

# Cherry Creek Basin Water Quality Authority

## 2006 ANNUAL REPORT ON ACTIVITIES

March 28, 2007





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## CONTROL REGULATION 72 REPORTING REQUIREMENTS



Look for this symbol in the margin of the 2006 Annual Report to see sections that correlate to the reporting requirements, listed in Section 72.9, Reporting, of Regulation No. 72 – Cherry Creek Reservoir Control Regulation.

Control Regulation Section Number and Reporting Requirement	Section of Annual Report
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<sup>1</sup> Following recommendations provided by the Division and complying with reporting requirements specified in the 2001 Control Regulation 72, the format of the Annual Reports after 2002 will be comparable.



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## CONTROL REGULATION 72 TASK REQUIREMENTS



Look for this symbol in the margin of the 2006 Annual Report to see how the Authority is taking steps to meet the task requirements outlined in Regulation No. 72 – Cherry Creek Reservoir Control Regulation.

Control Regulation <u>Section Number and Task Requirement</u>	<u>Section of Annual Report</u>
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## ABBREVIATIONS

ac-ft	acre-feet
ACWWA	Arapahoe County Water and Wastewater Authority
Annual Report	Cherry Creek Basin Water Quality Authority 2006 Annual Report on Activities
Authority	Cherry Creek Basin Water Quality Authority
BMP	Best Management Practice
CDOT	Colorado Department of Transportation
CDPHE	Colorado Department of Public Health and Environment
CIP	Capital Improvement Project
COE	U.S. Army Corp of Engineers
Commission	Colorado Water Quality Control Commission
Control Regulation 72	Regulation No. 72 – Cherry Creek Reservoir Control Regulation
DESC	Drainage, Erosion and Sediment Control
Division	Colorado Water Quality Control Division
DMR	Discharge Monitoring Report
DRCOG	Denver Regional Council of Governments
Education Initiative	Cherry Creek Basin Water Stewardship and Education Initiative
EMC	Event Mean Concentration
GESC	Grading, Erosion and Sediment Control
ISDS	Individual Sewage Disposal System
lbs	pounds
LID	Low-impact development
µg/L	micrograms per liter
mg/L	milligrams per liter
MS4	Municipal Separate Storm Sewer Systems
NPDES	National Pollutant Discharge Elimination System
Park	Cherry Creek State Park
Partners	Cherry Creek Stewardship Partners
PRF	Pollutant Reduction Facility
Requirements	Cherry Creek Reservoir Watershed Stormwater Quality Requirements
SEO	State Engineers Office
SRP	Soluble Reactive Phosphorus
TABOR	Tax Payers' Bill of Rights
TAC	Authority's Technical Advisory Committee



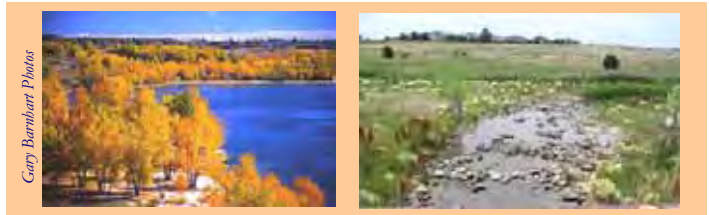
TMAL	Total Maximum Annual Load
UDFCD	Urban Drainage and Flood Control District
WWTP	Wastewater Treatment Plant
2006 Annual Draft Monitoring Report	2006 Annual Aquatic Biological-Nutrient Monitoring Study and Cottonwood Creek Phosphorus Reduction Facility Monitoring



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## EXECUTIVE SUMMARY

The purpose of the 2006 Annual Report on Activities (Annual Report) is to provide a status report on Cherry Creek Reservoir water quality and review Cherry Creek Basin Water Quality Authority (Authority) progress towards achieving water quality standards in 2006. The Annual Report reviews the Authority's activities to ensure the strategies employed to meet the water quality standards and goals are appropriate and effective in the short and long term. Several objectives guide the development of the Annual Report to achieve this purpose.



- Document the steps taken in 2006 to perform required tasks.
- Meet Control Regulation 72 reporting requirements.
- Present the results of monitoring activities.
- Review the effectiveness of watershed management strategies.
- Provide an Executive Summary that can act as a stand-alone abbreviated report of 2006 activities and progress.

The mission of the Authority is to “maintain beneficial uses in the Cherry Creek Reservoir by preserving its water quality.” Authority activities discussed in the Annual Report are components of a plan directed toward meeting water quality standards, enhancing environmental health in the Cherry Creek Reservoir watershed (Figure ES-1), and implementing the phased Total Maximum Annual Load (TMAL). These activities include monitoring water quality, measuring loads to the Cherry Creek Reservoir, implementing point and nonpoint source controls and programs, conducting special study efforts required by Control Regulation 72 to update the TMAL, and discussing additional strategies for meeting reservoir water quality standards and goals in the foreseeable future.

### ES.1 Status of Water Quality

The Authority continued to implement a routine annual water quality monitoring program in the Cherry Creek Reservoir and watershed. The program monitors reservoir water quality, reservoir inflow and loading, surface and groundwater quality in the watershed, and the effectiveness of Authority pollutant reduction facilities (PRFs).

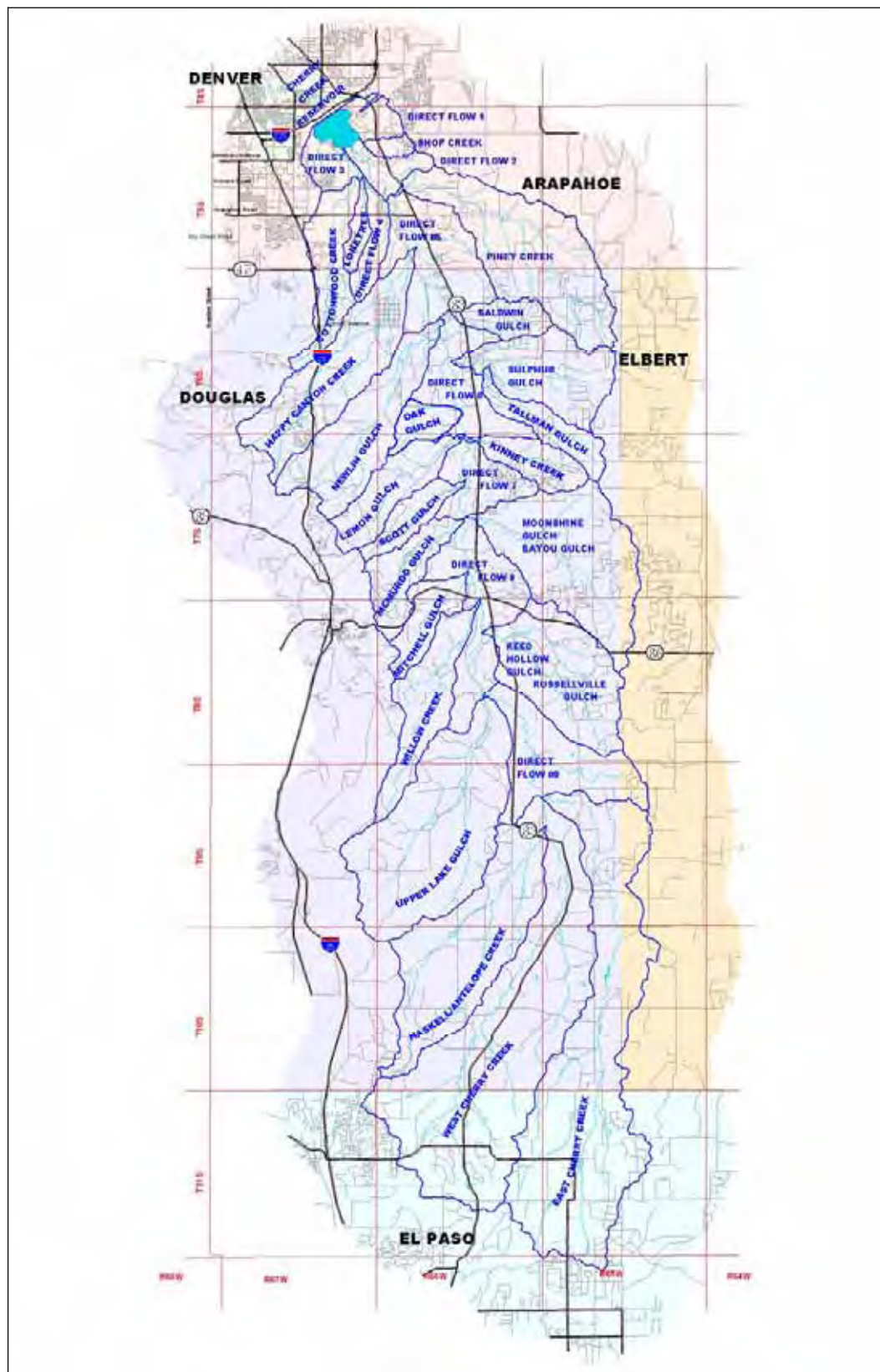
#### ES.1.1 2006 Water Quality Summary

- Summer mean chlorophyll *a* of 14.7 µg/L was less than the 15 µg/L reservoir standard.
- Summer mean total phosphorus of 87 µg/L exceeded the reservoir goal of 40 µg/L.
- Total phosphorus load of 6,185<sup>1</sup> pounds to the reservoir was below the TMAL of 14,270 lbs/year.

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<sup>1</sup> Reservoir inflow and load data are provisional. These data are subject to change based on final review of U.S. Army Corps of Engineers (COE) reservoir inflow data.

Figure ES-1. Cherry Creek Reservoir Watershed Map



- Cottonwood-Peoria Pond and Cottonwood Perimeter Pond PRFs demonstrated phosphorus load reduction effectiveness of 24% and 36%, respectively. The PRF load reductions were an improvement over 2005 and similar to the long-term load reductions of approximately 30% (based on 5 years of data for the Cottonwood-Peoria Pond and 10 years for Cottonwood Perimeter Pond).

Historical sampling of the PRFs on Shop Creek and Quincy Drainage indicate an average annual phosphorus reduction of 63% or 173 pounds (1990 to 2000) and 99% or 138 pounds (1996 to 1999), respectively.

### ES.1.2 Long-term Water Quality Summary

The Cherry Creek Reservoir chlorophyll *a* standard of 15 µg/L has only been met three times in the past 15 years, and the phosphorus goal of 40 µg/L has not been achieved in the past 15 years. However, the phosphorus loads have been lower than the TMAL of 14,270 pounds in 14 of the past 15 years (Table ES-1).

**Table ES-1. Water Quality (July–September Average Concentration) and Total Phosphorus Load Data for Cherry Creek Reservoir, 1992 – 2006**

Year	Chlorophyll <i>a</i> (µg/L)	Total Phosphorus (µg/L)	Total Nitrogen (µg/L)	Annual Phosphorus Load (lbs/yr) <sup>1</sup>	Annual Inflow (ac-ft) <sup>1</sup>	Standardized Phosphorus Load (lbs/ac-ft)	Net Phosphorus Load (lbs/yr) <sup>2</sup>
1992	17	66	970	<b>5,857</b>	7,474	0.78	4,543
1993	<b>14.4</b>	62	826	<b>4,110</b>	5,905	0.7	3,399
1994	<b>10</b>	59	1,144	<b>4,049</b>	7,001	0.58	3,056
1995	<b>9.4</b>	48	913	<b>7,972</b>	11,781	0.68	5,923
1996	20.5	62	944	<b>4,715</b>	7,644	0.62	3,723
1997	22.3	96	1,120	<b>5,761</b>	10,362	0.56	4,765
1998	26.5	89	880	<b>13,577</b>	20,903	0.65	9,370
1999	28.9	81	753	17,471	27,739	0.63	7,821
2000	25.2	81	802	<b>12,593</b>	18,610	0.68	8,905
2001	26.1	87	757	<b>9,837</b>	17,250	0.57	4,995
2002	18.8	74	858	<b>4,246</b>	7,498	0.57	2,745
2003	25.8	90	1,121	<b>8,568</b>	14,929	0.57	3,590
2004	18.4	102	977	<b>12,512</b>	17,177	0.73	7,007
2005	17.1	116	990	<b>10,047</b>	18,534	0.54	6,378
2006	<b>14.7</b>	87	914	<b>6,185<sup>3</sup></b>	12,009 <sup>3</sup>	<b>0.51<sup>3</sup></b>	3,376 <sup>3</sup>
Mean	19.8	80	931	8,500	13,654	0.62	5,306
Median	18.8	81	914	7,972	12,009	0.62	4,765

Notes:

<sup>1</sup> This represents the total load and inflow to Cherry Creek Reservoir from stream, alluvium, and precipitation.

<sup>2</sup> The net phosphorus load is the total load to the reservoir minus the reservoir outflow load.

<sup>3</sup> Provisional inflow and load data from January through December are based upon GEI measured inflow rather than the COE inflow that is presented for earlier years – final values pending receipt of data from COE.

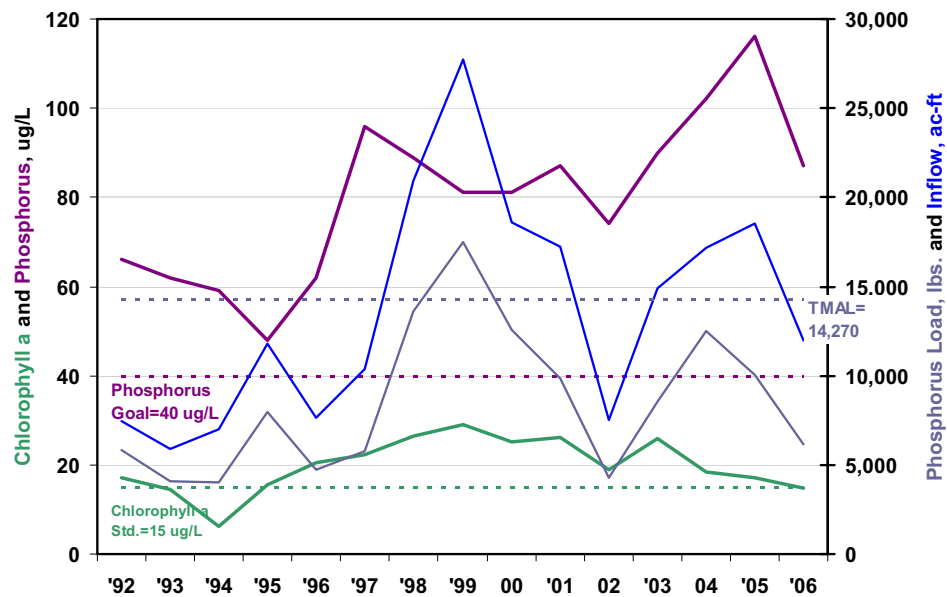
**Bold indicates value meets the respective standard, goal, or TMAL value.**

Figure ES-2 provides a picture of water quality concentrations, phosphorus loads, and inflow to the reservoir since 1992. This figure demonstrates how phosphorus loads track closely with inflows to the reservoir and that chlorophyll *a* and phosphorus concentrations do not necessarily have an immediate or significant response to changes in phosphorus loads. For example, load reductions that coincided with the recent drought years (2000 to 2002) did not result in a similar continuous decrease in phosphorus and chlorophyll *a* concentrations.

The Authority's watershed management strategies focus on reducing nutrient loading, both through structural and non-structural management strategies. The Authority PRF monitoring typically shows the PRFs are effective in reducing phosphorus, but the reservoir monitoring does not demonstrate immediate improvements in reservoir water quality related to watershed management strategies. However, the impacts of watershed management strategies are beneficial over the long term, but do not necessarily result in immediate measurable results in the reservoir.

The data indicate that the Authority needs to continue with watershed management strategies, but the Authority also faces a challenge to demonstrate near-term water quality improvements and needs to consider additional strategies. A 2003 special study on nutrient enrichment in Cherry Creek Reservoir identified that nitrogen, not phosphorus, may be the limiting nutrient and suggested reservoir mixing as a possible solution. Subsequently, the Authority evaluated in-lake management strategies (reservoir destratification) to assist with short-term water quality improvements. The Colorado Water Quality Control Commission (Commission) adopted a phased TMAL process that would provide for the continued implementation of both point and nonpoint source control strategies. This phased approach allows the Authority to investigate impacts on reservoir water quality and formulate additional and alternative control strategies, such as in-lake management.

**Figure ES-2. Cherry Creek Reservoir Water Quality, Load, and Inflow, 1992-2006**



## ES.2 Background

Regulation No. 72 – Cherry Creek Reservoir Control Regulation (Control Regulation 72) is established by the Commission and sets forth actions and requirements that the Authority must meet. The Commission revised Control Regulation 72 in November 2004, which became effective on December 30, 2004.

- Emphasis is placed on implementation of watershed measures to control the water quality in Cherry Creek Reservoir.
- The Cherry Creek Reservoir has a chlorophyll *a* water quality standard of 15 µg/L mean July-September concentration to be met 9 out of 10 years.
- The Cherry Creek Reservoir has a phosphorus concentration goal of 40 µg/L.

## ES.3 Overview of Progress Made

Although the Cherry Creek Reservoir did meet the chlorophyll *a* water quality standard for the reservoir in 2006, the Authority continues to take initiative towards meeting standards through key planning, implementation, and evaluation actions.

- **Planning** – Recommendations of the Watershed Plan 2003 continue to guide the Authority’s Work Plan. During the budgeting process, the Authority set aside funds for stream corridor preservation partnering opportunities, a sinking fund for long-term PRF operations and maintenance, and exploring the feasibility of measures to reduce the impact of the TABOR amendment on the Authority’s budget.
- **PRF Implementation** – The Authority completed the design for reservoir destratification and completed a conceptual design for the Arapahoe Road Sediment Pond. Design Phase II of Cottonwood Creek Reclamation was resumed despite delays due to pending relocation of Peoria Street and Belleview Avenue.
- **Facilitation and Coordination** – The Authority worked closely with land use agencies to coordinate stormwater permit requirement compliance in the Cherry Creek basin. In addition, the Authority continued the unique program of the “phosphorus facilitator,” that focused on transportation corridor requirements, low-impact development, and stakeholder education.
- **Education** – The Authority coordinated with the Partners to implement more avenues for educating the public (e.g., brochure, training, volunteer workdays, and conference).



- **Monitoring** – The Authority continued to monitor water quality, loads, and PRF performance to provide a means of measuring effectiveness of watershed management strategies. This information feeds back into the dynamic planning process.

#### ES.4 Progress Made in Specific Management Programs

Listed below are specific watershed management programs that the Authority implemented in 2006 to improve watershed health and water quality, along with the associated progress made through each program.

##### ES.4.1 Wastewater Facility Controls

- Wastewater facility discharges did not exceed annual permitted wasteload allocations or effluent phosphorus concentrations.
- The Authority reviewed and approved two applications for site location approval for the construction of lift stations, one wastewater utility plan amendment and one wastewater treatment facility expansion within the Cherry Creek Reservoir watershed for compliance with applicable regulations and guidance documents. This includes compliance with wasteload allocations and wastewater utility plans.

##### ES.4.2 Nonpoint Source Controls

The Authority has made progress in meeting the requirements of Control Regulation 72 for control of nonpoint source pollution in the following ways.

- Coordinated and assisted local land use agencies in implementing Phase II stormwater permit requirements consistent with Control Regulation 72.
- Completed the third year of the “Phosphorus Facilitator” program to work with local developers to implement best management practices (BMPs) that go well beyond minimum requirements. Identified improvements to the program for 2007 that include promoting the transferability of enhanced BMPs in an on-the-ground project.
- Increased the local land use agencies’ understanding of Authority goals and requirements relative to water quality through development and distribution of education materials and by providing review comments on land-use change applications.
- Completed feasibility investigations for one additional PRF, finalized design and began bidding for in-lake management facilities, included the projects on the master CIP list, and allocated funds for further activity during 2007. Although currently all PRFs are located within Cherry Creek State Park, the Authority continues to focus on watershed BMPs and PRFs in the upper basin.
- Initiated a process to update the Authority’s requirements for consistency with the 2004 Control Regulation 72 revisions and the land use agency stormwater quality requirements developed as part of the Phase II stormwater permits. The revised document, in the form of a guidance document, will represent the collective experience of the Authority



and the land use agencies while implementing Phase II stormwater regulations and other measures to protect the water quality of the Cherry Creek Reservoir watershed. The guidance document is expected to address additional or more stringent best management practices related to the following.

- Construction and post-construction storm runoff.
- Industrial and commercial activities not regulated elsewhere that could result in a discharge of pollution such as, but not limited to, gas stations and fueling areas, equipment storage, cleaning, and maintenance areas.
- Land disturbances within stream preservation areas.
- Rural road construction and maintenance.
- Highway and roadway reconstruction.
- Large lot single family development.
- Recreational trail construction.
- Other discharges the Authority determines to be detrimental to meeting the TMAL requirement in Control Regulation 72.

**STEPS**  
**REG 72**

#### **ES.4.3 Trading Program**

In 2006, the Authority improved and built upon its trading program.

- Completed revisions to the Trading Program and Reserve Pool Guidelines.
- Approved a new trade project - Pond W6/W7 for the Arapahoe County Water and Wastewater Authority (ACWWA).

#### **ES.4.4 Public Education Actions and Partnerships**

The Authority made progress in meeting the requirements of Control Regulation 72 for implementing public information and education programs in the following ways.

**STEPS**  
**REG 72**

- Leveraged resources by supporting the Partners and coordinating with other entities to implement the Education Initiative, a comprehensive and coordinated education strategy and action plan.
- Maintained the Authority's website through cooperation with the Partners to facilitate the dissemination of information to parties interested in the Authority's activities.
- Collaborated on information and education efforts with other entities with common interests and goals for the watershed.



- Collaborated with the Cherry Creek Stewardship Partners, who facilitate broad community involvement and benefit long-term environmental stewardship through outreach efforts to watershed school programs.

#### **ES.4.5 Phased TMAL Implementation**

The Authority has continued to develop and implement point and nonpoint source controls and has worked with the Water Quality Control Division (Division) to complete one more, and make progress on two, required investigations for the phased TMAL.

- The Authority completed the depth profiling study, a required special study that evaluated the variability in water chemistry between separate zones within the alluvial sediments.
- The Authority continued implementation of two special studies, required as part of the phased TMAL, which will be completed in 2007.
- The Authority made significant progress on determining how to address phosphorus fate and transport in the watershed through the watershed model update. The model update process is a collaborative effort with the Division, and the model update will be completed in 2007.
- The Authority initiated the Reservoir model update, which incorporated the past five years of flow and water quality data.
- The Authority cooperatively worked with the Division to address Division concerns regarding the calculation procedures for external phosphorus load to the reservoir.
- The Authority and Division jointly proposed changes to Control Regulation 72 for the Commission to consider at the 2006 informational hearing.

#### **ES.4.6 Water Quality Monitoring**

- The Authority completed annual water quality monitoring and analysis for the reservoir, watershed, alluvium, and selected PRFs in accordance with the Sampling, Analysis, and Quality Assurance Work Plan.
- The Cottonwood Creek-Peoria Pond PRF showed improvement in removing total phosphorus from the stream flows in 2006, especially when compared to 2005 data. Standardized phosphorus loads (lbs/ac-ft) were slightly less downstream of the pond as compared to standardized loads upstream of the system.
- The Cottonwood Creek Perimeter Pond PRF showed a decrease in the phosphorus load downstream of the system, with the percent reduction in load being similar to the long-term mean. The standardized phosphorus loads (lbs/ac-ft) also revealed that the system was effective at removing total phosphorus from Cottonwood Creek flows.




- Despite the provisional nature of the annual load data, the projected total phosphorus load to the reservoir is expected to be less than the TMAL.
- There has been a statistically significant decrease in seasonal whole-reservoir chlorophyll *a* concentrations since 1999, with the 2006 seasonal mean concentration of 14.7 µg/L.

## **ES.5 Results and Conclusions**

The Authority recognizes the challenge of meeting water quality standards, and continues to plan, gather information, implement strategies, monitor, and reevaluate approaches to meet the challenge. The Authority has undertaken actions through a variety of programs to “maintain beneficial uses in the Cherry Creek Reservoir by preserving its water quality.” These actions are components of a plan directed toward meeting water quality standards and enhancing environmental health in the Cherry Creek basin.

The 2006 reservoir data, as well as the long-term monitoring, indicate the relationship between chlorophyll *a* and phosphorus concentrations (or between phosphorus concentration and load) needs consideration. With the addition of five years of reservoir data (since 2000), the Authority initiated an update to the Reservoir model to evaluate these relationships in the reservoir and refine the TMAL.

The Authority’s management strategies have strong focus on the watershed, including the construction of PRFs that have shown to be effective in reducing phosphorus loads. The Authority believes watershed management strategies are beneficial over the long term, but they have not resulted in immediate measurable improvements to reservoir water quality. The Authority is actively implementing an in-lake management strategy for more short-term improvements to reservoir water quality. Overall nutrient loading from the watershed is expected to increase in the future, primarily as a function of increases in stormwater runoff and stream erosion. As a result, the Authority focuses on continued reduction of nutrient loads from the watershed through watershed management strategies.



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## 1. PURPOSE OF THE ANNUAL REPORT

The purpose of the 2006 Annual Report is to summarize activities performed by the Authority in 2006. Authority activities are directed towards meeting water quality standards and enhancing environmental health in the Cherry Creek Reservoir watershed, and implementing the phased TMAL. Activities discussed in the Annual Report are components of a plan for protecting the health of the watershed, and include monitoring water quality, measuring loads to the Cherry Creek Reservoir, implementing point and nonpoint source controls and programs, completing special studies to update the TMAL, and evaluating additional strategies for meeting water quality standards and goals in the Cherry Creek Reservoir.

Several objectives guide the development of the Annual Report to achieve this purpose.

### **Objective 1 – Document the steps taken in 2006 to perform required tasks**

The Authority's actions are primarily governed by Control Regulation 72, as developed by the Colorado Department of Public Health and Environment's (CDPHE) Colorado Water Quality Control Commission. Control Regulation 72 establishes various requirements for the purpose of meeting water quality standards and the phased TMAL. Throughout the Annual Report, the "Steps" icon in the left margin indicates the Authority's progress towards completing Control Regulation 72 tasks, which are listed in the Table of Contents.



### **Objective 2 – Meet Control Regulation 72 reporting requirements**

Control Regulation 72 requires that the Authority complete an Annual Report in accordance with specific reporting requirements. The Authority submits the Annual Report to the Commission for review on March 31. The Authority's activities and the Annual Report include more than what Control Regulation 72 requires for reporting. The "Reg 72 Reporting" icon highlights reporting requirements, which are listed in the Table of Contents.



### **Objective 3 – Present the results of monitoring activities**

The Authority continually monitors water quality to evaluate compliance with water quality standards, establish reservoir and watershed water quality conditions, and document changes in water quality. These monitoring efforts also provide the basis for measuring phosphorus loadings to the reservoir and evaluating the effectiveness of PRFs. The data are also utilized by the Division, Colorado State Parks Department, the U.S. Army Corp of Engineers (COE), and other interested parties.



#### **Objective 4 – Provide a framework for a review of strategies**

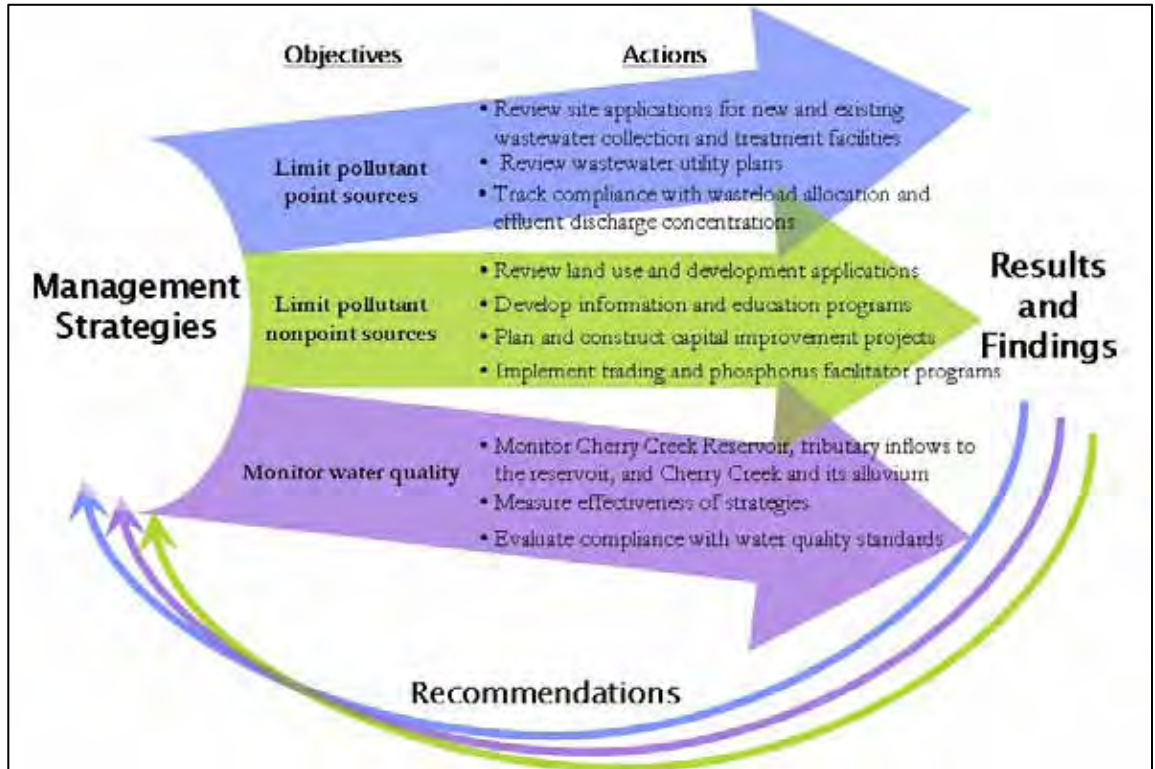
Each section in the Annual Report concludes with a “Progress Made” section, which identifies outcomes of activities, where measurable, and reports if those activities are meeting target goals. Section 10 provides recommendations for directing future water quality efforts, and Section 8 provides the outcomes of special studies that provide additional options for water quality improvements. This information provides a framework for determining if strategies employed to meet Control Regulation 72 requirements are appropriate and effective in the near and long term.

#### **Objective 5 – Provide an abbreviated report of 2006 activities and progress made**

The Executive Summary of the Annual Report serves as a stand-alone document providing a brief summary of the Authority’s activities in 2006 and progress made towards the phased TMAL. The Executive Summary can be distributed to interested agencies and individuals, and also used to supplement other reports or grant applications developed by the Authority.

## 2. THE AUTHORITY

The mission of the Authority is to “maintain beneficial uses in the Cherry Creek Reservoir by preserving its water quality.” From this mission, the Authority has developed water quality management strategies to minimize point and nonpoint pollutant sources by implementing specific programs and monitoring water quality to evaluate progress. This process creates an effective water quality management approach, as shown on Figure 2-1.

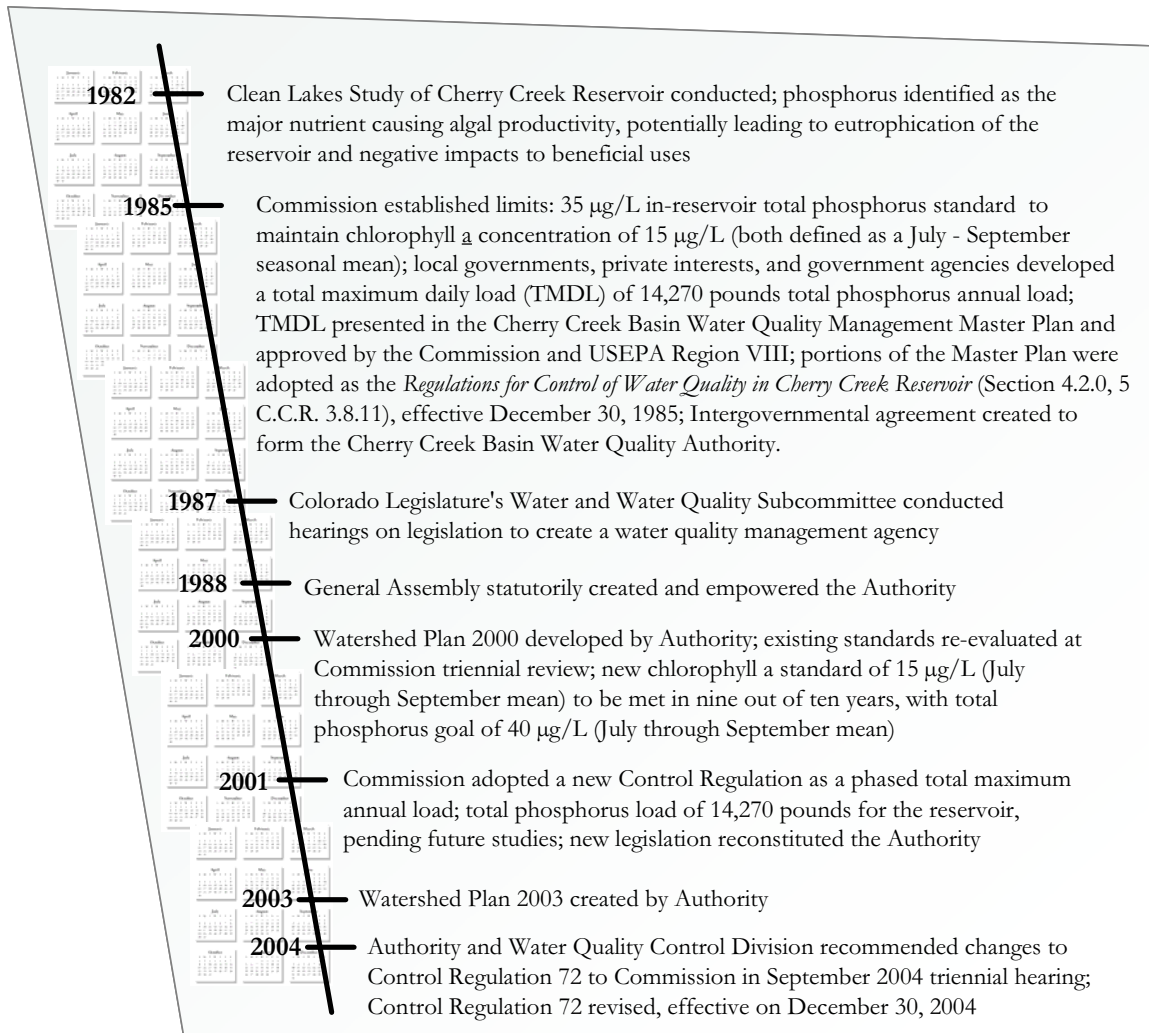


**Figure 2-1. Water Quality Management Approach**

This section provides information on the Authority’s history, members of the Authority, 2006 annual budget and funding sources, and 2006 reference materials.

### 2.1 History

The Authority was formally created in 1985 by the Colorado Legislature to preserve water quality within the Cherry Creek Reservoir watershed. Figure 2-2 provides a summary of the Authority’s history pertinent to regulations. In August 2006, the Commission held an informational hearing to identify potential changes to Control Regulation 72. These changes will be addressed during the next triennial review hearing in August 2007.



**Figure 2-2. Summary of Authority History**

## 2.2 Today's Authority

The Authority consists of a Board and Technical Advisory Committee (TAC). Table 2-1 lists the entities that are represented on the Board, per Control Regulation 72.

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

Entities That Must be Represented	Number of Representatives
County (Arapahoe, Douglas)	2
Municipality (Aurora, Castle Rock, Centennial, Foxfield, Greenwood Village, Lone Tree, Parker)	7
Special Districts	1
Appointed by the Governor	7
<b>Total members of Authority Board <sup>1</sup></b>	<b>17</b>

The TAC consists of members representing various agencies and interests within the Cherry Creek Reservoir watershed. 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. Table 2-2 provides a list of entities that are represented on the TAC.

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


<b>Entities Represented</b>	<b>Number of Members</b>
County (Arapahoe, Douglas)	2
Municipality (Aurora, Castle Rock, Greenwood Village, Lone Tree, Parker)	5
Special districts	1
Board appointed	4
Other (Cherry Creek State Park, COE, DRCOG)	3
<b>Total members of TAC</b>	<b>15</b>

### **2.3 Work Plan**

The Work Plan guides the activities of the TAC and Board. The Work Plan is a spreadsheet that lists all of the upcoming tasks for the calendar year. As shown on Figure 2-3, the Work Plan from December 2006 provides the following information for each task.

- Task description
- Corresponding category in the Authority’s budget
- Fulfillment of appropriate Control Regulation 72 section
- Fulfillment of corresponding Watershed Plan 2003 recommendation
- Schedule for completion
- Progress status

Ongoing tasks, tasks scheduled for future years, and completed tasks are also listed on separate pages. The Work Plan is updated on a monthly basis and is reviewed at every TAC meeting.



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Figure 2-3. 2006 Work Plan

Budget/Task Category	Task	Task Description	Control Regulation Section	Fulfillment of Control Regulation by:	Watershed Plan 2003 Recommendations	Month Start (first of month)	Status	Due Date
<b>2006 Ongoing</b>								
<b>Meetings</b>	Monthly Board and TAC meetings					Ongoing	Ongoing	Ongoing
<b>TAC Work Plan</b>	Maintain and update TAC Work Plan	Update monthly and submit to TAC for review			B - Implement Watershed Plan 2003 as a coordinated management program	Ongoing	Ongoing	Ongoing
	Submit to Board quarterly	Submit abbreviated TAC Work Plan to Board			B - Implement Watershed Plan 2003 as a coordinated management program	Ongoing	Ongoing	Ongoing
<b>Public Information and Education</b>	Promote use of Educational Fact Sheets	Continued distribution of The BMP Series fact sheet program	72.6(2)	Update Public Information and Education Program	L - Develop and implement public involvement plan; A - Consider funding options to achieve capital budget increase	Ongoing	Ongoing	Ongoing
	Implement Cherry Creek Basin Water Stewardship and Education Initiative	Implement Information and Education Program from Needs Assessment and coordinate with stakeholders	72.6(2)	Implement Public Information and Education Program	L - Develop and implement public involvement plan; A - Consider funding options to achieve capital budget increase	Ongoing	Ongoing	Ongoing
<b>Trading Program</b>	Review of Trade Applications		72.5(3)(a)	Trading program	E - Promote trading incentives	Ongoing	Ongoing	Ongoing
<b>Watershed Mgmt - Land Use Applications</b>	Review Land Use Development Applications referred to Authority		72.6(1)	Encouraging and ensuring adequate nonpoint source (especially stormwater) BMPs	H - Encourage local gov'ts to work with developers to construct innovative demonstration projects; I - Explore options to reduce septic system loading in Cherry Creek	Ongoing	Ongoing	Ongoing
<b>Watershed Mgmt - Site Application Review</b>	Review of Site Applications		72.4(4)	Effluent discharge		Ongoing	Ongoing	Ongoing
<b>Watershed, Reservoir, and PRF Monitoring</b>	Implement monitoring programs		72.8	Nutrient monitoring		Ongoing	Ongoing	Ongoing
<b>2006</b>						1/1/2004		
<b>Capital Projects</b>	Annual Operations and Maintenance Report	Identify operation and maintenance needs	72.3(4)	Construction of nonpoint source control projects	C - Fund, design, and construct high priority stream improvements	6/1/2006	Completed	8/30/2006
	Operation and Maintenance	Shop Creek Wetlands Assessment	72.3(4)	Construction of nonpoint source control projects	D - Design and construct additional PRFs	9/1/2006	In progress	12/20/2006
	Reservoir Shoreline Assessment		72.3(4)	Construction of nonpoint source control projects	D - Design and construct additional PRFs	5/18/2006	Completed	8/30/2006
	Cherry Creek Sediment Pond at Arapahoe Road	Contracting	72.3(4)	Construction of nonpoint source control projects	D - Design and construct additional PRFs	10/1/2005	Completed	12/5/2005
	Cherry Creek Sediment Pond at Arapahoe Road	Preliminary design	72.3(4)	Construction of nonpoint source control projects	D - Design and construct additional PRFs	1/6/2006	Draft Completed	11/30/2006
	Cherry Creek State Park Wetlands	Phase I design - Contracting	72.3(4)	Construction of nonpoint source control projects	D - Design and construct additional PRFs	10/1/2005	Completed	1/19/2006
	Cherry Creek State Park Wetlands	Phase I design/construction	72.3(4)	Construction of nonpoint source control projects	D - Design and construct additional PRFs	1/6/2006	On hold	
	Cottonwood Creek Reclamation	Phase II design/construction - Contracting	72.3(4)	Construction of nonpoint source control projects	C - Fund, design, and construct high priority stream improvements	10/1/2005	Completed	12/5/2005
	Cottonwood Creek Reclamation	Phase II design/construction	72.3(4)	Construction of nonpoint source control projects	C - Fund, design, and construct high priority stream improvements	1/6/2006	In progress	2007
	Cottonwood Creek Reclamation	Phase II construction	72.3(4)	Construction of nonpoint source control projects	C - Fund, design, and construct high priority stream improvements	1/6/2006		2007
	Reservoir Destratification	Prepare preliminary design and cost analysis	72.3(4)	Construction of nonpoint source control projects	B - Implement the Cherry Creek Reservoir Watershed Plan 2003 as a coordinated management program	7/1/2005	Completed	1/19/2006
	Reservoir Destratification	Develop O&M Agreement	72.3(4)	Construction of nonpoint source control projects	B - Implement the Cherry Creek Reservoir Watershed Plan 2003 as a coordinated management program	6/15/2006	Completed	12/21/2006
	Reservoir Destratification	Final design and advertise	72.3(4)	Construction of nonpoint source control projects	B - Implement the Cherry Creek Reservoir Watershed Plan 2003 as a coordinated management program	2/1/2006	Completed	8/30/2006
	Reservoir Destratification	Construction	72.3(4)	Construction of nonpoint source control projects	B - Implement the Cherry Creek Reservoir Watershed Plan 2003 as a coordinated management program	10/1/2006	In progress	2007
<b>Annual Budget</b>	Identify 2007 budget items	Identify 2007 budget items and present to Board/Budget Committee			A,3 - Develop and implement an overall business program and financing plan.	8/5/2006	Completed	10/15/2006
<b>Long-term Funding</b>	Overall business program and financing plan	Board develop approach			A,3 - Develop and implement an overall business program and financing plan.			
	Identify a funding champion to generate financial resources for water quality	Board to set up process to pursue funding champion			A,1 - Identify a funding champion to generate financial resources for water quality			
	Overall business program and financing plan	Board develop plan			A,3 - Develop and implement an overall business program and financing plan.			
<b>Reporting - 2005 Monitoring and Annual Reports</b>	Annual Report	Including updates of: trading program activities; progress of adoption of Model Ordinance regulations; future non point source control projects; O&M activities; Public Information and Education Program; Floodplain Preservation and Conservation Easement Activities; Annual Routine Monitoring Program.	72.9, including 72.5(3)(a), 72.6(1), 72.6(2),	Gathering and updating required information (see Description) into an Annual Report		1/1/2006	Completed	3/31/2006
	Annual Report - TAC and WQCD provide comment on draft	TAC receives draft and provides comment	72.9	Annual Report		2/3/2006	Completed	2/10/2006
	Annual Report - Board provide comment on draft	Board receives draft at Board meeting, provide comment in a week	72.9	Annual Report		2/16/2006	Completed	2/22/2006
	Annual Report - TAC provide comment on final draft	TAC receives draft for TAC meeting, provide comment at TAC meeting	72.9	Annual Report		2/17/2006	Completed	3/23/2006
	Monitoring Report - TAC provide comment	TAC receives draft for TAC meeting, provide comment at TAC meeting	73.9	Annual Report		2/17/2006	Completed	3/23/2006
	Board approval of Annual Report	Board reviews and provides approval of Annual Report	72.9	Annual Report		3/10/2006	Completed	3/24/2006
	Annual Report - Submit final to WQCD and WQCC		72.9	Annual Report		3/31/2006	Completed	3/31/2006
	Present Annual Report to DRCOG WEPC	Develop summary presentation and present	72.9	Annual Report		6/1/2006	Completed	6/30/2006
	Present Annual Report to WQCC	Develop summary presentation and present to the WQCC	72.9	Annual Report		7/3/2006	Completed	8/14/2006
<b>Special Project - Phosphorus Broker</b>	Phosphorus Broker	Consultant document 2005 activities			G - Encourage local governments to work with developers to construct innovative demonstration projects	12/1/2005	Completed	5/23/2006
	Phosphorus Broker	Consultant scope 2006 activities			G - Encourage local governments to work with developers to construct innovative demonstration projects	12/1/2005	Completed	3/23/2006
	Phosphorus Broker	Contract with consultant			G - Encourage local governments to work with developers to construct innovative demonstration projects	3/23/2006	Completed	5/18/2006
	Phosphorus Broker	Coordinate with land use agencies and developers. Implement tasks.			G - Encourage local governments to work with developers to construct innovative demonstration projects	1/31/2006	Completed	12/31/2006
	Phosphorus Broker	Consultant document 2006 activities			G - Encourage local governments to work with developers to construct innovative demonstration projects	12/1/2006		1/31/2007
	Phosphorus Broker	Develop 2007 scope of work			G - Encourage local governments to work with developers to construct innovative demonstration projects	10/1/2006	In progress	1/31/2007
<b>Speical Project - Lake Appreciation Event</b>	Participate in activities at Cherry Ck State Park	Coordinate with planning committee for July 29 event	72.6(2)		L,1 - Develop public involvement plan	6/1/2006	Completed	7/29/2006
<b>Speical Project - Lake Appreciation Event</b>	Review and comment on technical appendix	Comment on technical appendix and coordinate with DRCOG	72.6(2)		L,1 - Develop public involvement plan	4/27/2006	Completed	10/3/2006
<b>Special Project - Nonpoint Source Grant</b>	finalize process for implementing the three special studies under 319 Grant	Develop request for proposals and consultant selection process	72.3(4)	Completion of tasks identified		4/27/2005	Completed	10/31/2005
<b>Special studies</b>	TMAL Actions Study 1 - Depth profiling of nutrient content for GW	Contract with consultant	72.3(4)	Completion of tasks identified	K - Conduct special studies to optimize water quality improvements	12/1/2005	Completed	2/16/2006
	TMAL Actions Study 1 - Depth profiling of nutrient content for GW	Conduct study	72.3(4)	Completion of tasks identified	K - Conduct special studies to optimize water quality improvements	2/16/2006	Completed	9/22/2006
	TMAL Actions Study 2 - Evaluation of P removal of phosphorus control projects	Refine scope of work and complete consultant selection process	72.3(4)	Completion of tasks identified	K - Conduct special studies to optimize water quality improvements	4/27/2005	Completed	1/19/2006
	TMAL Actions Study 2 - Evaluation of P removal of phosphorus control projects	Contract with consultant	72.3(4)	Completion of tasks identified	K - Conduct special studies to optimize water quality improvements	1/19/2006	Completed	2/16/2006
	TMAL Actions Study 2 - Evaluation of P removal of phosphorus control projects	Conduct study	72.3(4)	Completion of tasks identified	K - Conduct special studies to optimize water quality improvements	2/16/2006	In progress	6/1/2007
	TMAL Actions Study 3 - Further quantification of soil and GW background P levels	Contract with consultant	72.3(4)	Completion of tasks identified	K - Conduct special studies to optimize water quality improvements	12/1/2005	Completed	1/19/2006
	TMAL Actions Study 3 - Further quantification of soil and GW background P levels	Conduct study	72.3(4)	Completion of tasks identified	K - Conduct special studies to optimize water quality improvements	1/19/2006	In progress	1/15/2007
	TMAL Actions Grant Reporting	Semi-Annual Reporting	72.3(4)	Completion of tasks identified	K - Conduct special studies to optimize water quality improvements	3/1/2006	Completed	3/29/2006
	TMAL Actions Grant Reporting	Semi-Annual Reporting	72.3(4)	Completion of tasks identified	K - Conduct special studies to optimize water quality improvements	8/25/2006	In progress	12/31/2006
<b>Update Authority website</b>	Update Authority website	Update Authority website	72.6(2)	Update Public Information and Education Program	L,1 - Develop public involvement plan; work with Partners to develop website	1/2/2006	Ongoing	12/31/2006
<b>Trading Program</b>	Make modifications to Trading Guidelines		72.5(3)(a)	Trading program	E-Promote trading incentives	6/1/2005	Completed	5/10/2006
	ACWWA Pond W-6/W-7 Trade Project Application	Accept application	72.5(3)(a)	Trading program	E-Promote trading incentives	6/16/2005	Completed	12/15/2005
	ACWWA Pond W-6/W-7 Trade Project Application	Review application for TAC consideration	72.5(3)(a)	Trading program	E-Promote trading incentives	12/15/2006	Completed	2/2/2006
	ACWWA Pond W-6/W-7 Trade Project Application	TAC Recommendation/Board Selection	72.5(3)(a)	Trading program	E-Promote trading incentives	12/15/2005	Completed	2/16/2006
<b>Watershed Mgmt - Land Use Applications</b>	Coordinate with UDFCD on Cottonwood Creek Master Plan		72.7	Cooperate to Implement Stormwater Permit Requirements	B - Implement Watershed Plan 2003 as a coordinated management program	2/1/2005	Completed	12/31/2005

Figure 2-3. 2006 Work Plan

Budget/Task Category	Task	Task Description	Control Regulation Section	Fulfillment of Control Regulation by:	Watershed Plan 2003 Recommendations	Month Start (first of month)	Status	Due Date
	Update Stormwater Quality Requirements	Form TAC Subcommittee	72.7	Cooperate to Implement Stormwater Permit Requirements	B.1-Develop stormwater policy and criteria specifically targeted at stream stabilization design for enhanced water quality.	12/5/2005	Completed	1/26/2006
	Update Stormwater Quality Requirements	Develop proposed revisions	72.7	Cooperate to Implement Stormwater Permit Requirements	B.1-Develop stormwater policy and criteria specifically targeted at stream stabilization design for enhanced water quality.	1/26/2006	In progress	12/31/2006
	Coordinate with WQCD	Proposed revisions	72.7	Cooperate to Implement Stormwater Permit Requirements	B - Implement Watershed Plan 2003 as a coordinated management program	3/1/2006	In progress	12/31/2006
<b>Watershed Mgmt - Site Application Review</b>	Pinery WUP Amendment	Site Application Review	72.4	Maintaining compliance/planning for wastewater facility wasteload allocations and effluent limitations		9/23/2005	Completed	1/19/2006
	Aurora Shop Creek Lift Station	Site Application Review	72.4			5/5/2006	Completed	6/15/2006
	Sierra Ridge Lift Station	Site Application Review	72.4			8/15/2006	In progress	12/31/2006
	Meridian WWTP Expansion	Site Application Review	72.4			9/1/2006	Completed	10/11/2006
	Lift Station 15/Kings Pointe Interceptor	Site Application Review	72.4			11/20/2006	In progress	1/30/2007
<b>Watershed Model Update</b>	Fate and transport/watershed model update	Monthly subcommittee and review team meetings	72.8(5)	Use monitoring data to determine nutrient fate and transport and calibrate models for next phase of TMAI		5/26/2005	In progress	12/30/2006
	Fate and transport/watershed model update	Action Items for 2006	72.8(5)			12/15/2006	Completed	1/25/2006
	Fate and transport/watershed model update	Model documentation	72.8(5)			5/30/2006	In progress	3/30/2007
	Fate and transport/watershed model update	WQCD/EPA Review	72.8(5)			5/26/2005	In progress	6/1/2007
<b>Reservoir Model Update</b>	Reevaluate target reservoir load	Evaluate potential for acquiring funding for reservoir model update in 2006	72.8(5)	Use monitoring data to determine nutrient fate and transport and calibrate models for next phase of TMAI		9/1/2005	Completed	12/31/2005
	Reevaluate target reservoir load	Initiate reservoir model review/update	72.8(5)			1/2/2006	Completed	5/30/2006
	Reevaluate target reservoir load	Contract for reservoir model update	72.8(5)			5/2/2006	Completed	5/18/2006
	Reevaluate target reservoir load	Revisit/update reservoir model to calculate target load	72.8(5)			5/1/2006	In progress	12/31/2006
<b>Triennial Review</b>	Informational Hearing	Identify potential Control Regulation issues and revisions	72.9	Reporting Progress		1/1/2006	Completed	7/28/2006
	Informational Hearing	Notice	72.9	Reporting Progress		5/15/2006	Completed	6/15/2006
	Informational Hearing	Informational Hearing	72.9	Reporting Progress		8/14/2006	Completed	8/14/2006
<b>TMAI Revision</b>	Revisecalcs of background sources, industrial processes, ISDS contributions		72.4(4)	Completion of tasks identified	K - Conduct special studies to optimize water quality improvements	7/1/2006		2007
	Reevaluate/determine how to allocate load		72.4(4)	Completion of tasks identified	K - Conduct special studies to optimize water	10/1/2006		2007

## 2.4 Financial Matters

The Authority receives funding for its activities primarily from property taxes, Cherry Creek State Park (Park) user fees, wastewater bill surcharges, and building permit fees. These primary sources are supplemented with funds from various grants and other fees and charges.

The Authority's budget for the 2006 calendar year was approximately \$1,692,000 in revenue and approximately \$2,896,000 in expenditures. Colorado State Statute § 25-8.5-111(3) dictates that the Authority must spend at least 60% of the annual authorized revenues on the construction and maintenance of PRFs. The budgeting process for PRFs is discussed in Section 5.6. The remaining 40% is allocated towards monitoring, special studies, planning documents, technical reports or memoranda, and administrative costs.

### 2.4.1 Funding Sources

Approximately \$1,113,000 (66%) of the Authority's budgeted revenue was tax based, \$500,000 (29%) was from fees and surcharges on wastewater, and \$79,000 (5%) was from miscellaneous sources, such as reimbursed expenses, grants, and the trading program. In 2006, the Authority was required under provisions of Article X, Section 20, of the Colorado Constitution (TABOR) to temporarily reduce its authorized mill levy. This requirement reduced the Authority's tax-based revenue by \$294,560.

### 2.4.2 Grants

The Authority was awarded two Colorado Nonpoint Source Program grants, which were contracted on October 27, 2005. The two grant projects are the "Cherry Creek State Park Wetlands" involving the design and construction of Phase 1 of the multi-phase wetlands construction project, and "TMAL Actions" to conduct three special studies specified in Control Regulation 72. The Cherry Creek State Park Wetlands project cost is \$159,500 (\$95,700 in grant funds and \$63,800 in Authority matching funds). The TMAL Actions project cost is \$240,000 (\$144,000 in grant funds and \$96,000 in Authority matching funds). The Authority began work on both grants in 2006.

## 2.5 2006 Reference Documents

The Authority generated documents in 2006 that serve as references for the status of water quality in Cherry Creek Reservoir, guidelines and educational material on water quality BMPs, technical sources on various aspects of water quality, and watershed planning and management strategies. Table 2-3 lists key reference documents generated by the Authority in 2006.

**Table 2-3. 2006 Reference Documents**

<p><b>2005 Annual Report of Activities by the Cherry Creek Basin Water Quality Authority</b> Update on activities completed by the Authority in 2004 and progress made towards the phased TMAL.</p>
<p><b>2005 Annual Report of Baseline Water Quality Data Collection Study for the Upper Cherry Creek Basin</b> Flow and water quality data collected at surface and groundwater stations in the upper Cherry Creek Reservoir watershed.</p>
<p><b>2006 Annual Inspection of Pollutant Reduction Facilities</b> 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.</p>
<p><b>2005 Phosphorus Facilitator Report – Transportation Corridors</b> Describes recommended BMPs for transportation corridors.</p>
<p><b>Cherry Creek Basin Water Stewardship and Education Initiative Update</b> Update to 2-Year Action Plan for Education in the Cherry Creek Reservoir Watershed.</p>
<p><b>Cherry Creek Reservoir 2005 Annual Aquatic Biological and Nutrient Monitoring Study</b> Characterization of potential relationships between nutrient loading and reservoir productivity.</p>
<p><b>Cherry Creek Reservoir Reserve Pool Guidelines</b> Guidelines for the sale or lease of phosphorus credits from the Reserve Pool.</p>
<p><b>Cherry Creek Reservoir Trading Program Guidelines</b> Guidelines for phosphorus trading from new projects through the Trading Program.</p>
<p><b>Cottonwood Creek Reclamation Project Phase I Record Drawings</b></p>
<p><b>Design of the Cherry Creek Sediment Basin and Stream Stabilization Measures</b> Conceptual design for the Proposed Arapahoe Road Sediment Basin PRF.</p>
<p><b>Depth Profile Study of Phosphorus Concentrations in the Cherry Creek Alluvial Aquifer</b> Results of depth profiling study identified in Control Regulation 72, and discussed in Section 8.</p>
<p><b>Cherry Creek Reservoir Destratification Design Documents</b> Design drawings and specifications for the installation of a submerged focused mixing system in the reservoir to destratify and strongly mix the deepest portions of the reservoir, vertically mix algae to compromise their habitat and reduce production of blue-green algae, and oxidize of the deep bottom sediments to reduce the release of nutrients from the sediments into the water column.</p>
<p><b>Honorary Proclamation for Cherry Creek Basin Water Quality Authority Appreciation Day</b> The Governor of Colorado proclaims July 29, 2006 as Cherry Creek Basin Water Quality Authority Appreciation Day</p>
<p><b>Reference Reach Evaluation for Cottonwood Creek Reclamation Project</b> Evaluation to show that the proposed reclamation project is appropriately designed with respect to water use, with the intent that the State Engineers Office will view the project as acceptable without an augmentation plan.</p>
<p><b>Work Plan</b> A routinely updated comprehensive schedule of activities, as prescribed by Control Regulation 72 and recommended by Watershed Plan 2003.</p>

### 3. DESCRIPTION OF CHERRY CREEK RESERVOIR WATERSHED

Originally built for flood control, Cherry Creek Reservoir is owned and operated by the COE. The reservoir, with a surface area of approximately 850 acres, and surrounding land were leased to the State of Colorado for use as the Cherry Creek State Recreation Area in 1957. The 3,915-acre park almost immediately received extensive recreational use, a pattern that has continued to the present day. The park had 1.1 million visits last year (2005-6 fiscal year). 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.

Cherry Creek Reservoir was designed as a terminal stormwater 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, along with subsurface flows from below the dam, has maintained Cherry Creek downstream of the reservoir in a free-flowing condition. As a storage facility with regulated outflows, upstream flows have accumulated, over almost 50 years, sediment to depths of up to 6 meters at the outlet works with an average overall depth of almost 3 meters. 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's watershed includes approximately 245,500 acres and 32 sub-watersheds (Figure 3-1). The northern portion of the watershed has been urbanizing over the past twenty years, 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 mostly in the southern upstream half of the watershed. The reservoir is currently classified for warm water aquatic life, primary recreation, water supply, and agriculture.



Photo 1 courtesy of Gary Barnhart





### 3.1 Water Quality History and Regulations

Figure 2-2 in Section 2, entitled Summary of Authority History, provides background information on the Authority, water quality, and changes in regulations. The Cherry Creek Reservoir chlorophyll *a* standard of 15 µg/L has only been met in three of the past 15 years, and the phosphorus goal of 40 µg/L has never been achieved in the past 15 years. However, the phosphorus loads have been lower than the TMAL of 14,270 pounds in 14 of the past 15 years. In 2006, Reservoir chlorophyll *a* was 14.7 µg/L and phosphorus was 87 µg/L, while the phosphorus load to the reservoir was 6,185<sup>1</sup> pounds.

Watershed Plan 2003 identifies investigations and strategies to evaluate as part of arriving at achievable goals and standards. Information from investigations and special studies, discussed in Section 8, will assist in determining how to refine the phased TMAL and identify additional control measures. In the meantime, the phased TMAL process provides a framework for the adoption of point source and nonpoint source controls that will provide protection for the reservoir.

Table 3-1 lists the current Phase I TMAL annual phosphorus allocations, per Control Regulation 72.

**Table 3-1. Phase I TMAL Annual Phosphorus Allocations**

Allocation Type	Total Phosphorus Pounds/Year
Nonpoint and Regulated Stormwater Sources	10,506 <sup>1</sup>
Background Sources	1,170
Wastewater Facility Sources (Including Reserve Pool and Phosphorus Bank)	2,094
Industrial Process Wastewater Sources	50
Individual Sewage Disposal Systems	450
<b>Total Maximum Annual Phosphorus Load</b>	<b>14,270</b>

Notes:

<sup>1</sup> As part of the 2004 Triennial Review Hearing for Control Regulation No. 72, the Commission eliminated the 216 pounds allocated in the Phosphorus Bank for phosphorus trading, which limited the Trading Program. The 216 phosphorus pounds originally in the Phosphorus Bank are now accounted for in the Nonpoint and Regulated Stormwater Sources.

<sup>1</sup> Reservoir inflow and load data are provisional. These data are subject to change based on final review of U.S. Army Corps of Engineers (COE) reservoir inflow data.



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## 4. WASTEWATER FACILITY CONTROLS

Wastewater and industrial process wastewater sources must have a sufficient phosphorus wasteload allocation prior to discharging in the Cherry Creek Reservoir watershed. Wastewater utilities in the Cherry Creek Reservoir watershed are also required to meet certain standards and follow procedures for the purpose of limiting phosphorus loads that can ultimately reach Cherry Creek Reservoir. Six point source dischargers within the Cherry Creek Reservoir watershed provide centralized wastewater treatment service.

### 4.1 Wasteload Allocation

Wastewater treatment facilities provide phosphorus removal and treatment using either secondary treatment followed by land application or advanced wastewater treatment followed by land application or direct discharge. As listed in Table 4-1, each facility is limited to an annual allocation of phosphorus pounds.

#### 4.1.1 Monthly and Annual Loading

The Colorado Discharge Permit System permits require dischargers to monitor and quantify the concentration and total pounds of phosphorus discharged. Tables 4-1 and 4-2 present the phosphorus allocations and annual and monthly loads, respectively, for the wastewater dischargers in 2006.



**Table 4-1. Cherry Creek Reservoir Watershed Point Source Allocation and 2006 Point Source Phosphorus Annual Contribution<sup>1</sup>**

Facility	Allocation (pounds)	2006 Phosphorus (pounds) <sup>1</sup>
Arapahoe County Water and Wastewater Authority/Cottonwood Water & Sanitation District <sup>2</sup>	402	132.9
Pinery Water and Sanitation District	304	40.0
Inverness Water and Sanitation District	129	33.2
Parker Water and Sanitation District <sup>3</sup>	593	157.3
Meridian Water and Sanitation District <sup>1</sup>	113	0.0
Stonegate Village Metropolitan District	161	27.2
Plum Creek Wastewater Authority <sup>4</sup>	25	8.5
City of Aurora <sup>4</sup>	10	
Semi-Urban Areas <sup>3,5</sup>	141	
Industrial Process Wastewater Sources <sup>6</sup>	50	
<b>Subtotal</b>	<b>1,928</b>	
Reserve Pool	216	
Phosphorus Bank	0	
<b>Total</b>	<b>2,144</b>	399

Notes:

- <sup>1</sup> The 2006 phosphorus pounds are as reported to the Division in discharge monitoring reports (DMRs). Meridian reported zero phosphorus contributions (i.e., effluent applied at agronomic rates).
- <sup>2</sup> ACWWA has 57 pounds of conditionally approved phosphorus trade credits in addition to its 402 pound allocation.
- <sup>3</sup> In December 2005, the Authority Board approved the Parker Water & Sanitation District Wastewater Utility Plan Amendment and an allocation from the semi-urban area of 60 pounds.

- <sup>4</sup> In 2004, phosphorus pounds were transferred from the semi-urban area allocation to the Plum Creek Wastewater Authority and the City of Aurora for Land Applications within the Cherry Creek Watershed.
- <sup>5</sup> Semi-urban areas are potential development areas outside the Denver Regional Council of Governments (DRCOG) urban growth boundary or are assigned areas not affiliated with a service provider. These areas have not been included within a designated service area assigned to existing wastewater facilities that have wasteload allocations but are designated planning areas planned for urbanization after 20 years.
- <sup>6</sup> There are currently no industrial process wastewater sources with a wasteload allocation.

**Table 4-2. 2006 Point Source Phosphorus Monthly Contribution <sup>1</sup>**

Month	Discharges to Cherry Creek				Discharges to Lone Tree Creek
	Parker Water and Sanitation District (pounds/month)	Pinery Water and Sanitation District (pounds/month)	Stonegate Village Metropolitan District (pounds/month)	Plum Creek Wastewater Authority <sup>2</sup> (pounds/month)	Arapahoe County Water and Wastewater Authority (pounds/month)
January	18.6	4.3	3.3		7
February	16.9	4.6	3.3		6.9
March	11.7	3.3	9.1		6.9
April	14.7	3.3	2.5	0.5	8.6
May	13.4	3.4	1.0	1.6	10.8
June	14.5	2.9	0.6	2.2	12.3
July	11.7	2.8	1.7	0.9	12.2
August	13.3	2.5	1.0	1.0	16.2
September	13.0	3.1	1.3	1.1	14.3
October	9.2	3.0	1.0	0.7	16
November	8.8	3.3	1.2	0.6	10.4
December	11.4	3.6	1.2		11.3
<b>Total</b>	157.3	40.0	27.2	8.5	132.9

Notes:

<sup>1</sup> The 2006 phosphorus pounds provided are as reported to the Division.

<sup>2</sup> The Plum Creek Wastewater Authority discharges in the Cherry Creek Reservoir watershed are through reuse irrigation and only occur during the irrigation season.

#### 4.1.2 Temporary Transfer and Reserve Pool Actions

Control Regulation 72 allows the temporary transfer of the unused portion of a phosphorus wasteload allocation from an existing discharger to another facility (Section 72.5(1)). Both the transferring and receiving facilities must agree upon the temporary transfer.

There were no temporary transfers or reserve pool actions in 2006.

#### 4.2 Wastewater Permits and Limits

Control Regulation 72 requires that the Annual Report also include wastewater facility permit violations with regard to phosphorus concentration limits and annual phosphorus loads. There were no reported phosphorus permit violations in 2006.

The wastewater utilities in the Cherry Creek Reservoir watershed met the following Control Regulation 72 discharge requirements:



- By August 1, 2004 direct dischargers in the Cherry Creek Reservoir watershed must discharge phosphorus at a 30-day average effluent concentration less than 0.05 mg/L and dischargers using land application must discharge a 30-day average phosphorus concentration less than 0.05 mg/L divided by the return flow factor.
- Where land application relies on lysimeters to determine phosphorus groundwater returns, the effluent concentration prior to land application shall not exceed 1.0 mg/L total phosphorus.

### 4.3 Site Location Approval Review



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

Applications for site location approval are reviewed to determine if the criteria in the following documents have been met.

- Cherry Creek Basin Water Quality Management Master Plan/Control Regulation 72 (Commission, December 2004).
- Emergency Response Plan Criteria for the Cherry Creek Reservoir Watershed (Authority, March 2002).
- Regulation No. 22, "Site Location and Design Approval Regulations for Domestic Wastewater Treatment Works" (Commission, June 2004).
- Metro Vision 2020 Clean Water Plan: "Wastewater Utility Plan Guidance" (Denver Regional Council of Governments, January 2003) and "Lift Station Report Guidance and Checklist" (DRCOG, October 2000).
- Policy 96-1, "Design Criteria Considered in the Review of Wastewater Treatment Facilities" (Commission, expiration date May 31, 2007).

The Authority developed the Emergency Response Plan Criteria for the Cherry Creek Reservoir watershed to establish criteria for emergency response plans, and requires that emergency response plans are included with each application for site location approval.

In addition, the Authority performs a cursory review of the pump selection and sizing for lift stations to ensure that there were no obvious problems with the equipment proposed for the lift station. The purpose of the review is summarized as follows.

- Provide a summary and brief review of the engineering report and application for site location approval, relative to the requirements of the Authority.

- Provide opinions on the thoroughness and completeness of the engineering report and application for site location approval.
- Provide opinions on whether the engineering report and application meet all criteria as defined by the control regulations.

DRCOG relies on completeness and thoroughness of review by the Authority for acceptance of the site location approval because the Authority is a designated 208 agency. The Authority reviewed two lift station applications for site location approval, one wastewater utility master plan amendment and one wastewater treatment plant expansion in 2006 (Tables 4-3 and 4-4). All wastewater utilities in the Cherry Creek watershed have approved Wastewater Utility Master Plans.

**Table 4-3. Summary of 2006 Applications for Site Location Approval**

Application for Site Location Approval	Design Features	Wastewater Service Provider
Lift Station 15 and Kings Pointe Interceptor	Flow – 0.7 mgd, daily average Force main – 12” Onsite emergency storage - Diverts flows to another lift station with capacity and emergency onsite storage.	Aurora Water
Sierra Ridge Lift Station	Flow – 0.28 mgd (Phase 3), daily average Force main – 10” Onsite emergency storage – 4 hr at average flow	Parker Water and Sanitation District
Expansion of the Meridian Metro District Wastewater Treatment Facility	Flow – expansion from 1.25 mgd to 1.5 mgd	Meridian Metro District

**Table 4-4. Summary of Wastewater Utility Master Plan Amendment in 2006**

Wastewater Utility Master Plan	Description
Pinery Water and Sanitation District	Amendment confirms the addition of the Canyons South Development to the District’s service area and updates mapping of the wastewater utility service area, Clean Water Plan planning area, and urban growth boundaries.

#### 4.3.1 Aurora Water — Lift Station 15 and Kings Pointe Interceptor Project

The new lift station, associated forcemain, and interceptor will provide greater capacity for the Cornerstar and Kings Pointe Development. Flow collected from the Aurora service area will be diverted to Lift Station 15 via the Cherry Creek Interceptor, which is a shared interceptor under agreement with the Arapahoe County Water and Wastewater Authority. The collected wastewater will be pumped to Metro Wastewater Reclamation District for wastewater treatment.

The Authority approved the application on January 18, 2007.

#### **4.3.2 Sierra Ridge Metropolitan District — Sierra Ridge Lift Station**

The Sierra Ridge Lift Station Application for Site Location was submitted for review on August 4, 2006. In response to review comments, the applicant provided supplemental information on November 13, 2006 and January 2, 2007. The proposed new lift station will serve the Sierra Ridge Development. The Sierra Ridge Metropolitan District will construct, own, operate, and maintain the lift station and associated forcemain and sewer mains. Parker Water and Sanitation District (PWSD) will provide wastewater treatment and assume ownership of the lift station. PWSD will also operate and maintain the lift station and forcemain after construction and approval by PWSD.

The Authority approved the application on January 18, 2007.

#### **4.3.3 Meridian Metro District — Wastewater Treatment Facility Expansion**

Meridian Metro District submitted an Application for Site Location Approval to expand its wastewater treatment facility on August 18, 2006. The proposed wastewater treatment facility expansion was prompted by the upcoming Meridian Village residential development and would increase the hydraulic and organic loading capacities of the plant.

The Authority approved the application on October 19, 2006.

#### **4.3.4 Pinery Water and Wastewater District — Wastewater Utility Master Plan Amendment**

Pinery Water and Sanitation District submitted a Wastewater Utility Plan (WUP) Amendment for review on September 22, 2005; revised information was submitted on December 29, 2005. The submittal amends Pinery Water and Sanitation District's 2000 WUP. The WUP amendment adds The Canyons South Development to the wastewater utility service area (WUSA), updates mapping of the WUSA and Clean Water Plan planning areas, and distinguishes between semi-urban and urban growth boundary areas.

The anticipated increase in wastewater flows from The Canyons was included in the approved WUP, but the service agreement was not finalized until December 23, 2004. Therefore, the WUP amendment does not modify the District's wastewater flow, phosphorus allocation, collection, or treatment systems from what is approved in the current WUP.

The Authority approved the application on February 16, 2006.

#### **4.4 Revisions to DRCOG Clean Water Plan Technical Appendix**

The TAC and special districts participated in the review and provided comments to DRCOG to assist in the update to the technical appendix.



#### 4.5 Progress Made

- Wastewater facility discharges did not exceed annual permitted wasteload allocations or effluent phosphorus concentrations.
- The Authority reviewed and approved two applications for site location approval for the construction of lift stations, one wastewater utility plan amendment and one wastewater treatment facility expansion within the Cherry Creek Reservoir watershed for compliance with applicable regulations and guidance documents. This includes compliance with wasteload allocations and wastewater utility plans.

## 5. NONPOINT SOURCE CONTROLS

Due to the broad scope of nonpoint and regulated sources in the Cherry Creek Reservoir watershed, several programs are in place to target nonpoint source pollutant reduction. Programs include regulations for stormwater controls and long-term planning for PRF construction, discussed in this section, as well as public education and outreach programs (Section 7) and Cherry Creek Reservoir and watershed monitoring.

### 5.1 Land Use Agency Implementation of Stormwater Permit Requirements

#### STEPS REG 72

In 1999, the National Pollutant Discharge Elimination System (NPDES) Stormwater Phase II Rule expanded the Phase I Rule to include several of the land use agencies that are part of the Authority. Prior to 2004, the City of Aurora was the only agency in the Cherry Creek Reservoir watershed covered under the Phase I Rule. Phase II permits became effective on March 10, 2003.

The Phase II Rule requires small municipal separate storm sewer systems (MS4s) to, at a minimum, adopt BMPs for six minimum control measures, implement them to the “maximum extent practicable,” 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 Reservoir watershed as part of Control Regulation 72. Erosion and sediment control and post-construction BMP programs for each agency under the NPDES Phase II requirements are complimentary to the same programs required under Control Regulation 72. Phase II permittees in the Cherry Creek Reservoir watershed formed cooperative workgroups to coordinate Phase II compliance and identify opportunities for effective stormwater program implementation to minimize overlap and redundancies.

#### Reg 72 Reporting

Stormwater permit reporting information was provided to the Authority by the land use agencies on the following key elements (Table 5-1).

- Sediment and erosion control permit, inspection, and enforcement actions
- Construction BMP inspection and enforcement actions
- Permanent BMP construction, inspection, and maintenance actions

Detailed information on implementation for each Phase I and Phase II permittee can be found in the Stormwater Annual Reports for MS4s submitted to the Division.

**Table 5-1. Summary of Cherry Creek Reservoir Watershed Permit, Inspection, and Enforcement Actions**

Land Use Agency <sup>1</sup>	Permit Inspection Actions <sup>2</sup>	Permit Enforcement Actions <sup>2</sup>	Other
Arapahoe County	Illicit discharges: 3 inspections Construction: 307 inspections (GESC) Post-construction: 168 inspections for permanent BMPs and 6 inspections for permanent BMP operation and maintenance	Illicit discharges: no enforcement actions Construction: 4 reinspection fines issued and 1 notice of violation Post-construction: no construction site or permanent BMP enforcement actions	<p>All entities have public education and outreach programs that include, but are not limited to:</p> <ul style="list-style-type: none"> <li>▪ Coordination with other entities (Authority, Phase II Co-op workgroup, Partners, UDFCD).</li> <li>▪ Distribution of issue-specific fact sheets and brochures to residents and commercial entities.</li> <li>▪ Participation on school programs (e.g., project WET).</li> <li>▪ Educational projects such as willow planting with scout troops.</li> <li>▪ Web sites, hot lines, surveys, public service announcements.</li> </ul>
Douglas County	Illicit discharges: 97 Construction: 2,409 inspections (GESC) Single-family dwelling construction: 1,744 DESC inspections No complaints regarding permanent water quality BMPs	Illicit discharges: 97 response actions Level I GESC Violations (stop work orders): 74 DESC complaint visits: 830	
City of Aurora	Construction: 118 inspections	Construction: 15 notices of violation	
City of Centennial	Illicit discharges: 5 inspections Construction: 193 inspections based on Erosion Control program (prior to GESC approval) Post-construction: 12 inspections for installation of extended detention ponds with new development and 2 inspections for permanent BMP operation and maintenance	Illicit discharges: no enforcement actions Construction: 2 enforcement actions Post-construction: no enforcement actions	
City of Greenwood Village	Illicit discharges: 66 inspections Construction: 6,602 inspections at 697 sites Post-construction: 39 BMP inspections for final construction and 70 inspections for permanent BMP operation and maintenance:	Illicit discharges: 8 actions to identify source of discharge and require responsible party to mitigate. Construction: no formal enforcement actions required Final Construction and Permanent BMP Operation and Maintenance: No enforcement actions	
City of Lone Tree	Illicit discharges: 7 inspections Construction: 12 inspections	Illicit discharges: no notices of violation Construction: 6 minor violations, 3 major violations	
Town of Castle Rock	Illicit discharges: 7 inspections Construction: 580 inspections (GESC) and 4,470 inspections for single-family residential (DESC) Post-construction: 328 inspections, 20 post-storm inspections	Illicit discharges: no violation issued Construction: 9 notices of non-compliance issued for single-family residential DESC	

Land Use Agency <sup>1</sup>	Permit Inspection Actions <sup>2</sup>	Permit Enforcement Actions <sup>2</sup>	Other
Town of Parker	Illicit discharges: 64 inspections Construction: 870 inspections (GESC) Post-construction: 106 inspections of detention basins	Illicit discharges: 2 notices of violation and 2 citations Construction: 823 non-compliance notices, 6 stop work orders Post-construction: 270 maintenance activities	

Notes:

GESC = Grading, erosion, and sediment control (permitting/inspection process for land-disturbing activities)

DESC = Drainage, erosion, and sediment control (permitting/inspection process for detached single-family residential)

<sup>1</sup> The land use agencies do not separately track inspection and enforcement action within the Cherry Creek Reservoir watershed. Information provided represents actions for the entire land use agency area.

<sup>2</sup> Foxfield is not a phase II community and is not included in this table.

## 5.2 Cherry Creek Reservoir Watershed Stormwater Quality Requirements

### STEPS REG 72

In 2000, the Authority adopted requirements related to construction activities and post-construction control of stormwater quality in the Cherry Creek Reservoir watershed entitled the “Cherry Creek Reservoir Watershed Stormwater Quality Requirements” (Requirements). The purpose of the Requirements is to recommend implementation of substantive BMP measures to control the quality of stormwater runoff from land disturbances on private and public property. The Requirements are necessary to reduce and maintain nonpoint source and stormwater phosphorus loads in accordance with the TMAL set forth in Control Regulation 72. In addition, the requirements establish the minimum construction and post-construction BMPs in the reservoir watershed for all new development activities.

Land use agencies within the Cherry Creek Reservoir watershed now have NPDES Phase II stormwater permits which have requirements that meet, and in some cases, exceed the Authority Requirements. As a result, the Authority and land use agencies are recommending changes to Control Regulation 72 and developing an accompanying guidance document. Proposed changes will be presented to the Commission at the 2007 triennial review hearing.

## 5.3 Land Use Application Review

### STEPS REG 72

The Authority serves as a referral agency in the land use application process for nine 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 the Authority’s Requirements.

In March 1997, Brown and Caldwell, as consultant to the Authority, began providing review of land use and development applications on behalf of the Authority. Table 5-2 provides a review of the number of land use and development applications that the Authority has reviewed annually since March 1997.

**Table 5-2. History of Land Use and Development Applications Reviewed by Authority**

Year	Number of Land Use and Development Applications Reviewed by Authority
March – December 1997	103
1998	179
1999	135
2000	190
2001	144
2002	126
2003	156
2004	176
2005	189
<b>2006</b>	<b>177</b>
<b>Total</b>	<b>1575</b>

In 2006, the Authority reviewed and provided comment on 177 land use and development applications. Table 5-3 provides a breakdown of the various agencies that referred land use applications to the Authority in 2006.

**Table 5-3. Sources of Land Use and Development Application Referrals**

Referring Agency	Number of Land Use and Development Applications Referred to Authority in 2006
Arapahoe County	18
Douglas County	47
City of Aurora	24
City of Centennial	6
E-470 Public Highway Authority	1
Town of Castle Rock	4
Town of Foxfield	4
Town of Parker	73
<b>Total</b>	<b>177</b>

The Authority's review of each application focuses on nonpoint pollutant source impacts and water quality considerations related to the proposed project. Review comments generally fall into the categories listed in Table 5-4. The Authority took no exception for 76% percent of the land use applications reviewed, and did not recommend approval for 12%. In many of these cases, the Authority reserves the right to review future submittals to determine if recommendations were incorporated. Of the five applications that were not within the watershed, four were related to the same project.

**Table 5-4. Summary of Comments on Land Use and Development Applications in 2006**

Comment Category	Number of Applications	Percent of Applications
<b>No exception</b>	<b>135</b>	<b>76%</b>
No exception, minimum requirements are met	34	19%
No exception, provided additional recommendations met	42	24%

<b>Comment Category</b>	<b>Number of Applications</b>	<b>Percent of Applications</b>
No exception, reserve right to review subsequent submittals	58	33%
No exception, previous concerns were addressed	0	0%
No exception, project is part of larger approved project	1	1%
<b>No approval</b>	<b>21</b>	<b>12%</b>
No approval until BMPs requirements are met	3	2%
No approval, provided recommendations	15	8%
Insufficient materials (e.g., drainage reports referenced but not provided)	3	2%
<b>BMP recommendations only (early in application process)</b>	<b>3</b>	<b>2%</b>
<b>Special cases</b>	<b>2</b>	<b>1%</b>
<b>Comments not required (e.g., notice of annexation)</b>	<b>11</b>	<b>6%</b>
<b>Not in Cherry Creek Reservoir watershed</b>	<b>5</b>	<b>3%</b>

#### **5.4 Compliance with Cherry Creek Reservoir Watershed Stormwater Quality Requirements**

The Authority's review of applications for land-use change in the Cherry Creek Reservoir watershed provides the following benefits.

1. 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 Towns of Parker and Castle Rock in several tributaries that previously were undeveloped. This pattern points to the need to focus on preventing erosion in the tributaries by stabilizing the tributary simultaneously with, if not in advance of, development.
2. A better understanding of how well developers are complying with Authority Requirements and improved communication with the land-use agency personnel. Previously, some community officials were unaware of the Authority and its Requirements to protect the water quality in the Cherry Creek Reservoir watershed. Currently, the Authority's review and comments are integral to the development process and a negative response from the Authority can result in changes to the land use application.
3. An opportunity for the Authority to work more closely with developers during the initial stages of land use planning, by identifying projects where land use plans that include water quality enhancements would be more appropriate. The Authority develops these opportunities through the Phosphorus Facilitator program (Section 5.5) and coordination with land use agency staff.

4. The opportunity to stress the importance of meeting minimum requirements for BMPs through negative referrals, which have resulted in implementation of better water quality plans, some of which have gone beyond minimum requirements.

#### **5.4.1 Proprietary Best Management Practices**

The Authority and local land-use agencies receive requests to utilize proprietary BMPs for erosion and sedimentation control and to substitute proprietary BMPs for the Authority's minimum BMP requirement, which is extended detention basins. The Authority relies primarily on recommendations of the Urban Drainage and Flood Control District (UDFCD), provided in the Urban Storm Drainage Criteria Manual Volume 3 Best Management Practices (UDFCD 1999), when evaluating proprietary BMPs. Referrals to the Authority have been reviewed on a case-by-case basis and the Authority has approved the use of proprietary BMPs in some cases, as a test-case for others, and not approved in other applications.

The Authority does not have the resources to properly evaluate all proprietary BMPs to make a specific recommendation on which units are acceptable and which are not. We rely on the design engineer and other independent agencies, such as the UDFCD, to provide guidance, justification, and recommendations. The Authority, therefore, requires the applicant's engineer to evaluate various BMP units and recommend a specific unit based on the following criteria.

- The ability to remove floatables, oil/grease, and phosphorus. Contaminant removal efficiency should be the primary basis for selecting a unit. The standard deviation in performance differences, as stated by the manufacturer, should be considered.
- Requirements of the local jurisdictions.
- Operation and maintenance requirements that are assigned to a governmental or quasi-governmental organization. These cases will be given priority over other organizations, such as home owner associations.
- Cost. Cost is a secondary consideration for selecting one unit over the other after the other criteria are considered.

#### **5.5 Phosphorus Facilitator**

In 2006, the Authority continued the Phosphorus Facilitator program. The role of the Phosphorus Facilitator, an independent consultant, is to investigate opportunities to improve water quality by working with developers and local governments to improve land-use plans and exceed minimum requirements for immobilization of phosphorus. The development of such plans is being accomplished through a coordinated working relationship between a land use agency, a developer, and their planners and engineers (collectively called "development group"). The intent is to identify water quality opportunities within a parcel of land before a developer selects a land-use plan, and to encourage the developer to implement an enhanced water quality plan. The land use agency can provide various incentives to encourage

developers to implement enhanced water quality plans. However, sometimes the developer recognizes the benefits of an enhanced water quality plan in terms of cost savings, greater open space, and good-will and implements the plan without local government incentives.

The Phosphorus Facilitator focused on two activities in 2006: transportation corridor requirements and involvement in the development process of two commercial developments.

### **5.5.1 Transportation Corridor Requirements**

Transportation corridor projects require special and separate considerations due to the linear nature of the project area, which leaves little room for implementation of some BMPs, especially for those requiring water quality capture volume. BMP requirements for transportation corridors are different than for residential and commercial development, requiring greater expertise to identify, design, and implement. There is also the question of what constitutes local standard practices for minimum BMPs within a transportation corridor, which may be different than other types of land use changes.

In 2006, the Phosphorus Facilitator completed research on the potential pollutant loading impact from transportation corridors and BMPs that would provide treatment levels beyond the Authority's minimum requirements. The Phosphorus Facilitator prepared a guidance document for transportation corridors.

### **5.5.2 Working with Developers**

#### **5.5.2.1 Anthology**

The Phosphorus Facilitator worked with the engineer for the Anthology (formerly Stroh Ranch) development, which prepared preliminary roadway and drainageway designs for submittal to the Town of Parker. This site consists of a 3000-acre, mixed-use development located between Hess and Stroh Roads. The preliminary roadway plans follow the typical design guidelines required by the Town of Parker and, after acceptance of the preliminary design, the Phosphorus Facilitator and the engineer will meet with the Town of Parker to discuss the addition of grass-lined swales and extended dry detention within the roadway corridor. Conceptual designs indicate that these water quality features can be successfully incorporated within the right-of-way and buffer areas for Stroh Road and Chambers Road, two arterial roads that intersect the development.

The preliminary design for the major drainageways within Anthology is consistent with the UDFCD Master Plan recommendations, with some improvements that will provide water quality benefits. Instead of the conventional concrete check structures installed at-grade, which allow three feet of erosion on the downstream face, the preliminary plan includes check structures installed one foot above grade. This change will allow the check structures to capture some sediment upstream of the drops, preventing a large net loss of sediment from the site. The developer expressed an interest during final design to replace some of the check structures with small, wide, boulder drops to spread out the flow and encourage wetland growth in the channel, which will provide additional water quality benefits.

### 5.5.2.2 Cornerstar

The developer submitted a General Development Plan accompanied by a Master Drainage Report for a 158-acre commercial and residential development located at the southwest intersection of Arapahoe and Parker Roads. The plan as submitted includes the grading of a riparian area long the main channel of Cherry Creek that has the potential for creating significant water quality benefits. The proposed grading would create a wetland area that would improve the quality of moderate size (2-5 yr) storms in Cherry Creek plus stormwater discharges for the Cornerstar Development.

The Phosphorus Facilitator worked with the Cornerstar team (Vision Land Consultants) to get Corps of Engineers support of the concept. The Corps indicated that it could be constructed without the necessity for a 404 permit since it did not include the deposit of any fill materials below the “ordinary high water mark” of Cherry Creek.

The Cornerstar development plan has the potential to include multiple features that go beyond the minimum requirements for stormwater management in the basin. Several details, however, need to be resolved to be sure that the system-wide proposal does in fact go beyond the minimum requirements. There are also technical details that need to be worked out to assure that the Cherry Creek channel design does include all of the channel stabilization features that would be required to assure a functioning system over the long term.


## 5.6 Capital Improvement Projects



In accordance with statutory requirements, the Authority must spend at least 60% of the annual budget on design, construction, operation, and maintenance of pollutant abatement projects. To meet this requirement, the Authority conducts a multi-year, capital improvement project (CIP) planning process (currently five-year projections are made) to construct potential PRF projects. Potential PRFs are identified and evaluated, and costs are estimated over the life of design and construction for the project. The five-year projections, which are part of the Authority’s annual budgeting process, are separated into design, capital, land acquisition, water augmentation requirements, and operations and maintenance costs. These costs are then spread-out over a multi-year period for longer-range planning purposes, subject to available Authority funds.


The first step in the process is development of 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. 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 Board Authorized work towards design and construction is considered to be part of capital expenses of the Authority.

The next step is the selection of the best projects from the master list of PRFs to be included on the three-year CIP list, as listed in Table 5-5. The TAC annually evaluates the projects on the master list and forwards recommendations to the Board for inclusion on the



five-year CIP. The Board then selects projects for the five-year CIP, subject to available funds. The PRF projects that progressed during 2006 and those projects recommended for further consideration in 2007 are discussed below.

- Reservoir Destratification
- Cherry Creek State Parks Wetlands Reclamation
- Cherry Creek Sediment Pond at Arapahoe Road
- Cottonwood Creek Stream Reclamation, Phases II
- Projects Projected for 2007 Activity



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CHERRY CREEK BASIN WATER QUALITY AUTHORITY  
**TABLE 2 - SUMMARY OF RECOMMENDED POLLUTANT REDUCTION FACILITIES**  
**2007 BUDGET SUMMARY (1000\$)**

September 8, 2006

Project No.	Project Title	Project Budget						Previous Expend. Note 11	Residual PRF Costs	Proposed 2007 Budget					Residual PRF Costs	Proposed 2008 Budget Total	Residual PRF Costs	Proposed 2009 Budget Total	Residual PRF Costs	Proposed 2010 Budget Total	Residual PRF Costs	Proposed 2011 Budget Total	Residual PRF Costs	
		Capital <sup>1</sup>	Land	Water	Total	O&M	Authority Portion			Design <sup>6</sup>	Capital	Land	Water	Total										
CCR-1	Reservoir De-stratification (mixing) <sup>10</sup>	\$ 862	\$ -	\$ -	\$ 862	\$ 50	100%	\$ 372	\$ 490	\$ 45	\$ 445	\$ -	\$ -	\$ 490	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
CCB-1	CCSP Wetlands <sup>5,7</sup>	\$ 1,928	\$ -	\$ -	\$ 1,928	\$ 19	100%	\$ 6	\$ 1,922	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 1,928	\$ 63	\$ 1,865	\$ 63	\$ 1,802	\$ 63	\$ 1,739	\$ 63	\$ 1,676	
CCB-5.1	Cherry Creek Sediment Pond at Arapahoe Road <sup>4</sup>	\$ 4,278	\$ 50	\$ -	\$ 4,328	\$ 90	12%	\$ 70	\$ 511	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 511	\$ 175	\$ 336	\$ 336	\$ (0)	\$ -	\$ (0)	\$ -	\$ (0)	
CCB-5.2	Arapahoe/Douglas County Line Stream Stabilization (Parker) <sup>17</sup>	\$ 700	\$ -	\$ -	\$ 700	\$ 1	25%	\$ -	\$ 175	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 175	\$ -	\$ 175	\$ 175	\$ -	\$ -	\$ -	\$ -	\$ -	
CCB-5.4	Cherry Creek Stream Stabilization at Mainstreet (Parker) <sup>17</sup>	\$ 1,300	\$ -	\$ -	\$ 1,300	\$ 1	25%	\$ -	\$ 325	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 325	\$ 325	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
CCB-5.6	Cherry Creek Stream Stabilization at Lincoln Avenue (Parker) <sup>17</sup>	\$ 1,315	\$ -	\$ -	\$ 1,315	\$ 1	20%	\$ -	\$ 263	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 263	\$ -	\$ 263	\$ -	\$ 263	\$ 30	\$ 233	\$ 233	\$ -	
CCB-5.7	Cherry Creek Stream Stabilization at Eco-Park (Arap County) <sup>17</sup>	\$ 294	\$ -	\$ -	\$ 294	\$ 1	20%	\$ -	\$ 59	\$ -	\$ 59	\$ -	\$ -	\$ 59	\$ (0)	\$ -	\$ (0)	\$ -	\$ (0)	\$ -	\$ (0)	\$ -	\$ (0)	
CCB-5.8	Cherry Creek Stream Stabilization U/S Arapahoe Rd (Centennial)	\$ 518	\$ -	\$ -	\$ 518	\$ 1	25%	\$ -	\$ 130	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 130	\$ -	\$ 130	\$ 130	\$ (1)	\$ -	\$ (1)	\$ -	\$ (1)	
CCB-11	Advanced Water Treatment Plant <sup>16</sup>	\$ 4,593	\$ 100	\$ 100	\$ 4,793	\$ 69	100%	\$ -	\$ 4,793	\$ 100	\$ -	\$ -	\$ -	\$ 100	\$ 4,693	\$ 125	\$ 4,568	\$ 350	\$ 4,218	\$ 2,000	\$ 2,218	\$ 2,218	\$ -	
CCB-12.1	Bowtie Phase <sup>9</sup>	\$ 616	\$ 450	\$ -	\$ 1,066	\$ 6	100%	\$ -	\$ 1,066	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 1,066	\$ -	\$ 1,066	\$ 50	\$ 1,016	\$ -	\$ 1,016	\$ 50	\$ 966	
CCB-13.2	Cottonwood Creek Reclamation <sup>3</sup>	\$ 2,041	\$ -	\$ -	\$ 2,041	\$ 12	96%	\$ 783	\$ 1,211	\$ 135	\$ 1,076	\$ -	\$ -	\$ 1,211	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
CCB-16	Stream Corridor Preservation <sup>2</sup>	\$ -	\$ 500	\$ -	\$ 500	\$ -	100%	\$ -	\$ 500	\$ -	\$ -	\$ 100	\$ -	\$ 100	\$ 400	\$ 100	\$ 300	\$ 100	\$ 200	\$ 100	\$ 100	\$ 100	\$ -	
CCB-17	Reservoir Shoreline Stabilization <sup>13</sup>	\$ 550	\$ -	\$ -	\$ 550	\$ 5	69%	\$ -	\$ 380	\$ 60	\$ -	\$ -	\$ -	\$ 60	\$ 320	\$ 75	\$ 245	\$ 305	\$ (60)	\$ -	\$ (60)	\$ 500	\$ (560)	
<b>SUB-TOTALS</b>		<b>\$ 18,995</b>	<b>\$ 1,100</b>	<b>\$ 100</b>	<b>\$ 20,195</b>	<b>\$ 257</b>		<b>\$ 1,231</b>	<b>\$ 11,824</b>	<b>\$ 340</b>	<b>\$ 1,580</b>	<b>\$ 100</b>	<b>\$ -</b>	<b>\$ 2,020</b>	<b>\$ 9,810</b>	<b>\$ 863</b>	<b>\$ 8,947</b>	<b>\$ 1,509</b>	<b>\$ 7,438</b>	<b>\$ 2,193</b>	<b>\$ 5,245</b>	<b>\$ 3,164</b>	<b>\$ 2,081</b>	

CHERRY CREEK BASIN WATER QUALITY AUTHORITY  
**TABLE 2 - SUMMARY OF RECOMMENDED POLLUTANT REDUCTION FACILITIES**  
**2007 BUDGET SUMMARY (1000\$)**

September 8, 2006

Project No.	Project Title	Project Budget						Previous Expend.	Residual PRF Costs	Proposed 2007 Budget					Residual PRF Costs	Proposed 2008 Budget	Residual PRF Costs	Proposed 2009 Budget	Residual PRF Costs	Proposed 2010 Budget	Residual PRF Costs	Proposed 2011 Budget	Residual PRF Costs
		Capital <sup>1</sup>	Land	Water	Total	O&M	Authority Portion			Note 11	Design <sup>6</sup>	Capital	Land	Water									
<b>OPERATIONS AND MAINTENANCE</b>																							
<i>Rehabilitation Categories</i>																							
OM-1	Restore Cottonwood Perimeter Road	\$ 113	\$ -	\$ -	\$ -	\$ 113	100%	\$ -	\$ 113	\$ 8	\$ -	\$ -	\$ -	\$ 8	\$ 105	\$ 105	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
OM-2	Shop Creek Wetlands Restoration <sup>12</sup>	\$ 200	\$ -	\$ -	\$ -	\$ 200	100%	\$ -	\$ 200	\$ 16	\$ -	\$ -	\$ -	\$ 16	\$ 184	\$ 184	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
OM-8	Cottonwood/Peoria sediment removal <sup>14</sup>	\$ 24	\$ -	\$ -	\$ -	\$ 24	25%	\$ -	\$ 6	\$ -	\$ 6	\$ -	\$ -	\$ 6	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
<b>SUB-TOTALS</b>		<b>\$ 337</b>				<b>\$ 337</b>		<b>\$ -</b>	<b>\$ 319</b>	<b>\$ 24</b>	<b>\$ 6</b>	<b>\$ -</b>	<b>\$ -</b>	<b>\$ 30</b>	<b>\$ 289</b>	<b>\$ 289</b>	<b>\$ -</b>	<b>\$ -</b>	<b>\$ -</b>	<b>\$ -</b>	<b>\$ -</b>	<b>\$ -</b>	<b>\$ -</b>
<i>Restorative Categories</i>																							
OM-3	Quincy Drain embankment	\$ 2	\$ -	\$ -	\$ -	\$ 2	100%	\$ -	\$ 2	\$ -	\$ 2	\$ -	\$ -	\$ 2	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
OM-4	East Boat Ramp riprap	\$ 1	\$ -	\$ -	\$ -	\$ 1	100%	\$ -	\$ 1	\$ -	\$ 1	\$ -	\$ -	\$ 1	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
OM-10	East Shade Shelter	\$ 5	\$ -	\$ -	\$ -	\$ 5	100%	\$ -	\$ 5	\$ -	\$ 5	\$ -	\$ -	\$ 5	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
OM-11	Dixon Grove	\$ 8	\$ -	\$ -	\$ -	\$ 8	100%	\$ -	\$ 8	\$ -	\$ 8	\$ -	\$ -	\$ 8	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
OM-5	Tower Loop	\$ 13	\$ -	\$ -	\$ -	\$ 13	100%	\$ -	\$ 13	\$ -	\$ 13	\$ -	\$ -	\$ 13	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
OM-12	Cottonwood Perimeter Road Outlet works	\$ 8	\$ -	\$ -	\$ -	\$ 8	100%	\$ -	\$ 8	\$ -	\$ 8	\$ -	\$ -	\$ 8	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
OM-13	Shop Creek Sediment Removal	\$ 25	\$ -	\$ -	\$ -	\$ 25	25%	\$ -	\$ 6	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 6	\$ 6	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
OM-6	Interpretive Signage restore	\$ -	\$ -	\$ -	\$ -	\$ -	50%	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
<b>SUB-TOTALS</b>		<b>\$ 62</b>				<b>\$ 62</b>		<b>\$ -</b>	<b>\$ 43</b>	<b>\$ -</b>	<b>\$ 37</b>	<b>\$ -</b>	<b>\$ -</b>	<b>\$ 37</b>	<b>\$ 6</b>	<b>\$ 6</b>	<b>\$ -</b>	<b>\$ -</b>	<b>\$ -</b>	<b>\$ -</b>	<b>\$ -</b>	<b>\$ -</b>	<b>\$ -</b>
<i>Routine Categories</i>																							
OM-9	Sinking Fund Contribution <sup>8</sup>	\$ 125	\$ -	\$ -	\$ -	\$ 125	100%	\$ -	\$ 125	\$ -	\$ -	\$ -	\$ -	\$ 25	\$ 100	\$ 25	\$ 75	\$ 25	\$ 50	\$ 25	\$ 25	\$ 25	\$ -
OM-7	Reservoir Destratification <sup>9</sup>	\$ 212	\$ -	\$ -	\$ -	\$ 212	100%	\$ -	\$ 212	\$ -	\$ -	\$ 11	\$ 1	\$ 12	\$ 200	\$ 50	\$ 150	\$ 50	\$ 100	\$ 50	\$ 50	\$ 50	\$ -
<b>SUB-TOTALS</b>		<b>\$ 337</b>	<b>\$ -</b>	<b>\$ -</b>	<b>\$ -</b>	<b>\$ 337</b>		<b>\$ -</b>	<b>\$ 337</b>	<b>\$ -</b>	<b>\$ -</b>	<b>\$ 11</b>	<b>\$ 1</b>	<b>\$ 37</b>	<b>\$ 300</b>	<b>\$ 75</b>	<b>\$ 225</b>	<b>\$ 75</b>	<b>\$ 150</b>	<b>\$ 75</b>	<b>\$ 75</b>	<b>\$ 75</b>	<b>\$ -</b>
<b>SUB-TOTAL O&amp;M</b>		<b>\$ 736</b>	<b>\$ -</b>	<b>\$ -</b>	<b>\$ -</b>	<b>\$ 736</b>		<b>\$ -</b>	<b>\$ 699</b>	<b>\$ 24</b>	<b>\$ 43</b>	<b>\$ 11</b>	<b>\$ 1</b>	<b>\$ 104</b>	<b>\$ 595</b>	<b>\$ 370</b>	<b>\$ 225</b>	<b>\$ 75</b>	<b>\$ 150</b>	<b>\$ 75</b>	<b>\$ 75</b>	<b>\$ 75</b>	<b>\$ -</b>
<b>GRAND TOTAL</b>		<b>\$ 19,731</b>	<b>\$ 1,100</b>	<b>\$ 100</b>	<b>\$ 20,195</b>	<b>\$ 993</b>		<b>\$ 1,231</b>	<b>\$ 12,523</b>	<b>\$ 364</b>	<b>\$ 1,623</b>	<b>\$ 111</b>	<b>\$ 1</b>	<b>\$ 2,124</b>	<b>\$ 10,405</b>	<b>\$ 1,233</b>	<b>\$ 9,172</b>	<b>\$ 1,584</b>	<b>\$ 7,588</b>	<b>\$ 2,268</b>	<b>\$ 5,320</b>	<b>\$ 3,239</b>	<b>\$ 2,081</b>

NOTES:

- 1 Includes engineering, administration, and contingency
- 2 Specific project not identified. Budget based on available funds.
- 3 WQCD 319 Grant provides \$76,467. Phase I completed in 2004 at a const cost of \$475,000. Portion of Ph II design completed in 2004. Ph II delayed until Peoria St. relocated. Finish design in 2006
- 4 TetraTech Contract = \$70k + 2k. Total CIP = \$4,278M (TetraTech 2006). Project budget is for CCBWQA stream stabilization portion of project as partnering with Arapahoe County and UDFCD is anticipated
- 5 Multi-phase project to restore and enhance wetlands along Cherry Creek. WQCD 319 Grant provides \$63,800 toward total project of \$159,500.
- 6 Includes technical feasibility, design, construction observation and administrative costs
- 7 Due to lowering of the operating water level in the Reservoir, project may be infeasible. Evaluate water level changes on project for future budget considerations.
- 8 Based on a fixed amount for each year for the period of the projection.
- 9 Construction of project delayed until Piney Creek stabilization is further along and until Arapahoe Road sediment pond completed.
- 10 Equipment bid = \$301,566, installation = \$455,823, total const. = \$757,389 (AMEC memo 8/14/2006). AMEC services = \$93,000, BC services = \$11,300, Total projection = \$861,689
- 11 Accumulative expenditures for the project, based on previous years accounting and estimate of current year expenses
- 12 Create greater open water to wetlands ratio for performance. First phase is to determine feasibility of effort.
- 13 Cost based on similar projects for east side of Reservoir, from Tower Loop to the East Boat Ramp.
- 14 Assume Authority provides 25% of funds, with remaining under UDFCD cost sharing with Arapahoe County for O&M
- 15 O&M for CCSP projects based on 2006 Annual O&M Inspection Report
- 16 Cost of land and water acquisition unknown. \$100k used as "place holder". 2007 Budget for technical feasibility
- 17 Time line based on local entity CIP projections

## 5.6.1 Reservoir Destratification

Reservoir destratification employs aggressive and focused mixing of the reservoir with the goal of reducing algal growth and internal nutrient loading. Reservoir destratification is not specifically a PRF, because the project does not reduce external nonpoint source pollutants to the reservoir, but it is a capital improvement project identified to improve reservoir water quality.

### 5.6.1.1 Project Purpose

The Authority has been implementing watershed-based BMPs and constructing PRFs for 17 years. However, the chlorophyll *a* standard (15 µg/l) was exceeded from 1996 through 2005 and the phosphorus goal (40 µg/l) has been exceeded since 1992. The chlorophyll *a* standard was met in 2006 with a seasonal average of 14.7 µg/l, but the phosphorus level (87 µg/l) still exceeded the 40 µg/l goal. The reservoir has an overabundance of phosphorus. Algal growth is currently limited by nitrogen. Despite the Authority's programs to reduce phosphorus loads from the reservoir watershed, it will likely take many years before phosphorus once again becomes the limiting nutrient and water quality benefits are seen in Cherry Creek Reservoir.

A 2004 special study of in-lake nutrient enrichment indicated that, at that time, nitrogen was the limiting nutrient and that artificially mixing Cherry Creek Reservoir could decrease the tendency for algal blooms and lower chlorophyll *a* concentrations. In addition, anoxic bottom water, typical of eutrophic conditions, occurs irregularly in summer despite the top-to-bottom mixing (polymixis) that occurs on windy days in shallow areas. When the reservoir is stratified, significant amounts of ammonia, iron, and phosphate are released to the deep water and subsequently to the surface waters when the lake mixes a few days or weeks later. Reservoir mixing would also move oxygen rich water from the surface to the bottom, reducing the release of ammonia, iron and phosphates.

While watershed management is a necessary component of the Watershed Plan 2003 and both BMPs and PRFs must be implemented along with any in-lake management techniques, reservoir destratification (i.e., mixing) could provide multiple water quality benefits over a shorter period of time than relying solely on watershed measures.

### 5.6.1.2 Project History

The Authority conducted a technical feasibility investigation, including 35% level design, construction specifications, and cost estimate, in 2005 into in-lake management techniques that could be beneficial to reducing chlorophyll *a* and nutrient concentrations and increasing dissolved oxygen concentrations in the near term. The Authority considered destratification as a method to address internal loading and other factors that increase algal growth, such as chlorophyll *a*, and phosphorus and nitrogen concentrations. The consultant team recommended the installation of a submerged focused mixing system in that portion of the reservoir greater than 20 feet deep.

### 5.6.1.3 Project Activity

The recommendations of the technical feasibility investigation were presented to the TAC and Board in January 2006. The Authority approved the final design contract in early 2006 and equipment and installation plans were bid in late 2006, as discussed below. The arrival of equipment and final award of the installation contracts is expected early 2007 and completion of the installation no later than May 2007. The Authority is attempting to make arrangements with other qualified organizations for operations and maintenance of the system in 2007.

In 2006, final design plans and specification were prepared with input from the stakeholders group which included representatives from Cherry Creek State Park, Colorado Division of Wildlife, Water Quality Control Division, U.S. Army Corps of Engineers, Cherry Creek Marina, Sailing Association of Intermountain Lakes, a fisherman's group, Arapahoe County and the Authority.

The project was bid in 2006, first as a pre-purchase of equipment, then as installation and construction contracts separated by "below water" and "above water" work. The low bids for equipment and installation were within the Authority's budget and a conditional notice-of-award was issued in November 2006. The project was not awarded in 2006 because final plan approval from the U.S. Army Corps was not obtained until early 2007. A summary of the bids and estimates is presented in Table 5-3.

**Table 5-6. Summary of Bids and Estimates for Reservoir Destratification**

Item	Engineer's Estimate	Contractor's Low Bid	Contractor/Supplier
Compressor	\$59,000	\$58,490	Power Service of Colorado
Hydraulic Hose and Fittings	\$217,458	\$174,396	Discount Hydraulic Hose
Sanitaire Diffusers	\$3,125	\$2,325	Sanitaire
Regulator Assemblies	\$75,000	\$66,355	AMEC United Kingdom
Above Shoreline Installation	\$245,740	\$290,000	American Civil Constructors
Below Shoreline Installation	\$111,250	\$142,500	Inland Marine
Xcel Power Extension	\$20,000	\$11,575	Xcel Energy
Contingency/Mobilization	\$48,838	\$ -	n/a
Excavation for Compensating Storage	\$30,000	\$30,000	American Civil Constructors
<b>Total</b>	<b>\$810,411</b>	<b>\$775,641</b>	

The project plans included a bid alternate to enlarge the access berm across part of the dam face to make the berm an official State Parks trail, with the difference in cost paid by the State of Colorado. An intergovernmental agreement (IGA) for funding between the State and the Authority is in progress. In addition, an IGA for operations and maintenance of the

destratification system between the State and the Authority is also in progress with expected approvals of both IGAs in early 2007 prior to installation. Subject to weather delays, the reservoir destratification system is expected to be ready for the 2007 growing season.

The reservoir de-stratification system is projected to achieve the following:

1. Reduce the releases of phosphorus and nitrogen nutrients from the bottom sediments into the reservoir in a typical year by 810 lbs/yr and 1,140 lbs/yr, respectively.
2. Decrease the seasonal mean (July-September) chlorophyll *a* concentrations by approximately 8 µg/L under typical year conditions.
3. Decrease annual peak chlorophyll *a* concentrations by up to 30 µg/L.
4. Increase dissolved oxygen concentrations, in the deepest and most vulnerable zones of the reservoir, into the range of 5 mg/L.
5. Reduce the production of blue-green algae by vertical mixing to make the habitat of the reservoir less suitable for the production of blue-green algae.

To monitor the effectiveness of the destratification system, the Authority will increase the frequency of temperature monitoring during 2007 in the reservoir by installing temperature loggers at the three monitoring locations in the reservoir. During the period from early April through October, data loggers will record temperatures at 1-meter increments. In addition, the Authority will also perform a monthly (July-September) oxidation-reduction-potential (ORP) profile along the same transect used to gather ORP information during final design. The combination of the two additional chemistry measurements, along with the routine monitoring of the reservoir, will help determine if Cherry Creek Reservoir is mixing and how effective the mixing has been.

The recommended system will accomplish these objectives without harming existing uses of the lake and will complement the continuing watershed-based control measures to reduce nutrient loadings to the reservoir. The capital costs for the recommended submerged focused aeration system are estimated to be \$945,000, and the annual operation, maintenance and replacement costs are estimated to be \$27,700. Based on these costs and an estimated annual phosphorus removal of 810 lbs/year, the phosphorus removal cost is \$127 per pound of phosphorus.

## **5.6.2 Cherry Creek State Park Wetlands Reclamation Project**

The Cherry Creek State Park Wetlands Reclamation project consists of a combination of wetlands restoration and reclamation, with some constructed wetlands, all within the Park. The general project area starts near the reservoir and extends upstream along Cherry Creek.

### **5.6.2.1 Project Purpose**

As Cherry Creek meanders through the delta area of the reservoir, the main channel has become incised and floodplain flows have become more concentrated over time by sediment

deposition in the floodplain and erosion of the channels. These changes have reduced the quality and quantity of wetlands within the delta. The purpose of the project is to restore and enhance the wetland environment. Specific strategies proposed as part of the concept are listed below.

- Provide better distribution of flows at the culvert crossings along the Park Perimeter Road so that Cherry Creek is allowed to spread over a wider floodplain area. This will redistribute Cherry Creek flows across the flood plain and will restore and increase wetland area and functionality.
- Improve the distribution of surface flows in the existing incised reach of Cherry Creek (downstream of the Perimeter Road). This will be achieved by raising the invert of the main channel of Cherry Creek and promoting more frequent overtopping of storm runoff into the adjacent floodplain, increasing treatment through bio-filtration and infiltration.
- Create temporary impoundments within the flood plain by raising the elevation of selected trails. These impoundments would capture and temporarily detain storm flows and promote phosphorus reduction through settling, infiltration, and wetland treatment. Such improvements will balance cut and fill within the same flood storage zone so that there will be no net loss in storage in the reservoir area.
- Create additional wetland treatment cells. These cells would be excavated in small open areas within and adjacent to the existing cottonwood woodlands.

The entire project, when completed, will restore about 60 acres of wetlands at a capital cost of \$1,928,000 and will immobilize 600 pounds of phosphorus per year, resulting in a long-term average annual cost of \$280 per pound of phosphorus. The project implementation will be phased over several years to minimize impacts on the heavily used recreation area and the wetlands themselves. Design and construction of the demonstration project (approximately \$90,000) has been indefinitely delayed due to water augmentation requirements for evapotranspiration losses from the wetlands and potential drought impacts.

### **5.6.2.2 Project History**

The concepts for the Cherry Creek State Park Wetlands project were reviewed with the Park staff during 2005 preliminary design phase. Park staff were supportive of the concept because it involved multiple, smaller projects that minimize impacts to the Park and because it focuses on restoration of wetlands, the existing land use. The Park and the Authority also recognized that smaller, focused projects could be used for education purposes through volunteer activities to supplement the projects.

### **5.6.2.3 Project Activity**

Design of the first phase of the wetlands restoration project was begun in 2005 for a demonstration project, but construction has been subsequently delayed. Because of the relatively small size of the demonstration project, the Authority determined that it was more

cost effective to construct the wetlands restoration under the same contract as the Cottonwood Creek Reclamation Phase II (Section 5.6.4). However, Cottonwood Creek Reclamation Phase II was also delayed by the proposed realignment of Peoria Street and Belleview Avenue, and limited activity on the wetlands demonstration project occurred in 2006. There is an indefinite project delay due to augmentation requirements and drought conditions.

In August 2006, the Authority met with representatives of the State Engineers Office (SEO) to determine what water augmentation, if any, would be required by the Cherry Creek Wetlands Reclamation project. During the field inspection of the project, the SEO opined that since any wetlands in the delta area are the result of water stored in the reservoir and are not “natural” wetlands, then any reclamation or restoration of wetlands would require augmentation for evapotranspiration losses. Augmentation often requires purchase of a water right, and changing the point of diversion and use in Water Court, which can take several years and require significant financial resources.

In addition, the 2002 through 2006 drought has caused the water surface in the reservoir to fluctuate much more than in the past, with levels temporarily dropping over 2 feet in 2006. It has been determined that the elevation of the restored wetlands could be too high to sustain their growth during periods when the reservoir would be at lower elevations and, therefore, would be at a greater risk of severe damage than normally.

Because of the potential need for augmentation and the impacts of the drought, the TAC has put the final design and construction on hold indefinitely.

### **5.6.3 Cherry Creek Sediment Pond at Arapahoe Road**

The Cherry Creek Sediment Pond at Arapahoe Road project begins upstream of Arapahoe Road and extends downstream to the confluence with Piney Creek, near the Bowtie Project, for a distance of approximately 6,000 feet.

#### **5.6.3.1 Project Purpose**

Project objectives are to design a sediment basin and stream stabilization measures that accomplish the following:

1. Minimize sediment load for base flows in Cherry Creek, and therefore, attached phosphorus, from reaching the reservoir.
2. Minimize erosion of channel bed and banks during floods up to the 100-year flood.
3. Minimize operation and maintenance requirements while preserving long-term performance.
4. Integrates and enhances existing and proposed multiple uses along Cherry Creek.

### **5.6.3.2 Project History**

In January 2004, the UDFCD completed a master drainageway plan for Cherry Creek from Cherry Creek Reservoir to Scott Road in cooperation with Arapahoe and Douglas Counties, the Cities of Aurora and Centennial, and the Town of Parker. The Authority reviewed and recommended to the UDFCD that Alternative 5, Reclamation and Water Quality Enhancements, be selected for preliminary design. The consultant prepared the preliminary design of the project, which included a sediment basin on Cherry Creek at Arapahoe Road and stream stabilization measures in Cherry Creek.

A conceptual analysis of the phosphorus immobilized by the proposed sediment basin was conducted in 2003 based on data collected by the Authority. The conceptual analysis concluded that about 3,100 tons of sediment would be trapped annually, which could include up to 2,000 pounds of phosphorus attached to the sediment. The TAC reviewed the project and recommended that a technical feasibility study be included in the 2005 CIP, which was adopted by the Authority Board in 2005. The Authority requested proposals to conduct a technical feasibility study from qualified consultants. After interviewing two consultants, the Authority awarded a contract in December 2005 to a consultant to perform a feasibility investigation and prepare preliminary design.

### **5.6.3.3 Project Activity**

Work was initiated in January 2006, the preliminary feasibility report was completed in March 2006, and the conceptual design report was completed and accepted by the TAC in December 2006.

A report on Phase 1 of the preliminary design was submitted by the consultant in March 2006 suggesting that sediment loads could be higher than originally anticipated. However, the amount of phosphorus contained in the sediment collected by the sediment basin was likely significantly less than anticipated, which would result in the project having a very high cost per pound of phosphorus removed.

The TAC recommended additional sampling and analysis of the sediment in the project area to refine the amount of phosphorus that could be removed by the sediment basin. The Board authorized the work on June 15, 2006. The results were submitted to the Authority in a Technical Memorandum dated August 17, 2006, which confirmed that the phosphorus amount was significantly less. As the result of the lower phosphorus concentrations in the coarser sediment, the cost per pound for the entire project was estimated to be almost \$5,000.

The TAC reviewed the findings and determined that because of the high costs of the project preliminary design should not be prepared at this time, but that the consultants scope of work should be revised to provide approximately 30% design information plus investigate the feasibility of partnership with others and marketing the sand as by product of the sediment basin. A revised scope of work was approved by the Board in October 2006.

The conceptual design report was completed and accepted by the TAC in December 2006. Important findings of the technical feasibility investigation and conceptual design include the following.

- The location of the sediment basin, as currently proposed downstream of Arapahoe Road is optimal, compared to other potential locations.
- Sediment samples and estimated loading indicate that the sediment basin could collect between 85 and 850 pounds of phosphorus per year based on a phosphorus concentration of 15 mg/kg in the stream bed soils and collection of between 3,600 to 36,000 cubic yards per year of sediment. The wide variation in sediment quantity is the result of variations in storm runoff amounts from year to year.
- The sediment basin covers approximately 4 acres of area, with 11.6 ac-ft of potential storage. Based on a range of sediment volume between 3,600 to 36,000 cubic yards, maintenance operations will be required 1 to 6 times per year.
- Based on the revised conceptual plan and cost estimate, the cost to remove phosphorus is estimated to range between \$ 1,270 and \$ 3,200 per pound per year depending on the volume of sediment trapped in the basin.
- There are potential private-public partnerships to offset the costs of operating and maintaining the sedimentation basin. A variety of landscape suppliers and sand and gravel companies in the metropolitan area could potentially remove the sediment from the basin, and use the sand and gravel to offset their costs while creating net environmental benefits in the Cherry Creek Basin. The landscape suppliers and sand and gravel industry have expressed a genuine interest in promoting environmental stewardship.

The Authority included the Sediment Basin project in its 2007 long term CIP projection based on partnership with others at approximately 12% of the total cost, which would result in an Authority cost per pound of approximately \$600.

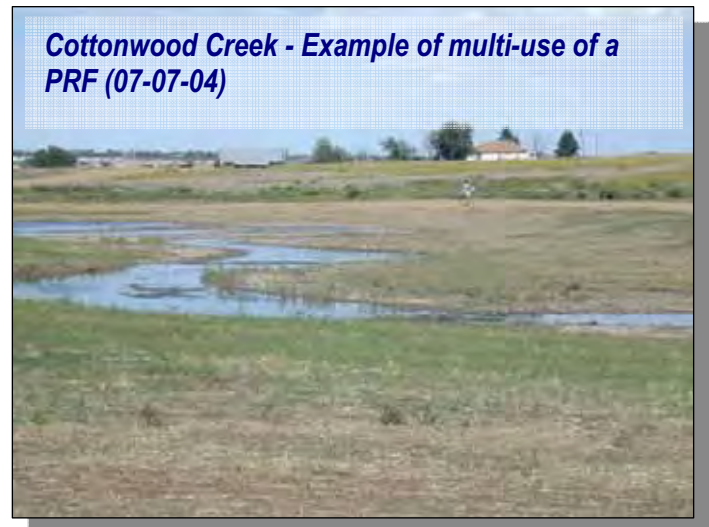
#### **5.6.4 Cottonwood Creek Stream Reclamation**

The Cottonwood Creek Stream Reclamation project begins at the Perimeter Road, within Cherry Creek State Park, and extends about 11,600 feet upstream to the Cottonwood/Peoria Street PRF (completed in 2002).

##### **5.6.4.1 Project Purpose**

The primary purpose of the reclamation project is to reduce soil erosion of the streambed and stream banks, which contains phosphorus and other pollutants that makes its way into Cherry Creek Reservoir and contributes to water quality degradation in the reservoir. The project will also restore riparian vegetation, attract wildlife, and provide passive recreation opportunities, all of which are important objectives in the design approach.

Cottonwood Creek reclamation will go beyond simply stabilizing the creek in place. The design will re-create, as closely as possible, a natural, well-vegetated, functional stream system that will provide water quality, habitat, and aesthetic benefits for the Authority and the Park. Based on the Authority's experience with the Shop Creek channel, the proposed concept for Cottonwood Creek channel can reduce phosphorus loading through wetlands treatment, infiltration, and settling, in addition to immobilizing phosphorus through stream stabilization. When both phases of the Cottonwood Creek Reclamation are completed, the project is expected to cost \$2,100,000 and immobilize 730 pounds of phosphorus annually, which results in an average annual cost of \$330 per pound of phosphorus.



#### 5.6.4.2 Project Activity

Substantial completion of Phase I was accomplished on May 3, 2004, which is the reach from Peoria Street down to the confluence with Lone Tree Creek. Design of Phase II of the reclamation began in early 2004 by coordinating the design with the relocation by Greenwood Village of Peoria Street and the planned expansion of the shooting range on Cherry Creek State Park. Relocation of Peoria Street provided the opportunity to move Cottonwood Creek back to historic location in the valley, affecting the restoration part of the project. Expansion of the shooting range is being accommodated by relocating the main channel to the west of the range. This will reduce, but not eliminate, the flooding potential of the shooting range.

Since construction of Phase II is dependent on relocation of Peoria Street, the street relocation must be near completion before starting Phase II construction. Peoria Street relocation is projected to begin in spring or summer of 2007 such that Phase II construction can begin around winter 2007 and be completed in 2008.

In August 2006, the Authority met with representatives of the State Engineers Office (SEO) to determine what water augmentation, if any, would be required for Phase II reclamation of Cottonwood Creek. The first discussions (2003) with the SEO during Phase I resulted in no requirements for augmentation, because it was demonstrated through a simple watershed analysis that evapotranspiration associated with the proposed Cottonwood Creek Reclamation Project will be more than offset by the increased urban runoff that makes the project necessary. Whereas the SEO did not approve the project in writing, they verbally accepted the analysis as evidence that an augmentation plan would not be required.

During the 2006 field inspection of the project, the SEO opined that since Cottonwood Creek reclamation would result in more riparian vegetation than *currently exists*, that an augmentation would be required for evapotranspiration losses. The Authority prepared a rebuttal to the initial SEO opinion offering the following arguments:

1. **The project will not result in a controlled diversion from the main channel.** No “controlled diversion” is proposed for Phase II, as the USACE does not require that vegetation in the existing, un-natural alignment of Cottonwood Creek be preserved. In addition, neither Cherry Creek State Park nor the owners of the shooting range concession want to preserve the existing alignment of Cottonwood Creek through the shooting range.
2. **The project will not result in storage of runoff.** The design of the riffle-pool grade control structures does not result in any storage of surface flows.
3. **The project mimics what nature would do, given sufficient time.** The basic argument is that a channel would eventually be formed with a width that reflects urbanized hydrology with a wider band of riparian vegetation than exists today. However, during the time it takes for nature to “heal” the channel and create new riparian area, significant erosion and water quality impacts would occur. Therefore, the Authority’s approach only changes *when* the stabilization occurs, and not necessarily *how* natural stabilization occurs. This argument is supported by basic

geomorphic science and the “reference reach” approach to determine acceptable riparian vegetation types and widths.

4. **The ET that occurs in the reclaimed channel is a normal “transmission losses” expected to occur anytime water is delivered through a channel or most man-made conveyances.** Often when an augmentation plan is developed, it involves a change in the point of diversion, which changes how much water there is in a ditch or other conveyance, including natural channels. In each case, there is a “transmission” loss that occurs, partly due to seepage, but also due to ET in natural channels. Therefore the approach recognizes that any ET loss in the improved Cottonwood channel would have occurred eventually and is part of the normal transmission loss recognized by the water courts.

The report was submitted to the SEO in December 2006 and they responded by email stating their acceptance of the project moving forward without a plan for augmentation, though future court orders or statute changes might impact the current decision.

Based on these findings and on relocation of Peoria Street and Bellevue Avenue by Greenwood Village, the Authority plans to complete final design and start construction in 2007.

#### **5.6.4.3 Project History**

The feasibility analysis was completed in January 2003 and final design for two phases of the project began in February 2003. Phase I design from Peoria Street to the confluence with Lone Tree Creek was completed and bid in December 2003. A contract was awarded for \$477,299 and construction of Phase I began in late December 2003 and was substantially complete as of May 3, 2004. Phase II design is expected to be completed in 2008 with construction beginning in late 2007 or early 2008. Phase II is projected to cost \$1,400,000, which includes design, construction oversight, and construction.

The Authority has worked closely with Park staff and the Park Board to develop a concept that was acceptable to the Park. A presentation was made to the Park Board on September 18, 2003 and a public informational meeting was held on October 16, 2003, at the request of the Park Board. The Park Board officially approved the project at their November 2003 meeting contingent upon the following.

1. The shooting center plans as approved by the Park are adequately addressed by the Authority in the planning process.
2. An agreement between the Authority and the Park memorializes the ownership, function and maintenance of the project.
3. Trail planning and construction is an integral part of the project.
4. An adequate monitoring program is put in place to ensure that the project supports Park values.

### 5.6.5 Projects Projected for 2007 Activity

Since the projects planned for implementation in 2007 are within the Authority's current ability to fund in 2007, we anticipate construction of the Reservoir De-stratification (mixing) and beginning Phase II of Cottonwood Creek stream reclamation.

### 5.6.6 Operations and Maintenance Activities

The Authority is required by statute and Control Regulation 72 to operate and maintain (or arrange for) all PRF constructed by the Authority. To this end, the Authority includes in its annual budget funds for operation and maintenance for specific facilities and, beginning in the 2004 budget (Table 5-5), has included a "sinking fund" in anticipation of future needs. For O&M purposes, there are currently two IGA with State Parks, one covering operations and maintenance of PRFs within Cherry Creek State Park and the second covering Cherry Creek Reservoir Destratification facilities.

#### 5.6.6.1 PRF O&M Agreement

In 2004, the Authority began drafting an agreement with the Park for maintenance of all existing and future PRF located within the Park. The agreement, which was signed on January 12, 2006, identifies requirements for routine and restorative maintenance activities and responsibilities between the Authority and the State. As a condition of the PRF agreement, the required annual inspection of PRFs located with the Park was conducted in August 2006 and recommendations were made to the Authority for consideration in the 2007 budget. Because of the relatively minor construction aspects of O&M activities, the Authority has begun investigation of more economical alternatives to make routine and restorative repairs, such as sharing services with other governmental agencies with similar requirements.

#### 5.6.6.2 Destratification O&M Agreement

In 2006, the Authority and the State worked together to develop an operations and maintenance agreement for the mixing facilities. This agreement again sets forth the Authority's responsibility for restorative and rehabilitative maintenance of the facilities, but also sets the long-term goal of eventual removal of the system and continued commitment by the Authority to implementing watershed management strategies. The Agreement is expected to be signed by both parties in early 2007.

### 5.7 Riparian and Wetlands Protection

As described in the Section 5.6, the Authority has contributed wholly, or in part, to the construction of projects during 2006 as part of its capital improvement program that address riparian and wetlands enhancement and restoration. In addition to capital projects, the Authority's Requirements also recognize the importance of stream corridors to water quality by placing additional restrictions on development within the stream preservation area. When a land disturbance is proposed within the stream preservation area (except for implementation of water quality facilities themselves), the Authority requires additional

BMPs (above minimum requirements). These additional BMP must enhance infiltration of stormwater to protect and enhance riparian habitat. In addition, the Authority's near future focus for PRFs will be more on implementing upper-basin, stream stabilization measures for Cherry Creek and its tributaries after completing projects within the Park.

### 5.8 Progress Made



The Authority has made progress in meeting the requirements of Control Regulation 72 for control of nonpoint source pollution in the following ways.

- The Authority coordinated and assisted local land use agencies in implementing Phase II stormwater permit requirements consistent with Control Regulation 72.
- The Authority completed the third year of the "Phosphorus Facilitator" program, to work with local developers to implement BMPs that go well beyond minimum requirements. Identified improvements to the program, for 2007, that include promoting the transferability of enhanced BMPs in an on-the-ground project.
- The Authority increased the local land use agencies understanding of Authority goals and requirements relative to water quality through development and distribution of education materials and by providing review comments on land-use change applications.
- The Authority completed feasibility investigations for one additional PRF, final design and bidding for in-lake management facilities, included the projects on the master CIP list, and allocated funds for further activity during 2007. Although currently all PRFs are located within Cherry Creek State Park, the Authority continues to focus on watershed BMPs and PRFs in the upper basin.
- The Authority initiated a process to update the Authority's Requirements for consistency with the 2004 Control Regulation 72 revisions and the land use agency stormwater quality requirements developed as part of the Phase II stormwater permits. The revised document, in the form of a guidance document, will represent the collective experience of the Authority and the land use agencies while implementing Phase II stormwater regulations and other measures to protect the water quality of the Cherry Creek Reservoir watershed. The guidance document is expected to address additional or more stringent best management practices related to the following.
  - Construction and post-construction storm runoff.
  - Industrial and commercial activities not regulated elsewhere that could result in a discharge of pollution such as, but not limited to, gas stations and fueling areas, equipment storage, cleaning, and maintenance areas.
  - Land disturbances within stream preservation areas.
  - Rural road construction and maintenance.
  - Highway and roadway reconstruction.
  - Large lot single family development.
  - Recreational trail construction.
  - Other discharges the Authority determines to be detrimental to meeting the TMAL requirement in Control Regulation 72.

## 6. TRADING PROGRAM AND RESERVE POOL



The Authority initiated the Cherry Creek Reservoir watershed phosphorus trading program in 1997. The trading program allows point source dischargers and other entities requiring a load or wasteload allocation (i.e., allocatee) to receive phosphorus pounds for new or increased phosphorus allocations in exchange for phosphorus load reductions from other sources. The Authority can also sell or lease phosphorus credits through the Reserve Pool.

The Authority did not receive any new trade project applications in 2006.

### 6.1 Trading Program

The Authority is authorized to implement and maintain a Trading Program in the Cherry Creek Reservoir watershed that allows phosphorus trading from the Phosphorus Bank. Through the Trading Program, entities in the watershed that require a load or wasteload allocation (i.e., point source dischargers, holders of wastewater reuse authorizations, entities providing land applications, industrial dischargers) can receive phosphorus pounds for new or increased phosphorus wasteload allocations from the Phosphorus Bank in exchange for phosphorus loading reductions from nonpoint source control projects that are built by the entity or third parties. These entities are also called “allocatees.” Landowners, local governments, and allocatees can construct phosphorus removal projects and receive credits for their own use or to transfer to an allocatee. The goal of the Trading Program is to encourage and facilitate the construction of nonpoint source control projects and retrofit existing stormwater facilities with water quality enhancements that were not in the original design.

#### 6.1.1. Trading Program Guidelines

The Authority completed revisions to the Trading Program and Reserve Pool Guidelines in 2006, which incorporated Authority responses to comments the Division provided on March 15, 2006. The Board approved the resolution adopting the Trading Program and Reserve Pool Guidelines in October 2006. The TAC addressed the following Division comments in 2006.

- Justify maintaining the Reserve Pool.
- Clarify there is no upper limit on trade ratios.
- Clarify that trade project applications shall be filed concurrently with the Authority and the Division.
- Clarify that the required annual certification of trade project operation is to substantiate trade credits.
- State the basis for the minimum trade ratio of 2:1.

### 6.1.2. Tracking Trades

Watershed-based trading is a successful water quality management strategy that will provide net reductions to the phosphorus TMAL, as well as provide additional environmental benefits in the Cherry Creek Reservoir watershed. Trading provides incentive for landowners, local governments, and allocatees to subsidize the design and construction of additional stormwater controls and phosphorus removal technologies that go beyond baseline BMPs. Watershed-based trading is a water quality management strategy that promotes incentive opportunities for entities in the Cherry Creek Reservoir watershed to implement additional phosphorus removal technologies needed to achieve the Cherry Creek Reservoir TMAL, sooner than later.

An example of how trades are tracked is provided in Table 6-1, which reflects the ACWWA trade project approved in 2003. ACWWA constructed a project to remove 165 pounds, and by applying a calculated trade ratio of 2.9:1, ACWWA will receive 57 phosphorus credits. For accounting, ACWWA will receive an increased allocation of 57 pounds and the nonpoint/regulated stormwater allocation will be reduced by 114 pounds, by applying a conservative 2:1 ratio (minimum allowable trade ratio). This results in a net reduction of the TMAL.

**Table 6-1. Example of Tracking Trades**

Facility	Allocation	Post Trade Allocation
ACWWA/Cottonwood	402	459
Pinery Water and Sanitation District	304	304
Parker Water & Sanitation District	593	593
⋮	⋮	⋮
Semi-urban Areas	141	141
<b>Subtotal</b>	<b>1,878</b>	<b>1,935</b>
Reserve Pool	216	216
Trading Program (currently held pounds)	0	0
<b>Total Point Source Allocation</b>	<b>2,094</b>	<b>2,151</b>

Allocation Source	Allocation, Lbs/Yr	Post Trade Allocation, Lbs/Yr
Nonpoint and Regulated Stormwater	10,506	10,392
Background	1,170	1,170
Wastewater Facilities	2,094	2,151
Industrial Process Wastewater	50	50
Individual Sewage Disposal Systems	450	450
<b>Total Maximum Annual Load</b>	<b>14,270</b>	<b>14,213</b>

### 6.1.3. Trade Projects

Table 6-2 summarizes approved trade projects.

**Table 6-2. Cherry Creek Basin Approved Trade Projects**

Applicant	Project Title	Destination of Trade Credits	Approved Phosphorus Credits	Trade Ratio	Conditional Approval
ACWWPID	Pond L-3 Retrofit	ACWWA	57	2.9:1	January 2004
ACWWPID	Pond W6/W7	ACWWA	28	2.5:1	February 2006

**6.1.3.1. ACWWA Pond L-3 Trade Project**

The Authority approved the ACWWA Pond L-3 trade project in 2003. This trade project includes retrofitting the existing stormwater dry detention pond (Pond L-3). The retrofit includes modifying the outlet works to extend the detention time from 6 to 24 hours, increasing the sediment forebay storage, and creating a micropool at the outlet. ACWWA conditionally received 57 pounds of trade credits.

ACWWA completed construction in 2005, monitoring equipment installation was initiated late in 2006, and annual reporting will be submitted in 2007.



**6.1.3.2. ACWWA Pond W6/W7 Trade Project Application**

The Authority approved the Arapahoe County Water and Wastewater Public Improvement District (ACCWPID) trade project in February 2006.

The project was an eligible new trade project as “additions to existing development.” The project combines and modifies two existing stormwater, dry-detention ponds (Pond W-6 and W-7). The modifications include adding forebays, micro-pools, modified outlet works to extend the detention time to 40 hours, and water quality capture volume to treat storm runoff from a 1.2-square mile watershed.

ACCWPID requested phosphorus trade credits from development that existed prior to January 2000. Since BMPs were not constructed during the original development activities, phosphorus removals from added BMPs are available for trading. The ACWWA Lone Tree Creek Wastewater Treatment Facility will receive 28 pounds of trade credits.

The project was completed in October 2005 at a total project cost of \$1.18 million, of which \$773,000 was for construction.

**STEPS**  
**REG 72**



## 6.2 Reserve Pool

The Authority is authorized to implement and maintain the sale or lease of phosphorus pounds from the Reserve Pool. The Reserve Pool includes 216 pounds of phosphorus credits from projects already constructed by the Authority (and approved by the Commission) and can be sold by the Authority to allocatees in the watershed. The Reserve Pool phosphorus credits are based on the following historic Authority projects:

- Shop Creek detention and wetlands (1991)
- Quincy Drainage detention (1995)
- East Shade Shelter streambank improvements and parking area retrofit (1995)
- Cottonwood Perimeter Road pond (near Reservoir) (1997)

The 216 pounds of phosphorus allocated to the Reserve Pool are available for transfer and may be purchased or leased from the Authority at a price established by the Authority. Pounds sold or leased from the Reserve Pool are subtracted from the Reserve Pool and allocated to the entity acquiring the pounds, for long-term or short-term use.

There were no Reserve Pool actions in 2006.

## 6.3 Progress Made

In 2006, the Authority improved and built upon its trading program.

- The Authority completed revisions to the Trading Program and Reserve Pool Guidelines.
- The Authority approved a new trade project, Pond W6/W7.



Reg 72  
Reporting



STEPS  
REG 72

## 7. PUBLIC EDUCATION ACTIONS AND PARTNERSHIPS



As part of the Authority's water quality management approach (Figure 2-1) and as prescribed by Control Regulation 72, the Authority is committed to providing educational programs that provide policy makers, government agencies, local land use agencies, private industry, and the general public with information and suggested actions to reduce nonpoint source pollution to Cherry Creek Reservoir.

### 7.1 Education Initiative

The Authority has provided manpower and funding to support the Partners in developing a comprehensive and coordinated education strategy and action plan on a reservoir watershed scale. This plan was completed in 2004 and is entitled the Cherry Creek Basin Water Stewardship and Education Initiative (Education Initiative).

The purpose of the Education Initiative is to set forth the approach recommended by the Partners and the Authority. This document contains a compilation of the key education and public involvement goals, strategies, and activities that will be used to engage the community in active stewardship of Cherry Creek, parks, open space, trails, and tributaries within 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 Control Regulation 72 and the objectives identified in Cherry Creek Basin Watershed Plan 2003.

In September 2006, a 2-year update on projects identified in the Education Initiative was completed with input from various stakeholders, including the Authority, the MS4s in the watershed, Cherry Creek State Park, and the Partners.

The emphasis for 2007 will be to revisit the Education Initiative and update the 2-year Action Plan with input from the same stakeholders listed above.

#### 7.1.1 Cherry Creek Stewardship Partners

The 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; the business community; and interested citizens.

In 2006, the Authority provided \$18,500 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 such as restoration of riparian areas along Cherry Creek at the Cherry Creek Valley Ecological Park, restoration support for the Cottonwood Creek PRF, and projects that provide a

positive and fun spin on our watershed's recreational opportunities, such as the 2005 and 2006 "Run for the Watershed" relay race.



These projects take much time and effort in planning, coordination, and successful completion. The Partners enable watershed entities, such as stormwater permittees, the Park, and the Authority to more efficiently implement collaborative education and outreach activities. The following provides a summary of the Partners' 2006 outreach accomplishments, which are further described in the Partners' 2006 Annual Report ([www.cherry-creek.org](http://www.cherry-creek.org)).

#### *Awards presented for the 2006 Run for the Watershed*

- **Audubon Raptor Walk, January 28th:** *The Partners Open Space Committee hosted this Audubon Society of Greater Denver field trip along the Cottonwood Creek riparian area.*
- **Metro Regional Science Fair, February 27 & 28:** *The Partners Education Committee provided judging and awarded prizes on behalf of the Authority and Arapahoe County SPLASH Group.*
- **Cherry Creek High School Science Symposium, April 18<sup>th</sup>:** *Another Partners effort to engage basin teachers and students in nearby learning sites.*
- **Cherry Creek Valley Ecological Park Volunteer Work Day, April 22<sup>nd</sup>:** *Working with Arapahoe County, the Open Space Committee joined with the private sector to organize/participate in a 'weed pulling' and planting effort.*
- **Training for Enhanced BMP Implementation, Workshop #2, May 10<sup>th</sup>: "How to Design"** - *Second in a series of 4 workshops to assist design engineers, developers, and government staff.*
- **Watershed Education Center Open House, May 16<sup>th</sup>:** *The Partners hosted a forum on the feasibility of an education facility.*
- **Bio Blitz, June 23<sup>rd</sup> & 24<sup>th</sup>:** *Partners hosted an inventory and record-keeping effort monitoring fauna and flora species along Cottonwood Creek.*
- **4<sup>th</sup> Annual Project WET Training, June 26<sup>th</sup> through 28<sup>th</sup>, Aurora:** *Hands-on training for local area teachers, highlighting Partners educational kits.*
- **"Get to Know your Watershed – Thorne Ecological Institute", July 19<sup>th</sup>:** *Outreach effort with classroom activities and outdoor program that included monitoring and inlet labeling at Aspen Grove in Littleton at the South Platte.*

- **Colorado Cares Day, July 29<sup>th</sup>:** *Cherry Creek State Park and Marina & Yacht Club hosted the Governor and many volunteers for a day of cleanup and formal recognition of the Authority with an “Appreciation” award.*
- **2<sup>nd</sup> Annual Run for Watershed, September 30<sup>th</sup>.**
- **Training for Enhanced BMP Implementation, Workshop #3, October 4<sup>th</sup>:** *“How to Construct and Inspect”:* *Third in a series of 4 workshops to assist design engineers and government staff.*
- **8<sup>th</sup> Annual Conference, “Connecting the Dots: Watershed, Creek, and Reservoir Stewardship Efforts,” November 3<sup>rd</sup>.**
- **Colorado Science Teachers Convention, November 16<sup>th</sup> & 17<sup>th</sup>:** *Excellent opportunity to develop relationships with local teachers, with a Partners presentation and 2 days of booth exhibits.*
- **“Get to Know your Watershed–Renaissance School in Castle Rock”, December 1<sup>st</sup> /4<sup>th</sup>:** *Outreach effort with classroom activities and outdoor program, including monitoring and inlet labeling.*

#### 7.1.1.1. Seventh Annual Cherry Creek Stewardship Partners Conference

The Authority, which is an active member of the Partners, contributed funding for the Partners’ 7<sup>th</sup> annual conference held in November 2006 in Parker, Colorado. The conference theme for 2006 was “Connecting the Dots: Watershed, Creek, and Reservoir Stewardship Efforts.” Numerous TAC members have lead roles in planning and coordination of the conference and participated in the conference as session moderators, and four Authority consultants made presentations on Authority activities.

#### 7.1.1.2. Run for the Watershed

The Partners organized the second annual Run for the Watershed Relay, “Celebrating the splendor and diversity of the watershed, from the top of the basin downhill to Cherry Creek State Park.” The relay spanned 50 miles with 13 race legs ranging from a 2-mile walk to a 6-mile run.



### 7.1.1.3. Partners Workshop for Enhanced BMP Implementation

On October 4, 2006, the Partners hosted the third successful workshop in the “how to” series of half-day conferences for contractors, developers, design engineers, inspectors, and government staff to promote enhancement of permanent BMPs. This year’s workshop was titled “If You Build It They Will Come: Constructing Enhanced BMPs.”

## 7.2 Website

The Authority website provides information and education on water quality issues within Cherry Creek Reservoir watershed and also serves as a storehouse of documents generated by, and related to, the Authority. The website can be found at [www.cherrycreekbasin.org/cc\\_home.asp](http://www.cherrycreekbasin.org/cc_home.asp).



In June 2006, the Authority website host upgraded its server software, enabling an annual summary to show site usage. The website had an average of 1,092 visitors per month and a total of 6,551 visitors over the last 6 months of 2006. In

addition to visitors within the United States, the Authority website has been the destination of users from ten other countries, including Canada, China, the United Kingdom, France, Germany, Israel, and the Philippines.

The 2005 Annual Report was the most frequently downloaded document, with a total of 2,226 downloads. The 2003 Trading Program Summary and Cottonwood Creek Feasibility Memo were among the top five most downloaded documents.

In addition to usage patterns, tracking on the website can be used to add useful content based on user queries, adjust site layout to provide a friendlier user interface, and fix problems with broken links, misnamed pages, or missing documents. Small content changes were made through the year including: adding new News items, replacing out of date documents, adding or updating content on pages, and image recompressing for faster loading of pages.

## 7.3 Collaboration with Other Entities

The Authority has built relationships with several entities to carry out water quality objectives.

### 7.3.1 Land Use Agencies

The Authority continues to work directly with the nine local land use agencies in the Cherry Creek Reservoir watershed through activities such as the following.

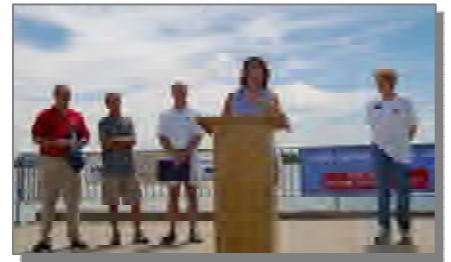
- TAC routine monthly meetings and subcommittees to scope and coordinate special projects (e.g., Stormwater Quality Requirements revisions).
- Review of land use and development applications for compliance with Authority’s Requirements (Section 5.2).

## 7.4 Tours of PRFs at Cherry Creek State Park

The Authority and the Park staff continue to conduct tours for various groups to discuss the pollution reduction facilities constructed to manage urban storm runoff. The program typically starts out with a brief overview of the watershed, the Park, and the role of the Authority in managing water quality in the watershed. Then a walking/bus tour is conducted to one or more PRFs to discuss the aspects and benefits of the PRF.

## 7.5 Colorado Cares Day at Cherry Creek Reservoir

July 2006 was National Lakes Appreciation Month, and Cherry Creek Reservoir was this year's featured lake for Colorado Cares Day. The Governor of Colorado, Bill Owens, also proclaimed July 29, 2006 the Cherry Creek Basin Water Quality Authority Appreciation Day through an Honorary Proclamation. The day's activities included volunteer work projects, water quality monitoring activities, educational displays, and the Official Secchi Dip-In Even with Lt. Governor Jane Norton.




## 7.6 Progress Made

The Authority made progress in meeting the requirements of Control Regulation 72 for implementing public information and education programs in the following ways.

- The Authority leveraged resources by supporting the Partners and coordinating with other entities to implement the Education Initiative, a comprehensive and coordinated education strategy and action plan.
- The Authority continued the use of its website through 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.
- The Cherry Creek Stewardship Partners facilitated broad community involvement and benefited long-term environmental stewardship through outreach efforts to watershed school programs.

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## 8. PHASED TMAL ACTIVITIES

The Commission adopted Control Regulation 72 as a phased TMAL to provide for the implementation of point and nonpoint source requirements and controls while concurrent required investigations are implemented “to better define hydrology, phosphorus sources, chemical processes, and relative loads to the watershed and reservoir” (Commission 2004). The Commission recognized “that until additional investigations are completed, a new TMAL cannot be calculated.”

Control Regulation 72 identifies 13 specific activities to provide reasonable progress in attaining water quality standards and support revisions to the TMAL. Table 8-1 provides a description and status of these activities and other studies that have since been identified. The Authority completed one study in 2006 and two additional studies are ongoing.

**Table 8-1. Updated List of Activities and Proposed Priorities**

<i>Proposed Priority</i>	<b>Special Study</b>	<b>Description/Purpose</b>	<b>Status</b>
1	Evaluation of phosphorus removal effectiveness of nonpoint source control	Evaluate the infiltration component of various detention/retention BMPs to determine the infiltration contribution to phosphorus loading in the watershed. Results used to estimate performance of BMPs to predict impacts of future growth and controls on phosphorus loads by the watershed model.	<b>2006</b> - The study was initiated in 2005, but the study encountered delays due to difficulties in project site selection. The study is ongoing and will be completed in 2007.
2	Depth profiling of nutrient content for groundwater	Conduct alluvial sampling at various depths to determine phosphorus concentration variation with depth of alluvium.	<b>Completed August 2006.</b>
3	Further quantification of soil and groundwater background phosphorous levels	Characterization of Cherry Creek water quality based on limited human influences (i.e., natural, background conditions). The results would be used to establish background as part of the TMAL source load.	<b>2006</b> - The study is on going and will be completed in 2007.
4	Further development of event mean concentrations (EMCs) for storm water flows	Characterization of storm runoff quality based on monitoring runoff of various land-uses in the Cherry Creek watershed. EMCs are used in the watershed model to predict impacts of future growth and controls on phosphorus loads.	Lower priority level as determined by Division and Authority. After discussions between the Authority and Division, the Division supported narrowing the study requirements to focus on a site-specific EMC for undeveloped land.
5	Monitoring of shallow alluvial groundwater loading in tributaries	Nature of the study undetermined at this time. Purpose is to better understand fate and transport of phosphorus for the watershed model and ultimately for determining TMAL allocations.	Lower priority level as determined by Division and Authority.



<i>Proposed Priority</i>	<b>Special Study</b>	<b>Description/Purpose</b>	<b>Status</b>
6	Quantification of individual sewage disposal system phosphorus loading	Nature of the study undetermined at this time. Purpose is to better understand fate and transport of phosphorus for the watershed model and ultimately for determining TMAL allocations.	Lower priority level as determined by Division and Authority.
7	Characterization of watershed hydrology to establish reference condition for evaluation of phosphorus loading	Develop specific set of hydrologic conditions to represent an index hydrological year such that annual phosphorus loads can be referenced to this index. Results used to adjust the TMAL for wet and dry runoff conditions.	Results of ongoing update of watershed model to provide insight to this special study. The watershed model will be completed in 2007.
8	Revised calculations of background sources, industrial process wastewater sources, and individual sewage disposal systems sources of phosphorus contributions	Complete special studies and revise the watershed model to identify these point and nonpoint source components of the TMAL.	<i>Requires the completion of other special studies and activities.</i>
9	Reservoir study on groundwater inflow	Evaluate groundwater flow and phosphorus flux into the reservoir. This study is not required by the Control Regulation, but the Division identified this as a high priority.	Completed on February 9, 2005.
10	Reservoir nutrient studies	Determine the concentration of phosphorus in the Reservoir necessary to suppress the growth of algae by a field study of nutrient limitations.	Completed on January 22, 2004
11	Implementation of lower phosphorus effluent limits	No direct discharge with an effluent total phosphorus concentration greater than 0.05 mg/L as a 30-day average and no land application discharge of a 30-day flow-weighted average total phosphorus concentration greater than 0.05 mg/L/land application return flow factor.	Completed on August 1, 2004
12	Identify industrial process wastewater sources and associated phosphorous loading	Investigate existing industrial process type land uses to estimate contribution to phosphorus loading in Cherry Creek and to establish limits for the TMAL.	In 2003, the Authority confirmed there were no permitted industrial sources with phosphorus allocation.
13	Construct nonpoint source control projects	The Authority plans and implements a capital improvement program on a continuous basis.	Completed and ongoing

### 8.1 Three Special Studies Funded by the “TMAL Actions” Grant

The Authority was awarded a Colorado Nonpoint Source Grant to conduct the following three implementation actions, or special studies, required for the Cherry Creek Reservoir phased TMAL.

1. Conduct depth profiling of phosphorus concentrations in the Cherry Creek alluvium.
2. Quantify phosphorus infiltration to the alluvium from pollutant reduction facilities.
3. Determine background phosphorus levels in alluvial soils, groundwater, and surface water for the revised TMAL.

The objectives of the grant project focus on fate and transport of phosphorus through the Cherry Creek Reservoir watershed, including determining soil-phosphorus equilibrium, confirming effectiveness of BMPs, and defining background phosphorus.

Contracting for the three studies began in December 2005 and January 2006.

## **8.2 Depth Profiling of Phosphorus Concentrations in the Cherry Creek Alluvium**

Lytle Water Solutions, LLC was retained by the Authority to investigate variability in hydrogeologic and water quality conditions within the alluvial aquifer. The purpose of this study was to evaluate the heterogeneity of the Cherry Creek alluvial aquifer at four separate locations within the basin. Specifically, the study was designed to investigate the degree of stratification within the alluvial sediments and, where separate and distinct zones could be identified, to evaluate the variability in water chemistry between these separate zones.

The following conclusions related to the depth profiling study are based on the field studies completed and water quality analyses performed.

1. Subsurface geologic conditions vary between the test sites; however, the sediments are predominantly sand and gravel. There was evidence of stratification (layering) in each of the test holes formed by intermittent layers of silt and clay. Layers of silt and clay do not appear to be laterally continuous.
2. There is a great deal of vertical and spatial variability in aquifer hydraulic conductivities in the water-bearing sediments.
3. Concentrations of total phosphorus, soluble reactive phosphorus, and nitrate vary both vertically at individual depth profile test sites and between sites. The variations do not appear to be systematic. In some cases, the highest concentrations occur in the deepest parts of the aquifer, while in others, the highest concentrations occur at shallower depths. However, the highest concentrations generally occur in the deeper half of the aquifer.
4. Concentrations of major cations and anions are more consistent vertically and between test sites. Water at all test sites is classified as calcium bicarbonate water for all the intervals sampled. This is also the case for Authority monitoring wells MW4, MW5, and MW9. Water at MW2 is notably different than at all other locations. (See Chapter 9 for monitoring well locations in the basin).
5. Water quality data at the depth profile test hole at MW2 (DP2) is distinctly different from water quality at MW2. DP2 water quality is consistent with the other depth profile

boreholes and the monitoring wells, which provides justification for the modification of MW2 water quality in the fate and transport model.

6. Hydraulic properties are relatively consistent at test holes DP2, DP4, and DP9. Transmissivity at test hole DP5 is extraordinarily low, which may be due in part to the fact there is a greater thickness of finer grained sediments (silts and clays) at this site than at the other test sites.
7. The average concentrations of total phosphorus, soluble reactive phosphorus, and nitrate obtained from the combined intervals for a given depth profile hole are not well correlated with concentrations measured for composite samples obtained from adjacent monitoring wells.
8. Differences between estimates of channel transport based on weighted sample concentration and those based on composite sample concentrations are significant at other locations further upstream in the basin for some chemical constituents, although these differences are not systematic. These results suggest that estimates of chemical transport should, wherever possible, be based on site-specific aquifer properties and depth-specific sampling.

A key finding of the study was that phosphorus loading at the reservoir is reasonably well represented by the composite monitoring well sampling. One-time depth profile sampling indicates that the results of weighted sampling and composite sampling differed by 7 percent.

### 8.3 Quantify Phosphorus Infiltration to the Alluvium from Pollutant Reduction Facilities

The Authority had initially selected three sites for the BMP monitoring study, but due to issues with access, the study was delayed many months to investigate and select other monitoring locations. The following three projects were selected and monitoring began in October 2006.

- Cottonwood\Peoria Street Detention - This site is a good example of a large, extended detention basin with wetlands, so it is considered as enhanced.
- The TriMark Windimere Extended Detention Basin at Peoria Street - This BMP has reasonable access, sufficient drainage area to result in frequent storm runoff, and suitable locations for boreholes and monitoring wells. This site is a good example of a typical extended detention basin that includes a concrete trickle channel. Since concrete trickle channels will likely continue to be a standard for extended detention basins in the metropolitan area, this site is considered a good example for monitoring.
- The Inverness Pond Tributary C Cottonwood Creek - This BMP has reasonable access, sufficient drainage area to result in frequent



storm runoff, and suitable locations for boreholes and monitoring wells. This site is also a good example of an enhanced BMP, since it includes a “serpentine” low flow channel and wetlands in the bottom.

#### **8.4 Determine Background Phosphorus Levels in Alluvial Soils, Groundwater, and Surface Water for the Revised TMAL**

The objective of this study is to evaluate background phosphorus levels in groundwater and surface water for the Cherry Creek Reservoir basin. The study includes monitoring and evaluating a reference site that has relatively minor man-made (e.g., development) influences. Monitoring will be conducted for one year and include monthly and semi-monthly sampling of surface and groundwater. Due to denied access by the property owners, the initial monitoring location needed to be relocated upstream. The final selected monitoring location watershed contains approximately two-thirds (51 square miles) of the area originally proposed (87 square miles) but does not significantly change the land use distribution (primarily rural with 11% imperviousness). Monitoring began in the spring of 2006.

#### **8.5 Watershed Model Update**

The Authority convened a TAC subcommittee to develop agreement on refining the Authority’s 2000 watershed model and better define the change in water quantity and phosphorus as it moves from the point of origin in the watershed to Cherry Creek Reservoir (i.e., fate and transport). The subcommittee developed the following working definition for fate and transport:

*The change in water quantity and quality as it moves from the point of origin in the watershed to Cherry Creek Reservoir.*

The Authority identified the need to better define phosphorus fate and transport for evaluating watershed trade projects, identifying the most effective BMPs, providing input to the reservoir model for refining source loads and allocations as part of the refined TMAL.

The subcommittee determined that refining the 2000 watershed model, which predicts phosphorus loads and runoff volumes, was the best way to address fate and transport and to answer the questions regarding additional special studies. The goal of the watershed model is to provide at least seasonal, if not monthly, runoff volume and phosphorus loads to Cherry Creek Reservoir that better estimate:

- Annual phosphorus loads and runoff volumes for land-use conditions in the Cherry Creek Reservoir watershed.
- Effective annual phosphorus load reductions for watershed-based BMPs and individual PRFs. This knowledge will help identify, evaluate, and prioritize BMPs and PRFs in the watershed.
- Effects of pumping and point source discharges and phosphorus attenuation within the Cherry Creek alluvium. This information will help evaluate impacts of alluvial pumping and control of point and nonpoint source discharge concentrations on phosphorus loads into the reservoir.

- Potential benefits from phosphorus trades between point and nonpoint source projects.

In 2006, the Authority continued to update and calibrate the watershed spreadsheet model, which included the following primary activities:

- Expanding the model from the initial test reach, in the upstream portion of the watershed, down to Cherry Creek Reservoir.
- Defining the water balance and associated algorithms.
  - Precipitation and runoff
  - Franktown input
  - Infiltration
  - Bank storage
  - Evapotranspiration loss
  - Pumping
  - Wastewater discharges
  - Return flows
  - Surface flow
  - Alluvial flow
- Integrating review and input from a review committee, which includes four consultants that are familiar with the watershed data and conditions and a representative from the Division.
- Calibrating the water balance and identifying additional information needs.
- Calibrating the phosphorus load balance.

## **8.6 Cherry Creek Reservoir Model Update**

To begin preparing for the 2007 triennial review for Control Regulation 72, the Authority needs to update the existing reservoir model as part of reevaluating the target reservoir phosphorus load (i.e., TMAL). The Authority contracted with Dr. Gertrud Nurnberg of Freshwater Research to update the model. The reservoir model update includes incorporating the past five years of data and multiple study results to re-evaluate long-term trends, re-evaluate nutrient and chlorophyll *a* relationships, test the scenario model, and calculate permissible load for revising the TMAL.

In 2006, the Division requested the Authority reevaluate how external loads to the reservoir are calculated. Two primary issues included: 1) how to balance the hydrology of reservoir inflows for calculating loads, and 2) how to calculate export loads (e.g., using flow and phosphorus concentrations downstream of the reservoir or using data from the reservoir near the outlet). The Authority's consultants and the Division initiated discussions to resolve issues and come to a compromise late in 2006 and discussions will continue into 2007. Completion of the reservoir model is on hold until these issues are resolved.

## 8.7 Planning Progress for 2007 Triennial Review

In 2006, the Authority and Division jointly presented proposed changes to Control Regulation 72 for the Commission to consider at the triennial review informational hearing. The Commission scheduled a triennial review hearing for August 2007.

## 8.8 Progress Made

The Authority has continued to develop and implement point and nonpoint source controls and has worked with the Division to complete one more, and make progress on two, required investigations for the phased TMAL.

- The Authority completed the depth profiling study, a required special study that evaluated the variability in water chemistry between separate zones within the alluvial sediments.
- The Authority continued implementation of two required special studies, required as part of the phased TMAL, which will be completed in 2007.
- The Authority made significant progress on determining how to address phosphorus fate and transport in the watershed through the watershed model update. The model update process is a collaborative effort with the Division, and the model update will be completed in 2007.
- The Authority initiated the Reservoir model update, which incorporated the past five years of flow and water quality data.
- The Authority cooperatively worked with the Division to address Division concerns regarding the calculation procedures for external phosphorus load to the reservoir.
- The Authority and Division jointly proposed changes to Control Regulation 72 for the Commission to consider at the 2006 informational hearing.



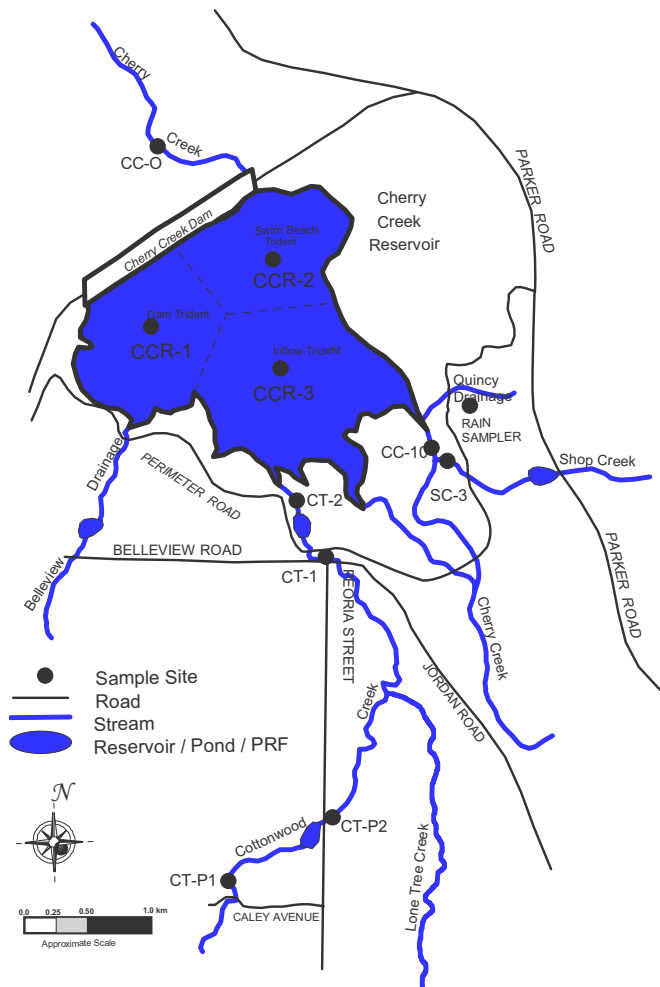
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## 9. WATER QUALITY MONITORING – POINT SOURCE AND NONPOINT SOURCE LOADS



The Authority continued to implement a routine annual water quality monitoring program in the Cherry Creek Reservoir and basin. The program monitors reservoir water quality, reservoir inflow and loading, surface and groundwater quality in the watershed, and effectiveness of Authority PRFs.

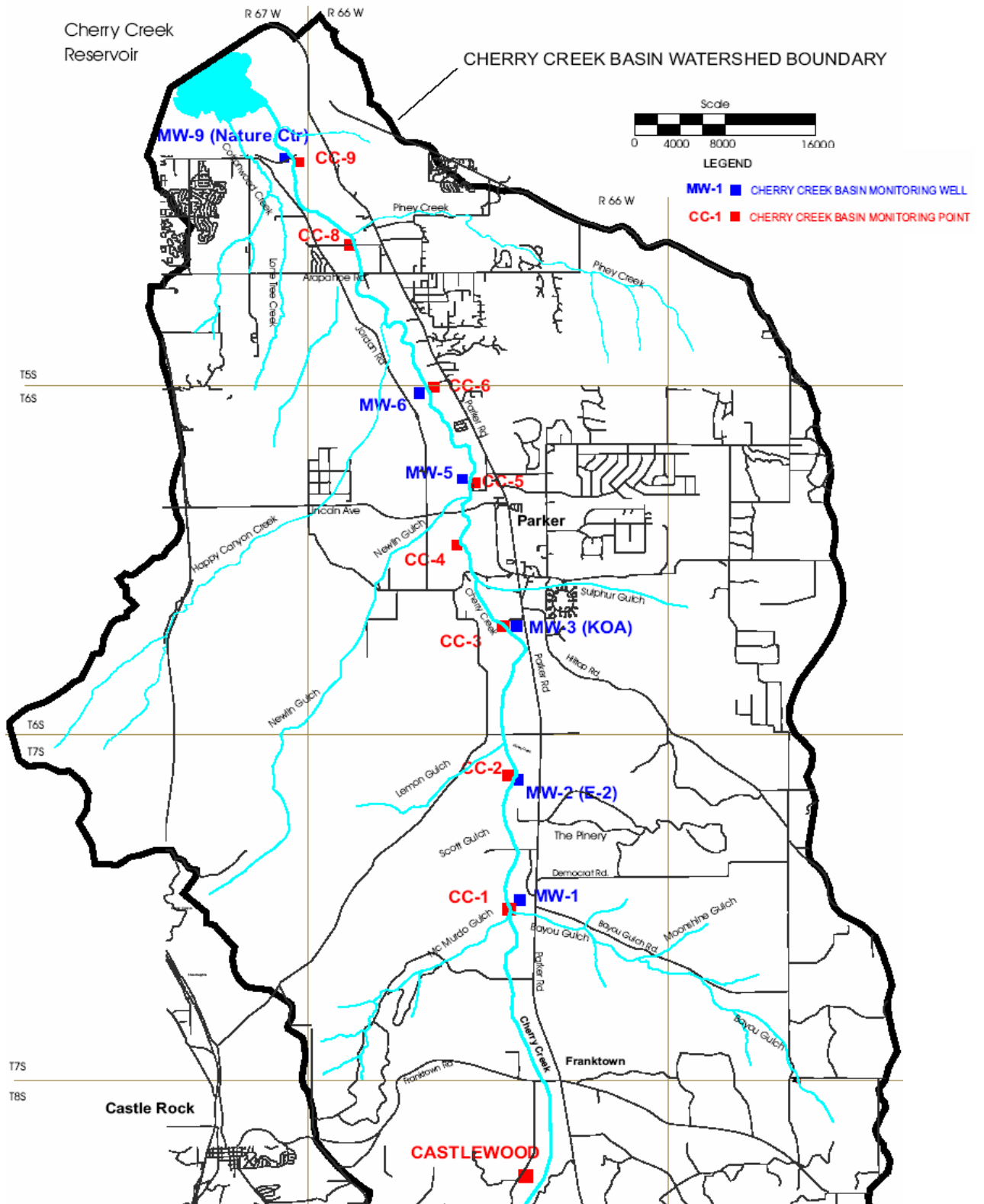
**Figure 9-1. Sampling Sites on Cherry Creek Reservoir and Selected Streams**



The Authority conducted reservoir and tributary sampling at ten sites in 2006, including three sites in Cherry Creek Reservoir, six sites on tributary streams, and one site on Cherry Creek downstream of the reservoir (Figure 9-1). The Authority conducts sampling at sites upstream and downstream of the Cottonwood Creek-Peoria Pond and the Cottonwood Creek Perimeter Pond to evaluate the effectiveness of these PRFs.

Watershed monitoring includes an additional nine surface water sites along Cherry Creek, from Castlewood Canyon to Cherry Creek Reservoir, and nine alluvial groundwater well locations from Franktown to Cherry Creek Reservoir (Figure 9-2). Complete data reports are provided in the Cherry Creek Reservoir 2006 Annual Aquatic Biological-Nutrient Monitoring Study and Cottonwood Creek Phosphorus Reduction Facility Monitoring Report prepared by GEI Consultants Inc. (2006 Annual Monitoring Report.), and the 2006 Water Quality Data Report – Baseline Water Quality Data for the Upper Cherry Creek Basin prepared by John C. Halepaska and Associates, Inc. More details regarding assumptions, calculations, analyses, and results are provided in the 2006 Annual Monitoring Report.

Figure 9-2. Surface Water and Alluvial Groundwater Sampling Sites in the Watershed



## 9.1 Summary of Long-term Cherry Creek Reservoir Water Quality

Presented below is a summary of water quality in Cherry Creek Reservoir as determined by various constituents. This summary is based on the past fifteen to twenty years of monitoring, as presented in the 2006 Annual Monitoring Report. Data are untransformed and generally represent whole-lake mean values with estimates of variation. However, data used in statistical analyses may be transformed depending upon the distributional characteristics of the data. If the transformation did not improve normality, the untransformed data were used in subsequent analyses.

### 9.1.1. Chlorophyll *a*

- Whole-lake chlorophyll *a* concentrations varied greatly throughout 2006, ranging from 5.5 µg/L in late May to 41.6 µg/L in early November. The annual mean chlorophyll *a* concentration was 15.9 µg/L.
- The 2006 summer mean chlorophyll *a* concentration was 14.7 µg/L, which is less than the July-September chlorophyll *a* standard of 15 µg/L (Table 9-1). This is the first time the standard has been met since 1994 and only the third occurrence in last fifteen years of monitoring. While the summer mean chlorophyll *a* concentration has varied greatly over the long term (1992-2006), there has been a significant decreasing trend ( $p < 0.001$ ) in summer mean chlorophyll *a* concentration since 1999.

**Table 9-1. Water Quality (July–September Average Concentration) and Total Phosphorus Load Data for Cherry Creek Reservoir, 1992 – 2006**

Year	Chlorophyll <i>a</i> (µg/L)	Total Phosphorus (µg/L)	Total Nitrogen (µg/L)	Annual Phosphorus Load (lbs/yr) <sup>1</sup>	Annual Inflow (ac-ft/yr) <sup>1</sup>	Standardized Phosphorus Load (lbs/ac-ft)	Net Phosphorus Load (lbs/yr) <sup>2</sup>
1992	17	66	970	5,857	7,474	0.78	4,543
1993	14.4	62	826	4,110	5,905	0.70	3,399
1994	6.2	59	1,144	4,049	7,001	0.58	3,056
1995	15.6	48	913	7,972	11,781	0.68	5,923
1996	20.5	62	944	4,715	7,644	0.62	3,723
1997	22.3	96	1,120	5,761	10,362	0.56	4,765
1998	26.5	89	880	13,577	20,903	0.65	9,370
1999	28.9	81	753	17,471	27,739	0.63	7,821
2000	25.2	81	802	12,593	18,610	0.68	8,905
2001	26.1	87	757	9,837	17,250	0.57	4,995
2002	18.8	74	858	4,246	7,498	0.57	2,745
2003	25.8	90	1,121	8,568	14,929	0.57	3,590
2004	18.4	102	977	12,512	17,177	0.73	7,007
2005	17.1	116	990	10,047	18,534	0.54	6,378
2006	14.7	87	914	6,185 <sup>3</sup>	12,009 <sup>3</sup>	0.51 <sup>3</sup>	3,376 <sup>3</sup>
15-yr Mean	19.8	80	931	8,500	13,654	0.62	5,306
15-yr Median	18.8	81	914	7,972	12,009	0.62	4,765

Notes:

- <sup>1</sup> The annual phosphorus load represents the total load to the reservoir from stream, alluvium, and precipitation. The COE monitors inflow as a function of change in storage (i.e., reservoir volume) based on changes in reservoir level, measured outflow, precipitation, and evaporation.
- <sup>2</sup> The net external phosphorus load is the total load to the reservoir minus the reservoir outflow load.
- <sup>3</sup> Provisional inflow and load data from January 1 through December 31, 2006 are based upon GEI-measured inflow rather than the COE inflow that is presented for earlier years. Final values will be provided upon receipt of data from COE.  
**Bold indicates value meets the respective standard, goal, or TMAL value.**

### 9.1.2. Phosphorus

- Whole-lake total phosphorus concentrations ranged from 44 µg/L in late September to 129 µg/L in early July. The 2006 annual mean total phosphorus concentration was 81 µg/L.
- The 2006 summer mean total phosphorus concentration was 87 µg/L, which exceeded the seasonal phosphorus goal of 40 µg/L. The summer mean total phosphorus concentrations have varied greatly over the years, with the 2006 mean total phosphorus concentration being slightly greater than the long-term median of 81 µg/L. Since 1999, the summer mean phosphorus concentrations have revealed a significantly increasing trend. Cherry Creek Reservoir has exceeded the current seasonal goal in all years since 1989.

### 9.1.3. Nitrogen

- Whole-lake total nitrogen concentrations ranged from 0.57 mg/L in early May to 1.21 mg/L in early November. The 2006 annual mean total nitrogen concentration was 0.90 mg/L.
- The 2006 summer mean total nitrogen concentration was 0.91 mg/L and is equal to the long-term median value. There is not a total nitrogen goal or standard for Cherry Creek Reservoir. The mean summer total nitrogen concentration has also varied greatly over the long term, and since 1999 has revealed a significant increasing trend.

### 9.1.4. Transparency

- Lake transparency values (as measured by Secchi depth) in 2006 ranged between 0.75 and 1.80 meters during the summer, on average were approximately 8% deeper than in 2005, and were equal to the long-term mean value of 1.05 meters. [*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.*]

### 9.1.5. Temperature and Dissolved Oxygen

- Periodic thermal stratification was observed in the reservoir in 2006. During periods of stratification, the lower layers of the reservoir experienced decreased dissolved oxygen concentrations (e.g., <5 mg/L). Low dissolved oxygen concentrations were also observed during the summer season when the lake was not thermally stratified.

### 9.1.6. Phosphorus Loading

The COE is in the process of finalizing the 2006 data, and were only able to provide GEI provisional data from January 1 to September 30, 2006. Therefore, total inflow as calculated by GEI using stream level, precipitation, and an alluvial constant flow are presented herein, and have not been adjusted to match the COE Total Inflow. Net loads are also calculated using the GEI calculated total phosphorus load for the streams (January - December) and the provisional COE outflow load (January -September).

- The 2006 provisional total external phosphorus load is 6,185 lbs, and, once adjusted to the COE total inflow, the annual load is expected to be less than the phased TMAL of 14,270 lbs.
- The long-term median annual total phosphorus load is 7,972 lbs/yr for the past fifteen years (Table 9-1), meeting the phased TMAL each year, except for 1999. The exceedance of the phased TMAL in 1999 (referred to as a TMDL prior to May 2001) appeared to be related to substantially increased inflows (Table 9-1).
- The 2006 provisional total inflow (12,009 ac-ft/yr; GEI inflow rather than COE inflow) and total phosphorus load (6,185 lbs/yr) are expected to be less than the fifteen-year median values.

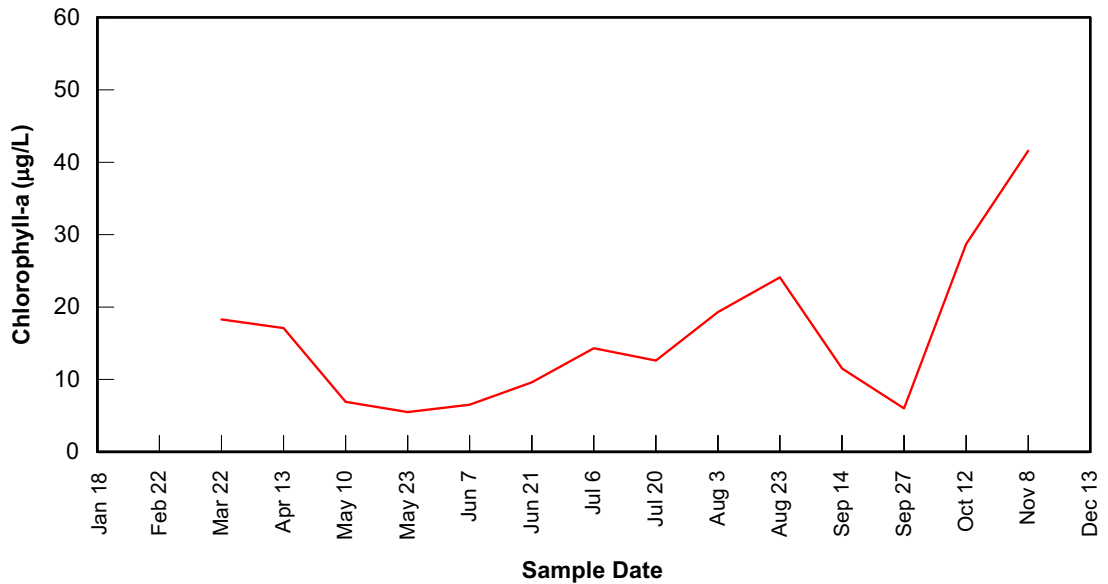
## 9.2 Cherry Creek Reservoir - Summary of 2006 Data

Presented below is a summary of 2006 water quality data for various constituents. This information is also summarized in the 2006 Annual Monitoring Report.

### 9.2.1. Chlorophyll *a*

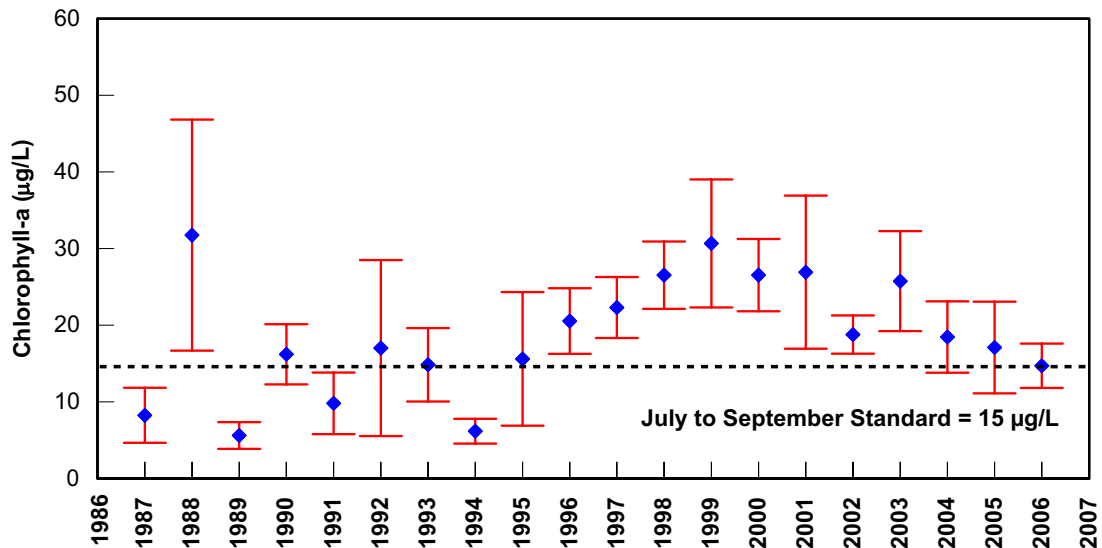
The annual pattern of chlorophyll *a* concentrations revealed relatively low concentrations (5-7 µg/L) in late May, June, and late September, with levels >20 µg/L occurring in late August, late October, and early November (Figure 9-3). The annual mean chlorophyll *a* concentration of 15.9 µg/L is similar to the 2005 value and represents the lowest annual value since 1997. The July through September mean chlorophyll *a* concentration was 14.7 µg/L, and is the first time since 1994 that chlorophyll *a* levels met the reservoir standard.

**Figure 9-3. Concentration of Chlorophyll a ( $\mu\text{g/L}$ ) in Cherry Creek Reservoir, 2006**



The long-term chlorophyll *a* record shows considerable variability within and among the seasons, with the standard being met in only five of the past twenty years. Since 1987, there has been no significant trend in the July through September mean concentration of chlorophyll *a* in Cherry Creek Reservoir (Figure 9-4). However, since 1999 there has been a steady decline in the seasonal mean chlorophyll *a* concentration.

**Figure 9-4. Seasonal Mean (July to September) Chlorophyll a Concentrations Measured in Cherry Creek Reservoir, 1987 to 2006**

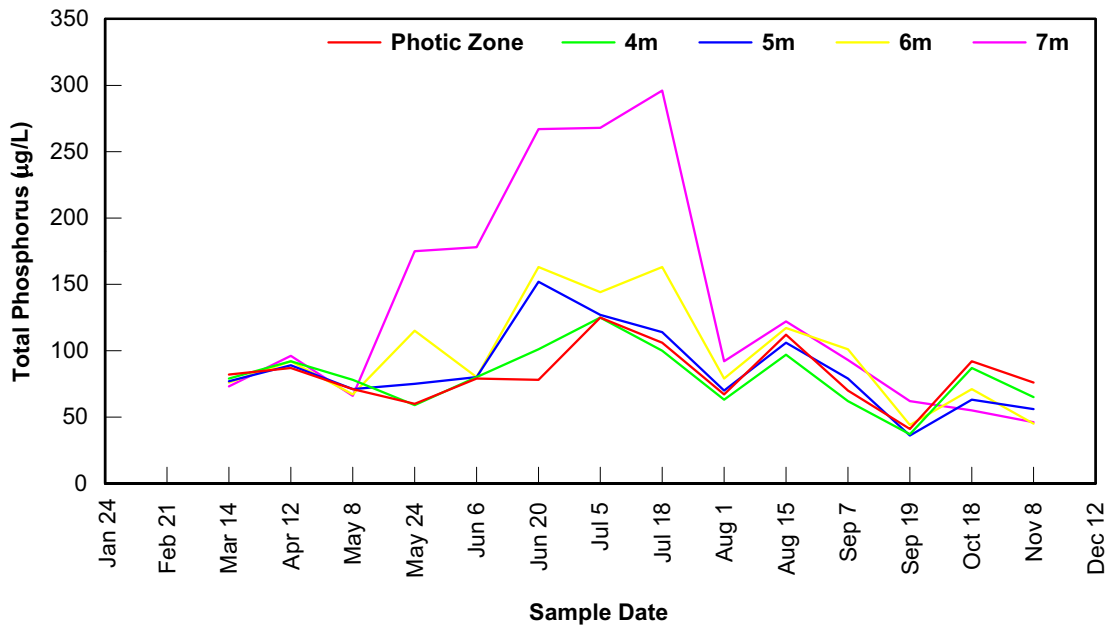


Note: Error bars represent a 95% confidence interval around each mean.

### 9.2.2. Phosphorus

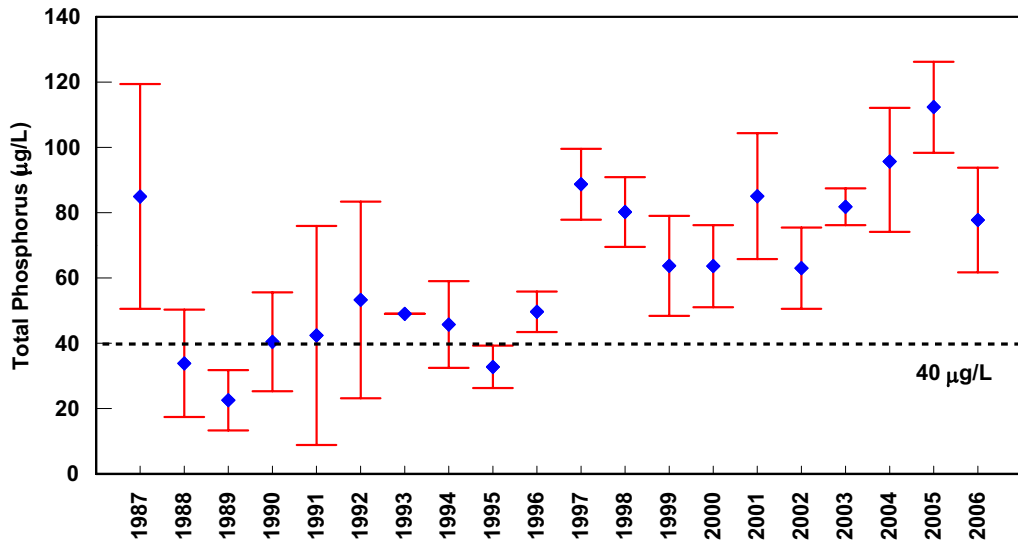
Nutrient profile samples collected in 2006 showed a well-mixed reservoir in spring and fall. There were extended periods of nutrient release from bottom sediments from May through early August as evidenced by increasing total phosphorus concentrations with increasing depth (Figure 9-5). During a portion of this period (May and June) the total dissolved phosphorus fraction accounted for 60-70% of the total phosphorus content, which also indicates that phosphorus was being released from the sediments during that time.

**Figure 9-5. Total Phosphorus Concentrations (µg/L) Measured at Site CCR-2 in Cherry Creek Reservoir, 2006**



Routine monitoring data collected since 1987 indicate an increasing trend ( $p < 0.01$ ) in the summer mean concentration of total phosphorus (Figure 9-6). In 2006, the summer mean concentration of total phosphorus was 87 µg/L, which is slightly greater than the long-term (1987-2006) median value of 75 µg/L and substantially less than the 2005 value of 116 µg/L.

**Figure 9-6. Seasonal Mean (July to September) Total Phosphorus Concentrations ( $\mu\text{g/L}$ ) Measured in Cherry Creek Reservoir, 1987-2006**



Note: Error bars represent a 95% confidence interval around each mean.

### 9.2.3. Temperature and Dissolved Oxygen

Analysis of past Cherry Creek Reservoir temperature profiles indicates that stratification occurs when there is a  $>2^{\circ}\text{C}$  difference between surface and bottom temperatures. Differences of approximately  $1^{\circ}\text{C}$  suggest a recent mixing event. Using these criteria, Cherry Creek Reservoir was investigated for periods of potential stratification and anoxic levels (Figure 9-7 and Figure 9-8). Periodic thermal stratification occurred through the summer, with significant whole-lake mixing events appearing to occur in early September. During the onset of thermal stratification in late May, the lower layers of the reservoir experienced low dissolved oxygen concentrations ( $<5\text{mg/L}$ ). Low oxygen levels persisted in the deep water layers until mid-August.

Figure 9-7. Temperature (°C) Profiles Recorded During Routine Monitoring at Site CCR-2 in 2006

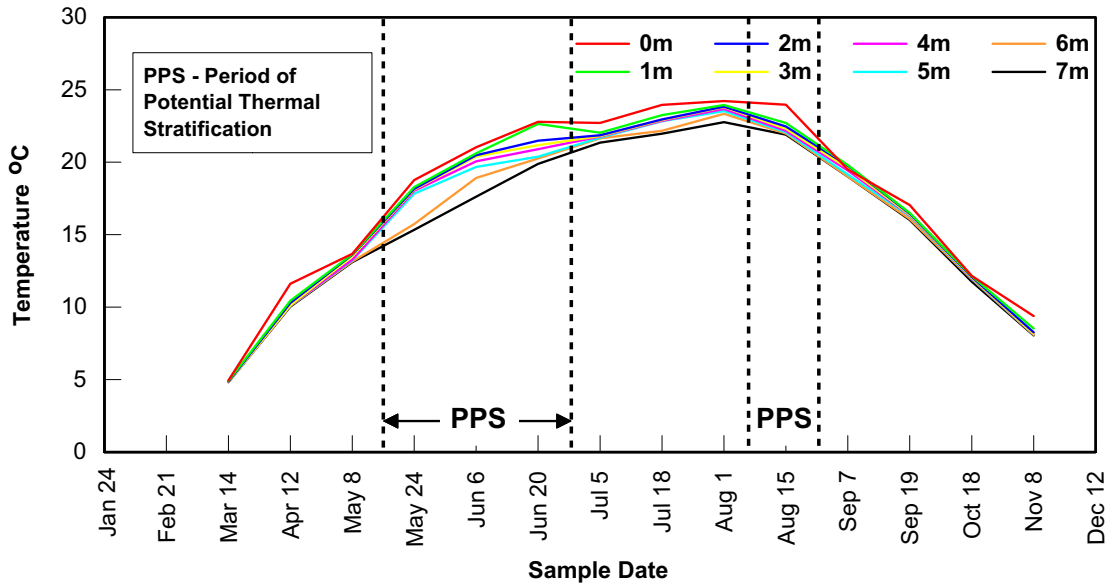
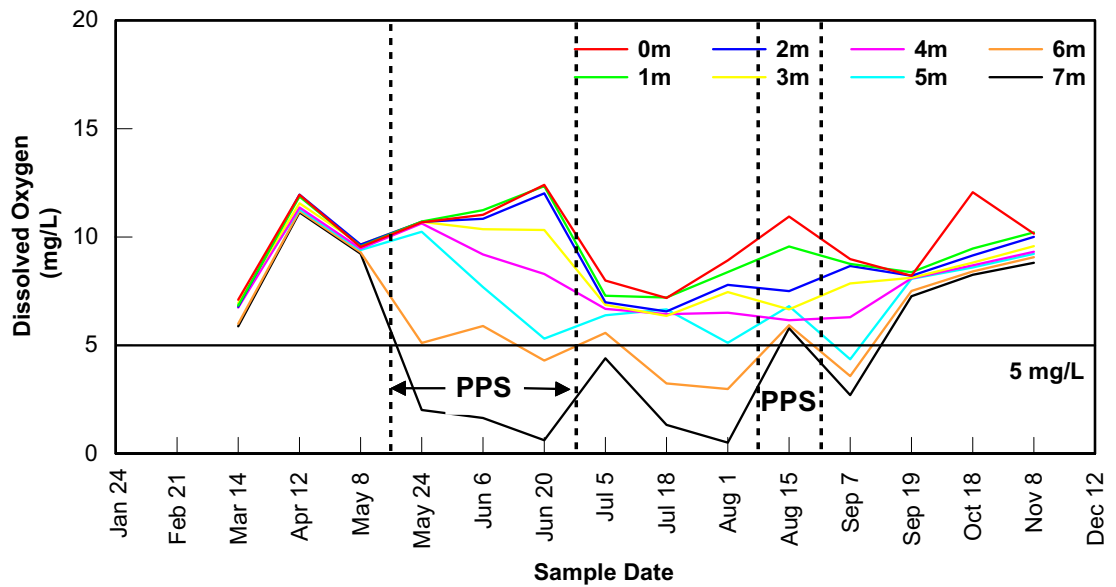


Figure 9-8. Dissolved Oxygen (mg/L) Profiles Recorded During Routine Monitoring at Site CCR-2 in 2006



### 9.3 Cherry Creek Mainstem Monitoring

The Cherry Creek mainstem watershed monitoring was initiated in 1994 (Phase I Baseline Water Quality Data Collection Study) and is conducted by John C. Halepaska and Associates, Inc. The monitoring includes semi-annual sampling at nine surface water sites and nine alluvial groundwater sites along Cherry Creek for the following constituents.

- Nitrate
- Ammonia
- Total dissolved phosphorus
- Total phosphorus (surface water only)
- Soluble reactive phosphorus (SRP)
- Chloride
- Sulfate

The sampling frequency over the years was reduced from monthly monitoring to semi-annual monitoring (May and November) in 2003. Table 9-2 shows the list of water quality monitoring sites for the Cherry Creek mainstem. Surface water and groundwater sites are paired at the same location and given corresponding numbers (e.g., CC-1 and MW-1). A summary of surface and groundwater monitoring data is provided in the following sections.

**Table 9-2. Quality Monitoring Stations for Cherry Creek Mainstem**

Site	Description
<b>Surface Water Location (upstream to downstream)</b>	
Castlewood	0.2 mile north of the USGS Cherry Creek near Franktown gaging station
CC-1	1 mile south of Scott Road
CC-2	$\frac{3}{4}$ mile south of Stroh Road
CC-3	1 mile south of West Parker Road (not a water quality sampling location)
CC-4	$\frac{1}{2}$ mile south of Lincoln Avenue
CC-5	$\frac{1}{2}$ mile north of Lincoln Avenue
CC-6	On Arapahoe/Douglas County Line
CC-7	$\frac{3}{4}$ mile south of Arapahoe Road (not a water quality sampling location; abandoned in 2000 due to development)
CC-8	$\frac{1}{2}$ mile north of Arapahoe Road
CC-9	In the Park near Nature Center. In 2002, site replaced by CC-10 (GEL)
<b>Groundwater (upstream to downstream)</b>	
MW-1	Monitoring well adjacent to Pinery production well #6
MW-2	Monitoring well E-2 downgradient of Pinery discharge
MW-3	Parker KOA production well
MW-4b	Parker NPDES monitoring well M-3
MW-5	Monitoring well adjacent to Arapahoe Loyd #2 production well
MW-6	Monitoring well adjacent to Arapahoe Race #1 production well
MW-7	Monitoring well adjacent to Arapahoe Ford #2 production well; abandoned in 2000 due to development
MW-8	Arapahoe Deem production well
MW-9	Monitoring well in Park near Nature Center
Kennedy	Denver production well adjacent to Kennedy Golf Course (downstream from reservoir)

### 9.3.1. Soluble Reactive Phosphorus

- The SRP concentrations in the underlying alluvial aquifer range from <0.082 to 0.54 mg/L with a median of 0.17 mg/L (1994-2006). Figure 9-9 and Figure 9-10 present annual average alluvial SRP concentrations.
- The SRP concentrations in Cherry Creek range from <0.01 to 0.37 mg/L with a median of 0.16 mg/L (1994-2006). Figure 9-11 and Figure 9-12 present annual average surface water SRP concentrations.
- Trends in SRP over time (1994 to present) indicate a decreasing trend for the most upstream surface water and groundwater sites and an increasing trend at the most downstream groundwater site (Table 9-3).

**Table 9-3. Summary of Soluble Reactive Phosphorus Temporal Trend Analysis**

Site	Type	Trend	Slope (mg/L per year)
Castlewood	Upstream surface water	Yes, decreasing	-0.002
CC9/CC10	Downstream surface water	No	
MW-1	Upstream groundwater	Yes, decreasing	-0.001
MW-9	Downstream groundwater	Yes, increasing	0.003

Note: To minimize the effects of seasonality, the Seasonal Kendall tau test was applied, which is a nonparametric test for trend (i.e. uses the relative magnitude of the data rather than the actual values) and removes seasonal cycles.

- Spatial trend evaluations to determine whether SRP concentrations are significantly different between upstream and downstream sites and surface and groundwater sites are summarized in Table 9-4.

**Table 9-4. Spatial Differences in Soluble Reactive Phosphorus**

Site	Spatial Difference in SRP Concentration?
Surface water upstream and downstream (Castlewood and CC9/CC10)	Yes, downstream>upstream
Groundwater upstream and downstream (MW-1 and MW-9)	Yes, upstream>downstream
Upstream surface water (CC1) and upstream groundwater (MW-1)	Yes, groundwater>surface water
Downstream surface water (CC9/CC10) and downstream groundwater (MW-9)	Yes, surface water>groundwater

Figure 9-9. Average SRP Concentrations in Cherry Creek Groundwater as a Function of Location

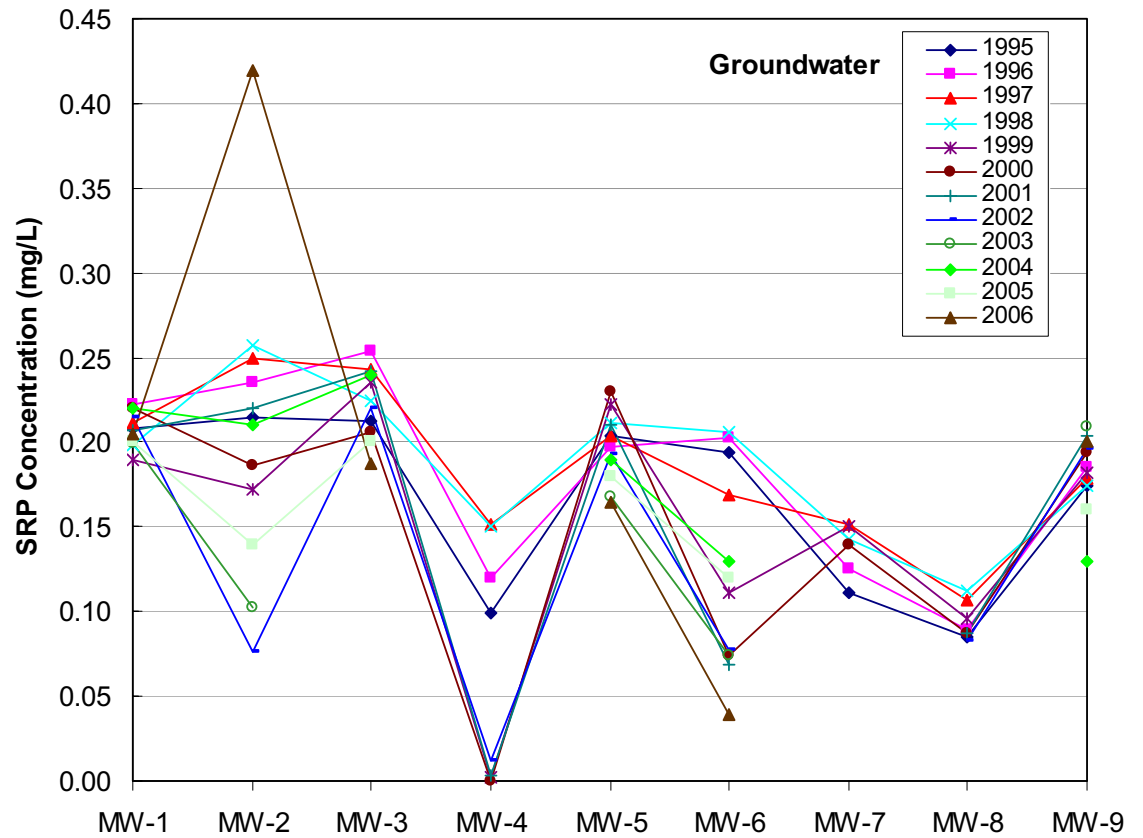


Figure 9-10. Average SRP Concentrations in Cherry Creek Groundwater as a Function of Time

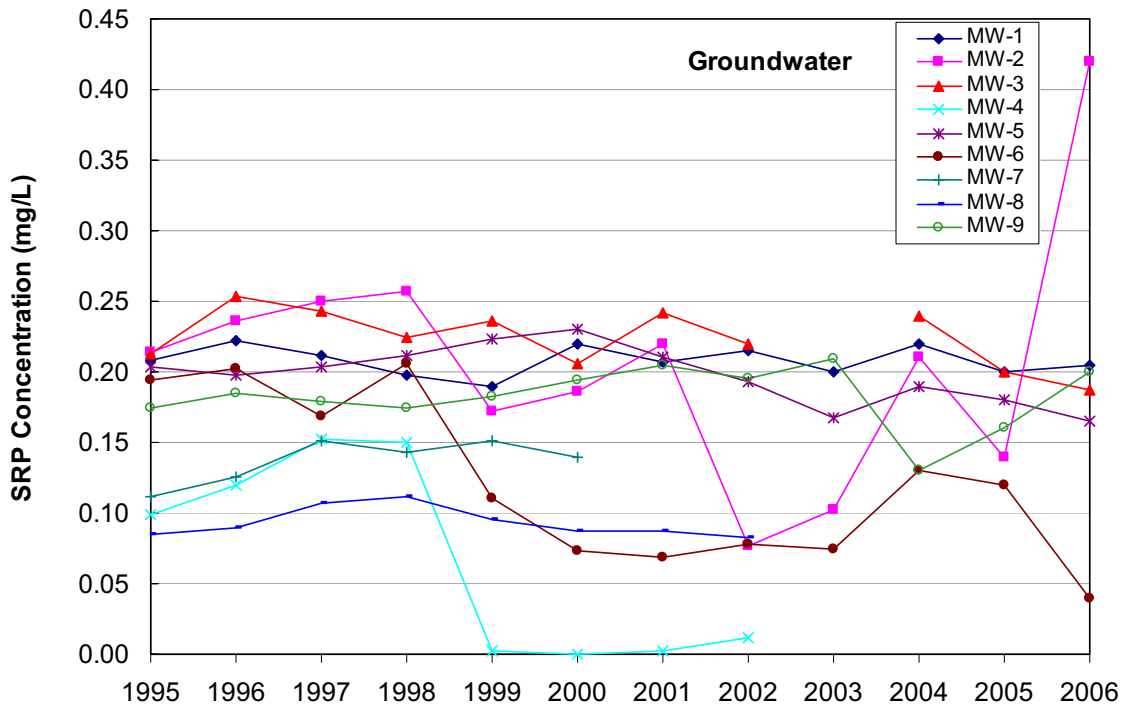


Figure 9-11. Average SRP Concentrations in Cherry Creek Surface Water as a Function of Location

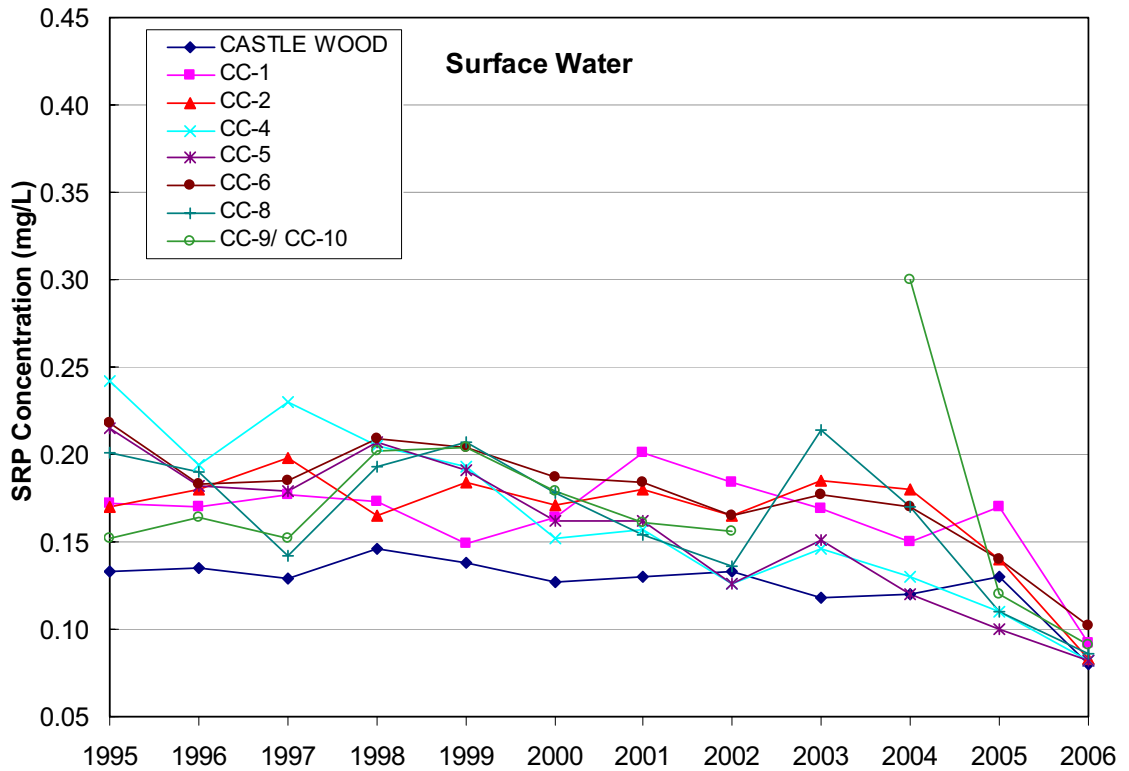
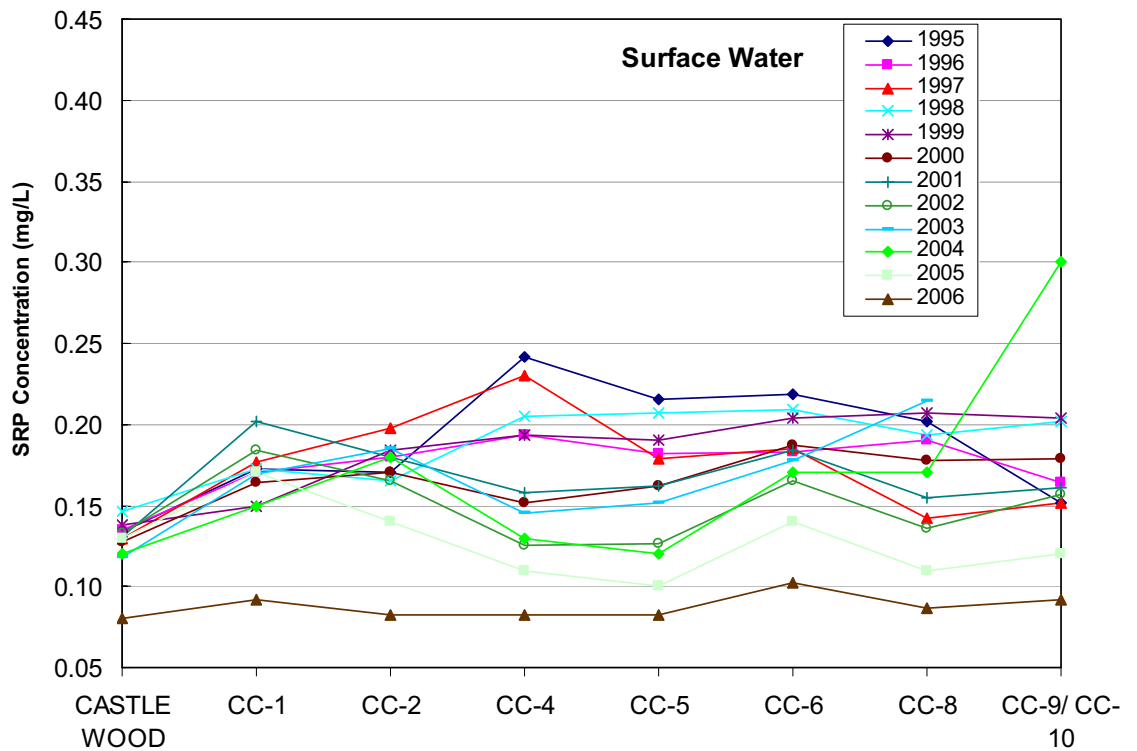


Figure 9-12. Average SRP Concentrations in Cherry Creek Surface Water as a Function of Time



### 9.3.2. Nitrate

- The nitrate concentrations in the underlying alluvial aquifer range from 0.1 to 6.47 mg/L with a median of 0.65 mg/L (1994-2006). Figure 9-13 and Figure 9-14 present annual average alluvial nitrate concentrations.
- The nitrate concentrations in Cherry Creek range from 0.009 to 16.7 mg/L (the maximum from 2006) with a median of 0.49 mg/L (1994-2006). Figure 9-15 and Figure 9-16 present annual average surface water nitrate concentrations.
- As shown in Figure 9-13, there are fluctuations in nitrate concentration between sampling sites, which is not expected since nitrate is conservative and does not attenuate over distance except from dispersion and biological assimilation. The shallow water table may facilitate assimilation of nitrate by riparian plants.
- Trends in nitrate over time (1994 to present) indicate increasing trends for the most upstream and downstream Cherry Creek sites and decreasing trends for the most upstream and downstream alluvial aquifer sites (Table 9-5).

**Table 9-5. Summary of Nitrate Temporal Trend Analysis**

Site	Type	Trend	Slope (mg/L per year)
Castlewood	Upstream surface water	Yes, increasing	0.008
CC9/CC10	Downstream surface water	Yes, increasing	0.040
MW-1	Upstream groundwater	Yes, decreasing	-0.050
MW-9	Downstream groundwater	Yes, decreasing	-0.258

Note: To minimize the effects of seasonality, the Seasonal Kendall tau test was applied, which is a nonparametric test for trend (i.e. uses the relative magnitude of the data rather than the actual values) and removes seasonal cycles.

- Spatial trend evaluations to determine whether nitrate concentrations are significantly different between upstream and downstream sites and surface and groundwater sites are summarized in Table 9-6.

**Table 9-6. Spatial Differences in Nitrate**

Site	Spatial Difference in Nitrate Concentration?
Surface water upstream and downstream (Castlewood and CC9/CC10)	Yes, downstream > upstream
Groundwater upstream and downstream (MW-1 and MW-9)	No
Upstream surface water (CC1) and upstream groundwater (MW-1)	Yes, surface water > groundwater
Downstream surface water (CC9/CC10) and downstream groundwater (MW-9)	Yes, groundwater > surface water

Figure 9-13. Average Nitrate Concentrations in Cherry Creek Groundwater as a Function of Location

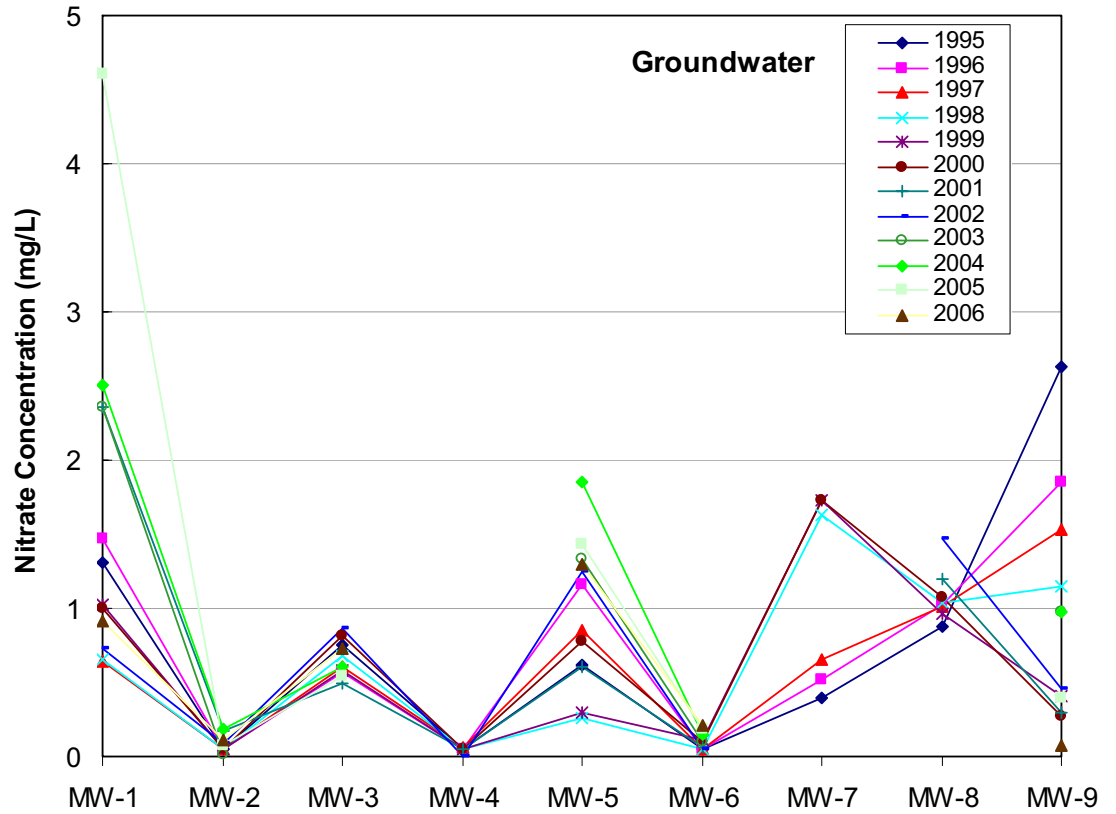


Figure 9-14. Average Nitrate Concentrations in Cherry Creek Groundwater as a Function of Time

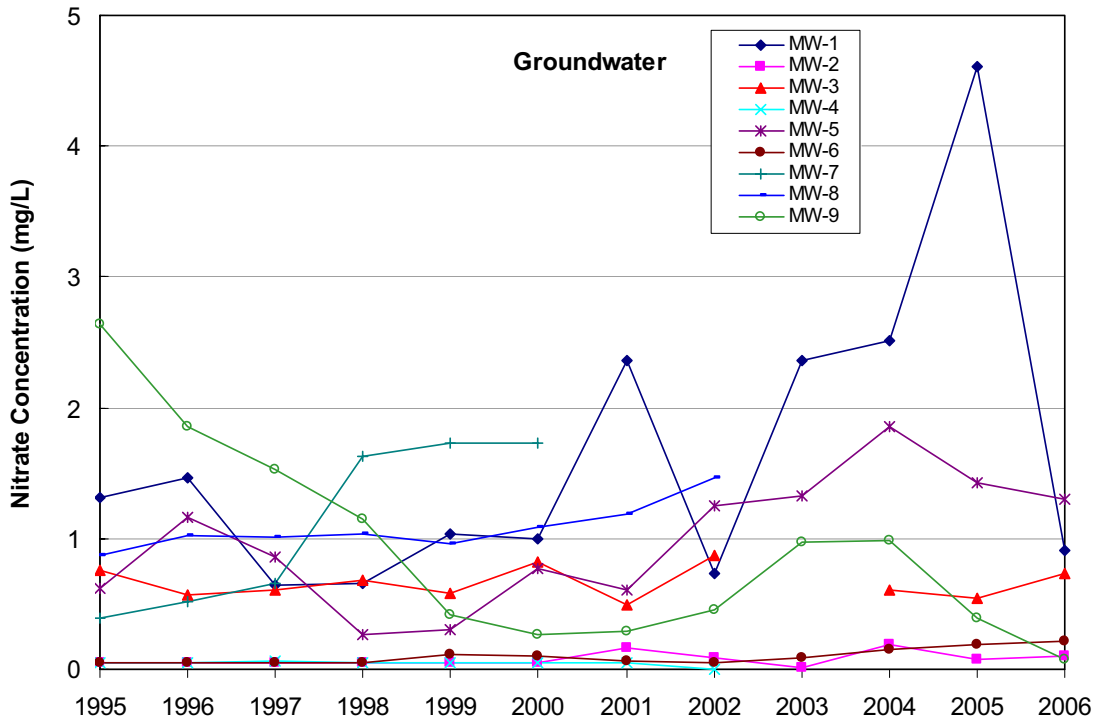


Figure 9-15. Average Nitrate Concentrations in Cherry Creek Surface Water as a Function of Location

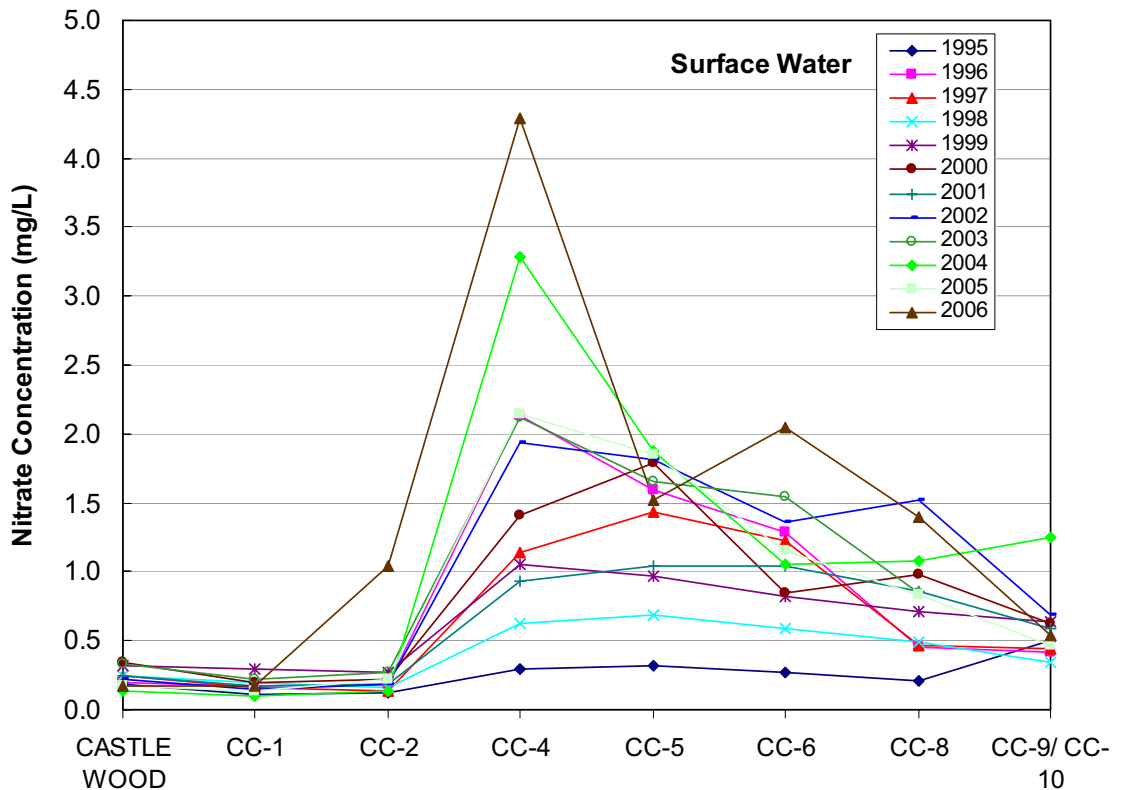
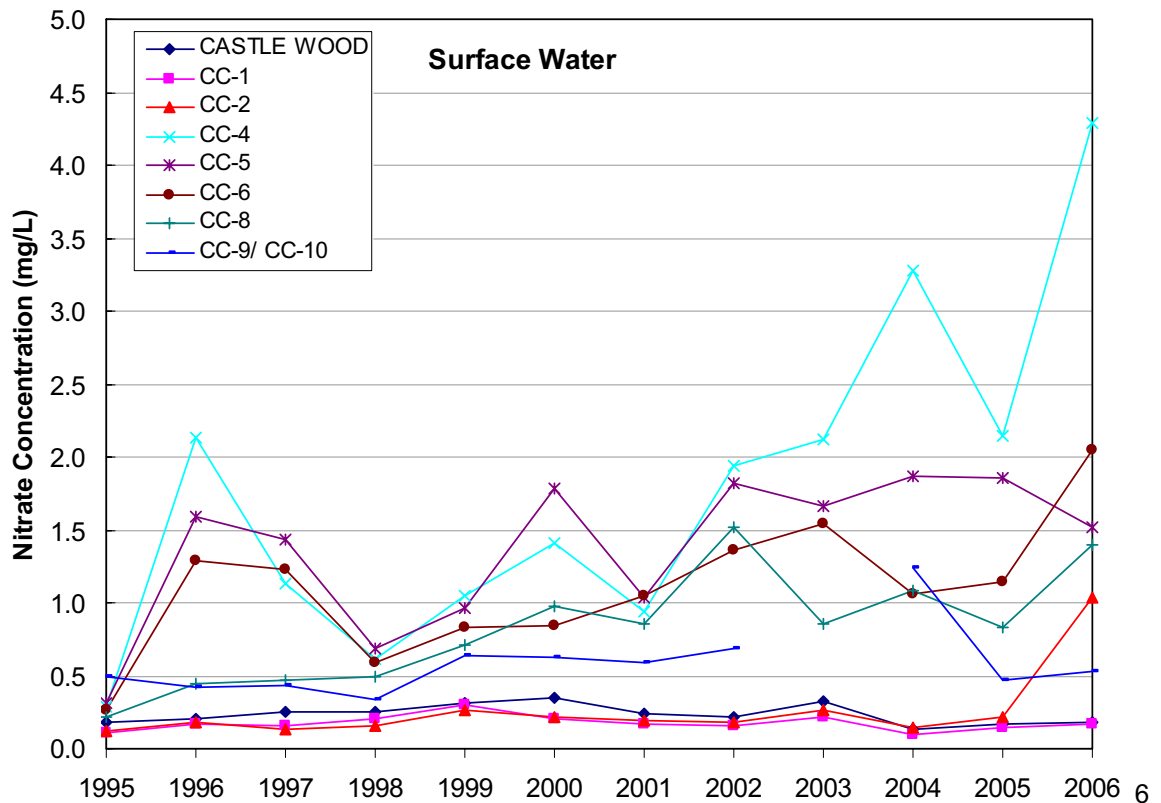


Figure 9-16. Average Nitrate Concentrations in Cherry Creek Surface Water as a Function of Time



#### 9.4 Phosphorus Loading to the Reservoir



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 past modeling efforts, net internal phosphorus loading to Cherry Creek Reservoir has been estimated to be 4,000 lbs/yr. Recent 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). Note that the phased TMAL of 14,270 lbs/year set in the May 2001 hearing does not include internal loads.

External sources of nutrients include inflow from streams and precipitation, which carry nutrients from soil erosion, agricultural and residual runoff, treated wastewater, and airborne particulates. Phosphorus loading was determined for several primary sources in 2006, including the tributary streams Cottonwood Creek, Cherry Creek, and Shop Creek, as well as from precipitation and alluvium, as summarized below.

### 9.4.1. Inflowing Streams

As part of the reservoir influent stream monitoring, annual phosphorus loading (based on calendar years) was calculated for Cherry Creek, Cottonwood Creek, and Shop Creek prior to their confluence with the reservoir. Note that for data prior to 1992, values are only available for water years. A water year begins on October 1 of the previous year and continues until September 30.

Total phosphorus loading to the reservoir from surface flows of Cherry Creek, Cottonwood Creek, and Shop Creek was estimated at 6,185 lbs in 2006<sup>1</sup> (Table 9-7). The provisional data indicate that the standardized phosphorus concentration is similar to 2005 data and is less than the long-term median value of 0.63 lbs/ac-ft (Figure 9-17).

Provisional inflow data, measured as the change in reservoir elevation by the COE, was heavily influenced by four major precipitation events in July and August 2006 (Figure 9-18). The projected total inflow for 2006 is expected to be similar to the long-term average of 13,772 ac-ft/yr.

**Table 9-7. Estimated Net Phosphorus Loading (lbs/yr) into Cherry Creek Reservoir, 1992 to 2006**

Data Source	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Mean
Shop Creek	131	83	135	115	107	117	127	96	82	103	79	103	210	127	76	112
Cherry Creek	2,894	1,727	2,142	2,795	2,347	2,041	7,666	8,745	8,306	3,412	1,105	4,637	7,379	6,636	3,481	4,941
Cottonwood Creek	1,081	117	321	2,184	553	646	1,143	1,822	1,087	1,292	789	1,130	2,592	1,697	1,219	1,346
<b>Subtotal for Streamflows</b>	<b>4,106</b>	<b>1,927</b>	<b>2,598</b>	<b>5,094</b>	<b>3,007</b>	<b>2,804</b>	<b>8,936</b>	<b>10,663</b>	<b>9,475</b>	<b>4,807</b>	<b>1,973</b>	<b>5,870</b>	<b>10,181</b>	<b>8,460</b>	<b>4,776</b>	<b>6,399</b>
Cherry Creek Alluvium	874	1,387*	967	1,676	968	1,937	3,787	5,912	2,341	4,444	1,006	2,307	2,181	1,123	1,034	2,393
Direct Precipitation	877	736	484	1,202	740	1,020	854	896	777	586	1,267	391	150	464	376	727
<b>Total Load</b>	<b>5,857</b>	<b>4,110</b>	<b>4,049</b>	<b>7,972</b>	<b>4,715</b>	<b>5,761</b>	<b>13,577</b>	<b>17,471</b>	<b>12,593</b>	<b>9,837</b>	<b>4,246</b>	<b>8,568</b>	<b>12,512</b>	<b>10,047</b>	<b>6,185</b>	<b>9,519</b>
Cherry Creek Outflow	1,314	711	993	2,049	992	996	4,207	9,650	3,688	4,842	1,501	4,978	4,812	3,669	2,810	3,683
<b>Net Load</b>	<b>4,543</b>	<b>3,399</b>	<b>3,056</b>	<b>5,923</b>	<b>3,723</b>	<b>4,765</b>	<b>9,370</b>	<b>7,821</b>	<b>8,905</b>	<b>4,995</b>	<b>2,745</b>	<b>3,590</b>	<b>7,007</b>	<b>6,378</b>	<b>3,375</b>	<b>5,779</b>

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

<sup>1</sup> Reservoir inflow and load data are provisional. These data are subject to change based on final review of COE reservoir inflow data.

Figure 9-17. Long-Term Trends in Total Phosphorus Load (lbs/yr), Inflow (ac-ft/yr), and Standardized Phosphorus Load (lbs/ac-ft) from Cherry Creek Reservoir, 1992-2006

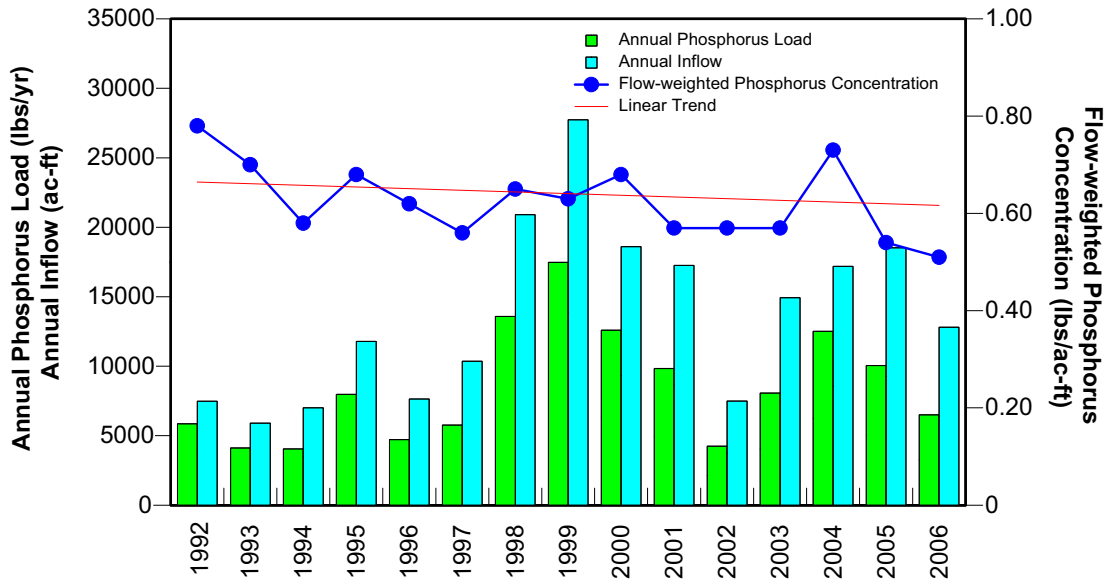
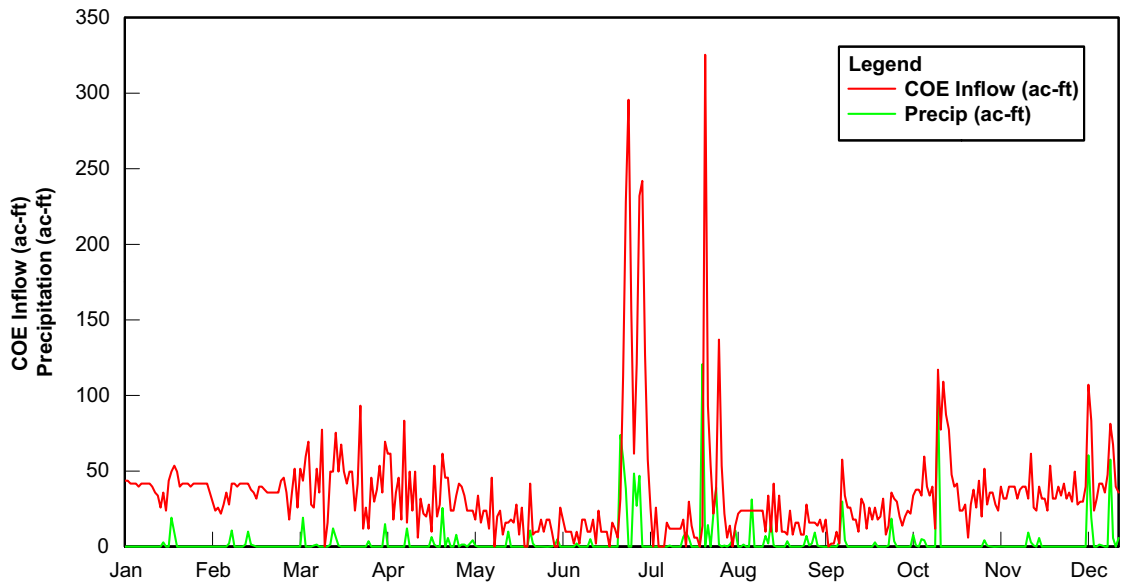


Figure 9-18. Comparison of Direct Precipitation on the Reservoir and Inflow for 2006



### **9.4.2. Precipitation**

Total annual precipitation in 2006, as measured by the KAPA rain gage located at Centennial Airport approximately 4.3 miles due south of Cherry Creek Reservoir, was 16.7 inches (Figure 9-19). This value is slightly less than the long-term mean (1987-2006) of 17.8 inches.

Given the approximate surface area of Cherry Creek Reservoir (850 acres), and the long-term (1995-2005) median total phosphorus concentration (116 µg/L) for precipitation events, total phosphorus loading was estimated to be 376 pounds for 2006.

### **9.4.3. Outflow**

The COE daily outflow and monthly total phosphorus concentrations from CC-out were used to estimate the total phosphorus export of 2,810 lbs from the reservoir via the outflow structure in 2006 (January - September). The projected export load appears to be similar to the long-term mean value of 3,683 lbs (Table 9-7).

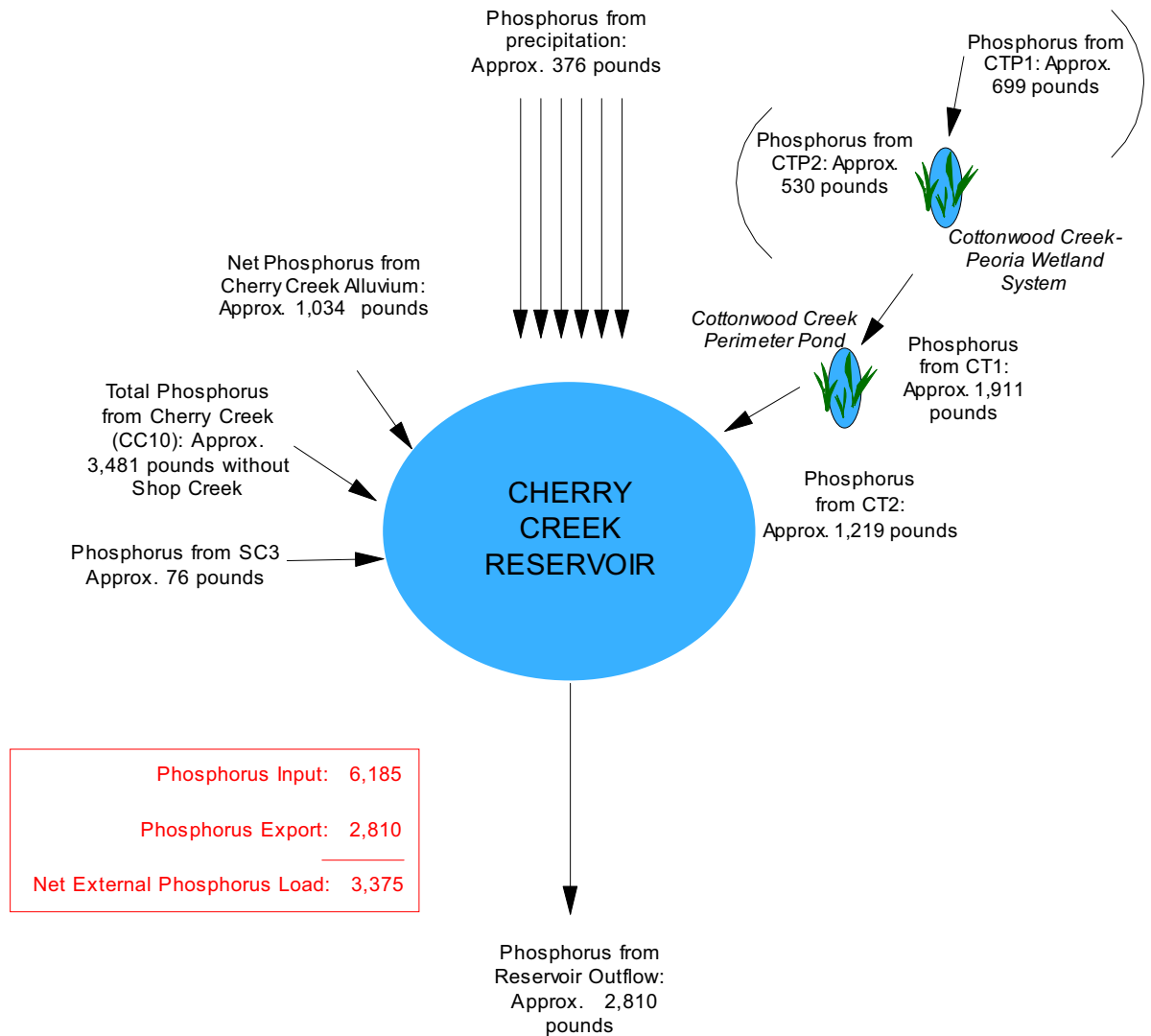
### **9.4.4. Alluvial Phosphorus**

The estimated alluvial phosphorus load for 2006 is 1,034 lbs. The 2006 load estimate utilizes a constant alluvial water budget value of 2,000 ac-ft/yr and a long-term median total dissolved phosphorus concentration from MW-9 of 190 µg/L.

### **9.4.5. Mass Balance Loadings for Phosphorus**

In general, the phosphorus load budget for Cherry Creek Reservoir is comprised of phosphorus inflow (influent streams, precipitation, and alluvium) and reservoir outflow. During 2006, phosphorus contribution from precipitation was an estimated 376 lbs, influent streams contributed 4,775 lbs, and alluvial inflow contributed 1,034 lbs (Figure 9-19) for a total load of 6,185 lbs (January -December). Outflow from the dam contained an estimated 2,810 lbs in 2006 (January -September). After totaling the additions and losses, the net loading of phosphorus was estimated at 4,122 lbs during 2006 (Table 9-1). The 2006 standardized phosphorus load (lbs/ac-ft) is similar to the range of values observed in previous years (Table 9-1 and Figure 9-19). In fact, while flows and phosphorus loads have generally varied over the past fourteen years based on a variation in annual flows, the standardized phosphorus load has generally exhibited a declining trend. Also of interest is that, while the projected 2006 phosphorus load appears to be similar to the long-term mean value, the mean summer chlorophyll *a* value in 2006 was 16% less than the long-term mean value.

**Figure 9-19. Mass Balance Diagram of Phosphorus Loading in Cherry Creek Reservoir, 2006<sup>2</sup>**



<sup>2</sup> Reservoir inflow and load data are provisional. These data are subject to change based on final review of COE reservoir inflow data.

## 9.5 Evaluation of PRFs

PRF effectiveness is gauged by monitoring the concentration of phosphorus and suspended solids and the phosphorus loading upstream and downstream of each facility. The effectiveness of the pollution reduction facilities constructed on Cottonwood Creek increased in 2006, with the overall percent reduction in loads being similar to the long-term percentages.

### 9.5.1. Cottonwood Creek-Peoria Pond

This structure came on line midway through 2002. As such, the values from 2002 represent less than a full calendar year (i.e., only July - December 2002). In 2006, the mean total phosphorus concentration both upstream and downstream of the PRF was nearly identical (Table 9-8). Total suspended solids were also slightly greater downstream of the PRF system when compared to the upstream value. The standardized phosphorus load upstream of the PRF was 0.38 lbs total phosphorus/ac-ft, while the standardized load downstream of the system was 0.37 lbs total phosphorus/ac-ft. Despite the comparable total phosphorus and total suspended solids values upstream and downstream of the PRF in 2006, the total phosphorus load downstream of the PRF system was reduced by 24%.

**Table 9-8. Annual Historical (2002-2006) Total Phosphorus and Total Suspended Solids Concentrations through the Cottonwood Creek-Peoria Wetlands System**

Parameter	Year	Sampling Sites		Difference	Percent Reduction
		CT-P1	CT-P2		
Average Total Phosphorus Concentration ( $\mu\text{g}/\text{L}$ ) (baseflow and storm samples combined)	2002	138	152	+ 14	(10)
	2003	101	92	- 9	9
	2004	142	123	- 19	13
	2005	92	101	+9	(9)
	2006	132	133	+1	(1)
	Mean	<b>121</b>	<b>120</b>	<b>-0.8</b>	<b>0.4</b>
Average Total Suspended Solids (mg/L)	2002	66	79	+ 13	(20)
	2003	31	34	+ 3	(10)
	2004	87	53	- 34	39
	2005	47	51	+4	(8)
	2006	38	47	+9	(10)
	Mean	<b>54</b>	<b>53</b>	<b>-1.0</b>	<b>-1.8</b>
Loading of Total Phosphorus (lbs)	2002	449	231	-228	64
	2003	771	574	- 197	26
	2004	2,590	1,499	- 1,091	42
	2005	596	649	+53	(9)
	2006	699	530	-169	24
	Mean	<b>1021</b>	<b>697</b>	<b>-326</b>	<b>29.4</b>

### 9.5.2. Cottonwood Creek Perimeter Pond

During 2006, the mean concentration of total phosphorus decreased from 170 to 161  $\mu\text{g}/\text{L}$  after passing through the PRF system (Table 9-9). The mean concentration of total suspended solids increased slightly, from 86 mg/L upstream to 95 mg/L downstream of the pond. The total phosphorus load decreased downstream of the pond, from 1,911 lbs to

1,219 lbs, with the standardized phosphorus load showing a similar reduction, 0.46 lbs/ac-ft to 0.37 lbs/ac-ft. The reduction in the standardized load indicates that this PRF continues to be effective in reducing total phosphorus loads to Cherry Creek Reservoir.

**Table 9-9. Annual Historical (1997 To 2006) Total Phosphorus and Total Suspended Solids Concentrations through the Cottonwood Creek Stormwater Detention Pond**

Parameter	Year	Sampling Sites		Difference	Percent Reduction
		CT-1	CT-2		
Annual Average Total Phosphorus Concentration (µg/L) (baseflow, storm samples combined)	1997	200	133	-67	34
	1998	289	210	-79	27
	1999	158	157	-1	0
	2000	187	149	-38	20
	2001	165	114	-51	31
	2002	146	143	-3	2
	2003	144	129	-15	10
	2004	212	151	-61	29
	2005	180	142	-38	21
	2006	170	161	-9	5
	Mean		<b>185</b>	<b>149</b>	<b>-36</b>
Annual Average Total Suspended Solids (mg/L)	1997	207	87	-120	58
	1998	311	129	-182	59
	1999	267	68	-199	74
	2000	96	64	-32	33
	2001	79	43	-36	46
	2002	130	79	-51	39
	2003	84	62	-22	26
	2004	155	77	-78	50
	2005	126	66	-60	48
	2006	86	95	9	(9)
	Mean		<b>154</b>	<b>77</b>	<b>-77</b>
Annual Loading of Total Phosphorus (lbs)	1997	3,351	1,103	-2,248	67
	1998	3,209	1,930	-1,279	40
	1999	6,329	3,868	-2,461	39
	2000	3,243	1,712	-1,531	47
	2001	3,356	2,205	-1,151	34
	2002	886	789	-97	11
	2003	1,777	1,130	-647	36
	2004	3,334	2,592	-742	22
	2005	1,399	1,697	298	(21)
	2006	1,911	1,219	-692	36
	Mean		<b>2,880</b>	<b>1,825</b>	<b>-1,055</b>

## 9.6 Historical Sampling of the PRFs on Shop Creek and Quincy Drainage

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

## 9.7 Status of Water Quality

In 2006, the July through September mean chlorophyll *a* content in Cherry Creek Reservoir was 14.7 µg/L, which met the standard of 15 µg/L. This standard has only been met five times in the past twenty years. The seasonal mean of total phosphorus (87 µg/L) exceeded the current goal of 40 µg/L. Despite the provisional nature of the load data, the 2006 projected annual phosphorus load is expected to meet the phased TMAL of 14,270 lbs.

## 9.8 Progress Made



- The Authority completed annual water quality monitoring and analysis for the reservoir, watershed, alluvium, and selected PRFs in accordance with the Sampling, Analysis, and Quality Assurance Work Plan.
- The Cottonwood Creek-Peoria Pond PRF showed improvement in removing total phosphorus from the stream flows in 2006, especially when compared to 2005 data. Standardized phosphorus loads (lbs/ac-ft) were slightly less downstream of the pond as compared to standardized loads upstream of the system.
- The Cottonwood Creek Perimeter Pond PRF showed a decrease in the phosphorus load downstream of the system, with the percent reduction in load being similar to the long-term mean. The standardized phosphorus loads (lbs/ac-ft) also revealed that the system was effective at removing total phosphorus from Cottonwood Creek flows.
- Despite the provisional nature of the annual load data, the projected total phosphorus load to the reservoir is expected to be less than the TMAL.
- There has been a statistically significant decrease in seasonal whole-reservoir chlorophyll *a* concentrations since 1999, with the 2006 seasonal mean concentration of 14.7 µg/L.

## 10. IMPLEMENTING WATERSHED PLAN 2003 RECOMMENDATIONS



Reg 72  
Reporting

Recommendations and specific opportunities for improving water quality can be found in the Watershed Plan 2003. The Watershed Plan 2003 and recommendations were developed by an independent consultant under the direction of the Authority. The Board has adopted the Watershed Plan 2003 and will consider these recommendations. Listed below are the recommendations provided in the Watershed Plan 2003 and progress made during 2006.


- Consider various funding options to achieve capital budget increase of \$2 million to \$4 million annually.
  - The Board’s 2006 budget included funds thought adequate to begin exploring the feasibility of addressing the impacts of the TABOR amendment on the Authority’s budget.
- Implement the Cherry Creek Reservoir Watershed Plan 2003 as a coordinated management program.
  - Watershed Plan 2003 recommendations are incorporated into the Work Plan and assist in prioritizing and determining activities for completion.
- Fund, design, and construct high priority stream improvements.
  - The Authority included funds in the 2006 annual budget for potential stream corridor preservation partnering opportunities.
- Design and construct additional pollutant reduction facilities.
  - Completed design and began contracting for reservoir destratification project.
  - Developed a conceptual design for the Cherry Creek Sediment Basin at Arapahoe Road and stream stabilization to Piney Creek confluence.
  - Continued final design for Phase II of the Cottonwood Creek Reclamation PRF.
- Promote trading incentives and request removal of the 216-pound “Reserve Pool” cap.
  - Finalized clarifications to the Trading Program and Reserve Pool Guidelines.
  - Approved new trade project.
- Encourage all land use agencies to adopt and implement the stormwater policy and design criteria outlined in the Authority’s Requirements.
  - Made significant progress in a cooperative effort with the land use agencies to propose revisions to Control Regulation 72 and develop accompanying guidance document to assist with implementation of MS4 permit program.
- Encourage local governments to work with developers to construct innovative demonstration projects.
  - Completed third year of Phosphorus Facilitator program.

- The Partners and Authority coordinated a training program for land use and development professionals.
- Encourage local governments to provide developer incentives to preserve and enhance stream corridors.
  - Continue to review land use applications and provide land use agencies and developers with comments and recommendations consistent with the Authority's Requirements.
- Explore options to reduce septic system loading in Cherry Creek.
 

*2004 revisions to Control Regulation 72 prohibit individual sewage disposal systems within the 100-year floodplain.*
- Promote reuse of wastewater through land application.
 


*2004 revisions to Control Regulation 72 and the trading program provide support for reuse projects.*
- Conduct special studies to optimize water quality improvements.
  - Completed the required depth profiling study.
  - Initiated two studies for determining background surface and groundwater phosphorus concentrations in the watershed and quantifying potential phosphorus infiltration from BMP projects.
- Develop and implement a comprehensive public involvement plan.
  - Continued support the Partners in implementing its significant efforts through the Education Initiative.
- Consider participation in several federally funded programs that support sustainable agriculture and habitat protection and restoration.
  - No specific activity in 2006.
- Coordinate with other stormwater Phase I and II entities and efforts.
  - The Authority's consultants regularly interface with land use agencies and stormwater permittees to answer questions and provide guidance for enhanced BMPS.
- Collaborate with other private and public interest groups to leverage funding mechanisms to meet watershed goals.
  - The Authority coordinated with the Partners' efforts and activities to promote education and outreach in the watershed for water quality enhancements.

Cherry Creek Reservoir met the chlorophyll *a* standard in 2006, but the reservoir did not meet the accompanying phosphorus concentration goal. The phosphorus loading to the reservoir continues to be below the TMAL. The 2006 reservoir data, as well as the long-term



monitoring indicate the relation between chlorophyll *a* and phosphorus concentrations (or between phosphorus concentration and load) needs consideration. With the addition of five years of reservoir data (since 2000), the Authority initiated an update to the Reservoir model to evaluate these relationships in the reservoir and refine the TMAL.


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. The Authority believes watershed management strategies are beneficial over the long term, but they have not resulted in immediate measurable improvements to reservoir water quality. The Authority made significant progress to finalize the design and begin construction contracting for a reservoir destratification system in 2006. This project is intended to help achieve more continued short-term improvements to reservoir water quality in conjunction with the Authority's continued efforts to develop and implement watershed management strategies as a priority.



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