

WATER FOR TOMORROW



The History, Results, Projections and Update of the
Integrated Resource Plan
Denver Board of Water Commissioners - February 2002

History is lived forward, but it is written in retrospect. We know the end before we consider the beginning, and we can never wholly recapture what it was to know the beginning only.

C. V. Wedgwood

Water for Tomorrow

An Integrated Water Resource Plan

Denver Water

February 2002

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Dedicated
to
Jay Britton
(1946-1996)
Denver Water
(1969-1996)

Table of Contents

I. Denver Water’s Integrated Resource Plan: An Introduction and Overview	1
A Look Backward	1
The Board’s Service Area Boundary	2
Geography and History: The Early Years.....	3
The 1970s and 1980s	6
The IRP Report	7
The Board’s Direction to Staff.....	8
2001 Supply and Demand: The Bottom Line	9
A Look Ahead.....	9
II. Denver Water’s System.....	10
Water Collection System	10
Operations	12
Firm Yield.....	13
Reusable and Non-Reusable Water.....	15
Exchanges and Transfers	16
Hydropower	16
Drought Response Plan.....	17
Treated Water System.....	19
Treated Water System Overview	19
Treated Water Planning Study	24
System Audit of Unaccounted-For Water.....	32
Distribution System Management Issues	33
III. Water Demand.....	38
Future Growth Within Areas Served by Denver Water	38
Water Usage Factors and the Demand Forecast Model	40
Natural Replacement.....	42
Combined Service Area Build-Out	44
Denver Water Demand Forecast	44
IV. Water Supply Development.....	45
Supply Option Analysis	45
The Board’s Near-Term Water Supply Strategy	46
Cooperative Actions.....	49
Upper Colorado River Basin Study.....	51
Eagle River Basin.....	51
The Moffat Project	52
Long-Term Water Supply Opportunities	54
V. Water Conservation.....	56
Historical Precedent.....	56
The Conservation Planning Process.....	56
Evaluating Overall Program Performance	57
Public Attitudes and Conservation.....	59

Options for Additional Savings	60
Next Steps in Conservation.....	61
VI. Resource Strategy Update	62
Strategy Development.....	62
Board Reaffirms Near-Term Strategy.....	63
VII. Public Involvement	65
Communicating the IRP Process	65
VIII. Outcomes of the IRP Process	67
The Board’s Resource Statement.....	67
The Board’s Combined Service Area: Its Relationship to Supply and Demand	68
Meeting the Shortfall	69
The Changed Roles of Efficiency and Surface Supplies	70
Outside Denver Water’s Combined Service Area	71
And in Conclusion	72
Appendices (Available separately from this report)	
Treated Water System	
Water Resources	
Demand Forecast	
Conservation	
Drought Response Plan	

List of Figures

<u>Figure No.</u>	<u>Title of Figure</u>	<u>Page No.</u>
Figure I-1:	Denver Water’s Combined Service Area	5
Figure II-1:	Water Collection System.....	11
Figure II-2:	Annual Water Use	13
Figure II-3:	Simulated Reservoir Contents	15
Figure II-4:	Major Distribution Facilities	20
Figure II-5:	Maximum Day Use Comparison.....	22
Figure II-6:	System Consumption.....	23
Figure II-7:	System Consumption Ratios	23
Figure II-8:	Historical and Projected Water Use	25
Figure II-9:	Transmission Improvements	29
Figure II-10:	Footage of Pipe Installed by Year in Denver and Total Service	35
Figure II-11:	System Improvements and Main Replacements	36
Figure III-1:	Areas Served by Denver Water vs. DRCOG’s Six-County Area.....	39
Figure III-2:	Population – Treated Water Service Area.....	40
Figure III-3:	Annual Usage per Single-Family Household Historical and Future Use	41
Figure III-4:	Denver Water Demand Forecast and Existing Supply.....	44
Figure V-1:	Projected vs. Actual Conservation Savings	58
Figure VI-1:	Near-Term Strategy Changes.....	64

List of Tables

<u>Table No.</u>	<u>Title of Table</u>	<u>Page No.</u>
Table II-1:	Collection System Hydropower Plants.....	17
Table II-2:	Treated Water Service Obligations.....	19
Table II-3:	Projected Demand in Million Gallons Per Day.....	24
Table II-4:	Capital Improvement Plan Cost Summary.....	28
Table II-5:	Reservoir Improvements.....	28
Table II-6:	Conduit Improvements.....	30
Table II-7:	Pump Improvements.....	31
Table III-1:	Demand Model Usage Factor Results.....	41
Table III-2:	Denver Water Fixed and Special Commitments.....	43
Table IV-1:	Update of Near-Term Strategy.....	46
Table IV-2:	System Refinement Projects.....	48
Table IV-3:	Long-Term Supply Options.....	55
Table V-1:	'Best Bets' Conservation Measures.....	60
Table VI-1:	Near-Term Strategy.....	64

I. Denver Water's Integrated Resource Plan: An Introduction and Overview

In 1994, the Denver Water Board embarked upon a process to develop an Integrated Resource Plan (IRP). Before undertaking that effort, Denver Water spent about 18 months developing a state-of-the-art raw water model, an updated demand model, and accompanying analytical tools that would enable staff to better examine supply and demand options. Using these tools, the Board completed its IRP work in December 1996, and in 1997 issued a report on its effort. That report included a "Board Resource Statement" outlining the Board's resource policy for the future.

The reissuance of this IRP report five years later is intended to provide an update and a progress check on Denver Water's work in implementing the tasks set out by the Board in 1996. Numerous initiatives have been undertaken in the past five years, and the 1997 report has been updated and supplemented to reflect the changes resulting from those initiatives. An effort has been made to weave together the previous conditions and the changes that have recently occurred to provide a basis for understanding and comparison.

While the IRP report is an on-going process, the synopsis contained in this document explains aspects of Denver Water's current water system, practices, programs and the planning methodologies that sustain the report's conclusions. Technical appendices supporting the diverse subjects covered in this report are available upon request.

A Look Backward

Denver Water's mission historically has been to provide its Denver city customers and its Contract Distributors with high-quality water and excellent service at the lowest possible price. While this mission continues, Denver Water's approach to water supplies has undergone profound change during the past several years. In part, this change has resulted from a new and complex political and regulatory environment that culminated in the federal government's 1991 veto of the Two Forks Dam and Reservoir project. That project was designed to capture and store an additional 1.1 million acre-feet of water and was intended to provide for the needs of much of the metropolitan Denver area well into the 21st century. An acre-foot of water is about 326,000 gallons and typically is estimated to serve a family of four when all attendant commercial, industrial and public uses are apportioned across the residential use.

With the project's veto, Denver Water moved to redefine the limits of its service area and reassess its traditional assumptions for providing the water supplies needed to meet customer demand in that area. This challenge required a new approach to planning. By 1993, it was determined that this new approach should be built around a more holistic planning tool, that of Integrated Resource Planning. Such planning includes techniques to factor in changing public and regulatory sentiment and new technologies, as well as traditional engineering and financial aspects of water utility planning.

Using an IRP process, Denver Water launched an intensive three-year study of the capacities of its water supply network as well as the possibilities for reducing customer demand. This effort

included extensive participation from the public and outside interests that have a stake in how Denver Water approaches present and future water supplies. While the IRP methodology is designed to be open-ended and evolutionary as new information or conditions warrant, by the end of 1996 the extended analysis arrived at conclusions that now form the basis of a near- and long-term strategy for Denver Water.

A principal policy decision made in the context of the IRP process was that Denver Water would not attempt to extend its service area. Denver Water clearly defined a “Combined Service Area” comprised of the City of Denver and 78 suburban Contract Distributors. Denver Water committed to serve the build-out needs of this area, and also provide limited amounts of water to certain entities outside of the Combined Service Area. This approach makes it manageable to estimate water needs as growth within the Combined Service Area proceeds to build-out. An ever-expanding service area would have meant aiming at a moving demand target with only one certainty: that more and more water would be needed.

The Board’s Service Area Boundary

The Board’s decision to draw a defined service area boundary was a momentous one. Until the Board’s action in the mid-1990s, there remained a lingering expectation among many metro area entities that Denver Water would somehow find a way to serve a broader range of future metro water needs. The Board made clear that was not to be the case.

When it became apparent in 1989 that the Two Forks Dam and Reservoir project would be vetoed by the U.S. Environmental Protection Agency, the Board issued a set of policy positions to address the anticipated changed circumstances. Two years later, after the EPA veto became final, the Board enunciated a “new path” policy which said that:

“... Denver’s Water Board may no longer serve a central planning role for water supply under current institutional and political constraints. Having assessed Denver assets and obligations in light of current events, the Water Board is preparing for a different role in metropolitan water supply and development.”

Historically, the suburban areas growing up around Denver chose annexation into the city, thus obtaining the right to water supplied by Denver Water. Many other suburban areas not seeking annexation were offered Denver Water water supply by limited contract. As late as 1960, most of the water planning for the Denver metro area centered on the Denver Water Board.

But a series of circumstances, culminating in the veto of Two Forks, served to change this historical pattern. Most significant was the 1974 passage of the Poundstone Amendment to the state constitution, which effectively precluded Denver from annexing further land to expand its boundaries.

Another factor was the changing perception of water storage in the west. As the best water storage sites were claimed and used, fewer locations were available for water storage opportunities. In addition, over time, the public came to place increased value on preserving stream flows and avoiding dams. The result was a series of regulatory requirements that severely limited water storage development, escalating costs and risks for such development. With the veto of Two Forks,

it became clear the Board could no longer take responsibility for the water supply future of a rapidly expanding Denver metropolitan area. There were too many political, legal, economic and other constraints, and too few opportunities to develop significant new water supplies for the benefit of those outside the areas served by the Board.

What the Board could do was focus on the build-out of its own Combined Service Area. Serving this area to build-out would become the basis for the Board's planning efforts (Figure I-1). Providing for the build-out of that Combined Service Area remains the foremost obligation of Denver Water. Only secondarily would Denver Water look outside its Combined Service Area boundary for potential efforts that might prove mutually beneficial to both Denver Water's Combined Service Area and metro regions beyond.

Geography and History: The Early Years

The years before the 1970s were marked by relatively unbroken population and economic growth in the Denver metro area, and Denver's water system followed suit. With a semi-arid climate averaging only 15 inches of rainfall annually, it did not take long for early settlers to determine that in order to survive here, they had to find a way to store and divert water from the rivers and streams and move it to where it could be used. As early as 1860, construction of City Ditch was begun to bring water from the South Platte River to the city. In 1879, work began on the High Line Canal, a water source linked to a private real estate venture.

Diverting the raw water was not enough; it also had to be treated to eliminate contaminants. Thus began the Kassler Treatment Plant in 1890, the first English-style slow sand filter east of the Mississippi River. Treatment, in turn, necessitated some means of storing the water until it could be treated, leading to the completion of Platte Canyon Reservoir in 1904 and then, in 1905, Cheesman Reservoir higher in the South Platte Basin.

From 1868 to 1918, water utility development in the city was divided among numerous private water entities and characterized by in-fighting, price gouging and unsavory competitive practices. While the private utilities laid a sound engineering base for a water supply system, their conflicts ultimately led Denver citizens to approve a city-owned water utility that would be non-political, autonomous from other city interests and agencies, and instructed by amendment to the city charter to charge the lowest rates possible consistent with good service. That mandate still shapes Denver Water's approach to water rate setting.

Cheesman Reservoir was soon followed by other storage reservoirs and tunnels to carry water to Denver. In order, they were: Antero Reservoir, built in 1909 and acquired by Denver Water in 1924; Eleven Mile Canyon Reservoir, completed in 1932; the Moffat Tunnel Collection System, also known as the Fraser System, which began operating in 1936; Williams Fork Reservoir, completed in 1938 and enlarged in 1959; Gumlick Tunnel, acquired by Denver Water in 1955; Gross Reservoir, completed in 1955; Roberts Tunnel, completed in 1962; Dillon Reservoir, which started operating in 1963; and Strontia Springs Reservoir, completed in 1983.

Denver Water's water system can store more than 600,000 acre-feet. In 1996, the system's water rights and facilities were capable of producing a reliable or firm yield of 345,000 acre-feet. Today,

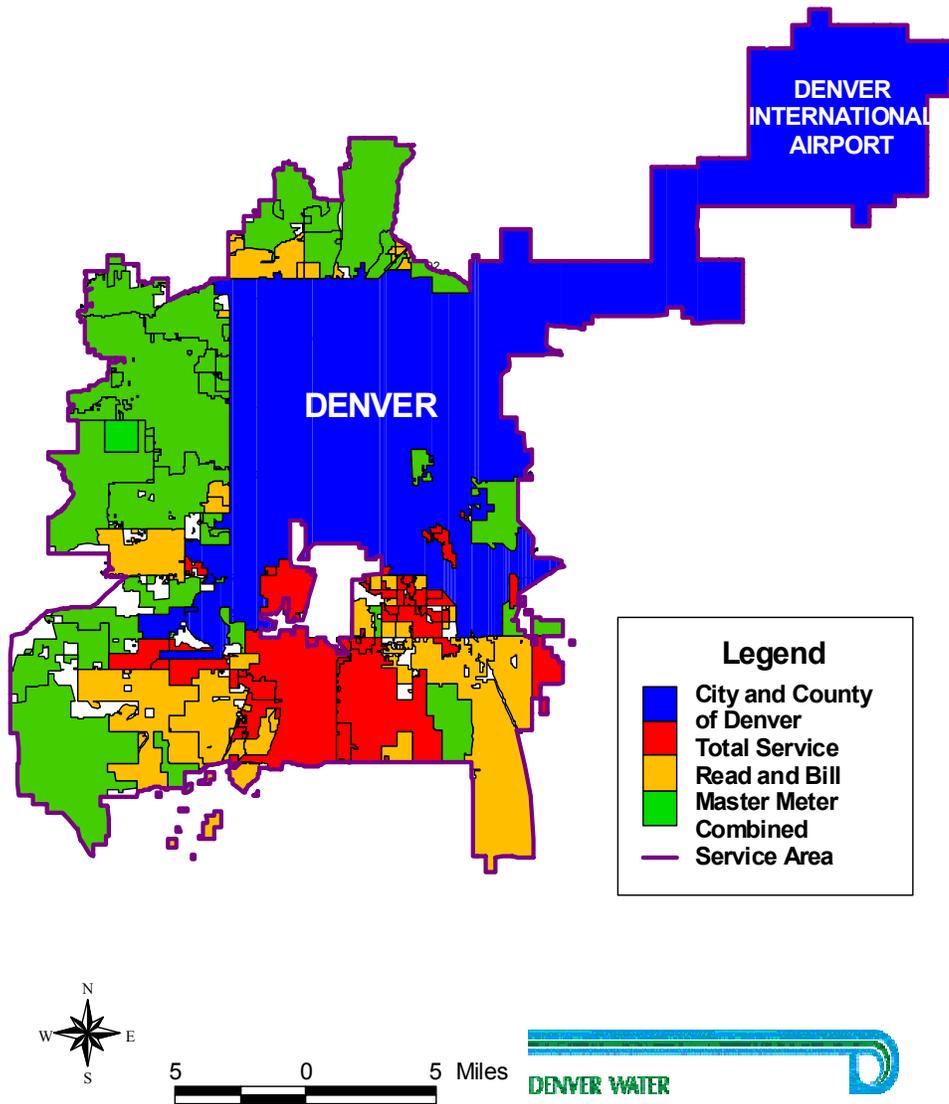
including the projects under construction, the system can produce a firm yield of 375,000 acre-feet. Denver Water has a maximum treatment capacity of 645 million gallons per day. If the need arose, that treatment capacity could be expanded to almost 1 billion gallons a day by doubling the size of the Foothills Plant. That plant was designed with an expectation that in future years, additional stages of the plant would be brought on-line up to a maximum capacity of 500 million gallons per day. Overall, the replacement cost of the collection, storage, treatment and distribution system has been estimated at between \$3 billion and \$6 billion; in reality, Denver Water's system is essentially irreplaceable.

New water treatment plants were brought on-line in tandem with reservoirs. The Marston Treatment Plant was built in 1928; Moffat Treatment Plant in 1937; and Foothills Treatment Plant in 1983. Similarly, as water collection and treatment facilities went forward, so did major transmission lines. Mammoth conduits, some as large as 10 feet in diameter, now form a backbone distribution system from the treatment plants, a system in which pumping is significantly reduced by virtue of water generally being conveyed to users by gravity.

In the era before environmental regulation, Denver Water's planning consisted largely of turning to the structural project that was least costly and highest-yielding to meet increased water demand. Water officials from 1868 to 1968 knew how to build a system, and how to do it well. The water was available to the system in the spring snowmelt of May, June and July. The challenge was to capture it, store it, treat it and distribute it as a permanent, reliable, high-quality supply 12 months a year.

"Reliability" of supply became an overriding consideration in the Denver Water system. Denver Water had experienced periodic drought, including a devastating three-year dry period in the 1950s that reduced its reservoir storage to minor pools of water. This mid-1950s drought became the "drought of record" for Denver, with all raw water supply planning taking that period as its point of departure. The 1950s' episode pointed up a principal challenge of water supply planning: to reduce risk of water supply shortages to the lowest feasible level. That challenge was often resolved by engineering and money. By carefully deploying both, Denver Water built a system of 11 major storage reservoirs; four tunnels through the mountains beneath the Continental Divide; three treatment plants; 2,500 miles of pipe; 17 pump stations; 30 treated water reservoirs; a state-of-the-art water quality lab; a successful direct potable water recycling demonstration project; and the beginning stages of a \$150 million non-potable recycled water project. The Denver Water system now serves a customer base of over 1.1 million people.

Figure I-1
Denver Water's Combined Service Area



The 1970s and 1980s

By the early 1970s, with the enactment of the National Environmental Policy Act (NEPA), the Clean Water Act (CWA), the Forest Land Policy Management Act (FLPMA), the Endangered Species Act (ESA), the Safe Drinking Water Act (SDWA), the Wilderness Act, and the Wild and Scenic Rivers Act, Denver Water was faced with a regulatory environment that would forever change its way of doing business. This alphabet soup of federal regulation meant that utilities were initially set adrift in uncharted regulatory waters. The controversy in the 1970s over building Foothills Treatment Plant and Strontia Springs Reservoir signaled the end of Denver Water making decisions with little public or regulatory scrutiny.

The ink had scarcely dried on the new federal laws when the resulting regulations were being tested on Denver's proposed Foothills and Strontia projects. Federal regulators from the U.S. Forest Service, the Army Corps of Engineers, the Bureau of Land Management, and the Environmental Protection Agency intervened to determine if the intended activity was to be permitted and, if so, how it was to proceed. The ensuing confusion carried over to state agencies with a role in the new federal legislation. This regulatory chess game ended after a half dozen years with a negotiated settlement in late 1978 and early 1979.

After that protracted and costly delay, the Foothills Treatment Plant and Strontia Springs Reservoir were constructed and placed on-line in 1983. But the negotiated settlement also carried some interesting conditions for Denver Water's future. Denver Water had to agree that before building any future supply facilities, it would conduct a system-wide environmental impact study to evaluate options and alternatives for future water supply and demand. Denver Water also had to commit to implementing a water conservation program intended to reach certain targeted levels over the coming two decades. To determine whether the levels were reached, the EPA would monitor the conservation efforts. And finally, a Citizens Advisory Committee to the Denver Water Board was created to bring public involvement into Denver Water policy and planning deliberations.

All of these conditions marked a major departure from the traditional water utility pattern. Denver Water had normally pursued the least costly structural alternative. Now, it would have to consider a variety of alternatives—including non-structural variables such as conservation and environmental impact—before proceeding with a project. Water conservation would have to become an integral part of Denver Water's new supply equation, not just a contingency in times of drought.

In large measure, Denver Water became a water utility test case for the new regulatory environment. Nowhere else had federal agencies conducted a system-wide environmental impact statement. Nowhere else had the newly created EPA, with no experience in water issues, taken responsibility for ensuring that a local water utility was satisfactorily implementing conservation measures. And nowhere else had federal agencies so deeply involved themselves in a local water utility's future supply and demand planning.

For Denver Water and many other Denver metro-area water entities, the 1980s were marked by a determined effort to fit the proposed Two Forks project into niches within the new federal regulations. The effort began in 1981 when Denver Water approached the Army Corps of Engineers to outline a "scope of work" for the system-wide environmental impact study of Denver

Water's total water system. It continued in 1982 with an agreement between Denver Water and 44 Denver-area water suppliers to help finance that study of general water supply options for the long-term future. It proceeded in 1984, when the system-wide impact statement was combined with a full-scale environmental impact statement on the proposed Two Forks project itself. Almost a decade and some \$37 million in study costs later—after the last of a long series of necessary local, state and federal approvals had been obtained—the project was preliminarily vetoed by the EPA. With these circumstances as the backdrop, Denver Water began a reassessment that would take it on a new path for the future.

The IRP Report

When the Board issued its IRP report in 1997, Denver Water's system had a water demand of 265,000 acre-feet annually by residential, commercial and public users. With reliable annual supplies of 345,000 acre-feet, Denver Water had an 80,000 acre-foot annual surplus in its water storage system.

Results of the IRP process indicated that if nothing were done to enhance system supplies or reduce demand, future system demand would catch up with available supply by the year 2013. By 2045, the presumed build-out date of Denver Water's Combined Service Area, an additional 100,000 acre-feet, or a total of 445,000 acre-feet of water, would be needed for Denver Water's customers. This included a 30,000 acre-foot "safety factor" as a hedge against potential loss of yield from catastrophic occurrences, faulty projections, or regulatory requirements.

The results of the 1997 IRP report also revealed that Denver Water could add 100,000 acre-feet from its own resources to build out its Combined Service Area. That is, Denver Water would not need to depend on new water rights to meet its future obligations. In the near term, Denver Water could implement strategies involving conservation, reuse of water, system refinements, and potential cooperative arrangements with other regional water interests to provide additional system efficiencies, demand management and water storage. These actions could yield an additional 55,000 acre-feet of water, extending the timeline when demand would meet supply from the year 2013 to approximately 2030. The Board determined that the period up to 2030 would constitute its "near-term" planning horizon, while post-2030 would denote the "long-term."

The Board fashioned its near-term strategy for specific actions prior to 2030; however, it noted that for the remaining 45,000 acre-feet needed to make up the entire 100,000 acre-foot shortfall for build-out, the time frame for obtaining the added 45,000 acre-feet was sufficiently distant that no project-specific commitments needed to be made at that time. The Board observed that options available for providing the long-term supply include additional conservation, expanded reuse, and the development of water rights with new or enlarged surface water structures. New demand management tools, reuse techniques, treatment technologies, consumption patterns, storage additions, and changing political sentiments or jurisdictions were thought to be too remote to anticipate.

The Board's Direction to Staff

In 1996, the Board issued its “Board Resource Statement” to guide its water resource strategy for the future. The document outlined a series of principles for the Board’s staff and included a series of potential actions to use available water supplies efficiently and to develop new water supply. The Board indicated that no single option or project would be sufficient to close the 100,000 acre-foot shortfall between its supply and demand for build-out of the system. As a central feature of its resource strategy, the Board emphasized the need for a strong water conservation ethic and additional cost-effective water conservation measures, including investments that provide opportunity for private sector participation. The Board also committed itself to development of a non-potable recycled water project and small-scale system management techniques, such as conversion of park land from potable to non-potable irrigation. The Board indicated that new surface water storage would likely be needed toward the end of the near-term strategy to supplement conservation, reuse and small-scale refinements. As for the water rights for such surface supply, the Board emphasized that since it is impossible to determine which of its rights will be required for future surface supply, it must preserve all of its conditional water rights.

To implement its near-term and long-term strategies, the Board set forth certain guidelines to help direct staff efforts. These included:

- **When meeting future needs, including development of cooperative projects with others, the Board will pursue resource development in an environmentally responsible manner;**
- **The Board cannot permanently dedicate to entities outside its Combined Service Area capacity within its system because all of the Board’s existing infrastructure, and more, will be needed to meet the Board’s water supply obligations within its service area;**
- **The Board recognizes that “cooperative actions” with other metropolitan entities outside its service area can enhance its near-term and long-term strategies, and the Board directed staff to explore such cooperative actions with all potential parties;**
- **The Board will consider short-term temporary leases of water outside its service area for no longer than five years so long as the Board’s system does not suffer adverse effects and so long as the party receiving water does not become reliant on that water, so that the supply is truly “temporary”;**
- **By maximizing use of its existing supply, the Board recognizes that there will be downstream effects north of Denver as well as in the fluctuation of its reservoirs, such as Dillon Reservoir; and**
- **The Board emphasizes that it will not undertake any future structural projects on the Western Slope unless such project is developed cooperatively with Western Slope entities for the benefit of all parties concerned.**

2001 Supply and Demand: The Bottom Line

As part of its 2001 update of the IRP, Denver Water revisited various water supply and demand management options using its raw water and demand models. The purpose was to use the latest available data and information to identify Denver Water's existing and future supply and demand.

The results of that update show that the Denver Water Board currently has a supply of 375,000 acre-feet of firm annual yield, an increase of 30,000 acre-feet over the 1996 figure. Much of that increase can be attributed to projects under construction and processes presently underway. For example, 17,000 acre-feet is from Denver Water's non-potable recycling project, which is under construction and will be fully used over the next decade. Similarly, 5,000 acre-feet are attributable to gravel pit storage, even though these storage reservoirs will not be fully operational for several years.

Current demand on the Denver Water system is now 285,000 acre-feet, a significant jump of 20,000 acre-feet over the figure published in 1997. Major growth in Denver Water's service area in the past half decade accounts for the increase. Even with that increase, Denver Water projects its requirement for build-out of the system in the middle of the 21st century at approximately 450,000 acre-feet, only a 5,000 acre-foot increase over that projected in 1997. Although population projections from the Denver Regional Council of Governments, the Colorado State Demographer and others increased dramatically as a result of unparalleled growth in the 1990s, that population increase has been offset by lower water usage factors among Denver Water's customers. The result is that the projected build-out demand between the original IRP report and the current update is essentially unchanged.

Included in that 450,000 acre-foot build-out demand is a 30,000 acre-foot safety factor. The Board continues to believe it is wise to retain such a safety factor against unexpected events that could drastically change its supply and demand picture.

A Look Ahead

Among the most important efforts undertaken by the Board in the 1990s has been its determination to work cooperatively with all interested parties in finding mutually beneficial solutions. That undertaking has made it possible to develop an Integrated Resource Planning tool for the future with realistic expectations built around the actions of others. It has also made it possible for the Board to enter into a score of agreements that have furthered the Board's Integrated Resource Planning goals. This report explains the Denver Water system as well as its problems, potentialities and possibilities. The report lays the foundation for the next update of the IRP to be completed in 2007.

II. Denver Water's System

Water Collection System

The water collection system is defined as all diversion, collection and transmission facilities that store and distribute raw water prior to treatment. There are three major systems: the South Platte Collection System, the Roberts Tunnel Collection System and the Moffat Tunnel Collection System. Locations of these facilities are shown in Figure II-1. These three systems can be grouped into two distinct collection categories:

- The South System, which is comprised of the Roberts Tunnel Collection System (including Dillon Reservoir) and the South Platte Collection System. These systems deliver water to Foothills and Marston treatment plants.
- The North System, which is comprised of the Moffat Tunnel Collection System that delivers water to the Moffat Treatment Plant.

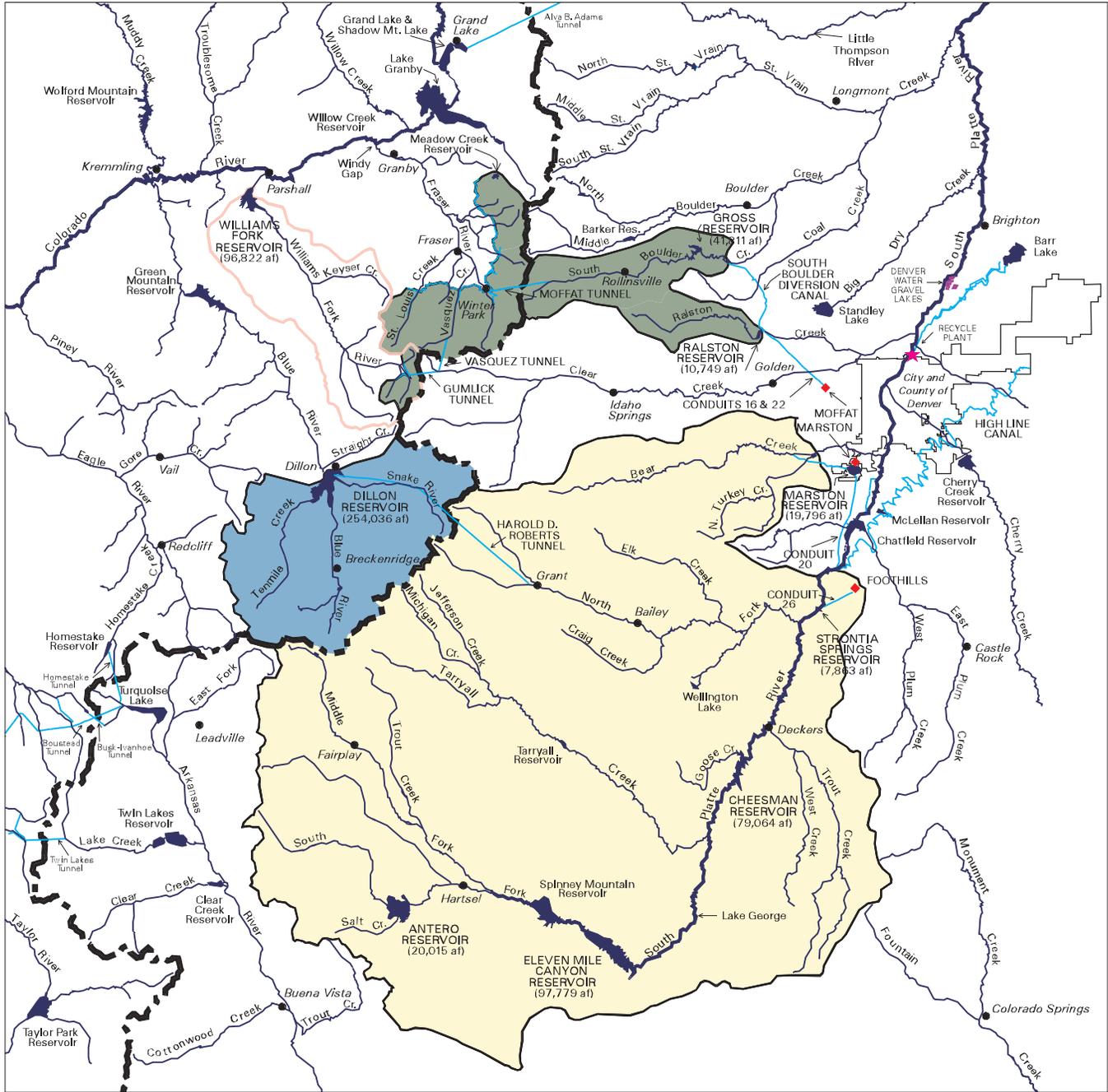
Williams Fork Reservoir supports the Roberts Tunnel and the Moffat Tunnel collection systems through water exchanges described later in this chapter. Some of the water in Woford Mountain Reservoir, which is owned and operated by the Colorado River Water Conservation District, is owned by Denver Water and is used to replace water “borrowed” from Green Mountain Reservoir by Denver Water at Dillon Reservoir.

The Roberts Tunnel Collection System includes Dillon Reservoir and Roberts Tunnel. These facilities capture and store water from tributaries in the Blue River Basin and subsequently deliver this water to the Eastern Slope for use in the Denver metropolitan area.

The South Platte Collection System captures water from the mainstem of the South Platte River, as well as from Bear Creek and Cherry Creek, and subsequently delivers this water to all the areas Denver Water serves. The major facilities in the system include Antero Reservoir, Eleven Mile Canyon Reservoir, Cheesman Reservoir, Strontia Springs Reservoir and Conduit No. 26, Platte Canyon Intake Dam and Conduit No. 20, Marston Reservoir, Platte Canyon Reservoir, Harriman Ditch and Conduit No. 15, and Cherry Creek wells. Denver Water also has a storage pool in Chatfield Reservoir and either owns or holds an interest in a number of ditch companies and ditch systems that operate in the metropolitan area, such as the High Line Canal and the Farmers and Gardeners Ditch. In addition, Denver Water and South Adams County have jointly acquired gravel pit sites along the South Platte River in Adams County. The pits will be converted to storage facilities and used to exchange reusable water upstream to Denver Water's facilities.

The Moffat Tunnel Collection System captures water from the Williams Fork River, the Fraser River, South Boulder Creek and Ralston Creek, and subsequently delivers this water for use in the Denver area. The major facilities in the system include the Williams Fork Collection System,

Figure II-1 Water Collection System



LEGEND



- | | |
|-----------------------------------|-------------------------|
| South Platte Collection System | Continental Divide |
| Roberts Tunnel Collection System | Major Stream or River |
| Moffat Collection System | Major Canal or Tunnel |
| Williams Fork Reservoir Watershed | Major Lake or Reservoir |
| Denver Water Treatment Plant | Town |



August P. Gumlick Tunnel (Jones Pass Tunnel), Vasquez Tunnel, the Fraser River Collection System, the Cabin-Meadow Creek Collection System, Moffat Tunnel, Gross Reservoir, South Boulder Diversion Canal, Ralston Reservoir, and Long Lakes. Denver Water also has a storage pool in Consolidated Mutual's Walter E. Welton Reservoir (Fortune Reservoir).

Williams Fork Reservoir is located on the Williams Fork River near its confluence with the Colorado River in Parshall, Colorado. The reservoir is used as a replacement facility for Denver Water's transmountain diversion projects. Williams Fork Reservoir is used to exchange water to the Fraser and Williams Fork collection systems and the Roberts Tunnel Collection System, and on occasion is used as a substitution source for Denver Water's obligation to Green Mountain Reservoir. Historically, most of the power generated at Williams Fork Reservoir has been delivered to the U.S. Department of Energy as partial payment for power generation interference caused to Green Mountain Reservoir Power Plant by Denver Water's upstream depletions of the Blue River at Dillon Reservoir. A portion of the power is used for Williams Fork service requirements; the remainder is currently being sold to an electric utility.

In addition to the above systems, construction of the water recycling project near the Metro Wastewater Reclamation District plant is underway. Upon its completion, the recycling plant capacity will be 45 million gallons a day, delivering more than 17,000 acre-feet of water per year to non-potable uses. Customers include the Cherokee Power Plant, Washington Park, City Park and Golf Course, Denver Country Club, the Park Hill Golf Course, re-development at Stapleton and Lowry, the Rocky Mountain Arsenal, Denver International Airport, and various parks and industrial users along the distribution system route. Additional details of the water collection system are provided in the Water Resources Appendix.

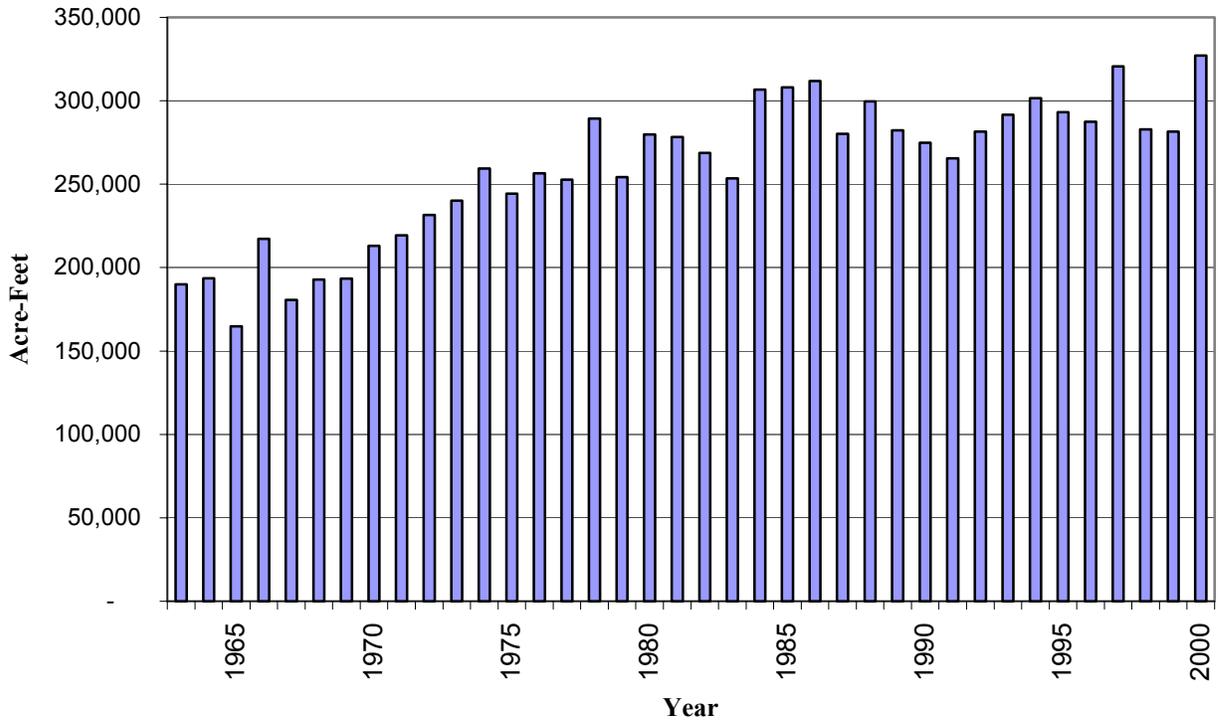
Operations

The primary goal of collection system operations is to supply a reliable, high-quality water supply to Denver Water's customers. Ultimate delivery of most of the collected water is to Denver's three water treatment plants—Moffat, Marston and Foothills—but some is used for irrigation and industrial purposes, or is provided to local suppliers such as the City of Arvada under special limited contracts. In addition to the primary goal, there are several other considerations, such as environmental enhancement and recreation, maximizing hydropower revenue, and minimizing treatment and distribution costs. In some instances, the collection system is used for flood reduction for local communities.

To optimize the reliability of the collection system, reservoir storage must be managed to provide space to capture spring runoff so that no reservoir spills water while another fails to fill. To attain these conditions, the water supply from all sources must be forecast or estimated. Construction projects, maintenance activities, water quality considerations, contractual obligations and numerous other factors also influence how the collection system is operated.

In most years, more water is available to the collection system during the runoff season than can be consumed or stored; however, during the winter months and in dry years, the available water from streams is less than the demand for water, so that water must be withdrawn from storage. Current water use averages about 285,000 acre-feet annually, although there is considerable year-to-year variability. The variability of historical annual water use is shown in Figure II-2.

**Figure II-2
Annual Water Use**



Typically, direct flow water rights are the first rights used to meet demand. The next increment of supply usually comes from exchanges using reusable water supplies. (Exchanges are explained later in this chapter.) The remaining water demand, if any, is normally supplied with storage releases from Strontia Springs, Marston or Ralston reservoirs. Most of the water in Marston and Strontia Springs is transferred from Dillon and Cheesman reservoirs or stored in Strontia Springs by exchange; Ralston Reservoir water is primarily transferred from Gross Reservoir. The water stored in Antero and Eleven Mile Canyon reservoirs is normally reserved for use in droughts, while Williams Fork Reservoir water is used for replacement of out-of-priority diversions.

Firm Yield

The concept of *firm yield* is critical to analysis of Denver Water supplies. It enables staff to compare existing and new resources on an equivalent basis, and it permits the comparison of available supply and customer demand.

Denver Water determines the firm yield of its existing water collection system by calculating the maximum water demand that could be met during a representative hydrologic study period. This approach uses the assumption that Denver Water’s current water supply facilities and water rights existed over the historical study period. To accomplish this analysis, Denver Water relies on an integrated system of computer programs called the Platte and Colorado Simulation Model

(PACSM). PACSM is used to simulate operations of Denver Water's and other water entities' collection systems within portions of the Platte, Arkansas and Colorado River basins. The model simulates stream flows, diversions, return flows, and reservoir functions operating under Colorado's water laws and numerous operating agreements. As such, the model is continually updated and revised to incorporate new facilities, water rights agreements, and operating assumptions.

The selection of the study period used by PACSM is important because it determines the frequency and duration of extreme hydrologic events that are simulated. The study period can influence the conclusions drawn from an analysis. For example, a water supply system may perform adequately under average runoff conditions, but may fail completely during severe drought conditions. From a water supply reliability perspective, the most important hydrologic event to a water supply study is the critical drought period. For Denver Water's collection system, the drought that began in late summer of 1953 and ended in spring of 1957 is the critical period used for water supply planning.

Since the critical period varies with the sustainability of a given water supply system, the duration of the study period must be long enough to encompass critical drought periods for the entire collection system. Denver Water has determined that the hydrologic study period from 1947 through 1991 is representative of the long-term conditions for the river basins of concern. This period encompasses the critical drought periods for all watersheds in Denver Water's collection system.

The weather and stream flow hydrology for the 1947-1991 period are applied to existing and proposed operating conditions. For example, PACSM simulates the operations of Dillon Reservoir in the drought of the 1950s, even though the reservoir was not constructed until the early 1960s. Similarly, PACSM is used to simulate how potential supply additions would have operated during the study period. This enables water resource managers to better understand how much water would be available to Denver Water's customers during drought conditions from various water supply options and how these options would alter stream flows.

PACSM simulates the operation of the water collection system to determine the maximum amount of water demand the system could meet without shortages through the study period. Although this water demand is reported as a fixed average number expressed in acre-feet per year, the actual demand and water supply that is needed varies daily, monthly and from year-to-year, and is modeled that way in PACSM. In a normal year, water demand in a summer month exceeds demand in a winter month by a factor of about three to one. Also, annual demand can be more than 30 percent greater in a hot, dry year than in a cool, wet one. These variations in water demand are largely attributable to outdoor uses of water, most notably lawn irrigation.

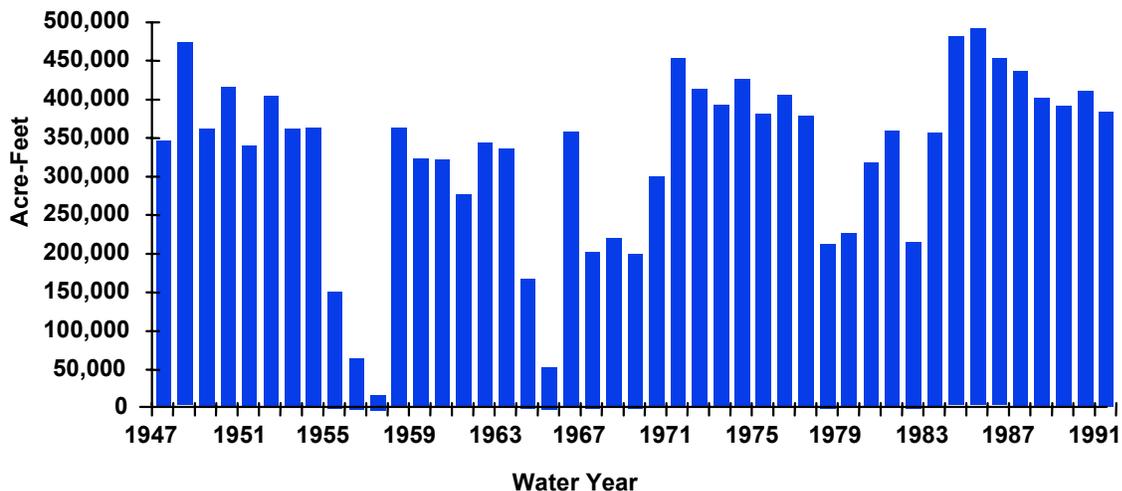
For example, over the simulated study period Denver Water's existing collection system can meet an average demand of 375,000 acre-feet per year. The delivery to demand ranged from approximately 430,000 acre-feet in dry years to as low as 330,000 acre-feet in the wet years. That is, customer demand was 100,000 acre-feet higher in the dry year than in the wet year.

To determine the collection system yield, PACSM simulates a trial level of customer water demand. If the simulation ends with surplus water in the storage reservoirs throughout the study period, the process is repeated at an increased level of customer water demand. Conversely, if the simulation indicates that the trial level of customer water demand cannot be met at all times, the process is repeated at a reduced level of demand. This iteration continues until the model simulation shows

the total reservoir storage approaching empty during the critical period and, immediately thereafter, beginning to refill without causing any shortfall in meeting demand.

Simulated reservoir contents for the existing collection system are shown in Figure II-3. This figure shows the combined end-of-month contents for Denver Water's storage reservoirs for every April from 1947 through 1991. April is shown because it is generally the month in which Denver's reservoirs are at their lowest level. Using today's collection system capabilities to provide the maximum amount of demand, the model simulation shows that the reservoirs would approach empty sometime in April 1957 and then began to refill. All water demands were met at the 375,000 acre-foot level of demand. Thus, the current collection system can meet a customer water demand of 375,000 acre-feet, assuming a hydrologic and climatological cycle similar to that of water years 1947 through 1991.

Figure II-3
Simulated Reservoir Contents



Reusable and Non-Reusable Water

In accordance with Colorado water law, all water delivered by Denver Water to its customers is classified as reusable or non-reusable. Whereas return flows of non-reusable water belong to downstream water rights and cannot be used a second time by Denver Water, return flows of reusable water can be used over and over again until that water is fully consumed. The main sources of reusable water in Denver Water's collection system are:

- Roberts Tunnel
- Meadow Creek system
- Transferred agricultural water rights

Reusable water delivered by Denver Water is tracked until it returns to a stream as effluent from a wastewater treatment plant or until it becomes groundwater return flow as a result of lawn irrigation.

The Metro Wastewater Reclamation District Plant and the Littleton-Englewood Wastewater Plant are the primary return flow points of Denver Water's reusable water. Denver Water's options for reusing its reusable water supply are described later in this report.

Exchanges and Transfers

In an exchange, water is added to a stream at a downstream point to enable diversion of the same amount at an upstream location. In a transfer, water is released from an upstream reservoir so it can be stored in a downstream reservoir or delivered to a water treatment plant. Exchanges increase the amount of water that can be legally diverted at an upstream location. Exchanges that would injure a senior water right between the replacement and diversion point cannot be performed. An important source of replacement water for Denver's exchanges is the reusable water returning to the South Platte as effluent from the Metro Reclamation District and the Littleton-Englewood wastewater treatment plants.

Exchanges and transfers give water operators the flexibility to move water from place to place within the collection system. For example, if operators want to store water in Dillon Reservoir when such storage is out-of-priority, they can perform a Williams Fork Reservoir-to-Dillon Reservoir water exchange. The exchange would be accomplished by releasing water out of Williams Fork Reservoir for use by downstream senior water rights and storing a like amount of water in Dillon Reservoir. An example of a transfer is the conveyance of water from Gross Reservoir to Ralston Reservoir to meet water needs at the Moffat Water Treatment Plant.

Some of the exchanges commonly performed within the collection system are listed below:

- Metro Wastewater Treatment Plant to Strontia Springs Reservoir
- Bi-City Wastewater Treatment Plant to Strontia Springs Reservoir
- Williams Fork Reservoir to Dillon Reservoir
- Williams Fork Reservoir to Moffat Tunnel
- Chatfield Reservoir to Cheesman Reservoir
- Blue River water to Cheesman Reservoir

As discussed later in this report, Denver Water and South Adams County Water and Sanitation District have jointly acquired gravel pit sites along the South Platte River in Adams County. The pits will be converted to storage facilities and used to maximize exchange of reusable water upstream to Denver Water's facilities.

Hydropower

There are five hydroelectric power plants associated with the raw water collection system. Key features of these power plants are given in Table II-1.

**Table II-1
Collection System Hydropower Plants**

<u>Name</u>	<u>Location</u>	<u>Capacity [Kilowatts]</u>
Williams Fork	Williams Fork Dam	3,150
Dillon	Dillon Dam	1,800
North Fork	East Portal Roberts Tunnel	5,500
Strontia Springs	Strontia Springs Dam	1,000
Foothills	Headworks of Foothills Plant	3,100

In 2001, the Federal Energy Regulatory Commission issued a license for Denver Water to construct a 5,000-kilowatt power plant at Gross Dam located on South Boulder Creek. Denver Water intends to begin power plant construction in 2003.

A secondary consideration of Denver Water’s collection system operations is to generate hydropower revenue without jeopardizing water supply. For this reason, the effect of operating decisions on power revenue is an ongoing concern.

Drought Response Plan

With input from the Citizens Advisory Committee and other groups, Denver Water staff prepared a Drought Response Plan in 1993 to be used as a guide for Board action in a drought. The Drought Response Plan was updated in 2001, but the core elements of the plan did not change.

Drought is a natural phenomenon that has recurred at varying intervals throughout history, but is curiously difficult to define. Denver Water defines drought as an extended period of below-average precipitation or streamflow that stresses its customers’ water supply. Denver Water’s supply strategy is to have enough water to meet customer demands without having to restrict use. Unfortunately, no one can predict how long droughts will last or if they will be worse than those used in Denver Water’s calculations. Therefore, even though Denver Water’s water supply currently exceeds its use, Denver Water must be prepared to recognize drought conditions early and respond appropriately. Denver Water’s primary drought response goal is to provide options that can be used to budget water use so that supply will be available for the most essential uses during the drought’s duration. The Drought Response Plan addresses three areas—water supply and use, strategies and potential drought response, and public outreach.

The Drought Response Plan is based on three levels of drought severity, each of which is triggered by the expected or actual reservoir storage levels in the Denver collection system on July 1 of any given year. A “mild” drought would be declared if predicted or actual July 1 storage drops below 80 percent of capacity. Similarly, “moderate” and “severe” droughts would be declared at storage levels below 60 percent and 40 percent full, respectively.

July 1 was deemed the trigger date for determination of a drought because most of the snowmelt runoff has occurred by that date, the highest water use days are ahead, and reservoir storage is near its peak for the year. July 1 storage levels are forecast from February through June every year, based on current snow pack, stream flow and storage levels.

The Drought Response Plan recommends that actions to increase water supply and/or reduce water use should be commensurate with the severity of the drought. The plan suggests water use reduction goals of 10 percent, 30 percent and 50 percent for “mild,” “moderate” and “severe” droughts, respectively.

<u>July 1 Storage</u>	<u>Drought Level</u>	<u>Reduction Goal Target</u>
Less than 80% full	Mild	10%
Less than 60% full	Moderate	30%
Less than 40% full	Severe	50%

A “Menu of Possible Board Actions to Cut Water Use” has been developed for each of the drought levels. These menus have been discussed with the Citizens Advisory Committee, the Distributors, the “Green Industry” and other interested stakeholders. The menu is meant as a starting point for the Board; the circumstances of a particular drought will determine which options, if any, the Board decides to implement.

During a drought, it is essential that Denver Water communicate effectively with its customers, other water suppliers, local governments, Western Slope representatives and interested groups that may be affected by Denver Water’s drought responses. The “Public Outreach” section of the Drought Response Plan provides recommendations for communications with these entities and groups.

Treated Water System

Treated Water System Overview

Denver Water serves treated water to the City and County of Denver and 78 suburban Distributors with Total Service, Read & Bill, or Master Meter contracts. Denver delivers treated water to 280,000 accounts and approximately 1 million persons. About 52 percent of the accounts are within the City of Denver.

Denver Water’s owned and operated treated water facilities include:

- Three treatment plants with a combined capacity of 645 million gallons per day.
- 17 pump stations with a pumping capacity of 1,053 million gallons per day.
- 30 treated water storage reservoirs in 16 locations totaling 344 millions gallons.
- 2,474 miles of pipe; 39,500 valves; and 14,000 hydrants.

On average, Denver Water customers currently use about 220 million gallons per day. Winter demand is about 120 million gallons, while water consumption on a peak summer day may exceed 500 million gallons.

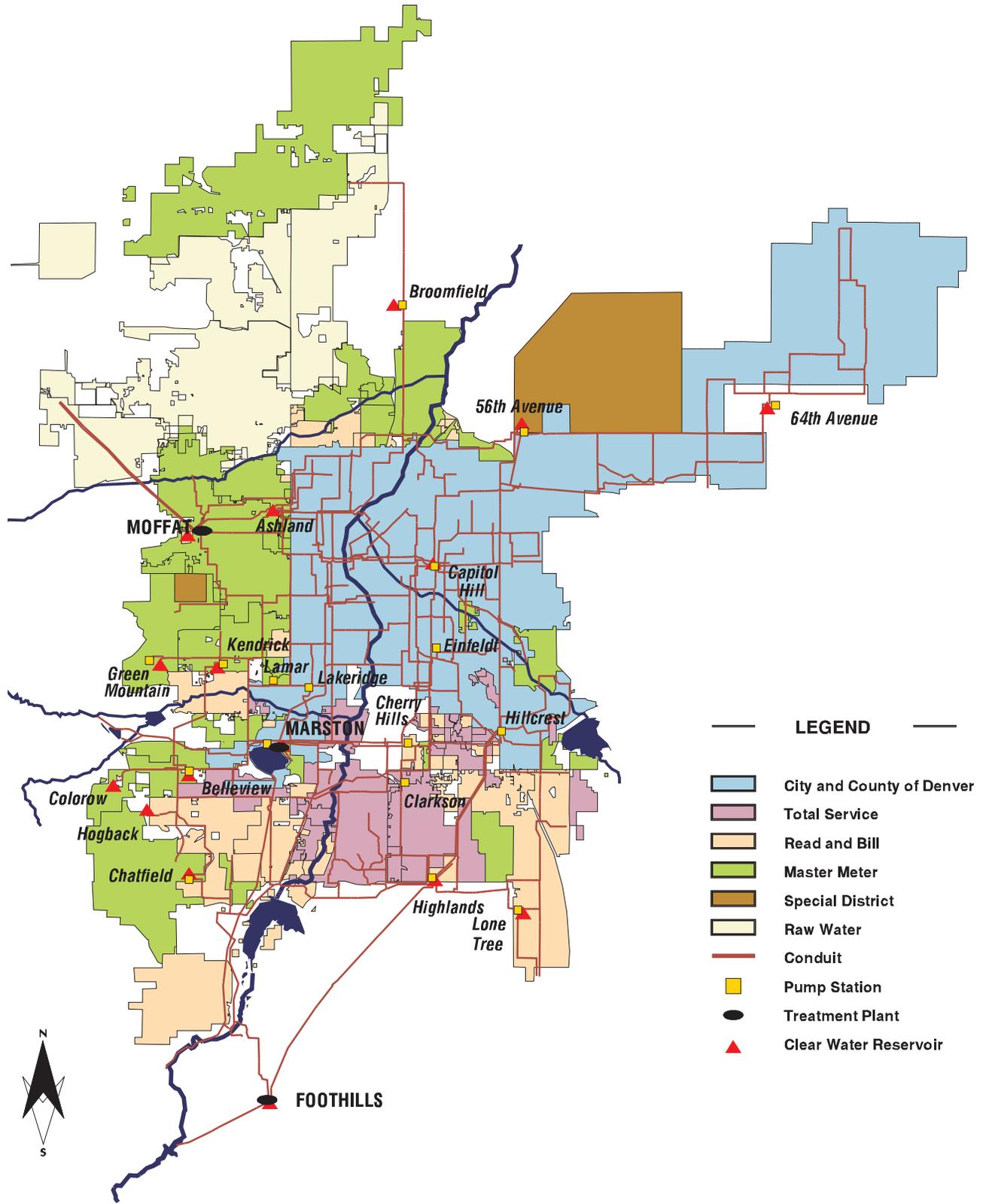
The Foothills and Marston treatment plants distribute water from the South Platte Collection System and Roberts Tunnel Collection System, while the Moffat Treatment Plant delivers water from the Moffat Collection System. In general, the Foothills Treatment Plant is “base loaded” because of its lower cost of operation and ability to provide for much of the areas Denver Water serves by gravity. The Marston Water Treatment Plant and Moffat Water Treatment Plant are used as peaking plants, with priority determined by supply considerations and cost of operation. From the treatment plants, main conduits deliver water either directly into the distribution system, or to pump stations and clear water storage reservoirs. These pump stations and reservoirs deliver water to the distribution system, which is divided into about 160 pressure zones. The distribution system is generally configured so that water from the conduits is distributed into a grid of 12-inch pipe on about one-half-mile centers. The 12-inch pipe grid, in turn, delivers water into the local 8-inch and 6-inch distribution pipe. The system is designed for dual feed to any area to minimize service interruption and to maintain fire protection capability. Figure II-4 shows the major treated water distribution features. Additional details on the configuration of the existing treated water system are provided in the Treated Water Appendix.

Table II-2
Treated Water Service Obligations

	<u>No. of Distributor Contracts</u>	<u>Area in Sq. Mi.</u>
City & County of Denver	-	155
Total Service	31	36
Read & Bill	19	54
Master Meter	<u>28</u>	<u>89</u>
Total	78*	334

* Counts Alameda as both a Master Meter and a Read & Bill district

Figure II - 4
Major Distribution Facilities



- LEGEND**
- City and County of Denver
 - Total Service
 - Read and Bill
 - Master Meter
 - Special District
 - Raw Water
 - Conduit
 - Pump Station
 - Treatment Plant
 - Clear Water Reservoir



In addition to providing water through three types of Distributor contracts, Denver Water provides water to a few special contract areas outside the City of Denver. These are generally wholesale accounts—an example is the Rocky Mountain Arsenal—with fixed limits on the quantity of water supplied in the future.

Operations in Total Service areas are the same as in the City of Denver. Although Denver Water is not responsible for system maintenance in Read & Bill areas, those areas are operationally integrated with the rest of the service area. Master Meter areas are on the periphery of the metro area and are served through a limited number of connections. Pipes through a Master Meter area are not used to serve any water districts outside of that area. Denver Water gives up operational control of the water when it passes into the Read & Bill distribution system or through a Master Meter. Because of increasing regulatory considerations, including water quality standards, Denver Water is reexamining its relationship with, and level of service provided to, Master Meter and Read & Bill Distributors. A one-page fact sheet on each of the treated water Distributors is available from Denver Water in its “Directory of Distributors.”

Treated Water System Layout

Treatment plant capacity is designed to meet maximum day demand, which usually occurs on a hot summer day. Pipes that are 24 inches and larger in diameter may be sized for maximum day or maximum hour demand, depending on the location and size of the area served. Clear water storage—that is, the storage of treated water—is used to span the difference between maximum day and maximum hour demands.

Sizing of the local 6-inch and 8-inch distribution system is usually determined by maximum demands and fire flow requirements. Fire flow needs are determined by whichever fire department has jurisdiction, usually with guidance from the Uniform Fire Code. Fire flow capacity in single-family residential areas is about 1,500 gallons per minute, with hydrant spacing up to 500 feet. Fire flow capacity in multi-family or commercial areas may rise to 3,500 gallons per minute or more. The treated water system also is designed for certain service level standards, such as looping, as well as fluctuations between minimum and maximum pressures. Several ongoing programs ensure that the water and delivery systems are maintained at high standards. These include periodic main flushing, valve operation, continuous system improvements and pipe replacements, hydrant maintenance, main rehabilitation, leak detection and repair, and telemetered system monitoring.

Changing Patterns of Water Use

Treated water use in the Denver Water system is changing. Maximum hour and daily demands have not been rising as fast as might be expected, given the growth in the system. The decline in “peak to average ratios” means that those facilities designed for peak capacity can now be stretched further into the future. This may require some system changes to maintain high water quality.

Today, as in the past, the maximum day hydrograph is driven by customers in single-family homes. Historically, the hydrograph had a single large afternoon peak caused by lawn watering, and a smaller morning peak. The typical current maximum daily hydrograph is very different: it is a two-peak hydrograph, with a lower afternoon peak and a higher use in late evening/early morning. Figure II-5 compares the current “two hump” hydrograph with a typical maximum daily use pattern

from 1970. Figures II-6 and II-7 show system consumption and ratios over 30 years. Since maximum hour and day use are weather driven, there is a great deal of variability in the graphs. The ratio indicates that maximum hour use—and to a lesser degree maximum day use—has not shown the same rate of increase as average day demand. In 1977, there was a marked drop due to lawn watering restrictions. Although mandatory restrictions were lifted several years later, the peaks have stayed down. An increased awareness of water as a resource, stimulated by the Two Forks debate, together with successful conservation efforts and increased use of automated irrigation systems at single-family homes, may account for the changes.

Figure II-5
Maximum Day Use Comparison

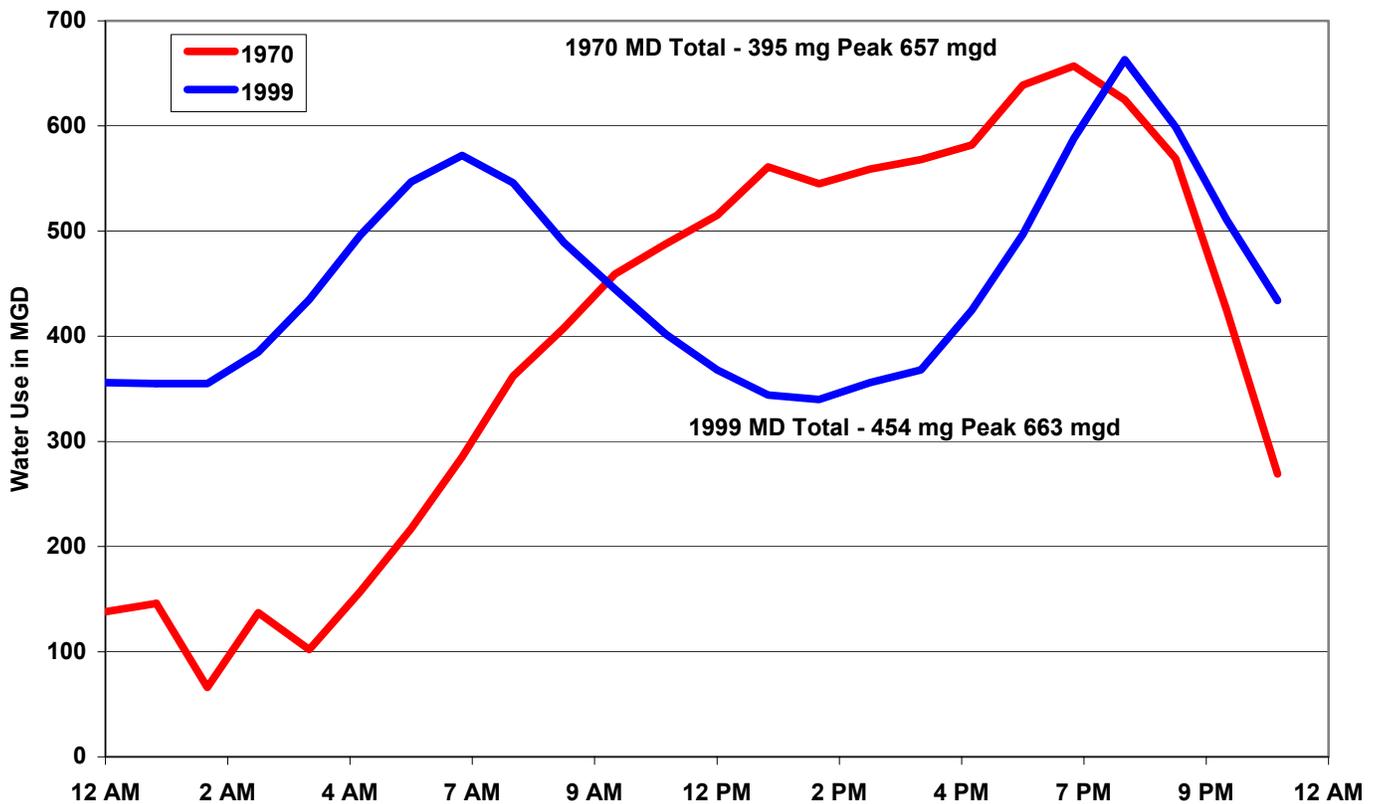


Figure II-6
System Consumption

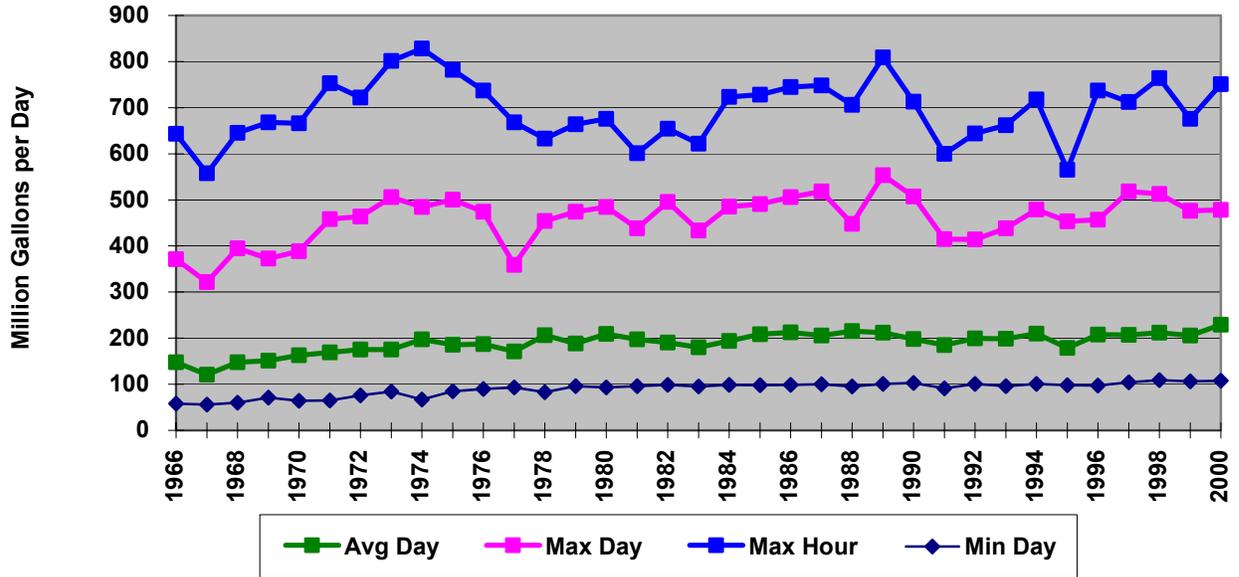
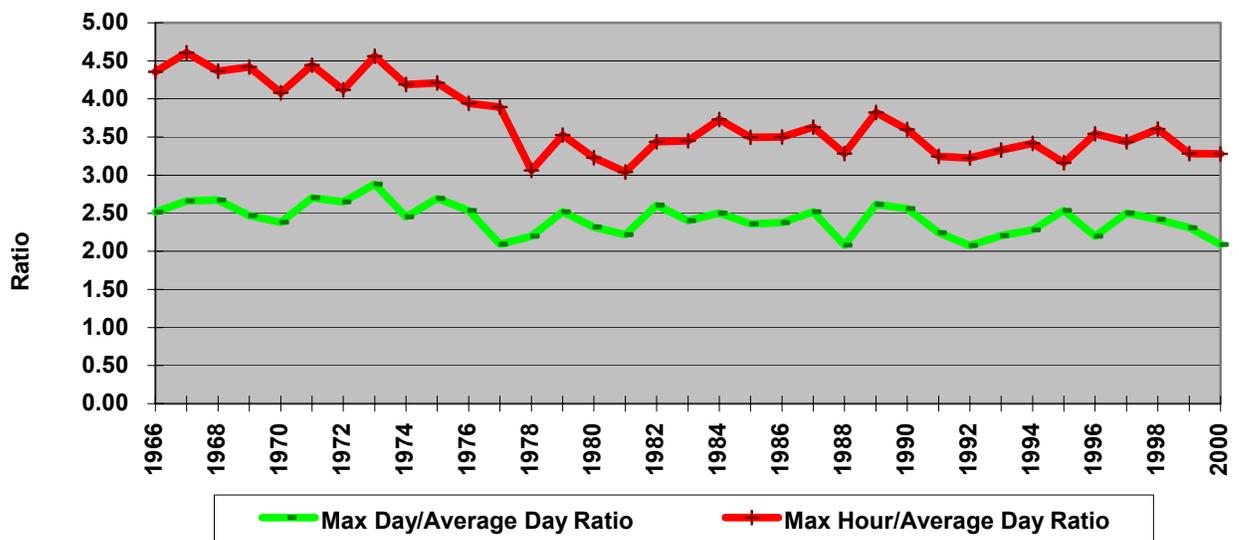


Figure II-7
System Consumption Ratios



Treated Water Planning Study

A comprehensive Treated Water Planning Study completed in late 2000 provides Denver Water with a long-range plan for improving and expanding Denver Water’s treated water system. Engineering consultants conducted the most recent study with assistance from Denver Water staff. This summary draws directly from the Treated Water Appendix and the December 2000 Treated Water Planning Study.

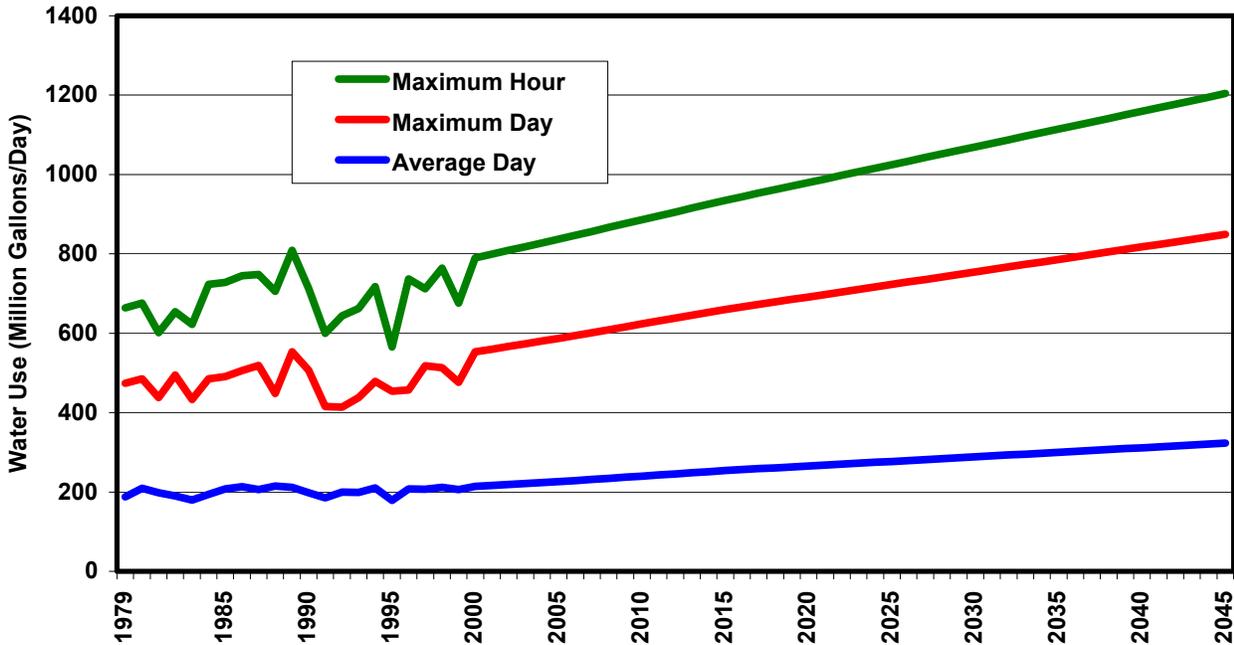
The Treated Water Planning Study focused primarily on evaluating the transmission, pumping and storage for system capacity, and the need for new facilities in the Combined Service Area. The evaluations considered normal operations, as well as vulnerability scenarios and water quality issues, in accordance with Denver Water’s service objectives and design criteria. The primary tool used to assess the system and define improvements was a set of hydraulic water transmission models in H₂ONET. The results of these evaluations serve as a basis for the layout, sizing and timing of facilities to meet Denver Water’s anticipated increases in treated water demand resulting from population growth, residential development and commercial development for the years 2001 through 2045.

Population and Demand Projection

Modeling of the future system is based on a forecast of treated water demand derived from anticipated population growth at a certain point in time and the rates at which various categories of customers use water. Denver Water conducted an analysis of population and customer class within the Combined Service Area and provided estimates for the years 1998, 2000, 2015, 2025 and 2045 (build-out) by traffic analysis zone. Population growth forecasts were based on the Vision 2020 process for the Denver Regional Council of Governments and adapted to Denver Water’s Combined Service Area. The evaluation of historical water use resulted in unit demand rates for various customer classes that were then applied to the population projections, yielding estimates of water demand. Since water demands must be set up in the hydraulic model according to pressure zones, the resulting traffic analysis zone demand data were overlaid on the pressure zone areas to define input values for the model. The Treated Water Appendix describes the demand data, peaking methodology, allocation and definition of pressure zones used in the study.

	Average Day	Max Day	Max Hour	Replenishment
2000	214	553	790	457
2005	226	587	837	486
2015	254	660	935	546
2025	277	723	1025	598
2045	323	849	1204	702

**Figure II-8
Historical and Projected Water Use**



Existing Treated Water System and Model Development

Initial models simulated 1996 maximum hour conditions from actual metered billing records and 1998 maximum hour, maximum day, and replenishment from traffic analysis zone demands. These models were then projected to future demands and operational conditions. Both steady state and extended period simulation models were developed for performing various analyses of the transmission system. Scenario management capabilities were used to maintain existing and future physical facility data in a single model.

Calibration analyses were performed to ascertain whether the hydraulic model could accurately simulate actual operating conditions within the Denver Water system under various historical demand conditions. The calibration process consisted of setting up the model to simulate an actual system condition, and then comparing the results of the simulation with the data obtained from the historical operating records.

The calibrated 1998 transmission system models are steady-state hydraulic models, which means they are capable of simulating transmission system hydraulics at a single instant in time. Thus, separate analyses had to be performed to evaluate each of the various critical conditions such as maximum day, maximum hour and storage replenishment. If the transmission system can adequately meet these extreme conditions, it can adequately meet the intermediate conditions as well as the average and minimum demand conditions. Steady

state analyses are generally sufficient to develop a capital improvement program that will be hydraulically adequate to meet future demand conditions.

In recent years, it has become standard engineering practice to utilize water system models to evaluate system operations and water quality issues in addition to system hydraulics. For these types of evaluations, it is necessary to develop a hydraulic model capable of performing extended period simulations (EPS). An EPS run consists of a series of steady-state analyses in which each successive analysis is automatically adjusted to take into account time-varying water demands, water level changes in clear water reservoirs, pump start-ups or shut-downs, and the action of pressure reducing valves or other control valves. An EPS model was developed for the Treated Water Study to evaluate the effect of recommended system operations and facilities on water quality and water age. Specifically, the EPS model was used to evaluate proposed operational changes and facility improvements to confirm that recommended changes would have no detrimental effect. Water quality concerns are usually greatest during the fall season when demands have decreased and water temperatures, although declining, have not yet reached the low levels experienced during the winter. This combination of low water demands and relatively warm water temperatures can result in low chlorine residuals within the transmission system. For this reason, a representative fall day was used for development of the EPS model.

System Evaluation and Recommended Capital Improvements

Recommended improvements were developed to address both existing and future normal conditions, potential vulnerability scenarios, and possible future water treatment plant expansions. Additionally, EPS water age analyses were performed to confirm that the final recommended Capital Improvement Plan would not have deleterious effects on water quality within the transmission network. The developed Capital Improvement Plan addresses system needs for transmission mains, reservoir requirements, pump improvements and valve improvements through the year 2045 in a prioritized program of improvements.

A total of 12 steady state “normal operations” demand scenarios were performed to evaluate and select system improvements to meet future demand conditions within acceptable water system performance criteria. The 12 “normal operations” hydraulic scenarios included maximum day, maximum hour and replenishment demand conditions for design years 2005, 2015, 2025 and 2045. These calibrated models were used as the base models and projected to the design years. Each demand scenario reviewed included a number of system configuration alternatives to develop the Capital Improvement Plan.

Hydraulic analyses were performed for 13 vulnerability and operational scenarios (a total of 28 hydraulic alternatives). The analyses were performed for a series of facility outages, such as water treatment plant and conduit out-of-service conditions. Evaluation of transmission system hydraulics during a scheduled or unscheduled water treatment plant outage was considered important because of the need to continue providing water to all customers even if one of the three water treatment plants is temporarily out of service. Scheduled outages generally involve shutting down a water treatment plant to perform routine maintenance, make needed repairs or implement system upgrades. Scheduled outages are planned to coincide with non-peak demand periods. Conversely, unscheduled

outages can occur at any time as a result of power failures, chemical process problems, turbidity problems, leak repair, flooding and temporary contamination of source water. Conduit outages to be evaluated were selected based on a number of factors, including the relative importance of a particular transmission main to the overall system hydraulics as well as the likely condition of the main and the corresponding probability of it failing. Based on these criteria, Conduits 93, 27, 111, 17, 28, 94, 109, 116 and 30 were selected for vulnerability analyses.

The vulnerability/operations analyses were performed for the 2015 maximum day demand condition. The 2015 design year was selected as the basis for the vulnerability analyses for a couple of reasons. It was felt that the 2005 design year was too near-term and that use of the 2005 demands could result in solutions that may not adequately address long-term concerns. Conversely, the 2025 and 2045 design years were considered to be so far in the future that vulnerability analyses based on these long-range projections would not be very meaningful.

Where the outage had a significant effect on a localized area and the full 2015 maximum day demand could not be supplied, the percentage of the maximum day demand that could be supplied was reported. System-wide demands supplied, system-wide demand factors and “special impacted area” demand factors were reported. Finally, probabilities of demands exceeding what could be supplied to the areas were determined. Some key vulnerability scenarios were found to have a significant effect on the transmission system and system improvements to address such effects were included in the Capital Improvement Plan.

Energy and operational considerations and evaluations were made for a number of improvements included in the Capital Improvement Plan. The hydraulic model was used to evaluate the hydraulic performance of these energy/operational improvements. Other energy and operational evaluations performed include investigation of Conduit W extension from Conduit 10 to the Kendrick facility. The 2045 maximum day special hydraulic analysis demonstrated that by extending Conduit W from Conduit 10 to the Kendrick facility, it would be possible to meet the entire 2045 maximum day demand without pumping (low or high) at the Marston facility.

The EPS model was used to perform water age analyses for the Denver Water system. All of the water age analyses were performed for average fall day demand conditions. The duration of the water age analyses was 21 days (504 hours). Diurnal demand patterns developed for the 10 areas served were applied to the future design year average day demands to yield average fall day diurnal demands for design years 2005, 2025 and 2045.

The final Capital Improvement Plan was based on the following hydraulic analyses: years 2005 through 2045 normal operations; vulnerability/operations; special analyses (e.g., Foothills Water Treatment Plan 500 million gallons per day supply); and EPS water age for years 1998, 2005, 2025 and 2045. The EPS model was used to evaluate and enhance the final Capital Improvement Plan recommended improvements shown in Tables II-4, II-5, II-6 and II-7. The Capital Improvement Plan projects listed under “special items by others” in Table II-6 are expected to be funded, constructed and operated by other customers, but are

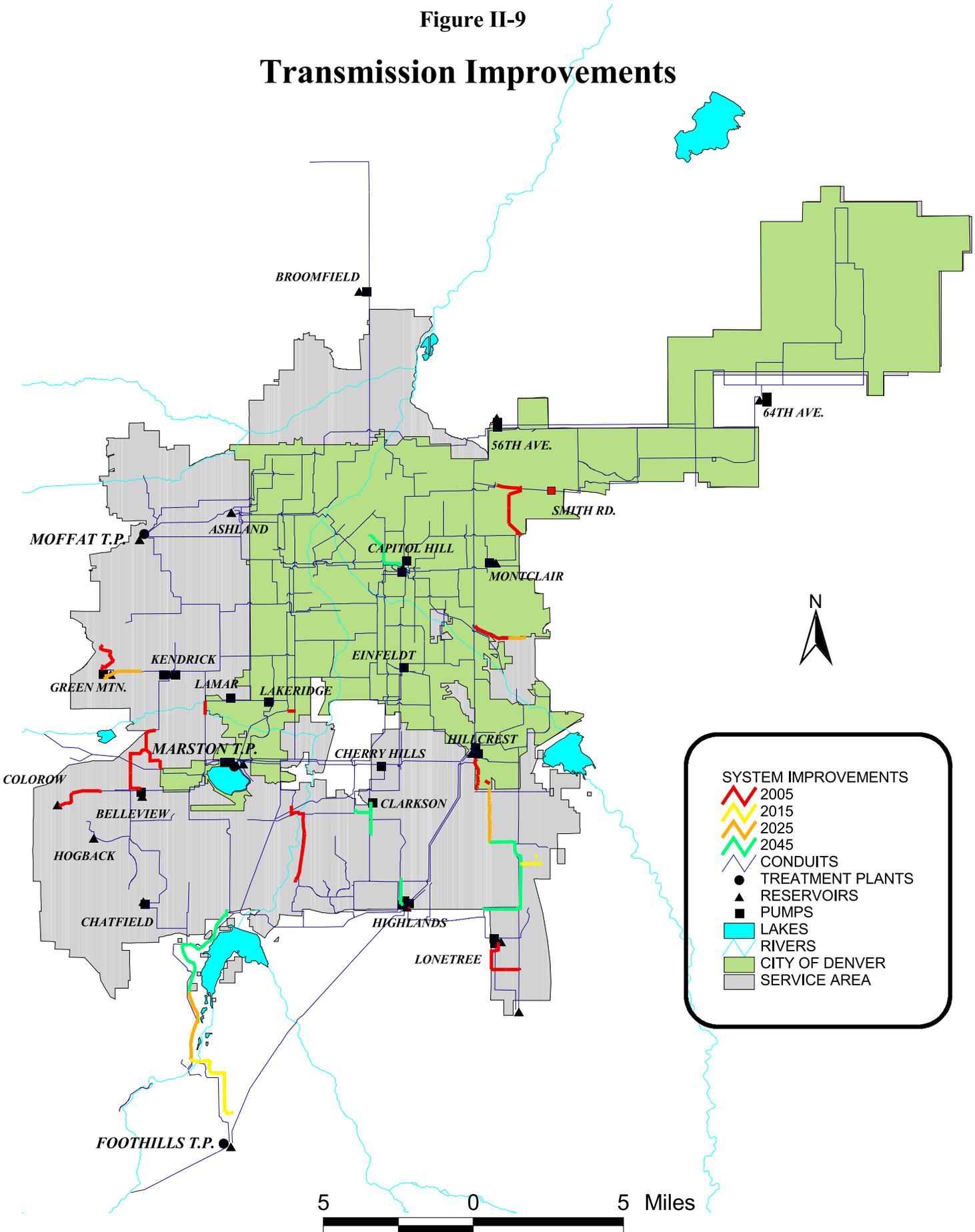
needed to provide service and are therefore listed in the Capital Improvement Plan tables for completeness. The capital costs for these projects are not included in the total estimated costs to Denver Water. Based on the hydraulic analyses, system improvements are staged to indicate the year in which the improvement is required. Estimated capital costs include construction, engineering, surveying, inspection, materials and right-of-way costs. Please see the Treated Water Study and the Treated Water Appendix for a complete description and list of improvements. The transmission improvements recommended in Tables II-4, II-5, II-6 and II-7 are shown in Figure II-9.

Table II-4 Capital Improvement Plan Cost Summary						
Improvement Category	Capital Cost (\$)					% of Total
	Year				Total Cost (\$)	
	2005	2015	2025	2045		
Mains (Conduits) ⁽¹⁾	14,186,900	9,818,600	9,153,700	21,889,300	\$55,048,500	64.8
Reservoirs	12,800,000	3,300,000	0	0	\$16,100,000	19.0
Pumps	3,966,000	225,000	2,647,000	5,780,500	\$12,618,500	14.9
Valves	430,400	231,300	172,500	355,000	\$1,189,200	1.4
TOTAL	\$31,383,300	\$13,574,900	\$11,973,200	\$28,024,800	\$84,956,200	
% of Total	36.9	16.0	14.1	33.0		

⁽¹⁾ Totals do not include costs for items by others

Table II-5 Reservoir Improvements					
Capital Improvement Plan No.	Year Req'd	Description	Volume (million gallons)	Unit Cost (\$/million gallons)	Capital Cost (\$)
R0	2005	Highlands	NA	NA	1,250,000
R1	2005	Marston	10.0	0.77	7,700,000
R2	2005	Moffat	5.0	0.77	3,850,000
R3	2015	Lonetree	5.0	0.66	3,300,000
TOTALS			20.0		\$16,100,000

Figure II-9
Transmission Improvements



SYSTEM IMPROVEMENTS

- 2005
- 2015
- 2025
- 2045
- CONDUITS
- TREATMENT PLANTS
- RESERVOIRS
- PUMPS
- LAKES
- RIVERS
- CITY OF DENVER
- SERVICE AREA

**Table II-6
Conduit Improvements**

	Year Req'd	Description/Location	Diam. (in)	Length (ft)	⁽¹⁾	Unit \$/foot	Capital Cost
1	2005	Conduit 151	36	11,180	U	138	1,542,800
2	2005	Monaco, Quincy to Bellevue, 20" replacement	30	5,710	D	194	1,107,700
3	2005	Union Ave. to Quebec	20	940	D	152	142,900
4	2005	Parallel Conduit 35, Monaco to Valentia	36	6,770	D	222	1,502,900
6	2005	Conduit 135	24	16,110	D	166	2,674,300
7	2005	Ken Caryl & Sheridan, 16"/18" connection	20	20	D	152	3,000
8	2005	Conduit 138, Phases II & III	36/30	15,960	D	222/194	2,910,000
9	2005	Conduit 129, Phase IV	30	10,300	D	194	1,998,200
11	2005	Conduit 74, end existing 42" east to Stapleton PRV	42	4,010	D	256	1,026,600
13	2005	Conduit 3 to Conduit 12 connection along Osceola Way	30	1,410	D	194	273,500
14	2005	Conduit 30 replacement at Bear Creek	60	2,500	D	402	1,005,000
15	2015	Conduit W, Foothills (108") to Kassler	96	16,450	U	554	9,113,300
16	2015	Easter Pl./Ave., east from C55 to Clinton Ave. (existing 16")	30	1,890	D	194	366,700
17	2015	Easter Ave., Clinton Ave to Fulton	24	2,040	D	166	338,600
19	2025	Conduit W, from Kassler north approx. 2.4 miles	96	12,640	U	554	7,002,600
20	2025	Parallel existing 18" along Monaco, Bellevue to Berry	24	9,320	D	166	1,547,100
21	2025	Parallel existing 16" along Mississippi, Valentia to Private Dr.	30	2,660	D	194	516,000
22	2025	Parallel existing 16" along Private Dr., Mississippi to Lakeshore	24	530	D	166	88,000
23	2045	Conduit W, from end 96" to Conduit 105	96	10,450	U	554	5,789,300
24	2045	Parallel Conduit 10, Conduit 105 to Conduit 116	66	11,250	D	457	5,141,300
25	2045	Parallel Conduit 55, C470 (existing 60") to Easter Pl.	42	14,570	D	256	3,729,900
26	2045	Parallel Conduit 55, Easter Pl. to Peakview Ave.	36	4,460	D	222	990,100
27	2045	Parallel Conduit 85, C96-C85 Valve to Dry Creek & University	36	4,930	D	222	1,094,500
28	2045	Parallel Conduit 84, Clarkson PS to Littleton Blvd.	30	1,890	D	194	366,700
29	2045	Parallel Conduit 84, Littleton Blvd. to Caley	24	3,990	D	166	662,300
30	2045	Parallel existing 16" along Littleton Blvd, Clarkson to Broadway	20	2,510	D	152	381,500
31	2045	Parallel existing 12" along Broadway, Littleton to Powers Ave.	16	720	D	118	85,000
32	2045	Parallel existing 18" along Peakview Ave, Conduit 55 to Quebec	24	4,330	D	166	718,800
33	2045	Parallel Conduit 102, end 42" segment to Green Mtn Reserv	30	7,120	D	194	1,381,300
34	2045	C36 Rehab/replace, Capitol Hill Reserv to Humboldt St. (3)	30	3,410	D	194	661,500
35	2045	C33 Rehab/replace, 11th Ave. to 13th Ave. (3)	24	1,140	D	166	189,200
36	2045	C33 Rehab/replace, 13th Ave. to 16th Ave. (3)	30	1,760	D	194	341,400
37	2045	24" Rehab/replace along 16 th Ave., Humboldt to Park Ave. (3)	24	270	D	166	44,800
38	2045	20" Rehab/replace along Park Ave., 16 th Ave. to Downing (3)	20	1,080	D	152	164,200
39	2045	16" Rehab/replace along Park Ave., Downing to 19th Ave. (3)	16	1,250	D	118	147,500
				TOTALS	195,570		\$55,048,500
Special Items by Others							
5	2005	Conduit 139	30	10,800	D	194	2,095,200
10	2005	Lakehurst, C138 to Lakehurst PS	24	5,430	D	166	901,400
12	2005	Parallel existing 18"/16", from W. Utah Ave. to Alameda Res.	24	7,320	D	166	1,215,100
18	2015	Costilla, Dayton to Emporia	12	490	D	97	47,500
Special Item Total				24,040			\$4,259,200

Notes on Table II-6:

- ⁽¹⁾ Unit costs are based on diameter and type of installation: D=Developed; U=Undeveloped
- ⁽²⁾ Costs for items 34, 35, 36, 37, 38, and 39 represent pipe replacement cost

**Table II-7
Pump Improvements**

CIP	Year Req'd	Description	Flow (mgd)	Head (ft)	Horsepower (Hp)	Capital Cost (\$)
P0	2005	Belleview Low Pumps No. 1 & No. 2	16	175	700	668,000
P1	2005	Highlands High Pump No. 2	15	265	1000	2,113,000
P2	2005	Hillcrest Low Pump No. 1 retire	1	169	50	0
P3	2005	Hillcrest Low Pump No. 2 retire	2	167	100	0
P8	2005	Smith Rd. & Havana Pumping Station, 30 mgd	30	75	600	1,185,000
P4	2015	Hillcrest High Pump No. 8 replacement	20	315	1500	225,000
P5	2025	Belleview High Pump No. 3	15	260	900	1,228,000
P6	2025	Highlands High Pump No. 5	20	265	1250	826,000
P7	2025	Marston High Pump No. 9 replacement	15	263	900	593,000
P9	2045	Chatfield Low Pump No. 4	10	150	350	843,000
P10	2045	Chatfield High Pump No. 7	8	320	600	397,000
P11	2045	Chatfield High Pump No. 6 replacement	8	320	600	361,500
P12	2045	Clarkson Pumping Station, 24 mgd	24	234	1300	948,000
P15	2045	Highlands High Pump No. 3	20	265	1250	276,000
P16	2045	Marston Low Pump No. 1 replacement	25	166	900	1,455,000
P17	2045	Marston Low Pump No. 2 replacement	25	166	900	375,000
P18	2045	Marston Low Pump No. 3 replacement	25	166	900	375,000
P19	2045	Marston Low Pump No. 4 replacement	25	166	900	375,000
P20	2045	Marston Low Pump No. 5 replacement	25	166	900	375,000
TOTAL						\$12,618,500

Future Model Development

The models developed for the Treated Water Planning Study utilized steady state and extended period simulations. These models were developed to perform various hydraulic and water quality analyses of the transmission system. Future model enhancement will build on these existing models and add water age/quality capabilities at the distribution system level. This level of analysis is needed to assist in determining what water quality parameters potentially may not meet future federally mandated criteria in the distribution system.

An all-pipe distribution model will allow a more accurate distribution of demand and a more accurate simulation of actual operating conditions. This will enable the analyst to better determine future system improvements and fire flow capabilities in new developments.

Water quality modeling of the distribution system will allow Denver Water to determine needed system improvements to enhance the quality delivered to the customer. These models will have the ability to trace constituents and chlorine residuals and assist in understanding the factors that influence the formation of disinfection byproducts such as total trihalomethanes. The models will also provide the analyst with the ability to determine source contaminate propagation for both reactive and non-reactive constituents. A peak day EPS distribution level model will allow evaluation of pumping and storage efficiencies. It

also will allow evaluation of appropriate pressure zone assignment and improve the level of service to the customer.

System Audit of Unaccounted-For Water

In 1995, a system audit was conducted on the treated water distribution system. The purpose of the audit was to estimate the component parts of unaccounted-for water and ultimately to find areas to save water, to increase revenue recovery, and to improve equity among ratepayers. For the 2001 IRP, the audit was revisited and updated to report total system figures and to indicate system improvements that have been implemented since the 1997 IRP report.

Unaccounted-for water is defined as the difference between water metered out of the three water treatment plants and the sum of water sold through retail customer meters and wholesale Master Meters. For convenience, Denver Water has split unaccounted-for water into three categories: water that is unregistered due to meter error (meter under-registration); water that is used but unmetered (beneficial uses); and distribution system losses. Before completion of Denver Water’s Universal Metering Program in the early 1990s, unaccounted-for water was estimated at 6 percent of treated water. This figure could not be confirmed until 1993 because of the large number of flat rate accounts. As shown below, the eight-year average of unaccounted-for water from 1993 through 2000 is about 5.4 percent:

1993	7.53%
1994	6.16%
1995	4.20%
1996	3.08%
1997	7.05%
1998	7.34%
1999	5.34%
2000	<u>2.87%</u>
Average	5.4%

In the past several years, the following improvements to reduce unaccounted-for water have been implemented.

Treatment Plant Meters: Denver Water now includes the plant meters in a program to check and calibrate instrumentation.

The Hydrant and Construction Permit Program: Most construction and temporary hydrant users are now required to install a hydrant meter and backflow prevention device. Fines for improper usage have been increased, and incentives instituted for field representatives who uncover unauthorized use.

Illegal Diversions: Under the “unauthorized water use” program, Denver Water has amended and streamlined the program and increased the fine assessed for illegal diversions. An additional program being investigated for the future is the installation of

detector check valves on fire lines. These could detect inadvertent or illegal taps of fire lines and the diversion of unmetered water.

Tank Cleaning: Although there may be ways to reduce these uses of water—for example, in-situ cleaning—in general, this category can probably be expected to increase. More rigorous regulatory requirements, together with a new Operational Memorandum of Understanding, means that tank cleaning will become more routine.

Flushing: The volume of water used in the flushing program fluctuates from year to year, based on need. A number of program improvements have been implemented since 1996, such as new standard operating procedures for flushing hydrants and blow-offs. Many sites have been eliminated through system improvements, shock chlorination or increased consumption in the area. There is an ongoing effort at Denver Water to eliminate problem areas with system improvements.

Meters: There is an ongoing Denver Water program to replace large meters (1.5 inches and larger). Small meters (5/8 inch, 3/4 inch and 1 inch) are being replaced under the Automated Meter Reading project now underway. Denver Water’s meter shop has also implemented improvements to the testing program, including a new database that calculates additional recovery of unaccounted-for water due to meter calibration.

Leak Detection: Several improvements to the Leak Detection Program have been implemented, including new equipment and division of the leak survey into leak zones to allow crews to focus their efforts on areas of known leak problems.

Valve Maintenance: The valve inspection program has been improved to include exercising valves each year. This program helps minimize losses by maintaining condition of the valves and allows for earlier detection of leaking valves.

Distribution System Management Issues

To continue its high level of service to its customers, Denver Water is becoming increasingly active in distribution system management. Management issues include the design, operation and maintenance of the infrastructure to serve water. The most pressing concerns are looping for design, water quality for operations and issues associated with increasing pipe age for maintenance of the system.

Distribution Design—Looping

Looping is essential for maintaining fire flow, service reliability and water quality. Over the last few years, several factors have led Denver Water to intensify its efforts to inform design engineers and Denver Water’s Distributors about looping and to require looping in developments. First, and perhaps most important, water quality regulations and requirements (not to mention customer concerns about quality) have become more stringent and more pressing. Second, Denver Water has seen an alarming trend in increased use by developers of “dead ends.” (Water systems are often laid out in a grid or loop system, with each end of any given main connected to other mains, to allow a greater amount of water to flow into or through a given area. In some cases, such as cul-de-sacs, mains may be dead-ended, causing reduced circulation and possible water quality problems.) Dead ends are

often used by developers to save money, even though there may be a detrimental impact on the water quality in the distribution system. Use of dead ends may also be increasing in some older parts of the Combined Service Area because of limited access in infill areas. Third, dead ends require Denver Water (or a Distributor) to flush, incurring additional operational cost and water waste.

Looping fulfills the objectives of numerous parties, including the customer, Denver Water, the agencies charged with regulating water quality, the various fire departments and others. The objectives include:

1. Maintenance of water quality
2. Fire protection
3. System reliability and service reliability
4. Conservation
5. Minimization of the operational costs of flushing
6. Minimization of discharge of chlorinated water

The Treated Water Appendix includes references on looping, as well as information on the practices of other utilities.

Distribution Water Quality and Operations Compliance Overview

Because of recent changes in regulatory standards and increased awareness of safe drinking water issues throughout the United States, Denver Water has augmented its efforts to ensure that it delivers safe drinking water to its customers and to maintain the high standard of water quality that has been its practice. Due to recent changes to drinking water regulations issued by the state and federal government, a draft Memorandum of Understanding was created between the Water Quality Control Division, Denver Water, and Denver's Distributors to document compliance with the regulatory requirements. Although the Memorandum of Understanding has not been finalized, Denver Water is creating an operations plan for its Distributors to aid in complying with drinking water regulations. This plan will become part of Denver Water's Engineering Standards when it is approved.

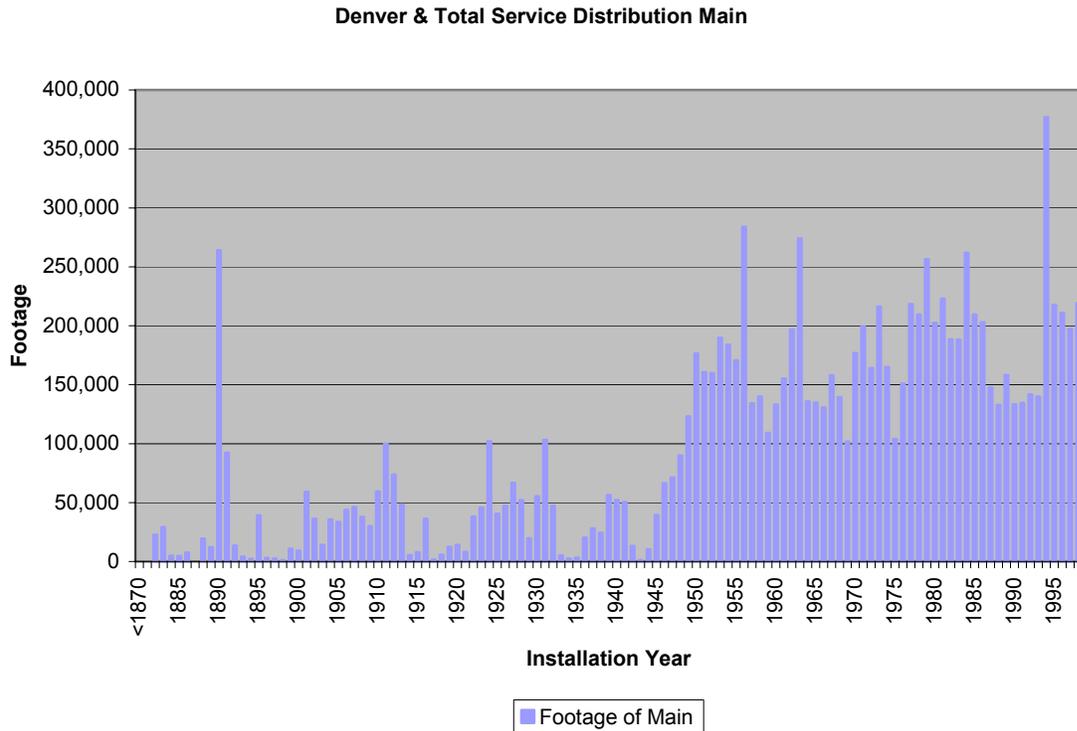
In conjunction with the above activities, Denver Water also has been exploring the option of converting a number of Master Meter and Read & Bill districts to Total Service districts. These conversions will relieve small districts of the burden of complying with increasingly complex regulatory requirements. At the same time, the change ensures that Denver Water will have control over the operation and maintenance of the distribution systems and not rely on other entities' management practices to deliver safe drinking water. So far, 12 districts have been examined for Total Service conversion.

Aging Water Distribution System

Many water utilities now face the issue of aging water distribution systems that require increasing maintenance expenditures to maintain current standards. At the same time, Denver Water can expect increasingly stringent regulations. The current program provides adequate protection, but increased efforts should be anticipated. Denver Water, like many utilities, saw a dramatic surge in construction beginning in the late 1940s. Denver Water

will soon face the need to increase replacement and rehabilitation rates to keep up with its aging infrastructure.

Figure II-10
Footage of Pipe Installed by Year in Denver and Total Service



Denver Water determines main replacement needs based on number of leaks and an inventory of apparent and specific replacement needs. Many of these pipes were installed 80 or more years ago. The post-World War II pipe installation rate was three to four times that of previous history. It is likely that Denver Water can expect a rise in future maintenance needs. Deferral of replacement may mean an increased incidence of leaks, unscheduled disruption of service and damage to property.

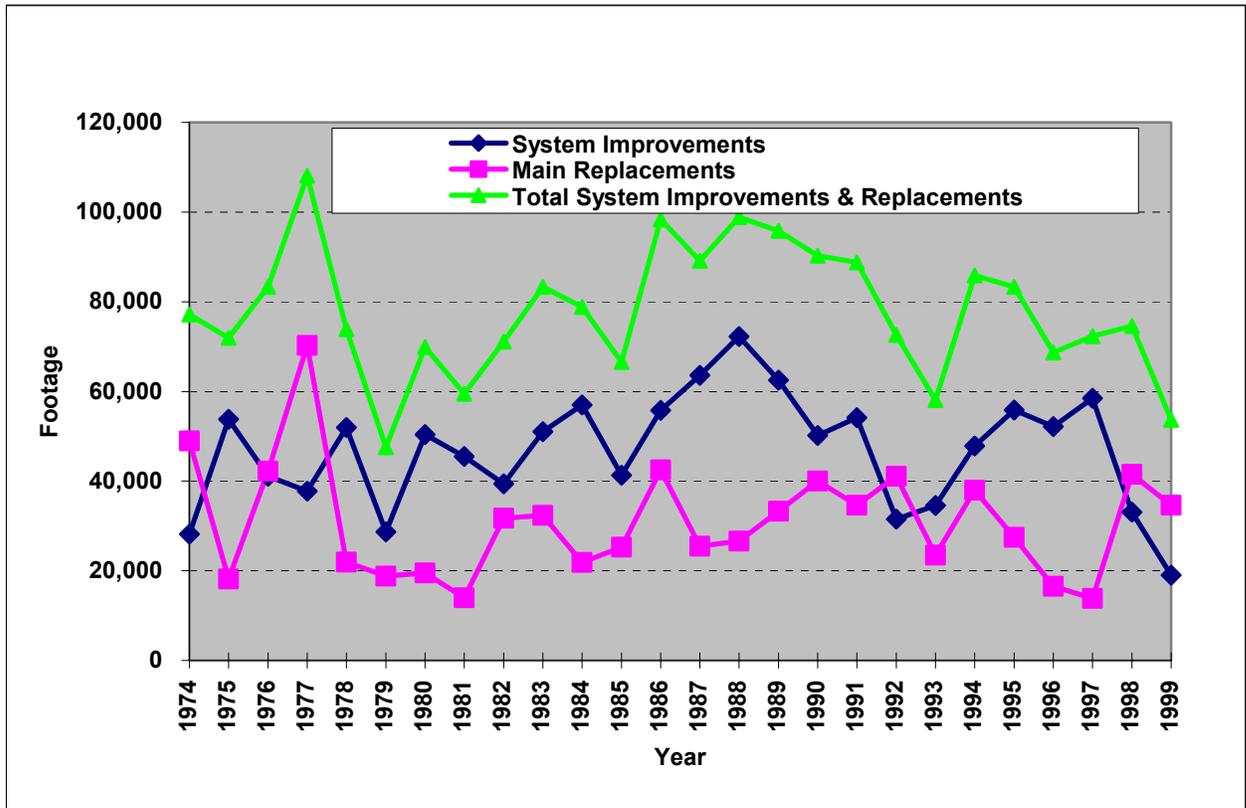
Denver Water conducts several programs for monitoring the distribution system. These include:

- Leak Detection Program
- Distribution Water Quality Testing Program
- Corrosion Monitoring and Testing
- C-Value Testing
- Fire Flow Testing

These programs cover both the interior condition of the pipe for flow capacity and water quality, and the exterior condition for monitoring of structural integrity.

Denver Water has several programs for distribution system maintenance and improvements. These include the main replacement, system improvements and main rehabilitation programs. In general, these programs have been largely reactive rather than proactive. The current main replacement program is based on leak history and uses a point system to evaluate and prioritize mains for replacement. In the past, the system improvement program has been motivated by the need to correct known distribution problems, notably the looping of dead ends, the improvement of supply to some areas, and the replacement of undersized and nonstandard size mains. As for the main rehabilitation program, it has historically focused on conduits. In recent years, the program has switched to distribution rehabilitation, but most often in areas where there is a need to increase fire flows for redevelopment. The focus of these three programs is expected to change somewhat in the future in response to issues involving the aging infrastructure.

Figure II-11
System Improvements and Main Replacements



In the future, Denver Water expects to modify its main replacement program to include a proactive search for potential candidates. Through the use of the geographic information system (GIS) database, Denver Water can correlate items such as date of installation, pipe material and area pressure. A query of Denver Water's existing improvement and replacement database indicates that 75 percent of all main replacements occur where static pressure is greater than 80 psi. Additionally, Denver Water can identify where mains historically have been installed as replacements. The pieces of data that have been collected, but not yet included in the database, are soil resistivity and main break history. This data relates the potential of corrosive interaction between the soil and unprotected pipe and the geographic location of recorded main breaks. The addition of this information will allow for the correlation of all the pertinent factors and provide Denver Water with a significant predictive tool for identifying potential main break candidates. The result will be an increase in the overall amount of main designated for replacement and a corresponding decrease in future main breaks and customer outages.

The focus of the current system improvement program is to search for areas with unlined cast iron mains not of appropriate size (based on the standard grid) and with multiple large services, particularly fire lines. In the future, the system improvement program will identify all unlined cast iron mains not of appropriate size based on Denver Water's standard grid. Currently, only those mains fitting the criteria in the north half of Denver have been identified. This process will be continued for the south half of the city and expanded into Total Service districts. Additionally, water quality will continue to play a larger role in the identification of system improvements.

Of the 1,160 miles of cast iron mains within the Denver Water system, an estimated 50 percent is unlined pipe installed prior to 1950. Based on compiled measurements of frictional coefficients (C-value), studies have shown that these pipes have both a substantially reduced fire flow delivery capacity and a greater potential for reduced residual chlorine and subsequent water quality problems. Roughly one-third of these mains will eventually be replaced through the main replacement, system improvement and redevelopment processes. Since at the current rate of rehabilitation, it will take too many years to refurbish all of the older pipe in the system, Denver Water will look closely at increasing the footage of pipe to be rehabilitated annually.

Lastly, Denver Water will be able to make use of changing technology to increase efficiencies in Denver Water's evaluation and scheduling of distribution system improvements. This includes better GIS mapping techniques, integrated databases, information sharing with other agencies (particularly coordination with City of Denver paving efforts), and advances in the areas of field installation, such as pipe bursting and slip lining, and new materials technology.

III. Water Demand

The demand forecast is an integral component of any long-rang planning process. It defines how much additional water a utility will need beyond its existing supplies and when that water will be needed. Accordingly, Denver Water’s demand forecast effectively drives all future plans for capacity expansion of the collection system and treated water system.

Forecasting water demand is primarily a function of two variables: future demographic growth (population, households, employment) within the Combined Service Area, and the rates of water usage for those demographics. The demographic growth within the Combined Service Area is derived from regional demographic forecasts, along with estimates of where metro area growth will occur. The usage relationships emerge from detailed analysis of historical water usage patterns. Based on this analysis, Denver Water developed a model to forecast demand to the build-out of the Combined Service Area. The model results were then modified to reflect two additional factors: a reduction over time for “natural replacement” of plumbing fixtures and appliances with more efficient fixtures, and the addition of demands for fixed and special contracts in which Denver Water is obligated to provide water beyond the Combined Service Area boundary.

Future Growth Within Areas Served by Denver Water

Denver Water based demographic growth forecasts within its Combined Service Area on the latest regional forecast (1999) from the Denver Regional Council of Governments (DRCOG). That forecast is prepared under the direction of DRCOG’s Economic Task Force, a group of economic and demographic experts within the region. DRCOG independently prepares its demographic forecasts to meet its Metropolitan (transportation) Planning Organization and long-range regional development planning functions. This forecast extends to the year 2020.

Denver Water also relies on DRCOG’s geographic distribution of its demographic forecast because Denver Water’s Combined Service Area comprises only a portion of six counties of DRCOG’s planning area (Figure III-1). DRCOG performs this distribution of the future growth in the metro area for its own planning purposes. DRCOG’s distribution of future metro growth is based on detailed analysis and is consistent with DRCOG’s “Metro Vision” strategy.

Denver Water employed a consultant to extend DRCOG’s 2020 forecast for the areas served by Denver Water to 2050. These extensions were consistent with DRCOG’s 2020 forecasts. Figure III-2 illustrates the population history and forecast in the areas served by Denver Water. Currently, Denver Water serves approximately 1 million people within its Combined Service Area and provides water under fixed and special contracts that support approximately 120,000 people beyond its service area. When the population under fixed contracts is added to the Combined Service Area population in 2050, approximately 1.9 million people will be using Denver’s water.

Figure III-1
Areas Served by Denver Water vs. DRCOG's Six-County Area

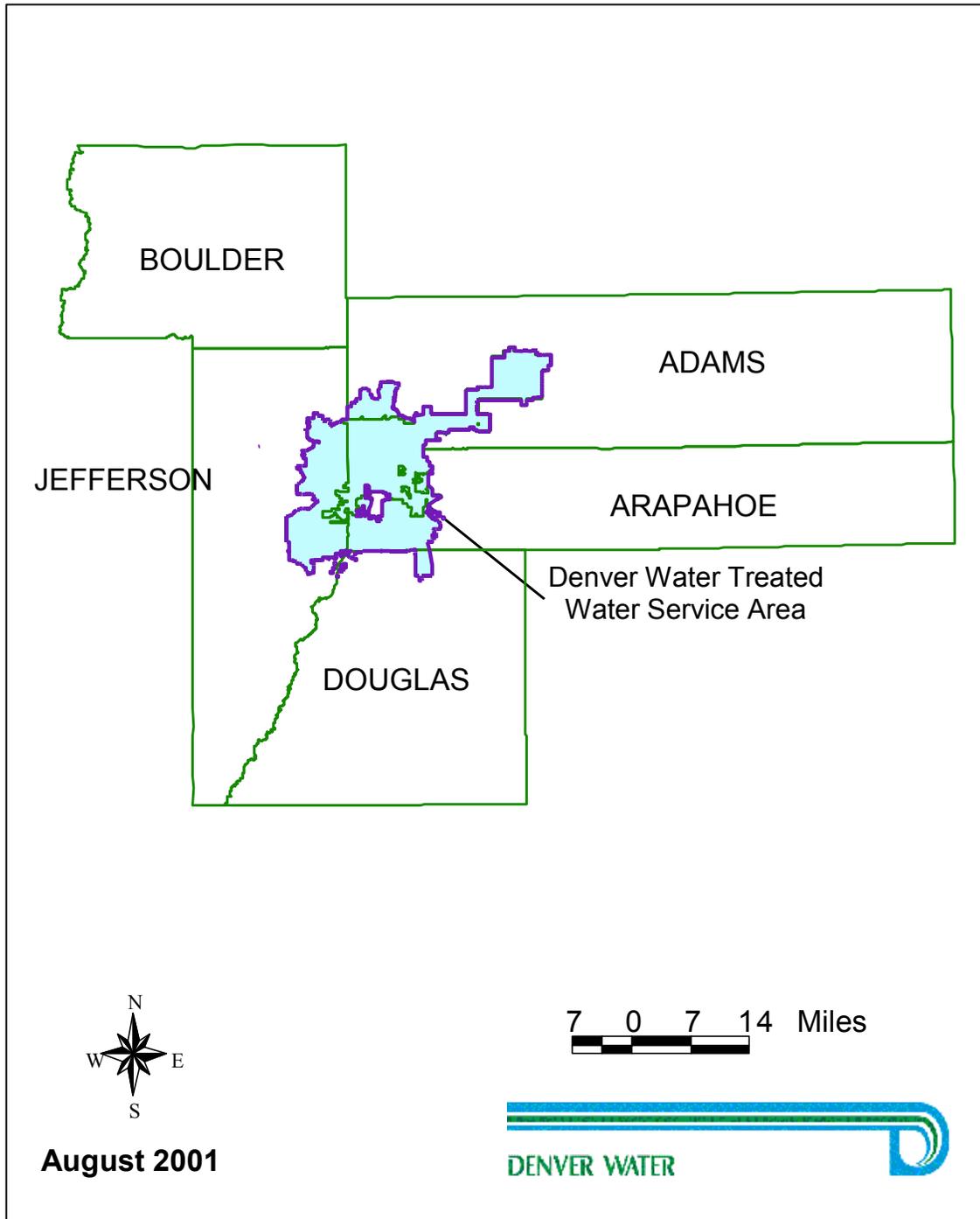
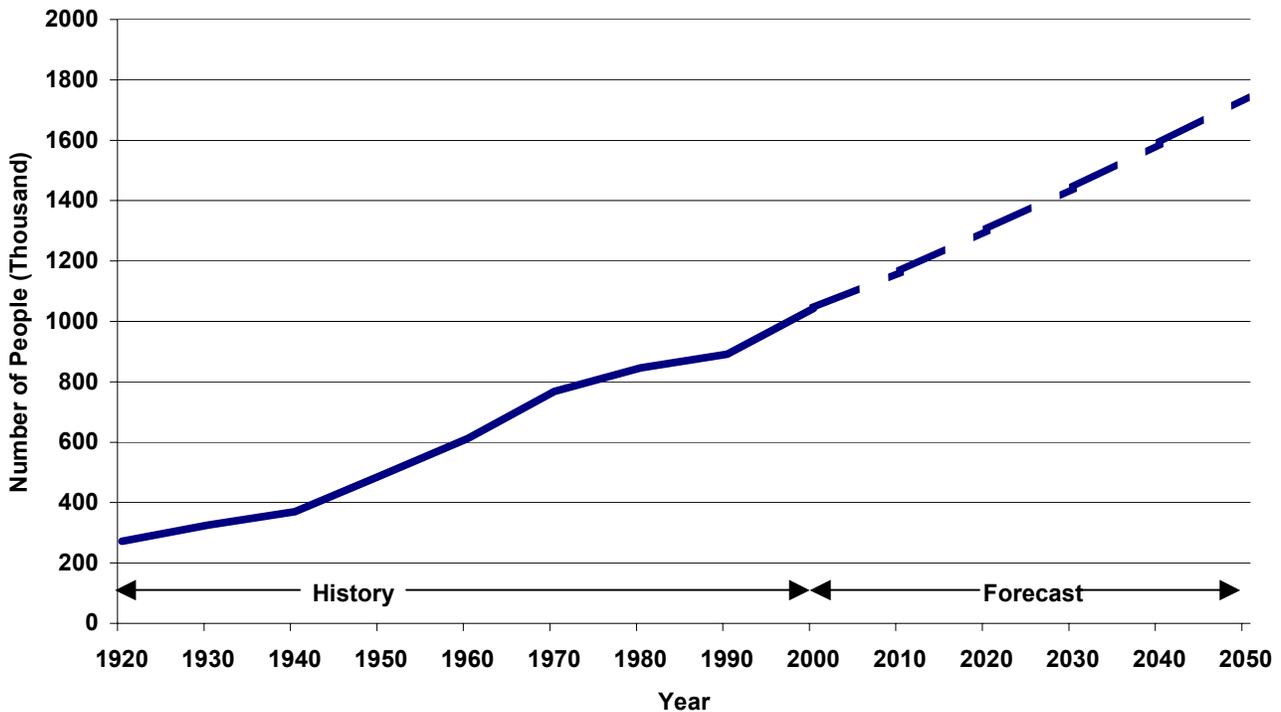


Figure III-2
Population – Treated Water Service Area

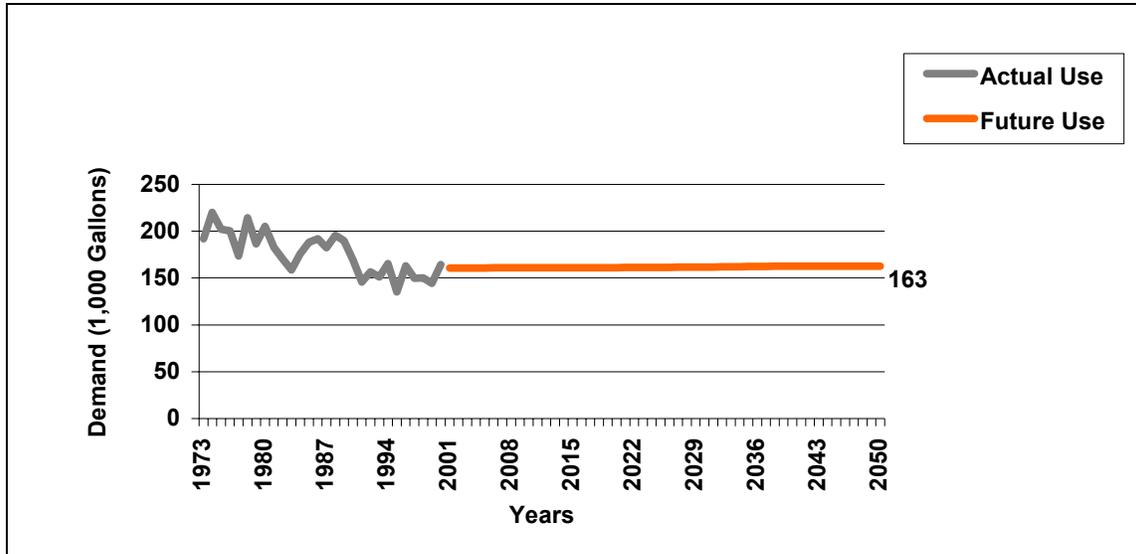


Water Usage Factors and the Demand Forecast Model

Denver Water’s demand forecasting model was recently developed by a consultant in an extensive study of historical customer usage patterns to estimate current and future usage relationships. This study was in response to changes in customer usage occurring over time. Figure III-3 displays historical and modeled future usage for single-family residential customers. These values represent gross usage. Although Denver Water has always encouraged efficient water use, 1980 marked the start of rigorous efforts to promote water conservation. There is a corresponding decline in single-family customer usage beginning in 1980.

Figure III-3

Annual Usage per Single-Family Household Historical and Future Use



The result of the study was an econometric model that states usage relationships for various demographic and socio-economic factors. Table III-1 summarizes the usage factor results from the demand model in comparison to actual 2000 usage.

**Table III-1
Demand Model Usage Factor Results**

	Actual 2000 Usage	Model Results (at Build-Out)	
		Gross Usage	Net Usage *
Single Family Customers			
Annual Household Use (1,000 Gallons)	164	163	151
Household Use Per Day (Gallons per Day)	450	445	413
Combined Commercial, Multifamily, and Industrial Customers			
Usage Per Employee Per Day (Gallons per Day)	110	103	89
Governmental/Institutional Customers			
Usage Per Person Per Day (Gallons per Day)	17	18	17
System-wide Gallons Per Person Per Day	206	189	170

* Net of additional future natural replacement – see below.

A detailed description of the model specification for predicting single-family customer demand is included in the appendix of the demand forecast. This description also includes an example of the calculation of demand for single-family customers in 2050. The model specification is essentially an equation that expresses future single-family usage as a function of the number of single-family households, household income, the density of households per acre, the inches of precipitation, the number of people per household, the percentage of customers metered, the marginal price of single-family rates, and the three-year average of conservation expenditures. The demand model is generally more complex for the single-family customer class than the demand model equations for other customer classes. While the model forecasts annual demand for average weather conditions, demand for outdoor uses will vary in the future with temperature and precipitation.

Natural Replacement

As a result of legal and regulatory changes, as well as advances in technology, it can be anticipated that usage will decline in the future. This phenomenon is referred to as “natural replacement.” It occurs, for example, when a customer buys a low-flow toilet to replace one of higher flows. This reduction in water use is independent of conservation programs implemented by Denver Water. Since future natural replacement is not captured in the demand model usage factors, staff reduced the model-predicted build-out demand line by about 40,000 acre-feet per year to account for this phenomenon.

Fixed/Special Contract Commitments

Denver Water has special contracts with, or other commitments to, about 30 entities, mostly outside the Combined Service Area, that obligate Denver Water to provide additional water to that modeled in the Combined Service Area. These commitments are generally for raw water. As shown in Table III-3, the total unused commitments under these contracts add another 25,000 acre-feet per year to the 2050 modeled demands.

**Table III-2
Denver Water Fixed and Special Commitments**

	Commitment (Acre-Feet)	2000 Consumption (Acre-Feet)
Moffat Collection System Deliveries:		
Arvada	19,525	16,321
North Table Mountain	6,000	2,205
Westminster	4,500	2,094
Rocky Flats (Dow Chemical)	1,396	345
Consolidated Mutual	443	250
Miscellaneous Smaller Commitments	634	406
Subtotal – Moffat System	32,498	21,621
South Platte River System Deliveries:		
Washington & City Parks, Denver Country Club	2,850	2,672
Excel Energy – Arapahoe	3,620	732
Englewood/Cabin Meadow Creek	2,320	3,400
Centennial	1,000	640
East Cherry Creek Valley	771	0
Antero Contracts (delivered thru High Line Canal)	414	414
Aurora	300	0
Kennedy Golf Course	600	461
Overland/South Platte for Epperson Ditch	600	255
Fairmount Cemetery	537	537
Miscellaneous Smaller Commitments	1,062	978
Total South Platte River System:	14,074	10,089
TOTAL RAW WATER	46,572	31,710
Recycle Water:		
Excel Energy (Cherokee Plant)	5,200	4,125
Rocky Mountain Arsenal (So. Adams Co. Agreement)	1,200	0
Lowry Golf Course	530	0
Park Hill Golf Course	350	0
Gateway Park Development	135	0
DIA Carwash	115	0
Total Recycle Water^[1]	7,530	4,125
Treated Water:		
Broomfield	6,500	4,225
South Adams County Water and Sanitation District	4,000	2,148
Lockheed Martin (special distributor contract)	1,300	517
Miscellaneous Smaller Commitments	494	380
Total Treated Water:	12,294	7,270
Raw Water Requirement at the Treatment Plant:^[2]	13,079	7,485
TOTAL FIXED AND SPECIAL CONTRACT COMMITMENTS:	67,181	43,320

(1) Although current recycled water commitments are for 7,530 acre-feet, the identified demands are approximately 17,000 acre-feet

(2) Assumes 6% loss at the treatment plant

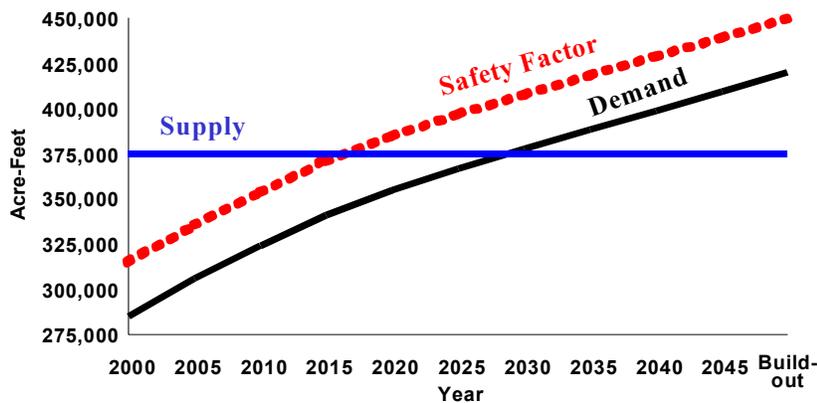
Combined Service Area Build-Out

Analysis was performed to evaluate the forecasts of future demands in relation to the availability of undeveloped land within Denver Water’s Combined Service Area including plans for major known future developments and redevelopments. This analysis indicates that the Combined Service Area will be fully developed by 2050.

Denver Water Demand Forecast

Figure III-4 presents the demand forecast through build-out, along with existing supplies. As is the case with any forecast of future demands, Denver Water must monitor changes in the areas it serves as well as service policies, demographics, socio-economic factors and usage over time, making necessary adjustments to the demand forecast as required. Staff plans a routine review of the demand forecast, making necessary adjustments at least every five years in the future.

Figure III-4
Denver Water Demand Forecast and Existing Supply



*The 375,000 acre-feet of supply is the supply Denver Water expects to have operational within 10 years and is shown here as “in-hand” for display purposes. For a complete description of supply, please see Chapter II.

IV. Water Supply Development

Supply Option Analysis

The current Denver Water collection system, while having more than sufficient capacity to reliably provide high-quality service to current customers, will require additions and upgrades to supply the projected Combined Service Area build-out demand.

During the initial IRP process in the mid-1990s, the analysis of options to add additional water to the Denver Water system proceeded in several steps:

- Defining supply option possibilities
- Screening options
- Categorizing remaining options
- Selecting and analyzing representative options from each category

To help ensure that no potentially viable supply alternative was inadvertently omitted from IRP consideration, the analytical process began by defining a reasonably inclusive list. Staff from each Denver Water division were convened in brainstorming sessions to develop a list based on the knowledge of projects and proposals studied and discussed over the years.

The list included an extensive assortment of supply options from the Metropolitan Water Supply Environmental Impact Statement of the early 1980s. These were supplemented by input from numerous stakeholder groups, including the Citizens Advisory Committee, an Eastern Slope stakeholder group, a Western Slope stakeholder group, and various individuals knowledgeable in water supply throughout Colorado. A list of more than 200 possibilities was identified; it included different types of structural and non-structural alternatives without regard to cost, technical feasibility or other potential limitations. Particular care was taken to see that all possible adjustments to, and efficiencies in, Denver Water's water system were included as well.

The options were then subjected to a "fatal flaw" screening. A fatal flaw in a given project could include site limitations, insufficient water yield, an inability to deliver water where needed, extremely negative public perception, unacceptable environmental effects, or insurmountable institutional obstacles. The first screening resulted in 44 options being rejected. Another 34 were expected to require cooperative effort between Denver Water and one or more metropolitan area water suppliers outside Denver Water's Combined Service Area. Since the Governor's Metropolitan Water Supply Investigation, begun in 1993, was concurrently examining potential cooperative action projects between Denver Water and entities outside its Combined Service Area, it was determined to leave such projects to that process.

The remaining 154 options were retained for further study and fell into five functional categories: effluent reuse, south system storage, north system storage, new stream

diversions, and miscellaneous or “system refinements.” By using an approach that categorized projects by their function, staff was able to select a few representative options for each category to analyze for water yield, cost and environmental impacts. This helped staff avoid the unrealistic task of attempting to extensively analyze all 154 options. The five functional categories and the detailed analysis are described in the July 1997 IRP report.

The Board’s Near-Term Water Supply Strategy

In 1996, the Board designed a near-term water supply strategy to produce 66,000 acre-feet of new firm yield to meet needs until the year 2030. Early efforts were to focus on conservation, non-potable reuse and system efficiency. The Board directed staff to explore cooperative actions with other water suppliers. The Board also indicated that new large-scale supply projects may be needed toward 2030 to supplement other near-term efforts.

Table IV-1 shows updated firm yield and completion dates for the near-term strategy:

Table IV-1
Update of Near-Term Strategy
Firm Yield (acre-feet)

<u>Component</u>	<u>1996 Projection</u>	<u>2001 Projection</u>	<u>Completion Date</u>
Conservation	16,000	16,000	2030
Non-Potable Recycling	15,000	17,000	2011
System Refinements	10,000	13,000	Varies
Cooperative Projects	10,000	10,000	Unknown
New Supply Projects	<u>15,000</u>	<u>15,000</u>	Unknown
Total	66,000	71,000	

Conservation. The conservation programs approved by the Board in 1996 emphasized education and awareness programs such as free Xeriscape seminars, planning and design clinics, and mass media campaigns promoting water conservation. Two programs also offered incentives for water saved — the Irrigation Efficiency Incentive program and the Commercial/Industrial Incentive program. Since 1996, these programs collectively have resulted in an ongoing annual savings of approximately 1,400 acre-feet. Conservation programs are discussed at length later in this report.

Non-Potable Reuse. As previously noted, all water delivered by Denver Water to its customers is classified as reusable or non-reusable. Denver Water has the following options for reuse of this water:

1. Perform exchanges to upstream facilities. In an exchange, reusable water is added to a stream at a downstream location to enable diversion of a like amount of water at an upstream location. To maximize these exchanges on the South Platte River, Denver Water is constructing 8,000 acre-feet of gravel pit storage.
2. Deliver the water to a recycling plant, treating the water and distributing it for non-potable uses. Denver Water’s recycling plant requires an additional 4,000 acre-feet of gravel pit storage so that the plant can reliably meet its demand.

3. Deliver the water to a treatment plant, treat it to drinking water standards and distribute it to Denver Water's customers for potable use.

When Denver Water's new recycling project is fully operational in 2013 (discussed below), the combination of exchanges and the recycling project will, in effect, maximize the yield that can be generated from reusable water until additional reusable water becomes available in the future.

As demand on Denver Water's existing collection system increases, the amount of available reusable water will increase. Denver Water's current demand is 285,000 acre-feet; its collection system supply is approximately 375,000 acre-feet. As demand on Denver Water's treated water system increases, more water will be diverted from Dillon Reservoir through the Roberts Tunnel, providing additional reusable water in the late-fall through winter months. In wet years when diversions through Roberts Tunnel are significantly reduced, there would be no excess reusable water for extended periods. However, with adequate storage any additional reusable water could be managed to meet new water demands—non-potable or potable. But until such time as added storage may be available, all of Denver Water's reusable effluent, including lawn irrigation return flows, is needed for exchanges and the recycling project, as well as to meet the obligation to provide 5,000 acre-feet per year of reusable water to the Farmers Reservoir and Irrigation Company for municipal uses. In effect, Denver Water's currently available reusable water is fully committed.

In meeting the build-out demands of the Combined Service Area, Denver Water will require additional water supply beyond what the existing collection system is capable of providing. The amount of additional reusable water that may become available depends on what future supplies are developed. Other factors that affect the amount of Denver Water's existing and potential future reusable water include:

- The ability to legally maximize exchanges could be restricted.
- Water use restrictions during droughts would decrease the amount of reusable water otherwise diverted through the Roberts Tunnel.
- Operational constraints could reduce the amount of reusable water during certain periods.

Denver Water is currently constructing a non-potable water recycling project. In Colorado, 15 recycling projects are on-line, including Colorado Springs, Aurora and Westminster. Broomfield is planning a new project, and expansions of existing systems are also planned. When constructed, Denver Water's project will be the largest in the state.

The water recycling project will take secondary treated wastewater from the Denver Metro Reclamation District plant and treat it to a tertiary level. The basic treatment processes include coagulation, sedimentation, filtration and disinfection with chlorine. Colorado recently implemented control regulations for non-potable reuse water service for urban irrigation areas. The state also has draft guidelines for other types of reuse water service. Denver Water's proposed water quality goals for its recycled water project will meet or exceed the new and draft state guidelines.

The project will be constructed in three phases. The first phase is currently under construction and operations are scheduled to begin in 2004. The distribution system and operations for Phase II and Phase III are scheduled for completion in 2008 and 2013, respectively. The ultimate plant capacity is expected to be 45 million gallons per day for all phases combined.

Phase 1:	8,907 acre-feet	completed by the end of 2003
Phase 2:	4,000 acre-feet	completed by 2008
Phase 3:	<u>4,753</u> acre-feet	completed by 2013
Total	17,660 acre-feet	

System Refinements or Modifications. In 1996, the IRP process identified numerous small-scale projects to improve water system efficiency by adding 10,000 acre-feet of firm yield. The current yield estimate is 13,000 acre-feet. As a result of the long lead-time and uncertainties of many of these projects, staff is implementing the largest projects to determine their capabilities. Estimated yields and completion dates are shown below.

**Table IV-2
System Refinement Projects***

<u>Project</u>	<u>Firm Yield (acre-feet)</u>	<u>Scheduled Completion</u>
Gravel Pit Storage	5,000	2008
High Line Canal Efficiency	3,000	2009
Strontia Fish Flow Recovery	3,000	2003
Lawn Irrigation Return Flows**	500	2009
Others***	<u>1,500</u>	Varies
Total	13,000	

*1,000 acre-feet from the City Ditch project are included in the Non-Potable Recycling Project.

**Nominal yield from river exchanges. Higher yield expected as source for raw water deliveries and augmentation plans.

***Includes projects for Platte Canyon Reservoir, Marston Reservoir Seepage, Harriman Lake, Farnell Lane well field, F & G Ditch, and water rights for Meadow Creek, Elk Creek and Antero contracts.

Denver Water and South Adams County have jointly acquired six gravel mining sites to develop the 8,000 acre-feet of storage needed for river exchanges and 4,000 acre-feet for augmenting the recycling project. An agreement with the Fulton Ditch Company allows conveyance of water to the sites and an increase of the Fulton diversion dam and ditch capacity for gravel pit deliveries.

Nearing completion is a Future Management Study investigating the effects of reducing deliveries in the lower third of the High Line Canal and conveyance of that section to a recreation management entity. Aurora has expressed interest in operating most of the lower

canal and helping provide canal flow to maintain the vegetation. Negotiations to remove Fairmount Cemetery from the lower third of the canal are underway.

The Lawn Irrigation Return Flow study began in 2000 and is expected to be complete in 2004. Negotiations are continuing with Aurora and Centennial Water District for an option to build a pump station near Chatfield Reservoir to recover Waterton Canyon fish flows released by Denver Water. Denver Water customers on or near the City Ditch are being converted to the recycling plant. Most park conversions to alternative supplies are expensive and have been delayed until needed, since these conversion opportunities will exist in the future.

New Supply Projects. New supply projects are divided into “south end,” “north end,” and “new stream projects.” They are either enlargements of existing reservoirs or construction of new facilities. In 1996, the Board indicated that new large-scale supply projects would likely be needed closer to the year 2030 to supplement the other near-term efforts.

Cooperative Actions

In the Board’s 1996 Resource Statement, the staff was directed to “explore cooperative actions with water suppliers outside the Combined Service Area based upon a set of guidelines to be developed by the Board.” The Board issued these guidelines in a document entitled “Cooperative Actions With Metropolitan Water Suppliers Outside The Board’s Service Area.” Since then, staff has sought to implement the Board’s guidelines. An initial step was to work with the metro Denver area as four geographic regions—Aurora, northeast, northwest, and south metro. Denver Water invited interested parties within the regions to discuss water supply issues and capabilities so potential cooperative actions could be identified. While participants in these discussions have defined some possible cooperative actions and are now implementing them, other options are still being explored. New opportunities may emerge so long as the avenues of discussion among water users remain open. The following cooperative actions have been discussed or implemented within the four metro regions:

Aurora. Aurora and Denver Water are discussing possible preliminary steps for rebuilding Denver Water’s Antero Dam to allow storage of the full decreed amount in the reservoir. Cooperation on the enlargement of Denver Water’s Eleven Mile Reservoir also is part of the discussion. The Antero project would provide an additional 65,000 acre-feet of storage, while the Eleven Mile project could provide an added 18,000 acre-feet of storage. Preliminary steps include an engineering feasibility study, on-site environmental evaluation, an outreach program in Park County to identify crucial issues, and an assessment of probable regulatory hurdles.

Northeast. The northeast regional group includes Aurora, Brighton, Farmers Reservoir and Irrigation Company, South Adams County Water and Sanitation District (South Adams), Thornton, the Rocky Mountain Arsenal, and the State of Colorado. Early meetings of this group also included Public Service Company of Colorado (now Xcel Energy) and Metro Wastewater Reclamation District. Denver Water has implemented one cooperative action in this region—a three-way agreement among Denver, South Adams and the Rocky Mountain

Arsenal. This agreement has South Adams and Denver Water cooperatively building 8,000 acre-feet of gravel pit storage for Denver Water's use. Denver Water will use the 8,000 acre-feet of gravel pit storage to manage some of its reusable effluent to produce 5,000 acre-feet of new yield by way of river exchanges to Denver Water's upstream facilities. South Adams receives 4,000 acre-feet of this new yield, and Denver Water acquires the remaining 1,000 acre-feet. South Adams and Denver Water also will develop storage needed to augment diversions made by the recycling project. The Rocky Mountain Arsenal receives 1,200 acre-feet of non-potable water from Denver Water's new recycling project in exchange for deeding to Denver Water water rights on the High Line and in Antero Reservoir that can be converted into yield for Denver Water's customers. Additionally, Denver Water and Xcel Energy entered into an agreement for delivery of water from the recycling project for use by the Cherokee Power Plant. A further outcome of northeast regional efforts is an agreement between Denver Water, Farmers Reservoir and Irrigation Company, and two other irrigation companies that settled long-standing disputes surrounding the acceptability of Denver Water's reusable effluent as a replacement supply and Denver Water's ability to use pumps at Metro Wastewater to operate exchanges.

Northwest. The northwest regional group includes Arvada, Broomfield, Consolidated Mutual and Westminster. Denver Water's first priority in this region is to solve its Moffat System problem. Denver Water and Consolidated Mutual have entered into an arrangement that provides Denver Water with 440 acre-feet of yield in exchange for Denver Water paying \$3 million toward the construction of a small reservoir (Walter S. Welton Reservoir) built by Consolidated Mutual. This arrangement was based partly upon the knowledge exchange that occurred within the northwest cooperative effort. Results of this knowledge exchange were documented in reports developed by the consultant for the regional effort. Participants in the northwest regional group continue to search for a regional cooperative action. In 1999, the Board entered into an agreement with the City of Arvada to purchase land and preserve the option to build Leyden Gulch Reservoir as a possible answer to Denver Water's Moffat reliability problem.

South Metro. The south metro group includes Douglas County, the Town of Castle Rock, Centennial Water & Sanitation District, Parker Water & Sanitation District, East Cherry Creek Valley Water & Sanitation District, Castle Pines North Metropolitan District, Cottonwood Metropolitan District, Inverness Water & Sanitation District, Stonegate Village Metropolitan District, Meridian Metropolitan District, Pinery Water & Wastewater District, Roxborough Park Metropolitan District, and Arapahoe County Water & Wastewater Authority. Denver Water, the Colorado River Water Conservation District, and the south metro entities listed above have agreed to study collaboratively possible water supply options based upon the goals contained in a Douglas County Resolution and a joint Denver Water Board/Colorado River District resolution. The expected completion date for the study is June 2002. When the study is completed, the Douglas County water users expect to prepare a cooperative action proposal for Board consideration. Denver Water staff is working with the south metro group to assure that the Board's interests are incorporated in any proposed cooperative action developed by the region.

Upper Colorado River Basin Study

While not a part of the metro Denver regional efforts, the Board has extended its outreach to the Western Slope as well as to the Northern Colorado Water Conservancy District (Northern). On the Western Slope, Denver Water has been engaged in a three-year effort known as the Upper Colorado River Basin Study. The study includes as participants the Colorado River Water Conservation District (Colorado River District), Summit County, Grand County, the Northwest Colorado Council of Governments' "QQ Committee," the Northern Colorado Water Conservancy District, and Colorado Springs. Other interested entities, including the environmental community, have participated from time to time. The study has been aimed at identifying current and future impacts of growth and increasing water demand on the Upper Colorado River Basin, whether from the headwater counties themselves or the Eastern Slope. That study is now moving toward the "negotiation" stage to see if mutually beneficial solutions can be found for the problems and issues identified in the study's data-gathering efforts.

Beyond the Upper Colorado River Basin Study, Denver Water has worked cooperatively with the Colorado River District on both "threatened and endangered species" problems affecting the Upper Colorado River Basin and on Eagle River Basin issues. Northern has been involved in the endangered species efforts as well. Northern and Denver Water have filed for water and storage rights for a proposed Sulphur Gulch Reservoir some 50 miles upstream of Grand Junction adjacent to the Colorado River. Sulphur Gulch has the potential to help with endangered species solutions.

Eagle River Basin

In the Eagle River Basin, the Board has numerous water rights in Eagle County that can be combined into two distinct water supply projects: the Eagle-Piney and the Eagle-Colorado projects. The Eagle-Piney project would divert water by gravity from tributaries of the Piney and Eagle rivers. A significant portion of the Eagle-Piney project would require construction of tunnels within (under) the Eagles Nest Wilderness Area to divert water. The Board, recognizing the problematic nature of constructing a water supply project in a wilderness area, directed staff to study alternatives for the Eagle-Piney project. In October 2000, a consultant firm completed a study for the Board entitled "An Evaluation of Eagle-Piney/Eagle-Colorado Reconfiguration Alternatives." The report, in part, concluded that:

"Development of Denver's Upper Eagle River rights may directly enhance yield to Denver's system. However, the process associated with the Eagle River Assembly discussions has produced considerable thought and analysis on development options by Colorado Springs and Aurora, the Vail Consortium and Climax. Although Denver has its own set of water rights in this area, Denver should work collaboratively with these entities and participate in the development of the joint use alternatives that meet the needs of Denver and these other entities."

After the consultant reported the results of the reconfiguration study to the Board on October 17, 2000, the Board directed staff to explore joint alternatives with Colorado Springs, Aurora, the Vail Consortium and Climax.

Prior to the Board's direction to staff, Colorado Springs, Aurora, the Vail Consortium, Climax and a host of others in Eagle County convened the Eagle River Assembly to search for cooperative projects that would help all parties. This cooperative effort was a direct result of the costly and protracted battles between Eagle County, Colorado Springs and Aurora about efforts to build the Homestake II Project in the Homestake Wilderness Area. Eagle County, using its land use authority, eventually defeated the Homestake II Project. The Eagle River Assembly, after years of meetings and studies, developed an understanding that Eagle County needed water and that a cooperative approach to water supply development in the Vail Valley had benefits for all parties. Based upon this effort, Colorado Springs, Aurora, Vail Consortium, Climax and the Colorado River District entered into the Eagle River Memorandum of Understanding (MOU). The MOU established a 20,000 acre-foot limit on the amount of water Colorado Springs and Aurora could divert from the basin in exchange for an agreement that the Homestake II Project would not be constructed. The MOU also provided for 10,000 acre-feet of water for in-basin uses, resulting in a total use of 30,000 acre-feet.

As the signatories of the MOU were beginning to negotiate issues related to implementing conditions of the MOU, Denver's consultant study was issued and staff from Denver Water expressed a desire to explore options for a joint project with MOU signatories. Since that time, Denver Water's discussions with the signatories and others in Eagle County have centered on how Denver Water might be included in the MOU. The only condition imposed on these discussions was that the limit of 30,000 acre-feet of Eagle River Basin water would remain unchanged. The signatories' concern was that revisiting the 30,000 acre-foot limit would jeopardize the fragile political agreement between Colorado Springs, Aurora, Eagle County and other Western Slope interests. None of the MOU signatories wanted to subject that political agreement to the risk of collapse. However, all the signatories expressed a willingness to explore ways that Denver Water could be accommodated under the diversion cap.

Since October 2000, Denver Water staff and the MOU signatories have been exploring cooperative options in Eagle County. The most promising project defined in these discussions would have Eagle County reduce its share of water from 10,000 acre-feet to about 7,000 acre-feet; Colorado Springs and Aurora would reduce their shares of the 20,000 acre-feet of out-of-basin diversions, allowing Denver Water to receive 5,000 acre-feet of firm yield. Discussions on this cooperative project are ongoing.

The Moffat Project

Denver Water is facing an increased likelihood that it will not be able to meet its customers' water demands reliably on the north end of its system during some dry periods. The reason is a water availability problem at the Moffat Water Treatment Plant. The cause of this problem is not a lack of overall water supply available to Denver Water's system during dry periods, but an unequal distribution of the available water. That is, Denver Water currently

has adequate water in its supply system, but not enough of that water is available for treatment at the Moffat plant.

The Moffat Collection System supplies about 37,000 acre-feet of water in a dry year. Denver Water's annual raw water commitment to customers outside of the Combined Service Area from its Moffat Collection System exceeds 32,000 acre-feet, which leaves a very limited amount of water available for Denver's use at its Moffat Treatment Plant. This dry-year supply shortage becomes even more serious as demand on Denver Water's collection system increases with the build-out of the Combined Service Area. The amount of additional Moffat Collection System supply needed at build-out to resolve this shortage depends on how operations are restricted at the Moffat Treatment Plant.

Without additional water supply for the Moffat Collection System, the Moffat Treatment Plant would have to be shut down each year by mid-October until the following May as a normal operating practice. In order to guarantee that adequate water is available in case the next year is a drought, use of the Moffat Treatment Plant would need to be further limited to guarantee that Gross and Ralston reservoirs are at least 75 percent full each October.

When a drought occurs, Moffat Treatment Plant operations would require even more onerous restrictions. For example, treatment rates would be restricted to a maximum of 30 million gallons per day (Moffat Treatment Plant has a capacity of 210 million gallons per day) between May 1 and mid-October. The only exception to this restriction would be on days that Denver Water's overall treated water demand exceeds 660 million gallons per day—when Marston and Foothills treatment plants are nearly at capacity. Even with this very restrictive operation, the active contents of Gross and Ralston reservoirs would be zero by the spring following a single severe dry year. In a multiple-year drought, the Moffat Treatment Plant would be operated in this very restricted mode for consecutive years. While these operational restrictions might seem overly burdensome and unreasonable, the above operation is a "best-case" scenario. A basic, and unreasonable, assumption in the above discussion is that both the treated water system and the collection system would have to operate perfectly for at least two years of a drought. If, for example, the Moffat Treatment Plant was required to operate at full capacity for just one week more because of an outage elsewhere in the treated water system or collection system, an additional 4,500 acre-feet of Moffat Collection System supply would be required to make it through the drought period. This additional 4,500 acre-feet of water is not available without the construction of new facilities.

If new facilities were constructed adding 35,000 acre-feet of supply to the Moffat Collection System, the Moffat Treatment Plant would still be shut down from about mid-October until the following May every year to assure adequate reserves for the next year. Also, during the first year of a drought, the plant would still operate in the restricted rate mode—maximum rate of 30 million gallons per day between May 1 and mid-October—except on days when Denver Water's overall treated water demand exceeds 660 million gallons per day. The benefit from the additional 35,000 acre-feet of supply occurs in the second year of a drought. During the summer load season of that second year, the treatment plant could operate significantly above the 30 million gallons per day rate restriction required the first year. Also, this additional supply reduces risk of a water shortage should other parts of

Denver Water's collection system or treated water system not operate perfectly during a drought.

If new facilities were constructed that added 70,000 acre-feet of supply to the Moffat Collection System, the Moffat Treatment Plant could operate significantly above 30 million gallons per day during the peak demand season in all drought years. In addition, there would be substantially less risk of a water shortage should part of the collection system or treated water system not operate perfectly during a drought. However, the treatment plant would still have to be shut down each winter to assure adequate reserves for the next year.

Denver Water is examining potential solutions for providing more water to the Moffat plant during dry years. A few potential solutions—such as bringing water north through a new transmission line from existing reservoirs on the South Platte and Blue rivers, or enlarging Denver Water's two other treatment plants, including building new treated water transmission lines—reposition existing water resources to address the water availability problem at the Moffat plant. Potential solutions that reposition water draw more heavily on Denver Water's existing supply in the southern portion of its system and do not add new water to Denver Water's system. Other potential solutions—enlarging Gross Reservoir; building a new off-channel reservoir; or recycling water for drinking purposes—would have the additional benefit of adding new water to Denver Water's system to help meet future demand.

The amount of new water supply needed to attenuate Denver Water's Moffat Collection System problem does not consider possible water supplies necessary for regulatory obligations; negotiations with Grand, Jefferson and Boulder counties; environmental considerations; or other purposes that might be required in solving the Moffat Collection System problem.

Long-Term Water Supply Opportunities

The Board has invested considerable resources in assuring that there will be future opportunities to supply water to its customers. Included in the Board's portfolio of water supply options are projects that will be needed to meet new demands beyond 2030 and extend to the ultimate build-out of its Combined Service Area. There is little reason to commit today to a particular water supply that will not be needed until at least 30 years hence. That is why the Board, in its 1996 Resource Statement, stated that it cannot determine at this point which projects will be needed and which water rights will be required. The Board has determined that it must preserve its water rights to assure availability in the future and to maintain flexibility. Table IV-3 summarizes long-term future supply opportunities beyond those included in the near-term strategy.

**Table IV-3
Long-Term Supply Options**

<u>Category</u>	<u>Source</u>	<u>Opportunity</u>	
1. North System Storage	Moffat System	West Slope Storage; East Slope Storage; Conjunctive Use	
2. South System Storage	Blue River	North Fork Storage; South Fork Storage; Conjunctive Use	
	South Platte River	New South Platte Storage; North Fork Storage; Offstream Storage; Downstream Storage; Conjunctive Use	
3. New Stream Diversions	Eagle River	Denver's Water Rights; Joint Development with Others	
	Colorado River	Pumpback Facilities; Storage Development and Operations; Call Reductions	
	Williams Fork River	Denver's Water Rights; Downstream Pumpback; Joint Use with Others	
	Blue River	Tributaries below Dillon; Pumpback from Green Mountain	
4. Effluent Reuse	Metro Area	South Platte River	New Supply to Meet Contractual Obligation and Park Irrigation; Nontributary Ground Water Development
		Pumpback of Reusable Effluent and Return Flows; Effluent Storage and Management; Indirect Potable Reuse	

Since there is no way to be certain that significant surface diversion and storage rights associated with projects not yet built (e.g., Williams Fork extension and enlargement, Two Forks, Eagle/Piney—Eagle/Colorado Systems) will remain unneeded, the Board continues to reserve and develop for its use all of its conditional water rights.

V. Water Conservation

Historical Precedent

Since the early 1900s, Denver Water has consistently encouraged wise water use. By the mid-1970s, Denver Water had taken a leadership role among water utilities by adopting a formal plan for water conservation and setting specific goals for the public to reduce demand. The chart below lists some of the conservation measures implemented in the past 25 years:

<u>Conservation Measure</u>	<u>Started</u>
Schools outreach	1976
Every-third-day lawn watering restrictions (now voluntary)	1977
Evapo-transpiration (ET) rates for irrigating blue grass	1981
Sonic leak detection	1981
Xeriscape demonstration garden	1981
Formation of Metro Water Conservation, Inc. (MWCI)	1985
Founding of the National Xeriscape Council, Inc.	1986
Residential audit/retrofits	1987
Meters replace flat rate billing	1987
Alternative source irrigation	1990
Ultra low volume (ULV) toilet rebates	1990
Bus board advertising	1990
Commercial and industrial audits	1990
Conservation Hotline	1991
Conservation rate structure	1991
Multifamily audit/retrofits	1992
City and County of Denver conservation plumbing code	1992
“Ten-acre Irrigation Rule”	1993
Audits for low-income customers	1994
Commercial and industrial incentives	1996
Irrigation incentives	1997
Parks incentives	1998
New home incentives	1998

The Conservation Planning Process

In 1994, when Denver Water began work on its IRP report, Denver Water for the first time put conservation on an equal footing with supply-side and recycling projects as a legitimate source of water to meet future demand. In the first phase of the IRP report, staff looked at

customer groups and all known methods and equipment for achieving water conservation within each group. To provide a larger perspective on workable solutions, the Citizens Advisory Committee to the Water Board convened a task force, which met several times, to study conservation issues and conduct workshops on the public perception and acceptance of potential new conservation measures. The result was the following list of criteria to evaluate conservation options that are still used in the evaluation process:

- Is the measure feasible?
- Can the results be tracked?
- Are the water savings reliable and lasting?
- Is the option cost-effective to Denver Water and its customers?
- Does the measure fit with area goals and values?
- Is Denver Water the best vehicle to implement the measure?
- Is a conservation measure needed to achieve water savings?

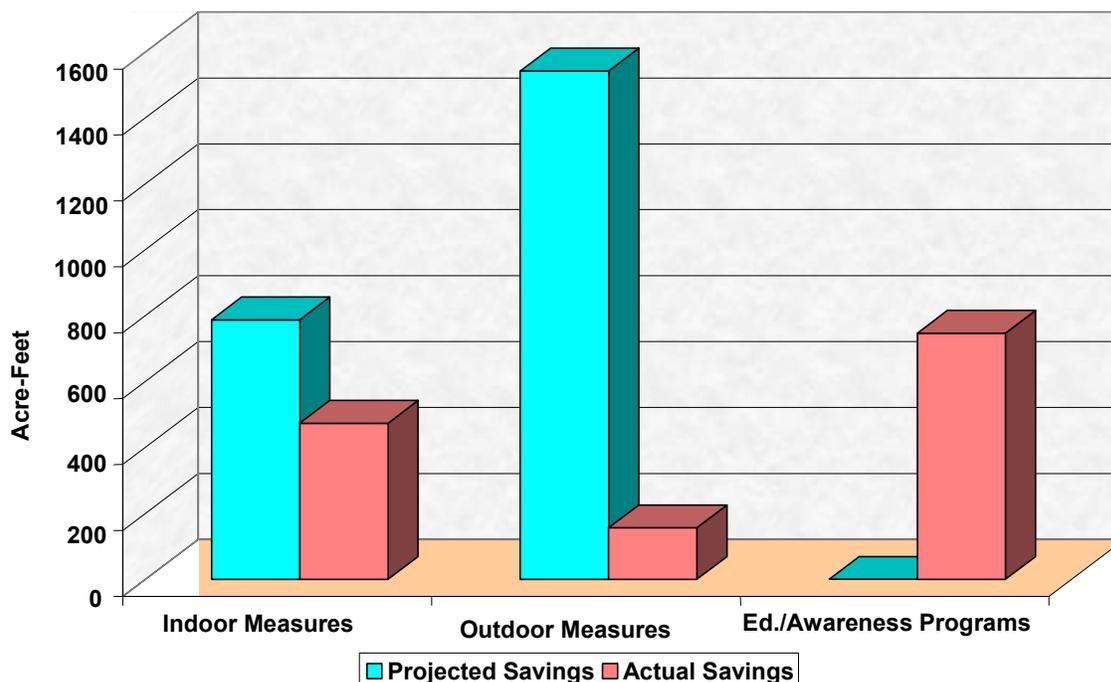
The staff then developed a palette of water conservation measures, modified them based on input from outside experts and the Citizens Advisory Committee, and presented them to the Board. In 1996, the Board selected a conservation package designed to achieve a savings of approximately 29,000 acre-feet of water by the time Denver Water's Combined Service Area is fully built out.

Evaluating Overall Program Performance

In 2000, Denver Water began work on quantifying the savings achieved to date and identifying measures that may need to be modified or replaced. It soon became apparent that some had been more successful than others. The Irrigation Efficiency and Commercial/Industrial incentives had exceeded expectations, and sales of front-load washers were brisk. However, measures designed to address outdoor savings among Denver Water's single-family residential customers had lagged. Most of these measures were educational in nature, and it proved very difficult to track savings from them. In most cases, savings could only be estimated based on overall consumption trends.

Overall, Denver Water's indoor, outdoor and educational measures saved almost 1,400 acre-feet from 1996 to 2000. In 1996, the Board set a goal of saving 29,000 acre-feet through additional conservation efforts by the year 2045. The IRP identified two planning horizons: the near-term from 1996 through 2030 and the long-term from 2030 through build-out of the Combined Service Area. The near-term conservation goal established in the IRP was 16,000 acre-feet of the total 29,000 acre-feet. Based on this near-term goal, the conservation measures should have saved approximately 2,300 acre-feet (Figure V-1).

Figure V-1
Projected vs. Actual Conservation Savings



To assess more accurately the performance of the conservation program overall and of specific measures to date, Denver Water worked with consultants to perform a qualitative review of Denver Water’s conservation program, estimates, projected savings and actual savings, and then compared those with results achieved in other successful conservation programs across the nation. A report was completed in May 2001 and contained some significant findings:

- Denver Water’s current program would not produce the goal of 29,000 acre-feet saved per year by 2050.
- Denver Water’s conservation program had already produced the easy savings; any further savings would be more difficult and probably more expensive to achieve.
- Most of Denver Water’s conservation measures are focused on customer education and information, and thus do produce savings (2 percent to 5 percent over time), but will probably not produce any further savings regardless of the amount of effort put forth by staff. In fact, Denver Water needs to continue the existing level of customer education and information just to maintain existing savings.
- Incentives are having minimal success because of staffing limitations and because the level of payments offered are inadequate to motivate maximum participation.

The report recommended a plan of action for the future, including:

- To get the targeted savings, Denver Water needs to offer a blend of education, rates, and mandates or regulatory measures.
- Because there is no impending crisis, savings from natural replacement of indoor fixtures can wait; no new measure needs to be implemented yet.
- Incentives need higher emphasis and higher payments for water saved.
- Initiatives need to be targeted to the area with the largest potential for savings rather than the broad application method used in the past. Specifically, this means changing the residential water audit and retrofits to an outdoor commercial project focusing on specific multi-family properties and only the largest single-family users.
- Goals need to be adjusted to target outdoor use more than multi-family use, and some goal should be set for “unaccounted-for water.”
- Modifications need to be made to the current program, including:
 1. Focusing more resources on getting savings in outdoor water use, because 80 percent of potential future savings will come from this sector;
 2. Raising the incentive payments;
 3. Lowering the threshold for participation in the current incentive project from 5 acre-feet potential savings to 1 acre-foot;
 4. Lowering the acreage limit for plan review from 10 acres to between three and 6 acres;
 5. Strengthening the efforts for monitoring and evaluating savings.
- New measures and new adjustments to existing measures need to be added that target specific savings goals.
- Adjustments need to be made in past estimates for savings due to plumbing codes that require installation of water-saving devices and fixtures.

Public Attitudes and Conservation

As with the initial phase of the IRP, a critical step was to track public attitudes toward water conservation. In October 1999 a telephone survey of Denver Water’s customers was conducted. Five hundred people were surveyed—67 percent from inside Denver and 33 percent from suburbs served by Denver Water. The survey showed that Denver Water’s conservation message is getting across, but that some areas still need attention. Among other things, the survey found that the number of customers with automatic sprinkler systems has increased from 50 percent in 1995 to 61 percent, but that only about 6 percent of customers with automatic sprinkler systems had some type of rainfall sensor. Also, less than half of the customers with automatic sprinkler systems adjusted their watering times during the irrigation season.

On the positive side, 26 percent of those surveyed said they had Xeriscaped at least a part of their own yards—up from 21 percent in 1995. Eight percent had front-load washing machines, a good number considering the cost and relative newness of such machines in the U.S. market. And 90 percent of those surveyed thought it was important to conserve water.

Options for Additional Savings

Based on the analysis of the current program, data from the May 2001 report and the phone survey, staff looked at three new scenarios for achieving the 29,000 acre-foot goal, each offering a sampling of possible measures representing different philosophical approaches. The three approaches were:

- Incentives
- Rates
- Mandates

After analysis, it became apparent that while all three of the scenarios could achieve the targeted savings, there were some problems with each. Some of the incentive measures were costly, and participation rates were difficult to predict, making savings projections less reliable. Savings from mandates would be more reliable, but the costs of enforcing many of the mandates would be prohibitive. And, while preliminary studies indicated that savings might be possible from the implementation of a more conservation-oriented rate structure, further studies are needed to quantify the magnitude of those savings and determine any interaction with other conservation programs.

Staff then went through each scenario and selected a combination of measures that represents the “best bets”—those measures believed to be most likely to succeed as a package or new conservation program. Four approaches were presented to the Board, and in November 2001 the Board indicated its preference for the “best bets” combination shown in Table V-1.

**Table V-1
“Best Bets” Conservation Measures**

Measure	Audience	Acre-feet Saved	Annual Cost	Total Cost/Acre-foot
Revise Irrigation Efficiency measure to increase rebate - \$4,500 per acre-foot saved	All customers	9,500	\$995,600	\$4,500
Revise current 10-acre Plan Review to require compliance with recommendations	All new sites over 10 acres	5,000	\$1,200	\$10
Revise Commercial/Industrial measure to increase incentive - \$4,500 per acre-foot saved	All C/I customers	4,500	\$473,500	\$4,500
Offer a \$20 rebate for installing rainfall sensors	All SFR customers w/auto. sprinklers	2,700	\$125,000	\$2,000
Offer an audit and wastewater incentive for monitoring, recycling cooling tower water	All customers with cooling towers	250	\$7,400	\$1,300
Xeriscape 28 acres of Denver Water property	Denver Water	28	\$2,400 ¹	\$24,000
	TOTAL	21,978	\$1,626,702	\$3,600
Plus savings from water-efficient washers		9,000		
Plus savings achieved to date		1,400		
TOTAL SAVINGS		32,378		

¹annual cost based on 10-year program

Next Steps in Conservation

Staff is currently researching more details for new incentive measures, effective mandates and reasonable rates that meet other Board goals as well as the conservation goal. This new approach will include the education and information measures already in place, as well as even more cooperation with neighboring utilities, non-profit organizations and trade associations to maximize results.

VI. Resource Strategy Update

Early in the development of the IRP report, the Board spent considerable time reviewing various “resource strategy” alternatives. A “resource strategy” was defined as the development of resources and facilities that would provide for build-out of Denver Water’s Combined Service Area by the middle of this century.

Strategy Development

While the resource strategy must be flexible and able to adapt to uncertainties of the future, it must also lay out a path for near-term facility development to ensure that the system is able to stay ahead of projected customer demand. To help develop this strategy, the Board concluded that a reasonable conservation program followed by non-potable recycling should precede significant new storage supplies.

The Board also determined that to add to system reliability, a 30,000 acre-foot per year “safety factor” of supply should be maintained above demand. Additionally, the Board did not want to treat drought-year usage restrictions as a “resource.” Rather, the Board preferred that such restrictions were to be used only in emergency conditions, not as a normal dry-year resource.

Based upon the Board’s direction, the staff developed alternative resource strategies that began with a reasonable degree of conservation followed by non-potable reuse. Additionally, miscellaneous system refinements and supply options were included in the resource strategy development.

The final near-term strategy developed in 1996 focused on:

- 16,000 acre-feet from conservation;
- 10,000 acre-feet of system refinements;
- 15,000 acre-feet of non-potable reuse water;
- The assumption that cooperative actions would yield 10,000 acre-feet;
- The need for 15,000 acre-feet of additional surface storage supply toward the end of the near term;
- Maintenance of the 30,000 acre-foot safety factor.

The Board observed that determining with precise accuracy the yield for both conservation and system refinements is very difficult. It therefore decided to implement a 10-year program to establish and “prove-up” that yield for both. At the end of the 10 years, the yields for both programs would be adjusted based on results of monitoring and evaluation.

Board Reaffirms Near-Term Strategy

After receiving a five-year IRP information update from staff in 2001, the Board reaffirmed its near-term resource strategy. The update emphasized the change in population projections with the adoption of the growth scenarios included within the Denver Regional Council of Governments' "2020 Vision" Program and the increase of the Board's safe annual yield. The staff's analyses suggest that there should be no need for a major supply addition until at least the late stages of the near-term strategy. However, the Board said it remains open to adding new supply through "targets of opportunity" in cooperation with other entities and is committed to resolving the Moffat Collection System problem.

The 2001 **updated** near-term resource strategy supply options as contrasted with the projections in 1996 are shown on the next page.

Figure VI-1
Near-Term Strategy Changes
(Acre-Feet)

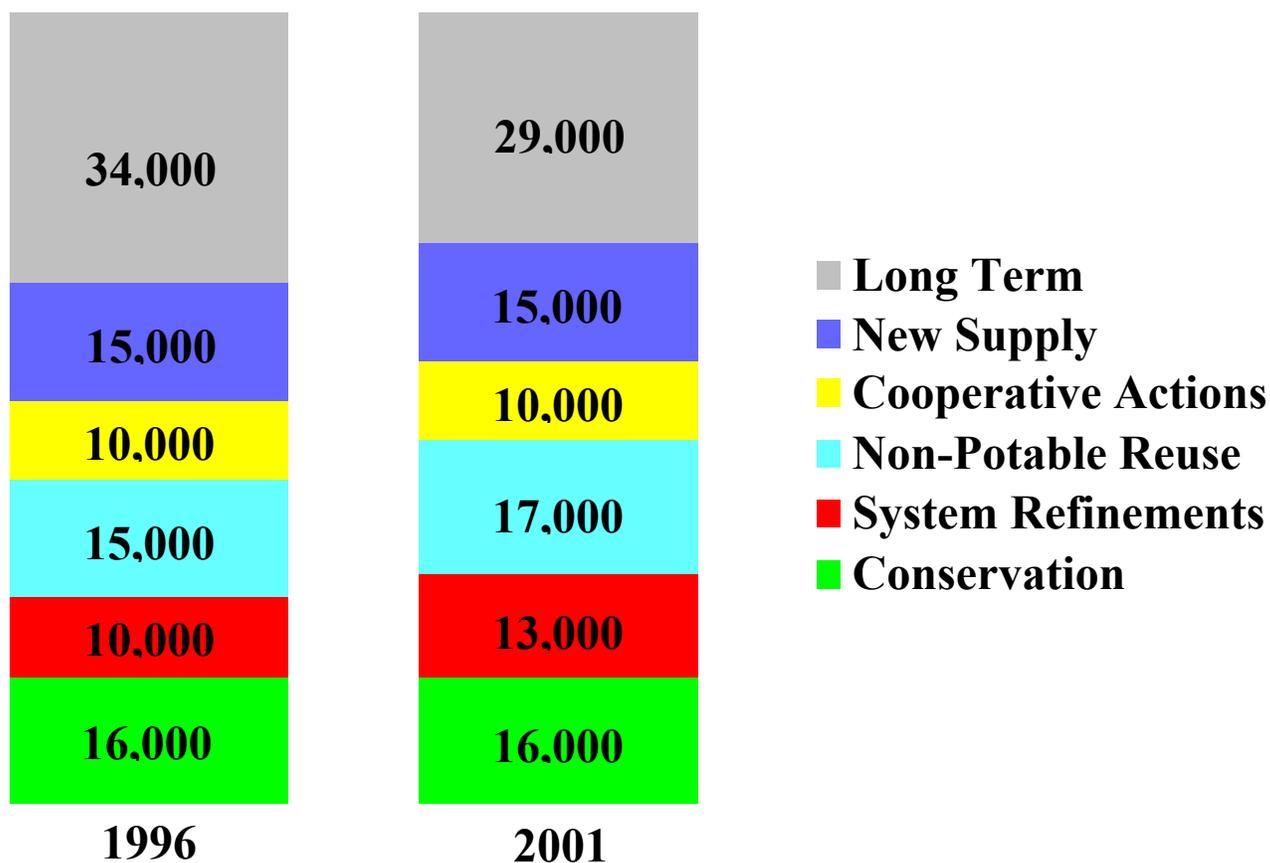


Table VI-1
Near-Term Strategy

<u>Component</u>	<u>Type</u>	<u>Acre-Feet</u> <u>(1996)</u>	<u>Acre-Feet</u> <u>(2001)</u>	<u>Acre-Feet</u> <u>Change</u>
Conservation	Conserved	16,000	16,000	0
Non-Potable Reuse	Recycle	15,000	17,000	2,000
System Refinements	Supply	10,000	13,000	3,000
Cooperative Projects	Supply	10,000	10,000	0
New Supply Projects	Supply	15,000	15,000	0
Total		66,000	71,000	5,000

VII. Public Involvement

Communicating the IRP Process

The public involvement process for the original IRP (1994-1996) was an extensive effort. A complete stakeholder involvement process was required to consider the transition from the Two Forks era—a project designed to help answer the water supply needs for the greater Denver metropolitan area—to a “new” vision of Denver Water. That vision centered on Denver Water limiting the areas it served and developing sufficient future water supply to meet the needs of those areas.

The result of that extended public involvement process was the October 1996 Board Resource Statement, which articulated the Board’s newly defined role in water planning and resource development in the Denver metropolitan area. The Board Resource Statement has been included in this report as Attachment A.

As the time for the five-year update to the IRP report drew near, Denver Water staff discussed the design for the accompanying public involvement process. It was expected that the Board would not dramatically change its strategy for the future, but would essentially reaffirm its 1996 vision and ask for an IRP progress report. Since public reaction to the Board’s IRP Process and Resource Statement over the past five years has been uniformly favorable, the Board’s “public involvement process” for the IRP progress report was viewed principally as an outreach effort to supplement the program update.

During the development of the progress report, Denver Water staff held meetings with major interest groups involved with the IRP effort. This included the Board’s Citizens Advisory Committee, Denver Water Distributors, the suburban Cooperative Action Groups, and Western Slope interests. The meeting agendas consisted of the staff’s review of the schedule for the IRP update, an explanation of the Board Resource Statement, and an overview of the updated information to be discussed with the Board at Board retreats on the progress report. At the meetings, staff asked participants to provide their concerns, as well as new ideas or other long-range resource strategies the interest group would like included in the staff’s update of the Board.

The recurring theme expressed by participants in the meetings was that the Board should continue in the direction set by the IRP in 1996. While some expressed regret that the Board is no longer leading the way in water resource planning for the total metro area, virtually all parties supported Denver Water’s limited areas-served policy. Most entities appear to have adjusted their development programs to accommodate that philosophy. For the Board to stake out a new direction at this point might require a rethinking of the water service and development plans of numerous other participants.

In addition to the printing of this updated IRP report, staff has begun the process of returning to the major interest groups to report on Board decisions and to review developmental

proposals for the next five years. Denver Water's activities during the coming time period will continue to be guided by the 1996 Resource Statement, particularly the "Combined Service Area" concept set forth in that statement.

VIII. Outcomes of the IRP Process

In 1996, Denver Water's IRP process had identified proposed projects and future directions. These were fine-tuned through continuation of the IRP effort in the years following 1996. In the intervening years, Denver Water staff took the IRP package of projects and sought to budget, schedule and implement it in increments through its 10-Year Capital Program process. As Denver Water did so, the projects were modified as appropriate.

The Board's Resource Statement

In October 1996, the Board concluded the initial phase of the IRP by issuing the Board Resource Statement. The October statement both superseded and expanded upon one issued in April 1989 in the heat of the Two Forks controversy. The statement identified the basic parameters within which the Board would allocate its water resources in the foreseeable future. The statement is subject to future modification; however, the Board's long deliberation over the policy ideas during the three years of the initial IRP, including extensive input from public groups and other water entities, means the Board would propose to modify the positions set forth in the statement only with the greatest of care and consideration. In fact, in the 2001 update of the IRP process, the Board chose not to make any changes in its Resource Statement.

The importance of the Board Resource Statement is that it formally

- Constitutes a major policy declaration guiding the Board's future decision-making on allocating water resources;
- Reaffirms that the foremost obligation of the Board is to serve the City of Denver to build-out;
- Defines the Board's service area to include Denver and its suburban contract Distributors, with the Board serving to build-out within that area, but not taking responsibility for water supply outside that area;
- Points to the use by the Board, for the first time, of conservation savings in planning forecasts on an equal footing with traditional supply sources;
- Maintains a "placeholder" future supply storage project or projects, including possible reservoir enlargements, in the event conservation, reuse and small-scale efforts do not suffice;
- Reserves all Board water rights for ultimate use since the Board does not know which water rights would be required for added yield, and which of those rights might lend themselves to development;
- Notes that the Board will proceed in all instances in an environmentally sensible manner;
- Emphasizes that the Board has sufficient potential yield from its own resources to build out its service area, without having to depend on the resources of those outside its service area, though it must develop that added capacity in the midst of

regulatory, catastrophic or other potential limitations to its existing or future yield and infrastructure;

- Indicates that the Board, without necessarily taking a lead position on any future cooperative action, will work with suburban entities outside its service area on cooperative efforts, while ensuring appropriate suburban attention to conditions such as compensation to the Board, regard for South Platte stream flows, relations with Western Colorado, and other considerations;
- Points out that since all of the Board's capacity is needed to build out its service area, it cannot dedicate yield or infrastructure assets permanently to those outside its service area, though it will lease water and capacity temporarily, and it will use its assets to further joint cooperative efforts carried out on a regional basis when its service area receives major benefit;
- Stresses the Board's desire to work cooperatively with Western Colorado and other areas and interests in the state, though the Board recognizes that full use of its system will place a greater draw on existing facilities such as Dillon Reservoir or the South Platte River.

While the Board—through its actions at its regular bimonthly meetings—had always set incremental policy, it had never before enunciated a comprehensive approach to its future resource allocation responsibilities. The Resource Statement constitutes a far-reaching pronouncement of the Board's approach to those responsibilities.

The Board's Combined Service Area: Its Relationship to Supply and Demand

The centerpiece of that approach is the Board's obligation to serve the City of Denver until build-out is accomplished. The Board's system belongs to the citizens of Denver, who have the paramount claim on water from that system. While it appeared in the 1970s that Denver was being "landlocked" by the Poundstone Amendment, developmental opportunities at the new Denver International Airport and redevelopment opportunities at the old Stapleton Airport, the former Lowry Air Force Base and the Central Platte Valley provide significant growth potential for Denver's future. Indeed, projections indicate that of the almost 700,000 of increased population that can be expected in the Board's Combined Service Area at build-out, about 43 percent of the increase will be in the City of Denver.

A second critical Board obligation is to provide water for build-out of the areas served outside Denver. To determine the dimensions of that obligation, the Board first had to define its Combined Service Area boundary. Until the veto of Two Forks, it was generally assumed the Board would continue to add Distributors when appropriate. Through the 1996 Resource Statement, the Board made clear that its Combined Service Area is fixed. While the Board emphasized it will serve water for building out its suburban Distributors, it will not take responsibility for water supply outside its Combined Service Area.

By fixing its Combined Service Area boundary, Denver Water is able to determine with a higher degree of accuracy the population it will be serving at build-out. Given those

population projections, Denver Water in 2001 determined it would require 450,000 acre-feet to build out its Combined Service Area—a 5,000 acre-foot increase over the 1996 figure. The 450,000 acre-foot figure includes a 30,000 acre-foot safety factor as a hedge against future uncertainty. Given that Denver Water’s present demand is 285,000 acre-feet, future demand can be expected to increase substantially in the system. While the Denver Water system currently serves slightly over 1.1 million customers including fixed amount contracts outside Denver Water’s Combined Service Area, that figure is expected to rise to some 1.9 million at the time of build-out.

To meet that demand, Denver Water currently has 375,000 acre-feet of yield available or in construction. That means a current excess of 90,000 acre-feet of supply over demand; but it also means a shortfall of 75,000 acre-feet to meet the 450,000 acre-foot build-out figure, which includes the 30,000 acre-foot safety factor. Except for its Moffat System problem, Denver Water’s present 375,000 acre-foot yield is sufficient to serve its increasing demand until the year 2016, at which time Denver Water’s demand and supply lines will cross if no further supplies have been added or no further demand reductions have been made.

Meeting the Shortfall

Where, then, is that extra 75,000 acre-feet to be found? Prior to the 1990s, the answer would have been easy: the least-cost structural storage project—that is, a dam and reservoir—next on the drawing board would be built. However, the answer is no longer so simple, given the present climate of public attitudes and values, and given the regulatory climate within which utilities must operate. Instead, the Board’s answer in its Resource Statement is that conservation, reuse and small-scale system refinements must be utilized in the near term to close the gap, with structural storage efforts to be called upon generally if the other approaches are insufficient, and only toward the latter part of the near-term time frame. An exception would be a “target of opportunity”—a time-limited cooperative opportunity that might never recur. A second exception would be a specific problem on the Denver Water system, such as the supply availability situation currently affecting Denver Water’s Moffat Water Treatment Plant. Additionally, the list of system refinement projects includes such items as gravel pit storage and other limited structural measures.

In the Board’s 1996 Resource Statement, the Board indicated that in the “near term”—the period up to the year 2030—the Board has the potential to develop demand reduction and supply projects it has identified that would push the crossing of the supply and demand lines out beyond 2030. Expectations for this near-term strategy have increased in the ensuing five years such that the strategy is now expected to produce 71,000 acre-feet, rather than the previous estimate of 66,000. The result is that if the near-term strategy is successfully implemented, Denver Water’s demand and supply lines will cross in about the year 2035.

It is important to recognize that of the 71,000 acre-feet slated for implementation in the near term, 30,000 acre-feet has been completed, or is under development. That has raised the Board’s firm annual yield to 375,000 acre-feet, with 41,000 acre-feet still to be acquired in the near-term strategy. With a build-out shortfall of 75,000 acre-feet, if the 41,000 acre-feet

is successfully implemented, the Board will be faced with a 34,000 acre-foot shortfall in its long-term strategy after the year 2035.

With respect to the long term, the Board determined that since its near-term strategy pushes the crossing of the supply and demand lines so far out in the future—that is, beyond the year 2035, there is little reason for it to identify today what actions it believes a future board should take 35 years hence. The IRP process identifies a promising list of future projects ranging from added conservation to significant potential for future potable water recycling to continued opportunities for conjunctive use to a long list of possible surface storage additions (whether enlarged facilities or new ones) which future boards will have decades to consider.

The Changed Roles of Efficiency and Surface Supplies

A vital part of the Board’s strategy is the role of future water conservation. In the 1996 IRP, the Board for the first time explicitly included conservation savings as a part of planning forecasts on par with traditional supply sources. For several years, water utilities across the country have been increasing their efforts in the field of conservation. But few have been willing to accord water conservation savings the same credibility in their planning and forecasting as that received by conventional water supplies. The fear among utility planners has been that while conservation savings might be present one year, given their dependence on public attitudes, practices and weather—all of which are subject to change—these savings could disappear the next year. If the next year happened to be a dry one in which conservation savings were to be depended upon, what was the utility to do for water?

The Board, by its action in its Resource Statement, affirmed its confidence in the permanent presence of conservation savings within its system. And indeed, even while Denver Water has saved over 25,000 acre-feet annually through conservation in the past decade and a half, the Board expects an added savings of approximately 30,000 acre-feet more a year apart from “natural replacement” prior to build-out in its system.

Not only did the Board signal that conservation would be treated on an equal footing for planning purposes with structural supply sources; it also put conservation at the head of the line when considering how to meet future water demands. That is, even as larger-scale surface storage projects are relegated to later time frames, conservation projects will go on continuously and be expanded. Similarly, non-potable recycling of water and system refinement projects that make the Denver Water system more efficient will also have priority. It is not that major surface storage efforts will never again be built by Denver Water; it is that apart from “cooperative action” initiatives and targeted efforts aimed at specific system problems, such projects will be seriously considered only after Denver Water has first developed conservation, reuse and small-scale refinement efforts.

Since there is no way to be certain that significant surface storage projects will remain unneeded, the Board indicated in its Resource Statement that it reserves for its use all of its water rights, both conditional and absolute. That is, the Board cannot be certain that conservation, reuse and system refinements will suffice in meeting all of Denver Water’s

future demand. If they do not, then the Board must reserve its water rights so that future storage efforts can be undertaken. Since it is impossible to say with certainty which conditional water rights might ultimately succeed in being developed, all water rights must be protected. Given the uncertain nature of accomplishing structural storage projects as a result of stringent regulation, environmental impact, high cost, politically charged issues, and the diminishing nature of attractive reservoir sites, the Board believes it is necessary to make clear that all of its water rights are reserved for future use.

In implementing the IRP package, including the conservation portion, the Board indicated that it will always proceed in an environmentally sensible manner. For Denver Water, that guideline has become axiomatic. It believes that in all of its actions, good environmental practices are also good public and water policy.

Outside Denver Water's Combined Service Area

It is important to recognize that the Board believes it can find the added water to build out its Combined Service Area from its own resources. That is, the Board is not dependent on resources—water rights, facilities, or dollars—from those outside its Combined Service Area to find the added water supply or demand reduction needed to meet its future obligations in the Combined Service Area. The combination of Denver Water's infrastructure and extensive conditional water rights puts it in an enviable position in terms of preparation for its future.

However, the Board also realizes that there may be economies and efficiencies to be gained by pooling its efforts and resources with those outside its Combined Service Area. While the Board recognizes it can get there alone, it also believes it may be more beneficial to achieve its objective cooperatively with others, so long as the efforts undertaken prove to be mutually beneficial.

The Board's Resource Statement makes clear that Denver Water will engage in cooperative actions with those outside its Combined Service Area. However, the Board is not willing to permanently dedicate to those outside its Combined Service Area its infrastructure or water rights capacity in circumstances in which neither its own infrastructure nor its water yield is benefited. The distinction is a subtle one. The Board is open to finding joint or cooperative projects where its water yield or infrastructure capacity is benefited even as it permanently contributes some of its conditional water rights or infrastructure capacity for use by others; what the Board is not willing to do is contribute those assets for the use of others outside its Combined Service Area without receiving yield, infrastructure or commensurate benefit.

On many occasions, Denver Water has been called upon to offer its system to move water from party A to party B, with Denver Water receiving a small stipend for use of its facilities. What the Board has determined is that it will need all of its water rights and infrastructure assets to meet the long-term needs of its Combined Service Area. To parcel those assets out on a piecemeal basis to users outside the Combined Service Area without receiving any added yield or infrastructure benefits in return simply results in those water rights and infrastructure being used up before Denver Water is able to provide fully for its own

Combined Service Area. That would mean, in turn, that when growth pressures in its Combined Service Area require those assets, Denver Water will have to replicate at incredibly high cost that capacity it has relinquished.

Nonetheless, the Board indicates in its Resource Statement that it is willing to lease its water and capacity on a temporary or short-term basis. So long as the Denver Water system continues to enjoy an excess of supply over demand, Denver Water is ready to make short-term leases of no more than five years in duration. The Board has indicated that at the lease termination date, it is willing to explore five-year renewals.

Throughout its IRP deliberations, the Board stressed the importance of working cooperatively not only with other water utilities, but with non-water utility interests outside metro Denver. For example, the Resource Statement indicates that “any future structural projects located on the Western Slope should be developed cooperatively with Western Slope entities for the benefit of all parties.” While such cooperation takes considerable time, patience, and painstaking effort, the Board’s message to the Western Slope is essentially, if we don’t do such projects together, then we won’t be able to do them at all.

Yet the Board recognizes that full utilization of its system will place a greater demand on its facilities both within and outside the Denver area. For example, the Board acknowledges that full use its facilities will demand more of the Dillon Reservoir system. It also understands that added South Platte River projects such as non-potable reuse will mean flow changes on that river. In both cases, the increased use is of Denver Water’s existing infrastructure or assets—that is, using Dillon Reservoir for municipal water supply purposes as was intended in its appropriation of water rights and subsequent construction of facilities, and reusing wastewater effluent from the transmountain flows Denver Water brings to the South Platte basin as good practice, efficiency and Colorado water policy dictate.

In summary, through its Resource Statement and adopted resource strategy, the Board has crafted a sound road map to help it navigate an uncertain future. Through careful deliberation, the Board has made major progress toward bringing some certainty to that future.

And in Conclusion

The Board recognizes that the IRP must be an ongoing planning process. It has an obligation to continue to monitor the course of future events and make mid-course planning corrections. This permits the Board to assess programs against changing criteria and public attitudes so as to ensure the path chosen is the most reasonable, given the operative circumstances. As an example, the Board is currently reviewing how the Denver Regional Council of Governments’ “Metro Vision” and “Urban Growth Boundaries” can help inform the Board’s decisions on possible provision of water outside the Board’s Combined Service Area. Presumably, the Board could add such a consideration to its list of “Cooperative Action” guidelines.

The IRP is a continuing effort to determine how best to supply Denver and the Board's Combined Service Area with water over the coming half century. As such, the IRP is dependent on an ability to look at current conditions and historical circumstances in such matters as population projections, conservation attitudes, weather patterns and future stream flows so as to make judgments about an uncertain future. While the Board's IRP sets a sound direction for that future, this direction must be continually revisited to assure that the Board's customers receive in perpetuity the same high-quality, reliable water supply they have come to expect.

In the space of one hundred and seventy-six years, the Lower Mississippi has shortened itself 242 miles. That is an average of a trifle over one mile and a third per year. Therefore, any calm person who is not blind or idiotic can see that in the old Oolitic Silurian Period, just a million years ago next November, the Lower Mississippi River was upward of one million three hundred thousand miles long. By the same token any person can see that seven hundred and forty-two years from now the Lower Mississippi will be only a mile and three quarters long. There is something fascinating about science. One gets such wholesale returns of conjecture out of such a trifling of fact.

Mark Twain

Board Resource Statement

October 15, 1996

I. Introduction

- A. This policy statement guides the future allocation of Denver Water's resources to meet the water needs of customers within our service area.
- B. This policy statement promotes productive interaction with entities outside the Board's service area.
- C. This statement is a result of the Board's Integrated Resource Planning process and supersedes the April 4, 1989 Statement of the Board of Water Commissioners.

II. Statement of Current Resource Situation

- A. Under the assumptions contained in the Integrated Resource Plan, Denver Water's currently available water supply of 345,000 acre-feet will meet projected demand until approximately the year 2013.
- B. The Board cannot rely completely on this projection because of a number of risk factors associated with its supply, including:
 - 1. Developing and maintaining municipal water supplies today is more challenging than in the past due to a combination of political forces and the federal government's increased regulatory role.
 - 2. Water supply in semi-arid regions is highly unpredictable.

III. The Board's Current Water Supply Obligations

- A. The Board is obligated under the Charter to provide an adequate supply of water to the people of the City and County of Denver, consistent with the city's quality-of-life and planning goals.
 - 1. The Board's assets are owned by the people of Denver.
 - 2. The Board is committed to the responsible financial management of those assets.
- B. The Board is permitted by Charter to lease water for use outside Denver. The Board is obligated by contract to provide treated water service to the Combined Service Area (CSA), which is the geographic area composed of the service areas of all the Distributors who rely solely on the Board's treated water for their water supply.
 - 1. For the foreseeable future, the Board will not undertake responsibility for water supply for areas outside the CSA.
 - 2. For Distributors who have signed the new Distributor contract, the Board is committed to providing all water necessary to serve the full development of all land within the Distributors' service areas, and to imposing water use restrictions, when necessary, in the same manner as imposed inside Denver.

3. For current Distributors who do not sign the new contract, the Board reserves the right, pursuant to the contracts of these distributors, to impose a tap allocation program and water use restrictions that may be different than those imposed within Denver.
 4. As required by the Charter, rates and charges for Distributors outside the city will differ from inside-Denver rates, and will be designed to fully reimburse the people of Denver for the cost of furnishing the service, plus a reasonable return.
 5. The Board also has contract obligations for fixed amounts of treated or raw water to suburban entities who are not Distributors.
- C. The Board has adequate water resources and options, including opportunities for conservation, reuse and development of its water rights, to fulfill its obligations, including service for the CSA through build-out. Nevertheless, the Board recognizes that cooperative arrangements with entities outside the CSA may benefit customers within the CSA.

IV. Future Strategy

- A. No single resource strategy is sufficient to meet the Board's water service obligations, and each strategy has its own environmental and other consequences. The Board intends to invest in and manage a diverse portfolio of resources to meet its future needs and minimize risks. The Board will pursue opportunities that increase supply through conservation, reuse and water rights development, either alone or in cooperation with others.
- B. When meeting future water needs, including development of cooperative projects with others, the Board will pursue resource development in an environmentally responsible manner.
- C. The Board acknowledges that its treatment, transmission and distribution system will need to be maintained and expanded as growth occurs in the Board's service area and as federal regulatory requirements change.
- D. For the foreseeable future, the Board will maintain a safety factor of 30,000 acre-feet to protect against risks the Board faces in meeting its customers' needs. Potential risks include:
 1. Catastrophic events
 2. Unexpected build-out demand
 3. Lower than expected yield from programs, projects, or existing facilities
 4. A longer than anticipated drought

V. Near-Term Strategy

- A. The Board's near-term strategy is designed to produce approximately 55,000 acre-feet of additional water in order to extend its water supply beyond the year 2013 to the year 2030. The resources in the near-term

strategy will be diverse and will contain conservation, non-potable reuse, small-scale system modifications and supply projects, including potential cooperative projects with others and private sector involvement.

- B. The Board will maintain a strong water conservation ethic and will invest in additional cost-effective water conservation, including investments that provide opportunity for private sector participation. The Board will rely on a volume of savings from conservation in its planning, and will refine the projected volume of savings based on actual results obtained.
- C. Beginning in 1997, the Board will move forward with system management techniques and may acquire small water rights as they become available.
- D. The Board will develop non-potable reuse of water as demand increases and as opportunities arise.
- E. The Board believes that new surface water storage will be needed at the end of the near-term timeline. The Board cannot determine at this time which of its water rights will be required for this surface water supply, so the Board intends to preserve its conditional water rights.
- F. Opportunities for cooperative actions which will benefit the CSA are certain to arise. The Board is adopting a cooperative posture toward these opportunities.

VI. Long-Term Strategy:

- A. The long-term strategy is designed to produce the final 45,000 acre-feet to make up the difference between the total system supply after completion of the near-term strategy (400,000 acre-feet) and the supply needed to serve the CSA to buildout (445,000 acre-feet).
- B. Various options exist for the long term and the Board, in the interest of maintaining flexibility, need not make project-specific commitments at this juncture. Some of these options include additional conservation, expanded reuse and the development of water rights with new or enlarged surface water structures. The Board cannot determine at this point which water rights will be required, so the Board must preserve its water rights to assure their availability in the future and to maintain flexibility in the ever-changing and complex world of water supply.

VII. Metropolitan Role

- A. The Board recognizes that the Denver metropolitan area is a socially and economically integrated whole. In that light, the Board recognizes that cooperative actions with other metropolitan entities should be explored, in order to enhance the Board's near-term and long-term strategies.
- B. When a potential project primarily benefits Denver and the CSA, the Board will consider assuming a major role in the regulatory, financial, political and legal risks of the project. The Board is interested in minimizing the risk to the existing yield of its water system in undertaking any cooperative project.

- C. The Board's staff is directed to explore cooperative actions with water suppliers outside the CSA based on a set of guidelines to be developed by the Board.
- D. The Board has determined that it cannot permanently dedicate to entities outside the CSA capacity within its system because all of the Board's existing infrastructure and more will be needed to meet the Board's water supply obligations.
- E. The Board will consider short-term leases of water under the following conditions:
 - 1. The lease is five years or less in duration
 - 2. The Board's system suffers no adverse impact
 - 3. Reliance on Denver Water is truly temporary, meaning that the lessee will identify in the agreement a substitute for Board-supplied water
 - 4. Proper compensation is made to the Board using a cost-based formula
 - 5. The lease is consistent with the Board's water right decrees

VIII. Beyond the Metro Area

- A. The Board will emphasize aggressive conservation, efficient reuse and small-scale system modifications.
- B. In order to meet demand between now and 2013, the Board will be required to maximize use of its existing supply of 345,000 acre-feet, causing, among other impacts, reduced return flows north of Denver as a result of aggressive conservation and reuse programs and increased fluctuation of water levels at the Board's reservoirs, including Dillon Reservoir.
- C. Any future structural projects located on the Western Slope should be developed cooperatively with Western Slope entities for the benefit of all parties. The Board believes that Wolford Mountain Reservoir and the Clinton Reservoir-Fraser River Agreement are useful examples of Eastern Slope-Western Slope cooperation.

**Cooperative Actions With Metropolitan Water Suppliers
Outside The Board's Service Area
October 15,1996**

As a result of its Integrated Resource Planning process, the Denver Board of Water Commissioners has issued, a Resource Statement to guide future allocation of Board resources. In the Resource Statement, the Board acknowledges its primary responsibility to provide an adequate supply of water to the Combined Service Area (CSA), consisting of the City and County of Denver as well as the suburban contract Distributors currently served by the Board. The Board has adequate water resources and options, including opportunities for conservation, reuse and development of water rights, to fulfill its obligations to serve the CSA through build-out. The Board has no plans to expand the CSA or to assume responsibility for water service to areas outside the CSA.

Nevertheless, the Resource Statement recognizes that cooperative arrangements with existing metropolitan water suppliers outside the CSA may benefit customers within the CSA and may improve provision of water service within the Denver metropolitan area. Accordingly, the Board's Resource Statement directs Denver Water staff to evaluate potential cooperative actions that may be proposed by other metro area water suppliers. To evaluate cooperative actions appropriately, the staff will consider a number of factors, which are listed below. The staff will present to the Board for further consideration only those proposals that best respond to the listed factors. The Board will then determine whether any of the proposed cooperative actions should be pursued.

The Board intends to fulfill its primary responsibilities to the CSA by implementing the near-term strategy outlined in the Resource Statement. Therefore, the effort to identify potential cooperative actions with others is a secondary priority. The staff estimates that the process of developing and evaluating cooperative actions will require at least two years to complete.

To be considered by the Board, a proposed cooperative action should provide a tangible benefit to the Board and address the factors listed below. A proposal is most likely to receive consideration by the Board if it:

- A. Provides both a significant water benefit and a significant financial benefit to the Board. A water benefit could include a significant water yield or water saving for use within the CSA; improved operational efficiency for the Board's water system; or better use of the Board's existing water rights.
- B. Minimizes the Board's regulatory, financial, legal and political risk. A proposal should not pose a risk to the Board's existing yield or to the prospective yield or effective operation, integrity and water quality of the Board's system.

- C. Limits the Board's obligations to the customers of the proposing agency to a particular amount of water. The Board does not intend to become responsible for water service to areas outside the CSA.
- D. Assures that the proposing agency will implement an effective water conservation program in its service area. The most desirable water conservation program would be comparable to that which Denver Water practices.
- E. Ensures that the proposing agency will pursue available non-potable reuse options to maximize the efficient use of water within its service area.
- F. Maximizes the use of the Board's existing water rights rather than requiring development of new water rights by the Board.
- G. Consolidates water supply proposals initiating from the same geographic region or sub-region.
- H. Fosters environmental protection, including maintaining "boatable" river flows through Denver, protecting and enhancing wetlands, and protecting and enhancing wildlife and aquatic habitats.
- I. Demonstrates an effort by the proposing entity to gain acceptance of the proposal from those outside the Denver metro area who might be impacted by the proposal. This would include efforts to mitigate those impacts.
- J. Ensures that groundwater resources are sustainable if the proposal relies on groundwater.
- K. Provides visible benefits to the citizens of Denver, which could include purchase and dedication to open space or parks at Lowry Air Force Base, Stapleton Airport or the South Platte River Corridor through Denver.

Staff will explore cooperative actions with existing water suppliers in the metro area before considering proposals from water brokers. There is no deadline for submission of cooperative actions by existing water suppliers, and no commitment to review or respond within a specific time period. Once proposals from existing water suppliers have been evaluated and the Board has decided which, if any, cooperative actions to pursue, the Board may direct staff to consider proposals from water brokers that address the above factors.