

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 agency 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.

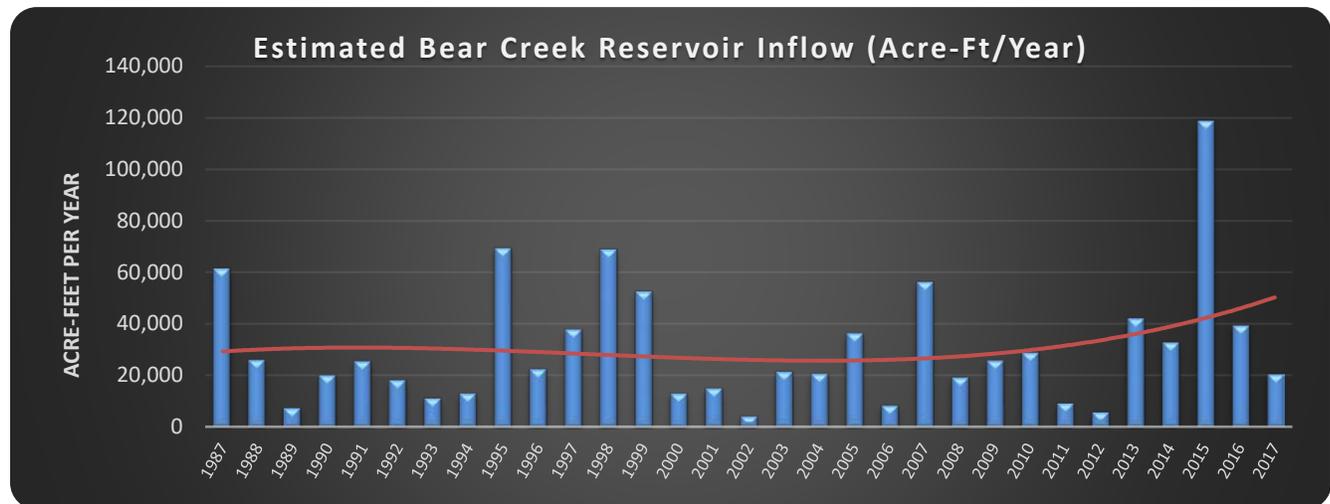


Figure 1 Estimated Bear Creek Reservoir Inflow 1987-2017

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 loading problem (total phosphorus) with Bear Creek Reservoir has not diminished over the last 10-years (Figure 2). The total phosphorus deposition into reservoir bottom sediments is 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 to 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).

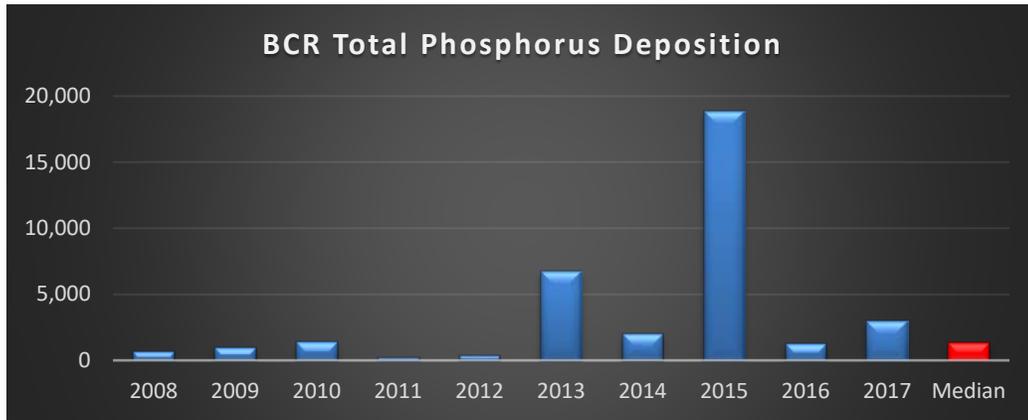


Figure 2 Annual Total Phosphorus Deposition into Bear Creek Reservoir Bottom Sediments

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 pollutant loading problems (*BCWA Policy 29 BCWA Integration with Other Planning Efforts*).

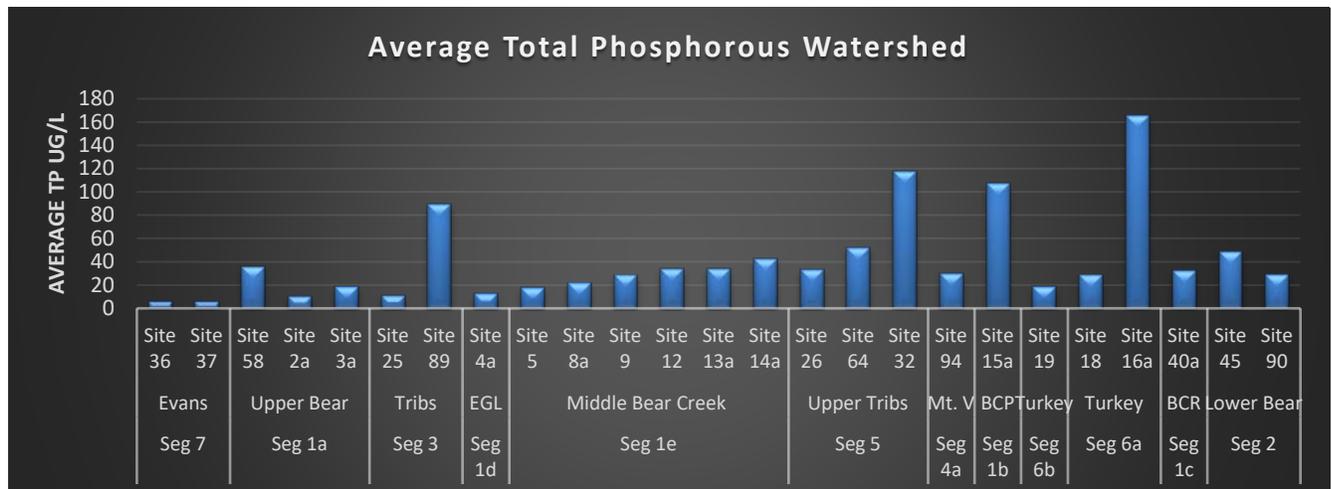


Figure 3 Total Phosphorus Loading by Stream Segments in the Watershed

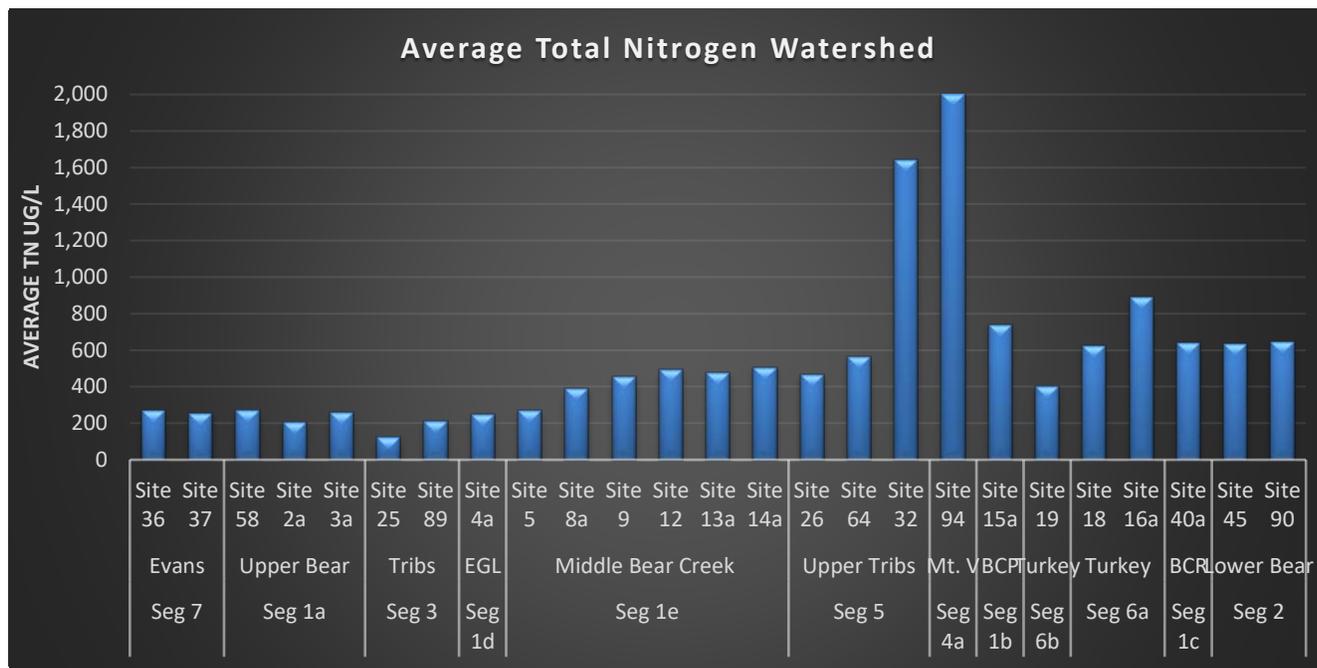


Figure 4 Total Nitrogen Loading by Stream Segment in the Watershed

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 two exceedances of the *Weekly Average Temperature* (WAT) and 0 exceedances of 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 August. There was recreational fishing throughout the year.

In Bear Creek and Turkey Creek segments, there were several temperature compliance problems in the warm and cold seasons with 98% compliance for the WAT and 98% compliance for the DM. Sampling and monitoring was performed at 38 sites within the watershed at varying intervals. Measurements of pH and DO showed 99% compliance for pH and 96% compliance for Dissolved Oxygen. There was 96% compliance for the proposed Total Nitrogen of 1250 µg/L and 91% compliance for the proposed Total Phosphorus of 110 µg/L below the treatment facilities. There were exceedances 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).

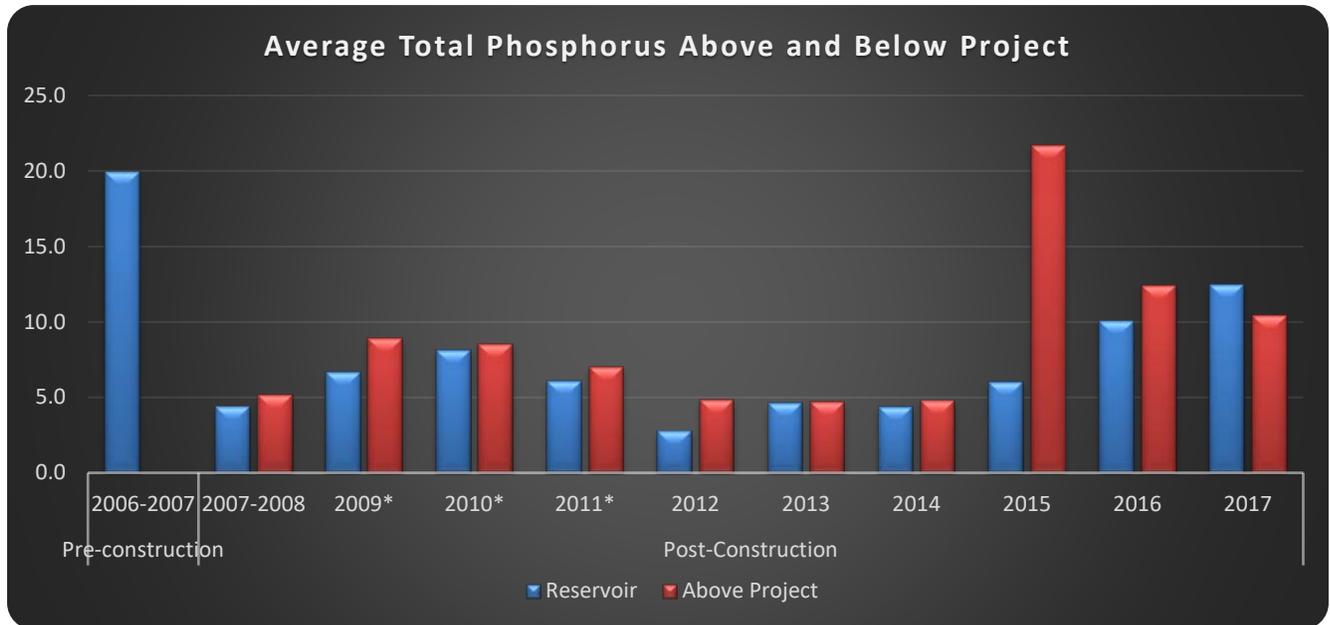


Figure 6 Total Phosphorus Reduction at Coyote Gulch Restoration Site