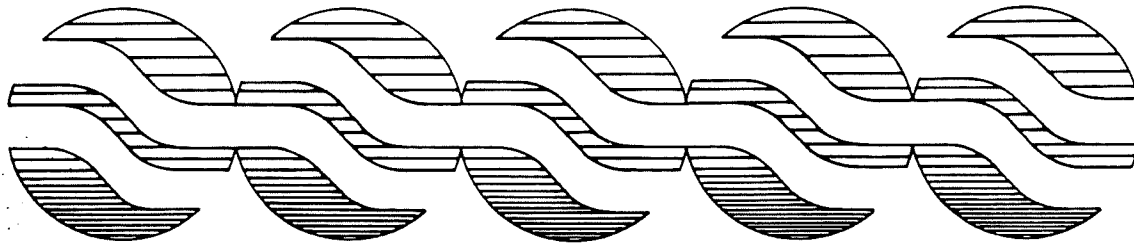


# **Cherry Creek Basin**



## **Water Quality Management Master Plan**

**DRCOG**

**Denver Regional Council of Governments**



CHERRY CREEK BASIN  
WATER QUALITY MANAGEMENT  
MASTER PLAN

Denver Regional Council of Governments  
2480 West 26th Avenue, Suite 200B  
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in cooperation with  
Counties, Municipalities,  
Water and Sanitation Districts  
in the Cherry Creek Basin

and  
Colorado Department of Health  
Water Quality Control Division  
4210 East 11th Avenue  
Denver, Colorado 80220



## ABSTRACT

TITLE	Cherry Creek Basin Water Quality Management Master Plan
AUTHOR	Denver Regional Council of Governments
SUBJECT	This water quality plan for the Cherry Creek Basin defines point and nonpoint phosphorus control strategies necessary to protect Cherry Creek Reservoir.
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ABSTRACT	This water quality management plan presents a phosphorus control program for the Cherry Creek Basin. The intent of the control program is to limit the annual load of phosphorus entering Cherry Creek Reservoir to ensure that the 0.035 milligram per liter total phosphorus reservoir standard [as established by the Water Quality Control Commission] is maintained. The plan identifies the location, number and type of wastewater treatment facilities in the basin and recommends a nonpoint control program capable of removing 50 percent of the annual nonpoint load. Specific phosphorus allocations are made for each point source discharge and an institutional framework is recommended which is responsible for implementing the phosphorus control program.



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## EXECUTIVE SUMMARY

In order to maintain the water quality in Cherry Creek Reservoir, a basinwide cooperative effort was undertaken by all local governments in the Cherry Creek Basin in cooperation with the Denver Regional Council of Governments to produce a water quality management master plan. This management plan will identify the most effective methods for protecting the water quality of Cherry Creek Reservoir while complying with the 0.035 milligrams per liter (mg/L) total phosphorus standard adopted for the reservoir by the Colorado Water Quality Control Commission (WQCC). While this plan will not replace the need for individual facility plans, it will identify appropriate treatment methods, location and number of treatment facilities, a point source or wastewater treatment plant phosphorus allocation program, a nonpoint or stormwater runoff control program and the institution responsible for implementing the plan. The WQCC has asked DRCOG to present portions of the management plan suitable for rulemaking in relation to site applications, discharge permits and nonpoint control regulations.

Completing the master plan was a joint effort by local governments, state and federal agencies, and water and sanitation districts in the basin. Funding was provided by the local governments, water and sanitation districts, and the Colorado Department of Health. A complete listing of the participating agencies appears at the back of this plan. Following is a summary of the major topics contained in this management plan.

### Plan Development

Projections of growth and development in the basin were defined from local comprehensive land use plans. The local plans defined land use within the basin at buildout. Based on the local land use projections, population and employment are projected to be 188,000 and 163,000 respectively at the "critical phosphorus loading point." The critical phosphorus loading point occurs when the phosphorus produced in the basin results in an in-lake phosphorus concentration of 0.035 mg/L. The estimates of population and employment were then staged for the years 1990, 2000, and 2010. This information was the primary source from which future wastewater flow projections and nonpoint or stormwater runoff projections were made.

### Basin Phosphorus Allocation and Limitation

With adoption of the 0.035 mg/L total phosphorus standard for Cherry Creek Reservoir by the WQCC, it was necessary to determine the maximum quantity of phosphorus which could enter the reservoir annually while complying with the standard. Using an in-lake phosphorus model, it was possible to define the annual load of phosphorus from all sources combined that would be within the phosphorus limit for the reservoir. Therefore, it was necessary to define the maximum allowable annual load based on the 0.035 mg/L standard. This allowable annual load became the phosphorus limit for the basin. The annual load of phosphorus from wastewater treatment facilities (point sources), nonpoint sources, and the background conditions were quantified.



Equating the 0.035 mg/L standard in the reservoir to pounds of phosphorus, it was determined that a system of twelve treatment plants, using various treatment technologies and the expected nonpoint loading, a total of 14,270 pounds of phosphorus could enter the Reservoir. The pounds allocated are not owned by the owners of the facilities. Rather, they will be reviewed and reallocated as necessary based on quality of treatment and the actual level of development within the area served by each facility. This limit of 14,270 pounds will ensure that the reservoir standard is maintained.

Both point source loading and nonpoint source loading will increase as growth occurs in the basin. The point in the future when the combined total of these two sources reaches the 14,270 pound figure is defined as the "critical load." In the plan the critical point results in the following distribution of phosphorus between sources:

<u>Source</u>	<u>Pounds of Phosphorus</u>
Point Sources	2,310
Nonpoint Sources	10,290
Septic Systems	450
Industrial Sources	50
Background	<u>1,170</u>
Total	14,270

The 2,310 pounds available to the point sources were then allocated to each of the 12 wastewater treatment facilities. This poundage limitation required that the plan focus on a shorter time frame represented by the critical point loading rather than focus on a specific time frame out to the year 2010.

#### Nonpoint Source Control

Nonpoint source phosphorus or stormwater runoff is the major contributor of phosphorus to the reservoir. In spite of the degree of success of controlling point sources, the control of nonpoint is required in order to maintain the reservoir standard. The plan specifies that the entire wastewater treatment program is predicated on the fact that a nonpoint control program will be implemented immediately. The nonpoint program requires that structural measures such as detention and filtration be installed in the basin for the purpose of removing a minimum of 50 percent of the annual nonpoint phosphorus load. The 50 percent removal rate is a conservative estimate for planning purposes only. Actual removal rates may be higher but until water quality monitoring data is analyzed which would indicate higher removal ratio, the 50 percent removal will be considered the goal. The basinwide goal of 50 percent annual nonpoint removal requires that local governments in the basin adopt best management practices relating to erosion control and septic systems.

#### Point Source Control

A point source program was recommended which allows 12 wastewater treatment facilities to provide service in the basin. A number of different wastewater



treatment scenarios were evaluated, all of which were capable of producing acceptable effluent and could meet the water quality standards for the reservoir. Of all the wastewater scenarios evaluated, the 12-plant option was selected due to its minimal impact on water rights and other non-quantifiable criteria and impact and, to a lesser degree, due to its costs. The location of each facility, type of wastewater treatment and facility service area are identified in the plan.

The annual allocation of phosphorus among the 12 treatment facilities was distributed as follows:

<u>Discharger</u>	<u>Annual Pounds</u>
Arapahoe W & S District	354
Cottonwood W & S District	213
Denver Southeast Suburban W & S District	365*
Inverness W & S District	68
Meridian Metropolitan District	114
Parker W & S District	533
Stonegate Center Metropolitan District	53
Castle Rock (Mitchell Creek)	128
Castle Rock (Cherry Creek)	21
Castle Rock (McMurdo Gulch)	64
Castle Rock (Newlin Gulch)	86**
Rampart Range	160**
Total	2,159

\*The present facility at Denver Southeast Suburban W & S District (DSESW&SD) utilizes 365 pounds of phosphorus annually. The 365 pound phosphorus allocation to DSESW&SD is temporary and shall be reduced to 213 pounds of phosphorus in 1990 or when DSESW&SD completes construction of their 1.4 mgd facility, whichever occurs first.

\*\*The Castle Rock, Cherry Creek plant will probably serve a portion of the Newlin Gulch facility up to 51 pounds annually. In this case, 51 pounds would be subtracted from the 86 pounds listed on this table and added to the Castle Rock, Cherry Creek facility.

The 2159 pounds allocated leaves a reserve pool of 151 pounds which will increase to 303 pounds after the allocation to Denver Southeast drops to 213 pounds. The pool is part of the total point source phosphorus pounds which may be contributed annually. The reserve may be used by any discharger listed above which will exceed its annual allocation due to emergencies, bypass or breakdowns. The reserve will be managed and distributed by the Colorado Department of Health, Water Quality Control Division, upon recommendation of the Basin Authority.

### Institutional System

The entire phosphorus control program will be implemented by a Basinwide Authority which is created by intergovernmental agreement. The Authority will be made up of all local governments in the basin and it will be responsible for constructing, financing, and operating the nonpoint control systems. It will also be responsible for monitoring the water quality in the reservoir and basin to document the trends in water quality and to monitor the effectiveness of control measures. The Authority will be involved with the state water quality regulating process by making specific recommendations on individual phosphorus allocations, discharge permits, and site applications.

This water quality management master plan will be implemented by the management agency. The plan identifies a series of steps to be taken within the next year which will demonstrate a commitment by local governments to implement the plan. The cost of maintaining the water quality in Cherry Creek Reservoir is estimated at \$34 million per year. This cost includes the expenditure for those facilities already in place as well as those to be constructed. These costs will be shared by residents and land owners in the basin. Although the program is expensive, it is the only way to allow the basin to develop while protecting the quality of Cherry Creek Reservoir.

## I. INTRODUCTION

Governmental entities in the Cherry Creek Basin have been concerned about water quality in Cherry Creek Reservoir. As a result, a basinwide cooperative effort was undertaken by the entities in cooperation with the Denver Regional Council of Governments (DRCOG) to provide a water quality management master plan for the basin. This water quality management plan will be an update to the DRCOG Clean Water Plan.<sup>1</sup> The purpose of this plan is to identify the most feasible and effective means for achieving the 0.035 milligrams per liter (mg/L) total phosphorus water quality standard in Cherry Creek Reservoir established by the Water Quality Control Commission (WQCC). This standard was adopted on August 14, 1984. The 0.035 mg/L total phosphorus standard was adopted to protect the reservoir from accelerated eutrophication. It was established after a two-year, EPA-sponsored Clean Lakes Study.

This master plan is the result of the cooperative efforts of DRCOG, state and federal agencies, and local governments in the Cherry Creek Basin. These parties formed a task force which was responsible for guiding the study and making final recommendations to the DRCOG Board of Directors and the WQCC. The task force effort and these recommendations are based upon intensive technical analyses documented in a supporting technical report.<sup>2</sup> This master plan contains the policy recommendations for the basin developed in accordance with the approved scope of work.

The master plan does not replace the need for individual facility plans. It identifies appropriate treatment methods, location of treatment facilities, non-point control strategies and a point source phosphorus allocation program. Implementation of the entire plan relies upon creation of an institutional mechanism responsible for ensuring that these recommendations are followed. The institution would be composed of the local governments in the basin and enabled, through intergovernmental agreement and existing land use controls, to exercise the necessary authority to regulate the program.

The master plan as presented will serve two functions. First, it can be used as a planning tool for addressing the basin's water quality issues. Second, part of the document is prepared in a format suitable for rulemaking and adoption by the WQCC. This latter function was requested by the WQCC for use in acting upon site applications, discharge permits, nonpoint control regulations and the point source phosphorus allocation program.

### Proposed Rule Adoption

As noted previously, not all of this master plan is recommended for adoption as rule for the Cherry Creek Basin by the WQCC. It is anticipated that this plan

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<sup>1</sup>Denver Regional Council of Governments, Clean Water Plan, 1984 Update, September, 1984, Denver, Colorado.

<sup>2</sup>Denver Regional Council of Governments, Cherry Creek Basin Water Quality Management Master Plan Technical Report, (to be published) Denver, Colorado.



will be adopted by DRCOG and the WQCC as an amendment to the Clean Water Plan and appropriate portions adopted as regulation by the WQCC.

It is recommended that the proposed rule focus on the main issues which relate to controlling phosphorus in the basin. Inherent in these issues is the institution responsible for implementing the plan; however, the institution itself is not proposed to be part of the adopted rule. The topics proposed for adoption as rule are:

1. Authority. Recognizes the state statutes which authorize the WQCC to promulgate water quality control regulations.
2. Definitions. Specific water quality terminology used throughout the regulation and this plan is defined.
3. Wasteload Allocation for Total Phosphorus Discharge. The maximum annual phosphorus loads from individual sources are defined.
4. Allowed Phosphorus Discharge (lbs./yr.). Each point source discharger in the basin is allocated a maximum annual phosphorus poundage limit. An annual poundage limit is also placed on septic systems and industrial dischargers. A reserve pool of phosphorus is also maintained for emergency purposes.
5. Municipal, Domestic and Industrial Effluent Limitations. Maximum daily phosphorus effluent concentrations are defined as well as a 30-day average effluent design concentration.
6. Control of Nonpoint Sources. A nonpoint control strategy is outlined which establishes a control program to remove 50 percent of the annual nonpoint phosphorus load.
7. Monitoring of Phosphorus. A basinwide monitoring program is required to determine that the point and nonpoint sources are in compliance with the regulation and to report on the water quality status of Cherry Creek Reservoir.
8. Commission Review. After two years, the WQCC shall review the regulation and, if necessary, adjust the regulation so that the phosphorus control program is effectively maintaining the reservoir phosphorus standard.
9. Basis and Purpose. A re-statement of the Basis and Purpose for the WQCC adoption of the 0.035 mg/L total phosphorus standard for Cherry Creek Reservoir.

The following chapters present the detailed recommendations relevant to the phosphorus control program in the Cherry Creek Basin. Implementation of the control regulation is necessary to preserve the beneficial uses of Cherry Creek Reservoir while at the same time providing for the growth and development anticipated in the basin.



## II. BASIN DEVELOPMENT

The type and rate of growth in the Cherry Creek Basin will have a direct impact on the water quality of Cherry Creek Reservoir. In order to determine the extent of the impact, it was necessary to estimate current and future levels of population, employment and wastewater flow.<sup>3</sup> These values were used to predict future loading to the reservoir from both point and nonpoint sources. By analyzing various control scenarios, a "critical load" was determined which is the point in time when loading from wastewater plants, stormwater runoff, and background sources will equal the standard established for the reservoir. It is the prediction of this critical point which is the goal of the population and employment projections.

These projections reflect the anticipated land use in the basin. Land use information used in this plan was that provided by the local governments as of June, 1984 and includes information on Newlin Gulch development as supplied in March, 1985. Newlin Gulch represents an area that will urbanize but will probably be part of the Castle Rock system. Land use information on Newlin Gulch reflects the expected land use pattern at full buildout and does not necessarily reflect existing zoning or platting. This land use information was then translated into projections of population, employment and wastewater flow for the years 1990, 2000, and 2010. It recognized that the assumptions used to develop the land use will change with time. The plan is flexible enough to allow these changes through the annual plan update process if requested by a management agency. Details of the methods used to convert land use information into population and employment appear in the technical report.<sup>3</sup>

Normally, projections of growth are used to determine wastewater treatment facility sizing and staging for discrete years (1985, 1990, 2000). Since treatment facilities in the Cherry Creek Basin will be limited to a phosphorus load allocation which is regulated by a regularly reviewed basinwide phosphorus limit, projections of growth at the discrete years becomes an ineffective way to plan for sizing and staging. The controlling factor for sizing and staging is the critical point source loading and the individual facility phosphorus allocation. The population and employment served by a facility is determined by the phosphorus allocation. To the extent that a facility can remove more non-point phosphorus or treat wastewater to a higher degree, it can serve more population. This concept is discussed in subsequent chapters in this plan. Projections developed in this planning effort were used to help define the critical point source loading based on certain point and nonpoint treatment assumptions.

### Land Use

The development pattern expected to occur in the Cherry Creek Basin is shown in Figure 1. Based on the information provided by the local governments, open space is expected to continue to be the predominant use in the basin. This definition of open space includes parks, floodplains and agricultural uses which

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<sup>3</sup>Ibid



will cover 102,000 of the 246,000 acres in the basin. However, most of this open space will be concentrated in the southern portion of the basin extending into El Paso County. At this time, neither Douglas County nor El Paso County foresees any development other than some large lot residential areas south of Franktown.

North of Franktown, the development pattern is expected to become predominantly urban. This change from agricultural uses is already underway with much large lot development already in place. The future plan suggests that large lot areas will occupy the eastern ridge and portions of the western ridges of the basin. Urban residential and commercial development is expected to occur in the valley areas.

This urbanized area is generally separated into office-commercial-industrial development at the extreme northern end of the basin and residential areas extending from the Arapahoe County line south to Castle Rock. The Centennial Airport is one factor in this forecast since planning has recognized a non-residential buffer around the airport. The non-residential area also extends along I-25, recognizing the access provided by that transportation corridor.

#### Projections of Population and Employment

With the land use defined for the basin, the next step was to stage the development over time and distribute it to subbasins. The natural drainage subbasins are shown in Figure 2. The staging took land use information and projected population, employment and wastewater flows for 1990, 2000, and 2010.

In 1983, the basin population was estimated at 43,300. Nearly one-quarter of this population was located in the Shop Creek Basin in Aurora. Other major basins were Piney Creek, which is all large lot development, and Direct Flow #1, an area also located in Aurora.







Table 1 contains the forecasts of total population for 1990, 2000 and 2010 for each subbasin. Basinwide population is expected to double by 1990 and double again by 2000. The growth rate slows slightly during the first decade of the 21st century.

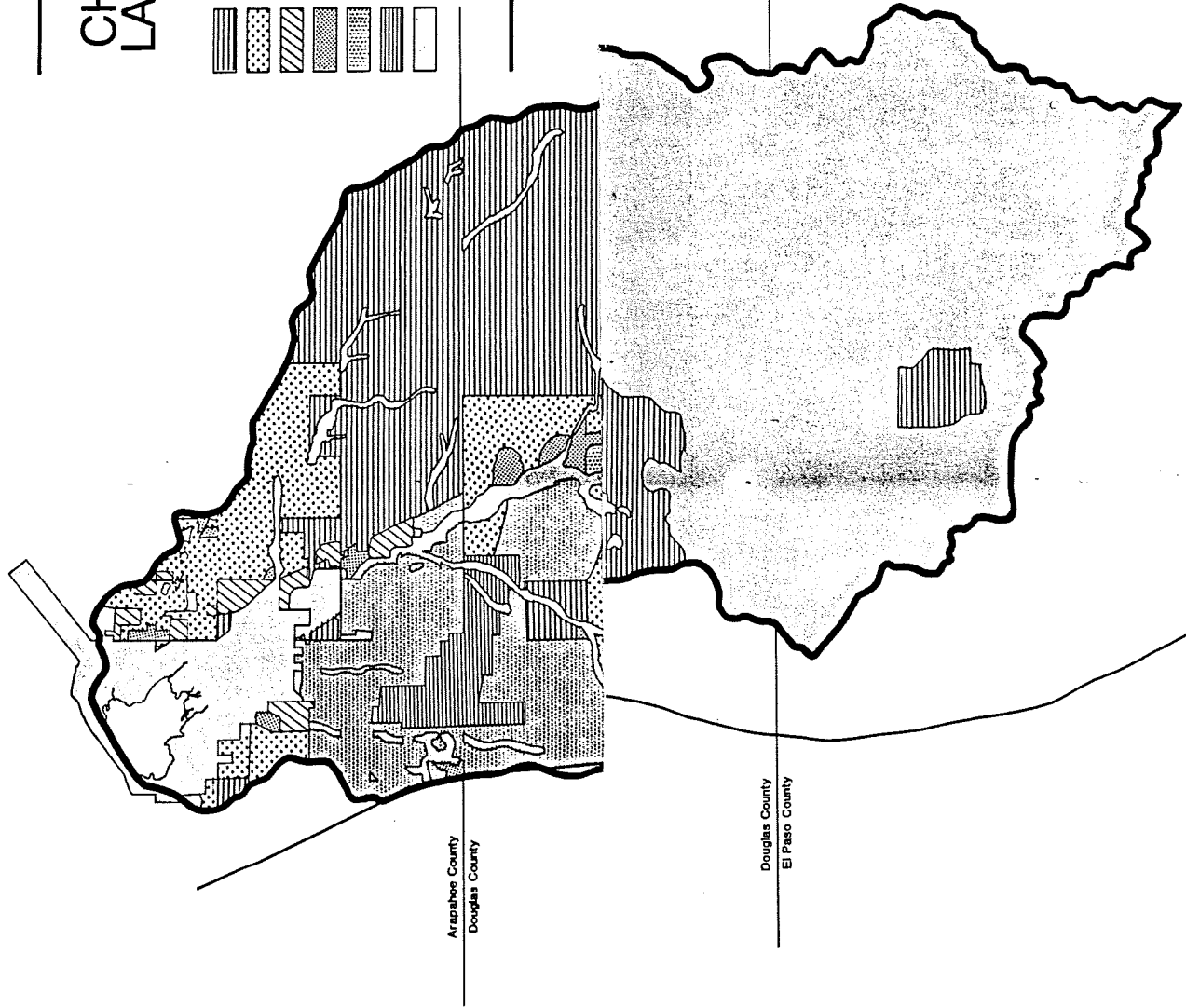
Of concern to this water quality plan is the number of persons in these categories: sewer population, large lot population and that portion of the population which will be sewer to a facility discharging outside of the Cherry Creek Basin. This split more accurately defines that population which would be contributing directly to a wastewater treatment facility (sewer population) and the population which would be using septic systems (large lot). The third category, labeled out of basin service, defines the population which is connected to a wastewater treatment facility located outside of the Cherry Creek Basin. This population will be located primarily on the east and west sides of the reservoir and is sewer through Metropolitan Denver Sewage Disposal District No. 1. Table 2 presents the projections for these three subsets for the year 2000. This year is close to the critical point and provides a comparison of these



Figure 1

# CHERRY CREEK BASIN LAND USE AT ULTIMATE BUILD-OUT

-  Large Lot Residential ( $\leq 1$  D.U./AC.)
-  Residential ( $> 1$  D.U./AC.)
-  Residential ( $> 11$  D.U./AC.)
-  Commercial (Retail & Office)
-  Industrial (Light Industry & Office)
-  Airport Property
-  Open Space (Park, Flood Plains & Agriculture)





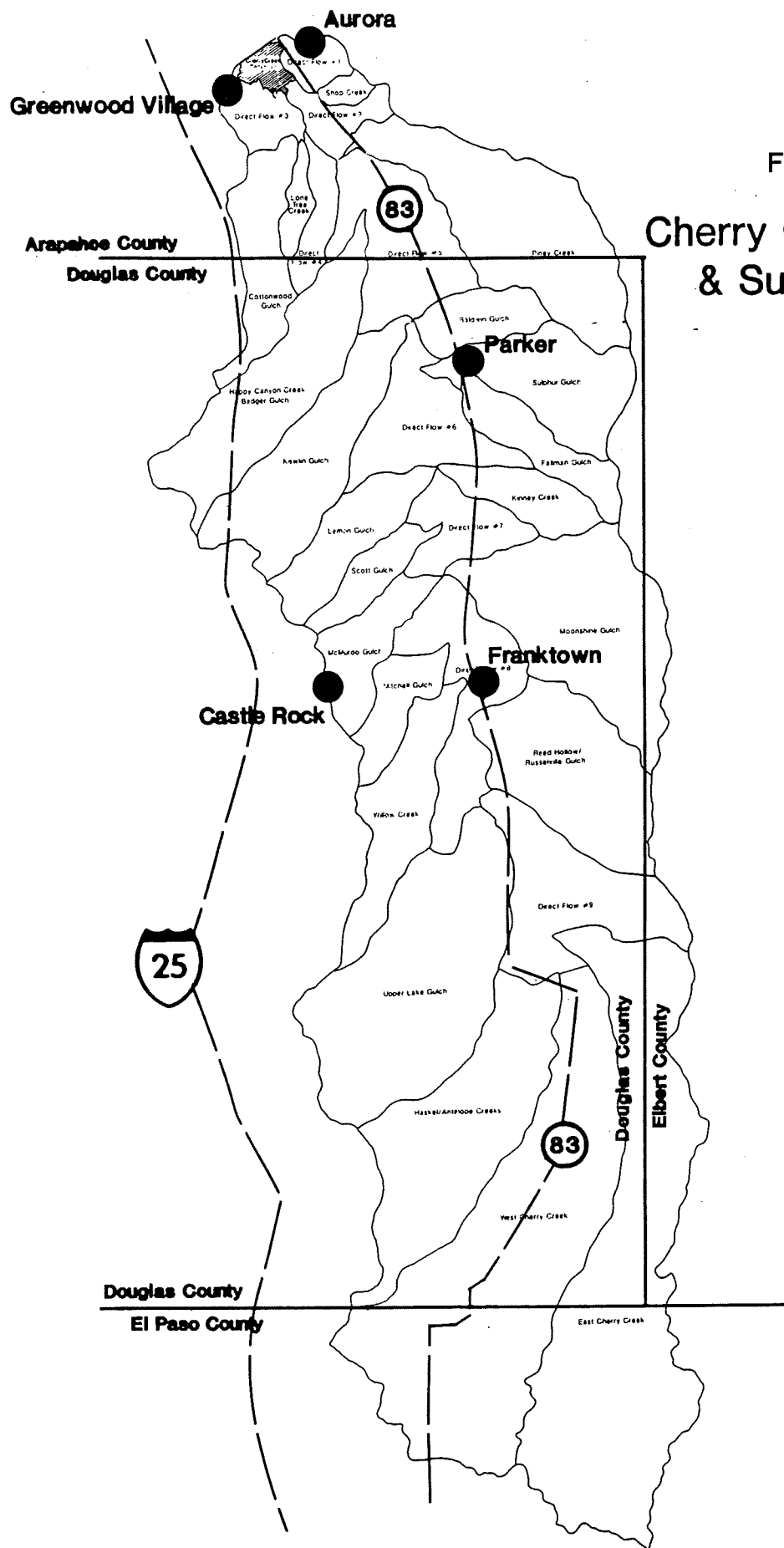


Figure 2

## Cherry Creek Basin & Subbasins

Table 1

## Projections of Total Basin Population By Subbasin

	1990	2000	2010
Baldwin Gulch	3,000	4,400	6,100
Cottonwood Gulch	1,700	2,200	2,900
East Cherry Creek	0	0	0
Happy Canyon	5,600	15,500	27,000
Haskel/Antelope Cr	500	1,400	2,500
Kinney Creek	3,300	7,700	12,800
Lemon Gulch	2,800	8,700	15,800
Lone Tree Gulch	0	0	0
McMurdo Gulch	2,500	7,700	13,700
Mitchell Creek	1,200	3,600	6,400
Moonshine Gulch	5,900	14,200	24,000
Newlin Gulch	4,700	14,400	25,800
Piney Creek	8,800	14,600	21,400
Reed Hollow	1,100	2,000	3,100
Scott Gulch	1,600	5,000	9,000
Shop Creek	10,000	10,100	10,300
Sulphur Gulch	3,500	6,000	8,900
Tallman Gulch	2,400	6,800	11,900
Upper Lake Gulch	300	900	1,500
West Cherry Creek	100	200	300
Willow Creek	800	2,200	3,900
Direct Flow #1	5,600	6,400	7,300
Direct Flow #2	3,100	5,000	7,200
Direct Flow #3	4,200	5,200	6,500
Direct Flow #4	300	500	700
Direct Flow #5	5,100	9,800	15,200
Direct Flow #6	6,200	18,600	33,100
Direct Flow #7	4,500	10,300	17,300
Direct Flow #8	1,600	4,200	7,200
Direct Flow #9	0	0	0
Total	90,400	187,600	301,800

Table 2  
Year 2000 Projections of Population by Subgroup

Basin	Sewered Population		Large Lot Population	Total
	In Basin	Out of Basin		
Baldwin Gulch	2,800		1,600	4,400
Cottonwood Gulch	0	2,100	100	2,200
East Cherry Creek	0		0	0
Happy Canyon	9,600	3,200	2,700	15,500
Haskel/Antelope Cr	0		1,400	1,400
Kinney Creek	6,400		1,300	7,700
Lemon Gulch	7,700		1,000	8,700
Lone Tree Gulch	0		0	0
McMurdo Gulch	6,800		900	7,700
Mitchell Creek	2,900		800	3,700
Moonshine Gulch	9,900		4,300	14,200
Newlin Gulch	12,200		2,200	14,400
Piney Creek		9,100	5,500	14,600
Reed Hollow	0		2,000	2,000
Scott Gulch	4,400		600	5,000
Shop Creek		10,100	100	10,200
Sulphur Gulch	3,800		2,200	6,000
Tallman Gulch	5,500		1,300	6,800
Upper Lake Gulch	0		900	900
West Cherry Creek	0		200	200
Willow Creek	1,800		400	2,200
Direct Flow #1		6,300	100	6,400
Direct Flow #2		4,700	300	5,000
Direct Flow #3		5,000	200	5,200
Direct Flow #4	500		100	600
Direct Flow #5	7,600		2,200	9,800
Direct Flow #6	16,600		2,000	18,600
Direct Flow #7	9,300		1,000	10,300
Direct Flow #8	2,800		1,400	4,200
Direct Flow #9	0	0	0	0
Total	110,600	40,500	36,800	187,900

different projections. Data for other years are available in the technical report. While the population presently sewered within the basin is the smallest of these three groups, it is expected to grow rapidly. By 1990, it will nearly equal the large lot population. It will be the largest group in 2000 and is expected to total 142,200 in 2010.

The population sewered out of the basin will grow very slowly. In addition to the area served through the Metro District, a portion of the Castle Pines development lies in the Cherry Creek Basin but is sewered through a plant in the Plum Creek Basin.

Increase in the areas served by septic systems could be significant. From 19,500 persons in 1990, population could reach 52,600 in 2010. This is a trend that should be closely monitored to determine the impacts of numerous septic systems. Additional large subdivisions, dependent upon septic systems, should not be approved unless the developers can prove that (1) the septic systems can meet the effluent concentration proposed for wastewater treatment systems and (2) that the systems in total will not exceed the phosphorus allocation of 450 pounds/year.

Employment is expected to be a major growth element in the basin. In 1983, the basin had an estimated total employment of 20,200. Eighty percent of this total was located in the Cottonwood Gulch subbasin surrounding Centennial Airport. This same subbasin is expected to remain the largest center of employment with almost 95,000 employees in 2010. The subbasin presently contains the Inverness and Meridian office parks as well as vacant lands expected to develop in non-residential uses.

The entire basin is projected to grow at an average rate of growth of 9.5 percent per year. Table 3 provides the 1990, 2000, and 2010 employment projections for the basin and subbasin. By 2010 the employment level is projected to be 300,000, or less than half of the capacity of the employment land uses. In addition to Cottonwood Gulch, other subbasins projected to have over 25,000 employees in 2010 are: Happy Canyon (the Rampart Range development), Newlin Gulch, Direct Flow #4 (east of Centennial Airport) and Direct Flow #5 (along Cherry Creek from Arapahoe Road to Parker).

These projections were used to predict future wastewater flows and storm runoff into Cherry Creek Reservoir. The actual year when these values occur is less important than the relationship of the point and nonpoint loads. These loads and the methods used to control them are described in the next chapters.

Table 3  
Projections of Employment By Subbasin

	1990	2000 .	2010
Baldwin Gulch	2,350	5,610	9,940
Cottonwood Gulch	26,970	55,990	94,470
East Cherry Creek	0	0	0
Happy Canyon	3,880	14,150	27,770
Haskel/Antelope Cr	0	0	0
Kinney Creek	360	1,310	2,570
Lemon Gulch	100	370	740
Lone Tree Gulch	2,970	7,610	13,780
McMurdo Gulch	70	260	520
Mitchell Creek	210	750	1,470
Moonshine Gulch	480	1,140	2,030
Newlin Gulch	5,190	18,940	37,160
Piney Creek	270	990	1,950
Reed Hollow	0	0	0
Scott Gulch	0	0	0
Shop Creek	30	120	230
Sulphur Gulch	900	3,280	6,440
Tallman Gulch	0	0	0
Upper Lake Gulch	0	0	0
West Cherry Creek	0	0	0
Willow Creek	0	0	0
Direct Flow #1	280	1,010	1,990
Direct Flow #2	140	530	1,040
Direct Flow #3	170	610	1,200
Direct Flow #4	3,900	13,360	25,900
Direct Flow #5	6,630	20,560	39,030
Direct Flow #6	1,610	5,870	11,520
Direct Flow #7	1,870	6,830	13,410
Direct Flow #8	960	3,500	6,860
Direct Flow #9	0	0	0
Total	59,340	162,790	300,020





### III. BASIN PHOSPHORUS LIMITATION AND ALLOCATION

The 0.035 mg/L total phosphorus standard on Cherry Creek Reservoir is the factor which determines the maximum quantity of phosphorus which can be annually transmitted from the basin into the reservoir. The standard will be achieved by controlling the amount of phosphorus allowed into the reservoir. This amount is termed the "allowable annual reservoir phosphorus loading." Of the three primary sources of phosphorus--point, nonpoint, and background--only the point and nonpoint sources can be controlled as the background consists of the uncontrollable sources including groundwater, and precipitation.

The primary sources of the annual reservoir phosphorus load are the natural and man-made conditions in the Cherry Creek Basin, specifically stormwater runoff (nonpoint sources) and wastewater treatment facilities (point sources). The present phosphorus load into the reservoir is largely the result of the stormwater runoff or nonpoint sources of phosphorus but as conditions in the basin change and more development occurs, treated wastewater will add more phosphorus. However, the increase in developed land or urbanization will also create an increase in the quantity of stormwater which reaches the reservoir. As a result, the nonpoint sources are expected to remain the dominant source (86 percent by the year 2000) of the annual reservoir phosphorus load. This increase in the amount of nonpoint phosphorus generated basinwide must be controlled to maintain the 0.035 mg/L phosphorus standard.

#### Allowable Annual Reservoir Phosphorus Loading

In determining the allowable annual reservoir phosphorus loading, it was necessary to define the quantity of phosphorus contributed by each source. As noted above, point and nonpoint sources increase as land use changes and growth occurs. In 1982, a total of 5,180 pounds of phosphorus was contributed to the reservoir. Most of this loading (77 percent) came from nonpoint sources with the remainder due to background sources. Less than 1.0 percent of the 1982 load was attributable to point sources due to the relatively small quantity of wastewater produced. The expected quantity of point source phosphorus is shown in Table 4 and the anticipated nonpoint quantity in the basin appears in Table 5. Background sources are listed in Table 6 and represent those conditions measured in 1982 as part of the Cherry Creek Reservoir Clean Lakes Study.<sup>4</sup>

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<sup>4</sup>Denver Regional Council of Governments, Cherry Creek Reservoir Clean Lakes Study, April, 1984, Denver, Colorado.

Table 4

## Projected Annual Point Source Loading

	<u>1990</u>	<u>2000</u>	<u>2010</u>
Phosphorus Load (pounds)	657	2,310	4,210
Volume (acre-feet)	5,153	16,132	29,352

Table 5

## Projected Annual Nonpoint Source Loading

	<u>1990</u>	<u>2000</u>	<u>2010</u>
Phosphorus Load (pounds)	10,835	21,531	43,909
Volume (acre-feet)	3,675	10,997	26,557

Table 6

Projected Annual Background Loading<sup>5</sup>

	<u>Baseflow</u>	<u>Groundwater</u>	<u>Precipitation</u>	<u>Total</u>
Phosphorus Load (pounds)	350	130	690	1,170
Volume (acre feet)	400	-220	1,360	1,560

These sources were combined for 1990, 2000 and 2010 to define the annual phosphorus load. These annual phosphorus loads were modeled to determine the resulting in-lake phosphorus concentration. The Canfield/Bachmann in-lake phosphorus model was used for these calculations.<sup>6</sup> Using the in-lake model and

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<sup>5</sup>Ibid.

<sup>6</sup>Ibid.



the three sources of phosphorus for the three discrete years provided a methodology which predicted the in-lake phosphorus concentration based on any total annual load. This relationship between annual phosphorus loading and the in-lake phosphorus concentration was used to determine the annual allowable reservoir phosphorus loading. By incorporating the reservoir phosphorus standard (0.035 mg/L) into the Canfield/Bachmann equation, it was possible to predict the annual phosphorus load which would protect the in-lake standard.

The modeling determined that a maximum phosphorus load of 14,270 pounds could enter the reservoir on an annual basis and meet the 0.035 mg/L total phosphorus standard. The 14,270 pounds represent a combination of the point, nonpoint, and background sources of phosphorus. The annual load is dependent upon the type of wastewater treatment used throughout the basin. By changing the type of treatment, the allowable annual load can fluctuate between 12,000 and 16,200 pounds. This fluctuation is due to the flushing effect from a direct discharging treatment facility as compared to a land application facility. Wastewater treatment systems such as direct discharges and rapid infiltration are assumed to contribute 100 percent of treated flow to the reservoir. A land application system is assumed to lose one-half of its water to crop consumption. Therefore, less treated flow reaches the reservoir from these systems than from other systems. The net effect is that land application systems produce less phosphorus annually and can treat more wastewater from this type of treatment while complying with the in-lake standard.

The 14,270 pounds is composed of phosphorus from all sources; however, only a portion of this annual load is directly attributable to point sources. That portion of the annual allowable reservoir phosphorus loading which is due to point sources is termed the "critical point source load."

#### Critical Point Source Loading

It is necessary to determine the quantity of point source phosphorus that, when combined with the nonpoint and background pounds, will not exceed the limit of 14,270 pounds. This critical point source loading will occur as a function of the actual loading in the basin resulting from growth and development and will not necessarily coincide with the planning years of 1990, 2000, or 2010.

The method used to determine the critical point source load is documented in the technical report.<sup>7</sup> Once the critical point source is determined, the critical nonpoint source can also be identified. The critical point source load, critical nonpoint source load and the background loading are based on the following assumptions:

1. The point source load is based on the number of treatment systems and the mix of wastewater treatment methods identified in Chapter V. Any changes in the number of facilities, type of treatment, or quantity of wastewater

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<sup>7</sup>Denver Regional Council of Governments, Cherry Creek Basin Water Quality Management Master Plan Technical Report.



generated will change the critical point source loading limit in addition to changing the allowable annual reservoir phosphorus load.

2. The nonpoint source load is dependent upon the land use forecast and associated runoff coefficients. The land uses recognized in this planning effort include large lot residential, urban residential at two different densities, commercial industrial, airport property, and open space. The actual rate and distribution of growth may be different resulting in different nonpoint loading rates. Any significant changes in the nonpoint contribution, as measured through an annual monitoring program, will change the annual critical nonpoint loading and the allowable annual phosphorus limit.
3. The critical nonpoint source loading is actually 10,790 pounds which contains 450 pounds of phosphorus from septic systems.<sup>a</sup> Lacking an intensive study to more precisely define the contribution from septic systems, the plan recognizes an annual loading of 450 pounds from this source regardless of the population served by septic systems. It also contains 50 pounds for industrial dischargers.
4. The 1,170 background source loading is considered to represent an average condition. If this amount changes, its affect on the allowable annual phosphorus limit will need to be determined. In any event an increase in the uncontrollable background loading in any one year which is the result of an act of nature should not jeopardize or reduce the point source allocation.

The allocation process needs to recognize two other contributors of phosphorus, septic systems and industrial dischargers. Although it was not possible to quantify the exact contribution of septic system phosphorus, information suggested an appropriate allocation would be 450 pounds. This allocation is considered to be a part of nonpoint load. Although there may not be any industrial dischargers presently permitted in the basin, phosphorus is allocated to this source since industrial dischargers may operate within the basin independent of domestic wastewater facilities. Therefore, a nominal quantity of 50 pounds has been allocated to this point source. Table 7 displays the critical phosphorus loading from all sources.

**Table 7**  
**Critical Loading From All Sources**  
**(Pounds Per Year)**

Point Sources	2,310
Nonpoint Sources	10,290
Septic Systems	450
Industrial Sources	50
Background	<u>1,170</u>
Critical Load	14,270

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<sup>a</sup>Ibid

#### IV. NONPOINT CONTROL

Nonpoint source phosphorus contribution to Cherry Creek Reservoir is significant on an annual basis. Data generated in this planning effort indicates that nonpoint sources contribute more phosphorus annually than other sources combined. Because the nonpoint is such a high proportion of the annual phosphorus load, it is necessary to reduce this source of phosphorus in order to protect the beneficial uses of the reservoir while the basin develops.

##### Existing Situation

Presently, there are no requirements to control nonpoint sources of phosphorus in the Cherry Creek Basin. However, the Cherry Creek Reservoir Clean Lakes Study<sup>9</sup> indicated that 77 percent of the total (4,010 pounds of phosphorus) was contributed to the reservoir from nonpoint sources. This uncontrolled phosphorus contribution will continue at an accelerated rate unless control structures are implemented. The significance of the annual nonpoint phosphorus contribution directs the need for nonpoint control regulations.

##### Future Situation

As the Cherry Creek Basin becomes more urbanized, the nonpoint phosphorus contribution will increase. The load and runoff volume in Table 8 are the direct result of the land use projections in conjunction with a year of average rainfall. If actual growth in the basin differs from the projection or a non-average rainfall year occurs, the loading rates and runoff volumes will change. If the future nonpoint loading is uncontrolled, it is projected that the reservoir phosphorus standard will be exceeded prior to 1990 (including base flow conditions). The nonpoint source contribution will have to be reduced such that the combined load from point sources, nonpoint sources and base flow conditions does not exceed the basinwide phosphorus limit. This goal will be accomplished by implementing a nonpoint control program.

##### Basinwide Nonpoint Control Program

In Chapter III, the annual basinwide phosphorus limit was identified as well as the critical point source load. These two loading limits result in a balance of 10,290 pounds of phosphorus annually which are allocated to nonpoint sources. As long as the 10,290 nonpoint pounds are not exceeded, the reservoir will be protected up to the year at which the critical load appears, assuming appropriate point source controls are in place. The objective of the nonpoint control program will be to control or stay below this initial target of 10,290 annual nonpoint pounds by implementing effective nonpoint control measures. Since the basin is already contributing approximately 5,000 annual nonpoint pounds, it is critical that nonpoint control measures be initiated immediately.

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<sup>9</sup>Denver Regional Council of Governments, Cherry Creek Reservoir Clean Lakes Study.

Table 8

## Projected Annual Basinwide Nonpoint Contribution by Subbasin

Subbasins <sup>1</sup>	1990		2000		2010	
	Runoff Ac-ft	P. Load Pounds	Runoff Ac-ft	P. Load Pounds	Runoff Ac-ft	P. Load Pounds
Baldwin Gulch	70	117	210	324	480	720
Cottonwood Gulch	1,188	1,615	4,084	5,373	10,214	13,241
East Cherry Creek	28	84	28	84	28	84
Happy Canyon	51	238	643	1,037	1,750	2,767
Haskel/Antelope	27	82	27	82	27	82
Kinney Creek	42	80	148	267	355	639
Lemon Gulch	25	54	70	135	147	280
Lone Tree Creek	87	122	425	558	1,209	1,558
McMurdo Gulch	32	64	112	211	263	497
Mitchell Creek	25	50	94	172	226	413
Moonshine Gulch	68	147	157	303	301	559
Newlin Gulch	63	128	214	390	244	886
Piney Creek	80	168	143	278	237	444
Reed Hollow	20	60	20	60	20	60
Scott Gulch	20	40	71	135	168	322
Shop Creek	607	5,585	633	5,679	666	5,796
Sulphur Gulch	50	99	116	204	229	379
Tallman Gulch	25	53	82	157	185	352
Upper Lake Gulch	36	107	36	107	36	107
West Cherry Creek	35	104	35	104	35	104
Willow Creek	17	44	29	65	46	94
Direct Flow #1	223	430	345	645	535	970
Direct Flow #2	68	129	159	299	321	602
Direct Flow #3	117	224	196	368	322	594
Direct Flow #4	114	164	806	1,069	2,558	3,322
Direct Flow #5	203	329	924	1,374	2,529	3,656
Direct Flow #6	112	204	562	983	1,550	2,712
Direct Flow #7	109	190	506	833	1,380	2,241
Direct Flow #8	36	75	106	186	231	379
Direct Flow #9	16	49	16	49	16	49
Total	3,594	10,835	10,997	21,531	26,308	43,909

<sup>1</sup>See Figure 2 for location of subbasins.



## Nonpoint Control Strategy

Specific performance requirements are necessary in order to implement an effective control program. The minimum requirements and criteria necessary to meet the nonpoint control recommendations are:

1. Adoption of a 50 percent basinwide nonpoint phosphorus removal goal. A limited national data base exists which would help define an implementation program or define phosphorus removal efficiencies of various structures. This indicates that a nonpoint control program should be conservative in its estimates of phosphorus removal efficiencies. Therefore, a 50 percent basinwide removal efficiency is recommended. The control program should be implemented on a drainage basin approach rather than by political boundaries.
2. Construction of control structures which effectively reduce phosphorus. The master plan concluded that detention followed by rapid infiltration (assumed 95 percent removal efficiency), rapid infiltration (assumed 95 percent removal efficiency), and detention followed by filtration (assumed 50 percent removal efficiency) were all options which could be installed on a subbasin level and would effectively reduce the nonpoint phosphorus. These removal efficiencies are based on a review of literature. However, such facilities must be monitored in order to determine their exact removal efficiencies. While these three methods were evaluated, any structures or combinations of structures are acceptable which achieve the goal of 50 percent phosphorus reduction. Wetlands were evaluated as a basinwide control measure, but were not recommended now because the known removal efficiency is unreliable especially in arid areas where the wetlands may not remain wet on a continuous basis. Future basin conditions will increase urbanized areas which will increase the base flow of water, resulting in more drainage ways with a continuous flow. Under these conditions, wetlands may be a viable option for site specific cases.
3. Creation of an institution which is responsible for implementing and regulating the program. The institution will be made up of Douglas and Arapahoe counties, municipalities in the basin, and water and sanitation districts in the basin.
4. Annual determination of the quantity of phosphorus which needs to be removed so that the combined nonpoint, point, and baseflow phosphorus load, does not exceed 14,270 pounds. ↙
5. Control of nonpoint phosphorus on a subbasin basis. The master planning effort has determined that a subbasin approach is the best way to control the phosphorus and achieve the basinwide goal of 50 percent reduction. Consideration was given to site-specific controls but such controls provide only minor reductions when compared to the need to remove 10,290 pounds (50 percent of the total 20,580 nonpoint pounds) basinwide. The subbasin approach within a basinwide institutional framework controlling the nonpoint program will require participation and financial support by all relevant parties (counties, municipalities, and districts) in the Cherry Creek Basin.



6. Implementation of control structures in priority subbasins. Table 8 indicates that five subbasins (Shop Creek, Cottonwood Gulch, Happy Canyon, Direct Flow #4, Direct Flow #5) are contributing a significant portion of the annual load by 2000 and it would be cost effective to install control structures on these basins. Controlling the nonpoint on these five subbasins as a priority will help to remain below the 10,290 annual poundage limit and provide enough time for development of point source controls and to plan for future nonpoint control needs on other subbasins. Figure 3 shows the five priority subbasins.
7. A first-phase nonpoint control program can be defined based on the analysis of nonpoint control measures and priority subbasins. The nonpoint control program should be implemented immediately focusing on building control structures in the five priority subbasins. Controlling the five priority subbasins would result in a reduction of 6,900 pounds, well below the 10,290 pound limit. This assumes the controls are only 50 percent effective and no other basins are controlled, both conservative assumptions.

The analysis of control measures suggests that a rapid infiltration basin be constructed in Shop Creek and detention with sand filtration be built in the other four. These should be considered initially preferred alternatives prior to detailed engineering analysis of each basin. Other alternatives exist such as directing flows from Shop Creek and Direct Flow #1 away from Cherry Creek Reservoir and into the emergency spillway. However, if the initial recommendation is correct, the expected equivalent annual cost to provide control in these five subbasins would be approximately \$936,000.

Also, the controls on these basins will serve as pilot projects to determine the real removal efficiencies of such controls. Based on the estimates in item 6, the rapid infiltration system on Shop Creek should be able to achieve 95 percent efficiency, removing 5,300 pounds instead of 2,800 pounds. If that is correct, detention/rapid infiltration can be designed to reflect this improvement.

8. Adopt uniform drainage criteria requirements for the basin. This would require all general purpose governments to adopt a set of uniform drainage criteria that will complement a basinwide nonpoint control program. With uniform drainage criteria, the basin authority will be able to coordinate nonpoint structures with drainage requirements and not be burdened with a lack of or conflicting sets of drainage requirements. The uniform criteria also eliminate the advantage one area would have over another due to less stringent drainage requirements.
9. Implement an effective Best Management Practices Program. These minimum requirements will be an effective part of the basinwide phosphorus control program. It should be recognized that other possibilities exist for reducing nonpoint phosphorus. If these are used and the annual basinwide nonpoint removal is greater than 50 percent, then a credit can be applied to the point source allocation. If the subbasin control measures achieve a





greater removal efficiency than anticipated, the nonpoint institution could re-distribute the credit to all point source dischargers. If a municipality or district installs site-specific controls which remove phosphorus above the 50 percent basinwide goal, then a point source credit can be obtained on some basis to be established by the Basinwide Authority.

10. Nonpoint design criteria. The planning criteria used to design nonpoint control structures was based on 1-1/2 inches of rainfall over any given subbasin. Using this criteria allowed for the control structure to be sized for the runoff from all of the different land uses within the subbasin. This method was perceived as the most feasible means of achieving the overall goal of 50 percent phosphorus removal basinwide. An alternative to this approach would be to design control structures according to 1/2 inch of runoff generated from impervious areas within the subbasin. The determination as to which design criteria to use could be made during the initial engineering design work as defined in this plan.

Using the 1/2 inch runoff from all impervious areas within a subbasin should be based on the following criteria:

- a. the 1/2 inch runoff from all impervious areas within the entire sub-basin.
- b. impervious surfaces are defined as all paved, roofed, or areas stripped of vegetation, including dirt or gravel parking lots and roads and any other area without a vegetative surface.
- c. unless better site specific or basinwide specific impervious data is available, refer to Table 3-1 in the Runoff Chapter of the Urban Storm Drainage Criteria Manual (Urban Drainage and Flood Control publication) to calculate the percent imperviousness for each tributary sub-basin.

#### Best Management Practices (BMPs)

Best Management Practices (BMPs) for nonpoint control are an important element of the phosphorus control program. The allowable annual phosphorus load and the nonpoint control program are based upon general purpose governments adopting erosion control ordinances for new development in order to prevent excessive phosphorus loading by erosion from construction sites. Essentially, no measure should be rejected as a viable control option if it removes phosphorus. However, it is prudent to concentrate on those BMPs which effectively remove phosphorus and are feasible for the Cherry Creek Basin.

A wide range of BMPs were investigated during the course of this study. Table 9 lists all of those which were. Of these, only a few have documented pollutant removal efficiencies and are encouraged for use if site specific controls are desired.

Table 9

POSSIBLE BEST MANAGEMENT PRACTICES EVALUATED<sup>1</sup>

Erosion Control on Construction Activities\*  
Septic System Policy\*  
Detention Basins  
Dry Basins  
Wet Basins\*  
Dual Purpose Basins\*  
Street Sweeping  
Grass Swales  
Wetlands\*

<sup>1</sup>Source: US EPA, Results of the Nationwide Urban Runoff Program, Final Report, Volume 1, December 1983.

\*BMPs encouraged for site specific use in the Cherry Creek Basin.

According to the source of this information, only dual purpose basins and wet basins were documented as being effective in removing pollutants. Wetlands were not specifically evaluated but it was recognized by EPA that pollutant removal from wetlands is possible.

Two non-structural BMPs identified in Table 9 are critical in helping meet the allowable annual phosphorus load. These two BMPs are local erosion control regulations for construction activities and septic tank regulations. Both of these BMPs are important factors in reducing the the annual phosphorus load and it is assumed that all general purpose governments will adopt specific regulations governing these activities if the nonpoint control program is to achieve a 50 percent removal efficiency. The load of phosphorus from these sources is important enough to allocate a portion of the annual phosphorus load to septic systems (as discussed in Chapter V) and recognize that erosion can produce a load of phosphorus equal to or greater than most point source allocations.

Other BMPs are encouraged on a site specific basis but since their pollutant removal efficiency is unknown or variable, they are not a part of the recommended nonpoint control program. However, if installed, these BMPs may help reduce the loading rates and maintenance requirements on the subbasin control structures.

Erosion Control For Construction Activities

Soil loss from erosion due to construction activity can be as great as 156 tons per acre per year.<sup>10</sup> This is considerably higher than the erosion rate of less

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<sup>10</sup>USDA-SCS-MD 1975 in DRCOG "Managing Erosion and Sedimentation from Construction Activities", April, 1980, p. 10.



than 1 ton per acre per year occurring on agricultural watersheds and in already urbanized drainage basins.<sup>11</sup> Soil tests in the Cherry Creek basin showed the soil phosphorus content to vary from 1.0 ppm to an extreme of 60 ppm.<sup>12</sup> Using the average of 7.96 ppm, the amount of phosphorus contained in the increased sediment generated annually by construction activity on one acre of land is 2.5 pounds. Given the likelihood of at least 200 acres of construction occurring anywhere in the basin at one time, the total phosphorus generated by construction activity would be at least 500 pounds. Using these calculations, the amount of phosphorus eroding from construction sites would exceed the phosphorus allocation of most of the point sources, a fact which illustrates the necessity for erosion control on construction sites.

Examples of effective erosion control programs are available from EPA, Adams County and DRCOG. Specific erosion control assistance is available from the USDA-Soil Conservation Service and West Arapahoe and Douglas County Soil Conservation Districts. As a minimum requirement, it is recommended that local erosion control ordinances incorporate the following factors:

1. Scheduling. Define the steps and timing necessary for completing an erosion control plan for a proposed development area. This would include identification of the step in the zoning or subdivision process at which time the plan must be submitted.
2. Effective temporary control measures. The ordinance should specifically identify temporary control measures such as straw bales and filter fences as structures which should be installed at the onset of construction activity.
3. Revegetation. Revegetation of disturbed areas upon completion of construction.
4. Low maintenance landscaping. Native vegetation and other low water consuming vegetation is appropriate as a measure to reduce water consumption and excessive fertilization.
5. Greenbelt areas. Greenbelt areas or open space are recommended. Such areas are to be located so as to act as sediment traps which filter out eroded soils.
6. Limited vehicle access. Limited vehicle access should be designed into the development so as to reduce the amount of disturbed soil.
7. Performance guarantee. A performance guarantee is recommended to insure that structures perform, sediments do not exit the site beyond historic levels, and that revegetation is successful.

\* <sup>11</sup>USDA-SCS-MD 1975 Ibid., p. 10; and Daniel, T.C., et al, "Sediment and Nutrient Yield from Residential Construction Sites", Journal of Environmental Quality. Vol. 8, pp. 304-8.

<sup>12</sup>Personal Communication, Darrel Schafer, County Extension Director, CSU Extension Service, 5 June 1985.

8. Streambank stabilization: Streambanks should be stabilized to prevent erosion of the bank.
9. Soil inventory. All soils should be inventoried and catalogued according to their erodibility and suitability for development. .
10. Overlot grading. Effective temporary control measures should be included on overlot graded areas.
11. Special use permits. Special use permits should be required on stables, livery operations and livestock operations. Such permits should stipulate that runoff from these operations not enter any water way, that soil erosion not occur from overgrazing, and that streams be fenced to keep livestock out of waterways.
12. Stream crossings. Minimum performance standards for temporary and permanent bridges should be defined.
13. Road building practices. Minimum erosion control standards to be used during the construction of roads should be defined.

#### Septic System Policy

Septic systems provide another source of phosphorus which is presently unregulated with respect to phosphorus. If the basin must regulate point and non-point phosphorus, it follows that septic systems should also meet certain phosphorus performance standards. Arapahoe and Douglas counties, in cooperation with Tri-County Health Department, shall develop septic system criteria for meeting phosphorus standards. With the large population projected to be using septic systems in the basin (52,600 by 2010) it is logical to expect that a significant quantity of phosphorus could be generated from this source. By establishing septic system phosphorus performance standards, it may be possible to keep this source of phosphorus to a minimum.

Douglas and Arapahoe counties should work with Tri-County Health Department to develop regulations as soon as possible requiring phosphorus performance criteria for septic systems. The performance criteria could be based on allowing septic systems in soils which would initially remove more than 95 percent of the phosphorus. The criteria could be based on an onsite system design which evaluates soil type, percolation rates, loading rates and unsaturated soils depths in order to achieve an overall removal efficiency of approximately 80 percent after 20 years of use. Such a criterion would necessitate soil testing to determine which soils are conducive to the highest rate of phosphorus removal. In addition to the recommendation already outlined, the following recommendations are made:

1. Douglas and Arapahoe counties in cooperation with Tri-County Health and the Basinwide Authority should be responsible for initiating a research program to quantify existing loadings from septic systems; to evaluate soil types in the Cherry Creek Basin; and to evaluate other factors such as location of systems within the Basin.
2. An initial allocation of 450 pounds of phosphorus be assumed for septic systems until more information is known about their affect on the reservoir.

#### In-Lake Control Measures

During the course of this planning effort, in-lake phosphorus reduction techniques were discussed. These techniques, such as chemical additions and dredging or mechanical treatment of the lake water, offered some possibilities for reducing the in-lake phosphorus concentration. However, their overall removal efficiency is unknown and these techniques are usually viewed as a temporary solution. Because of these limitations, such measures are not recommended as an immediate control strategy.

## V. POINT SOURCE CONTROL

One of the significant elements of this master plan is to determine the location of wastewater treatment facilities and the type of treatment to be used by each facility. To arrive at a selected wastewater treatment system, 10 basin wastewater treatment scenarios with a variety of treatment methods were evaluated. This evaluation included treatment provided by joint-use facilities, individual facilities and a combination of individual and joint-use facilities. Types of treatment evaluated ranged from common treatment among all dischargers to a mixture of land application and direct discharge. Part of the evaluation was completed by an independent consultant.<sup>13, 14, 15</sup> The recommended wastewater treatment option is a system of 12 treatment plants with individual service areas which would provide service to the entire urbanized portion of the basin. The rationale for selecting this option is as follows:

1. All scenarios were evaluated in terms of water quality impacts. The evaluation determined that the number of wastewater treatment plants in the basin did not improve or degrade the water quality in the reservoir. Rather, the type of wastewater treatment and effluent phosphorus concentration controlled the reservoir water quality.
2. The ability to reuse wastewater in the basin is vital for both water rights and water supply reasons. Water users whose water supply comes solely from deep bedrock aquifers must reuse their wastewater for irrigation because of the physical and legal constraints on the amount of water which can be pumped from the aquifers and to conserve the water in those aquifers. Water users whose water supply comes from Cherry Creek must return their wastewater to Cherry Creek at their point of effluent discharge to prevent injury to the water rights of other water users on the stream pursuant to the requirements of court decreed augmentation plans. Each scenario which includes joint use facilities required that treated wastewater be pumped back from the joint use facility to the individual water user to satisfy these requirements. Since there is no greater impact on water quality with 12 plants than with fewer plants, it is an unnecessary expense to pump treated effluent back to the place where the effluent was generated.
3. The 12 plant option ranked highest when compared to the other scenarios according to non-quantifiable criteria such as environmental impacts,

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<sup>13</sup>Richard P. Arber Associates, Inc., "Costs of Wastewater Treatment Options," Volume 1, prepared for the Denver Regional Council of Governments, May, 1985.

<sup>14</sup>Richard P. Arber Associates, Inc., "Costs and Water Rights Impacts of Selected Point Source Treatment Alternatives," Volume 2, prepared for the Denver Regional Council of Governments, May 1985.

<sup>15</sup>Richard P. Arber Associates, Inc., "Costs of Nonpoint Control Options," Volume 3, prepared for the Denver Regional Council of Governments, May 1985.

land use impacts, implementation flexibility, reliability, reuse potential, and impact on existing facilities.

4. Although not the least expensive alternative, this scenario of 12 treatment plants was only marginally higher than the least expensive (\$2,150/1,000 gal. of treated wastewater for the 12 plant option versus \$2,120/1,000 gal. of treated wastewater for the 10 plant option including four joint-use facilities).

#### Location of Wastewater Treatment Facilities and Method of Treatment

Figure 4 identifies the recommended facility service areas and the location of each treatment facility within the basin. The service areas cover the urbanized portion of the basin and represent what each local government or special district perceives as being the area in which it can provide service.

Projections of sewered population, employment and wastewater flow appear in Table 10 for each facility service area. The type of treatment and effluent concentration used by each discharger appears in Table 11.

The point source control program for these facilities is predicated on three principal assumptions:

1. The point source discharge permits and site applications assume that a nonpoint control program is operating in the Basin and effectively removing 50 percent of the annual nonpoint load.
2. No point source within the Cherry Creek Basin will discharge an effluent with a total phosphorus concentration greater than 0.5 mg/L as a daily maximum.
3. Phosphorus allocations for site approvals and permits issued to existing facilities within the Cherry Creek Basin will be based on total phosphorus effluent quality of 0.1 milligrams per liter (mg/L) or better at the design capacity of the treatment plant.

#### Phosphorus Allocation Process

The critical point source loading defines how much phosphorus can be allocated to the point sources in the basin. A point source allocation process, which will be reviewed annually and incorporated into an annual basinwide water quality assessment report, will be incorporated into discharge permits in order to maintain regulatory control over the process. Incorporating the allocation into discharge permits is the only means by which the State Department of Health can enforce the phosphorus control program and have the guarantee that a discharger is in compliance with the basinwide allocation program.



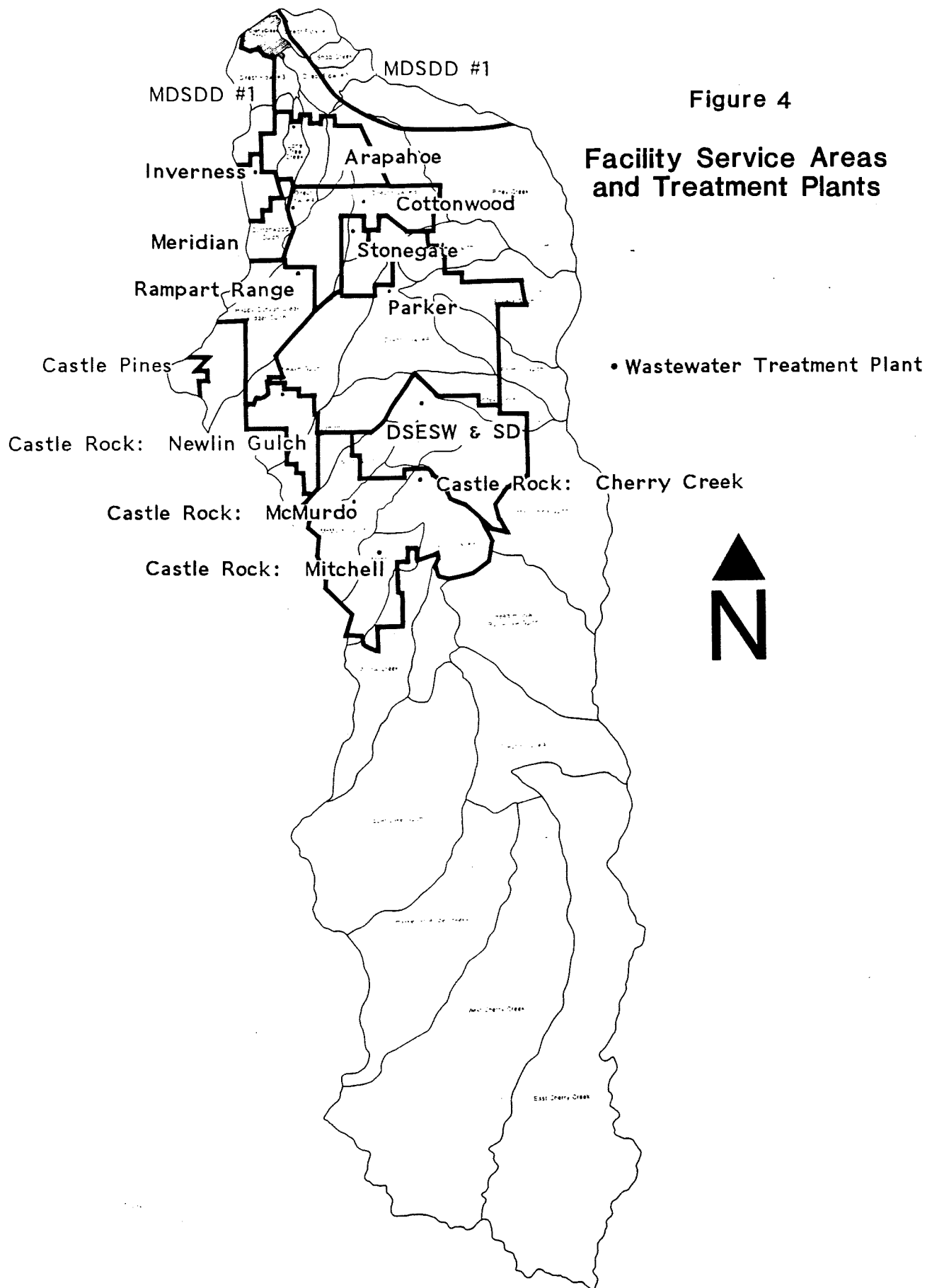


Table 10

Projections of Population, Employment, Wastewater Flow  
and Present Facility Capacities

Facility	Population			Employment			Wastewater Flow (mgd)			Present Capacity (mgd)
	1990	2000	2010	1990	2000	2010	1990	2000	2010	
Arapahoe	700	2,100	3,900	14,400	39,400	72,500	0.60	1.6	2.9	0.4
Inverness	0	0	0	14,300	22,200	32,800	0.50	0.78	1.1	0.9
Meridian	0	0	0	7,600	16,600	28,500	0.26	0.58	1.0	1.5
Cottonwood	5,200	10,100	16,000	3,400	10,300	19,600	0.56	1.2	2.0	0.75
Stonegate	1,500	3,300	5,400	4,400	9,400	16,100	0.28	0.60	1.0	0.25
Parker	15,000	43,600	78,800	6,500	19,600	37,100	1.5	4.4	8.0	2.0
Denver Southeast	11,100	26,500	45,400	2,500	8,600	16,800	1.0	2.6	4.4	0.35
Castle Rock:										
Cherry Creek	1,300	4,200	7,700	1,000	3,600	7,100	0.15	0.48	0.9	0
McMurdo	2,100	6,700	12,300	100	200	300	0.18	0.58	1.1	0.2
Mitchell	1,500	4,700	8,500	200	800	1,500	0.13	0.42	0.78	0.2
Newlin Gulch	0	2,900	6,400	0	13,000	30,100	0	0.70	1.6	0
Rampart Range	0	4,600	10,300	0	6,400	15,800	0	0.62	1.4	0
Total	38,400	108,700	194,700	54,400	150,100	278,200	5.16	14.6	26.2	6.6

Table 11

**Wastewater Treatment Facilities  
and Method of Treatment**

<u>Discharger</u>	<u>Type of Treatment and Effluent Concentration<sup>1</sup></u>
Arapahoe	AWT, discharge, 0.1 mg/L phos. for 1/2 year, sec. treatment, land application, 0.05 mg/L for 1/2 year
Inverness	Sec treatment, land application, 0.05 mg/L
Meridian	Sec treatment, land application, 0.05 mg/L
Cottonwood	Sec treatment, rapid infiltration, 0.05 mg/L
Stonegate	Sec treatment, land application, 0.05 mg/L
Parker	AWT, discharge, 0.1 mg/L for 1/2 year, Sec treatment, land application, 0.05 mg/L for 1/2 year
Denver Southeast	AWT, Rapid infiltration, 0.05 mg/L
Castle Rock (Cherry Creek, McMurdo, Mitchell Creek, and Newlin Gulch)	AWT, land application, 0.05 mg/L
Rampart Range	AWT, discharge, 0.1 mg/L for 1/2 year, Sec treatment, land application, 0.05 mg/L for 1/2 year

<sup>1</sup>Effluent concentrations are those recognized for the specific type of treatment by the Colorado Department of Health, Water Quality Control Division.

The phosphorus control program is dependent upon allocation of phosphorus to the primary sources so that the 14,270 annual pounds are not exceeded. As a minimum, the phosphorus allocation process contains the following elements:

1. An institutional mechanism be established which would be responsible for recommending phosphorus allocations to point source facilities. This recommendation will be forwarded to the Department of Health, Water Quality Control Division, for use in issuing discharge permits.
2. An annual point source phosphorus allocation be established for each facility; phosphorus allocations be established for nonpoint sources, septic systems, industrial systems, and background sources. The initial recommended allocations are those shown in Table 7. The initial recommended allocations to facilities are shown later in this chapter. The entire allocation process is dependent upon nonpoint source removal and the basin's ability to achieve a 50 percent basinwide reduction in nonpoint source phosphorus.

3. The type of wastewater treatment and wastewater flows recommended in this plan. If these factors change, the allowable annual load and the critical point source load will need to be recalculated and adjusted accordingly.

This is necessary as the critical load and the critical point source load are very sensitive to the type of wastewater treatment and the total wastewater flow. The method for computing the allowable annual load and the critical point source load are contained in the technical report.

4. All of the point source phosphorus allocations would be recommended by the Basinwide Authority. The point sources would not be entitled to a specified quantity of phosphorus but would operate their treatment works in a manner which stays below their annual allocation. The Basinwide Authority would have the responsibility to recommend reallocation of phosphorus during its annual review and also request that discharge permits be reopened where violations of the phosphorus allocation are occurring.

#### Phosphorus Allocation by Facility

Based on these assumptions and applying a 12-plant system to the basin, individual phosphorus allocations by facility were determined. The critical point source load available for wastewater dischargers as identified in Chapter III is 2,310 pounds of phosphorus annually. The allocation of this annual load to the 12 facilities is based upon existing capacities plus the next planned expansion. This method of allocation was selected by the Task Force. It consumes most of the available point source phosphorus but keeps a reserve for emergency situations. The recommended allocations are shown in Table 12.

The recommended allocation is below the critical annual load of 2,310 pounds. As long as any combination of allocations is below the critical point source load, the reservoir total phosphorus standard of 0.035 mg/L will be protected. This method of allocation reflects how the future conditions can be adjusted by locally prepared independent forecasts which will be within the critical point source allocation.

The 2,159 annual pounds allows for a current reserve of 151 pounds per year increasing to a reserve of 303 pounds after Denver Southeast constructs its new treatment facility. The existing capacities result in an unallocated total of 1,099 pounds. This reserve could be used in the event a discharger needs to bypass or experiences an emergency situation where a breakdown might cause a temporary exceedance of the facilities' allocation. The phosphorus allocations set forth in Table 12 are not "owned" by the individual dischargers, but have been allocated as a part of the phosphorus control program. The entity established to implement the phosphorus control program will be responsible for reviewing the phosphorus allocations and recommending reallocations of phosphorus pounds to the Department of Health on the basis of quality of treatment and the actual level of development within the area served by each discharger. Review of the allocations by the entity established to implement the phosphorus control program and reallocations by the Department of Health are necessary in order to avoid any "stockpiling" by any discharger whose service area is not being developed as rapidly as that of the other dischargers. This will be an

Table 12  
Twelve-Plant Phosphorus Allocation

<u>Discharger</u>	<u>Existing Discharge</u>	<u>Future Allowed Phosphorus Discharge (lbs/yr)</u>
Arapahoe	122	354
Inverness	68	68
Meridian	114	114
Cottonwood	114	213
Stonegate	19	53
Parker	379	533
Denver Southeast	365	365*
Castle Rock		
Cherry Creek	0	21
McMurdo	15	64
Mitchell	15	128
Newlin Gulch	0	86**
Rampart Range	<u>0</u>	<u>160</u>
TOTAL	1,211	2,159

\*The present facility at Denver Southeast Suburban Water and Water and Sanitation District requires 365 pounds of phosphorus annually. The 365 pound phosphorus allocation to Denver Southeast is temporary and should be reduced to 213 pounds of phosphorus in 1990 or when Denver Southeast completes construction of its 1.4 mgd facility, whichever occurs first.

\*\*The Castle Rock, Cherry Creek plant will probably serve a portion of the Newlin Gulch facility up to 51 pounds annually. In this case, 51 pounds would be subtracted from the 86 pounds listed in this table and added to the Castle Rock, Cherry Creek facility.

annual review if requested but no less than once every three years which would be coordinated with the state's tri-ennial review of water quality standards.

Projections of development in the basin indicate the need for more point source phosphorus than is indicated in Table 12. Table 13 shows the point source phosphorus that would be needed at buildout.

Table 13  
Projected Phosphorus Needs at Buildout

<u>Discharger</u>	<u>Phosphorus at Ultimate Buildout</u>
Arapahoe	2,435
Inverness	114
Meridian	304
Cottonwood	517
Parker	1,518
Stonegate	114
Denver Southeast	852
Castle Rock	
Cherry Creek	274
McMurdo	244
Mitchell	244
Newlin Gulch	551
Rampart Range	<u>1,328</u>
TOTAL	8,495

The information in Table 13 indicates that only 26 percent of the phosphorus needed at buildout is recommended for allocation to facilities. Before the allocations in Table 12 are adjusted beyond the critical point source load, either more nonpoint control will be necessary or wastewater treatment technologies will have to be implemented to remove more phosphorus from the point sources.

As noted earlier the point source allocation program is based on a successful nonpoint control program. If nonpoint source control projects demonstrate that more than 50 percent of the phosphorus is removed, phosphorus credits could be granted for additional point source or nonpoint source projects.

The individual facility allocation process described herein is designed to protect the reservoir phosphorus standard. Any changes in the location of facilities, types of wastewater treatment, number of facilities and the critical point source loading will necessitate review with respect to the 0.035 mg/L standard and possibly changes to the Clean Water Plan.

## VI. INSTITUTION

One of the major components of the Cherry Creek Basin Master Plan is defining an acceptable institution. The institution would be responsible for implementing the point and nonpoint control recommendations as well as recommending the phosphorus allocations. This chapter discusses the existing institutions and addresses the roles an institution must play in implementing the plan. The criteria for selecting an institution is also discussed and the recommended system presented.

### Existing Situation

Existing institutions responsible for maintaining water quality in the basin are identified in DRCOG's Clean Water Plan (CWP).<sup>16</sup> The CWP recognizes that Douglas County, Arapahoe County and the Town of Castle Rock are designated management agencies in the basin. Their responsibility is to ensure implementation of the CWP with respect to wastewater treatment within their boundaries. However, this arrangement does not address phosphorus allocation within the basin or the nonpoint control requirements.

The existing regulatory authority in the basin lies entirely with the State Health Department. The intent of this master plan is to develop an institutional mechanism which has the ability to address all aspects of the phosphorus control issue. It will also have, as members, local governments which will be responsible for implementing the plan. Various roles of the institution will need to be defined in order to regulate the point source, nonpoint source and phosphorus allocation program.

### Roles

A single institution is recommended to control the point sources, nonpoint program and the phosphorus allocation program. Creation of separate institutions responsible for the point source implementation, nonpoint source control and the allocation process would not address the dynamics of the phosphorus problem and would likely jeopardize the necessary coordination.

To effectively address these issues the institution will need to have four basic functions: planning, construction, operation, and financing.

During the development of this master plan, consideration was given to using existing entities and, if necessary, to create a new institution. The authority of existing entities (counties, towns, special districts and private firms) was examined to determine if these entities could carry out the basic functions. While all of these individual institutions met the basic roles, no single entity could provide the necessary basinwide coordination.

A new entity with all the necessary authority and roles could be created by the General Assembly, but formation by legislative action could take several years.

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<sup>16</sup>Denver Regional Council of Governments, Clean Water Plan, 1984 Update.

The recommended institution needs to be an entity which could be formed immediately to begin implementing the phosphorus control program.

Based on experience in Summit County, an intergovernmental agreement is viewed as a logical solution for forming the institution. The agreement would establish a Basinwide Authority which would be responsible for planning, operating, constructing and financing of nonpoint control facilities. It would also be responsible for recommending phosphorus allocations among the point source dischargers. With this type of agreement, local governments in the basin would have control of the phosphorus control program. Members of the Basinwide Authority, as established by the intergovernmental agreement, are recommended to be:

Arapahoe County  
Douglas County  
Municipalities in the Cherry Creek Basin  
Special districts in the Cherry Creek Basin  
involved in the collection, operation  
and treatment of wastewater and wastewater treatment facilities

The advantages of a Basinwide Authority created by intergovernmental agreement are: that all local governments with land use power and/or wastewater responsibility would be members; that the Authority would retain local control of basinwide water quality issues; and that the Authority could be created with relative ease. Also, as parties to this agreement, the local governments would bring into the Authority their statutory land use powers and other authority. Regulatory actions taken by the Authority which will be necessary to implement the plan can be taken by the level of government having the proper statutory authority to do so. To ensure that all phosphorus related issues are addressed by the institution, it is necessary to define criteria which it should meet. The needed institutional criteria are:

1. That it be based on local control;
2. That it encompass the developing portion of the basin with provisions to include undeveloped portions of the basin in the future;
3. That it have the ability to construct, finance, operate and maintain nonpoint source controls;
4. That it be able to collect fees and recommend mill levies which will be specifically used for phosphorus control structures; and
5. That it become the management agency for the basin.

In reviewing these criteria, a Basinwide Authority created by intergovernmental agreement appears to be the best institution for incorporating all the criteria.

#### Recommended Institution

In view of the advantages of a Basinwide Authority created through intergovernmental agreement, this institution is recommended as the preferred alternative. The Authority would be responsible for recommending the allocation of the available phosphorus among point sources and implementing a nonpoint control program. Point source facilities would continue to be constructed and



operated by municipalities and districts. Planning would be done primarily by the Authority with DRCOG's responsibility being the coordination of planning from a regional context. Since this Authority would be dealing with the major water quality issues in the basin, it would be designated as the management agency, replacing the existing system. Initial members of the Authority would be Arapahoe County, Douglas County, Castle-Rock, Parker, Greenwood Village, Aurora, Arapahoe Water and Sanitation District, Cottonwood Metropolitan District, Denver Southeast Suburban Water and Sanitation District, Inverness Water and Sanitation District, Meridian Metropolitan District, Parker Water and Sanitation District and Stonegate Center Metropolitan District.

The agreement will have to be flexible enough to allow for unforeseen changes which may be necessary. It will have to specifically address the following issues:

1. All local governments with land use power and/or wastewater treatment and collection responsibility within the basin must sign the agreement.
2. The ability to require new districts or municipalities to sign the agreement. This could be accomplished through existing statutory zoning requirements or some other land use control method.
3. The authority to recommend phosphorus allocations and a process for equitably distributing the allocation among dischargers.
4. The ability to recommend that the Water Quality Control Division reopen the discharge permit of any permit holder violating its allocation.
5. The ability to recommend that the Water Quality Control Division reopen the discharge permits of permit holders who do not participate in the nonpoint control program if that entity is required to do so.
6. The responsibility to amend the DRCOG Clean Water Plan on an annual basis, if necessary.



## VII. IMPLEMENTATION

This basin master plan is an ambitious program to provide wastewater service in a rapidly growing area while protecting the water quality of Cherry Creek Reservoir. Implementation of the plan will require clearly defined steps in the point source, nonpoint source and institutional areas. This chapter identifies and presents those steps plus the estimated costs for the structural elements of both the point and nonpoint elements of the plan.

### Implementation Steps

Implementing the plan will require careful scheduling. This section outlines the anticipated steps for implementing each major element of the plan. The agency or agencies responsible for implementation are identified so that their progress can be monitored.

An annual report may be prepared by the Basinwide Authority to describe progress made in implementing the plan. This report would also provide an opportunity for proposing amendments to the plan. The information in this report could be incorporated into DRCOG's annual update to the Clean Water Plan.

The steps necessary to implement the institution are:

1. Master plan task force develops a document creating a Basinwide Authority.
2. Counties, municipalities and special districts formally create the Basinwide Authority.

The steps necessary to implement the point source program are:

1. DRCOG and the WQCC recognize the 12 plants and their service areas in the DRCOG Clean Water Plan.
2. The WQCC amend discharge permits to include the phosphorus allocations adopted as part of the plan.
3. Operating agencies develop individual facility plans and construction programs.

The steps necessary to implement the nonpoint control program are:

1. The Basinwide Authority selects initial subbasins for control structures.
2. The Basinwide Authority retains engineering firm(s) to design control structure(s).
3. The Basinwide Authority develops financial package and implements controls.

4. The Basinwide Authority develops monitoring program(s) to determine the effectiveness of control structures.
5. The Basinwide Authority schedules remaining priority subbasins.
6. The Basinwide Authority determines if, and when, other subbasins need to be controlled based upon the results from the monitoring program.

The steps necessary to implement the Best Management Practices for nonpoint control are:

1. General purpose governments adopt erosion control ordinances.
2. Tri-County Health Department evaluates septic system design criteria for phosphorus control.
3. Counties and Tri-County Health Department adopt septic system design criteria.
4. General purpose governments adopt uniform stormwater drainage criteria.

#### Costs of Implementation

The structural elements of both the point source and nonpoint source programs were developed based on a number of criteria including costs. The selected alternatives were determined to be cost effective but will still require significant expenditures to construct and operate.

Table 14 describes the capital and operation and maintenance costs of the 12 plants in the point source control program. These are based on the predicted size of each facility at the time treatment capacity reaches the critical point source load, a basin total of 14.4 mgd.



Table 14

Cost of Twelve Plant System  
at the Critical Point Source Load

	Equivalent Annual Costs (EAC) <sup>1</sup>
Arapahoe	\$ 2,926,800
Inverness	2,032,700
Meridian	1,833,700
Cottonwood	2,800,000
Stonegate	1,788,700
Parker	5,480,600
Denver Southeast	4,510,600
Castle Rock	
Cherry Creek	2,355,900
McMurdo	2,529,900
Mitchell	2,240,300
Newlin Gulch	2,715,600
Rampart Range	1,927,700
TOTAL	\$33,142,500

<sup>1</sup>Source: Richard P. Arber Associates, Inc., "Costs and Water Rights Impacts of Selected Point Source Treatment Alternatives," Volume 2, May, 1985.

The total of \$33.14 million presented in Table 14 is an equivalent annual cost (EAC) expressed in 1985 dollars which amortizes the capital costs for wastewater treatment and phosphorus control over 20 years at 10 percent interest. This figure does not account for investment in wastewater treatment works already in place in the basin. While not the lowest in cost, it was one of the lowest among the alternatives considered. This total cost was used for alternatives analysis but the actual costs will be paid by those served by the facility.

One way to describe this annual cost would be the cost per resident or employee. With projected sewered population at the critical point of 109,000, and an employment of 150,000, the costs for wastewater treatment can be expressed for each group. A projected annual cost of \$242 per person and \$45 per employee is anticipated at the critical point. This difference in cost is due to the difference in wastewater generation rates for population and employees. Per capita generation rates used for the population were 85 gallons per day and the employee generation rates were 35 gallons per day. These generation rates result in less wastewater produced by the employment community at a lower treatment cost. Of these annual treatment costs, approximately 11 percent are attributed to phosphorus removal.

This cost is not directly comparable to monthly fees charged by wastewater providers since most providers rely upon a mixture of revenue sources. Tap fees and property tax revenue are often a major source of capital financing and may provide a portion of the operating budget.

One important factor is the portion of this cost that is due to phosphorus removal. Calculation of this factor is complicated by the fact that a number of systems utilize land application systems for the water rights and water supply benefits resulting in phosphorus removal benefits. In this analysis, costs for phosphorus removal were only defined where the specific type of treatment was being used only for phosphorus removal. Examples of this would be advanced treatment with direct discharge and advanced treatment with rapid infiltration.

Of the projected equivalent annual cost, the costs attributable solely to phosphorus removal are expected to be \$2.4 million. Phosphorus removal also increases operation and maintenance costs through additional chemicals and sludge processing. Of the projected total operation and maintenance budget of \$6 million per year, phosphorus removal is expected to cost \$1.3 million.

The structural portion of the nonpoint control program consists of subbasin stormwater treatment facilities in the five subbasins which will be generating a large portion of the phosphorus by the year 2000. Detailed engineering in each subbasin will better define the best type of facility for that basin and provide a more refined cost estimate. For the purpose of this plan, the cost analysis was based on the expected flow in each subbasin in the year 2010. In Shop Creek, the least expensive method was a rapid infiltration system. In the other subbasins, a preliminary soils analysis indicated that rapid infiltration was not feasible. In these subbasins, detention with sand infiltration is recommended and projected to be the least costly.

Table 15 summarizes the costs for these five basins for a facility of adequate size to treat the runoff from a 1-1/2 inch storm. The total equivalent annual cost for the five subbasins is slightly less than \$1 million. As described elsewhere in this report, it is anticipated that this cost will be shared by all entities in the basin through the Basinwide Authority.

Table 15

Land Area Requirements and Costs  
for Nonpoint Control Facilities  
in Five Subbasins for the Year 2010

Subbasin	Land Required (acres)	Total Capital Cost (1985 \$) <sup>1</sup>	Total O&M Cost (1985 \$) <sup>1</sup>	Total Equivalent Annual Cost
Shop Creek	6.1	73,000	24,000	80,000
Cottonwood Gulch	14.8	973,000	56,000	279,000
Happy Canyon	7.9	558,000	47,000	205,000
Direct Flow #4	4.6	345,000	40,000	161,000
Direct Flow #5	8.4	582,000	48,000	211,000
TOTAL	41.8	2,531,000	215,000	936,000

<sup>1</sup>Source: Richard P. Arber Associates, Inc., "Costs of Nonpoint Control Options," Volume 3, May, 1985.



## CHERRY CREEK BASIN WATER QUALITY MASTER PLAN TASK FORCE

### AGENCY

Douglas County  
Arapahoe County  
Town of Castle Rock  
Town of Parker  
U.S. EPA  
Colorado Department of Health  
Colorado Division of Wildlife  
Colorado Water Quality Control Commission  
Colorado Dept. of Parks and Outdoor Rec.  
U.S. Army Corps of Engineers  
Tri-County Health Department  
City of Greenwood Village  
City of Aurora  
Urban Drainage and Flood Control District  
South Cherry Creek Land Company  
Denver Southeast Suburban Water and San. Dist.  
Stonegate Center Metropolitan Dist.  
Parker Water and Sanitation Dist.  
Cottonwood Water and Sanitation Dist.  
Inverness Water and Sanitation Dist.  
East Cherry Creek Valley Water and Sanitation Dist.  
Arapahoe Water and Sanitation Dist.  
Calkins, Kramer, Grimshaw & Haring  
Meridian Water and Sanitation District  
Happy Canyon Ranch  
Gemini Properties Corp.

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