CHERRY CREEK RESERVOIR

2003 ANNUAL AQUATIC BIOLOGICAL-
NUTRIENT MONITORING STUDY AND
AND COTTONWOOD CREEK PHOSPHORUS
REDUCTION FACILITY MONITORING

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INTRODUCTION

An inter-governmental agreement was executed in 1985 by several local governmental entities within the Cherry Creek basin to form the Cherry Creek Basin Water Quality Authority (CCBWQA). This Authority was created for the purpose of coordinating and implementing the investigations necessary to maintain the quality of water resources of the Cherry Creek basin while allowing for further economic development. Based on a clean lakes water study (Denver Regional Council of Governments [DRCOG] 1984), the Colorado Water Quality Control Commission (CWQCC) set standards for phosphorus, and a TMDL for phosphorus. An in-lake phosphorus standard of 35 µg/L was adopted to maintain a seasonal mean chlorophyll *a* goal of 15 µg/L. Subsequently, a phosphorus TMDL was prepared for the reservoir allocating loads among point sources, background, and nonpoint sources within a net annual load of 14,270 lbs total phosphorus.

The Cherry Creek Basin Master Plan (DRCOG 1985), approved by the CWQCC in 1985, was adopted in part as the "Regulations for Control of Water Quality in Cherry Creek Reservoir" (Section 4.2.0, 5C.C.R.3.8.11). An annual monitoring program (In-Situ, Inc. 1986, as amended, ASI 1994 a and b) was implemented at the end of April 1987 to assist in the assessment of several aspects of the Master Plan. These monitoring studies have included long-term monitoring of 1) nutrient levels within the reservoir and from tributary streams during base flows and stormwaters, 2) nutrient levels in precipitation, and 3) chlorophyll *a* levels within the reservoir. In addition, a number of incidental studies have been conducted using such methods as benthic respirometers and limnocorrals.

In September 2000, following a hearing before the CWQCC, the standard for Cherry Creek Reservoir was changed to a July - September mean value of 15 µg/L of chlorophyll *a* to be met nine out of ten years, with an underlying total phosphorus goal of 40 µg/L, also as a July - September mean. In May 2001 at the CWQCC hearing, a new control regulation was adopted for the Cherry Creek Reservoir which maintained the annual allowable total phosphorus load (TMAL) of 14,270 lbs/year as part of a “phased-TMDL” for the reservoir.

In 1994, Chadwick Ecological Consultants, Inc. (CEC) was retained by the CCBWQA to conduct annual aquatic biological and nutrient analyses on Cherry Creek Reservoir and selected tributaries. Results have been summarized in annual monitoring reports (CEC 1995 - 2003). Through 2000, these data were also technically reviewed by Dr. John Jones of the University of Missouri-Columbia and with his latest review presented to the Authority in his annual reports (Jones 1994 - 1999, 2001). The present study was designed to continue the characterization of the potential relationships between nutrient loading (both in-lake and external) and reservoir productivity. The specific objectives of this annual monitoring study include the following:

- Determine the concentrations of selected nutrients, primarily nitrogen and phosphorus compounds, in Cherry Creek Reservoir and various streams flowing into the reservoir, and the reservoir outflow.

- Determine the pounds of phosphorus entering Cherry Creek Reservoir from streams and precipitation and leaving the reservoir through its outlet.

- Determine biological productivity in Cherry Creek Reservoir, as measured by algal biomass (chlorophyll *a* concentrations) and algal densities. In addition, determine species composition of the algal community.

- Determine potential relationships between the nutrient levels and biological productivity in Cherry Creek Reservoir through correlation of the various measurements made during the study.

- Assess the effectiveness of pollutant reduction facilities (PRF) to reduce phosphorus loads into the reservoir.

Note that in past reports, CEC used provision (preliminary) inflow estimates from the COE when estimating inflows and loads to the reservoir. In 2002, CEC became aware that these provisional estimates had been finalized by the COE, as summarized on their website. To ensure accurate numbers, CEC revised inflow and load estimates for 1992 - 2001 as part of last year's report to match the more accurate, and finalized, inflow values from the COE.

STUDY AREA

Cherry Creek Reservoir was impounded in 1950 by the U.S. Army Corps of Engineers (COE) to protect the City of Denver from flash floods that may originate in the reservoir's 995 km^2 drainage basin. The reservoir has maintained a surface area of approximately 350 ha (approximately 850 acres) since 1959. The reservoir and surrounding state park have also become an important recreational site, providing opportunities for activities which include fishing, boating, swimming, bicycling, bird watching, and hiking.

Sampling Sites

Sampling in 2003 was conducted at ten sites, including three sites in Cherry Creek Reservoir, six sites on tributary streams, and one site on Cherry Creek downstream of the reservoir (Fig. 1). The sampling sites are summarized below:

Cherry Creek Reservoir

CCR-1 This site is also called the Dam site, and was established in 1987. CCR-1 corresponds to the northwest trident within the lake (Knowlton and Jones 1993). Sampling was discontinued at this site in 1996 following determination that this site exhibited similar characteristics to the other two sites in this well-mixed reservoir. Sampling recommenced in July 1998 at the request of consultants for Greenwood Village.

CCR-2 This site is also called the Swim Beach site, and was established in 1987. Site CCR-2 corresponds to the northeast trident within the lake (Knowlton and Jones 1993).

CCR-3 This site is also called the Inlet site and was established in 1987, corresponding to the south trident within the lake (Knowlton and Jones 1993).

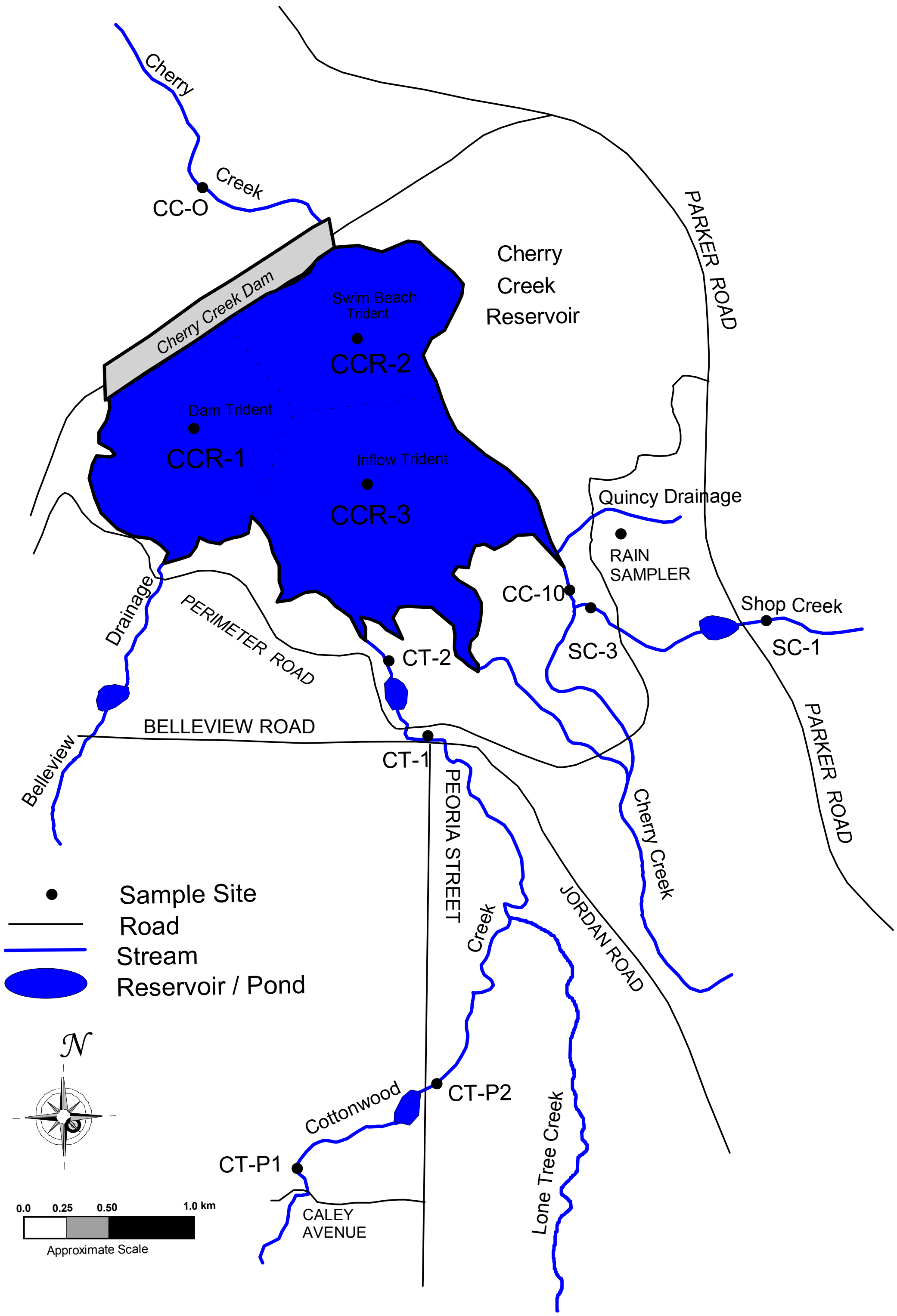

FIGURE 1: Sampling sites on Cherry Creek Reservoir and selected streams, 2003.

Shop Creek

SC-3 This site was established on Shop Creek in 1990 upstream of the Perimeter Road and downstream of the then new Shop Creek detention pond and most of the wetland system. This site was moved just downstream of the Perimeter Road in 1994 and again farther downstream to a location just upstream of its confluence with Cherry Creek in 1997. This site serves to monitor the water quality of Shop Creek as it joins Cherry Creek.

Cherry Creek

CC-10 This site was originally established in 1987 on Cherry Creek near the historic USGS "Melvin" gage (roughly due west of the intersection of Parker Road and Orchard Road). This location is in an area of Cherry Creek that frequently becomes dry during summer months as a result of the natural geomorphology and alluvial pumping for domestic water supply (Halepaska & Associates, Inc. [JCHA] 1999, 2000).

In 1995, this site was relocated farther downstream between the Perimeter Road and the reservoir, approximately ½ km upstream of the reservoir. This site was moved still farther downstream in 1996, just upstream of the confluence with Shop Creek and closer to the reservoir. In 1999, it was moved below the confluence with Shop Creek to eliminate the effect of a stream crossing on the CC-10 hydrograph. Since 1995, Cherry Creek has been monitored in a reach with perennial flow, allowing for more accurate monitoring of water quality and surface flows in Cherry Creek before it enters the reservoir.

This site was previously called CC-I, but was renamed CC-10 to place it in context with concurrent monitoring in Cherry Creek mainstem upstream of the reservoir (JCHA 1999 - 2003). Since 1994, monthly surface flow and water quality data have been collected at ten sites on Cherry Creek upstream of the Perimeter Road (JCHA 1999 - 2003). These ten sites extend from the Castlewood site in Castlewood Canyon downstream to Site CC-9 at the Perimeter Road.

CC-O This site was established in 1987 on Cherry Creek downstream of Cherry Creek Reservoir and upstream of the Hampden Avenue-Havana Street junction in the Kennedy Golf Course (near the USGS gage). Site CC-O monitors the water quality of Cherry Creek downstream of the reservoir outlet.

Cottonwood Creek

CT-P1 This site was established in 2002 and is located just north of where Caley Avenue crosses Cottonwood Creek, west of Peoria Street. This site monitors the water quality of Cottonwood Creek before it enters a new wetland PRF, also created in 2001/2002 on the west side of Peoria Street.

CT-P2 This site was established in 2002 and is located downstream from the PRF, on the east side of Peoria Street. This site monitors the effectiveness of the PRF on water quality.

CT-1 This site on Cottonwood Creek was established in 1987 where the Cherry Creek Park Perimeter Road crosses the stream. It was chosen to monitor the water quality of Cottonwood Creek before it enters the reservoir. During the fall/winter of 1996, a PRF, consisting of a water quality/detention pond and wetland system, was constructed downstream of this site. As a result of the back-flow from this pond, this site was relocated farther upstream near Belleview Avenue in 1997.

CT-2 This site was established in 1996 and is located downstream from the PRF on Cottonwood Creek. This site monitors the effectiveness of this structure on water quality and monitors the quality of Cottonwood Creek before it enters the reservoir.

METHODS

Sampling Methodologies

Field and calculating methods for monitoring the reservoir and study sites follow the Cherry Creek Reservoir Sampling and Analysis Plan (CEC 2003) (Appendix A).

Reservoir Sampling

The general sampling schedule included regular sampling trips to the reservoir at varying frequencies over the annual sampling period, as outlined below, with increased sampling frequency during the summer growing season. Sampling was not conducted in January, February and December 2003 due to unsafe ice conditions on the reservoir.

Sampling Trips per Sampling Period

Sampling Period	Frequency	Trips/Period
Oct - Apr	Monthly	4
May - Sept	Bi-Monthly	11
	Total	15

During each sampling episode on the reservoir, three main tasks were conducted, including 1) determining water clarity, 2) taking depth profile measurements for temperature, dissolved oxygen, pH, conductivity, and oxygen-reduction potential, and 3) collecting water samples for chemical and biological analyses.

Water Clarity

Transparency was determined using a Secchi disk and double deck photometer. Detailed methods of both instruments can be found in the Sampling and Analysis Plan located in Appendix A.

Profile Measurements

The second task involved taking dissolved oxygen, temperature, conductivity, and pH measurements every meter from the surface to near the bottom of the reservoir to develop depth profiles for each site during each sampling episode. Readings were taken with a YSI meter, Model #600 XL multi-probe meter. This meter was calibrated monthly to ensure accurate measurements.

Water Sampling

Water samples for nutrient, phytoplankton, and chlorophyll *a* analyses were collected at the three lake sites. The Sampling and Analysis Plan in Appendix A outlines the detailed methods used to collect lake water samples, as well as some of the laboratory methods in sample handling and preparation.

Fish Population Data

As in the past, this monitoring study has also reviewed fish stocking and population data collected by the Colorado Division of Wildlife (CDOW). As part of their sampling schedule to reduce mortality to a walleye brood-stock population in Cherry Creek Reservoir, CDOW had been sampling fish populations only every two to three years. No sampling took place in 2002 or 2003.

Stream Sampling

Low-Flow/Ambient Sampling. Standard sampling was conducted according to the schedule below during the regular reservoir sampling trips to Cherry Creek Reservoir. This sampling was performed in order to provide information during non-storm event periods, corresponding to the low-flow ambient samples collected in past studies. Monthly samples are assumed to be representative of non-storm, low-flow events.

Sampling Trips per Sampling Period

Sampling Period	Frequency	Trips/Period
Jan - Dec	Monthly	12

Storm Sampling. Storm events were sampled at Site CC-10 on Cherry Creek, Sites CT-1, CT-2, CT-P1, and CT-P2 on Cottonwood Creek, and Site SC-3 on Shop Creek during the 2003 sampling season (Table 1). A detailed outline of storm sampling protocols can be found in Appendix A.

TABLE 1: Number of storm samples taken from tributary streams to Cherry Creek Reservoir, 2003.

	Site						
	SC-3	CC-10	CC-O	CT-1	CT-2	CT-P1	CT-P2
Number of Storm Samples	4	4	1	5	5	5	5

Surface Hydrology

Pressure transducers attached to ISCO Series 4200 or 6700 flowmeters measured and recorded water levels (stage) at six sites on three tributaries to Cherry Creek Reservoir (Fig. 1). These flow meters recorded water depth in 15-minute intervals year round. Streamflow (discharge) was estimated at these six sites using stage-discharge relationships developed for each stream site. Periodic stream discharge measurements were taken using a Marsh McBirney Model 2000 flowmeter. For a complete description of streamflow determination, see Appendix D.

Laboratory Procedures

Nutrient Laboratory Analysis

Nutrient analyses for the water collected in the study, as described above, were conducted by the C&A laboratory in Littleton, Colorado. Randomly selected water samples were sent to James Saunders, University of Colorado, Center of Limnology, for chemical analyses as a quality assurance check. Table 2 lists the parameters analyzed and the methods that were used. Detailed methodologies and laboratory QA/QC procedures are available from C&A.

TABLE 2: Parameter list, laboratory, method number, and detection limits for chemical and biological analyses of water collected from Cherry Creek Reservoir and tributaries, 2003.

Parameter	Lab	Method	Detection Limit
Total Phosphorus	C&A	QC 10-115-01-1-U	2 µg/L
Total Dissolved Phosphorus	"	QC 10-115-01-1-U	2 µg/L
Orthophosphorus	"	QC 10-115-01-1-T	3 µg/L
Total Nitrogen	"	APHA 4500-N B (modified)	4 µg/L
Total Dissolved Nitrogen	"	APHA 4500-N B (modified)	4 µg/L
Ammonia	"	QC 10-107-06-3-D	3 µg/L
Nitrate and Nitrite	"	QC 10-107-04-1-B	5 µg/L
TSS	"	APHA 2540D	4 mg/L
TVSS	"	APHA 2540E	4 mg/L
Chlorophyll *a*	"	APHA 10200 H (modified)	1 µg/L

Biological Laboratory Analysis

Biological analyses of the samples collected in the study were conducted by C&A and the University of Colorado Center of Limnology. These analyses included species identifications and counts for phytoplankton, and analysis of chlorophyll *a*. The methods for these analyses, with appropriate QA/QC procedures, are available from C&A. These analyses provided cell counts per unit volume (cells/mL) and chlorophyll *a* concentrations in µg/L.

Quality Assurance/Quality Control

To ensure data quality, a number of quality assurance checks were used. During the first half of the field season, a duplicate sample was taken at one of the reservoir sites and at Site SC-3, resulting in approximately 14% of the samples each sampling episode having a QA duplicate. These duplicate samples were analyzed by C&A. In mid-June, the TAC requested a change in the QA program. From mid-June through November, only the one randomly selected reservoir duplicate was shipped to James Saunders for analysis at his laboratory at CU. No duplicate samples were taken from stream sites. This resulted in approximately 7% of the samples having a QA duplicate, but still provided an independent assessment of lake water nutrient analyses conducted by C&A.

In addition, field sampling quality control included the use of a field blank. This field blank contained laboratory grade deionized water in a sample container identical to those used in the field collections and was carried through the entire sampling episode. The cap of this container was removed at each reservoir site and left open during the regular sampling effort at that site. Upon completion of sampling at that site, the cap was replaced. One field blank was used for every sampling trip. The field blanks and duplicate samples were analyzed for all the parameters, identical to a routine sample. Chain of custody procedures were observed during the field sampling and delivery of samples to C&A, and for samples shipped to James Saunders.

Detailed methods and results of QA/QC checks performed on the water quality data from the reservoir for 2003, with comparison between labs, are located in Appendix F. This analysis showed that results from the analytical labs were quite similar. As such, all values reported herein are based on the average of results from both laboratories, unless otherwise noted.

Calculation of Phosphorus Loading

Phosphorus loading to Cherry Creek Reservoir from streams and precipitation was estimated for the 2003 calendar year using data on streamflow and precipitation, and their respective concentrations of phosphorus. Detailed discussion of the streamflow measurements and derivation of loads can be found in Appendix D.

Note that in past reports, CEC used provision (preliminary) inflow estimates from the COE when estimating inflows and loads to the reservoir. In 2002, CEC became aware that these provisional estimates had been finalized by the COE, as summarized on their website. To ensure accurate numbers, CEC revised inflow and load estimates for 1992 - 2001 to match the more accurate, and finalized, inflow values from the COE.

Calculation of Long-Term Trends in Cherry Creek Reservoir

Long-term analyses for Secchi depth, total phosphorus, and chlorophyll *a* levels were determined by averaging yearly seasonal (July to September) values from each reservoir site between 1987 and 2003.

Yearly values were compared using linear regression analysis (described below). Additionally, annual results were analyzed using a 95% confidence interval. These analyses were used to determine if there were any significant increasing or decreasing trends in Secchi depth, total phosphorus, and chlorophyll *a* levels over time.

Statistical analyses to determine the relationship between total phosphorus concentration and flow, stage discharge relationship, QA/QC between labs, and comparisons of biological and physical parameters for each site were conducted using NCSS 2000 statistical software (Hintze 2001). Natural log transformations were performed to obtain a linear relationship and more constant variance to satisfy assumptions of statistical tests chosen for the different analysis. In most cases, the natural log transformation did not improve the relationship and therefore, the non-transformed values were used in a linear regression to provide estimates of certain data. The least-squares linear regression was used to estimate slope and then an ANOVA was used to determine if the slope was significantly different than zero. A probability level of ≤ 0.05 was used to indicate statistical significance. In the cases of the linear regressions, the R^2 value provided a measure of how well variance is explained by the regression equation. R^2 values measure the proportion of total variation that is explained or accounted for by the fitted regression line, i.e., it is a measure of the strength of the straight-line relationship.

RESULTS AND DISCUSSION

Reservoir Water Quality

<u>Transparency</u>

The whole-reservoir mean Secchi depth varied from a low of 0.50 m in early May to a high of 1.08 m in early June. The whole-reservoir mean was 0.86 m (standard deviation of 0.10 m) between July and September 2003. This value is virtually the same as in 2002 (Fig. 2). The whole-reservoir mean maximum depth of 1% light transmittance ranged from a high of 2.75 m in mid-May to a low of 1.25 m in early June. Deepest recorded 1% transmittance values were observed March - July (mean = 3.31 m, median = 3.50 m). However, measurements of 1% light transmittance were sporadic in 2003 due to a malfunctioning logger and photocells. No significant relationship could be determined between Secchi depth, chlorophyll *a*, and 1% transmittance concentrations and phytoplankton densities (Fig. 3).

Long-Term Secchi Transparency Trends in Cherry Creek Reservoir

In general, seasonal mean (July to September) Secchi depths increased from 1987 to 1996, then decreased from 1996 to 2003. There is not, however, a statistically significant long-term upward or downward trend ($p > 0.05$, $R^2 = 0.04$) for seasonal mean Secchi depths over the period of record (Fig. 2).

Dissolved Oxygen and Temperature

Analysis of past Cherry Creek Reservoir temperature profiles indicates that stratification occurs when there is a >2EC difference between surface and bottom temperatures (Jones 1998). Differences of approximately 1EC suggest a recent mixing event (Jones 1998). Using the above criteria, Cherry Creek Reservoir was investigated for periods of potential stratification and anoxic levels (Figs. 4 - 9).

The temperature in Cherry Creek Reservoir ranged from a high of 24.62EC in mid-August to a low of 5.40EC in late March. As in previous years, periods of thermal stratification were observed in the reservoir. These stratification periods were observed at all lake sites (Figs. 4, 6, and 8). The first period of potential stratification at Site CCR-1 occurred from early June through early July, while the second period of stratification occurred in late September. Two periods of potential stratification were observed at Site CCR-2, the first in early May and the second from early June through mid-July. Short periods of potential stratification were seen at Site CCR-3 in May, June, and September (Fig. 8).

The concentration and depth distribution of dissolved oxygen were similar at the two deep-water sites, CCR-1 and CCR-2 (Figs. 5 and 7). The DO concentrations at Site CCR-3 followed the same trend as was observed at the deep-water sites, but because of the lesser stratification and shallow depth at this site, the magnitude of DO change was less than that at the deep-water sites (Fig. 9). Significant whole lake mixing events appeared to occur in late May and late July (Figs. 4 - 9).

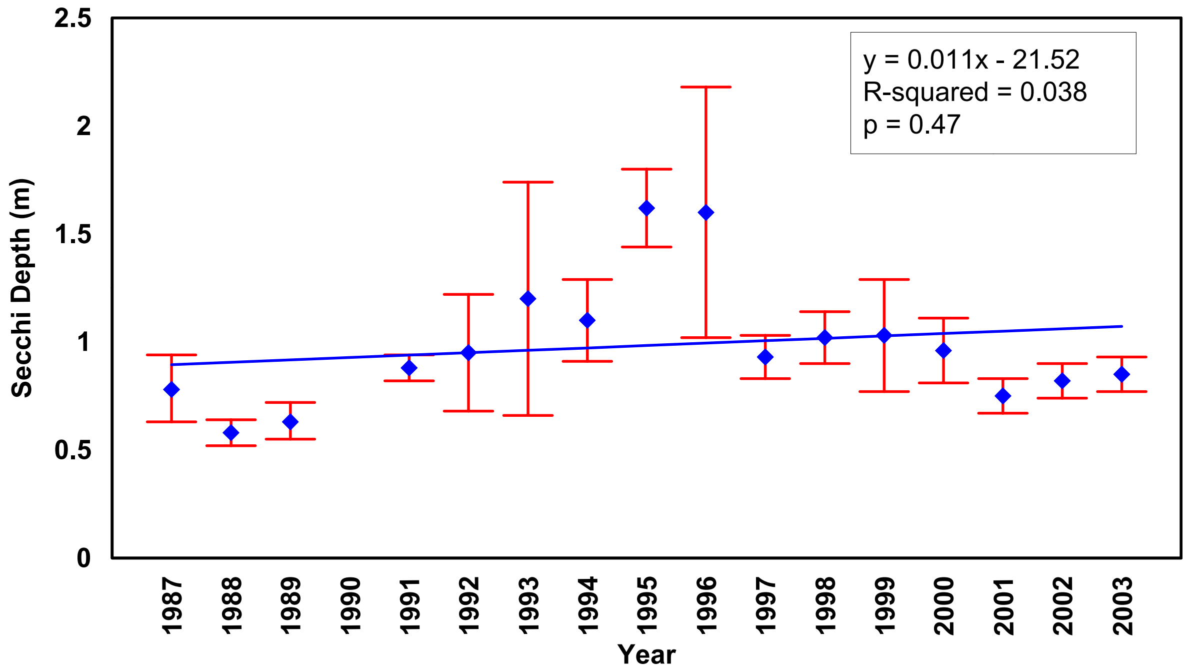

FIGURE 2: Seasonal mean (July to September) Secchi depths (m) measured in Cherry Creek Reservoir (1987 to 2003). Error bars represent a 95% confidence interval around each mean.

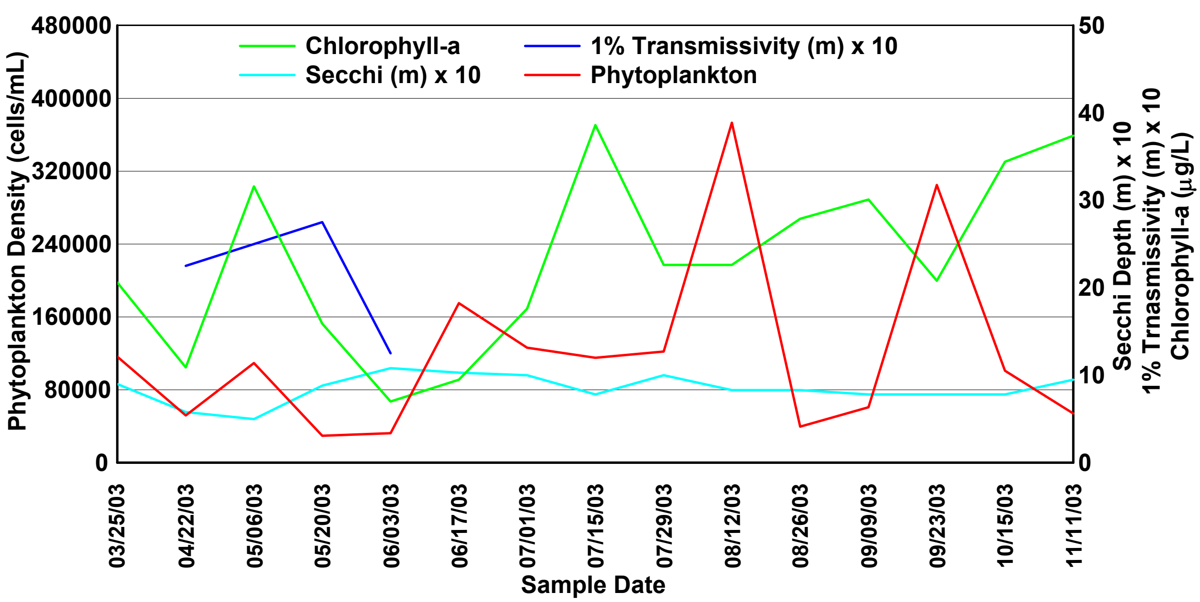

FIGURE 3: Relationship between phytoplankton density, Secchi depth (× 10), 1% transmissivity (× 10), and chlorophyll *a* in Cherry Creek Reservoir, 2003.

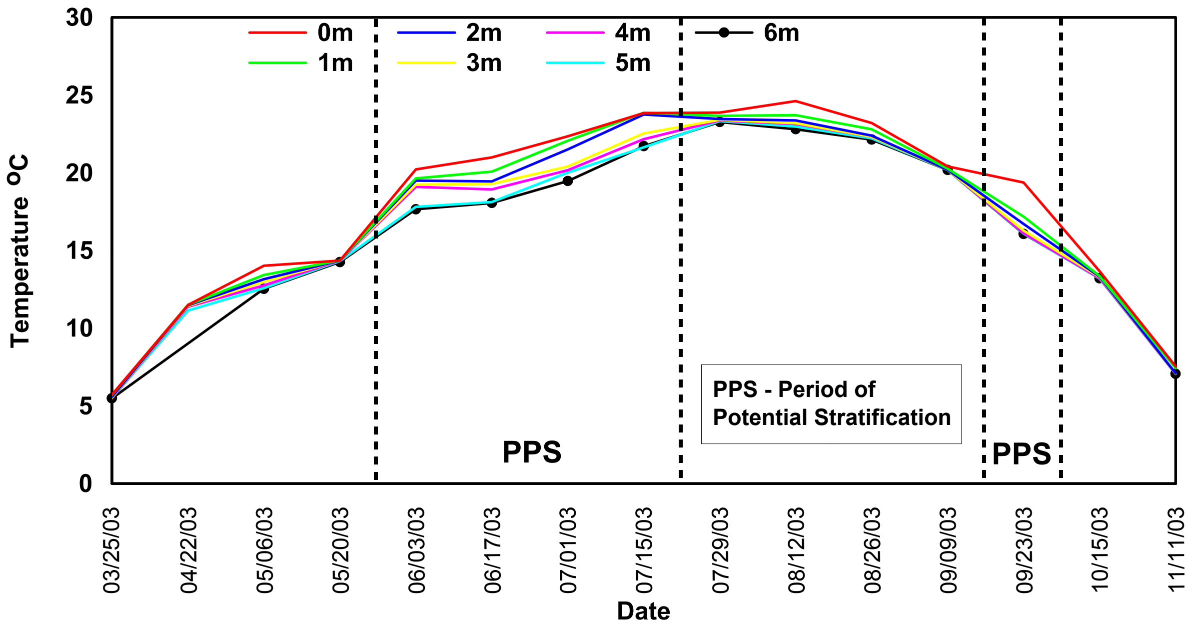

FIGURE 4: Temperature (EC) profiles recorded during routine monitoring at Site CCR-1 in 2003.

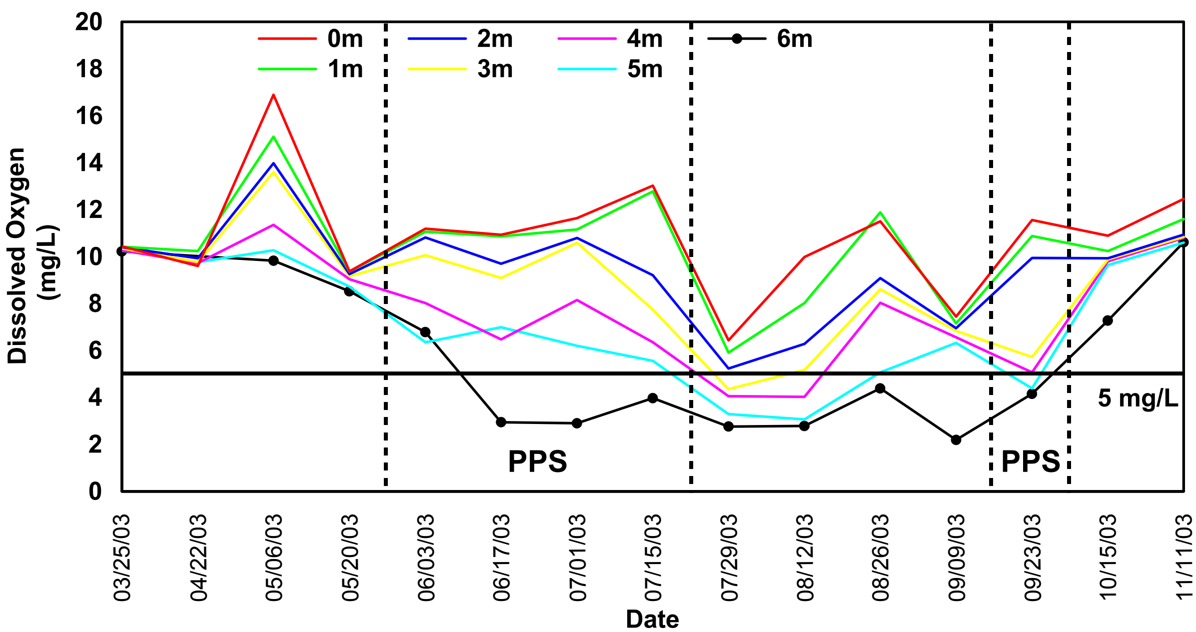

FIGURE 5: Dissolved oxygen (mg/L) profiles recorded during routing monitoring at Site CCR-1 in 2003.

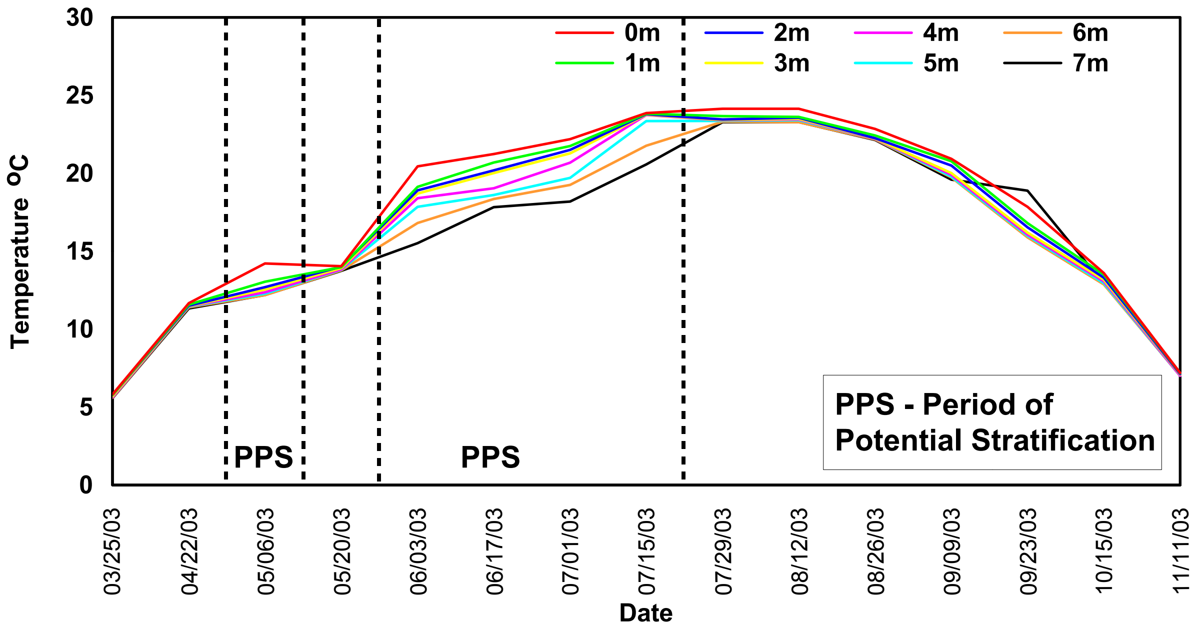

FIGURE 6: Temperature (EC) profiles recorded during routine monitoring at Site CCR-2 in 2003.

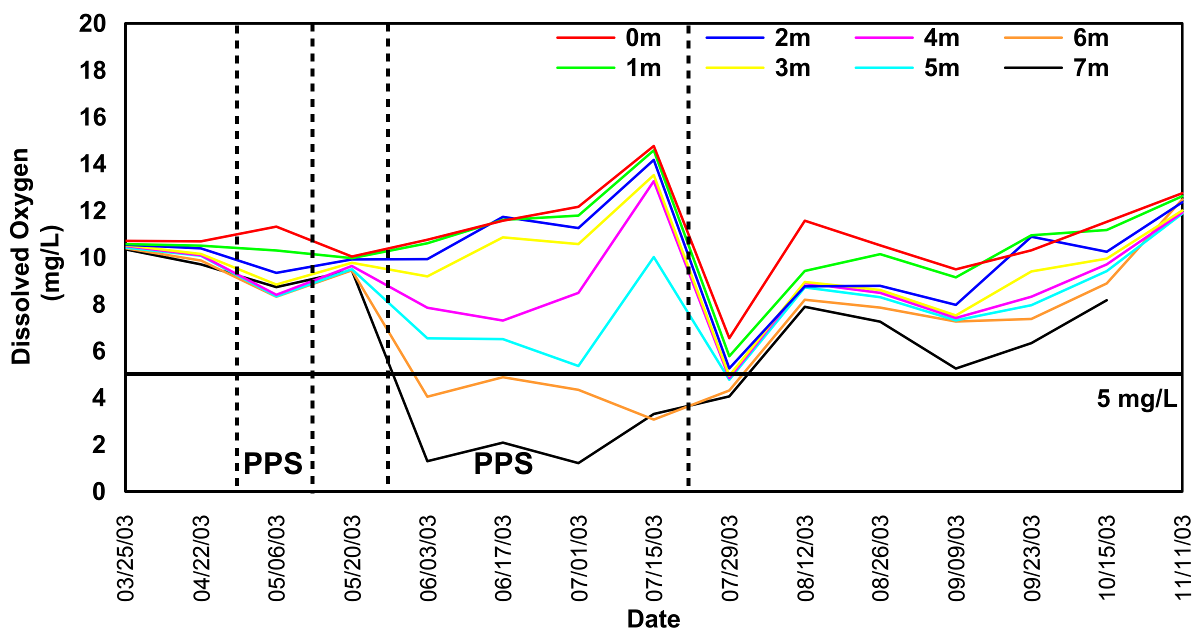

FIGURE 7: Dissolved oxygen (mg/L) profiles recorded during routine monitoring at Site CCR-2 in 2003.

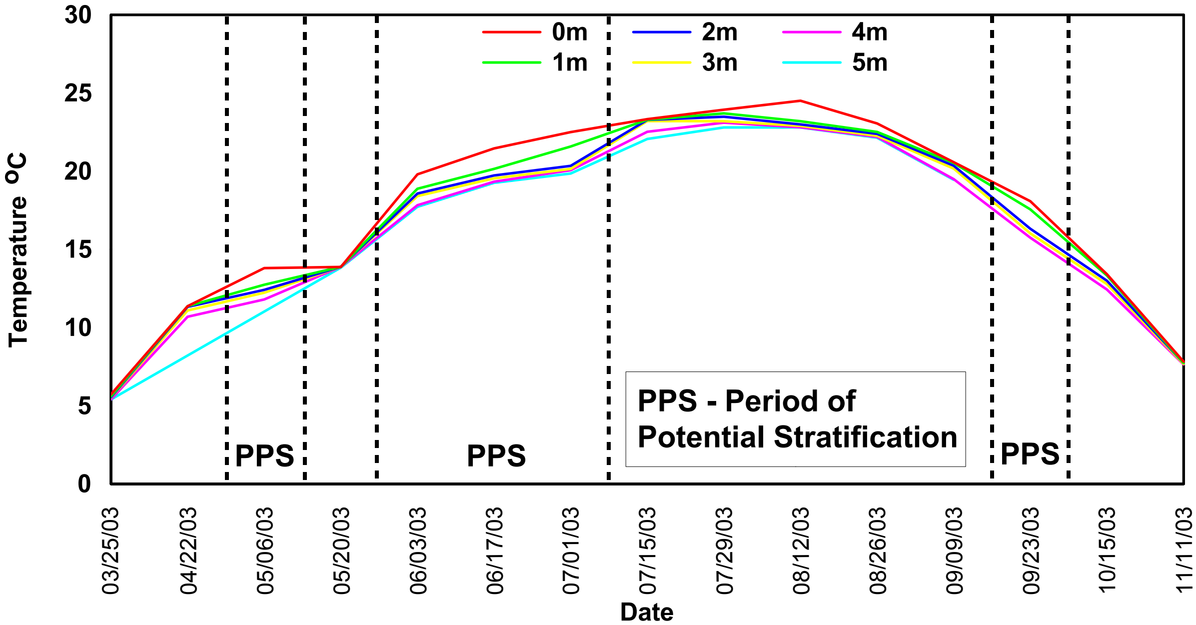

FIGURE 8: Temperature (EC) profiles recorded during routine monitoring at Site CCR-3 in 2003.

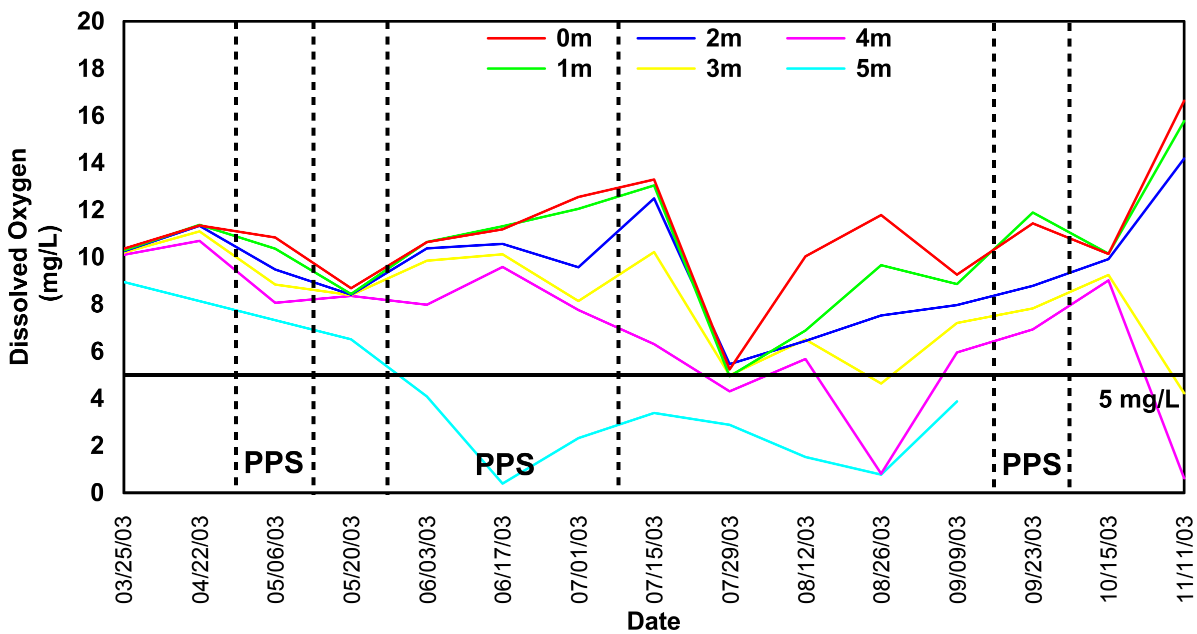

FIGURE 9: Dissolved oxygen (mg/L) profiles recorded during routine monitoring at Site CCR-3 in 2003.

The reservoir was examined for periods of depressed dissolved oxygen levels, those below 5 mg/L. This value has been set by the Colorado Department of Public Health and Environment ([CDPHE] 2001) as the year round warmwater aquatic life standard. For lakes, this criteria is intended to apply to the upper levels when the lake is stratified, i.e., the epilimnion and metalimnion (CDPHE 2000). As such, during those periods when the lake appears to be stratified (i.e., greater than a 2EC difference from surface to bottom), the 5 mg/L criteria would apply primarily to the middle and upper depths (perhaps 4-5 m). However, the 5 mg/L standard applies throughout the water column during mixed conditions.

DO concentrations were highest in the spring, fall, and winter as would be expected. During periods of stratification, the lower layers of the reservoir experienced depressed DO concentrations. At Site CCR-1, the DO concentration dropped below 5.0 mg/L at levels at and below 4 m from mid-July to the beginning of August. This DO depression extended as shallow as 3 m during late-July at Site CCR-1. Similar concentrations were observed at Site CCR-2 at levels at and below 6 m from early June to late July. During June and July, which had extensive periods with DO < 5 mg/L in the deeper waters, 2.3% of the whole-lake volume experienced DO depletion below 5.0 mg/L. No depletion occurred the rest of the year at Site CCR-2. One extended period of DO depletion was observed at Site CCR-3. This occurred from early June to early September.

Reservoir Nutrients

Monitoring at Cherry Creek Reservoir has focused on the concentrations of phosphorus and nitrogen. Phosphorus and nitrogen are inorganic nutrients in aquatic systems and are necessary for life. Often, these nutrients are the limiting factor in the growth of algae (Cole 1979, Goldman and Horne 1983, Wetzel 2001, Cooke *et al*. 1993). Excessive amounts of these nutrients in aquatic systems may result in algal blooms which create aesthetic problems as well as potentially hazardous conditions for aquatic life.

In 2003 the whole reservoir mean concentration of total phosphorus in the photic zone ranged from 54 to 112 µg/L with an overall annual mean of 87 µg/L (Fig. 10). Between July and September the concentration of total phosphorus in the photic zone ranged from 84 to 97 µg/L, with a mean of 90 µg/L. These values are somewhat higher than those observed in 1997 through 2002 (Table 3). Although some peak values appeared related to inflow events (e.g., mid-April), others occurred during periods of no significant inflow (e.g., mid-August and October). Over the year, total phosphorus concentration in the photic zone was not significantly related to inflow ($p > 0.05$, $R^2 = 0.25$).

Regression analyses were also performed to determine if correlations exist between total phosphorus and other parameters measured in the reservoir. The whole reservoir mean concentration of phosphorus in the photic zone was not significantly ($P > 0.05$) related to chlorophyll *a* (slope = 0.30, $R^2 = 0.15$), Secchi depth (slope = -0.06, $R^2 = 0.23$), 1% transmittance (slope = 0.25, $R^2 = 0.43$), or phytoplankton density (slope = 1,914.7, $R^2 = 0.06$).

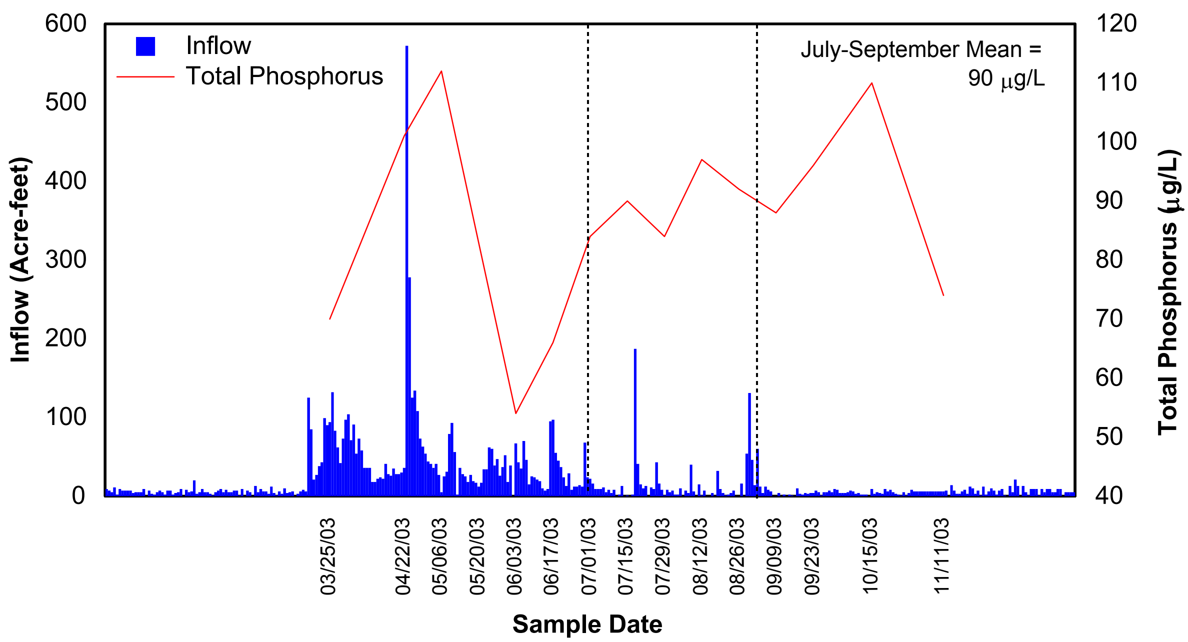

FIGURE 10: Relationship between TP (µg/L) and inflow (AF) in Cherry Creek Reservoir, 2003.

TABLE 3: Comparison of annual mean (monitoring period) and July-September mean phosphorus, nitrogen, and chlorophyll *a* levels in Cherry Creek Reservoir, 1987-2003. Annual means based on January through December sampling.

	Source	Total Nitrogen (µg/L)		Total Phosphorus (µg/L)		Mean Chlorophyll *a* (µg/L)	
Year	of Data	Annual	July-Sept.	Annual	July-Sept.	Annual	July-Sept.
1987	In-Situ 1987	1,580	741	86	93	11.1	8.3
1988	In-Situ 1988	902	1,053	52	49	21.8	31.8
1989	ASI 1990	803	828	45	39	8.5	5.6
1990	ASI 1991a	600	--	58	55	2.3	8.6
1991	ASI 1991b	1,067	1,237	86	56	9.7	9.8
1992	ASI 1993	790	970	54	66	12.1	17.0
1993	ASI 1994a	790	826	50	62	12.5	14.4
1994	CEC 1995	1,134	1,144	86	59	8.8	10.0
1995	CEC 1996	910	913	48	48	10.2	9.4
1996	CEC 1997	889	944	54	62	16.9	20.5
1997	CEC 1998	976	1,120	75	96	16.1	22.3
1998	CEC 1999	850	880	82	89	20.4	26.5
1999	CEC 2000	715	753	80	81	20.8	28.9
2000	CEC 2001	784	802	81	81	22.0	25.2
2001	CEC 2002	740	741	81	87	26.7	26.1
2002	CEC 2003	847	858	70	74	21.7	18.8
2003	Present Study	990	1,121	87	90	23.2	25.8
Long-term average		904	933	69	70	15.6	18.2
Median		850	897	75	66	16.1	18.8

Nutrient profile samples collected in 2003 showed a well-mixed reservoir in spring and fall (Fig. 11). It appears there were brief periods of nutrient release from bottom sediments in June, August, and November as evidenced by increasing TP concentrations with increasing depth (Fig. 11), despite little or no surface inflow to the reservoir (Fig. 10).

The whole reservoir mean concentration of total nitrogen in the photic zone ranged from 707 to 1,299 µg/L, with a mean of 990 µg/L in 2002 (Table 3). During the July to September period the whole reservoir mean total nitrogen concentration ranged from 988 to 1,299 µg/L, with a mean concentration of 1,121 µg/L (Table 3). Total nitrogen was significantly ($P < 0.05$) related to chlorophyll *a* (slope = 0.04, $R^2 = 0.39$), but not to Secchi depth (slope = 0.00, $R^2 = 0.13$).

Long-Term Phosphorus Trends in Cherry Creek Reservoir

Routine monitoring data collected since 1987 indicates a generally increasing trend in summer mean concentration of total phosphorus (Fig. 12). In 2003, the summer mean concentration of total phosphorus was 90 µg/L. This value is higher than the values observed in 1999 - 2002. Statistical analyses performed on 1987 - 2003 seasonal mean TP data indicates a significant ($p = 0.020$, slope = 1.98, $R^2 = 0.32$) upward trend. There appears to be a slight decreasing trend in July - September mean TP over the past seven years (Fig. 12). With the exception of 1989, seasonal mean TP values in Cherry Creek Reservoir have consistently exceeded the goal of 40 µg/L over the past 17 years of monitoring. One-way analysis of variance test (ANOVA) did not show any significant difference in mean annual TP values from 1997 through 2003.

Chlorophyll *a* Levels

The mean whole reservoir concentration of chlorophyll *a* showed a general increasing trend from June through mid-November (Fig. 13). Concentrations spiked to their highest annual level in mid-July (38.6 µg/L). Following the spike, concentrations of chlorophyll *a* decreased through the rest of the year. The reservoir experienced its lowest concentration, 7.0 µg/L, in early June. The annual mean chlorophyll *a* concentration of 23.2 µg/L is lower than the 2001 value (26.7 µg/L). The July to September mean chlorophyll *a* concentration of 25.8 µg/L was comparable to past values (Table 3), and still exceeded the standard of 15 µg/L chlorophyll *a* for the reservoir.

Long-Term Chlorophyll *a* Trends in Cherry Creek Reservoir

July to September mean chlorophyll *a* concentrations have met the standard of 15 µg/L only four out of the past 17 years (Fig. 14), and not since 1995. Since 1987, there has been a slight, but insignificant ($p > 0.05$), increasing trend (slope = 0.20, $R^2 = 0.013$) in the July - to - September mean concentration of chlorophyll *a* in Cherry Creek Reservoir (Fig. 14). To obtain further statistical analysis of these data, a one-way analysis of variance was performed. Results of this test indicate that there is no statistically significant difference between seasonal mean chlorophyll *a* concentrations, from 1996 through 2003.

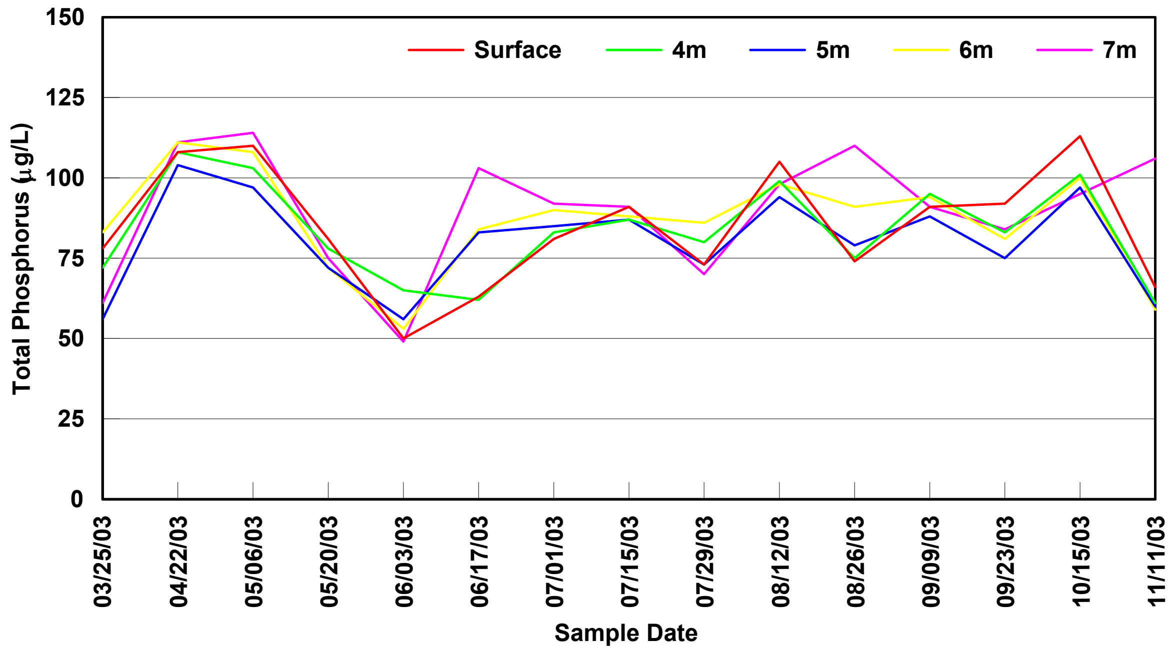

FIGURE 11: Phosphorus concentrations from profile samples at Site CCR-2, Cherry Creek Reservoir, 2003.

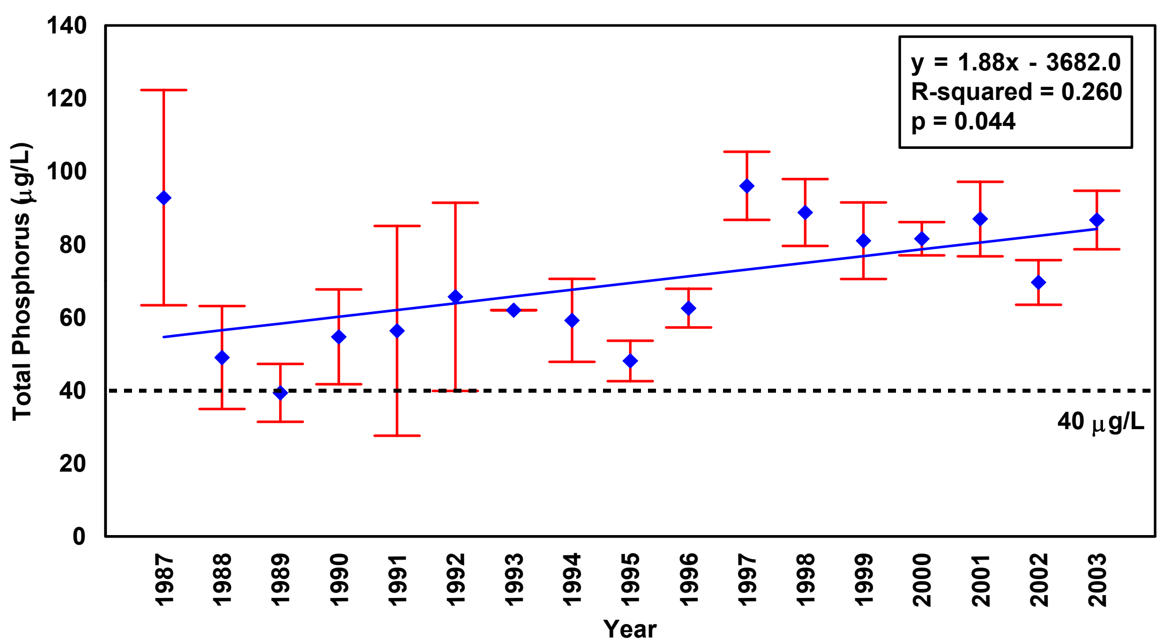

FIGURE 12: Seasonal mean (July to September) total phosphorus concentrations (µg/L) measured in Cherry Creek Reservoir, 1987-2003. Error bars represent a 95% confidence interval around each mean.

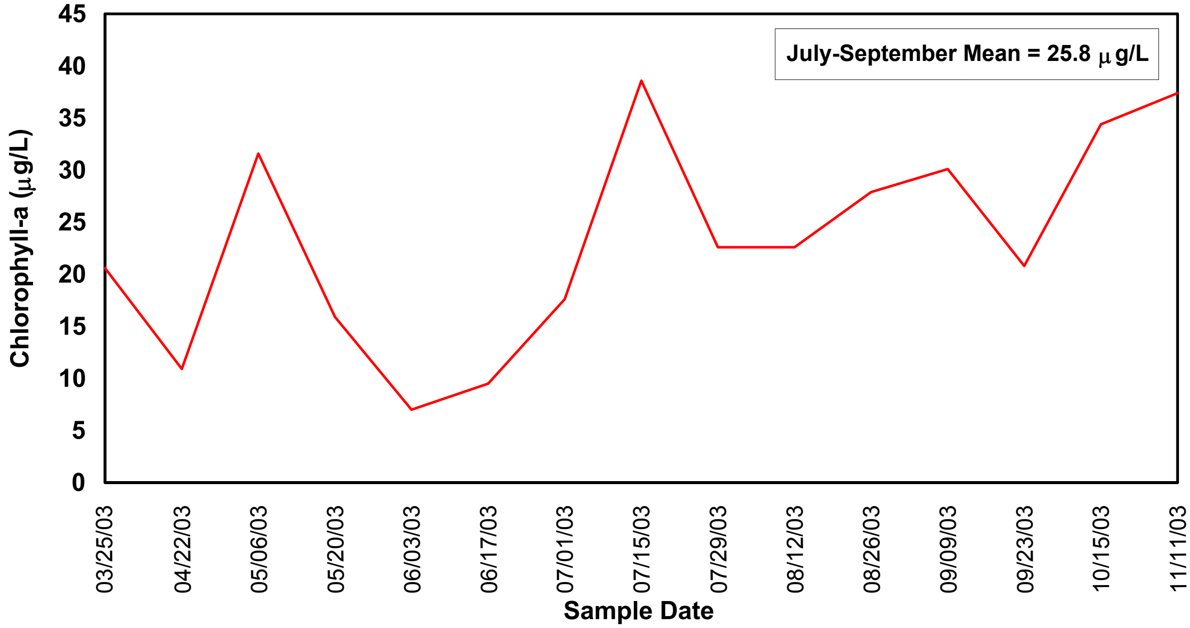

FIGURE 13: Concentration of chlorophyll *a* (μg/L) in Cherry Creek Reservoir, 2003.

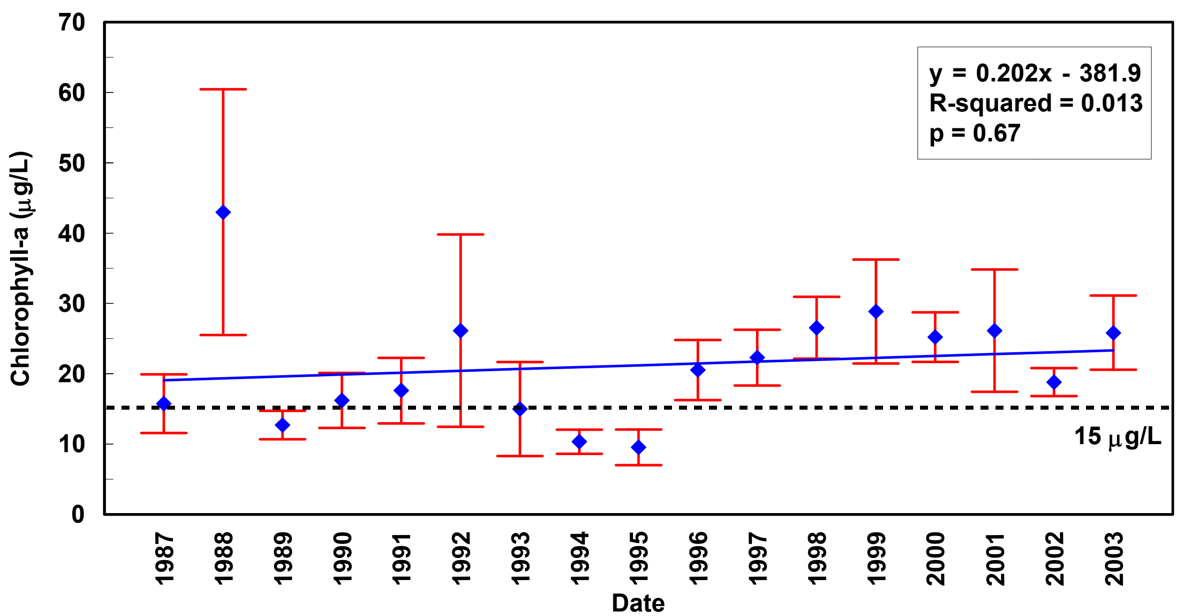

FIGURE 14: Seasonal mean (July to September) chlorophyll *a* concentrations measured in Cherry Creek Reservoir, 1987 to 2003. Error bars represent 95% confidence interval around each mean.

Reservoir Biology

Phytoplankton

Phytoplankton Populations

The photic density of phytoplankton in Cherry Creek Reservoir ranged from 29,655 cells/mL on May 20 to 373,180 cells/mL on August 12 (Table 4). The number of taxa present in the reservoir ranged from a low of 27 on March 25 and May 6, and reached a high of 60 on September 23. Phytoplankton abundances were highest in the spring, summer, and fall months. Annually, the community was dominated by blue-green algae. Green algae was the second most prevalent group. The August and September spikes do not appear to be related to a concurrent total phosphorus concentration spike (Fig. 15). Regression analysis found no significant correlation ($p > 0.05$) between phytoplankton density and total phosphorus concentration during 2003. Additionally, no significant relationship could be determined between phytoplankton density and chlorophyll *a* or total nitrogen concentrations.

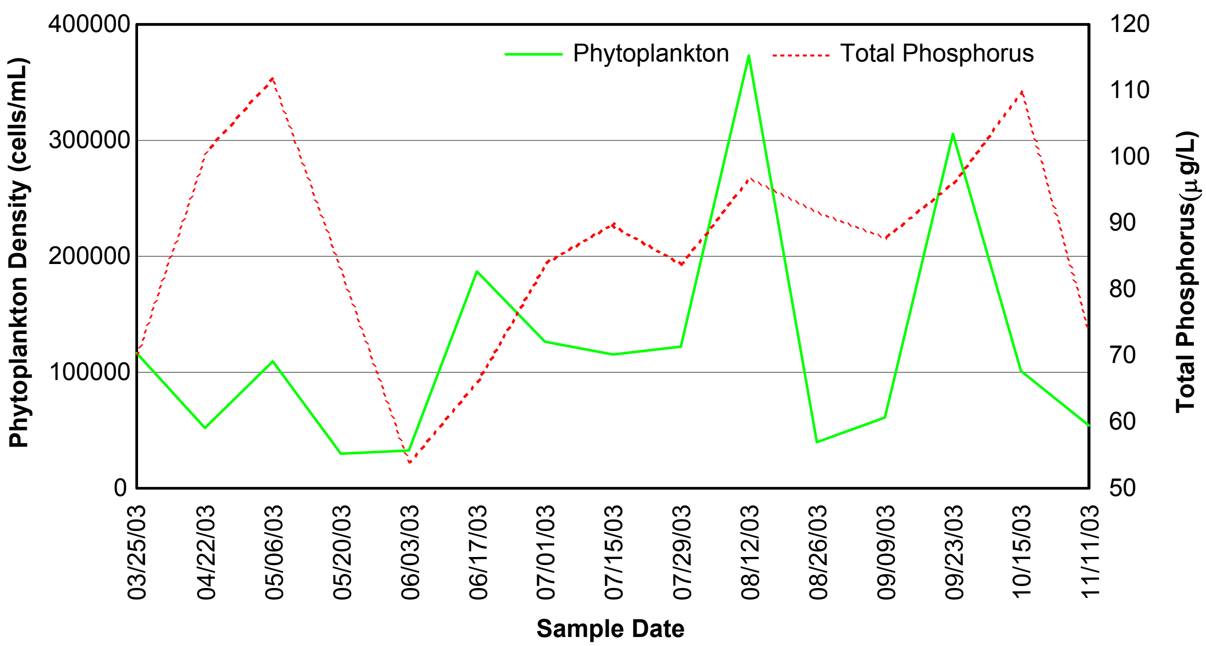

FIGURE 15: Comparison of photic phytoplankton densities from the three reservoir sampling sites to mean total phosphorus concentrations from three sites in Cherry Creek Reservoir, 2003.

Historical Phytoplankton

The phytoplankton community was dominated by blue-green algae in 2003 (Table 5). The proportion of total phytoplankton abundance accounted for by blue-green algae in 2003 (49%) was greater than all values dating back to 1984. This, in part, may be due to different methods used to analyze phytoplankton samples. The new methods and techniques appear to use technologies which are better at identifying smaller species of algae. Additionally, the proportions of the phytoplankton community comprised by diatoms, dinoflagellates, and cryptomonads were greater than all values observed since 1984. The proportions of the community made up of golden brown algae and euglenoids were similar to those observed in recent years. Historically, micro blue-green algae have dominated the phytoplankton community in Cherry Creek Reservoir.

Fish Populations

Historically, the fish community in Cherry Creek Reservoir has been composed of many species, including omnivores, insectivores, zooplanktivores, and piscivores. Fish can exert a strong influence on the structure and productivity of phytoplankton and zooplankton communities through food web pathways between different levels (phytoplankton, zooplankton, and fish) of the aquatic ecosystem (Carpenter *et al.* 1985). In addition, these trophic dynamics can affect the variability, distribution, and ratios of limiting nutrients, such as phosphorus and nitrogen (Vanni *et al*. 1996). Mechanisms that may possibly result because of fish predation include decreased herbivory by zooplankton when fish are abundant, modification of nutrient recycling rates by herbivorous zooplankton as fish abundance varies, and nutrient recycling by fish (Vanni and Layne 1996).

Stocking data from the Colorado Division of Wildlife (CDOW) shows that ten species and two hybrids have been stocked in Cherry Creek Reservoir from 1985 to 2003 (Table 6). The two stocked hybrids were the wiper, a cross between the striped bass and the white bass, and the tiger musky, a cross between a northern pike and a muskellunge. Of these 12 stocked fish taxa, rainbow trout and walleye have been stocked every year. Only three fish species were stocked in 2003 (Table 6).

TABLE 4: Density (cells/mL) of phytoplankton and total number of taxa collected from all three sites on Cherry Creek Reservoir, 2003.

Taxa	25 Mar	22 Apr	6 May	20 May	3 June	17 June	1 July	15 July
Diatoms								
Centrics	283	839	2,040	3,215	1,848	768	400	1,040
Pennates	2,138	0	125	385	21	29	155	3,015
Green Algae	84,071	30,937	93,235	21,104	13,958	81,902	107,277	74,895
Blue-Green Algae	28,425	18,870	7,580	620	15,552	95,160	17,951	35,360
Golden-Brown Algae	0	0	0	120	0	0	51	60
Euglenoids	5	6	0	0	1	3	2	0
Dinoflagellates	0	0	5	10	0	30	91	11
Cryptomonads	1,393	1,256	6,385	4,201	1,000	8,882	220	525
Haptomonads	0	0	0	0	0	0	0	0
Microflagellates	0	0	0	0	0	10	120	0
Total Density	**116,315**	**51,908**	**109,370**	**29,655**	**32,380**	**186,784**	**126,267**	**115,176**
Total Taxa	**27**	**34**	**27**	**35**	**38**	**37**	**51**	**39**

Taxa	29 July	12 Aug	26 Aug	9 Sept	23 Sept	15 Oct	11 Nov
Diatoms							
Centrics	2,180	380	1,170	2,240	560	4,727	1,815
Pennates	150	0	30	150	95	265	330
Green Algae	20,257	134,550	14,945	37,140	62,755	21,775	29,050
Blue-Green Algae	93,300	236,840	18,780	17,255	233,590	58,020	14,140
Golden-Brown Algae	5	0	5	0	160	0	254
Euglenoids	5	15	30	95	210	4,095	160
Dinoflagellates	61	15	20	5	5	40	0
Cryptomonads	2,330	740	1,610	1,210	5,460	9,260	4,765
Haptomonads	0	0	0	0	0	0	1,040
Microflagellates	3,760	640	2,960	2,800	2,800	2,800	2,480
Total Density	**122,048**	**373,180**	**39,550**	**60,895**	**305,635**	**100,982**	**54,034**
Total Taxa	**40**	**47**	**54**	**49**	**60**	**58**	**52**

TABLE 5: Reservoir mean phytoplankton density (cells/mL) and number of taxa in Cherry Creek Reservoir, 1984 to 2003.

Density, Richness	1984	1985	1986	1987	1988	1989	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Blue-Green Algae																			
Density	71,780	66,496	99,316	168,259	155,180	273,175	307,691	77,516	15,708	10,015	18,194	16,599	19,716	44,951	15,263	164,290	148,691	941	54,114
Taxa Richness	7	7	6	18	24	24	14	16	7	3	7	9	10	11	8	19	12	3	21
Green Algae																			
Density	5,864	11,760	25,595	11,985	19,177	55,415	18,688	41,899	1,198	314	355	738	2,461	1,809	898	43,881	33,217	1,973	55,190
Taxa Richness	11	10	13	58	76	66	46	48	16	2	11	11	1,518	18	18	71	56	27	70
Diatoms																			
Density	1,776	3,863	5,428	10,677	12,880	9,311	4,160	1,243	946	194	2,189	2,354	1,109	628	838	12,019	5,256	978	2,026
Taxa Richness	6	4	7	34	30	31	21	11	15	2	15	13	8	18	16	34	22	24	22
Golden-Brown Algae																			
Density	--	7	125	469	56	505	821	93	158	3	63	249	227	56	--	391	1,346	34	44
Taxa Richness	--	1	1	6	4	7	5	4	1	1	2	4	2	2	--	14	13	3	5
Euglenoids																			
Density	514	135	208	251	276	108	89	23	231	196	304	409	838	698	1,252	126	91	22	308
Taxa Richness	2	1	1	9	9	6	3	5	2	1	2	3	3	3	1	6	4	3	9
Dinoflagellates																			
Density	--	13	19	19	83	28	23	54	--	31	5	21	--	18	45	80	157	193	20
Taxa Richness	--	1	1	2	4	3	2	2	--	1	2	4	--	2	2	8	6	5	3
Cryptomonads																			
Density	1,513	718	1,113	1,090	2,689	1,689	628	529	332	450	919	1,104	1,487	1,393	559	2,472	2,851	355	3,282
Taxa Richness	2	3	3	6	4	5	2	3	1	1	1	1	1	1	1	4	6	4	8
Miscellaneous																			
Density	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1,923	5,714	15	1,294
Taxa Richness	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	1	1	3
Total Density	**81,447**	**82,992**	**131,804**	**192,750**	**190,341**	**340,231**	**329,773**	**121,357**	**18,573**	**11,203**	**22,029**	**21,474**	**25,838**	**49,453**	**18,855**	**225,182**	**197,323**	**4,510**	**116,278**
Total Taxa	**28**	**27**	**32**	**133**	**151**	**142**	**93**	**89**	**42**	**11**	**40**	**45**	**39**	**55**	**46**	**157**	**120**	**70**	**141**

The size of stocked fish has been variable both between species and within a given species. For example, channel catfish are stocked as fingerlings, rainbow trout as juveniles and adults, and walleye as fry (Table 6). Tiger musky are stocked as juveniles. Wipers have been stocked mostly as fry, but the CDOW did stock 10-inch long wipers in 1992. Other popular gamefish species stocked in smaller quantities and less regular intervals included largemouth bass and bluegill.

The CDOW did not conduct any fish population sampling in Cherry Creek Reservoir in 2002 or 2003. The Division had planned to sample every two to three years, but has not yet fulfilled that goal.

Phosphorus Concentration in Streams

The mean annual concentration of total phosphorus ranged from a low of 61 µg/L at CT-P2 to a high of 221 µg/L at CC-10 (Table 7). At most stream sites, the summer (July to September) mean concentration of total phosphorus was higher than the annual mean. The summer mean concentration of total phosphorus ranged from a low of 95 µg/L at Site CT-P2 to a high of 220 µg/L at Site SC-3. As expected, the concentration of total phosphorus measured in the storm flows in these streams was considerably higher than that observed under base flow conditions. The mean concentration of total phosphorus in storm samples ranged from a low of 164 µg/L at Site CT-P2 to a high of 363 µg/L at Site CC-10.

Long-Term Trends in Phosphorus Concentrations in Cherry Creek Reservoir Tributaries

Additional analyses were performed on data from the three main tributaries at Cherry Creek Reservoir (Sites CC-10, SC-3, and CT-2) to determine trends in phosphorus and orthophosphate concentrations from 1995 to 2003. Over this period, mean phosphorus concentration was highest at Site CC-10 (231 µg/L) and lowest at Site CT-2 (105 µg/L) (Table 8). Mean orthophosphate concentration was also highest at Site CC-10 (180 µg/L) and lowest at Site CT-2 (43 µg/L). Orthophosphate comprised 78% of the total phosphorus concentrations measured at Site CC-10 and 77% at Site SC-3. At Site CT-2, orthophosphate made up only 41% of total measured phosphorus (Fig. 16).

TABLE 6: Quantity and size of fish stocked in Cherry Creek Reservoir, 1985 to 2003.

Year	Species	Size (inches)	Number
1985	Black crappie	5	7,234
	Channel catfish	2-8	116,784
	Rainbow trout	8-12	75,753
	Walleye	0.3	2,346,000
	Yellow perch	2	90,160
1986	Bluegill	1	111,968
	Channel catfish	4	25,594
	Cutthroat trout	6	52,228
	Rainbow trout	2-18	414,136
	Tiger musky	5-6	4,723
	Walleye	0.3	1,734,000
	Wiper	0.2	80,000
1987	Bluegill	0.2	70,000
	Channel catfish	4	25,600
	Largemouth bass	5	10,000
	Rainbow trout	2-26	129,715
	Tiger musky	7	4,000
	Walleye	0.2	1,760,000
1988	Channel catfish	3	16,000
	Largemouth bass	5	10,000
	Rainbow trout	9-10	293,931
	Tiger musky	8	4,500
	Walleye	0.2	1,760,000
1989	Channel catfish	2-4	10,316
	Largemouth bass	6	8,993
	Rainbow trout	8-22	79,919
	Walleye	0.2	1,352,000
	Wiper	0.2	99,000
1990	Channel catfish	3-4	25,599
	Rainbow trout	9-15	74,986
	Tiger musky	8	2,001
	Walleye	0.2	1,400,000
	Wiper	1	8,996
1991	Channel catfish	3	13,500
	Rainbow trout	9-10	79,571
	Tiger musky	5-8	6,500
	Walleye	0.2	1,300,000
	Wiper	1	9,000
1992	Blue catfish	3	9,000
	Channel catfish	4	13,500
	Rainbow trout	9-10	101,656
	Tiger musky	7	4,940
	Walleye	0.2	2,600,000
	Wiper	10	15,520
1993	Channel catfish	4	13,500
	Rainbow trout	9-10	92,601
	Tiger musky	9	4,500
	Walleye	0.2	2,600,000
	Wiper	1	9,003

TABLE 6: Continued.

Year	Species	Size (inches)	Number
1994	Blue catfish	3	21,000
	Channel catfish	4	23,625
	Cutthroat trout	9	9,089
	Flathead catfish	1	148
	Tiger musky	8	900
	Walleye	0.2	2,600,000
	Wiper	1-4	26,177
	Rainbow trout	9-18	62,615
1995	Channel catfish	4	18,900
	Rainbow trout	9-20	139,242
	Tiger musky	8	4,500
	Walleye	0.2	2,600,000
	Wiper	1	4,500
1996	Channel catfish	3	8,100
	Cutthroat trout	9-10	85,802
	Tiger musky	7	3,500
	Rainbow trout	4-22	163,007
	Walleye	0.2	3,202,940
	Wiper	1	8,938
1997	Channel catfish	3	13,500
	Cutthroat trout	3-9	22,907
	Rainbow trout	10-24	74,525
	Tiger musky	6	4,500
	Walleye	0.2	2,600,000
	Wiper	1	9,000
1998	Channel catfish	4	7,425
	Rainbow trout	10-12	59,560
	Tiger musky	7	4,000
	Walleye	1.5	40,000
	Wiper	1.3	9,000
1999	Channel catfish	3.5	13,500
	Rainbow trout	10-19	32,729
	Tiger musky	7	3,000
	Walleye	0.2	2,400,000
	Wiper	1.3	9,000
2000	Channel catfish	4.1	13,500
	Northern pike	–	46
	Rainbow trout	4.5-20.3	180,166
	Rainbow/Cutthroat trout hybrid	–	5,600
	Tiger musky	8	4,086
	Walleye	0.23	2,400,000
2001	Channel catfish	3.5	13,500
	Rainbow trout	10-19	23,065
	Tiger musky	7	4,000
	Walleye	0.2	2,400,000
2002	Rainbow trout	10	13,900
	Tiger musky	7	4,000
	Walleye	0.2	2,519,660
2003	Rainbow trout	10-11	30,111
	Walleye	0.25	4,136,709
	Channel catfish	2-2.5	33,669

TABLE 7: Comparison of mean baseflow and mean stormflow concentrations of total phosphorus (TP) and total suspended solids (TSS) in tributaries to Cherry Creek Reservoir, 2003.

	Baseflow Samples				Storm Samples	
	Summer		Annual		June - September	
Stream, Site	TP (µg/L)	TSS (mg/L)	TP (µg/L)	TSS (mg/L)	TP (µg/L)	TSS (mg/L)
Cherry Creek						
CC-10	199	27	221	36	363	188
CCO	180	53	152	50	--	--
Cottonwood Creek						
CT-1	98	62	78	51	301	164
CT-2	104	58	91	49	221	91
CT-P1	98	32	64	24	191	49
CT-P2	95	42	61	28	164	48
Shop Creek						
SC-3	220	83	124	27	199	14

TABLE 8: Comparison of annual total phosphorus and orthophosphate concentrations for Sites CC-10, SC-3, and CT-2 from 1995 to 2003.

		Stream Site		
		CC-10	SC-3	CT-2
Total Phosphorus (µg/L)	Minimum	22	0.1	0.1
	Maximum	553	456	415
	Mean	231	122	105
Orthophosphate (µg/L)	Minimum	0.1	0.1	3
	Maximum	362	401	175
	Mean	180	94	43

Concentrations of total phosphorus exhibited an increasing but insignificant trend over time at Site CC-10 ($p = 0.104$, $R^2 = 0.02$, slope = 0.34) (Fig. 17). Concentrations of orthophosphate at Site CC-10 (Fig. 18) were also not significantly related to time ($p > 0.05$, $R^2 = 0.002$). The relationship between total phosphorus and with orthophosphate concentration with time was significant and indicated a slight upward trend at Site SC-3 (Fig. 20). Both the total phosphorus and especially orthophosphate show a decreasing trend at Site CT-2 (Figs. 21 and 22), with the trend statistically significant for orthophosphate ($p < 0.01$,

R^2 = 0.38, slope = -0.68). The observed downward trend and reduced variability in phosphorus concentrations at Site CT-2 from 1995-2003 may be an indication of the increasing effectiveness of the Cottonwood Creek PRF, which was installed in 1996. There appears to be a seasonal pattern in phosphorus concentration at all sites, which was not specifically addressed in the trend analysis.

Long-Term Trends in Phosphorus Concentrations in Cherry Creek Reservoir Alluvium

Data for alluvial phosphorus concentrations from Site MW-9 were obtained from Halepaska (2003 unpublished). These data were used to estimate loadings from alluvial flows to the reservoir, as summarized below. Regression analyses were performed on data from Site MW-9 to determine trends in alluvial total dissolved phosphorus and orthophosphate concentrations from 1994 to 2003 (Figs. 23 and 24). Total dissolved phosphorus was used because total phosphorus is not measured at Site MW-9. Alluvial concentrations of total dissolved phosphorus exhibited a significant increasing trend over time at Site MW-9 ($p = 0.01$, $R^2 = 0.068$, slope = 0.13) (Fig. 23), although this regression explains less than 7% of the observed variance. Total dissolved phosphorus concentrations ranged from 192 µg/L to 199 µg/L, with a mean of 195 µg/L. Alluvial concentrations of orthophosphate at Site MW-9 (Fig. 24) were significantly correlated to time ($p < 0.01$, $R^2 = 0.278$, slope = 0.34) and indicated a slight upward trend. Orthophosphate concentrations at Site MW-9 ranged from 205 µg/L to 214 µg/L, with a mean concentration of 210 µg/L.

Historic Trends in Total Phosphorus Concentration and Discharge

Total phosphorus concentration was plotted against discharge for the three upstream tributaries (Figs. 25 - 27). Flow did not appear to track with total phosphorus concentrations at Site CC-10. At Sites SC-3 and CT-2, total phosphorus concentration appears to be somewhat better matched with discharge. Statistical analyses performed on data sets from Sites CC-10 and SC-3 indicate that there is no significant relationship between total phosphorus concentration and discharge ($p > 0.05$) at these two sites. The relationship between total phosphorus concentration and discharge was significant, and indicated a positive correlation at Site CT-2 ($p < 0.01$, $R^2 = 0.056$, slope = 2.50).

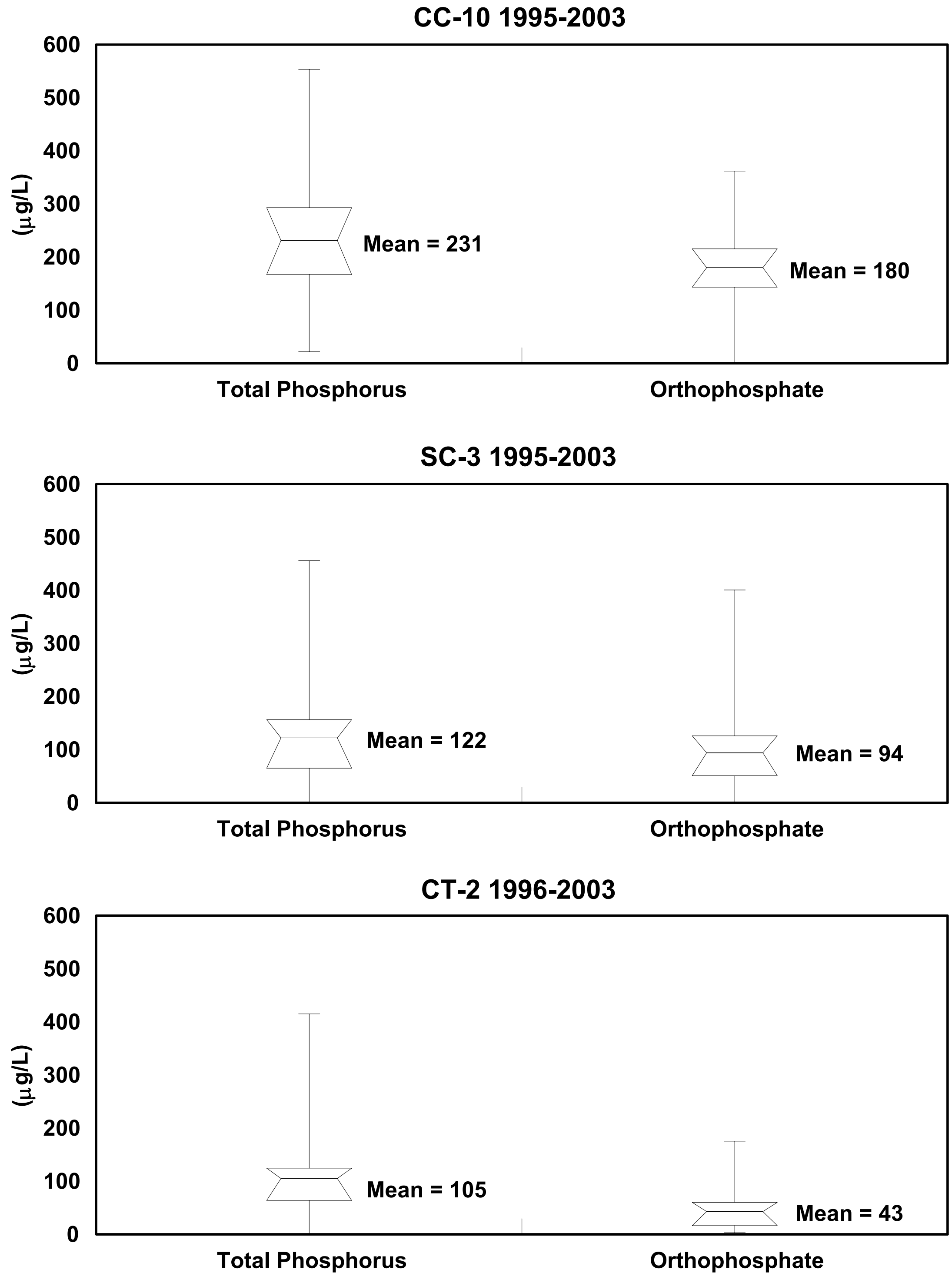

FIGURE 16: Total phosphorus and orthophosphate mean concentrations and box-plots in Cherry Creek Reservoir upstream tributaries (1995-2003).

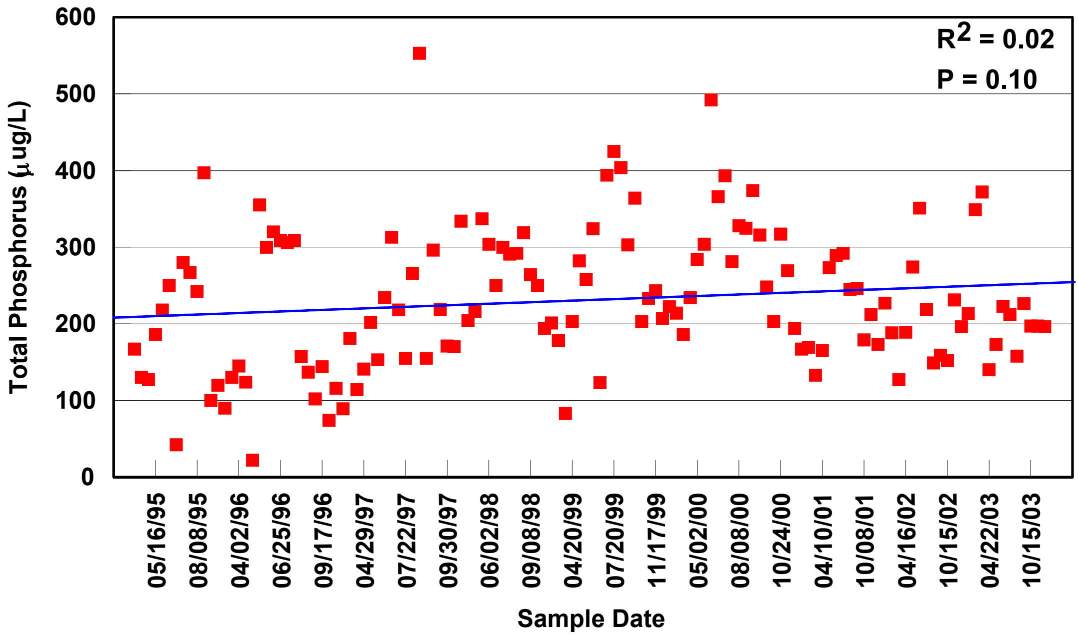

FIGURE 17: Mean total phosphorus concentrations measured in Site CC-10 (1995-2003).

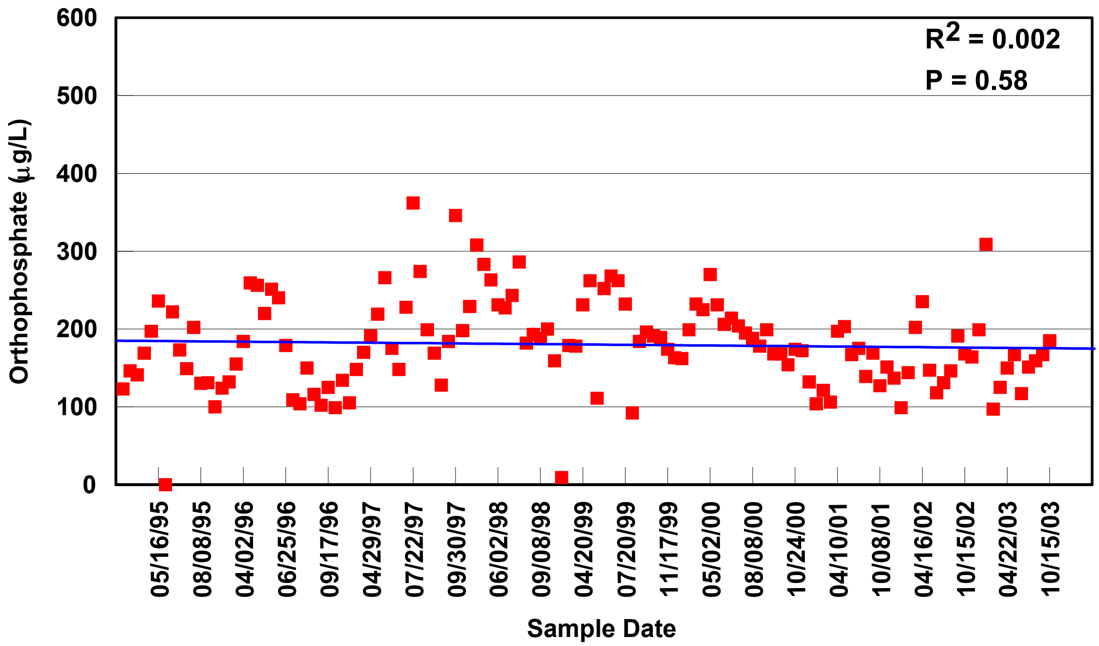

FIGURE 18: Mean orthophosphate concentrations measured in Site CC-10 (1995-2003).

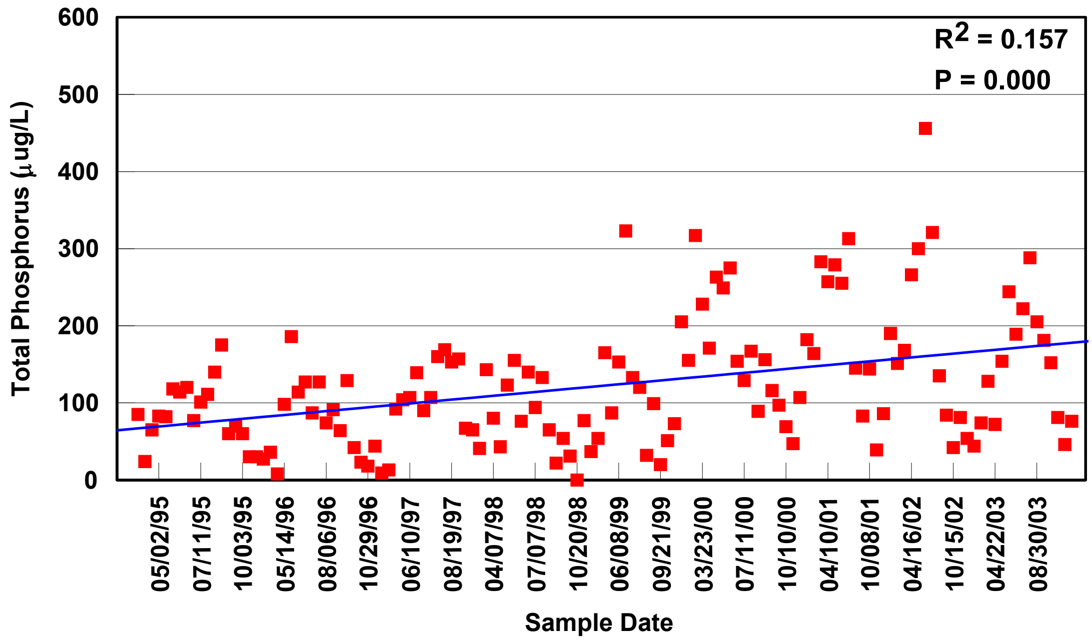

FIGURE 19: Mean total phosphorus concentrations measured in Site SC-3 (1995-2003).

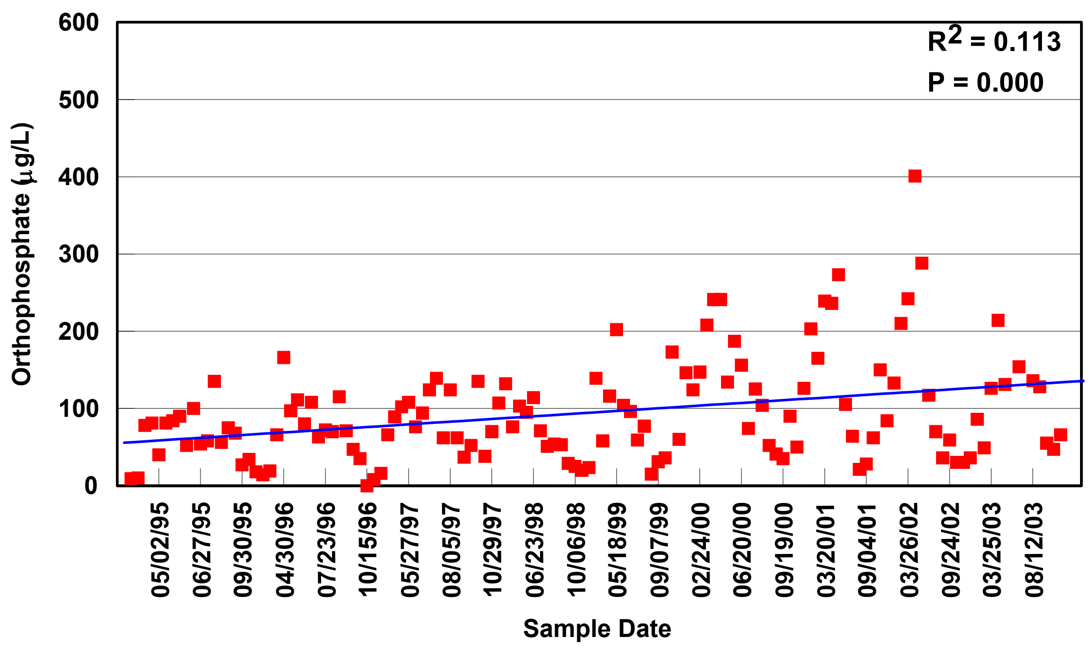

FIGURE 20: Mean orthophosphate concentrations measured in Site SC-3 (1995-2003).

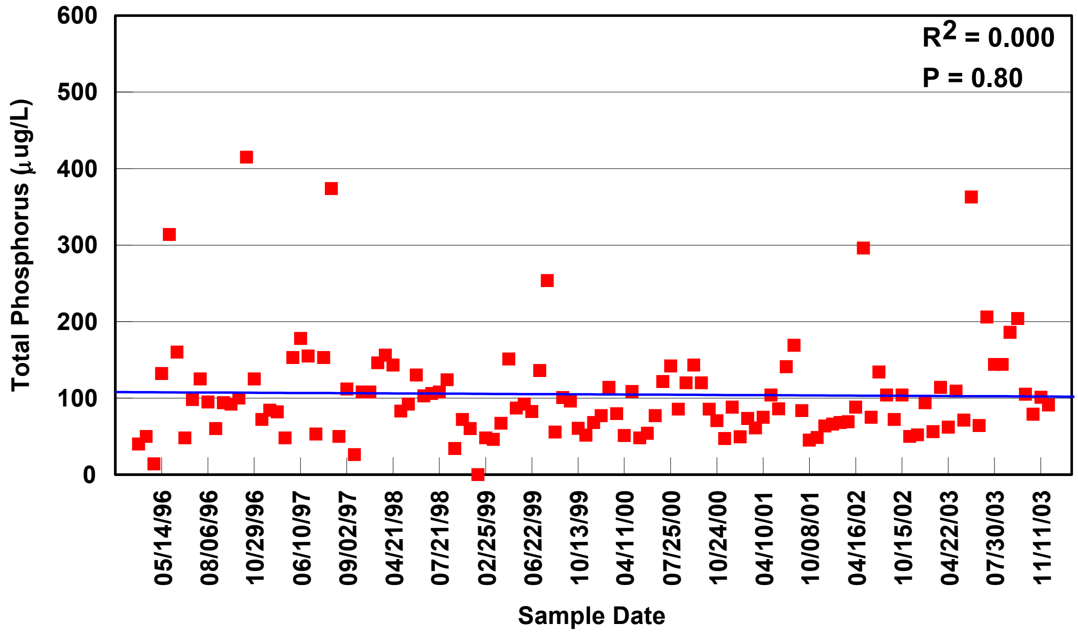

FIGURE 21: Mean total phosphorus concentrations measured in Site CT-2 (1995-2003).

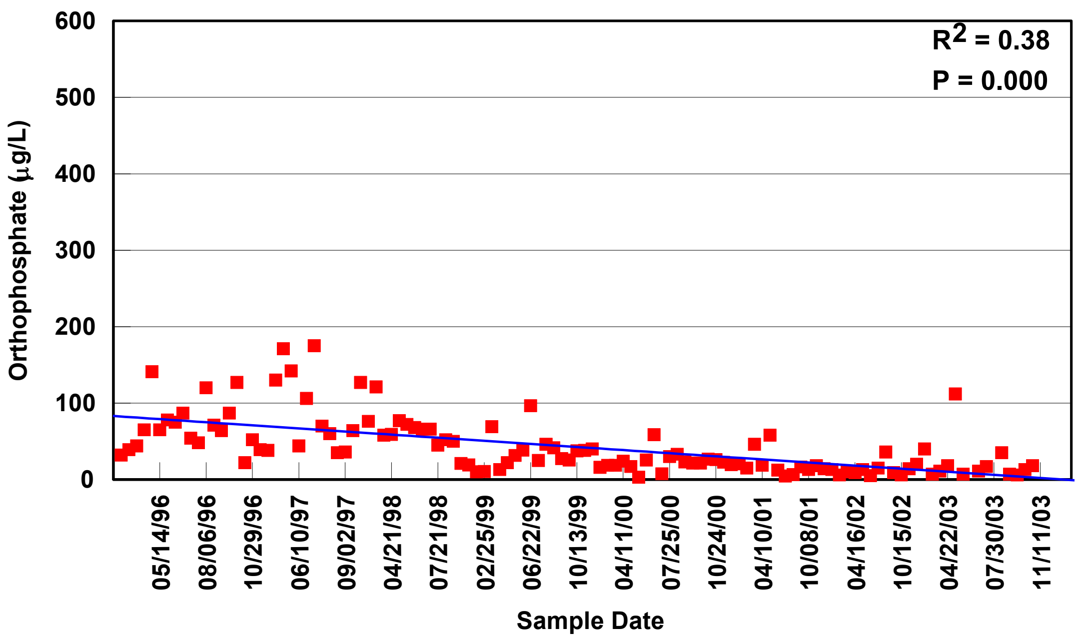

FIGURE 22: Mean orthophosphate concentrations measured in Site CT-2 (1995-2003).

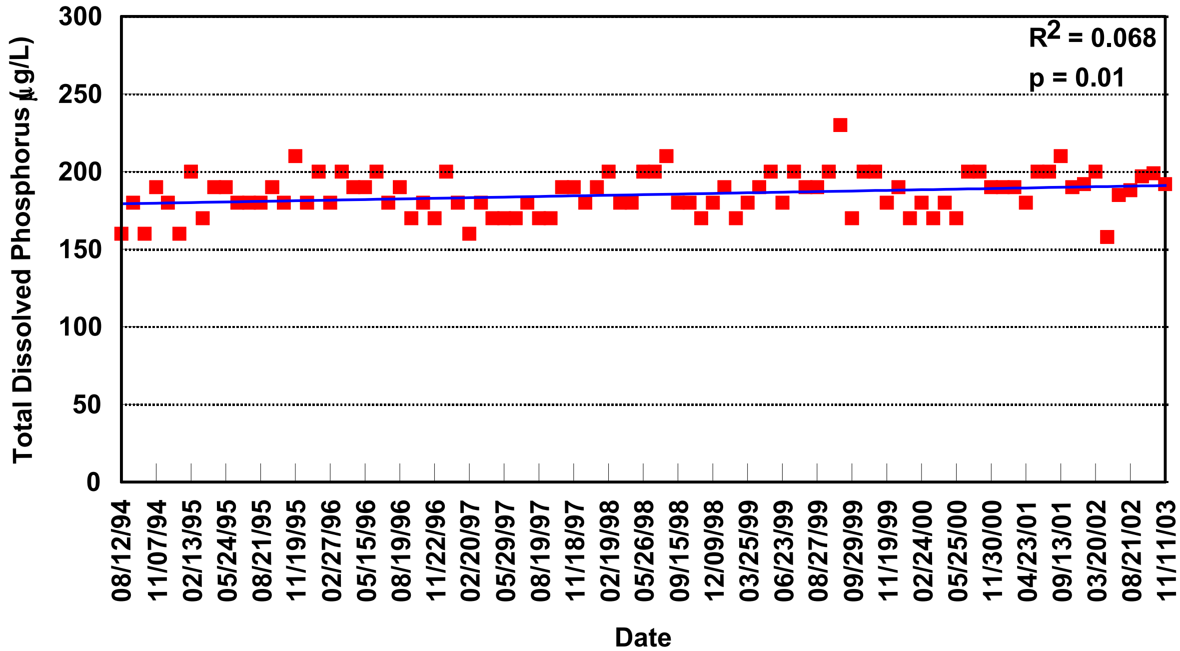

FIGURE 23: Mean total dissolved phosphorus concentrations measured at Site MW-9 (1994-2003).

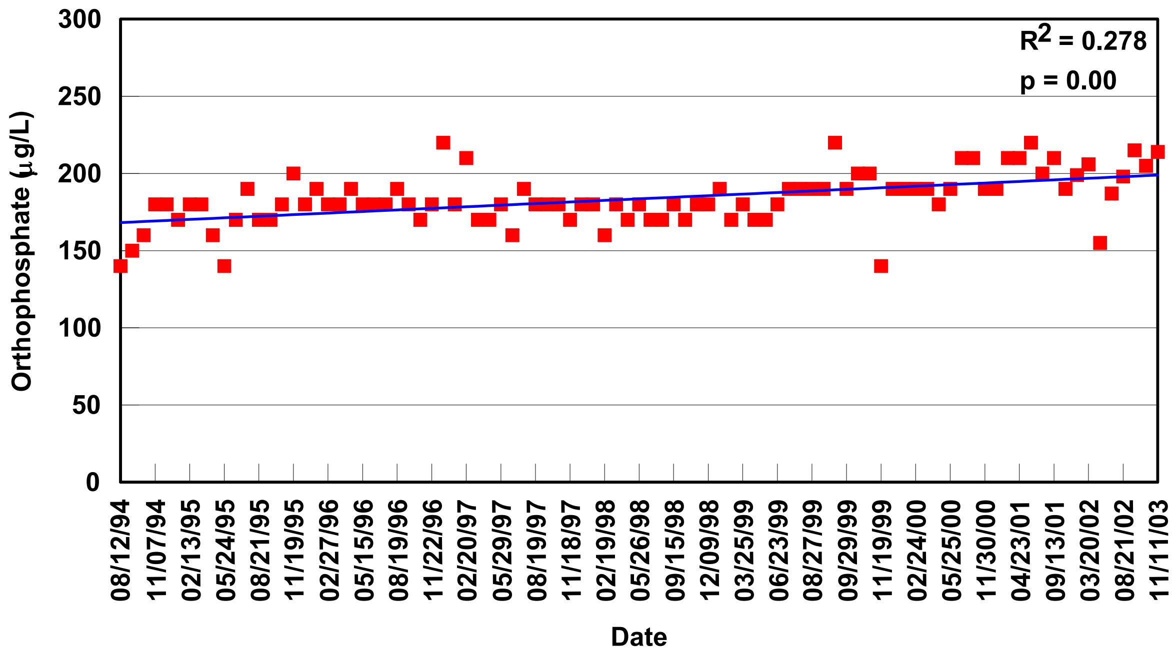

FIGURE 24: Mean orthophosphate concentrations measured at Site MW-9 (1994-2003).

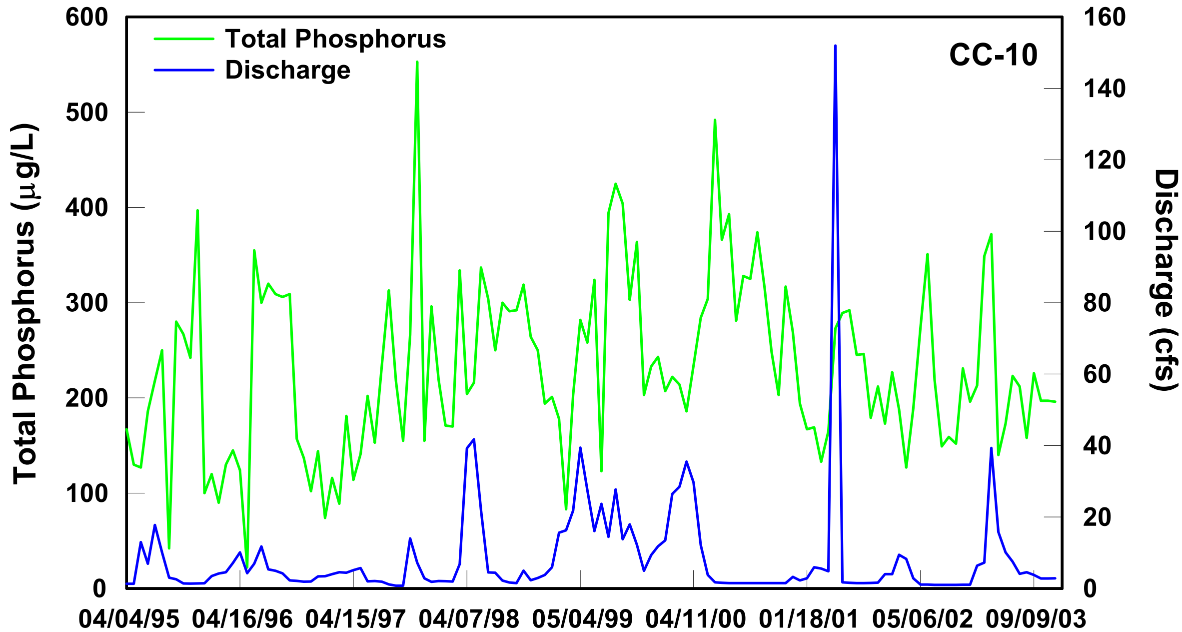

FIGURE 25: Relationship between total phosphorus concentrations and discharge measurements in Site CC-10, 2003.

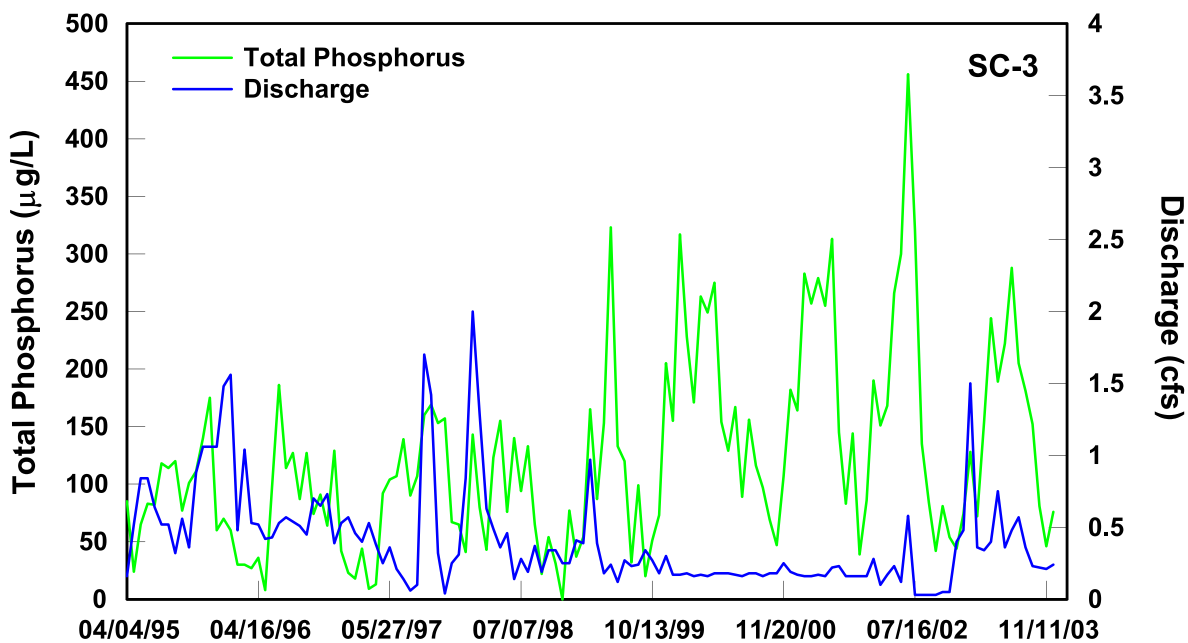

FIGURE 26: Relationship between total phosphorus concentrations and discharge measurements in Site SC-3, 2003.

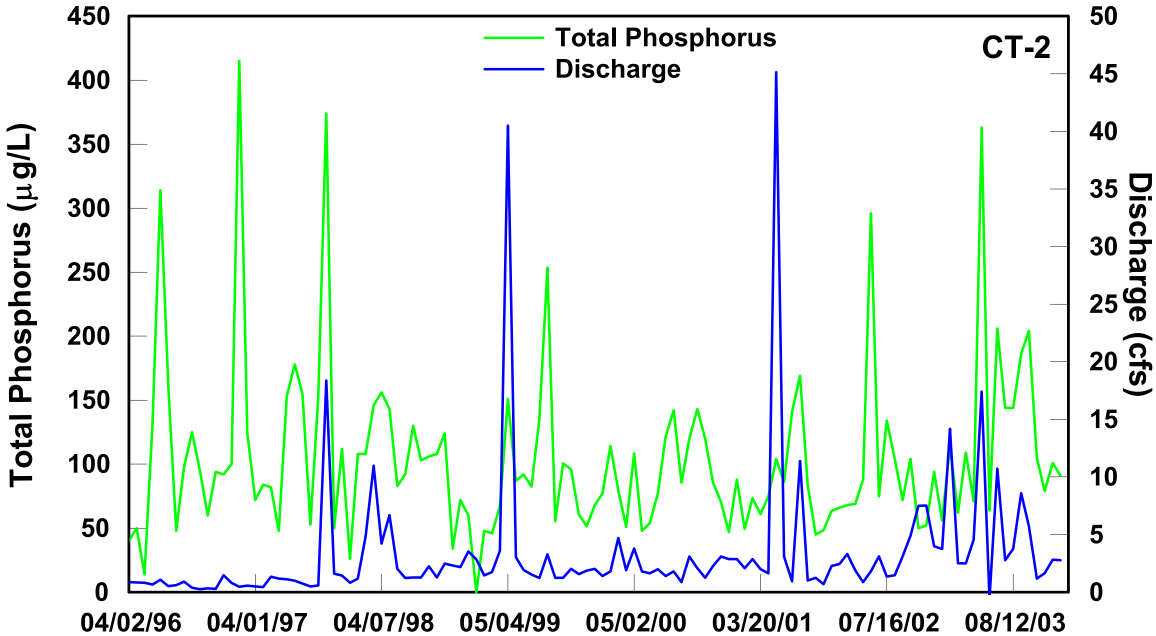

FIGURE 27: Relationship between total phosphorus concentrations and discharge measurements in Site CT-2, 2003.

Phosphorus Loading to Reservoir

Nutrients which can limit or enhance algal growth in a reservoir have many sources, both within the reservoir (internal loading) or from outside the reservoir (external loading). Fish and plankton excrement, direct sediment resupply, and the decay of organic matter are all internal sources of nutrients in a reservoir (Goldman and Horne 1983). Net internal phosphorus loading to Cherry Creek Reservoir has been estimated to be 4,000 lbs/year (Nürnberg and LaZerte 2000). Note that the phased TMAL of 14,270 lbs/year set in the May 2001 hearing does not include these internal loads.

External source of nutrients include inflow from streams and precipitation, which carry nutrients from soil erosion, agricultural and residual runoff, treated wastewater, and airborne particulates. While both phosphorus and nitrogen are potentially important, past analyses have concluded that Cherry Creek Reservoir is generally phosphorus limited (DRCOG 1985). However, a nutrient enrichment study by Lewis *et al.*

(2004) indicated that nitrogen was the limiting nutrient in Cherry Creek Reservoir during the growing season. Phosphorus (unlike nitrogen) does not have a gas phase. Thus, phosphorus concentrations cannot be reduced by interactions with the atmosphere or gases within the water column. For these reasons, efforts in past years and during the present study have concentrated on the calculation of phosphorus loading. Phosphorus loading was determined for several primary sources in 2003, including the tributary streams Cottonwood Creek, Cherry Creek, and Shop Creek, as well as from precipitation and alluvium, as summarized below.

Phosphorus Loads from Tributary Streams

The greatest proportion of the phosphorus load to the reservoir was from surface flows in the Cherry Creek mainstem (4,637 lbs). Because Cherry Creek is monitored downstream of Shop Creek, the 103 lbs contributed by Shop Creek has been subtracted from the total load calculated from the site. Additional phosphorus was contributed by Cottonwood Creek (1,130 lbs). The total phosphorus load to Cherry Creek Reservoir from tributary streams in 2003 was 5,870 lbs (Table 9).

Phosphorus Loads in Reservoir Outflow

The total outflow from Cherry Creek Reservoir as measured by the COE was 12,027 AF (Appendix D). The calculated phosphorus load leaving the reservoir in 2003 was determined to be 4,978 lbs (Table 9).

Phosphorus Loading from Precipitation

The mean concentration of total phosphorus in the rain samples collected in 2003 was 107 µg/L. This value is considerably (79%) lower than the 2002 value and may reflect a reduction in “dry fall” from weekly cleansing of the sampler (See Appendix A). As a result, a year with above average annual precipitation, 18.8 inches, leads to a lower than average total phosphorus load of 391 pounds per year (Table 9, and Appendix D). The long-term mean estimated total phosphorus loading from rain samples collected at the reservoir between 1987 and 2003 is 822 lbs (Table 10).

TABLE 9: Estimated net phosphorus loading (lbs/year) into Cherry Creek Reservoir, 1992 to 2003.

Source of Data	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	Mean	% of Mean Total Load
Shop Creek	131	83	135	115	107	117	127	96	82	103	79	103	107	1
Cherry Creek	2894	1727	2142	2795	2347	2041	7666	8745	8306	3412	1105	4637	3985	48
Cottonwood Creek	1081	177	321	2184	553	646	1143	1822	1087	1292	789	1130	1019	12
Subtotal for Streamflows	**4106**	**1987**	**2598**	**5094**	**3007**	**2804**	**8936**	**10663**	**9475**	**4807**	**1973**	**5870**	**5110**	
Cherry Creek Alluvium	874	1,387*	967	1676	968	1937	3787	5912	2341	4444	1006	2307	2384	29
Direct Precipitation	877	736	484	1202	740	1020	854	896	777	586	1267	391	819	10
Total Load	**5857**	**4110**	**4049**	**7972**	**4715**	**5761**	**13577**	**17471**	**12593**	**9837**	**4246**	**8568**	**8230**	
Cherry Creek Outflow	1314	711	993	2049	992	996	4207	9650	3688	4842	1501	4978	2993	
Net Load	**4543**	**3399**	**3056**	**5923**	**3723**	**4765**	**9370**	**7821**	**8905**	**4995**	**2745**	**3590**	**5236**	

* Based on mean of 1994-1997 total alluvial loads.

Phosphorus Loading from Alluvium

The water quality of alluvial flows into Cherry Creek Reservoir was monitored by JCHA. CEC estimated the total alluvial flow into Cherry Creek Reservoir to be 4,350 AF based on the analysis summarized below and in Appendix D. The total alluvial addition to the reservoir was estimated to be 2,307 lbs total phosphorus in 2003 (Table 9).

The COE monitors inflow to Cherry Creek Reservoir as a function of change in storage, based on changes in reservoir level, measured outflow, precipitation, and evaporation, to provide daily and monthly inflow (AF). This method for calculating reservoir value does not account for inflow due to the difficulty in quantifying groundwater inflow via alluvium. CEC monitors inflow to the reservoir using gaging stations on Cherry Creek, Cottonwood Creek, and Shop Creek (the three main surface inflows). Estimates of direct precipitation were provided by the COE, and estimates of alluvial phosphorus concentrations were provided by JCHA. From these data, CEC calculates an estimated total inflow (AF) and phosphorus loading (lbs) to the reservoir.

TABLE 10: Phosphorus loading into Cherry Creek Reservoir from precipitation, 1987 to 2003. Note that data from 1987-1991 are based on water years, while data for 1992 to present are based on calendar years.

Source of Data	Year	Annual Precipitation (in)	Estimated Annual Total Phosphorus from Precipitation (lbs)
In-Situ 1987	1987	18.1	870
In-Situ 1988	1988	23.3	1,119
ASI 1990	1989	13.0	625
ASI 1991a	1990	15.2	730
ASI 1991b	1991	16.5	793
ASI 1993	1992	18.5	877
ASI 1994a	1993	15.6	735
C&A 1995	1994	10.2	484
CEC 1996	1995	25.3	1,202
CEC 1997	1996	15.5	740
CEC 1998	1997	21.8	1,020
CEC 1999	1998	20.0	854
CEC 2000	1999	21.5	896
CEC 2001	2000	17.8	777
CEC 2002	2001	16.0	586
CEC 2003	2002	12.9	1,267
Present Study	2003	18.8	391
Mean		**17.6**	**822**

Given differences in the two methods for determining inflow, combined with the potential for unmonitored multiple Cherry Creek channels in the wetlands adjacent to the reservoir and the potential for the COE calculations to underestimate dam leakage (Lewis and Saunders 2002), an exact match between COE and CEC calculated inflows is not expected. In 2003, COE inflows were calculated at 14,929 AF, while CEC calculated inflows at 9,239 AF (see Appendix D). In past years, CEC adjusted (normalized) inflow values from the stream sites to account for this difference (i.e., added flow to the stream values). Those normalization procedures can be found in CEC (1998b, 1999, 2000, 2001, and 2002). In 2002 and 2003, CEC did not "normalize" inflow data by adding flow to the surface stream site data. Instead, we based our adjustments on conclusions reached by Lewis and Saunders (2002). They believe the COE method results in a systematic underestimate of inflow to the reservoir from alluvium. When estimating inflow, the COE does not specifically quantify alluvial inflows or outflows although, functionally, these alluvial flows must account for a portion of the variations in reservoir storage. Based on the Lewis and Saunders (2002) analysis, CEC believes the difference in inflow values between the COE calculations and CEC streamflows could be attributed wholly to net alluvial inflow. Using this approach, alluvial inflow was estimated to be 4,350 AF in 2003. This flow and the mean phosphorus concentration of 195 µg/L were then used to calculate alluvial load the reservoir. Past estimates of alluvial load were similarly recalculated using the same approach (Table 9).

Mass Balance/Net Loading of Phosphorus to the Reservoir

There are three principle sources of phosphorus loading to Cherry Creek Reservoir: tributary streams, alluvial flows, and precipitation (Table 9). During 2003, the three tributary streams contributing phosphorus loads to the reservoir included Cherry Creek (4,637 lbs without Shop Creek), Cottonwood Creek (1,130 lbs), and Shop Creek (103 lbs). The net load of phosphorus to the reservoir from the Cherry Creek alluvium was estimated at 2,307 lbs. The estimated phosphorus load to the reservoir from precipitation was 391 lbs. The estimated total load of phosphorus entering the reservoir in 2003 was determined to be 8,568 lbs (Table 9), which meets the TMAL of 14,270 lbs per year. The estimated phosphorus load leaving the reservoir in 2003 was determined to be 4,978 lbs. Using these two values, the net load of phosphorus to Cherry Creek Reservoir in 2003 was determined to be 3,590 lbs (Fig. 28, and Table 9).

Effectiveness of Cottonwood Creek Pollutant Reduction Facilities

Cottonwood Creek- Peoria Pond

As with the Cottonwood Creek Perimeter Pond, the effectiveness of the new Cottonwood Creek-Peoria Pond is gaged by monitoring the concentration of phosphorus and TSS and the loading of phosphorus upstream and downstream of the facility. As noted earlier, this structure came on-line during 2002. As such, the values from 2002 represent less than a full calendar year (i.e., only July - December 2002). The mean concentration of total phosphorus in 2003 decreased from 101 µg/L at Site CT-P1 to 92 µg/L at Site CT-P2 (Table 12). The mean concentration of TSS exhibited little difference upstream of the pond/wetland system to downstream of the pond/wetland system (Table 12). Conversely, the estimated load of phosphorus below the pond/wetland system was reduced 26% from 771 lbs at Site CT-P1 to 574 lbs at Site CT-P2. No difference ($p > 0.05$) in mean total phosphorus or mean TSS concentrations could be determined from statistical analysis (t-test) for Sites CT-P1 and CT-P2. Despite the two-7ear average concentration of total phosphorus and TSS increasing downstream of the PRF, the estimated load of phosphorus was still significantly reduced downstream of the PRF. This indicates that the new PRF was effective in reducing the pollutant load to the reservoir in 2002 and 2003 (Table 11).

TABLE 11: Annual historical (2002-2003) total phosphorus and total suspended solids concentrations through the Cottonwood Creek-Peoria wetlands system.

Parameter	Year	Data Source	Sampling Sites CT-P1	Sampling Sites CT-P2	Difference	% Reduction
Average Total Phosphorus Concentration (µg/L)						
(baseflow and storm samples combined)	2002	CEC	138	152	+14	-10
	2003	CEC	101	92	- 9	9
	Mean		**120**	**122**	**3**	**-0.5**
Average Total Suspended Solids (mg/L)	2002	CEC	66	79	+13	-20
	2003	CEC	31	34	+ 3	-10
	Mean		**49**	**57**	**+ 8**	**-25**
Loading of Total Phosphorus (pounds)	2002	CEC	449	221	-228	51
	2003	CEC	771	574	-197	26
	Mean		**610**	**398**	**-213**	**37**

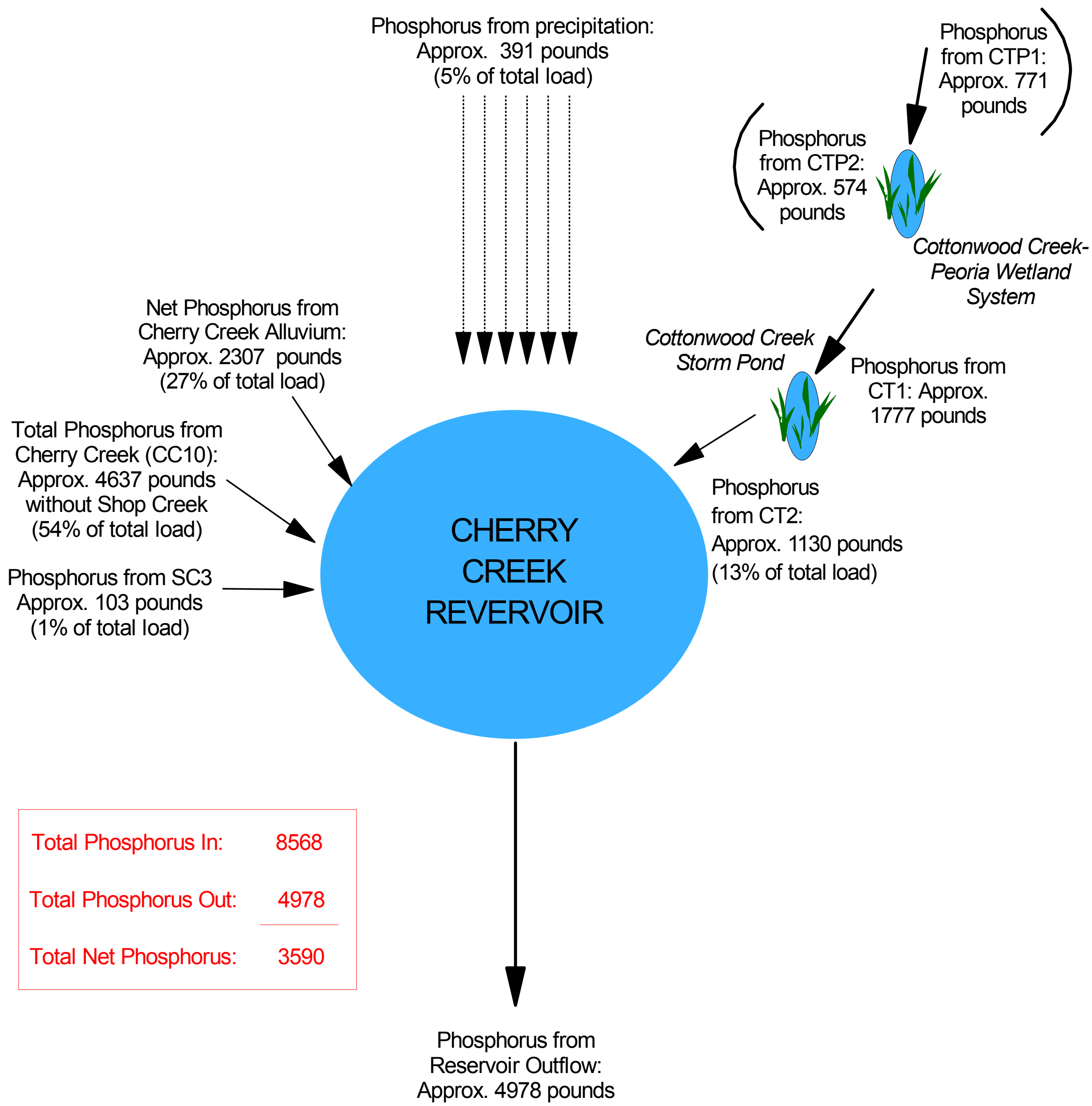

FIGURE 28: Mass balance diagram of phosphorus loading in Cherry Creek Reservoir, 2003.

TABLE 12: Annual phosphorus, flow and total suspended solids (baseflows and stormflows combined) in Cottonwood Creek stormwater detention pond, 2003. Annual phosphorus, flow, and total suspended solids for Cottonwood Creek-Peoria wetlands system (baseflows and stormflows combined), 2003.

Sampling Site	Total Water Volume (AF)	Total Phosphorus Load (lbs)	Average Total Phosphorus (µg/L)	Average Total Suspended Solids (mg/L)
Annual				
Cottonwood Creek				
CT-P1	2144	771	101	31
CT-P2	2050	574	92	34
CT-1	2585	1777	144	84
CT-2	2470	1130	129	62

<u>Cottonwood Creek Perimeter Pond</u>

The effectiveness of the existing Cottonwood Creek stormwater "Perimeter Pond" in reducing pollutant loads to the reservoir can be gaged by comparing concentration of total phosphorus and TSS and the loads of total phosphorus upstream and downstream of the pond (Table 12). During 2003, the mean concentration of total phosphorus decreased from 144 to 129 µg/L after passing through the pond (Table 12). This represents a 10% reduction in phosphorus concentration, the third lowest percent reduction since the pond's inception (Table 13). The load of total phosphorus was reduced from 1,777 lbs upstream of the pond to 1,130 lbs downstream of the pond, representing a 36% reduction in load (Table 13). This value is about average for the pond (Table 13). The concentration of TSS was decreased by 26% from 84 mg/L upstream to 62 mg/L downstream of the pond (Table 12). However, statistical analysis (t-test) determined that these differences in mean total phosphorus or TSS concentrations between Sites CT-1 and CT-2 were not statistically significant ($p > 0.05$). Regardless, the load reduction indicates that this PRF continues to be effective in reducing the loads of suspended solids and total phosphorus to Cherry Creek Reservoir.

TABLE 13: Annual historical (1997 to 2002) total phosphorus and total suspended solids concentrations through the Cottonwood Creek stormwater detention pond.

Parameter	Year	Data Source	Sampling Sites CT-1	Sampling Sites CT-2	Difference	% Reduction
Annual Average Total Phosphorus	1997	CEC	200	133	-67	34
Concentration (µg/L)	1998	CEC	289	210	-79	27
(baseflow, storm samples	1999	CEC	158	157	- 1	0
combined)	2000	CEC	187	149	-38	20
	2001	CEC	165	114	-51	31
	2002	CEC	146	143	- 3	2
	2003	CEC	144	129	-15	10
	Mean		184	148	-36	18
Annual Average Total Suspended	1997	CEC	207	87	-120	58
Solids (mg/L)	1998	CEC	311	129	-182	59
	1999	CEC	267	68	-199	74
	2000	CEC	96	64	- 32	33
	2001	CEC	79	43	- 43	46
	2002	CEC	130	79	- 51	39
	2003	CEC	84	62	- 22	26
	Mean		168	76	- 92	48
Annual Loading of Total	1997	CEC	3,351	1,103	-2,248	67
Phosphorus (pounds)	1998	CEC	3,209	1,930	-1,279	40
	1999	CEC	6,329	3,868	-2,461	39
	2000	CEC	3,243	1,712	-1,531	47
	2001	CEC	3,356	2,205	-1,151	34
	2002	CEC	886	789	- 97	11
	2003	CEC	1,777	1,130	- 647	36
	Mean		3,164	1,820	-1,345	39

Shop Creek and Quincy Drainage Pond

Historical sampling of the PRFs on Shop Creek and Quincy Drainage indicate efficient phosphorus removal in these streams. Shop Creek was monitored from 1990 to 2000 and had an average phosphorus load reduction of 173 lbs, with an average of 63% reduction in load. Quincy Drainage was even more efficient with 99% reduction in loads over the period of 1996-1999. The average phosphorus load reduction was 138 lbs.

SUMMARY AND CONCLUSIONS

Transparency

The highest transparency in Cherry Creek Reservoir was observed in the reservoir in early June, and the lowest was measured in early May. The whole-reservoir mean Secchi depth was 0.9 m during the July to September period, a similar value to that observed in 2002, but slightly lower than 1993-2000 values (Table 14).

TABLE 14: Water quality and total phosphorus loads data for Cherry Creek Reservoir, July-September 1992-2003. **Bold** indicates value meets the respective standard, goal, or TMAL value.

Year	Chlorophyll *a* (μg/L)	Secchi Depth (m)	Total Phosphorus (μg/L)	Total Nitrogen (μg/L)	Annual Phosphorus Load (lbs/yr)*	Annual Inflow (ac/ft)*	Standardized Phosphorus Load (lbs/ac-ft)
1992	17.0	0.9	66	970	**5857**	7474	0.78
1993	**14.4**	1.2	62	826	**4110**	5905	0.70
1994	**10.0**	1.1	59	1144	**4049**	7001	0.58
1995	**9.4**	1.6	48	913	**7972**	11781	0.68
1996	20.5	1.6	62	944	**4715**	7644	0.62
1997	22.3	1.0	96	1120	**5761**	10362	0.56
1998	26.5	1.0	89	880	**13577**	20903	0.65
1999	28.9	1.0	81	753	17471	27739	0.63
2000	25.2	1.0	81	802	**12593**	18610	0.68
2001	26.1	0.8	87	757	**9837**	17250	0.57
2002	18.8	0.9	74	858	**4246**	7498	0.57
2003	25.8	0.9	90	1121	**8568**	14929	0.57
11-Year Mean	20.4	1.0	75	924	8230	13091	0.63
Median	21.4	1.0	78	897	6915	11072	0.63

* Stream, alluvium, and precipitation.

Temperature and Dissolved Oxygen

Periods of thermal stratification were observed in the reservoir in 2003. Dissolved oxygen profiles indicated that anoxic conditions were present through the summer, as oxygen concentrations were frequently reduced in lower depths of the reservoir. The temperature and oxygen profiles observed in the reservoir in 2003 were similar to those recorded in past years.

Total Phosphorus

The 2003 reservoir summer mean total phosphorus concentration of 90 µg/L was higher than that measured in 2002, and exceeded the goal of 40 µg/L total phosphorus. The summer mean total phosphorus concentration was higher than values recorded in 1992 through 2002 (Table 14), except for the value recorded in 1997. Since 1987, the goal of 40 µg/L total phosphorus as a July - September mean has only been met once, in 1989.

Chlorophyll *a*

The summer mean chlorophyll *a* concentration in Cherry Creek Reservoir was 25.8 µg/L, a value in excess of the 15 µg/L standard (Table 14). The summer mean concentration of chlorophyll *a* was higher than the mean value reported for 2002. The long-term summer mean chlorophyll *a* concentrations since 1996 indicate no significant difference between seasonal mean chlorophyll *a* concentrations over the past seven years. Since 1987, the July - September chlorophyll *a* standard of 15 µg/L has been met in four of 17 years, but only three times in the last 12 years and not since 1995 (Table 14).

Phosphorus Loading

The total precipitation at Cherry Creek Reservoir during 2003 was 18.8 inches. The mean concentration of total phosphorus collected from rain samples in 2003 was 152 µg/L, a decrease of 79% from the 2002 value of 508 µg/L. This decrease in rain sample total phosphorus concentration resulted in the lowest annual phosphorus load from precipitation into the reservoir for the past 17 years (Table 10). The total inflow from tributary streams was 9,239 AF, which was higher than the 4,606 AF observed in 2002. The total phosphorus loads to the reservoir were estimated to be 391 lbs from precipitation, 5,870 lbs from surface flows, and 2,307 lbs from Cherry Creek alluvial flow. The total external load in 2003 of 8,568 lbs met the phased TMAL of 14,270 lbs/year. The total of 8,568 lbs in 2003 represents a 51% decrease in total load over that observed during peak flows in 1999. This 51% drop in TP loads compares to an 11% decrease in July - September chlorophyll *a* over the same period.

PRF Effectiveness

Pollution reduction facilities constructed on Cottonwood Creek continued to be effective in reducing the loads of phosphorus to the reservoir. The Cottonwood Creek-Peoria Pond reduced phosphorus loading by 26% in 2003. In 2003, the Cottonwood Creek Perimeter Pond reduced the instream load of phosphorus by 36%. In the past, the PRFs on Shop Creek and Quincy Drainage were also monitored. These established wetland ponds proved to be very efficient in reducing the phosphorus load. Shop Creek averaged 63% reduction in phosphorus load, while Quincy Drainage averaged 99% load reduction.

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APPENDIX A

Cherry Creek Reservoir
Sampling and Analysis Plan

CHERRY CREEK RESERVOIR

AQUATIC BIOLOGICAL AND NUTRIENT SAMPLING AND LABORATORY ANALYSES

SAMPLING, ANALYSIS, AND QUALITY ASSURANCE WORK PLAN

MAY 2003

Submitted to:

Cherry Creek Basin Water Quality Authority
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INTRODUCTION

An inter-governmental agreement was executed in 1985 by several local governmental entities within the Cherry Creek basin to form the Cherry Creek Basin Water Quality Authority (Authority). The Authority initially created by an intergovernmental agreement, was specially authorized by legislation adopted in 1988. The Authority develops and implements the means to protect the water quality of Cherry Creek Basin and Reservoir. Following recent legislation, the Board was reconstituted in 2001 and now includes Arapahoe and Douglas Counties, seven municipalities (Aurora, Castle Rock, Centennial, Foxfield, Greenwood Village, Lone Tree, and Parker), one member representing the seven special districts (Arapahoe, Cottonwood, Inverness, Meridian, Parker, Pinery, and Stonegate Village), and seven citizens appointed by the governor. This Authority was created for the purpose of coordinating and implementing the investigations necessary to protect and to preserve the quality of water resources of the Cherry Creek basin while allowing for further economic development.

The Cherry Creek Basin Master Plan (DRCOG 1985), approved by the Colorado Water Quality Control Commission (CWQCC) in 1985, was adopted in part as the "Regulations for Control of Water Quality in Cherry Creek Reservoir" (Section 4.2.0, 5C.C.R.3.8.11). An annual monitoring program was implemented at the end of April 1987 to assist in the assessment of several aspects of the Master Plan. These monitoring studies have included long-term monitoring of 1) nutrient levels within the reservoir and from tributary streams during base flows and stormwater, 2) nutrient levels in precipitation, and 3) chlorophyll *a* levels within the reservoir. This monitoring program has been modified over the years in response to changes in the Control Regulation, various research goals, and suggestions from outside reviewers, including input from the Water Quality Control Division (WQCD).

PROJECT DESCRIPTION

The Authority has prepared this Sampling, Analysis, and Quality Assurance Work Plan (Sampling and Analysis Plan) for aquatic biological nutrient analyses to be conducted on Cherry Creek Reservoir and selected off-lake sampling sites in 2003. This Sampling and Analysis Plan sets out field and laboratory protocols necessary to achieve quality data designed to help characterize the potential relationships between nutrient loading (both in-lake and external) and reservoir productivity. The specific objectives of the Sampling and Analysis Plan study are:

1. Determine the concentrations of selected nutrients, primarily nitrogen and phosphorus species, in Cherry Creek Reservoir as well as in various streams flowing into the reservoir and measure nutrients in the reservoir outflow.

2. Determine the pounds of phosphorus entering Cherry Creek Reservoir from streams and precipitation and leaving the reservoir through the outlet.

3. Determine biological productivity in Cherry Creek Reservoir, as measured by chlorophyll *a* concentrations and algal densities.

4. Provide data on the effectiveness of pollutant removal from Pollutant Removal Facilities (PRF) constructed by the Authority.

This Sampling and Analysis Plan presents the proposed 2003 sampling and analyses requirements for Cherry Creek Reservoir and includes discussions of: 1) project organization and responsibilities; 2) quality assurance objectives for the measurement of data in terms of accuracy, representativeness, comparability, and completeness; 3) field sampling and sample preservation procedures; 4) laboratory processing and analytical procedures; and 5) guidelines for data verification and reporting, quality control checks, corrective actions, and quality assurance reporting.

PROJECT ORGANIZATION AND RESPONSIBILITIES

All personnel involved in the investigation and in the generation of data are implicitly a part of the overall project and quality assurance program. Certain individuals have specifically delegated responsibilities, as described below.

Project Manager

The Project Manager for the aquatic biological and field sampling portions of the study is responsible for fiscal oversight and technical management of the project and for ensuring that all work is conducted in accordance with Scope of Service, Sampling and Analysis Plan, and approved procedures. Tasks include:

- Maintain routine contact with the project's progress, regularly review the project schedule, and review all work products.
- Evaluate impacts on project objectives and the need for corrective actions based on quality control checks, and whenever the data quality objective of 100% completeness is not met.
- Maintain a central file, which contains or indicates the location of all documents relating to this project.
- Review and update of this Sampling and Analysis Plan, as needed.
- Coordinate with the Authority, the WQCD, and the Authority's other consultants to ensure compliance with the Cherry Creek Reservoir Control Regulation No. 72.

Quality Assurance Manager

Quality Assurance oversight will be provided by a qualified individual with specific education and experience in water quality sampling and analysis. The Quality Assurance Manager shall be responsible for evaluation and review of all data reports relevant to the project and perform data verification. The Quality Assurance Manager shall work with the Project Manager to determine the need for corrective actions and, together, will make recommendations for any needed changes to either sampling methodologies or laboratory analytical procedures.

Analytical and Biological Laboratory Managers

The Analytical Laboratory Manager shall ensure that all water quality samples are analyzed in a technically sound and timely manner. The Analytical Laboratory Manager shall be responsible for ensuring all laboratory quality assurance procedures associated with the project are followed, including proper sample entry, sample handling procedures, and quality control records for samples delivered to the laboratory. The Analytical Laboratory Manager will be responsible for all data reduction and verification and ensure that the data is provided in a format agreed upon between the Project Manager, the Analytical Laboratory Manager, and the Authority.

The Biological Laboratory Manager shall ensure that all biological samples are analyzed in a technically sound and timely manner. The Biological Laboratory Manager shall be responsible for ensuring all laboratory quality assurance procedures associated with the project are followed, including proper sample entry, sample handling procedures, and quality control records for samples delivered to the laboratory. The Biological Laboratory Manager will be responsible for all data reduction and verification, and ensure that the data is provided in a format agreed upon between the Project Manager, the Analytical Laboratory Manager, and the Authority.

Sampling Crew

The field sampling efforts shall be conducted by individuals qualified in the collection of chemical, physical, and biological surface water samples. Field tasks and sampling oversight will be provided by the Project Manager. The Sampling Crew shall be responsible for following all procedures for sample collection, including complete and accurate documentation.

AQUATIC BIOLOGICAL AND NUTRIENT SAMPLING

Reservoir Monitoring Sites

Sampling would be conducted at sites established during past sampling efforts, as modified herein (see Figure 1 for location of all sites).

Cherry Creek Reservoir

CCR-1 This site is also called the Dam site and corresponds to the northwest trident when partitioning the lake by estimations of volume.

CCR-2 This site is also called the Swim Beach site and corresponds to the northeast trident when partitioning the lake by estimations of volume.

CCR-3 This site is also called the Inlet site and corresponds to the south trident when partitioning the lake by estimations of volume.

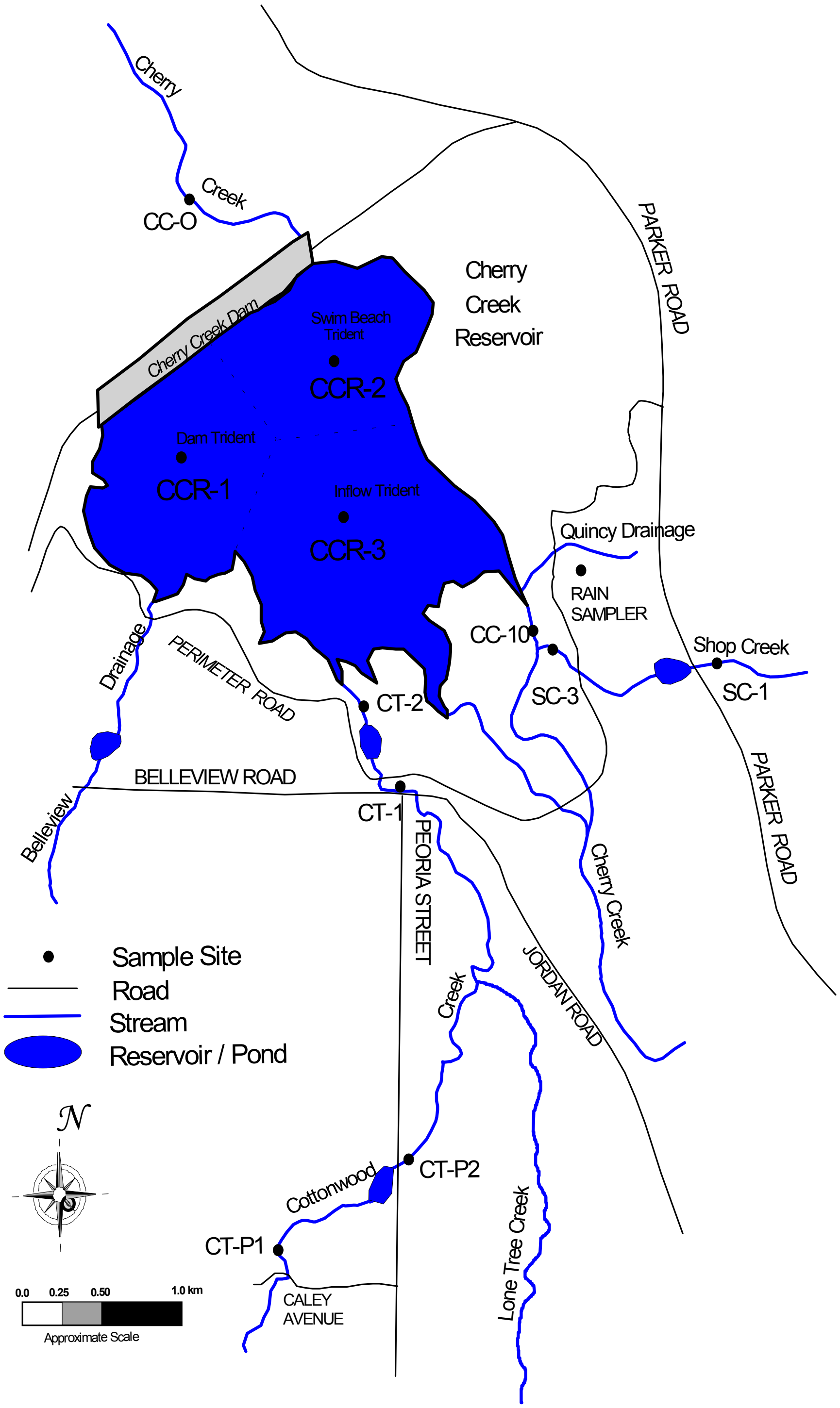

Figure 1: Sampling sites on Cherry Creek Reservoir and selected streams.

Stream Monitoring Sites

Cherry Creek

CC-10 This site is on Cherry Creek immediately downstream of the Shop Creek confluence, approximately 0.5 km upstream of Cherry Creek Reservoir. This site measures loads from Cherry Creek and Shop Creek that enter the reservoir.

CC-O This site is on Cherry Creek downstream of Cherry Creek Reservoir near the USGS gaging station within the Kennedy Golf Course.

Cottonwood Creek

CT-2 This site is immediately downstream of the phosphorus control facility (PRF), upstream of Cherry Creek Reservoir (i.e., Perimeter Road Pond). Although this site also measures the performance of the Perimeter Road Pond PRF, it is included in the reservoir portion of the effort since it is needed to measure loads to the reservoir from Cottonwood Creek.

PRF Monitoring Sites

Shop Creek

SC-3 This site is downstream of the Shop Creek detention pond and wetland complex above the confluence with Cherry Creek mainstem, and downstream of the Perimeter Road.

Cottonwood Creek

CT-P1 This site is located on Cottonwood Creek upstream of the new detention pond PRF at Peoria Street.

CT-P2 This site is located on Cottonwood Creek just downstream of Peoria Street Pond PRF and in the upper end of the streambank stabilization reach.

CT-1 This site is on Cottonwood Creek just downstream of Belleview Avenue, upstream of the Cherry Creek Park Perimeter Road. Note that Site CT-2 is included in the reservoir monitoring requirements.

Precipitation Sampling Site

This site is located near the Quincy Drainage, upstream of the Perimeter Road. The sampler consists of a clean, inverted plastic trash can lid used to funnel rain into a one-gallon container.

Analyte List

The sampling and analyses shall be conducted in accordance with the methods and detection limits provided in Table 1.

TABLE 1: Standard methods for analysis.

Analyte	Standard Methods*	Other Method Designations	Recommended Hold Times	Detection Limit
Manual Analyses				
pH		Denver Instrument pH/ATC Ag/AgCl combination electrode	24 hrs.	
Alkalinity	2320 B		24 hrs.	2 mg/$CaCO_3$/L
Hardness	2340 C (modified)	HACH Method 8266, ManVer 2 Buret Titration	24 hrs.	2 mg/$CaCO_3$/L
Total Suspended Solids	2540 D		7 days	4 mg/L
Total Volatile Suspended Solids	2540 E		7 days	4 mg/L
Chlorophyll	10200 H (modified)	Hot Ethanol Extraction	-24 hrs. before filtration	0.1 mg/m^3
Nutrient Analyses				
Orthophosphate	4500-P G	QuickChem 10-115-01-1-T	48 hrs.	3 µg/L
Total Phosphorus	4500-P G	QuickChem 10-115-01-1-U, with manual digestion	-24 hrs. before digestion	2 µg/L
Nitrate + Nitrite	4500-NO3 I	QuickChem 10-107-04-1-B	48 hrs.	5 µg/L
Total Nitrogen	4500-N B (modified)		-24 hrs. before digestion; -7 days after digestion	4 µg/L
Ammonia	none	QuickChem 10-107-06-3-D	24 hrs.	3 µg/L
Biological Analyses				
Phytoplankton	Analyzed by Dr. Jim Sanders, Associate Director Center for Limnology, University of Colorado			

* From *Standard Methods for Examination of Water and Waste Water* (20th Edition).

Sampling Schedule

Reservoir Sampling

The general sampling schedule includes regular sampling trips to the reservoir at varying frequency over the annual sampling period, as outlined below. Sampling in our winter months (November - February) will depend on ice conditions and safety concerns.

TABLE 2: Reservoir Sampling Schedule

Sampling Period	Frequency	Trips/Period
January to April (not February)	Monthly	3
May to September	Every 2 Weeks	11
October to November (not December)	Monthly	2
	Total	16

Stream Sampling

Standard sampling is conducted monthly concurrent with the regular reservoir sampling trips when possible to generally provide information during non-storm event periods, corresponding to the low-flow ambient samples collected in earlier studies.

TABLE 3: Stream Sampling Schedule

Sampling Period	Frequency	Trips/Period
January to December	Monthly	12
	Total	12

Representative Storm Event Sampling

There are six stream sites for storm event sampling(i.e., S-3, CC-10, CT-1, CT-2, CT-P1, and CT-P2). Storm samples are not collected at Site CC-O downstream of the reservoir, unless the Army Corps of Engineers (Corps) alerts the Consultant to an outflow event that could be tied to a storm-related inflow. Up to five storm events shall be collected over the summer for Cherry Creek (Site CC-10) and on Shop Creek (Site S-3). Up to seven storm events shall be collected at the four sites on Cottonwood Creek (CT-1, CT-2, CT-P1, and CT-P2). The actual number of storm events for which samples are obtained will be subject to weather patterns.

The recommended storm sampling period is April through September to attempt to capture some of the late spring snowmelt events as well as the summer "monsoon" season..

Precipitation Sampling

Precipitation samples are to be collected after "significant" rainfall events, defined as 0.5 inches or more. The sampler shall be inspected weekly and emptied of any accumulations of insignificant precipitation and the collector (inverted trash can lid) cleaned. This procedure is required to minimize insignificant amounts of precipitation contaminating the sample by allowing "dry-fall" to be washed into the sampler between significant events.

Field Methodologies

Reservoir Sampling

Transparency

Transparency shall be determined using a Secchi disk and a combined-deck photometer. The Secchi reading would be taken from the shady side of the boat. If this is not possible, sunglasses or other shading will be used to reduce glare. The disk is lowered slowly until the white quadrants disappear, at which point the depth is recorded to the nearest tenth of a meter. The disk is then lowered roughly 1 m further and slowly brought back up until the white quadrants reappear and again the depth is recorded. The Secchi disk depth is recorded as the average of these two readings.

A second method to measure the depth of the euphotic zone is to determine the depth at which 1% of the light penetrates the water column. This is considered the point at which, on average, light no longer can sustain photosynthesis in excess of oxygen consumption from respiration (Goldman and Horne 1983). This is accomplished by using a double-deck photometer. One photocell remains on the surface, and the other is lowered into the water on the sunny side of the boat. Both photocells are attached to a data logger, which records the amount of light in micromoles per second per square meter. The underwater photocell is lowered until the value displayed on the data logger is 1% of the value of the surface photocell, and then the depth is recorded.

Depth Profile Measurements

Measurements for dissolved oxygen, temperature, conductivity, and pH shall be taken at 1 m intervals using a YSI meter, Model # 600XL multi-probe meter. This meter shall be calibrated at the C&A Laboratory prior to each sampling episode to ensure accurate readings. To determine maximum depth, a Secchi disk will be lowered until it reaches the bottom. This reading will be taken on the opposite side of the boat from where water samples are being taken to minimize chances of sample contamination from the sediment. Profile measurements are taken no deeper than 0.5 m off the bottom to minimize potential contamination of the probes.

Water Samples

A primary task is sampling of water for nutrient and biology analyses. An upper-reservoir composite sample shall be taken at each of the three reservoir sites, kept separate for each site, and analyzed individually for nutrients and chlorophyll. A composite comprised of equal contributed aliquots collected with a vertical Van Dorn water sampler (approximately 3 L) at 1 m increments beginning at the surface and continuing to the 3 m depth (the upper 3 m of the reservoir represents 71% of the lake volume).

Samples are collected using a vertical Van Dorn sampler (3 L volume) by lowering to the appropriate depth (as outlined above). A "messenger" is sent to trip the sampler, and the water is brought to the boat and transferred to a clean plastic bucket for splitting into aliquots, as described above. The sampler is rinsed thoroughly with lake water between samples and between sites. Aliquots are taken from the photic composite for chemical analyses consisting of three 4-L just (two for chlorophyll and one for nutrients).

Water sample depth profile sampling is also conducted at Site CCR-2 in the deepest area in the reservoir. At this site, additional water samples shall be obtained at the 4, 5, 6, and 7 m depths. The last sample (7 m) would be collected roughly 1 m off the bottom, to minimize disturbance of bottom sediments during sampling. With variation in reservoir elevation throughout the year, it may not be possible to actually collect a sample at the 7 m depth every sampling episode. Samples are collected using a vertical Van Dorn sampler (3 L volume). The sampler is lowered to the appropriate depth (as outlined above). A "messenger" is sent to trip the sampler, and the water is brought to the boat and transferred to a clean bucket for splitting into aliquots, as described above. The sampler is rinsed thoroughly with lake water between samples and between sites.

Based on this sampling scheme, the number of samples taken at each site is as below:

TABLE 4: Samples per Station/Sampling Episode

Location		Photic Composite	1-m Increment Depth Samples
Dam	(CCR-1)	1	0
Swim Beach	(CCR-2)	1	4
Inflow	(CCR-3)	1	0
Total Samples/Sample Episode		3	4
Grand Total		7	

Water Quality Analyses

1. Nutrients, alkalinity, hardness, and pH analyses conducted in all reservoir water samples.

2. Chlorophyll would be analyzed in the 3 m photic depth profile samples only from June - September, one set per month.

3. Phytoplankton would be sampled twice monthly from April - October, and monthly from November - March from the 0-3 m water composite samples.

See Table 1 for the list of analytes, laboratory methods, and detection limits.

Stream Sampling

One sample shall be collected from each of the stream sampling sites during the sampling period, when there is sufficient flow. Samples shall be taken as mid-stream mid-depth grab samples with a polyethylene scoop and composited in a 5-gallon plastic bucket. Aliquots shall be taken from the composite for chemical analyses consisting of two 4-L jugs for analysis of parameters, as listed below in Table 5.

During these sampling episodes, water was collected from each of the seven stream sampling sites (sites on tributary streams and on Cherry Creek downstream of the reservoir) and analyzed for nutrients and suspended solids. No samples were collected at Site CC-O during January, February, October, and December due to lack of water. With the exception of Site SC-3 in July, flows were sufficient at each tributary site through the year to obtain all scheduled samples. Two samples were collected for chemical and suspended solids analysis from each of the stream sampling sites and consisted of a mid-stream, mid-column grab sample using two 1 L bottles. After collecting water samples, dissolved oxygen, temperature, conductivity, pH, and oxidation-reduction potential readings were taken at each stream site. Readings were taken with a YSI meter, model #600 XL multi-probe meter.

Stream Sampling

One sample shall be collected from each of the stream sampling sites during the sampling period, when there is sufficient flow. Samples shall be taken as mid-stream mid-depth grab samples with a polyethylene scoop and composited in a 5-gallon plastic bucket. Aliquots shall be taken from the composite for chemical analyses consisting of two 4-L jugs for analysis of parameters, as listed below in Table 5.

Automatic Sampler

Each stream sampling station upstream of the reservoir also contains an Authority-owned ISCO flow meter and sampling device, which is powered by a 12-volt battery. The flow meter is a pressure transducer that measures stream water level. Rating curves were developed for each sampling site by measuring stream discharge (ft^3/sec) with a Marsh McBirney Model # 2000 flowmeter, and recording the water level at the staff gage (ft) and ISCO flowmeter (ft). Discharge is measured using methods outlined in Harrelson *et al* 1994. To determine flow rate, the level must be translated into flow rate using a "stage-discharge" relationship. The Authority has developed such a relationship for each site over the years. Since stage-discharge relationships can change over the years, the relationship is calibrated annually using a flow meter to take stream flow measurements three to four times per year at a range of flows. These data shall be combined with previous data to validate and modify the stage-discharge relationship for that site.

Water level data are stored in the ISCO sampler and must be downloaded to calibrate the station. Downloading of the data shall occur at least monthly to minimize the risk of a bad battery or other power failure resulting in a loss of data. The flow data and stage-discharge rating curves shall be checked throughout the year by comparing calculated flow estimates to actual flow measurements taken in the field with a flowmeter. Flow at time of sampling shall be calculated using stage-discharge relationships and is used to develop the flow-to-phosphorus relationship necessary to calculate daily loads (which are totaled for monthly and annual loads). The Corps is also contacted and daily precipitation and inflows/outflows from the reservoir obtained.

Storm Event Sampling

Samples from stormwater flow events are collected with ISCO automatic samplers, which collects samples when the water reaches a pre-set level. The level is determined by analyzing annual hydrographs from each stream and determining storm levels. When the pre-set level is reached, the ISCO collects a sample every 15 minutes for approximately 2.5 hours (i.e., a timed composite) or until the water recedes below the pre-set level. This sampling procedure occurs at Sites S-3, CC-10, CT-1, CT-2, CT-P1, and CT-P2. Following the storm event, water collected by the automatic samplers shall be composited (timed composite) and transferred to water jugs for analysis. Approximately 4 L would be collected from the 24 bottles, with each bottle contributing a sample amount representative of the flow at which it was taken. During the seasons in which no storm samples are taken, the storm samplers are disabled.

Precipitation Sampling

After each significant storm, the sample bottle shall be removed and taken to a qualified laboratory for analysis of total phosphorus, total nitrogen, and nitrite-nitrate. If sufficient volume remains, samples shall be tested for alkalinity, water hardness, pH, and suspended solids. The sampler shall be inspected and cleaned of any accumulations of insignificant precipitation on a weekly basis. This will prevent extraneous "dry fall" from being washed into the sampler between significant storm events.

Field-Related Quality Assurance/Quality Control

To ensure data quality, a number of quality assurance checks will be used. During each standard sampling episode, 1-split from the reservoir and 1-split from the stream (i.e., 28 total samples) shall be shipped to the University of Colorado (CU) laboratory for analysis.

Field sampling quality control will consist of the use of a field blank. This field blank shall contain laboratory-grade deionized water that will be carried through the entire sampling episode. The cap of this jug will be removed at a particular site and left open during the regular sampling effort, after which time the cap will be replaced. One field blank will be used for every sampling trip. The field blanks and trip duplicates will be analyzed for the same parameters as a routine sample and later compared to samples analyzed by a qualified laboratory to provide QA/QC checks. Chain of custody procedures will be observed during the field sampling and delivery of samples to a qualified laboratory and to the CU laboratory.

LABORATORY PROCEDURES

Chemical Laboratory Analysis

Chemical analyses for the water collected in the study (Table 1) will be conducted by a qualified laboratory. Water samples will be analyzed for the parameters listed below.

TABLE 5: List of Analytes by Sample Depth

3-m Photic Composite Samples	1-m Increment Depth Samples	Stream Samples Precipitation Samples
pH, Conductivity, and Temperature	TP, TDP, SRP	TD, TDP, SRP
Total Phosphorus (TP), Total Dissolved Phosphorus (TDP), and Soluble Reactive Phosphorus (SRP)	TN, TDN, NO_3+NO_2, Ammonia	TN, TDN, NO_3+NO_2, Ammonia
Total Nitrogen (TN, Total Dissolved Nitrogen (TDN), NO_3+NO_2, and Ammonia		Total Suspended Solids (TSS)/ Total Volatile Suspended Solids (TVSS) (not on precipitation)
Chlorophyll		
Phytoplankton (sampled on reservoir sampling dates: twice monthly from April - October, and monthly from November - March from the 0-3 m water composite samples)		

Biological Laboratory Analysis

Biological analyses for the samples collected in the study, as described above, will be conducted at a qualified laboratory and analyzed for chlorophyll *a*. The methods of these analyses, with appropriate QA/QC procedures shall be in accordance with the methods provided in Table 1. Phytoplankton samples will be sent to the Colorado University Center for Limnology to be analyzed by Dr. Jim Saunders.

DATA VERIFICATION, REDUCTION, AND REPORTING

Data verification shall be conducted to insure that raw data are not altered. All field data, such as those generated during any field measurements and observations, will be entered directly into a bound Field Book. Sampling Crew members will be responsible for proof reading all data transfers, if necessary. At least ten percent of all data transfers will be checked for accuracy.

The Quality Assurance Project Manager will conduct data verification activities to assess laboratory performance in meeting quality assurance requirements. Such reviews include a verification that: 1) the correct samples were analyzed and reported in the correct units; 2) the samples were properly preserved and not held beyond applicable holding times; 3) instruments are regularly calibrated and meeting performance criteria; and 4) laboratory QA objectives for precision and accuracy are being met.

Data reduction for laboratory analyses is conducted by Consultant's personnel in accordance with EPA procedures, as available, for each method. Analytical results and appropriate field measurements are input into a computer spreadsheet. No results will be changed in the spreadsheet unless the cause of the error is identified and documented.

A data control program will be followed to insure that all documents generated during the project are accounted for upon their completion. Accountable documents include: Field Books, Sample Chain of Custody, Sample Log, analytical reports, quality assurance reports, and interpretive reports.

Data shall be summarized and provided to the Authority's Technical Advisory Committee on a monthly basis and presented in an annual report.

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American Public Health Association. 1998. *Standard Methods for Examination of Water and Wastewater*, 20th Edition. American Public Health Association, Washington, DC.

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Harrelson, Cheryl C., Rawlins, C.L., Potyondy, John P. 1994. *Stream channel reference sites : an illustrated guide to field technique.* Gen. Tech. Rep. RM-245. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 61p.

APPENDIX B

Reservoir Water Quality Data

CCR-1 C&A Water Chemisty Data

Sample Date	Sample Name/ Location	Total Phosphorus µg/L	Total Dissolved Phosphorus µg/L	Ortho-Phosphate µg/L	Total Nitrogen µg/L	Total Dissolved Nitrogen µg/L	NO3+NO2-N µg/L	NH4-N µg/L	Average Chlorophyll α mg/m^3
	Analytical Detection Limits	2	2	3	4	4	5	3	
03/25/03	CCR-1 Photic	74	14	3	947	498	<5	14	19.2
04/22/03	CCR-1 Photic	106	23	16	1013	498	11	49	10.9
05/06/03	CCR-1 Photic	122	40	12	1207	548	5	15	44.0
05/20/03	CCR-1 Photic	77	17	6	807	485	<5	14	15.3
06/03/03	CCR-1 Photic	57	14	3	776	539	<5	16	7.4
06/17/03	CCR-1 Photic	68	20	9	934	666	<5	37	8.4
07/01/03	CCR-1 Photic	89	26	10	1179	799	9	21	16.2
07/15/03	CCR-1 Photic	90	19	3	1455	717	<5	29	41.6
07/29/03	CCR-1 Photic	93	16	6	1110	590	5	17	24.1
08/12/03	CCR-1 Photic	88	18	5	1256	842	9	33	18.3
08/26/03	CCR-1 Photic	84	17	5	1284	773	5	22	26.7
09/09/03	CCR-1 Photic	91	16	3	1060	604	<5	21	31.5
09/23/03	CCR-1 Photic	108	16	5	1032	526	<5	10	23.1
10/15/03	CCR-1 Photic	113	12	5	1127	588	<5	19	32.9
11/11/03	CCR-1 Photic	73	13	3	873	560	25	49	32.3

CCR-2 C&A Water Chemisty Data

Sample Date	Sample Name/ Location	Total Phosphorus µg/L	Total Dissolved Phosphorus µg/L	Ortho-Phosphate µg/L	Total Nitrogen µg/L	Total Dissolved Nitrogen µg/L	NO3+NO2-N µg/L	NH4-N µg/L	Average Chlorophyll α mg/m^3
Analytical Detection Limits		2	2	3	4	4	5	3	
03/25/03	CCR-2 Photic	78	13	3	807	407	<5	5	22.1
03/25/03	CCR-2 4m	72	14	<3	753	425	<5	4	ND
03/25/03	CCR-2 5m	56	14	<3	740	440	<5	4	ND
03/25/03	CCR-2 6m	83	14	4	785	425	<5	6	ND
03/25/03	CCR-2 7m	61	12	3	737	438	<5	5	ND
04/22/03	CCR-2 Photic	108	32	16	953	478	13	42	11.3
04/22/03	CCR-2 4m	108	27	16	834	476	13	40	ND
04/22/03	CCR-2 5m	104	25	15	817	494	13	46	ND
04/22/03	CCR-2 6m	111	26	16	923	469	14	44	ND
04/22/03	CCR-2 7m	111	28	17	877	519	14	59	ND
05/06/03	CCR-2 Photic	110	31	13	958	490	5	10	29.8
05/06/03	CCR-2 4m	103	29	18	858	505	8	20	ND
05/06/03	CCR-2 5m	97	33	16	817	451	6	10	ND
05/06/03	CCR-2 6m	108	29	18	893	491	7	12	ND
05/06/03	CCR-2 7m	114	31	19	848	512	9	19	ND
05/20/03	CCR-2 Photic	81	17	5	745	454	<5	9	16.1
05/20/03	CCR-2 4m	78	16	5	827	475	<5	14	ND
05/20/03	CCR-2 5m	72	16	5	777	473	<5	15	ND
05/20/03	CCR-2 6m	72	17	5	762	457	<5	9	ND
05/20/03	CCR-2 7m	75	17	5	801	490	<5	7	ND
06/03/03	CCR-2 Photic	50	12	<3	651	456	<5	8	7.3
06/03/03	CCR-2 4m	65	13	3	720	441	<5	9	ND
06/03/03	CCR-2 5m	56	13	3	718	471	<5	9	ND
06/03/03	CCR-2 6m	53	13	3	694	452	<5	8	ND
06/03/03	CCR-2 7m	49	14	3	724	519	<5	10	ND
06/17/03	CCR-2 Photic	63	16	5	734	460	<5	14	10.3
06/17/03	CCR-2 4m	62	16	5	669	418	<5	10	ND
06/17/03	CCR-2 5m	83	33	23	689	451	<5	14	ND
06/17/03	CCR-2 6m	84	35	25	686	443	<5	17	ND
06/17/03	CCR-2 7m	103	52	43	671	406	<5	14	ND

* "ND" denotes "No Data"

CCR-2 C&A Water Chemisty Data

Sample Date	Sample Name/ Location	Total Phosphorus µg/L	Total Dissolved Phosphorus µg/L	Ortho-Phosphate µg/L	Total Nitrogen µg/L	Total Dissolved Nitrogen µg/L	NO3+NO2-N µg/L	NH4-N µg/L	Average Chlorophyll α mg/m^3
Analytical Detection Limits		2	2	3	4	4	5	3	
07/01/03	CCR-2 Photic	81	20	6	1071	666	<5	17	16.2
07/01/03	CCR-2 4m	83	19	7	903	527	<5	15	ND
07/01/03	CCR-2 5m	85	24	12	860	542	<5	12	ND
07/01/03	CCR-2 6m	90	31	21	823	533	<5	38	ND
07/01/03	CCR-2 7m	92	28	15	918	548	<5	16	ND
07/15/03	CCR-2 Photic	91	18	3	1309	538	<5	15	43.2
07/15/03	CCR-2 4m	87	17	<3	1287	528	<5	12	ND
07/15/03	CCR-2 5m	87	18	3	1268	513	<5	12	ND
07/15/03	CCR-2 6m	88	18	<3	1337	586	<5	19	ND
07/15/03	CCR-2 7m	91	17	3	1047	544	<5	16	ND
07/29/03	CCR-2 Photic	73	15	5	946	553	5	12	15.2
07/29/03	CCR-2 4m	80	16	5	1042	588	5	15	ND
07/29/03	CCR-2 5m	73	15	5	982	520	5	12	ND
07/29/03	CCR-2 6m	86	16	6	1125	651	7	18	ND
07/29/03	CCR-2 7m	70	13	5	911	516	5	11	ND
08/12/03	CCR-2 Photic	105	19	5	1187	615	<5	20	25.9
08/12/03	CCR-2 4m	99	17	5	1072	518	<5	9	ND
08/12/03	CCR-2 5m	94	17	5	1023	541	<5	11	ND
08/12/03	CCR-2 6m	98	19	7	1087	615	<5	20	ND
08/12/03	CCR-2 7m	98	16	6	1018	550	<5	18	ND
08/26/03	CCR-2 Photic	74	17	5	1358	854	5	26	20.2
08/26/03	CCR-2 4m	75	16	4	918	537	<5	6	ND
08/26/03	CCR-2 5m	79	23	5	1141	658	5	19	ND
08/26/03	CCR-2 6m	91	18	7	1078	596	5	15	ND
08/26/03	CCR-2 7m	110	23	11	1420	864	12	47	ND
09/09/03	CCR-2 Photic	91	12	<3	1058	523	<5	14	32.3
09/09/03	CCR-2 4m	95	13	<3	957	520	<5	13	ND
09/09/03	CCR-2 5m	88	12	<3	1016	469	<5	10	ND
09/09/03	CCR-2 6m	94	12	<3	876	501	<5	13	ND
09/09/03	CCR-2 7m	91	12	<3	979	488	<5	11	ND

* "ND" denotes "No Data"

CCR-2 C&A Water Chemisty Data

Sample Date	Sample Name/ Location	Total Phosphorus µg/L	Total Dissolved Phosphorus µg/L	Ortho-Phosphate µg/L	Total Nitrogen µg/L	Total Dissolved Nitrogen µg/L	NO3+NO2-N µg/L	NH4-N µg/L	Average Chlorophyll α mg/m^3
Analytical Detection Limits		2	2	3	4	4	5	3	
09/23/03	CCR-2 Photic	92	22	5	982	521	<5	8	19.9
09/23/03	CCR-2 4m	83	17	5	856	482	<5	4	ND
09/23/03	CCR-2 5m	75	16	5	811	480	<5	4	ND
09/23/03	CCR-2 6m	81	15	5	837	479	<5	5	ND
09/23/03	CCR-2 7m	84	19	8	833	475	<5	16	ND
10/15/03	CCR-2 Photic	113	12	5	1086	553	<5	13	39.6
10/15/03	CCR-2 4m	101	11	6	956	512	<5	9	ND
10/15/03	CCR-2 5m	97	11	5	935	502	<5	11	ND
10/15/03	CCR-2 6m	100	11	6	943	544	<5	31	ND
10/15/03	CCR-2 7m	ND	ND	ND	ND	ND	ND	ND	ND
11/11/03	CCR-2 Photic	66	17	3	825	524	28	43	32.8
11/11/03	CCR-2 4m	61	13	3	756	506	29	56	ND
11/11/03	CCR-2 5m	60	12	3	773	529	29	60	ND
11/11/03	CCR-2 6m	59	12	3	761	510	29	61	ND
11/11/03	CCR-2 7m	106	12	4	888	527	29	77	ND

* "ND" denotes "No Data"

CCR-3 C&A Water Chemisty Data

Sample Date	Sample Name/ Location	Total Phosphorus µg/L	Total Dissolved Phosphorus µg/L	Ortho-Phosphate µg/L	Total Nitrogen µg/L	Total Dissolved Nitrogen µg/L	NO3+NO2-N µg/L	NH4-N µg/L	Average Chlorophyll α mg/m^3
	Analytical Detection Limits	2	2	3	4	4	5	3	
03/25/03	CCR-3 Photic	59	12	3	727	424	<5	5	20.6
04/22/03	CCR-3 Photic	89	22	14	836	495	11	44	10.6
05/06/03	CCR-3 Photic	103	34	17	870	472	5	10	21.1
05/20/03	CCR-3 Photic	90	18	5	812	501	<5	10	16.2
06/03/03	CCR-3 Photic	55	12	<3	695	464	<5	9	6.2
06/17/03	CCR-3 Photic	68	16	5	715	441	<5	13	9.9
07/01/03	CCR-3 Photic	82	17	5	836	482	<5	10	20.4
07/15/03	CCR-3 Photic	88	17	3	1134	567	<5	15	31.0
07/29/03	CCR-3 Photic	87	17	7	1161	656	5	17	28.6
08/12/03	CCR-3 Photic	98	17	5	1081	557	<5	11	23.5
08/26/03	CCR-3 Photic	118	18	5	1159	545	<5	10	36.9
09/09/03	CCR-3 Photic	81	12	<3	943	469	<5	14	26.6
09/23/03	CCR-3 Photic	89	16	5	950	505	<5	5	19.5
10/15/03	CCR-3 Photic	103	11	6	973	530	<5	19	30.6
11/11/03	CCR-3 Photic	83	16	4	937	450	<5	11	47.0

CCR University of Colorado Water Chemisty Data

Sample Date	Sample Name/ Location	Total Phosphorus µg/L	Total Dissolved Phosphorus µg/L	Ortho-Phosphate µg/L	NO3+NO2-N µg/L	NH4-N µg/L
Analytical Detection Limits		2	2	3	5	3
03/25/03	CCR-1 Photic	55.7	17.7	1.3	0.0	16.9
04/22/03	CCR-2 5m	67.2	28.8	14.9	8.7	56.0
05/07/03	CCR-2 5m	72.9	40.6	21.2	0.0	27.7
05/20/03	CCR-3 Photic	59.3	19.5	3.8	0.0	19.5
06/03/03	CCR-2 Photic	47.6	18.3	2.1	0.0	12.5
06/17/03	CCR-2 Photic	62.9	30.4	4.6	0.0	34.2
07/01/03	CCR-2 5m	82.0	39.3	21.5	5.5	18.7
07/15/03	CCR-2 7m	65.8	21.4	3.0	0.0	24.9
07/29/03	CCR-2 6m	73.7	33.9	10.8	0.0	12.2
08/12/03	CCR-1 photic	65.6	28.2	6.9	2.7	22.6
09/09/03	CCR-3 photic	59.2	19.6	1.9	0.0	9.4
10/15/03	CCR-2 5m	69.4	23.2	5.6	0.0	21.7
11/11/03	CCR-2 4m	59	17.1	1.5	22.1	71.8

CCR C&A Water Chemisty Data

Sample Date	Sample Name/ Location	Total Phosphorus µg/L	Total Dissolved Phosphorus µg/L	Ortho-Phosphate µg/L	NO3+NO2-N µg/L	NH4-N µg/L
Analytical Detection Limits		2	2	3	5	3
03/25/03	CCR-1 Photic	74	14	3	<5	14
04/22/03	CCR-2 5m	104	25	15	13	46
05/07/03	CCR-2 5m	97	33	16	6	10
05/20/03	CCR-3 Photic	90	18	5	<5	10
06/03/03	CCR-2 Photic	50	12	2.1	<5	8
06/17/03	CCR-2 Photic	63	16	5	<5	14
07/01/03	CCR-2 5m	85	24	12	<5	12
07/15/03	CCR-2 7m	91	17	3	<5	16
07/29/03	CCR-2 6m	86	16	6	7	18
08/12/03	CCR-1 photic	88	18	5	9	33
09/09/03	CCR-3 photic	81	12	1.9	<5	14
10/15/03	CCR-2 5m	97	11	5	<5	11
11/11/03	CCR-2 4m	61	13	3	29	56

CHERRY CREEK
D.O. DATA, 2003
Site CCR-1

CCR-1 03/25/03
Secchi: 1.00 m
1% Trans: ND

Depth (m)	Temp °C	Cond.	DO	pH
0	5.72	626	10.43	8.31
1	5.69	624	10.42	8.32
2	5.59	621	10.40	8.33
3	5.55	622	10.35	8.33
4	5.50	620	10.27	8.31
5	5.51	621	10.26	8.33
6	5.48	620	10.22	8.31

CCR-1 04/22/03
Secchi: 0.50 m
1% Trans: 2.75 m

Depth (m)	Temp °C	Cond.	DO	pH
0	11.49	736	9.60	8.24
1	11.50	735	10.24	8.23
2	11.47	733	9.93	8.22
3	11.43	733	9.77	8.22
4	11.38	733	9.72	8.23
5	11.13	727	9.76	8.22

CCR-1 05/06/03
Secchi: 0.50 m
1% Trans: 2.75 m

Depth (m)	Temp °C	Cond.	DO	pH
0	14.02	723	16.89	8.57
1	13.42	714	15.11	8.49
2	13.15	708	13.98	8.34
3	12.99	707	13.60	8.29
4	12.75	704	11.35	8.12
5	12.58	700	10.27	8.03
6	12.53	700	9.82	8.02

CCR-1 05/20/03
Secchi: 0.90 m
1% Trans: 2.75 m

Depth (m)	Temp °C	Cond.	DO	pH
0	14.35	725	9.37	8.51
1	14.36	725	9.36	8.51
2	14.35	724	9.25	8.50
3	14.36	726	9.16	8.50
4	14.35	725	9.03	8.48
5	14.32	725	8.72	8.43
6	14.25	723	8.52	8.52

CCR-1 06/03/03
Secchi: 1.00 m
1% Trans: ND

Depth (m)	Temp °C	Cond.	DO	pH
0	20.22	848	11.19	8.48
1	19.65	838	11.06	8.47
2	19.50	835	10.82	8.44
3	19.24	832	10.06	8.36
4	19.10	828	8.02	8.26
5	17.81	808	6.35	8.07
6	17.66	810	6.78	8.13

CCR-1 06/17/03
Secchi: 1.00 m
1% Trans: ND

Depth (m)	Temp °C	Cond.	DO	pH
0	20.99	848	10.93	8.53
1	20.08	829	10.86	8.51
2	19.45	819	9.69	8.41
3	19.28	816	9.09	8.33
4	18.94	810	6.47	8.07
5	18.12	794	6.99	7.93
6	18.06	796	2.94	7.96

CCR-1 07/01/03
Secchi: 1.00 m
1% Trans: ND

Depth (m)	Temp °C	Cond.	DO	pH
0	22.35	864	11.64	8.57
1	22.07	856	11.16	8.53
2	21.51	848	10.79	8.45
3	20.41	830	10.59	8.15
4	20.17	826	8.15	7.96
5	20.01	825	6.20	7.80
6	19.47	815	2.90	7.62

CCR-1 07/15/03
Secchi: 1.00 m
1% Trans: ND

Depth (m)	Temp °C	Cond.	DO	pH
0	23.85	876	13.02	8.42
1	23.87	874	12.78	8.38
2	23.76	873	9.20	8.22
3	22.54	864	7.74	7.95
4	22.17	861	6.35	7.88
5	21.65	854	5.56	7.85
6	21.72	852	3.97	7.74

* "ND" denotes "No Data"

CCR-1 DO Data Continued

CCR-1 07/29/03
Secchi: 1.00 m
1% Trans: ND

Depth (m)	Temp °C	Cond.	DO	pH
0	23.88	882	6.43	8.18
1	23.67	877	5.91	8.06
2	23.47	874	5.23	7.95
3	23.42	877	4.35	7.80
4	23.37	876	4.05	7.75
5	23.33	874	3.29	7.67
6	23.27	874	2.76	7.61

CCR-1 08/12/03
Secchi: 1.00 m
1% Trans: ND

Depth (m)	Temp °C	Cond.	DO	pH
0	24.62	897	9.98	8.46
1	23.72	881	8.02	8.18
2	23.37	876	6.28	7.98
3	23.20	874	5.17	7.88
4	23.14	872	4.03	7.70
5	22.98	871	3.06	7.63
6	22.81	868	2.78	7.60

CCR-1 08/26/03
Secchi: 1.00 m
1% Trans: ND

Depth (m)	Temp °C	Cond.	DO	pH
0	23.21	894	11.50	8.53
1	22.80	885	11.89	8.47
2	22.39	880	9.08	8.33
3	22.33	879	8.60	8.20
4	22.31	879	8.03	8.13
5	22.22	878	5.07	7.97
6	22.14	878	4.38	7.92

CCR-1 09/09/03
Secchi: 0.75 m
1% Trans: ND

Depth (m)	Temp °C	Cond.	DO	pH
0	20.42	829	7.44	8.07
1	20.27	828	7.15	8.02
2	20.21	826	6.95	7.99
3	20.19	825	6.83	7.96
4	20.20	826	6.56	7.92
5	20.19	826	6.32	7.88
6	20.18	827	2.19	7.84

CCR-1 09/23/03
Secchi: 0.75 m
1% Trans: ND

Depth (m)	Temp °C	Cond.	DO	pH
0	19.37	759	11.56	8.35
1	17.19	721	10.88	8.34
2	16.71	713	9.94	8.31
3	16.29	708	5.72	8.03
4	16.13	706	5.07	8.07
5	16.10	705	4.38	7.96
6	16.07	704	4.15	7.91

CCR-1 10/15/03
Secchi: 0.80 m
1% Trans: ND

Depth (m)	Temp °C	Cond.	DO	pH
0	13.67	684	10.89	8.29
1	13.35	678	10.24	8.33
2	13.31	677	9.93	8.36
3	13.29	677	9.88	8.38
4	13.22	673	9.80	8.40
5	13.18	675	9.63	8.40
6	13.21	676	7.27	8.17

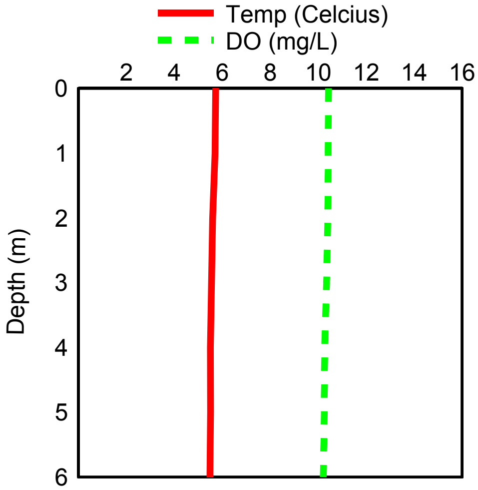
CCR-1 11/11/03
Secchi: 1.10 m
1% Trans: ND

Depth (m)	Temp °C	Cond.	DO	pH
0	7.54	588	12.46	8.64
1	7.42	589	11.60	8.61
2	7.08	583	10.94	8.53
3	7.07	583	10.84	8.53
4	7.06	583	10.79	8.54
5	7.06	583	10.60	8.53
6	7.06	583	10.61	8.51

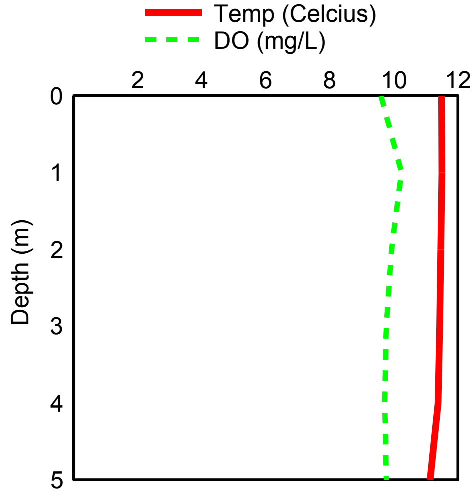
* "ND" denotes "No Data"

CCR-1

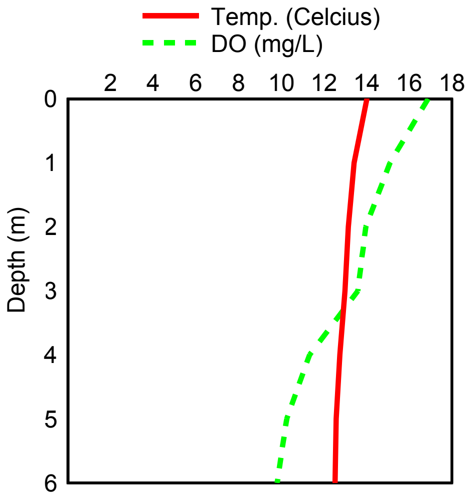
March 25, 2003



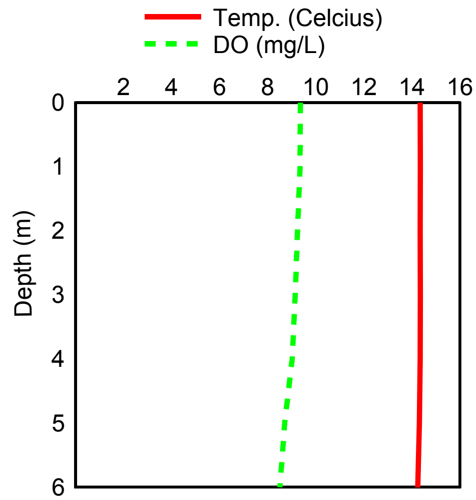
April 22, 2003



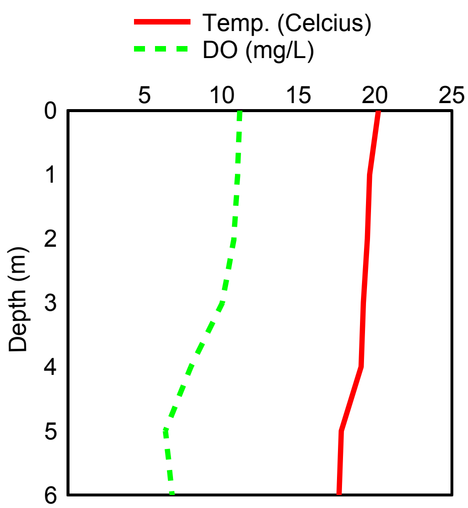
May 6, 2003



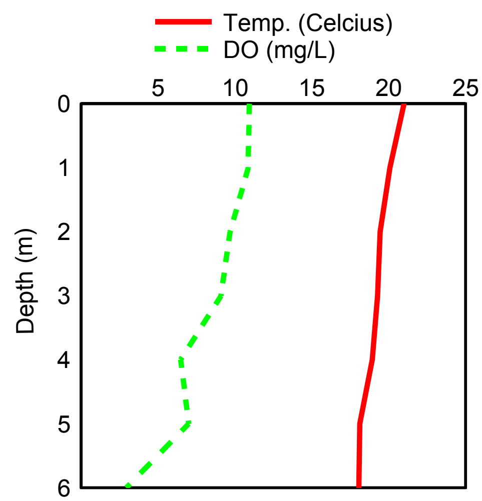
May 20, 2003



June 3, 2003

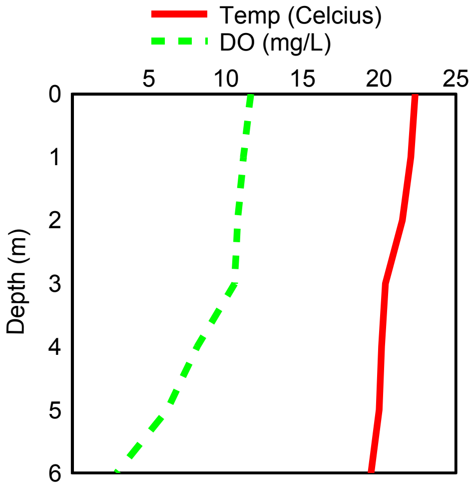


June 17, 2003

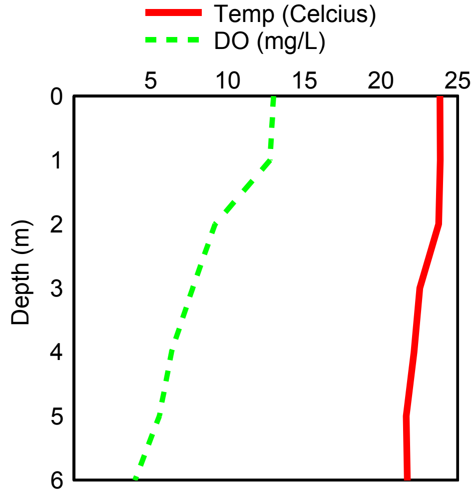


CCR-1

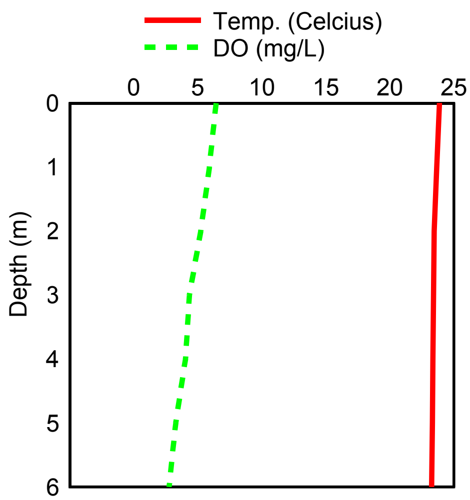
July 1, 2003



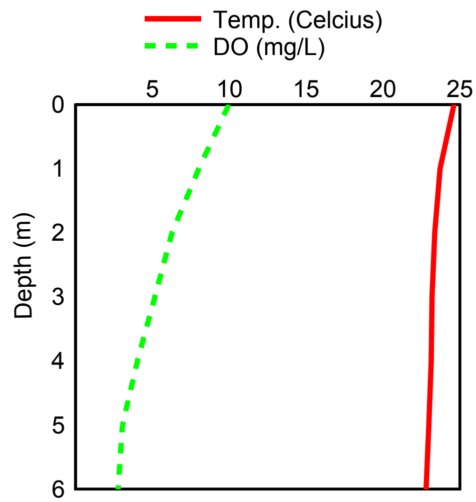
July 15, 2003



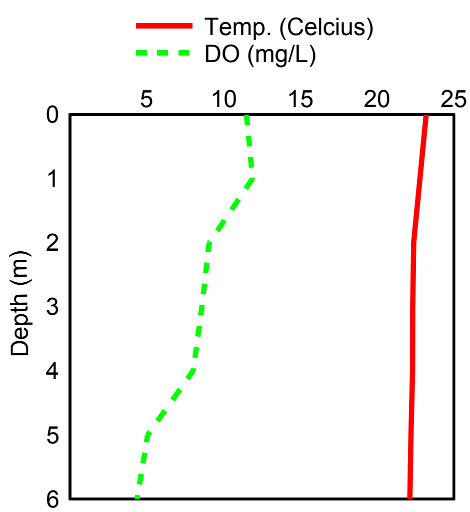
July 29, 2003



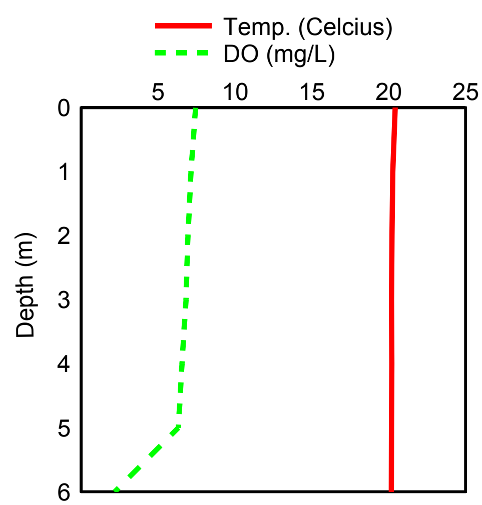
August 12, 2003



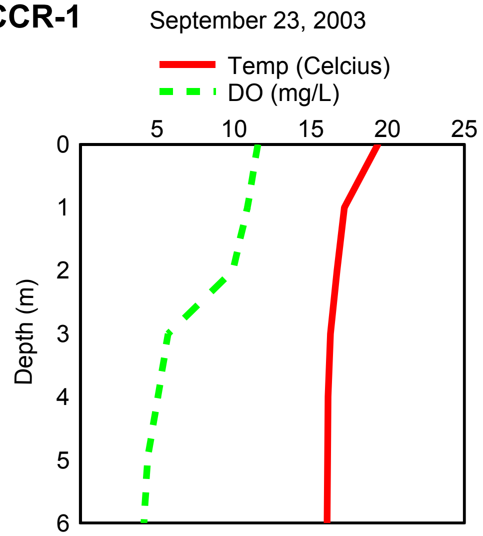
August 26, 2003

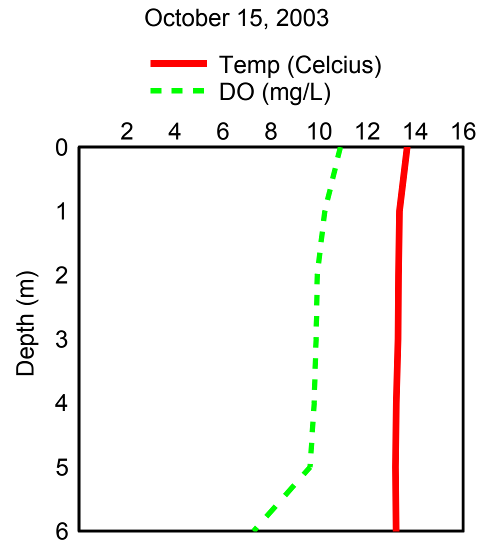


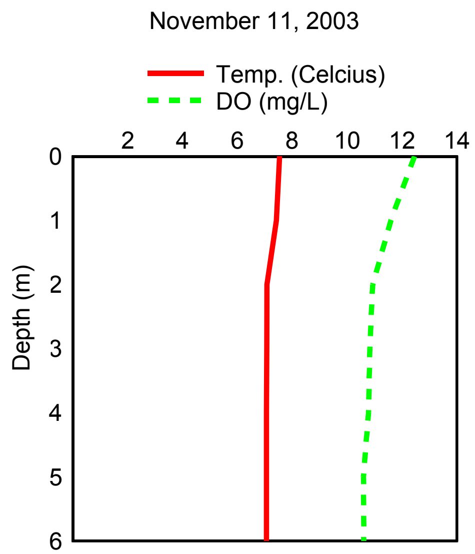
September 9, 2003



CCR-1


September 23, 2003
Temp (Celcius)
DO (mg/L)
5 10 15 20 25
0 1 2 3 4 5 6
Depth (m)


October 15, 2003
Temp (Celcius)
DO (mg/L)
2 4 6 8 10 12 14 16
0 1 2 3 4 5 6
Depth (m)


November 11, 2003
Temp. (Celcius)
DO (mg/L)
2 4 6 8 10 12 14
0 1 2 3 4 5 6
Depth (m)

CHERRY CREEK
D.O. DATA, 2003
Site CCR-2

CCR-2	03/25/03			
Secchi:	0.90 m			
1% Trans:	ND			
Depth (m)	**Temp °C**	**Cond.**	**DO**	**pH**
0	5.81	627	10.71	8.32
1	5.79	626	10.58	8.32
2	5.77	625	10.55	8.33
3	5.69	625	10.53	8.33
4	5.63	624	10.49	8.32
5	5.63	624	10.42	8.33
6	5.59	623	10.40	8.33
7	5.57	623	10.35	8.32

CCR-2	04/22/03			
Secchi:	0.50 m			
1% Trans:	2.00 m			
Depth (m)	**Temp °C**	**Cond.**	**DO**	**pH**
0	11.66	737	10.69	8.29
1	11.57	735	10.51	8.27
2	11.50	733	10.39	8.26
3	11.47	731	10.15	8.25
4	11.46	732	10.10	8.25
5	11.44	732	10.08	8.24
6	11.40	733	9.87	8.23
7	11.32	731	9.70	8.23

CCR-2	05/06/03			
Secchi:	0.50 m			
1% Trans:	2.25 m			
Depth (m)	**Temp °C**	**Cond.**	**DO**	**pH**
0	14.21	726	11.32	8.57
1	13.04	705	10.30	8.48
2	12.69	700	9.34	8.34
3	12.54	697	8.84	8.28
4	12.37	696	8.40	8.21
5	12.27	694	8.33	8.21
6	12.18	693	8.32	8.21
7	12.19	694	8.73	8.27

CCR-2	05/20/03			
Secchi:	1.00 m			
1% Trans:	3.00 m			
Depth (m)	**Temp °C**	**Cond.**	**DO**	**pH**
0	14.03	718	10.04	8.56
1	13.98	718	9.97	8.55
2	14.00	716	9.91	8.54
3	13.91	715	9.77	8.52
4	13.83	714	9.63	8.50
5	13.81	713	9.50	8.50
6	13.77	713	9.45	8.48
7	13.74	713	9.45	8.48

CCR-2	06/03/03			
Secchi:	1.25 m			
1% Trans:	ND			
Depth (m)	**Temp °C**	**Cond.**	**DO**	**pH**
0	20.45	855	10.76	8.48
1	19.14	830	10.61	8.46
2	18.90	825	9.93	8.40
3	18.70	822	9.19	8.33
4	18.40	818	7.85	8.23
5	17.85	807	6.54	8.11
6	16.82	791	4.05	7.92
7	15.52	768	1.29	7.77

CCR-2	06/17/03			
Secchi:	1.10			
1% Trans:	ND			
Depth (m)	**Temp °C**	**Cond.**	**DO**	**pH**
0	21.23	850	11.57	8.61
1	20.69	844	11.61	8.60
2	20.19	832	11.74	8.59
3	20.01	828	10.86	8.51
4	19.04	812	7.30	8.17
5	18.61	805	6.51	8.09
6	18.35	801	4.88	7.97
7	17.83	790	2.08	7.85

CCR-2	07/01/03			
Secchi:	1.00 m			
1% Trans:	ND			
Depth (m)	**Temp °C**	**Cond.**	**DO**	**pH**
0	22.20	862	12.17	8.60
1	21.75	853	11.79	8.58
2	21.51	848	11.26	8.53
3	21.28	844	10.58	8.47
4	20.68	835	8.48	8.25
5	19.71	811	5.36	7.95
6	19.26	803	4.34	7.85
7	18.19	731	1.21	7.70

CCR-2	07/15/03			
Secchi:	0.75 m			
1% Trans:	ND			
Depth (m)	**Temp °C**	**Cond.**	**DO**	**pH**
0	23.86	875	14.77	8.52
1	23.82	875	14.58	8.50
2	23.79	875	14.17	8.47
3	23.77	874	13.52	8.44
4	23.74	873	13.26	8.38
5	23.35	873	10.02	8.22
6	21.77	856	3.07	7.68
7	20.57	833	3.31	7.72

* "ND" denotes "No Data"

CCR-2 DO Data Continued

CCR-2 07/29/03
Secchi: 1.00 m
1% Trans: ND

Depth (m)	Temp °C	Cond.	DO	pH
0	24.15	886	6.55	8.26
1	23.67	877	5.78	8.11
2	23.46	874	5.26	8.03
3	23.42	874	4.94	7.99
4	23.39	873	4.85	7.97
5	23.36	873	4.77	7.95
6	23.31	873	4.31	7.92
7	23.28	873	4.06	7.90

CCR-2 08/12/03
Secchi: 0.75 m
1% Trans: ND

Depth (m)	Temp °C	Cond.	DO	pH
0	24.15	889	11.57	8.49
1	23.62	881	9.42	8.28
2	23.56	880	8.76	8.23
3	23.50	880	8.95	8.25
4	23.45	879	8.90	8.25
5	23.40	878	8.72	8.23
6	23.28	876	8.19	8.19
7	23.29	878	7.89	8.19

CCR-2 08/26/03
Secchi: 1.00 m
1% Trans: ND

Depth (m)	Temp °C	Cond.	DO	pH
0	22.85	890	10.52	8.44
1	22.43	859	10.14	8.38
2	22.25	877	8.79	8.29
3	22.23	880	8.61	8.27
4	22.21	877	8.48	8.26
5	22.21	876	8.30	8.25
6	22.17	877	7.86	8.22
7	22.14	876	7.25	8.23

CCR-2 09/09/03
Secchi: 0.85 m
1% Trans: ND

Depth (m)	Temp °C	Cond.	DO	pH
0	20.93	836	9.49	8.44
1	20.77	834	9.15	8.38
2	20.50	831	7.97	8.22
3	20.02	823	7.52	8.15
4	19.90	822	7.41	8.13
5	19.79	821	7.31	8.15
6	19.74	820	7.26	8.14
7	19.60	817	5.25	8.14

CCR-2 09/23/03
Secchi: 0.80 m
1% Trans: ND

Depth (m)	Temp °C	Cond.	DO	pH
0	17.85	745	10.31	8.30
1	16.81	714	10.95	8.39
2	16.54	708	10.89	8.45
3	16.20	706	9.40	8.39
4	16.08	703	8.32	8.32
5	15.99	702	7.96	8.29
6	15.89	701	7.37	8.24
7	18.89	701	6.34	8.17

CCR-2 10/15/03
Secchi: 0.80 m
1% Trans: ND

Depth (m)	Temp °C	Cond.	DO	pH
0	13.60	681	11.53	8.47
1	13.49	678	11.18	8.51
2	13.30	675	10.25	8.48
3	13.16	675	9.95	8.46
4	13.06	673	9.70	8.44
5	12.95	671	9.41	8.43
6	12.87	671	8.89	8.41
7	12.89	672	8.17	8.30

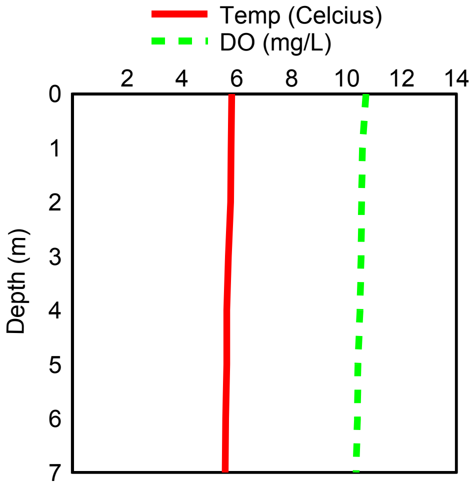
CCR-2 11/11/03
Secchi: 1.00 m
1% Trans: ND

Depth (m)	Temp °C	Cond.	DO	pH
0	7.20	583	12.75	8.67
1	7.18	583	12.62	8.66
2	7.12	581	12.36	8.65
3	7.08	581	12.01	8.63
4	7.01	580	11.92	8.63
5	7.00	580	11.87	8.63
6	7.01	581	12.48	8.65

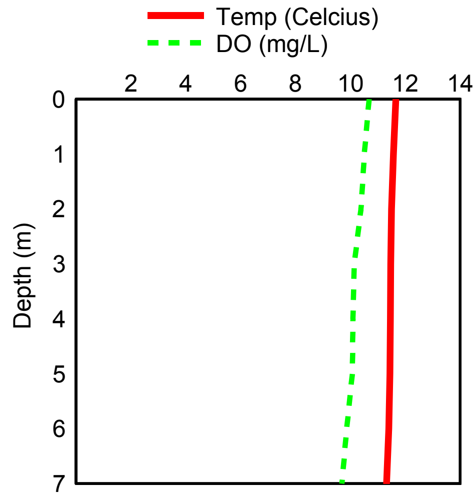
* "ND" denotes "No Data"

CCR-2

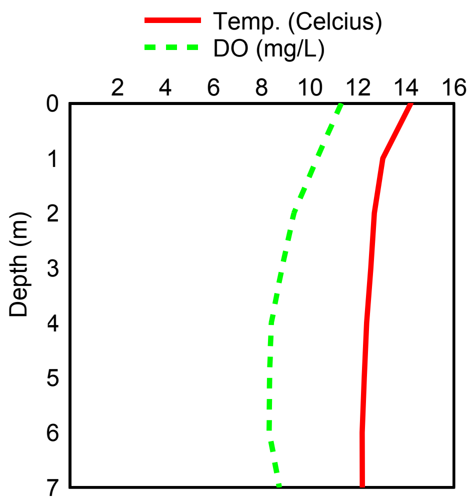
March 25, 2003



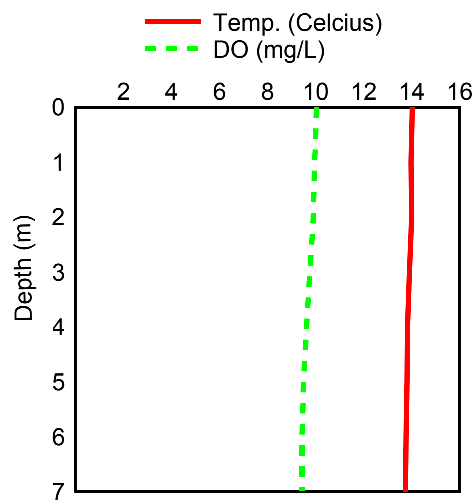
April 22, 2003



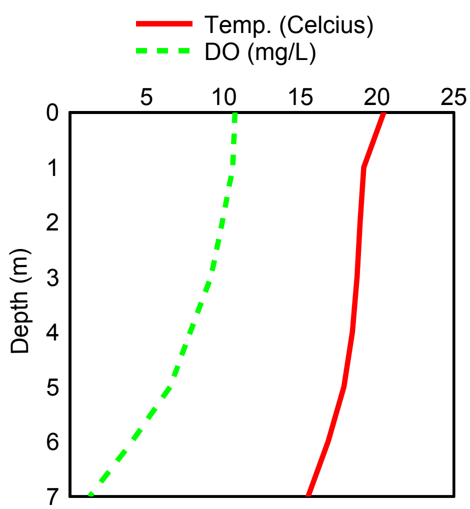
May 6, 2003



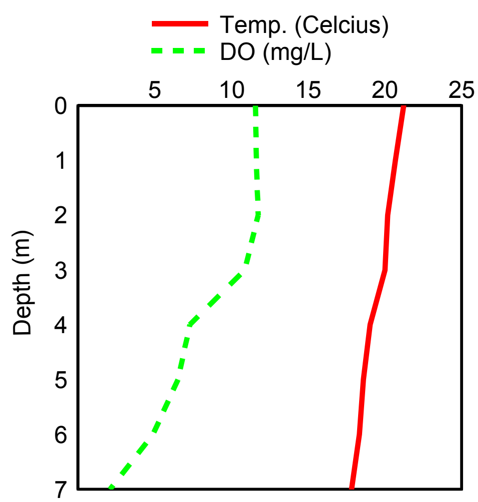
May 20, 2003



June 3, 2003

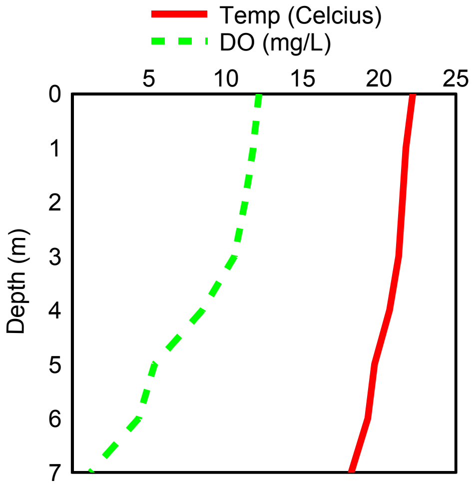


June 17, 2003

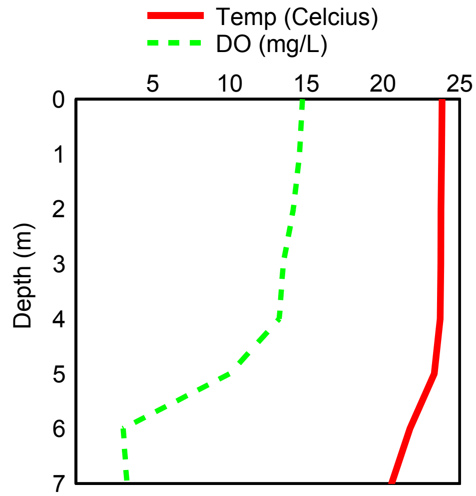


CCR-2

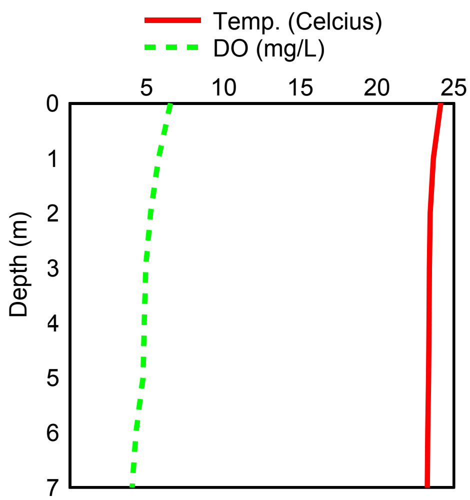
July 1, 2003



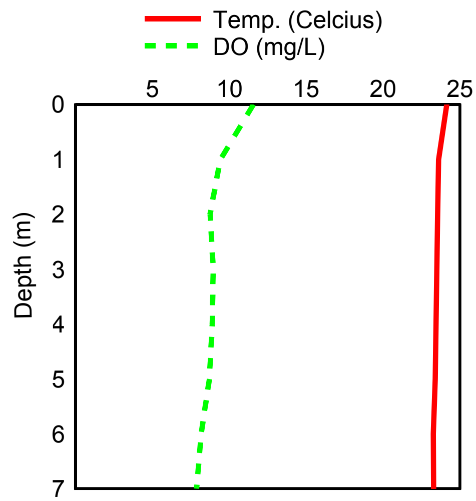
July 15, 2003



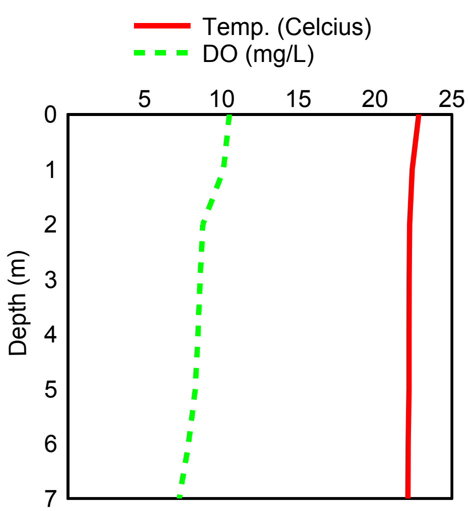
July 29, 2003



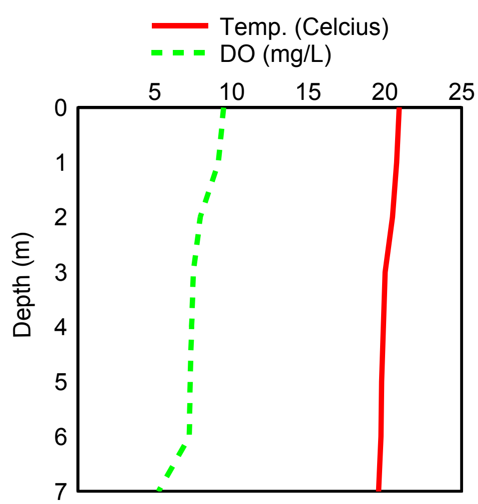
August 12, 2003



August 26, 2003

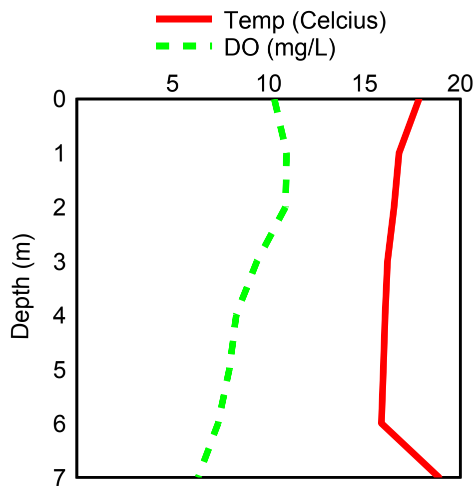


September 9, 2003

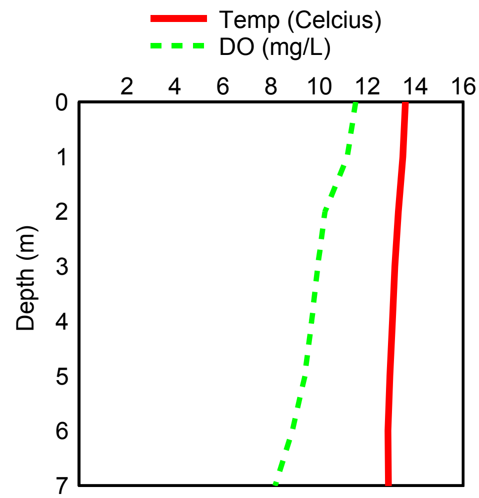


CCR-2

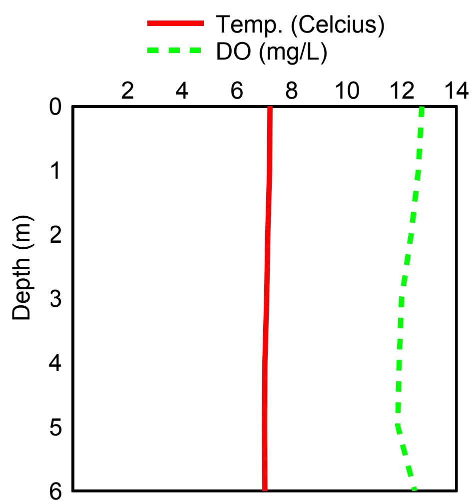
September 23, 2003



October 15, 2003



November 11, 2003



CHERRY CREEK
D.O. DATA, 2003
Site CCR-3

CCR-3 03/25/03
Secchi: 0.80 m
1% Trans: ND

Depth (m)	Temp °C	Cond.	DO	pH
0	5.73	626	10.36	8.33
1	5.61	624	10.29	8.33
2	5.55	622	10.25	8.33
3	5.51	622	10.19	8.33
4	5.41	620	10.10	8.32
5	5.40	618	8.94	8.31

CCR-3 04/22/03
Secchi: 0.75 m
1% Trans: 2.00 m

Depth (m)	Temp °C	Cond.	DO	pH
0	11.37	733	11.34	8.31
1	11.37	731	11.07	8.30
2	11.33	728	10.96	8.28
3	11.09	723	10.79	8.26
4	10.69	718	10.33	8.22

CCR-3 05/06/03
Secchi: 0.50 m
1% Trans: ND

Depth (m)	Temp °C	Cond.	DO	pH
0	13.81	718	10.83	8.49
1	12.74	700	10.36	8.40
2	12.41	694	9.47	8.30
3	12.23	692	8.83	8.24
4	11.80	686	8.05	8.17

CCR-3 05/20/03
Secchi: 0.75 m
1% Trans: 2.50 m

Depth (m)	Temp °C	Cond.	DO	pH
0	13.87	718	8.67	8.44
1	13.88	716	8.43	8.43
2	13.88	717	8.40	8.42
3	13.89	718	8.38	8.42
4	13.88	717	8.35	8.41
5	13.83	717	6.51	8.18

CCR-3 06/03/03
Secchi: 1.00 m
1% Trans: 1.25 m

Depth (m)	Temp °C	Cond.	DO	pH
0	19.80	844	10.63	8.46
1	18.89	826	10.64	8.46
2	18.58	822	10.37	8.43
3	18.42	823	9.84	8.39
4	17.83	812	7.97	8.36
5	17.73	810	4.08	8.35

CCR-3 06/17/03
Secchi: 1.00 m
1% Trans: ND

Depth (m)	Temp °C	Cond.	DO	pH
0	21.46	857	11.18	8.57
1	20.15	833	11.31	8.56
2	19.74	826	10.56	8.51
3	19.55	822	10.12	8.47
4	19.34	820	9.58	8.40
5	19.26	805	0.39	7.92

CCR-3 07/01/03
Secchi: 1.00 m
1% Trans: ND

Depth (m)	Temp °C	Cond.	DO	pH
0	22.50	868	12.55	8.59
1	21.59	841	12.05	8.55
2	20.34	832	9.56	8.34
3	20.15	829	8.13	8.24
4	20.07	827	7.75	8.19
5	19.86	823	2.32	8.01

CCR-3 07/15/03
Secchi: 0.60 m
1% Trans: ND

Depth (m)	Temp °C	Cond.	DO	pH
0	23.34	873	13.29	8.38
1	23.30	873	13.04	8.35
2	23.29	872	12.49	8.31
3	23.22	872	10.21	8.18
4	22.53	865	6.30	7.83
5	22.07	858	3.38	7.71

* "ND" denotes "No Data"

CCR-3 DO Data Continued

CCR-3	07/29/03			
Secchi:	1.00 m			
1% Trans:	ND			
Depth (m)	**Temp °C**	**Cond.**	**DO**	**pH**
0	23.94	884	5.23	7.99
1	23.70	881	4.94	7.97
2	23.49	875	5.45	8.00
3	23.21	870	4.98	7.92
4	23.11	868	4.30	7.81
5	22.80	852	2.88	7.66

CCR-3	08/12/03			
Secchi:	0.75 m			
1% Trans:	ND			
Depth (m)	**Temp °C**	**Cond.**	**DO**	**pH**
0	24.51	896	10.03	8.21
1	23.20	877	6.88	7.96
2	23.00	872	6.44	7.92
3	22.91	871	6.50	7.89
4	22.81	870	5.67	7.78
5	22.80	869	1.52	7.58

CCR-3	08/26/03			
Secchi:	0.50 m			
1% Trans:	ND			
Depth (m)	**Temp °C**	**Cond.**	**DO**	**pH**
0	23.06	893	11.78	8.34
1	22.52	886	9.65	7.68
2	22.39	883	7.52	7.55
3	22.28	883	4.63	7.50
4	22.20	883	0.81	7.54
5	22.15	881	0.77	7.63

CCR-3	09/09/03			
Secchi:	0.75 m			
1% Trans:	ND			
Depth (m)	**Temp °C**	**Cond.**	**DO**	**pH**
0	20.59	832	9.25	8.34
1	20.53	831	8.85	8.28
2	20.36	828	7.96	8.16
3	20.17	825	7.20	7.98
4	19.50	818	5.95	7.74
5	19.45	815	3.87	7.96

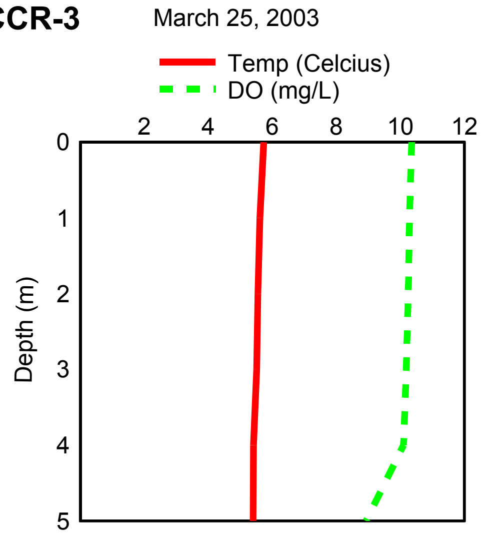
CCR-3	09/23/03			
Secchi:	0.80 m			
1% Trans:	ND			
Depth (m)	**Temp °C**	**Cond.**	**DO**	**pH**
0	18.09	738	11.43	8.59
1	17.56	723	11.89	8.69
2	16.33	707	8.77	8.55
3	16.03	702	7.82	8.44
4	15.76	701	6.93	8.34

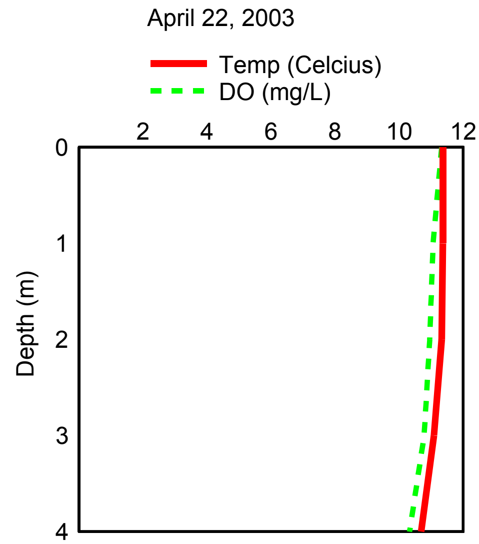
CCR-3	10/15/03			
Secchi:	0.75 m			
1% Trans:	ND			
Depth (m)	**Temp °C**	**Cond.**	**DO**	**pH**
0	13.41	677	10.13	8.33
1	13.33	677	10.15	8.40
2	13.00	670	9.91	8.41
3	12.78	668	9.24	8.38
4	12.43	663	9.01	8.36

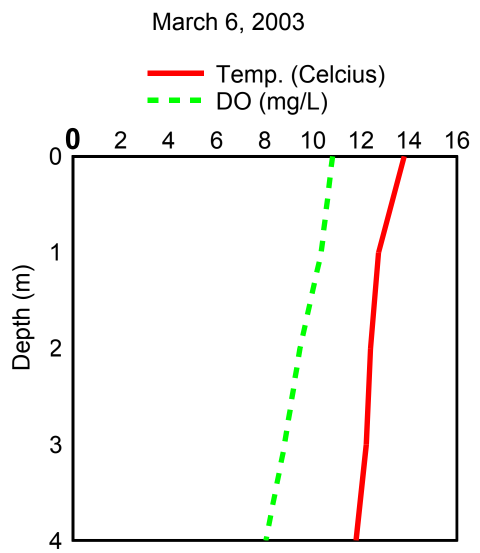
CCR-3	11/11/03			
Secchi:	0.75 m			
1% Trans:	ND			
Depth (m)	**Temp °C**	**Cond.**	**DO**	**pH**
0	7.81	594	16.63	9.81
1	7.74	593	15.77	8.72
2	7.73	592	14.18	8.63
3	7.67	592	4.22	8.40
4	7.64	591	0.61	8.23

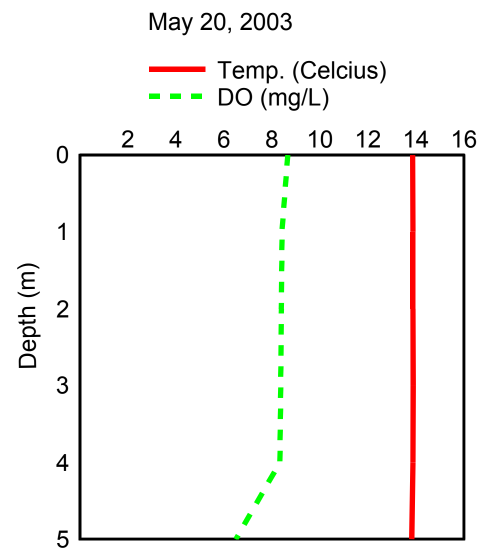
* "ND" denotes "No Data"

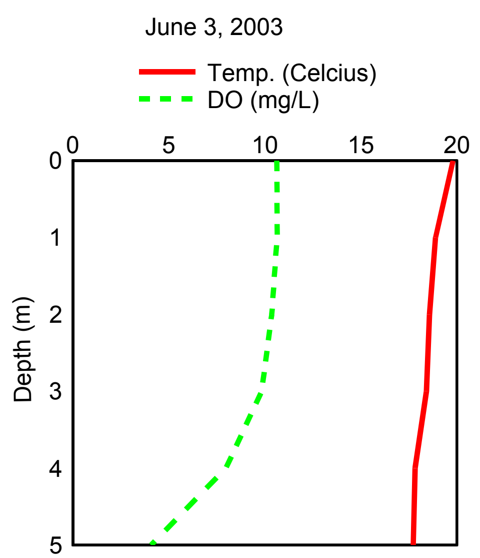
CCR-3

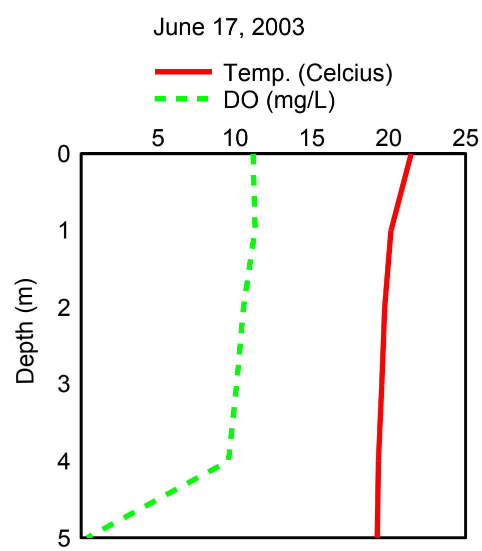

March 25, 2003
Temp (Celcius)
DO (mg/L)
2 4 6 8 10 12
0 1 2 3 4 5
Depth (m)


April 22, 2003
Temp (Celcius)
DO (mg/L)
2 4 6 8 10 12
0 1 2 3 4
Depth (m)

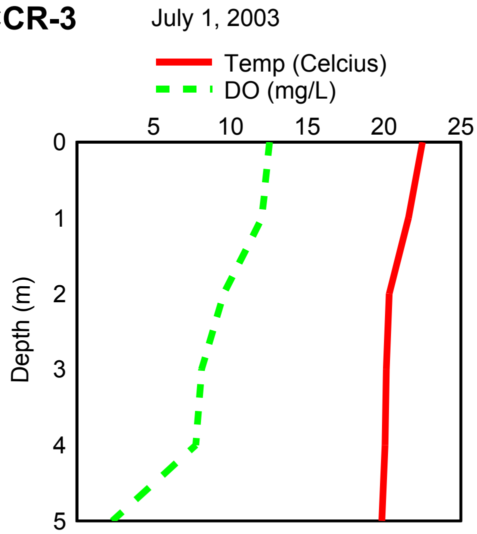

March 6, 2003
Temp. (Celcius)
DO (mg/L)
0 2 4 6 8 10 12 14 16
0 1 2 3 4
Depth (m)

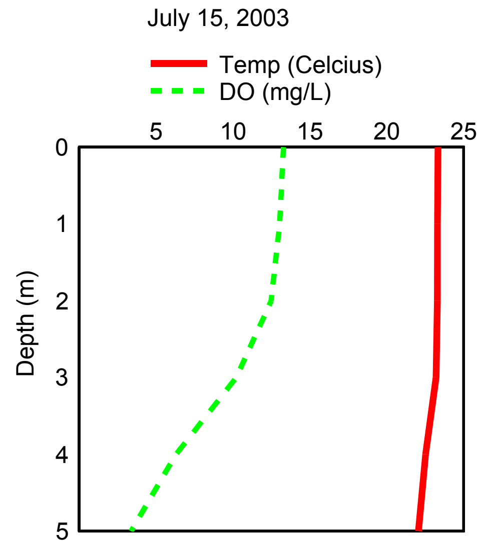

May 20, 2003
Temp. (Celcius)
DO (mg/L)
2 4 6 8 10 12 14 16
0 1 2 3 4 5
Depth (m)

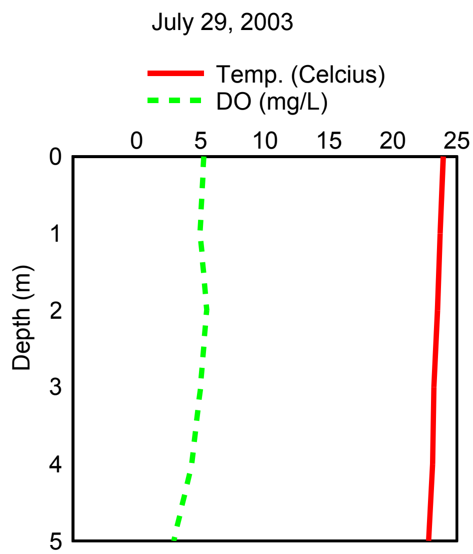

June 3, 2003
Temp. (Celcius)
DO (mg/L)
0 5 10 15 20
0 1 2 3 4 5
Depth (m)

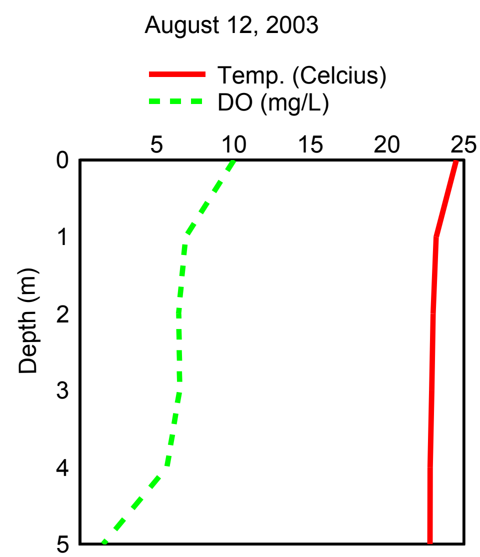

June 17, 2003
Temp. (Celcius)
DO (mg/L)
5 10 15 20 25
0 1 2 3 4 5
Depth (m)

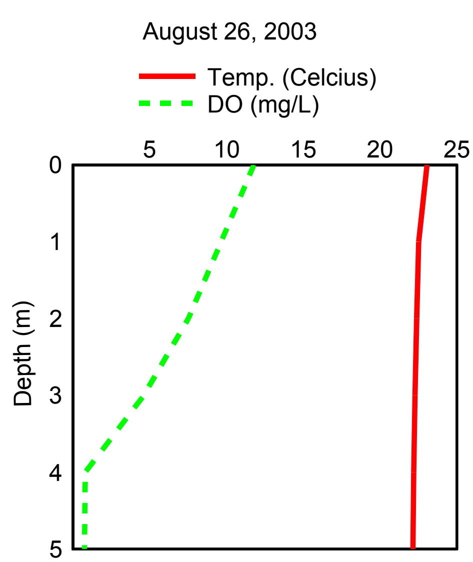
CCR-3

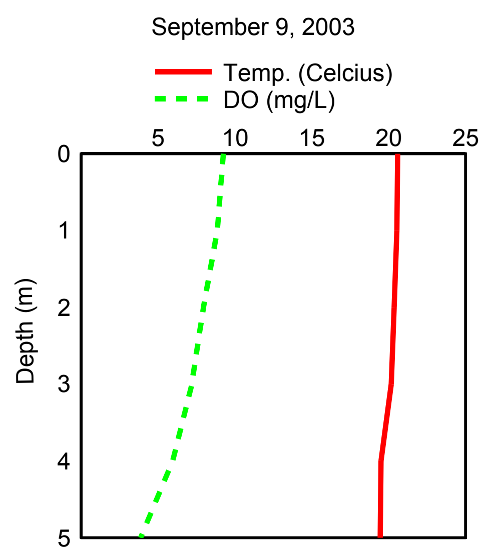

July 1, 2003
Temp (Celcius)
DO (mg/L)
5 10 15 20 25
Depth (m)
0 1 2 3 4 5


July 15, 2003
Temp (Celcius)
DO (mg/L)
5 10 15 20 25
Depth (m)
0 1 2 3 4 5


July 29, 2003
Temp. (Celcius)
DO (mg/L)
0 5 10 15 20 25
Depth (m)
0 1 2 3 4 5

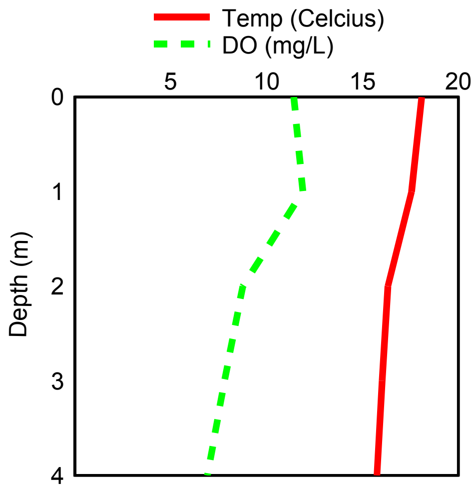

August 12, 2003
Temp. (Celcius)
DO (mg/L)
5 10 15 20 25
Depth (m)
0 1 2 3 4 5


August 26, 2003
Temp. (Celcius)
DO (mg/L)
5 10 15 20 25
Depth (m)
0 1 2 3 4 5

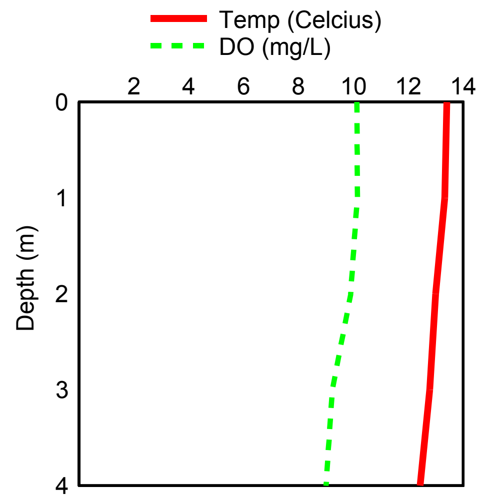

September 9, 2003
Temp. (Celcius)
DO (mg/L)
5 10 15 20 25
Depth (m)
0 1 2 3 4 5

CCR-3

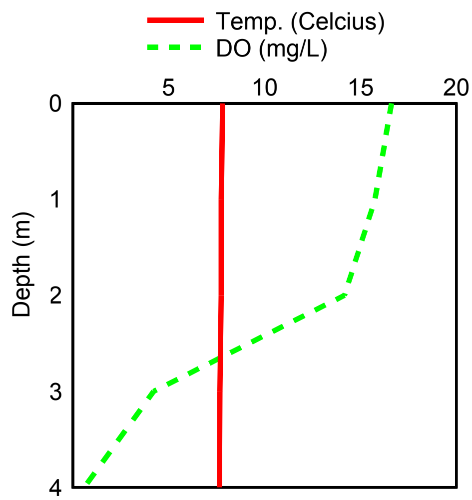
September 23, 2003



October 15, 2003



November 11, 2003



Cherry Creek Reservoir Secchi and 1% Transmissivity Depths for 2003

CCR-1				CCR-2				CCR-3			
Date	Secchi (m)	1% Trans (m)	Ratio	Date	Secchi (m)	1% Trans (m)	Ratio	Date	Secchi (m)	1% Trans (m)	Ratio
03/25/03	1.00	ND	ND	03/25/03	0.90	ND	ND	03/25/03	0.80	ND	ND
04/22/03	0.50	2.75	5.50	04/22/03	0.50	2.00	4.00	04/22/03	0.75	2.00	2.67
05/06/03	0.50	2.75	5.50	05/06/03	0.50	2.25	4.50	05/06/03	0.50	ND	ND
05/20/03	0.90	2.75	3.06	05/20/03	1.00	3.00	3.00	05/20/03	0.75	2.50	3.33
06/03/03	1.00	ND	ND	06/03/03	1.25	ND	ND	06/03/03	1.00	1.25	1.25
06/17/03	1.00	ND	ND	06/17/03	1.10	ND	ND	06/17/03	1.00	ND	ND
07/01/03	1.00	ND	ND	07/01/03	1.00	ND	ND	07/01/03	1.00	ND	ND
07/15/03	1.00	ND	ND	07/15/03	0.75	ND	ND	07/15/03	0.60	ND	ND
07/29/03	1.00	ND	ND	07/29/03	1.00	ND	ND	07/29/03	1.00	ND	ND
08/12/03	1.00	ND	ND	08/12/03	0.75	ND	ND	08/12/03	0.75	ND	ND
08/26/03	1.00	ND	ND	08/26/03	1.00	ND	ND	08/26/03	0.50	ND	ND
09/09/03	0.75	ND	ND	09/09/03	0.85	ND	ND	09/09/03	0.75	ND	ND
09/23/03	0.75	ND	ND	09/23/03	0.80	ND	ND	09/23/03	0.80	ND	ND
10/15/03	0.80	ND	ND	10/15/03	0.80	ND	ND	10/15/03	0.75	ND	ND
11/11/03	1.10	ND	ND	11/11/03	1.00	ND	ND	11/11/03	0.75	ND	ND
Average	0.89	2.75	4.69	Average	0.88	2.42	3.83	Average	0.78	1.92	2.42
Median	1.00	2.75	5.50	Median	0.90	2.25	4.00	Median	0.75	2.00	2.67

* "ND" denotes "No Data"

APPENDIX C

Streamwater Quality and Precipitation Data

CC-10 C&A Water Chemisty Data

Sample Date	Sample Name/ Location	Total Phosphorus µg/L	Total Dissolved Phosphorus µg/L	Ortho-Phosphate µg/L	Total Nitrogen µg/L	Total Dissolved Nitrogen µg/L	NO3+NO2-N µg/L	NH4-N µg/L	TSS mg/L	TVSS mg/L
	Analytical Detection Limits	2	2	3	4	4	5	3	4	4
01/14/03	CC-10	213	158*	164*	1612	1480	1255	116	36.8	7.6
02/25/03	CC-10	349	186*	199*	1966	1689	1530	84	79.0	11.2
03/25/03	CC-10	372	327	309	1369	1194	757	30	66.2	10.6
04/22/03	CC-10	140	98	97	769	693	388	20	21.8	6.2
05/20/03	CC-10	173	123*	125*	917	821	554	33	25.2	6.8
06/17/03	CC-10	223	147*	150*	1074	946	676	86	32.6	7.2
07/15/03	CC-10	212	174	167	979	860	678	24	32.0	6.8
08/12/03	CC-10	158	152	117	1490	1374	957	20	11.4	6.0
09/09/03	CC-10	226	153	151	859	737	532	66	38.4	9.0
10/15/03	CC-10	197	164	159	694	606	380	13	15.2	6.0
11/11/03	CC-10	197	177	167	897	857	663	64	14.2	5.8
12/16/03	CC-10	196	188	185	1492	1231	808	227	60.3	9.0
06/18/03	CC-10 storm	278	158	151	1226	968	559	40	150.0	37.0
07/27/03	CC-10 storm	242	ND	ND	1045	ND	ND	ND	61.8	11.0
08/30/03	CC-10 storm	479	ND	ND	2732	ND	ND	ND	345.0	36.0
09/03/03	CC-10 storm	451	206	190	1261	906	534	8	196.0	29.0

CC-O C&A Water Chemisty Data

Sample Date	Sample Name/ Location	Total Phosphorus µg/L	Total Dissolved Phosphorus µg/L	Ortho-Phosphate µg/L	Total Nitrogen µg/L	Total Dissolved Nitrogen µg/L	NO3+NO2-N µg/L	NH4-N µg/L	TSS mg/L	TVSS mg/L
	Analytical Detection Limits	2	2	3	4	4	5	3	4	4
01/14/03	CC-O	ND	ND	ND	ND	ND	ND	ND	ND	ND
02/25/03	CC-O	ND	ND	ND	ND	ND	ND	ND	ND	ND
03/25/03	CC-O	195	23	13	970	415	28	10	138.0	23.3
04/22/03	CC-O	115	25	14	962	474	16	39	44.2	12.8
05/07/03	CC-O	114	23	10	847	476	5	10	35.0	9.4
05/20/03	CC-O	84	18	6	757	459	<5	10	27.6	10.0
06/17/03	CC-O	205	128	119	776	543	33	130	28.6	10.4
07/15/03	CC-O	277	116	81	1487	598	<5	8	40.8	16.4
08/12/03	CC-O	119	21	9	1282	767	9	27	36.2	11.8
09/09/03	CC-O	145	15	5	869	436	<5	20	81.2	19.8
10/15/03	CC-O	ND	ND	ND	ND	ND	ND	ND	ND	ND
11/11/03	CC-O	118	29	11	1363	835	216	76	21.6	8.8
12/16/03	CC-O	ND	ND	ND	ND	ND	ND	ND	ND	ND

"ND" denotes "No Data"

CT-1 C&A Water Chemisty Data

Sample Date	Sample Name/ Location	Total Phosphorus µg/L	Total Dissolved Phosphorus µg/L	Ortho-Phosphate µg/L	Total Nitrogen µg/L	Total Dissolved Nitrogen µg/L	NO3+NO2-N µg/L	NH4-N µg/L	TSS mg/L	TVSS mg/L
	Analytical Detection Limits	2	2	3	4	4	5	3	4	4
01/14/03	CT-1	119	17	16	2979	2583	2190	127	92.7	16.0
02/25/03	CT-1	81	20	18	2693	2466	1627	673	49.6	11.0
03/25/03	CT-1	130	43	38	1174	840	630	44	117.0	23.0
04/22/03	CT-1	55	19	11	1355	1191	880	26	28.2	8.0
05/20/03	CT-1	57	26	23	1810	1695	1232	119	26.8	8.0
06/17/03	CT-1	36	22	19	1275	1173	863	19	12.8	5.6
07/15/03	CT-1	52	16	10	1195	1005	620	15	56.0	10.6
08/12/03	CT-1	156	27	17	1719	1256	733	6	83.5	23.5
09/09/03	CT-1	85	21	18	1713	1433	1159	25	47.8	12.0
10/15/03	CT-1	40	12	11	2549	2191	1713	12	19.6	8.0
11/11/03	CT-1	49	47	19	1986	1899	1490	156	23.2	5.0
12/16/03	CT-1	75	23	20	3338	3236	2511	244	48.7	10.0
06/18/03	CT-1 storm	474	118	107	1931	1354	805	305	235.0	55.0
07/27/03	CT-1 storm	274	ND	ND	2485	ND	ND	ND	172.0	27.5
07/30/03	CT-1 storm	217	25	14	1699	1013	488	35	89.5	17.5
08/30/03	CT-1 storm	331	ND	ND	1888	ND	ND	ND	206.5	25.5
09/03/03	CT-1 storm	211	45	34	1745	1287	862	53	115.0	23.0

"ND" denotes "No Data"

CT-2 C&A Water Chemisty Data

Sample Date	Sample Name/ Location	Total Phosphorus µg/L	Total Dissolved Phosphorus µg/L	Ortho-Phosphate µg/L	Total Nitrogen µg/L	Total Dissolved Nitrogen µg/L	NO3+NO2-N µg/L	NH4-N µg/L	TSS mg/L	TVSS mg/L
	Analytical Detection Limits	2	2	3	4	4	5	3	4	4
01/14/03	CT-2	94	15	14	3263	3044	2698	169	63.8	13.8
02/25/03	CT-2	56	22	20	2734	2668	1782	689	23.0	6.0
03/25/03	CT-2	114	52	40	1053	878	558	44	53.3	12.3
04/22/03	CT-2	62	12	7	1164	936	600	12	30.8	8.6
05/20/03	CT-2	109	19	11	1697	1400	885	128	72.7	15.3
06/17/03	CT-2	71	20	18	1329	1168	798	76	36.4	8.2
07/15/03	CT-2	64	13	7	1241	1042	577	60	40.0	6.8
08/12/03	CT-2	144	28	17	1797	1292	774	9	89.0	17.5
09/09/03	CT-2	105	13	7	1762	1277	923	118	44.0	10.4
10/15/03	CT-2	79	7	6	2337	2265	1728	27	40.2	10.2
11/11/03	CT-2	101	28	13	2114	1956	1457	253	65.2	10.0
12/16/03	CT-2	91	20	18	3271	2941	2310	227	34.3	9.0
06/18/03	CT-2 storm	363	123	112	1499	1039	590	123	139.0	31.0
07/27/03	CT-2 storm	206	ND	ND	2393	ND	ND	ND	95.0	26.5
07/30/03	CT-2 storm	144	27	11	1587	1057	530	43	49.2	13.5
08/30/03	CT-2 storm	186	ND	ND	1929	ND	ND	ND	84.0	21.5
09/03/03	CT-2 storm	204	44	35	1733	1270	819	75	86.5	23.5

"ND" denotes "No Data"

CT-P1 C&A Water Chemisty Data

Sample Date	Sample Name/ Location	Total Phosphorus µg/L	Total Dissolved Phosphorus µg/L	Ortho-Phosphate µg/L	Total Nitrogen µg/L	Total Dissolved Nitrogen µg/L	NO3+NO2-N µg/L	NH4-N µg/L	TSS mg/L	TVSS mg/L
	Analytical Detection Limits	2	2	3	4	4	5	3	4	4
01/14/03	CT-P1	35	6	6	1026	920	575	32	21.6	6.6
02/25/03	CT-P1	34	8	4	930	786	377	42	12.4	4.2
03/25/03	CT-P1	117	52	45	985	815	490	54	39.7	11.3
04/22/03	CT-P1	43	13	5	887	611	271	16	14.0	6.6
05/20/03	CT-P1	40	18	10	897	809	327	67	12.0	6.0
06/17/03	CT-P1	85	17	9	919	675	270	58	25.0	8.0
07/15/03	CT-P1	53	25	13	1964	1741	743	126	34.0	7.2
08/12/03	CT-P1	166	31	12	1759	1030	427	16	40.5	20.5
09/09/03	CT-P1	74	13	4	1103	699	272	51	21.2	9.2
10/15/03	CT-P1	44	4	5	1101	944	492	17	24.4	8.2
11/11/03	CT-P1	62	11	5	1076	954	514	57	24.4	6.8
12/16/03	CT-P1	17	5	5	1168	1104	706	43	18.0	8.7
06/18/03	CT-P1 storm	300	32	25	1616	1037	603	153	78.0	26.0
07/27/03	CT-P1 storm	156	ND	ND	1998	ND	ND	ND	59.5	22.5
07/30/03	CT-P1 storm	195	16	5	1549	800	215	8	47.0	17.2
08/30/03	CT-P1 storm	134	ND	ND	1384	ND	ND	ND	25.2	7.2
09/03/03	CT-P1 storm	168	48	34	1493	949	490	33	36.0	11.8

"ND" denotes "No Data"

CT-P2 C&A Water Chemisty Data

Sample Date	Sample Name/ Location	Total Phosphorus µg/L	Total Dissolved Phosphorus µg/L	Ortho-Phosphate µg/L	Total Nitrogen µg/L	Total Dissolved Nitrogen µg/L	NO3+NO2-N µg/L	NH4-N µg/L	TSS mg/L	TVSS mg/L
	Analytical Detection Limits	2	2	3	4	4	5	3	4	4
01/14/03	CT-P2	24	4	3	1278	1147	888	14	20.6	6.2
02/25/03	CT-P2	32	7	4	1104	961	629	16	13.0	4.2
03/25/03	CT-P2	108	47	41	998	815	523	54	40.3	12.3
04/22/03	CT-P2	38	11	4	937	729	388	12	13.8	6.6
05/20/03	CT-P2	62	14	6	1254	1076	632	54	35.2	8.8
06/17/03	CT-P2	51	18	11	940	789	404	30	12.0	6.4
07/15/03	CT-P2	78	26	16	1307	1032	535	56	78.0	12.8
08/12/03	CT-P2	143	28	12	1641	1056	498	9	28.0	13.0
09/09/03	CT-P2	65	12	5	1308	995	617	19	20.2	10.2
10/15/03	CT-P2	37	4	4	1159	1003	586	15	18.8	6.6
11/11/03	CT-P2	39	5	4	1310	921	878	35	26.8	6.4
12/16/03	CT-P2	60	5	6	1598	1452	1103	27	32.3	11.7
06/18/03	CT-P2 storm	187	47	38	1386	1050	575	129	97.0	35.0
07/27/03	CT-P2 storm	171	ND	ND	2104	ND	ND	ND	44.0	16.0
07/30/03	CT-P2 storm	178	21	8	1581	867	297	6	42.3	16.3
08/30/03	CT-P2 storm	133	ND	ND	1516	ND	ND	ND	24.4	7.6
09/03/03	CT-P2 storm	153	47	35	1506	1103	629	59	33.4	10.6

"ND" denotes "No Data"

SC-3 C&A Water Chemisty Data

Sample Date	Sample Name/ Location	Total Phosphorus µg/L	Total Dissolved Phosphorus µg/L	Ortho-Phosphate µg/L	Total Nitrogen µg/L	Total Dissolved Nitrogen µg/L	NO3+NO2-N µg/L	NH4-N µg/L	TSS mg/L	TVSS mg/L
	Analytical Detection Limits	2	2	3	4	4	5	3	4	4
01/14/03	SC-3	44	31	30	3275	3141	3049	38	14.8	6.6
02/25/03	SC-3	74	42	36	2605	2453	2264	69	9.6	4.2
03/25/03	SC-3	128	97	86	1217	1056	827	13	16.4	8.4
04/22/03	SC-3	72	59	49	533	419	178	14	11.0	5.0
05/20/03	SC-3	154	131	126	743	653	371	11	10.2	6.0
06/17/03	SC-3	244	223	214	443	411	61	32	14.2	7.2
08/12/03	SC-3	288	161	154	1336	1046	668	26	145.0	18.0
09/09/03	SC-3	152	135	128	457	433	152	47	20.4	8.2
10/15/03	SC-3	81	59	55	497	410	123	7	23.4	8.4
11/11/03	SC-3	46	41	47	1453	1399	1263	20	8.0	4.2
12/16/03	SC-3	76	74	66	1825	1745	1468	45	20.3	6.3
06/18/03	SC-3 storm	189	151	131	1536	1355	958	51	11.6	4.8
07/27/03	SC-3 storm	222	ND	ND	1554	ND	ND	ND	12.6	7.2
08/30/03	SC-3 storm	205	ND	ND	2133	ND	ND	ND	19.4	6.2
09/03/03	SC-3 storm	181	153	136	1372	1330	1000	20	13.8	6.0

"ND" denotes "No Data"

Rain Gauge C&A Water Chemisty Data

Sample Date	Sample Name/ Location	Total Phosphorus µg/L	Total Dissolved Phosphorus µg/L	Ortho-Phosphate µg/L	Total Nitrogen µg/L	Total Dissolved Nitrogen µg/L	NO3+NO2-N µg/L	NH4-N µg/L
	Analytical Detection Limits	2	2	3	4	4	5	3
06/18/03	Rain Gauge	37	20	15	1226	1042	423	554
07/27/03	Rain Gauge	184	ND	ND	4939	ND	ND	ND
09/03/03	Rain Gauge	99	63	55	1829	1637	672	805

"ND" denotes "No Data"

APPENDIX D

Streamflow, Rainfall, Phosphorus Loading Calculations, and Normalized U.S. Army Corps of Engineers Inflow Data

Streamflow Determination

Stream discharges for Cherry Creek, Cottonwood Creek and Shop Creek were determined by developing a stage discharge relationship for each site (Table C-1). Water levels (stage) were monitored using ISCO Model 4220 and 6700 flowmeters. Flows were monitored daily on Cottonwood Creek, Shop Creek, and Cherry Creek with some dates estimated due to icing or flowmeter malfunctions. Rating curves were developed for each sampling site by measuring stream discharge (ft^3/sec) with a Marsh McBirney Model 2000 flowmeter, and recording the water level at the staff gage (ft) and ISCO flowmeter (ft). Only data from 2003 was used in calculating rating curves at all sites except Site CT-2. Due to an undefined channel and an abundance of aquatic vegetation, flow measurements were not taken at this site in 2003. Therefore, a rating curve was developed using flow measurements from previous years. In 2003, five measurements over a range of discharges were taken at Sites CC-10, CT-1, CT-P1, and CT-P2. Four measurements were taken at Site SC-3, and one measurement was taken at Site CT-2.

TABLE D-1: Stage (H in ft) discharge (Q in cfs) relationships for Sites CC-10, CT-1, CT-2, SC-3, CT-P1, and CT-P2.

Site	Equation	R^2
CC-10	$Q = H^2 \times 2.7 + 0.6$	0.91
CT-1	$Q = H^{3.5} \times 0.57 - 0.6$	0.67
CT-2	$Q = H^{2.5} \times 0.78 - 5$	0.97
SC-3	$Q = H^{2.66} \times 0.79 + 0.16$	0.70
CT-P1	$Q = H^{2.44} \times 8.69$	0.82
CT-P2	$Q = H^{2.2} \times 1.25$ (prior to 3/26)	0.97
	$Q = H^{1.9} \times 9.6 + 1.5$ (after 3/25)	0.85

Phosphorus Loading from Tributary Streams

For all streams, water chemistry, including concentration of total phosphorus was measured from stream samples taken at regular intervals and from storms during the months of January through December 2003 (Appendix C). Since 1999, all estimates of loading to Cherry Creek Reservoir were based upon calendar year (January to December). In previous years, loading had been estimated on a water year (October to September), but were later converted to calendar year from 1992 on.

The concentration of total phosphorus in the samples and corresponding flows, measured at sampling time, were paired in regression relationships (Table D-2). Regressions using data from previous reports (ASI 1994a, Chadwick Ecological Consultants, Inc. 1995, 1996, 1997, 1998, 1999, 2000, 2001, 2002, 2003), combined with data from 2003, were developed to predict phosphorus concentrations from flow measurements for 2003 load calculations. Note that for some sites, there is no significant relationship between flow values and phosphorus concentrations (e.g., the Cherry Creek mainstem inflow, reservoir outflow, and Site SC-3). In those cases, the phosphorus concentrations for load calculations were based on the mean value from the current year.

TABLE D-2: Mean total dissolved phosphorus concentration (P_{con}) from alluvium and regression equations relating streamflow (Q, ft^3/sec) to concentration of total phosphorus (P_{con}) in Cherry Creek, Cottonwood Creek, and Shop Creek for 2003.

Site	Equation	R^2
Alluvium	P_{con} (mg/L) = 0.195	--
CC-10	P_{con} (mg/L) = 0.257	--
CC-O	P_{con} (mg/L) = 0.152	--
CT-1	P_{con} (mg/L) = 0.0087 × Q + 0.0844	0.66
CT-2	P_{con} (mg/L) = 0.0164 × Q + 0.054	0.82
SC-3	P_{con} (mg/L) = 0.143	--
CT-P1	P_{con} (mg/L) = 0.0356 × $Q^{0.6078}$	0.56
CT-P2	P_{con} (mg/L) = 0.0078 × Q + 0.0398	0.56

Using these relationships, the average daily phosphorus (P_{con}) was calculated from average daily flow for each tributary stream. Daily loadings in pounds/day (L_{day}) into the reservoir were then calculated using the equation below (Eq. 1), with L_{day} then summed over 2003 to obtain total annual phosphorus loading.

EQUATION 1:

$$L_{day} = \text{mg/L} \left(Q_{in} \left(\frac{86400 \text{ sec}}{\text{day}} \left(\frac{28.3169 \text{ L}}{\text{cf}} \left(\frac{2.205 \times 10^{-6} \text{ lbs}}{\text{mg}} \right.\right.\right.\right.$$

where:

L_{day} = pounds per day phosphorus loading,

mg/L = concentration of total phosphorus for a particular daily flow (based on the equation in Table D-2)

Q_{in} = mean daily flow in ft^3/sec.

Phosphorus Loading from Precipitation

Precipitation data are collected at the Cherry Creek dam by the U.S. Army Corps of Engineers (COE). To estimate phosphorus loading into the reservoir due to precipitation, COE data from 2003 were used, based on the assumption that precipitation generally fell evenly across the reservoir (Appendix D), although rain showers in the Cherry Creek Reservoir area can be localized. Calculation of phosphorus loading into Cherry Creek Reservoir from precipitation was based on the mean phosphorus concentration from 2003 and Equation 2.

EQUATION 2:

$$L_{precip} = PR\ /12\ (\ A_{res}\ (\ 43650\ ft^2/acre\ (\ mg/L\ (\ \frac{28.31692}{cf}\ (\ \frac{2.206 \times 10^{-6}\ lbs}{mg}$$

where:

L_{precip} = pounds of phosphorus from precipitation,
PR = rainfall precipitation in inches,
A_{res} = surface area of the reservoir (852 ac), and
mg/L = median concentration of phosphorus.

Cherry Creek Reservoir Outflow

Streamflow out of Cherry Creek Reservoir is monitored by a COE flow station throughout the year. Water samples were taken once a month in Cherry Creek downstream at the dam during 2003. These samples were assessed for water quality, and a regression relationship between the concentration of total phosphorus and the measured flow in the stream was attempted. However, this regression was not significant. In the relationship in Equation 1, loads leaving the reservoir were calculated based on a mean total phosphorus concentration of 0.152 mg/L in 2003 (Table D-2).

Phosphorus Loading from Alluvium

The COE monitors inflow to Cherry Creek Reservoir as a function of change in storage, based on changes in reservoir level, measured outflow, precipitation, and evaporation, to provide daily and monthly inflow (AF). CEC monitors inflow to the reservoir using gaging stations on Cherry Creek, Cottonwood Creek, and Shop Creek (the three main surface inflows). Estimates of direct precipitation were provided by the COE, and estimates of alluvial phosphorus concentrations were provided by JCHA. From these data, CEC calculates an estimated total inflow (AF) and phosphorus loading (lbs) to the reservoir.

Given differences in the two methods for determining inflow, combined with the potential for unmonitored multiple Cherry Creek channels in the wetlands adjacent to the reservoir and the potential for the COE calculations to underestimate dam leakage (Lewis and Saunders 2002), an exact match between COE and CEC calculated inflows is not expected. In 2003, COE inflows were calculated at 14,929 AF, while CEC calculated inflows at 10,579 AF (see following summary data tables). In past years, CEC adjusted (normalized) inflow values from the stream sites to account for this difference. Those normalization procedures can be found in CEC (1998b, 1999, 2000, 2001, and 2002). Beginning in 2002, CEC did not "normalize" inflow data by adding flow to the surface stream site data. Instead, we based our adjustments on conclusions reached by Lewis and Saunders (2002). They believe the COE method results in a systematic underestimate of inflow to the reservoir from the alluvium. When estimating inflow, the COE does not specifically quantify alluvial inflows or outflows although, functionally, those flows must account for a portion of the variations in reservoir storage. Based on these findings, CEC believes the difference in inflow values between the COE calculations and CEC streamflows could be attributed wholly to alluvial inflow. Using this approach, total alluvial inflow was estimated to be 4,350 AF in 2003. Calculation of alluvial phosphorus loading into Cherry Creek Reservoir was based on the mean alluvial phosphorus concentration for 2003 (0.195 mg/L) and Equation 3.

EQUATION 3:

$$L_{alluvium} = mg/L \; (\; Q_{alluvium} \; (\; \frac{2.205 \times 10^{-6} \text{ lbs}}{\text{mg}} \; (\; \frac{325{,}851 \text{ gal}}{\text{Ac-ft}} \; (\; \frac{\text{L}}{0.2642 \text{ gal}}$$

where:

$L_{alluvium}$ = alluvial phosphorus loading in pounds per year

mg/L = mean alluvial phosphorus concentration for the year

$Q_{alluvium}$ = total alluvial flow in Ac-ft per year

To ensure comparability over time, alluvial flows and loads for 1994 to 2001 were then recalculated in 2002, using the same approach outlined above. For 1993, annual alluvial loads were based on the mean of 1994 through 1997 values.

Note also that in the past, CEC used provisional (preliminary) inflow estimates from the COE in preparation of this monitoring report. When addressing the alluvial flow issue in 2002, we became aware that these provisional estimates had been finalized by the COE, as summarized on their website. To ensure accurate numbers, we revised inflow and load estimates for 1992 - 2001 to match the more accurate, and finalized, inflow values from the COE.

2003	Total In Af CEC	Total In Af COE
January	647.00	340.56
February	602.30	334.62
March	1434.96	2183.94
April	2472.62	4682.70
May	1077.29	2225.52
June	932.77	1918.62
July	464.39	999.90
August	382.26	732.60
September	319.60	457.38
October	227.55	279.18
November	336.48	368.28
December	342.07	405.90
Total	9239.28	14929.20

CC-10	Af CEC	P lbs CEC
January	397.07	278.04
February	369.61	258.81
March	961.95	673.58
April	2078.04	1455.09
May	839.81	588.05
June	674.04	471.98
July	403.82	282.77
August	306.81	214.84
September	225.42	157.84
October	171.64	120.18
November	168.94	118.29
December	172.04	120.46
	6769.17	4739.93

CT-2	Af CEC	P lbs CEC
January	249.93	86.53
February	232.69	78.30
March	473.01	326.72
April	394.59	215.69
May	237.48	97.44
June	258.73	119.56
July	60.57	27.46
August	75.44	45.33
September	94.18	30.06
October	55.91	10.84
November	167.54	46.18
December	170.04	46.22
	2470.10	1130.33

SC-3	Af CEC	P lbs CEC
January	25.09	9.77
February	21.75	8.47
March	44.17	17.21
April	38.06	14.83
May	23.07	8.99
June	22.01	8.58
July	18.06	7.04
August	16.18	6.31
September	13.52	5.27
October	12.69	4.95
November	13.88	5.41
December	15.21	5.92
	263.69	102.74

	Precip (af)	Outflow (af)
January	9.94	0.00
February	57.51	0.00
March	352.16	1334.52
April	221.52	3627.36
May	67.45	3443.22
June	160.46	1554.30
July	152.65	673.20
August	261.28	354.42
September	39.05	976.14
October	5.68	63.36
November	3.55	0.00
December	8.52	0.00
	1339.77	12026.52

	Precip (lbs)	Outflow (lbs)
January	2.90	0.00
February	16.78	0.00
March	102.74	552.68
April	64.63	1502.23
May	19.68	1425.97
June	46.82	643.70
July	44.54	278.80
August	76.23	144.32
September	11.39	404.26
October	1.66	26.24
November	1.04	0.00
December	2.49	0.00
	390.89	4978.19

	Alluvium (af)	Alluvium (lbs)
2003 Total	4350.15	2306.93

CT-1

	Af CEC	P lbs CEC
January	32.92	8.01
February	30.40	7.45
March	413.66	332.06
April	620.83	577.86
May	193.15	81.17
June	488.68	400.68
July	94.46	30.40
August	239.89	207.42
September	107.51	30.32
October	95.82	25.59
November	118.84	33.04
December	148.77	42.92
	2584.93	1776.92

CT-P1

	Af CEC	P lbs CEC
January	63.12	6.02
February	66.14	7.25
March	362.95	171.73
April	407.84	290.94
May	189.61	53.47
June	225.58	63.08
July	112.92	18.78
August	208.48	80.54
September	138.33	23.54
October	137.31	21.78
November	123.02	18.76
December	108.70	15.04
	2144.01	770.93

CT-P2

	Af CEC	P lbs CEC
January	88.42	11.95
February	82.76	11.62
March	282.33	101.65
April	577.83	249.73
May	170.60	35.71
June	220.88	51.73
July	119.08	20.14
August	169.58	42.97
September	104.65	15.89
October	92.44	12.98
November	90.35	12.72
December	50.71	7.12
	2049.64	574.22

2003
Cherry Creek 10
Average Discharge (cfs)

Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	6.59	6.47	7.13	45.37	24.92	6.59	9.94	4.02	9.12	2.79	3.01	2.85
2	6.54	6.51	6.90	48.43	21.98	6.76	6.34	3.93	4.34	2.79	2.92	2.83
3	6.45	6.97	7.25	47.71	22.82	6.89	5.42	3.83	12.61	2.79	2.94	2.82
4	6.42	6.97	7.04	39.22	19.56	6.77	5.13	3.82	5.21	2.79	2.90	2.82
5	6.41	6.63	7.25	38.35	16.81	9.60	4.95	3.76	4.35	2.79	2.88	2.80
6	6.39	6.57	6.95	34.82	14.29	12.38	4.86	3.69	4.21	2.79	2.88	2.79
7	6.40	7.14	6.59	29.00	13.86	16.05	4.80	3.66	4.36	2.79	2.87	2.79
8	6.39	7.21	6.47	24.16	13.86	11.01	4.65	3.73	4.32	2.79	2.79	2.79
9	6.38	6.45	6.45	21.86	13.21	8.77	4.50	3.97	3.75	2.79	2.79	2.80
10	6.57	6.72	6.87	21.03	14.35	8.66	4.40	3.58	3.40	2.79	2.79	2.83
11	6.40	6.70	6.61	18.85	19.56	16.52	4.34	3.58	3.29	2.79	2.79	2.94
12	6.37	6.37	6.56	17.48	16.37	10.01	4.28	4.57	3.16	2.79	2.79	2.81
13	6.37	6.32	6.53	16.15	14.32	8.69	4.22	3.75	3.16	2.79	2.79	2.79
14	6.36	6.48	6.52	14.88	12.72	7.20	4.18	3.63	3.12	2.79	2.79	2.79
15	6.40	6.46	6.49	14.48	11.97	6.28	4.10	3.59	3.02	2.79	2.79	2.82
16	6.57	6.47	6.55	21.57	12.67	5.92	3.98	3.55	2.93	2.79	2.79	2.83
17	6.46	6.47	7.12	17.19	11.54	7.49	3.92	3.55	2.88	2.79	2.79	2.80
18	6.59	6.45	11.50	14.75	11.07	17.17	5.19	5.88	2.94	2.79	2.79	2.79
19	6.47	6.38	12.64	18.21	10.55	18.31	43.78	7.54	2.90	2.79	2.79	2.79
20	6.47	6.43	11.08	16.86	10.13	22.32	20.27	4.29	2.86	2.79	2.79	2.79
21	6.47	6.43	11.14	16.07	9.59	20.01	5.51	3.80	2.83	2.79	2.86	2.79
22	6.47	6.45	11.43	15.77	8.96	12.99	4.81	3.63	2.81	2.79	2.87	2.79
23	6.58	6.61	14.03	25.08	8.05	10.53	4.65	3.54	2.79	2.79	2.88	2.79
24	6.47	6.89	42.32	119.50	7.92	9.47	4.44	3.50	2.79	2.79	2.86	2.79
25	6.46	7.20	39.32	87.95	27.09	8.33	4.35	3.45	2.79	2.79	2.87	2.79
26	6.48	6.93	47.10	69.16	16.65	7.07	4.33	3.42	2.79	2.81	3.01	2.79
27	6.51	6.95	55.64	71.68	10.65	6.49	5.10	3.38	2.79	2.81	2.89	2.79
28	6.55	7.06	32.57	51.55	8.03	6.13	4.59	3.35	2.79	2.82	2.84	2.79
29	6.53		24.71	38.14	7.38	6.17	4.48	3.34	2.79	2.81	2.81	2.79
30	6.51		22.62	34.24	6.81	39.83	4.32	6.41	2.79	2.85	2.83	2.79
31	6.50		34.44		6.46		4.13	35.22		2.91		2.79
Total	200.54	186.67	485.84	1049.51	424.14	340.42	203.95	154.96	113.85	86.69	85.32	86.89
Max	6.59	7.21	55.64	119.50	27.09	39.83	43.78	35.22	12.61	2.91	3.01	2.94
Min	6.36	6.32	6.45	14.48	6.46	5.92	3.92	3.34	2.79	2.79	2.79	2.79
Ac-ft	397.07	369.61	961.95	2078.04	839.81	674.04	403.82	306.81	225.42	171.64	168.94	172.04

2003
Cherry Creek 10
Phosphorus Loading (lbs)

Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
1	9.13	8.97	9.88	62.90	34.54	9.14	13.78	5.58	12.64	3.86	4.17	3.95
2	9.06	9.03	9.57	67.15	30.47	9.37	8.79	5.44	6.02	3.86	4.04	3.92
3	8.94	9.66	10.05	66.14	31.64	9.56	7.51	5.31	17.48	3.86	4.08	3.91
4	8.90	9.66	9.77	54.38	27.12	9.39	7.11	5.30	7.22	3.86	4.02	3.90
5	8.89	9.19	10.05	53.16	23.30	13.31	6.86	5.21	6.03	3.86	3.99	3.88
6	8.86	9.11	9.64	48.27	19.82	17.17	6.74	5.11	5.83	3.86	3.99	3.86
7	8.88	9.90	9.14	40.20	19.21	22.25	6.65	5.07	6.04	3.86	3.97	3.86
8	8.87	10.00	8.97	33.50	19.21	15.27	6.44	5.17	5.99	3.86	3.86	3.86
9	8.84	8.94	8.94	30.31	18.31	12.17	6.24	5.50	5.20	3.86	3.86	3.88
10	9.11	9.31	9.53	29.16	19.90	12.01	6.11	4.97	4.71	3.86	3.86	3.92
11	8.88	9.29	9.16	26.14	27.12	22.90	6.02	4.96	4.56	3.86	3.86	4.07
12	8.83	8.83	9.10	24.23	22.70	13.88	5.94	6.33	4.38	3.86	3.86	3.90
13	8.83	8.76	9.05	22.39	19.85	12.05	5.85	5.20	4.38	3.86	3.86	3.87
14	8.81	8.99	9.04	20.63	17.64	9.98	5.80	5.04	4.33	3.87	3.86	3.86
15	8.88	8.95	9.00	20.07	16.59	8.71	5.68	4.98	4.18	3.86	3.86	3.90
16	9.11	8.97	9.09	29.91	17.56	8.21	5.52	4.93	4.06	3.86	3.86	3.92
17	8.95	8.97	9.87	23.84	16.00	10.39	5.44	4.92	3.99	3.86	3.86	3.88
18	9.14	8.94	15.94	20.45	15.34	23.80	7.20	8.16	4.08	3.86	3.86	3.86
19	8.98	8.84	17.53	25.25	14.63	25.38	60.70	10.45	4.02	3.86	3.86	3.86
20	8.97	8.92	15.36	23.37	14.05	30.94	28.10	5.95	3.97	3.86	3.86	3.86
21	8.98	8.91	15.45	22.29	13.30	27.74	7.64	5.26	3.92	3.86	3.97	3.86
22	8.98	8.94	15.85	21.86	12.43	18.01	6.67	5.03	3.90	3.86	3.98	3.86
23	9.12	9.16	19.45	34.77	11.16	14.60	6.45	4.90	3.87	3.86	3.99	3.86
24	8.97	9.55	58.68	165.68	10.97	13.12	6.16	4.85	3.86	3.86	3.97	3.86
25	8.95	9.98	54.52	121.94	37.55	11.55	6.03	4.79	3.86	3.87	3.98	3.86
26	8.99	9.61	65.30	95.88	23.08	9.80	6.01	4.74	3.86	3.90	4.17	3.86
27	9.02	9.64	77.14	99.38	14.76	9.00	7.07	4.68	3.86	3.90	4.00	3.86
28	9.09	9.79	45.16	71.47	11.13	8.50	6.36	4.65	3.86	3.90	3.93	3.86
29	9.05	0.00	34.25	52.89	10.24	8.55	6.20	4.64	3.86	3.90	3.89	3.86
30	9.03	0.00	31.37	47.48	9.44	55.23	5.98	8.89	3.86	3.95	3.92	3.86
31	9.01	0.00	47.74	0.00	8.95	0.00	5.72	48.84	0.00	4.03	0.00	3.86
Total	278.04	258.81	673.58	1455.09	588.05	471.98	282.77	214.84	157.84	120.18	118.29	120.46
Mean	8.97	8.35	21.73	46.94	18.97	15.23	9.12	6.93	5.09	3.88	3.82	3.89
Max	9.14	10.00	77.14	165.68	37.55	55.23	60.70	48.84	17.48	4.03	4.17	4.07
Min	8.81	0.00	8.94	0.00	8.95	0.00	5.44	4.64	0.00	3.86	0.00	3.86

2003
Cherry Creek Outflow
Discharge (cfs)

Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0	0	0	99	149	31	35	10	20	14	0	0
2	0	0	0	99	149	31	35	10	10	10	0	0
3	0	0	0	99	149	30	34	10	0	8	0	0
4	0	0	0	99	148	31	34	10	0	0	0	0
5	0	0	0	99	148	31	34	10	0	0	0	0
6	0	0	0	99	148	31	34	10	0	0	0	0
7	0	0	0	99	116	31	25	10	0	0	0	0
8	0	0	0	86	54	31	5	10	9	0	0	0
9	0	0	0	75	30	10	5	10	26	0	0	0
10	0	0	0	74	31	10	5	10	26	0	0	0
11	0	0	0	53	31	10	3	10	26	0	0	0
12	0	0	0	34	31	10	0	10	26	0	0	0
13	0	0	0	34	0	10	0	10	25	0	0	0
14	0	0	0	34	31	10	0	10	25	0	0	0
15	0	0	0	34	31	10	0	10	25	0	0	0
16	0	0	0	34	31	10	0	9	25	0	0	0
17	0	0	0	34	31	20	0	9	25	0	0	0
18	0	0	0	34	31	20	0	8	25	0	0	0
19	0	0	0	34	31	35	0	0	19	0	0	0
20	0	0	0	34	31	35	0	0	25	0	0	0
21	0	0	0	34	31	35	0	0	25	0	0	0
22	0	0	0	34	30	35	1	0	22	0	0	0
23	0	0	0	29	30	35	10	0	4	0	0	0
24	0	0	18	20	30	35	10	0	15	0	0	0
25	0	0	62	20	31	35	10	0	15	0	0	0
26	0	0	99	20	31	35	10	0	15	0	0	0
27	0	0	99	21	31	35	10	0	15	0	0	0
28	0	0	99	66	31	34	10	0	15	0	0	0
29	0		99	151	31	34	10	0	15	0	0	0
30	0		99	150	31	35	10	0	15	0	0	0
31	0		99		31		10	3		0		0
Total	0	0	674	1832	1739	785	340	179	493	32	0	0
Mean	0.00	0.00	21.74	61.07	56.10	26.17	10.97	5.77	16.43	1.03	0.00	0.00
Max	0	0	99	151	149	35	35	10	26	14	0	0
Min	0	0	0	20	0	10	0	0	0	0	0	0
Ac-ft	0.00	0.00	1334.52	3627.36	3443.22	1554.30	673.20	354.42	976.14	63.36	0.00	0.00

2003
Cherry Creek Outflow
Phosphorus Loading (lbs)

Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0.00	0.00	0.00	81.18	122.18	25.42	28.70	8.20	16.40	11.48	0.00	0.00
2	0.00	0.00	0.00	81.18	122.18	25.42	28.70	8.20	8.20	8.20	0.00	0.00
3	0.00	0.00	0.00	81.18	122.18	24.60	27.88	8.20	0.00	6.56	0.00	0.00
4	0.00	0.00	0.00	81.18	121.36	25.42	27.88	8.20	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	81.18	121.36	25.42	27.88	8.20	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	81.18	121.36	25.42	27.88	8.20	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	81.18	95.12	25.42	20.50	8.20	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	70.52	44.28	25.42	4.10	8.20	7.38	0.00	0.00	0.00
9	0.00	0.00	0.00	61.50	24.60	8.20	4.10	8.20	21.32	0.00	0.00	0.00
10	0.00	0.00	0.00	60.68	25.42	8.20	4.10	8.20	21.32	0.00	0.00	0.00
11	0.00	0.00	0.00	43.46	25.42	8.20	2.46	8.20	21.32	0.00	0.00	0.00
12	0.00	0.00	0.00	27.88	25.42	8.20	0.00	8.20	21.32	0.00	0.00	0.00
13	0.00	0.00	0.00	27.88	0.00	8.20	0.00	8.20	20.50	0.00	0.00	0.00
14	0.00	0.00	0.00	27.88	25.42	8.20	0.00	8.20	20.50	0.00	0.00	0.00
15	0.00	0.00	0.00	27.88	25.42	8.20	0.00	8.20	20.50	0.00	0.00	0.00
16	0.00	0.00	0.00	27.88	25.42	8.20	0.00	7.38	20.50	0.00	0.00	0.00
17	0.00	0.00	0.00	27.88	25.42	16.40	0.00	7.38	20.50	0.00	0.00	0.00
18	0.00	0.00	0.00	27.88	25.42	16.40	0.00	6.56	20.50	0.00	0.00	0.00
19	0.00	0.00	0.00	27.88	25.42	28.70	0.00	0.00	15.58	0.00	0.00	0.00
20	0.00	0.00	0.00	27.88	25.42	28.70	0.00	0.00	20.50	0.00	0.00	0.00
21	0.00	0.00	0.00	27.88	25.42	28.70	0.00	0.00	20.50	0.00	0.00	0.00
22	0.00	0.00	0.00	27.88	24.60	28.70	0.82	0.00	18.04	0.00	0.00	0.00
23	0.00	0.00	0.00	23.78	24.60	28.70	8.20	0.00	3.28	0.00	0.00	0.00
24	0.00	0.00	14.76	16.40	24.60	28.70	8.20	0.00	12.30	0.00	0.00	0.00
25	0.00	0.00	50.84	16.40	25.42	28.70	8.20	0.00	12.30	0.00	0.00	0.00
26	0.00	0.00	81.18	16.40	25.42	28.70	8.20	0.00	12.30	0.00	0.00	0.00
27	0.00	0.00	81.18	17.22	25.42	28.70	8.20	0.00	12.30	0.00	0.00	0.00
28	0.00	0.00	81.18	54.12	25.42	27.88	8.20	0.00	12.30	0.00	0.00	0.00
29	0.00	0.00	81.18	123.82	25.42	27.88	8.20	0.00	12.30	0.00	0.00	0.00
30	0.00	0.00	81.18	123.00	25.42	28.70	8.20	0.00	12.30	0.00	0.00	0.00
31	0.00	0.00	81.18	0.00	25.42	0.00	8.20	0.00	0.00	0.00	0.00	0.00
Total	0.00	0.00	552.68	1502.23	1425.97	643.70	278.80	144.32	404.26	26.24	0.00	0.00
Mean	0.00	0.00	17.83	48.46	46.00	20.76	8.99	4.66	13.04	0.85	0.00	0.00
Max	0.00	0.00	81.18	123.82	122.18	28.70	28.70	8.20	21.32	11.48	0.00	0.00
Min	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

2003
Cottonwood Creek 1
Discharge (cfs)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0.63	0.53	0.19	10.74	2.31	1.93	1.39	1.31	4.50	1.49	1.73	2.08
2	0.84	0.54	0.18	7.05	2.40	1.98	1.15	1.25	2.39	1.49	1.87	1.86
3	0.70	0.56	0.16	4.79	2.36	2.04	1.00	1.26	5.17	1.47	2.16	1.81
4	0.53	0.58	0.23	3.28	2.06	2.13	1.16	1.26	1.89	1.47	2.10	1.85
5	0.53	0.59	0.45	2.35	2.00	6.74	1.07	1.07	1.59	1.47	2.07	2.02
6	0.56	0.61	0.41	3.86	1.70	12.06	0.99	0.91	1.64	1.49	2.04	2.05
7	0.55	0.71	0.25	5.85	1.46	16.67	0.95	0.81	1.93	1.60	2.01	2.01
8	0.86	0.72	0.17	4.31	1.58	7.05	0.83	0.94	1.88	1.70	2.14	2.10
9	0.99	0.59	0.11	3.28	1.69	4.79	0.76	3.20	1.61	1.54	2.10	2.46
10	0.54	0.65	0.10	2.83	22.03	5.85	0.75	0.92	1.58	1.49	2.19	2.76
11	0.42	0.79	0.10	2.48	12.04	13.48	0.77	0.91	1.48	1.52	1.91	2.28
12	0.41	0.68	0.10	2.23	4.73	5.85	0.85	3.43	1.50	1.53	1.76	2.17
13	0.44	0.66	0.11	2.04	3.00	4.79	0.80	1.22	1.56	1.57	1.73	2.10
14	0.43	0.68	0.11	1.93	2.75	4.79	0.72	0.93	1.73	1.61	1.86	2.21
15	0.50	0.70	0.11	1.87	2.60	3.86	0.75	0.91	1.65	1.65	1.95	2.49
16	0.47	0.66	0.12	9.26	3.14	3.05	0.72	1.03	1.51	1.62	1.97	3.10
17	0.48	0.66	0.48	2.44	2.19	94.91	0.71	1.25	1.43	1.62	1.96	2.51
18	0.47	0.66	7.05	1.78	1.84	30.91	0.80	1.76	1.50	1.60	1.63	2.54
19	0.46	0.36	3.86	7.28	1.88	4.87	5.85	5.85	1.46	1.58	1.64	2.71
20	0.48	0.16	4.31	3.23	1.85	2.50	1.25	1.49	1.41	1.57	1.69	2.70
21	0.45	0.14	5.85	1.95	1.88	2.57	0.83	1.03	1.47	1.57	1.99	2.68
22	0.46	0.14	11.61	1.76	1.84	1.73	0.79	0.83	1.47	1.55	1.94	2.72
23	0.51	0.47	69.22	14.91	1.70	1.54	0.86	1.76	1.49	1.58	2.75	2.77
24	0.49	1.12	23.07	187.51	1.77	1.73	0.78	1.49	1.49	1.64	2.19	2.71
25	0.48	0.42	16.67	11.77	3.60	1.48	0.81	1.25	1.49	1.54	2.56	2.59
26	0.48	0.35	13.48	3.29	1.91	1.28	1.90	1.03	1.49	1.53	1.93	2.59
27	0.48	0.39	21.95	1.95	1.87	1.26	10.51	0.83	1.49	1.52	1.90	2.61
28	0.48	0.23	8.40	1.91	1.81	1.32	2.10	0.83	1.49	1.51	1.95	2.60
29	0.48		5.85	3.09	1.81	2.15	1.53	1.03	1.49	1.52	2.14	2.65
30	0.49		4.31	2.52	1.87	1.49	2.67	38.72	1.49	1.65	2.15	2.71
31	0.51		9.92		1.87		1.69	40.66		1.71		2.70
Total	16.63	15.35	208.92	313.55	97.55	246.81	47.71	121.16	54.30	48.39	60.02	75.14
Max	0.99	1.12	69.22	187.51	22.03	94.91	10.51	40.66	5.17	1.71	2.75	3.10
Min	0.41	0.14	0.10	1.76	1.46	1.26	0.71	0.81	1.41	1.47	1.63	1.81
Ac-ft	32.92	30.40	413.66	620.83	193.15	488.68	94.46	239.89	107.51	95.82	118.84	148.77

2003
Cottonwood Creek 1
Phosphorus Load (lbs)

Date	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1	0.31	0.25	0.09	10.30	1.31	1.05	0.72	0.68	3.00	0.78	0.93	1.15
2	0.41	0.26	0.08	5.54	1.36	1.09	0.59	0.64	1.36	0.78	1.01	1.01
3	0.34	0.27	0.07	3.26	1.34	1.12	0.50	0.65	3.60	0.77	1.21	0.98
4	0.26	0.28	0.11	2.00	1.14	1.18	0.59	0.65	1.03	0.77	1.16	1.00
5	0.25	0.29	0.21	1.33	1.10	5.20	0.54	0.54	0.84	0.77	1.15	1.11
6	0.27	0.30	0.19	2.46	0.91	12.31	0.50	0.45	0.87	0.78	1.13	1.13
7	0.27	0.34	0.12	4.27	0.76	20.63	0.48	0.40	1.05	0.85	1.11	1.11
8	0.43	0.35	0.08	2.83	0.84	5.54	0.41	0.47	1.03	0.91	1.19	1.16
9	0.50	0.29	0.05	2.00	0.90	3.26	0.38	1.93	0.86	0.81	1.16	1.41
10	0.26	0.31	0.05	1.66	32.82	4.27	0.37	0.46	0.84	0.78	1.23	1.61
11	0.20	0.39	0.05	1.42	12.29	14.67	0.38	0.45	0.78	0.80	1.04	1.28
12	0.20	0.33	0.05	1.25	3.20	4.27	0.42	2.11	0.79	0.81	0.94	1.21
13	0.21	0.32	0.05	1.13	1.79	3.26	0.40	0.62	0.82	0.83	0.93	1.16
14	0.20	0.33	0.05	1.05	1.61	3.26	0.35	0.47	0.93	0.85	1.01	1.23
15	0.24	0.34	0.05	1.02	1.50	2.46	0.37	0.45	0.88	0.88	1.07	1.43
16	0.23	0.32	0.06	8.24	1.89	1.83	0.35	0.52	0.80	0.86	1.08	1.87
17	0.23	0.32	0.23	1.39	1.22	242.70	0.35	0.64	0.75	0.86	1.07	1.44
18	0.22	0.32	5.54	0.96	1.00	58.93	0.39	0.94	0.79	0.85	0.87	1.46
19	0.22	0.17	2.46	5.80	1.02	3.33	4.27	4.27	0.76	0.84	0.87	1.58
20	0.23	0.07	2.83	1.96	1.00	1.43	0.64	0.78	0.73	0.83	0.90	1.57
21	0.21	0.06	4.27	1.07	1.03	1.48	0.41	0.52	0.77	0.83	1.09	1.55
22	0.22	0.06	11.61	0.95	1.00	0.93	0.39	0.41	0.77	0.82	1.06	1.58
23	0.24	0.23	177.00	17.22	0.91	0.81	0.43	0.94	0.78	0.84	1.60	1.62
24	0.24	0.57	35.49	479.47	0.95	0.93	0.38	0.78	0.78	0.87	1.23	1.58
25	0.23	0.20	20.63	11.86	2.24	0.78	0.40	0.64	0.78	0.81	1.47	1.50
26	0.23	0.17	14.67	2.01	1.04	0.66	1.03	0.52	0.78	0.81	1.05	1.50
27	0.23	0.18	32.61	1.07	1.01	0.65	9.96	0.41	0.78	0.80	1.03	1.51
28	0.23	0.11	7.14	1.04	0.98	0.68	1.16	0.41	0.78	0.79	1.07	1.50
29	0.23		4.27	1.85	0.98	1.20	0.81	0.52	0.78	0.80	1.19	1.54
30	0.24		2.83	1.45	1.01	0.78	1.55	88.01	0.78	0.88	1.19	1.58
31	0.24		9.13		1.01		0.90	96.12		0.92		1.57
Total	8.01	7.45	332.06	577.86	81.17	400.68	30.40	207.42	30.32	25.59	33.04	42.92
Mean	0.26	0.27	10.71	19.26	2.62	13.36	0.98	6.69	1.01	0.83	1.10	1.38
Max	0.50	0.57	177.00	479.47	32.82	242.70	9.96	96.12	3.60	0.92	1.60	1.87
Min	0.20	0.06	0.05	0.95	0.76	0.65	0.35	0.40	0.73	0.77	0.87	0.98

2003
Cottonwood Creek 2
Discharge (cfs)

Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	4.09	4.43	3.94	11.69	6.03	2.71	1.69	0.84	10.05	1.12	1.26	2.81
2	4.39	4.56	3.69	9.23	4.63	2.90	1.33	0.69	3.72	1.06	1.96	2.55
3	4.40	4.78	3.76	6.67	4.39	3.12	0.97	0.44	5.75	0.99	3.30	2.48
4	4.10	4.84	3.79	5.21	3.58	2.46	0.92	0.47	2.64	0.92	3.22	2.46
5	4.03	4.55	4.07	4.37	3.23	4.33	0.92	0.02	1.31	0.86	3.18	2.84
6	4.10	4.46	4.05	5.34	2.92	7.85	0.60	-0.26	1.40	0.79	3.10	2.84
7	4.22	4.38	3.77	6.55	2.79	8.17	0.60	-0.50	1.72	0.80	2.71	2.75
8	4.36	4.33	3.33	5.07	2.65	7.10	0.29	-0.34	2.20	0.92	2.94	2.86
9	4.82	4.29	2.82	4.38	2.68	3.93	0.29	3.82	1.18	0.98	2.96	3.10
10	4.66	4.28	2.54	3.67	8.99	4.79	-0.02	0.34	0.96	0.58	3.00	3.67
11	4.42	4.35	2.53	3.22	15.50	6.63	-0.02	-0.21	0.70	0.49	2.82	3.15
12	4.19	4.34	2.30	3.08	9.46	4.08	-0.31	3.76	0.68	0.54	2.67	2.91
13	4.08	4.22	2.11	2.88	5.23	2.74	-0.42	0.88	0.77	0.84	2.61	2.79
14	3.98	4.24	2.22	2.81	4.29	2.21	-0.53	-0.17	1.23	1.19	2.67	2.75
15	4.05	4.27	2.06	2.72	4.17	1.92	-0.56	-0.42	1.13	1.65	2.89	3.12
16	4.15	4.26	1.83	7.61	4.13	1.72	-0.60	-0.55	0.79	1.53	2.96	2.78
17	4.14	4.34	3.02	5.72	3.43	4.56	-0.59	-0.59	0.59	1.46	2.99	2.74
18	4.07	4.34	15.71	3.18	2.48	17.41	-0.02	0.92	0.77	1.26	2.72	2.80
19	4.03	3.92	9.48	7.16	2.35	12.36	7.16	5.23	0.75	1.12	2.60	2.79
20	4.05	3.50	9.78	4.78	2.49	5.89	1.96	0.60	0.79	0.99	2.55	2.72
21	4.10	3.50	15.06	3.10	2.31	4.31	0.92	-0.02	0.76	0.92	2.74	2.64
22	4.22	3.10	17.69	2.51	2.39	3.06	0.17	-0.31	0.96	0.92	2.93	2.69
23	4.27	3.50	21.55	5.08	1.97	2.40	-0.81	0.92	0.92	1.06	2.96	2.79
24	4.19	4.78	16.96	18.12	1.87	2.49	-1.76	-0.02	0.78	1.53	3.06	2.73
25	4.15	3.75	14.18	16.34	2.71	2.30	-0.82	-0.19	0.68	0.99	3.49	2.59
26	4.12	3.87	15.00	11.80	2.33	1.87	-0.36	-0.31	0.64	0.73	2.93	2.50
27	4.07	4.26	15.42	9.56	2.33	1.56	10.72	-0.48	0.74	0.60	2.79	2.53
28	4.09	4.05	11.81	10.11	1.96	1.33	3.67	-0.59	0.81	0.47	2.81	2.53
29	4.17		7.10	9.40	1.96	2.38	0.77	-0.31	1.04	0.35	2.91	2.61
30	4.26		6.35	7.95	2.33	2.11	2.77	8.60	1.10	0.29	2.91	2.69
31	4.34		10.97		2.36		1.65	15.82		0.29		2.65
Total	130.32	117.52	238.89	199.29	119.94	130.67	30.59	38.10	47.57	28.24	84.62	85.88
Max	4.82	4.84	21.55	18.12	15.50	17.41	10.72	15.82	10.05	1.65	3.49	3.67
Min	3.98	3.10	1.83	2.51	1.87	1.33	-1.76	-0.59	0.59	0.29	1.26	2.46
Ac-ft	258.03	232.69	473.01	394.59	237.48	258.73	60.57	75.44	94.18	55.91	167.54	170.04

2003
Cottonwood Creek 2
Phosphorus Loading (lbs)

Date	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1	2.68	3.03	2.52	15.49	4.97	1.44	0.74	0.31	11.86	0.44	0.51	1.52
2	2.98	3.17	2.28	10.23	3.25	1.59	0.54	0.24	2.31	0.41	0.91	1.32
3	3.00	3.42	2.34	5.88	2.98	1.77	0.37	0.15	4.60	0.37	1.92	1.27
4	2.68	3.49	2.38	3.92	2.18	1.25	0.34	0.16	1.38	0.34	1.85	1.25
5	2.61	3.16	2.65	2.96	1.87	2.92	0.34	0.01	0.53	0.31	1.82	1.54
6	2.68	3.06	2.63	4.08	1.60	7.74	0.21	-0.07	0.58	0.29	1.75	1.54
7	2.81	2.97	2.35	5.70	1.50	8.28	0.21	-0.12	0.76	0.29	1.44	1.47
8	2.95	2.93	1.95	3.75	1.40	6.53	0.09	-0.09	1.07	0.34	1.62	1.56
9	3.46	2.88	1.53	2.97	1.42	2.51	0.09	2.40	0.47	0.37	1.64	1.75
10	3.28	2.87	1.31	2.26	9.77	3.43	0.00	0.11	0.36	0.20	1.67	2.27
11	3.02	2.94	1.30	1.85	25.77	5.82	0.00	-0.06	0.25	0.16	1.52	1.80
12	2.77	2.93	1.14	1.73	10.67	2.66	-0.08	2.34	0.24	0.18	1.41	1.60
13	2.66	2.81	1.01	1.57	3.95	1.46	-0.11	0.33	0.28	0.31	1.36	1.50
14	2.56	2.83	1.09	1.52	2.88	1.08	-0.13	-0.05	0.49	0.47	1.41	1.47
15	2.63	2.85	0.98	1.44	2.75	0.88	-0.14	-0.11	0.44	0.72	1.58	1.77
16	2.74	2.84	0.83	7.34	2.71	0.76	-0.14	-0.13	0.28	0.65	1.64	1.49
17	2.72	2.93	1.69	4.57	2.04	3.17	-0.14	-0.14	0.20	0.62	1.66	1.46
18	2.65	2.93	26.40	1.82	1.27	31.88	0.00	0.34	0.28	0.51	1.45	1.51
19	2.61	2.50	10.71	6.62	1.17	17.11	6.62	3.95	0.27	0.44	1.36	1.50
20	2.63	2.11	11.32	3.42	1.28	4.79	0.91	0.21	0.28	0.37	1.32	1.45
21	2.68	2.11	24.45	1.75	1.14	2.90	0.34	0.00	0.27	0.34	1.46	1.38
22	2.81	1.75	32.82	1.29	1.20	1.72	0.05	-0.08	0.36	0.34	1.61	1.43
23	2.86	2.11	47.36	3.76	0.92	1.21	-0.18	0.34	0.34	0.41	1.64	1.50
24	2.77	3.42	30.38	34.31	0.86	1.27	-0.24	0.00	0.28	0.65	1.72	1.46
25	2.74	2.34	21.92	28.38	1.44	1.14	-0.18	-0.05	0.24	0.37	2.09	1.35
26	2.70	2.45	24.28	15.75	1.16	0.86	-0.09	-0.08	0.22	0.26	1.62	1.28
27	2.65	2.84	25.51	10.87	1.16	0.67	13.30	-0.12	0.26	0.21	1.50	1.30
28	2.67	2.64	15.78	11.98	0.91	0.55	2.26	-0.14	0.29	0.16	1.52	1.30
29	2.75		6.53	10.56	0.91	1.20	0.28	-0.08	0.40	0.11	1.60	1.36
30	2.84		5.42	7.91	1.16	1.01	1.49	9.04	0.43	0.09	1.60	1.43
31	2.93		13.85		1.18		0.72	26.75		0.09		1.40
Total	86.53	78.30	326.72	215.69	97.44	119.56	27.46	45.33	30.06	10.84	46.18	46.22
Mean	2.79	2.80	10.54	7.19	3.14	3.99	0.89	1.46	1.00	0.35	1.54	1.49
Max	3.46	3.49	47.36	34.31	25.77	31.88	13.30	26.75	11.86	0.72	2.09	2.27
Min	2.56	1.75	0.83	1.29	0.86	0.55	-0.24	-0.14	0.20	0.09	0.51	1.25

2003
Cottonwood Creek Peoria 1
Discharge (cfs)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	1.02	1.29	1.27	8.09	2.77	3.64	1.59	1.88	4.20	2.28	2.61	1.78
2	1.52	1.31	1.38	5.42	2.74	3.04	1.49	1.69	3.87	2.30	2.48	1.80
3	1.28	1.45	1.41	3.90	2.60	2.81	1.38	1.50	5.32	2.29	3.19	1.66
4	1.13	1.43	1.70	3.00	2.40	2.07	1.38	1.55	2.61	2.24	2.51	1.59
5	1.13	1.13	1.72	2.61	2.20	10.39	1.34	1.46	2.24	2.20	2.25	1.59
6	1.18	1.17	1.49	5.95	2.11	4.53	1.34	1.27	2.20	2.22	2.13	1.68
7	1.33	1.16	1.21	3.38	2.07	10.72	1.31	1.22	2.63	2.32	2.04	1.74
8	1.17	1.13	1.04	3.09	2.08	3.46	1.31	1.99	2.47	2.55	1.99	1.81
9	1.01	1.11	0.92	2.66	2.95	3.06	1.27	2.83	2.19	2.18	1.98	2.62
10	0.93	1.06	0.89	2.31	21.73	7.22	1.27	1.55	2.02	2.11	2.07	2.30
11	0.92	1.24	0.88	2.40	8.15	4.34	1.24	1.95	1.91	2.15	2.06	1.96
12	0.93	1.17	0.91	1.93	3.65	3.15	1.24	4.21	1.91	2.16	2.00	1.78
13	0.95	1.17	0.91	1.90	2.59	2.38	1.21	2.14	1.91	2.31	1.96	1.75
14	0.96	1.14	0.92	1.84	2.21	1.95	1.21	1.61	1.90	2.36	1.90	2.01
15	0.93	1.11	0.88	3.42	2.27	1.72	1.17	1.32	1.68	2.42	1.91	1.99
16	0.90	1.08	0.90	6.76	3.00	1.63	1.14	1.24	1.76	2.39	1.91	1.80
17	0.93	1.05	2.02	2.72	2.25	9.10	1.14	1.39	1.71	2.39	1.91	1.85
18	0.91	1.02	6.72	2.19	2.05	13.26	1.52	5.26	1.94	2.27	1.87	1.89
19	0.94	1.02	4.31	7.87	2.27	3.61	3.90	5.29	1.96	2.21	1.84	1.76
20	0.92	0.99	5.04	3.50	1.89	2.52	1.85	2.54	1.99	2.23	1.84	1.74
21	0.90	0.99	6.19	2.45	1.79	2.52	1.34	1.90	1.99	2.22	1.83	1.75
22	0.88	0.96	9.79	2.27	1.84	1.73	1.15	1.70	2.06	2.18	1.91	1.75
23	0.92	0.99	41.61	19.96	1.90	1.66	1.09	2.54	2.08	2.36	1.87	1.65
24	0.95	1.08	18.07	78.84	2.36	2.18	0.98	1.96	2.03	2.49	2.31	1.62
25	0.96	1.24	12.22	8.80	2.79	1.80	1.11	1.57	2.04	2.02	2.30	1.62
26	0.95	2.05	16.48	4.55	2.09	1.48	5.23	1.44	2.13	1.96	1.97	1.66
27	0.99	1.43	12.46	3.09	1.89	1.38	5.18	1.33	2.24	1.96	1.85	1.59
28	0.96	1.45	5.17	3.87	1.80	1.85	2.10	1.31	2.26	1.98	1.79	1.52
29	1.00		4.21	3.75	1.77	2.62	2.30	1.51	2.41	2.01	1.96	1.53
30	1.14		8.75	3.46	1.76	2.08	4.80	27.69	2.19	2.05	1.90	1.54
31	1.25		11.84		1.76		2.46	18.47		2.55		1.56
Total	31.88	33.40	183.31	205.98	95.76	113.93	57.03	105.30	69.86	69.35	62.13	54.90
Max	1.52	2.05	41.61	78.84	21.73	13.26	5.23	27.69	5.32	2.55	3.19	2.62
Min	0.88	0.96	0.88	1.84	1.76	1.38	0.98	1.22	1.68	1.96	1.79	1.52
Ac-ft	63.12	66.14	362.95	407.84	189.61	225.58	112.92	208.48	138.33	137.31	123.02	108.70

2003
Cottonwood Creek Peoria 1
Phosphorus Load (lbs)

Date	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1	0.20	0.29	0.28	5.53	0.99	1.53	0.41	0.53	1.93	0.72	0.90	0.48
2	0.38	0.30	0.32	2.91	0.97	1.15	0.37	0.45	1.69	0.73	0.83	0.50
3	0.29	0.35	0.33	1.71	0.89	1.01	0.32	0.37	2.82	0.73	1.24	0.43
4	0.23	0.34	0.45	1.13	0.78	0.62	0.32	0.39	0.90	0.70	0.84	0.41
5	0.23	0.23	0.46	0.90	0.68	8.28	0.31	0.35	0.70	0.68	0.71	0.40
6	0.25	0.25	0.36	3.37	0.64	2.18	0.31	0.28	0.68	0.69	0.65	0.44
7	0.30	0.24	0.26	1.36	0.62	8.71	0.30	0.26	0.91	0.74	0.60	0.47
8	0.25	0.23	0.20	1.18	0.63	1.42	0.30	0.58	0.82	0.86	0.58	0.50
9	0.20	0.23	0.17	0.93	1.09	1.16	0.28	1.02	0.68	0.67	0.57	0.90
10	0.17	0.21	0.16	0.74	27.12	4.61	0.28	0.39	0.60	0.64	0.62	0.73
11	0.17	0.27	0.16	0.78	5.60	2.03	0.27	0.56	0.54	0.66	0.61	0.57
12	0.17	0.25	0.16	0.55	1.54	1.22	0.27	1.94	0.55	0.66	0.59	0.48
13	0.18	0.25	0.17	0.54	0.89	0.77	0.26	0.65	0.54	0.74	0.57	0.47
14	0.18	0.24	0.17	0.51	0.69	0.56	0.26	0.41	0.54	0.76	0.54	0.59
15	0.17	0.23	0.16	1.38	0.72	0.46	0.25	0.30	0.44	0.79	0.54	0.58
16	0.16	0.22	0.16	4.14	1.13	0.42	0.24	0.27	0.48	0.78	0.54	0.49
17	0.17	0.21	0.60	0.96	0.71	6.69	0.24	0.33	0.46	0.78	0.55	0.51
18	0.16	0.20	4.11	0.68	0.61	12.25	0.38	2.77	0.56	0.72	0.53	0.53
19	0.17	0.20	2.01	5.29	0.72	1.52	1.71	2.80	0.57	0.69	0.51	0.48
20	0.17	0.19	2.59	1.44	0.53	0.85	0.51	0.86	0.58	0.70	0.51	0.47
21	0.16	0.19	3.60	0.81	0.49	0.85	0.31	0.54	0.58	0.69	0.51	0.47
22	0.16	0.18	7.52	0.72	0.51	0.46	0.24	0.45	0.61	0.67	0.55	0.47
23	0.17	0.19	77.04	23.64	0.54	0.44	0.22	0.86	0.63	0.76	0.53	0.43
24	0.18	0.22	20.16	215.30	0.76	0.67	0.19	0.57	0.60	0.83	0.74	0.42
25	0.18	0.27	10.75	6.33	1.00	0.50	0.23	0.40	0.60	0.60	0.73	0.42
26	0.18	0.61	17.39	2.19	0.63	0.36	2.74	0.35	0.65	0.57	0.57	0.43
27	0.19	0.34	11.08	1.18	0.53	0.32	2.70	0.30	0.70	0.57	0.52	0.41
28	0.18	0.35	2.69	1.69	0.50	0.52	0.63	0.30	0.71	0.57	0.49	0.38
29	0.19		1.94	1.61	0.48	0.90	0.73	0.37	0.79	0.59	0.57	0.38
30	0.24		6.28	1.42	0.48	0.63	2.39	40.04	0.68	0.61	0.54	0.38
31	0.28		10.21		0.48		0.82	20.87		0.86		0.39
Total	6.02	7.25	171.73	290.94	53.47	63.08	18.78	80.54	23.54	21.78	18.76	15.04
Mean	6.09	6.96	181.65	285.41	52.96	61.55	0.61	2.60	0.78	0.70	0.63	0.49
Max	5.72	6.67	181.33	282.50	51.99	60.40	2.74	40.04	2.82	0.86	1.24	0.90
Min	11.45	13.57	352.72	571.74	104.56	122.47	0.19	0.26	0.44	0.57	0.49	0.38

2003
Cottonwood Creek Peoria 2
Discharge (cfs)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	1.85	1.54	1.45	15.29	3.61	3.21	1.58	1.60	3.84	1.50	1.59	1.50
2	2.04	1.62	1.49	12.24	3.18	5.41	1.52	1.54	2.22	1.50	1.55	1.50
3	1.86	1.70	1.53	8.42	2.81	2.09	1.52	1.51	4.76	1.50	1.82	1.50
4	1.68	1.68	1.72	4.96	2.47	1.76	1.53	1.51	1.89	1.50	1.57	1.50
5	1.67	1.54	1.73	3.74	2.19	6.63	1.50	1.51	1.64	1.50	1.51	1.50
6	1.68	1.49	1.72	10.19	1.95	5.13	1.50	1.50	1.62	1.50	1.50	1.50
7	1.70	1.45	1.44	9.08	1.87	9.23	1.50	1.50	1.81	1.50	1.50	1.50
8	1.77	1.44	1.33	9.63	1.92	3.61	1.50	1.58	1.72	1.53	1.50	1.50
9	1.56	1.46	1.16	8.61	2.10	2.58	1.50	3.51	1.60	1.50	1.50	1.55
10	1.47	1.52	1.08	7.71	13.37	5.23	1.50	1.55	1.54	1.50	1.50	1.56
11	1.50	1.70	1.04	8.79	9.46	5.29	1.50	1.56	1.52	1.50	1.50	1.50
12	1.55	1.57	0.99	9.46	4.48	2.57	1.50	3.83	1.52	1.50	1.50	1.50
13	1.56	1.55	0.99	9.80	2.61	2.17	1.50	1.78	1.52	1.50	1.50	1.50
14	1.36	1.62	0.99	10.33	2.17	1.81	1.50	1.55	1.53	1.50	1.50	1.50
15	1.20	1.60	0.99	8.98	2.12	1.67	1.50	1.50	1.50	1.50	1.50	1.50
16	1.17	1.50	0.99	14.29	2.67	1.63	1.50	1.50	1.50	1.50	1.50	1.50
17	1.23	1.45	1.17	6.88	1.82	8.28	1.50	1.50	1.50	1.50	1.50	1.50
18	1.22	1.40	2.34	5.97	1.69	14.50	1.52	2.36	1.51	1.50	1.50	
19	1.24	1.32	1.80	13.05	1.92	5.72	3.05	6.44	1.51	1.50	1.50	
20	1.20	1.26	1.87	8.32	1.72	3.01	1.60	2.06	1.51	1.50	1.50	
21	1.18	1.28	1.92	6.36	1.75	3.04	1.51	1.62	1.51	1.51	1.50	
22	1.19	1.26	2.62	5.86	1.74	2.11	1.52	1.55	1.51	1.50	1.50	
23	1.21	1.28	5.43	16.15	1.73	2.00	1.51	1.84	1.51	1.52	1.50	
24	1.25	1.31	3.05	44.92	1.77	2.17	1.50	1.84	1.50	1.57	1.53	
25	1.25	1.34	2.62	10.42	3.08	1.76	1.50	1.52	1.50	1.50	1.54	
26	1.25	1.67	30.83	5.09	1.80	1.58	2.38	1.50	1.50	1.50	1.50	
27	1.31	1.68	19.92	4.07	1.70	1.54	8.74	1.50	1.51	1.50	1.50	
28	1.25	1.56	10.90	4.58	1.64	1.62	2.33	1.50	1.50	1.50	1.50	
29	1.33		8.79	4.58	1.58	2.43	1.85	1.50	1.52	1.50	1.50	
30	1.42		11.60	4.07	1.64	1.78	3.60	15.44	1.50	1.50	1.50	
31	1.51		17.10		1.60		1.88	14.44		1.53		
Total	44.65	41.80	142.59	291.84	86.16	111.56	60.14	85.65	52.85	46.69	45.63	25.61
Max	2.04	1.70	30.83	44.92	13.37	14.50	8.74	15.44	4.76	1.57	1.82	1.56
Min	1.17	1.26	0.99	3.74	1.58	1.54	1.50	1.50	1.50	1.50	1.50	1.50
Ac-ft	88.42	82.76	282.33	577.83	170.60	220.88	119.08	169.58	104.65	92.44	90.35	50.71

2003
Cottonwood Creek Peoria 2
Phosphorus Load (lbs)

Date	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1	0.54	0.43	0.40	13.12	1.32	1.12	0.44	0.45	1.45	0.42	0.45	0.42
2	0.61	0.46	0.41	8.94	1.11	2.39	0.42	0.43	0.68	0.42	0.44	0.42
3	0.55	0.49	0.43	4.79	0.93	0.63	0.42	0.42	1.97	0.42	0.53	0.42
4	0.48	0.48	0.49	2.10	0.79	0.51	0.43	0.42	0.56	0.42	0.44	0.42
5	0.48	0.43	0.50	1.39	0.67	3.27	0.42	0.42	0.47	0.42	0.42	0.42
6	0.48	0.41	0.49	6.56	0.58	2.21	0.42	0.42	0.46	0.42	0.42	0.42
7	0.49	0.40	0.40	5.42	0.55	5.56	0.42	0.42	0.53	0.42	0.42	0.42
8	0.51	0.40	0.36	5.97	0.57	1.33	0.42	0.44	0.49	0.43	0.42	0.42
9	0.44	0.40	0.30	4.97	0.64	0.83	0.42	1.27	0.45	0.42	0.42	0.43
10	0.41	0.42	0.28	4.16	10.39	2.27	0.42	0.43	0.43	0.42	0.42	0.44
11	0.42	0.49	0.27	5.14	5.80	2.31	0.42	0.44	0.42	0.42	0.42	0.42
12	0.44	0.44	0.25	5.80	1.80	0.83	0.42	1.44	0.42	0.42	0.42	0.42
13	0.44	0.43	0.25	6.14	0.85	0.67	0.42	0.52	0.42	0.42	0.42	0.42
14	0.37	0.46	0.25	6.71	0.66	0.53	0.42	0.43	0.43	0.42	0.42	0.42
15	0.32	0.45	0.25	5.32	0.65	0.47	0.42	0.42	0.42	0.42	0.42	0.42
16	0.31	0.42	0.25	11.66	0.87	0.46	0.42	0.42	0.42	0.42	0.42	0.42
17	0.33	0.40	0.31	3.47	0.53	4.67	0.42	0.42	0.42	0.42	0.42	0.42
18	0.33	0.38	0.73	2.78	0.48	11.96	0.43	0.74	0.42	0.42	0.42	
19	0.33	0.36	0.52	9.96	0.57	2.61	1.05	3.13	0.42	0.42	0.42	
20	0.32	0.34	0.55	4.69	0.49	1.03	0.45	0.62	0.42	0.42	0.42	
21	0.31	0.34	0.57	3.07	0.51	1.04	0.42	0.46	0.42	0.42	0.42	
22	0.31	0.34	0.85	2.70	0.50	0.64	0.42	0.43	0.42	0.42	0.42	
23	0.32	0.34	2.41	14.44	0.50	0.60	0.42	0.54	0.42	0.42	0.42	
24	0.33	0.35	1.05	94.57	0.51	0.66	0.42	0.54	0.42	0.44	0.43	
25	0.33	0.36	0.85	6.80	1.06	0.51	0.42	0.42	0.42	0.42	0.43	
26	0.33	0.48	46.61	2.18	0.52	0.44	0.75	0.42	0.42	0.42	0.42	
27	0.35	0.48	20.97	1.57	0.49	0.43	5.09	0.42	0.42	0.42	0.42	
28	0.33	0.44	7.34	1.87	0.47	0.46	0.73	0.42	0.42	0.42	0.42	
29	0.36		5.14	1.87	0.44	0.77	0.54	0.42	0.42	0.42	0.42	
30	0.39		8.15	1.57	0.46	0.52	1.32	13.35	0.42	0.42	0.42	
31	0.42		15.97		0.45		0.55	11.87		0.43		
Total	11.95	11.62	101.65	249.73	35.71	51.73	20.14	42.97	15.89	12.98	12.72	7.12
Mean	0.40	0.42	3.39	8.32	1.19	1.72	0.65	1.39	0.53	0.42	0.42	0.42
Max	0.61	0.49	46.61	94.57	10.39	11.96	5.09	13.35	1.97	0.44	0.53	0.44
Min	0.31	0.34	0.25	1.39	0.44	0.43	0.42	0.42	0.42	0.42	0.42	0.42

2003
Shop Creek 3
Discharge (cfs)

Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0.40	0.40	0.40	0.68	0.35	0.31	0.27	0.22	0.23	0.21	0.21	0.22
2	0.40	0.40	0.40	0.55	0.35	0.31	0.26	0.22	0.19	0.21	0.21	0.22
3	0.40	0.40	0.40	0.49	0.35	0.32	0.25	0.21	0.36	0.21	0.23	0.22
4	0.40	0.40	0.40	0.46	0.34	0.33	0.25	0.21	0.28	0.21	0.23	0.22
5	0.40	0.40	0.40	0.45	0.35	0.47	0.26	0.21	0.24	0.21	0.22	0.22
6	0.40	0.31	0.40	0.62	0.35	0.37	0.26	0.21	0.24	0.21	0.22	0.22
7	0.40	0.31	0.40	0.47	0.36	0.60	0.27	0.20	0.26	0.21	0.22	0.21
8	0.40	0.31	0.40	0.43	0.36	0.36	0.26	0.22	0.30	0.20	0.22	0.22
9	0.40	0.31	0.40	0.40	0.37	0.34	0.24	0.33	0.23	0.20	0.21	0.23
10	0.40	0.31	0.40	0.39	1.01	0.41	0.22	0.23	0.22	0.20	0.22	0.35
11	0.40	0.40	0.40	0.39	0.80	0.34	0.21	0.22	0.22	0.21	0.21	0.25
12	0.40	0.40	0.40	0.38	0.40	0.30	0.21	0.48	0.21	0.19	0.22	0.24
13	0.40	0.40	0.40	0.38	0.37	0.33	0.21	0.25	0.22	0.20	0.22	0.24
14	0.40	0.40	0.40	0.39	0.35	0.29	0.18	0.22	0.22	0.21	0.22	0.25
15	0.43	0.40	0.40	0.40	0.34	0.28	0.17	0.21	0.22	0.22	0.22	0.26
16	0.45	0.40	0.40	0.74	0.35	0.28	0.17	0.20	0.22	0.22	0.22	0.24
17	0.43	0.40	0.43	0.40	0.32	0.40	0.18	0.20	0.21	0.22	0.22	0.27
18	0.45	0.40	0.53	0.37	0.32	0.75	0.22	0.43	0.23	0.21	0.21	0.26
19	0.43	0.40	0.55	0.69	0.34	0.43	1.83	0.49	0.22	0.21	0.21	0.25
20	0.40	0.40	0.53	0.44	0.34	0.43	0.47	0.28	0.22	0.21	0.21	0.25
21	0.40	0.40	0.53	0.36	0.33	0.47	0.27	0.24	0.22	0.20	0.22	0.23
22	0.40	0.40	0.54	0.36	0.32	0.37	0.24	0.23	0.21	0.20	0.22	0.22
23	0.45	0.43	0.69	0.83	0.33	0.34	0.23	0.23	0.21	0.20	0.23	0.22
24	0.40	0.45	4.89	5.42	0.33	0.32	0.22	0.23	0.21	0.21	0.28	0.22
25	0.40	0.48	1.50	0.67	0.37	0.30	0.22	0.21	0.21	0.21	0.40	0.22
26	0.40	0.43	1.62	0.53	0.32	0.28	0.22	0.21	0.20	0.20	0.27	0.22
27	0.40	0.40	1.58	0.42	0.32	0.28	0.36	0.21	0.20	0.20	0.27	0.22
28	0.40	0.40	0.65	0.39	0.31	0.27	0.24	0.21	0.20	0.20	0.27	0.26
29	0.40		0.51	0.37	0.31	0.30	0.24	0.21	0.20	0.20	0.26	0.26
30	0.40		0.58	0.36	0.30	0.56	0.27	0.57	0.20	0.20	0.26	0.39
31	0.40		0.76		0.30		0.22	0.39		0.20		0.40
Total	12.67	10.98	22.31	19.22	11.65	11.12	9.12	8.17	0.05	6.41	7.01	7.68
Max	0.45	0.48	4.89	5.42	1.01	0.75	1.83	0.57	0.03	0.22	0.40	0.40
Min	0.40	0.31	0.40	0.36	0.30	0.27	0.17	0.20	0.03	0.19	0.21	0.21
Ac-ft	25.09	21.75	44.17	38.06	23.07	22.01	18.06	16.18	0.03	12.69	13.88	15.21

2003
Shop Creek 3
Phosphorus Loading (lbs)

Date	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1	0.31	0.31	0.31	0.53	0.27	0.24	0.21	0.17	0.18	0.16	0.16	0.17
2	0.31	0.31	0.31	0.43	0.27	0.24	0.20	0.17	0.15	0.16	0.16	0.17
3	0.31	0.31	0.31	0.38	0.27	0.25	0.20	0.16	0.28	0.16	0.18	0.17
4	0.31	0.31	0.31	0.35	0.26	0.25	0.20	0.17	0.22	0.16	0.17	0.17
5	0.31	0.31	0.31	0.34	0.27	0.36	0.20	0.16	0.19	0.16	0.17	0.17
6	0.31	0.24	0.31	0.48	0.27	0.28	0.20	0.16	0.19	0.16	0.17	0.17
7	0.31	0.24	0.31	0.36	0.28	0.46	0.21	0.16	0.20	0.16	0.17	0.16
8	0.31	0.24	0.31	0.33	0.28	0.27	0.20	0.17	0.23	0.16	0.17	0.17
9	0.31	0.24	0.31	0.31	0.29	0.26	0.19	0.25	0.18	0.16	0.16	0.18
10	0.31	0.24	0.31	0.30	0.78	0.31	0.17	0.17	0.17	0.16	0.17	0.27
11	0.31	0.31	0.31	0.30	0.62	0.26	0.16	0.17	0.17	0.16	0.17	0.19
12	0.31	0.31	0.31	0.29	0.31	0.23	0.16	0.37	0.17	0.14	0.17	0.18
13	0.31	0.31	0.31	0.29	0.28	0.26	0.16	0.19	0.17	0.16	0.17	0.19
14	0.31	0.31	0.31	0.30	0.27	0.22	0.14	0.17	0.17	0.16	0.17	0.19
15	0.33	0.31	0.31	0.31	0.26	0.21	0.13	0.16	0.17	0.17	0.17	0.20
16	0.35	0.31	0.31	0.57	0.27	0.22	0.13	0.16	0.17	0.17	0.17	0.18
17	0.33	0.31	0.33	0.31	0.25	0.31	0.14	0.15	0.16	0.17	0.17	0.21
18	0.35	0.31	0.41	0.28	0.25	0.58	0.17	0.34	0.18	0.16	0.17	0.20
19	0.33	0.31	0.43	0.53	0.26	0.33	1.41	0.38	0.17	0.16	0.17	0.19
20	0.31	0.31	0.41	0.34	0.26	0.33	0.36	0.22	0.17	0.16	0.16	0.19
21	0.31	0.31	0.41	0.28	0.25	0.36	0.21	0.19	0.17	0.16	0.17	0.18
22	0.31	0.31	0.42	0.28	0.25	0.28	0.18	0.18	0.16	0.16	0.17	0.17
23	0.35	0.33	0.53	0.64	0.25	0.26	0.18	0.18	0.16	0.16	0.18	0.17
24	0.31	0.35	3.77	4.18	0.25	0.25	0.17	0.17	0.16	0.16	0.21	0.17
25	0.31	0.37	1.16	0.52	0.29	0.23	0.17	0.17	0.16	0.16	0.31	0.17
26	0.31	0.33	1.25	0.41	0.25	0.22	0.17	0.16	0.15	0.16	0.21	0.17
27	0.31	0.31	1.22	0.33	0.25	0.21	0.27	0.16	0.15	0.16	0.21	0.17
28	0.31	0.31	0.50	0.30	0.24	0.21	0.18	0.16	0.15	0.16	0.21	0.20
29	0.31		0.39	0.29	0.24	0.23	0.18	0.16	0.16	0.16	0.20	0.20
30	0.31		0.45	0.28	0.23	0.43	0.21	0.44	0.16	0.16	0.20	0.30
31	0.31		0.59		0.23		0.17	0.30		0.16		0.30
Total	9.77	8.47	17.21	14.83	8.99	8.58	7.04	6.31	5.27	4.95	5.41	5.92
Mean	0.32	0.30	0.56	0.49	0.29	0.29	0.23	0.20	0.18	0.16	0.18	0.19
Max	0.35	0.37	3.77	4.18	0.78	0.58	1.41	0.44	0.28	0.17	0.31	0.30
Min	0.31	0.24	0.31	0.28	0.23	0.21	0.13	0.15	0.15	0.14	0.16	0.16

2003
Cherry Creek Precipitation (in.)

Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0.12	0	0.00	0	0	0	0	0	0	0	0	0
2	0	0	0.01	0	0	0	0	0	0	0	0.01	0
3	0	0.32	0	0	0	0	0	0	0.36	0	0.01	0
4	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0.1	0.12	0	0	0.45	0	0	0	0	0	0
6	0.02	0.08	0	0.15	0	0	0	0	0	0	0	0
7	0	0.01	0	0	0	0.4	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0.14	0	0	0.11
9	0	0	0.00	0	0	0	0	0.45	0	0	0	0
10	0	0	0	0	0.9	0.08	0	0	0	0	0	0
11	0	0	0	0	0	0.05	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0.2	0	0	0	0
13	0	0	0	0	0	0.05	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0.03	0	0	0	0	0	0	0	0	0	0.01
16	0	0	0	0.32	0	0	0	0	0	0	0	0
17	0	0	0	0	0.00	0	0	0	0	0	0	0
18	0	0	1.93	0	0	1.05	0	0	0	0	0	0
19	0	0	0.00	0.31	0	0.05	2.05	1.25	0	0	0	0
20	0	0	0	0	0	0	0.1	0	0	0	0	0
21	0	0	2.9	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0.03	0
23	0	0.06	0	0.04	0	0	0	0	0	0	0	0
24	0	0.02	0	1.95	0	0	0	0	0.05	0	0	0
25	0	0	0	0.15	0	0	0	0.08	0	0	0	0
26	0	0.13	0	0	0	0	0	0	0	0	0	0
27	0	0.02	0	0	0	0	0	0	0	0	0	0
28	0	0.04	0	0	0	0	0	0	0	0	0	0
29	0		0	0.07	0	0.05	0	0	0	0	0	0
30	0		0	0.13	0.05	0.08	0	0.55	0	0.01	0	0
31	0		0		0		0	1.15		0.07		0
Total	0.14	0.81	4.96	3.12	0.95	2.26	2.15	3.68	0.55	0.08	0.05	0.12
Mean	0.00	0.03	0.16	0.10	0.03	0.08	0.07	0.12	0.02	0.00	0.00	0.00
Max	0.12	0.32	2.90	1.95	0.90	1.05	2.05	1.25	0.36	0.07	0.03	0.11
Min	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ac-ft	9.94	57.51	352.16	221.52	67.45	160.46	152.65	261.28	39.05	5.68	3.55	8.52

2003
Cherry Creek Precipitation
Phosphorus Loading (lbs)

Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	2.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.00
3	0.00	6.63	0.00	0.00	0.00	0.00	0.00	0.00	7.46	0.00	0.21	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	2.07	2.49	0.00	0.00	9.32	0.00	0.00	0.00	0.00	0.00	0.00
6	0.41	1.66	0.00	3.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.21	0.00	0.00	0.00	8.29	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.90	0.00	0.00	2.28
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.32	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	18.64	1.66	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	1.04	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.14	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	1.04	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21
16	0.00	0.00	0.00	6.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	39.98	0.00	0.00	21.75	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	6.42	0.00	1.04	42.47	25.89	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	2.07	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	60.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.62	0.00
23	0.00	1.24	0.00	0.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.41	0.00	40.39	0.00	0.00	0.00	0.00	1.04	0.00	0.00	0.00
25	0.00	0.00	0.00	3.11	0.00	0.00	0.00	1.66	0.00	0.00	0.00	0.00
26	0.00	2.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	0.41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	0.00	0.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	0.00		0.00	1.45	0.00	1.04	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00		0.00	2.69	1.04	1.66	0.00	11.39	0.00	0.21	0.00	0.00
31	0.00		0.00		0.00		0.00	23.82		1.45		0.00
Total	2.90	16.78	102.74	64.63	19.68	46.82	44.54	76.23	11.39	1.66	1.04	2.49
Mean	0.09	0.60	3.31	0.00	0.63	1.56	1.44	2.46	0.38	0.05	0.03	0.08
Max	2.49	6.63	60.07	0.00	18.64	21.75	42.47	25.89	7.46	1.45	0.62	2.28
Min	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

APPENDIX E

Biological Data

2003 CHERRY CREEK PHYTOPLANKTON
COMPOSITE

GENUS/SPECIES	03/25/03	04/22/03	05/06/03	05/20/03	06/03/03	06/17/03	07/01/03	07/15/03	07/29/03	08/12/03	08/26/03	09/09/03	09/23/03	10/15/03	11/11/03
BACILLARIOPHYTA															
Order Centrales															
Aulacoseira granulata var. angustissima							70	375							
Aulacoseira italica var. tenuissima					4										
Aulacoseira sp.				10			40							6	115
Cyclotella ocellata		3		520	1,480		15	10	240	40	80	1,280	320	400	
Cyclotella sp.	280	820	1,720	1,840							600	960	240	2,480	1,680
Stephanodiscus agassizensis	3	13	320	845	24	88	75	15	20		50			1	
Stephanodiscus hantzschii		3			340	680	200	640	1,920	340	440			1,840	
Stephanodiscus niagarae															20
Order Pennales															
Asterionella formosa			70	350											
Diatoma tenuis						10									
Fragilaria crotonensis			50					2,800							
Fragilaria sp.							110								
Nitzschia acicularis					20	8		15				50	5		
Nitzschia closterium	1,860		5												
Nitzschia fonticola							5								
Nitzschia gracilis				30	1	5	25						55	65	200
Nitzschia palea				5								25	5		
Nitzschia paleacea													25	155	110
Synedra delicatissima var. angustissima	78					1					10			10	10
Synedra rumpens var. familiaris	200					5	15	60	60		20	75	5	35	10
Synedra rumpens								120	80						
Synedra sp.								20	10						
CHLOROPHYTA															
Ankistrodesmus falcatus var. falcatus					1	1				10				240	5
Ankyra judayi										20					
Chlamydomonas globosa										20	10				100
Chlamydomonas reinhardtii													320	300	120
Chlamydomonas sp.									10						
Chlorella minutissima	75,375	28,375	55,000	10,000	5,500	62,500	96,000	73,000	16,500	126,500	2,500	16,500	46,500	12,500	18,000
Chlorella sp.				125											
Chlorogonium sp.									200	40	160	35	20	80	
Closterium acutum var. variabile					1	5		10	20	5	50	5	15		
Closterium sp.		1													
Coelastrum microporum					8		40							640	
Coelastrum sphaericum						480	110			120	1,280	100	5	960	80

GENUS/SPECIES	03/25/03	04/22/03	05/06/03	05/20/03	06/03/03	06/17/03	07/01/03	07/15/03	07/29/03	08/12/03	08/26/03	09/09/03	09/23/03	10/15/03	11/11/03
CHLOROPHYTA (cont.)															
Cosmarium abbreviata										10					
Cosmarium bioculatum var. depressum												5			
Crucigenia fenestrata												80			
Crucigenia tetrapedia	80	40	180		1,680	1,440	160	160	160		480	720	320	1,280	1,440
Dictyosphaerium ehrenbergianum										80				320	
Dictyosphaerium pulchellum	60										3,040				
Dimorphococcus sp.															3,200
Diplochloris lunata	320	360		1,920	1,920	160	125		440	440	1,120	3,520	8,560	640	160
Elakatothrix viridis							20								
Kirchneriella dianae					360	40									
Kirchneriella irregularis					20										
Kirchneriella lunaris	80	20		40	60	20	62					240			
Kirchneriella obesa	40	40						40					10		
Lagerheimia genevensis					20										480
Micractinium pusillum								10						240	
Monoraphidium contortum														20	
Monoraphidium griffithii										10		5	5	5	
Monoraphidium minutum	20	10					20		200	40		40	20	400	640
Monoraphidium mirabile												5		5	
Mougeotia sp.												25	10		
Nephrocytium agardhianum		40			40					160					160
Oocystis borgei					7			40	240		320		800		80
Oocystis lacustris					2		10	20		80	120				
Oocystis parva				160											
Oocystis solitaria							20								
Oocystis sp.	8	160													
Pandorina smithii									12		160	80	130	60	
Pediastrum boryanum			40									10			
Pediastrum duplex var. duplex		3			44	20		90						60	60
Pediastrum duplex var. gracillimum					8	70				5	240		90		
Pediastrum simplex												80			40
Pediastrum tetras			20		16			40			320	640	140	50	
Pseudodictyosphaerium sp.	7,000	1,000	37,000	6,500	3,250	13,000	9,500	1,000	1,500	6,000	500	9,000			1,760
Phacotus lenticularis				280							1,520	4,480	20		
Pteromonas aculeata				3										20	
Raphidocelis contorta	240	40													60
Raphidocelis microscopia											720		160	80	480
Scenedesmus acuminatus		5	20	30		160		40	40	200	80	140	100	320	
Scenedesmus arcuatus var. gracilis							40								
Scenedesmus armatus	80			320								20		320	
Scenedesmus bicaudatus									80						

GENUS/SPECIES	03/25/03	04/22/03	05/06/03	05/20/03	06/03/03	06/17/03	07/01/03	07/15/03	07/29/03	08/12/03	08/26/03	09/09/03	09/23/03	10/15/03	11/11/03
CHLOROPHYTA (cont.)															
Scenedesmus communis		20	90		20	40	80	60	40	80	160	160	1,280	1,280	160
Scenedesmus ecornis			80		80		280		80	40	40				
Scenedesmus ellipticus						30	125	40		40	40			20	
Scenedesmus intermedius		120	400	200	260	1,440	480		240	360	1,120	1,120	1,760	1,280	1,120
Scenedesmus obliquus					80	10									20
Scenedesmus subspicatus	280	280	40	400		320				40	5		320		160
Schroederia setigera				5		5	5	5		160	880	100	560	160	
Spermatozopsis exsultans							5			60	10				
Spondylosium planum										20	20				
Staurastrum sp.		3	5	40	1		10	20						5	
Tetraedron caudatum									10			10	720		
Tetraedron trigonum var. gracile				1					5	10	10		5	10	5
Tetraedron minimum	8	80	40	440	340	2,000	60	320	480		40	20	80	160	80
Tetraedron sp.		20					5						5		
Tetrastrum elegans	320			160	80	1	40								320
Tetrastrum heterocanthum													640		
Tetrastrum staurogeniaeforme	160	320	320	480	160	160	80						160	320	320
CYANOPHYTA															
Anabaena catenula var. affinis							1,000						50		
Anabaena circinalis									360	430					
Anabaena flos-aquae						160	280		100	80					
Anabaena peturbata							40	28,800	2,140	190	60	480	40	20	
Anabaenopsis elenkinii											780	650	50	60	
Aphanizomenon flos-aquae								90							
Aphanizomenon issatschenkoi								10	3,780	80	80				
Aphanocapsa delicatissima									20,500	6,000	1,000	500	11,000	2,000	
Aphanocapsa incerta													13,000		3,500
Aphanocapsa sp.											960				
Aphanothece minutissima													3,040	1,500	250
Aphanothece smithii	25,000	18,750	7,500	500	15,000	95,000	16,500	5,000	65,000	205,500	6,000	2,000	191,000	50,000	4,000
Aphanothece sp.								1,520			2,000			2,000	
Cyanobium sp.	375									100			500		
Dactylococcopsis fascicularis	3,050	120	80	10	80		1	40	1,000	160	3,360	1,040	2,160	1,120	480
Jaaginema angustissimum										20,840	2,300	1,000	6,400	600	2,880
Jaaginema subtilissima								110	140	160	1,000	1,440	480		
Merismopedia tenuissima													4,000		360
Planktolyngbya limnetica					440		90	60	280						
Planktothrix agardhii				110	20					2,230	1,120	545	110		
Pseudoanabaena limnetica					12		40			1,070	120	9,600	1,760	720	2,670

GENUS/SPECIES	03/25/03	04/22/03	05/06/03	05/20/03	06/03/03	06/17/03	07/01/03	07/15/03	07/29/03	08/12/03	08/26/03	09/09/03	09/23/03	10/15/03	11/11/03
CHRYSOPHYTA															
Bicosoeca planctonica				120											
Chromulina sp.													160		250
Dinobryon divergens							15	55							
Dinobryon sociale var. americanum							35	5			5				4
Mallomonas sp.							1		5						
EUGLENOPHYTA															
Euglena acus													5		
Euglena sp.					1	1	1				10	15	5	10	
Euglena viridis							1		5	10	10				
Phacus caudatus										5					
Phacus sp.		1				2								5	
Trachelomonas hispida var. coronata												40			5
Trachelomonas hispida var. crenulatocelis												30	200	3,440	150
Trachelomonas varians											10	10			
Trachelomonas volvocina	5	5												640	5
CRYPTOPHYTA															
Campylomonas (Cryptomonas) marsonii	8	58	60	16		1	10	5							20
Campylomonas (Cryptomonas) reflexa	5	5	5	15		1					10		20		20
Chroomonas nordstedtii													960	2,000	800
Cryptomonas erosa		45	910	320			10		10	360	640	160	320	6,050	1040
Cryptomonas ovata			5	10								10			
Cryptomonas rostratiformis		8	5											10	5
Komma (Chroomonas acuta) caudata	1,380	1,080	5,400	3,840	1,000	8,880	200	520	2,320	380	960	1,040	4,160	1,200	2,880
Plagioselmis sp.		60													
DINOPHYTA															
Ceratium hirundinella			5				1	1	1	10	20	5	5		
Peridiniopsis kulczynskii				10		30	80		60	5				40	
Peridiniopsis polonicum							10	10							
HAPTOPHYTA															
Chrysochromulina parva															1,040
PRASINOPHYTA															
Nephroseimis olivacea													1,680	2,000	
Tetraselmis cordiformis						10	120		3,760	640	2,960	2,800	1,120	800	2,480
Total Density (Cells/ml)	116,315	51,908	109,370	29,655	32,380	186,784	126,267	115,176	122,048	373,180	39,550	60,895	305,635	100,982	54,034
Total # of Taxa	27	34	27	35	38	37	51	39	40	47	54	49	60	58	52

APPENDIX F

Quality Assurance/quality Control

QA/QC Analysis

A number of steps are taken to assure the quality of water chemistry and chlorophyll *a* data being collected. First, field blanks are taken into the field during water quality sampling. Secondly, Chadwick & Associates, Inc. (C&A) laboratory performs internal QA/QC for each set of samples for each sampling period, including duplicate analysis of all samples, frequent checks against known standards, and frequent calibration of equipment. Lastly, duplicate aliquots are sent to an independent laboratory (University of Colorado [CU]) for analysis. Chlorophyll *a* analysis is conducted by C&A aquatic biological laboratory.

Data quality for total phosphorus (TP), total dissolved phosphorus (TDP), soluble reactive phosphorus (SRP, measured as orthophosphate), nitrate-nitrite, and ammonia for C&A and CU laboratories were compared using a simple, least squares regression analysis. To determine if the laboratories are in agreement on the data, the regression must meet the following criteria:

1. The linear regression must represent a significant relationship (p # 0.05),
2. The regressions should have a slope at or near 1, and
3. The regression should explain the majority of the observed variance (i.e., R^2 $ 0.50).

When these three criteria are met, the values reported by C&A and CU are averaged. In cases when one or more of the criteria are not met, the data do not meet the independent QA/QC and only the CU data would be used.

2003

Comparison of data collected during the 2003 field season shows good agreement between C&A and CU for TP, TDP, SRP, nitrate-nitrite, and ammonia (Table F-1). Regression slopes were all significantly different (p # 0.05) from zero, with slope values ranging from 0.60 to 1.15. Values for R^2 ranged from 0.41 to 0.87. Because of the close correlation between the results from the two labs, values from both labs were averaged. C&A and CU found all values for nitrate-nitrite to be below the analytical detection limit (5 µg/L). This demonstrates agreement between labs, but prevented the development of a statistical regression.

TABLE F-1: Summary statistics from comparison between Chadwick & Associates, Inc. laboratories and University of Colorado laboratories for phosphorus and nitrogen species for 2003. ND = no difference; all values were below analytical detection limits.

	p	Slope	R^2	QA/QC Criteria Met
Total Phosphorus	0.00	0.93	0.94	Yes
Total Dissolved Phosphorus	0.00	1.03	0.99	Yes
Soluble Reactive Phosphorus (Orthophosphate)	0.00	1.31	0.96	Yes
Nitrate-Nitrite	0.00	1.10	0.99	Yes
Ammonia	0.00	0.70	0.70	Yes

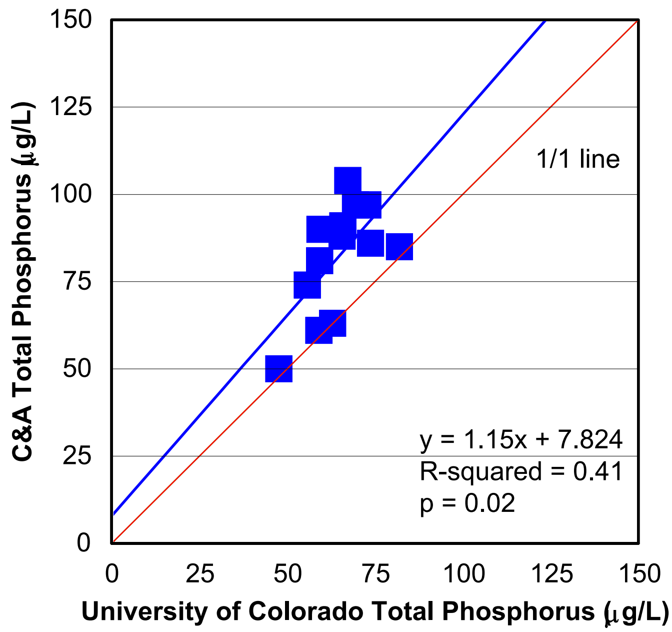


FIGURE F-1: Relationship between Chadwick & Associates, Inc. laboratory total phosphorus and University of Colorado total phosphorus for 2003.

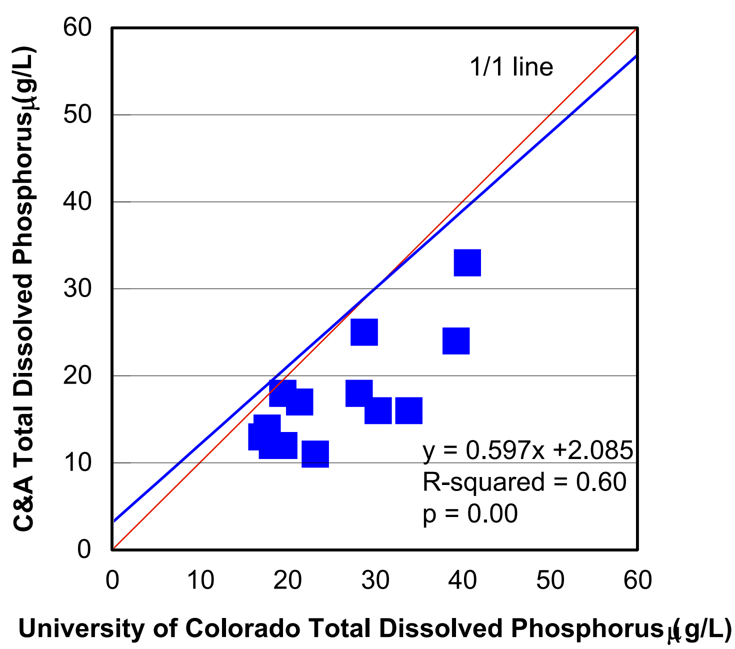


FIGURE F-2: Relationship between Chadwick & Associates, Inc. laboratory total dissolved phosphorus and University of Colorado total dissolved phosphorus for 2003.

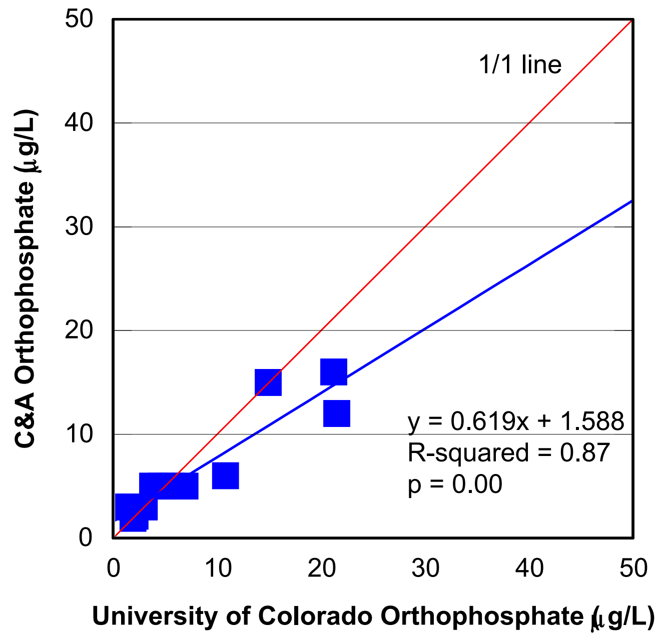


FIGURE F-3: Relationship between Chadwick & Associates, Inc. laboratory orthophosphate and University of Colorado orthophosphate for 2003.

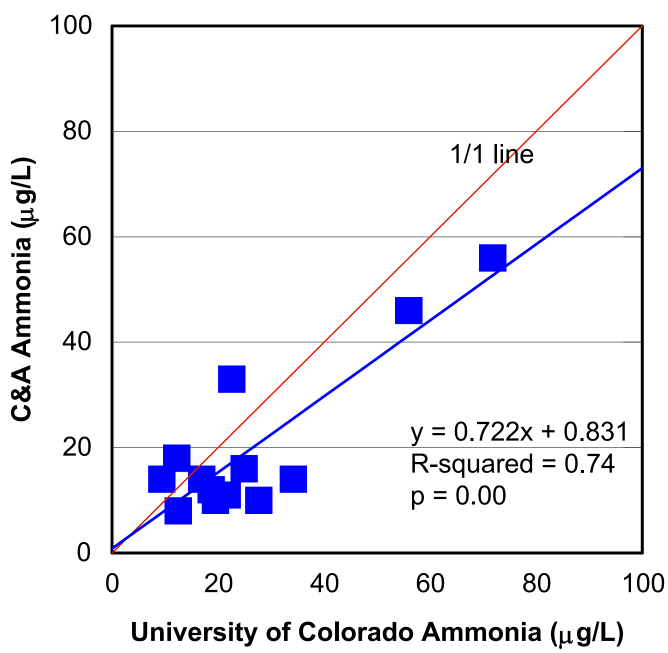


FIGURE F-4: Relationship between Chadwick & Associates, Inc. laboratory ammonia and University of Colorado ammonia for 2003.