2002 ANNUAL REPORT OF ACTIVITIES BY THE CHERRY CREEK BASIN WATER QUALITY AUTHORITY

MARCH 2003

Chadwick Ecological Consultants, Inc.

5575 S. Sycamore St., Suite 101, Littleton, CO 80120
Ph: (303) 794-5530 Fax: (303) 794-5041 Chadeco@aol.com

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Authority Members in 2002:

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 Representative

Seven Governor's Appointees

Prepared by:

Cherry Creek Basin Water Quality Authority
c/o R. S. Wells L.L.C., Suite 102
Fiddler's Green Center, Building 1
6399 South Fiddlers Green Circle
Greenwood Village, Colorado 80111-2050

with assistance from

Chadwick Ecological Consultants, Inc.
5575 South Sycamore Street, Suite 101
Littleton, Colorado 80120

John C. Halepaska and Associates, Inc.
26 West Dry Creek Circle, Suite 640
Littleton, Colorado 80120

Brown and Caldwell, Inc.
1697 Cole Boulevard, Suite 200
Golden, Colorado 80401

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EXECUTIVE SUMMARY

The 1982 Clean Lakes Study of Cherry Creek Reservoir determined that eutrophication of the reservoir could negatively impact beneficial uses of the reservoir. The reservoir was originally built for flood control, and is classified for warmwater aquatic life, primary recreation, water supply, and agriculture. The reservoir and surrounding state park serve as an important source of recreation, presently and historically. The Cherry Creek Basin Water Quality Authority (Authority), initially created by an intergovernmental agreement, was specially authorized by legislation adopted in 1988. The Authority develops and implements the means to protect the water quality of Cherry Creek Basin and Reservoir. Following recent legislation, the Board was reconstituted in 2001 and now includes Arapahoe and Douglas Counties, seven municipalities (Aurora, Castle Rock, Centennial, Foxfield, Greenwood Village, Lone Tree, and Parker), one member representing the seven special districts (Arapahoe, Cottonwood, Inverness, Meridian, Parker, Pinery, and Stonegate Village), and seven citizens appointed by the governor.

A. Reservoir Water Quality Standards and TMAL

In 1985, an in-reservoir phosphorus standard of 35 µg/L was adopted by the Colorado Water Quality Control Commission (CWQCC) to maintain a seasonal mean chlorophyll *a* goal of 15 µg/L. Subsequently, a phosphorus total maximum daily load (TMDL) was prepared for the reservoir allocating loads among point sources, background, and nonpoint sources within a total annual phosphorus load of 14,270 pounds. In September 2000, following a hearing before the CWQCC, the standard for Cherry Creek Reservoir was changed to a July - September value of 15 µg/L of chlorophyll *a* to be met nine out of ten years, with an underlying total phosphorus goal of 40 µg/L, also as a July - September mean. In May 2001, at the CWQCC hearing, a new control regulation was adopted for the Cherry Creek Reservoir, which maintained the annual allowable total phosphorus load (phased TMAL) of 14,270 pounds/year as part of a phased TMAL.

This report summarizes Authority activities during 2002. The Authority develops and implements water quality management strategies that address point and nonpoint pollutant sources, as well as monitoring water quality to measure the effectiveness of strategies and evaluate compliance with water quality standards. Specific Authority activities include reviewing site applications for new and existing wastewater collection and

treatment facilities, reviewing wastewater utility plans, reviewing land use and development applications, developing information and education programs, planning and constructing capital improvement projects (CIP), and monitoring data collected by the Authority in 2002 during its monitoring activities on Cherry Creek Reservoir, the tributary inflows to the reservoir, and the Cherry Creek mainstem upstream of the reservoir.

B. Basin Authority Review of Site Applications and Development Proposals

The Authority reviews Site Applications and Utility Plans for wastewater collection and treatment facilities proposed in the Cherry Creek Basin. These applications are reviewed with a concern for potential impacts on phosphorus loading to Cherry Creek Reservoir. During 2002, seven separate proposals were reviewed. Additionally, in an effort to mitigate potential water quality impacts from the continuing development in the Cherry Creek watershed, the Authority has taken an active role as a referral agency in the land-use application review process. Land use applications are reviewed against the criteria and standards in the Cherry Creek Reservoir Watershed Stormwater Quality Regulation. During 2002, the authority reviewed and commented on 120 land use applications.

C. EPA 319 Grants

Information and Education Grant

The EPA 319 Grant awarded to the Authority, "The Role Of BMPs And PRFs In Water Quality Protection," has three main objectives: public sector education; private sector education; and education of the general public. For each of the target audiences, "education" as stated in the objectives relates to increasing the awareness of water quality issues within Cherry Creek Basin and the role that Best Management Practices (BMPs) and Pollutant Reduction Facilities (PRFs) serve as potential remedial actions to improve water quality.

A program has been developed consisting of a series of fact sheets that complement the existing land use application process within the Cherry Creek Basin, and that could be dynamic and updated with changes in regulations and requirements. This program is entitled *The BMP Series*. A draft of *The BMP Series* was presented to the Education and Outreach Committee of the Cherry Creek Stewardship Partners on August 21,

2002, and to the Authority's Technical Advisory Committee on October 3, 2002, and presented at the November 1, 2002, Cherry Creek Stewardship Partners Annual Conference. The fact sheets will be finalized and distributed in 2003.

Lower Cottonwood Creek Water Quality Plan Activities Under the EPA 319 Grant

The main goal of the EPA 319 Grant awarded to the Authority, "The Lower Cottonwood Creek Water Quality Plan," is to minimize erosion of Cottonwood Creek within the Cherry Creek State Park and to protect and improve the performance of the Perimeter Road Water Quality Pond. The "The Lower Cottonwood Creek Water Quality Plan" outlines six main objectives to be carried out in order to achieve the main goal. These include reducing sediment input from streambank erosion, monitoring phosphorus removal from constructed facilities, and increasing public awareness of BMPs.

The Authority was also 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, to contribute funding to the design and construction of the Cottonwood-Peoria Street Water Quality Detention Pond. UDFCD managed the project. Construction began in the summer of 2001, and the water quality portion of the Peoria Street Pond was substantially complete on May 31, 2002, and is currently functioning.

The Authority has also conducted a feasibility analysis and initiated the design for reducing sediment from streambank erosion in Lower Cottonwood Creek.

D. Capital Improvement Projects

Authority Capital Improvement Program Planning

The Authority implemented a multi-year CIP planning process in 2002 by identifying potential pollution reduction facility (PRF) projects and costs, and extending them over a three-year period. The multi-year projections, which are part of the Authority's annual budgeting process, divides each potential project into

capital, land acquisition, water requirements, and operations and maintenance costs. These costs are then spread-out over a three-year period for longer-range planning purposes and are subject to available Authority funds.

Bowtie Property Acquisition

The Authority has partnered with UDFCD, Trust for Public Lands, City of Centennial and Arapahoe County to purchase property adjacent to Cherry Creek State Park at the confluence of Piney Creek and Cherry Creek (called Bowtie property). The property to be acquired totals 21.5-acres, of which the Authority will obtain rights to construct and operate a PRF on 10.5 acres. The conceptualized design for the PRF includes channel stabilization, wetlands, and a sediment pond (located off the Bowtie land on property owned by Arapahoe County). Long-term, annual phosphorus immobilization is expected to be 235-pounds, which results in an annual cost of $400 per pound of phosphorus.

Cherry Creek State Park Wetlands and Lower Cottonwood Creek

The Authority hired a consultant to conduct a feasibility analysis and begin initial design for the Cherry Creek State Park wetlands and Lower Cottonwood Creek pollutant reduction facilities.

Construction Adjacent to Cherry Creek State Park

The Authority has reviewed and commented on several proposed projects adjacent to Cherry Creek State Park, at the request of Parks. The Authority worked directly with Greenwood Village on the Belleview Avenue and Union/Dayton Avenue street modification projects to incorporate additional Best Management Practices (BMPs) to minimize sediment, trash and debris entering the park. The Authority also worked with CDOT to implement similar BMP into CDOT's proposed modifications to the Parker Road/Quincy Avenue interchange.

Cherry Creek Corridor Major Drainageway Planning Study

The Authority participated in the planning of the Cherry Creek major drainageway, along with the sponsoring agencies the UDFCD, Arapahoe County, Douglas County, Town of Parker and Cities of Centennial and Aurora. Stabilization of Cherry Creek has been identified as a priority since the Authority's 1985 Cherry Creek Master Plan. The Alternative Evaluation Report (URS 2002) evaluated five alternatives for the Cherry Creek Corridor, including "no-action", corridor acquisition, and extensive stabilization. The consultant recommended *"Channel Stabilization and Reclamation/Water Quality Enhancements" (*Alternative 5) to the project sponsors for conceptual design in the next phase (Phase B) of the study. Alternative 5 integrates stream reclamation and water quality improvements.

E. Water Quality and Aquatic Biological Monitoring of Cherry Creek Reservoir Watershed - 2002

Cherry Creek Reservoir

Based on data collected by Chadwick Ecological Consultants, Inc. (CEC), the following statements can be made: 1) average July - September chlorophyll *a* content was 18.8 µg/L in 2002, greater than the new standard of 15.0 µg/L, but lower than the 2001 value (26.1 µg/L) and 2000 value (25.2 µg/L); 2) the July - September seasonal mean of phosphorus of 74 µg/L in 2002 was lower than the values measured in the last five years, but higher than the eleven-year mean and the underlying goal of 40 µg/L; and 3) Secchi depth (transparency) averaged 0.9 m in 2002, greater than the 2001 value of 0.8 m (see accompanying table).

Nutrients and chlorophyll *a* have varied over time, with changes often related to the variation in annual loads from external sources (but, not consistently). These data suggest that year-to-year variations in both external loading and internal loading play a role in the regulation of levels of nutrients and chlorophyll *a* in the reservoir.

Sampling of aquatic biota and nutrients in reservoir and influent streams, conducted during 2002 by CEC, demonstrated that water transparency varied throughout the year. Water temperature data suggest that Cherry Creek Reservoir experiences infrequent periods of complete mixing interspersed with periods of thermal

stratification during the summer. The reservoir is currently on the "Monitoring and Evaluation" list with regard to dissolved oxygen as a result of values less than 5 mg/L observed during the summer.

Water Quality and Total Phosphorus Loads Data for Cherry Creek Reservoir, July - September 1992 - 2002

Year	Chlorophyll *a* (µg/L)	Secchi Depth (m)	Total Phosphorus (µg/L)	Total Nitrogen (µg/L)	Annual Phosphorus Load (lbs/yr)*	Annual Inflow (ac/ft)*	Standardized Phosphorus Load (lbs/ac-ft)
1992	17.0	0.9	66	970	5,857	7,474	0.78
1993	14.4	1.2	62	826	4,110	5,905	0.70
1994	10.0	1.1	59	1,144	4,049	7,001	0.58
1995	9.4	1.6	48	913	7,972	11,781	0.68
1996	20.5	1.6	62	944	4,715	7,644	0.62
1997	22.3	1.0	96	1,120	5,761	10,362	0.56
1998	26.5	1.0	89	880	13,577	20,903	0.65
1999	28.9	1.0	81	753	17,471	27,739	0.63
2000	25.2	1.0	81	802	12,593	18,610	0.68
2001	26.1	0.8	87	757	9,837	17,250	0.57
2002	18.8	0.9	74	858	4,246	7,498	0.57
11-Year Mean	19.9	1.1	73	906	8,199	12,924	0.64
Median	20.5	1.0	74	880	5,857	10,362	0.63

* Stream, alluvium, and precipitation.

Fish stocking was continued in 2002 by the Colorado Division of Wildlife (CDOW). Species number and composition of stocked fish were similar to previous years (1985-2001), but no channel catfish were stocked in 2002. No sampling of the Cherry Creek Reservoir fish community was conducted in 2002 by the CDOW.

Cherry Creek Watershed Sampling

The Phase I Baseline Water Quality Data Collection Study for the Basin, conducted by John C. Halepaska and Associates, Inc. (JCHA), was begun in 1994 and continued through 2002. Data collected to date indicate that phosphorus concentrations show a slight upward trend over time at the downstream end of

the study reach, near the reservoir. There was no such trend observed at the upper reaches of the basin (i.e., Castlewood Canyon). As expected, increases in flow lead to an increase in phosphorus concentrations. There are no discernable increases in concentrations at monitoring locations downgradient of direct dischargers.

Nitrate-nitrogen concentrations fluctuated throughout 2002 and were generally higher in the alluvium than in the surface water. It appears that a large portion of the nitrate-nitrogen concentration in the groundwater system is from nonpoint sources, such as agricultural uses and leach field discharges.

Increased levels of chloride and sulfate were observed in surface waters in the vicinity of direct discharges. Concentrations of chloride and sulfate were below the drinking water standard, but sulfate concentrations approach the standard just prior to entering Cherry Creek Reservoir.

Phosphorus Loading

Phosphorus loading from the tributaries to the reservoir, Cherry Creek, Cottonwood Creek, Shop Creek, and the Cherry Creek alluvium (all considered to be nonpoint sources), was estimated at 2,979 pounds for 2002. Phosphorus loading from precipitation was 1,267 pounds during 2002, for a total loading to the reservoir of 4,246 pounds, a 57% decrease in pounds of total phosphorus from that measured in 2001. Phosphorus leaving the reservoir in 2002 through the outflow was 1,501 pounds. The total load of 4,246 pounds entering the reservoir in 2002 met the phased TMAL of 14,270 pounds.

1. BACKGROUND

The Clean Lakes Study of Cherry Creek Reservoir conducted in 1982 identified that eutrophication of the reservoir could negatively impact the beneficial uses of the reservoir (Denver Regional Council of Governments [DRCOG] 1984). The Clean Lakes Study identified phosphorus as the major nutrient causing algal productivity and, therefore, potential eutrophication of the reservoir. Based on the Clean Lakes Study in 1985, the Colorado Water Quality Control Commission (CWQCC) established an in-reservoir total phosphorus standard of 35 µg/L to maintain an average in-reservoir chlorophyll *a* level at concentrations no higher than 15 µg/L during the "growing season" (both defined as a July - September seasonal mean). These standards were recently re-evaluated in September 2000 at a hearing before the CWQCC. Following this hearing, the CWQCC set a new chlorophyll *a* standard of 15 µg/L (July through September mean), to be met in nine out of ten years, with an underlying total phosphorus goal of 40 µg/L (July through September mean).

During 1985, the Cherry Creek local governments (cities, counties, and special districts), private interests, and representatives of the state and federal agencies developed a total maximum daily load (TMDL) of 14,270 pounds total phosphorus annual load and strategies to meet the earlier reservoir standard and TMDL. The TMDL was presented in the Cherry Creek Basin Water Quality Management Master Plan (DRCOG 1985) and approved by the CWQCC. Also, portions of the Master Plan were adopted as the "Regulations for Control of Water Quality in Cherry Creek Reservoir" (Section 4.2.0, 5 C.C.R. 3.8.11), effective December 30, 1985. The TMDL and Master Plan were approved by the U.S. Environmental Protection Agency (USEPA) Region VIII office. In May of 2001, the CWQCC approved a new Control Regulation, which included an allowable total phosphorus load of 14,270 pounds as part of a phased total maximum annual load (TMAL) for the reservoir, pending future studies.

In 1985, an intergovernmental agreement was executed by the local governments within the Cherry Creek Basin, forming the Cherry Creek Basin Water Quality Authority (Authority). The Authority was created to develop and implement the means to protect the water quality of Cherry Creek Basin and Reservoir, while allowing economic development to occur. In 1987, the Colorado Legislature's Water and Water Quality Subcommittee conducted hearings on legislation to create a water quality management agency for the Cherry

Creek Basin. Legislation introduced and enacted in the 1988 General Assembly statutorily created and empowered the Authority. Additional legislation in 2001 reconstituted the Authority as follows:

One member from each County with property within the Authority	=	2
One member from each Municipality	=	7
One member for all Special Districts	=	1
Seven members appointed by the Governor	=	7
Total members of Authority Board	=	**17**

This legislation also requires the Authority to submit a new Water Quality Control Plan within two years (2003), and spend at least 60% of the authorized revenues on the construction and maintenance of phosphorus reduction facilities.

2. PURPOSE OF THE ANNUAL REPORT

The purpose of this Annual Report is to inform the CWQCC, the Colorado State Parks Department, the U.S. Army Corp of Engineers (COE), and other interested parties of the Authority's reservoir and watershed monitoring activities during 2002.

3. DESCRIPTION OF CHERRY CREEK RESERVOIR AND 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 (344 ha), 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 (1,584 ha) 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, 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 reservoir's watershed includes approximately 245,500 acres (99,350 hectares). The northern portion of the watershed has been urbanizing over the past ten years, especially in the subbasins immediately adjacent to the reservoir. Developed land uses include high-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 warmwater aquatic life, primary recreation, water supply, and agriculture.

The Authority develops and implements water quality management strategies that address point and nonpoint pollutant sources, as well as monitoring water quality to measure the effectiveness of strategies and evaluate compliance with water quality standards. Specific Authority activities include reviewing site applications for new and existing wastewater collection and treatment facilities, reviewing wastewater utility plans, reviewing land use and development applications, developing information and education programs, planning and constructing CIPs, and monitoring data collected by the Authority in 2002 during its monitoring activities on Cherry Creek Reservoir, the tributary inflows to the reservoir, and the Cherry Creek mainstem upstream of the reservoir.

4. WASTEWATER FACILITY CONTROLS

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. The NPDES permits require dischargers to monitor and quantify the concentration and total ponds of phosphorus discharged. Table 1 presents the phosphorus allocations and loads for the wastewater dischargers in 2002.

The Cherry Creek Reservoir Control Regulation No. 72 (Control Regulation) requires that the annual report also include wastewater facility permit violations with regard to phosphorus concentration limits and

annual phosphorus loads. There were no permit violations in 2002 for TP concentrations or loads for wastewater treatment facilities in the basin.

TABLE 1: Cherry Creek Basin Point Source Allocation and 2002 Point Source Phosphorus Contribution in Pounds

Facility	Allocation (pounds)	2002 Phosphorus (pounds)
Arapahoe Water & Wastewater Authority/ Cottonwood Water & Sanitation District	402	85
Pinery Water & Sanitation District (f/k/a Denver Southeast Water & Sanitation District)	304	57
Inverness Water & Sanitation District	129	0
Parker Water & Sanitation District	533	304
Meridian Water & Sanitation District	113	0
Lincoln Park Metropolitan District (f/k/a Stonegate Village Metropolitan District	161	51
Semi-Urban Areas	236	
Industrial Process Wastewater Sources	50	
Subtotal	**1,928**	**497**
Reserve Pool	216	
Phosphorus Bank	216	
Total	**2,360**	

Notes: The 2002 phosphorus pounds reported were provided by the individual plants.
Inverness and Meridian reported zero phosphorus contributions (i.e., no leachate in down-gradient lysimeters).
Effluent was applied at agronomic rates.

5. AUTHORITY REVIEW OF SITE APPLICATIONS

The Authority reviews Site Applications and Utility Plans for wastewater collection and treatment facilities proposed in the Cherry Creek Basin. Site application reviews address protection of the Cherry Creek Reservoir specifically with respect to phosphorus and water quality in general, protection of downstream water supplies, adequacy of proposed design processes, and capacity and process designations identified in the Master Plan.

Site applications are reviewed against the following documents:

- Regulation No. 22, "Regulation for Site Application Process" (April 2001),
- Cherry Creek Basin Water Quality Management Master Plan (1989) and Watershed Plan 2000 (June 2000),
- Regulation No. 72, "Cherry Creek Reservoir Control Regulation" (September 2001),
- Metro Vision 2020 Clean Water Plan: "Wastewater Utility Plan Guidance", Denver Regional Council of Governments (DRCOG) (January 2001), and
- Policy 96-1, "Design Criteria Considered in the Review of Wastewater Treatment Facilities," expiration date May 31, 2001 ("Colorado guidance").

5.1 Development of Emergency Response Plan Criteria

The Authority's site application reviews focus on potential impacts to the watershed, streams, and reservoir. The release of untreated wastewater compromises water quality, and in 1997 and 2001, sanitary sewer overflows impacted water quality and also caused the closure of the Cherry Creek State Park swim beach. In 2001, the Authority initiated a process to develop Emergency Response Plan Criteria as a proactive approach to raise awareness and strengthen wastewater facility design and planning to eliminate water quality impacts from sanitary sewer overflows. The purpose of the Emergency Response Plan Criteria is to provide recommended requirements for sanitary sewer overflow emergency response plans in the Cherry Creek Basin to reduce the likelihood of sanitary sewer overflows and contaminants reaching Cherry Creek and Cherry Creek Reservoir. The Authority finalized the Cherry Creek Reservoir Watershed Emergency Response Plan Criteria on March 28, 2002.

Site applications in the Cherry Creek Basin are now required to include an Emergency Response Plan that satisfies the Authority's criteria that outlines the minimum planning information required in an emergency response plan as part of a site application. In addition to state requirements (Policy 96-1) for overflow

protection, pump redundancy, back-up power, and alarm systems, the Cherry Creek Emergency Response Plan Criteria also require that the applicant provide for onsite storage or an alternative. Alternatives can include:

- Bypass designed into lift station,
- Engine driven self-priming pump in separate structure with separate controls,
- Hauling plan with demonstrated adequate capacity (truck cycles, number of trucks, etc.), firm agreements for hauling and discharge, and
- Another alternative approved by the Authority.

2002 site applications submitted after the Emergency Response Plan Criteria were finalized were required to comply with the Criteria.

5.2 Site Application Reviews

The Authority reviewed the following submittals in 2002:

City of Aurora (Aurora) - *Wastewater Utility Plan (WUP)* - Aurora submitted a WUP dated January 2, 2002. The WUP outlines future growth and associated future improvements to the facilities within Aurora's Wastewater Utility Service Area (WUSA) through ultimate buildout. Only a portion of the Aurora's WUSA is within Cherry Creek Basin. Aurora is a member of the Metro Wastewater Reclamation District (Metro) and most of its untreated wastewater is conveyed to Metro. Aurora also owns and operates the Sand Creek Water Reuse Facility (SCWRF) that treats a portion of the total wastewater for reuse (e.g., irrigation of parks and golf courses) and can also discharge to Sand Creek.

Aurora anticipates that four treatment facilities will eventually be operational within Aurora's Clean Water Plan (CWP) boundary. None of the treatment facilities are located in or discharge to the Cherry Creek Basin. Aurora anticipates that four future lift stations and associated interceptors and force mains will be

located in the Cherry Creek Basin. Aurora developed and analyzed three concepts for wastewater service and recommended an alternative emphasizing gravity flow with limited pumped flow that "strives to balance the complexity and amount of facilities needed with the quantity of water available for reuse." This alternative includes the infrastructure improvements for Cherry Creek, as well as all the improvements for this alternative that are outside of the Cherry Creek Basin. The WUP identifies reuse as a primary driver for the recommended facilities and describes four future reuse applications (golf courses) within the Cherry Creek Basin. As reuse applications become available in the Cherry Creek Basin, Aurora will have to comply with state reuse regulations, discharge limits, and the phosphorus allocation for land application established by the Authority and the Control Regulation.

The proposed facilities are not discharging into the Cherry Creek Basin. Aurora does not have a wasteload allocation in the Basin and is not subject to the requirements of the phosphorus allocation unless future reuse opportunities become available. As reuse opportunities develop in the Cherry Creek Basin, Aurora will need to initiate the process to obtain a wasteload allocation. The Aurora WUP was recommended for approval, and the Authority approved the WUP on August 15, 2002.

Maher Ranch Metro District Nos. 4 and 5 (Maher Ranch) - *Maher Ranch Lift Station Site Application* - Maher Ranch submitted a Site Application and Preliminary Design Report for the Maher Ranch Lift Station on March 18, 2002. The report proposes to design and construct a lift station to service the Maher Ranch Subdivision. The developer is responsible for the capital cost of the construction and financing of the lift station. The Town of Castle Rock is the wastewater service provider, which has an agreement with Plum Creek Wastewater Authority for treatment that discharges outside the Cherry Creek Basin. The Maher Ranch Lift Station was recommended for approval, and the Authority approved the site application on May 16, 2002.

Aurora - Kings Point Lift Station Site Application - Aurora submitted the Kings Point Lift Station Site Application dated March 27, 2002. The site application proposed to design and construction of the first phase of a multi-phase lift station and force main, which will serve the Cherry Creek School District's Middle School No. 8 (600 students). The new lift station and proposed service area is within the boundaries of Aurora's Clean Water Plan planning area, Wastewater Utility Service Area and Urban Growth Boundary and will be owned and operated by Aurora. The lift station will pump wastewater outside the Cherry Creek Basin

to the Sand Creek Wastewater Reclamation Facility and Metro Wastewater Reclamation District for treatment. The Kings Point Lift Station was recommended for approval, and the Authority approved the site application on May 16, 2002.

Parker Water and Sanitation District (District) - Wastewater Utility Plan (WUP) - The District submitted a WUP dated April 2002. The WUP outlines future growth and associated future improvements to the facilities within the District's WUSA through 2020. The WUP did not include a site application for modification or expansion. The District's anticipated future capital improvements include:

- AWT improvements to the South WWTP and derating it to 1.5 mgd,
- Expanding the North WWTP to 2 mgd with AWT,
- Two new lift stations and associated interceptors and force mains, and
- Effluent force main and reservoir improvements.

The District reviewed five alternatives for wastewater treatment in 1985 as part of the site application for the South WWTP. As part of that process the District selected AWT followed by direct discharge in addition to secondary treatment followed by slow rate land application during the irrigable months. The District used this same alternative analysis to justify the North WWTP expansion and due to reliability of the South WWTP, the District continues to use similar process controls for the North WWTP. The District projects that it will reach its phosphorus wasteload allocation of 533 pounds in 2010 at 3.5 mgd. To handle the projected 2020 flow rate of 5.2 mgd, the District would require a phosphorus allocation of 772 pounds per year (assuming proposed effluent phosphorus concentration of 0.05 mg/l). The District stated that it is committed to staying within the 533 pound allocation and will utilize a variety of water control strategies post-2010 to stay under the allocation, including implementation of watershed-based trading, reducing the direct discharge volume to Cherry Creek and providing for direct reuse of effluent at Rueter Hess Reservoir. The District WUP was recommended for approval, and the Authority approved the WUP on July 18, 2002.

Town of Castle Rock - Mitchell Creek Lift Station Site Application - The Town of Castle Rock submitted the Mitchell Creek Lift Station Site Application and Lift Station Report on September 1, 2002. The site application proposed a lift station expansion at the Mitchell Creek Wastewater Treatment Plant. The lift station is within the Town of Castle Rock service area and will be built under a joint agreement between Castlewood Ranch Metropolitan District, Villages at Castle Rock Metropolitan District #4, and the Town of Castle Rock. The Town of Castle Rock is the wastewater service provider and the Plum Creek Wastewater Authority will treat the wastewater and discharge outside the Cherry Creek Basin. The Mitchell Creek Lift Station was recommended for approval, and the Authority approved the site application on October 17, 2002.

Castle Oaks Metropolitan District - Castle Oaks Lift Station Site Application - The Castle Oaks Metropolitan District submitted the Castle Oaks Lift Station Site Application and Lift Station Report. The lift station report proposes a new lift station for the Castle Oaks Development. The Town of Castle Rock is the wastewater service provider and the Plum Creek Wastewater Authority will treat and discharge the wastewater outside the Cherry Creek Basin. The Castle Oaks Lift Station was recommended for approval, and the Authority approved the site application on November 21, 2002.

Arapahoe County Water and Wastewater Authority (ACWWA) - Wastewater Utility Master Plan (WUMP) - ACWWA submitted a WUMP for review on November 1, 2002. The WUMP provides a planning framework for ACWWA and Cottonwood Water & Sanitation District (CWSD) wastewater service over the next twenty years. The WUMP does not include a site application for wastewater treatment facility expansion within the next WUMP cycle (5 years). ACWWA's anticipated future capital improvements related to treatment facility rehabilitation needs and collection system improvements include:

- Treatment facility rehabilitation (Phase 1) to address process redundancy, membrane operation and maintenance, and membrane life expectancy,
- Increase capacity of an existing lift station and construct an overflow bypass,
- Parallel and extend interceptors, and
- Construct pipeline for alternate discharge point.

ACWWA reviewed process alternatives for wastewater treatment and selected the membrane bioreactor process, which was implemented in 1998. ACWWA's current annual phosphorus allocation is 402 pounds. At current capacity (2.4 mgd), ACWWA's annual phosphorus load is 365 pounds (effluent phosphorus concentration of 0.05 mg/L). Based on DRCOG's forecasts, the treatment facility has capacity through 2020. ACWWA's flow projections suggest the treatment facility may reach capacity as early as 2011. If the treatment facility does need to increase capacity beyond 2011, the WUMP states that ACWWA would comply with the phosphorus allocation by treating to a lower effluent phosphorus concentration. Based on ACWWA's flow projections, a potential expansion to 3.5 mgd (2015 to 2020) would require an effluent phosphorus concentration of 0.038 mg/L and potential buildout flow of 5.5 mgd (beyond 2025) would require an effluent phosphorus concentration of 0.024 mg/L. The ACWWA WUMP was recommended for approval, and the Authority approved the WUMP on December 19, 2002.

6. NONPOINT SOURCE CONTROLS

In 2002, the Authority conducted a survey of land use agencies in the Cherry Creek Basin to document the status of Erosion and Sediment Control and Water Quality (ESC/WQ) Best Management Practice (BMP) programs. The survey confirmed that the land use agencies in the Cherry Creek Basin have ESC/WQ BMP programs with associated staff. These agencies include Arapahoe County, the Town of Parker, the City of Aurora, Greenwood Village, Douglas County, the Town of Castle Rock, and Centennial. ESC/WQ BMP programs at these agencies have been in place for up to 15 years and are generally staffed with engineers, inspectors, and other support personnel.

6.1 Training

Most agencies have some means of providing ESC/WQ BMP training for staff, either through internal training courses/reviews or through courses offered by CDPHE or other outside consultants. Several agencies provide training to the regulated community, generally during field meetings that include contractors and land owners. On a weekly basis, the City of Aurora offers more structured training for the regulated community by presenting a training video supplemented by information provided by their erosion control staff.

6.2 Ordinances, Inspection, and Enforcement

The ESC/WQ BMP programs for each agency have ordinances in place that provide definition for the program and a means for enforcement. The ordinances generally address the intent and requirements for ESC/WQ BMPs found in the Cherry Creek Stormwater Quality Requirements and the Control Regulation. This is accomplished through changes in the zoning regulations and adoption of stormwater drainage criteria manuals into ordinance. The Town of Castle Rock, the Town of Parker, Centennial, Greenwood Village, Arapahoe County, and Douglas County have plans to update their ESC/WQ BMP programs. Generally, the planned changes focus on updating and strengthening ordinances and guidance manuals and refining inspection checklists. In addition, the Town of Castle Rock is developing a Stormwater Master Plan that will aid in focusing ESC/WQ BMP efforts and refining guidance.

Development plans are reviewed in each agency by staff associated with the ESC/WQ BMP program and/or by the public works or land use services engineers or outside engineering consulting firms. Criteria from the ordinance provide guidance during development plan review.

Development sites are inspected by personnel that are part of the ESC/WQ BMP program or are public works or land use services inspectors. The frequency of inspections can vary depending on the size and complexity of the project. Some agencies require inspections at distinct times during construction and others inspect on a routine basis not connected with construction status. Inspections are often required prior to the start of earth disturbing activities to ensure that adequate erosion and sediment control measures are in place. Many agencies inspect sites following storm events to determine the adequacy of stormwater controls. Final inspections are often called for to confirm that the site has achieved final stabilization prior to issuance of a Certificate of Occupancy. Most agencies have forms that the inspectors use to note the status of construction, the type of BMPs being implemented, and corrective actions necessary to improve or repair the BMPs.

Each agency has a compliance enforcement program that varies in breadth, but is generally based on the severity and frequency of violations. For instance, Douglas County issues two types of violations, routine and priority. Routine violations are less of a threat to the health and safety of people and the environment. This type of violation is typically required to be remediated within 48 hours. Priority violations pose an

immediate threat to the health and safety of people or the environment, which warrants a stop work order to allow for the violation to be corrected and reinspected. Several agencies are able to levy fines for violations, while others withhold permits or collect from collateral/guarantees that the property owner is required to submit for a construction permit.

6.3 Phase II Stormwater Rule

The NPDES Stormwater Phase II Final Rule expands the Phase I rule to include all the agencies that are part of the Authority. The City of Aurora was the only agency covered under the Phase I rule in the basin. Phase II requires these small municipal separate storm sewer systems (MS4s) to, at a minimum, specify 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 new requirements will fit closely with the current ongoing programs in the basin. Changes to the ESC/WQ BMP programs for each agency will likely focus on integrating with the NPDES Phase II requirements to minimize overlap and redundancy while maximizing results. For example, Phase II permittees in Douglas County and the basin have developed ad-hoc workgroup committees to discuss and plan for Phase II coordination and identify opportunities for effective stormwater program implementation.

7. AUTHORITY REVIEW OF DEVELOPMENT PROPOSALS

The Cherry Creek Basin continues to experience development. To mitigate potential water quality impacts from construction activities and urbanization, the Authority developed a strategy to improve coordination with land use agencies to address development (i.e., land-use application) and storm drainage quality. This strategy includes the Authority taking an active role in the development (e.g., land-use applications) review process as a referral agency.

The Authority reviews focus on point and nonpoint pollutant source impacts and water quality considerations related to the proposed land use projects. The land use applications are reviewed against the criteria and standards in the Cherry Creek Reservoir Watershed Stormwater Quality Regulation. Storm runoff

from all new development must be "treated," using minimum BMPs, to reduce phosphorus discharges into Cherry Creek. The minimum standard is the "extended detention basin," which is expected to reduce total phosphorus discharges by an average of 50%. In addition, where land disturbances occur in a stream preservation area, additional measure (e.g., infiltration) are required. If the development proposal does not include these minimum requirements, the Authority recommends to the land use agency that the approval be denied.

7.1 Cherry Creek Reservoir Watershed Stormwater Quality Requirements

In 1999, the Authority adopted Stormwater Quality Requirements related to construction activities and post-construction control of stormwater quality. The purpose of these Requirements is to:

- Recommend substantive requirements to control the quality of stormwater runoff in the Cherry Creek Basin from private and public property, and to

- Reduce the loads of contaminants reaching Cherry Creek and Cherry Creek Reservoir in furtherance of health, safety, and general welfare in the Cherry Creek Basin.

The Requirements establish minimum requirements for technical measures (BMPs) that address construction erosion and sediment control and water quality enhancement for completed developments (permanent BMPs). The BMPs address impacts from residential, commercial, mining, and industrial development. The regulations also address protection of groundwater drinking supplies and stream preservation areas. A program to monitor and enforce BMP implementation is addressed by the Regulation.

In addition to recommending that each municipality and county within the Cherry Creek Basin adopt and enforce standards and criteria substantially similar to the *Cherry Creek Reservoir Watershed Stormwater Quality Regulation*, the Authority is a referral agency that reviews land use development applications within the Cherry Creek Basin.

7.2 Development Reviews

In 2002, the Authority reviewed and commented on 121 land use applications, or an average of ten reviews per month (Table 2).

TABLE 2: Sources of Land Use Application Referrals

Land Use Planning Agency	Number of Land Use Applications
Arapahoe County	16
Centennial Community Development Department	14
City of Aurora	14
City of Greenwood Village	3
Inverness Water & Sanitation District	1
Douglas County Planning	25
Town of Castle Rock	2
Town of Foxfield	3
Town of Parker Planning	43
Total	**121**

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 fall into three general categories: 1) approval of applications that meet minimum requirements, 2) the Authority takes no exception but provides recommendations or reserves the right for further review, and 3) disapproval of applications that do not meet minimum requirements.

The Authority recommended approval for 39 percent of the land use applications reviewed. Applications may receive approval if the development: meets minimum requirements, is part of an approved Master Drainage Plan that includes water quality requirements, or is served by a regional detention pond or water quality facility in accordance with Volume 3.

The Authority took no exception to about 52 percent of the applications, but provided recommendations and reserved the right for further review. Many of these applications are submitted prior to

completion of a drainage plan because they may be plats, rezoning, minor subdivisions, minor developments, sketch plans, or use by special review applications. For these applications, the Authority takes no exception at this point in the review process and identifies the requirements that must be met by the applicant. The Authority takes no exception to the applications if the applicant would agree to comply with the requirements of the Authority, Urban Drainage and Flood Control District standards, or requirements of the local land use agency that have been approved by the Authority.

The Authority did not recommend approval for 17 percent of the land use applications, because the applications were not in accordance with the Authority's Stormwater Quality Requirements. Approximately a fourth of those applications were subsequently modified and approved. However, the Authority does not always receive confirmation that the comments were addressed and, in some cases, an application that is modified to meet the requirements may be submitted in the following year As noted earlier, stormwater runoff for all new development must be "treated" using BMPs to reduce phosphorus discharges into Cherry Creek using the minimum standards outlined above. If the development proposal does not include these minimum requirements, the Authority recommends to the land use agency that the approval be denied.

8. SUMMARY OF EPA 319 GRANTS

The Environmental Protection Agency (EPA) Section 319 grants are awarded annually to projects that target nonpoint source pollution control. The Authority was awarded two EPA Section 319 grants. Both grants target nonpoint source pollution reduction within the Cherry Creek Basin through the effective utilization of BMPs and Pollutant Reduction Facilities (PRFs).

8.1 Information and Education Grant

The EPA 319 Grant awarded to the Authority, "The Role Of BMPs And PRFs In Water Quality Protection," has three main objectives: public sector education; private sector education; and education of the general public. For each of the target audiences, "education" as stated in the objectives relates to increasing the awareness of water quality issues within Cherry Creek Basin and the role that BMPs and PRFs serve as potential remedial actions to improve water quality.

Objective 1: Public Sector Education

The goal of Objective 1, Public Sector Education, is to increase the abilities of local city and county personnel to implement and control nonpoint source pollutant controls within Cherry Creek Basin; and the work products for Objective 1 are educational programs complemented by existing materials such as videos and curricula, for government entities in the Basin. To begin the development of educational programs, the Authority researched existing training materials. In order to compile and gather existing training materials, actions completed under this task included meeting with representatives from various entities, such as UDFCD, DRCOG, and Arapahoe County, researching materials on the internet, phone calls with planning agencies with the Cherry Creek Basin, and participating in the November 2001 Cherry Creek Stewardship Partners Annual Conference. At the conference, the Authority displayed posters of the two EPA 319 grant projects awarded to the Authority to raise awareness of the ongoing water quality efforts within the Cherry Creek Basin. The Authority also distributed survey forms at the conference for other participants to provide input on what existing educational materials they were aware of and what educational programs they would like to see developed. Through these efforts, sufficient materials were identified to serve as a foundation for building an education program.

Taking research findings into consideration, a program was developed consisting of a series of fact sheets that complement the existing land use application process within the Cherry Creek Basin, and that could be dynamic and updated with changes in regulations and requirements. This program is entitled *The BMP Series*. The purpose of *The BMP Series* is to educate the variety of audiences involved in all aspects of the land use application review process about the goals and criteria of the Authority, such as those described in the Authority's Stormwater Quality Requirements. In addition, *The BMP Series* will increase awareness of the role and benefit of BMPs in the development process for the purpose of improving water quality. Within a given town, city or county, planning agencies, engineers, and council members or commissioners will be provided with fact sheets during the proposed land use application review process. In order to receive feedback from various advisory boards, a draft of *The BMP Series* was presented to the Education and Outreach Committee of the Cherry Creek Stewardship Partners on August 21, 2002 and to the Authority's Technical Advisory Committee on October 3, 2002, and presented at the November 1, 2002 Cherry Creek Stewardship Partners Annual Conference. The fact sheets will be finalized and distributed in 2003.

Objective 2: Private Sector Education

The goal of Objective 2, Private Sector Education, is to increase the abilities of local private sector contractors, developers and engineering personnel to plan for design, implement and control non-point source pollutant controls within Cherry Creek Basin; and the work product for Objective 2 is educational and training materials for private sector personnel involved with the planning, design, construction, and maintenance of BMPs and PRFs in the Basin. The Authority has completed the research of existing training materials related to construction education. UDFCD and DRCOG were able to provide information on training materials developed for private sector personnel. In addition, private sector contractors and associations were contacted to inquire about what educational materials are available and used, and what additional materials would be beneficial if developed. Internet research was conducted to determine what information was readily available.

The BMP Series was expanded so that it could meet both Objectives 1 and 2. In addition to having fact sheets that are targeted towards planning agencies, engineers, and council members or commissioners, specific fact sheets will be distributed to local contractors, developers and engineering personnel to provide guidance in planning, designing, and implementing nonpoint source pollutant controls (i.e., BMPs), in the land use application review process. Through *The BMP Series*, fact sheets will be available to both to land use agencies and construction sites.

Objective 3: Public Education

The goal of Objective 3, public education, is to work with Cherry Creek State Park staff and water and wastewater utilities in the Cherry Creek Basin to increase awareness regarding the importance and value of BMPs in Cherry Creek Reservoir, for the purpose of gaining public support and participation in protecting water quality; and the work products for Objective 3 are pre- and post-surveys, a kiosk at the park, and newsletter articles for distribution to watershed inhabitants. Work completed includes meetings held with park staff, a drafted scope of work for a communications consultant for signage development, and discussions to determine the location of the kiosk within the park. Next steps include scheduling meetings to coordinate between the Authority, park staff, and a communications consultant, to continue kiosk planning. Information

was identified for distribution to residents of the Cherry Creek Basin, and was incorporated into a fact sheet that is part of *The BMP Series*.

8.2 Lower Cottonwood Creek Water Quality Plan Activities Under the EPA 319 Grant

The main goal of the EPA 319 Grant awarded to the Authority, "The Lower Cottonwood Creek Water Quality Plan," is to minimize erosion of Cottonwood Creek within the Cherry Creek State Park and to protect and improve the performance of the Perimeter Road Water Quality Pond. The "The Lower Cottonwood Creek Water Quality Plan" (Plan) outlines six main objectives to be carried out in order to achieve the main goal.

The work product for Objective 1, to reduce sediment migration from streambank erosion in Lower Cottonwood Creek, is to construct grade control structures, re-grade steep banks, and encourage natural vegetation in order to achieve sediment and phosphorus load reduction in 7,700 linear feet of stream. The Authority has performed the following tasks under Objective 1:

- The Authority has developed a detailed scope of services for the design of the pollutant reduction facility,
- Consultants submitted qualifications and a short list was developed by the Authority,
- Consultants prepared detailed proposals and made oral presentations to the Selection Committee,
- A consultant was selected by the Authority's Board, and
- Investigations were conducted to quantify the benefits of stream restoration, in terms of additional phosphorus reduction. These investigations were conducted because restoration differs from stabilization in that the focus of restoration is to construct a channel and floodplain that mimics the conditions prior to significant anthropogenic influences in the

region. A restored channel allows regular occurring floods to become connected to the floodplain and allow for filtration and/or infiltration of runoff.

The work product for Objective 2, to reduce sediment migration from streambank erosion upstream of target area, is the construction of detention pond, Cottonwood-Peoria Street Water Quality Detention Pond, for subsequent phosphorus load reduction. 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, to contribute funding to the design and construction of the Cottonwood-Peoria Street Water Quality Detention Pond. UDFCD managed the project. Construction began in the summer of 2001, and the water quality portion of the Peoria Street Pond was substantially complete on May 31, 2002, and is currently functioning. Other aspects of the project, such as utility components, are still in progress. The project was constructed with a sediment basin to improve the overall performance of the pond and to further protect the Perimeter Road Water Quality Pond.

The work product for Objective 3, to reduce sediment migration from streambank erosion downstream of the target area, is the construction of detention pond for subsequent phosphorus load reduction. As per the grant schedule, this Objective has not yet begun.

The work product for Objective 4, to measure phosphorus removal from constructed facilities, are the water quality data and documenting the effectiveness of pollutant removal. Water quality sampling has occurred to provide current and baseline data. These efforts include site visits to assess stream conditions and select permanent monitoring sites that bracket the new Peoria Street Water Quality Detention Pond, and field collection of water quality samples during baseflow and storm events.

The work products for Objective 5, to monitor the design and construction of Cottonwood-Peoria Street portion of the Plan, are regular monthly meetings, routine site visits, and review of documents. The schedule indicates that this will be carried out from the first quarter through the twelfth quarter of the contract duration. The final design for the project was completed in May 2001 and construction started July 2001. The Authority performed the following tasks relative to Objective 5:

- Reviewed and provided direction during final design of the project,
- Participated in the bid and award process, and
- Monitored the status of construction.

The work product for Objective 6, to increase general public awareness of BMPs, is to develop educational signage describing the Plan. Once the design phase of Objective 1 is underway, these meetings and review will begin.

9. CAPITAL IMPROVEMENT PROJECTS

9.1 Authority Capital Improvement Program Planning

The Authority implemented a multi-year capital improvement project (CIP) planning process in 2002 by identifying potential PRF projects and costs, and extending them over a three-year period. The multi-year projections, which are part of the Authority's annual budgeting process, divides each potential project into capital, land acquisition, water requirements, and operations and maintenance costs. These costs are then spread-out over a three-year period for longer-range planning purposes and are subject to available Authority funds.

It is anticipated that during each Authority budgeting period, the 3-year projections will be updated to reflect new projects and projects completed, deferred, abandoned, or modified in some way. The multi-year CIP projections also help to track capital expenditures such that statutory requirements (Colorado Revised Statutes) are met, since some project costs are allocated in one year but often encumbered in subsequent years.

9.2 Funding Opportunities

Because the CIP project costs exceed the Authority's ability to fund the program, the Authority has investigated potential sources to assist with construction, operation and maintenance of future PRFs. One

source is the U.S. Army Corps of Engineers (USACE) Continuing Authorities Program (CAP). Since projects under CAP do *not* require congressional authorization for a particular project, implementation from planning to construction in three years is feasible.

The Authority PRF projects could fall into one of two programs under the CAP, either Section 1135 (Water Resources Development Act of 1995) "Project Modifications for Improvement of the Environment" or Section 206 "Aquatic Ecosystem Restoration". Both of these programs have upper limits of $5,000,000, which includes study, design and construction.

Under the 1135 Program, the project must be tied to an existing USACE project and the cost sharing requirements are 75/25. This requirement may limit projects to Cherry Creek Reservoir itself, which the Authority currently has near-term plans. Under the 206 Program, however, the funds are for improvements to rivers, lakes and wetlands with cost-effective environmental benefits, with a cost sharing of 65/35.

The Authority will investigate other funding opportunities as part of the Watershed Plan 2003 in fiscal year 2003.

9.3 Bowtie Property Acquisition

The Authority has partnered with UDFCD, Trust for Public Lands, City of Centennial and Arapahoe County (collectively called Parties) to purchase property adjacent to Cherry Creek State Park at the confluence of Piney Creek and Cherry Creek (called Bowtie property). The property to be acquired by the Parties totals 21.5-acres, of which the Authority will obtain rights to construct and operate a PRF on 10.5 acres.

The conceptualized design for the PRF includes channel stabilization, wetlands, and a sediment pond (located off the Bowtie land on property owned by Arapahoe County). Project costs are estimated to $1.1 million, which includes $300,000 from the Authority to purchase rights to construct the PRF as part of property acquisition. Long-term, annual phosphorus immobilization is expected to be 235-pounds, which results in an annual cost of $400 per pound of phosphorus.

The Authority will also obtain rights in one shallow tributary well (Permit No. 2357-F) and a deep, non-tributary well (Permit No. 10659-F), with a yield from 38 to 52 acre-feet per year. These wells are located on property adjacent to the Bowtie property and can be used for augmentation purposes in the future.

9.4 Cherry Creek State Park Wetlands

The Authority initiated the design process and completed a feasibility evaluation of the Cherry Creek State Park Wetlands PRF project. The results of the feasibility evaluation determined that the original concept was not feasible due to concerns for adequate water supply. But, the evaluation identified a feasible alternative design concept with potential for increased phosphorus reduction. The alternative design concept proposes to improve flow distribution in existing riparian corridor upstream of the reservoir, to enlarge and enhance existing natural wetlands treatment processes along the creek, and to reduce phosphorus in baseflows and storm runoff through settling, soil filtration, and wetlands treatment. Phosphorus removal is estimated to be 600 to 1,200 pounds on a long-term average annual basis.

9.5 Cottonwood Creek Stream Stabilization Project

The Authority initiated the design process and completed a feasibility evaluation of the Cottonwood Creek Stream Stabilization Project PRF (also see Section 6, Summary of EPA Grants, Lower Cottonwood Creek Water Quality Plan Activities under the EPA 319 Grant, Objective 1). The results of the feasibility evaluation determined that this project is feasible and practical, and is projected to exceed the initial water quality goals for the project. The proposed project will go beyond stabilizing Cottonwood Creek between Peoria Street and the state park perimeter, and will recreate a natural, well-vegetated, functional stream system that will provide water quality, habitat, and aesthetic benefits. The project will reclaim the creek as a meandering, shallow prairie stream that will overtop with fairly frequent storm events to reduce velocities and erosional forces. In addition, depressions and impoundments will be created to detain storm runoff and promote settling and infiltration. Estimated long-term average annual phosphorus reduction is expected to be between 300 and 600 pounds at a cost of $300 to $600 per pound of phosphorus reduced.

9.6 Construction Adjacent to Cherry Creek State Park

The Authority has reviewed and commented on several proposed projects adjacent to Cherry Creek State Park, at the request of Parks. The Authority's review is based on Authority Requirements (Authority 2000b) for minimum best-management-practices for land disturbances in the Reservoir Watershed and potential direct impacts to the Cherry Creek State Park.

The Authority worked directly with Greenwood Village on the Belleview Avenue and Union/Dayton Avenue street modification projects to incorporate additional BMP to minimize sediment, trash and debris entering the park. The Authority also worked with CDOT to implement similar BMP into CDOT's proposed modifications to the Parker Road/Quincy Avenue interchange. The Authority will continue to work with local jurisdictions to protect Cherry Creek State Park.

9.7 Cherry Creek Corridor Major Drainageway Planning Study

The Authority participated in the planning of the Cherry Creek major drainageway, along with the sponsoring agencies the UDFCD, Arapahoe County, Douglas County, Town of Parker and Cities of Centennial and Aurora. Stabilization of Cherry Creek has been identified as a priority since the Authority's 1985 Cherry Creek Master Plan. The Alternative Evaluation Report (Plan) (URS 2002) evaluated five alternatives for the Cherry Creek Corridor, including "no-action", corridor acquisition, and extensive stabilization. The consultant recommended *"Channel Stabilization and Reclamation/Water Quality Enhancements" (*Alternative 5) to the project sponsors for conceptual design in the next phase (Phase B) of the study. Alternative 5 integrates stream reclamation and water quality improvements.

The Authority believes that implementation of Alternative 5 will improve the overall water quality in Cherry Creek and the Reservoir as follows and has endorsed the Plan:

- *Stream corridor preservation and reclamation*. Land conservation has been identified as a critical tool to manage water quality in most watersheds, from those categorized as "sensitive" to those highly impacted but "restorable" systems (Center for Watershed Protection 1998).

The Authority strongly supports this approach and will be investigating its potential more thoroughly in our *Watershed Plan 2003*.

- *Vertical bed control stabilization with 2-foot high drop structures*. This measure will reduce the total sediment load into Cherry Creek Reservoir, which has been a priority for the Authority since the original 1985 Master Plan.

- *Constructed wetlands as part of the bank stabilization measures*. The *Plan* identified approximately 65 acres of wetlands that would be constructed as part of bank stabilization measures. This measure will "filter" some of pollutants out of the storm runoff and base flows in Cherry Creek before reaching the Reservoir, thereby improving water quality.

- *Enhanced wetland creation as part of the vertical bed control*. Bed stabilization using drop structures across the riparian zone can result in soil saturation, which typically results in wetland corridors in the channel bed. The *Plan* identifies approximately 30,000 linear feet of "enhanced wetlands with varying widths."

The Authority's "Bowtie" project, which is similar in concept, proposes to stabilize approximately 1,100 linear feet of Piney and Cherry Creeks with the expectation of enhancing wetland areas by 8 acres. Whereas 30,000 linear feet could result in over 200-acres of wetlands, this project is highly speculative. It does, however, illustrate the significant potential for stabilization measure to improve water quality.

9.8 Arapahoe County Water and Wastewater Authority (ACWWA)

The Authority previously identified in its Watershed Plan 2000 (Authority 2000a) modifications to two detention ponds to create PRF. These two ponds (Pond L-3 and Pond W-8) are located within the jurisdiction of ACWWA, one in Lone Tree Creek and one in Windmill Creek, both tributaries to Cottonwood Creek. Due in part to potential phosphorus trades for retrofitting of existing facilities (CWQCC 2001), ACWWA has reserved the right to modify the two detention ponds to increase phosphorus immobilization. As such, the two projects were dropped from the Authority's capital projects list for 2002 and additional projects have been added.

10. RIPARIAN AND WETLANDS PROTECTION

As described in the CIP section, the Authority has initiated three projects in its CIP planning process that addresses riparian and wetlands enhancement and restoration (i.e., Bowtie property, Cherry Creek State Park wetlands, and Lower Cottonwood Creek PRFs). In addition to capital projects, the Authority's Stormwater Quality Requirements also require additional BMPs (above minimum requirements) for development activities in stream preservation areas.

11. WASTELAND ALLOCATION

There were no temporary transfers or Reserve Pool actions in 2002.

12. TRADING PROGRAM

In 2002, the Authority began revising the Trading Program guidelines to concur with the Control Regulation. Revisions are expected to be completed in spring 2003.

13. CHERRY CREEK RESERVOIR WATERSHED MONITORING ACTIVITIES

13.1 Cherry Creek Reservoir

Cherry Creek Reservoir - Summary of Data

Based on the past eleven years of monitoring (as summarized in CEC 2003), the following observations can be made:

- Average July - September mean chlorophyll *a* content in 2002 was lower than those observed in 1996 to 2001. The July - September 2002 chlorophyll *a* concentration was the first value below 20 µg/L since 1995 (Table 3). There is no statistical difference in the summer mean chlorophyll *a* levels over the past seven years. Only three of the last eleven (1993-1995) have met the new standard of 15.0 µg/L. The 1992 - 2002 July - September seasonal means of

total phosphorus (ranging from 48 to 96 µg/L) have all exceeded the current goal of 40 µg/L. The nitrogen concentration measured in 2002 was higher than in 2001.

TABLE 3: Water quality and total phosphorus loads data for Cherry Creek Reservoir, July - September 1992 - 2002.

Year	Chlorophyll *a* (µg/L)	Secchi Depth (m)	Total Phosphorus (µg/L)	Total Nitrogen (µg/L)	Annual Phosphorus Load (lbs/yr)*	Annual Inflow (ac/ft)*	Standardized Phosphorus Load (lbs/ac-ft)
1992	17.0	0.9	66	970	5,857	7,474	0.78
1993	14.4	1.2	62	826	4,110	5,905	0.70
1994	10.0	1.1	59	1,144	4,049	7,001	0.58
1995	9.4	1.6	48	913	7,972	11,781	0.68
1996	20.5	1.6	62	944	4,715	7,644	0.62
1997	22.3	1.0	96	1,120	5,761	10,362	0.56
1998	26.5	1.0	89	880	13,577	20,903	0.65
1999	28.9	1.0	81	753	17,471	27,739	0.63
2000	25.2	1.0	81	802	12,593	18,610	0.68
2001	26.1	0.8	87	757	9,837	17,250	0.57
2002	18.8	0.9	74	858	4,246	7,498	0.57
11-Year Mean	19.9	1.1	73	906	8,199	12,924	0.64
Median	20.5	1.0	74	880	5,857	10,362	0.63

* Stream, alluvium, and precipitation.

- Lake transparency (as measured by Secchi depth) increased slightly (i.e., clearer water) in 2002, but was lower than values observed from 1993 to 2000.

- Annual total phosphorus loads have averaged 8,199 pounds/year over this eleven-year period (Table 3), meeting the phased TMAL of 14,270 pounds each year, except for 1999. The exceedance of the phased TMAL (referred to as a phased TMDL prior to May 2001) in 1999 appeared to be related to substantially increased inflows (Table 3). Inflow (7,498 ac/ft) and phosphorus load (4,246 lbs) were below the eleven-year mean values in 2002. The phased TMAL for total phosphorus was not exceeded in 2002.

Annual Reservoir Monitoring Activities - 2002

The aquatic biological and nutrient monitoring study on Cherry Creek Reservoir and selected off-lake sampling sites (tributary streams) was conducted by CEC in 2002. These data can be found in the *2002 Annual Monitoring Report* (CEC 2003). The specific objectives of this study included the following:

- Determine the concentrations of selected nutrients, primarily nitrogen and phosphorus species, in Cherry Creek Reservoir, tributaries to the reservoir, and the reservoir outflow.

- Determine loading rates of phosphorus to Cherry Creek Reservoir from tributaries and precipitation, and the amount leaving the reservoir through its outlet.

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

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

Sampling in 2002 was conducted at ten sites, eight of which were established during past sampling efforts with two new stream sites established in 2002 (CEC 2003). There are three sites in Cherry Creek Reservoir, six sites on influent streams, and one site on Cherry Creek downstream of the reservoir (Fig. 1). The Authority also contracted with State Parks Department to provide assistance with field sampling for the summer in-lake water quality samples. The sampling season in 2002 for water chemistry and biota was from January through December. Due to unstable ice on the reservoir in February and December, lake sampling did not occur during those months.

Water transparency (or water clarity as measured by Secchi disk depth) for the entire 2002 monitoring period averaged 0.8 m, and the July to September period averaged 0.9 m (Table 3). Values were greatest in July, and varied through the remainder of the sampling season (CEC 2003). Water clarity was also monitored with a combined-deck photometer using the 1% transmissivity to approximate the photic zone. The 2002 mean 1% transmissivity depth was 2.9 m, and the July to September average depth was 2.8 m.

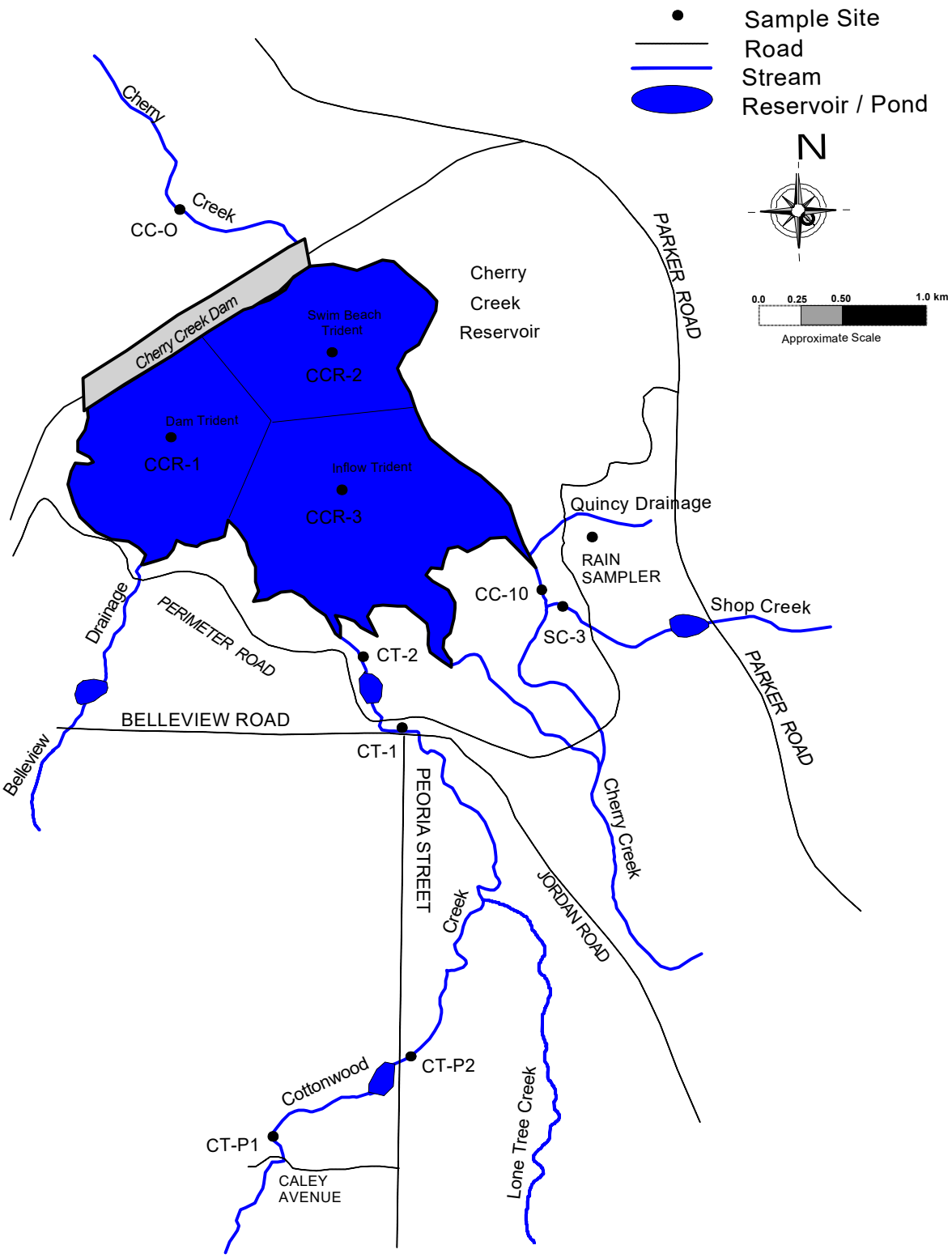

FIGURE 1: Sampling sites on Cherry Creek Reservoir and influent streams, 2002.

Analysis of past Cherry Creek Reservoir temperature profiles indicates that stratification occurs when there is a >2• C difference between surface and bottom temperatures (Jones 1998). Differences of approximately 1• C suggest a recent mixing event (Jones 1998). Using the above criteria, the deep-water site at Cherry Creek Reservoir (CCR-2) experienced a period of thermal stratification in 2002 from late May to early July (Fig. 2).

Dissolved oxygen concentrations were periodically reduced in the lowest levels of the reservoir. Dissolved oxygen concentrations at the bottom of the reservoir (5-7 m) dropped to anoxic levels from late May to mid-August (Fig. 3). The warmwater aquatic life standard for dissolved oxygen is 5 mg/L (Colorado DPHE 2001). For lakes, this criteria is intended to apply to the upper levels when the lake is stratified, i.e., the epilimnion and metalimnion (Colorado Department of Public Health and Environment 2001). As such, during those periods when the lake appears to be stratified (i.e., greater than 2• C difference from surface to bottom), as summarized in Fig. 2, the 5 mg/L criterion would apply primarily to the middle and upper depths (perhaps the upper 4-5 m). The 5 mg/L standard applies throughout the water column during mixed conditions. Exceedances of the criterion were measured during the period of stratification at depths of 4 and 5 m. There are also "non-stratified" periods when the deeper waters had dissolved oxygen below 5 mg/L (Fig. 3), specifically from early July to mid-August. These may constitute exceedances of the 5 mg/L criterion for those portions of the reservoir with low dissolved oxygen. When these values occurred, those depths with low dissolved oxygen represented approximately 9-18% of lake volume. The reservoir is currently on the "Monitoring and Evaluation" list for dissolved oxygen.

The mean concentration of chlorophyll *a* measured in the reservoir from July to September was 18.8 µg/L in 2002 (Table 3). This value was lower than the value observed in 2001 (26.1 µg/L), but exceeded the standard of 15 µg/L. During the July through September period, concentrations of total phosphorus averaged 74 µg/L in 2002 (Table 3). This value exceeded the 40 µg/L goal established in September 2000, and was equal to the eleven-year median value of 74 µg/L. Total nitrogen averaged 858 µg/L from surface samples during 2002, and was lower than the eleven-year mean. Nutrient profile samples collected in 2002 showed a well mixed reservoir in spring and fall (Fig. 4). It appears there were brief periods of possible nutrient release from the bottom sediments through the summer as evidenced by increasing total phosphorus concentrations with increasing depth (Fig. 4).

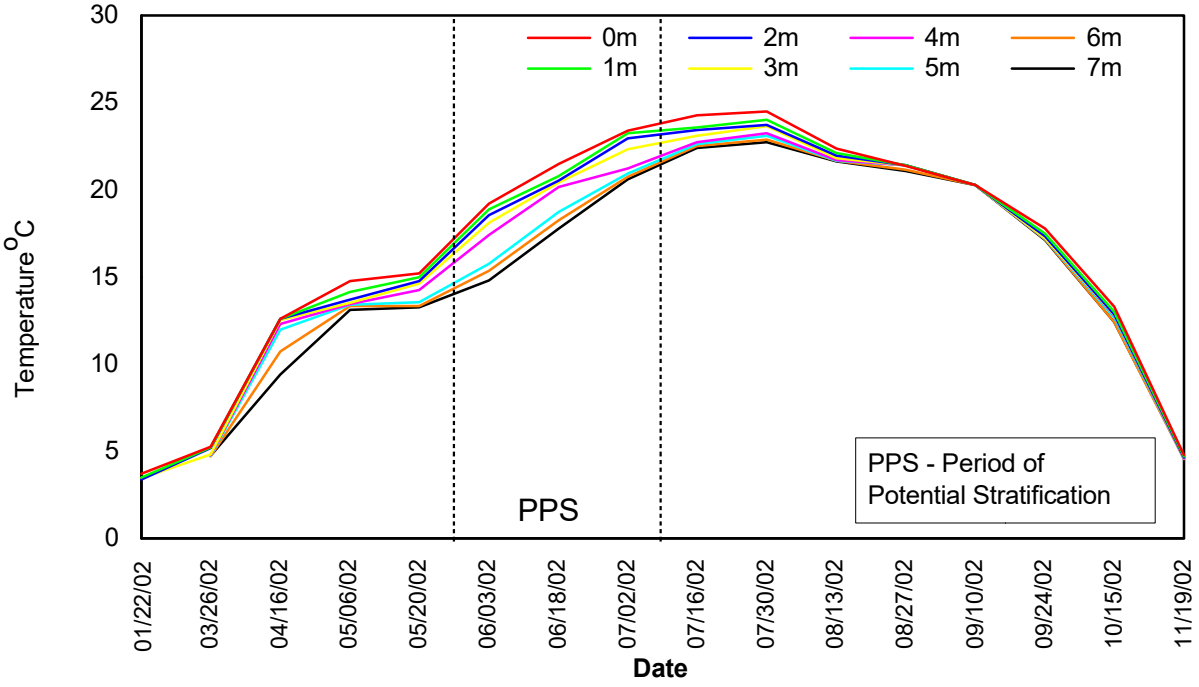

FIGURE 2: Temperature (•C) profiles recorded during routine monitoring at CCR-2 in 2002.

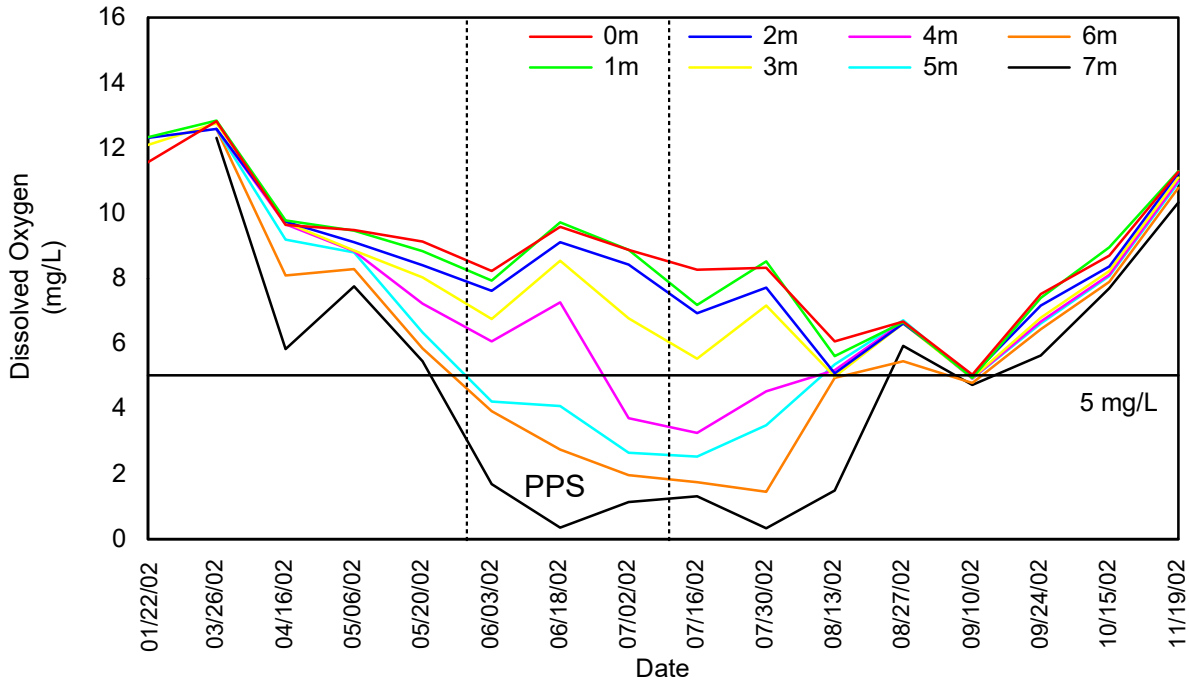

FIGURE 3: Dissolved oxygen (mg/L) profiles recorded during routine monitoring at CCR-2 in 2002 (warmwater dissolved oxygen criteria = 5 mg/L).

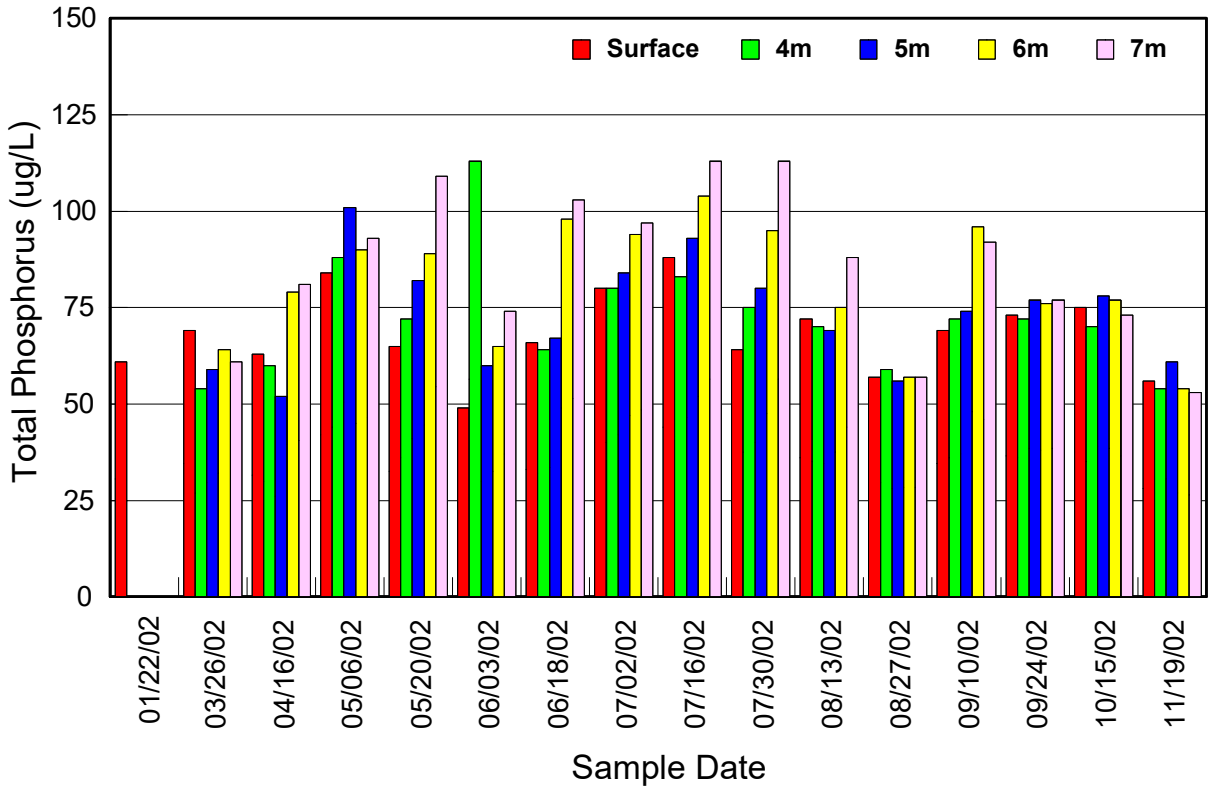

FIGURE 4: Phosphorus concentrations from profile samples at Site CCR-2, Cherry Creek Reservoir, 2002.

Phytoplankton densities and species richness varied throughout 2002 (CEC 2003). Green algae were the most abundant algal group during the majority of the sampling events, comprising 44% of the total algal densities in 2002. Historically, blue-green algae have dominated the phytoplankton community in Cherry Creek Reservoir.

From 1985 to 2002, ten fish species and two hybrids have been stocked by the CDOW in Cherry Creek Reservoir. Rainbow trout and walleye have been stocked every year; channel catfish were stocked every year until 2002. Past sampling by CDOW indicates the fish community in Cherry Creek Reservoir is dominated by gizzard shad, an effective zooplanktivore (CEC 1998, 1999).

13.2 Cherry Creek Mainstem Monitoring

Phase I Baseline Water Quality Data Collection Study for Cherry Creek Mainstem

The Phase I Baseline Water Quality Data Collection Study for the Upper Cherry Creek Basin watershed was initiated in August 1994 and has been operated continuously through calendar year 2002. This study is being conducted for the Authority by John C. Halepaska and Associates, Inc. (JCHA).

As part of this study, water quality data are collected at ten surface water stations from Castlewood Canyon to Cherry Creek Reservoir and from nine alluvial ground water well locations from just downstream of Franktown to Cherry Creek Reservoir (Table 4). Surface water station CC-7 and ground water well location MW-7 were abandoned during calendar year 2000 due to development. Surface water station CC-9 was abandoned as a sampling and monitoring location in 2002. Data provided by CEC from location Site CC-10 was used as the downstream end of the reach for calendar year 2002.

During calendar year 2002, the Phase I Water Quality Data Collection Study was reduced in scope to re-focus efforts on evaluating nutrient loading in the basin upstream of Cherry Creek Reservoir. Therefore, water quality monitoring for 2002 included monthly sampling for (a) phosphorus and nitrogen species and (b) chloride and sulfate. This water quality monitoring parameter list represents a reduction from the parameters monitored during the previous years of the study (Table 5).

All flow and water quality monitoring in the Phase I baseline study is conducted using standardized quality assurance/quality control (QA/QC) procedures based on a QA/QC manual which was prepared to describe the procedures to be used for all field measurements and sample collection (JCHA, June 1994).

TABLE 4: Water Quality Monitoring Stations for Phase I Baseline Study.

Surface Water	Location
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 Lin
CC-7	¾ mile south of Arapahoe Road (no longer a water quality sampling location)
CC-8	½ mile north of Arapahoe Road
CC-9	in Cherry Creek State Park, near Nature Center
Ground Water	
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[1)]	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
MW-8	Arapahoe Deem production well
MW-9	monitoring well in Cherry Creek State Park near Nature Center
Kennedy	Denver production well adjacent to Kennedy Golf Course

[1)] Replaced MW-4 in January 1995 when MW-4 was abandoned due to development.

TABLE 5: Water Quality Monitoring Parameters List

Monthly Water Sampling[1)]	Semi-Monthly Sampling[3)]
Ammonia	Total Dissolved Phosphorus
Nitrate	Soluble Reactive Phosphorus
Total Dissolved Phosphorus	Total Phosphorus[2)]
Soluble Reactive Phosphorus	
Total Phosphorus[2)]	
Chloride	
Sulfate	

[1)] At all ground water and surface water sampling sites.

[2)] Analyzed only in surface water samples.

[3)] At only surface water sampling sites during February through May.

Surface Water Quality Summary

The water quality data collected to date indicate that soluble reactive phosphorus (SRP) concentrations in both the Cherry Creek channel and in the underlying alluvial aquifer are generally in the range of 0.01 to 0.3 mg/L (Fig. 5). When the water quality data at the upstream end of the study reach (Castlewood) are compared to the downstream end of the study reach (Sites CC-9 and CC-10), there appears to be an increasing trend in phosphorus concentrations at Sites CC-9 and CC-10 versus Castlewood, although the correlation of the data to the trend line is very weak, as noted by the low R^2 value (Fig. 6). These SRP concentration data would indicate virtually no changes over the course of the study period at the background station at Castlewood, while there have been increasing concentrations at the downstream stations CC-9 and CC-10.

To evaluate this perceived trend, we have also correlated trends in changes in flow over the study period and a correlation between flow and SRP concentrations. Figure 7 shows the correlation of flow over the study period (1994-2002), which indicates that there has been slightly increasing flow at Castlewood, while at Sites CC-9 and CC-10, the flow pattern has been relatively stable over the course of the study period. It should be noted that the increase in flow with time at Castlewood, with no associated flow change at Sites CC-9 and CC-10, is unusual, as the Cherry Creek drainage area more than doubles, from 169 square miles to 385 square miles in this reach. While water use is relatively minimal upstream of Castlewood Canyon, water use between Castlewood and Cherry Creek Reservoir is very significant. The Cherry Creek Water Users Association operates the majority of its irrigation wells in this reach, as well as municipal water supply providers operating large production alluvial wells, (the Pinery Water and Sanitation District, the Parker Water and Sanitation District, Stonegate Metropolitan District, Cottonwood Water and Sanitation District, the City of Aurora, and Arapahoe Water and Wastewater Authority). Therefore, while it is expected that there would be significantly more flow at Sites CC-9 and CC-10, given the increase in drainage area, this generally does not occur, due to the multiple uses of water through the study reach.

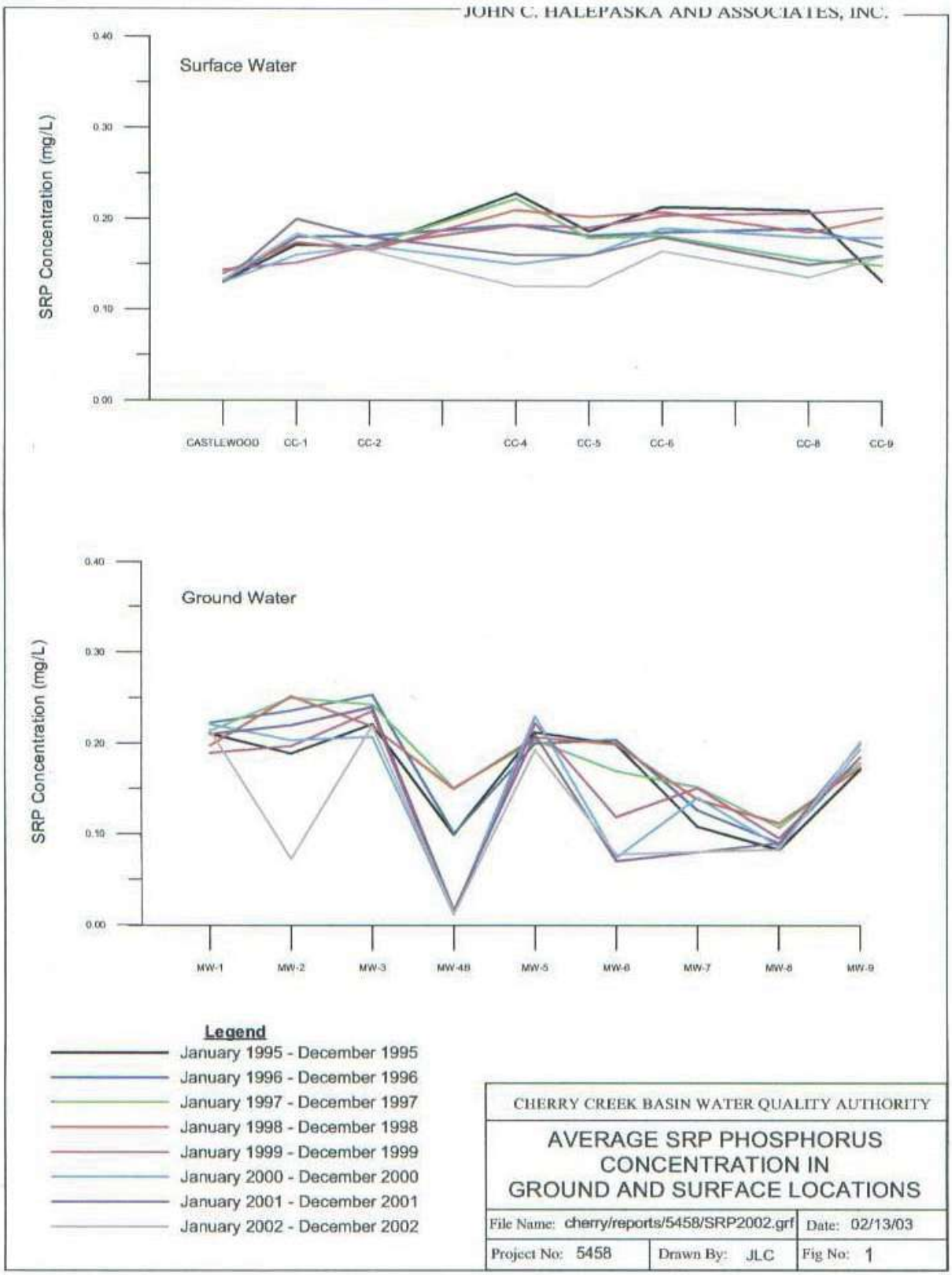

FIGURE 5: Average SRP phosphorus concentration in ground and surface locations, 1995-2002.

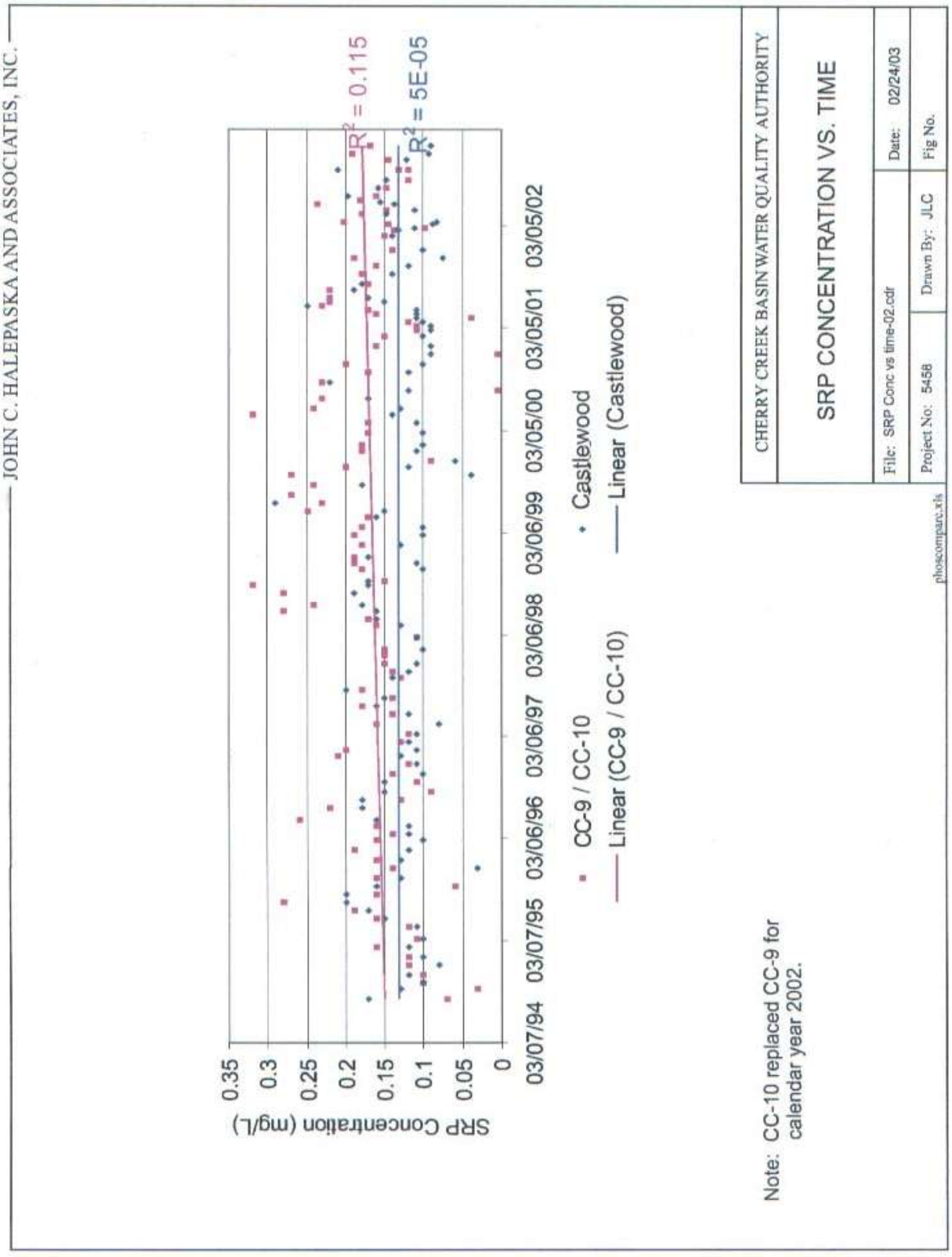

FIGURE 6: Soluble reactive phosphorus concentrations over time at Castlewood Canyon, CC-9, and CC-10 sampling locations on Cherry Creek, 1994-2002.

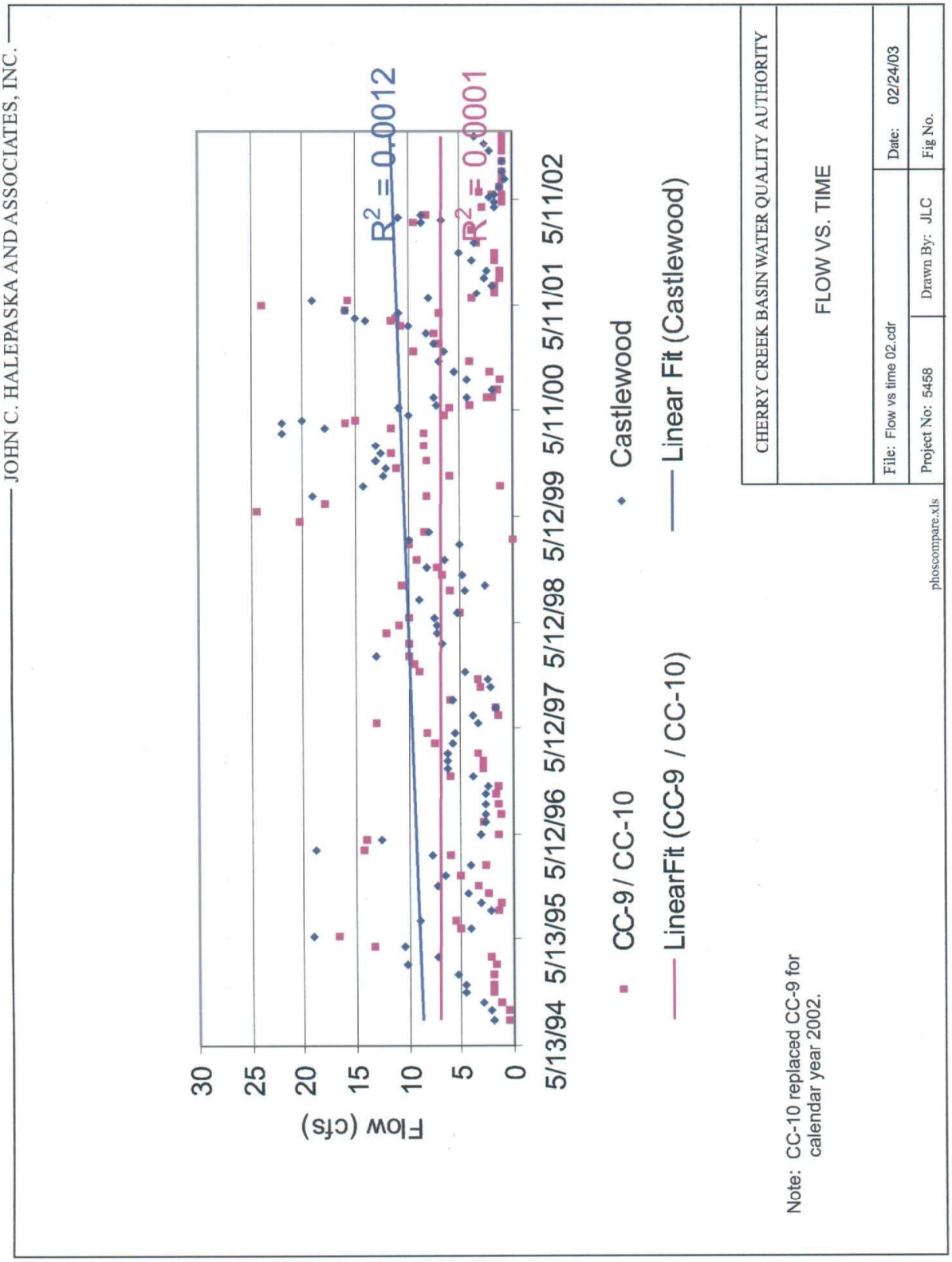

FIGURE 7: Measured flow at Castlewood Canyon, CC-9, and CC-10 sampling locations, Cherry Creek, over time, 1994-2002.

When flow is correlated to SRP concentration at the Castlewood and Sites CC-9 and CC-10, it is indicated that SRP concentrations increase as a function of increased flow at the downstream stations (Sites CC-9 and CC-10), but change very little at the upstream station (Castlewood). As flows increase in a stream channel, there is more wetted perimeter that provides additional contact with phosphorus-rich sediments in the creek channel (which are known to exist through the study reach from past quarterly sediment samples). This may be the reason for the increased SRP concentrations with increases in flow at the downstream station, which is in an earthen channel, but not at the upstream station, which flows over bedrock. However, the relationship of change in SRP concentration per unit increase in flow appears to be different at Castlewood versus Sites CC-9 and CC-10, as shown in Figure 8. Again, the fit of the data to the trend line is weak, and these data should be viewed accordingly.

There are several potential reasons that the SRP concentration correlation to flow is different at Castlewood than at Sites CC-9 and CC-10. These factors include (a) less agricultural activity upstream of Castlewood than in the study reach from Castlewood to Cherry Creek Reservoir, (b) urbanization through the study reach is exposing additional soils to surface runoff that have historically not been exposed, which increases the potential for mobilization of SRP, and/or (c) increased precipitation runoff in the urbanized areas has increased the potential for mobilization of SRP to achieve a chemical equilibrium in the stream.

There are no discernable changes in phosphorus concentrations at monitoring locations downgradient of direct dischargers that would imply dischargers are currently impacting phosphorus loads to the reservoir (Fig. 5). This is to be expected, as municipal wastewater dischargers are required to meet a 0.05 mg/L effluent limit, which is generally well below ambient phosphorus concentrations in the stream.

Using phosphorus concentration and flow data at Cherry Creek Reservoir (Sites CC-9, CC-10, and MW-9) and comparing those data to the discharge monitoring report (DMR) data from each direct discharger, indicates that nonpoint phosphorus loads are consistently greater than 90 percent of the total load entering Cherry Creek Reservoir from the main stem of Cherry Creek. These data have been collected on a monthly basis since 1994 and are consistent, regardless of flow conditions (Fig. 9). These data are indicative of natural geologic conditions, where phosphorus in the form of calcium phosphate in the soil is mobilized by surface runoff, either from natural surfaces or urbanized areas, and ground water underflow.

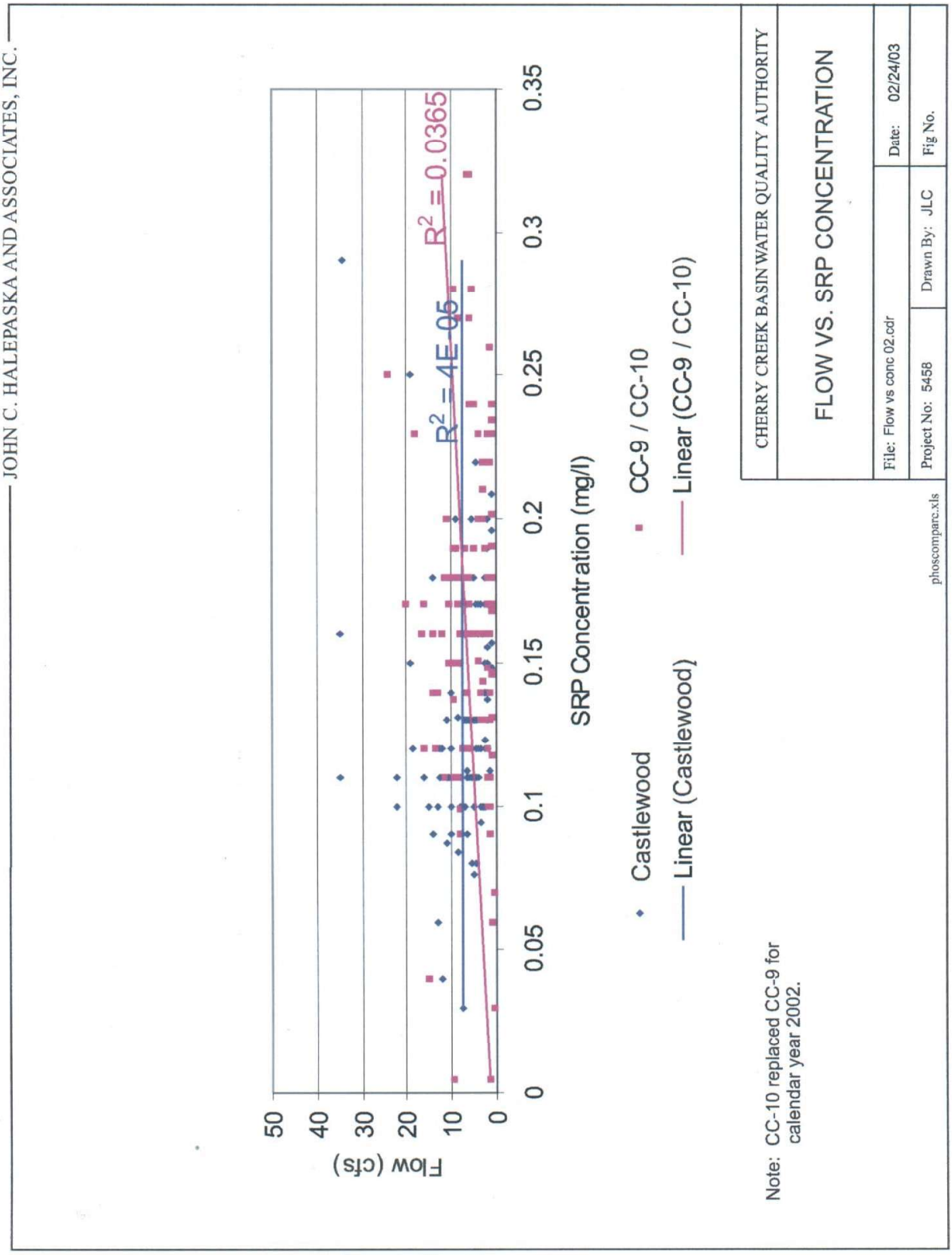

FIGURE 8: Relationship between measured flows and soluble reactive phosphorus concentrations at Castlewood Canyon, CC-9, and CC-10 sampling locations, Cherry Creek, 1994-2002.

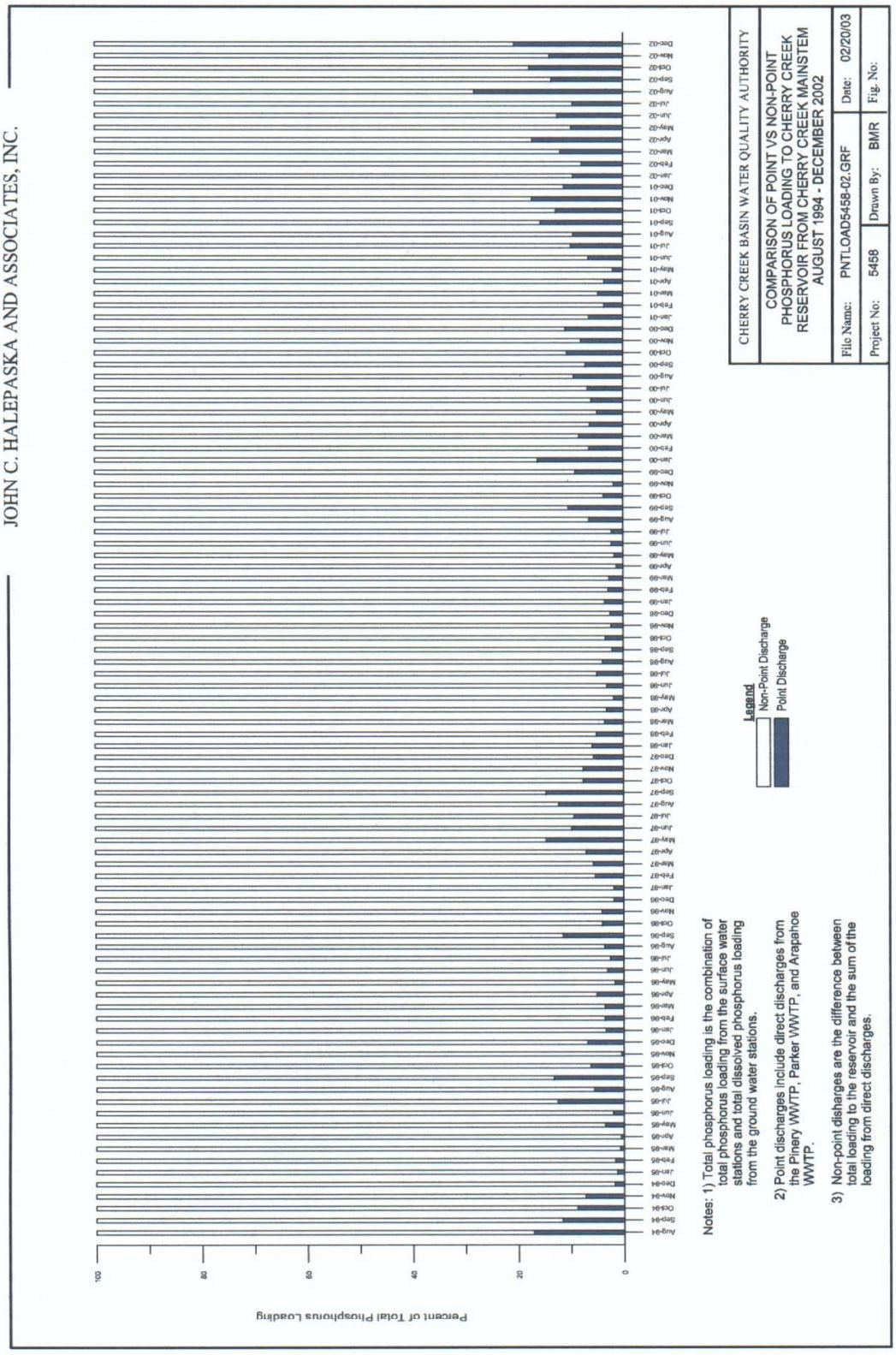

FIGURE 9: Comparison of point vs. nonpoint phosphorus loading to Cherry Creek mainstem at Site CC-9, 1994-2002.

Based on these monitoring data for calendar year 2002, the phosphorus loading to Cherry Creek Reservoir from the main stem of Cherry Creek upstream of Cherry Creek Reservoir is approximately 2,916 pounds (1,048 pounds from surface water and 1,868 pounds from ground water). For comparison purposes, the annual loading in the mainstem upstream of the reservoir in 2001 was estimated at 4,813 pounds (2,954 pounds from surface water and 1,859 pounds from ground water). The change in phosphorus load in the past 2 years is related to the decrease in surface flows in 2002.

The phosphorus loading as Castlewood for 2002 was 931 pounds, so the net load through the study reach is 1,985 pounds. Therefore, the background phosphorus load at Castlewood is 931 pounds (5.5 pounds per square mile), and there is 1,985 pounds (9.2 pounds per square mile) of additional phosphorus load added through the urbanized study reach.

Nitrate-nitrogen concentrations fluctuated significantly throughout the study reach (Fig. 10). Concentrations during 2002 generally ranged from non-detectable (less than 0.05 mg/L) to greater than 3.4 mg/L. When nitrate-nitrogen concentrations are compared at Castlewood (as the background water quality station in the study reach) to Sites CC-9 and CC-10 (located just upstream of Cherry Creek Reservoir), both show an increasing trend in nitrate-nitrogen concentrations with time, although higher concentrations are observed at Sites CC-9 and CC-10 than at Castlewood (Fig. 11).

The fluctuations and/or increases in nitrate-nitrogen concentrations may be caused by several different mechanisms. There appears to be a correlation between increased nitrate-nitrogen concentrations and direct discharges. This is to be expected because concentrations of nitrate-nitrogen discharged from the wastewater treatment plants are generally greater than ambient concentrations in the creek. There are also significant fluctuations in nitrate-nitrogen concentrations through the study reach. This is generally not expected, as nitrate is a conservative ion that doesn't attenuate over distance, except due to dispersion and biological assimilation. Being a shallow water table system, it is likely that phreatophytes (riparian plants) are assimilating nitrate. It is also a somewhat layered system, where varying screened sections in the wells can contribute to the observed variations in concentration.

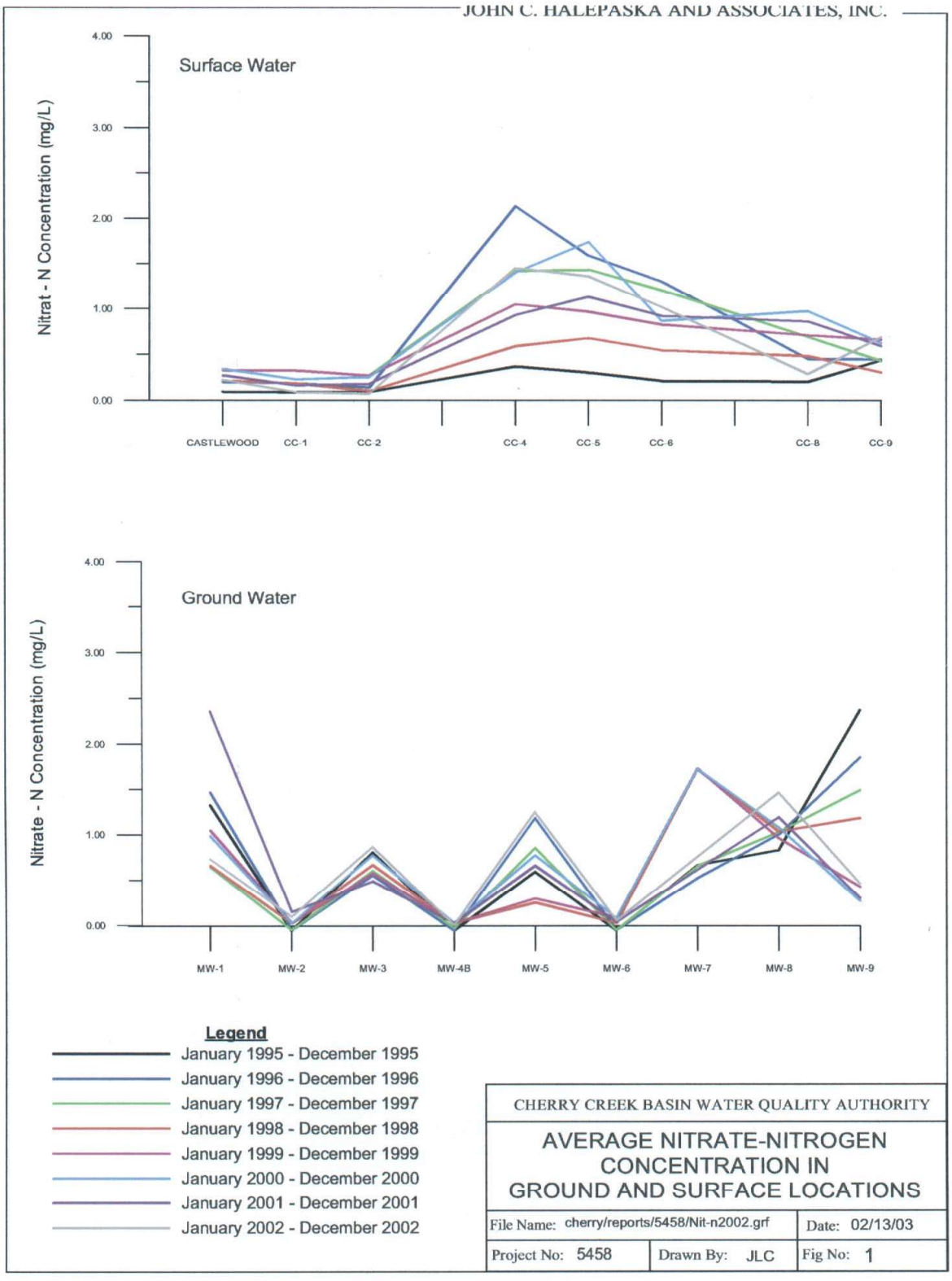

FIGURE 10: Average nitrate-nitrogen concentrations in ground and surface locations on Cherry Creek, 1995-2002.

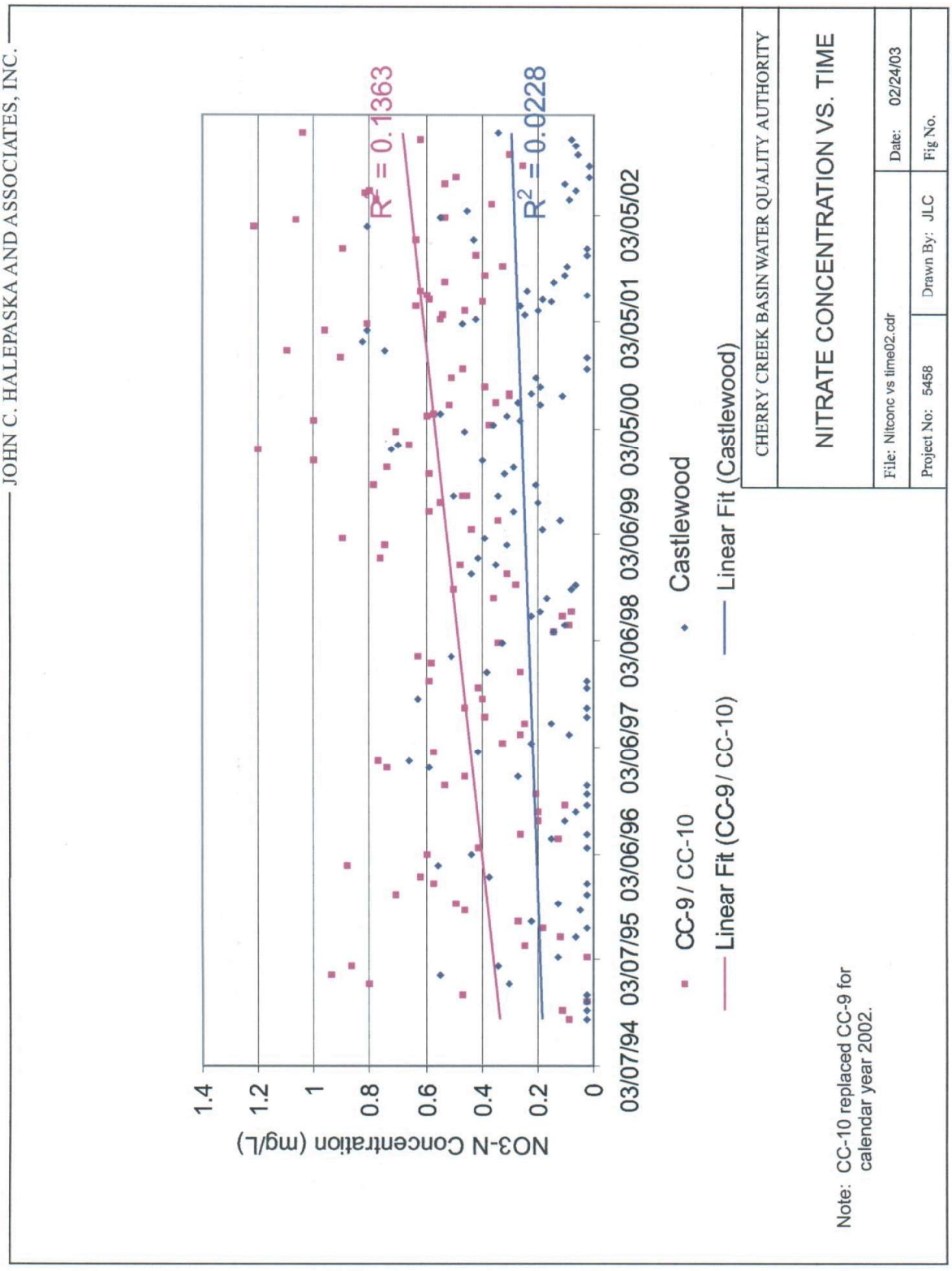

FIGURE 11: Nitrate-nitrogen concentrations at Castlewood Canyon, CC-9, and CC-10 sampling locations in Cherry Creek, 1994-2002.

Overall, nitrate-nitrogen concentrations in the surface water increase from an average of 0.22 mg/L at Castlewood Canyon to 0.69 mg/L at Site CC-10 (just upstream of Cherry Creek Reservoir). Nitrate-nitrogen concentrations in the alluvial ground water are higher than in the surface water, with an average concentration at Site MW-1 (just downstream of Castlewood Canyon) of 0.73 mg/L, and an average nitrate-nitrogen concentration at Site MW-9 of 0.46 mg/L. These indicate a relatively minor overall decrease in nitrate-nitrogen concentrations, with the absolute concentrations being approximately ten times less than the drinking water standard (10 mg/L). It should also be noted that there is a relatively large nitrate-nitrogen component in the ground water at the upstream end of the study reach, most likely related to agricultural uses of the land in the upper portion of the basin, and also potentially from leach field discharges.

Ammonia concentrations have continued to increase within the last couple of years. These increased concentrations have been observed at all surface water monitoring locations downstream of PWSD's discharge point (Sites CC-4 to CC-9). Since 2000, surface water concentrations at these stations have ranged from below the detection limit to 3.94 mg/L (Site CC-4, November 2001). Surface water stations CC-4 through CC-6 had between twelve and thirteen samples with ammonia concentrations above detection limits in the year 2002, as compared to the averages for years prior to 2000 of one to three samples.

Ammonia concentrations have been, on a frequent basis, above detection limits at ground water monitoring locations MW-2 and MW-4, since 1995 and 1999, respectively. These concentrations have ranged from 0.1 to 0.5 mg/L. It should be noted, however, that the monitoring locations downstream of Sites MW-2 and MW-4 (MW-3 and MW-5) have never shown any concentrations above the detection limit through 2001. The detection limit was lowered for 2002 from 0.1 mg/L to 0.003 mg/L. The new detection limits produced concentrations of ammonia ranging from undetected to 0.09 mg/L in Sites MW-3 and MW-5. The decrease in ammonia concentration from Sites MW-2 to MW-3, and Site MW-4 to MW-5 may be indicative of (a) a possible species change from ammonia to nitrate, (b) the dilution effect due to increased flows downstream, (c) lack of recharge from the surface flows into the alluvium at these locations, or (d) some combination of the above.

Two water quality parameters that appear to be affected by direct discharges in the Upper Cherry Creek Basin are chloride and sulfate concentrations. Both parameters show increasing concentrations in the vicinity of direct discharges (Figs. 12 and 13). Overall, the chloride concentrations are increasing from approximately less than 10 mg/L at the upstream end of the study reach to approximately 40 mg/L upstream

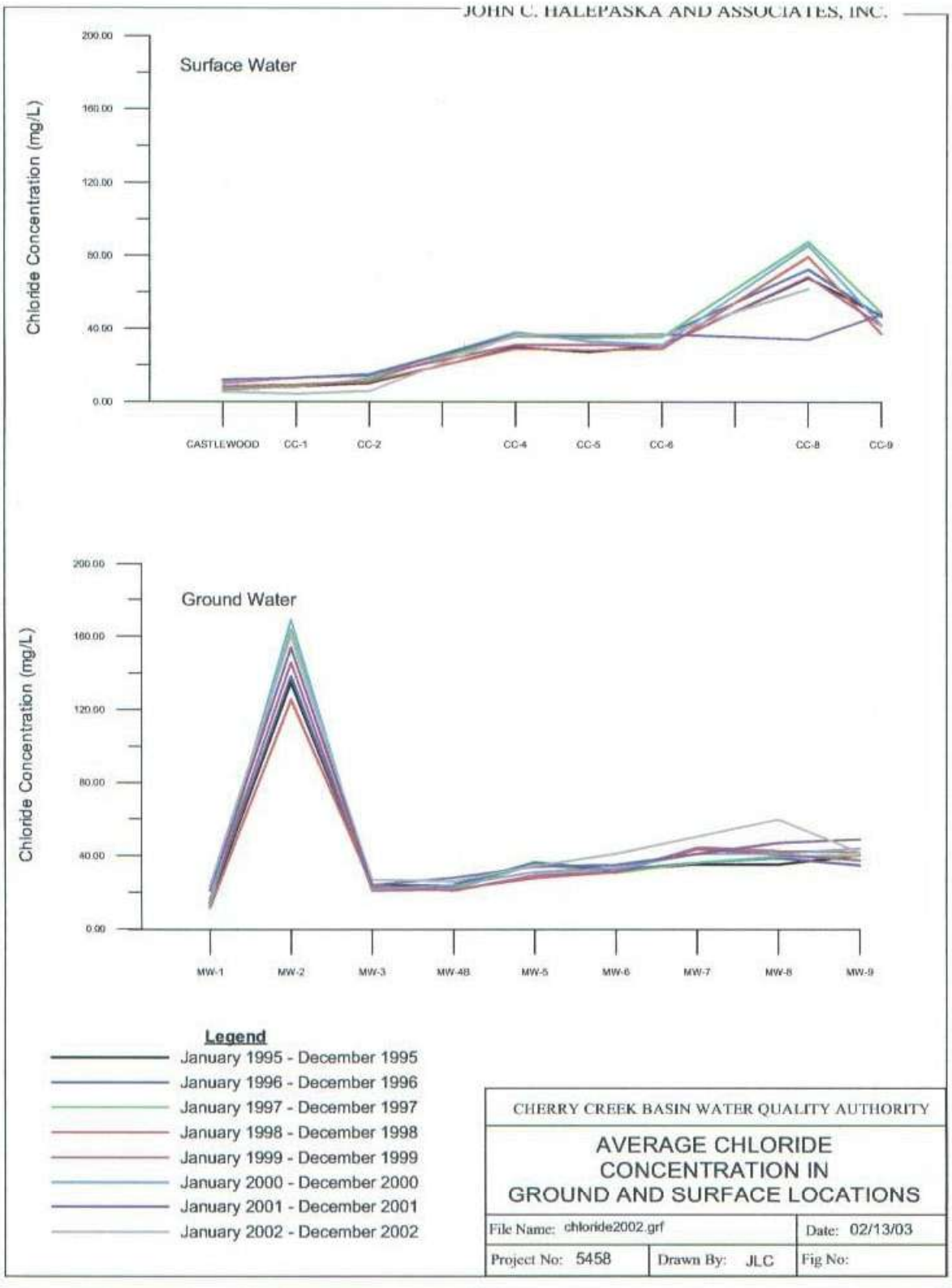

FIGURE 12: Average chloride concentrations in surface and groundwater sampling locations on Cherry Creek, 1994-2002.

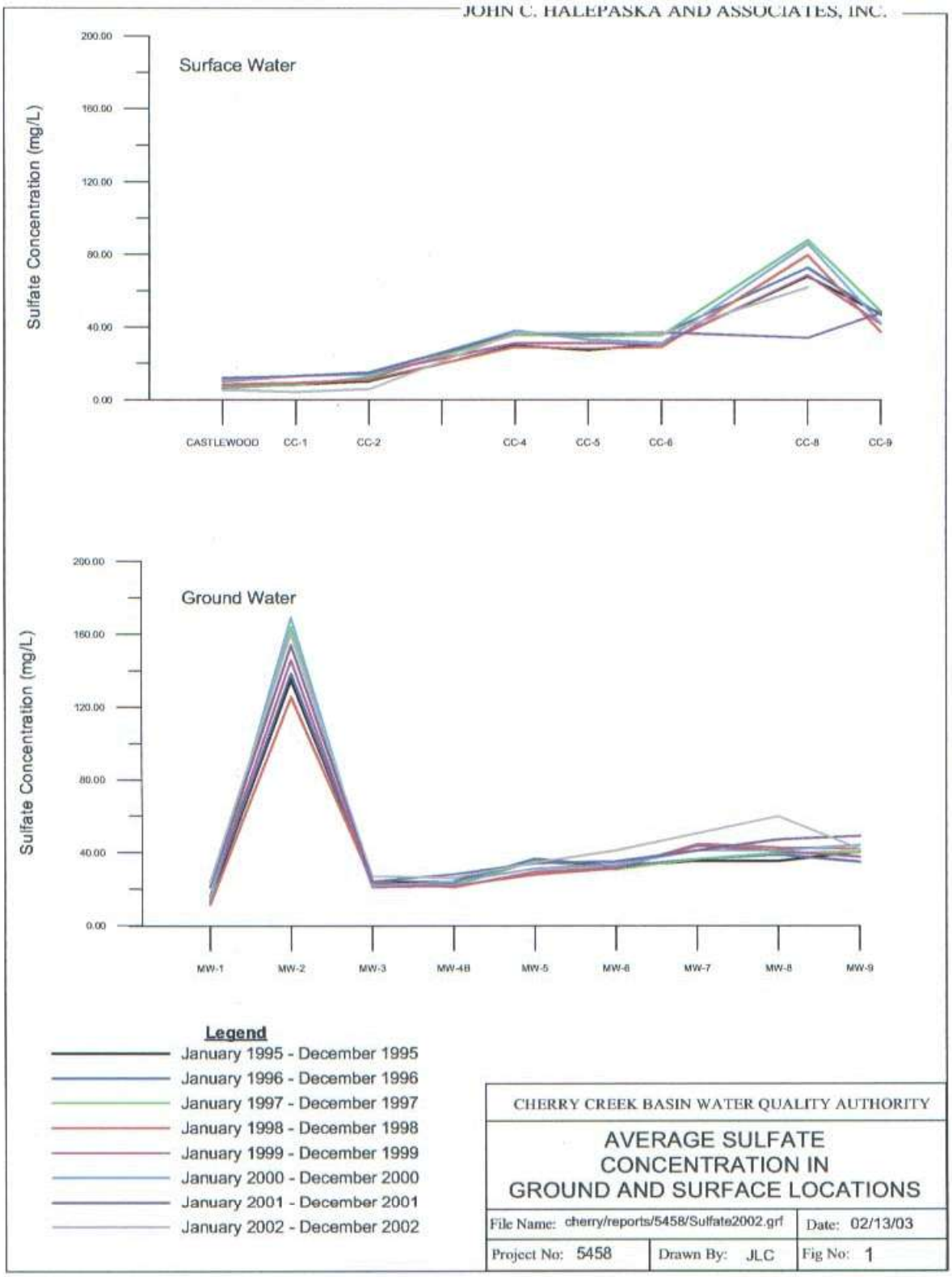

FIGURE 13: Average sulfate concentrations in surface and groundwater sampling locations on Cherry Creek, 1994-2002.

of Cherry Creek Reservoir (Fig. 12). PWSD discharges to Cherry Creek between Sites CC-2 and CC-4, and a distinct increase in chloride concentration is evident in the stream flow. Likewise, the Pinery discharges to rapid infiltration basins between Sites MW-1 and MW-2, and a significant change in chloride concentration is noted in the alluvial ground water (Fig. 12). The increase in chloride concentrations at Site CC-8 may be related to land application of secondary effluent at the Valley Country Club and/or irrigation return flows from turf farms still operating in this area. At certain times of the year, it also may be related to road salt (magnesium chloride and sodium chloride).

Sulfate concentrations have exhibited a similar trend of increasing concentrations downgradient of direct discharges, with a general trend of increasing concentrations throughout the study reach (Fig. 13). Sulfate concentrations are generally in the range of 10 to 20 mg/L at the upstream end of the study reach in both surface water and ground water, while concentrations are reaching 120 to 160 mg/L in the surface water and 150 to 200 mg/L in the alluvial ground water prior to entering Cherry Creek Reservoir. Given a drinking water standard of 250 mg/L, sulfate concentrations are approaching the standard. Since aluminum sulfate is the chemical that is generally used to remove phosphorus in the advanced wastewater treatment process, there appears to be a tradeoff between lowering phosphorus levels to meet the Cherry Creek Reservoir Control Regulation, and maintaining acceptable sulfate concentrations in the creek channel and in the alluvial aquifer. This is a concern, and direct dischargers are evaluating this relationship and the possibility of using alternative chemicals for phosphorus removal.

13.3 Phosphorus Loading to The Reservoir

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 (WY) begins on 1 October of the previous year and continues until 30 September.

Note also that in past reports, CEC used provisional (preliminary) inflow estimates from the COE when estimating inflows and loads to the reservoir. In 2002, CEC became aware that these provisional estimates had been finalized by the COE, as summarized on their website (CEC 2003). To ensure accurate numbers, CEC revised inflow and load estimates for 1992-2001 to match the more accurate, and finalized, inflow values from the COE (Tables 3 and 6).

TABLE 6: Estimated net phosphorus loading (lbs/year) into Cherry Creek Reservoir, 1992 to 2002.

Source of Data	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	Mean
Shop Creek	131	83	135	115	107	117	127	96	82	103	79	107
Cherry Creek	2,894	1,727	2,142	2,795	2,347	2,041	7,666	8,745	8,306	3,412	1,105	3,925
Cottonwood Creek	1,081	117	321	2,184	553	646	1,143	1,822	1,087	1,292	789	1,009
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**	**5,041**
Cherry Creek Alluvium	874	1,387*	967	1,676	968	1,937	3,787	5,912	2,341	4,444	1,006	2,391
Direct Precipitation	877	736	484	1,202	740	1,020	854	896	777	586	1,267	858
Total Load	**5,857**	**4,110**	**4,049**	**7,972**	**4,715**	**5,761**	**13,577**	**17,471**	**12,593**	**9,837**	**4,246**	**8,199**
Cherry Creek Outflow	1,314	711	993	2,049	992	996	4,207	9,650	3,688	4,842	1,501	2,813
Net Load	**4,543**	**3,399**	**3,056**	**5,923**	**3,723**	**4,765**	**9,370**	**7,821**	**8,905**	**4,995**	**2,745**	**5,386**

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

Total phosphorus loading to the reservoir from surface flows of Cherry Creek, Cottonwood Creek, and Shop Creek was estimated at 1,973 pounds in 2002 (Table 6). Total phosphorus loading from the above influent streams did not exceed the eleven-year mean value, and the standardized loading in pounds per acre foot for 2002 was one of the lowest values observed since the inception of monitoring efforts (Table 3).

The reduction in phosphorus loading between 2002 and 2001 was due, in part, to the 57% decrease in inflow in 2002 relative to 2001 (Table 3, Fig. 14). Inflow volume in 2002 was below the long-term average of 12,924 ac/ft. Inflow, measured as the change in reservoir elevation by the COE, was highest during the winter/spring of 2002 with streamflow peaks noted in May and June (Fig. 15).

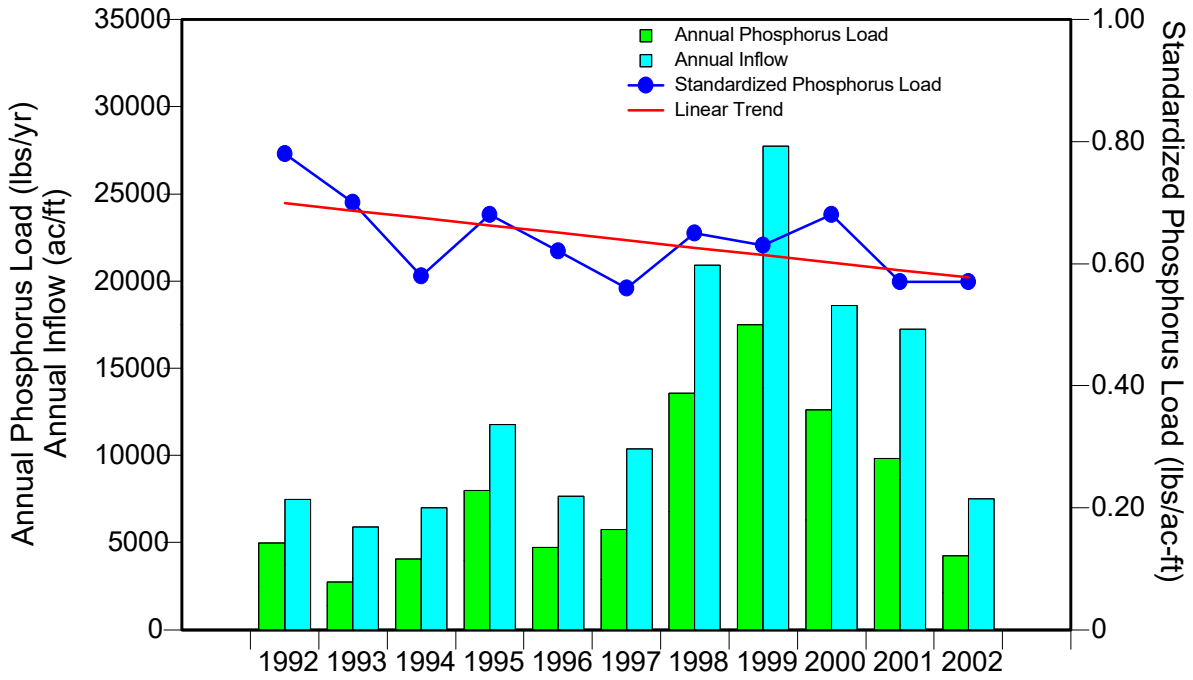

FIGURE 14: Long-term trends in total phosphorus load (lbs/yr), inflow/ac ft (yr), and standardized phosphors load (lbs/ac ft) from Cherry Creek Reservoir, 1992-2002.

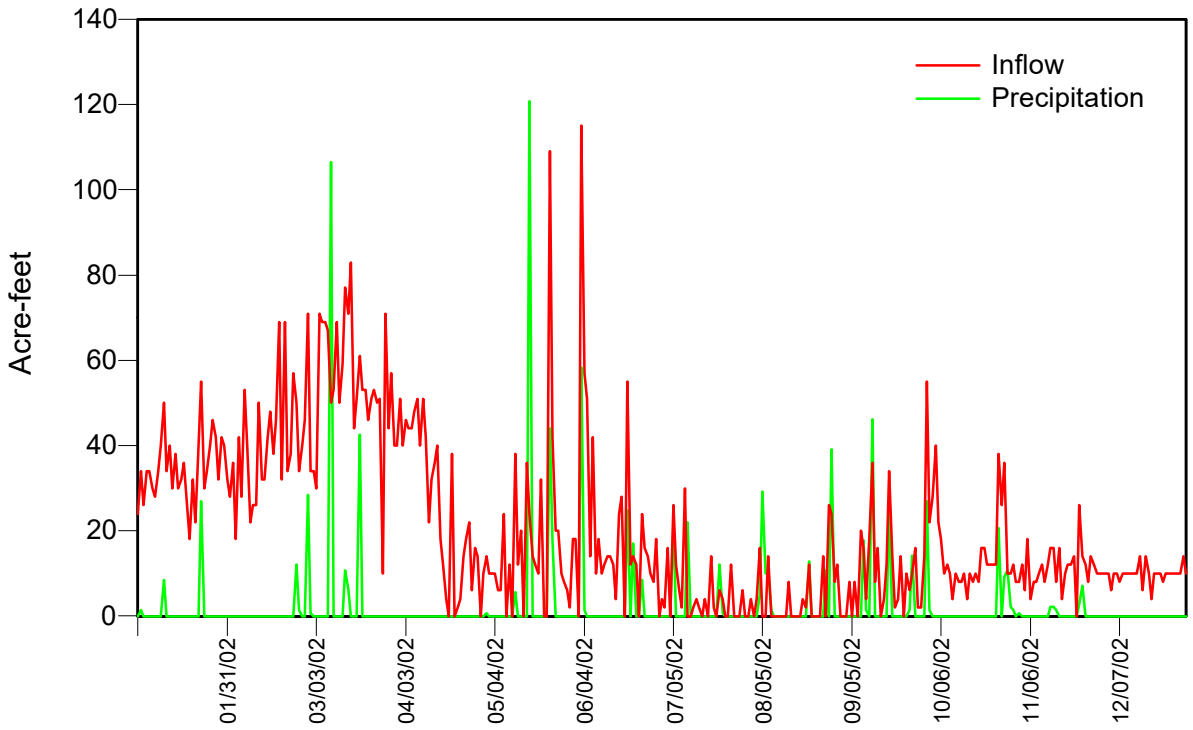

FIGURE 15: Comparison of precipitation and inflow for 2002.

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 eight-year period (1995-2002). Total phosphorus concentrations at Cherry Creek and Shop Creek exhibited significant, increasing trends over time. Likewise, the trend of orthophosphate concentration over time at Shop Creek was significant and increasing. Concentrations of orthophosphate at Cottonwood Creek exhibited a significant, decreasing trend over time. Decreasing total phosphorus concentrations at Cottonwood Creek and orthophosphate concentrations at Cherry Creek were not significant.

Precipitation

As measured by the rain gage located on Cherry Creek dam, total precipitation at Cherry Creek Reservoir was 12.9 inches in 2002. This was the lowest measured annual precipitation since 1994 (10.2 in). Additionally, the 2002 annual precipitation total was lower than the 1987-2002 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 1,267 pounds for 2002, which is greater than historical values (Table 5). This increase in load can be attributed to a 60% increase in mean concentration of total phosphorus collected from rain samples in 2001 (202 µg/L) to 2002 (508 µg/L), possibly reflecting a greater influence of "dry fall" between rain events despite weekly maintenance of the rainfall sampler. The mean value for annual loading from precipitation from 1987-2002 is 848 pounds.

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 1,501 pounds for 2002. This value is lower than that observed in 2001 and less than the 1992-2002 mean of 2,813 pounds (Table 5).

Ground Water

Recent sampling by JCHA has provided data on alluvial ground water quality for the Cherry Creek mainstem. Based on these data, the estimated phosphorus loading to the reservoir from the Cherry Creek alluvium in 2002 was 1,868 pounds. In addition, phosphorus leaving the reservoir through ground water downstream of the reservoir (underflow) was estimated at 1,025 pounds for 2002 (based on an assumed constant water level in the reservoir of 5,550 ft MSL). Given differences in phosphorus concentrations in the alluvium upstream and downstream of the reservoir, it appears that some portion of the alluvial underflow is retained in the reservoir, while the rest flows under the reservoir beneath the keywall. The portion entering the reservoir can be estimated by taking the difference in alluvial phosphorus loads upstream and downstream. This analysis results in an estimated net alluvial phosphorus load retained in the reservoir of 843 pounds in 2002.

CEC also estimated net alluvial phosphorus load in 2002. These calculations can be found in CEC (2003). CEC estimated the net alluvial phosphorus load to be 1,006 pounds. This is a 16% difference from the 843 pounds estimated by JCHA. Based on the similarity of the values, even using different methods of calculation, the CEC estimate (1,600 pounds) was used to calculate total and net loads to the reservoir in 2002 to be consistent with other CEC-developed loading values.

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 2002, phosphorus contribution from precipitation was an estimated 1,267 pounds, influent streams contributed 1,973 pounds, and alluvial inflow contributed 1,006 pounds (Fig. 16) for a total load of 4,246 pounds. Outflow from the dam contained an estimated 1,501 pounds in 2002. After totaling the additions and losses, the net loading of phosphorus was estimated at 2,745 pounds during 2002 (Table 6).

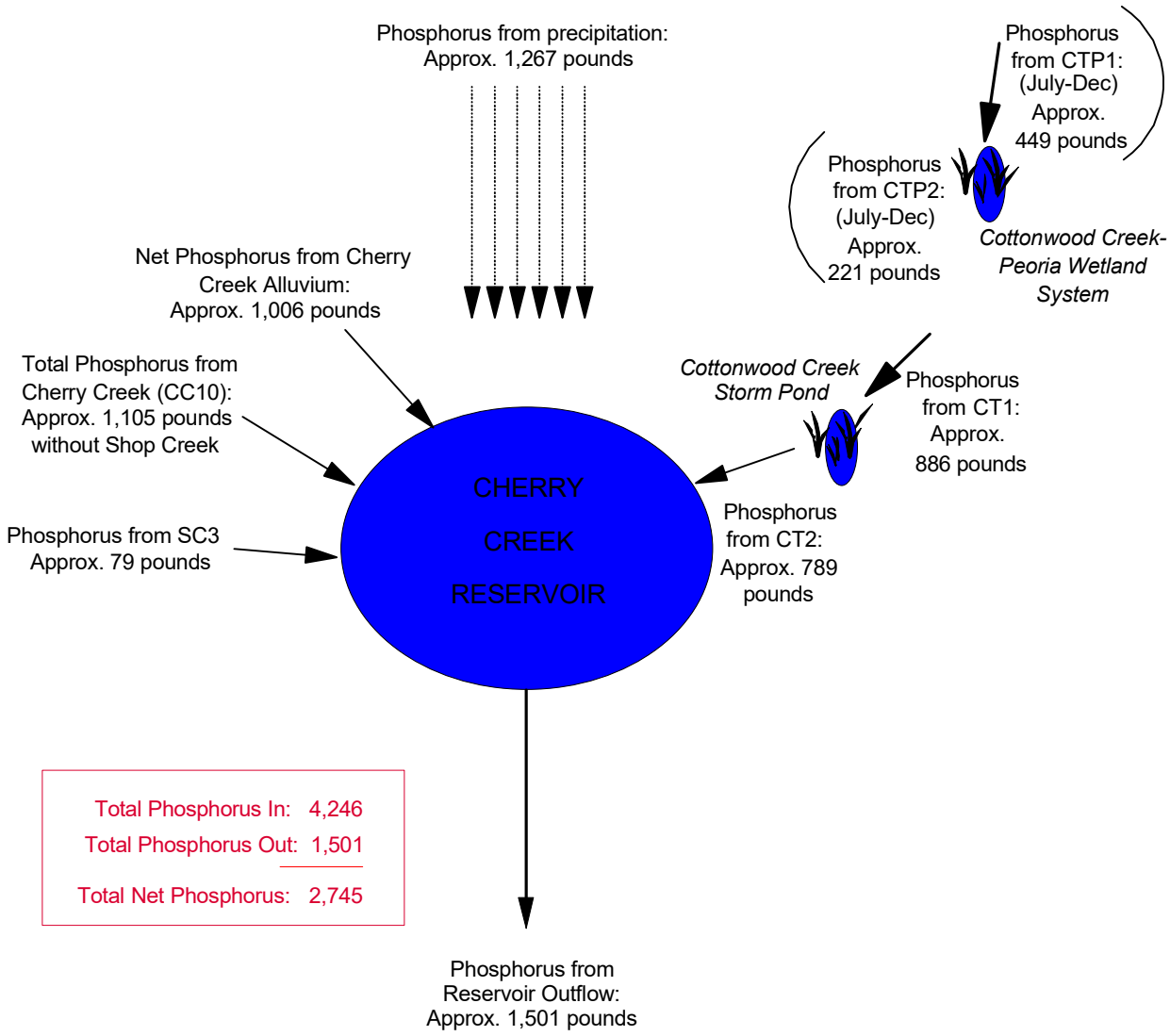

FIGURE 16: Mass Balance Diagram of Phosphorus Loading in Cherry Creek Reservoir, 2002.

The total load of 4,246 pounds measured in 2002 represented a 57% decrease in total phosphorus load over that measured in 2001. The phosphorus load in 2002 met the phased TMAL of 14,270 pounds established for Cherry Creek Reservoir. The pounds per acre foot measured in 2002 was well within the range observed in previous years (Table 3 and Fig. 14). In fact, while flows and phosphorus loads have generally varied over the past eleven years based on a variation in annual flows, the standardized phosphorus loads (lbs/ac ft) have exhibited a declining trend (Fig. 14).

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