

Cherry Creek Basin Water Quality Authority 2004 ANNUAL REPORT ON ACTIVITIES

March 31, 2005

Authority Members in 2004

Arapahoe County	Town of Foxfield
Douglas County	City of Greenwood Village
City of Aurora	City of Lone Tree
Town of Castle Rock	Town of Parker
City of Centennial	Special Districts
Seven Governor's Appointees	

Prepared for



Cherry Creek Basin Water Quality Authority

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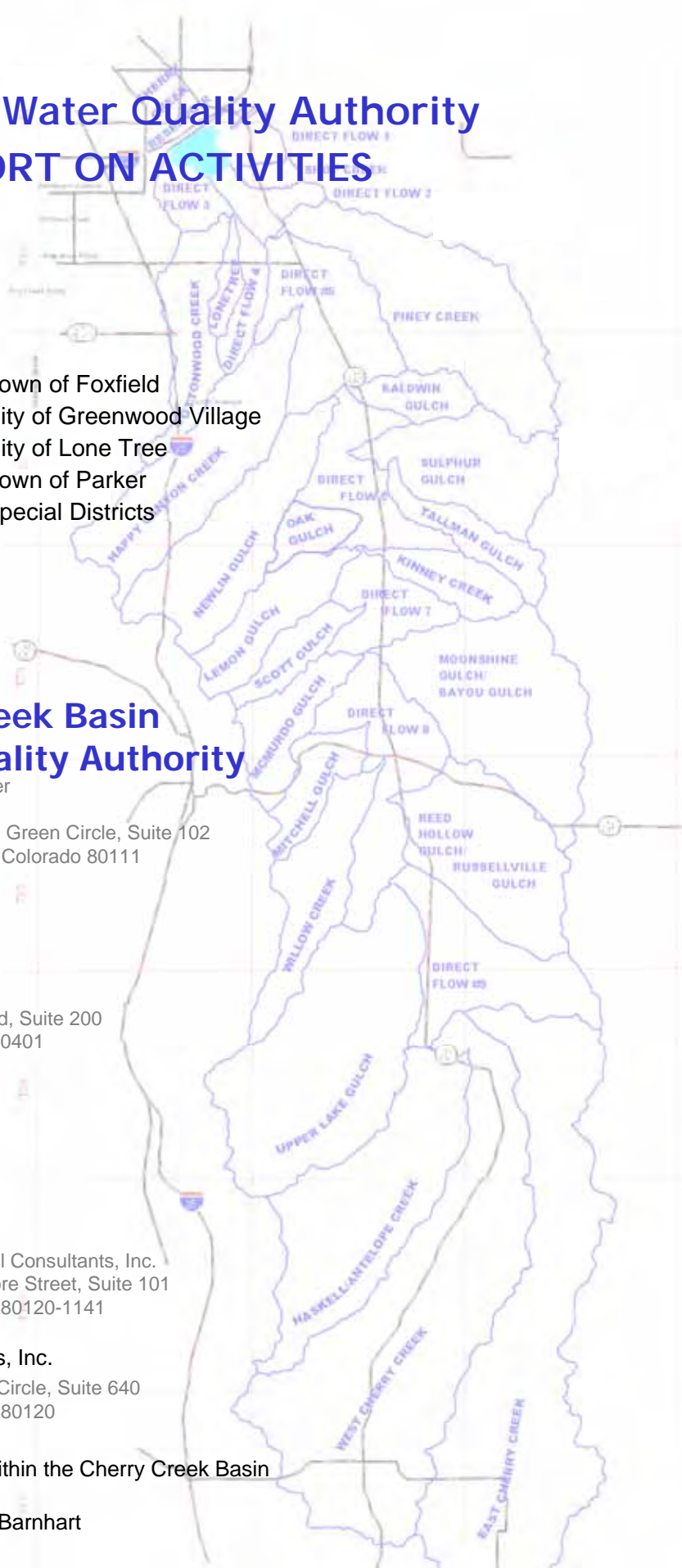
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Land Use Agencies and Utilities within the Cherry Creek Basin

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**2004 ANNUAL REPORT ON ACTIVITIES
TABLE OF CONTENTS**

Section	Page Number
EXECUTIVE SUMMARY	ES-1
ES.1 Status of Water Quality	ES-1
ES.1.1 2004 Water Quality Summary.....	ES-1
ES.1.2 Long-term Water Quality Summary	ES-3
ES.2 Background.....	ES-4
ES.3 Overview of Progress Made.....	ES-5
ES.4 Progress Made in Specific Management Programs.....	ES-6
ES.4.1 Wastewater Facility Controls.....	ES-6
ES.4.2 Nonpoint Source Controls	ES-6
ES.4.3 Trading Program	ES-7
ES.4.4 Public Education Actions and Partnerships.....	ES-7
ES.4.5 Phased TMAL Implementation	ES-7
ES.4.6 Water Quality Monitoring.....	ES-8
ES.5 Results and Conclusions	ES-8
 1. PURPOSE OF THE ANNUAL REPORT.....	 1-1
 2. THE AUTHORITY	 2-1
2.1 History.....	2-1
2.2 Today's Authority.....	2-2
2.3 Work Plan.....	2-3
2.4 Financial Matters	2-5
2.4.1 Funding Sources	2-5
2.4.2 Grants.....	2-5
2.5 2004 Reference Documents.....	2-6
2.6 Changes to Control Regulation 72.....	2-6
 3. DESCRIPTION OF CHERRY CREEK RESERVOIR WATERSHED	 3-1
3.1 Water Quality History and Regulations.....	3-3
 4. WASTEWATER FACILITY CONTROLS	 4-1
4.1 Wasteload Allocation	4-1
4.1.1 Monthly and Annual Loading.....	4-1
4.1.2 Temporary Transfer and Reserve Pool Actions.....	4-2
4.2 Wastewater Permits and Limits.....	4-3
4.3 Site Application Review.....	4-3
4.3.1 Arapahoe County Water and Wastewater Authority (ACWWA)— Valley Country Club Lift Station Site Application and Amendment	4-5
4.3.2 Castle Pines North Metropolitan District—Castle Pines North New Lift Station No. 2	4-5
4.3.3 Inverness Water and Sanitation District— Lift Station No. 2.....	4-5
4.3.4 Arapahoe County Water and Wastewater Authority—Wastewater Utility Plan Update.....	4-5

**2004 ANNUAL REPORT ON ACTIVITIES
TABLE OF CONTENTS**

4.3.5 Arapahoe County Water and Wastewater Authority—Wastewater Treatment Plant Expansion.....	4-5
4.3.6 Inverness Water and Sanitation District — Wastewater Utility Plan Update	4-6
4.3.7 Meridian Metropolitan District — Wastewater Utility Plan.....	4-6
4.3.8 Stonegate Village Metropolitan District — Wastewater Utility Master Plan.....	4-6
4.4 Progress Made.....	4-6
5. NONPOINT SOURCE CONTROLS	5-1
5.1 Land Use Agency Implementation of Stormwater Permit Requirements	5-1
5.2 Cherry Creek Reservoir Watershed Stormwater Quality Requirements	5-3
5.3 Land Use Application Review	5-3
5.3.1 Compliance with Cherry Creek Reservoir Watershed Stormwater Quality Requirements.....	5-5
5.3.2 Proprietary Best Management Practices.....	5-5
5.4 Phosphorus Facilitator.....	5-6
5.4.1 Pilot Commercial Development.....	5-6
5.4.2 Pilot Residential Development	5-7
5.5 Capital Improvement Projects.....	5-8
5.5.1 Cherry Creek State Park Wetlands Reclamation Project	5-10
5.5.2 Cottonwood Creek Stream Reclamation.....	5-11
5.5.3 Piney Creek Stream Stabilization.....	5-14
5.5.4 Projects Projected for 2005 Activity.....	5-14
5.5.5 Operations and Maintenance Activities	5-16
5.6 Riparian and Wetlands Protection	5-16
5.7 Progress Made.....	5-17
6. TRADING PROGRAM	6-1
6.1 Tracking Trades	6-1
6.2 ACWWA Pond L-3 Trade Project.....	6-2
6.3 Progress Made.....	6-2
7. PUBLIC EDUCATION ACTIONS AND PARTNERSHIPS	7-1
7.1 Educational Signage	7-1
7.2 Website and Brochure	7-2
7.3 Education Initiative.....	7-2
7.4 Collaboration with Other Entities	7-2
7.4.1 Cherry Creek Stewardship Partners	7-2
7.4.2 Projects with Direct Impact to Cherry Creek State Park.....	7-3
7.4.3 Land Use Agencies	7-4
7.4.4 Colorado Department of Transportation Annual Conference.....	7-4
7.5 Volunteer Education.....	7-5
7.6 Tours of PRFs at Cherry Creek State Park.....	7-5
7.7 Progress Made.....	7-6

**2004 ANNUAL REPORT ON ACTIVITIES
TABLE OF CONTENTS**

8. PHASED TMAL ACTIVITIES	8-1
8.1 Reservoir Nutrient Enrichment Study	8-2
8.2 Groundwater Phosphorus Loading to Reservoir	8-3
8.3 Funding for Three Special Studies	8-3
8.4 Watershed Model Update.....	8-3
8.5 Planning Progress for 2007 Triennial Review	8-4
8.6 Progress Made.....	8-4
9. WATER QUALITY MONITORING – POINT SOURCE AND NONPOINT SOURCE LOADS	9-1
9.1 Summary of Long-term Cherry Creek Reservoir Water Quality.....	9-2
9.1.1. Chlorophyll a	9-2
9.1.2. Phosphorus.....	9-2
9.1.3. Nitrogen	9-2
9.1.4. Transparency	9-2
9.1.5. Temperature and Dissolved Oxygen	9-2
9.1.6. Phosphorus Loading	9-3
9.2 Cherry Creek Reservoir - Summary of 2004 Data.....	9-3
9.2.1. Chlorophyll a	9-4
9.2.2. Phosphorus.....	9-4
9.2.3. Temperature and Dissolved Oxygen	9-5
9.3 Cherry Creek Mainstem Monitoring.....	9-7
9.3.1. Soluble Reactive Phosphorus.....	9-8
9.3.2. Nitrate.....	9-10
9.4 Phosphorus Loading to the Reservoir.....	9-12
9.4.1. Inflowing Streams.....	9-12
9.4.2. Precipitation.....	9-14
9.4.3. Outflow	9-15
9.4.4. Alluvial Phosphorus	9-15
9.4.5. Mass Balance Loadings for Phosphorus	9-15
9.5 Evaluation of PRFs	9-17
9.5.1. Cottonwood Creek- Peoria Pond.....	9-17
9.5.2. Cottonwood Creek Perimeter Pond	9-17
9.6 Historical Sampling of the PRFs on Shop Creek and Quincy Drainage.....	9-18
9.7 Status of Water Quality.....	9-19
9.8 Progress Made.....	9-19
10. IMPLEMENTING WATERSHED PLAN 2003 RECOMMENDATIONS.....	10-1
11. REFERENCES.....	11-1

**2004 ANNUAL REPORT ON ACTIVITIES
TABLE OF CONTENTS**

FIGURES

Figure ES-1. Cherry Creek Reservoir Watershed Map ES-2
 Figure ES-2. Cherry Creek Reservoir Water Quality, Load, and Inflow, 1992-2004 ES-4

Figure 2 1. Water Quality Management Approach..... 2-1
 Figure 2 2. Summary of Authority History..... 2-2
 Figure 2 3. 2004 Work Plan 2-4

Figure 3-1. Cherry Creek Reservoir Watershed Map 3-2

Figure 5 1. Cottonwood Creek Stream Reclamation - Before 5-12
 Figure 5 2. Cottonwood Creek Stream Reclamation - After..... 5-12
 Figure 5 3. Cottonwood Creek Stream Reclamation Phase 1 5-13

Figure 7-1. Cottonwood-Peoria Pond Sign Installation 7-1
 Figure 7-2. Cottonwood Creek Reclamation – Volunteer Planting..... 7-5

Figure 9 1. Sampling Sites on Cherry Creek Reservoir and Selected Streams 1
 Figure 9 2. Concentration of Chlorophyll a ($\mu\text{g/L}$) in Cherry Creek Reservoir, 2004..... 9-4
 Figure 9 3. Seasonal Mean (July to September) Chlorophyll a Concentrations
 Measured in Cherry Creek Reservoir, 1987 to 2004..... 9-5
 Figure 9 4. Seasonal Mean (July to September) Total Phosphorus Concentrations
 ($\mu\text{g/L}$) Measured in Cherry Creek Reservoir, 1987-2004 9-5
 Figure 9 5. Temperature (C) Profiles Recorded During Routine Monitoring at Site
 CCR-2 in 2004..... 9-6
 Figure 9 6. Dissolved Oxygen (mg/L) Profiles Recorded During Routine Monitoring
 at Site CCR-2 in 2004..... 9-6
 Figure 9 7. Average SRP Concentrations in Cherry Creek Groundwater..... 9-9
 Figure 9 8. Average SRP Concentrations in Cherry Creek Surface Water 9-9
 Figure 9 9. Average Nitrate Concentrations in Cherry Creek Groundwater..... 9-11
 Figure 9 10. Average Nitrate Concentrations in Cherry Creek Surface Water..... 9-11
 Figure 9 11. Long-Term Trends in Total Phosphorus Load (pounds/year),
 Inflow/acre-feet (year), and Standardized Phosphorus Load (pounds/acre
 feet) from Cherry Creek Reservoir, 1992-2004 9-13
 Figure 9 12. Comparison of Precipitation and Inflow for 2004..... 9-14

**2004 ANNUAL REPORT ON ACTIVITIES
TABLE OF CONTENTS**

TABLES

Table ES-1. Water Quality and Total Phosphorus Load Data for Cherry Creek Reservoir, July-September 1992-2004.....	ES-3
Table 2 1. Authority Board Members.....	2-2
Table 2 2. Authority TAC Members.....	2-3
Table 2 3. 2004 Reference Documents	2-6
Table 3-1. Phase I TMAL Annual Phosphorus Allocations	3-3
Table 4 1. Cherry Creek Reservoir Watershed Point Source Allocation and 2004 Point Source Phosphorus Annual Contribution	4-1
Table 4 2. 2004 Point Source Phosphorus Monthly Contribution	4-2
Table 4 3. Summary of 2004 Site Applications	4-4
Table 4 4. Summary of New and Updated Wastewater Utility Master Plans in 2004.....	4-4
Table 5 1. Summary of Cherry Creek Reservoir Watershed Permit, Inspection and Enforcement Actions	5-1
Table 5 2. History of Land Use and Development Applications Reviewed by Authority	5-3
Table 5 3. Sources of Land Use Application Referrals	5-4
Table 5 4. Summary of Comments on Land Use Applications.....	5-4
Table 5 5. 2005 Three-Year Capital Improvement Projections.....	5-9
Table 6-1. Example of Tracking Trades.....	6-2
Table 8-1. Special Studies	8-1
Table 9 1. Water quality and total phosphorus loads data for Cherry Creek Reservoir, July - September 1992 - 2004.....	9-3
Table 9 2. Quality Monitoring Stations for Cherry Creek Mainstem	9-7
Table 9 3. Summary of Soluble Reactive Phosphorus Temporal Trend Analysis	9-8
Table 9 4. Spatial Differences in Soluble Reactive Phosphorus.....	9-8
Table 9 5 Summary of Nitrate Temporal Trend Analysis	9-10
Table 9 6. Spatial Differences in Nitrate.....	9-10
Table 9 7. Estimated Net Phosphorus Loading (pounds/year) into Cherry Creek Reservoir, 1992 to 2004	9-13
Table 9 8. Annual Historical (2002-2004) Total Phosphorus and Total Suspended Solids Concentrations through the Cottonwood Creek-Peoria Wetlands System.....	9-17
Table 9 9. Annual Historical (1997 To 2004) Total Phosphorus and Total Suspended Solids Concentrations through the Cottonwood Creek Stormwater Detention Pond.....	9-18


CONTROL REGULATION 72 REPORTING REQUIREMENTS



Look for this symbol in the margin of the 2004 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
Section 72.9 - Reporting	
72.9(1) Annual Report Submittal	Cover Letter
72.9(1)(a) Wastewater Facility Controls	
Monthly and annual loads	4.1.1
Permit violations	4.2
Approved site applications	4.3
Effectiveness in reducing nutrient loads	4.4
72.9(1)(b) Nonpoint Source Controls	
Sediment and erosion control permit, inspection, and enforcement actions.....	5.1
Construction BMPs inspection and enforcement actions	5.1
Permanent BMPs construction, inspection, and maintenance actions	5.1
Flood control facilities retrofitting, inspection, and maintenance actions	5.5
Effectiveness in reducing nutrient loads	5.7, 9.5
Funding of nonpoint source control projects	5.5
Monitoring of nonpoint source control projects	9.5
Public information and education actions	7
72.9(1)(c) Riparian and Wetlands Protection	
Protection, enhancement and restoration actions.....	5.6
72.9(1)(d) Wasteload Allocation	
Temporary transfers, reserve pool allocations, and semi-urban area transfers	4.1.2
72.9(1)(e) Trading Program	
Point and nonpoint source actions, including reporting TMAL reductions from Trading Program	6
72.9(2) Provide data and information on the following:	
Water quality monitoring.....	9
Point and nonpoint source loadings	4.1, 9.4
Status of compliance with discharge permit limits and conditions	4.2
Recommendations on new or proposed expansion of treatment facilities	4.3
Recommendations for improving water quality	10
Annual report format shall provide comparability among previous years	n/a ¹

¹ 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.



72.9(3) Include evidence or agreements for the following:

Financing of nonpoint source projects.....	2.4, 5.5
Implementation of stormwater permit requirements	5.1
Adoption and implementation of BMPs by local governments	5.1
Demonstrate reasonable progress towards control of point and nonpoint sources of phosphorus.....	4.4, 5.7

CONTROL REGULATION 72 TASK REQUIREMENTS

STEPS
REG 72

Look for this symbol in the margin of the 2004 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 Section Number and Task Requirement	Section of Annual Report
Section 72.3 Phase I Total Maximum Annual Phosphorus Load Allocations	
72.3 (4) Future Activities to attain TMAL	
72.3 (4)(1) Construct nonpoint source control projects	5.5
72.3 (4)(2) Conduct reservoir nutrient studies	8
72.3 (4)(3) Develop event mean concentrations for stormwater flows.....	8
72.3 (4)(4) Quantify soil and groundwater background phosphorous levels	8
72.3 (4)(5) Identify industrial process wastewater sources and associated phosphorous loading	8
72.3 (4)(6) Evaluate phosphorus removal effectiveness of nonpoint source control structures.....	8
72.3 (4)(7) Monitor shallow alluvial ground water loading in tributaries	8
72.3 (4)(8) Quantify individual sewage disposal system phosphorus loading.....	8
72.3 (4)(9) Implement lower phosphorus effluent limits.....	4.2
72.3 (4)(10) Characterize watershed hydrology to establish reference condition for evaluation of phosphorus loading.....	8
72.3 (4)(11) Conduct depth profiling of nutrient content for ground water	8
72.3 (4)(12) Revise calculations of background sources, industrial processes, wastewater sources, and individual sewage disposal systems sources of phosphorus contributions	8
72.3 (4)(13) Revise control regulation TMAL for next triennial review.....	8
Section 72.4 Wastewater Facility Load Allocations/Limitations	
72.4(3) Wasteload allocation	4.1
72.4(4) Direct discharges and land application phosphorus concentration.....	4.2
72.4(7) Wasteload allocation for semi-urban areas	4.1.2
72.4(8) Determine monthly and annual quantity of phosphorus discharged	4.1.1
Section 72.5 Point Source Wasteload Allocation Modifications	
72.5(1) Temporary transfer of phosphorus allocation	4.1.2
72.5(2) Reserve Pool	4.1.2
72.5(3) Trading Program	6
Section 72.6 Nonpoint Source and Individual Sewage Disposal System Nutrient Controls	
72.6(1)(a) Nonpoint source best management practices	5
72.6(1)(c) List of prioritized capital improvement projects.....	5.5
72.6(1)(d) Operation and maintenance of nonpoint source projects	5.5.5
72.6(2) Develop public information and education program	7

72.6(6) Floodplain preservation	5.5, 5.6
Section 72.7 Stormwater Permit Requirements	
72.7(2) Minimum requirements	5.1, 5.2,5.3
Section 72.8 Nutrient Monitoring	
72.8(1) Nutrient monitoring by wastewater dischargers	4.1, 4.2
72.8(2) Develop and implement routine annual water quality monitoring program.....	9
72.8(3) Consults with Division on monitoring program	9
72.8(4) Authority consult with Division and other entities on special studies.....	8
72.8(5) Uses of monitoring data.....	8, 9
Section 72.9 Reporting (see page vi)	
Section 72.10 Commission Review	
72.10(1) Report progress to control phosphorus loads	ES, 4, 5, 6, 7, 8, 9
72.10(2) Recommendations to Commission at each triennial review.....	2.6

ABBREVIATIONS

ACWWA	Arapahoe County Water and Wastewater Authority
Annual Report	Cherry Creek Basin Water Quality Authority 2004 Annual Report
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
GESC	Grading, Erosion and Sediment Control
ISDS	Individual Sewage Disposal System
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
PWSD	Parker Water and Sanitation District
Requirements	Cherry Creek Reservoir Watershed Stormwater Quality Requirements, dated February 16, 2000
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
2004 Annual Draft Monitoring Report	2004 Annual Aquatic Biological-Nutrient Monitoring Study and Cottonwood Creek Phosphorus Reduction Facility Monitoring

EXECUTIVE SUMMARY

The purpose of the 2004 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 2004. 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 2004 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 2004 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 water quality monitoring, measurement of loads to the Cherry Creek Reservoir, and implementing point and nonpoint source controls and programs, special study efforts to update the TMAL, and a preliminary discussion of 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 its routine annual water quality monitoring program in 2004 for Cherry Creek Reservoir, the watershed, and to evaluate the effectiveness of Authority pollutant reduction facilities (PRFs).

ES.1.1 2004 Water Quality Summary

- Summer mean chlorophyll *a* of 18.4 µg/L exceeded the 15 µg/L standard
- Summer mean total phosphorus of 102 µg/L exceeded the goal of 40 µg/L
- Total phosphorus load of 12,512 pounds to the reservoir was below the TMAL of 14,270 lbs/year

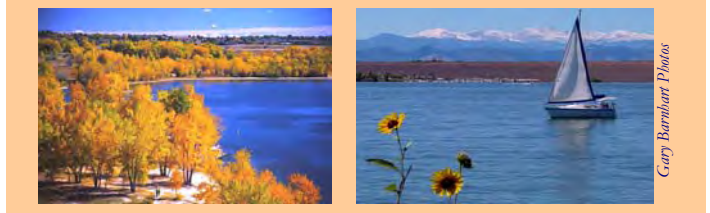
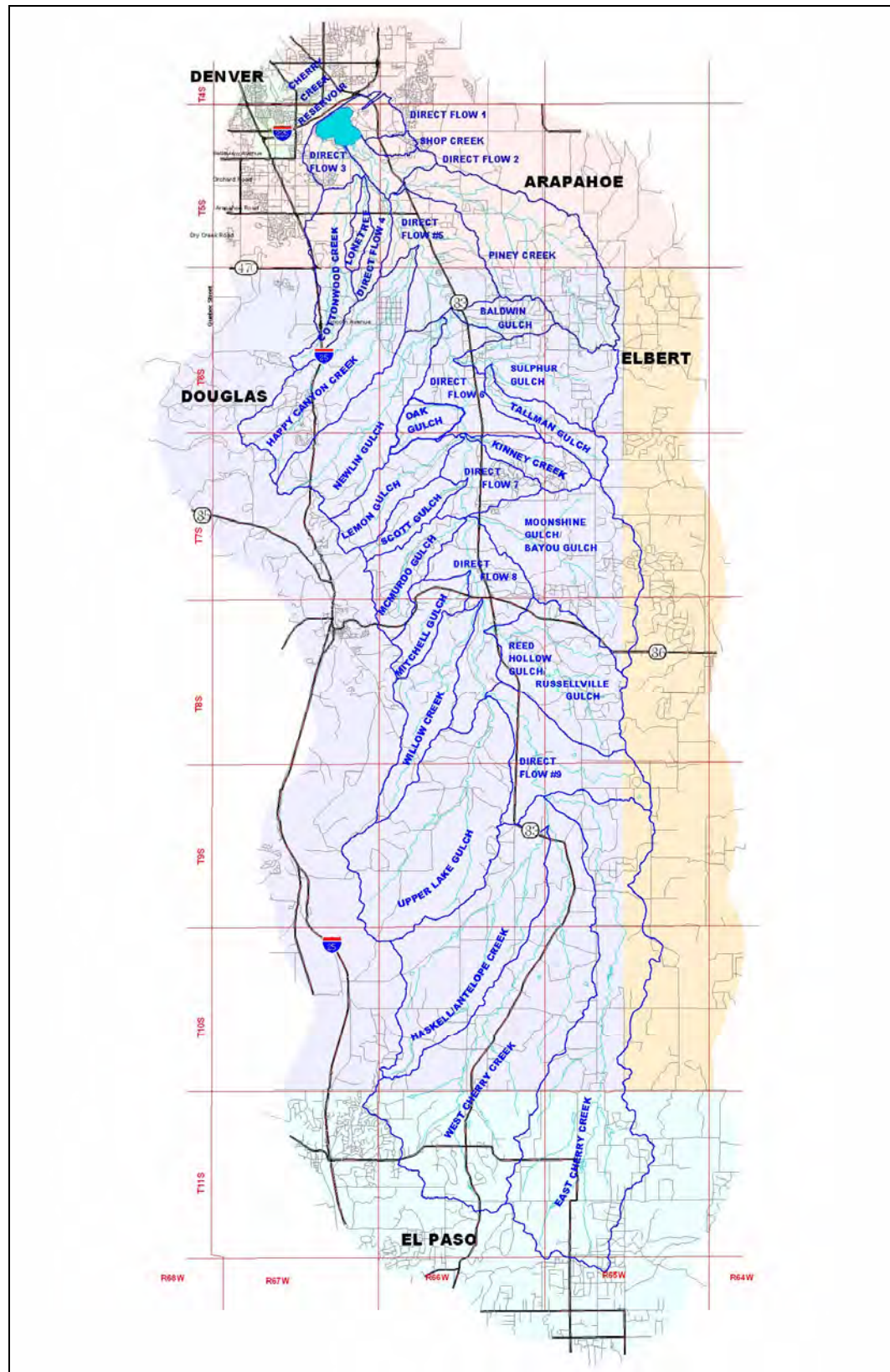


Figure ES-1. Cherry Creek Reservoir Watershed Map



- PRFs demonstrated phosphorus removal effectiveness: Cottonwood-Peoria Pond, 42% phosphorus reduction, and Cottonwood Perimeter Pond, 22% phosphorus reduction. Historical sampling of the PRFs on Shop Creek and Quincy Drainage indicated an average phosphorus reduction of 63% and 99%, 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 13 years, and the phosphorus goal of 40 µg/L has not been achieved in the past 13 years. However, the phosphorus loads have been lower than the TMAL of 14,270 pounds in 12 of the past 13 years (Table ES-1).

Table ES-1. Water Quality and Total Phosphorus Load Data for Cherry Creek Reservoir, July-September 1992-2004

Year	Chlorophyll <i>a</i> (µg/L)	Total Phosphorus (µg/L)	Total Nitrogen (µg/L)	Annual Phosphorus Load (lbs/yr) ¹	Annual Inflow (ac/ft) ¹	Standardized Phosphorus Load (lbs/ac-ft)	Net Phosphorus Load (lbs/yr) ²
1992	17	66	970	5,857	7,474	0.78	4,543
1993	14.4	62	826	4,110	5,905	0.7	3,399
1994	10	59	1,144	4,049	7,001	0.58	3,056
1995	9.4	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
Mean	20.3	77	928	8,559	13,406	0.64	5,195
Median	20.5	81	913	7,972	11,781	0.63	4,765

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

² The net phosphorus load is the total load to the reservoir minus the reservoir outflow load.

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

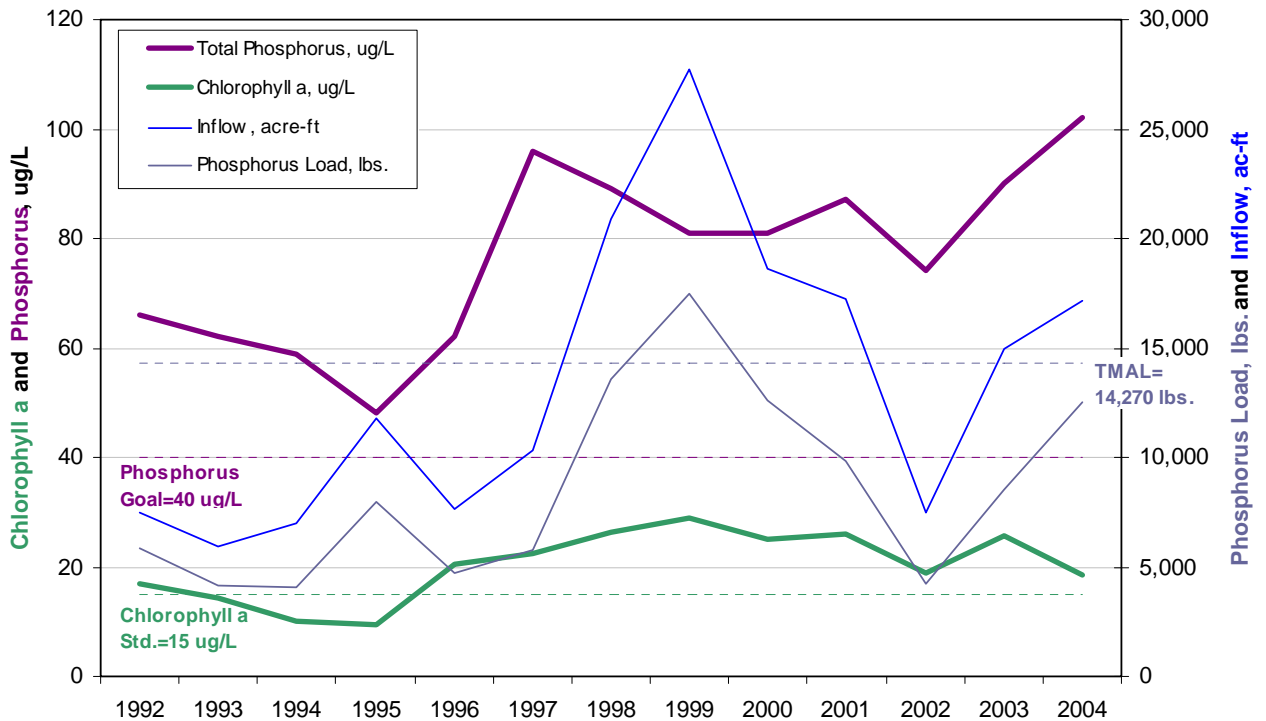
Figure ES-2 provides a picture of water quality concentrations, phosphorus loads, and inflow to the reservoir since 1992. This figure demonstrates how phosphorus loads track closely with inflows to the reservoir and that chlorophyll *a* and phosphorus concentrations do not necessarily have an immediate 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. As stated above, Authority PRF monitoring shows the PRFs are effective in reducing phosphorus. 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 and needs to consider additional strategies, particularly for more near-term reservoir improvements. A 2003 special study on nutrient enrichment in Cherry Creek Reservoir suggested that nitrogen, not phosphorus, may be the limiting nutrient and that the Authority should consider in-lake management strategies 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 while the Authority further investigates impacts on reservoir water quality and formulates additional and alternative control strategies.

Figure ES-2. Cherry Creek Reservoir Water Quality, Load, and Inflow, 1992-2004



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.

- 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 not meet the chlorophyll *a* water quality standard for the reservoir in 2004, the Authority continues to take initiative towards meeting standards through key planning, implementation, and evaluation actions, including the following.

- **Planning** – Recommendations of the Watershed Plan 2003 continue to guide the Authority's Work Plan. The Authority evaluated in-lake management strategies for short-term water quality improvement in addition to long-term watershed management strategies. In addition, the Authority worked with the Colorado Water Quality Control Division (Division) to make revisions to Control Regulation 72 through the triennial review rulemaking hearing in 2004.
- **PRF Implementation** – Made progress in initiating design and construction of additional on-the-ground PRFs. This included constructing Phase I of the Cottonwood Creek Stream Reclamation, contributing to the completion of Piney Creek Stream Stabilization, and refining the design approach for the Cherry Creek State Park Wetlands Reclamation.
- **Facilitation and Coordination** – Worked closely with land use agencies to coordinate stormwater permit requirement compliance in the Cherry Creek basin. In addition, the Authority coordinated with the Cherry Creek Stewardship Partners (Partners) to foster education efforts through a broad stakeholder group and continued the unique program of the "phosphorus facilitator," that included two pilot projects with Crown Point, a commercial development in the Town of Parker, and AscentPointe/SunMarke, a residential community in Douglas County. These projects provided great opportunity to illustrate a wide variety of innovative surface water solutions to benefit the developers, the community and the environment.
- **Education** – Coordinated with the Partners to find more avenues for educating the public (i.e., website and conference) and participated in development of the Cherry Creek Basin Water and Stewardship and Education Initiative (Education Initiative). Constructed signage at Cherry Creek State Park, and coordinated volunteer vegetation planting associated with PRF construction.
- **Monitoring** – 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 2004 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 seven and approved four site applications and wastewater utility management plans within the Cherry Creek Reservoir watershed for compliance with applicable regulations and guidance documents. This includes compliance with wasteload allocations and wastewater utility management plans. The remaining three site applications will be completed in 2005.
- Through the Control Regulation 72 Triennial Review, the Commission approved a change to the Control Regulation that enables the Authority to add new reuse dischargers requiring a phosphorus allocation without amending Control Regulation 72.
- The Plum Creek Wastewater Authority and the City of Aurora were allocated phosphorus pounds for land application. The allocations were transferred from the Semi-urban area allocation.

ES.4.2 Nonpoint Source Controls

- Coordinated and assisted local land use agencies in implementing Phase II stormwater permit requirements consistent with Control Regulation 72.
- Completed the first year of the “phosphorus facilitator” program, to work with local developers to implement best management practices (BMPs) that go well beyond minimum requirements. Initial response to the program by developers has been positive the Authority plans on continuing the program in 2005.
- 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 two additional PRFs, included the projects on the master Capital Improvement Project (CIP) list, and allocated funds for further activity during 2005.
- Participated in stream stabilization measures for Piney Creek and Cottonwood Creek, streams that contribute sediment and phosphorus to the reservoir.
- Achieved changes to Control Regulation 72 which prohibit future individual sewage disposal systems (ISDS) within the 100-year floodplain.

ES.4.3 Trading Program

In 2004, the Authority improved and built upon its trading program.

- Changes made to Control Regulation 72, such as the removal of the existing 216-pound cap, will facilitate future trading. Changes also included removing the limit on trade ratios.
- A process was developed to track trades.
- ACWWA began construction on the Pond L-3 trade project, which will be completed in 2005.

ES.4.4 Public Education Actions and Partnerships

- Continued distribution of the BMP Series educational fact sheets to increase awareness of water quality BMPs and the Authority's role and efforts in improving water quality, specifically related to the land use and development process within the Cherry Creek Reservoir watershed.
- Continuation of the Authority's website through cooperation with the Partners to facilitate the dissemination of information to parties interested in the Authority's activities.
- Collaborating on information and education efforts with other entities with common interests and goals for the watershed.
- Participating in sub-watershed major drainageway planning investigations by the Urban Drainage and Flood Control District (UDFCD) to further the Authority's goal of implementing watershed-based BMPs.
- Supported the Cherry Creek Stewardship Partners and coordinated with other entities to develop the Education Initiative, a comprehensive and coordinated education strategy and action plan.
- Constructed educational signage by the Cottonwood-Peoria Pond, a PRF constructed by the Authority.
- Facilitated volunteer vegetation planting with Park staff as part of the Cottonwood Creek Phase I Reclamation project.

ES.4.5 Phased TMAL Implementation

- Under the management of the Division, the Authority completed one special study in 2004 that lead to re-evaluation of in-lake management opportunities. The re-evaluation of reservoir destratification went through conceptual analysis in 2004 and will be a capital improvement project in 2005, beginning with preliminary design.
- Under the management of the Division, a second special study progressed to estimate the groundwater inflow rate and phosphorus flux through reservoir seepage. This study will be completed in early 2005.

- The Authority obtained funding and finalized project implementation plans for three special studies that are required as part of the phased TMAL. These studies will be initiated in 2005.
- The Authority made significant progress on determining how to address the question of phosphorus fate and transport in the watershed and developed a scope of work to update the watershed model in 2005.

ES.4.6 Water Quality Monitoring

- 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.
- Confirmed phosphorus load reductions from the Cottonwood Creek-Peoria Pond PRF (42% phosphorus load reduction) and Cottonwood Creek Perimeter Pond PRF (22% phosphorus load reduction). These reductions in loads at the Perimeter Pond PRF were observed despite the potential for increased loads resulting from the channel reconstruction activities upstream during 2004, again pointing to the effectiveness of this structure in reducing phosphorus loads to the reservoir.
- Total phosphorus load to the reservoir was below the TMAL.
- There has been no statistically significant increase (or decrease) in seasonal reservoir chlorophyll *a* concentrations since 1996.

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 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 results of the special study on nutrient enrichment led to investigating additional strategies for more short-term improvements to reservoir water quality.

The review of Authority watershed management activities and monitoring indicate that current watershed approaches are needed to reduce external nutrient loads, but the Authority also faces a challenge in meeting water quality standards. In addition to watershed strategies the Authority is also considering additional strategies, including in-lake management that could be beneficial to reducing chlorophyll *a* concentrations in the near term.

1. PURPOSE OF THE ANNUAL REPORT

The purpose of the 2004 Annual Report is to summarize activities performed by the Authority in 2004. 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, and 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 2004 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 indicates the Authority's progress towards completing Control Regulation 72 tasks, which are listed on page viii of 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 Annual Report is submitted to the Commission for review on March 31 of the following year. 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 on page vi of 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. This data is 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 near term 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.

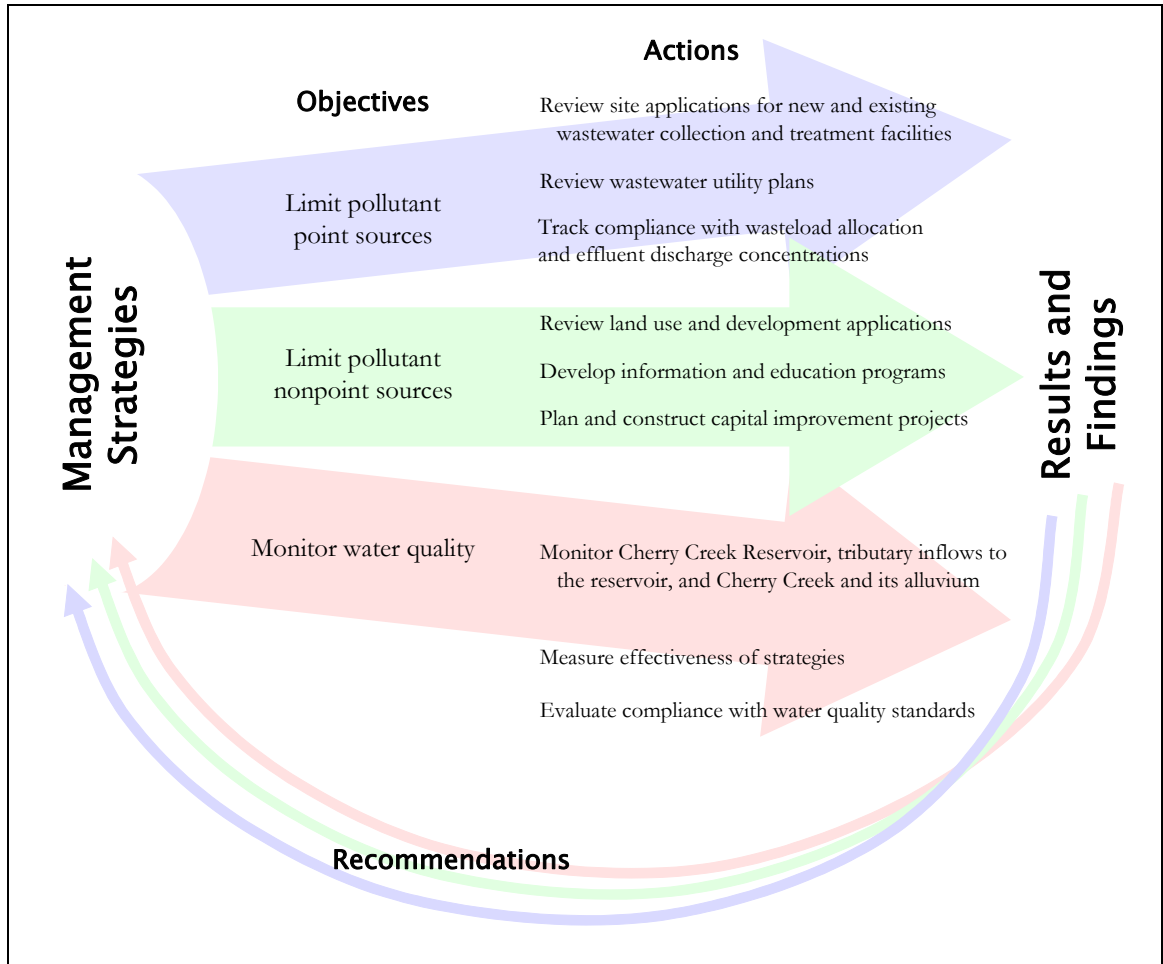
Objective 5 – Provide an abbreviated report of 2004 activities and progress made

The Executive Summary of the Annual Report serves as a stand-alone document providing a brief summary of the Authority’s activities in 2004 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

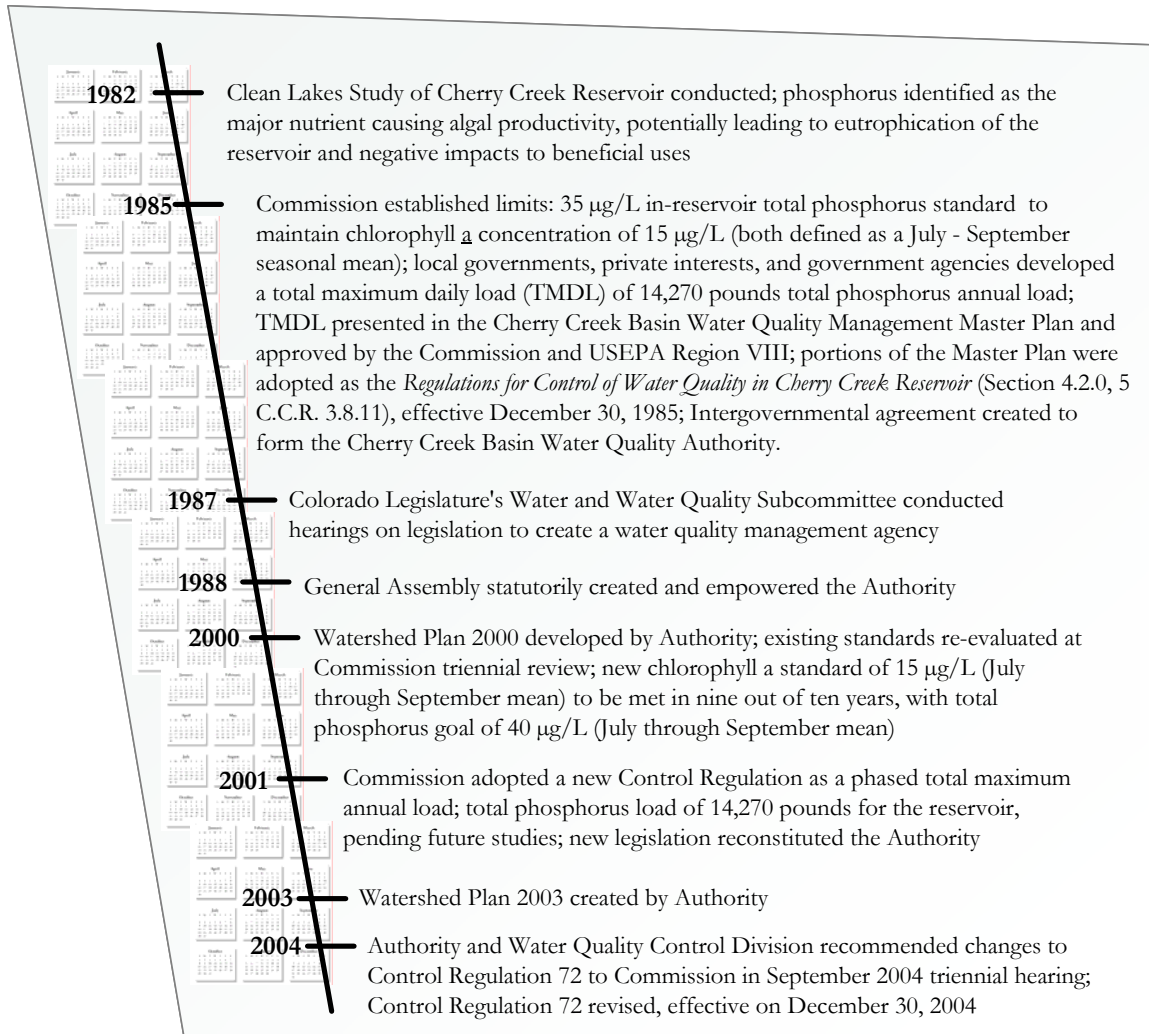


This section provides information on the Authority’s history, the members of the Authority, the 2004 annual budget and funding sources, and 2004 reference materials.

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.

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
Total members of Authority Board ¹	17

¹ Arapahoe County and the Town of Foxfield were represented by one individual on the Board in 2004.

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

Entities Represented	Number of Members
County (Arapahoe, Douglas)	2
Municipality (Aurora, Castle Rock, Centennial, Greenwood Village, Lone Tree, Parker)	6
Special districts	1
Board appointed	4
Other (Cherry Creek State Park, COE, DRCOG, City and County of Denver)	4
Total members of TAC	17

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 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 are also listed on separate pages. The Work Plan is updated on a monthly basis and is reviewed at every TAC meeting.

Figure 2-3. 2004 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)	Month Finish
2004 Ongoing							
Meetings	Monthly Board and TAC meetings					Ongoing	
Work Plan	Maintain and update TAC Work Plan	Update monthly and submit to TAC for review one week prior to monthly TAC meetings			B - Implement Watershed Plan 2003 as a coordinated management program	Ongoing	
	Submit to Board quarterly	Submit abbreviated TAC Work Plan to Board			B - Implement Watershed Plan 2003 as a coordinated management program		1/15/04, 4/15/04, 7/15/04, 10/21/04
Trading Program	Review of Trade Applications		72.5(3)(a)	Trading program	E - Promote trading incentives	Ongoing	
Watershed Mgmt - Land Use Applications	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	
Watershed Mgmt - Site Application Review	Review of Site Applications		72.4(4)	Effluent discharge		Ongoing	
2004							
Capital Projects	Cottonwood Creek Reclamation	Phase I construction	72.3(4)	Construction of nonpoint source control projects	C - Fund, design, and construct high priority stream improvements	12/1/2003	4/15/2004
	Cottonwood Creek Reclamation	Phase II design	72.3(4)	Construction of nonpoint source control projects	C - Fund, design, and construct high priority stream improvements	1/1/2004	12/31/2004
	Cherry Creek State Park Wetlands	Phase I design	72.3(4)	Construction of nonpoint source control projects	D - Design and construct additional PRFs	8/1/2004	11/30/2004
Long-term Funding	Develop and implement an overall business program and financing plan.				A,3 - Develop and implement an overall business program and financing plan.	2/1/2004	2005
	Identify a funding champion to generate financial resources for water quality improvement.				A,1 - Identify a funding champion to generate financial resources for water quality improvement	2/1/2004	2005
Monitoring - 2003 Annual Report	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), 72.6(5), 72.6(6)	Gathering and updating required information (see Description) into an Annual Report		1/1/2004	3/31/2004
	Annual Report - TAC and WQCD provide comment on draft	TAC receives draft two weeks before TAC meeting, provide comment by TAC meeting	72.9	Annual Report		1/22/2004	2/5/2004
	Annual Report - Board provide comment on draft	Board receives draft at Board meeting, provide comment within one week	72.9	Annual Report		2/19/2004	2/26/2004
	Annual Report - TAC provide comment on final draft	TAC receives draft at TAC meeting, provide comment within one week	72.9	Annual Report		3/4/2004	3/18/2004
	Annual Report - Submit final to WQCD and WQCC		72.9	Annual Report			3/31/2004
Public Information and Education	Promote use of Educational Fact Sheets (Completed through existing 319 I&E Grant)	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	1/1/2004	12/31/2004
Regulations	Implementation of lower P effluent limits	Effluent discharge requirements in place: effluent P concentration < 0.05 mg/l; land application < 0.05 mg/l / return flow	72.4(4)	Controls on effluent discharge		4/1/2004	8/1/2004
Special Project - Phosphorus Facilitator	Phosphorus Facilitator	Coordinate with land use agencies and developers. Identify and implement demonstration projects.			G - Encourage local governments to work with developers to construct innovative demonstration projects	12/1/2003	12/1/2004
Special Projects - 319 Grant Implementation	Educational Signage at Cherry Creek State Park (Existing 319 I&E Grant)	ECOS to complete signage	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	12/1/2003	10/30/2004
Special Projects - 319 Grant Pursuit	Pursue two 319 Nonpoint Source Program grants	Draft proposals, attend Committee Meetings, finalize and present proposal			A,2 - Achieve capital budget increase; federal funding	12/1/2003	2/17/2004
	Submit Colorado 319 Nonpoint Source Program Grant Proposals	Applications for Colorado 319 Nonpoint Source Program Grants due.			A,2 - Achieve capital budget increase; federal funding		1/30/2004
	Colorado 319 Nonpoint Source Program Grant presentations	Present 319 Nonpoint Source Program Grant proposals to NPS Council.			A,2 - Achieve capital budget increase; federal funding		2/17/2004
	Grants awarded						4/15/2004
Special Projects - CC Stewardship Partners	Develop Authority website	Partners to develop Authority website; utilize website to display educational materials	72.6(2)	Update Public Information and Education Program	L,1 - Develop public involvement plan; work with Partners to develop website	12/1/2003	3/30/2004
	Incorporate Partners Work Plan with Authority Work Plan as appropriate				O - Collaborate with other private and public interest groups to leverage funding mechanisms to meet watershed goals	1/1/2004	3/30/2004
	Review Partners Work Plan				O - Collaborate with other private and public interest groups to leverage funding mechanisms to meet watershed goals	9/1/2004	10/5/2004
	Review Education Initiative	Partners to develop Authority website; utilize website to display educational materials	72.6(2)	Update Public Information and Education Program	L,1 - Develop public involvement plan\	2/1/2004	11/1/2004
Special studies	Re-prioritize list of special studies	Propose revised prioritized list of special studies to WQCD	72.4(4)	Completion of tasks identified	K - Conduct special studies to optimize water quality improvements	12/1/2003	2/27/2004
	Fate and transport study	Develop scope to refine watershed model	72.8(5)	Completion of tasks identified	K - Conduct special studies to optimize water quality improvements	1/1/2004	11/1/2004
	Reservoir nutrient enrichment studies	Conducted by WQCD - review work products	72.4(4)	Completion of tasks identified	K - Conduct special studies to optimize water quality improvements	1/1/2004	2/28/2004
	Identification of industrial process WW sources and associated loads	Obtain list of permitted facilities; assess potential P sources	72.4(4)	Completion of tasks identified	K - Conduct special studies to optimize water quality improvements	2/1/2004	4/30/2004
	Depth profiling of nutrient content for GW		72.4(4)	Completion of tasks identified	K - Conduct special studies to optimize water quality improvements	10/1/2004	12/31/2005
	Evaluation of P removal of phosphorus control projects		72.4(4)	Completion of tasks identified	K - Conduct special studies to optimize water quality improvements	1/1/2005	12/31/2005
Stormwater Quality Requirements	Investigate need for update of Stormwater Quality Requirements/Model Ordinance		72.7	Encouraging compliance with stormwater permit requirements	F - Encourage all land use agencies to adopt and implement Authority "Requirements"	3/1/2004	5/30/2004
	If determined necessary - Draft new Stormwater Quality Requirements/Model Ordinance		72.7	Encouraging compliance with stormwater permit requirements	F - Encourage all land use agencies to adopt and implement Authority "Requirements"	6/1/2004	2005
	If determined necessary - Submit draft Stormwater Quality Requirements/Model Ordinance to TAC	TAC receive draft 2 weeks prior to 10/04 TAC meeting; submit comments at TAC meeting	72.7	Encouraging compliance with stormwater permit requirements	F - Encourage all land use agencies to adopt and implement Authority "Requirements"	9/23/2004	2005
	If determined necessary - Submit final Stormwater Quality Requirements/Model Ordinance to Board	Board receive draft at Board meeting; submit comments within 2 weeks	72.7	Encouraging compliance with stormwater permit requirements	F - Encourage all land use agencies to adopt and implement Authority "Requirements"	10/21/2004	2005
Trading Program	Establish Trading Program Accounting		72.5(3)(a)	Trading program		2/1/2004	4/30/2004
Triennial Review Hearing	Revise Control Regulation	Draft revised Control Regulation language	72.4(4)	Completion of tasks identified		2/1/2004	4/14/2004
	TAC and WQCD review and comment on draft revised Control Regulation	TAC and WQCD receive draft at TAC meeting, provide comment within 2 weeks	72.4(4)	Completion of tasks identified		3/1/2004	3/15/2004
	Board review and comment on draft revised Control Regulation	Board receives draft one week prior to Board meeting, provide comment at meeting	72.4(4)	Completion of tasks identified		3/19/2004	3/26/2004
	Submit final revised Control Regulation to WQCD and WQCC		72.4(4)	Completion of tasks identified			4/14/2004
	Commission review of proposed changes to Control Regulation		72.4(4)	Completion of tasks identified			5/10/2004
	Prepare for Triennial Review Hearing and submit testimonies and documents		72.10	Commission review		6/1/2004	8/13/2004
	Triennial Review Hearing		72.10	Commission review			9/13/2004

Future activities beyond 2004 are included in the Work Plan (e.g., capital projects, special studies, activities for revising TMAI) but only the 2004 activities of the Work Plan are included here.

2.4 Financial Matters

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

The Authority's budget for the 2004 calendar year was \$1.4 million. Colorado State Statute § 25-85-M dictates that the Authority must spend at least 60% of the authorized revenues on the construction and maintenance of PRFs. The budgeting process for PRFs is discussed in Section 5.3. The remaining 40% is allocated towards monitoring, special studies, planning documents, technical reports or memoranda, and administrative costs.

2.4.1 Funding Sources

Approximately \$960,400 of the Authority's budget was tax based, \$390,000 from fees and surcharges on wastewater, and \$21,800 from miscellaneous sources, such as reimbursed expenses, grants, and trading program. In 2004, 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 \$287,000.

2.4.2 Grants

In 2001, the Authority was awarded funding from the Colorado Nonpoint Source Program, based on EPA's Section 319 Nonpoint Source Program, for two projects. These projects targeted nonpoint source pollution reduction within the Cherry Creek Reservoir watershed through the effective utilization of best management practices (BMPs) and PRFs. One grant project, "The Role of BMPs and PRFs in Water Quality Protection" focused on education, and is discussed in Section 7.1. The other grant project, "The Lower Cottonwood Creek Water Quality Plan," involved the construction and evaluation of various PRFs, including the Cottonwood Creek Stream Reclamation Project (Section 5.5.2). In 2001, both nonpoint source grants were awarded to the Authority, totaling \$219,000 for reimbursable funding. The Authority was one of several cooperating agencies, including Urban Drainage Flood Control District (UDFCD), Arapahoe County, Greenwood Village, Landmark Metro District, and Arapahoe County Water and Wastewater Authority that contributed funding for design and construction. This contribution provided \$1.5 million in grant match, far exceeding the Lower Cottonwood Creek Water Quality Plan grant funding. Work was completed in 2004 for both grants, and the Authority received the remaining reimbursable funding.

In 2003, the Authority again decided to pursue funding from the Colorado Nonpoint Source Program and prepared applications for two projects: the "Cherry Creek State Park Wetlands, Phase 1" 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. In 2004, the Authority completed the grant application process and

was awarded both grants. The Authority will provide \$160,000 in matching funds and work on both grants will begin in 2005.

2.5 2004 Reference Documents

The Authority generated documents in 2004 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 2004.

Table 2-3. 2004 Reference Documents

2004 Annual Report of Baseline Water Quality Data Collection Study for the Upper Cherry Creek Basin Flow and water quality data collected at surface and ground water stations in the upper Cherry Creek Reservoir watershed
2004 Annual Report of Activities by the Cherry Creek Basin Water Quality Authority Update on activities completed by the Authority in 2004 and progress made towards the phased TMAP
2004 Monitoring Plan and Quality Assurance Project Plan Description of planned reservoir and stream monitoring activities for 2004
2004 Studies of Phytoplankton Response to Nutrient Enrichment in Cherry Creek Reservoir Study of algal limitation by phosphorus
Authority Website (www.cherrycreekbasin.org/cc_home.asp) Information and education on the Authority and water quality issues within Cherry Creek Reservoir watershed and a storehouse of documents generated by and related to the Authority
Cherry Creek Basin Water Stewardship and Education Initiative A compilation of water quality education efforts in the Cherry Creek Basin and needs assessment and recommendations for future efforts
Cherry Creek Phosphorus Facilitation Summary Describes outreach program to encourage inclusion of stormwater BMPs through an incentive-based approach
Cherry Creek Reservoir 2004 Annual Aquatic Biological and Nutrient Monitoring Study Characterization of potential relationships between nutrient loading and reservoir productivity
Cherry Creek Reservoir Control Regulation 72 Adopted by the Commission in 2004. Incorporated jointly proposed revisions by the Authority and the Division.
Conceptual Investigation for Reservoir Destratification for Cherry Creek Reservoir. Investigation of methods, costs, benefits, and potential impacts from reservoir mixing alternatives
Work Plan A routinely updated comprehensive schedule of activities, as prescribed by Control Regulation 72 and recommended by the Watershed Plan 2003

2.6 Changes to Control Regulation 72

The Authority participated in the triennial review rulemaking hearing, held by the Commission for Control Regulation 72 on September 15, 2004, during which the Authority

and the Water Quality Control Division jointly submitted recommended changes or clarifications to Control Regulation 72 for consideration by the Commission. The following changes were adopted and incorporated into Control Regulation 72, amended on November 8, 2004 and effective on December 30, 2004.

1. **Changes in definitions**

“Individual sewage disposal system” amended to include wastewater, not just sewage.

“Industrial process wastewater sources” includes construction dewatering to be regulated as an industrial process wastewater source.

“Land disposal” indicates that no treatment is intended for pollutant-containing waters applied to land for disposal.

“Phosphorus Bank” indicates that trade credits could be voluntarily assigned to the Phosphorus Bank and that the project proponent retains control over the transfer or use of credits in the Phosphorus Bank.

“Reserve Pool” consists of those phosphorus pounds available from historic Authority nonpoint source projects.

2. **The 216-pound cap was removed for new trade projects.** The 216 pounds that were allocated in the Phosphorus Bank for the trading program are now accounted for in the Nonpoint and Regulated Stormwater Sources allocation. This removes the limit on available trading credits and provides more incentive for trade project development.
3. **Clarification on how to account for trade projects beyond the 216-pound cap.** Language has been added describing how phosphorus pounds are accounted for in the various allocations as transfers of these pounds occur.
4. **Increased flexibility in how dischargers determine return flow factors for land application sites.** For consistency with water rights return flow factors will be determined from a decreed augmentation plan where one exists. If there is not an approved augmentation plan, return flows may be determined from a available study of return flow factors, upon Division approval. A third option allows dischargers to use lysimeter data to determine the amount of applied flow returned to ground water.
5. **Sale of phosphorus pounds.** Language was modified to reflect that the Authority is only allowed to sell pounds out of the Reserve Pool.
6. **Trade ratios ceiling eliminated.** The ceiling on the trading ratio of 3:1 was eliminated to provide more flexibility when approving trading requests.
7. **Restrictions on construction of Individual Sewage Disposal Systems.** The control regulation was changed to prohibit construction of new Individual Sewage Disposal Systems within the 100-year floodplain in the Cherry Creek watershed in Arapahoe and Douglas Counties. This change establishes a consistent watershed-wide policy.
8. **Stormwater permit requirements and exemption from the 40-acre/30-day land disturbance limitation.** Allows authorized exemptions to the 40-acre limit when the owner can demonstrate the 40-acre limit is physically and/or financially impracticable.

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 was 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 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.

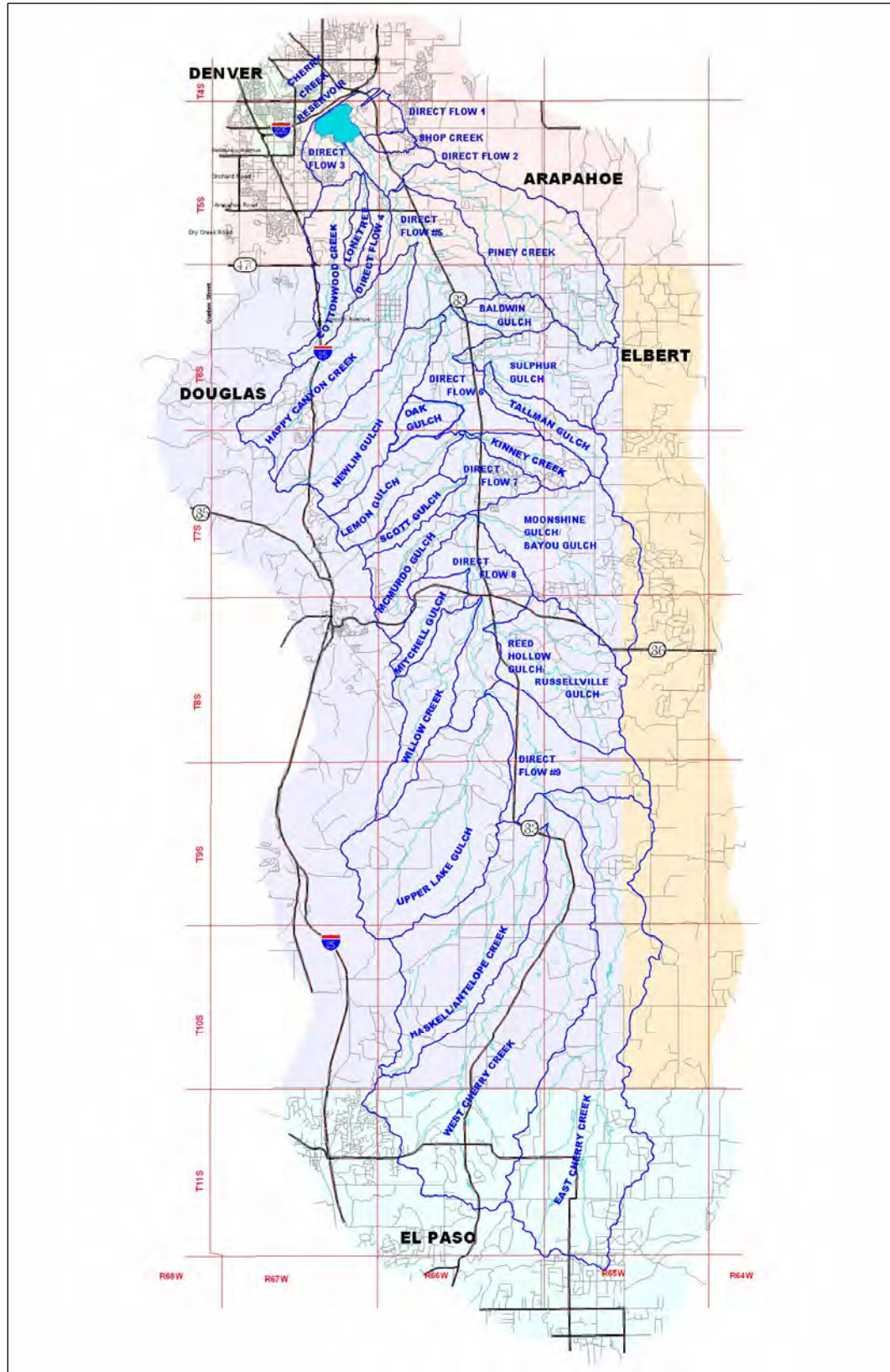
Cherry Creek Reservoir was designed as a terminal stormwater storage facility, intended to hold runoff water that would then be discharged to maintain an acceptable downstream flow and a predetermined lake level. The reservoir, along with subsurface flows from below the dam, has maintained Cherry Creek downstream of the reservoir in a free-flowing condition. As a storage facility with regulated outflows, upstream flows have, over 40 years, accumulated 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 with its exposure to 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.



Photos 1 and 2 courtesy of Gary Barnhart

Figure 3-1. Cherry Creek Reservoir Watershed Map



3.1 Water Quality History and Regulations

Figure 2-2 in Section 2, entitled History Summary, provides background of 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 13 years, and the phosphorus goal of 40 µg/L has never been achieved in the past 13 years. However, the phosphorus loads have been lower than the TMAL of 14,270 pounds in 12 of the past 13 years. Watershed Plan 2003 identifies investigations and strategies to evaluate as part of arriving at successful and achievable goals and standards. Information from further 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 ¹
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
Total Maximum Annual Phosphorus Load	14,270

¹ 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.

Table 2-3 in Section 2 provides a list of reference materials generated by the Authority that provide more detailed information on this topic.

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 for 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 below, 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 2004.



Table 4-1. Cherry Creek Reservoir Watershed Point Source Allocation and 2004 Point Source Phosphorus Annual Contribution ¹

Facility	Allocation (pounds)	2004 Phosphorus (pounds)
Arapahoe County Water and Wastewater Authority/Cottonwood Water & Sanitation District ²	402	148
Pinery Water and Sanitation District	304	60
Inverness Water and Sanitation District	129	0
Parker Water and Sanitation District	533	268
Meridian Water and Sanitation District	113	0
Stonegate Village Metropolitan District	161	46
Plum Creek Wastewater Authority ³	25	14
City of Aurora ³	10	
Semi-Urban Areas ⁴	201	
Industrial Process Wastewater Sources ⁵	50	
Subtotal	1,928	536
Reserve Pool	216	
Phosphorus Bank	0	
Total	2,144	

¹ The 2004 phosphorus pounds are as reported to the Division in discharge monitoring reports (DMRs).

Inverness and Meridian reported zero phosphorus contributions (i.e., effluent applied at agronomic rates)

² ACWWA has 57 pounds of conditionally approved phosphorus trade credits in addition to its 402 pound allocation.

³ Phosphorus pounds were transferred from the Semi-urban Areas allocation to the Plum Creek Wastewater Authority and the City of Aurora for Land Applications within the Cherry Creek Watershed.

- ⁴ Semi-urban areas are potential development areas outside the 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.
- ⁵ There are currently no industrial process wastewater sources with a wasteload allocation.

Table 4-2. 2004 Point Source Phosphorus Monthly Contribution ¹

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 (pounds/month)	Arapahoe County Water and Wastewater Authority (pounds/month)
January	17.6	9.2	10.9		7.1
February	22.8	4.1	5.1		7.5
March	34.6	4.3	3.1		7.8
April	23.1	7.1	2.4		7.1
May	24.7	5.7	3.2	2.9	18.2
June	27.5	5.9	2.5	4.1	17.8
July	34.1	3.5	2.9	4.8	13.8
August	25.8	3.9	0.7	2.4	22.0
September	18.8	3.5	0.7		13.1
October	14.5	4.3	5.7		15.7
November	16.5	4.0	5.6		10.5
December	7.9	4.5	3.3		7.6
Total	267.9	60.0	46.1	14.2	148.2

¹ The 2004 phosphorus pounds provided are as reported to the Division.



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.

In September 2003, the Plum Creek Wastewater Authority, located in the Chatfield Reservoir watershed, identified the need for a phosphorus allocation in the Cherry Creek Reservoir watershed to apply reuse irrigation at the Castle Pines North golf course. A portion of the golf course is in the Cherry Creek Reservoir watershed. Since the Plum Creek Wastewater Authority was not a designated facility in Control Regulation 72, the Division advised that the Plum Creek Wastewater Authority was not eligible for phosphorus credit through the Authority's Historic Credit Sales from the Phosphorus Bank but could acquire credits through a temporary transfer. At the request of the Plum Creek Wastewater Authority, the Pinery Water and Sanitation District agreed to provide a portion of its allocation, 25 pounds of phosphorus annually, to the Plum Creek Wastewater Authority. The Authority Board approved the temporary transfer in January 2004. The Control Regulation was subsequently revised, as part of the 2004 rulemaking hearing, to include a 25-pound allocation for the Plum Creek Wastewater Authority.

There were no reserve pool actions in 2004.



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 2004



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 milligrams per liter (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 ground water returns, the effluent concentration prior to land application shall not exceed 1.0 mg/L total phosphorus.



4.3 Site Application Review

As the designated regional water quality management agency for the Cherry Creek Reservoir watershed, the Authority reviews site applications, as required by Control Regulation 72, for site location and design approval of domestic wastewater treatment works. Site application 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.

Site applications 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, September 2001)
- Emergency Response Plan Criteria for the Cherry Creek Reservoir Watershed (Authority, March 2002)
- Regulation No. 22, “Regulation for Site Application Process” (Commission, April 1998)
- 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 site application.

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 Site Application, relative to the requirements of the Authority
- Provide opinions on the thoroughness and completeness of the engineering report and Site Application
- 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 Application. The Authority reviewed eight lift station site applications and wastewater utility master plans in 2004 (Table 4-3 and 4-4). With the completion of the Stonegate Village Metropolitan District Wastewater Utility Master Plan, all wastewater utilities in the Cherry Creek watershed now have approved Wastewater Utility Master Plans.

Table 4-3. Summary of 2004 Site Applications

Site Application	Design Features	Wastewater Service Provider
Valley Country Club Lift Station and Amendment	Flow - 11.1 mgd, daily average Force main - 24" and 10" Onsite emergency storage - 3 hrs. at avg. flow	Arapahoe County Water and Wastewater Authority
Castle Pines North New Lift Station No. 2	Flow - 1.01 mgd, daily average Force main - 10" Onsite emergency storage - 37 hrs. at avg. flow	Plum Creek Wastewater Authority (Chatfield Reservoir watershed)
Inverness Lift Station No. 2	Flow - 0.9 mgd, daily average Force main - 14" Onsite emergency storage - 15 hrs. at avg. flow	Arapahoe County Water and Wastewater Authority

Table 4-4. Summary of New and Updated Wastewater Utility Master Plans in 2004

Wastewater Utility Master Plan	Description
Arapahoe County Water and Wastewater Authority	Update to plan for expansion of the Lone Tree Creek Wastewater Treatment Plant
Inverness Water and Sanitation District	Update to address wastewater service consolidation with Arapahoe County Water and Wastewater Authority
Meridian Metropolitan District	Amendment to change the wastewater service area boundaries
Stonegate Village Metropolitan District	Summary of wastewater service plan through 2020

4.3.1 Arapahoe County Water and Wastewater Authority (ACWWA)—Valley Country Club Lift Station Site Application and Amendment

The lift station site application proposed to upgrade and replace an existing lift station, located at the Valley Country Club Golf Course, to increase pumping capacity, replace aging equipment, and consolidate the smaller Prairie Estates lift station with the Valley Country Club lift station. ACWWA will construct the lift station and provide wastewater treatment at the Lone Tree Creek Wastewater Treatment Plant.

The Authority approved the Site Application in May 2004, but ACWWA modified the design and submitted a Site Application Amendment in August 2004 to address constructability and associated cost issues. The Authority approved the Site Application Amendment on October 21, 2004.

4.3.2 Castle Pines North Metropolitan District—Castle Pines North New Lift Station No. 2

The lift station report proposed a new lift station for the Castle Pines North Metropolitan District. The new lift station will replace an existing lift station that was built in the mid 1980's and is nearing the original design capacity. The Castle Pines North Metropolitan District will construct the lift station and own, operate, and maintain the lift station and associated forcemain and sewer mains. The Plum Creek Wastewater Authority will be the wastewater service provider, and the effluent will be treated and discharged outside the Cherry Creek Reservoir watershed to the Chatfield Reservoir watershed. The Authority initiated review of the Castle Pines North New Lift Station No. 2. The Authority approved the Site Application on July 17, 2004.

4.3.3 Inverness Water and Sanitation District—Lift Station No. 2

In December 2004, the Inverness Water and Sanitation District (IWSD) submitted a Site Application for construction of Lift Station No. 2 to convey wastewater to the ACWWA WWTP. Review of the plan will be continued in 2005.

4.3.4 Arapahoe County Water and Wastewater Authority—Wastewater Utility Plan Update

ACWWA submitted a Wastewater Utility Master Plan Update that identified wastewater treatment plant upgrades and expansion. In addition, ACWWA plans to treat wastewater from the Inverness Water and Sanitation District and return treated wastewater for non-potable irrigation use. The Authority approved the Wastewater Utility Plan Update on July 17, 2004.

4.3.5 Arapahoe County Water and Wastewater Authority—Wastewater Treatment Plant Expansion

ACWWA submitted a Site Application for expanding the Lone Tree Creek Wastewater Treatment Plant. Review of the plan will be continued in 2005.

4.3.6 Inverness Water and Sanitation District — Wastewater Utility Plan Update

The IWSD submitted a Wastewater Utility Master Plan Update, which proposed existing and future projected IWSD wastewater flows would be treated at ACWWA's existing Lone Tree Creek Wastewater Treatment Plant. Tertiary effluent will be returned to IWSD for non-potable irrigation use. The IWSD Secondary WWTP will be decommissioned after flows are diverted to ACWWA. The IWSD will continue to treat the flows and operate the facilities in the interim. Some of the tankage at the IWSD Secondary WWTP will be reused for future emergency storage at the proposed Lone Tree Creek Lift Station. Authority approved the Wastewater Utility Plan Update on July 17, 2004.

4.3.7 Meridian Metropolitan District — Wastewater Utility Plan

The Meridian Metropolitan District submitted Amendment No. 2 to its Wastewater Utility Plan to change the Meridian Metropolitan District wastewater service area boundaries. Authority approved the Wastewater Utility Plan Amendment on November 18, 2004.

4.3.8 Stonegate Village Metropolitan District — Wastewater Utility Master Plan

The Stonegate Village Metropolitan District submitted a Wastewater Utility Master Plan for wastewater service through 2020. The plan was approved on February 17, 2005.

4.4 Progress Made

- Wastewater facility discharges did not exceed annual permitted wasteload allocations or effluent phosphorus concentrations.
- The Authority reviewed seven and approved four site applications and wastewater utility management plans within the Cherry Creek Reservoir watershed for compliance with applicable regulations and guidance documents. This includes compliance with wasteload allocations and wastewater utility management plans. The remaining three site applications will be completed in 2005.
- Through the Control Regulation 72 Triennial Review, the Commission approved a change to the Control Regulation that enables the Authority to add new reuse dischargers requiring a phosphorus allocation without amending Control Regulation 72.
- The Plum Creek Wastewater Authority and the City of Aurora were allocated phosphorus pounds for land application. The allocations were transferred from the Semi-urban area allocation.



5. NONPOINT SOURCE CONTROLS

Due to the broad scope of nonpoint sources in the Cherry Creek Reservoir watershed, several programs are in place to target nonpoint source reduction, including regulations for stormwater controls and long-term planning for PRF construction, discussed in this section, as well as Cherry Creek Reservoir and reservoir watershed monitoring (Section 9), and public education and outreach programs (Section 7).



5.1 Land Use Agency Implementation of Stormwater Permit Requirements

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 reservoir watershed covered under the Phase I Rule in the reservoir watershed. Phase II requires the small municipal separate storm sewer systems (MS4s) to, at a minimum, adopt BMPs for six minimum control measures, and 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 ongoing programs in the Cherry Creek Reservoir watershed. Erosion and sediment control and water quality BMP programs for each agency are integrated with the NPDES Phase II requirements to minimize overlap and redundancy while maximizing results. For example, Phase II permittees in the reservoir watershed formed cooperative workgroups to coordinate Phase II compliance and identify opportunities for effective stormwater program implementation.

Stormwater permit reporting information was provided by the land use agencies on the following key elements, provided for each agency in Table 5-1.

- Sediment and erosion control permit, inspection, and enforcement actions
- Construction BMPs inspection and enforcement actions
- Permanent BMPs 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	Permit Inspection Actions	Permit Enforcement Actions	Other
City of Aurora (only a portion of the city is in this watershed)	Construction: 40 inspections	Construction: 4 violations	All entities have public education and outreach programs that include, but are not limited to:

Land Use Agency	Permit Inspection Actions	Permit Enforcement Actions	Other
Douglas County	Illicit discharges: 26 Construction: 3,163 inspections (GESC) Post construction: 3,079 inspections (DESC)	Illicit discharges: 14 response actions	<ul style="list-style-type: none"> ■ Coordination with other entities (Authority, Phase II Co-op workgroup, Partners, UDFCD) ■ Distribution of issue-specific fact sheets and brochures to residents and commercial entities ■ Participation on school programs (e.g., project WET) ■ Educational projects such as willow planting with scout troops ■ Web sites, hot lines, surveys, public service announcements
Arapahoe County	Illicit discharges: Developed outfall systems mapping of 275 drainage structures Construction: 605 inspections at 60 sites (GESC) Post construction: 78 inspections	Construction: 35 notices of non-compliance issued	
Town of Castle Rock	Illicit discharges: 2 inspections Construction: 533 inspections (GESC) 1,162 inspections for single-family residential (DESC) Post construction: 25 inspections, 150 post-storm inspections	Illicit discharges: 1 violation issued Construction: 3 notices of non-compliance issued for single-family residential DESC	
City of Lone Tree	Illicit discharges: 7 inspections Construction: 21 inspections	Construction: 14 minor violations, 2 major violations	
Greenwood Village	Illicit discharges: 4 inspections Construction: 3,316 inspections at 450 sites Post construction: 21 inspections	Illicit discharges: all discharges mitigated	
City of Centennial	Illicit discharges: 2 inspections Construction: 92 inspections at 36 sites Post construction: 9 inspections at 28 sites	Illicit discharges: problems voluntarily corrected Construction: no notices of non-compliance issued Post construction: 3 deficiencies identified and corrected	
Town of Parker	Illicit discharges: 2 complaints Construction: 1,345 inspections (GESC) Post construction: inspections occurred but not tracked until 2005	Illicit discharges: referred to appropriate jurisdiction Construction: 1,290 non compliance issues, 7 stop work orders	

GESC – Grading, erosion, and sediment control; DESC – Drainage, erosion, and sediment control

5.2 Cherry Creek Reservoir Watershed Stormwater Quality Requirements

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 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 water quality BMPs in the reservoir watershed for all new development activities.

5.3 Land Use Application Review

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 late March of 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
Total	1,209

In 2004, the Authority reviewed and provided comment on 176 land use and development applications. Table 5-3 provides a breakdown of the various agencies that referred land use applications to the Authority in 2004.

Table 5-3. Sources of Land Use Application Referrals

Referring Agency	Number of Land Use and Development Applications Referred to Authority in 2004
Arapahoe County	24
CDOT	1
City of Aurora	28
City of Centennial	12
City of Lone Tree	1
Douglas County	36
E-470 Public Highway Authority	1
Greenwood Village	3
Town of Castle Rock	8
Town of Parker	62
Total	176

The Authority's review of each application focuses on point and 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 78% percent of the land use applications reviewed, and did not recommend approval for 11%. In many of these cases, the Authority reserves the right for review of future submittals to ensure that recommendations are incorporated.

Table 5-4. Summary of Comments on Land Use Applications

Comment Category	Number of Applications	Percent of Applications
No exception	131	78%
No exception, minimum requirements are met	70	42%
No exception, provided additional recommendations	52	31%
No exception, previous concerns were addressed	1	1%
No exception, project is part of larger approved project	8	5%
No approval	19	11%
No approval until BMPs requirements are met	5	3%
No approval, provided recommendations	10	6%
Insufficient materials (e.g. drainage reports referenced but not provided)	4	2%
BMP recommendations only (early in application process)	7	4%
Special cases	5	3%
Not in Cherry Creek Reservoir watershed	6	4%

5.3.1 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, the occurrence of development.
2. A better understanding of how well developers are complying with Authority's 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 reservoir watershed. Currently, the Authority's review and comments are integral to the development process and a negative response from the Authority often results 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 expects to capitalize on these opportunities through the Phosphorus Facilitator program (Section 5.4).
4. The opportunity to stress the importance of meeting minimum requirements for BMP through negative referrals from the Authority which has resulted in implementation of better water quality plans, some of which have gone beyond minimum requirements.

5.3.2 Proprietary Best Management Practices

The Authority and local land-use agencies get requests to utilize proprietary BMP for erosion and sedimentation control and to substitute proprietary BMP for the Authority's minimum BMP requirement, which is extended detention basins. Referrals to the Authority have been reviewed on a case-by-case basis and the Authority has approved the use of proprietary BMP in some cases, as a test-case for others, and not approved in other applications. However, the Authority does not have the resources to properly evaluate all proprietary BMP to make a specific recommendation on which units are acceptable and which are not. We rely on other the design engineer and other independent agencies, such as the UDFCD to provide guidance, justification, and recommendations. The Authority therefore, requires the engineer to evaluate various units and recommend a specific unit based on the following criteria.

- Requirements of the local jurisdictions.
- Cost should not be the only or primary basis for selecting one unit over the other.

- The ability to remove floatables, oil/grease and phosphorus should be the primary basis for selecting a unit. The standard deviation in performance differences, as stated by the manufacturer, should be considered.
- Operation and maintenance requirements assigned to a governmental or quasi-governmental organization will be given priority over other organizations, such as home owner associations.

5.4 Phosphorus Facilitator

In 2004, 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 to improve land-use plans and exceed minimum requirements for immobilization of phosphorus. The development of such plans is being accomplished through a more 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.

The first step was to identify two projects scheduled for development in the near future. Various developers in the watershed were contacted to measure their interest in working with the Authority to improve water quality. One of the positive outcomes of the investigation at this time is the high level of interest in “smart-growth for clean water” development. More than 12 potential projects were identified and evaluated using a qualitative rating system. Based on these ratings, a residential development (AscentPointe/SunMarke (3,000 acres)) and a commercial development (Crown Point (50 acres)) were selected for the pilot program.

5.4.1 Pilot Commercial Development

Commercial properties and their associated parking lots can contribute significant quantities of phosphorus in stormwater runoff from automotive byproducts such as hydraulic fluids, fuels, tires, and synthetic rubber compounds. Directing parking lot runoff through grass-lined swales and infiltrating it into the ground can provide water quality management benefits beyond those achieved through conventional dry detention pond BMPs. Following several work sessions with the Phosphorus Facilitator Team, the developer agreed to modify its initial development plans to include the following improvements.

- 1,800-ft long grass-lined swale along the northern boundary of the property to convey stormwater runoff to an extended dry detention pond. The grass-lined swale collects runoff from approximately 26% of the 50-acre site and replaces a major storm sewer.
- Porous landscape detention facilities in parking lot areas to serve approximately 26% of the property.

Infiltrating the parking lot runoff into the ground at the porous landscape sites reduces stormwater runoff from multiple areas, thereby further reducing the size of the traditional storm sewer collection system. The benefits to the watershed of this approach include the removal of 19% more phosphorus from the stormwater runoff than the required BMPs. The benefits to the developer include tangible benefits of reduced infrastructure costs and potential intangible benefits of a more attractive commercial property as a result of the greenspace associated with the grass-lined swale and porous landscape detention areas.

5.4.2 Pilot Residential Development

Four distinct opportunities were identified, ranging from a chain of wetland ponds to a significantly different way of draining a wide transportation corridor. Final plans for these facilities are still under review. The benefits to the developer for the above-cited examples were not quantified in terms of dollars nor did they result in specific requests for open space credits, density bonuses, etc. Rather, the benefits were believed to rest primarily in the improvement of the quality of life in the proposed development, thereby providing it with a marketing edge when compared with competing properties. These benefits are generally described in the following terms.

- Ecology
 - Improvement of water quality by filtering pollutants via grass-lined swales or infiltration into the soil
 - Returning water to shallow aquifers to sustain base flows in streams
 - Providing wildlife habitat
- Community
 - Providing neighborhood destination points of interest for all ages
 - Providing educational opportunities
 - Adding interest to outdoor experiences
 - Knitting community together rather than creating visual barriers
- Art
 - Providing transitional elements from formal recreational facilities to nature
 - Lending a sense of place
 - Connecting the community to its natural surroundings via natural landscapes
- Economics
 - Increased property values due to additional and clearly visible amenities



5.5 Capital Improvement Projects

In accordance with statutory requirements, the Authority must spend at least 60% of the annual budget on the construction and maintenance of PRFs. To meet this requirement, the Authority carries out a multi-year capital improvement project (CIP) planning process (currently 3-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 multi-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 PRF (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 a project(s) appears to be reasonable, the TAC recommends to the Board that the project be included on the 'master PRF list'. Once the Board approves the project for inclusion on the master list, any future work towards design and construction 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 3-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 3-year CIP. The Board then selects projects for the 3-year CIP subject to available funds. The PRF projects that progressed during 2004 and those projects recommended for further consideration in 2005 are discussed below

- Cherry Creek State Parks Wetlands Reclamation
- Cottonwood Creek Stream Reclamation, Phases I and II
- Piney Creek Stream Stabilization
- Projects Projected for 2005 Activity

Table 5-5. 2005 Three Year Capital Improvement Projections

August 13, 2004

Project No.	Project Title	Project Budget						Previous Expend.	Residual PRF Costs	Proposed 2005 Budget					Residual PRF Costs	Proposed 2006 Budget					Residual PRF Costs	Proposed 2007 Budget					Residual PRF Costs
		Capital ¹	Land	Water	Total	O&M	Authority Portion			2004	Design ⁶	Capital	Land	Water		Total	Design	Capital	Land	Water		Total	Design	Capital	Land	Water	
CCR-1	Reservoir De-stratification	\$ 500	\$ -	\$ -	\$ 500	\$ 50	100%	\$ -	\$ 500	\$ 75	0	\$ -	\$ -	\$ 75	\$ 425	\$ -	\$ 100	\$ -	\$ -	\$ 100	\$ 325		\$ 325			\$ 325	
CCB-1	CCSP Wetlands ^{5,7}	\$ 1,928	\$ -	\$ -	\$ 1,928	\$ 19	100%	\$ 8	\$ 1,920	\$ 36	54	\$ -	\$ -	\$ 90	\$ 1,838	\$ 10	\$ 53			\$ 63	\$ 1,775	\$ 6	\$ -			\$ 6	\$ 1,769
CCB-5.1	Cherry Creek Sediment Pond at Arapahoe Road ⁴	\$ 3,893	\$ 50	\$ -	\$ 3,943	\$ 134	50%	\$ -	\$ 1,972	\$ 75				\$ 75	\$ 1,897					\$ -	\$ 1,897		\$ 50		\$ 50	\$ 1,847	
CCB-5.2	Arapahoe/Douglas County Line Stream Stabilization ⁴	\$ 218	\$ -	\$ -	\$ 218	\$ 1	25%	\$ -	\$ 55					\$ -	\$ 55					\$ -	\$ 55		\$ 55		\$ 55	\$ -	
CCB-5.3	Cottonwood Bridge Stream Stabilization ⁴	\$ 436	\$ -	\$ -	\$ 436	\$ 2	25%	\$ -	\$ 109					\$ -	\$ 109					\$ -	\$ 109		\$ 109		\$ 109	\$ -	
CCB-12.1	Bowtie Phase I ⁹	\$ 616	\$ 450	\$ -	\$ 1,066	\$ 6	100%	\$ -	\$ 1,066					\$ -	\$ 1,066					\$ -	\$ 1,066		\$ 50		\$ 50	\$ 1,016	
CCB-13	Cottonwood Creek Reclamation ³	\$ 2,100	\$ -	\$ -	\$ 2,100	\$ 30	96%	\$ 696	\$ 1,353	\$ 50	\$ 600			\$ 650	\$ 754	\$ 72	\$ 600			\$ 672	\$ 82				\$ -	\$ 82	
CCB-16	Stream Corridor Preservation ²	\$ -	\$ 100	\$ -	\$ 100	\$ -	100%	\$ -	\$ 100					\$ -	\$ 100					\$ -	\$ 100		\$ 100		\$ 100	\$ -	
	SUB-TOTALS	\$ 9,691	\$ 600	\$ -	\$ 10,291	\$ 243		\$ 704	\$ 7,074	\$ 236	\$ 654	\$ -	\$ -	\$ 890	\$ 6,243	\$ 82	\$ 753	\$ -	\$ -	\$ 835	\$ 5,408	\$ 6	\$ 489	\$ 200	\$ -	\$ 695	\$ 4,713
	Operations and Maintenance																									\$ -	
	1. Restore Cottonwood/Perimeter Road				\$ 100									\$ 100						\$ -	\$ 100		\$ 100		\$ 100		
	2. Sinking Fund Contribution ⁸					\$ 25								\$ 25						\$ 25					\$ 25		
	SUB-TOTALS				\$ 100	\$ 25								\$ 25	\$ 100					\$ 25	\$ 100				\$ 125	\$ -	
	GRAND TOTALS	\$ 9,691	\$ 600	\$ -	\$ 10,391	\$ 268		\$ 704	\$ 7,074	\$ 236	\$ 654	\$ -	\$ -	\$ 915	\$ 6,343	\$ 82	\$ 753	\$ -	\$ -	\$ 861	\$ 5,508	\$ 6	\$ 489	\$ 200	\$ -	\$ 820	\$ 4,713

\$ 703

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 at cons cost of \$475,000. Portion of Ph II design completed in 2004 Will require Ph II be divided into two parts, due to annual budget limitations.
- 4 Project budget is for CCBWQA portion of project.
- 5 Multi-phase project to restore and enhance wetlands along Cherry Creek
- 6 Includes design, construction observation and administrative costs
- 7 WQCD 319 Grant provides \$63,800 toward total project of \$159,500
- 8 Assumes an interest rate of 5% and that it will be 8-years before all the projected O&M funds will be required.
- 9 Construction of project delayed until Piney Creek stabilization is further along and until Arapahoe Road sediment pond completed.

5.5.1 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 the Cherry Creek.

5.5.1.1 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. 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 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 Cherry Creek and promoting more frequent overtopping of storm runoff into the adjacent floodplain, increasing treatment through biofiltration and infiltration.
- Create impoundments within the flood plain by raising the elevation of selected trails. These impoundments would temporarily capture and detain storm flows and promote phosphorus reduction through settling, infiltration, and wetland treatment. Such improvements will balance cut and fill 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 result in about 60 acres of wetlands at a capital cost of \$1,928,000 and immobilize 600 pounds of phosphorus per year, resulting in a long-term average annual cost of \$280 per pound of phosphorus.

5.5.1.2 Project Activity

Activity during 2004 consisted of some data sampling and analysis, refinement of the overall design approach and design of a smaller demonstration project. The demonstration project approach was elected to first test the wetlands reclamation concept in a smaller area, but also to provide opportunities to use volunteer labor during construction as an educational tool. It was also decided that the demonstration project be part of the bid package for Phase II of Cottonwood Creek Reclamation (discussed in Section 5.5.3) to obtain better prices for

construction. The Cherry Creek State Park Wetlands project will be phased over several years to minimize impacts on the heavily used recreation area. Design of the demonstration project is expected to be completed in 2005 with construction beginning in 2006.

5.5.1.3 Project History

The concepts for the Cherry Creek State Park Wetlands project were reviewed with the Park staff. 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 Authority and the design engineer have and will continue to coordinate construction details with the Park for all phases of the project.

5.5.2 Cottonwood Creek Stream Reclamation

The Cottonwood Creek Stream Reclamation project begins at the Perimeter Road and extends about 11,600 feet upstream to the Cottonwood/Peoria Street PRF, which was completed in 2002.

5.5.2.1 Project Purpose

The primary purpose of the reclamation project is to reduce soil erosion of the streambed and stream banks, which contains phosphorus that makes its way into Cherry Creek Reservoir and contributes to water quality degradation in the reservoir. The project will also enhance growth of riparian vegetation, will attract wildlife, and will 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 concept proposes to 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.

5.5.2.2 Project Activity

Substantial completion of Phase I was accomplished on May 3, 2004. 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. Figures 5-1 and 5-2 show the conditions at Cottonwood Creek before and after stream reclamation activities.

Figure 5-1. Cottonwood Creek Stream Reclamation - Before



Figure 5-2. Cottonwood Creek Stream Reclamation - After



On August 18, 2004, Cottonwood Creek experienced a flood with an estimated magnitude of 1,400 cfs at Peoria Street, which is compared to a future projected 100-year flood of 4,000 cfs. The newly constructed portion of the channel experienced only minor damage, even though the stabilizing vegetation had only begun to emerge. The success of the design concept is attributed mostly to the “low flow energy” approach to channel stabilization. This approach reduces flow velocity (therefore energy) by allowing flood flows to spread into a wide floodplain area, which also provides water quality benefits, as shown in Figure 5-3.

Figure 5-3. Cottonwood Creek Stream Reclamation Phase 1



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 fall 2005 such that Phase II construction can begin around winter 2005 and extend into 2006.

5.5.2.3 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.

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.

5.5.3 Piney Creek Stream Stabilization

The Authority contributed \$118,000 in 2002 to the stabilization of Piney Creek from east of Parker Road to west of Buckley Road. Construction of 5,100 feet of stream stabilization began in late 2003 and was completed in 2004.

5.5.3.1 Project Purpose

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

When completed, this 5,100 feet section of Piney Creek is expected to cost \$714,000 and immobilize 90 pounds of phosphorus per year. Based on the Authority's contribution (\$118,000), the project results in a long-term average annual cost of \$115 per pound of phosphorus.

5.5.3.2 Project Activity

During 2004, a representative of the Authority attended the construction meetings and observed the progress of the work. The construction project was administered by the UDFCD, with Arapahoe County as the primary project sponsor.

5.5.4 Projects Projected for 2005 Activity

Two projects placed on the CIP in 2004 (Table 5-5), are scheduled for activity in 2005, one is called Reservoir Destratification and the other is Cherry Creek Sediment Pond at Arapahoe Road. Both of these projects were evaluated at a conceptual level, found to be technically feasible and placed on the master PRF list.



5.5.4.1 Reservoir Destratification

The Authority has been implementing watershed-based BMPs and constructing PRFs for many years. However, the chlorophyll *a* standard (15 µg/L) and phosphorus goal (40 µg/L) have not been met since the mid-1990s. The recent special study of in-lake nutrient enrichment, completed in 2004 by Drs. William Lewis and James Saunders, indicates that nitrogen is the limiting nutrient at this time. Despite the Authority's programs to reduce phosphorus loads from the reservoir watershed (external), it will likely take many years before water quality benefits are seen in the reservoir.

Consequently, the TAC discussed in-lake management techniques that could be beneficial to reducing chlorophyll *a*, as well as nutrients (internal loads) and increasing dissolved oxygen (DO) concentrations in the near term. Dr. Lewis suggested de-stratification (mixing) as a method to address internal loading and other factors that increase algae growth and therefore, chlorophyll *a* and phosphorus and nitrogen concentrations. In addition, there is an extensive body of literature that demonstrates the benefits of destratification and of increasing oxygen in a reservoir. It is understood, however, that watershed management is a necessary component of the Watershed Plan 2003 and both BMPs and PRFs will continue to be implemented.

In May 2004, Brown and Caldwell, the Authority's watershed consultant, provided a review of destratification alternatives, including benefits, costs, recommendations and items for a scope of work for preliminary and final design. The conclusion was that reservoir destratification was technically feasible and it was recommended that in-lake mixing be included on the 2005, 3-year CIP list. Potential water quality benefits of reservoir destratification include the following:

1. Measurable reduction in the number of algae blooms, particularly from blue-green algae.
2. Measurable increase in overall reservoir dissolved oxygen concentration.
3. Possible reduction in overall reservoir phosphorus concentrations.
4. Reduction in anoxic zone and possibly increase in DO concentration above 5 mg/L.

The Authority plans on conducting additional investigations to independently verify feasibility and preparing preliminary design for reservoir destratification.

5.5.4.2 Cherry Creek Sediment Pond at Arapahoe Road

In cooperation with the UDFCD, Arapahoe and Douglas County, Cities of Aurora and Centennial, and the Town of Parker prepared a master drainageway plan for Cherry Creek from the reservoir to Scott Road in the upper Cherry Creek Reservoir watershed. In 2003, the Authority reviewed and recommended to the UDFCD that Alternative 5, Reclamation and Water Quality Enhancements, be selected for preliminary design. In 2004, the preliminary design of the project, was completed and included a sediment basin on Cherry Creek at Arapahoe Road (URS, 2004).

The Authority's watershed consultant prepared an analysis of the phosphorus immobilized by the proposed sediment basin, based on data collected by the Authority (Ruzzo, 2003). Stream flow, sediment concentrations, and phosphorus concentration data collected by the Authority were used to first estimate the annual sediment load deposited in the reservoir watershed, and then to estimate the amount of phosphorus attached to the sediment. The conclusion was that about 3,100 tons of sediment would be trapped annually, which equates to 2,800 pounds of phosphorus. For long range planning purposes, the estimate was reduced to 2,000 pounds of phosphorus immobilized annually. Potential water quality benefits of a sediment basin include the following.

- Measurable reduction in the quantity of sediment that reaches Cherry Creek State Park and the reservoir.
- Measurable reduction in the pounds of phosphorus that reaches the reservoir. Calculations suggest the reservoir watershed could immobilize 2,000 pounds of phosphorus in the sediment annually.
- Stabilization of Cherry Creek streambeds and stream banks downstream of the sediment pond.

The Authority plans on conducting additional investigations to independently verify feasibility and preparing preliminary design for the Sediment Basin at Arapahoe Road.

5.5.5 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 2005 budget (Table 5-5), has included a "sinking fund" in anticipation of future needs.

In 2004, the Authority began drafting an agreement with the Park for maintenance of all existing and future PRF located within Cherry Creek State Park. The agreement identifies requirements for routine and restorative maintenance activities and responsibilities between the Authority and the State. Signing of the agreement is anticipated in 2005.

5.6 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 2004 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.





5.7 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.

- Coordinated and assisted local land use agencies in implementing Phase II stormwater permit requirements consistent with Control Regulation 72.
- Completed the first year of the “Phosphorus Facilitator” program., to work with local developers to implement BMPs that go well beyond minimum requirements. Initial response to the program by developers has been positive the Authority plans on continuing the program in 2005.
- 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 two additional PRF, included the projects on the master CIP list, and allocated funds for further activity during 2005.
- Participated in stream stabilization measures for Piney Creek and Cottonwood Creek, streams that contribute sediment and phosphorus to the reservoir.
- Achieved changes to Control Regulation 72 which prohibit future ISDS within the 100-year floodplain.

The Authority has gained experience in implementing nonpoint source pollution controls on a watershed scale through its capital improvement program and review of land use changes. From this experience, the Authority identified a potential need to update the technical requirements outlined in the Requirements. Possible updates could include the following.

- Address minimum stream-stabilization measures to prevent erosion and sediment transport (along with attached phosphorus) along the drainage system. Currently, minimum requirements allow some degradation of the streambed that would result in significant sediment transport. The updated criteria would place requirements that are more stringent on stream stabilization during development, and would target critical sub-watersheds.
- Evaluate the need to be more restrictive in floodplain development, such as increasing restrictions regarding encroachments into the floodplain. Exceptions could be made for roads, utilities, water quality facilities, and others. Impervious surfaces, fill, and others, if appropriate could be expressly prohibited.
- Establish a buffer to the floodplain limits. The Town of Parker adopted an ordinance that could be used as a model, with modifications if necessary, for other agencies.
- Consider minimum BMP requirements for developments that discharge to “waters of the state” when the runoff drains to a regional stormwater quality facility, in recognition of NPDES requirements.

6. TRADING PROGRAM



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 Cherry Creek Reservoir watershed trading program includes two types of trading:

1. New trade projects. Landowners, local governments, and allocatees can construct phosphorus removal projects and receive the associated credits for their own use, to transfer to an allocatee, or to retire.
2. Historic credit sales. Allocates can purchase phosphorus credits from the Authority, which has 216 pounds of credits established with phosphorus control projects it previously constructed (i.e., Shop Creek detention pond and wetlands, Quincy drainage detention, East Shade Shelter streambank improvements, and the Cottonwood Perimeter Road Pond).

The Authority did not receive any new trade project applications in 2004. Interest in trade projects continues to be strong, and two potential trade projects were identified for 2005 involving Inverness Water and Sanitation District and Arapahoe County Water and Wastewater Authority.

6.1 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. 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. As a result, 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 is constructing 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

Allocation Source	Current 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
Total Maximum Annual Load	14,270	14,213

Facility	Current Allocation	Post Trade Allocation
ACWWA/Cottonwood	402	459
Denver Southeast Suburban	304	304
Inverness	129	129
•	•	•
•	•	•
•	•	•
Semi-urban Areas	201	201
Subtotal	1,878	1,935
Reserve Pool	216	216
Trading Program (currently held pounds)	0	0
Total Point Source Allocation	2,094	2,151

6.2 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 began phased construction for this project in July 2004. The first phase, which included modifications to the outlet structure and creating the micropool, was completed in 2004. ACWWA anticipates completing the last phase, to increase the forebay storage and install monitoring equipment, by April 2005.

6.3 Progress Made

In 2004, the Authority improved and built upon its trading program.

- Changes made to Control Regulation 72, such as the removal of the existing 216-pound cap, will facilitate future trading.
- A process was developed to track trades.
- ACWWA began construction on the Pond L-3 trade project, which will be completed in 2005.



7. PUBLIC EDUCATION ACTIONS AND PARTNERSHIPS

Reg 72
Reporting

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REG 72

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 tools that provide policy makers, government agencies, local land use agencies, private industry, and the general public with information and suggested actions to improve nonpoint source pollution issues facing Cherry Creek Reservoir.

7.1 Educational Signage

As mentioned in Section 2.3.2, the Authority was awarded a Colorado Nonpoint Source Program grant entitled "The Role of BMPs And PRFs In Water Quality Protection." In 2003, the Authority completed tasks under the first two objectives of the grant and developed an educational fact sheet program, The BMP Series, on the water quality issues within Cherry Creek Reservoir watershed and the role that BMPs and PRFs serve as potential remedial actions to improve water quality. The third objective of the grant, the development of educational signage for the Cottonwood-Peoria Pond, a PRF constructed by the Authority, was completed in 2004.

The signage consists of three panes, each discussing a different component of water quality (see Figure 7-1). The first panel describes how the Cottonwood-Peoria Pond contributes to water quality, the second discusses the impact of urbanization and lists steps that an individual can take to improve water quality, and the third focuses on the Authority's actions in the watershed and the relationship of the Cottonwood subwatershed to the entire Cherry Creek Reservoir watershed.

Figure 7-1. Cottonwood-Peoria Pond Sign Installation



7.2 Website and Brochure

The Authority contributed funding to the Cherry Creek Stewardship Partners (Partners) for the development of an educational brochure to discuss the issue of phosphorus in the Cherry Creek Reservoir watershed and the role of the Authority. This brochure is being designed for distribution to Park visitors as well as to any other interested parties. The Authority also provided funding for the Partners to create a website for the Authority, which would disseminate 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 project expanded when the Partners began working with a consultant to create a website for the Watershed Plan 2003 outreach efforts. The Authority designated funding in 2004 for an expansion and completion of the webpage, found at http://www.cherrycreekbasin.org/cc_home.asp.



7.3 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). 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. The purpose of the Education Initiative is to set forth the approach recommended by the Cherry Creek Stewardship Partners and the Authority. 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 No. 72.

7.4 Collaboration with Other Entities

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

7.4.1 Cherry Creek Stewardship Partners

The Partners is an informal association of a broad range of stakeholders actively promoting effective stewardship of 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. The Partners sponsors an annual conference to promote stewardship ideals for Cherry Creek.

The Authority, which is an active member of the Partners, contributed funding for the Partners annual conference held on November 5, 2004 at the DoubleTree Inn Conference Center in Aurora, Colorado. Representatives from the Authority also participated in the conference as session moderators. The conference theme for 2004 was “Harvesting the Benefits of Water Quality Enhancement.”

In addition to the Partners annual conference, the Authority’s website and the Education Initiative, the Authority and the Partners are collaborating on ways to implement the watershed management recommendations provided in the Authority’s Watershed Plan 2003.

7.4.2 Projects with Direct Impact to Cherry Creek State Park

Though most of the land adjacent to the Park is developed, local jurisdictions often make improvements to the infrastructure, particularly the roadways that surround the Park. Improvements or incidents within the Park boundaries can impact water quality in the Reservoir, if not properly managed

During 2004, the Authority worked directly with the Park staff and local jurisdictions on the following projects or incidences:

- Union/Dayton Street improvements in Greenwood Village
- Parker/Quincy interchange improvements in the City of Aurora
- Clean Water Act Section 404 permit violation that had potential to impact the Park
- Fuel spill near Parker Road that entered the Park in the Quincy Drainage
- Review of Park erosion control plans for improvements to a campground and recommendations for plan improvements

Working with the Authority, the agencies agreed to implement permanent BMP measures on the Union/Dayton and the Parker/Quincy projects to protect water quality and the Park environment, even though both roadway projects were primarily upgrades to the existing roadways. Providing permanent BMPs for retrofit development is not mandatory under the Authority’s Requirements.

In their construction plans, Greenwood Village included stormwater detention and a proprietary BMP to improve water quality before discharging into the Park. Construction of the improvements were completed in 2004.

The City of Aurora and the Colorado Department of Transportation have agreed to investigate proprietary BMPs to reduce sediment and trash entering the Park, as part of the Parker Road upgrade of the storm sewer system.

The Long Meadows Estates development in the City of Greenwood Village received a notice of violation of the Clean Water Act for failure to obtain a Section 404 permit. Storm runoff from the project drains directly onto the west end of the Park. The violation notice resulted in a stop-work order that left the site in a highly disturbed state, which could result in severe erosion and sedimentation on the Park. The Authority worked with the Corps of Engineers regulatory branch to develop an erosion control plan to protect the Park while the project was modified to mitigate for wetland impacts.

In late February 2004, the team conducting the nutrient enrichment special study (Section 8) discovered petroleum residues on Quincy drain near the Perimeter Road and reported it to the Park staff. An incident report filed by the City of Aurora Fire Department identified a gasoline spill at 4200 S. Parker Road at Quincy Avenue that occurred on February 20, 2004. The Authority investigated the site on March 2, 2004, but found no noticeable indications of a petroleum residue at the site. The spill was believed to be contained by the Quincy detention pond constructed by the Authority, although no substantiating evidence was found at the pond.

7.4.3 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 several sub-committees to scope and coordinate special projects (e.g., scopes of work for the watershed modeling, Control Regulation 72 revisions).
- Review of land use and development applications for compliance with Authority's Requirements (Section 5.3).
- Participation in and review of outfall system and major drainageway systems planning studies conducted in conjunction with UDFCD. In 2003, the Authority was part of the review committee for the Cherry Creek Corridor – Reservoir to Scott Road, Major Drainageway Planning Study. The recommendations of this study for reclamation of Cherry Creek are important to meeting the Authority's Watershed Plan 2003. One of the Authority's capital projects scheduled for 2005 (Sediment Pond at Arapahoe Road, see Section 5) was obtained from the Preliminary design report.

7.4.4 Colorado Department of Transportation Annual Conference

The Colorado Department of Transportation (CDOT) Environmental Programs division presents an annual conference for its employees to provide education on requirements for environmental programs that affect the State's transportation projects, including the stormwater program. The Authority presented information at the March 2-4, 2004 conference titled "Environmental Stewardship Makes Good Sense." The Authority discussed the importance of compliance with Authority's Requirements for projects in the Cherry Creek Reservoir watershed and presented ways to meet these requirements.

CDOT's stormwater permit from the Division requires, among other items, that they identify sensitive waters in the State and evaluate the need to develop special programs for these sensitive waters. Since Cherry Creek Reservoir is on the Colorado 303(d) list and has a phased TMAL, the reservoir is considered a sensitive water by the State. Control Regulation 72 and the Authority's Watershed Plan 2003 identify special programs to address sensitive waters. As a result, CDOT is coordinating its activities with the Authority to meet CDOT's permit conditions and to help the Authority meet its water quality goals. The Authority is seeking to create a cooperative relationship with CDOT.

7.5 Volunteer Education

The Authority and the Park staff arranged for a volunteer day planting of vegetation for Phase I of Cottonwood Creek Reclamation (Section 5). On April 17, 2004, approximately 25 volunteers participated in willow planting and education on wetland habitat restoration benefits (Figure 7-2). In addition to planting willow stakes, the volunteers constructed about 40-feet of willow bundles that were then buried along the shoreline for additional erosion protection. All willows stakes were harvested from within the Park and were a supplement to the planting required by the construction contract for Cottonwood Creek Phase I.

Figure 7-2. Cottonwood Creek Reclamation – Volunteer Planting



7.6 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.



7.7 Progress Made

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

- Continued distribution of the BMP Series educational fact sheets to increase awareness of water quality BMPs and the Authority's role and efforts in improving water quality, specifically related to the land use and development process within the Cherry Creek Reservoir watershed.
- Continuation of the Authority's website through cooperation with the Partners to facilitate the dissemination of information to parties interested in the Authority's activities.
- Collaborating on information and education efforts with other entities with common interests and goals for the watershed.
- Participating in sub-watershed major drainageway planning investigations by the UDFCD to further the Authority's goal of implementing watershed-based BMPs.
- Supported the Partners and coordinated with other entities to develop the Education Initiative, a comprehensive and coordinated education strategy and action plan.
- Constructed educational signage by the Cottonwood-Peoria Pond, a PRF constructed by the Authority.
- Facilitated volunteer vegetation planting with Park staff as part of the Cottonwood Creek Phase I Reclamation project.

8. PHASED TMAL ACTIVITIES

STEPS REG 72

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, 2001). The Commission recognized “that until additional investigations are completed, a new TMAL cannot be calculated.” As described in Section 2, Control Regulation 72 was revised in the 2004 triennial review hearing to reflect changes to classifications, jointly submitted by the Division and the Authority.

Control Regulation 72 identifies 10 specific investigations. Table 8-1 provides a description and status of these 10 studies and other studies that have since been identified. The Authority and the Division completed one study in 2004 and a second ongoing study will be completed early in 2005.

Table 8-1. Special Studies

Special Study	Description/Purpose	Status
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 January 22, 2004
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.	In progress and managed by the Division. Completion date is February 2005.
Further development of event mean concentrations for storm water flows	Characterization of storm runoff quality based on monitoring runoff of various land-uses in the Cherry Creek watershed. Event mean concentrations are used in the watershed model to predict impacts of future growth and controls on phosphorus loads.	Discussion underway with Division on the need for this study and priority.
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.	Authority was awarded Nonpoint Source Program Grant in 2004 to fund 1 year of monitoring in upper watershed.
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.

STEPS REG 72

STEPS REG 72

Special Study	Description/Purpose	Status
Evaluation of phosphorus removal effectiveness of nonpoint source control	Evaluate the infiltration component of various detention/retention BMP to determine the infiltration contribution to phosphorus loading in the watershed. Results used to estimate performance of BMP to predict impacts of future growth and controls on phosphorus loads by the watershed model.	Authority was awarded Nonpoint Source Program Grant in 2004 to fund 1 year of monitoring in various BMPs.
Monitoring of shallow alluvial ground water 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.
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.
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.	Lower priority level as determined by Division and Authority.
Depth profiling of nutrient content for ground water	Conduct alluvial sampling at various depths to determine phosphorus concentration variation with depth of alluvium.	Authority was awarded Nonpoint Source Program Grant in 2004 to conduct this study.
Revised calculations of background sources, industrial process wastewater sources, and individual sewage disposal systems sources of phosphorus contributions	Revise the watershed model to identify these point and nonpoint source components of the TMAL.	Requires the completion of other special studies, which are input to the watershed model.

8.1 Reservoir Nutrient Enrichment Study

The in-lake nutrient enrichment study was completed in 2004 by Drs. William Lewis and James Saunders. The primary result of the study indicates that nitrogen is the limiting nutrient at this time and that it would take a reduction of at least 50% in phosphorus concentrations to induce phosphorus as the limiting nutrient. The principal outcome of these findings is that a viable method to control algal blooms is to enhance mixing and destratification of the Reservoir to reduce the potential for algal growth. Reservoir destratification was conceptually evaluated and preliminary design is anticipated to occur during 2005.

8.2 Groundwater Phosphorus Loading to Reservoir

Under management of the Division, the Authority is funding a study to estimate the groundwater inflow rate and phosphorus flux through reservoir seepage sampling. The study was initiated in October 2003 as part of a Colorado Nonpoint Source Program Grant. It is estimated that data collection and reporting will be completed by February 2005.

8.3 Funding for Three Special Studies

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 soil-phosphorus equilibrium, confirming effectiveness of BMPs, and defining background phosphorus. These three special studies will fill an informational void and provide input to the watershed model.

8.4 Watershed Model Update

The Authority convened a TAC subcommittee in July 2004 to develop agreement on refining the Authority's watershed model and better define the change in water quantity and quality, particularly phosphorus, as it moves from the point of origin in the watershed to Cherry Creek Reservoir (i.e., fate and transport). 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. Most of the special studies required in Control Regulation 72, were identified to better define nutrient fate and transport mechanisms. The subcommittee has been identifying how to address current information gaps and update the model algorithms on a conceptual level. The next step, for 2005, is to update and recalibrate the model.

The subcommittee objectives included identifying what is meant by fate and transport of phosphorus and what additional special studies, if any, are needed to answer the question. 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 subcommittee determined that refining the existing 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 load input to the Cherry Creek Reservoir Model by refining the technical procedures for calculating:

- Annual phosphorus loads and runoff volumes for future land-use conditions in the Cherry Creek Reservoir watershed.
- Annual phosphorus load decreases due to implementation of watershed-based BMPs and individual, PRFs. This knowledge will help identify, evaluate and prioritize BMPs and PRFs in the watershed.
- Pumping and point source discharge effects and phosphorus attenuation effects within Cherry Creek alluvium. This information will help evaluate impacts and benefits 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.

The Authority's 2005 work plan identifies updating the watershed model, and includes data collection to update data for the model input, detailing the algorithms identified through the 2004 TAC subcommittee process to define the model framework, refining the spreadsheet model, recalibrating and validating the watershed model, and identifying additional information needs.

8.5 Planning Progress for 2007 Triennial Review


To begin preparing for the 2007 triennial review for Control Regulation 72, the Authority will need to review the existing reservoir model as part of reevaluating the target reservoir phosphorus load. The Authority has expanded its 2005 work plan to include planned activities for 2006 and 2007, including revisiting the reservoir model in 2005 and revising phosphorus source load estimates, reviewing load allocations, and preparing for 2006 information hearing and 2007 triennial review hearing.

8.6 Progress Made

The Authority has continued to develop and implement point and nonpoint source controls over the past three years and has worked with the Division to implement two required investigations for the phased TMAL beginning in 2003.

- Under the management of the Division, the Authority completed one special study in 2004 that led to re-evaluation of in-lake management opportunities. The re-evaluation of reservoir destratification went through conceptual analysis in 2004 and will be a capital project in 2005.
- Under the management of the Division, a second special study progressed to estimate the groundwater inflow rate and phosphorus flux through reservoir seepage. This study will be completed in early 2005.



- 
- The Authority obtained funding and finalized project implementation plans for three special studies that are required as part of the phased TMAL. These studies will be initiated in 2005.
 - The Authority made significant progress on determining how to address the question of phosphorus fate and transport in the watershed and developed a scope of work to update the watershed model in 2005.

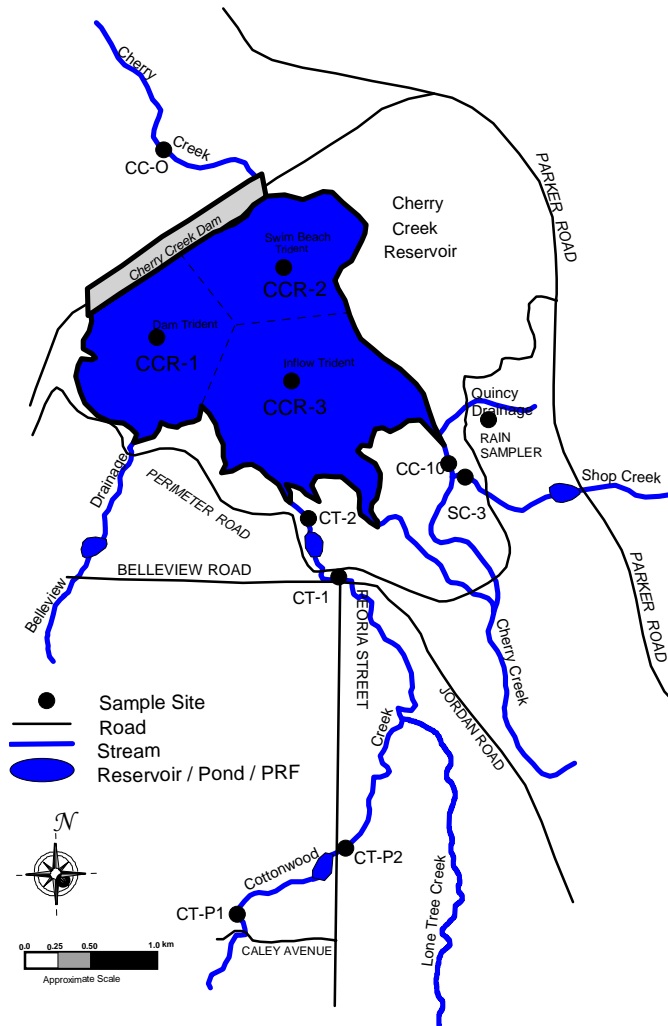
9. WATER QUALITY MONITORING – POINT SOURCE AND NONPOINT SOURCE LOADS



STEPS
REG 72

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 2004, 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 ground water well locations from Franktown to Cherry Creek Reservoir. Complete data reports are provided in the Cherry Creek Reservoir 2004 Annual Aquatic Biological-Nutrient Monitoring Study and Cottonwood Creek Phosphorus Reduction Facility Monitoring Report prepared by Chadwick Ecological Consultants Inc. (2004 Annual Monitoring Report.), and the 2004 Water Quality Data Report – Baseline Water Quality Data for the Upper Cherry Creek Basin prepared by John C. Halepaska and Associates, Inc.

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 thirteen to seventeen years of monitoring, as presented in the 2004 Annual Monitoring Report.

9.1.1. Chlorophyll *a*

- There is no statistical difference in the reservoir summer mean chlorophyll *a* levels from 1996 to 2004.
- The reservoir did not meet the new chlorophyll *a* standard of 15 µg/L (July - September) in 2004 and has only met the standard in three of the last thirteen years and not since 1995.
- 2004 summer mean chlorophyll *a* in the reservoir was lower than those observed in past eight years (Table 9-1).

9.1.2. Phosphorus

- Monitoring data collected since 1987 indicate a generally increasing trend in the reservoir summer mean concentration of total phosphorus.
- The Cherry Creek Reservoir did not meet the phosphorus goal of 40 µg/L in 2004.
- Summer mean total phosphorus in the reservoir has exceeded the current goal of 40 µg/L in all years since 1989.

9.1.3. Nitrogen

- There is no statistical difference in the reservoir summer mean nitrogen levels from 1987 to 2004.

9.1.4. Transparency

- Lake transparency values (as measured by Secchi depth) in 2004 were similar to 2003 values, and were lower than values observed from 1992 to 2000.

9.1.5. Temperature and Dissolved Oxygen

- Periodic thermal stratification was observed in the reservoir in 2004. During periods of stratification, the lower layers of the reservoir experienced depressed dissolved oxygen concentrations (e.g., <5 mg/L). Lower dissolved oxygen was occasionally observed also when the lake was not stratified.

9.1.6. Phosphorus Loading

- The 2004 total external phosphorus load (12,512 pounds) was below the phased TMAL (14,270 pounds).
- Annual total phosphorus loads have averaged 8,559 pounds/year over the past thirteen years (Table 9-1), meeting the phased TMAL of 14,270 pounds each year, except for 1999. The exceedance of the phased TMAL in 1999 (referred to as a phased TMDL prior to May 2001) appeared to be related to substantially increased inflows (Table 9-1).
- Inflow (17,177 ac/ft) and phosphorus load (12,512 lbs) were above the thirteen-year mean values in 2004 reflecting, in large part, the effects of flood events observed in August 2004.

Table 9-1. Water quality and total phosphorus loads data for Cherry Creek Reservoir, July - September 1992 - 2004

Year	Chlorophyll <i>a</i> (µg/L)	Total Phosphorus (µg/L)	Total Nitrogen (µg/L)	Annual Phosphorus Load (lbs/yr) ¹	Annual Inflow (ac/ft) ¹	Standardized Phosphorus Load (lbs/ac-ft)	Net Phosphorus Load (lbs/yr) ²
1992	17	66	970	5,857	7,474	0.78	4,543
1993	14.4	62	826	4,110	5,905	0.7	3,399
1994	10	59	1,144	4,049	7,001	0.58	3,056
1995	9.4	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
Mean	20.3	77	928	8,559	13,406	0.64	5,195
Median	20.5	81	913	7,972	11,781	0.63	4,765

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

² The net phosphorus load is the total load to the reservoir minus the reservoir outflow load.

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

9.2 Cherry Creek Reservoir - Summary of 2004 Data

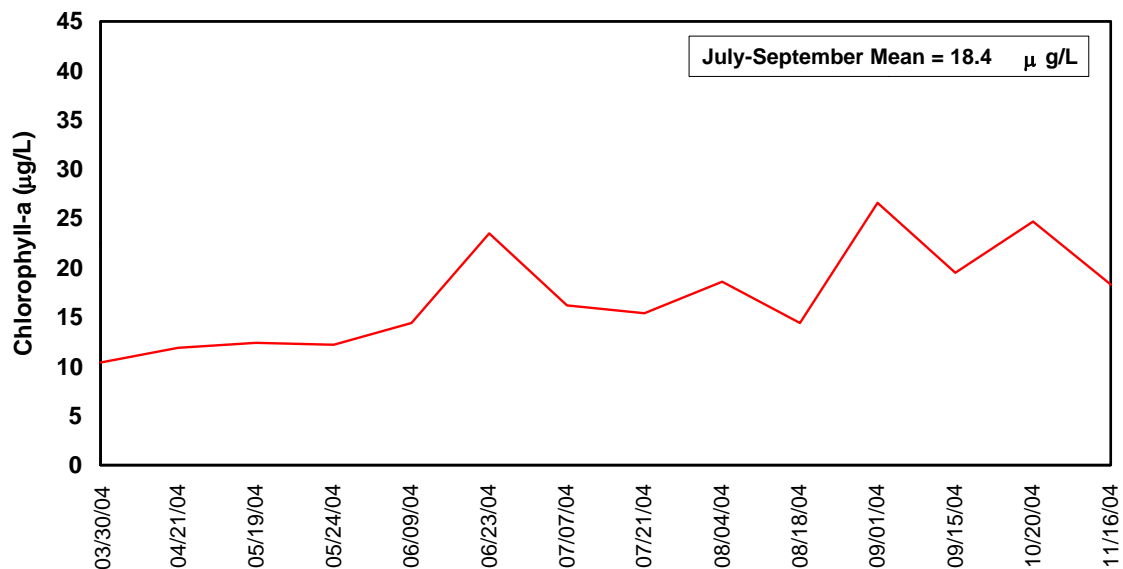
Presented below is a summary of 2004 water quality data for various constituents. This information is also summarized in the 2004 Annual Monitoring Report.

9.2.1. Chlorophyll *a*

The mean whole reservoir concentration of chlorophyll *a* showed a generally increasing trend from June through September (Figure 9-2). Concentrations spiked to their highest annual level in early September (26.6 µg/L). Following the spike, concentrations of chlorophyll *a* decreased through the rest of the year. The lowest concentration of 10.4 µg/L was observed in late March. The 2004 July to September mean chlorophyll *a* concentration of 18.4 µg/L was comparable to past values, and still exceeded the chlorophyll *a* standard of 15 µg/L for the reservoir.

July to September mean chlorophyll *a* concentrations have met the standard of 15 µg/L only five out of the past 18 years, and not since 1995. Since 1987, there has been a slight, and slightly significant ($p < 0.05$) increasing trend (slope = 0.72, $R^2 = 0.239$) in the July to September mean concentration of chlorophyll *a* in Cherry Creek Reservoir (Figure 9-3). Despite this long-term trend, there is no statistical difference in the reservoir summer mean chlorophyll *a* levels over the past 9 years.

Figure 9-2. Concentration of Chlorophyll *a* (µg/L) in Cherry Creek Reservoir, 2004

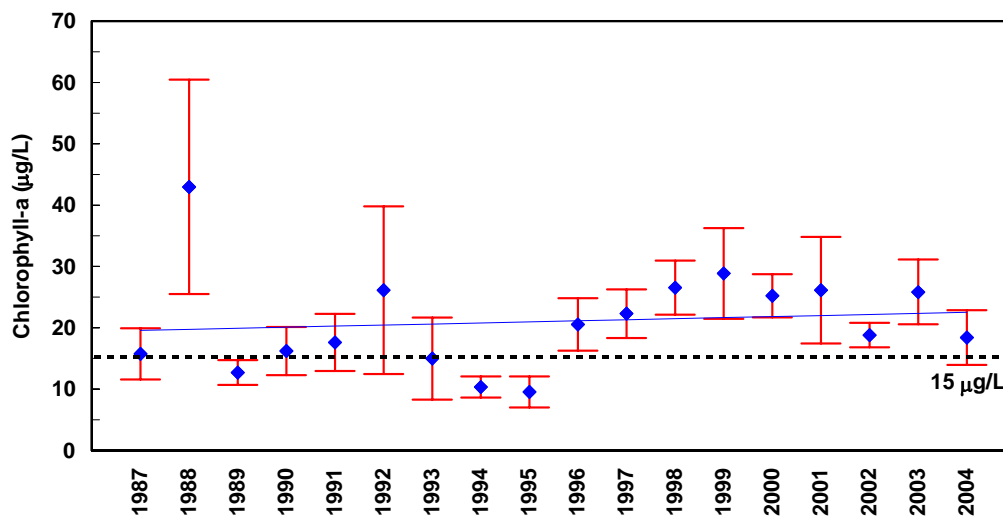


9.2.2. Phosphorus

Nutrient profile samples collected in 2004 showed a well-mixed reservoir in spring and fall. It appears there were brief periods of nutrient release from bottom sediments in June, August, and November as evidenced by increasing total phosphorus concentrations with increasing depth, despite little or no surface inflow to the reservoir.

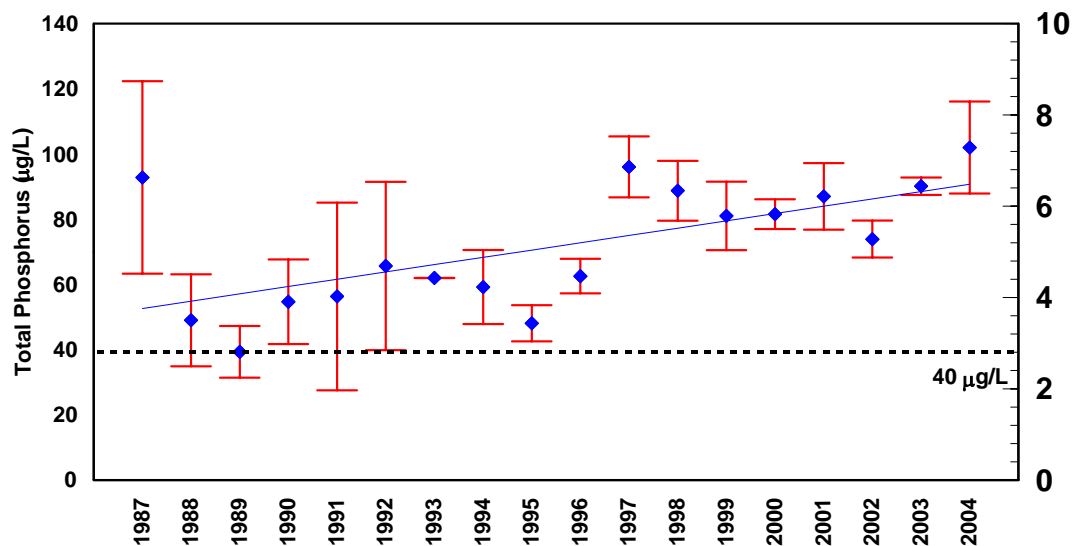
Routine monitoring data collected since 1987 indicate an increasing trend in the summer mean concentration of total phosphorus ($p < 0.010$, slope = 2.24, $R^2 = 0.40$) (Figure 9-4). In 2004, the summer mean concentration of total phosphorus was 102 µg/L. This value is the highest observed over the past 13 years. There is no statistical difference in mean annual total phosphorus values from 1997 through 2004.

Figure 9-3. Seasonal Mean (July to September) Chlorophyll a Concentrations Measured in Cherry Creek Reservoir, 1987 to 2004



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

Figure 9-4. Seasonal Mean (July to September) Total Phosphorus Concentrations (µg/L) Measured in Cherry Creek Reservoir, 1987-2004



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°C suggest a recent mixing event. Using the above criteria, Cherry Creek Reservoir was investigated for periods of potential stratification and anoxic

levels (Figures 9-5 and 9-6). Periodic stratification occurred through the summer, with significant whole lake mixing events appearing to occur in late early July and late July.

Figure 9-5. Temperature (C) Profiles Recorded During Routine Monitoring at Site CCR-2 in 2004

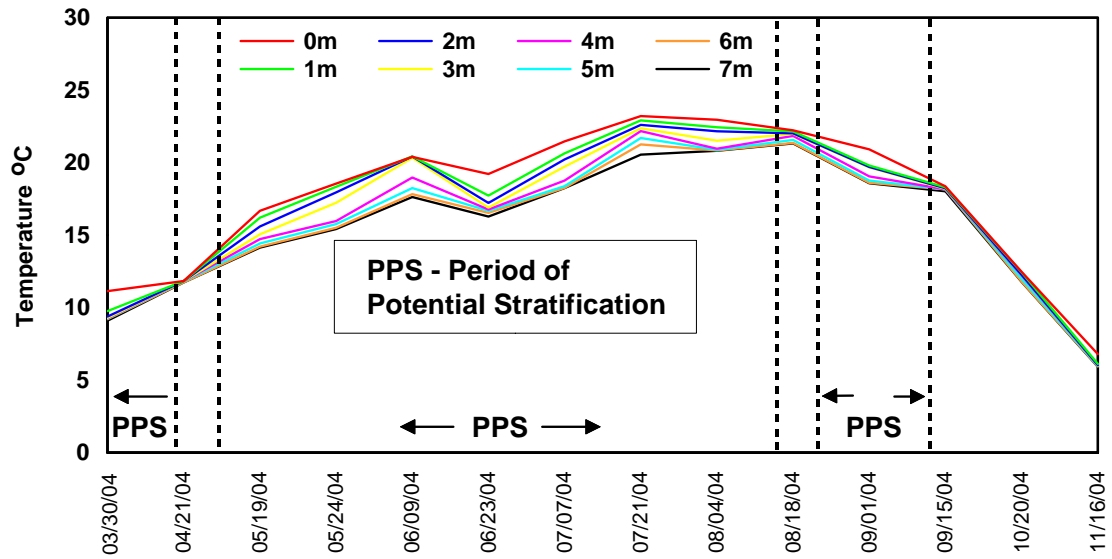
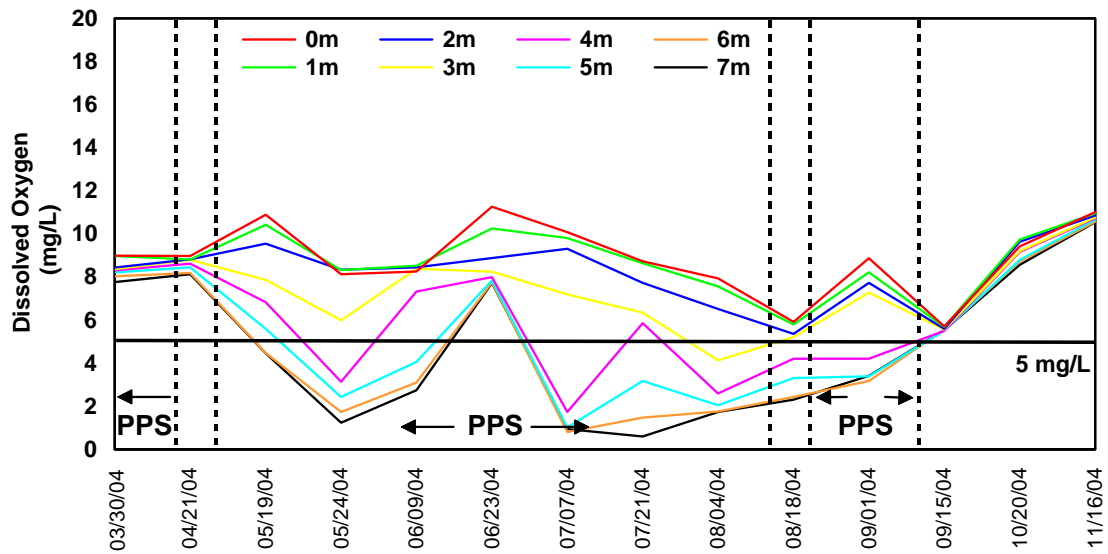


Figure 9-6. Dissolved Oxygen (mg/L) Profiles Recorded During Routine Monitoring at Site CCR-2 in 2004



During periods of stratification, the lower layers of the reservoir experienced depressed dissolved oxygen concentrations. During July and August, which had extensive periods with dissolved oxygen at less than 5 mg/L in the deeper waters, two percent of the lake volume experienced depletions below 5 mg/L.

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 ground water 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
Surface Water (upstream to downstream)	
Castlewood	0.2 mile north of the USGS Cherry Creek near Franktown gaging station
CC-1	1 mile south of Scott Road
CC-2	¾ mile south of Stroh Road
CC-3	1 mile south of West Parker Road (not a water quality sampling location)
CC-4	½ mile south of Lincoln Avenue
CC-5	½ mile north of Lincoln Avenue
CC-6	On Arapahoe/Douglas County Line
CC-7	¾ mile south of Arapahoe Road (not a water quality sampling location; abandoned in 2000 due to development)
CC-8	½ mile north of Arapahoe Road
CC-9	In the Park, near Nature Center. In 2002, site replaced by CC-10 (Chadwick Ecological Consultants)
Ground Water (upstream to downstream)	
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

Site	Description
MW-9	Monitoring well in Cherry Creek State 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 Cherry Creek range from <0.01 to 0.65 mg/L (the maximum from 2004) with a median of 0.16 mg/L (1994 through 2004).
- The SRP concentrations in the underlying alluvial aquifer range from <0.01 to 0.97 mg/L (the maximum from 2004) with a median of 0.18 mg/L (1994 through 2004).
- Higher than typical (>mean+4 standard deviations) SRP concentrations were detected at all ground and surface water locations during the October 2004 monitoring event. Typically, 99% of data is within 4 standard deviations of the mean (assuming normal distribution), therefore it is speculated that these data are outliers.
- Trends in SRP over time (1994 to present) for the most upstream and downstream surface water and ground water sites only indicated an increasing trend at MW-9, the most downstream ground water 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	No	Not applicable
CC9/CC10	Downstream surface water	No	Not applicable
MW-1	Upstream ground water	No	Not applicable
MW-9	Downstream ground water	Yes/increasing	0.004

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 ground water 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: The downstream surface water (CC9/CC10) concentration is greater than the upstream surface water concentration. This may be a function of increased flows downstream and urbanization that exposed additional soils to runoff.
Ground water upstream and downstream (MW-1 and MW-9)	Yes: The upstream ground water concentration (MW-1) is greater than the downstream ground water concentration (MW-9)
Upstream surface water (CC1) and upstream ground water (MW-1)	Yes: The upstream surface water concentration (CC-1) is less than the upstream ground water concentration (MW-1).
Downstream surface water (CC9/CC10) and downstream groundwater (MW-9)	Yes: The ground water concentration is greater than the surface water concentration.

Figure 9-7. Average SRP Concentrations in Cherry Creek Groundwater

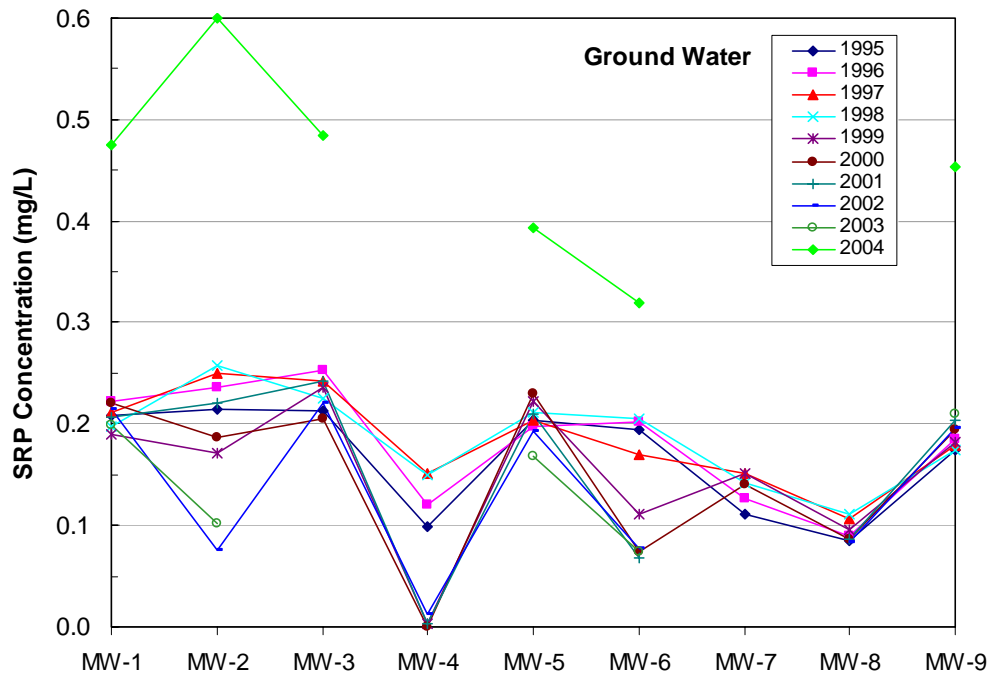
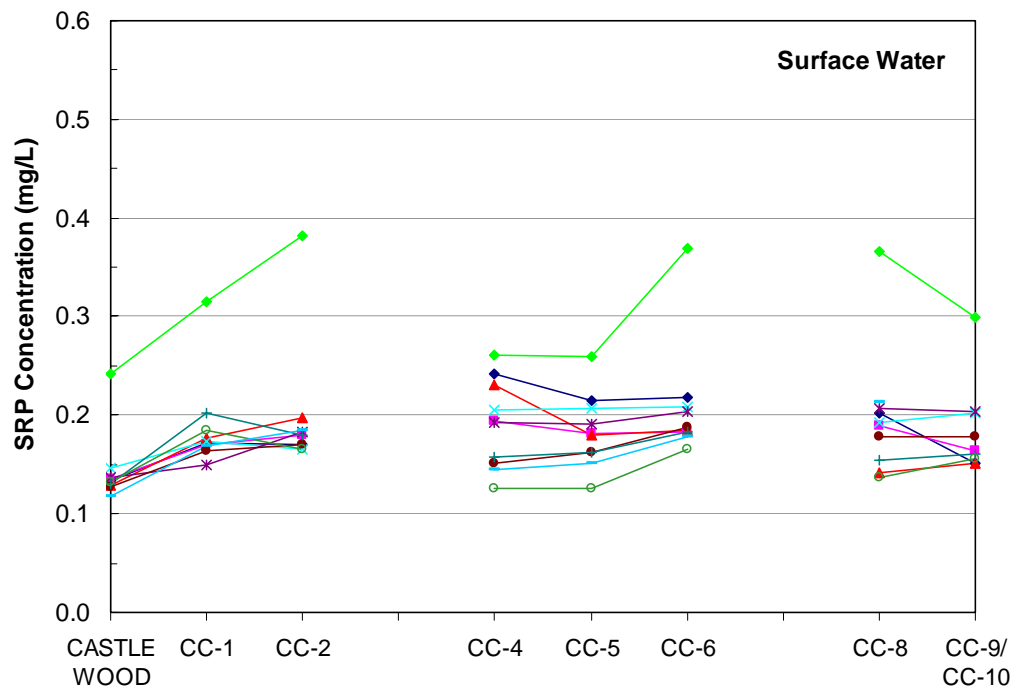


Figure 9-8. Average SRP Concentrations in Cherry Creek Surface Water



9.3.2. Nitrate

- The nitrate concentrations in Cherry Creek ranges from <0.05 and 20.3 mg/L (the maximum from 2004) with a median of 0.47 mg/L (1994 through 2004).
- The nitrate concentrations in the underlying alluvial aquifer range from <0.05 to 19.7 mg/L (the maximum from 2004) with a median of 0.51 mg/L (1994 through 2004).
- Higher than typical (>mean+4 standard deviations) nitrate concentrations were detected at all ground and surface water locations during the October 2004 monitoring event. Typically, 99% of data is within 4 standard deviations of the mean (assuming normal distribution), therefore it is speculated that these data are outliers.
- Trends in nitrate over time (1994 to present) indicated 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).
- Spatial trend evaluations to determine whether nitrate concentrations are significantly different between upstream and downstream sites and surface and ground water sites are summarized in Table 9-6.

Table 9-5 Summary of Nitrate Temporal Trend Analysis

Site	Type	Trend	Slope (mg/L per year)
Castlewood	Upstream surface water	Yes/increasing	0.01
CC9/CC10	Downstream surface water	Yes/increasing	0.05
MW-1	Upstream ground water	Yes/decreasing	-0.07
MW-9	Downstream ground water	Yes/decreasing	-0.28

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.

Table 9-6. Spatial Differences in Nitrate

Site	Spatial Difference in Nitrate Concentration?
Surface water upstream and downstream (Castlewood and CC9/CC10)	Yes: The downstream surface water concentration (CC9/CC10) is greater than the upstream surface water concentration (Castlewood).
Ground water upstream and downstream (MW-1 and MW-9)	No difference between the most upstream and downstream ground water.
Upstream surface water (CC1) and upstream ground water (MW-1)	Yes: The upstream surface water concentration (CC1) is less than the upstream ground water concentration (MW-1).
Downstream surface water (CC9/CC10) and downstream groundwater (MW-9)	Yes: The downstream surface water concentration (CC9/CC10) is less than the downstream ground water concentration (MW-9).

Figures 9-9 and 9-10 present average nitrate concentrations in Cherry Creek and the underlying alluvial aquifer from upstream to downstream (1995 to 2004).

There are fluctuations in the nitrate levels, which is not expected since nitrate is conservative and does not attenuate over distance, except due to dispersion and biological assimilation. The shallow water table may facilitate assimilation of nitrate by riparian plants.

Figure 9-9. Average Nitrate Concentrations in Cherry Creek Groundwater

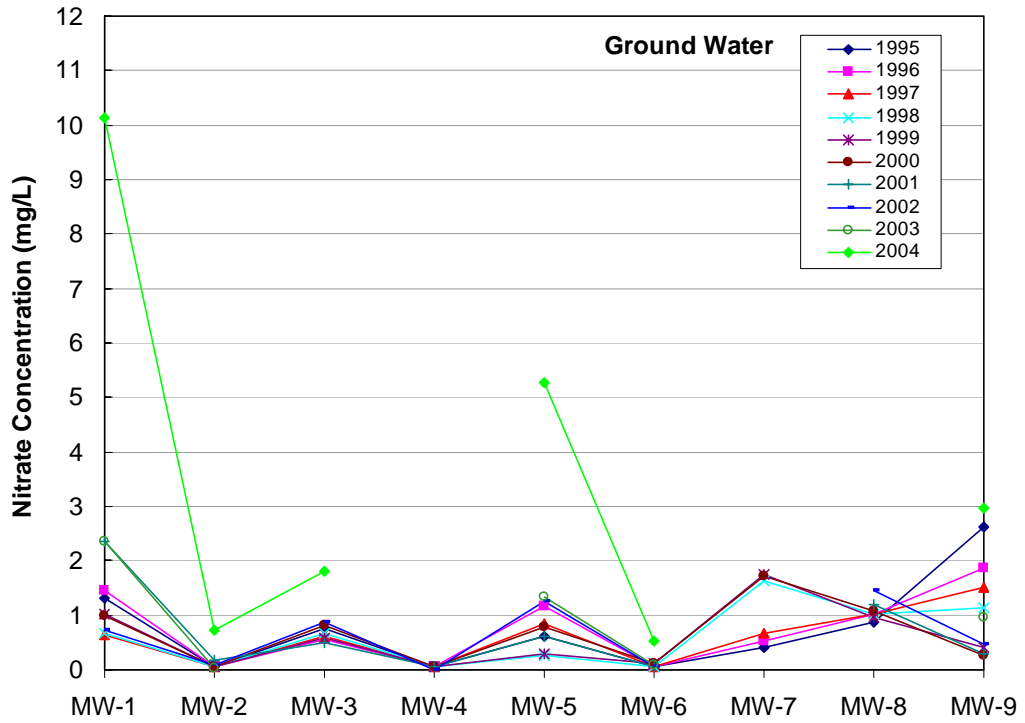
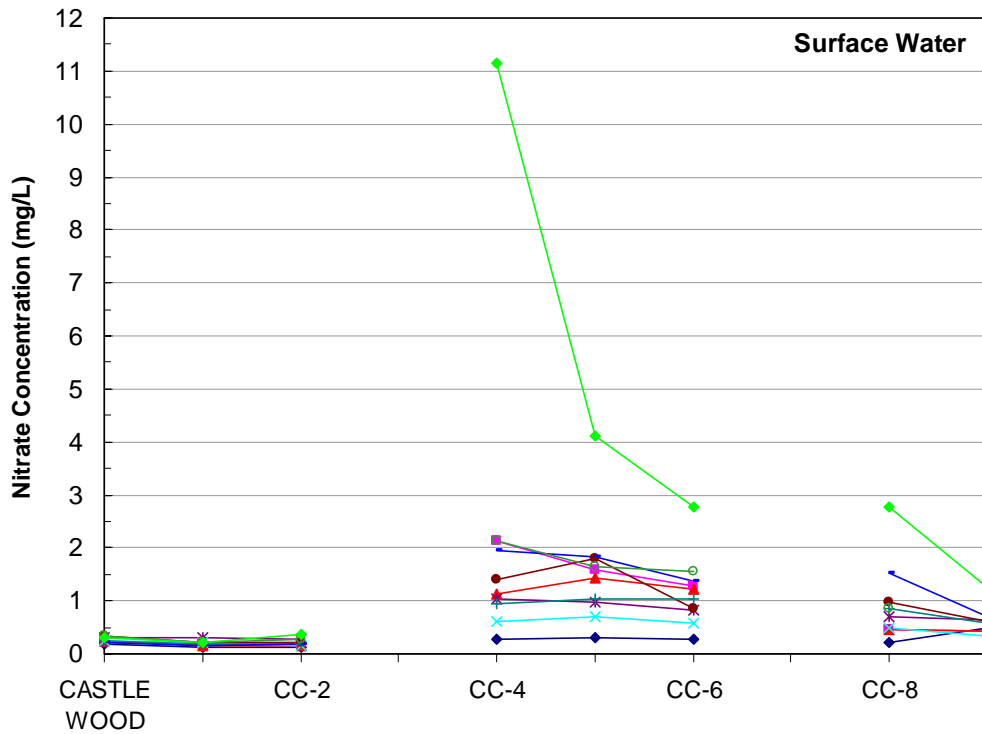


Figure 9-10. Average Nitrate Concentrations in Cherry Creek Surface Water



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/year. Note that the phased TMAL of 14,270 lbs/year set in the May 2001 hearing does not include these 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 2004, 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, phosphorus loading 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 10,181 pounds in 2004 (Table 9-7). Total phosphorus loading from the above influent streams was considerably higher than the thirteen-year mean value (Table 9-1), primarily as a result of greater loads from the Cherry Creek mainstem. Despite the higher loads, the standardized loading in pounds per acre foot for 2004 was similar to the mean values observed since the inception of monitoring efforts (Figure 9-11).

The increase in phosphorus loading between 2003 and 2004 was due, in part, to the 13 percent increase in inflow in 2004 relative to 2003 (Table 9-1, Figure 9-11). Inflow volume in 2004 was above the long-term average of 13,406 ac/ft. Inflow, measured as the change in reservoir elevation by the COE, was dominated in 2004 by the summer rainstorm/flood event in mid-August (Figure 9-12). This increase in inflow can also be attributable to higher annual precipitation. Precipitation in 2004 increased approximately 1.4 inches from 2003 precipitation.

Table 9-7. Estimated Net Phosphorus Loading (pounds/year) into Cherry Creek Reservoir, 1992 to 2004

Data Source	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	Mean
Shop Creek	131	83	135	115	107	117	127	96	82	103	79	103	210	115
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	7379	4,235
Cottonwood Creek	1,081	117	321	2,184	553	646	1,143	1,822	1,087	1,292	789	1,130	2592	1,140
Subtotal for Streamflows	4,106	1,987	2,598	5,094	3,007	2,804	8,936	10,663	9,475	4,807	1,973	5,870	10,181	5,500
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	2,291
Direct Precipitation	877	736	484	1,202	740	1,020	854	896	777	586	1,267	391	150	768
Total Load	5,857	4,110	4,049	7,972	4,715	5,761	13,577	17,471	12,593	9,837	4,246	8,568	12,512	8,559
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	3,126
Net Load	4,543	3,399	3,056	5,923	3,723	4,765	9,370	7,821	8,905	4,995	2,745	3,590	7,007	5,195

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

Figure 9-11. Long-Term Trends in Total Phosphorus Load (pounds/year), Inflow/acre-feet (year), and Standardized Phosphorus Load (pounds/acre feet) from Cherry Creek Reservoir, 1992-2004

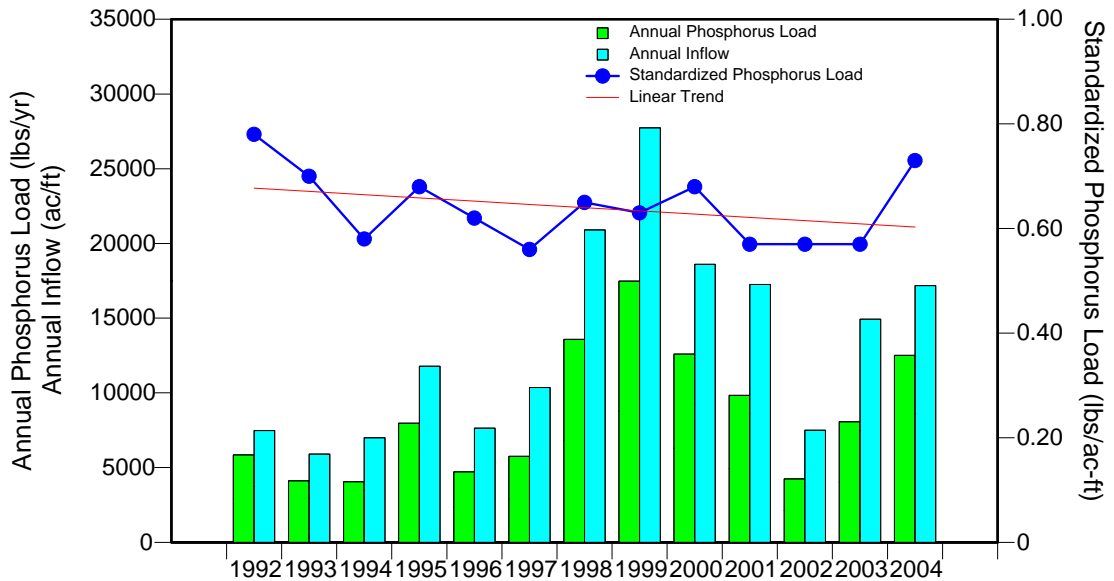
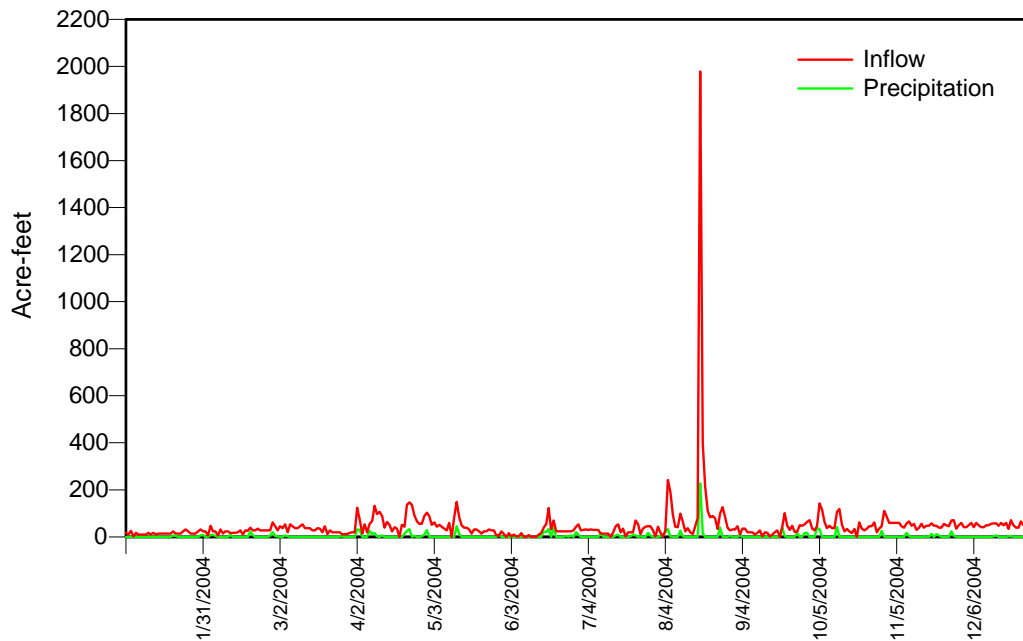


Figure 9-12. Comparison of Precipitation and Inflow for 2004



In order to provide further evaluation on inflowing streams, additional analyses were performed on data from the three main tributaries at Cherry Creek Reservoir. Concentrations of total phosphorus and orthophosphate were examined for a ten-year period (1995-2004). Total phosphorus and orthophosphate concentrations in Shop Creek exhibit significant, increasing trends over time. Concentrations of orthophosphate at the Cottonwood Creek inflow site exhibit a significant, decreasing trend over time. Other trends in Cherry Creek phosphorus concentrations were not statistically significant.

9.4.2. Precipitation

As measured by the rain gage located on Cherry Creek dam, total precipitation at Cherry Creek Reservoir was 20.3 inches in 2004. This was higher than the measured annual precipitation in 2003 (18.9 in). Additionally, the 2004 annual precipitation total was higher than the 1987-2003 mean of 17.6 inches.

Given the approximate surface area of Cherry Creek Reservoir (850 acres), total phosphorus loading due to precipitation was estimated to be 150 pounds for 2004, which is the lowest value recorded. This decrease in load can be attributed to a 37 percent decrease in mean concentration of total phosphorus collected from rain samples in 2003 (107 $\mu\text{g}/\text{L}$) to 2004 (40 $\mu\text{g}/\text{L}$). The mean value for annual loading from precipitation from 1987-2004 is 784 pounds.

9.4.3. Outflow

When measuring phosphorus loading in Cherry Creek Reservoir, phosphorus leaving Cherry Creek Reservoir in the outflow from the dam to Cherry Creek downstream of the reservoir is also important. Total phosphorus leaving the reservoir from the outflow was estimated at 4,812 pounds for 2004. This value is lower than that observed in 2003; however it was higher than the 1992-2004 mean of 3,126 pounds (Table 9-7).

9.4.4. Alluvial Phosphorus

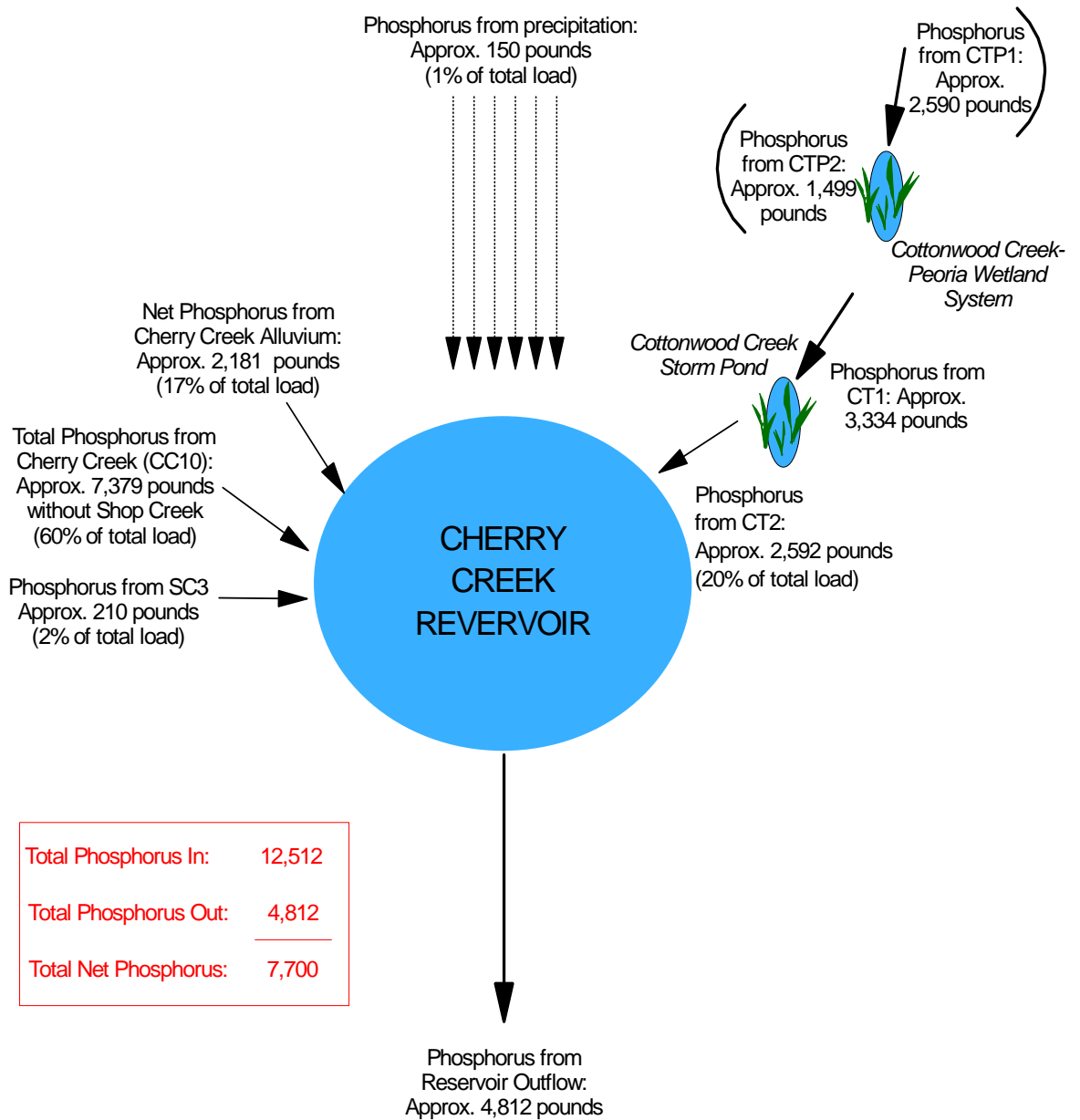
The estimated net alluvial phosphorus load for 2004 is 2,181 pounds.

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 2004, phosphorus contribution from precipitation was an estimated 150 pounds, influent streams contributed 10,181 pounds, and alluvial inflow contributed 2,181 pounds (Figure 9-13) for a total load of 12,251 pounds. Outflow from the dam contained an estimated 4,812 pounds in 2004. After totaling the additions and losses, the net loading of phosphorus was estimated at 7,700 pounds during 2004 (Table 9-6).

The total load of 12,512 pounds measured in 2004 represented a 32% increase in total phosphorus load over that measured in 2003. The phosphorus load in 2004 met the phased TMAL of 14,270 pounds established for Cherry Creek Reservoir. The pounds per acre-foot measured in 2004 was well within the range observed in previous years (Table 9-1 and Figure 9-11). In fact, while flows and phosphorus loads have generally varied over the past twelve years based on a variation in annual flows, the standardized phosphorus loads (pounds/ac ft) have generally exhibited a declining trend. Also of interest is that while loads increased 32% in 2004, mean summer chlorophyll values in 2004 were 28% lower than in 2003.

Figure 9-13. Mass Balance Diagram of Phosphorus Loading in Cherry Creek Reservoir, 2004



9.5 Evaluation of PRFs

Pollution reduction facilities constructed on Cottonwood Creek continued to be effective in reducing the loads of phosphorus to the reservoir. PRF effectiveness is gauged by monitoring the concentration of phosphorus and suspended solids and the phosphorus loading upstream and downstream of each facility.

9.5.1. Cottonwood Creek- Peoria Pond

This structure came on line midway during 2002. As such, the values from 2002 represent less than a full calendar year (i.e., only July - December 2002). The mean concentration of total phosphorus in 2004 decreased from 142 µg/L at Site CT-P1 to 123 µg/L at Site CT-P2 (Table 9-8). The mean concentration of TSS exhibited little difference upstream of the pond/wetland system to downstream of the pond/wetland system. The estimated load of phosphorus below the pond/wetland system was reduced 42% from 2,590 lbs at Site CT-P1 to 1,499 lbs at Site CT-P2. No difference ($p > 0.05$) in mean total phosphorus or mean TSS concentrations could be determined from statistical analysis (t-test) for Sites CT-P1 and CT-P2. Despite the average concentration of total phosphorus and TSS increasing slightly downstream of the PRF, the estimated load of phosphorus was still significantly reduced downstream of the PRF. This indicates that the new PRF was effective in reducing the pollutant load to the reservoir in 2002, 2003, and 2004.

Table 9-8. Annual Historical (2002-2004) Total Phosphorus and Total Suspended Solids Concentrations through the Cottonwood Creek-Peoria Wetlands System

Parameter	Year	Data Source	Sampling Sites		Difference	Percent Reduction
			CT-P1	CT-P2		
Average Total Phosphorus Concentration (µg/L) (baseflow and storm samples combined)	2002	CEC	138	153	+ 14	10
	2003	CEC	101	92	- 9	9
	2004	CEC	142	123	- 19	13
	Mean		127	123	- 7	11
Average Total Suspended Solids (mg/L)	2002	CEC	66	79	+ 13	20
	2003	CEC	31	34	+ 3	- 10
	2004	CEC	87	53	- 34	39
	Mean		61	55	-6	16
Loading of Total Phosphorus (pounds)	2002	CEC	449	231	228	5
	2003	CEC	771	574	- 197	26
	2004	CEC	2,590	1,499	- 1,091	42
	Mean		1,270	768	-353	24

9.5.2. Cottonwood Creek Perimeter Pond

During 2004, the mean concentration of total phosphorus decreased from 212 to 151 µg/L after passing through the pond (Table 9-9). This represents a 20% reduction in phosphorus concentration, the third lowest percent reduction since the pond's inception. The load of total phosphorus was reduced from 3,334 lbs upstream of the pond to 2,592 lbs downstream of the pond, representing a 22% reduction in load. This value is about average for the pond. The concentration of TSS was decreased by 47 percent from 155 mg/L upstream to 81 mg/L downstream of the pond. However, statistical analysis (t-test) determined that these

differences in mean total phosphorus or TSS concentrations between Sites CT-1 and CT-2 were not statistically significant ($p > 0.05$). In past years, higher phosphorus concentrations observed at the Cottonwood Creek perimeter pond, when compared to the Cottonwood Creek – Peoria wetland system, indicate potential loading from stream channel erosion. In an effort to reduce phosphorus loading in the reservoir from the stream itself, channel reconstruction was conducted on Cottonwood Creek downstream of the Cottonwood Creek – Peoria wetland system in 2004. This reconstruction may have accounted for the increased loads observed between these two existing PRFs, e.g., 1,499 lbs at Site CT-P2 and 3,334 lbs TP at Site CT-1 (Table 9-9 and 9-10). Regardless, the load reduction indicates that these PRFs continue to be effective in reducing the loads of suspended solids and total phosphorus to Cherry Creek Reservoir

Table 9-9. Annual Historical (1997 To 2004) Total Phosphorus and Total Suspended Solids Concentrations through the Cottonwood Creek Stormwater Detention Pond

Parameter	Year	Data Source	Sampling Sites		Difference	Percent Reduction
			CT-1	CT-2		
Annual Average Total Phosphorus Concentration ($\mu\text{g/L}$) (baseflow, storm samples combined)	1997	CEC	200	133	-67	34
	1998	CEC	289	210	-79	27
	1999	CEC	158	157	-1	0
	2000	CEC	187	149	-38	20
	2001	CEC	165	114	-51	31
	2002	CEC	146	143	-3	2
	2003	CEC	144	129	-15	10
	2004	CEC	212	151	-61	29
	Mean		188	148	-39	19
Annual Average Total Suspended Solids (mg/L)	1997	CEC	207	87	-120	58
	1998	CEC	311	129	-182	59
	1999	CEC	267	68	-199	74
	2000	CEC	96	64	-32	33
	2001	CEC	79	43	-43	46
	2002	CEC	130	79	-51	39
	2003	CEC	84	62	-22	26
	2004	CEC	155	77	-74	48
	Mean		166	77	-90	48
Annual Loading of Total Phosphorus (pounds)	1997	CEC	3,351	1,103	-2,248	67
	1998	CEC	3,209	1,930	-1,279	40
	1999	CEC	6,329	3,868	-2,461	39
	2000	CEC	3,243	1,712	-1,531	47
	2001	CEC	3,356	2,205	-1,151	34
	2002	CEC	886	789	-97	11
	2003	CEC	1,777	1,130	-647	36
	2004	CEC	3,334	2,592	-742	22
	Mean		3,186	1,916	-1,270	37

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

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

9.7 Status of Water Quality

In 2004, the average July-September mean chlorophyll *a* content in Cherry Creek Reservoir was 18.4 µg/L, which exceeds the standard set at 15 µg/L. This standard has only been met five times in the past 18 years. The seasonal mean of total phosphorus (102 µg/L) also in exceeded the current goal of 40 µg/L. However, the annual phosphorus load in 2004 was 12,512, which did not exceed the phased TMAL of 14,270 pounds.

9.8 Progress Made



- 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.
- Confirmed phosphorus load reductions from the Cottonwood Creek-Peoria Pond PRF (42% phosphorus load reduction) and Cottonwood Creek Perimeter Pond PRF (22% phosphorus load reduction). These reductions in loads at the Perimeter Pond PRF were observed despite the potential for increased loads resulting from the channel reconstruction activities upstream during 2004, again pointing to the effectiveness of this structure in reducing phosphorus loads to the reservoir.
- Total phosphorus load to the reservoir was below the TMAL.
- There has been no statistically significant increase (or decrease) in seasonal reservoir chlorophyll *a* concentrations since 1996.

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. 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 2004.

- Consider various funding options to achieve capital budget increase of \$2 million to \$4 million annually.
 - 2004 The Board adopted a budget that included funds thought adequate to begin exploring the feasibility of “de-Brucing” the Authority’s budget (i.e., removing TABOR requirement). The Board will continue to explore this in 2005.
 - 2004 The Authority was awarded two Nonpoint Source Program grants for near-term funding to assist with both capital projects and revising the TMAL.
- Implement the Cherry Creek Reservoir Watershed Plan 2003 as a coordinated management program.
 - 2004 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.
 - 2004 Phase I of Cottonwood Creek Stream Reclamation within Cherry Creek State Park completed.
 - 2004 Completed stabilization of 5,100 feet of Piney Creek by working with local land use agencies.
- Design and construct additional pollutant reduction facilities.
 - 2004 Design of Phase II of Cottonwood Creek Stream Reclamation and Cherry Creek State Park Wetlands in progress.
 - 2004 Conducted conceptual evaluation of reservoir destratification alternatives.
- Promote trading incentives and request removal of the 216-pound “Reserve Pool” cap.
 - 2004 Revised Control Regulation 72 to remove trading cap and limitation on trading opportunities .
- Encourage all land use agencies to adopt and implement the stormwater policy and design criteria outlined in the Authority’s Requirements.
 - 2004 All land use agencies within the reservoir watershed adopted the Authority’s Requirements.

- Encourage local governments to work with developers to construct innovative demonstration projects.

2004 Completed first year of Phosphorus Facilitator program

- Encourage local governments to provide developer incentives to preserve and enhance stream corridors.

2004 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 Revised Control Regulation 72 to 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.

2004 Completed the Reservoir Nutrient Enrichment study in 2004.

- Develop and implement a comprehensive public involvement plan.

2004 Worked with the Partners to develop the Education Initiative.

- Consider participation in several federally funded programs that support sustainable agriculture and habitat protection and restoration.

2004 Participated in Preliminary Restoration Plan under the COE 1135 Program for Belleview Wetlands and the 206 Program for Piney Creek stream stabilization.

- Coordinate with other stormwater Phase I and II entities and efforts.


2004 The Authority's consultants regularly interface with land use agencies and stormwater permittees to answer questions and provide guidance for enhanced BMPS.

2004 Participated in the CDOT Annual Conference.

- Collaborate with other private and public interest groups to leverage funding mechanisms to meet watershed goals.

2004 The Authority used the Cherry Creek Stewardship Partners' efforts and activities to promote education and outreach in the watershed for water quality enhancements.

Cherry Creek Reservoir did not meet the chlorophyll a standard or phosphorus goal in 2004,



but the phosphorus loading to the reservoir was below 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 results of the special study on nutrient enrichment and the conceptual analysis of reservoir destratification suggest that reservoir destratification, should be considered for more short-term improvements to reservoir water quality.

The review of Authority watershed management activities and monitoring indicate that current watershed approaches are needed to reduce external nutrient loads, but the Authority also faces a challenge in meeting water quality standards. In addition to watershed strategies the Authority also is also considering additional strategies, including in-lake management, that could be beneficial to reducing chlorophyll *a* concentrations in the near term.

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