Chapter 3.
Future Water Demands and Sources of Supply

Long-term economic growth throughout Colorado, but especially in the South Platte, Arkansas, and Colorado River basins may require significant new sources of supply despite the demand-side management programs that have been, and continue to be, developed by water supply agencies. This chapter provides a brief overview of the Colorado economy and then uses the State Demographer's forecasts to prepare a characterization of the general magnitude of future water demands. Conclusions are then developed in relation to the size of the future demand and the amount of water that could be provided under three alternative CRRP sizes. The chapter concludes with a discussion of the possible sources of supply that might be developed without the CRRP. Seven general categories of water supply options are defined. Later, in Chapter 8, the general attractiveness of these seven types of alternatives to the CRRP are compared and contrasted with the economic, environmental and other attributes of the CRRP at a reconnaissance level.

Brief Overview Of The Colorado Economy

The following description provides an economic context for the CRRRS. Demographic conditions, employment, earnings and business activity are addressed.

Population

Colorado experienced substantial population growth in the 1980s and even more rapid increases during the 1990s. Colorado's number of residents expanded from 2,889,733 in 1980 to 3,294,394 in 1990, and to 4,301,261 by 2000.[1] In that 20-year period, Colorado's population grew by almost one-half. Current estimates of Colorado's population are 4,506,542[2] for 2002 and 4,555,200[3] for 2003.

Geographic Distribution

Table 3-1 presents population and employment by state planning region. The regions presented in the table are defined by the Colorado Department of Local Affairs (DOLA).

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1 U.S. Census Bureau decennial censuses.

2 U.S. Census Bureau.

3 University of Colorado at Boulder's Colorado Leeds School of Business, Business Research Division. *Thirty-Eighth Annual Colorado Business Economic Outlook 2003.*

Table 3-1: Geographic Distribution of 2001 Colorado Employment and Population

Planning Region and Counties	Population	% of Total	Employment	% of Total
Region 1				
Logan, Morgan, Phillip s, Sedgwick, Washington	70,324	1.6%	30,860	1.4%
Region 2				
Larimer, Weld	454,421	10.3%	225,595	10.2%
Region 3				
Adams, Arapahoe, Boulder, Clear Creek, Gilpin, Denver, Douglas, Jefferson	2,427,790	56.0%	1,302,785	59.0%
Region 4				
El Paso, Park, Teller	570,433	12.9%	273,051	12.4%
Region 5				
Cheyenne, Elbert, Kit, Carson, Lincoln	37,389	0.8%	20,042	0.9%
Region 6				
Baca, Bent, Crowley, Kiowa, Otero, Prowers	51,527	1.2%	19,440	0.9%
Region 7				
Pueblo	114,955	3.3%	55,201	2.5%
Region 8				
Alamosa, Conejos, Costilla, Mineral, Rio Grande, Saguache	46,223	1.0%	19,198	0.9%
Region 9				
Archuleta, Dolores, La Plata, Montezuma, San Juan	82,274	1.9%	38,703	1.8%
Region 10				
Delta, Gunnison, Hinsdale, Montrose, Ouray, San Miguel	88,573	2.0%	39,243	1.8%
Region 11				
Garfield, Mesa, Moffat, Rio Blanco, Routt	204,156	4.6%	98,560	4.5%
Region 12				
Eagle, Grand, Jackson, Pitkin, Summit	96,362	2.2%	48,394	2.2%
Region 13				
Chaffee, Custer, Fremont, Lake	75,101	1.7%	29,082	1.3%
Region 14				
Herfano, Las Animas	23,186	0.5%	9,345	0.4%
Total	**4,417,714**		**2,209,598**	

Source: U.S. Census Bureau and Colorado Department of Labor and Employment, from the *Colorado Economic and Demographic Information System*.

The Denver-Boulder Metropolitan area, Region 3, accounted for over half of the state's 2001 population and employment. The Front Range from Pueblo to Ft. Collins includes Regions 2, 3, 4 and 7, and it accounted for more than 80 percent of the state's population and employment.

Employment

Colorado's labor force and number of employed persons has grown substantially in the past 20 years; however, recent trends have revealed increasing unemployment rates (see Table 3-2 below).

Table 3-2: Colorado Labor Force and Employment

	1980	1990	2000	2001
Labor Force	1,502,005	1,764,181	2,275,545	2,294,897
Unemployed Persons	88,006	89,057	62,501	111,419
Unemployment Rate	5.86	5.05	2.75	4.86%
Employed Persons	1,413,999	1,675,124	2,213,044	2,229,038
Estimated Total Jobs	1,688,218	2,021,517	2,872,899	2,762,118

Source: Colorado Department of Local Affairs.

The largest Colorado employment sectors in 2001 were services (42 percent), non-farm proprietors (19 percent) and wholesale and retail trade (14 percent). Colorado has also experienced more than 20 years of steady job growth, especially in the services, construction, finance, insurance and real estate industries. A few industries — namely mining and agricultural services — have experienced job losses in this same time period, and farm employment has remained relatively stable. The number of non-farm proprietors, indicative of small business start-ups, more than doubled in this 20-year period (see Table 3-3).

Table 3-3: Colorado Wage and Salary Employment by Industry

	1980	1990	2000	2001	% Change, 1980-2001
Total full-time and part-time employment	**1,654,180**	**2,054,770**	**2,958,899**	**2,988,640**	**80.7%**
Farm proprietors employment	26,820	27,225	29,712	30,211	12.6%
Non-farm proprietors employment	260,188	372,197	565,062	580,392	123.1%
Farm employment	45,801	43,690	44,999	45,785	0.0%
Ag. services, forestry, fishing and other	12,909	20,189	39,615	9,557	-26.0%
Mining	43,389	31,384	22,256	22,272	-48.7%
Construction	102,472	97,386	226,571	236,570	130.9%
Manufacturing	185,430	197,879	217,257	194,052	4.6%
Transportation and public utilities	84,623	107,235	162,394	92,319	9.1%
Wholesale trade	80,223	92,254	121,241	111,300	38.7%
Retail trade	274,739	344,149	494,125	316,828	15.3%
Finance, insurance, and real estate	160,250	179,826	298,216	303,939	89.7%
Services	370,660	608,358	949,118	1,264,393	241.1%
Government and government enterprises	293,684	332,420	383,107	391,625	33.3%

Note: For certain economic sectors, there were discrepancies between 1980-2000 data and 2001 data as BEA switched from the SIC to the NAICS coding system.

Source: U.S. Bureau of Economic Analysis, Regional Economic Information System.

Income

Services, government, and trade (wholesale and retail) were the largest sectors in terms of personal income contribution in Colorado in 2001, accounting for 41 percent, 15 percent and 12 percent, respectively. Personal incomes in Colorado have risen steadily in the past 20 years, with sizable increases in personal incomes and earnings in the proprietors, construction, finance, insurance and real estate, and government sectors (see Table 3-4).

Gross Sales And Numbers Of Establishments

Colorado had roughly 120,000 private business establishments with employees and 325,000 single proprietorship establishments in 1997. Those establishments generated more than $230 billion in gross sales, receipts and shipments. A breakdown of gross sales by sector indicates that retail and wholesale trade with 44 percent, services with 25 percent, manufacturing with 17 percent, and construction with 9 percent contributed most to Colorado business activity.

Table 3-4: Colorado Personal Incomes and Earnings, 2001

	1980	1990	2000	2001	% Change 1980-2001
Per capita personal income (year 2001 dollars)	25,312	26,989	33,853	33,455	32.2%
Total personal income (thousands of year 2001 dollars)	73,630,232	89,273,111	146,476,270	148,238,613	101.3%
Proprietors' income	6,528,587	8,084,400	15,519,309	15,745,272	141.2%
Farm earnings	676,360	1,251,405	539,416	709,489	4.9%
Non-farm earnings	56,986,239	64,999,191	113,340,144	113,975,248	100.0%
Ag. services, forestry, fishing and other	238,711	345,429	797,705	132,787	-44.4%
Mining	3,121,911	1,602,813	1,694,365	1,799,567	-42.4%
Construction	4,567,070	3,493,645	9,389,276	9,927,246	117.4%
Manufacturing	8,880,164	8,976,179	11,451,762	9,976,445	12.3%
Transportation and public utilities	4,656,839	5,900,267	12,146,711	4,466,940	-4.1%
Wholesale trade	3,861,468	3,930,776	6,679,857	6,022,231	56.0%
Retail trade	6,118,147	6,160,023	9,917,024	7,253,356	18.6%
Finance, insurance, and real estate	3,548,186	4,202,827	10,823,934	10,423,679	193.8%
Services	10,607,348	16,967,920	34,084,923	46,973,327	342.8%
Government and government enterprises	11,386,390	13,419,306	16,354,583	16,999,670	49.3%

Note: There were discrepancies among certain economic sectors between the 1980-2000 data and 2001 data as US Bureau of Economic Analysis switched from the Standard Industrial Classification to the North American Industry Classification System codes. Personal income data is displayed in constant year 2001 dollars, adjusted using the national consumer price index maintained by the U.S. Bureau of Labor Statistics.

Source: U.S. Bureau of Economic Analysis, Regional Economic Information System.

Colorado's gross state product, which was $89.9 billion in 1980, rose to $102.4 billion by 1990 and to $173.4 billion by 2000. In 2001, Colorado's gross state product topped $173.8 billion.[1]

Retail Sales

Retails sales in Colorado have risen steadily from a 1990 figure of $59.1 billion to $99.7 billion in 2000, and to $100.2 billion in 2001.[2] Colorado has experienced a significant increase in retail sales in the past decade.

Agriculture

In 1997, Colorado had 30,000 farms and ranches with 31.3 million acres of land.[3] An estimated 3.4 million of those acres were irrigated farmland. More than 60 percent of 2001 Colorado agricultural production values were derived from cattle, calves and other animals. About 26 percent was attributable to crop harvests, and the remainder was

[1] U.S. Bureau of Economic Analysis. These gross state product figures are in constant year 2001 dollars, adjusted using the national consumer price index maintained at the U.S. Bureau of Labor Statistics.

[2] Colorado Department of Local Affairs. These retail sales figures are in constant year 2001 dollars, adjusted using the national consumer price index maintained at the U.S. Bureau of Labor Statistics.

[3] U.S. Department of Agriculture, Census of Agriculture 1997.

accounted for mostly by forestry and agricultural services. Total agricultural output in 2001 was valued at $5.4 billion, while total production expenses amounted to $4.5 billion, resulting in nearly $1.0 billion in farm and ranch income.[4]

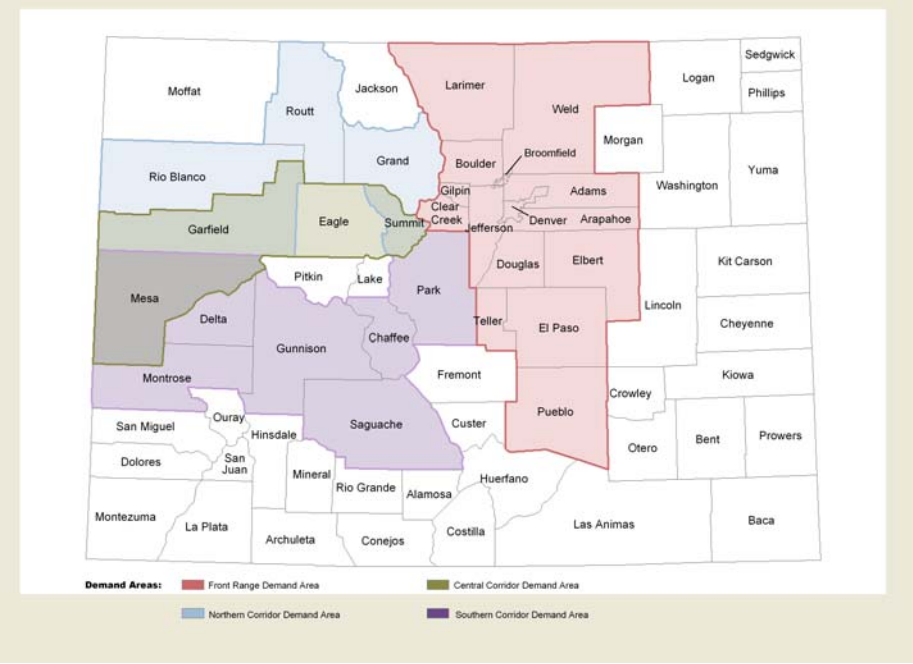
Demand Projections

The CRRP represents a potentially major increase in water supply available to Colorado. Reconnaissance level water demand projections were prepared for areas in Colorado that have a potential demand for additional water supplies. A secondary purpose of the water demand projections is the financial feasibility assessment for CRRP, which is addressed subsequently in this study.

Water Demand Areas

Demand projections were prepared for the areas that the project could potentially serve, that is, the Colorado, South Platte, and Arkansas River basins. Since the potential pipeline alignments cover such a broad area in western Colorado and demographic data is readily available on a county-by-county basis, the demand projections were prepared as shown in Figure 3-1. Demand projections were prepared for the following aggregations: Arkansas and South Platte Basins Area, the Northern Corridor Demand Area, the Central Corridor Demand Area, and the Southern Corridor Demand Area. It should be noted that one but not all three of the pipeline corridors might ultimately be chosen for the route and so the water demand projections in this report assume only the Central Corridor, the fastest growing corridor that includes Eagle, Grand and Summit counties, plus the Front Range Demand Area. Conveyance corridors are described in Chapter 2.

Figure 3-1: Potential Water Demand Areas for the CRRP



[4] Colorado Department of Agriculture, Colorado Agricultural Statistics Service. *Colorado Agriculture: A Profile*, May 2003.

Demand Projection Methodology

The following approach was used to characterize magnitude of potential future water demands for the development of this reconnaissance-level characterization.

First, Jim Westkott, the State Demographer with the DOLA, provided projections of population and average household size for the years 2000 to 2030.[5] Second, United States average annual population growth rates for 2030 through 2060 from the U.S. Census Bureau were applied to each of the study areas to produce the long-term projections[6]. Then DOLA's projected average household size for the state of Colorado was applied to these population projections for the Front Range and the three Pipeline Corridors, to derive projections of number of households in the study areas through 2060[7].

Next, future water usage patterns were applied to the household projections to derive estimates of future water demand for the respective demand areas. This reconnaissance level approach produced generalized, average levels of water usage for the Front Range and for the three Pipeline Corridors. Water usage patterns were collected and extracted from water planning and demand studies among numerous water providers and entities across Colorado; the bibliography of these studies is provided at the end of this section. From those studies, average water usage per household or per residential account encompasses all municipal and industrial demand that would arise for CRRP water in the future divided by the number of all households in the potential delivery areas.

Households are a useful unit of measure for water use since outdoor water use varies more directly by the number of households, and households provide a ready set of forecasts for the financial feasibility study in terms of future tap sales. Estimates of water use per household were then multiplied by the estimated number of additional households to derive water demand projections for the CRRP.

Population And Household Projections

Figures 3-2 and 3-3 present projections of populations and households, respectively, for the Front Range Demand Area and the Central Pipeline Corridor Demand Area. The Central Pipeline Corridor was selected for these graphs only by way of example. If the Northern Pipeline or the Southern Pipeline Corridor is selected in future studies of the CRRP, the population and household projections for 2060 vary by only 3.2 to 8.8 percent among the three corridor demand areas. Between the year 2000 and 2060, the Front Range Demand Area is expected to grow by nearly 3.5 million persons, or 100 percent. The Front Range Demand Area households will increase by 1.6 million, or 109 percent during this same period. The Central Pipeline Corridor Demand Area is expected to grow by 335,000 persons (145 percent) and 140,000 households (156 percent) between the year 2000 and 2060. These economic and demographic changes suggest large increases in water demand.

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[5] DOLA provided projections of average household size through 2025. The Project Team held DOLA's projection of average state household size for 2025 constant through 2060.

[6] The Project Team used US Census Bureau national growth rates for 2030 through 2060 because the State of Colorado did not make projections that far out into the future and because the Team took a conservative approach and assumed that Colorado would slow in growth rate to the national level by 2030.

[7] The Project Team projected population and households to 2060 to capture the full timeframe in which the full supply generated by the CRRP might be effectively utilized in the demand areas. In other parts of this report, other slightly shorter but consistent time horizons are used; 2050 is an example.

Figure 3-2: Population Projections for the Front Range and Central Pipeline Corridors

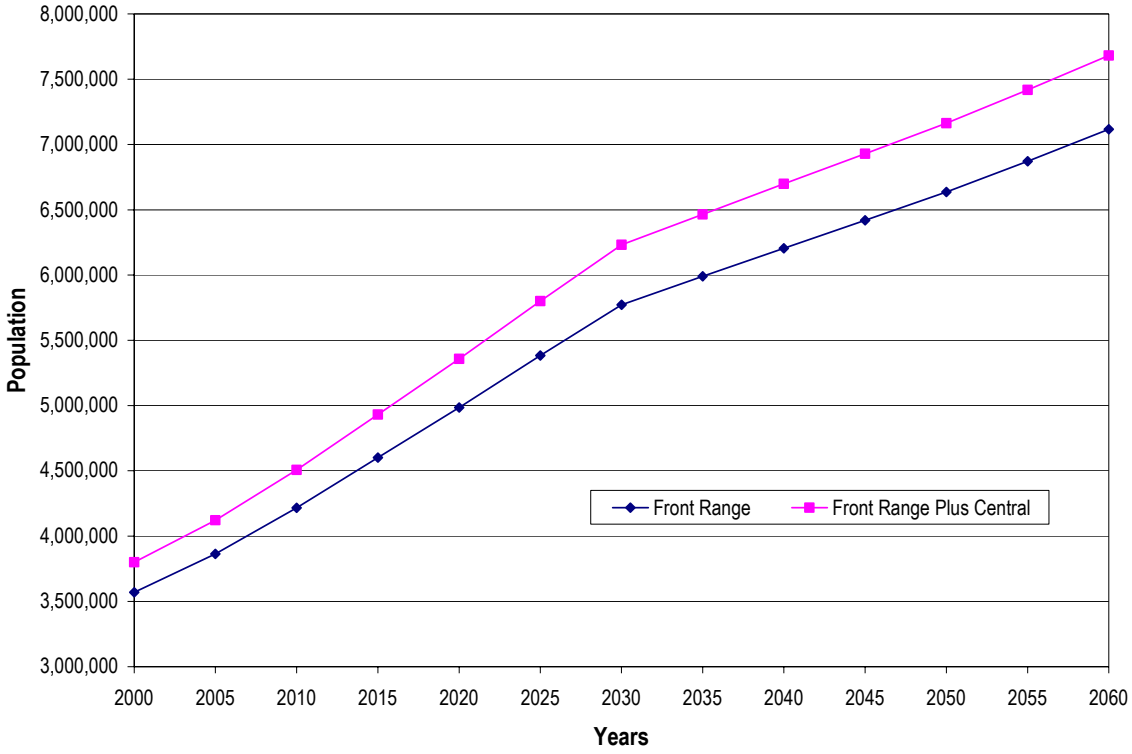
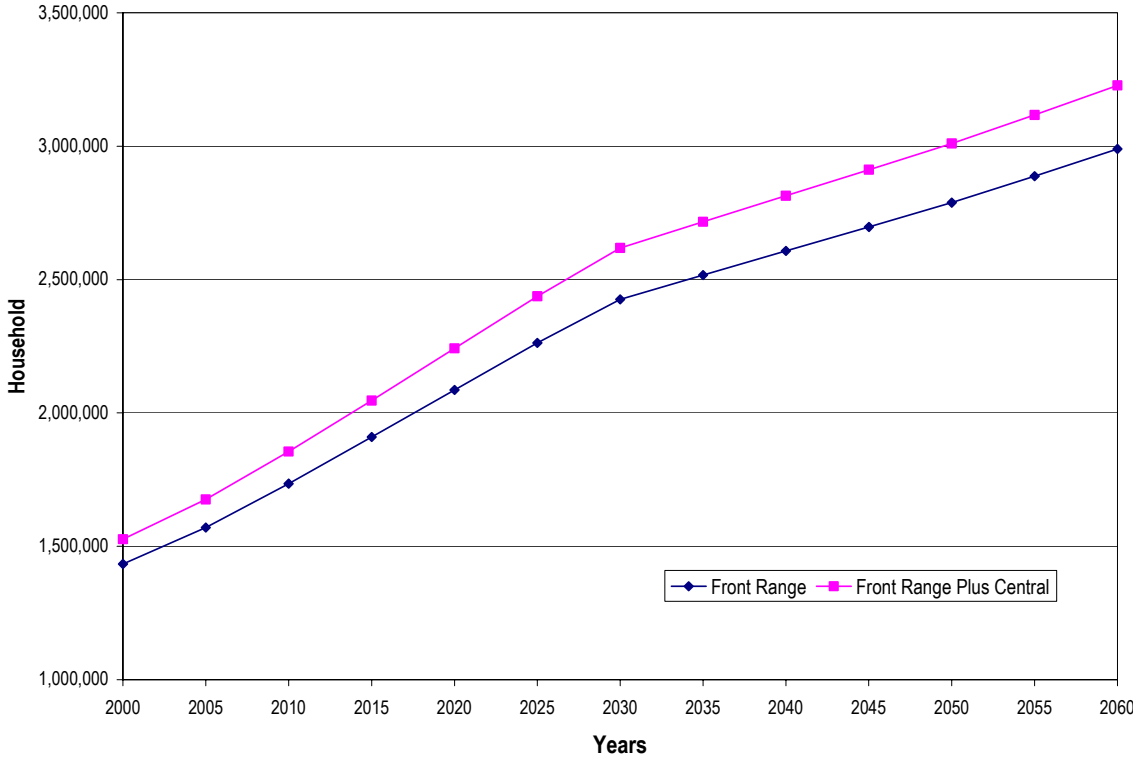


Figure 3-3: Household Projections for the Front Range and Central Pipeline Corridors



Water Usage Patterns

Based upon a review of various water demand studies, it was determined that average water use per household was higher in the three pipeline corridors as compared with the Front Range Demand Area. This is probably attributable to snowmaking and large numbers of visitors or seasonal residents using water in western Colorado.

For the Front Range Demand Area, water usage patterns from those studies reviewed ranged from 400 to more than 780 gallons per household per day, while for the Pipeline Corridors, water usage patterns ranged from 600 to 750 gallons per household per day. Weighted averages of the study values approximate 500 gallons per household per day for the Front Range Demand, and 700 gallons per household per day for the Pipeline Corridors of the CRRP. U.S. Geological Survey studies of water use patterns throughout Colorado, dated 1995, tended to corroborate the assumptions adopted in this study. These assumed gallons per household per day of water use relate to raw water demand projections that do not account for system loss.

CRRP Water Demand Projections

Long range forecasts of water demand levels and the economic and demographic projections upon which they are based typically provide a range to account for the various uncertainties associated with projections. There are a number of economic and demographic methodologies for making those forecasts, each of which is driven by a set of assumptions. In developing long-range water demand projections for this study, the uncertainty around the underlying assumptions that drive these forecasts has not been explored or fully considered. Because of that, a forecasting range has not been provided. Based upon past experience and judgment, it is believed that the water demand projections resulting from the approach and assumptions described above are higher-end projections. Hence, we have adopted final water demand projections that are 10 percent less for a more conservative set of projections appropriate for examining the feasibility of a new project. These 10 percent adjusted projections are those presented in Figure 3-4.

Figure 3-4: Water Demand Projections for the Front Range and Central Pipeline Corridors

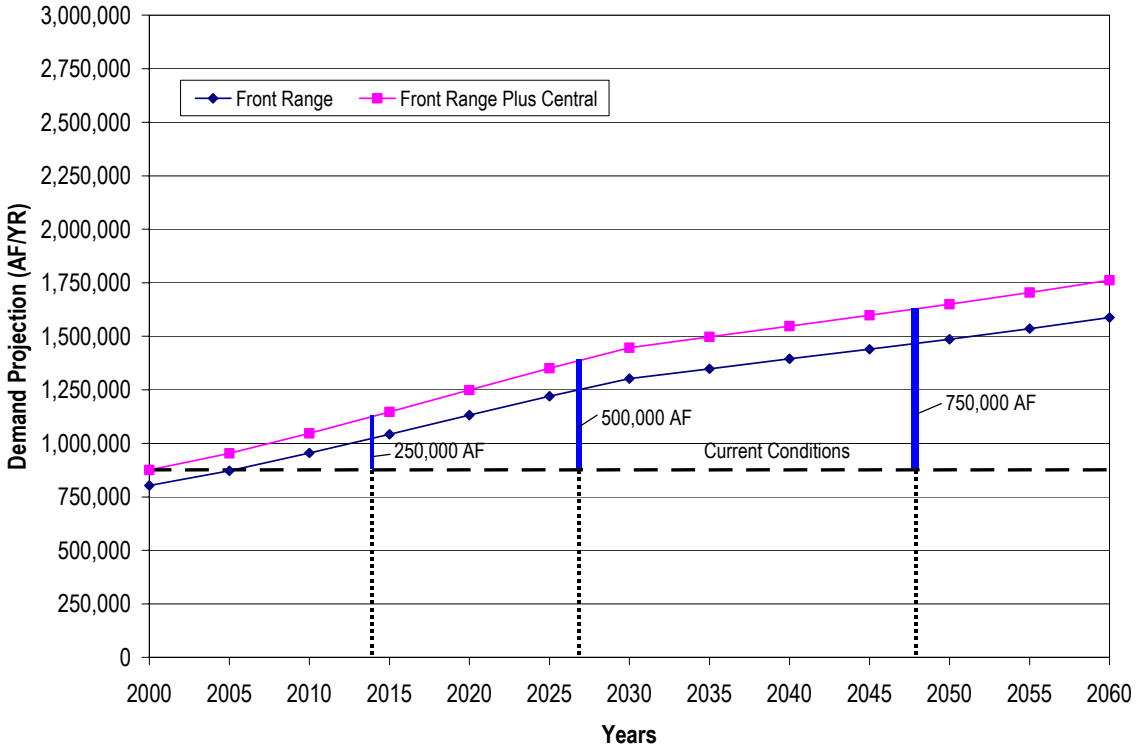


Figure 3-4 presents water demand projections for the Front Range and Central Corridor Demand Areas.

These water demand projections indicate that an additional 784,000 af of raw water will be required from structural and nonstructural resources in the Front Range between the year 2000 and 2060. Including incremental water demands from the Central Pipeline Corridor Demand Area in the Colorado River Basin, a total of 887,000 af of additional water needs will need to be met by 2060.

The water demand projections presented in Figure 3-4 encompass all estimated domestic, commercial and industrial water needs for the Front Range Demand Area and Central Pipeline Corridor Demand Areas through 2060. These projections do not include estimated water needs for agriculture in or outside these study areas.

Need For CRRP Supply

Under the water demand projections adopted for the CRRRS, Figure 3-4 shows that the CRRP supply at the 250,000 af per year delivery level could be needed by new market demand as early as year 2014. The 500,000 af per year delivery level could be theoretically needed by the year 2027, and the 750,000 af scenario could hypothetically be needed by the year 2048. The Front Range Demand Area alone could absorb the high 750,000 af delivery scenario by 2057.

Many urban and other water providers are actively in the process of developing new water supplies on their own. Comparisons between the CRRP and other water resource development alternatives being considered by water providers are discussed later in this chapter.

While current or planned structural and non-structural projects may diminish the need for CRRP's water supply, there are several other sources of potential future water demand in the study areas that were not represented in Figure 3-4. One future source of demand is replacement of current supplies that are likely to become unavailable in the future. Present groundwater use in the urbanized Front Range, for example, might be unsustainable as a base load supply without new augmentation or conjunctive use sources. Nontributary groundwater is clearly a finite, nonrenewable water supply. Other sources might also have long-term availability issues or water quality standards might become more strict. These necessary replacement water supplies might range from around 30,000 af up to an unknown amount over the next 50 years[1]. Mineral and Energy development such as oil shale, could be a source of future demand in western Colorado. Endangered species recovery or preservation, or other environmentally-related needs, may be found for CRRP water. The Colorado River Recovery Program is an existing example. Another source of potential demand is the agricultural sector. Though agriculture may not be able to pay the rates that will likely prevail with CRRP water, this sector might utilize unused water until it can be effectively employed by municipal and industrial users, as evident with the Central Arizona Project. Potential water demand from environmental or agricultural sources were not estimated at this reconnaissance level of study.

Conclusion

Colorado's water supply will be need significant increase over the long-term. The timing of that need is uncertain given existing planned water supply additions and future demands from replacement water, environmental and other needs.

[1] US Geological Survey, Water Use Data by Country, 1985-1995.

Demand Bibliography

Table 3-5 is a compilation of currently available studies and reports that address current and projected demand in the Colorado, Arkansas, and South Platte basins. These studies were referenced in providing overall background and corroborative information for the analysis described above, as was personal communication with individuals responsible for planning among some of the major providers on the Front Range. The general list of sources for this report contains citations for the latter.

In addition to the sources listed below, there are several significant studies that are approaching completion but not yet available. These include the South Metro Water Supply Study, in which approximately a dozen providers between Castle Rock and Denver participated. Similarly, the Colorado Springs Utilities Environmental Impact Statement (EIS) on their Southern Water Delivery System will contain estimates of projected demand to the year 2040.

Table 3-5: Water Demands Bibliography

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Alternatives to the CRRP

Numerous water supply projects have been considered and rejected in past studies or environmental permitting processes and many new projects are currently in various stages of consideration and/or development to meet projected growth in the South Platte and Arkansas basins. These are grouped by types of projects and include discussions of several specific projects in each river basin. Later, in Chapter 8, the relative advantages and disadvantages of these types of projects are compared to the CRRP, after the economic and environmental aspects of the CRRP are presented in Chapters 6 and 7.

- *Agricultural water rights transfers*. Municipal water providers have increasingly sought to purchase and transfer agricultural water rights from Colorado irrigators and to convey the consumptive use of those rights into their urban water systems. Although this has been common practice for more than 20 years, the acceleration of interest and pressure for agricultural water rights transfers has grown in recent years as demands and price for water in urban areas have increased. The Arkansas Basin, Park County and Elbert County are examples of recent locations this has occurred.

- *Water reuse*. This water resource alternative entails second use of municipal effluent, or first use of untreated water by municipal customers. Denver recently built reuse, treatment, and distribution facilities, and Aurora is in the process of expanding both their reuse treatment and delivery capabilities. Denver has identified indirect potable reuse as a possible alternative in enhancing flexibility, reliability, and supply of their northern (Moffat Tunnel deliveries and Moffat WTP) system. Many other South Platte basin and Arkansas basin municipal water supplies have implemented, or plan to implement water reuse projects. The utilization of effluent or water discharged from wastewater treatment plants in exchanges is also increasing. Non-potable uses include industrial process water, landscape irrigation and other commercial uses. By law, reuse volumes are limited to rights that may be fully consumed, including transbasin diversions, non-tributary groundwater, and consumptive portions of rights that have been changed to municipal use.

- *Conservation*. Water conservation has also received much greater interest in Colorado in recent years with the escalating price of water and the difficulty of developing water resource alternatives, and with the recent drought. Water conservation encompasses a host of programs and measures in the agricultural and municipal

water use sectors. This study does not evaluate or compare each conservation program with the CRRP but adopts a more generalized comparison. Special, temporary drought response measures are not considered comparable to the CRRP or relevant in this instance, since such measures must always be held in reserve for unexpected but temporary circumstances.

- *New storage*. Construction of new dams and reservoir storage facilities has been a traditional means for increasing firm annual yield of river systems in Colorado and elsewhere. There are many new storage projects in the active stage of planning by Denver Water, Colorado Springs Utilities, and the Northern Colorado Water Conservation District, among others. Relatively small-scale gravel pit storage alongside the South Platte River has been developed in conjunction with water reuse, for seasonal storage of reusable effluent so that it can be released to allow upstream diversion by exchange.

- *Transbasin diversions*. An historically important water resource alternative has been the movement of water from one basin, where it was perceived to be available, to another basin, which was perceived to be short of water. The headwaterds of streams in western Colorado have been a major source of water for the Front Range since early in the 20th century. Examples include:

    - In the mid-1970's, Denver Water explored the possibility of collecting water from Turkey Creek and Gore Creek tributaries, the Piney River, and the Colorado River near State Bridge. Major features in the "Eagle-Colorado" configuration included a 350,000 af reservoir near Wolcott, a major pump station lifting water 2,000 vertical feet from the reservoir, and a tunnel under Vail Pass. The "Eagle-Piney" configuration involved long collection systems on the tributaries to Gore and Turkey Creek, and a Vail Pass Tunnel. In 2000, Denver Water looked again at these alternatives. New wilderness areas, established since the 1974 effort, and an overarching consideration for cooperative planning with Eagle basin users were new elements of the reconfiguration. A yield of 141,000 af was estimated for the updated Eagle-Colorado/Eagle-Piney project.

    - Alternatives in the Denver Water reconfigurations involved elements contemplated by Aurora, Colorado Springs, and the Eagle River Forum in separate projects. These involved pumping Eagle River diversions up to either an enlarged Eagle Park Reservoir or a conjunctive use project at Camp Hale, for eventual delivery to the East Slope. The cooperative approach taken by Aurora and Colorado Springs was a result of their experience with the Homestake II project, which was to have diverted approximately 20,000 af/yr to the cities. The project was unable to receive Eagle County permitting for construction of facilities.

    - Another alternative being reviewed by Aurora and Colorado Springs is a pumpback from Ruedi Reservoir to the Boustead Tunnel, for delivery to the Arkansas basin via the Boustead Tunnel. This scenario has been described as a replacement for the Homestake II project. Source water is from the Roaring Fork rather than Eagle basin.

    - Headwaters of the Gunnison River have been the subject of several applications for transmountain diversions, including the Collegiate Range Project and the Union Park Project. The latter contemplated a large reservoir above Taylor Park Reservoir and a gravity system under the Continental Divide, across the Arkansas Valley, and into South Park. Another approach to the development of Gunnison basin water supplies is the potentially available marketable yield of Blue Mesa Reservoir.

- Planning for what became Wolford Mountain Reservoir considered the possibility of a pumpback system from Green Mountain Reservoir to Dillon Reservoir and Roberts Tunnel. The pumpback scenario featured a replacement reservoir capable of serving all or part of the function of Green Mountain Reservoir, and a pressure pipeline that would deliver physically available flows or storage at Green Mountain Reservoir to Dillon Reservoir. The pumping would require about 1100 feet of lift over about 26 miles of pipeline, for up to 130 cfs. Use of Wolford Mountain Reservoir as a replacement supply to enable out of priority diversions at Dillon, without the pumpback, has increased Denver Water's yield to the Roberts Tunnel. The extent to which Wolford Mountain's yield is being effectively moved to Dillon Reservoir, and whether pumping would be feasible without the addition of more replacement storage would require further study.

- *Non-renewable groundwater*. The development of groundwater wells in aquifers not connected to surface water systems has been a popular water resource alternative for smaller municipal providers and rapidly growing suburban and rural areas, such as the southern and eastern ends of the Denver Metropolitan Area. Throughout the 1990's, several projects were proposed for importing non-tributary groundwater from the San Luis Valley to the Front Range. Yield of the project was largely available due to interception of evapotranspiration by non-beneficial vegetation. Much of the land that was to have been used for wellfields in these projects has become part of the Great Sand Dunes National Monument and Preserve, and is unlikely to be available for this kind of development.

- *Conjunctive use projects*. Conjunctive use involves maximizing yields from surface and groundwater supply by the efficient management of both resources. Conjunctive use can be configured very differently given local supply, hydrogeologic conditions, and economics. Aurora applied unsuccessfully for a unique project in the South Park basin that would use flood flows in the upper South Platte to recharge the aquifer in that mountain valley. The water would be pumped during times of drought, when, it was estimated, the project could deliver 17,500 af/yr. Because the project would operate at highest levels during dry years, it would increase the City's overall system firm yield by 9,600 af/yr, even though average yield would be only 5,500 af/yr. The south metro area providers have been working for several years to determine how to conjunctively use the Denver basin aquifer as a storage site for excess surface flows in the South Platte closer to the metropolitan area.