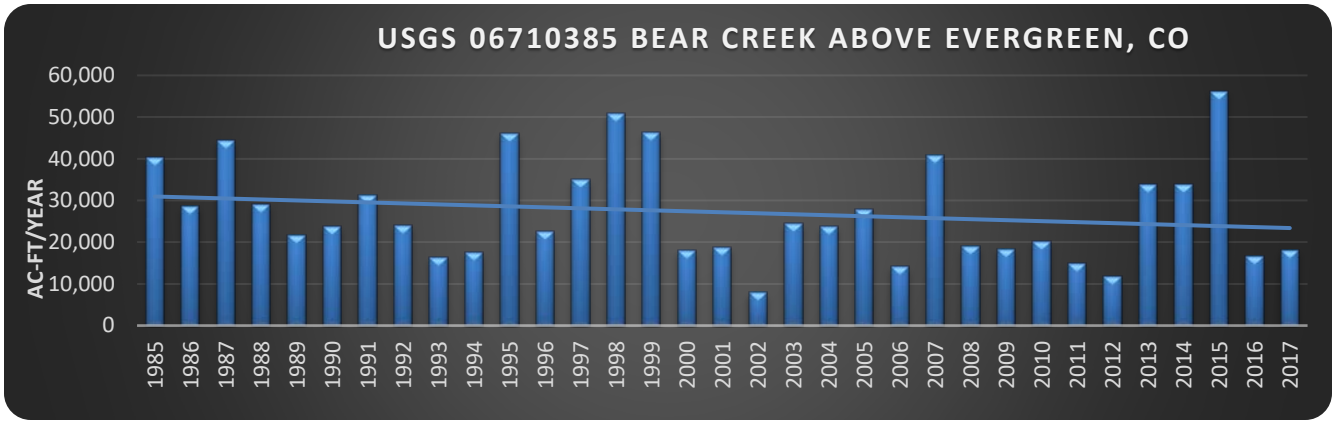


Figure 14 Bear Creek at Keys-on-the-Green, above Evergreen

Water Quality Studies

The BCWA summarizes its watershed-monitoring program in a data report (Bear Creek Watershed Association Data Report, April 2017). The BCWA collects annual water quality data from multiple sampling locations throughout the watershed. The watershed-monitoring program has three major water quality and environmental data generating elements, as defined in the ***Water Monitoring Program and Sample Analyses Plan Version 2017.01, BCWA January 2017, and subsequent annual updates***:

1. Bear Creek Watershed surface water characterizations during selected months beginning at the headwaters of both Bear Creek and Turkey with a primary focus on nutrients and base field parameters,

2. Bear Creek Watershed surface water temperature characterization by major stream segments for both the cold and warm seasons, which is also defined in the ***Water Monitoring Program and Sample Analyses Plan Version 2017.01, BCWA January 2017, and subsequent annual updates.***

3. Special water quality characterization and analyses studies completed on a site-specific basis.

The 2017 P1 data results are contained in the MS*2017 Bear Creek Master Spreadsheet* posted on the Association website monitoring page and a specific watershed spreadsheet for the temperature data. Monthly summary reports are provided to the Association Board. Stream and lake sampling and monitoring data, including pH, Temperature, Dissolved Oxygen, Specific Conductance, Ammonia, Nitrate +Nitrite, Total Inorganic Nitrogen (calculated), Total Nitrogen, Dissolved Phosphorus, Total Phosphorous, and Total Suspended Solids were collected from July through September, including the special pollution study sites in Mount Evans Wilderness Area. Stream and lake temperature data-loggers were placed at 28 sites, including the Evergreen Lake profile station, and the Bear Creek Reservoir profile station, excluding the five WWTPs. Eight selected sites collected data logger temperatures from January through December. The remaining sites collected temperature data from April through September and May through October. Some data-loggers were lost. All loggers were removed, and data downloaded after September 2017.

The Association produces an annual series of technical memorandum designed to summarize the site-specific studies for any given year (Table 4).

Table 4 2017 Technical Memorandum of the Association

TM2017.01	Sediment Survey BCR
TM2017.02	UBCW Summary
TM2017.03	Coyote Gulch Summary
TM2017.04	BCR Summary Statistics and Graphs
TM2017.05	MBCW 2017 Nutrient Summary
TM2017.06	P1 Summary
TM2017.07	Barr Milton TMDL Summary
TM2017.08	EGL Summary
TM2017.09	BCR Phytoplankton Summary

TM2017.10 Fisheries
TM2017.11 Macroinvertebrates
TM2017.12 Copper Study
TM2017.13 Regulation 85 Summary

Table 5 lists the 2017 middle watershed seasonal average chemistry results (full results shown in 2017 Master Spreadsheet). BCWA Technical Memorandum 2017.05 summarizes the middle watershed data. Table 6 lists the Summit Lake area watershed chemistry results (full results shown in 2017 Master Spreadsheet). BCWA Technical Memorandum 2017.02 summarizes the Summit Lake data.

Table 5 Middle Watershed Chemistry

Site ID	Site Location by Stream Segment	Seasonal Average	
		TN Ug/l	T Phos Ug/l
Site 36	Summit Lake	270	6
Site 37	Bear Creek Below Summit Lake	256	6
Site 58	Bear Creek below Wilderness	270	36
Site 2a	Golden Willow Road UBC	206	11
Site 3a	Above Evergreen Lake at CDOW Site	259	19
Site 25	Vance Creek (Mt. Evans Wilderness drainage)	123	11
Site 89	Yankee Creek, Mouth	214	90
Site 4a	Evergreen Lake	251	13
Site 5	Above EMD WWTP, CDOW downtown site	271	18
Site 8a	Bear Creek Cabins at CDOW Site	393	22
Site 9	O'Fallon Park, west end at CDOW Site	454	29
Site 12	Lair o' the Bear Park, at CDOW site	494	34
Site 13a	Below Idledale, Shady Lane at CDOW site	477	34
Site 14a	Morrison Park west, CDOW Site	508	43
Site 26	Cub Creek, Mouth	469	34
Site 64	Troublesome at Culvert above West Jeff	566	52
Site 32	Troublesome Mouth	1,644	118
Site 94	Mt Vernon Drainage, Morrison	2,002	30
Site 15a	Bear Creek Park	741	107
Site 19	North Turkey Creek Flying J Ranch Bridge	403	19
Site 18	South Turkey Creek Aspen Park	623	29
Site 16a	South Turkey Creek, Park	890	166
Site 40a	Bear Creek Reservoir	644	32
Site 45	Bear Creek below BCR	638	49
Site 90	Bear Creek Wadsworth	647	29

Table 6 Upper Watershed (Summit Lake) Chemistry

Site	Parameter	6/29/2017	7/14/2017	8/15/2017	9/12/2017	Average
BCWA Segment Sample Sites						
36 - Outlet Summit Lake	Total Nitrogen, ug/l	266	259	317	239	**270**
	Phosphorus, total, ug/l	6	7	7	4	**6**
37 - Upper Bear Creek	Total Nitrogen, ug/l	263	263	246	253	**256**
	Phosphorus, total, ug/l	6	6	6	6	**6**
Site 63 - Bottom Fen	Total Nitrogen, ug/l	331	138	331	1803	**651**
	Phosphorus, total, ug/l	78	128	237	1794	**559**

Reservoirs

Bear Creek Reservoir and Inflow Nutrients

The watershed-monitoring program characterizes nutrient loading into Bear Creek Reservoir from two primary drainages: Bear Creek and Turkey Creek. The Association monitors for total phosphorus, dissolved phosphorus, nitrate-nitrite nitrogen, and total nitrogen monthly. The Association has established preferred management strategies for Bear Creek Reservoir (*BCWA Policy 20*). The total phosphorus load from the watershed comes from a combination of wastewater treatment plant point source loads, un-regulated point sources, and nonpoint

sources, including runoff. There are over 9,000 septic systems in the watershed. The estimated total phosphorus load in 2017 from all sources reaching the reservoir was 6,034 pounds at a flow of about 20,625 acre-feet. Bear Creek drainage contributed 79% of the TP load (Figure 15). The management program targets reduction of total phosphorus reaching the reservoir on an annual basis. Figure 16 shows the total phosphorus reservoir trend.

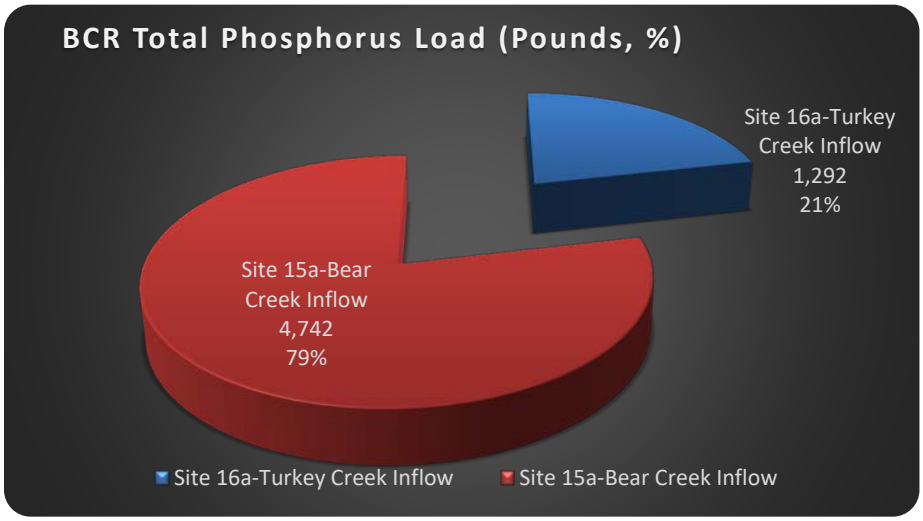


Figure 15 Estimated Total Phosphorus loading into Bear Creek Reservoir

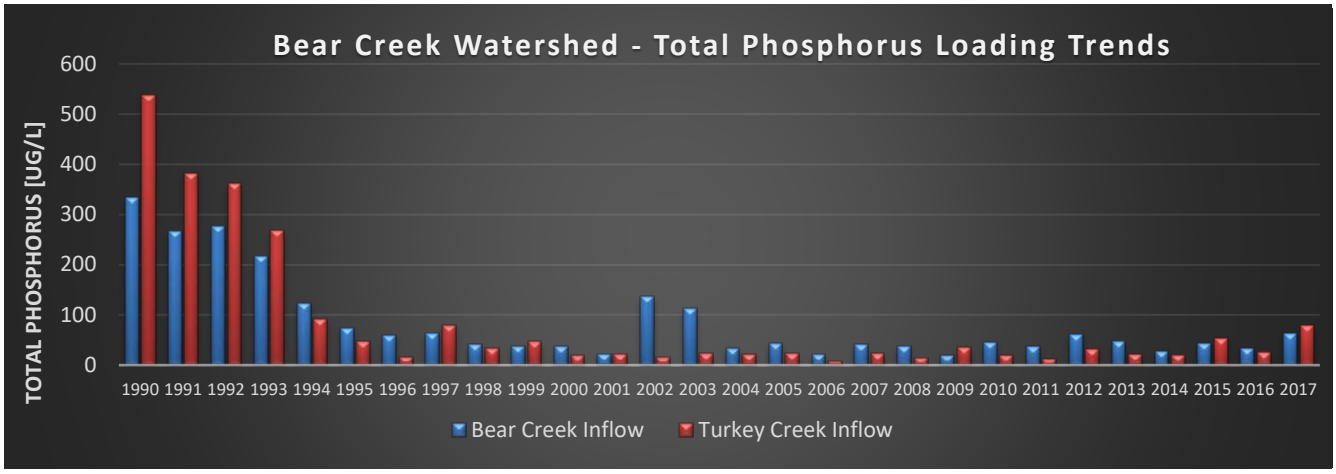


Figure 16 Total Phosphorus Trend BCR

The total nitrogen loading (Figure 17, about 48,410 pounds) had 76% of the load coming from Bear Creek. Figure 18 shows the Total Nitrogen trend in BCR.

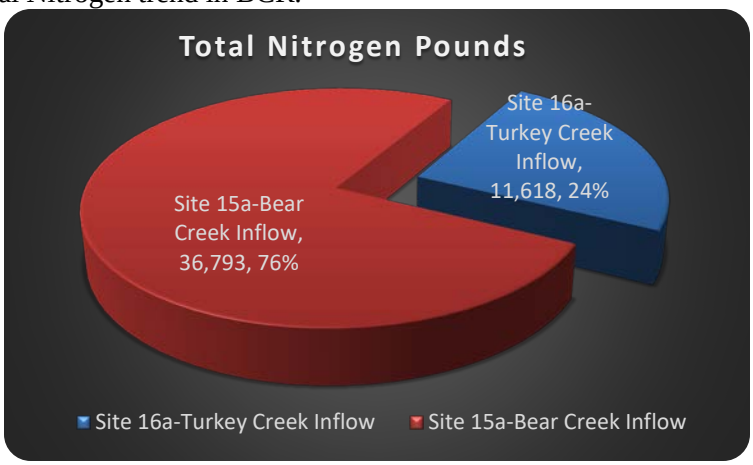


Figure 17 Total Nitrogen Loading into Bear Creek Reservoir

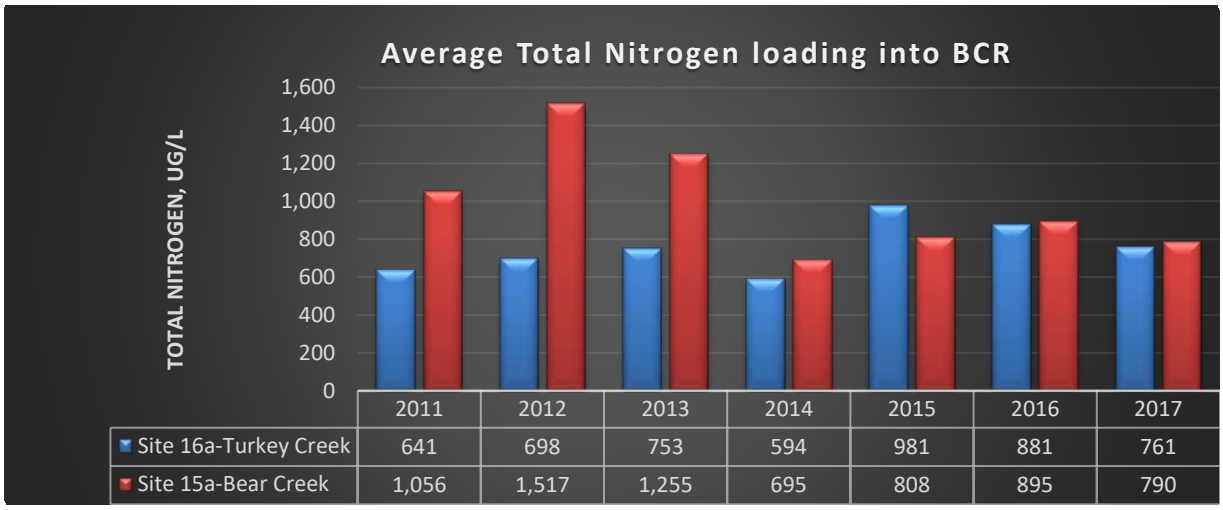


Figure 18 Estimated Total Nitrogen Loading Trend for Bear Creek Reservoir

Bear Creek Reservoir Indicator Trend Variables

The Association's reservoir monitoring program collects samples to analyze nutrient (nitrogen and phosphorus) concentrations, chlorophyll-a, total suspended sediments, dissolved oxygen, pH, specific conductance, Secchi depth, and phytoplankton population dynamics as trend variables. Table 7 lists the summary statistics for the monitoring variables. Table 8 summarizes the reservoir loading data. Table 9 compares 2016 data with the long-term patterns from 1991 through 2016. In 2016, the chlorophyll concentrations were below the long-term trends, while nitrogen loads were elevated and total phosphorus in the surface waters were reduced. Table 10 summarizes the phytoplankton data. Figure 19 shows the phytoplankton species diversity during summer sampling period. Figure 20 shows the general clarity trend in the water column using Secchi measurements. May through October had the poorest clarity caused by runoff.

Table 7 Bear Creek Reservoir Summary Statistics (July September)

Reservoir Monitoring Parameters	Reservoir
Chlorophyll (Site 40)	
Average Growing Season Chlorophyll-a [ug/l (-1m)]	22.5
Average Annual Chlorophyll-a [ug/l (-1m)]	12.8
Peak Chlorophyll-a [ug/l]	44.2
Total Phosphorus	
Average Annual Total Phosphorus [ug/l]: Water Column	45.0
Average Annual Total Phosphorus [ug/l] -1m	32.9
Average Annual Total Phosphorus [ug/l] -10m	57.1
Growing Season Total Phosphorus [ug/l]: Water Column	61.8
Growing Season Total Phosphorus [ug/l]: -1m	51.0
Growing Season Total Phosphorus [ug/l]: -10m	72.7
Peak Annual Total Phosphorus [ug/l] Water Column	111.0
Total Nitrogen	
Average Annual Total Nitrogen [ug/l]: Water Column	771
Average Total Nitrogen [ug/l]: -1m	74
Average Total Nitrogen [ug/l]: -10m	795
Growing Season Total Nitrogen [ug/l]: Water Column	669
Growing Season Total Nitrogen [ug/l]: -1m	680
Growing Season Total Nitrogen [ug/l]: -10m	658
Clarity (All Profiles)	
Average Annual Secchi Depth (meters)	2.17
Growing Season Average Secchi Depth (meters)	1.92
Dissolved Oxygen (site 40 Profile)	
Annual Average at -1/2m - 2m [mg/l]	9.56
Seasonal Average at -1/2 - 2m [mg/l]	7.54

Reservoir Monitoring Parameters	Reservoir
Seasonal Minimum at -1/2 - 2m [mg/l]	5.02
pH	
Annual Average at -1/2m - 2m [mg/l]	8.18
Seasonal Average at -1/2 - 2m [mg/l]	8.08
Seasonal Maximum at -1/2 - 2m [mg/l]	8.03
Specific Conductance	
Annual Average at -1/2m - 2m [uS/cm]	429.5
Seasonal Average at -1/2 - 2m [us/cm]	316.8
Seasonal Minimum at -1/2 - 2m [us/cm]	308.8
Phytoplankton Species	
Phytoplankton Co-dominant Species - Site 40 (July-September 2017)	*Anabaena flos-aquae*
	Microcystis aeruginosa
	Cryptomonas erosa
	Diatoma vulgare
	Gomphoneis herculeana
	Melosira granulata
	Stephanodiscus niagarae
	Chlamydomonas sp.
Peak Phytoplankton	
Microcystis aeruginosa	Density cells/ml = 75,154
Microcystis aeruginosa	Peak Biovolume (um^3/mL) = 2,268,627

Table 8 Annual Bear Creek Reservoir Load Estimates

Loading - Annual Pounds	
Total Nitrogen -Total Load In to BCR	48,411
Total Nitrogen -Total Load From BCR	36,360
Total Nitrogen -Total Deposition into BCR	11,950
Total Phosphorus -Total Load In to BCR	6,034
Total Phosphorus -Total Load From BCR	3,051
Total Phosphorus -Total Deposition into BCR	2,983

Table 9 Bear Creek Reservoir Select Trend Parameters

Parameter		2017	91-2017 Mean	91-2017 Median
Chlorophyll-a (ug/L)	Top	13	13.8	13.2
Total Nitrogen ug/l	Top	746.0	730.2	752.5
	Bottom	795.0	748.0	761.5
	Water Column	771.0	739.2	761.3
Total Phosphorus (ug/L)	Top	33.0	58.0	38.7
	Bottom	57.0	84.4	59.8
	Water Column	45	68.1	50.3
Secchi Depth (m)	Top	2.2	2.1	2.1

Table 10 Bear Creek Reservoir Phytoplankton Summary Data

Sample Date	10-Jul-17	8-Aug-17	11-Sep-17
Total Density (#/mL)	1,804	16,791	76,359
Total Biovolume (um^3/mL)	2,413,448	4,248,160	3,607,883
Trophic State Index	56.2	60.3	59.1

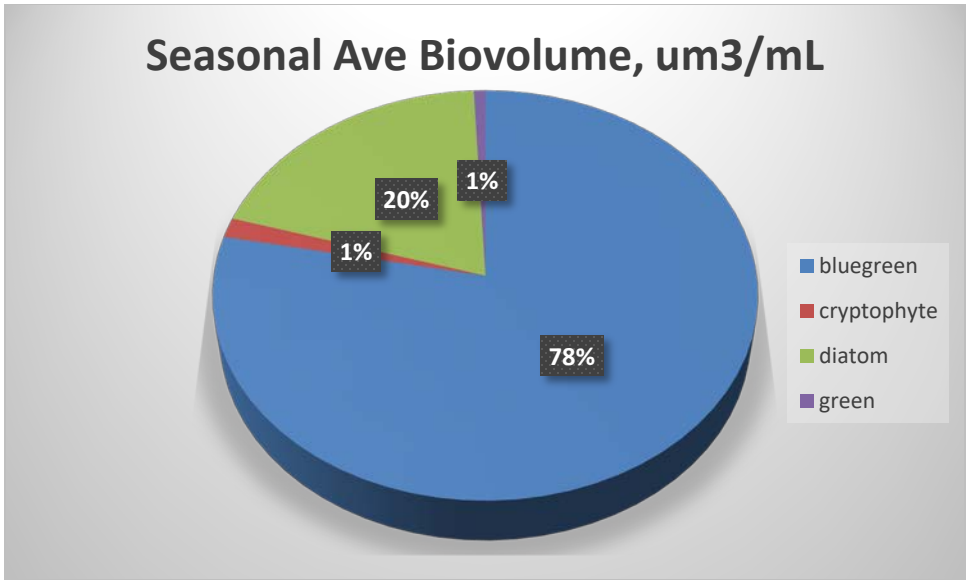


Figure 19 **Bear Creek Reservoir Phytoplankton Biovolume**

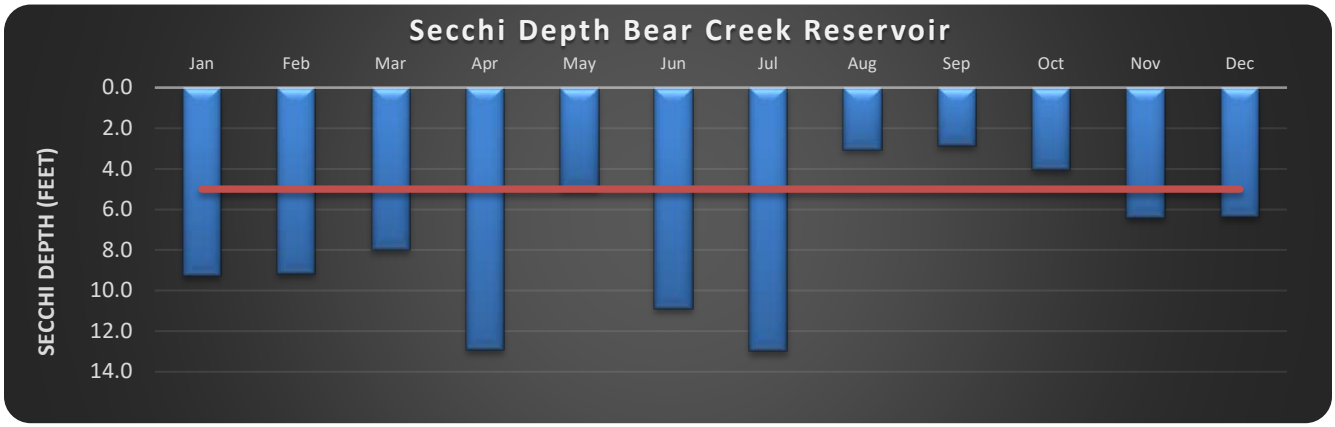


Figure 20 **Secchi Depth Bear Creek Reservoir**

The reservoir had several algal blooms in 2017 as evidenced by peak August through September chlorophyll concentrations (Figure 21). The peak *Microcystis* phytoplankton Biovolume was 2,268,600 um3/mL caused by blue-greens phytoplankton bloom. Historically, blue-green phytoplankton species are associated with major blooms in the reservoir (*BCWA Fact Sheet 57 Cyanotoxins and BCWA Fact Sheet 58 Cyanobacteria Guide BCR*). The reservoir trophic state was eutrophic (Walker Index, Figure 22). The Carlson Index shows a similar eutrophic trend. Although external nutrient loads were lower than historic trends, the reservoir continues to have an internal nutrient loading problem, which causes eutrophic water quality conditions.

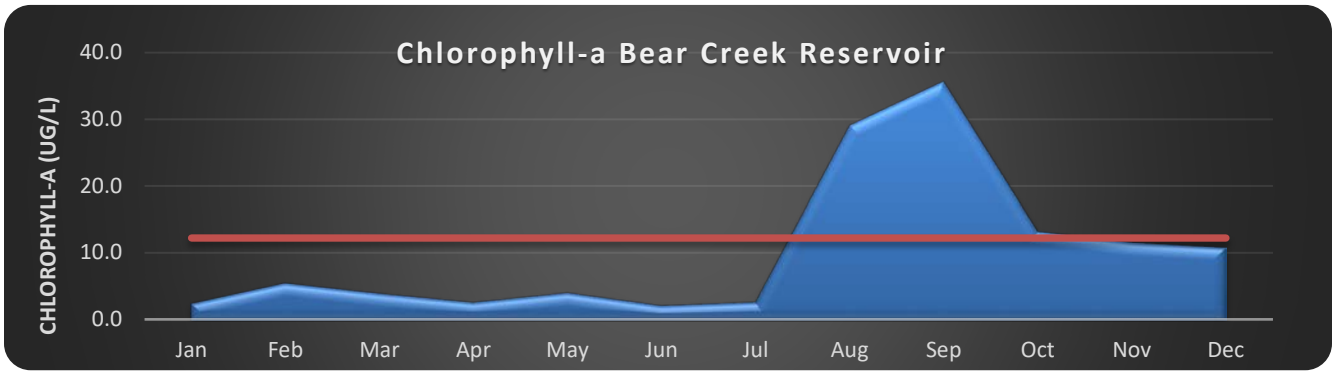


Figure 21 **Bear Creek Reservoir Chlorophyll Trend**

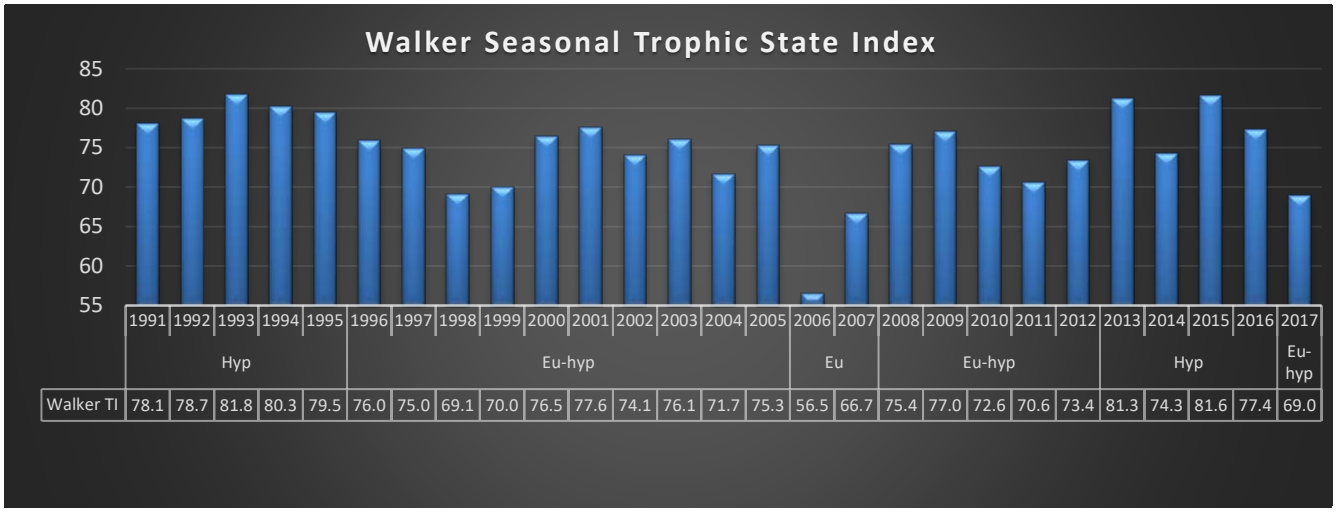


Figure 22 Walker Trophic Index Trend Bear Creek Reservoir

Bear Creek Reservoir Aeration Practice Manages Summer Dissolved Oxygen

The reservoir aeration system reduces chlorophyll productivity, possibly through the partial control of internal nutrient loading that can trigger algal blooms (*BCWA Policy 8 Bear Creek Reservoir Aeration*). The Association adopted Policy 8 to make the reservoir aeration system a permanent reservoir management tool. The Association determined through ongoing monitoring that the de-stratifying aeration system in Bear Creek Reservoir is a necessary and long-term or permanent management practice necessary to protect the quality reservoir fishery (Figure 23) and prevent Dissolved Oxygen standard exceedances during summer months of June 1-September 30.

Reservoir aeration is also a necessary management tool in low flow conditions. The aeration system has been operational since the summer of 2002 and uses a fine-bubble diffusion system with aerators distributed across the hypolimnion. In 2017, the Association and Lakewood operated the aeration system to maximize oxygen transfer during phased on-off cycling (Figure 24), with the aeration system phased primarily on in the growing season. In 2017, the Dissolved Oxygen in the upper water column was below the standard in early August. The aeration system can increase the Dissolved Oxygen concentrations throughout the water column by about 2 mg/l within a two-week period.

Figure 23 Fishing Very Popular on Bear Creek Reservoir, Both Winter and Summer

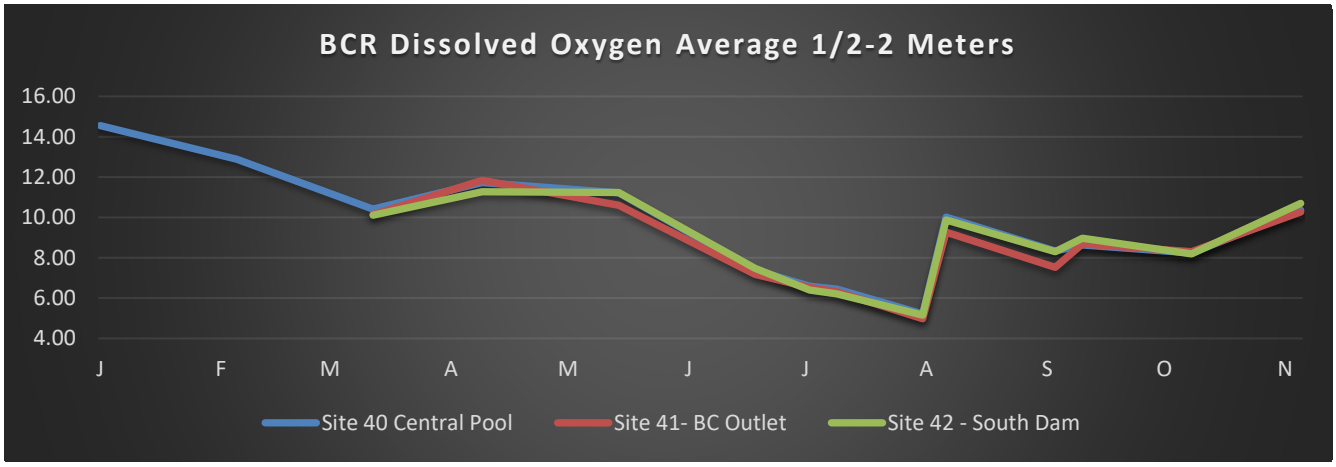


Figure 24 Bear Creek Reservoir Dissolved Oxygen Trend

Aeration System BCR

The September 2013 flood event used Bear Creek Reservoir as a major flood control structure, which caused displacement and reduced efficiency of the in-reservoir aeration system as installed by the City of Lakewood and monitored by the BCWA (*BCWA Fact Sheet 6 Aeration BCR).* A video survey was completed on the BCR aeration system on April 30, 2014 (*BCWA TM2014.01 BCR Video Survey Aerators*). The survey demonstrated air supply line damage (kinks and holes), aeration pan displacement, overturned aeration pans, reduced function, and some losses, which reduced the overall system efficiency by 40-70% (*BCWA Fact Sheet 47 New BCR Aeration System*).

Since FEMA requires *like-kind* replacement, Lakewood determined it would be more cost effective to upgrade and replace the aeration system using Lakewood funding. The BCWA assisted with new aeration configuration, system requirements and replacement options. BCWA and Lakewood staff removed most of the old aeration system and recycled these materials. The company *Underwater Repairs Specialist* installed 6 Quad Duraplate Diffusers (DDP9X4 Keeton Industries) and weighted line in November 2014 with assistance of Lakewood staff that corresponds to the pattern shown in Figure 25. The diffusers are fine bubble (air supplied by a 15 hp compressor) and they will increase the dissolved oxygen transfer into the reservoir water column. Lakewood and BCWA are conducting a three-year evaluation (2016-2018) on the effectiveness and efficiency of the new aeration system in the spring/ summer growing season.

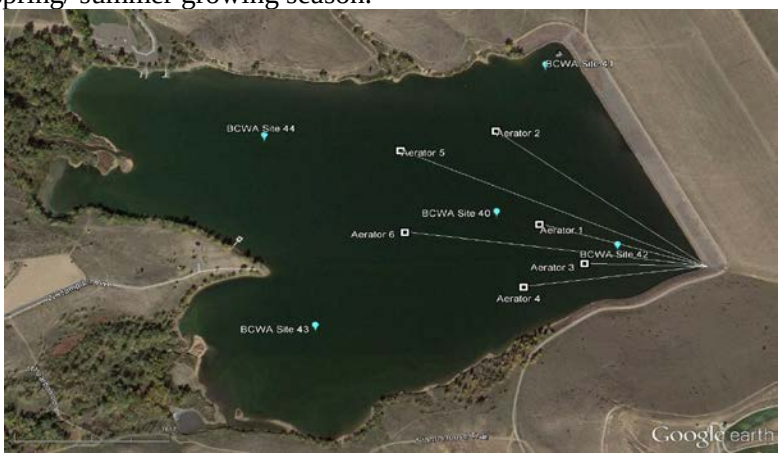


Figure 25 New BCR Aeration Configuration

Sediment Studies Bear Creek Reservoir and Evergreen Lake

The total suspended sediment load in the reservoir has been generally constant over the historic monitoring period with periodic storm events dumping large volumes of sediment into the reservoir. Bottom sediments are a mixture of fine sand, silt and mud. The September 2013 flood event introduced extremely large amounts of sediments. The BCWA had no reliable method to determine the total amount of sediment transported by the 2013 floods. The BCWA approximated the amounts deposited into Evergreen Lake (Table 11) and Bear Creek

Reservoir (Table 12). It is very apparent that storm waters moved millions of pounds of sediments. There was extensive erosion throughout the watershed. Streambanks were lost, and channels configurations were altered throughout the segment 1e. In August 2017, the BCWA collected sediment samples from six locations in BCR. Sediments were analyzed for total phosphorus content (Table 13 and Figure 26) and organic content (*BCWA TM 2017.01 BCR Sediment Survey*).

Table 11 Estimated Sediment Load into Evergreen lake

Evergreen Reservoir			
Sep-13		Oct-13	
TSS Based (SSL Load)		TSS Based (SSL Load)	
Tons/month	Cubic Yards/Month	Tons/month	Cubic Yards/Month
905	745	28	23
Estimated Bedload		Estimated Bedload	
Tons/month	Cubic Yards/Month	Tons/month	Cubic Yards/Month
13,582	11,179	142	117

Table 12 Estimated Sediment Load into Bear Creek Reservoir

Bear Creek Reservoir			
Sep-13		Oct-13	
TSS Based (SSL Load)		TSS Based (SSL Load)	
Tons/month	Cubic Yards/Month	Tons/month	Cubic Yards/Month
40,933	33,690	1,587	1,306
Estimated Bedload		Estimated Bedload	
Tons/month	Cubic Yards/Month	Tons/month	Cubic Yards/Month
1,023,331	842,248	7,933	6,529

Table 13 Phosphorus Content of BCR Sediments

		mgP/kg Mud
Bear Creek Transect	SedBC03	11.82
	SedBC05	5.21
Pelican Point Transect	SedPel08	3.86
	SedPel10	5.33
Turkey Creek Transect	SedTC14	4.20
	SedTC16	4.51

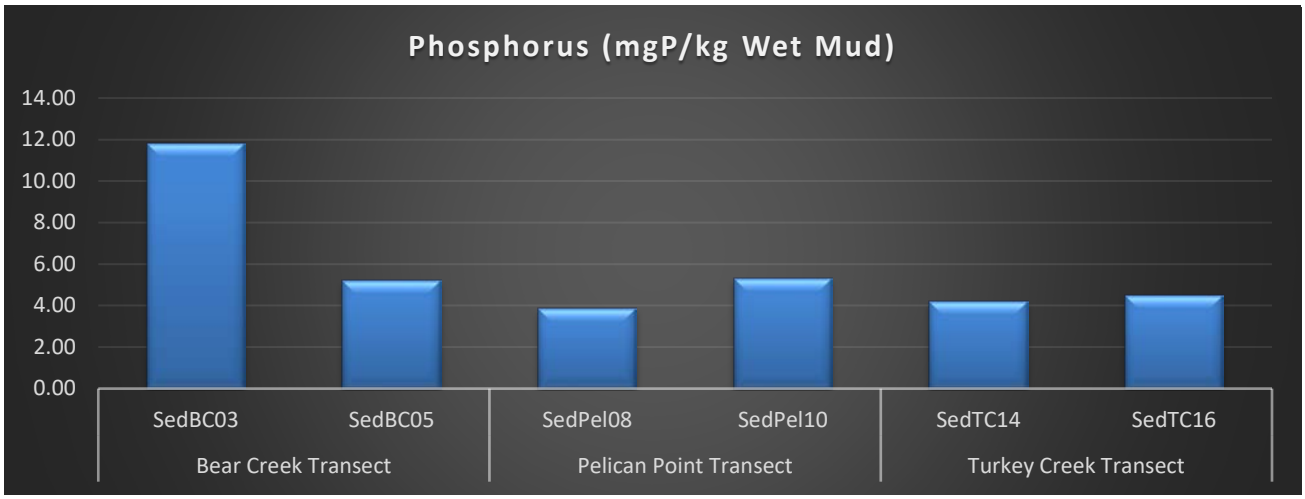


Figure 26 Sediment Phosphorus by Transect in BCR

Evergreen Lake Study

Evergreen Lake (Segment 1d) is a small reservoir constructed in 1927 and serves as a major direct use water supply for the Evergreen community. The lake is an important year-round recreational facility with fishing and winter ice activities. The Evergreen Park & Recreation District provides maintenance around Evergreen Lake. These efforts aid in maintaining good water quality. The District maintains the wetlands located on the west end of the lake, retaining walls and rocks structure that support the road and walking paths, maintains erosion control features of the area and periodically removes rooted vegetation located along the shoreline and in the lake. In recent years, the Association has increased monitoring efforts to better characterize the reservoir and help protect the quality (Table 14). The Association has established preferred management strategies for Evergreen Lake (*BCWA Policy 20*).

In the last few years, the dissolved oxygen concentrations in the water column were becoming very low with periodic bottom waters having less than 5 mg/l DO. The Evergreen Metropolitan District in cooperation with the recreation district installed an aeration system near the dam outlet area to help maintain elevated DO levels throughout the lake. The districts in cooperation with the Colorado Department of Parks and Wildlife introduced Grass Carp into the reservoir with the first release of about 100 fish at 20 inches' length. This program reduces the excess Elodea algal (introduced invasive species) growth that contributes to the depressed DO problem. The combination of the aeration system and grass carp program resulted in DO compliance in 2017 monitoring program. The water quality summary data is shown in Tables 14 and 15. The Association monitoring program data supports the designation of Evergreen Lake as a direct use water supply.

Table 14 Water Quality Data Summary for Evergreen Lake

Site	Parameter (ug/l)	5/17/2017	6/19/2017	7/12/2017	8/9/2017	9/13/2017	10/12/2017	Average
EGL 4a	Total Nitrogen	287	287	270	253	161	250	251
	Phosphorus, total	13	11	11	17	11	13	13
	Residue, Non-Filterable (TSS)	4.8	4.0					4
	Chlorophyll a Average	3.2	1.1	4.0	3.5	1.7	4.4	3.0
EGL 4e	Total Nitrogen	290	257	424.0	381	131	258	290.2
	Phosphorus, total	18.0	14	16.0	163	14	17	40.3
								Total
EGL 4a	Total Nitrogen, Pounds/month	29.5	49.7	32.6	28.1	11.6	21.8	173
	Total Phosphorus, Pounds/month	1.3	1.9	1.3	1.9	0.8	1.1	8
	TSS, pounds/month	492.8	692.7	0.0	0.0	0.0	0.0	1185

Table 15 Field Summary Data Evergreen Lake

	Parameter Summary	5/17/2017	6/19/2017	7/12/2017	8/9/2017	9/13/2017	10/12/2017
Water Column	Dissolved Oxygen 1/2-2m	10.55	6.56	7.14	6.23	8.54	8.54
	Temperature (C) 1/2-2m	13.02	14.63	16.55	14.48	15.28	15.28
	pH water column	7.53	7.32	7.34	7.73	7.92	7.92
	Specific Conductance (us/m)	90.0	54.4	54.1	61.1	59.27	59.27
Flows	Bear Creek Keys (cfs) Monthly Avg	37.7	63.6	44.4	40.8	26.4	32.0
	Bear Creek EGL (cfs) daily	36	66	38	65	24	38

IV. Meeting Water Quality Goals and Standards for the Watershed

Dissolved Oxygen Compliance in Bear Creek Reservoir

The Association takes multiple profile readings at three to five profile stations in the reservoir to determine Dissolved Oxygen compliance. The Association Dissolved Oxygen data set from 2003-2017 for Bear Creek Reservoir shows over 99% compliance with the standard for the upper water column (surface through the mixed layer). The monthly Dissolved Oxygen values in the mixed layer in 2017 were generally greater than 6 mg/l (Figure 26). There was an oxygen sag in early August, that correlated with a massive phytoplankton bloom.

Data collected in the 2017 growing season shows the aeration system adds a maximum of 1.5 mg/l dissolved oxygen to the water column when under normal operation. Generally, the aeration system increases water column dissolved oxygen by about 1 mg/l, which results in dissolved oxygen compliance within the mixed layer.

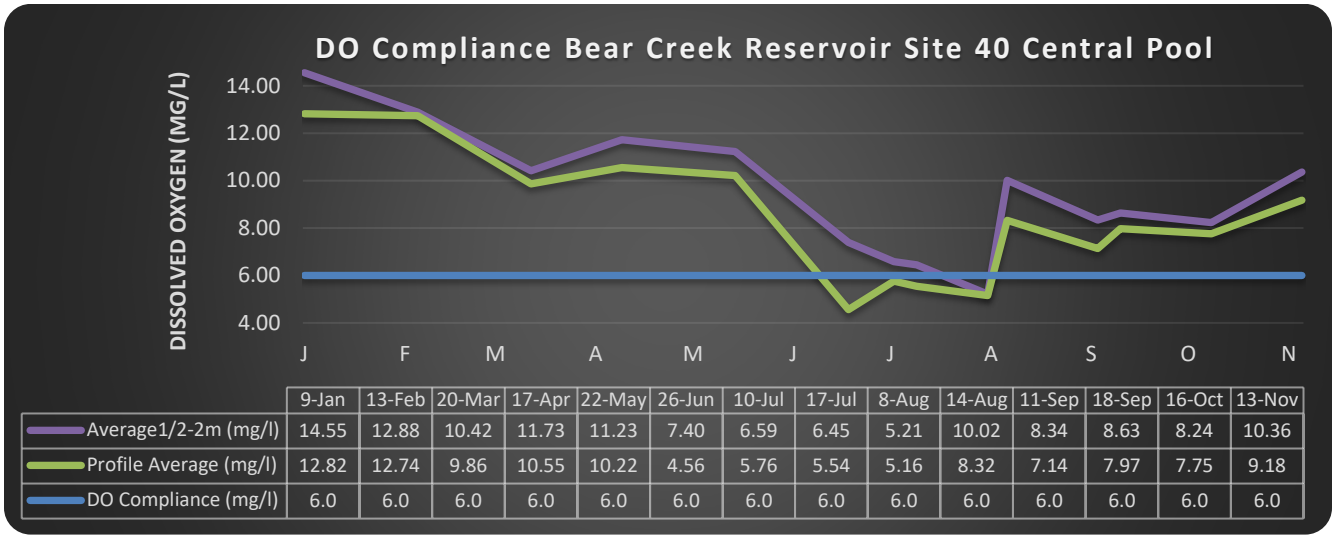


Figure 27 DO Compliance Bear Creek Reservoir

Temperature Standards Bear Creek Watershed

Table 16 shows the adopted temperature standards by segment for the watershed.

Table 16 Temperature Standards in Bear Creek Watershed

Segment	Segment	Standard	Month	Standard (°C) (MWAT)	Standard (°C) (DM)	Month	Standard(°C) (MWAT)	Standard(°C) (DM)
1a	Mainstem of Bear Creek from the boundary of the Mt. Evans Wilderness area to the inlet of Evergreen Lake	T=TVS(CS-I) °C	June-Sept	17.0	21.2	Oct-May	9.0	13.0
1b	Mainstem of Bear Creek from Harriman Ditch to the inlet of Bear Creek Reservoir	T=TVS(CS-II) °C, April-Oct; T(WAT)=19.3 °C	April-Oct	19.3	23.8	Nov-March	9.0	13.0
1c	Bear Creek Reservoir.	T=TVS(CLL) °C; April-Dec; T(WAT)=23.3 °C	April-Dec	23.3	23.8	Jan-Mar	9.0	13.0
1d	Evergreen Lake.	T=TVS(CLL) °C	April-Dec	18.2	23.8	Jan-Mar	9.0	13.0
1e	Mainstem of Bear Creek from the outlet of Evergreen Lake to the Harriman Ditch.	T=TVS(CS-II) °C; April-Oct; T(WAT)=19.3 °C	April-Oct	19.3	23.8	Nov-March	9.0	13.0
2	Mainstem of Bear Creek from the outlet of Bear Creek Reservoir to the confluence with the South Platte River.	T=TVS(WS-II) °C	March-Nov	27.5	28.6	Nov-March	13.7	14.3
3	All tributaries to Bear Creek, including all wetlands, from the source to the outlet of Evergreen Lake, Except for specific listings in Segment 7.	T=TVS(CS-I) °C	June-Sept	17.0	21.2	Oct-May	9.0	13.0
4a	All tributaries to Bear Creek, including all wetlands, from the outlet of Evergreen Lake to the confluence with the South Platte River, except for specific listings in Segments 5, 6a, and 6b.	T=TVS(WS-I) °C	March-Nov	24.2	29	Dec-Feb	12.1	14.5
5	Swede, Kerr, Sawmill, Troublesome, and Cold Springs Gulches, and mainstem of Cub Creek from the source to the confluence with Bear Creek.	T=TVS(CS-II) °C	April-Oct	18.2	23.8	Nov-March	9.0	13.0

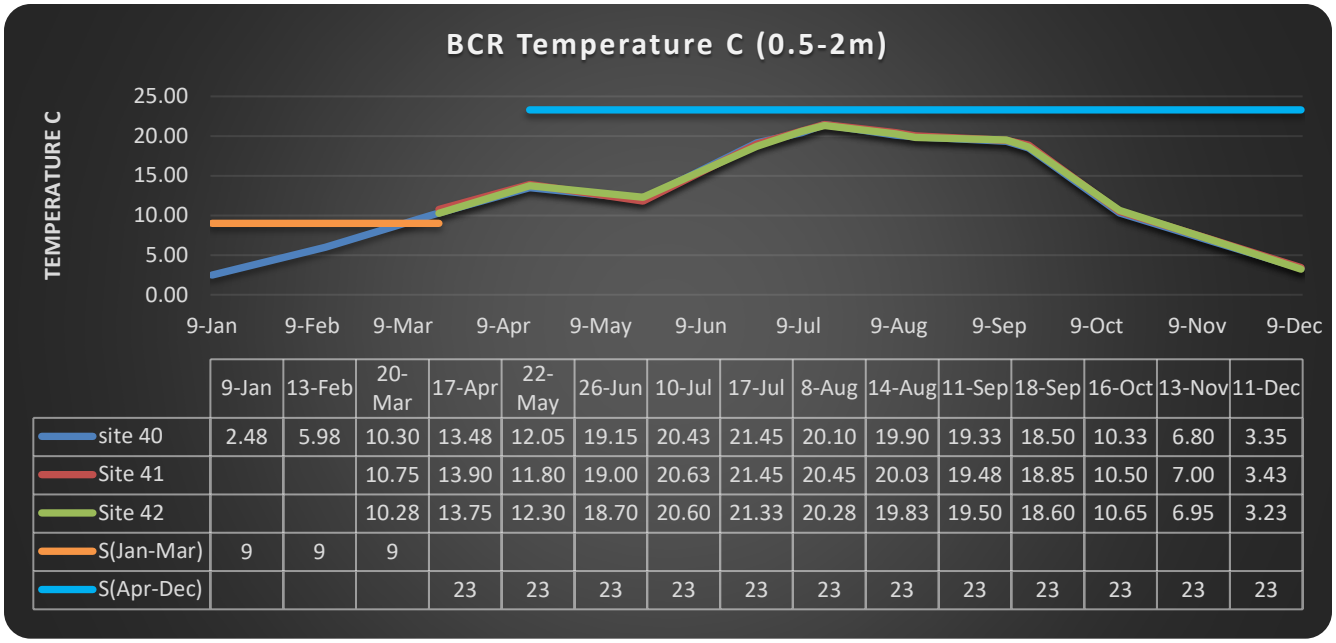
Segment	Segment	Standard	Month	Standard (°C) (MWAT)	Standard (°C) (DM)	Month	Standard(°C) (MWAT)	Standard(°C) (DM)
6a	Turkey Creek system, including all tributaries and wetlands, from the source to the inlet of Bear Creek Reservoir, except for specific listings in Segment 6b.	T=TVS(CS-II) °C	April-Oct	18.2	23.8	Nov-March	9.0	13.0
6b	Mainstem of North Turkey Creek, from the source to the confluence with Turkey Creek.	T=TVS(CS-I) °C	June-Sept	17.0	21.2	Oct-May	9.0	13.0
7	Mainstem and all tributaries to Bear Creek, including wetlands, within the Mt. Evans Wilderness Area.	T=TVS(CS-I) °C	June-Sept	17.0	21.2	Oct-May	9.0	13.0
8	Lakes and reservoirs in the Bear Creek system from the sources to the boundary of the Mt. Evans Wilderness area.	T=TVS(CL) °C	April-Dec	17.0	21.2	Jan-Mar	9.0	13.0
9	Lakes and reservoirs in the Bear Creek system from the boundary of the Mt. Evans Wilderness area to the inlet of Evergreen Lake.	T=TVS(CL) °C	April-Dec	17.0	21.2	Jan-Mar	9.0	13.0
10	Lakes and reservoirs in drainages of Swede Gulch, Sawmill Gulch, Troublesome Gulch, and Cold Springs Gulch from source to confluence with Bear Creek.	T=TVS(CL) °C	April-Dec	17.0	21.2	Jan-Mar	9.0	13.0
11	Lakes and reservoirs in the Bear Creek system from the outlet of Evergreen Lake to the confluence with the South Platte River, except as specified in Segments 1c, 10, and 12; includes Soda Lakes.	T=TVS(CL) °C	April-Dec	17.0	21.2	Jan-Mar	9.0	13.0
12	Lakes and reservoirs in the Turkey Creek system from the source to the inlet of Bear Creek Reservoir	T=TVS(CL) °C	April-Dec	17.0	21.2	Jan-Mar	9.0	13.0

Bear Creek Reservoir Temperature Compliance

The Association takes multiple profile readings at three to five profile stations in the reservoir and has a temperature data-logger set at site 40 to determine temperature compliance. Figure 28 show temperature standards and the monthly sampling compliance record for Bear Creek Reservoir. The temperature probe string at site 40 measures temperature in the top 2m of the water column (-1/2m, -1m, -1.5m, and 2m); the lower probe was lost during the summer season. Table 17 summarizes the temperature record for the probes. The reservoir had two daily maximum temperature exceedances in 2017 during the cold season shoulder period. There were no exceedances in the warm season.

Table 17 Temperature Compliance Summary Bear Creek Reservoir

Segment 1c Data logger Temperature Summary 2017								
All Temperatures in °C	30-Min Temp. Cold/Warm SEASON		Nov 1-Mar 31 Stream Std. WAT (9 °C)	Nov 1-Mar 31 2-Hr Avg. Temp.	Nov 1-Mar 31 Stream Std. DM (13 °C)	Apr 1-Oct 31 Stream Std. WAT (19.3 °C)	Apr 1-Oct 31 2-HR Avg. Temp.	Apr 1-Oct 31 Stream DM (23.8 °C)
Min	9.3	3.1	10.3	9.3	10.0	4.8	3.1	9.6
Max	11.4	23.9	10.3	11.3	11.3	22.2	23.4	23.4
Avg	10.2	14.9	10.3	10.2	10.6	15.1	14.9	17.2
Std. Dev.	0.5	5.4	0.0	0.5	0.4	5.2	5.4	4.1
Measurements	528		1	132	11	36	3053	122



	9-Jan	13-Feb	20-Mar	17-Apr	22-May	26-Jun	10-Jul	17-Jul	8-Aug	14-Aug	11-Sep	18-Sep	16-Oct	13-Nov	11-Dec
site 40	2.48	5.98	10.30	13.48	12.05	19.15	20.43	21.45	20.10	19.90	19.33	18.50	10.33	6.80	3.35
Site 41			10.75	13.90	11.80	19.00	20.63	21.45	20.45	20.03	19.48	18.85	10.50	7.00	3.43
Site 42			10.28	13.75	12.30	18.70	20.60	21.33	20.28	19.83	19.50	18.60	10.65	6.95	3.23
S(Jan-Mar)	9	9	9												
S(Apr-Dec)				23	23	23	23	23	23	23	23	23	23	23	23

Figure 28 Temperature Compliance Bear Creek Reservoir

Watershed Stream and Lake Compliance

The Association conducts special stream monitoring programs within the Bear Creek Watershed including Bear Creek, and a portion of the Turkey Creek Drainage (North and South Turkey Creek). The monitoring year divides into a warm-season period with more intense sampling and a cold-season period, designed to provide minimal winter and spring data. The Association 2017 Data Report summarizes temperature and water quality monitoring data, sampling results obtained from in-stream locations, and data from five-wastewater treatment plant effluents. The complete water quality data set is an electronic data report.

249,574 individual temperature data points were obtained from the twenty-three data logger sites within the watershed (excluding the WWTP data). The warm-season and cold-season temperature compliance summary is shown in Table 18. A limited number of temperature compliance problems occurred in the cold season during the shoulder season and the warm season.

Table 18 Watershed Temperature Compliance Summary Warm/ Cold Seasons

Segment	Cold-season		Warm Season	
Segment 3	**9 ºC WAT**	**13 ºC DM**	**17 ºC WAT**	**21.2 ºC DM**
# Exceedances	0	15	0	0
% Compliance	100%	94%	100%	100%
Segment 1a	**9 ºC WAT**	**13 ºC DM**	**17 ºC WAT**	**21.2 ºC DM**
# Exceedances	3	10	0	0
% Compliance	94%	97%	100%	100%
Segment 1d	**9 ºC WAT**	**13 ºC DM**	**17 ºC WAT**	**21.2 ºC DM**
# Exceedances			0	0
% Compliance			100%	100%
Segment 1e	**9 ºC WAT**	**13 ºC DM**	**17 ºC WAT**	**21.2 ºC DM**
# Exceedances	0	0	0	0
% Compliance	100%	100%	100%	100%
Segment 1b	**9 ºC WAT**	**13 ºC DM**	**17 ºC WAT**	**21.2 ºC DM**
# Exceedances	0	1	0	0
% Compliance	100%	99%	100%	100%
Segment 5	**9 ºC WAT**	**13 ºC DM**	**17 ºC WAT**	**21.2 ºC DM**
# Exceedances	0	0	0	0
% Compliance	100%	100%	100%	100%
Segment 6a	**9 ºC WAT**	**13 ºC DM**	**17 ºC WAT**	**21.2 ºC DM**
# Exceedances	0	1	0	0
% Compliance	100%	99%	100%	100%

Segment	Cold-season		Warm Season	
Segment 6b	**9 ºC WAT**	**13 ºC DM**	**17 ºC WAT**	**21.2 ºC DM**
# Exceedances	0	0		
% Compliance	100%	100%		
Segment 2	**13.7°C WAT**	**14.3°C DM**	**27.5°C WAT**	**28.6°C DM**
# Exceedances	0	0	0	1
% Compliance	100%	100%	100%	100%
Segment 1c	**9°C WAT**	**13°C DM**	**23.3°C WAT**	**23.8°C DM**
# Exceedances	2	0	0	0
% Compliance	0%	100%	100%	100%

Stream and lake sampling and monitoring data, including pH, Temperature, Dissolved Oxygen, Specific Conductance, Total Nitrogen and Total Phosphorous was collected from May through October (Table 19). Stream and lake temperature dataloggers located at 28 Sites, including the Evergreen Lake profile station and Bear Creek Reservoir profile station, excluding the five-wastewater treatment plants. Manual flows measured at 22 sites during the May to October timeframe. An aeration system was installed and operational for Evergreen Lake. The only water chemistry exceedances of standards measured in the 2017 watershed-monitoring program occurred at Summit Lake.

Table 19 Water Quality Compliance at Watershed Monitoring Sites

	Stream Std.	Stream Std.	Proposed Stream Std	Proposed Stream Std
	pH (6.5-9 SU)	DO (6.0 mg/L 2-meter avg. for lakes)	Total Nitrogen 1250 ug/L	Total Phosphorous (110 ug/L)
Segment 8				
# Exceedances	1	5	1	4
# Measurements	16	16	16	16
% Compliance	94%	69%	94%	75%
Segment 7				
# Exceedances	0	0	0	0
# Measurements	4	4	4	4
% Compliance	100%	100%	100%	100%
Segment 3				
# Exceedances	0	0	0	1
# Measurements	12	12	12	12
% Compliance	100%	100%	100%	92%
Segment 1a				
# Exceedances	0	0	0	1
# Measurements	21	21	18	18
% Compliance	100%	100%	100%	94%
Segment 1d				
# Exceedances	0	0	0	1
# Measurements	69	69	12	12
% Compliance	100%	100%	100%	92%
Segment 1e				
# Exceedances	0	0	0	1
# Measurements	61	61	36	36
% Compliance	100%	100%	100%	97%
Segment 1b				
# Exceedances	0	0	2	2
# Measurements	16	16	15	15
% Compliance	100%	100%	87%	87%
Segment 5				
# Exceedances	0	0	3	2
# Measurements	18	18	18	18
% Compliance	100%	100%	83%	89%
Segment 6a				
# Exceedances	0	1	0	0

	Stream Std.	Stream Std.	Proposed Stream Std	Proposed Stream Std
	pH (6.5-9 SU)	DO (6.0 mg/L 2-meter avg. for lakes)	Total Nitrogen 1250 ug/L	Total Phosphorous (110 ug/L)
# Measurements	21	21	20	20
% Compliance	100%	95%	100%	100%
Segment 6b				
# Exceedances	0	0	0	0
# Measurements	6	6	6	6
% Compliance	100%	100%	100%	100%
Segment 4a				
# Exceedances	0	0	6	0
# Measurements	18	18	6	6
% Compliance	100%	100%	0%	100%
Segment 2				
# Exceedances	0	1	2	1
# Measurements	31	31	28	28
% Compliance	100%	97%	93%	96%

303(d) Listing

Table 20 shows the stream segments in the Bear Creek Watershed that are on the Colorado 303(d) list. In January 2017, the Colorado Water Quality Control Commission adopted a revised 303(d) list of priority pollutants causing impairment or those needing further monitoring and evaluation (Effective date March 2018).

Table 20 303(d) List Bear Creek Watershed

WBID	Segment Description	Portion	Colorado's M & E List	303(d) Impairment	303(d) Priority
COSPBE01a	Mainstem of Bear Creek from the boundary of the Mt. Evans Wilderness area to the inlet of Evergreen Lake.	Bear Creek below the confluence with Yankee Creek		Temperature	H
COSPBE01b	Mainstem of Bear Creek from Harriman Ditch to the inlet of Bear Creek Reservoir	all	-	Temperature	M
COSPBE01c	Bear Creek Reservoir	all		Chl-a, phosphorus	H
COSPBE01e	Mainstem of Bear Creek from the outlet of Evergreen Lake to the Harriman Ditch.	Kerr/Swede to Mt Vernon Creek	-	Temperature	H
COSPBE01e	Mainstem of Bear Creek from the outlet of Evergreen Lake to the Harriman Ditch.	Mount Vernon Creek to the Harriman Ditch	-	Cu, Temperature	H
COSPBE02	Bear Creek below Bear Creek Reservoir to South Platte River	Below Wadsworth Boulevard	-	*E. coli (May-Oct)*	H
COSPBE02	Bear Creek below Bear Creek Reservoir to South Platte River	Kipling to South Platte	-	Aquatic Life (provisional), As	L/L
COSPBE03	All tributaries to Bear Creek, from the source to the outlet of Evergreen Lake	Vance Creek		Temperature	H
COSPBE06a	Turkey Creek system, including all tributaries from the source to the inlet of Bear Creek Reservoir	Turkey Creek below Parmalee Gulch	Temperature		
COSPBE06b	Mainstem of North Turkey Creek, from the source to the confluence with Turkey Creek	all	Temperature		
COSPBE11	Lakes and reservoirs in the Bear Creek system from the outlet of Evergreen Lake to the confluence with the South Platte River	Harriman Reservoir	As		

Barr/Milton Model Input and Bear Creek Load Predictions

The Bear Creek Watershed is in the defined "data" shed for the BMW pH/DO TMDL. 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 a source that contributes about 1.8 % of the external load of Total Phosphorus. The BMW pH/DO TMDL established the limiting 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. In the period from 2000 through 2017, the average Total Phosphorus at BCWA site 45 was 3,051 pounds/year (*BCWA TM 2017.07 Barr Milton TMDL*

Summary). The Association annually provides the Barr/Milton Watershed Board a technical memorandum detailing water quality data at site 45 BCWA TM 2017.07, March 2018).

Macroinvertebrate Analysis and Aquatic Life Compliance

Since 2004, the Association has conducted macroinvertebrate sampling and data collection at 14 sites, including Colorado Parks and Wildlife fish survey sites along Bear Creek: Morrison (west end), Idledale, Lair o' the Bear Park, O' Fallon Park, Bear Creek Cabins, Main Street Evergreen (across from the Little Bear), above Evergreen Lake upstream within Dedisse Park, Bear Tracks, above Singing River Ranch at the Mt. Evans Boundary area, and Golden Willow Bridge. The sampling design in Bear Creek has targeted a combination of slow and fast riffles with various amounts of cobble substrate at the sites. The program provides information on site variation, including both spatial and temporal variation at each site. Table 21 summarizes existing macroinvertebrate data. There was macroinvertebrate sampling done in 2017 (*BCWA TM2017.11 Macroinvertebrate Summary*). There was an MMI compliance problem at the Little Bear and Wadsworth monitoring station.

Table 21 MMI Attainment and Impairment Summary for Bear Creek Watershed

WQCD Station ID	BCWA Station ID	Location	Biotype	MMI							
				2009	2010	2011	2012	2014	2015	2016	2017
5756a	15a	BCLP @ bridge	Transition					66.4	59.1	67.0	56.4
122	14a	Morrison @ Gage	Transition	69.8	80.5	74.5	72.9	48.8	73.5	72.0	63.9
122C	13a	Idledale	Transition	62.1	69.8	57.1	68.0	59.3	59.2	50.0	62.2
122a	12	Lair O' Bear	Transition	58.5	62.2	56.4	51.3	49.5	72.2	46.0	62.9
122b	9	O' Fallon	Transition	53.6	57.7	45.5	49.9	44.8	59.1	57.0	60.1
5762	8b	BCC @ Bridge	Transition	55.6	39.1	51.1	44.3	49.6	62.3	59.0	57.4
5763	5	Little Bear	Transition	52.3	56.6	42.9	40.0	56.2	68.9	75.0	38.4
5764	3a	Keys @ bridge	Mountain	38.6	36.9	45.3	46.9	43.9	63.6	37.0	57.9
5768d	2a	Golden Willow	Mountain				71.9	60.8	56.6	65.0	58.1
5768c	58	Mt Evans Wilderness	Mountain			55.5	72.5	67.0	53.8	67.0	75.6
BCWA90	90	Wadsworth	Transition							55.0	39.9

V. Wastewater Treatment Facilities Loading and Compliance

Wasteload Compliance

The total wasteload allocation of phosphorus from all wastewater treatment facilities in the Bear Creek Watershed is 5,255 pounds per year. Table 22 lists the permitted wastewater treatment facilities. Each discharger is limited to an annual wasteload of total phosphorus, except as provided through trading provisions. Wastewater discharges cannot exceed a total phosphorus effluent concentration of 1.0 mg/l as a 30-day average. Two facilities exceeded the assigned wasteload allocations (Table 21): Brook Forest Inn and Geneva Glen. No compliance action was taken by WQCD enforcement section for these significant non-compliance problems.

Table 22 Treatment Facility Wasteload Allocations

Bear Creek Watershed Wastewater Treatment Plants by Drainage Basin	WQCC Adopted Phosphorus WLA Pounds/ year	2017 Discharged Phosphorus Pounds/year	% Allocation Used by WWTF
Bear Creek Drainage			
Jefferson County Schools – Mt. Evans Outdoor Lab	**20**	4.76	24%
Brook Forest Inn[1]	**5**	22	440%
Evergreen Metropolitan District	**1,500**	250.73	17%
West Jefferson County Metro District	**1,500**	268.33	18%
Kittredge Sanitation and Water District	**240**	47.39	20%
Genesee Water and Sanitation District	**1,015**	318.67	31%
Forest Hills Metropolitan District	**80**	21.35	27%
Town of Morrison	**600**	74.19	12%
Bear Creek Total	**4,960**	**1,007.42**	**20%**
Turkey Creek Drainage			
Conifer Metropolitan District	**40**	3.7	9%
Conifer Sanitation Association	**40**	0.95	2%

Bear Creek Watershed Wastewater Treatment Plants by Drainage Basin	WQCC Adopted Phosphorus WLA Pounds/ year	2017 Discharged Phosphorus Pounds/year	% Allocation Used by WWTF
Aspen Park Metropolitan District	**40**	6.9	17%
Jefferson County Schools - Conifer High School	**110**	3.9	4%
Geneva Glen[2]	**5**	19.96	399%
Bear Creek Development Corp. - Tiny Town[3]	**5**	Hauling Columbia	
Turkey Creek Total	**240**	**35.41**	**15%**
Total Operational Facilities Lbs./year	***5,200***	***1,042.83***	20%
Reserve Pool[4]	**55**	0	0%
Total Phosphorus Wasteload lbs./year	**5,255**		
1-Brook Forest Inn - Compliance Advisory, Reported Effluent Violation Notice of Significant Non-Compliance by WQCD. Exceeded phosphorus concentration limits and pounds as reported by WQCD. No compliance action by WQCD enforcement section.			
2-Geneva Glen - Compliance Agreement. Exceeded phosphorus concentration limits and pounds as reported to WQCD. New LAMP in progress. No compliance action by WQCD enforcement section.			
3-Records from Columbia Sanitary show they hauled 131,400 gallons in the 2017 operation season			
4- The reserve pool in the Control Regulation is 2 pounds of total phosphorus, the 55 pounds listed by the BCWA includes pounds from closed treatment facilities (Singing River Ranch (30), The Fort Restaurant (18), Bear Creek Cabins (5))			

Permit Compliance and Plant Expansions/Actions

Table 23 shows permitted and closed wastewater treatment facilities (still listed in control regulation) in the watershed, estimated 5-year status of wastewater planning, and reported permit compliance problems. All wastewater treatment plants in the watershed are minor facilities using the WQCD permit classification system. The Association does continuous planning and review efforts for all facilities and produced a series of summary information sheets specific for dischargers.

Table 23 Wastewater Treatment Plant Planning Status

Facility	Wastewater Utility Plan	Electronic Planning Documents	Recent Upgrades (3 yrs.)	Facility Upgrades [2017-2022]	Existing Compliance Concerns[1]	Informational Sheet
Evergreen Metropolitan District	Yes	WQCD Fact Sheet, WQA, Permit	Lift Station	Yes	TIN	IFS01
West Jefferson County	Yes	WQCD Fact Sheet, WQA, Permit	Lift Station	Yes	TIN	IFS03
Genesee	Yes	WQCD Fact Sheet, WQA, Permit	No	No	TIN	IFS04
Morrison	Yes	WQCD Fact Sheet, WQA, Permit	No	Yes	Mixing zone, Low Flows	IFS05
Kittredge	Yes	WQCD Fact Sheet, WQA, Permit	No	Yes	TIN	IFS02
Forest Hills Metropolitan District	Yes	Site Application Engineering Report, Permit (2009)	No	No	No	IFS06
Conifer Metropolitan District	Yes	WQCD Fact Sheet, WQA, Permit	Yes, Filter	Yes	TDS	IFS08
Conifer Sanitation Association	Yes	Lift Station Rpt	No	Yes	Lift Station Line Breaks	IFS08
Aspen Park Metro District	Yes	WQCD Fact Sheet, WQA, Permit	No	Yes	Gallery Operation	IFS07
JCS Conifer High School	Yes	Site Application, Lift Station	UV	No	No	IFS10
JCS Mt Evan Outdoor	Yes	Site Application, New Plant Rpt	New Plant	No	No	IFS11
Bear Creek Development Corp. - Tiny Town	No	Land Application Rpt	Hauling Columbia	Yes	Reporting, WLA	No
Bear Creek Cabins	No	Permit	New OWTS	Closed Permit	No	Closed
Brook Forest Inn	No	WQCD Rational, WQA, Permit, Review	No	Yes	WLA/TP, Compliance Order	IFS09

Facility	Wastewater Utility Plan	Electronic Planning Documents	Recent Upgrades (3 yrs.)	Facility Upgrades [2017-2022]	Existing Compliance Concerns[1]	Informational Sheet
Geneva Glen	No	Permit, WQA, WQCD Fact Sheet	No	New Land Application	WLA/TP, Compliance Order	In Progress
The Fort	Yes	Site Application Closed	New OWTS	Closed Permit	No	Closed
Singing River Ranch	No	WQCD Fact Sheet, WQA, Permit	OWTS	Closed Permit	No	Closed

[1] - All treatment facilities have expecting new discharge limits (within 5-years) for total phosphorus and temperature. Several facilities are monitoring for temperature. Under Regulation 85 there are expected new nitrogen limits necessary to meet stream nitrogen standards.

Utility Supported Programs

Pharmaceutical Recycling Program

The Association financially supports a used medicine drop-off location in Evergreen (BCWA Fact Sheet 23). The utilities have sent notices with their monthly billings to support pharmaceutical recycling programs.

Sanitary Sewer Incentive Programs in the Evergreen Area.

The Evergreen Metropolitan District and Upper Bear Creek Water and Sanitation District offer a 50% discount to the current sewer tap fee to property owners within the District Boundaries with Individual Septic Disposal Systems willing to connect.

The West Jefferson County Metropolitan District offers a discount of $9,000 to the current sewer tap fee to property owners within the District Boundaries willing to connect their ISDS to the distribution system.

Trading Program

The Association maintains a pollutant-trading program as defined in *Trading Guidelines* (Association 2006) and in *Bear Creek Reservoir Control Regulation #74* for total phosphorus trades specific to the Bear Creek Watershed: Point source to point source trades (regulation and permit); and Nonpoint source to point source total phosphorus trading specific to the Bear Creek Watershed (*Trading Guidelines*). The *Bear Creek Trading Guidelines* allow permitted point source dischargers (Colorado Wastewater Discharge Permits) to either receive phosphorus pounds for new or increased phosphorus wasteload allocations in exchange for phosphorus loading reductions from nonpoint source pollutant reduction or through approved point source trades. Table 23 lists all Association trades. The reserve pool held 55 pounds in 2016, due to the closure of three WWTFs. The trades in the watershed remain consistent with the total wasteload allocations listed in Table 24. The Association has developed three policies to support the trading program:

1. BCWA Policy 1 Trading Program - The BCWA supports nutrient (nitrogen and phosphorus) trading as a long-term and necessary water-quality management practice for the Bear Creek Watershed. The BCWA will maintain and periodically update Nutrient Trading Guidelines.

2. BCWA Policy 19 Nutrient Trade Eligibility - The BCWA defines eligible participants and sets minimum criteria for eligibility in a Bear Creek Association Trade Agreement.

3. BCWA Policy 26 Point to Point Trade Administration – The BCWA establishes a trade administration program to help assist small wastewater dischargers in the watershed and sets a value to phosphorus trade credits.

Table 24 Phosphorus Trading Activity in Bear Creek Watershed

Involved Agencies	Type of Trade	Active Trading in 2013
Forest Hills Metro District (FHMD) had trade agreement with West Jefferson County Metro District(WJCMD)[1]	Point Source to Point Source	No- Discontinued in 2012
City of Lakewood Coyote Gulch Project	Nonpoint Source trade credits	Under data collection/ reviewed by Association; trade credit calculated in 2011/ confirmed 2013
The Fort Restaurant	Reserve Pool to Point Source (Return to Reserve Pool)	Closure in Progress; Trade reflected in reserve pool limit previously granted by the WQCC

Involved Agencies	Type of Trade	Active Trading in 2013
Jefferson County Schools (Conifer High School and Mt. Evans Outdoor School	Point Source to Point Source	In Discharge Permits; no change in pounds; reallocation between facilities
Conifer Metropolitan District	Reserve Pool to Point Source	Trade reflected in reserve pool limit previously granted by the WQCC

Watershed Stormwater Management

City of Lakewood MS4 Program

The City of Lakewood has a municipal separate storm sewer permit (*CDPS Stormwater Permit Annual Report for 2017, Municipal Stormwater Permit No.: COS-000002*; City of Lakewood, April 1, 2018). The Stormwater Management Program for the City of Lakewood, Part I.B.1 of the City's permit, consists of six different programs: Commercial/Residential Management Program, Illicit Discharges Management Program, Industrial Facilities Program, Construction Sites Program, Municipal Facility Runoff Control Program, and the Wet Weather Monitoring Program.

Lakewood supports many stormwater management programs in the watershed, including the *Rooney Road Recycling Center*, which also serves as watershed pollution prevention BMP. Household hazardous waste (includes electronic waste, household chemicals, paints, propane cylinders and automotive products) materials collected at the Rooney facility since 1994 total more than 6,278,498 lbs of potential surface water and ground water pollutants. Unfortunately, yard waste, construction lumber and tree limbs are no longer collected at the facility to be, ground, chipped and 100% recycled into mulch and compost. The Lakewood facility collects multiple types of waste products for proper disposal (includes oil, paint, antifreeze, misc. chemicals, and solid wastes) from the mountain areas as well as the Front Range. This process keeps materials out of septic systems and helps reduce illegal dumping in the watershed. Lakewood regularly reports to the Association on stormwater management practices and programs. More information about Lakewood's municipal stormwater program is contained in their CDPS Stormwater Permit Annual Report.

Jefferson County MS4 Program

Jefferson County has a municipal separate storm sewer permit and Jefferson County's program includes Public Education and Outreach; Public Participation and Involvement; Illicit Discharge Detection and Elimination; Construction Site Runoff Control; Post Construction Site Runoff Control; and Pollution Prevention/Good Housekeeping. The county provides opportunities for residents and visitors in the watershed to learn and be involved in environmental stewardship and programs that promote water quality. The county has a comprehensive storm sewer outfall map to trace sources of potential illicit discharges and illegal dumping in the watershed. Jefferson County continues to participate with Rooney Road Recycling Facility and in 2017 the facility collected over 680,000 pounds of household hazardous waste. Jefferson County participated in several public events to reach diverse audiences for their MS4 and floodplain management programs.

Jefferson County also maintains an erosion and sediment control program as part of their MS4 permit. The county maintains a small-site erosion control manual that explains the basic principles of erosion control and illustrates techniques to control sediment from small development sites. Jefferson County has an inspection program for illicit discharges, construction activities, and includes post-construction Inspections. Jefferson County regularly reports to the Association on stormwater management practices and programs. More information about Jefferson County's municipal stormwater program is contained in their CDPS Stormwater Permit Annual Report.

BCWA Stormwater Monitoring Program

The Association gathers data prior to, during and after storm events occurring in the watershed. Continuous monitoring of storm events could allow up to 36 hours of data. The parameters are temperature, dissolved oxygen, pH, and conductivity. The intent is to measure changes in these parameters due to run off from adjacent properties including roadways, parking lots and open spaces. The Association is developing a separate stormwater data set.

The Association monitors selected stormwater loadings in locations in the middle section of the watershed. The Association identified several potential stormwater runoff locations requiring corrective land use controls. The Association works with local businesses that cause minor nonpoint source runoff from their business sites with

the implementation of runoff controls. These runoff control programs are successful. The Association actively identifies erosion problem areas for potential future projects.

The *BCWA Policy 3 4-Step Review Process* used by the Association (referral processes for land use applications from Jefferson and Clear Creek Counties) is directed at land disturbances that have a potential to cause water quality degradation. Specifically, the policy directs the Association to evaluate stormwater runoff and determine if the application contains appropriate techniques to mitigate any significant runoff that could degrade receiving water quality.

Clear Creek County Stormwater Management Program

Clear Creek County has posted several educational materials on the county website directed at stormwater management on home-sites, commercial properties, along mountain roadways and driveways, to protect groundwater and surface water resources. The report *Managing Stormwater to Protect Water Resources in Mountainous Regions of Colorado* (Clear Creek County Community Development, July 2009) outlines appropriate best management practices, techniques to maintain pre-development hydrology, and resource impacts from development in mountainous terrain.

VI. Nonpoint Source Program

Onsite Wastewater Treatment System Management

In 2017, the Association continued limited discussions with Jefferson County Health Department based on previous presentations made to the Jefferson County Board of Health and the Jefferson County Commissioners. Jefferson and Clear Creek counties reviewed their onsite wastewater treatment system (OWTS) regulations. The Association suggest that OWTS in several specific areas in the Bear Creek Watershed contribute to water quality degradation. There are 9,000 +onsite systems in the watershed, depending on the estimation method. Based on existing county taxing records, there are an estimated 12,000+ lots where there is a permitted onsite system, un-permitted system or developable lot.

The Association has two policies directed toward site-specific wastewater treatment/ disposal systems in the watershed.

1. *BCWA Policy 11 Site-Specific Wastewater Treatment/ Disposal Systems* - There are five types of human-generated wastewater treatment/disposal types currently in use within the Bear Creek Watershed. Besides point sources, there are four types of small site-specific wastewater treatment/disposal systems include both publicly-owned and individual or private systems. State and county regulations cover these systems (Clear Creek, Jefferson and Park counties). There are not good inventories, only rough estimates, available to the BCWA for these small site-specific wastewater treatment/disposal systems. *The BCWA asserts any publicly owned and operated site-specific wastewater treatment/disposal systems (SSWDs) have the potential to adversely affect water quality within the Bear Creek Watershed. Pollution caused by SSWDs will be considered by the BCWA as "point sources". As such, nutrient point source pollution sources in the watershed maybe subject to a wasteload allocation under existing regulation. Water quality degradation associated with publicly owned SSWDs may be included in the BCWA annual report to the Colorado Water Quality Control Commission as an unregulated point source pollution problem.*

2. *BCWA Policy 11 Supplement* – 1) Clear Creek County ISDS Vault and Privy Regulations and 2) Jefferson County ISDS Vault and Privy Regulations

Kerr/Swede Gulch and Cub Creek

The Association had two special monitoring efforts to determine surface water quality affected from areas on OWTS: Kerr/Swede Gulch and Cub Creek. The Kerr/Swede Gulch focused on a limited number of OWTS (<35) that potentially add nutrients to the lower portion of the drainage between site 52 (Confluence) and site 53 (Riefenberg). The monitoring program suggests there is a nutrient load that is potentially related to OWTS discharge (*TM 2015.03 Kerr Swede 2015 Complete)*.

The Association is also monitored upstream and downstream on Cub Creek where there are > 1,000 OWTS. Many these systems are located within the alluvial corridor. These systems have a greater potential to seep nutrients into Cub Creek (*BCWA WQSD06 Nutrient Loading Cub Creek 2013-2016*). Total nitrogen and total phosphorus concentrations and loads from Cub Creek [BCWA Sites 38 and 88 (Upper Cub Creek and Site 50 (lower Cub Creek Cub Creek)], indicate a nutrient loading concern that is not attributable to the Brook Forest Inn wastewater discharge *(BCWA WQSD06 Cub Creek*). There was speculation that this nutrient loading could be associated with other unspecified upstream nonpoint source loads. The BCWA has sampled Cub Creek from 2012-2016, as part of the watershed sampling program. In 2016, a special field investigation was done to identify potential upstream "hot" spots along this creek. The special survey's nutrient results are included in this data summary. The total phosphorus load distinctly increases from upstream to downstream. The measured nitrogen levels appear to decrease with instream uptake. The visual evidence of nutrient loading in Cub Creek is very evident at the lower site (50) with the coverage of periphyton (algal growth) on hard substrate in the stream often exceeding 50% by late summer.

Cub Creek from 2012-2016, discharged from 250 to 3,040 pounds of total phosphorus per monitoring season into Bear Creek downstream of Evergreen Lake. The seasonal average total phosphorus load in upstream waters is 304 pounds with the downstream average substantially increasing to 1,378 pounds. While there are other types of nonpoint source nutrient sources within the Cub Creek corridor, OWTS are the most likely source for the excess total phosphorus loading along Cub Creek. This nutrient loading has also been seen on other tributaries within the watershed that have OWTS (e.g., Kerr/ Swede Gulch, *TM 2015.03 Kerr Swede 2015 Complete* and Yankee Creek, *BCWA WQSD02 Upper Bear*) or at special monitoring sites located downstream of an OWTS cluster (Troublesome, *BCWA WQSD01 Troublesome*). Consequently, the BCWA believes the phosphorus load in this drainage is a result of seepage from these OWTS located within the alluvial corridor. This is a major nutrient contributing tributary in the middle of the watershed.

Selected Watershed Nonpoint Source Programs

The management of nonpoint sources in the Bear Creek Watershed is a component of the Association planning and management programs. Phosphorus reduction from nonpoint sources is still required in the watershed. A lack of implementation authority limits the nonpoint source program. The Association does maintain a comprehensive watershed-monitoring program to determine sources of nutrient loading into waterways.

Policy Direction

The Association has established policies to help manage nonpoint sources within the watershed:

1. *BCWA Policy 15 Nonpoint Source Strategies and BMPs* - The Association maintains a comprehensive watershed-monitoring program to determine sources, including nonpoint sources, of nutrient loading into waterways. The policy shows management strategies and implementation tools used by the Association.

2. *BCWA Policy 17 Beneficial Recycling of Natural Resources in Bear Creek Watershed* - The Association considers recycling as a best management practice that can help manage natural resources and protect water and environmental quality in the watershed. Recycling programs protect water quality by reducing or eliminating pollutants before they become a problem. Recycling programs can manage household hazardous waste products, organic material/yard wastes, slash, manure generated at stabling operations, clean fill material, recyclable materials (e.g., cans and bottles).

3. *BCWA Policy 18 Illegal Material Dumping as a Pollutant in Bear Creek Watershed* - The Association considers the disposal of, including but not limited to, construction waste, yard waste, organic material (e.g., pine needles) or other plant materials into waterways within the watershed as nonpoint source pollution. This form of waste disposal can harm water quality and is not an acceptable practice in the watershed.

4. *BCWA Policy 27 Source Water Protection* - The BCWA supports the designated areas of concern identified in the Phase 2 Bear Creek Wildfire/Watershed Assessment Report and acknowledges that there is a potentially high risk from wildfires that could significantly impact water supply infrastructure and source waters within portions of the watershed

Water Quality Monitoring Tiers

Activities, unregulated point sources and nonpoint sources in the watershed have the potential to generate water quality pollutants. However, not all activities, unregulated point sources or minor "non-point" sources of pollutants cause measurable degradation of waters within the watershed. As such, the BCWA asserts it will be more effective over the next 6-years (through 2023) to target a more limited subset of unregulated point and non-point sources within the watershed that have the greatest potential to cause either site-specific or watershed–wide water quality degradation (*BCWA Policy 10 Water Quality Monitoring Priority Tier Designations*).

Online Management System (ACM DSS)

Association member organizations and staff were involved in collaborative development of an online watershed management system through a Colorado State University dissertation research case study project. The purpose of the system was to increase the capacity of BCWA to adapt to changing circumstances and to cooperate more effectively with public landowners and community members to achieve greater reductions over time. Modules include issues reporting, interactive maps, group search, a topical knowledge base, projects and options, and watershed plan input. The Association established an Adaptive Co-Management Decision Support System (ACM DSS) as a BCWA best management practice (*BCWA Policy 21 Online management System*), which can help address nonpoint sources within the watershed.

Nonpoint Source Analysis in EPA BASINS GWLF-E

The CSU research project also included detailed analysis of non-point source pollution and system complexity and uncertainty. Wastewater dischargers have already reduced phosphorus discharges by over ninety percent with little effect on seasonal total phosphorus and chlorophyll-a levels or Bear Creek Reservoir trophic status, which remains stably eutrophic. Therefore, it is important to determine other potential sources of nutrients to improve water quality in Bear Creek Reservoir. Geographic Information Systems were used to developed thematic layers for subbasins, soils, landuse, elevation, horse densities and pastures, paved and unpaved roads, streams, point discharges, weather, and urban areas. This information was used in EPA BASINS GWLF-E mass balance analysis to provide a screening level estimate of potential nutrient sources.

Results indicate that the over 9,000 septic systems in the watershed may contribute a similar total phosphorus load as wastewater discharges or slightly more. The many roads adjacent to streams, and unpaved private drives, in addition to streambank erosion and urban development, contribute fifteen times more, mostly particulate, phosphorus. The large contribution of sediment-based phosphorus agrees with the original 1990 Clean Lakes Study estimates, USGS Sparrow model results for the greater Missouri Basin, and BCWA's own estimates of suspended load from storms, snowmelt runoff, and flooding events. Statistical analysis also indicates that total phosphorus does not typically decrease with increasing flow, which would be expected as wastewater discharges were diluted, if they were the main cause. This may indicate further reduction in WWTF discharge load allowances may not improve Bear Creek Reservoir water quality. Therefore, policies and projects that more directly address the effects of nonpoint sources and other reservoir management alternatives will be targeted in future years.

Nonpoint Source Education

The Association has an education and outreach program to help raise awareness with watershed citizens on the need for nonpoint source management and controls. Association members are involved in numerous educational and training efforts for schools, clubs, and local agencies and often assist with seminars and conferences. The Association actively promotes use of *smart management practices* to lessen water quality and environmental degradation caused by nonpoint sources (BCWA Policy 15 *Nonpoint Source Strategies and BMPs*).

Watershed Education and Training Efforts

The Association provides information in the form of brochures, fact sheets, maps, training classes and presentations to the community on water quality management and environmental issues and supports educational programs/ activities (e.g., Evergreen Chamber Duck Races, Earthday, Audubon, Evergreen Trout Unlimited, City of Lakewood, and the Clear Creek Water Festival). The Association participated in two panel discussions for Earthday events. The Association has a Watershed 101 class for watershed citizens. The Association was involved in cooperative meetings with the Barr-Milton Watershed Association, the Lower Bear Creek Watershed Group, Denver Department of Environmental Health, and the Colorado Lake and Reservoir Management Association. The Association was a member of the special Clear Creek/ Bear Creek Fire Hazard Study.

BCWA Newsletter

The Association has established a triannual newsletter that is distributed to membership and many watershed citizens. The newsletter contains one or more articles directed at nonpoint pollution management or education. The Association newsletter reaches over 300 watershed citizens.

Future Watershed Manager Program

The Association has a future watershed manager program and works with watershed high schools and middle schools to provide educational opportunities, training classes and materials related to watershed and water quality management. The Association has a "Watershed 101" training course and develops more courses as requested for the outreach program. The Association worked with students at Evergreen High School to develop several monitoring and restoration projects on the school property and along Wilmont Creek. These students designed and, built a rain garden that fixes a stormwater runoff problem at the school.

Geo-Locate Sign Program

The Association developed and installed a new educational signage project in the watershed. The 11 kiosks have educational messages that target nonpoint problems and solutions. Signs are located at public accessible sites beginning at the Jefferson County Outdoor School to the Lakewood City buildings. Each sign has a base message and a site-specific message. People will be able to Geo-locate BCWA signs, collect the keywords from each sign, and share findings with Association through the web site www.bearcreekwatershed.org.

Bear Creek Regional Parks, Lakewood

The city has several education and campfire programs held at Bear Creek Park (e.g., Junior Naturalist) that includes environmental and water quality elements. There were >100 education programs for about 4,000 participants (does not include outreach events). The Association has developed education materials, handouts and otherwise supported the park programs. The total visitation for BCLP exceeded 415,000 visitors, excluding bicyclists. The city estimates use for Green Mountain and the Bear Creek Greenbelt (from trail cameras, preliminary estimates) at over 240,000 for the Greenbelt and over 200,000 for Green Mountain.

Evergreen Trout Unlimited

The Association works with Evergreen Trout Unlimited and other partners in identifying and implementing new stream restoration projects/programs. Evergreen Trout Unlimited conducts spring and fall cleanout operations in Evergreen Lake, Bear Creek downtown, O'Fallon. ETU collects over 10 cubic yards of trash and debris, annually. ETU contributes time and materials to the temperature monitoring program. Several Association members are members of ETU.

Wilmot Elementary School in Evergreen

Annually, the fourth-grade classes at Wilmot Elementary School in Evergreen participate in a one-day class on centered on the ecology of Evergreen Lake. They do walking tours around the lake. Several sites around the lake are set up for each group to spend time at, including a stop at the Evergreen Metropolitan District Water Treatment Facility.

Buchanan Ponds

The BCWA worked with science teachers from Evergreen Middle School, on a special water quality study at the nearby Buchanan Ponds (*BCWA Fact Sheet 55 Evergreen Middle School Buchanan Ponds Special Study*). There were 220 students involved in the project (*BCWA WQSD05 Buchanan Ponds*). The program was divided into 4 phases: 1) an introduction presentation to the classes on healthy water quality in the Bear Creek Watershed, 2) an adventurous field trip to the monitoring sites where students made observations, took flow measurements, used a water quality multi-probe to measure water chemistry and collected water for laboratory analyses, 3) a presentation to the classes to review the various field and laboratory findings, and 4) selected junior watershed managers helped develop this report and an article for the BCWA newsletter.

Manure Management

The Bear Creek Watershed Association recognizes animal manure and the associated liquid waste stream is a contributing factor in nonpoint source pollution within Bear Creek Park *BCWA Policy 4 Manure Management* and as evaluated in BCWA Technical Memorandum 2013.04 - Manure Management Bear Creek Park, Lakewood). An *Animal Facility* or similar project can lead to an accumulation of nutrients in the park over the

long term, especially in areas with repeated applications, such as the stables and trails. Manure management strategies used in the Bear Creek Park should not increase the total annual load of total nitrogen or total phosphorus above ambient conditions where such waste can potentially reach surface waters in the watershed or alluvial groundwater. Bear Creek Park staff manages manure control practices that include construction of composting bins for large animal waste products and managing trail crossings at waterways.

Summit Lake

Bear Creek Watershed Association continued to monitor four sampling stations at Summit Lake and upper Bear Creek, Mt Evans Wilderness, Clear Creek County Colorado (*BCWA Technical Memorandum 2017.02 - UBCW*). The Association historic sampling Site 36 (Summit Lake at outfall) and Upper Bear Creek Site 37 monitor "background" conditions. Monitoring data show atypical water quality results for an alpine ecoregion. The station data demonstrates there is a pollution source(s) causing elevated nutrient loads, low pH conditions and reduced dissolved oxygen. Association observations suggest that one origin of the pollutants was the new/old toilet vaults at the Summit Lake parking lot. Denver Parks and Recreation in 2013 repaired the new vaults and the 2017 water quality data suggests this helped resolve part of the nutrient loading. The Association provides the City and County of Denver, Colorado Department of Parks and Wildlife, Colorado Water Quality Control Division, State Forest Service and National Forest Service technical memorandums with data results and conclusions. Denver has committed to additional characterizations of the water quality problem(s) and is working towards mitigation of any problem(s) associated with the Denver Mountain Park Facilities.

Although the fen plume monitoring site continues to produce an elevated phosphorus loading, this load is not reflected in the concentrations and load measured downstream at site 37. This indicates that algal productivity is consuming much of the nutrient load prior to this monitoring site. Most of the recent algal grow appears to be several species of green algae. There does continue to be a potential problematic bluegreen algae that may be associated with the observed fish kills. Almost all this algal mat material will die over the winter and flush downstream in the spring runoff. As such, the nutrient load gets flushed downstream as organic matter.

Fen Complex Study Summit Lake

A type of tributary wetland in the watershed is called a fen. In the Mt. Evans portion of the watershed, these wetland fens are an important and unique wetland type. They are ancient ecosystems 8,000 to 12,000 years old. They "provide important headwater quality functions," including carbon storage, water storage, wildlife habitat, and biodiversity. Fens are peat-forming wetlands that receive nutrients from sources other than precipitation: usually from upslope sources through drainage from surrounding mineral soils and from groundwater movement (*BCWA Fact Sheet 49 Wetlands, Fens and WQ BCW).*

In 2014, the Association conducted a special survey of three Fen ponds to establish background or expected conditions on "non-polluted" Fen Ponds (*BCWA Fact Sheet 52 Mt Evans Fen WQ*). The Association selected three Fen pond sizes to establish backgrounds: a small Fen (25 square feet, about 1-foot-deep), medium Fen (85 square feet, about 2 feet deep), and a larger Fen (125 square feet, about 4 feet deep). There were no indications of any anthropogenic influences on these Fen ponds. The Fen ponds were sampled on September 17, 2014, with an expectation that this would show the season low nutrient conditions. The results for total nitrogen and total phosphorus were much higher than suspected. The median total phosphorus for this limited special survey was 165 ug/l. The preliminary data strongly suggests the chemistry and nutrient dynamics in the Fen complex is more complicated than predicted. As such, the Association began a five-year special study to establish the background or expected nutrient conditions for the Fen complex.

The Association summarized evidence in the Regulation #38 Rulemaking Hearing for South Platte Basin Standards that suggests fen wetlands have background phosphorus levels that exceed Table Value Standards (TVS) even though streams in the same segment do not have elevated phosphorus levels (*Fact Sheet 53 BCR 2015 Regulation 38 Update*). It is not yet known what background level would be appropriate or if it varies among these fens. The Colorado Water Quality Commission applauds the efforts of BCWA to obtain data that improves our understanding of existing conditions. Site-specific standards are needed for all, or part, of Segment 7 for which phosphorus standards are required, but there is uncertainty about the habitat type or the geographic scope of applicability for site-specific standards (or conversely for the TVS). Resolving the uncertainty will require additional sampling to obtain representative data. Delaying the effective date by five years gives BCWA, time to collect additional data and propose site-specific phosphorus and Total Nitrogen standards as

appropriate for the Fen complex. Total Phosphorus standards were delayed until an effective date of 12/31/2020. In 2017, the Association established a control fen located on the south side of Bear Creek. This site has no visible human impact. All the fens on the north side of Bear Creek have varying degrees of anthropogenic degradation (*BCWA TM 2017.02 UBCW Summary*) (Figure 29 and Figure 30).

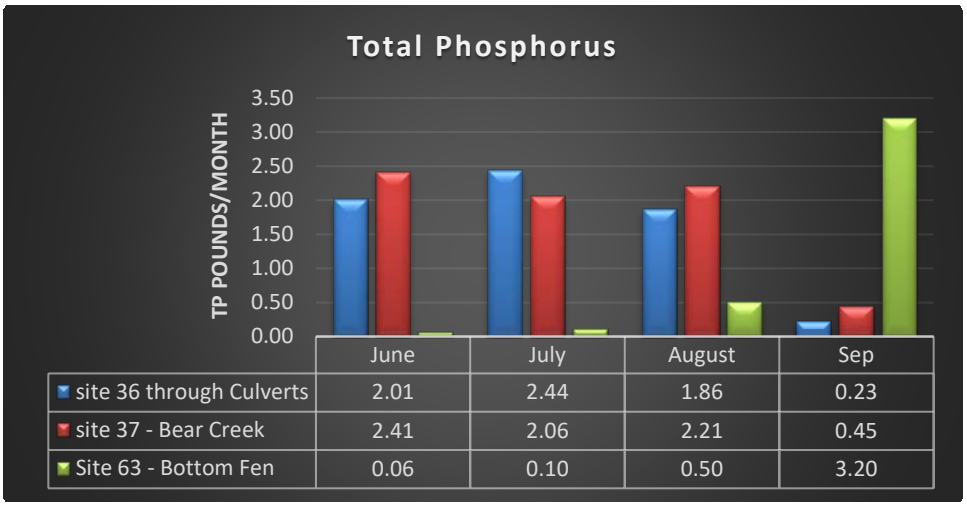


Figure 29 Total Phosphorus Seasonal Averages in Fen Complex

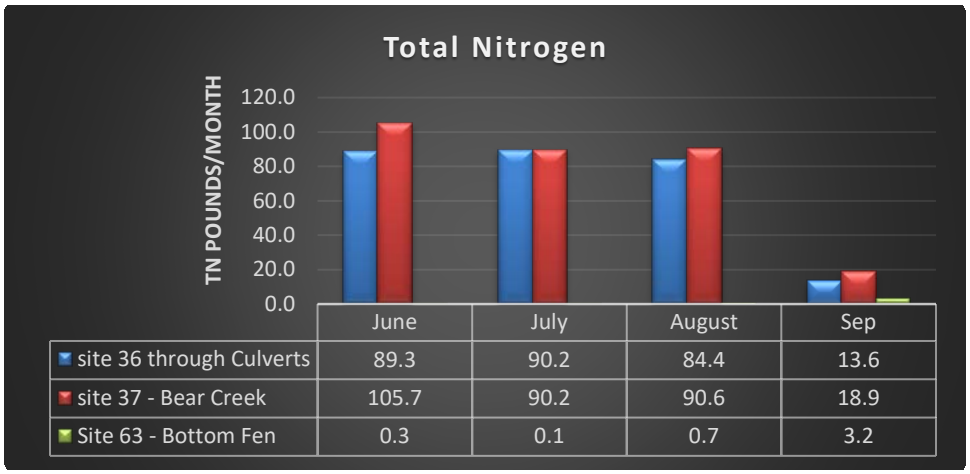


Figure 30 Total Nitrogen Seasonal Averages in Fen Complex

Clear/Bear Creek Wildfire/Watershed Assessment

The Association was a partner in a watershed assessment that identified and prioritized sixth –level creek/watersheds based upon their hazards of generating flooding, debris flows and increased sediment yields following wildfires that could have impacts on water supplies. The study expanded on current wildfire hazard reduction efforts by including water supply watersheds as a community value. The watershed assessment followed procedures prescribed by the Front Range Watershed Protection Data Refinement Work Group (2009). This Bear Creek assessment provides an identification of opportunities and constraints for each Zone of Concern in the watershed (http://www.jw-associates.org/clearbearcreek.html).

Evergreen Metropolitan District Source Water Assessment

Evergreen Metro District worked with the Colorado Rural Water Association and a steering committee to develop a Source Water Protection Plan (SWPP). Source water protection is a voluntary, non-regulatory, proactive approach to preventing the pollution of lakes, rivers, streams, and groundwater that serve as sources of drinking water. A SWPP includes: the area in need of protection, the potential sources of contaminants, and management approaches that could help to reduce the risk of contaminants entering the source waters. The wildfire watershed assessment report identifies a zone above the reservoir as a high priority zone of concern. The protection plan includes best management practices necessary to lessen the water quality impact to

Evergreen Lake following a major upstream wildfire. It is anticipated that significant nonpoint source pollution could be generated by storm events following a major fire. The district has identified areas in need of protection and several potential sources of contamination. This data is assimilated into the district's GIS system.

Evergreen Metropolitan District Canal Cleaning Operation

The district monitors and maintains a storm sewer catch basin at Evergreen Lake. Generally, the district on an annual basis removes fine sand and silt from the inlet channel to Evergreen Lake to reduce the sedimentation rate in the lake. In previous years, this material was disposed at a location to prevent subsequent erosion into waterways. The District monitors the performance of this catch basin and evaluates if the installation of additional catch basins along upper Bear Creek would benefit the stream.

Coyote Gulch Nonpoint Source Restoration

The Association is involved in a nonpoint source project sponsored by the City of Lakewood that restored a severely eroded section of Coyote Gulch. Coyote Gulch revegetation began in June 2007 and became well established in 2008. The Association has a paired water-sampling program, which allows a determination on the effectiveness of the restoration effort at phosphorus reduction (Table 25). The Association Technical Memorandum Coyote Gulch Summary (TM 2017.03) provides a summary of the monitoring program and data analysis. Table 26 identifies the annual available total phosphorus trade pounds consistent with the Association trade program. Based on seven years of data, there is 84 pounds of total phosphorus available for the trade program. Figure 31 shows the total phosphorus reduction. The Coyote Gulch restoration project is an effective phosphorus reduction project and management practice.

Table 25 Coyote Gulch Nutrient Base Loads

			Loading Pounds/Period	
Location	Date	Flow Estimate	Total Nitrogen	Total Phosphorus
Upper Coyote	Jan-Feb	19.8	135.4	1.2
	Mar-Apr	43.7	71.8	2.4
	May-Jun	30.8	80.6	9.5
	Jul-Aug	154.9	315.5	43.0
	Sep-Oct	81.4	595.7	4.4
	Nov-Dec	34.7	227.0	1.9
Lower Coyote	Jan-Feb	20.1	131.4	1.1
	Mar-Apr	44.4	66.7	1.9
	May-Jun	32.2	78.5	10.5
	Jul-Aug	187.6	370.4	51.6
	Sep-Oct	89.9	335.3	7.3
	Nov-Dec	53.2	371.6	2.3

Table 26 Coyote Gulch Total Phosphorus Trade Pounds

Total Phosphorus Trade Pounds				
	Total Base Flow		Trade Ration Pounds	
	Monthly	Annual	Monthly	Annual
Average	6.6	78.8	6.7	**80.4**
Median	6.0	72.5	7.0	**83.5**
Monthly TRP=PC Base Load-TBF Monthly Pounds/2				
The base trade ratio is 2:1 for Association Trade Projects				
Base Flows Exclude April Storm Loadings				
Annual Trade Pounds Available = 80 pounds Total Phosphorus				

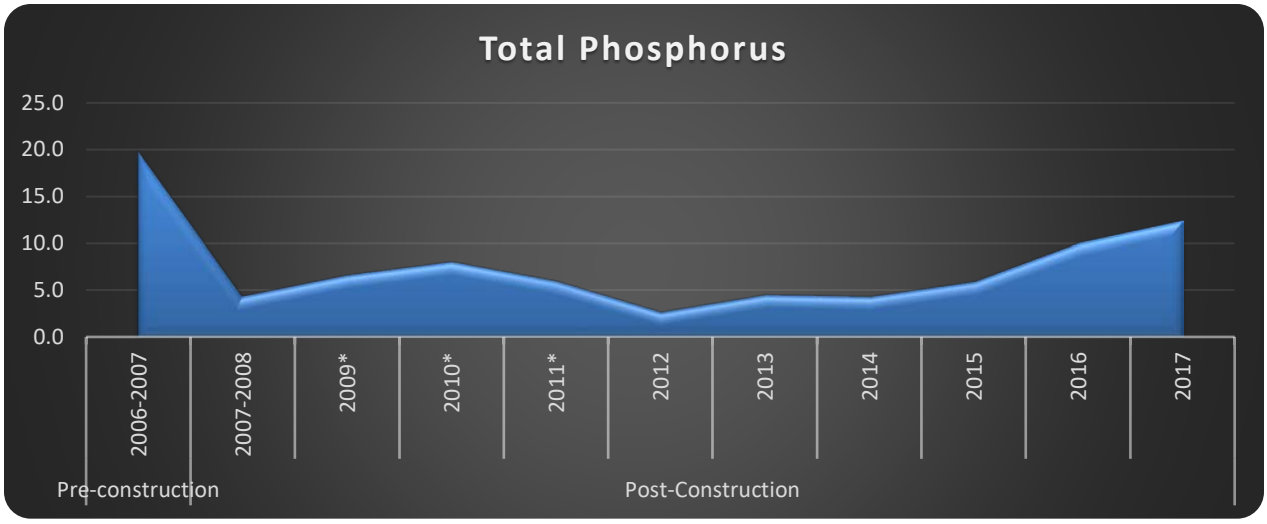


Figure 31 Total Phosphorus Reduction at Coyote Gulch Project

Association Land-Use Review

The Association has 36 "policies" to help with management of the watershed program. The Association is a referral agency to land use agencies within the Bear Creek Watershed, including cities and counties. The Association reviews referral applications for consistency with local, regional, state, and environmental regulations, associated policies and the watershed management plan. To assist the Association in the referral process, a "Referral Review Guidance" (Association 2007) outlines general components of the Association land disturbance mitigation preferences, including Association review and comment guidance. This guidance addresses nonpoint sediment loading before it becomes a watershed problem. Referred land use applications that cause a land disturbance and/or a potential to degrade water quality are subject to review and comment by Association. The Association completed 4 referrals in 2017 that addressed issues related to erosion, septic management, land disturbance, re-zoning, water quality degradation and appropriate use of best management practices. The Association supports Jefferson County and Clear Creek County in the update and development of community plans for select portions of the watershed.

BCWA and Membership Special Programs

Denver Water Department Watershed Assessment

The Denver Water Department completed an independent review of water quality in the Bear Creek Watershed and a cost alternative analysis to determine cost-effective clean-up options *(Bear Creek / Turkey Creek Watershed Water-Quality Alternatives and Costs Bear Creek / Turkey Creek Watershed Project Technical Memorandum 2 Contract Number 13223A, Prepared for the Denver Water Board, Hydro Consultants, April 15, 2011)*. DWD is evaluating implementation programs as addressed in the study and providing findings and recommendations with the Association.

Lakewood Regional Parks Recycling Efforts

The City of Lakewood is in their 13th year of recycling and litter management at their regional parks, including Bear Creek Park. In 2017, the program recycled motor oil, scrap metal, mixed paper, cans, glass and plastic, electronics, all batteries, paints, and other chemicals which are disposed of at the Rooney Road Recycling Center. The city continues trash clean up along Bear Creek and Turkey Creek drainages and around the reservoirs. Activities included maintenance of manure management bins, volunteer erosion control projects, willow planting and wetlands enhancement, park clean-up, trail work, trail stream-crossing closures and vegetation management. There was over 5,000 hours of volunteer effort. Recycle Your Fishing String program also helps keep shorelines clean.

Aspen Park/ Conifer Waste Recycling Program

The Conifer Area Council has maintained a "Recycling / Sustainability Committee", which supports community recycling. Information from this committee is distributed to the Association membership. The committee has

begun a slash removal program for pine beetle damaged trees. The program also takes recycled materials to the Rooney Road Recycling Center.

The Rooney Road Recycling Center

The Rooney Road Recycling Center provides proper disposal programs for residents of Unincorporated Jefferson County and the cities and towns of, Arvada, Golden, Lakewood, Mountain View, Lakeside, Edgewater, Morrison, and Wheat Ridge, to recycle their household hazardous waste (HHW). HHW includes electronic waste, household chemicals, paints, propane cylinders and automotive products. HHW materials collected at the facility since 1994 total more than 6 million lbs of potential surface water and ground water pollutants. The HHW program serviced over 4,000 participants, with City of Lakewood accounting for over 25 % of the total participation and the Bear Creek Watershed accounting for 38% of the total participants.

Invasive Species Protection Programs

Aquatic Nuisance Species Bear Creek Reservoir

Bear Creek Lake Park is involved in Colorado efforts to stop the spread of Aquatic Nuisance Species in Colorado waters. A Watercraft Inspection and Decontamination station is in the Whitetail parking lot. All trailer and motorized boats require inspection by state certified inspectors at the station for any aquatic invaders. Station staffed from 6am to 8pm on Fridays and the weekends, then every morning and evening during the week. During the middle of a weekday, the entrance gate would call out when a boat came in and the nearest staff member would do the inspection. Annually, the lake closes from November 15 to March 15. The park did > 2,000 standard inspections with no positive samples.

Aquatic Nuisance Species Evergreen Lake

The Evergreen Park & Recreation District requires a permit for all personal watercraft to be on Evergreen Lake. This is an opportunity to do the mussel inspection at the Lake House prior to launch. The Recreation District staff inspects boats and trailers. The recreation district and the Evergreen Metropolitan District have a program to harvest and compost the invasive algal species Elodea from the lake in the summer months. The district introduced grass carp to manage the Elodea growth.

Noxious Weed Management

Clear Creek, Jefferson and Denver Counties have noxious weed management programs. The Association reports sightings of noxious weeds and otherwise cooperates with these programs.

Invasive Algal Species in Bear Creek and Turkey Creek

The Association has begun collecting and identifying invasive algal species found in streams throughout the watershed.

U.S. Army Corps of Engineers

The U.S. Army Corps of Engineers has an updated master plan for Bear Creek Dam and reservoir (Bear Creek Dam and Lake Project South Platte River, Colorado, Design memorandum PB-10, July 2012). The Corps of Engineers released a sedimentation analysis for Bear Creek Reservoir (Tri-Lakes Sedimentation Studies Area-Capacity Report Revised: July 2011; M.R.B. Sediment Memorandum 23a). There has been a decrease in gross storage capacity:

> *Gross storage capacity in Bear Creek Lake has decreased from the original capacity of 78,101 acre-feet in 1980 to 77,293 acre-feet in 2009, the year of the latest sediment range line survey. This amounts to a total storage reduction of 808 acre-feet, or an average depletion rate of 27.9 acre-feet per year. The original projected storage depletion rate for Bear Creek Lake was approximately 20 acre-feet per year. The Bear Creek Lake flood control pool storage capacity has decreased from of 28,762 acre-feet in 1980 to 28,514 acre-feet in 2009, an average of 8.6 acre-feet per year.*

The U.S. Army Corps of Engineers continued clean-up operations to remove debris, upgrades around the outlet structure, road maintenance and dam stabilization projects.

Colorado Department of Parks and Wildlife

The Association supports the Division of Parks and Wildlife fishery surveys. These surveys characterize how trout populations respond to both natural and human induced alterations, including changes to water and

environmental quality. The Association maintains a Fishery Analysis and Protocols Guidance. The *BCWA Fact Sheet 48 Bass and Saugeye Fishery BCR*, summaries a survey of sports fish in Bear Creek Reservoir. There was a 2017 fishery survey (*BCWA TM 2017.10 Fisheries*) (Table 29 and Figure 32).

Table 27 2017 Fishery Summary Results

Station	Width (ft)	Species	2017		
			No/Mile Total	No./Acre Total	lbs/Acre Total
Golden Willow	23	Brown	1551	556	107
		Rainbow	0	0	0
		Total	1551	556	107
Dedisse Park	33	Brown	2666	666	80
		Rainbow	184	46	5
		Total	2849	712	85
Evergreen	34	Brown	1932	469	147
		Rainbow	726	176	55
		Total	2658	645	202
O'Fallon Park	28	Brown	2364	697	122
		Rainbow	57	17	3
		Total	2421	713	125
Lair O' the Bear	29	Brown	1363	388	95
		Rainbow	176	50	12
		Total	1538	438	107
Idledale	30	Brown	2130	703	203
		Rainbow	151	50	14
		Total	2281	753	217
Morrison West	30	Brown	2163	595	144
		Rainbow	177	49	12
		Total	2341	644	156
Note - No Bear Creek Cabin Sample					

Figure 32 2017 Total Fish per Mile

Evergreen Lake Dredging

In September of 2013, a series of flood events occurred in the Evergreen area over a period of one week. The flooding caused property damage along Bear Creek from above Evergreen Lake to the bottom of the watershed and resulted in a significant amount of sediment being deposited in the Lake. The Bear Creek Watershed Association Manager, Russell Clayshulte, could calculate the approximate volume of sediment deposited in the Lake by using flow and water quality parameters. Evergreen Metropolitan District applied for and received Federal and State grants for removal of the sediment. The District contracted to have approximately 12,000 cubic yards of material dredged from Evergreen Lake and the Bear Creek inlet to the lake. The dredging operation began in late May and was completed by the 3rd week of July. The dredging was concentrated on the north side where Bear Creek flows into Evergreen Lake. The dewatered silt was transported to a former solid waste transfer station on Highway 73. Water samples were also tested during dredge operations by both the Bear Creek Watershed Association and Evergreen Metropolitan District. Raw water analysis at the water treatment plant showed no degradation to water quality and required no additional treatment. The inlet channel

that was less than 1 foot deep in some areas was dredged to an average depth of 8 feet. The dredge operation did restrict some access to fishing on the north side of the lake but did not appear to have any effect to the fishery. Department of Parks and Wildlife maintained their fish stocking program as scheduled throughout the project. There was no effect on other recreational activities on the lake. There appeared to be no impact to local wildlife and elk were still present in the wetland area adjacent to the project. Based on bathymetric measurements taken of the Lake before and after the dredge project, the District could determine that an additional 60,000 cubic yards of sediment has been deposited in Evergreen Lake since a 1985 dredging operation was completed. To recapture lost water storage capacity, Evergreen Metro District is continuing with the process of obtaining Federal, State, and County permitting to allow for scheduled periodic dredge operations in the Lake.

Copper Study

In December 2015, The Colorado Water Quality Control Commission adopted a revised 303(d) list of priority pollutants causing impairment or those needing further monitoring and evaluation. The Colorado 303(d) List identifies those water bodies, where there are exceedances of water quality standards or non-attainment of uses. While the original proposal was to list the entire segment 1e for copper, the BCWA demonstrated successfully that the problem was only documented for a very limited portion of the segment within Morrison (See the Copper Database BCW Segment 1e spreadsheet). There were only four sample dates that exceeded the standard between 2008-2013. As such, the WQCC limited the listing to extend from the mouth of Mt Vernon Creek to the inlet of the Harriman Ditch. The Association is undertaking a copper specific monitoring program to better document the copper issue and potentially identify a copper source(s) near Morrison (Table 28) (*BCWA TM2017.12 Copper Study*). The Association will work with the Denver Water Department to obtain their entire water quality database for sites within the watershed and work to coordinate programs. Morrison will assist with the monitoring program. GEI is doing a low-level copper testing, which includes a hardness titration. Since this is a 303(d) listing, a 5-year monitoring program is necessary for delisting purposes. Three monitoring sites will be necessary for each sample date. The monitoring site locations maybe adjusted each year depending on annual data results. If a copper source(s) are found, then program may become limited.

Table 28 2017 Special Copper Study Results

Segment	Site ID	Site Location by Stream Segment	Annual Pounds
1e	Site 14a	Mainstem Bear Creek, Morrison Park west	97.3
4a	Site 87/34b	Mt Vernon Drainage, Morrison	6.5
1e	Site 14c	Mainstem Bear Creek, Morrison at Harriman	109.0

VII. Association Watershed Plan and Annual Reports

The Association produces an annual data report and a *2017 Master Data Spreadsheet (April 2018)* that includes data analyses, and raw data (Association website www.bearcreekwatershed.org). The Association transmits these data reports to the Water Quality Control Division Staff. The watershed-monitoring program summarized in an Association data report.

Most of the Association annual reporting documents are available electronically and posted on the website. The Association provides multiple reporting documents designed to meet the multiple functions of various groups (BCWA *PGO2 Document Categories)*. The reporting helps member entities with reporting to their respective boards, commissions and groups. There is also a citizen interest in the watershed and reporting helps keep the public informed. Many educational groups visit the watershed and it has become a widely used outdoor classroom. The Association supplies water quality and environmental materials for various educational uses.

Be a Watershed Warrior!

Geo-locate all eleven BCWA informational signs, collect the keywords from each sign, and share your findings on our website or by e-mail. If you collect all the keywords, your name will be posted on our Watershed Wall of Fame. Don't forget to look for the different animals on the signs. All of these animals are found somewhere in the watershed. Each sign has GPS coordinates that show where the upstream and downstream signs are found from your present position. You'll find the first sign at the entrance to a Jefferson County School Outdoor Learning Facility. The BCWA challenges you to take a geo-locate trip through our Bear Creek Watershed.

BCWA Watershed Plan

The Association has determined and established a policy that generating a single document to serve the watershed planning elements is not practical or efficient process. A single or fixed watershed plan would be too inflexible and require frequent updating. The Association instead is using a flexible and adaptive watershed planning process maintained electronically and accessible on a designated BCWA Web site. The electronic watershed plan is an Association Watershed Plan table of contents with linked PDF files or spreadsheets, and program element descriptions. The Association Watershed Plan is flexible, adaptive and dynamic. The online watershed plan contains elements and information required to meet 3-types of water quality planning.

The Association has adopted a series of policies, technical reports and factsheets that define the program (*BCWA PGO1 Master Index and PGO2 Document Categories*). The Association maintains a series of standardized maps providing watershed information and characterization. The Association maintains sets of water quality and other environmental data in spreadsheets and data reports. The Association produces annual reports to meet regulatory reporting requirements. The compilation of the various Association watershed planning documents and databases meets the state and Environmental Protection Agency requirements for a watershed plan.