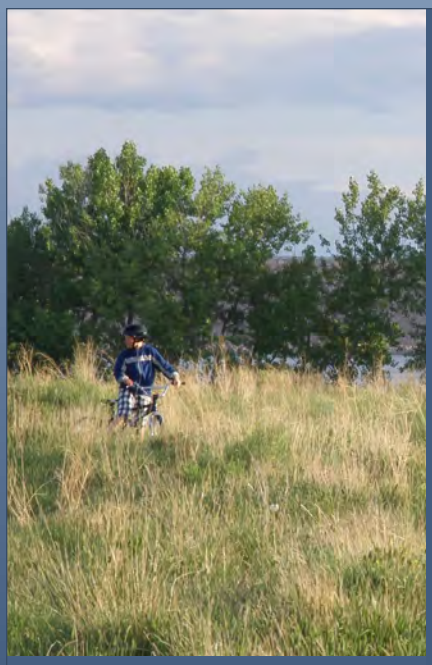
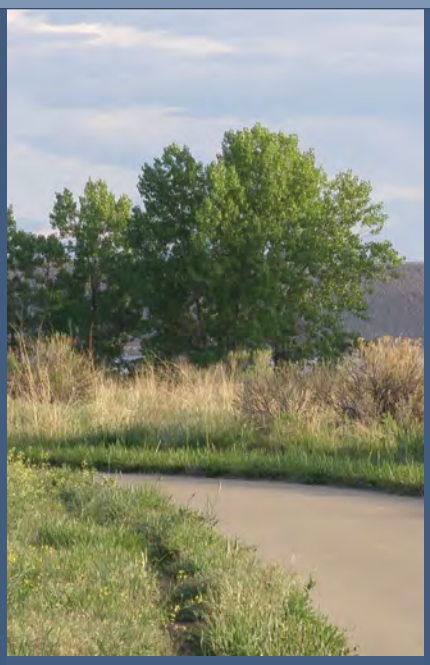
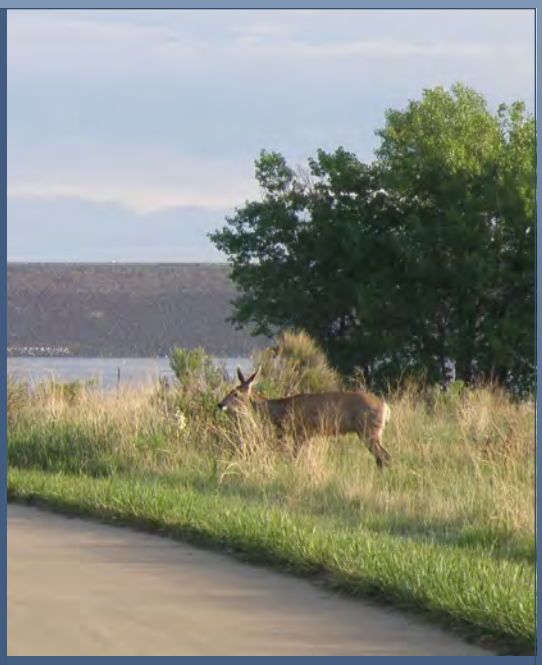
# 2011
# Annual Report on Activities

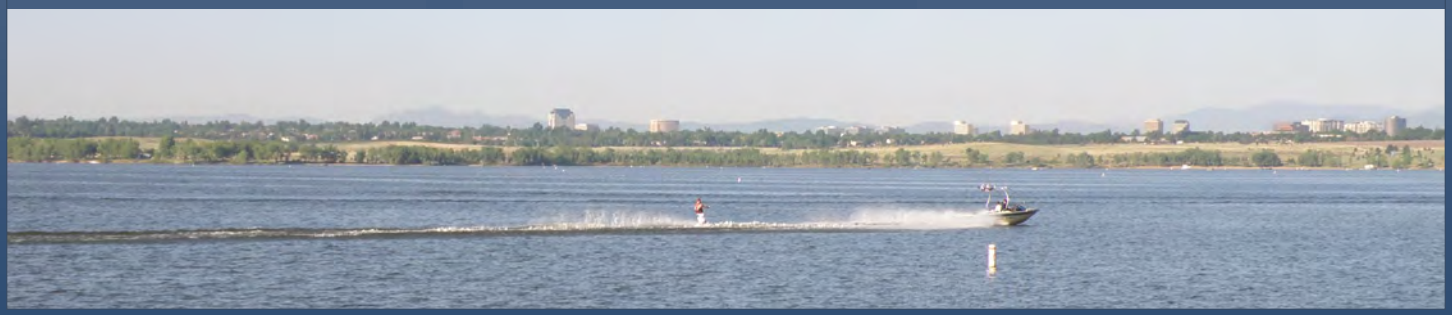
# Cherry Creek Basin Water Quality Authority

March 31, 2012









# 2011 Annual Report on Activities

# Cherry Creek Basin
## Water Quality Authority

**Cherry Creek Basin Water Quality Authority**
Chuck Reid, Manager
CliftonLarsonAllen LLP
8390 E. Crescent Parkway, Suite 500
Greenwood Village, CO 80111
Phone: 303-779-4525
Email: chuck.reid@cliftonlarsonallen.com

**PREPARED BY:**

**Leonard Rice Engineers, Inc.**

**William P. Ruzzo, P.E., L.L.C.**

**GEI Consultants, Inc.**

**John C. Halepaska and Associates, Inc.**

**Cherry Creek Land Use Agencies and Utilities**

**Cherry Creek Stewardship Partners**

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Photo Credits include Todd Brophy, Logan Burba, Mike Carnevale, Casey Davenhill, Katie Fendel, Martha Jones, Alan Pratt, Bill Ruzzo, Janet Williams

Thanks to Casey Davenhill for her contributions to Sections 4 and 6 and to Craig Wolf for the contributions in Section 7.

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## CONTROL REGULATION 72 REPORTING REQUIREMENTS CHECKLIST

This report is being submitted to both the Colorado Water Quality Control Commission and the Water Quality Control Division on or before March 31, 2012, in fulfillment of the reporting requirements of Regulation No. 72 – Cherry Creek Reservoir Control Regulation (Regulation 72). The following list shows where the reporting requirements of the Cherry Creek Reservoir Control Regulation can be found in this report. Reporting information includes all requirements of Regulation 72, effective January 1, 2010.

# LIST OF ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| ac-ft | Acre-feet |
| ACWWA | Arapahoe County Water & Wastewater Authority |
| Authority | Cherry Creek Basin Water Quality Authority, A.K.A. CCBWQA |
| BMP | Best Management Practice |
| CDOT | Colorado Department of Transportation |
| CDPS | Colorado Discharge Permit System |
| CIP | Capital Improvement Projects |
| COE | U.S. Army Corps of Engineers |
| Commission | Colorado Water Quality Control Commission |
| CSU | Colorado State University |
| Regulation 61 | Colorado Discharge Permit System Regulations |
| Regulation 72 | Cherry Creek Reservoir Control Regulation, A.K.A. Control Regulation |
| Division | Colorado Water Quality Control Division |
| DRCOG | Denver Regional Council of Governments |
| EPA | U.S. Environmental Protection Agency |
| ISDS | Individual Sewage Disposal System |
| lbs/yr | Pounds per year |
| µg/l | Micrograms per liter |
| mg/l | Milligrams per liter |
| MEP | Maximum Extent Practicable |
| MS4 | Municipal Separate Storm Sewer System |
| O&M | Operations and Maintenance |
| Partners | Cherry Creek Stewardship Partners |
| PRF | Pollutant Reduction Facility |
| SEMSWA | Southeast Metro Stormwater Authority |
| SRP | Soluble Reactive Phosphorus |
| TAC | Authority's Technical Advisory Committee |
| TCHD | Tri-County Health Department |
| UDFCD | Urban Drainage and Flood Control District |
| WY | Water Year |

# EXECUTIVE SUMMARY

The purpose of the 2011 Annual Report on Activities is to provide a status of the Cherry Creek Reservoir water quality and review progress made by the Cherry Creek Basin Water Quality Authority (Authority) towards achieving water quality standards in 2011.

**Authority Mission Statement**
"Protect beneficial uses by preserving, enhancing, and balancing water quality in Cherry Creek Reservoir and Cherry Creek."

The Authority is tasked with improving, protecting, and preserving the water quality of Cherry Creek and Cherry Creek Reservoir and achieving and maintaining state water quality standards for the reservoir and watershed. The Colorado Water Quality Control Commission has officially designated the following uses for Cherry Creek Reservoir: (1) aquatic life, (2) primary contact recreation, (3) water supply, and (4) agriculture. It has also adopted numeric water quality standards to protect these designated uses. Authority activities discussed in the Annual Report are components of a plan directed toward meeting water quality standards and enhancing environmental health in the Cherry Creek Reservoir and watershed. These activities include:

- Monitoring water quality;
- Measuring chlorophyll α, dissolved oxygen, phosphorus, and nitrogen concentrations in Cherry Creek Reservoir and streams;
- Implementing point, nonpoint, and regulated stormwater source controls and programs; and
- Identifying additional strategies for meeting water quality standards and goals in the foreseeable future.

The Authority's enabling legislation (C.R.S. Title 25 Article 8.5) defines the boundaries of the Authority as being generally limited to Arapahoe and Douglas Counties. Figure ES-1 shows the entire Cherry Creek watershed, which is defined in the Cherry Creek Reservoir Control Regulation (Regulation 72) as consisting of:

*"all lands that drain into the following: (a) the mainstem of Cherry Creek, from the source of East and West Cherry Creek to the inlet of Cherry Creek Reservoir (Segment 1), including alluvial groundwater; (b) Cherry Creek Reservoir (Segment 2), including alluvial groundwater; (c) all tributaries to Cherry Creek, including wetlands and alluvial groundwater, from the sources of East and West Cherry Creeks (parts of Segment 4); and all lakes and reservoirs in the Cherry Creek Reservoir watershed".*

During 2011, the reservoir and watershed were again monitored for reservoir water quality, reservoir inflow and loading, reservoir outflow and loading, surface and groundwater quality in the watershed, and the effectiveness of Authority's Pollutant Reduction Facilities (PRFs). In addition to the routine monitoring, 2011 was the fourth year of a multiple-year special monitoring program within the Cherry Creek Reservoir to measure changes due to the reservoir destratification project that began operation in 2008.

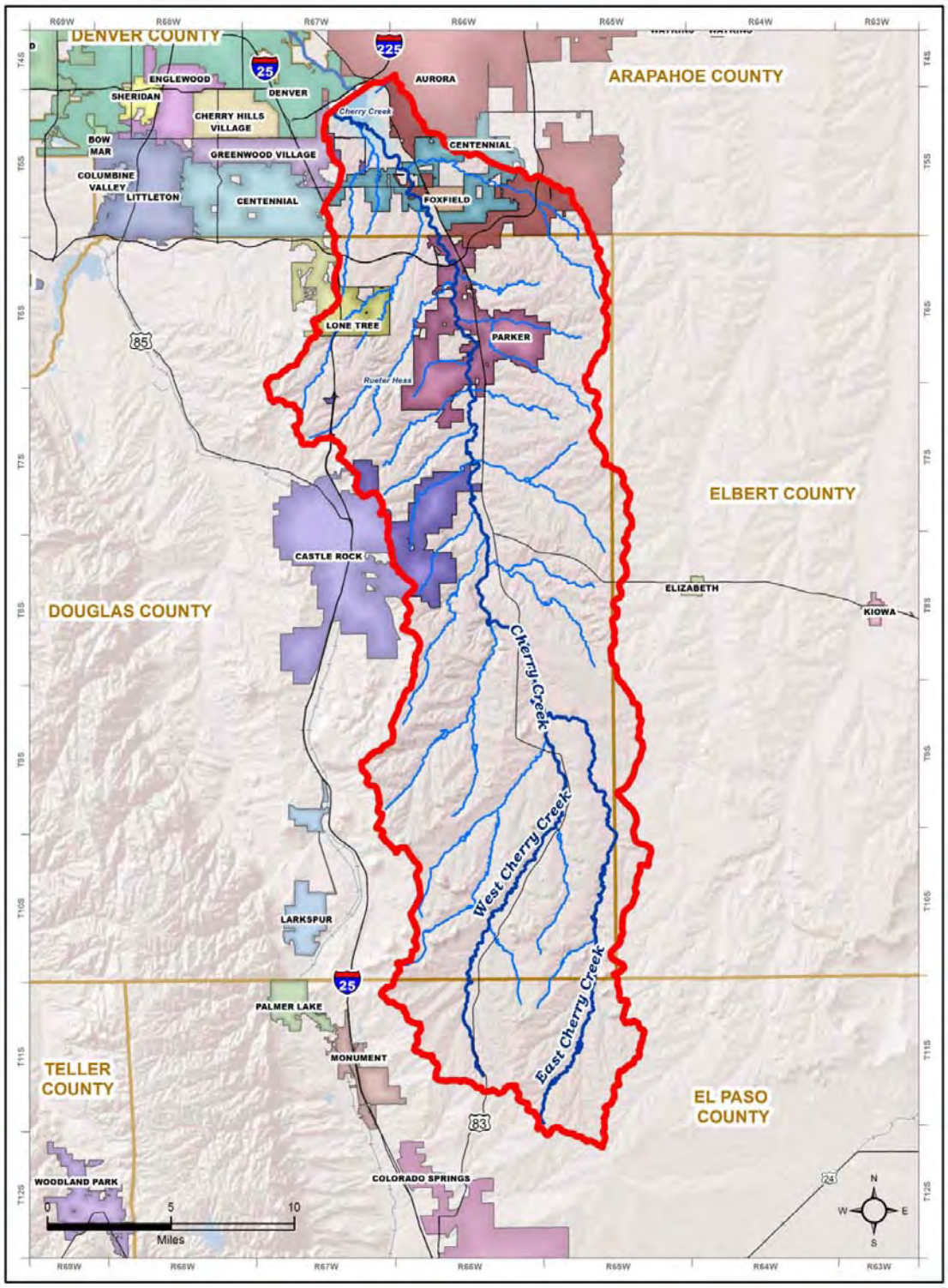



Figure ES-1 Cherry Creek Reservoir Watershed Showing County Lines and City Limits.

# Reservoir Water Quality

In 2011, the July through September mean chlorophyll α content in Cherry Creek Reservoir was 26.7 µg/l, which exceeded the seasonal standard of 18 µg/l. This is the second consecutive year when the seasonal mean chlorophyll α value has exceeded the growing season standard of 18 µg/l. As a result, the reservoir is not attaining the site-specific chlorophyll α standard based on the allowable exceedance frequency of once in five years. A discussion of what likely led to this condition in 2011 follows. The 2011 water year (WY) flow-weighted phosphorous concentration for all of the sources of inflow to the reservoir was 212 µg /l.

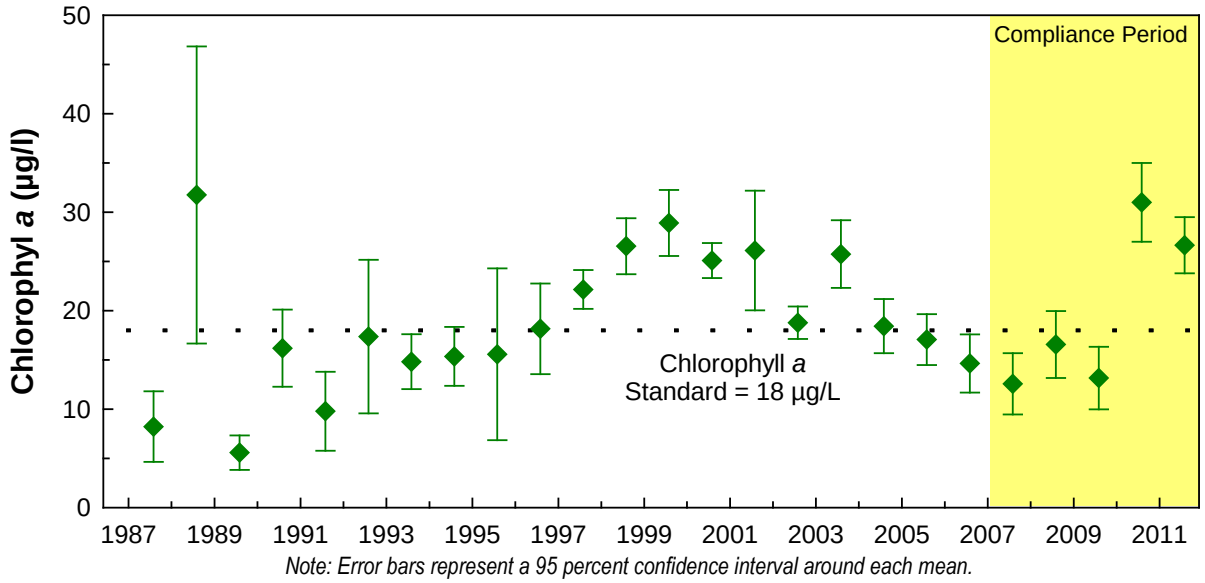



Figure ES-2. Seasonal Mean (July to September) Chlorophyll α Concentrations Measured in Cherry Creek Reservoir, 1992 to 2011

In 2008, the Authority embarked on a new reservoir management strategy based upon aeration to control nuisance algal growth (large bodied cyanobacteria) within the reservoir through destratification[1]. The destratification system was primarily designed to reduce the periods of thermal stratification as well as to reduce the suitable habitat conditions for cyano-bacteria by vertical mixing. Over time, it was estimated the destratification system could reduce the internal phosphorus load to approximately 50 percent of historical conditions by limiting the periods of stratification. In addition, the destratification system was anticipated to reduce both the seasonal mean and peak annual chlorophyll α concentrations in the reservoir by controlling nuisance cyanobacteria blooms.


[1] When the reservoir has sufficient temperature differences between the surface and the bottom, the reservoir is said to be "stratified", hence the name "destratification".

This past 2011 summer season represented the fourth operating year for the destratification system. The destratification system has been effective in reducing the periods of thermal stratification in the reservoir, which was one of the primary objectives of system.

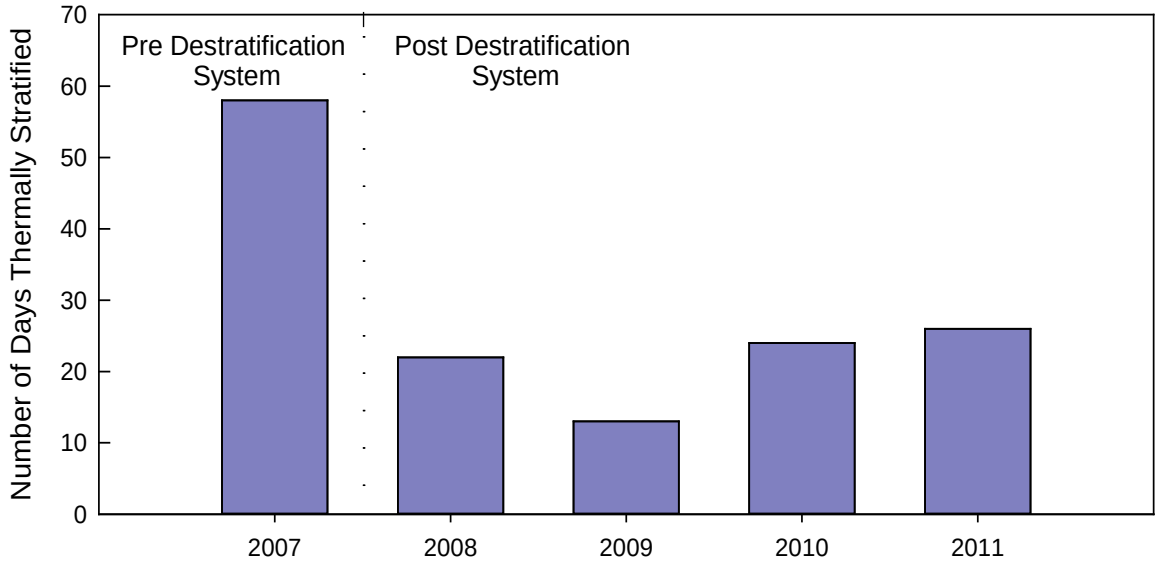



Figure ES-3. Number of Days that Cherry Creek Reservoir was Thermally Stratified, Pre- and Post-Operation of the Destratification System

The reservoir, however, continues to release soluble reactive phosphorus (SRP) from the sediment. Due to the mixing action of the destratification system, this SRP rapidly became available to the algal community in the upper water layers. It will likely take a number of years for the destratification system to reduce the internal loading of SRP from the sediments.

There was no indication of phosphorus limitation during the summer of 2011. During 2011, the dissolved inorganic nitrogen fraction was present in sufficient quantities throughout the water column; the reservoir did not appear to be nitrogen-limited, either. Similar to recent years' data, the algal community revealed typical responses to nutrient availability as evident in chlorophyll α concentrations. The change in relative species composition to one dominated by more beneficial algae rather than cyanobacteria remains a consistent pattern.

One of the primary objectives of the destratification system was to reduce the suitable habitat conditions for cyanobacteria (blue-green algae) by vertical mixing, which would disrupt the ability of cyanobacteria to efficiently grow in the upper water layers. Cyanobacteria can produce toxins that inhibit the growth of competing algae as well as inhibit grazing by zooplankton that rely on algae as a food source. Historically, the nuisance chlorophyll α levels (i.e., > 30 mg/l) during the summer have always been associated with cyanobacteria blooms. However, during the past three years the reservoir has exhibited a shift in the algal species composition such that cyanobacteria have been a very small component of the assemblage (Figure 7-18). Prior to the operation of the destratification system, cyanobacteria represented between 40 and 80 percent of assemblage. During the first season of operation in 2008, green algae and cyanobacteria were still the dominant types of algae, with cyanobacteria dominating the summer assemblage. However, since 2009 the cyanobacteria population has been greatly reduced, representing between 1 and 7 percent of the algal assemblage in terms of density.

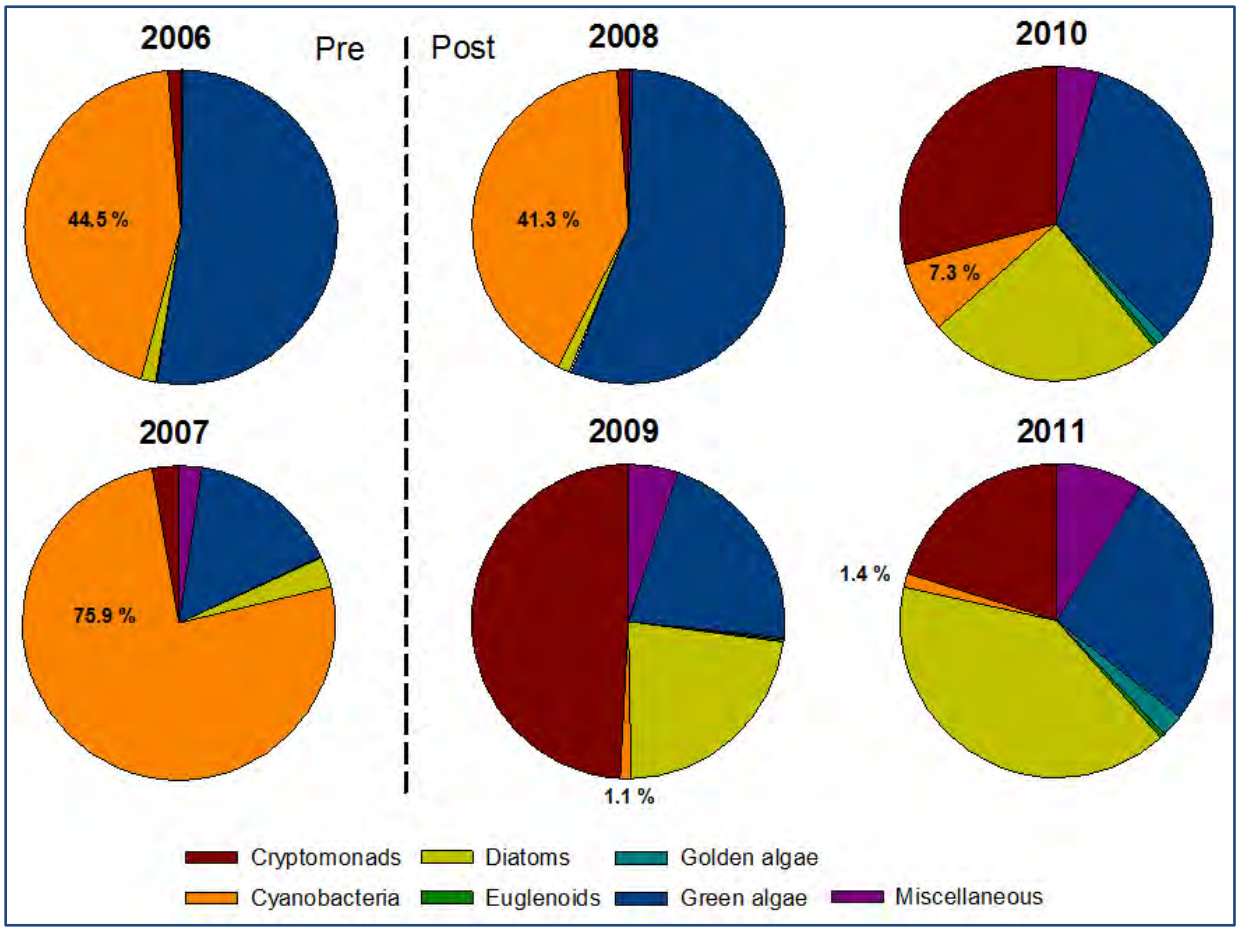



Figure ES-4. Percent Algal Density by Major Taxonomic Grouping for Cherry Creek Reservoir, Pre- and Post-Operation of the Destratification System.

Cryptomonads, diatoms, and green algae have become the dominant algal types, all of which are a substantial food source for zooplankton and fish. This shift in algal composition is notable as it provides some initial results that validate the effectiveness of the destratification system at achieving another of the primary objectives – reducing suitable habitat conditions for cyanobacteria. The destratification system's efficient vertical mixing allows the beneficial algal types (e.g. cryptomonads, diatoms, and green algae) a competitive advantage over cyanobacteria, in terms of nutrient and light resources. However, as a consequence of the efficient mixing, the relatively constant supply of soluble nutrients to algal community allows them to maximize their productivity. As a result, the reservoir exhibited extremely high chlorophyll α levels during the July to September 2011 growing season, which again exceeded the growing season chlorophyll α standard.

This response of the algal community to the new management strategy is not well understood, and the Authority is currently outlining an approach to focus on the mechanisms and effects that these results may have on other biological assemblages such as the zooplankton and fish as well as other uses of the reservoir. As mentioned earlier, it may take considerably more time for the destratification system to reduce the sediment oxygen demand and effectively control internal nutrient loading, which seems to drive the late summer production.

Long-term trends in reservoir phosphorus and nitrogen concentrtion are shown in Figures ES-5 and ES-6.

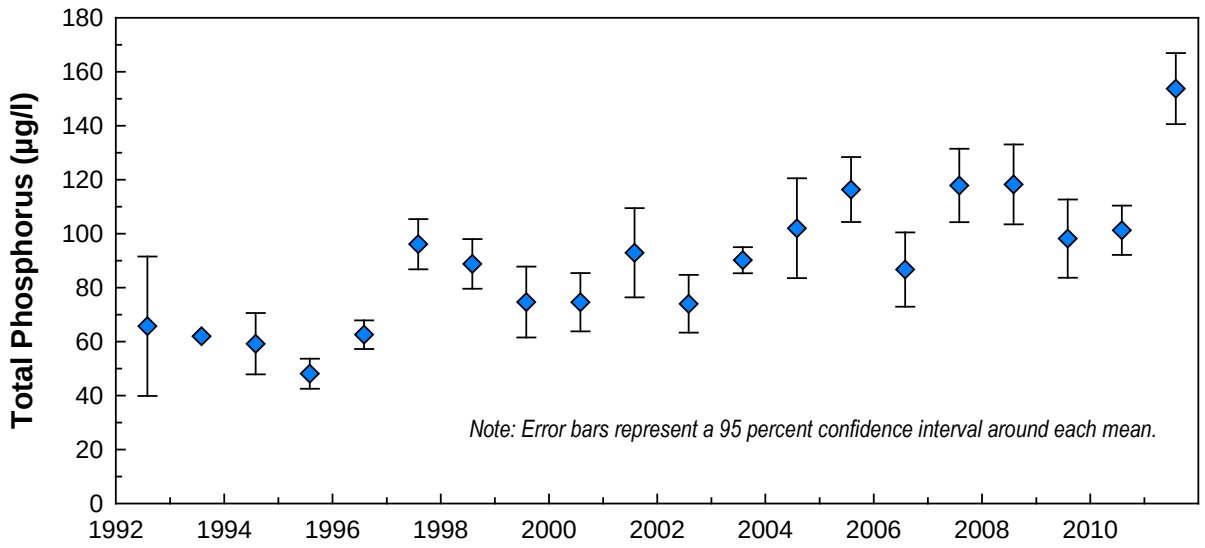



Figure ES-5. Seasonal Mean (July to September) Total Phosphorus Concentrations in Cherry Creek Reservoir.

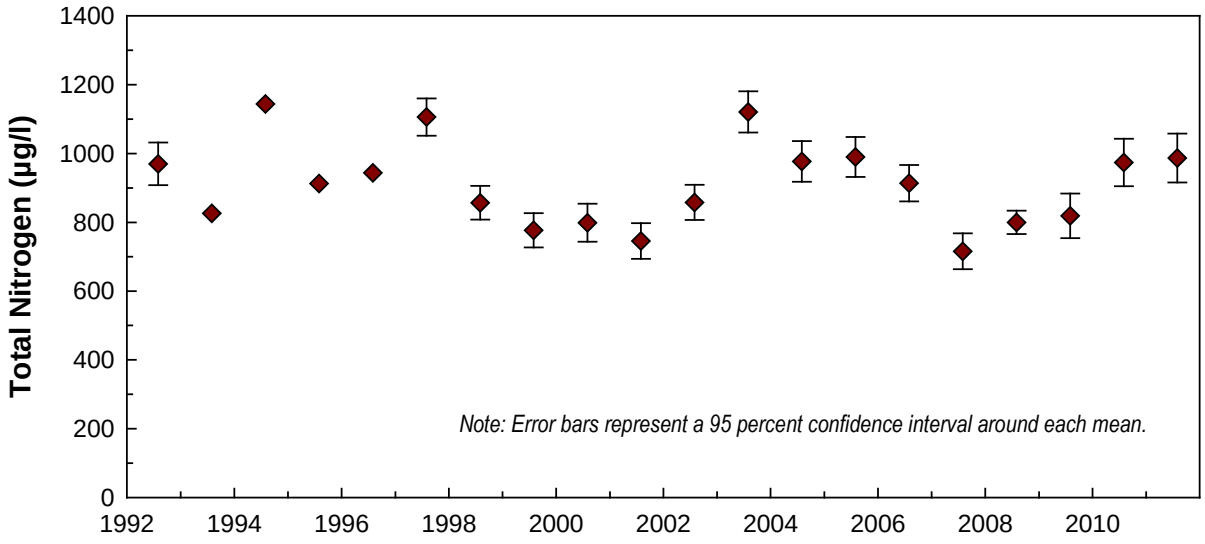



Figure ES-6. Seasonal Mean (July to September) Total Nitrogen Concentrations in Cherry Creek Reservoir.

# Point Source Controls

The control requirements placed on the six point source dischargers to the Cherry Creek Basin have been effective in reducing phosphorus concentrations in the watershed and reservoir. All wastewater treatment plants again have met or exceeded their phosphorus discharge limits in water year 2011, meaning therefore that there were no permit violations for phosphorus limits for any of the point sources during the 2010 year.

The total phosphorus effluent limits required of wastewater facilities and industrial process wastewater sources (less than 0.05 mg/l total phosphorus concentration as a 30-day average) are significantly less than the flow-weighted total phosphorus concentrations currently entering the reservoir and in the stream where they discharge. For 2011, the flow-weighted influent concentration of Cherry Creek as it entered the reservoir was 0.212 mg/l. Actual concentrations discharged by wastewater treatment plants were consistently below the 0.05 mg/l limits and well below the 0.200 mg/l flow-weighted phosphorus concentration goal supported by the Authority to help attain the standard. The wastewater treatment facilities are, in fact, discharging treated effluent that is well below the receiving water's total phosphorus concentration.

Effective January 2010, Regulation 72 also added a phosphorus limit (0.2 mg/l )for wastewater discharges from drinking water treatment plants. Colorado has a general permit, CO641000, which covers water treatment plants. This permit expired October 31, 2010, and has been administratively extended. This permit does not presently include any phosphorus discharge limits for facilities in the Cherry Creek basin; monitoring and reporting only are required. As the permit is renewed, it should incorporate the new 30-day average total phosphorus limitation of 0.2 mg/l for water treatment plant dischargers in the Cherry Creek basin. At present there is only one discharge of this type in the basin.

Control requirements placed on the point source dischargers and discussed in more detail in Section 3 of this report have been found to support attainment of the water quality standard.

There were no new site applications in the basin in 2011.

In 2011, the Authority also prepared an inventory of lift stations within the basin. There are about 50 active lift stations in the basin. The Authority also attempted to determine how many were constructed (or upgraded) after Regulation 72 was adopted in November 1985 and how many were completed after the implementation of the Authority's Emergency Response Plan Criteria in March 2002. Further followup in this area is expected to occur in 2012.

# Regulated Stormwater Source Controls

Regulation 72 changes also affected regulated stormwater sources controls. A three-tiered approach to stormwater management best management practice (BMP) was adopted to coincide with the Regulation 61 requirements while addressing specific concerns within the basin. Because of this and other changes to Regulation 72, the Authority began evaluating its stormwater requirements and is discussing potential modifications to these requirements to preserve consistency with Regulation 72. This is expected to continue in 2012.

Municipal Separate Storm Sewer System (MS4) communities are required to implement measures to control the quality of stormwater runoff from land disturbances in the reservoir watershed for all new development and redevelopment activities. The total number of all construction sites, inspections, and enforcement actions by county within the basin are shown and discussed in Section 4 of this report. There were 800 construction sites in the basin in 2011, inspected a total of 6,276 times, which resulted in discovery of 1,243 situations that

required some sort of an enforcement response. In addition, there were 348 [2] permanent BMPs or BMP sites that were inspected 1,034 times, resulting in 34 enforcement actions.

BMPs and other control measures that have been used to address regulated stormwater have been confirmed to be effective in improving water quality. By monitoring both upstream and downstream of PRFs, the Authority also measures the cumulative benefits of BMP implementation in the watershed since PRFs control both regulated and unregulated stormwater.

The Authority reviews land use or development application referrals to comment on the potential water quality impacts of the proposed application prior to construction. Section 4 summarizes the number of land use and development applications reviewed by the Authority annually since 1997, as well as land use and development application referrals by land use agency.

## Nonpoint Source Stormwater Controls

In 2011, the Authority's capital construction program focused on stream reclamation projects as a way to reduce phosphorus concentrations entering Cherry Creek Reservoir. PRFs are nonpoint source stormwater controls that are constructed by the Authority. These water quality enhancement measures, such as stream reclamation, shoreline stabilization, detention, wetlands, and others, reduce pollutants carried by stormwater from existing and future land disturbances. PRFs are discussed in more detail in Section 5 of this report.

Specific PRFs that have shown success in 2011 are the reservoir destratification system as well as the various PRFs that have been constructed along Cottonwood Creek and Cherry Creek. Ten different PRFs were either under preliminary investigation, design, and/or construction in 2011. From 1991 through 2011, over $6 million has been spent on completed PRF projects; ongoing projects have additional committed funds of more than $3.3 million. The following table summarizes the PRFs constructed to date.

[2] 348 includes 161 BMP sites in Douglas County, not all of which were in Cherry Creek Basin.

| Table ES-1. Summary of Pollutant Reduction Facility Costs | | | | |
|---|---|---|---|---|
| Project | Category | Activity | Year | Cost |
| Completed PRFs: | | | | |
| Shop Creek | Detention with Wetlands | Design & Construction | 1991 | $668,286 |
| Cottonwood Wetlands | Detention with Wetlands | Design & Construction | 1996 | $342,978 |
| Quincy Drainage | Detention with Infiltration | Design & Construction | 1995 | $218,672 |
| East Shade Shelter | Shoreline Stabilization | Design & Construction | 1996 | $125,754 |
| East Boat Ramp | Shoreline Stabilization | Design & Construction | 1996 | $120,000 |
| East Shoreline Extension | Shoreline Stabilization | Design & Construction | 1999 | $69,000 |
| Tower Loop | Shoreline Stabilization | Design & Construction | 1999 | $142,000 |
| Dixon Grove | Shoreline Stabilization | Design & Construction | 1999 | $27,600 |
| Cottonwood/Peoria Pond | Detention with Wetlands | Design & Construction | 2001 | $100,000 |
| Piney Creek-Parker to Buckley | Stream Reclamation | Cost-share with Arapahoe | 2001 | $118,000 |
| Bowtie Property Acquisition | Stream Corridor Preservation | Property Purchase | 2003 | $300,000 |
| Cottonwood Creek Reclamation | Stream Reclamation | Design & Construction | 2004 (Phase I)<br>2008 (Phase II) | $2,405,000 |
| Cherry Creek Sediment Pond At Arapahoe Road | Stream Sediment Control | Preliminary Investigation | 2005 | $70,000 |
| Reservoir Destratification | Mixing to Control Algae Species | Design & Construction | 2008 | $968,100 |
| Cottonwood Creek at Easter Ave. | Stream Reclamation | Cost-share w/ SEMSWA | 2011 | $338,000 |
| Subtotal | | | | $6,013,000 |
| PRFs in Progress:<br>(committed funds) | | | | |
| Cherry Creek at Shop Creek Trail | Stream Stabilization | Preliminary Investigation | 2010 | $39,000 |
| West Boat Ramp Parking Lot | Recreation WQ Mitigation | Preliminary Investigation | 2011 | $32,000 |
| Mountain & Lake Loop | Shoreline Stabilization | Final Design | 2011 | $130,000 |
| Cherry Creek Reclamation-Eco Park | Stream Reclamation | Cost-share w/ SEMSWA | 2011 | $955,000 |
| Cherry Creek Reclamation-PJCOS | Stream Reclamation | Cost-share w/ PJMD | 2011 | $642,800 |
| McMurdo Gulch Reclamation | Stream Reclamation | Cost-share w/ Castle Rock | 2010 | $660,000 |
| Cherry Creek Reclamation-Arapahoe to Piney | Stream Reclamation | Cost-share w/ SEMSWA | 2011* | $25,000 |
| Cherry Creek at Hess Road | Stream Reclamation | Cost-share w/ UDFCD | 2011* | $20,000 |
| Cherry Creek Reclamation-12-Mile House Phase I | Stream Reclamation | Design & Construction | 2011* | $454,000 |
| Cottonwood Wetlands | PRF Restoration | Design & Construction | 2011* | $359,400 |
| Tower Loop | PRF Restoration | Design & Construction | 2011* | $48,600 |
| Subtotal | | | | $3,366,000 |
| Total | (Note: Costs do not include routine maintenance costs.) | | | $9,379,000 |

*year funds committed

# Riparian and Wetlands Protection

Since 2001, the Authority has stressed stream reclamation as the preferred approach to channel and stream stabilization. Channel or stream reclamation typically includes riparian and floodplain vegetation planting or enhancements and a channel cross section that results in more frequent connection and flooding of the overbank area. Riparian vegetation promotes filtration of fine particles with attached nutrients, and overbank flooding promotes additional filtration and to some extent infiltration, which both reduce nutrient loads and concentrations.

As part of its ongoing efforts to evaluate the effectiveness of its control strategies, the Authority undertook an investigation to address the following questions:

- Is stream reclamation beneficial to water quality, and if so, why?
- Is stream reclamation used by others to improve water quality, and what is their experience?
- Is stream reclamation a cost effective way to improve water quality in the reservoir and creek?
- What additional information is needed to further document water quality benefits of stream reclamation?
- How does stream reclamation fit into future PRFs and other watershed management techniques?

The Authority's Stream Reclamation Water Quality Benefit Evaluation Interim Status Report, finalized in 2011, investigated the costs and benefits of stream reclamation and stablization in the watershed relating to water quality. It concluded that stream reclamation is beneficial to water quality in the stream and the reservoir. Stream reclamation reduces sediment and other pollutant loads and concentrations, including phosphorus and nitrogen. Load and concentration reductions during base and storm flow conditions occur by reducing flow velocities, providing greater areas for filtration and infiltration of stormwater, and, to some extent, through increases in dissolved oxygen. This finding is further supported by the Authority water quality data.

In 2011, the extensive improvements made in Cottonwood Creek continued to show that low phosphorus concentrations can be achieved through stream reclamation and other PRFs combined in series. Stream reclamation has been found to be successful in reducing sediment and other pollutant loads and concentrations.

# Public Education

The Cherry Creek Stewardship Partners (Partners) handle a great deal of the Authority's responsibility for public education. In November of 2011, the Partners held their Annual Conference during which they again distributed a written questionnaire regarding specific water quality and general watershed concerns to public participants. Results of this questionnaire are detailed in Section 6 of this report. When given options for ranking the biggest water quality concerns in the Cherry Creek Basin, the following were listed in order from most important to least:

- A healthy vegetation corridor along Cherry Creek and its tributaries,
- Stream channel erosion along Cherry Creek and its tributaries,
- Nutrients in the reservoir, and
- Water clarity in the reservoir.

Highlights in 2011 of the Authority's public information and education efforts include:

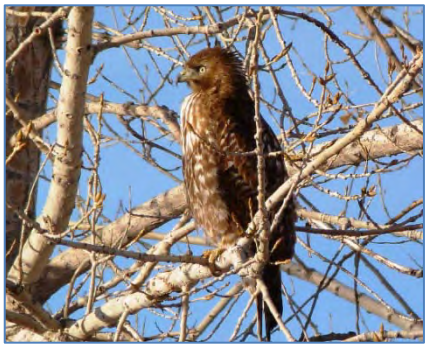
- The Authority continued to support the Partners and coordinate with other entities to implement the Education Initiative, a comprehensive and coordinated education strategy and action plan;
- The TAC worked with the Partners in determining the appropriate BMPs and measuring goals for public education and outreach.,
- The Authority continued the use of its website in cooperation with the Partners to facilitate the dissemination of information to parties interested in Authority activities;
- The Authority collaborated on information and education efforts with other entities with common interests and goals for the watershed; and
- The Partners facilitated broad community involvement and benefited long-term environmental stewardship from a large variety of outreach efforts.

# Conclusions

Regulation 72 requires that the annual report provide information on the effectiveness of point source controls, as well as demonstrate that implementation of nonpoint source controls and regulated stromwater controls is reducing phosphorus concentrations into the reservoir to the maximum extend practicable.

All wastewater treatment plants were in compliance in 2011 with their required phosphorus limits in 2011. When the State's general permit for water treatment plant discharges is renewed, phosphorus limits should be incorporated per the recent Regulation 72 requirements.

MS4s in the basin continue to implement aggressive stormwater quality programs. In 2011, the Stormwater Permit Requirements document was updated and finalized.



The Authority has to date invested nearly $10,000,000 in Pollutant Reduction Facilities, or PRFs. Several PRFs, as well as stringent local stormwater requirements and voluntary initiatives, have been implemented in the Cottonwood Creek watershed in the past several years. These efforts, coupled with wastewater treatment facility improvements, have resulted in significant decreases in phosphorus concentrations, to levels below 0.100 mg/l. This is well below the Authority's goal of 0.200 mg/l to achieve the chlorophyll α standard. A similar, but more pronounced downward trend in phosphorus concentrations has been observed for storm flow conditions. These data show that concentrations can be reduced, even as urbanization occurs. A key factor is the reclamation of unstable streams. This success has provided the Authority with the confidence to implement similar control measures on a larger scale within Cherry Creek itself, which has a much larger watershed.

In addition, the Authority is focused on controlling nuisance type algae to more desirable levels and promoting the more beneficial algae groups that play an important role in maintaining beneficial uses. The Authority has targeted one nuisance algal group called cyanobacteria or "blue-green algae" which can be toxic to aquatic life, often making them a less desirable food source for zooplankton and fish. Blue-green algae are also known to cause rashes on swimmers who come in contact during nuisance level algae blooms.

While the data shows that water quality has been relatively unaffected by urbanization, the Authority and State Park also deals with anecdotal evidence, the most telling of which is that when comparing 2010 and 1994 visitor counts at Cherry Creek State Park, there has been a 29% increase in park visitation. A more significant trend in Park use is that Cherry Creek State Park has routinely reached capacity during peak-use periods, suggesting that beneficial uses for Cherry Creek are being met. In addition, this past year's walleye egg harvest was the largest on record, according to CPW, providing further anecdotal evidence that uses are being met.

The water quality monitoring program was also reviewed in 2011, with recommended modifications to obtain needed data to further the Authority's efforts.

# 1 THE AUTHORITY

**Authority Mission Statement**
"Protect beneficial uses by preserving, enhancing, and balancing water quality in Cherry Creek Reservoir and Cherry Creek."

The Cherry Creek Basin Water Quality Authority (Authority) was formally created in 1988 by the Colorado Legislature. The Authority was created as a quasi-municipal corporation and political subdivision of the state, and was provided with certain specific authorities. The Authority is tasked with improving, protecting, and preserving the water quality of Cherry Creek and Cherry Creek Reservoir and achieving and maintaining state water quality standards for the reservoir and watershed.

The Legislature found that the Authority will, among other things, benefit the inhabitants and landowners within the basin by preserving water quality in both Cherry Creek and Cherry Creek Reservoir and benefit the people of the state of Colorado by preserving waters for recreation, fisheries, water supplies, and other beneficial uses. The Authority has developed water quality management strategies to minimize point, nonpoint, and regulated stormwater pollutant sources by implementing specific programs and monitoring water quality to evaluate progress. Together, these strategies create an effective water quality management approach.

## General Statutory Powers of Authority* (C.R.S. 25-8.5-111)

- **Develop and implement, with such revisions as become necessary in light of changing conditions, plans for water quality controls for the reservoir, applicable drainage basin, waters, and watershed, to achieve and maintain the water quality standards.**
- **Conduct pilot studies and other studies that may be appropriate for the development of potential water quality control solutions.**
- **Develop and implement programs to provide credits, incentives, and rewards within the Cherry Creek basin plan for water quality control projects.**
- **Recommend the maximum loads of pollutants allowable to maintain the water quality standards.**
- **Recommend erosion control and urban runoff control standards and conduct educational programs regarding such controls in the basin.**
- **Recommend septic system maintenance programs.**
- **Acquire, lease, rent, manage, operate, construct, and maintain water quality control facilities or improvements for drainage, nonpoint sources, or runoff within or without the Authority boundaries.**

* Not including administrative and financial powers

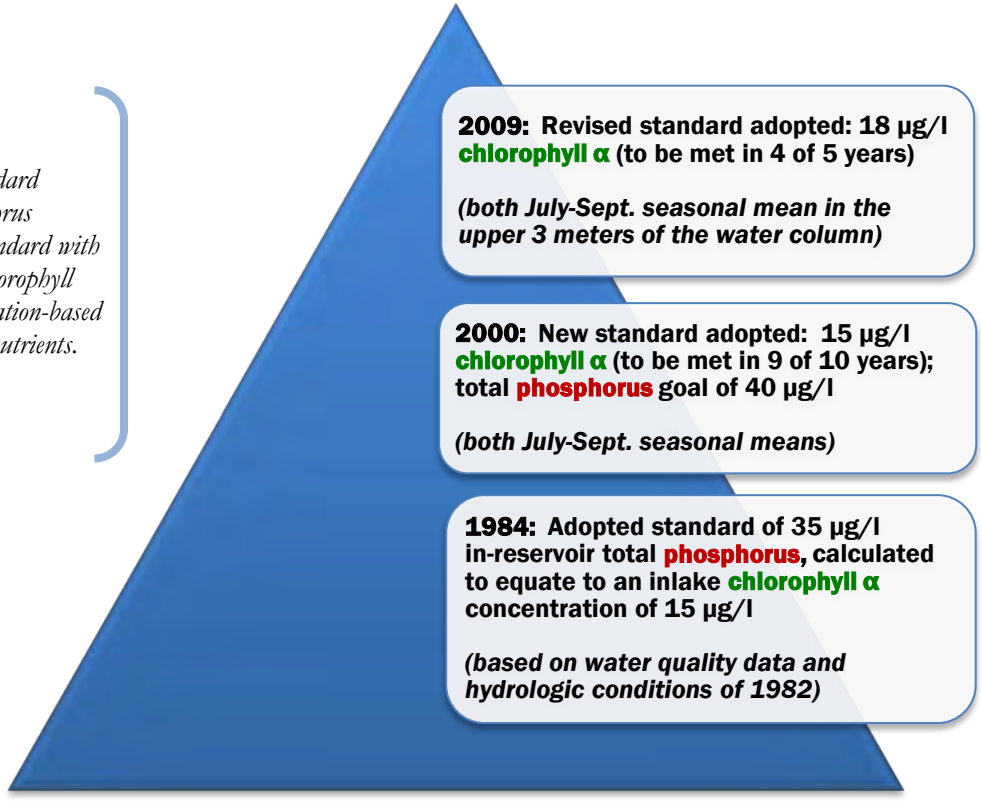
## 1.1 History

In 1982, a Clean Lakes Study of Cherry Creek Reservoir identified phosphorus as the major nutrient causing algal productivity, potentially leading to eutrophication with potential negative impacts to beneficial uses of the reservoir. The Colorado Water Quality Control Commission (Commission) first adopted a water quality standard for the reservoir in 1984. The following year, the Commission adopted a control regulation for the reservoir, to provide a mechanism for protecting the quality of Cherry Creek Reservoir, given modeling based upon 1982 hydrologic conditions. The Total Maximum Annual Load (TMAL) of phosphorus that could enter the reservoir and still maintain the phosphorus standard was calculated. This phosphorus load was calculated to equate to an inlake chlorophyll α concentration of 15 µg/l.

In 2000, the Commission adopted a new standard for the protection of Cherry Creek Reservoir. The new standard, a maximum growing season average of 15 µg/l of chlorophyll α, was determined to be protective of the uses of the reservoir along with a phosphorus goal of 40 mg/l. . An amended control regulation to meet the new water quality standard and protect the designated uses was adopted the following year, based on a phased TMAL approach. The phased TMAL required adoption of both point and nonpoint source requirements to provide protection for the reservoir, leading to the investigation of additional studies to identify contributing problems to the reservoir quality.

Based on recommendations by the Authority, the Commission adopted a revised water quality standard and control regulation in 2009. A seasonal mean chlorophyll α standard of 18 µg/l was established. Compliance is measured in the upper 3 meters of the water column for the months of July through September, with an exceedance frequency of once every 5 years. Changes to Regulation 72 that were effective in 2010 included establishment of concentration-based nutrient management approach, removal of all TMAL-related components, establishment of discharge effluent limit of 0.20 mg/l total phosphorus for drinking water treatment plant discharges, and establishment of a 3-tiered stormwater system for development and redevelopment.

*The water quality standard evolved from a phosphorus standard, to a chlorophyll standard with a phosphorus goal, to a chlorophyll standard linked to a concentration-based management approach for nutrients.*



## 1.2 Today's Authority

The C.R. 25-8.5-105 Statute defines the Authority membership. There are currently 18 members on the Authority: two counties, eight municipalities, one member representing all special districts, and seven Governor-appointees. These seven appointees are to represent sports persons, recreational users, and concerned citizens. At least two shall be from sporting or recreational organizations that have members who use the reservoir. At least two shall be from citizens or environmental organizations who have members that reside in the basin who are interested in preserving water quality. At least three must have professional backgrounds in water quality issues.

**Table 1-1. Authority Members**

| Entity Type | Number of Representatives |
|---|---|
| County<br>(Arapahoe, Douglas) | 2 |
| Municipality<br>(Aurora, City of Castle Pines, Castle Rock, Centennial, Foxfield, Greenwood Village, Lone Tree, Parker) | 8 |
| Special Districts (represents all water and wastewater service district providers) | 1 |
| Appointed by the Governor | 7 |
| Total members of Authority Board | 18 |

The Authority consists of a Board of Directors (Board) and a Technical Advisory Committee (TAC). According to the statute, each Authority member shall appoint a representative (and alternates) to serve on the Board.

According to the bylaws, the county, municipal, and special district members may each appoint one non-elected member to serve on the TAC. The Board can also, from time to time, appoint individuals to the TAC who represent educational or public interest groups having an interest in stormwater drainage and water quality within the basin. The Board can also appoint individuals who represent local governments that are not members of the Authority but have an interest in stormwater drainage and water quality within the Cherry Creek basin. The role of the TAC is to consider and report to the Board on matters of a scientific or technical nature, as directed by the Board. Such duties may include (but are not limited to) the following: assistance with technical and scientific matters, development and submission of referral comments, review and provision of comments/recommendations on 401 and 404 permit applications, and review and provision of comments/recommendations on local government decisions including rezoning, subdivisions, special projects, new rules and regulations, etc. The current makeup of the TAC is shown below.

**Table 1-2. Authority TAC Members**

| Entity Type | Number of Members |
|---|---|
| County<br>(Arapahoe, Douglas) | 2 |
| Municipality<br>(Aurora, City of Castle Pines, Castle Rock, Centennial, Foxfield, Greenwood Village, Lone Tree, Parker) | 8 |
| Special Districts | 1 |
| Board-appointed (TAC Chair, SEMSWA, Cherry Creek Stewardship Partners, Corps of Engineers, State Parks, Tri-County Health, UDFCD) | 8 |
| Total Members of TAC | 19 |

## 1.3 Financial Matters

The Authority receives funding for its activities primarily from property taxes, Cherry Creek State Park user fees, wastewater surcharges, and building permit fees. The 2011 budget, for example, included about $1.4 million in property taxes, $155,000 in user fees, $60,000 in building permit fees, and $150,000 in wastewater surcharges. These primary sources are supplemented with funds from various grants, other fees and charges, and miscellaneous sources, such as reimbursed expenses and interest earnings.

The Authority's budget for the 2011 calendar year included about $1.9 million total in new revenue (with approximately $6.0 million available from all funds including the fund balance) and approximately $3.4 million in expenditures (the Authority spent funds from its reserves). Expenditures and revenues are often not matched each calendar year because implementation and timing of project costs for the capital improvement program can vary significantly from year to year. Colorado State Statute 25-8.5-111(3) mandates that the Authority must spend at least 60 percent of the annual authorized revenues on the construction and maintenance of PRFs. The remaining 40 percent is allocated towards monitoring, special studies, planning documents, technical reports or memoranda, and administrative costs.

## 1.4 Reference Documents

In 2011, the Authority created or updated several documents that serve as references for the status of water quality in Cherry Creek Reservoir, guidelines and educational material on water quality best management practices (BMPs), technical sources on various aspects of water quality, and watershed planning and management strategies. These are listed in Table 1-3.

**Table 1-3. New and Updated Reference Documents**

| |
|---|
| 2011 Revisions to Authority's Stormwater Permit Requirements Guidance Document.<br>(Detailed guidance used to implement Section 72.7 of Control Regulation for stormwater permitting requirements) |
| 2011 Stream Reclamation, Water Quality Benefit Evaluation – Interim Status Report<br>(Description of need, investigations, considerations, and conclusions for pursuing stream reclamation PRFs in Cherry Creek Basin). |
| 2011 Annual Report of Activities by the Cherry Creek Basin Water Quality Authority<br>(Update submitted to Water Quality Control Commission on activities completed by the Authority in 2011) |
| 2011 Annual Inspection of Pollutant Reduction Facilities<br>(Inspection of PRFs constructed by the Authority at Cherry Creek State Park to assess whether PRFs are functioning as designed and to identify routine, restorative, and rehabilitative maintenance requirements) |
| 2011 - 2015 Five-Year Capital Improvement Projects Plan<br>(Summary of potential pollutant reduction facilities) |
| Monthly CIP Status Reports to Board<br>(Summary of 2011 progress on capital improvement projects - updated twice each month) |
| DRAFT Cherry Creek Reservoir 2011 Water Year Aquatic Biological Nutrient Monitoring Study and Cottonwood Creek Pollutant Reduction Facilities Monitoring<br>(Characterization of potential relationships between nutrient loading and reservoir productivity) |

# 2 DESCRIPTION OF CHERRY CREEK RESERVOIR WATERSHED

The Cherry Creek watershed is one of the most dominant geographical and cultural features of the Denver Metropolitan area. The creek connects communities in Denver, Arapahoe, and Douglas counties. For centuries this connection was used by Native Americans, trappers, traders, and adventurers. Today some of this history is preserved in two historic stage stops along the trail which generally follows Parker Road; one the 17-Mile House in Arapahoe County and the other the 4-Mile House in Denver. The area supported the first lumber industry and the initial purebred cattle industry within the state.

The watershed was also important agriculturally from the late 1800s through the 1930s, due to rich soil and flat land. There were numerous dairy farms, truck farms, orchards, and potato fields from Franktown to downtown Denver. Water was supplied from Castlewood Reservoir, built in 1890. Originally the plan was to provide water to irrigate about 30,000 acres of farmland downstream.


*Early Agricultural Operations in Cherry Creek Valley*

*1864 Cherry Creek Flood in Denver*

Though early settlers in the region were warned of the potential for flooding along Cherry Creek, early Denver grew along its banks and was subsequently flooded several times. One of the first recorded large floods in the basin occurred in May 1864. This flood originated in the upper end of the Cherry Creek and Plum Creek watersheds and killed 19 people.

*1933 Castlewood Flood Waters*

*Castlewood Dam Today*

On August 3, 1933, the Castlewood Dam burst after several days of torrential rain. This released a wall of water into Cherry Creek, as high as 20 feet in spots, eventually reaching Denver. Remains of Castlewood Dam can be still be seen at Castlewood Canyon State Park. The Castlewood flood was the impetus for building the Cherry Creek Dam and Reservoir. Cherry Creek dam was built in 1950 to protect downstream areas from catastrophic floods that had plagued the area for more than 100 years. During the 1965 Denver flood, all flow upstream from Cherry Creek was stored in Cherry Creek Reservoir, helping mitigate the flood.

Originally built for flood control, Cherry Creek Reservoir is owned and operated by the U.S. Army Corps of Engineers (COE). The reservoir, with a surface area of approximately 852 acres, and surrounding land (3,346 acres) were leased to the State of Colorado for use as the Cherry Creek State Recreation Area in 1959. The park almost immediately experienced extensive recreational use, a pattern that has continued to the present day. Recently reported figures show the park had 1.44 million visitors in 2008. The reservoir and surrounding state park serve as an important urban recreational site, providing opportunities for a variety of activities including sport fishing, boating, swimming, bicycling, bird watching, horseback riding, and hiking. Additionally, the state park provides important wildlife habitat including grasslands, wetlands, forests, meadows, and ponds.

Cherry Creek Reservoir was designed for flood control management and evolved into a terminal water storage facility, intended to hold runoff water that would then be discharged to maintain an acceptable downstream flow and a predetermined lake level. The reservoir, combined with subsurface flows from below the dam, has maintained Cherry Creek downstream of the reservoir in a free-flowing condition. The water in the reservoir undergoes chemical changes from the influences of inflows, sediments, sunlight, temperature, and wind; all of which influence algal growth.

The Cherry Creek Reservoir watershed includes approximately 245,500 acres and several tributary watersheds (Figure ES-1, Executive Summary). The northern portion of the watershed has been urbanizing over the past several decades, especially in the sub-watersheds immediately adjacent to the reservoir. Developed land uses include high-to-moderate density suburban residential areas, large lot subdivisions, commercial and light industrial parks, and office buildings. Traditional agricultural and agribusiness uses are still present, but are mostly in the southern upstream half of the watershed. The designated uses of the reservoir include warm water class 1 aquatic life, existing primary contact recreation, water supply, and agriculture.

# 3 POINT SOURCE CONTROLS

Wastewater treatment facilities (WWTFs) in the basin provide phosphorus removal by using advanced wastewater treatment followed by land application or direct discharge. Several facilities within the Cherry Creek Reservoir watershed provide centralized wastewater treatment service. One point source discharger (Plum Creek Wastewater Authority) is located outside the watershed but applies some of its treated effluent as irrigation water within the watershed.

Wastewater and industrial process wastewater sources are limited in the amounts of phosphorus they can discharge to the Cherry Creek Reservoir watershed. Regulation 72 places the emphasis on phosphorus concentration-based limits for point source dischargers. Under the previous regulation, dischargers also had a maximum annual poundage limit for phosphorus; however, the new regulation removed all references to TMAL components. Permits were reissued for Pinery, Parker, and Stonegate in 2011, and the annual phosphorus poundage limits were removed. It is anticipated that this will also occur when Meridian's and Plum Creek's permits are also reissued. Expiration dates for all wastewater treatment facilities' permits are shown in Table 3-1 below. Note that if a permit is past its expiration date, this usually means that the State has not yet issued a new permit. In these situations, the permit is normally administratively extended and kept in effect until the new permit is issued. Locations of these wastewater treatment facilities can be seen in Figure 3-1.

**Table 3-1. Cherry Creek Watershed Wastewater Dischargers and Permit Expiration Dates**

| Permittee | Permit Number | Expiration Date | Comments | Does Permit Still Contain Pound Limits? |
|---|---|---|---|---|
| Arapahoe County Water & Wastewater Authority | CO0040681 | 12/31/2010 | Administratively extended | Yes |
| Pinery Water & Sanitation District | CO0041092 | 10/31/2016 | Active | Yes |
| Parker Water & Sanitation District | CO0046507 | 01/31/2017 | Active | Yes |
| Meridian Water & Sanitation District | CO0039110 | 6/30/2001 | Administratively extended | Yes |
| Stonegate Village Metro District | CO0040291 | 10/31/2016 | Active | Yes |
| Plum Creek Wastewater Authority | CO0038547 | 9/30/2008 | Administratively extended | Yes |

Note: Data obtained from EPA's ECHO (Enforcement & Compliance History Online) Detailed Facility Reports, 1/24/11 Search and 12/29/2011 Search (EPA)

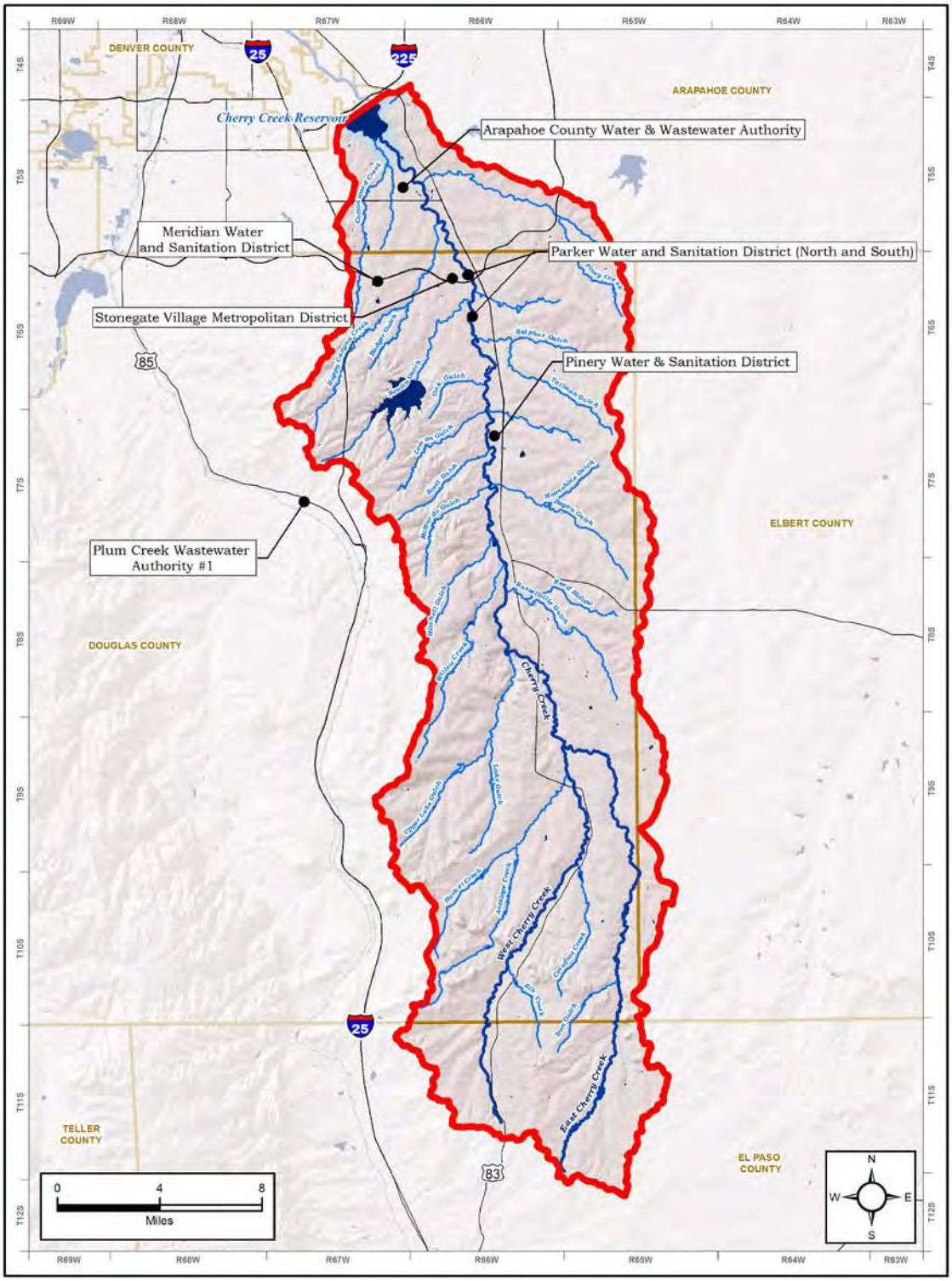



Figure 3-1. Wastewater Treatment Plant Locations

## 3.1 Phosphorus Concentrations

Under Regulation 72, discharge limits are:

- For wastewater facilities and industrial process wastewater sources with direct discharges: ≤ 0.05 mg/l total phosphorus as a 30-day average, unless a 90-day average is approved by the Division at the request of the discharger;
- For drinking water treatment facilities: ≤ 0.2 mg/l total phosphorus concentration as a 30-day average, unless a 90-day average is approved by the Division at the request of the discharger;
- For dischargers using land application and relying on a return flow factor: 30-day flow-weighted average phosphorus concentration ≤ 0.05 mg/l total phosphorus divided by the land application return flow factor; and
- For dischargers using land application and relying on lysimeters: ≤ 1.0 mg/l total phosphorus concentration as a 30-day flow-weighted average in effluent being applied to the land, unless a 90-day averaging period is approved by the Division at the request of the discharger.

Current Colorado Discharge Permit System (CDPS) permits require all WWTFs to monitor for phosphorus. Table 3-2 presents the concentration-based limits and the 30-day and maximum reported concentrations from October 2010 through September 2011 for the wastewater dischargers.

**Table 3-2. Cherry Creek Watershed Wastewater Permit Limit Data 2011**

| Facility | 30-day Avg. Phosphorus Limit (mg/l) | Maximum Reported 30-day Avg. Concentration (mg/l) | Phosphorus Permit Limit Violation? (yes/no) |
|---|---|---|---|
| Arapahoe County Water & Wastewater Authority/Cottonwood Water & San Dist. | 0.05 | 0.048 | no |
| Pinery Water and Sanitation District | 0.05 | 0.0365 | no |
| Parker Water & Sanitation District | 0.05 (Outfall 001A) | 0.040 (001A) | no |
| | 0.33 (Outfall 001B) [3] | No discharge (001B) | no |
| Meridian Water & Sanitation District | 1.02 [1] | 0 [2] | no |
| Stonegate Village Metropolitan District | 0.25 (Outfall 001A) [3] | 0.02 (001A) | no |
| | 0.05 (Outfall 002A) | 0.010 (002A) | no |
| Plum Creek Wastewater Authority | 0.05 | 0.04 | no |

[1] Limit is lysimeter-based, calculated per Regulation 72
[2] Lysimeters reported as being "dry"
[3] Limit calculated based on land application factor, per Regulation 72

Compliance for discharges from water treatment plants (for which there is now a phosphorus limit of 0.2 mg/l under Regulation 72) was evaluated using Discharge Monitoring Reports requested from CDPHE for each of the facilities. All reported discharge concentrations are included in these reports, including phosphorus which is discussed herein. Thirty-day average phosphorus limits are presented in each discharge permit. Discharging water treatment plants can be covered under either an individual or a general permit. Colorado has a general permit, CO641000, which covers water treatment plants. This permit expired October 31, 2010. This permit does not include any phosphorus discharge limits for facilities in the Cherry Creek basin; monitoring and reporting only are required. As the permit is renewed, it should incorporate the new 30-day average total phosphorus limitation of 0.2 mg/l for water treatment plant dischargers in the

Cherry Creek basin. Numerous general permits have been issued in the past several years in the basin under the construction dewatering (COG070000), well development (COG603000), and sand and gravel process water/stormwater (COG500000) permits. All of these permits only contain phosphorus monitoring and reporting requirements for dischargers in the Cherry Creek Basin.

## 3.2 Monthly Phosphorus Concentrations

Table 3-3 summarizes the monthly phosphorus concentrations in the effluent for each wastewater treatment plant from their monthly Discharge Monitoring Reports. All dischargers were consistently below their phosphorus discharge limits in 2011 (Section 3.1). In addition, all of the discharges were well below the overall flow-weighted 0.200 mg/l phosphorus concentration goal supported by the Authority to help attain the standard.

**Table 3-3. Wastewater Treatment Plants' Monthly Phosphorus Concentrations 2011**

| | Parker Water & Sanitation District | | Pinery Water & Sanitation District | Stonegate Village Metropolitan District | | Plum Creek Wastewater Authority[1] | Meridian Water & Sanitation District[1] | Arapahoe County Water & Wastewater Authority |
|---|---|---|---|---|---|---|---|---|
| | 001A | 001B | | 001A | 002A | | | |
| (Limit➔) | (0.05) | (0.33) | (0.05) | (0.25) | (0.05) | (0.05) | (1.0) | (0.05) |
| Month | (monthly mg/l) | | (monthly mg/l) | (monthly mg/l) | | (monthly mg/l) | (monthly mg/l) | (monthly mg/l) |
| Oct. | 0.031 | 0.034 | NODIC[2] | 0.027 | nothing reported | 0.028 | 0.031 | 0.034 |
| Nov. | 0.026 | 0.025 | 0.01 | 0.024 | nothing reported | 0.023 | 0.026 | 0.025 |
| Dec. | 0.033 | 0.026 | 0.02 | 0.022 | nothing reported | 0.024 | 0.033 | 0.026 |
| Jan. | 0.028 | 0.036 | 0.01 | NODIC[2] | nothing reported | 0.027 | 0.028 | 0.036 |
| Feb. | 0.03 | 0.0365 | 0.02 | NODIC[2] | nothing reported | 0.026 | 0.03 | 0.0365 |
| March | 0.03 | 0.036 | 0.02 | 0.027 | nothing reported | 0.025 | 0.03 | 0.036 |
| April | 0.037 | 0.023 | 0.02 | 0.04 | nothing reported | 0.028 | 0.037 | 0.023 |
| May | 0.031 | 0.023 | 0.01 | 0.027 | nothing reported | 0.045 | 0.031 | 0.023 |
| June | 0.025 | 0.028 | 0.04 | 0.027 | nothing reported | 0.044 | 0.025 | 0.028 |
| July | 0.025 | 0.027 | 0.01 | 0.025 | nothing reported | 0.048 | 0.025 | 0.027 |
| Aug. | 0.021 | 0.028 | 0.01 | 0.026 | nothing reported | 0.031 | 0.021 | 0.028 |
| Sept. | Limtd-Ovrdu[3] | 0.022 | 0.02 | 0.027 | nothing reported | 0.037 | Limtd- Ovrdu[3] | 0.022 |

[1] The Plum Creek Wastewater Authority and Meridian discharges in the Cherry Creek Reservoir watershed are through reuse irrigation.
[2] NODIC represents "No Discharge".
[3] Limtd-Overdu means the report has not been received yet.

## 3.3 Permit Compliance

Regulation 72 requires that the Annual Report identify wastewater facility permit violations with regard to phosphorus concentration limits. In 2011, no permits were in violation of set phosphorus concentration limits. For 2011, the six wastewater treatment facilities all were within the effluent limits included in their current or administratively extended permits.

## 3.4 Individual Sewage Disposal Systems

Individual Sewage Disposal Systems (ISDS) serve a number of residents within the Cherry Creek Basin, totaling around 6,600 total systems. The Tri-County Health Department (TCHD) serves Arapahoe and Douglas Counties in the Cherry Creek Basin and is responsible for the regulation of ISDS. TCHD has established standards, rules, and regulations for ISDS in Adams, Arapahoe, and Douglas Counties. The map to the right shows the locations of ISDS in the Authority's boundaries and was compiled from data supplied by TCHD.

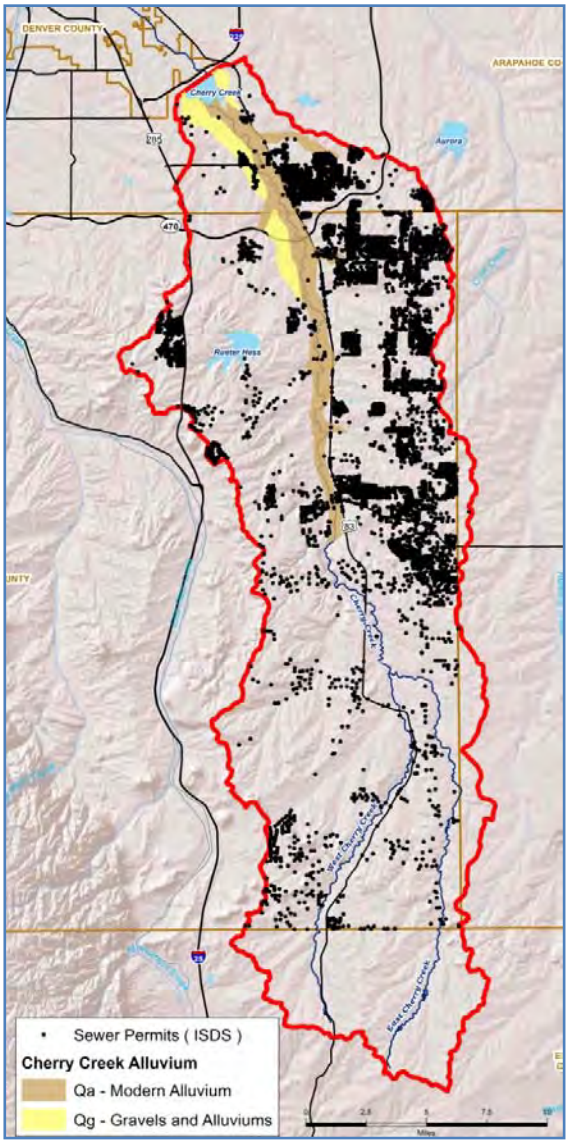



Figure 3-2. ISDS in Cherry Creek Basin.

Effective July 1, 2011, TCHD approved new requirements requiring a use permit for all ISDS users (Board of Health of Tri-County Health Department 2011). Historically, permits were only required to construct, repair, or expand an ISDS. The new requirements add a "minor repair permit", allowing for a significantly reduced cost to replace a septic tank compared with the previously required major repair permit for the same replacement. The introduction of this minor repair permit provides incentive to replace a septic tank based on the reduced cost. The focus is not minor repairs; the focus is on the inspection of ISDS upon the sale of the property. Any deficiencies found must be corrected prior to the use permit being granted.

## 3.5 Approved Site Applications

As the designated regional water quality management agency for the Cherry Creek Reservoir watershed, the Authority reviews applications for site location approval for domestic wastewater treatment works. Reviews of site location approval address protection of Cherry Creek Reservoir and the watershed with respect to phosphorus, general water quality, protection of downstream water supplies, and adequacy of proposed design processes and capacity to protect water quality. As required by Regulation 72, the Authority must report on approved site applications annually.

Applications for site location approval are reviewed in conformance with the following documents:

- Cherry Creek Reservoir Regulation 72;
- Emergency Response Plan Criteria for the Cherry Creek Reservoir Watershed (Authority, March 2002);
- Regulation 22, "Site Location and Design Approval Regulations for Domestic Wastewater Treatment Works" (Commission, September 2009);
- Metro Vision Clean Water Plan: "Wastewater Utility Plan Guidance" (Denver Regional Council of Governments (DRCOG), January 2003)
- "Lift Station Report Guidance and Checklist" (DRCOG, October 2000); and
- Policy 96-1, "Design Criteria Considered in the Review of Wastewater Treatment Facilities" (Commission, expiration date May 31, 2008).

In 2011, no applications for new site location approvals were received.

In 2011, the Authority also prepared an inventory of lift stations within the basin. There are about 50 active lift stations in the basin. CDPHE's records contained Site Application files for 27 of them. Twenty-five of the 27 lift stations with CDPHE files were constructed (or upgraded) after Regulation 72 was adopted in November 1985. Based on conversations with the owners or others with knowledge of the facilities, an additional six facilities are known to have been constructed (or upgraded) after Regulation 72's adoption. Nine of the 27 lift stations with CDPHE files were constructed (or upgraded) after the implementation of the Authority's Emergency Response Plan Criteria in March 2002. Again, based on converstations with the owners or others with knowledge, an additional five facilities are known to have been constructed (or upgraded) after Regulation 72's adoption. It is anticipated that further followup regarding the potential impact of lift stations will occur in 2012.

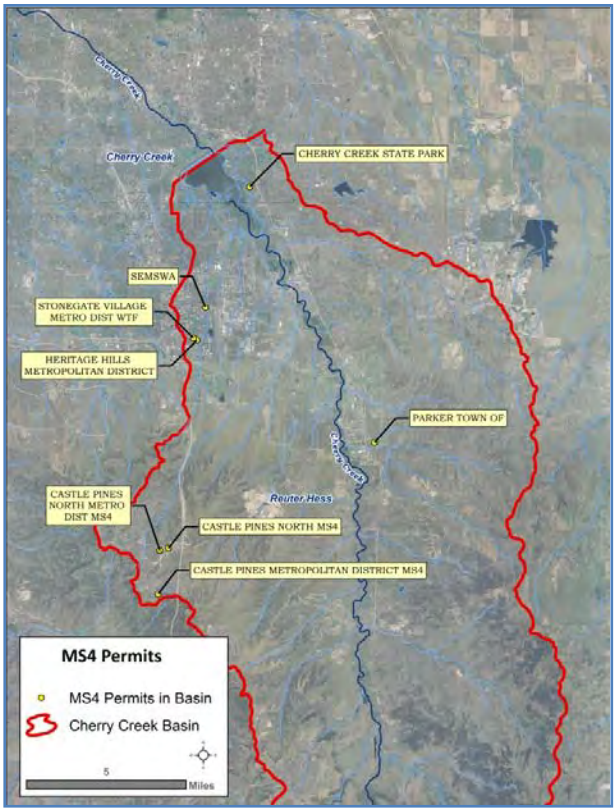
## 3.6 Effectiveness in Reducing Nutrient Concentrations

The control requirements placed on the point source dischargers described above appear to have been effective in reducing or controlling phosphorus concentrations to the watershed and reservoir. All wastewater treatment plants met their phosphorus discharge limits, which are designed to help meet the reservoir standard and the goals of the Regulation 72 control program.

It is also noted that the required effluent limits for total phosphorus concentrations discharging from wastewater facilities and industrial process wastewater sources (i.e., for most dischargers, less than 0.05 mg/l total phosphorus concentration as a 30-day average) are significantly less than the flow-weighted total phosphorus concentrations currently entering the reservoir. For 2011, the flow-weighted influent concentration was 0.212 mg/l. Actual concentrations discharged by wastewater treatment plants were consistently below the 0.05 mg/l limits and well below the 0.200 mg/l flow-weighted phosphorus concentration goal.

# 4 REGULATED STORMWATER SOURCE CONTROLS

Regulated stormwater is stormwater runoff that discharges to state waters (including the reservoir, streams, and groundwater) from regulated entities, which include commercial and industrial facilities, and from municipal separate storm sewer systems (MS4s). MS4s are essentially storm sewer systems that are owned or operated by a state, city, town, county, district, or association having jurisdiction over the management of stormwater.




Regulated stormwater sources are subject to the Colorado Discharge Permit System Regulations (Regulation 61). Larger sources were originally regulated under the EPA's Stormwater Phase I Rule (1990), which covered entities with populations over 100,000 and other significant dischargers. The City of Aurora and Colorado Department of Transportation (CDOT) were the only Cherry Creek Basin entities that were included under Phase I. In 1999, the Stormwater Phase II Rule expanded the Phase I Rule to include several of the land use agencies that are part of the Authority. The Phase II Rule requires small MS4s to, at a minimum, adopt BMPs for six minimum control measures, implement them to the maximum extent practicable (MEP), identify measurable goals for control measures, show an implementation schedule of activities or frequency of activities, and define the entity responsible for implementation. These requirements fit closely with the current programs in the Cherry Creek watershed as required by Regulation 72. The six minimum requirements are:

- Public education and outreach
- Public involvement/participation
- Illicit connections and discharge detection and elimination
- Construction site stormwater runoff control
- Post-construction stormwater management in development/redevelopment
- Pollution prevention/good housekeeping for municipal operations

Phase II MS4s in the Cherry Creek Basin may apply for coverage under General Permit COR080000, "Stormwater Discharges Associated with Cherry Creek Reservoir Drainage Basin Municipal Separate Storm Sewer Systems (MS4s)". This permit incorporates relevant requirements of Regulation 72. More detailed

information on implementation for each small MS4 permittee can be found in the Stormwater Annual Reports that small MS4s are required to submit to the Division by March 10 of every year. Small MS4 permittees must conduct an annual review of their stormwater programs including an assessment of compliance with measurable goals for each of the six program areas, the results of any monitoring, and plans for stormwater activities in the next year. In addition, there was a one-time required inventory due on March 10, 2010 (for renewal permittees), of the written procedures used for the pollution prevention/good housekeeping for municipal operations programs program element.

Regulation 72 also spells out several requirements that are to be applied to regulated stormwater discharges. These include stringent watershed-specific requirements for MS4 permits, including public education and outreach efforts that target nutrient sources, detailed construction site controls, and tiered post-construction stormwater management requirements for new development and redeveloped areas, with special requirements for stream preservation areas (§72.7).

## 4.1 Sediment and Erosion Control Permits

Regulation 72 requires that an Erosion and Sediment Control Plan must be submitted to and approved by the local MS4 entity. All land use agencies require that an erosion and sediment control permit and/or plan be submitted and approved prior to the start of any new land-disturbance activity. Land-disturbance activities include clearing, grading, or excavation of land; construction, expansion, or alteration of a residential, commercial, or industrial site or development; and construction of public improvements and facilities (e.g., roads, airports, and schools). Erosion and sediment control requirements during construction for each agency under the stormwater Phase I and II requirements are complementary to the programs required under Regulation 72.

## 4.2 Construction BMPs

In 2011, the Authority adopted revisions to its requirements related to construction activities in the Cherry Creek Reservoir watershed entitled "Stormwater Permit Requirements Guidance Document". These requirements recommend implementation of substantive BMP measures to control the quality of stormwater runoff from land disturbances on private and public property. In addition, the requirements establish the minimum construction and post-construction BMPs in the reservoir watershed for all new development activities. All the land use agencies also maintain design standards for construction BMPs to limit the amount of sediment that enters the watershed during the construction of projects within the basin.

The numbers of construction sites covered by the different entities' construction site runoff control programs in 2011 are summarized in Table 4-1 below. Inspection and enforcement actions for both construction sites and post-construction permanent BMPs are also included in Table 4-1, as well as the number of inspection and enforcement actions conducted in 2011 by the MS4s for construction sites.

## 4.3 Post-Construction BMPs

The Cherry Creek Reservoir Watershed Stormwater Quality Requirements described above also include requirements for post-construction control of stormwater quality. All regulated new development and redevelopment projects must submit a post-construction BMP plan to the MS4 for review and approval prior to commencing land-disturbance activities. Each of the land use agencies maintains design standards for permanent BMPs that remove pollutants from stormwater runoff prior to the runoff being released into the watershed. Plans for permanent BMPs are reviewed and must be approved by the local land use agency prior to the start of construction on a project. The Authority also has adopted the following three-tiered approach to stormwater management for post-construction development and redevelopment in the watershed.

Table 4-1 below summarizes the number of water quality-control BMPs (or sites with permanent BMPs), number of inspections, and number of enforcement actions for post-construction activities.

**Table 4-1. Summary of Cherry Creek Reservoir Stormwater Permit, Inspection, and Enforcement Actions**

| Land Use Agency | Construction Sites | Construction BMPs | | Permanent BMPs | | |
|---|---|---|---|---|---|---|
| | Total Sites | Number of Inspections | Number of Enforcement Actions | Number of BMPs (or BMP Sites) Constructed | Number of Inspections | Number of Enforcement Actions |
| Arapahoe County | 81 | 778 | 3 [5] | 26 | 2 [8] | 0 |
| Douglas County | 111 | 1380 | 525 [2] | 161 [3] | 12 | 0 |
| City of Aurora | 26 | 144 | 2 | 1 | 4 | 0 |
| City of Centennial/SEMSWA | 83 | 799 | 8 [5], 5 [6] | 8 [7], 25 [8] | 107 [7], 5 [8] | 5 [6,7], 5 [8,9] |
| City of Greenwood Village | 1 | 6 | 0 | 6 | 6 | 0 |
| City of Lone Tree | 27 | 228 | 50 | 112 | 167 | 22 |
| City of Castle Pines | 8 | 23 | 10 | 2 | 6 | 0 |
| Town of Castle Rock | 416 | 2668 | 630 | 2 | 450 | 0 |
| Town of Parker | 42 [1] | 237 | 18 | 5 [4] | 274 [1] | 2 |
| CDOT | 5 | 13 | 0 | 0 | 1 | 0 |

[1] The numbers reported are for the calander year of 2011 instead of the water year 2011
[2] The number reported is the approximate number of all levels of violations
[3] The number reported indicates the number of BMPs accepted on plans for the entire County
[4] The Town of Parker had a total of 272 BMPs constructed
[5] The number of re-inspections
[6] The number of recommended holds for the Certificate of Occupancy
[7] The number prior to final acceptance or during the construction of the BMP
[8] The number after final acceptance or long term operations of the BMP
[9] The number of written notifications

### Development and Redevelopment Tiers:

**Tier 1:** Any land disturbance < 1 acre that is independently developed, and which results in < 500 square feet of imperviousness for new development or ≥ 500 square feet of increased imperviousness for redevelopment

**Tier 2:** Any land disturbance < 1 acre that is independently developed, and which results in > 500 square feet but < 5,000 square feet of imperviousness for new development or ≥ 500 square feet and < 5,000 square feet of increased imperviousness for redevelopment, including disturbances of existing impervious areas

**Tier 3:** Any land disturbance > 1 acre, or which results in < 5,000 square feet of imperviousness for new development or ≥ 500 square feet of increased imperviousness for redevelopment, including disturbances of existing impervious areas

## 4.4 Flood Control Facilities Retrofitting, Inspection, and Maintenance Actions

The Authortity supports the retrofitting of stormwater facilities in order to maintain and improve any potential water quality issues identified through monitoring and reporting of existing facilities. In 2011, the Arapahoe County Public Airport Authority was designing an upgrade to the detention ponds located at the end of their runways. It was identified that propylene glycol, an agent of deicers being used, was running off into the original detention ponds, which are tributary to Cottonwood Creek. Once made aware of this, the Authority became involved and has been working with the Airport Authority to retrofit the design to include nutrient controls to help with the water quality issues, specifically a potential reduction in dissolved oxygen at this location. At this point, the pond retrofit has become a PRF due to the involvement of the Authority. The Authority is contributing funds for construction of the project that includes combining two ponds into one pond, which meets current requirements for detention ponds with water quality enhancements.

## 4.5 Effectiveness in Reducing Phosphorus Concentrations

The Commission has previously concluded that point source, nonpoint source, and regulated stormwater controls for total phosphorus (including the permitted MS4 activities) are successfully reducing total phosphorus concentrations in stormwater and surface water flows to the reservoir. This is supported by ongoing monitoring being conducted both upstream and downstream of the PRFs, which effectively measures the cumulative benefits of BMP implementation in the upstream watershed. The data confirm that the BMPs and other controls placed on regulated stormwater continue to be effective. Watershed and reservoir modeling results have shown that, although population growth and surface flows have increased in the basin, the total phosphorus concentration in the inflow to the reservoir has remained relatively constant.

In addition to the controls required by Regulation 72 for regulated stormwater sources, the Authority also ensures implementation of effective BMPs through other activities. The Authority serves as a referral agency in the land use application process for several local land use agencies within the Cherry Creek Reservoir watershed. When a land use agency receives an application for land use or development, a copy is sent to the Authority for review. The Authority then has the opportunity to comment on the potential water quality impacts of the proposed application prior to construction and to determine whether the proposed project complies with Regulation 72 and Authority's requirements. Table 4-2 provides a review of the number of land use and development applications that the Authority has received annually since March 1997, and Table 4-3 provides a summary of 2011 referrals by land use agency. The number of land use referrals continues to be down when compared to a few years ago, consistent with the current economic downturn.

| Table 4-2. Land Use and Development Applications Reviewed by Authority 1997 - 2011 | |
|---|---|
| Year | # of Applications |
| March – December 1997 | 103 |
| 1998 | 179 |
| 1999 | 135 |
| 2000 | 190 |
| 2001 | 144 |
| 2002 | 126 |
| 2003 | 156 |
| 2004 | 176 |
| 2005 | 189 |
| 2006 | 177 |
| 2007 | 199 |
| 2008 | 183 |
| 2009 | 97 |
| 2010 | 54 |
| 2011 | 78 |
| Total | 2,108 |

| Table 4-3. Land Use and Development Application Referrals by Entity 2011 | |
|---|---|
| Referring Agency | # of Applications |
| Arapahoe County | 10 |
| Douglas County | 20 |
| City of Aurora | 3 |
| City of Centennial | 3 |
| City of Castle Pines | 1 |
| Greenwood Village | 0 |
| Town of Castle Rock | 5 |
| Town of Parker | 7 |
| Town of Foxfield | 0 |
| SEMSWA | 17 |
| Colorado Department of Transportation | 3 |
| Total | 78 |

The Authority's review of applications for land use changes in the Cherry Creek Reservoir watershed provides the following benefits:

- A better understanding of where and how development is occurring in the Cherry Creek Reservoir watershed. Currently, the bulk of development is occurring in the central reservoir watershed around the Douglas County, Town of Parker, City of Aurora, and City of Centennial in several tributaries that previously were undeveloped. This pattern points to the need to focus on preventing or minimizing erosion in the tributaries by stabilizing the tributary drainage ways simultaneously with, if not in advance of, development.
- A better understanding of how well developers are complying with Authority requirements and improved communication with the land use agency personnel. Currently, the Authority's review and comments are integral to the development process, and a negative response from the Authority has resulted in changes to the land use application.
- An opportunity for the Authority to work more closely with developers during the initial stages of land use planning to identify projects where water quality enhancements would be more appropriate.
- The opportunity to stress the importance of meeting minimum requirements for BMPs through negative referrals. These BMPs have resulted in implementation of better water quality plans, some of which have gone beyond minimum requirements.

The Authority updated and adopted a revised Stormwater Permit Requirements Guidance Document in 2011 to support the implementation of stormwater requirements found in the CR – 72.7. The most noteable changes to Section 72.7 were the tiered approach to post-construction BMPs based on impervious area and specific exclusions for specific activities such as rural road construction and maintenance, large lot single family development, and trail construction. However, before these activities could be excluded from the requirements of Section 72.7, local governments were required by the Commission to develop BMPs specific to these activities. Therefore, the CR – 72.7 Guidance Documents includes separate chapters describing the minimum post-construction BMPs for these activities. In addition, the CR – 72.7 Guidance Document also provides guidance to address stormwater quality of runoff from industrial and commercial activities that, in the opinion of local government, may result in an illicit discharge. A separate chapter is included in the

document addressing minimum BMPs for these activities. Additional information was included related to highway and roadway construction. These detailed requirements help ensure that BMPs are designed and constructed to effectively remove nutrients.

## 4.6 Funding of Regulated Stormwater Projects

For new and redevelopment construction projects within the jurisdictional boundaries of the land use agencies, the developer or land owner is held responsible for planning, construction, operation, and maintenance of BMPs. The developer must also make any necessary repairs to construction BMPs immediately after a defect or need for repair is discovered. For permanent BMPs, the Post-Construction BMP plan requirement is to address the design, construction, and long-term operation and maintenance. The plan must contain procedures for maintenance and inspections to ensure the continued effectiveness of the permanent BMPs, as well as commitments from the responsible agency or owner to maintain the BMPs. The plan must also contain provisions for dedication by easement or other legal means of access for operation, maintenance, and inspection by the public entities.

## 4.7 Monitoring of Regulated Stormwater Projects

The Commission requires the Authority to monitor and maintain all PRFs for total phosphorus concentration controls. (PRF monitoring is further discussed in Chapter 5.) The Commission also concluded that individual monitoring of BMPs need not occur because PRF monitoring upstream and downstream of the project effectively measure the cumulative benefits of BMP implementation in the upstream watershed. PRF monitoring results are discussed in Section 7.4.

In addition to Authority monitoring, MS4s are required to report separately to the Division (as part of their annual reports) on any monitoring data collected and analyzed to assess the effectiveness of stormwater controls in reducing the discharge of pollutants.

## 4.8 Public Information and Education Actions of MS4s

All MS4 entities have public information and outreach programs. These include:

- Websites, hot lines, surveys, and public service announcements;
- Issue-specific fact sheets and brochures for residents and businesses;
- Educational programs in schools, e.g., Project WET (Water Education for Teachers)
- Work projects that include the public, such as willow planting, stenciling, channel repairs and stabilization projects; and
- Coordination with other entities including the Stewardship Partners, UDFCD, SEMSWA, Arapahoe SPLASH, etc.

The City of Greenwood Village held its 13th annual Public Works Day Event in May of 2011. Over 100 students and citizens were in attendance to learn how the department contributes to the quality of life for the residents of Greenwood Village. This year's theme "Caring for You and Your Community" brought awareness to how government assures that public facilities are safe, useable, clean, and aesthetically pleasing. The stormwater cycle was explained and residents shown how their actions can affect water quality within the Basin.

Stormwater Permittees for Local Awareness of Stream Health, or SPLASH, is a group of governmental and quasi-governmental entities within Arapahoe County that work together and coordinate efforts to meet MS4 Permit Measurable Goals, including education and outreach, public participation and involvement, and good-housekeeping and pollution prevention. SPLASH also provides staff training to increase awareness of each person's role in protecting water quality.

# 5 NONPOINT SOURCE STORMWATER CONTROLS

Nonpoint source stormwater controls consist of PRFs constructed by the Authority. These water quality measures, such as stream reclamation, shoreline stabilization, detention, wetlands, and others, reduce pollutants carried by stormwater from existing and future land disturbances. PRFs are different from the BMPs that are implemented by local land use agencies (i.e., MS4s) under the regulated stormwater program discussed in Section 4 above. The difference between PRFs and BMPs is formally recognized in the definitions in Regulation 72.

*PRFs are defined in Regulation 72 as "projects that reduce nonpoint source pollutants in stormwater runoff that may also contain regulated stormwater. PRFs are structural measures that include, but are not limited to, detention, wetlands, filtration, infiltration, and other technologies with the primary purpose of reducing pollutant concentrations entering the reservoir or that protect the beneficial uses of the reservoir."*

PRFs are selected based on a prioritization method using cost/benefit evaluations that require both quantitative and qualitative assessments and Authority consideration of all reasonable evaluation criteria. Evaluation criteria include estimates of pollution reduction, economic baselines, the expected timeframe for benefits to be seen, cost, and potential downstream impacts.

## 5.1 Updated List of PRFs Implemented

In accordance with statutory requirements, the Authority must spend at least 60 percent of its annual budget on design, construction, operation, and maintenance of PRFs. This was accomplished in 2011. To implement this requirement, the Authority conducts a multi-year Capital Improvement Project (CIP) planning process to identify PRF construction projects. Potential PRFs are first identified and evaluated, and costs are estimated over the life of design and construction for each project.

The next step is development of a list of all potential PRFs (called the master PRF list), which includes capital, operation, and maintenance costs compared with potential benefits in terms of phosphorus reduction. As pollution reduction opportunities are identified during the year, they are evaluated at the conceptual level to determine costs and benefits. If project costs and benefits appear to be reasonable, the TAC recommends to the Board that the project be included on the master PRF list. Once the Board approves the project for inclusion on the master list, any future work towards design and construction, which also must be authorized by the Board, is considered to be part of capital expenses of the Authority.


The next step is to select the best projects from the master list of PRFs to be included on the five-year CIP list. The TAC annually evaluates projects on the master list and forwards recommendations to the Board for inclusion on the five-year CIP. The Board then annually selects projects from the five-year CIP, based on recommendations from the TAC and subject to available funds. A summary of recommended PRFs for 2012-2016 is found in Table 5-1 in this chapter.

## *CHERRY CREEK BASIN WATER QUALITY AUTHORITY*

### 2011 Capital Project and Maintenance Status Report

December 5, 2011

1. **Cherry Creek Stream Reclamation at Eco-Park**
   a. Description: Co-funding for design of stream reclamation project with SEMSWA
   b. Status: Board approved IGA w/SEMSWA on 4-15-2010 for design funds of $56,000. Estimated project cost, based on 50% plans dated 4-19-11, is $3,830,000. Board approved SEMSWA request for additional $100,000 construction funds for a total construction funding amount of $905,000. Authority to perform PRF monitoring at d/s end of project. *IGA amendment for construction funds in progress*. *Alternative evaluation in progress.*
   c. Action Items: Authority monitors final design process.
2. **Cherry Creek Stream Reclamation at Parker Jordan Centennial Open Space (PJCOS)**
   a. Description: Co-funding for design of stream stabilization project with SEMSWA, Centennial, and PJMD.
   b. Status: Final design completed. Board approved construction funds in the amount of $586,871 on 3/17/11. Board approved IGA with PJMD on June 16, 2011. Bids opened on July 15, 2011. Authority's contribution to project is $586,838. Pay-estimate #2 approved on 11/07/2011.
   c. Action Items: Monitor construction.
3. **Cherry Creek Stream Reclamation at 12-Mile Park**
   a. Description: Preliminary design of stream reclamation by Authority consultant.
   b. Status: Board selected CH2M Hill and approved contract on 05-20-2010. Authority provided comments on draft Stream Reclamation Plan (SRP) dated 2-11-2011. Board approved scope/budget for final design to restore channel breach area on 01-20-2011 and NTP issued 02-07-2011. CH2M Hill presented alternatives at May 5, 2011 TAC meeting. TAC approved updated cost benefit analysis on 6-02-2011. Board approved CH2M Hill request for additional survey funds and for construction services on 9-15-2011. *Board awarded project to 53 Corporation, LLC for $227,588 and funds for additional quantities on 11-17-01.*
   c. Action Items: *Issue NTP.* *CH2M Hill to present project to Board TAC approval.*
4. **Reservoir Shoreline Stabilization at Mountain Loop**
   a. Description: Final design of improvements based on preliminary design in 2008.
   b. Status: Board approved award at June 18, 2009 meeting. Design modified to account for ice forces experienced in 2009\2010. MEC presented final documents on March 21, 2011. USACE approved plans on 6/01/2011. GESC plans approved 8/1//2011.
   c. Action Items: MEC to provide proposal in 2012 for construction services. Revise construction to fall 2012.
5. **McMurdo Gulch Stream Reclamation**
   a. Description: Co-funding for design of stream stabilization project with Castle Rock
   b. Status: Board approved IGA on 11-19-09. Board approved Castle Rock's request for additional construction funds on 12-16-10. TAC approved monitoring locations on 7-07-11. Final punch list prepared 9-21-2011. *Project may be under budget and Authority may be due a refund. See project summary report.*
   c. Action Items: *Project IGA close-out*.
6. **Stream Corridor Preservation**
   a. Description: Co-funding of property acquisition of stream buffers
   b. Status: Waiting for opportunity.
   c. Action Items: None
7. **West Boat Ramp Parking Lot PRF**
   a. Description: Design and construction of Parking Lot BMP
   b. Status: Conceptual design completed. Board approved scope limited to alternative formulation and RFP to preselected consultants w/o interviews on 2-17-2011. Board approved contract with AMEC 5-19-11. NTP issued 6-17-11. Comments on draft alternatives analysis provided 10/31/2011. TAC selected alternatives for further evaluation on 11-03-11. *TAC selected alternative plan and approved going to final design as the next step, instead of preliminary design on 12-03-11.*
   c. Action Items: *Authority to meet with stakeholders to discuss funding options.*

8. **Cherry Creek Stream Reclamation – Arapahoe Road to Piney Creek**
    a. Description: Preliminary design of reclamation in partnership with SEMSWA
    b. Status: RFP issued 01-31-11. Board approved $25,000 for design funding and directed counsel to prepare IGA. Team selected consultant on 4/05/11. MEC team developing stream reclamation alternatives based on independent sediment analysis by Cotton and Simons. *MEC evaluating floodplain issues. CDOT plans bridge widening with 100-yr capacity.*
    c. Issue: Valley Country Club Board voted on 7-20-11 to not allow trail to pass through the golf course.
    d. Action Items: Assist project partners with engineering evaluation and planning.
9. **Cherry Creek Stream Reclamation – Country Meadows**
    a. Description: Preliminary design of reclamation in partnership with Parker, Douglas County, and UDFCD
    b. Status: Board approved IGA w/UDFCD, Douglas County, Town of Parker on 12/16/10. UDFCD signed contract with consultant on 6/03/11. Progress meetings held on 6-23-2011 and 8-31-2011. Project team scaled back project due to lack of water quality benefits of one side channel. *Meeting w/local HOA 11/17/2011 resulting in plan modifications.*
    c. Action Items: Assist project partners with engineering evaluation and planning.
10. **Peoria Tributary B/Airport East and West Pond**
    a. Description: Preliminary design of pond improvements in partnership with Centennial Airport
    b. Status: Authority provided recommendations to Centennial Airport to further modify existing detention ponds and improve the treatment of glycol deicers. Airport Authority requested funding for design/construction costs. Authority Board approved Airport request for funds on 10-20-2011.
    c. Action Items: *Authority preparing funding agreement with Airport.*

**MAINTENANCE**

11. **PRF Weed Control**
    a. Description: Weed control at PRFs within CCSP who has separate contract with VMI. Authority pays VMI directly for related work. Reseeding of Cottonwood Creek PRF due to prairie dog damage.
    b. Status: Two proposals for reseeding received on 4-06-11. Minimum bid ($43,000) exceeded Authority's budget and all bids rejected. Project specifications, seeding area, and bidders list updated and project was rebid 11-07-11. *Only one bid received on 11-29-11 that was 2.7-times engineers' opinion.*
    c. Action Items: *TAC directed engineer to negotiate with only bidder and contractor who will be doing work at the Park for the Authority.*
12. **Reservoir Destratification**
    a. Description: Routine O&M and system evaluation.
    b. Status-Compressor: Start up system after March 1, 2011. TAC reaffirmed start up process on 02-03-11. Air conditioner installed on 8-1-11 to control oil temperatures. Board awarded contract to Eaton Energy Solutions for compressor evaluation on 11-17-11. *System shut-down scheduled for week of 11/21/2011.*
    c. Status-Aerators: System started on 2-24-2011 at 3:02 pm. Aerator maintenance completed in August.
    d. Action Items: Monitor and evaluate system. *Attorney to prepare agreement with Eaton.*
13. **Cottonwood Wetlands Restoration (aka Perimeter Road Pond).**
    a. Description: Maintenance design to remove sediment and restore water quality function.
    b. Status: Placed on hold in 2009 due to discovery of clay pigeons on site which require disposal at certified land fill. Meeting with USACE and State Parks determined responsibility lies with State Parks (CSP). CSP allocated funds for 2010 to remove clay pigeons. Board approved MEC contract amendment for final design on 01-21-10. State Park contracted with MEC for construction services. Board signed IGA on 09-15-11. *Only one bid received on 11-22-11 that was 3.6% lower than engineers' opinion.*
    c. Action Items: *Amend funding agreement with State (see action item memo)*
14. **2011 Tower Loop Maintenance Program**
    a. Description: Ice damage to shoreline protection during 2009/2010 winter.
    b. Status: Board authorized William P. Ruzzo, PE, LLC on Jan. 20, 2011to design repairs and obtain bids. Draft plans for repairs provided at June 2, 2011 TAC meeting. LRE comments/suggestions on the plans have been incorporated. Bids received 09-14-2011. NOA issued on 10-20-201.
    c. Action Items: *Contractor provides bonds/certificates. Issue NTP in December 2011. Monitor construction.*

CHERRY CREEK BASIN WATER QUALITY AUTHORITY

## TABLE 5.1 - SUMMARY OF RECOMMENDED POLLUTANT REDUCTION FACILITIES

## 2012 - 2016 BUDGET PROJECTIONS (1000$)[5]

November 17, 2011

See "2012 CIP Notes" for revisions to this Spreadsheet. Previous CIP projects included in Spreadsheet if ongoing during the 5-year projection

| | | Current Project Budget | | | | | | Obligated Funds[3] | Residual PRF Costs | Proposed 2012 Budget | | | | | Proposed 2013 Budget | Proposed 2014 Budget | Proposed 2015 Budget | Proposed 2016 Budget |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Project No. | Project Title | Capital[1] | Land | Total | O&M | Authority Portion | Authority Portion | | | Design[2] | Capital | Land | Water | Total | Total | Total | Total | Total |
| CCB-5.4 | Cherry Creek Stream Reclamation at Mainstreet (Parker) | $ 1,776 | $ - | $ 1,776 | $ 1 | $ 200 | 11% | $ - | $ 200 | $ - | $ - | $ - | $ - | $ - | $ - | $ 200 | $ - | $ - |
| CCB-5.6 | Cherry Creek Stream Reclamation at Lincoln Avenue (Parker) | $ 1,447 | $ - | $ 1,447 | $ 1 | $ 304 | 21% | $ - | $ 304 | $ - | $ - | $ - | $ - | $ - | $ - | $ 20 | $ 284 | $ 284 |
| CCB-5.7 | Cherry Creek Stream Reclamation at Eco-Park (SEMSWA) | $ 3,830 | $ - | $ 3,830 | $ 1 | $ 955 | 25% | $ 453 | $ 502 | $ - | $ 502 | $ - | $ - | $ 502 | $ - | $ - | $ - | $ - |
| CCB-5.8 | Cherry Creek Stream Reclamation U/S Arapahoe Rd (Aurora) | $ 1,150 | $ - | $ 1,150 | $ 1 | $ 403 | 35% | $ - | $ 403 | $ - | $ - | $ - | $ - | $ - | $ - | $ 130 | $ - | $ - |
| CCB-5.9.1 | Cherry Creek Stream Stabilization at 12-Mile Park (CCSP) - Phase I | $ 360 | $ - | $ 360 | $ 1 | $ 360 | 100% | $ 50 | $ 310 | $ - | $ 310 | $ - | $ - | $ 310 | $ - | $ - | $ - | $ - |
| CCB-5.9.2 | Cherry Creek Stream Stabilization at 12-Mile Park (CCSP) - Phase II | $ 1,507 | $ - | $ 1,507 | $ 1 | $ 1,507 | 100% | $ 97 | $ 1,410 | $ 120 | $ - | $ - | $ - | $ 120 | $ 1,290 | $ - | $ - | $ - |
| CCB-5.10 | Cherry Creek Stream Reclamation at PJCOS (Vermillion Creek, PJMD) | $ 3,017 | $ - | $ 3,017 | $ 2 | $ 643 | 21% | $ 643 | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| CCB-5.11 | Cherry Creek Stream Reclamation at Norton Open Space (Parker) | $ 900 | $ - | $ 900 | $ 1 | $ 252 | 28% | $ - | $ 252 | $ - | $ - | $ - | $ - | $ - | $ 30 | $ 222 | $ - | $ - |
| CCB-5.13 | Cherry Creek Stream Reclamation at Shop Creek Trail | $ 728 | $ - | $ 728 | $ 1 | $ 728 | 100% | $ - | $ 689 | $ 90 | $ - | $ - | $ - | $ 90 | $ 599 | $ - | $ - | $ - |
| CCB-5.14 | Cherry Creek Stream Reclamation - Arapahoe Rd to Piney Creek | $ 7,000 | $ - | $ 7,000 | $ 1 | $ 1,540 | 22% | $ 25 | $ 1,515 | $ 150 | $ - | $ - | $ - | $ 150 | $ 700 | $ 665 | $ - | $ - |
| CCB-5.15 | Cherry Creek Stream Reclamation at Country Meadows | $ 2,170 | $ - | $ 2,170 | $ 2 | $ 520 | 24% | $ 20 | $ 500 | $ - | $ 500 | $ - | $ - | $ 500 | $ - | $ - | $ - | $ - |
| CCB-6.3 | Piney Creek Sediment Removal @ Saddle Rock GC | $ 1,300 | $ - | $ 1,300 | $ 1 | $ 325 | 25% | $ - | $ 325 | $ - | $ 325 | $ - | $ - | $ 325 | $ - | $ - | $ - | $ - |
| CCB-12.1 | Bowlie Phase I | $ 235 | $ 200 | $ 435 | $ 7 | $ 435 | 100% | $ - | $ 435 | $ - | $ - | $ - | $ - | $ - | $ - | $ 50 | $ 385 | $ - |
| CCB-13.4 | Peoria Trib B/Airport East and West Pond (Outfall C-1) | $ 523 | $ - | $ 523 | $ - | $ 131 | 25% | $ - | $ 131 | $ - | $ 131 | $ - | $ - | $ 131 | $ - | $ - | $ - | $ - |
| CCB-16 | Stream Corridor Preservation | $ 100 | $ - | $ 100 | $ - | $ 100 | 100% | $ - | $ 100 | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| CCB-17.2 | Reservoir Shoreline Stabilization Mountain Loop Trail | $ 935 | $ - | $ 935 | $ 5 | $ 935 | 100% | $ 80 | $ 855 | $ 150 | $ 353 | $ - | $ - | $ 503 | $ 355 | $ - | $ - | $ - |
| CCB-17.3 | West Boat Ramp Parking Lot WQ Improvements | $ 212 | $ - | $ 212 | $ 3 | $ 212 | 100% | $ 32 | $ 180 | $ 25 | $ - | $ - | $ - | $ 25 | $ 155 | $ - | $ - | $ - |
| CCB-17.4 | East Boat Ramp Shoreline Stabilization Phase II | $ 57 | $ - | $ 57 | $ - | $ 57 | 100% | $ - | $ 57 | $ 9 | $ - | $ - | $ - | $ 9 | $ 48 | $ - | $ - | $ - |
| CCB-17.5 | East Shade Shelter Shoreline Stabilization Phase II | $ 38 | $ - | $ 38 | $ - | $ 38 | 100% | $ - | $ 38 | $ 9 | $ - | $ - | $ - | $ 9 | $ 29 | $ - | $ - | $ - |
| CCB-18 | ISDS Sewer Service[4] | $ 100 | $ - | $ 100 | $ - | $ 100 | 100% | $ - | $ 100 | $ - | $ - | $ - | $ - | $ - | $ 100 | $ - | $ - | $ - |
| CCB-19 | Non-point Pollutant Management[4] | $ 100 | $ - | $ 100 | $ - | $ 100 | 100% | $ - | $ 100 | $ - | $ 100 | $ - | $ - | $ 100 | $ - | $ - | $ - | $ - |
| | *SUB-TOTALS* | *$ 27,485* | *$ 200* | *$ 27,685* | *$ 29* | *$ 9,844* | *$ 13* | *$ 1,400* | *$ 8,405* | *$ 553* | *$ 2,221* | *$ -* | *$ -* | *$ 2,774* | *$ 3,306* | *$ 1,287* | *$ 669* | *$ 284* |

CHERRY CREEK BASIN WATER QUALITY AUTHORITY

## TABLE 5.1 - SUMMARY OF RECOMMENDED POLLUTANT REDUCTION FACILITIES

## 2012 - 2016 BUDGET PROJECTIONS (1000$)[5]

November 17, 2011

See "2012 CIP Notes" for revisions to this Spreadsheet. Previous CIP projects included in Spreadsheet if ongoing during the 5-year projection

| | | Current Project Budget | | | | | | Obligated Funds[3] | Residual PRF Costs | Proposed 2012 Budget | | | | | Proposed 2013 Budget | Proposed 2014 Budget | Proposed 2015 Budget | Proposed 2016 Budget |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Project No. | Project Title | Capital[1] | Land | Total | O&M | Authority Portion | Authority Portion | | | Design[2] | Capital | Land | Water | Total | Total | Total | Total | Total |
| | ***OPERATIONS AND MAINTENANCE*** | | | | | | | | | | | | | | | | | |
| | ***Rehabilitation Categories*** | | | | | | | | | | | | | | | | | |
| OM-1 | Restore Cottonwood Wetlands Pond | $ 311 | $ - | $ - | $ 311 | $ 311 | 100.0% | $ 78 | $ 233 | $ - | $ 233 | $ - | $ - | $ 233 | $ - | $ - | $ - | $ - |
| OM-17 | Compressor oil cooling system | $ 125 | $ - | $ - | $ 125 | $ 125 | 100.0% | $ 25 | $ 100 | $ 25 | $ 75 | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| | ***SUB-TOTALS*** | $ 436 | | | $ 436 | | | $ 103 | $ 333 | $ 25 | $ 308 | $ - | $ - | $ 233 | $ - | $ - | $ - | $ - |
| | ***Restorative Categories*** | | | | | | | | | | | | | | | | | |
| OM-14 | PRF weed control in CCSP | $ - | $ - | $ - | $ 63 | $ 63 | 100.0% | $ - | $ 63 | $ - | $ - | $ - | $ 63 | $ 63 | $ - | $ - | $ - | $ 10 |
| | ***SUB-TOTALS*** | $ - | | | $ 63 | | | $ - | $ 63 | $ - | $ - | $ - | $ 63 | $ 63 | $ - | $ - | $ - | $ 10 |
| | ***Routine Categories*** | | | | | | | | | | | | | | | | | |
| OM-7 | Reservoir Destratification | $ 64 | $ - | $ - | $ 64 | $ 64 | 100.0% | $ - | $ 64 | $ - | $ 64 | $ - | $ - | $ 64 | $ 64 | $ 64 | $ 64 | $ 64 |
| OM-16 | Mountain/Lake Loop Individual 404 Permit monitoring | $ 18 | $ - | $ - | $ 18 | $ 18 | 100.0% | $ - | $ 18 | $ 18 | $ - | $ - | $ - | $ 18 | $ 18 | $ 18 | $ 18 | $ 18 |
| | ***SUB-TOTALS*** | $ 82 | $ - | $ - | $ 82 | | | $ - | $ 82 | $ 18 | $ 64 | $ - | $ - | $ 82 | $ 82 | $ 82 | $ 82 | $ 82 |
| | ***SUB-TOTAL O&M*** | $ 518 | $ - | $ - | $ 581 | | | $ 103 | $ 478 | $ 43 | $ 372 | $ - | $ 63 | $ 378 | $ 82 | $ 82 | $ 82 | $ 92 |
| | ***GRAND TOTAL*** | $ 28,002 | $ 200 | $ 27,685 | $ 610 | | | $ 1,503 | $ 8,883 | $ 596 | $ 2,593 | $ - | $ 63 | $ 3,152 | $ 3,388 | $ 1,369 | $ 751 | $ 376 |

**NOTES:**

1 Includes engineering, construction, administration, and contingency
2 Includes technical feasibility, design, construction observation and administrative costs
3 Accumulative expenditures for the project, based on previous years accounting and estimate of current year expenses
4 Capital costs and potential benefits unknown. Values are place holders.
5 This budget is the TAC recommendation. The funds allocated to each project are subject to further Board approval. Where noted, some funds have been previously obligated to the specific project by the Board

Following is a summary of PRF projects that have been implemented in the basin by the Authority to date, updated in October 2011.

**Table 5-2. Summary of Pollutant Reduction Facility Costs**

| Project | Category | Activity | Year | Cost |
|---|---|---|---|---|
| Completed PRFs: | | | | |
| Shop Creek | Detention with Wetlands | Design & Construction | 1991 | $668,286 |
| Cottonwood Wetlands | Detention with Wetlands | Design & Construction | 1996 | $342,978 |
| Quincy Drainage | Detention with Infiltration | Design & Construction | 1995 | $218,672 |
| East Shade Shelter | Shoreline Stabilization | Design & Construction | 1996 | $125,754 |
| East Boat Ramp | Shoreline Stabilization | Design & Construction | 1996 | $120,000 |
| East Shoreline Extension | Shoreline Stabilization | Design & Construction | 1999 | $69,000 |
| Tower Loop | Shoreline Stabilization | Design & Construction | 1999 | $142,000 |
| Dixon Grove | Shoreline Stabilization | Design & Construction | 1999 | $27,600 |
| Cottonwood/Peoria Pond | Detention with Wetlands | Design & Construction | 2001 | $100,000 |
| Piney Creek-Parker to Buckley | Stream Reclamation | Cost-share with Arapahoe | 2001 | $118,000 |
| Bowtie Property Acquisition | Stream Corridor Preservation | Property Purchase | 2003 | $300,000 |
| Cottonwood Creek Reclamation | Stream Reclamation | Design & Construction | 2004 (Phase I)<br>2008 (Phase II) | $2,405,000 |
| Cherry Creek Sediment Pond At Arapahoe Road | Stream Sediment Control | Preliminary Investigation | 2005 | $70,000 |
| Reservoir Destratification | Mixing to Control Algae Species | Design & Construction | 2008 | $968,100 |
| Cottonwood Creek at Easter Ave. | Stream Reclamation | Cost-share w/ SEMSWA | 2011 | $338,000 |
| Subtotal | | | | $6,013,000 |
| PRFs in Progress:<br>(committed funds) | | | | |
| Cherry Creek at Shop Creek Trail | Stream Stabilization | Preliminary Investigation | 2010 | $39,000 |
| West Boat Ramp Parking Lot | Recreation WQ Mitigation | Preliminary Investigation | 2011 | $32,000 |
| Mountain & Lake Loop | Shoreline Stabilization | Final Design | 2011 | $130,000 |
| Cherry Creek Reclamation-Eco Park | Stream Reclamation | Cost-share w/ SEMSWA | 2011 | $955,000 |
| Cherry Creek Reclamation-PJCOS | Stream Reclamation | Cost-share w/ PJMD | 2011 | $642,800 |
| McMurdo Gulch Reclamation | Stream Reclamation | Cost-share w/ Castle Rock | 2010 | $660,000 |
| Cherry Creek Reclamation-Arapahoe to Piney | Stream Reclamation | Cost-share w/ SEMSWA | 2011* | $25,000 |
| Cherry Creek at Hess Road | Stream Reclamation | Cost-share w/ UDFCD | 2011* | $20,000 |
| Cherry Creek Reclamation-12-Mile House Phase I | Stream Reclamation | Design & Construction | 2011* | $454,000 |
| Cottonwood Wetlands | PRF Restoration | Design & Construction | 2011* | $359,400 |
| Tower Loop | PRF Restoration | Design & Construction | 2011* | $48,600 |
| Subtotal | | | | $3,366,000 |
| Total | (Note: Costs do not include routine maintenance costs.) | | | $9,379,000 |

**year funds committed*

Similar to 2010, stream reclamation projects have been a primary focus in 2011 as an effective way to reduce nutrient concentrations flowing into Cherry Creek Reservoir. Stream reclamation projects provide water quality benefits beyond just reduction of phosphorus loading, including the reduction of nitrogen and metals while increasing oxygen levels. Load and concentration reductions are realized through the reduction of flow velocities which provide greater areas of filtration and infiltration of stormwater. Monitoring data from Cottonwood Creek show that stream reclamation projects can reduce both phosphorus and nitrogen loads and concentrations. Stream reclamation also improves the overall ecological health of the stream system by improving habitat for benthic macroinvertebrates and terrestrial wildlife, which are indirect measures of water quality. Stream reclamation can lead to greater public understanding of the importance of water quality. A more detailed quantification of various water quality benefits, such as those mentioned above, is included in the Stream Reclamation Water Quality Benefits Report, which the Authority accepted and endorsed for use in 2011.[3]

In 2011, most PRFs focused on stream reclamation, shoreline stabilization, and PRF restoration. Following is a discussion on some of the larger stream reclamation PRFs in progress during 2011. Additionally, modifications to the west boat ramp parking lot for water quality mitigation are discussed below.

**Stream Reclamation at Eco-Park**

The Authority partnered with Southeast Metro Stormwater Authority to design and construct a stream reclamation project at Eco-Park. Improvements to Eco-Park were first included on the CIP list in 2009. The project design was found to result in water quality benefits through the reduction in velocity, shear force, and stream power. Final design was in progress as of December 2011.

**Stream Reclamation at 12-Mile Park**

During 2011, a preliminary design of stream reclamation at the dog park at 12-Mile Park was developed by a consultant with Authority approval. Because of high traffic in this area, large areas of visible bare soil along stream banks have contributed to sediment runoff in the stream. There are over 450,000 visitors to this area throughout the year, making this one of the largest dog off-leash areas in the Denver Metropolitan area. The Authority is coordinating its stream reclamation efforts with the Dog Off-Leash Area Management Plan that was adopted by State Parks in October of 2010.

3 "CCBWQA. Stream Reclamation Water Quality Benefit Evaluation – Interim Status Report. 2011."

**McMurdo Gulch Stream Reclamation**

The Authority partnered with Castle Rock for the construction of a stream reclamation project at McMurdo Gulch, a major tributary to Cherry Creek. The design occurred during 2009 and 2010, and the construction for the project was completed in 2011 for the 2.84-mile reach. This PRF was implemented as a proactive solution to an area that is projected to have major development in the future. This is expected to reduce sediment and nutrient loads into Cherry Creek prior to increased stormwater runoff and degradation as a result of that development.

The McMurdo Gulch project is important because it addresses impacts before they have occurred and stabilizes streams before they have "unraveled". This is a much more cost-effective solution than having to restore and reclaim the area after the impacts have occurred**,** as was the case in Cottonwood Creek.

**West Boat Ramp Parking Lot PRF**

In 2011, the Authority approved improvements to the West Boat Ramp Parking Lot after evaluation and review by the TAC. The project area includes boat and vehicle parking which produces oils and grease, sediment, debris, and nutrients that are being discharged directly into the reservoir without any treatment. The PRF area, located on the west end of the reservoir, consists of around 4.5 acres of parking lot for marina users, boaters, and general park users. The objective for the project is to develop a management plan for the project area to identify a preferred alternative to reduce pollutant discharge from the parking lot, minimize operation and maintenance requirements, and result in the least disturbance and interruption of park and marina facilities and operations. In December 2011, the TAC selected the preferred alternative plan and approved the final design as the next step in the process.

## 5.2 Floodplain Preservation/Conservation Easements

The Commission recognizes protection of floodplain, riparian corridor, and other environmentally sensitive lands through public acquisition or conservation easements and restoration of the same lands for nutrient control through erosion control, revegetation, or other means, to control nutrient. The Authority and local governments may collaborate with other entities in pursuing easements, ownerships, and rights to protect the streams, riparian corridors, tributaries, and wetlands in the Cherry Creek watershed.

In the past, the Authority was a funding partner in the acquisition of 21.5 acres of land at the confluence of Piney Creek and Cherry Creek whose shape resembled a bowtie and was hence called the Bowtie Property. The purchase was a joint effort between the City of Centennial, Arapahoe County, the UDFCD, and the Authority and preserved the channel and riparian corridor of Piney Creek from future development, and returned an existing developed area into open space park.

## 5.3 Effectiveness in Reducing Phosphorus Concentration

**Cottonwood Creek Peoria Pond**

The effectiveness of the Cottonwood Creek Peoria Pond is gaged by monitoring the concentrations of phosphorus and total suspended solids (TSS), and the flow-weighted phosphorus concentrations upstream and downstream of the facility. This PRF continues to be effective in reducing the amount of total suspended solids and total phosphorus as stream flow passes through this system. The total suspended solids were reduced by approximately 38% in 2011, with the long-term average showing a 20% reduction. Over the life of the project, the PRF shows approximately a 14% reduction in the flow-weighted total phosphorus concentration at the downstream site.

**Cottonwood Creek Perimeter Pond**

The effectiveness of the Cottonwood Creek storm water Perimeter Pond in reducing phosphorus loads to the reservoir is similarly gaged by comparing data from sites upstream and downstream of the PRF. In 2011, this PRF continues to be variable in its removal efficiency of both total suspended solids and total phosphorus. During the 2010 WY, the PRF was not effective, while in 2011 it again showed some effectiveness in removing both suspended sediment and total phosphorus. This PRF is currently being renovated by removing sediment from the pond and expanding the wetland vegetation and shoreline area.

## 5.4 Funding of PRFs

The Authority either funds or co-funds the PRFs together with local land use agencies. As noted above, the 5-year CIP ( Table 5-1) identifies various cost components for the PRFs including design, capital, land acquisition, water augmentation requirements, and operations and maintenance costs. The Authority's portion of the costs for co-funded projects can be seen in the 5-year CIP. These costs are then spread out over a multi-year period for longer-range planning purposes, subject to available Authority funds. In addition, Table 5-2 above shows the amount spent (and committed) to date by the Authority for the various PRFs that have been completed or that are in progress. On pages 5-2 and 5-3 is also a copy of the two-page Capital Project and Maintenance Status Report, current as of December 5, 2011. This table is updated monthly for the TAC and Board meetings. It provides brief summary of ongoing capital and maintenance projects, as well as current and planned activities for each.

## 5.5 Monitoring of PRFs

The Authority contracted in 2011 with GEI Consultants, Inc. (GEI) to implement its annual PRF monitoring program. Monitoring is conducted on Cottonwood Creek at sites above and below both the Peoria Pond PRF and the Perimeter Pond PRF. Shop Creek and Quincy Drainage PRFs have also been monitored for for effectiveness since 2000. This monitoring is discussed in detail in Section 7.4.

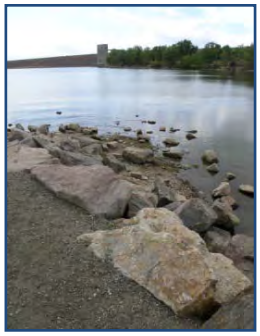
Since the completion of the Cottonwood Creek Reclamation Project in 2008, the flow-weighted total phosphorus concentrations at sites both above and below the Cottonwood Creek Perimeter Pond have decreased by approximately 40 and 45 percent, respectively. Similar reductions have occurred in the suspended solids concentrations at these sites. Prior to the reclamation project, the mean flow-weighted total phosphorus concentration for Cottonwood Creek was 142 µg/l, whereas the flow-weighted concentration has been less than 81 µg/l for the past 3 years. The decrease in suspended solids and total phosphorus concentrations is likely attributed to the relocation of Cottonwood Creek into a wide, shallow channel that slows the velocity of the water and dissipates the hydraulic energy of the flows, reducing the erosion potential through this reach. In addition, the redesigned drop structures along Cottonwood Creek have reduced the erosion potential that has historically occurred within this reach. These data continue to support the findings that stream stabilization/reclamation provides a water quality benefit to the Cherry Creek Watershed and Reservoir by reducing the amount of suspended solids and phosphorus due to stream bank erosion.

### 5.5.1 Annual Inspection of PRFs

The purpose of the annual inspection is to assess whether PRFs are functioning as designed and to identify routine, restorative, and rehabilitative maintenance reqirements. Sample findings are discussed below.

**Shop Creek**

There is a noticeable visual improvement in water quality at the downstream structure as compared to the upstream structures in terms of vegetation and water clarity. The presence of duckweed is persistent from year to year, but this year the lower three ponds were not covered in duckweed. Preliminary research suggests that duckweed may not be a water quality concern and may in fact be beneficial to water qualitiy.



**Dixon Grove**

There were no signs of wind, wave, or ice damage to the large-rock shoreline protection. Concrete backfill of the large rock appears to be functioning satisfactorily, preventing sluicing of soil through the voids. Smaller rock placed in front of the large rock creates a buttress that may deflect the ice sheets upward, minimizing ice force and rock movement.

**Tower Loop**

There was significant damage to some of the fishing pods where large boulders were moved, likely the result of wind, wave, and ice forces. The large boulders, although backfilled with concrete, did not have smaller buttress rock similar to Dixon Grove and East Shade Shelter, which likely contributed to the significant movement and displacement. Plans for restoration have been approved for work in the near future.

The conclusions of the 2011 annual inspection were:

- All PRFs are performing as designed; but some routine, restorative, and rehabilitation maintenance activities are recommended and are planned for 2011 and beyond.
- The projected total O&M cost as the result of this inspection is $ 388,000 compared to the last inspection, which was $ 292,600.
- The largest expenditure is rehabilitation of the Cottonwood Perimeter Road wetlands projected to be up to $311,000 based on 2010 final design plans; this work is identified as a specific line item in the 2011 budget.
- The remaining maintenance projection is $95,400 for minor restorative and rehabilitative maintenance work for Tower Loop due to ice/wind/wave damage.

## 5.6 Public Education and Information by Authority and Partners

Pursuant to Regulation 72, the Authority is to develop and implement a public information and education program in addition to the stormwater requirements in section 72.7. This program is to focus on the prevention of pollution from sources that could be mobilized during storm events from present and future activities as well as measures that could abate known nonpoint source pollution. Areas for abatement include, but are not limited to, general agricultural and silvicultural practices, individual sewage disposal systems, large lot development greater than one acre, and other potential nutrient sources.

As part of its ongoing revisions to the 2003 Watershed Plan, the Authority has been evaluating various management strategies, including opportunities for public education and information programs, in areas including agricultural operations, animal wastes, individual sewage disposal systems, and stream erosion. Recommended strategies will be prioritized and included in the 2012 Watershed Plan Update.

The Cherry Creek Stewardship Partners (Partners) is an association of a broad range of stakeholders actively promoting effective stewardship and providing education and outreach activities in the Cherry Creek Reservoir watershed. The Partners emerged from the first Cherry Creek Reservoir watershed forum held in the fall of 1999. The Partners bring together representatives from:

- Land use jurisdictions
- State and federal resource management agencies
- Conservation, recreation, and historic preservation groups
- Business communities
- Interested citizens

Hawk Walk 2011

In 2004, the Partners, through funding and staff provided by the Authority, developed a comprehensive and coordinated education strategy and action plan on a reservoir watershed scale entitled the "Cherry Creek Basin Water Stewardship and Education Initiative". This plan contains a compilation of the key education and public involvement goals, strategies, and activities aimed to engage the community in active stewardship of Cherry Creek, parks, open space, trails, and tributaries within the watershed.


Eagle Scouts at Eco Park

The purpose of the Education Initiative is to describe the approach recommended by the Partners and the Authority to promote active stewardship in the basin. The purpose of active stewardship is to preserve, protect, and restore water quality, wildlife habitat, recreational opportunities, and the natural function of the watershed. In coordination with key stakeholders in the Cherry Creek watershed, the Education Initiative makes recommendations and identifies next steps for the development and implementation of a public information and education outreach program for the Cherry Creek watershed that meets the regulatory requirements of Regulation 72 and the objectives identified in Cherry Creek Basin Watershed Plan.

In 2011, the Authority provided $23,000 to the Partners to help implement priority activities identified in the Education Initiative. In addition to organizing and sponsoring a wide variety of activities in the Cherry Creek Reservoir watershed that support water quality goals, the Partners are frequently asked to help identify, plan, and support open space projects. Throughout 2011, the Partners coordinated and participated in over 30 public activities focused on enabling participants to get to know the watershed, provided education and training, or integrated watershed interests. Activities occur in every month of the year.

| | |
|---|---|
| January | Audubon Raptor Walk |
| February | Metro Regional Science Fair |
| March | Spring Equinox Event |
| April | Trailhead Opening Event |
| May | 16th Annual Aurora Water Fest |
| June | Summer Solstice Event |
| July | Teacher Training Workshop |
| August | Stormwater Conference |
| September | Fall Equinox Event |
| October | Stormwater Tour |
| November | Annual Stewardship Conference |
| December | Winter Solstice Event |

Volunteer water quality monitoring is encouraged by providing volunteer instructors to local business, school, and community groups. The CCSP refers to CSU Extension Service materials, Colorado River Watch, and uses and provides testing kits as part of its educational program coordinated through the Partners. In an effort to protect water quality, Cherry Creek Reservoir, Cherry Creek and its tributaries have been the subject of regulation and monitoring for over 25 years. Geologists, hydrologists, engineers, and chemists have compiled data to create both a reservoir and a watershed model in an effort to understand how a prairie stream reacts to development, changes in hydrology, and reclamation efforts. Local residents and wildlife specialists have compiled lists of animal activity and dazzling photographs sharing their knowledge with other budding naturalists. Cherry Creek has proven to be an extraordinary outdoor classroom.

The Partners also regularly hold information-sharing forums and participate in various projects and activities focused on helping to enhance water resources in the basin and to promote stewardship in the community. A main focus of the Partners is to help bridge the gap between quantity and quality of water within the Basin by helping to build collaborative relationships. Opening the door for entities to begin sharing data, experiences, and ideas helps to find a common ground and influence the best possible solutions and ideas to be reached throughout the Basin.


**Annual Stewardship Partners Conference**

On November 9, 2011, the 13th Annual Cherry Creek Conference was held, focusing on Cherry Creek as a "Treatment Train". In addition to a variety of speakers focusing on different topics within the Cherry Creek Basin, poster exhibits were displayed around the conference hall to distribute more information to attendees. The Authority had a poster exhibit focusing on the Cherry Creek Watershed Plan and providing general information on the overall health and plans within the Basin. The main focus for this display was to inform any interested attendees specifically about the 2012 Watershed Plan.

At the conclusion of the conference, a questionnaire regarding public water quality perceptions within the Cherry Creek basin was provided. The majority of respondents did not live within the Cherry Creek basin but visit Cherry Creek State Park a few times each year and consider the water quality within the basin to affect their quality of life. Most respondents were interested in learning more about the Watershed Plan through the Authority's website. The majority of attendees were from local government, but ranged from consultants to residents, government employees to volunteers.

When given options for ranking the biggest water quality concerns in the Cherry Creek Basin, the following were listed in order from most important to least: a healthy vegetation corridor along Cherry Creek and its tributaries, Stream channel erosion along Cherry Creek and its tributaries, nutrients in the reservoir, and water clarity in the reservoir.

Highlights in 2011 of the Authority's public information and education efforts include:

- The Authority continued to support the Partners and coordinate with other entities to implement the Education Initiative, a comprehensive and coordinated education strategy and action plan;
- The TAC worked with the Partners in determining the appropriate BMPs and measurable goals for public education and outreach,
- The Authority continued the use of its website in cooperation with the Partners to facilitate the dissemination of information to parties interested in Authority activities;
- The Authority collaborated on information and education efforts with other entities with common interests and goals for the watershed; and
- The Partners facilitated broad community involvement and benefited long-term environmental stewardship from a large variety of outreach efforts.

# 6 RIPARIAN AND WETLANDS PROTECTION

## 6.1 Protection, Enhancement, and Restoration Actions

The protection of floodplains, riparian corridors, and other environmentally sensitive lands through public acquisition or conservation easement and restoration of the same lands for nutrient control through erosion control, revegetation, or other means is recognized in Regulation 72 as one method to control nutrients. Despite the difficulty in quantifying the amount of nutrient reductions from these actions, it is clear that such activities will assist in reducing future nutrient contributions to the reservoir. In addition, floodplain, wetlands, and riparian corridor restoration will provide recreational and aesthetic value to the watershed. The Authority and local governments are encouraged to voluntarily collaborate with other entities in pursuing easements, ownerships, and rights to protect the streams, riparian corridors, tributaries, and wetlands in the Cherry Creek watershed. However, the Commission also has recognized the difficulty in quantifying the amount of phosphorus-loading reduction from these actions. Informal monitoring is done by citizens and volunteers during events such as the Hawk Walk, Spring Equinox, Winter Solstice, and Eagle Scout Projects.

*Stream reclamation means adding measures or enhancements to traditional stream stabilization projects, resulting in frequent connection with and flooding of the overbank area.*

## 6.2 Stream Reclamation

Since 2001, as reflected in its budget, the Authority has stressed stream reclamation as the preferred approach to channel and stream stabilization. Channel or stream reclamation typically includes riparian and floodplain vegetation planting or enhancements and a channel cross section that results in more frequent connection and flooding of the overbank area. Riparian vegetation promotes filtration of fine particles with attached nutrients, and overbank flooding promotes additional filtration and to some extent infiltration, which both reduce nutrient loads and concentrations.

As part of its ongoing efforts to evaluate the effectiveness of its control strategies, the Authority undertook an investigation to address the following questions:

- Is stream reclamation beneficial to water quality, and if so, why?
- Is stream reclamation used by other agencies or organizations to improve water quality, and what is their experience?
- Does the Authority's data support stream reclamation as a cost effective way to improve water quality in the reservoir and Cherry Creek?

- What additional information is needed to further document water quality benefits of stream reclamation?
- How does stream reclamation fit into future PRFs and other watershed management techniques?

The Authority's Stream Reclamation, Water Quality Benefit Evaluation-Interim Status Report, finalized in 2011, concluded that stream reclamation is beneficial to water quality in the stream and the reservoir. Stream reclamation reduces sediment and other pollutant loads and concentrations, including phosphorus and nitrogen. Load and concentration reductions during base and storm flow conditions occur by reducing flow velocities, providing greater areas for filtration and infiltration of stormwater, and, to some extent, through increases in dissolved oxygen. This finding is supported by the Authority's water quality data collected to evaluate PRFs. For example, the data for Cottonwood Creek (discussed in further detail in Section 5.5 above) shows that stream reclamation projects can reduce phosphorus loads and concentrations to levels below the target flow-wieghted concentration levels of 0.20 mg/l suggested by the Authority during the last triennial review of Regulation 72. The Cottonwood Creek data also suggest that stream reclamation may reduce nitrogen loads and concentrations. These findings are supported by the literature. More monitoring data are needed to further evaluate the benefits of stream reclamation projects. The report also documented two quantitative methodologies that could be used for evaluating stream reclamation projects. The first is based primarily on economic factors, and the second is based solely on hydraulic characteristics of the stream. The report also provided several recommendations for further evaluations and refinement of the procedures used to calculate nutrient reductions and to estimate costs and benefits.

Stream reclamation has been and should continue to be a priority for the Authority in the future.

# 7 WATER QUALITY MONITORING – RESERVOIR AND WATERSHED CHARACTERISTICS AND STATUS OF WATER QUALITY COMPLIANCE

The Authority continued to implement a routine annual water quality monitoring program in the Cherry Creek Reservoir and basin, which has been in place since 1992. The program monitors reservoir and tributary water quality, inflow and outflow, loads and exports, surface and groundwater quality in the watershed, and PRF effectiveness.

## 7.1 Sampling Sites

Reservoir sampling during the 2011 water year was routinely conducted at three sites in Cherry Creek Reservoir (CCR-1, CCR-2, and CCR-1, Figure 7-1). The Authority also conducted intensive samplings along a reservoir transect to help evaluate the effectiveness of the destratification system (sites D1-D10).

Tributary streams (Cherry Creek, Cottonwood Creek, and Shop Creek) were monitored just upstream of the reservoir to calculate inputs to the reservoir; one site downstream of the reservoir was also monitored to determine net annual loading (CC-10, CT-2, SC-3, and CC-0).

Sites upstream and downstream of the Cottonwood Creek Peoria Pond PRF (CT-P1 and CT-P2) and the Cottonwood Creek Wetlands Pond PRF (CT-1 and CT-2), are sampled to evaluate the effectiveness of the Cottonwood Creek Stream Reclamation Project .

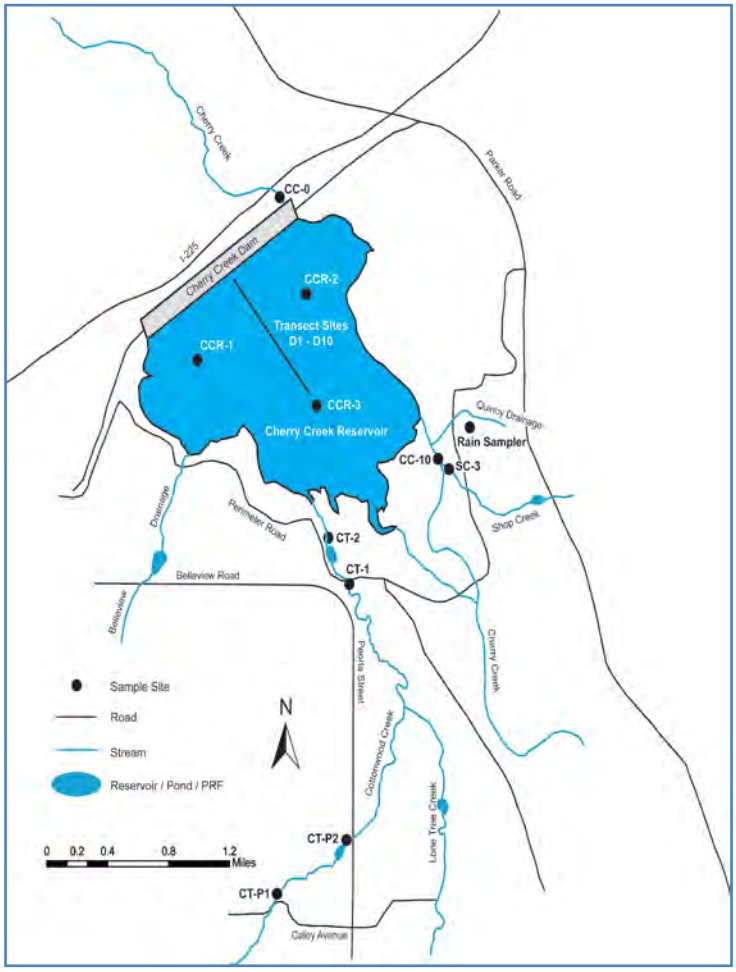



Figure 7-1. Sampling Sites on Cherry Creek Reservoir and Selected Streams.

Watershed monitoring includes an additional seven surface water sites along Cherry Creek, from Castlewood Canyon to Cherry Creek Reservoir (CC-1 through CC-8; note that CC-7, not shown, was abandoned in 2000 due to development), and seven alluvial groundwater well locations from Franktown to Cherry Creek RCastlewood and MW-1 through MW-9; note that MW-4, abandoned in 2002 due to development, MW-7, abandoned in 2000, and MW-8, abandoned in 2002, are not shown.) (Figure 7-2).

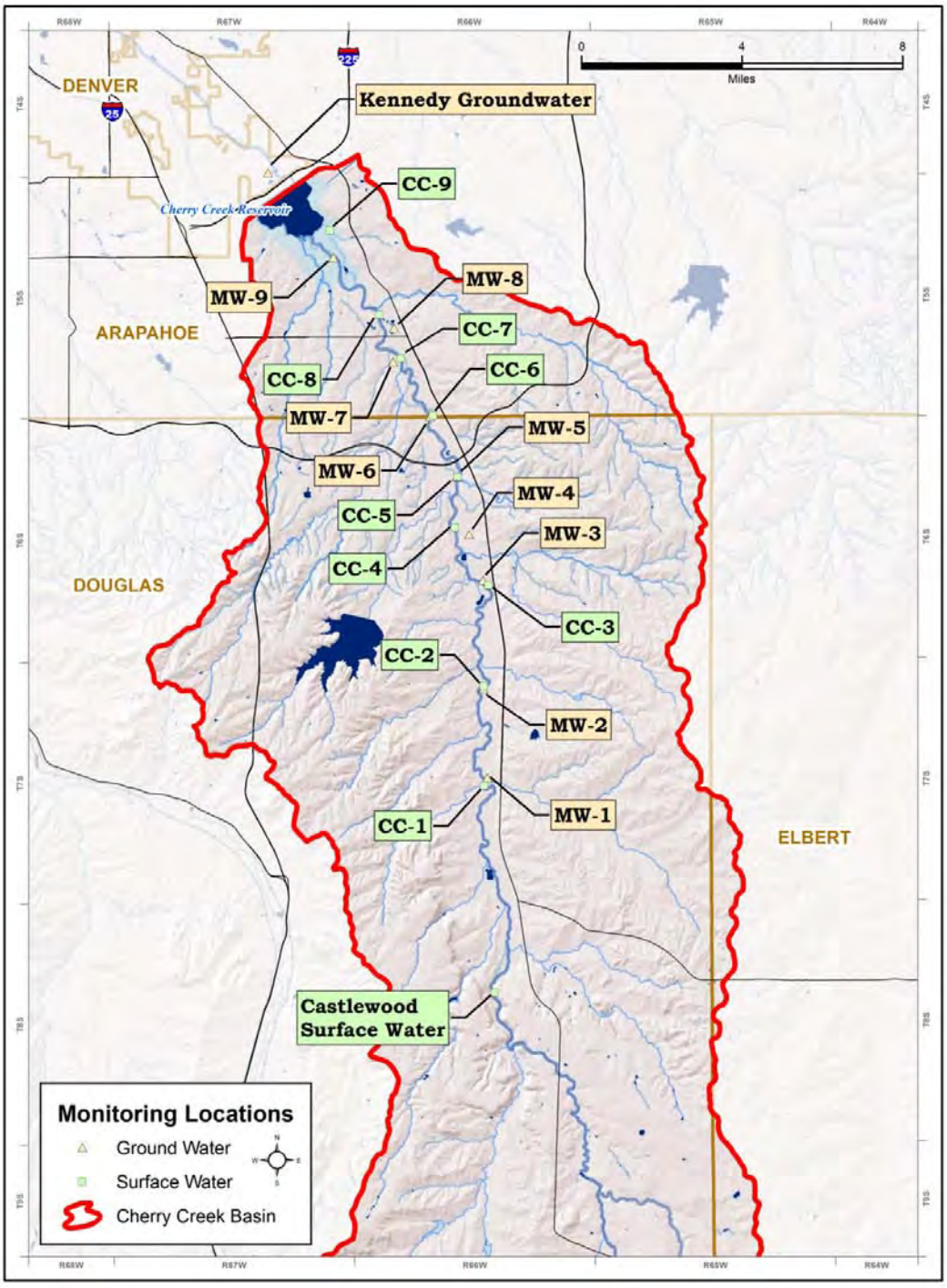



Figure 7-2. Surface Water and Alluvial Groundwater Sampling Sites in the Watershed.

Complete data report for the reservoir and PRFs provided in the Cherry Creek Reservoir 2011 Water Year Aquatic Biological-Nutrient Monitoring Study and Cottonwood Creek Pollutant Reduction Facilities Monitoring Report prepared by GEI Consultants, Inc. (2011 Annual Monitoring Report).

## 7.2 Reservoir Water Quality

Presented below is a summary of water quality in Cherry Creek Reservoir as determined by various water quality parameters. This summary is based on the past 20 years of monitoring, as presented in the 2011 Water Year Monitoring Report. The 2011 flows, loads, and flow-weighted concentrations are based on the water year designation (October 2010 - September 2011); and all historical flows, loads, and flow-weighted concentrations were recalculated to provide comparative results.

### 7.2.1 2011 Reservoir Water Quality

In 2011, the July through September mean chlorophyll α content in Cherry Creek Reservoir was 26.7 µg/l, which exceeded the seasonal standard of 18 µg/l. This is the second consecutive year when the seasonal mean chlorophyll α value has exceeded the growing season standard of 18 µg/l. As a result, the reservoir is not attaining the site-specific chlorophyll α standard based on the allowable exceedance frequency of once in five years. The 2011 water year (WY) flow-weighted phosphorous concentration for all of the sources of inflow to the reservoir was 212 µg/l.

#### *7.2.1.1 Chlorophyll α*

The pattern of chlorophyll α concentrations was quite variable with chlorophyll α less than 18 µg/l during the spring and early summer, but higher during late summer and fall 2011. Algal production is typically the lowest during the spring time of year, when the reservoir experiences flushing flows from spring runoff and seasonal storms. During the fall and winter, diatoms typically dominate the algal community and the chlorophyll α levels increase due to their increased chloroplast size and light capturing abilities of these algae (Figure 7-3). The January sampling event occurred during ice-covered conditions (~8 inches ice with snow cover) and the chlorophyll α level was 22.0 µg/l.

The summer growing season exhibited chlorophyll α concentrations ranging from 21.9 µg/l to a peak of 35.5 µg/l in September. The seasonal mean chlorophyll α concentration was 26.7 µg/l . This value is greater than the seasonal mean chlorophyll α standard of 18 µg/l that is to be attained in four out of five consecutive years.

Chlorophyll α concentrations over the entire water year ranged from a low of 13.6 µg/l in mid-June to 48.6 µg/l in early August 2011.

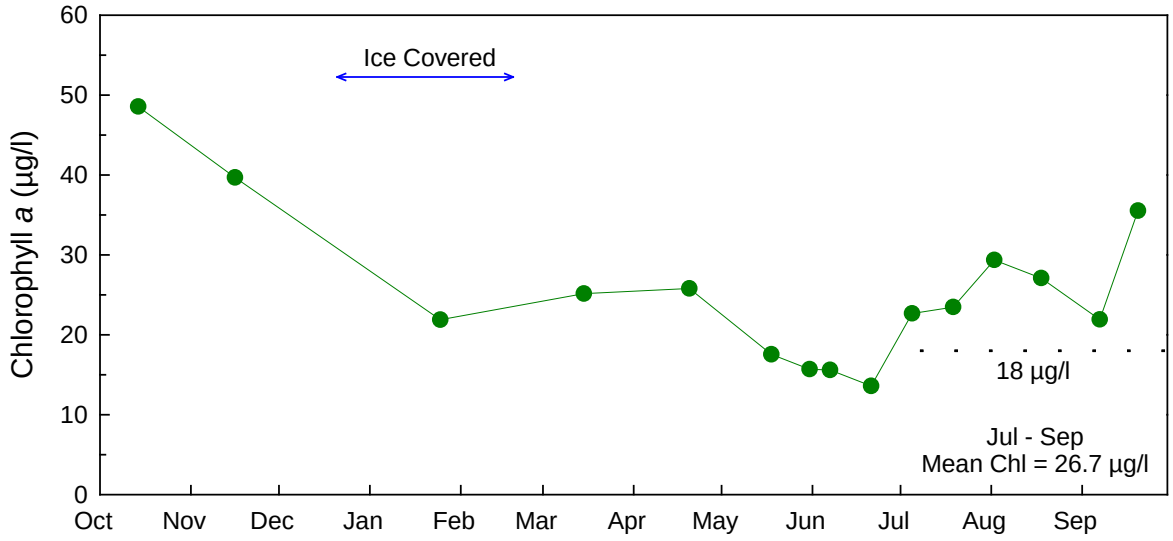



Figure 7-3. Chlorophyll *α* (µg/l) Levels in Cherry Creek Reservoir, 2011 WY

### 7.2.1.2 Phosphorus

Nutrient profile samples showed the reservoir was well-mixed throughout the year. Nutrients were released from bottom sediments from mid-May through late August, peaking in mid-July, as revealed by the increasing phosphorus concentrations for the 7 m layer (Figure 7-4). This layer showed the highest phosphorus concentrations (up to 270 µg/l). The upper layers (photic zone to 5m) were more consistent, though also elevated. This is due to the upward diffusion of phosphorus from the bottom sediment layer (approximately 7.5 meters) and the eventual circulation within the upper layers by the destratification system. The destratification system creates a well-mixed phosphorus layer from the surface down to approximately 5 to 6 m, which is slightly above the aerator heads (approximately 0.75 m above the sediment). During July and August, the soluble reactive phosphorus fraction at the sediment interface accounted for approximately 47 to 69 percent of the total phosphorus content, also indicating phosphorus release from the sediments.

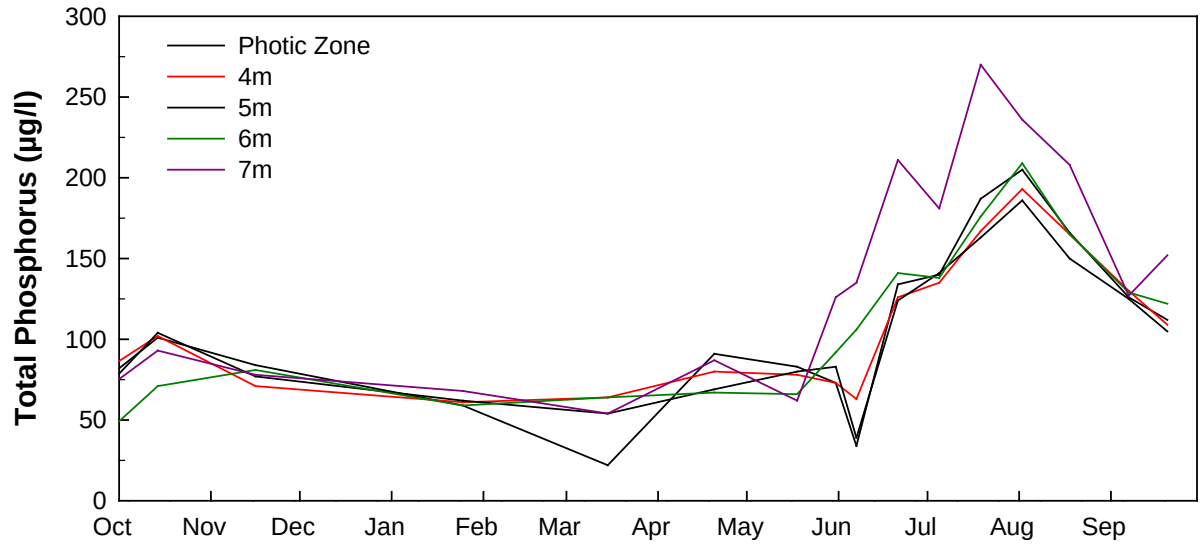



Figure 7-4. Total Phosphorus Concentrations Measured in Cherry Creek Reservoir, 2011 WY

### 7.2.1.3 Nitrogen

Photic zone total nitrogen concentrations at Site CCR-2 ranged from 550 to 1,231 µg/l, with a WY mean value of 905 µg/l (Figure 7-5). At this site, during the July to September period, the photic zone total nitrogen concentration ranged from 804 to 1,231 µg/l, with a mean concentration of 1,045 µg/l. The internal loading component from a total nitrogen standpoint is not as evident as total phosphorus when compared to baseline conditions throughout the water year; although there are periods when ammonium is released from the sediments and is readily available for assimilation by algae.

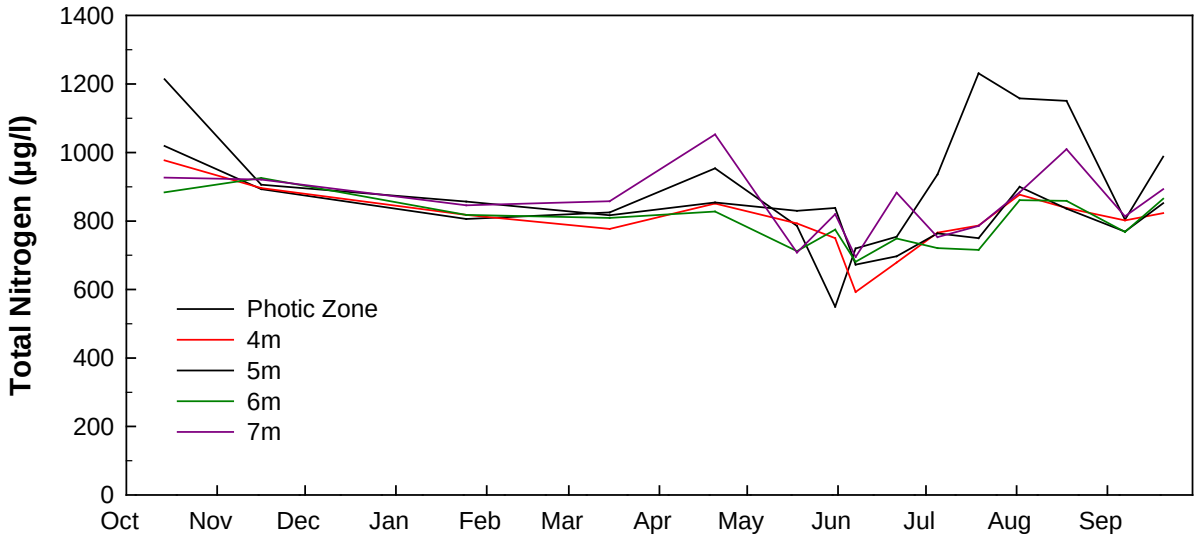



Figure 7-5. Total Nitrogen Concentrations Measured in Cherry Creek Reservoir, 2011 WY

### 7.2.1.4 Transparency

Lake transparency values (as measured by Secchi depth) in 2011 ranged between 0.51 m in mid-October 2010 to 1.28 m in early May. The seasonal mean Secchi depth was 0.77 m, which is lower than the long-term mean value of 1.07 m.

[Note: A Secchi disk is lowered into the water to measure transparency or clarity of the water. The Secchi depth is the depth at which the disk is no longer visible from the surface.]

### 7.2.1.5 Temperature and Dissolved Oxygen

Analysis of past Cherry Creek Reservoir temperature profiles indicates that stratification occurs when there is a >2°C difference between surface and bottom temperatures. Differences of less than approximately 1°C suggest a recent mixing event. Using these criteria, Cherry Creek Reservoir was investigated for periods of stratification using the continuous temperature record at multiple depths for Site CCR-2 (May to September) and dissolved oxygen levels (Figures 7-6, 7-7, and 7-8). Temperature loggers were deployed on April 20, 2011 when the reservoir typically begins to show evidence of variation in water temperature. Based on Site CCR-2 data, the reservoir showed signs of brief thermal stratification for approximately five days in early June, three

days in mid-June, eight days in late June, and nine days in mid-July. During these brief stratification periods mid-July, the deeper water layers of the reservoir exhibited low dissolved oxygen concentrations (<5mg/l). These low dissolved oxygen levels persisted in the deeper waters throughout much of the summer period, despite the effectiveness of the destratification system at minimizing thermal stratification.

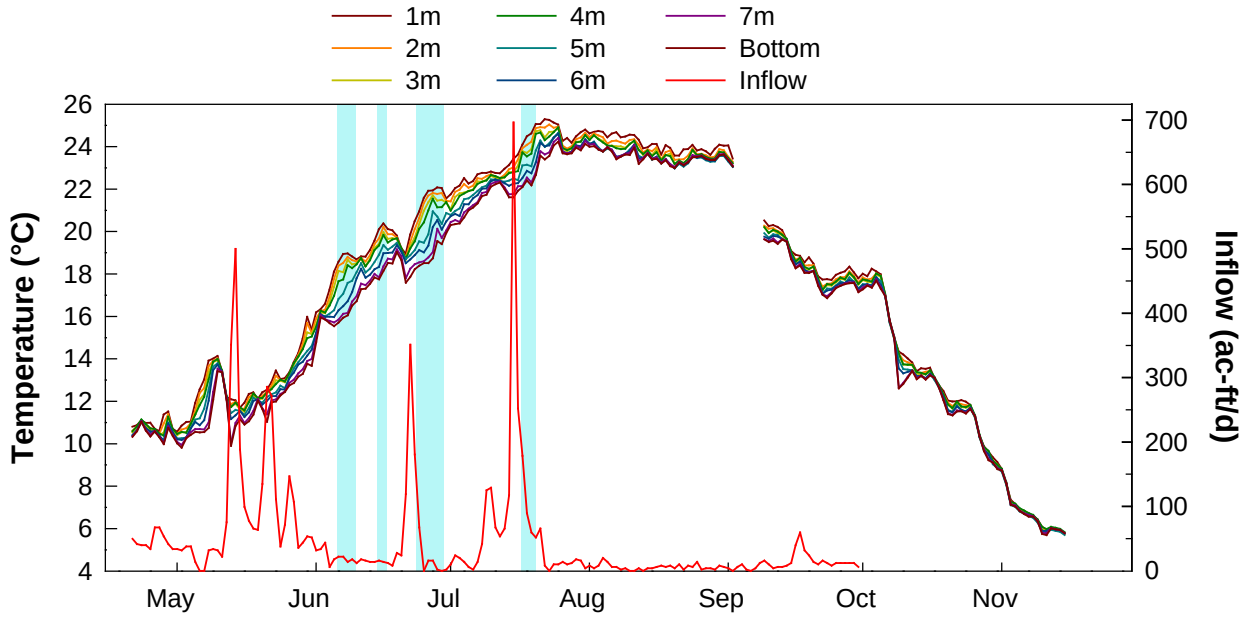



Figure 7-6. Temperature (°C) Profiles Recorded During Continuous Monitoring at Site CCR 2 COE Inflow During the 2011 (highlighted areas represent thermal stratification and duration, and the break in the data resulted from redeploying the array)

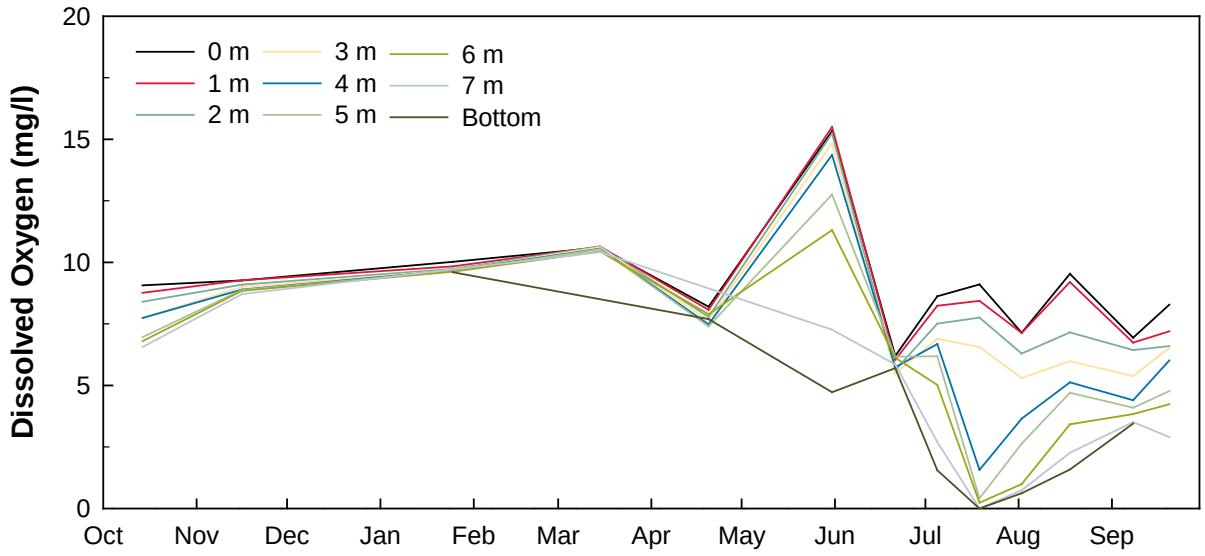



Figure 7-7. Dissolved Oxygen (mg/l) Profiles Recorded During Routine Monitoring at Site CCR 2 in 2011 WY

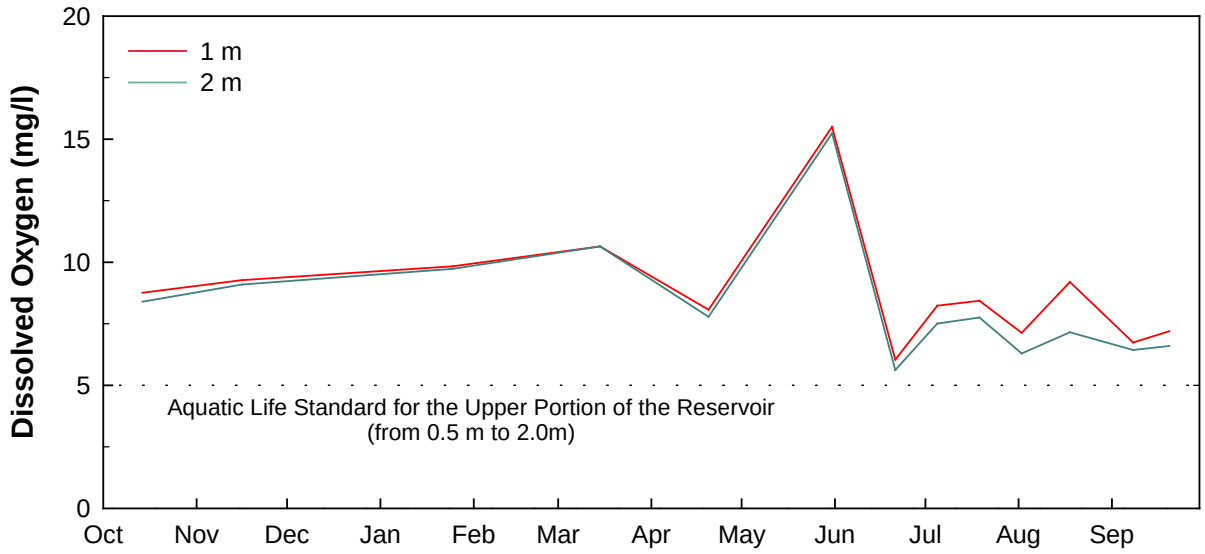



Figure 7-8. Dissolved Oxygen (mg/l) Profiles Recorded During Routine Monitoring at Upper Portion of Reservoir at Site CCR 2 in 2011 WY

In 2011, the July through September mean chlorophyll αcontent in Cherry Creek Reservoir was 26.7 µg/l, which exceeded the seasonal standard of 18 µg/l. This is the second consecutive year when the seasonal mean chlorophyll α value has exceeded the growing season standard of 18 µg/l. As a result, the reservoir is not attaining the site-specific chlorophyll α standard based on the allowable exceedance frequency of once in five years. The 2011 water year (WY) flow-weighted phosphorous concentration for all of the sources of inflow to the Reservoir was 212 µg /l. In terms of other physical and biological standards such as temperature, dissolved oxygen and pH, the reservoir was in attainment with the relevant water standards during the 2011 WY.

The daily maximum temperature (rolling 2-hour average, DM) and maximum weekly average temperature (MWAT), at a depth of 1 meter below the surface, were 26.6°C and 25.0°C, respectively. The Warm Lakes summer (April – December) DM and MWAT standards are 29.3°C and 26.5°C, respectively. The average dissolved oxygen concentration within the 1 to 2m layer of the Reservoir ranged from 5.5 to 10.8 mg/l for 68 sample events and was in attainment of the Warm Class 1 dissolved oxygen standard of 5.0 mg/l for the Reservoir. Given the high seasonal chlorophyll α levels, there is also the possibility of elevated pH levels. As algae photosynthesize and take up carbon dioxide ($CO_2$) the pH will increase. The maximum pH level observed during any sampling event throughout the water column (0 – 6 m) ranged between 7.5 and 8.8 pH units, while the minimum pH levels was always greater than 7.3 pH units. The table value standards for the reservoir is a range from 6 to 9 pH units.

### 7.2.2 Long-Term Cherry Creek Reservoir Water Quality

Table 7-1 summarizes chlorophyll α and nutrient data over the growing season for the past 20 years. It is important to note that:

- Chlorophyll α levels have exceeded the standard of 18 µg/l for the past two years, causing the reservoir to be out of compliance with standard which allows an exceedence frequency of only once in five years.
- The 2011 seasonal mean total phosphorus concentration (154 µg/l) is the largest concentration on record for the reservoir and considerably greater than the long-term median of 88 µg/l.
- The 2011 seasonal mean total nitrogen concentration was 987 µg/l, which was greater than the long-term median value of 929 µg/l.

| Table 7-1. Growing Season Chlorophyll α and Nutrient Data and Water Year Inflow and Loading Data for Cherry Creek Reservoir, 1992 – 2011 | | | | | | |
|---|---|---|---|---|---|---|
| Year | Chlorophyll *α* (µg/l) Jul - Sep | Total Phosphorus (µg/l) Jul - Sep | Total Nitrogen (µg/l) Jul - Sep | Phosphorus Load (lbs/yr) WY | Inflow (ac-ft/yr) WY | Flow-weighted Phosphorus Concentration (µg/l) WY |
| 1992 | 17.4 | 66 | 970 | 4,800 | 8,029 | 220 |
| 1993 | 14.8 | 62 | 826 | 3,185 | 5,898 | 199 |
| 1994 | 15.4 | 59 | 1,144 | 3,929 | 7,353 | 196 |
| 1995 | 15.6 | 48 | 913 | 5,576 | 11,484 | 179 |
| 1996 | 18.2 | 62 | 944 | 4,571 | 7,976 | 211 |
| 1997 | 22.0 | 96 | 1,120 | 4,338 | 7,920 | 201 |
| 1998 | 26.5 | 89 | 880 | 13,673 | 21,114 | 238 |
| 1999 | 28.6 | 81 | 753 | 16,508 | 25,821 | 235 |
| 2000 | 25.1 | 81 | 802 | 14,598 | 20,265 | 265 |
| 2001 | 26.1 | 87 | 741 | 10,077 | 18,726 | 198 |
| 2002 | 18.8 | 74 | 858 | 3,751 | 8,045 | 171 |
| 2003 | 25.8 | 90 | 1,121 | 9,372 | 15,035 | 229 |
| 2004 | 18.4 | 102 | 977 | 7,386 | 13,492 | 201 |
| 2005 | 17.1 | 116 | 990 | 11,526 | 20,404 | 208 |
| 2006 | 14.7 | 87 | 914 | 6,184 | 12,192 | 187 |
| 2007 | 12.6 | 118 | 716 | 19,611 | 28,443 | 254 |
| 2008 | 16.6 | 118 | 800 | 9,388 | 19,525 | 177 |
| 2009 | 13.2 | 98 | 819 | 16,063 | 27,152 | 218 |
| 2010 | 31.0 | 101 | 974 | 14,496 | 26,638 | 200 |
| 2011 | 26.7 | 154 | 987 | 9,312 | 16,120 | 212 |
| **Mean** | **20.2** | **89** | **933** | **9,417** | **16,082** | **210** |
| **Median** | **18.3** | **88** | **929** | **9,341** | **15,577** | **205** |

### 7.2.2.1 Long-Term Chlorophyll α Concentrations

The long-term chlorophyll α record shows considerable variability within and among the seasons (Figure 7-9).

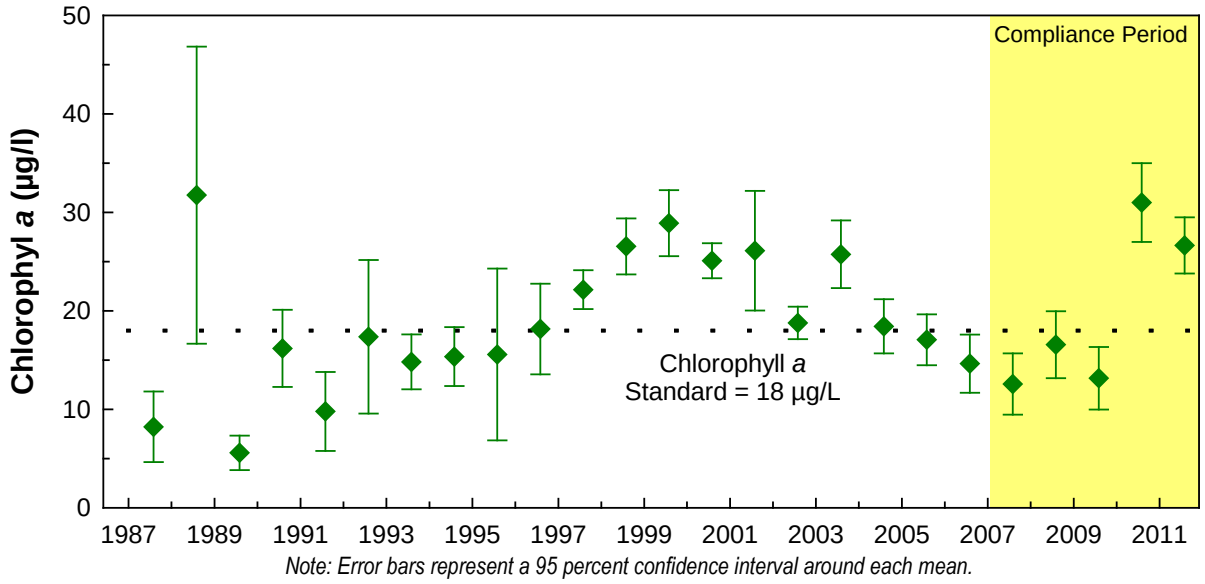



Figure 7-9. Seasonal Mean (July to September) Chlorophyll α Concentrations Measured in Cherry Creek Reservoir, 1992 to 2011

### 7.2.2.2 Long-Term Phosphorus Concentrations

Routine monitoring data collected since 1992 indicate an increasing trend in the seasonal mean concentration of total phosphorus (Figure 7-10).

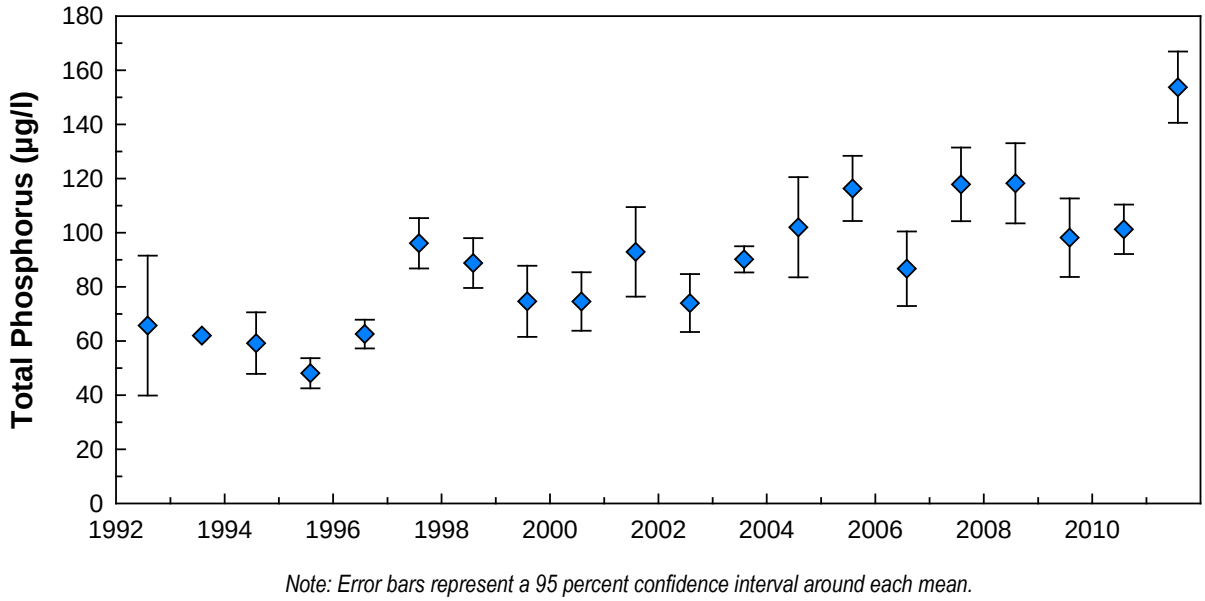



Figure 7-10. Seasonal Mean (July to September) Total Phosphorus Concentrations (µg/l) Measured in Cherry Creek Reservoir, 1992-2011

### 7.2.2.3 Long-Term Nitrogen Concentrations

Routine monitoring data collected since 1992 indicate there is no trend in the seasonal mean concentration of total nitrogen (Figure 7-11).

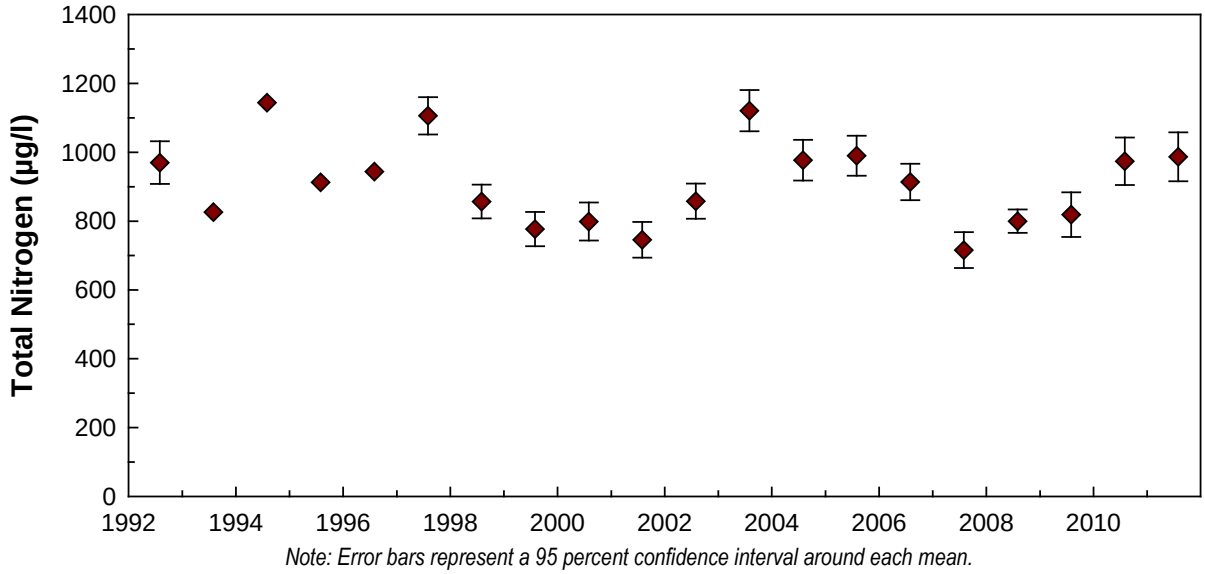



Figure 7-11. Seasonal Mean (July to September) Total Nitrogen Concentrations (µg/l) Measured in Cherry Creek Reservoir, 1987-2011

## 7.3 Reservoir Inflows

Nutrients that can limit or enhance algal growth in a reservoir have many sources, either within the reservoir (internal loading) or from outside the reservoir (external loading). Fish and plankton excrement, direct sediment re-supply, and the decay of organic matter are all internal sources of nutrients in a reservoir. Based on recent modeling efforts, net internal phosphorus loading to Cherry Creek Reservoir has been estimated to be 2,000 lbs/yr (Nürnberg and LaZerte 2008). Other studies evaluating internal loading using a variety of methodologies suggest phosphorus loading ranges between 810 lbs/yr and 1,590 lbs/yr (AMEC et al. 2005), and alluvial phosphorus loads of approximately 1,170 lbs/yr (Lewis et al. 2005).

External sources of nutrients include inflow from streams and precipitation, which carry nutrients from soil erosion, agricultural and municipal runoff, treated wastewater, and airborne particulates. Phosphorus loading was determined for several primary sources in 2011, including the tributary streams Cottonwood Creek, Cherry Creek, and Shop Creek, as well as from precipitation and alluvium, as summarized below.

Total phosphorus loading to the reservoir from surface flows of Cherry Creek and Cottonwood Creek was estimated at 8,009 lbs for the 2011 WY (Table 7-2). The annual flow-weighted phosphorus concentrations from surface flows of Cherry Creek and Cottonwood Creek were 263 µg/l and 81 µg/l, respectively, and when combined the flow-weighted total phosphorus concentration for surface streams was 222 µg/l. When the other two sources of inflow, precipitation and alluvium, are considered the external flow-weighted phosphorus concentration for all sources of inflow to the reservoir was 212 µg/l during the 2011 WY.

**Table 7-2. Normalized Phosphorus Loads, Exports, and Flow-Weighted Phosphorus Concentrations for Cherry Creek Reservoir, 1992 to 2011**

| | Loads and Exports | | | Flow-weighted Concentrations | | |
|---|---|---|---|---|---|---|
| Water Year | Cherry Creek Load (lbs/yr) | Cottonwood Creek Load (lbs/yr) | Total External Load[A] (lbs/yr) | Cherry Creek Flow-weighted (µg/l) | Cottonwood Creek Flow-weighted (µg/l) | External Flow-weighted (µg/l) |
| 1992 | 3,007 | 344 | 4,800 | 268 | 172 | 220 |
| 1993 | 1,534 | 233 | 3,185 | 251 | 189 | 199 |
| 1994 | 2,524 | 169 | 3,929 | 247 | 88 | 196 |
| 1995 | 2,081 | 1,400 | 5,576 | 190 | 203 | 179 |
| 1996 | 2,587 | 602 | 4,571 | 234 | 331 | 211 |
| 1997 | 2,159 | 622 | 4,338 | 266 | 184 | 201 |
| 1998 | 10,107 | 1,827 | 13,673 | 282 | 176 | 238 |
| 1999 | 10,606 | 1,279 | 16,508 | 271 | 134 | 235 |
| 2000 | 11,822 | 1,384 | 14,598 | 312 | 159 | 265 |
| 2001 | 6,293 | 2,108 | 10,077 | 257 | 130 | 198 |
| 2002 | 2,098 | 443 | 3,751 | 221 | 88 | 171 |
| 2003 | 6,215 | 1,055 | 9,372 | 287 | 138 | 229 |
| 2004 | 4,316 | 1,643 | 7,386 | 247 | 157 | 201 |
| 2005 | 8,770 | 1,351 | 11,526 | 247 | 120 | 208 |
| 2006 | 3,580 | 1,230 | 6,184 | 231 | 132 | 187 |
| 2007 | 15,999 | 2,075 | 19,611 | 295 | 149 | 254 |
| 2008 | 7,263 | 833 | 9,388 | 205 | 84 | 177 |
| 2009 | 13,608 | 937 | 16,063 | 276 | 62 | 218 |
| 2010 | 12,065 | 1,039 | 14,496 | 239 | 78 | 200 |
| 2011 | 7,354 | 655 | 9,312 | 263 | 81 | 212 |
| **Mean** | **6,669** | **1,061** | **9,417** | **254** | **143** | **210** |
| **Median** | **6,254** | **1,047** | **9,342** | **254** | **138** | **205** |

[A]*Includes ungaged residual load.*

Long-term trends in total phosphorus, inflow, and flow-weighted total phosphorus cohcentrations in the reservoir are shown in Figure 7-12.

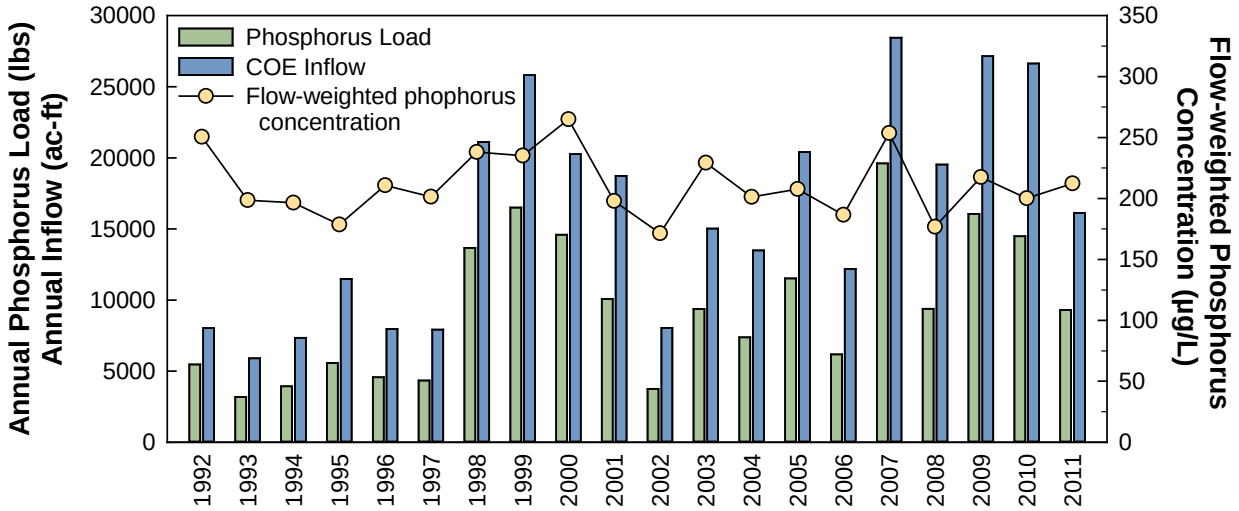



Figure 7-12. Long-Term Trends in Total Phosphorus Load (lbs/yr), Inflow (ac-ft/yr), and Flow-weighted Total Phosphorus Concentration (µg/l) from Cherry Creek Reservoir, 1992 to 2011 WY

Inflow data, measured as the change in reservoir elevation by the COE, was influenced by storm flow events in 2011 (Figure 7-13). In particular, the storm events on June 20 and July 15 greatly influenced reservoir conditions as evident in the temperature and dissolved oxygen conditions in the reservoir). The 2011 WY inflow was 16,120 acre-feet.

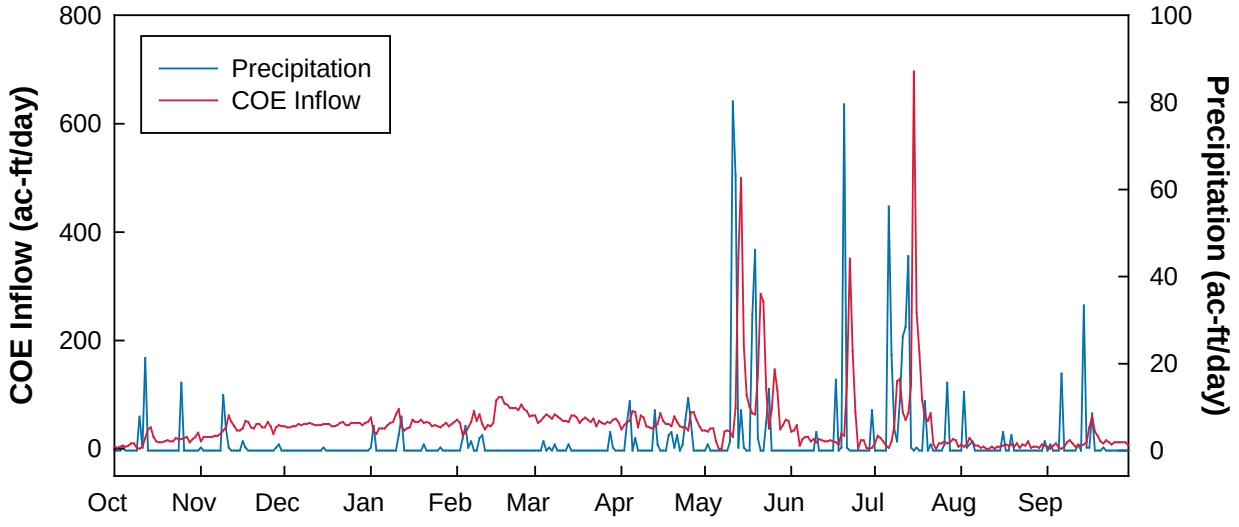
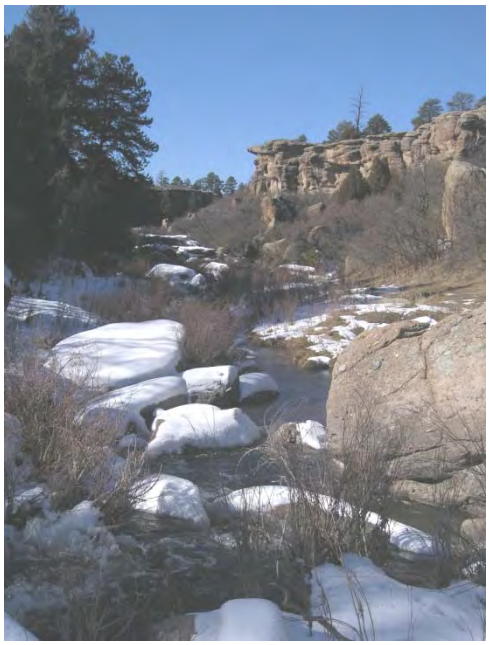



Figure 7-13. Comparison of Direct Precipitation on the Reservoir and Inflow for 2011 WY

### 7.3.1 Phosphorus Contributions from Precipitation

The 2010 WY precipitation, as measured by the KAPA rain gage located at Centennial Airport approximately 4.3 miles due south of Cherry Creek Reservoir, was 12.4 inches and accounted for approximately 5 percent of the total COE inflow volume. Given the approximate surface area of Cherry Creek Reservoir (852 acres), and the long-term (1995-2005) median total phosphorus concentration (116 µg/l) for precipitation events, total phosphorus loading was estimated to be 278 pounds.

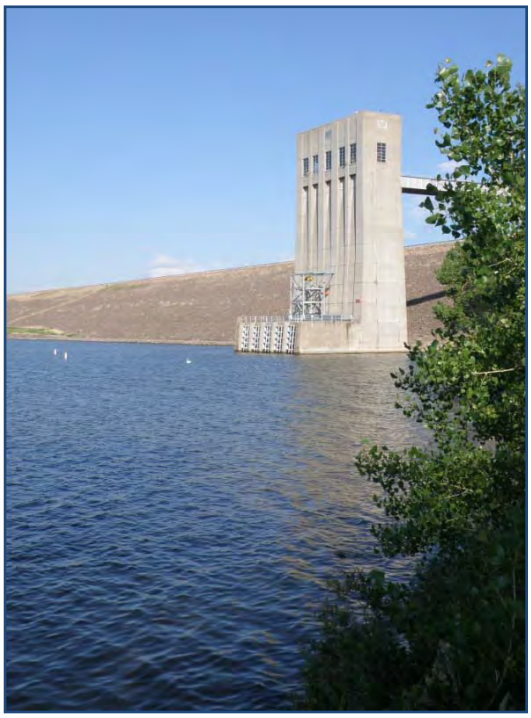


### 7.3.2 Alluvial Phosphorus Inflows

The alluvial phosphorus load for the 2011 WY was 1,025 lbs. The 2011 WY load estimate utilized a normalized alluvial water budget value of 1,983 ac-ft/yr and a long-term median total dissolved phosphorus concentration from MW-9 of 190 µg/l.

### 7.3.3 Reservoir Outflows

The COE daily outflow and monthly total phosphorus concentrations from the outlet structure at the base of the dam near Interstate Highway I-225 were used to estimate the total phosphorus export of 4,113 lbs from the reservoir via the outflow structure during the 2011 WY. The reservoir export flow-weighted total phosphorus concentration was 108 µg/l for the 2011 WY.



### 7.3.4 Phosphorus Mass Balance

In general, the phosphorus mass balance for Cherry Creek Reservoir is comprised of phosphorus inflow (influent streams, precipitation, and alluvium) and reservoir outflow. During the 2011 WY, phosphorus contribution from precipitation was an estimated 278 lbs, influent streams contributed 8,009 lbs, and alluvial inflow contributed 1,025 lbs (Figure 7-13) for a total load of 9,312 lbs. Outflow from the dam contained an estimated 4,133 lbs. After totaling the additions and losses, the net loading of phosphorus was estimated at 5,179 lbs during the 2011 WY (Figure 7-14). The 2011 WY flow-weighted total phosphorus concentration for all sources inflow to the Reservoir is 212 µg/l (Table 7-2).

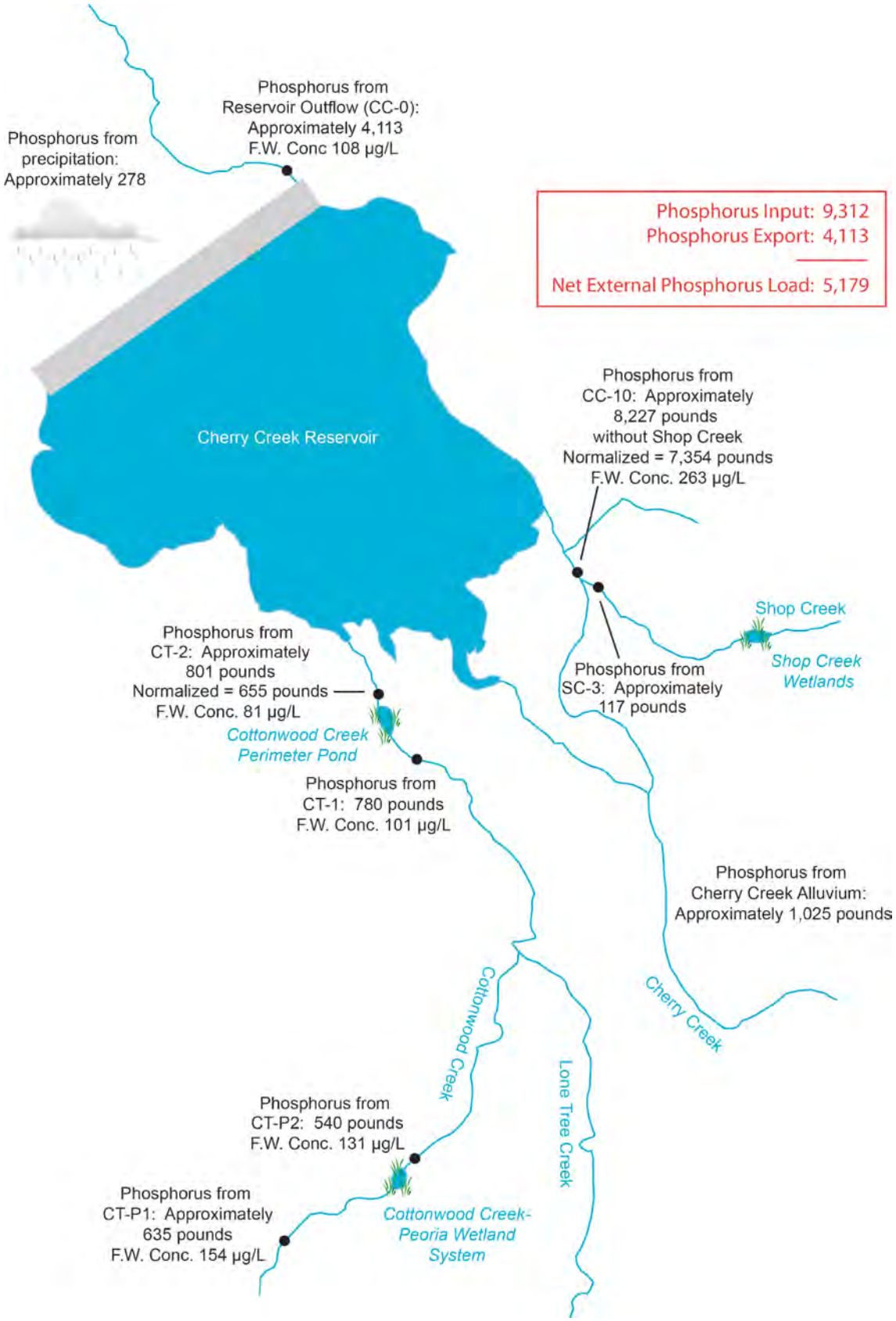



Figure 7-14. Mass Balance Diagram of Phosphorus Loading in Cherry Creek Reservoir, 2011 WY

## 7.4 Reservoir Destratification System

In 2008, the Authority embarked on a new reservoir management strategy based upon aeration to control nuisance algal growth (large bodied cyanobacteria) within the reservoir through destratification. The destratification system was primarily designed to reduce the periods of thermal stratification as well as to reduce the suitable habitat conditions for cyano-bacteria by vertical mixing. Over time, it was estimated the destratification system could reduce the internal phosphorus load to approximately 50 percent of historical conditions by limiting the periods of stratification (AMEC 2005). In addition, the destratification system was anticipated to reduce both the seasonal mean and peak annual chlorophyll α concentrations in the reservoir by controlling nuisance cyanobacteria blooms. The uncertainty associated with these objectives lies both in the timing (when) and magnitude (how) of potential benefits that the reservoir might experience. This past 2011 summer season represented the fourth operating year for the destratification system. To help evaluate the effectiveness of the destratification system, the Authority installed continuous temperature loggers at 1 m intervals at three reservoir monitoring sites, as well as performed additional transect surveys at approximately 100 m intervals perpendicular to the dam to evaluate temperature, dissolved oxygen, and oxidation reduction potentials at the sediment-water interface.

Based on the continuous temperature data recorded at three sites over the past five years, the reservoir has experienced a substantial reduction in the number of days it was thermally stratified during the summer season (Figure 7-15). The destratification system has been effective in reducing the periods of thermal stratification in the reservoir – which was one of the primary objectives of system.

Despite the efficient mixing characteristics of the destratification system as observed in the temperature and nutrient data, the reservoir continues to exhibit low dissolved oxygen conditions and a reducing environment at the water-sediment interface (Figure 7-16). In July, the transect profiles (D1-D10) revealed dissolved oxygen conditions were generally less than 3 mg/l at the 5 meter depth and became anoxic (<1 mg/l) at the sediment interface (Figure 7-16). The oxidation reduction potential (ORP) also revealed a highly reducing environment (<-180 mV) at the sediment-water interface. Under these conditions, soluble reactive

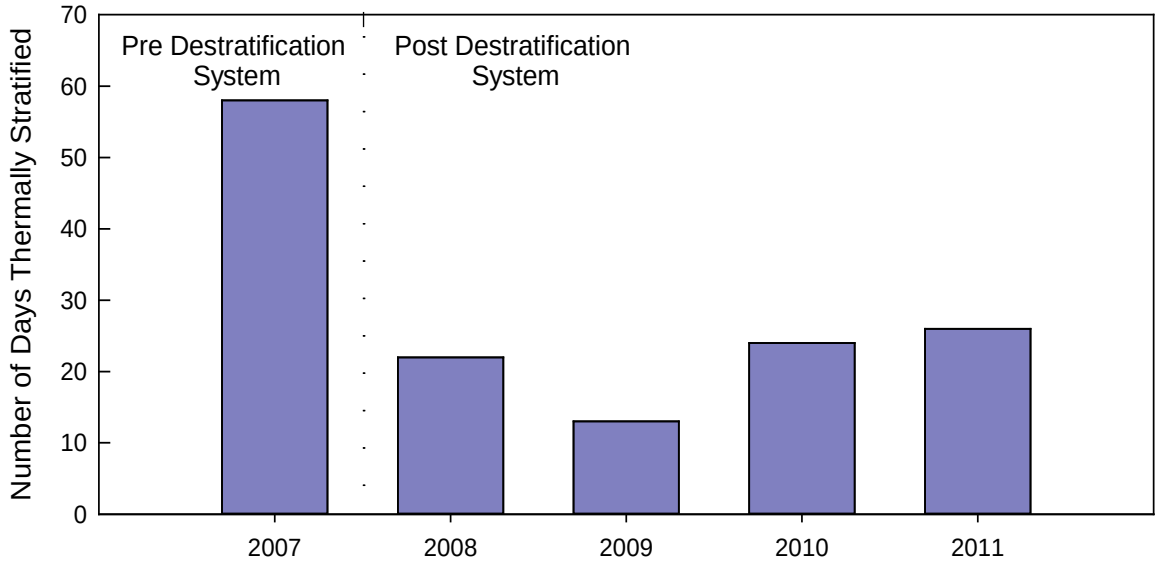



Figure 7-15. Number of Days that Cherry Creek Reservoir was Thermally Stratified, Pre- and Post-Operation of the Destratification System

phosphorus (SRP) was released from the sediment and rapidly became available to the algal community in the upper water layers through the mixing action of the system. These reservoir conditions, low dissolved oxygen and reducing environment at the sediment-water interface, which are favorable for internal nutrient loading were present from early June to mid-August. The sediment oxygen demand remains high for the reservoir and it will likely take a number of years for the destratification system to reduce the oxygen demand at the sediment interface.

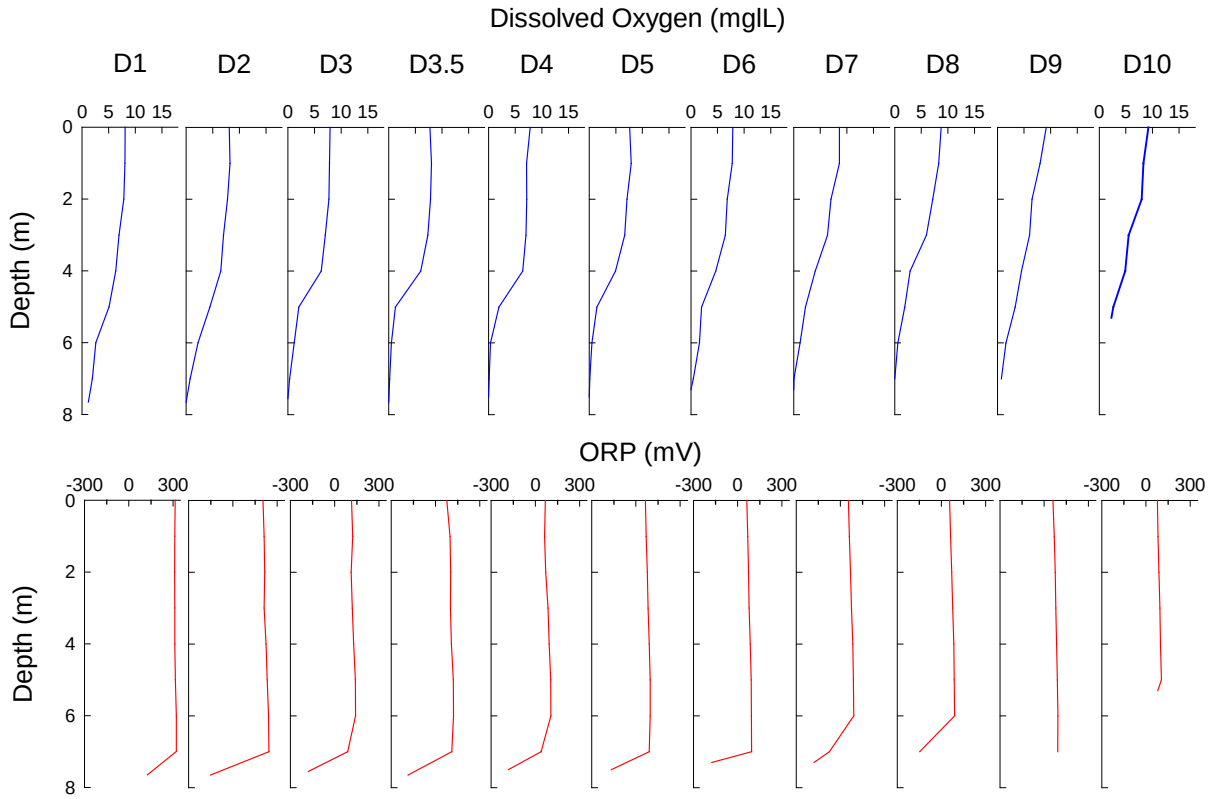



Figure 7-16. Dissolved Oxygen and Oxidation Reduction Potential in Cherry Creek Reservoir, July 2011

As observed in previous years, the algal community showed a time-lag response to the influx of SRP being released from the sediment as indicated by the pattern of high chlorophyll αconcentrations in July and August (Figure 7-17). In early September the internal loading component greatly decreased which coincided directly with the sharp decline in algal biomass as measured by chlorophyll α. There was one period in early June when the algal assemblage appeared to be able to incorporate a large fraction of SRP pool in the upper photic zone, 4 m and 5m layers as evident in the reduction of SRP while 7m concentration was increasing through this period. However, there was no indication of phosphorus limitation during the summer 2011. During 2011 the dissolved inorganic nitrogen fraction ( DIN) was present in sufficient quantities throughout the water column. Similar to recent years data, the algal community revealed typical responses to nutrient availability as evident in chlorophyll α concentrations, and the change in relative species composition to one dominated by more beneficial algae rather than cyanobacteria remains a consistent pattern.

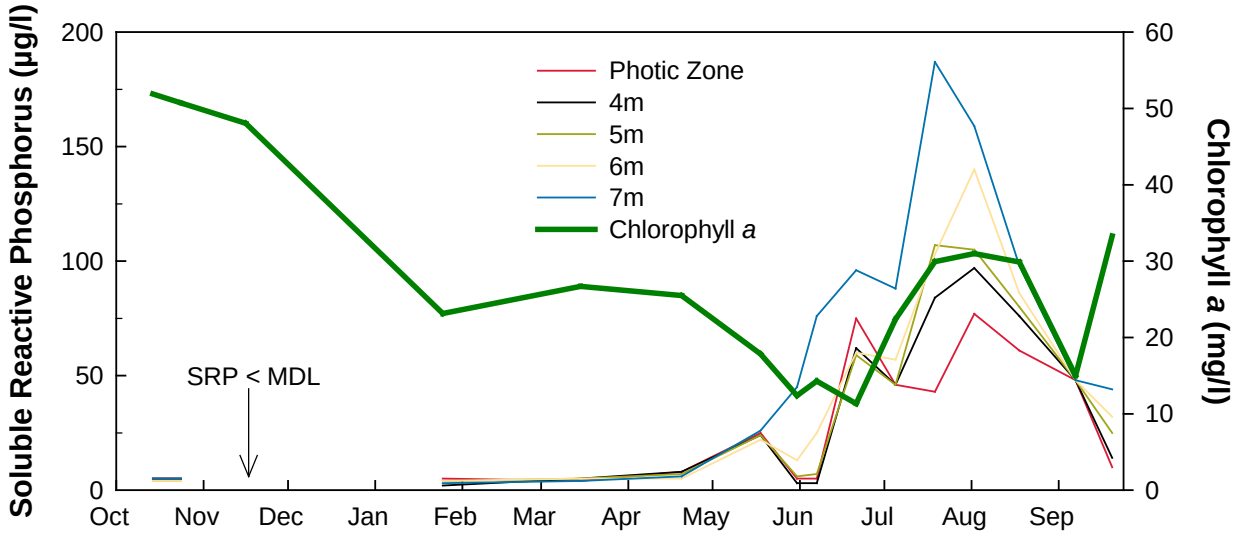



Figure 7-17. Soluble Reactive Phosphorus and Chlorophyll α Concentrations Measured in Cherry Creek Reservoir, 2011 WY

One of the primary objectives of the destratification system was to reduce the suitable habitat conditions for cyanobacteria (blue-green algae) by vertical mixing which would disrupt the ability of cyanobacteria to efficiently grow in the upper water layers. Cyanobacteria can produce toxins that inhibit the growth of competing algae as well as inhibit grazing by zooplankton that rely on algae as a food source. Historically, the nuisance chlorophyll α levels (i.e., > 30 mg/l) during the summer have always been associated with cyanobacteria blooms. However, during the past three years the reservoir has exhibited a shift in the algal species composition such that cyanobacteria have been a very small component of the assemblage (Figure 7-18). Prior to the operation of the destratification system, cyanobacteria represented between 40 and 80 percent of assemblage in terms of density (cells/ml). During the first season of operation in 2008, green algae and cyanobacteria were still the dominant types of algae, with cyanobacteria dominating the summer assemblage. However, since 2009 the cyanobacteria population has been greatly reduced representing between 1.3% and 7% of the algal assemblage in terms of density cyanobacteria population has been greatly reduced, representing between 1 and 7 percent of the algal assemblage in terms of density (Figure 7-18).

Cryptomonads, diatoms, and green algae have become the dominant algal types, all of which are a substantial food source for zooplankton and fish. This shift in algal composition is notable as it provides some initial results that validate the effectiveness of the destratification system at achieving another of the primary objectives – reducing suitable habitat conditions for cyanobacteria. The destratification system's efficient vertical mixing allows the more beneficial algal types (eg. cryptomonads, diatoms, and green algae) a competitive advantage over cyanobacteria, in terms of nutrient and light resources. However, as a consequence of the efficient mixing, the relatively constant supply of soluble nutrients to algal community

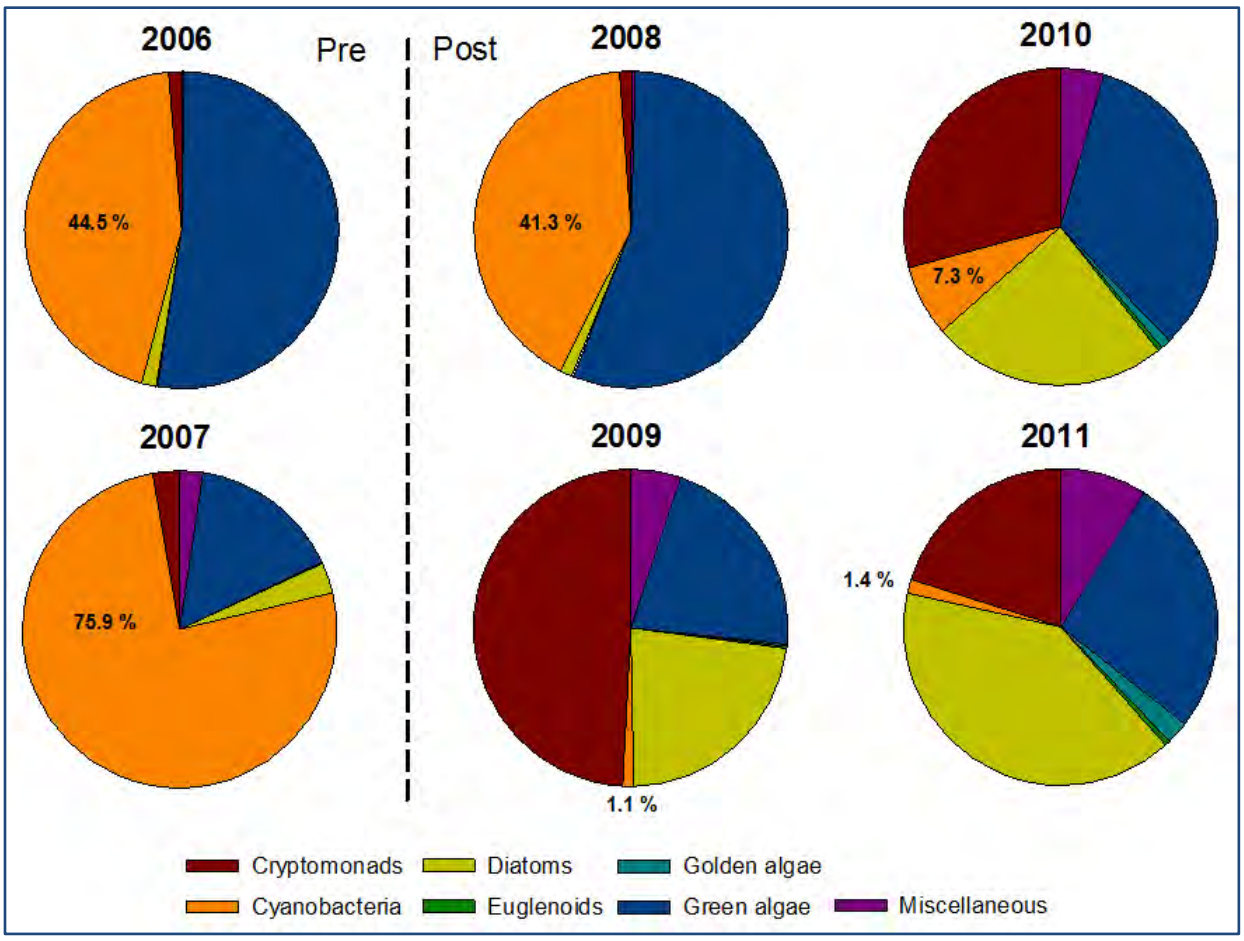



Figure 7-18. Percent Algal Density by Major Taxonomic Grouping for Cherry Creek Reservoir, Pre- and Post-Operation of the Destratification System. Data are representative of biological production year (i.e., calendar year rather than water year).

allows them to maximize their productivity. As a result, the reservoir exhibited extremely high chlorophyll α levels during the July to September 2011 growing season which again exceeded the growing season chlorophyll α standard. The response of the algal community to the new management strategy is not well understood, and the Authority is currently outlining an approach to focus on the mechanisms and effects that these results may have on other biological assemblages such as the zooplankton and fish as well as other uses of the reservoir. As mentioned earlier, it may take considerable more time for the destratification system to reduce the sediment oxygen demand and effectively control internal nutrient loading which drives the late summer production.

The observed shift in algal composition combined with the exceedance of the chlorophyll α standard raises other questions regarding ecosystem function and the food web. While the shift in algal composition is apparent, it remains uncertain whether other biological assemblages have had sufficient time to respond to the changes at the base of the food web. For example, how did the zooplankton respond to the increased primary productivity? Were zooplankton able to effectively graze on the algae and reduce algal biomass or has the gizzard shad (fish) population been over grazing the zooplankton population such that algae received little grazing pressure by the zooplankton. Understanding these basic food chain interactions and evaluating the responses of other aquatic life under the new reservoir management practices became a focus of the Authority as zooplankton data were collected in 2011.

## 7.5 PRF Monitoring

PRF effectiveness is gauged by monitoring the concentration of phosphorus and suspended solids and the phosphorus loading upstream and downstream of each facility. Evaluation of the effectiveness of the Cottonwood Creek Stream Reclamation Project was performed using the data collected at the existing PRFs both upstream and downstream of the reclamation reach.

### 7.5.1 Cottonwood Creek-Peoria Pond

The 2011 WY flow-weighted phosphorus concentration upstream of the PRF was 153 µg/l, while the flow-weighted concentration downstream of the system was 131 µg/l (Table 7-3). This represents a 14 percent decrease in flow-weighted total phosphorus concentrations downstream of the PRF. Total suspended solids also showed a substantial decrease downstream of the PRF, being reduced by 38 percent. This PRF underwent sediment removal maintenance in 2008, and continues to be very efficient in reducing phosphorus and sediment from Cottonwood flows.

**Table 7-3. Annual Average Total Suspended Solids and Flow-Weighted Total Phosphorus Concentrations Through the Cottonwood Creek-Peoria Wetland Pond**

| Parameter | Water Year | Sampling Sites | | Difference | Percent Change Downstream |
|---|---|---|---|---|---|
| | | CT-P1 | CT-P2 | | |
| Average Total Suspended Solids (mg/l) | 2002 | 81 | 74 | -7 | -9 |
| | 2003 | 30 | 33 | 3 | 10 |
| | 2004 | 104 | 51 | -53 | -51 |
| | 2005 | 50 | 53 | 3 | 6 |
| | 2006 | 13 | 13 | 0 | 0 |
| | 2007 | 78 | 41 | -37 | -47 |
| | 2008 | 36 | 34 | -2 | -6 |
| | 2009 | 48 | 27 | -21 | -44 |
| | 2010 | 34 | 26 | -8 | -24 |
| | 2011 | 48 | 30 | -18 | -38 |
| | **Mean** | **52** | **38** | **-14** | **-20** |
| Flow-weighted Total Phosphorus (µg/l) | 2002 | 142 | 118 | -24 | -17 |
| | 2003 | 117 | 109 | -8 | -7 |
| | 2004 | 132 | 132 | 0 | 0 |
| | 2005 | 129 | 119 | -10 | -8 |
| | 2006 | 146 | 140 | -6 | -4 |
| | 2007 | 156 | 120 | -36 | -23 |
| | 2008 | 128 | 92 | -36 | -28 |
| | 2009 | 114 | 83 | -31 | -27 |
| | 2010 | 106 | 96 | -10 | -9 |
| | 2011 | 153 | 131 | -22 | -14 |
| | **Mean** | **132** | **114** | **-18** | **-14** |

## 7.5.2 Cottonwood Creek Reclamation and Wetlands Pond

In 2008, the Cottonwood Creek Reclamation Project was completed which relocated the channel to its historic location and substantially reduced the amount of erosion by widening the channel and dissipating the flow energy through this reach. This channel stabilization and reclamation project has greatly reduced the amount of phosphorus in flows through this reach. The 2011 WY flow-weighted phosphorus concentration at the upstream reach of the Cottonwood Creek Reclamation Project was 131 µg/l (Site CT-P2, Table 7-3) while the flow-weighted phosphorus concentration at the downstream reach was 101 µg/l (Site CT-1; Table 7-4). During the past four years, the flow-weighted phosphorus concentration at this site has been reduced by approximately 45 percent as compared to the previous 10 years. Similarly, the total suspended solids concentration has been greatly reduced during the past few years at the downstream reach of the reclamation project (Site CT-1). These data support the Authority's goal for stream stabilization/reclamation to provide a water quality benefit to the Cherry Creek Watershed and Reservoir.


During the 2011 WY, the Cottonwood Creek Wetlands Pond PRF exhibited some variable results as compared to recent year's efficiencies, because the PRF actually showed some efficiency of removing sediment and total phosphorus from the flows despite the accumulated sediment in the basin. The 2011 WY flow-weighted total phosphorus concentration upstream of the Wetlands Pond PRF was 101 µg/l while the downstream flow-weighted concentration was 81 µg/l, indicating a net loss due to the PRF. The mean total suspended solid concentration upstream and downstream of the Wetland Pond PRF was 48 mg/l and 31 mg/l , respectively, also indicating a net benefit downstream of the PRF. While the results show this PRF was efficient during the 2011 WY, the effectiveness of the Cottonwood Wetlands Pond has diminished over the past few years. During the 2012 winter, this PRF will undergo maintenance with the accumulated sediment being removed in a effort to enhance the overall efficiency of the PRF again.

| Table 7-4. Annual Average Total Suspended Solids and Flow-Weighted Total Phosphorus Concentrations Through the Cottonwood Wetlands Pond | | | | | |
|---|---|---|---|---|---|
| Parameter | Water Year | Sampling Sites | | Difference | Percent Change Downstream |
| | | CT-1 | CT-2 | | |
| Annual Average Total Suspended Solids (mg/l) | 1997 | 207 | 87 | -120 | -58 |
| | 1998 | 311 | 129 | -182 | -59 |
| | 1999 | 267 | 68 | -199 | -75 |
| | 2000 | 96 | 64 | -32 | -33 |
| | 2001 | 79 | 43 | -36 | -46 |
| | 2002 | 150 | 86 | -64 | -43 |
| | 2003 | 83 | 58 | -25 | -30 |
| | 2004 | 156 | 128 | -28 | -18 |
| | 2005 | 123 | 65 | -58 | -47 |
| | 2006 | 31 | 20 | -11 | -35 |
| | 2007 | 93 | 64 | -29 | -31 |
| | 2008 | 31 | 59 | 28 | 90 |
| | 2009 | 31 | 32 | 1 | 3 |
| | 2010 | 33 | 33 | 0 | 0 |
| | 2011 | 48 | 30 | -18 | -38 |
| | Mean | 116 | 64 | -52 | -28 |
| Flow-weighted Total Phosphorus (µg/l) | 1997 | 485 | 183 | -302 | -62 |
| | 1998 | 311 | 176 | -135 | -43 |
| | 1999 | 143 | 129 | -14 | -10 |
| | 2000 | 266 | 161 | -105 | -39 |
| | 2001 | 163 | 146 | -17 | -10 |
| | 2002 | 124 | 105 | -19 | -15 |
| | 2003 | 193 | 124 | -69 | -36 |
| | 2004 | 194 | 149 | -45 | -23 |
| | 2005 | 141 | 120 | -21 | -15 |
| | 2006 | 165 | 135 | -30 | -18 |
| | 2007 | 170 | 148 | -22 | -13 |
| | 2008 | 87 | 86 | -1 | -1 |
| | 2009 | 70 | 61 | -9 | -13 |
| | 2010 | 77 | 77 | 0 | 0 |
| | 2011 | 101 | 81 | -20 | -20 |
| | Mean | 179 | 125 | -54 | -21 |

## 7.6 Water Quality in Cherry Creek and Cottonwood Creek

As noted in Section 7.1, watershed monitoring includes an additional seven surface water sites along Cherry Creek. These data are summarized below, using data from monitoring stations at Castlewood Canyon (upstream background), CC-1, CC-4, and CC-9. Site CC-1 is located on Cherry Creek at the confluence with McMurdo Gulch, below Castle Rock. Site CC-4 is located below the Pinery and Parker Water and Sanitation South wastewater treatment facility discharges. Site CC-9 is located just upstream of the reservoir.

The results of the 2011 data for Cherry Creek are summarized in the following series of figures, showing data for the Castlewood, CC-1, CC-4, and CC-9 sites. In all figures, the darkest color is the furthest upstream site (Castlewood), grading to the lightest color which is the furthest downstream site (CC-9). By comparing differences in concentrations at each of these surface flow stations, the changes in water quality resulting from urbanization can be seen. Little or no change in concentrations can be interpreted as maintaining water quality, while reduction in concentrations suggest that watershed control measures may be improving water quality. Interpretations for station CC-9, just before Cherry Creek enters the reservoir, are the focus of the discussion below.

Figure 7-19 shows total phosphorus concentrations from 1994 through 2011. Total phosphorus is the measure of the combined impact from total dissolved phosphorus (TDP), soluble reactive phosphorus (SRP), and particulate forms of phosphorus. The data show that total phosphorus has increased at CC-9 but may now be in a downward trend at CC-9, which suggests that watershed controls may be working.

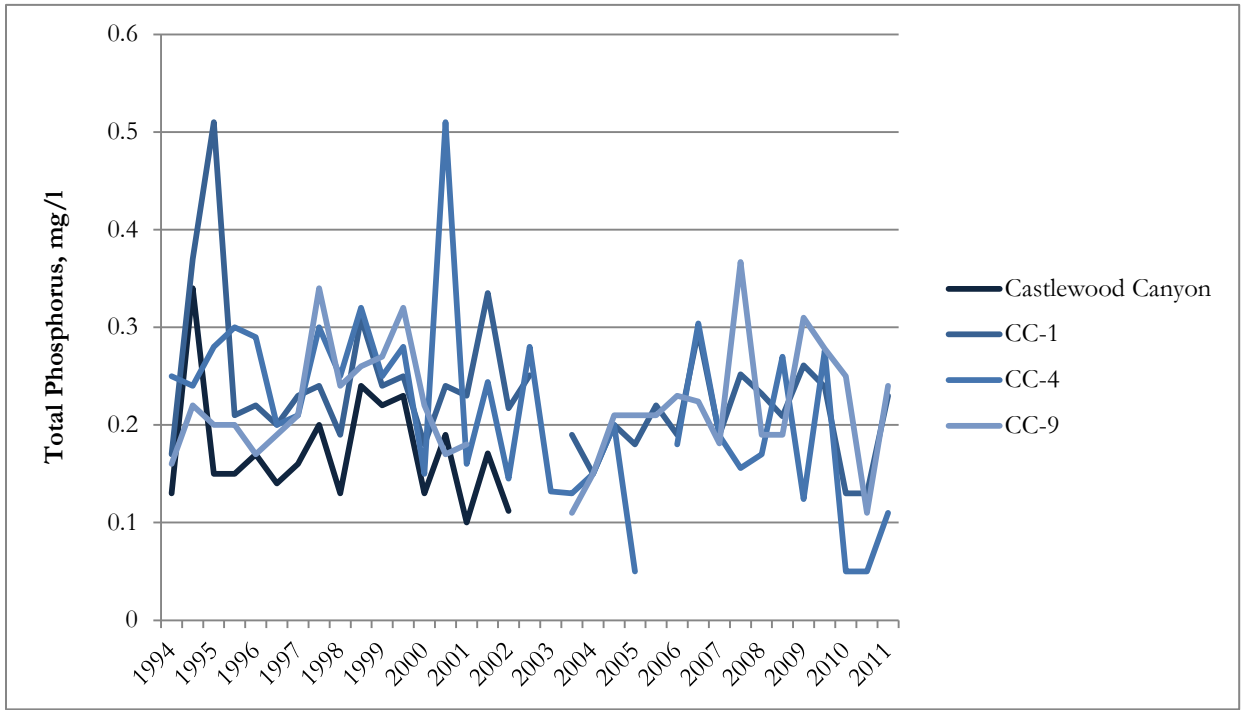



Figure 7-19. Total Phosphorus Concentration Measured at Surface Water Stations Castlewood, CC-1, CC-4, and CC-9

Figure 7-20 shows SRP concentrations from 1994 through 2011. SRP is a measure of the more biological available form of phosphorus that promotes algal growth. The data show that SRP has increased at CC-9 but appears to be more constant over time. Since nutrients generally increase with urbanization, this trend suggests that watershed controls may be working.

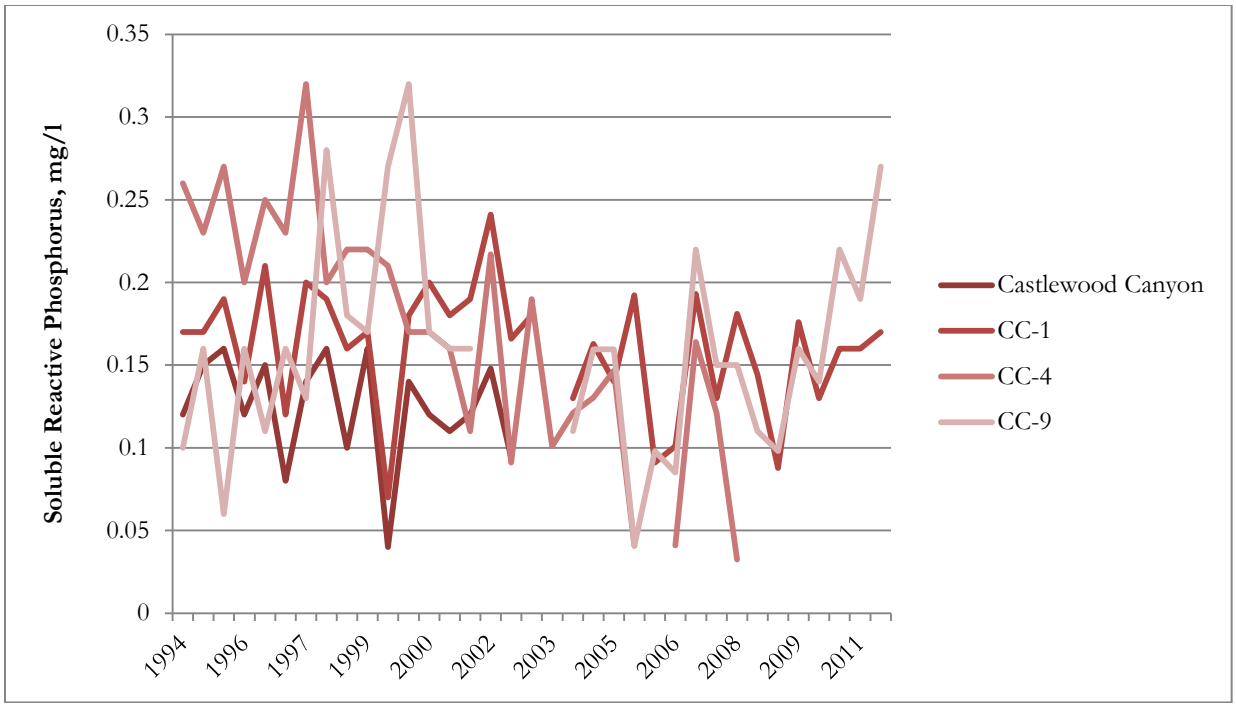



Figure 7-20. Soluble Reactive Phosphorus Concentration Measured at Surface Water Stations Castlewood, CC-1, CC-4, and CC-9

Figure 7-21 shows nitrate levels. Nitrogen is a nutrient found in several forms (e.g., ammonia ($NH_4$), nitrite ($NO_2$), and nitrate ($NO_3$)), with nitrate being the most important relative to water quality in Cherry Creek. It is key that concentrations at CC-9 are significantly lower than at CC-4, showing significant removal of nitrate from CC-4. Concentrations at CC-9 are very similar to upstream background concentrations. The data show that nitrate has slightly increased at CC-9 but has remained stable over time. Since nutrients generally increase with urbanization, this trend suggests watershed controls are working.

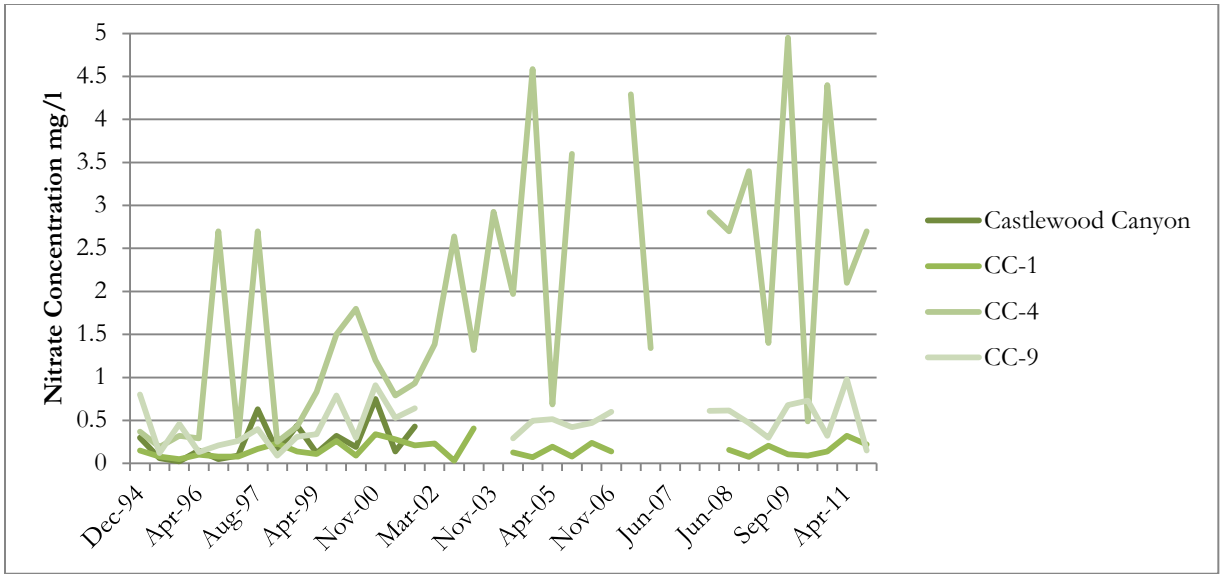



Figure 7-21. Nitrate Concentration Measured at Surface Water Stations Castlewood, CC-1, CC-4, and CC-9

Chloride concentrations are shown in Figure 7-22 for the same stations. Chloride is a chemical compound often found in de-icing agents used to control roadway ice and in water softeners for in-home use. The data show chloride has increased at CC-9 and dramatically over time. Waterhsed controls for de-icing agents through education and use-specific BMPs are a requirement of Control Regulation 72.

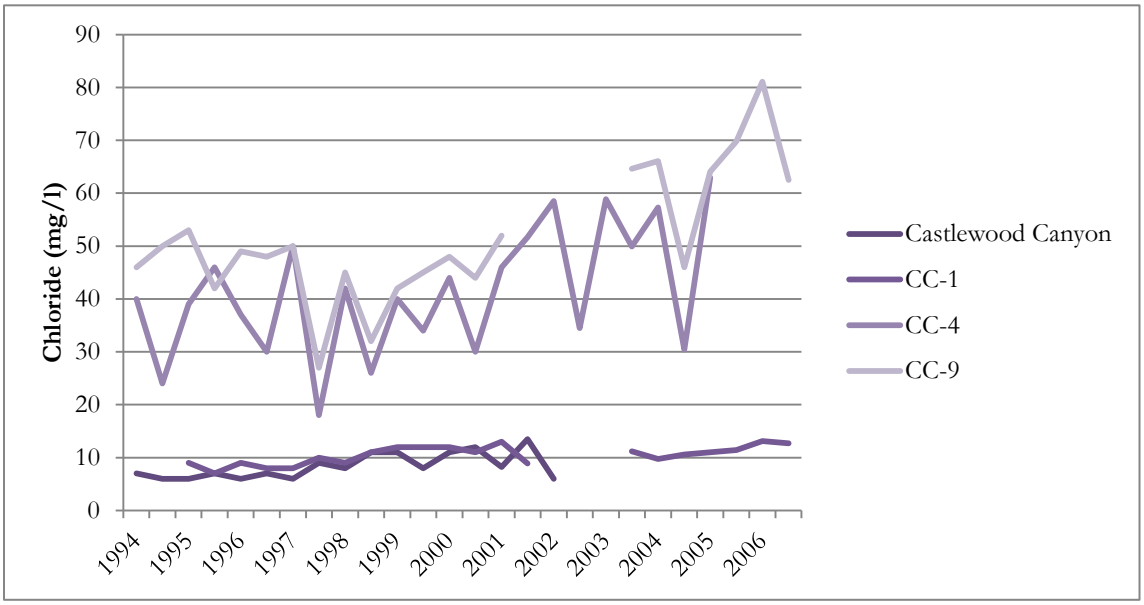



Figure 7-22. Chloride Concentration Measured at Surface Water Stations Castlewood, CC-1, CC-4, and CC-9

Sulfate concentrations are shown in Figure 7-23. Sulfates are the result of wastewater treatment practices to remove phosphorus from the discharge. The data show that sulfates have increased at CC-9 and are currently increasing over time.

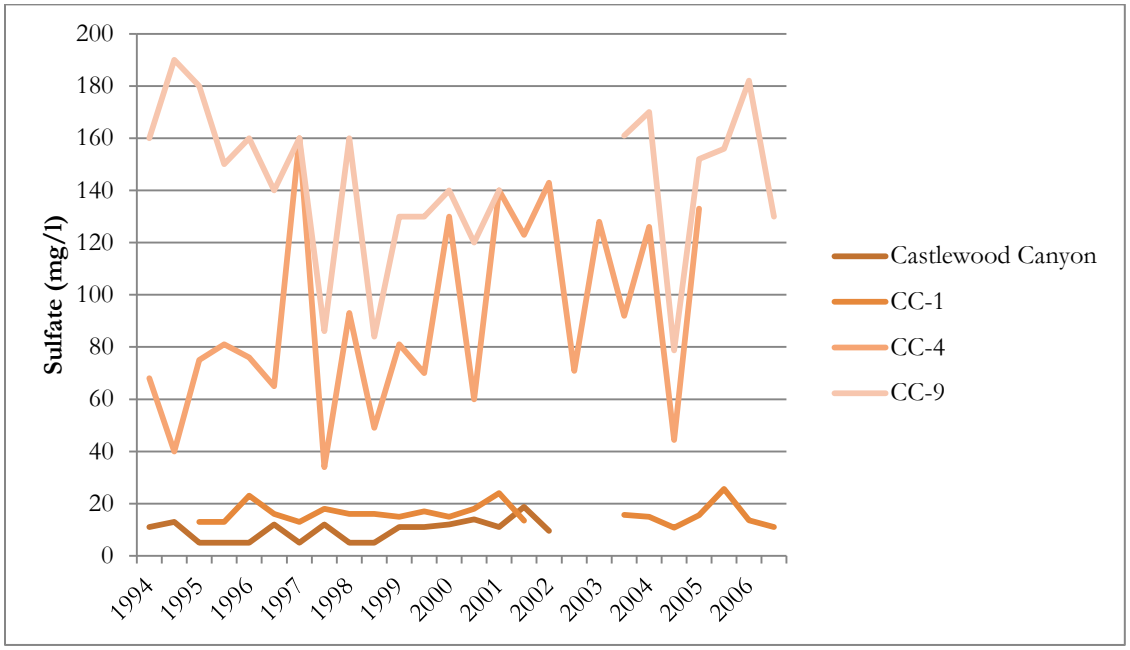



Figure 7-23. Sulfate Concentration Measured at Surface Water Stations Castlewood, CC-1, CC-4, and CC-9

Groundwater monitoring site MW-9 is used to help identify the quality of alluvial groundwater entering Cherry Creek Reservoir. In 2011, it was estimated that 1,025 pounds of phosphorus entered the reservoir via alluvial groundwater.

### 7.6.1 Cottonwood Creek – A Watershed Approach to Phosphorus Controls

Cottonwood Creek is an 8.1-square mile watershed is a direct tributary to Cherry Creek Reservoir draining highly urbanized land from both Arapahoe and Douglas Counties. The watershed underwent extensive growth during the past 20 or so years, with Douglas County being one of the nation's fastest growing counties. It was during this growth period that management techniques described above were implemented by local governments and the Authority. In particular, two large wetland-detention areas and 2.2 miles of stream reclamation were constructed on Cottonwood Creek beginning near the confluence with the reservoir. Construction of these staged measures began in 1996 and was completed in 2008. Local government also began an aggressive regulatory program to implement construction and post-construction BMPs in the tributary watershed during the same period. In addition, wastewater treatment plants were modified at a considerable cost to reduce their discharge of phosphorus to a level of 0.050 mg/l.[4] All of these control measures are believed to be the reasons behind the low phosphorus concentrations in Cottonwood Creek.

Figure 7-24 below shows the history of phosphorus concentrations near the mouth of Cottonwood Creek for base flow using the "box and whisker" approach. The box represents the data range between 25 and 75 percent with the 50 percent value show by the line within the box. The vertical line represents the data range between 5 and 95 percent. The figure shows that base-flow phosphorus concentrations have been reduced over time including the large variation in concentrations. Also note that the data from 2008 through 2011 are below the proposed phosphorus stream-standard (i.e., 170 µg/l) being considered by the Commission.

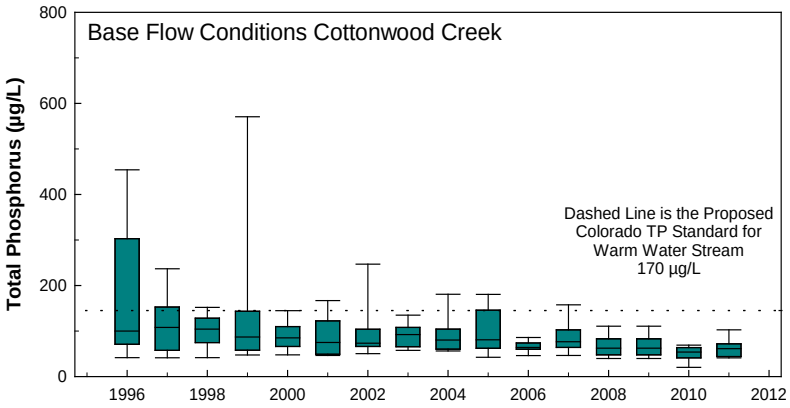



Figure 7-24. Base Flow Phosphorus Concentrations

A similar, but more pronounced trend for reduction in storm-flow phosphorus concentration over time is shown in, Figure 7-25 which shows the data for storm flow conditions. Completion of the stream reclamation in 2008 shows the most dramatic reduction in concentrations, demonstrating how sensitive phosphorus concentrations can be for unstable stream conditions. Also note that the system reduces concentrations to at or below the proposed stream standard for phosphorus, even during storm flow events.

[4] Note that this concentration is less than the Water Quality Control Division's currently proposed phosphorus stream standard of 0.170 mg/l for the March 2012 Rulemaking Hearing for Regulation 31 and Regulation 85.

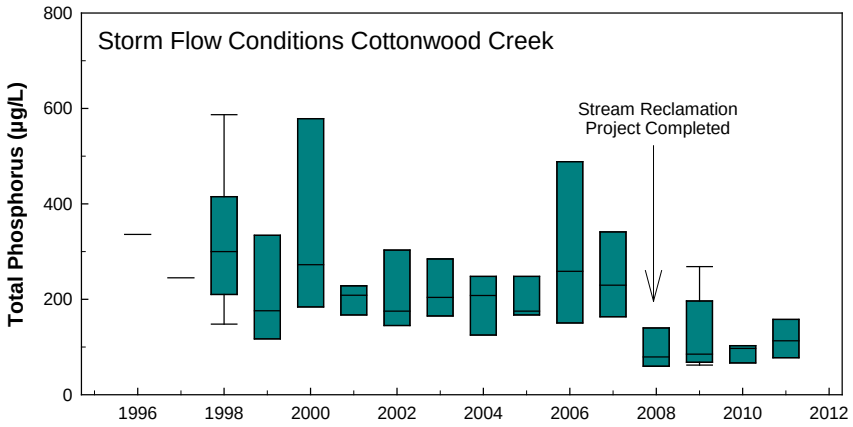



Figure 7-25. Storm Flow Phosphorus Concentrations

## 7.6.2 Cherry Creek – A Larger Watershed Approach in Progress

The phosphorus reduction results achieved in Cottonwood Creek have provided the Authority with the confidence to implement similar control measures on a larger scale within Cherry Creek itself, which is a 386-square-mile watershed. One of the important findings from the Cottonwood Creek example is that any unstable reach of the stream can be a significant source of phosphorus. The Authority in cooperation with local governments has embarked on an extensive program of stream reclamation, focusing nearest to the Reservoir and extending upstream of the Town of Parker and even into a Cherry Creek tributary, McMurdo Gulch, which drains a portion of the Town of Castle Rock. Implementation of stream reclamation in Cherry Creek, in addition to other control measures discussed above, will likely take a decade or more. During this time, Cherry Creek could have higher phosphorus concentrations than Cottonwood Creek.

Because stream reclamation in Cherry Creek is far from complete, the long-term phosphorus data only provides an indication of the potential benefits when compared to Cottonwood Creek, which shows a more definite improvement trend. Keeping in mind that only disconnected reaches of Cherry Creek have been reclaimed[5], the data presented in Figure 7-26 below left tells a different story, one where base flow concentrations have been kept closer to the proposed standard since 2003 and the variations appear to be smaller.

Stormflow concentrations also appear to be decreasing (see) as various reaches of Cherry Creek are reclaimed. However, concentrations are still higher than the proposed stream standard suggesting unstable reaches of Cherry Creek still exist. The reclamation project currently under construction near the dog off-leash area within the Park will restore the Creek alignment to the historic location prior to the Creek breaching its right bank. The breach damaged existing wetlands and caused considerable erosion. Creek alignment restoration is expected to reduce concentrations at this monitoring station, which located at Lake View Road in the Park.

[5] Approximately 2 miles of stream reclamation are currently under construction or will begin in 2012.

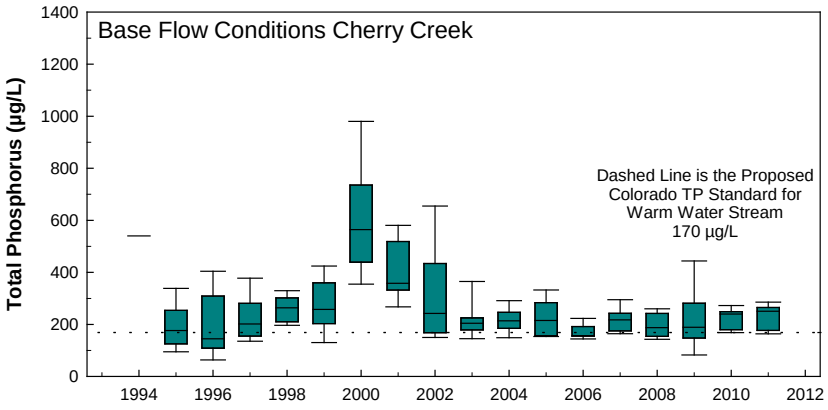



Figure 7-26. Base Flow Total Phosphorus Concentrations Upstream of the Reservoir

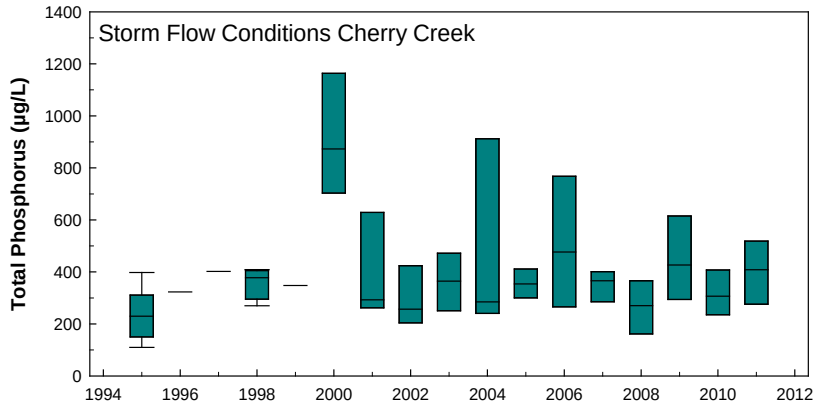



Figure 7-27. Storm Flow Total Phosphorus Concentrations Upstream of the Reservoir

## 7.7 Proposed Modifications to Monitoring Program

The Authority is proposing to add an upstream monitoring well at the McMurdo Gulch Stream Reclamation PRF, to help document PRF benefits. In addition, additional parameters, including sulfates and chlorides, are proposed for addition to the watershed monitoring program to better assess trends in these constituents over time. The collection and analysis of zooplankton has also been proposed for addition to the reservoir monitoring porgram, to better understand food chain interactions.

An online data viewer is currently being developed for all of the Authority's water quality monitoring data, and is in the beta-testing stage. Users will be able to access water quality data that has been collected along Cherry Creek and in Cherry Creek Reservoir over the past two decades, and data collected from this point forward will be added to this database. A collection of interactive visualization tools, including area maps and system diagrams, will allow users to freely explore, filter, and analyze the data in graphs and tables. Figures within this report represent the type of information that can be explored in the future through this online tool.

# 8 PROGRAM EFFECTIVENESS

The Authority's management strategies have focused on the watershed, including the construction of PRFs that have shown to be effective in reducing phosphorus loads and concentrations from both unregulated and regulated stormwater. The Authority believes watershed management strategies are beneficial over the long term, but it has taken several years to see improvements to reservoir water quality. Below is additional information required to be included in the Annual Report under Regulation 72.

## 8.1 Status of Compliance with Discharge Limits and Conditions

All wastewater treatment plants were in compliance in 2011 with their required phosphorus limits. CDPS General Permit No. CO641000 for water treatment plant discharges expired October 31, 2010; it has not yet been renewed. The old permit only requires monitoring and reporting for phosphorus. The Authority assumes that when it is reissued in the near future, the new Regulation 72 thirty-day average total phosphorus limitation of 0.2 mg/l for water treatment plant dischargers in the Cherry Creek basin will be incorporated into the general permit.

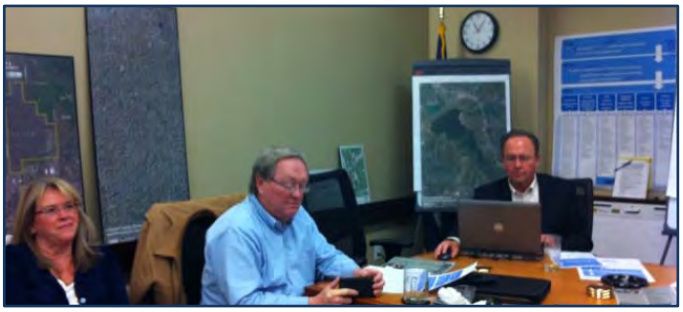
There are presently no new or proposed facility expansions.

## 8.2 Updated List of Planned PRFs with Implementation Schedule

On an annual basis, the Authority develops a list of all potential PRFs (called the master PRF list), which includes capital and operation and maintenance costs and potential benefits in terms of phosphorus reduction. In addition to Authority-initiated investigations, the Authority also identifies pollutant reduction opportunities by monitoring watershed drainage master plans conducted by the UDFCD and local jurisdictions or master plans developed independently by local jurisdictions, such as Castle Rock. These master plans historically have often recommended implementation of detention and stream stabilization measures throughout the watershed with the goal of reducing flood damages. More recently, these watershed master plans have included the goal of improving the stormwater quality in the planning process, such as the Airport Authority's retrofitting of stormwater detention ponds and Castle Rock's plan for McMurdo Gulch, which have resulted in a more integrated approach at the sub-watershed or tributary watershed level. Table 5.1 shows a summary of PRFs recommended for 2012 through 2016.

## 8.3 Recommendations for Improving Water Quality

Currently, the Authority is using a phased approach to update the Cherry Creek Basin Watershed Plan. The last update of the Watershed Plan was completed in 2003. The intent of phasing the Plan development is to facilitate communication resulting in collaborative agreement among the TAC, Board, and other stakeholders during the drafting of the document.



The Watershed Plan Revision, to be completed in 2012, will be used to guide Cherry Creek water quality control efforts in both the reservoir and watershed for the next several years.


Beginning in 2010, the vision, mission, goals, and objectives for the Authority were updated. What has been done to date was also reviewed. This included the following components:

**Authority Mission Statement: Vision, Goals, Objectives**

**History of Authority, Program Accomplishments**

**Review of Control Regulation 72 and Recent Changes in Focus**

**Analysis of Existing and Projected Conditions in the Watershed**

**Stakeholder Coordination**

In 2011, the focus was on developing strategies to implement the vision: "water quality in Cherry Creek Reservoir and Watershed that optimizes beneficial uses for the public". This year's work included:

**Develop and Assess Management Strategies to Reduce Nutrients and Other Contaminants**

**Develop and Assess Funding Strategies**

Next year, we will be prioritizing strategies and making recommendations to address each pollutant source, including recommended timelines.

## 8.4 Decisions and Agreements to Implement Goals

In 1985, local governments in the Cherry Creek basin worked with the Division, federal agencies, and DRCOG to develop a watershed management master plan for Cherry Creek Reservoir. One of the management plan recommendations was the creation of a single entity with legislative authority to control point and nonpoint sources of pollution. Initially, the Authority was formed by an intergovernmental agreement in 1985. In 1988, the legislature passed a bill creating the Authority that was subsequently revised in 2001 altering the structure of the Authority members.
The governmental and Governor-appointed members continue to actively participate in the Authority, working cooperatively to develop and implement Authority goals and objectives.

## 8.5 Financing of Nonpoint Source Projects

The Authority funds (or co-funds with other land use entities) nonpoint source projects through taxes, fees, and wastewater surcharges. Total revenue has varied from $1,700,000 in 2006 to $1,940,000 for 2011. During the same period, capital expenditures ranged from around $400,000 to over $3,400,000 (in 2011), with the variation due in part to the multiple year process required for PRFs from concept through construction. As the result, the Authority funds have been sufficient to plan for and implement the projects in the 5-year CIP. Whereas the Authority expects revenues to decline for 2012, the current funding level of PRFs is

*Capital Funds Spent:*

*1991 through 2011 Completed Projects: $6,013,000*
*2011 Ongoing Projects: Additional $3,366,000*

expected to continue for the next year or two. Implementation and timing of projects can vary from year to year; projects are sometimes funded through capital reserves.

## 8.6 Regulated Stormwater Permit Requirements

The Authority continues to work with local MS4s to implement an aggressive stormwater management program. In April 2011, Section 72.7 titled "Stormwater Permit Requirements Guidance Document" was finalized with Board approval.

## 8.7 Adoption and Implementation of BMPs by Local Governments

All MS4s in the watershed have adopted stormwater regulations-setting requirements for construction and post-construction BMPs for new and redevelopment projects within their jurisdiction. In 2010, the MS4s worked with UDFCD to update UDFCD's Urban Storm Drainage Criteria Manual Volume 3 Best Management Practices to further improve the science and engineering for the design, construction, and maintenance of BMPs. In 2011, MS4s worked to incorporate changes into their local programs based on the revisions to the UDFCD Volume 3 Manual.

## 8.8 MEP Reduction of Phosphorus Concentrations into Reservoir

Phosphorus concentrations into the reservoir are meeting the MEP criteria from Regulation 72, as evidenced by the following information presented for the control categories required to be addressed under the regulation. Since the Authority was established in 1988, significant progress has been made controlling both point source and nonpoint source phosphorus loads. We are meeting the new concentration-based approach now prescribed in Regulation 72. The Authority is exploring what tools/standards other states currently use to regulate adverse impacts from algae on beneficial uses.

In 2011, all wastewater treatment plant dischargers were consistently below their allowed concentration limits. Note that phosphorus concentrations in direct discharges to Cherry Creek or its tributaries are generally limited to 0.05 mg/l; this is well below the 0.20 mg/l flow-weighted phosphorus goal for discharges to the reservoir. The wastewater treatment facilities are accomplishing this through the use of Best Available Technologies (i.e., "BAT") including treatment techniques such as advanced wastewater treatment (AWT) and biological nutrient removal (BNR) for phosphorus removal.

Phase I MS4s are required by the State's Permit Regulations (Regulation 61) to develop programs to reduce the discharge of pollutants to the maximum extent practicable using management practices, control techniques and system, design and engineering methods, and other appropriate methods. Permit conditions to reduce pollutants in discharges to the maximum extent practicable are then included in the stormwater permit issued by the state. Phase II MS4s must also, at a minimum, adopt certain BMPs for six minimum control measures and implement them to the maximum extent practicable. Additional control measures are required by Regulation 72 for MS4s within the Cherry Creek basin. The MS4s submit an annual report every year to the Division, documenting their compliance with the requirements, including MEP mandates. Monitoring in the watershed confirms that the BMPs and other controls placed on regulated stormwater

continue to be effective, and the total phosphorus concentration in the inflow to the reservoir has remained relatively constant.

The Authority's PRFs have been designed to maximize the reduction in nutrients, particularly phosphorus, that flow into the reservoir from the tributary streams such as Cherry Creek, Shop Creek, and Cottonwood Creek. The Cottonwood Creek monitoring data show that the mean annual flow-weighted total phosphorus concentrations into the reservoir are significantly below what are believed to be background conditions for the watershed, contrary to some scientific beliefs that BMP performance is limited to background concentrations (Center for Watershed Protection). In fact, the average of the 2008 through 2011 flow-weighted phosphorus concentrations entering the reservoir from Cottonwood Creek was 0.076 mg/l, which is below the lowest concentration (i.e., 0.150 mg/l) suggested as possible by the Center for Watershed Protection. Therefore, the Authority's Cottonwood Creek PRF monitoring results support the position that PRFs can reduce phosphorus concentrations into the reservoir by the maximum extent practicable.

All wastewater treatment plants were in compliance in 2011 with their required phosphorus limits in 2011. When the State's general permit for water treatment plant discharges is renewed, phosphorus limits should be incorporated per the recent Regulation 72 requirements.

MS4s in the basin continue to implement aggressive stormwater quality programs. In 2011, the Stormwater Permit Requirements document was updated and finalized.

The Authority has to date invested nearly $10,000,000 in Pollutant Reduction Facilities, or PRFs. Several PRFs, as well as stringent local stormwater requirements and voluntary initiatives, have been implemented in the Cottonwood Creek watershed in the past several years. These efforts, coupled with wastewater treatement facility improvements, have resulted in significant decreases in phosphorus concentrations, to levels below 0.100 mg/l. This is well below the Authority's goal of 0.200 mg/l to achieve the chlorophyll αstandard. A similar, but more pronounced downward trend in phosphorus concentrations has been observed for storm flow conditions. These data show that concentrations can be reduced, even as urbanization occurs. A key factor is the reclamation of unstable streams. This success has provided the Authority with the confidence to implement similar control measures on a larger scale within Cherry Creek itself, which has a much larger watershed.

In addition, the Authority is focused on controlling nuisance type algae to more desirable levels, and promoting the more beneficial algae groups that play an important role in maintaining beneficial uses. The Authority has targeted one nuisance algal group called cyanobacteria or "blue-green algae" which can be toxic to aquatic life often making them a less desirable food-source for zooplankton and fish. Blue-green algae are also known to cause rashes on swimmers who come in contact during nuisance level algae blooms.

While the data shows that water quality has been relatively unaffected by urbanization, the Authority and State Park also deals with anecdotal evidence, the most telling of which is that when comparing 2010 and 1994 visitor counts at Cherry Creek State Park , there has been a 29% increase in park visitation. A more significant trend in Park use is that Cherry Creek State Park has routinely reached capacity during peak-use periods suggesting that beneficial uses for Cherry Creek are being met. In addition, this past year's walleye egg harvest was the largest on record, according to CPW, providing further anecdotal evidence that uses are being met.

The water quality monitoring program was also reviewed in 2011, with recommended modifications to obtain needed data to further the Authority's efforts.

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LeonardRice
ENGINEERS, INC.