



Bear Creek Watershed Report 2000:

Water Quality Monitoring, Summary Data and Trends

Bear Creek Watershed Association

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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, Brook Forest Inn, Bear Creek Development Corporation, Geneva Glen & Davidson Lodge

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TABLE OF CONTENTS

INTRODUCTION.....	1
Association management program	1
Wastewater treatment facilities	3
Status of total maximum annual load (TMAL).....	4
Colorado Department of Transportation independent monitoring program.....	6
WATER QUALITY MONITORING AND MANAGEMENT PROGRAM	7
Monitoring sites.....	7
Parameters and sampling program.....	8
Stormwater management	9
City of Lakewood reservoir aeration program	9
Septic system management plan.....	9
WATERSHED AND RESERVOIR TRENDS	11
Reservoir trophic status	11
2000 phytoplankton distributions	13
2000 monitoring program.....	13
Long-term water quality trends	18
CONTROL REGULATION REVIEW AND ASSOCIATION RECOMMENDATION.....	22
ASSOCIATION REFERENCES	23

LIST OF TABLES AND FIGURES

Table 1 Water Quality Management Activities.....	2
Table 2 Treatment Facility Annual Phosphorus Poundage	4
Table 3 Bear Creek Watershed TMAL Elements	5
Table 4 Water Quality Monitoring Stations	7
Table 5 Water Quality Parameters	8
Table 6 Bear Creek Reservoir 2000 - Selected Trophic Indicators	14
Table 7 Bear Creek Reservoir Mean Annual Concentrations 1991-2000.....	18
Figure 1 Carlson TSI	12
Figure 2 Walker Seasonal TSI Trophic Trend	12
Figure 3 2000 Phytoplankton Distributions in Reservoir	13
Figure 4 2000 Discharge Rates.....	15
Figure 5 Estimated Inflows from Turkey Creek and Bear Creek	15
Figure 6 2000 Total Phosphorus Trends	16
Figure 7 2000 Dissolved Oxygen Profiles	16
Figure 8 2000 Total Suspended Solids Trends	17
Figure 9 2000 Total Phosphorus Loading	17
Figure 10 2000 Nitrate Loading.....	17
Figure 11 2000 Suspended Sediment Loading	18
Figure 12 Nitrate Input and Outflow Trends	19
Figure 13 Reservoir Average Nitrate Trend.....	19
Figure 14 Total Phosphorus Averages	20
Figure 15 Reservoir Total Phosphorus Trend	20
Figure 16 Total Phosphorus Inflow Trend	21
Figure 17 Reservoir Chlorophyll Trend.....	21

INTRODUCTION

The Bear Creek Watershed Association (Association) is the designated water quality management agency for the Bear Creek Watershed 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.

The Bear Creek 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. 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 minor plants have shown 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.

Association management program

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 and Geneva Glen.

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.

Table 1 Water Quality Management Activities

Management Activity	Status
<i>Wastewater Management</i>	
Compliance by wastewater treatment facilities with control regulation	Major facilities are meeting permit compliance; small facility reporting is problem.
Wastewater utility planning	Development and review of wastewater utility plans; develop wastewater management strategies; treatment system reviews; coordination; information exchange
<i>Reservoir and Park Management</i>	
Hypolimnetic aeration in reservoir; system operating during growing season	City of Lakewood manages system; provides an annual report to Association
Park facilities support recreational uses	Management program
<i>Water Quality Monitoring</i>	
Conduct long-term trend monitoring program for reservoir inputs, reservoir and output from reservoir	In progress, on-going program with periodic review by Association and WQCD; annual data report; model support; trend characterization
Turkey Creek groundwater study	Jefferson County, Phase I
Special CDOT construction-monitoring	Ongoing effort by CDOT; reports to

Management Activity	Status
program; evaluates effectiveness of BMPs	Association
<i>Data Management</i>	
Review, update and prepare all water quality data collected by the Association for upload into new STORET system; review monitoring and data needs; review quality assurance plan	Access data set ready for upload; monitoring program and data characterization complete; review of the quality assurance plan
<i>Watershed Management</i>	
Construction project review and recommendations	Reviewing construction actions and providing appropriate comments; develop and review site-specific BMPs
Membership involvement, review of management program for cost effectiveness, and evaluation of monitoring program for sites and parameters	Monitoring program review, established program as cost effective; need on-going efforts in evaluating membership involvement and public processes
Re-affirmed mission and goal of Association	Evaluation; need new workshop to for public input into mission and goals

Wastewater treatment facilities

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, Brook Forest Inn, Bear Creek Development Corporation, Bear Creek Cabins and Geneva Glen.

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 Table 2. 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. The lack of reporting to the Association is problematic and hinders the effective development of wastewater management strategies.

The Town of Morrison and the City and County of Denver have executed a memorandum of understanding to have wastewater produced at the Red Rocks recreation area be treated by Morrison at the Morrison treatment plant. This consolidation effort makes the Morrison treatment plant a regional facility and will result in the elimination of large septic systems in the Red Rocks recreation area.

A wastewater utility plan for the Mount Evans Outdoor School (Jefferson County Schools) was approved by the Association and accepted as part of the Metro Vision 2020 Clean Water Plan. This utility plan will result in an upgraded treatment process and provide the necessary reporting to the Association.

Table 2 Treatment Facility Annual Phosphorus Poundage

Facility	Reported Pounds Per Year			
	Control Regulation	1998	1999	2000
Evergreen Metropolitan District	1,500	630	1046	721
West Jefferson County Metro District	1,500	536	537	744
Genesee Water and Sanitation District	1,015	534	408	279
Town of Morrison	600	73	79	99
Kittredge Sanitation and Water District	240	65	108	75
Forest Hills Metropolitan District ¹	80	NR ²	285	170
Jefferson County Schools - Conifer High School	125	2	2	3
Conifer Center Sanitation Association	40	14	8	15
West/Brandt Foundation - Singing River Ranch	30	6	NR	NR
Brook Forest Inn	5	NR	NR	NR
Bear Creek Development Corp. - Tiny Town	5	NR	2	NR
Jefferson County Schools - Outdoor Lab School	5	NR	NR	NR
Bear Creek Cabins	5	1	8	NR
Geneva Glen ³	5	NR	NR	NR
Reserve Pool	100	100	100	100
Total	5,255	1,331	2,616	2,206

¹ The Forest Hills Metro District has a trading agreement with West Jefferson County Metro District and is in compliance with the control regulation.

² NR - No Report Provided to Association.

³ The Geneva Glen treatment plant is not discharging, but no report of activities has been provided to the Association.

Status of total maximum annual load (TMAL)

The Bear Creek Reservoir Control Regulation (Regulation #74, Appendix A) incorporates the TMAL that controls wasteload allocations for point sources and the allowable nonpoint source load. The TMAL will result in the Bear Creek Reservoir meeting all designed uses and classifications. 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 3.

Table 3 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.

Colorado Department of Transportation independent monitoring program

The Colorado Department of Transportation (CDOT) conducts a special surface water quality monitoring program along the U.S. 285 corridor through the Turkey Creek drainage. Phased construction activities have resulted in ongoing highway construction. CDOT does independent water quality monitoring to evaluate the effectiveness of BMPs being used during construction. CDOT continues involvement with the Association through the regular meeting program.

Turkey Creek, a major tributary to Bear Creek, flowing directly into Bear Creek Reservoir. Water-quality concerns in the Reservoir and downstream in the South Platte River have heightened sensitivity to activities in the Turkey Creek watershed that potentially impact water quality. U.S. Highway 285 is a major route into the Denver metropolitan area from the west. Growth and development in the area served by U.S. Highway 285 has resulted in increased traffic volumes and created the need for expansion of the roadway. The Colorado Department of Transportation has underway with a significant construction effort along parts of Highway 285 that transect the Turkey Creek drainage.

Following a 4-year (1995-98) cooperative monitoring program between DRCOG and CDOT, Exponent and TDS Consulting, CDOT contractors, are in their third year of a multi-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 Phases IV and V of the U.S. Highway 285 project. During 2000, particular focus of monitoring results (16 monitoring sites, 14 field surveys) was made in the Windy Point area of intense Phase-IV construction (effectiveness of a sedimentation basin), the Meyer Ranch Jefferson County Open-Space area (check-dams and upper end of Phase IV), and developing a baseline for Phase-V construction, which began in the fall.

The monitoring program also provides data reflecting the impacts of increased residential and commercial development throughout the watershed. Intermittent CDOT presentations before the Bear Creek Watershed Association (BCWA) during 2000 have 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 has provided to date to CDOT and BCWA interested parties. In addition, monitoring-program results and assessment of BMP effectiveness were included in a technical presentation at the annual symposium of the American Water Resources Association (Kenny et. al. 2001). The 2001 CDOT monitoring program is continuing, and plans are being made to extend the program through calendar year 2004. In addition, CDOT continues its involvement with the BCWA with monitoring-program status updates periodically at regular monthly meetings.

WATER QUALITY MONITORING AND MANAGEMENT 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.

Monitoring sites

The five routine monitoring stations and reservoir station (Table 4) are as follows:

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.

Table 4 Water Quality Monitoring Stations

2000 Water Quality Monitoring Stations		
Watershed Inflow	Reservoir	Reservoir Outflow
Turkey Creek (Inflow)	Reservoir (Top 1-m)	Bear Creek (Outflow)
Bear Creek (Inflow)	Reservoir (Middle)	Lower Bear Creek
	Reservoir (Bottom)	
	Reservoir Profile (0m)	
	Reservoir (1m)	
	Reservoir (2m)	
	Reservoir (3m)	
	Reservoir (4m)	
	Reservoir (5m)	
	Reservoir (6m)	
	Reservoir (7m)	
	Reservoir (8m)	
	Reservoir (9m)	
	Reservoir (10m)	

Parameters and sampling program

The watershed and reservoir 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 5.

Table 5 Water Quality Parameters

Parameter (units)	Watershed Inflows	Reservoir	Reservoir Outflow/ Downstream
Physical/Field			
Discharge (cu m/s)	X		X
Specific Conductance (umhos/cm)	X	X (Profile)	X
Secchi (meters)		X	
Dissolved Oxygen (mg/l)	X	X (Profile)	X
Temperature (C)	X	X (Profile)	X
Total Suspended Sediments (mg/l)	X	X	X
pH (standard unit)	X	X	X
Biological			
Fecal Coliform Bacteria (cts/100ml)	X	X	X
Chlorophyll a (ug/l)		X	
Phytoplankton		X	
Zooplankton		X	
Nutrients			
Ammonia (ug/l)	X		X
Nitrate (ug/l)	X	X	X
Total Particulate Phosphorus (ug/l)	X	X	X
Total Dissolved Phosphorus (ug/l)	X	X	X
Ortho-Phosphorus (ug/l)	X	X	X
Total Phosphorus (ug/l)	X	X	X

Temperature, dissolved oxygen and specific conductance are profiled at one-meter intervals from surface to bottom, which results in eight to ten measurements per sampling set. Depth sampling is done at three vertical stations for the remaining physical and chemical parameters. These integrated vertical station depths are as follows: 1) Surface at -0.5 meter; 2) Mid-water column at -5.0 meter; and 3) Bottom at +0.5 meter (about 8 meter).

Phytoplankton characterization is confined to near surface waters within the photic zone of the reservoir (top 3.5 meters of the water column). The algal monitoring includes genera characterization and a count of numerical density of major genera. A single zooplankton characterization is made in the growing season. An integrated water column sample is collected to estimate zooplankton genera. The zooplankton sampling

is used to determine any major changes in species composition and as a comparative tool with other front range reservoirs. The zooplankton assemblage is relatively stable in the reservoir and compares with other front range reservoirs.

There are 16 reservoir 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 that cannot be sampled due to poor ice conditions. If a winter monitoring set can't be taken due to unsafe conditions, then the monitoring set is added at a later time period to the annual monitoring program.

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.

City of Lakewood reservoir aeration program

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.

In conjunction with the aeration program, a hypolimnetic withdrawal management effort has been shown to also benefit water quality. The withdrawal method requires discharge gate management by the U. S. Army Corp of Engineers. Although this management program has not been used in recent years, the Association continues to support the strategy as an additive management program that should be used with aeration.

Septic 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.

WATERSHED AND RESERVOIR TRENDS

Reservoir trophic status

Bear Creek Reservoir has a water quality goal established by the Water Quality Control Commission instead of a numeric standard. The reservoir goal, as defined by the site-specific narrative standard, listed in the Watershed Control Regulation (WQCC 1996) 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 annual monitoring program characterizes reservoir quality in relation to the narrative goal. The use of trophic indicators is one method to determine compliance with the control regulation. The reservoir program evaluates seasonal as well as long-term changes in the following three categories:

1. Nutrient (nitrogen and phosphorus) concentrations and trends;
2. Indicator biological characteristics (phytoplankton and zoology);
3. Characterization of mass loading into reservoir.

Two 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 two models differ in that Walker's TSI bases the scale on chlorophyll- α levels rather than Secchi depth levels to correct for non-algal light-attenuating factors. Carlson's trophic state index is based on phosphorus limited northern temperate lakes. The Carlson TSI shows the reservoir trophic index has shifted toward the eutrophic-mesotrophic boundary, but remains a eutrophic waterbody (Figure 1). Like Carlson's TSI, Walker's TSI was also developed based on data from northern temperate lakes.

The Walker seasonal TSI evaluation shows a similar trend to Carlson (Figure 2). Although nutrient total loading was reduced in 2000, the trophic index shows a slight decrease in overall quality. The trophic state in the reservoir remains in flux and additional monitoring at the current level of effort is still required. Based on the historical trend analysis and all water quality models, the reservoir is shifting toward the desirable mesotrophic-eutrophic system from the eutrophic-hypereutrophic condition measured during the *Bear Creek Reservoir Clean Lake Study*. Over the recent period

of data record, the overall trend in reservoir trophic status classification is a eutrophic state.

Figure 1 Carlson TSI

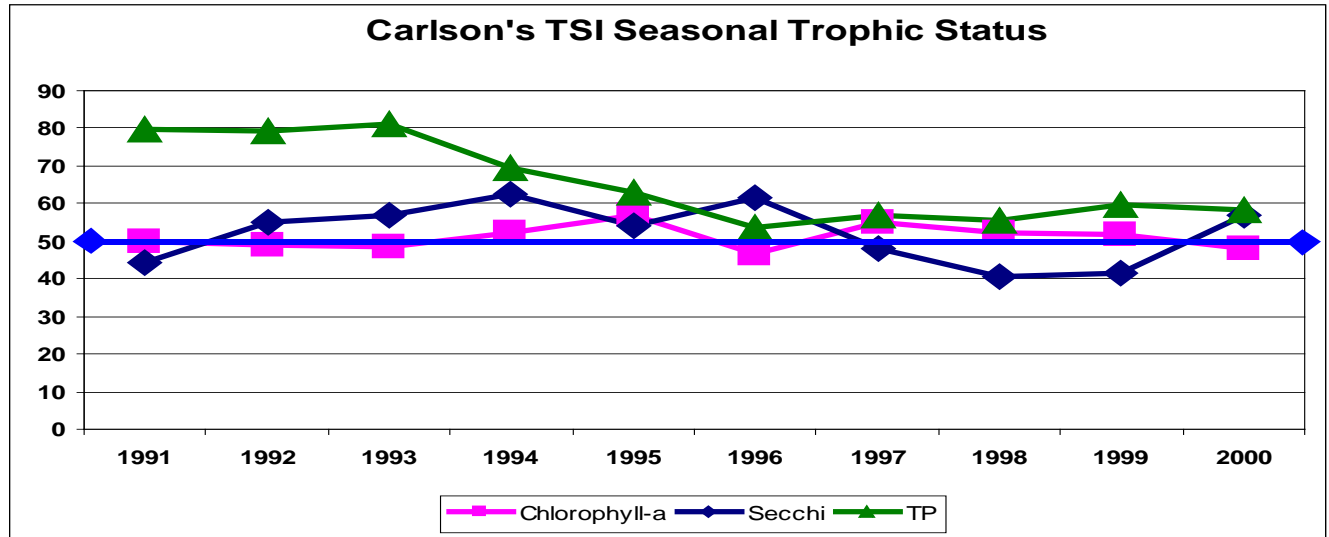
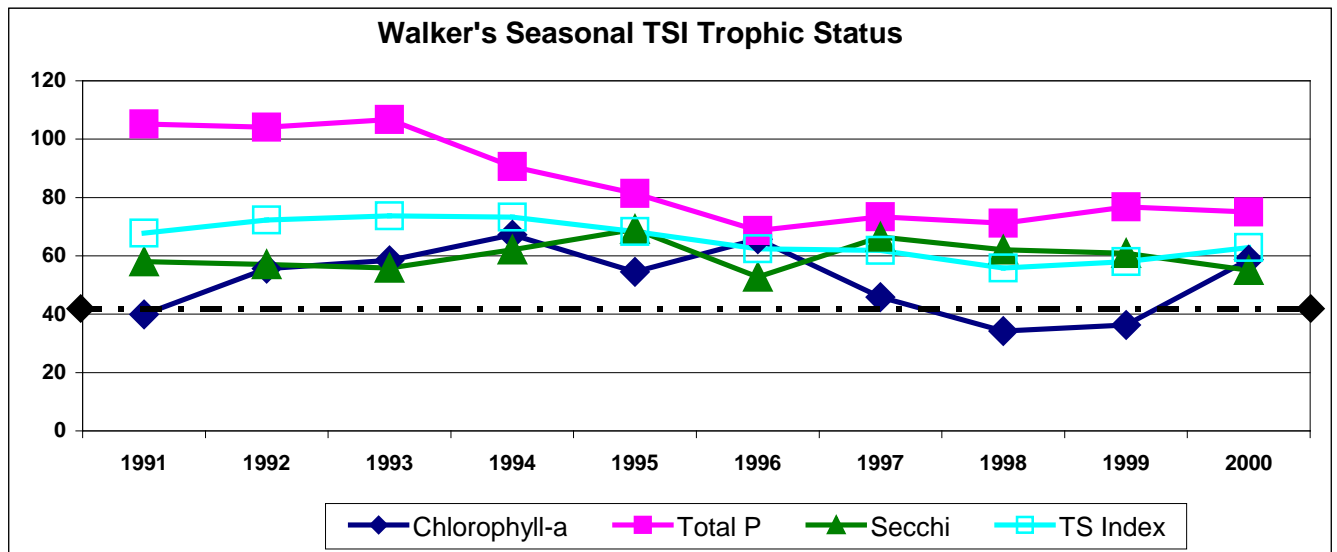


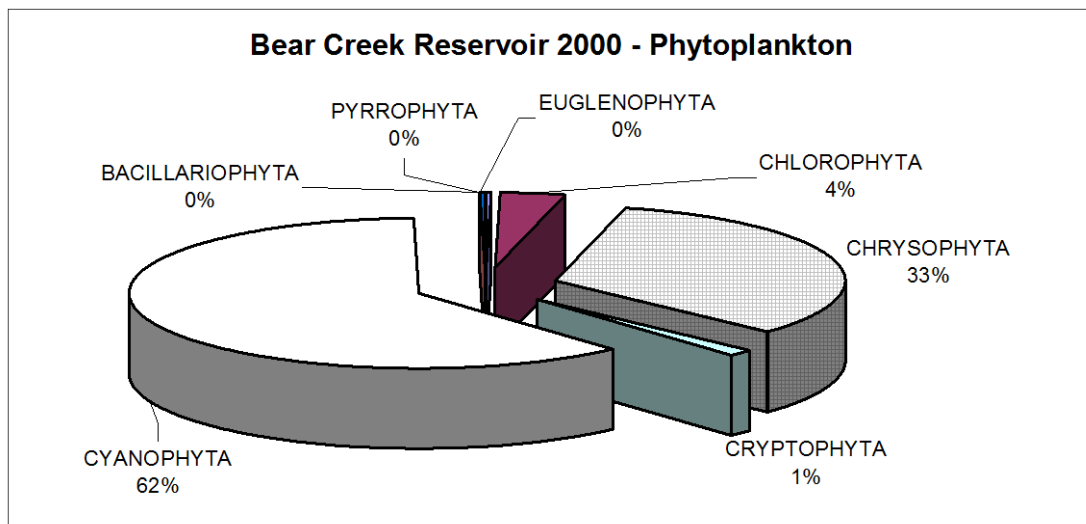
Figure 2 Walker Seasonal TSI Trophic Trend



2000 phytoplankton distributions

The biological integrity of Bear Creek Reservoir can be 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) can indicate declining water quality. In 2000, the blue-green species made up on the average 62% of plants present in the reservoir. Fourteen species of blue-green algae were found in the reservoir with a maximum total density of 139,000 cells/ml in the August 2000 sample data. This total density suggests a minor algal bloom. No fish kills or problems were reported for the reservoir in August or any other month. The Chrysophyta or golden algae/diatoms made up 33% of the remaining species. Certain species of diatom can be problematic from a water supply perspective. The zooplankton species are typical of front-range reservoirs.

Figure 3 2000 Phytoplankton Distributions in Reservoir



2000 monitoring program

The 2000 monitoring program trophic indicators for the reservoir are shown in Table 6. Figures 3-7 shown some water quality trends for selected parameters from the 2000-monitoring program. The discharge rates for Turkey Creek were relatively low throughout 2000 (Figure 3 and 4). The dissolved oxygen profiles show low oxygen levels are still occurring in bottom waters of the reservoir late in the growing season (Figure 6). A total phosphorus flux from bottom sediments occurred from late August through October (Figure 5).

Large suspended sediment loading occurred at three distinct periods from the Turkey Creek drainage (Figure 7). The Association has been monitoring construction activities

associated with the Willow Springs North development site. The Willow Springs North development on the lower Turkey Creek drainage is a major source of sediments reaching Bear Creek Reservoir. The excessive erosion caused by site development and subsequent sediment loading into Turkey Creek is having a measurable water quality impact on the reservoir. Consequently, the Association, as the water quality management agency, requested Jefferson County require additional mitigation measures to reduce on-site erosion and downstream sedimentation.

Reservoir loading for total phosphorus, nitrate and suspended sediments are shown in Figures 8, 9 and 10, respectively. The total phosphorus, nitrate and suspended sediment loadings to the reservoir are substantially reduced over historic conditions.

Table 6 Bear Creek Reservoir 2000 - Selected Trophic Indicators

Trophic Indicator	Value in Reservoir
Average Growing Season Chlorophyll-a [ug/l (surface waters only)]	30.9
Peak Chlorophyll-a [ug/l]	105.0
Average Total Phosphorus [ug/l]	60.3
Peak Total Phosphorus [ug/l]	104.4
Peak Ortho Phosphorus [ug/l]	81.1
Secchi Depth [meters]	2.4
Peak Total Suspended Sediments	39.5
Phytoplankton Species Co-dominant Species	Green – <i>Chlorella minutissima</i>
	Chrysophyta - <i>Chromulina mikroplankton</i>
	Bluegreen - <i>Woronichinia compacta</i>
	Bluegreen - <i>Microcystis aeruginosa</i>
Peak Phytoplankton Density	139,000 cells/ml (August)

Figure 4 2000 Discharge Rates

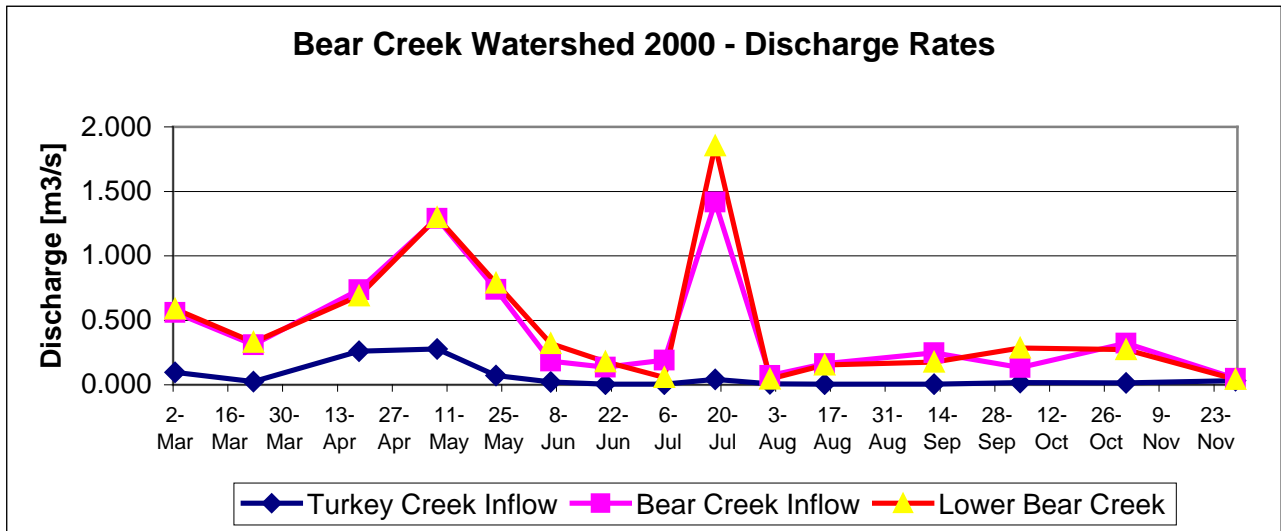


Figure 5 Estimated Inflows from Turkey Creek and Bear Creek

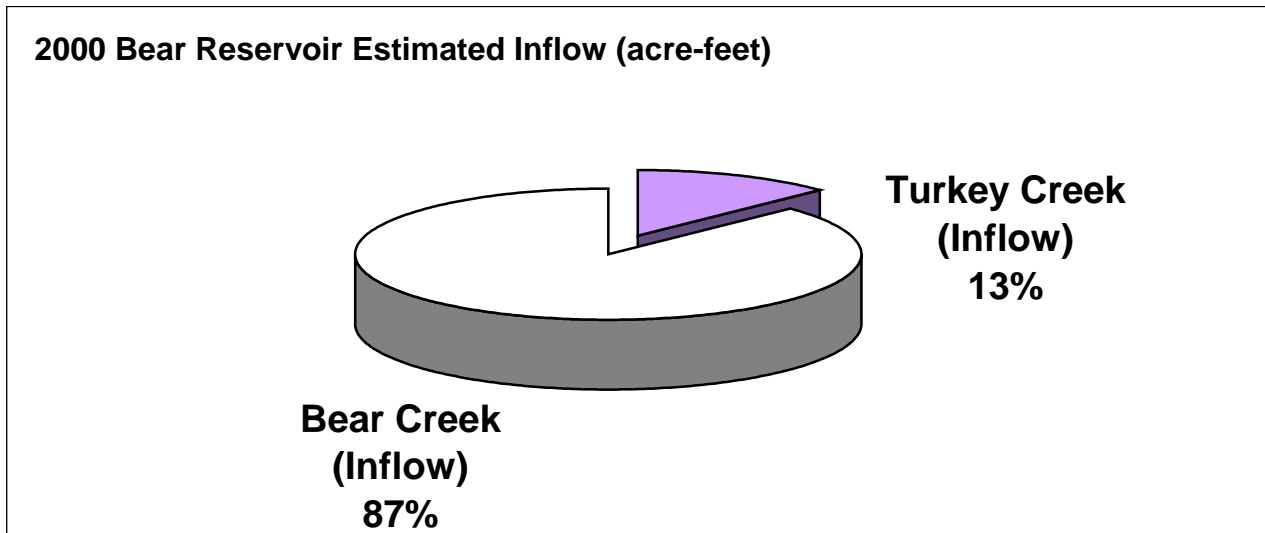


Figure 6 2000 Total Phosphorus Trends

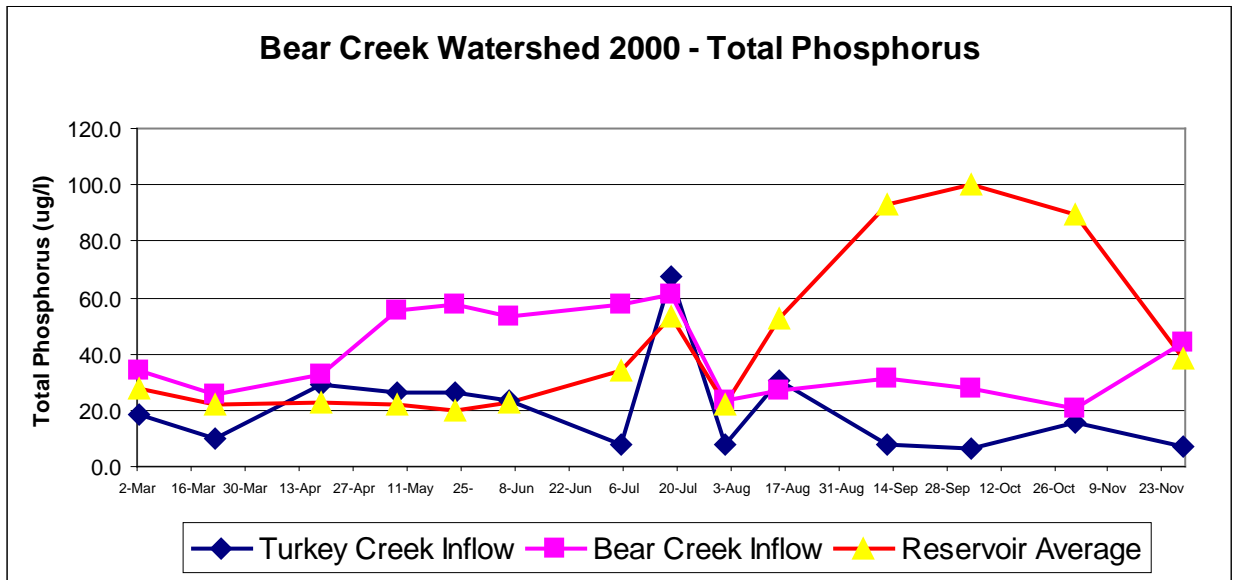


Figure 7 2000 Dissolved Oxygen Profiles

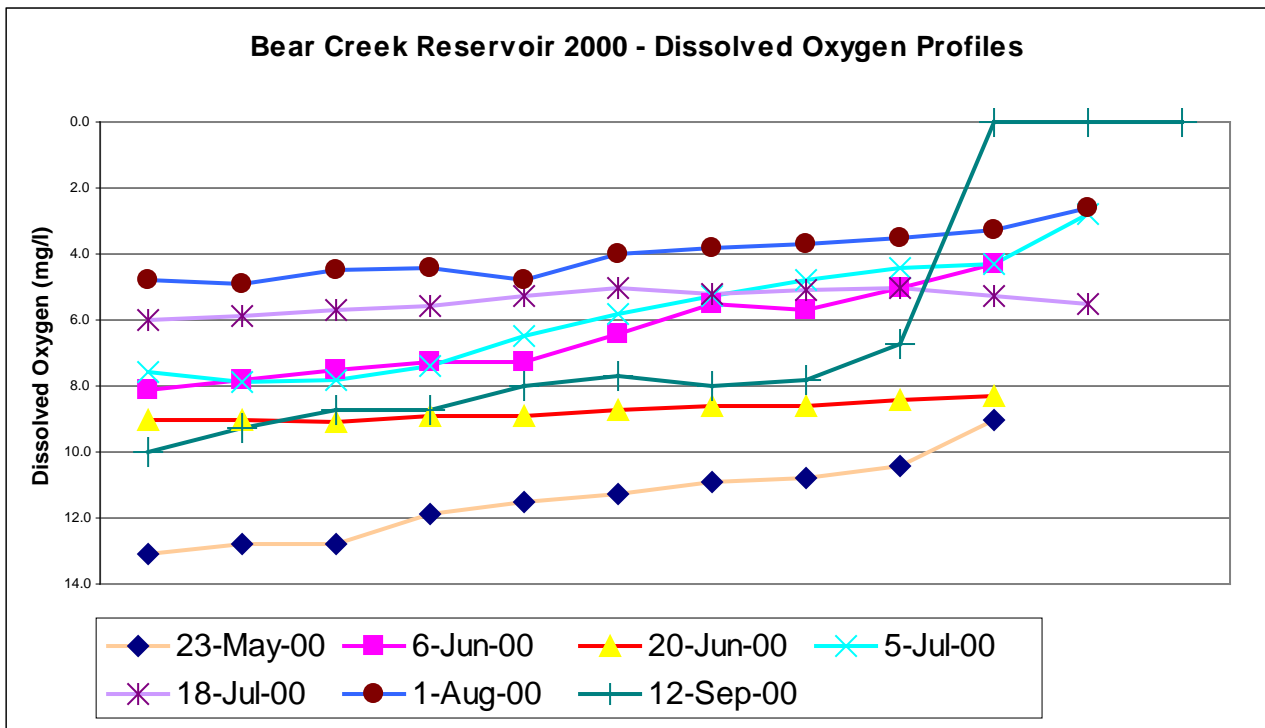


Figure 8 2000 Total Suspended Solids Trends

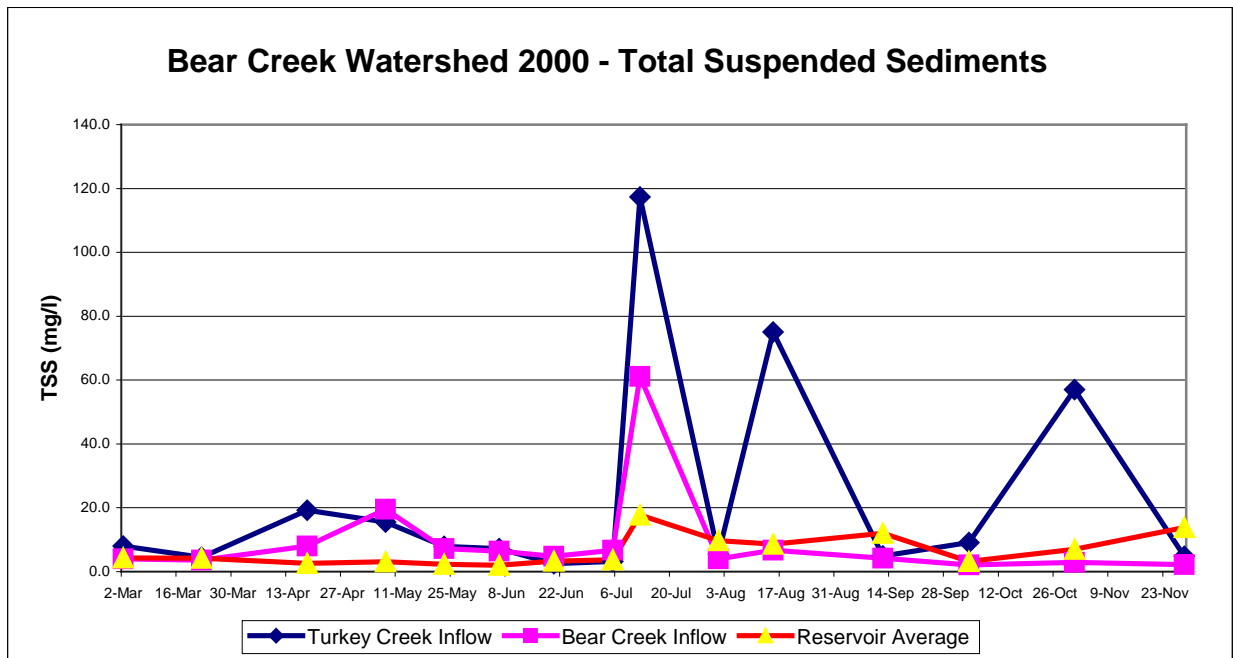


Figure 9 2000 Total Phosphorus Loading

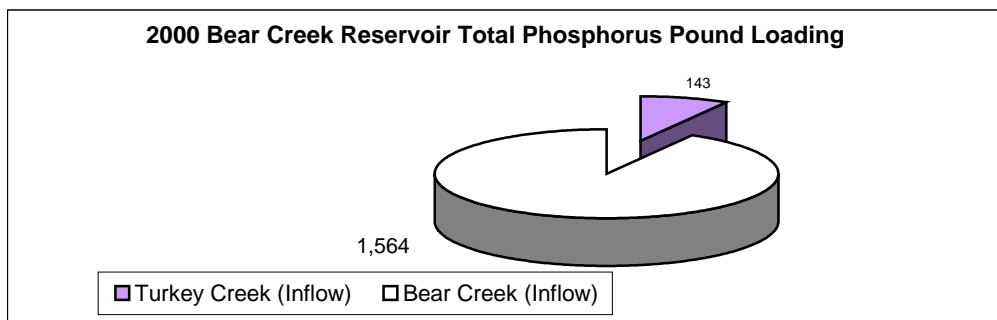


Figure 10 2000 Nitrate Loading

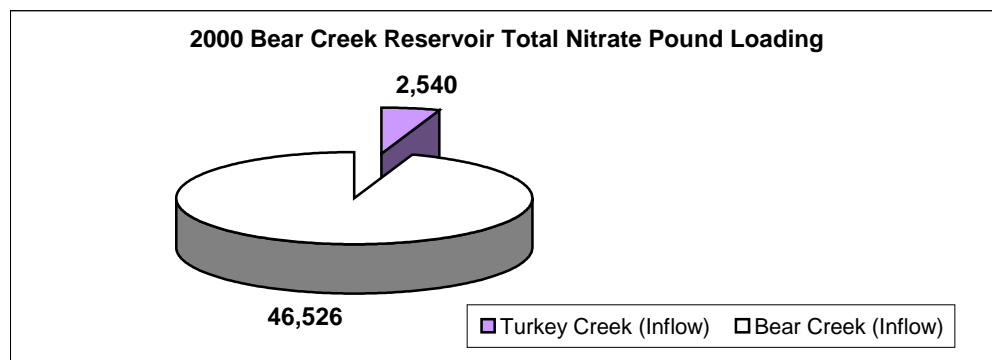
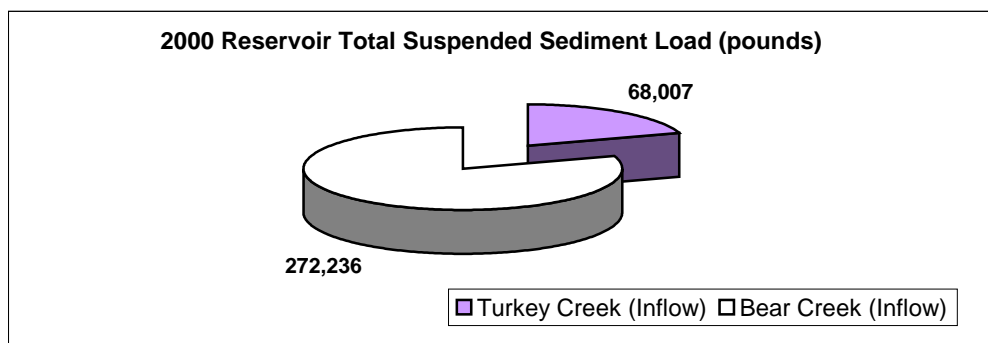


Figure 11 2000 Suspended Sediment Loading



Long-term water quality trends

The water quality goal for the watershed is to obtain a mesotrophic/eutrophic state in the reservoir. Implementation of the watershed management program has had a significant impact on the water quality in the reservoir. Figures 11-16 and Table 7 characterize selected water quality trends.

Table 7 Bear Creek Reservoir Mean Annual Concentrations 1991-2000

Parameter	Site	Mean Annual Concentrations										
		1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	91-00 Mean
Chlorophyll-a (ug/L)	Reservoir 0-2.5 m	17.7	26.0	13.7	29.7	9.4	17.1	8.2	4.9	6.2	23.9	15.7
	Reservoir 5-10 m	19.8	15.5	5.9	17.0	6.2	10.3	2.4	5.4	5.5	8.9	9.7
	Water Column Mean	18.7	20.8	9.8	23.4	7.8	13.7	5.3	5.2	5.9	14.1	12.5
Nitrate-Nitrogen (ug/L)	Reservoir 0-2.5 m	442	289	504	382	474	578	393	388	224	431	411
	Reservoir 2.5-10 m	381	282	451	356	502	589	365	372	220	443	396
	Reservoir 5-10 m	341	228	333	308	503	561	341	342	231	483	367
	Water Column Mean	388	266	429	349	493	576	366	367	225	441	390
Total Phosphorus (ug/L)	Reservoir 0-2.5 m	144	146	175	83	34	29	38	33	34	59	78
	Reservoir 2.5-10 m	138	140	164	79	37	33	45	40	37	57	77
	Reservoir 5-10 m	270	201	240	99	52	66	86	69	54	56	119
	Water Column Mean	184	162	193	87	41	43	56	47	42	60	92
Total Suspended Solids (mg/L)	Reservoir 0-2.5 m	6	7	4	9	6	4	12	6	7	6	7
	Reservoir 2.5-10 m	8	6	6	8	7	4	15	8	9	5	8
	Reservoir 5-10 m	19	8	5	9	13	7	22	12	12	8	12
	Water Column Mean	11	7	5	9	9	5	16	9	9	6.4	9
Secchi Depth (m)	Reservoir	2.17	2.1	2.84	1.79	2.14	2.51	1.7	1.8	1.8	2.4	2.1

Figure 12 Nitrate Input and Outflow Trends

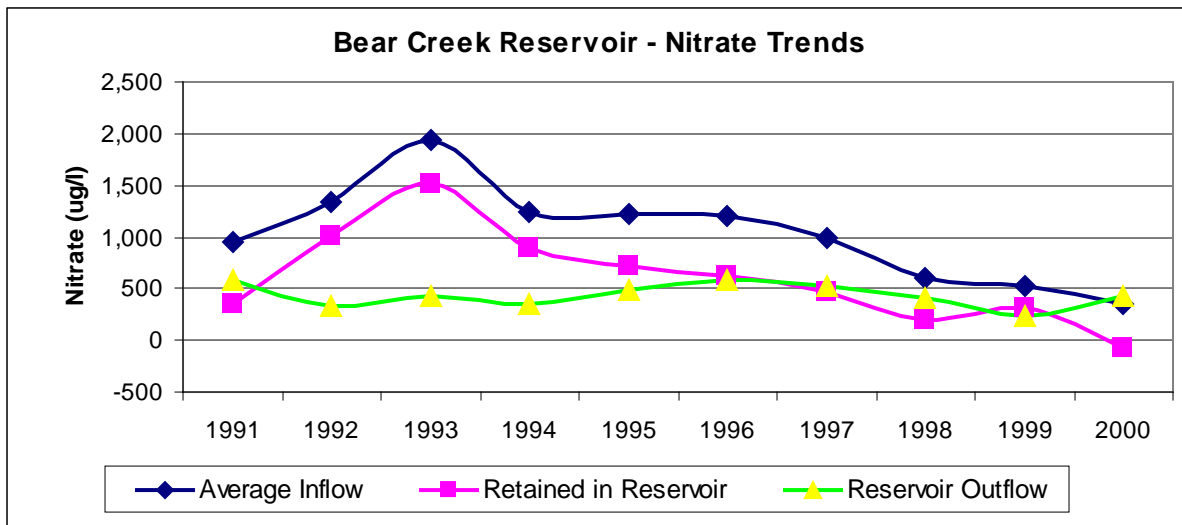


Figure 13 Reservoir Average Nitrate Trend

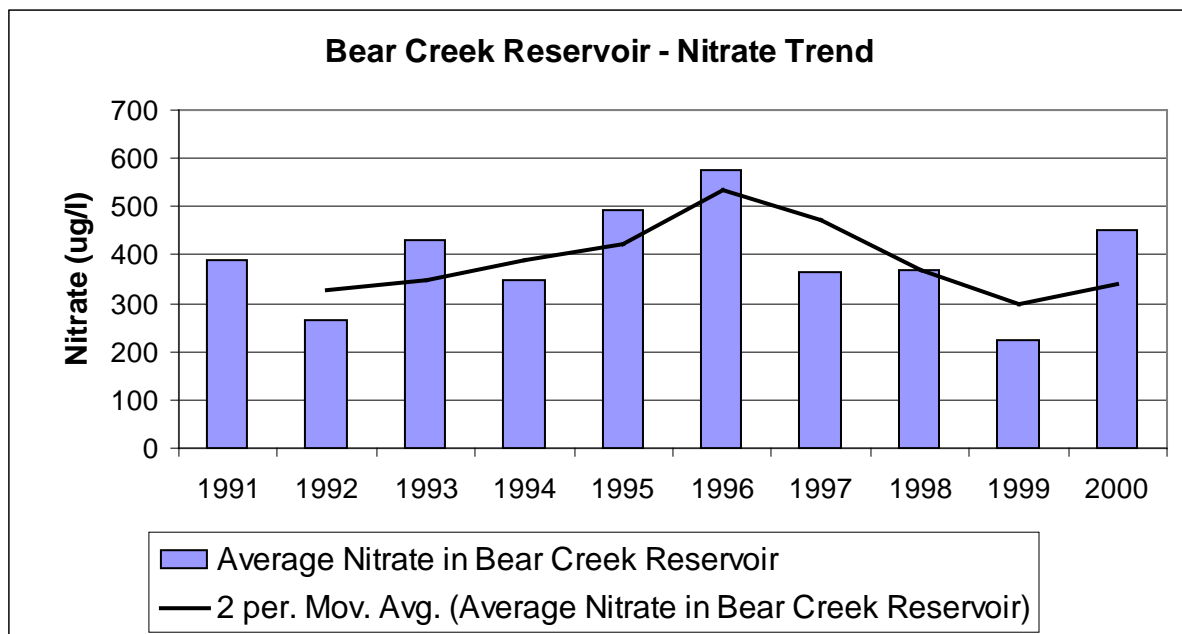


Figure 14 Total Phosphorus Averages

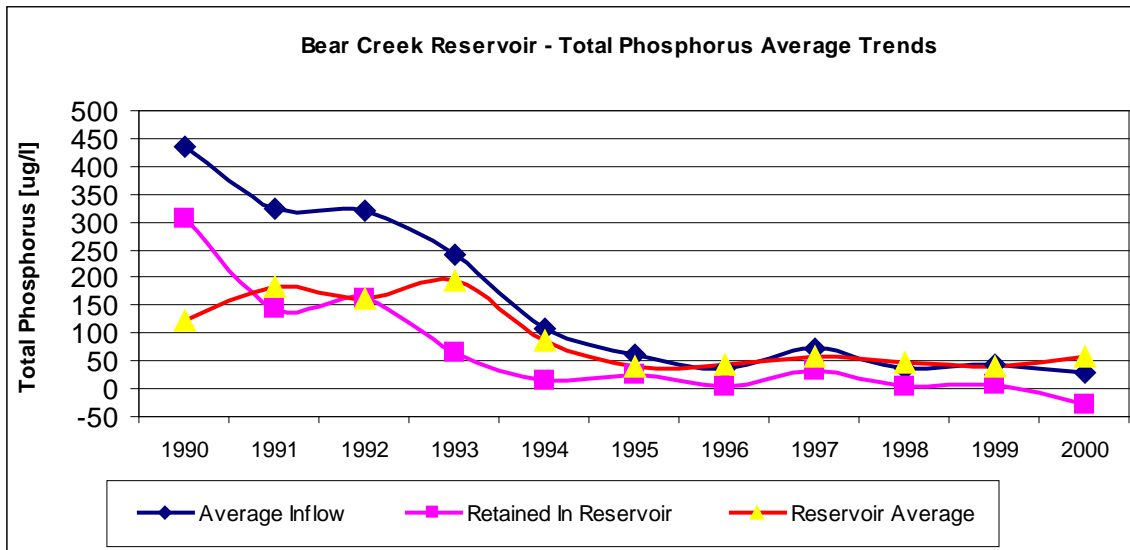


Figure 15 Reservoir Total Phosphorus Trend

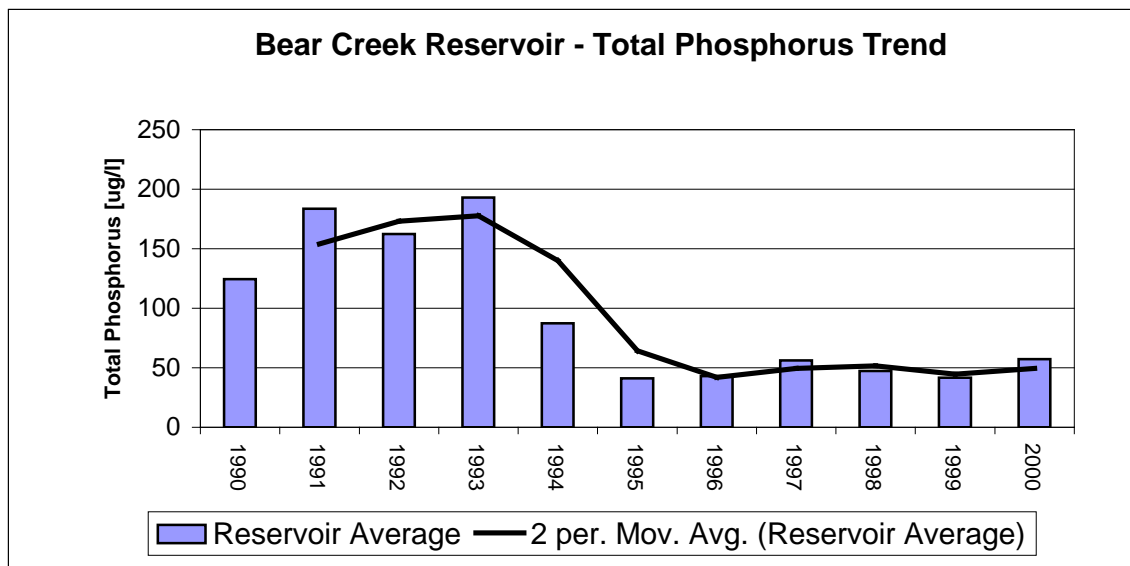


Figure 16 Total Phosphorus Inflow Trend

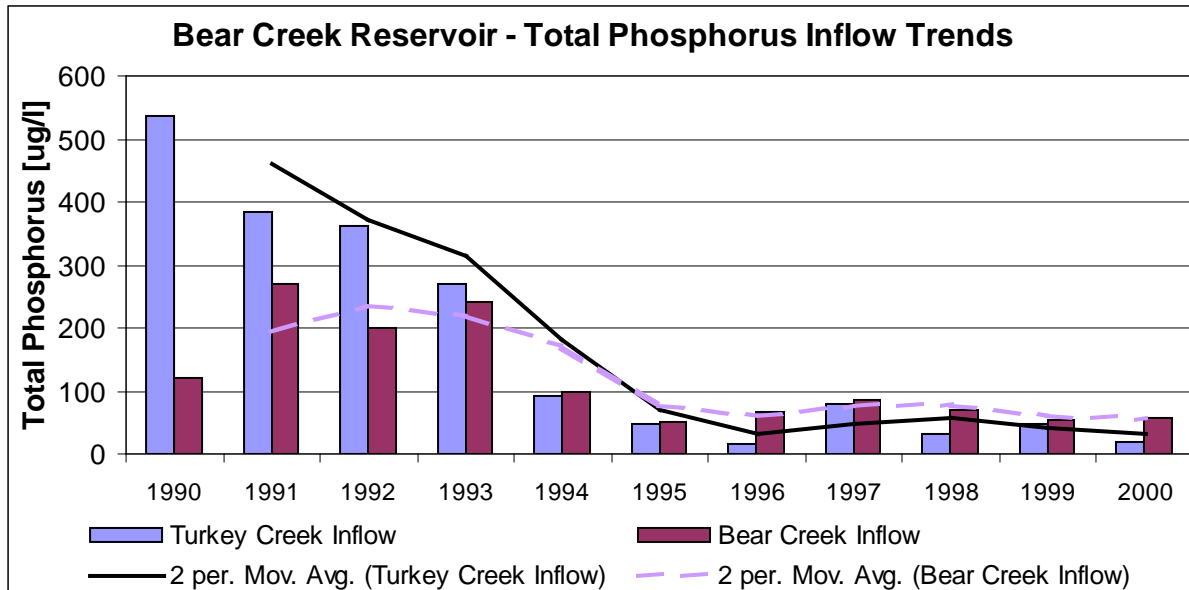
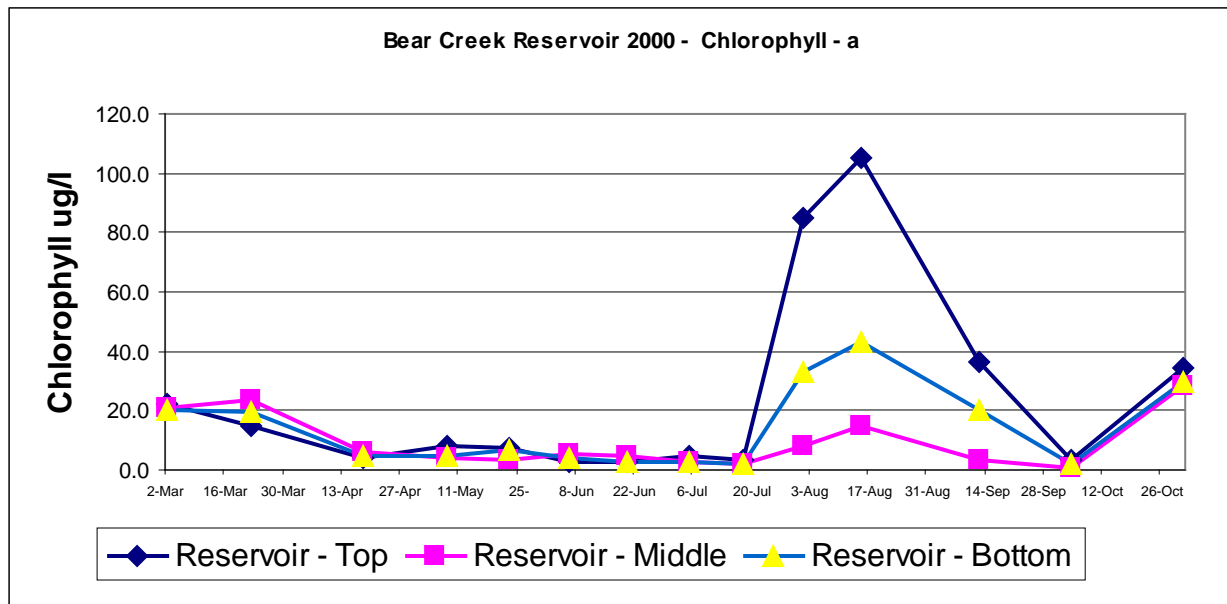


Figure 17 Reservoir Chlorophyll Trend



CONTROL REGULATION REVIEW AND ASSOCIATION RECOMMENDATION

The Association reviewed the Bear Creek Reservoir Control Regulation (Regulation #74) for editorial comments and potential changes. Based on this Association review, no recommended changes are necessary as part of this 2001 triennial review.

The Association intends to maintain the current level of water quality monitoring and reporting. The monitoring water quality assurance plan will be reviewed by the Association in conjunction with the Water Quality Control Division staff and updated as necessary.

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