

I. WQCC Summary

The Bear Creek Watershed is a specific geographic area identified in the Bear Creek Watershed 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 (1987-2019) was 29,769 acre-feet per year. The 2019 inflow is estimated at 18,450 acre-feet (Figure 1) with the June runoff flow at 33% of the annual total flow. There was no flood stage (> 2,000 ac-ft) for BCR. The U.S. Army Corps of Engineers lowered BCR from February to March and again from October to November by about 575 ac-ft.

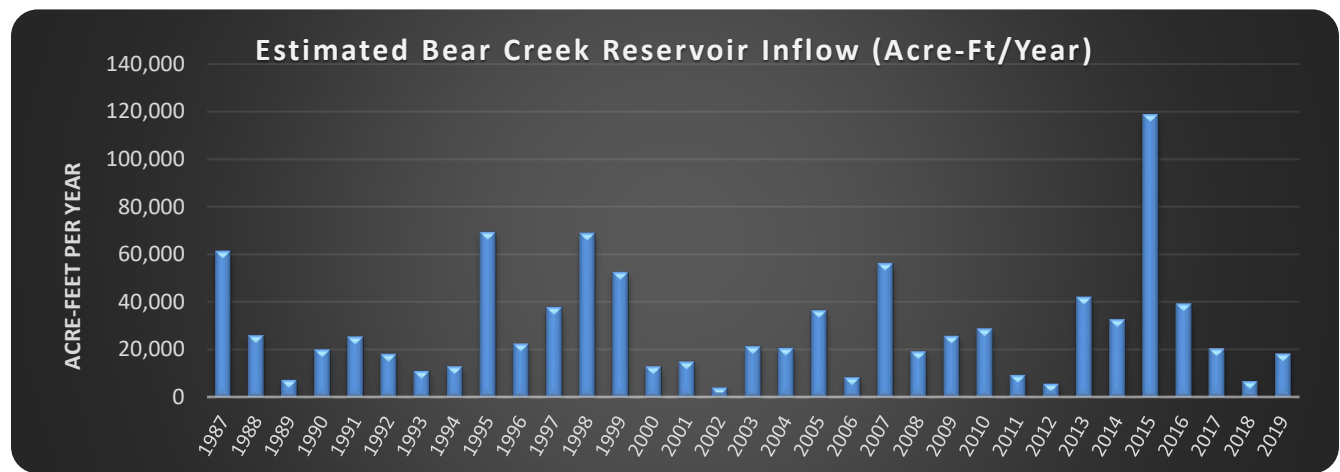


Figure 1 Estimated Bear Creek Reservoir Inflow 1987-2019

The estimated annual Bear Creek inflow into Bear Creek Reservoir was about 16,340 acre-feet (89%) and 2,111 acre-feet (11%) from Turkey Creek. The internal loading problem (total phosphorus) with Bear Creek Reservoir has not diminished over the last 11-years (Figure 2). The total phosphorus deposition into reservoir bottom sediments is about 36,721 pounds since 2008.

The reservoir continues to experience late summer phytoplankton blooms (2019 peak density of *Fragilaria crotonensis*, peak biovolume of 2,280,056 $\mu\text{m}^3/\text{ml}$; *BCWA TM 2019.09 BCR Phytoplankton Summary*), which is linked to the internal nutrient loading problem. The problematic bluegreen algae was *Microcystis aeruginosa* (Peak density was 38,843 cells/ml with peak biovolume of 372,892 $\mu\text{m}^3/\text{ml}$. This biovolume of *Microcystis* shouldn't produce harmful toxins. *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. Fact Sheet 60 *Managing Harmful Algal Blooms* and Fact Sheet 61 *HABs Exposure and Risks* were developed by the BCWA to help manage problem bluegreen blooms. The BCWA has identified some strategies to address the internal loading problem (*BCWA Policy 20 Preferred Management Strategies EGL and BCR*).

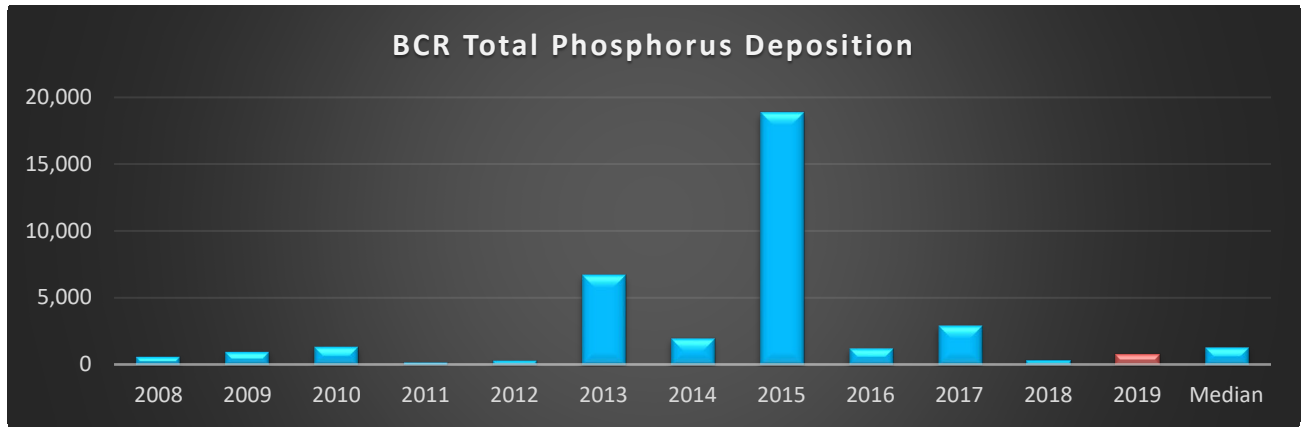


Figure 2 Annual Total Phosphorus Deposition into Bear Creek Reservoir Bottom Sediments

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 2019 from all sources reaching the reservoir was normal with about 2,052 pounds (89% from Bear Creek). There was about 32,235 pounds of total nitrogen loading into the reservoir with 89% 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. 2019 was an average nutrient loading year with 54% of the total phosphorus (Figure 3) and 33% of the total nitrogen (Figure 4) load occurring in the June-July runoff period. Most nutrient load is generated within 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. Although nutrient concentrations from the tributaries maybe high (e.g., Figure 3 and 4, Site 32), the actual poundage loading is reduced because of lower flows (Figure 5, site 32).

There was about 533 pounds of total phosphorus passed through Evergreen Lake, with an additional 205 pounds added from the Cub Creek drainage. Additional total phosphorus loading into Bear Creek between Evergreen to Morrison was over 2,100 pounds during the monitoring season. 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*).

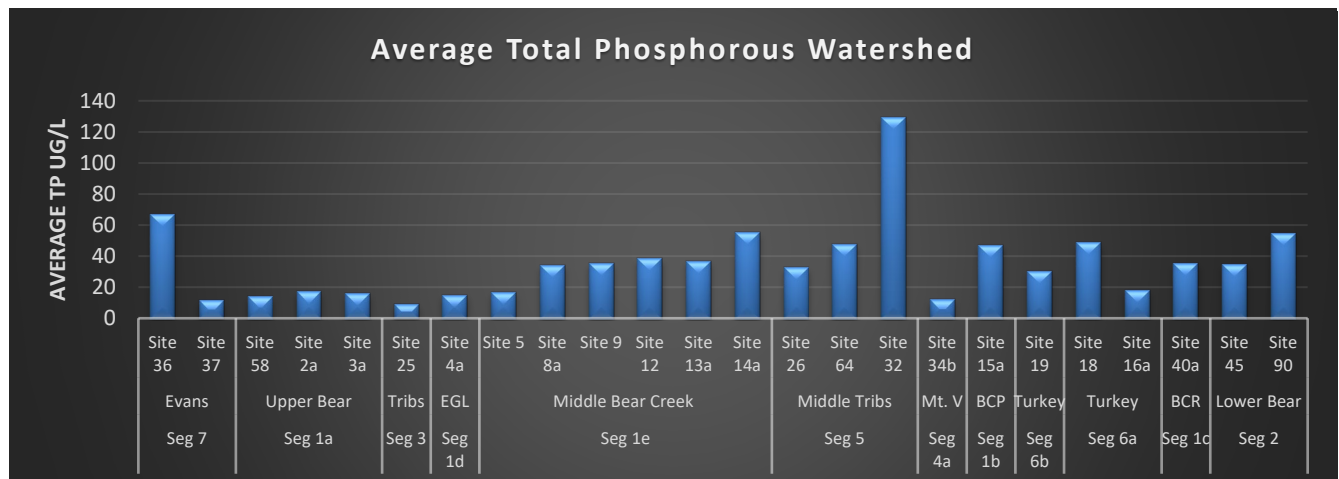


Figure 3 Total Phosphorus Concentrations by Stream Segments in the Watershed

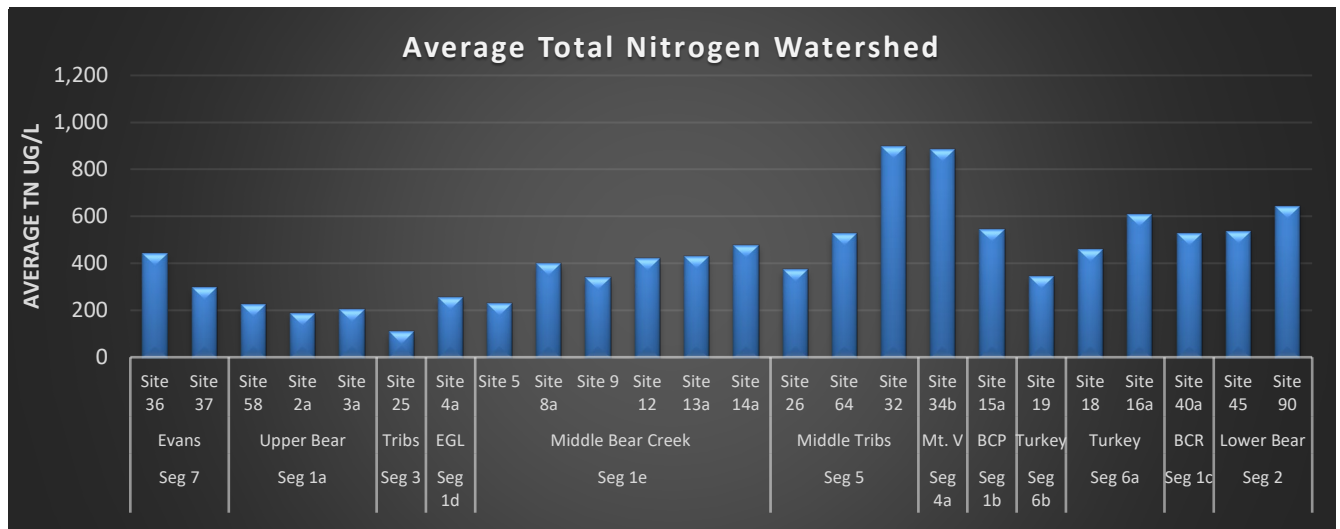


Figure 4 Total Nitrogen Concentrations by Stream Segment in the Watershed

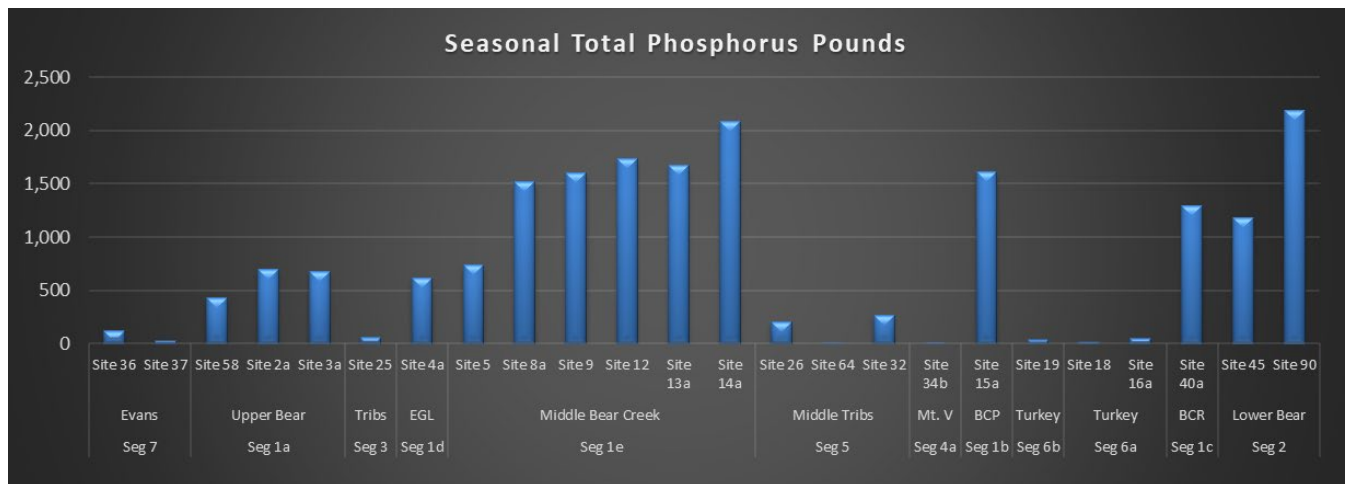


Figure 5 Total Phosphorus Loading (pounds) by Stream Segment in the Watershed

2. Wastewater Treatment Facilities Loading and Compliance

In 2019, wastewater dischargers reduced total phosphorus waste load contributions to just 1,145.1 pounds annually (22% of allocated load). 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. Geneva Glen remains under compliance orders with the Water Quality Control Division until an acceptable new wastewater treatment option is approved by the WQCD permit section. The Brook Forest Inn treatment facility is under new ownership but is not utilizing the existing wastewater treatment works. At closure, the treatment works was 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. These two former treatment works are still listed in the Control Regulation #74. They 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.

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. Some 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 12-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 anywhere from 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 2019 (Table 1) was 1,145.1 pounds. The estimated nonpoint source load in Bear Creek above the Harriman Diversion was about 1,000 pounds with about 50% of this load diverted into the Harriman Diversion. On average over 19 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 2019 nonpoint source phosphorus loading was heavily influenced by the spring runoff period.

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

	2019 Total Phosphorus Loading (Pounds)				
	Total TP Load	PS	%PS	NPS	%NPS
Turkey Creek Drainage	234	19	8.1%	215	92%
Bear Creek Drainage	1,818	1,126	61.9%	692	38%
Discharged into Reservoir	2,052	1,145	55.8%	907	44%
Site 45 Outflow BCR	1,262				
BCR Total Phosphorus Deposition	789				
Site 90 - Lower Bear Creek	2,218				
NPS load increase between 45 and 90	43%				

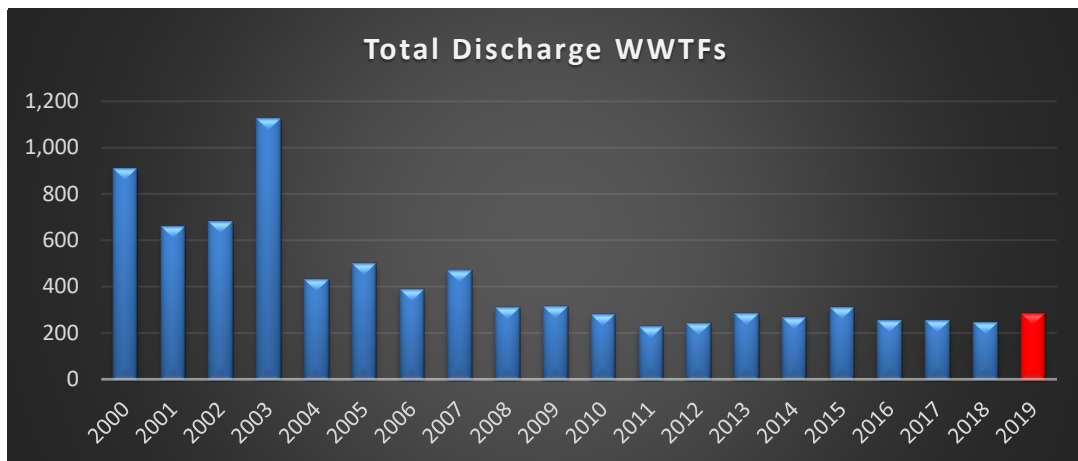


Figure 6 Point Source Load Reaching Bear Creek Reservoir

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 June 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, Upper Bear segment was

the largest source of total phosphorus (90%) load. Under historic flow conditions, Vance Creek 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 and annual data collection at the mouth of Cub Creek shows this tributary discharge ranges from 250 to 3,040 pounds of total phosphorus per monitoring season into Bear Creek downstream of Evergreen Lake. The 2019 total phosphorus load was estimated at about 205 pounds during the monitoring season. 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 (37) 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 38-years of active service to the watershed in Clear Creek, Jefferson and Park Counties. The Association has 35-years of data and studies to support watershed science. During this time, the Association has removed or immobilized about 378 tons of phosphorus in the watershed. The 88 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 2019 average seasonal total phosphorus of 89.6 µg/L in Bear Creek Reservoir far exceeds the 22.2 µg/L goal-standard. Average seasonal chlorophyll-a of 13.9 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 were normal. There were no exceedances of the *Weekly Average Temperature* (WAT) or the *Daily Maximum Temperature* (DM). The Association is monitoring the effectiveness of the aeration configuration and oxygen transfer during the growing season (BCWA Fact Sheet 47 *New BCR Aeration System*, BCWA Fact Sheet 62 *BCR Aeration System Operation and BCWA Fact Sheet 63 2014 BCR Aeration System Evaluation*). Lake aeration maintained dissolved oxygen levels at or above 6 mg/L throughout the growing season. The aeration system helps maintain an exceptional

recreational fishery throughout the year.

In the Turkey Creek segments, there were no temperature compliance problems in the warm or cold seasons. In Bear Creek segments, there were only two cold season exceedances of the daily maximum (DM) on segment 3 (Vance Creek) and segment 1a Bear Creek mainstem above Evergreen Lake and two exceedances the warm season DM below Bear Creek Reservoir at site 45, segment 2. All weekly average temperatures (WATs) complied with standards. Sampling and monitoring were performed at 38 sites within the watershed at varying intervals. Measurements of pH complied with standards. Dissolved Oxygen measurements were compliant with standards except for sites near Summit Lake (segment 7). There were exceedances for the proposed Total Nitrogen target of 1250 ug/L at Summit Lake, Bear Creek mainstem near Bear Creek Reservoir, below the reservoir and on several tributaries. The proposed Total Phosphorus target of 110 ug/L below the treatment facilities was exceeded on both Turkey Creek and Bear Creek mainstem and tributaries. There were exceedances of the new total phosphorus target measured at the site-specific Summit Lake Fen study area (*BCWA TM 2019.02 UBCW Summary*). The Summit Lake sites continue to show elevated nutrients.

5. Phosphorus Trading Program

There was no active total phosphorus trading by Association membership in 2019 (See Table 24 in the *BCWA 2019 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 76.9 pounds (*BCWA TM 2019.03 Coyote Gulch Summary*). The project has effectively reduced total phosphorus loading by about 75% on an annual basis (Figure 6).

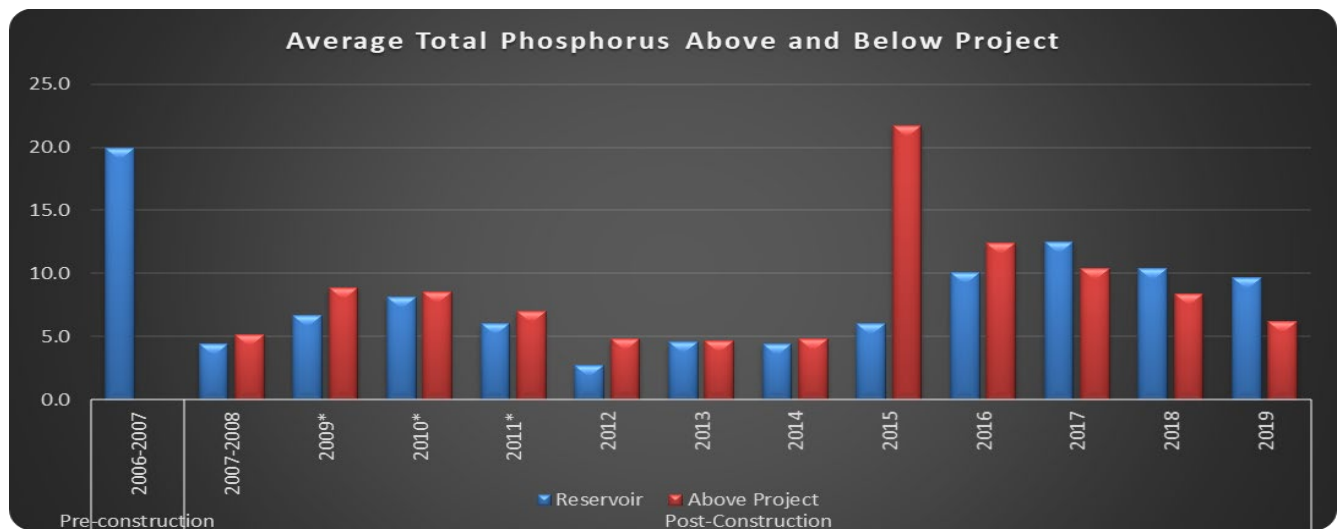


Figure 7 Total Phosphorus Reduction at Coyote Gulch Restoration Site