CHERRY CREEK BASIN

WATER QUALITY AUTHORITY

Annual Report

Authority Members:

Arapahoe County
Arapahoe Water and Wastewater Authority
City of Aurora
Cottonwood Water & Sanitation District
Denver Southeast Suburban Water & Sanitation District
Douglas County
City of Greenwood Village
Inverness Water & Sanitation District
Lincoln Park Metropolitan District
Meridian Metropolitan District
Parker Water & Sanitation District
Town of Castle Rock
Town of Parker

Cherry Creek Basin Water Quality Authority
6200 South Syracuse Way
Suite 150, Carrara Place
Englewood, CO 80111

Cover: Cherry Creek Basin Water Quality Authority Decal for Annual Entrance Fee to Cherry Creek Reservoir.

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A. INTRODUCTION

The Cherry Creek Basin Water Quality Authority is a quasi-governmental agency with a specific directive — to assure that the waters of Cherry Creek Reservoir will be enjoyable for generations to come.

Cherry Creek Reservoir is a center for outdoor recreation in the southeast Denver area, with more than one million users and visitors every year. Because the Reservoir was built for flood control, the permanent pool of water is maintained at a relatively low level. Occasional algae blooms in the Reservoir are unacceptable to swimmers and boaters.

The Authority is charged with the responsibility of developing and implementing plans to maintain acceptable levels of water quality in the Reservoir and preserve the Reservoir as an outdoor recreation amenity.

Cherry Creek Reservoir History

Cherry Creek Reservoir, now the focus of on-going water quality efforts, was never envisioned as a recreational site. It was built for flood control, and recreation was introduced as Denver's population grew.

Cherry Creek Reservoir was completed in 1950, following two decades of extensive flooding in the Cherry Creek Basin. When Denver was built at the confluence of the South Platte River and Cherry Creek, the land to the southeast of the city was open range and small farms. Because the Cherry Creek Basin is 385 square miles higher in elevation than Denver, melting snow and heavy rainfall from the surface creek network in the Basin naturally flows to the South Platte River through Cherry Creek. The flood of August 3, 1933 was the most destructive flood ever to occur in the Southeast Denver area, destroying homes and disrupting commerce in the city. It was followed by another late Spring storm in 1935, not as destructive but just as disruptive. Responding to civic pressures, the federal government designed the Reservoir as a flood control measure, and the Army Corps of Engineers assumed responsibility for completing the project.

Cherry Creek Dam and Reservoir were authorized in 1941, but the Second World War forced a delay until 1946, when work began on the earthen fill dam. The site was rolling hills sloping to a gradual ravine, with a few farms and the original Smoky Hill Road located in the creek valley.

The Dam, of rolled earth construction containing 13 million cubic yards of fill, is 14,300 feet long and 141 feet high from base to top, with a 30 foot roadway on the top.

Although the Dam was completed in 1950, it did not serve its original purpose to hold back flood waters until 1957. Average spring runoff had filled the area behind the Dam to a few

feet in depth. When waters rose to new elevations in 1957, many people began to see the potential for recreational opportunities.

The reservoir is 1½ miles long and slightly more than a mile across, and generally holds 10,394 acre feet of water (about 3.4 billion gallons of water) covering 850 acres. Its maximum depth is 26 feet, with 50% of the surface area less than 10 feet deep.

The land surrounding the Reservoir was leased to the State of Colorado as the Cherry Creek State Recreation Area in 1957, and almost immediately received extensive recreation use — a pattern that has continued to present day.

The Cherry Creek Basin, which is 385 square miles, includes all streams and aquifers, as well as land with runoff, tributary to the Cherry Creek watershed.

B. THE PUBLIC'S ROLE

Reservoir Status

Cherry Creek Reservoir was designed as a terminal storage facility, intended to hold water that would be discharged as needed to maintain the predetermined lake level, and over time together with underflows has maintained Cherry Creek in a free-flowing condition. As a storage facility with only small outflows, the sediment from upstream flows has, over 40 years, accumulated to depths of up to 20 feet at the outlet works with an average overall sediment depth of nine feet. The water in the Reservoir undergoes chemical changes with its exposure to sediments, sunlight, temperature and wind, which may influence algae growth.

Algae growth and the associated appearance of the Reservoir are extremely difficult to predict, and as the Authority has learned, even more difficult to explain and control.

Goals for the Reservoir

The public wants the clearest water feasible. Cherry Creek Reservoir water probably will always be shades of green or brown, because of the soil that's entered the Reservoir through runoff, and has collected on the Reservoir bottom. The soils in the Basin contain sand, clays, minerals, chemical elements and bacteria, all of which have an effect on the water composition and color.

For all its history, the Reservoir has had reasonable success in maintaining water quality.

C. THE FRAMEWORK

Profile of the Authority

The Cherry Creek Basin Water Quality Authority is the designated 208 Management for the Cherry Creek Basin. The Authority initially operated pursuant to a contractual agreement between the affected jurisdictions: 2 counties, 4 cities and 7 special districts, (operating wastewater treatment facilities) within the Cherry Creek Basin. However, given the activities

that needed to be undertaken, the benefits to the public, as well as the Authority members, from water quality enhancement and costs and allocation of costs for water quality projects, the Authority determined that it needed special powers and authorization to function effectively. The Cherry Creek Basin Water Quality Authority was created by the Colorado Legislature in 1988. (See, Appendix I, Legislation; Colorado Revised Statutes, Section 25-8.5-101, et seq.) The Authority operates pursuant to that special legislation, which created and authorized the Authority to undertake water quality planning and projects, impose controls for water quality and charge fees and assessments to support its programs. The Authority crosses county boundaries and city limits, and encompasses a number of government entities. It is rooted in the spirit of cooperation for a common purpose.

The Authority includes Arapahoe and Douglas Counties, the cities of Aurora and Greenwood Village, the towns of Castle Rock and Parker, and seven water and wastewater special districts — Arapahoe, Cottonwood, Inverness, Meridian, Parker, Pinery and Stonegate Center. All the members are general purpose local governments or have wastewater treatment responsibilities in the Cherry Creek Basin. The Authority also has several ex-officio members, including the Water Quality Control Division, Denver Regional Council of Governments, Urban Drainage and Flood Control District, U.S. Army Corps of Engineers, Department of National Resources, Division of Parks and Recreation, and Tri-County Health Department. The Authority was created because no one agency could assume that responsibility. The Corps of Engineers are the owners of the Dam, Reservoir and surrounding property. The Division of Parks and Recreation of the Colorado Department of Natural Resources, as the lessee and operator of the Cherry Creek Park, encourages the use of the Park as a recreational asset. The Parks Division and the Corps certainly have a stake in maintaining the Reservoir as a tremendous resource and are ex-officio members of the Authority.

Mission of the Authority

The Authority's mission statement developed by the members and ex-officio members early in 1994 was carefully crafted, after considerable discussion, to more fully described the Authority's mission:

> TO PROMOTE THE PRESERVATION OF WATER QUALITY IN THE CHERRY CREEK WATERSHED THROUGH MITIGATION OF URBAN IMPACTS FOR THE BENEFIT OF THE PUBLIC FOR RECREATION, FISHERIES, WATER SUPPLIES AND OTHER BENEFICIAL USES WITHIN THE ECONOMIC ABILITIES OF THE AUTHORITY.

Funding Mechanisms

Funding for the Authority's work is provided from park admission fees, grading fees, charges to wastewater operators and property taxes. The Authority receives revenues from residents within its boundaries as property taxes, those landowners and developers affected by its regulations, wastewater treatment operators, and the users of Cherry Creek State Recreation Area.

The Authority's revenues are proportionately, as follows:

52.2%	property tax;
22.2%	recreation user fees;
25.6%	grading fees, wastewater surcharges, and interest income.

The "Basin Authority" decal is the most visible sign of the Authority's mission, and a substantial segment of the Authority's income. Users pay a $1 per day fee, or $3 for an annual decal. Revenue from the decal is primarily used to fund the ongoing research and projects to control algal growth in the Reservoir.

The Authority's yearly budget averages $1.2 million dollars, although a substantial portion of the budget is carryover capital reserves for major projects rather than new monies. The expenditures are heavily weighed toward identifying water quality projects and establishing capital resources for those projects, water quality monitoring and regulatory compliance with various federal and state agencies. The Authority has elected to build capital reserves for construction of projects rather than incur bonded indebtedness. The Authority does not retain a full-time staff; rather, management and clerical services are provided on a contract basis.

Residents inside the Authority's boundaries want to know how their tax dollars are being used. Park visitors paying admission charges see how the money is being used to preserve the Reservoir's water quality.

The Authority has used public speaking campaigns, brochures, a videotaped documentary and summaries of its findings on water quality of the watershed to inform agencies, associations and concerned individuals about the Reservoir and the Authority's activities. The annual report is another step in that process.

D. REGULATION

Water Quality Control Commission

The Clean Lakes Study of Cherry Creek Reservoir conducted in 1982 identified phosphorus as the major nutrient causing algal production in the Reservoir. The Colorado Water Quality Control Commission adopted in 1984 a phosphorus standard of 35 ug/L for Cherry Creek Reservoir to ensure compliance with a seasonal mean algal chlorophyll value of 15 ug/L. This standard was based on the assumption that algal growth in the reservoir is limited by phosphorus and that algal biomass will respond correspondingly to the increases or decreases in the phosphorus content of the waterbody (Jones and Bachmann, 1976). This standard presumes that the relation between algal chlorophyll and in-lake phosphorus, as a ratio, is 0.4 (15 ug/L chl / 35 ug/L TP = 0.4). This was consistent with the then (1982) limnological research demonstrating that, on the basis of the seasonal mean, the chlorophyll-to-phosphorus ratio (Chl:TP) in most temperate lakes of moderate fertility ranges between 0.3 and 0.5.

Data indicates that the relation between algal chlorophyll and total phosphorous in Cherry Creek Reservoir has not been constant over time. Conditions were typical of a temperate waterbody in 1982 (Chl:TP ratio of 0.36) and supported the 1984 assumptions underlying the phosphorus standard. Since 1982, however, the phosphorus standard has been exceeded each year and the target chlorophyll value of 15 ug/L has been matched once (in 1984) and exceeded twice (in 1988 and 1992). During the years 1984-1987 and 1989-1991, the Chl:TP ratio was low relative to the norm for temperate lakes; ranging between ≤ 0.1 and 0.15.

Collectively, limnological data from Cherry Creek Reservoir show that the relation between phosphorus and algal chlorophyll is not constant from year to year and that algal chlorophyll does not necessarily increase or decrease in response to changes in the phosphorus content of the lake. A summary of mean annual phosphorus and chlorophyll a values for the past ten years is presented below.

TABLE 1

Phosphorus and Chlorophyll A Levels
Cherry Creek Reservoir

Year	Phosphorus as ug/l	Chlorophyll a as ug/l	Ratio of Chl:TP
Adopted Std	35	15.0	0.42
1982	30	10.7	0.36
1984	74	15.3	0.21
1985	63	4.2	0.07
1986	62	4.0	0.06
1987	95	8.3	0.09
1988	50	32.0	0.64
1989	45	5.6	0.12
1990	59	8.6	0.15
1991	109	9.8	0.09
1992	54	23.4	0.43
1993	53	12.5	0.24

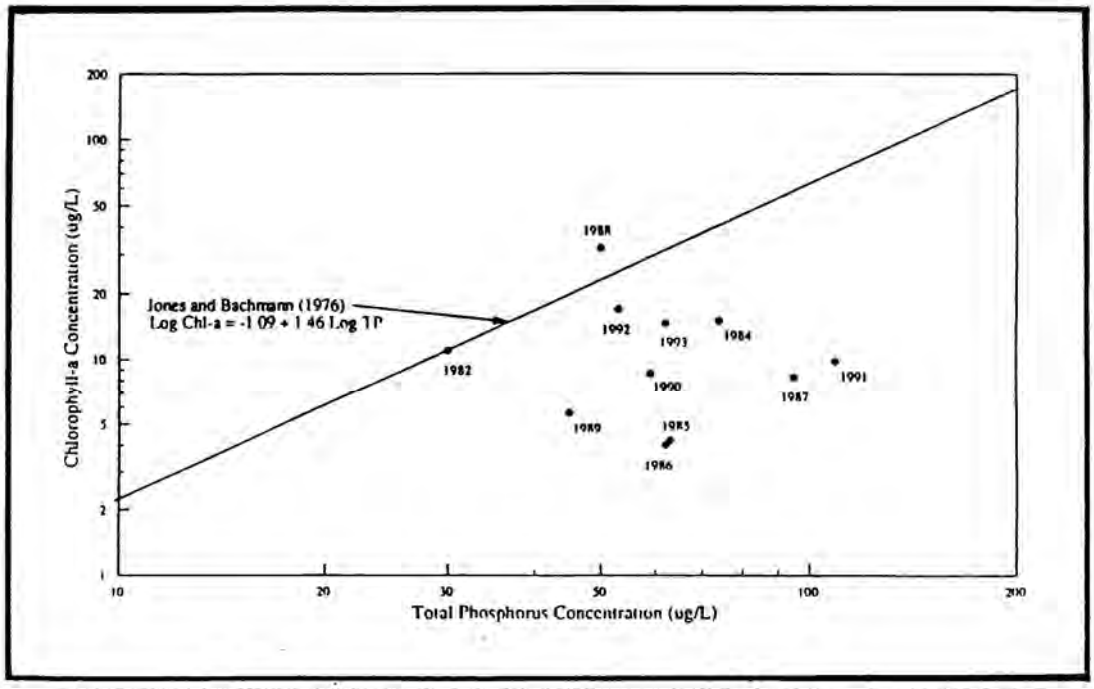
For several years, the Cherry Creek Reservoir levels of chlorophyll a have been below 15 micrograms.

Dr. Jack Jones reported that the 1992 Cherry Creek measurements had a seasonal mean of 54 micrograms per liter total phosphorus and 23.4 micrograms per liter (ug/l) algal chlorophyll. Further, he reported that the 1993 seasonal mean measurements were 53 mg/l phosphorus and 12.5 ug/l algal chlorophyll. However, the relationship between seasonal mean phosphorus levels and chlorophyll a have not been in accordance with the Jones/Bachman model. Results tend to indicate that restrictions on phosphorus loadings to the Reservoir do not appear to have a corresponding effect on chlorophyll a levels. [Excerpts from Dr. Jones' 1992 and 1993 Reports are attached as Appendices II and III, respectively.]

In 1993, the Colorado Division of Parks retained Dr. William Lewis, limnologist, University of Colorado, to review the information collected on Cherry Creek Reservoir and analyze the Reservoir and make recommendations concerning the water quality programs. [Excerpted material from Dr. Lewis' Report is attached as Appendix IV.] Both Dr. Jones and Dr. Lewis have recommended a re-examination of the phosphorus standard.

The relationship of mean annual 1993 phosphorus and mean 1993 chlorophyll a is relatively low; below the confidence limits of the Jones-Bachman model. (See, Table 2 below) The seasonal mean phosphorus measurements in 1992 and 1993 were similar, even though substantially higher inflows were reported in 1992. The chlorophyll a levels vary through-out the year, with lower levels in the Spring, increasing in August and September. Therefore, Dr. Jones, a limnologist who developed the Jones/Bachman Model, is further investigating the daily and seasonal relationships of chlorophyll a and phosphorus, rather than annual relationships.

TABLE 2



JULY-THROUGH-SEPTEMBER VALUES OF CHLOROPHYLL-A vs. TOTAL PHOSPHORUS
CHERRY CREEK RESERVOIR 1984 - 1993

Cherry Creek Reservoir meets all state health standards for waters used for swimming, fishing and boating. Monthly water quality samples for coliform and bacteria are within the limits. Fish thrive in the Reservoir and the fish taken from it are safe for consumption.

E. WHAT'S IN THE RESERVOIR?

Monitoring

Cherry Creek Reservoir has been, and is being, carefully monitored. The monitoring over the years has included monthly stream flow samplings at 14 locations or on the tributaries, retention ponds and streams south of the Reservoir; extensive laboratory analysis, and special water quality studies by graduates and professional engineers. In addition to monitoring phosphorus in 3 forms (total phosphorus, ortho phosphorus and dissolved ortho phosphorus), the Authority also monitors the tributaries and best management projects for ammonia, nitrite, nitrate, kjeldahl nitrogen, nitrogen, suspended solids, temperature and ph. In the Reservoir, the monitoring includes the above constituents plus turbidity, dissolved oxygen, specific conductance, volatile suspended solids, non-volatile suspended solids and secchi depth (clarity). In conjunction with the Authority's program, the Urban Drainage and Flood Control District has also been sampling the Shop Creek project for heavy metals and trace organics.

Because the water quality of the Reservoir and its tributaries is a dynamic and changing system, it's been extremely difficult to reach any firm conclusions on the effects of certain nutrients or activities on water quality.

In 1992 and 1993, the Authority had Dr. John R. Jones, a nationally acclaimed limnologist from the University of Missouri, direct the monitoring program. In addition to establishing the parameters and monitoring sites, Dr. Jones analyzed duplicate samples, conducted algal experiments and analyzed the data.

Dr. Jones reports that due to the very small changes over time, it has not been possible to assess whether water quality in the lake has improved, declined, or stayed the same. Algae blooms that are considered offensive have occurred only three months over the past seven years. Not only is it difficult to pinpoint the factors that cause algae growth, we are unable to predict if and when they will occur again.

Profile of Water Column

The top 12-18" of the water "column" contains most of the photoplankton and algae, that give the water its color. The algae thrive on sunlight and nutrients, and depending on the time of year, this layer of water may have a few algae strands, or many living microorganisms.

Under the algae, the water clears somewhat, where sunlight does not penetrate. Fish, smaller organisms that are their food supply, and some types of aquatic plants fill this region. The Reservoir has been stocked with several varieties of fish over the years, including trout, smallmouth and largemouth bass, walleye, perch, sunfish and gizzard shad. Only rainbow trout are now stocked on an annual basis, and the other species reproduce and maintain populations on their own.

Nearer the bottom, aquatic plants take root and provide cover and food for fish. The bottom is covered with silt — the muddy residue of sand, loam and clay swept in from upstream.

The erosion control and practices recommended by the Authority and adopted by the land use agencies have caused a substantial decline in the amount of silt flowing into the Reservoir.

Point Source Contributions and Controls

When Cherry Creek Dam was built, 20,000 people lived in the Cherry Creek Basin. In 40 years, the population of the Basin has increased to 450,000, all of whom have homes and may work in the area.

To meet the Reservoir phosphorus standard, wastewater treatment facilities upstream of the Reservoir have been limited in the amount of nutrients, notably phosphorous, that can be contributed to the Reservoir.

The Water Quality Control Commission adopted control regulations that control, among other matters, the quality of water discharged from wastewater plants inside the Basin. Plant operators (municipalities and special districts) meet those standards on a daily, monthly and annual basis. Treated wastewater may be used, and further treated, through irrigation of greenbelt and open space areas, or may be discharged recharging Cherry Creek and the alluvium.

The Cherry Creek Basin Control Regulation allocated phosphorus pounds for wastewater treatment plants; nonpoint sources, such as runoff; and background, such as rain and septic systems. Of the 12 approved wastewater treatment plants in Cherry Creek, only 6 are constructed and currently operating. The annual allocation for wastewater treatment plants is 2,310 pounds of phosphorus. During 1992, wastewater treatment plants contributed a total of 585 pounds of phosphorus and during 1993 the phosphorus contributions of wastewater treatment plants totaled 500 pounds. The wasteload allocation, maximum pounds of phosphorus discharged annually by each wastewater plant was set. The wasteload allocation and the total phosphorus pounds discharged and reported by each facility in 1992 and 1993 are set forth in Table 3.

TABLE 3

Point Source Phosphorus Contributions

FACILITY	ALLOCATION	PHOSPHORUS [1] 1992 LBS.	PHOSPHORUS [1] 1993 LBS.
Arapahoe Water and Sanitation District[2]	354	462	384
Cottonwood Water and Sanitation District[3]	213	0	0
Denver Southeast Suburban Water and Sanitation District	213	47	26
Inverness Water and Sanitation District	68	0	0
Parker Water and Sanitation District	533	76	90[4]
Meridian Metropolitan District	114	0	0
Lincoln Park Metropolitan District (f/k/a Stonegate Center Metropolitan District)	53	0	0
Castle Rock (Mitchell Creek Plant[5])	128	___	___
Castle Rock (Cherry Creek Plant[6])	21	___	___
Castle Rock (McMurdo Gulch Plant[6])	64	___	___
Rampart Range[6]	160	___	___
Castle Rock (Newlin Gulch[6])	86	___	___
Reserve Pool	303	0	0
TOTAL	2,310	585	500

[1] The 1992/1993 phosphorus pounds for each wastewater treatment plant are from each facilities' December DMRs for the respective year, reporting cumulative phosphorus totals. Although wasteload models being developed by the Division may yield slightly different results, the Division concurs that during 1992 and 1993, the total point source loads from wastewater treatment plants did not exceed the 2,310 phosphorus pounds for either year.

[2] In 1992, an amendment to the DRCOG Clean Water Plan transferred to Arapahoe Water and Wastewater Authority, which commenced treating and discharging Cottonwood Water & Sanitation District's wastewater. Cottonwood's phosphorus allocation.

[3] The existing wastewater treatment has limited its operations solely to provide effluent for the irrigation at E-470.

[4] Estimated phosphorus pounds based on fifteen percent return flow rate.

[5] The wastewater treatment plant has not been operated.

[6] No wastewater treatment plant has been constructed.

Nonpoint Source Contributions

Point source refers to the outflow of specific "points" of water source such as wastewater treatment plants. Nonpoint sources are natural water sources such as streams, or man-made construction which creates runoff.

Of the phosphorus entering the Reservoir, it has been estimated that 90 percent is from nonpoint sources, and 10 percent is from wastewater treatment plants meeting their irrigation and return flow obligations. Nonpoint phosphorus loads to the Reservoir, according to the control regulation, shall not exceed 10,290 pounds per year. It is estimated that annualized phosphorus loads to Cherry Creek Reservoir were 9,200 pounds in 1992 and 1,935 pounds in 1993 (ASI, 1994). Annually, the Authority estimates the total acre feet of surface inflow to the Reservoir and phosphorus and nitrogen loadings. Total phosphorus and nitrogen loadings have varied with the volume of inflow. The inflow and nutrient loadings are shown on Table 4.

TABLE 4

Inflows and Nutrient Loadings

Cherry Creek Reservoir[1]

YEAR	Annualized Inflows (af)	Annualized Total Phosphorus (lbs).	Annualized Total Nitrogen (lbs)
1987[2]	10,960	7,950	65,680
1988[3]	8,960	9,520	72,280
1989[4]	7,080	7,230	67,800
1990[5]	6,700	3,720	39,240
1991[6]	7,210	3,860	38,080
1992[5]	9,540	9,200	55,880
1993[6]	4,665	1,935	24,482

Dr. Jones' findings suggest that the relationship between the point source and nonpoint source phosphorus contributions and in-lake phosphorus and algal concentrations are not closely

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1 Source: ASI "Cherry Creek Reservoir and Basin, 1993 Annual Water Quality Monitoring Report" March 31, 1994

2 Water Year (October through September), with October through April in-filled.

3 Water Year (October through September), with no missing months.

4 Water Year (October through September), with February and March in-filled.

5 Water Year (October through September), with October through March in-filled.

6 Water Year (October through September), with October through April in-filled.

correlated. [Jones, 1994]. And, Dr. William Lewis suggested that land use practices and nutrient sources within the Basin, but distant from the Reservoir, are less important to reservoir water quality than those activities closer to the Reservoir. [Lewis, 1994].

Nonetheless, the current nonpoint source management strategy will continue while research continues to focus on the very difficult problem.

F. CONTROL STRATEGIES

Over the years, the Authority has proceeded with management practices for nonpoint sources intended to limit the introduction of all nutrients, including phosphorus and sediment into the Reservoir, in the belief that the reduced nutrient and sediment levels would protect water quality. The Authority is continuing to implement and test the effectiveness of best management practices, because there appears to be substantial benefits, although not yet quantified. There are two major types of nonpoint source controls: (1) construction-related practices designed to reduce the nutrient and sediment loads from temporary grading and construction activities; and (2) long-term projects designed to reduce the nutrient and sediment loads from developed areas.

Best Management Practices

Construction Related Practices

The best construction site erosion control management practices developed by the Authority and adopted by the local governments limit erosion, thereby reducing the possibility of silt runoff through a variety of methods. To limit erosion, best management practices are necessary when the soil is disturbed by grading, excavation or construction. The best management practices are imposed when any building or grading permit is issued. Building inspectors review the disturbed sites as grading and construction is underway to ensure that erosion controls are implemented and maintained. Those controls may include strategically placed hay bales, silt fences, temporary detention areas and revegetation practices.

Although erosion control is implemented throughout the Cherry Creek Basin, knowing from its experience that the erosion control is effective, Douglas County has sponsored seminars to inform and educate developers, engineers and contractors on best management practices.

The Authority's strategy has been to control algae-fostering nutrients at the source, through grading techniques, planting vegetation, using wetlands and sediment ponds. For the foreseeable future, this strategy will continue to be used, because it is effective and also has beneficial side effects to community, notably the creation of new open space, aesthetic and erosion control features.

Permanent Projects

Obvious indicators of the best management practices are the retention ponds in office parks such as Inverness and Meridian, or water around features in housing areas such as

Stonegate. The ponds and water channels add beauty, but they also serve a functional purpose, and that's one of reduction of chemicals, nutrients and silt entering the Reservoir.

The Authority directly, through its own financing, has constructed and arranged for the operation and maintenance of permanent water quality projects. Also, because of the Authority's regulations and programs, other public agencies and private developers have constructed water quality projects in the Cherry Creek watershed. The following are examples of those projects:

Shop Creek Project

The Shop Creek Project, directly west of Parker Road and south of Quincy Avenue on the Park's eastern edge, was developed by the City of Aurora and the Authority in 1991. The Shop Creek Project has won a national Honor Award from the American Council of Consulting Engineers for its innovative design.

The Shop Creek Project included stabilization of badly eroded streambanks and a series of retention ponds to trap sediment released in stormwater. The ponds themselves retain the sediment and, thereby, the phosphorous attached to the sediment. The wetlands developed downgradient of the ponds have value not only for erosion control, but also for nutrient removal. Further, the wetlands may provide for flood storage detention, retention of stormflow and habitat for fisheries and waterfowl.

During 1992 and 1993, the Authority has monitored the water quantity and quality throughout the Shop Creek Project to determine that the project does effectively remove sediments and nutrients. The data indicates that the Shop Creek detention pond removes suspended particulate phosphorus, while the wetlands system removes dissolved phosphorus.

Baldwin Pond

Baldwin Pond is a demonstration project located on the east side of Parker Road in Parker. Baldwin Pond captures runoff water from 14 acres of developed single family homes and 100 acres of Douglas County Open Space.

The pond incorporates a sediment pond lined with nutrient absorbing smooth brome grass and an underground water collection system to collect and filter the water after in-pond treatment.

The innovative project captures the runoff water in the constructed pond where it is held and allowed to percolate through a sand and lay filter media. The filtered water is then collected in a network of perforated pipes which then discharges downstream into a natural drainage channel.

It is believed that the three-fold approach to treatment of runoff water will be effective in nutrient removal; the removal of silt as water stands quietly in the pond, the removal of nutrients by plant uptake and the filter bed. The project will require maintenance, removing

the silt, cutting the grass, and replacing the filter media (probably every five to ten years). Preliminary tests in 1992 reported favorable results, even though the smooth brome grass had not matured.

Baldwin Pond was constructed and became functional in 1992. Unfortunately, damage to the underdrain system was caused by the use of All Terrain Vehicles in the area. Now fencing and signs have been erected. Monitoring at the rehabilitated Baldwin Pond is scheduled for 1994.

Clark Farms

Clark Farms, a housing subdivision in Douglas County, contains a "dry" pond to retain stormwater runoff. In those occasions when rainfall causes the pond to fill, silt and phosphorous from the runoff is contained in the soil base of the pond. The Authority has periodically monitored Clark Farms and determined the efficiency of this type of facility for removal of sediment and nitrates.

Control Options

The Authority is participating with Urban Drainage and Flood Control District, Arapahoe County and Douglas County in the planning process to develop flood retention and water quality projects for the Lone Tree, Windmill and Cottonwood watersheds which would provide nonpoint source control for an urbanized portion of the watershed.

As the Authority investigates methods to prevent deterioration of the Reservoir's water quality, options for remediation and prevention are constantly under review.

There appears to be some value to creating new wetlands or sediment ponds upstream from the Reservoir, but until such projects as Baldwin Ponds have been in use for at least five years, the effectiveness cannot be evaluated and assumed.

Sediment ponds are certainly beneficial because they prevent large amounts of stormwater, invariably carrying phosphorous and other nutrients, from entering the Reservoir. Dr. Jones' reports raise the question about just how much phosphorous is infused into the reservoir after major storms, since their findings indicate that the overall effect of stormwater phosphorus maybe short-lived.

G. ACTIVITIES

1992 Activities

During 1992, the Authority participated as a party in hearings before the Colorado Water Quality Control Commission regarding the adoption of a numeric water quality standard for wetlands. A regulation was proposed that would require that all wetlands meet the same water quality standards as the adjacent water bodies. The Authority presented evidence that there is not necessarily a relationship between wetlands water quality and the water quality of the

adjacent water body. The regulation, as adopted, ensured that man-made, constructed wetlands, such as the Shop Creek Project, would be excluded from the wetlands to which numeric water quality standards would apply, so that the incentive to construct wetlands as a control strategy would not be impaired.

Dr. John R. Jones of the University of Missouri's School of Natural Resources conducted an extensive examination and analysis of the historical data for the basin and review of the entire monitoring program. The review included scrutiny of the accuracy and precision of the data, sampling techniques, laboratory procedures, QA/QC, data analysis and projection of data trends. Dr. Jones compared the findings for Cherry Creek Reservoir with lakes under study in other states. Based on that data review and in-reservoir work conducted in June and August of 1992 by the University of Missouri, Dr. Jones opined that the Cherry Creek Reservoir's water quality is maintained and controlled more by internal lake dynamics than by external forces such as wind and inflow water. Dr. Jones' experiments also indicated that controlling influences on algal growth might be the nonavailability of nitrogen and the availability of light due to turbidity. Dr. Jones also reported that his evaluation of historic data indicated that storm events have a tendency to reduce phosphorus as the free phosphorus attaches to the suspended solids and settles out in the lake in-flow areas. Dr. Jones has questioned the reliability of prior data on the Reservoir, due to the variability between control samples, indicating questionable laboratory procedures. The prior data, therefore, may be unsuitable to make judgments about the Reservoir and upstream basin. Dr. Jones recommended further screening of past data for reliability, intensive in-lake monitoring, and monitoring of in-lake conditions immediately after storm events.

At the triennial review of the Cherry Creek Reservoir Control Regulation, the regulation was revised to establish an administrative procedure to effect phosphorus allocation transfers between dischargers. The authority also considered revising the regulation so that background phosphorus levels would be considered in effluent limits, but decided to postpone the issue until further factual data is developed.

1992 Site Applications

The Authority is responsible for reviewing all site applications, compliance schedules, and special permits for wastewater treatment plants to ensure the plants comply with the Cherry Creek Basin Master Plan. The Authority has a technical review committee which reviews each application and recommends point source and nonpoint source controls. During 1992, the Authority took a number of actions regarding point source discharges.

The Authority approved the purchase by the Parker Water and Sanitation District of the wastewater treatment plant owned by the Town of Parker.

The Authority approved an amendment to the Clean Water Plan, which combined the service areas of the Arapahoe County Water and Wastewater Authority and the Cottonwood Water and Sanitation District. A portion of Cottonwood's phosphorus allocation was transferred to Arapahoe while retaining for Douglas County phosphorus which would be associated with the undeveloped portion of the Cottonwood service area.

The Authority approved construction of a sewage lift station by the Stonegate Center Metropolitan District, north of Lincoln Avenue and east of Jordan Road to serve the south and east portion of the district.

The Authority approved an application by Denver Southeast Suburban Water and Sanitation district to process and land apply sludge.

The Authority approved a 2250 gallons per day private disposal system located southeast of Castle Rock, which is not within the service area of an existing treatment agency.

1993 Activities

The Authority authorized the expenditure of $6,400.00 to repair the drain line damage to Baldwin Pond caused by All Terrain Vehicles in 1992, and also to construct a cable barrier.

Dr. Jones made recommendations for the monitoring program which were incorporated into the 1993 monitoring program. Those recommendations were: (1) development and implementation of QA/QC program; (2) review of precision and accuracy of results; and (3) investigation of internal flux of nutrients. The 1993 samples were collected by Advanced Sciences, Inc. and forwarded for testing to the University of Missouri, the Authority contract laboratory and Dr. Lewis, who is a consultant for State Parks. Sample results were sent to Dr. Jones who prepared monthly reports and a summary of results. The Authority also retained Chadwick & Associates, Inc. to perform chlorophyll-a and algal species evaluation.

Cherry Creek State Recreation Area was the site of a number of World Youth Day activities in 1993. The Authority requested that State Parks impose best management practices to mitigate the effects of the activities. State Parks installed silt fences, hay bales and other measures to mitigate run-off contamination, and the World Youth Day organization deposited funds with State Parks for revegetation and other restoration activities.

The Authority participated in funding a boat pump-out station and public restrooms at the Cherry Creek Marina. The Authority contributed $10,000.00 on the basis that providing the boating public with a convenient method of disposing of septic waters would benefit Reservoir water quality.

The Authority proposed a one-day retreat to be held in January 1994 on its mission, planning, goals and strategies. The Authority solicited the input and invited interested agencies, such as State Parks, the Denver Regional Council of Government, the Division of Wildlife, and the Army Corps of Engineers, regarding the activities and priorities of the Authority. Using this information, and guided by its experience, legislative mandate and control regulations, the Authority developed a new mission statement, goals, and priorities for Authority projects.

The Authority participated in a study of drainage and water quality, for Lone Tree/Windmill/Dove Creek, along with Arapahoe County and the Urban Drainage and Flood Control District. The study resulted in an implementation planning report and project recommendations.

1993 Site Applications

During 1993, the Authority took additional actions regarding point source dischargers.

Stonegate requested that the Authority approve site applications for the Stonegate Challenger Park lift station, and to upgrade the Stonegate Wastewater Treatment Plant to advanced wastewater treatment and direct discharge into Cherry Creek. The Authority approved the site application for the sewage lift station, and also approved the site application for advanced wastewater treatment and direct discharge to Cherry Creek, with the recommendation to the Colorado Department of Health that treatment plant effluent which will be discharged to Cherry Creek meets the drinking water standards for nitrates, and that effluent fecal coliform be considered too.

Parker Water and Sanitation District submitted to the Authority requests for approval of two site applications. The first site application would activate a previously approved and constructed advanced wastewater treatment plant and allow direct discharge to Cherry Creek. The second site application would allow the construction of a previously approved advanced wastewater treatment plant, and increase direct discharge from six months to year-round discharge. The Authority approved both site applications, with the recommendation to the Colorado Department of Health that effluent which will be diverted to Cherry Creek must meet the drinking water standards for nitrates.

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ARTICLE 8.5

Cherry Creek Basin Water Quality Authority

25-8.5-101. Legislative declaration. (1) The general assembly hereby finds and declares that the organization of a Cherry Creek basin water quality authority will:

(a) Be for the public benefit and advantage of the people of the state of Colorado;

(b) Benefit the inhabitants and landowners within the authority by preserving water quality in Cherry Creek and Cherry Creek reservoir;

(c) Benefit the people of the state of Colorado by preserving waters for recreation, fisheries, water supplies, and other beneficial uses;

(d) Promote the health, safety, and welfare of the people of the state of Colorado.

(2) It is further declared that the authority will provide for effective efforts by the various counties, municipalities, special districts, and landowners within the boundaries of the authority in the protection of water quality.

(3) It is further declared that the authority should provide that new developments and construction activities pay their equitable proportion of costs for water quality preservation and facilities.

(4) This article, being necessary to secure the public health, safety, convenience, and welfare, shall be liberally construed to effect its purposes.

Source: L. 88, p. 1029, § 1.

25-8.5-102. Definitions. As used in this article, unless the context otherwise requires:

(1) "Agricultural lands" means all lands except land rezoned by a county or municipality for business, commercial, residential, or similar uses or subdivided lands. Those include property consisting of a lot one acre or more in size which contains a dwelling unit.

(2) "Authority" means the Cherry Creek basin water quality authority created pursuant to section 25-8.5-103.

(3) "Board" means the governing body of the authority provided for in section 25-8.5-106.

(4) "County" means any county enumerated in article 5 of title 30, C.R.S.

(5) "Municipality" means a municipality as defined in section 31-1-101 (6), C.R.S.

(6) "Publication" means three consecutive weekly advertisements in a newspaper or newspapers of general circulation within the boundaries of the authority. It shall not be necessary that an advertisement be made on the same day of the week in each of the three weeks, but not less than twelve days, excluding the day of first publication, shall intervene between the first publication and the last publication. Publication shall be complete on the date of the last publication.

(7) "Resolution" means an ordinance as passed by a member municipality or a resolution as passed by a member county or special district.

(8) "Soil conservation district" means any soil conservation district created pursuant to article 70 of title 35, C.R.S.

(9) "Special district" means any district created pursuant to article 1 of title 32, C.R.S., which has the power to provide sanitation services or water and sanitation services and has wastewater treatment facilities within the boundaries of the authority.

(10) "Wastewater treatment facility" means a facility providing wastewater treatment services which has a designed capacity to receive sewage for treating, neutralizing, stabilizing, and reducing pollutants contained therein prior to the disposal or discharge of the treated sewage. "Wastewater treatment facility" does not include any pretreatment facilities, lift stations, interceptor lines, or other transmission facilities to transmit sewage effluent outside the boundaries of the authority.

Source: L. 88, p. 1030, § 1.

25-8.5-103. Creation and organization. The Cherry Creek basin water quality authority is hereby created. The authority shall be a quasi-municipal corporation and political subdivision of the state, with the powers provided in this article.

Source: L. 88, p. 1030, § 1.

Am. Jur.2d. See 61A Am. Jur.2d, Pollution Control, § 141.

25-8.5-104. Boundaries of the authority. (1) The boundaries of the authority shall be determined by the authority, subject to the following:

(a) The boundaries shall be limited to the drainage basin of Cherry Creek from its headwaters to the dam at Cherry Creek reservoir, which the general assembly hereby finds to be:

(I) Arapahoe county: Portions of sections thirty-five and thirty-six, township four south, range sixty-seven west of the sixth principal meridian; a portion of section thirty-one, township four south, range sixty-six west of

the sixth principal meridian: portions of sections one, two, three, ten, fifteen, twenty-two, twenty-three, twenty-seven, and thirty-four, and all of sections eleven, twelve, thirteen, fourteen, twenty-four, twenty-five, twenty-six, thirty-five and thirty-six, township five south, range sixty-seven west of the sixth principal meridian; all of sections seven, seventeen, eighteen, nineteen, twenty, twenty-one, twenty-two, twenty-five, twenty-six, twenty-seven, twenty-eight, twenty-nine, thirty, thirty-one, thirty-two, thirty-three, thirty-four, thirty-five, thirty-six and portions of sections five, six, eight, nine, fourteen, fifteen, sixteen, twenty-three and twenty-four, township five south, range sixty-six west of the sixth principal meridian; all of section thirty-one and portions of sections nineteen, twenty-nine, thirty, and thirty-two, township five south, range sixty-five west of the sixth principal meridian;

(II) Douglas county: Portions of sections four, nine, sixteen, twenty-one, twenty-eight and thirty-three, and all of sections five, six, seven, eight, seventeen, eighteen, nineteen, twenty, twenty-nine, thirty, thirty-one, and thirty-two, township six south, range sixty-five west of the sixth principal meridian; township six south, range sixty-six west of the sixth principal meridian; portions of sections three, ten, fifteen, twenty-one, twenty-two, twenty-eight, thirty-one, thirty-two and thirty-three, and all of sections one, two, eleven, twelve, thirteen, fourteen, twenty-three, twenty-four, twenty-five, twenty-six, twenty-seven, thirty-four, thirty-five and thirty-six, township six south, range sixty-seven west of the sixth principal meridian; portions of sections four, nine, sixteen, and twenty-one, and all of sections five, six, seven, eight, seventeen, eighteen, nineteen, twenty, twenty-eight, twenty-nine, thirty, thirty-one, thirty-two, and thirty-three, township seven south, range sixty-five west of the sixth principal meridian; township seven south, range sixty-six west of the sixth principal meridian; portions of sections four, five, nine, fourteen, fifteen, sixteen, twenty-three, twenty-five, twenty-six, and thirty-six, and all of sections one, two, three, ten, eleven, twelve, thirteen, and twenty-four, township seven south, range sixty-seven west of the sixth principal meridian; portions of sections twenty-eight and thirty-three and all of sections four, five, six, seven, eight, nine, sixteen, seventeen, eighteen, nineteen, twenty, twenty-one, twenty-nine, thirty, thirty-one, and thirty-two, township eight south, range sixty-five west of the sixth principal meridian; portions of sections six, seven, eighteen, nineteen, twenty-nine, thirty, and thirty-one, and all of sections one, two, three, four, five, eight, nine, ten, eleven, twelve, thirteen, fourteen, fifteen, sixteen, seventeen, twenty, twenty-one, twenty-two, twenty-three, twenty-four, twenty-five, twenty-six, twenty-seven, twenty-eight, thirty-two, thirty-three, thirty-four, thirty-five and thirty-six, township eight south, range sixty-six west of the sixth principal meridian; a portion of section one, township eight south, range sixty-seven west of the sixth principal meridian; all of sections four, five, six, seven, eight, nine, sixteen, seventeen, eighteen, nineteen, twenty, twenty-one, twenty-eight, twenty-nine, thirty, thirty-one, thirty-two and thirty-three, township nine south, range sixty-five west of the sixth principal meridian; all of township nine south, range sixty-six west excepting portions of sections six and seven; portions of sections thirteen, twenty-three, twenty-four, twenty-five, and thirty-six, township nine south, range sixty-seven west of the sixth principal meridian; portions of sections twenty-eight and thirty-three, and all of sections four, five, six, seven, eight, nine, sixteen, seventeen, eighteen, nineteen, twenty,

twenty-one, twenty-nine, thirty, thirty-one, and thirty-two, township ten south, range sixty-five west of the sixth principal meridian; portions of sections five, six, seven, eight, seventeen, eighteen, nineteen, twenty-nine, thirty, thirty-one, and all of sections one, two, three, four, nine, ten, eleven, twelve, thirteen, fourteen, fifteen, sixteen, twenty, twenty-one, twenty-two, twenty-three, twenty-four, twenty-five, twenty-six, twenty-seven, twenty-eight, thirty-two, thirty-three, thirty-four, thirty-five and thirty-six, township ten south, range sixty-six west of the sixth principal meridian; a portion of section one, township ten south range sixty-seven west of the sixth principal meridian;

(b) Lands may be included within the boundaries of the authority pursuant to section 25-8.5-119.

(c) Lands within the boundaries identified in paragraph (a) of this subsection (1) may be excluded from the authority pursuant to section 25-8.5-120.

(2) The authority shall maintain a current map, showing all lands that are included in the authority's boundaries.

Source: L. 88, p. 1031, § 1.

25-8.5-105. Authority members. (1) The following governmental entities shall be members of the authority:

(a) Every county which has property within the authority's boundaries;

(b) Every municipality which has property within the authority's boundaries; and

(c) Every special district which includes in its service area property within the Cherry Creek basin and which owns and operates a wastewater treatment services facility in the Cherry Creek basin. For the purposes of this paragraph (c), wastewater treatment services shall mean a wastewater treatment facility with a designed capacity to receive more than two thousand gallons of sewage per day.

Source: L. 88, p. 1032, § 1.

25-8.5-106. Board of directors. (1) The governing body of the authority shall be a board of directors which shall exercise and perform all powers, rights, privileges, and duties invested or imposed by this article.

(2) Each authority member shall appoint one representative and two alternates to serve on the board. Any county, municipality, or special district that provides wastewater treatment services by contract with another entity which is a member of the authority shall not be entitled to a separate member on the board.

(3) Directors shall be appointed for terms of two years. Notice of each appointment shall be given to the recording secretary for the authority.

(4) No director shall receive compensation as an employee of the authority. Reimbursement of actual expenses for directors shall not be considered compensation.

(5) An appointment to fill a vacancy on the board shall be made by the authority member for the remainder of the unexpired term.

(6) If a board member or designated alternate fails to attend two consecutive regular meetings of the board, the authority may submit a written request

to the appointing authority member to have its representative attend the next regular meeting. If, following such request, said representative fails to attend the next regular board meeting, the board may appoint an interim representative from the authority member's jurisdiction to serve until the authority member appoints a new representative.

(7) An authority member, at its discretion, may remove from office any board member or designated alternate representing the authority member and appoint a successor.

(8) The board shall elect one of its members as chairman of the authority and one of its members as secretary-treasurer and shall appoint a recording secretary who may be a member of the board.

(9) The recording secretary shall keep, in a well-bound book, a record of all of the authority's meetings, resolutions, certificates, contracts, bonds given by employees or contractors, and all corporate acts which shall be open to inspection of all interested parties.

(10) The secretary-treasurer shall keep strict and accurate accounts of all money received by and disbursed for and on behalf of the authority.

Source: L. 88, p. 1032, § 1.

25-8.5-107. Voting. (1) Each authority member, through its designated director or designated alternate acting in the director's place, shall be entitled to one vote.

(2) Board action upon waste load allocations, site location, or site plans selected pursuant to section 25-8-702, discharge permits secured pursuant to section 25-8-501, amendments to the authority's wastewater management plan, and all budget and funding decisions shall require a vote of the following combinations of member votes:

(a) An affirmative vote of fifty percent of the counties which are members of the authority; and

(b) An affirmative vote of a majority of the municipalities which are members of the authority; and

(c) An affirmative vote of a majority of the special districts which are members of the authority.

(3) All decisions of the board not enumerated in subsection (2) of this section shall be made and decided by a majority of the quorum.

(4) A director shall disqualify himself from voting on any issue in which he has a conflict of interest unless such director has disclosed such conflict of interest in compliance with section 18-8-308, C.R.S., in which case such disclosure shall cure the conflict. A director shall abstain from voting if the director would obtain a personal financial gain from the contract or services being voted upon by the authority.

Source: L. 88, p. 1033, § 1.

25-8.5-108. Ex officio members. (1) Ex officio members shall be provided with notice of the authority meetings. Ex officio members shall not serve on the board. Ex officio members are not voting members. The following shall be considered ex officio members:

(a) Every soil conservation district of which more than two-thirds of its territory is included within the authority's boundaries;

(b) Any other governmental or quasi-governmental agency designated as an ex officio member by the authority.

Source: L. 88, p. 1034, § 1.

25-8.5-109. Meetings. (1) The board shall fix the time and place at which its regular meetings shall be held and provide for the calling and holding of special meetings.

(2) Notice of the time and place designated for all regular meetings shall be posted at the office of the county clerk and recorder of each of the counties included within the authority. Such notices shall remain posted and shall be changed in the event that the time or place of such regular meetings is changed.

(3) Special meetings of the board shall be held at the call of the chairman or upon request of two board members. The authority shall inform all board members five calendar days before the special meeting and shall post notice in accordance with subsection (2) of this section at least three days before the special meeting of the date, time, and place of such special meeting and the purpose for which it is called.

(4) All business of the board shall be conducted only during said regular or special meetings, and all said meetings shall be open to the public, but the board may hold executive sessions as provided in article 9 of title 29, C.R.S.

Source: L. 88, p. 1034, § 1.

25-8.5-110. Powers of board - organization - administration. (1) The board has the following powers relating to carrying on the affairs of the authority:

(a) To organize, adopt bylaws and rules of procedure, and select a chairman and chairman pro tempore;

(b) To make and pass resolutions and orders which are necessary for the governance and management of the affairs of the authority, for the execution of the powers vested in the authority, and for carrying out the provisions of this article;

(c) To fix the location of the principal place of business of the authority and the location of all offices maintained under this article;

(d) To prescribe by resolution a system of business administration, to create any and all necessary offices, to establish the powers and duties and compensation of all employees, and to require and fix the amount of all official bonds necessary for the protection of the funds and property of the authority;

(e) To appoint and retain employees, agents, and consultants to make recommendations, coordinate authority activities, conduct routine business of the authority, and act on behalf of the authority under such conditions and restrictions as shall be fixed by the board;

(f) To prescribe a method of auditing and allowing or rejecting claims and demands and a method for the letting of contracts on a fair and competitive basis for the construction of works, structures, or equipment or for the performance or furnishing of such labor, materials, or supplies as may be required for the carrying out of any of the purposes of this article.

Source: L. 88, p. 1034, § 1.

25-8.5-111. Powers of authority - general and financial. (1) In order to accomplish its purposes, the authority has the power to:

(a) Develop and implement, with such revisions as become necessary in light of changing conditions, plans for water quality controls for the reservoir, applicable drainage basin, waters, and watershed;

(b) Conduct pilot studies and other studies that may be appropriate for the development of potential water quality control solutions;

(c) Develop and implement programs to provide credits, incentives, and rewards within the Cherry Creek basin plan for water quality control projects;

(d) Recommend the maximum loads of pollutants allowable to maintain the water quality standards and allocate, if delegated the power to pursuant to federal or state law, waste loads among both present and future sources of pollutants;

(e) Recommend erosion controls and urban runoff control standards;

(f) Recommend septic system maintenance programs;

(g) Incur debts, liabilities, and obligations;

(h) Have perpetual existence;

(i) Have and use a corporate seal;

(j) Sue and be a party to suits, actions, and proceedings;

(k) Enter into contracts and agreements affecting the affairs of the authority including, but not limited to, contracts with the United States and the state of Colorado and any of their agencies or instrumentalities, political subdivisions of the state of Colorado, corporations, and individuals;

(l) Acquire, hold, lease (as lessor or lessee), and otherwise dispose of and encumber real and personal property;

(m) Acquire, lease, rent, manage, operate, construct, and maintain water quality control facilities or improvements for drainage, nonpoint sources, or runoff within or without the authority;

(n) Establish rates, tolls, fees, charges, and penalties except on agricultural land for the functions, services, facilities, and programs of the authority; except that the total annual budgeted rates, tolls, fees, and charges for property owners shall not exceed thirty percent of the annual authority budget and shall not exceed the total annual budgeted fees to be paid by users of the Cherry Creek reservoir;

(o) Establish in cooperation with the department of natural resources fees for Cherry Creek reservoir users, which amounts shall be subject to the review and approval of the board of parks and outdoor recreation, which shall not unreasonably withhold approval. Said reservoir fees, including all users regardless of activity, however established, shall not in total exceed the amount that would be collected if the reservoir user fee was one dollar per reservoir user per year.

(p) (I) Levy and collect ad valorem taxes on and against all taxable property within the authority subject to the limitation that no mill levy for any fiscal year shall exceed one-half mill; however, ad valorem taxes greater than one-half mill can be levied by the authority if it is approved by the electors at an election held according to the procedures of part 8 of article 1 of title 32, C.R.S.

(II) No property tax shall be levied until the fees from the recreation users and the development fees are established.

(q) Issue and refund revenue and assessment bonds and pledge the revenues of the authority or assessments therefor to the payment thereof in the manner provided in part 4 of article 35 of title 31, C.R.S., and as provided in this article;

(r) Invest any moneys of the authority in securities meeting the investment requirements established in part 6 of article 75 of title 24, C.R.S.;

(s) Review and approve water quality control projects of any entity other than the authority within the boundaries of the authority;

(t) Except that the authority shall not have the power to regulate agricultural nonpoint source activities; such agricultural nonpoint source activities shall be subject only to the provisions of section 25-8-205 (5);

(u) Have and exercise all rights and powers necessary or incidental to or implied from the specific powers granted to the authority by this article. Such specific powers shall not be considered as a limitation upon any power necessary or appropriate to carry out the purposes and intent of this article.

Source: L. 88, p. 1035, § 1; L. 89, p. 1111, § 17.

Am. Jur.2d. See 61A Am. Jur.2d, Pollution Control, § § 141, 151.

25-8.5-112. Power to issue bonds. To carry out the purposes of this article, the board is authorized to issue revenue or assessment bonds of the authority. Bonds shall bear interest at a rate such that the net effective interest rate of the issue of bonds does not exceed the maximum interest rate set forth in the resolution adopted by the board authorizing the issuance of the bonds, payable semiannually, and shall be due and payable serially, either annually or semiannually, commencing not later than three years after date of issuance. The form and terms of said bonds, including provisions for their payment and redemption, shall be determined by the board. If the board so determines, such bonds may be redeemable prior to maturity upon payment of a premium not exceeding three percent of the principal thereof. Said bonds shall be executed in the name and on behalf of the authority, signed by the chairman of the board with the seal of the authority affixed thereto, and attested by the secretary of the board. Said bonds shall be in such denominations as the board shall determine, and the bonds and coupons shall bear the original or facsimile signature of the chairman of the board.

Source: L. 88, p. 1036, § 1.

25-8.5-113. Revenue refunding bonds. Any revenue bonds issued by the authority may be refunded by the authority, or by any successor thereof,

in the name of the authority, subject to the provisions concerning their payment and to any other contractual limitations in the proceedings authorizing their issuance or otherwise appertaining thereto, by the issuance of bonds to refund, pay, and discharge all or any part of such outstanding bonds, including any interest on the bonds in arrears or about to become due, for the purpose of avoiding or terminating any default in the payment of the interest on and principal of the bonds, of reducing interest costs or effecting other economies, or of modifying or eliminating restrictive contractual limitations appertaining to the issuance of additional bonds or to any system appertaining thereto or for any combination of such purposes. Refunding bonds may be delivered in exchange for the outstanding bonds refunded or may be sold as provided in this article for an original issue of bonds.

Source: L. 88, p. 1036, § 1.

25-8.5-114. Use of proceeds of revenue refunding bonds. The proceeds of revenue refunding bonds shall either be immediately applied to the retirement of the bonds being refunded or be placed in escrow in any state or national bank within the state which is a member of the federal deposit insurance corporation to be applied to the payment of the bonds being refunded upon their presentation therefor; but, to the extent any incidental expenses have been capitalized, such refunding bond proceeds may be used to defray such expenses, and any accrued interest and any premium appertaining to a sale of refunding bonds may be applied to the payment of the interest thereon or the principal thereof, or both interest and principal, or may be deposited in a reserve therefor, as the board may determine. Any such escrow shall not necessarily be limited to proceeds of refunding bonds but may include other moneys available for its purpose. Any proceeds in escrow, pending such use, may be invested or reinvested in securities meeting the investment requirements established in part 6 of article 75 of title 24, C.R.S. Such proceeds and investments in escrow, together with any interest to be derived from any such investment, shall be in an amount at all times sufficient as to principal, interest, any prior redemption premium due, and any charges of the escrow agent payable therefrom to pay the bonds being refunded as they become due at their respective maturities or due at any designated prior redemption dates in connection with which the board shall exercise a prior redemption option. Any purchase of any refunding bond issued under this article shall in no manner be responsible for the application of the proceeds thereof by the authority or any of its officers, agents, or employees.

Source: L. 88, p. 1037, § 1; L. 89, p. 1111, § 18.

25-8.5-115. Facilities - comprehensive program. (1) The authority, acting by and through the board, may acquire, construct, lease, rent, improve, equip, relocate, maintain, and operate water quality control facilities, any project, or any part thereof for the benefit of the authority and the inhabitants thereof, after the board has made such preliminary studies and otherwise taken such action as it determines to be necessary or desirable.

(2) (a) The authority shall develop a comprehensive program for the water quality control facilities specified in subsection (1) of this section. A comprehensive program may consist of one project or more than one project.

(b) A hearing on the proposed comprehensive program shall be scheduled, and notice of the hearing shall be given by publication and posted in the office of the county clerk and recorder of each member county. Upon closure of the hearing, the board may either require changes to be made in the comprehensive program or the board may approve or reject the comprehensive program as prepared.

(c) If any substantial changes to the comprehensive program are ordered at any time, a further hearing shall be held pursuant to notice which shall be given by publication.

Source: L. 88, p. 1037, § 1.

Am. Jur.2d. See 61A Am. Jur.2d, Pollution Control, § § 141, 151.

25-8.5-116. Coordination with drainage and flood control measures. (1) Any exercise by the authority of the powers granted by section 25-8.5-111 or 25-8.5-115 which affects drainage and flood control shall be consistent with and conform to the drainage and flood control program of the urban drainage and flood control district adopted pursuant to section 32-11-214, C.R.S., the resolutions, rules, regulations. and orders of the district issued pursuant to section 32-11-218 (1) (e), C.R.S., and any flood plain zoning resolutions, rules, regulations, and orders of any public body having jurisdiction to adopt the same.

(2) Construction by the authority of drainage or water quality control facilities which might or will affect drainage or flood control within the boundaries of the urban drainage and flood control district shall not be undertaken until a proposal therefor has been presented to and approved by the board of directors of said district. Such proposal shall demonstrate compliance with the requirements of subsection (1) of this section, and the board shall apply the same standards of flood control and drainage criteria for approval thereof as it applies for review of proposals presented for approval pursuant to section 32-11-221, C.R.S. The provisions of section 32-11-221, C.R.S., shall apply to the presentation, consideration, and determination by said board of directors of any such proposal or modification thereof.

Source: L. 88, p. 1038, § 1.

25-8.5-117. Transfer of powers. (1) Upon the adoption of the board of directors of the urban drainage and flood control district and the board of directors of the authority created herein of a joint resolution delegating the agreed-upon responsibility to the urban drainage and flood control district for carrying out and meeting, within the district's boundaries, the compliance requirements and the permitting requirements imposed with respect to storm water runoff quality by the federal "Water Quality Act of 1987" and any regulations and standards adopted pursuant thereto or pursuant to state law,

all powers contained in this act to deal with water quality control and compliance relating to the agreed-upon aspects of storm water runoff and nonpoint sources of pollution, including financial powers and special assessment powers but not including ad valorem taxation powers, shall be transferred to the urban drainage and flood control district.

(2) Upon the transfer of powers as provided in subsection (1) of this section, any allocation of waste loads affecting storm water runoff or nonpoint sources of pollution proposed or adopted by the authority shall be effective only upon adoption thereof or concurrence therewith by the board of directors of the urban drainage and flood control district.

(3) If the urban drainage and flood control district accepts the responsibility and the transfer of powers as provided in subsection (1) of this section, after completion of a plan for water quality controls by the authority which involves storm drainage runoff or nonpoint sources and after commencement of implementation of such plan, the district shall be bound to carry out the plan as it relates to the storm water and nonpoint source powers transferred to it within the time requirements, if any, of the plan.

Source: L. 88, p. 1038, § 1.

25-8.5-118. Power to levy special assessments. (1) The board, in the name of the authority, for the purpose of defraying all the cost of acquiring or constructing, or both, any project or facility authorized by this article, or any portion of the cost thereof not to be defrayed with moneys available therefor from its own funds, any special funds, or otherwise, also has the power under this article:

(a) To levy assessments against all or portions of the property within the authority and to provide for collection of the assessments pursuant to part 6 of article 20 of title 30, C.R.S.;

(b) To pledge the proceeds of any assessments levied under this article to the payment of assessment bonds and to create liens on such proceeds to secure such payments;

(c) To issue assessment bonds payable from the assessments, which assessment bonds shall constitute special obligations of the authority and shall not be a debt of the authority; and

(d) To make all contracts, to execute all instruments, and to do all things necessary or convenient in the exercise of the powers granted in this article or in the performance of the authority's duties or in order to secure the payment of its assessment bonds.

(2) The authority shall give notice, by publication once in a newspaper of general circulation in the authority, to the owners of the property to be assessed, which shall include:

(a) The kind of improvements proposed;

(b) The number of installments and the time in which the cost of the project will be payable;

(c) A description of the properties which will be assessed;

(d) The probable cost per acre or other unit basis which, in the judgment of the authority, reflects the benefits which accrue to the properties to be assessed; except that no benefit shall accrue to agricultural lands;

(e) The time, not less than thirty days after the publication, when a resolution authorizing the improvements will be considered;

(f) A map of the properties to be assessed, together with an estimate and schedule showing the approximate amounts to be assessed, and a statement that all resolutions and proceedings are on file and may be seen and examined by any interested person at the office of the authority or other designated place at any time within said period of thirty days; and

(g) A statement that all complaints and objections by the owners of property to be assessed in writing concerning the proposed improvements will be heard and determined by the authority before final action thereon.

(3) The finding, by resolution, of the board that said improvements were ordered after notice given and after hearing held and that such proposal was properly initiated by the said authority shall be conclusive of the facts so stated in every court or other tribunal.

(4) Any resolution or order regarding the assessments or improvements may be modified, confirmed, or rescinded at any time prior to the passage of the resolution authorizing the improvements.

Source: L. 88, p. 1039, § 1.

25-8.5-119. Inclusion of territory. (1) Any municipality, county, or special district, or any portion thereof, shall be eligible for inclusion upon resolution of its governing body requesting inclusion in the authority and describing the property to be included. The authority, by resolution, may include such property on such terms and conditions as may be determined appropriate by the board.

(2) Upon receipt of a resolution requesting inclusion, the board shall cause an investigation to be made within a reasonable time to determine whether or not the municipality, county, or special district, or portion thereof, may feasibly be included within the authority, whether the municipality, county, or special district has any property which is tributary to the basin, waters, or watersheds governed by the authority, and the terms and conditions upon which the municipality, county, or special district may be included within the authority. If it is determined that it is feasible to include the municipality, county, or special district, or portion thereof, in the authority, and the municipality, county, or special district has property tributary to the basin, waters, or watersheds governed by the authority, the board by resolution shall set the terms and conditions upon which the municipality, county, or special district, or portion thereof, may be included within the authority and shall give notice thereof to the municipality, county, or special district. If the board determines that the municipality, county, or special district, or portion thereof, cannot feasibly be included within the authority or otherwise determines that the municipality, county, or special district should not be included within the authority, the board shall pass a resolution so stating and notifying the municipality, county, or special district of the action of the board. The board's determination that the county, municipality, or special district, or portion thereof, should not be included in the authority shall be conclusive.

(3) (a) If the governing body of the municipality, county, or special district desires to include the municipality, county, or special district, or portion

thereof, within the authority upon the terms and conditions set forth by the board, the governing body shall adopt a resolution declaring that the public health, safety, and general welfare requires the inclusion of said municipality, county, or special district within the authority and that the governing body desires to have said municipality, county, or special district, or portion thereof, included therein upon the terms and conditions prescribed by the board. The governing body of such municipality, county, or special district, before final adoption of said resolution, shall hold a public hearing thereon, notice of which shall be given by publication in a newspaper of general circulation within such municipality, county, or special district, which shall be complete at least ten days before the hearing. Upon the final adoption of said resolution, the clerk of the governing body of such municipality, county, or special district shall forthwith transmit a certified copy of the resolution to the board and to the division of local government in the department of local affairs.

(b) After receipt of a copy of such resolution, the board shall pass and adopt a resolution including said municipality, county, or special district, or portion thereof, in the authority and shall cause a certified copy thereof to be transmitted to the division of local government and a certified copy to the governing body of the municipality, county, or special district.

(4) The director of said division, upon receipt of a certified copy of the resolution of the board, shall forthwith issue a certificate reciting that the municipality, county, or special district, or portion thereof, described in such resolution has been duly included within the authority according to the laws of the state of Colorado. The inclusion of such territory shall be deemed effective upon the date of the issuance of such certificate, and the validity of such inclusion shall not be contestable in any suit or proceeding which has not been commenced within thirty days from such date. The said division shall forthwith transmit to the governing body of such municipality, county, or special district and to the board five copies of such certificate, and the clerk of such governing body shall forthwith record a copy of the certificate in the office of the clerk and recorder of each county in which such municipality, county, or special district, or portion thereof, is located and file a copy thereof with the county assessor of each such county. Additional copies of said certificate shall be issued by the division of local government upon request.

Source: L. 88, p. 1040, § 1.

25-8.5-120. Exclusion of property. (1) Any owner of property within the boundaries of the authority may petition to be excluded from the authority.

(2) In order for such property to be excluded, the board shall determine that the property to be excluded does not receive wastewater treatment services or have an individual sewage disposal system located within the authority and either:

(a) Was improperly included within the authority; or

(b) Is not tributary to the basin, waters, or watersheds governed by the authority or will not benefit from projects or improvements provided by the authority.

(3) Any petition for exclusion shall specify the property to be excluded and evidence that the property complies with the criteria of subsection (2) of this section.

(4) The authority shall provide notice of the date, time, and place of the authority's meeting to consider the petition for exclusion.

(5) The authority may approve, modify, or deny a petition for exclusion.

(6) If the authority approves a petition for exclusion of property, the authority shall file a copy of said resolution with the division of local government and with the county, municipality, or special district authority members which includes within its boundaries the excluded property, record a copy of the resolution in the office of the county clerk and recorder in the county in which said excluded property is located, and file a copy with the county assessor in such county.

Source: L. 88, p. 1041, § 1.

is well within the powers conferred upon the commission and the division to regulate approval as to location, construction, and remodeling of domestic wastewater treatment facilities. Barr Lake Village Metropolitan District v. Colorado Water Quality Control Comm'n., 835 P.2d 613 (Colo. App. 1992).

ARTICLE 8.5

Cherry Creek Basin Water Quality Authority

25-8.5-109. Meetings. (4) All business of the board shall be conducted only during said regular or special meetings, and all said meetings shall be open to the public, but the board may hold executive sessions as provided in part 4 of article 6 of title 24, C.R.S.

Source: (4) amended, L. 91, p. 821, § 5, effective June 1.

ARTICLE 9

Water and Wastewater Treatment Plant Operators

25-9-103. Plant operators certification board - composition - repeal of article. (4) This article is repealed, effective July 1, 1996. Prior to such repeal, the plant operators certification board shall be reviewed as provided for in section 24-34-104, C.R.S.

Source: (4) amended, L. 91, p. 688, § 58, effective April 20.

ARTICLE 11

Radiation Control

PART 1

GENERAL PROVISIONS

25-11-101. Definitions. (2.5) "Mammographer" means a person who operates a machine source of ionizing radiation, commonly known as an "x-ray machine" in the conduct of a mammography exam.

APPENDIX II

Limnological Investigations of Cherry Creek Lake - Preliminary Findings

by

John R. Jones, Professor of Limnology

and

Matthew F. Knowlton, Post-doctoral Fellow

School of Natural Resources
University of Missouri
Columbia, Missouri

Submitted to:

Cherry Creek Basin Water Quality Authority
6200 South Syracuse Way
Suite 150, Carrara Place
Englewood, Colorado

October 1992

Introduction

Cherry Creek Lake is a shallow, wind-swept reservoir in the Denver, Colorado metropolitan area. Recreational use of the lake is heavy in summer. Swimming, water skiing, fishing, and sailing are popular activities. In summer Cherry Creek Lake is subject to periodic blooms of large cyanobacteria that form occasional surface scums and degrade the visual appearance of the water. Cyanobacteria may also be responsible for instances of contact dermatitis affecting several lake users each year.

Plans for extensive development in the Cherry Creek Lake drainage basin put forth in the early 1980's raised concern for protecting water quality in the lake from further degradation. This concern lead to establishment of the Cherry Creek Basin Water Quality Authority (CCBWQA) in 1985. A major goal of CCBWQA has been to prevent an increase in phosphorus loading to Cherry Creek Lake. A 1982 limnological survey of the reservoir (DRCOG, 1984) suggested that biomass of lake phytoplankton (as chlorophyll) was phosphorus-limited and could be expected to co-vary with in-lake concentrations of total phosphorus (TP) as suggested by the chlorophyll-TP regression model of Jones and Bachmann (1976). It was further expected that in-lake TP would vary with annual loading of TP from inflowing streams.

The CCBWQA has conducted a program of monitoring TP and other variables in the lake and inflowing streams for several years. These data do not support the hypotheses upon which the plan for protection of Cherry Creek Lake was based. Annual estimates of TP loading to the lake show no clear relation to in-lake TP and algal biomass as chlorophyll (CHL) has not co-varied with TP as predicted by the Jones-Bachmann model.

Data from limnological surveys of other midwestern reservoirs suggest that conditions in Cherry Creek Lake are typical of shallow, turbid impoundments in the region. In a survey of 94 Missouri reservoirs (Jones and Knowlton, in press), we have found a log-curvilinear relation between CHL and TP in which the response of algal biomass to increased TP seemed to reach an asymptote above mean TP of about 50 µg/L (Figure 1). A similar trend exists among reservoirs and natural lakes in Iowa, Kansas and Oklahoma (Knowlton and Jones, in press). May-September means of CHL and TP from Cherry Creek Lake fall in the asymptotic portion of this relationship (Figure 1).

Midwestern reservoirs with mean summer TP >50 µg/L tend to be shallow and affected by moderate to high concentrations of inorganic suspended solids. Our studies of such lakes in Missouri have shown that variation in light conditions can stimulate rapid growth and declines in algal biomass. In turbid lakes, light conditions are profoundly affected by climatic events that control thermal stratification, mixing, and the input and resuspension of sediment.

Conclusions and Recommendations

At the time of this writing our tasks in reviewing the historical limnological data base for Cherry Creeks Lake and evaluating our findings for summer 1992 are incomplete. We must reassess the historic records in the light of our most recent findings about the quality of those data. Also we are still in the process of compiling and analyzing weather data and stream flow records from this year as they become available to us. Because of doubts about the reliability of past records, it is it is important that we obtain as complete a factual base as possible about conditions in the past growing season. Several weeks will required for the completion of these tasks. We can, however, present here a preliminary summary and assessment of our work to date.

Historic data base - Available records suggest that the monitoring data for Cherry Creek Lake suffer from unacceptably low precision and that phosphorus and, perhaps, chlorophyll data contain large negative biases. If these problems affect the entire period of record then the entire CCBWQA phosphorus and chlorophyll data base is of very limited value. Such data cannot be used with any confidence for estimation of seasonal averages or annual loading. We cannot determine on the basis of the records provided whether large errors affect the entire data base or just the past few years. We believe that all past records should be considered suspect except those that can individually verified from the original laboratory records. At a minimum it needs to be shown that appropriate standards and blanks were run with each set of analyses and that the recovery of known standards was uniform. Erratic recovery of standards and poor precision in analysis of replicate samples are indicative of procedural problems.

Present condition of Cherry Creek Lake -- The data available suggest that phytoplankton dynamics in Cherry Creek Lake are driven primarily by internal processes. Algal biomass is probably limited by low availability of dissolved inorganic nitrogen except when the lake is colonized by nitrogen-fixing cyanobacteria. We do not yet understand why these organisms bloom in some years and not others. At first glance, phosphorus availability does not seem to be the key. Ambient supplies of phosphorus are adequate to support higher biomass than is usually present in the lake. But normal concentrations of phosphorus may be too low for cyanobacteria to fully exploit their competitive advantages and grow to bloom proportions. The data base on phosphorus dynamics in the lake is of insufficient quality to test any hypotheses regarding variation in phosphorus as a key to the timing of algal blooms.

Irrespective of the role of phosphorus in initiating algal blooms, it is highly probable that the severity of blooms is limited at some point by ambient phosphorus supplies. It would be inadvisable to allow future increases in phosphorus as result of human activity. It is an open question, however, as to what

extent human activities in and around the lake influence in-lake phosphorus dynamics. Lake bottom materials contain large supplies of phosphorus that may be partly available to the microbial community, so variation in external loading may be relatively unimportant. In any case, available data seem to show no relation between loading from inflowing streams and phosphorus in the lake. Assuming this finding is not purely the product of bad data, it may be because much of the loading to the Cherry Creek Lake complex is intercepted by surrounding wetlands before entering the lake itself. Internal processes and exchange with groundwater may simply overshadow the influence of surface water inputs. Under this scenario it would be very difficult to measure the effect of any future increase in phosphorus loading in the drainage basin unless it was accompanied by a major change in the lakes hydrologic regime such as a large increase in base flow in the tributaries.

If we consider periodic large algal blooms to be the principal water quality problem in Cherry Creek Lake then the principal goal in managing the lake is to prevent future increases in their frequency and severity. To attain this goal at minimal expense requires a better understanding of the conditions that encourage the blooms to form, or conversely, the factors that prevent their formation in some years. Strict limitation of phosphorus loading in the drainage basin may or may not be of use in preventing future increases in blooms. Likewise, dredging to remove phosphorus-rich bottom materials or application of alum to reduce phosphorus in the water might or might be effective. The great expense of these measures argues against their application until there is some assurance that they will succeed. This assurance can only come through a more thorough understanding of the phenomena in question -- the occurrence of large blooms of nitrogen fixing cyanobacteria. The first step in attaining this understanding is to acquire reliable information on conditions in the lake.

Future monitoring -- The current Cherry Creek Lake monitoring program is based on the assumption that external loading from inflowing streams is the key to water quality in the lake. This assumption now seems unfounded. Surface water inflows may have little real effect on water quality in the lake. There seems to be little justification for continuing to emphasize stream sampling in the program and there is some justification for discontinuing stream work. Estimating nutrient loading in streams is very consumptive of time and resources. Streams vary enormously in discharge and nutrient concentrations. Thus even very intense and expensive sampling programs may provide only approximate estimates of loading. Such estimates may be valuable if there is good reason to believe stream loading is of critical importance, but in the case of Cherry Creek Lake any further attempts to estimate stream loading would seem a poor investment relative to the expected return. The resources used in stream sampling could be put to better use acquiring accurate information about variation of conditions in the lake.

We would recommend that Cherry Creek Lake be monitored closely for a period of at least three successive year using an intensified sampling program. This project would have the dual purpose of searching for clues to the occurrence of algal blooms and acquiring information with which to design a permanent monitoring program for the lake. An important purpose in monitoring a lake is to detect any permanent change in water quality that could be traced to human influences. But lakes vary greatly over time, with or without human intervention, so detecting permanent changes is a challenging undertaking requiring use of appropriate sampling design and statistical analysis. Designing a long term sampling program requires baseline data on seasonal and interannual variability. We do not believe the existing data base is adequate for this purpose. A revised and intensified sampling program is needed.

The specific design of the baseline study should be reviewed by a statistician practiced in time series analysis. It is our initial recommendation that the lake should be sampled biweekly during May-September and monthly in the remainder of the open water season. Sampling of shallow water sites such as the "Inflow" and "Swim Beach" sites should be abandoned in favor of sampling sites representing large proportions of the total water mass in the lake. Shallow sites are overly influenced by local and ephemeral variation that has little effect on the lake as a whole. The lake should be sampled at least three deep water (>6 m) sites each located at the approximate center of mass of one third of the lake volume as determined from a planimetry using a bathymetric map. Samples for laboratory analysis should be collected as composites of the upper 5 m and all laboratory analyses should be conducted in triplicate. Additional subsamples of the composites should be appropriately preserved and stored as voucher samples until lab analysis is completed and results evaluated. Samples showing poor precision should be reanalyzed using the voucher samples. Observations with erratic or poorly reproduced results should be recorded as such in the data base.

Before beginning this program it is vitally important that a laboratory be located that is capable of achieving high precision in analysis of lake water samples. We recommend that candidates for this job be tested by requiring them to analyze a range of USEPA standard materials in order to evaluate the accuracy and precision of their results. Data in Table 2 provide an indication of the level of precision that should be expected in routine laboratory work. Furthermore, the quality of laboratory results should be checked on a routine basis by analysis of additional USEPA standards or their equivalent. It is very important that the data set represent a high and consistent level of analytical quality.

APPENDIX III

Limnological Investigations of Cherry Creek Lake
-
Final Report

by

Matthew F. Knowlton, Post-doctoral Fellow

and

John R. Jones, Professor of Limnology

School of Natural Resources
University of Missouri
Columbia, Missouri

Submitted to:

Cherry Creek Basin Water Quality Authority
6200 South Syracuse Way
Suite 150, Carrara Place
Englewood, Colorado

February 1993

Executive Summary

Cherry Creek Lake is a Corps of Engineers flood control reservoir south of Aurora, Colorado, in a rapidly expanding portion of the Denver metropolitan area. The lake and surrounding park lands are heavily used for recreation so there is strong incentive to protect the water quality of the reservoir from degradation that might result from the current urbanization of the lake's formerly rural catchment. Current management plans for the lake basin focus on control of phosphorus inputs as a means of reducing cultural eutrophication of the lake. But management plans are based on limited data about the lake's ecology and the efficacy of phosphorus control remains uncertain. We were asked by the Cherry Creek Basin Water Quality Authority (CCBWQA) to conduct experimental sampling of the lake in 1992 and to review and summarize historic limnological data from the reservoir as an aid to planning future water quality management. This report describes selected findings of our work.

Lake monitoring data collected by the Corps of Engineers and by contractors to the CCBWQA and its predecessors show Cherry Creek Lake to be shallow and moderately turbid with wide fluctuations in nutrients and algal biomass. The lake usually stratifies and mixes diurnally in summer with the result that dissolved oxygen is usually near saturation at the surface and is partly depleted, but never totally absent, in deeper waters. Salinity is moderate and varies with the lake's flood-drought hydrologic cycle. Inflowing flood waters carry heavy loads of sediment and nutrients but have surprisingly little effect on conditions in the lake. Limnological conditions during the record high inflows of 1983-1988 differed only slightly, if at all, from dryer periods before and after. Sediment and nutrients in floods presumably settle rapidly out of the water column or are intercepted by wetlands surrounding the lake. Loading of nutrients from inflowing streams seems to have little or no effect on nutrient concentrations in the lake. In 1992, we observed very little resuspension of sediment and nutrients from the lake bottom in response to storms and boat traffic, but this mechanism may have been more important in the past.

In its present condition, water quality in Cherry Creek Lake seems relatively immune from degradation by high concentrations of suspended sediment or severe oxygen depletion. And algal standing crop is usually too low to degrade the visual appearance of lake water or otherwise present a problem. But for several weeks in 1988 and 1992 the lake supported blooms of large colonial cyanobacteria (bluegreen algae) that reached nuisance proportions. It is unclear whether such blooms also occurred in the past or are a recent phenomenon only. In the absence of such blooms, algal standing crop seems to be limited by low availability of dissolved inorganic nitrogen, a deficiency overcome during blooms by the fixation of atmospheric nitrogen by the phytoplankton involved (Aphanizomenon and Anabena). Available data fail to explain why blooms have occurred in some years and not others.

From our current understanding of nutrient-algal dynamics in Cherry Creek Lake it is not clear that phosphorus control measures will provide the benefits intended in their application. But to err on the side of caution, we do not recommend abandoning phosphorus control until less equivocal information is available about factors regulating algal blooms and the dynamics of phosphorus in the lake and catchment. To plan the protection of future water quality in the lake, more must be known about the fate of phosphorus released in the basin and carried by inflowing streams and the role of phosphorus, if any, in controlling blooms of nitrogen-fixing algae. We recommend intensified research on these subjects. We also recommend modification of current lake and stream monitoring programs to improve the precision of the data obtained. Past data have suffered from problems with analytical methods and erratic reproducibility of laboratory results that reduce their value for research applications.

Conclusions and Recommendations

At the time of this writing our tasks in reviewing the historical limnological data base for Cherry Creeks Lake and evaluating our findings for summer 1992 are incomplete. We must reassess the historic records in the light of our most recent findings about the quality of those data. Also we are still in the process of compiling and analyzing weather data and stream flow records from this year as they become available to us. Because of doubts about the reliability of past records, it is it is important that we obtain as complete a factual base as possible about conditions in the past growing season. Several weeks will required for the completion of these tasks. We can, however, present here a preliminary summary and assessment of our work to date.

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APPENDIX IV

Final Report

Assessment of Current Information on Water Quality and Environmental Status of Cherry Creek Reservoir with Recommendations for Future Programs

Prepared by: William M. Lewis, Jr.

Prepared for: Mel Langdon
Colorado Department of Parks and Outdoor Recreation

Carolyn Armstrong
Cherry Creek Park

Date of preparation: 28 January 1994

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Introduction

Federal and state governments are promoting watershed management as a basis for protection and wise use of water resources. This concept is appealing because the amount and quality of water resources are determined by the sum of activities in an entire watershed.

Despite the advantage that it offers for control and protection of resources, watershed management is presently unusual in the United States because the administrative framework for regulation and protection of resources is typically defined according to boundaries that transect watersheds. In this sense the Cherry Creek Basin Authority, which brings together the common interests of the Cherry Creek Basin, is both unusual and advantageous as a basis for rational management of water resources. It also provides a valuable revenue base for the evaluation and solution of problems.

The Cherry Creek Basin Authority has proven its value in control of sediment transport to Cherry Creek Reservoir and in promoting and supporting aesthetic and physical improvements such as those of Shop Creek. The Authority has also invested heavily in studies of phosphorus transport and of trophic state for Cherry Creek Reservoir. These studies, while clearly important, have been less successful than the sediment control projects because they have not yet led to firm conclusions that can be translated into management options.

The purpose of this report is to provide an overview of the present state of knowledge about Cherry Creek Reservoir and its watershed, to evaluate the adequacy of present study programs to produce information that will be useful in management, and to draw conclusions about the advisability of various management options.

Overview of Cherry Creek Reservoir and Its Tributary Waters

Cherry Creek Reservoir began to accumulate water in 1957 but was not subject to intensive environmental scrutiny until the Clean Lakes Study of 1981-82 (DRCOG 1984). The Clean Lakes Study led to the adoption of site-specific water quality standards for phosphorus in 1984. Although the Corps of Engineers has monitored water quality in the Reservoir since 1975, there is no information on water quality for the first 18 years of the reservoir's history. Therefore, the original status of the reservoir is difficult to reconstruct and cannot be used as a point of reference for the present status of the lake.

Cherry Creek Reservoir has been monitored intensively since 1984 under sponsorship of the Cherry Creek Basin Authority. This monitoring and the earlier Clean Lakes Study should have provided a firm basis for assessment of the current and recent past status of the reservoir. For a variety of reasons to be summarized in this report, the intensive data collection effort has not produced as much reliable information as it might have, and a number of basic but important aspects of water quality in the basin remain unresolved.

The geologic setting, land use patterns, climate, and physical features of the Cherry Creek Basin and of the reservoir have been well described in the Clean Lakes Report (DRCOG 1984) and in a recent review by Knowlton and Jones (1993), and need not be repeated here. However, it is useful to focus attention on a few features of the Cherry Creek Reservoir and its watershed that might be considered somewhat unusual or especially significant to the evaluation of water quality. A summary of these special features is given in Table 1.

Cherry Creek Reservoir has a longer water retention time than most reservoirs. This means that algal populations in the lake are very unlikely to be controlled by physical removal, even during relatively wet intervals, and it also suggests that horizontal uniformity of water quality is likely to be higher than it would be in some reservoirs that have high rates of water replacement.

The watershed of Cherry Creek is very large in relation to the size of the lake. This feature of the watershed, when taken in combination with the absence of surface base flow in Cherry Creek, creates some special difficulties for the evaluation of land use in relation to nutrient transport: land use practices or nutrient sources that are distant from the lake may have less practical importance than those closer to the lake in this situation.

Hydrology presents some special difficulties in the Cherry Creek setting. Much of the water from the upstream portion of the basin is intercepted by pumping from the Cherry Creek alluvium. Even so, substantial amounts of groundwater reach Cherry Creek Reservoir in the form of seepage and discharge from the surface of the alluvium within the wetland area at the upper end of the reservoir. Because of the large wetland at the upper end of the lake, delivery of suspended or dissolved materials from the watershed to the lake is really a 3-part process (watershed to wetland to lake) rather than a 2-part process (watershed to lake), as it would be for many reservoirs. The wetland can intercept or modify dissolved or suspended solids from the watershed, and thus may influence the mass loading of the lake. The wetland may also affect the water budget of the lake.

The volume and mean depth of the lake have been greatly reduced in the past by sedimentation. Although the rate of sedimentation has

been greatly reduced by the Cherry Creek Authority, Cherry Creek Reservoir is very shallow by comparison of most reservoirs of smaller size. Shallow reservoirs are less likely to develop severe oxygen depletion than deep ones because they experience sufficient mixing or turbulence to transport oxygen from the upper layers to the lower layers. The presence of oxygen near the bottom of the lake minimizes the return of phosphorus from the sediment surface to the water column, and in this sense is beneficial in controlling of trophic state. On the other hand, a shallow water column may promote the growth of algae, and particularly of nuisance blooms, because it reduces the shading of algal populations that would occur if the lake were deeper. Also, certain types of nuisance bluegreen algae seem to be favored by shallow lakes.

Another important feature of Cherry Creek Reservoir is the prominence of storm loading as a transport mechanism for suspended solids and nutrients. The surface flow of Cherry Creek at the Park boundary occurs entirely in response to storms or unusual periods of wet weather lasting several days. This type of transport regime, when combined with semi-arid conditions and disturbed soils, results in large pulses of suspended solids and associated nutrients. Phosphorus that is associated with the suspended solids under these conditions is subject to especially high sedimentation rates in the reservoir. In contrast, phosphorus that enters along with base flow from seepage in the Cherry Creek channel, and from Shop Creek and Cottonwood Creek, is far less subject to sedimentation after it enters the reservoir. Therefore, an understanding of the relationship between phosphorus concentrations in the reservoir and phosphorus loads reaching the reservoir requires a particularly careful analysis of sedimentation

The studies of such watersheds should include both ground water and storm flow, and should be conducted according to mass balance principles. The raw data cannot be used directly to forecast background concentrations of the lake, because allowance must be made for sedimentation. However, given the results of the sedimentation studies recommended above, it should ultimately be possible to estimate the background concentrations for the lake.

Association Between Nutrient Yield and Land Use

For nutrient management and forecasting purposes, it is important that some information be collected on the relationship between nutrient yield and land use. Such studies should be conducted by mass balance principles and should include both storm flow and ground water. One point of major concern is residential development, which changes water yield. It should be possible to forecast a change in nutrient export associated with various kinds of development in Cherry Creek Basin.

Estimate of Water Flow Beneath Cherry Creek

A provisional estimate has been made of the flow of water beneath the Cherry Creek Dam. Because this estimate is based on calculations rather than measurements, it is important that some empirical studies be done. This information is important not so much for its own sake as for the more accurate calculation of inflows to Cherry Creek Reservoir.

Evaluation of Management Strategies

The Shop Creek project is an excellent example of water quality control. A number of other projects have been studied or at least discussed over the past several years. These projects can be put into three groups: (1) projects that are now advisable and feasible, (2) projects that should be deferred or that require further study, (3) projects that are probably inadvisable (Table 3).

Sediment and Nutrient Control on Drainages Near the Reservoir

There has been some discussion of sediment and phosphorus control projects on Cottonwood Creek and on Lonetree and Windmill drainages. These projects would involve construction of check dams leading to the trapping of sediment and the formation of more extensive wetland and riparian zones on these creeks. Projects of this type are justified by three kinds of benefits: (1) interception of phosphorus and sediment that might otherwise reach the reservoir, (2) aesthetic improvement in the drainages themselves, and (3) creation of new riparian and wetland habitat.

Dredging the Reservoir

If the reservoir loses substantial additional volume, dredging may be the only way in which its uses can be restored. For the present, however, it seems more prudent and cost effective to continue increasing the efficiency with which sediment is intercepted before it reaches the lake, thus greatly slowing the accumulation of sediment in the reservoir.

There are several arguments against dredging under present circumstances. First, the shallow end of the reservoir provides

insufficient depth for power boats, and this creates a natural refuge zone for water birds and other wildlife. In addition, many species of water birds are specifically attracted to extensive areas of shallow water such as those found at the upper end of Cherry Creek.

Dredging on a sufficient scale to have much effect on the reservoir would pose some serious environmental problems. If the sediment were trucked from the area, as presumably it would have to be, the noise and disturbance would be quite substantial and would extend over a long period of time. Some of the beneficial effects of dredging might be offset by accelerated transport of sediments from the upper end of the basin and the wetland area to deeper water as a result of dredging.

Control of Shoreline Erosion

Site inspection shows that an erosion problem is associated with specific water level changes. One possible means of managing erosion would be to work with the Corps of Engineers to assure that water levels remain within a zone of minimum erosion corresponding to historic mean levels.

Active management of shoreline erosion is also possible, although it may not be necessary if water levels are held within specific bounds. Installation of rip rap, gabions or even vegetation in sufficient amounts to control erosion completely might interfere with the accessibility and usefulness of the lake margin. Many visitors to the lake presently use the smooth near-shore area as a place to walk or fish.

The priority for active control of shoreline erosion is probably only for areas that show the highest rates of erosion, and only if

these areas cannot be managed by restrictions on water level.

Additional Regulation of Treatment Plant Practices

Restrictions have been placed on practices of wastewater treatment plants for treatment and disposal of effluent. The restrictions are logical given the very high concentrations of phosphorus found in secondary effluent. However, an important question at present is whether or not additional restrictions can be justified by the need to intercept phosphorus that might enter Cherry Creek Reservoir. The information at hand is insufficient to provide an answer to this question. Progress should be made toward better definition of the pathways of phosphorus flow to Cherry Creek Reservoir, which will set the stage for a meaningful evaluation of restrictions on phosphorus in wastewaters.

Re-examination of the Phosphorus Standard

The phosphorus standard should be re-examined in collaboration with the Colorado State Department of Health Water Quality Control Division. This will require a better information base than now exists. Pathways for phosphorus loading of the reservoir must be understood better, and there must be some quantitative information on background concentrations of phosphorus originating in portions of the watershed that are not heavily used.

Aeration

Aeration is sometimes used in lakes that suffer high degrees of eutrophication. Aeration can be helpful in two ways. First, it may change the species composition of algae, thus shifting the balance

from species that are more likely to cause nuisances to species that are less likely to do so. In addition, aeration of lakes that are strongly stratified may disrupt stratification sufficiently to allow oxygen to reach anoxic sediments. Neither of these two justifications seems particularly compelling for Cherry Creek Reservoir at the present time. The incidence of nuisance blooms of algae is relatively small. Aeration is not always effective in disrupting or replacing these blooms, and in some cases causes changes that are even less desirable than the original condition. The potentially stronger justification in some lakes is disruption of stratification, but stratification is very weak in Cherry Creek Reservoir, and there is no severe oxygen depletion over the sediments.

References

Denver Regional Council of Governments. 1984. Cherry Creek Reservoir Clean Lakes Study.

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