Bear Creek Watershed Report 2003:

Annual Report & Water Quality Summary Sheets

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Members: Lakewood, Morrison, Clear Creek County, Jefferson County, Park County, Evergreen Metropolitan District, West Jefferson County Metropolitan District, Genesee Water & Sanitation District, Kittredge Sanitation & Water District, Willowbrook Water &Sanitation District, Forest Hills Metropolitan District, Jefferson County Schools, Conifer Center Sanitation Association, West/Brandt Foundation, Aspen Park Metropolitan District, Conifer Metropolitan District, Brook Forest Inn, Bear Creek Development Corporation, Geneva Glen & Davidson Lodge

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The Bear Creek Watershed Association is a water quality management agency for the Bear Creek Watershed. The Association implements the *Bear Creek Reservoir Control Regulation* (Regulation #74). The control regulation assures watershed point and nonpoint source water quality compliance consistent with adopted Colorado stream standards and classifications.

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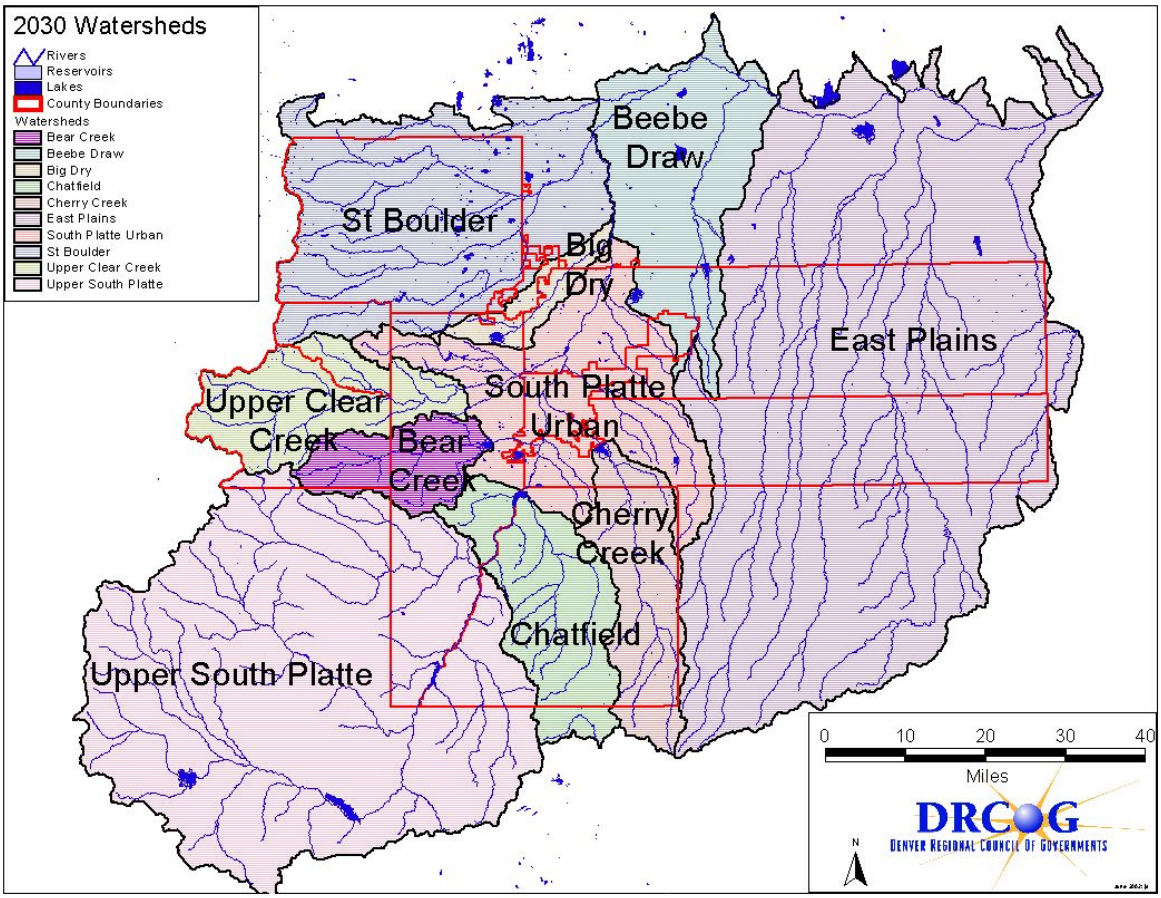
Introduction

The Bear Creek Watershed Association (Association) is the designated water quality management agency for the Bear Creek Watershed (Figure 1) as recognized by the Denver Regional Council of Governments in *the Metro Vision 2020 Clean Water Plan* (DRCOG 1998). Water quality data was originally collected as part of an intense one-year *Bear Creek Reservoir Clean Lake Study* (DRCOG 1989). A generally continuous collection of surface quality data has been done in the watershed and reservoir beginning in 1990. Data collection has included specific chemical, physical and biological parameters.

Figure 1 Bear Creek Watershed



The Bear Creek Reservoir Control Regulation (Regulation #74) defines the water quality goal, wasteload allocation for total phosphorus, monitoring program and other control strategies for the Bear Creek Watershed. The Association is responsible for implementing the control regulation. The Association also produces a summary data report for the Water Quality Control Commission and Water Quality Control Division. The report characterizes water quality monitoring activities, data tabulation, and general

trends in the Bear Creek Watershed including water quality and wastewater management efforts.

The long-term management strategies of the Association have improved water quality at the reservoir and within the watershed, including Turkey Creek (Figure 2) and Bear Creek (Figure 3). The trophic status of the reservoir has shifted from hypertrophic-eutrophic toward the eutrophic-mesotrophic boundary. All major wastewater treatment plants are in compliance with the control regulation and meet specific wasteload allocations. Several plants had compliance problems and/or lack of reporting to the Association. Overall, the point source nutrient loading to the reservoir is well controlled. Nonpoint source reductions of total phosphorus will be a major focus in the near future. Activities of the Association are limited due to funding and resource constraints.

Figure 2 Lower Turkey Creek at Morrison

Figure 3 Upper Bear Creek at Evergreen

Figure 4 Bear Creek Reservoir

Bear Creek Reservoir Control Regulation

The Association is responsible for implementing the Bear Creek Reservoir Control Regulation # 74. The control regulation assures watershed point and nonpoint source water quality compliance is consistent with adopted Colorado stream standards and classifications. The Association maintains a water quality monitoring program designed to assure compliance with adopted standards and classifications and the Bear Creek Reservoir Control Regulation #74.

Total Maximum Annual Load

The Bear Creek Reservoir Control Regulation #74 incorporates the total maximum annual load (TMAL) that controls total phosphorus wasteload allocations for point sources and the allowable nonpoint source load for the Bear Creek Watershed (Figure 1). The TMAL, which is consistent with a total maximum daily load, results in the Bear Creek Reservoir meeting designed beneficial uses and classifications as listed in regulation #38. The reservoir has a narrative standard based on established trophic indices. The TMAL describes prohibitions, standards, concentrations, and effluent limitations on the extent of specifically identified pollutants that may discharge into the watershed. The elements of the Bear Creek TMAL as approved by Region VIII Environmental Protection Agency and the Water Quality Control Commission are shown in Table 1. The total maximum annual load distributions of total phosphorus by sources are based on the following formula:

Total Maximum Annual Load (TMAL) = Chatfield Watershed (reservoir base-load + background sources + wasteload allocation) + Upper South Platte River Watershed (reservoir base-load + background sources) + Margin of Safety (MOS).

Table 1 Bear Creek Watershed TMAL Elements

Allocation	Endpoints	Target
Point Source Wasteload Allocation	Total phosphorus effluent poundage limit	The total wasteload allocation for all point sources of phosphorus in the Bear Creek Watershed is 5,255 pounds per year. Each individual discharger is limited to an annual wasteload of total phosphorus (pounds per year), except under trading provisions. Reserve pool maintained for future dischargers.
	Total phosphorus effluent concentration limit	Point source discharges can't exceed a total phosphorus effluent concentration of 1.0 mg/l as a 30-day average, except under trading provisions.
Margin of Safety (MOS)	Implicit MOS	A margin of safety is built into the wasteload and nonpoint source allocations as an implicit MOS.
Nonpoint Source Load Allocation	Reservoir narrative standard	Jefferson County, Clear Creek County, Park County, municipalities, and districts in the Bear Creek Watershed will implement best management practices for control of erosion and sediments.
	Monitoring trophic status indicators	At a minimum, local entities in the watershed will ensure that water quality monitoring is conducted on Turkey Creek, Bear Creek, and in Bear Creek Reservoir on a monthly basis to measure the phosphorus loading reaching the reservoir and other factors which affect the water quality, as well as the attainment of beneficial uses for the reservoir, including meeting the reservoir narrative standard. Data results must be reported to the Water Quality Control Commission and Water Quality Control Division.

Trophic Indicators

The reservoir-monitoring program provides data for use in assessing compliance with the reservoir narrative standard. Therefore, monitoring parameters are also trophic state indicators. The watershed program evaluates nutrient loading trends and balances for nitrogen and phosphorus species. Secchi depth and total suspended solids characterize the clarity of the water column. Algal productivity is measured by chlorophyll a samples and phytoplankton characterization. Since the growing season is critical for reservoir compliance as defined in the Bear Creek Reservoir Control Regulation (Regulation #74), then monitoring program targets additional sampling during this season.

Monitoring and Evaluation Listing

Segment 1a Bear Creek

Based on a recommendation by the Association, Bear Creek segment 1a was placed on the 2002 Colorado monitoring and evaluation list. Decreased flows in 2001 supposedly began to stress resident trout populations, based on local reporting claims made to the Water Quality Control Division, but not presented to the Association. In 2002, Bear Creek was subjected to worst drought on record for the stream with stream flow dropping below measurable values in the middle of the summer. The Association recognized the naturally caused low flow impacted the trout populations. Consequently, the Association implemented special instream monitoring efforts beginning in the summer of 2001 and continuing through 2003 to obtain scientifically defensible data to characterize the potential chemical changes at low flow conditions. The Association focused this special monitoring on in-situ temperature, ammonia and pH.

Bear Creek segment 1a is on the 2004 Colorado Monitoring and Evaluation List (Regulation #94) for continued evaluation of the listed parameters of concern associated with aquatic life use, ammonia and temperature. The Association has collected over 10,000 water quality data records for various parameters in the watershed at a cost of about $400,000. This extensive data record has been used to assess the watershed's compliance with conditions listed in regulation #74. The Association has used a watershed based approach with specific emphasis on water quality within Bear Creek Reservoir. Loading from the watershed has been treated as a reservoir load. However, the Association has and will continue to be protective of water quality throughout the watershed.

The Association has established a supplemental water quality monitoring program for Bear Creek segment 1a, which is being incorporated into the base watershed routine monitoring program. The Association is applying the same rigorous quality control and quality assurance program to this supplemental monitoring effort as used in the base monitoring program. As long as Bear Creek segment 1a is on the monitoring and evaluation list, the Association will continue supplemental monitoring and data analysis and evaluation. It is not appropriate or scientifically accurate to list the stream segment for aquatic life, temperature or ammonia impairment based on available long-term water quality data record. The Association's long-term water quality monitoring program data record, supported by a Water Quality Control Division approved water quality assurance and quality control plan, does not support an impaired stream status based on water chemistry for temperature or ammonia nitrogen.

The suspected aquatic life impairment is based on trout stress in one out of nine years of available shocking information collected by the Colorado Division of Wildlife. The 2002 trout population stress and decline was caused by the lowest flow conditions ever recorded for Bear Creek segment 1a segment with 100-years of flow record available at the downstream Morrison U.S. Geological Survey gauging station.

Chadwick Ecological Consultants completed a report titled U*pdate Of The Status Of Trout Populations In Bear Creek, Jefferson County, Colorado 1994-2003* (Chadwick 2003). The report evaluated historic trout populations using data collected by the Colorado Division of Wildlife. The report concludes that the drought of 2002 interrupted many established spatial and temporal trout populations in Bear Creek. The report shows the general downstream migration of Brown and Rainbow Trout caused by low flow conditions. The number of adult trout was reduced in 2002 at the upper survey sites. The number of adult trout remained low at the upper two sites in 2003. The report shows good classes of young of the year in both 2002 and 2003.

The trout population in 2003 was recovering with the total density of trout per acres, based on Division of Wildlife surveys, higher than in most previous years. Adult trout began to migrate back upstream and new classes of young trout were found throughout segment 1a. The long-term purported decline in native trout population is not supported by fish surveys. The Colorado Division of Wildlife analysis fish surveys do not support the purported decline in trout populations prior to 2002 drought conditions. In fact the surveys show a very health population of reproduction Brown Trout and a good population of Rainbow Trout. The 2002 drought season stressed the trout populations in the upper reaches of Segment 1a where flows were reduced to zero or near zero. The survey indicated a general downstream migration of trout into those lower reaches with some flow. The good return of fish density in 2003 is a strong indicator that the stream segment will have a natural recovery from the drought stress. Consequently, it is not accurate to claim that fish populations have been negatively impacted by stream water quality. In fact the temporary decline in trout populations simply occurred due to lack of stream flow caused by severe drought conditions.

Segment 1c Bear Creek Reservoir

The Bear Creek Watershed Association and the City of Lakewood (member of the Association) maintain separate water quality monitoring programs on Bear Creek Reservoir segment 1b. The Association monitoring program is designed to assess the trophic state of the reservoir and compliance with the Bear Creek Reservoir Control Regulation # 74. The Association is responsible for implementing the control regulation. The City of Lakewood maintains an aeration system in the reservoir as part of the control strategies to restore and enhance the reservoir water quality consistent with the control regulation. The Lakewood monitoring program has been designed to determine the effectiveness of their aeration system. These two monitoring programs are complimentary and essential to the water quality management goals of the Association.

The Association and Lakewood are addressing three critical water quality issues associated with the reservoir:

1. Low Dissolved Oxygen - The 2002 and 2004 Colorado Monitoring and Evaluation Lists have identified Bear Creek Reservoir as potentially impaired due to low dissolved oxygen concentrations in the water column during the growing season. Lakewood has addressed this issue by installing a new expanded aeration

system, which appears to have resolved the dissolved oxygen problem. The Association and Lakewood need to document and provide evidence of success in order to recommend a future delisting of this problem from the 2006 list.

2. Elevated Reservoir pH - The routine water quality monitoring program maintained by the Bear Creek Watershed Association and the City of Lakewood monitoring program have measured water column pH values in excess of the Colorado State upper limit standard of 9.0 pH units. Elevated pH values are generally indicative of excess algal primary productivity in shallow reservoir systems. A more detailed collection of pH data with a greater temporal and special distribution of samples is needed to determine the magnitude of this potential problem.

3. Reservoir Temperatures Not Supportive of Cold Water Classification - The near surface temperatures in the reservoir have shown an increasing trend over the last five years with numerous measurements in excess of 20 degrees centigrade (C), which is the upper limit for a cold water class 1 waterbody in Colorado. The water column in 2003 from June through August was above 20 C. Additional evaluation and modeling of the temperature information is necessary to determine a management strategy for the reservoir. A question the Association needs to query is if the reservoir classification is correct.

Water Quality Monitoring

Routine Monitoring Program

The monitoring program characterizes water quality inflow into Bear Creek Reservoir from Bear Creek and Turkey Creek, outflow from Bear Creek Reservoir as a tail-water discharge and downstream water quality. The reservoir is monitored at a single representative station located in the central pool beyond the Bear Creek and Turkey Creek inlets. The monitoring program was reviewed in 2001 and updated as the *2002-2005 Bear Creek Watershed: Sample Analysis Plan (SAP) And Quality Assurance Project Plan (QAPP)* (Bear Creek Watershed Association 2001). This monitoring plan provides the basis for all monitoring activities in the Bear Creek Watershed.

Monitoring Sites

The five routine monitoring stations and reservoir station are as follows (*2002-2005 Bear Creek Watershed: Sample Analysis Plan (SAP) And Quality Assurance Project Plan (QAPP),* Bear Creek Watershed Association 2001):

1. Mainstem of Turkey Creek prior to discharge into Bear Creek Reservoir, within Bear Creek Park, adjacent to the City of Lakewood Maintenance Yard;

2. Mainstem of Bear Creek prior to discharge into Bear Creek Reservoir, within Bear Creek Park, adjacent to the bridge at the western edge of the park;

3. Tail-water discharge from Bear Creek Reservoir in the concrete channel which starts the lower Bear Creek;

4. Mainstem of Bear Creek about 1-mile below Bear Creek Reservoir; and

5. Bear Creek Reservoir, center of main pool beyond the Bear Creek and Turkey Creek Inlets.

Parameters and Sampling Program

The monitoring program provides necessary data to make statistical water quality trend assessments and verify the effectiveness of control and alternative management programs. The minimum required physical, chemical and biological components listed in the control regulation and shown in Table 2.

Sample Frequency

The routine watershed-monitoring program focuses on inputs to and outputs from Bear Creek Reservoir. There are 16 reservoir and stream samples taken per calendar year with biweekly monitoring in May, June, July and August, and monthly for other months. There may be some sample periods in the winter where Bear Creek Reservoir cannot be sampled due to poor ice conditions. The stream sampling program is conducted without reservoir sampling. The stream input and output-sampling program targets data collection for all months within a calendar year. A maximum of 16 stream data sets will be collected per year. If a winter reservoir monitoring set cannot be taken due to unsafe conditions, then the reservoir monitoring set will be added at a later time period to the annual monitoring program, which will result in a total of 16 monitoring sets per calendar year within the reservoir.

Table 2 2002-2005 Water Quality Parameters

Parameter (units)	Watershed Inflows	Reservoir	Reservoir Outflow/ Downstream
Physical/Field			
Discharge (cu m/s)	X		X
Specific Conductance (umhos/cm)	X	(Profile)	X
Secchi (meters)		(Single measurement)	
Dissolved Oxygen (mg/l)	X	(Profile)	X
Temperature (C)	X	(Profile)	X
Total Suspended Sediments (mg/l)	X	(3 Depths)	X
pH (standard unit)	X	(3 Depths)	X
Biological			
E. Coli (cts/100ml)	(April to October)	(March to November)	(April to October)
Chlorophyll a (ug/l)		(Surface Sample)	

Parameter (units)	Watershed Inflows	Reservoir	Reservoir Outflow/ Downstream
Phytoplankton		(Surface Sample)	
Zooplankton		(Vertical Tow)	
Nutrients			
Ammonia (ug/l)	X		X
Nitrate (ug/l)	X	(3 Depths)	X
Total Particulate Phosphorus (ug/l)	X	(3 Depths)	X
Total Dissolved Phosphorus (ug/l)	X	(3 Depths)	X
Ortho-Phosphorus (ug/l)	X	(3 Depths)	X
Total Phosphorus (ug/l)	X	(3 Depths)	X

Change In Monitoring Station

The Bear Creek Watershed Association at their April 14, 2004 Association meeting moved the current primary monitoring station located on Lower Bear Creek near Sheridan Boulevard to upper Bear Creek segment 1a at *Lair O' The Bear* open space park. The Sheridan monitoring station was established by the Association to determine if the Lakewood golf course had a water quality impact on lower Bear Creek. The current data set is sufficient to address this issue and the Association can't show any water quality degradation directly associated with the golf course. A comparison of these stations will be included in the Association 2004 annual report. The new primary monitoring station will provide a good water quality characterization of upper Bear Creek. The monitoring station switch will occur for the May 2004 sampling set. There will be no changes to the monitoring parameters, quality controls or sampling procedures. The Association's quality assurance plan will be modified to show this sample location change.

Segment 1a Supplemental Monitoring

The Bear Creek supplemental monitoring program is beginning to collect data record in the summer growing season of the diurnal fluctuation of temperate at multiple sites within selected sections of Bear Creek. The July 2003 stream data record is shown below. This 24-hour sampling program does show that maximum temperatures can exceed the 20 degree Celsius temperature threshold at specific locations within the stream, but remains within the 3 degrees Celsius and is still meeting the temperature standard as adopted. The average downstream temperature remains below 20 degrees Celsius at the indicator monitoring site. The temperature issue clearly requires more evaluation and a more detailed data record. The Association is working diligently to obtain this data record. However, more evaluation of this data record is required to determine if there is a possible impairment issue. There is no available data record that shows these temperatures are impairing aquatic life in Bear Creek. In fact quite the opposite could be shown by the fish surveys.

Table 3 Bear Creek Supplemental Monitoring - 2003 Example Data

DATE: 7/14/2003	PARAMETER				Min	Max
	pH	Temp	DO	NH3-N	Temp	Temp
IN-STREAM SITE	S.U.	C°	mg/L	mg/L	C°	C°
Above EMD WWTP	7.43	17.92	7.85	0.0157	16.7	18.2
Above KSWD WWTP	7.75	17.37	8.48	0.0131	15.2	21.7
Above GWSD WWTP	7.77	16.50	8.74	0.0176	14.1	21.7
Below Idledale	7.73	16.92	8.40	0.0121	14.1	21.7
Above Harriman Ditch	7.84	17.35	8.70	0.0127	14.8	21.3
Above Morrison WWTP	7.84	19.07	7.84	0.0139	15.6	22.4
DISCHARGERS						
EMD WWTP effluent	6.61	18	4.29	0.71*	17.4	19.4
WJCMD WWTP effluent	6.75	18.5	3.7	0.157*	17.4	18.2
KSWD WWTP effluent	7	19.25	4.3	0.37*		
GWSD WWTP effluent	6.69	19	7.1	0.153*	17.4	17.8
Morrison WWTP effluent	7.10			<0.80^	20.5	20.9

* = NH3-N data for 7/17/03
^ = NH3-N data for 7/16/03

Bear Creek Reservoir Supplemental Monitoring

The Bear Creek Watershed Associating is conducting special stream monitoring program for Bear Creek Segment 1a. This supplemental monitoring program began in June 2003 and will extend through 2005. The instream monitoring program provides more detailed water quality information specifically for temperature, pH, dissolved oxygen, conductivity and ammonia in Bear Creek segment 1a. The monitoring program design specially addresses listing parameters of temperature for the 2002 Colorado Monitoring and Evaluation List and aquatic life, temperature and ammonia as included in the 2004 Colorado Monitoring and Evaluation List.

- The 2002 and 2004 Colorado Monitoring and Evaluation Lists identify Bear Creek segment 1a as potentially impaired due to aquatic life, temperature and ammonia. The Association is obtaining detailed water quality data throughout segment 1a to determine if temperature and ammonia are a water quality problem.

- The routine water quality monitoring program maintained by the Bear Creek Watershed Association has not demonstrated a temperature or ammonia toxicity problem; consequently the supplemental monitoring effort will be assess gaps in the monitoring routine monitoring program and expand the temporal and spatial monitoring efforts on the stream. Once the more detailed stream data is

analyzed, the Association can determine the best location and sampling protocol to characterize segment 1a.

- The Association will obtain water quality data that can be used in future stream modeling and prediction. Additional evaluation and modeling of the temperature information is necessary to determine a management strategy for the stream.

- The listing for aquatic life require a more detailed stream characterization to assess how the trout populations are responding to both natural and human induced alternations. The supplemental data set will allow the Association to determine if chemical affects are part of the problem.

- Evaluate the cause and affect response to stream chemistry and recommend a management strategy to the Association.

Colorado Department of Transportation Construction Monitoring

The Colorado Department of Transportation (CDOT) completed a special surface water quality-monitoring program along the U.S. 285 corridor through the Turkey Creek drainage. Phased construction activities in the Bear Creek Watershed were completed in 2003. CDOT water quality monitoring evaluated the effectiveness of BMPs used during construction. Post-construction monitoring has demonstrated, in large part, that any during-construction adverse impacts have been substantially controlled by effective use of BMPs. See Fact Sheet #27 for more information on project and the Association references list all CDOT reports on the monitoring program. CDOT continues involvement with the Association through the regular meeting program.

Exponent and TDS Consulting, CDOT contractors, did a five year effort of monitoring water quality at several locations in Turkey Creek and evaluating the effectiveness of construction-related BMPs implemented by CDOT associated with the U.S. Highway 285 project. For 2003, TDS worked under a task order with Carter-Burgess for the Turkey Creek monitoring and was assisted by Clear Creek Consultants (CCC). Monitoring in the Turkey drainage by CDOT represented post-construction data. Intermittent CDOT presentations before the Bear Creek Watershed Association (BCWA) during 2003 described results of the monitoring program, the dynamic aspects of the program required to adapt to the progression of construction, and some of the information benefits it provided to date to CDOT, BCWA and other interested parties.

Management Program

Purpose of Association

The Association includes the City of Lakewood, Town of Morrison, Clear Creek County, Jefferson County, Park County, Evergreen Metropolitan District, West Jefferson County Metropolitan District, Genesee Water and Sanitation District, Kittredge Sanitation and Water District, Willowbrook Water and Sanitation District, Forest Hills

Metropolitan District, Jefferson County Schools, Conifer Center Sanitation Association, West/Brandt Foundation (also called Singing River Ranch), Brook Forest Inn, Bear Creek Development Corporation (Tiny Town), Bear Creek Cabins, Geneva Glen, Aspen Park Metropolitan District and Conifer Metropolitan District. The Fort Restaurant has a treatment plant, but is not a member or participant of the Association.

The Association provides the framework and opportunity for joint participation in planning, coordinating and review activities for the purpose of implementing a continuing area wide water quality and wastewater management program for the Bear Creek Watershed. Membership entities are general-purpose governments, special districts and all other National Pollutant Discharge Elimination System (NPDES) dischargers within the Bear Creek Watershed as permitted by the Water Quality Control Division. The Association's memorandum of understanding and by-laws describe the roles, responsibilities and meeting requirements of the management agency, operating agencies and general-purpose governments as related to water quality management activities in the Bear Creek Watershed.

The management agency implements water quality and management strategies, decides on the need for and specific characteristics of wastewater treatment processes and details implementation within specified parameters (Table 1). A watershed Association approach provides an opportunity to coordinate water quality activities at a local level. The Association provides three primary benefits:

1. Ensures an effective watershed level water quality management program consistent with the *Bear Creek Reservoir Control Regulation* and the *Metro Vision 2020 Clean Water Plan*;

2. Ensures cost effective local wastewater management systems within the parameters of the *Metro Vision 2020 Clean Water Plan* and wastewater discharge permits; and

3. Identifies activities that meet water quality compliance.

Community Outreach

Earthday

The Association helps with Evergreen Earthday activities and provides information to the community on water quality management and environmental issues. The Association develops and distributes educational materials on request. Members of the Association are available for local presentations and training programs.

Community Plans for Aspen Park Village Center and Evergreen

Jefferson County Planning and Zoning Division has benefited from the support of the Bear Creek Watershed Association respect for recommendations in the community plans. The Association and its members have held public meetings to review

development proposals and worked with the community to write a strategy for wastewater treatment in the Aspen Park-Conifer Village Center. The Evergreen community has benefited from the attendance and expertise that Bear Creek Watershed members have provided in the land use planning meetings. Water quantity and quality are the two most important issues that the community plan participants discussed. Thanks to the review and continued interest of the Bear Creek Watershed Association, the County's more recent plan updates recommend strategies to protect the water quality in the southern mountains of Jefferson County.

Colorado Geological Survey

Special study by Karen Berry (Colorado Geological Survey) assessing the transferability of a water erosion model. Karen is working with the NRCS, Jefferson County, and other local agencies to gather slope, detailed soils, drainage, rangeland and other land use parameters. The data is used to develop model input files for Turkey Creek. The Association is a supporting group for the study and will valuate the completed model for use in watershed management.

As part of the Central Plains Community Plan, the Colorado Geological Survey defined hazards. Jefferson County has mapped many of the hazards and constraints in the county with assistance from the Colorado Geological Survey, United States Geological Survey, Colorado State Forest Service, and the Federal Emergency Management Agency. Geologic hazards have been classified into Low, Moderate, and High categories. Hazards should be identified, eliminated, mitigated and/or avoided to prevent the loss of life, property, or costly remediation and to protect the public health and environment. Potential problems need to be identified early in the planning and development process before economic losses and environmental damage occur.

Monitoring Bridge Reconstruction

The Association work with CDOT and Jefferson County to monitor water quality in Bear Creek during bridge reconstruction in Evergreen, which was completed in 2003. The project caused only minor short-term water quality degradation during construction.

Long-Range Planning and Jefferson County Reviews

The Association works closely with Jefferson County planning and actively reviews any development proposal that could affect watershed environmental or water quality. The Association is a referral agency for Jefferson County.

Jefferson County Department of Health and Environment Onsite Regulations

On July 4, 2003 Jefferson County's latest revision of its Individual Sewage Disposal System (ISDS) regulations went into place. Although there were significant technical improvements - including a requirement for dosing siphons for all systems -

the most far-reaching change was a requirement for issuance of a Use Permits when a property is sold. Jefferson County Department of Health and Environment estimates that there are approximately 20,000 systems in the county, mostly in the Evergreen and Conifer areas and that about 500-750 will be inspected each year in the new ISDS Use Permit program. "Every individual sewage disposal system is a potential source of groundwater pollution," noted Jim Dale, MPH, DVM, Director, Environmental Health Services Division, "and this new program will help in protecting groundwater and in assuring that the new owners have a properly functioning ISDS." The Department established minimum approval standards, specific inspection criteria, including a standardized report form, third-party testing and certification of inspectors, and protocols for dealing with failing systems. The program became effective January 1, 2004 and to date over 200 permits have been issued.

Water Quality Monitoring and Fact Sheets

The water quality monitoring program is characterized in a series of fact sheets. These fact sheets are designed to provide specific information about the water quality and management program that can be used for multiple purposes independent of the other fact sheets. The fact sheets denote both the 2003 water quality within the watershed and Bear Creek Reservoir, as wells, the long-term trends.

Wastewater Treatment Facilities

Major operating agencies in the watershed include the Town of Morrison, Evergreen Metropolitan District, West Jefferson County Metropolitan District, Genesee Water and Sanitation District, Kittredge Sanitation and Water District, Forest Hills Metropolitan District, Jefferson County Schools, Conifer Center Sanitation Association, West/Brandt Foundation, and Aspen Park Metropolitan District. The four minor operating agencies are Brook Forest Inn, Bear Creek Development Corporation, Bear Creek Cabins, and Geneva Glen. The lack of reporting to the Association from these minor operating agencies is problematic and hinders the effective development of wastewater management strategies.

The total phosphorus wasteload allocation for all point sources in the Bear Creek Watershed is 5,255 pounds per year. The reporting point source total annual phosphorus discharges are shown fact sheet 9. The Association believes the intent of the control regulation is clear in requiring all treatment facilities to be in compliance and report this information to the Association for incorporation into the annual report. Major reporting treatment facilities are well within their wasteload allocations.

Wastewater Discharge Impacts To Fishery

The municipalities along Bear Creek divert water from Evergreen Lake and Bear Creek, and discharge wastewater treatment plant effluent back to the stream. The report, *Evaluation Of The Effects Of Wastewater Treatment Plants On Trout*

Populations In Bear Creek, Jefferson County, Colorado, 1994-2001 [Chadwick Ecological Consultants, Inc., 2002], presents historical fish population data available for Bear Creek, identifies spatial trends in trout populations and shows temporal trends from year to year. The data evaluation assessed status of trout populations to determine changes associated with reported fish kills and temperature effects of wastewater discharges. Brown and rainbow trout populations for Bear Creek decline in density and biomass from upstream near Evergreen downstream to near Morrison. However this trend was reversed during the 2002 drought year due to the downstream migration of both Rainbow and Brown Trout. The general trend occurs in all sampling years, except 2002. The trend relates to the transition of the stream from a coldwater mountain stream to a warm-water plains stream below Morrison. Trout density in 1999 was relatively low at all sites. In 2000 and 2001, trout density and biomass were higher than previous years. A substantial increase in trout density and biomass at all sites occurred between 1999 and 2000. Trout biomass in Bear Creek is consistently above average for Rocky Mountain streams at almost all sites and in most years, and exceeds the biomass criterion for Gold Medal Trout Waters in Colorado during recent years.

The presence of healthy trout populations at sites downstream of treatment plant discharges indicates no adverse effect on trout populations. Modeling of water temperature indicates discharge of wastewater effluent has a slight cooling effect on Bear Creek. The important factor determining trout population density and abundance is related to the magnitude of spring runoff. In years with high runoff there are fewer trout, and in years of low runoff, trout populations increase. The presence of very strong year classes of both brown and rainbow trout in 2000 indicates conditions during the summer of 2000 were suitable to sustain resident trout populations, including sensitive young trout. The severe drought of 2002 resulted in low flow conditions and elevated temperatures in sections of Bear Creek 1a. This combination of low water with elevated temperatures clearly stressed resident trout populations of Bear Creek. However, the reality is that high quality wastewater discharges provide most of the flow, which allowed resident fish population to survive an extreme natural disaster.

Stormwater Management

The Association is concerned with the quality of dry-weather and stormwater runoff associated with significant development sites. Significant development sites are generally related to urban development construction activities. The Association has developed a project specific monitoring guidance report (BCWA 1996c). However, the Association has no direct responsibility for regulating development activities or implementing site-specific water quality or stormwater control facilities. The Association works with its members through local review processes to ensure that development follows the watershed water quality management strategy using the best available management practices. The Association reviews BMPs and makes recommendations as requested by local governments. Jefferson County and the City of Lakewood began stormwater permitting programs in 2003. Fact sheet 24 defines the Lakewood stormwater program.

Jefferson County hired stormwater staff ad began storm drain outfall mapping. Additional staff will locate outfalls in the Jefferson permit coverage area. A majority or all of the Jefferson County permit coverage area is expected to be completed in 2003. A storm drain marking program is anticipated to begin this fall. Affected county staff received stormwater regulation training and compliance assistance such as the Road and Bridge Department with construction site permitting requirements. Jefferson County supported the Colorado Water Protection program for a radio advertisement. This organization assisted Jefferson County with Phase II compliance under the Public Ed element of the stormwater permit. Jefferson County is one of many Phase I and II entities that donated to this public service announcement. Jefferson County Stormwater Management Program shared a booth with Long Range Planning at the Evergreen Earthday Event on April 19. In 2003 staff will design a standard change to require developers to include the iron grate storm drain "No dumping" message and custom manhole covers on R-30 inlets. Jefferson County Staff are adding stormwater section to the County's Community Plans as they are revised including North Plains, Central Plains and Evergreen Community plans. The goal is to have citizens understand stormwater runoff, Right -of- way, cost, infiltration, groundwater recharge, pollution prevention and techniques that can be used to approximate predevelopment hydrology so that rezoning and subsequent development have less impact than previous development techniques.

The Board of County Commissioners approved staff to research a utility fee for unincorporated residents and businesses related to capital improvement projects, development design review, and storm sewer maintenance. The county created a flyer for sediment and erosion control and a Jefferson County stormwater management brochure. These are handed out to citizens getting building permits or inquiring about land development. Also, there is a display on the 3 rd floor near planning and zoning on erosion and sediment control samples. The display is titled, "Drought, Landscaping, and Water Quality - Where do you fit in?" The display includes erosion control blanket samples, rice wattle, invisible structures products, and silt fence with pictures of proper use. The county hands out Xeriscape information to interested citizens

Onsite System Management Plan

Water quality impacts are occurring from onsite wastewater systems in a number of specific areas in the Bear Creek Watershed. However, the presence and nature of these problems is not been well verified or rigorously documented in the watershed. In fact, few well-documented studies have been done in Colorado that directly link water quality or health risks with onsite wastewater systems. Examples of identified impacts include elevated nitrate and/or bacteria levels in ground water used for drinking water, and nutrient loadings adversely affecting surface waters. Researchers from Colorado State University identified many mountain homes potentially using bacterial laden well water caused by misplacement of leach fields *(How Safe Is Mountain Well Water,* CSU 1972). Other studies done by the Colorado State University and local health department document elevated nitrates in groundwater for specific locations.

Although few site-specific studies have been completed, it appears that substantial cumulative loadings of nutrients to Bear Creek Watershed waters are likely occurring in some areas where there are a significant total number and density of onsite wastewater systems. There are areas of known nitrate contamination and increased nitrate levels in ground water in areas of high density (lots less than one acre) and a significant number of homes.

In some surface water basins, phosphorus loadings from onsite wastewater systems are a potentially significant water quality factor. Phosphorus loading into Bear Creek Reservoir has caused adverse water quality impacts that have led to the development of a control regulation to control phosphorus loadings. Water quality monitoring in the Bear Creek Watershed over a 15-year period has shown that there is a phosphorus-loading problem in Bear Creek Reservoir. Screening surveys completed by the Association show elevated levels of phosphorus in areas with a higher density of on-site wastewater systems, such as the community of Idledale (Bear Creek Watershed Association, 1998; 1997 Bear Creek Watershed Association Annual Report; Bear Creek Watershed Association, 1997a, *Management Program Review and 1990-1995 Water Quality Summary*).

The Association recognizes the need for a comprehensive septic management plan for the watershed that addresses the nutrient loading issue. The county members of the Association should take the lead in developing a septic management program. The Denver regional Council of Governments is in the process of developing a septic management plan guidance document. Once this guidance document is accepted the Council's Board of Directors, the guidance can be used to assess the septic management program needs of the watershed.

City of Lakewood Reservoir Aeration Operation

The City of Lakewood maintains a reservoir aeration program. This aeration system increases the amount of dissolved oxygen throughout the water column. The program helps support the fishery goal of the Association for the reservoir. This aeration effort has proven to be a successful management practice and the continued operation is necessary to maintain quality in the reservoir. The aeration system was replaced with a more efficient system that is designed to de-stratify the reservoir water column and introduce more uniform aeration within the reservoir main pool.

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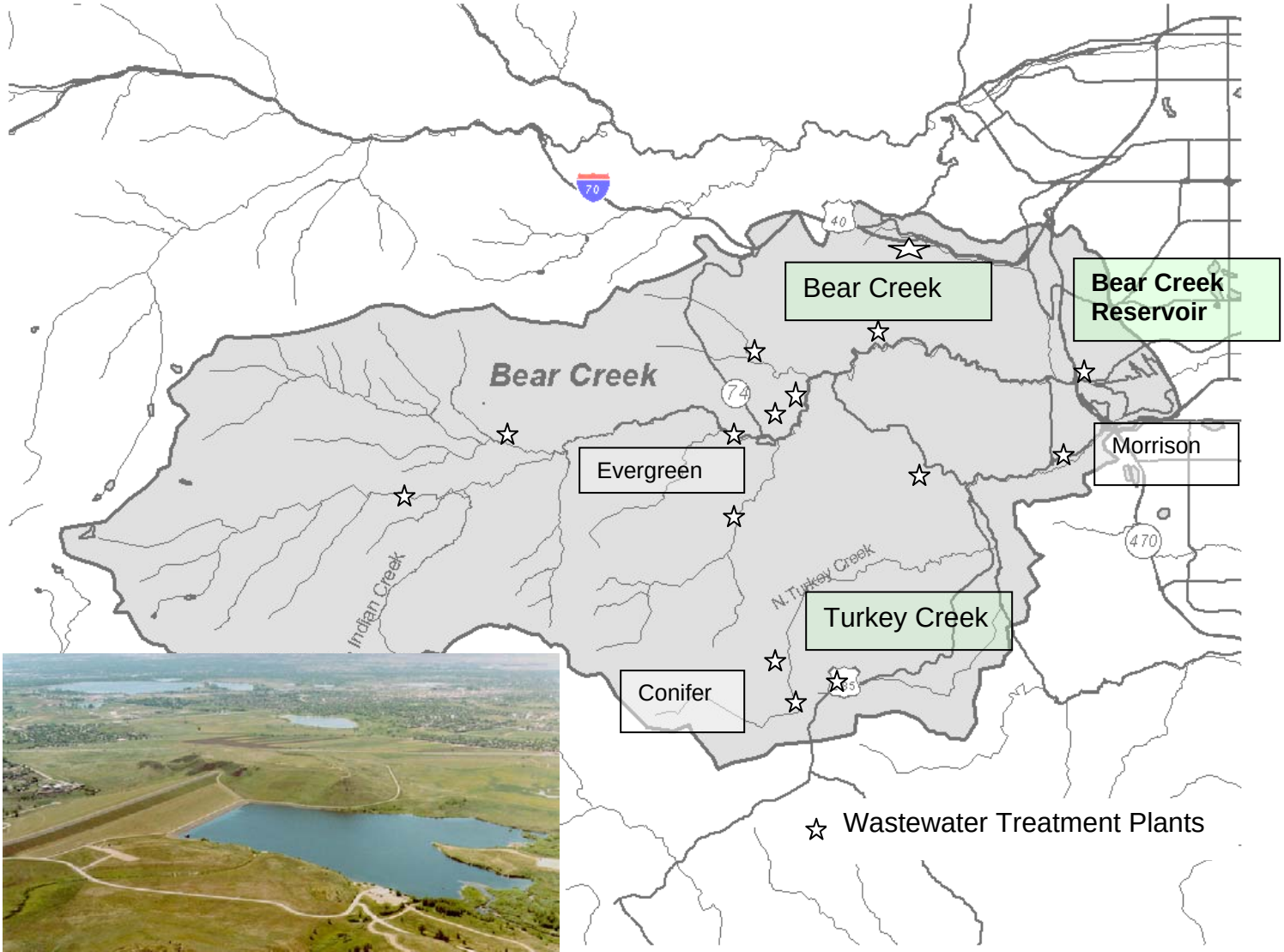
Fact Sheet 1. Bear Creek Watershed

Bear Creek Reservoir receives drainage from the Bear Creek and Turkey Creek with drainage from Park County, Clear Creek County and Jefferson County. The total watershed area is 83,665 acres. The reservoir is at an elevation of 5600 feet, while the mountains that form the upper boundary are at an average elevation of 10,000 feet.

The watershed contains the Town of Morrison and the communities of Evergreen, Genesee, Kittredge, El Rancho, Idledale, Indian Hills, Tiny Town, Bergen Park, Conifer, Aspen Park, Brook Forest, Sprucedale, Marshdale and Brookvale.



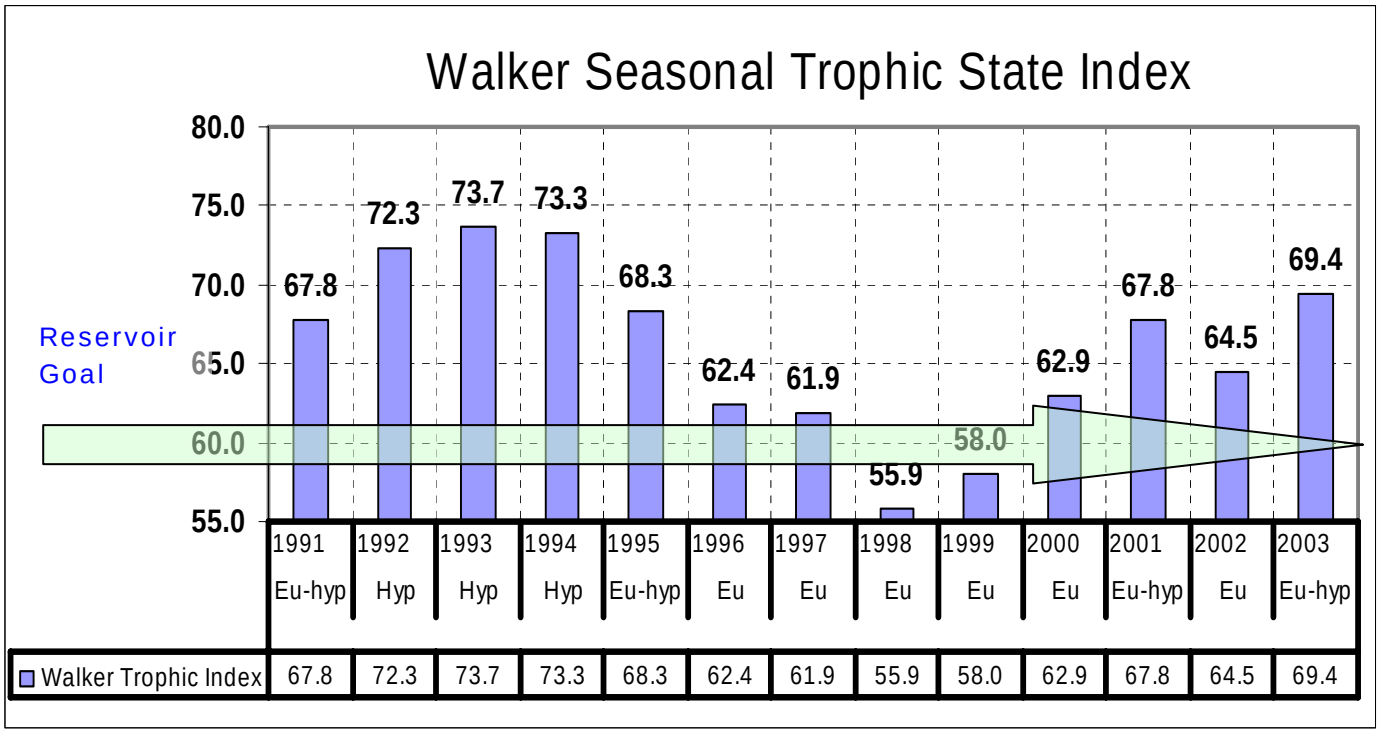
Bear Creek Reservoir, Jefferson County

Fact Sheet 2. Water Quality Goal and Narrative Standard for Bear Creek Reservoir

Bear Creek Reservoir has a water quality goal established by the Water Quality Control Commission instead of a numeric standard. The reservoir goal, defined as a site-specific narrative standard, reads as follows:

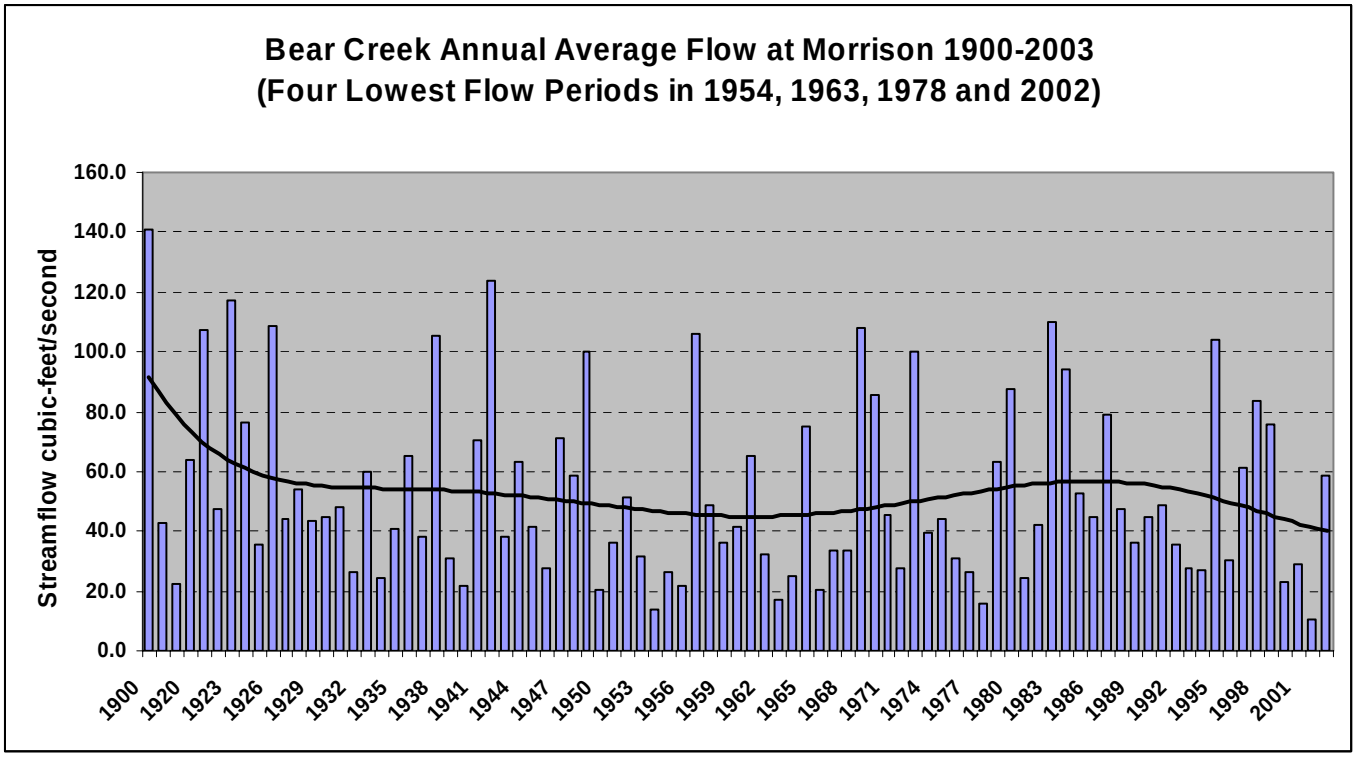
> *Concentrations of total phosphorus in Bear Creek Reservoir shall be limited to the extent necessary to prevent stimulation of algal growth to protect beneficial uses. Sufficient dissolved oxygen shall be present in the upper half of the reservoir hypolimnion layer to provide for the survival and growth of cold-water aquatic life species. Attainment of this standard shall, at a minimum, require shifting the reservoir trophic state from a eutrophic and hypereutrophic condition to a eutrophic and mesotrophic condition, based on currently accepted limnological definitions of trophic states*.

The Bear Creek management program has reduced average total phosphorus concentrations entering the reservoir. Effective point source controls with a sediment and erosion control program by Jefferson County are responsible for this phosphorus reduction. The trophic status (overall measure of quality) has moved toward a desirable mesotrophic-eutrophic range. The goal for the reservoir is to balance the trophic state based on either the Walker Seasonal Trophic model (developed for reservoir in Clean Lakes Study as goal) or the Carlson index in the lower eutrophic range. In terms of the Walker index shown below, the long-range goal is to maintain an index value of less than 60 as a composite Walker trophic index during the growing season. Since many factors influence the trophic state, it requires a long-term management program to change a reservoir quality toward the mesotrophic-eutrophic boundary.



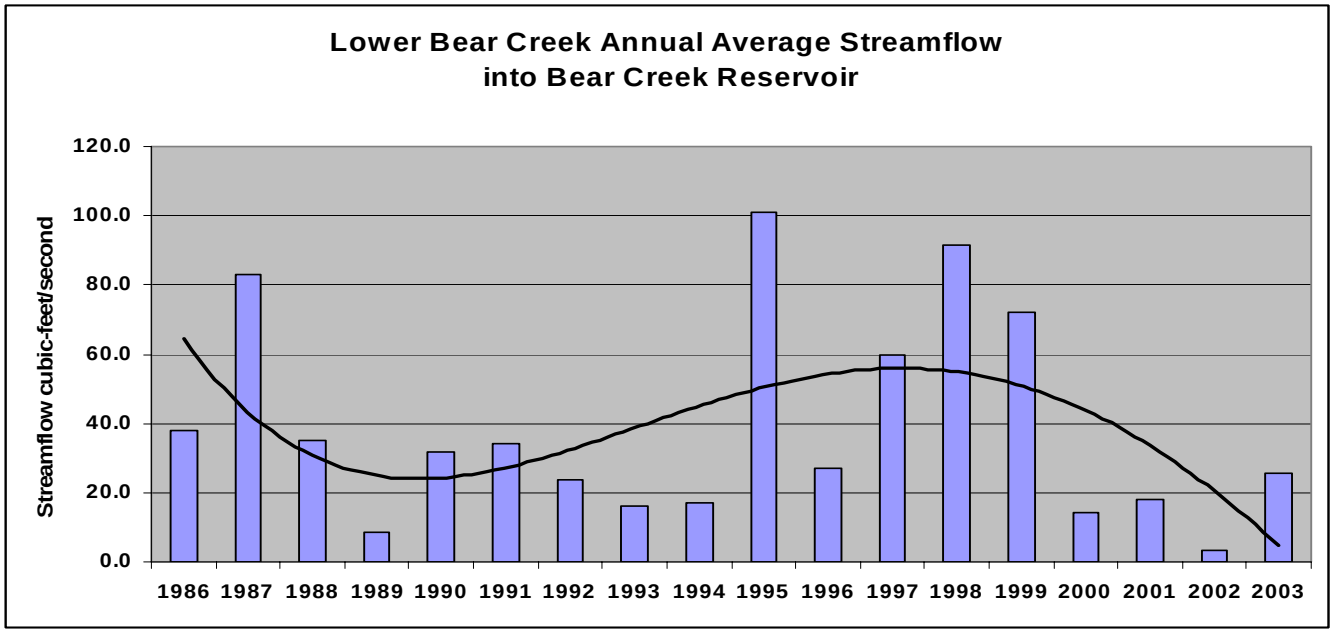
Fact Sheet 3. USGS 1900-2003 Bear Creek at Morrison Drought Review

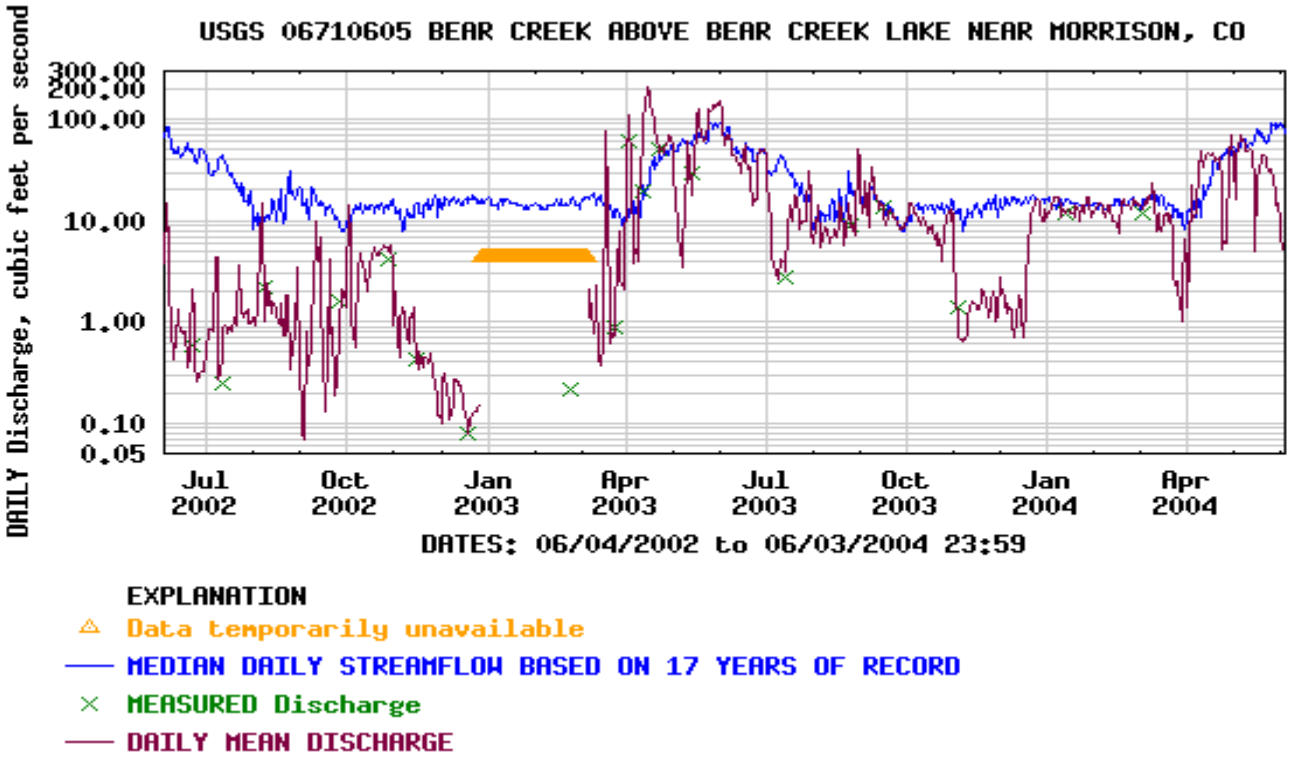
The graph shows 1900-2003 flow records and the lower graph show 2003 daily mean discharge in Bear Creek. 2002 was the lowest flow on record for lower Bear Creek segment 1a in over 100 years of record with other low periods in 1954, 1963, and 1978. The 2003 streamflow record show a recovery to near normal flows; however several months of 2003 streamflow data were well below normal conditions. A single runoff event in 2003 produced a substantial portion of the entire 2003 streamflow. The streamflow record at Morrison shows a weak long-term cycle with 10-20 years between lower flow events. Generally low flow periods are followed by several years of increased flows. Consequently, fish species in Bear Creek are subjected to very divergent flow patterns over a decade period.



Fact Sheet 4. USGS Lower Bear Creek Streamflow Records (Segment 1b)

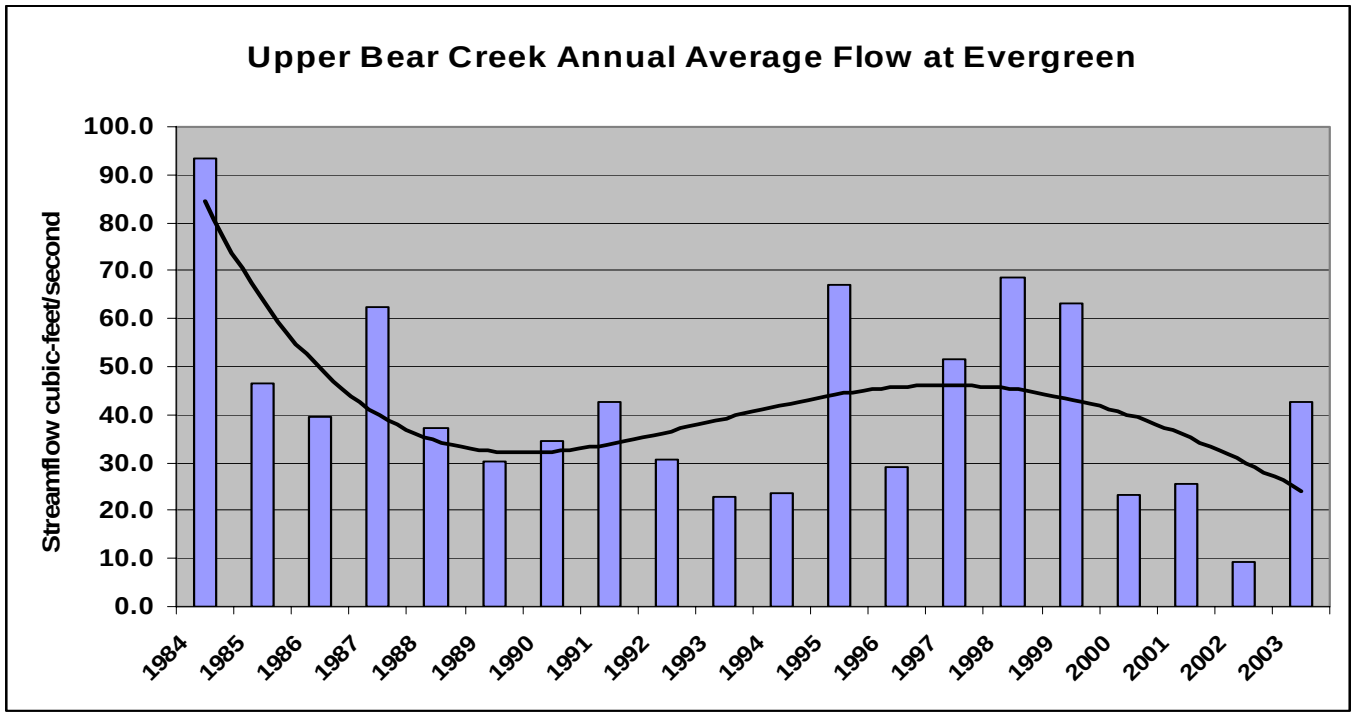
The top graph shows 1900-2003 flow records and the lower graph show 2002 to recent daily mean discharge in Bear Creek.





Fact Sheet 5. USGS Bear Creek at Evergreen Stream Flow Records

The top graph shows 1984-2003 flow records and the lower graph show 2003 daily mean discharge in Bear Creek above Evergreen. The 2003 flows (blue line) were substantially below the median daily streamflow (16 years of total record).

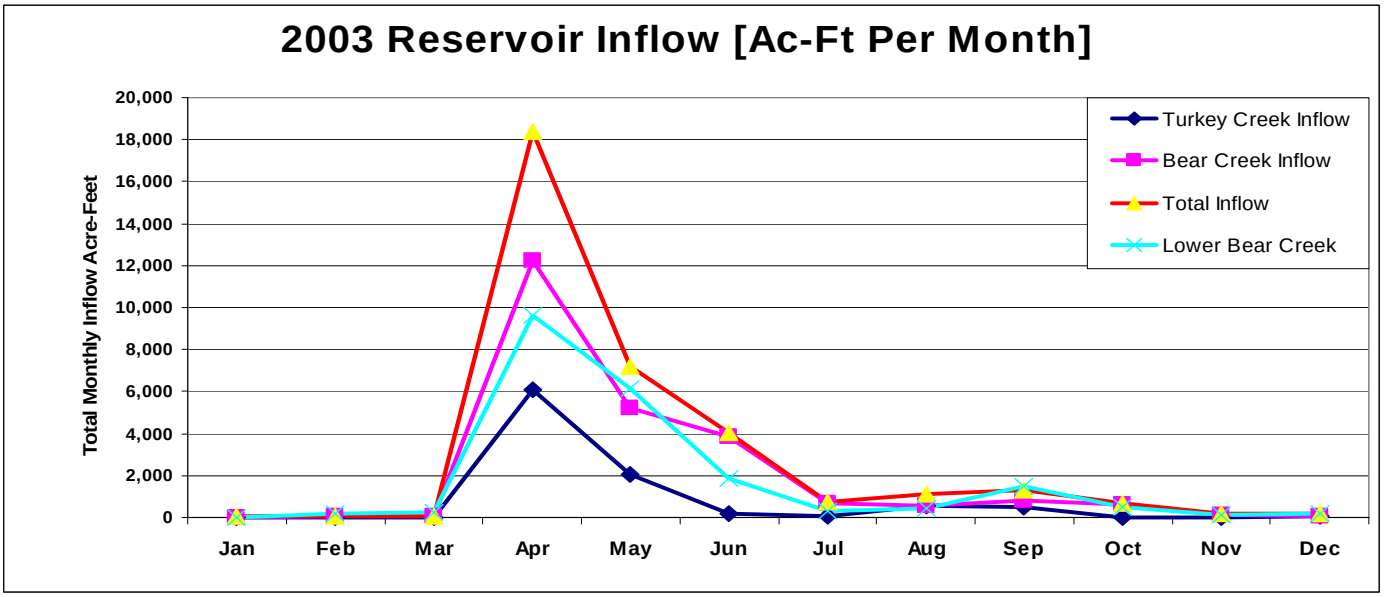


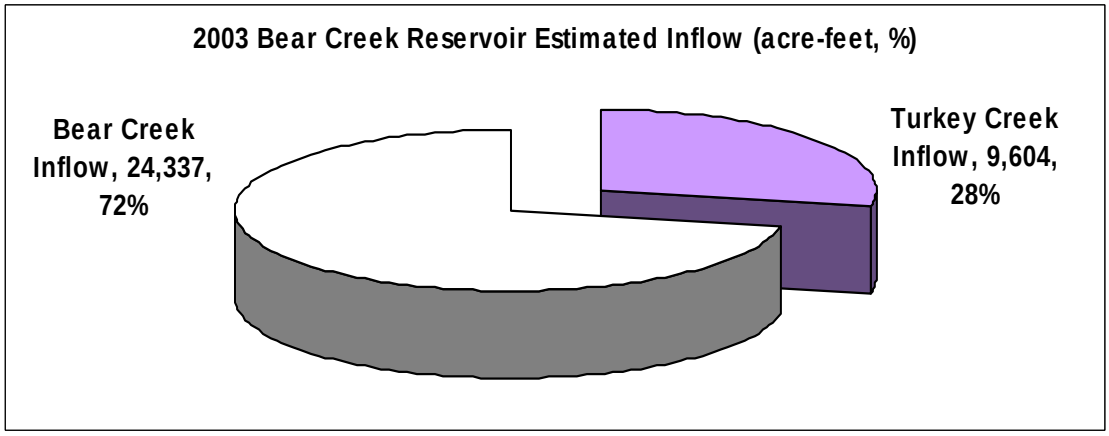
Fact Sheet 6. Bear Creek Reservoir Inflow Flow Records

2003 was a drought year and the Bear Creek Watershed was characterized by extremely low flows. Bear Creek Flows were lower than the recording instrumentation could reasonable measure for several months. Most water coming down Bear Creek and Turkey Creek during the growing season was diverted for beneficial purposes. The estimated inflow into Bear Creek Reservoir was 2,220 acre-feet.

Ac-ft/month Bear Creek Reservoir

Days	31	28	31	30	31	30	31	31	30	31	30	31	Annual ac-ft/yr
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Turkey Creek	13.2	11.8	12.2	6109.1	2026.0	201.2	56.8	550.1	510.9	26.6	21.3	64.5	9603.9
Bear Creek	24.9	39.2	49.9	12263.4	5190.6	3865.2	667.5	573.0	778.9	642.0	151.5	91.2	24337.3
Total Inflow	38.1	51.0	62.1	18372.5	7216.6	4066.4	724.3	1123.2	1289.8	668.6	172.8	155.8	33941.2





Fact Sheet 7. Bear Creek Watershed Association Management Activities

The Association provides the framework and an opportunity for joint participation in planning, coordinating and reviewing activities to implement a continuing water quality and wastewater management program for the Bear Creek Watershed. Membership entities are general-purpose governments, special districts and holders of discharger permits. The Association's memorandum of understanding and by-laws describe the roles, responsibilities and meeting requirements of the management agency, operating agencies and general-purpose governments as related to water quality management.

Management Activity	Status
i) Wastewater Management	
Compliance by wastewater treatment facilities and control regulation	Major facilities met permit limits; small facilities still have a reporting and compliance problem
Wastewater utility planning	Development & review of wastewater utility plans & management strategies; coordination; information exchange; Utility plans for Evergreen, West Jefferson, Kittredge and Conifer; City & County Denver (Wastewater service to Denver Red Rock Park linked with Morrison); Aspen Park Metro District; The Fort Restaurant (Septic System); Wastewater strategy for Aspen Park
Aspen Park Metropolitan District	New wastewater treatment plant for Aspen Park area; Revised wastewater management strategy
Reservoir and Regional Park Management	
Hypolimnetic aeration in reservoir; operating during growing season	City of Lakewood manages system; provides an annual report to Association; operated new aeration system; supplemental reservoir monitoring and dissolved oxygen evaluation
Park facilities support recreational uses	Park management program; sediment & erosion control
Water Quality Monitoring	
Long-term trend monitoring program for reservoir inputs, reservoir and output	Monitoring program with periodic review by Association and WQCD; annual data report; model support; trend studies
Special Studies	Fishery and temperature [special reports]
Turkey Creek groundwater study	Implementation of strategies
CDOT construction-monitoring program	Ongoing effort by CDOT; reports to Association
Water Quality Monitoring Council	Data swap for Association and Lakewood
Data Management	
Place historical water quality data in EPA STORET	Historical Access data-set uploaded into STORET; data base maintained in spreadsheet for membership
(ii) Watershed Management	
Construction project review and recommendations	Reviewing construction actions and providing appropriate comments; develop and review site-specific BMPs
Membership involvement and review; Management program effectiveness	Monitoring program review; on-going efforts in evaluating membership involvement and public processes
Stormwater Management	
Jefferson County & City of Lakewood Stormwater Management Programs	Public education; mapping; resource allocations; local partnerships

Fact Sheet 8. Bear Creek Watershed Nonpoint Source Management Strategy

The management of nonpoint sources in the Bear Creek Watershed is a component of the planning and management program and a tool for implementing the adopted total maximum annual load control strategy for total phosphorus. Based on water quality monitoring data, point source controls have significantly reduced their phosphorus loading to Bear Creek Reservoir. However, phosphorus reduction from nonpoint sources will be required to maintain the reservoir goal at the mesotrophic and eutrophic boundary as measured by modeled trophic indexes.
A series of management strategies are used to help address nonpoint source problems. The implementation of a nonpoint source program is severely limited by available resources. Unless additional resources are identified, the Association can't pursue an aggressive nonpoint source control program. Additionally, the Association membership has limited nonpoint source implementation authority.

Summary of Management Strategies	Summary Of Implementation Tools
1. Local support	1. Local involvement in associated programs & activities; presentations; information source
2. Stable funding source	2. Seek nonmember funding and grants
3. Provide recommendations to WQCD/ WQCC	3. Data & annual reports; triennial review of control regulation
4. Characterize trends in water quality	4. Maintain a trend water quality monitoring network to measure inputs & output from the reservoir
5. Track nutrient loading by Bear Creek & Turkey drainage systems	5. Characterize nutrient loading by the two major drainage systems
6. Maintain watershed & reservoir models	6. Maintain & use reservoir models (Trophic index, Secchi depth and nutrient loading) developed during the Clean Lake Study
7. Annually review water quality management program & best management practices	7. Maintain a list of appropriate best management practices for review
8. Involved in total maximum daily load allocations	8. Conduct appropriate TMDL screenings using established methods, as required
9. Develop & implement water quality education efforts & technology transfer	9. Develop & maintain list of stakeholders; provide information and assistance as requested
10. Actively promote the implementation of water quality projects & activities	10. Maintain a repository of documents, data & other information; support local water quality plans and efforts as feasible
11. Maintain a nonpoint source/stormwater management program	11. Maintain an education implementation plan; support County processes; review documents as appropriate
12. Support other watershed efforts and groups	12. Continued involvement in Turkey Creek groundwater study, ISDS regulation review & sediment & erosion control regulation review

Fact Sheet 9. Wasteload Allocations & 2003 Total Phosphorus Pounds

The total wasteload allocation for all point sources of phosphorus in the Bear Creek Watershed is 5,255 pounds per year. Each individual discharger in the Bear Creek Watershed is limited to an annual wasteload of total phosphorus, which can't be exceeded, except as provided for in trading provisions. Point source discharges can't exceed a total phosphorus effluent concentration of 1.0 mg/l as a 30-day average except as provided in trading provisions. All point source dischargers are required to meet the 1.0 mg/l total phosphorus concentration effluent limitation and the annual total phosphorus allocation established in the Bear Creek Reservoir Control Regulation. The Bear Creek Cabins is out of compliance. Additionally, the Water Quality Control Division should treat the lack of reporting from several other small treatment plants as a noncompliance problem with the Bear Creek Reservoir Control Regulation.

Treatment Plant	TMAL Phosphorus Pounds/ year	2003 Phosphorus Pounds/ year
Evergreen Metropolitan District	1,500	694
West Jefferson County Metro District	1,500	696
Genesee Water and Sanitation District	1,015	414
Town of Morrison	600	214[2]
Kittredge Sanitation and Water District	240	77.3
Forest Hills Metropolitan District	80	44[1]
Jefferson County Schools - Conifer High School	125	2.43
Conifer Center Sanitation Association	40	12.8
West/Brandt Foundation - Singing River Ranch	30	NR[2]
Mary Ann Gallagher - Brook Forest Inn	5	1[2]
Bear Creek Development Corp. - Tiny Town	5	NR[2]
Jefferson County Schools – Mt. Evans Outdoor School	5	2.93
Bear Creek Cabins (Bruce & Jayne Hungate)	5	NR[3]
Geneva Glen	5	0[4]
Aspen Park Metropolitan District	38	0[5]
Reserve Pool	100	62[5]
Total Point Source Phosphorus Wasteload	**5,255 lbs/year**	**2,010.56**

1-Forest Hills Metro District has trade agreement with West Jefferson County Metro District and is in compliance with permit, which lists 44 pounds of phosphorus allowed in trade.

2-NR - No Report Provided to Association. The Association recommends non-reporting facilities be issued a notice of noncompliance with the Bear Creek Reservoir Control Regulation by the Water Quality Control Division.

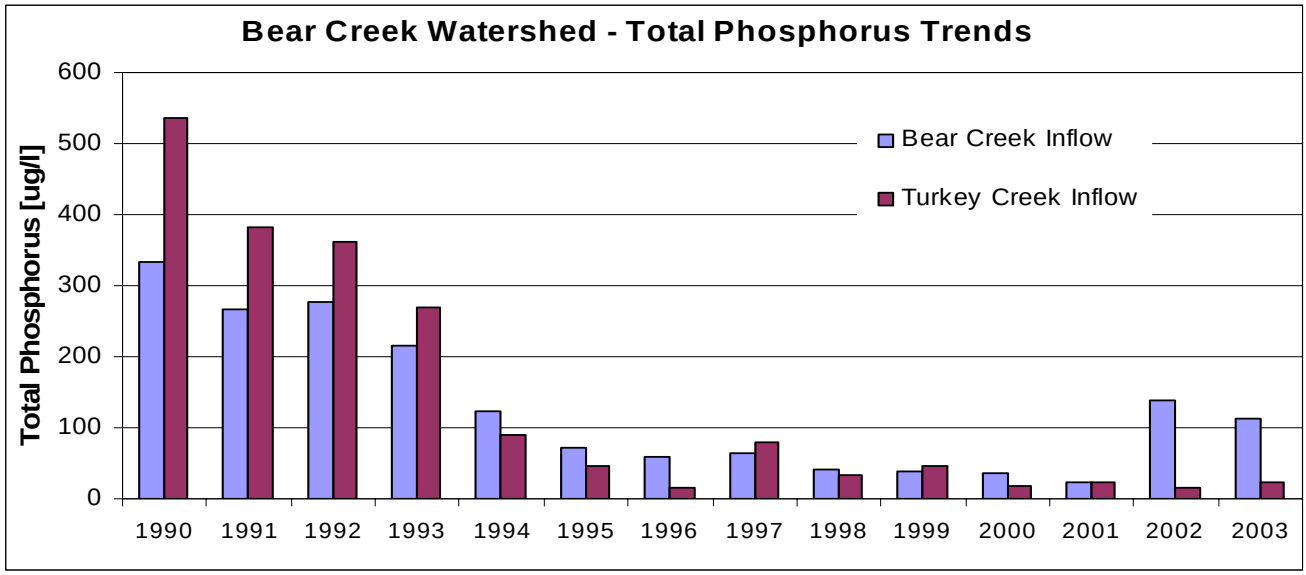
3-The Bear Creek Cabins exceeded total phosphorus monthly allocations 5 times in two years and may have exceeded the annual total phosphorus allocation. The wastewater flow projections reported in the Discharge Monitoring Reports are suspect as low and don't reflect occupancy. The Association recommends the facility be issued a notice of noncompliance by the Water Quality Control Division.

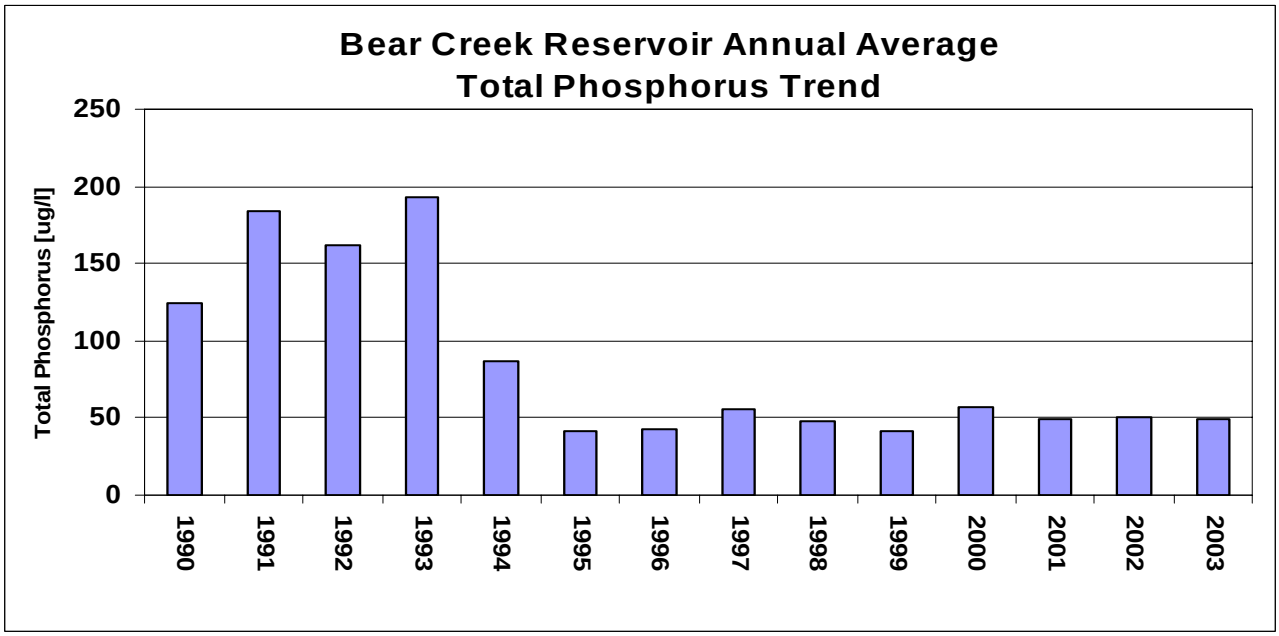
4-The Geneva Glen treatment plant is not discharging as reported to the Association.

5-38 pounds of the reserve pool is allocated to the Aspen Park Metropolitan District, Treatment plant under construction.

Fact Sheet 10. Total Phosphorus Trends for Watershed & Reservoir

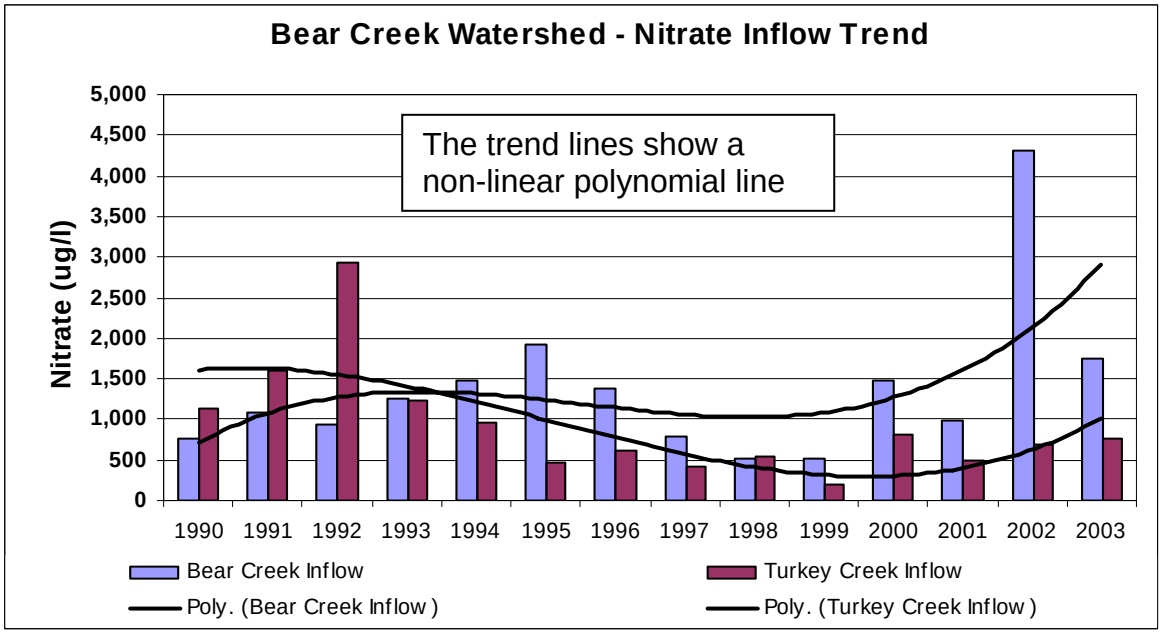
The monitoring program measures total phosphorus into Bear Creek Reservoir and within the water column. The total phosphorus target for the reservoir is to maintain the water column average below 60 ug/l. This target goal has been achieved through point source management from 1995-2003. Controlling total phosphorus source inputs is also a control strategy for reducing chlorophyll levels in the reservoir and meeting the reservoir narrative standard. The low flow in Bear Creek impacted the total phosphorus concentration measured at the Morrison site where less water was available for dilution of the Morrison treatment plant effluent. Consequently, the increased Bear Creek total phosphorus was associated with drought & low flow conditions.

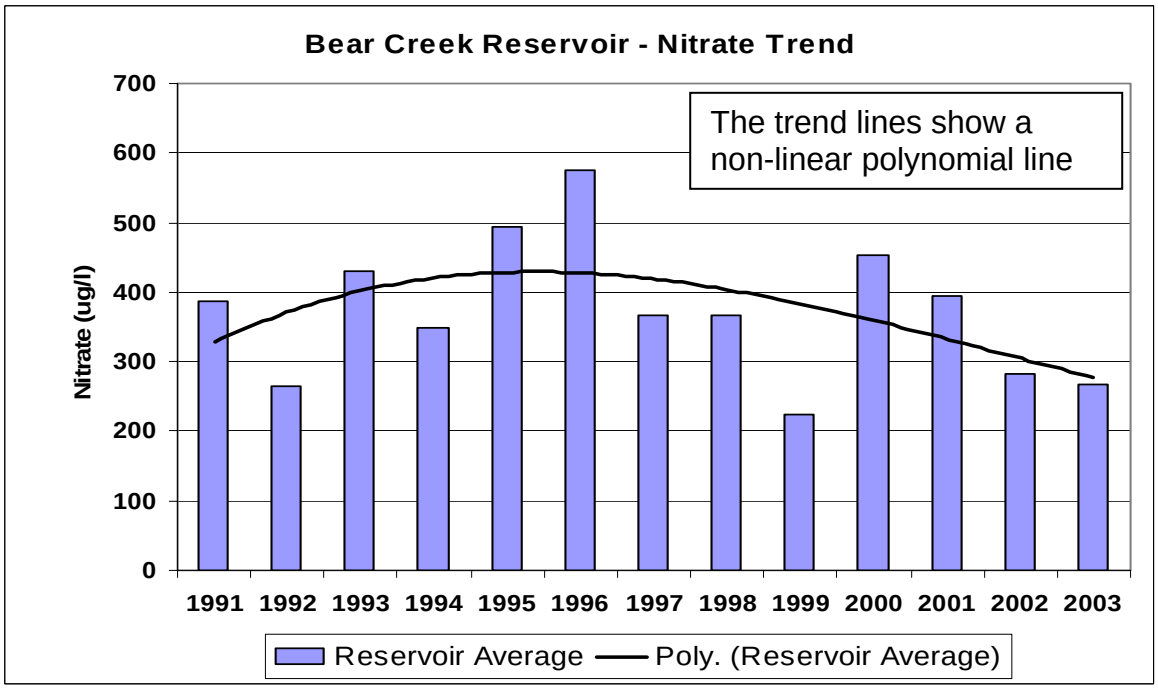




Fact Sheet 11. Nitrate Trends for Watershed and Bear Creek Reservoir

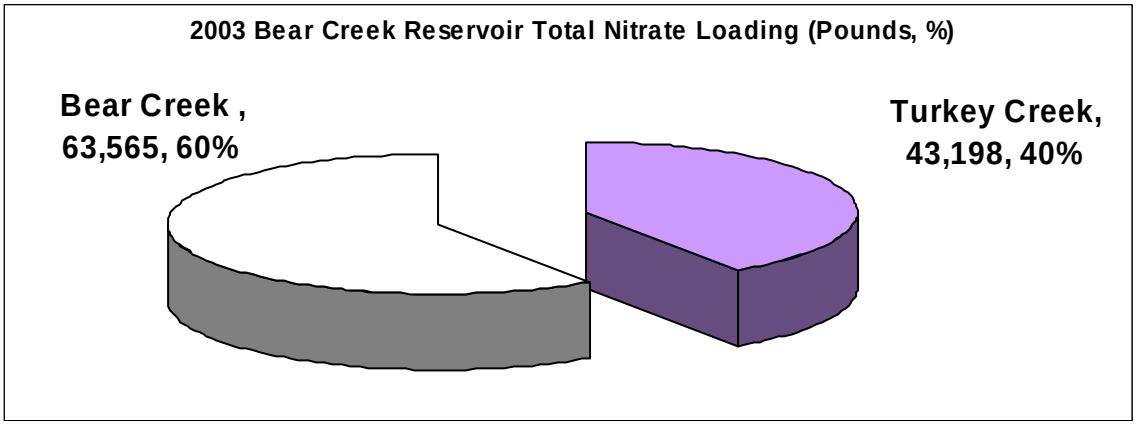
The monitoring program measures inflow nitrate from Turkey Creek and Bear Creek and within Bear Creek Reservoir. In recent years the concentrations of nitrate reaching the reservoir have increased particularly from the Bear Creek drainage. Nitrate has not been a water quality problem in the reservoir. The high 2002-2003 nitrate levels in Bear Creek were associated with low flows and drought conditions. It is suspected that the Morrison Treatment Plant discharge elevated Bear Creek nitrate concentrations, because no flow was available in the stream to dilute the nitrate and ammonia concentrations.

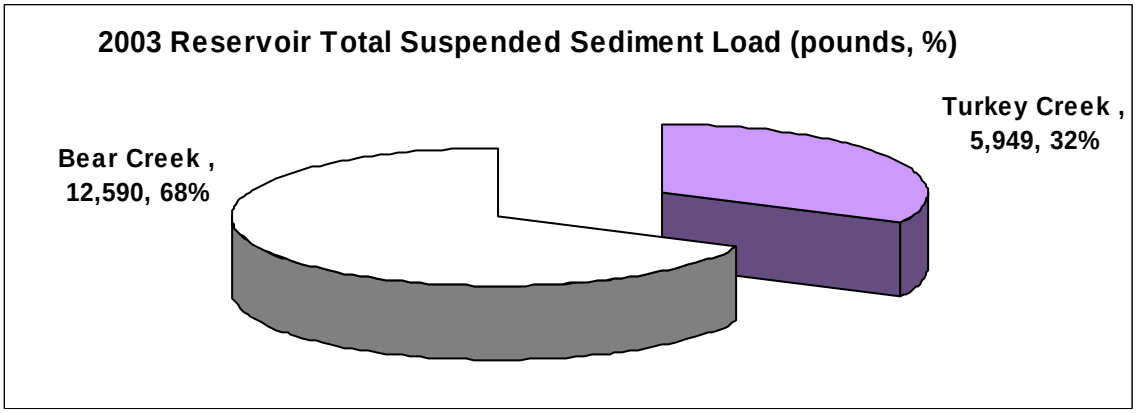


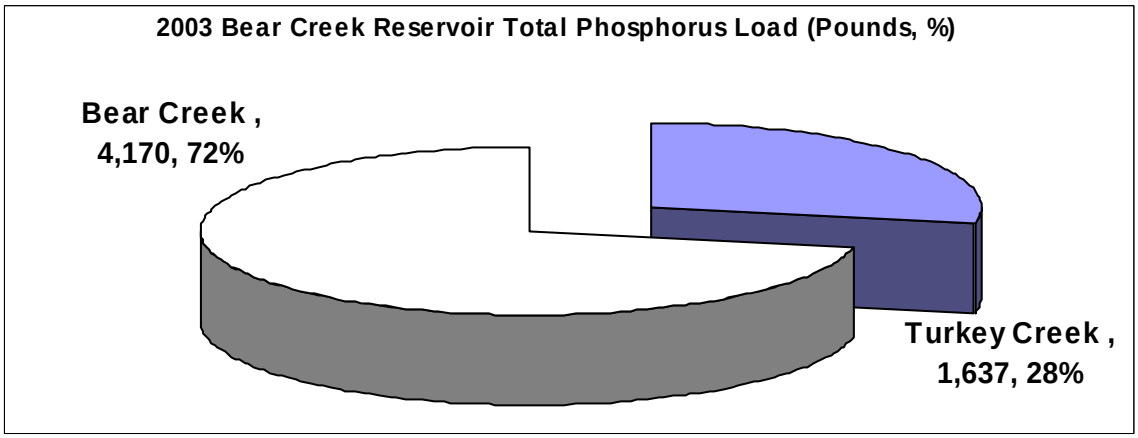


Fact Sheet 12. Phosphorus, Nitrate & Total Suspended Sediment Loads Trends

The monitoring program measures loading into Bear Creek Reservoir from Bear Creek and Turkey Creek. Wastewater treatment plants and a combination of nonpoint sources within the watershed produce the total phosphorus load. The total phosphorus load in 2003 from all sources reaching the reservoir was 5,807 pounds at a flow of 33,941 acre-feet. Although the point source discharges of total phosphorus were about 2,000 pounds, the water diversions above the reservoir are removing most of this phosphorus load and inflow water before it reached the reservoir. The nitrate (106,763 pounds) and suspended sediment (18,540) loading were increased over 2002 conditions. There were no nutrient or sediment loading problems in 2003.







Fact Sheet 13. Bear Creek Reservoir 10-Year Data Summary

The reservoir program evaluates nutrient (nitrogen and phosphorus) concentrations, chlorophyll-a, total suspended sediments and Secchi depth as key trophic state indicators. These parameters are used to determine compliance with the narrative standard adopted for the reservoir. The reservoir data from 1991 through 2003 are summarized below. The control program for the watershed has targeted the reduction of total phosphorus reaching the reservoir on an annual basis. The data supports the success of this management effort.

While the nitrogen data has fluctuated over the years, no clear pattern has emerged. However the surface Chlorophyll concentration increased from 2000 and 2003. This suggests an internal nutrient loading problem triggering algal blooms. Additionally, the algal blooms appear to correlate with drier hydrologic conditions. This is evident by the increased average chlorophyll concentrations in surface waters during 2000 to 2003. Future monitoring and some special studies (if this trend continues through 2003-4) will be needed to address the algal production problem in the reservoir.

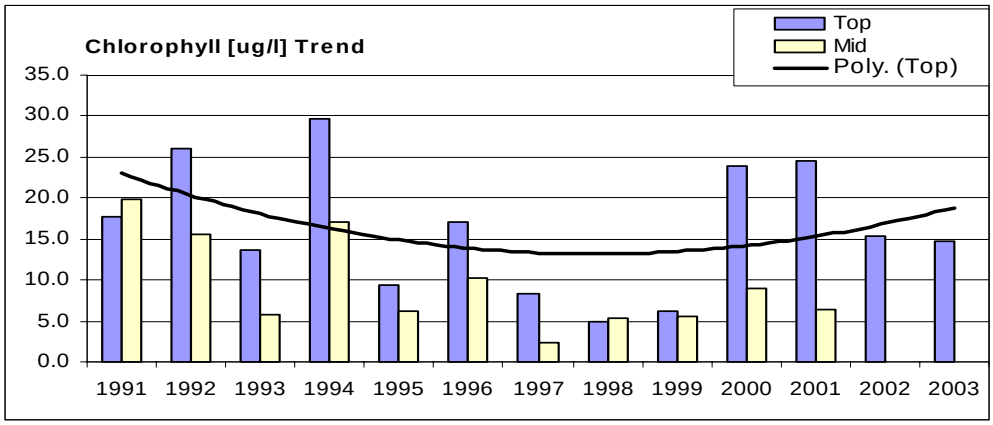
The total suspended sediment load in the reservoir has been generally constant over the monitoring periods with periodic storm events dumping large volumes of sediment into the reservoir. The average depth of the reservoir has declined by over 3 meters (10-11 feet) since 1991. Bottom sediments are fine sand, silt and mud.

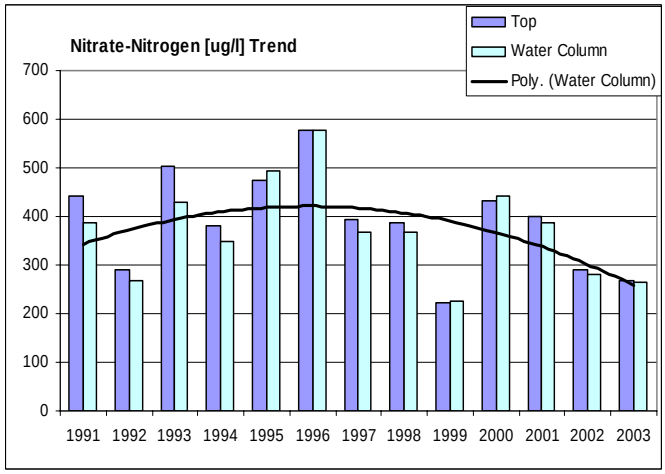
Bear Creek Reservoir Mean Annual Concentrations 1991-2003

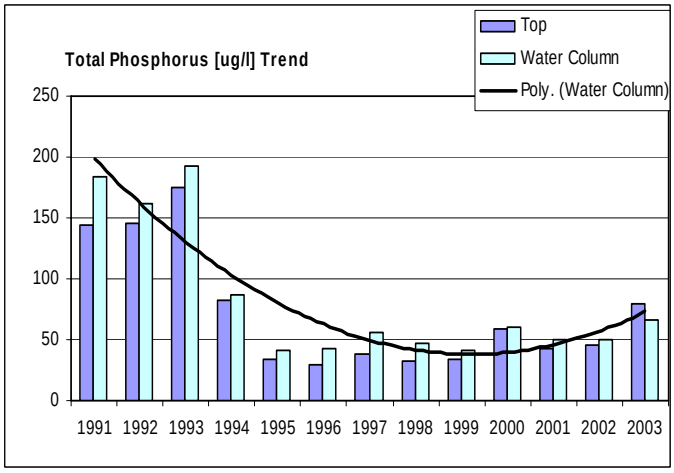
Parameter	Site	Reservoir Annual Average Concentrations													
		1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	91-03 Mean
Chlorophyll-a (ug/L)	Top	17.7	26.0	13.7	29.7	9.4	17.1	8.2	4.9	6.2	23.9	24.6	15.4	14.8	**16.3**
	Mid	19.8	15.5	5.9	17.0	6.2	10.3	2.4	5.4	5.5	8.9	6.3			**9.4**
	Water Column	18.7	20.8	9.8	23.4	7.8	13.7	5.3	5.2	5.9	14.1	14.6	15.4	14.8	**13.0**
Nitrate-Nitrogen (ug/L)	Top	442	289	504	382	474	578	393	388	224	431	401	289	268	**389**
	Mid	381	282	451	356	502	589	365	372	220	443	395	288	271	**378**
	Bottom	341	228	333	308	503	561	341	342	231	483	390	268	259	**353**
	Water Column	388	266	429	349	493	576	366	367	225	441	387	282	266	**381**
Total Phosphorus (ug/L)	Top	144	146	175	83	34	29	38	33	34	59	42	46	79	**72**
	Mid	138	140	164	79	37	33	45	40	37	57	42	49	63	**71**
	Bottom	270	201	240	99	52	66	86	69	54	56	64	56	56	**105**
	Water Column	184	162	193	87	41	43	56	47	42	60	50	50	66	**85**
Total Suspended Solids (mg/L)	Top	6	7	4	9	6	4	12	6	7	6	7	5	7	**7**
	Mid	8	6	6	8	7	4	15	8	9	5	7	5	6	**7**
	Bottom	19	8	5	9	13	7	22	12	12	8	10	5	8	**11**
	Water Column	11	7	5	9	9	5	16	9	9	6.4	8	5	7	**8.3**
Secchi Depth (m)	Top	2.17	2.1	2.84	1.79	2.14	2.51	1.7	1.8	1.8	2.4	2.3	3	1.7	**2.2**

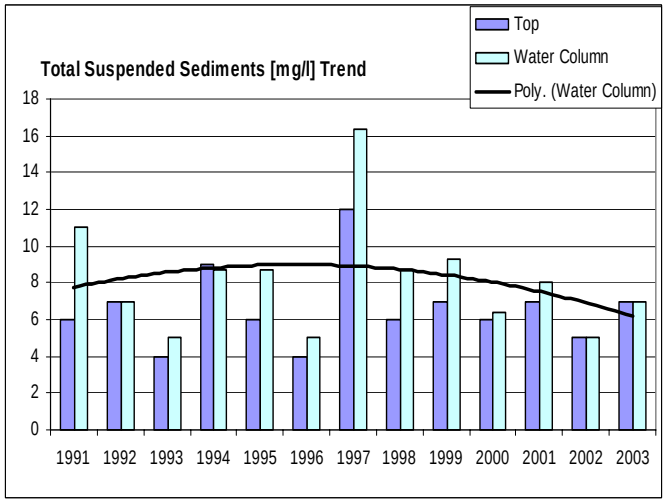
Fact Sheet 14. Bear Creek Reservoir Long-Term Water Quality Trends

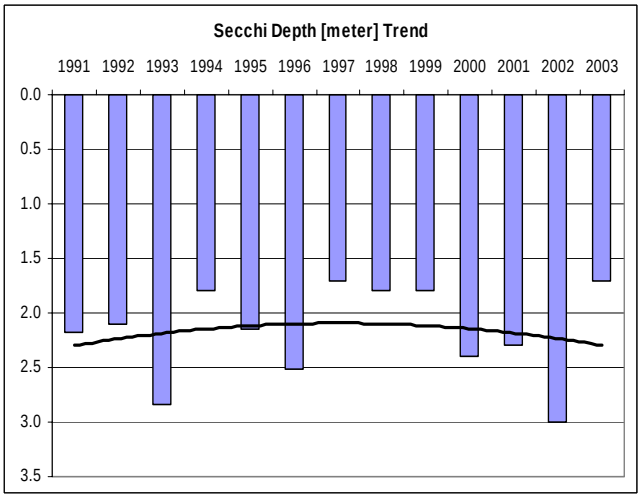
The reservoir program evaluates seasonal, annual and long-term changes in nutrient (nitrogen and phosphorus) concentrations, chlorophyll-a, total suspended sediments and Secchi depth. The reservoir trends from 1991 through 2003 are graphically summarized below. The trend line shows a non-linear polynomial curve fit to the data.











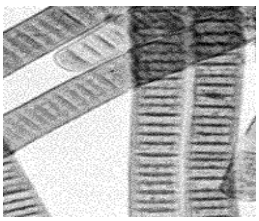
Fact Sheet 15. Trophic Indicators For Bear Creek Reservoir

Since the management goal is to change Bear Creek Reservoir from a poorer quality hypereutrophic system to a better quality mesotrophic-eutrophic system, the various trophic indicators provide a means to evaluate progress toward this goal. Reservoir water quality models use total phosphorus, Secchi depth and chlorophyll-α levels as indicators of the trophic state of the reservoir. The biological integrity of Bear Creek Reservoir is assessed by monitoring changes in plant (phytoplankton) and animal (zooplankton) communities. The increased abundance within a reservoir of certain types of algae or plants (e.g., blue-green algae or Cyanophyta) indicates declining water quality. Implementation of the watershed management program has impacted water quality in the reservoir and generally helped improve the overall reservoir quality.

Algal production was slightly increased under the 2003 drought hydrologic conditions; even though the total phosphorus loading was low. The algal production consumed most of he nitrate within the water column over the growing season. The growing season Chlorophyll-a concentration is indicative of declining quality or eutrophic-hypertrophic conditions. The following trophic indicators and values are used in the reservoir Walker and Carlson water quality models and a Secchi depth quality prediction model to evaluate the reservoir response to water quality management. The dominate phytoplankton species are typical nuisance species.

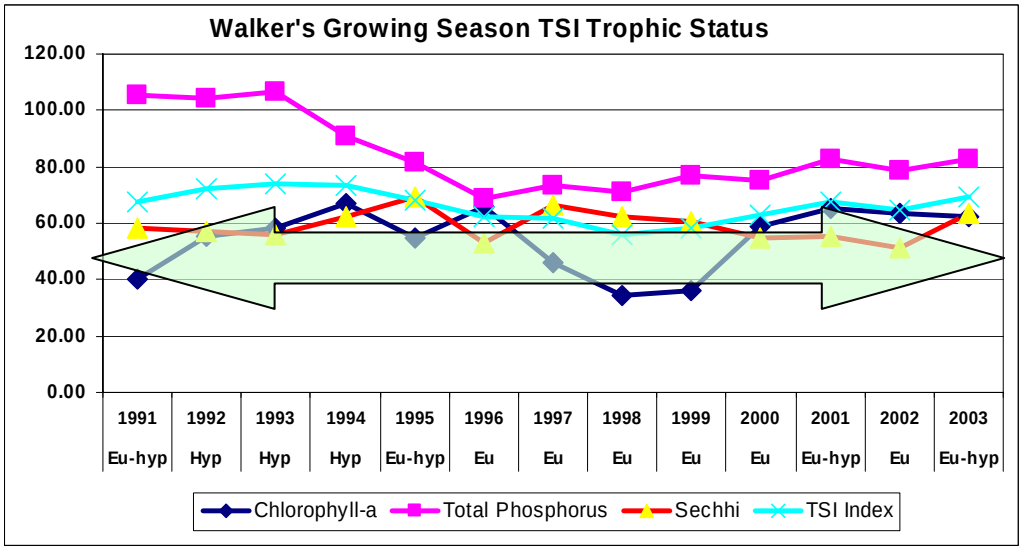
Bear Creek Reservoir 2003 - Selected Trophic Indicators

Trophic Indicator	Reservoir
Average Growing Season Chlorophyll-a [ug/l (surface waters only)]	18.5
Peak Chlorophyll-a [ug/l]	41.4
Average Total Phosphorus [ug/l]	49.5
Peak Total Phosphorus	117.7
Peak Ortho Phosphorus	57.7
Secchi Depth [meters]	1.7
Peak Total Suspended Sediments	22.2
Phytoplankton Co-dominant Species	Green – *Chlorella minutissima*
	Green – *Monomastrix sp*
	Cryptophyta- *Plagioselmis nannoplanctica*
	Chrysophyta - *Chromulina sp.*
	Bluegreen - *Aphanizomenon flos-aquae*
	Bluegreen - *Aphanothece smithii*
	Bluegreen - *Anabaena flos-aquae*
Peak Phytoplankton Density	390,000 cells/ml (September)



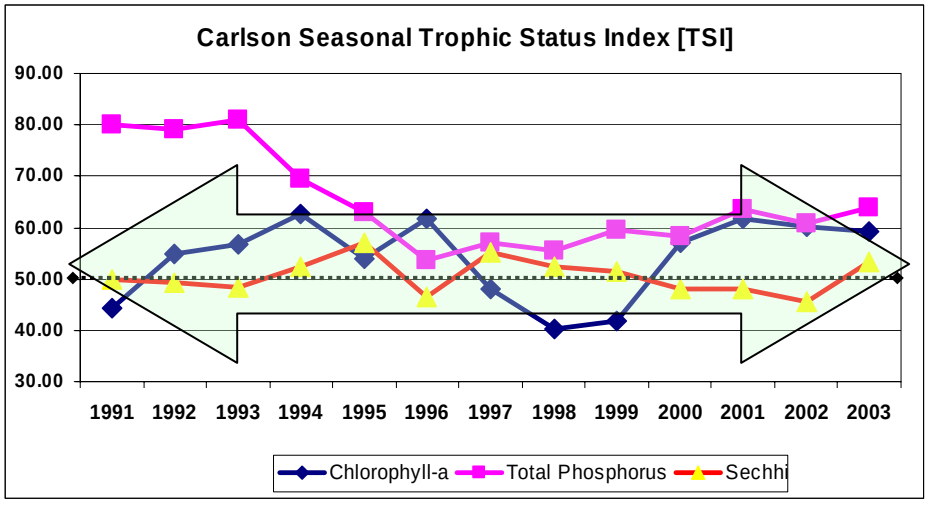
Fact Sheet 16. Carlson & Walker Reservoir Trophic Models

Models are used to evaluate the current trophic state: Walker (annual and seasonal); and Carlson (annual and seasonal). Both models use the total phosphorus, Secchi depth and chlorophyll-α levels for the evaluation. The Carlson and Walker models both show the reservoir quality has improved from historic conditions by having the trophic status shift toward the eutrophic-mesotrophic boundary, but the reservoir remains a eutrophic waterbody. Although the point sources are in compliance with the control regulation, the reservoir quality remains in flux. Based on the nonpoint source loading, additional nonpoint source load reductions are needed to stabilize the reservoir at the mesotrophic boundary.



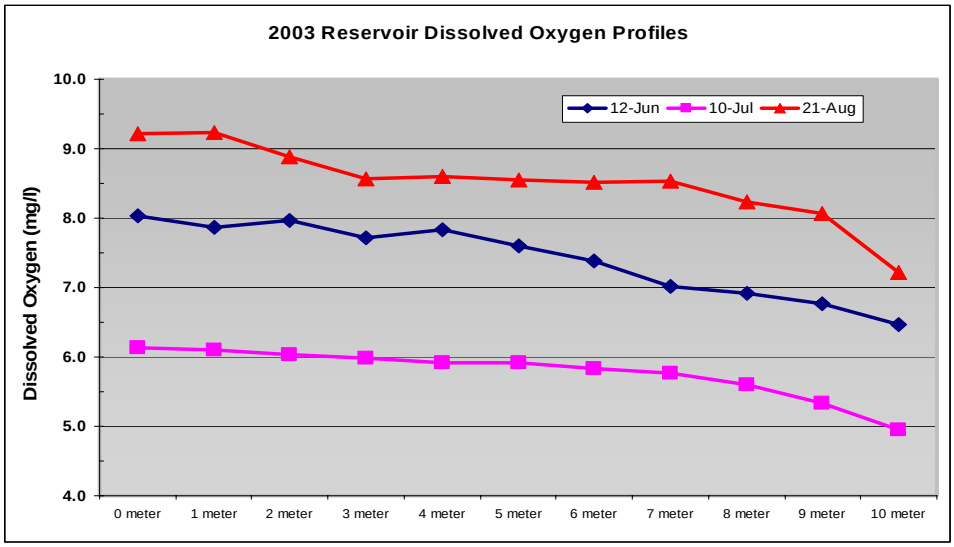
0-25	oligotrophic
25-30	oligotrophic-mesotrophic
30-45	mesotrophic
45-50	mesotrophic-eutrophic
50-65	eutrophic
65+	hypereutrophic

0<25	Oligotrophic
25-30	Oligotrophic-Mesotrophic
30-45	Mesotrophic
45-50	Mesotrophic-Eutrophic
50-65	Eutrophic
65+	Hypereutrophic

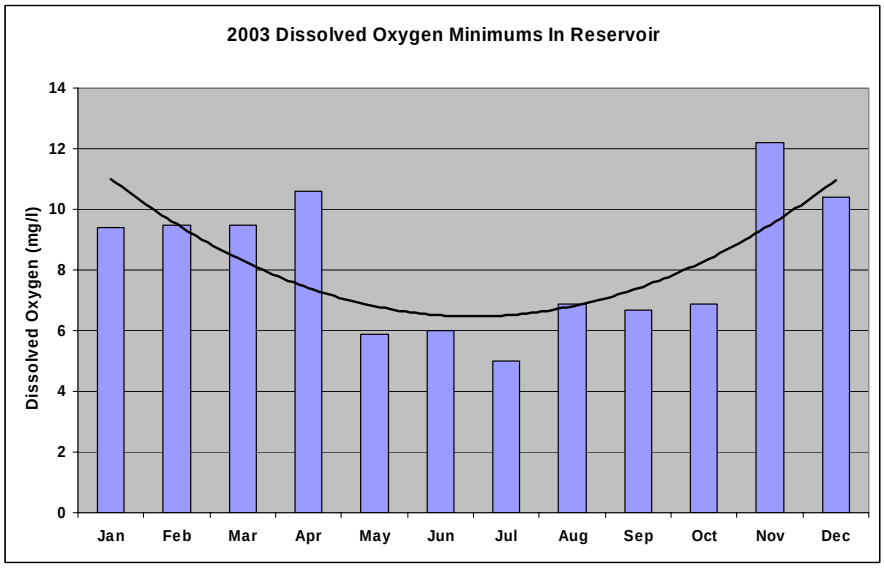


Fact Sheet 17. Bear Creek Reservoir Dissolved Oxygen Trends

The dissolved oxygen concentrations in the water column are profiled in 1-meter intervals at the central sampling site. Dissolved oxygen is a reservoir trophic indicator, where dissolved oxygen concentrations below 5 mg/l indicate a potential water quality and biological problem. Low dissolved oxygen concentrations stress aquatic life species.



Oxygen levels that remain below 1-2 mg/l for a few hours can result in fish kills. Since fish within the reservoir can migrate to better-oxygenated water, the amount of water column with low dissolved oxygen is an important tropic indicator. Low dissolved oxygen concentrations have commonly occurred below 4 meters (about 14 feet) beginning in June and extending through November. Generally, dissolved oxygen concentrations in the water column zero out between 10-13 meters (33-43 feet). However, the dissolved oxygen standard applies to the middle mixing zone (metalimnion) and surface (epilimnion) waters of the reservoir (generally above 4 meters). The low dissolved oxygen values in bottom waters are not a standard exceedence problem.

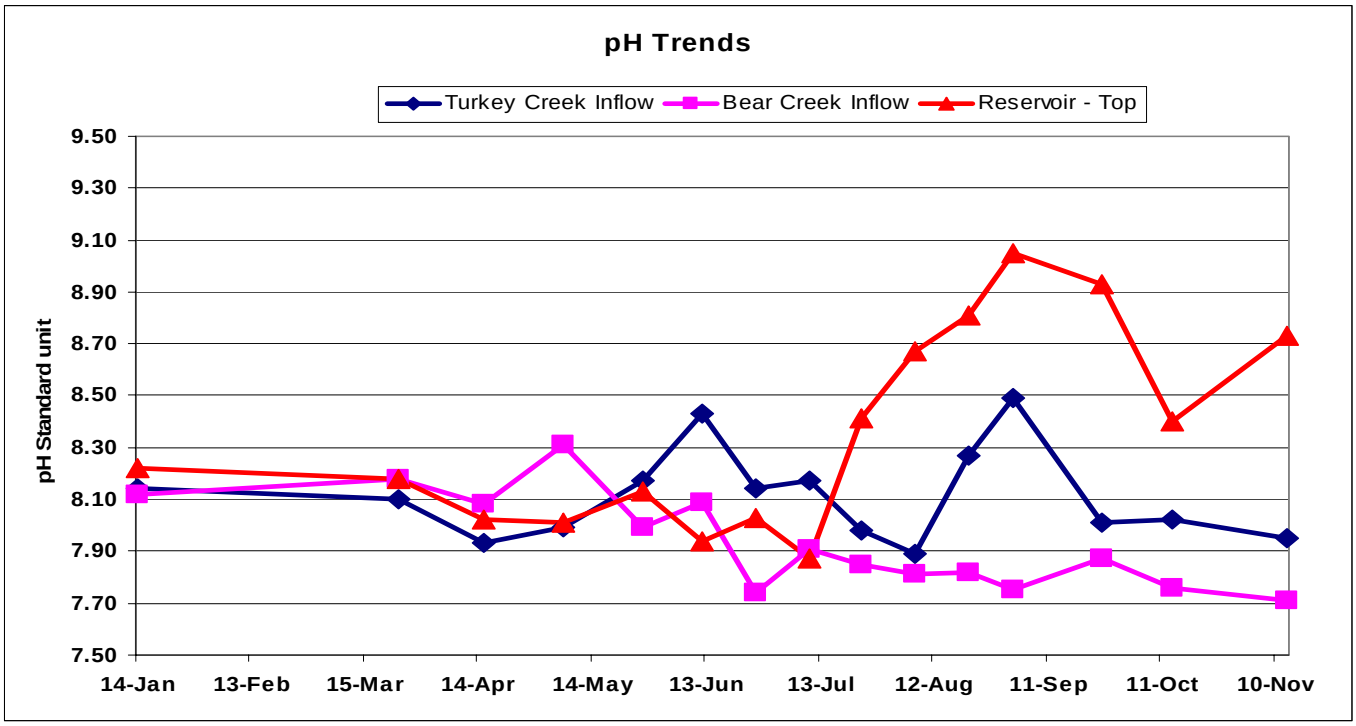


To resolve the low oxygen problem, the City of Lakewood re-established in August of 2002 a new reservoir aeration system in the reservoir. The system extends aeration lines throughout the reservoir to reduce dead spots. The system uses a fine bubble diffuser system to increase total water column aeration with oxygen supplied by an on-shore pump station. This aeration system has reduced or eliminated reservoir water column stratification, which raises a potential concern about increasing water column temperature. The system is monitored to determine changes to temperature and dissolved oxygen. Based on 2003 data, this new aeration addresses the oxygen problem, doesn't affect temperatures and reduces the potential for stress of aquatic species.

The Basic Standards And Methodologies For Surface Water (5 CCR 1002-31, Regulation #31) -*The dissolved oxygen criterion is intended to apply to the epilimnion and metalimnion strata of lakes and reservoirs. Dissolved oxygen in the hypolimnion may, due to the natural conditions, be less than the table criteria. No reductions in dissolved oxygen levels due to controllable sources are allowed. "Existing quality" shall be the15th percentile for dissolved oxygen.*

Fact Sheet 18. Bear Creek Watershed and Reservoir pH Trends

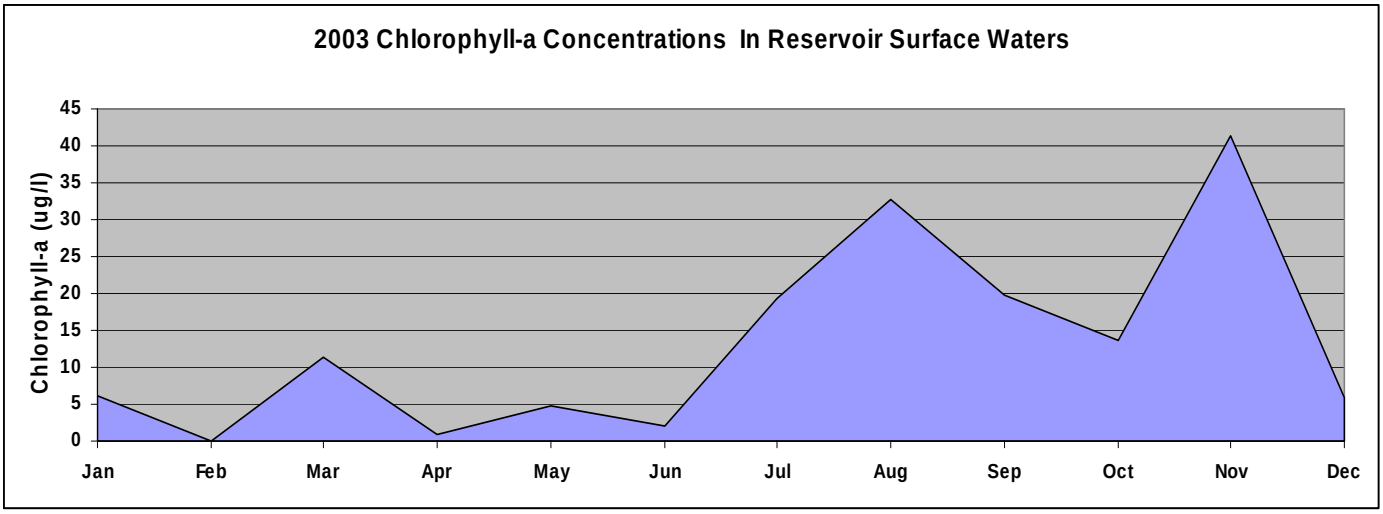
The pH values in the water column are profiled in 1-meter intervals at the central sampling site. Water column pH can be a reservoir trophic indicator measure, where pH values above 9.0 indicate a potential water quality and biological problem. The pH scale measures relative quantities of the hydroxyl and hydrogen ions on a scale of 0 to 14. Where the hydrogen ion predominates in acidic solutions [measured as 0 on the scale] and hydroxyl ions predominate in very alkaline solutions [measured as 14 on the scale]. At around pH 7 the numbers of both species present are equal and the water is said to be neutral. The pH scale is a logarithmic measurement of the concentration of hydrogen ions, which means that each one unit change in the scale equals a ten-fold increase or decrease. Plant photosynthesis is the main cause of high pH and diurnal pH fluctuations. High alkalinity water [pH > 9.0] can cause direct physical damage to fish skin, gills and eyes. Prolonged exposure of aquatic life to sub-lethal pH levels can cause severe stress or result in death of species with a narrow pH tolerance.

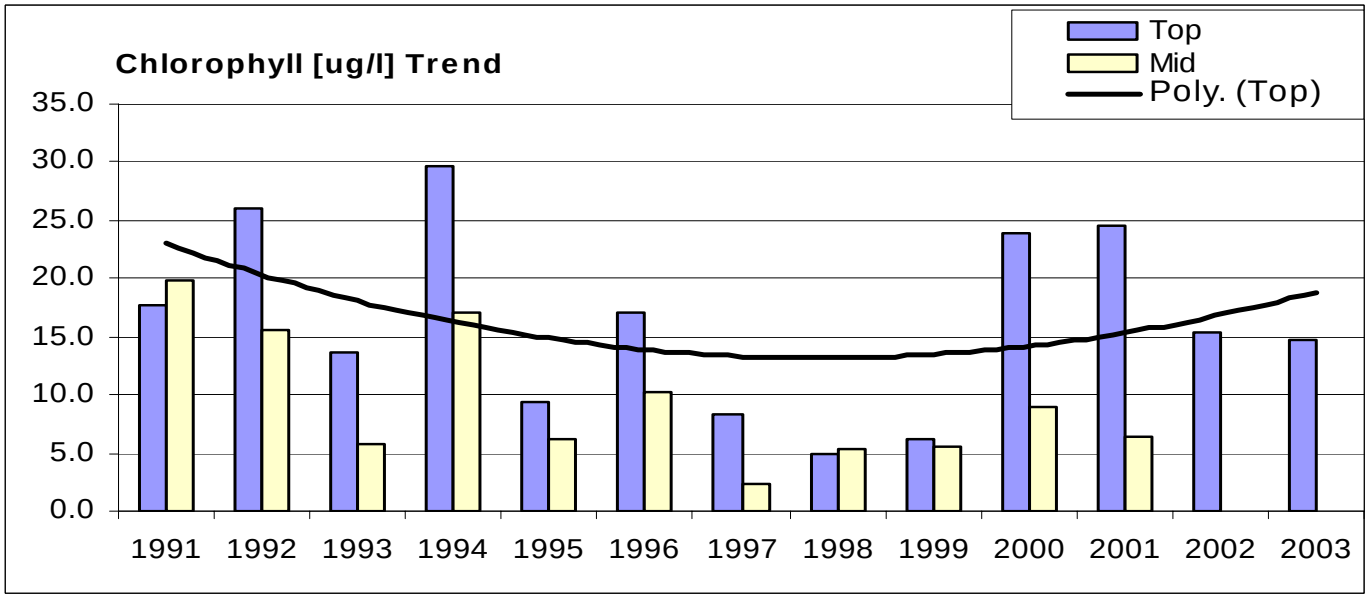


The reservoir pH was in excess of 9 units during the month of September 2003. The inflow water from Bear Creek and Turkey Creek was within expected values and consistent with historical data. Consequently, the factor raising the reservoir pH is an internal mechanism. The elevated pH measurements in the reservoir are associated with algal production; phytoplankton biomass measurements were moderate at 390,000 cells/ml. The new aeration system hasn't eliminated this water quality problem. Operational adjustments of the aeration system could help reduce the pH fluctuations. The Association is monitoring reservoir pH conditions in 2004-05 to determine cause and affect.

Fact Sheet 19. Bear Creek Reservoir Chlorophyll-a Trends

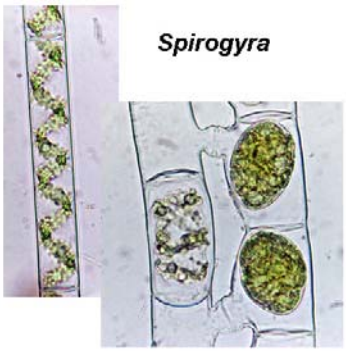
The reservoir monitoring program provides necessary data to make statistical water quality trend assessments and verify the effectiveness of control and alternative management programs. The concentration of chlorophyll-a within the reservoir water column is a critical measure of the how the reservoir responds to water quality management strategies. The control regulation is designed to reduce the loading total phosphorus reaching the reservoir and subsequently limiting algal production in the reservoir. Algal blooms are associated with declining water quality. The target reservoir concentration for the chlorophyll concentrations in the growing season should not exceed 20 ug/l as an average growing season value to be consistent with the intent of the narrative standard. The 2003 growing season chlorophyll-a (18.5 ug/l) was below the target.

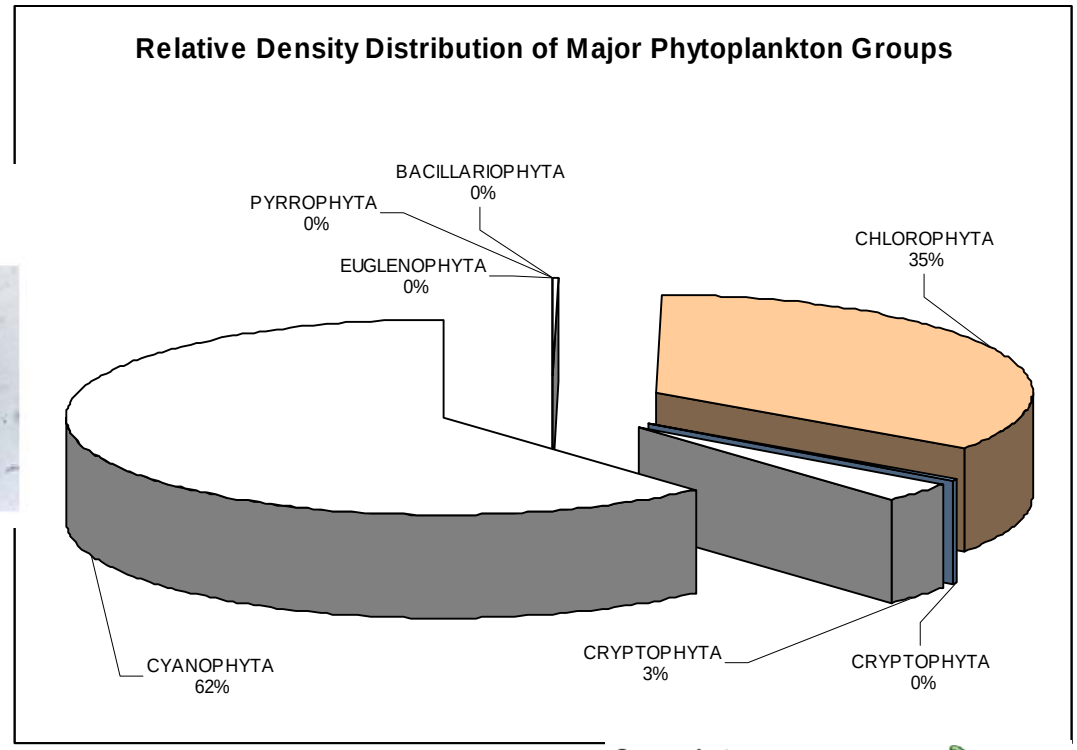


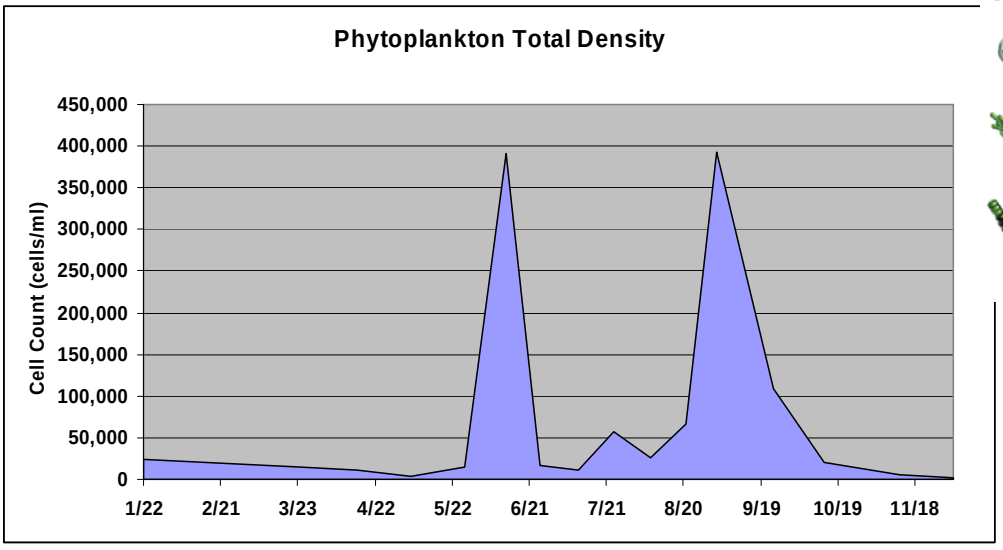


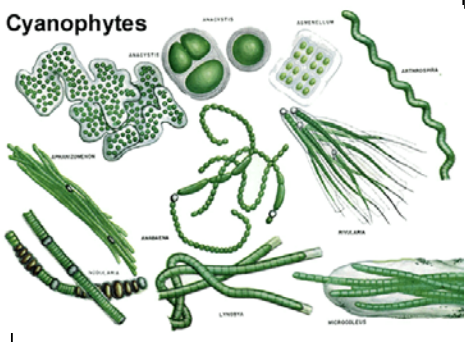
Fact Sheet 20. Bear Creek Reservoir Phytoplankton Distribution

The biological integrity of Bear Creek Reservoir is assessed by monitoring changes in growing season plant (phytoplankton) communities. The increased abundance within a reservoir of certain types of algae or plants (e.g., blue-green algae or Cyanophyta) can indicate declining water quality. In 2003, the blue-green species made up on the average 62% of plants present in the reservoir. Twelve species of blue-green algae were found in the reservoir with a maximum total density at 390,000 cells/ml (September; see lower graph), which was classified as a visual algal bloom. The green algae comprised 35% of the biomass (11 species) with a density over 375,000 cells/ml (June; see lower graph), which was also classified as a visual algal bloom. The diatoms (Bacillariophyta and Chrysophyta) made up most of the 3% remaining species. Certain species of diatom are problematic from a water supply perspective. No fish kills or algal related problems were reported for the reservoir.









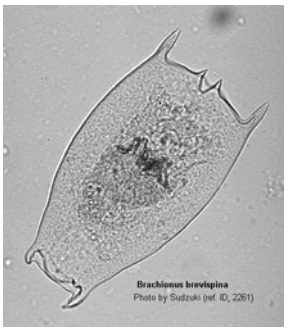
Fact Sheet 21. Bear Creek Reservoir Zooplankton Distribution

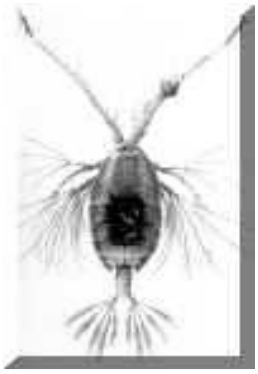
A more detailed evaluation of zooplankton species presence was assessed from June through August 2001. Species were counted as present without density determinations. Similar species were identified in 2003, although the survey detail was not as comprehensive as the 2001 survey. The zooplankton species found in the reservoir are divided among three major groups of copepods, cladocerans and rotifers, which are typical of front-range reservoirs. Zooplankton are common in the upper regions of the reservoir where assemblages include 16 species of rotifers, six species of cladocerans and eight species from the class Copepoda. Copepods are usually a dominant group in the reservoir. The microcrustacean class Ostracoda is missing from the reservoir, but has been found in other front-range waterbodies. Most species of three functional groups make their living grazing algae from either the water column or off surfaces. Zooplankton is a vital link for passing energy up the food chain to fish.

2003 Zooplankton Species		
Copepoda	Cladocera	Rotifera
Diacyclops thomasi	***Daphnia pulex - group***	***Brachionus angularis***
Leptodiaptomus siciloides	***Leptodora kindti***	***Cephalodella sp.***
Mesocyclops edax		***Euchlanis dilatata***
Skistodiaptomus pallidus		***Keratella quadrata***
		Lophocaris sp.
		Polyarthra vulgaris
		Pompholyx sulcata
		Proales sp.

Zooplankton At Bear Creek Reservoir

Copepoda	Cladocera	Rotifera
Acanthocyclops vernalis	*Alona sp.*	*Asplanchna girodi*
Aglaodiaptomus clavipes	*Bosmina longirostris*	*Brachionus urceolaris*
Diacyclops thomasi	*Chydorus sphaericus*	*Collotheca sp.*
Eucyclops spp.	*Daphnia mendotae*	*Conochilus unicornis*
Leptodiaptomus siciloides	*Daphnia pulex - group*	*Euchlanis dilatata*
Mesocyclops edax	*Leptodora kindti*	*Kellicottia longispina*
Skistodiaptomus pallidus		*Keratella cochlearis*
Tropocyclops prasinus		*Keratella quadrata*
		Lecane (L.) spp
		Lecane (M.) sp.
		Lepadella sp.
		Polyarthra vulgaris
		Pompholyx sulcata
		Synchaeta pectinata
		Trichocerca sp.
		bdelloid





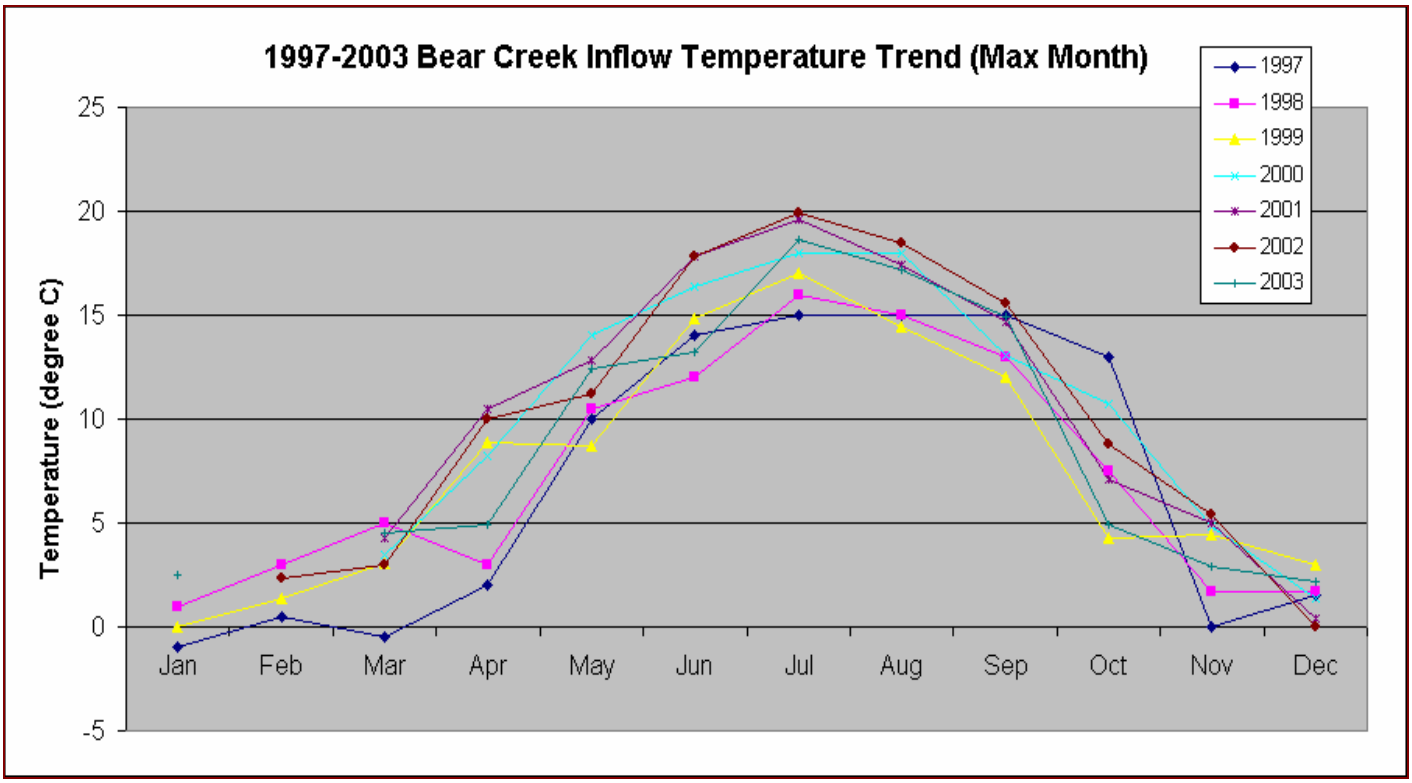
Rotifers have incredible reproductive rates. Population densities often exceed 1000 individuals per liter. They play important roles in energy flow and nutrient cycling, accounting for more than 50% of the zooplankton production in the reservoir.

Fact Sheet 22. Temperature Inflow Trends For Bear Creek

Aquatic life species are sensitive to excessive temperature fluctuations. Large changes in water temperature are due to a combination of factors including, geography, season, source inputs (e.g., wastewater) and anthropogenic activities. While the optimum temperature range for trout is below 18 degrees Celsius (C) (64.5 F), trout can survive in waters up to 25 C (77 F). Water temperatures over 25 C can stress trout. Based on temperature measurements in summer months, the reservoir is a marginal cold-water fishery (classified as cold warm fishery), while Bear Creek and Turkey Creek meet temperature requirements for a cold-water fishery.

Optimum Temperature Ranges For Trout

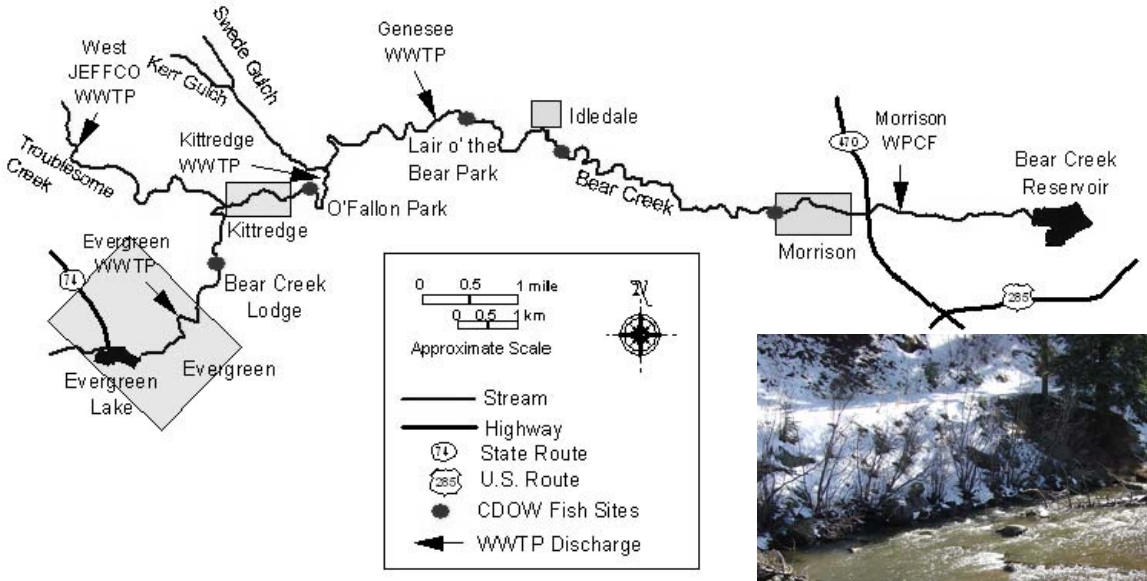
Trout Species	Rearing		(iii) Spawning	
	F	C	F	C
Brown	43-64	6.0-18	45-55	7-13
Cutthroat	45-61	7.0-16	48-54	9-12
Rainbow	61-65	16-18	50-60	10-16
Brook	54-65	12-18	45-55	7-13



Fact Sheet 23. Bear Creek Special Trout Population Trend Study

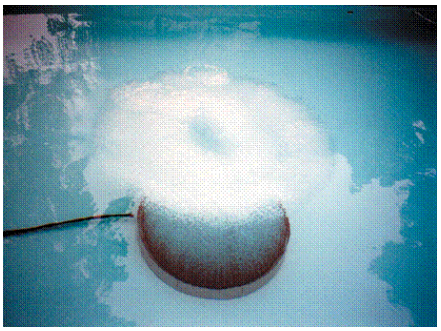
Evaluation Of The Effects Of Wastewater Treatment Plants On Trout Populations In Bear Creek, Jefferson County, Colorado, 1994-2001 [Chadwick Ecological Consultants, Inc., 2002]

The municipalities along Bear Creek divert water from Evergreen Lake and Bear Creek, and discharge wastewater treatment plant effluent back to the stream. The report presents historical fish population data available for Bear Creek, identifies spatial trends in trout populations and shows temporal trends from year to year. The data evaluation assessed status of trout populations to determine changes associated with reported fish kills and temperature effects of wastewater discharges. Brown and rainbow trout populations for Bear Creek decline in density and biomass from upstream near Evergreen downstream to near Morrison. This general trend occurs in all sampling years. The trend relates to the transition of the stream from a coldwater mountain stream to a warm-water plains stream below Morrison. Trout density in 1999 was relatively low at all sites. In 2000 and 2001, trout density and biomass were higher than previous years. A substantial increase in trout density and biomass at all sites occurred between 1999 and 2000. Trout biomass in Bear Creek is consistently above average for Rocky Mountain streams at almost all sites and in most years, and exceeds the biomass criterion for Gold Medal Trout Waters in Colorado. The presence of healthy trout populations at sites downstream of treatment plant discharges indicates no adverse effect on trout populations. Modeling of water temperature indicates discharge of wastewater effluent has a slight cooling effect on Bear Creek. The important factor determining trout population density and abundance is related to the magnitude of spring runoff. In years with high runoff there are fewer trout, and in years of low runoff, trout populations increase. The presence of very strong year classes of both brown and rainbow trout in 2000 indicates conditions during the summer of 2000 were suitable to sustain resident trout populations, including sensitive young trout. The severe drought of 2003 resulted in low flow conditions in which temperatures probably had a detrimental effect on the trout populations of Bear Creek.



Fact Sheet 24. City of Lakewood Bear Creek Reservoir Aeration System

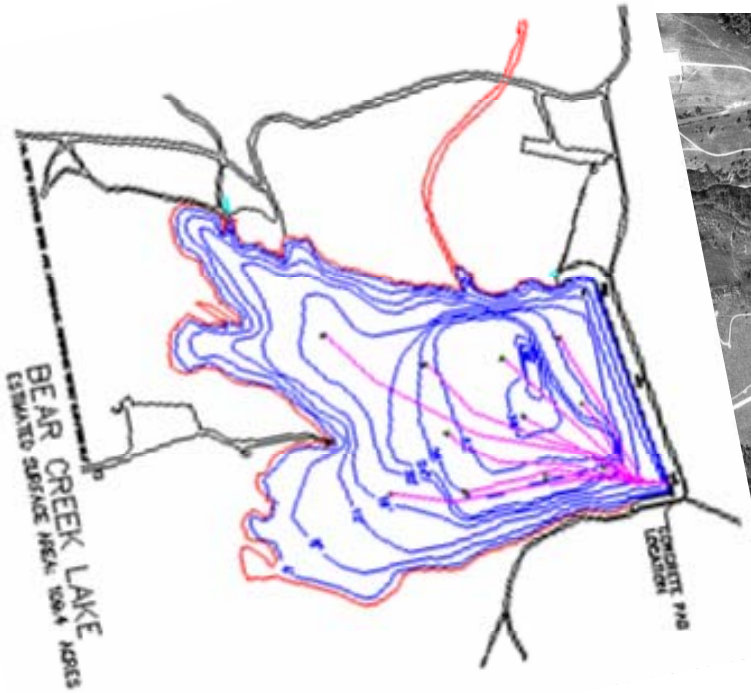
The City of Lakewood maintains an aeration system in Bear Creek Reservoir as a water quality enhancement best management practice consistent with the Bear Creek Reservoir Control Regulation. This aeration system increases the amount of dissolved oxygen in the water column to protect the existing fishery. The original aeration system was designed to oxygenate the water column through a series of anchored towers. This Hypolimnetic aeration system didn't de-stratify the water column. Beginning in 2002 the aeration system began to structural fail from continued freezing in the winter, which resulted in minimal oxygen transfer efficiency. Consequently, the City of Lakewood bid and installed a new complete aeration system in early fall of 2002. This new system has greater coverage throughout the reservoir and much high oxygen transfer potential. Key features of the new aeration system include:



- Eleven Air Diffusion Systems LTC Stainless Steel Modules
- Six Dura-Venturi aerators (From previous installation)
- 22 Million Gallon per Day per Module pumping rate
- Approximately one complete reservoir turnover every 3 days

The aeration system is expected to Increased dissolved oxygen concentrations throughout the entire water column; increased availability of habitat for all fish species (warm and cold); result in pH values that are homogenous and stabilized and cause water column temperatures to be more homogenous throughout the entire water column**.**

Lake Aeration Treatment Systems Operational History: Hypolimnetic Aeration System (1993); Dura-Venturi Installation (1999); ASI Lakebed Aeration System (2002**)**



Fact Sheet 25. City of Lakewood Stormwater Program

Lakewood provides stormwater education programs in elementary, middle and high schools within the City. Lakewood made presentations and stenciled inlets in 2003 with more than 450 students and teachers. Lakewood staff continues to work with the Colorado Department of Public Health and Environment (CDPHE) to meet the terms of our Phase I National Pollutant Discharge Elimination System (NPDES) permit. Water quality enforcement actions are required by our existing NPDES permit to stop illicit connections and prevent illegal discharges from entering the stormwater conveyance system. In some cases, grease traps from commercial properties such as restaurants or dumpsters may be poorly maintained allowing them to overflow and reach stormwater facilities. Approximately eight contacts have been made in recent months with commercial property owners or tenants regarding pollution prevention.

The dumpster shown above in the upper portion of the picture has not been properly maintained and is allowing unwanted fluids to leak and eventually be washed into the stormwater conveyance system. Lakewood responded to this and other sites requiring expeditious compliance from property owners.

Lakewood supports the Rooney Road Recycling Center (RRRC) as part of our Phase I NPDES permit

Significant Accomplishments:
The following are considered significant accomplishments of the program in 2003:

- 2,629 residents have had access to proper disposal of their hazardous household waste (HHW)
- 8.9% increase in overall participation over 2001
- 368,431 pounds collected “Door-to-Door” or dropped off at the Center during 2003
- Slash program was introduced and approximately 2,750 households utilized the program
- Electronic waste recycling program introduced with 21,891 pounds collected and recycled
- Significant increases in number of pounds of waste collected
- Survey results excellent
- Program is tracking within budget for the period
- The Center and Authority were presented with an award by the State of Colorado for offering the most innovative environmental programs to the residents

Fact Sheet 26. Jefferson County Stormwater Program

Jefferson County stormwater permit activities

- Applied for and received coverage under the General Permit for Stormwater Discharges Associated with Municipal Separate Storm Sewer Systems
- Prepared a storm sewer outfall map to trace sources of potential illicit discharges and illegal dumping
- Added stormwater information to the County's web page
- Revised County's standard for storm sewer inlets, requires "*No Dumping*" insignia on inlets

- Jefferson County provides opportunities for residents and visitors to learn and be involved in environmental stewardship.

Fact Sheet 27. Recreational Uses in Watershed

Jefferson County Open Space

Lair 'o the Bear Park

Acreage: 319 acres
Annual Visitation: 52,000
Activities: Hiking, biking, horseback riding, wildlife viewing, fishing, picnicking

Mount Falcon Park

Acreage: 1,705 acres
Annual Visitation: 118,000
Historical Point of Interest
Activities: Hiking, biking, horseback riding, wildlife viewing, fishing, picnicking

Alderfer/ Three Sisters Park

Acreage: 770 acres
Annual Visitation: 62,500
Activities: Hiking, biking, horseback riding, wildlife viewing, picnicking

Elk Meadow Park

Acreage: 1,650 acres
Annual Visitation: 72,500
Activities: Hiking, running, biking, horseback riding, wildlife viewing, picnicking

Mainstem Bear Creek

Annual Visitation: >275,000
Activities: Trout fishing (cut-throat, brook trout, browns, rainbows), hiking, biking, horseback riding, wildlife viewing, photography, picnicking, historical points of interest

Bear Creek Reservoir

Lakewood Bear Creek Lake Park Acreage: 2,600
Annual Visitation: 350,000
Activities: Fishing (Saugeye, rainbow trout, smallmouth bass, channel catfish, yellow perch, tiger musky), boating, sail boarding, swim beach, hiking, biking, horseback riding, wildlife viewing, picnicking, camping, nature center, educational activities, archery, glider plane flying, special event facilities, historical point of interest

Fact Sheet 28. CDOT Monitoring Program And Best Practice Effectiveness

The Turkey Creek Surface-Water Quality Monitoring Program 2003 Annual Report (TDS Consulting Inc. 2003) provides results of a final year's monitoring program for the Turkey Creek watershed and Kennedy Gulch area. It is a fifth (and final) report in an annual series provided since 1999 on behalf of the Colorado Department of Transportation (CDOT) for assessing the overall effectiveness of best management practices (BMPs) along the U.S. 285 highway corridor just west of the Denver metropolitan area. The 2003 basic-data results for 12 monitoring sites are within or border the Turkey Creek watershed, along with supplemental hydrologic and water-quality information. 2003 monitoring results when coupled with data for previous years (1995-2002) have addressed the continuing concerns relative to the U.S. 285 highway-related construction impacts. *Post-construction monitoring has demonstrated, in large part, that any during-construction adverse impacts have been substantially controlled by effective use of BMPs.* On the other hand, late-season 2003 flows in the watershed continued to be characterized by below-normal precipitation. Thus, the potential for storm-generated sediments were relative low during the summer and early-fall months of 2003.

Sedimentation basin above Site AP-1, 5/15/03