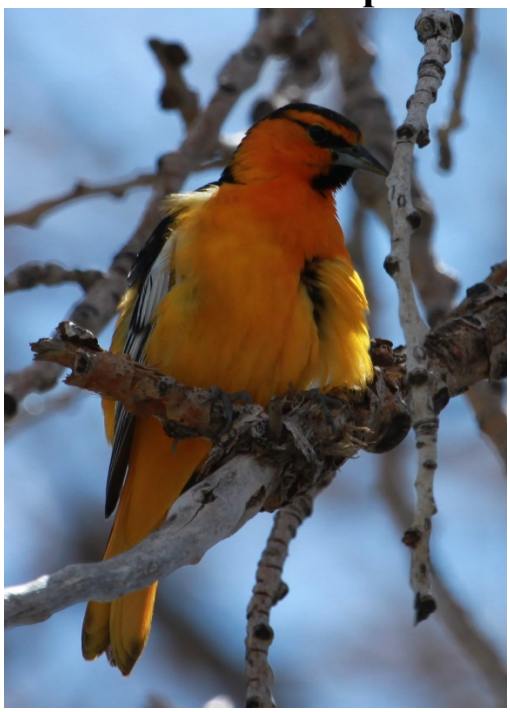
Bear Creek Watershed Association

2020 Annual Report



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July 14, 2021

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 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 (1987-2020) was 29,125 acre-feet per year. The 2020 inflow is estimated at 7,828 acre-feet (Figure 1) with the April/May runoff flow at 50% 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 September to December by about 500 ac-ft.

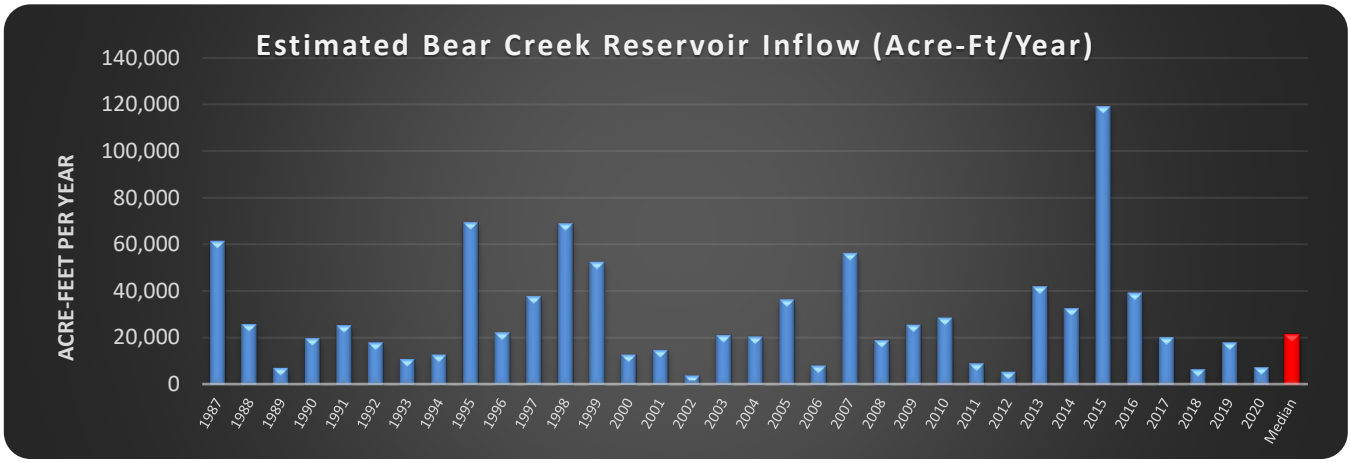


Figure 1 **Estimated Bear Creek Reservoir Inflow 1987-2020**

The estimated annual Bear Creek inflow into Bear Creek Reservoir was about 5,336 acre-feet (68%) and 2,511 acre-feet (32%) from Turkey Creek. Although there was no net phosphorus deposition into bottom sediments in 2020, the internal loading problem (total phosphorus) with Bear Creek Reservoir has not diminished over the last 12-years (Figure 2). The total phosphorus deposition into reservoir bottom sediments is about 36,721 pounds since 2008.

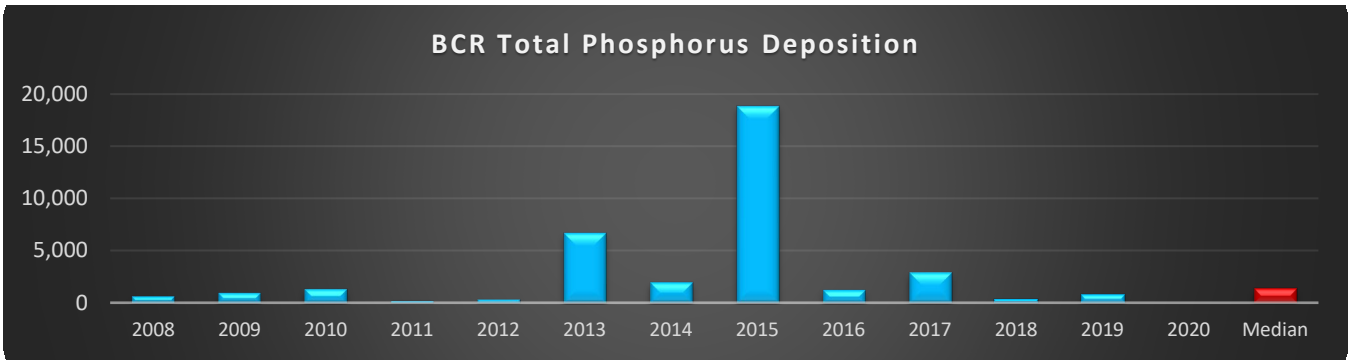


Figure 2 **Annual Total Phosphorus Pounds Deposition into Bear Creek Reservoir Bottom Sediments**

The reservoir continues to experience late summer phytoplankton blooms (2020 peak density of *Asterionella formosa*, peak biovolume of 8,508,115 um3/ml; BCWA TM 2020.09 BCR Phytoplankton Summary), which is linked to the internal nutrient loading problem. The problematic bluegreen algae was *Aphanizomenon flos-aquae* (Peak biovolume of 3,583,517 um3/ml). The August phytoplankton sample taken near Bear Creek dam contained 3 species of bluegreens, which are common in the reservoir. Cyanobacteria, in high concentrations (> 20,000 cells/ml of water), can produce toxins. Release of toxins during an algal bloom generally occurs when algal cells die or are subject to lysis (i.e., cell wall ruptures). Most commonly occurring genera of bluegreens found in Bear Creek Reservoir over the last 10-years are Microcystis, Anabaena, Oscillatoria, and Aphanizomenon. Potential cyanotoxins found in reservoir blooms are microcystins, cylindrospermopsin, anatoxins and saxitoxins. The biovolume of *Aphanizomenon* is considered a moderate to high risk for cyanotoxin production.

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. 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).

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 2020 from all sources reaching the reservoir was below normal with about 423 pounds (56% from Bear Creek). There was about 36,721 pounds of total nitrogen loading into the reservoir with 74% 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. 2020 was a below average nutrient loading year with 55% of the total phosphorus (Figure 3) and 35% of the total nitrogen (Figure 4) load occurring in the April-May 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 33 pounds of total phosphorus passed through Evergreen Lake, with an additional 57 pounds added from the Cub Creek drainage. Additional total phosphorus loading into Bear Creek between Evergreen to Morrison was over 977 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*).

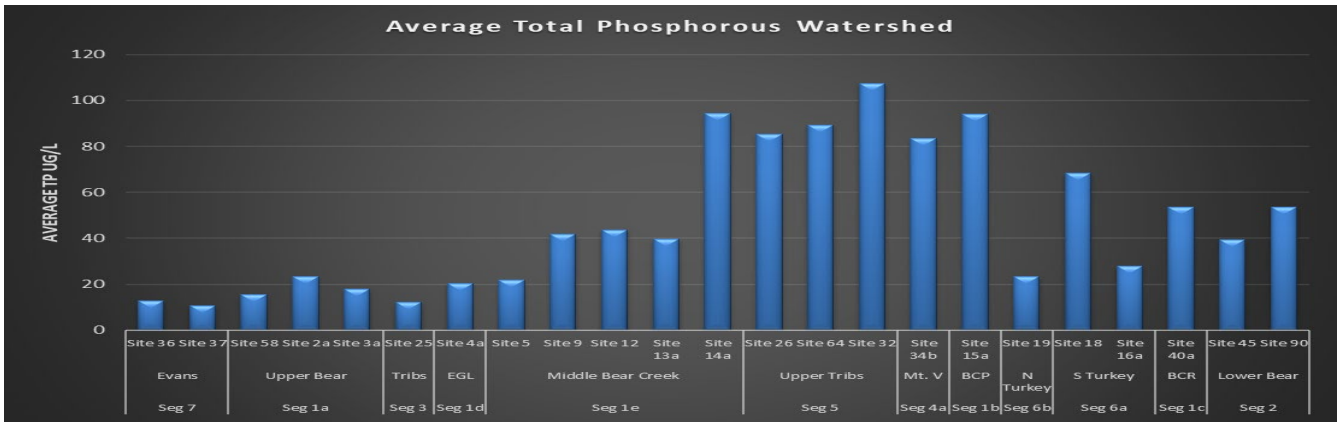


Figure 3 Total Phosphorus Concentrations by Stream Segments in the Watershed

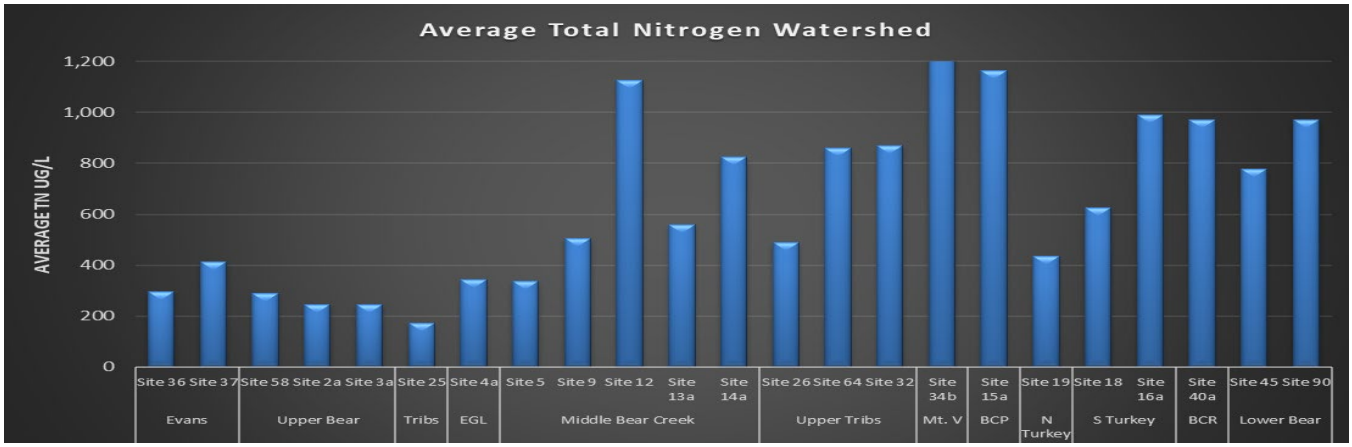


Figure 4 **Total Nitrogen Concentrations by Stream Segment in the Watershed**

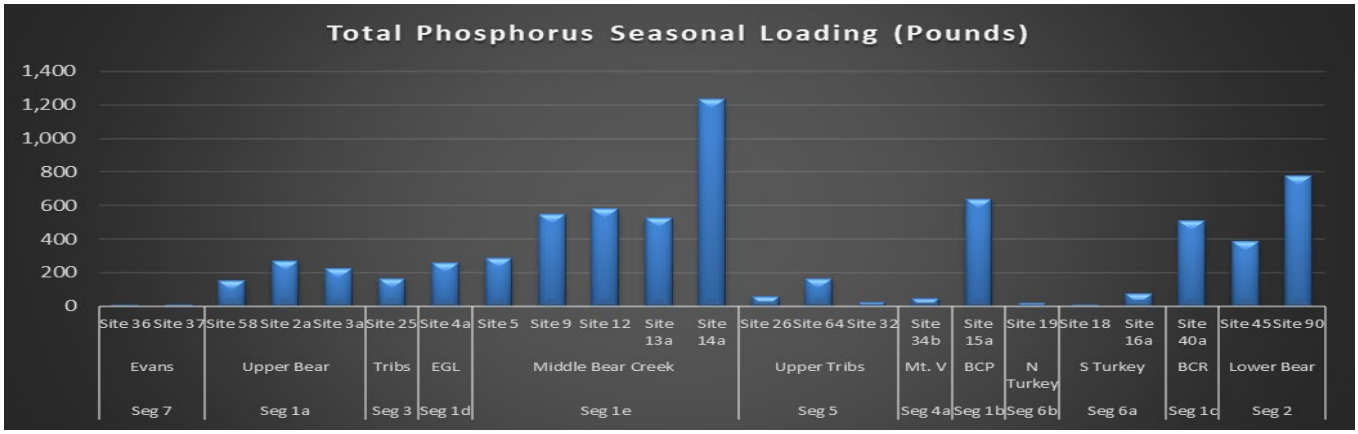


Figure 5 **Total Phosphorus Loading (pounds) by Stream Segment in the Watershed**

2. Wastewater Treatment Facilities Loading and Compliance

In 2020, wastewater dischargers reduced total phosphorus waste load contributions to just 1,177 pounds annually (23% 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 (2018), 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, as demonstrated in 2013. 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 2020 (Table 1) was 1,177 pounds. Part of the estimated nonpoint source load in Bear Creek above the Harriman Diversion is diverted into the Harriman Diversion. On average over 20 years of data record, only about 30% of the total phosphorus load reaching Bear Creek Reservoir is attributable to point sources (Figure 6). 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 2020 nonpoint source phosphorus loading was heavily influenced by the spring runoff period.

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

	2020 Total Phosphorus Loading (Pounds)				
	Total TP Load	PS	%PS	NPS	%NPS
Turkey Creek Drainage	331	20	6.0%	311	94%
Bear Creek Drainage	423	1,157	273.5%	-734	-174%
Discharged into Reservoir	754	294	39.0%	460	61%
Site 45 Outflow BCR	790				
BCR Total Phosphorus Deposition	-36				
Site 90 - Lower Bear Creek	1,315				
NPS load increase between 45 and 90	40%				

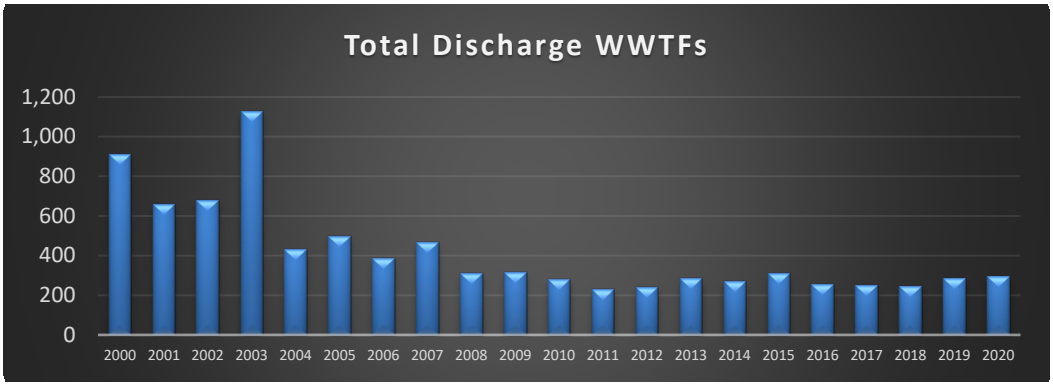


Figure 6 Point Source Load Reaching Bear Creek Reservoir

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 2020 total phosphorus load was estimated at about 57 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 39-years of active service to the watershed in Clear Creek, Jefferson, and Park Counties. The Association has 36-years of data and studies to support watershed science. During this time, the Association has removed or immobilized about 380 tons of phosphorus in the watershed. The +90 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 2020 average seasonal total phosphorus of 47.3 µg/L in Bear Creek Reservoir far exceeds the 22.2 µg/L goal-standard. Average seasonal chlorophyll-a of 14.8 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 2020.02 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 2020 (See Table 24 in the *BCWA 2020 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 77.7 pounds (*BCWA TM 2020.03 Coyote Gulch Summary*). The project has effectively reduced total phosphorus loading by about 75% on an annual basis (Figure 7).

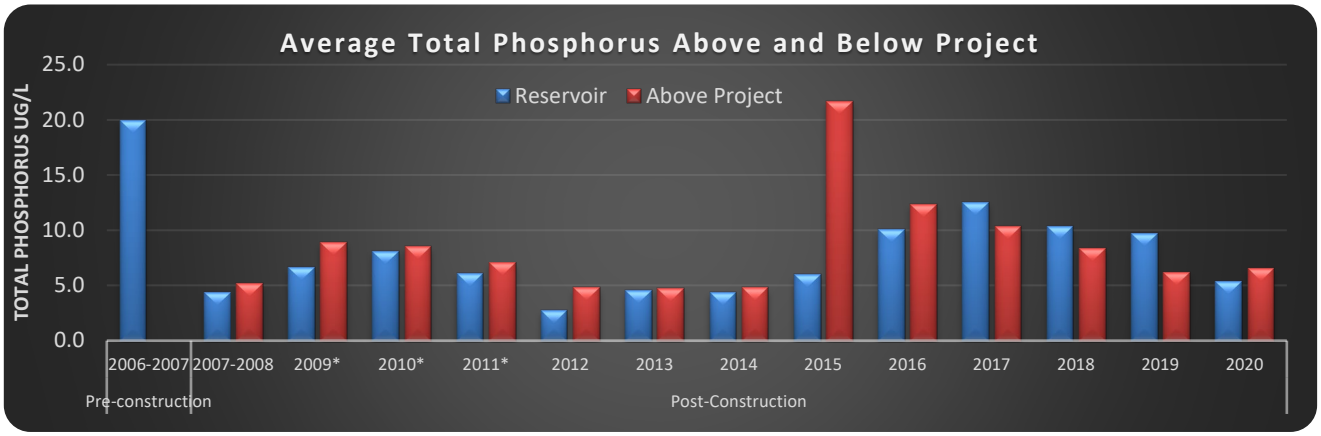


Figure 7 **Total Phosphorus Reduction at Coyote Gulch Restoration Site**

II. Bear Creek Watershed Association Program

The Bear Creek Watershed (Figure 8) 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*).

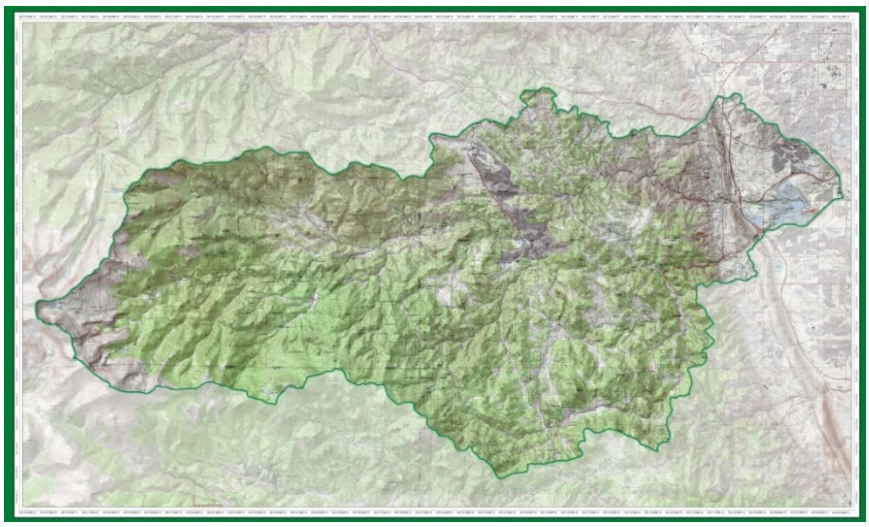


Figure 8 **Bear Creek Watershed**

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	2020 Participation
Counties		
Jefferson County		Active
City and County of Denver		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	Active
Jefferson County School District	Yes	Active
Kittredge Water & Sanitation District	Yes	Active
Tiny Town Foundation, Inc.	Yes	Paid, Not Active
West Jefferson County Metropolitan District	Yes	Active
Other Member		
Denver Water Department		Active
Participant Agencies		
U.S. Army Corps of Engineers		Not Active
Jefferson Conservation District		Active
WQCD		Attended
ETU		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 2020 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 2020 monitoring program (version 2020.01) 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.

Figure 9 Reservoir Monitoring Stations; Site 40 is the Routine P1 Station

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 9; 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 2020). 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 10 shows all active and historic monitoring stations within Bear Creek Park. The Association maintains maps of recent and historic sampling sites, wastewater treatment plant locations and special study areas in the Association's electronic watershed plan.

Figure 10 Monitoring Stations (Active and Historic) 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 are measured at up to 17 sites during the May to November timeframe. Year-round flows are measured at the P1 sites. The Association also conducts tributary stream flow studies.

Hydrology

The BCWA evaluates the basin hydrology. The average inflow into Bear Creek Reservoir from both Turkey Creek & Bear Creek (1987-2020) was 29,125 acre-feet per year (Table 3). From 2016-2020 the average inflow into Bear Creek Reservoir was 18,693 acre-feet. The 2020 inflow is estimated at 7,848 acre-feet (Figure 11) with most of the flow in April and May. The reservoir was not in flood stage in 2020 (Figure 12). The pool level was lowered from September through December.

Table 3 Average and median Reservoir Inflow Over Period of Record

	Years	Reservoir Inflow (Acre-Ft/Year)
Average	1987-2020	29,125
Median	1987-2020	21,283
Average	1987-2010	22,148
Average	2010-2020	20,626
5-Yr Average	2016-2020	18,693

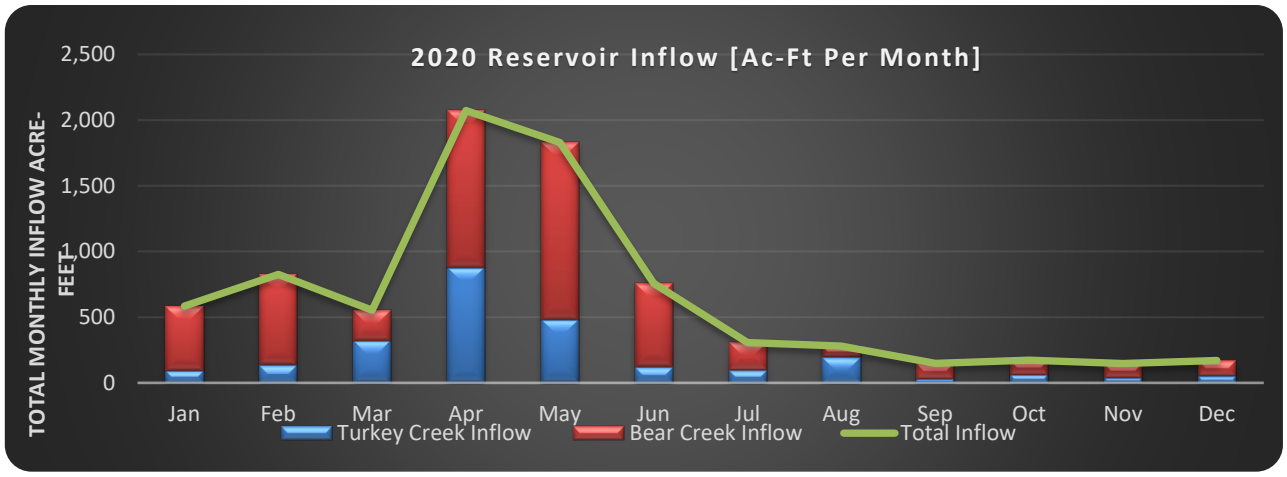


Figure 11 In-Flow Estimates by Month into Bear Creek Reservoir

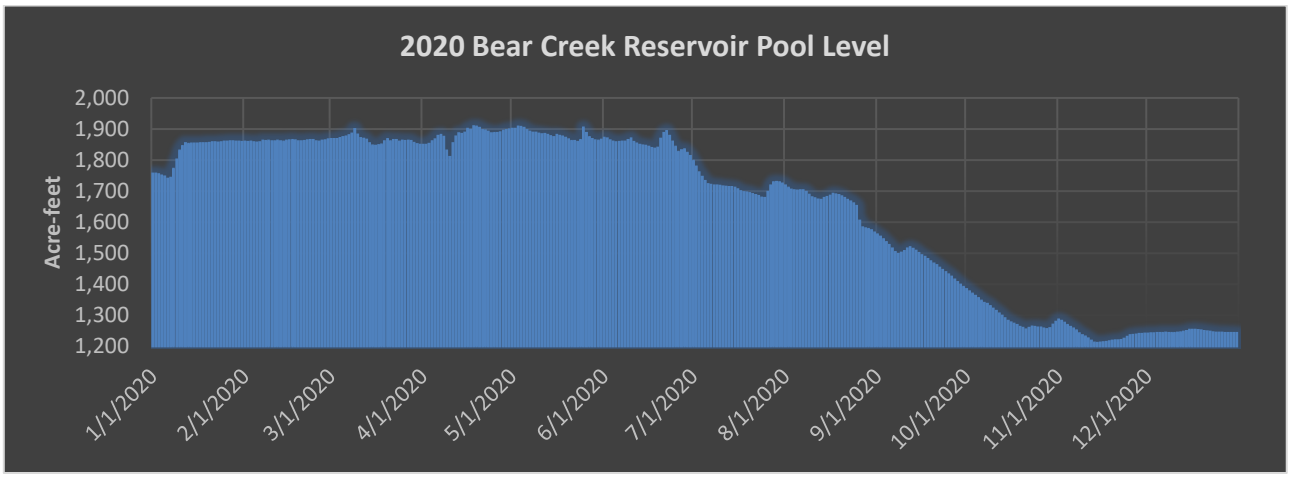


Figure 12 No Flood Stage in Bear Creek Reservoir

Bear Creek flow diverts at the Harriman Ditch in Morrison, and a portion of the Turkey Creek flow diverts for water users. 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, the Harriman can divert water for up to 275 days with about 5,000 acre-feet of removal as reported by Denver Water Department. Lower Bear Creek between the Harriman/ Ward ditch diversions and the inlet into Bear Creek reservoir is often dewatered (<5 cfs flow) for about 50 days annually or 15% of the time. The BCWA analyzed the nutrient load removal from the Harriman Ditch (Table 4). The diversion reduces the total phosphorus load to Bear Creek Reservoir by about 20%. The 2020 diversion record is like the 1992-2018 data record.

Table 4 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 (2020 - 8,383 ac-feet) and at the BCWA site in Bear Creek Park (2020 - 5,336 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 2020 the Bear Creek water use diversions reduced flow to the reservoir by about 3,046 ac-ft (-37 %).

The reservoir inflow represents flows below the water diversions and is not representative of the total watershed flows. Figure 13 compares the 2020 reservoir monthly inflow estimates from Bear Creek (68%) and Turkey Creek (32%). Peak spring and stormwater runoff occurred in April-May 2020 (50% of annual flow). Figure 14 shows the Bear Creek in-flow estimates (1987-2020) above Bear Creek Reservoir, in Bear Creek Park. Figure 15 shows the flow estimates at the Evergreen station. Additionally, the longer time trends shown in 15 depict a basic linear trend of declining flow in Bear Creek.

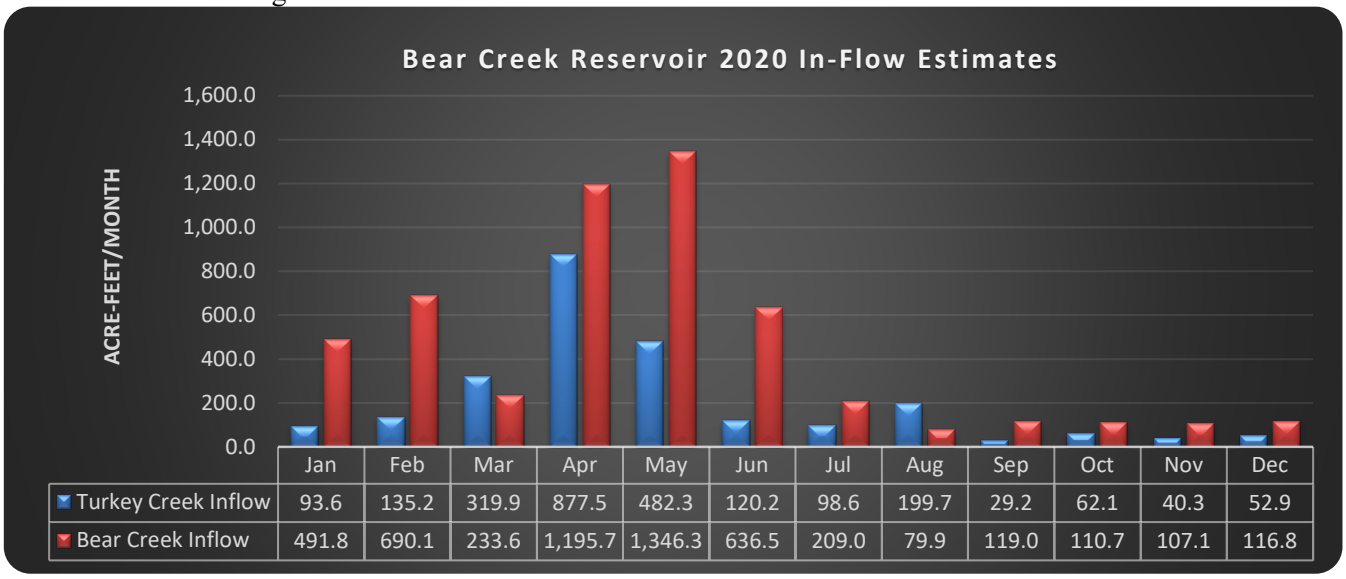


Figure 13 Annual Flows into Bear Creek Reservoir

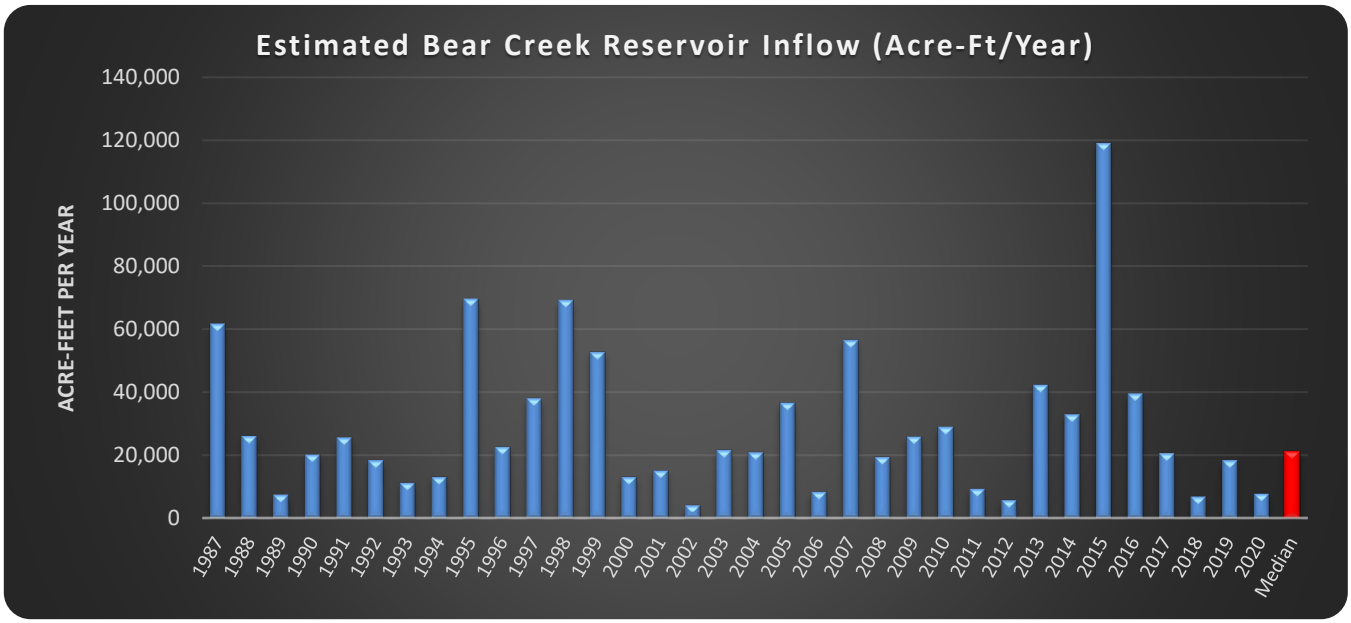


Figure 14 **Bear Creek Reservoir Inflow Estimates**

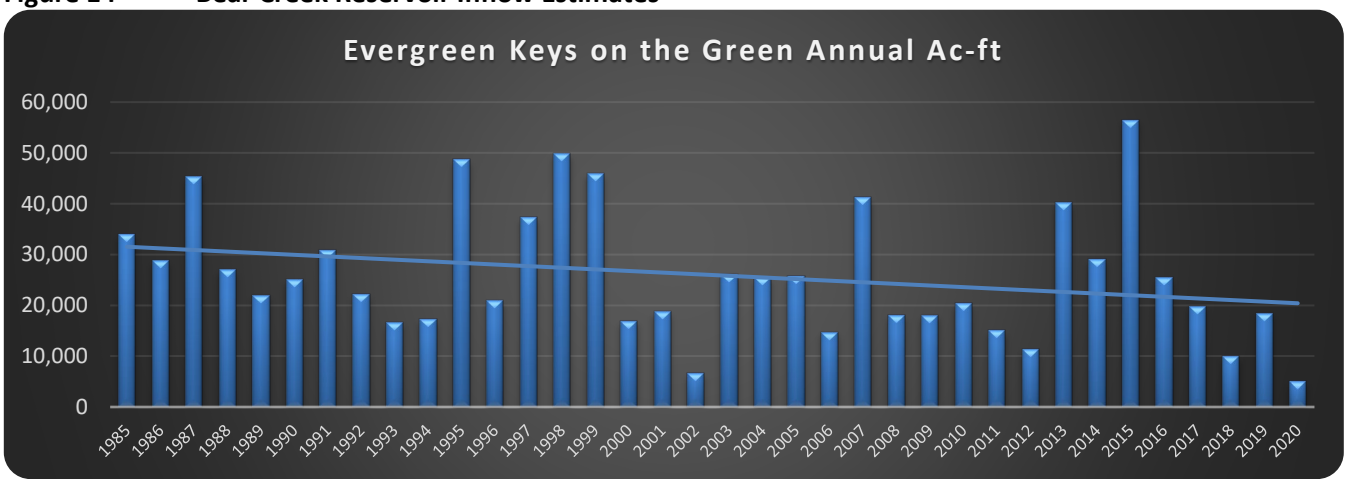


Figure 15 **Bear Creek at Keys-on-the-Green, above Evergreen**

Water Quality Studies

The BCWA summarizes its watershed-monitoring program in a data report (Bear Creek Watershed Association Data Report, June 2020). 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 2020.01, BCWA January 2020, 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 2020.01 and subsequent annual updates.***

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

The 2020 P1 data results are contained in the MS*2020 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, Total Nitrogen and Total Phosphorous 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 16 sites, including the Evergreen Lake profile station, and the Bear Creek Reservoir profile station, excluding five WWTPs. Six 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 October 2020.

The Association produces an annual series of technical memorandum designed to summarize the site-specific studies for any given year (Table 5). There was no fishery survey or macroinvertebrate collection done in 2020 due to the exceptionally low flows in the summer and fall. Although, there was a sediment collection taken from Bear Creek Reservoir bottom sediments, these samples were not processed in the laboratory due to site visit restrictions.

Table 5 2020 Technical Memorandum of the Association

TM2020.02	UBCW Summary
TM2020.03	Coyote Gulch Summary
TM2020.04	BCR Summary Statistics and Graphs
TM2020.05	Tributary & Mainstem Nutrient Loading Summary
TM2020.06	P1 Summary
TM2020.07	Barr Milton TMDL Summary
TM2020.08	EGL Summary
TM2020.09	BCR & EGL Phytoplankton Summary
TM2020.13	Regulation 85 Summary

Table 6 lists the 2020 tributary and mainstem Bear Creek seasonal average chemistry results (full results shown in 2020 Master Spreadsheet). BCWA Technical Memorandum 2020.05 summarizes the middle watershed data. Table 7 lists the Summit Lake area watershed chemistry results (full results shown in 2020 Master Spreadsheet). BCWA Technical Memorandum 2020.02 summarizes the Summit Lake data.

Table 6 Middle Watershed Chemistry

		Site ID	Site Location by Stream Segment	Seasonal Average		May-Oct	Seasonal Pounds	
				TN Ug/l	T Phos Ug/l	Ac-ft	TN	TP
Seg 7	**Evans**	Site 36	Summit Lake	297	13	215	174	7
		Site 37	Bear Creek Below Summit Lake	414	11	304	343	9
Seg 1a	**Upper Bear**	Site 58	Bear Creek below Wilderness	288	16	3,569	2,798	152
		Site 2a	Golden Willow Road UBC	246	23	4,254	2,847	270
		Site 3a	Above Evergreen Lake at CDOW Site	245	18	4,605	3,074	224
Seg 3	**Tribs**	Site 25	Vance Creek (Mt. Evans Wilderness drainage)	174	12	4,819	2,279	162
Seg 1d	**EGL**	Site 4a	Evergreen Lake	343	21	4,597	4,294	257
Seg 1e	**Middle Bear Creek**	Site 5	Above EMD WWTP, CDOW downtown site	336	22	4,819	4,411	286
		Site 9	O'Fallon Park, west end at CDOW Site	506	42	4,820	6,637	549
		Site 12	Lair o' the Bear Park, at CDOW site	1,127	44	4,878	14,974	581
		Site 13a	Below Idledale, Shady Lane at CDOW site	559	40	4,878	7,425	527
		Site 14a	Morrison Park west, CDOW Site	825	94	4,801	10,783	1,233
Seg 5	**Upper Tribs**	Site 26	Cub Creek, Mouth	490	85	247	330	57
		Site 64	Troublesome at Culvert above West Jeff	860	89	664	1,555	161
		Site 32	Troublesome Mouth	869	107	77	183	23
Seg 4a	**Mt. V**	Site 34b	Mt Vernon Drainage, Morrison	1,279	83	193	671	44
Seg 1b	**BCP**	Site 15a	Bear Creek Park	1,163	94	2,501	7,919	640
Seg 6b	**N Turkey**	Site 19	North Turkey Creek Flying J Ranch Bridge	434	23	313	370	20
Seg 6a	**S Turkey**	Site 18	South Turkey Creek Aspen Park	627	68	46	79	9
		Site 16a	South Turkey Creek, Park	989	28	992	2,671	76
Seg 1c	**BCR**	Site 40a	Bear Creek Reservoir	970	54	3,493	9,223	510
Seg 2	**Lower Bear**	Site 45	Bear Creek below BCR	778	40	3,595	7,611	387
		Site 90	Bear Creek Wadsworth	970	54	5,312	14,026	776

Table 7 Upper Watershed (Summit Lake) Chemistry

Site	Parameter	6/11/2020	7/10/2020	8/7/2020	9/3/2020	Average
36 - Outlet Summit Lake	Total Nitrogen, ug/l	339	305	300	242	**297**
	Phosphorus, total, ug/l	9	7	17	18	**13**
37 - Upper Bear Creek	Total Nitrogen, ug/l	671	324	356	306	**414**
	Phosphorus, total, ug/l	12	8	13	10	**11**
Site 63 - Bottom Fen	Total Nitrogen, ug/l	149	663	206	262	**320**
	Phosphorus, total, ug/l	97	440	148	168	**213**
Flow acre-feet/month						
	June	**July**	**August**	**Sep**	**Season Totals**	
Site 36 through Culverts	0.58	127	55	32	214.7	
Site 37 - Bear Creek	13	141	112	37	304.4	
Site 63 - Bottom Fen	0.6	1.2	2.0	0.6	4.4	
Total Phosphorus, Pounds/month						
Site 36 through Culverts	0.01	2.43	2.53	1.57	6.5	
Site 37 - Bear Creek	0.43	3.08	3.98	1.02	8.5	
Site 63 - Bottom Fen	0.16	1.43	0.79	0.28	2.7	
Total Nitrogen, Pounds/month						
Site 36 through Culverts	0.5	105.7	44.7	21.2	172.1	
Site 37 - Bear Creek	23.9	124.7	109.1	31.2	288.9	
Site 63 - Bottom Fen	0.2	2.1	1.1	0.4	3.9	

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 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 2020 from all sources reaching the reservoir was 754 pounds at a flow of about 7,868 acre-feet. Bear Creek drainage contributed 56% of the TP load (Figure 16). The management program targets reduction of total phosphorus reaching the reservoir on an annual basis. Figure 17 shows the total phosphorus reservoir trend.

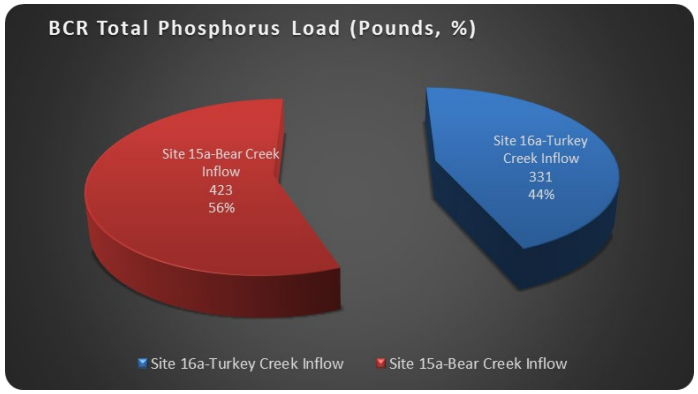


Figure 16 Estimated Total Phosphorus loading into Bear Creek Reservoir

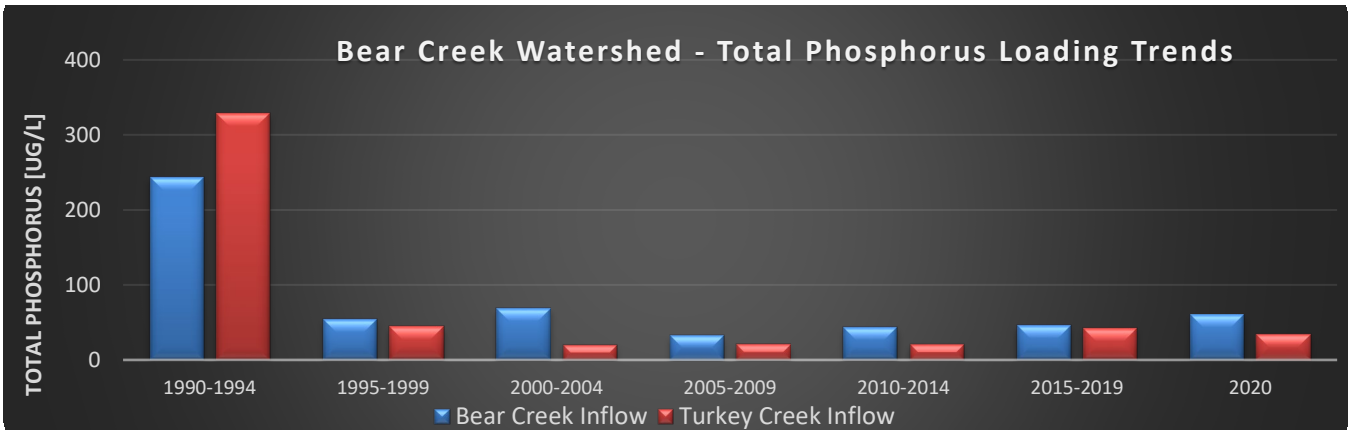


Figure 17 5-Year Average Total Phosphorus Trend BCR Compared with 2020

The total nitrogen loading (Figure 18, about 18,031 pounds) had 74% of the load coming from Bear Creek. Figure 19 shows the Total Nitrogen trend in BCR.

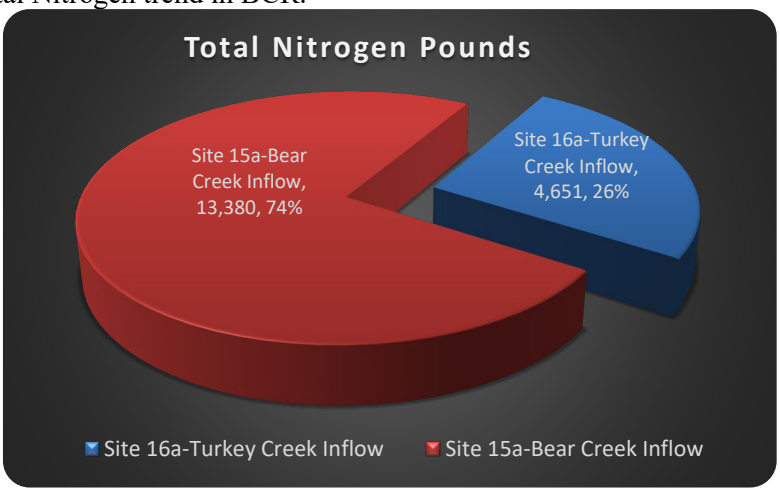


Figure 18 **Total Nitrogen Loading into Bear Creek Reservoir**

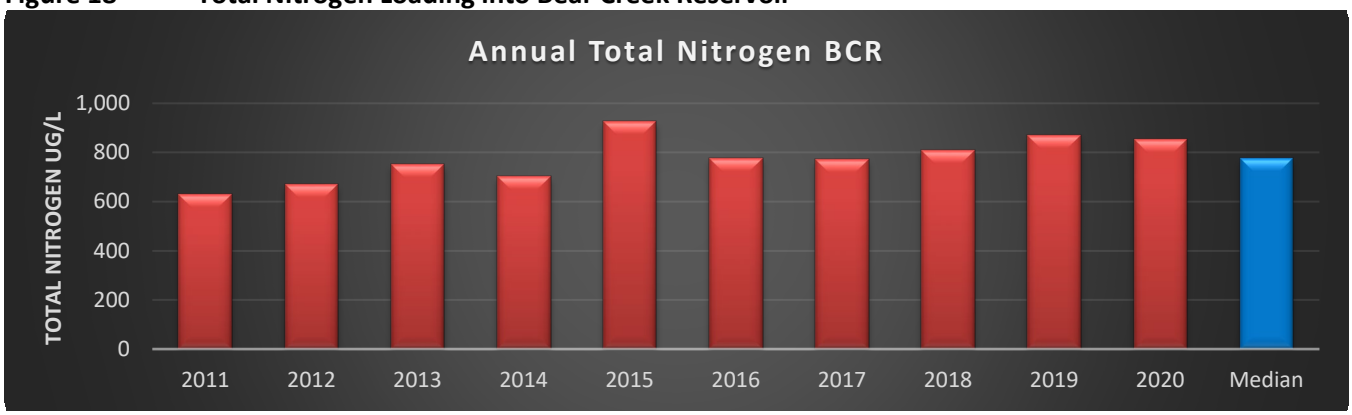


Figure 19 **Estimated Total Nitrogen Loading Trend for Bear Creek Reservoir**

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 (rarely), dissolved oxygen, pH, specific conductance, Secchi depth, and phytoplankton population dynamics as trend variables. Table 8 lists the summary statistics for the monitoring variables. Tables 9 and 10 summarize the reservoir loading data. Table 9 compares 2020 data with the long-term patterns from 1991 through 2020. In 2020, the chlorophyll concentrations were below the long-term trends, while nitrogen loads were elevated, and the total phosphorus loads were reduced in the surface waters. Table 11 summarizes the phytoplankton data. Figure 20 shows the phytoplankton species diversity during summer sampling period. Figure 21 shows the general clarity trend in the water column using Secchi measurements. June through November had the poorest clarity caused by runoff and phytoplankton blooms.

Table 8 **Bear Creek Reservoir Summary Statistics (July September)**

Reservoir Monitoring Parameters	Reservoir
Chlorophyll (Site 40)	
Average Growing Season Chlorophyll-a [ug/l (-1m)]	14.8
Average Annual Chlorophyll-a [ug/l (-1m)]	11.7
Peak Chlorophyll-a [ug/l]	37.0
Total Phosphorus	
Average Annual Total Phosphorus [ug/l]: Water Column	38.3
Average Annual Total Phosphorus [ug/l] -1m	33.2
Average Annual Total Phosphorus [ug/l] -10m	43.5
Growing Season Total Phosphorus [ug/l]: Water Column	47.3
Growing Season Total Phosphorus [ug/l]: -1m	39.0

Reservoir Monitoring Parameters	Reservoir
Growing Season Total Phosphorus [ug/l]: -10m	55.0
Peak Annual Total Phosphorus [ug/l] Water Column	90.0
Total Nitrogen	
Average Annual Total Nitrogen [ug/l]: Water Column	854
Average Total Nitrogen [ug/l]: -1m	830
Average Total Nitrogen [ug/l]: -10m	878
Growing Season Total Nitrogen [ug/l]: Water Column	678
Growing Season Total Nitrogen [ug/l]: -1m	690
Growing Season Total Nitrogen [ug/l]: -10m	667
Clarity (All Profiles)	
Average Annual Secchi Depth (meters)	1.7
Growing Season Average Secchi Depth (meters)	1.3
Dissolved Oxygen (site 40 Profile)	
Annual Average at -1/2m - 2m [mg/l]	9.44
Seasonal Average at -1/2 - 2m [mg/l]	7.39
Seasonal Minimum at -1/2 - 2m [mg/l]	6.03
pH	
Annual Average at -1/2m - 2m [mg/l]	8.24
Seasonal Average at -1/2 - 2m [mg/l]	8.30
Seasonal Maximum at -1/2 - 2m [mg/l]	8.60
Specific Conductance	
Annual Average at -1/2m - 2m [uS/cm]	732.0
Seasonal Average at -1/2 - 2m [us/cm]	730.0
Seasonal Minimum at -1/2 - 2m [us/cm]	607.0
Phytoplankton Species	
Phytoplankton Co-dominant Species - Site 40 (July-November 2020)	Anabaena circinalis
	Anabaena flos-aquae
	Aphanizomenon flos-aquae
	Cryptomonas erosa
	Rhodomonas minuta
	Asterionella formosa
	Diatoma vulgare
	Fragilaria crotonensis
	Melosira ambigua
	Stephanodiscus niagarae
	Ceratium hirundinella
	Trachelomonas volvocina
Peak Phytoplankton	
Rhodomonas minuta	Density cells/ml = 9.917
Asterionella formosa	Peak Biovolume (um^3/mL) = 8,508,115

Table 9 Annual Bear Creek Reservoir Load Estimates

Loading - Annual Pounds	
Total Nitrogen -Total Load In to BCR	18,380
Total Nitrogen -Total Load From BCR	18,813
Total Nitrogen -Total Deposition into BCR	-782
Total Phosphorus -Total Load In to BCR	754
Total Phosphorus -Total Load From BCR	790
Total Phosphorus -Total Deposition into BCR	-36

Table 10 Bear Creek Reservoir Select Trend Parameters

Parameter		2020	91-2020 Mean	91-2020 Median
Chlorophyll-a (ug/L)	Top	12	13.9	12.5
Total Nitrogen ug/l	Top	830	767	795
	Bottom	878	779	442

Parameter		2020	91-2020 Mean	91-2020 Median
	Water Column	854	773	372
Total Phosphorus (ug/L)	Top	33	56	49
	Bottom	44	82	45
	Water Column	38	66	8
Secchi Depth (m)	Top	1.7	2.0	2.1

Table 11 **Bear Creek Reservoir Phytoplankton Summary Data**

Group	Density %	Biovolume um^3/mL	Number Species
Bluegreen	159	212,586	6
chrysophyte	40	7,218	4
cryptophyte	409	207,454	10
diatom	58	122,221	35
dinoflagellate	28	276,093	1
euglenoid	56	106,267	1
green	22	6,379	8

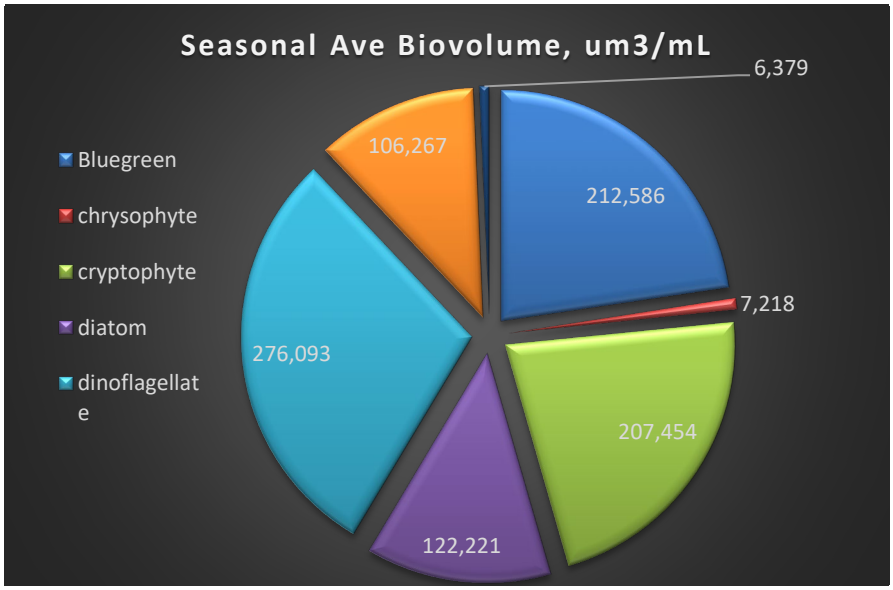


Figure 20 **Bear Creek Reservoir Phytoplankton Biovolume**

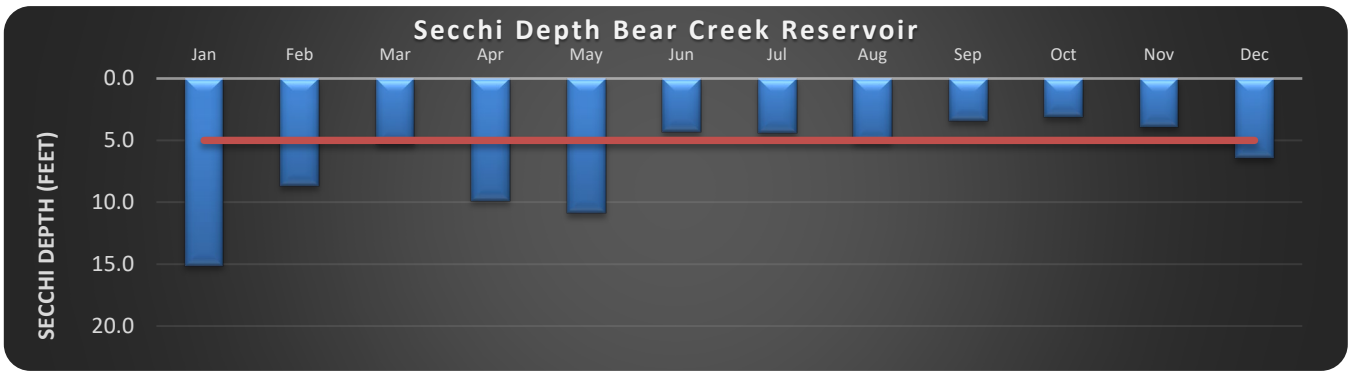


Figure 21 **Secchi Depth Bear Creek Reservoir**

The reservoir had several algal blooms in 2020 as evidenced by peak August through November chlorophyll concentrations (Figure 22). The peak *Asterionella formosa* phytoplankton biovolume was 8,508,115 um^3/mL caused by cryptophyte phytoplankton bloom. Historically, blue-green phytoplankton species are associated with major

blooms in the reservoir (*BCWA Fact Sheet 57 Cyanotoxins, BCWA Fact Sheet 58 Cyanobacteria Guide BCR, Fact Sheet 60 Managing Harmful Algal Blooms, and Fact Sheet 61 HABs Exposure and Risks*).

The genus *Limnothrix* is a filamentous cyanobacteria. This bluegreen produces a novel toxin called Limnothrixin, which has been associated to damage in liver, lungs, and gastrointestinal tract of mice (Humpage et al., 2012) as well as toxic activity against Bufo marinus larvae(frogs) (Daniels et al., 2014).

Anabaena circinalis is well known as a producer of potent neurotoxins. This Cyanobacteria species is particularly worrisome. Not only does this species produce toxins, but it is also a nitrogen fixer. By providing the nutrients that increase *A. circinalis* populations, additional reactive nitrogen further disrupts the ecosystem. Literature reports widespread occurrence of saxitoxins and related neurotoxins in blooms of *Anabaena circinalis* in rivers and water storage reservoirs. *Anabaena circinalis* produces heat-stable neurotoxin, anatoxin a, which has been found to be a blocking agent for postsynaptic neuromuscular transmission.

Ceratium hirundinella, a dinoflagellate was found in Bear Creek Reservoir. Ceratium species belong to the group of dinoflagellates known as dinophysiales, meaning they contain armored plates. Ceratium species do not produce toxins, however they are considered as "harmful algae", since they deplete nutrients under bloom conditions. Ceratium are found in the upper regions of the water, where there is enough light for photosynthesis. Unlike other dinoflagellate species, Ceratium are relatively harmless organisms. Although Ceratium hirundinella is non-toxic, they can cause a red tide if conditions allow for excessive blooming. While this red tide is not toxic, it can deplete resources in its environment, causing strain on the ecosystem.

The reservoir trophic state was eutrophic (Walker Index, Figure 23). 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.

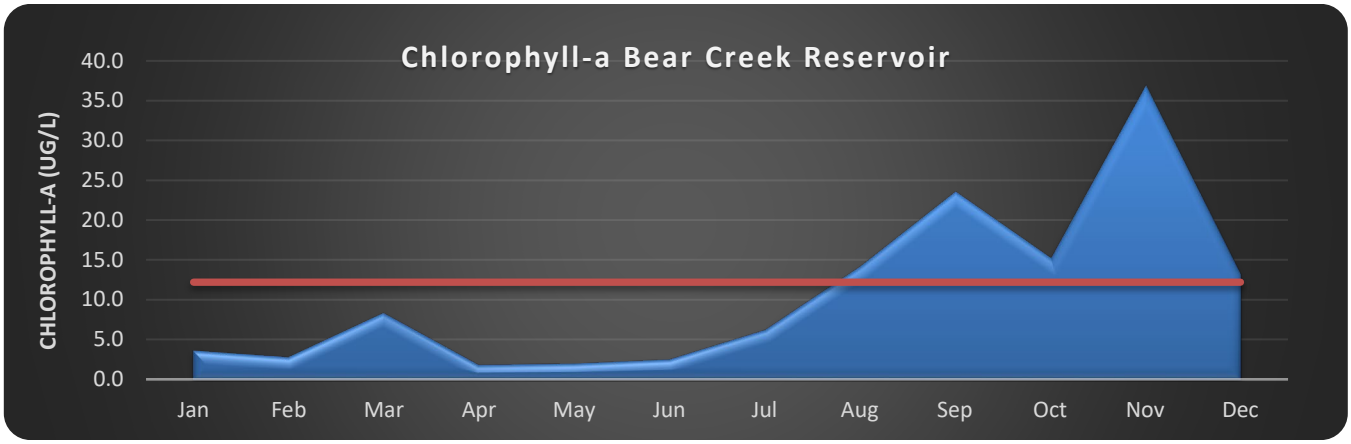


Figure 22 Bear Creek Reservoir Chlorophyll Trend

Figure 23 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 long-term or permanent management practice necessary to protect the quality reservoir fishery (Figure 24) 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 2020, the Association and Lakewood operated the aeration system to maximize oxygen transfer during phased on-off cycling (Figure 25), with the aeration system phased on in the growing season. In 2020, the dissolved oxygen in the lower water column was below the standard in mid-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 24 Fishing Very Popular on Bear Creek Reservoir, Both Winter and Summer

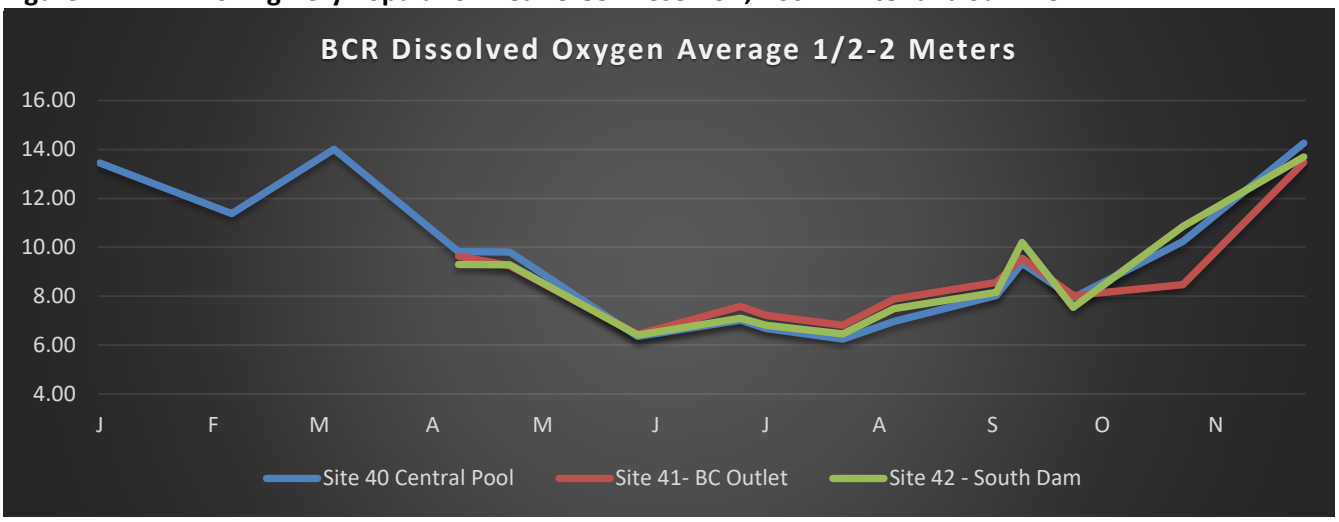


Figure 25 Bear Creek Reservoir Dissolved Oxygen Trend

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 26. 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 conducted a five-year evaluation (2016-2020) on the effectiveness and efficiency of the new aeration system in the spring/ summer growing season (*Fact Sheet 62 BCR Aeration System Operation* and *Fact Sheet 63 2014 BCR Aeration System Evaluation*). The Association and Lakewood recommend the addition of several new aeration modules in the reservoir.

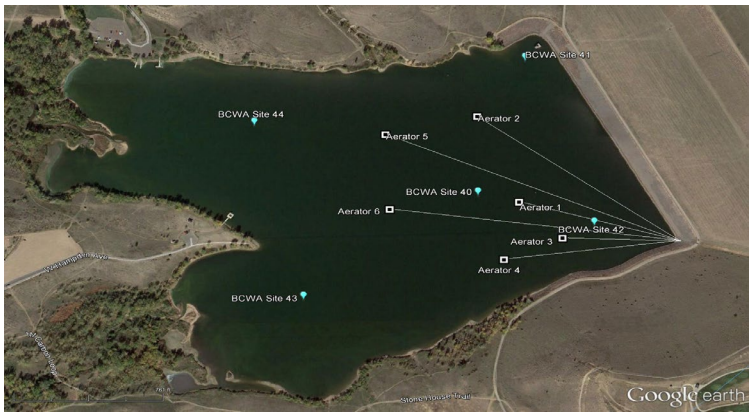


Figure 26 BCR Aeration Configuration

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 channel configurations were altered throughout the segment 1e. In August 2020, the BCWA collected sediment samples from six locations in BCR. Sediments were not analyzed for total phosphorus content due to Covid 19 restrictions.

Table 12 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 13 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

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 rock structures 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 exceptionally 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 2020 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)**	5/13/2020	6/10/2020	7/8/2020	8/12/2020	9/16/2020	10/15/2020	**Average**
EGL 4a	Total Nitrogen	376	357	454	362.0	263	246	343
	Phosphorus, total	14	21	20	35	16	17	21
	Chlorophyll a Average	3.7	13.3	3.3	14.0	4.3	2.8	6.9
EGL 4e	Total Nitrogen	383	302	394	347	252	223	317
	Phosphorus, total	17	21	25	51	17	15	24
								Total
EGL 4a	Total Nitrogen, Pounds/month	51.9	33.4	28.7	13.6	10.0	9.3	147
	Total Phosphorus, Pounds/month	1.9	2.0	1.3	1.3	0.6	0.6	8

Table 15 Field Summary Data Evergreen Lake

	Parameter Summary	5/13/2020	6/10/2020	7/8/2020	8/12/2020	9/16/2020	10/15/2020
Water Column	Dissolved Oxygen 1/2-2m	9.78	7.89	7.22	6.04	8.42	8.56
	Temperature (C) 1/2-2m	12.12	16.75	19.08	18.88	14.25	10.38
	pH water column	7.56	7.57	7.63	7.66	8.22	8.80
	Specific Conductance (us/m)	101.69	88.95	85.00	88.03	90.02	89.11
Flows	Bear Creek Keys (ac-ft/month)	**50.7**	**34.4**	**23.2**	**13.8**	**13.9**	**13.9**
	Bear Creek EGL (cfs) daily	23.7	17.9	10.4	7.0	7.6	6.3

There was a dinoflagellate (*Glenodinium* species) identified from an Evergreen Lake phytoplankton sample in 2020. The biovolume was 4,047 um^3/mL, which was about 2.5% of the sample. *Glenodinium is in the* genus *Gymnodinium,* a genus of freshwater dinoflagellate algae (family *Gymnodiniaceae*). Dinoflagellates are unicellular eukaryotes that can produce toxins or paralytic algal blooms. All dinoflagellates feature two flagella and they have both plantlike and animal-like characteristics. Some may be bioluminescent. They can form periodic water blooms that tend to color water yellow or red. A few species produce toxins similar to that of the dinoflagellate *Gonyaulax*; these toxins are fatal to fish and can irritate the nose and throat of humans, if inhaled. Natural toxins like saxitoxin, yessotoxin, and brevetoxins are produced by dinoflagellates. There are 10–12 species of Dinoflagellata can produce toxins or other poisonous substances. The famous red tides are created by the poisonous or harmful blooms produced by dinoflagellates.

The August phytoplankton sample taken near the dam contained 3 species of bluegreens, which are common in Bear Creek Reservoir, but new to Evergreen Lake. These new Evergreen species can produce toxins. Cyanobacteria, in high concentrations (> 20,000 cells/ml of water), generally produces toxins. Release of toxins during an algal bloom generally occurs when algal cells die or are subject to lysis (i.e., cell wall ruptures). Most commonly occurring genera of bluegreens found in Bear Creek Reservoir over the last 10-years are Microcystis,

Anabaena, Oscillatoria, and Aphanizomenon. Potential cyanotoxins found in reservoir blooms are microcystins, cylindrospermopsin, anatoxins and saxitoxins. The biovolume of Aphanizomenon measured in Evergreen Lake is considered a moderate to high risk for cyanotoxin production (Table 16).

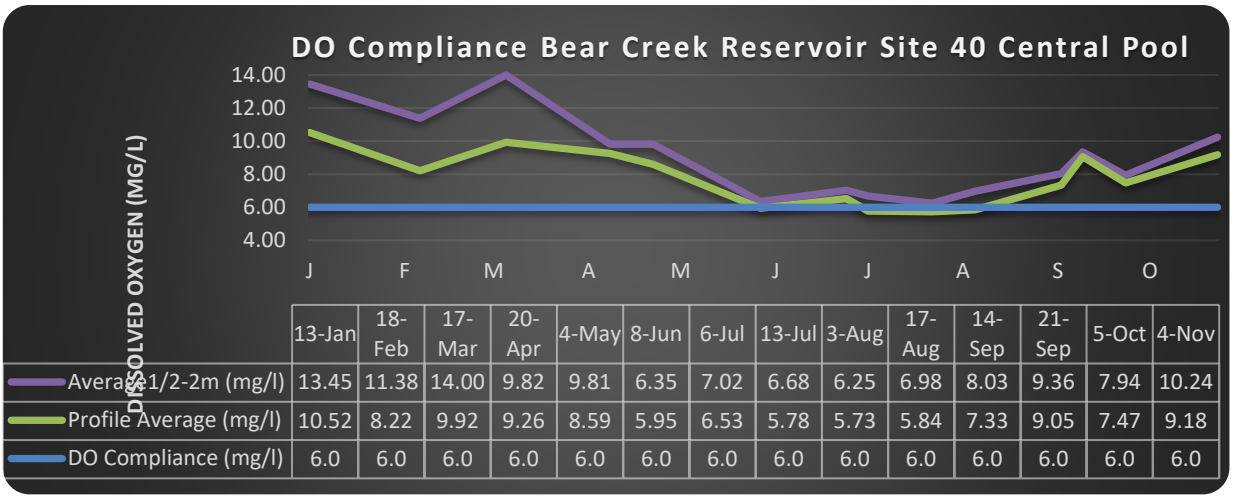
Table 16 Problematic Phytoplankton Evergreen Lake

Species	Density #/mL	Density %	Biovolume um^3/mL	Biovolume %	Group
Anabaena circinalis	14	0.9	17,278	3.6	bluegreen
Anabaena flos-aquae	44	0.4	59,249	0.4	bluegreen
Aphanizomenon flos-aquae	12,093	97.2	13,713,451	98.8	bluegreen
Microcystis aeruginosa	177	1.4	16,979	0.1	bluegreen

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 profile stations in the reservoir to determine dissolved oxygen compliance. The Association dissolved oxygen data set from 2003-2019 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 2019 were generally greater than 6 mg/l (Figure 28). There was an oxygen sag in early August, that correlated with a phytoplankton bloom. Data collected in the 2019 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.



	13-Jan	18-Feb	17-Mar	20-Apr	4-May	8-Jun	6-Jul	13-Jul	3-Aug	17-Aug	14-Sep	21-Sep	5-Oct	4-Nov
Average 1/2-2m (mg/l)	13.45	11.38	14.00	9.82	9.81	6.35	7.02	6.68	6.25	6.98	8.03	9.36	7.94	10.24
Profile Average (mg/l)	10.52	8.22	9.92	9.26	8.59	5.95	6.53	5.78	5.73	5.84	7.33	9.05	7.47	9.18
DO Compliance (mg/l)	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0

Figure 27 DO Compliance Bear Creek Reservoir

Temperature Standards Bear Creek Watershed

Table 17 shows the adopted temperature standards by segment for the watershed. The Association deploys up to twenty-five temperature data loggers at various sites within the watershed. The data loggers collect temperature data on a 30-minute interval. The loggers used in the program are Onset Computer Corporation brand, Temp Pro v2 (U22) programmable dataloggers. Every other year all model dataloggers are returned to Onset for a NIST (National Institute of Standards and Technology) one-point certification and a tune-up. Downloaded temperature data is maintained in a spreadsheet format. The data is evaluated against the underlying standards including Weekly Average Temperature (WAT) criteria, Daily Maximum Temperature (DM) criteria and for Bear Creek Reservoir Maximum Weekly Average Temperature (MWAT) criteria.

Bear Creek Watershed Site-Specific Temperature Standards and Longevity Plan

There are three site-specific temperature standards adopted for the watershed: Bear Creek Reservoir, the mainstem of Bear Creek from the outlet of Evergreen Lake to the Harriman Ditch in Morrison and from the Harriman Ditch to the inlet of Bear Creek Reservoir Table 17 (highlighted in red). The Association continues to

collect temperature data on these segments to support retaining these site-specific standards. Data loggers are annually deployed that collect temperatures on a 30-minute interval for both the warm and cold seasons. Annually, the Association collects about 280,000 individual temperature data points at up to twenty-five data logger sites within the watershed (about 5.88 million temperature data points over the period of record). This temperature data logging is intended to meet the site-specific standard longevity plan assessment requirements in Regulation 31 (1.7(1)(b)(ii) and (iii) and 31.7(1)(c)). The Association longevity plan provides for ongoing collection of evidence like that used to support the development and adoption of the site-specific temperature standards (Rulemaking Hearing Regulation 38, June 2009). The ongoing data collection supports retaining the adopted site-specific temperature standards.

The cold- and warm-season timeframe is defined in Regulation 38, which assigned calendar dates by segment for cold-season and warm season regarding water quality standards for temperature. The cold season is defined as approximately November to March, depending on specific stream segments (which are outlined in Appendix C of Reg. 74). Cold-season locations include sites in all segments excluding segment 1d situated in Evergreen Lake, Segment 1a (Sites 58, 2a and 3a), Segment 1b (Site 15a), Segment 1e (5,8a, 9,12, 13a, and14a), Segment 3 (Site 25), Segment 5 (Site 26), Segment 6a (Site 18 and 16a), and Segment 16b (Site 19). Many of these sites only record data during the shoulder season the month before the warm season began and post warm season. The warm-season program locations included twenty-five sites in Bear Creek Segments 1a, 1b, 1c, 1d, 1e, 2, 3, 5, (including four totals at the Evergreen Lake profile station, and the Bear Creek Reservoir profile station), and three sites in Turkey Creek Segments 6a and 6b.

Table 17 Temperature Standards in Bear Creek Watershed

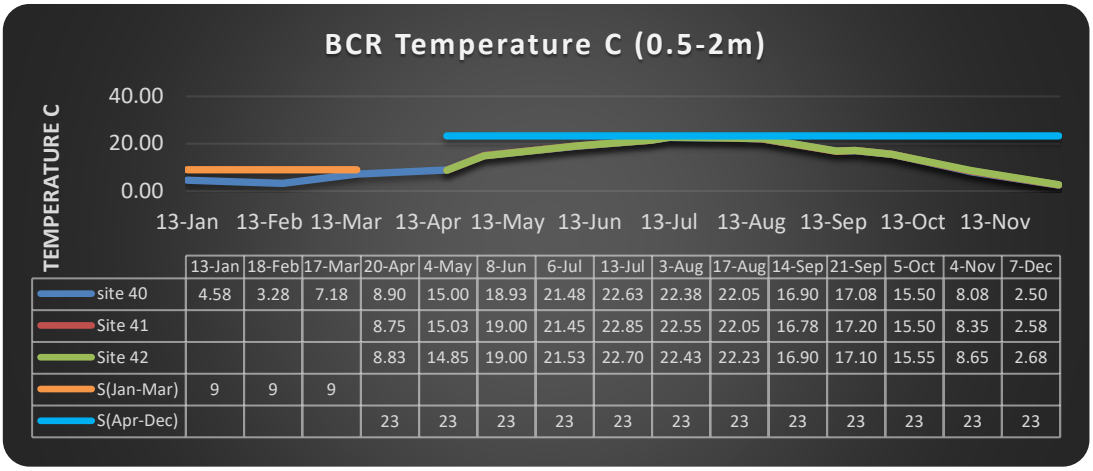
Segment	Description	Standard	Month	STANDARD (°C)		Month	STANDARD (°C)	
				(MWAT)	(DM)		(MWAT)	(DM)
1a	Mainstem Bear Creek from Mt. Evans Wilderness to Evergreen Lake	T=TVS(CS-I) °C	June-Sept	17.0	21.2	Oct-May	9.0	13.0
1b	Mainstem Bear Creek from Harriman Ditch to Bear Creek Reservoir	T=TVS(CS-II) °C, 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 Bear Creek from Evergreen Lake to 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 Bear Creek from Bear Creek Reservoir to 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 from source to outlet of Evergreen Lake	T=TVS(CS-I) °C	June-Sept	17.0	21.2	Oct-May	9.0	13.0
4a	All tributaries to Bear Creek from the outlet of Evergreen Lake to South Platte River	T=TVS(WS-I) °C	March-Nov	24.2	29.0	Dec-Feb	12.1	14.5
5	Swede, Kerr, Sawmill, Troublesome, and Cold Springs Gulches, and mainstem of Cub Creek	T=TVS(CS-II) °C	April-Oct	18.2	23.8	Nov-March	9.0	13.0
6a	Turkey Creek system from source to Bear Creek Reservoir	T=TVS(CS-II) °C	April-Oct	18.2	23.8	Nov-March	9.0	13.0
6b	Mainstem of North Turkey Creek	T=TVS(CS-I) °C	June-Sept	17.0	21.2	Oct-May	9.0	13.0
7	Mainstem and all tributaries 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 Mt. Evans Wilderness area	T=TVS(CL) °C	April-Dec	17.0	21.2	Jan-Mar	9.0	13.0
9	Lakes and reservoirs from Mt. Evans Wilderness area to 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	T=TVS(CL) °C	April-Dec	17.0	21.2	Jan-Mar	9.0	13.0
11	Lakes and reservoirs from the outlet of Evergreen Lake to South Platte River	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	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 profile stations in the reservoir and has a temperature data-logger set at site 40 to determine temperature compliance. Figure 28 shows 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). Table 18 summarizes the temperature record for the probes. The reservoir had no daily maximum (DM) or weekly average (MWAT) temperature exceedances in 2020 during the warm or cold seasons. Figure 29 shows the daily maximum temperatures in the reservoir.

Table 18 Temperature Compliance Summary Bear Creek Reservoir

All Temperatures in °C	30-minute Interval	April 1-October 31		November 1- March 31	
	3/18/2020 - 12/7/2020	MWAT 23.3 °C	DM 23.8 °C	MWAT 9.0 °C	DM 13.0 °C
Average (0.5-2m)	15.28	17.11	17.80	6.17	6.81
Median (0.5-2m)	16.46	17.56	18.12	6.67	6.96
Minimum (0.5-2m)	2.53	8.21	8.01	2.79	2.89
Maximum (0.5-2m)	23.58	22.77	23.58	8.43	9.30
Daily Temperature >23.8	0				
Water Column Measurements	50,784				
Exceed MWAT		0		0	
Exceed DM			0		0



	13-Jan	18-Feb	17-Mar	20-Apr	4-May	8-Jun	6-Jul	13-Jul	3-Aug	17-Aug	14-Sep	21-Sep	5-Oct	4-Nov	7-Dec
site 40	4.58	3.28	7.18	8.90	15.00	18.93	21.48	22.63	22.38	22.05	16.90	17.08	15.50	8.08	2.50
Site 41				8.75	15.03	19.00	21.45	22.85	22.55	22.05	16.78	17.20	15.50	8.35	2.58
Site 42				8.83	14.85	19.00	21.53	22.70	22.43	22.23	16.90	17.10	15.55	8.65	2.68
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

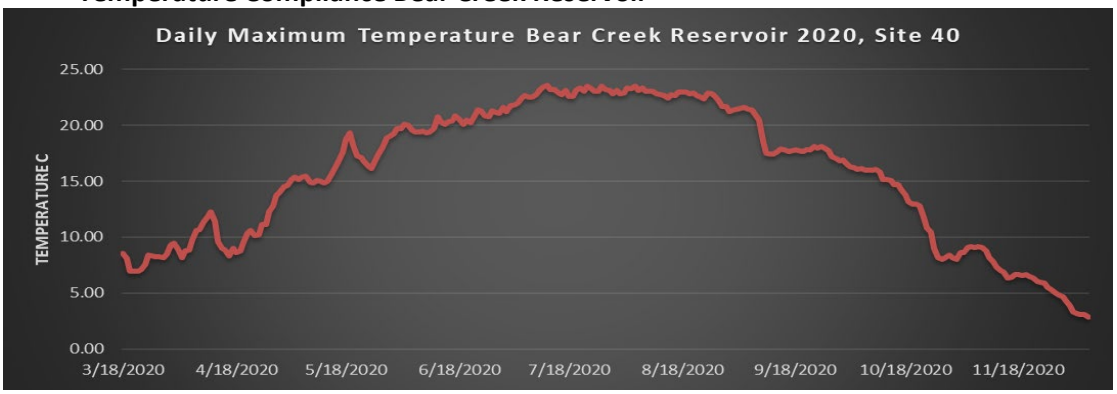


Figure 29 Daily Maximum Temperature Probe Record BCR

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 2020 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.

About 208,500 individual temperature data points were obtained from eighteen data logger sites within the watershed (excluding the WWTP data). The warm-season temperature compliance summary is shown in Table 19. A limited number of temperature compliance problems occurred during the shoulder season and the warm season. Some of the daily maximum exceedances on segment 1e were a result of people tampering with the temperature probes and periodically removing them from flow, and exposure of the probes during exceptionally low flow conditions. The temperature probes in Evergreen Lake malfunctioned and no useable data was collected in 2020.

Table 19 Watershed Temperature Compliance Summary Warm Season

Segment	Months	Warm Season	
Segment 3	**June-Sep**	**17°C WAT**	**21.2°C DM**
# Exceedances		0	2
Segment 1a	**Apr-Sept**	**17°C WAT**	**21.2°C DM**
# Exceedances		2	0
Segment 1d	**Apr-Dec**	**18.2°C WAT**	**23.8°C DM**
# Exceedances		na	na
Segment 1e	**Apr-Oct**	**19.3°C WAT**	**23.8°C DM**
# Exceedances		5	17
Segment 1b	**Apr-Oct**	**19.3°C WAT**	**23.8°C DM**
# Exceedances		1	1
Segment 5	**Mar-Nov**	**18.2°C WAT**	**23.8°C DM**
# Exceedances		0	7
Segment 6a	**Apr-Oct**	**18.2°C WAT**	**23.8°C DM**
# Exceedances		7	0
Segment 6b	**Apr-Oct**	**17°C WAT**	**21.2°C DM**
# Exceedances		0	0
Segment 2	**Mar-Nov**	**27.5°C WAT**	**28.6°C DM**
# Exceedances		0	0
Segment 1c	**Apr-Oct**	**23.3°C WAT**	**23.8°C DM**
# Exceedances		0	0

Stream and lake sampling and monitoring data, including pH, temperature, dissolved oxygen, specific conductance, total nitrogen and total phosphorous was collected from May through November. Manual flows measured at 18 sites during the May to December timeframe. An aeration system was installed and operational for Evergreen Lake. There were several exceedances of proposed nutrient standards in 2020 (Table 20).

Table 20 Nutrient Compliance at Watershed Monitoring Sites

		# Exceedances of Proposed Stream Standards (6 samples)	
		Total nitrogen (1250 ug/L)	Total Phosphorous (110 ug/L)
Site 12	Lair o' the Bear Park, at CDOW site	2	
Site 14a	Morrison Park west, CDOW Site	1	2
Site 64	Troublesome at Culvert above West Jeff	1	2
Site 32	Troublesome Mouth	1	4
Site 34b	Mt Vernon Drainage, Morrison	3	1
Site 15a	Bear Creek Park	2	1
Site 16a	South Turkey Creek, Park	2	
Site 40a	Bear Creek Reservoir	1	1
Site 90	Bear Creek Wadsworth	1	1
Site 18	South Turkey Creek Aspen Park		2
Site 26	Cub Creek, Mouth		2

303(d) Listing

Table 21 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 21 303(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 of 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 "datashed" 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 2020, the average Total Phosphorus at BCWA site 45 was 2,518 pounds/year (*BCWA TM 2020.07 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 2020.07, March 2020).

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 22 summarizes existing macroinvertebrate data. There was no macroinvertebrate sampling done in 2020 due to exceptionally low water conditions and Covid 19 restrictions.

Table 22 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	2018	2019	2020
5756a	15a	BCLP @ bridge	Transition					66.4	59.1	67.0	56.4	51	30.2	na
122	14a	Morrison @ Gage	Transition	69.8	80.5	74.5	72.9	48.8	73.5	72.0	63.9	66	55.6	na
122C	13a	Idledale	Transition	62.1	69.8	57.1	68.0	59.3	59.2	50.0	62.2	65	51.3	na
122a	12	Lair O' Bear	Transition	58.5	62.2	56.4	51.3	49.5	72.2	46.0	62.9	52	54.7	na
122b	9	O' Fallon	Transition	53.6	57.7	45.5	49.9	44.8	59.1	57.0	60.1	56	44.2	na
5762	8b	BCC @ Bridge	Transition	55.6	39.1	51.1	44.3	49.6	62.3	59.0	57.4	50	48.4	na
5763	5	Little Bear	Transition	52.3	56.6	42.9	40.0	56.2	68.9	75.0	38.4	29	37.6	na
5764	3a	Keys @ bridge	Mountain	38.6	36.9	45.3	46.9	43.9	63.6	37.0	57.9	51	41.4	na
5768d	2a	Golden Willow	Mountain				71.9	60.8	56.6	65.0	58.1	64	51.8	na
5768c	58	Mt Evans Wilderness	Mountain			55.5	72.5	67.0	53.8	67.0	75.6	68	72.2	na
BCWA90	90	Wadsworth	Plains & Xeric							55.0	39.9	60	49	na

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 23 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. No facility exceeded the assigned wasteload allocations (Table 23).

Table 23 Treatment Facility Wasteload Allocations

Bear Creek Watershed Wastewater Treatment Plants by Drainage Basin	WQCC Adopted Phosphorus WLA Pounds/ year	2020 Discharged Phosphorus Pounds/year	% Allocation Used by WWTF
Bear Creek Drainage			
Jefferson County Schools – Mt. Evans Outdoor Lab	**20**	0.83	4%
Brook Forest Inn[1]	**5**	0	0%
Evergreen Metropolitan District	**1,500**	402.88	27%
West Jefferson County Metro District	**1,500**	283.16	19%
Kittredge Sanitation and Water District	**240**	36.48	15%
Genesee Water and Sanitation District	**1,015**	375.13	37%
Forest Hills Metropolitan District	**80**	29.73	37%
Town of Morrison	**600**	28.86	5%
Bear Creek Total	**4,960**	**1,157.07**	**23%**
Turkey Creek Drainage			
Conifer Metropolitan District	**40**	1.56	4%
Conifer Sanitation Association	**40**	0.55	1%
Aspen Park Metropolitan District	**40**	8.1	20%
Jefferson County Schools - Conifer High School	**110**	1.92	2%
Geneva Glen[2]	**5**	0	0%
Bear Creek Development Corp. - Tiny Town[3]	**5**	0	0%
Turkey Creek Total	**240**	**12.13**	**5%**
Total Operational Facilities Lbs./year	***5,200***	***1,169.20***	22%
Reserve Pool[4]	**55**	0	0%
Total Phosphorus Wasteload lbs./year	**5,255**		

1-Brook Forest Inn - Under Compliance Advisory, Still permitted with no reported flow
2-Geneva Glen was not open in 2020
3-Records from Columbia Sanitary show no 2020 Hauling, Facility closed
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 24 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 24 Wastewater Treatment Plant Planning Status

Facility	Wastewater Utility Plan	Electronic Planning Documents	Recent Upgrades (3 yrs.)	Facility Upgrades [2018-2022]	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

Facility	Wastewater Utility Plan	Electronic Planning Documents	Recent Upgrades (3 yrs.)	Facility Upgrades [2018-2022]	Existing Compliance Concerns[1]	Informational Sheet
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	Closed Facility	Compliance Order	IFS09
Geneva Glen	No	Permit, WQA, WQCD Fact Sheet	No	Yes, Not Determined	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 supported 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 2020, due to the closure of three WWTFs. The trades in the watershed remain consistent with the total wasteload allocations listed in Table 25. 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 25 Phosphorus Trading Activity in Bear Creek Watershed

Involved Agencies	Type of Trade	Active Trading in 2019
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
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 2020, Municipal Stormwater Permit No.: COS-000002*; City of Lakewood, April 1, 2021). 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 7,500,000 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 (MS4) 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. Household hazardous waste (includes electronic waste, household chemicals, paints, propane cylinders and automotive products) materials collected at the Rooney Road Recycling facility since 1994 total more than 7,500,000 pounds of potential surface water and ground water pollutants. This process keeps materials out of septic systems and helps reduce illegal dumping in the watershed. Jefferson County participated in several public events to reach diverse audiences for their MS4 and floodplain management programs.

Jefferson County also maintains a land disturbance program as part of their MS4 permit. The county maintains a small-site erosion control manual that explains the basic principles of erosion and sediment control and illustrates techniques to control sediment from small development sites. Jefferson County has an inspection program for illicit discharges, construction activities, and post-construction inspections. Jefferson County regularly reports to the BCWA 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 may gather 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

The Association data suggests 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 completed 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 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 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 has a Watershed 101 class for watershed citizens. The Association can be 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 periodic 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 350 watershed citizens.

Future Watershed Manager Program

The Association has a future watershed manager program and works with 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.

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. Typically, 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. These programs were limited in 2020. The total visitation for BCLP exceeded 475,000 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, downtown Evergreen and O'Fallon Park. Generally, ETU collects over 10 cubic yards of trash and debris. No cleanup operations were done in 2020. ETU contributes time and materials to the temperature monitoring program. Several Association members are members of ETU.

Manure Management

The Bear Creek Watershed Association recognizes animal manure as a nutrient load source, 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.

Jefferson Conservation District

The Jefferson Conservation District (JCD) managed 17 acres of forest restoration and 200 acres of noxious weed management on private lands within the BCWA focus area. Plans are underway to treat more than 300 acres of forest land in the Upper Bear Creek area in 2021-22. Additionally, JCD in collaboration with BCWA and the Colorado State University Extension conducted an event for local landowners to discuss small pasture management, noxious weed control, and water quality.

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 2020.02 - 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 (Figure 30), low pH conditions and reduced dissolved oxygen.

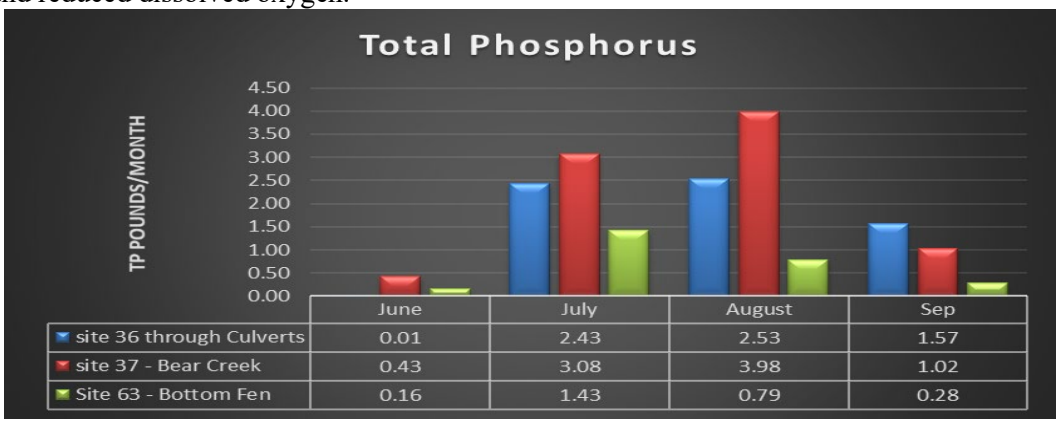


Figure 30 Total Phosphorus loading Summit Lake

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 2020 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 growth 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 2020.02 UBCW Summary*) (Figure 31).

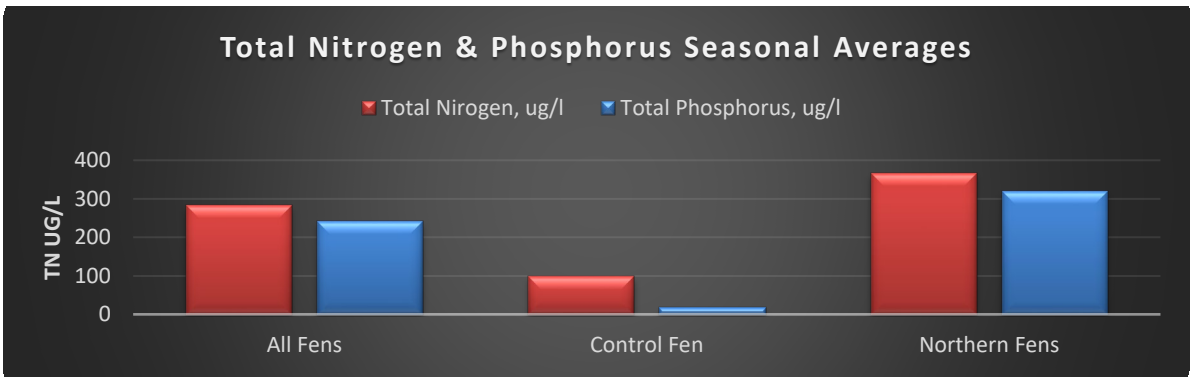


Figure 31 Total Phosphorus and Total Nitrogen Seasonal Averages in Fen Complex

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.

Evergreen Lake Dam Work

The Evergreen Metropolitan District is in Phase 2 of the project. This work involved replacement of a valve on the lake side of the dam. This work was completed in late winter of 2020. Phase 3 will then follow. The new lake-side valve will allow for additional inspection of the outlet works and a determination of the work necessary to get the outlet works functional, which will be done in a Phase 4.

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 26). The Association Technical Memorandum Coyote Gulch Summary (TM 2020.03) provides a summary of the monitoring program and data analysis. Table 27 identifies the annual available total phosphorus trade pounds consistent with the Association trade program. Based on 10 years of data, there is 77 pounds of total phosphorus available for the trade program (Table 27). Figure 31 shows the total phosphorus reduction. The Coyote Gulch restoration project is an effective phosphorus reduction project and management practice.

Table 26 Coyote Gulch Nutrient Base Loads

			Loading Pounds/Period	
Location	Date	Flow Estimate	Total Nitrogen	Total Phosphorus
Upper Coyote	Jan-Feb	107.1	531.6	7.9
	Mar-Apr	54.7	209.2	3.0
	May-Jun	29.7	87.9	8.3
	Jul-Aug	47.6	155.5	14.0
	Sep-Oct	65.4	212.9	4.1
	Nov-Dec	30.2	147.5	2.3
Lower Coyote	Jan-Feb	84.5	412.0	6.4
	Mar-Apr	53.2	188.7	2.6
	May-Jun	24.2	68.9	6.0
	Jul-Aug	49.2	128.2	12.6
	Sep-Oct	64.1	179.8	3.8
	Nov-Dec	29.0	188.9	1.0

Table 27 Coyote Gulch Total Phosphorus Trade Pounds

Total Phosphorus Trade Pounds				
	Total Base Flow		Trade Ratio Pounds	
	Monthly	Annual	Monthly	Annual
Average	7.0	84.1	6.5	**77.7**
Median	6.1	72.9	6.9	**83.3**
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 = 77 Pounds Total Phosphorus				

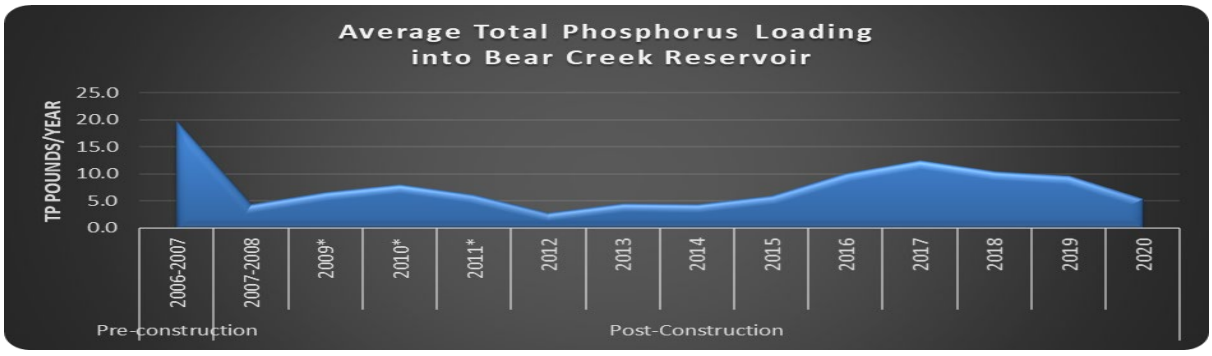


Figure 32 Total Phosphorus Reduction at Coyote Gulch Project

Coyote Crossing and Rooney Gulch Nonpoint Source Assessments

Coyote Crossing discharges directly into Bear Creek Reservoir at the boat launch parking lot. This historically was an intermittent drainage receives flows from Green Mountain. In the last 3-5 years, this discharge tended to flow year-round with exceptionally low winter flows. The new development on Green Mountain has resulted in increased flows. The new monitoring site 97a is located at the road crossing bridge near the parking lot. The site is monitored for background Total Nitrogen and Total Phosphorus (Table 28). It appears some of the flow comes from a leak in the Ward Ditch near Morrison Road. This drainage has produced amphibian and bird kills in Bear Creek Reservoir in the past. The increased development on Green Mountain is likely to make this a year-year loading source to the reservoir. There are some opportunities for mitigation above the maximum pool level within the park. After investigating a monitoring site 97b near Morrison Road, it was not necessary to start an upstream monitoring station in 2020.

Rooney Gulch discharge is carried through a culvert under Morrison Road and discharges into Bear Creek near the park entrance. This historically was an intermittent drainage receiving flow from the large Rooney Valley area (2,740 acres). In the last 1-2 years, this discharge tended to flow more frequently, and within the last year there is flow most of the year, even in this drier year. There is a substantial new development and land clearing operation just north of Morrison Road in Rooney Valley. There is evidence of increased silty deposition within the stream channel in the park. There has also been increased large flow events. The new monitoring site 98a is in the park below the culvert (difficult access). The specific conductance was exceptionally high at this site (4,583 uS). It is highly likely that this site will receive year-round flow in the coming years and will be a significant loading point to Bear Creek Reservoir. The site is monitored for background Total Nitrogen and Total Phosphorus (table 29). An investigation will be made north of Morrison Road to determine if a better upstream monitoring site is available to the Association.

Table 28 Rooney Gulch and Coyote Crossing Nutrient Loading

					Monthly		Seasonal	
			Days	Ac ft/ month	TP Load	TN Load	TP Load	TN Load
Site 97a	Coyote Crossing	7/13/2020	31	130.0	31.86	253.49		
		8/3/2020	31	245.2	76.11	416.58		
		9/14/2020	30	75.5	18.50	102.99		
		10/5/2020	31	55.7	13.05	73.89		
		11/4/2020	30	35.9	5.78	54.03		
		12/7/2020	31	11.1	8.16	30.01	153.5	931.0
Site 98a	Rooney Gulch	8/3/2020	31	92.9	5.56	166.14		
		9/14/2020	30	25.2	3.56	72.91		
		10/5/2020	31	7.4	0.38	10.74		
		11/4/2020	30	7.2	0.45	11.63		
		12/7/2020	31	66.9	6.37	175.52	16.3	436.9

Association Land-Use Review

The Association has 37 "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 6 referrals in 2020 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 17th year of recycling and litter management at their regional parks, including Bear Creek Park. In 2020, 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. Volunteer efforts were limited in 2020. 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 7 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.

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. The Jefferson Conservation District completed 232.7 acres of noxious weed treatments and 49 acers of seeding projects.

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*, summarize a survey of sports fishing in Bear Creek Reservoir. There was no 2020 fishery survey.

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. 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 were 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 on 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.

Effectiveness of the Evergreen Lake Dredging

The flood event of 2013 resulted in a heavy sediment load within Evergreen Lake. BCWA manager Russell Clayshulte was able to calculate an estimated load based on flood flow and water quality analysis. The calculation resulted in a sediment load of 12,000 cubic yards from the flood. Evergreen Metro was able to use the calculation to procure an FEMA disaster relief grant for the removal of the sediment. A Dredging Project was established and once all procurement, permitting, and administration procedures were in place, the operation was performed in the summer of 2016. The dredging was effective in removal of 12,000 cubic yards. As of fall 2019 the main channel into Evergreen Lake still had an average depth of 9’ demonstrating less sediment getting to the

lake. A bathometric survey performed on the lake after the dredging demonstrated a significant increase in the lake depth at the location the dredging was performed. As an added benefit, the dredged material was used at a closed landfill/transfer station located on property owned by Denver Mountain Parks in the Evergreen area. The material was used to provide a cap to the site which was seeded and transformed into a meadow.

VII. Association Watershed Plan and Annual Reports

The Association produces an annual data report and a *2020 Master Data Spreadsheet (April 2020)* 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 is 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 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.

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.