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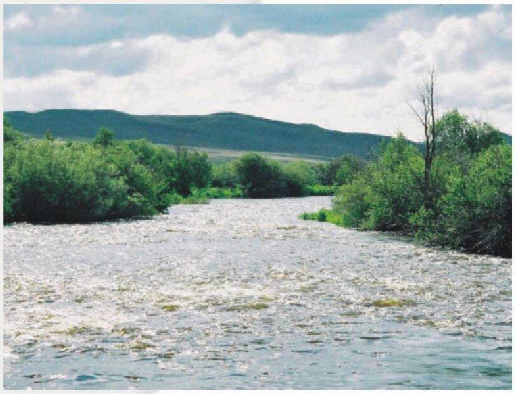
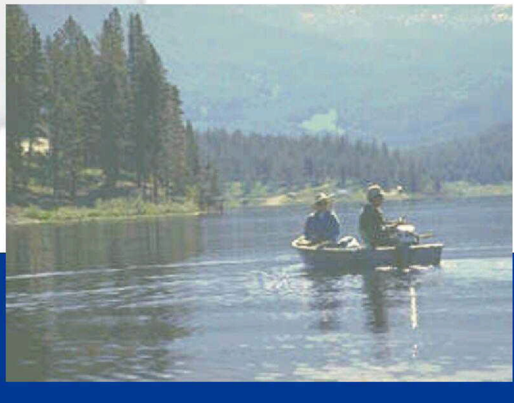
COLORADO DEPARTMENT OF NATURAL RESOURCES

Colorado Department of Natural Resources

Water Supply and Needs Report for the North Platte Basin

June 2006





Report

North Platte Basin Water Supply and Needs Report

North Platte Basin

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Acronyms

AF	acre-feet
AF/Ac/Yr	acre-feet per acre per year
AFY	acre-feet per year
CDPHE	Colorado Department of Public Health and Environment
cfs	cubic feet per second
CGS	Colorado Geological Survey
CNHP	Colorado Natural Heritage Program
CPR	Conserve, Protect, Restore
CU	consumptive use
CWCB	Colorado Water Conservation Board
DOLA	Department of Local Affairs
DSS	Decision Support Systems
DWR	Division of Water Resources
gpcd	gallons per capita per day
IBCC	Interbasin Compact Committee
IWR	irrigation water requirement
M&I	municipal and industrial
RICDs	Recreational in-channel diversions
SDWA	Safe Drinking Water Act
SEO	State Engineer's Office
SSI	self-supplied industrial
SWSI	Statewide Water Supply Initiative
TMDL	Total Maximum Daily Load
UPCO	Upper Colorado River Basin Study
USGS	U.S. Geological Survey
WQCC	Water Quality Control Commission
WSL	water supply limited

Section 1
Introduction

North Platte Basin

1.1 The Interbasin Compact Process

In June 2005, Colorado Governor Bill Owens signed into law the Colorado Water for the 21st Century Act (the Act) creating the Interbasin Compact Process. The Act affirms Colorado's existing prior-appropriation doctrine for water rights, while acknowledging that water is a limited resource and there is a need for statewide cooperation. The Act creates Basin Roundtables for each of Colorado's eight major river basins plus a distinct roundtable for the Denver metropolitan area. The Basin Roundtables are comprised of a diverse cross-section of citizens, representing a variety of interests such as water conservation and conservancy districts, recreational and environmental interests, local governments, and water providers.

In order to facilitate and encourage collaboration among Colorado's river basins, the Act also created the Interbasin Compact Committee (IBCC). The IBCC is comprised of gubernatorial appointments, legislative appointments, and two representatives from each Basin Roundtable. The IBCC is responsible for guiding discussions and voluntary negotiations between basins.

Each Basin Roundtable is charged with developing a basinwide water needs assessment. This is to consist of:

> *Using data and information from the Statewide Water Supply Initiative and other appropriate sources … develop a basinwide consumptive and nonconsumptive water supply needs assessment, conduct an analysis of available unappropriated waters within the basin, and propose projects or methods, both structural and nonstructural, for meeting those needs."*

This Basin Water Supply and Needs Report provides a starting point for the Colorado Water Needs Assessment. The report is taken largely from information generated during Phase 1 of the Statewide Water Supply Initiative (SWSI). Phase 2 of SWSI, currently underway, aims to further analyze, evaluate, and develop consensus in four key areas:

- Water Conservation and Efficiency
- Alternative Agricultural Transfers to Permanent Dry-up
- Prioritize and Quantify Recreational and Environmental Needs
- Addressing the 20 Percent M&I Gap, Agricultural Shortages, and Environmental and Recreational Needs Including Development of Alternatives

1.2 The Statewide Water Supply Initiative

In 2003, the Colorado legislature recognized the critical need to understand and better prepare for our long-term water needs, and authorized the Colorado Water Conservation Board (CWCB) to implement SWSI, a comprehensive study of how Colorado will meet its future water needs.

SWSI also conducted public information and Basin Roundtable activities that were designed to provide a mechanism and forum for the CWCB Board to solicit and exchange information, and was essential to the success of the project. The SWSI Basin Roundtables, with the support of the CWCB Board, defined the overall water management objectives, established performance measures to meet these objectives, and identified solutions for meeting future water needs.

The overall objective of SWSI is to **help Colorado maintain an adequate water supply for its citizens and the environment**. SWSI is not intended to take the place of local water planning initiatives. Rather, it is a "forum" to develop a common understanding of existing water supplies and future water supply needs and demands throughout Colorado, and possible means of meeting those needs. CWCB, through SWSI and future efforts, will help support and/or identify solutions to these water supply needs. To help attain this goal, SWSI summarized by river basin, at a reconnaissance level, existing water supplies and demands and projected demands up to 30 years into the future, and a range of potential options to meet existing and future demands. SWSI also studied agricultural uses and non-consumptives uses such as environmental flows throughout the state. This information will allow water providers, state policy makers, and the General

Assembly to make informed decisions regarding the management and use of Colorado's surface and groundwater resources.

In many areas, local planning entities have completed studies, identified projects, and are capable of implementing those projects. SWSI documented and summarized these identified projects or processes that are in place to address future water needs. Where entities need implementation assistance, SWSI addressed planning and implementation needs, identified projects for possible implementation, and developed strategies for project implementation including potential cooperative and collaborative efforts. For areas where specific projects were not identified by water providers or water users, SWSI relied on a stakeholder process. The options developed by the SWSI stakeholder process generally fall within the following categories:

- Conservation
- Agricultural transfers
- Reservoir storage
- Conjunctive use of alluvial or non-tributary groundwater
- Water reuse
- Control of non-native phreatophytes (water consuming plants)

By taking both a basin and statewide perspective, SWSI has identified issues and water supply needs and projects that may require coordination by more than one planning entity or that may be beyond the capabilities of a single entity. Through the SWSI effort, CWCB has identified possible solutions to achieve a cooperative and collaborative initiative. The Interbasin Compact Process will build on this by further enhancing collaboration among the river basins to develop implementable and sustainable solutions.

1.3 Major Findings of SWSI

SWSI explored all aspects of Colorado's water use and development on both a statewide and an individual basin basis. SWSI focused on in-basin issues first; analyses of supply and demand at the statewide level are being conducted as part of Phase 2. Major findings identified during the first phase of work are based on technical analyses and feedback gathered through SWSI Basin Roundtable input.

Even though some of these findings are readily apparent to some, it was important that they be affirmed as part of building a foundation and common understanding. Other findings were determined and/or clarified through the SWSI process. These findings are summarized below.

1. **Significant increases in Colorado's population – together with agricultural water needs and an increased focus on recreational and environmental uses – will intensify competition for water.**
2. **Projects and water management planning processes that local municipal and industrial (M&I) providers are implementing or planning to implement have the ability to meet about 80 percent of Colorado's M&I water needs through 2030, under the most optimistic scenario.**
3. **To the extent that these identified M&I projects and processes are not successfully implemented, Colorado will see a significantly greater reduction in irrigated agricultural lands as M&I water providers seek additional permanent transfers of agricultural water rights to provide for the demands that would otherwise have been met by specific projects and processes.**
4. **Supplies are not necessarily where demands are; localized shortages exist, especially in headwater areas, and compact entitlements in some basins are not fully utilized.**
5. **Increased reliance on nonrenewable, non-tributary groundwater for permanent water supply brings serious reliability and sustainability concerns in some areas, particularly along the Front Range.**
6. **In-basin solutions can help resolve the remaining 20 percent gap between M&I supply and demand, but there will be tradeoffs and impacts on other uses – especially agriculture and the environment.**
7. **Water conservation (beyond Level 1) will be relied upon as a major tool for meeting future M&I demands, but conservation alone cannot meet all of Colorado's future M&I needs.**

Significant water conservation has already occurred in many areas.

8. **Environmental and recreational uses of water are expected to increase with population growth. These uses help support Colorado's tourism industry, provide recreational and environmental benefits for our citizens, and are an important industry in many parts of the state. Without a mechanism to fund environmental and recreational enhancement beyond the project mitigation measures required by law, conflicts among M&I, agricultural, recreational, and environmental users could intensify.**
9. **The ability of smaller, rural water providers and agricultural water users to adequately address their existing and future water needs is significantly affected by their financial capabilities.**
10. **While SWSI evaluated water needs and solutions through 2030, very few M&I water providers have identified supplies beyond 2030. Beyond 2030, growing demands may require more aggressive solutions.**

These Findings and the Recommendations found in Section 11.3 of the SWSI Report were drawn from all aspects of the SWSI process. However, they should not be viewed as consensus products of the SWSI Basin Roundtables.

1.4 Major Findings in the North Platte Basin

Below is an overview of the individual issues in the North Platte Basin identified in the SWSI Report. These findings are provided here to assist the reader in linking issues in the North Platte Basin to SWSI implementation and to the goals set forth by the Interbasin Compact Process.

- One of Colorado's only basins with concern over lack of growth and economic development.
- There is a desire to ensure protection of existing water supplies, and a concern over the impact of the lack of forest management. It is important that Endangered Species issues on the Platte River in Central Nebraska are successfully resolved and in a manner that does not put pressure on North Platte water users to reduce existing uses.
- The equitable apportionment decree quantifies the amount of available water and lands that can be irrigated.

1.5 SWSI Phase 2

The SWSI Report was completed in 2004 and established a path forward for SWSI based on its findings. Phase 2 is expected to conclude in mid-2006; however, full implementation of SWSI elements will take place over a period of years and decades. In tandem, the Interbasin Compact Process further establishes the framework for long-term water supply planning in Colorado on an interbasin basis. Helping ensure Colorado's water future is a complex and difficult challenge. Addressing our water future means that we must ensure the social, economic, and cultural health and integrity of all of our river basins.

Goals should be met by developing sound implementable objectives that can be met regularly over a longer term if SWSI's success is to be capitalized on. We now know, based on the SWSI Basin Roundtable information, **Colorado can potentially meet 80 percent of its M&I water needs by 2030; however, some water suppliers may need help building infrastructure, mitigating and permitting projects, enhancing and improving the environment, and conserving water.** We also now know that the state can reassure the General Assembly and other state decisionmakers to an extent never before possible that we are not facing an immediate water crisis, but long-term challenges. There are certainly some tough decisions to be made and parts of the state need to take action sooner than others, but realistically, none of these tough decisions or actions can be made overnight or in an atmosphere of crisis.

1.5.1 The 80 Percent Solution for M&I

SWSI has catalogued the specific projects, plans, and processes that local water suppliers have identified and are undertaking as components of their own water supply planning efforts to meet the needs they themselves have identified. As a whole, if these projects are implemented, 80 percent of the state's long-term M&I needs will be met. This is the most optimistic scenario, but there is uncertainty, and hurdles to overcome. Therefore, the mission of the state with respect to meeting 80 percent of our M&I water needs by 2030 should be:

Following the lead of local water suppliers, the state will monitor long-term water needs, provide technical and financial assistance to put the necessary plans, projects and programs in place to meet those needs, and foster cooperation to avoid being forced to make trade-offs that would otherwise harm Colorado's environment, lifestyle, culture, and economy.

The goals of this mission are to:

1. **Follow the lead of local water suppliers.** In order for the CWCB to follow, local water suppliers must not only lead, but also must share information and be inclusive so that state leaders can confidently make decisions and provide the support required to ensure the fourth goal can be met.

2. **Monitor long-term water needs**. One of the major hurdles faced was the difficulty in collecting water use and water planning data. Our information about agricultural water use comes from statistics, water commissioner records, and aerial and satellite imagery that demonstrate that over time growing patterns and crops change over geographic areas. The state has even less information to share that is provided on a regular basis about M&I water use and demand. We must develop a better system that still protects water rights holders.

3. **Provide technical and financial assistance to put the necessary plans, projects, and programs in place to meet those needs.** The Drought Assessment that was conducted by the CWCB highlights that most water suppliers want technical and financial assistance from the state. SWSI provided for some categorization among water users so that we can pinpoint the type of help and assistance needed.

4. **Foster cooperation to avoid being forced to make trade-offs that would otherwise harm Colorado's environment, lifestyle, culture and economy.** SWSI makes it clear that future plans include drying up farmland to provide water for cities, towns, communities, and industries. While there will be the inevitable reductions of irrigated acres as development occurs on these lands, some of the additional projected losses of irrigated lands can be reduced if viable alternatives are available to M&I providers. Options exist that could reduce the need to dry up additional irrigated agricultural lands, but cooperation is essential and the state may be able to help level the field so that "win-win" options can be chosen. This must be done in a way that enhances our environment and protects recreational resources.

There are numerous issues that should be explored in this dialogue:

- Competition among water providers for the same sources of water.
- The trade-offs between in-basin agricultural transfers and new water supply development.
- How to create win-win scenarios where the basin or area of origin and the area of beneficial use both derive sufficient benefits from a proposed water development project.
- How to collaborate on the implementation of the Identified Projects and Processes, and further development of the options for meeting future needs.
- Identify options to allow for more use of non-permanent transfers of water from agriculture.

1.5.2 The 20 Percent M&I Gap, Agricultural Shortages, and Environmental and Recreational Enhancements

Another major achievement of SWSI was the identification of an inevitable gap in water supply that exists between current M&I water supply planning and the projected need for water. In addition, localized agricultural shortages have been identified in all basins and significant environmental and recreational needs were identified. Articulating the CWCB's role in helping to narrow and eventually eliminate this gap is much trickier – both institutionally and politically.

It is this gap that must be filled with "new" water so to speak. If water suppliers had the water to meet the demand represented by this gap, there would be no gap.

The mission for the state in filling this gap should be:

Foster cooperation among water suppliers and citizens in every water basin to examine and implement options to fill the gap between ongoing water planning and future water needs.

The goals of this mission are to:

1. **Foster cooperation among water suppliers and citizens in every water basin.** And, because SWSI is an *initiative*, work must obviously continue. The CWCB should continue the discussions that began at the Basin Roundtable meetings about in-basin projects and needs. The state should also identify and help foster the discussion about when these in-basin plans and projects are likely to impact out-of-basin interests, and what if anything, can be done to mitigate, or better yet *improve* water resource management and the economic, social, and environmental conditions in both basins – keeping in mind that if water development proceeds as planned, these discussions focus on only 20 percent of our long term M&I needs. These discussions must be conducted in such a manner that our 80 percent solutions aren't jeopardized by institutional, political, or social rancor. Remember, we are planning to meet water needs by 2030.

2. **Examine and implement options to fill the gap between ongoing water planning and future water needs.** SWSI did not produce a list of specific projects to fill the 20 percent M&I gap, or provide for environmental and recreational needs. SWSI did identify the options, both at the conceptual and project specific level that would most likely be pursued to meet the gap between supply and demand. The examination and implementation of these options should be placed in the context of goal number one.

3. **Examine and implement options to fill the gap associated with local agricultural shortages and environmental and recreational enhancements.** As we move forward in addressing statewide needs, we should look to foster multipurpose projects that could also satisfy M&I, environmental, and recreational needs. These multipurpose projects will enhance project feasibility. In addition, opportunities for nonpermanent agricultural transfers warrant further consideration.

Crafting new water supply alternatives to address anticipated supply gaps will be the work of the SWSI Basin Roundtables for Phase 2 of SWSI in those basins where a gap exists. These alternatives can serve two purposes – that of a new water supply project, and as an alternative to Identified Projects and Processes that may be unsuccessful. The options to be used as building blocks for these water supply projects have been presented in Section 10.

1.6 An Overview of the North Platte Basin Water Supply and Needs Report

This report presents the information contained in the SWSI Report that is specific to the North Platte Basin as a starting point for the North Platte Basin Roundtable to develop the needs assessment required by the Interbasin Compact Process. For additional data and discussion of analyses used in the development of the information presented here, the reader is referred to the SWSI Report and its appendices. The entire SWSI Report may be found on the CWCB website at http://cwcb.state.co.us/SWSI/index.htm.

Following is a description of the contents of this Basin report:

- Section 2 outlines the **Statewide Demographic, Economic, and Social Setting**. More detailed demographic data will be required as Colorado Water for the 21st Century Act activities move forward.
- Section 3 describes the **Physical Environment of the North Platte Basin**.
- Section 4 provides an overview of the **Legal Framework for Water Use** in Colorado.
- Section 5 describes the **Consumptive Water Supply Needs in the North Platte Basin**.
- Section 6 provides an overview of the **Nonconsumptive Water Supply Needs in the North Platte Basin**.

- Section 7 summarizes the **Water Supplies in the North Platte Basin** that were estimated using the CWCB's Decision Support Systems.
- Section 8 discusses **Options for the North Platte Basin**.
- Section 9 outlines **Options for Meeting Future Water Needs**.
- Section 10 describes the **Evaluation Framework** used in SWSI.

Section 2
Statewide Demographic, Economic, and Social Setting

As the state's population continues to grow, additional demands will be placed upon Colorado's water supplies. To characterize recent trends and existing conditions, this section presents an overview of the state's current and projected population and other key demographic factors.

Each of these components has an important role in determining current and future water use patterns in the state. Section 3 explores some of these parameters on a more detailed basis for the Colorado Basin.

2.1 Colorado's Historical and Projected Demographics

2.1.1 Population

The State of Colorado, the 24th most populous state in the United States according to the 2000 Census, was the third fastest growing state in the nation in the 1990s, surpassed only by Nevada and Arizona. Population increases have a significant impact on water planning and management strategies. Accurate population estimates are critical in understanding future water demands and therefore affect the decisions involved in meeting those demands.

Population projections were obtained from the Colorado Department of Local Affairs (DOLA) Colorado Demography Office. The DOLA dataset includes county population projections from 2000 to 2030 in annual increments.

Some counties in Colorado cross major river basin boundaries, which required their populations to be appropriately allocated among basins. Given the reallocation of population for the multi-basin counties, the total population per basin was determined. The population projections for years 2000 and 2030, percent change over 30 years, and the annual growth rates are shown in Table 2-1 for each basin.

Colorado's population is expected to increase by 65 percent from over 4.3 million people to approximately 7.1 million people between 2000 and 2030. Of the approximate 2.8 million population increase projected over this time frame, slightly more than 1.5 million or 54 percent is due to net migration into the state. The remainder is a function of birth rates that are substantially higher than the number of deaths projected for each year (DOLA 2003).

The populations in the West Slope basins of the Colorado, Dolores/San Juan/San Miguel, and Gunnison Rivers are projected to nearly double over the next 30 years. The populations in the Arkansas, Rio Grande, South Platte, and Yampa/White/Green Basins will increase between 35 percent and 65 percent. The North Platte Basin is projected to have the lowest growth rate over the 30-year planning period.

Table 2-1 Population Projections by Basin

Basin	2000	2030	Increase in Population	Percent Change 2000 to 2030	Percent Annual Growth Rate
Arkansas	835,100	1,293,000	457,900	55	1.5
Colorado	248,000	492,600	244,600	99	2.3
Dolores/San Juan/ San Miguel	90,900	171,600	80,700	89	2.1
Gunnison	88,600	161,500	72,900	82	2.0
North Platte	**1,600**	**2,000**	**400**	**25**	**0.7**
Rio Grande	46,400	62,700	16,300	35	1.0
South Platte	2,985,600	4,911,600	1,926,000	65	1.7
Yampa/White/Green	39,300	61,400	22,100	56	1.5
TOTAL	**4,335,500**	**7,156,400**	**2,820,900**	**65**	**1.7**

Source: Colorado DOLA Demography Section

Additional detail regarding the population projections and their use in developing estimates of future water use is included in Section 5.

2.1.2 Additional Demographic Information

Historical demographic data are compiled by DOLA and the U.S. Census Bureau. Beyond basic population figures, demographic factors influence the rates and patterns of water use. To characterize recent trends and current conditions, the following data were examined for Colorado, and where available data allowed, aggregated on a major river basin basis:

- Households and family size
- Age
- Employment
- Median household income

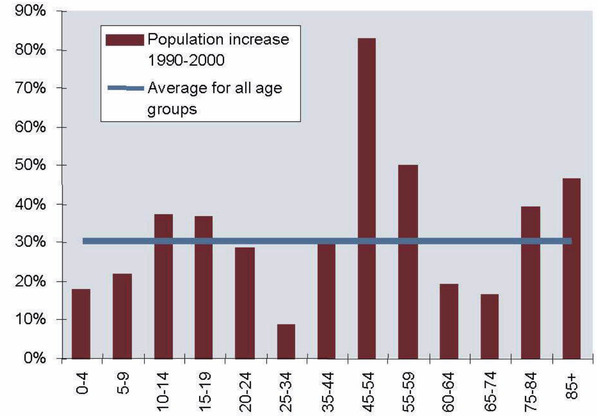
Table 2-2 summarizes current (2000) conditions and changes in the number of households, housing units, and families. While Colorado's population increased from 1990 to 2000 by about 31 percent, the number of households, families, and housing units increased at slightly lower rates, indicating an increase in the average household and family size.

Table 2-2 Statewide Demographic Trends 1990 to 2000

Parameter	1990	2000	Change
Total households	1,282,489	1,658,238	29.3%
Total housing units	1,477,349	1,808,037	22.4%
Total families	854,214	1,084,461	27.0%
Average household size	2.51	2.53	0.9%
Average family size	3.07	3.09	0.7%

Source: Colorado DOLA Profile of General Demographic Characteristics 1990-2000

Trends in the age of Colorado's population were also evident in the 1990s, as indicated in Figure 2-1. These data suggest that the state's population follows the national trend of an aging populace as the "baby boomers" advance in age and average life expectancies increase. This in turn could have implications on water use patterns as they relate to movement to multi-unit dwellings, changes in recreational activities, and associated water use quantities and patterns.



Source: Colorado DOLA Profile of General Demographic Characteristics 1990-2000

Figure 2-1
Colorado Population Increase by Age Group, 1990-2000

Colorado's economy is dependent on a diverse set of employment sectors. In 2000, about 2.2 million civilians over the age of 16 were employed in the state. County-level DOLA employment data for 2000 were aggregated into major basins. The North Platte Basin makes up less than one percent of the State's total employment. Table 2-3, below, shows employment in the North Platte Basin by industry.

Table 2-3 2000 Employment by Industry as a Percentage of Total Jobs in the North Platte Basin

Employment by Industry		% of Total
Agriculture, Forestry, Hunting & Mining	242	3%
Construction	86	9%
Manufacturing	23	14%
Wholesale Trade	27	3%
Retail Trade	69	13%
Transportation, Warehousing, and Utilities	38	3%
Information	16	3%
Finance, Insurance, & Real Estate	25	5%
Professional, Scientific, Management, and Administrative	45	10%
Education, Health, and Social Services	113	21%
Arts, Entertainment, Recreation, Lodging and Food Services	31	9%
Other Services	30	4%
Public Administration	48	3%
Total	**793**	**100%**

Section 3
Physical Environment of the North Platte Basin

3.1 Statewide Overview

Evaluations conducted under SWSI followed CWCB's delineations of Colorado's eight major river basins, as shown in Figure 3-1. The basins include the Arkansas, Colorado, Dolores/San Juan/San Miguel, Gunnison, North Platte, Rio Grande, South Platte, and Yampa/White/Green Basins. This section provides a description of the North Platte Basin that includes:

- Geography
- Climate
- Topography
- Land Use
- Surface Geology
- Surface Water
- Groundwater
- Water Quality
- Areas of Environmental Concern, Special Attention Areas, and Threatened and Endangered Species
- Energy and Mineral Resources

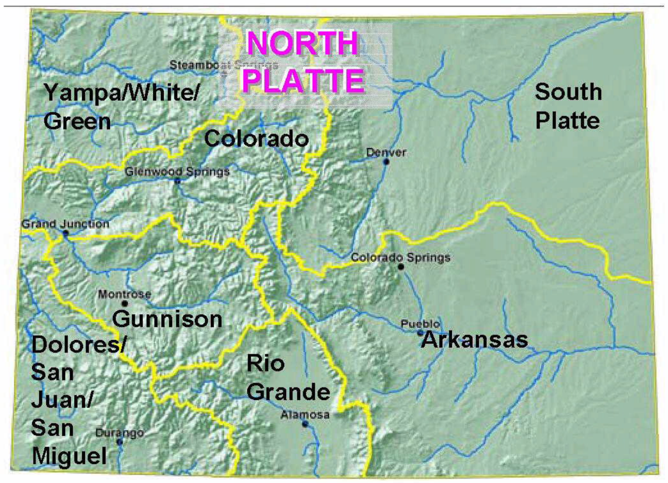


Figure 3-1
Colorado's Eight Major River Basins

Virtually all of these topics are interconnected or affect the state's water supplies and water quality – either through natural or man-made/induced factors. The topography of the Continental Divide, the backbone of Colorado's Rocky Mountains, dictates the direction of water flow either to the west or to the east for each of the river systems in the state. The Divide is also home to the headwaters of several major rivers and their tributaries that run throughout Colorado, including the Colorado.

In contrast, over half of Colorado's land area and 85 percent of the state's population lies in the South Platte and Arkansas Basins, which contribute only about 5 percent of the flows leaving the state. These two river systems travel from the east side of the Continental Divide to the Mississippi River and ultimately the Gulf of Mexico.

Groundwater resources also play a pivotal role in meeting Colorado's water needs. In 1995, groundwater withdrawals in Colorado were slightly more than 2.5 million acre-feet (AF), with agricultural users comprising about 90 percent of this amount. Overall, groundwater withdrawals by agricultural and M&I users in 1995 represented slightly more than 20 percent of the state's total for these uses, with the remainder coming from surface water supplies. The median value for groundwater use as a percentage of total use for all counties in the state is 9 percent, with agricultural areas in the eastern plains and in the San Luis Valley in south central Colorado relying more substantially on groundwater over surface water sources (Colorado Geological Survey [CGS] 2003).

The state's unique topography and climate are clearly intertwined with its water resources. Topography is an important component of water resources planning, in that it dictates the direction of natural flows within a watershed. Much of the state's precipitation is concentrated on its mountainous and western slope areas. Snowpack in the state's alpine headwaters areas provides the vast majority of water supplies, with spring runoff causing significant flow peaking in virtually all of the state's river systems. Groundwater storage and its recharge are also largely affected by the topography and climatological patterns that characterize the state.

Water quality can be affected by geography and various land uses including runoff from point and non-point discharge sources. For example, mining in the mountainous regions, urbanization along the Front Range, and agriculture in the eastern plains and elsewhere can impact the quality of the state's waters and aquatic habitats. Habitat degradation, nutrient loading, soil erosion, and increased stormwater runoff are only a few examples of the concerns associated with rapid urbanization, particularly in the mountain recreational areas (Colorado Department of Public Health and Environment [CDPHE] 2000).

Improving water quality and restoration and protection of water bodies in Colorado is occurring through programs such as the Total Maximum Daily Load (TMDL) process, Gold Medal fisheries establishment, instream flow programs, and federal and state listed threatened, endangered, and species of special concern.

3.2 North Platte Basin Physical Environment

3.2.1 Geography

The North Platte Basin, shown in Figure 3-2, is located in north central Colorado in Jackson and a small portion of Larimer Counties. The basin covers an area of roughly 2,050 square miles. The population of Walden in Jackson County is 727 people (DOLA 2003).

3.2.2 Climate

The average annual precipitation for the North Park Basin, which covers the majority of the North Platte Basin, is 19 inches. This average ranges from 11 inches in the valley center, near Walden, to more than 50 inches in the mountains that surround the valley (CGS 2003). Figure 3-3 shows color-fill contours for the average annual precipitation throughout the basin.

3.2.3 Topography

The North Platte Basin in Colorado is bounded on the east by the Front Range, on the west by the Park Range, on the south by the Rabbit Ears Range, and on the north by the Colorado-Wyoming state line. The land surface elevation of the basin valley ranges between 8,000 and 9,000 feet (CGS 2003).

3.2.4 Land Use

Land use in the North Platte Basin (USGS 1992) is shown in Figure 3-4 and summarized in Table 3-1. Almost half of the basin is forest (46 percent), located on the edges of the basin boundaries, followed by shrubland (24 percent), and grassland (17 percent). The shrubland is concentrated in the central portion of the basin. Grassland is typically located near the basin edges near the forested areas. Agricultural areas generally follow the basin's streams and rivers.

Table 3-1 Land Cover Data for the North Platte Basin

	Basinwide		Statewide	
Land Cover	Area (sq. miles)	Percent of Total	Area (sq. miles)	Percent of Total
Forest	934	45.7%	29,577	28.4%
Shrubland	481	23.5%	16,883	16.2%
Grassland	357	17.4%	41,051	39. 5%
Planted/ Cultivated	222	10.9%	13,737	13.2%
Open Water	24	1.2%	590	0.6%
Barren	23	1.1%	1,219	1.2%
Wetland	3	0.1%	80	0.08%
Developed	3	0.1%	923	0.9%
TOTAL	**2,047**		**104,067**	

Source: USGS 1992 NLCD

3.2.5 Surface Geology

The mountain regions in the North Platte Basin are composed of Precambrian age metamorphic rocks that are extensively intruded by granitic igneous rocks. The North Park Basin is filled with sedimentary rock layers. The sedimentary layers range from flat-lying to steeply dipping folded and faulted structures (Pearl 1974).

3.2.6 Surface Water

The North Platte Basin drains the north-central portion of Colorado and consists of the North Platte River and two major tributaries: the Laramie River and Sand Creek. The North Fork, Grizzly Creek, Michigan River, Canadian River, and Illinois River are tributaries that flow into the North Platte River in Colorado. Sand Creek and the Laramie River flow northward out of Colorado and join the North Platte River in Wyoming. The North Platte River, Laramie River, and Sand Creek are shown in Figure 3-2.

To monitor these streamflows, the USGS has gages in place in the North Platte Basin. Figure 3-5 shows the location of three of these streamflow gages. These gages are located on the North Platte River near Northgate, on the Laramie River near Glendevey, and on Sand Creek at the Colorado-Wyoming state line. They provide representative historical streamflows of the stream systems in the basin, as shown in Table 3-2, which also includes the length of record and the drainage area for each gage. Figure 3-5 also shows the locations of major diversions in the basin and segments with CWCB decreed instream flow rights.

Table 3-2 Summary of Selected USGS Stream Gages for the North Platte River Basin

Site Name	USGS Site Number	Mean Annual Streamflow (AFY)	Mean Annual Streamflow (cfs)	Period of Record (Years)	Drainage (sq. miles)
Laramie River near Glendevey	06657500	52,312	72	1904-1982	101
Sand Creek at Colorado-Wyoming State Line	06659580	7,518	10	1968-2002	29
North Platte River near Northgate	06620000	310,389	429	1915-2002	1,431

Source: USGS NWIS web/HydroBase database

3.2.7 Groundwater

The more important aquifers in the basin include:

- Valley-fill alluvium
- North Park Formation
- Coalmont Formation

Figure 3-6 shows the location of the significant aquifers in the basin separated into two groups: alluvial (valley-fill alluvium) and bedrock (North Park and Coalmont). The valley-fill alluvium is composed of sand, gravel, clay, and silt and is 80 feet thick in some areas (Pearl 1974). The North Park Formation is a 2,000-foot layer of calcareous sandstone with interbedded layers of siltstone, clay, and volcanic ash. Well yields from this aquifer are typically less than 50 gallons per minute (gpm) (Pearl 1974). The Coalmont Formation is a 6,000 to 9,000 foot layer of sandstone, shale, conglomerate, and coal beds. This is the primary aquifer in the basin, and well yields are generally less than 10 gpm (Pearl 1974). The Coalmont Formation is estimated to contain 120 million AF of recoverable groundwater; however, only 39 million AF are considered to be economical for withdrawal (CGS 2003). Figure 3-34 also shows the location of wells with permitted or decreed capacities greater than or equal to 500 gpm. In the North Platte Basin there is only one such well located to the west of South Delaney Lake.

Groundwater recharge and discharge are assumed to be equal as there has been no substantial change in the volume of storage in the North Park Basin. The volume of water withdrawn each year is very small compared to the total volume of groundwater storage (CGS 2003).

3.2.8 Water Quality

The North Platte and its tributaries are generally of high-quality water (CDPHE 2002). Elevated levels of total dissolved solids (TDS) are of concern in portions of the basin's groundwater resources affected by coal mining (CGS 2003). The basin has very few permitted wastewater discharges; stream erosion and sediment are the primary water quality issues of concern in the basin. The state's 2002 303(d) list did not include any listings in the North Platte Basin. However, the proposed 2004 303(d) list includes impairment of tributaries to the North Platte in the Illinois River drainage for iron, and Spring Creek for dissolved oxygen. Stream segments proposed for listing via the 2004 303(d) list and the accompanying Monitoring and Evaluation list are described in Colorado Water Quality Control Commission (WQCC) Regulations 93 and 94.

3.2.9 Areas of Environmental Concern, Special Attention Areas, and Threatened and Endangered Species

As mentioned above, an area of environmental concern in the North Platte Basin is the high TDS concentrations in groundwater in certain historic coal mine areas. There are no federal and/or state listed fish species found in the North Platte Basin. However, some other species are federally and/or state listed as threatened and endangered species in the North Platte Basin. A complete list of these species can be found in Appendix C of the SWSI Report. Figure 3-7 shows areas of environmental concern in the North Platte Basin.

In addition, two areas in the basin have received Gold Medal designation.

- The North Platte River from the Routt National Forest boundary downstream to the Colorado-Wyoming line (5.3 miles). The predominant fish in the North Platte River are brown trout, with rainbow trout also offering sport.
- One of the three lakes in the Delaney Butte Lakes State Wildlife Area, North Delaney Butte Lake. North Delaney Butte Lake is an extremely productive lake that grows trophy brown trout. This wildlife area is located about 10 miles west of Walden.

Figure 3-7 shows the locations of some of the basin's key aquatic species habitat.

3.2.10 Energy and Mineral Resources

There are no hydroelectric plants in the North Platte Basin. Historical coal mine production has contributed significantly to the economy of the basin in the past.

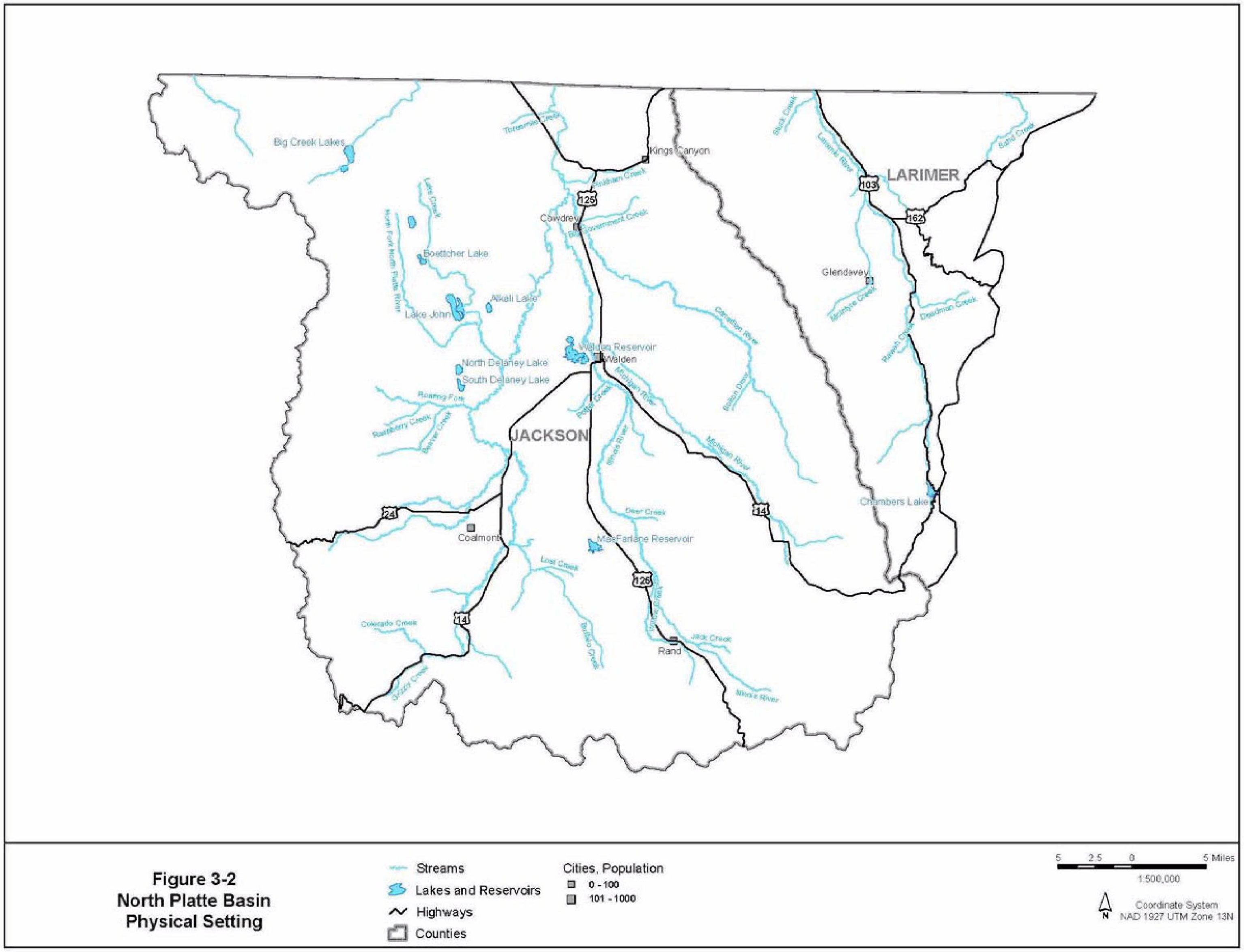


Figure 3-2
North Platte Basin
Physical Setting

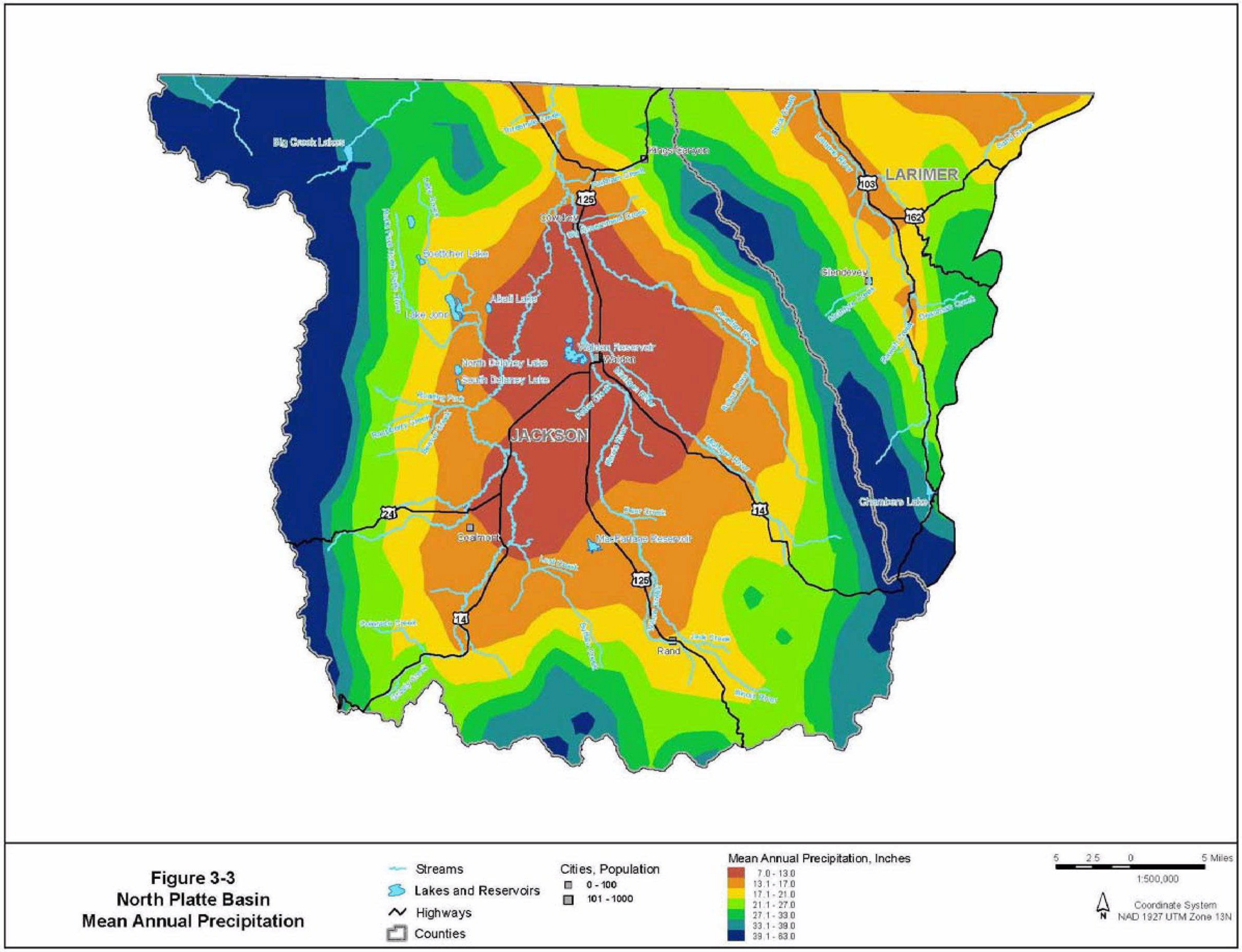


Figure 3-3
North Platte Basin
Mean Annual Precipitation

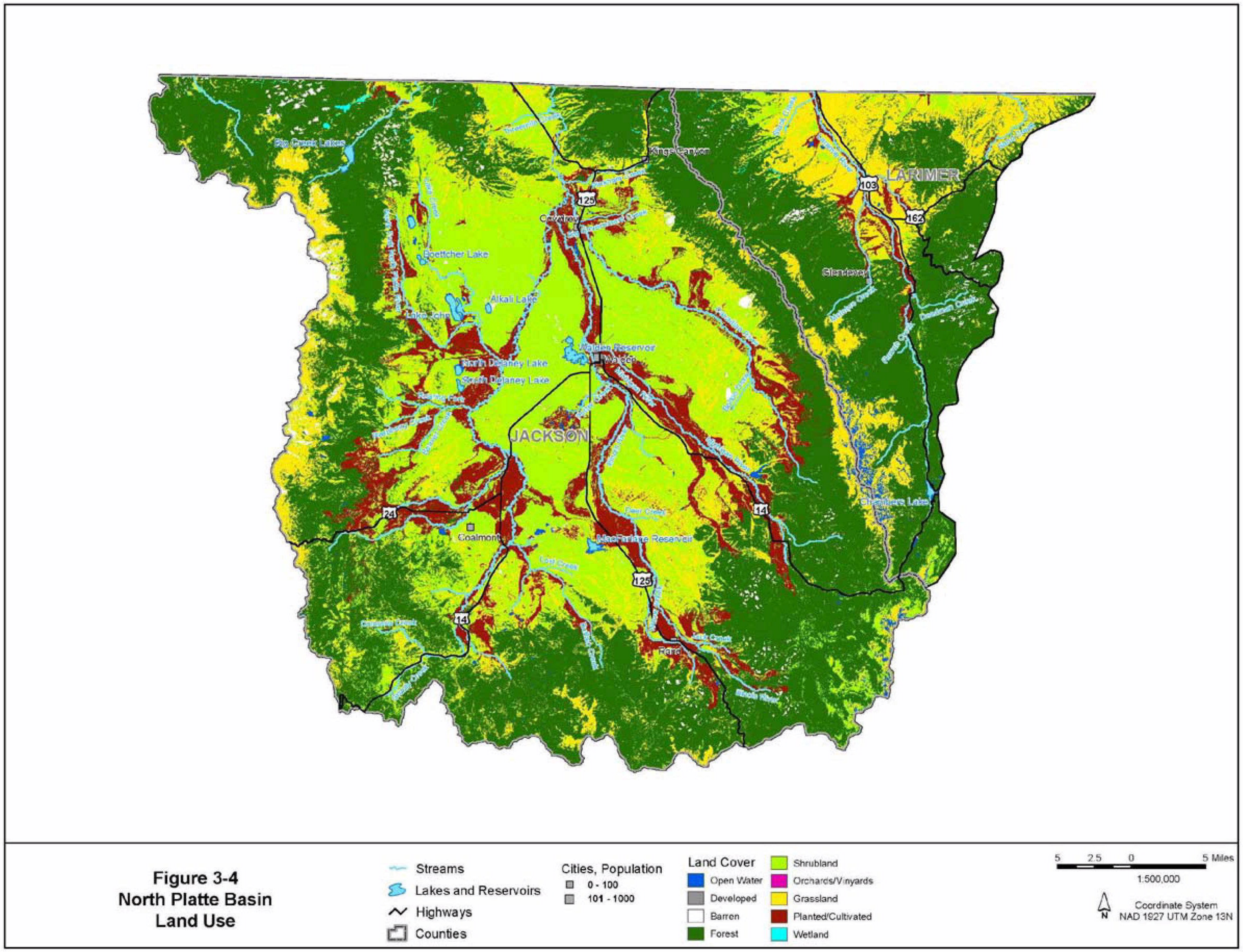


**Figure 3-4
North Platte Basin
Land Use**

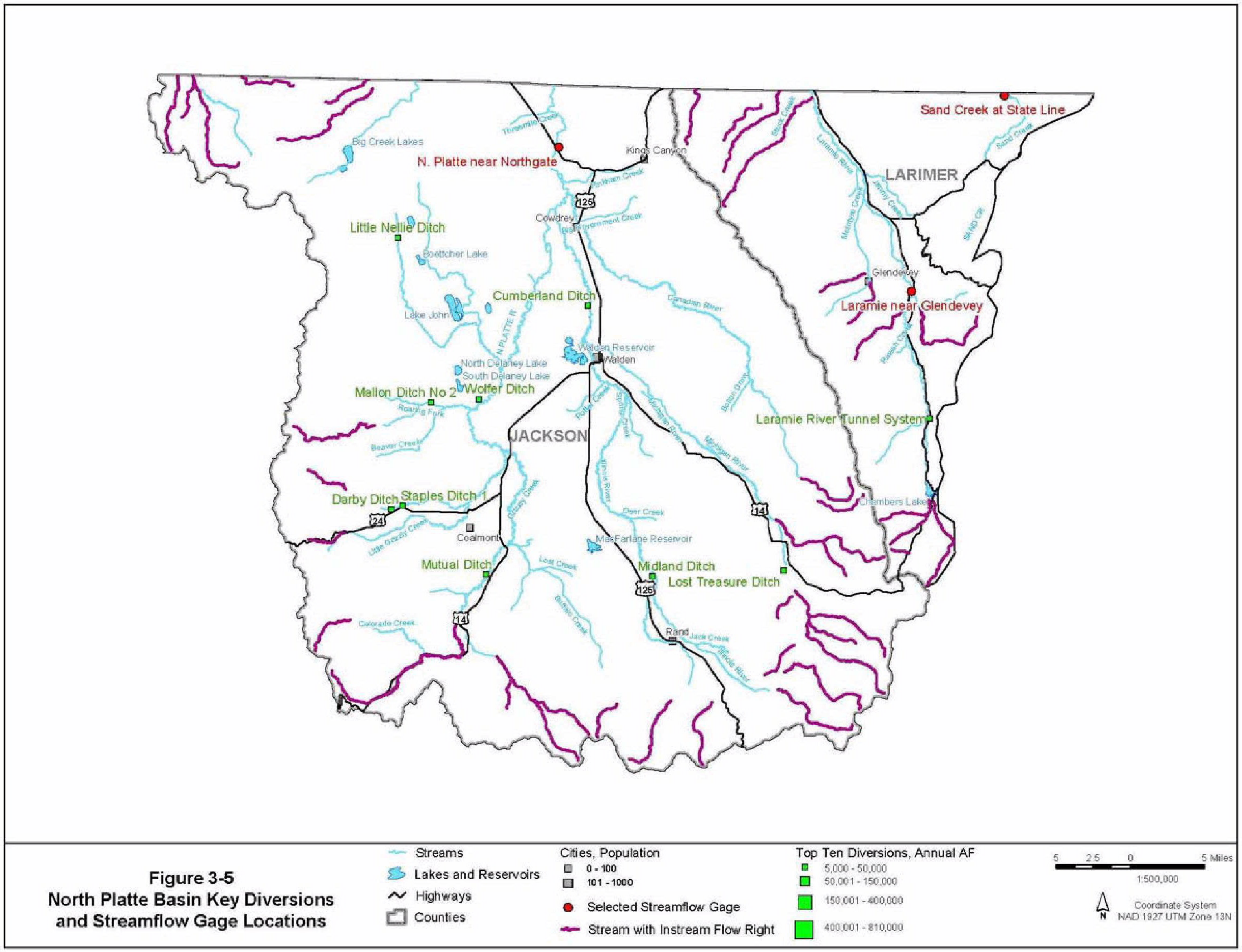


Figure 3-5
North Platte Basin Key Diversions and Streamflow Gage Locations

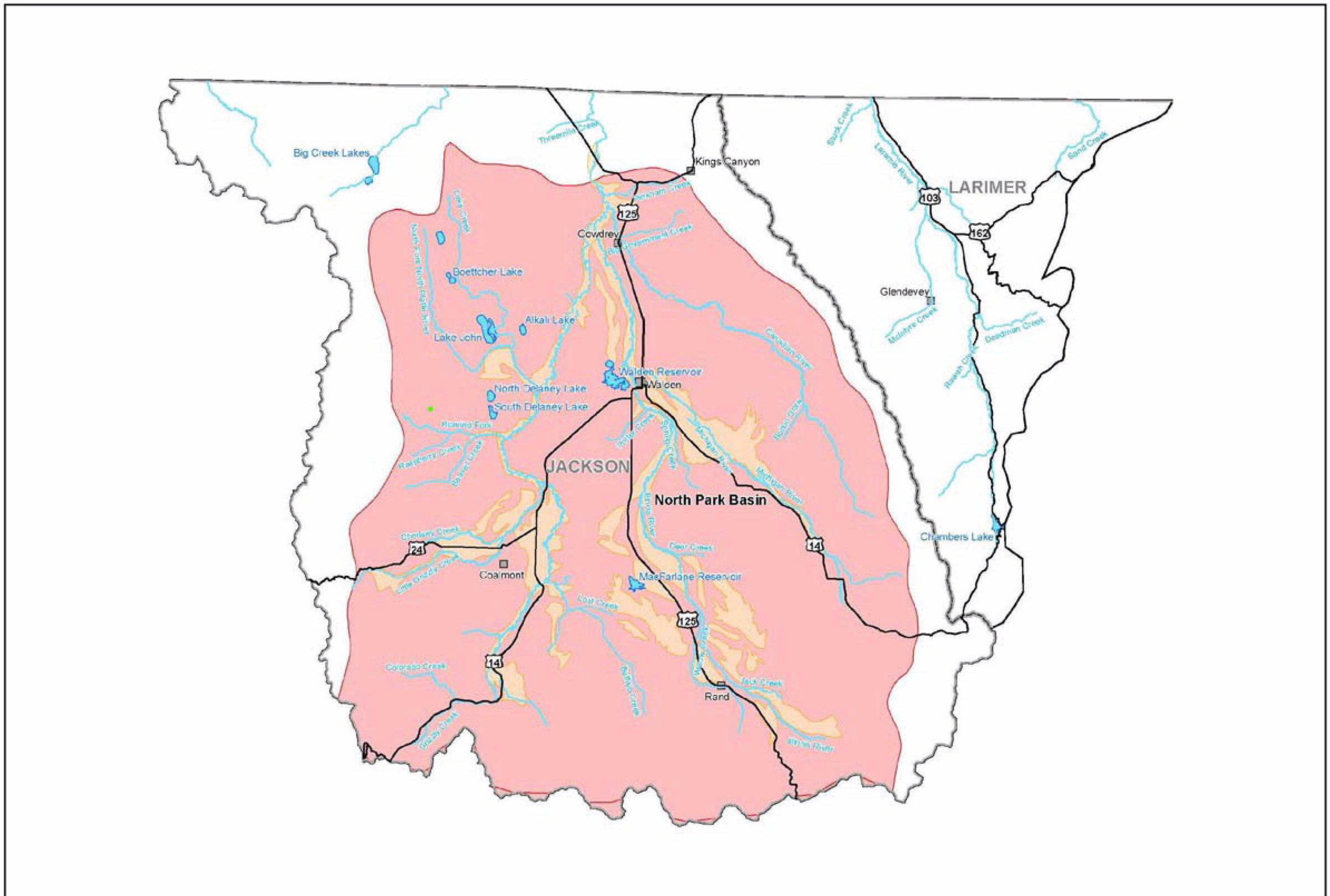


Figure 3-6
North Platte Basin
Wells and Aquifers

Streams
Lakes and Reservoirs
Highways
Counties

Cities, Population
0 - 100
101 - 1000

Wells (Permitted/Decreed Yields >= 500 GPM)
Alluvial Aquifer
Bedrock Aquifer

5 2.5 0 5 Miles
1:500,000
N
Coordinate System
NAD 1927 UTM Zone 13N

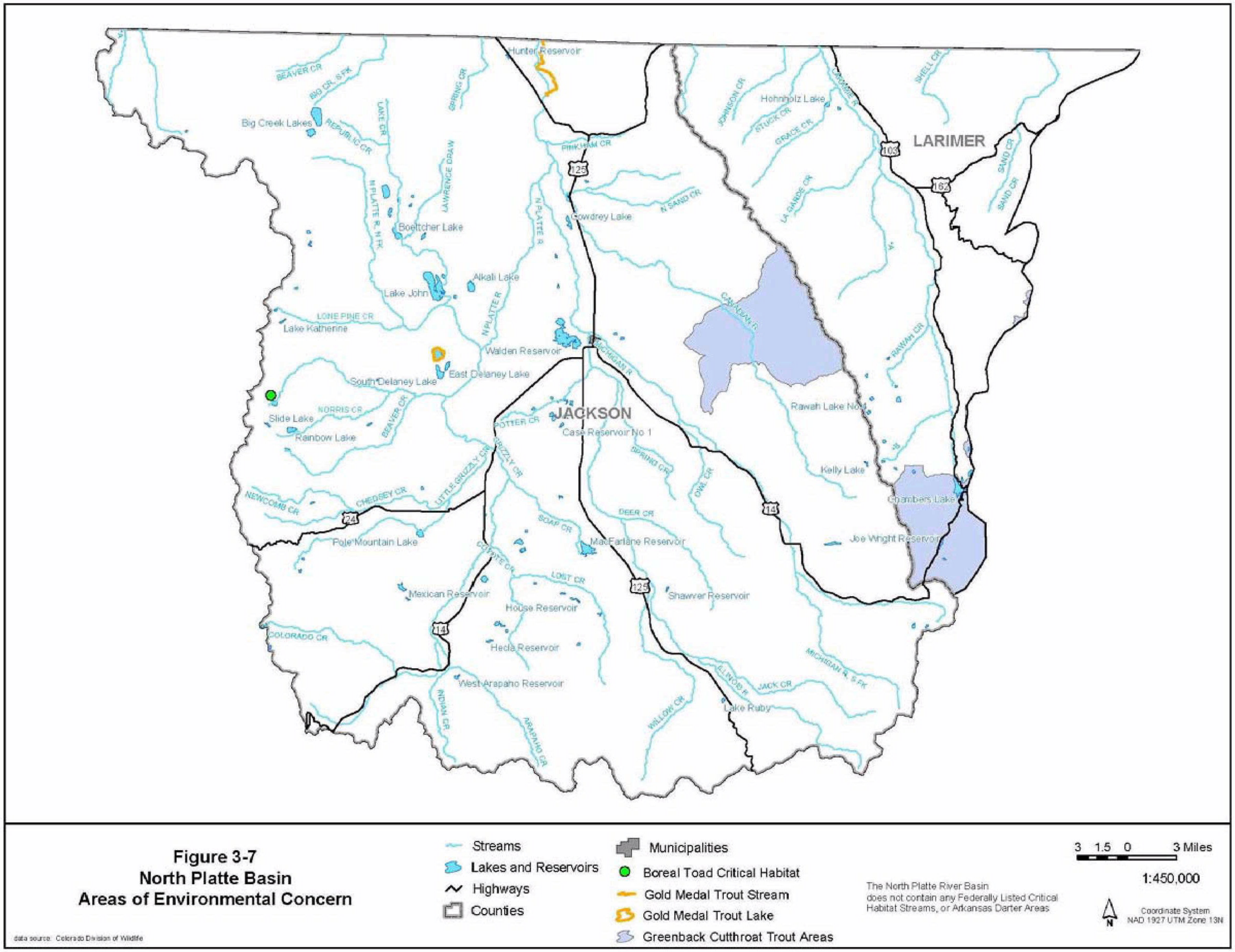


Figure 3-7
North Platte Basin
Areas of Environmental Concern

Section 4
Legal Framework for Water Use

North Platte Basin

4.1 Overview of State Water Laws

The following basic overview of Colorado Water Law is derived primarily from Chapter 5 of the CWCB's Drought and Water Supply Assessment Report and the Colorado Foundation for Water Education's Citizen's Guide to Colorado Water Law.[1]

4.1.1 Colorado's Prior Appropriation System

As in most arid western states, the allocation of water in Colorado is governed by the doctrine of "prior appropriation," commonly described as "first in time, first in right."[2] Under this doctrine, rights to water are granted upon the appropriation of a certain quantity of water for a beneficial use.[3] The date of appropriation determines the priority of the water right, with the earliest appropriation establishing the most senior, or superior, right.[4] Thus, the right to use water in Colorado is based on a prior appropriation, rather than by grant from the state.[5] The right to use water is a valuable property right that arises by placing unappropriated water to beneficial use.[6] This right is protected under Colorado law and is rooted in Colorado's Constitution, which establishes that public uses of water in Colorado are subject to the right to appropriate a water right for private use:

> The water of every natural stream, not heretofore appropriated within the State of Colorado, is hereby declared to be the property of the public, and the same is dedicated to the use of the people of the state, subject to appropriation as hereinafter provided. Colo. Const. Art. XVI, § 5.
>
> The right to divert the unappropriated waters of any natural stream to beneficial uses shall never be denied. Colo. Const. Art. XVI, § 6.

Like other property rights, vested water rights may not be taken without payment of just compensation, and they may be conveyed separate from the land on which they are used.[7]

As the doctrine of prior appropriation has been interpreted through case law, two major principles regarding the requirement of "beneficial use" and the concept of water as a property right have emerged. First, a water right does not include the right to waste the resource. Second, the right to use water must be sufficiently flexible to accommodate changes of use and the free transferability of water rights in order to allow the maximum use of water. With regard to the former, Colorado courts have required water users to employ an efficient means of diversion, and have limited the amount of water that may be appropriated to the amount necessary for the actual use. With regard to the later – flexible use of water rights – Colorado law recognizes

1 This overview is general in nature. For additional, more detailed information, see Chapter 5 of the CWCB's Drought and Water Supply Assessment Report; Vranesh's Colorado Water Law (Revised ed. 1999) James N. Corbridge Jr. and Teresa Rice; Citizens Guide to Colorado Water Law, (Revised ed. 2004) Justice Gregory Hobbs, Jr.

2 See Irwin v. Phillips, 5 Cal. 140 (1885)

3 See Colo.Const. Art. XVI, § 6 (The right to divert the unappropriated waters of any natural stream to beneficial uses shall never be denied"); see also C.R.S. § 37-92403(3(a) ("Appropriation" means the application of a specified portion of the waters of the state to a beneficial use pursuant to the procedures prescribed by law"); and Board of County comm'rs v. Upper Gunnison River Water Conservancy Dist., 838 P.2d 840 (Cob. 1992) ("To be effective, an appropriation must divert a definite quantity of water with the intent of applying such water to beneficial use").

4 See Colo.Const,. Art.XVI, § 6 ("Priority of appropriation shall give the better right as between those using the water for the same purpose"); Farmers' High Line Canal & Reservoir Co. v. Southworth, 21 p. 1028 (1889) ("Priority of right to water by priority of appropriation is older than the constitution itself, and has existed from the date of the earliest appropriations of water in the boundaries of Colorado").

5 The other major approach to water rights allocation in the United States is known as the "riparian" system, which is prevalent in the water rich states of the eastern United States. Under this system, water is allocated based on land ownership. Most riparian states now have permit statutes, under which an administrative official determines the quantity of water that may be diverted, and the terms and conditions for its use, based on criteria adopted by the legislature to protect public interests in the resource.

6 See Sherwood Irrigation Co. v. Vandewark, 331 P.2d 810 (1958) ("Water is a valuable property right, subject to sale and conveyance"); see also Justice Gregory Hobbs, "Colorado Water Law: An Historical Overview," 1 U. Denv. Water L. Rev. 1 at 2 ("Western prior appropriation water law is a property rights-based allocation and administration system, which promotes multiple use of a finite resource.").

7 See Strickier v. City of Colorado Springs, 26 P. 313, 316 (Cob. 1891) ("A priority to the use of water for irrigation or domestic purposes is a property right and as such is fully protected by the constitutional guaranties relating to property in general").

water storage rights, conditional water rights, augmentation plans, changes of water rights, appropriative rights of exchange, and instream flow rights, all of which allow water users to make the most of a scarce resource. In addition to making efficient beneficial use of water, interstate compacts and equitable apportionment decrees limit the amount of water Colorado can use. These interstate compacts and decrees are discussed in Section 4.3.

4.1.1.1 The Priority System

The priority system of water allocation is designed to cope with water scarcity.[8] Under the doctrine of prior appropriation, if water is insufficient to meet the needs of all water users, those with senior rights can require full or partial curtailment of diversions by junior water users, such that users with later priorities receive less than their allotted amount of water, or none at all.[9] Essentially, this doctrine protects those who first begin using the water from injury by those whose use began later in time.[10] Thus, typically, the more senior the water right, the more valuable it is, particularly in times of drought.

As mentioned above, water rights may be conveyed and changed to a new type, place, and manner of use. As a general matter, municipalities and other water users can satisfy their water needs by appropriating new water rights, including water storage rights, and/or by purchasing senior water rights (typically agricultural use) and changing them to municipal, commercial, or industrial uses according to the statutory procedures for changing a water right.

4.1.1.2 Beneficial Use

The single most important restriction on the appropriation of water in Colorado is the constitutional requirement that water be placed to a "beneficial use."[11] "Beneficial use" is defined in the Water Right Determination and Administration Act of 1969, Section 37-92-101 et seq. (hereafter 1969 Act) as follows:

> Beneficial use is the use of that amount of water that is reasonable and appropriate under reasonably efficient practices to accomplish without waste the purpose for which the appropriation is lawfully made[.][12]

The purpose of the beneficial use requirement is to prevent waste, hoarding, and speculation by appropriators, and to encourage the quick and efficient use of the resource.[13] The beneficial use requirement acts to limit the amount of water that may be appropriated for private use throughout the life of the water right. In order to establish a valid appropriation for an absolute water right, a water user must demonstrate that a certain amount of water has been applied to a beneficial use.[14] The amount decreed is limited to the amount placed to beneficial use.

In order to obtain a conditional water right, a right for water that has not yet been placed to beneficial use, a water user must establish that it "can and will" place a certain amount of water to beneficial use within a reasonable amount of time.[15] A water user may not appropriate more water than it actually needs for its intended use.

Courts have further applied the principle of beneficial use in holding that a water user has no right as against junior appropriators to divert more water than can be used beneficially,[16] regardless of the amount decreed, or to expand its use beyond the amount needed for the decreed use.[17]

A water user that diverts more water than it can place to beneficial use may have its diversions curtailed by the

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8 See James N. Corbridge Jr. and Teresa Rice, Vranesh's Colorado Water Law (Revised ed. 1999) at 2 ("The primary advantage of the appropriation system is the development of methods for the orderly distribution of water in water-short regions by establishing procedures for both the quantification and prioritization of water rights").

9 See CR5. § 37-92-301(3) (requiring the state engineer to distribute water in accordance with the priority system).

10 Application of Hines Highlands Partnership, 929 P.2d 718 (Cob. 1996).

11 See Vranesh, supra, at 43, citing Thomas v. Guiraud, 6 Cob. 530 (Cob. 1883) (referring to the beneficial use requirement as the "true test of an appropriation of water").

12 C.R.5.§ 37-92-103(4) (2002).

13 See Vranesh, snpra, citing, Combs v. Agricultural Ditch Co., 152, 28 P. 966, 968 (Cob. 1892).

14 See CR5. § 37-92-103(a) (this section sets forth Colorado's "anti-speculation doctrine," requiring that an applicant for an absolute or conditional water right show that the proposed appropriation is not based upon the "speculative sale or transfer of the appropriative rights[,]" and that the applicant has "a specific plan and intent to divert, store or otherwise capture, possess, and control a specific quantity of water for specific beneficial uses").

15 See C.R.5. § 37-92-305(9)(b).

16 See, Comstock v. Ramsay, 133 P. 1107, 1110-11 (Cob. 1913).

17 See Weibert v. Rothe Bros. Inc. 618 P.2d 1367,1373 (Cob. 1980).

Division Engineer.[18] If a water right is not placed to beneficial use for an extended period of time, and an intent to abandon the water right is demonstrated, the right may be lost. [19]

Thus, beneficial use limits the quantity of water initially allocated under individual water rights, ensures, through administration, that the amount of water used under a water right over time remains limited to the amount actually needed, and conserves water for other uses and users.

4.1.1.3 Maximum Utilization

Colorado courts have held that water should be allocated and administered in a way that promotes the "maximum utilization" of the resource.[20] This principle was formulated in reliance on Article XVI, Section 6 of the Colorado Constitution, which states "[the right to divert the unappropriated waters of any natural stream to beneficial uses shall never be denied."[21] Maximum utilization has been applied by the courts in two ways: (1) to require an efficient means of diversion with the purpose of making more water available to other water users; and (2) to support of the adoption of statutory tools allowing flexible administration, including, for example, augmentation plans, exchanges, and the "futile call doctrine."

Augmentation plans promote maximum utilization by allowing junior appropriators to divert out-of-priority, while protecting seniors from injury by replacing all out-of-priority depletions. [22]

Water exchanges also promote maximum utilization. Under an exchange, a substitute supply of water is made available to a downstream senior appropriator and an equal amount of water is then taken at an upstream point of diversion. Exchanges facilitate the movement of water to promote maximum utilization.

Like augmentation plans, the "futile call doctrine" also allows junior water users to divert out-of-priority under certain circumstances. Under this doctrine, a junior water user will be curtailed only if such curtailment actually makes water available to a senior water user calling for water.[23] This allows juniors to continue diverting in times of scarcity, even if a senior is not receiving its whole entitlement, if curtailment of the junior would not allow any additional water to reach the senior.

4.2 Specific Tools for Addressing Water Needs

There are a number of specific tools within the current legal framework of the Priority System that can be used to address various water supply needs. These specific tools include the following.

4.2.1 Water Storage Rights

There are two different types of water rights – direct flow water rights and storage water rights.[24] Direct flow rights allow a water user to divert water for immediate use, while storage rights allow a water user to divert water and store it to make a beneficial use at a later time. Storage rights, like other water rights, are assigned a priority and must be exercised without injury to other water rights.[25] Storage rights are obviously a very important mechanism for ensuring that water supplies will be adequate in times of drought. Moreover, reservoirs provide year-round water when stream levels

[18] See § 37-92-502(2)(a) "Each division engineer shall order the total or partial discontinuance of any diversion in his division to the extent that the water being diverted is not necessary for application to a beneficial use[.]"

[19] See City & County of Denver v. Middle Park Water Conservancy District, 925 P.2d 283, 286 (Cob.1996).

[20] See Fellhauer v. People, 447 P.2d 986, 994 (Cob. 1968).

[21] See id. at 994 ("It is implicit in these constitutional provisions that, along with Vested rights, there shall be Maximum utilization of the water of this state") (capitalization in original); see also CR5. § 37-92-102(1)(a) (Under the "basic tenets of Colorado water law," the legislature has codified the doctrine of maximum utilization, declaring that "it is the policy of this state to integrate the appropriation, use, and administration of underground water tributary to a stream with the use of surface water in such a way as to maximize the beneficial use of all of the waters of this state") (emphasis added).

[22] See C.R.S., § 37-92-501.5, requiring the State Engineer to "exercise the broadest latitude possible in the administration of waters under their jurisdiction to encourage and develop augmentation plans and voluntary exchanges of water . . . in order to allow continuance of existing uses and to assure maximum beneficial utilization of the waters of this state."

[23] See CR5., §§ 37-92-102(2)(d) ("No reduction of any lawful diversion because of the operation of the priority system shall be permitted unless such reduction would increase the amount of water available and required by water rights having senior priorities"); and 37-92-502(a) ("Each division engineer shall order the total or partial discontinuance of any diversion in his division. to the extent that the water being diverted is required by persons entitled to use water under water rights having senior priorities, but no such discontinuance shall be ordered unless the diversion is causing or will cause material injury to such water rights having senior priorities").

[24] CR5. § 37-87-101

[25] Id

drop following the snow melt each year.[26] Over the years, there have been numerous water storage projects undertaken by Colorado irrigation districts, water conservation districts, M&I water providers, and the federal government.[27]

4.2.2 Conditional Water Rights

A conditional water right is defined in the 1969 Act as "a right to perfect a water right with a certain priority upon the completion with reasonable diligence of the appropriation upon which such water right is based."[28] A conditional water right allows an appropriator to secure a place in the priority line before any water is actually applied to beneficial use. To obtain a conditional water right, the applicant must show that the "first step" towards the appropriation has been taken. The "first step" includes the intent to appropriate, plus a demonstration of that intent through "physical acts sufficient to constitute notice to third parties."[29] Once the appropriator actually places the water to beneficial use, an absolute decree may be issued with a priority date relating back to the date the appropriation was initiated through the "first step."

As explained by the Colorado Supreme Court in Public Service Co. vs. Blue River Irrig. Co.,[30] a conditional water right "encourage[s] development of water resources by allowing the applicant to complete financing, engineering, and construction with the certainty that if its development plan succeeds, it will be able to obtain an absolute water right." Conditional water rights are crucial to large-scale development projects, including most transmountain diversions and storage projects, because they allow an appropriator to secure a priority and protect its investment when water cannot immediately be placed to beneficial use.[31] Thus, conditional water rights are a tool that may be used to complete major water projects, including storage reservoirs, transmountain diversion projects, or pipelines to meet water needs.

[26] See Hobbs, I U. Deny. Water L. Rev. 1 at 13, *supra*
[27] See id. (for discussion of 1902 Reclamation Act and reclamation storage projects in Colorado).
[28] C.R.5.§ 37-92-103(6)
[29] City of Aspen v. Colorado River Water Conservation Dist., 696 P.2d 758, 761 (Cob. 1985).
[30] 753 P.2d 737, 739 (Cob. 1988).
[31] See Vranesh, supra at 99.

4.2.3 Changes of Water Rights

A change of water rights is another tool that allows water users flexibility to maximize the potential use of water. As described in the 1969 Act, a change of water rights includes "a change in the type, place, or time of use, a change in the point of diversion," and changes in the manner or place of storage. A change of water right will not be allowed unless it is approved by the water court,[32] upon a finding that the change "will not injuriously affect the owner of, or persons entitled to use, water under a vested water right or a decreed conditional water right."[33]

In a change case, the measure of the water right is the amount that was historically consumed (not the amount diverted) under the water right. Thus, only the amount of water that historically has not returned to the stream system under the original decreed use may be changed to a new place or type of use. This limitation ensures that the change will not enlarge the historical impact of the water right on the stream system, avoiding injury to other water users. In addition, in a change of water right proceeding, the applicant must take appropriate steps to ensure that historical return flows from the use of the water in amount, timing, and location are maintained. This is required because other water users rely, and are legally entitled to rely, on those return flows to support their appropriation and uses of water.

Changes of water rights allow for the reallocation of water resources to meet changing demands. For example, in Colorado, the largest water demand is for irrigated agriculture. With increasing urbanization, however, ever larger amounts of water are needed for municipal uses. To meet this demand, municipal entities can purchase senior agricultural water rights and change them to municipal uses. Likewise, the CWCB can also purchase agricultural water rights and change them to instream flow uses. All of these activities, however, must satisfy the "no injury" requirements in terms of maintaining historical return flows and preventing an expansion of historical consumptive use (CU).

Increasing the efficiency of use of a water right may not require a change of water right proceeding in all instances. For example, an agricultural user may change his method of irrigation (e.g., from flood to drip or

[32] See Northern Colo. Water v. Three Peaks Water, 859 P.2d 836 (Cob. 1993).
[33] CR5. § 37-92-305(3).

sprinkler irrigation), yet still maintain the overall decreed use of irrigation. Although such activities may not require a change of use proceeding in water court, arguably this activity could have a detrimental impact on other water users to the extent that the change in irrigation alters return flows or the CU of a right.

Adjudicating a change of water rights can be time consuming and costly, and formal notification is required by law. Even when no parties object to the change, the process of water court approval takes a minimum of 3 months, and often much longer due to the heavy case load of water court judges. If parties do oppose a change case, it can take years to get a change decree approved by the court. In addition to paying attorneys' fees, an applicant for a change of water rights generally must hire an engineering consultant to prepare a report explaining the technical aspects of the change and develop an accounting form for administering the change. In order to avoid these costs and to speed the process, Colorado's legislature recently enacted legislation that authorizes a water right owner to lease water under the right without formal adjudication of change of water right. This legislation is discussed immediately below.

4.2.4 Leases of Water

During the 2003 legislative session, C.R.S. §§ 37-80.5-101 to 105 were amended to authorize the State Engineer to create water banks within each water division, and to adopt rules governing their operation. The aim of this legislation is to simplify the process for temporary transfers of water rights by eliminating the adjudication proceedings required for a permanent change of water rights. The statute provides that the rules shall allow for the "lease, exchange, or loan of stored water within a water division," including a transfer to the CWCB for instream flow purposes, without the need to submit to any adjudication proceedings. Notwithstanding the fact that the lease, exchange, or loan is not adjudicated, such arrangements will still be subject to administration by the Division Engineer, within the priority system, to prevent material injury to other water users.

Another area of potential leasing involves agreements between agricultural and municipal/industrial users for interruptible supplies. Although this approach may require obtaining a change of use decree, it would potentially allow flexibility between agricultural and municipal/industrial users to rotate or fallow crops in certain years, thereby freeing up water supplies for municipal/industrial uses during such years. The terms of any such interruptible supply agreements would vary on a case-by-case basis, but could potentially allow for continued agricultural use in some, but not all, years. In order to be effective, such agreements need to be sufficiently long-term and reliable for municipal/industrial users to allow the sale of municipal taps on such basis. Moreover, any such arrangement would necessarily require protections to ensure that no expansion of use could occur to the detriment of junior water rights holders.

4.2.5 Augmentation Plans

An augmentation plan allows a water user to divert water out-of-priority from its decreed point of diversion, so long as replacement water is provided to the stream from another source, to make up for any deficit to other water users.[34] An augmentation plan, like a change of water right, must be approved by the water court and is also subject to the "no injury rule." Accordingly, the 1969 Act requires substituted water to be "of a quality and quantity to meet the requirements for which the water of the senior appropriator has normally been used[.]"[35]

As explained by the Colorado Supreme Court in In re Application of Midway Ranches v. Midway Ranches Property Owners Association, Inc., [36] "[a]ugmentation plans implement the Colorado doctrine of optimum use and priority administration, which favors management of Colorado's water resource to extend its benefit for multiple beneficial purposes." Augmentation plans provide a statutory mechanism for many different types of water users, big and small, to obtain water when and where they need it, by using other sources of water to replace or "augment" the out of priority depletions that result from their water use. In times of scarcity, an augmentation plan allows a water user to continue diverting even under a relatively junior priority, so long as it can provide replacement water to satisfy the needs of downstream seniors. As noted above, however, under an augmentation plan, a water user is essentially replacing the amount of water consumed with a different source of water. The water user gets credit for the amount of water it diverts that returns to the stream unconsumed. As a

34 CR5. § 37-92-305(5).
35 Id.
36 938 P.2d 515,522 (Cob. 1997).

CDM

result, increased efficiency of use under an augmentation plan potentially reduces the amount of credit a water user receives for water returned to the stream unconsumed.

4.2.6 Instream Flows

Under the 1969 Act, the CWCB is authorized to appropriate water for "minimum stream flows or for natural surface water levels or volumes for natural lakes to preserve the natural environment to a reasonable degree."[37] Appropriations for instream flows may only be made by the CWCB, not by private individuals (however, it is noted that a few private instream flows were obtained in the early 1970s upon initial passage of the statute, but this is no longer allowed under the law), and must be made within the priority system, consistent with the restrictions in Sections 5 and 6 of Colorado's Constitution. The CWCB can also acquire water rights for instream flows "by grant purchase, donation, bequest, devise, lease, exchange, or other contractual agreement." [38]

In recent years, Colorado's legislature has expanded the resources available to the CWCB to protect instream flows. In 2002, the legislature increased the sources of funding that the CWCB may use to acquire water for instream flows, to include "any funds available to it, other than the construction fund created in section 37-60-121, for acquisition of water rights and their conversion to instream flow rights.[39] In 2003, the legislature amended § 37-83-105, C.R.S., which provides for temporary loans or exchanges of water between water users in times of drought without requiring adjudication of a change of water rights, to allow the CWCB to receive loaned water for instream flow purposes on a temporary basis, not to exceed 120 days, in any basin where the Governor has declared a drought or other emergency.[40] Such loans are subject to a determination by the State Engineer that other water users will not be injured.

It is essential that the state be able to acquire water rights for instream flow purposes in order to protect wildlife and the environment in a prior appropriation state during times of drought. Since Colorado water law does not allow the state to consider environmental factors in allocating or administering water, the only way for the state to ensure protection of stream flows for public purposes is by acquiring water rights, itself, within the priority system. By acquiring a water right with an enforceable priority, the state can place environmental concerns on equal footing with agricultural, commercial, municipal, and other uses of water. This means that in times of scarcity, the state's instream flows will be protected in a manner consistent with their priorities – to the extent the priorities are junior to other water rights, the CWCB's instream flows will be curtailed to make water available to other senior water users, and to the extent the CWCB's priorities are senior, the CWCB may request the Division Engineer to curtail more junior users to protect its instream flows.

In Colorado, recreation is a recognized beneficial use. Governmental entities can appropriate water solely for the purposes of recreation and boating. Recent enthusiasm for kayaking, and the appropriation of water for in-channel use, has sparked further debate among water users regarding this use of water.

For example, the City of Golden pursued an application for an in-channel water right for a kayak course. Golden sought to appropriate 1,000 cubic feet per second (cfs) for this purpose, which essentially equates to all the water in Clear Creek during peak flow in most years. On appeal, the Supreme Court, from which one member recused himself, split equally, so that the water court's decree adjudicating this issue was affirmed.

In reaction to various claims for in-channel recreation rights, the General Assembly enacted legislation limiting the right to appropriate recreational in-channel diversions (RICDs) to municipal entities for "minimum streamflow as it is diverted, captured, controlled, and placed to beneficial use between specific points defined by physical control structures for a reasonable recreation experience in and on the water." [41] Applicants for such rights now must forward their application to the CWCB for review.[42] After reviewing the application, the CWCB makes a recommendation to the water court on whether the application should be granted, granted with conditions, or denied. [43]

37 CR5. § 37-92-102(3).
38 Id.
39 See id
40 House Bill 03-1320.
41 § 37-92-103 (10.3), C.R.S.
42 § 37-92-102(5), C.R.S.
43 Id.

4.2.7 New Appropriations

Making a new appropriation is always an option for water planning. Although some river basins are currently over-appropriated, in every basin there are usually a few days a year in which a free river condition exists and all rights can divert. Thus, while a 2004 priority is a very junior right, and will probably not have a reliable supply of water during the periods of high senior demands, it may still be possible to divert water under such a right at peak flow times. In addition, one could use an augmentation plan in conjunction with a very junior right to obtain a stable water supply.

To make an appropriation, one must have a specific intent to divert water for a beneficial use and perform a physical act in furtherance of that intent. Today, new appropriations are often made by filing an Application for a Water Right in the water court. However, no appropriation can be made when "the proposed appropriation is based on the speculative sale or transfer of the appropriative rights."[44] This anti-speculation doctrine prevents individuals or entitles from acquiring water rights solely to sell to others. The waters of Colorado are a public resource and as such are not to be hoarded by those who do not have a present use for the water.

4.2.8 Groundwater Rights

In Colorado, there are four different types of groundwater:

- Tributary groundwater
- Non-tributary groundwater
- Not non-tributary groundwater
- Designated groundwater

The classification in which the groundwater falls determines how the water is allocated. Thus, while tributary groundwater is subject to the prior appropriation system, non-tributary groundwater and not non-tributary groundwater is allocated according to land ownership, and designated groundwater is subject to a modified prior appropriation system within each designated basin.

Tributary groundwater is water that is hydrologically connected to a surface stream.[45] In Colorado, all groundwater is presumed to be tributary to a surface stream. In the early 1900s, Colorado courts held that tributary groundwater is subject to the prior appropriation system.[46] The court based its decision, in part, on the fact that wells that intercept tributary groundwater actually deplete the stream flow to the detriment of senior surface appropriators.[47]

Non-tributary groundwater is statutorily defined as that groundwater, outside the boundaries of a designated basin, "the withdrawal of which will not, within one hundred years, deplete the flow of a natural stream ... at an annual rate greater than one-tenth of one percent of the annual rate of withdrawal."[48] The right to use non-tributary groundwater is purely a function of statute.[49] The General Assembly has recognized that non-tributary groundwater is a finite resource and has specifically declared that "such water shall be allocated…upon the basis of ownership of overlying land.[50] Rights to use non-tributary groundwater are limited to "that quantity of water, exclusive of artificial recharge, underlying the land owned by the applicant or underlying land owned by another" who has consented to the applicant's withdrawal.[51] The annual withdrawal of this type of groundwater is further limited in accordance with a 100-year aquifer life.[52]

Not non-tributary groundwater is groundwater located within one of the Denver Basin aquifers (the Dawson, Denver, Arapahoe, and Laramie-Fox Hills aquifers in the Denver Basin, which extends roughly from Fort Collins to Colorado Springs and from the foothills eastward), but outside the boundaries of a designated basin, the "withdrawal of which will, within one hundred years, deplete the flow of a natural stream…at an annual rate of greater than one-tenth of one percent."[53] Not non-tributary groundwater is also allocated on the basis of land ownership. However, the owner of a not non-tributary well must have a plan for augmentation in place before withdrawing such water.[54]

Designated groundwater is groundwater that would not be available to fulfill surface rights or groundwater that

44 § 37-92-130(3)(a), C.R.S.
45 McClennan v. Hurdle, 33 P. 280 (Colo. 1893).

46 Comstock v. Ramsay, 133 P. 1107 (Colo. 1913).
47 Id.
48 § 37-90-103(10.5), C.R.S.
49 § 37-90-102(2), C.R.S.
50 Id.
51 § 37-90-137(4)(b)(II), C.R.S.
52 § 37-901-137(4).
53 § 37-90-103(10.7), C.R.S. (emphasis added)
54 § 37-90-137(9)(c)(I), C.R.S.

has been the principal water supply for the area for at least 15 years and is not adjacent to a naturally flowing stream.[55] Designated groundwater exists within designated groundwater basins. The Ground Water Commission establishes designated groundwater basins through a notice and hearing procedure when evidence becomes available that groundwater within a specific geographic area meets the above noted criteria.[56] Each designated groundwater basin is administered according to a modified prior appropriation system. Locations of designated groundwater basins are presented in Section 7.

4.2.9 Reuse

Colorado law generally provides for one use of water by the original appropriator. The water that is not consumed by an appropriator's first use is returned to the stream system, either as surface run-off or through subsurface infiltration. Junior appropriators, who are entitled to have stream conditions as they exist at the time of their appropriation, rely on these return flows to fulfill their decreed rights.

Thus, water that is brought into a watershed from a source unconnected with the receiving system termed "foreign" water may be reused by its owner.[57] Foreign water includes non-tributary groundwater introduced into a surface stream as well as water imported from an unconnected stream system ("transmountain water").[58] Importers of foreign water enjoy rights of reuse that native water appropriators do not have. Such water is deemed "fully consumable" and can be used and reused to extinction so long as the user maintains dominion and control over the water. Dominion and control in this context refers to the intent to recapture or reuse such water, and is not lost when a municipal provider delivers water to a customer's tap or when consumers use such water to irrigate lawns.[59] Dominion over the water is not lost if the importer intends to reuse such water and has some method to track or recapture the water.

In addition, agricultural water rights that are changed to municipal use may also generate fully consumable water that can be used to extinction. This is because the applicant in a change of use proceeding may take credit for, and reuse, the historical CU associated with the prior decreed use. Under this scenario, the amount of water attributable to the historical CU of the senior water right may be used and reused to extinction. Although this is not "foreign water" by definition, it is another source of fully consumable water.

In addition, in some circumstances, applicants for new water rights may obtain decrees that allow a new appropriation to carry with it a "fully consumable" designation that allows the diverted water to be used and reused to extinction if the initial appropriator has, from the beginning, a plan to reuse the water. Recently, challenges to these types of applications have focused on whether the claimed use and reuse to extinction is speculative in nature.

Any water that is deemed fully consumable may be reused to extinction. In practice, municipal exchanges involving fully consumable water (in most instances municipal effluent or lawn irrigation return flow credits), have been a means to reuse fully consumable water. Recently, municipal entities have also started to operate wastewater reclamation projects where fully consumable water, in the form of effluent, is treated to a high standard and used for outdoor irrigation purposes within the municipality's service area. These projects involve pumping the treated, fully consumable effluent to irrigate portions of a service area and thereby reducing demand for municipal potable supplies for irrigation. Reuse projects involving either pumping or exchanges potentially help increase efficiencies and reduce or postpone the overall demand for new water supplies.

4.2.10 Conservation Activities

Conservation practices associated with both municipal and agricultural uses can be an important tool in meeting long-term water supply needs. Demand reduction is an important component of water planning. To the extent that conservation practices are reliable, and/or permanent in nature, such practices can reduce the overall demand for water and thereby reduce any shortfall in supply.

Conservation measures can also take the form of increased efficiencies. However, not all water conserved through more efficient uses corresponds to an increase in overall water supply to a water user. For example, a

55 § 37-90-103(6).
56 § 37-90-106.
57 City of Thornton v. Bijou Irr. Co., 926 P.2d 1,66 (Colo. 1996)
58 Id.
59 Public Service Co. v. Willows Water Dist., 856 P.2d 829, 834 (Colo. 1993).

water user could take steps to eliminate certain phreatophytes and thereby "salvage" additional water. That water, however, is owed to the stream and does not necessarily accrue to the benefit of the specific water user conducting the "salvage" activity, since a water user cannot take credit for a "salvage" activity and thereby divert more water.[60] Salvage water is owed to the stream to be diverted by downstream water users pursuant to the priority system.

4.3 Interstate Compacts, Equitable Apportionment Decrees, and Memoranda of Understanding

Similar to limitations imposed by the prior appropriation system, interstate compacts and equitable apportionment decrees also place limitations on water use in Colorado. Allocation of water supplies among states has been accomplished using compacts (negotiated interstate agreements ratified by Congress and the legislatures of the participating states) or interstate litigation. The following summarize the relevant interstate compacts and decrees for each river basin. For more information used in this subsection and additional details on the individual compacts and decrees, the reader is referred to Appendix D of the SWSI Report, A Summary of Compacts and Litigation governing Colorado's Use of Interstate Streams (Division of Water Resources [DWR] 2000) and the CWCB website at: http://cwcb.state.co.us/SecD/interstate.htm.

The CWCB actively protects the authority, interests, and rights of the state and its citizens in matters pertaining to interstate waters. The CWCB and other representatives appointed by the Governor are engaged in ongoing discussions with federal agencies and other states about water availability and utilization.

4.3.1 Nebraska vs. Wyoming 325 U.S. 665 (1945) and 345 U.S. 981 (1953)

The Nebraska vs. Wyoming U.S. Supreme Court Decree equitably apportions water in the North Platte River between Colorado, Nebraska, and Wyoming. Those portions of the decree affecting Colorado limit total irrigation in Jackson County to 145,000 acres and 17,000 AF of storage for irrigation during any one irrigation season. It also limits total water exports from the North Platte River in Colorado to no more than 60,000 AF during any 10-year period.

4.3.2 Wyoming vs. Colorado, 260 U.S. 1 (1922) and 309 U.S. 572 (1940)

The Wyoming vs. Colorado U.S. Supreme Court Decree establishes the right of Colorado and Wyoming to water in the Laramie River Basin. Those portions of the decree affecting Colorado limit total diversions from the Laramie River in Colorado to a total of 39,750 AF, divided among specific water facilities, including 15,500 AF through the Laramie-Poudre Tunnel; 18,000 AF through the Skyline Ditch; and 4,250 AF through various "meadow land appropriations."

4.3.3 Sand Creek Memorandum of Agreement (1939 and revised 1997)

This Memorandum of Agreement between Colorado and Wyoming allocates the waters of Sand Creek between the states in accordance with the priority water rights in each state and provides for certain minimum deliveries to the state line by Colorado, if physically available and needed for irrigation in Wyoming.

60 Southeastern Colorado Water Conservancy Dist. v. Shelton Farms, Inc., 187 Colo. 181 (1975).

Section 5
Consumptive Water Needs in the North Platte Basin

Water is managed in Colorado to meet the many important needs of our citizens and our environment, and is vital to Colorado's present and future. Our economy, our quality of life, our recreational opportunities, the environment, and human life itself are all dependent on water. The broad diversity of water uses in Colorado is indicative of the many ways in which we are affected by the water that is available to us and our environment, and how we choose to use it. Severe and continuing drought conditions throughout the state in the early 2000s in conjunction with rapid growth and concern over compact obligations have brought focus to the constraints on our state's water resources and the challenges associated with meeting multiple objectives and needs.

As a significant step toward reaching SWSI's goal of helping Colorado maintain an adequate water supply for our citizens and the environment, SWSI evaluated water use in 2030 in each of the state's major river basins for the following categories of water use (as described in Section 4):

- M&I
- Agricultural
- Recreation and Environmental

A consistent and comprehensive method was developed in SWSI to estimate baseline (year 2000) and future (2030) water uses in the state. M&I and agricultural water projections represent "traditional" uses in water planning, and are generally associated with off-stream uses that have a consumptive component. In order to estimate current and future water needs for these uses, SWSI obtained historical water use data, population projections, and irrigated acreage data for each of the state's major river basins. Decreed CWCB instream flow and RICD water rights were inventoried, and a process for evaluating environmental and recreational uses was initiated – recognizing that these uses differ significantly from M&I and agricultural needs in that they are non-consumptive, flow-related uses. Approaches to defining water needs for environmental and recreational uses are described in Section 6.

Demands on Colorado's water resources are projected to increase dramatically through 2030. In large part, this will be driven by continuing population increases, while agricultural uses remain high, environmental water uses continue, and more people participate in water-based recreational activities. The following sections describe the methods used in determining reconnaissance level water use projections for 2030, and the results of those analyses.

5.1 Overview of Projection Methods

Standard methods were adapted for use in SWSI for projecting future M&I and agricultural uses throughout Colorado, then aggregated by the state's eight major river basins. Because of the unique, in-channel flow and non-consumptive nature of environmental and recreational uses – and some inherent conflicts even between different environmental and recreational uses in the types and timing of flows desired – Colorado's statutory framework for CWCB minimum instream flows was used as the initial basis for estimating future uses for recreation and the environment. Further enhancement of flows was considered in the options analysis phase of SWSI.

The objectives of the SWSI water use analysis efforts were to:

- Develop a reconnaissance-level water use forecast
- Use consistent data and method throughout the state
- Maximize the use of available data

While numerous past evaluations and reports have projected future water use in the state, a standard method for SWSI was deemed important. Past efforts vary widely in their method and demographic projections, and do not provide complete coverage of the state. Nonetheless, past evaluations and databases were referenced in the development of SWSI water use projections to help guide the evaluation and validate results. The estimates developed in SWSI are intended to be reconnaissance-level estimates to guide a discussion of addressing the state's future water needs, and do not supersede demand projections for individual water providers or users.

Water use projections for consumptive use and diversions throughout this report are presented in units of acre-feet per year (AFY). An AF of water is approximately 326,000 gallons. Non-consumptive water uses are indicated in flow-based units (i.e., the volume of water passing a given point over a certain time step, such as cfs or AF volumes) as described elsewhere in this report.

An overview of the methods used to estimate future water use is provided in the following subsections. Sections 5.2 and 5.3 present the results of the water use analyses.

5.1.1 Method for Estimating Municipal and Industrial Use

In the United States, only Nevada and Arizona grew at a faster rate than Colorado in the 1990s, and State Demographer projections suggest that vigorous increases in population can be expected well into the future. Projecting the water needs that accompany the corresponding municipal, industrial, and commercial uses of water are therefore a key part of addressing the state's future water needs.

5.1.1.1 Overview of Method for Estimating M&I Use

The M&I water use analysis methods employed in SWSI resulted in a summary of baseline water uses (estimated for year 2000) and a forecast of such water uses for the year 2030. In SWSI, all publicly-supplied and self-supplied residential, commercial, institutional, and industrial water uses are identified as M&I water users. In addition, major self-supplied industrial (SSI) water users are also accounted for.

Key terms used in M&I water use projections are presented in Table 5-1.

Table 5-1 Definition of M&I Demand Terms

Demand Terminology	Definition
M&I Demand	All of the water use of a typical municipal system, including residential, commercial, industrial, irrigation, and firefighting
SSI Demand	Large industrial water uses that have their own water supplies or lease raw water from others
M&I and SSI Demand	The sum of M&I demand and SSI
CU Demand	That portion of the water demand for a specific category of water use that is consumed and does not return to the stream system through return flow

This water use analysis included the following components:

- Collection of available statewide water use, demographic, and weather data
- Evaluation of available information to determine factors that influence M&I water use
- Review of M&I water use studies conducted throughout the state
- Preparation of a statewide forecast of future urban water use to the year 2030 by county and by basin
- Assessment of the current level of conservation efforts by county

The method used for estimating urban water demand is based on a sample of water providers throughout the state as described in this section. The estimated per capita water use rates for each county were multiplied by the projected population of each county to estimate current and future municipal water demand (i.e., the residential, commercial, and industrial water use) of each county.

Population projections are summarized in Section 5.1.1.2. Per capita estimates of M&I water use are discussed in Section 5.1.1.3, and SSI uses are discussed in Section 5.1.1.4. The effects of Level 1 conservation measures are reviewed in Section 5.1.1.5. Section 5.1.1.6 provides a discussion of CU factors and estimated CU given the range of data available on the subject. The M&I water use forecasts presented in Section 5.2 represent the baseline SWSI forecasts. Detailed data and results are included in appendices to the SWSI Report.

5.1.1.2 Population Projections

Future population projections were obtained from the Colorado DOLA, Demography Section. This dataset contains county population projections from 2000 to 2030 in annual increments. Populations for counties that lie within two or more basins were allocated to the respective basins based on estimates from known population centers within each basin.

From 2000 to 2030, Colorado's population is projected to increase by about 2.8 million additional people – a 65 percent increase – to a 2030 population of over 7.1 million. Aggregated basin summaries of the data are presented in Figure 5-1 and Table 5-2. The vast majority of the state's population in 2030 will live in the South Platte and Arkansas Basins.

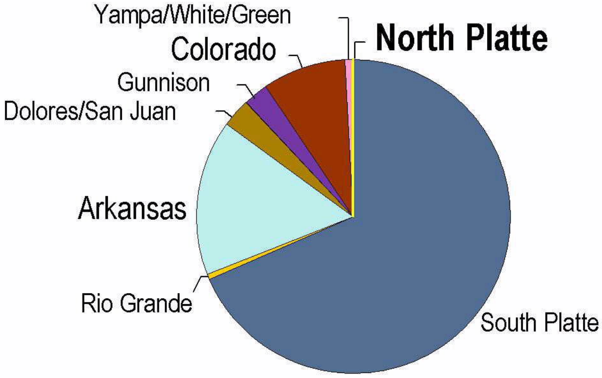


Figure 5-1
Relative 2030 Populations in Each Basin

On a basin level, West Slope growth rates are projected to be the highest, with the Colorado Basin population almost doubling and Gunnison River and Dolores/San Juan/San Miguel Basins' populations increasing by 82 and 89 percent, respectively.

5.1.1.3 Estimates of Per Capita M&I Water Use

Numerous factors affect per capita water use rates, and through the course of SWSI, differences in the water use components that are included or excluded from individual entities' per capita estimates clearly affected the resulting values. Per capita water use rates are in large part a function of:

- Number of households
- Persons per household
- Median household income
- Mean maximum temperature
- Total precipitation
- Total employment
- Ratio of irrigated public land areas (e.g., parks) to population in service area
- Level of tourism and/or second homes
- Ratio of employment by sector (e.g., agriculture, commercial, industrial)
- Urban/rural nature of county

Table 5-2 Population Projections by Basin

Basin	2000	2030	Increase in Population	Percent Change 2000 to 2030	Percent Annual Growth Rate
Arkansas	835,100	1,293,000	457,900	55	1.5
Colorado	248,000	492,600	244,600	99	2.3
Dolores/San Juan/San Miguel	90,900	171,600	80,700	89	2.1
Gunnison	88,600	161,500	72,900	82	2.0
North Platte	**1,600**	**2,000**	**400**	**25**	**0.7**
Rio Grande	46,400	62,700	16,300	35	1.0
South Platte	2,985,600	4,911,600	1,926,000	65	1.7
Yampa/White/Green	39,300	61,400	22,100	56	1.5
TOTAL	**4,335,500**	**7,156,400**	**2,820,900**	**65**	**1.7**

Source: Colorado DOLA, Demography Section

Several sources of information were consulted in estimating per capita M&I water use. The CWCB's Drought and Water Supply Assessment study's database was used as an initial data source, and was supplemented in SWSI by sending a follow-up survey to more than 200 water providers. Including the responses to the follow-up survey, the resulting database used in SWSI includes nearly 250 water providers covering most of the state, as indicated in Figure 5-2. Regression analyses of available data indicated that location was the dominant factor in determining the variation of per capita water use among the sample data.

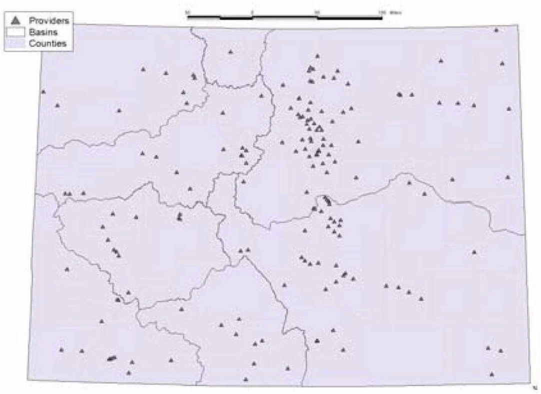


Figure 5-2
Providers in SWSI per Capita Demand Database

The provider per capita values in each county were weighted by their respective populations to produce a weighted average per capita value by county. In addition, the weighted average per capita water use per basin was also calculated. The basin weighted average per capita rate was used for areas of the county that did not have representation in the sample database. The underlying assumption is that water use will be similar throughout the county. The estimated county gallons per capita per day (gpcd) water use rates were multiplied by the county population projections to derive the estimated M&I water forecast for each county. These M&I forecasts are shown in Section 5.2.

The sample data provided a per capita water use rate for 58 of the 64 counties within the state. The aggregated basin average per capita water use estimates are depicted in Figure 5-3. Overall, the population-weighted average per capita M&I water demand for the state was estimated to be 210 gpcd for the year 2000.

This estimation of county per capita water use assumes that all residences, businesses, and industries throughout a county (including most self-supplied users) use water at the same rate as the provider-supplied residences, businesses, and industries as represented in the sample database. Where data were available regarding unique large self-supplied water users in specific counties, these self-supplied water uses were added to the county M&I water demand estimate, as described in the following section.

Due to wide variations in the factors presented above, per capita use rates are difficult to directly compare between counties or basins. High per capita rates are not necessarily indicative of inefficient use, much as low rates do not necessarily imply efficient use. For example, water use related to tourism is reflected in historical demand data but not in census data, thus increasing the calculated per capita demands. Major industrial water uses supplied through municipal water systems could also drive per capita values upward. Residential or commercial properties such as golf courses might be irrigated from non-municipal sources, such as wells or ditch rights, lowering the calculated per capita demand.

Changes in per capita rates might also be anticipated if a community's park system is essentially "built out" but population growth is still anticipated, or in cases where changes in industrial use do not directly correlate to changes in residential use. Basin Roundtable members and local water providers provided input that can be used to refine the per capita water use estimates for certain counties in future SWSI efforts.

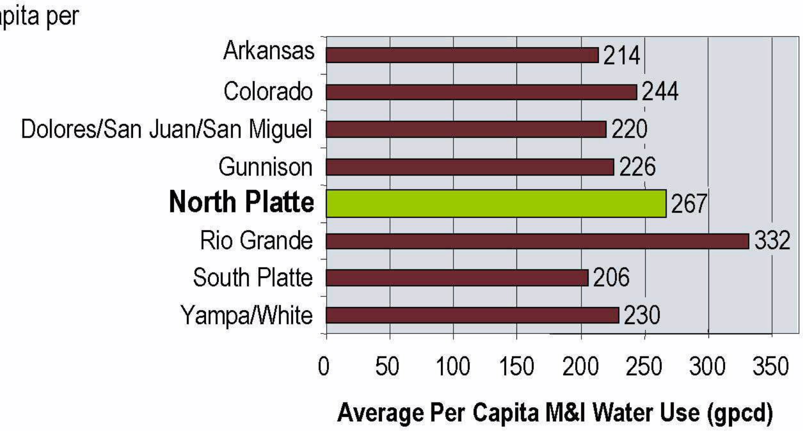


Figure 5-3
Estimated Year 2000 Average per Capita M&I Water Use

5.1.1.4 Self-Supplied Industrial Use

SSI uses were estimated for baseline and projected future water needs in order to more accurately characterize the state's anticipated increase in water use between 2000 and 2030. The CWCB Drought and Water Supply Assessment database of SSI uses was used as an initial source of information for this analysis. These data were supplemented in SWSI with calls to major industrial water users to verify, update, and expand the information used in the SWSI analyses.

SSI water uses estimated in SWSI include:

- Coal-fired and natural gas power generating facilities that consume significant quantities of water
- Snowmaking facilities
- Other identified industrial facilities with significant water use such as brewing, manufacturing, and food processing

Estimates of baseline and future water use at various power generation facilities in Colorado were sought. Current water use data were obtained for several facilities. These data were for facilities in Larimer County.

Two dozen regional water use studies were reviewed to identify estimates of current and future projected water use for snowmaking in Colorado counties, with a wide range of conclusions regarding typical rates. Ultimately, the recent Upper Colorado River Basin Study ("UPCO" study) was determined to have the most up-to-date and thorough assessment of snowmaking use at ski areas. Data from this study were used to derive an average snowmaking use per ski area and applied to known or anticipated ski areas in each basin. The estimates for some ski areas were supplemented and refined by directly contacting and interviewing representatives of selected ski areas on an individual basis.

5.1.1.5 Effect of Level 1 Conservation

Naturally-occurring water conservation savings are defined as water savings that result from the impacts of plumbing codes, ordinances, and standards that improve the efficiency of water use. These conservation savings are called "passive" savings because water utilities do not actively fund and implement programs that produce these savings. In contrast, water conservation savings resulting from utility-sponsored water conservation programs are referred to as "active" savings. For the purposes of SWSI, passive conservation is also termed Level 1 conservation. Active conservation measures – beyond those currently in place – were evaluated in SWSI as options toward addressing future water needs in each basin, as part of alternatives developed by the SWSI team in conjunction with Basin Roundtable participants.

The National Energy Policy Act of 1992 set manufacturing standards for improved water efficiency for toilets, urinals, showerheads, and faucets. These standards became effective in 1994. The standards for commercial fixtures became effective in 1997. These standards affect the types of water-using fixtures available for new construction as well as remodeled or renovated facilities, and result in improved indoor water use efficiency. In addition, some municipalities have ordinances that limit turf or irrigated areas, which reduce outdoor water use.

Typically, estimates of Level 1 conservation savings for a given water utility service area, or other planning area, are a function of characteristics of the service area such as the percent of water efficient fixtures present at some base period in time and subsequent new construction and remodeling.

The allocation of total water use among various uses may be seasonal. For example, irrigation is expected to be a larger component of total water use in summer months than in winter months. Locations affected by landscaping ordinances may have a greater impact from Level 1 conservation in the summer months, while locations without landscaping ordinances may find the impact of Level 1 conservation to be more noticeable in winter months.

The estimation of conservation savings requires an initial baseline forecast of water demand without conservation. The baseline water demand forecast is driven by projections of future demographic growth for the study area and does not account for the effects of future water conservation. Impacts of conservation savings can then be determined from the baseline water demand forecast.

Five studies of estimated conservation savings that followed similar methodologies for estimating conservation savings were reviewed in estimating Level 1 conservation savings for SWSI. The average expected percent reduction in baseline water demand from Level 1 conservation savings based on these studies were identified as shown in Table 5-3.

Table 5-3 Anticipated Level 1 Conservation Savings by Year

Year	2000	2010	2020	2030
Expected Savings	2.5%	5.0%	7.0%	8.5%
Increase above 2000	0%	2.5%	4.5%	6.0%

Year 2000 water use data were used to develop the SWSI baseline demand forecast. Thus, the SWSI baseline demand forecast is reflective of water conservation (both passive and active) in effect in the year 2000. Conservation adjustments to the SWSI baseline demand forecast should reflect future impacts of conservation.

The M&I baseline water demand for each county was adjusted by these percent savings factors to account for the impact of Level 1 conservation savings. The resulting estimate is used as the lowest conservation scenario (Level 1).

5.1.1.6 Estimate of M&I CU Rates

Water use can be considered both in terms of gross water needs – the total amount of water delivered to a user – and in CU. Both are important considerations in water planning. The difference between gross and CU is the amount that is realized as return flows (i.e., through wastewater treatment plants and lawn watering). CU is generally higher in arid and semi-arid regions such as Colorado, where more water is used for irrigation and lost to evapotranspiration.

5.1.1.7 Existing Agricultural Demands Method

The North Platte Basin does not have Decision Support System (DSS) data sets. Hence agricultural demands were estimated using preliminary estimates of irrigation water requirements (IWR) and irrigated acres developed during preliminary work on the South Platte DSS. Projections of future agricultural use were made based on existing irrigation practices and water availability conditions, and projected changes in irrigated acreage.

Summaries of the agricultural demand sources for the North Platte Basin is included in Table 5-4.

Table 5-4 Agricultural Demand Information Sources

Basin	Source of Irrigated Acres	Year of Est. of Irrigated Acres	Source of Demand per Acre	Period of Record of Supporting Data
North Platte	CWCB	2001	Preliminary work on DSS	1993-2002

5.1.1.8 Future Agricultural Demands Method

Future (2030) agricultural water requirements were estimated by basin using annual average requirements on a per acre basis, and projected future irrigated acreage. The current requirements (AFY) are normalized to the current irrigated acreages (acre-feet per acre per year [AF/Ac/Yr]) and multiplied by the projected 2030 acreages to arrive at a future total agricultural requirement (AFY). In other words,

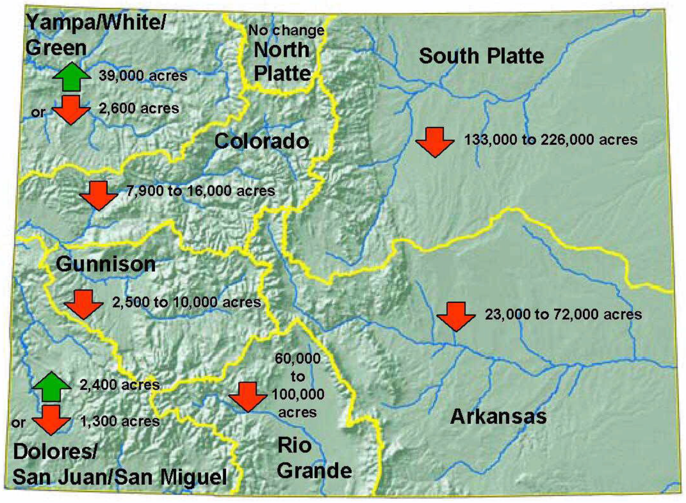
2030 Ag Irrigation Water Requirement (AFY) = Current Average IWR Requirement (AF/Ac/Yr) x Projected Irrigated Lands (Ac) (5.1)

where

Current Average Requirement (AF/Ac/Yr) = IWR/Current Irrigated Lands (5.2)

2030 water supply limited (WSL) CU; incidental losses, livestock watering, and stock pond evaporation; and gross diversions were estimated using the same approach (Equations 5.1 and 5.2). Projected WSL values represent anticipated crop CU, assuming the ratio of available supply to irrigated acreage stays the same. Incidental losses, livestock watering, and stock pond evaporation represent additional water consumption associated with the projected irrigated acres. Gross diversions reflect the anticipated amount of water actually diverted at the stream to provide this level of combined CU. Basin average annual diversions (averaged over the period of record) were used in Equation 5.1 for these calculations. Results are presented and discussed in Section 5.3.

Projecting future agricultural water demands includes an evaluation of potential changes in irrigated acres, as well as an estimate of agricultural water use per acre.



Source: Colorado's Decision Support Systems and Basin Roundtable/ Basin Advisor input.

Figure 5-5
Potential Changes in Irrigated Acreage by 2030

By 2030, reductions in irrigated acres are expected to occur in most basins as agricultural lands are developed for M&I use and/or water is transferred from agriculture to M&I use to provide for M&I water needs.

Table 5-5 provides an estimate of the range of potential changes in irrigated acres in each basin. Future changes will be impacted by many factors, including the development of additional storage to provide firm water supplies for agriculture, policies of M&I water users regarding the acquisition of agricultural water rights, M&I growth rates and the location of future growth, and whether there are cost-effective alternative sources of water to meet future M&I water needs. There could be significant additional reductions in irrigated acres beyond the estimates provided in Table 5-5 if water providers are unsuccessful in implementing their identified plans such as developing additional storage to firm existing water supplies. Figure 5-5 illustrates an estimate of potential changes statewide.

Table 5-5 Breakdown of Potential 2030 Changes in Irrigated Acreage

Basin	Potential Decrease in Irrigated Acres resulting from transfers	Potential Decrease in Irrigated Acres resulting from urbanization of irrigated lands	Potential Decrease in Irrigated Acres for other reasons	Potential Increase in Irrigated Acres if additional supplies are developed	Range of Potential Net Change in Irrigated Acres
Arkansas	17,000-59,000	2,300-4,500	4,000-8,000	—	23,000-72,000 Decrease
Colorado	1,200-2,700	6,700-13,000	—	—	7,900-16,000 Decrease
Dolores/ San Juan/ San Miguel	100-200	1,500-3,100	—	2,000-4,000	1,300 Decrease up to 2,400 Increase
Gunnison	300-1,500	2,200-8,500	—	—	2,500-10,000 Decrease
North Platte	**No significant change expected**	**No significant change expected**	**No significant change expected**	**No significant change expected**	**—**
Rio Grande	600-1,100	100-200	59,000-99,000	—	60,000-100,000 Decrease
South Platte	40,000-79,000	38,000-57,000	55,000-90,000	—	133,000-226,000 Decrease
Yampa/White/ Green	100-200	1,100-2,400	—	0-40,000	2,600 Decrease up to 39,000 Increase
TOTAL	**59,000-144,000**	**52,000-89,000**	**118,000-197,000**	**2,000-44,000**	**185,000-428,000 Decrease**

CDM

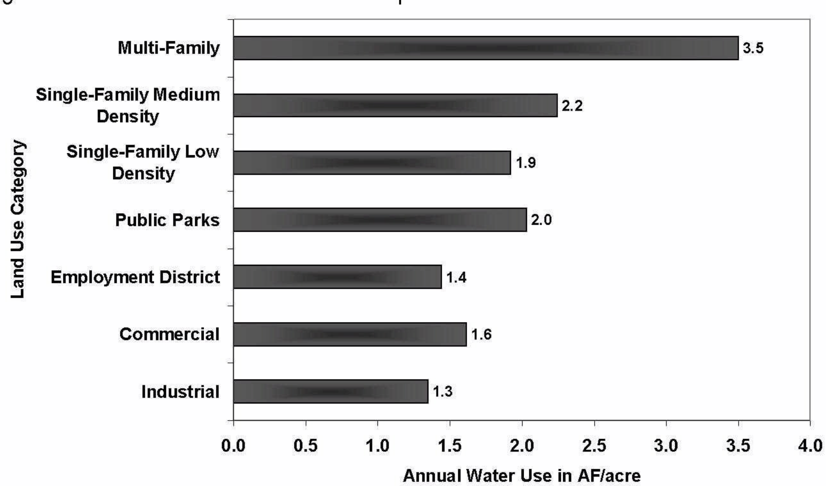
As noted, reductions in agricultural irrigated acres may occur due to development, acquisition for M&I needs, dry-up for instream flow purposes, or as a result of lack of long-term supply availability such as lack of augmentation for well pumping or over pumping of groundwater. As described in Section 8, not all of the reduction in agricultural irrigated acres will result in additional supplies available for M&I or other uses. In addition, not all of the development of irrigated agricultural lands for M&I use will result in a reduction of irrigation demands. Some of the development of agricultural irrigated acres will be for large lot residential development of 1 to 5 acres or ranchettes of 5 to 35 acres. For many of these parcels, if the water rights are not sold and transferred at the time of development, there may be some continued irrigation for hay or pasture for domestic animals kept on the properties. SWSI Basin Roundtable feedback was mixed on whether new residential owners would tend to irrigate as diligently as the former rancher or farmer and whether overall water demands would change as a result of this new land use.

Typical water use per acre for different types of M&I land use development in the South Platte Basin are shown in Figure 5-6. Generally, as residential densities increase, the gross water use per acre also tends to increase. Figure 5-6 shows that average gross water use can range from 1.3 AF/acre for industrial use to 3.5 AF/acre for higher density residential uses, such as apartments. Agricultural water deliveries and consumptive to historically irrigated lands vary widely and are dependent upon seniority of water rights, physical availability of supplies, timing of deliveries, delivery losses, and application efficiencies. The ability to use agricultural water rights existing on the land to meet the needs of M&I use as the land is developed is highly dependent upon these factors, plus the need for a portion of the water to be stored to meet non-irrigation M&I demands and to provide for firm yield for below average runoff years. These considerations are explained in greater detail in Section 8.

5.2 Estimated 2000 and Projected 2030 M&I and SSI Use

Of the many factors affecting M&I water use, the projected increases in population clearly drive the increases in M&I use from 2000 to 2030. The effects of Level 1 conservation result in a projected reduction in per capita M&I water use of approximately 6 percent over this 30-year planning period. This reduction is reflected in the 2030 M&I water use projections presented in this section. M&I and SSI water use projections presented in this section represent the gross or total diversion amount, as opposed to the consumptively-used portion as described in Section 5.1.1.6.

To reiterate, M&I projections were developed by multiplying the estimated (2000) or projected (2030) populations by per capita demands for each of the state's 64 counties, then reducing water use associated with Level 1 conservation measures for the 2030 scenario. These results were aggregated on a basin basis, as well as on a subbasin basis for use in the water supply "gap analysis" as presented in Section 8.



Source: Cities of Westminster and Greeley and NCWCD

Figure 5-6
Estimated Gross Urban Water Demands by Land Use (Indoor and Outdoor Use)

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Overall, combined **M&I and SSI gross water use is expected to increase statewide by about 53 percent (630,000 AFY) over 2000 levels by 2030**, as shown in Table 5-6. These projections do not include the impacts of water conservation efforts beyond Level 1 that are being implemented or planned by many M&I providers. These future conservation efforts are important strategies for meeting future water demands. The increase in M&I and SSI water use over this period by basin, and relative (percent) increase over 2000 M&I water use, are each presented in Figure 5-7. A summary of projected SSI water uses by type of industry and by county is provided in Table 5-7.

Table 5-6 Summary of Combined Gross Water Use for M&I and SSI in 2000 and 2030

Basin	Total Estimated 2000 Gross Demand (AFY)	Total Projected 2030 Gross Demand without Level 1 Conservation (AFY)	Total Projected 2030 Gross Demand with Level 1 Conservation (AFY)	Projected Level 1 Conservation Savings (AFY)	Projected Increase in Gross Demand (AFY)
Arkansas	256,900	373,500	354,900	18,600	98,000
Colorado	74,100	143,800	136,000	7,800	61,900
Dolores/San Juan/San Miguel	23,600	44,800	42,400	2,400	18,800
Gunnison	20,600	37,600	35,500	2,100	14,900
North Platte	**500**	**600**	**600**	**—**	**100**
Rio Grande	17,400	23,100	21,700	1,400	4,300
South Platte	772,400	1,250,800	1,182,100	68,700	409,700
Yampa/White/Green	29,400	52,600	51,700	900	22,300
TOTAL	**1,194,900**	**1,926,800**	**1,824,900**	**101,900**	**630,000**

Table 5-7 Estimate of Average Annual SSI Water Use in 2000 and 2030 by County and User Type

County	Power Generation		Snowmaking		Industrial and Mining Processes		Total Estimated Self-Supplied		Increa
	2000	2030	2000	2030	2000	2030	2000	2030	
Adams	9,600	9,600	0	0	NE	NE	9,600	9,600	0
Arapahoe	0	0	0	0	NE	NE	0	0	0
Boulder	2,900	2,900	400	600	NE	NE	3,300	3,600	300
Clear Creek	NE	NE	400	600	NE	NE	400	600	200
Denver	2,400	2,400	0	0	NE	NE	2,400	2,400	0
Eagle	NE	NE	400	600	NE	NE	400	600	200
Garfield	NE	NE	400	600	NE	NE	400	600	200
Grand	NE	NE	1,200	1,900	NE	NE	1,200	1,900	700
Gunnison	NE	NE	300	500	NE	NE	300	500	200
Jefferson	NE	NE	0	0	52,400	52,400	52,400	52,400	0
La Plata	NE	NE	400	600	NE	NE	400	600	200
Larimer	5,200	11,200	0	0	NE	NE	5,200	11,200	6,00
Mesa	NE	NE	400	600	NE	NE	400	600	200
Moffat	11,500	19,100	0	0	2,100	3,900	13,500	23,000	9,50
Montrose	1,900	3,900	0	0	NE	NE	1,900	3,900	2,00
Morgan	5,900	13,900	0	0	NE	NE	5,900	13,900	8,00
Pitkin	NE	NE	2,000	3,200	NE	NE	2,000	3,200	1,20
Pueblo	9,000	17,800	0	0	49,400	49,400	58,500	67,300	8,80
Routt	2,700	7,600	300	600	2,800	5,600	5,800	13,800	8,00
San Miguel	NE	NE	400	600	NE	NE	400	600	200
Summit	NE	NE	1,500	3,700	NE	NE	1,500	3,700	2,20
Weld	3,100	7,400	0	0	NE	NE	3,100	7,400	4,30
TOTAL	**54,200**	**95,800**	**8,100**	**14,100**	**106,700**	**111,300**	**169,000**	**221,400**	**52,40**

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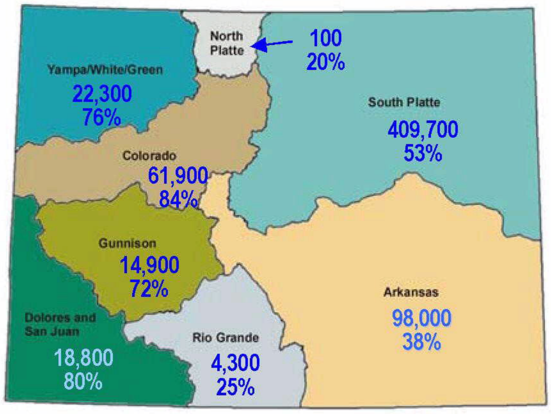


Figure 5-7
Projected Increase in Combined Gross M&I and SSI Demand (AFY) and Percent Increase from 2000 to 2030 by Basin

Similar to the population patterns described earlier in this section, *rates* of M&I water use increases over the 30-year planning period are generally higher for the West Slope basins than for the Front Range. However, the bulk of the increase in water uses *in terms of AFY* will be in the South Platte and Arkansas Basins, which together represent about 80 percent of the total projected increase in Colorado's gross M&I and SSI demands.

High and low estimates were also developed around the baseline M&I and SSI water use projections described above. Results of the high and low analysis are presented on a basin basis in Figure 5-8. These values represent the range of demands that might be expected to occur in each basin in 2030. Enhanced conservation efforts that could further reduce the "low" water use projections were considered in the options evaluation phase as described in Section 9.

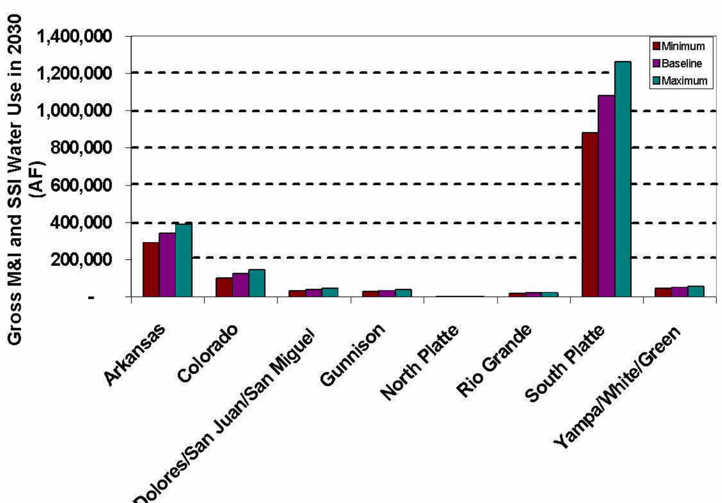


Figure 5-8
Range of Potential Gross M&I and SSI Water Use in 2030

5.3 Projected 2030 Agricultural Demand

Projections of 2030 agricultural demands and supporting data are presented in Table 5-8. As a result of the estimated potential changes in irrigated acres, agricultural demands and their associated gross diversions are shown as decreasing in the Arkansas, Colorado, Gunnison Rio Grande, and South Platte Basins. Demands in the Dolores/San Juan/San Miguel and Yampa/ White Green Basins may have a net increase if additional agricultural supplies are developed to provide for the increase in irrigated acres.

A summary of total projected Colorado agricultural use relative to M&I and SSI demands is shown in Figure 5-9. As can be seen, agricultural use is expected to still comprise the majority of these uses in 2030.

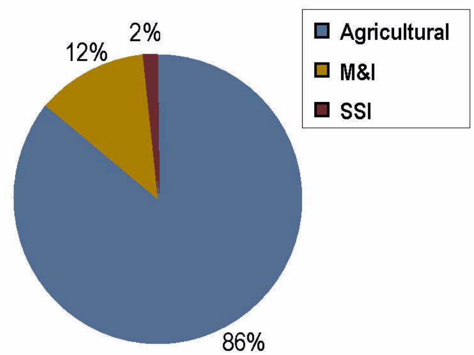


Figure 5-9
Relative Proportions of Agricultural, M&I, and SSI Water Use in 2030

To better anticipate future conditions, it is helpful to examine existing supply and demand. There are a number of factors that impact the calculation of water shortages such as the relative priority of water rights, the physical supply of water available for diversion at any given point, and irrigation practices. These factors are discussed in greater detail below. First, under the Colorado prior appropriation system, water is allocated based on the priority of the water right, so that during times of average to less than average streamflows, some water rights will not be in priority, resulting in a shortage of water to meet irrigation water requirements.

Table 5-8 Current and Range of Potential 2030 Agricultural Demands (AFY)

Basin	Irrigated Acres	Irrigation Water Requirement (IWR)	Water Supply Limited (WSL)	Incidental Losses + Stock Pond Evaporation	Gross Diversions
Current:					
Arkansas	405,000	748,000	619,000	69,000	1,770,000
Colorado	238,000	366,000	319,000	36,000	1,764,000
Dolores/San Juan/San Miguel	255,000	370,000	294,000	33,000	953,000
Gunnison	264,000	473,000	396,000	44,000	1,705,000
North Platte	**116,000**	**96,000**	**96,000**	**11,000**	**397,000**
Rio Grande	633,000	1,108,000	776,000	87,000	1,660,000
South Platte	1,027,000	1,798,000	1,541,000	173,000	2,606,000
Yampa/White/Green	118,000	138,000	123,000	14,000	642,000
STATE TOTAL	**3,056,000**	**5,097,000**	**4,164,000**	**467,000**	**11,497,000**
2030 Projections:					
Arkansas	333,000-382,000	616,000-707,000	510,000-584,000	57,000 - 65,000	1,457,000-1,670,000
Colorado	222,000-230,000	342,000-354,000	298,000-309,000	33,000 – 35,000	1,644,000-1,706,000
Dolores/San Juan/San Miguel	252,000-259,000	368,000-373,000	292,000-296,000	33,000 – 33,000	948,000-962,000
Gunnison	254,000-261,000	455,000-468,000	381,000-392,000	43,000 – 44,000	1,640,000-1,689,000
North Platte	**116,000**	**116,000**	**96,000**	**11,000**	**397,000**
Rio Grande	533,000-573,000	932,000-1,003,000	653,000-703,000	73,000-79,000	1,398,000-1,503,009
South Platte	801,000-894,000	1,402,000-1,565,000	1,202,000-1,342,000	135,000-150,000	2,033,000-2,269,000
Yampa/White/Green	116,000-158,000	135,000-183,000	120,000-163,000	13,000-18,000	627,000-852,000
STATE TOTAL	**2,726,000-2,932,000**	**4,366,000-4,769,000**	**3,552,000-3,885,000**	**398,000-435,000**	**10,144,000-11,048,000**

Second, the lack of available physical supply can also be a factor that contributes to the calculation of water shortage. For example, a ranch may irrigate hay meadows from a number of small streams running through the ranch. These small streams will normally dry up in late summer, resulting in a lack of available supply even though the water right may be in priority. Additional water supplies could be put to beneficial use if water were available. Shortages as a result of the priority of water rights and the lack of physical supply could potentially be reduced if additional storage were developed to supplement existing supplies.

A third factor that contributes to water shortage calculations results from irrigation practices. These calculated shortages are attributable to farming operational practices, where farmers choose to cease irrigation before the end of the growing season. In other words, the shortages are by choice rather than due to water availability. For example, irrigation may cease for the season in late July or early August, even though water supplies may be available. This is to allow hay to be cut, dried, and baled. The theoretical need for water remains, and additional application of water would result in additional CU. This type of water shortage cannot be reduced through additional water supplies and has not been further evaluated.

For the basins having DSS tools, water districts that have significant water shortages resulting from the relative priority of the water rights or lack of physical supply have been identified. A more detailed description of the methodology for evaluating these shortages can be found in Appendix F of the SWSI Report. Figure 5-10 shows those basins that have been determined to have significant water shortages as described above. Based on the prevalence of calls throughout the entire Arkansas Basin, even during average year streamflow conditions, widespread agricultural water shortages can be expected.

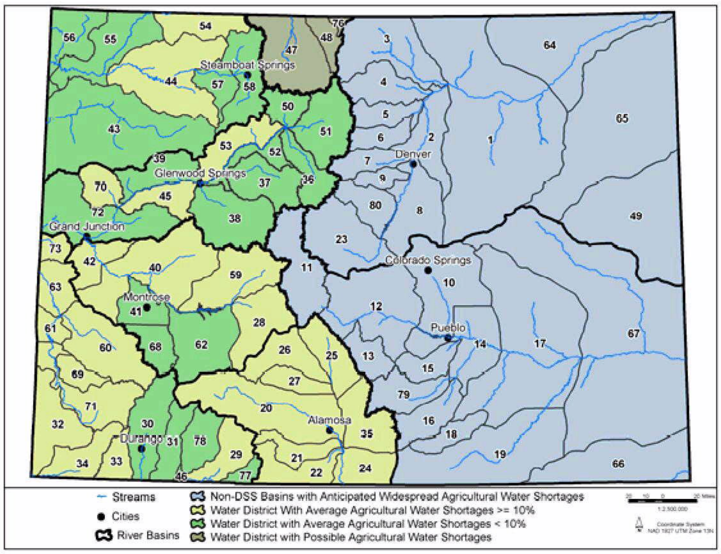


Figure 5-10
Summary of Agricultural Water Shortages by Water District

Generally, the cost of water development exceeds the ability of agriculture to pay for the development of additional water supplies. As a result, it may not be practical or cost-effective to attempt to develop water supply alternatives for areas having agricultural water shortages unless multi-purpose projects could be developed. Section 9 lists potential options for reducing agricultural shortages that have been identified during the process. Funding and ability to pay must be addressed if any of these projects are to be developed.

Section 6
Non-Consumptive Water Supply Needs in the North Platte Basin

In addition to the projected increase in demand for water to serve consumptive uses as described in Section 5, demand for water to serve environmental and recreational needs is expected to increase as well. Recreational and environmental water needs are generally in-channel flow-based and non-consumptive. This section provides a synopsis of the input received during the SWSI process from environmental and recreational interest groups as a possible starting point for defining environmental and recreational flow goals.

6.1 Concepts for Environmental Flow Management

While flow enhancement for environmental and recreational uses was identified by many SWSI participants as being important, few Identified Projects and Processes, aside from river compact deliveries and the CWCB's instream flow program, directly address flow enhancements beyond statutory legal requirements.

One concept for environmental and recreational flow management brought forth by environmental and recreational interest group representatives in SWSI was the "Conserve, Protect, and Restore" (CPR) approach. The "Conserve" component is centered on keeping currently "healthy" – both in terms of quality and quantity – rivers healthy. The "Protect" component suggested by the interest groups includes keeping threatened but currently healthy reaches whole, or as close to whole as possible. The "Restore" component suggested by the interest group representatives revolves around restoration of dry, low-flow, or low-quality segments. Project re-operations and ditch lining are two possible strategies that could be employed.

Environmental and recreational interest groups suggested that in characterizing environmental water needs, a two-step approach could be implemented:

- Identify and locate critical water-dependent species and natural systems
- Assess the environmental demands (or ecological flow needs) of those systems

Key sources for information for water-dependent species and systems might include:

- CDOW
- Colorado Natural Heritage Program (CNHP)
- Colorado Water Trust
- The Nature Conservancy Ecoregional Plans
- Colorado River Endangered Fish Recovery Programs

It was also suggested that a model could be developed to determine environmental or instream needs of these communities by identifying integral components of the flow regime such as:

- Base flows
- Normal high flows
- Drought and flood conditions
- Interannual variability

6.2. Recreational and Environmental Information

No CWCB instream flow rights have been decreed on the North Platte River. Decreed rights on tributaries in the basin can be found at http://cwcb.state.co.us/isf/ Downloads/ Index.htm.

There are no reaches in the North Platte Basin in Colorado that are listed for rafting use by American Whitewater.

The North Platte River from the Routt National Forest boundary downstream to the Colorado-Wyoming line (5.3 miles) has received Gold Medal designation. The predominant fish in the North Platte River are brown trout and rainbow trout.

One of the three lakes in the Delaney Butte Lakes State Wildlife Area, North Delaney Butte Lake, is an extremely productive lake that grows trophy brown trout, and has received Gold Medal designation. This wildlife area is located about 10 miles west of Walden.

Section 7
Availability of Existing Water Supplies in the North Platte Basin

North Platte Basin

7.1 Methods and Tools Employed to Evaluate Surface Water Supply Availability

The availability of surface water and groundwater supplies for each basin are summarized in this section. Physical availability of surface and groundwater resources must be carefully evaluated against the legal right to divert, pump, or consume these resources. Surface water supply availability was estimated at selected points in each major river basin in Colorado. Colorado's DSS surface water allocation model, StateMod, and supporting datasets, were the primary tools used for this analysis when available. StateMod simulates daily or monthly hydrologic water availability in a river basin based on a stream's water rights, structures, and operating rules (http://cdss.state.co.us). For those basins without StateMod datasets, alternative sources and studies were used to summarize available water to the extent possible.

7.2 Overview of Groundwater Supplies and Availability

Groundwater is present throughout the state. It is found in a variety of aquifers, from unconsolidated sand and gravel in the floodplains of the major rivers to bedrock deposits buried deep below the surface. The key aquifers in the state are located primarily in the unconsolidated deposits. These include the alluvial aquifer systems of the Arkansas, South Platte, Gunnison, Colorado, and North Platte Rivers. In addition, there is a significant aquifer located in unconsolidated deposits in the San Luis Valley in south central Colorado within the Rio Grande Basin. Of the many aquifer systems located in bedrock deposits, the most significant of these are the aquifers of the Denver Basin, located east of the Front Range, and the Ogallala (High Plains) aquifer located in eastern Colorado.

7.2.1 Definition of Groundwater Resources

Groundwater is administered by the State DWR to regulate and manage its use. Section 4 provides additional information on water rights as it affects groundwater resources. To reiterate, Colorado recognizes four types of groundwater and has separate sets of rules for each. These are based on interaction with surface water and/or on geographic location:

- **Tributary** – groundwater that is hydrologically connected to a natural stream.
- **Non-tributary** – groundwater located outside of a designated basin, the withdrawal of which will not, within 100 years, deplete the flow of a stream at an annual rate greater than one-tenth of 1 percent of the annual rate of withdrawal.
- **Designated Basin** – groundwater in areas not adjacent to a continuously flowing stream or required to fulfill decreed surface water rights, and located within the boundaries of a designated basin as defined by the legislature.
- **Denver Basin** – groundwater located outside of a designated basin and located within the boundaries of the Denver Basin aquifers as defined in 1985.

Tributary and non-tributary groundwater supplies are located throughout the state, while Denver Basin and designated basin groundwater are located in specified areas in eastern Colorado.

Tributary groundwater occurs in the shallow alluvial aquifers adjacent to streams. This type of groundwater is administered under the Prior Appropriation System of water rights as are surface water supplies. In most basins, groundwater use is junior to surface water and so its use is allowed only if augmentation plans have been filed with the State Engineer that describe how the predicted depletions of stream flow due to the groundwater usage are offset.

Non-tributary groundwater occurs in deeper bedrock aquifers. This type of groundwater is administered based on ownership of the land overlying the aquifer, independent of the Prior Appropriation System. Permits limit annual usage to depleting a certain percentage of the computed aquifer volume, usually 1 percent.

In many cases the groundwater supplies are limited either by their physical or legal availability. The physical availability is the amount of water an aquifer can produce. The legal availability is the amount of groundwater that can be extracted from an aquifer under the water rights system that is present for the specific groundwater basin.

The amount of groundwater that each of these aquifers can produce is difficult to determine. This is due to several factors including uncertainty about the transmissivity, porosity, thickness of an aquifer, its extent, and locally, the effects of pumping that draws down the groundwater supply.

The transmissivity of an aquifer describes its potential to provide water. An aquifer with high transmissivity can provide a large amount of water per foot of aquifer drawdown. Transmissivity is a product of the aquifer saturated thickness and its water-bearing properties. Both of these aspects vary naturally throughout an aquifer. The aquifer saturated thickness and the extent of an aquifer usually are estimated based on a review of driller's logs of the subsurface and mapping of the permeable aquifer zones. An aquifer is composed mostly of soil or rock particles, with the groundwater existing in the porous void spaces in between. Soil and rock strata of both aquifer and non-aquifer materials change in composition due to how the strata were deposited, so the void spaces also vary. The water-bearing properties of an aquifer, defined as its hydraulic conductivity, are related to the size, number, and interconnectedness of the void spaces. It can vary by several orders of magnitude due to natural variations in the aquifer materials. Estimates of hydraulic conductivity can be made from the aquifer grain size and from aquifer pumping tests. The natural variation in porosity affects the ability to accurately estimate the amount of groundwater in storage in an aquifer. The range in porosity also can be up to several orders of magnitude for consolidated bedrock deposits and by a factor of 2 or 3 and for unconsolidated deposits. Due to the natural variations of these aquifer properties, any estimates of the amount of groundwater in storage and its availability will have a larger amount of uncertainty associated with them than will estimates of surface water availability.

The groundwater resources in each basin have been characterized based on published reports and data for the major aquifer systems.

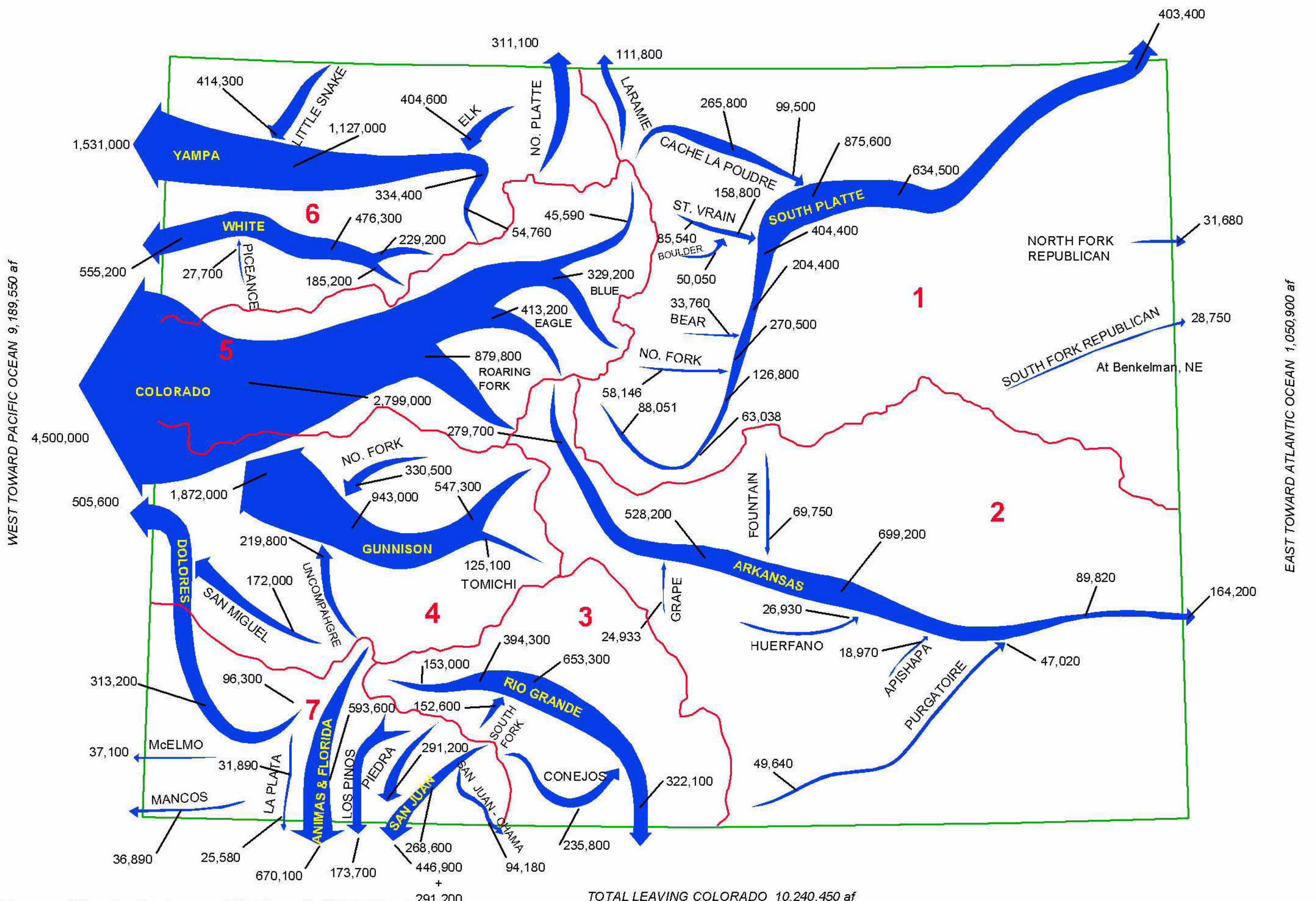
7.3 Available Surface Water and Alluvial Groundwater Supply

Historical flows at key gages in all river basins are monitored by the State Engineer's Office (SEO). This map, commonly referred to as the "Snake Diagram" is a useful tool for illustrating the volume of flows throughout the state. The snake diagram is shown in Figure 7-1. It is important to note that the snake diagram does not include consideration of Colorado's commitments under compacts and decrees. Therefore, only a portion of the flows that are shown are available to Colorado.

There are numerous factors that may affect the physical and/or legal availability of surface water supplies. Some of the factors that are specific to individual basins are listed in the basin subsections below. General factors that must be considered when evaluating the availability of supply are listed in Table 7-1. As can be seen in the table, it is difficult to characterize supply availability without stating which factors have or have not been included in some fashion in the analysis.

Table 7-1 Factors that May Affect Future Availability (Legal and/or Physical) of Supplies in the North Platte Basin

Factors That May Decrease Availability of Water Supplies	Factors That May Increase Availability of Water Supplies
Increases in M&I and Self-Supplied Industrial CUs	Reduction in M&I and Self-Supplied Industrial CUs such as reducing lawn areas and industrial process improvements
Evaporation from new or enlarged reservoirs	Return flows from CU agricultural transfers that cannot be recaptured and reused
Increased reuse of existing consumable return flows	Unused CU yields from an agricultural transfer that cannot be stored by M&I or SSI users
New or increased transbasin diversions out of the basin	Increase in transbasin imports
Increase in agricultural CU ▪ Increase in irrigated lands ▪ Development of additional supplies to reduce or eliminate agricultural shortages ▪ Changes in irrigation efficiency such as conversion to sprinklers ▪ Changes to higher CU crops ▪ Diversion by downstream agricultural users of increases in M&I return flows	Decrease in agricultural CU ▪ Reduction in irrigated lands to lack of supplies for well augmentation ▪ Transfer of agricultural rights for dedication to in stream flows (increase in availability below the instream flow reach) ▪ Changes to lower CU by crops ▪ Changes in crop types
Development of irrigated lands resulting in a net increase in CU (increased depletions per acre)	Development of irrigated lands resulting in a net decrease in CU (decreased depletions per acre)
Additional flow requirements for species protection (e.g., endangered species)	Runoff from increase in impervious areas
RICDs and instream flow water rights filings (decrease in legal availability above the water right)	Return flows from increased non-tributary groundwater pumping (to the extent not reused)
Increase in coverage of phreatophytes or change in type of phreatophytes	Flow Management Agreements and/or Coordinated Reservoir Operations (increase in environmental or recreational flows for the specific reach at specific times)
Additional bypass flow requirements for existing projects	Endangered species recovery by means other than flows (stocking, habitat improvements, etc.)
Increase in coverage of phreatophytes or change in type of phreatophytes	Reduction in coverage of phreatophytes or change in type of phreatophytes
Hydrologic variability (e.g., climate change resulting in reduced runoff or extended droughts)	Hydrologic variability (e.g., climate change resulting in increased runoff or extended wet periods)



Prepared by the Hydrographic Branch (2003 Revision)
Historic averages obtained from USGS Water-Data Report CO-02

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COLORADO DIVISION OF WATER RESOURCES

Figure 7-1
Colorado "Snake Diagram"

7.3.1 Surface Water Supplies

StateMod datasets are not available for the North Platte Basin. There are, however, a number of USGS flow gages, with extensive periods of record, located throughout the basin. Two of these gages, shown in Figure 7-2, were used to characterize historical physically available flow in the basin. These flows are measured and correspond to actual historical, rather than current, diversions and demands. The period of record varies by gage, spanning the time period 1915 to 2001 (full calendar years). The selected gage locations are:

- North Platte River near Northgate (1916-2001)
- Laramie River near Glendevey (1915-1981)

Minimum, median, and maximum annual measured flows are summarized for each location in Figure 7-3. To better represent the effects of seasonal and year to year hydrologic variation, annual time series, and monthly summaries of historical physical flows are shown in Figures 7-4 through 7-7. Median annual flows and 3-year running averages are also included on the annual time series plots. The monthly analyses highlight the fact that physical flows vary greatly with season, with the greatest amounts of water present in the summer months and a sharp decline in flows in the autumn and winter. The annual time series plots also show large variation with a notable extended drought periods in the mid-1950s and the early 1990s. Extended wet periods appear to have occurred in the mid-1980s and mid-1990s.

The interpretation above is in general agreement with the CWCB Drought Study (HDR 2003), which summarized the history of drought in Colorado and identified significant drought periods in the last 100 years. The Drought Study states that the most recent drought analyzed for years 2000 to 2003 exceeds many of the drought records established during the 20th century.

The North Platte River Basin Decree is a Supreme Court decree that limits the total number of acres that can be irrigated in the North Platte Basin. The decree also limits the amount of water that can be stored for irrigation and the amount of water than can be exported out of the basin. This decree is described in Section 4. Currently, Colorado is not maximizing its allocation of water rights available under the decree. Estimates indicate that there is the potential to irrigate additional acres based on hydrologic conditions from 1975 to 2002. Transbasin diversions have also not been maximized per the Decree over the period of record. Transbasin diversion limits are limited on a running ten year total to 60, 000 AF. Recent diversions have averaged 44,600 AF for the most recent 10-year period (Leonard Rice Consulting Water Engineers 2004).

Another factor to be considered when assessing supply availability in the basin is the need and/or desire to maintain or enhance environmental flows. Environmental considerations are further developed in Sections 6 and 9 of this report.

7.4 Availability for Water Supply Development under Interstate Compacts and Decrees

Colorado has entered into and is affected by nine interstate compacts, two equitable apportionment decrees, and one international treaty. These agreements establish how water is apportioned between states and the Country of Mexico and have a significant effect on how Colorado can develop our future water supply as shown in Table 7-2. There are no reliable additional water supplies that can be developed in the Arkansas and Rio Grande Basins, though water may be available in very wet years. The North Platte has the ability to increase irrigated acres consistent with the North Platte Decrees, but during the Basin Roundtable process, this was not proposed due the inability of agricultural users to pay for the infrastructure.

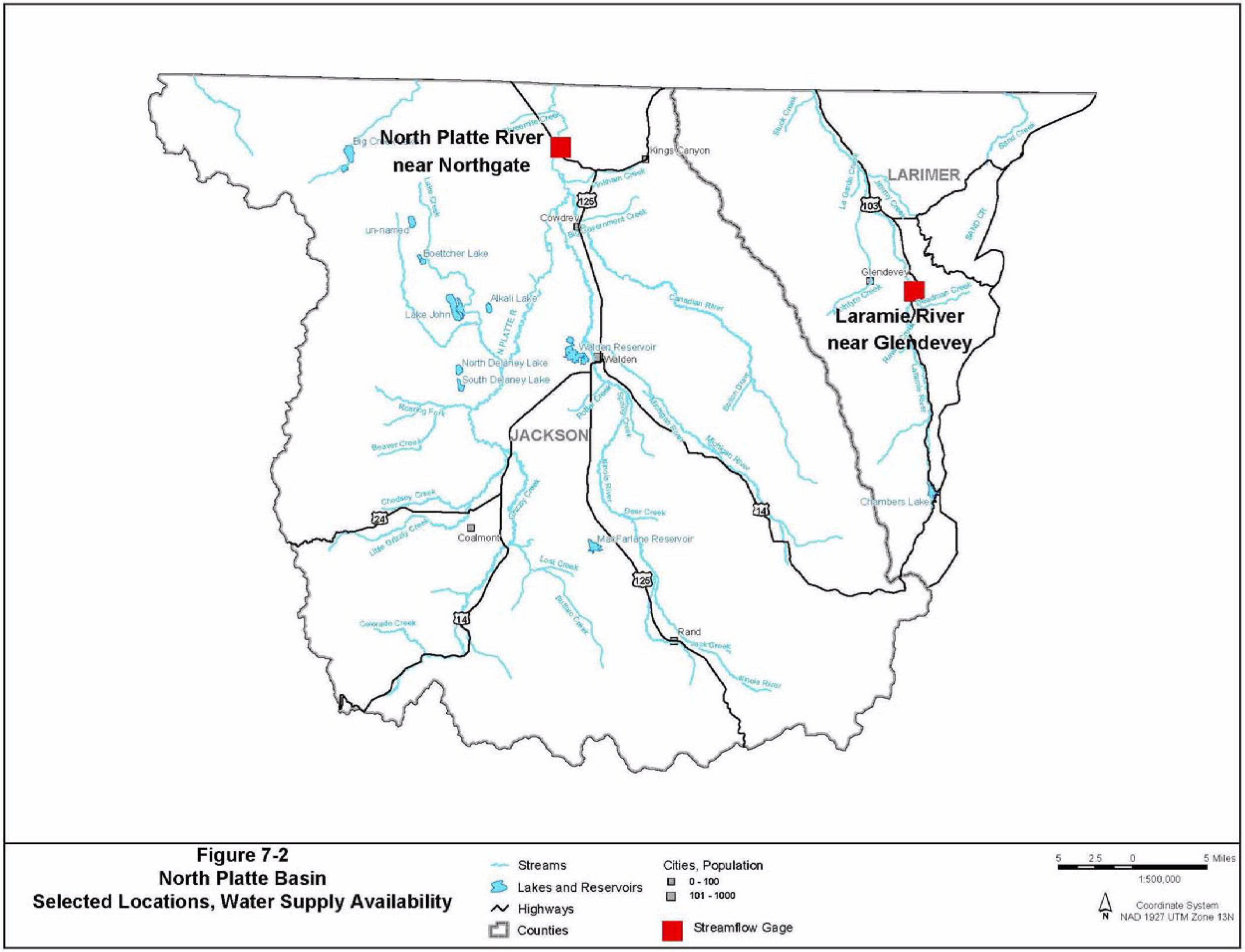

Figure 7-2
North Platte Basin
Selected Locations, Water Supply Availability

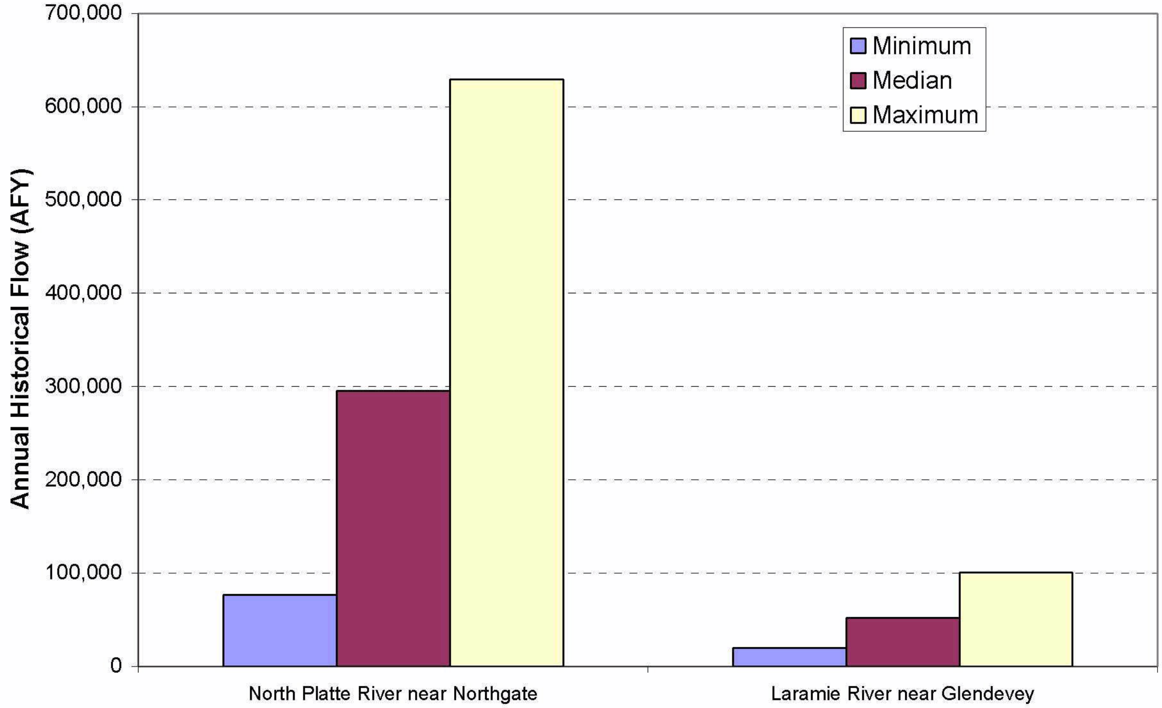

Figure 7-3
Minimum, Median, and Maximum Annual Historical Flows
North Platte Basin

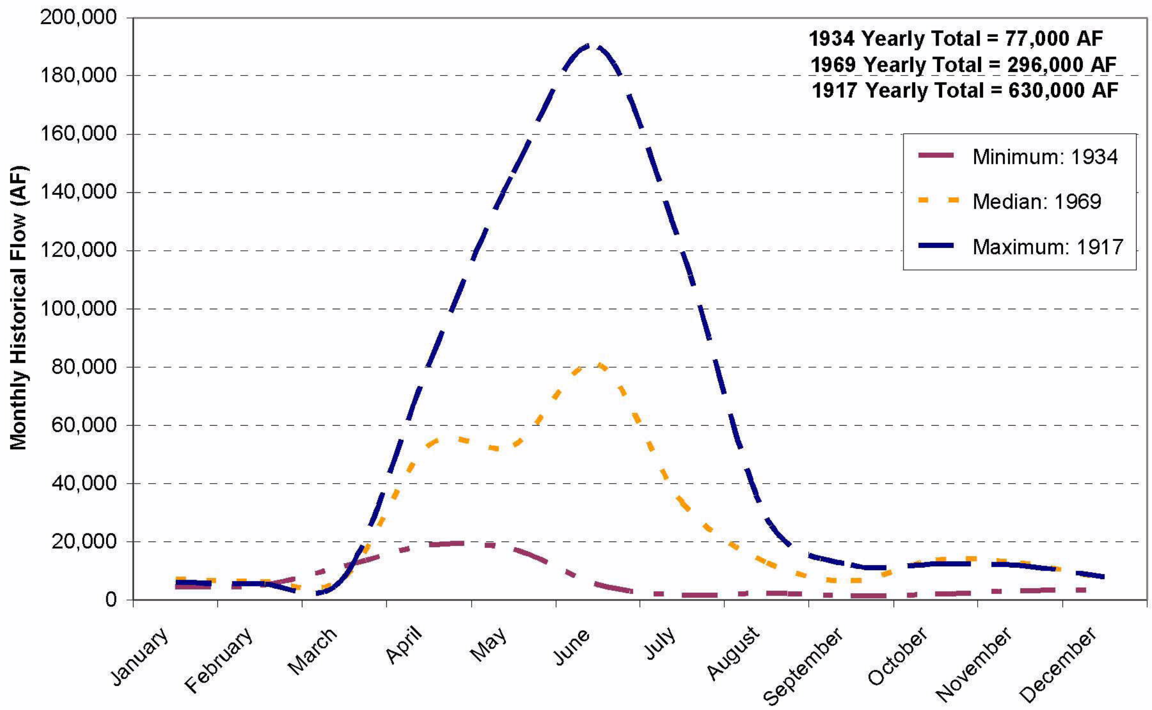

Figure 7-4
Monthly Historical Flow
North Platte River near Northgate (1916-2001)

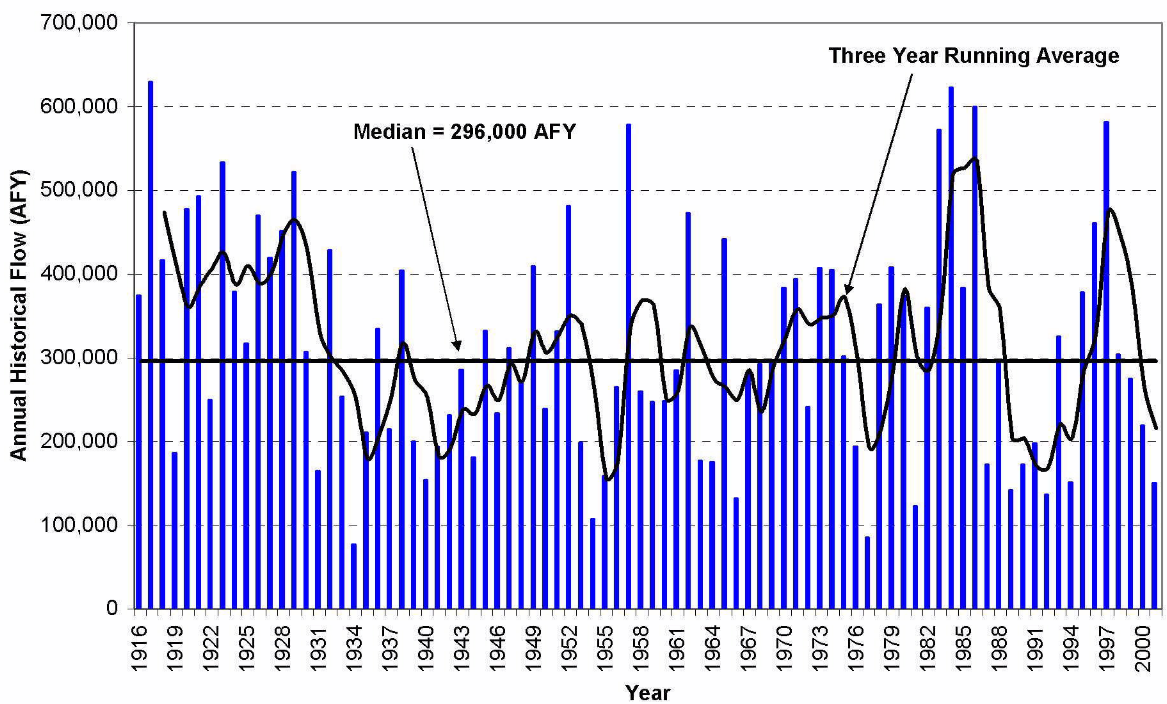

Figure 7-5
Annual Legally Available Flow
North Platte River near Northgate (1916-2001)

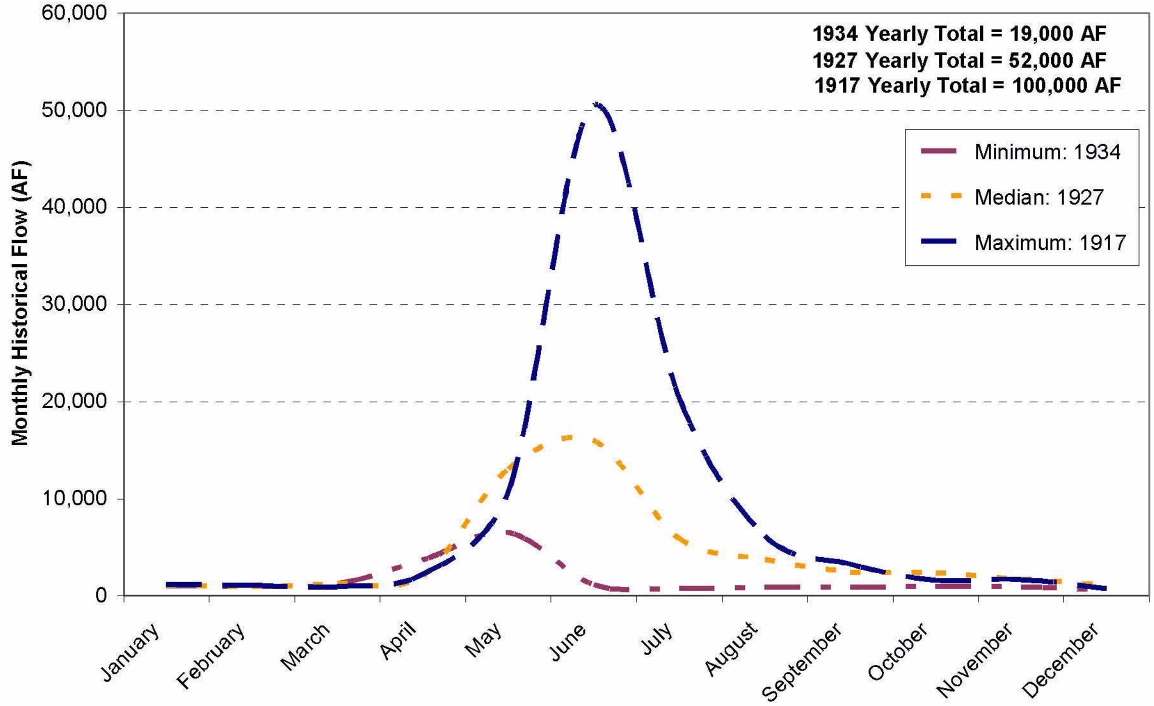

Figure 7-6
Monthly Historical Flow
Laramie River near Glendevey (1915-1981)

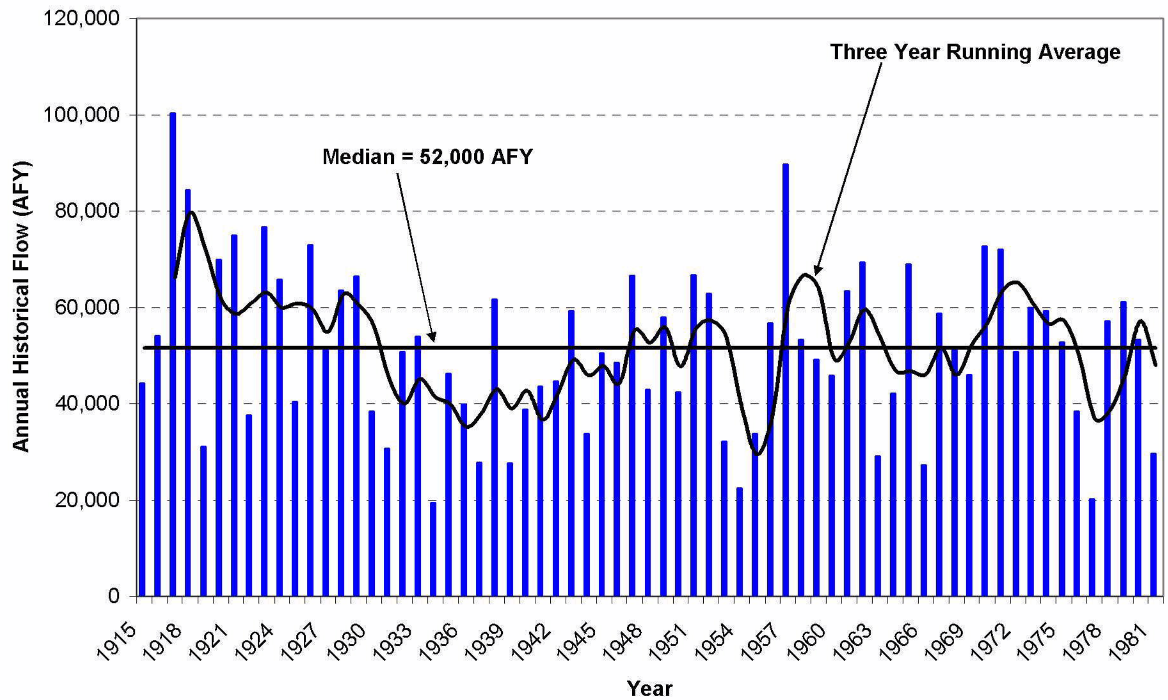

Figure 7-7
Annual Historical Flow
Laramie River near Glendevey (1915-1981)

Table 7-2 Major Interstate Compacts, Decrees, and Endangered Species Programs by Basin

River Basin	Flows Legally Available under Compact or Decrees for Future Development	Interstate Compact, Equitable Apportionment Decrees and Endangered Species Recovery Programs	Year of Compact or Decree
Arkansas		Arkansas River Compact	1948
		Kansas vs. Colorado	1995
Colorado	✓	Colorado River Compact	1922
		Upper Colorado River Compact	1948
		Upper Colorado Endangered Fish Recovery Program	—
Dolores/San Juan/ San Miguel	✓	Colorado River Compact	1922
		La Plata River Compact	1922
		Upper Colorado River Compact	1948
		Animas-La Plata Project Compact	1969
		San Juan Endangered Fish Recovery Program	—
Gunnison	✓	Colorado River Compact	1922
		Aspinall Unit Operations	—
		Upper Colorado River Compact	1948
		Upper Colorado Endangered Fish Recovery Program	—
North Platte/Laramie	✓	Nebraska vs. Wyoming	1945
		Wyoming vs. Colorado	1957
		Platte River Endangered Species Program	—
Rio Grande		Rio Grande River Compact	1938
		Costilla Creek Compact	1944
South Platte	✓	South Platte River Compact	1923
		Republican River Compact	1942
		Platte River Endangered Species Program	—
Yampa/White/Green	✓	Colorado River Compact	1922
		Upper Colorado River Compact and Yampa River Portion	1948
		Upper Colorado Endangered Fish Recovery Program	—

Section 8
Options for the North Platte Basin

North Platte Basin

This section presents the future water supply options that water providers are pursuing to meet their needs. SWSI has termed these options "Identified Projects and Processes" and it is estimated, under a best case scenario, that approximately 80 percent of Colorado's future needs can be met by implementation of these options. However, that leaves a remaining gap of 20 percent (118,200 AF). In addition, if some portion of the Identified Projects and Processes are not successfully implemented, it may be prudent to have some conceptual solutions that could be pursued. The types of options available are described in Section 9.

This section outlines some of the basin-specific options, which when combined are termed Alternatives, that could help address unmet future water supply needs.

8.1 Methods Employed to Assess Water Needs

As described in Section 5, all types of water use, from M&I to agricultural, recreational to environmental, are expected to be significant in 2030. Using input and feedback from the SWSI Basin Roundtables as a foundation, SWSI examined how the future water needs of each use and user could be met. Water providers and users, interest groups, organizations, and individuals throughout Colorado have identified a plethora of potential solutions to address future needs. In many cases, water management solutions were more numerous and further developed for M&I uses, while agricultural, recreational, and environmental solutions were fewer or more conceptual in nature. This is partially a result of the technical, planning, and financial resources available to M&I users that allow for more detailed planning and financial resources for implementation.

This section documents the results of SWSI's efforts to:

- Catalog and characterize specific water management solutions that are being contemplated around the state for each type of use.
- Identify the amount of water, by basin and subbasin, that will be produced by projects or processes that are expected to move forward with a reasonable degree of certainty by 2030 – called "Identified Projects and Processes" in SWSI.
- Estimate the remaining amount of water needed (the "gap" in supply) in each basin to meet 2030 needs, assuming each of the Identified Projects and Processes completely meets its supply goals.
- Consider the potential implications if a portion of the Identified Projects and Processes are not successfully implemented.

A detailed discussion of the methods employed to assess water needs for the North Platte and other basins can be found in Section 6.1 of the SWSI Report.

Supply availability is discussed in Section 7. Water management solutions that are less ready for implementation, but could be considered for addressing the remaining "gap" between supply and demands (after subtracting the yields of the Identified Projects and Processes), are described in Section 9.

Key findings of the water needs assessment conducted under SWSI include:

- Most M&I water providers that responded to survey data requests indicated that they either have identified plans or processes underway to meet their estimated demands through 2030.
- It is critical that the Identified Projects and Processes are successfully implemented to meet those future M&I needs or the gap between supply and demand will increase.
- While M&I demands will increase substantially by 2030, as much as 80 percent of that increase could be met through the successful implementation of the Identified Projects and Processes already underway or planned for implementation by M&I water providers.
- Solutions for addressing agricultural, recreational, and environmental water needs are less well-defined and less certain in their implementation due to a number of factors, such as funding constraints, or an inability or mechanism for the beneficiary to contribute financially.
- The CWCB has one of the most proactive and ambitious instream flow programs in the United

States. CWCB's instream flow programs have been in existence since 1973 and have protected approximately 8,500 miles of Colorado streams and approximately 500 natural lake levels. The CWCB is authorized to acquire and file water rights to protect the natural environment to a reasonable degree. As part of the SWSI process, many of the SWSI Basin Roundtable members expressed the desire to explore other mechanisms beyond CWCB's flow authorities.

- To date, other than through CWCB's instream flow program, there is no coordinated process or widely-accepted method for estimating recreational and environmental flow enhancement goals or prioritizing stream segments or ecological areas for such enhancement.

8.2 Implications of Uncertainty in Identified Projects/Processes and Existing Supplies

In considering the M&I Identified Projects and Processes, the SWSI team and SWSI Basin Roundtable members recognized that there may be significant uncertainty in the implementation of many of these projects and processes. That is, any project that is not yet fully implemented could fail to result in the full amount envisioned, for various reasons. Reasons for projects not being fully implemented could include:

- Competition for available water supplies as many providers have identified the same future sources.
- Identified Projects and Processes may yield less or store less than currently envisioned due to permitting constraints or other factors. Some projects may never be permitted or otherwise never be constructed due to implementation constraints.
- The ability to develop water supply projects may be affected by the management of flows and habitat for endangered species as most water supply development projects will require certain federal permits.
- Areas depending on non-renewable, non-tributary groundwater have reliability and sustainability concerns. Continued pumping of non-renewable groundwater to meet existing demands may become problematic due to declining water levels resulting in reduced well yields.
- Agricultural and smaller water providers will have difficulty funding water development projects.

Without judging the merits of any individual water provider or basin's Identified Project and Processes, SWSI sought to understand the potential implications of the uncertainty associated with the Identified Projects and Processes. It was assumed that the projected additional savings associated with Level 1 conservation are certain to occur, because low-flow devices will continue to be installed in new fixtures and replace older, higher-flow devices in response to the National Energy Policy Act of 1992. Initial uncertainty levels of 25 percent and 50 percent were applied to the yield of the Identified Projects and Processes to illustrate the importance of currently-identified solutions in meeting Colorado's future water demands.

Figure 8-1 indicates the implications of uncertainty in the Identified Projects and Processes. To any extent that the Identified Projects and Processes fail to be fully implemented, demand and competition for Colorado's water resources will be further increased and the need to implement alternative solutions will be evident.

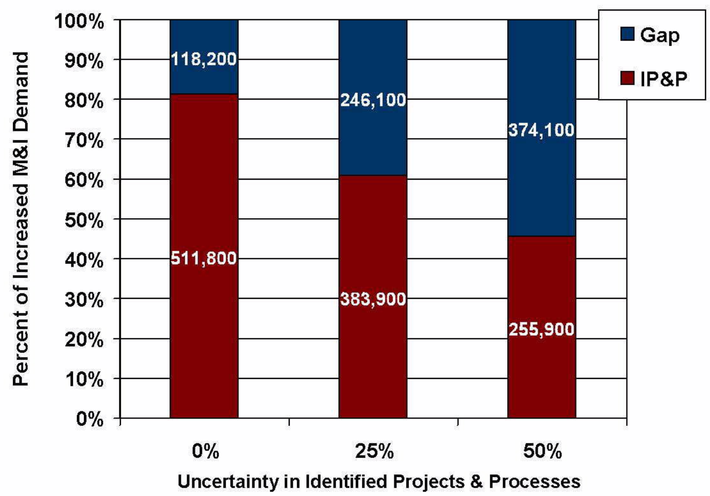

Figure 8-1
Implications of Uncertainty in Identified Projects and Processes on Meeting 2030 M&I and SSI Water Needs

Any yield that would otherwise have come from Identified Projects and Processes for M&I use might likely instead be satisfied with additional permanent agricultural transfers. History has shown that M&I providers will indeed find a way to meet their customers' needs, and agricultural water is the most readily-available source for meeting those needs. As discussed earlier, agricultural transfer will still require storage and infrastructure to move water from its source to treatment facilities and distribution systems.

Thus, it is possible that a failure to implement the Identified Projects and Processes would result in even greater impacts to irrigated agriculture and the economies dependent thereon. A range of potential changes to irrigated acres was shown in Figure 5-5. The lower end of the range reflects the assumption that all Identified Projects and Processes, including additional conservation, are successfully implemented. As noted, not all of the reduction in irrigated acreage would be available for transfer to meet M&I needs. To illustrate the possible impacts of the uncertainty of the successful implementation of Identified Projects and Processes.

Figure 8-2 shows the additional acres of irrigated farm land that might be put out of irrigated production if 25 to 50 percent of the Identified Projects and Processes were not successfully implemented. Agricultural transfers, however, are also not without risk and uncertainty due to the water court process, volume of storage required, and local and federal permits needed for construction of necessary facilities.

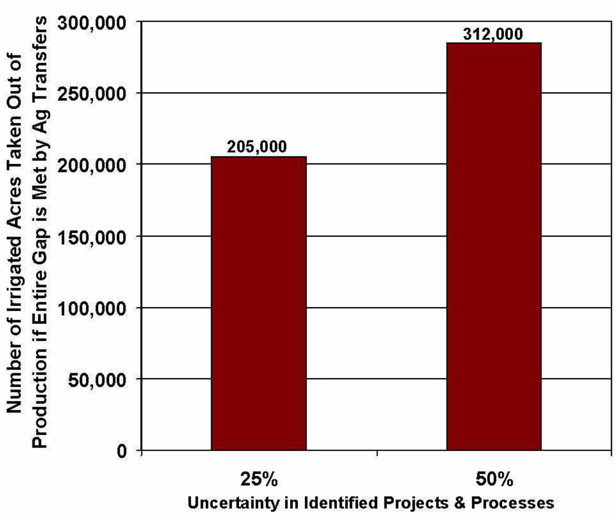

Figure 8-2
Potential Impact on Irrigated Agricultural Acres if Identified Projects & Processes are Not Implemented

Funding and permitting remain the primary challenges in implementing water management solutions in Colorado.

8.3 Identified Projects and Processes in the North Platte Basin

The catalog of Identified Projects and Processes is presented in this section. Table 8-1 provides a summary of each basin's increased M&I and SSI demands, the amount of that increase provided by the Identified Projects and Processes, and the general locations of the gap.

Figure 8-3 presents this information on a map of the state. In many cases, the Identified Projects and Processes have benefits for multiple users, such as agriculture, recreation, and environmental needs.

A broad range of water management solutions with varying levels of supply are planned for each of the basins. Many water providers are pursuing multiple projects and will need all of these identified projects to meet their increased demand. This is due to the reality that each of the Identified Projects and Processes has risk associated with them and that they may not yield all of the anticipated water supply. Many of these projects and processes will benefit multiple beneficiaries and therefore address a number of objectives concurrently. However, challenges exist in determining funding sources and acquiring water rights to support the multiple uses. The following subsection provides a brief description of the major Identified Projects and Processes in the North Platte Basin. Details of each. A discussion of environmental and recreational flow issues is provided in Section 6.

Table 8-1 Statewide M&I and SSI Gaps in 2030

Basin	Increase in M&I and SSI Demand (AFY)	Estimated Yield of Identified Projects and Processes if Fully Implemented (AFY)	Estimated Remaining M&I/SSI Gap After Identified Projects and Processes (AFY)	Locations of Gap
Arkansas	98,000	80,900	17,100	Upper and Southwestern regions (augmentation credits) and Lower region and unincorporated El Paso County (firm water supply).
Colorado	61,900	58,900	3,000	Garfield, Grand and Summit Counties
Dolores/San Juan/San Miguel	18,800	13,900	4,900	San Miguel (water supply), Dolores (need for augmentation credits) and San Juan (infrastructure to deliver existing and future water supplies).
Gunnison	14,900	12,500	2,400	Crested Butte Mountain Resort, Upper Gunnison and Ouray County (need for augmentation credits) and other unincorporated areas not served by Water Districts.
North Platte	**100**	**100**	**0**	**No gap anticipated, but storage required for drought reliability**
Rio Grande	4,300	4,200	100	Physical availability of groundwater, but will need augmentation credits for well pumping.
South Platte	409,700	319,100	90,600	South and Denver Metro, Northern, Upper Mountains and Lower Platte.
Yampa/White/ Green	22,300	22,300	0	Concerns over drought reliability due to transit losses. Oil shale development in White River basin could significantly increase demands.
Total	**630,000**	**511,800**	**118,200**	

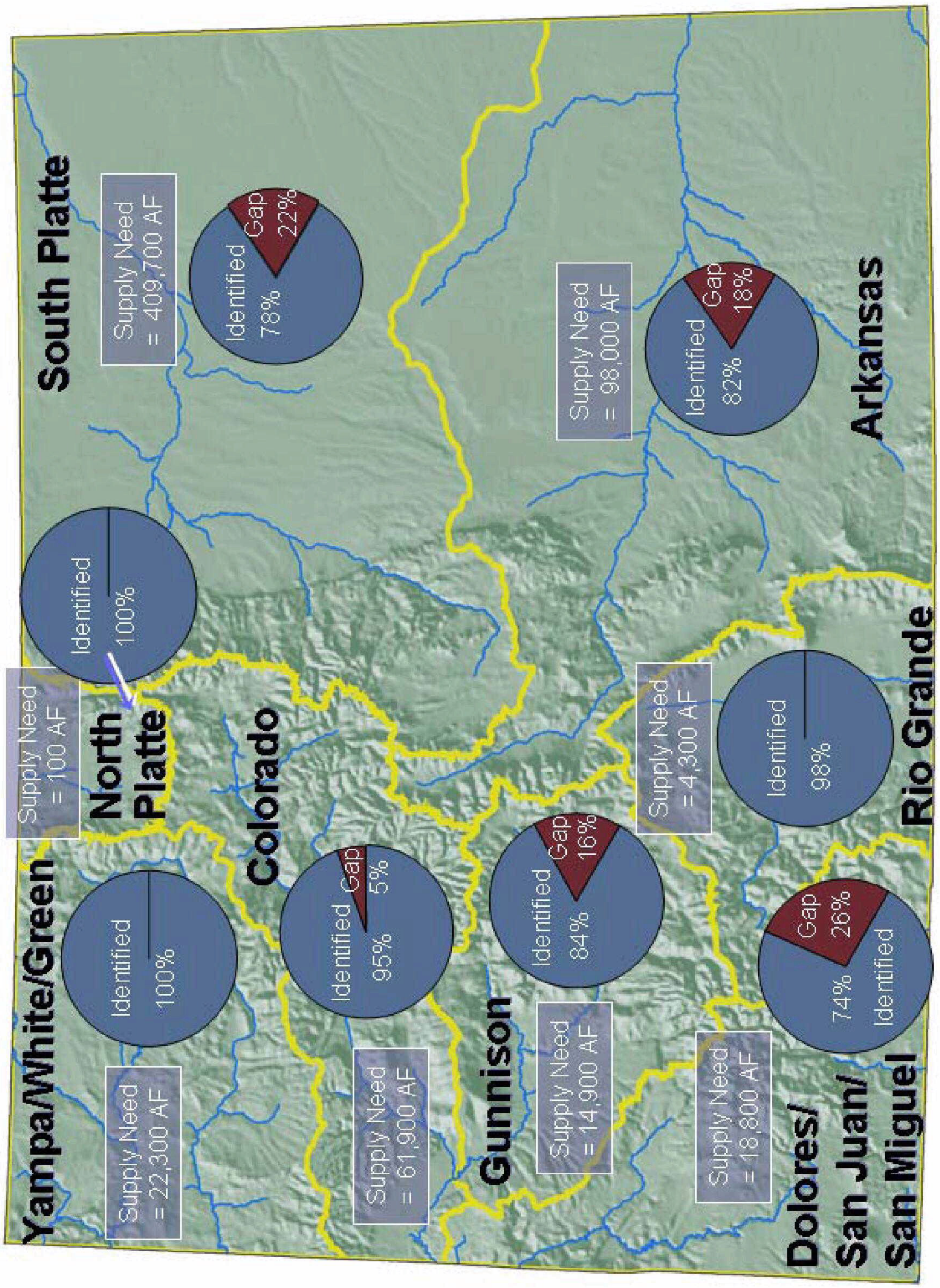

Figure 8-3
Effectiveness of Identified Projects and Processes in Meeting 2030 M&I and SSI Demands

CDM

8.3.1 Identified Projects and Processes for M&I, SSI, and Agricultural Users

The North Platte River headwaters in Colorado are a relatively small portion of the overall North Platte Basin. Farming and ranching are the predominant economic base. The North Platte Basin is expected to see a relatively small increase in M&I and SSI demands (about a 100 AF increase between 2000 and 2030), so major Identified Projects and Processes were not brought forth for formal cataloging in SWSI. It is anticipated that this increase in demand will be met primarily via the application of existing supplies and water rights.

8.4 Specific Issues in the North Platte Basin

Key activities related to water supply planning and basin specific issues in the North Platte Basin were identified during the SWSI process and SWSI Basin Roundtable Technical Meetings. This section summarizes the basin specific activities and issues related to water planning and water resource management and environmental and recreational options. In addition, existing conditional storage rights and restricted reservoir sites in each basin were identified and discussed during the process and are also summarized.

The North Platte Basin includes the North Platte and Laramie Rivers. The North Platte Basin is one of Colorado's only basins with concern over the lack of growth and economic development. Other issues include a desire to ensure protection of existing water supplies, and a concern over the impact of the lack of forest management. It is important to ensure that Endangered Species issues on the Platte River in central Nebraska do not put pressure on North Platte water users to reduce existing uses.

8.4.1 Conditional Storage Rights

Consistent with SWSI's objective of identifying various water management possibilities, the concepts of enhancing water supplies throughout Colorado by perfecting conditional storage rights and rehabilitating existing reservoirs were explored. As was described in Section 4.1.1, a conditional water right is not an absolute water right, and therefore has not been put to beneficial use. A conditional storage right must have two elements in order to exist. First, there must be an intent, and secondly, an act. An intent is a plan that includes diligently proceeding with actions until eventually the full beneficial use of the water is realized. An act could be as simple as staking the location of the structure. Cities are given more flexibility in this process, having only to show expected requirements based on validated growth projections. However, because some conditional storage rights holders have priority dates senior to existing absolute junior rights, if they fully exercise their rights, junior water rights holders would be affected. Conditional storage rights can therefore play an important role in the development of the state's water resources if they were to be fully implemented. Conditional storage rights in the North Platte Basin are discussed in more detail in Section 8.4.4.

8.4.2 Gap Analysis Issues

Because no M&I gap is anticipated, no issues arose in the North Platte Basin Roundtable process for this use.

8.4.3 Supply Availability Issues

The North Platte Decree, as described in Section 4 and 7, limits the total irrigated acres, agricultural reservoir storage, and transmountain diversions.

RICDs and CWCB instream flow water rights may impact the ability to manage water supplies upstream of such water rights.

8.4.4 Summary of North Platte Basin Conditional Storage Rights

To portray the conditional storage rights present in the North Platte Basin, the area was described using water districts as shown in Figure 8-4.

The two water districts in the North Platte Basin can also be described using the main stream systems, which are shown in Table 8-2.

Table 8-2 North Platte Basin Water Districts and Associated Stream Names

Water District	Stream Name
47	North Platte River
48	Laramie River

The two water districts in the North Platte Basin have conditional storage rights of approximately 45,000 AF with a priority of between 1900 and 1920, and 25,000 AF with a priority between 1980 and 2002. As shown in Table 8-3, there is a total of approximately 70,000 AF of conditional storage rights in the basin, which far exceeds the amount allowed under the North Platte Decree. The numbers presented in this table describe the total volume of conditional rights by priority time period and not the number of individually decreed conditional rights. These priority time periods are based on adjudication dates and used solely for the purpose of aggregating the numerous conditional rights into a table for presentation.

Water District 48 in the North Platte Basin has the largest volume of conditional storage rights, comprising almost 45,000 AF. Water District 47 comprises the remaining 25,000 AF. This is depicted in Table 8-3 and also presented graphically in Appendix H of the SWSI Report.

Figure 8-5 focuses on the priority date of the conditional storage rights. All of the conditional storage rights in Water District 48 in the North Platte Basin have priority dates between 1900 and 1920. Water District 47 has conditional rights with priority dates between 1940 and 2002.

A map of the locations of the conditional storage rights in the North Platte Basin is shown in Figure 8-6. Different colored circles are used to represent the total volume of conditional rights that each location holds. This figure also shows the locations of potential damsites in the North Platte Basin, as discussed in Section 8.4.5 below.

The development of conditional water rights in the North Platte Basin is limited by interstate decree as described in Section 7.

8.4.5 Summary of Restricted Reservoirs and Potential Storage Sites

One restricted reservoir exists in the North Platte Basin and is listed in Table 8-4. The reservoir, located in Water District 48, is the Johnson Dam, which has an improper freeboard and erosion and seepage problems. This site loses 68 AF of storage due to these problems.

Figure 8-6 shows the locations of potential damsites identified by the CWCB in the North Platte Basin, along with the conditional storage rights locations. Different colored circles are used to represent the total volume of conditional rights that each location holds. Potential damsites are classified by total potential storage. Coalmont is a viable future site, but the conditional water right for this reservoir was cancelled by the Water Court in 2001. Hyannis Reservoir was discussed at the Basin Roundtable Technical Meeting as a possible project as there were two conditional decrees for this reservoir site. The original was for 2,123 AF with a conditional enlargement for 737 AF. Both of these conditional rights were cancelled by the Water Court in 2001, when the applicant indicated they no longer wished to pursue diligence (Plaska 2004).

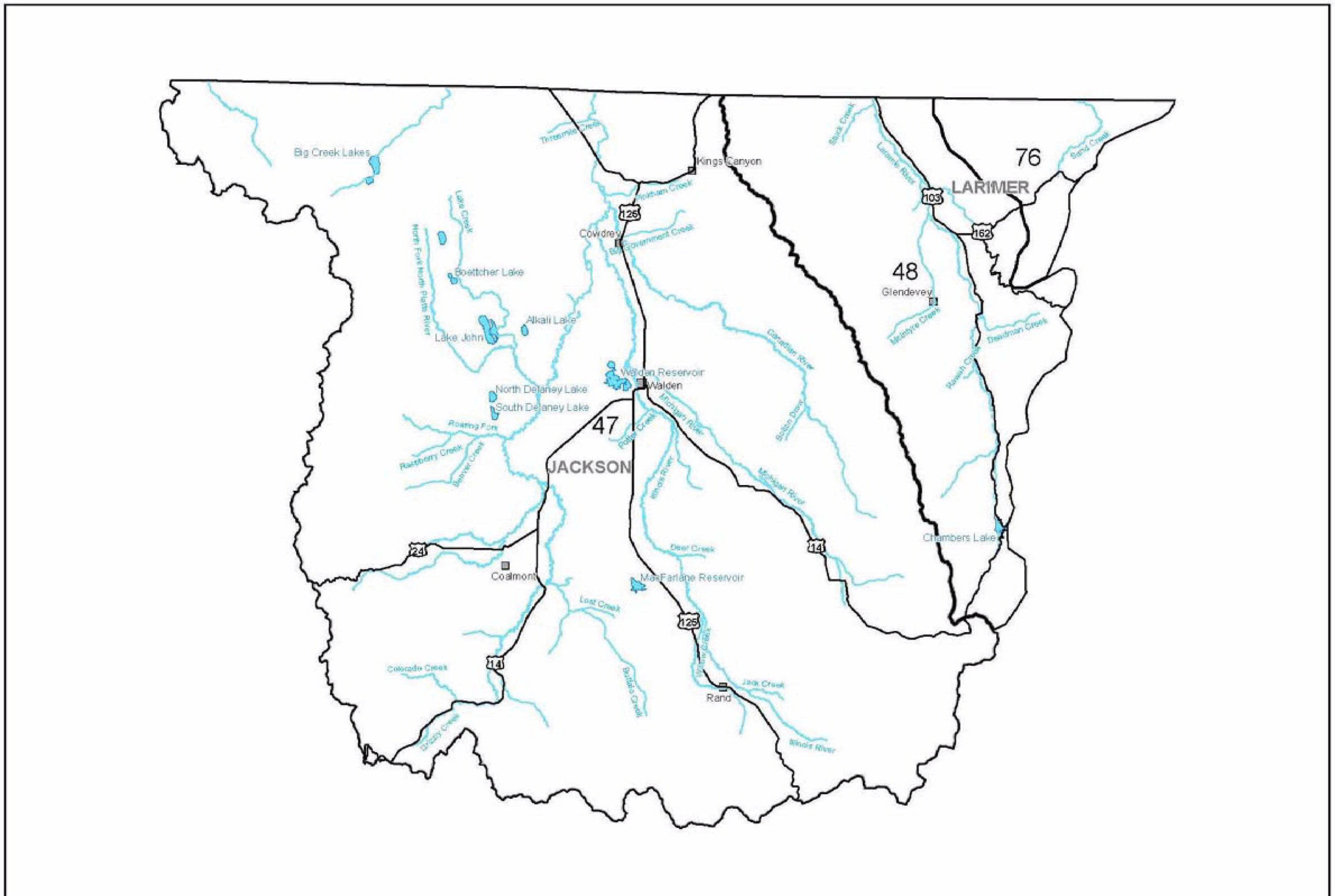

Figure 8-4
North Platte Basin
Water Districts

Streams
Lakes and Reservoirs
Highways
Counties

Cities, Population
0 - 100
101 - 1000
Water District

5 2.5 0 5 Miles
1:500,000

N
Coordinate System
NAD 1927 UTM Zone 13N

Table 8-3 Volume of Conditional Storage Rights by Priority (AF) in the North Platte Basin

Water District	Stream Name	1900-1920	1920-1940	1940-1960	1960-1980	1980-2002	Total
47	North Platte River	0	0	68	402	24,804	25,274
48	Laramie River	44,536	0	0	0	0	44,536
Total		**44,536**	**0**	**68**	**402**	**24,804**	**69,810**

Table 8-4 Restricted Damsite Inventory in the North Platte Basin

DAMID	Water District	Dam Name	Restricted Reservoir Level	Reason for Restriction	Gage Height	Action Date	Volume Lost
480101	48	Johnson	4.0 Crest (3.0 Crest Irr. Season)	Eros on U/S face, Improper FB., Seep/D/S Toe	0	7/18/1994	68

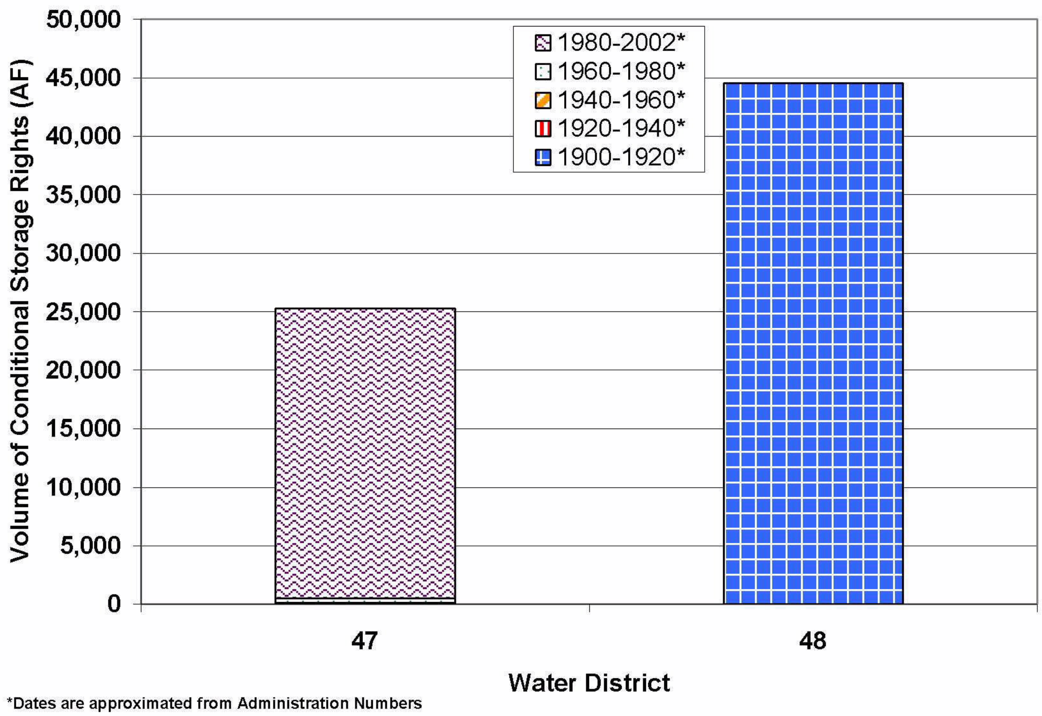

Figure 8-5
Volume of Conditional Storage Rights by Priority (AF) in the North Platte Basin

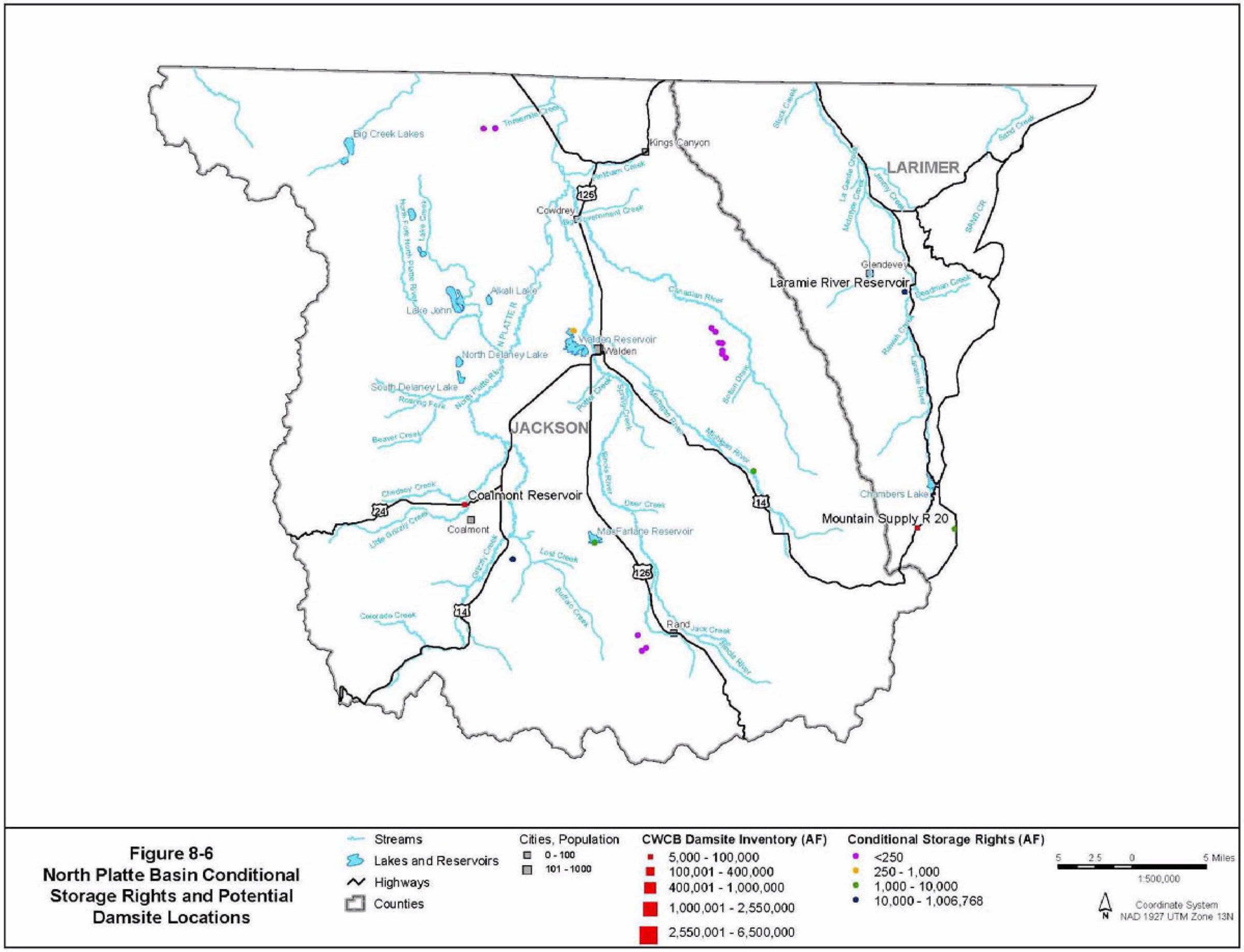

Figure 8-6
North Platte Basin Conditional Storage Rights and Potential Damsite Locations

8.5 Environmental and Recreational Options

Colorado's current and future environmental and recreational water needs bring a unique set of issues to water management. As highlighted in Section 6.1.3, a number of new and innovative approaches to meeting environmental and recreational needs and moving from mitigation to enhancement were discussed through the course of SWSI and the SWSI Basin Roundtable Technical Meetings. However, to date, there is no single agreed upon approach or set of criteria, other than the CWCB instream flow program, for prioritizing stream reaches for environmental and recreational enhancement or setting associated flow goals.

Section 6 also provided background on existing flow goals and key programs geared toward meeting environmental and recreational flows on major rivers and tributaries in each basin. Many of the identified flow goals do not have an associated Identified Project or Process to meet the goals, though some Identified Projects and Processes meet multiple goals that can include environmental and recreational benefits.

Looking ahead, SWSI sought to further identify approaches and possible new projects or management strategies – many of which are stand-alone, many of which could potentially be integrated into multi-beneficiary projects – that could be used to address environmental and recreational water needs. In this section, the key concepts guiding the development of future environmental and recreational "options" are discussed along with some potential statewide approaches to environmental and recreational flow enhancement. Section 8.6 presents a discussion of specific M&I, agricultural, and environmental and recreational options that could be used to meet future needs.

8.5.1 Overview of Environmental and Recreational Options

The primary objectives of the environmental and recreational options compiled and discussed in SWSI are to provide flow and/or habitat enhancement of surface water features – both streams and lakes. Specifically, environmental and recreational options may provide for enhancement of:

- Fish habitat
- Endangered species habitat
- Aquatic recreation
- Water quality
- Wetlands
- Riparian corridors

Some key characteristics and features of these types of options are:

1. Environmental and recreational options are not intended to merely provide mitigation of the impacts of other water supply projects. Mitigation of environmental impacts of new projects is required by law and is already a critical component of project planning. Mitigation is performed to offset potentially deleterious impacts of these projects. Environmental and recreational options, on the other hand, are meant to provide enhancement of resources. As an example, replacing wetlands impacted by a new water supply pipeline is considered environmental mitigation rather than an environmental and recreational option.
2. Environmental and recreational options may be stand-alone projects or may be integrated into other water supply projects (e.g., M&I or agricultural).
3. Environmental and recreational options are to be implemented consistent with state water law and interstate compacts.
4. Environmental and recreational options are subject to NEPA, Clean Water Act (CWA), ESA, and other applicable laws with respect to mitigating unintended adverse impacts of the options.

8.5.2 Existing Statewide Environmental and Recreational Options

The CWCB has an existing program for appropriating, acquiring, and protecting instream flow water rights and natural lake levels. This stream and lake protection program is designed to "preserve and improve the natural environment to a reasonable degree." The CWCB appropriates minimum stream flows or natural surface water levels or volumes for natural lakes to preserve the natural environment to a reasonable degree. The CWCB is also authorized "to acquire, by grant, purchase,

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donation, bequest, devise, lease, exchange, or other contractual agreement, from or with any person, including any governmental entity, such water, water rights or interests in water in such amount as the Board determines is appropriate for stream flows or natural surface water levels or volumes for natural lakes to preserve or improve the natural environment to a reasonable degree." The CWCB protects these instream flow water rights both by obtaining terms and conditions in water rights decrees filed by other water users and by monitoring stream flows and assisting the State and Division Engineers in administering the prior appropriation system so that the CWCB's instream flow water rights are not injured.

Additionally, the passage of Senate Bill 216 in 2001, which recognizes a new type of water right – RICDs – has provided a legal avenue for establishing recreational options.

The presence of endangered fish in basins across the state, as described in Section 3, influences current stream management in accordance with the ESA. Critical habitat designations have been applied to many reaches in the state with corresponding flow recommendations. While these recommendations are not legally binding, water users are making good faith efforts to meet the recommendations. In this way, the ESA has provided for the establishment of environmental options, albeit non-legally binding options.

In addition, interstate compacts and decrees and senior water rights serve to ensure that river flows are maintained. For example, approximately 75 percent of the water in the Colorado River and its tributaries must flow out of the state pursuant to the compact.

8.5.3 Possible Future Statewide Environmental and Recreational Options

Statewide environmental and recreational options are those that are not specific to a stream reach or locality, and that could potentially be applicable in more than one part of the state. Possible statewide environmental options discussed in the SWSI Basin Roundtable Technical Meetings include:

- Sizing of new storage projects to include a dedicated "pool" for environmental instream flow management
- Acquiring by purchase or lease existing water rights to maintain higher instream flows
- Voluntary re-operation of existing projects to enhance environmental benefits without impacting yield
- Releasing reservoir water in a pattern that generally follows "natural" flow conditions; e.g., The Nature Conservancy paper (Richter 1997):
  - Releasing periodic high flows
  - Maintaining average monthly stream flows within ±1 standard deviation of historical average monthly flows

Possible statewide recreational options discussed in the SWSI Basin Roundtable Technical Meetings include:

- New reservoir pool sizing to allow for recreational opportunities
- Developing minimum reservoir pool levels to maintain flatwater recreational appeal
- Voluntary flow management agreements
- Voluntary re-operation of existing projects to enhance recreational benefits without impacting yield
- Establishing new RICDs

The acquisition by purchase and transfer of existing water rights may be necessary for many of the options above. Leases and/or interruptible water supply agreements may also play a role. Water leases provide temporary water rights to users while interruptible water supply agreements refer to agreements whereby water supplies may be interrupted during water short years. Specific environmental and recreational options identified through the SWSI Basin Roundtable process are presented in Section 8.6.

CDOW has identified several "statewide" approaches that could be implemented to address environmental needs, as indicated in Table 8-5. This table also shows a conceptual strategy (the "Three-Species Conservation Strategy") that could be applied to Colorado's Western Slope basins.

Numerical analyses were performed with the WatSIT model, described in Section 7, to illustrate how an environmental option might be quantitatively incorporated into the planning of a new water supply project.

As an illustrative example, Figure 8-7 shows storage to yield curves for a hypothetical reservoir located on Leroux Creek in the Gunnison River Basin. Predicted yield versus storage values are a function of legally available flows for the site (as simulated by the Gunnison River Basin DSS, described in Section 7) and assumed monthly evaporation. Two curves are shown in this figure corresponding to:

Alternative A – A management alternative in which the reservoir is allowed to completely empty.

Alternative B – A management alternative in which a minimum pool volume of 30 percent of capacity is maintained as a recreational option.

Table 8-5 CDOW Statewide and Western Slope Water Management Options

Project	Description	CDOW Priority	State of Implementation
Three-Species Conservation Strategy	Five-State Conservation Agreement and Strategy document(s) for long-term conservation and protection of three native fish populations (bluehead sucker, roundtail chub, flannelmouth sucker)	High	Conservation Agreement between AZ, WY, UT, NM, and CO to be signed in spring 2004. Strategy document draft due Dec. 2004. La Plata and Mancos River roundtail chub broodstocks at Mumma Native Aquatic facility.
Water Quality	Continue to work through State's water quality rule-making procedures to improve standards and classifications for streams and water bodies. ▪ Continue/ improve monitoring data collection, standardization, analyses, and posting; ▪ Continue advising watershed assemblies on water quality and wildlife issues.	High	Ongoing Division of Wildlife participation in WQCC hearings and other local processes to ensure non-degradation and cooperation on wildlife issues.
Dynamic flows	Improve coordination and communication w/ water suppliers so that within operational, institutional, and hydrologic constraints, dynamic releases can be made to simulate natural flow conditions.	Medium	No substantive discussions have occurred to date. Successful implementation in other western river systems and Canada.
Return Flow Mitigation Project	Recognition of connectivity between irrigated agriculture and late-season baseflow and water temperatures. Ensure that changes to agricultural practices (e.g., sprinklers, or type-conversions) do not significantly impair or reduce these benefits.	Low to Medium	No discussions. Inventory of affected areas not compiled and anecdotal to date.
Western Slope: Three-Species Conservation Strategy	Five-State Conservation Agreement and Strategy document(s) for long-term conservation and protection of three native fish populations (bluehead sucker, roundtail chub, flannelmouth sucker) in Arizona, Wyoming, Utah, New Mexico, and Colorado.	High	Strategy document draft due Dec. 2004. La Plata and Mancos River roundtail chub broodstocks at Mumma Native Aquatic facility.

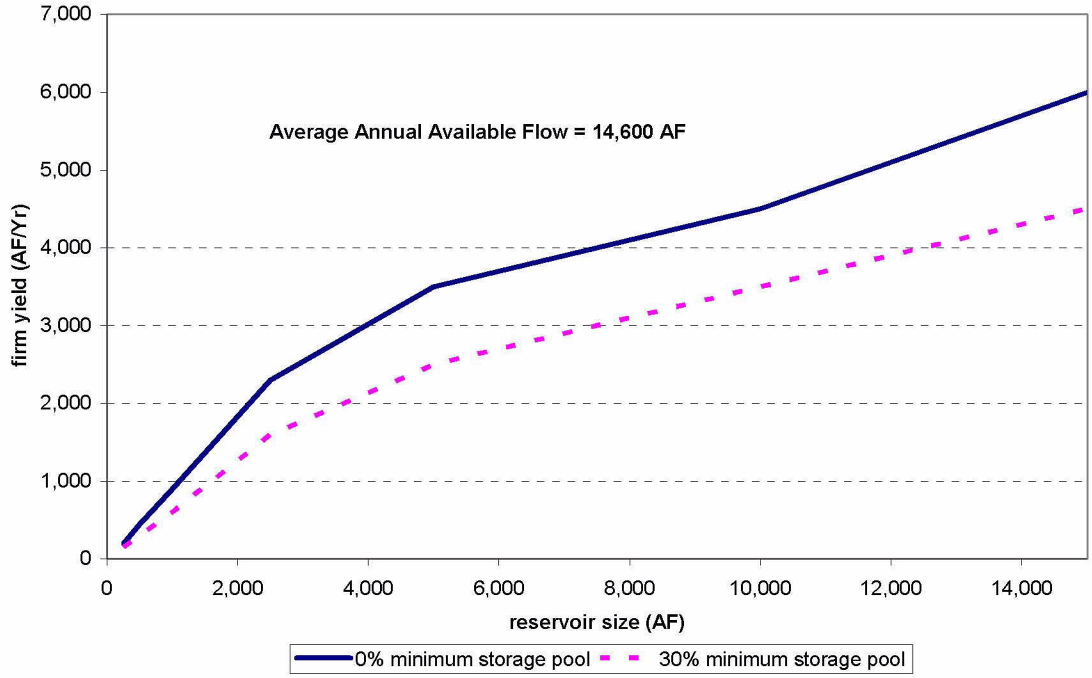

Figure 8-7
Example Storage to Yield Curve for Environmental and Recreational Options: Minimum Pool
Leroux Creek Reservoir - Gunnison River Basin: Agricultural Use

The model simulations show that to achieve a firm yield of 4,000 AFY, for example, without minimum reservoir capacity considerations (Alternative A), approximately 8,000 AF of storage is required. Alternatively, for the same system but with a minimum permanent pool requirement of 30 percent (Alternative B), approximately 12,000 AF of storage is required. The additional storage requirement (4,000 AF) for Alternative B would allow for the capture and storage of a greater percentage of the legally available flows, which can then provide the minimum pool. The acquisition of additional water rights may be required for the implementation of Alternative B. Costing of the two reservoir options could then be performed and assessed relative to the recreational benefits gained from maintaining the minimum pool.

As a second example, Figure 8-8 shows model simulations for a hypothetical reservoir located on Little Bear Creek in the Yampa River basin. Predicted yield curves are again a function of legally available flows for the location, as predicted by the Yampa River basin CDSS. For this analysis, the two curves shown on the figure correspond to:

Alternative A – A management alternative in which no minimum release requirements are maintained.

Alternative B – A management alternative that follows the approach outlined by The Nature Conservancy in the paper "How much water does a river need?" This approach maintains average historical monthly flows, minus 1 standard deviation, downstream of the reservoir.

Minimum release flow values for Alternative B were calculated using legally available flows captured by the reservoir. Model simulations show that, for the environmental Alternative B, significantly larger reservoirs are needed to provide the same firm yield when compared to the alternative without environmental considerations (A). For example, to provide 2,000 AF per year of firm yield, Alternative A requires approximately 2,000 AF of storage, while Alternative B requires approximately 17,000 to 18,000 AF of storage. It is possible for releases from the reservoir for downstream uses can serve a dual purpose and provide for the target environmental flows. This is a site specific issue and is determined by the location of the diversion from the reservoir for the water use.

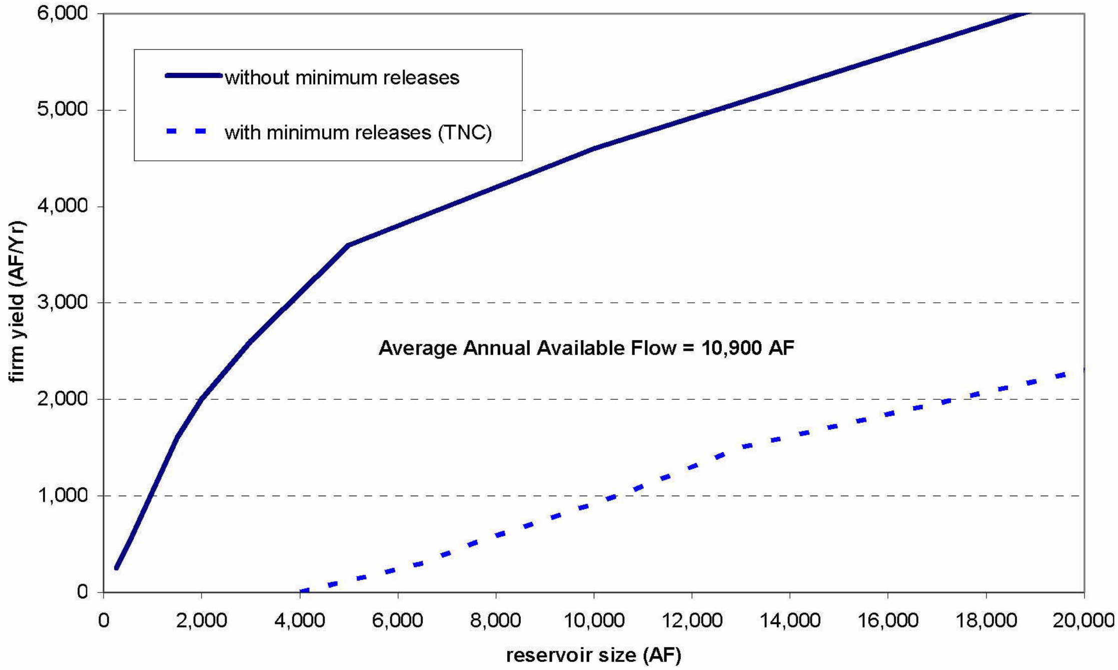

Figure 8-8
Example Storage to Yield Curve for Environmental and Recreational Options: Instream Flow
Little Bear Creek Reservoir - Yampa River Basin: Agricultural Use

Both sets of simulations show that these types of environmental and recreational alternatives are technically feasible with the proper planning. The simulations also show that the potential costs associated with environmental and recreational options may be significant. These costs might be monetary, such as those associated with larger storage requirements, or they might be in the form of yield reductions. While the benefits realized from environmental and recreational options are clear, to date, there is no clearly-accepted or widely implemented mechanism for investing in these types of flow enhancement projects.

8.6 Potential Options for Addressing Remaining Water Needs and Enhancements

Throughout the course of SWSI, using SWSI Basin Roundtable Technical Meetings and Public Information Meetings as forums for discussion, many potential approaches to meeting Colorado's future water needs were identified. Specific options moving forward toward implementation for addressing water needs were categorized as Identified Projects and Processes, as described in Section 8.3.2. Generalized water supply options for meeting future needs are outlined in Section 9. Additional basin specific water management solutions discussed and developed through SWSI are presented for each basin in the sections below.

These solutions are less certain in their implementation, in many cases due to one or more of the following:

- More significant implementation concerns or barriers
- Lack of an identified project sponsor
- Status of development, e.g., conceptual level versus a more defined solution that may be among the Identified Projects and Processes

In the section that follows, specific options are presented that were discussed in SWSI but not categorized as Identified Projects and Processes for each basin. The options include those brought forth and discussed in SWSI for M&I, agricultural, environmental, and recreational uses beyond the Identified Projects and Processes. These options could be used toward meeting the remaining gap in supply for basins and/or uses where the Identified Projects and Processes do not fully address the projected future water needs. Moreover if a percentage of the Identified Projects and Processes are not fully implemented, the options discussed in this section could be used toward addressing the resulting increase in gaps. It is also emphasized that there is not unanimity regarding these options. More dialogue and consensus building would be needed to move these options forward.

As discussed in Section 6.2, the North Platte Basin is not expected to see significant increases in M&I water needs between now and 2030. As noted in Section 5, the North Platte Basin's irrigated agricultural acreage is expected to remain within the amount allowed under the decree. The basin's future demands will primarily be met using existing supplies and water rights, and as such, specific Identified Projects and Processes were not cataloged for the North Platte Basin. As in each basin, opportunities to manage water to enhance the environment and recreational opportunities may exist in the North Platte Basin.

A list of projects or water management options for further consideration in meeting the basin's future water needs is presented in Table 8-6. This list was developed and refined through the series of three Basin Roundtable Technical meetings held in the North Platte Basin, augmented by additional input from the Basin Advisor, Basin Roundtable members, and individual entities throughout the basin.

As noted in the table, each of the water management options brought forth through SWSI for the North Platte Basin revolves around additional storage to firm up water supplies for M&I and agricultural users. In many cases, the options are at a conceptual stage of development and therefore have relatively little information available about their yield or other characteristics. In most cases, additional studies or information would be needed to advance these water management options toward implementation.

Depending on the nature of each of the storage projects, it may be possible to broaden their purpose to include storage and releases for environmental and recreational needs. However, as noted throughout SWSI and in each basin, cost allocation and funding/financing for such modifications and beneficiaries would need to be addressed before these enhancements could be incorporated. In addition, storage limitations under the decree may limit future options.

Environmental and recreational water management solutions were discussed conceptually in SWSI, with many of the concepts aligning with the approaches (such as "conserve, protect, and restore") highlighted in Section 6.1.3. No specific recreational projects were brought forth through the Basin Roundtable process for the North Platte Basin. However, CDOW has proposed an environmental enhancement option for the North Platte Basin. CDOW suggests that expanding Lake John could be accomplished by raising existing dams by 4 feet. This could in turn provide additional augmentation water for the North Platte River and address evapotranspiration losses from the reservoir. CDOW anticipates that this option could then eliminate the problems associated with winter kills of the trophy sport fishery in North Park. Listed as a medium priority by CDOW, this project is conceptual at present, and no project authorization or expansion filing is in place to date.

Table 8-6 Potential Future North Platte Basin Water Management Options

Project	Sponsor	Type of Project	Additional Storage (AF)	Additional Yield (AFY)	Project Purpose and Notes
Forest Management	None	Management Practice	Not Available	Not Available	Increase runoff from national forest.
Coalmont Reservoir	None	Additional Storage	30,000	Not Available	Would improve ag reliability on Little Grizzly Creek for existing agricultural users. Conditional water right abandoned in 2001. Would need financial assistance.
Damifiano/Richland Reservoir	None	Additional Storage	12,000	Not Available	Big Grizzly Creek; Conditional rights abandoned. Could provide supplies for existing agricultural users.
Unnamed Reservoir	None	Additional Storage	50,000	Not Available	Colorado Creek; No existing conditional water rights. Could provide supplies for existing agricultural users.
Case Flats Reservoir	None	Additional Storage	100,000	Not Available	Illinois River; Located on a refuge; Limited supply due to existing reservoirs on Illinois River. Could provide supplies for existing agricultural users.
Willow Creek Reservoir	None	Additional Storage	20,000	Not Available	Willow Creek; No water right; source would be other creeks. Could provide supplies for existing agricultural users.
Unnamed Reservoir	None	Additional Storage	300,000	Not Available	Michigan River; Has been evaluated in past study. Could potentially provide for endangered species flows.
Unnamed Reservoir	None	Additional Storage	550,000	Not Available	North Platte River; May be workable under Compact; Could drop water into Laramie and increase supply to South Platte for M&I use.

Section 9
Options for Meeting Future Water Needs

9.1 Developing Options for Future Water Needs

This section outlines the broad strategies that can be used to address Colorado's water supply needs. These strategies are comprises of different methods or "options" that can be implemented independently or in combination with other options. When several options are combined, the resulting portfolio of options is termed a water supply alternative. A group of individual options that are similar in nature can also be combined into "families of options" as described in the next subsection. Implementation of the Identified Projects and Processes is critical to meeting Colorado's future water demands. Unless these projects and plans move forward, significant additional water supplies, in addition to the remaining gaps projected in Section 8, will be required.

As discussed in Section 8, through the SWSI Basin Roundtable process it was determined that approximately 80 percent of Colorado's future water supply needs can be addressed via projects and processes that are being pursued by local water providers. Water supply options that could be used to address the remaining 20 percent and the uncertainty associated with the Identified Projects and Processes were developed during the SWSI Basin Roundtable process. This section discusses these options and their pros and cons.

9.2 Families of Options

The Identified Projects and Processes listed in Section 8 and additional future options generally fall under one of the following categories, or "families" of options:

- Water Conservation, including:
  - Active M&I Conservation
  - Agricultural Efficiency Measures
- Agricultural Transfers, including:
  - Permanent Agricultural Transfer
  - Interruptible Agricultural Transfer
  - Rotating Agricultural Transfer Fallowing with Firm Yield for Agriculture
- Development of Additional Storage, including:
  - Development of New Storage Facilities
  - Enlargement of Existing Storage Facilities
- Conjunctive Use of Surface Water and Groundwater, including:
  - Bedrock Aquifers
  - Alluvial Aquifers
- M&I Reuse, including:
  - Water Rights Exchanges
  - Non-potable Reuse
  - Indirect Potable Reuse
- Control of Non-Native Phreatophytes

The options included under these categories can be evaluated individually or in combination to help meet the remaining water supply needs for each basin. The likelihood that these options will be successfully implemented and sustainable depends, in part, on the public and institutional support. That support is to a large extent dependent on how well each option meets the SWSI water management objectives. Thus, the above options were evaluated in terms of their performance according to the management objectives and grouped into alternatives.

A brief description of water use in Colorado can help put in context the limitations of some of these alternatives that would produce additional water supplies through increasing the efficiency of water uses. More detail regarding basic provisions of Colorado water law can be found in Section 4. At the start of the SWSI Basin Roundtable process, the overriding objective of compliance with the Colorado water rights system and interstate compacts provided the framework for evaluating potential strategies for meeting future water needs. A primary tenet of Colorado water law applicable to water rights change of use is that return flows resulting from beneficial use of water under an appropriation are "owed" to the stream, where they provide water for subsequent appropriators. This tenet derives from the fact that typically not all the water diverted from the stream is 100 percent consumed. For example, when irrigating crops, water may seep into the ground as it is conveyed through the irrigation canal or infiltrate into the ground once it is applied to the field. Much of this infiltrated water makes its way back to a surface water stream and is then diverted by downstream water users.

Figure 9-1 is a schematic of the return flows from agricultural water use. Under water law, appropriators have a legal right to rely on the continuation of stream conditions in effect when they made the appropriation, including return flows to the stream from diversions made by other appropriators. The result of this pattern of water use is that water in Colorado can be diverted and used and then subsequently rediverted and used many times, as return flows from one irrigator's use of water form the supply for a downstream user's water right. Other benefits of these return flows include the recharge of aquifers. Many domestic and irrigation wells would dry up if groundwater recharge from historical irrigation practices were not maintained. Return flows can also result in improved riparian habitat and more even stream flows, which help maintain year-round fisheries that would otherwise not exist. Thus, for example, many of the small urban creeks that flow through urban areas support riparian habitat and aquatic species as a result of return flows from lawn irrigation and other urban water uses.

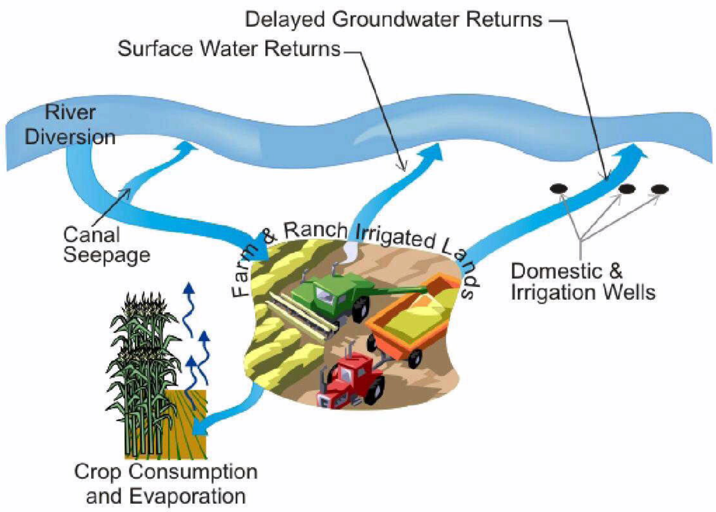

Figure 9-1
Return Flows from Agricultural Use of Surface Water

9.2.1 Conservation

9.2.1.1 Municipal and Industrial Water Conservation

M&I water conservation programs result in improved water use efficiency. M&I water savings occur through the modification of water-using fixtures (e.g., showers, landscapes, cooling towers) and behaviors (e.g., showering time, irrigation schedules, maintenance schedules, etc.). The effects of conservation on M&I water demand are the result of both passive and active water conservation efforts. These conservation efforts, though somewhat unpredictable in their rate of success since they require changes in consumer behavior, can be effective means of reducing water supply needs, with little cost to the community.

Table 9-1 summarizes five levels of water conservation developed during SWSI. Each level shows examples of water conservation programs that a utility or water provider might implement at the given level of conservation effort. In addition, the table indicates an estimated percent reduction in total M&I demand that might result from each level of conservation; and a generalized cost of the water savings at each level. Such generalized savings and costs may vary with the program implementation conditions of each water provider.

- **Level 1 Water Conservation Savings:** This level is defined as water savings that result from the impacts of plumbing codes, ordinances, and standards that improve the efficiency of water use. These conservation savings are sometimes termed "passive" savings because water utilities do not actively fund and implement the programs that produce these savings. These savings occur as new construction and remodeled buildings become more water efficient over time. In addition, landscaping ordinances contribute to these passive savings. Level 1 conservation is included in the SWSI baseline water demand forecast.

In contrast, water conservation savings resulting from utility-sponsored water conservation programs are referred to as "active" savings. The options included as potential future options for SWSI in terms of M&I conservation, correspond to the different levels of active conservation (Level 2 through 5) are described below.

Table 9-1 Active Conservation Matrix

Level	Types of Programs	Percent Reduction in Future M&I Demand				Cost $ per AF
		2000	2010	2020	2030	
1	Plumbing codes	n/a*	2.5%	4.5%	6%	$0
	Fixture standards from National Energy Policy Act					
2	Metering	n/a*	4%	4%	4%	$100
	Leak detection		(6.5%)	(9.5%)	(10%)	
3	All of the above (Level 2)	n/a*	5%	8%	10%	$500
	Education		(7.5%)	(12.5%)	(16%)	
	Rebates for toilets and washers					
	Audits: residential and commercial					
	Landscape audits					
	Increasing rate structure					
4	All of the above (Level 3)	n/a*	10%	15%	20%	$1,000
	Steep pricing rate and surcharges		(12.5%)	(19.5%)	(26%)	
	Rebate for landscape changes					
	Turf replacement & restrictions					
	Rebates for irrigation sensors & controllers					
	Sub-metering of master-meter properties					
	Fixture retrofit upon sale of property					
	Ordinance eliminating single-pass cooling					
5	All of the above (Level 4)	n/a*	15%	25%	35%	$2,000
	Replacement of all inefficient water fixtures & appliances		(17.5%)	(29.5%)	(41%)	
	Eliminate leakage by all customers					
	Eliminate high-water using landscape					
	Install non-water using urinals by non-residential customers					

n/a* The 2000 level of water use implicit in the county gpcd values includes "current" conservation savings.
The percent reduction indicated for Levels 2 through 5 is "above and beyond" the Level 1 reduction; the cumulative percent reduction is shown in parentheses.

Note that emergency conservation programs and short-term drought-response restrictions are not included among these long-term water conservation programs. Temporary drought restrictions include requests for voluntary demand reductions or mandatory water use restrictions during drought conditions. This type of demand modification usually involves drastic, temporary behavioral changes such as not watering the lawn or washing the car. Droughts can also result in permanent water conservation benefits, such as retrofitting indoor plumbing devices with more efficient water saving devices or reducing or eliminating high water use landscaping. During the most recent drought, it was reported that mandatory restrictions resulted in short-term water demand reductions of 20 to 30 percent (Kenny and Klein 2004).

- **Level 2 (Basic) M&I Conservation:** This level of conservation consists of programs for metering and leak detection, and can generally achieve about a 4 percent water demand reduction in addition to the passive conservation reductions. It is assumed that water providers would continue to fund programs to maintain this level of savings in future years, thus the estimated percent reduction is a steady percent.
- **Level 3 (Moderate) M&I Conservation:** This level of conservation typically includes programs for metering and leak detection, education, rebates for water-efficient toilets and washers, and a rate structure that promotes effective water use. This level of effort generally corresponds with implementation of the nine water conservation measures recommended by the CWCB for consideration in Colorado water conservation plans. This level of conservation can generally achieve about 5 percent water demand reduction in the short- to mid-term (10 years).
- **Level 4 (Aggressive) M&I Conservation:** This level of conservation typically includes programs above and beyond moderate conservation, including steep pricing rate and surcharges, rebate for landscape changes, residential and commercial audits, turf replacement and restrictions, rebates for irrigation sensors and controllers, sub-metering of master-meter properties, and fixture retrofit upon sale of properties. This level of conservation can generally

achieve about 10 percent water demand reduction in the short- to mid-term (10 years).

- **Level 5 M&I Conservation:** Program savings are influenced by the level of participation and compliance with a given program. The prior levels of conservation effort (2 through 4) assume a reasonable level of program participation. Level 5 assumes total participation by all customers and is intended to represent a maximum level of effort in water use efficiency. Such a level of conservation is estimated to achieve about 15 percent water demand reduction in the short- to mid-term (10 years).

It is important to note that the matrix shown in Table 9-1 shows *future* conservation potential. The SWSI baseline county water use values of gpcd are based upon year 2000 data and therefore implicitly include the "current" level of conservation effort. One cannot simply apply an assumed level of conservation to a county demand number and expect the referred percent savings, because water providers may be at or above the assumed level of conservation.

It is also important to note that the *realistic* level of future water demand varies by location given the currently implemented or budgeted water conservation programs. For example, Level 3 conservation represents a set of conservation programs similar to what Denver Water has already implemented, as of the base year 2000. Continued implementation of Level 3 programs will further increase market saturation and enhance program savings. Therefore, the future water demand for Denver County should be further reduced by the Level 3 percentages to reflect the future impacts of continuing the *currently* implemented conservation programs. Furthermore, Denver Water is considering for future implementation a set of programs commensurate with Level 4. Thus, if the additional programs are implemented, it would be realistic to further reduce the Denver County demand projections by the difference between Level 3 and Level 4 (i.e., simply apply the Level 4 percent reduction). This would provide a realistic projection of future water demand for Denver County. However, the base period of the SWSI analysis is 2000. Therefore, the level of conservation in the year 2000 is assumed for the *current* conservation level.

In order to develop a more realistic assessment of future water demand throughout the state, the appropriate *current* (year 2000) level of conservation was identified for each county. The classification of the level of effort for each county is subjectively based on a review of available water conservation plans submitted by water providers to the CWCB and survey results collected by the Colorado Municipal League. The resulting classification of each county is summarized in Table 9-2. It is estimated that these current active conservation programs will result in water demand savings ranging from 3 to 14 percent by basin, or an estimated 231,000 AF, by 2030 if the current level of effort is sustained into the future.

Table 9-2 Current Level of Water Conservation Effort

County	Level of Current Conservation Effort - 2000				
	1	2	3	4	5
Adams			✓		
Alamosa		✓			
Arapahoe			✓		
Archuleta		✓			
Baca		✓			
Bent			✓		
Boulder			✓		
Broomfield		✓			
Chaffee		✓			
Cheyenne	✓				
Clear Creek	✓				
Conejos	✓				
Costilla	✓				
Crowley		✓			
Custer	✓				
Delta	✓				
Denver			✓		
Dolores		✓			
Douglas			✓		
Eagle			✓		
El Paso		✓			
Elbert		✓			
Fremont		✓			
Garfield			✓		
Gilpin	✓				
Grand		✓			
Gunnison		✓			
Hinsdale	✓				
Huerfano	✓				
Jackson	✓				
Jefferson			✓		
Kiowa	✓				
Kit Carson	✓				
La Plata			✓		
Lake	✓				
Larimer			✓		
Las Animas			✓		
Lincoln		✓			

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Table 9-2 Current Level of Water Conservation Effort (cont.)

County	Level of Current Conservation Effort - 2000				
	1	2	3	4	5
Logan		✓			
Mesa			✓		
Mineral			✓		
Moffat		✓			
Montezuma		✓			
Montrose		✓			
Morgan			✓		
Otero		✓			
Ouray	✓				
Park	✓				
Phillips	✓				
Pitkin			✓		
Prowers		✓			
Pueblo		✓			
Rio Blanco	✓				
Rio Grande	✓				
Routt		✓			
Saguache	✓				
San Juan	✓				
San Miguel	✓				
Sedgwick			✓		
Summit		✓			
Teller			✓		
Washington	✓				
Weld		✓			
Yuma		✓			

Source: survey by Colorado Municipal League.

9.2.1.2 Evaluating New Supply from M&I Water Conservation

The ability to develop new supplies from water conservation or to carry over conserved water for later use is dependent on the type of water rights used. The potential for conservation must be evaluated on an individual M&I water provider basis, considering the types of water rights owned and the return flow obligations that apply to these water rights. Figure 9-2 illustrates the M&I return flow cycle for surface water diversions. The benefits of water conservation include:

- Implementation costs can be significantly lower than new water supply development or other alternatives.
- There are no permitting requirements to implement water conservation.
- Implementation is within the control of the local water provider and does not require approval of other entities.
- No new diversions are required from rivers or streams.
- Existing water supplies can be stretched to supply demands of new growth.
- Lesser environmental impacts than new water storage development.
- Can reduce water and wastewater treatment, distribution, collection, capital, and operations and maintenance costs.

Some of the issues involved in evaluating the net available water supply produced from M&I water conservation are:

- M&I direct flow water rights cannot be stored or carried over for drought periods (absent a change of use proceeding in water court), thus conserving water and reducing the demand on direct flow rights may not create reliable supply to meet new demands (for example for new growth.)
- CU water rights, such as transbasin, non-tributary, groundwater, or CU agricultural transfers, on the other hand, can be stored. If the overall demands on CU supplies can be reduced, the "saved" water can be used to meet the demands of new growth, improve reliability or both, if adequate storage is available to carry over the conserved water for use in drought periods.
- Many M&I water users have substantial agricultural rights that provide for the diversion of the entire historical amount of irrigation use as long as CU is not increased and historical return flows are maintained.

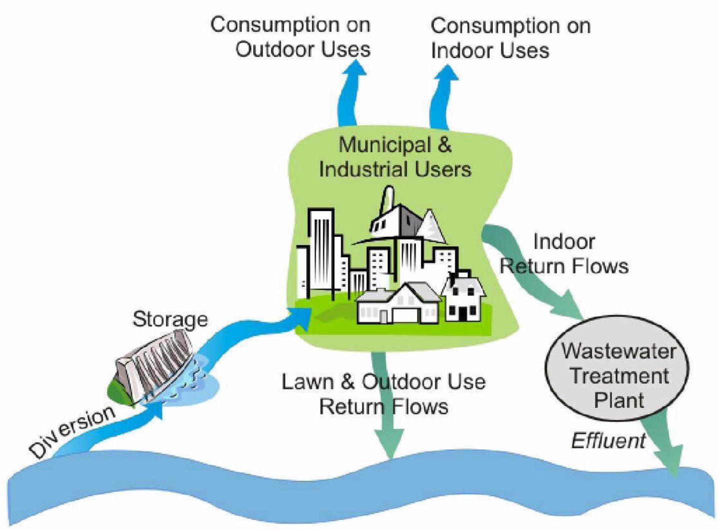

Figure 9-2
Return Flows from M&I Use of Surface Water

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In these instances, wastewater returns and return flows from lawn irrigation have been quantified and may be used to maintain historical return flows such that historical CU is not increased. Conservation that results in reduced volumes of wastewater or lawn return flows can require M&I users to acquire additional water supplies to maintain these historical returns.

- Augmentation plans can be developed that account for wastewater and lawn return flows, and only require that the M&I CU be replaced. As a result, conservation would not result in an increase in supply unless the M&I CU is reduced, such as through the reduction in total irrigated areas of lawn. The assumed CU is usually decreed in an augmentation plan and as a result, any attempt to use conserved water would require a re-opening of the augmentation decree to re-quantify CU. This action would likely be costly and could present a high level of risk to the water provider.
- M&I landscape irrigation return flows, in addition to satisfying downstream rights, also creates delayed return flows than can have instream and riparian environmental benefits, and maintains aquifers for domestic and irrigation wells.

9.2.1.3 Agricultural Conservation (Efficiency Improvements)

Agricultural conservation or agricultural efficiency implementation is a means to create new water supply that must be carefully evaluated since Colorado water law and interstate compacts may limit or preclude the use of this option to increase supply. This option involves increasing the efficiency of water used for irrigation, so that more of the water that is diverted from streams and rivers or pumped from groundwater meets the direct CU needs for agricultural crops. Typical agricultural efficiency measures include canal lining or the conversion of irrigation practices and technology from flood irrigation to gated pipe or the installation of sprinklers or drip irrigation systems. These measures are designed to reduce the delivery losses that occur as water is diverted from a stream or as groundwater is pumped and delivered to the farm or ranch or as it is applied to the crops.

Table 9-3 shows the range of expected application efficiencies for different types of irrigation practices and the approximate costs to install these irrigation delivery systems.

Table 9-3 Estimated Efficiencies and Costs for Irrigation Methods

Type of Irrigation	Range of Efficiency	Average Capital Cost/Acre	Average Annual Cost/Acre
Flood	30-50%	—	—
Furrow	40-60%	$37	$30
Gated Pipe	~60%	$178	$51
Center Pivot Circle	~85%	$433	$64
Center Pivot with Corner	~85%	$568	$80

The benefits of agricultural efficiency measures include:

- Increased ability to deliver water to the crops can stretch existing supplies. This benefit would apply to water short irrigators that would benefit if additional water could be delivered to their crops. If the irrigator that has water short crops typically experienced 50 percent losses, reducing those losses will result in an increased delivery to the water short crops and a resulting increase in crop CU.
- Agricultural efficiency may reduce non-crop CU. Some of the CUs and losses may be due to tailwater from irrigation ponding at the end of fields and evaporating, rather than returning as surface or groundwater return flows.
- There may be potential water quality benefits. Canal seepage and/or flood or furrow irrigation may result in the leaching of minerals from the soils that result in impacts to the water quality of the return flows. Lining canals or the installing sprinklers may reduce the leaching of these minerals. This must be examined on a site-specific basis, as some irrigated fields may require periodic flushing of salts and minerals that accumulate in the soils in order to remain productive. The benefits of these improvements accrue to many, and programs like the Colorado River Salinity Control Program exist to encourage these types of improvements.
- No new diversions are required from rivers or streams.
- Permits are not required for implementation.

There are a number of potential issues and conflicts that must be evaluated for the potential implementation of agricultural efficiency measures.

- Historical agricultural return flows are a vital part of the flows in all basins and downstream surface water diverters and downstream states have relied on these return flows.

- These return flows, in addition to satisfying downstream water rights, also create delayed flows that can have instream and riparian environmental benefits and maintain aquifers for domestic and irrigation wells.
- Typically, any water that is saved by efficiency measures such as canal lining or the conversion of irrigation practices and technology from flooding to gated pipe, center pivot circle, and center pivot with corner can only be used on lands for which the appropriation was originally made. Selling or delivering "saved" water to other users would constitute an improper expansion of use.

9.2.2 Agricultural Transfers

Agricultural uses currently account for more than 80 percent of the water diverted and consumed in Colorado. Many agricultural users hold senior water rights that can potentially be changed in use to provide a significant source of M&I water supply. In agricultural transfers, farm land is usually "dried up" or no longer irrigated and the water historically used for irrigation of this land is used for meeting M&I or other needs, such as dedication to CWCB for instream flow purposes.

Section 4 of this report describes the general background of agricultural transfers. The total water available under a change of agricultural water rights typically depends on the historical CU of the water for agricultural purposes: this is a measure of the water right for transfer. In addition, the yield of an agricultural water right may depend upon the location of the new use of the water. For example, in general, if the water is to be diverted through the same ditch system as historically, a transfer to M&I use may allow diversions of all of the water previously diverted at the historical farm headgate though the historic CU cannot be increased. The water that may be diverted on a transfer of water from an agricultural use to one out of the basin will be limited to the historical CU. Meanwhile the historical return flows must be maintained; storage may be needed to ensure that other water rights that historically relied on return flows are protected. After the historical return flows have been replicated, it is legal for the transferred "consumable" water to be used and reused to extinction. A graph illustrating the yield from an agricultural transfer project, shown in conjunction with the reuse of a portion of the return flows used for M&I irrigation of landscaping, is provided in Figure 9-3.

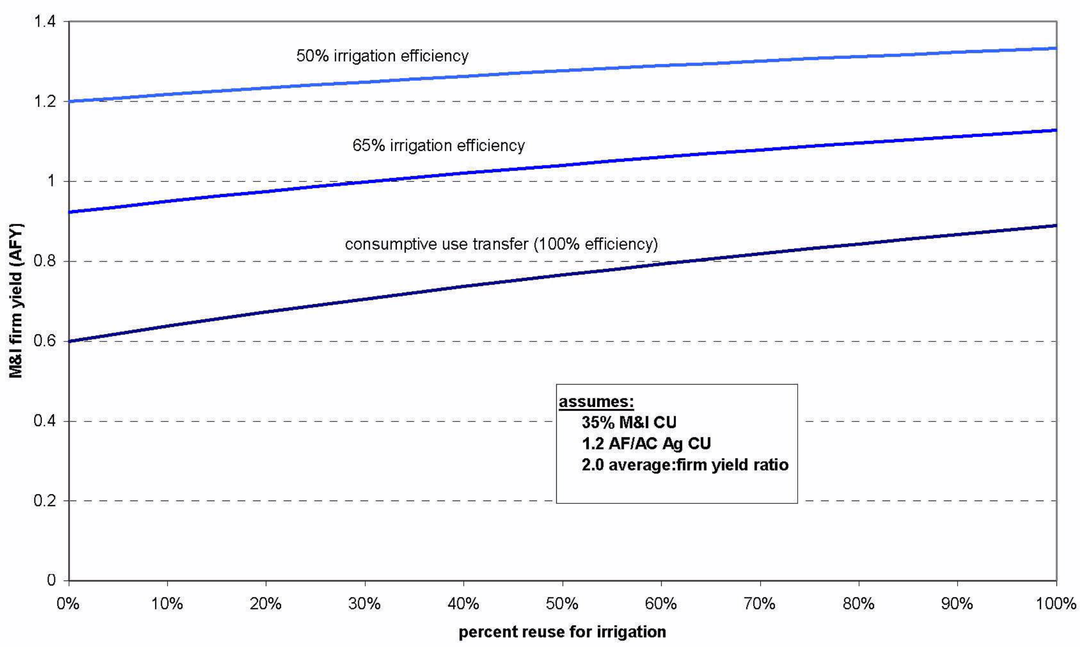

Figure 9-3
Firm Yield to M&I User from the Dry Up and Transfer of 1 Acre of Irrigated Agricultural Water Use

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In some areas of the state, and particularly the Front Range, agricultural transfers are commonly used to develop supplies to meet M&I needs, and are important options included in the SWSI process. Three types of agricultural transfers are discussed: permanent, interruptible, and rotating.

9.2.2.1 Permanent Agricultural Transfers

Permanent agricultural transfers involve the permanent acquisition of agricultural water rights, the cessation of irrigation on the historically irrigated lands (dry up), and the transfer or change of a water right to M&I or other uses, such as dedication to the CWCB for instream flow purposes.

The benefits of permanent agricultural transfers include:

- A permanent water right is acquired and future uncertainty over future water supply availability is reduced.
- Agricultural water rights generally have more senior priorities; these senior rights provide a more reliable supply since the water right will be in priority for longer periods than a junior or new water rights filing. Less storage is required to produce a firm annual yield than from new in-basin water supply development projects with junior water rights.
- Permitting may be simpler for such transfers than for development of a new water supply project, since the agricultural water to be acquired has already been diverted from the stream system and a portion consumed. This can result in a higher level of certainty than construction of a new reservoir storing junior water rights, where environmental issues and the effects of new depletions will be evaluated.
- Overall basin depletions are not increased.
- Return flows from the historic CU are consumable and can be reused.
- Lesser environmental impacts than a new water storage project.

Permanent agricultural water transfers, though widely practiced in certain areas of the state as a water supply option for M&I users, have several potential issues and conflicts:

- Localized socio-economic impacts result from dry-up of agricultural lands. Irrigation of agricultural lands has historically resulted in the development of a local economy. In addition to supporting the farmer or rancher, associated economic benefits of the irrigated agriculture may form the basis of the entire economy of the local community. Permanent dry-up of lands may have a significant negative effect on the local community unless the irrigated lands are converted to other uses such as residential, commercial, or industrial.
- Dry land has a substantially lower assessed value than irrigated agricultural land. In Colorado, unless the farm or ranch has development potential, much of the value of a farm or ranch may be derived from the water rights. Once the water rights are transferred and the land no longer irrigated, the assessed value is reduced significantly. This results in a significant loss of tax base to the local governments and school districts.
- A water court procedure is required to change the use of agricultural water rights. This procedure can be a very lengthy and expensive process, and is not without risk.
- Revegetation of formerly irrigated lands is required by law under certain circumstances. Colorado statue, in some instances, requires that an entity transferring and permanently drying up irrigated lands ensure that the land is revegetated with plants not requiring supplemental irrigation. This can be a difficult and costly process.
- Continued agricultural use of lands maintains the open space nature of the property to the benefit of the general public. If water is transferred from irrigated lands, the land may be more susceptible to development for other uses, since agricultural use will be harder to support.
- There is a potential loss of wetlands and riparian habitat. Return flows from irrigated agriculture often result in the creation of local wetlands and riparian habitat.
- Approximately 2 to 3 AF of storage is required to produce 1 AF of firm annual yield for M&I use. Agricultural transfer yields are not, by themselves, firm since they are typically seasonal and susceptible to drought conditions. Storage is needed to carry over agricultural supplies from the irrigation season to the non-irrigation months and to ensure that adequate water can be stored in average to above average runoff years for use in below average years.
- Return flows from agricultural lands may provide important seasonal instream flow benefits, the timing of which may be altered by a transfer. Flood irrigation

of mountain meadow hay fields often result in delayed return flows of high quality, cold water, supporting aquatic habitat in the late fall and winter months.

- There is a potential impact on groundwater tables and wells in the area unless historical returns are made in the exact location. Many domestic and irrigation wells are kept viable by the return flows from irrigation.

9.2.2.2 Interruptible Agricultural Transfers

Interruptible agricultural transfers consist of temporary arrangements where agricultural water rights can be used for other purposes. The agreement with agricultural users allows for the temporary cessation of irrigation so that the water can be used to meet other needs.

Interruptible agricultural transfers offer several benefits:

- A permanent transfer of agricultural water rights may not be needed, avoiding some of the negative impacts of a permanent dry up of agricultural lands.
- Interruptible agreements are useful during below average runoff conditions, when the available supplies to meet M&I, environmental, or recreational needs are reduced. The need to construct significant volumes of new storage to carry over water from average to above average runoff years for use in below average years can be minimized.
- Since agricultural water rights are often more senior, the temporary transfer of this water to other uses can result in meeting an M&I, environmental, or recreational need during critical dry periods without the expense and issues of a permanent agricultural transfer or the development of storage or an expensive new water supply project.
- A better or more stable income to agricultural users can be assured, since during a drought supplies may not be adequate to produce a crop, even if the agricultural water right were used for irrigation and the net income from an interruptible arrangement can exceed the revenue that would be realized from farming that year.

There are numerous potential issues and conflicts with interruptible transfers that may limit the usefulness of this option as a tool for meeting future water needs:

- One premise of an interruptible supply arrangement is that the agricultural water right will remain in irrigation in perpetuity. An interruptible arrangement will be of very limited benefit to meet long-range water supply needs unless the interruptible supply arrangement is permanent and the farmer is bound to keep the water in agricultural use.
- Interruptible agreements must be evaluated on a case by case basis, as not all agricultural rights can be transferred to M&I water use. For example, interruptible transfers are very limited in the Denver Metro and South Metro subbasins of the South Platte, where there is very little agricultural water use that can be interrupted on an annual basis and transferred to existing M&I intakes.
- The agricultural rights involved in the interruptible transfer must have dry year yields. Many agricultural water users also experience significant shortages during below average runoff conditions and these supplies may be of little benefit in a dry year.
- The determination of the transferable amount can be complicated; as in a water transfer the rights of those other water users must be protected. There must be a mechanism to ensure that the transfer does not result in an increase of historical CU and return flows are maintained during the temporary interruption. CRS 37-9-309 allows the State Engineer to approve and administer interruptible transfers under certain conditions. Otherwise a change of water right will be required.
- Soil, weed, labor, and equipment management issues must be considered during those periods when the interruptible transfer is occurring and there is no irrigation. A farm operation involves not only the planting, irrigating, and harvesting of crops, but the hiring of labor and maintenance of equipment. In addition, the management of soil erosion and weed growth will be issues on irrigated fields that are temporarily dried up.
- Some agricultural crops, such as orchards, vineyards, and some hay crops are difficult to fallow and may not be appropriate for an interruptible transfer.

9.2.2.3 Rotating Agricultural Transfers with Storage to Firm Agricultural Demands

A third concept was developed during the SWSI Basin Roundtable process in an attempt to capture the benefits of a permanent agricultural transfer without the negative impacts. This concept, rotating agricultural transfers with storage to firm agricultural supply consists of a type of interruptible agricultural transfer arrangement involving several agricultural parties and one or more M&I users. Each agricultural user would agree not to irrigate for 1 year out of a set period of years corresponding to the number of agricultural users in the program making the flows available to M&I users. For example, if 10 agricultural users joined the arrangement, each would take their turn not irrigating in 1 year out of 10. The M&I user would obtain a constant annual yield, with this yield coming from a different agricultural user each year. An additional element would be to set aside of a portion of the water from the agricultural lands not irrigated in each year to be placed into storage to firm the yield to the agricultural users that are part of the agreement. This agricultural firming pool would be used in below average years to increase the yield for those agricultural users that are irrigating that year.

The benefits of this rotating agricultural transfer approach include:

- M&I reliability is improved since there is a guaranteed additional supplemental supply of water each year.
- A better or more stable income can be provided to agricultural users, since an income would be guaranteed during the fallowing year and the firming of agricultural yield will result in a more predictable farm yield during a drought.
- A permanent transfer of agricultural water rights may not be needed, avoiding some of the negative impacts of a permanent agricultural transfer.
- Maximizes the benefits of a non-tributary groundwater conjunctive use program. Non-tributary, non-renewable groundwater has a firm annual yield that does not vary from wet to dry years as long as the resource is not significantly depleted. The life of this groundwater resource could be extended by relying on a rotating agricultural fallowing program in average to above average years and pumping groundwater only during below average years. In these below average years, the yield from the rotating fallowing can be used to firm the yield of the agricultural users that are irrigating during those years.

Potential issues and conflicts with rotating agricultural transfers include:

- As for other interruptible supply arrangements, the lands involved remain in irrigation in perpetuity. The agricultural users would need to bind themselves to continue agricultural irrigation use and to fallow the land for a year as required.
- This may be more expensive approach than a permanent agricultural transfer. Incentives would need to be significant to induce an agricultural user to forego the right to sell the water in the future. Annual payments would be required for the agricultural users that are fallowing each year. In addition, the transaction costs to assemble a suitable program could be significant.
- Some agricultural crops, such as orchards, vineyards, and some hay crops are difficult to fallow and may not be appropriate for a rotating fallowing program.
- Agricultural supplies under a rotating program may not be in the needed location or of sufficient quantity. The water from the fallowed lands must be transferred to the M&I water supply intakes if the yield is to be used for this purpose rather than instream needs.
- A change of use from agricultural to M&I or other uses would likely be required. Determination of the transferable amount can be complicated and other water users must be protected. Legal and engineering costs will be incurred.
- Soil, weed, labor, and equipment management issues must be considered for the fallowed lands. A farm operation involves not only the planting, irrigating, and harvesting of crops, but the hiring of labor and maintenance of equipment. In addition, the management of soil erosion and weed growth will be issues on irrigated fields that are temporarily dried up.
- Storage would be required to firm the yield for all parties. M&I users would need storage to carry irrigation season water over to the non-irrigation months and storage will be needed to firm the agricultural supplies and provide for the replacement of delayed return flows from the fallowed lands.

9.2.2.4 Water Bank

In addition to permanent agricultural transfers, water banks have been authorized by the Colorado legislature. A pilot program was established in the Colorado Basin. The water bank provides a mechanism for leasing water on a short-term basis without permanently transferring a water right to another user. Entities with stored water rights have the options to lease their water during times of drought or when it will not be put to beneficial use.

The benefits of water banks include:

- Water supplies are improved for users acquiring water from the water bank.

- Agricultural use can be preserved by allowing alternative uses on an interim basis, without a permanent dry up.
- A better or more stable income to agricultural users can be provided, since the net income from a lease can exceed the revenue that would be realized from farming in a dry year.
- Provides for flexibility in water management, as there is a free market mechanism through which water supplies can be transferred within a basin.

The potential issues and conflicts with the use of water banks for meeting future water needs include:

- Water may not be available from the water bank when needed. There is no guarantee or requirement for a party to place its water in a bank.
- Determination of transferable amount can be complicated and other water users must be protected.
- Soil, weed, labor, and equipment management issues must be considered during those years when irrigation is not occurring.
- Challenges in starting a market. An entity needs to be responsible for implementing advertising and maintaining the Bank.

9.2.3 Development of Additional Storage

Storage projects capture water during high flow years and seasons to be used during low flow periods. These storage projects include the construction of new reservoirs, enlargement of existing reservoirs, or rehabilitation of existing reservoirs that have reduced storage volumes due to various structural problems (e.g., spillways unable to meet the current probable maximum flood criteria, etc.). Storage options included in the SWSI process include the construction of new storage facilities to capture legally available flows under a new water rights appropriation, the construction of new storage facilities to maximize the yields of existing water rights, including exchange priorities and conditional storage rights, and the enlargement of existing reservoirs. The rehabilitation of existing reservoirs that are under voluntary or mandatory storage restrictions was evaluated during the SWSI Basin Roundtable process. It was determined that while there are many reservoirs with restricted capacities, the total potential storage to be gained from rehabilitation efforts is small in comparison to Colorado's overall need. This issue is discussed in greater detail for the North Platte Basin in Section 8.

9.2.3.1 New Storage Projects

New storage projects include the construction of dam embankments to create on-channel or off-channel reservoirs. Off-channel reservoirs require the construction of diversion or pumping facilities from the river or stream to deliver the diverted water to storage. Another option for the development of new storage is the conversion of gravel pits to gravel lakes. These lakes are formed by reclaiming and lining pits created through gravel mining operations. Diversion or pumping facilities are also required to deliver water to gravel lakes. Storage options will vary greatly in their feasibility, and project considerations, such as firm yield, capital costs, and permitting are site specific.

The benefits of developing new storage projects include:

- Water sources will be diversified if the water to be stored is from a new source. This can reduce the risk of supply shortfalls as not all water sources may experience shortages at the same time.
- The development of storage to capture unappropriated water can potentially reduce the pressure to transfer water from existing uses (i.e., agricultural water) to meet future water needs.
- The reliability of the overall water supply system can be increased and the risks reduced. The development of additional new storage can help protect against potential water shortages due to structural failures such as storage restrictions or the temporary inability to use a supply due to water quality concerns such as those associated with a forest fire in the watershed.
- Existing water rights are not affected if the water to be stored is under a new water right.
- The development of storage for unappropriated water captures an unused resource.
- The development of storage maximizes compact entitlements for beneficial use within the State of Colorado.
- Overall system efficiencies are increased by minimizing system spills.
- The yields of exchanges and non-potable reuse for irrigation are increased. Maximizing the reuse of consumable return flows requires storage, since return flows occur year-round, but reuse for irrigation only occurs during the summer months.
- Storage is required to firm the yield of transfers of agricultural water rights. If storage is not constructed,

additional agricultural water rights will be needed to ensure adequate supply during below normal runoff conditions.

- New reservoirs provide flat water recreation opportunities. Boating, swimming, and lake fishing opportunities are increased.
- Storage often provides consistent flows below the storage facility that can provide ideal cold water fishery habitat. Many of the Gold Medal fisheries in Colorado are below storage facilities.
- There is the potential for hydropower generation.

The potential issues and conflicts in developing new storage projects include:

- There may be environmental impacts to the aquatic and terrestrial environment. These impacts are likely to be more significant than those resulting from enlarging existing storage facilities.
- Loss of recreation associated with free-flowing streams, such as fishing, rafting, and kayaking.
- Water quality impacts can be associated with impounded water.
- Cultural impacts associated with inundation of lands.
- Permitting and mitigation can be more expensive and lengthy than other water supply options and have an uncertain outcome.
- A significant amount of storage may be required to produce an acre-foot of firm yield. The amount of storage required will be basin and water rights specific.

9.2.3.2 Expansion of Existing Storage Facilities

The expansion of existing storage facilities can be a cost-effective means to develop additional storage. Options for increasing storage in existing facilities include raising dam embankments, dredging of sediments, and deepening reservoirs and raising spillway levels.

The expansion of existing storage facilities has several benefits including:

- There are likely to be less environmental and recreational issues than for new storage, since the reservoir already exists.
- Permitting and mitigation requirements may be less difficult than for construction of a new storage facility.
- Existing water rights are not affected if the water is to be stored under a new water right.
- The expansion of storage to capture unappropriated water can potentially reduce the pressure to transfer water from existing uses (i.e., agricultural water) to meet future water needs.
- The expansion of storage for unappropriated water captures an unused resource.
- The expansion of storage helps to maximize compact entitlements for beneficial use within the State of Colorado.
- Overall system efficiencies are increased by minimizing system spills.
- The yields of exchanges and non-potable reuse for irrigation are increased. Maximizing the reuse of consumable return flows requires storage, since return flows occur year-round, but the demand for irrigation is seasonal.
- Storage is required to firm the yield of transfers of agricultural water rights. If additional storage is not constructed, additional agricultural water rights will be needed to ensure adequate supply during below normal runoff conditions.

The potential issues and conflicts in expanding existing reservoirs include:

- Environmental and recreation impacts can also occur here depending on the size of facility.
- Expanding existing storage facilities does not diversify water sources and the risks of structural failures or water quality catastrophes are not reduced.
- Permitting and mitigation, though typically less difficult than that for new storage, can still be expensive and lengthy with an uncertain outcome.
- A significant amount of storage may be required to produce an acre-foot of firm yield. The amount of storage required will be basin and water rights specific.
- There are a limited number of reservoirs that can be enlarged. Many reservoirs are not cost-effective to enlarge.
- There is a limited volume of increased storage available through reservoir enlargements.
- The enlargement of existing reservoirs may not be cheaper than new storage. The original dam embankments and spillways, in many instances, were

not designed or constructed to current engineering standards. Upgrading the existing facilities to be compatible with an enlargement may not be cost-effective.

9.2.4 Conjunctive Use of Surface Water and Groundwater

Colorado's groundwater supplies are abundant but are limited in many areas by physical or legal availability or economic feasibility issues. Physical limitation affects the reliability and sustainability of groundwater as a source of supply. Physical availability measures the amount of water an aquifer can produce, both in the short- and long-term, and primarily affects the sustainability of the resource. Legal availability relates to the amount of water that can be extracted from an aquifer under the water rights administration system that exists in a particular area, and can affect the reliability of the supply.

In the context of water supply, aquifers can be categorized as being renewable or non-renewable. Aquifers that are located adjacent to rivers in the alluvial floodplain deposits usually have a hydrologic interaction with those rivers, and dynamically get water from or discharge water to the rivers throughout their reaches. Aquifers of this type are referred to as tributary aquifers. They usually are unconfined aquifers that are relatively shallow. Tributary aquifers are considered to be a renewable source of water since they are hydrologically linked to renewable supplies such as precipitation and infiltration of surface water.

The other category of aquifer, non-renewable, is one that is not replenished from renewable sources such as rivers or infiltration of rainfall. Non-renewable aquifers generally are located deep below the land surface, in consolidated bedrock deposits, and would be classified as confined aquifers. A non-renewable aquifer may be capable of producing water reliably under varying climate conditions (wet and dry years); but it may only last 50 to 100 years and would therefore not be considered a sustainable resource. Recharge of non-renewable bedrock aquifers is very slow and withdrawal rates usually exceed recharge. As water levels decline in a non-renewable aquifer additional wells would be required to maintain a given pumping rate. These non-renewable aquifers are unreliable as a permanent, sustainable water supply.

Conjunctive use of surface water and groundwater can maximize the benefits and reliability of both surface water and groundwater sources of supply. In its simplest form, conjunctive use involves using surface water when surface supplies are ample, such as during average to above average runoff conditions, and recharging aquifers with available surface water. When surface water supplies are in short supply, such as during below average runoff conditions, groundwater supplies would be used to a larger degree to meet demands. Both bedrock and alluvial aquifers can be used in a conjunctive use water supply operation by serving as a water storage bank. Deposits are made in times of surface water supply surplus and withdrawals occur when available surface water supply falls short of demand.

9.2.4.1 Bedrock Aquifer Conjunctive Use

Bedrock aquifer conjunctive use involves capturing and using surplus surface water supplies for immediate use or injecting these surplus surface water supplies into the bedrock aquifer through wells. The intent is to extend the life of non-renewable groundwater sources.

The benefits of bedrock aquifer conjunctive use storage and recovery include:

- Maximizes the benefits of bedrock aquifers and extends their long-term reliability. The use of surplus surface water supplies can reduce the need to withdraw non-renewable groundwater. The recharge of the aquifer extends the life of the groundwater reserve.
- Evaporation is minimized. Once the water has been recharged, there is no additional evaporation as compared to surface water storage.
- There may be fewer environmental impacts than surface reservoir storage.
- Requires less surface area for water storage.
- The permitting process is simpler than for developing surface water storage.
- Existing infrastructure designed for peak demands can be used during non-peak demand periods. Existing wells developed to meet peak demands can be used as injection wells during non-peak periods.
- Potable quality water can be withdrawn. Most bedrock aquifers are of potable water quality and do not require water treatment except for disinfection.

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- Fewer risks of contamination and disruption of supply. Being far below the surface insulates the supply from contamination and since aquifer supplies would typically be extracted using multiple wells there is redundancy built into the system.
- Significant volumes of potential aquifer storage are available. Most of the major bedrock aquifers in Colorado have significant volumes of storage.

Issues and conflicts with implementation of bedrock aquifer conjunctive use include:

- Surface water supplies must be available for recharge.
- The surface water diverted for recharge to a bedrock aquifer must be treated both to potable water quality and must be chemically compatible with the native aquifer groundwater so that dissolved constituents do not precipitate and clog the aquifer.
- All of the recharged water may not be recoverable.
- Recharge rates for non-tributary aquifers often are low.
- High energy costs are incurred for aquifer recharge and pumping.
- May require the construction of specialized wells or refitting of existing wells that can be used to both inject and pump water. Such wells are referred to as aquifer storage recovery wells, or ASR wells.
- There may be a need for additional infrastructure (wells, surface water storage, and water treatment) constructed to meet peak demands.
- Additional surface storage may be needed to capture peak surface water flows that would be used later to recharge the aquifer. Surplus supplies are normally available during peak runoff periods, which can be when water demands are highest and existing wells will not be available for recharge.

9.2.4.2 Alluvial Aquifer Conjunctive Use

Alluvial aquifer conjunctive use involves diverting surplus surface water supplies and recharging the alluvial aquifer. Recharging is typically accomplished by canal infiltration or spreading basins, and then pumping the groundwater when needed as a source of supply or when the timing of accretions to the river system is needed to meet demands (for example, stream depletion requirements or streamflow enhancements). The benefits of alluvial aquifer conjunctive use include:

- Maintains high groundwater levels, benefiting wetlands, nearby streams and other nearby surface water features.
- Evaporation is minimized. Once the water has been recharged, there is no additional evaporation as compared to surface water storage.
- There may be fewer environmental impacts than for surface reservoir storage.
- Often requires less land for water storage.
- The permitting process is simpler than developing surface water storage.
- Streamflows can be diverted and recharged without additional treatment costs.
- Existing structures can often be used for recharge, such as river diversion structures and canals.
- Recharge can occur with low capital and operating costs since the recharge can occur through ditch or pond seepage as opposed to pumped injection.
- Tributary aquifers usually have a high recharge rate.
- Significant volumes of potential aquifer storage are available.
- Can be used to regulate streamflows for environmental enhancements. Timing the stream accretions from alluvial recharge can occur so that the water is accreted to the stream to benefit the environment.
- Can be used to augment agricultural well pumping. Timing the accretions from alluvial recharge can occur so that the water reaches the stream to match and augment depletions from agricultural well pumping.

Issues and conflicts with implementation of alluvial aquifer conjunctive use and storage and recovery include:

- Surface water supplies must be available for recharge.
- May lead to high water table conditions, which could reduce infiltration rates and be potentially damaging to nearby structures.
- The water quality may be degraded during recharge as additional salts and minerals may be leached during the infiltration.
- Advanced water treatment may be required if the recovered water is used for potable purposes. Alluvial

aquifers are also recharged by agricultural and urban return flows and may be high in salts, minerals and nitrates. Advanced water treatment techniques, such as reverse osmosis, are commonly used to treat alluvial aquifer water for M&I use. The disposal of the waste streams from reverse osmosis treatment can be very expensive.

- The recharged water will eventually return to the river system if not used or recaptured, and so may not be recoverable when needed.
- Additional wells may need to be constructed to meet peak demands.
- Storage may need to be developed to capture peak surface water flows that are used for later recharge.
- A water court approval process, which may be lengthy and expensive, is required.

9.2.5 Municipal and Industrial Reuse

M&I reuse involves a second or consecutive uses of consumable water supplies that have first been used to meet municipal or industrial needs but not fully consumed. The first aspect important to understand in reuse projects is the consumptive and non-consumptive components of water use. Water use is generally divided into CU (i.e., water that is in effect consumed and eliminated from the system) and non-CU (i.e., water returning to the system after use by infiltration into the ground, or water returning to the system as effluent from wastewater treatment plants after use in households). Reuse projects seek to recycle that portion of the water not consumed.

M&I consumable return flows can be reused through several methods. Three general types of reuse projects were included for consideration in the SWSI process: water rights exchanges, non-potable reuse and indirect potable reuse.

9.2.5.1 M&I Reuse by Water Rights Exchanges

M&I reuse by water rights exchanges involves the exchange of legally reusable return flows for water diverted at a different location. Water is diverted at one source in exchange for water replaced to downstream users from a different source. In an M&I reuse exchange, the amount of non-CU water returned to the system, e.g., via effluent flows and/or return flows from landscape irrigation, depends on the CU associated with the demand (i.e., the higher the CU, the lower the percent of total diversions that can be reused).

The non-CU water can be reused multiple times, theoretically to extinction, with the total available water reduced with each application, since each time the water is diverted for reuse, a portion of it is consumed by the use. A schematic illustrating the exchange of consumable return flows is shown in Figure 9-4.

The increases in yield that can be achieved through the successive use and reuse of the return flows to extinction are shown in Figure 9-5. For example, if there are no return flows from the use of 1 AF of consumable water, then there is no additional yield and the total yield is one acre-foot. If 50 percent of the return flows from an M&I use of consumable water were exchanged and the return flows from each successive use used to extinction, the total yield realized from 1 AF of consumable water is 1.6 AF. This is based on an assumed M&I CU of 35 percent and return flows of 65 percent.

Potential benefits of exchanging reusable flows include:

- Improves M&I reliability by providing for additional yields.
- Maximizes water use through successive uses.
- Maximizes beneficial use of water.
- May not require additional diversion structures or other facilities.
- Lesser environmental impacts than a new water supply project.

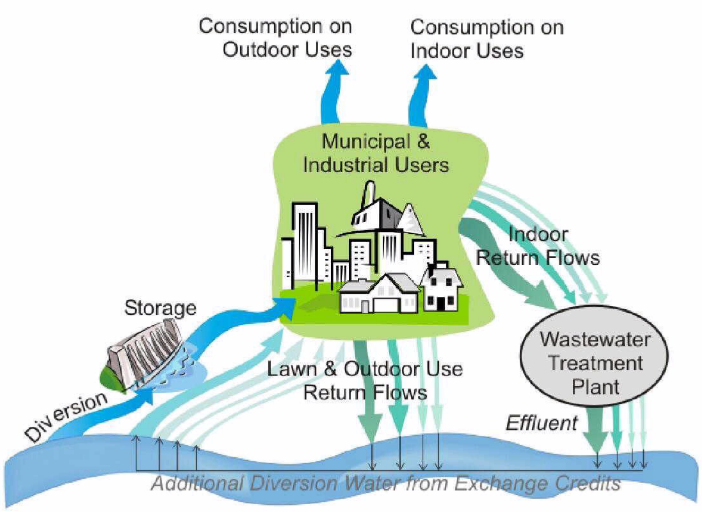

Figure 9-4
M&I Water Rights Exchange

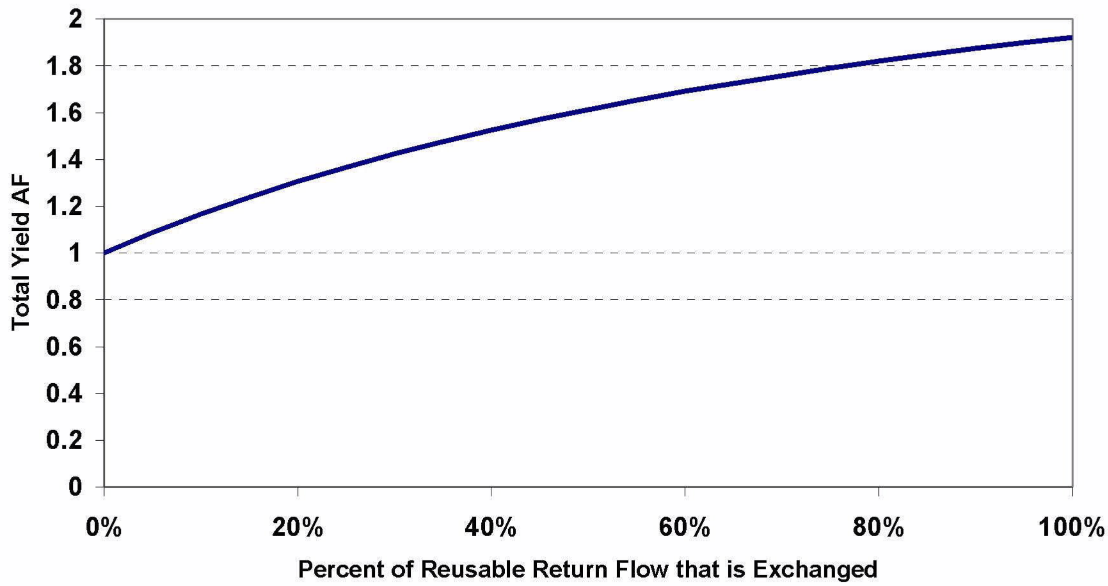

Figure 9-5
Total Yield from Exchange of 1 AF of Consumable Water Based on Reuse to Extinction

Potential issues and conflicts involving reuse by exchange include:

- There must be adequate exchange potential (physical supply) available at the upstream point of diversion.
- The substitute supply (the reusable water that is used to replace the water diverted by exchange) must be suitable for downstream water uses as required by statute.
- There may be water quality objections from downstream users. The substitute supply may be of a different water quality from what the downstream user would have received absent the exchange. A water court procedure allows these issues to be addressed.
- Storage may be needed to regulate year round effluent return flows. The timing of return flows may not match the times when there is exchange potential. For example, winter effluent may need to be stored for exchange to agricultural users during the irrigation season.
- Previously unused reusable effluent historically resulted in reduced or more junior river calls controlling the river.
- As water availability decreases, M&I users are looking to develop or expand the reuse of existing reusable return flows via water rights exchanges. To the extent these reusable flows have been returning to the rivers, they have been used by downstream water users.
- As reusable supplies that have been historically used by downstream users are reused, river calls may become more senior, impacting all users.

9.2.5.2 Non-potable Reuse

Non-potable reuse involves the capture and use of legally reusable return flows for the irrigation of urban landscapes or for industrial uses such as cooling or process water. Since return flows from landscape irrigation are hard to capture in one location, non-potable reuse to date has involved the reuse of consumable effluent discharged from wastewater treatment facilities. The effluent undergoes additional treatment to meet non-potable reuse standards. This treatment usually involves filtration and additional disinfection.

As noted, it is infeasible to capture return flows from landscape irrigation, though additional yield could be achieved if the landscape irrigation return flow points and amounts are identified and exchanged to upstream points. A schematic illustrating non-potable reuse for landscape irrigation is shown in Figure 9-6.

Figure 9-7 shows how the total yield from 1 AF of consumable water based on the percent of the effluent return flows that are used for landscape irrigation can be increased. For example, if 50 percent of the effluent return flows from an M&I use of consumable water were reused for landscape irrigation the total yield realized from 1 AF of consumable water is 1.25 AF.

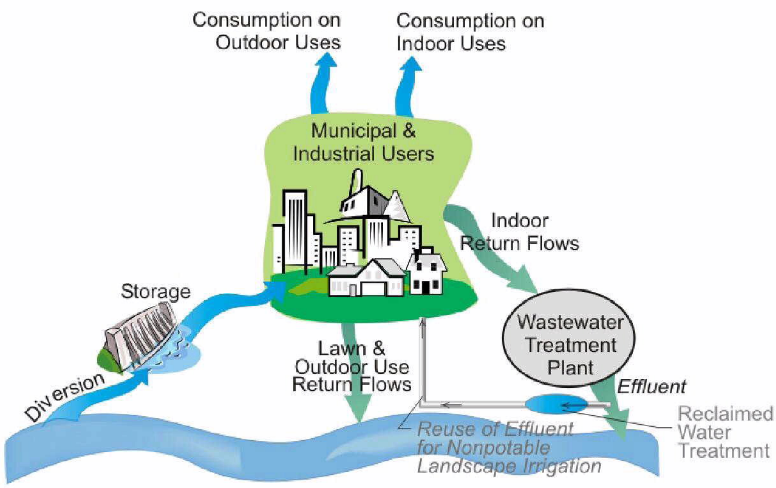

Figure 9-6
Irrigation Reuse

Potential benefits of non-potable reuse include:

- Improves M&I reliability.
- Maximizes successive uses of water.
- Maximizes beneficial use of water.
- May not require new diversion structures.
- Lesser environmental impacts than a new water supply project.
- Does not use higher quality drinking water for irrigation.

Potential issues and concerns include:

- Can be very expensive.
- Must have consumable effluent to reuse or identified return flows.
- Wastewater treatment plant needs to be near irrigation demands.
- Must have storage to regulate year round effluent flows and meet demands during irrigation season.
- As M&I users develop or expand the reuse of existing reusable return flows via water rights exchanges less water may be available to downstream users.
- Previously unused reusable effluent historically resulted in reduced or more junior river calls controlling the river.
- River calls may become more senior, impacting all users.
- Public acceptance of the reuse of effluent for landscape irrigation must be achieved.

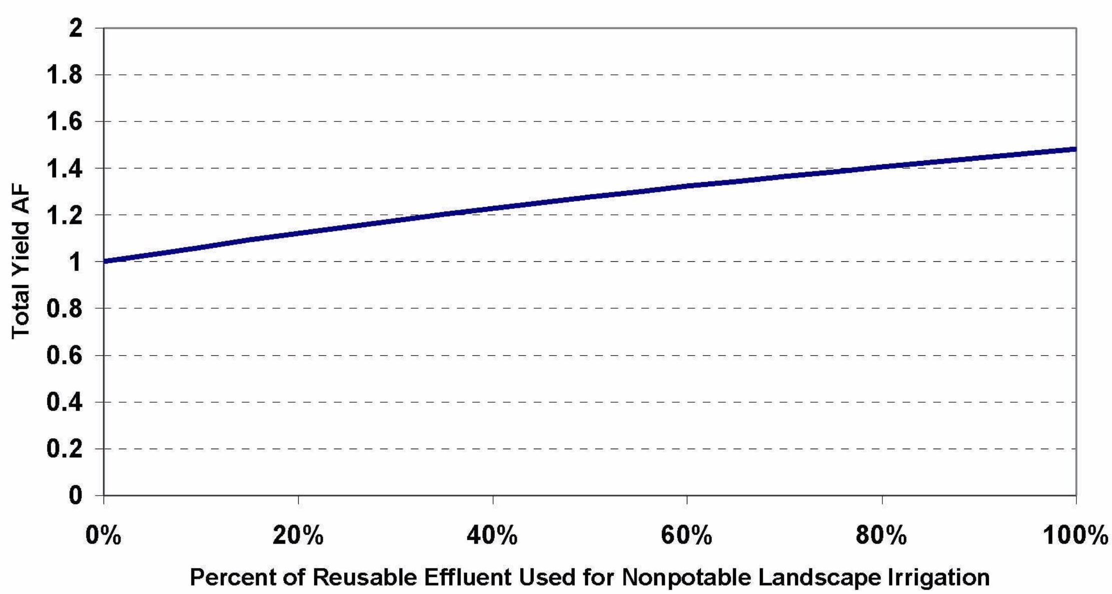

Figure 9-7
Total Yield from Non-potable Reuse of 1 AF of Consumable Water Based on One-time Reuse for Landscape Irrigation

9.2.5.3 Indirect Potable Reuse

Indirect potable reuse involves the capture of legally reusable return flows and reintroduction of these captured flows into the municipal raw water supply. The return flows that are captured may have been discharged to a river or stream and mixed with other waters. Other options include the capture of treated wastewater effluent and additional treatment. The captured flows are then reintroduced into the M&I raw water supply system. The water may require advanced water treatment methods beyond the existing level of treatment used for the current water supply before the recaptured water was introduced into the raw water supply.

Potential benefits of indirect reuse include:

- Improves M&I reliability.
- Maximizes use through successive use.
- Maximizes beneficial use of water.
- Lesser environmental impacts than a new water supply project.
- May not require new diversion structures.

The potential issues and conflicts of indirect potable reuse are:

- Can be very expensive. Infrastructure and operations and maintenance costs will be high.
- Must have consumable effluent to reuse.
- Raw water treatment plant and/or pump back station needs to be constructed. Infrastructure is required to divert and store return flows, pump back to raw water supply storage and additional treatment.
- Existing and future regulatory compliance concerns. Safe Drinking Water Act (SDWA) regulations have to be met at a minimum. Concerns over disinfection byproducts and pollutants in captured return flows can result in expensive, advanced water treatment processes.
- The disposal of water treatment waste products is becoming increasingly problematic and costly.
- Previously unused reusable effluent historically resulted in reduced or more junior river calls controlling the river.
- As M&I users develop or expand the reuse of existing reusable return flows via water rights exchanges less water may be available to downstream users.
- River calls may become more senior, impacting all users.
- Public acceptance of the reuse of return flows for drinking water must be achieved.

9.2.6 Control of Non-Native Phreatophytes

This option would consist of a basinwide or a focused-area program for the removal and control of non-native phreatophytes that consume water that could otherwise be used by any of the basin users: agricultural, M&I, recreational, or environmental. Non-native phreatophytes are invasive plant species that consume water. Of particular concern in Colorado are tamarisk trees. Methods of removal include: mechanical removal, prescribed burning, biological control, and herbicide application. While state and federal programs are beginning to evaluate phreatophyte control options in more depth, the costs and benefits (e.g., yields) of phreatophyte control programs are largely unknown at this time. Demonstration projects are planned in the Rio Grande and Arkansas Basins, and USGS is updating estimates of potential water savings.

Potential benefits of non-native phreatophyte control are:

- Benefits all users: M&I, Agriculture, Environment, and Recreation in accordance with water right priorities.
- Reduces non-beneficial consumption of water.
- Creates additional supplies without new water storage or other infrastructure.

Potential conflicts or issues associated with non-native phreatophytes are:

- Any water saved would be administered under the water rights system.
- Does not benefit specific users and thus funding by water users will be a challenge.
- Would require regional cooperation and funding from a regional, state or federal agency.
- It is not clear that the vegetation that replaces the non-native species will use less water.

Section 10
Evaluation Framework

North Platte Basin

A water supply gap analysis was conducted for each of the eight river basins as described in Section 8. This analysis concluded that the planned water supply projects (the "Identified Projects and Processes") that have been formulated by water providers and users across the state, if completely successful, will provide about 80 percent of the projected M&I water needs by 2030. There is also uncertainty associated with these numbers.

Gaps between water demand or need and available supplies are also anticipated for other types of water use in virtually all basins, and the gaps in each basin could be significantly larger if the Identified Projects and Processes are not successfully and fully implemented.

As such, Section 9 describes families of future water supply options based on: (1) projects and other solutions identified through the Basin Roundtable discussions; (2) projects and other solutions identified from existing reports and studies; and (3) concepts identified by the SWSI team.

To explore the merits of these potential water supply options, an evaluation framework was needed. The purpose of the evaluation framework was to ensure that projects could be analyzed in a consistent, transparent, and understandable manner. SWSI has identified and considered a broad range of options.

Families of options were described in Section 9 and are evaluated in this section. Section 8 describes specific options that could be used in developing portfolios of options. Any remaining gap not addressed by the Identified Projects and Processes could be addressed via these options.

Subsequent SWSI work can build on this information and work toward consensus developing and evaluating combinations or "portfolios" of options that would form basinwide or statewide alternatives for comparison and possible implementation.

This section presents the following:

- An overview of the stakeholder process
- An overview of the method used in evaluating ways to address each basin's future water needs, or evaluation framework
- The specific water management objectives, sub-objectives, and associated performance measures
- The method and results used to gauge individual Basin Roundtable members' preferences – the importance each member placed on each objective and sub-objective
- The evaluation method that was employed to evaluate the families of options and the results

10.1 Stakeholder Process

SWSI was designed to emphasize local input at the basin/local level, reaching out to municipal water providers, agricultural interests, business interests, governmental agencies, environmental interests, recreation interests, and the public at large. These different interests represent the major stakeholders for water use in Colorado. In total, over 40 Basin Roundtable Technical Meetings and Public Information Meetings were held throughout the state to solicit and exchange information and ideas.

The SWSI stakeholder process was made up of three elements (Figure 10-1):

- Colorado Water Conservation Board
- SWSI Basin Roundtables
- Public Outreach

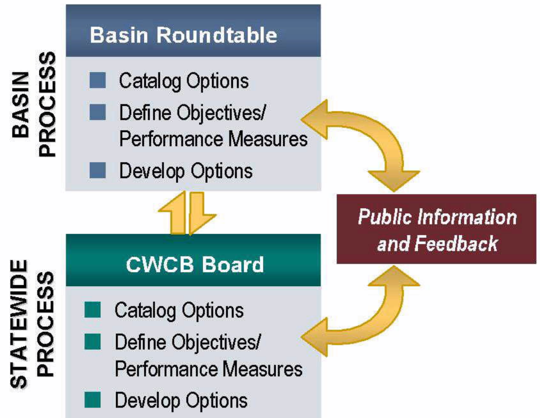

Figure 10-1
SWSI Stakeholder Process

Colorado Water Conservation Board (CWCB) – The CWCB includes representatives from each river basin, as well as key state policy makers. CWCB reviewed information from the Basin Roundtable Technical Meetings and Public Information Meetings, and provided crucial input on the development of planning objectives and strategies for achieving the objectives and implementing solutions.

SWSI Basin Roundtables – SWSI Basin Roundtable Technical Meetings provided a forum for local interests (municipal water providers, agricultural water districts, local governments, state and federal governments, and environmental and recreational interest groups) to review and present water demand and supply information, help guide the development of water management objectives and performance measures, and exchange ideas on how to meet the water needs of the region. The focus of these SWSI Basin Roundtables, which met up to four times in each river basin, was to develop consensus on specific water resources issues. SWSI Basin Roundtable members' input was used as the primary means of identifying, developing, and evaluating water management solutions in SWSI.

Public Outreach – The SWSI public outreach program provided a forum specifically for presenting information to the general public, and for obtaining feedback on the process and conclusions. A series of Public Information Meetings was held within each of the river basins near the beginning of SWSI. A second round of Public Information Meetings was held in conjunction with the last round of SWSI Basin Roundtable Technical Meetings. In addition, public comments were received at each Basin Roundtable Technical Meeting and at each CWCB Board Meeting. The members of the SWSI Basin Roundtables are shown in Section 11.

10.2 Overview of Evaluation Framework

The following terms were used to ensure that stakeholders had a common language during the planning process.

Objectives	The overarching interests in water management – they define major goals of water users in clear, understandable terms
Preferences	Stakeholder values, specifically the weights that they assign to each objective, relative to the other objectives
Performance Measures	Indicators of how well the objectives are being achieved
Options	The individual water supply projects or management strategies that could be implemented to meet the objectives
Family of Options	A grouping of similar types of options, as described in Section 9
Alternatives	Combinations of options that appear to best meet water management objectives, which may be developed in subsequent phases of SWSI

The overall evaluation framework is summarized in Figure 10-2. This framework was conducted for each of the eight basins.

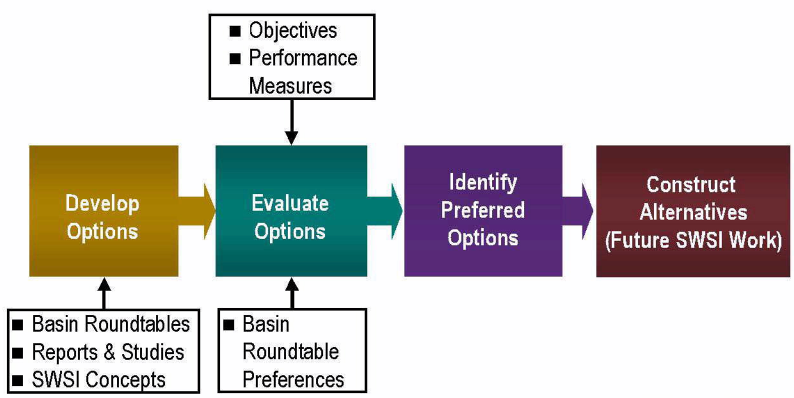

Figure 10-2
Overview of Evaluation Framework

The approach to developing alternatives for each basin in subsequent phases of SWSI could be based on the use of options – individual projects or solutions – as "building blocks" for basinwide alternatives. Alternatives could be developed using options that have the likelihood of being preferred by the stakeholders in each basin, as described more specifically below. This approach consists of the following steps:

- Develop options based on Basin Roundtable Technical Meeting discussions
- Group options into families of options, as described in Section 9
- Evaluate families of options against objectives and sub-objectives using performance measures and Basin Roundtable member preferences
- Identify preferred families of options and use them (with specific options from those families as available/appropriate to the basin) to construct alternatives to meet the demand gaps for each basin in subsequent phases of SWSI

These options were evaluated against a set of performance measures, developed by the SWSI team and confirmed by CWCB and Basin Roundtable members. Stakeholder preferences (weights of importance assigned to each objective) were also factored into the evaluation as described below.

The unique aspect of this approach for SWSI is that the preferences (or objective weights) for each individual Basin Roundtable member are maintained. In other words, this evaluation method was applied to all of the participating stakeholders. This helps allow for discovery of common ground through facilitated discussion, rather than a strictly numeric or "voting" approach (Keeney 1992).

Quantitative scoring provides guidance to decisionmakers, but it is not intended to "make" the decision. Depending on the weights placed on the objectives, the quantitative comparison will differ from person to person and illuminate the tradeoffs associated with each option.

Figure 10-3 illustrates the overall evaluation framework used in SWSI. By deliberately first analyzing the objectives (our goals in water management) separately from the options (specific projects or solutions intended to meet those goals), we are better able to draw out interests over positions, illustrate tradeoffs, and identify creative solutions that might otherwise not come forward. Additional discussion about interest-based dialogue versus position-based debate is provided in Section 10.4.

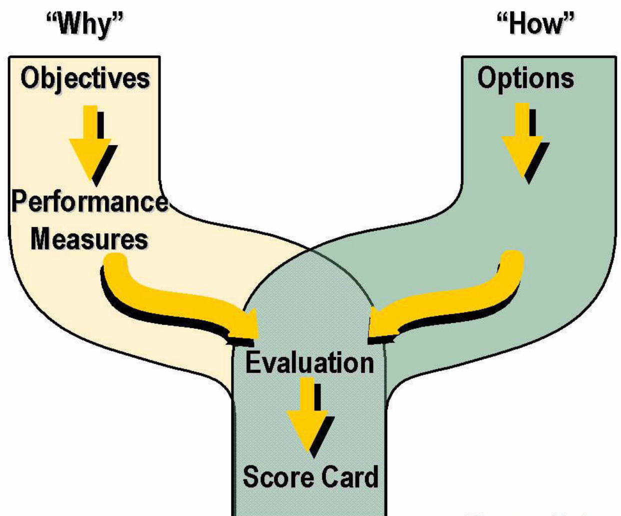

Figure 10-3
Evaluation "Road Map"

The "why" portion outlines which aspects of water management are important to someone, as illustrated through the objectives. The "how" portion describes how one addresses a water management need – specific projects or ways in which the objectives could be accomplished.

10.3 Defining Objectives and Performance Measures

The first step in the evaluation framework was to define the water management objectives for Colorado water users and uses and the associated performance measures. These form the evaluation criteria that options and alternatives can be compared against.

A draft list of water management objectives was developed by the SWSI team. These objectives were modified significantly based on comments provided by the CWCB, the SWSI Basin Roundtables, and public input.

The final set of water management objectives is shown in Figure 10-4, not listed in any particular order. Each Basin Roundtable member was asked to provide his or her own relative preference for each objective, as described in Section 10.4.

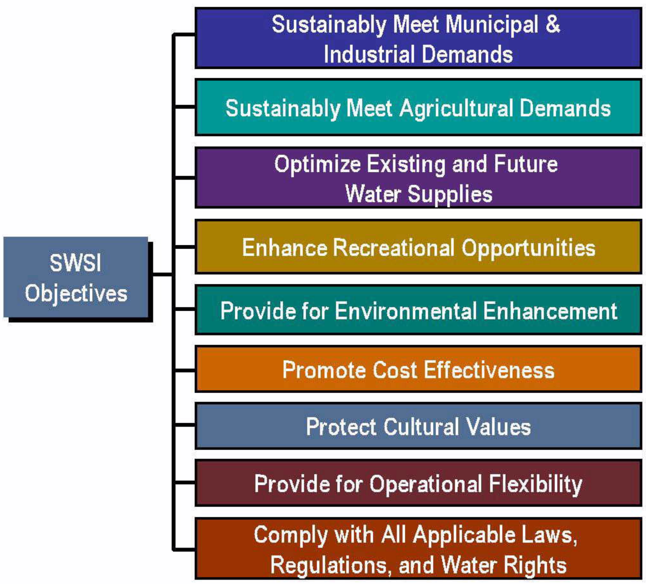

Figure 10-4
SWSI Water Management Objectives

Each of these objectives has one or more sub-objectives that help further define the goal. Once the objectives were defined, performance measures were developed to indicate how well the objective and its sub-objectives were being achieved. These performance measures were used to score and rank the options before alternatives can be built.

Termed "Comply with All Applicable Laws, Regulations, and Water Rights," the ninth water management objective, was developed based on input from the Basin Roundtable Technical meetings. Each option developed under SWSI will comply with applicable laws and regulations, the water rights system, and individual rights. This ninth objective was thus included as a baseline requirement but was not used to compare options. It instead represents a minimum condition or "gate" that all alternatives must pass through to be considered for implementation.

Recognizing that SWSI is a reconnaissance-level process and that feasibility studies would likely be needed before implementation of the options evaluated, two sets of performance measures were developed.

The first set of performance measures was developed to evaluate options for consideration in SWSI. These are qualitative performance assessments that were made based on engineering judgment, using the best available information.

The second set of performance measures could be used as projects move toward implementation, for more detailed feasibility-level planning in which specific options will be evaluated prior to implementation. These performance measures are more quantitative and would rely more heavily on the state's DSS and other more refined data and information.

Table 10-1 summarizes the water management objectives, sub-objectives, and associated performance measures for SWSI.

Table 10-1 SWSI Water Management Objectives and Performance Measures

Objectives/Sub-objectives	Reconnaissance Level Performance Measures Used in SWSI	Future Feasibility Level Performance Measures
1. Sustainably Meet Municipal & Industrial Demands		
▪ Meet M&I demands during drought	On a scale of 1 to 5: 1 does not have the ability to reliably provide additional supply during 1950s drought; and 5 has the most ability to reliably provide additional supply during 1950s drought.	Amount of additional supply provided during 1950s drought on a basinwide level as aggregated from County demands; and percent of major water providers that have shortages during 1950s drought.
2. Sustainably Meet Agricultural Demands		
▪ Meet agricultural demands when and where needed	On a scale of 1 to 5: 1 does not have the ability to reliably provide additional supply during 1950s drought; and 5 has the most ability to reliably provide additional supply during 1950s drought.	Amount of additional supply provided during 1950s drought on a basinwide level; and amount of identified agriculture shortage reduced by alternative.
3. Optimize Existing and Future Water Supplies		
▪ Minimize non-beneficial consumption (e.g., evaporation, phreatophytes)	On scale of 1 to 5: 1 has high evaporation; and 5 has low evaporation.	Qualitative score based on reservoir surface area and phreatophyte control water applied to crops that is not being consumed.
▪ Maximize successive uses of non-tributary groundwater and other legally reusable water	On scale of 1 to 5: 1 impacts successive uses of agriculture water; and 5 does not impact successive uses of agriculture.	Amount of additional municipal reuse (acre-ft/year); and Qualitative score that is based on projects that could impact successive uses such as canal lining and higher efficiency irrigation practices.
▪ Maximize use of existing and new in-basin supplies	Not used for Reconnaissance Level screening	Percent of existing in-basin water supplies and water rights that are fully used plus the percent of existing trans-basin rights that are fully reused.
4. Enhance Recreational Opportunities		
▪ Provide adequate water for recreation when and where needed	On scale of 1 to 5 for river based recreation reaches, the number of months of river based recreation will be the indicator: 1 is lower months of river based recreation; and 5 is higher months of river based recreation.	Qualitative score based on estimate of sustained high flows in commercial rafting reaches.
▪ Encourage the cooperative multiple use of water to enhance recreational and wildlife opportunities	Not used for Reconnaissance Level screening	Qualitative score based on guarantee of minimum pool or stream flows during 1950's drought.
5. Provide for Environmental Enhancement		
▪ Provide adequate water for environment when and where needed	On scale of 1 to 5 using existing environmental coverages: 1 reduces in-stream flows; 3 maintains current in-stream flows; and 5 increases in-stream flows.	Qualitative score based on measurement of instream flows in current environmental coverages which contain habitat areas consisting of gold metal trout areas and cold/warm water fisheries.
▪ Avoid/mitigate environmental impacts of new projects	Not used for Reconnaissance Level screening	Qualitative score that examine flows in relation to allowed depletions for areas within Programmatic Biological Opinions.
▪ Protect and improve water quality	On scale of 1 to 5: 1 degrades water quality; 3 maintains water quality; and 5 improves water quality.	A qualitative evaluation of water quality and flow on a basinwide basis.

Table 10-1 SWSI Water Management Objectives and Performance Measures

Objectives/Sub-objectives	Reconnaissance Level Performance Measures Used in SWSI	Future Feasibility Level Performance Measures
6. Promote Cost Effectiveness		
▪ Allocate cost to all beneficiaries fairly	Not used for Reconnaissance Level screening	All alternatives will address this in implementation based on allocation of costs.
▪ Achieve benefits at lowest cost	On scale of 1 to 5: 1 is highest unit cost; and 5 has lowest unit cost.	Estimate of capital and O&M costs over the life of the project/alternative
▪ Provide for funding eligibility	On scale of 1 to 5: 1 has low chance for federal funding; and 5 has high chance for federal funding.	Qualitative score based on if project qualifies for federal funding.
▪ Mitigate for third-party economic impacts	Not used for Reconnaissance Level screening	All alternatives will address this in implementation.
7. Protect Cultural Values		
▪ Maintain quality of life unique to each basin	For urban areas, on scale of 1 to 5: 1 is a loss of current irrigation and landscape practices, such as bluegrass lawns; and 5 maintains the ability to landscape as desired and water at an affordable price. For rural areas, on a scale of 1 to 5: 1 is a loss of the current economy and related quality of life; and 5 maintains the current economy and quality of life.	Cultural values may be specific to subbasins. Qualitative score will reflect the specific issues unique to each basin.
▪ Maintain open space	On a scale of 1 to 5: 1 is a loss of open space; and 5 is no (or minimal) loss of open space.	Estimate of lost open space (in acres).
8. Provide for Operational Flexibility		
▪ Provide for short-term transfer of water to different users/uses, while protecting water rights	On scale of 1 to 5: 1 does not produce interruptible supply options; and 5 does produce interruptible supply options.	Amount of water produced by interruptible water supply options such as water banks or short-term leases (acre-feet/yr).
10. Comply with All Applicable Laws, Regulations, and Water Rights		
▪ Baseline requirement for all alternatives; not used in comparison of alternatives	Not applicable	Not applicable

10.4 Individual Preferences

Individual Basin Roundtable members' preferences were solicited for each of the river basins in order to determine the region-by-region values and interests. To solicit preferences, each of the participating members of the SWSI Basin Roundtables was asked to complete a weighting exercise for the water management objectives. An approach called *Pair-Wise Comparison* was used for this effort.

In Pair-Wise Comparison, a person must indicate their preference between two objectives, compared to each other. For example, which objective is more important to you, Enhance Recreational Opportunities or Protect Cultural Values? Basin Roundtable members were told that although both objectives might be important to them, they must choose which is *more* important. Each possible pair of objectives – 28 combinations in all – was put before each of the Roundtable members. Individual results were maintained, but anonymous to the other Roundtable members.

The Pair-Wise Comparison is not a voting process. Rather, it was used to identify and illustrate the values and preferences different individuals place on goals and objectives for water management in Colorado for use in SWSI. By exploring these different preferences, discovery of common ground or consensus is more likely. This helps move the process from "position-based" debates to "interest-based" dialogue.

A position-based debate is one where stakeholders lay down positions, such as "new reservoirs are absolutely needed" or "water conservation is the only way to solve our water needs." Both of these positions are intractable – often leading to stalemate. Any alternative that has a new reservoir will surely be seen as adversarial to the stakeholder desiring water conservation, for example.

An interest-based dialogue, in contrast to position-based debate, is where stakeholders identify their preferences (or interests) for well understood and accepted objectives. For example, the stakeholder whose *position* was "water conservation is the only way to solve our water needs" may have an *interest* to protect the environment (which is likely shared by many other stakeholders, but in varying degrees). And the stakeholder whose *position* was "new reservoirs are absolutely needed" may have the *interest* in reliably meeting municipal demands during a drought (which is also likely shared by many other stakeholders, but with varying degrees).

Moving from positions to interests, and understanding how stakeholders value these interests, allows solutions to be identified that can achieve multiple interests. This is how consensus and common ground can be discovered. This report illustrates how different families of options can address the state's water needs while meeting multiple objectives (Section 9); subsequent SWSI work can continue this process for the development and assessment of portfolios of options, described in this process as "alternatives." **Over a period of 18 months, the SWSI team met with the SWSI Basin Roundtables on four occasions. This was a short timeframe to address all the technical data in the basins, and to have Basin Roundtable members achieve consensus. Developing more trust and further exploration of water resource management solutions that meet multiple interests appears to be warranted.**

The results of the individuals' objective preferences (weighting) were plotted for each river basin. What is shown on the following graphs is the weight (expressed as a percentage based on Pair-Wise Comparison results) that Basin Roundtable members gave to each of the objectives shown in Figure 10-4. By design, the maximum weight that any Basin Roundtable member could give an objective is 25 percent. For each individual, the total of the weights for all objectives adds up to 100 percent. The red line indicates the range of weights that the entire group of participants gave to a particular objective. If the red line starts at zero, this means that at least one participant assigned a zero percentage weight to that objective. If the red line goes up to 25, then at least one participant assigned a 25 percentage weight to that objective.

The black diamond on each red line indicates the average weight of all the participants within the river basin for that objective.

Also plotted on the red line are the average weights for three interests, under which the majority of Basin Roundtable members were grouped: (1) municipal water providers – as indicated by blue circles; (2) agricultural/ ranching – as indicated by yellow triangles; and (3) environmental/recreational – as indicated by green squares. Some members did not fall into any of these groups, but are reflected in the overall group averages.

It is important to note that the average weightings for each Basin Roundtable and certain subsets thereof are presented here only to illustrate the overall tenor of each group. However, in no case was the average weight used in evaluating options. Rather, each individual's objective weighting was used to develop and track their individual ranking of options.

10.4.1 Basin Roundtable Members' Individual Preferences

The results for the North Platte Basin are shown in Figure 10-5.

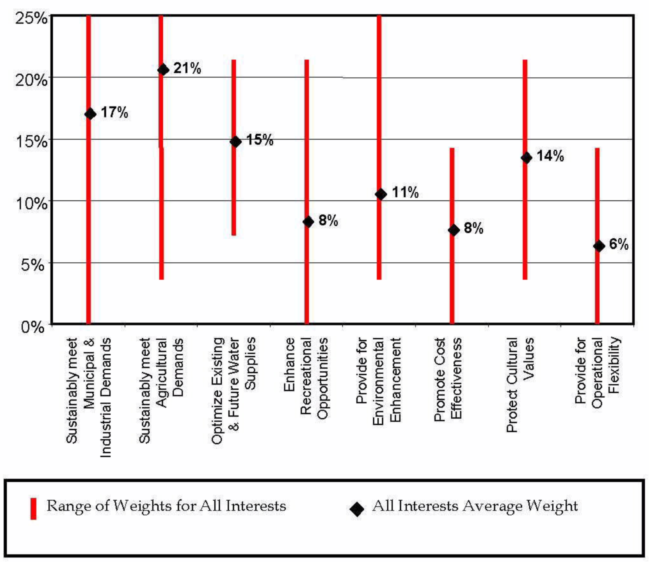

Figure 10-5
North Platte River Basin Objective Weights

North Platte Basin

Section 11 Acknowledgements

SWSI is the product of the vision, commitment, and dedication of countless Coloradans toward meeting the state's future water needs. Governor Owens and the Colorado Legislature provided strong direction and support for moving the project forward. The DNR and its Director, Russell George, gave continuous support to SWSI. CWCB Board members are to be commended for providing the foresight needed to undertake SWSI, committing significant time in shaping and guiding the process, and giving unwavering support for the Initiative. The Director of CWCB, Rod Kuharich, likewise committed his time and support for the project and dedicated staff resources toward ensuring SWSI's success. CWCB's Project Manager, Rick Brown, was consistently the "voice of SWSI," devoting much of his energy to meeting the significant demands of the project, and working hard to truly understand the issues and interests of Basin Roundtable members and the general public.

The SWSI consultant team led by CDM was staffed as follows: Project Director – Susan Morea; Technical Director – Kelly DiNatale; Engineering Analysis – John Rehring; Project Management – Nicole Rowan; Project Facilitation – Paul Brown; Decision Science – Dan Rodrigo; Water Supply Analysis – Gordon McCurry; Demographics/Demands – Bill Davis; Public Relations – Steve Coffin, GBSM; Data Analysis – Steven Malers, Riverside Technology inc. and Erin Wilson, Leonard Rice Consulting Water Engineers; Environmental Analysis – Tom Pitts, Water Consult.

We are also grateful to the following CWCB staff who helped produce this final report: Randy Seaholm, Dan McAuliffe, Ray Alvarado, Dan Merriman, Steve Miller, Andy Moore, Michelle Garrison, Mike Serlet, and Carolyn Fritz.

SWSI Basin Roundtable members provided untold hours of work on SWSI and served as a wealth of historical knowledge, guiding principles and ideas for meeting the state's diverse and growing uses for water. This participation and insight is greatly appreciated. SWSI Basin Roundtable members are acknowledged below.

North Platte Basin Representatives

Agricultural, Ranching, Ditch and Reservoir Companies

Blaine Evans, MacFarland Reservoir
Tom Hackelman, Walden Reservoir Company
Cary Lewis, North Park Stockgrowers
Lucy Meyring, Colorado Cattlemen Association

Environmentalists and Related Organizations

Eric Wagner, Coalition for Sustainable Resources

Local Governments not Directly Providing Water

Rick Wyatt, Jackson County Commissioner

Municipal Water Providers

Kyle Fliniau, Town of Walden
Mark Russell, Walden Public Works

Recreational and Related Organizations

Chad Brown, Owl Mountain Ranch
John Ziegman, Buffalo Creek Ranch

Water Conservancy/Conservation Districts

Jim Baller, Water Conservancy District
Bob Carlstrom, Water and Power Authority
Ken Crowder, Jackson County Administrator

Technical Advisors

Robert Burr, CWCB Board Member
Dave Harr, Bureau of Land Management
Mark Lanier, U.S. Fish and Wildlife Service
Bob Plaska, Division Engineer
Steve Puttmann, Division of Wildlife
Carl Trick II, Basin Advisor

Section 12
References

This section represents a comprehensive set of references used in the preparation of the SWSI Report. Not all sources may be referenced in this document; however, they have been left intact for readers wishing to do further research.

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